Planting the Future
Linear Consulting Botanical Garden Development Proposal

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University of British Columbia

CIVL 445

November 28, 2013

CIVIL 445

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Abstract

The following report outlines the interdisciplinary process that our group will undertake in order to determine possible improvements to the UBC Botanical Garden. This report will analyze the background requirements and mandates set forth by the UBC Botanical Garden, and will provide a series of detailed project milestones.

In addition, this document will provide extensive conceptual designs and process considerations for areas pertaining to water runoff, garden accessibility and attractions. Further still, given the financial stipulations attached to the following project, an incremental implementation process will be detailed for a variety of key milestone projects which would address major areas of improvement in the garden. Primary to the botanical garden's mandate is that the categorization and integrity of the flora and fauna be maintained. As such, all proposed conceptual designs and additions will aim to improve patronage while minimizing the impact on the garden's operation. All major conceptual designs will provide generalized scheduling for a one, five and ten year time frame to allow the botanical garden administration to partially implement any improvements put forward in this report.

In order to gain further insight into the benefits of the conceptual designs within the report, general feasibility studies and case studies of other garden installations will be looked at and discussed briefly as well.

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Executive Summary

The following report outlines the interdisciplinary process that our group will undertake in order to determine possible improvements to the UBC Botanical Garden. This report will analyze the background requirements and mandates set forth by the UBC Botanical Garden, and will provide a series of detailed project milestones.

All major conceptual designs will provide generalized scheduling for a six month, one, two and ten year time frame to allow the botanical garden administration to partially implement any improvements put forward in this report. In addition this document will provide extensive conceptual designs and process considerations for areas pertaining to water runoff, garden accessibility and attractions.

In order to gain further insight into the benefits of the conceptual designs within the report, general feasibility studies and case studies of other garden installations will be looked at and discussed briefly as well.

Concept Mandate and Requirements

- Maintain the botanical garden's integrity and original purpose
- Improve patron experience of the four major corners of the garden
- Provide innovative designs and concepts for various garden issues
- Provide a scheduling timeline for project implementation

In addition this document will provide extensive conceptual designs and process considerations for areas pertaining to water runoff, garden accessibility and attractions. Further still, given the financial stipulations attached to the following project, an incremental implementation process will be detailed.

Areas of investigation

- Stormwater Runoff
- Multiuse space/glass house/restaurant/café
- Multistory parking structures
- Pedestrian accessibility and signage

As such all proposed conceptual designs and additions will aim to improve patronage while minimizing the impact on the garden's operation. All major conceptual designs will provide generalized scheduling for a six month, one, two, five and ten year time frame to allow the botanical garden administration to partially implement any improvements put forward in this report.

Assigned Roles

- Research and graphics for Stormwater treatment – Steven
- Research and graphics for Multi-use commercial space – Mike, Rayna
- Research and graphics for Parking stuctures- Saman
- Research and graphics for pedestrian accessibility and signage – Dan, Iris

Further still, given the financial stipulations attached to the following project, an incremental implementation process will be detailed for a variety of key milestone projects which would address major areas of improvement in the garden. Primary to the botanical garden's mandate is that the categorization and integrity of the flora and fauna be maintained. As such all proposed conceptual designs and additions will aim to improve patronage while minimizing the impact on the garden's operation.

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1.0 Introduction

The focus of our proposal rests on infrastructure improvements, new attractions, visitor experience, accessibility, and parking to increase the popularity of the UBC Botanical Garden. Addressing the four corners of the botanical garden was first and foremost in the design process for the conceptual development plans for the future of the organization. Key areas of concern were parking, accessibility and the ability to simultaneously draw in new patrons while adhering to the integrity of the original mandate set forth by the garden administration. With any great undertaking, progress is gradual and rooted in the firmament of quality and integrity. To ensure the continued success of the gardens and the enjoyment of patrons of all generations Linear Consulting will ensure that development of the garden spaces minimize any user experience interference and utilize green sustainable construction practices.

1.1 Background

The methodology used to accomplish the goal of redeveloping the UBC Botanical Garden is an engineering-based design process that provides comprehensive analysis and solutions to the primary areas of concern at the UBC Botanical Garden. The design process includes conceptual mock-ups, engineering construction methodologies, cost estimates, and general timeline for implementation. Concepts and designs put forward by Linear Consulting were the result of extensive consultation and collaboration with expert engineers, garden administration and individual engineering experience.

The overall cost of the project is estimated at approximately $47 million as shown in Table 1 below. Further financial analysis is performed in each discrete section of garden improvements within this report.

Estimated Overall Cost		
Component	**Addresses**	**Estimated Cost ($)**
Stone Oven	*Usable education space*	$40,000.00
Multipurpose Space Phase1		$18,000,000.00
Multipurpose Space Phase2		$20,000,000.00
Cattail Marshes	*Accessibility*	$40.00
Service Yard Improvement		$774,000.00
Parking Structure		$6,000,000.00
Pedestrian Overpass		$2,100,000.00
Stormwater Drainage System	*Stormwater/Drainage*	$148,000.00
Tunnel Improvements	*User Expereince*	$250,000.00
Additional Improvements		$50,000.00
TOTAL COST		$47,362,040.00

Table 1 - Estimated Preliminary Cost

Given the budgetary constraints of the garden, a phased implementation has been set forth. As shown in Table 2, there is a proposed timeline of 6 months, 1 year, 2 years, 5 years and 10 years, for all major garden improvements. Utilizing this deployment technique will provide patrons with continued ease of access while the garden administration installs and remediates the areas and issues outlined within the following report.

Timeline	*Components*					
	Multipurpose Space Phase 1	**Multipurpose Space Phase 2**	**Accessiblity**	**Stormwater Treatment**	**Tunnel Improvements**	**Additional Improvements**
6 months	stone oven installation		improved signage	stormwater collection tanks	Installation of sound dampening materials and LED lighting system	Smartphone APP development
1 year	first floor installation		cattail marsh installation		Implementation of Herbarium Exhibition	Improved Garden events
2 year	onsite nursery development		service yard install	stormwater processing	Installation of projected scenic vistas	
5 year	second floor installation		parking structure installation		Installation of solar collection systems	
10 year	restaurant and café installation	construction of entire multipurpose space phase 2	pedestrian overpass installation	maintenance	Maintenance and Renovation	

Table 2 - Implementation Timeline

2.0 Multipurpose Spaces

2.1 Phase one

As outlined in the provided specifications to Linear Consulting, a proposal which encompasses increased foot traffic, and patronage while maintaining the original mandate of the UBC Botanical Gardens is of paramount concern. It is evident, that given the Lower Mainland's significant culinary culture and generally higher standard of living that a revision of the existing gift shop into a high end multipurpose space comprised of learning spaces, commercial space and a café/restaurant structure would contribute positively to the objectives put forward by the UBC Botanical Garden. From careful consideration and initial site visits, it is clear that a frontward facing attraction that is visible to passing vehicles and pedestrian foot traffic would be ideal. Furthermore, the proposed space will provide a centralized hub for all garden activities to take place within. Serving as a front end attraction, the installation would allow the Botanical Garden to maintain its internal processes and address the concerns of usable space and financial stability.

2.1.1 Incremental Change

Given the current budgetary constraints of the UBC Botanical Garden, a phased incremental implementation has been proposed. Adjacent to the current gift shop the redevelopment of the picnic area would be an ideal location for the first phase of the proposed improvements. Placement of a stone oven with a recycled wood terrace and trellis with additional seating areas is showcased in Figure 1 - Stone Oven Improvement. The introduction of a stone oven, would provide the gardens with additional flexibility in the formation of community events and corporate attractions. In essence, the stone oven space serves not only as a usable space, but would signify the reinvigoration of the gardens and its renewed vision. The aforementioned vision would be that of continued growth as both an institution which catalogues and curates plant species, while providing the general populace with academic and educational enrichment through its activities.

Figure 1 - Stone Oven Improvement

The stone oven space could serve as a classroom space for culinary institutes, utilizing partnerships with local industry and restaurants for events and garden features. Additionally, the stone oven will serve as the anchoring point for the eventual forward facing multi-purpose space outlined in Section 2.1.2 As seen in Table 3, the associated costs and required floor space of the stone oven patio is well within physical and financial constraints set forth by the gardens. Moreover, the stone oven will provide a symbolic indication of potential change to come, allowing for partnerships with various commercial institutions and community groups.

2.1.2 Central Hub Structure

The final proposed structure would require a 2 story, recycled wood frame and steel framed structure with capacity for approximately 1000 patrons on the lower floors, and 800 patrons on the upper floors. In total, the multipurpose structure has a spacious total floor area of 20000 sq.ft., promoting open concept designs and use of natural light. Utilizing sustainable technologies and green building practices the structure would keep in line with the University of British Columbia's cultural identity of pioneering environmental improvements. Further still, achieving a LEED Gold certification would allow the building to gain notoriety in various design circles, making it an attraction for both the lay person and engineering expert. Architecture inspired by the works of

Frank Lloyd Wright and Arthur Erickson, the first multipurpose space utilizes large open spaces which intertwine the clean lines of modern construction techniques with the organic symmetry and patterns of natural biological systems.

The proposed interior space as seen in Figure 2 - Multipurpose Space Main Atrium, would feature a large primary atrium serving as a focal point to the structure allowing patrons to actively participate in shaping the garden's cultural identity. Working in conjunction with the parking lot and pedestrian bridge, the primary multipurpose space would act as a primary thoroughfare for the garden.

Figure 2 - Multipurpose Space Main Atrium

On site, the structure would feature a large state of the art nursery and laboratory center which would allow garden staff to properly catalogue, research and study all form factors of flora and fauna. This would ensure an intimate setting and the elevation of the structure would provide some panoramic views of the gardens below. In essence, providing a high profile gateway would invariably draw more patrons to the gardens, and allow them to see the noble efforts of the institution. Furthermore, the ability to showcase sustainable and healthy green alternatives in fine dining would invariably draw positive media and public attention to the gardens. Providing a premium dining option would draw in larger crowds, and allow the garden to generate potential additional revenue as the restaurant operates.

Restaurant operation would require a full kitchen staff with at least one highly trained head chef. Additional culinary staffing could be fulfilled in conjunction with the Pacific Culinary Institute as there is a wealth of aspiring students at the institution. Moreover, on the ground floor a combination boutique café and produce/food based gift shop would provide attendees of the garden a common gathering point that could be revisited on a regular basis by patrons.

