UBC BOTANICAL GARDEN REDEVELOPMENT CONCEPTUAL DESIGN REPORT

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University of British Columbia

CIVL 445

November 28, 2013

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CONCEPTUAL DESIGN REPORT

CIVIL 445 GROUP 10
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LETTER OF TRANSMITTAL

November 28, 2013

UBC Botanical Garden
6804 SW Marine Drive,
Vancouver, BC V6T 1Z4

Dear Sir/Madam:

RE: Redevelopment of UBC Botanical Garden - Conceptual Design
UBC Botanical Garden – Vancouver, BC File No.: VAN 12345.P002

The enclosed document is submitted in response to a request for a Proposal for the redevelopment of the UBC Botanical Garden.

In preparing our response, we have carefully read and examined the requested items, visited the site with our team members, and have reviewed other similar investigations.

Diversified Engineering Services has completed the UBC Botanical Garden Redevelopment Conceptual Design Report with a methodology that will maximize the benefit to the UBC Botanical Garden while meeting all of the project objectives. We understand the UBC Botanical Garden's incremental approach to project implementation, and have presented our report in such a way that allows UBCBG management to consider each recommendation independently.

Thank you for considering Diversified Engineering Services for your consulting needs. Please do not hesitate to contact us if you have any questions.

Yours truly,
DIVERSIFIED ENGINEERING SERVICES LTD.

Kamal Braich ([redacted]
Stephen Hillier ([redacted]
Haena Kim ([redacted]
Garen Mackie ([redacted]
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UBC Botanical Garden Redevelopment

Conceptual Design Report

November 28, 2013

Prepared for:

UBC Botanical Garden
6804 SW Marine Drive,
Vancouver, BC V6T 1Z4

Prepared by:

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EXECUTIVE SUMMARY

The University of British Columbia Botanical Garden (UBCBG) is situated on the southwest corner of the University of British Columbia along the edge of the Pacific Ocean in Vancouver, British Columbia. UBCBG is the oldest continuously operating university garden in Canada and contains a world-class collection of plants for the purposes of research and teaching. Currently, the UBCBG is a collections based garden which attracts a small group of the general public.

The UBCBG management is interested in exploring development opportunities that could benefit the garden. Through discussions with staff, a number of key issues were identified including accessibility of the garden for pedestrians and drivers, sustainability concerns involving the use of potable water, and a desire to increase visitor numbers. This Conceptual Design Report presents our vision of the UBCBC Improvement Plan that addresses these issues.

Accessibility

A number of accessibility improvements are proposed in order to facilitate access for pedestrians, transit users and motorists, and to support further development of the garden:

- Pedestrian traffic control on Marine Drive
- Expanded parking facilities to handle overflow during summer months
- Signage to increase garden awareness and visibility for visitors to UBC campus

Stormwater Management

Garden staff have identified a sustainability issue with the operation of the garden. Currently, all water used at UBCBG is potable water from the City reservoir. It is proposed that a stormwater collection and management system be implemented in order to take advantage of Vancouver's significant rainfall and to reduce the garden's impact on the City supply. This can have spin-off benefits in sustainability education and research and will promote the garden as a responsible, forward-thinking organization.

Anchor Attractions

It is proposed that the garden develop anchor or destination attractions in order to better maintain a consistent level of visitors during the off-season and to boost peak season attendance. Potential additions may include:

- a Gazebo
- an Educational Centre
- a Conservatory
- a Treehouse Café

These additions could help to draw visitors by providing extra and more diverse attractions, some of which can be enjoyed rain or shine.

1. INTRODUCTION

As requested by Garden Director of the UBC Botanical Garden, Diversified Engineering Services Ltd. (Team 10) has prepared a Conceptual Design Report (CDR) for the redevelopment of UBC Botanical Garden, located at 6804 SW Marine Drive in Vancouver, BC. The purpose of the CDR is to introduce the design concepts for the redevelopment of UBC Botanical Garden which will incorporate economic, community, and environmental value.

2. OBJECTIVES

Based on the presentations that were given by the UBC Botanical Gardens staff, we tried to assess their needs and to develop suggestions aimed at making improvements to the Botanical Garden.

We had three main objectives when brainstorming ideas on how to improve the Botanical Gardens: to improve accessibility, to enhance the stormwater management system, and to add more anchor attractions in order to increase the size and diversity of visitors throughout the year.

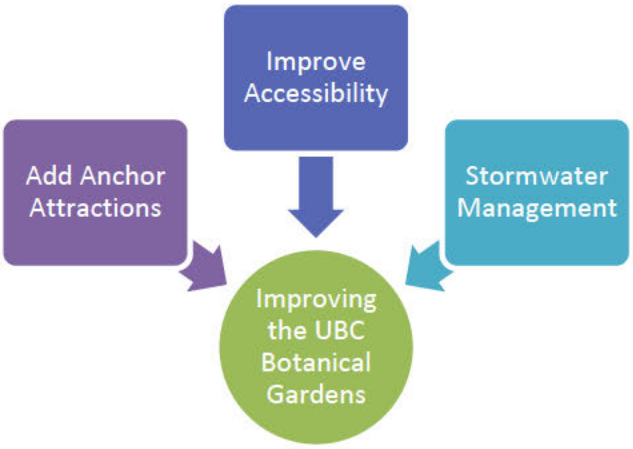


Figure 1 – Three Main Objectives of the Project

Once we had identified the three objectives of the project, we contrasted different ideas in a Multi-Criteria Decision Making Matrix, which allowed us to compare different options using weighted criteria (see Appendix A). Based on the results of this matrix, several concepts were chosen that were found to best meet the needs of the Botanical Gardens:

- New stormwater management system
- Increasing parking capacity in the current lot and adding a parkade
- Signalized intersection
- Improved signage
- Gazebo
- Treehouse Café
- Education Center
- Conservatory

These components will be discussed in more detail in the sections below. See Figure 3 for proposed location of each component.

3. BACKGROUND

The UBC Botanical Garden is located in the southwest corner of the campus. The South Garden is bounded by Old Marine Dr. to the south and SW Marine Dr. to the North. The North Garden is bounded by W 16th Ave. to the east, SW Marine Dr. to the south and Stadium Rd. to the west and north. See Figure 2 for site location of the UBC Botanical Garden.

