University of British Columbia

Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Wesbrook Mall Redesigne – Phase 4

Prepared by: Hussain Abdulameer, Aidan Janz, Derrick Kwok, David Li, Katie Morrison, Asal Rahbari Solut

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SEEDS Sustainability Program

UBC sustainability

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EXECUTIVE SUMMARY

The Wesbrook Mall corridor from 16th Avenue to Chancellor Boulevard has been undergoing a refurbishment to address the deteriorating road structure, the increasing demand, the existing safety requirements, and to prioritize sustainable modes of transportation. This final design report is developed as per the aforementioned factors, and the client's requirements and feedback from the preliminary design and previous design stages.

R&G has adopted a triple-bottom-line framework and performed detailed population, intersection, traffic, and roundabout analyses. Based on the results, our design is optimized to maximize economic, environmental, and societal benefits. R&G has embedded significant consideration into the design to enhance safety, active and public transportation, traffic flow, aesthetics, comfort, and usability while effectively tying into existing works.

As a result of our robust and comprehensive design methodology, R&G presents the following design:

- A 1.8-metre raised, protected bike in both directions.
- A multi-use path with delineated spaces for pedestrians and cyclists in the northbound direction.
- A resurfacing of the damaged sidewalk in the southbound direction.
- A peak-hour bus lane in the northbound direction and bus lane maintained in the southbound direction.
- A pedestrian overpass near the Thunderbird Stadium, comprising of a precast concrete deck, square concrete columns and footings, two flights of steel stairs and a green roof.
- A variety of green infrastructure embedded throughout the corridor by using a green street approach, such as sloped sidewalks and paths, 18 rain gardens and 11 infiltration trenches and an anticipated removal of 5-10 trees.

R&G has performed a Class A cost estimate where we have outlined our estimated construction costs to be **$6,254,661 including a 10% contingency** accounting for the project's time constraint. Based on our final detailed design and construction sequencing, our team has developed a construction schedule with a project timeline from **2-May-22 to 8-Sep-22**.

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1. INTRODUCTION

Wesbrook Mall Redesign – Phase 4 spans from the roundabout at 16th Avenue to Thunderbird Boulevard which ties into the completed Phase 2 of this project. The goal of our design is to prioritize sustainable modes of transportation while maintaining and improving the function of this arterial roadway. The Phase 4 final design:

- Ties in with the existing roadway to the north (Phase 2) and the roundabout to the south,
- Prioritizes sustainable transportation by:
    a. Incorporating green infrastructure and improving aesthetics of the roadway,
    b. Minimizing disturbance to current green spaces and parking,
- Provides cost-effectiveness and accommodate 2050 traffic demands, and
- Embeds a pedestrian overpass south of the Thunderbird Arena in replacement of the existing crosswalk.

1.1. PREVIEW OF THE FINAL DETAILED DESIGN

To aid your understanding and visualization of this report, Figure 1 provides a brief preview of one of the sections of our final detailed design, highlighting the key features of our design. More 3D-models can be found in Appendix B. For a detailed breakdown, please see Section 3.0.

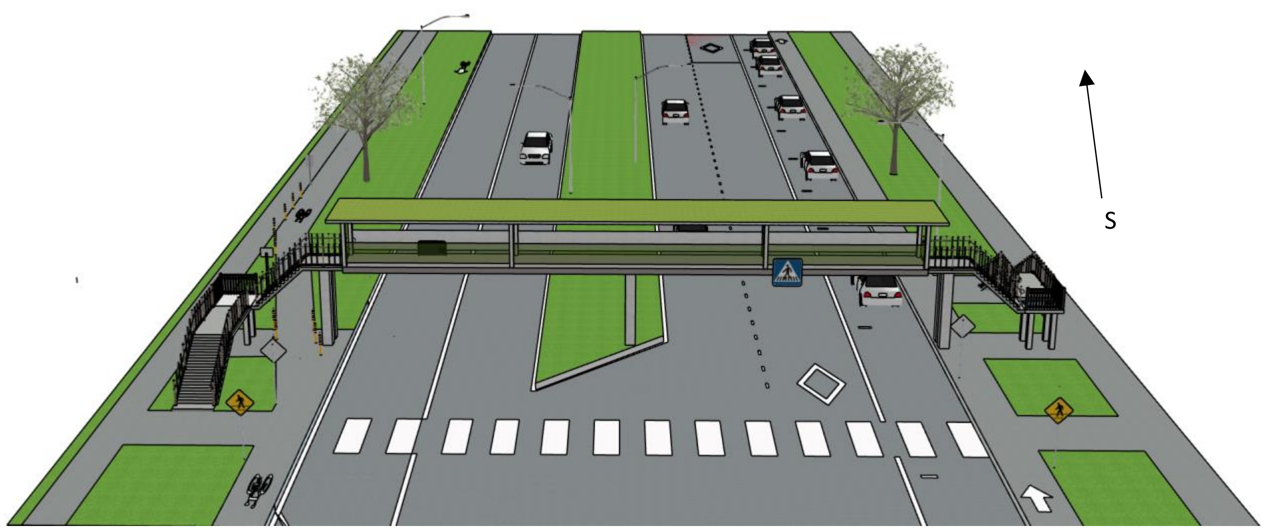


Figure 1. Final Detailed Design Preview

1.2. REPORT OUTLINE

This final detailed report will include the approach applied to yield our final design, including site issues, design criteria and detailed data analyses. Followed by a comprehensive design overview of the design's key components and parameters (including, pedestrian and cyclists' paths, public transport, roadway resurfacing, pedestrian overpass, green infrastructure, and aesthetics). Furthermore, we will expand upon our proposed design with justification for every design component and consideration made. Lastly, we have developed a construction plan, along with a Class A cost estimate and a construction schedule.

For further information regarding R&G's project proposal, conceptual designs, and preliminary design, please see our team's previous submissions.

1.3. CONTRIBUTIONS

As requested, the Table 1 summarizes each team member's contribution to the report.

Table 1. Contributions of Team Members

Team Member	Contributions
Hussain Abdulameer *(10538775)*	Exec Summary, Intro, Design Approach, Conclusion, Appendix A
Aidan Janz *(71443824)*	Design Specifications, 3D Modelling, Green Infrastructure
Derrick Kwok *(99153272)*	Design Rationale, Design Approach
David Li *(40236804)*	Design Analysis, Plan Drawings
Kate Morrison *(45885555)*	Overpass Design and Calculations
Asal Rahbari *(99705360)*	Cost Estimate, Schedule, and Construction Plan

2. DESIGN APPROACH

2.1. KEY ISSUES AND CHALLENGES

R&G has identified key issues associated with the existing corridor which have been addressed within the design criteria and detailed design. The key issues have been identified through detailed site investigation, client consultation and stakeholder engagement throughout the various design stages.

Table 2. Outline of Key Issues

Health and Safety Risks

- The safety of non-motorized road users is currently compromised due to the deteriorating sidewalks and roadway.
- Cyclists currently face unsafe interactions with other motorized and non-motorized users.

Environmental Challenges

- With UBC's growing population, it is a delicate balance between prioritizing traffic users and preserving green spaces. Environmental measures need to be enhanced because of climate change.

Budget Management

- Due to COVID-19 and supply chain issues, certain design items are anticipated to cost more than normal.

Constructability and Traffic Management Design

- Being a major arterial road for the University, constructability and traffic management will be a major challenge to maintain roadway operation while constructing the final design.

Social Challenges

- Due to the corridor's integral service to the University, robust stakeholder and Indigenous engagement is needed to ensure the longevity of the design and the addressing of users' needs and expectations.
- Being home to various sporting facilities and residential homes, the new roadway design must not impede on regular operation.

2.2. DESIGN CRITERIA

The above issues have been translated and addressed within the design criteria.

2.2.1. TECHNICAL

To successfully redesign Wesbrook Mall, conducting detailed population and traffic analyses were prioritized to ensure the corridor can sustain future demand projections. In addition, robust traffic modelling is a key criterion in informing the technical components of the design. Detailed AutoCAD drawings, along with 3D models of the pedestrian crossing was generated to accurately capture the design's components and functionality. Within our design, innovative and creative solutions are encouraged to maximize space and meet design objectives in locations with limited clearance. Active and sustainable modes of transportation are selected over traditional, polluting, and congesting forms of transportation, such as priority bus lanes and bike paths. The works of Phase 2 were studied to ensure the design of Phase 4 effectively ties into the existing roadway. Furthermore, bus shelters, bus stops, existing property lines and onsite parking are some but not all the components and criteria accounted for. A service life of 50 years governs the design, while aesthetics and comfort are minorly considered.

2.2.2. ECONOMIC

A key governing criterion is the mitigation of costs associated with this design to ensure feasibility. The detailed design has minimal construction, maintenance, and lifetime costs. The design avoids high replacement costs by conducting robust future traffic and population analyses. Construction planning is thorough and detailed to mitigate any delays or unforeseen circumstances. The design integrates systems thinking to minimize the relocation of key assets and infrastructure such as utilities, to mitigate costs while meeting design objectives.

2.2.3. CONSTRUCTION PLANNING

The project's construction will result in noise pollution, traffic disruptions and road detours, possible utility cuts, dust, and vibration. The design and construction team will implement the necessary steps to ensure minimal disturbance to nearby residences, UBC facilities, ongoing university events, classes, etc. Nearby facilities and buildings will remain accessible and functioning throughout construction. When necessary, detours and traffic management will be employed, including proper consultation with TransLink. Construction will be restricted to 8-hour shifts from Mondays to Saturdays, to minimize noise pollution during evening time, nighttime, and Sundays. Construction planning takes into consideration the project's proximity to Pacific Spirit Park by minimizing adverse effects on wildlife. Stakeholder needs and preferences are accounted for and accommodated as much as possible within construction.

2.2.4. REGULATORY

All design and construction aspects comply with the following standards, regulations, and guidelines as set out by the University of British Columbia and other governing bodies:

- Transportation Association of Canada (TAC) Geometric Design Guide for Canadian Roads
- Third party utility requirements and guidelines
- Transit Regulations
- British Columbia Active Transportation Design Guide, 2019 Edition
- UBC Technical Guidelines (Earthworks and Utilities)
- UBC SEEDs Sustainability guidelines

The following standards and codes have been used with the design of the pedestrian overpass:

- Cycle Highway Manual from North-West Europe
- British Columbia Building Code 2018

The following permits are required for the project and the necessity of these was confirmed by liaising with UBC: Streets and Landscape Permit (SLP), Tree Removal Permit, and a Development Permit as required by UBC Campus and Community Planning. Communication with the appropriate parties will be executed early to avoid any delays.

2.2.5. ENVIRONMENTAL

R&G is committed to an environmentally sustainable design by maximizing greenspace and the trees located on site. Any trees which require removal due to the construction of this project will be transplanted to a different location on Campus after consultation with the UBC arborist. Our team has embedded green infrastructure within the design, and the green street will incorporate vegetation, soil, and engineered systems such as permeable pavements for effective stormwater management. Due to this project's proximity to Pacific Spirit Park, the design and its construction will have minimal impact on the ecosystem and the natural environment in these locations. Materials used in construction will be free of any toxic substances to avoid any seeping into the environment and construction machinery emissions will be monitored and minimized throughout the project's duration. The construction and lifetime of the new design will have a minimal footprint (e.g., carbon and GHG emissions, air pollution, etc.) on the surrounding environment.

2.2.6. SOCIETAL AND STAKEHOLDERS

Safety is a major criterion incorporated within the design, such as the careful selection of design measures and the embedding of a pedestrian overpass to minimize traffic and user interactions. Creative solutions have been implemented by clearly identifying areas of medium to high danger and finding ways to mitigate the severity and likelihood of these interactions. Intensive site studies and stakeholder engagement assisted the process by ensuring the design is both functional and safe.

R&G has and will continue to conduct stakeholder engagement (see Appendix A for the detailed communications plan) with the affected groups to ensure stakeholder awareness of the project and their input in the project's design and construction:

- Indigenous Community (i.e., Musqueam people)
- UBC Facilities (i.e., UBC Athletics and Recreation)
- External Parties (e.g., TransLink)
- Project Clients (incl. UBC SEEDS and UBC Campus and Community Planning)
- UBC Community (incl. UBC residents, students, faculty, and staff)

An array of public engagement methods and outreach has been employed when interacting with stakeholders; the communications plan used is outlined in Appendix A. The stakeholder consultation accomplished the following goals:

- Identified stakeholder needs and wants.
- Identified stakeholder attitudes and perceptions.
- Addressed stakeholder concerns regarding community impacts.
- Solicited feedback on proposed detailed designs and construction plans.

These accomplishments directly informed the technical aspects of the detailed design and the details of our construction plan. Stakeholders will be continuously updated and informed regarding the project's milestones, and feedback is always solicited to continue bettering the process.

2.3. DESIGN ANALYSIS

To conduct a thorough and accurate analysis, the following software packages were utilized throughout the duration of this project.

- **Microsoft Office Suite**: Generated reports, presentations, and conducted population and traffic analyses.
- **Synchro 6.0:** Performed capacity analysis and optimized traffic signal timings.
- **AutoCAD:** Drafted detailed design drawings.

Project analysis was conducted for the future populations and traffic demands for the general UBC area. Our results estimate that by the design year of 2050, it is expected that UBC's average daytime population will increase from the current population of 80,000 to up to 120,000. Additionally, it is expected that the average weekday person trips to and from UBC will increase from 120,000 to approximately 200,000 trips.

Various projects and policy changes are anticipated to take place throughout Metro Vancouver. These changes are expected to shift current transportation mode splits towards a more sustainable approach. Projects such as the Broadway Subway line to UBC, Surrey Langley Skytrain, Expo and Millennium Line upgrades and SkyTrain Fleet Expansion were all considered. Their impacts were estimated and incorporated into our analysis approach.

2.3.1. POPULATION ANALYSIS

As stated earlier, R&G estimates that by 2050, UBC will have an average daytime population of 120,000 which is an increase of 40,000 people from the current daytime population. Please refer to Figure 2.

Total daytime population growth is based off numerous factors, such as the population growth of Metro Vancouver, nearby residential developments, future transit projects, dynamic workplace and school environments, and future policies. Additionally, historical data were obtained from UBC such as enrolment and employment reports and used to observe the general trends of population changes.

A general equation to predict the population up to the design year of 2050 is developed as shown below:

$$Population_{year} = f(ax_1 + bx_2 + cx_3 \ldots) + Population_{year-1}$$

Population growth for the year is assumed to be a function of a set of variables such as ax_n where a is an influence factor for the variable x_n the population growth from a particular source. The influence factors and population growth source vary from year to year.

Student Population: Student populations were broken down into domestic and international students, while total enrolment numbers were taken from 2012 to 2020 to generate two separate trendlines. Future enrolment numbers were predicted by extrapolation based on the trendlines with the consideration of other potential influencing factors such as the accessibility of an online learning environment.

Faculty and Staff: Similarly, faculty and staff employment numbers were predicted utilizing the same methodology, however, with different influencing factors.

Overall, three population projection scenarios were generated with varying factors, using the average daytime population of 120,000 as our design value, shown below.

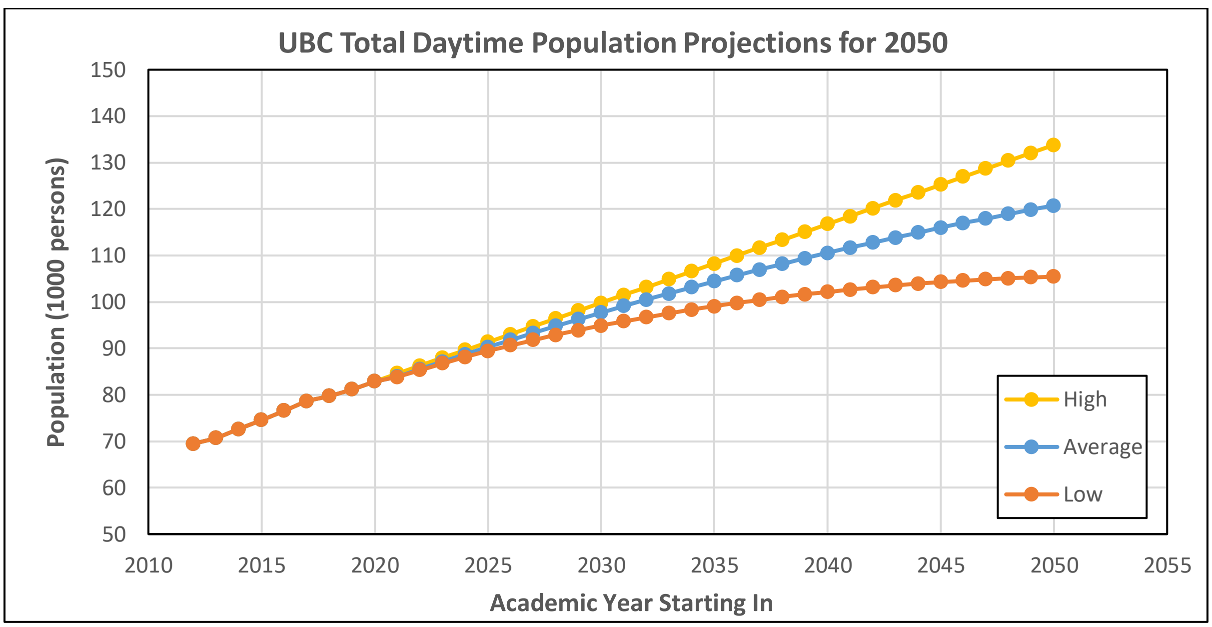


Figure 2. UBC Total Daytime Population Projections for 2050

2.3.2. TRAFFIC ANALYSIS

Our team estimates that by the year 2050, we can expect the following changes in traffic flow:

- Public transit is expected to increase by 56%.

- Passenger cars is expected to decrease by 37%.
- Cyclists and pedestrians are expected to increase by 13%.

Traffic projections for the design year of 2050 are calculated using the UBC total daytime population projection for 2050 (Figure 3) and 2018 and 2019 peak-hour traffic flow data. The peak-hour traffic flow data consists of morning, mid-day, and evening vehicle flow values for single-occupant vehicles, heavy vehicles, cyclists, busses, and pedestrians.

The 2050 traffic data is derived by scaling population data to the collected traffic data and by applying other considerations such as historical trends, future transit projects, and technological changes. The following graph presents the modelled results for transportation modes each year, separated into 4 categories where others represent cyclists, pedestrians, and heavy vehicles.

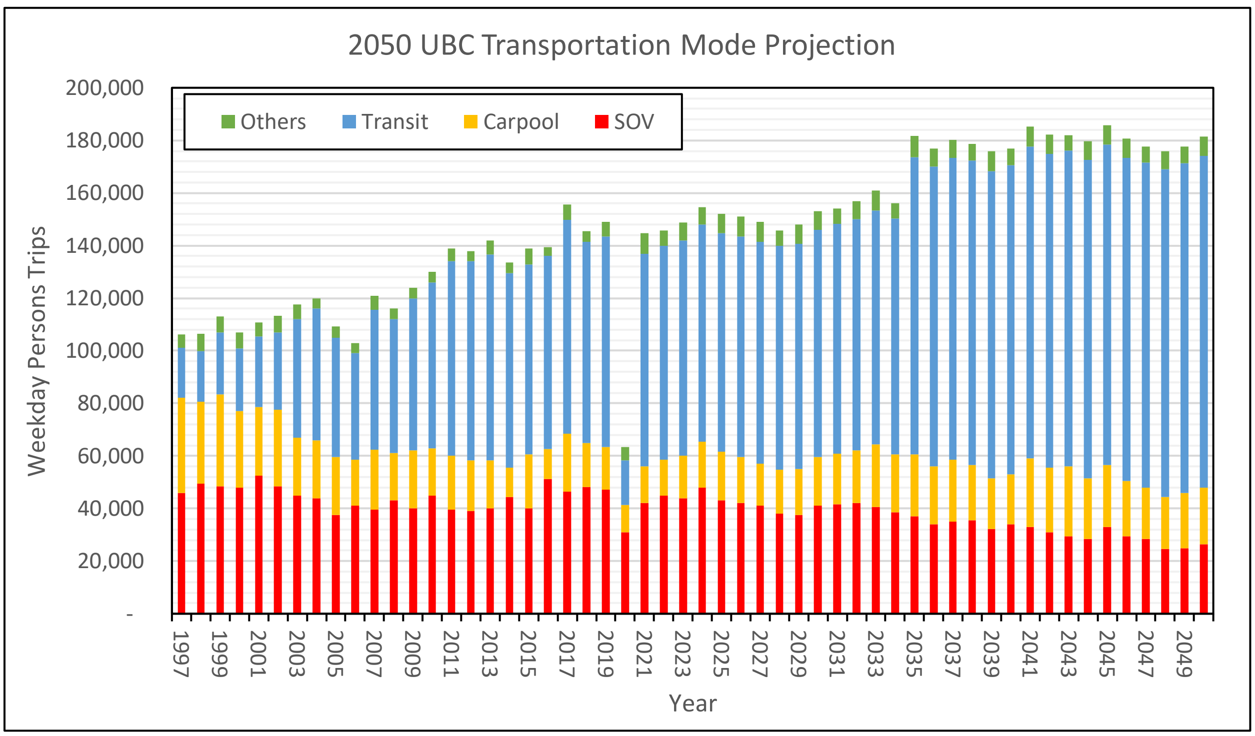


Figure 3. 2050 UBC Transportation Mode Projection

Due to expected rapid transit projects, EV policies, as well as Climate Change actions, it is expected that transit ridership will increase significantly through to the design year of 2050. Additionally, we expect passenger car volumes to decrease due to varying factors such as increases in the cost of vehicle ownership and operation, limited parking access, and overall better accessibility and affordability of public transit.

Table 3. Vehicle Classification Summary - Wesbrook Mall & 16th Avenue

Time Period		Passenger Cars		Heavy Vehicles		Buses	
		2019	**2050**	**2019**	**2050**	**2019**	**2050**
Morning	(7AM-10AM)	4,471	2,900	36	72	314	524
Midday	(11AM-1PM)	2,730	1,770	25	48	149	261
Afternoon	(3PM-6PM)	5,581	3,592	10	20	285	480
Total		**12,782**	**8,262**	**71**	**140**	**748**	**1,265**

Table 4. Vehicle Classification Summary - Westbrook Mall & Thunderbird Boulevard

Time Period		Passenger Cars		Heavy Vehicles		Buses	
		2019	**2050**	**2019**	**2050**	**2019**	**2050**
Morning	(7AM-10AM)	3,098	2,022	26	52	317	511
Midday	(11AM-1PM)	1,851	1,213	24	44	142	231
Afternoon	(3PM-6PM)	4,061	2,631	2	4	303	485
Total		**9,010**	**5,866**	**52**	**1**	**762**	**1,227**

Due to COVID-19, transportation values were significantly lower for the year 2020 since UBC transitioned to online workplace and learning environments. For this reason, our team has utilized a 3-Year Moving Average to analyze the general growth trend (Figure 4). A large increase in transit usage around 2030 is expected as major transit projects will be completed.

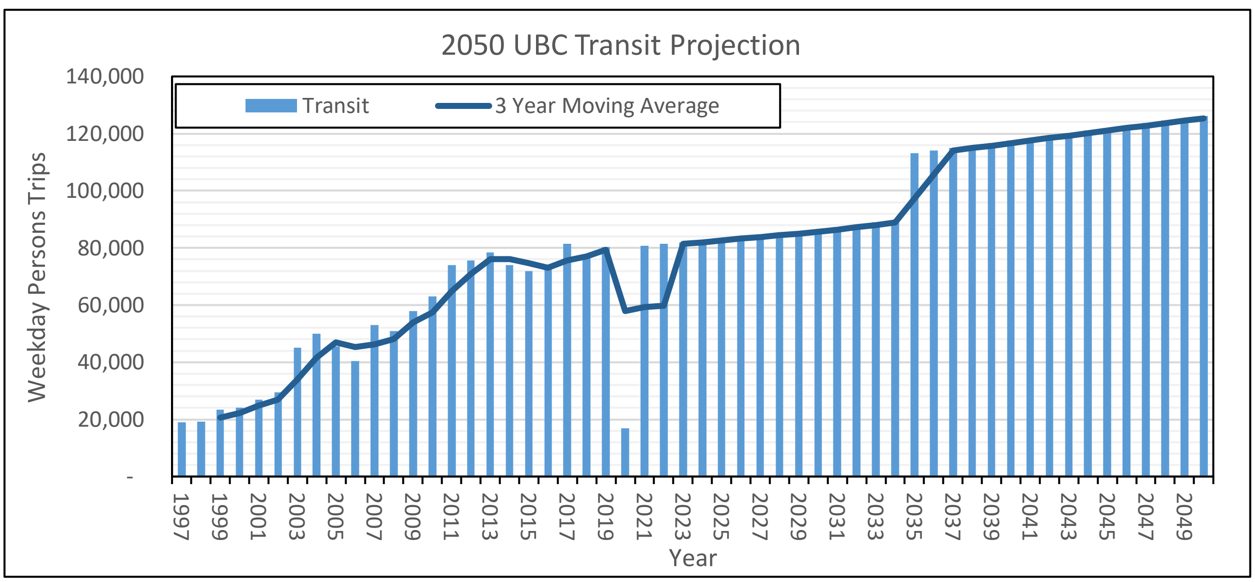


Figure 4. 2050 UBC Transit Projection

2.3.3. INTERSECTION AND ROUNDABOUT ANALYSIS

To reproduce the traffic flow within the corridor, Synchro (a traffic simulation modelling software) was utilized. The analysis was conducted for the design year of 2050. Estimated traffic conditions for the proposed corridor design and for the design year of 2050 were inputted into Synchro to obtain modelling results.

Figure 5 provides an example of the layout of the Synchro model used to conduct the analysis. The values displayed may vary depending on different peak hours. A separate simulation was conducted for each peak period, adjusting various parameters including but not limited to the traffic volumes, conflicting pedestrian and bicycles, and heavy vehicle percentage. The analysis period was set to 60 minutes and SimTraffic simulations were set to a duration of 120 minutes with a 5-minute seeding period.

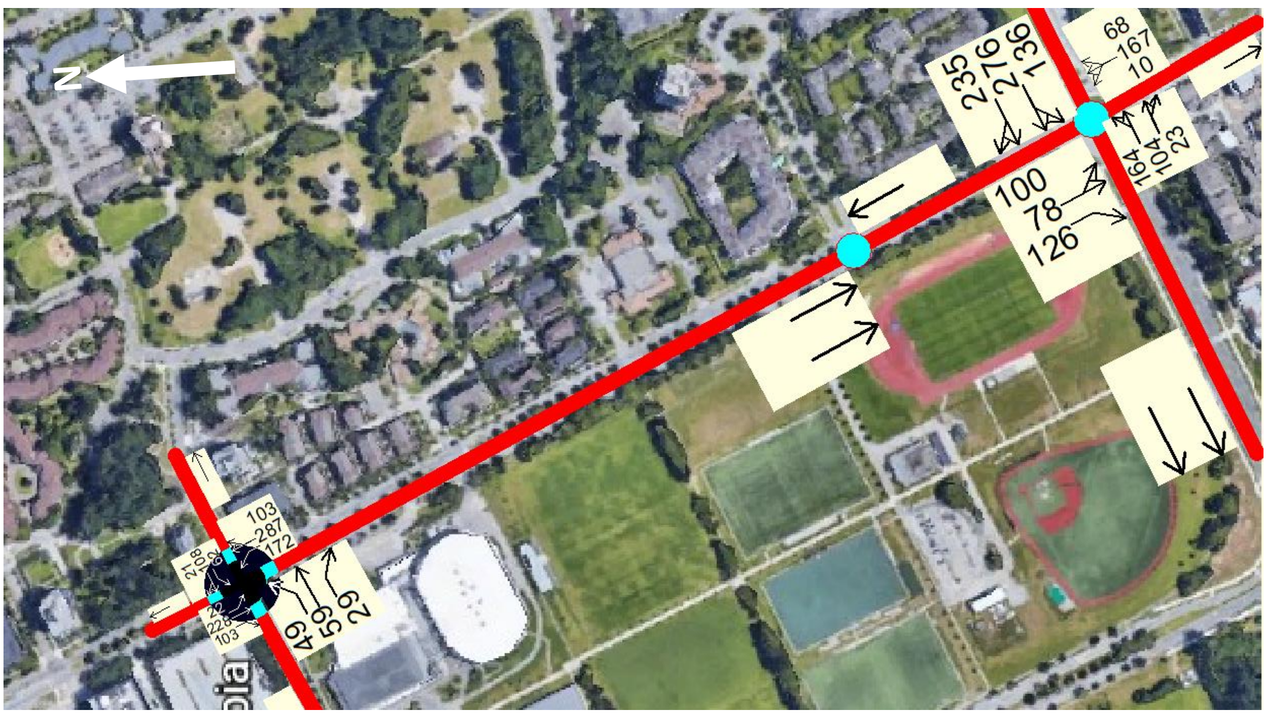


Figure 5. Synchro Model Example - Thunderbird Boulevard (Left), West 16 Avenue (Right)

Synchro analysis reports for the morning, midday, and afternoon peak periods are provided in Appendix D. Overall, it was determined that the achieved Level of Service (LOS) simulated for all peak periods was satisfactory and/or exceeded our expectations and requirements for our final design. The following three tables summarize the key findings.

