University of British Columbia

Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Wesbrook Mall Redesign – Phase 4

Prepared by: Evan Kear, Bagas Linanda, Nish Manesh, Joshua McAllister, Joseph McNeilly, Omeid Niyaz

Prepared for:

Course Code: CIVL 446

University of British Columbia

Date: 8 April 2022

UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Wesbrook Mall Redesign – Phase 4

Evan Kear, Bagas Linanda, Nish Manesh, Joshua McAllister, Joseph McNeilly, Omeid Niyaz

University of British Columbia

CIVL 446 – Design Project II

April 8, 2022

Executive Summary

BOJNOJ Consultants has created a detailed design report which describes our suggested design for Phase 4 of the Wesbrook Mall Redesign from W 16th Avenue to Thunderbird Avenue. In recent years, the University of British Columbia campus has experienced consistent development and growth. As the population of both the campus and the Point Grey area in general continues to increase, ensuring accessibility is key to maintaining the well-being of all residents. Therefore, the main objective of the redesign is to provide a sustainable, resilient, and efficient solution to the transportation needs of the UBC community. Our team considered criteria from a wide range of perspectives and have created a design that prioritizes both mobility and environmental protection to improve the experience for all users.

BOJNOJ Consultants' proposed design will create a separate raised cyclist lane in both the northbound and southbound direction. The positioning of the parking lanes will be swapped with the current cycling lanes to eliminate conflicts between vehicles and cyclists and prevent accidents. An overpass will be added near the Panhellenic Village to comply with UBC's desires. Additionally, several green infrastructure upgrades will be implemented throughout the corridor to improve rainwater infiltration.

Additionally, the necessary maintenance has been accounted for and our team has provided the advised procedures to ensure proper function of all key corridor components. Taking into consideration geometry rearrangements, infrastructure upgrades, and overpass construction, the overall project is estimated to cost **$6,047,901.61.** Construction is scheduled to begin **early May 2022 and be completed over 12-week period**. The following report documents our detailed design solution, the decision-making process used to arrive at that design and important constraints and criteria evaluated.

TABLE OF CONTENTS

LIST OF FIGURES

List of Tables

1.0 Introduction

BOJNOJ Consultants have been given the opportunity by UBC SEEDS to develop a detailed design report for phase 4 of the redesign of Wesbrook Mall, specifically the area between Thunderbird Boulevard and W 16th Avenue. As one of the primary arterial roads in the region, Wesbrook Mall is a critical corridor in funneling thousands of users to and from UBC each day. Wesbrook Mall serves as the primary access road to the eastern edge of the UBC campus, along which several residences, university buildings, and amenities are situated. Due to both the natural aging of infrastructure and the changes in the needs of its userbase, Wesbrook Mall has been undergoing a significant makeover, with two of the planned four segments having already undergone modernization, and construction for the third stage set to commence in early 2022.

This development is crucial for improving the quality of transportation at UBC. BOJNOJ Consultants' process began with fact-finding and site visits, to determine the existing geometry, facilities, and traffic patterns. Additionally, BOJNOJ Consulting was provided with a set of demands, preferences, and constraints by the University of British Columbia. This information was utilized as the basis to create a proposal and multiple design options for the project. The advantages and disadvantages of each of these options were considered, and our final design option was selected using a weighted decision matrix.

This report will breakdown, in detail, all requirements and constraints considered and the various components of our design. The design was completed to improve the efficiency, accessibility, safety, and aesthetic appeal of the area. In addition, the design will be comprehensively broken down and shown in terms of materials, drawings, and our rationale behind these decisions.

The following table outlines the key tasks completed by various team members:

2.0 Site Overview

The project site for Phase 4 of the Wesbrook Mall Redesign is located between the streets of W 16th Avenue and Thunderbird Boulevard. It is important to note that since the entire university resides on First Nations' territory, the appropriate First Nations have been consulted by our team regarding the proposed project. The current roadway does not accommodate all modes of transportation very well and can be dangerous to use. This is due to the natural aging of the site and the unclear or cluttered layout of the street. Figure 1 below displays an overviewed image of the site analyzed in this report:

Figure 1: Overhead View of the Site

One of the main flaws with the area that was noticed is that the current roadway paving is in poor quality. There are potholes and cracks as shown in Figure 2 below. New paving will be needed along much of the roadway. Examples can be seen below:

Figure 2: Paving Issues

3.0 Project Overview

3.1 Objectives

The main objective of the Phase 4 Wesbrook Mall Redesign is to provide a sustainable, resilient, and efficient solution to the transportation needs of the UBC community. The following objectives were included into the project scope and guided our design process.

- Provide seamless connection with previous developments (Phase 2) completed north of the project site and the roundabout at W 16th Avenue to the south.
- Design to prioritize transit, cyclists, and pedestrians over private vehicles
- Minimize overall costs and optimize construction scheduling
- Construct a pedestrian tunnel or overpass south of Thunderbird Arena
- Integrate green infrastructure into the design to improve stormwater management
- Include efficient and safe pick-up/drop-off/short-term parking facilities for field users with separated bike lane.
- Minimize loss of existing parking space
- Minimize removal of trees and vegetation loss

4.0 Design Criteria

4.1 Technical Considerations

The following were the primary technical criteria used to inform the general design:

- Ensure an efficient and improved traffic flow for transit riders, cyclists and pedestrians
- Ensure an efficient short-term parking system for sporting events pick up/drop off
- Ensure a coherent connection with the Phase 2 design and roundabout on W 16th Avenue
- Maintain the same amount of parking vehicles available for private vehicles as before
- Retain substantial rainwater with green infrastructure
- Must provide a 50-year design life

Specific to the overpass design are the following parameters:

- An expected annual usage of 80,000 pedestrians
- Limited interference with bicycle, transit, and vehicle traffic
- Creation of additional infiltration area, and appropriate drainage pathways
- Reduce likelihood of pedestrian-vehicle collisions along Wesbrook Mall corridor

4.2 Economic Considerations

BOJNOJ Consultants strived to create a design that is both economical and feasible for the current economic conditions. With the world still reeling from the effects of the COVID-19 pandemic, there are additional considerations that must be made in terms of the economic feasibility of the project. The global supply chain issue has impacted almost every aspect of the economic system. Material prices around the world have gone up in addition to transportation and labour costs. Inflation has reached a high of 7.9% in February of 2022. These economic factors influenced our decision making in terms of the budget and design.

4.3 Construction Planning Considerations

The following considerations were taken into account with regard to construction planning:

- The time period over which the project will be completed
- Material/material removal needs for overpass or underpass
- Maintaining adequate traffic flow during disruptions
- Determine necessary construction services (paving, concrete pouring, etc.)

4.4 Regulatory Considerations

BOJNOJ Consultants followed all the standards and codes as set out by the relevant authorities. This includes engineering manuals and building codes from both government and non-government organizations. See Section 10.0 for a full list of standards and regulations consulted in the design process.

4.5 Environmental Considerations

With the ongoing impact of climate change on the local community, it was important to consider the environmental impacts of the project. To this effect, a range of green infrastructure was integrated throughout the corridor to mitigate the impacts of excess rainfall. More specifically, the team focused on improving the stormwater management of the corridor. Some of the key criteria during the design process are listed in the 2.0 Project Objectives section above. A full description of the green infrastructure incorporated into the design and the environmental analysis conducted is provided in Section 7.0 Environmental Aspects.

4.6 Community and Societal Considerations

Stakeholder engagement was a major priority throughout the design process. This engagement allowed to BOJNOJ to gain an understanding of the community priorities and values, which ultimately influenced the design process. Key stakeholders incorporated include the following:

- UBC Students & Staff
- Cyclists
- Bus Drivers
- Indigenous Community
- Local Residents

The key feedback received from this consultation was regarding the bike lane, which current in its location causes conflicts with vehicles. Cyclists may not be comfortable with busses crossing into their space to access the bus stops, and cars crossing into their space to access the parking.

5.0 Description of Detailed Design

5.1 General Layout

The proposed modifications to the Wesbrook Mall corridor that spans between Thunderbird Blvd and W 16th Ave can be seen in Appendix G (Detailed Design Drawings). Due to the length of the corridor, the corridor will be split into four sections for the purposes of this report. Figure 3 below displays the sections and their corresponding titles.

Figure 3: Sections of Wesbrook Mall Corridor

To describe some of the features in the design, a close-up illustration of Section 3: RCMP, specifically around the 2900 Block bus stop, is shown below in Figure 4. The illustration below displays all the key facilities on the corridor such as a bus stop, parking lane, bike lane and standard travel lane. On the left side of the figure, the new position of the raised and protected bike lane can be seen in between the parking lane and green space. On the right side of the figure, a protected bike lane is shown curving around a bus stop with the pedestrian sidewalk to its right.

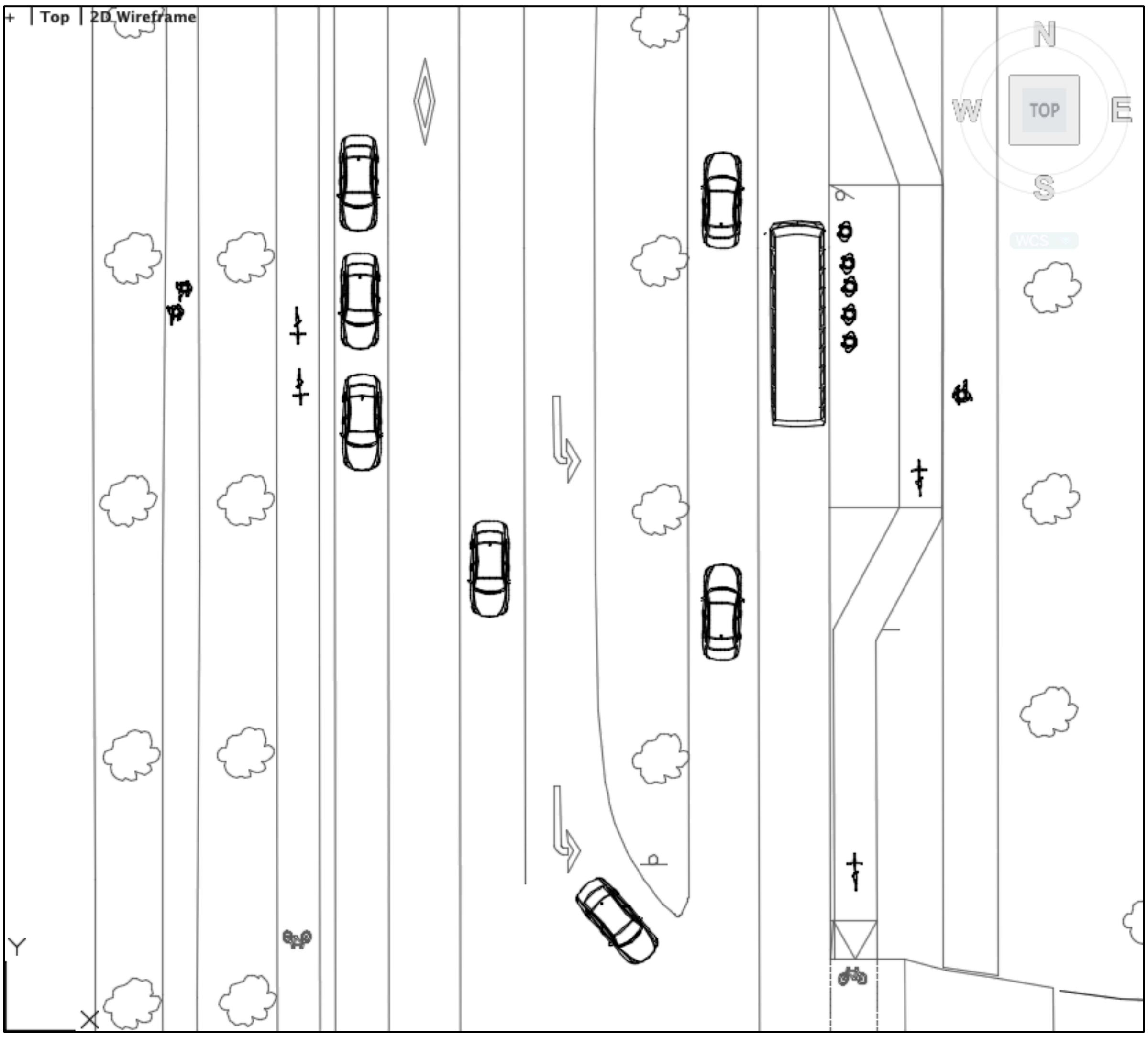


Figure 4: Illustration of Design in Section 3 Near the 2900 Block Bus Stop

5.2 Traffic Infrastructure

5.2.1 Road and Curb Design

To determine the necessary thicknesses for road design, our team consulted the City of Vancouver Engineering Design Manual. Based on these guidelines, the following dimensions were determined for the material thicknesses. These specifications meet the requirements for bus routes and therefore will be used for the entire road section. The thickness and type of material that will be used for the road and curb design is based on the City of Vancouver's Engineering Design Manual. These extend to specifications for bus routes and therefore can be applied to the entire road section.

Table 1: Road Pavement Thickness and Material

Pavement Structure Type	**Minimum Required Thickness (mm)**
AC Surface Course	50
AC Lower Course	180
Granular Base	150
Subbase	300

Dimensions for the travel and parking lanes were all compared with City of Vancouver Engineering Design Manual which is assumed to reflect the requirements in the BC Ministry of Transportation Design Guidelines. The width of the two northbound travel lanes as well as the southbound travel lane will be slightly reduced, however, their lane widths throughout the corridor will be consistent.

Table 2: Road Lane Widths

Feature	**Lane Width (m)**
General Travel Lane without Curb	3.3
General Travel Lane with Curb	3
Bus Lane	3.3
Parking Lane	2.5

A road grade of 2.5% is applied to the entire road corridor for stormwater runoff to be diverted into the stormwater management facilities implemented in our design. As the road corridor will not be symmetrical due to different road lane widths, the road grade will still begin at the centerline of each road direction. Stormwater runoff will be diverted away from the centerline and onto the curb. The grade is visualized in the Cross-Section View detailed drawing shown in Appendix G (Detailed Design Drawings).

The curb that will be used throughout the corridor will be Concrete Curb Type F which is a curb specifically designed to be adjacent to bicycle lanes. The detailed dimensions of the Concrete Curb Type F are shown in Appendix G (Detailed Design Drawings).

The dimensions of the bus bays followed specifications from TransLink's Bus Infrastructure Design Guidelines. Specifically, the bus bays were designed to accommodate the larger articulated bus which is a major component of TransLink’s fleet. A detailed drawing of the area and the cross-section of it is available in Appendix G (Detailed Design Drawings)

Even though the road widths meet the minimum requirements, almost all the road widths have been reduced by approximately 0.1-0.7 meters depending on the section in the corridor. While this will reduce the LOS of private vehicle usage, the reduction in road widths was necessary to accommodate for space for the new raised and protected bike lanes and buffer. This reflects the prioritization of cycling and multi-modality in our design philosophy. On top of accommodating the new bike lanes, the reduction in road widths results in a net increase in green space which will improve stormwater management. The net increase in green space will be elaborated in Section 7.0 Environmental Infrastructure. There was heavy emphasis on keeping the existing features such as parking and minimizing any tree loss which resulted in very limited space constraints. These aspects ultimately led to the reduction in road width for entire corridor.

A grade of 2.5% was utilized as per road design guidelines. Given the large volume of precipitation that falls on Vancouver throughout the year, a steeper grade of 2.5% versus 2% would allow for the water to runoff more quickly which prevents any sediment collection on the road.

The use of Concrete Curb Type F was determined based on its suitability to be placed adjacent to a bicycle lane as stated in the City of Vancouver Engineering Design Manual. Its applicability is demonstrated by the curb width, which matches with buffer requirements for a raised and protected bike lane of 0.15 meters. This will be elaborated in the following section.

5.3.1 Raised and Protected Bike Lane

Like the road design, the dimensions for the raised and protected bike lanes meet the minimum requirements set out in the City of Vancouver Engineering Design Manual.

Table 3: Bicycle Lane and Buffer Widths

Feature	**Width (m)**
Bicycle Lane	2
Bike Lane Buffer next to Travel Lane	0.15
Bike Lane Buffer next to Parking	0.7

The curb ramp that will connect the road to the protected and raised bike lane will have a grade of 1:12.8 or a length of 1.8 meters. It will have a height of 150 mm above the road grade.

The material thicknesses of the bike lane meet the minimum specifications stated in the Metro Vancouver Stormwater Source Control Guidelines. The main material that allows for the permeability is the permeable asphalt. The thicker layer underneath the top surface is reflective of the need for extra support for this type of road design as it is generally considered to be weaker compared to standard road pavement.

Table 4: Bike Lane Pavement Thickness and Material

Pavement Structure Type	**Minimum Required Thickness (mm)**
Permeable Asphalt	80
Aggregate Bedding	50

Open Graded Base	100
Open Graded Sub-Base	400

A raised and protected bike lane was determined to be the most optimal solution due to the safety and compatibility of the facility in providing the best experience for cyclists. The following table presents the benefits of implementing a raised and protected bike lane along this corridor. In addition to the clear benefits of comfort and safety, some of the benefits stated below such as preventing cyclists from using sidewalk were based on research by NACTO.

Table 5: Benefits of Raised and Protected Bike Lane

Benefits	Description
Eliminate Vehicle Conflicts	The raised and protected bike lane will provide riders with dedicated lanes that eliminate the presence of cars and buses which pose the greatest risk to cyclists' safety. The separation of bikes from vehicles will provide the most impactful change in terms of improving the safety and comfort of cyclists.
Integration with Phase 2 of Wesbrook Redesign	The previous phases of the Wesbrook Mall development implemented raised and protected bike lanes as well. The consistency of the raised and protected bike lanes along the corridor will improve the overall experience of cycling along Wesbrook Mall.
Separation of Cyclists and Pedestrians	As a result of the poor existing cycling infrastructure, cyclists may be tempted to use the sidewalks to travel along the corridor. By providing a dedicated lane to cyclists, it will deter cyclists from using the sidewalks which improves the safety of pedestrians.
User Accessibility	It is likely that the current cycling infrastructure deters some number of potential cyclists. By providing a more safe and comfortable experience, it may encourage more people to travel along this corridor using bikes.

Minimize Maintenance	Because buses and private vehicles will not need to cross and drive over the bike lane, the loads that the bike lanes will experience will be significantly reduced. This will extend the lifespan of the bike lane and reduce overall maintenance required on the bike lane.
Overtaking	With a width of 2 meters, the new bike lanes will provide sufficient space for cyclists to comfortably travel along the corridor. It will allow cyclists to overtake one another if they that situation arises which is a key feature of any bike lane. Furthermore, the width of the bike lane will stay the same throughout the corridor which provides key benefits. These include simplified construction procedures and an improved cycling experience for riders.
Lane Width Consistency	The width of the bike lane will stay the same throughout the corridor which provides key benefits. These include simplified construction procedures and an improved cycling experience for riders.

The grade of 1:12.8 used for the on and off ramp exceeds the minimum grade of 1:12 which will provide a smoother transition for cyclists as they cycle up and down the ramp. Additionally, the on and off ramps built in previous phases of the Wesbrook Mall development uses the same grade which will provide consistency of facilities across the entire corridor.

While the buffer of 0.15 - 0.7 meters meet minimum requirements, there is still sufficient space for the cyclists to feel safe and comfortable during their ride. The 0.15 m buffer will be placed along bike lanes that are adjacent to the travel lanes and the 0.7 m buffer will be for bike lanes adjacent to parking. The larger 0.7 m buffer has been provided to neutralize the effect of car passengers opening their doors in the direction of the bike lane.

5.4.1 Pedestrian Sidewalk

The width of the new pedestrian sidewalk will be 2.1 meters. This is in accordance with the City of Vancouver's Engineering Design Manual. It is important to note that the 2.1-meter sidewalks will be instituted in sections where alterations are necessary due to other design changes, such as the bike lane.

More specifically, these changes will be located around the corridor's bus stops. The width of the existing sidewalk will largely remain the same.

The material thickness for the new sidewalks meets the specifications laid out in City of Vancouver's Engineering Design Manual. Compliance of material components and design with existing guidelines allow for standardization of the work being done which will simplify the procurement and construction process.

Table 6: Pedestrian Sidewalk Thickness and Material

Pavement Structure Type	**Minimum Required Thickness (mm)**
MMCD Upper Course	50
Granular Base	150

Due to the changes mainly being around the bus stop, a 2.1-meter width was determined to be appropriate due to the relatively high volume of pedestrians and bikes that will be using the facility when buses drop off and pick up passengers. A 2.1-meter sidewalk should provide sufficient space for pedestrians to comfortably walk along this corridor.

The decision to minimize changes to the widths of the existing sidewalks is due to several factors. The first is that improving cycling infrastructure was prioritized due to the poor existing cycling infrastructure throughout the corridor. Creating a raised and protected bike lane takes up a significant amount of space when including the buffer zones. Secondly, considerations for improving stormwater management through the increase in green space and the proximity of buildings and trees provided limited available space in certain areas. Given that majority of the pedestrian sidewalks are still in relatively good condition, it was determined that expansion of the sidewalks was not necessary.

5.5 Pedestrian Overpass

One of the major changes of the Phase 4 redesign is the addition of a pedestrian overpass at the Panhellenic House. This feature will accommodate pedestrian traffic and will eliminate the necessity of most vehicle-pedestrian interactions in this section of the corridor.

5.5.1 Design Considerations

The following factors were the primary aspects considered to have a major influence on the final design, in addition to the design criteria outlined in section 4.1.

There is a lack of available data concerning the soil conditions in the area surrounding the Panhellenic Village, as well as on the UBC campus as whole. What data is has been gathered indicates inconsistent soil, indicating a potential for poor bearing strength at the proposed site. To accommodate for this, the structure will allow for less concentrated disbursement of gravity loads.

5.5.2 Roadway Span

The overpass crosses two multi-lane paved regions, with areas for support only available at the median and at the on either end. With a total length of just under 36m, the longer unsupported section will be required to span approximately 20m. The lack of space available for arch supports has led to a necessarily robust design of the beams.

5.5.3 Design Loads

The following table details the design loads considered in the design of the structure:

Table 7: Design Loads for Overpass

Load Designation	Load Type	Loading
Planter Weight	Dead	1.9 kPa
Art Wall Weight	Dead	1.5 kPa
Veneer Weight	Dead	0.1 kPa
Concrete Self-Weight	Dead	23.5 kN/m^3
Pedestrian Load	Live	1.9 kPa
Snow Load	Snow	1.5 kPa

The designs of all structural elements (slab, beams, columns, footings) were governed by gravity load cases.

5.5.4 Description Overview

The overpass structure will span 35.8 meters across Wesbrook Mall, just south of the existing pedestrian crossing at the Panhellenic Village, and with a height of 4.65 meters above the roadway. This crossing will be accessible via four staircases located at the north and south approaches to the overpass along both the east and west sidewalks. The central walkway will have a width of 2m, with planters 1.5m in width bordering on either side. Each staircase will have a length of 6.5 meters, and the total staircase and platform footprint length will be 19 meters at both the east and west entrance (see Figure 5 below for visual representation). For further specific information, the complete set of detailed overpass drawings can be found in Appendix G.

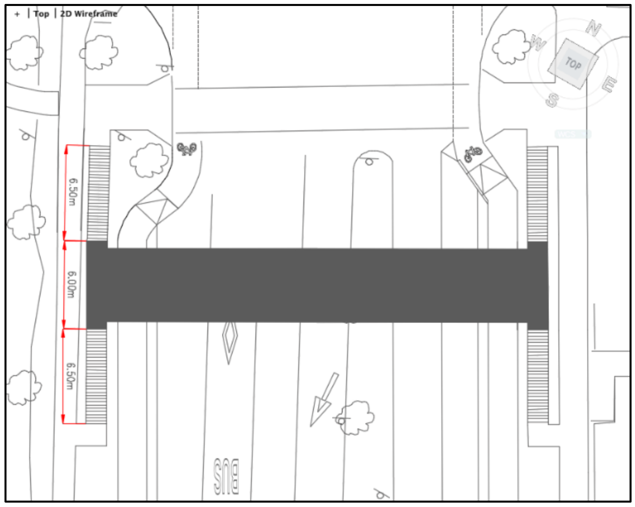


Figure 5: Overpass Footprint

5.5.5 Structural Components

The primary structural element utilized in the overpass design is reinforced concrete. Two subterranean concrete footings will be cast in place one meter below grade at both the eastern and western curbs, as well as the median, for a total of six pads supporting the structure. Each footing will support a column rising 4.65m above the road surface, meeting the bottom surface of the beams. Two laterally reinforced concrete girders will cross both the northbound and southbound lanes, integrated with the columns on either side and at the median. This will be overlaid by a reinforced concrete slab which will serve as the walkway for the overpass.

5.5.6 Art Barrier

The walls of the walkway will be composed of 2.0m tall Douglas-Fir columns spaced at 3.6m. These columns will run along both sides of the walkway and will support panels with artwork serving as the guardrails. The University of British Columbia will be able to commission local First Nations artists, as well as past graduates to create works on each panel. These panels are non-structural elements and can be swapped out or removed for maintenance easily as necessary.