Figure 2 - UBC Botanical Site Location Plan

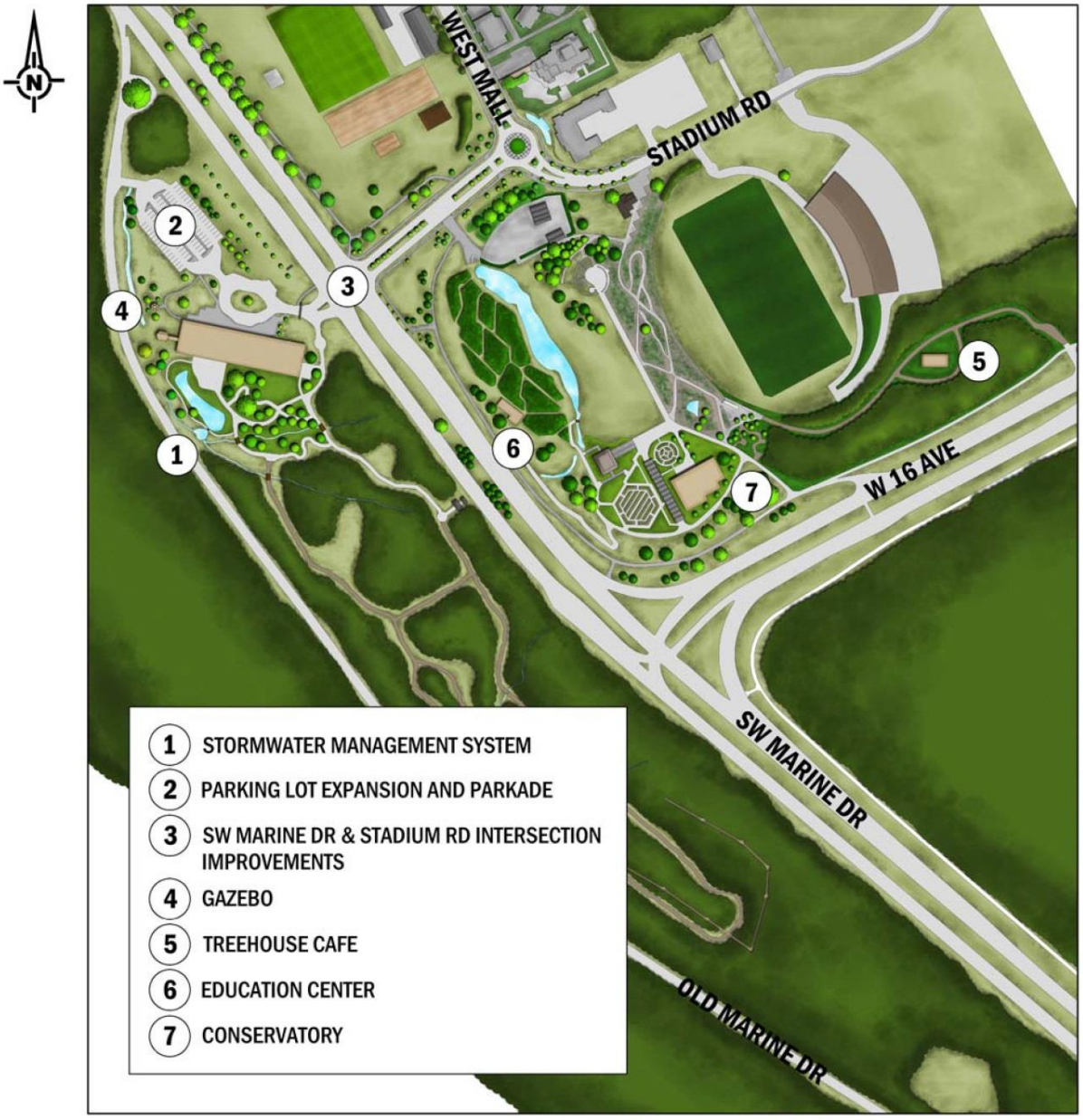


Figure 3 - UBC Botanical Garden Proposed Site Layout

4. TRANSPORTATION

The current location of the Botanical Garden is quite offset from the main campus, located in the southwest corner of the campus. This distant location is one of the disadvantages in attracting visitors or tourists compared to the Nitobe garden located in the more central Northwest area of the main campus.

Improving the transportation system in terms of accessibility, parking facilities, and safety will have a vital part to play in attracting more visitors and tourists. This redevelopment project will take a holistic approach to transportation at Botanical Garden.

4.1. Pedestrian Activated Flashing Lights

To arrive to UBC Botanical Garden by public transit, the C20 shuttle bus from the UBC bus loop is available every 20 minutes from Monday to Friday and every 30 minutes on Saturday. As shown in the figure below, the bus stop is located across the street which requires pedestrians to cross the street to access the garden.

At Stadium and SW Marine Drive, we propose installing pedestrian activated flashing lights to the existing crosswalk on SW Marine Drive. This will increase the accessibility and safety of visitors who uses public transit to enter the garden. This option is more cost effective and efficient than other infrastructure such as pedestrian bridge as they would require structural analysis and involve complex construction. This option is more cost effective and simple to construct; therefore, it is more likely to get approved by BC Ministry of Transportation, the owner of SW Marine. A comparison and more detailed decision making chart is provided in Appendix A.

Figure 4 - Intersection between Stadium Rd and SW Marine Dr

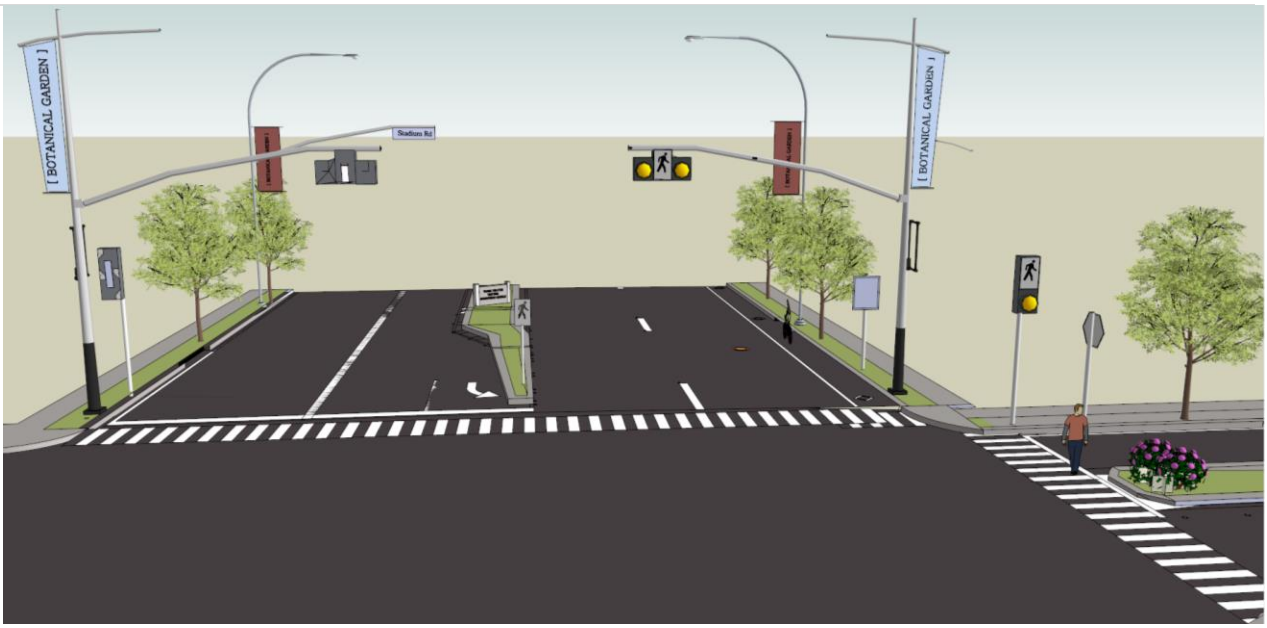


Figure 5 - Conceptual Model of Pedestrian Activated Lights at Stadium St & SW Marine Drive

The addition of pedestrian actuated flashing lights and additional signage on SW Marine Drive requires obtaining permits from the owner, BC Ministry of Transportation (BC MOT). To obtain their permission, the BC MOT would require conceptual sketches, effects of the new roadway and details of potential lane closures during the installation of the flashing lights.

4.2. Improvement of Signage

We suggest installing additional signage along SW Marine Drive to promote awareness of the UBC Botanical Gardens. Overhead welcome signage will aesthetically emphasize the entrance of the garden, attracting more visitors. Attractive signage ideas could be contributed by visitors through activities such as design contests.