Table 5. Intersection at Thunderbird and Boulevard Level of Service – Morning Peak Period

Time Period	East Bound LOS			West Bound LOS			North Bound LOS			South Bound LOS		
	Left	Thru.	Right	Left	Thru.	Right	Left	Thru.	Right	Left	Thru.	Right
Morning	B	B	A	C	C	-	A	B	-	B	B	A
Approach LOS		**B**			**C**			**A**			**B**	

Table 6. Intersection at Thunderbird and Boulevard Level of Service – Midday Peak Period

Time Period	East Bound LOS			West Bound LOS			North Bound LOS			South Bound LOS		
	Left	Thru.	Right	Left	Thru.	Right	Left	Thru.	Right	Left	Thru.	Right
Midday	C	B	A	C	C	-	B	A	-	B	B	A
Approach LOS		**B**			**C**			**A**			**A**	

Table 7. Intersection at Thunderbird and Boulevard Level of Service – Afternoon Peak Period

Time Period	East Bound LOS			West Bound LOS			North Bound LOS			South Bound LOS		
	Left	Thru.	Right	Left	Thru.	Right	Left	Thru.	Right	Left	Thru.	Right
Afternoon	B	B	A	C	C	-	B	A	-	C	B	A
Approach LOS		**B**			**C**			**A**			**B**	

2.4. PEDESTRAIN OVERPASS COMPUTATIONS

The pedestrian overpass was designed using the loads specified in the BC Building Code. The concrete components of the overpass were designed using CSA A23.3:19. The green roof and the steel stairs detailed design will be performed by suppliers. The load from the green roof was obtained from the Conservation Technology Green Roof Handbook. The load value employed in the design was conservative to ensure the concrete structure will be able to support the final design. Detail sample calculations are included in Appendix F.

The bearing capacity of the soil was determined using a geotechnical report from a surrounding area. Since there are no existing geotechnical investigations for the site, the soil was assumed to be Quadra Sand with a bearing capacity of 100 kPa and that the water table is well below the footing depths.

3. PROPOSED DETAILED DESIGN

3.1. KEY COMPONENTS AND PARAMETERS

3.1.1. DESIGN OVERVIEW

To enhance user experience, safety, design feasibility and functionality, and sustainability (including economic, social, and environmental aspects), all design criteria are heavily assessed and met to a high extent. In doing so, R&G's design for the Wesbrook Mall project offers a wide range of features that all seamlessly interface with one another to form a well purposed, meaningful stretch of transportation infrastructure. These main features include a user-friendly pedestrian overpass, green and sustainable infrastructure, public transport features and pedestrian and cyclist paths. Additionally, user parking is maintained, while overall aesthetics and comfort are drastically improved. This section aims to further elaborate on the features mentioned above. The following figure provides a general overview of various design features.

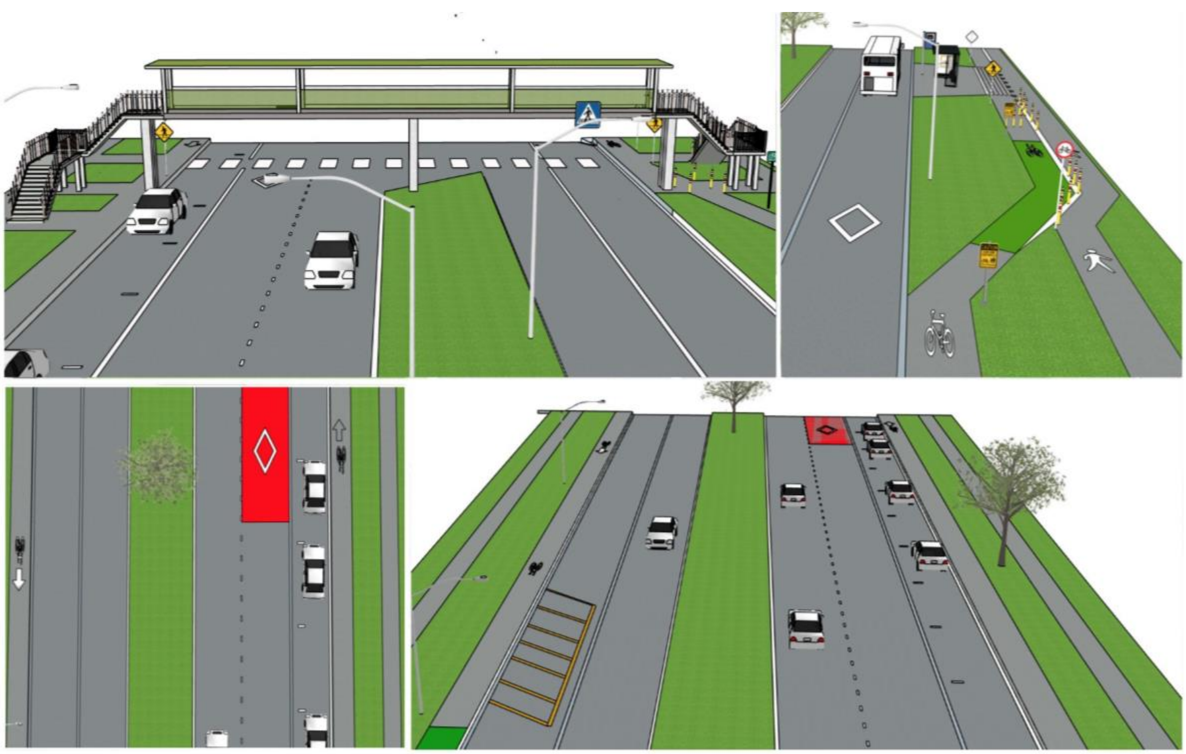


Figure 6. Different Features of the Proposed Design

3.1.2. PEDESTRIAN AND CYCLIST PATHS

A major focal point of this design is to upgrade the user experience and safety for cyclists and pedestrians. R&G is incorporating a 1.8-metre raised bike lane combined with a 3.2-metre shared multi-use path to improve safety and user experience. The new design comprises of a raised bike lane for most of the project span, in both directions. To effectively minimize disturbance to parking lanes and to maintain green space, a shared path is implemented for a portion of the southbound direction. This path begins on the south side of the RCMP Fire Hall driveway and continues until Thunderbird Boulevard. In addition, the curb line will be altered in both northbound and southbound directions, hence the existing catch basins will be relocated to the new curb line. For the effective drainage of raised bike lanes, they will be built with a 2% grade, draining to the adjacent green space in between the bike lane and the sidewalk (Refer to Appendix B). Figure 7 illustrates the transition from a raised bike lane to a shared path in the northbound direction, as well as the raised bike lane in southbound direction. Please refer to Appendix C for the detailed design drawings with plan views of these facilities.

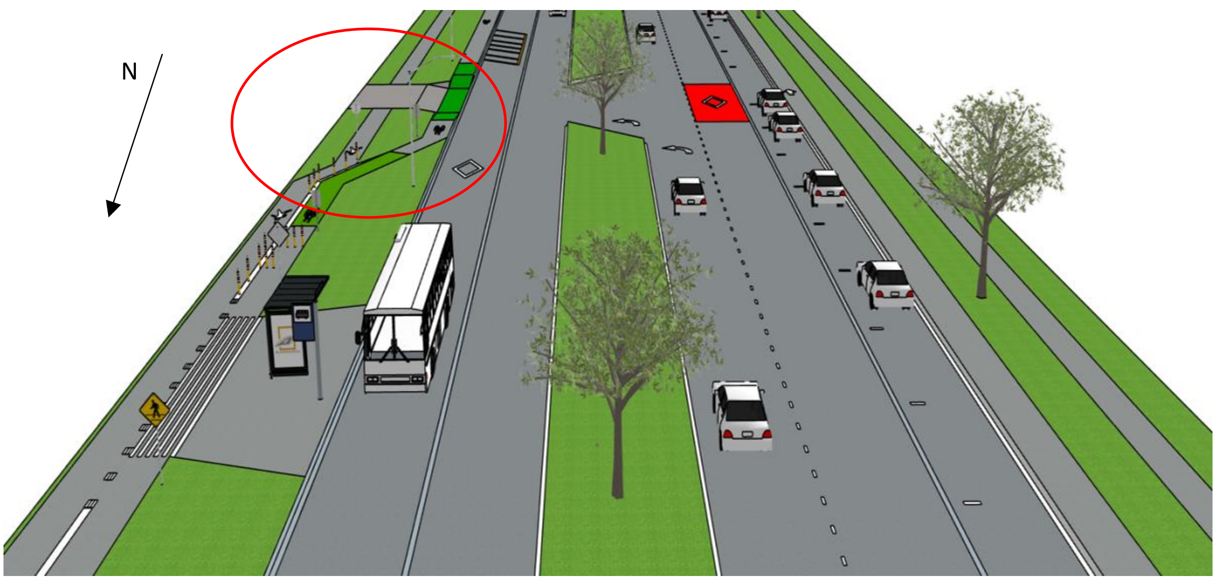


Figure 7. General Overview of Bike Lanes in Both Directions

R&G recognizes the importance of interactions between cyclists, pedestrians, and vehicles. Bike lanes will be painted green when at road-grade to prompt cyclists to remain on the bike lane; this is shown in front of the driveway in Figure 7 (circled in red). In addition, where the bike lane merges into the shared path, the green paint will aid in ensuring cyclists to remain on their path. Figure 8 illustrated the merge with the green paint and delineation that R&G is proposing to install for enhancement of user safety.

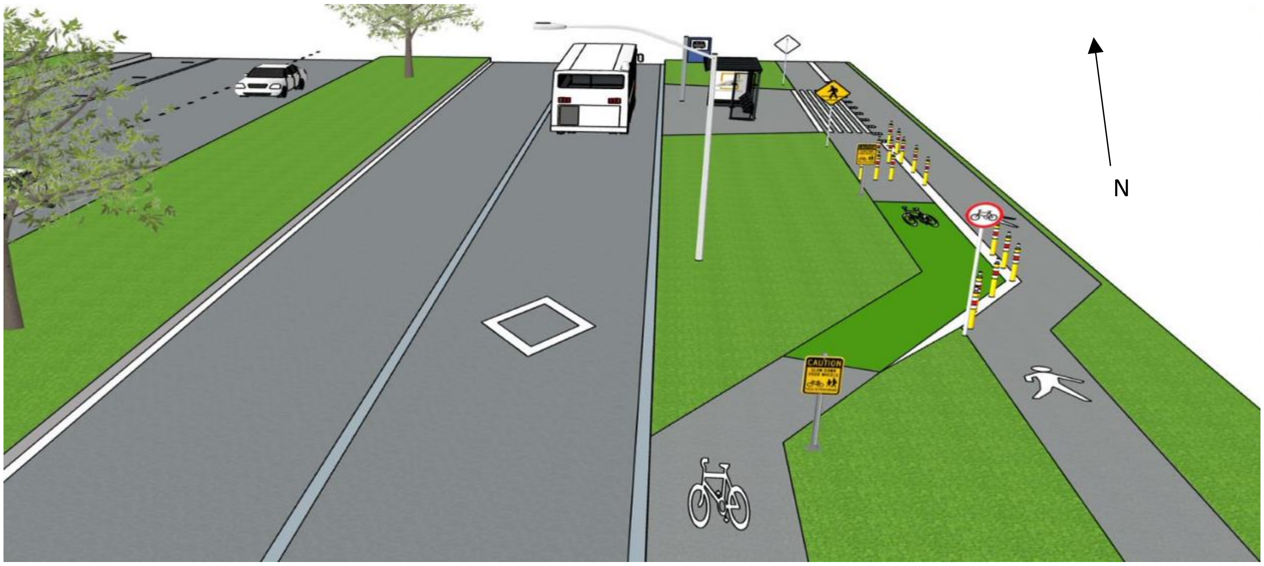


Figure 8. Point of Interaction between Bike Path and Pedestrian Sidewalk

In the design of raised bike lanes, the other location of interaction between various users is at bus stops. Approaching these stops, the raised bike lane will shift and continue behind the new bus shelter location, crossing the sidewalk that continues in front of the bus shelter. Figure 9, a snapshot from the detailed drawings, highlights the features that we are planning to employ in improving these interactions and safety of users while reducing misunderstandings. As demonstrated in the 3D models, delineation and signage will aid in communicating the correct paths to each user.

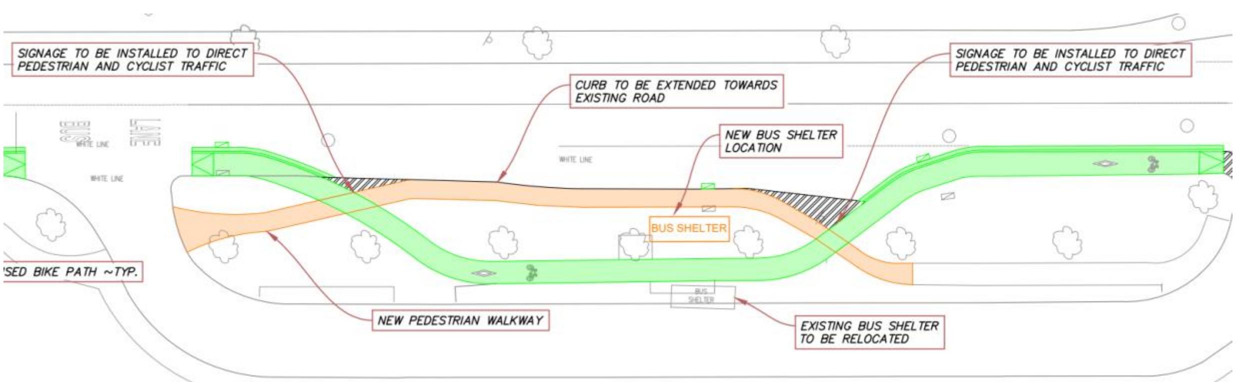


Figure 9. Plan View of the Bus Stop with Bike Lane and Sidewalk

Due to the current unsuitable conditions of the southbound sidewalk (south of the Thunderbird Stadium to the roundabout at West 16th Avenue) such as surface cracks, R&G is including the re-surfacing of the existing sidewalk to improve safety and user experience.

3.1.3. PUBLIC TRANSPORT

R&G has developed a design that prioritizes active transportation. In the southbound direction, the current bus lane will be maintained. In the northbound direction, modified parking lane restrictions are enacted to accommodate a bus lane during peak traffic hours, AM and PM peaks. The modified bus lane runs along the entire corridor. The design is intended to avoid impacting the overall locations of the current bus stops; however, there are minor changes to the bus shelters' locations to accommodate bike lanes as shown in Appendix C, (e.g., the bus stop in front of Thunderbird Arena). These minimal relocations of bus shelters are done adequately so the shelters can be re-used, saving project costs.

As outlined in Section 4.1.2., appropriate signage and delineation will be utilized to ensure the safety of all users and provide efficient access to buses.

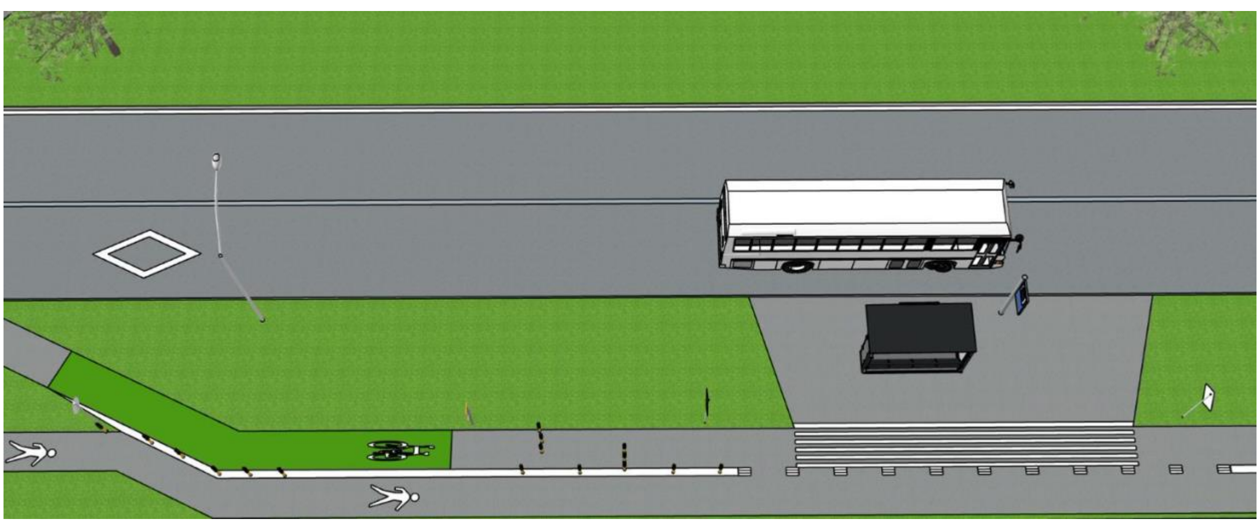


Figure 10. Aerial View of Design Portraying Modified Bus Lane in the NB Direction

3.1.4. PEDESTRIAN OVERPASS

R&G will implement a pedestrian overpass south of the Thunderbird Arena, in place of the existing pedestrian crossing. Drawing C006 and C007 in Appendix C includes a comprehensive and detailed breakdown of the overpass concrete design, reinforcement, and dimensions. Figure 11 provides an artistic rendering of how the overpass will be embedded within the existing infrastructure.

The overpass features a precast slab and beam system that consists of two 0.3 m wide by 0.5 m thick beams supporting a 21 m long by 3.0 m wide by 0.15 m thick slab (Figure 12). The deck will be supported by 6- 0.3 m square concrete columns, two at each end and two at the roadway median. Each column will be supported by 1.4 m square footings. Two flights of steel stairs on either side connecting at a 90-deg. angle with a 3 m square platform. Calculations for concrete beam, slab, column, and footing sizes can be found in Appendix F. The soil was assumed to be Quadra Sand with a bearing capacity of 100 kPa and that the water table is well below the footing depths based off geotechnical reports from surrounding areas at UBC. As the reports are not conducted specifically for this site, additional geotechnical investigations may be needed, and the footing sizes may increase because of this.

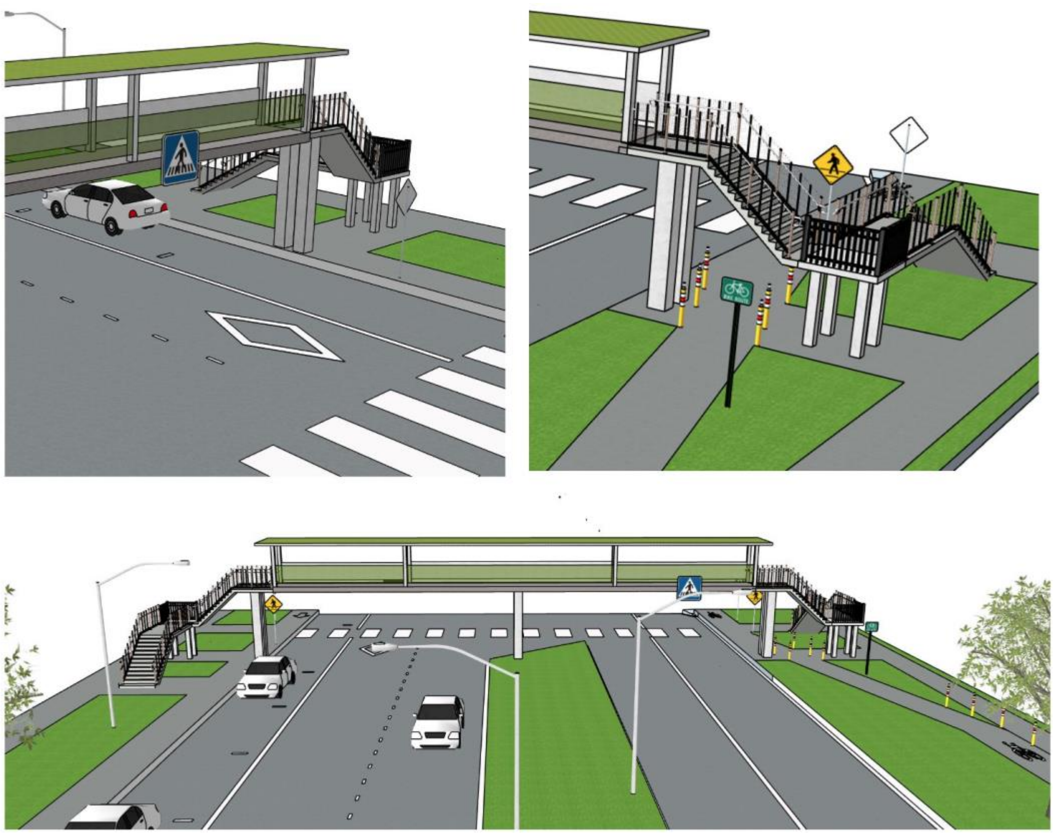


Figure 11. Artistic Rendering of Pedestrian Overpass

The stairs are supported at the landing by four steel columns and footings. The overpass incorporates a green roof covering the deck slab to maximize water retention and improve storm water runoff. Due to the minimal available space at this location, the overpass lacks a ramp to accommodate individuals with accessibility concerns. The crosswalk will remain in its current location just north of the proposed overpass and pedestrian activated signals will be placed on the overpass deck to accommodate those individuals safely.

The calculated dimension of the overpass fits within the location parameters while maximizing pedestrian safety and comfort. The overpass maximizes parking retention as it does not displace any existing spaces. For increased safety, the multi-use path diverges into a separate bike lane traveling under the upper stair flight with a 3-metre clearance, while the pedestrian lane diverges to the other side of the stairs, minimizing possible collisions between users (Figure 11*)*. This ensures pedestrians exiting the staircase will not collide with bikes using the facility. This will prompt the paving of some existing green space; however, the green roof will compensate for the area removed.

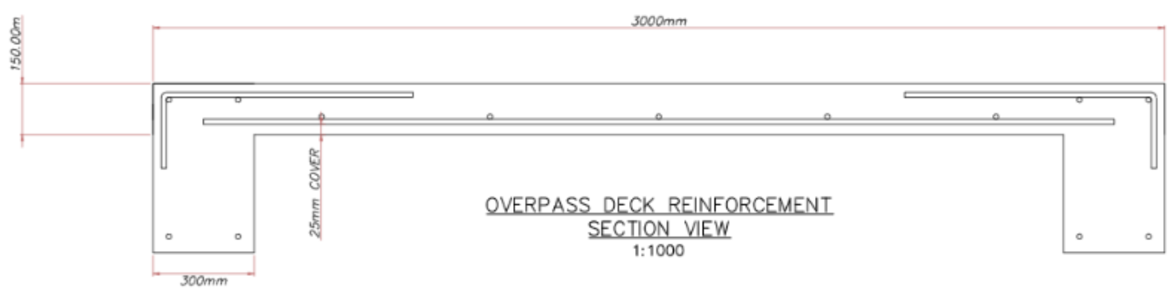


Figure 12. Overpass Deck Design

3.1.5. ROADWAY RESURFACING

As identified by client consultation meetings and site investigations of the present deteriorating road structure, R&G is planning on resurfacing the asphalt on the roadway for the entire corridor. The resurfacing roadway plan will consist of removing the 50 mm thick asphalt alongside the underlying 19 mm gravels and rebuilding a new road structure on the existing 75 mm subgrade base. Therefore, the road structure's new design includes rehabilitating the road structure that is removed in accordance with current standards and guidelines. Additionally, as the curb line is shifted, all the catch basins will be relocated within the roadway. The same crossfall design, the road crowning at the medians will be kept the same and the catch basins will be located at the gutters of the new curb line in both directions.

3.1.6. GREEN INFRASTRUCTURE

Our design embeds a green street approach, utilizing a variety of water retention systems through the integration of green stormwater management with the purpose of limiting the impacts on the surrounding storm system. This includes:

- Sloped sidewalks and bike paths directly into green infrastructure.
- Porous asphalt on cyclist and pedestrian paths.
- Eleven infiltration trenches dispersed throughout the roadway and located adjacent to the curb.
- Eighteen rain gardens installed in open areas beside sidewalks and shared multi use paths.

Each component has the purpose of reducing surface runoff, increasing surface permeability, and protecting bodies of water near UBC from pollutants washed from paved areas all while enhancing natural aesthetics. Each additional aspect is mindful of the local environment and stakeholder interests in maintaining the current function and aesthetic of the natural landscape.

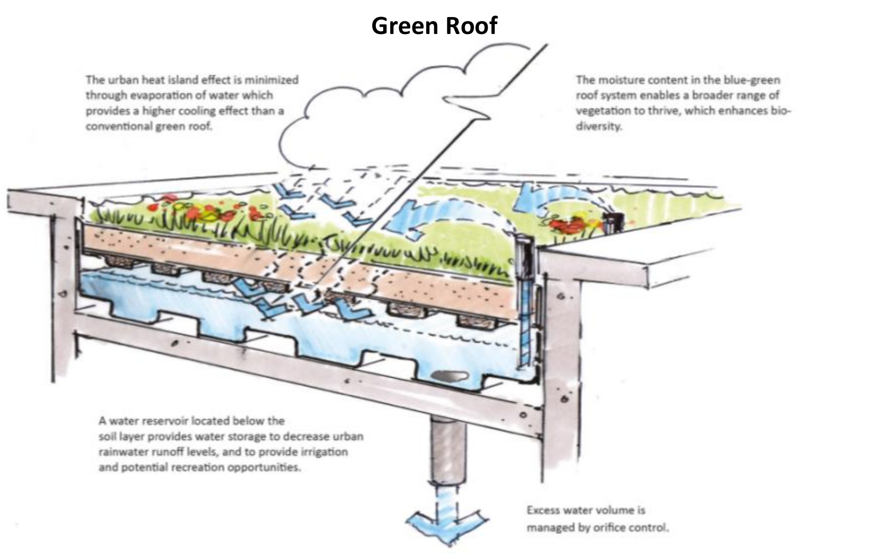


Figure 13. City of Vancouver Typical Detail for Resilient Green Roofs

In our design, we have minimized the loss of green space where possible. To maximize the green space, we have designed for a 1.8-metre sidewalk in the southbound direction. Due to the nature of this project, it is unavoidable to disturb the current tree locations due to spacing constraints. Where necessary, we plan to relocate and replant any trees that would be disturbed; we anticipate that 5 to 10 trees will be relocated during construction. A green roof is incorporated within the design of the pedestrian overpass to compensate for the loss of green space in the redesign of the sidewalk. An example of a standard green roof is shown in Figure 13.

Urban rainwater runoff is designed to flow directly into the neighbouring green space and structural soil. This is achieved by sloping sidewalks and bike paths directly into rain gardens and infiltration trenches which allows for the runoff to be treated and kept from entering the storm drainage system. An example of a standard sloping sidewalks is shown in Figure 14.