5.5.7 Planters

A row of planters with seasonal flowers will run down either side of the walkway. This feature will add both colour to overpass, and provide infiltration, soaking up a large amount of water that would otherwise end up as run-off. A space of 600mm between planters has been allocated at each support to allow for easy access and maintenance to both the art panels and the planters.

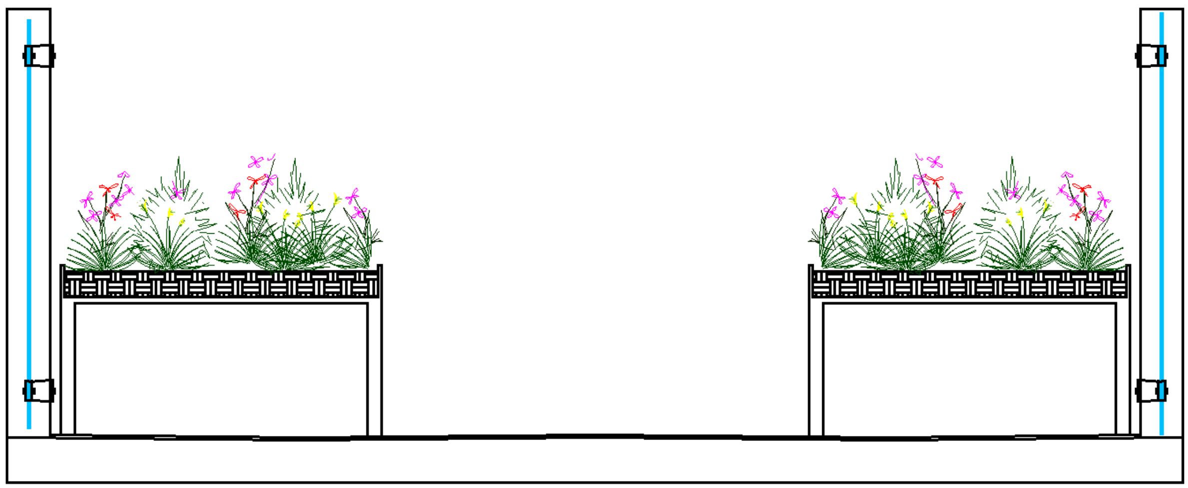


Figure 6: Typical Overpass Cross-Section

5.5.8 Drainage

The slab will feature two culverts, which will run underneath the planters. The flow shall be directed towards these culverts by a 1% slope in the slab. The slab will also be cast at a 1% grade from the midpoint towards the landings to direct run-off down towards the drainage collection at the landings. From here the run-off will be collected at in one of the four drainage pipes along the stairwells and will be directed to green area at the base of the structure. The full layout of this system can be found in the detailed drawings in Appendix G.

5.5.9 Other Elements

The slab will be overlaid with a thin, waterproof veneer layer. This will give the structure an organic feel, while also insulating the top layer of concrete and limiting freeze thaw damage. The stairs will be composed of timber beams, with steel connectors attaching the PVC drainage pipes at the side.

5.5.10 Materials and Dimensions

The following Tables 8 & 9 outline the primary dimensions and materials for the overpass design.

Table 8: Primary Overpass Dimensions

Element	**Dimension (m)**	
Stairs	Length	6.5
	Width	1.4
	Height	4.8
Walkway	Length	35.8
	Slab Minimum Thickness	0.2
	Walkable Width	2
	Barrier Height	2.15
Columns	Width & Breadth	0.5
	Height (Total)	6.4
	Height (Above Ground)	1.0
Footings	Thickness	0.75
	Width & Breadth	2.5

Table 9: Materials for Pedestrian Overpass

Component	Material
Columns	Reinforced Concrete
Walkway Slabs	
Walkway Beams	
Footings	
Wall Supporting Art Panels	No. 2 Douglas Fir Posts
Stairs	Sawn Timber
Panels	Softwood, Mixed Types
Planters	Soil, Insulating Layer

For full dimension and material details, see the overpass design drawings in Appendix G.

6.0 Environmental Infrastructure

6.1 Green Infrastructure

One of our primary goals in this project was to increase rainwater retention and reduce runoff along the corridor. On average, the area receives 1290mm of precipitation yearly. During a rainfall or snowmelt, much of the water is held by the natural landscape, but in urban areas with less green space much of this water will go directly down storm drains. On the way to storm drains runoff picks up pollutants, (gas, garbage, fertilizer, etc.) which then will then be routed into nearby waterways. These pollutants pose a risk to wildlife and, increased flows can also cause erosion in the areas they are being transferred to.

By adding green infrastructure, we can increase the amount of water held, absorbed, and treated by the landscape. Retaining rainwater and runoff has many benefits, it will: reduce and filter pollutants going into the environment, capture water and allow plants and soil to absorb it, and reduce the overall amount of water going down storm drains.

6.1.1 Technical Considerations

While designing our green infrastructure we considered:

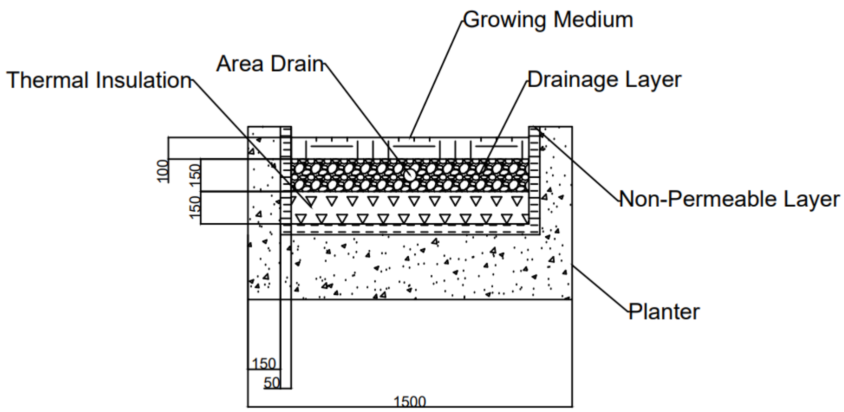
- Annual Precipitation
- Existing Stormwater management
- Soil characteristics
- Ease of Maintenance
- Feasibility

6.1.2 Green Space

In areas where there is a buffer between the new bike lanes and new parking lanes there will be added green space. This greenspace can intercept and clean rainwater. There will be an overall gain in green space of 240m^2.

6.1.3 Raised Planters on Overpass

The original plan to have a green roof on the overpass was changed to a simpler raised planters along the sides of the overpass. The green roof would have been difficult to maintain due to its location, limited space, and lack of accessibility. Instead, we have modified the design of the overpass to include raised planters that will provide a similar amount of rainwater retention with lower maintenance costs.



`

Figure 7: Cross Section of Raised Planters

6.1.4 Permeable Asphalt Cyclist Lanes

We had originally designed the top layer of the new bike lanes to be concrete pavers which posed a few potential issues. The pavers may not have had appropriate friction with bicycle tires, resulting in cyclists experiencing sliding. Also, the surrounding bike lanes are constructed using asphalt, to keep the bike lanes consistent with previous construction our final cyclist lanes will be made of permeable asphalt.

The permeable asphalt bicycle lanes will have a top layer of permeable asphalt that will allow water to pass into the layers below and percolate into the soil. Should the soil become overly saturated there is an overflow inlet. The new cyclist lane locations are shown in Appendix G. They will be designed as partial infiltration asphalt pathways. A cross section of the cyclist lane and its layers can be seen below in Figure 8.

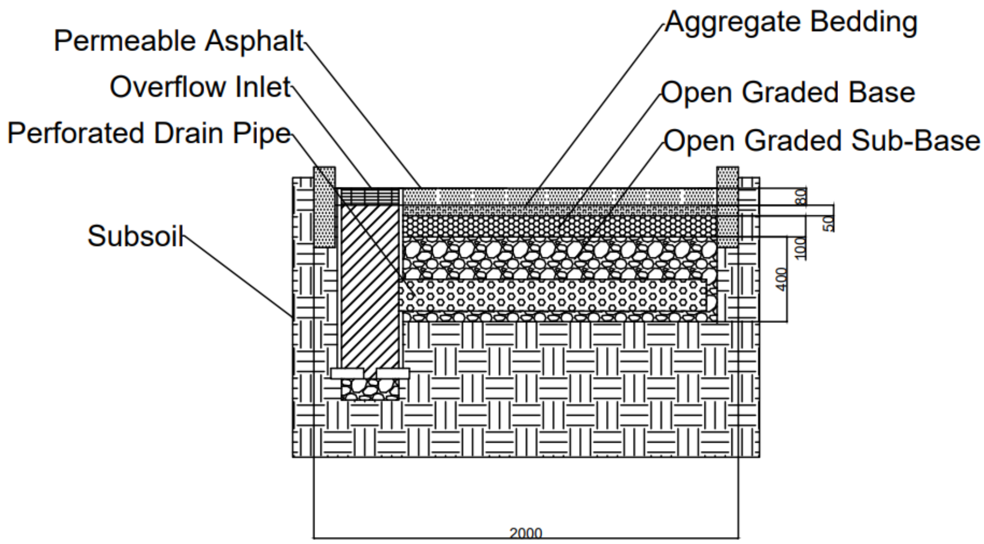


Figure 8: Cross Section of Permeable Pavement Cyclist Lane

6.1.5 Rain Gardens

We have designed rain gardens at three locations along Westbrook Mall. The first rain garden will be located north of the W 16th Ave and Westbrook Mall roundabout on the southbound side of the road in Section 4 (Hampton Place). The second rain garden will be located near the entrance of Hampton Pl also in Section 4 (Hampton Place). The third rain garden will be located on the median that is south of the Doug Mitchell Thunderbird Sports Centre in Section 1 (Thunderbird Blvd).

Figure 9: Rain Gardens 1, 2, and 3 (from left to right)

These rain gardens are designed as partial infiltration rain gardens due to the soil type near the location. Using the outline from Metro Vancouvers Stormwater Source Control Guidelines we have come up with a design and estimates for the maximum amount of rainfall and runoff that could be contained per year.

The rain gardens will have slightly different specifications due to their differences in size but overall will be quite similar. They will have ponding depths of 200 millimetres but the total areas at maximum depths will vary, and the side slopes may vary as well (none will exceed the 2:1 maximum incline). A cross section of Rain Garden 1 is shown below and all of the detailed CAD drawings of the rain gardens and other green infrastructure are included in Appendix G.

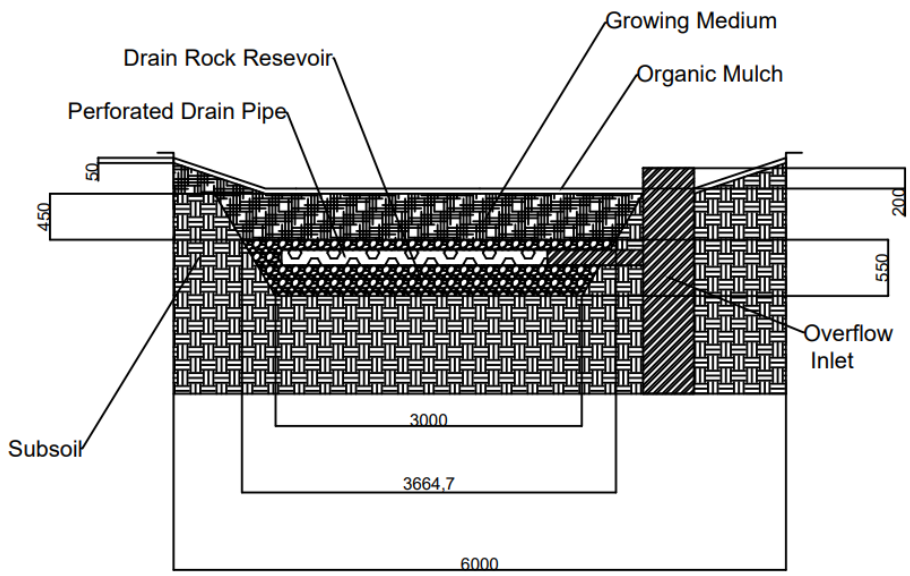


Figure 10: Cross Section of Rain Garden 1

6.2 Hydrological & Stormwater Impacts

This project aims to have a significant positive hydrological impact. The addition of several types of green infrastructure outlined in the section above will reduce runoff in the area and increase overall rainwater retention.

With the dimensions outlined in the tables below, we have estimated the amount of water they could potentially absorb in an entire year. These values have been calculated based on the area within the catchment that is non-permeable, as nearby green space will have less runoff. The raised planters on the overpass adds the least rainwater retention but does so in a unique and aesthetic way. The rain gardens make a large impact despite their relatively small size. The permeable asphalt cyclist lanes make the largest impact on runoff and also cover the most area. The approximate values for rainwater retention are shown below in Tables 10,11, and 12. In our previous report we believe to have slightly overestimated the amounts of water retained, these values have been updated to reflect what we believe to be more accurate estimates.

Table 10: Approximate Green Roof Water Absorption

Base Area (m^2)	Rainfall Absorbed (m^3)	Rainfall Absorbed (L)
100	**49**	**49,020**

Table 11: Approximate Rain Garden Water Absorption

Rain Garden	Length (m)	Width (m)	Base Area (m^2)	Tributary Area (m^2)	Impervious Tributary Area (m^2)	Rainfall Absorbed (m^3)	Rainfall Absorbed (L)	Previous Rainfall Absorbed (L)	Total Gain Absorbed Rainfall (L)
1	25	6	150	1,800	900	1,161	1,161,000	193,500	
2	14	5	70	840	420	542	541,800	90,300	
3	9	4	36	432	216	279	278,640	46,440	
SUM			**256**	**3072**	**1536**	**1,981**	**1,981,440**	**330,240**	**1,651,200**

Table 12: Approximate Permeable Concrete Water Absorption

Bike Lane Section	Base Area (m^2)	Tributary Area (m^2)	Rainfall Absorbed (m^3)	Rainfall Absorbed (L)
1	490	490	582	581,532
2	1,110	1,110	1,317	1,317,348
3	660	660	783	783,288
4	2,260	2,260	2,682	2,682,168
SUM	**4,520**	**6,780**	**5,364**	**5,364,336**

The decision to essentially swap the locations of bike lanes and parking lanes in some areas will require some catchment basins to be relocated. Originally, most storm drains on Westbrook Mall were located along the curb. This will continue to be the case, however, in locations where the previous storm drain is now underneath the new bike lane it will be relocated onto the parking lane. Storm drains located in the immediate vicinity of rain gardens will be converted into overflow inlets to drain excess water should it pool during an extreme rainfall event.

7.0 Vehicle Traffic Flow Analysis (Synchro)

As provided in the Preliminary Design Report. Figure 13 below displays the synchro analysis that was conducted on the Wesbrook Mall roadway section.

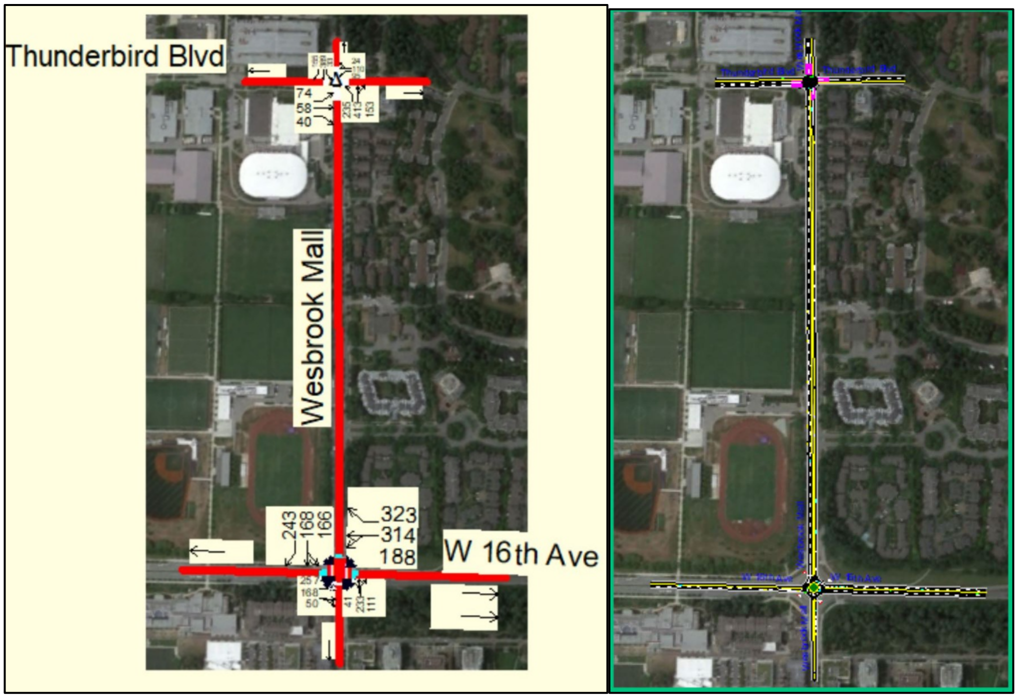


Figure 11: Syncrho6 Model

For the traffic flow data, AM Peak Flow were gathered (via provided data set) for cars, bus, and heavy vehicles. These results, shown in Table 13 and 14 below, were then converted to PCE for Synchro.

Table 13: Wesbrook Mall & Thunderbird Blvd Peak Flow Data

Wesbrook Mall & Thunderbird Blvd Intersection													
Mode	PCE Ratio	NORTH Approach			SOUTH Approach			WEST Approach			EAST Approach		
		L	TH	R	L	TH	R	L	TH	R	L	TH	R
Cars	1	33	249	155	235	273	150	74	58	38	95	110	24
Heavy Vehicles	2	0	5	0	0	5	0	0	0	1	0	0	0
Buses	2.5	0	52	0	0	52	1	0	0	0	0	0	0
PCE		33	389	155	235	413	153	74	58	40	95	110	24

Table 14: Wesbrook Mall & W 16th Ave Peak Flow Data

Wesbrook Mall & W 16th Ave Intersection													
Mode	PCE Ratio	NORTH Approach			SOUTH Approach			WEST Approach			EAST Approach		
		L	TH	R	L	TH	R	L	TH	R	L	TH	R
Cars	1	131	139	117	39	196	108	176	166	48	188	312	276
Heavy Vehicles	2	0	2	3	1	1	0	3	1	1	0	1	1
Buses	2.5	14	10	48	0	14	1	30	0	0	0	0	18
PCE		166	168	243	41	233	111	257	168	50	188	314	323

To assess the current vehicle traffic flows, a performance report was generated for the network through Synchro. The results of the report are shown in Table 15 and 16 below.

Table 15: Thunderbird Blvd & Wesbrook Mall Intersection Analysis

ICU %	67.9%
ICU Level of Service	C
Intersection Delay	9.9 seconds
Intersection LOS	A

Table 16: W 16th Ave & Wesbrook Mall Roundabout Analysis

ICU %	96.0%
ICU Level of Service	F

From the results above, it can be seen that the current Thunderbird Blvd intersection is performing well. South of Thunderbird Blvd, the synchro simulation demonstrated good traffic flowing in both directions until it reaches W 16th Ave. The current roundabout at W 16th Ave (Figure 14 below) is performing at a nearly 100% capacity, with an ICU LOS rating of F.

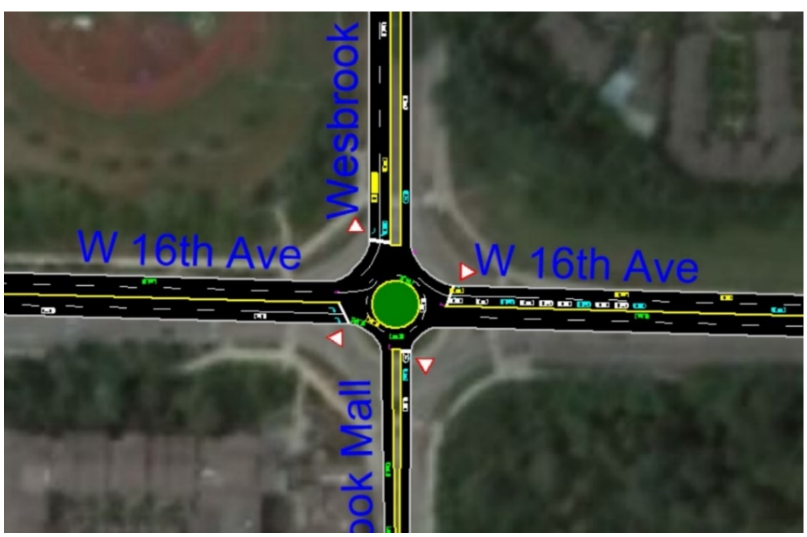


Figure 12: Wesbrook Mall & W 16th Ave Roundabout Synchro Simulation

To improve the roundabout flow, an analysis was conducted to explore the feasibility of adding a bus lane going northbound from the roundabout on W 16th Ave to 2900 Block bus top. The peak hour flow (per Phase 4 data) of busses travelling onto Wesbrook Mall from the roundabout is 62. This is an extremely high bus volume, and this study is to determine if adding a bus lane will help improve the vehicle flow and public transit experience.

The following benefits were found:

- Dedicated lane for public transit results in less conflicts with passenger cars
- Seamless transition into the 2900 Block bus stop results in less lane change
- Creates two travel lanes until 2900 Block which reduces congestion after the roundabout

The following drawbacks were found:

- Synchro analysis reported an increased ICU value for the roundabout from 96% to 103%, meaning the roundabout will perform more poorly with the extra lane. Due to limitations with Synchro6, adding dedicated bus lanes is not an option, therefore a regular vehicle lane was added instead. The results from this Synchro6 measurement are not fully conclusive.
- 150 sq m of green space would have to be removed
- 10 sq m of pedestrian space at the roundabout would have removed

In conclusion, the dedicated bus lane will not be implemented into the design. The major reason is because it will cause pedestrian and green space to be removed from the design. Also, Synchro6 traffic modelling is unable to display that it improves traffic flow through the roundabout.

8.0 Service Life Maintenance Plan

8.1 Roadway

Upon completion, the roadwork will require maintenance in order to ensure the safety of users. The roadwork maintenance will follow BC MOTI guidelines on frequency and best practices. It outlines how each road is assessed based on the risk of undesired consequences due to surrounding hazards. These hazards include landslides, flooding, soil erosion, poor drainage, etc. From the risk assessment tool provided, Wesbrook Mall is classified as a low-risk road. Therefore, Wesbrook Mall should be subject to at least one road maintenance inspection every two years. These road maintenance inspections are aimed to reveal any deficiencies in the road that need repairing. Once the inspections are done, a report will be generated which will be used to obtain contractors to fix the deficiencies found.

Special considerations will be made during the winter season as snow build up pose more serious risk of injury and collision. With heavy snow and ice buildup, snowplows will be deployed to clear up the snow in addition to spraying salt on the road to remove the ice.

8.2 Green Infrastructure

The green infrastructure designed as part of this project will all require varying levels of maintenance to keep them functioning as intended. The water flowing into the rain gardens will carry debris and pollutants. The voids within the permeable cyclists' lanes will be gradually filled with debris as they are used. The raised planters on the overpass should not experience any debris as it is not absorbing any runoff and therefore should just require regular garden maintenance.

To maintain the raingardens and planters on the overpass several things must be done. During the first few years they may need to be watered and weeded to help encourage plant growth. The raingardens will need to be mulched annually in the spring to maintain a three-inch mulch layer. Plants will need to be pruned annually and replaced/removed if they have died. In the rain garden, layers of sediment that have accumulated over time will also need to be removed annually. Every 2-3 years the pH of the soil in the gardens should be checked and normalized if needed.

To maintain the permeable asphalt cyclist lanes the debris will need to be removed. In order to do this a special type of equipment will be required. A Regenerative Air Sweeper or a Pure Vacuum Sweeper will be required to remove debris from the asphalt, the latter being recommended. This cleaning should be performed annually or semi-annually.

8.3 Pedestrian Overpass

The concrete elements of the overpass will need to be monitored to ensure its structural integrity. An annual check will be carried out on the structure in the spring each year to check for cracking or fractures due to freeze-thaw cycles or stress due to excess loading.

The art panels along the walkway are accessible via the openings between the planters at the timber supports. Should the University desire to commission new works, or perform maintenance on existing panels, they can be removed and replaced with a temporary panel for a period.

The drainage culverts along the overpass will pick up small amounts of debris, and will require bi-annual checks to remove any blockage.

9.0 Construction Work and Schedule

9.1 Construction Sequence

The breakdown of the schedule, assumed to be implemented in May of 2022, can be found in Appendix C as a Gantt Chart. The scheduling was designed and organized to minimize the project duration and traffic disruptions. The months of May, June, and July have been strategically chosen given the campus roadways experience less traffic and pedestrian activity during this period compared to other times of the year. All statutory holidays were taken into consideration for the construction schedule and excluded from the days of work under consideration. The construction work was divided into three distinct phases to minimize the amount of the roadway that would be unavailable for public use, starting with the northbound lane. During the second portion, this will encompass the pedestrian side of the southbound lane. The third phase involves completed the median side of the southbound lane. For the overpass, the major components will be cast and created off-site, before being brought on-site for final assembly. Additionally, reasonably conservative estimates of the activity durations have been provided to ensure sufficient float for the timely completion of the construction process with good quality of output work. The chart below provides a broad overview of the construction phases.