Figure 6 – Example of An attractive Sign

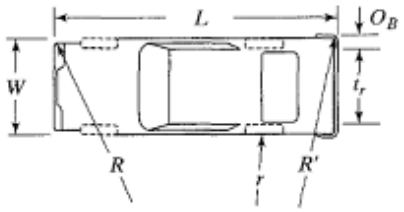
Figure 7 – Conceptual Model of the Intersection with New Signs

4.3. Surface Parking Facility

Parking is important for the success of the Botanical Garden as it provides both parking spaces for visitors and space for event use. The management of parking could potentially become a powerful tool for increasing the amount of visitors, as well as quality of service. Parking supports additional urban friendly functions, providing additional spaces for events such as the apple festival. If parking is not addressed effectively, some possible undesirable effects can result including lack of parking space and parking on offsite parking lots. Parking facility upgrades as a part of the BG redevelopment plan recognized the need to examine additional strategies for off street conditions and the potential for organizational changes as described in the following.

4.3.1. Removal of Existing Median

We recommend increasing the amount of parking stalls at the gardens by removing medians in the parking lot. The extended area will provide additional 20 stalls increasing ground level parking capacity from 120 to about 140 stalls. Parking is currently offered free of charge. It is advised to designate separate parking areas for “small cars” to maximize total parking capacity. Figure 8 below illustrates the basic criteria for the two design vehicles used in parking facility design.



W = overall width, inches
L = overall length, inches
O_R = rear overhang, ft
O_B = body overhang from center of rear tire, ft
t_r = width from center of rear tires, ft

Minimum Turning Radius
r = inside rear wheel, ft
R = outside point, front bumper, ft
R' = outside point, rear bumper, ft

Dimension	Design Vehicle	
	Large Car	Small Car
Width, W (inches)	77	66
Length, L (inches)	215	175
Outside Front Bumper Radius, R (ft)	20.5	18.0
Inside Rear Wheel Radius, r (ft)	12.0	9.6
Rear Width, t_r (ft)	5.1	4.6
Body Overhang, Rear Tire, O_B (ft)	0.63	0.46
Rear Radius, R' (ft)	17.4	15.0

Figure 8 – Design Vehicles for Parking Design (Used with permission of Eno Foundation for Transportation, Weant, R and Levinson, H., Parking, Westport, CT, 1990, reformatted from Table 8.1, pg, 157.)

The extended surface parking lots will operate as one way traffic. The currently closed Northwest exit will be open to the public, which will add another option for visitors to exit to the old Marine Drive. This will improve traffic flow in the parking lot, increasing level of service. The figures below show a conceptual design for the extended parking lot.

Figure 10 – Existing Surface Parking Facility

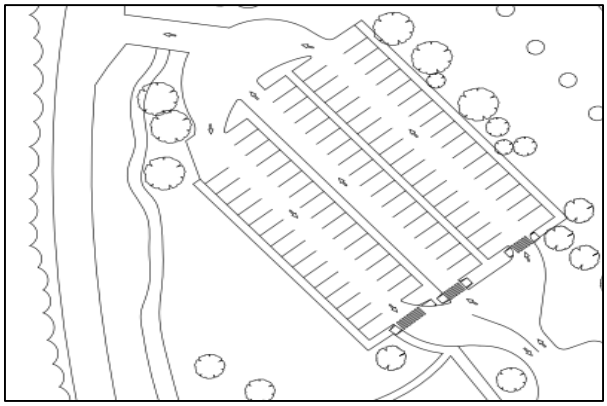


Figure 9 - Proposed Surface Parking Facility

Figure 11 – Conceptual Model of the Proposed Surface Parking Facility

4.3.2. Cost Estimate – Surface Parking lot

According to "Traffic Engineering" by Roger P. Roess *et. al.,* surface lots cost between $1,500 and 2,500 per space provided. In our case, we estimate $2000 per parking stall. Please note that preliminary discussion with the City and UBC indicates the Building Permit will cost 1.25% of the total construction cost.

Table 1 – Cost Estimate for the Proposed Surface Parking Facility

Description	Opinion of Probable Cost
Access / Demolition / General Conditions	$ 495,000.00
137 stalls * $2000 per a stall	$ 275,000.00
Finishes	$ 385,000.00
Subtotal	**$ 1,155,000.00**
10% Contingency (rounded)	$ 115,000.00
Consulting Fees (rounded)	$ 155,000.00
Subtotal (rounded)	**$ 1,425,000.00**
12% HST (rounded)	$ 171,000.00
Total Opinion of Cost (rounded)	**$ 1,596,000.00**

4.4. Underground Parking Facility

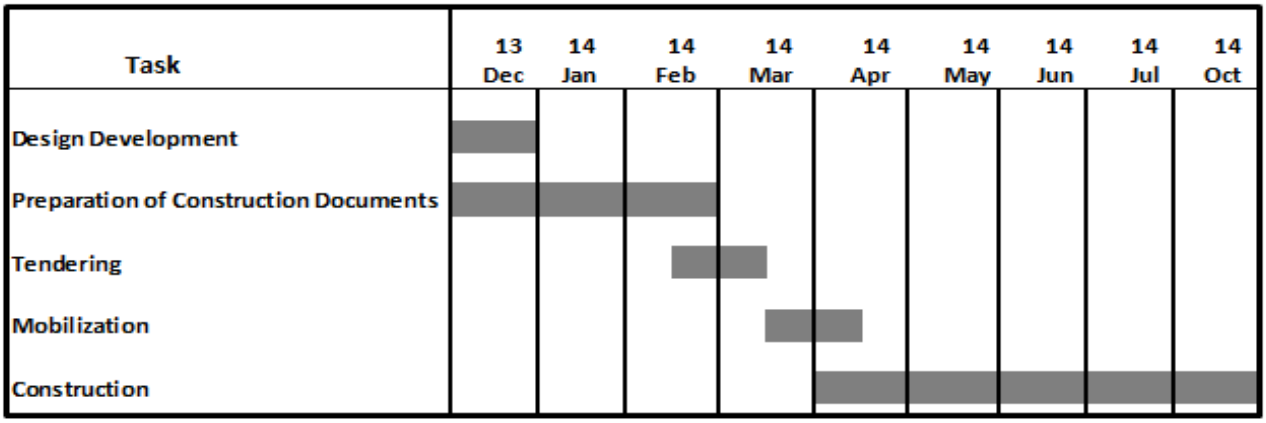
As UBC limits geographic expansion for parking, we propose underground parking facility under the existing parking lot to meet the entire garden's parking demands. When the parking demand is high during events such as apple festivals and weddings, underground parking can be used fully with lower parking rates than other parking lots on campus. During winter when parking demand is low, the underground parking facility can be used as an extra storage area for the garden's equipment or for renting out for various purposes.

The location of the proposed underground parking facility is next to the existing parking lot as indicated in the map below. The size of the underground parking lot is suggested to be the half size of the existing parking lot due to space limitation and complexity of construction.

4.4.1. Proposed Schedule

The duration of construction is estimated about a year, including planning for parking space allocations, signage, elevator and budgeting. The table below describes the conceptual project schedule.

Table 2 - Conceptual Project Schedule for Proposed Underground Parking Facility



4.4.2. Additional Services

The new underground parking will implement pay by phone service. It will also include electric vehicle charging stations, promoting sustainability. It can be distinguished from any other underground parking facilities on campus by having a car wash facility which can also be an anchor point to attract visitors.