As detailed in Table 3, the multipurpose space could be built as a staged construction project with the main atrium existing as an open air structure during initial stages as funding is acquired by the administration. Utilizing a modular construction system, the scheduling and ease of construction would allow the Botanical Garden greater flexibility in the staged implementation of the structure. The ability to maintain garden operations while construction is underway is paramount, as such, a block based construction system which allows for gradual installation of features and components would allow for parallelization of the garden activities. Further still, in anticipation for the potential increased patronage, it is proposed that the parking lot be expanded into the nearby field which runs past the observation tower as detailed in Section 3.4. Moreover, with the successful implementation of the multipurpose, the increased patronage could request valet parking which would be an additional revenue stream. Comprehensive economic preliminary feasibility studies are outlined in 2.3 Economic Viability.

2.2 Phase two

UBC Botanical Garden and Centre for Plant Research maintains ex situ living material of rare plants and provides education in areas of biodiversity science and ecosystem conservation. In order to provide an enhanced environment for plant research and garden development, the second phase of multipurpose space proposed by Linear Consulting focuses on features such as lecture rooms, biological research centers, self-study rooms, and a greenhouse space.

2.2.1 Site Overview

The proposed rear multipurpose space will have a 4800 sq/ft footprint with a total floor space of 24,800 square feet. Furthermore, it will be situated adjacent to the service yard for ease of material transport. Structurally, the space will be fabricated using steel and aluminum frames which are then surfaced with an architectural glass finish. The three-dimensional view of this multipurpose space is shown in Figure 3 and Figure 4.

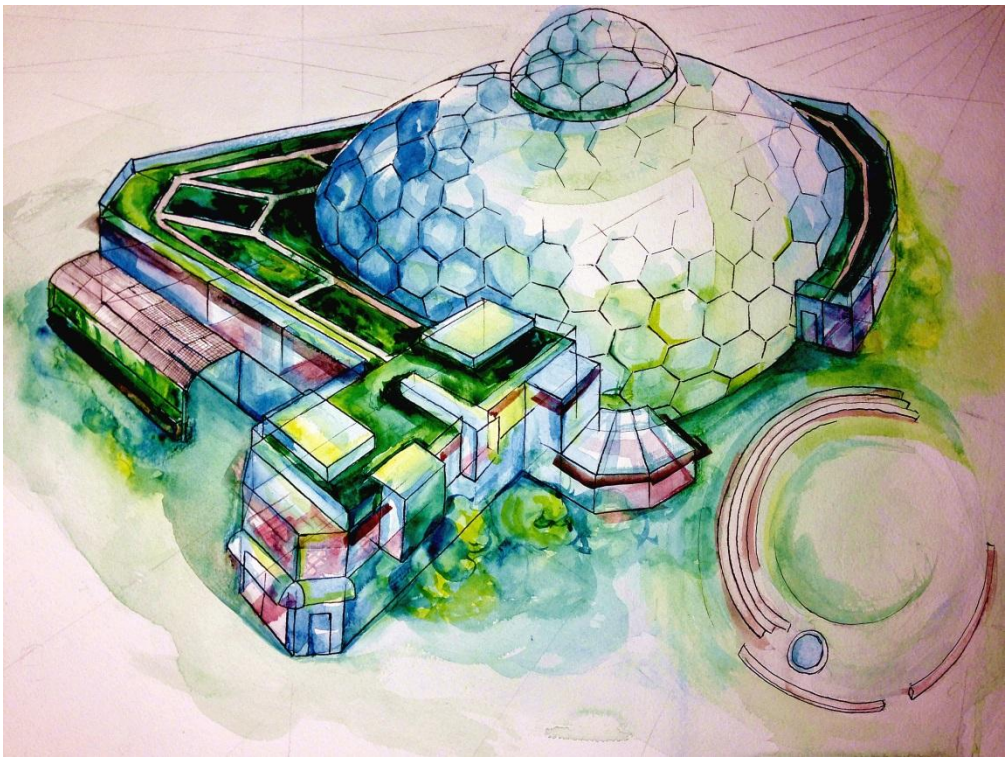

Figure 3 - Phase 2 Multipurpose Space

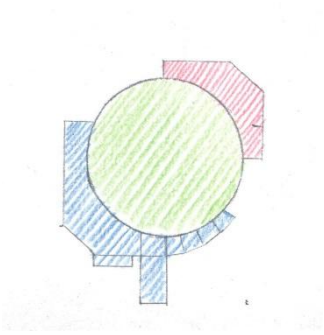

Figure 4 - Multipurpose Space Floor Plan

The structure is comprised of three main components: The North Wing (indicated in read), the South Wing (indicated in blue), and the Greenhouse which is centrally located in the structure (indicated in green). The North Wing is a two-floor structure that consists of 6 studying rooms on each floor, with a 35-person capacity. The South Wing is a three-floor structure with three primary lecture rooms on its first floor accommodating an audience of 50 to 200. The second and third floors of the South Wing will be used as a biological research center that consists of laboratory rooms and discussion rooms. The Greenhouse has an area of 2,500 square feet and will be located at the center of this multipurpose space.

2.2.2 Sustainability

In order to achieve UBC's goal of sustainability, the proposed structure draws inspiration from the UBC Centre for Interactive Research on Sustainability (CIRS) construction plan. Two primary green technologies employed by the Multipurpose Space are green roof surfaces and an advanced solar-energy collection system.

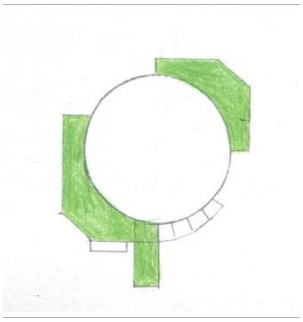

Figure 5 - Sustainable Technology Implementation

As shown in Figure 5, the rainwater is first collected from the roofs (both North and South Wings) together with the gray-water from the building, and it runs into a filtration and treatment system. After the water has been filtered and treated, the resulting potable water can be distributed within the building for use. In case the weather is dry, a backup connection to the storm-water treatment system is needed.

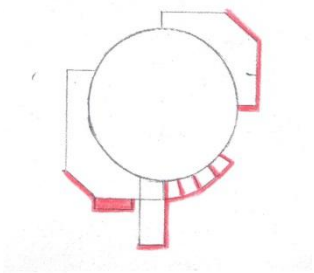

Figure 6 - Solar Collector Installation (aerial view)

Figure 6 shows the installation locations for PV Solar Shades (indicated in red). In order to reduce energy consumption costs, the proposed structure is designed to utilize solar energy as its main power source. Should the energy requirements of the building grow beyond the initial specifications, the solar power harvested could be used as a power source for other garden facilities.

2.2.3 Benefits

Once the second phase of the multipurpose space development is completed it will yield many benefits to research and provide additional financial revenue streams to the UBC Botanical Garden. This new multipurpose Space will provide patrons with an engaging space to directly interact and observe rare flora and fauna in the controlled environment of a greenhouse. Another benefit is that the space will be an attractive locale to visit for local and international patrons throughout the seasons. In addition, the structure will work in conjunction with the proposed redesign of the service yard to increase the overall operational efficiency of the garden. An in depth discussion of the service yard is included in Section 3.2 below.

2.3 Economic Viability

A multistory innovative commercial and learning space would be a significant financial undertaking; as such, significant preliminary research has been performed by Linear Consulting. Given the complexity of the incremental changes for various garden improvements, cost comparables and basic cost estimations were utilized. Given the cost of the CIRS building at 36 million, a comparably sized structure such as the final multipurpose space would have an associated cost of 20 million. This is in line with the projected phased construction process comprised of the stone oven terrace corner stone, and floors one and two of the multistory space as outlined in Table 3 - Size and Costing Analysis

Estimated Installation Details			
Feature	**Square Footage (sq/ft)**	**Estimated Cost ($)**	**Implementation Timeline**
Stone Oven and Dining Area	1500	$ 40,000.00	**6months**
Multipurpose Space Floor 1	15000	$ 10,500,000.00	**1 year**
Onsite Nursery	5000	$ 500,000.00	**2 year**
Multipurpose Space Floor 2	5000	$ 7,000,000.00	**5 year**
Multipurpose Space Phase 2	20000	$ 20,000,000.00	**10 year**
TOTAL COST		$ 38,040,000.00	

Table 3 - Size and Costing Analysis

In order to address the concerns of economic growth and continued garden operations, a variety of revenue streams and financial benefits are associated with the creation of the multipurpose space. Cafes and restaurants would provide an immediate cost benefit, allowing for the creation of a consistent and stable consumer base who would likely visit the gardens on a regular basis. Fostering a sense of a community would promote the gardens through word of mouth and social reputation. Additionally, social media integration and utilization of various connectivity suites would modernize the garden, attracting and engaging younger audiences who could ensure the future success of UBC Botanical Garden.

As an architectural feature, the multipurpose space could serve as an ideal location for onsite filming, and cinematography shots garnering incoming from the large television and film industry present in British Columbia. The rental of spaces as crew parks, and provisions for on location filming would allow the garden to generate consistent revenue streams previously unrealized, given its proximity to other structures on campus which are used for various film set pieces. Further still, the rental of classrooms and floor spaces to various commercial institutions such as banks, food services and clothing retailers would allow the gardens to gain

income from local industry, while maintaining the overall integrity of the garden operations. This can be achieved through centralizing all commercial and industrial operations within the primary multipurpose space. Ensuring that the primary garden mandates are upheld is essential in the operation of this structure, as such the onsite nurseries and various vital garden research functions can remain separate from the public, commercial venues. However, given the visual complexity and richness of the garden operations, new facilities and engaging community activities, garden memberships would become a desired commodity. Provisions for premier sponsorships and partnerships must be evaluated closely as any potential degradation of the garden's mandate must not be permitted.