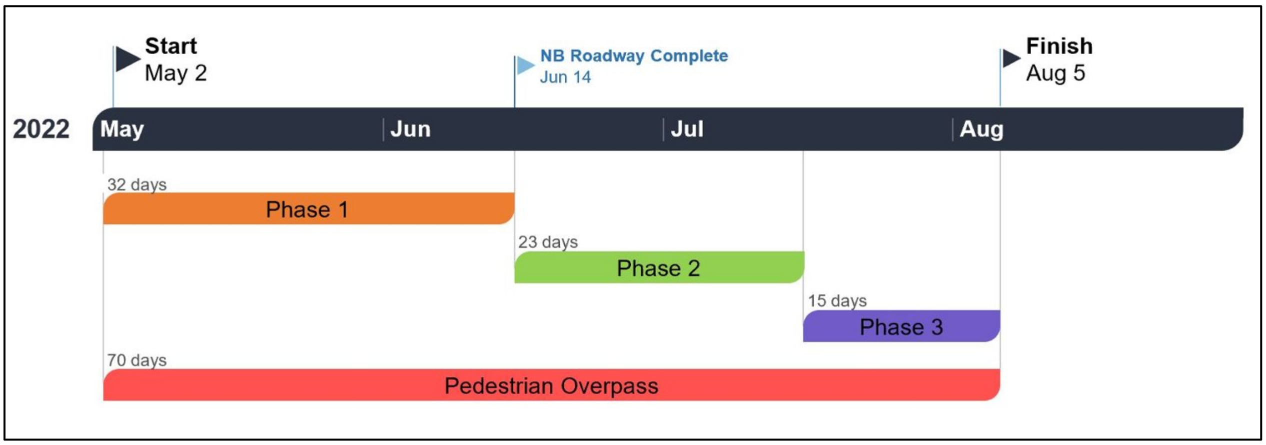


Figure 13: Construction Schedule

The schedule above reflects 70 working days (excludes weekends and holidays) required for completion. If crews fall behind on the schedule, working on weekends may be considered.

Table 17: Phase 1: Construction of northbound phase

Type	**Task**	**Estimated Time**
General	Site Preparation for NB region. (Fencing, signage, roundabout prep)	2 days
Roadwork	Removal of Top Pavement and Excavation of roadway	21 days
Roadwork	Relocating storm water infrastructure	7 days
Roadwork	Paving new Asphalt Roads	21 days
Roadwork	Paving new raised permeable bike lane	14 days
Roadwork	Misc. (Road painting, landscaping, Curbs)	5 days
Rain Gardens	Excavation	5 Days
Rain Gardens	Installation of drainage infrastructure	5 Days
Rain Gardens	Backfill and relaying of organic mulch	5 Days

Many of the tasks above will be happening at the same time and will all be completed in 32 working days.

Table 18: Phase 2: Construction of southbound phase (pedestrian side)

Type	Task	Estimated Time
General	Site Preparation for SB region. (Fencing, signage, roundabout prep)	1 day
Roadwork	Removal of Top Pavement and Excavation of roadway	14 days
Roadwork	Relocating storm water infrastructure	7 days
Roadwork	Paving new Asphalt Roads	14 days
Roadwork	Paving new raised permeable bike lane	14 days
Roadwork	Misc. (Road painting, landscaping, Curbs)	5 days
Rain Gardens	Excavation	5 Days
Rain Gardens	Installation of drainage infrastructure	5 Days
Rain Gardens	Backfill and relaying of organic mulch	5 Days

Many of the tasks above will be happening at the same time and will be completed in 23 working days.

Table 19: Phase 3: Construction of southbound phase (median side)

Type	Task	Estimated Time
General	Site Preparation for SB region. (Fencing, signage, roundabout prep)	1 day
Roadwork	Removal of Top Pavement and Excavation of roadway	10 days
Roadwork	Paving new Asphalt Roads	10 days
Roadwork	Misc. (Road painting, landscaping, Curbs)	3 days

Rain Gardens	Excavation	5 Days
Rain Gardens	Installation of drainage infrastructure	5 Days
Rain Gardens	Backfill and relaying of organic mulch	5 Days

Many of the tasks above will be happening at the same time and will be completed in 15 working days.

Table 20: All Phases: Pedestrian Overpass

Type	Task	Estimated Time
Overpass	Ordering Pre-cast structures	30 days
	Excavation	15 days
	Footings and Platform placement	10 days
	Slab Placement	8 days
	Staircase and column installation	10 Days
	Superstructure deck installation	10 Days
	Garden and Finishing	7 Days

These tasks will happen in order with some overlap and will be completed for the overall project time of 70 working days.

9.2 Traffic Management Plan

Summertime traffic flows were not available for use; however, it can be assumed that the flows will be significantly lower than the school year. This significant reduction in volume allows for a reduction in roadway capacity that will make construction much simpler. The following traffic flow plan is proposed:

During all phases:

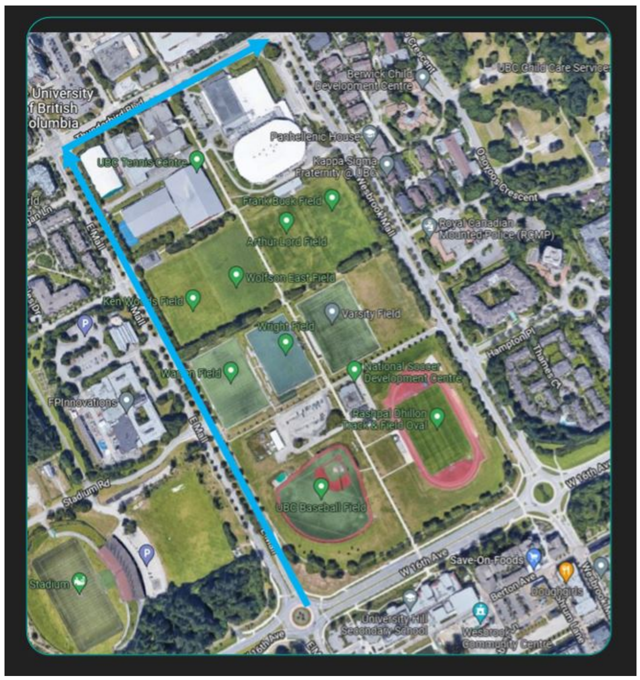


Figure 14: R4 Bus Diversion

To reduce volume on Wesbrook Mall, Figure 16 above displays the proposed re-routing of the R4 Bus. For incoming busses, this includes travelling along East Mall, turning onto Thunderbird Blvd, and connecting back onto Wesbrook Mall to complete its route. For outgoing busses, this includes turning right onto Thunderbird Blvd from Wesbrook Mall, then turning left onto East Mall to connect back to W 16th Ave.

Phase 1:

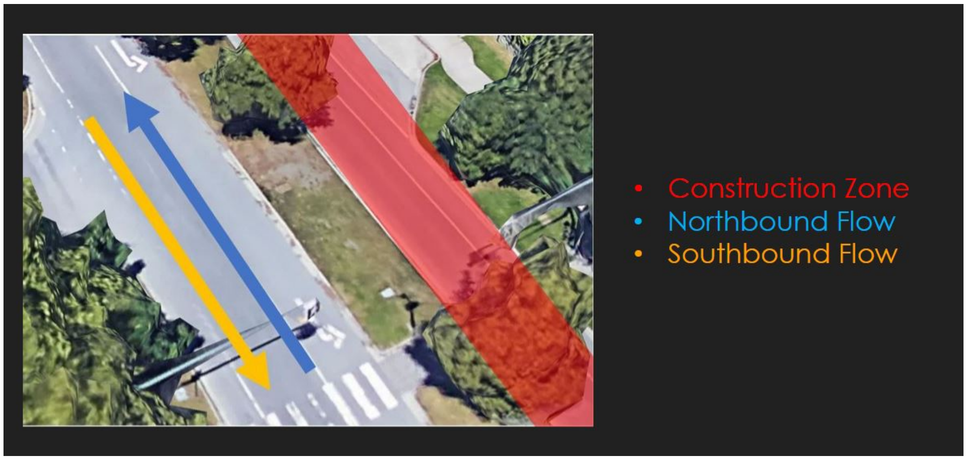


Figure 15: Phase 1 Traffic Management

This first phase of traffic management, this includes construction of the NB direction. The entire NB lane will be cut off, and all the northbound flow will be diverted into the SB lane. This will have one lane traffic going in both directions. The thinnest section of the SB direction is just over 6m, which is sufficient to support this plan. Adjustments need to be sidewalk near the roundabout on W 16th Ave to allow for a smooth turning onto this lane.

Phase 2:

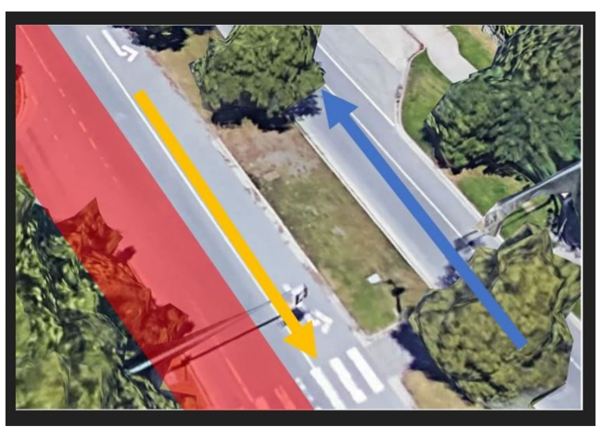


Figure 16: Phase 2 Traffic Management

The second phase consists of the construction of the SB direction. Due to the sufficient lane width provided in this direction, construction will first occur on the pedestrian side, and traffic will flow on the median side. Traffic delineators will need to be set up to divide the two sections.

Phase 3:

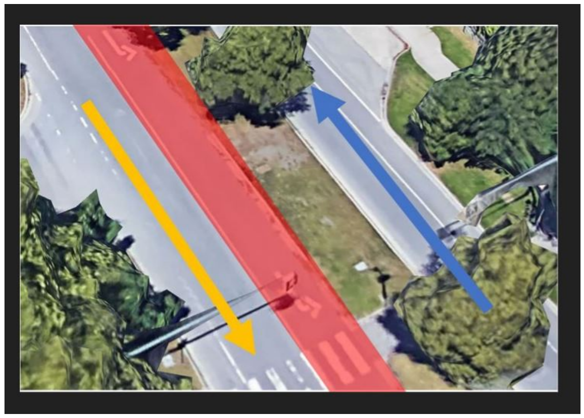


Figure 17: Phase 3 Traffic Management

The third phase consists of construction of the median side of the SB direction. Traffic will flow on the newly constructed pedestrian side of the road. Traffic delineators will need to be set up to divide the two sections.

9.3 Construction Requirements

Table 21: List of Construction Requirements

General	**1. Permitting and Compliance with Regulation** **2. Procurement of Materials and Equipment** **3. Site Preparation** **a. Fencing** **b. Signage** **c. Traffic Management** **d. Clearance** **4. Checks and Inspection**
Roadwork	1. Removal of Top Pavement 2. Sidewalk and Road Excavation 3. Relocation/Installation of Storm Water Infrastructure 4. Installation of Curb 5. Installation of Green Infrastructure (Rain Gardens)

	6. Paving of new asphalt road 7. Paving of new raised permeable bike lane 8. Painting of roadway and installation of signage 9. Landscaping
Overpass	1. Preparation for arrival of Pre-cast Concrete components 2. Excavation 3. Footing and Platform placement 4. Slab laying 5. Overpass Slab Glass Wall 6. Installation of Stairs 7. Elevated Garden 8. Finishing
Rain Gardens	1. Excavation of Topsoil 2. Excavation to desired depth of rain garden 3. Installation of overflow inlet 4. Installation of drain rock reservoir 5. Installation of drainpipe 6. Backfill of growing medium 7. Relaying of organic mulch

9.4 Anticipated Issues

The team has identified three issues that may arise during construction of the project. First, general community complaints and concerns arise from the noise, congestion, and overall inconvenience of construction. In relation to this, transit users should expect delays and increase in travel time due to the necessary road closures and increased walking distance from bus stations. The construction traffic management plan is designed to reduce the disruption of construction as much as possible. However, additional measures can be implemented such as adding workers to speed up construction and installing noise screening fences along sections next to residential buildings to reduce the noise. While these measures would lessen the impact of construction on the community, it would increase the cost of construction and possibly delay the completion of the project.

Lastly, given the lack of information on UBC's underground infrastructure, the construction team may encounter unexpected underground infrastructure during construction. Additional work must be done to relocate such infrastructure which will result in delays to the schedule and increase in costs. While informing all construction workers about this potential issue is beneficial, it is understood that this issue is difficult to predict and account for in the construction planning.

10.0 Standards, Codes, Guidelines, and Software Utilized

Table 22: Standards, Codes, Guidelines, Software Utilized

Element	Standards, Codes, and Guidelines	Software
Roadway and Bike Lanes	• *Canadian Highway Bridge Design Code (CHBDC)* • *City of Vancouver Engineering Design Manual* • *British Columbia Active Transportation Guide* • *Geometric Design Guides for Canadian Roads*	• *AutoCAD* • *Synchro*
Green Infrastructure	• *Metro Vancouver Stormwater Source Control Design Guidelines* • *NACTO Urban Street Stormwater Guide*	• *AutoCAD*
Pedestrian Overpass	• *CSA O86:19 (Timber Design)* • *CSA S16:19 (Steel Design)* • *CSA A23.3 (Concrete Design)* • *BCBC 2018*	• *AutoCAD*

11.0 Detailed Cost Estimate (Class A*)

BOJNOJ Consultants has completed a Class A cost estimate of the detailed design discussed in this report. This cost estimate was completed with the intention of verifying the economic practicability of the proposed design and minimizing expenses by utilizing cost effective solutions. This analysis was developed based on two main components: construction and consulting costs. The construction cost was calculated through quantifying the services necessary during the proposed construction of the design and the values of materials needed. The overhead cost of the contractor, contingencies and maintenance were also considered. The consulting fees were based upon standard fees charged by BOJNOJ Consultants.

BOJNOJ Consultants estimates a total cost of approximately **$6,047,901.61** for the phase 4 redesign of Wesbrook Mall from W 16th Avenue to Thunderbird Avenue. This includes construction, consulting, contingency and contractor overhead and fee costs. The annual operations and maintenance cost is $45,000.00. The following tables below summarize the values for each component:

Table 23: Total Cost Summary

Total Cost Summary	
Item	**Cost**
Construction Activities Cost	$ 4,740,135.40
Contractor Fee (7%)	$ 331,809.48
Contractor Overhead	$ 125,600.00
Consulting Services	$ 61,500.00
Contingency (15%)	$ 788,856.73
Total Cost	**$ 6,047,901.61**

Table 24: Annual Operations and Maintenance Cost

Operations & Maintenance	
Item	**Cost**
Landscaping	$ 30,000.00
Painting	$ 20,000.00
Cleaning	$ 10,000.00
Total Operations and Maintenance Cost	**$ 60,000.00**

The corresponding proposed project schedule and the comprehensive breakdown for each of these expenses can be found in Appendix D and Appendix E respectfully. It is important to note that delays in the construction phase may result in differences of materials and/or service costs.

12.0 Conclusion

BOJNOJ Consultants' detailed design successfully adheres to all project objectives and meet the needs of all stakeholders involved. Through the analysis outlined in the report, **the raised and protected bike lane design** for the Phase 4 Wesbrook Mall Redesign was described and shown through detailed drawings. As discussed, the cycling infrastructure is improved by implementing a raised and protected bike lane throughout the entire site area. Also, the minimal reductions in parking space and tree removals will ensure continued motor vehicle usage, an aesthetic appeal and a preservation of the environment. Finally, an overpass will be constructed south of Thunderbird Arena to assist in pedestrian traffic control.

Accounting for geometry rearrangements, infrastructure upgrades, and overpass construction, the overall projected is estimated to cost approximately **$6,047,901.61**. Construction is scheduled to begin **early May 2022 and be completed over 12-week period**.

BOJNOJ Consultants would like to thank UBC Seeds for the opportunity to conduct a detailed design.

13.0 Appendices

Appendix A: References

"6.4 Road Maintenance Inspections." *Province of British Columbia*, Province of British Columbia, 23 Jan. 2019, https://www2.gov.bc.ca/gov/content/industry/natural-resource-use/resource-roads/engineering-publications-permits/engineering-manual/road-structure-inspection-maintenance/road-maintenance-inspections#inspection_frequency.

A complete guide to building and maintaining a rain garden: TRCA. Toronto and Region Conservation Authority (TRCA). (2021, July 6). Retrieved April 6, 2022, from https://trca.ca/news/complete-guide-building-maintaining-rain-garden/

BC Ministry of Transportation and Infrastructure, British Columbia Active Transportation Design Guide (2019).

City of Vancouver, & Pate, M., Engineering Design Manual (2019). Vancouver, BC; City of Vancouver.

CITY OF VICTORIA STORMWATER UTILITY. (2015). (rep.). *Rainwater Management Standards*. Victoria, BC: CITY OF VICTORIA.

Drew, B., Yim, B., Lo, D., & Liu, I. (2011). (rep.). *An Investigation into Rain Gardens*. Vancouver, BC: UBC SEEDS.

Jin, J. (2016). (rep.). *Green Stormwater Infrastructure on City Streets*. Vancouver, BC.

Lanarc Consultants Ltd., Kerr Wood Leidal Associates Ltd., & Ngan, G. (2012). (rep.). *Stormwater Source Control Design Guidelines 2012*. Vancouver, BC: Greater Vancouver Sewerage & Drainage District.

NACTO. (n.d.). *Raised Cycle Tracks*. Urban Bikeway Design Guide. Retrieved from https://nacto.org/publication/urban-bikeway-design-guide/cycle-tracks/raised-cycle-tracks/.

Oraevskiy, S. (n.d.). *About IDF curves – FlowWorks support center*. FlowWorks. Retrieved November 20, 2021, from https://support.flowworks.com/hc/en-us/articles/115002564603-About-IDF-Curves.

Piteau Associates. (2002). (rep.). *Hydrogeological and Geotechnical Assessment of Northwest Area UBC Campus, Vancouver*. Vancouver, BC: UBC Properties Trust.

Rutgers Water Resource Program. (n.d.). (rep.). *Maintaining Your Rain Garden*. Retrieved April 6, 2022, from https://water.rutgers.edu/Projects/RGRebate/RGMaintenance.pdf.

Sustainable Technologies . (n.d.). (rep.). *Permeable Pavement Fact Sheet*. Retrieved April 6, 2022, from https://sustainabletechnologies.ca/app/uploads/2018/02/Permeable-Pavement-Fact-Sheet.pdf.

Sweeping Porous Pavement. For Construction Pros. (n.d.). Retrieved April 6, 2022, from https://www.forconstructionpros.com/pavement-maintenance/sweepers/article/10293833/research-shows-vacuum-sweepers-are-best-when-sweeping-porous-pavement

TransLink, Bus Infrastructure Design Guidelines (2018).

Government of British Columbia. (2018). Appendix C Climatic and Seismic Information for Building Design in British Columbia. British Columbia.

Appendix B: Sample Calculations

Green Infrastructure Calculations

Overpass Green Area

Sizing for % capture of Average Annual Rainfall.

Using a topsoil depth of 100mm and an Annual Rainfall of 1100mm we found a capture % of 38% consulting the chart in appendix H.

Pervious Paving

Sizing for % capture of Average Annual Rainfall.

Consult Paving Chart using 1100mm of rainfall as that is closest to area, use 2mm/hr (this value is assumed from the geological figure shown in Appendix H) assume 92% actual rainfall capture. I/P = 2. Because we are not considering the grass on one side and the side nearest to street use I/P = 1 instead for tributary Impervious Area Calculation.

$$PerviousArea = \frac{\text{Tributary Impervious Area}}{\text{I/P}}$$

Tributary Impervious Area =2,260 * 1

Tributary Impervious Area =2,260

Assume,

Approximate Rainfall Absorbed = Annual Rainfall * Tributary Impervious Area * Actual rainfall Capture

Approximate Rainfall Absorbed = 1.29m * 2,260 * 0.92

Approximate Rainfall Absorbed = 2,682m^3

Rain Garden

Sizing for depth capture

Finding the depth of the rock reservoir. Assuming a Hydraulic Conductivity of 2mm/hr, an allowable drain time of 4 days, and porosity of rock in the reservoir of 0.35.

$$D_R = \frac{Ks \times T \times 24}{n}$$

D_r = (2mm/hr *4days * 24)/0.35

D_r = 549mm

Finding the imperviable to pervious ratio. Assuming standard depth of pooling of 200mm, soil layer depth of 450mm, and a rainfall capture depth of 41mm which is half of a 2-year storm as indicated in appendix H.

$$I / P = \frac{24 \times Ks + D_P + D_R \times n + 0.2 \times D_S}{R} - 1$$

I/P = (24 * 2mm/hr + 200mm + 550mm * 0.35 + 0.2 * 450mm) / 41mm -1

I/P = 12

12 < 20 (which is given for Major Roads or Collector Roads)

Tributary Impervious Area = Total Pervious Area * I/P

Tributary Impervious Area = 256m^2 * 12

Tributary Impervious Area = 3,072 m^2

Because not all the tributary area is on impervious ground, we estimated graphically that the actual Tributary Impervious Area was 1,536 m^2.