4.4.3. Cost Estimate – Underground Parking Lot

Garages are more complex and below-ground garages are far more costly than above-ground structures. Below-ground garages may cost between 16,000 and 20,000 per space. Following

the similar cost estimate process proposed for surface parking lot expansion, overall cost for underground parking is estimated as 3 million dollars.

4.5. On-Street Parking along SW Marine Drive

As UBC is planning to decommission one of the lanes along SW Marine Drive in the future, we suggest using one lane for on-street parking. In terms of constructability, on-street parking will be the easiest way to satisfy parking demands with minimal requirements for parking supply. Permitting on-street parking may take longer time for BC MOT to process compared to obtaining permits for off street parking facilities from UBC.

Figure 12 - Potential Area for On-Street Parking Along SW Marine Drive

5. GAZEBO

We propose adding a gazebo to the open field next to the parking lot. A conceptual sketch of this anchor attraction is shown Figure 13 below.

Figure 13 – A Conceptual Design of the Gazebo among the Cherry Trees

The UBCBG is already planning to re-grade the area and to plant cherry trees (see Figure 14 below); a gazebo surrounded by cherry blossoms would create a beautiful spot for visitors to sit down and enjoy the atmosphere of the garden even during the rain. Furthermore, it will create a fantastic photo opportunity, especially for weddings.

The addition of this feature is relatively inexpensive and has the potential to transform a beautiful forest of cherry trees into an anchor attraction for visitors. An upper estimate of the cost of this gazebo would be $75/sq. ft., but this price could easily be reduced by using recycled building materials or beetle wood. This would also serve to reduce the ecological footprint of adding this feature to the Botanical Gardens.

Figure 14 - Proposed Location for the Gazebo (The UBC Botanical Gardens is planning to regrade this area and plant cherry trees)

6. CONSERVATORY

A climate-controlled conservatory should be considered for the UBC Botanical Gardens. This conservatory would provide a year-round attraction for visitors, increasing attendance during all seasons. Furthermore, the conservatory could be used to expand the Garden's collection to species that would not normally survive Vancouver's climate, enabling the University to expand its research and education activities.

6.1. Benefits to Garden

The addition of a conservatory could provide several benefits to the UBC Botanical Gardens: an increase in visitors to the gardens, a potential source of revenue during the traditionally low revenue winter season and a boost to the Garden's collections capacity and capability.

A very large conservatory could attract visitors on its own, however, due to cost and space constraints, a more modest conservatory of about 5000 square feet is proposed. This will provide another reason for the public to visit without being the sole point of interest for visiting groups. This is line with the vision for anchor attractions that draw visitors while fostering interest in the entire garden. As the conservatory is rain or shine, it could act as a "destination" attraction during winter months.

By housing plant species that would not grow outdoors in Vancouver, the Garden would be able to increase its collection. This would generate research and education opportunities that would not otherwise be possible at the University.

6.2. Location within Garden

The proposed location for the conservatory is the grassy area between the Food Garden and the Native Forest. This will allow space for a modest 5000 square foot conservatory, while also placing it in a central area near other features such as the Tea House, the proposed Education Center, the Food Garden and future outdoor kitchen, and within short distance of the amphitheatre. This location is easily accessible to garden staff by either foot or maintenance vehicle.

6.3. Collections in Conservatory

Collections in the conservatory should be grouped according to climate. The first step to adding to the collection will be to consider which climates are to be represented and based on this decision, specific species can be selected. Our proposal is based on a conservatory with one artificial tropical climate in order to maximize the space available for the wide variety of plants that thrive in this climate. However, based on Garden needs, creating two artificial climates by partitioning the structure could be an option. If the Garden staff prefer flexibility in this matter,

a partition could be incorporated in the design which could be left open until such time that two distinct climates are required. Some changes to the heating and cooling mechanisms will be required in order to accommodate this flexibility. Pairing two climates with large differences in characteristics, especially temperature, should be avoided in order to avoid reduced efficiency of the heating and cooling systems.

6.4. Heating and Cooling Systems

In keeping with UBC's sustainability policy, the proposed conservatory should have a heating and cooling system that minimizes energy usage. It is recommended that the conservatory be built to meet the standard set by the LEED Platinum Certified Phipp's Conservatory facility in Pittsburgh, Pennsylvania. The Phipp's facility has incorporated a number of features which should be considered at the Garden:

- Strategic placement of double and single paned paned windows (double paned glass is effective at reducing heat loss but does not allow as much light to pass through as single paned glass)
- Automated shades installed on glass that act to either restrict light, insulate the building or let maximum light in depending on weather conditions and heating/cooling needs
- Innovative cooling system that draws air through underground tubes to a depth of 5m where the moderate ground temperature can cool air before circulating it back into the conservatory during summer months or help to warm air when it is cold

6.5. Facility Costs

Recent decades have seen some conservatories, such as the Bloedel Conservatory in Vancouver, face the threat of closure due to high operating costs. However, these conservatories were built before advances in energy efficiency and sustainable building technology allowed leading edge, newly constructed conservatories to minimize their heating and cooling costs. For example, the previously mentioned Phipp's Tropical Conservatory was estimated to have a $2,400 per year heating bill and negligible cooling costs, compared to an estimated $16,800 annual cost for heating a traditional conservatory of the same size (Eco Structure, 2008). Phipp's Tropical Conservatory is 2-3 times larger than the proposed UBCBG conservatory.

Table 3 – Estimated Costs for the Proposed Conservatory

Estimated operating costs	Estimated construction costs
Heating: $1500 p/a Humidification/Steam: $1500 p/a	Building construction: $700,000 (based on 5000 sq feet at $140 per sq ft) Site preparation including underground pipes: $300,000

6.6. Relationship with VanDusen Gardens and Bloedel Conservatory

VanDusen Gardens, located a short distance away in Vancouver city proper, operates the Bloedel Conservatory, which serves a similar purpose and function to the conservatory proposed for UBCBG. This conservatory boasts species from three different climates (tropical rainforest, subtropical rainforest and desert). It may be desirable for UBCBG to choose species that are not already showcased at Bloedel; this will allow both conservatories to collaborate rather than to compete against each other.

6.7. Existing Examples

6.7.1. Bloedel Conservatory

The Bloedel Floral Conservatory, located within Queen Elizabeth Park in Vancouver, is an example of an existing local conservatory. It houses 500 plant species and 100 birds inside a 21 m high dome (Vancouver.ca, 2013). Tropical rainforest, subtropical rainforest, and desert climates are represented within the conservatory, allowing visitors to view and learn about a range of plant and bird species. The conservatory is operated by VanDusen Botanical Garden and is sustained by gate fees ($6.50 for an adult) and donations.

Figure 15 - Bloedel Floral Conservatory. Creative Commons: http://jaybanks.ca/vancouver-blog/2013/07/09/bloedel-floral-conservatory-photos/

6.7.2. Allen Gardens Conservatory

Allen Gardens Conservatory in Toronto contains plants and flowers in 6 greenhouses (a total of 16,000 square feet). Its collection includes a variety of species from tropical, temperate and arid climates. The conservatory was built in 1910 and is operated by the City of Toronto (Toronto Botanical Garden, 2011).

6.7.3. Phipps Conservatory

Phipps Conservatory and Botanical Gardens is located in Pittsburgh, Pennsylvania. Built in 1890 to house tropical plants, it today holds exotic plants from around the world in thirteen indoor rooms.