3.0 Accessibility

An integral component of the overall redevelopment plan of the UBC Botanical Garden (UBCBG) is finding a remedy to the garden's accessibility issues. As previously mentioned, Linear Consulting recognizes the UBCBG's limitations, as far as quickly addressing these issues. Thus, the overall concept of incremental change is applied to ensure that positive redevelopment of the garden still occurs, but with a minimized scale of financial burden. More specifically, the development plan is subdivided into three time periods to accommodate the increase in visitors, attractions, and overall revenue stream. The short-term accessibility goal is focused on the cattail marsh and the implementation of small wooden bridges that span over the width of the marsh. During the mid to long term period, Linear Consulting proposes a complete redesign of the service yard, adjacent to the events yard. The long term projects aimed at completely positively restructuring the Botanical Garden's accessibility includes the installation of a pedestrian bridge that spans over South West Marine Drive and a multi-storey, sustainable parkade located on the current parking lot.

3.1 Cat-tail marsh

The cat-tail is an essential feature of the garden which helps define UBCBG's mission of sustainability. As described by a prominent naturalist and author, marshes are truly environmental treasures, full of life, but vulnerable to the inherent impacts of human activities (Burt, 2007). Additionally, marshes provide habitat for flora and fauna to thrive. Seeing as the garden is used for academic research purposes as well, the cat-tail marsh provides educational opportunities for both staff and students. Furthermore, the marsh itself can serve a purpose in managing stormwater within the garden grounds. The soil medium on the base of the marsh serves as a filter for the water. The ability of a marsh to produce filtered water further justifies the usefuleness of marshes.

3.1.1 Design Alternatives/Chosen

Two major options were considered in the design of the cat-tail marsh. The first option involved simple platforms that projected over the waters, supported by small wooden piles that dig into the marsh bed. The second option involved simple wooden bridges that span across the width of the marsh. It is the wish of Linear Consulting to meet the requirements set out by the UBCBG: To ensure that all redevelopment works do not negatively impact the flora and the experience of garden visitors. Thus, it has been decided that the latter of the two designs is the most viable option for the cat-tail marsh since a simple wooden bridge would have a lower overall impact on the marsh system from the lack of embedded piles. Figure 7 below shows a conceptual model of the proposed installation of three wooden bridges.

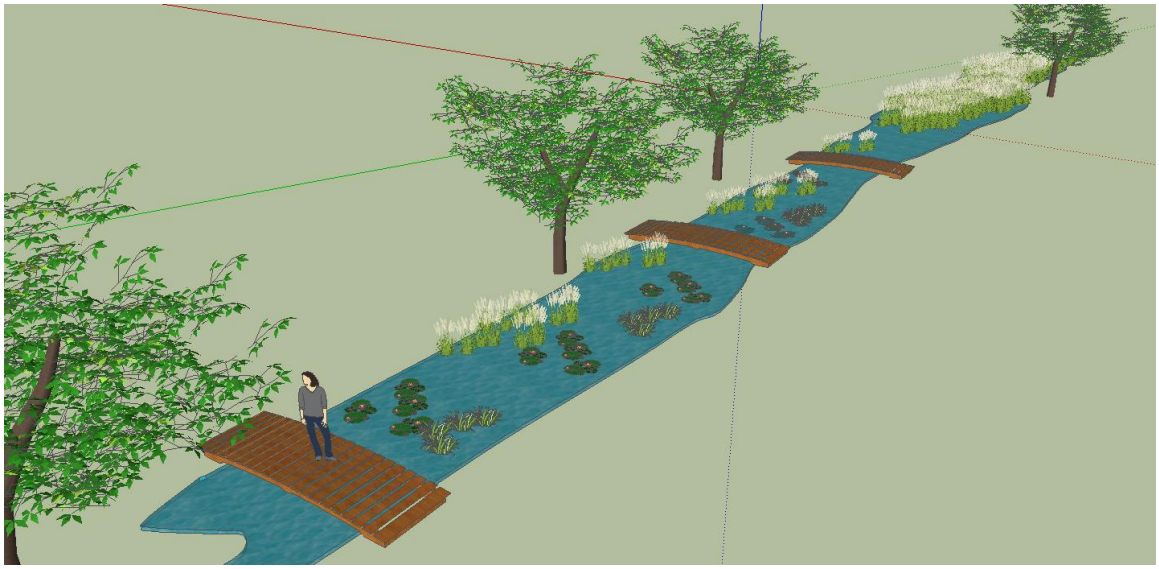

Figure 7 - Cattail Marsh Layout

The design includes a simple layout of 3 equally spaced 6”x7” hand hewn timber, while simple 2”x10” beams are spaced across the width of the bottom chord members. Reclaimed wood can be used for these bridges to further promote the sustainability concept of the Botanical Garden and decrease the overall costs of using new lumber materials.

3.1.2 Economic Viability

Table 4 below shows the associated estimated costs to construct these bridges. Prices vary depending on manufacturer specifications; the following is an example price quote from a manufacturer, which showcases the typical low prices for reclaimed wood products.

Estimated Installation Details for 1 small bridge			
Small Bridge Component	**Qty.**	**Beam Price ($/qty), Plank Price ($/ft.)**	**Estimated Cost ($)**
6"x7" Hand-hewn base beams	3	8.13	$24.39
2"x10" planks	20	0.12	$12.00
TOTAL COST PER BRIDGE			$36.39

Table 4 – CatTail Marsh Cost Analysis

Cost estimates are primarily based on current manufacturer values for reclaimed wood products. The benefit of using reclaimed wood is not only based on the sustainability aspect of the material, but it is cheaper than using new lumber cuts. Additionally, the large number of manufacturers specializing in reclaimed wood products in Vancouver provides more flexibility for the client in terms of choosing specific lumber members .

3.2 Service Yard

The service yard adjacent to the events yard is identified as the corresponding milestone project for the mid-to-long term accessibility redevelopment of the UBCBG. The administrators of the garden have expressed their concern of a lack of space for the ground staff to work. With that in mind, Linear Consulting has prepared a comprehensive list of service yard improvements to improve the accessibility of garden essentials transport and to better the staff’s ability to service the garden grounds.

3.2.1 Features

At present, a berm lines the north perimeter of the service yard. To increase staff space, Linear Consulting is proposing a complete removal of the berm. In keeping with the mandate of the UBCBG to preserve the plant species as much as possible and since the berm houses a variety of plants, the removal process would include a relocation plan for the plants into suitable garden areas. The resulting effect is an increase of 0.5 hectares of extra free space. A concrete overlay will cover the resulting removed berm area for durability purposes. As discussed previously, a multi-purpose space located on the events yard and adjacent to the service yard is part of the overall garden redevelopment project. In order to accommodate the future structure, the installation of a 2, 400 sq. ft. office space is proposed to help with the day-to-day activities in managing garden operations. The office will include a green roof system and will primarily rely on passive solar panels for energy and large windows for adequate illumination. The actual green roof system will play multiple purposes, from proper insulation, to rainwater collection, and to creating habitats for bird species. Since the garden is located in a fairly urbanized environment, the green roof will also be able to mitigate the heat island effect (Akbari, 2005). An increase in solar radiation absorption associated with urbanization leads to increased temperatures and increased energy demands, which in turn leads to increased emissions of air pollutants and greenhouse gases. Therefore, the use of a green roof system will mitigate the adverse effects of the proposed redevelopment projects. Directly next to the office space, a small 3,200 sq. ft. warehouse structure will be installed to store delivered garden necessities. The warehouse, similar to the cat-tail marsh bridges, will be primarily made using reclaimed wood materials. See Figure 8 below showing a conceptual view of the proposed service yard redesign.

Figure 8 - Service Yard Layout

3.2.3 Estimated Costs

The resulting financial costs will be from the concrete overlay of the removed berm space, the fully functional sustainable office building, and the storage facility made from structural reclaimed wood products. Table 5 below summarizes the cost contribution from each proposed service yard development component.

Estimated Installation Details for service yard	
Project Breakdown	**Estimated Cost ($)**
Concrete overlay	$94,000.00
Sustainable office	$410,000.00
Small warehouse	$270,000.00
TOTAL COST	$774,000.00

Table 5 – Service Yard Costing Analysis

The preceding estimated cost for the concrete overlay is based on quotes obtained from the local concrete supplier, LaFarge. The calculations assume a 100mm thick concrete overlay and 25 MPa General Use cement type concrete, values commonly found in Canadian sidewalk construction (Rajani, 2002). The estimated costs for both the sustainable office and small warehouse are based on RS Means US average data for the year of 2010. The values have been adjusted to account for location, time, and contingencies including solar panels, green roof installations, and the use of renewable wood materials.

3.3 Pedestrian Overpass

To fully consolidate UBC Botanical's Garden as an accessible, relevant, visible, and viable garden, Linear Consulting is proposing the installation of a pedestrian overpass to span across Southwest Marine Drive to the main garden entrance. Southwest Marine Drive (near the garden's entrance) is a 4-lane corridor with a grassy median in opposing traffic directions. The current speed postings transition from 80 km/hr to 60 km/hr near the intersection of 16th Avenue and Marine Drive. However, it has been observed that vehicles commonly travel at speeds greater than 60 km/hr. The intersection at 16th Avenue and Southwest Marine Drive is an uncontrolled intersection with a simple crosswalk to manage the crossing of pedestrians. This poses a serious safety threat for pedestrians trying to cross to and from the garden. Considering the increase in visitors from the redeveloped garden, a pedestrian bridge would provide safe passage for garden users, while minimizing the overall impact on the current flow of traffic. From a different point of view, a pedestrian bridge aids in emphasizing the identity of the Botanical Garden. It is there to promote the presence of the garden and help attract more visitors.

3.3.1 Design Alternatives/Chosen

Our group's conceptual design meetings considered using a wood and structural steel as the primary construction materials of the final structure. In the end, our team elected for a steel pedestrian bridge due to many reasons. For one, steel as a material is much stronger and more durable than wood, provided the steel components have been properly coated. Given the climatic weather of Vancouver, the bridge would be subjected to many weather conditions that can deteriorate key structural components. A wooden bridge would be exposed both to dry and wet conditions resulting in expansion and shrinkage induced internal stresses, especially at the connections. Additionally, for a wooden bridge to have the same strong characteristics as that of a steel bridge, the members would have to be sized up to take on the induced loads. While the use of a wooden bridge would definitely promote the sustainability theme of the garden, the large member sizes would obstruct the view of the surrounding environment. Steel members can be sized in smaller components, while still attaining the proper strength characteristics to resist the induced loads, minimizing the impact on the view of the surroundings. Figure 9 below shows the proposed conceptual model of a steel bridge across Southwest Marine Drive.