Sloped Pathways & Pavement Alternate

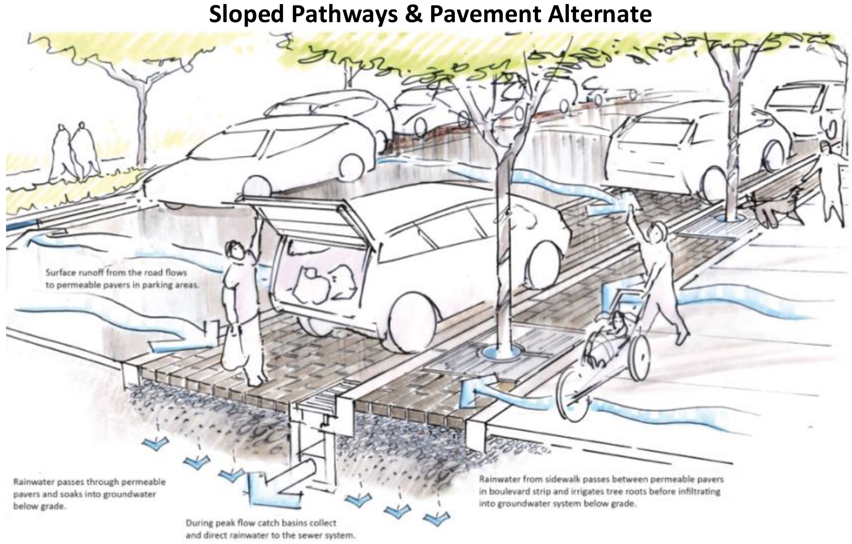


Figure 14. City of Vancouver Typical Detail for Positively Drained Runoff and Porous Pavement

Our design includes the usage of porous asphalt as an alternate to the conventional impervious hard surfaces commonly used which will increase surface permeability and reduce surface runoff. In recent years, the use of permeable concrete in low volume road applications (bike and pedestrian paths) has grown due to the environmental benefits associate with it. Although initial costs and maintenance is roughly two times the cost of traditional asphalt (refer to Section 6.0 – Cost Estimate), R&G believes that this is outweighed by the notion that the porous asphalt locations will not require side drains, overlays, storm water drainage systems, etc. thus balancing the overall cost to the project. Furthermore, because of their high void space and ability to expand during freeze-thaw cycles, porous asphalt is minimally affected by freeze-thaw cycles which decreases maintenance costs.

R&G has designed for the addition of rain gardens and infiltration trenches to help protect bodies of water near UBC from pollutants that are washed from paved areas. Rain gardens and infiltration trenches will treat rainwater all while reducing the impact on the stormwater infrastructure. R&G will install a total of 11 infiltration trenches which will be dispersed throughout the roadway and be located adjacent to the curb. A total of 18 rain gardens will be installed in open areas beside sidewalks and shared multi use paths to incorporate water retention systems while enhancing natural aesthetics. An example of a standard rain garden is shown in Figure 15.

Rain Gardens and Infiltration Trenches

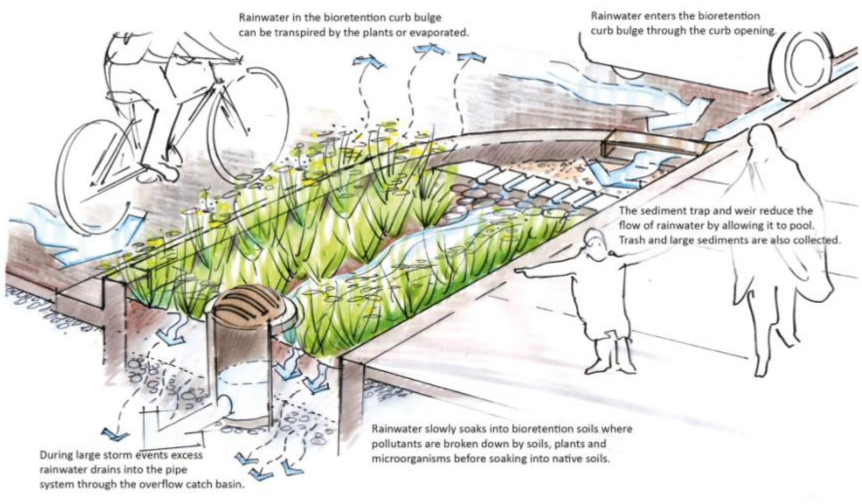


Figure 15. City of Vancouver Typical Detail for Subsurface Infiltration

3.1.7. AESTHETICS

The design incorporates various aesthetic road features where appropriate. The following is a list of additions added in the detailed design, including, but not limited to:

- Musqueam Roadway and Overpass Art
- Direction Signage (to separate bikers and pedestrians multi-use pathways)

3.2. DESIGN RATIONALE

In development of the project design, R&G has adopted the triple-bottom-line framework. This is an accountability framework which emphasizes on the financial, environmental, and social aspects of the project. In this section, R&G has summarized benefits and considerations of the project design.

3.2.1. ECONOMIC BENEFITS

To ensure the design is economically sensible, R&G has incorporated several cost-effective solutions in our design:

- **Pedestrian Overpass:** R&G has performed an elementary cost analysis and determined that constructing an overpass would be more economical compared to the underpass option, as it does not involve the relocation of utilities, and conducting a more detailed geotechnical assessment.
- **Optional Upgrades:** In the final detailed design, R&G has proposed the use of the most cost-effective solution while balancing environmental and societal aspects. However, R&G understands the importance of sustainability for the client. Therefore, our team has provided the client with optional upgrades that can be used to further improve the sustainability aspects of this traffic corridor. As an option, the client can opt to use porous asphalt as an alternative to Superpave asphalt for the bike lanes or shared paths (Option 1). We have also included the option to increase the number of rain gardens (Option 2) and infiltration trenches (Option 3). After the preliminary consultation, the client opted for Option 1 and Option 3. The associated costs of these upgrades are listed in the cost estimate (Section 6.0.).
- **Detailed Construction Planning:** R&G has incorporated detailed risk analysis and construction planning into the schedule and Class A cost estimate to minimize the unforeseen changes or major costs will be added in later stages.
- **Early Communication and Compliance with Permitting and Regulations Authorities:** Permitting authorities will be contacted early to attain the relevant permits and documentation to expediate the construction process and avoid any delays that can result in economic losses.

3.2.2. ENVIRONMENTAL BENEFITS

R&G recognizes the importance of environmental stewardship in engineering projects. Our team has considered the following into the design:

- **Maximizing Green Spaces and Minimizing Tree Loss:** To be conscientious of the environment and stormwater management, R&G has developed a design which incorporates green spaces (i.e., rain gardens, infiltration trenches, green roof) and tree relocation. By maintaining the green spaces and trees on site, our design will not increase the level of surface runoffs and, thus, the demand for the stormwater management system.
- **Minimizing Environmental Impacts:** The construction methodology is conscious of the surrounding environment and employs approaches with minimal GHG and carbon emissions while avoiding any possible contamination and seepage of toxic materials into nearby ecosystems such as Pacific Spirit Park. To minimize disturbance to the surrounding environment, our team has allocated a sufficient cost for environmental management of the project during construction.

3.2.3. SOCIETAL BENEFITS

R&G ensured that the project benefits the community by addressing the following stakeholder needs and expectations:

- **Minimizing Reduction in Parking Spaces:** As parking spaces are limited near UBC, individuals rely on the parking spots along Wesbrook Mall to access neighbouring recreational facilities. During development of our design, we ensured minimum disturbance to these existing parking lanes in both directions. R&G was successful in maintaining the parking lanes undisturbed, but restrictive parking hours will be implemented to allow bus usage of this lane. Nevertheless, little impact is expected to users during these hours.
- **High Stakeholder Satisfaction:** Due to the implementation of the robust and comprehensive stakeholder consultation plan, identified stakeholders (outlined in Section 2.2.6. and Appendix A) provided their input and informed the design and construction plan process.

- *Indigenous Community:* UBC Musqueam were consulted and raised concerns were addressed regarding environmental impacts, while incorporating Musqueam art where possible.
- *UBC Community (incl. UBC residents, students, faculty, and staff)*: Survey results and open houses identified the challenges faced by individuals who use and live near this corridor; challenges were mitigated with various design components such as pedestrian overpass and improved sidewalk conditions.
- *UBC Facilities:* Early consultation and collaboration with UBC Athletics and Recreation assisted in mitigating adverse effects to their operation during the construction phase.
- *External Parties:* Permitting authorities and organizations such as TransLink were consulted to ensure the design did not conflict with future projects, and abided by regulations, bylaws and permitting requirements.
- *Project Clients (incl. UBC SEEDS and UBC Campus and Community Planning):* Regular client meetings ensured design and construction plans accurately captured their needs.

3.2.4. SAFETY IMPROVEMENTS

The final detailed design underwent rigorous testing and modelling to ensure the safety of users when interacting with infrastructure in the corridor. The following components improve safety in comparison to the existing roadway:

- **Raised Bike Lane:** Safety of cyclists and comfort of drivers.
- **Shared Path:** Safety of cyclists with use of appropriate easy-to-read and self-explanatory signage to maximize safety between cyclists and pedestrians, particularly in high traffic areas such as bus stops.
- **Pedestrian Overpass:** Safety of pedestrians.
- **Sidewalk Repair:** Re-surfacing the damaged sidewalk areas to improve safety and comfort of pedestrians.
- **Asphalt Re-surfacing**: Safety of vehicle and bus drivers.

3.2.5. PROMOTION OF ACTIVE TRANSPORTATION

The detailed design promotes and prioritizes active modes of transportation through the following avenues:

- **Shared Path**: R&G's detailed design includes a shared path in the northbound direction. The path supports multi-modal transportation, such as walking, biking, and wheelchair use. The 3.2-metre shared path is designed to encourage and promote active, multi-modal transportation.
- **Raised Bike Lane**: R&G recognizes that bike users have little space between the moving traffic and the parked vehicles. With the location of the existing bike lane, it may deter some traffic users from cycling. In our detailed design, we have designed the bike lanes to be at the elevation of the sidewalk and on the safe side (away from moving traffic) of the parked cars. With this modification, the overall safety and user experience of bike lane will increase. This will attract more traffic users to cycle as opposed to driving their own vehicles which reduces the number of vehicles on the road and promotes active transportation.
- **Priority Bus Lane**: R&G is conscientious of the importance of prioritizing active, multi-modal transportation. Our team plans to accommodate a bus lane during peak traffic hours in the northbound direction by modifying existing parking lane restrictions. The bus lane encourages traffic users to use public transportation (i.e., buses) over private transportation (e.g., cars).

3.2.6. EFFECTIVE TIE-IN TO EXISTING WORKS

R&G recognizes that ensuring an effective tie-in to the existing infrastructure is a crucial part of the project design. Drawing inspiration from Phase 2 of the project, our team has ensured that our design can be well-integrated into the existing works. Proper signage and clear delineations will be provided where necessary to provide a cohesive road network to the UBC community.

3.2.7. MINIMAL TRAFFIC CONGESTION

To minimize traffic congestion in the area, R&G has incorporated:

- **Pedestrian Overpass:** The pedestrian overpass provides a safe alternative way to cross the busy Wesbrook Mall corridor. This overpass should relieve the demand for pedestrians to cross at crosswalks which will significantly enhance traffic flow and expand road capacity.
- **Priority Bus Lane:** This feature will maximize time efficiency for cars and busses when changing lanes. The bus lane will minimize the potential likelihood of conflicts in the busiest hours of the day. This is particularly beneficial to the local community, UBC students and staff, and other traffic users as the public transportation system allows for mass transit of travelers with fewer vehicles on the roadway. The bus lane reduces traffic congestion and increases the overall efficiency of neighbouring road networks. This ultimately results in an increase in traffic user satisfaction since the peak-hour bus lane will enable road users to spend less time in traffic, on average.

3.2.8. DESIGN AESTHETIC, COMFORT AND USABILITY

For a satisfactory user experience and to ensure aesthetic alignment with other UBC infrastructure, the following aesthetic design elements are incorporated:

- **Benches and Bus Stop Shelters:** Where appropriate, benches and bus stop shelters will be upgraded to increase user comfortability (i.e., shelter from rainfall).
- **Musqueam Roadway and Overpass Art:** Where possible, Musqueam art will be incorporated at crossings and on the pedestrian overpass.
- **Direction Signage:** Signage will be embedded throughout the corridor, with a marketing style similar to other UBC direction signs.

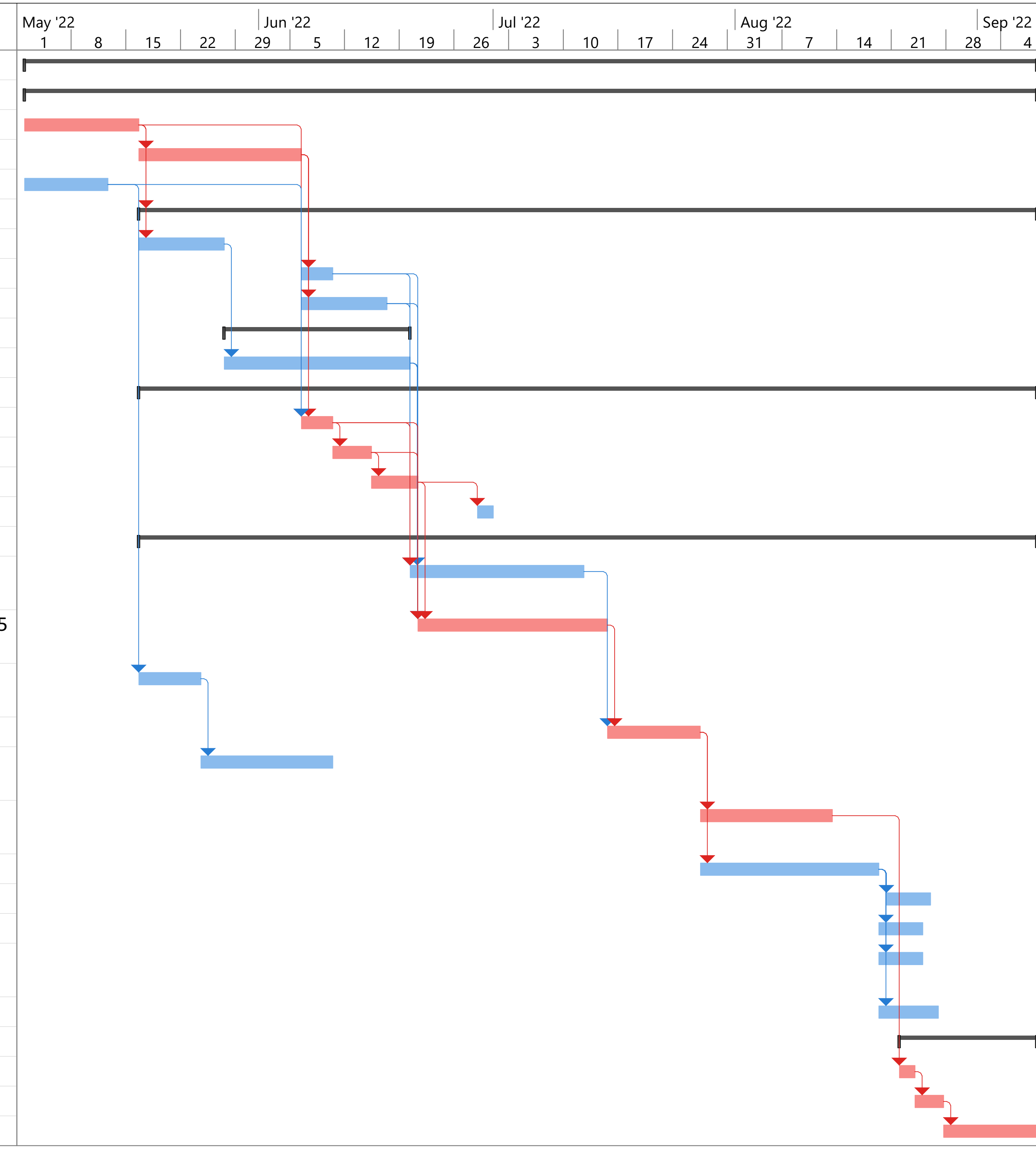
4. SCHEDULE

The construction of this design is expected to begin on Monday, 2-May-22 and will complete by Thursday, 8-Sept-22. The construction tasks are outlined in Figure 16. Since the duration of each task depends on the quantity of work to be completed and the general crew size, the following assumptions are made:

- To complete this phase before the first day of classes at UBC in September, working days consist of 8-hour shifts including Saturdays.
- The schedule outlines the activities that occur concurrently, commencing with removals and reinstallations, followed by placement and construction of the new infrastructure. These major tasks can be sequenced differently for various sections of the corridor based on contractor's traffic management and work plans, and discretion. We have dedicated a sufficient lump sum cost for traffic management to minimize delays (Refer to Section 6.0.).
- The critical activities highlighted in red will need to be prioritized to achieve the desired end-date of 8-Sep-22. Contrarily, the remaining tasks allow for float days which assists the contractor to assign more resources to critical activities if needed. The allowed contingency aids in capturing the extra cost to finish the project on-time (refer to Section 6.0.).
- For the activities that can occur in parallel, different crews will be employed to work simultaneously.
- The duration of each major activity has been chosen based on production rate per shift. These rates are outlined in Appendix E. R&G is confident that these production rates can be achieved with one general crew for every task, however, these rates may change based on the contractor's discretion.
- Minor activities have been set to be completed by a certain date to minimize impact to the critical path. However, these activities, such as line painting or landscaping, have not been given a specific rate, as their completion is necessary to meet the project end-date.
- The tasks that start after any concrete pour have been set to start seven days after the pour date to allow for concrete to develop its required strength.

Figure 16. Estimated Construction Schedule

ID	Task Name	Duration	Start	Finish	Predecessors
1	**Phase 4 - Wesbrook Mall Upgrade Project**	**114 days**	**Mon 5/2/22**	**Thu 9/8/22**	
2	**Removals - Roadworks and Flatworks**	**114 days**	**Mon 5/2/22**	**Thu 9/8/22**	
3	Curb and Gutter Removals	13 days	Mon 5/2/22	Mon 5/16/22	
4	Road Asphalt Removals	18 days	Mon 5/16/22	Mon 6/6/22	3
5	Concrete Sidewalk Removals	10 days	Mon 5/2/22	Thu 5/12/22	
6	**Removals - Drainage and Shallow Utilities**	**101 days**	**Mon 5/16/22**	**Thu 9/8/22**	**3**
7	Catch Basin Removals and Salvage	10 days	Mon 5/16/22	Fri 5/27/22	3
8	Manhole Adjustments	4 days	Mon 6/6/22	Fri 6/10/22	4
9	Relocation of Any Conflicting Utilities	10 days	Mon 6/6/22	Fri 6/17/22	4
10	**Drainage Installations**	**20 days**	**Fri 5/27/22**	**Mon 6/20/22**	
11	Catch Basin Re-install	20 days	Fri 5/27/22	Mon 6/20/22	7
12	**Bridge Structural Construction**	**101 days**	**Mon 5/16/22**	**Thu 9/8/22**	
13	Excavation and Grading for the Footings	4 days	Mon 6/6/22	Fri 6/10/22	3,4,5
14	Form and Pour the Footings	4 days	Fri 6/10/22	Wed 6/15/22	13
15	Form and Pour the Footing Columns	5 days	Wed 6/15/22	Tue 6/21/22	14
16	Installation of the Girder	2 days	Wed 6/29/22	Thu 6/30/22	15FS+7 days
17	**Roadworks and Flatworks**	**101 days**	**Mon 5/16/22**	**Thu 9/8/22**	
18	Placement and Grading of 19mm Gravels on the Road	20 days	Mon 6/20/22	Tue 7/12/22	8,9,11,13
19	Placement and Grading Gravels for Bike Lanes and Shared Paths	22 days	Tue 6/21/22	Fri 7/15/22	8,9,11,13,14,15
20	Placement and Grading of Gravels for the 1.8m Separate Sidewalk	7 days	Mon 5/16/22	Tue 5/24/22	5
21	Curb and Gutter Placement	10 days	Fri 7/15/22	Wed 7/27/22	18,19
22	Concrete Pour/Asphalt Pavement for the 1.8m Separate Sidewalk	15 days	Tue 5/24/22	Fri 6/10/22	20
23	Placement of 50mm Asphalt on Bike Lanes and Shared Paths	15 days	Wed 7/27/22	Sat 8/13/22	21
24	Placement of 140mm Asphalt for the Road	20 days	Wed 7/27/22	Fri 8/19/22	21
25	Line Painting	5 days	Sat 8/20/22	Thu 8/25/22	24FS+1 day
26	Landscaping of the Disturbed Green Areas	5 days	Fri 8/19/22	Wed 8/24/22	24
27	Installation of Any Aesthetic Road Features or Street Furnitures	5 days	Fri 8/19/22	Wed 8/24/22	24
28	Installation of Storm Water Retention Systems	7 days	Fri 8/19/22	Fri 8/26/22	24
29	**Bridge Finishing Works**	**16 days**	**Mon 8/22/22**	**Thu 9/8/22**	
30	Installation of Stairs	2 days	Mon 8/22/22	Tue 8/23/22	23FS+7 days
31	Installation of the Green Roof	4 days	Wed 8/24/22	Sat 8/27/22	30
32	Bridge Aesthetics and Finishing Works	10 days	Sat 8/27/22	Thu 9/8/22	31



Project: rev 1 Asal
Date: Thu 12/2/21

Task
Split
Milestone
Summary
Project Summary
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
External Tasks
External Milestone
Deadline
Critical
Critical Split
Progress
Manual Progress

5. CONSTRUCTION PLAN

The construction of the detailed design is divided into three major activities: removals, roadworks and flatworks and overpass constructions. This section aims to further elaborate on these activities. The major activities will be completed in the order listed in Section 5.0. While we have identified the sequence in which these major activities are undertaken, it is up to the contractor's discretion to segment the roadway with minimal disturbance to the traffic flow.

5.1. REMOVALS

To allow for any new construction and road upgrades, the construction is required to begin with removing the existing infrastructure in the boundary of new design. This will include the removals of:

- Curb and Gutter
- Asphalt
- Sidewalk
- Catch Basins
- Conflicting Utilities

Any deep and shallow utilities that need to be relocated will be salvaged to accommodate the new curb line.

5.2. OVERPASS CONSTRUCTION

Once the existing sidewalk adjacent to the overpass is removed, the construction of the foundation can commence with the excavation and grading for the footings, the installation of formwork and rebar, and the pouring of concrete for the footings and the columns.

Once the concrete is cured, the precast members can be placed. Followed by the installation of the prefabricated stairs after completing the backfill around the columns and the construction of the sidewalk and bike lane. The remaining finishing works of the overpass, such as aesthetics and the green roof, can begin at any time before the end of construction dependent on crew availability, the status of critical path activities and road closure windows.

5.3. ROADWORKS AND FLATWORKS

The construction of the road will begin by relocating the salvaged utilities such as catch basins and then re-building the removed gravels for the road structure. Before any asphalt is placed for pavement, concrete curb and gutter must be poured and cured. Then, the road can be paved.

The same procedure needs to be followed for the pavement of the bike lane and shared path. Concrete pour for the sidewalk will take place after placement and grading of the gravel base. After completion of pavement, line painting, installation of street furniture and signage and landscaping can take place.

5.4. ANTICIPATED CONSTRUCTION CHALLENGES

The following are some of the anticipated challenges associated with construction along this corridor.

- **Safety:** While safety is not a typical challenge, if compromised it can result in significant delays and cost overruns for construction projects. R&G will prioritize safety by selecting a contractor that understands and values its importance while possessing a strong reputation to avoid future complications.
- **Traffic Management Flow:** Since Wesbrook Mall is a major traffic corridor, disturbances to traffic flow may result in cost penalizations from the University. Therefore, identifying traffic flow as a challenge is essential to avoid any extra cost overruns to the budget. R&G has also allocated a sufficient budget to traffic management for implementing a robust traffic management plan during construction.
- **Unknown Underground Utilities:** As identified from previous client meetings and site visits, the location of underground utilities possesses a high degree of uncertainty and as such is a major challenge for construction. Our team has allocated a lump sum amount in the budget to over excavation costs in the situation where unknown utilities are discovered. This will minimize unnecessary delays and cost overruns.
- **Weather:** In Vancouver, rain can cause delays to some activities such as concrete pour and asphalt placement which we plan to monitor and operate activities accordingly.

- **Supply Shortage:** Because of current world events, R&G has identified supply shortages as a challenge to ensure material and equipment is received on-site in a timely manner. Due to these events, escalations in prices are anticipated and have been considered in the Class A cost estimate (outlined in Section 6.0).

5.5. SERVICE-LIFE MAINTENANCE PLAN

Maintenance of the proposed corridor is necessary to ensure the service life of 50 years is fulfilled. All maintenance and warranties to conform to UBC Vancouver Technical Specifications, Government of BC Schedule 1 – Section 6 General Specifications, and UBC Vancouver Campus Plan – Part 3 Design Guidelines. R&G's proposed maintenance plan includes the following actions:

- **Surface maintenance** is achieved to provide smooth, stable sealed surface for roadway and bicycle-pedestrian paths. This includes asphalt pavement maintenance, surface cleaning, surface treatment, dust control and base stabilization.
- **Drainage maintenance** is completed to provide unobstructed drainage for all roadways and neighbouring facilities.
- **Winter maintenance** includes snow removal and ice control on roadway and bicycle-pedestrian paths to provide and facilitate safe and orderly flow of traffic.
- **Roadside maintenance** is conducted to improve visibility, maintain green infrastructure, and facilitate drainage. This includes, but not limited to, plant and vegetation control, bus shelter and rest area maintenance, sign and pavement marking maintenance and litter collection.
- **Structures maintenance** is mainly attached to the maintenance of the pedestrian overpass which includes maintenance on the bridge deck, minor coatings, bridge railing maintenance and structures cleaning and drainage maintenance. All the aforementioned items, together, will provide a safe, uniform, smooth and durable bridge structure.

6. COST ESTIMATE

The total cost of Phase 4 will be **$6,254,661 including 10% contingency**. The cost breakdown is presented in Figure 17. R&G has allocated a large lump sum to traffic management, environmental management, quality management and project management services to ensure an efficient and sustainable delivery of the project.

The costs have been determined based on market values and previous project experience for each task. R&G members are experienced with unit rates from constructing part of the new Highway 91/17 Upgrade Project and have completed detailed and thorough analysis on determining unit rates for this Class A cost estimate. Comparable to the schedule, a general crew and appropriate equipment cost has been incorporated in the unit price generated. The below assumptions were made in preparation of our cost estimate:

- The supply of materials such as 19 mm and 75 m gravels, concrete and asphalt have been accounted for in their respective construction activity for flatworks and roadworks. The quantity of these materials has been calculated form standard details by the City of Vancouver and quantity take-offs from our detailed design drawings (Refer to Drawing C010 in Appendix C).
- All above ground and underground utilities and furniture, such as streetlights, bus stop shelters and catch basins, will be salvaged, and saved for re-installation or relocation upon removals. No cost has been dedicated for new street furniture purchase in these categories.
- An over excavation lump sum cost of $500,000 has been added in the Class A estimate to capture any extra works required if conflicting unknown underground utilities are found within our design boundary.
- Bridge materials have been listed as separate items due to the use of pre-cast and prefabricated materials.
- Minor activities such as landscaping, line painting, electrical works, and supply and installation of storm water retention systems have been listed as lump sum cost to ensure sufficient budget allocations.
- The tasks on the critical path have been allocated a higher unit rate to ensure that they are completed on schedule.

- Due to current inflation rates observed in British Columbia, coinciding with the supply shortage and unstable economy, prices for materials and operation have been escalated to avoid cost overruns during construction.
- The optional items presented to the client in the preliminary stage were accepted and have been incorporated into the Class A cost estimate. These items are the use of porous asphalt on the bike lanes and shared paths and eight additional infiltration trenches.
- As mentioned, a contingency of 10% has been considered due to the time constraint for the duration of construction and ensuring a project end-date of 8-Sept-22 before the start of classes at UBC.