Approximate rainfall absorbed = Impervious Area * Annual Rainfall

Approximate rainfall absorbed = 1,536 m^2 * 1.29m

Approximate rainfall absorbed = 1,981 m^3

Previous Approximate Rainfall Absorbed = Green Space Being Removed * Annual Rainfall

Previous Approximate Rainfall Absorbed = 256 * 1.29

Previous Approximate Rainfall Absorbed = 330 m^3

Total Gain in Absorbed Rainfall = Approximate rainfall absorbed - Previous Approximate Rainfall Absorbed

Total Gain in Absorbed Rainfall = 1,981 – 330

Total Gain in Absorbed Rainfall = 1651 m^3

Overpass Preliminary Structural Analysis Calculations

Slab Calculations

Loading: Self-Weight = 4.7 kPa
SDL = 3.9 kPa
LL = 1.9 kPa
S = 1.9 kPa

Clear Span: 4.5m
$\ell_n = 4.7m$

Slab Thickness = 200mm
$f'_c = 30$ MPa

$M_{f_{bottom}} = 12.4$ kNm/m
$M_{f_{top}} = 24.8$ kNm/m

Bottom Steel (BLL)

$$M_{r_{bot}} = \phi_s f_y A_s \cdot \left(d - \frac{\phi_s f_y A_s}{2\alpha_1 \phi_c f'_c b}\right)$$
$$= 0.85 \cdot 400 \cdot 400 \cdot \left(155 - \frac{0.85 \cdot 400 \cdot 400}{2 \cdot 0.805 \cdot 0.65 \cdot 30 \cdot 1000}\right)$$
$$= 21.1 \text{ kNm/m} > 12.4 \text{ kNm/m} \leftarrow \text{OK}$$

↳ 10M @ 250mm

$$A_g = \frac{400 \text{ mm}^2}{200 \cdot 1000} = 0.002 \geq 0.002 \leftarrow \text{OK}$$

Top Steel (TUL)

$$M_{r_{top}} = 0.85 \cdot 400 \cdot 600 \cdot \left(152.5 - \frac{0.85 \cdot 400 \cdot 600}{2 \cdot 0.805 \cdot 0.65 \cdot 30 \cdot 1000}\right)$$
$$= 34.6 \text{ kNm/m} \geq 24.8 \text{ kNm/m} \leftarrow \text{OK, extends}$$

$$A_g = \frac{600}{200 \cdot 1000} = 0.0033 \geq 0.003 \leftarrow \text{Ok}$$

BLL will take same dimensions as BUL

TLL

$\ell_n / 20 = 235$mm

$A_{s_{TLL}} \geq 0.04 \cdot 200 \cdot 1000$ within 235mm of beams

$A_{s_{TLL}} \geq 188$mm

TLL → 2-10M Bars @ 100mm

Hilroy

Beam Calcutions

Loading: Same as Slab
+ Beam Self-Weight = 6.5 kN/m

Span: 20 m
ℓ_n : 20.2 m

Beam Depth = 750 mm
Beam Thickness = 500 mm

$M_{f\,bot} = 724\ kNm$
$M_{f\,top} = 1450\ kNm$
$V_{max} = 845\ kN$

$f'_c = 30\ MPa$

Bottom Steel

$$M_{r\,bot} = \phi_s f_y A_s \left(d - \frac{\phi_s f_y A_s}{2\alpha_1 \phi_c f'_c b}\right)$$
$$= 0.85 \cdot 400 \cdot (6 \cdot 700) \cdot \left(685 - \frac{0.85 \cdot 400 \cdot 4200}{2 \cdot 0.80 \cdot 0.65 \cdot 30 \cdot 500}\right)$$
$$= 905\ kNm \geq 724\ kNm \leftarrow OK$$

↳ 1 row of 6-30M bars

Top Steel

$$M_{r\,top} = 0.85 \cdot 400 \cdot (3 \cdot 6 \cdot 700) \cdot \left(685 - \frac{0.85 \cdot 400 \cdot 12600}{2 \cdot 0.80 \cdot 0.65 \cdot 30 \cdot 500}\right)$$
$$= 1465\ kNm > 1450\ kNm$$

↳ 3 rows of 6-30M bars

Stirrups (Simplified Method)

$$V_c = \phi_c \beta \sqrt{f'_c} \cdot b_w \cdot d_v$$
$$= 0.65 \cdot 0.18 \cdot \sqrt{30} \cdot 500 \cdot 585$$
$$= 187\ kN << 845\ kN$$

$$V_s = \phi_s \cdot \frac{A_v f_y d_v}{s} \cot\theta$$
$$= 0.85 \cdot \frac{400 \cdot 400 \cdot 585}{175} \cdot \cot 35$$
$$= 960\ kN$$

$V_r = 1147\ kN \geq 845\ kN \rightarrow$ 2-10M stirrups @ 175 mm

Column Calculations

Design for Columns at median (maximum loading)

Loading: Slab = 4.7 kPa
SDL = 3.9 kPa
LL = 1.9 kPa
S = 1.5 kPa

Span 1 = 20 m
Span 2 = 13 m
Tributary Length = 16.5 m
Column Height = 6.4 m
f'_c = 30 MPa

$w_f = 43.5\ kN/m$

Column Self-Weight $= 0.5 \cdot 0.5 \cdot 6.4 \cdot 23.5\ kN/m^3$
$= 38\ kN$

$P_f = 43.5\ kN/m \cdot 16.5m + 1.25 \cdot 38\ kN$
$= 765\ kN$

Column Cross-Section: 500mm x 500mm
$A_s = 8-25M = 4000mm^2 \geq 0.01 \cdot 25000 \rightarrow OK$

$P_{r,o} = \phi_c f'_c \cdot (b \cdot w - A_s) + \phi_s f_y A_s$
$= 0.65 \cdot 30 \cdot (500 \cdot 500 - 4000) + 0.85 \cdot 400 \cdot 4000$
$= 5220\ kN$

$P_{r,max} = 0.8 \cdot 5220 = 4180\ kN >> 765\ kN$

$16 d_b = 16 \cdot 30 = 480\ mm$, least dimension = 500mm
$\rightarrow$ For tied columns, $s \leq 300mm$

$\therefore$ Ties @ 300mm

Hilroy

Footing Calculations

Column Loading: 765 kN

$+$ Self-Weight $= 2.5^2 \cdot 0.75 \cdot 23.5 = 110\text{ kN}$

$\hookrightarrow$ Total $= 875\text{ kN}$

$f'_c = 20\text{ MPa}$

Assuming poor soil, max bearing = 200 kPa

$$\text{Bearing} = \frac{875}{2.5 \times 2.5} = 140\text{ kPa} < 200\text{ kPa} \rightarrow \text{OK}$$

One Way Shear

$$V_f = P_f \cdot (x - d_v)/b =$$
$$= 875 \cdot (1 - 0.59)/2.5 =$$
$$= 144\text{ kN}$$

$$V_r = \phi_c \cdot \beta \cdot \sqrt{f'_c} \cdot b\,d_v$$
$$= 0.65 \cdot 0.21 \cdot \sqrt{20} \cdot 2500 \cdot 590$$
$$= 900\text{ kN} > 144\text{ kN} \rightarrow \text{OK}$$

Two Way Shear

$$V_f = p \cdot (b \cdot w) \cdot [(b \cdot w - (b_c + d_v) \cdot (w_c + d_v)] / b_c \cdot w_c$$
$$= 140 \cdot (0.5^2) \cdot [0.5^2 - (0.5 + 0.59)^2] / 0.5^2$$
$$= 688\text{ kN}$$

$$\frac{0.5}{0.5} = 1$$

$$V_{r_1} = \left(1 + \frac{2}{\beta_c}\right) \cdot 0.19 \cdot \phi_c \cdot \sqrt{f'_c} = 1657\text{ kN}$$
$$V_{r_2} = \left(\frac{\alpha_s \cdot d}{b_o} + 0.19\right) \cdot \phi_c \sqrt{f'_c} = 2200\text{ kN}$$
$$V_{r_3} = 0.38\,\phi_c \sqrt{f'_c} = 1105\text{ kN} > 688\text{ kN} \therefore \text{OK}$$

Timber Connections

Weight / Column

↳ $7.8\ kN/m^3 \cdot 3200 \cdot 1900 \cdot 75 \cdot 1.4 = 5.0\ kN$

$P_{rij} = 1.2 f_v (K_T K_{sc} K_D K_{ls}) \cdot n_c \cdot t \cdot S_R$

f_v, Douglas Fir $= 1.2$ MPa

$K_T = 1.0$

$K_{sc} = 0.91$ → Wet service, member > 114 mm

$K_D = 0.65$ → Long-term loading

$K_{ls} = 0.65$

$n_c = 1$ → 1 column of connectors

$t = 75mm$, bolt length

S_R = spacing b/w rows

$= 1.2 \cdot 1.2 \cdot (1.0 \cdot 0.91 \cdot 0.65^2) \cdot 1 \cdot 75 \cdot 100$

$= 4.2\ kN$

$PR_i = 0.7 \cdot PR_{ij} \cdot n_R$

$= 0.7 \cdot 4.2 \cdot 2$

$= 5.8\ kN > 5.0\ kN$

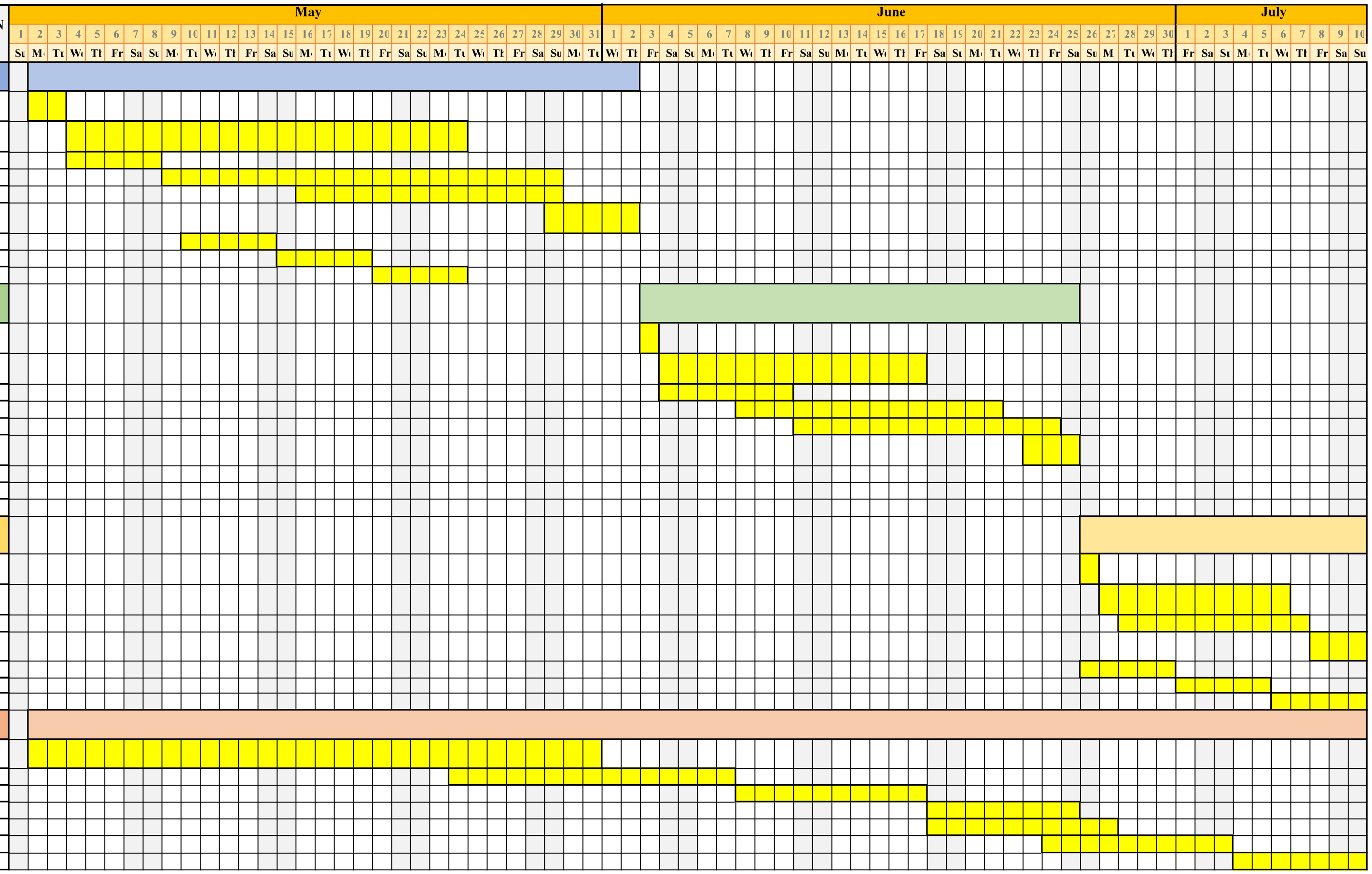
→ Net section failure not checked as member is not in tension

→ Group tear-out not checked as member is not in tension.

Hilroy

Appendix C: Construction Schedule

Task Number	TASK	START	END	DURATION (days)
1	**Phase 1: Northbound Construction**	**2022-05-02**	**2022-06-02**	**32**
1.1	**General Task** - Site Preparation for Northbound Region (Fencing, Signage, Roundabout Preparation	2022-05-02	2022-05-03	2
1.2	**Roadwork Task** - Removal of Top Pavement and Excavation of Roadway	2022-05-04	2022-05-24	21
1.3	**Roadwork Task** - Relocating Stormwater Infrastructure	2022-05-04	2022-05-08	5
1.4	**Roadwork Task** - Pavement of New Asphalt Roads	2022-05-09	2022-05-29	21
1.5	**Roadwork Task** - Paving New Raised Permeable Bike Lane	2022-05-16	2022-05-29	14
1.6	**Roadwork Task** - Miscellaneous Work (Road Painting, Landscaping, Curbs)	2022-05-29	2022-06-02	5
1.7	**Rain Garden Task** - Excavation Work	2022-05-10	2022-05-14	5
1.8	**Rain Garden Task** - Installation of Drainage Infrastructure	2022-05-15	2022-05-19	5
1.9	**Rain Garden Task** - Backfill and Relaying of Organic Mulch	2022-05-20	2022-05-24	5
2	**Phase 2: Southbound Construction (Pedestrian Side)**	**2022-06-03**	**2022-06-25**	**23**
2.1	**General Task** - Site Preparation for Southbound Region (Fencing, Signage, Roundabout Preparation	2022-06-03	2022-06-03	1
2.2	**Roadwork Task** - Removal of Top Pavement and Excavation of Roadway	2022-06-04	2022-06-17	14
2.3	**Roadwork Task** - Relocating Stormwater Infrastructure	2022-06-04	2022-06-10	7
2.4	**Roadwork Task** - Pavement of New Asphalt Roads	2022-06-08	2022-06-21	14
2.5	**Roadwork Task** - Paving New Raised Permeable Bike Lane	2022-06-11	2022-06-24	14
2.6	**Roadwork Task** - Miscellaneous Work (Road Painting, Landscaping, Curbs)	2022-06-23	2022-06-25	3
2.7	**Rain Garden Task** - Excavation Work	2022-06-09	2022-06-13	5
2.8	**Rain Garden Task** - Installation of Drainage Infrastructure	2022-06-14	2022-06-18	5
2.9	**Rain Garden Task** - Backfill and Relaying of Organic Mulch	2022-06-19	2022-06-23	5
3	**Phase 3: Southbound Construction (Median Side)**	**2022-06-26**	**2022-07-10**	**15**
3.1	**General Task** - Site Preparation for Southbound Region (Fencing, Signage, Roundabout Preparation	2022-06-26	2022-06-26	1
3.2	**Roadwork Task** - Removal of Top Pavement and Excavation of Roadway	2022-06-27	2022-07-06	10
3.3	**Roadwork Task** - Pavement of New Asphalt Roads	2022-06-28	2022-07-07	10
3.4	**Roadwork Task** - Miscellaneous Work (Road Painting, Landscaping, Curbs)	2022-07-08	2022-07-10	3
3.5	**Rain Garden Task** - Excavation Work	2022-06-26	2022-06-30	5
3.6	**Rain Garden Task** - Installation of Drainage Infrastructure	2022-07-01	2022-07-05	5
3.7	**Rain Garden Task** - Backfill and Relaying of Organic Mulch	2022-07-06	2022-07-10	5
4	**Pedestrian Overpass Bridge Construction**	**2022-05-02**	**2022-07-10**	**70**
4.1	**Bridge Task** - Ordering and Arrival of Pre-Cast Concrete Members	2022-05-02	2022-05-31	30
4.2	**Bridge Task** - Excavation Work	2022-05-24	2022-06-07	15
4.3	**Bridge Task** - Footings and Side-Platform Placements	2022-06-08	2022-06-17	10
4.4	**Bridge Task** - Slab Placement	2022-06-18	2022-06-25	8
4.5	**Bridge Task** - Staircase and Column Installations	2022-06-18	2022-06-27	10
4.6	**Bridge Task** - Deck Superstructure Installation	2022-06-24	2022-07-03	10
4.7	**Bridge Task** - Green Garden Installation and Bridge Finishing	2022-07-04	2022-07-10	7



Appendix D: Cost Estimate Breakdown

The tables found below provide further details for the proposed cost estimate. The items monetized were separated into consulting services and construction activities. The construction activities' items were then subdivided into categories of roadway, overpass, materials, and general contractor overhead.

Table 25: Consulting Services Costs

Consulting Services	
Item	**Cost**
Project Management	$ 40,000.00
Site Inspection	$ 2,000.00
Geotechnical Analysis	$ 6,000.00
Environmental Overview	$ 3,500.00
Construction Engineering	$ 10,000.00
Total Consulting Services Cost	**$ 61,500.00**

Table 26: Construction Activities Cost

Construction Activities				
Item	**Quantity**	**Unit**	**Rate ($/unit)**	**Cost**
Roadway				
Site Clearance and Mobilization	1	Lump Sum	$50,000.00	$ 50,000.00
Replace Roadway Pavement	12400	Squared Meters	$125.00	$ 1,550,000.00

New Permeable Bike Lane	2258	Squared Meters	$250.00	$ 564,500.00
Curbs	1746	Meters	$200.00	$ 349,200.00
New Green Space	250	Squared Meters	$200.00	$ 50,000.00
Painting of Roadway and Bike Lanes	1	Lump Sum	$40,000.00	$ 40,000.00
Underground Utilities	1	Lump Sum	$400,000.0	$ 400,000.00
Rain Gardens	290	Squared Meters	$750.00	$ 217,500.00
Landscaping and Cleanup	1	Lump Sum	$10,000.00	$ 10,000.00
Total Construction Cost				**$ 3,231,200.00**
Overpass				
Excavation and Backfill	1	Lump Sum	$90,000.00	$ 90,000.00
Foundation	1	Lump Sum	$200,000.0	$ 200,000.00
Concrete Assembly	1	Lump Sum	$300,000.0	$ 300,000.00
Deck	1	Lump Sum	$150,000.0	$ 150,000.00
Finishes	1	Lump Sum	$100,000.0	$ 100,000.00
Electrical & Drainage	1	Lump Sum	$75,000.00	$ 75,000.00
Mobile Crane	1	Each	$40,000.00	$ 40,000.00
Glazing	1	Lump Sum	$55,000.00	$ 55,000.00
Green Infrastructure Installation and Materials	1	Lump Sum	$70,000.00	$ 70,000.00
Total Overpass Cost				**$ 1,080,000.00**
Materials				
30 MPa Concrete	75	Cubed Meters	$215.00	$ 16,125.00
20 MPa Concrete	30	Cubed Meters	$200.00	$ 6,000.00
30M Rebar	1800	Linear Meters	$138.33	$ 248,994.00
25M Rebar	340	Linear Meters	$49.32	$ 16,768.80
15M Rebar	440	Linear Meters	$30.00	$ 13,200.00
10M Rebar	2600	Linear Meters	$12.30	$ 31,980.00

Douglas Fir Posts (0.114m x 0.114m)	52	Linear Meters	$17.30	$ 899.60
3/4" Bolts	325	Each	$0.08	$ 26.00
Wood Art Panels (3.2m x 1.9m)	22	Each	$200.00	$ 4,400.00
Bolt Plates	26	Each	$2.00	$ 52.00
Planters + Soil	18	Each	$5.00	$ 90.00
Veneer	200	Squared Meters	$452.00	$ 90,400.00
Total Materials Cost				**$ 428,935.40**
General Contractor Overhead				
Superintendent	1	Workers Needed	$60/hr	$ 28,800.00
Project Director	1	Workers Needed	$55 * (0.05)/hr	$ 1,320.00
Project Manager	1	Workers Needed	$45 * (0.25)/hr	$ 5,400.00
Project Coordinator	1	Workers Needed	$30 * (0.5)/hr	$ 7,200.00
Safety Officer	1	Workers Needed	$30/hr	$ 14,400.00
Foreman	1	Workers Needed	$35/hr	$ 16,800.00
Traffic Controller	3	Workers Needed	$22/hr	$ 31,680.00
Additional Overhead	1	Lump Sum	$20,000	$ 20,000.00
Total General Contractor Labor Cost				**$ 125,600.00**
OVERALL CONSTRUCTION ACTIVITIES COST				**$ 4,740,135.40**

A contractor fee of 7% was then calculated from the overall construction activities cost and a contractor overhead cost was taken from the general contractor labor cost. Labor factors were taken into consideration when estimating wages. Finally, a 15% contingency was applied to the cost analysis to account for the unpredictability of the project's financial requirements. This method of explaining our cost estimate was used with the intention of clearly explaining which aspects of the project are the most expensive. This cost estimate also is based on accurately estimated quantities of all items of work. The total cost can be found once again below for comparison:

Table 27: Total Cost Summary

Total Cost Summary	
Item	**Cost**
Construction Activities Cost	$ 4,740,135.40
Contractor Fee (7%)	$ 331,809.48
Contractor Overhead	$ 125,600.00
Consulting Services	$ 61,500.00
Contingency (15%)	$ 788,856.73
Total Cost	**$ 6,047,901.61**

Appendix E: Project Management Documentation

Project Charter

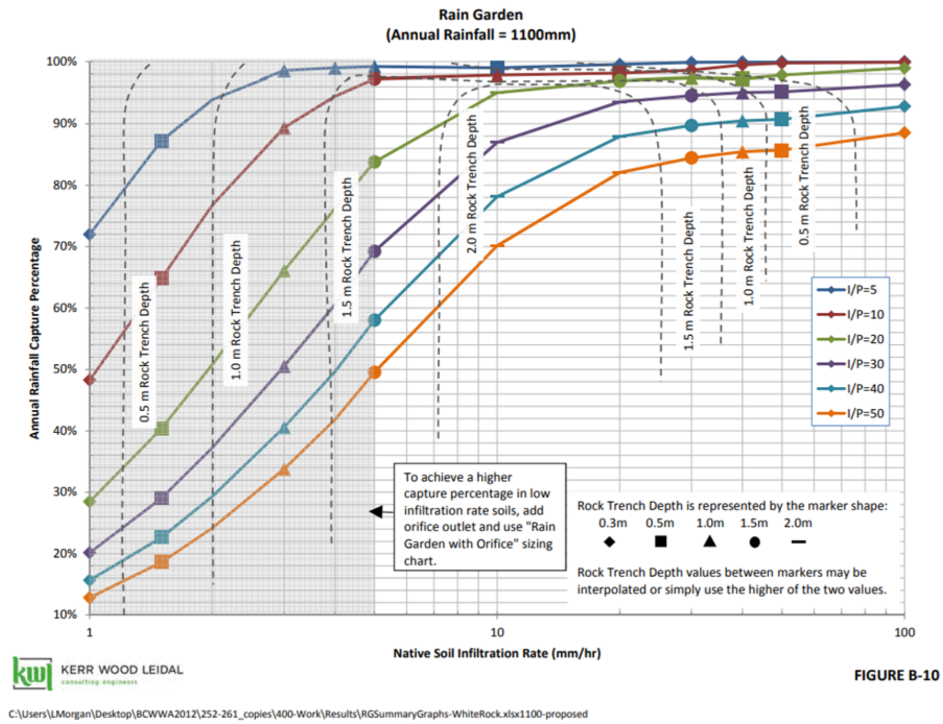
Project Name:		
Wesbrook Mall Roadway – Phase 4 Redesign		
Project Type:		
Public Infrastructure Design / Pedestrian Overpass Bridge Design		
Problem / Opportunity:	**Scope:**	**Constraints:**

- Public Infrastructure Redesign - Overpass Bridge Design	- Location - Project Type	- Traffic Activity - Finances - Geography
Assumptions:	**Goals:**	**Metrics:**
- Similar Future Traffic Activity - Infrastructure Continuity	- Greater Efficiency - Safety - Economical Solution	- Cost - Material - Traffic Modeling Outcomes

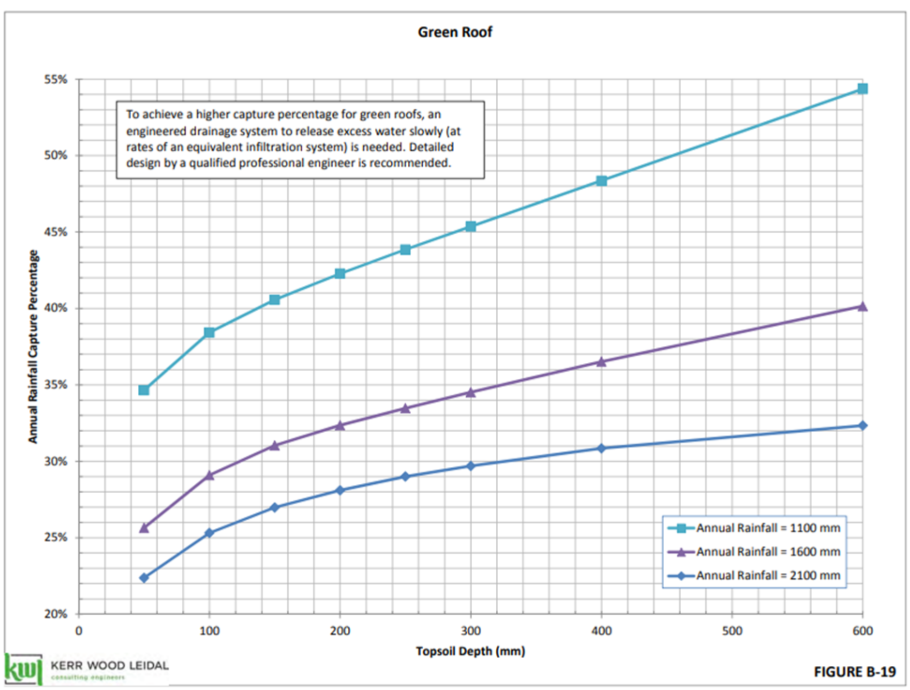
Detailed Design Project Key Tasks:	
1. Technical Considerations of Design	4. Class A Cost Estimate
2. Detail Drawing Issued “For Construction”	5. Finalized Schedule
3. Draft Plan of Construction Work	6. Project Maintenance Specifications