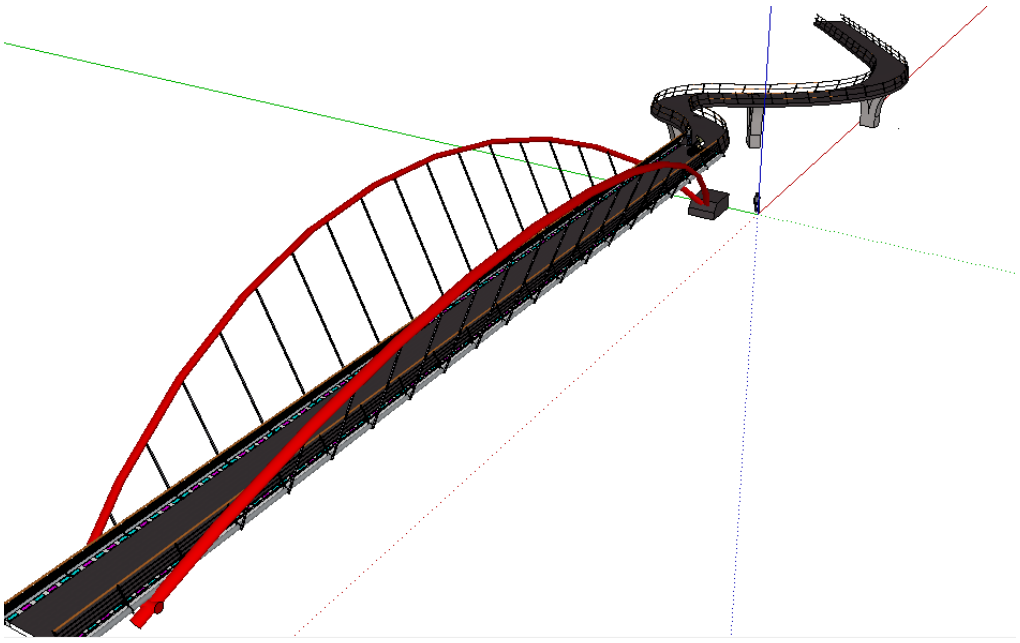

Figure 9 - Pedestrian Overpass Layout

The design features galvanized steel arches and tension cables to support the main concrete deck. The asymmetric steel arches eliminate the need for intermediate piers on Southwest Marine Drive, saving extra costs. Concrete piers are placed in key locations to support the approach ramp. Situated approximately 6 meters above the current ground, the main span is lined with LED lights that rely on solar panels to illuminate the deck at night. The handles on the rails are made of wooden members to slightly represent the outdoor/garden theme. While one end of the span leads to a snake-like ramp, the other connects to the Phase 1 multipurpose space situated in the garden entrance. A concrete anchor on the ramp side helps to hold the steel arches and transfer the loads to the ground.

3.3.2 Estimated Cost

In order to assess the feasibility of the chosen design, Linear Consulting conducted precedent studies on similar projects that have been previously completed. One key project involved a pedestrian bridge in the Sea-to-Sky Highway that uses the same steel arch system with tension cables to support the main concrete deck. The project designed by Hatch Mott MacDonald provides pedestrians a gateway to pass from one part of the Squamish Nation to another without crossing the Sea to Sky Highway and CN Rail ("Squamish Pedestrian Overpass," n.d.). Its ingenious design and architectural features, despite many limiting design factors, enabled HMM to obtain the Award of Excellence at the Canadian Consulting Engineers Awards Gala in Ontario. The construction cost of this bridge resulted to $2.1 million. It is expected that the pedestrian bridge to span across Southwest Marine Drive will be approximately similar to that of the Squamish Pedestrian Overpass.

3.4 Parking Structure

One of the major shortcomings associated with the current operation of the UBC botanical garden, as indicated by the garden staff, is the lack of sufficient parking space for the facility. This issue is more troublesome particularly during times at which there are special events organized within the park. These events include festivals, weddings and other activities within the garden that attract a large population at one time. Such events are greatly valuable for the garden as they provide considerable economic benefits that are vital to successful operation of the garden.

3.4.1 Proposed Design

The construction of a multi-storey parking is proposed as a potential solution to the current problem. The proposed design for the multi-storey parking structure is expected to increase parking capacity of the UBC botanical garden from about 80 cars to 270 cars. In order to satisfy the university guidelines for construction and development at the UBC botanical garden, the proposed parking structure will need to be built at the location of the existing parking space. Figure 10 represents a graphical model of the proposed multi-storey parking structure to be built at the location of the existing parking space at the UBC botanical garden.

Figure 10 – Multistory Parking Isometric View

The construction of the multi-storey car park at the botanical garden requires a significant amount of capital investment by university. Based on information obtained from Engineering News-Record and RSMeans cost databases, the estimated cost of construction of the proposed multi-story parking is expected to be about $**6 million dollars** (please refer to Appendix A for detailed calculations). The huge capital investment towards construction of multi-storey parking, however, can be justified considering the overall long term benefits that it provides for the university. The significant increase in parking capacity not only can be used towards the larger number of activities and events planned for the garden, but can also be used for other events and activities taking place within the university. The UBC Thunderbird Stadium for example, is located close to the botanical garden and in times of busy sports events the parking capacity of the botanical garden can be used to meet the high parking demands. Furthermore, the construction of parking provides an opportunity for the university to develop and prepare its infrastructure for future demands, considering the trend of expansion of UBC community and increase in population.

The planning and scheduling of construction work in this project are of high importance, as the construction activities are expected to cause disturbance to some of the major activities of the garden. As a result and in order to minimize the impacts of construction activities on the garden, it is proposed to arrange for the construction activity to take place during winter time.

3.4.2 Structure

The proposed design for the parking structure to be built at the UBC botanical garden is a four storey concrete structure with simple and efficient architecture. Primary to the design for this structure is the objective of maximizing the efficiency and functionality while minimizing the cost of construction and operation. A rectangular shape of the structure conforms to the restricted area on which construction is allowed to take place, and helps maximize the parking capacity at each floor of the structure. Further still, the proposed layout contributes to a simplified design and construction process. Furthermore, the general architectural plan for each floor of the structure with the exception of the ramp location is designed to be identical from the base level up to the last floor of the structure. This uniformity in design helps to maximize ease of construction while at the same time minimizing the cost.

Among the important components of the structure are two stairwells at each corner of the structure on the south side to transfer and guide parking users toward the main entrance of the garden. In addition, a main stairwell located at the center of the structure is intended to be used by the parking users at the north side of the structure and also to provide access to the roof of the structure. Furthermore, two storage rooms are designed for each floor of the structure, to be used for storage of equipment and also to house utilities systems. Figure 11 represents a typical floor area of the parking structure showing the arrangement of the parking spaces, two storage rooms, and the stairwells.

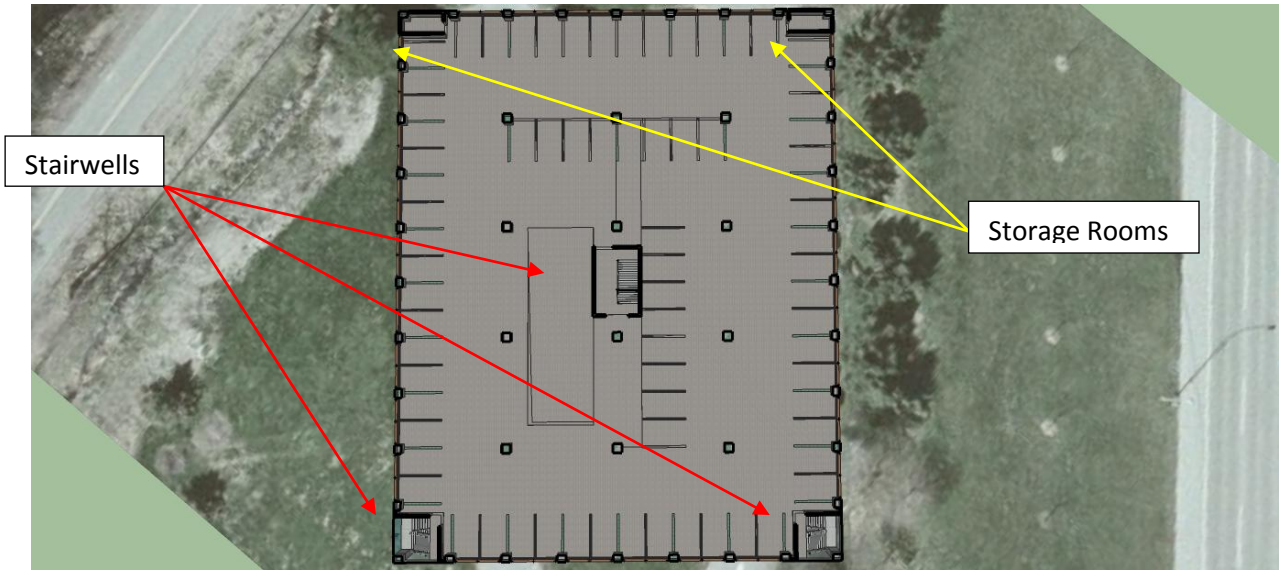

Figure 11 – aerial view of stairwells and storage spaces

3.4.3 Green Roof

One of the most important improvement plans proposed for the UBC botanical garden is the implementation of a water management system in the garden. The water management system is intended to make use of available water sources in a more sustainable manner. One of the major components of this water management system is collection of rain water from rooftops of the major structures in the garden. Utilization of a rain water collection system on the roof of the proposed parking structure, will contribute a significant amount of rain water to the gardens water system due to relatively large surface area.

In order to maximize the usability of the roof, a green roof is proposed to be utilized in the parking structure. The green roof serves two important functions. Firstly, the green roof will provide the opportunity for implementation of rain water collection system to collect and transfer rain water to water storage tanks. Secondly, the green roof provides capacity for variety of vegetation to be planted on the roof of the structure, helping the large structure to better match the green setting of the garden and increasing the aesthetic

qualities of the structure. Figure 12 represents a graphical model of the proposed green roof to be installed on top of the multi-storey parking structure.