Figure 17. Class A Cost Estimate

Item #	Description	Unit of Measure	Quantity	Unit Price ($)	Amount ($)
Section 1	**General**				
1.01	Mobilization	L.S	1	$ 100,000.00	$ 100,000.00
1.02	Traffic Management	L.S	1	$ 100,000.00	$ 100,000.00
1.03	Quality Management	L.S	1	$ 30,000.00	$ 30,000.00
1.04	Environmental Management	L.S	1	$ 25,000.00	$ 25,000.00
1.05	Project Management Services	L.S	1	$ 50,000.00	$ 50,000.00
Item #	Description	Unit of Measure	Quantity	Unit Price ($)	Amount ($)
Section 2	**Materials**				
2.1	**Bridge Materials**				
2.1.1	Cast-in-place Concrete	M3	12	$ 500.00	$ 6,000.00
2.1.2	Pre-fabricated Steel Stairs	Each	2	$ 12,000.00	$ 24,000.00
2.1.3	Pre-cast Slab	Each	1	$ 20,000.00	$ 20,000.00
Section 3	**Construction Activities**				
3.1	**Removals - Roadworks and Flatworks**				
3.1.1	Curb and Gutter Removals	LM	1240	$ 50.00	$ 62,000.00
3.1.2	Asphalt Removals	MT	11900	$ 20.00	$ 238,000.00
3.1.3	Concrete Sidewalk Removals	LM	750	$ 30.00	$ 22,500.00
3.1.4	Overexcavation cost	LS	1	$ 500,000.00	$ 500,000.00
3.2	**Removals - Drainage and Shallow Utilites**				
3.2.1	Catch Basin Removals and Salvage	Each	41	$ 3,500.00	$ 143,500.00
3.2.2	MH Adjustments (Raising)	Each	10	$ 1,500.00	$ 15,000.00
3.2.3	Relocation and Re-wiring Conduits and Cables	LS	1	$ 80,000.00	$ 80,000.00
3.3	**Drainage Installations**				
3.3.1	Catch Basin Re-install	Each	41	$ 4,000.00	$ 164,000.00
3.4	**Bridge Structural Construction**				
3.4.1	Excavation and Grading for the Footings	Each	4	$ 3,000.00	$ 12,000.00
3.4.2	Form and Pour the Footings	Each	4	$ 4,500.00	$ 18,000.00
3.4.3	Form and Pour the Footing Columns	Each	4	$ 4,000.00	$ 16,000.00
3.4.4	Installation of the Girder	Each	1	$ 15,000.00	$ 15,000.00
3.5	**Roadworks and Flatworks**				
3.5.1	Supply, Placement and Grading of 19mm Gravels for the Road	M2	11900	$ 30.00	$ 357,000.00
3.5.2	Supply, Placement and Grading of Gravels for Bike Lanes and Shared Paths	M2	1705	$ 75.00	$ 127,875.00
3.5.3	Supply, placement and Grading of Gravels for the 1.8m Separate Sidewalk	M2	1350	$ 70.00	$ 94,500.00
3.5.4	Concrete Pour for Curb and Gutter	LM	124	$ 170.00	$ 21,080.00
3.5.5	Concrete Pour/Asphalt Pavement for the 1.8m Separate Sidewalk	LM	550	$ 260.00	$ 143,000.00
3.5.6	Supply and Placement of 50mm Porous Asphalt on Bike Lanes and Shared Paths	M2	1705	$ 370.00	$ 630,850.00
3.5.7	Supply and Placement of 140mm Asphalt on the Road	M2	11900	$ 200.00	$ 2,380,000.00
3.5.8	Line Painting	LS	1	$ 80,000.00	$ 80,000.00
3.5.9	Landscaping of the Disturbed Green Areas	LS	1	$ 12,000.00	$ 12,000.00
3.4.10	Aesthetics, Road Features and Street Furniture	LS	1	$ 50,000.00	$ 50,000.00
3.6	**Storm Water Retention**				
3.6.1	Supply and Install of Rain Gardens	Each	10	$ 3,000.00	$ 30,000.00
3.6.2	Supply and Install of Infiltration Trenches	Each	11	$ 8,000.00	$ 88,000.00
3.7	**Bridge Finishing Works**				
3.7.1	Stair Installation	Each	2	$ 6,000.00	$ 12,000.00
3.7.2	Bridge Aesthetics and Finishing Works	LS	1	$ 15,000.00	$ 15,000.00
3.7.3	Green Roof Installation	M2	15	$ 250.00	$ 3,750.00
				Sub-total	**$ 5,686,055.00**
Section 4	**Contingency**	%	10		$ 568,605.50
				Total	**$ 6,254,660.50**

7. CONCLUSION

R&G's final detailed design has the following features:

- A 1.8-metre raised, protected bike in both directions.
- A multi-use path with delineated spaces for pedestrians and cyclists in the northbound direction.
- A resurfacing of the damaged sidewalk in the southbound direction.
- A peak-hour bus lane in the northbound direction and bus lane maintained in the southbound direction.
- A pedestrian overpass near the Thunderbird Stadium, comprising of a precast concrete deck, square concrete columns and footings, two flights of steel stairs and a green roof.
- A variety of green infrastructure embedded throughout the corridor by using a green street approach, such as sloped sidewalks and paths, 10 rain gardens and 11 infiltration trenches and an anticipated removal of 5-10 trees.

Along with the above infrastructure upgrades, R&G performed detailed data analyses to account for future population growth and capacity demands throughout the Wesbrook Mall corridor. The design prioritizes sustainability by incorporating rain gardens, infiltration trenches, and a green roof on the overpass. Furthermore, the final detailed design places heavy emphasis and consideration on economic, environmental, and societal impacts. **The estimated construction timeline is to be from 2-May-22 to 8-Sep-22 with a total cost of $6,254,661.**

REFERENCES

Antunes, L., Ghisi, E., & Thives, L (2018). Permeable Pavement Life Cycle Assessment: A Literature Review https://www.researchgate.net/publication/328723484_Permeable_Pavements_Life_Cycle_Assessment_A_Literature_Review

BC Publications (2018). "British Columbia Building Code 2018, Division B." https://free.bcpublications.ca/civix/document/id/public/bcbc2018/bcbc_2018dbp4s41.

City of Vancouver (2019). "Rain City Strategy: A Green Rainwater Infrastructure and Rainwater Management Initiative." https://vancouver.ca/files/cov/one-water-gri-typologies.pdf.

City of Vancouver (2010). "Roofing Green Home Renovation Healthy Homes for a Healthy Environment." https://vancouver.ca/files/cov/green-roofing-guide.pdf.

Conservation Technology (2008) "Green Roof Handbook Systems and Components for Optimal-Performance Green Roofs." http://www.conservationtechnology.com/documents/GreenroofHandbook0116.pdf.

CSA A23.3:19 (2019) "Design of Concrete Structures" https://www.csagroup.org/store/product/CSA%20A23.3%3A19/?gclid=CjwKCAjwxZqSBhAHEiwASr9n9Ca3mD3lo-DFl-sxWAhYvsbR8Y4xvoINFokZtAupPQ-ynjrd0cRVKBoCQ6IQAvD_BwE

Government of British Columbia (2020). "Schedule 1 – Section 6 General Specifications.

https://www2.gov.bc.ca/assets/gov/driving-and-transportation/transportation-infrastructure/highway-bridge-maintenance/highway-maintenance/maintenance-agreements/maintenance-specifications/schedule_1a_specifications_revised_2020-02-01.pdf

Interreg North-West Europe. "Design Principles: Clearance (Lack of) Obstacles." https://cyclehighways.eu/index.php?id=226.

Technical Preservation Services. "Green Roof Benefits." https:/G/www.nps.gov/tps/sustainability/new-technology/green-roofs/benefits.htm.

The University of British Columbia (2010). "UBC Vancouver Campus Plan – Part 3: Design Guidelines" https://planning.ubc.ca/sites/default/files/2019-11/PLAN_UBC_CampusPlanDesignGuidelines.pdf

The University of British Columbia (2021). "UBC Technical Guidelines" http://www.technicalguidelines.ubc.ca/technical/divisional_specs.html#Div01

APPENDIX A – STAKEHOLDER COMMUNICATIONS PLAN

1. KEY STAKEHOLDERS

1.1. INDIGENOUS COMMUNITY

This project will take place on the traditional, ancestral, and unceded territory of the Musqueam people, and as such, appropriate consultation is integrated within the decision-making process and R&G will address and understand any indigenous issues and concern. An array of engagement methods such as, consultation meetings with the Musqueam Chief will be held to address any land-use concerns, the environmental impacts, and educational and employment opportunities. Musqueam culture will be incorporated into the project, such as road art.

1.2. UBC COMMUNITY (INCL. UBC RESIDENTS, STUDENTS, FACULTY, AND STAFF)

With Wesbrook Mall being a critical facility in transportation of large populations in and out of UBC, the redesign of this project will heavily impact the UBC community. The design and construction team will implement proper procedures and communication channels to ensure minimal impacts to the UBC Community and Facilities. The engagement process will outline the periods of the year in which facilities are in high use levels, and as such, construction nearby can be offset to off-peak seasons and construction will be limited to non-peak hours.

1.3. PROJECT CLIENTS (INCL. UBC SEEDS AND UBC CAMPUS AND COMMUNITY PLANNING)

The clients of this project will be continuously consulted as the project advances and is finalized. Clients will be updated through reports and documentation, alongside bi-weekly review meetings to ask and answer questions. R&G will embed the clients' needs and expectations within the redesign while soliciting feedback on the project's progress.

1.4. TRANSLINK

With Wesbrook Mall being home to several transit lines, TransLink must be consulted to ensure the redesign meets its standards and regulations. Furthermore, TransLink will need to approve any changes to the bus routes and bus stop locations; as such, early consultation will be beneficial as the design is being drafted in easing the approval process. TransLink expertise may be requested to create temporary bus routes during construction and possibly design a temporary or permeant bus lane.

2. PUBLIC ENGAGEMENT AND OUTREACH METHODS

The following list of communication channels will be utilized to conduct the consultation process:

- A public website will be set up to include necessary information and updates regarding project progress, timeline, traffic plans, traffic delays, noise pollution and any other relevant information. The website will be updated weekly throughout the project.
- Bi-weekly consultation meetings will be held virtually and in-person (should COVID-19 restrictions allow) with the identified stakeholders. Stakeholders will be contacted directly to set up these meetings in which their input can be provided regularly.
- An online survey will be created and circulated to provide stakeholders with information and to identify their needs, expectations, and concerns. Feedback and survey results will be summarized and released back to the public for transparency of communication.
- Multiple public consultation open houses will be held to educate the public on the project, solicit their feedback on the project’s current stage, and address any concerns.
- Appropriate signage will be set up along Wesbrook Mall throughout the various stages of the project to ensure road users are informed.

2.1 TIMELINE

The stakeholder consultation process was conducted in three phases.

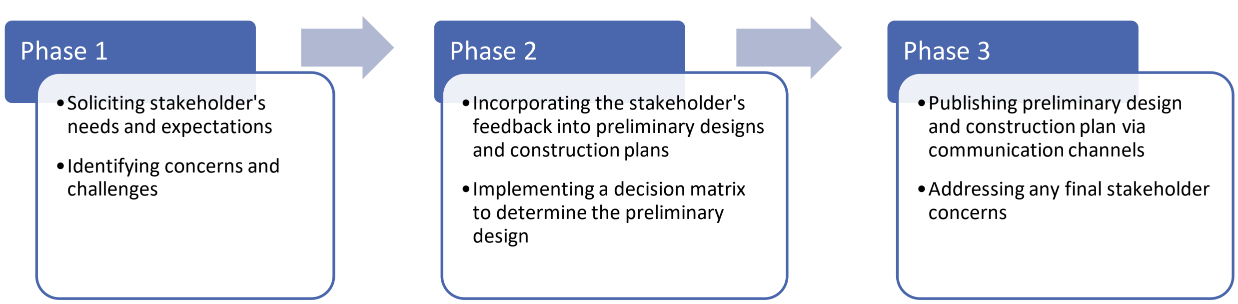


Figure 18. Stakeholder Timeline Overview

APPENDIX B – 3D MODELS

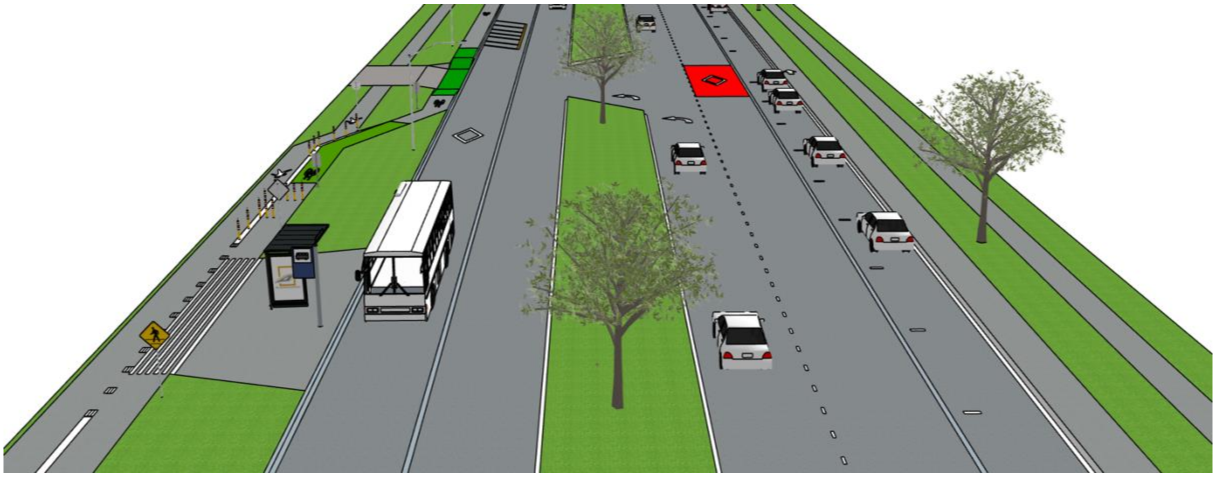


Figure 19. Transition from a Raised Bike Lane to Shared Path in the Northbound Direction

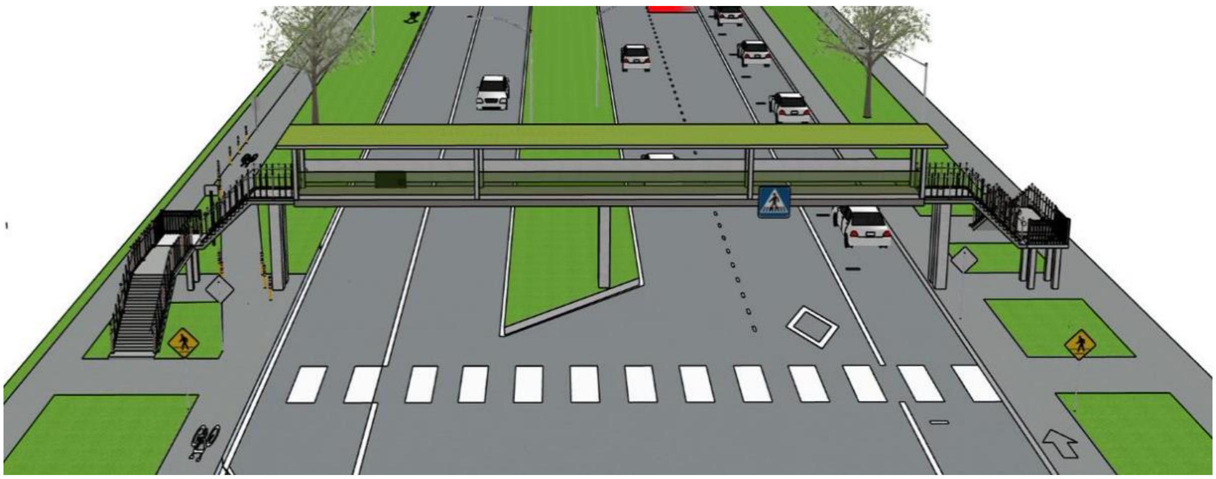


Figure 20. Overpass Facing South

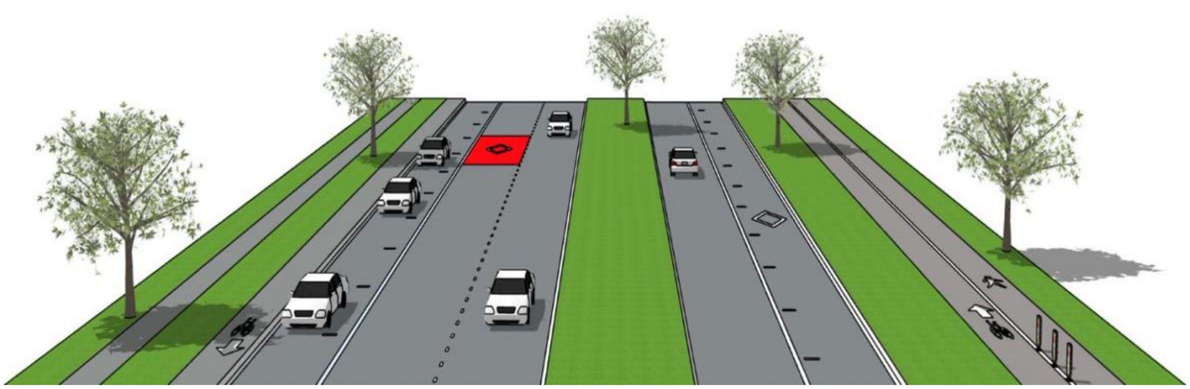


Figure 21. Raised Bike Lane and Share Path Looking North

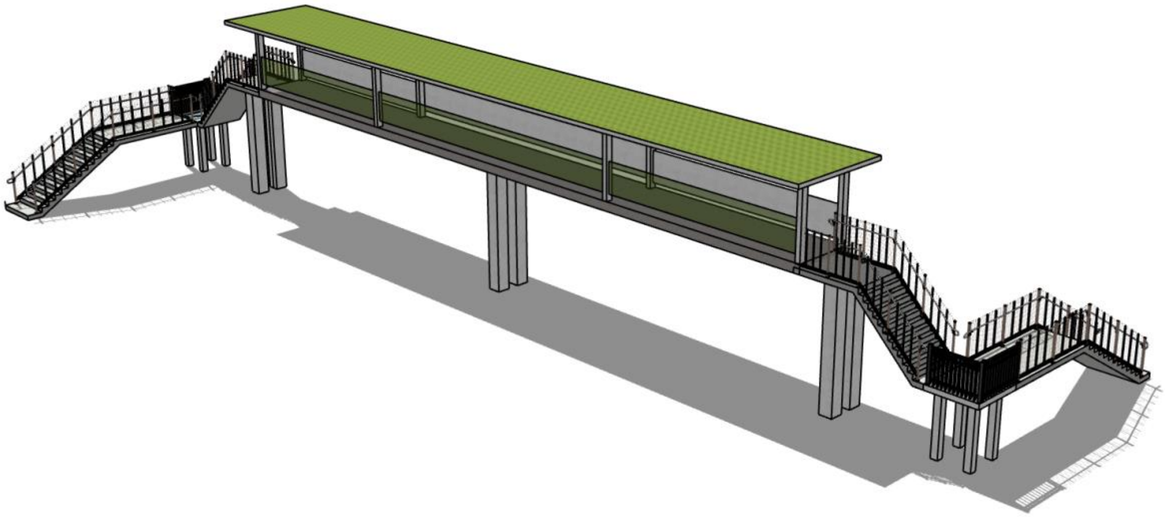


Figure 22. Overpass 3D Model

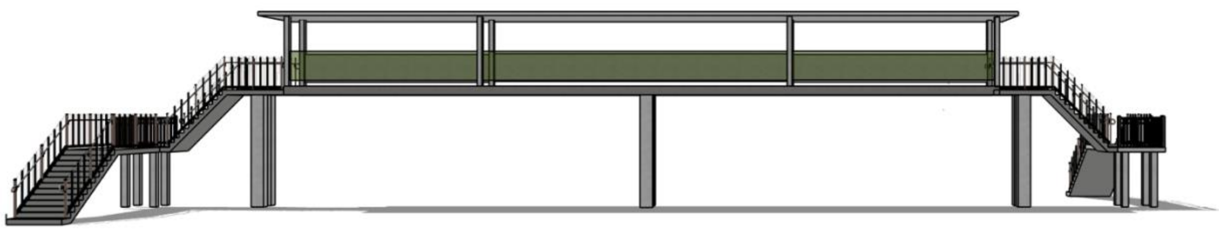


Figure 23. Overpass 3D Model South Facing

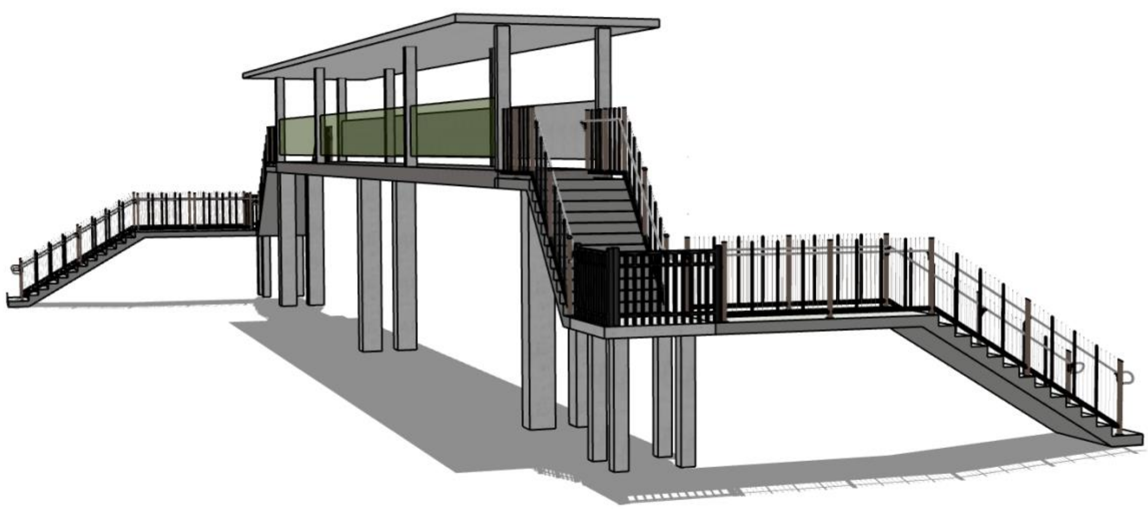


Figure 24. Overpass Stairs West Facing

APPENDIX C – DETAIL DESIGN DRAWINGS

WESBROOK MALL REDESIGN - PHASE 4

WEST 16 AVENUE TO THUNDERBIRD BOULEVARD

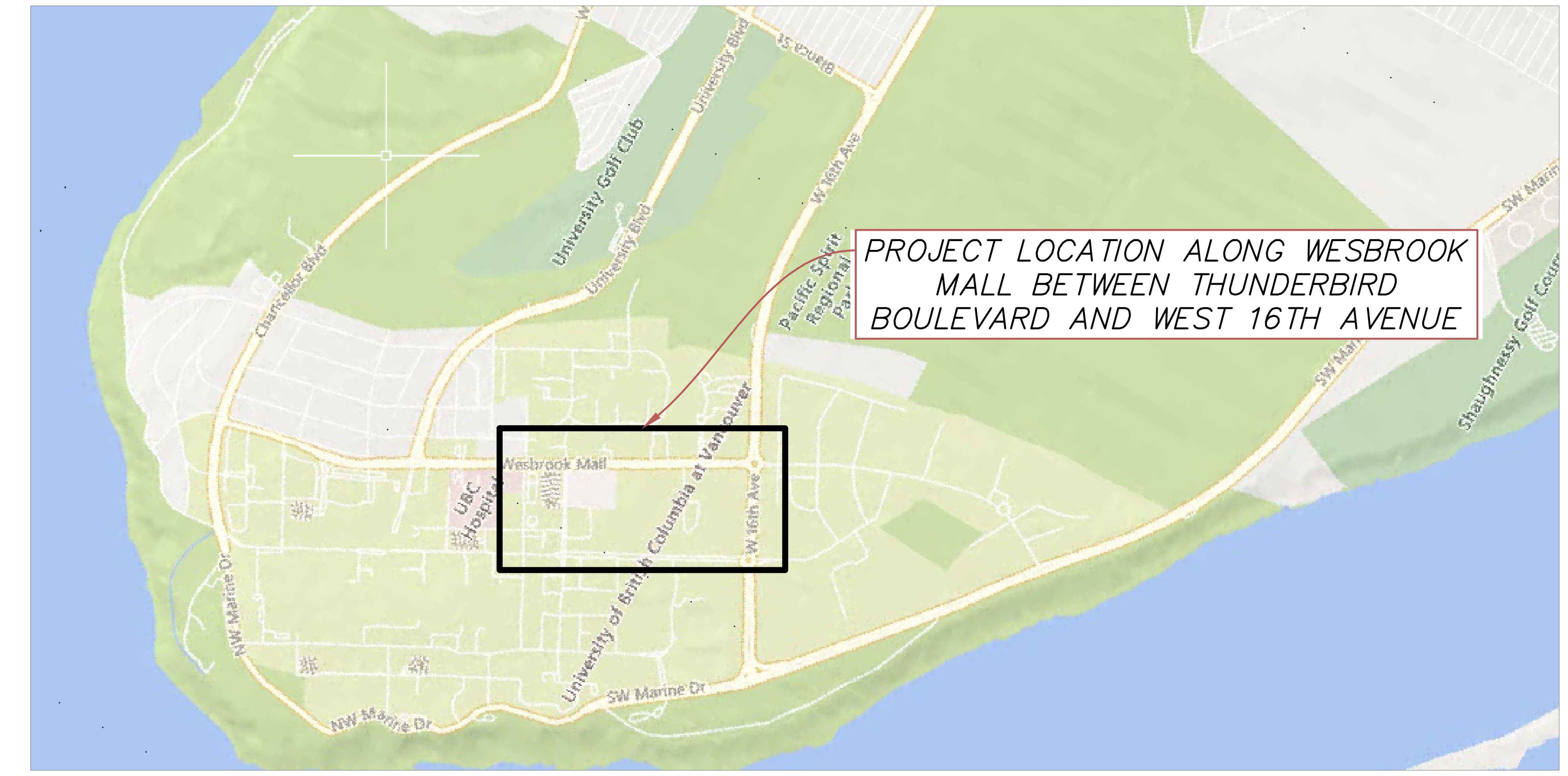
DETAILED DESIGN

INDEX OF DRAWINGS

DRAWING	TITLE
PLAN AND PROFILES	
C-001	COVER
C-002	THUNDERBIRD BOULEVARD SECTION
C-003	PEDESTRIAN OVERPASS SECTION
C-004	HAMPTON PLACE SECTION
C-005	WEST 16TH AVENUE SECTION
C-006	OVERPASS STRUCTURE DETAILS
C-007	OVERPASS REINFORCEMENT DETAILS
C-008	STANDARD DETAILS 1
C-009	STANDARD DETAILS 2
C-010	STANDARD DETAILS 3

DETAILED DESIGN

ISSUED FOR CONSTRUCTION



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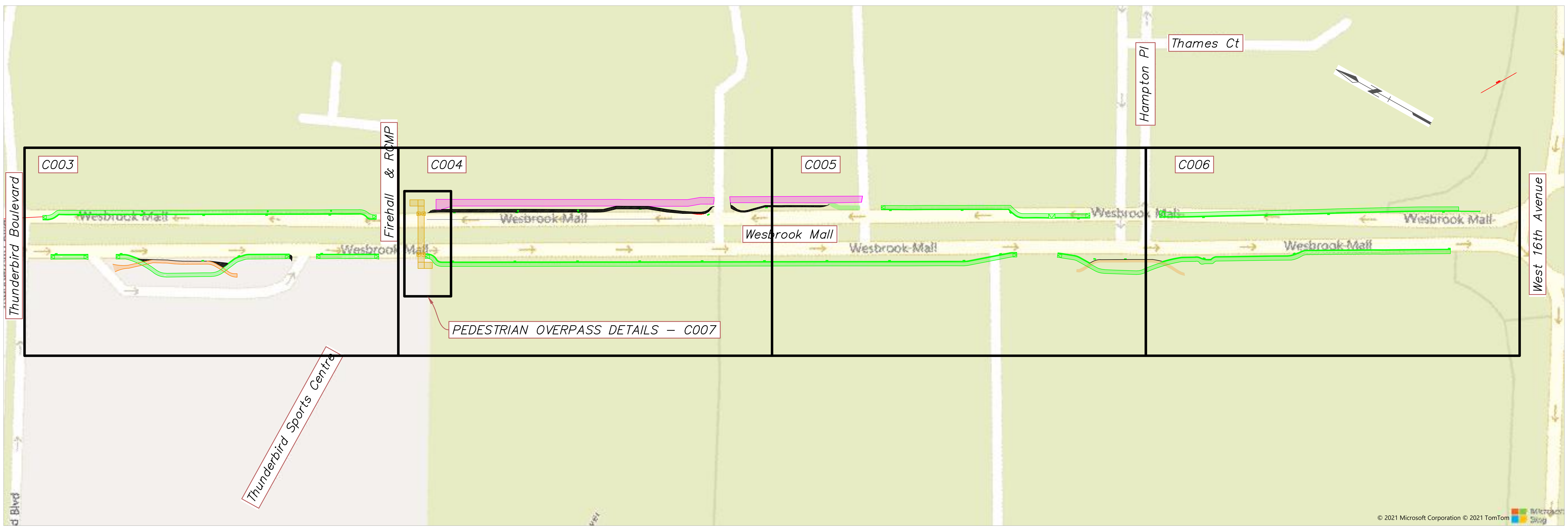