Prepared By:	BOJNOJ Consultants	**Approved By:**	CIVL 445 Teaching Staff

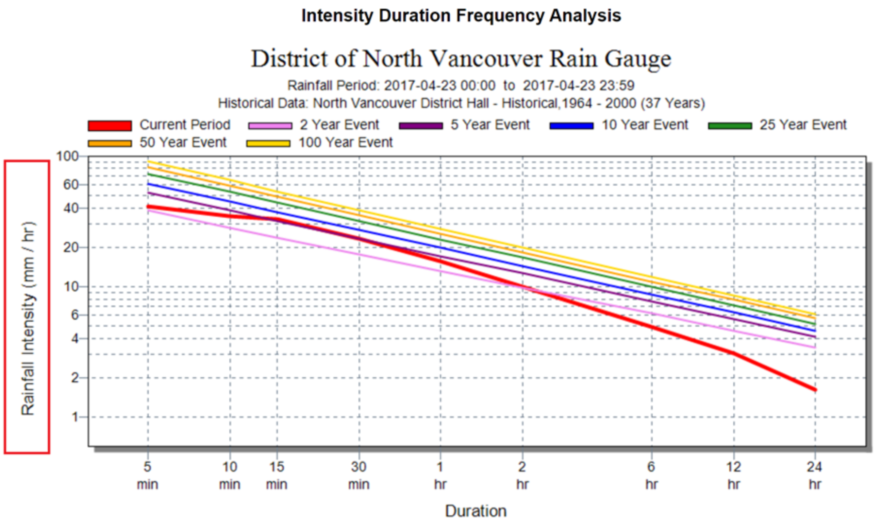
Appendix F: Environmental Aspects



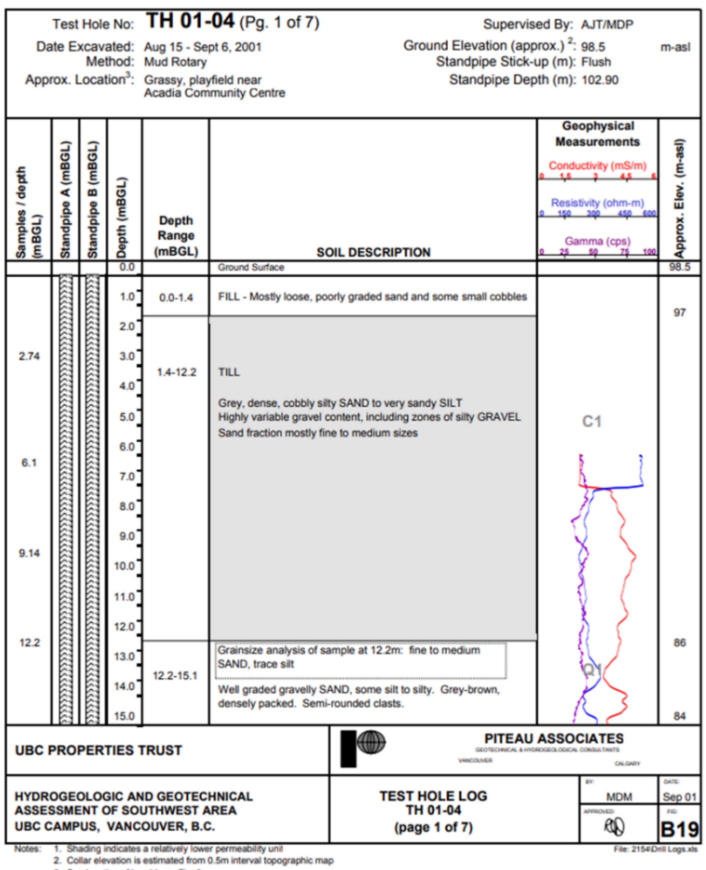
Source: Stormwater Source Control Design Guidelines 2012



Source: Stormwater Source Control Design Guidelines 2012

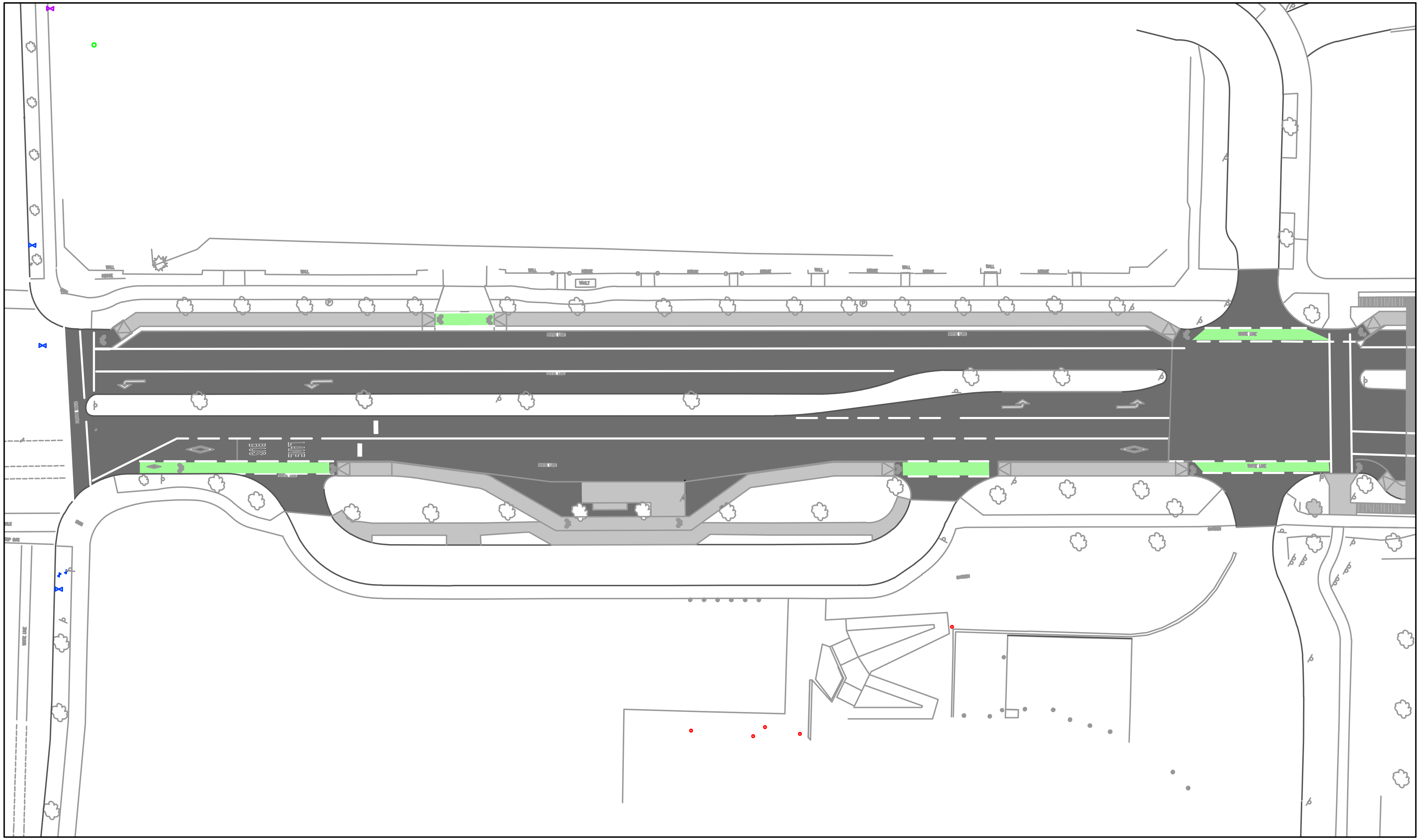


Source: FlowWorks.com



Source: Hydrogeological and Geotechnical Assessment of Northwest Area UBC Campus, Vancouver

Appendix G: Detailed Design Drawings



ISSUED FOR CONSTRUCTION			
NAME OF THE DRAWING:		ROADWAY CROSS-SECTION	
SCALE:	1:800	DRAWING NO:	
DATE:	MAR. 2022	SECTION 1	

DRAWN & DESIGNED BY:

THRAM NO.
N/A

PLOT NO.
N/A

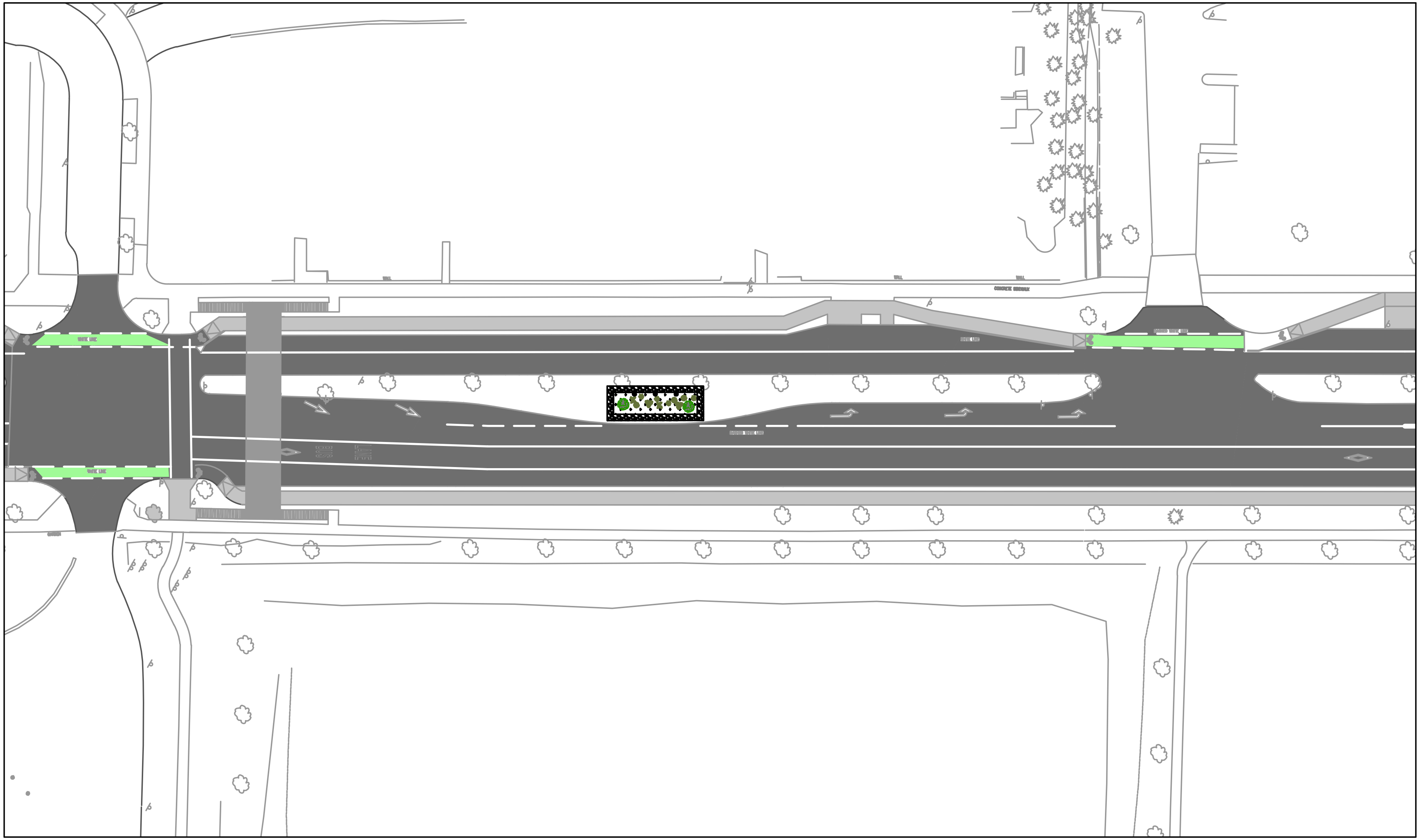
NOTE:

- -ALL DIMENSIONS IN MILLIMETERS.
- -REPORT ANY DISCREPANCIES TO THE DESIGNER
- -REPRESENTATIVE OF ONLY A SECTION OF CORRIDOR

REVISION	DATE:	CONTENT:

CLIENT:

UNIVERSITY OF BRITISH COLUMBIA-UBC SEEDS



ISSUED FOR CONSTRUCTION

NAME OF THE DRAWING:		ROADWAY CROSS-SECTION	
SCALE:	1:800	DRAWING NO:	
DATE:	MAR. 2022	SECTION 2	

DRAWN & DESIGNED BY:

THRAM NO.

N/A

PLOT NO.

N/A

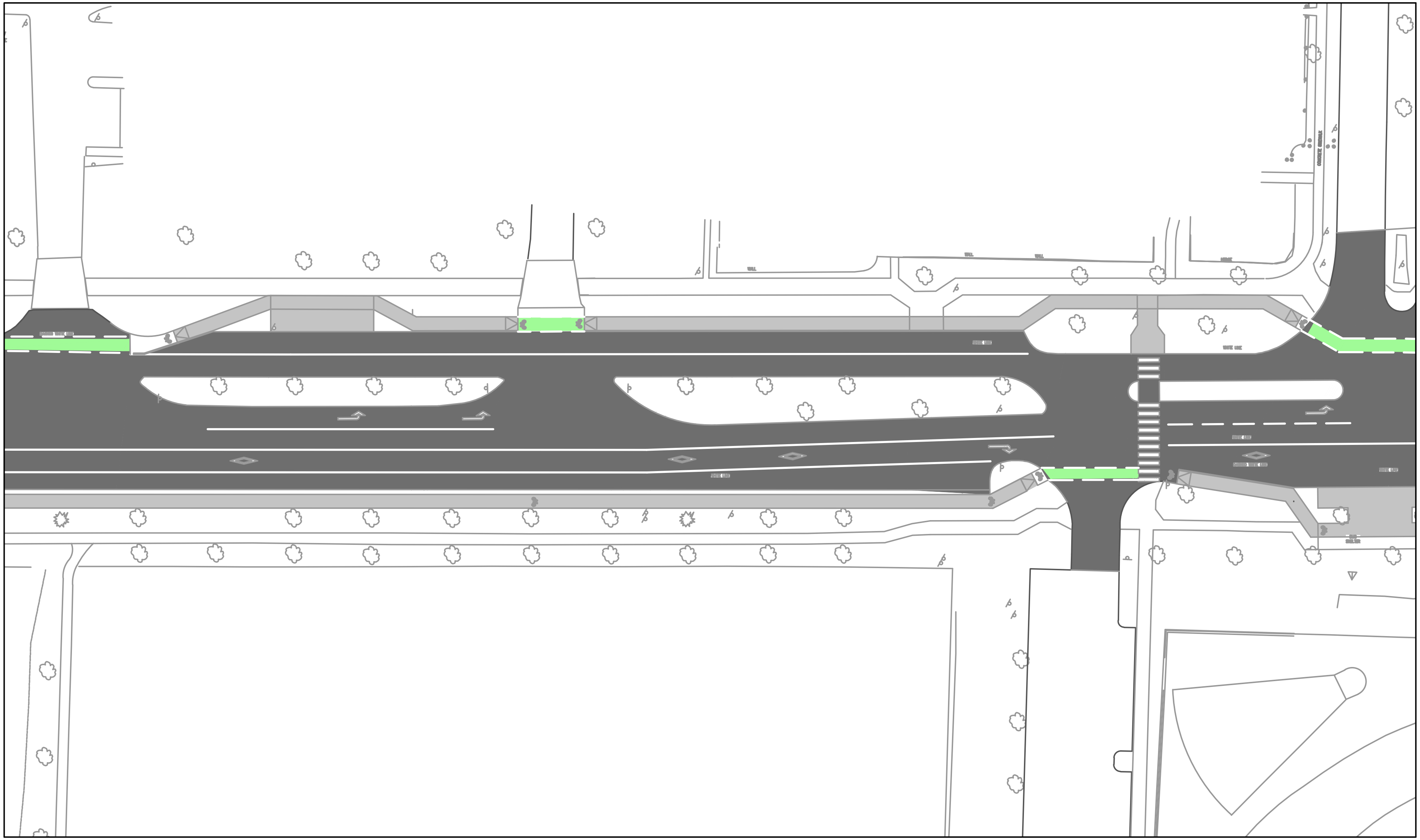
NOTE:

- ALL DIMENSIONS IN MILLIMETERS.
- REPORT ANY DISCREPANCIES TO THE DESIGNER
- REPRESENTATIVE OF ONLY A SECTION OF CORRIDOR

REVISION	DATE:	CONTENT:

CLIENT:

UNIVERSITY OF BRITISH COLUMBIA– UBC SEEDS



ISSUED FOR CONSTRUCTION

NAME OF THE DRAWING:		ROADWAY CROSS-SECTION	
SCALE:	1:800	DRAWING NO:	
DATE:	MAR. 2022	SECTION 3	

DRAWN & DESIGNED BY:

THRAM NO.

N/A

PLOT NO.

N/A

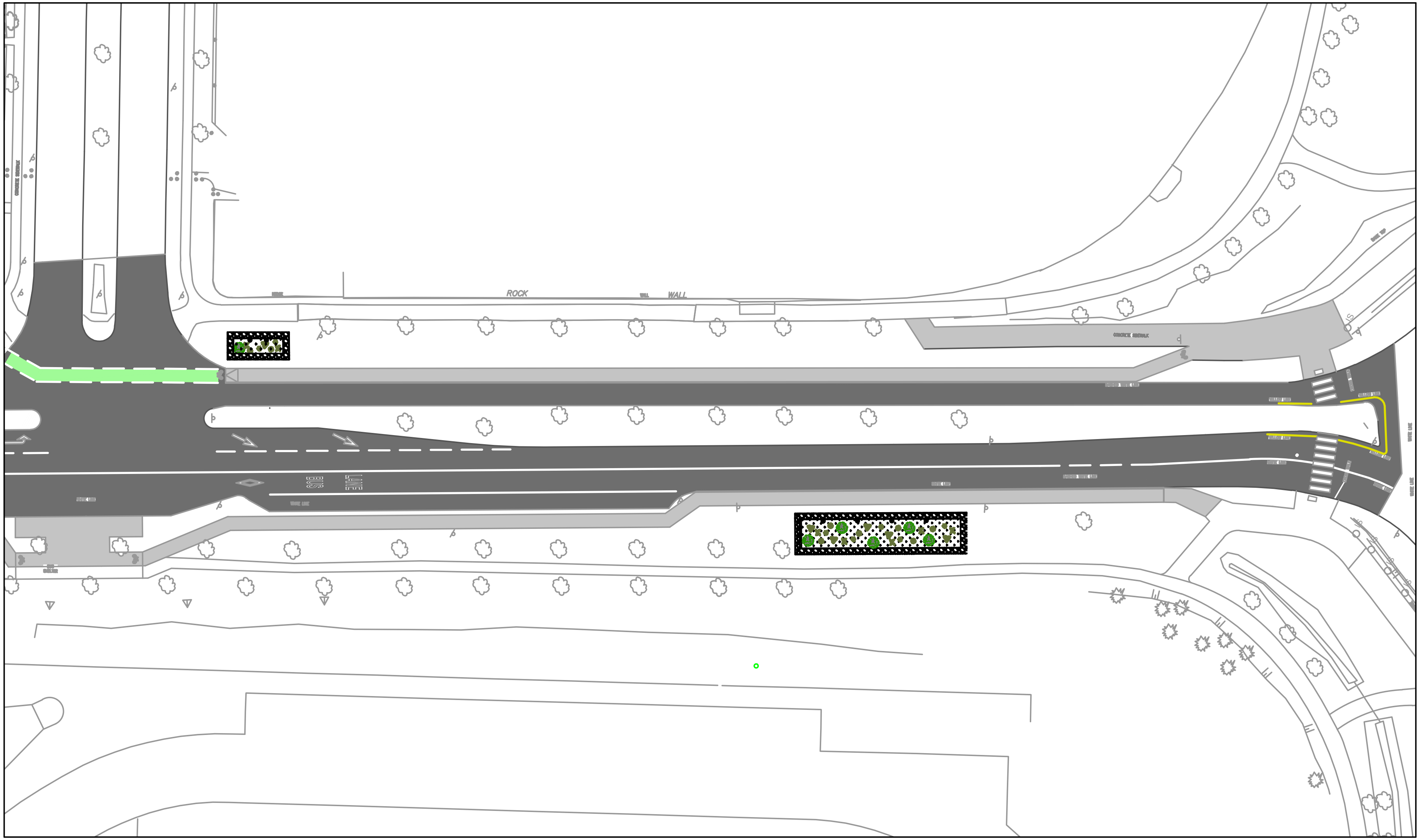
NOTE:

- ALL DIMENSIONS IN MILLIMETERS.
- REPORT ANY DISCREPANCIES TO THE DESIGNER
- REPRESENTATIVE OF ONLY A SECTION OF CORRIDOR

REVISION	DATE:	CONTENT:

CLIENT:

UNIVERSITY OF BRITISH COLUMBIA–UBC SEEDS



ISSUED FOR CONSTRUCTION

NAME OF THE DRAWING:		ROADWAY CROSS-SECTION	
SCALE:	1:800	DRAWING NO:	
DATE:	MAR. 2022	SECTION 4	

DRAWN & DESIGNED BY:

THRAM NO.

N/A

PLOT NO.

N/A

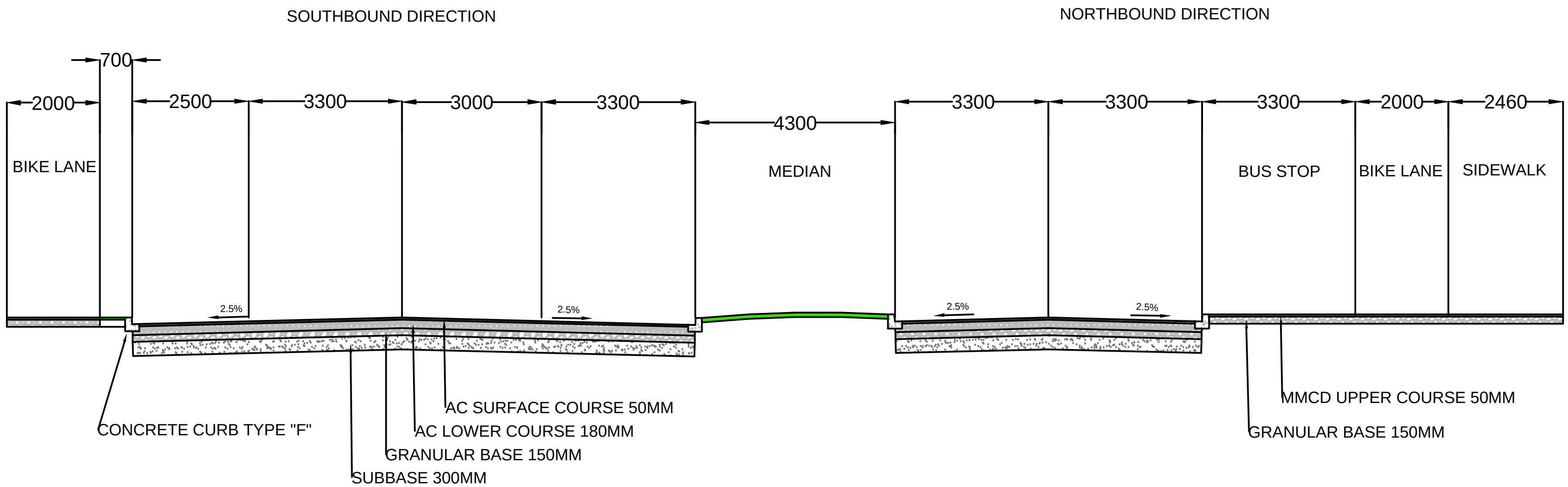
NOTE:

-ALL DIMENSIONS IN MILLIMETERS.
-REPORT ANY DISCREPANCIES TO THE DESIGNER
-REPRESENTATIVE OF ONLY A SECTION OF CORRIDOR

REVISION	DATE:	CONTENT:

CLIENT:

UNIVERSITY OF BRITISH COLUMBIA–UBC SEEDS



NOTES: ROAD AND SIDEWALK WIDTHS VARY THROUGHOUT CORRIDOR.

ISSUED FOR CONSTRUCTION

NAME OF THE DRAWING:	ROADWAY CROSS-SECTION
SCALE: 1:150	DRAWING NO:
DATE: MAR. 2022	R012022

DRAWN & DESIGNED BY:

THRAM NO. N/A

PLOT NO. N/A

NOTE:

- -ALL DIMENSIONS IN MILLIMETERS.
- -REPORT ANY DISCREPANCIES TO THE DESIGNER
- -REPRESENTATIVE OF ONLY A SECTION OF CORRIDOR

REVISION	DATE:	CONTENT:

CLIENT:

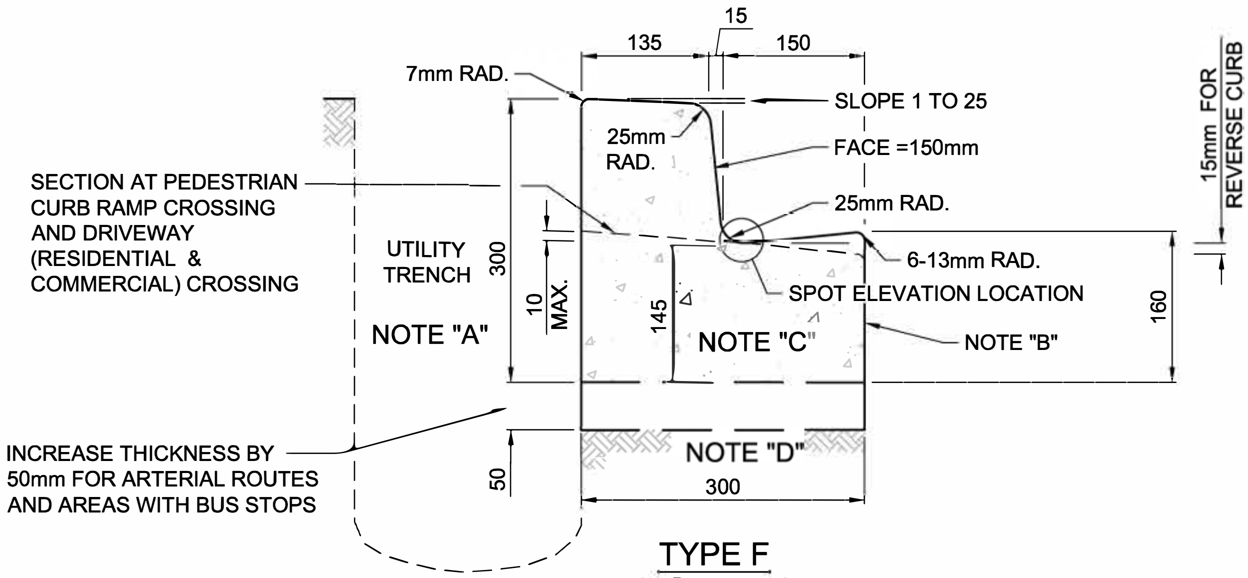
UNIVERSITY OF BRITISH COLUMBIA- UBC SEEDS

CITY OF VANCOUVER

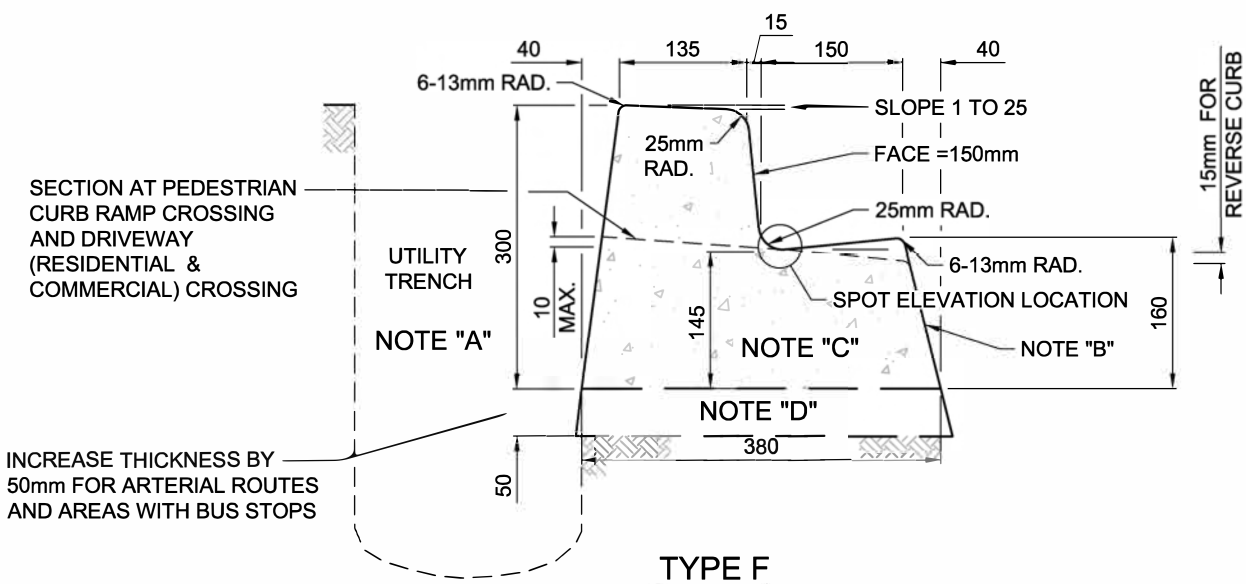
STANDARD DETAIL DRAWINGS

ENGINEERING SERVICES - VANCOUVER, B.C.