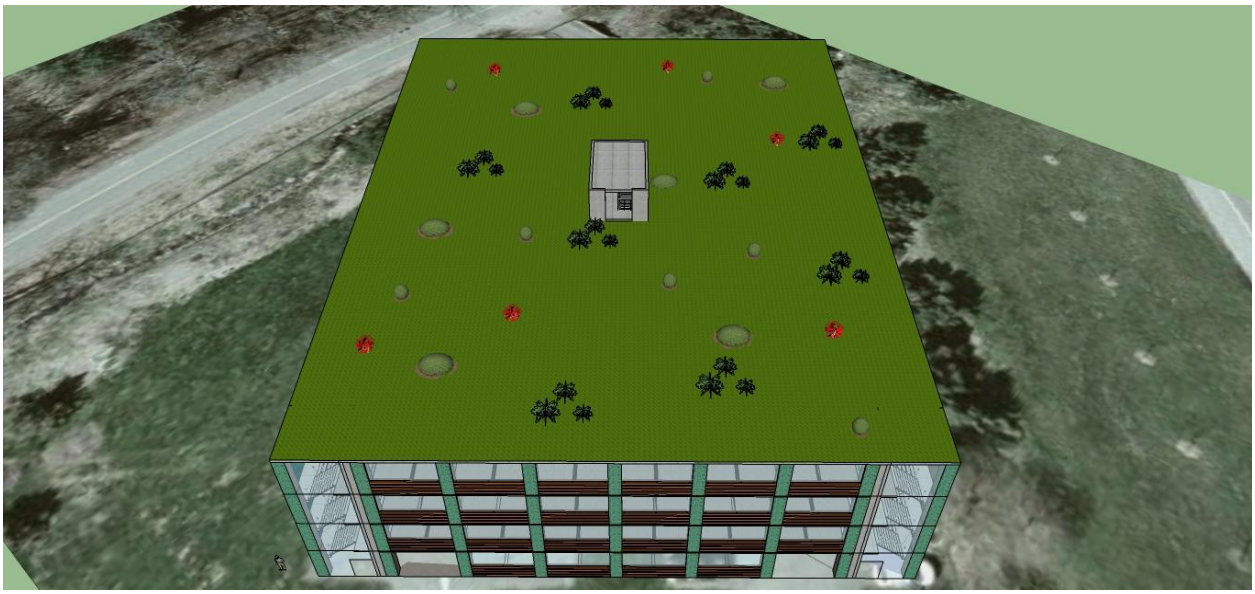

Figure 12- Green Roof Proposed Layout

3.4.4 Aesthetic qualities

An important consideration with regards to design of parking structure for the UBC botanical garden was utilization of unique design features to help improve aesthetic qualities of the structure. These design feature are greatly important and are intended to help with integration of the parking structure into the garden environment. In order to improve the aesthetic qualities of the parking structure, the walls that are located between the outside columns are made up of combination of wood panels and glass. This combination of wood and glass helps to provide safety while at the same time improving the aesthetic qualities. Figure 13 shows the graphical representation of the design proposed for the outside walls of the structure.

Figure 13 – Exterior Wall Detail

Glass panels are also extensively used in the stairwells at the southern corners of the structure, helping to provide a good view of the garden for parking users and improving the aesthetics of the structure. Finally, in

order to provide for better integration of the parking structure into the garden environment, the design makes use of vegetation on the sides of the building to cover the concrete columns. Figure 14 represents the graphical model of the proposed design for the staircases at the southern corners of the structure.

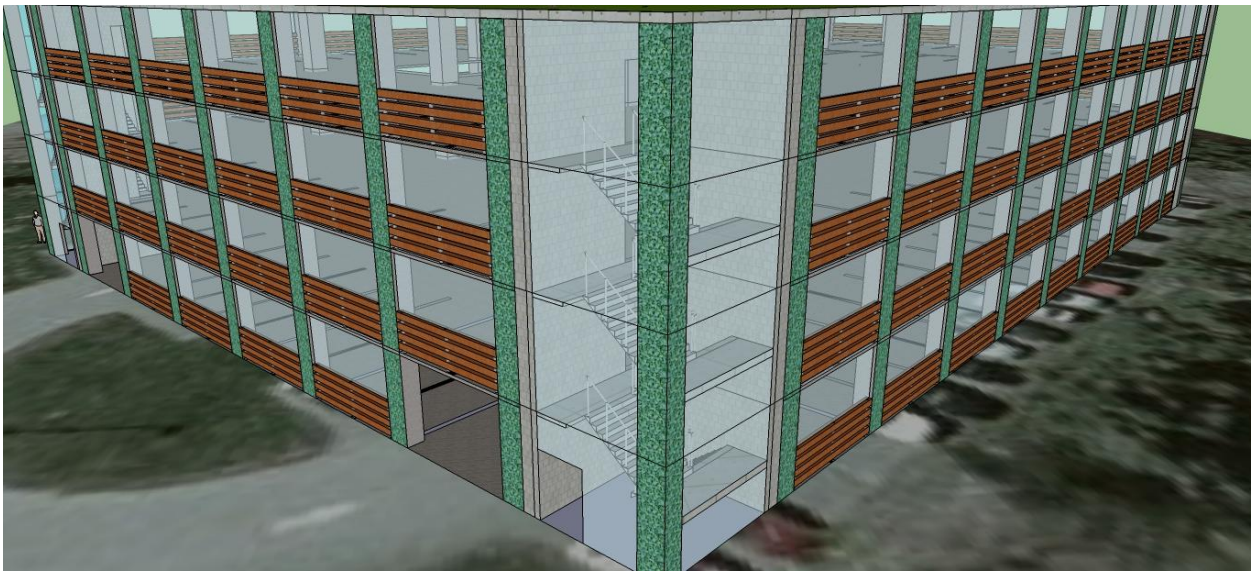

Figure 14 – Architectural Stairwell Glass Detail

4.0 Storm water treatment

The UBC Botanical Gardens are currently using potable water for all usage within the garden. This usage includes watering of plants, filling ponds, and other various uses. This is a blatant waste of potable water that should be used for more pressing issues.

Vancouver has a moderate oceanic climate and last year UBC received 1137mm of precipitation. UBC Botanical Gardens is approximately 30 hectares; using these two numbers, the amount of potential rainwater collected at the gardens is approximately 341 000 liters. The actual amount to be collected will be approximately 6000m^3 from roof collection systems installed in the gardens.

Collection of rainwater is a simple project that can be undertaken through a phased implementation of smaller construction projects. The projects can be phased to work with the gardens limited budget. Issues that should be addressed immediately include placing improved water barriers on the submerged perimeters of streams and ponds. This will help decrease the amount of water being lost to infiltration. Secondly, a small collection system can be established to fill these ponds. Finally, a full-scale operation can be implemented to collect large amounts of water and store it on-site. This water could then be treated and used in the watering of plants, filling of ponds, and usage within any fixtures buildings on site, where potable water is not required.

4.1 Water Collection

Collection of rainwater will be a limiting factor as to how large a decrease in potable water consumption the UBC Botanical Gardens can achieve. There are many ways to collect rainwater, this report will discuss two possible ways to collect and store this rainwater.

This report identifies that a rainwater collection system, utilizing roof drains collecting water into a large storage container is the most feasible option. The water can then be pumped to toilets and sprinklers through a pressurized system running through the gardens, significantly decreasing the potable water the UBC Botanical Gardens is currently using.

4.1.1 Roof Collection

The simplest way to collect rainwater is through a roof collection system. There are currently many commercial products available for this collection system.

As precipitation falls on the roofs of buildings in the gardens, it will collect into roof gutters and then follow drain paths into a large storage container either above ground or below ground. Before the water reaches the storage tank it will be filtered through screens to filter out bugs and vermin. When water is needed, it is pumped into a small treatment plant on site and then can be distributed in places where non-potable water can be used as seen in Figure 15 -Rainwater Collection and Storage (Stormsaver, 2013).

Figure 15 -Rainwater Collection and Storage (Stormsaver, 2013)

This system would be easy to implement, as only a small amount of construction is needed for the install of a tank and collection system. Once this system is in place it will need to be inspected annually to ensure all the screens and filtration systems are working properly.

Another assembly being used today is a green roof. This assembly is very useful if you plan on having growing medium on the roof. The drainage/storage are on this diagram could be replaced with a simple drainage mat to allow for more drainage through the green roof assembly. This will increase the amount of water collected, and will still leave enough water for the green roof to survive.

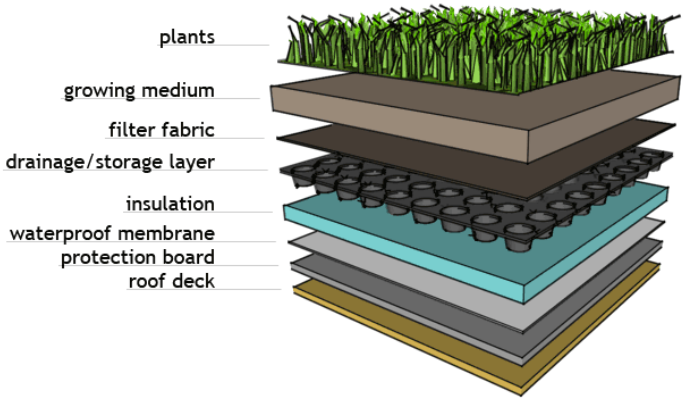

Figure 16 - Green Roof Assembly (Green Garage, 2007)

Green roofs are being utilized in many urban areas, and with companies like SkyHarvest and Green Garage, it is very easy to obtain information and pricing on these assemblies.

This report suggests a roof collection system be implemented, as it will allow for sufficient rainwater collection and possibly the option of having herbs, spices, and vegetables grown on the roofs of buildings to be used in the restaurant discussed in this report.

4.1.2 Retention Ponds

Retention ponds throughout the gardens could also be used as open top rainwater storage basins. This will not be as effective as using storage containers due to the possible disruption of surrounding ecosystems. Aquatic

animals may become reliant on these storage ponds, and if they were to be emptied for usage throughout the gardens, this would have a negative impact on biota using the ponds.

Retention ponds can be beneficial when esthetics is a concern for rainwater collection. Retention ponds can include native plants and small streams running intermittently between ponds. This creates a very natural feeling environment, while the gardens are still able to capture and reuse rainwater.