SITE PLAN
1:1000

NOTES:
1. ALL ELEVATIONS AND DISTANCES SHOW ARE IN METRES.
2. ELEVATIONS ARE DERIVED FROM UBC MONUMENT W-W, LOCATED ON EAST MALL IN FRONT OF THE CEME BUILDLING (BETWEEN AGRONOMY ROAD AND UNIVERSITY BOULEVARD) GEODETIC ELEVATION = 93.631
3. THIS PLAN MAY NOT SHOW ALL FEATURES LOCATED WITHIN THE PROJECT BOUNDARIES AND DOES NOT INDICATE BURIED SERVICES THAT MAY EXIST ON OR AROUND THE SUBJECT SITE
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Professional Seal

Issue	Date	Des'n	Dr'n	Chkd	App'd	Description
P2	20220406	ARS	DL	KM	HA	DETAILED DESIGN
P1	20211201	ARS	DL	KM	HA	PRELIMINARY DESIGN

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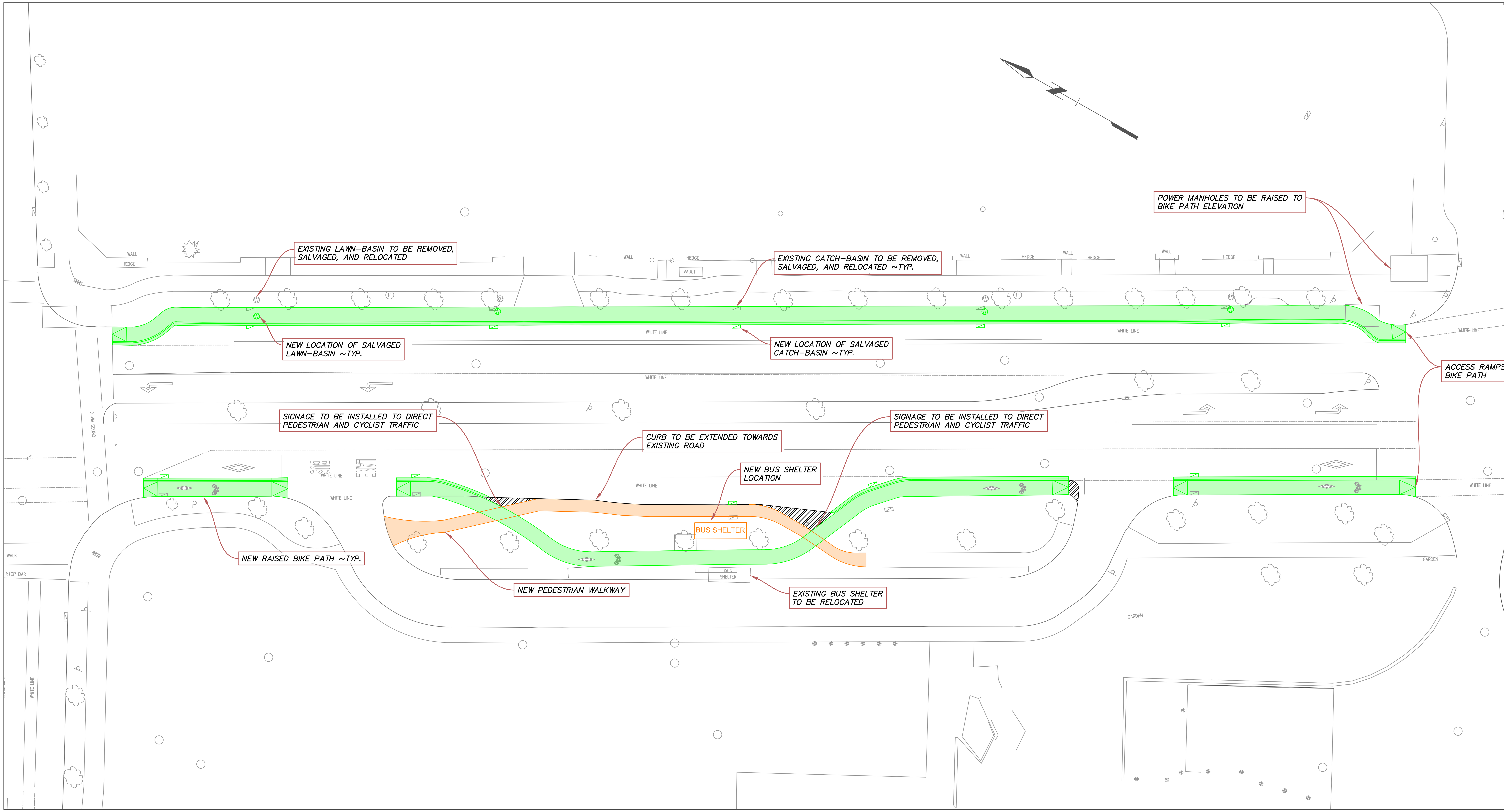
Design: ARS
Drawn: DL
Checked: KM
Approved: HA
Manager: KM

WESBROOK MALL REDESIGN PHASE 4
DETAILED DESIGN

SITE AND PROJECT LOCATION AND OVERVIEW

SCALE: AS NOTED
DISTRICT FILE: 00-0001
DRAWING NUMBER: C001

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO ➡ P2



SITE PLAN
1:4000

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Issue	Date	Des'n	Dr'n	Chkd	App'd	Description
P2	20220406	ARS	DL	KM	HA	DETAILED DESIGN
P1	20211201	ARS	DL	KM	HA	PRELIMINARY DESIGN

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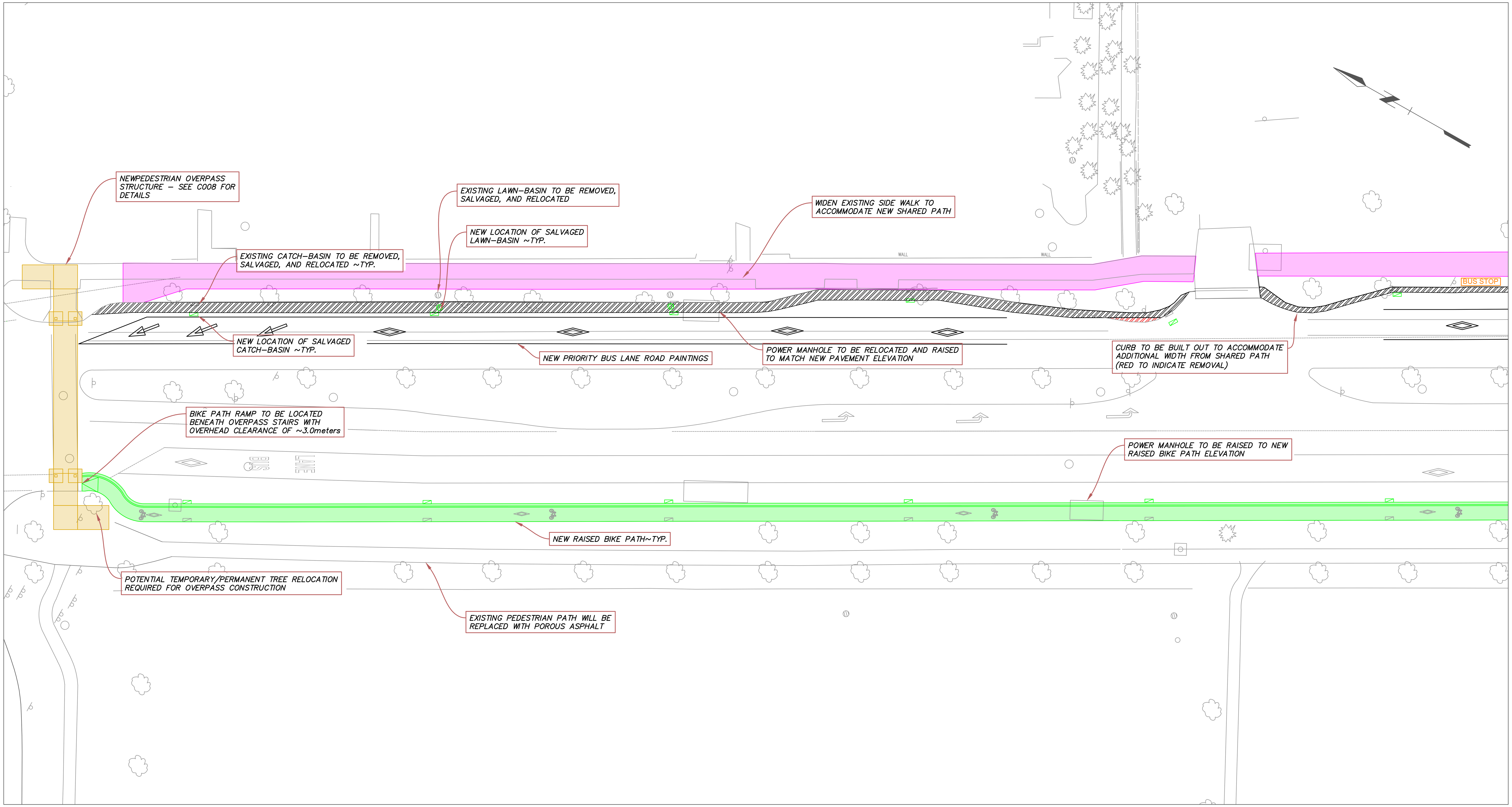
Drawn: DLK
Checked: KM
HA Approved
KM Manager

WESBROOK MALL REDESIGN PHASE 4
DETAILED DESIGN

WESBROOK MALL
THUNDERBIRD TO PEDESTRIAN OVERPASS

SCALE: 1:4000
DISTRICT FILE 00-0001
DRAWING NUMBER C002

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO P2



SITE PLAN
1:4000

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Issue	Date	Des'n	Dr'n	Chkd	App'd	Description
P2	20220406	ARS	DL	KM	HA	DETAILED DESIGN
P1	20211201	ARS	DL	KM	HA	PRELIMINARY DESIGN

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Drawn: DLK
Checked: KM
HA
Approved
KM
Manager

WESBROOK MALL REDESIGN PHASE 4
DETAILED DESIGN

WESBROOK MALL
PEDESTRIAN OVERPASS SECTION

SCALE: 1:4000
DISTRICT FILE 00–0001
DRAWING NUMBER C003

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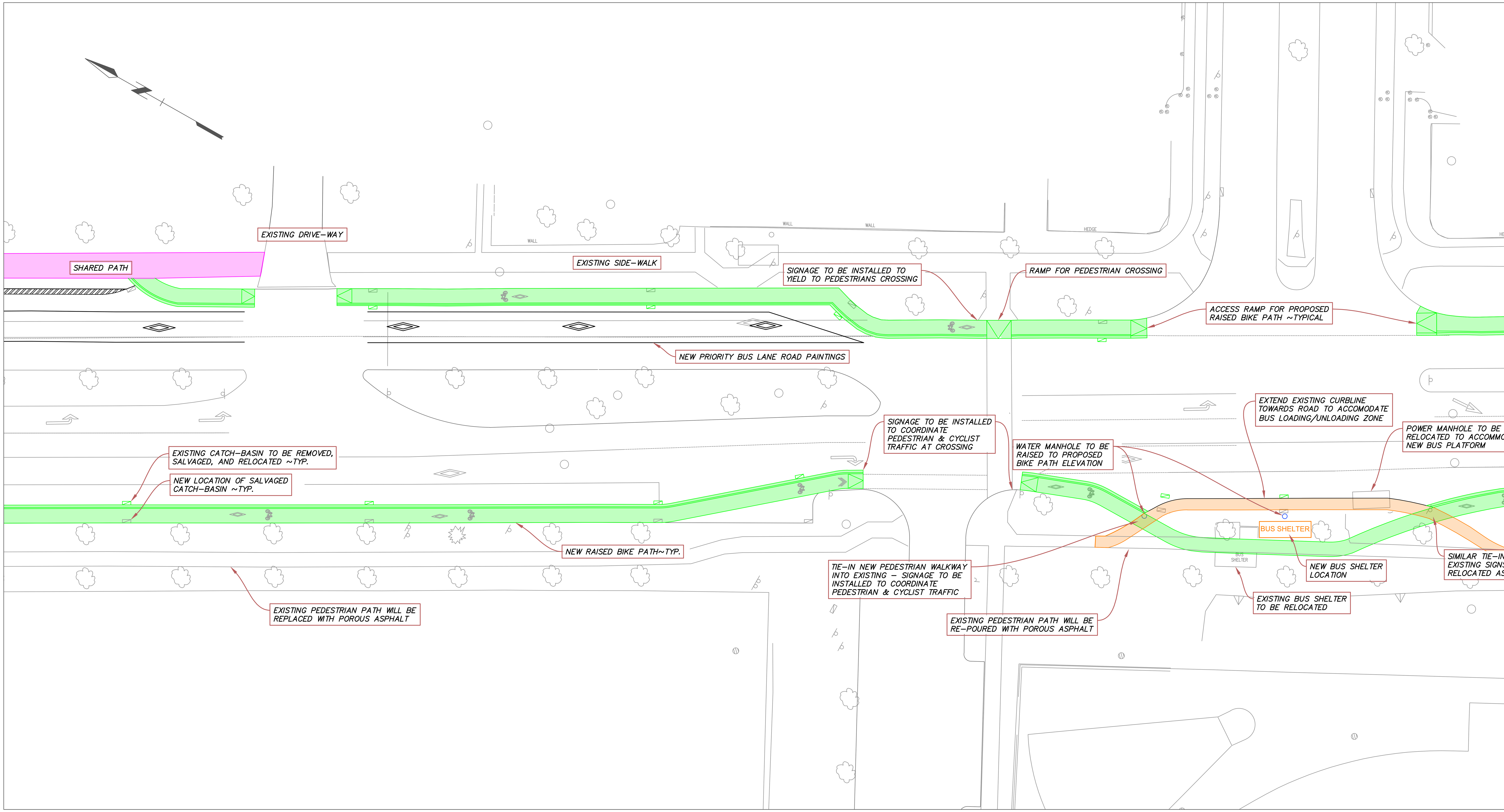

SITE PLAN
1:4000

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P2	20220406	ARS	DL	KM	HA	DETAILED DESIGN
P1	20211201	ARS	DL	KM	HA	PRELIMINARY DESIGN

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Drawn: DLK
Checked: KM
HA Approved
KM Manager

WESBROOK MALL REDESIGN PHASE 4
DETAILED DESIGN

WESBROOK MALL
HAMPTON PLACE SECTION

SCALE: 1:4000
DISTRICT FILE 00–0001
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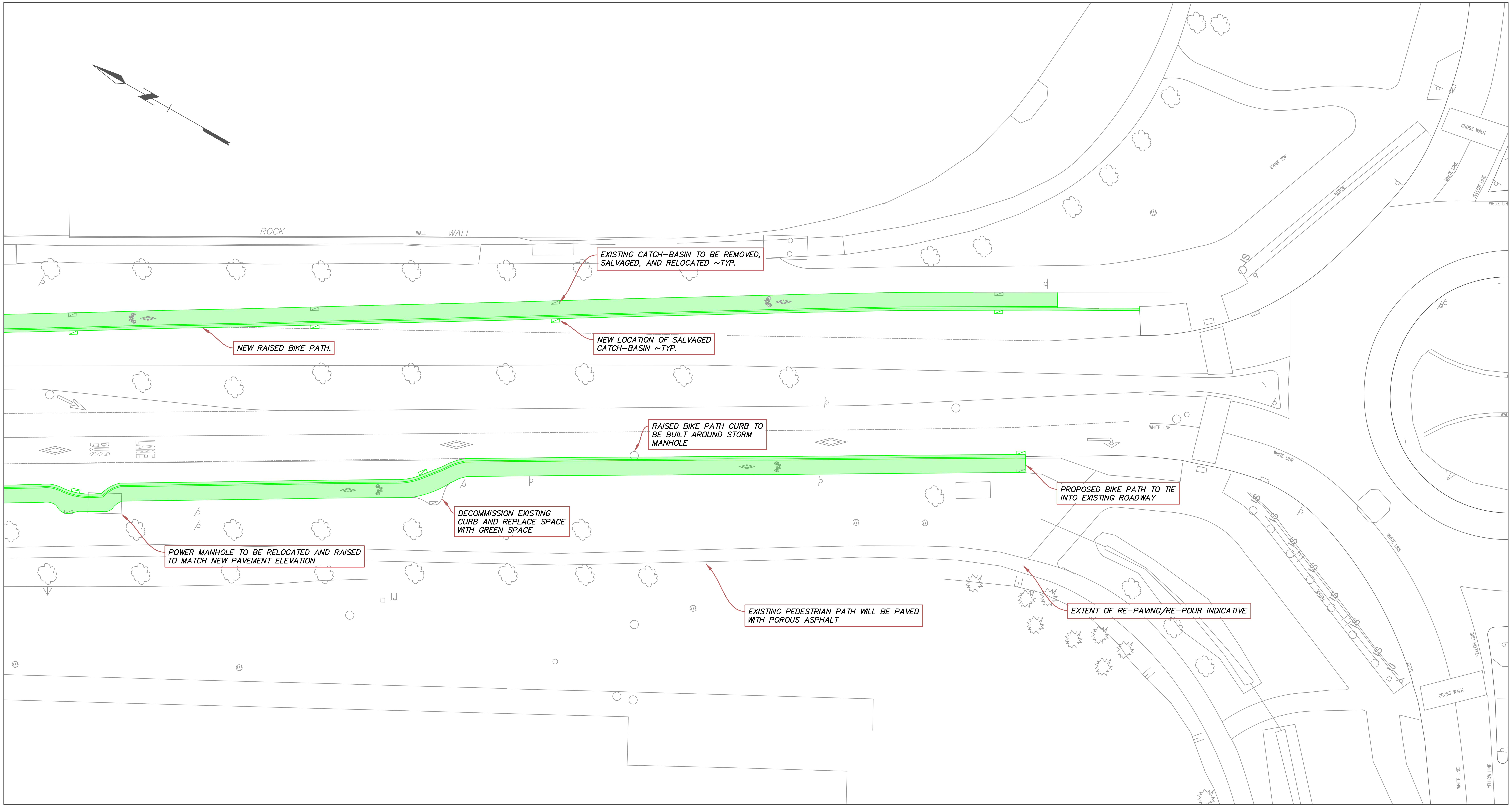

SITE PLAN
1:4000

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Issue	Date	Desn	Dr'n	Chkd	App'd	Description
P2	20220406	ARS	DL	KM	HA	DETAILED DESIGN
P1	20211201	ARS	DL	KM	HA	PRELIMINARY DESIGN

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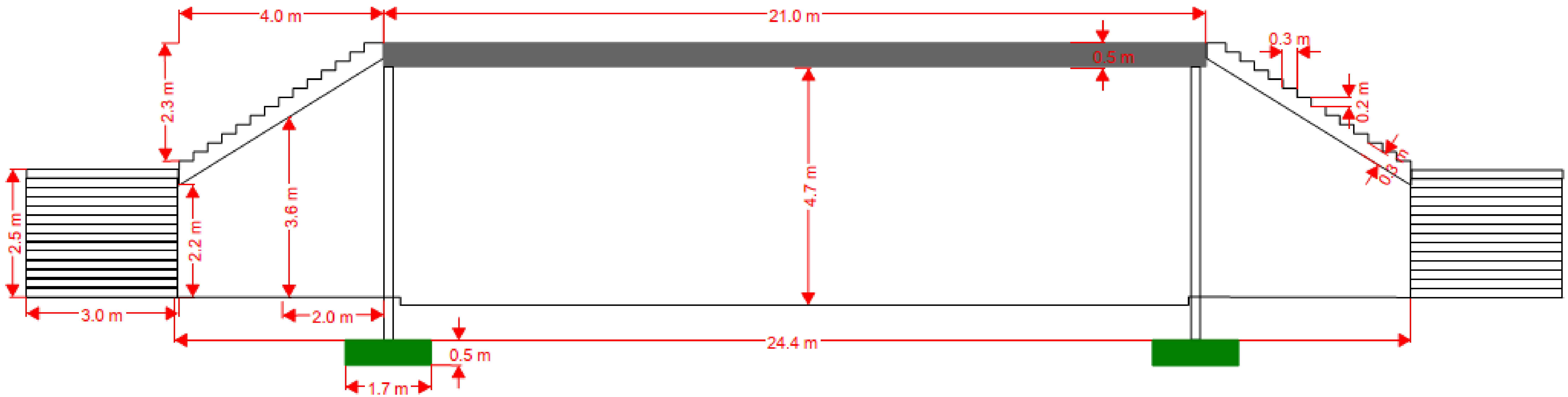
HA
Approved
KM
Manager

WESBROOK MALL REDESIGN PHASE 4
DETAILED DESIGN

WESBROOK MALL
WEST 16 AVENUE SECTION

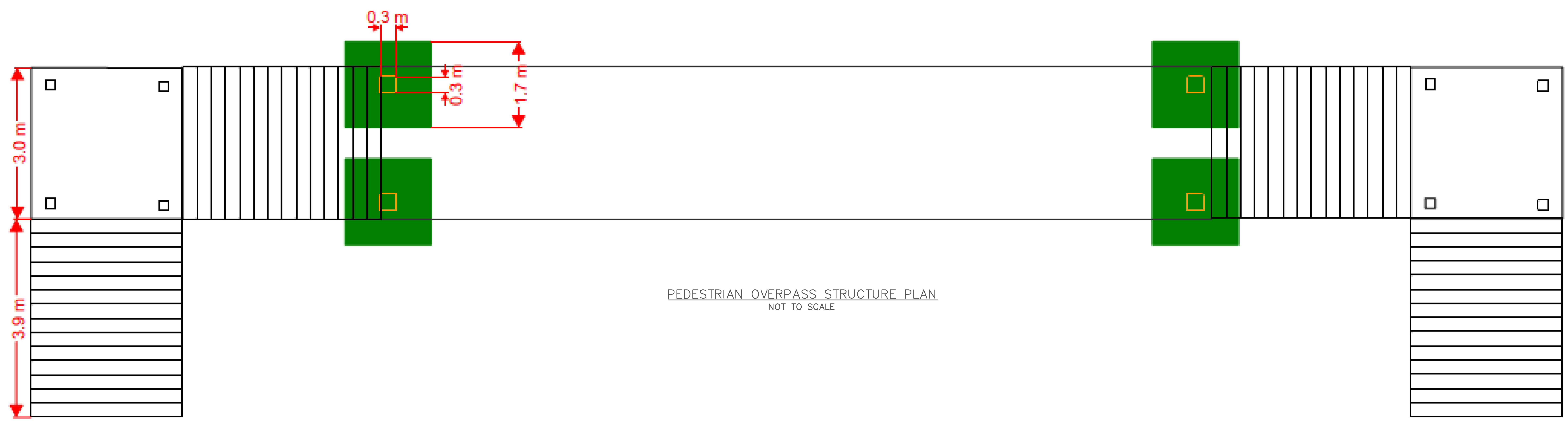
SCALE: 1:4000
DISTRICT FILE 00–0001
DRAWING NUMBER C005

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO P2



PEDESTRIAN OVERPASS STRUCTURE PROFILE

NOT TO SCALE



PEDESTRIAN OVERPASS STRUCTURE PLAN

NOT TO SCALE

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Issue	Date	Des'n	Dr'n	Chkd	App'd	Description
P2	20220406	ARS	DL	KM	HA	DETAILED DESIGN
P1	20211201	ARS	DL	KM	HA	PRELIMINARY DESIGN

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Drawn: ARS
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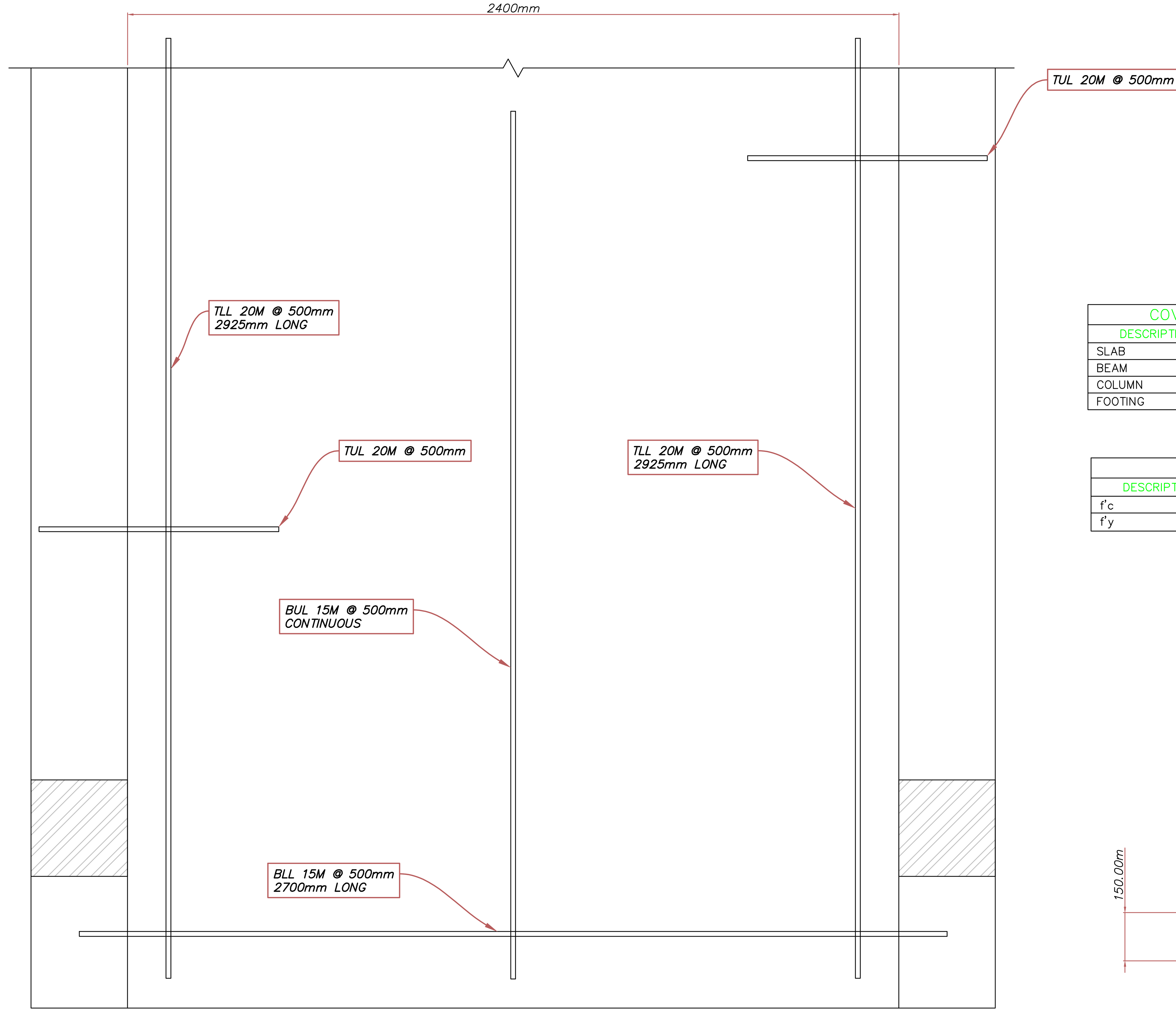
HA
Approved
KM
Manager

WESBROOK MALL REDESIGN PHASE 4
PRELIMINARY DESIGN

PEDESTRIAN OVERPASS
STRUCTURE DESIGN

SCALE: AS NOTED
DISTRICT FILE 00–0001
DRAWING NUMBER C006

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P1



OVERPASS DECK REINFORCEMENT
PLAN VIEW
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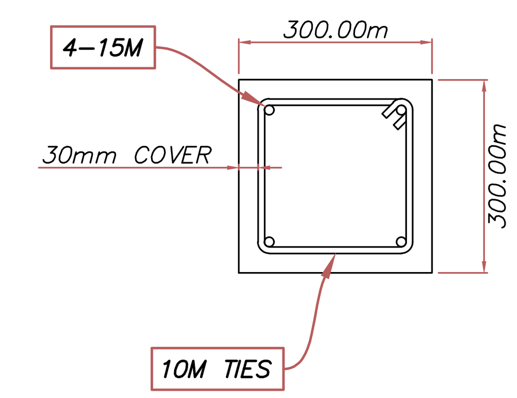

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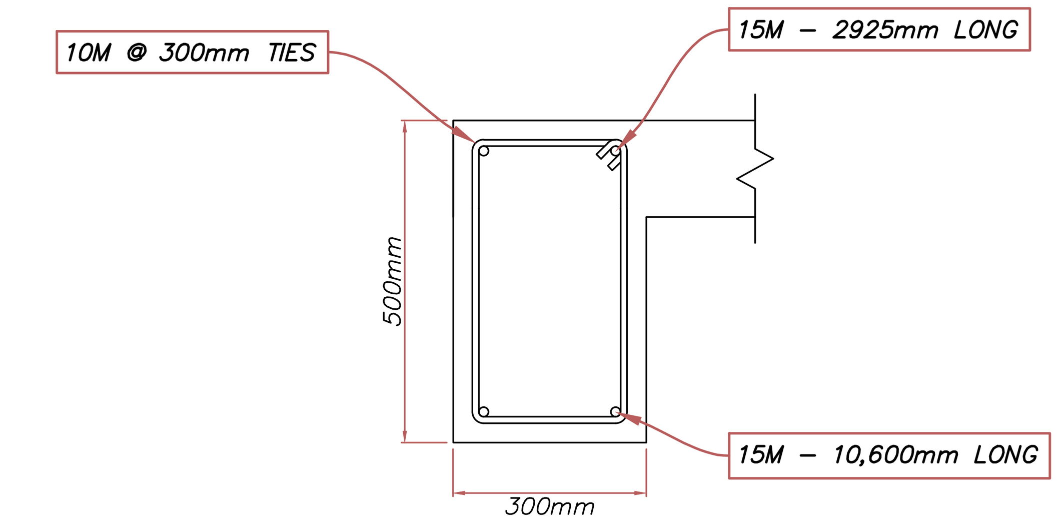

BEAM REINFORCEMENT
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COVER DIMENSIONS	
DESCRIPTION	VALUE (mm)
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BEAM	30
COLUMN	30
FOOTING	75

STRENGTHS	
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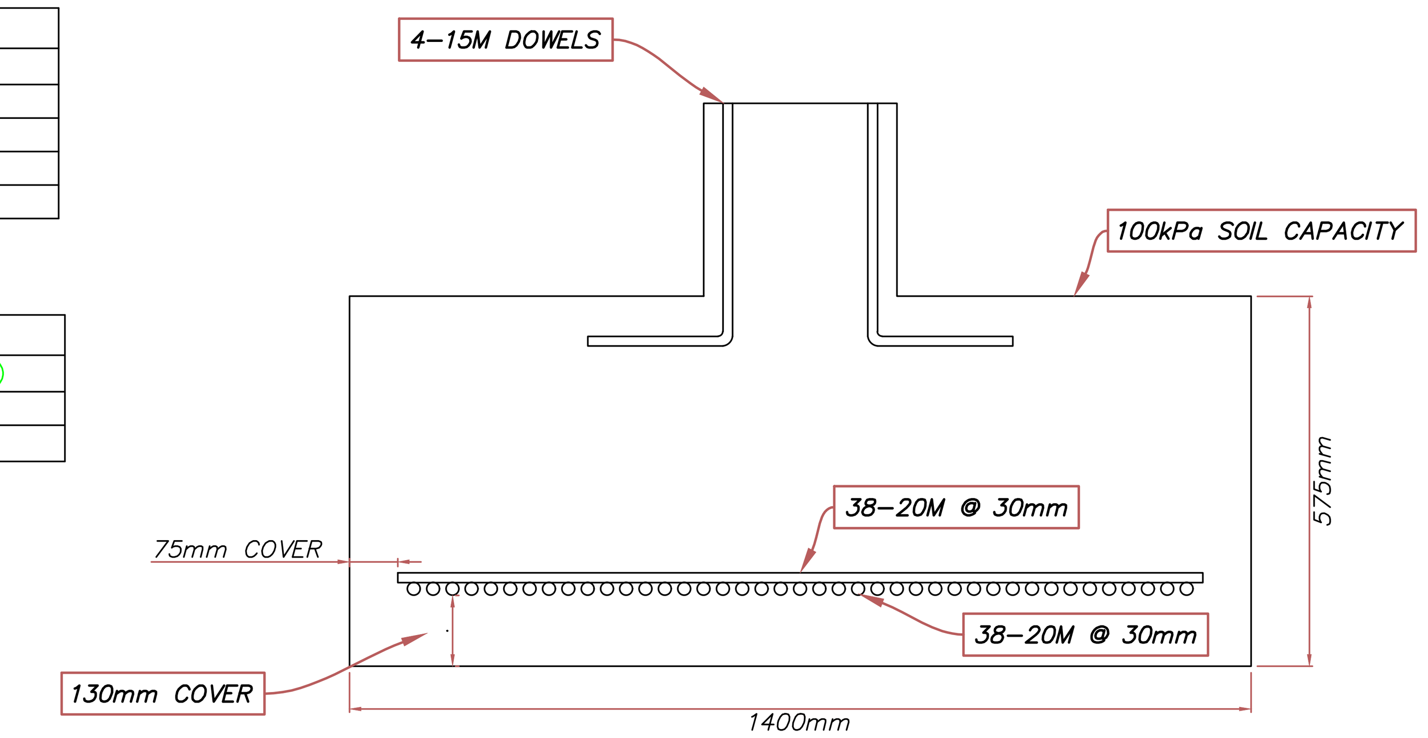

FOOTING REINFORCEMENT
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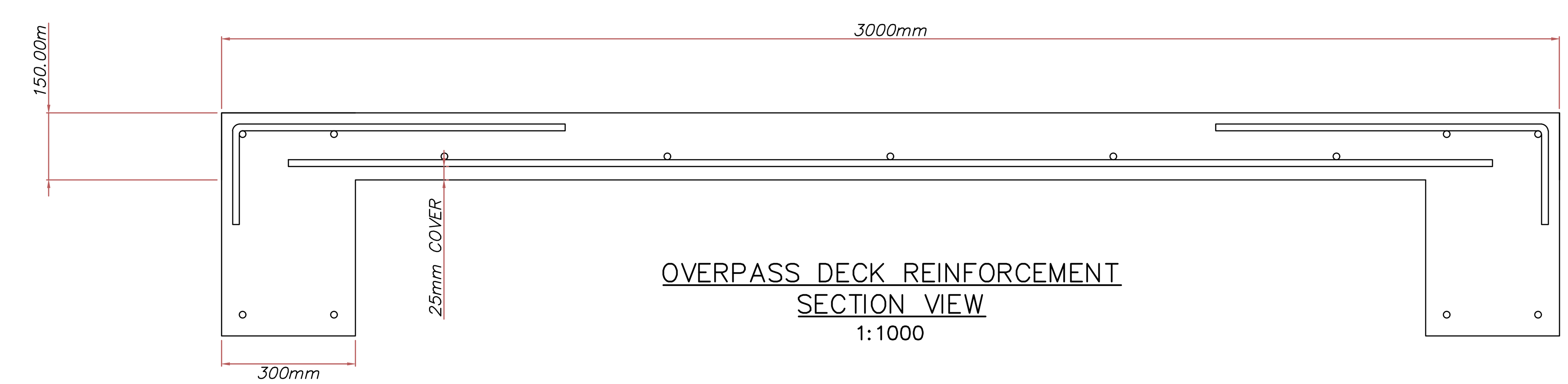

OVERPASS DECK REINFORCEMENT
SECTION VIEW
1:1000

REBAR PLAN
1:1000

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P1	20211201	ARS	DL	KM	HA	PRELIMINARY DESIGN

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THE UNIVERSITY OF BRITISH COLUMBIA – SEEDS

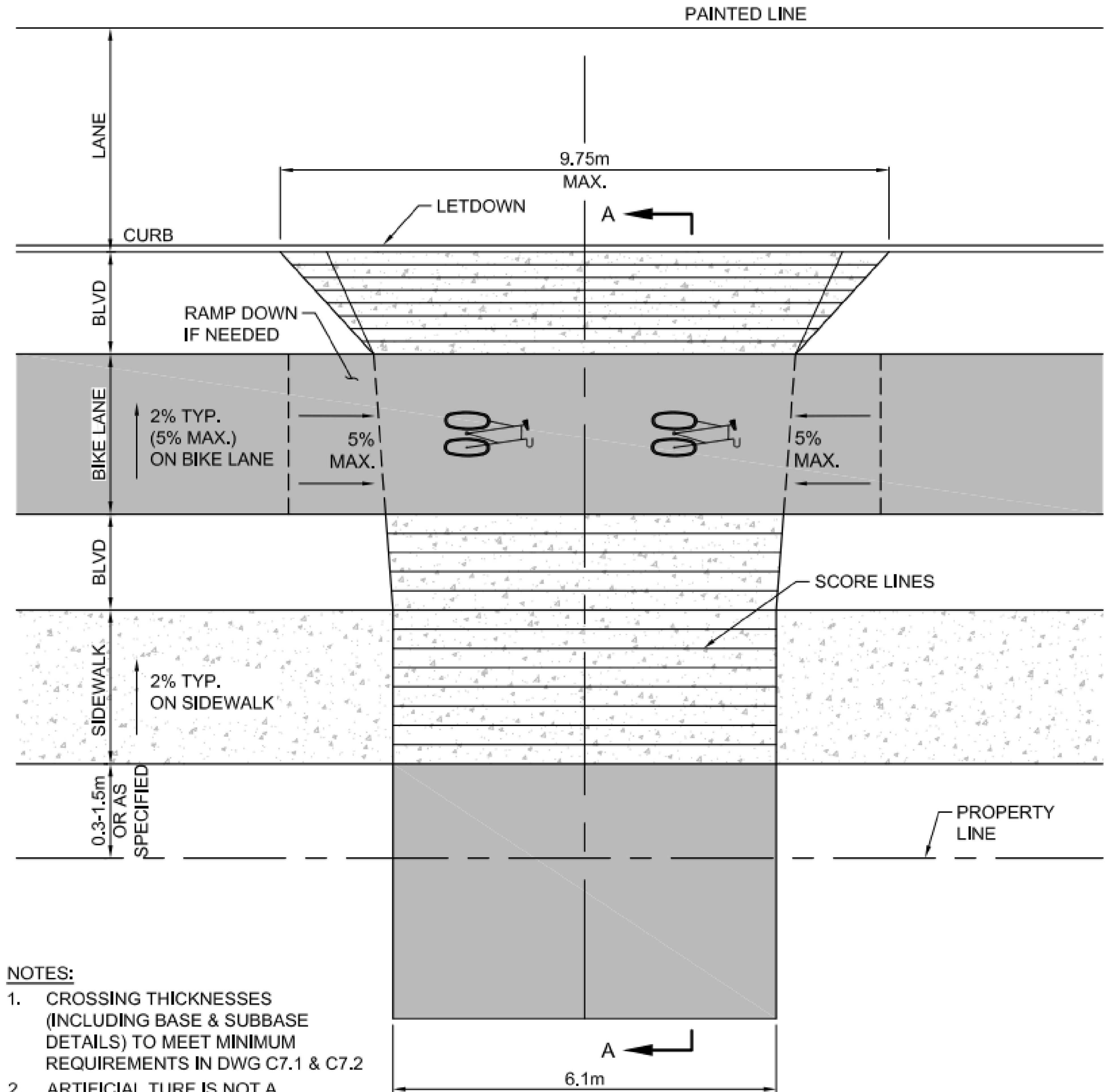
Design: KM
Drawn: DL
Checked: ARS
HA
Approved
Manager

WESBROOK MALL REDESIGN PHASE 4
DETAILED DESIGN

PEDESTRIAN OVERPASS
REINFORCEMENT PLAN

SCALE: 1:1000
DISTRICT FILE 00–0001
DRAWING NUMBER C007

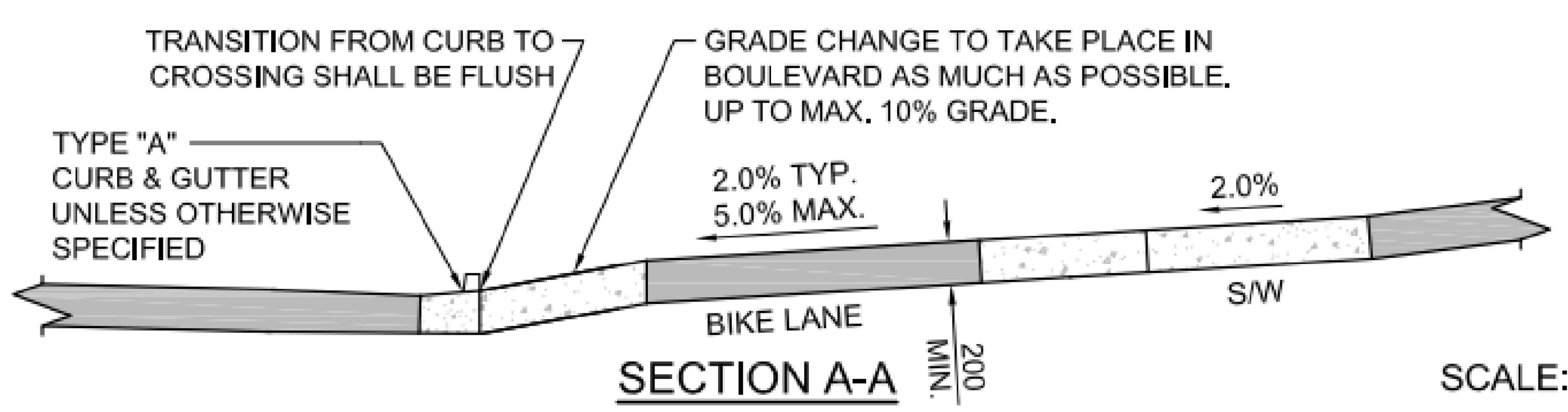
SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO P2



CROSSING

NOTES:

1. CROSSING THICKNESSES (INCLUDING BASE & SUBBASE DETAILS) TO MEET MINIMUM REQUIREMENTS IN DWG C7.1 & C7.2
2. ARTIFICIAL TURF IS NOT A SUPPORTED TREATMENT ON PUBLIC PROPERTY.

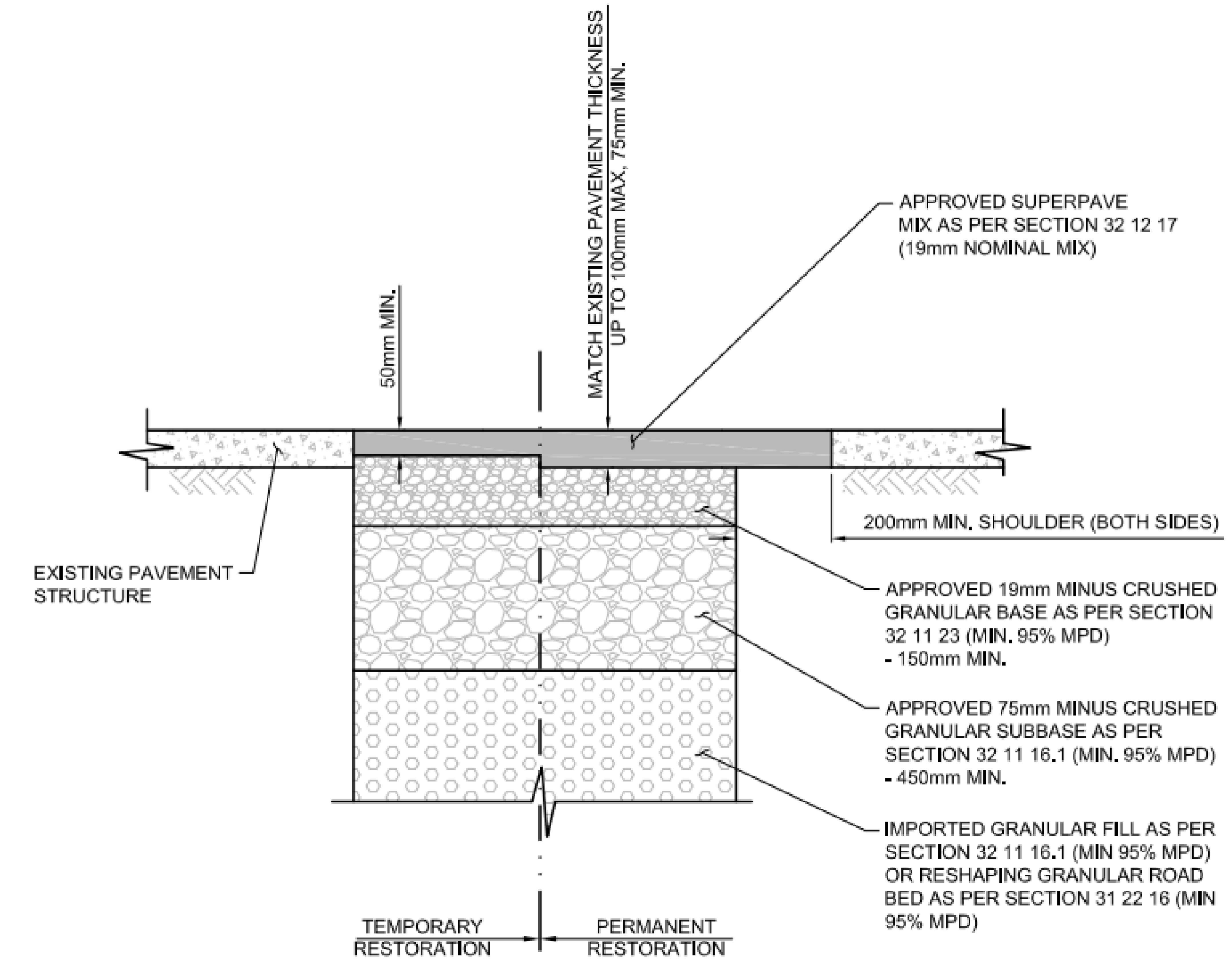


SECTION A-A

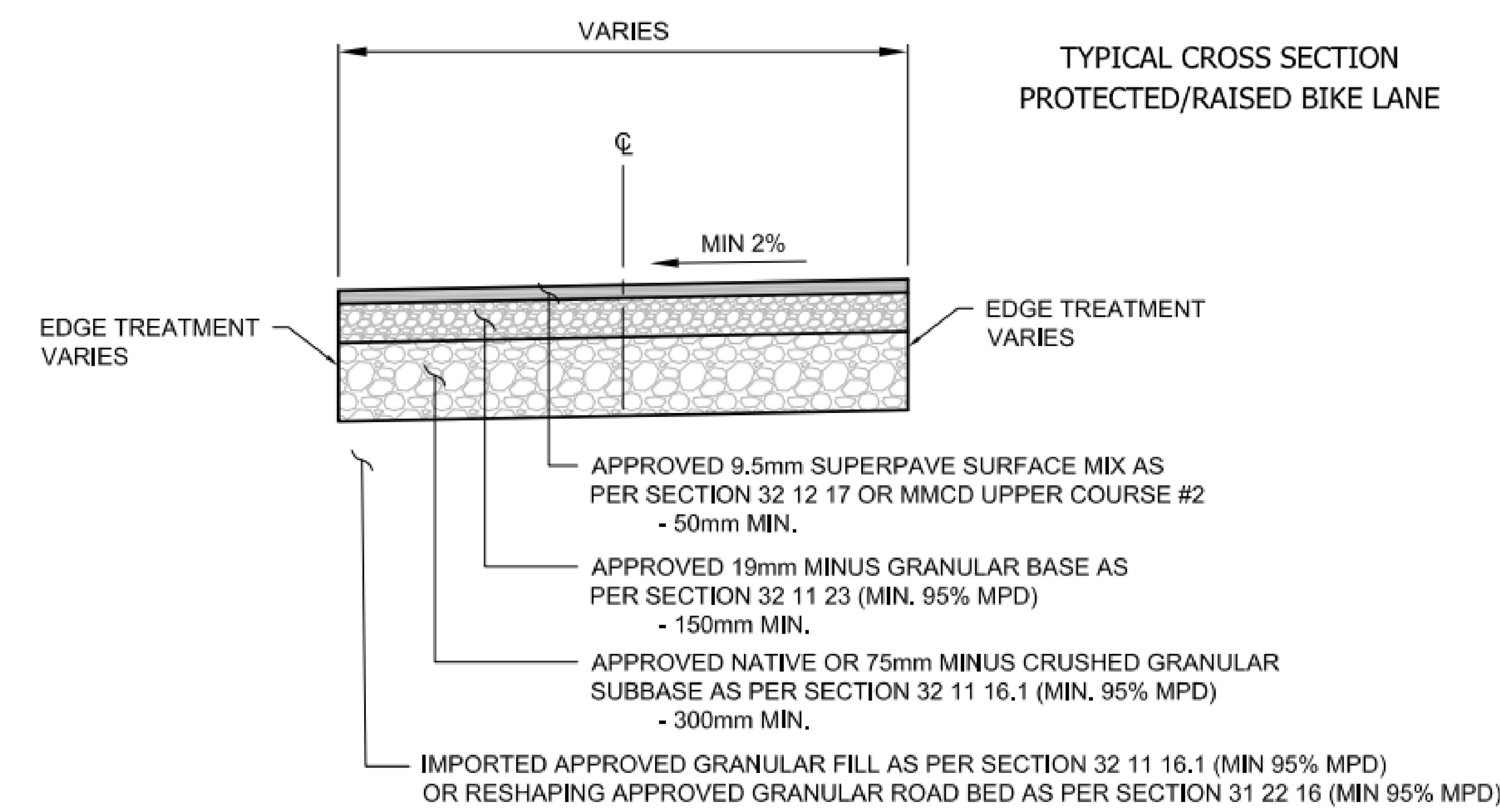
SCALE: N.T.S.

LANEWAYS
BIKE LANE LANEWAY CROSSING

SURFACE RESTORATION
RESIDENTIAL (LIGHT DUTY) - STREETS/LANES



TYPICAL CROSS SECTION
PROTECTED/RAISED BIKE LANE



NOTES:

1. ALL ELEVATIONS AND DISTANCES SHOW ARE IN METRES.
2. ELEVATIONS ARE DERIVED FROM UBC MONUMENT W-W, LOCATED ON EAST MALL IN FRONT OF THE CEME BUILDLING (BETWEEN AGRONOMY ROAD AND UNIVERSITY BOULEVARD) GEODETIC ELEVATION = 93.631
3. THIS PLAN MAY NOT SHOW ALL FEATURES LOCATED WITHIN THE PROJECT BOUNDARIES AND DOES NOT INDICATE BURIED SERVICES THAT MAY EXIST ON OR AROUND THE SUBJECT SITE
4. TREE SPECIES AND DIMENSIONS ARE NOT TO SCALE AND SHOULD BE CONFIRMED BY A QUALIFIED ARBORIST. TREE AND VEGETATION SYMBOLS ARE NOT INDICATIVE OF THE ACTUAL SPECIMENS.
5. THIS DESIGN IS COMPILED FROM SURVEY DATA AS ACQUIRED BY MURRAY AND ASSOCIATES BETWEEN THE DATES OF JUNE 15, 2006 AND SEPTEMBER 22, 2015 AND DATA PROVIDED BY BINNIE AND ASSOCIATES.
6. RED & GREEN CONSULTING MAKE NO WARRANTY NOR GUARANTEE AS TO THE COMPLETENESS OR ACCURACY OF THE DATA SHOWN.
7. ALL DATA SHOULD BE FIELD CONFIRMED PRIOR TO USE.

Professional Seal

Issue	Date	Des'n	Dr'n	Chkd	App'd	Description
P2	20220406	ARS	DL	KM	HA	DETAILED DESIGN
P1	20211201	ARS	DL	KM	HA	PRELIMINARY DESIGN

0 20 Bar is 20mm On Original Drawing. If Not On This Sheet, Adjust Scales Accordingly.

THE UNIVERSITY OF BRITISH COLUMBIA – SEEDS

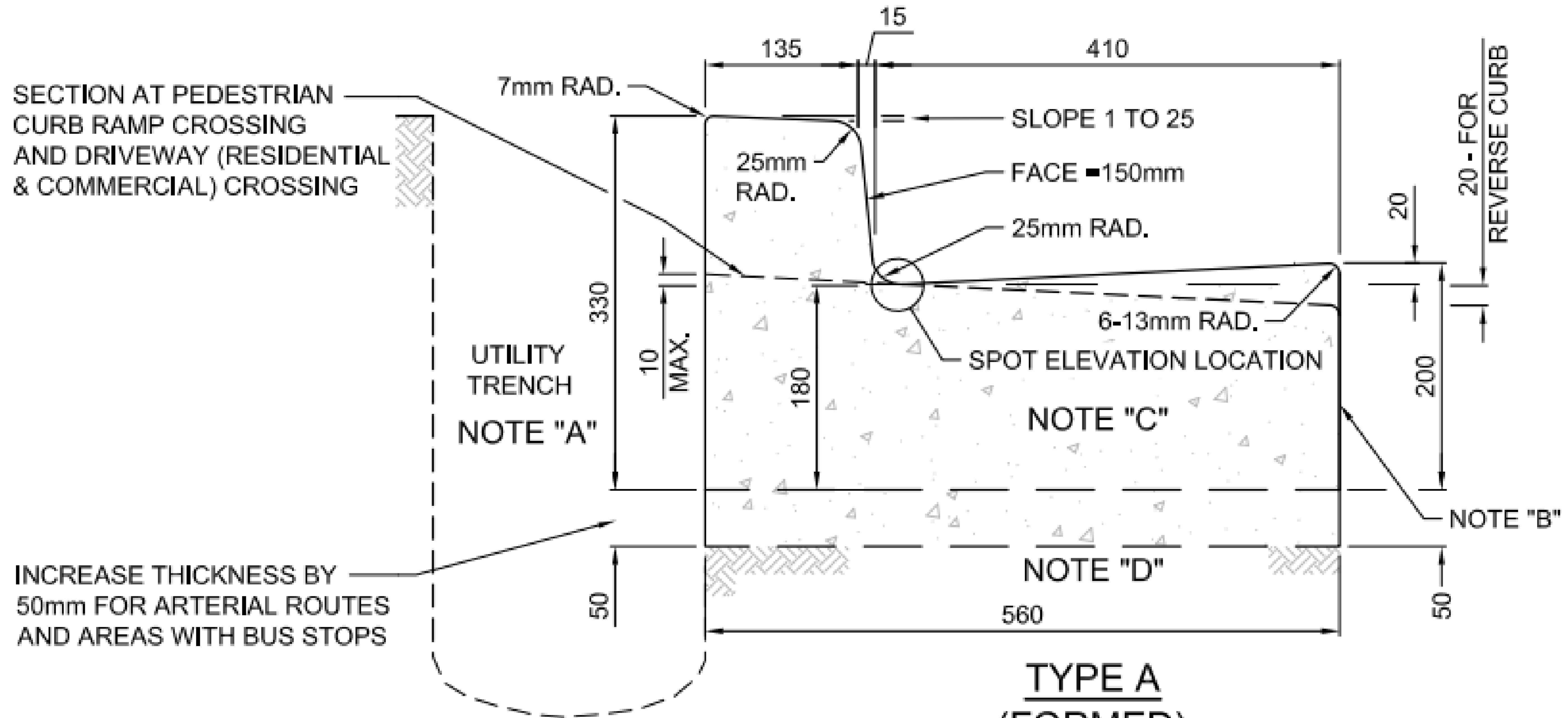
Design: KM
Drawn: ARS
Checked: DL
HA Approved
KM Manager

WESBROOK MALL REDESIGN PHASE 4
PRELIMINARY DESIGN

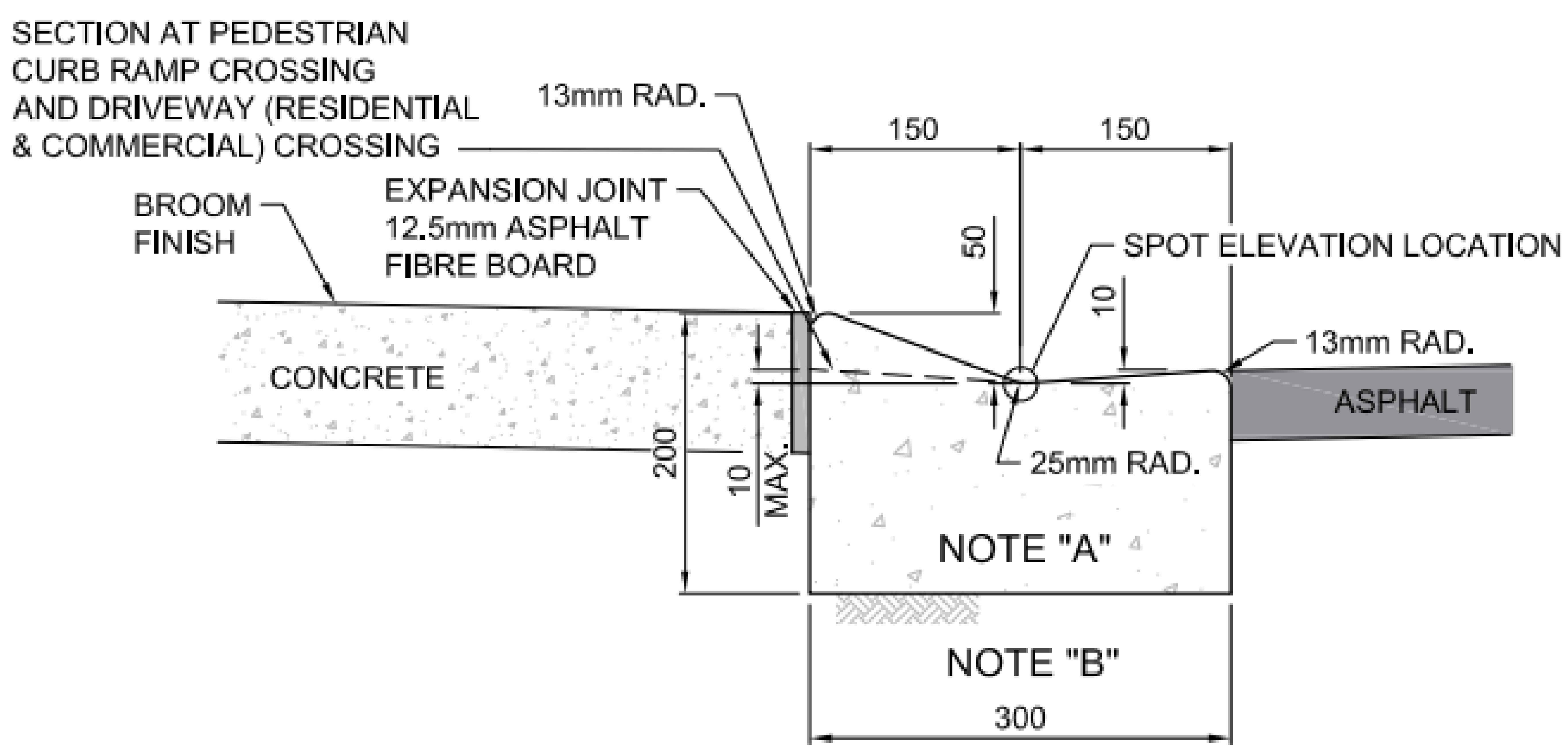
STANDARD DETAILS 1

SCALE: AS NOTED
DISTRICT FILE 00-0001
DRAWING NUMBER C008

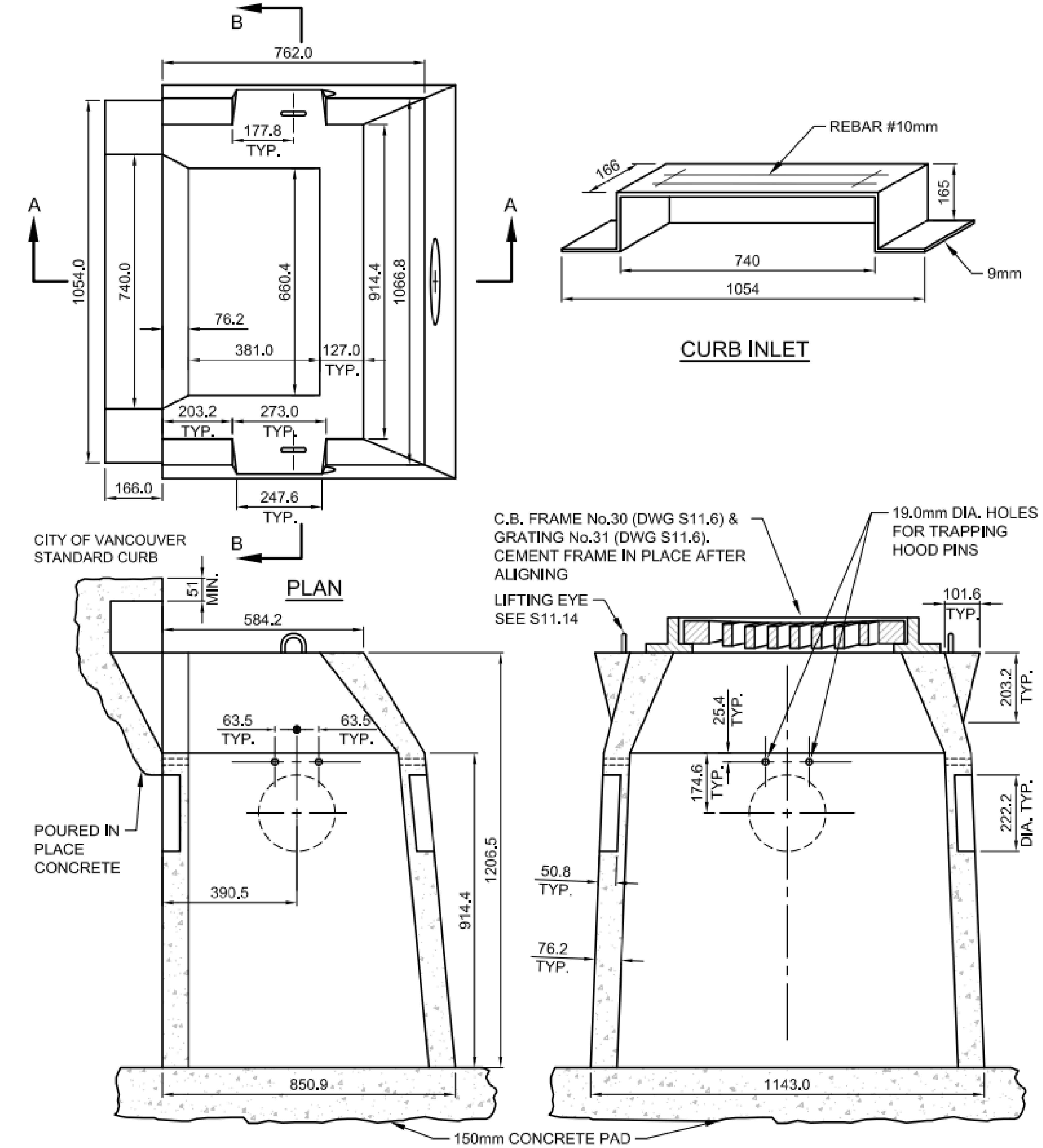
SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P2



TYPE A
(FORMED)



TYPE E
(BIKE/PEDESTRIAN MOUNTABLE SEPARATION CURB WITH GUTTER)



NOTES:
1. SEE DWG S11.2 FOR TRAPPING HOOD INSTALLATION DETAIL.
2. CATCHBASIN TO BE PURCHASED FROM CITY OF VANCOUVER.
3. ALL DIMENSIONS ARE SHOWN IN MILLIMETERS.

SCALE: N.T.S.

CATCHBASINS
PRECAST CONCRETE CURB INLET CATCHBASIN

NOTES:
1. ALL ELEVATIONS AND DISTANCES SHOW ARE IN METRES.
2. ELEVATIONS ARE DERIVED FROM UBC MONUMENT W-W, LOCATED ON EAST MALL IN FRONT OF THE CEME BUILDLING (BETWEEN AGRONOMY ROAD AND UNIVERSITY BOULEVARD) GEODETIC ELEVATION = 93.631
3. THIS PLAN MAY NOT SHOW ALL FEATURES LOCATED WITHIN THE PROJECT BOUNDARIES AND DOES NOT INDICATE BURIED SERVICES THAT MAY EXIST ON OR AROUND THE SUBJECT SITE
4. TREE SPECIES AND DIMENSIONS ARE NOT TO SCALE AND SHOULD BE CONFIRMED BY A QUALIFIED ARBORIST. TREE AND VEGETATION SYMBOLS ARE NOT INDICATIVE OF THE ACTUAL SPECIMENS.
5. THIS DESIGN IS COMPILED FROM SURVEY DATA AS ACQUIRED BY MURRAY AND ASSOCIATES BETWEEN THE DATES OF JUNE 15, 2006 AND SEPTEMBER 22, 2015 AND DATA PROVIDED BY BINNIE AND ASSOCIATES.
6. RED & GREEN CONSULTING MAKE NO WARRANTY NOR GUARANTEE AS TO THE COMPLETENESS OR ACCURACY OF THE DATA SHOWN.
7. ALL DATA SHOULD BE FIELD CONFIRMED PRIOR TO USE.

Professional Seal

Issue	Date	Des'n	Dr'n	Chkd	App'd	Description
P2	20220406	ARS	DL	KM	HA	DETAILED DESIGN
P1	20211201	ARS	DL	KM	HA	PRELIMINARY DESIGN

0 20 Bar is 20mm On Original Drawing. If Not On This Sheet, Adjust Scales Accordingly.

THE UNIVERSITY OF BRITISH COLUMBIA – SEEDS

Design: KM
Drawn: ARS
Checked: DL
HA Approved
KM Manager

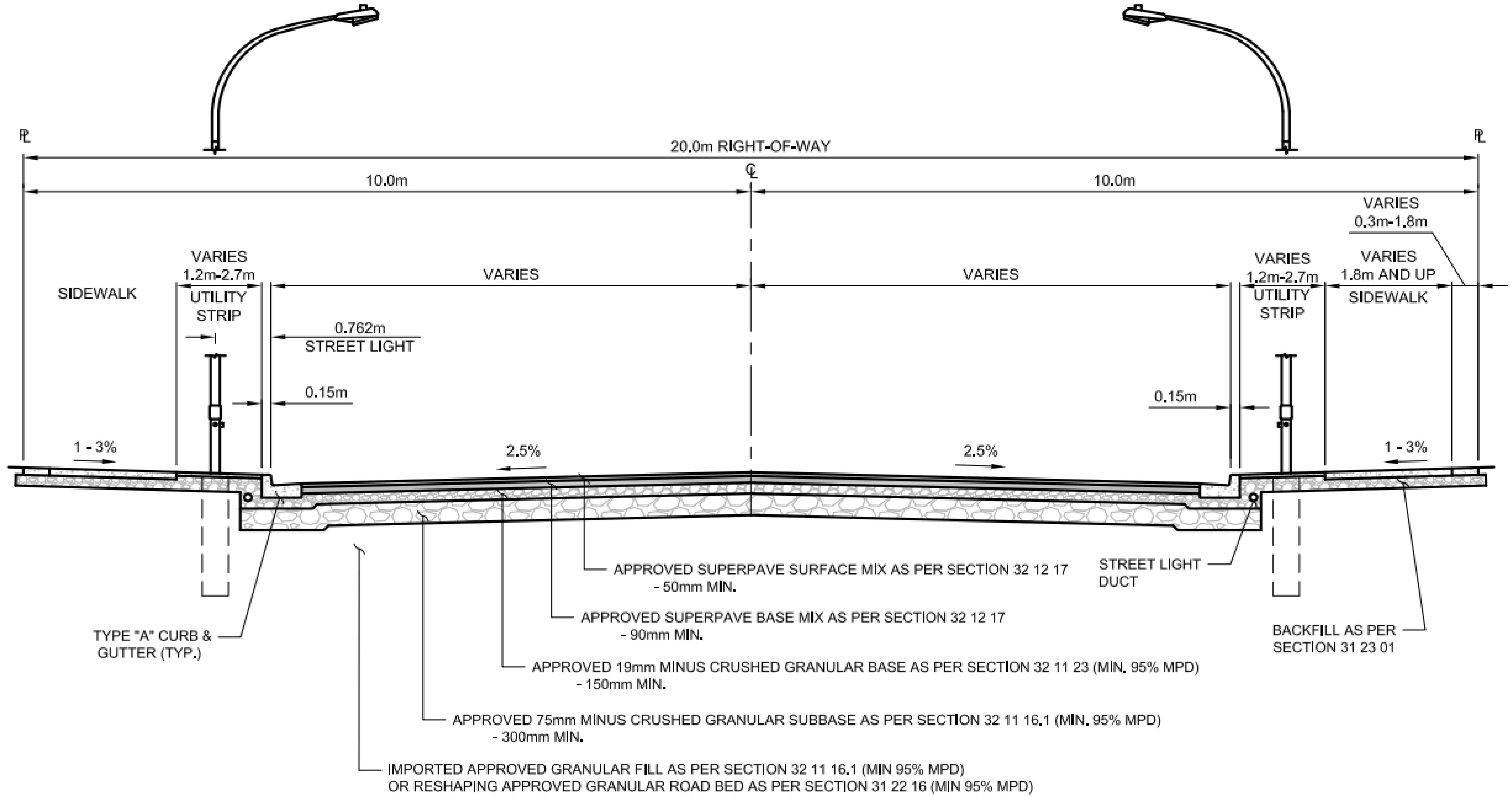
WESBROOK MALL REDESIGN PHASE 4
PRELIMINARY DESIGN

STANDARD DETAILS 2

SCALE: AS NOTED
DISTRICT FILE 00-0001
DRAWING NUMBER C009

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P2

TYPICAL CROSS SECTION
HIGHER-ZONED STREET



NOTES:

1. ONLY TO BE USED FOR NEW ROAD CONSTRUCTION.
2. FOR SUBGRADE SOIL CLASS SC, ML, OR CL ONLY. OTHER SOIL CLASSES REQUIRE SPECIAL TREATMENT GEOTECHNICAL ENGINEER REQUIRED TO DETERMINE SUBGRADE SOIL CLASSIFICATION.
3. FOR PORTLAND CEMENT CONCRETE ROADS, USE THE ROAD STRUCTURE ON G5.5.

NOTES:

1. ALL ELEVATIONS AND DISTANCES SHOW ARE IN METRES.
2. ELEVATIONS ARE DERIVED FROM UBC MONUMENT W-W, LOCATED ON EAST MALL IN FRONT OF THE CEME BUILDLING (BETWEEN AGRONOMY ROAD AND UNIVERSITY BOULEVARD) GEODETIC ELEVATION = 93.631
3. THIS PLAN MAY NOT SHOW ALL FEATURES LOCATED WITHIN THE PROJECT BOUNDARIES AND DOES NOT INDICATE BURIED SERVICES THAT MAY EXIST ON OR AROUND THE SUBJECT SITE
4. TREE SPECIES AND DIMENSIONS ARE NOT TO SCALE AND SHOULD BE CONFIRMED BY A QUALIFIED ARBORIST. TREE AND VEGETATION SYMBOLS ARE NOT INDICATIVE OF THE ACTUAL SPECIMENS.
5. THIS DESIGN IS COMPILED FROM SURVEY DATA AS ACQUIRED BY MURRAY AND ASSOCIATES BETWEEN THE DATES OF JUNE 15, 2006 AND SEPTEMBER 22, 2015 AND DATA PROVIDED BY BINNIE AND ASSOCIATES.
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7. ALL DATA SHOULD BE FIELD CONFIRMED PRIOR TO USE.

Professional Seal

Issue	Date	Des'n	Dr'n	Chkd	App'd	Description
P2	20220406	ARS	DL	KM	HA	DETAILED DESIGN
P1	20211201	ARS	DL	KM	HA	PRELIMINARY DESIGN

0 20 Bar is 20mm On Original Drawing. If Not On This Sheet, Adjust Scales Accordingly.

THE UNIVERSITY OF BRITISH COLUMBIA – SEEDS

Design: KM
Drawn: ARS
Checked: DL
HA
Approved
KM
Manager

WESBROOK MALL REDESIGN PHASE 4
PRELIMINARY DESIGN

STANDARD DETAILS 3

SCALE: NOT TO SCALE
DISTRICT FILE 00-0001
DRAWING NUMBER C010

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P2

APPENDIX D – SYNCHRO REPORTS

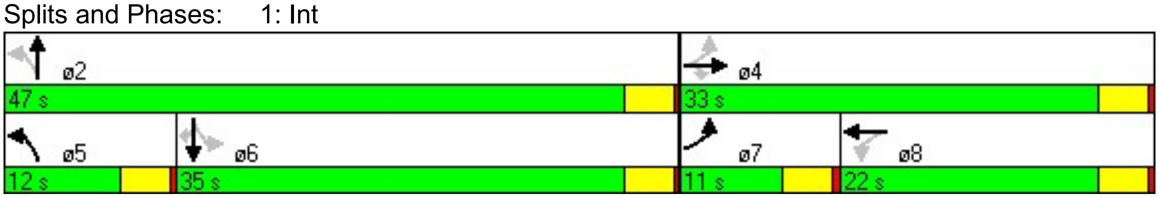
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (m)	0.0		0.0	0.0		0.0	110.0		0.0	55.0		0.0
Storage Lanes	1		1	1		0	1		0	1		1
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Leading Detector (m)	15.0	15.0	15.0	15.0	15.0		15.0	15.0		15.0	15.0	15.0
Trailing Detector (m)	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	0.0
Turning Speed (k/h)	25		15	25		15	25		15	25		15
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ped Bike Factor	0.76		0.69	0.73	0.94		0.86	0.93		0.85		0.75
Frt			0.850		0.976			0.960				0.850
Flt Protected	0.950			0.950			0.950			0.950		
Satd. Flow (prot)	1805	1900	1509	1805	1744	0	1805	1578	0	1805	1727	1615
Flt Permitted	0.528			0.719			0.491			0.531		
Satd. Flow (perm)	758	1900	1044	997	1744	0	804	1578	0	860	1727	1210
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)			29		11			35				103
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Link Speed (k/h)		50			50			50			50	
Link Distance (m)		167.0			117.5			786.8			82.9	
Travel Time (s)		12.0			8.5			56.6			6.0	
Volume (vph)	49	59	29	62	108	21	172	287	103	22	228	103
Confl. Peds. (#/hr)	152		220	220		152	106		114	114		106
Confl. Bikes (#/hr)			28			14			3			
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Heavy Vehicles (%)	0%	0%	7%	0%	0%	0%	0%	10%	0%	0%	10%	0%
Adj. Flow (vph)	49	59	29	62	108	21	172	287	103	22	228	103
Lane Group Flow (vph)	49	59	29	62	129	0	172	390	0	22	228	103
Turn Type	pm+pt		Perm	Perm			pm+pt			Perm		Perm
Protected Phases	7	4			8		5	2			6	
Permitted Phases	4		4	8			2			6		6
Detector Phases	7	4	4	8	8		5	2		6	6	6
Minimum Initial (s)	7.0	7.0	7.0	7.0	7.0		7.0	7.0		7.0	7.0	7.0
Minimum Split (s)	11.0	22.0	22.0	22.0	22.0		11.0	22.0		22.0	22.0	22.0
Total Split (s)	11.0	33.0	33.0	22.0	22.0	0.0	12.0	47.0	0.0	35.0	35.0	35.0
Total Split (%)	13.8%	41.3%	41.3%	27.5%	27.5%	0.0%	15.0%	58.8%	0.0%	43.8%	43.8%	43.8%
Maximum Green (s)	7.0	29.0	29.0	18.0	18.0		8.0	43.0		31.0	31.0	31.0
Yellow Time (s)	3.5	3.5	3.5	3.5	3.5		3.5	3.5		3.5	3.5	3.5
All-Red Time (s)	0.5	0.5	0.5	0.5	0.5		0.5	0.5		0.5	0.5	0.5
Lead/Lag	Lead			Lag	Lag		Lead			Lag	Lag	Lag
Lead-Lag Optimize?	Yes			Yes	Yes		Yes			Yes	Yes	Yes
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	3.0
Recall Mode	None	None	None	None	None		None	Max		Max	Max	Max
Walk Time (s)		7.0	7.0	7.0	7.0			7.0		7.0	7.0	7.0
Flash Dont Walk (s)		11.0	11.0	11.0	11.0			11.0		11.0	11.0	11.0
Pedestrian Calls (#/hr)		125	125	125	125			125		125	125	125
Act Effct Green (s)	22.9	22.9	22.9	16.2	16.2		49.4	50.5		41.0	41.0	41.0
Actuated g/C Ratio	0.28	0.29	0.29	0.20	0.20		0.62	0.65		0.52	0.52	0.52
v/c Ratio	0.16	0.11	0.09	0.31	0.36		0.29	0.38		0.05	0.25	0.15

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Control Delay	18.9	17.7	7.4	30.0	26.2		9.8	10.0		15.9	16.2	4.3
Queue Delay	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	0.0
Total Delay	18.9	17.7	7.4	30.0	26.2		9.8	10.0		15.9	16.2	4.3
LOS	B	B	A	C	C		A	B		B	B	A
Approach Delay		16.0			27.5			9.9			12.7	
Approach LOS		B			C			A			B	

Intersection Summary

Area Type: Other
Cycle Length: 80
Actuated Cycle Length: 78.1
Natural Cycle: 70
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.38
Intersection Signal Delay: 14.1 Intersection LOS: B
Intersection Capacity Utilization 63.0% ICU Level of Service B
Analysis Period (min) 60

Splits and Phases: 1: Int



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Turning Speed (k/h)	25		15	25		15	25		15	25		15
Lane Util. Factor	0.95	0.95	0.95	0.95	0.95	0.95	1.00	1.00	1.00	1.00	1.00	1.00
Ped Bike Factor												
Frt		0.984			0.942			0.962				0.850
Flt Protected		0.974			0.989			0.995			0.976	
Satd. Flow (prot)	0	3392	0	0	3297	0	0	1783	0	0	1818	1583
Flt Permitted		0.974			0.989			0.995			0.976	
Satd. Flow (perm)	0	3392	0	0	3297	0	0	1783	0	0	1818	1583
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Link Speed (k/h)		50			50			50			50	
Link Distance (m)		303.0			524.7			155.6			786.8	
Travel Time (s)		21.8			37.8			11.2			56.6	
Volume (vph)	161	110	33	125	220	215	26	160	74	109	114	138
Confl. Peds. (#/hr)	68		103	103		68	139		192	192		139
Confl. Bikes (#/hr)			4						22			15
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	161	110	33	125	220	215	26	160	74	109	114	138
Lane Group Flow (vph)	0	304	0	0	560	0	0	260	0	0	223	138
Sign Control		Yield			Yield			Yield			Yield	

Intersection Summary	
Area Type: Other	
Control Type: Roundabout	
Intersection Capacity Utilization 74.9%	ICU Level of Service D
Analysis Period (min) 60	

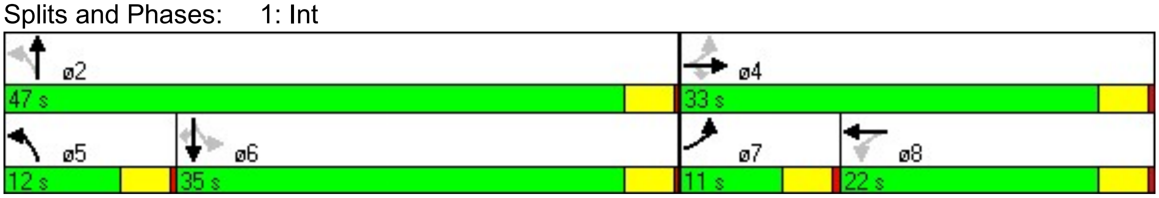
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (m)	0.0		0.0	0.0		0.0	110.0		0.0	55.0		0.0
Storage Lanes	1		1	1		0	1		0	1		1
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Leading Detector (m)	15.0	15.0	15.0	15.0	15.0		15.0	15.0		15.0	15.0	15.0
Trailing Detector (m)	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	0.0
Turning Speed (k/h)	25		15	25		15	25		15	25		15
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ped Bike Factor	0.94		0.93	0.95	0.92		0.86	0.90		0.86		0.79
Frt			0.850		0.911			0.927				0.850
Flt Protected	0.950			0.950			0.950			0.950		
Satd. Flow (prot)	1805	1900	1509	1805	1589	0	1805	1506	0	1805	1727	1615
Flt Permitted	0.366			0.694			0.613			0.638		
Satd. Flow (perm)	656	1900	1399	1246	1589	0	1001	1506	0	1038	1727	1275
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)			38		84			93				118
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Link Speed (k/h)		50			50			50			50	
Link Distance (m)		167.0			117.5			786.8			82.9	
Travel Time (s)		12.0			8.5			56.6			6.0	
Volume (vph)	112	98	38	113	93	134	17	97	93	111	101	118
Confl. Peds. (#/hr)	47		47	47		47	82		84	84		82
Confl. Bikes (#/hr)						11			8			15
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Heavy Vehicles (%)	0%	0%	7%	0%	0%	0%	0%	10%	0%	0%	10%	0%
Adj. Flow (vph)	112	98	38	113	93	134	17	97	93	111	101	118
Lane Group Flow (vph)	112	98	38	113	227	0	17	190	0	111	101	118
Turn Type	pm+pt		Perm	Perm			pm+pt			Perm		Perm
Protected Phases	7	4			8		5	2			6	
Permitted Phases	4		4	8			2			6		6
Detector Phases	7	4	4	8	8		5	2		6	6	6
Minimum Initial (s)	7.0	7.0	7.0	7.0	7.0		7.0	7.0		7.0	7.0	7.0
Minimum Split (s)	11.0	22.0	22.0	22.0	22.0		11.0	22.0		22.0	22.0	22.0
Total Split (s)	11.0	33.0	33.0	22.0	22.0	0.0	12.0	47.0	0.0	35.0	35.0	35.0
Total Split (%)	13.8%	41.3%	41.3%	27.5%	27.5%	0.0%	15.0%	58.8%	0.0%	43.8%	43.8%	43.8%
Maximum Green (s)	7.0	29.0	29.0	18.0	18.0		8.0	43.0		31.0	31.0	31.0
Yellow Time (s)	3.5	3.5	3.5	3.5	3.5		3.5	3.5		3.5	3.5	3.5
All-Red Time (s)	0.5	0.5	0.5	0.5	0.5		0.5	0.5		0.5	0.5	0.5
Lead/Lag	Lead			Lag	Lag		Lead			Lag	Lag	Lag
Lead-Lag Optimize?	Yes			Yes	Yes		Yes			Yes	Yes	Yes
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	3.0
Recall Mode	None	None	None	None	None		None	Max		Max	Max	Max
Walk Time (s)		7.0	7.0	7.0	7.0			7.0		7.0	7.0	7.0
Flash Dont Walk (s)		11.0	11.0	11.0	11.0			11.0		11.0	11.0	11.0
Pedestrian Calls (#/hr)		125	125	125	125			125		125	125	125
Act Effct Green (s)	24.7	24.2	24.2	15.6	15.6		45.9	46.0		43.8	43.8	43.8
Actuated g/C Ratio	0.31	0.31	0.31	0.20	0.20		0.53	0.59		0.56	0.56	0.56
v/c Ratio	0.37	0.17	0.08	0.45	0.59		0.03	0.21		0.19	0.10	0.15

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Control Delay	21.7	18.2	6.5	33.3	24.1		10.9	5.7		13.2	11.8	3.5
Queue Delay	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	0.0
Total Delay	21.7	18.2	6.5	33.3	24.1		10.9	5.7		13.2	11.8	3.5
LOS	C	B	A	C	C		B	A		B	B	A
Approach Delay		18.0			27.1			6.1			9.3	
Approach LOS		B			C			A			A	

Intersection Summary

Area Type: Other
Cycle Length: 80
Actuated Cycle Length: 78.2
Natural Cycle: 70
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.59
Intersection Signal Delay: 16.0 Intersection LOS: B
Intersection Capacity Utilization 56.0% ICU Level of Service B
Analysis Period (min) 60

Splits and Phases: 1: Int



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Turning Speed (k/h)	25		15	25		15	25		15	25		15
Lane Util. Factor	0.95	0.95	0.95	0.95	0.95	0.95	1.00	1.00	1.00	1.00	1.00	1.00
Ped Bike Factor												
Frt		0.944			0.945			0.987				0.850
Flt Protected		0.976			0.980			0.988			0.996	
Satd. Flow (prot)	0	3261	0	0	3278	0	0	1816	0	0	1855	1583
Flt Permitted		0.976			0.980			0.988			0.996	
Satd. Flow (perm)	0	3261	0	0	3278	0	0	1816	0	0	1855	1583
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Link Speed (k/h)		50			50			50			50	
Link Distance (m)		303.0			524.7			155.6			786.8	
Travel Time (s)		21.8			37.8			11.2			56.6	
Volume (vph)	62	17	47	25	13	22	76	213	30	19	223	60
Confl. Peds. (#/hr)	54		69	69		54	128		119	119		128
Confl. Bikes (#/hr)			4			2			4			
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	62	17	47	25	13	22	76	213	30	19	223	60
Lane Group Flow (vph)	0	126	0	0	60	0	0	319	0	0	242	60
Sign Control		Yield			Yield			Yield			Yield	

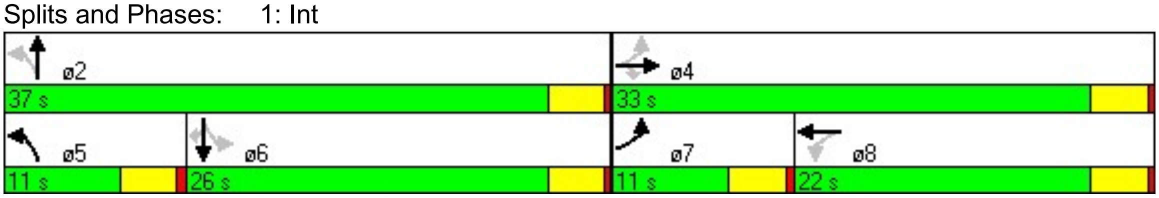
Intersection Summary	
Area Type: Other	
Control Type: Roundabout	
Intersection Capacity Utilization 54.2%	ICU Level of Service A
Analysis Period (min) 60	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (m)	0.0		0.0	0.0		0.0	110.0		0.0	55.0		0.0
Storage Lanes	1		1	1		0	1		0	1		1
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Leading Detector (m)	15.0	15.0	15.0	15.0	15.0		15.0	15.0		15.0	15.0	15.0
Trailing Detector (m)	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	0.0
Turning Speed (k/h)	25		15	25		15	25		15	25		15
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ped Bike Factor	0.97		0.90	0.93	0.97		0.77	0.85		0.80		0.65
Frt			0.850		0.930			0.923				0.850
Flt Protected	0.950			0.950			0.950			0.950		
Satd. Flow (prot)	1805	1900	1509	1805	1706	0	1805	1414	0	1805	1727	1615
Flt Permitted	0.362			0.625			0.568			0.608		
Satd. Flow (perm)	669	1900	1355	1106	1706	0	830	1414	0	922	1727	1053
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)			46		61			104				134
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Link Speed (k/h)		50			50			50			50	
Link Distance (m)		167.0			117.5			786.8			82.9	
Travel Time (s)		12.0			8.5			56.6			6.0	
Volume (vph)	91	213	46	121	137	121	21	117	125	230	134	134
Confl. Peds. (#/hr)	27		79	79		27	161		145	145		161
Confl. Bikes (#/hr)						2			6			26
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Heavy Vehicles (%)	0%	0%	7%	0%	0%	0%	0%	10%	0%	0%	10%	0%
Adj. Flow (vph)	91	213	46	121	137	121	21	117	125	230	134	134
Lane Group Flow (vph)	91	213	46	121	258	0	21	242	0	230	134	134
Turn Type	pm+pt		Perm	Perm			pm+pt			Perm		Perm
Protected Phases	7	4			8		5	2			6	
Permitted Phases	4		4	8			2			6		6
Detector Phases	7	4	4	8	8		5	2		6	6	6
Minimum Initial (s)	7.0	7.0	7.0	7.0	7.0		7.0	7.0		7.0	7.0	7.0
Minimum Split (s)	11.0	22.0	22.0	22.0	22.0		11.0	22.0		22.0	22.0	22.0
Total Split (s)	11.0	33.0	33.0	22.0	22.0	0.0	11.0	37.0	0.0	26.0	26.0	26.0
Total Split (%)	15.7%	47.1%	47.1%	31.4%	31.4%	0.0%	15.7%	52.9%	0.0%	37.1%	37.1%	37.1%
Maximum Green (s)	7.0	29.0	29.0	18.0	18.0		7.0	33.0		22.0	22.0	22.0
Yellow Time (s)	3.5	3.5	3.5	3.5	3.5		3.5	3.5		3.5	3.5	3.5
All-Red Time (s)	0.5	0.5	0.5	0.5	0.5		0.5	0.5		0.5	0.5	0.5
Lead/Lag	Lead			Lag	Lag		Lead			Lag	Lag	Lag
Lead-Lag Optimize?	Yes			Yes	Yes		Yes			Yes	Yes	Yes
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	3.0
Recall Mode	None	None	None	None	None		None	Max		Max	Max	Max
Walk Time (s)		7.0	7.0	7.0	7.0			7.0		7.0	7.0	7.0
Flash Dont Walk (s)		11.0	11.0	11.0	11.0			11.0		11.0	11.0	11.0
Pedestrian Calls (#/hr)		125	125	125	125			125		125	125	125
Act Effct Green (s)	24.4	23.9	23.9	15.5	15.5		34.8	35.0		32.9	32.9	32.9
Actuated g/C Ratio	0.35	0.36	0.36	0.23	0.23		0.46	0.52		0.49	0.49	0.49
v/c Ratio	0.26	0.31	0.09	0.47	0.59		0.04	0.31		0.51	0.16	0.23

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Control Delay	14.8	15.4	4.8	29.0	23.0		12.5	7.8		22.7	14.0	4.6
Queue Delay	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	0.0
Total Delay	14.8	15.4	4.8	29.0	23.0		12.5	7.8		22.7	14.0	4.6
LOS	B	B	A	C	C		B	A		C	B	A
Approach Delay		13.9			24.9			8.2			15.5	
Approach LOS		B			C			A			B	

Intersection Summary	
Area Type: Other	
Cycle Length: 70	
Actuated Cycle Length: 67	
Natural Cycle: 70	
Control Type: Semi Act-Uncoord	
Maximum v/c Ratio: 0.59	
Intersection Signal Delay: 16.2	Intersection LOS: B
Intersection Capacity Utilization 65.1%	ICU Level of Service C
Analysis Period (min) 60	

Splits and Phases: 1: Int



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Turning Speed (k/h)	25		15	25		15	25		15	25		15
Lane Util. Factor	0.95	0.95	0.95	0.95	0.95	0.95	1.00	1.00	1.00	1.00	1.00	1.00
Ped Bike Factor												
Frt		0.943			0.975			0.978				0.850
Flt Protected		0.979			0.975			0.992			0.996	
Satd. Flow (prot)	0	3267	0	0	3364	0	0	1807	0	0	1855	1583
Flt Permitted		0.979			0.975			0.992			0.996	
Satd. Flow (perm)	0	3267	0	0	3364	0	0	1807	0	0	1855	1583
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Link Speed (k/h)		50			50			50			50	
Link Distance (m)		303.0			524.7			155.6			786.8	
Travel Time (s)		21.8			37.8			11.2			56.6	
Volume (vph)	156	71	139	57	34	18	55	229	54	26	343	63
Confl. Peds. (#/hr)	139		129	129		139	220		171	171		220
Confl. Bikes (#/hr)			10			10			7			2
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	156	71	139	57	34	18	55	229	54	26	343	63
Lane Group Flow (vph)	0	366	0	0	109	0	0	338	0	0	369	63
Sign Control		Yield			Yield			Yield			Yield	

Intersection Summary	
Area Type:	Other
Control Type: Roundabout	
Intersection Capacity Utilization 79.1%	ICU Level of Service D
Analysis Period (min) 60	

APPENDIX E – PRODUCTION RATES

The following table outlines the production rates acquired for each scheduled activity.

Table 8. Production Rates for Major Tasks

Description of Activities	**Unit of Measure**	**Production Rate** *(Unit of Measure/Day)*
Curb and Gutter Removals	LM	95.38
Asphalt Removals	MT	661.11
Concrete Sidewalk Removals	LM	75
Catch Basin Removals and Salvage	Each	4.1
MH Adjustments (Raising)	Each	2.5
Relocation and Re-wiring Conduits and Cables	LS	0.1
Catch Basin Re-install	Each	2.05
Excavation and Grading for the Footings	Each	1
Form and Pour the footings	Each	1
Form and Pour the Footing Columns	Each	0.8
Install of Girder	Each	0.5
Supply, Placement and Grading of 19 mm Gravels for the Road	M2	595
Supply, Placement and Grading of Gravels for Bike Lanes and Shared Paths	M2	78
Supply, Placement and Grading of Gravels for the 1.8 m Separate Sidewalk	M2	193
Concrete Pour for Curb and Gutter	LM	12
Concrete Pour for 1.8 m Separate Sidewalk	LM	37
Supply and Placement of 50 mm Asphalt on Bike Lanes and Shared Paths	M2	114
Supply and Placement of 140 mm Asphalt on the Road	M2	595

APPENDIX F – OVERPASS CALCULATIONS

CONSTANT AND LOADS

Live Load	4.80 kPa	f'c	30 MPa
Green Roof	1.90 kPa	fy	40 MPa
Superimposed Deadload	1.25 kPa	Φc	0.65
Snow Load	1.92 kPa	Φs	0.85
Concrete Weight	23.5 kN/m³		

SLAB DESIGN

SELECT SLAB THICKNESS AND DETERIMIN CLEAR SPAN

The slab is suspended between two beams 3,000 mm apart.

ℓ_n=3,000 mm – 300 mm = 2,400 mm

t= ℓ_n/20=2,400 mm /20 =120 mm

Choose thickness = 150 mm

FACTORED LOAD OVER 1 M WIDE SLAB STRIP

$$Factored\ Load = 1.25\left(1.90\ kPa + 1.25\ kPa + 23.5\frac{kN}{m^3} * 0.15\ m\right)$$
$$+1.5(4.80\ kPa) + 1.92kPa = 15.3\ kPa * 1\ m = 15.3\ \frac{kN}{m}$$

DETERMINE SHEAR AND BENDING DIAGRAMS

l= ℓn+t=2,550 mm

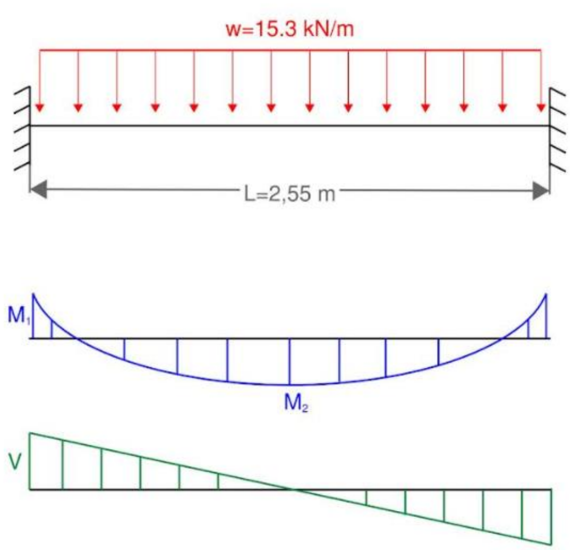
$M_1 = \frac{wl^2}{12}$=8.3 kNm

$M_2 = \frac{wl^2}{24}$=4.1 kNm

$V=V_f=\frac{wl}{2}$=19.5 kN

$V_c=\emptyset_c \beta \sqrt{f_c'} b_w d_v$
$= 0.65 * 0.21\sqrt{30\ MPa} * 0.9 * 150\ mm * 1000m$
=101 kN

V_f =19.5 kN ≤ V_c=101 kN Shear Check is good



DESIGN BLL

$s \leq \min(3t,500) = 450$ mm

A_b=0.002*s*t=0.002*450 mm*150 mm=135 mm^2

Choose 15 m bars at 500 mm spacing

2-hour fire corrosion cover=25 mm

d=150-25-15/2=117.5 mm

Check that $M_f < M_r$

$$M_r = 0.85 * 400\ MPa * \frac{200\ mm^2}{0.5m}\left[117.5mm - \frac{0.85 * 400\ MPa * \frac{200\ mm^2}{0.5m}}{2 * 0.81 * 0.65 * 30MPa * 1000mm}\right] = 25.0kNm$$

M_f=4.1 kNm < M_r 25 kNm Moment Check is good

DESIGN TUL

$s \leq \min(3t,500) = 450$ mm

A_b=0.003*s*t=0.003*450 mm*150 mm=203 mm^2

Choose 20 m bars at 500 mm spacing

2-hour fire corrosion cover=25 mm

d=150-25-20/2=115 mm

Check that $M_f < M_r$

$$M_r = 0.85 * 400\ MPa * \frac{200\ mm^2}{0.5m}\left[115mm - \frac{0.85 * 400\ MPa * \frac{200\ mm^2}{0.5m}}{2 * 0.81 * 0.65 * 30MPa * 1000mm}\right] = 24.4\ kNm$$

M_f=8.3 kNm < M_r 24.4 kNm Moment Check is good

DESIGN BUL

$s \leq \min(5t,500) = 500$ mm

A_b=0.002*s*t=0.002*450 mm*150 mm=150 mm^2

Choose 15 m bars at 500 mm spacing

DESIGN TLL

$$s \leq \min(3t,500) = 450 \text{ mm}$$

$$A_b=0.004*s*t=0.004*450 \text{ mm}*150 \text{ mm}=270 \text{ mm}^2$$

Choose 20 m bars at 500 mm spacing

REINFORCEMENT SUMMARY

Type	Bar Size	Spacing	Length
BLL	15M	500 mm	2,700 mm
BUL	15M	500 mm	continuous
TUL	20M	500 mm	675 mm
TLL	20M	500 mm	2,925 mm

BEAM DESIGN

SELECT SLAB THICKNESS AND DETERIMIN CLEAR SPAN

The beam spans 21 m with columns halfway

$$\ell_n=21{,}000 \text{ mm} /2 = 10{,}500 \text{ mm}$$

$$t= \ell_n/21=10{,}500 \text{ mm} /21 =500 \text{ mm}$$

$$\text{Choose width} = 300\text{mm}$$

FACTORED LOAD OVER 1 M WIDE SLAB STRIP

$$Factored\ Load = 1.25\left(1.90\ kPa + 1.25\ kPa + 23.5\frac{kN}{m^3} * (0.15\ m + 0.5\ m\right)$$
$$+1.5(4.80\ kPa) + 1.92kPa = 24.8\ kPa * 1.5\ m = 37.2\ \frac{kN}{m}$$

DETERMINE SHEAR AND BENDING DIAGRAMS

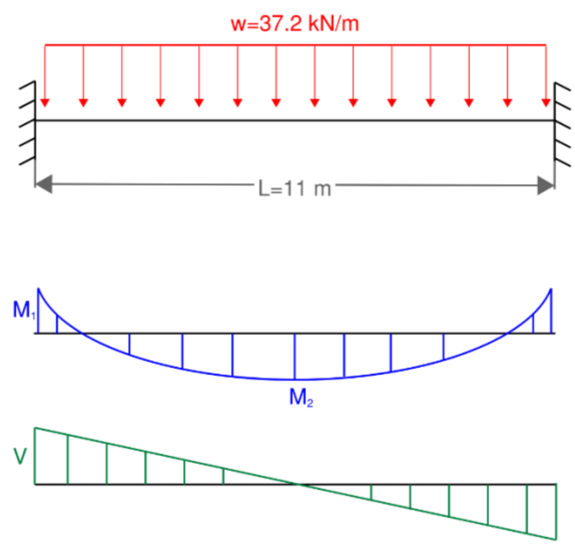
$$l= \ell n+t=11{,}000 \text{ mm}$$

$$M_1=\frac{wl^2}{12}=375.3 \text{ kNm}$$

$$M_2=\frac{wl^2}{24}=187.7 \text{ kNm}$$

$$V=V_f=\frac{wl}{2}=204.7 \text{ kN}$$

$$V_r=0.25\emptyset_c f_c' b_w d_v$$
$$= 0.65 * 0.25 * 30\ MPa * 0.9 * 500\ mm * 300m$$
$$=658.1 \text{ kN}$$



$V_f = 204.7\ kN \leq V_c = 658.1\ kN$ Shear Check is good

DESIGN BOTTOM REINFORMENT AT MIDSPAN

For cover choose 30 mm for corrosion

Choose 20 M bars with 10 M stirrups

Estimate jd=0.9(500 mm - 30 mm– 10 mm – 20/2mm) = 405 mm*

Tension force Required = T=Mf/jd=345 kN

Area of Steel = $As = T/\phi_s f_y = 1000\ mm^2$

Choose 20 M 3 bars

Crack Control = $z = 0.6 f_y (d_c A)^{1/3}$=27,473 N/mm < Z_{max} = 30,000 Crack Control is good

DESIGN TOP REINFORMENT AT ENDS

For cover choose 30 mm for corrosion

Choose 15 M bars with 10 M stirrups

Estimate jd=0.9(500 mm - 30 mm– 10 mm – 15/2mm) = 403 mm*

Tension force Required = T=Mf/jd=325 kN

Area of Steel = $As = T/\phi_s f_y = 2{,}000\ mm^2$

Choose 15 M 2 layers of 5 bars

Crack Control = $z = 0.6 f_y (d_c A)^{1/3}$=22,679 N/mm < Z_{max} = 30,000 Crack Control is good

DESIGN STIRRUPS

$$V_r = V_c + V_s$$

$$V_c = \emptyset_c \beta \sqrt{f_c'} b_w d_v = 86\ kN$$

$$V_s = \emptyset_s f_y A_s d_v \cot\theta / s = 139\ kN$$

V_r=225 kN < $0.25V_f$=654 kN Diagonal compression Check is good

$$A_{v\,min} = 0.06\sqrt{f_c'}\, b\, s / f_y = 77\ mm^2$$

Choose 10 M stirrups $A_v = 2*100\ mm^2$

$S = 0.7*d_v = 313\ mm^2$

Choose 10 M stirrups spaced 300 mm

COLUMN DESIGN

SQUARE COLUMN

Determine the point factored load for 1 column supporting the deck slab

Slab dead weight	*(10.5 m)(1.5 m)(0.15 m)(23.5 kN/m³)=56 kN*
Beam dead weight	*(10.5 m)(0.5 m)(0.3 m)(23.5 kN/m³)=37 kN*
Loads from the green roof	*(10.5 m)(1.5 m)(1.9 kPa)=30 kN*
Superimposed deadload	*(10.5 m)(1.5 m)(1.25 kPa)=20 kN*
Column self-weight (iterated)	*(0.3 m)(0.3 m)(=5.0 m)(23.5 kN/m³)=10 kN*
Live load	*(10.5 m)(1.5 m)(4.8 kPa)=76 kN*
	**From the BC Building code*
Snow load	*(10.5 m)(1.5 m)(1.92 kPa)=46 kN*
Governing Factors	***1.25D+1.5L+1S***

$$Factored\ Load = 1.25(56\ kN + 37\ kN + 30\ kN + 20\ kN + 10\ kN) + 1.5(76\ kN) + 46kN = 350\ kN$$

Choose 1% vertical reinforcement

$$P_{ro} = \alpha_1 \phi_c f_c' A_c + \phi_s f_y A_s = 1{,}894\ kN$$
$$P_{max} = 0.8 * 1{,}894\ kN = 1{,}515\ kN$$
$$P_{max} > 350\ kN$$

Choose 15 M bars

Number of bars needed= As/200 mm²= 4 bars

*Ties Spaced = s<16*d_b=240 mm*

Choose 10 M Ties spaced 240 mm

FOOTING DESIGN

SQUARE FOOTING DIMENSION

Plan dimension of the footings are determined using the allowable bearing stress due to unfactored loads and self-weight and the bearing capacity of the soil.

Description	Values	Unit
Footing Width	1,600	mm
Footing Thickness	575	mm
Reinforced Concrete Unit Weight*	23.1	kN/m³
Unfactored Axial Load	229	kN

*Unit weight is based off 0.95% steel

$$Footing\ Self\ Weight = (1.6m)^2(0.5m)\left(\frac{23.5kN}{m^3}\right) = 30.25\ kN$$
$$Total\ Unfactored\ Axial\ Load = 229kN + 30.25kN = 259\ kN$$

$$Footing\ Bearing\ Stress = \frac{Load}{Area} = \frac{259x10^3N}{(1600mm)(1600mm)} = 0.099MPa = 99kPa$$
$$Footing\ Bearing\ Stress = 99kPa < Bearing\ Capacity = 100kPa$$

SHEAR LOAD FOR SQUARE FOOTING

Since the shear varies linearly from the column to the edge of the footing, the slope can be determined and used to find the shear stress at a distance of d_v or d/2.

$$V = \frac{F_{COLUMN}}{2} = \frac{369kN}{2} = 185\ kN$$

Distance from Column *(mm)*	0	714
Shear Force *(kN)*	185	0
Slope *(kN/mm)*	0.26	

$$Slope\ = \frac{Force}{Distance} = \frac{185-0}{714-0} = 0.26\ kN/mm$$

ONE-WAY SHEAR

Please note, the following calculations are for square footings. Rectangular footings have a similar methodology with different values for the dimensions, forces, and factors.

Step 1: Calculate the shear depth d_v

$$d_v = 0.9d = 0.9(500mm) = 450mm$$

Step 2: Calculate the shear force at d_v

$$V_f = V - d_v * slope = 185kN - 450mm * 0.26kN/mm = \mathbf{68\ kN}$$

Step 3: Check if it is a deep footing

$$\frac{Footing\ side\ length - column\ side\ length}{2} \leq d_v$$
$$\frac{1{,}730mm - 300mm}{2} \leq 450mm$$

Therefore, the footing is not deep, and the beta factor must account for this.

Step 4: Calculate the one-way factored shear resistance

$$\beta = \frac{230}{1000 + d_v} = \frac{230}{1000+450} = 0.16$$
$$V_c = \emptyset_c \beta \sqrt{f_c'} b_w d_v = \frac{0.16 * \sqrt{45} * 1{,}730mm * 300mm}{1000} = \mathbf{827\ kN}$$

Step 5: Check if the factored shear resistance is greater than the shear force/load

$$V_c > V_f = 827\ kN \gg 68\ kN = meets\ load\ demands$$

TWO-WAY SHEAR

Please note, the following calculations are for square footings. Rectangular footings have a similar process with different values for the dimensions, forces, and factors.

Step 1: Calculate the shear depth d

$$d_{/2} = \frac{d}{2} = \frac{500mm}{2} = 250mm$$

Step 2: Calculate the shear force at d_v

$$v_f = \frac{V_f}{b_o d} = \frac{185kN * 1000}{3{,}200mm * (500mm - 75mm)} = \mathbf{0.136\ MPa}$$

Step 3: Calculate the two-way factored shear resistance

$$\propto_s = 2\ since\ corner\ column,\ \beta_c = 1,$$

$$b_o = 4 * (column\ side\ length + footing\ side\ length) = 4 * (500mm + 300mm) = 3200mm$$

1) $v_{c1} = \left(1 + \frac{2}{\beta_c}\right) 0.19\emptyset_c\sqrt{f_c'} = \left(1 + \frac{2}{1}\right)(0.19)(1)\left(\sqrt{45MPa}\right) = 3.8\ MPa$
2) $v_{c2} = 0.38\emptyset_c\sqrt{f_c'} = (0.38)(1)\left(\sqrt{45MPa}\right) = 2.5\ MPa$
3) $v_{c3} = \left(\frac{\propto_s d}{b_o} + 0.19\right)\emptyset_c\sqrt{f_c'} = \left(4 * \frac{500mm-75mm}{3200mm} + 0.19\right)(1)\left(\sqrt{45MPa}\right) = 3.1\ MPa$

The minimum of the three values is the factored shear resistance: **2. 5 MPa**

Step 4: Check if the factored shear resistance is greater than the shear force/load

$$v_c > v_f = 2.5\ MPa \gg 0.136\ MPa = meets\ load\ demands$$

LONGITUINAL REINFORMCENT

Moment caused by Upward Force=$M_r = 35\ kN$

Area of Steel, choose 1% As=25,819 mm^2

Choose 20 M bars, 25,819 mm^2 /300/2=38

With 4 dowels, 1 at each corner to resist Bearing force

APPENDIX G – STANDARDS AND SPECIFICATIONS

UBC Vancouver Technical Specifications – November 2021 Revision

01 General Requirements

Conform to Division 01 Sections 01 00 00 to 01 92 00

02 Existing Conditions

02 41 00 Demolition

03 Concrete

03 00 00 Concrete
03 33 00 Architectural Concrete

05 Metal

05 00 00 Metals
05 50 00 Metal Fabrications

Division 05 to conform to BC Building Code 2018 > Division B Acceptable Solutions > Part 4 Structural Design

09 Finishings

09 22 16 Non-Structural Metal Framing
09 90 00 Painting & Coating (for exposed structural steel)

11 Equipment

11 60 00 Cranes and Hoists
11 81 29 Facility Fall Protection

26 Electrical

26 05 00 Electrical – General Requirements
26 05 02 Installation Methods and Requirements

31 Earthwork

31 22 00 Grading

32 Exterior Improvements

32 00 10 Landscaping Design Requirements
32 01 90 Operation and Maintenance of Planting
32 01 93.01 Tree and Shrub Preservation
32 10 00 Bases, Ballasts, and Paving
32 14 00 Unit Paving
32 33 00 Site Furnishing
32 80 00 Irrigation
32 91 00 Planting Preparation
32 93 05 Relocation of Existing Plant Material

33 Utilities

33 00 10 Underground Utilities Services
33 01 30.41 Cleaning of Sewers
33 10 00 Water Utilities
33 30 00 Sanitary Sewerage Utilities
33 49 00 Storm Drainage
33 71 19 Electrical Underground Ducts and Manholes

UBC Vancouver Campus Plan: Part 3 Design Guidelines

2.1 Sustainability

2.2 Universal Accessibility

2.3 Architecture

Conform to Sections 2.3.1 to 2.3.10

2.4 Open Space

Conform to Sections 2.4.1 to 2.4.6

2.5 Surface Infrastructure

Conform to Sections 2.5.1 to 2.5.6

2.6 Site Furnishings

Conform to Sections 2.6.1 to 2.6.13

CSA A23.3 – Design of Concrete Structures (7th Edition)

4.0 General Requirements

7.0 Details of Reinforcements

8.0 Design – Limit States, Load Combinations, and Material Properties

10.0 Flexure and Axial Loads

11.0 Shear and Torsion

15.0 Foundations