Phipps is notable for its sustainability initiatives. Its greenhouse is the only facility of its kind to be Platinum LEED certified (Phipps.conservatory.org, 2013). The Center for Sustainable Landscapes—the administration, research and education building—is also Platinum certified and meets the requirements of the Living Building Challenge (zero net energy). The conservatory's collections rooms utilize a number of techniques to reduce energy consumption including a unique cooling and heating system. Phipps calls itself the most energy efficient public garden conservatory in the world and some of its practices and initiatives could be used as a model for a conservatory at the UBC Botanical Gardens.

Figure 16 - Phipps Conservatory. Creative Commons: http://en.wikipedia.org/wiki/File:Phipps6.jpg

7. EDUCATION CENTER

We propose to add an education center as one of the anchor attractions. This is an excellent opportunity for people to find out more about the specimens and the garden in general, and to ask staff questions about the garden. The center provides a great attraction in all weather and can accommodate those with limited mobility. By having featured exhibits that change every few months, this Education Center will give people a reason to return to the gardens more often. It will also allow people to gain a new perspective on the plants; for example, a microscope could be set up that allows people to view the specimens in more detail than wouldn't be possible with the naked eye. This building can also be used as a classroom. An aerial view of the Education Center is provided in Figure 17 below.

Figure 17 - An Aerial View of the Education Center

One of the complaints that the staff from the Botanical Garden had was that children would sometimes run around recklessly and cause damage to the delicate plants. By creating a space within the Education Center that is geared towards kids, we can try to keep them engaged with fun activities that won't damage the specimens. For example, kids could have the opportunity to plant a flower in a pot and take it home with them. When kids enjoy their time at the garden it will help to make it a great destination for the whole family and work towards our goal of creating a more diverse visitor base. Figure 18 and Figure 19 below provide a conceptual design for the interior of the building.

Figure 18 – The Interior of the Education Center

Figure 19 - Location of Kid's Corner and Observational Beehive

The UBC Botanical Gardens already has some beehives, but they are not displayed in a way that visitors can enjoy and learn about them. Since the knowledge and resources to maintain the beehives already exists at the garden, transforming the existing beehives into an anchor attraction is an easy process. Adding a glass fronted beehive will allow visitors to safely observe these fascinating insects; the bees' way of entering the beehive can be behind the building to reduce the risk of visitors being stung. Figure 20 shows an example of an observational beehive.

Figure 20 – An Observational Beehive. Source: http://jobspapa.com/bee-hive-tools-honey-hives-for-sale.html

It is recommended that some informational posters are put up next to the display to provide information to visitors about bees. Bees and flowers have a symbiotic relationship in which the bee collects pollen from various flowers and in doing so fertilizes the plant so that it can reproduce. Educating people about these fascinating insects creates a great visual attraction and appeals to a wide audience including children.

We would recommend adding this building in the open area West of Marine Drive, close to where the bee hives are currently located (see photo below). Some ground improvement and slope stability analysis may be required before this building can be constructed.

Figure 21 – Proposed Location of the Education Center

A cost estimate for this building, based on the pricing of similar one-storey buildings, is approximately $200/sq. ft. The model drawn in Sketchup™ is just over 1800 sq. ft., for a total

minimum cost of $360,000. All buildings on campus are required to be LEED Gold certified, so it's probable that additional expenses arise from the further design phases. Some methods of meeting the sustainability objectives of the UBC campus would be the addition of solar panels on the roof and the use of recycled building materials or beetle-wood during the construction. The CIRS building provides an excellent example for how to achieve sustainability. While such sustainability initiatives may increase the capital cost, they can help to decrease maintenance costs in the long run. In order to account for these additional expenditures, we have estimated the cost to end up being approximately $500,000. Depending on the needs of the UBC Botanical Gardens, we could also add a basement to this building for additional storage space.

8. TREEHOUSE CAFÉ

The Treehouse Café can be an anchor point in the UBC Botanical Garden. UBCBG has abundant trees that can be used for treehouse café. As shown in Figure 22 below, the treehouse will be constructed about 10 metres above the ground for an optimal view, preferably in a location where there are not many other trees to act as obstructions. It will be used as tea café, which serves teas produced in UBC BG. It will also appeal to children who fantasize about treehouses.

The herbs for the tea will be produced in the garden. Visitors will be able to see the process of herbal tea production on the way to the café. The herbs will be harvested in the garden close to café, and the treehouse will have an herb drying room.

Figure 22 - A Sketchup Model of the Proposed Treehouse Café (Ultimate treehouse, 2007)

8.1. Location

The Treehouse Café will be located at the end of garden close to Thunderbird Stadium. The location was decided with consideration of the gas pipeline, electricity, and presence of suitably large trees.

8.2. Tree Damage Caused by Treehouse Building

If tree bark is damaged during construction, the chance of the tree becoming diseased increases. An infection from airborne or insect-borne bacteria and fungi can cause trees to rot and die gradually or suddenly. The bark of the tree works as protection against infection. Therefore, the construction of a treehouse should proceed in a way that will minimize the damage to the tree bark. A tree is a living organism and damage to the tree can impede its growth. Trees grow very quickly when they are young and comparatively slowly when they are old. If a treehouse is built without consideration of the tree's growth, the presence of beams and slabs can restrict the growth of the tree. Compartmentalization is another issue of treehouse construction. When tree gets damaged, it attempts to reduce the spread of disease and rot by isolating the part. The tree may consider the holes from bolts used in treehouse building to be a disease, and it will try to separate the large area instead of few small areas. The construction method should be carefully decided to reduce the damage to the tree. (Fulton P., 2013)

8.3. Construction of Treehouse

There are three ways of supporting treehouse: the post method, bolt method, and suspension method. The first option is to suspend the treehouse from the tree using strong cables or rope. However, the suspension method does not work for supporting heavy structures. The most traditional method is the bolt method, which bolts beams or floors into the tree. Although the bolt method causes the most damage to the tree, use of proper materials can minimize the damage. The treehouse can also be supported by posts installed in the ground near the tree instead of attaching it to the tree itself. The post method causes the least damage to the tree. Therefore, UBC Botanical Garden treehouse café will be constructed using post method.

8.4. Cost Estimate

The treehouse café will be about 5000 square feet, and unit cost of the café is estimated to be about $250/sq. ft. The total cost of the café will be approximately $ 1,250,000. The cost of the café may vary since it depends on the construction method and choice of building materials.

8.5. Tea Drying Process

A brief overview of the tea preparation process that will take place in the UBCBG's is given in this section. Tea drying process has five basic steps: plucking, withering, rolling, oxidation, and drying.

Figure 23 – Rolling Stage of Tea (Ineeka, 2013)

The manufacturing of tea begins with plucking of leaves in the field; for freshness, it is recommended to use leaves right after harvesting them. The next step is the withering stage, in which leaves begin to wilt. Withering removes excess water from the leaves and allows slight oxidation. Rolling is the process of twisting the leaves and rupturing the cell wall of leaves to bring the juices to the surface of the leaves. Then, the untwisted leaves are separated from twisted leaves and put in the rollers until all the leaves are rolled. The rolled leaves are fermented. In fermentation, the enzymes in the juices go under oxidation and bring out the flavour, strength, and colour, and the process is usually carried on glass or tiled tables. Green tea leaves are not allowed to oxidize, so they are sealed after rolling stage. Lastly, the drying process lowers the moisture content of the leaves before they are ready to serve.

9. STORMWATER MANAGEMENT

9.1. Introduction

Currently, all water used at the UBC Botanical Gardens is potable, while a large quantity of stormwater runoff from rainfall events passes through the gardens unused. In order to achieve the objective of becoming a more sustainable garden, it is recommended that the garden

improve the existing stormwater management system by collecting stormwater runoff and storing it for use in the garden. Not only will a stormwater management system help to achieve UBC's sustainability goals but it will also improve the garden's desirability and public experience with added water features which will add aesthetic value to the garden.

9.2. Existing Stormwater Management Conditions

In the North Garden, the runoff collects in a low lying area between the Carolinian Forest and Great Lawn where it ponds. From the pond, water drains by a small stream to the west towards the Tunnel where it is captured by a catch basin at the inlet of a culvert. The culvert crosses under SW Marine Drive and outfalls near the Moon Gate in the South Garden (Outlet 3). The water then drains via an open channel towards an inlet on the west side of the South Garden along Old Marine Drive before draining into Pacific Spirit Regional Park. Two other main channels in the Garden drain to this outfall (Outfall 1). One channel drains from the northeast of Outfall 1 which collects runoff from a culvert crossing under SW Marine Drive (Outlet 4). This culvert collects runoff from a swale that runs along the southeast corner of SW Marine Drive and Stadium Road. The other channel drains from the northwest of Outfall 1 and runs along old marine drive to an outlet of a culvert (Outlet 2) at the north end of the South Garden on the southwest corner of SW Marine Drive and Old Marine Drive. Refer to Figure 24 for the existing stormwater management layout.

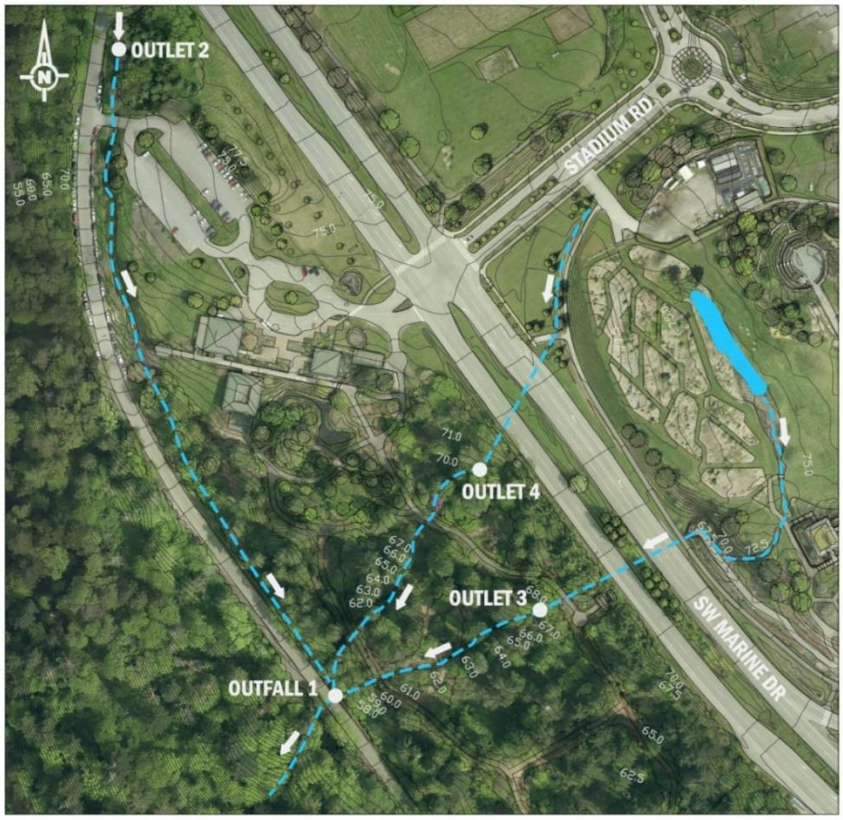


Figure 24 – Existing Stormwater Management Conditions

Outfall 1 has a catchment area of 56 ha (see Figure 25). It is estimated that an average of 1.1 m of rain covers the UBC area. Table 4 shows the average monthly rainfall for Vancouver.

Table 4 - Average Monthly Rainfall for Vancouver (Passport, 2013)

Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Avg. Rainfall (mm)	131.6	115.6	105.4	74.9	61.7	45.7	36.1	38.1	64.4	115.3	167.2	161.2
Total Rainfall (mm)	1117											

Figure 25 - Outfall 1 Catchment Area

Given the catchment area for Outfall 1 and the amount of rainfall over this area, roughly 670,000 m^3 of stormwater drains through the Garden per year. In order to determine the amount of stormwater runoff required to meet the needs of the Garden, the amount of water usage in the Garden is required. Currently no water usage measurements are available for the Garden; however the Garden's water usage may be estimated from the total water usage for UBC. UBC uses approximately 4,000,000 m^3 of water over an area of 400 ha per year (Chieng, 2013). The Botanical Gardens covers an area of 44 ha which is 11% of the total area of UBC. Taking 11% of the total water usage for UBC, an estimated 440,000 m^3 of water is used by the Gardens. However, about 88% of the total water usage for UBC is from waste water with the remaining 12% used for irrigation. The Botanical Gardens has a much lower population density relative to other areas of UBC and would therefore use less water for waste water and more water for irrigation, so the estimated value of 440,000 m^3 may be lowered. Approximately 65-75% of the catchment area for Outfall 1 drains down the channel from Outlet 2 at the north end of the South Garden. The estimated amount of runoff in the channel from Outlet 2 could be at least 440,000 m^3 and may be enough to meet the water needs of the Garden. However, should the Garden plan for future expansion and an increase in visitor volume, the Garden's water demand will increase, and therefore the proposed stormwater management system should maximize its runoff capture by collecting runoff from all the existing channels draining into Outfall 1.

9.3. Proposed Stormwater Management Layout

The proposed stormwater management system will collect runoff from the three main channels draining into Outfall 1 and divert the runoff to a wet pond. From the wet pond, the stormwater runoff will drain into a facility where it will be treated and stored for use in the garden. A separate water distribution system will need to be installed, and it will work in tandem with the existing water distribution system. See Figure 26 for proposed stormwater management layout.