Treatment will also be needed if water is stored in retention ponds. Runoff that ends up within the ponds may carry animal bacteria that may be harmful to humans. Sediments may build up within these ponds, and when water is being pumped through a system within the gardens, these sediments will be damaging to the system and can cause an unpleasant colour in toilets that use this rainwater.

Retention ponds are a possible option but are not as efficient as using a roof collection system. Retention ponds water will have to be treated before use, due to sedimentation build up within the ponds.

4.2 Water Storage

There are two options for the potential storage areas of collected rainwater. An above ground system or a below ground system can be developed for the storage and filtration of rainwater. Both of these options will have advantages and disadvantages. This report will highlight the advantages and disadvantages of each system to help the developer choose the correct system for the needs of the improvement.

4.2.1 Above Ground Storage

Perhaps the easiest to implement, an above ground storage system is one of the two options. Some of the advantages include:

- Ease of installation
- Accessibility
- Serviceability
- Less required piping
- No need for excavation
- Cheaper

This can be proposed to UBC as a money saving opportunity with a minor up-front cost. With the amount of money spent on the usage of potable water, any decrease of water usage will help address the cost associated with water usage.

However, there are several disadvantages to an above ground system which include:

- Freezing of pipes
- Subject to weathering
- Space consuming
- Can be an eyesore

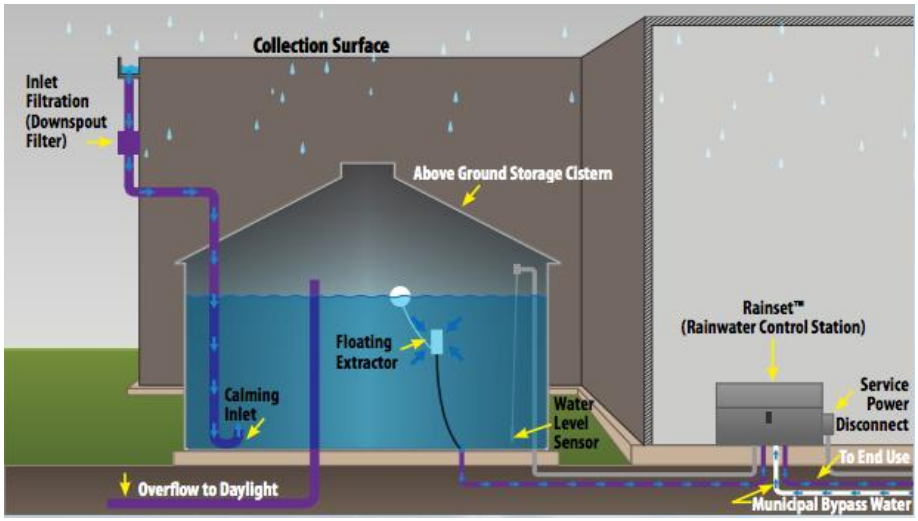

Figure 17 - Above Ground Stormwater System (Stormsaver, 2013)

As shown in **Error! Reference source not found.** an above ground system from BRAE Rainwater Harvesting systems is a potential solution. Not shown in this image, but would be included within the design for the UBC Botanical Gardens is a water filtration system as well as a small treatment plant.

4.2.2 Underground Storage

Similar to the above ground system, the underground storage system is comprised of a storage tank, piping, pump equipment, and a small water treatment plant. Like the above ground system, the underground system has its advantages and disadvantages. Some of the advantages are as follows:

- Maintain consistent water temperature through year
- Do not consume above ground space, and therefore a larger tank can be used
- Unexposed to weather

With excavation and construction of an underground system, some of the disadvantages are as follows:

- Expensive construction
- Difficult to maintain and remove
- Subject to soil movement
- Risk pollution from runoff if not correctly sealed

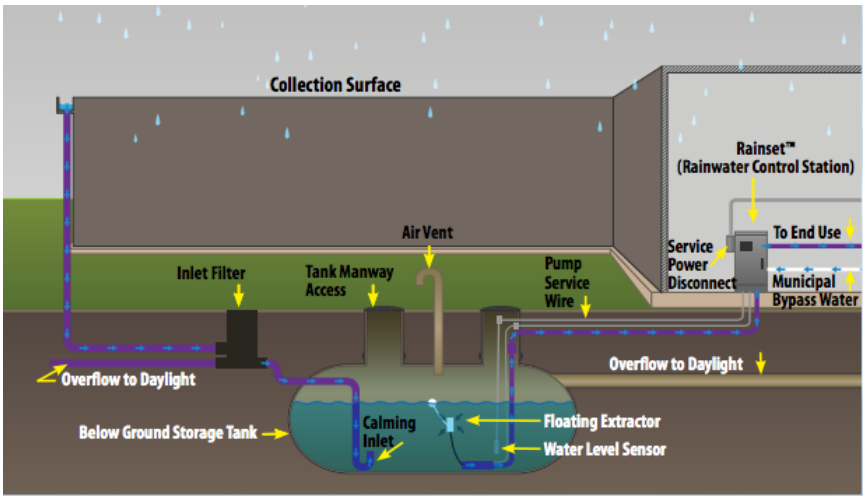

Figure 18 - Below Ground Stormwater System. (Stormsaver, 2013)

This report recognizes that both installations would be successful in storing treated rainwater. It will be the gardens choice as to which installation is wanted and the required size of the storage. The amount of storage will entirely depend on how much coverage of the gardens can be used for a collection system.

4.3 Water Treatment and Reuse

The amount of water treatment will depend on the area of the gardens water will be used. If the water is being used within facilities, the water will need to be treated to avoid problems with colour and possibly smell. However, if the water is being used within the gardens, treatment will not be required.

4.3.1 Water Treatment

A small water treatment plant can be used, as the amount of water needed within the facilities will not be of a significant demand relative to the agricultural needs. A small package treatment plant can be purchased from one of the many producers and these can be custom designed to fit the needs of the UBC Botanical Gardens.

Rainwater can be treated similar to wastewater, so a small treatment plant can be integrated within the gardens to treat the precipitation collected within the gardens. Euro Mec offers a small package plant that offers the required sanitization in a small enclosure that is not such an eyesore for visitors of the gardens. Seen below is illustration of the sub-surface plant. This plant should be placed near the largest area of runoff. For the botanical gardens this would be near the parking lot and main entrance buildings.

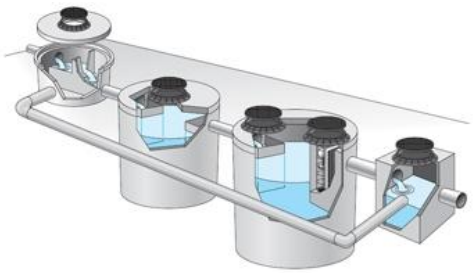

Figure 19 - Rainwater Treatment Plant (Euro Mec, 2013)

The rainwater could then be pumped to the required area after treatment and disposed of using the current wastewater disposal system. This collection process and treatment will greatly reduce the demand on potable water systems the garden is currently using.

4.3.2 Water Reuse

During a tour of the gardens, it was noted there currently is a problem with infiltration of water in ponds. To combat this, a suggestion is to implement a sub-surface drainage system. This system will return the water lost due to infiltration, and return it to the grey water reuse system. This reuse will decrease the demand on potable water even further, leading to a more sustainable garden. This option will only be considered valid if geomats are not lined in the ponds to eliminate infiltration entirely.

4.4 Cost of Rainwater Improvements

The estimated cost of the improvements for the rainwater collection system is explained in the following table:

Component	Description	Length ft	Unit Cost $/ft	Cost $
Package Water Treatment Facilities	A package storm water treatment plant used for the treatment of collected rainwater to allow for usage within the garden and garden facilities.	-	-	$25,000
Roof Collection Systems	Implemented on all new and existing roofs. The cost for roof collection systems on new buildings is assumed to be involved with the building cost.	-	-	$50,000
Storage Tanks	Two storage tanks either above ground or below ground. To be provided by third party company.	-	-	$20,000
Underground Piping	Costs include excavation and installation of rainwater collection downspouts and underground piping.	1200	$40	$48,000
Pumps and Other	Various pumps for transportation of rainwater and recirculation through treatment system	-	-	$15,000
Total				**$158,000**

Table 6 - Stormwater System Cost Breakdown

5.0 Tunnel Improvements

The tunnel in UBC Botanical Garden is key structure connecting the two halves of the garden that are separated by Marine Drive. Drawing from an Asian design principles, the Moon Gate situated at the west side of the tunnel was constructed to provide an aesthetic symbol to the entrance of tunnel.

Figure 20 - Moon Gate Entrance

5.1 Issues

From onsite visits it is clear that there is a significant lack of lighting and regular maintenance of the tunnel. The walls of the tunnel are comprised of corrugated steel sheathing, which is both unwelcoming and unappealing as seen in Figure 21. Further still, there are poor acoustic qualities to the tunnel resulting in significant echoes from foot traffic and conversations. Given the fact that the tunnel is an essential thoroughfare, such negative issues must be remediated as soon as possible. Also, making improving the tunnel passageway through significant renovations can increase the satisfaction of patrons.

Figure 21- Tunnel Interior

5.2 Conceptual Design

In order to improve the visitors' experience in UBC Botanical Garden, the renovation of the tunnel is essential. By considering the issues existing in the tunnel, a conceptual design has been developed to directly address and remediate the space utilizing innovative and sustainable design technologies. Central to the tunnel improvements are sound absorption, improved lighting, a herbarium exhibition, dynamically mapped digital nature scene projections, and the utilization of solar energy.