DRAWING No. C4.6



TYPE F
(FORMED)



TYPE F
(EXTRUDED)

NOTE "A" FOR DETAILS, SEE DWG C6.1.
NOTE "B" WHERE P.C. CONCRETE PAVEMENT BASE IS USED, CURB CONSTRUCTION SHALL BE AS SHOWN ON DWG C6.2.
NOTE "C" CONTROL JOINTS CUT AT 4.5m INTERVALS (MIN. 50mm DEPTH).
NOTE "D" PLACE A MIMIMUM OF 150mm APPROVED GRANULAR BASE AT 95% MPD (19mm MINUS CRUSHED GRANULAR). EXCAVATE 1.2m WIDE FOR CURB & GUTTER.

USE ONLY CITY APPROVED MIN. 32 MPa CONCRETE MIX.

NOTE:
1. ALL DIMENSIONS IN MILLIMETERS UNLESS STATED OTHERWISE.

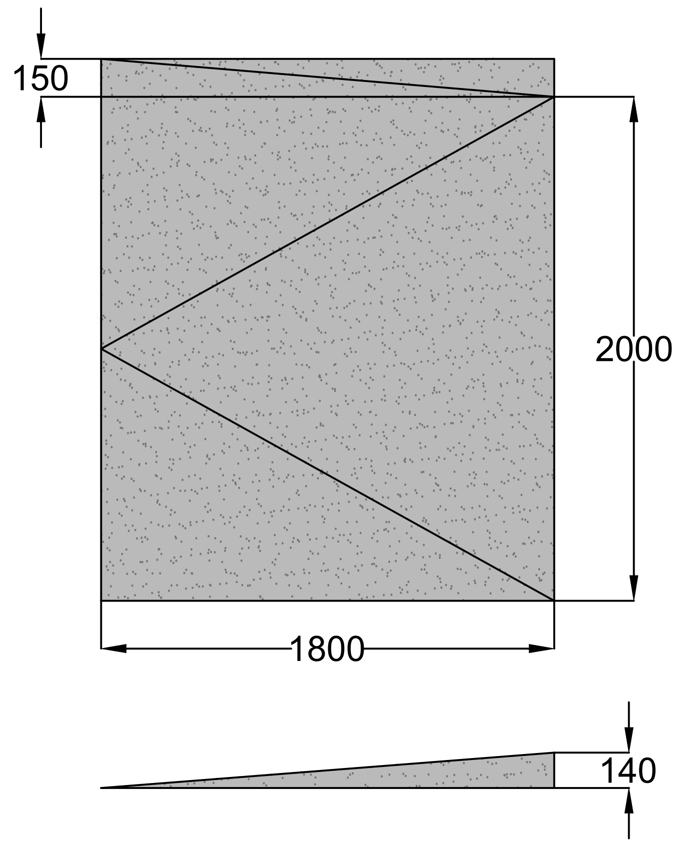
SCALE: N.T.S.

REV.	REVISION DATE	APPROVED

CURBS
CONCRETE CURB TYPE F

ISSUE DATE: SEPTEMBER 2018

APPROVED BY: J. LEE



ISSUED FOR CONSTRUCTION

NAME OF THE DRAWING:	BIKE LANE RAMP
SCALE: 1:30	DRAWING NO:
DATE: MAR. 2022	R12022

DRAWN & DESIGNED BY:

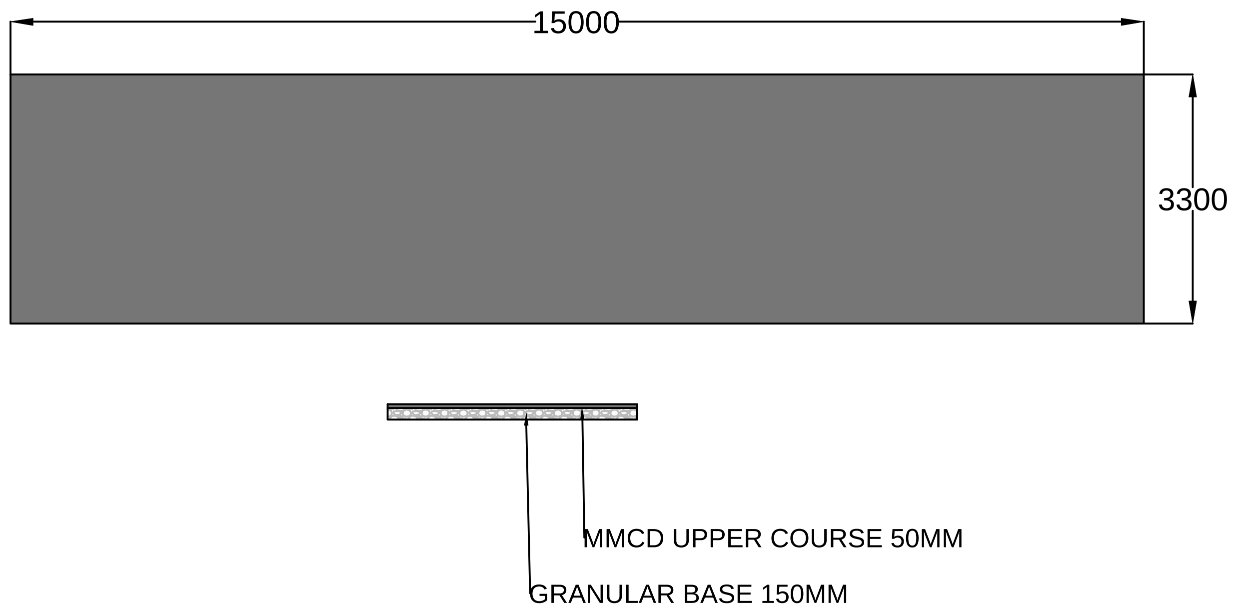
THRAM NO.
N/A

PLOT NO.
N/A

NOTE:
-ALL DIMENSIONS IN MILLIMETERS.
-REPORT ANY DISCREPANCIES TO THE DESIGNER

REVISION	DATE:	CONTENT:

CLIENT:
UNIVERSITY OF BRITISH COLUMBIA-UBC SEEDS



ISSUED FOR CONSTRUCTION

NAME OF THE DRAWING:	BUS BAY
SCALE: 1:100	DRAWING NO:
DATE: MAR. 2022	BB12022

DRAWN & DESIGNED BY:

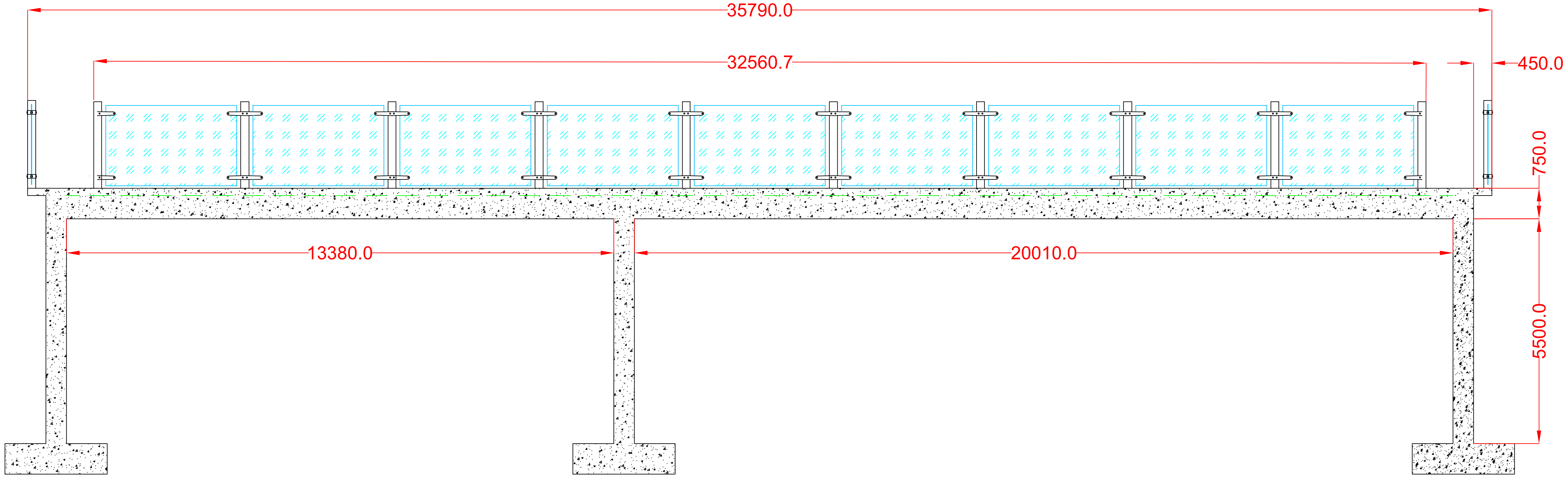
THRAM NO.: N/A

PLOT NO.: N/A

NOTE:
- ALL DIMENSIONS IN MILLIMETERS.
- REPORT ANY DISCREPANCIES TO THE DESIGNER

REVISION	DATE:	CONTENT:

CLIENT:
UNIVERSITY OF BRITISH COLUMBIA– UBC SEEDS



NOTES:
1. FOOTING CONCRETE STRENGTH F'C = 30MPA, ALL OTHER CONCRETE STRENGTH F'C = 30MPA, STEEL STRENGTH FY = 400MPA
2. DETAILING FOR SPECIFIC ELEMENTS CAN BE FOUND IN DETAILING DRAWINGS

ISSUED FOR CONSTRUCTION

NAME OF THE DRAWING:		FULL OVERPASS SIDE VIEW (FACING NB)
SCALE:	80:1	DRAWING NO:
DATE:	DEC. 2021	OPSV1

DRAWN & DESIGNED BY:

N/A

PLOT NO.

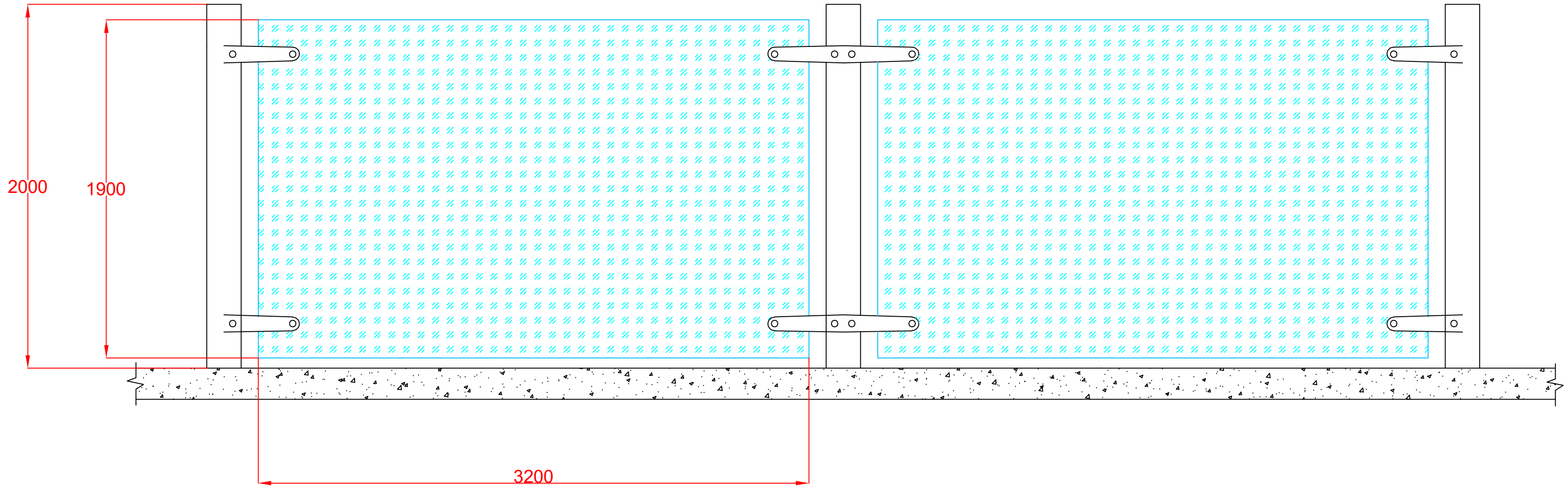
N/A

THRAM NO.

NOTE:

-ALL DIMENSIONS IN MILLIMETERS.
-REPORT ANY DISCREPANCIES TO THE DESIGNER
-SIDE FOOTINGS NOT DISPLAYED

REVISION	DATE:	CONTENT:	CLIENT:
			UNIVERSITY OF BRITISH COLUMBIA-UBC SEEDS



ISSUED FOR CONSTRUCTION

NAME OF THE DRAWING:	OVERPASS SECTION SIDE VIEW
SCALE: 1:40	DRAWING NO:
DATE: DEC. 2021	OPPSV1

DRAWN & DESIGNED BY:

THRAM NO. N/A

PLOT NO. N/A

NOTE:

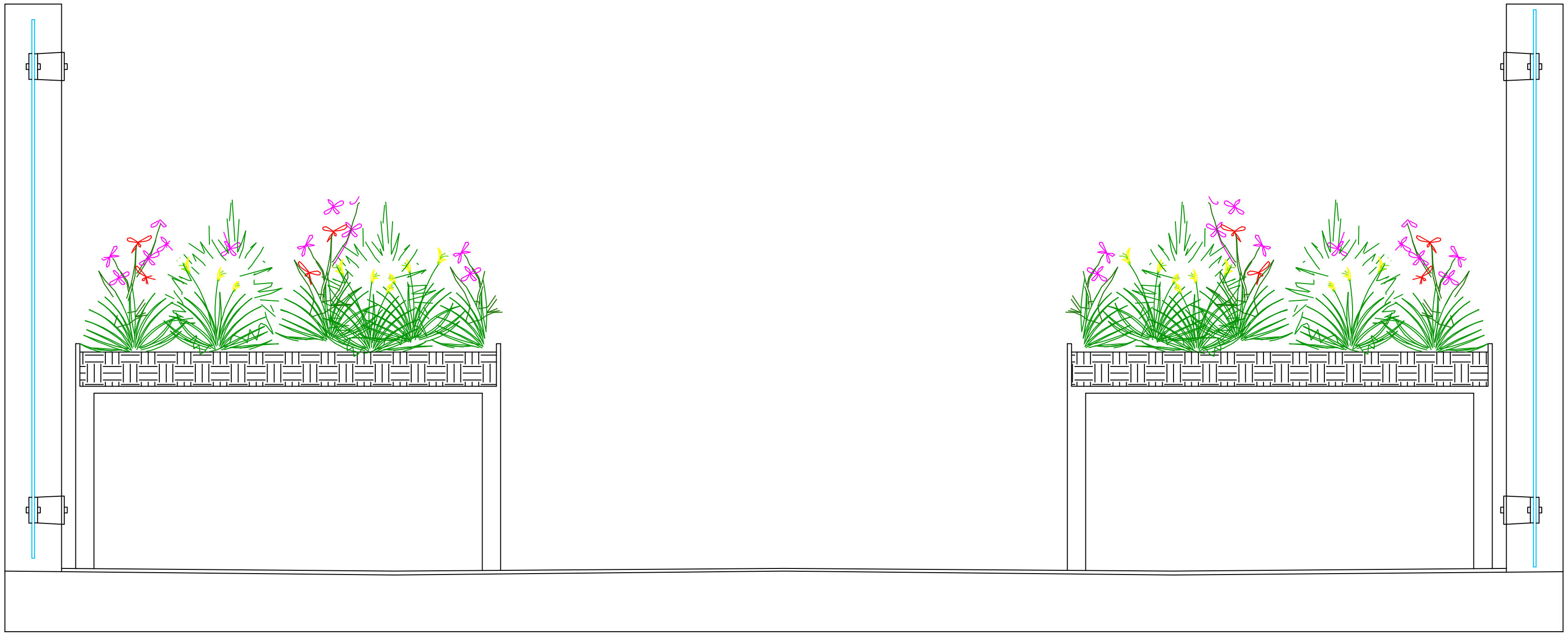
-ALL DIMENSIONS IN MILLIMETERS.
-DO NOT MEASURE FROM THIS DRAWING
-REPORT ANY DISCREPANCIES TO THE DESIGNER

REVISION	DATE:	CONTENT:

CLIENT:

UNIVERSITY OF BRITISH COLUMBIA– UBC SEEDS

NOTES:
1. 10MM WATERPROOF VENEER LAYER APPLIED TOP SLAB
2. CULVERTS UNDER EACH PLANTER, DIRECT RUNOFF TO DRAINAGE OUTLETS AT LANDINGS. SEE DRAINAGE DETAIL DRAWINGS FOR FURTHER DETAILS
3. PLANTERS SPACED @ POSTS TO ALLOW FOR MAINTENANCE
4. SEE TIMBER POSTS DRAWING FOR BOLTING CONNECTION DETAILS



ISSUED FOR CONSTRUCTION		
NAME OF THE DRAWING:		TYPICAL OVERPASS CROSS-SECTION
SCALE:	1:25	DRAWING NO:
DATE:	APR. 2022	OCS12022

DRAWN & DESIGNED BY:

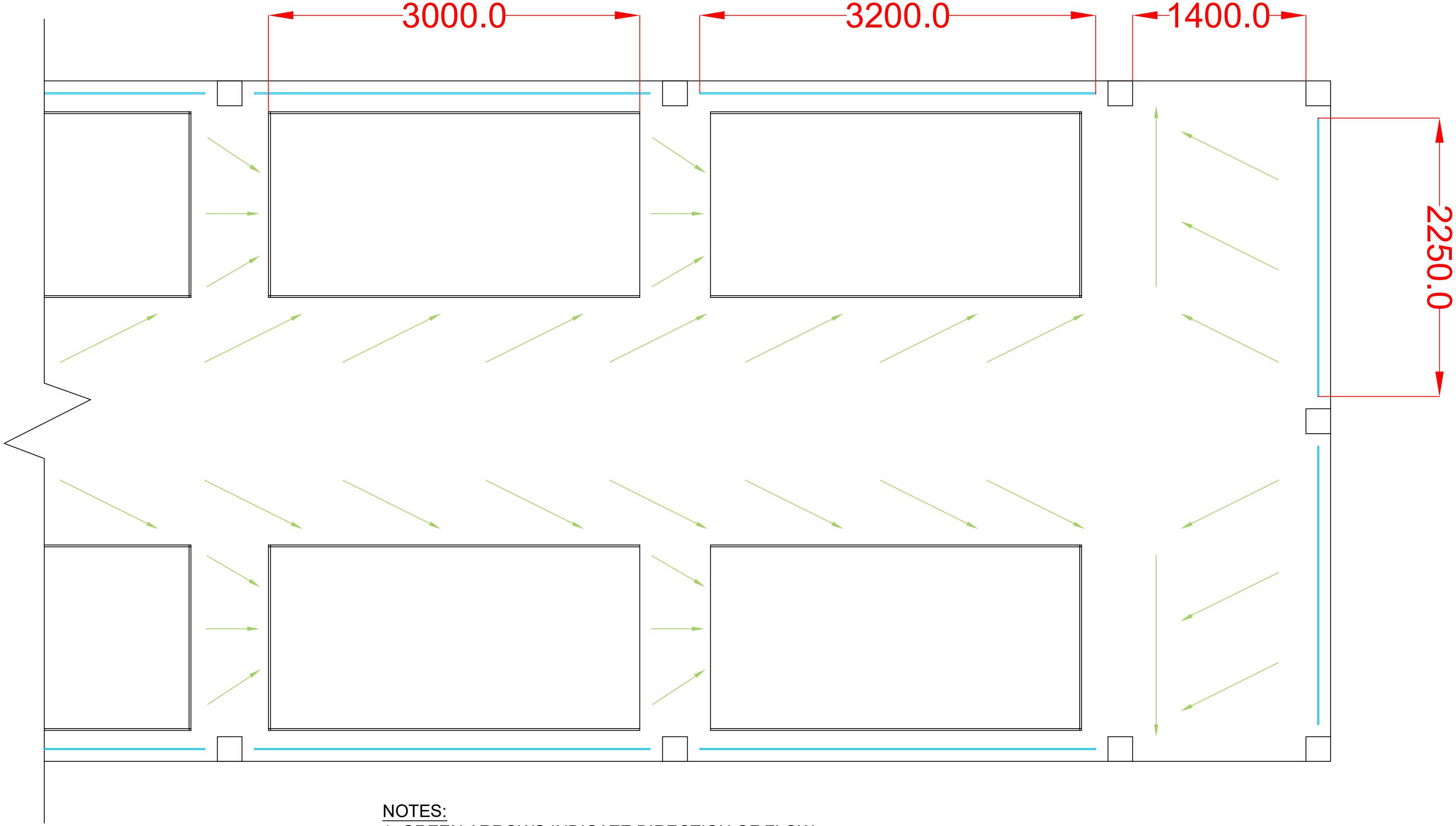
THRAM NO.: N/A

PLOT NO.: N/A

NOTE:
-ALL DIMENSIONS IN MILLIMETERS.
-REPORT ANY DISCREPANCIES TO THE DESIGNER

REVISION	DATE:	CONTENT:

CLIENT:
UNIVERSITY OF BRITISH COLUMBIA-UBC SEEDS



NOTES:
1. GREEN ARROWS INDICATE DIRECTION OF FLOW
2. CULVERTS ALLOW FLOW UNDER THE PLANTERS
3. IDENTICAL PATHWAYS EXIST AT EASTERN LANDING
4. SEE EXIT DRAINAGE IN STAIRS DRAWING

ISSUED FOR CONSTRUCTION

NAME OF THE DRAWING:	DRAINAGE PATHWAYS AT WESTERN LANDING
SCALE: 1:50	DRAWING NO:
DATE: MAR. 2022	DP12022

DRAWN & DESIGNED BY:

THRAM NO.