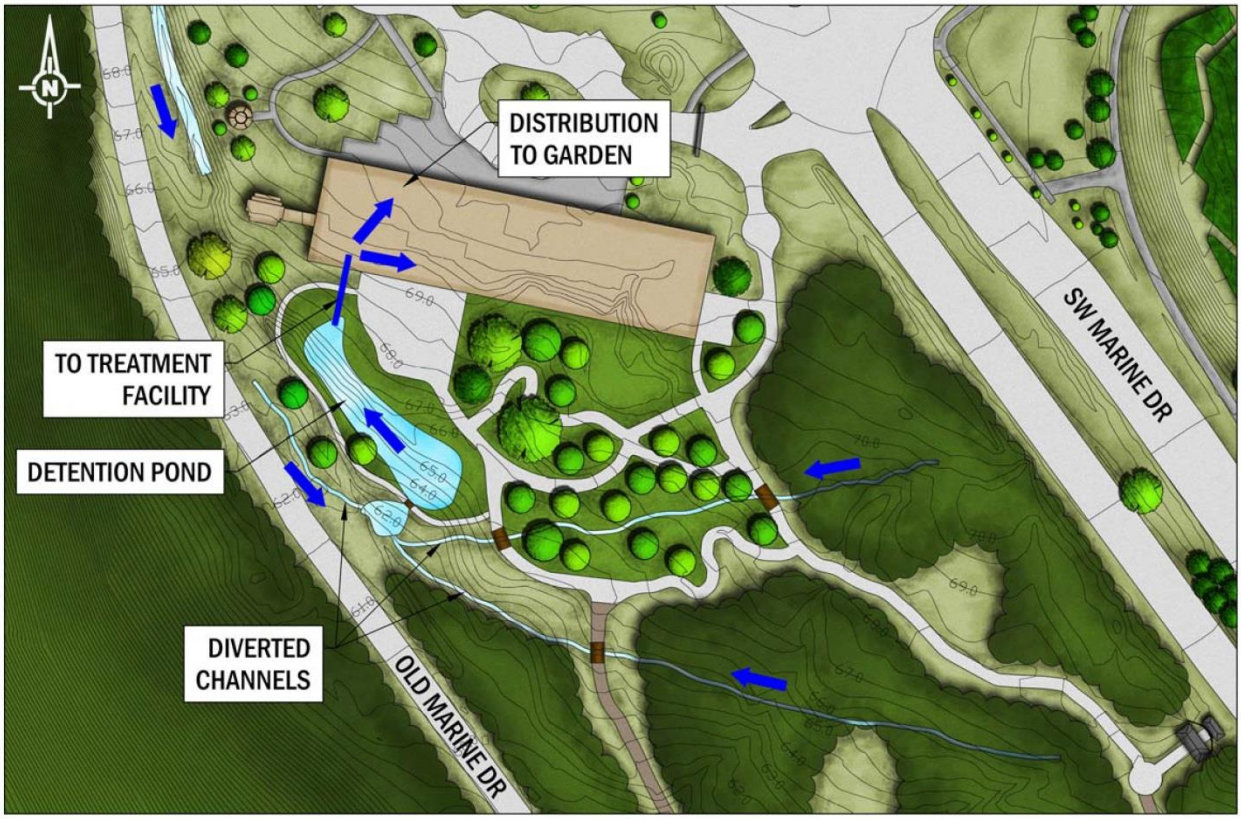


Figure 26 - Proposed Stormwater Management Layout

In order to minimize disturbances to the garden from underground pipe installation, the treatment facility and wet pond should be constructed as close to the existing water distribution network at possible. A shorter pipe length between the wet pond and treatment facility will also allow for the runoff to drain into the facility by gravity which will reduce the need for a pump. An existing water network surrounds the Gift Shop and Administration Centre, so the treatment facility should be placed in the same area either as a separate structure or an expansion to an existing one. The wet pond will be placed in the same area of the facility and will replace the existing pond south of the Gift Shop; however, the pond will need to be installed at an elevation that will allow all diverted channels to flow to the pond by

gravity. The area slopes downward towards the south west from an elevation of roughly 71 m at the Gift Shop and Administration Centre to 61 m at the channel along Old Marine Drive. In order to maintain a minimum 1% slope for the proposed channel from Outlet 3 to the proposed wet pond, the bottom of the pond will need to be at a maximum elevation of 62 m. The length of the pond will also need to be oriented to minimize the elevation difference through its cross section and the amount of cut. Orienting the pond parallel to the existing contours will minimize the elevation difference. Proposed channels will be constructed from Outlets 2, 3, and 4 and graded towards the wet pond along a path that minimizes impact on existing trees. The existing channels draining towards Outfall 1 will be filled. An area of approximately 2,000 m^2 will be cleared and re-graded for the wet pond. The two existing ponds north of the shop are currently filled with potable water and may be removed to reduce water usage.

From the wet pond, the water will drain into a facility where it will be treated and stored for distribution to the garden (see next section for treatment process). Additional watermains will be installed in-line with the existing water network to distribute the treated water to the garden. The proposed watermain will connect to the existing water network at the entry points of the existing distribution network for the garden. Flow between treated water and potable water from the existing service will be controlled by water valves. During periods where the treatment facility is under maintenance or during periods of low flow/low levels of available stormwater, the option to withdraw potable water from the existing water service will still be available. Also, having a separate water main to serve treated water to the North Garden, will allow for the option of servicing the North and South Gardens with treated water separately if a limited amount of stormwater is available. See Figure 27 for proposed water distribution schematic.

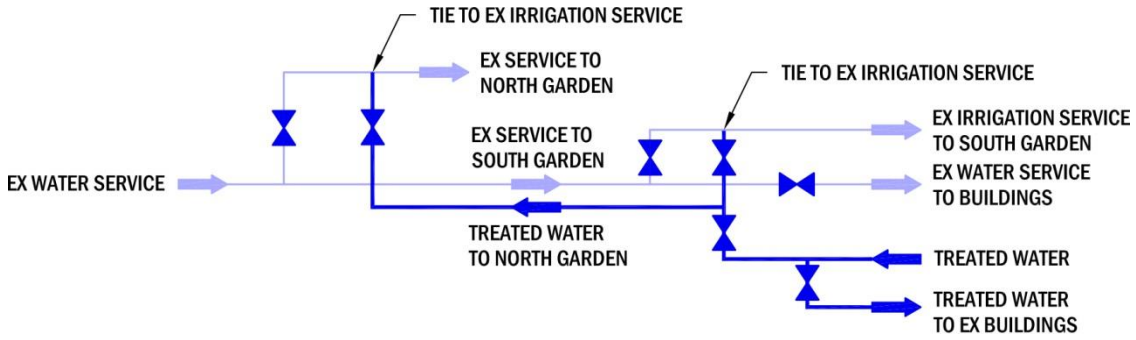


Figure 27 - Proposed Water Distribution Schematic

9.4. Treatment

Treatment of collected stormwater will be done in two phases. The two phases that the collected water will pass through are filtration and disinfection. After the water as passed through both phases, it will be clean enough to drink.

Filtering of stormwater will be done by using wet pond and sand filters. Water from stormwater catchments will pass through a forebay before entering the wet pond (See Figure 28). The forebay is a small pond which traps large sediment and debris before the water goes to the wet pond.

The wet pond will allow the sediments in the water to settle between storms. It will consist of grasses, shrubs, wetland plants, and under water berms. The vegetation will further filter the water by removing soluble contaminants from the water. The wet pond will have a minimum 1.5:1 length to width ratio, and a depth of 2m. Using these dimension limitations along with the underwater berms ensures the flow required for proper filtration of the stormwater will be achieved. The stormwater will then be sent to a treatment facility located near the wet pond.

The treatment facility will use a sand filter consisting of 3 phases (Figure 29). The first phase will be a slow sand filter that will remove large particles. The second phase will be a fine filter that will remove small particle and parasites. The final phase will be a carbon filter that will remove metals and atmospheric contaminates. After filtration, the water will be disinfected.

Figure 28 - Wet Pond

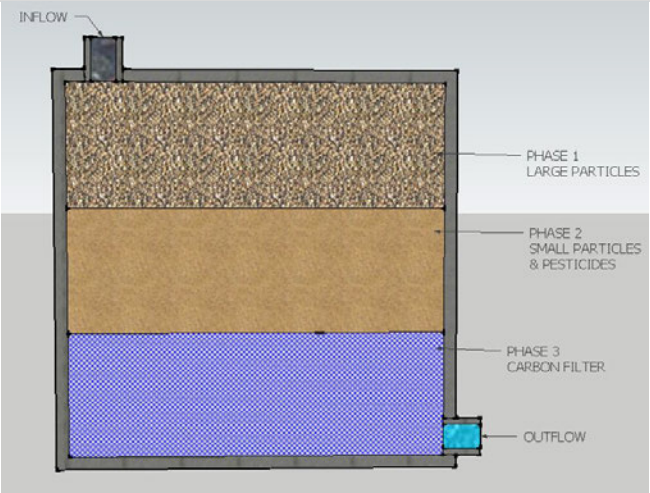


Figure 29 - Sand Filter

Disinfection of the water will be done by killing any remaining pathogens in the water. This will be done in two steps; the first step will be exposing the water to ultra violet light. The ultra violet light will kill the pathogens by damaging the chemical bonds that hold the DNA. The second step will be done by adding small amount of chlorine into the water to ensure that the water remains clean throughout distribution. Chlorine will kill the pathogens by breaking down the chemical bonds of the molecules that make up the pathogen. After the water has been disinfected, it will be safe to drink. The potable water will then be distributed throughout the garden for use.

The initial cost of the treating the storm water will be $81,710.00 with an annual maintenance cost of $3000.00. There is also the cost of the removing the sediments that the wet pond has collected. This removal will be done every 10 years and estimated to cost $3600.00. Table 5 shows details regarding the cost estimates.

Table 5 - Cost Estimate

Cost Category	Type pf Cost	Price	Per unit	Quanitity	Units	Cost
Capital Cost	Rip Rap (inlet)	12	m2	500	m2	$6,000.00
	Riser	5500	each	1	pc	$5,500.00
	Sand Filter	10000		1		$10,000.00
	Outlet Pipe	250	m	10	m	$2,500.00
	Disenfection	24210		1		$24,210.00
Total Capital Cost						$48,210.00
Installation Costs	Excavation	12	m3	2000		$24,000.00
	Earthworks	4	m3	2000		$8,000.00
	Vegetation	1	m2	1500		$1,500.00
Total Installation Costs						$33,500.00
Mainenance Costs	Landscaping	2	m2	1500		$3,000.00
	Sediment Removal(10 years)	120	m3	20		$2,400.00
Disposal Costs	Sediment Disposal (10 years)	60	m3	20		$1,200.00
Total Initial Cost						$81,710.00
Total Annual Maintence Cost						$3,000.00
10 Year Sediment Removal Cost						$3,600.00

10. CONCLUSION AND RECOMMENDATIONS

The three primary objectives addressed by this project are improving accessibility to the Garden, improving stormwater management, and increasing attendance by adding anchor attractions. A number of development options have been considered and chosen based on their potential to help meet these objectives, to add value to the Garden and its collection, and to improve visitor experience. Appendix B gives an overview of the costs associated with the different aspects of the proposal.

10.1. Accessibility

Access to the Garden will be improved by the proposed signalized pedestrian traffic control on SW Marine Drive, the parking capacity increase, and upgraded signage. This addresses current safety concerns about crossing SW Marine Drive to get from the UBC campus or the bus stop to the Garden entrance. A parking capacity increase will allow the Garden to handle larger volumes of visitors expected as attractions are added, and would help to alleviate parking shortages on weekends and during events. Upgraded signage provides an aesthetically appealing boost to visibility along SW Marine Drive.

10.2. Stormwater Management

A stormwater management plan has been developed for the Garden. Part of the goal of this plan is to address a growing concern about the amount of potable water used by the Garden's operations. Based on analysis of watersheds that runoff through the Garden property and rainfall figures for the local area, up to 440,000 m^3 of rainfall per year could potentially be diverted, treated and used for irrigation. Although the Garden would still require potable water, particularly during the dry summer months, the proposed stormwater management plan could greatly reduce the Garden's demand on Metro Vancouver's potable water reservoirs.

10.3. Anchor Attractions

Several anchor attractions have been recommended for the Garden:

- a Gazebo, providing a picturesque spot for visitors to enjoy the Garden atmosphere;
- an Educational Centre, complete with exhibits for children and adults;
- a Treehouse Café with views of the garden, serving Garden-grown teas and other refreshments;
- a Conservatory to house exotic plants from other parts of the world.

These attractions were selected from a range of options for their ability to draw visitors, improve the Garden experience and increase educational and research opportunities. The

three larger proposed developments (the Education Centre, Treehouse Café, and Conservatory) also serve as rain-or-shine attractions, making it easier for visitors to make plans to come to the Garden even when the weather forecast is unfavorable.

10.4. Development Priority

In the event that budgetary and other constraints prevent the implementation of the entire Garden improvement plan, it is recommended that the first priorities be improving pedestrian accessibility and implementing the stormwater management plan. Specifically, the pedestrian-controlled signal on SW Marine Drive should be considered in order to improve access and safety for visitors arriving by bus or by foot from the UBC campus. The stormwater management plan should also be considered in order to address the concern that the Garden is using a large amount of potable water, which may not be considered sustainable long term, especially if the Garden were to expand in the future. Although these two improvements would not necessarily have an immediate impact on visitor figures, they will help improve the current situation regarding both access and sustainability and will make it easier for future expansion.

Closing Remarks

Diversified Engineering Services has been pleased to work with the UBC Botanical Garden to prepare this conceptual design report on the UBCBG Improvement Plan. We believe that implementation of the recommendations contained within this report will help fulfil the objectives of improving access to the Garden, reducing the Garden's environmental footprint by the implementation of an improved stormwater management plan, and increasing visitor numbers by developing key attractions.

Yours truly,

Team 10

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APPENDIX A – DECISION MAKING MATRIX

	Weight	Pedestrian Overpass	Additional Signage	Signalized Intersection	Elevated Roundabout	Multi Purpose Room	Education Center	Gazebo	Treehouse Café	Regular Café	Parking Lot Improvements	Parkade	Roller Coaster	Restaurant	Storm water Mgmt	Improved Signage	Petting Zoo	Conservatory
Aesthetic Appeal	5	7	6	3	5	5	5	10	8	4	2	2	5	5	9	10	2	5
Educational Value	7	0	3	1	0	6	10	0	1	1	0	0	0	0	1	2	5	10
Environmental Friendliness	8	1	5	9	1	3	5	5	5	5	5	3	3	5	10	7	5	6
Increase amount of visitors	6	2	9	2	2	8	10	5	10	5	7	10	8	5	0	5	7	8
Cost effectiveness	5	1	10	10	1	2	4	7	4	5	10	8	1	5	10	10	1	7
Promote health/ diversity of plants	7	0	0	0	0	0	2	0	1	1	0	0	0	0	3	0	0	10
Maintenance Costs	3	3	8	9	3	5	5	9	3	3	10	4	0	0	10	8	0	3
Unique purpose within garden	8	3	5	3	3	0	10	7	10	5	7	7	8	6	10	6	8	10
Safety Improvement	10	10	1	10	10	0	0	0	0	0	0	0	0	0	1	2	0	0
SCORE		193	269	307	183	164	324	238	263	178	228	202	166	168	323	292	196	385

APPENDIX B – COST ESTIMATE FOR EACH PROJECT

Feature	Estimated Capital Cost	
Intersection	$	100,000.00
Improved Signage	$	20,000.00
Added parking spaces	$	1,596,000.00
Parkade	$	3,000,000.00
Stormwater Management	$	82,000.00
Gazebo	$	15,000.00
Treehouse Café	$	1,250,000.00
Conservatory	$	1,000,000.00
Education Center	$	500,000.00
TOTAL	$	7,563,000.00

It should be noted that these are very rough cost estimates. Costs will be more accurately determined during the detailed design phase of the project should the UBCBG choose to go ahead with these recommendations.