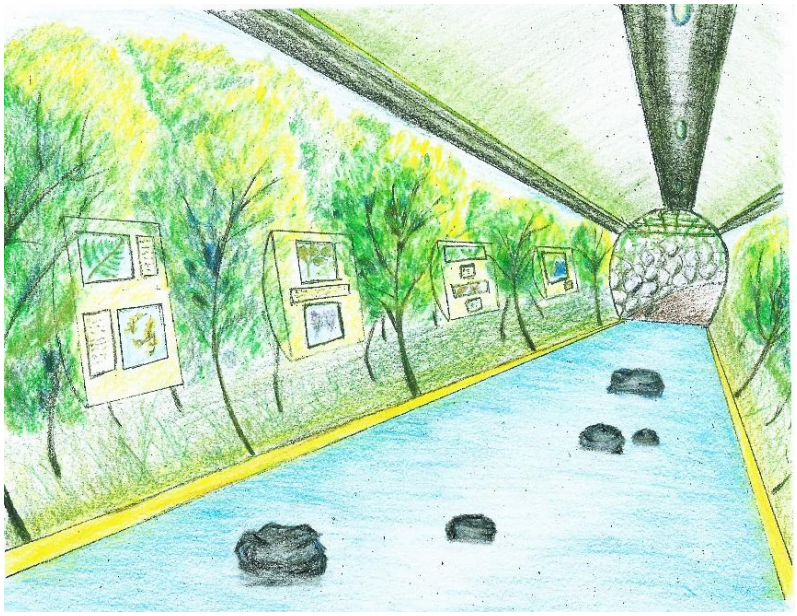

Figure 22 - Conceptual Tunnel Design

- **Sound Absorption and Improved Lighting**
  Initial stages of the tunnel renovation involve the installation of dense foam block cladding to reduce the acoustic resonance, and echo of the tunnel. Further still, the installation of high lumen LED bars along the roof of the tunnel, will provide a safer and more welcoming environment.

- **Herbarium Exhibition**
  In order to engage patrons as they traverse the tunnel a Herbarium Exhibition has been put forward. A series of secure glass cases will exhibit rare plant specimens with digital media screens displaying all pertinent information to individuals walking through the tunnel.

- **Dynamic Digital Natural Scene Map Projections**
  Advanced digital mapping software in combination with off the shelf high definition projection systems mounted along the ceiling of the tunnel will provide a mechanism to further immerse patrons in the beauty and natural splendor of the gardens. Dynamic scenes of various forests and waterway systems from around the world can be displayed on all surfaces of the tunnel structure.

- **Utilization of Solar Energy**
  Installation of solar panels on the entry and exit approaches of the tunnel can be used to power various internal mechanisms of the attraction and will keep in line with UBC's culture of sustainable technology promotion.

5.3 Feasibility and Estimate Budget

The tunnel renovation project has a high cost to performance ratio. Given the simplicity of the additions, and the pre-existing structure, renovation and construction time will be minimal. However, issues regarding accessibility during tunnel construction must be addressed as it is a primary thoroughfare. Proper access phasing and a detailed construction schedule is vital to the continued successful operation of all other garden facilities. Also, careful consideration must be taken during construction as additional wind blown dust, and airborne detritus will be arise. Moreover regular maintenance and upkeep of all LED lighting and projectors is required.

The budget of the renovation of the tunnel is estimated to be $250,000 as seen in Table 7, using cost comparables of similar tunnel structures in various parks.

Estimated Installation Details for Tunnel Improvements	
Items	**Estimated Cost ($)**
Sound Absorbing Material Installation	$30,000
Led Lighting Installation	$50,000
Herbarium Exhibition	$50,000
Natural Scene Creation Project	$50,000
Solar Energy Utilization System	$20.00
Unforeseeable Emergency Budget	$50,000
TOTAL COST	$250,000

Table 7 - Tunnel Improvement Cost Estimates

5.4 Additional Improvements

There are a number of low cost changes which can be implemented to address current garden issues of accessibility and patron retention.

- Events Throughout All The Seasons
  By holding events year round the gardens can maintain a consistent attendance rate through all seasons. Below is an example list of potential events.
  - Spring: tea tasting and gardening workshop
  - Summer: music festival and outdoor movie
  - Autumn: apple festival, Halloween night walk
  - Winter: Light festival and Christmas market

- Obstruction of unsightly roadways and maintenance channels.
  Utilizing vegetation to cover all fences and vehicle roadways can greatly enhance the sense of immersion in the botanical gardens.

- Improved Plant Labels and Printed Signage
  The current tags on plants in UBC Botanical Garden are too small to be seen. As a result, visitors may not be able to discern rare plant species and miss an opportunity to learn more about them. Using larger tags and improved colors schemes can address this issue.

7.0 Smartphone Application

7.1 Background

Mobile apps have fully engulfed the general population of today. Everywhere you go, you will see a cell phone, a tablet, or a laptop. Education is becoming a more technological field, as students have access to an infinite amount of knowledge at their fingertips. The key here is to utilize this adoption of technology to gain contact with individuals who show interest with the idea of a knowledge app for the UBC Botanical Gardens. On average, 82% of the adult population in the United States owns a mobile phone. Of these 82%, over 29% have cell phone apps installed on the phone. The increase in cell phone usage among a younger audience has increased dramatically over the past years. Figure 23 and Figure 24 showcases the potential audience an app developed for the UBC Botanical Gardens has, and the amount of people currently using mobile apps for various reasons.

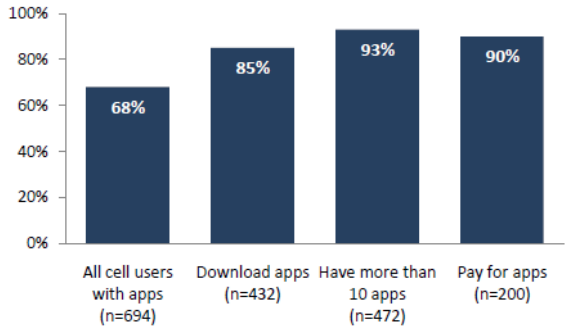

Figure 23 - Cellphone Usage Statistics

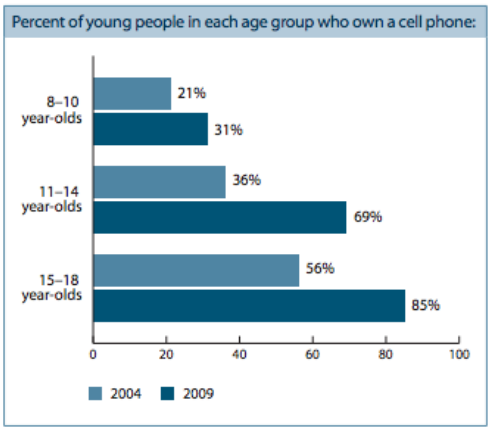

Figure 24 - Cellphone age demographics

Research has proven that using apps is very effective in relaying information to a very broad user base. The benefits from having a simple app teach the basic principles of the garden collections would be immeasurable.

7.2 The App

The idea for the app is simple; an easy to use interface that displays plant information and any other relevant material the botanical garden directors feel is pertinent to learning about the garden collections. The information that will be used in the beta version is as follows:

- A Photo
- Plant Name
- Family
- Origin
- History
- Growing Conditions
- Related Species

This information will be accessed via the main screen of the app. The main screen of the app will be a map of the gardens that has specific quadrants linked to a database of all the species in the gardens and their location. If this beta version is successful in gaining interest in the gardens, a mapping system can be developed to further the ease of use of the application. This mapping system will determine users coordinates based off the GPS in the handheld device and display plants in the vicinity of the user. A virtual tour is also a potential update to the app is it is successful.

For younger children, this app could be used as a game. Reports have shown that most apps downloaded are games compared to any other category of app. Children are thriving in the condition of learning through games. Learning through games allow for a child to gain a deeper understanding of the topic be taught. Inspiring these children at a younger age could bring more interest to the UBC Botanical Gardens, and therefore increase the funding offered from the university. It does not need to be a complex game, a simple trivia game asking questions as participants walk through the gardens. Once the tour is complete, the participant with the highest score wins the game and small prize.

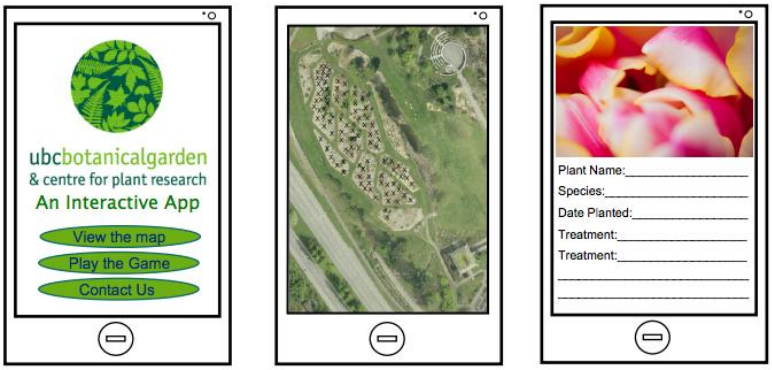

Figure 25 - App Layout

7.3 Development and Implementation

The greatest advantage of using an app to relay knowledge is the fact you will no longer need personnel to provide tours of the facilities. A group of individuals can use this app to explore the garden at their own pace, and will not require a tour guide, which results in cost savings for the gardens.

Designing this app could present a considerable challenge. Photos will be needed of all 7000 plant species to input into a database. If there is not a current database, all the plants will have to be logged and GPS tagged to allow for the map interface to work. This can be a very timely and costly process. However, if this database already exists, there will be a decreased cost associated with caching the data into a secure server.

The app will easily be accessed from any cell phone or tablet that can run an Internet browser. The app will be written in HTML5 to allow ease of use across all major cell phone devices. Using HTML5 will decrease the cost of developing on an Apple platform, as you have to pay a fee to have your app on the Apple store.

7.4 Cost

The cost of an app can vary greatly depending on the type of app being created. As this is a database intensive app, it can cost upwards of $50 000 dollars to create. As more and more services are added, this can push the price even further north. A simple beta version of this app could be in the neighbourhood of $8 000. The cost will depend greatly on the data collection phase. The cost will depend greatly on the amount of information to be gathered in the initial phases. Creating the app once the database is on a server will be the simplest task.

Using an app will be a very useful technique in drawing attention to the UBC Botanical Gardens. The cost of entrance can be reduced, as tour guides will no longer be necessary, and the information provided to the patrons can be tailored to exactly what they would like to see. The small initial investment could lead to an increase in funds from the University of British Columbia, and an overall greater appreciation for the gardens.

8.0 Conclusion

The rich heritage and cultural identity of UBC Botanical Garden is apparent in all of its endeavors. In order to continue the successful growth and operation of the garden, recommendations and improvement plans put forward by Linear Consulting should be thoroughly evaluated by UBC and the Botanical Garden Administration. Enhancement of the socio-economic landscape of the gardens while maintaining the Garden's original mandates is paramount to the success of the gardens for generations to come.

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Appendix A – Sample Calculations

Cost estimate of the construction of the multi-storey parking structure at the UBC botanical garden using information obtained from **Engineering News-Record** and **RSMeans** cost data:

Area of parking structure: $8000\ m^2 = 86111\ ft^2$

Median cost per square foot for parking structure based on data from RSMeans 2010 United States average (RsMeans cost data, 2010): $50.5\ \frac{\$}{ft^2}$

$$Cost = 86111\ ft^2 * 50.5 \frac{\$}{ft^2} = 4348605.5\ \$$$

Modify cost for size of the structure:

Typical parking size (RsMeans cost data, 2010) = $163000\ ft^2$

Size factor = $\frac{area\ of\ the\ proposed\ structure}{typical\ area} = \frac{86111\ ft^2}{163000\ ft^2} = 0.53$

Cost Multiplier (RsMeans cost data, 2010)= 1.09

$$Cost = 4348605.5\ \$ * 1.09 = 4739980\ \$\ (2010, United\ States)$$

Modify cost for Vancouver:

- Vancouver Index (RsMeans cost data, 2010)= 106.6
- United States Average Index (RsMeans cost data, 2010)= 100

$$Cost = 4739980\ \$ * \frac{106.6}{100} = 5052818.7\ \$\ (2010, Vancouver)$$

Modify cost for 2013:

- November 2013 index (Engineering News-Record,2013) = 5317
- June 2010 index (Engineering News-Record, 2010) = 4888

$$Cost = 5052818.7\ \$ * \frac{5317}{4888} = 5496284\ \$\ (2013, Vancouver)$$

Modify cost to account contingencies such as:

- Green roof
- Aesthetic qualities (glass and wood panels)

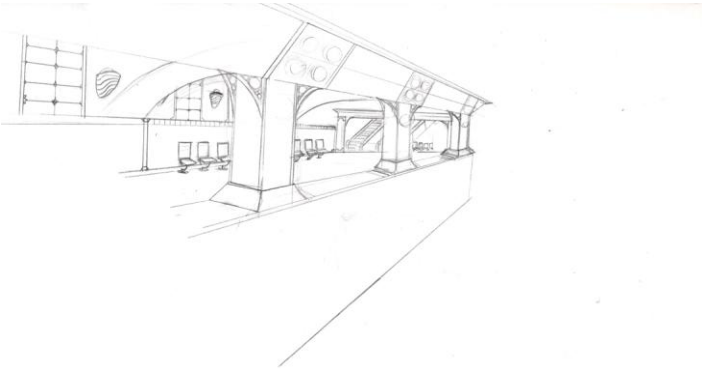
Modifying factor for contingencies = 1.1 (10%)

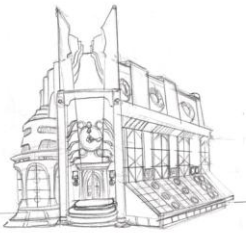
$$Total\ cost = \ 5496284\ \$ * 1.1 = 6045912.6\ \$$$

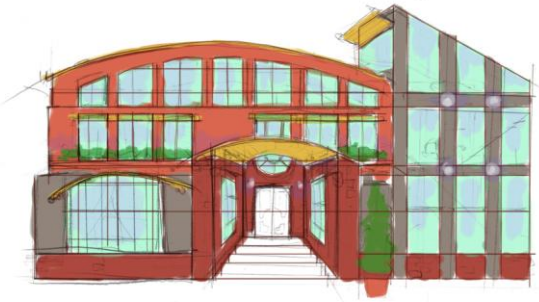
$$\boldsymbol{Total\ cost\ of\ the\ proposed\ parking\ structure \cong 6,000,000\ dollars}$$

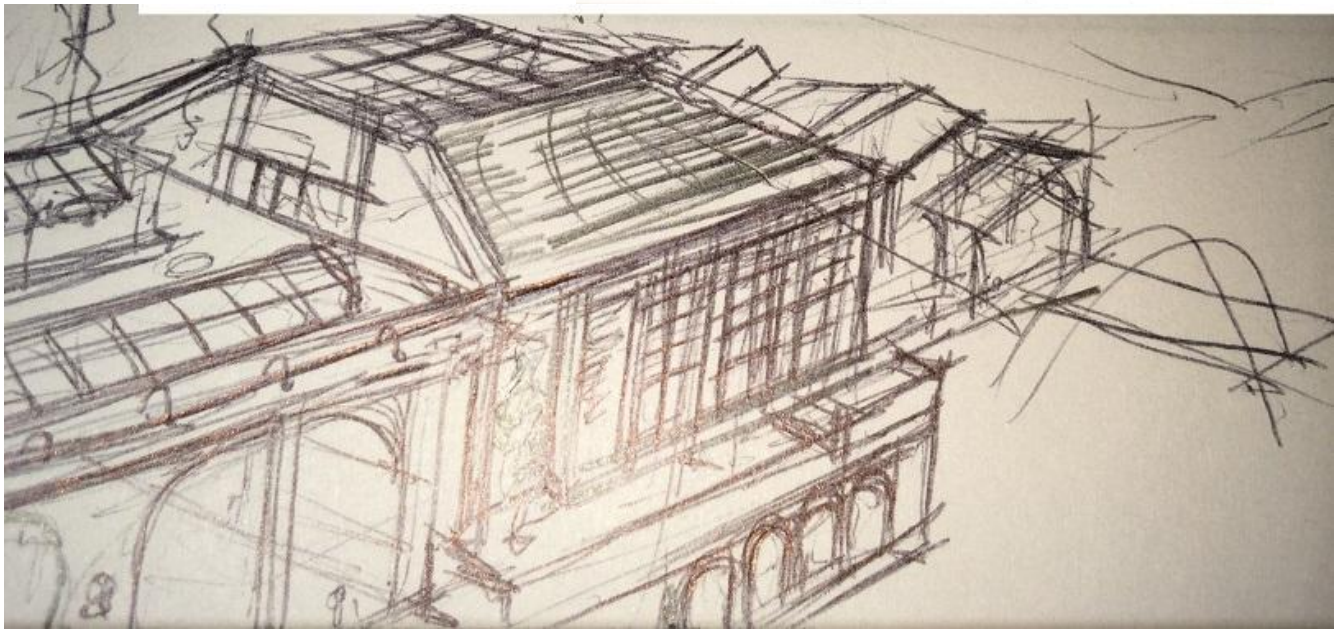
Appendix B – Preliminary Conceptual Designs

Multipurpose space conceptual designs

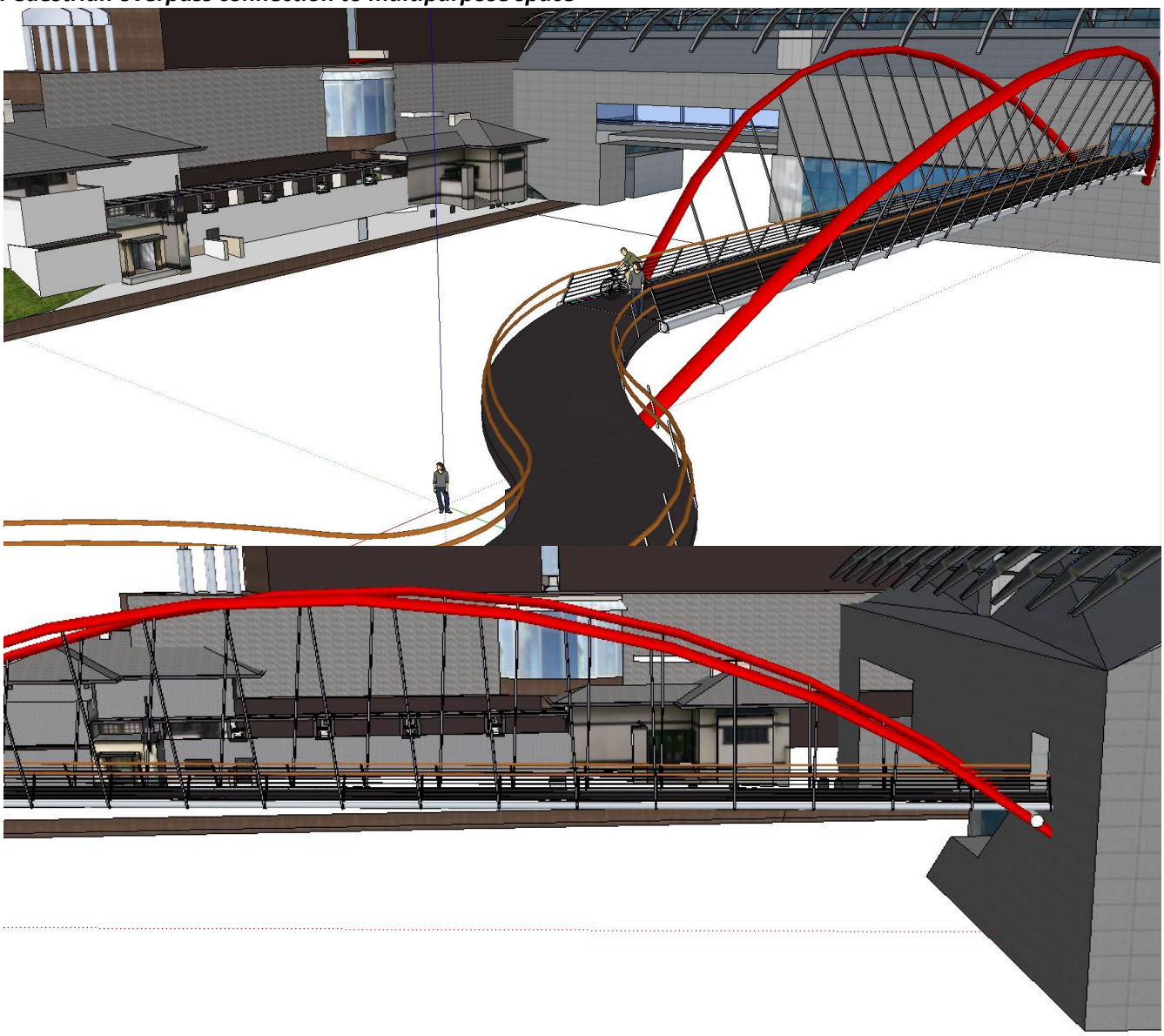








Pedestrian overpass connection to multipurpose space



Multipurpose space interior conceptual sketch