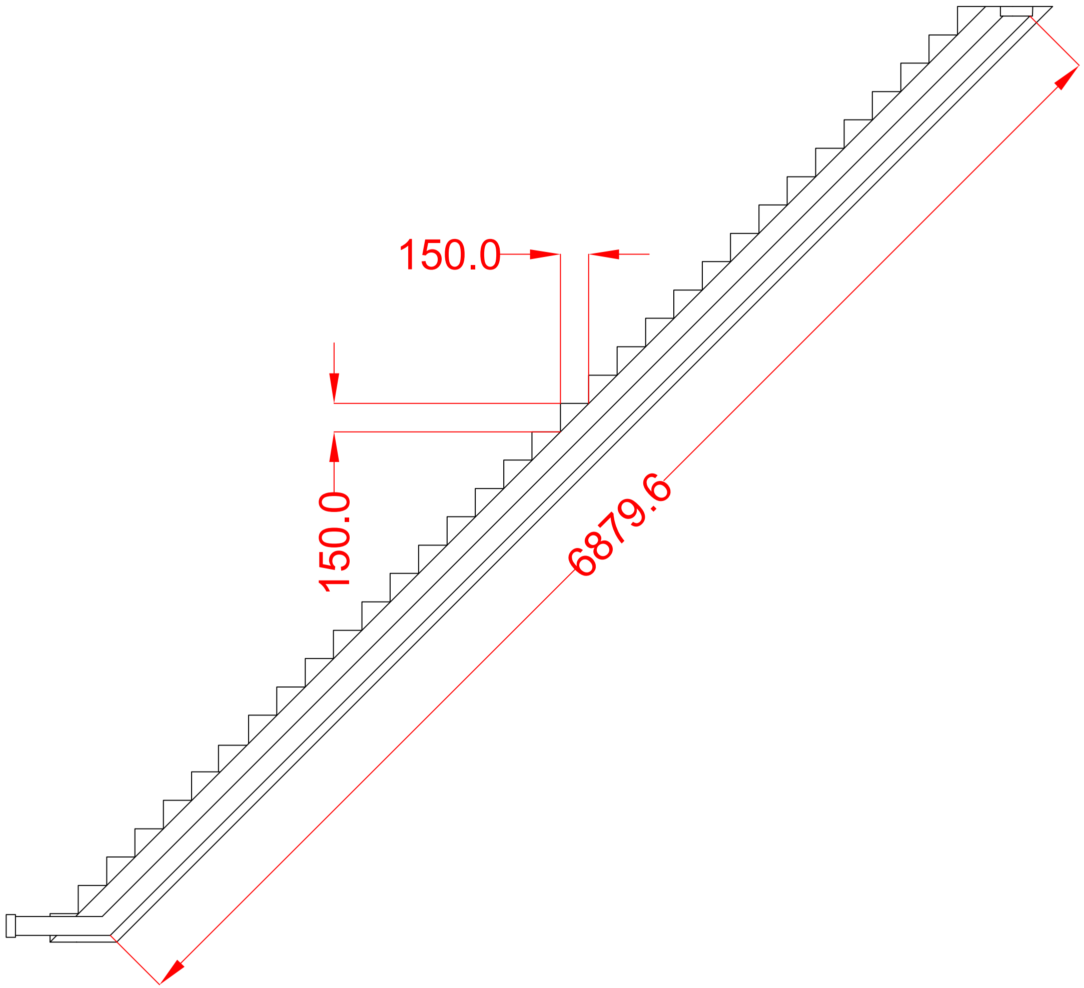
N/A

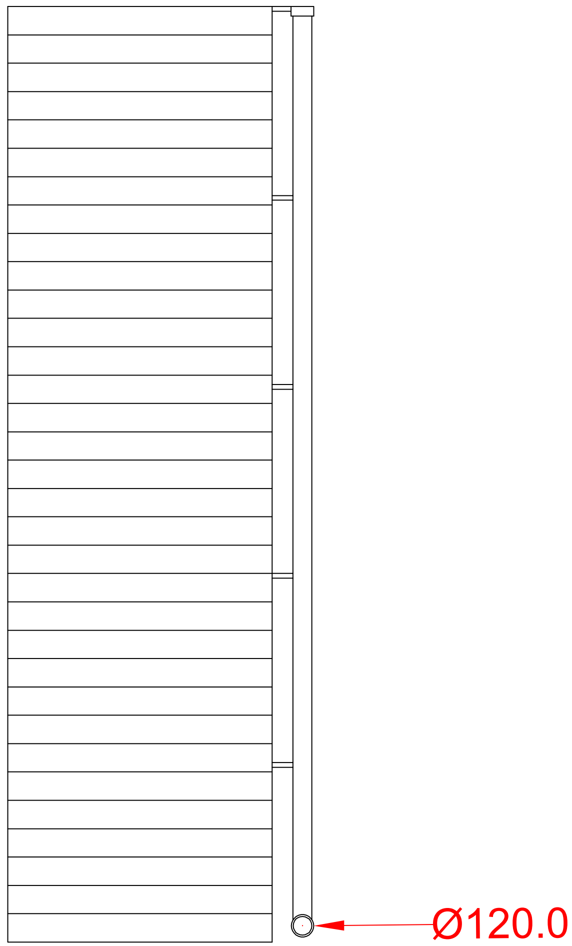
N/A

NOTE:
-ALL DIMENSIONS IN MILLIMETERS.
-REPORT ANY DISCREPANCIES TO THE DESIGNER
-DO NOT ATTEMPT TO MEASURE FROM THIS DRAWING, INTENDED ONLY TO DEMONSTRATE DRAINAGE MECHANISM

REVISION	DATE:	CONTENT:

CLIENT:
UNIVERSITY OF BRITISH COLUMBIA–UBC SEEDS





NOTES:
1. INNER DRAINAGE PIPE DIAMETER: 100MM
2. OUTER DRAINAGE PIPE DIAMETER: 100MM
3. STAIR DESIGN IS UNIFORM FOR ALL 4 APPROACHES

ISSUED FOR CONSTRUCTION

NAME OF THE DRAWING:	DRAINAGE AND STAIRS
SCALE: 1:40	DRAWING NO:
DATE: MAR. 2022	B12022

DRAWN & DESIGNED BY:

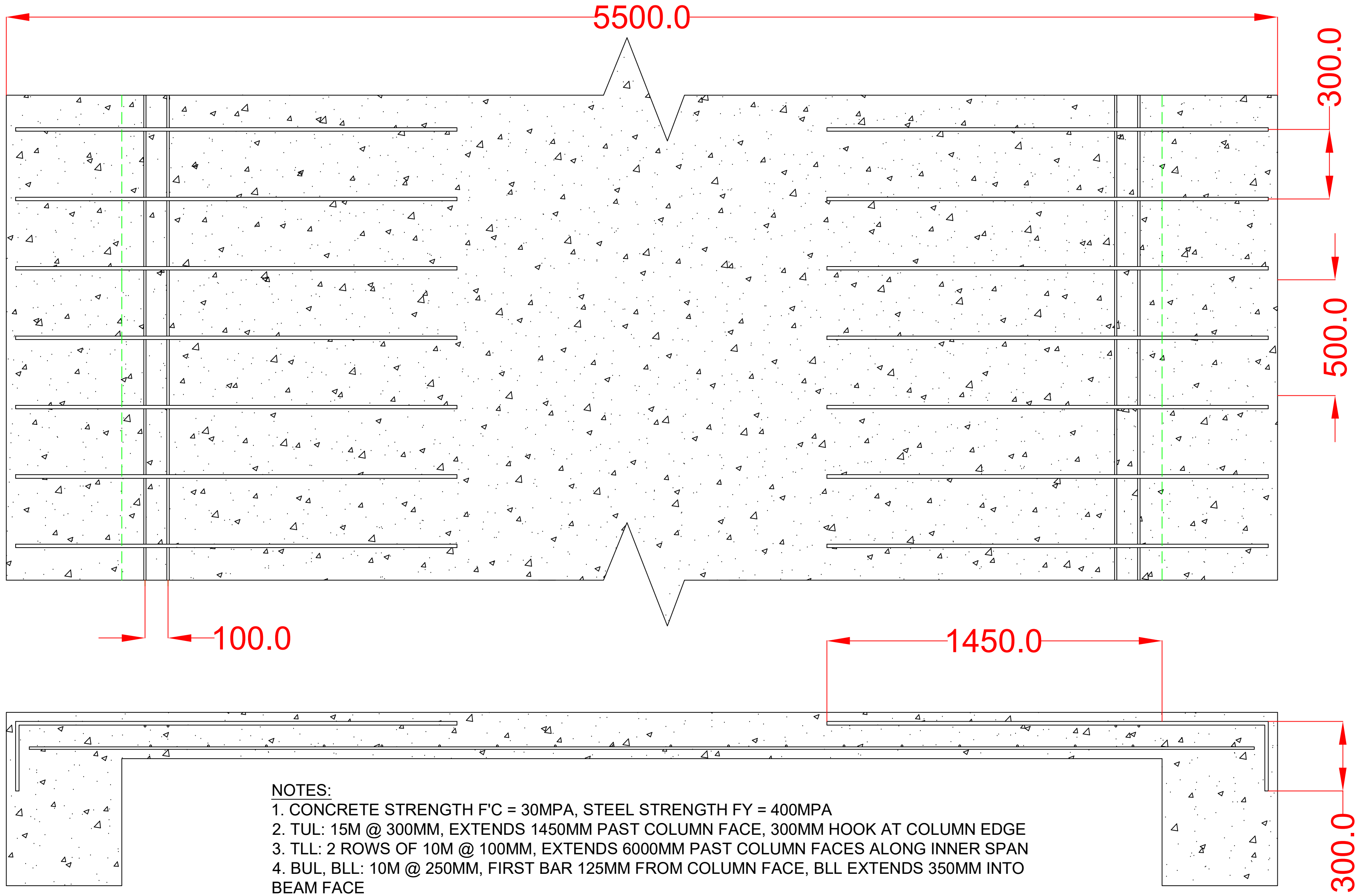
THRAM NO. N/A

PLOT NO. N/A

NOTE:
-ALL DIMENSIONS IN MILLIMETERS.
-REPORT ANY DISCREPANCIES TO THE DESIGNER

REVISION	DATE:	CONTENT:

CLIENT:
UNIVERSITY OF BRITISH COLUMBIA–UBC SEEDS



NOTES:
1. CONCRETE STRENGTH F'C = 30MPA, STEEL STRENGTH FY = 400MPA
2. TUL: 15M @ 300MM, EXTENDS 1450MM PAST COLUMN FACE, 300MM HOOK AT COLUMN EDGE
3. TLL: 2 ROWS OF 10M @ 100MM, EXTENDS 6000MM PAST COLUMN FACES ALONG INNER SPAN
4. BUL, BLL: 10M @ 250MM, FIRST BAR 125MM FROM COLUMN FACE, BLL EXTENDS 350MM INTO BEAM FACE
5. 40MM COVER ON ALL FACES
6. DETAILING IS UNIFORM THROUGHOUT SLAB. NOTE THAT TOP DRAWING ONLY DETAILS TUL AND TLL.

ISSUED FOR CONSTRUCTION

NAME OF THE DRAWING:	SLAB DETAILING 1
SCALE: 1:25	DRAWING NO:
DATE: MAR. 2022	SD12022

DRAWN & DESIGNED BY:

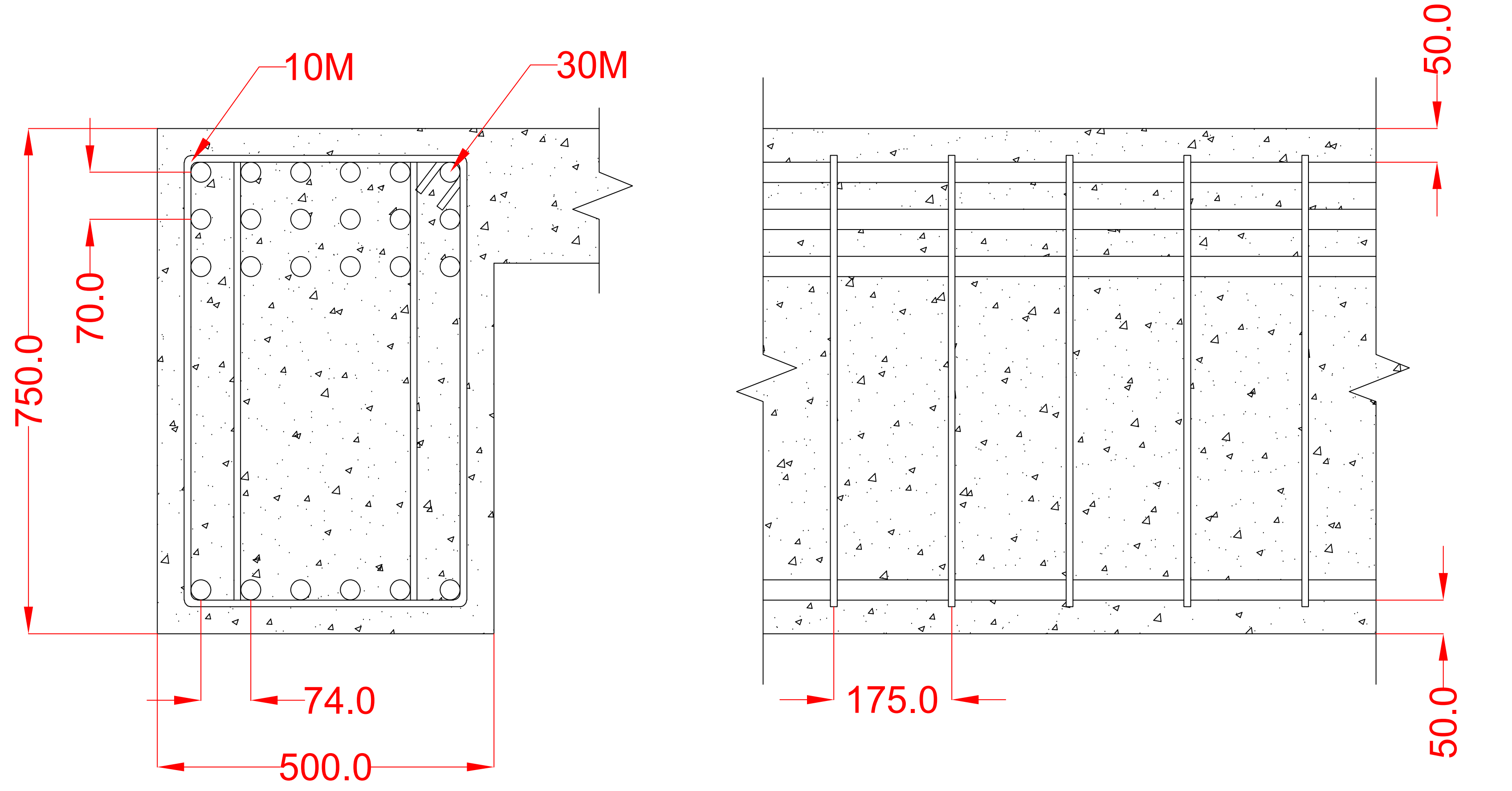
THRAM NO. N/A

PLOT NO. N/A

NOTE:
-ALL DIMENSIONS IN MILLIMETERS.
-REPORT ANY DISCREPANCIES TO THE DESIGNER

REVISION	DATE:	CONTENT:

CLIENT:
UNIVERSITY OF BRITISH COLUMBIA–UBC SEEDS



NOTES:
1. CONCRETE STRENGTH F'C = 30MPA, STEEL STRENGTH FY = 400MPA
2. TOP STEEL: 3 ROWS OF 6-30M @70MM
3. BOTTOM STEEL: 1 ROWS OF 6-30M
4. STIRRUPS: 2-10M (4 LEGS) @175MM
5. 40MM COVER ON ALL FACES
6. DETAILING IS UNIFORM THROUGHOUT BEAMS. SEE SLAB AND COLUMN DETAILING DRAWINGS FOR CONNECTION AND STEEL EXTENSION DETAILS

ISSUED FOR CONSTRUCTION

NAME OF THE DRAWING:	BEAM DETAILING
SCALE: 1:10	DRAWING NO:
DATE: MAR. 2022	B12022

DRAWN & DESIGNED BY:

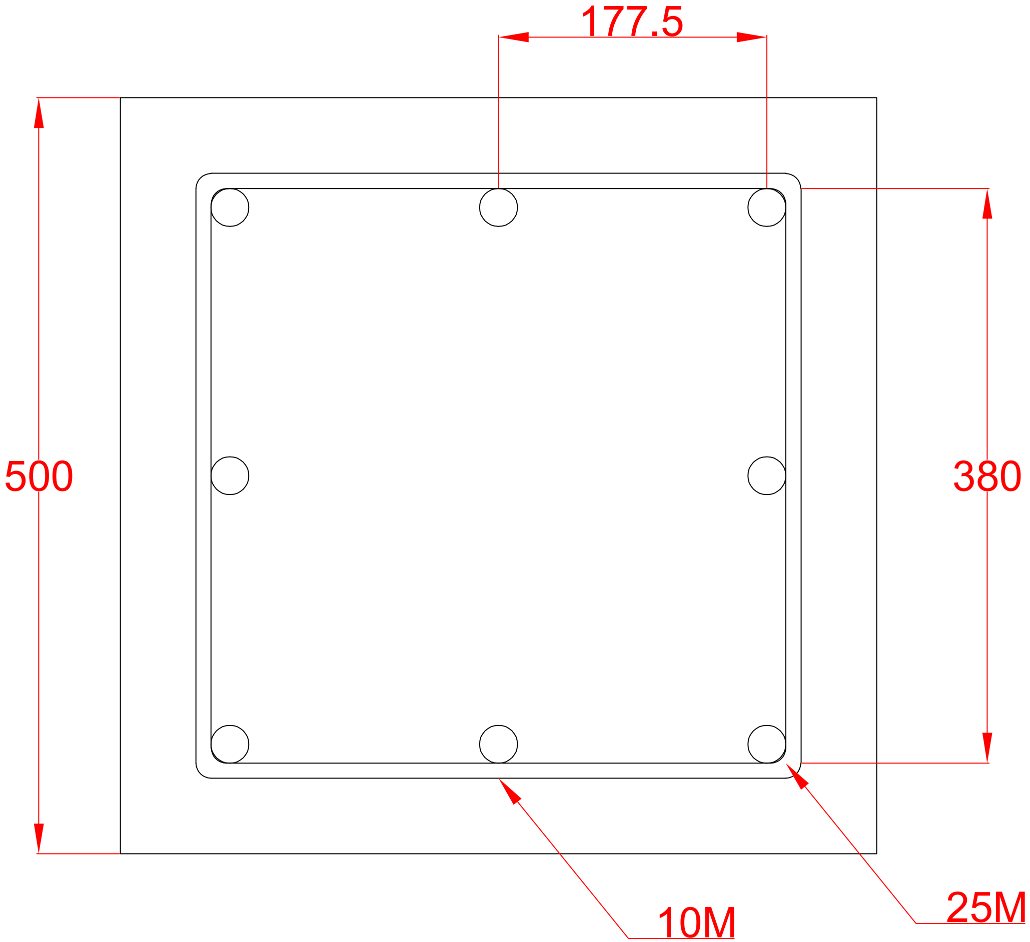
THRAM NO. N/A

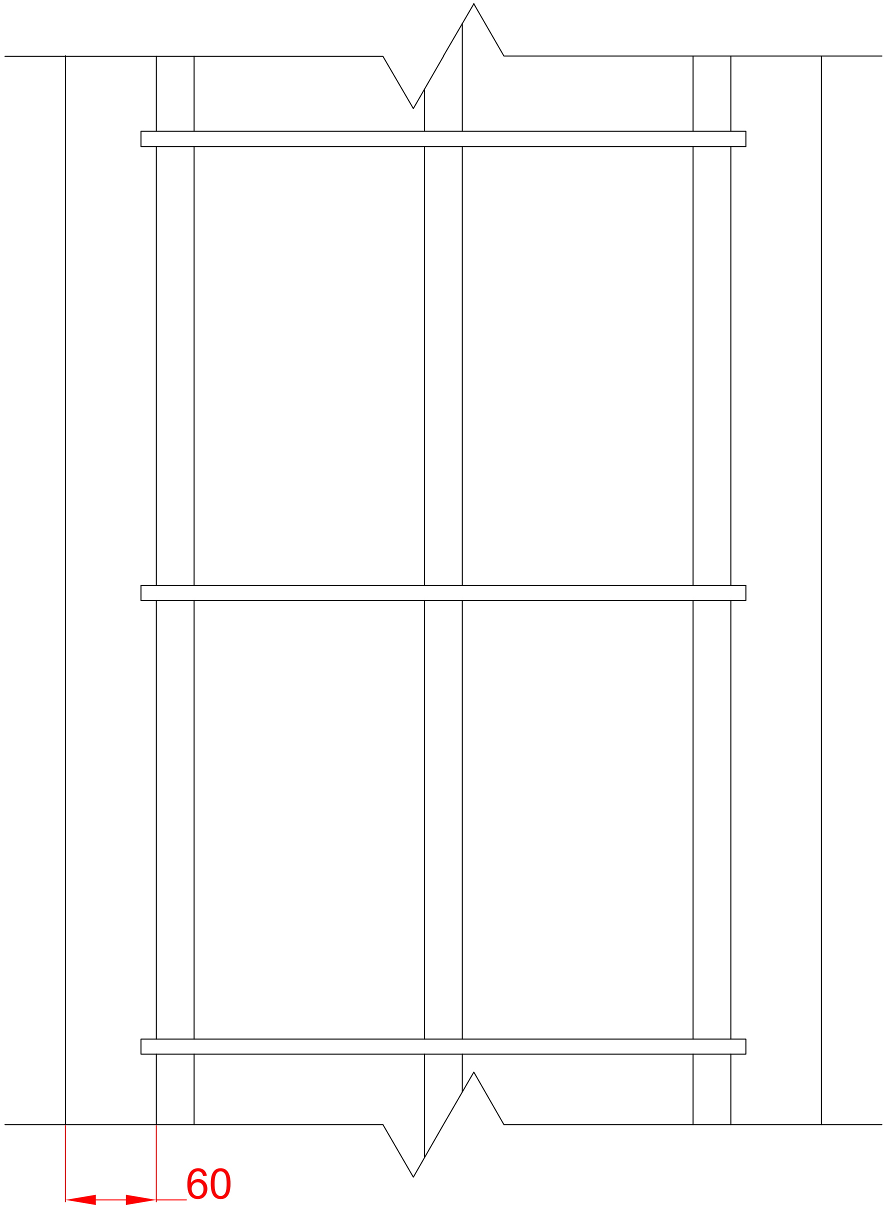
PLOT NO. N/A

NOTE:
-ALL DIMENSIONS IN MILLIMETERS.
-REPORT ANY DISCREPANCIES TO THE DESIGNER

REVISION	DATE:	CONTENT:

CLIENT:
UNIVERSITY OF BRITISH COLUMBIA– UBC SEEDS





NOTES:
1. CONCRETE STRENGTH F'C = 30MPA, STEEL STRENGTH FY = 400MPA
2. VERTICAL BARS: 9-25M SPACED @177.5MM
3. COLUMN TIES: 10M @300MM
4. 50MM COVER ON ALL FACES
5. DETAILING IS UNIFORM FOR ALL COLUMNS. SEE BEAM COLUMN CONNECTIONS DRAWING FOR CONNECTION DETAILING

ISSUED FOR CONSTRUCTION

NAME OF THE DRAWING: BEAM DETAILING

SCALE: 1:5

DRAWING NO: B12022

DATE: MAR. 2022

DRAWN & DESIGNED BY:

THRAM NO. N/A

PLOT NO. N/A

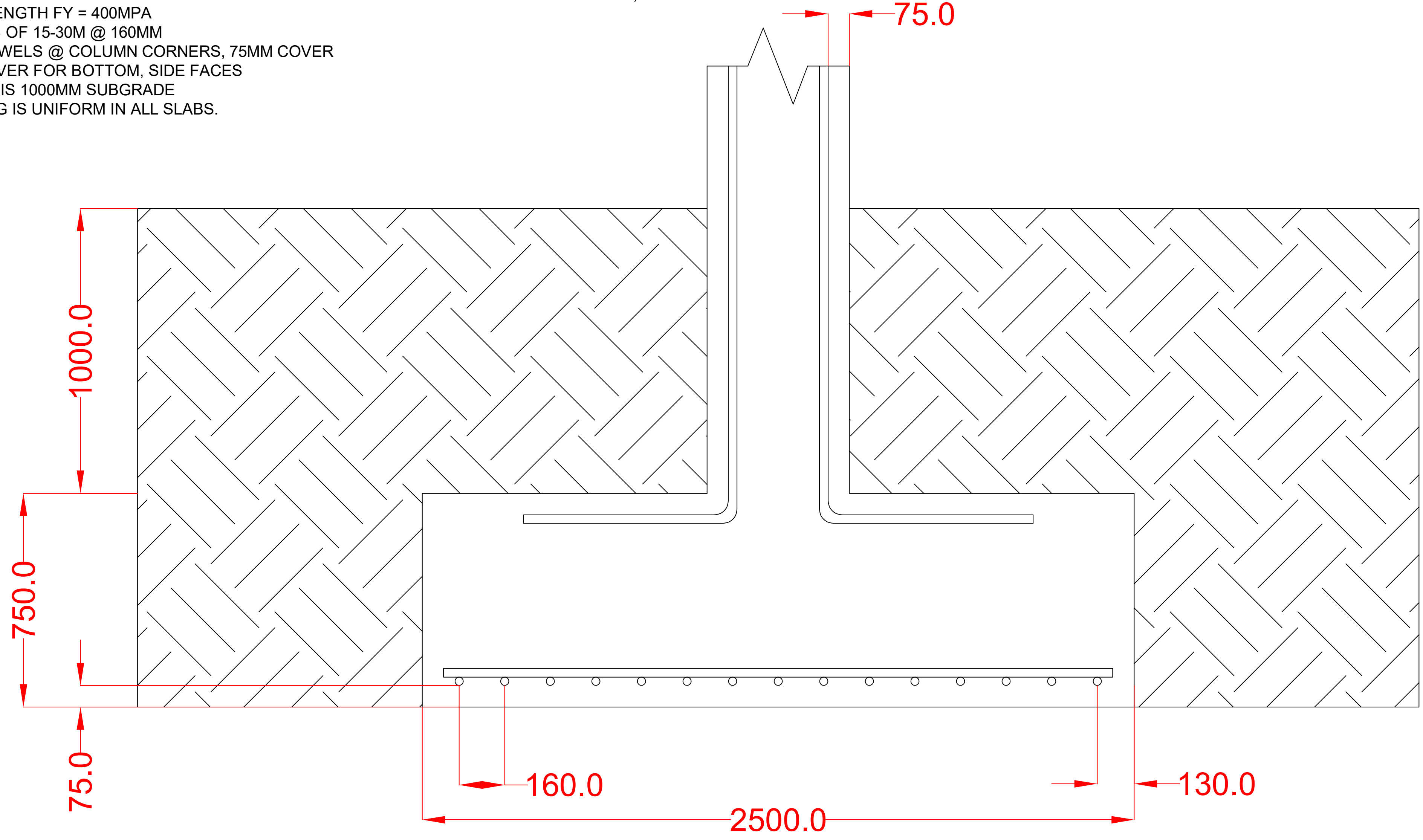
NOTE:
-ALL DIMENSIONS IN MILLIMETERS.
-REPORT ANY DISCREPANCIES TO THE DESIGNER

REVISION	DATE:	CONTENT:

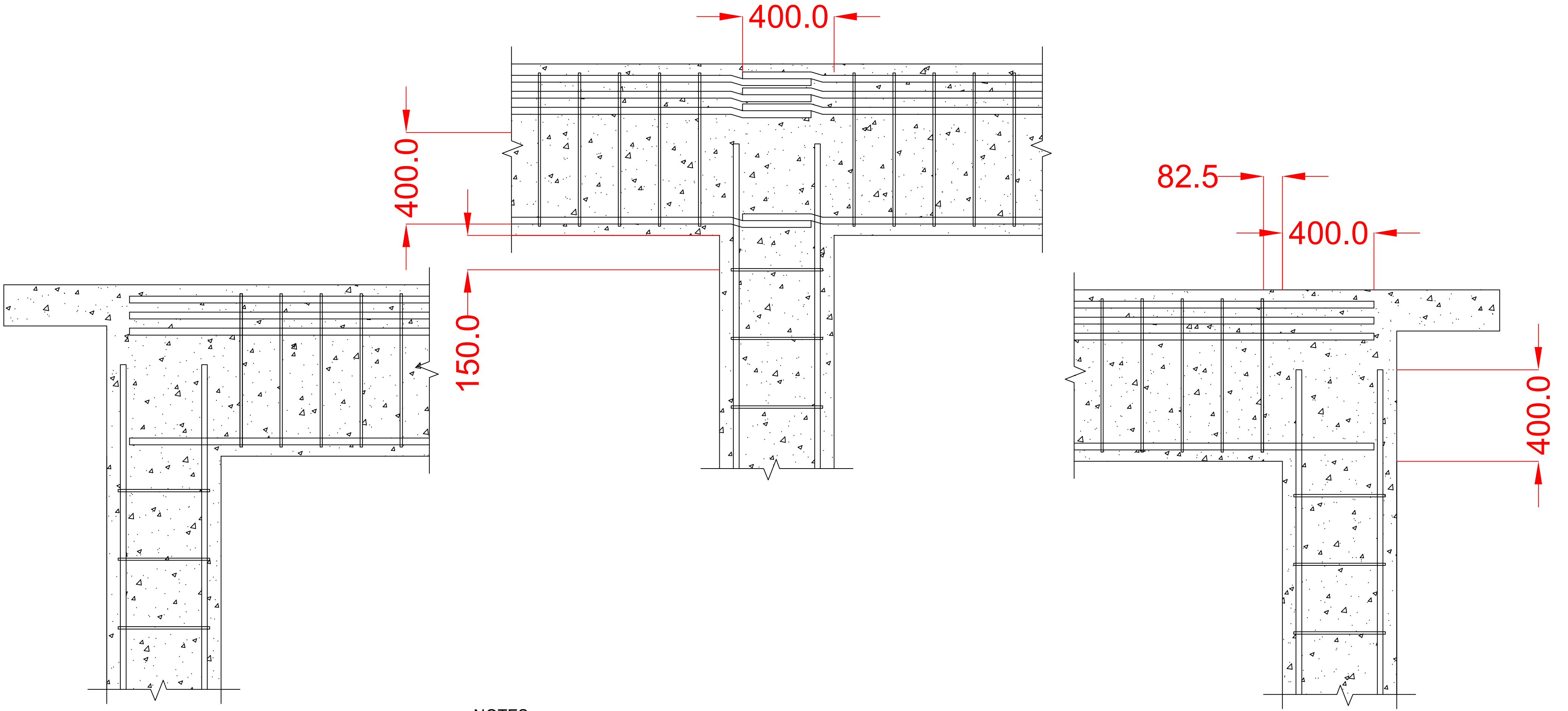
CLIENT:
UNIVERSITY OF BRITISH COLUMBIA- UBC SEEDS

NOTES:

1. FOOTING CONCRETE STRENGTH F'C = 20MPA COLUMN CONCRETE STRENGTH F'C= 30MPA, STEEL STRENGTH FY = 400MPA
2. 2 LAYERS OF 15-30M @ 160MM
3. 4-30M DOWELS @ COLUMN CORNERS, 75MM COVER
4. 75MM COVER FOR BOTTOM, SIDE FACES
5. FOOTING IS 1000MM SUBGRADE
6. DETAILING IS UNIFORM IN ALL SLABS.



ISSUED FOR CONSTRUCTION			DRAWN & DESIGNED BY:		THRAM NO.	NOTE:	REVISION	DATE:	CONTENT:	CLIENT:
NAME OF THE DRAWING:		FOOTING SIDE VIEW			N/A	-ALL DIMENSIONS IN MILLIMETERS. -REPORT ANY DISCREPANCIES TO THE DESIGNER				UNIVERSITY OF BRITISH COLUMBIA– UBC SEEDS
SCALE:	1:20	DRAWING NO:			PLOT NO.					
DATE:	MAR. 2022	SD12022			N/A					



NOTES:
1. CONCRETE STRENGTH F'C = 30MPA, STEEL STRENGTH FY = 400MPA
2. BEAM FLEXURAL STEEL EXTENDS 400MM INTO COLUMNS
3. COLUMN VERTICAL REINFORCING STEEL EXTENDS 400MM INTO BEAMS
4. FIRST BEAM STIRRUPS @ 82.5MM FROM COLUMN FACE
5. FIRST COLUMN TIE @ 150MM FROM BEAM FACE
6. SEE BEAM AND COLUMN DETAILING DRAWINGS FOR FULL DETAILING OF ELEMENTS

ISSUED FOR CONSTRUCTION

NAME OF THE DRAWING:	BEAM COLUMN CONNECTIONS
SCALE: 1:25	DRAWING NO:
DATE: APR. 2022	BC12022

DRAWN & DESIGNED BY:

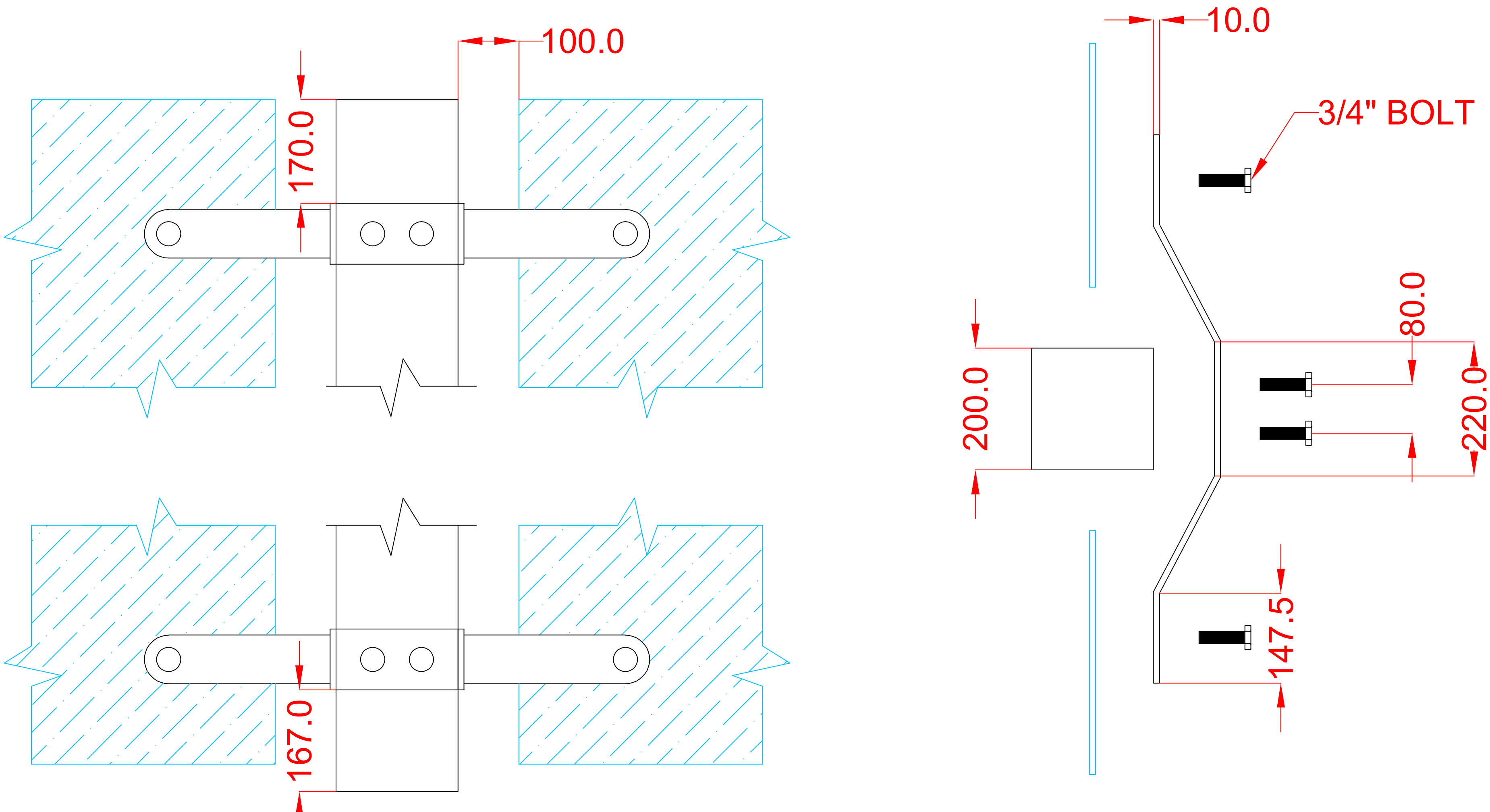
THRAM NO. N/A

PLOT NO. N/A

NOTE:
-ALL DIMENSIONS IN MILLIMETERS.
-REPORT ANY DISCREPANCIES TO THE DESIGNER

REVISION	DATE:	CONTENT:

CLIENT:
UNIVERSITY OF BRITISH COLUMBIA– UBC SEEDS



NOTES:
1. TIMBER: NO.2 DOUGLAS-FIR, 200MM X 200MM X 2000MM
2. ALL BOLTS ARE 3/4", 75MM PENETRATION DEPTH
3. STEEL PLATE IS 10MM THICK, 100MM WIDE ALONG POST, 90MM WIDE AT PANEL
4. DETAILING IS UNIFORM THROUGHOUT OVERPASS. SEE LAYOUT DRAWINGS FOR POST LOCATIONS

ISSUED FOR CONSTRUCTION

NAME OF THE DRAWING:	TIMBER COLUMN CONNECTIONS
SCALE: 1:10	DRAWING NO:
DATE: APR. 2022	TCC12022

DRAWN & DESIGNED BY:

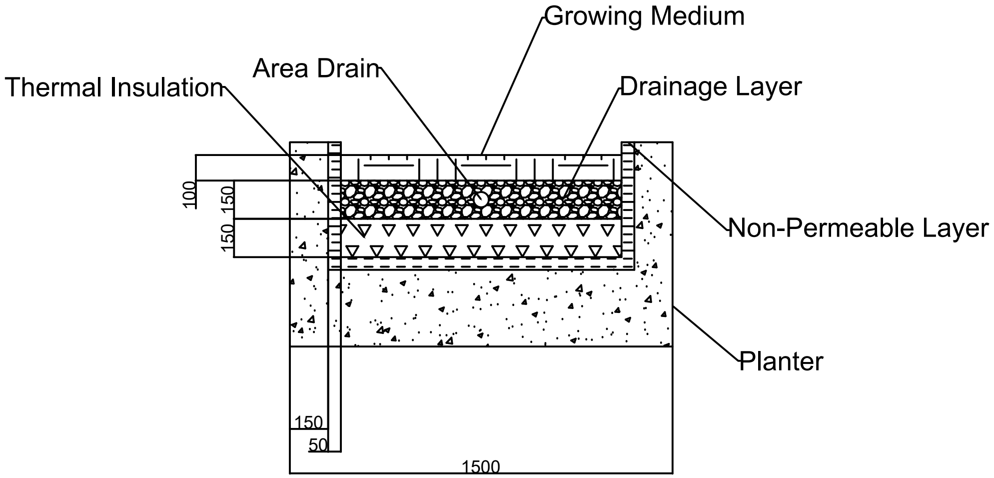
THRAM NO. N/A

PLOT NO. N/A

NOTE:
-ALL DIMENSIONS IN MILLIMETERS.
-REPORT ANY DISCREPANCIES TO THE DESIGNER

REVISION	DATE:	CONTENT:

CLIENT:
UNIVERSITY OF BRITISH COLUMBIA-UBC SEEDS



ISSUED FOR CONSTRUCTION			
NAME OF THE DRAWING:		Overpass Green Space	
SCALE:		DRAWING NO:	
DATE:	MAR. 2022	OG1	

DRAWN & DESIGNED BY:

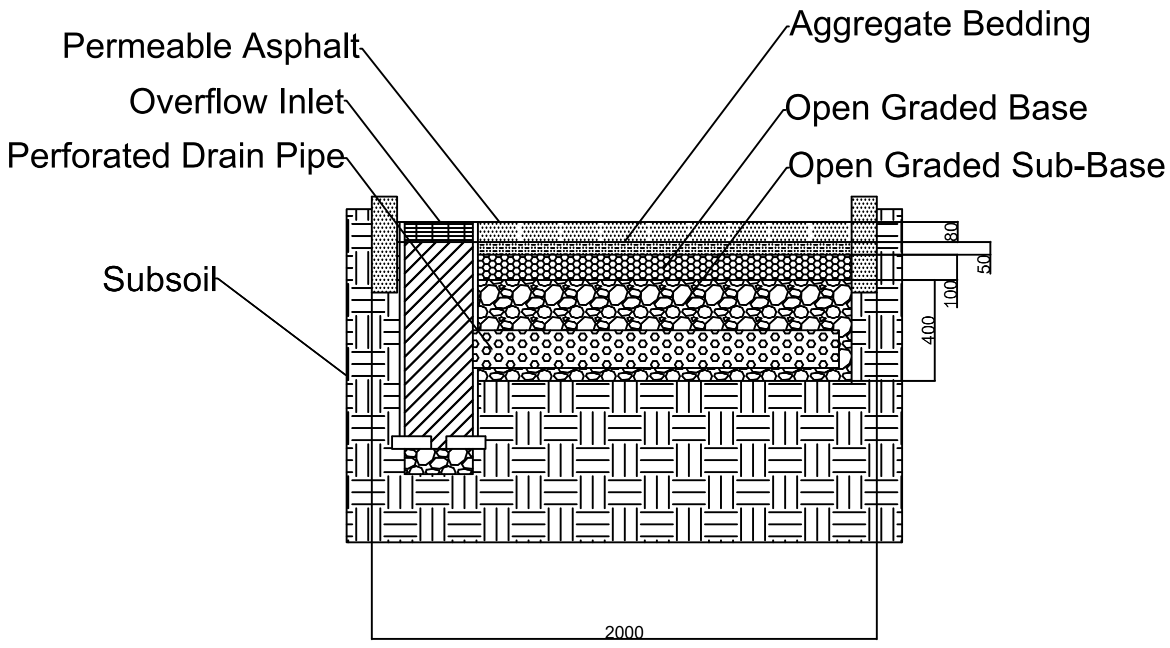
N/A

N/A

NOTE:

-ALL DIMENSIONS IN MILLIMETERS.
-REPORT ANY DISCREPANCIES TO THE DESIGNER

REVISION	DATE:	CONTENT:	CLIENT:
			UNIVERSITY OF BRITISH COLUMBIA– UBC SEEDS



ISSUED FOR CONSTRUCTION

NAME OF THE DRAWING:	Permeable Asphalt Bike Lane
SCALE:	
DRAWING NO:	BL1
DATE:	MAR. 2022

DRAWN & DESIGNED BY:

THRAM NO. N/A

PLOT NO. N/A

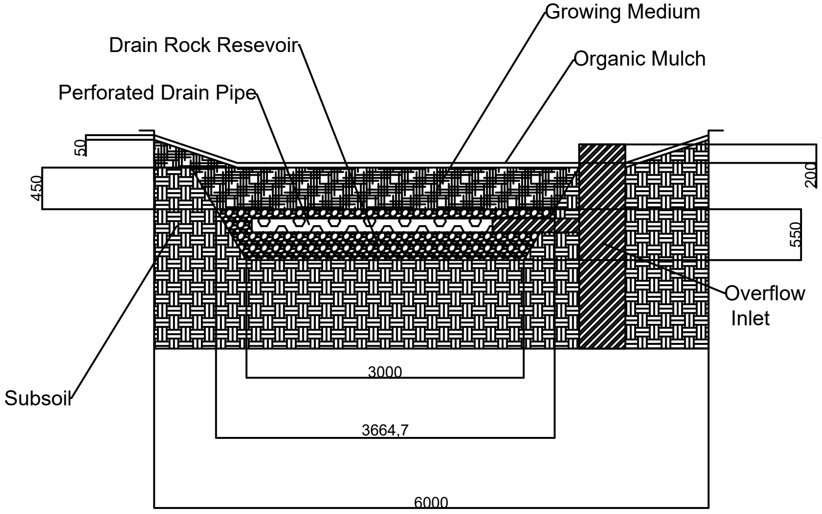
NOTE:

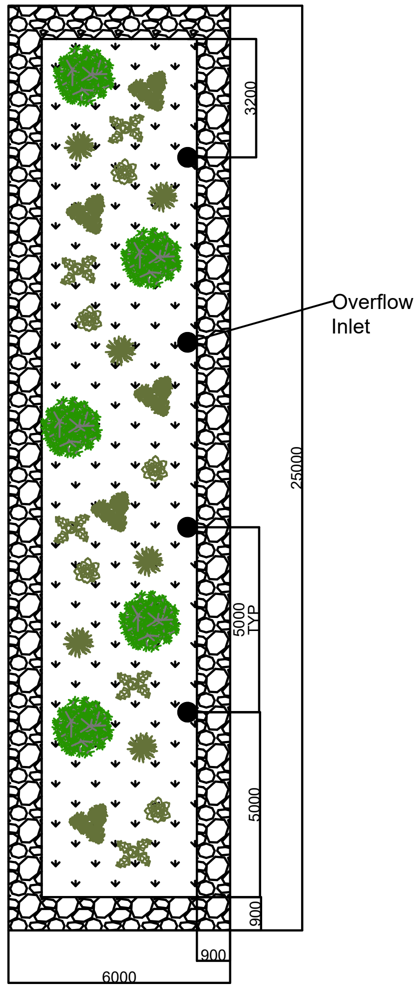
-ALL DIMENSIONS IN MILLIMETERS.
-REPORT ANY DISCREPANCIES TO THE DESIGNER

REVISION	DATE:	CONTENT:

CLIENT:

UNIVERSITY OF BRITISH COLUMBIA-UBC SEEDS





ISSUED FOR CONSTRUCTION

NAME OF THE DRAWING:	Rain Garden 1
SCALE:	DRAWING NO:
DATE: MAR. 2022	RG1

DRAWN & DESIGNED BY:

THRAM NO. N/A

PLOT NO. N/A

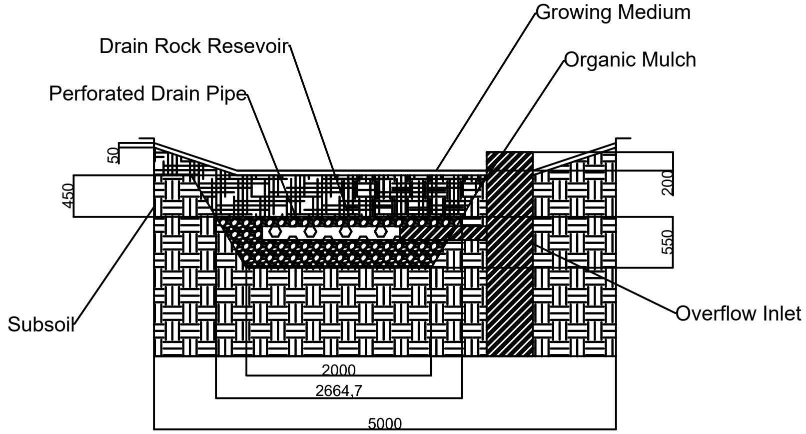
NOTE:

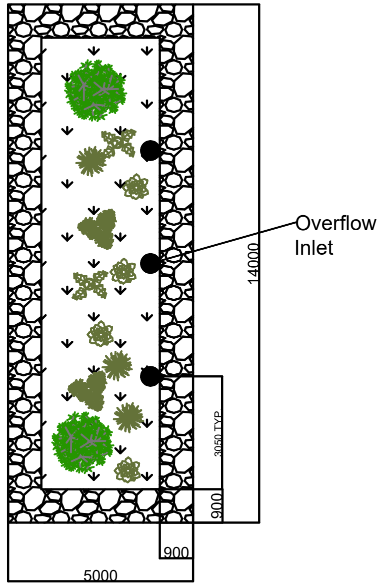
-ALL DIMENSIONS IN MILLIMETERS.
-REPORT ANY DISCREPANCIES TO THE DESIGNER

REVISION	DATE:	CONTENT:

CLIENT:

UNIVERSITY OF BRITISH COLUMBIA– UBC SEEDS





NAME OF THE DRAWING:	Rain Garden 2
SCALE:	
DRAWING NO:	RG2
DATE:	MAR. 2022

DRAWN & DESIGNED BY:

N/A

N/A

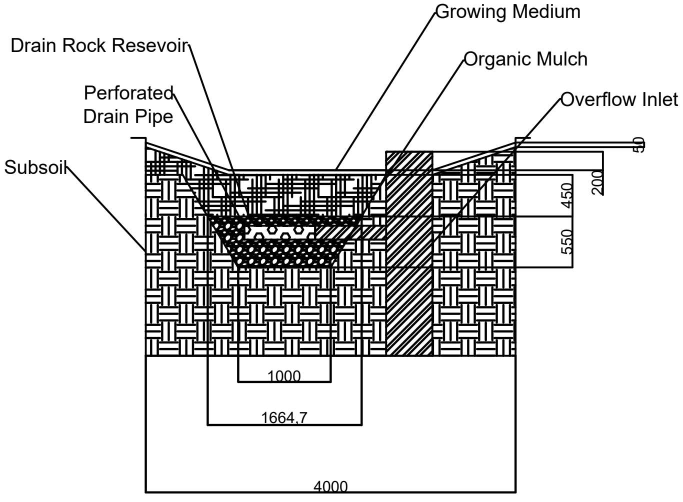
NOTE:

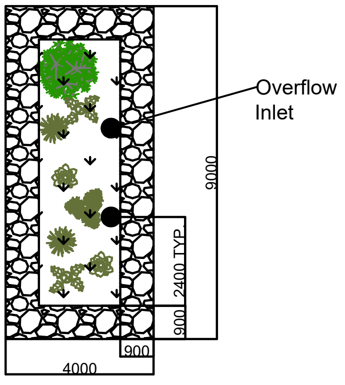
-ALL DIMENSIONS IN MILLIMETERS.
-REPORT ANY DISCREPANCIES TO THE DESIGNER

REVISION	DATE:	CONTENT:

CLIENT:

UNIVERSITY OF BRITISH COLUMBIA-UBC SEEDS





NAME OF THE DRAWING:	Rain Garden 3	DRAWN & DESIGNED BY:	N/A	NOTE: -ALL DIMENSIONS IN MILLIMETERS. -REPORT ANY DISCREPANCIES TO THE DESIGNER	CLIENT: UNIVERSITY OF BRITISH COLUMBIA–UBC SEEDS
SCALE:	DRAWING NO:		N/A		
DATE: MAR. 2022	RG3				

REVISION	DATE:	CONTENT: