UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Redesign of Chancellor Boulevard / Wesbrook Mall Intersection at UBC

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CIVL 445 - Engineering Design and Analysis II

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CIVL 446 Final Report

REDESIGN OF CHANCELLOR BOULEVARD / WESBROOK MALL INTERSECTION AT UBC

Submitted to:
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Transportation Engineer
UBC Campus and Community Planning

Client: University of British Columbia – UBC SEEDS (Social Ecological Economic Development) Sustainability Program

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Dear Ms. Krista Falkner,

Thank you for the opportunity to submit a design proposal to the University of British Columbia, for the Chancellor Boulevard and Wesbrook Mall Intersection design. At your request, the following tasks have been completed to design the intersection:

- Completing a study to identify the intersection design most suited to the site
- Modeling current and projected traffic with multiple designs
- Selecting an intersection design and completing preliminary drawings
- Producing a cost estimate
- Producing a construction schedule
- Providing a presentation of the proposed deliverables

Enclosed is our proposal which will provide you with our design, cost and a construction schedule for construction management services.

If you have any questions or would like any clarifications, please contact our project team. We look forward to working with you again in the future.

Regards,

Team 16 Consulting

Team 16 Consulting

Encl. Redesign of Chancellor boulevard and Wesbrook Mall Intersection at UBC

EXECUTIVE SUMMARY

The existing intersection at Chancellor Boulevard and Wesbrook Mall on the University of British Columbia Vancouver Campus (UBC) currently serves as the northern entry point into campus. The existing site does not support heavy vehicles or provide a welcoming entrance to UBC. Additionally, the intersection does not provide safe access for crossing pedestrians. The upgrade of Chancellor Boulevard and Wesbrook Mall was established as a project to address these issues.

The proposed upgrade will include a single lane roundabout with crosswalks at all approaches. Additionally, electrical conduits will be installed at each crosswalk for future upgrades to include pedestrian-controlled beacons. Furthermore, bike lanes will be provided along Chancellor Boulevard, as well as the removal of the existing merge-and-turn lanes along Chancellor Boulevard to create additional green-space. The roundabout centre itself will be 18 meters in diameter to accommodate heavy vehicle turning.

The center of the roundabout has a proposed gateway structure. The structure is a multi-purpose structure to serve both as a small exhibition center, viewing platform as well as a gateway entrance into campus. Entrance to the center will be provided via a staircase constructed along the westbound direction of Chancellor Boulevard, and an exposed elevated concrete walkway which will extend towards the main structure located in the roundabout. Additionally, a gateway sign of the University of British Columbia will be installed along the structure facing eastward to serve as an entrance into the campus.

In order to complete the construction of the roundabout with minimal impact to neighboring homes and the community, a phased construction schedule is proposed. Starting in May 2017 and completing in August 2017, the construction and traffic management plans allow for either two-way or one-way traffic along Chancellor Boulevard during all but one weekend of construction. Additionally, the gateway structure will be constructed at the beginning of the summer in 2018.

The cost of the project construction is estimated at $1,733,800. This includes $254,730 for the design of the project and $1,479,000 for the construction. Additionally, construction management fees have been included as this is the preferred project delivery method.

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DESIGN STANDARDS AND SOFTWARE PACKAGES

Software	Version	Use
Civil3D	2016	Geometric Design and Construction Drawings
Vehicle Tracking	2016	Traffic Analysis
Synchro	6	Traffic Analysis
SimTraffic	6	Traffic Analysis
SketchUp	2016	Graphics
Revit	2017	Graphics
SAP2000	19	Structural Analysis

Design Standard	Version	Use
HCM	2010	Highway Capacity Manual - Level of Service Designations
TAC	2007	Geometric Design Layouts and Site Distances
Worksafe BC	2016	Construction Phasing and Coordination
NBCC	2010	Structural Design Standard
ASTM	2008	Geotechnical Design Standard
MMCD	2010	Standard Details

1. INTRODUCTION

The existing intersection at Chancellor Boulevard and Wesbrook Mall serves as the northern entry point into the University of British Columbia (UBC). This stop and yield-controlled intersection will fail to meet future demands and currently does not support heavy vehicles. To address these issues, a roundabout replacement was proposed. This upgrade will include a single lane roundabout with crosswalks at all approaches and new bicycle lanes along Chancellor Boulevard. Furthermore, the removal of existing turning lanes and the addition of the roundabout, 18 meters in diameter, will create further green-space. The roundabout will feature a 6-meter high observation deck showcasing UBC's rich history and serve as an inviting gateway into the campus.

To minimize disturbance to neighboring homes and community, phased construction will commence May 2017 and be completed in August 2017. The proposed traffic management plan will allow for either two-way or one-way traffic along Chancellor Boulevard during all but one weekend of construction. Additionally, the gateway structure will be constructed at the beginning of the summer in 2018. The final cost of the project is estimated at $1,733,800.

Table 1 - Team Contribution Breakdown

Team Contribution Breakdown

Team Member	Role	Responsibility
Jeffrey Chun	*Structural Engineer*	*Regulatory Criteria, Social Criteria, Structural Considerations, Gateway Design, Construction Schedule*
Nathan Chan	*Structural Engineer*	*Key Project Criteria, Alternative Designs, Structural Considerations, Gateway Design, Construction Schedule*
Jessica Francis	*Project Manager*	*Title Page, Transmittal, Introduction, Construction Schedule, Traffic Management Plan, Formatting, Editing, Recorder, Appendices*
Nishchhal Gautam	*Geotechnical Engineer*	*Construction Materials, Geotechnical Considerations, Construction Schedule, 3D Modeller*
Ryan Li	*Traffic Engineer*	*Environmental Issues, Geometric Design, Synchro Analysis, Construction Schedule, Traffic Management Plan, AutoCAD, Utilities, Editing*
Jason Wen	*Estimator, Scheduler*	*Construction Schedule, MS Project, Cost Estimation*

2. KEY PROJECT ISSUES AND CRITERIA

The existing intersection configuration is becoming outdated in meeting growing demands, as it is unable to safely support pedestrian, cyclist, and vehicular traffic. The key issues of the intersection at Chancellor Boulevard are:

- Pedestrian safety, as the current intersection is not constructed with appropriate pedestrian and cyclist markings which is a major concern for public safety due to the lack of proper signage for the right of way
- The lack of accommodation for vehicular traffic as the existing configuration is unconventional which has caused confusion and a demand for more clear signage or road design.
- The growing demands of public transit from and towards the university, as the design capacity of the existing intersection will be exceeded in the near future

With the university's continued development and expansion, the intersection at Chancellor Boulevard serves as the main northern entrance into the campus and is a part of the university's plans for growth and improvement. Some of the key issues found through site inspections and research is the lack of accommodation for non-vehicular traffic, such as lack of bicycle exclusive lanes, pedestrian crosswalk features, and a paved sidewalk for pedestrians to cross, risking the safety of public. A major concern is the unconventional intersection layout that has caused confusion and demand for more clear signage or road design. The intersection currently does not cater to the safety of pedestrian users, which will be addressed and focused as a fundamental part of the intersection.

2.1. Project Overview

Improvements to the existing intersection will be necessary as it does not address the safety of the road users and cannot meet the projected future traffic demand of 2% traffic growth per year. The existing design is unconventional in the Metro Vancouver region and less efficient compared to other campus entry points, such as the roundabout in the southern entrance. The main focus of the project is to address the following:

- Safety of road users (Campus and Community Planning, 2014)
- Stormwater Management and Landscaping Improvement (UBC Sustainability, 2014)
- Provision of an attractive visual gateway into campus
- Ensure stakeholder issues are accommodated

2.2. Technical Issues

For the redesign of the Chancellor Boulevard and Wesbrook Mall intersection, there were various site-specific constraints that were observed during site visits and initial feasibility studies. These constraints are outlined below:

- Existing utilities and storm water drainage must be diverted during construction and relocated to allow for excavation of the project solution
- The design will accommodate for large buses leaving the UBC bus loop and semi-trucks (WB-17)
- Drainage monitoring should be conducted on a weekly basis or after large rainfall events to ensure drainage from the site is not harmful to the environment
- Traffic management plans during all stages of construction will minimize disturbance to daily traffic

2.3. Key Economic and Construction Issues

Some of the key economic and construction issues are listed below:

- Limited space for storage – equipment and material, as well as deliveries will need to be coordinated and organized in advance
- Traffic control – the intersection is to be kept operational for as long as possible
- Timeframe – the construction should have minimal impact on the winter I and winter II semester traffic at UBC
- Property Lines – the project is constructed between The University Neighbourhood Association – Chancellor Place, the University Endowment Lands, and the Ministry of Transportation and Infrastructure
- Funding – as this is a Ministry of Transportation road a funding scheme is to be determined

2.4. Regulatory Criteria

For the design of the Chancellor Boulevard and Wesbrook Mall intersection, there are many governing bodies which the design must adhere to.

City of Vancouver

For projects constructed in the City of Vancouver, there are 5 sets of construction standards which must be followed *(The City of Vancouver , 2016)*.

The Master Municipal Construction Document (MMCD) and the City's supplementary Street Restoration Manual provides specific measurements, drawings, and procedures for installing municipal infrastructure such as roundabouts. The TAC Geometric Design Guide will be used as the basis for the roundabout design as it provides recommended measurements and layouts for designing intersections. The Accessible Street Design Guide provides guidelines for street and sidewalk pedestrian accessibility to be used during the design phase of the intersection. The Street Tree Manual describes landscaping and tree planting concerns, which will be used during the restoration of the intersection after the main construction phase.

The University of British Columbia

The University of British Columbia has various guidelines and protocol for construction projects in the campus area outlined in Policy 92: Land Use and Permitting *(Campus and Community Planning, 2016)*. The policy encompasses UBC's Land Use, Neighbourhood, and Vancouver Campus development plans and their associated permits. The permits and approval needed for the project will be obtained prior to the construction start date.

Ministry of Transportation

Traffic control for the redesign of Chancellor Boulevard and Wesbrook Mall intersection will follow traffic control protocol as outlined in the BC Ministry of Transportation's Traffic Control Manual for Work on Roadways *(Ministry of Transportation and Infrastructure, 2015)*. In addition, construction practices for redesigning the intersection will adhere to Worksafe BC standards *(WorkSafeBC, 2016)*.

Federal

Currently there is no need for federal involvement in the project.

Musqueam

As this project is not on Musqueam land, there are not regulatory concerns. However, the Musqueam people will be engaged as part of the stakeholder process.

2.5. Environmental Issues

The current layout of the stop-controlled intersection of Chancellor Boulevard and Wesbrook Mall consists largely of impermeable surfaces, thus there is room for improvement in regards to stormwater management. In addition, in the event of rainfall, stormwater can potentially transport grease and oil from the bus loop towards Chancellor Boulevard and Wesbrook Mall – which lead to fish habitat downstream. Due to the inherent function of a stop-controlled intersection, there is a significant amount of idling from vehicles due to the requirement of stopping – even in low-traffic scenarios. As a result, reduction of CO_2 and improvement to air quality is one of the reasons of the recommendation of a roundabout. It should be noted the project is relatively small in scale and does not require an environmental impact assessment.

Stormwater Management

The implementation of a roundabout will provide a generous amount of greenspace – within the roundabout, approach islands, and boulevards – relative to the existing layout of Chancellor Boulevard and Wesbrook Mall. During the construction of the roundabout, there is an opportunity to improve stormwater management by allowing water to infiltrate, while simultaneously providing additional stormwater drains.

2.6. Social Criteria

The social engagement activities provides a means for various project stakeholder groups to contribute and engage in the development of the design. It is an iterative process that identifies the concerns and issues from different stakeholder groups to be addressed into the final design and construction planning. The intersection project will consider and incorporate the feedback and advice from various social engagement activities where appropriate.

Stakeholders

A stakeholder register can be found in *Appendix C – Stakeholder Register* which outlines key project stakeholders, their involvement, and interest levels. A public consultation will take place before the detailed design is completed to engage stakeholders. As aforementioned, the project aims to align with UBC's initiatives, such as UBC's Transportation Plan 2040 and UBC's Sustainability initiative thus, close liaison with various UBC stakeholders will be conducted during the planning and construction phases of the project. The stakeholder register is very flexible and subject to change throughout the project as well as the stakeholder management classifications. Within the register, stakeholders are grouped into management categories:

Daily Communications

Stakeholders categorized with a (D) are expected to contribute to daily communication throughout the project. Generally these are full time workers on project. Company email address' will be used as well as company telephones. Many communications need to written and at all meeting minutes shall be enforced. These will be uploaded onto a shared project directory to be approved by two members of the meeting within 24 business hours of the meeting.

Weekly Communications

Stakeholders categorized with a (W) have the same expectations as daily communications except on a weekly basis.

Monthly Meetings

Stakeholders categorized with a (M) are invited and some are expected to attending monthly project meetings. These are for updates on the project and general overview with a large invested audience. Meeting minutes are also expected to be taken, reviewed, and then posted on the shared project drive.

Informal Communications

Stakeholders categorized with a (I) are expected to have informally scheduled project updates. This may include only access to the project data base, public consultations, or constant meetings but only at a particular phase of the project. A representative from stakeholder groups (I) maybe be invited to monthly meetings depending on the agenda.

3. ROUNDABOUT DESIGN

The following section will discuss the roundabout preliminary design and rationale.

3.1. Key Design Features

The preferred design for the Chancellor Boulevard and Wesbrook Mall intersection will be to implement a roundabout similar to the other vehicular entrances into the campus, which will address the key issues of pedestrian safety and increase in future traffic demands. The implementation of a roundabout is recommended to best satisfy safety and sustainability issues, as well as provide room for the addition of visual features to form a gateway into the UBC campus. Other designs were considered and can be found in *Appendix A – Conceptual Design Alternatives*.

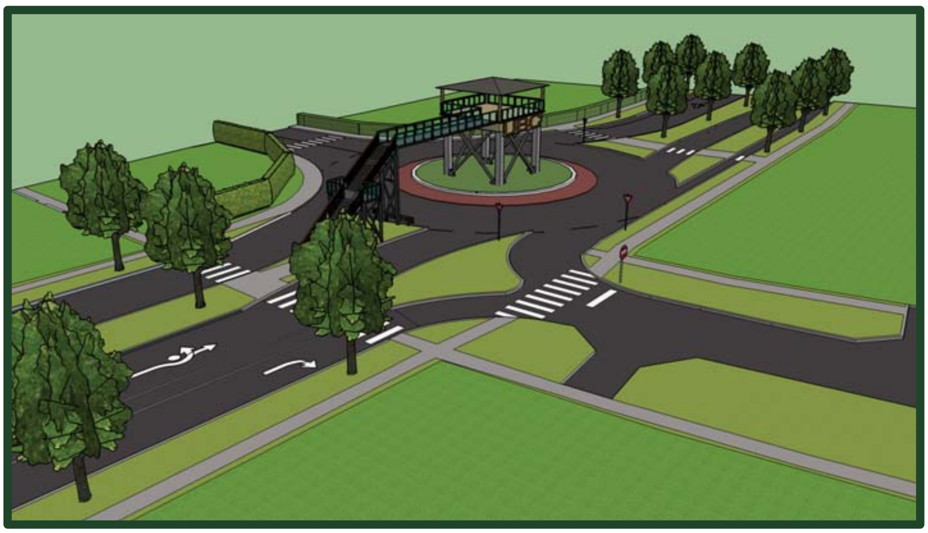

Figure 1 - Overview of Proposed Roundabout Design

1. <u>Intersection Safety</u>

- Additional safety features for both pedestrians and cyclists by implementing crosswalks and a boulevard which isolates vehicular traffic
- Electrical connections will facilitate the upgrade of LED lighting for pedestrian crosswalks at all approaches
- The east approach cyclist lane will be integrated into the roundabout to provide cyclists a choice of cycling routes; to merge with vehicular traffic or dismount to avoid vehicular traffic
- Due to the nature of a roundabout design, vehicle speeds are generally slower, minimizing chance of collision and reducing severity of collisions

- Roundabouts are inherently safer as the type of collision is forced to sideswipe collisions, which is significantly less fatal compared to head-on or side collision found in the traditional intersection
- There is a concrete apron within the roundabout that allows for heavy vehicles – such as WB-17 and Articulated busses – to overtrack safely.
- The concrete apron also provides access for landscaping crews to maintain the greenspace near the roundabout; including the roundabout itself

2. Project Sustainability

- Additional green space at the roundabout and along the northern corridor improves stormwater management and landscaping features
- The roundabout design provides a more natural gateway into UBC, and allows for more opportunities for implementation of green space and landscaping around the site.

3. Traffic Capacity

- The AM Peak scenario was chosen as the baseline to perform the analyses due to the largest amount of volume amongst the three peaks (AM, Mid-day, and PM)
- Under 2016 traffic volumes, the roundabout performs well with an average delay per vehicle of less than 5 seconds; the remaining scenarios operate with an average delay per vehicle of approximately 10 seconds
- Under 2040 projected traffic volumes, the roundabout performs significantly better than the other scenarios, for further details refer to *Appendix E – Traffic Analysis Results (Synchro)*
- Vehicle Tracking results in AutoCAD show that an articulated bus can operate within the roundabout

4. Economic Performance

- As the roundabout serves as one of the main entrances into the university campus, the increase in traffic capacity can reduce future costs and collateral effects such as increasing the traffic demand of other entrances.
- Improvements to the existing stormwater management system – include additional drains along the west leg, and south leg – as part of the project will save costs in the future.

3.2. Geometric Design

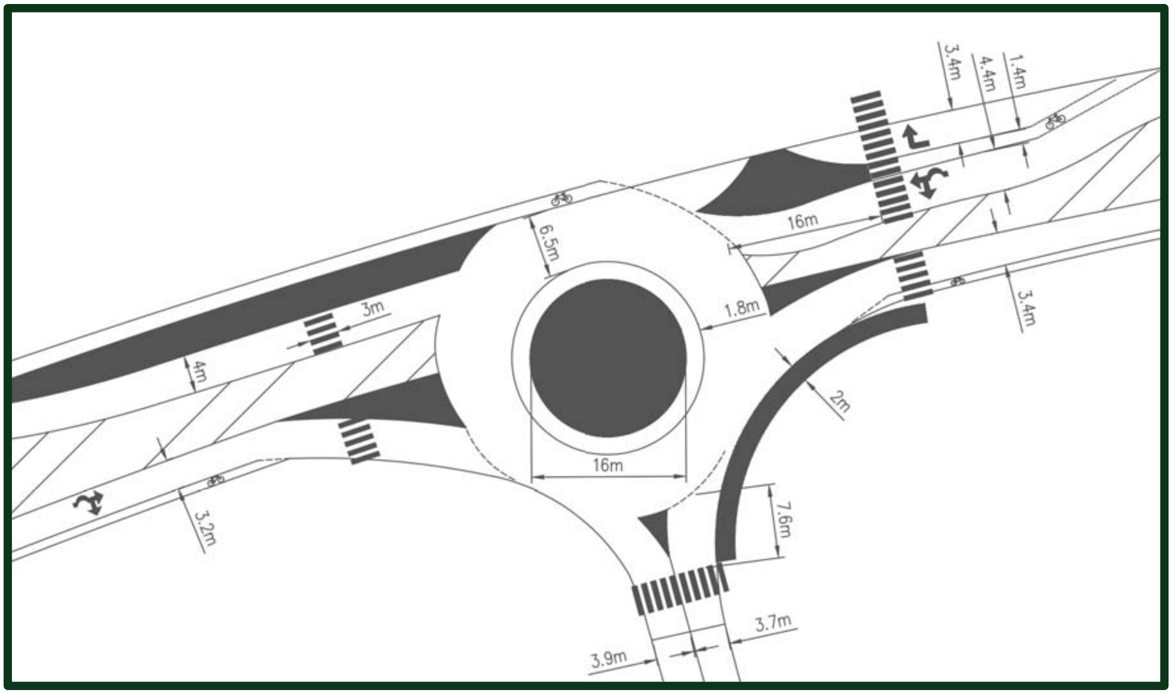

Figure 2 - Overview of Proposed Roundabout

As seen in *Figure 2 - Overview of Proposed Roundabout*, some of the key upgrades include additional crosswalks at all approaches, an additional sidewalk connecting Wesbrook Mall and Chancellor Boulevard, and improvements to the bicycle lane along the northern corridor of Chancellor Boulevard. In addition, LED flashers can be implemented at a further date – as there will be electrical stubs provided during the trenching phase – when additional traffic warrants the installation. Splitter islands at all approaches closely follow the Geometric Design Guide for Canadian Roads *(The City of Vancouver , 2016)*, the detailed design will come later along with a road safety audit.

For a detailed dimensional drawing please see *Appendix D – Drawing Package*. The existing bicycle lanes along the northern and southern corridor of Chancellor Boulevard will retain the existing dimensions. Much like the west side of the roundabout, the northern and southern corridor bicycle lanes will retain the existing dimensions. The northern corridor includes a channelized splitter island to provide access to the egress vehicles from Wesbrook Crescent. High visibility paint at significant portions of the bicycle lane will provide greater awareness to vehicular traffic. The inscribed roundabout circle dimension is 18m with a 2m apron.

3.3. Traffic Analysis

Traffic analysis results are based on the 2010 Highway Capacity Manual (HCM) Level of Service (LOS) tables for unsignalized intersections. The corresponding delays – in seconds – will be provided for each approach. In addition, the 95th percentile queue length for each approach will also be identified. Further details will be provided in the form of graphics for existing and future scenarios, and can be found in *Appendix E – Traffic Analysis Results (Synchro)* and *Appendix F – Traffic Analysis Results (SimTraffic)*.

Table 2 - Level of Service for Traffic Conditions

2010 HCM LOS Table	
LOS	*Delay (s)*
A	*<10*
B	*10-15*
C	*15-25*
D	*25-35*
E	*35-50*
F	*>50*

Existing Traffic Analysis

In the 2016 existing traffic operations, there are projected improvements at all approaches through the implementation of the proposed roundabout. In addition, the 95th percentile queue lengths are also projected to improve along the east and south approach, for both the AM Peak. Similar improvements are also expected in the PM Peak; however, all approaches are anticipated to have shortened 95th queue lengths.

Table 3 - Overview of SimTraffic Results: 2016 Morning (AM) Conditions

Intersection Configuration	*Approach*	*Delays (s)*	*Level of Service*	*95th Percentile Queue (m)*
Existing	*East*	*5-10*	*A*	*45*
	South	*5-10*	*A*	*25*
	West	*5-10*	*A*	*23*
Roundabout	*East*	*<5*	*A*	*42*
	South	*<5*	*A*	*21*
	West	*<5*	*A*	*28*

Table 4 - Overview of SimTraffic Results: 2016 Afternoon (PM) Conditions

Intersection Configuration	Approach	Delays (s)	Level of Service	95th Percentile Queue (m)
Existing	East	5-10	A	28
	South	5-10	A	25
	West	5-10	A	35
Roundabout	East	<5	A	17
	South	<5	A	19
	West	<5	A	24

Future Traffic Analysis

Under the projected 2040 traffic, significant delays along the east approach can be seen under the existing configuration of a stop-controlled intersection. With the implementation of the proposed roundabout, the east approach is anticipated to reduce delays and improve to a LOS A from LOS F, in the AM Peak. In the PM Peak, the west approach is expected to operate at LOS C under the existing stop-controlled configuration. However, the implementation of the proposed roundabout is anticipated to improve the west approach to operate at LOS A.

Table 5 - Overview of SimTraffic Results: 2040 Morning (AM) Conditions

Intersection Configuration	Approach	Delays (s)	Level of Service	95th Percentile Queue (m)
Existing	East	40-60	F	96
	South	5-10	A	32
	West	5-10	A	23
Roundabout	East	5-10	A	55
	South	<5	A	25
	West	5-10	A	40

Table 6 - Overview of SimTraffic Results: 2040 Afternoon (PM) Conditions

Intersection Configuration	Approach	Delays (s)	Level of Service	95th Percentile Queue (m)
Existing	East	5-10	A	30
	South	5-10	A	25
	West	15-25	C	90
Roundabout	East	<5	A	35
	South	5-10	A	40
	West	5-10	A	55

3.4. Geometric Inputs and Considerations

The proposed roundabout adheres to the standards found within the *BC Supplement to TAC Geometric Design Guide (Nyland, 2007)*. The articulated bus was selected as the design vehicle due to the Wesbrook Mall and Chancellor Boulevard junction serving as the collector route. AutoTURN/Vehicle Tracking was utilized to ensure the design vehicle is able to accommodate ingress to and egress traffic from UBC. As per the *BC Supplement to TAC Geometric Design Guide (Nyland, 2007)*, a minimum width of 1.8 m is to be provided at all sidewalks; the proposed roundabout upgrade provides a 2m sidewalk. Detectable warning surfaces are included at all sidewalk let-downs as additional means of providing warning of approaching vehicles. Calculations in regards to stopping sight distance and intersection sight distance can be seen in *Appendix G – Sample Roundabout Calculation*.

3.5. Traffic Operations

The proposed roundabout was analyzed under current traffic volumes and the anticipated 2040 volumes. The Highway Capacity Manual (HCM) 2010 standards for unsignalized operation was utilized for analysis *(Nyland, 2007)*. Synchro was calibrated to model the current and anticipated future conditions; as a result, under the 2016 traffic volumes, all approaches operated with a level of service (LOS) A; this corresponds to a delay of less than 5 seconds. Under the anticipated 2040 traffic volumes, the west and south approach is expected to increase in delays with a LOS B; the east approach remains as LOS A.

3.6. Construction Materials

Following excavation of the site to a suitable depth, all backfill materials will be placed in uniform lifts not exceeding 200 mm loose thickness. All backfill materials shall also be compacted to a specified 95% of Modified Proctor Maximum Dry Density (ASTM D1557) *(Engineering Services, 2008)*. Should the following specification be met, recycled asphalt product may be used.

Aggregates and Backfill

Road Base

150 mm of 19 mm Road Mulch of uniform quality, will be used up to the bottom of the asphalt. This material must adhere to the grading limits as shown below:

Table 7 - Road Base Grading Limits

SIEVE SIZE		% PASSING (by wt.)
19 mm	(3/4 in)	100
12.5 mm	(½ in)	61 - 95
9.5 mm	(3/8 in)	45 - 85
4.75 mm	(No. 4)	35 - 60
2.36 mm	(No. 8)	26 - 47
1.18 mm	(No. 16)	20 - 39
600 um	(No. 30)	13 - 29
300 um	(No. 50)	8 - 21
150 um	(No. 100)	5 - 15
75 um	(No. 200)	2 - 8

Sub-Base

450 mm of 75 mm crushed aggregates shall be placed between the sub-grade and the base course aggregates. This layer provides the strength and drainage to the pavement structure above. This material must meet the grading limits below:

Table 8 - Sub-Base Grading Limits

SIEVE SIZE		% PASSING (by wt.)
75 mm	(3 in)	100
19 mm	(3/4 in)	40 - 50
4.75 mm	(No. 4)	20 - 35
0.075 mm	(No. 200)	2 - 8

Sub-Grade Fill

The 75 mm crushed aggregate mentioned above may be used as sub-grade fill wherever needed. Native materials may also be used as sub-grade fill provided it is reviewed and approved by the City Engineer to save import costs.

Trench Backfill

Any trench fill to a maximum limit of 0.6 m below the base of pavement shall be done with a clean Sand fill. Clean sand contains trace to no organic matter and is of uniform quality. The grading limits should follow as shown below:

Table 9 - Trench Backfill Grading Limits

SIEVE SIZE		% PASSING (by wt.)
12.5 mm	(½ in)	100
9.5 mm	(3/8 in)	91 - 100
4.75 mm	(No. 4)	83 - 100
2.36 mm	(No. 8)	73 - 94
1.18 mm	(No. 16)	57 - 80
600 um	(No. 30)	33 - 60
300 um	(No. 50)	10 - 37
150 um	(No. 100)	4 - 17
75 um	(No. 200)	0 - 5

Pipe Bedding

20 mm crushed granular material of uniform quality and 100% mechanically crushed fragments with two or more fractured faces will be used as pipe bedding. The grading limits are shown below:

Table 10 - Pipe Bedding Grading Limits

SIEVE SIZE		% PASSING (by wt.)
19 mm	(3/4 in)	100
12.5 mm	(½ in)	28 - 46
9.5 mm	(3/8 in)	8 - 21
4.75 mm	(No. 4)	3 - 11
2.36 mm	(No. 8)	0 - 6
1.18 mm	(No. 16)	0 - 2

Concrete

Concrete to be used for the footings shall be of 32 MPa and for sidewalks and curbs, 25 MPa may be used with adequate air content and slump. Concrete used for footings and sidewalks must have air content between 4% to 7% with slump of 80±20 mm. Concrete used for curbs may have slumps as low as 30 mm as it needs to be extruded from a curbing machine. All concrete poured on site should be tested for slump and air at intervals of 50 m^3 to ensure specifications are being met. Concrete should be placed within 2 hours of batch time. Concrete using crushed recycled concrete as aggregates may be utilized if all other specifications are met.

Finished curb and gutter should have a smooth surface and free of voids or other irregularities. Sidewalks should be marked off in segments approximately 2.0 meters in length. If needed, control joints to minimize cracking may be installed as requested by the city. Furthermore, all sidewalk panels shall have a rough finish to aid with traction in wet conditions.

Landscaping Materials

Tree Placement is done with respect to the Street Tree Guidelines set forth by the City of Vancouver *(The City of Vancouver , 2016)*. Trees will be spaced in order to maximize tree coverage while still respecting site lines, utilities and street lighting. Any new trees planted after construction should also match existing trees and spacing of the block. Average tree spacing will be approximately 8-10 meters based on existing trees along the block.

3.7. Site Investigation

Prior to construction and geotechnical investigations, utility locates will be conducted. These tests should be done by an independent third party to confirm the location and depths of existing utilities and pipes under the site, and to avoid any potential conflicts.

On February 1 2017, 4 hand auger tests were dug to a depth of approximately 1.0m. These test holes were backfilled immediately upon completion of soil logging. The purpose of these holes was to confirm stripping depths of asphalt and road base material for preparation of the roundabout for costing purposes.

Following these test holes, 2 Cone penetration tests (CPT) was also carried out to confirm the geologic layering of the site. These holes were drilled using a truck mounted drill rig. Both holes were drilled to an approximate depth of 7 meters below existing grade. All test holes were sealed as per provincial requirements upon completion.

4. Gateway Design

The purpose of the gateway structure is to provide a large scale structure to provide a visual entrance for the northern approach into the campus. The structure will also serve as an observation and deck for leisure purposes, allowing visitors and tourists to see the campus from the deck. A showcase of UBC's rich history is also proposed through the 580ft^2 elevated showcase room. The structure will symbolize the campus' natural environment, abundant history and the modern sustainability objectives of the institution.

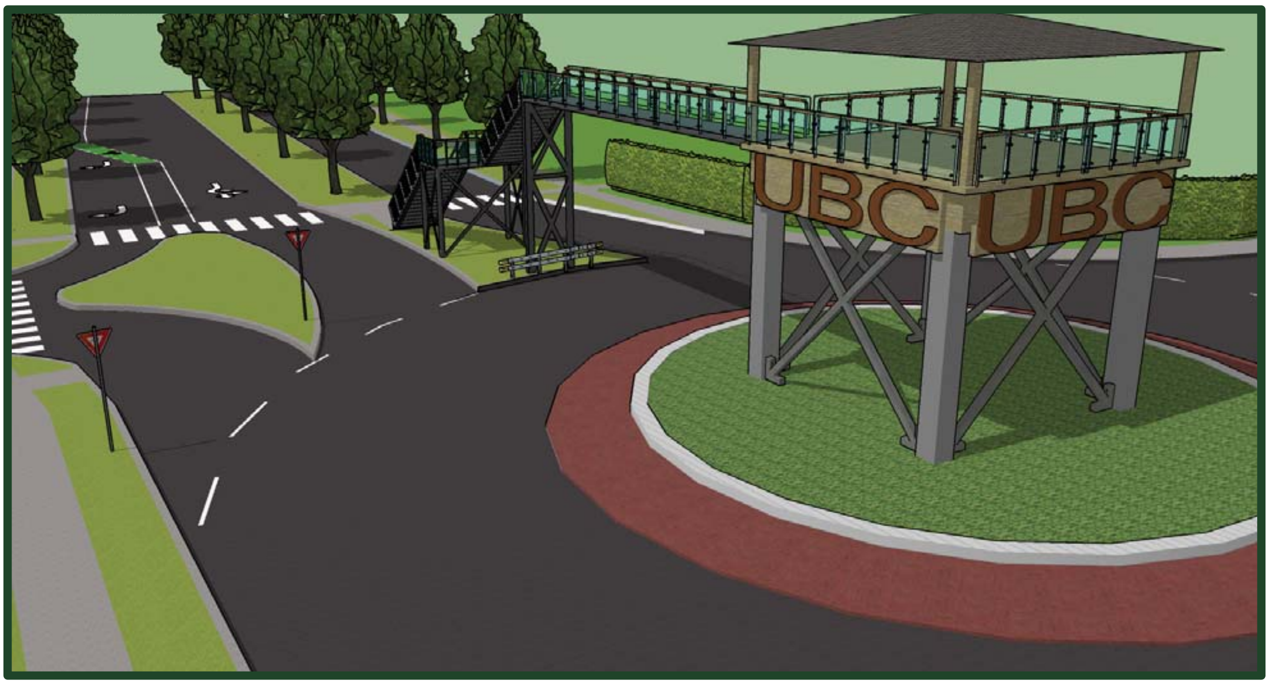

Figure 3 - Gateway Design

4.1. Structural Concept

The structure is composed of two main sections; the wooden platform structure and an open steel walkway respectively. Timber is used as the main design material where plausible to provide a sustainable and aesthetic structure. A steel staircase and walkway serve as an entrance into the wooden platform structure, and provide an open walkway for visitors.

Figure 4 - Gateway Design

The gateway is designed as a light frame structure composed of a combination of steel and timber. The structure serves as an observation platform and gathering place for leisure in the summertime, therefore designed for larger live loads (assembly loading). The main structural issues, including likely failure mechanisms are listed below:

Table 11 - Key Structural Design Parameters

Key Structural Design Issues/ Potential Failure Mechanisms	***Description***
Exposed Structure	*Need to address issue of exposed structural elements*
Earthquake Resistance	*Lateral stability and unpredictable failure mechanism*
Walkway over road	*Long span causing deflection issues, need to ensure clearance requirements for vehicles*
Accidental/Impact Loading	*Structure is exposed, key structural components exposed to hazards*
Large Gravity Loads	*Large live loads need to be accounted for (assembly area loading)*

4.2. Structural Design and Analysis

The structure was analyzed using SAP 2000 and designed in accordance with the Wood Design Manual 2010 and the Handbook of Steel Construction 2010 respectively. Detailed calculations and analysis of critical members and connections, as well as design loads as per NBCC 2010, are shown in *Appendix H – Sample Gateway Calculations*.

The governing gravity and lateral load combinations as per NBCC 2010 are summarized below:

Table 12 - Structural Load Combinations

<table>
<tr><th>Gravity</th><th>Loading Combination: 3</th><th>1.25DL + 1.5LL (+0.5SL)</th><th rowspan="2">DL = Dead Load
LL = Live Load
SL = Snow Load
E = Earthquake Load
(Elastic Analysis)</th></tr>
<tr><td>Lateral</td><td>Loading Combination: 5</td><td>1.0DL + 1.0E</td></tr>
</table>

4.3. Foundation Design

Square pad footings were selected to minimize excavation and costs while still suiting the structure's required loads. Additionally, to keep the design sustainable, the volume of concrete was minimized. A detail of one of the footings can be seen in *Appendix D – Drawing Package*.

The soil at the site of interest was taken as a Medium Sand with Friction angle (Φ) and Unit weight (γ) of 30° and 18 kN/m^3, respectively.

The allowable load on the soil was calculate using Terzaghi's bearing capacity theory. The table below summarizes the calculations. A factor of safety of 2.0 was used, where $FS = Q_{ult}/Q_{allowable}$.

$$Q_{ult} = \gamma' D N_q + 0.4\gamma' B N_\gamma$$

Where N_q and N_γ are Terzaghi's bearing capacity factors. Using a square footing of width, 1 meter, the allowable capacity ($Q_{allowable}$) was found to be 130 kPa. This ensures that 1 meter footings will suffice for a column loads up to 130 kN. All footings are placed 450 mm below ground to ensure frost protection.

4.4. Detailed Gateway Design

The critical members that were designed in the structure were the beams supporting the walkway, the columns supporting the walkway and staircase, the lateral bracing connection and the Cross-Laminated Timber decking on the wooden platform structure. A detailed summary of the structural members are shown in *Appendix D – Drawing Package*.

Table 13 - Structural Bill of Materials

Bill of Materials - Structural	
Steel	Qty.
W360x134	2
W360x33	6
HSS89x89x6.4	10
L76x76x7.9	12
A236 M22 Bolts	48
Timber	Qty.
5-PLY CLT, Stress Grade E2	1
D.Fir-L 24f EX 215x190	6
Timber Roof Truss	1

5. CONSTRUCTION METHODOLOGY

5.1. Construction Safety

The selected contractor will adhere WorkSafeBC's occupational health and safety (OHS) regulations, policies, and guidelines. The contractor is expected to prepare a project-specific safety management plan submitted to and approved by the owner, UBC Campus and Community Planning. During field inspections, should the contractor appear to be in violation of any articles from WorkSafeBC's OHS regulations, the field reviewer has authority to call for an inspection from WorkSafeBC at his/her discretion.

In this project, the prime consultant will require the following safety submissions from the contractor for review:

1. Shop drawings of trenching/shoring used for excavation, to be signed by independent reviewer specialized in trench/shore design. This can be done by contractor's in-house engineering, provided that it is submitted for review. Electrical and utilities trenching/tie-ins will not proceed without engineering sign-off.
2. Fall protection plan, produced by contractor's in-house and/or subcontracted engineering. To be approved by the owner's engineer(s). Gateway installation can be constructed up to ground level columns without owner's approval. Erection of the observation deck, walkway, and stairs cannot proceed without owner's approval.
3. Engineered rigging and lifts for critical lifts, to be signed off by a crane engineer. Rigging of heavy/wide gateway components (CLT deck slab, walkway girders) will be investigated by the crane subcontractor to determine if it is a critical lift. Erection of the observation deck and walkway cannot proceed without engineering sign-off.

The contractor shall be prepared to produce documentation of safety practices they have followed at any time, at the request of the owner and/or the prime consultant. These practices are not limited to activities listed above for submission and approval. The contractor and owner will also establish weekly safety shares and maintain a log of safety share minutes. When needed, the prime consultant, at the request of the owner and/or contractor, can attend safety shares to resolve site hazards.

5.2. Schedule

A preliminary construction schedule has been provided in *Appendix I –Construction Schedule.* Each stage of construction is discussed below with corresponding preliminary traffic management plan. Construction has been proposed in ten stages to keep traffic open for as long as possible. Generally construction work is scheduled for Monday to Friday, 7:00am – 3:00pm. When construction is not active, the existing intersection will be re-created with cones to keep traffic flowing. Once stage 9 is reached and the road is reopened the intersection will then operate as a roundabout. The below description and graphics of each construction phase will give an overview of construction activities and traffic diversions. At the end of each stage steel plate will cover trenches or gravel will be compacted for traffic to drive on. For length of activities please refer to the construction schedule provided in *Appendix I –Construction Schedule*. To determine the level of detail and risk for the traffic management plan the Ministry of Transportation checklist was completed and can be found in *Appendix K –Traffic Management Plan Checklist*.

5.3. Traffic Management Plan

The traffic management plan was developed in accordance to BC Ministry of Transportation and Infrastructure criteria as well as WorksafeBC. The stages outline below are for the construction of the roundabout only.

Stage 1 – Mobilization

Figure 5 - Stage 1: Mobilization & Site Plan

The fenced area show above is a locked compound where the general contractor may store items. The proposed site layout has two parking spots, one for the superintendent and the other for visitors such as inspectors who will only be present for a small amount of time. All other workers are expected to park at the Rose Garden or North Parkade. The Northern acceleration lane will be utilized for deliveries during this stage.

Stage 2 – South West Island Demolition

Figure 6 - Stage 2: Southwest Island Demolition

In order for more space to be obtained the southeast island was selected as the first stage of demolition. The right turn lane from the west approach will be closed off to provide space for the demolition and allow a truck for removal/delivery; however the intersection will function normally with the addition of two flaggers to ensure the safety of all workers and the general public. Once the island is removed it will be replaced will gravel and then compacted for vehicle to drive over in the future. Cones will be put in place to re-create the island and keep the intersection geometry the same as before construction.

Stage 3 – South East Island Demolition

Figure 7 - Stage 3: Southeast Island Demolition

Similar to the stage previous the southeast island will be removed next using the traffic plan as above.

Figure 8 - Stage 3: Temporary Bus Accommodation

In preparation for upcoming traffic diversions part of the median will need to be removed at the adjacent intersection eastward, Chancellor Boulevard and Western Parkway. During upcoming construction there will be one-way traffic on Chancellor Boulevard that will at times utilize either the eastbound or westbound lane; in order for articulated buses to make this lane change, the median must temporarily be cut back and compacted to be operated as road space.

Stage 4 – North East Median Construction

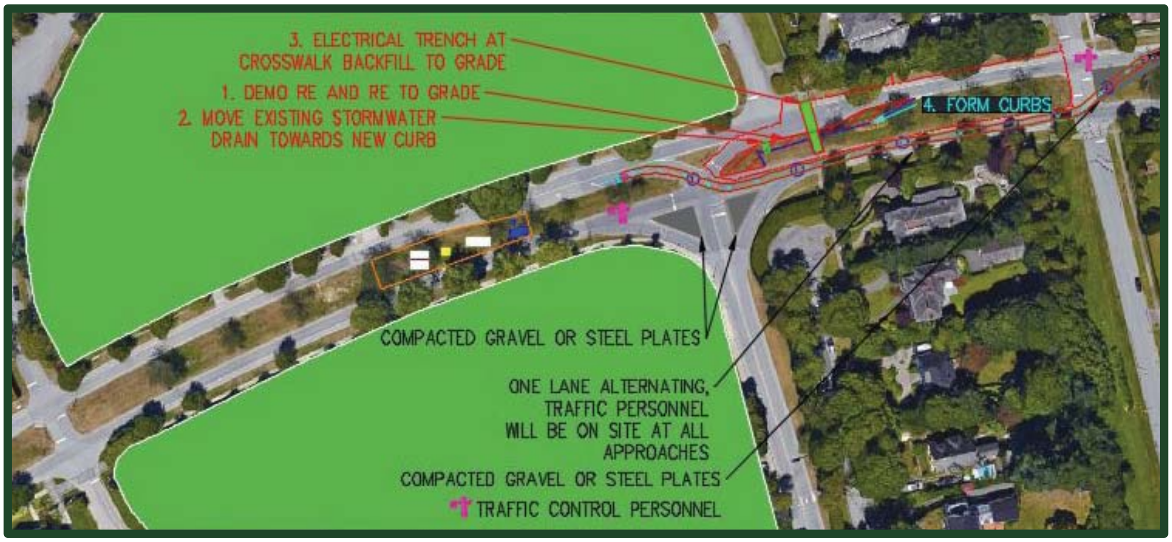

Figure 9 - Stage 4: East Median Demolition

In order to accommodate the roundabout the east approach to the intersection must be moved slightly south so through traffic does not continue is a straight trajectory. The east island must also be shortened to accommodate the center of the roundabout. In order for this construction to take place the east approach of Chancellor Boulevard must be closed from Western Parkway to Wesbrook Mall. Traffic will be one way on and diverted to the west approach. There will be flaggers present during the day and cones will be set up to re-create the existing intersection at night. Trenching will also begin to move the existing storm drain to the new curb as well as electrical for the future addition of pedestrian lights and roundabout lighting.

Stage 5 – North West Median Construction

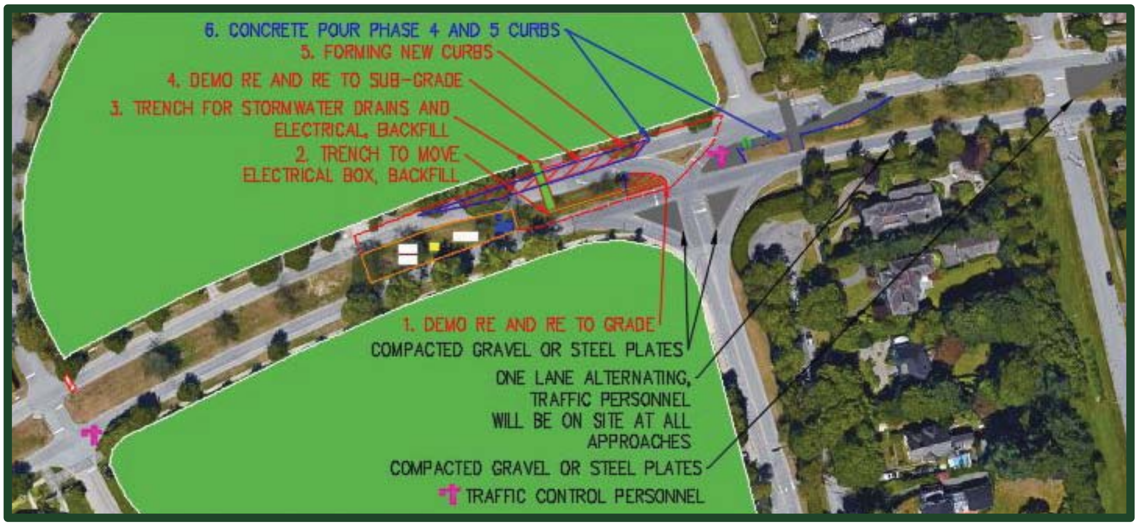

Figure 10 – Stage 5: West Median Demolition and Northwest Island Construction

Similar to the previous stage, the east approach of Chancellor Boulevard will be closed. In this stage the closure will start at Wesbrook Mall until Theology Mall. The closure to is to accommodate the construction on the new northwest island. As the roundabout design is utilizing the existing accelerate lane, the current through lane will become a new landscaped island, adding green scape to the area. Trenching will also happen during this phase to install electrical for the future pedestrian lights as well as roundabout lighting, as well as stormwater drains. There will be flaggers present during the day and cones will be set up to re-create the existing intersection at night. At the end of this stage there will be a concrete pour for all curbs and islands completed until this point.

Stage 6 – Northern Roundabout Construction

Figure 11 - Stage 6: Northern Roundabout Construction

In order to prepare for the center of the roundabout to be constructed the east approach of Chancellor Boulevard will be closed off for a few days. This closure will span from Western Parkway to Theology Mall and will have one-way traffic on the west approach of Chancellor Boulevard. Also there will not be access to Wesbrook Crescent during this stage. Additional flaggers will be added to the existing site team to ensure the safety of all. During this stage of construction the new northeast island will be prepared as well as the northern half of the roundabout. The east approach of Chancellor Boulevard will also be milled to make way for new asphalt.

Stage 7 – Southern Roundabout Construction

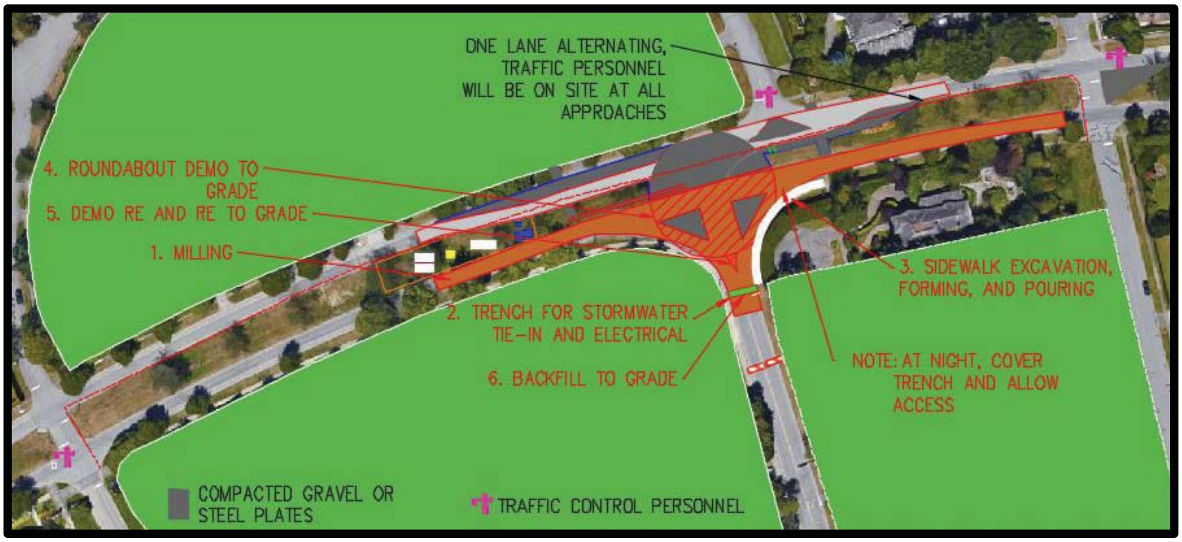

Figure 12 - Stage 7: Southern Roundabout Construction

This stage of construction will be very similar to the last expect the west approach of Chancellor Boulevard will now be closed and one-way traffic will be diverted onto the east approach. Wesbrook Crescent will now be open for access again but Wesbrook Mall will now be closed for access from Chancellor Boulevard. Buses will use Blanc and 16th instead of Chancellor Boulevard. Trenching for electrical and stormwater drains will also happen during this stage as well as milling.

Stage 8 – Electrical Trenching

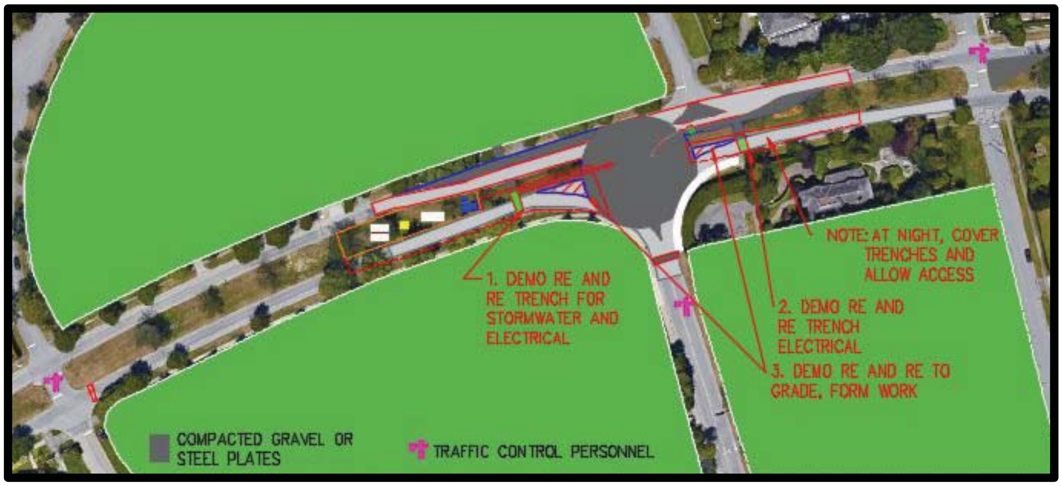

Figure 13 - Stage 8: Electrical Trenching

During this stage of construction the west approach of Chancellor Boulevard will be closed for Western Parkway to Theology Mall but there will be access to Wesbrook Mall. The final stages of trenching will commence to complete both electrical and stormwater drains. Flaggers will be present during the construction and the existing geometric layout will be recreated with cones during the night. The existing median on either side of the intersection will be modified to create a more channelized approach and exit from the future roundabout

Stage 9 - Roundabout Construction

Figure 14 - Stage 9: Roundabout Construction

During this stage of construction the entire intersection will temporality be closed. Vehicles including buses will be diverted to Blanca and West 16th Avenue, there will not be access to Wesbrook Mall. There will be adequate construction signs to alert vehicles of the upcoming changes as at night the intersection will open for the first time as a roundabout created with cones. All the concrete will be formed and poured during this stage for the roundabout as well as any curbs or island that have not been completed. This will include reinstalling the curb work at Western Parkway that was temporality removed for bus accommodations.

Stage 10 – Paving and Painting

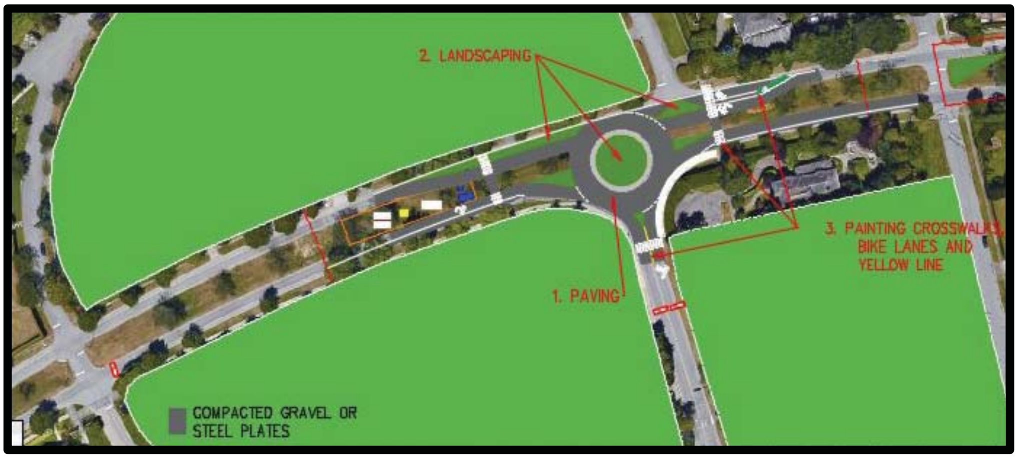

Figure 15 - Stage 10: Paving, Painting and Landscaping

Continuing from last stage this final stage will complete the construction process. New asphalt will be placed, the road will be painted, including the bicycle lanes and crosswalks, and landscaping will be completed. Final light posts and signage that had not been completed will be installed and the general contractor will demobilize from site.

Stage 11 – Gateway Installation

Figure 16 - Stage 11: Gateway Installation

Construction of the structural gateway is to begin in the summer following completion of the roundabout. This scheduled date is Monday, April 30, 2018, which marks the first week following the year end for UBC students. The gateway requires 7 weeks to be installed. It is scheduled to be completed and commissioned for use on Thursday, June 14, 2018.

During this phase of construction, a mobile crane is to be stationed on the road enclosing the roundabout. The crane will be needed through all stages of construction. Additionally, prefabricated gateway components will be stored in three main areas: the east median island, the roundabout, and the west median island.

Due to the need for storage space around the roundabout, as well as stationing a crane, this period of construction will require full closure of the roundabout. Flaggers and road signs will be stationed at subsequent major intersections of all roundabout approaches to inform commuters of the lack of access. Busses through the intersection will be diverted to turn at West 16th Avenue and Blanca. Full closure to accommodate gateway installation will last for 7 weeks.

6. COST ESTIMATION

The cost of consultation during pre-construction is approximately $254,730. The cost of roundabout construction is approximately $1,479,000. Detailed breakdown of these costs can be found in *Appendix L –Cost Estimate* and a summary can be found below in *Table 14*. The total capital cost is thus estimated to be $1,733,800.

Annual operating costs are incurred by landscape maintenance. Landscape maintenance is to be carried out weekly by a 2-person crew from UBC building operations. As per UBC building operations' charge out rates, the annual cost for landscaping is approximately $15,300 per year.

Table 14 - Summary of Cost Estimate

COST ESTIMATE			
DESIGN		***TOTAL:***	*$254,750*
Preliminary Design (Complete)		*$95,600*	
Detailed Design		*$116,200*	
Contract Administration and Construction Reviews		*$42,950*	
CONSTRUCTION		***TOTAL:***	*$1,479,000*
General Contractor	*$238,400*	*Permitting*	*$9,900*
Concrete	*$62,300*	*Gateway Structure*	*$578,900*
Excavation	*$77,800*	*Utilities*	*$120,000*
Curbwork	*$6,600*	*Asphalt*	*$92,300*
Material Testing	*$10,000*	*Landscaping*	*$26,400*
Painting	*$4,000*	*Signage*	*$5,000*
Flagging	*$113,000*	*Fee*	*$134,500*
ADDITIONAL BUDGETS			
Contingency		*$67,200*	
Maintenance		*$15,300 per year*	
		TOTAL:	***$1,733,800***

6.1. Permitting

As per the City of Vancouver's development permits and regulations, construction of the roundabout is subject to the following permits.

- Electrical
- Tree Removal
- Signage

– Noise

In addition, an allowance for excavation permitting has been incorporated into the estimate to cover costs not directly specified by City of Vancouver's regulations.

30-day parking permits will be issued for all workers on site for the duration of their work on site. These will allow workers to park at the Rose Garden and/or North Parkades. The total cost of permitting is approximately $9,900.

6.2. Consulting Project-Management

Consulting fees during pre-construction are approximately $254,730. Fees are based on a 40-hour work week, and assuming that the consulting staff will work half-time specifically on this project.

i. Detailed Design:
   - carried out by traffic/road engineer and CAD technician
   - project engineer to liaison with client, oversee project costs
   - project team supervised by management engineer for progress

ii. Surveying
   - carried out by a surveying team to confirm as-builts supplied by UBC

iii. Geotechnical Evaluation
   - carried out by geotechnical consultants to assist in design

iv. Final Design
   - utilizing data acquired from the surveying and geotechnical team, this stage is carried out by the same project team as the one in detailed design

Contractor Selection and Preparation

- carried out by project engineer and management engineer

Site visits, requests for information, field orders, and other interactions between the contractor and consultant are expected to occur during construction. Since the degree of involvement of the consulting staff is not foreseeable, consulting fees incurred during construction work have not been quantified in this estimate.

6.3. General Contractor

The general contractor shall supply a construction management staff, site equipment, temporary power, and an operations and maintenance manual. For this estimate, the general contractor is assumed to be self-performing on select concrete structures, and erection of the steel gateway structure.

Costs incurred by the general contractor include $238,400 in indirect costs, and $62,300 in self-performing concrete work (inclusive of the roundabout and sidewalk structures).

6.4. Subcontractors

As part of their quotes, subcontractors are expected to incorporate a quality control plan for their products. The general contractor will perform quality assurance on the delivered products and services, document results, and submit to the client when complete.

Excavation

The excavation subcontractor is to perform demolition of existing islands, trenching for electrical and stormwater installation, backfilling of excavations, as well as supply transfer trucks to remove excavated material from site. The subcontractor is to provide a workforce and heavy equipment as deemed necessary by their project staff. Costs incurred by the excavation subcontractor are approximately $77,800.

Utilities

Utilities work will be coordinated between an electrical subcontractor and a stormwater subcontractor. The electrical subcontractor is to perform installation of new electrical conduits, as well as fitting of relocated electrical pull pits. The stormwater subcontractor is to perform the same work for existing and new stormwater connections.

A total allowance of $120,000 has been incorporated into the estimate to account for utilities work. Final quotes for the utilities can be established after detailed design drawings are produced.

Formwork and Concrete

A separate subcontractor generally performs curb formwork and casting. The curb subcontractor will install curbs that line the perimeter of new islands in the intersection. Costs incurred by the curb subcontractor are approximately $6,600.

Asphalt & Material Testing

The asphalt/paving subcontractor is to perform milling of existing asphalt, and paving of new asphalt on the roads. Costs incurred by the paving subcontractor are approximately $93,300.

The material testing subcontractor shall perform compaction testing on backfilled excavations and testing of new asphalt. A $10,000 allowance has been incorporated into the estimate to account for their work.

Landscaping

The landscaping subcontractor is to perform installation of new sub-base, top soil, and grass in the new islands. Costs incurred by the landscaping subcontractor are approximately $26,400.

Painting

The painting subcontractor is to perform painting of new pedestrian crosswalks. A $4,000 allowance has been incorporated into the estimate to account for their work.

Signage

Temporary signage is to be performed by subcontracted flaggers. A $5,000 allowance has been incorporated into the estimate to account for signage during construction.

Flagging

Flaggers are needed throughout the duration of construction. During construction phases 1-5, two flaggers are stationed during active work hours on site. Following that, two more are added to the work crew. Costs incurred by the flagging subcontractor are approximately $113,000.

6.5. Gateway

The structural gateway to be installed at the roundabout is estimated to cost $578,900. A summarized breakdown of the gateway's cost items can be seen in *Table 15* below. Refer to *Appendix L –Cost Estimate* for further cost details regarding the gateway.

Table 15 - Summary of Gateway Cost

GATEWAY CONSTRUCTION		***TOTAL:***	***578,900***
General Contractor	*84,000*	*Permitting*	*4,000*
Flagging	*36,800*	*Mobile Crane*	*61,600*
Grass Rehabilitation	*5,000*	*Grass Protection*	*5,800*
Concrete Foundation	*162,400*	*Moisture Protection*	*8,000*
Gateway - Concrete	*11,100*	*Gateway - Wood*	*46,400*
Gateway - Steel	*103,500*	*Gateway - Railings*	*50,200*

6.6. Contingency

A contingency fee of 5% of the construction cost has been incorporated into the estimate. For the roundabout, contingency is valued at $67,200. This fee will account for circumstances such as:

i. Unknown conditions
   - Surveyor's as-builts do not match client-provided as-builts, resulting in errors in takeoffs
   - Unsuitable soil conditions following geotechnical evaluation, which requires additional work not accounted for in the original excavation scope

ii. Client-requested modifications
   - UBC wishes to incorporate more green space than what was issued in the construction drawings
   - UBC adjusts site working hours to reduce noise pollution

iii. Consultant modifications
   - Newly issued details from consultant require different grade of sub-base to be used to backfill perforated drainage pipes
   - New field orders from consultant require stormwater tie-ins to be completed before installation of a new electrical pull pit, altering the construction schedule

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Appendix A – Conceptual Design Alternatives

Alternative to the design of a roundabout, two other designs were considered during the conceptualization of the new intersection:

1. Signalized Intersection
2. Retain and Improve the Existing Intersection

This section will briefly describe the alternative concepts to upgrading the intersection. To select the design moving forward, a decision matrix was utilized, please see *Figure 19* and *Figure 20* for further details.

Signalized Intersection

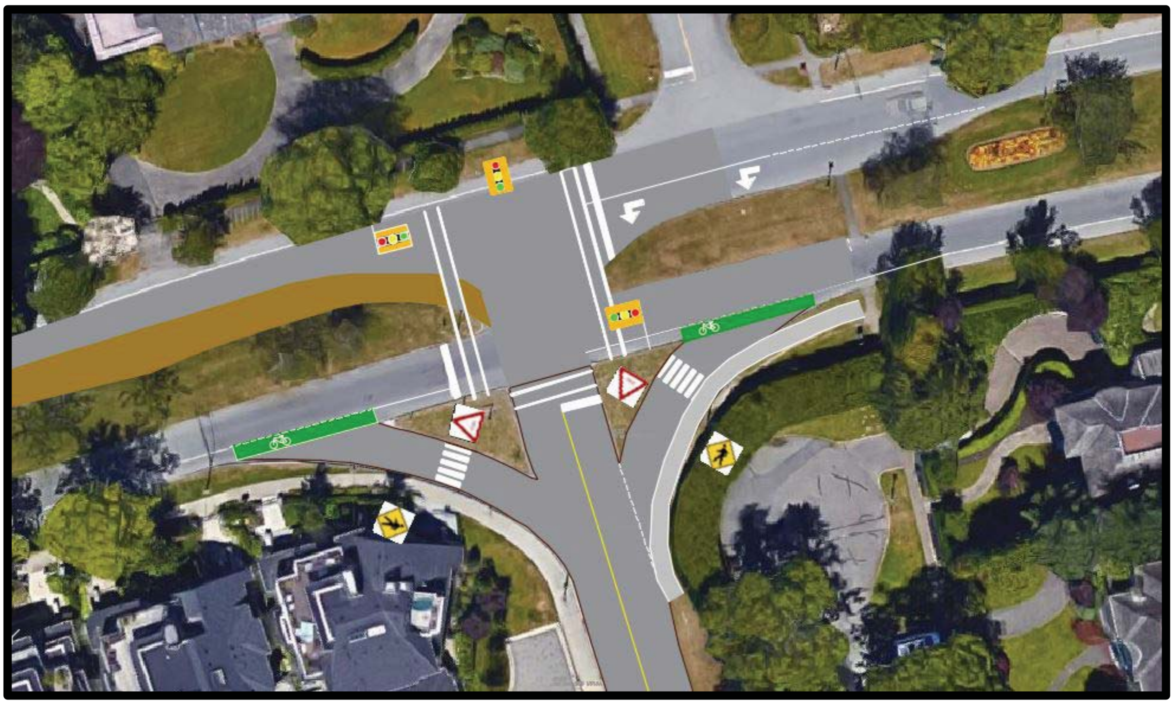


Figure 17 - Signalized Intersection: AutoCAD Layover

One alternative provided a pedestrian safety focused design concept; the signalized intersection concept proposed to implement signalized traffic signals on all approaches of the intersection, with minor road re-alignments. Implementing signalized pedestrian crosswalks on all directions will also provide a protected and guided pedestrian crossing system. Bicycle lanes are also designed to be integrated with road traffic, similar to other intersections and bicycle roads around UBC. The signalized intersection provides more capacity for heavy vehicles, pedestrians, and cyclists.

Retain and Improve the Existing Intersection

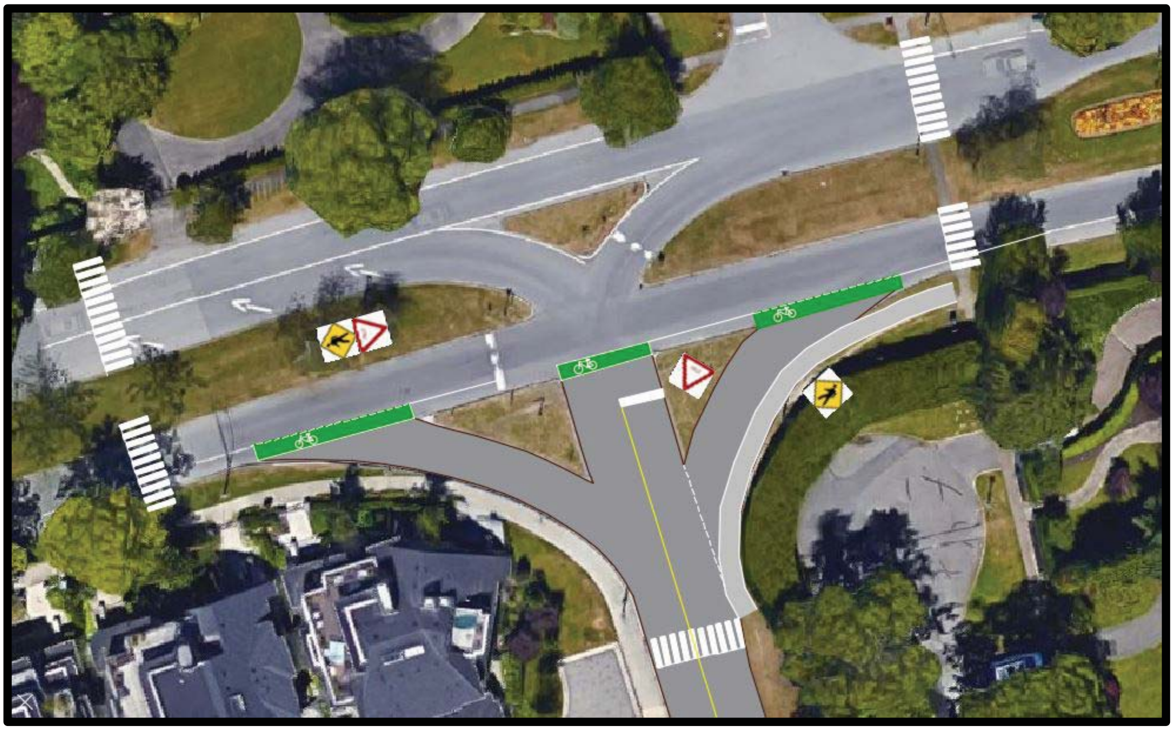


Figure 18 - Proposed Upgrades to Existing Intersection: AutoCAD Layover

A second alternative provided a cost and time effective design concept; the intersection is proposed to retain existing geometry. The concept proposed the addition of signalized pedestrian sidewalks with minor realignments of traffic islands, as well as redesign of the existing stormwater management system. Furthermore, a sidewalk was designed to connect all pedestrian approaches. The design highlights the possibility to satisfy most key design requirements with minimal cost and construction delays, however does not improve traffic capacity. The design however is more flexible and allows for less project risk whilst still capable of addressing the current issues.

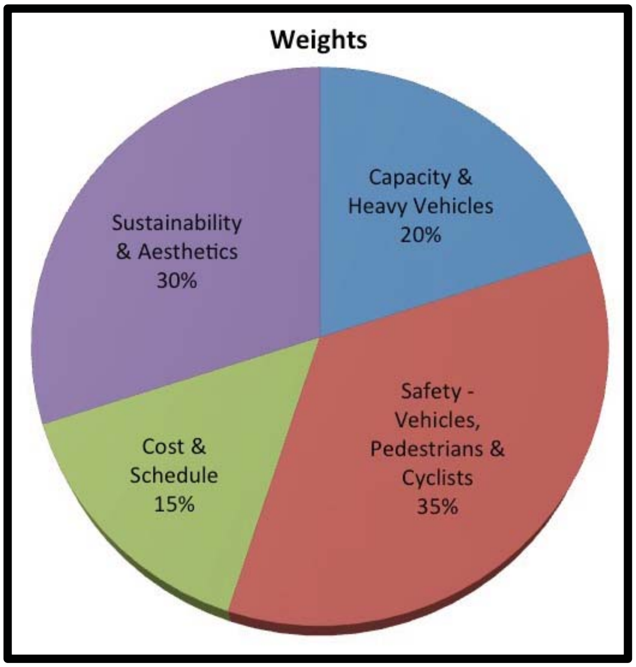


Figure 19 - Criteria Weight for Decision Process

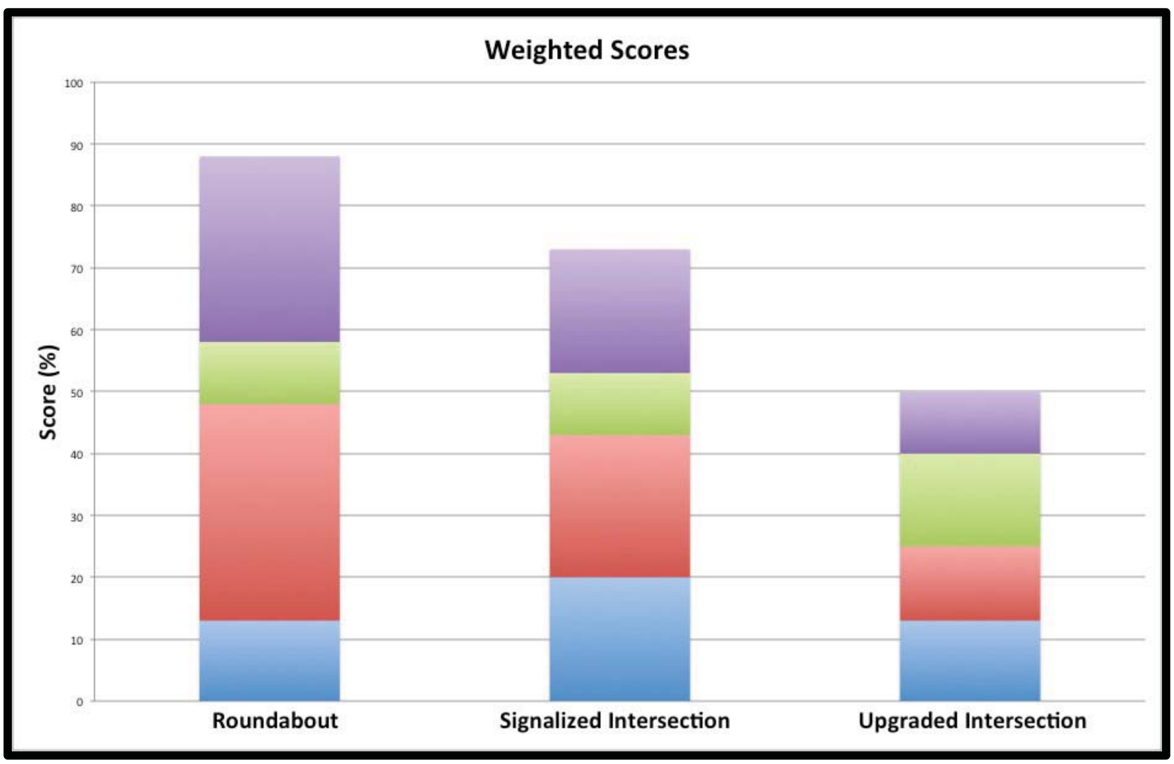
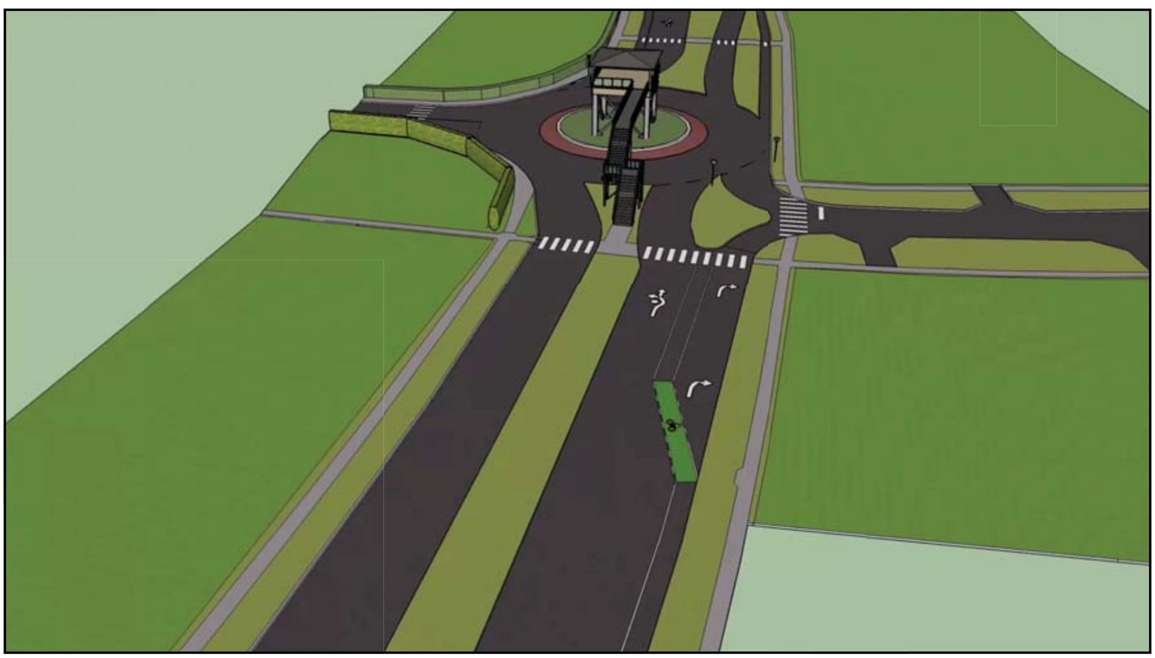


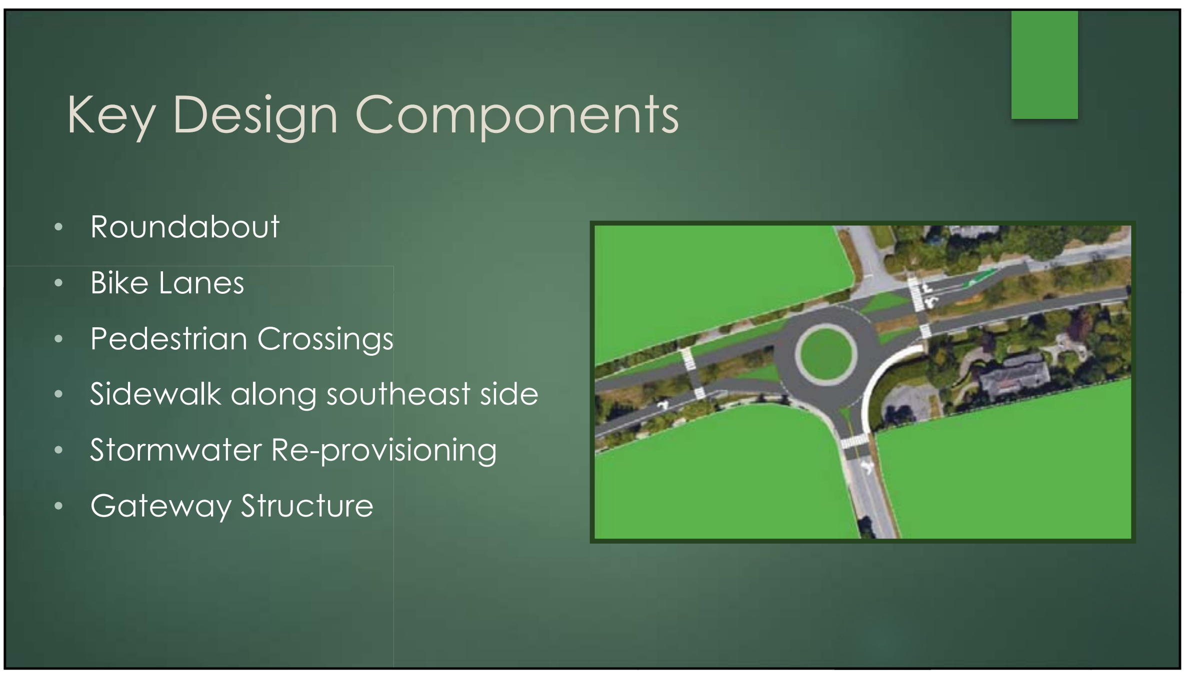
Figure 20 - Weighted Scores for Decision Making Process

Appendix B – Presentation Slides


UBC
TEAM 16
Redesign of Chancellor Boulevard and Wesbrook Mall Intersection

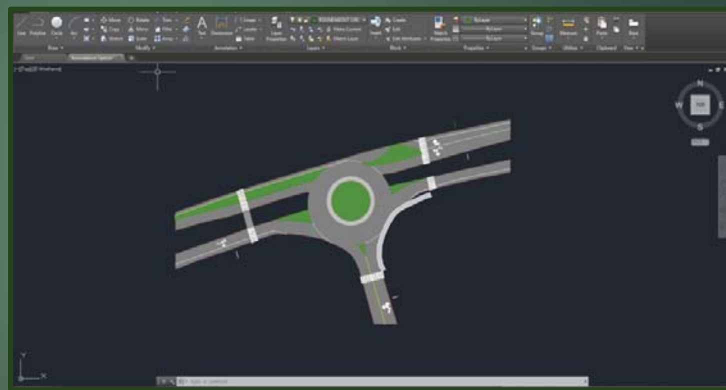



Project Objectives
Upgrade works for the current intersection at Chancellor Boulevard and Wesbrook Mall, UBC
Design Objectives
• Safety
• Vehicular Traffic Accommodation
• Sustainability
• Structural Gateway


Key Design Components
• Roundabout
• Bike Lanes
• Pedestrian Crossings
• Sidewalk along southeast side
• Stormwater Re-provisioning
• Gateway Structure

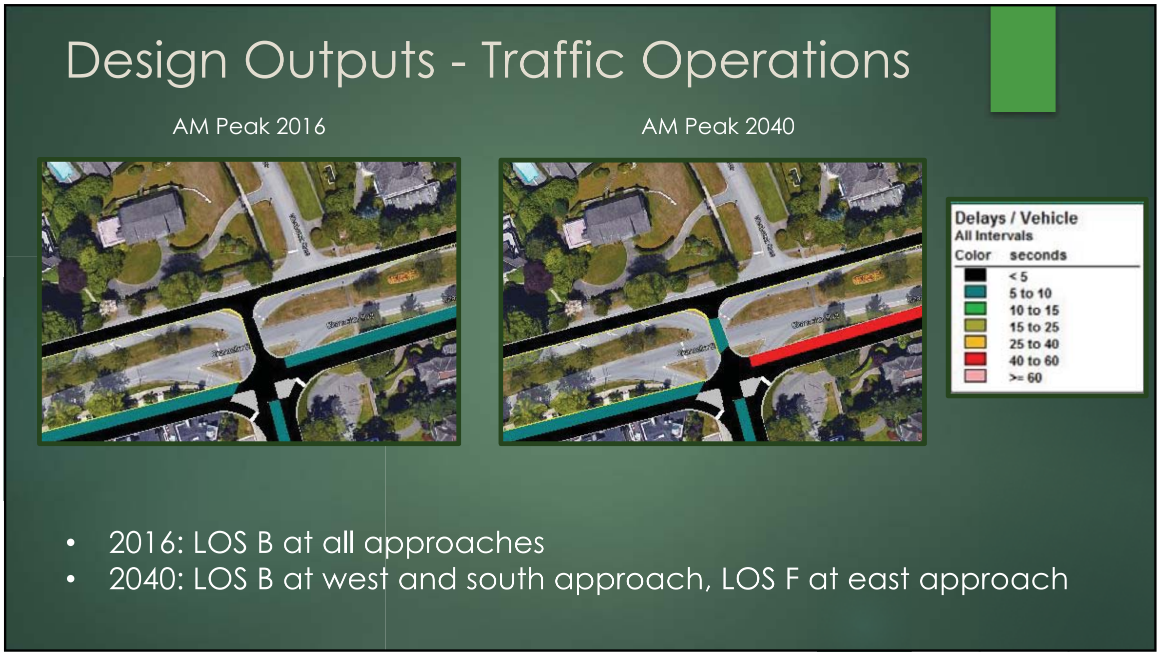
Software Packages and Standards

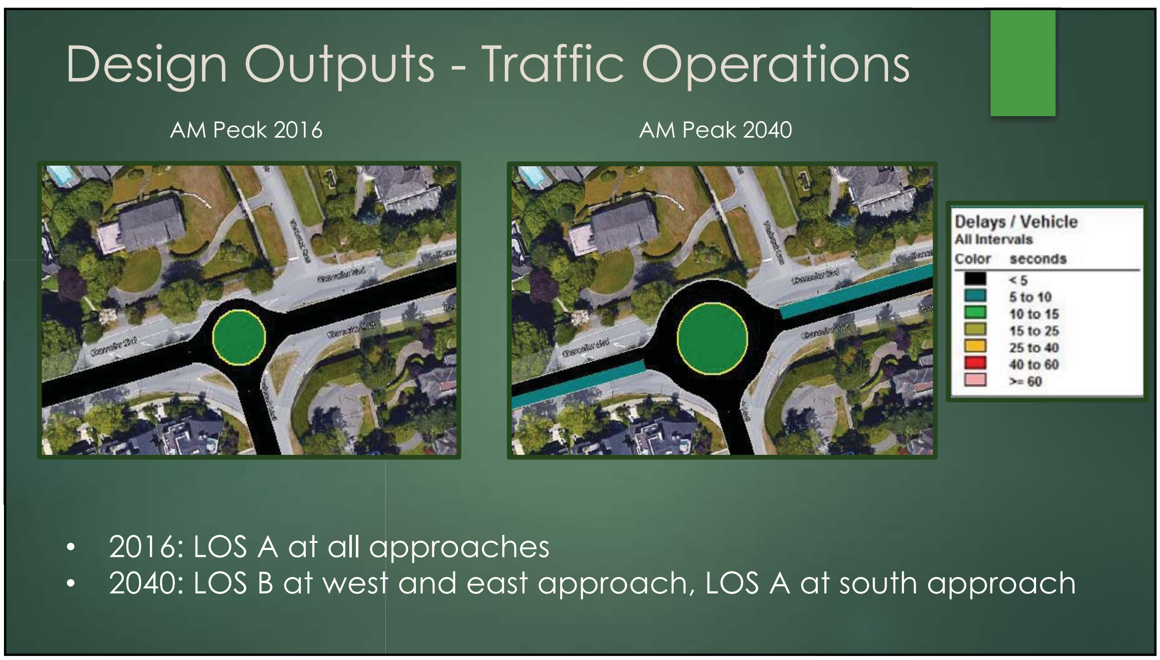
- AutoCAD
- SYNCHRO
- AutoTURN
- SketchUp
- SAP2000
- NBCC 2010
- BCBC
- ASTM



Technical Considerations - Roundabout

- Satisfactory LOS (Level of Service) performance under current and future conditions
- Accommodation of heavy vehicles
- Provide improved pedestrian safety; right-of-way's


Design Outputs - Traffic Operations
AM Peak 2016
AM Peak 2040
Delays / Vehicle
All Intervals
Color seconds
< 5
5 to 10
10 to 15
15 to 25
25 to 40
40 to 60
>= 60
• 2016: LOS B at all approaches
• 2040: LOS B at west and south approach, LOS F at east approach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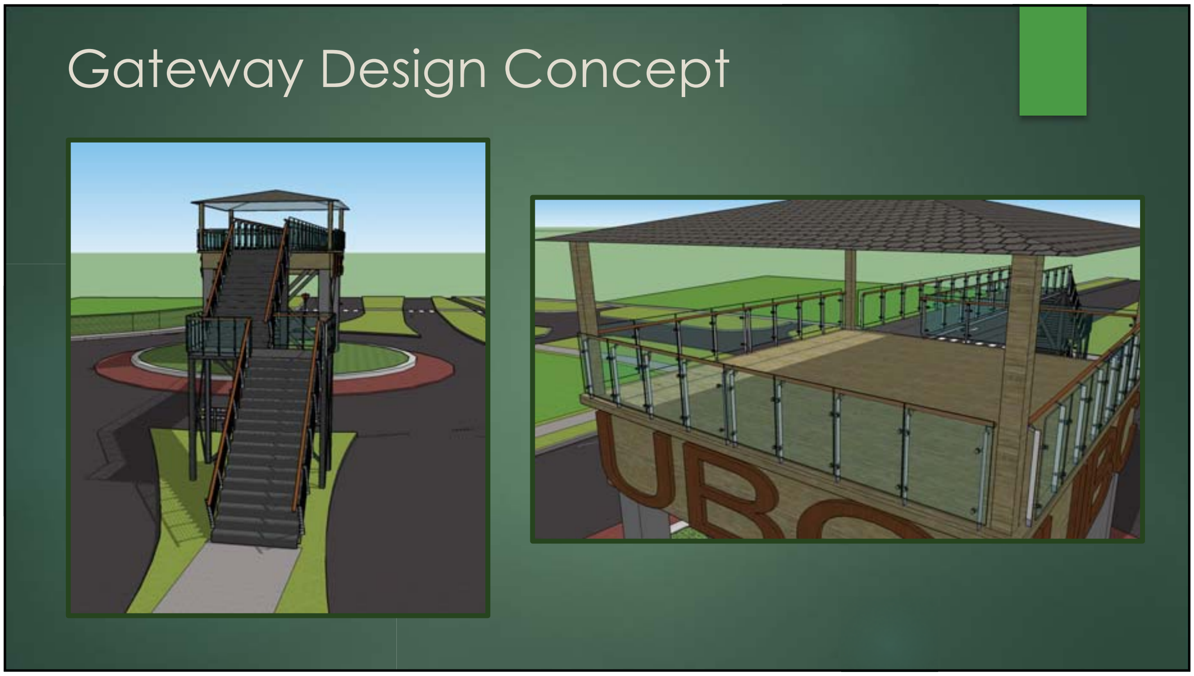
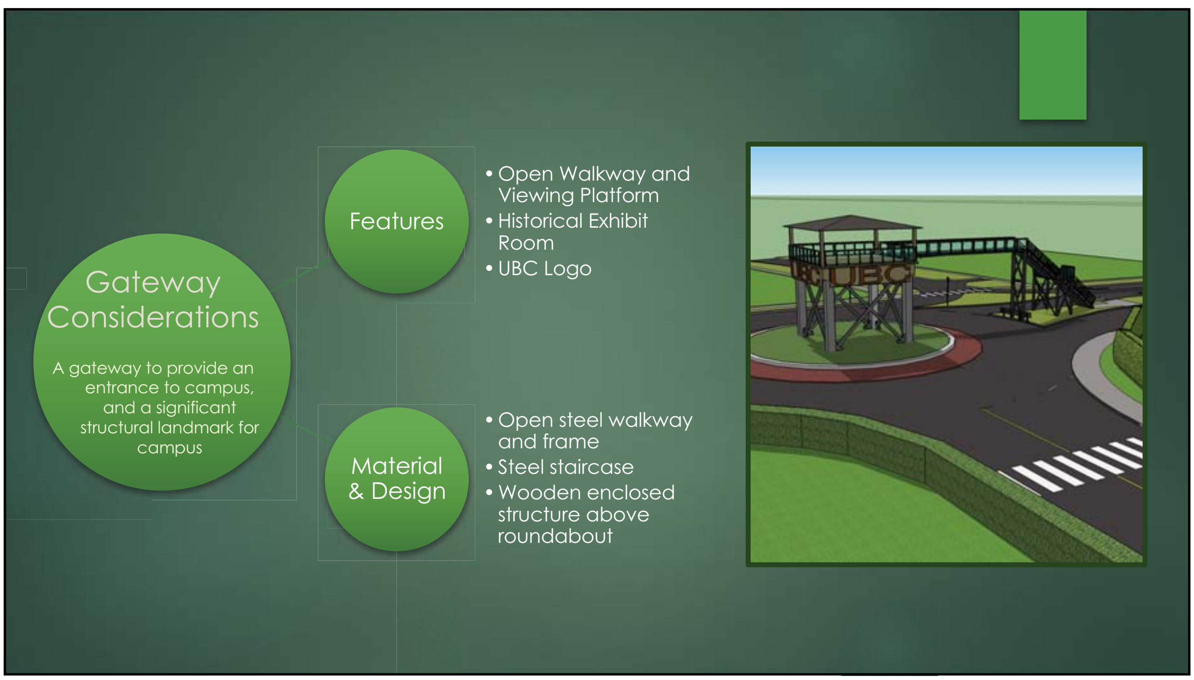
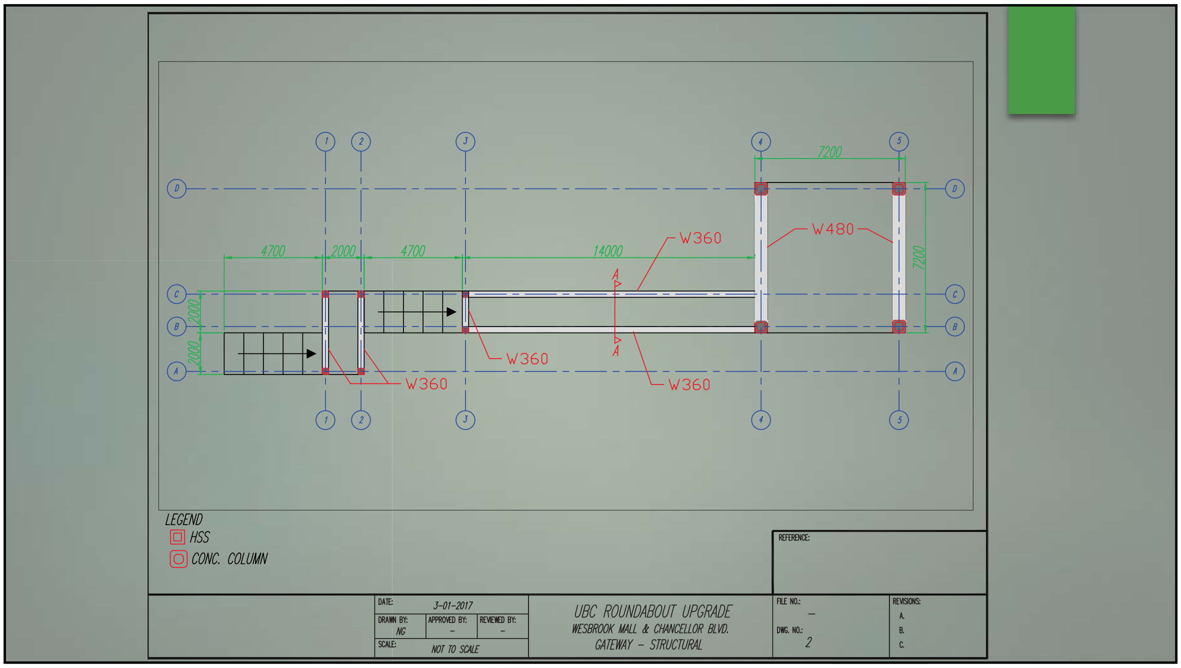
AM Peak 2040
Delays / Vehicle
All Intervals
Color seconds
< 5
5 to 10
10 to 15
15 to 25
25 to 40
40 to 60
>= 60
• 2016: LOS A at all approaches
• 2040: LOS B at west and east approach, LOS A at south approach


Gateway Design Concept
UBC


Gateway Considerations
A gateway to provide an entrance to campus, and a significant structural landmark for campus
Features
• Open Walkway and Viewing Platform
• Historical Exhibit Room
• UBC Logo
Material & Design
• Open steel walkway and frame
• Steel staircase
• Wooden enclosed structure above roundabout
UBC



COST ESTIMATE		
DESIGN		TOTAL: $254,750
Preliminary Design (Complete)	$95,600	
Detailed Design	$116,200	
Contract Administration and Construction Reviews	$42,950	
CONSTRUCTION		TOTAL: $1,547,400
General Contractor	$227,000	
Subcontracted Work	$538,800	
Gateway Structure	$641,000	
Fee	$140,600	
ADDITIONAL BUDGETS		
Contingency	$70,300	
Maintenance	$17,300 per year	
		TOTAL: $1,872,450

Construction Work

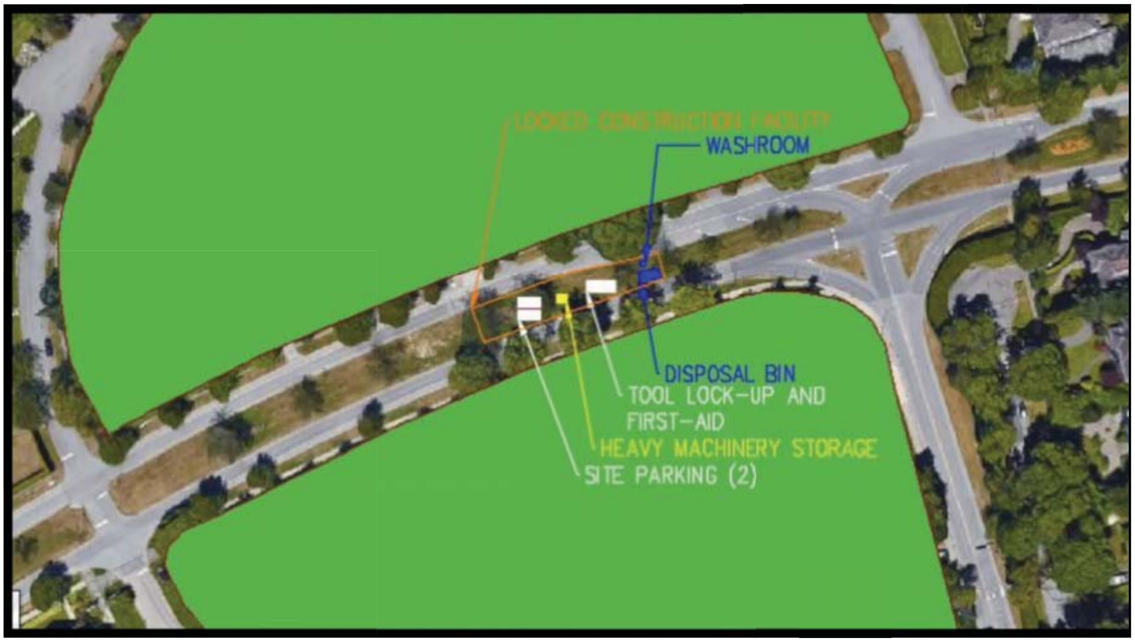
Considerations and sequencing

May – August 2017

Gateway: April – June 2018

Construction Requirements

Requirement	Solution
• Intersection bus routes need to be serviceable throughout construction	• Roundabout construction offers partial route through intersection; temp detours planned during full intersection close-off
• Noise disturbance	• Number of heavy machinery on site kept to a minimum
• Construction period should not overlap with academic period	• Beginning of major paving to coincide with U-Hill Elementary's summer vacation • Roundabout construction wrapped up before UBC's fall 2017 semester begins


LOCKED CONSTRUCTION FACILITY
WASHROOM
DISPOSAL BIN
TOOL LOCK-UP AND
FIRST-AID
HEAVY MACHINERY STORAGE
SITE PARKING (2)


Anticipated Site Issues
• Unknown depth of existing utilities
• Avoid fish routes
• Limited storage area
• Traffic management

Additional Data and Tests

- Surveying - Specifically property lines at the new sidewalk
- CPT - for the Gateway
- Scanning - Utility Depths and Locations
- Soil Samples - Bearing Capacity

Stage 1 - Mobilization

May 1 - 2

2 Days

Stage 2 - Southwest Island Demolition

May 2 - 4

2 Days

Stage 3 – South East Island Demolition

May 4 - 8

2 Days

Temporary Bus Accommodation

May 8 - 10

2 Days

Stage 4 – North East Median Construction

May 11 - 22

7.5 Days

Stage 5 – North West Median Construction

May 22 - June 8

13 Days

Stage 6 – Northern Roundabout Construction

June 8 - 19

7 Days

Stage 7 – Southern Roundabout Construction

June 19 -
July 3

10.5 Days

Stage 8 – Electrical Trenching

July 3 -
July 14

9 Days

Stage 9 – Roundabout Construction

July 14 - 25

8 Days

Stage 10 – Paving, Painting, Landscaping

July 25 -
Aug 9

11 Days

Stage 11 – Gateway Structure

Apr 30 –
Jun 12
2018

32 Days

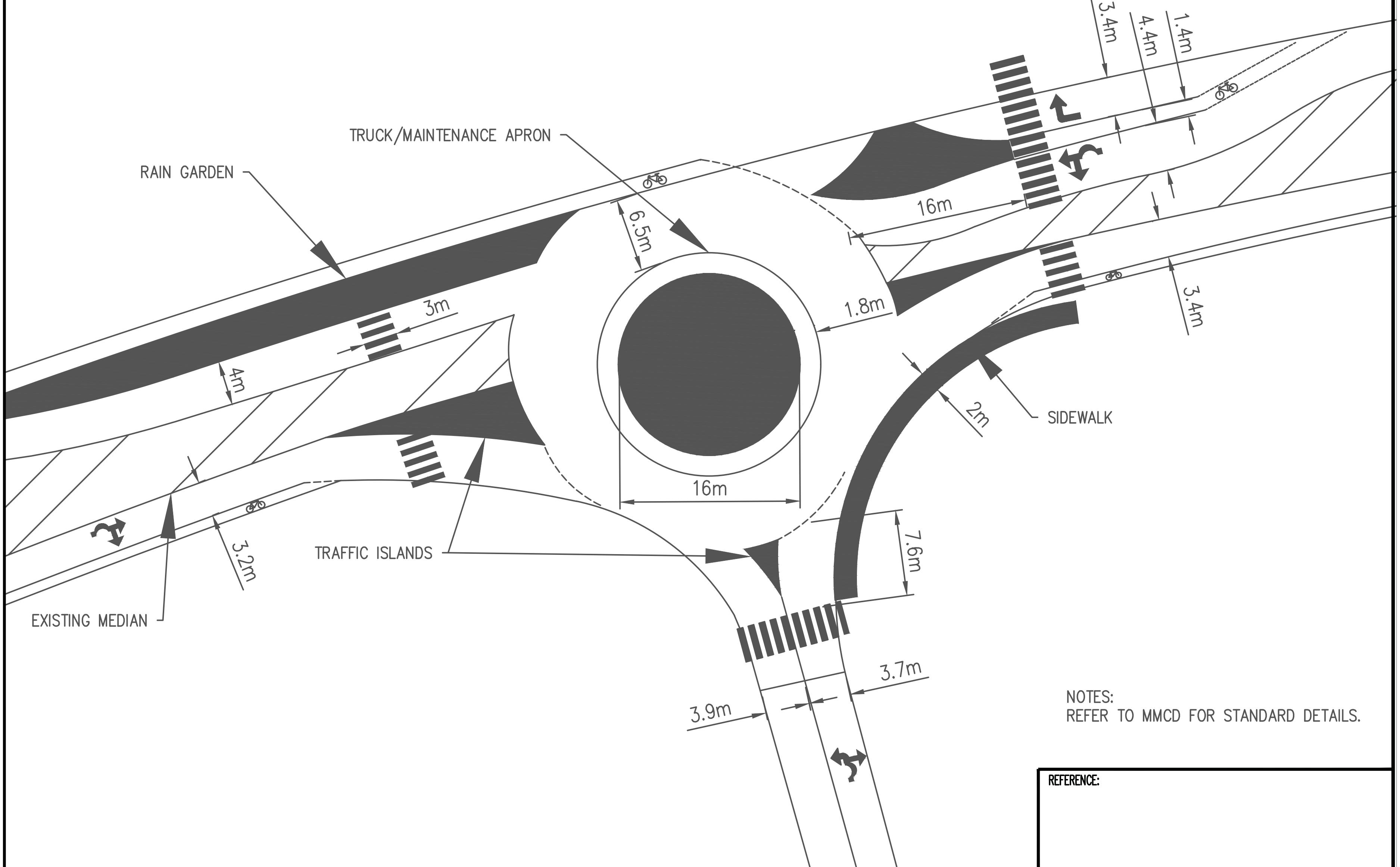
Appendix C – Stakeholder Register

Stakeholder Register

	High 5 Medium 3 Low 1	Power	Level of Concern	Management Category	Position	Expectation and Role
		Direct Control, Influence	Technical, Nontechnical	Daily, Weekly, Monthly, Informal	Supporter Neutral Resister	What Role Does the Stakeholder Have Regarding the Project?
	Stakeholder ID/Name	Score 1-5	Score: T or N	Score: D, or W or M or I	Score: S or N or R	What Does This Stakeholder Want?
A	UBC Campus and Community Planning	5	T	D	S	University Oversight, UBC Regulations
B	Ministry of Transportation	5	T	W	S	Design Approval, Ownership, Regulations
C	Musqueam	5	N	I	N	Land Close to Project
D	UBC Students	3	N	I	R	Construction Interference Concern
E	University Endowment Lands	5	N	W	N	Construction Interference Concern, Owns Property Close to Project
F	City of Vancouver	5	T	W	N	Interference with Current Traffic Routes, Re-Alignment of Drainage Systems
G	Pedestrians	4	N	I	S	User, New crosswalk and Markings to Ensure Safe Crossing
H	Cyclists	4	N	I	S	User, Additional safety features to isolate vehicular traffic
I	TransLink	4	T	W	R	User, Construction interference with current traffic routes
J	Neighbour Residents	5	N	I	R	Construction interference concern, Owns property close to project land
K	Consultants	5	T	D	N	Design, Environmental Assessment, Engineering, Technical Specifications
L	General Contractor	5	T	D	S	Building Specifications, Schedule, Budget, Scope, Permits, Labour

Appendix D – Drawing Package

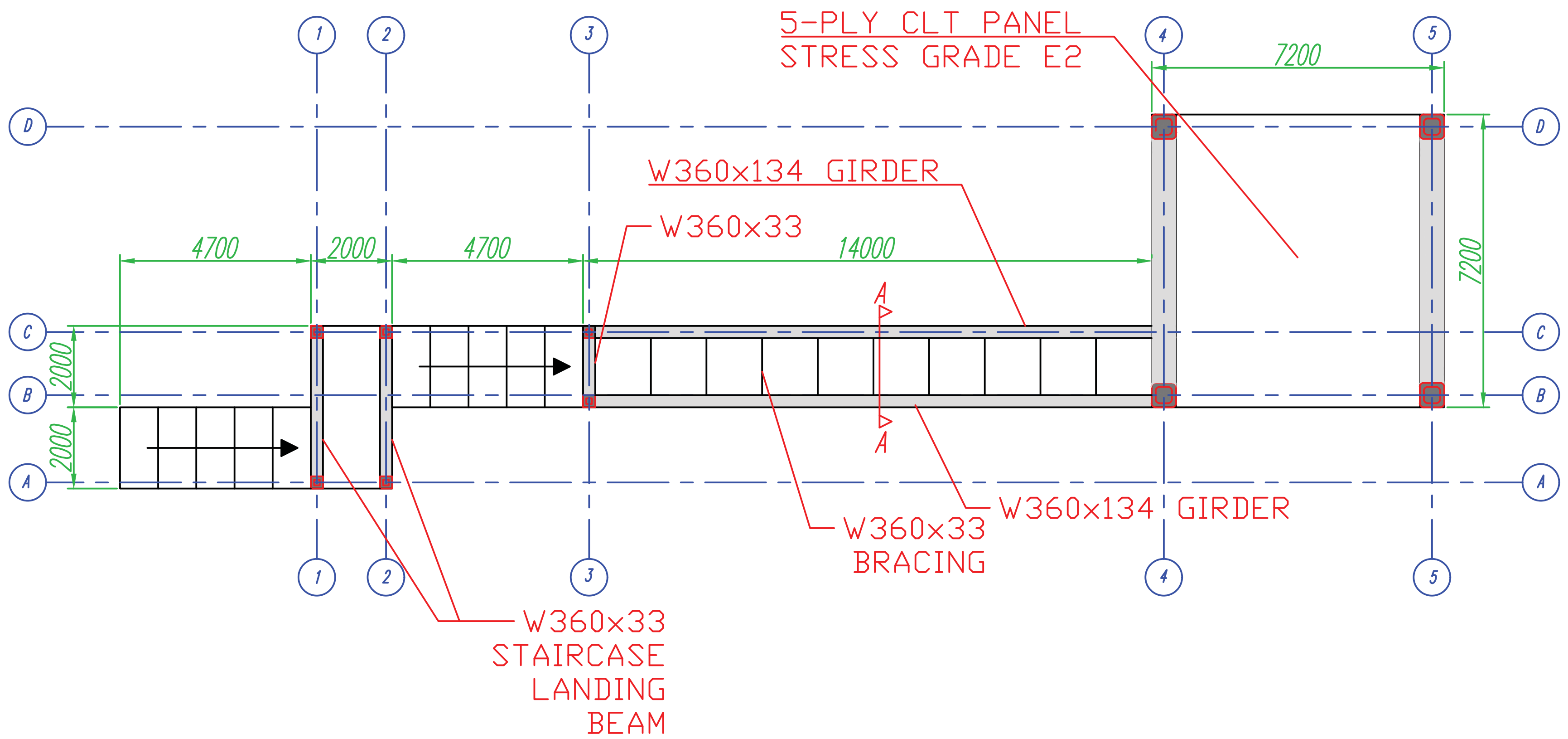
Civil Drawing



NOTES:
REFER TO MMCD FOR STANDARD DETAILS.

REFERENCE:				
DATE: 03-19-2017			UBC ROUNDABOUT UPGRADE WESBROOK MALL & CHANCELLOR BLVD.	FILE NO.: —
DRAWN BY: RL	APPROVED BY: –	REVIEWED BY: –		DWG. NO.: C-1
SCALE: 1:500				REVISIONS: A. B. C.

Structural Drawing



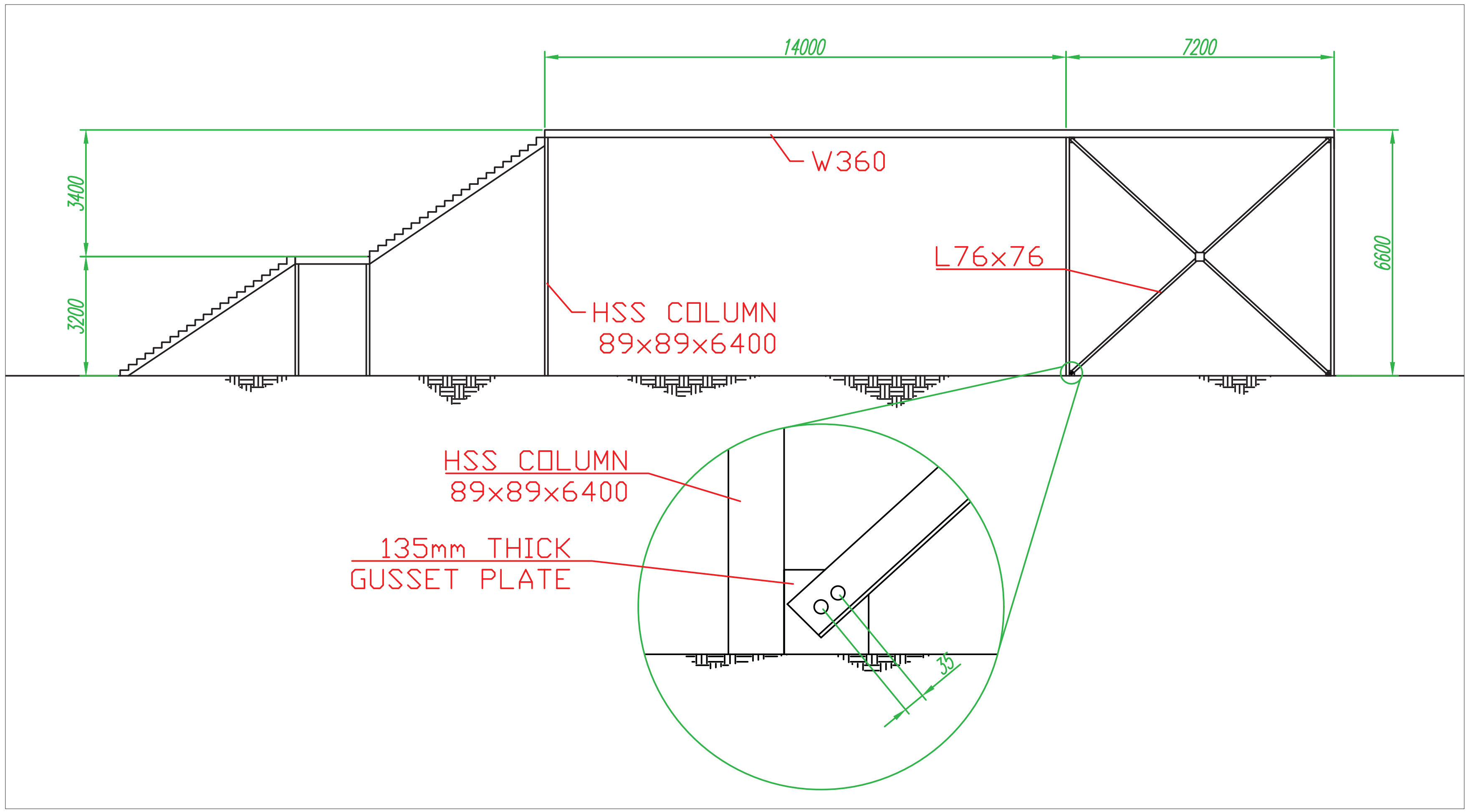
LEGEND
HSS COLUMN 89x89x640
COLUMN

REFERENCE:		
DATE: 3-24-2017		
DRAWN BY: NG	APPROVED BY: -	REVIEWED BY: -
SCALE: NOT TO SCALE		

UBC ROUNDABOUT UPGRADE
WESBROOK MALL & CHANCELLOR BLVD.
GATEWAY – STRUCTURAL

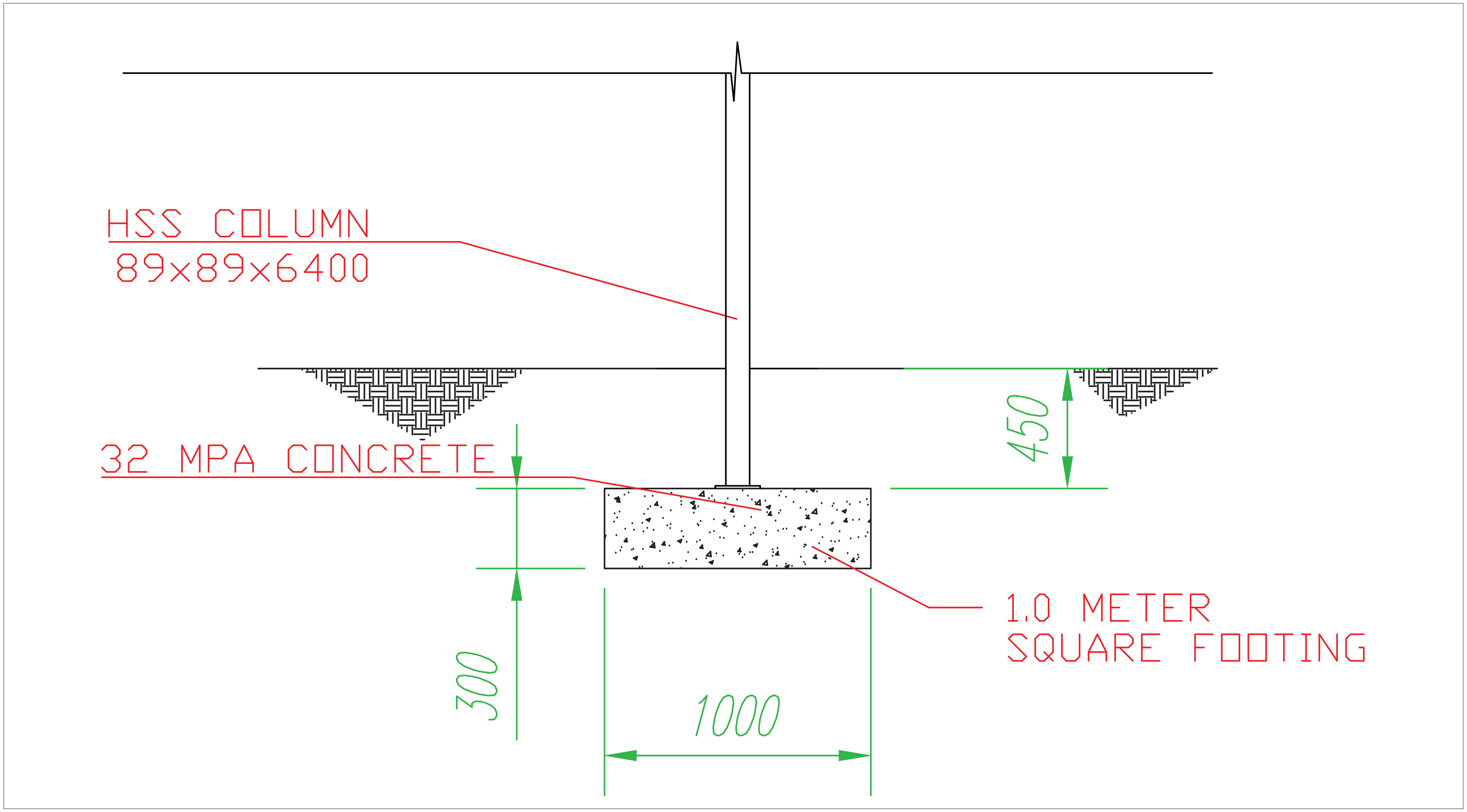
FILE NO.: –
DWG. NO.: S-1

REVISIONS:
A.
B.
C.



REFERENCE:

DATE: 4-01-2017			FILE NO.: –	REVISIONS:
DRAWN BY: NG	APPROVED BY: –	REVIEWED BY: –	UBC ROUNDABOUT UPGRADE WESBROOK MALL & CHANCELLOR BLVD. GATEWAY – STRUCTURAL	A.
SCALE: NOT TO SCALE			DWG. NO.: 2	B. C.

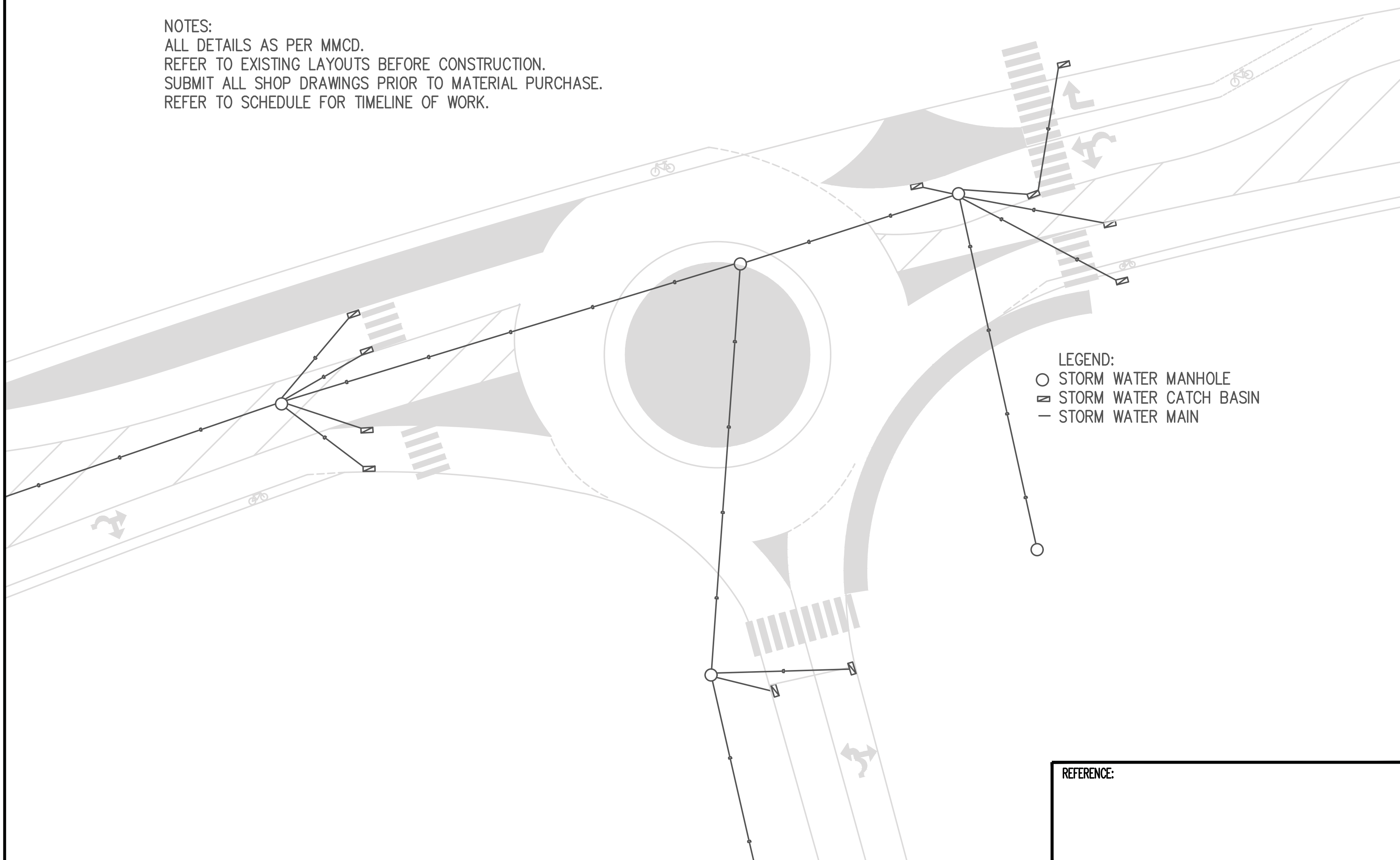


REFERENCE:

DATE: 4-01-2017			UBC ROUNDABOUT UPGRADE WESBROOK MALL & CHANCELLOR BLVD. FOUNDATION PROFILE	FILE NO.: –	REVISIONS:
DRAWN BY: NG	APPROVED BY: –	REVIEWED BY: –		DWG. NO.: S-3	A. B. C.
SCALE: NOT TO SCALE					

Mechanical Drawing

NOTES:
ALL DETAILS AS PER MMCD.
REFER TO EXISTING LAYOUTS BEFORE CONSTRUCTION.
SUBMIT ALL SHOP DRAWINGS PRIOR TO MATERIAL PURCHASE.
REFER TO SCHEDULE FOR TIMELINE OF WORK.

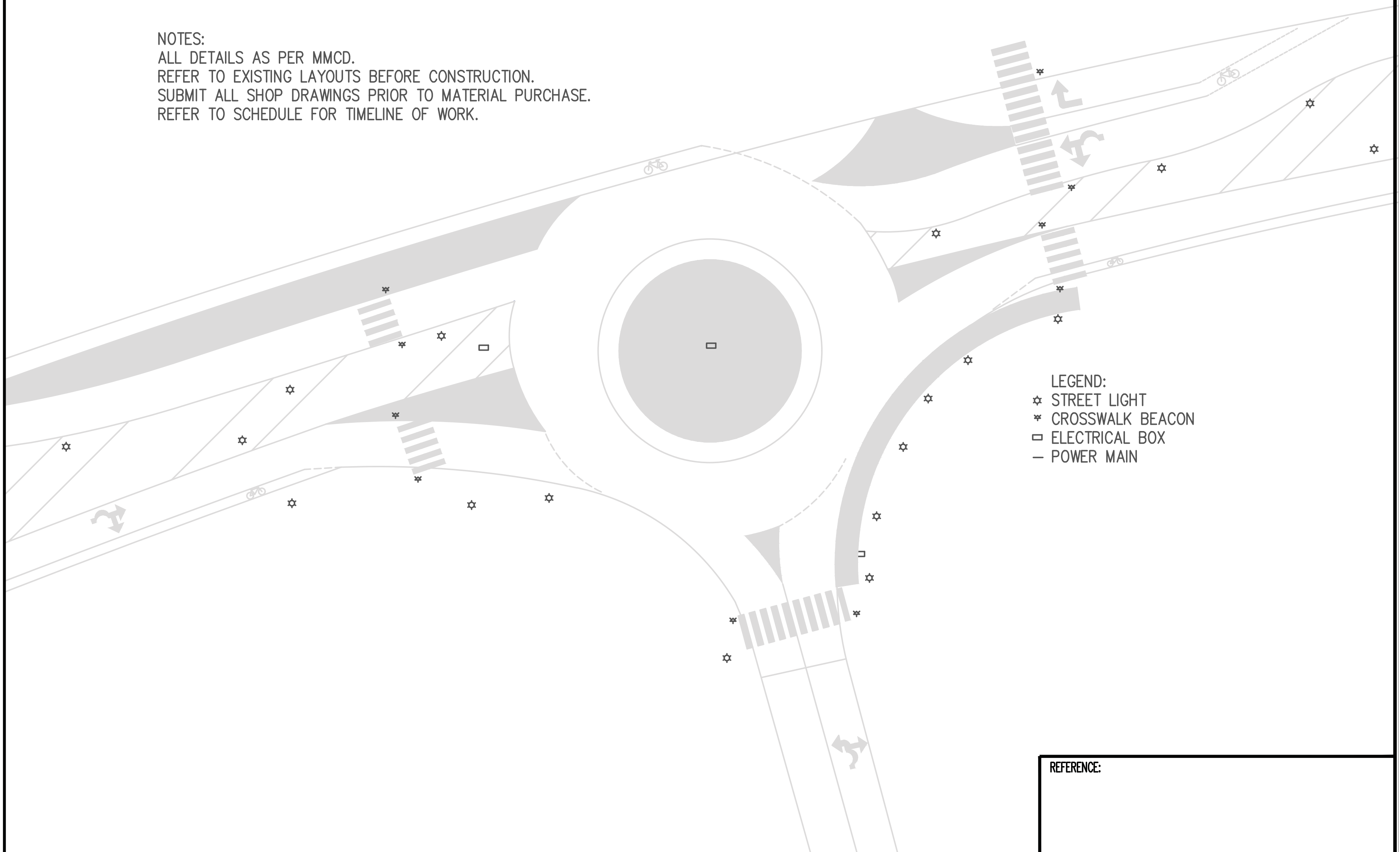


DATE: 03-19-2017			UBC ROUNDABOUT UPGRADE WESBROOK MALL & CHANCELLOR BLVD.	REFERENCE:
DRAWN BY: RL	APPROVED BY: -	REVIEWED BY: JF		FILE NO.: -
SCALE: 1:500				DWG. NO.: M-1

REVISIONS:
A.
B.
C.

Electrical Drawing

NOTES:
ALL DETAILS AS PER MMCD.
REFER TO EXISTING LAYOUTS BEFORE CONSTRUCTION.
SUBMIT ALL SHOP DRAWINGS PRIOR TO MATERIAL PURCHASE.
REFER TO SCHEDULE FOR TIMELINE OF WORK.



LEGEND:
☆ STREET LIGHT
* CROSSWALK BEACON
▭ ELECTRICAL BOX
— POWER MAIN

DATE: 03-19-2017			
DRAWN BY: RL	APPROVED BY: –	REVIEWED BY: JF	
SCALE: 1:500			

UBC ROUNDABOUT UPGRADE
WESBROOK MALL & CHANCELLOR BLVD.

REFERENCE:

FILE NO.: –

DWG. NO.: E-1

REVISIONS:
A.
B.
C.

Appendix E – Traffic Analysis Results (Synchro)

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	0	126	77	437	0	0	0	72	116	0	0	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	137	84	475	0	0	0	78	126	0	0	0

Direction, Lane #	EB 1	EB 2	WB 1	NB 1	NB 2
Volume Total (vph)	137	84	475	78	126
Volume Left (vph)	0	0	475	0	0
Volume Right (vph)	0	84	0	0	126
Hadj (s)	0.03	-0.55	0.23	0.07	-0.31
Departure Headway (s)	4.7	3.2	4.5	5.4	3.2
Degree Utilization, x	0.18	0.07	0.60	0.12	0.11
Capacity (veh/h)	737	1121	785	593	1121
Control Delay (s)	8.7	6.5	14.0	9.1	6.6
Approach Delay (s)	7.8		14.0	7.6	
Approach LOS	A		B	A	

Intersection Summary			
Delay	11.0		
HCM Level of Service	B		
Intersection Capacity Utilization	52.1%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↑	↱	↰				↑	↱			
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	0	365	80	96	0	0	0	53	243	0	0	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	397	87	104	0	0	0	58	264	0	0	0

Direction, Lane #	EB 1	EB 2	WB 1	NB 1	NB 2
Volume Total (vph)	397	87	104	58	264
Volume Left (vph)	0	0	104	0	0
Volume Right (vph)	0	87	0	0	264
Hadj (s)	0.02	-0.57	0.56	0.07	-0.52
Departure Headway (s)	4.2	3.2	5.0	5.1	3.2
Degree Utilization, x	0.46	0.08	0.15	0.08	0.23
Capacity (veh/h)	842	1121	693	644	1122
Control Delay (s)	10.8	6.5	8.9	8.5	7.2
Approach Delay (s)	10.0		8.9	7.4	
Approach LOS	A		A	A	

Intersection Summary			
Delay	9.0		
HCM Level of Service	A		
Intersection Capacity Utilization	42.8%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Right Turn Channelized						
Volume (veh/h)	126	77	437	412	72	116
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	137	84	475	448	78	126
Approach Volume (veh/h)	221			923	204	
Crossing Volume (veh/h)	475			78	137	
High Capacity (veh/h)	952			1303	1244	
High v/c (veh/h)	0.23			0.71	0.16	
Low Capacity (veh/h)	771			1087	1033	
Low v/c (veh/h)	0.29			0.85	0.20	

Intersection Summary			
Maximum v/c High	0.71		
Maximum v/c Low	0.85		
Intersection Capacity Utilization	81.2%	ICU Level of Service	D

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Right Turn Channelized						
Volume (veh/h)	372	82	98	109	54	248
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	404	89	107	118	59	270
Approach Volume (veh/h)	493			225	328	
Crossing Volume (veh/h)	107			59	404	
High Capacity (veh/h)	1274			1323	1007	
High v/c (veh/h)	0.39			0.17	0.33	
Low Capacity (veh/h)	1061			1105	820	
Low v/c (veh/h)	0.47			0.20	0.40	

Intersection Summary			
Maximum v/c High	0.39		
Maximum v/c Low	0.47		
Intersection Capacity Utilization	65.1%	ICU Level of Service	C

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↑	↱	↰				↑	↱			
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	0	203	124	703	0	0	0	116	187	0	0	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	221	135	764	0	0	0	126	203	0	0	0

Direction, Lane #	EB 1	EB 2	WB 1	NB 1	NB 2
Volume Total (vph)	221	135	764	126	203
Volume Left (vph)	0	0	764	0	0
Volume Right (vph)	0	135	0	0	203
Hadj (s)	0.03	-0.55	0.23	0.07	-0.31
Departure Headway (s)	5.2	3.2	4.9	6.2	3.2
Degree Utilization, x	0.32	0.12	1.03	0.22	0.18
Capacity (veh/h)	674	1121	747	560	1121
Control Delay (s)	10.7	6.6	62.7	11.0	6.9
Approach Delay (s)	9.1		62.7	8.5	
Approach LOS	A		F	A	

Intersection Summary			
Delay	37.2		
HCM Level of Service	E		
Intersection Capacity Utilization	70.3%	ICU Level of Service	C
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	0	598	132	158	0	0	0	87	399	0	0	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	650	143	172	0	0	0	95	434	0	0	0

Direction, Lane #	EB 1	EB 2	WB 1	NB 1	NB 2
Volume Total (vph)	650	143	172	95	434
Volume Left (vph)	0	0	172	0	0
Volume Right (vph)	0	143	0	0	434
Hadj (s)	0.02	-0.57	0.56	0.07	-0.52
Departure Headway (s)	4.4	3.2	5.5	5.9	3.2
Degree Utilization, x	0.80	0.13	0.26	0.15	0.39
Capacity (veh/h)	796	1121	630	569	1114
Control Delay (s)	22.9	6.7	10.4	9.9	8.2
Approach Delay (s)	19.9		10.4	8.5	
Approach LOS	C		B	A	

Intersection Summary			
Delay	14.8		
HCM Level of Service	B		
Intersection Capacity Utilization	64.7%	ICU Level of Service	C
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Right Turn Channelized						
Volume (veh/h)	203	124	703	663	116	187
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	221	135	764	721	126	203
Approach Volume (veh/h)	355			1485	329	
Crossing Volume (veh/h)	764			126	221	
High Capacity (veh/h)	755			1255	1165	
High v/c (veh/h)	0.47			1.18	0.28	
Low Capacity (veh/h)	597			1043	962	
Low v/c (veh/h)	0.60			1.42	0.34	

Intersection Summary			
Maximum v/c High	1.18		
Maximum v/c Low	1.42		
Intersection Capacity Utilization	121.8%	ICU Level of Service	H

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Right Turn Channelized						
Volume (veh/h)	598	132	158	175	87	399
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	650	143	172	190	95	434
Approach Volume (veh/h)	793			362	528	
Crossing Volume (veh/h)	172			95	650	
High Capacity (veh/h)	1211			1286	828	
High v/c (veh/h)	0.66			0.28	0.64	
Low Capacity (veh/h)	1003			1072	661	
Low v/c (veh/h)	0.79			0.34	0.80	

Intersection Summary			
Maximum v/c High	0.66		
Maximum v/c Low	0.80		
Intersection Capacity Utilization	98.0%	ICU Level of Service	F

Appendix F – Traffic Analysis Results (SimTraffic)

Delays – Morning (AM) 2016

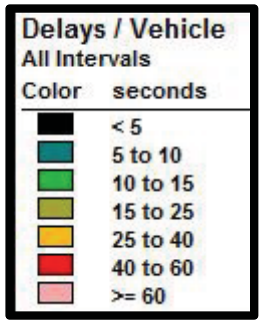


Figure 21 - Legend for Delays per Vehicle

Figure 22 - Delays: 2016 AM Existing Intersection

Figure 23 - Delays: 2016 AM Proposed Roundabout

Queues – Morning (AM) 2016

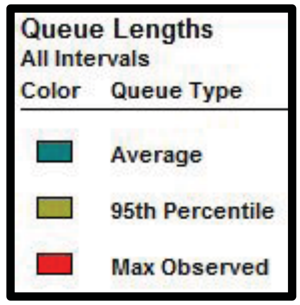


Figure 24 - Legend for Queues

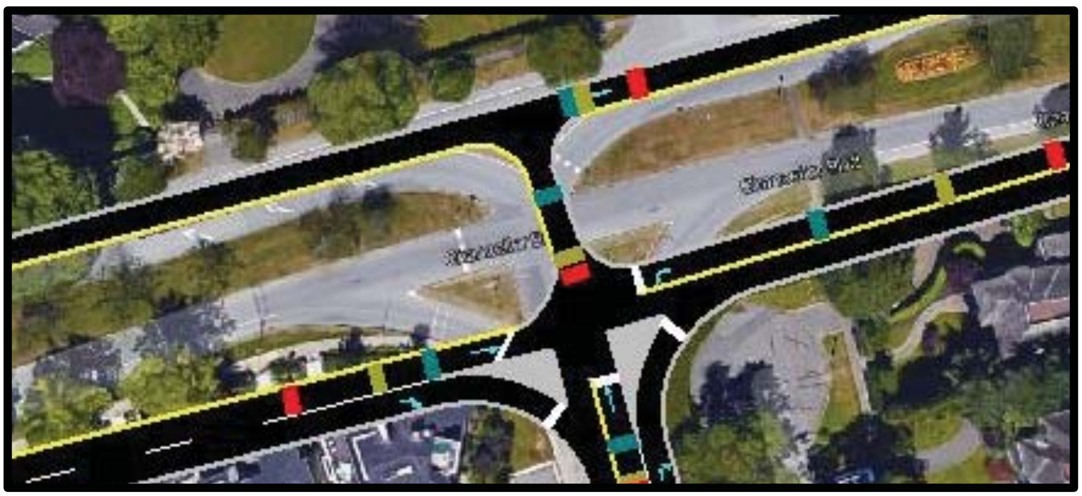


Figure 25 - Queues: 2016 AM Existing Intersection

Figure 26 - Queues: 2016 AM Proposed Roundabout

Delays – Afternoon (PM) 2016

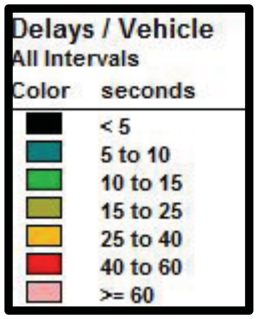


Figure 21 - Legend for Delays per Vehicle

Figure 27 - Delays: 2016 PM Existing Intersection

Figure 28 - Delays: 2016 PM Proposed Roundabout

Queues – Afternoon (PM) 2016

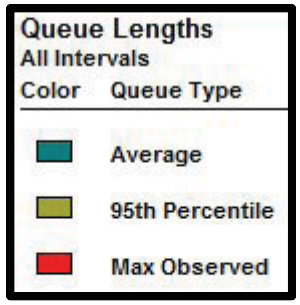


Figure 24 - Legend for Queues

Figure 29 - Queues: 2016 PM Existing Intersection

Figure 30 - Queues: 2016 PM Proposed Roundabout

Delays – Morning (AM) 2040

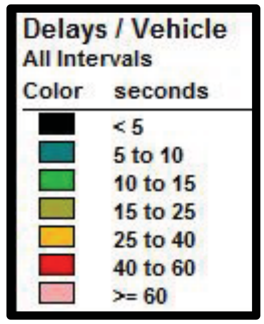


Figure 21 - Legend for Delays per Vehicle

Figure 31 - Delays: 2040 AM Existing Intersection

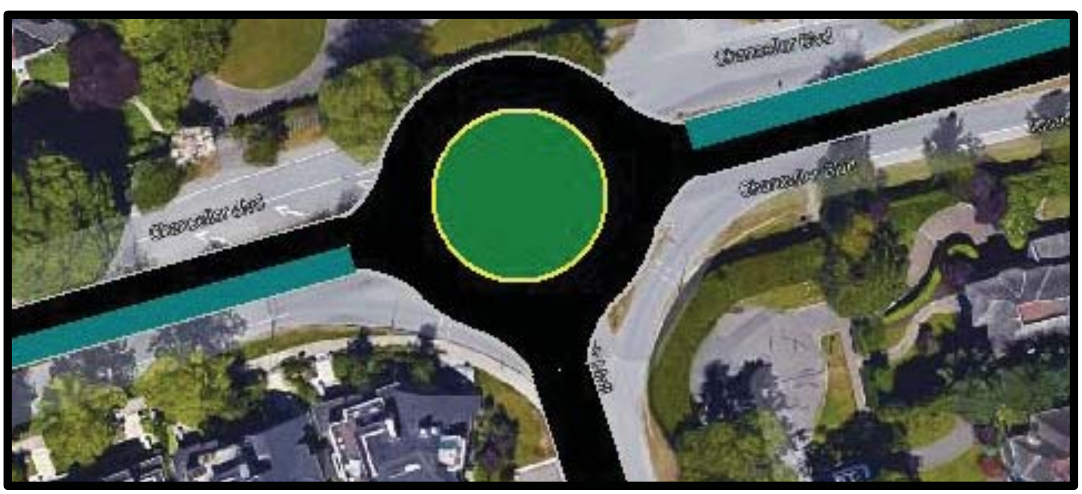


Figure 32 - Delays: 2040 AM Proposed Roundabout

Queues – Morning (AM) 2040

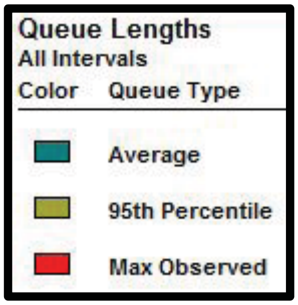


Figure 24 - Legend for Queues

Figure 33 - Queues: 2040 AM Existing Intersection

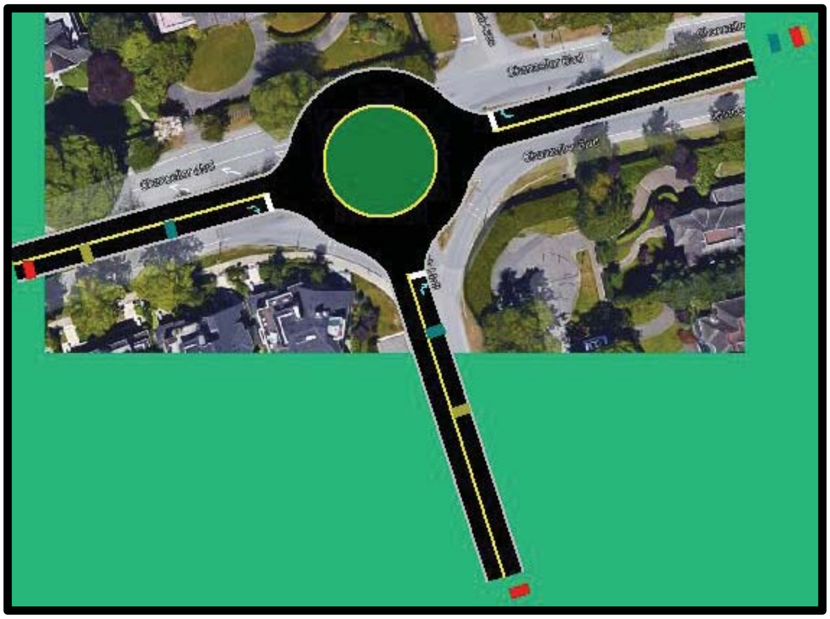


Figure 34 - Queues: 2040 AM Proposed Roundabout

Delays – Afternoon (PM) 2040

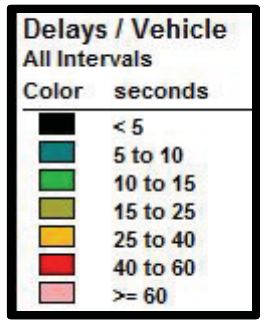


Figure 21 - Legend for Delays per Vehicle

Figure 35 - Delays: 2040 PM Existing Intersection

Figure 36 - Delays: 2040 PM Proposed Roundabout

Queues – Afternoon (PM) 2040

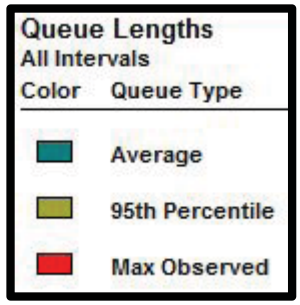


Figure 24 - Legend for Queues

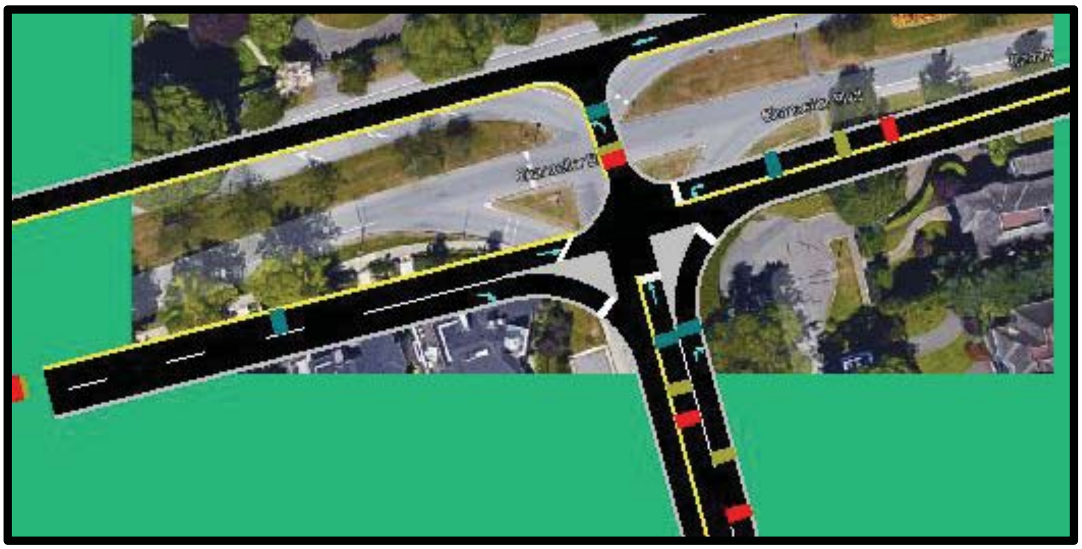


Figure 37 - Queues: 2040 PM Existing Intersection

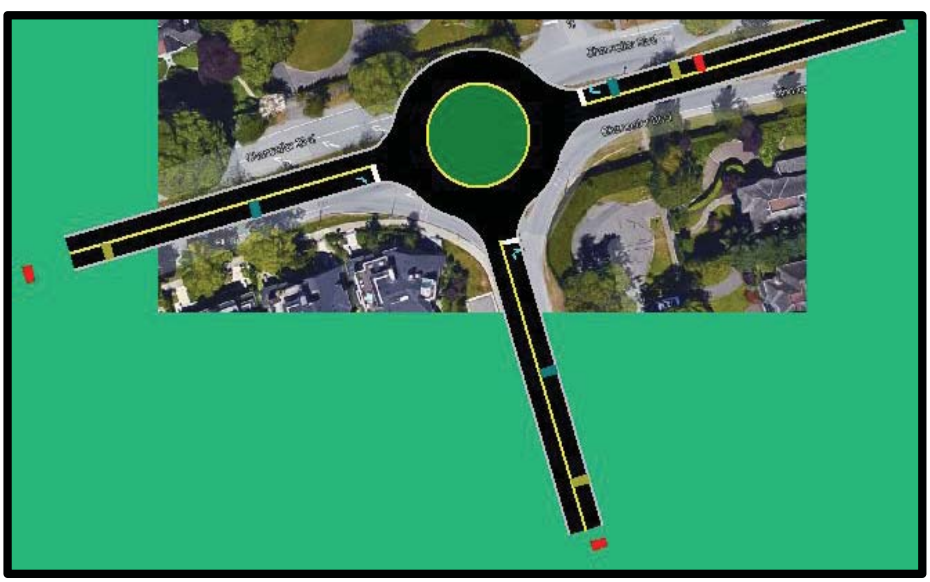


Figure 38 - Queues: 2040 PM Proposed Roundabout

Appendix G – Sample Roundabout Calculation

Roundabout Sample Calculations

Stopping sight distance:

$$d = 1.47(t)(V) + 1.075\left(\frac{V^2}{a}\right) = 1.47(2.5)(31) + 1.075\left(\frac{31^2}{11.2}\right) = 270\ ft = 82\ m$$

t = reaction time, assumed to be 2.5 seconds

V = approach speed, taken to be 50 km/h approaching roundabout, 31 mph

a = deceleration rate, 11.2 ft/s^2 *(Kittelson & Associates Inc. , 2014)*

Intersection sight distance:

$$d_1 = 1.47\left(V_{major,enterting}\right)(t_c) = 1.47(31)(5) = 227\ ft = 69\ m$$

$$d_2 = 1.47\left(V_{major,circulating}\right)(t_c) = 1.47(21)(5) = 154\ ft = 47\ m$$

d_1 = entering leg of sight triangle length, ft

d_2 = circulating leg of sight triangle length, ft

t_c = critical headway for entering the major road

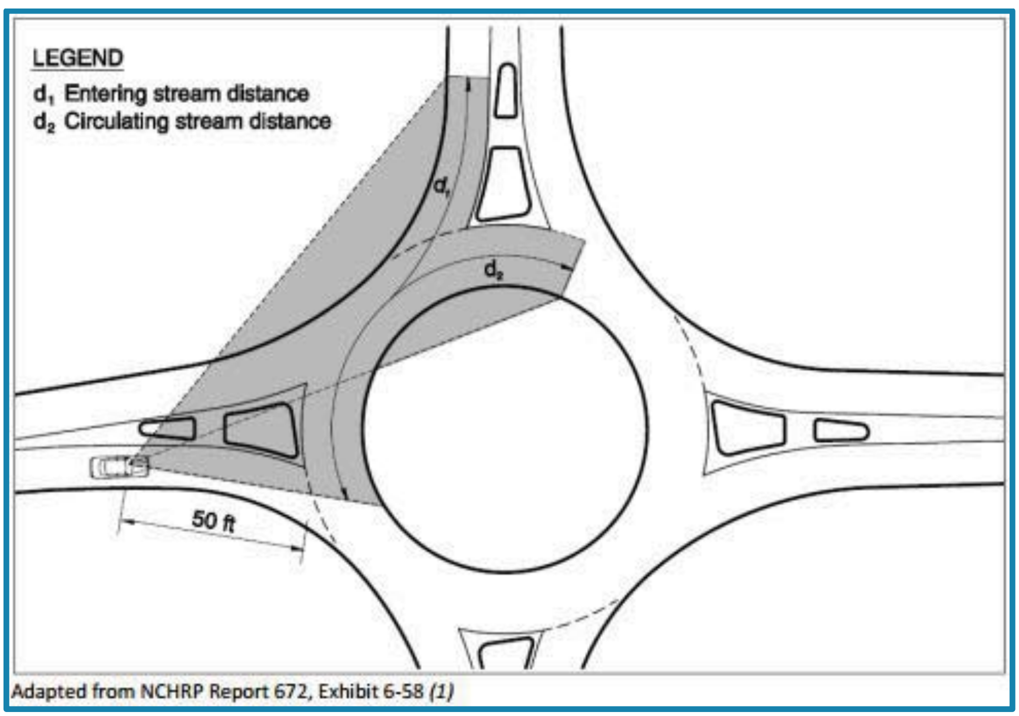


Figure 39 - Intersection Sight Distance
(Kittelson & Associates Inc. , 2014)

Appendix H – Sample Gateway Calculations

Observation Structure Sample Calculations

Dead Load

- Steel Columns
- Concrete Topping
- Steel Beams, Girders and Decks
- CLT Flooring
- Glass Panels
- Guardrails
- Glulam Columns, Beams

Live Load

Assembly Area $4.8kPa$

Snow Load

$$I_s(S_s(C_bC_eC_a)+S_r)=1.64kPa$$

Variable	Value	Units	Description
I_s	*1*	*Unit less*	*Importance Factor*
C_b	*0.8*	*Unit less*	*Basic Roof Snow Factor*
C_e	*1*	*Unit less*	*Roof Slope Factor*
S_s	*1.8*	*kPa*	*Snow Loading*
S_r	*0.2*	*kPa*	*Rain Loading*

Wind Load

$$I_wqC_eC_gC_p=0.84kPa$$

Variable	Value	Units	Description
I_w	*0.8*	*Unit less*	*Importance Factor*
q	*0.36*	*Unit less*	*Wind Loading*
C_e	*0.93*	*Unit less*	$\frac{h}{10}^{0.2}$ *Exposure Factor*
C_g	*2.5*	*Unit less*	*Gust Factor - For Small Structures*
C_p	*1.0*	*Unit less*	*External Pressure Coefficient*

Seismic (Walkway)

$$\frac{S_a(2.0)M_vI_eW}{R_dR_0}=22.5kN$$

Variable	Value	Units	Description
$S_a(2.0)$	*0.17*	*Unit less*	*Spectral Acceleration, T=2s*
M_v	*1*	*Unit less*	*Higher Mode Effect Factor - Ductile Moment Frame*
I_e	*1*	*Unit less*	*Importance Factor*
W	*940*	*kN*	*Walkway Dead Load*
R_d	*4*	*Unit less*	*Force Modification Factor (Ductility) - Moment Frame*
R_0	*1.7*	*Unit less*	*Force Modification Factor (Over strength) - Moment Frame*

Project	Intersection Redesign - Capstone	**Date**	20-Mar-17
Location	UBC	**Page**	1
Subject	Observation Deck (CLT)	**Code**	NBCC 2010
By	Group 16	**Design**	CSA-086-2016

i) **Loads**

NBCC 2010

Total Load	8.18	kPa	*(CLT = 450kg/m3)*
Tributary Width	7.20	m	
Factored Load	58.93	kN/m	
Mf	381.85	kNm	**OK**
Vf	212.14	kN	

ii) **CLT Panel**

Layers:	5	Nos. @	Stress Grade	E2
(Longitudinal)	3	Nos.		
(Transverse)	2	Nos.		
Height or Length	7200	mm		
Layer Thickness	35	mm		
Width	7200	mm		
Elong	10300	MPa		
Etrans	10000	MPa		
Area of 1 Layer	252000	mm2		

Layer		*Long.*			*Trans.*	
1	y2	0	mm	y2	1225	mm
2	y2	4900	mm	y2	1225	mm
3	y2	4900	mm	y2		mm
4	y2		mm	y2		mm
5	y2		mm	y2		mm
6	y2		mm	y2		mm

8.4.3 **Bending Resistance**

Mr = 0.9FbSeff,yKrb,y *(All layers effective in Major Axis)*

	Fb	23.9	MPa
	Seff,y	29353378.64	mm3
8.4.3.1	Krb,y	0.85	
	$\sum EI_x$	8.12053E+11	Nmm2
	$\sum EAy^2$	2.56427E+13	Nmm2
	(EI)eff	2.64547E+13	Nmm2

Mr = 536.7 kNm

Project	Intersection Redesign - Capstone	Date	20-Mar-17
Location	UBC	Page	2
Subject	Deck Design (GL 3 - 4)	Code	NBCC 2010
By	Group 16	Design	CSA-086-2016

Deck Girder (GL B, 3-4)

Deck Width w	2	m
Deck Span l	14	m

DL:

Guardrails	0.07	kN/m
1 1/2" Concrete Topping	0.9	kPa

LL:

Assembly	4.8	kPa
Guardrails	1.5	kN/m

SL:

Snow Loading	1.64	kPa

Load combination 3:

1.25DL + 1.5LL + 0.5S	9.1	kPa
Tributary Width	1	m
Total Factored UDL:	11.5	kN/m
Mf	281.8	kNm
Vf	80.5	kN

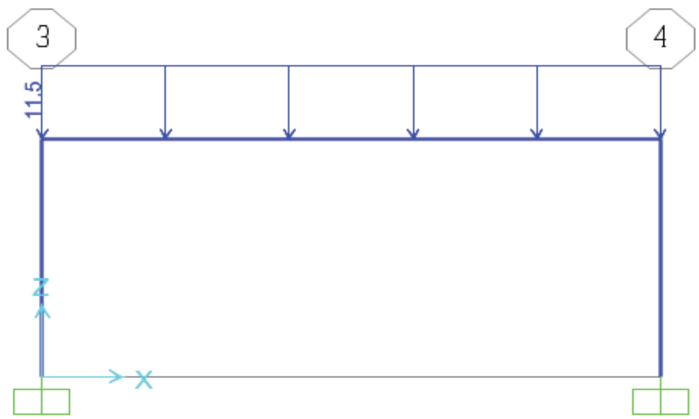
Deflection Criteria

L/240	58.3	DL+LL
L/360	38.9	LL

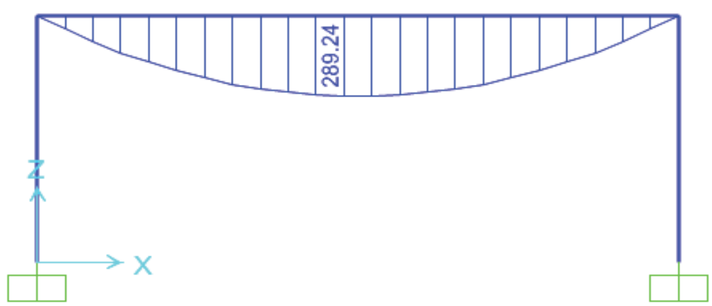
W360x134			
Mr	806	kNm	OK
Vr	425	kN	OK
Defl. DL + LL	43.8	mm	OK
Defl. LL	37.9	mm	OK

Project	Intersection Redesign - Capstone	Date	20-Mar-17
Location	UBC	Page	3
Subject	Deck Design (GL 3 - 4)	Code	NBCC 2010
By	Group 16	Design	CSA-086-2016

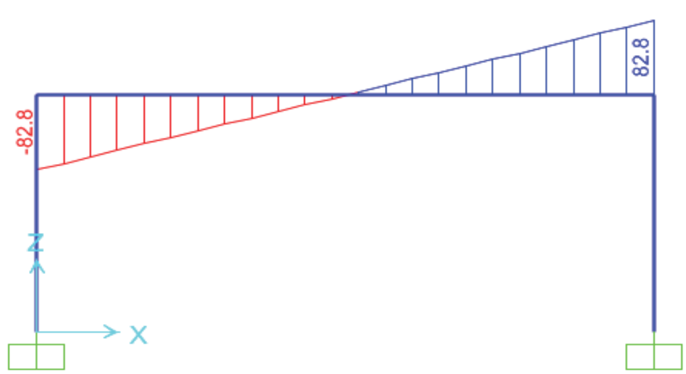
Deck Girder



Bending



Shear



Project	Intersection Redesign - Capstone	**Date**	20-Mar-17
Location	UBC	**Page**	4
Subject	Deck Design (GL 3 - 4)	**Code**	NBCC 2010
By	Group 16	**Design**	CSA-086-2016

Deck Span Bracing (Lateral Stability and Torsional Stiffness)

Brace length	2	m
Brace spacing	3	m

DL:

1/2" Concrete Topping	0.9	kPa

LL:

Assembly	4.8	kPa

SL:

Snow Loading	1.64	kPa

Load combination 3:

1.25DL + 1.5LL + 0.5S	9.1	kPa
Tributary Width	3	m
Total Factored UDL:	27.4	kN/m
Mf	30.9	kNm
Vf	41.2	kN

W360x33			
Mr	170	kNm	**OK**
Vr	335	kN	**OK**
Defl. DL + LL	8.3	mm	**OK**
Defl. LL	5.6	mm	**OK**

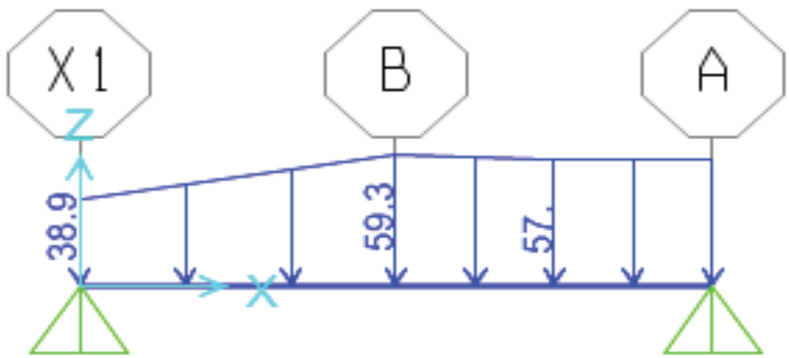
Steel Column (B3) Supporting Steel Deck

Deck Load	80	kN
Load Case 3	8.7	kPa
Staircase Trib.	2.4	m
Staircase Loading	20.88	kN
Pf	100.88	kN

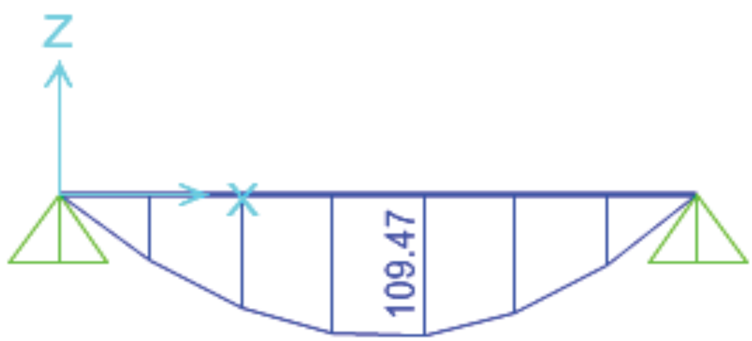
HSS 89x89x6.4			
Pr	101	kN	**OK**

Project	Intersection Redesign - Capstone	Date	20-Mar-17
Location	UBC	Page	5
Subject	Staircase Landing Beam (GL 2)	Code	NBCC 2010
By	Group 16	Design	CSA-086-2016

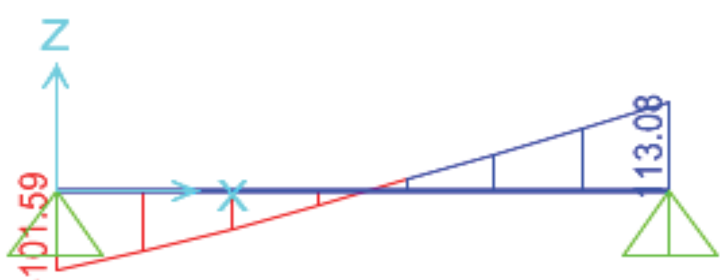
Staircase Landing Beam



Bending Moment



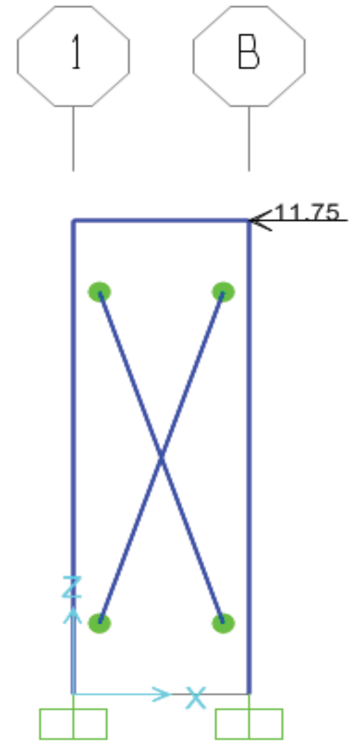
Shear



Project	Intersection Redesign - Capstone	Date	20-Mar-17
Location	UBC	Page	6
Subject	Deck Lateral Supporting Frame (GL 2)	Code	NBCC 2010
By	Group 16	Design	CSA-086-2016

Cross Bracing Design

Seismic Loading	23.5	kN
per frame	11.75	kN
Factored Load	20	kN
(Compressive and Tensile)		



L76x76x7.9

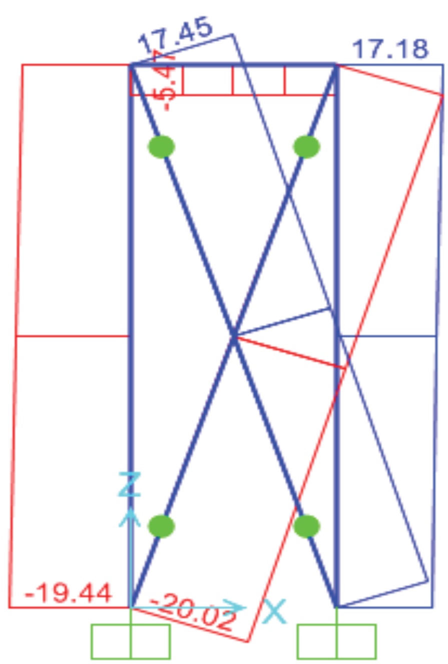
Compressive Resistance

Cr = 0.9AFy(1+H^(2n))^-1/n

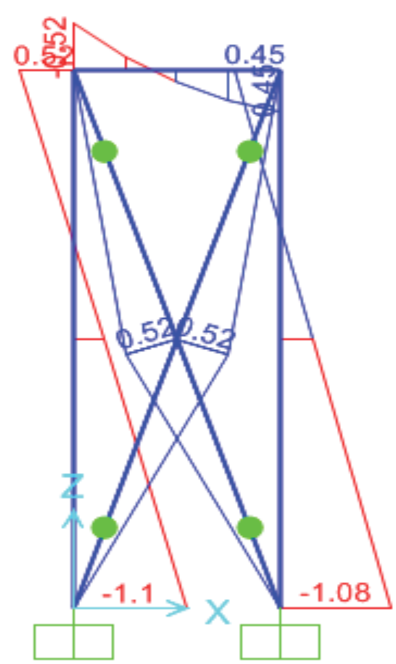
A	1150	mm2
Fy	480	30.3
L	6300	mm
r	23.4	mm
Fe	27.23205	MPa
H	4.198367	
Cr	27.74	kN

OK

Axial Force



Bending Moment



Project	Intersection Redesign - Capstone	**Date**	20-Mar-17
Location	UBC	**Page**	7
Subject	Lateral Brace Connection	**Code**	NBCC 2010
By	Group 16	**Design**	CSA-086-2016

Bolted Brace Connection (Tensile Resistance of Brace Member)

i) **Tensile Resistance**

Tr = 0.9 * Ag * Fy

Ag	1150	Fy	350	Mpa
Tr	362.3	kN		**OK**

ii) **Block Shear Tear Out**

Tr = 0.75(UtAnFu + 0.6Agv(Fy+Fu/2))

Ut	0.6		
An	174.68	mm2	*(22M dia. * 7.9mm thickess)*
Agv	1111.6	mm2	*2*(2*35mm spacing * 7.9mm thickness)*
Fy	350	Mpa	
Fu	480	MPa	
Tr	245.3	kN	**OK**

iii) **Tensile Fracture Resistance**

Tr = 0.75 * Ane * Fu

Fu	450	Mpa	
Ane	585	mm2	(0.6*(Ag- bolt dia. * thickness))
S. Lag	0,6		
Tr	197.5	kN	**OK**

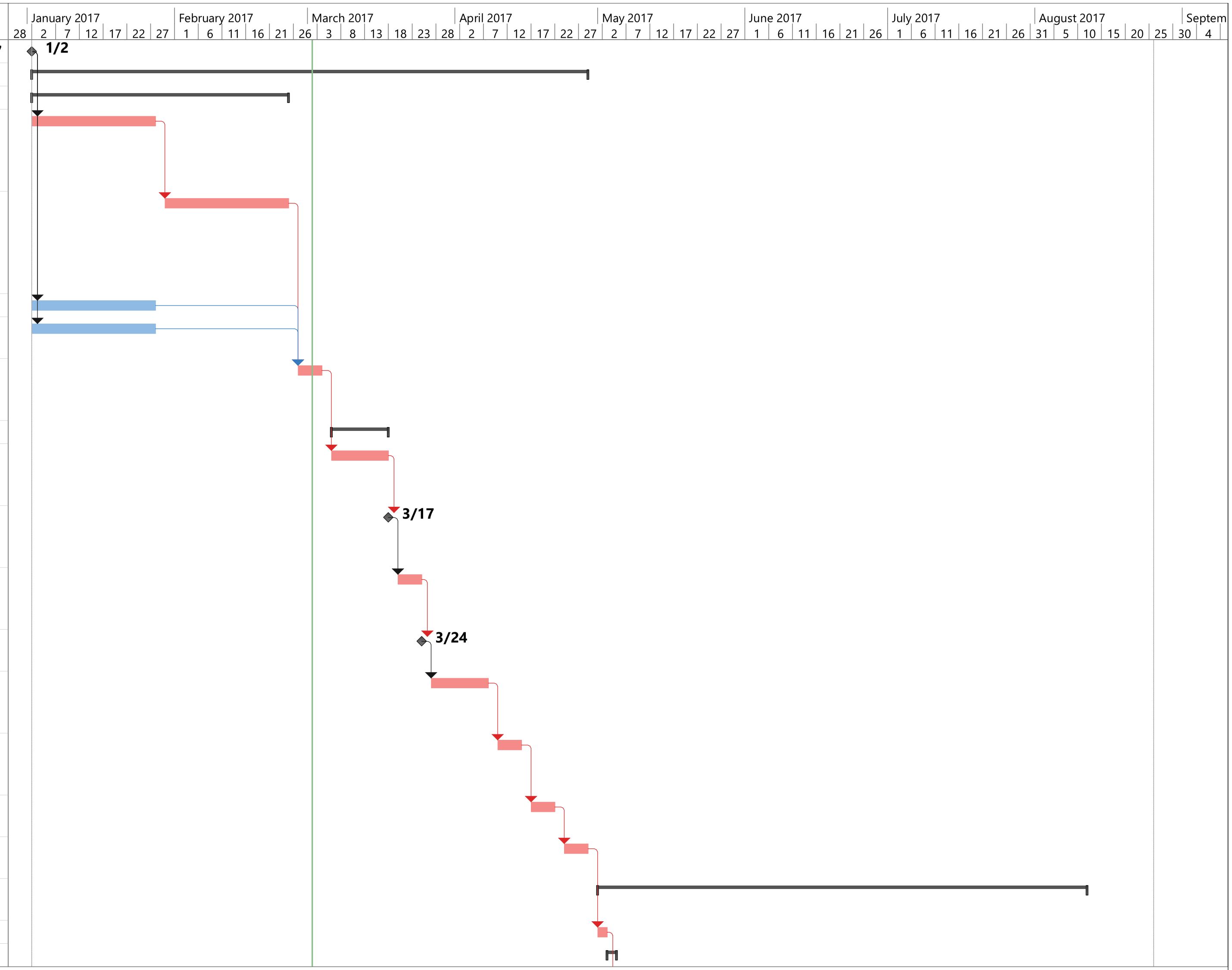
iv) **Bolt Tensile Resistance**

Tr = 0.75*0.8*Ab*Fu

Ab	380.1	mm2	
Fu	830	Mpa	
Tr	189.3	kN	**OK**

Appendix I –Construction Schedule: Phase 1 - Roundabout

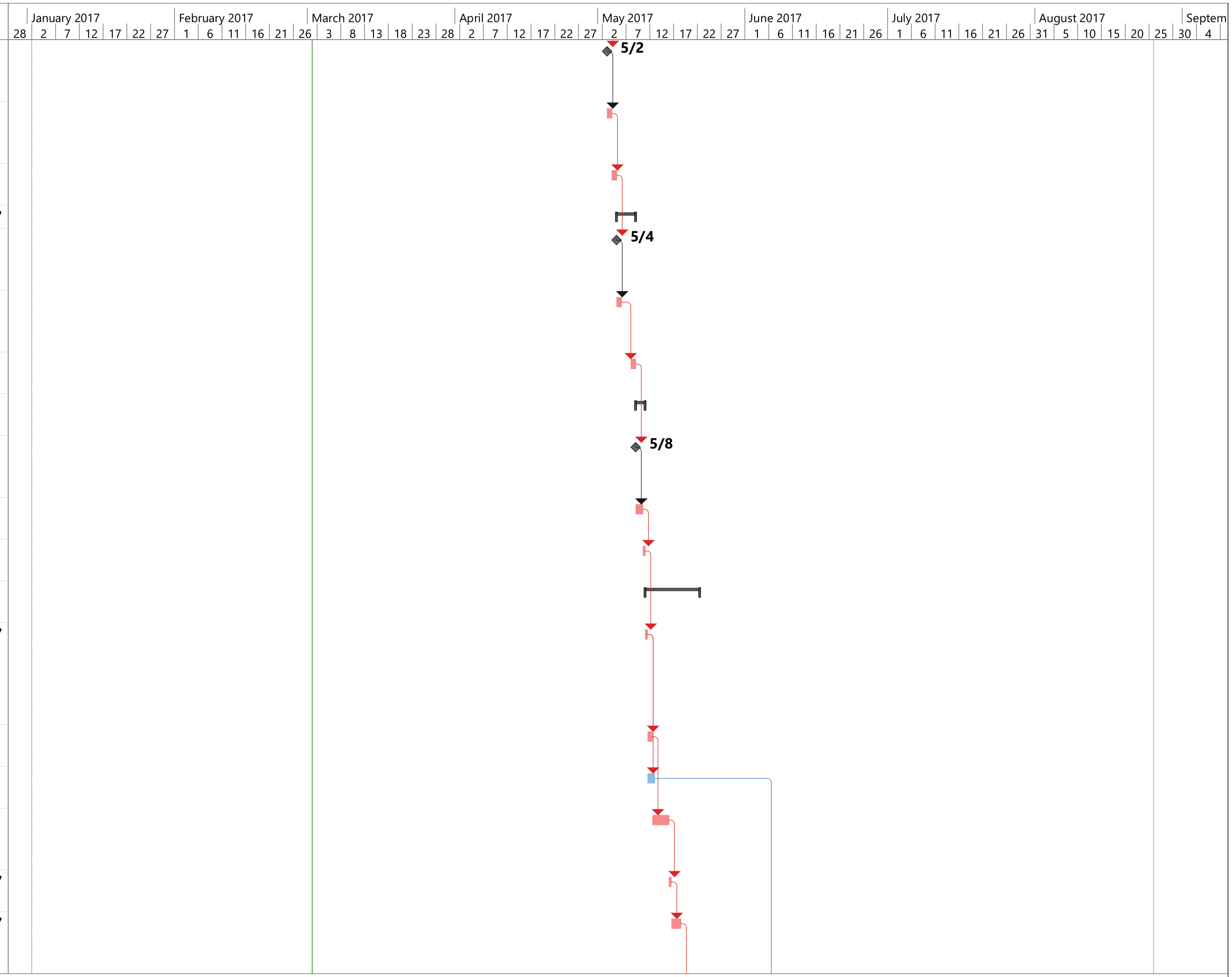
ID	Task Name	Duration	Start	Finish
1	**START**	**0 days**	**Mon 1/2/17**	**Mon 1/2/17**
2	**0 - PRECONSTRUCTIO**	**85 days**	**Mon 1/2/17**	**Fri 4/28/17**
3	**Preliminary Design**	**40 days**	**Mon 1/2/17**	**Fri 2/24/17**
4	60% Design Drawings preparation and submission	20 days	Mon 1/2/17	Fri 1/27/17
5	90% Design Drawings preparation and submission for permitting	20 days	Mon 1/30/17	Fri 2/24/17
6	Surveying	20 days	Mon 1/2/17	Fri 1/27/17
7	Geotechnical Evaluation	20 days	Mon 1/2/17	Fri 1/27/17
8	Client review and consulting team meeting	5 days	Mon 2/27/17	Fri 3/3/17
9	**Detailed design**	**10 days**	**Mon 3/6/17**	**Fri 3/17/17**
10	Final design drawings preparation	10 days	Mon 3/6/17	Fri 3/17/17
11	**Final design drawings submission**	**0 days**	**Fri 3/17/17**	**Fri 3/17/17**
12	Client review and consulting team meeting	5 days	Mon 3/20/17	Fri 3/24/17
13	**IFT released to contractors**	**0 days**	**Fri 3/24/17**	**Fri 3/24/17**
14	Bid preparation and submission by contractors	10 days	Mon 3/27/17	Fri 4/7/17
15	Bid recaps and contract award to general contractor	5 days	Mon 4/10/17	Fri 4/14/17
16	Subcontracts issued and signed	5 days	Mon 4/17/17	Fri 4/21/17
17	Contractor preparation	5 days	Mon 4/24/17	Fri 4/28/17
18	**1.0 - ROUNDABOUT CONSTRUCTION**	**76 days**	**Mon 5/1/17**	**Fri 8/11/17**
19	**1 - Mobilization**	**2 days**	**Mon 5/1/17**	**Tue 5/2/17**
20	**2 - SW Island Demc**	**2 days**	**Tue 5/2/17**	**Thu 5/4/17**



Project: Roundabout Construct
Date: Thu 3/2/17

Task | Milestone | Summary | Critical

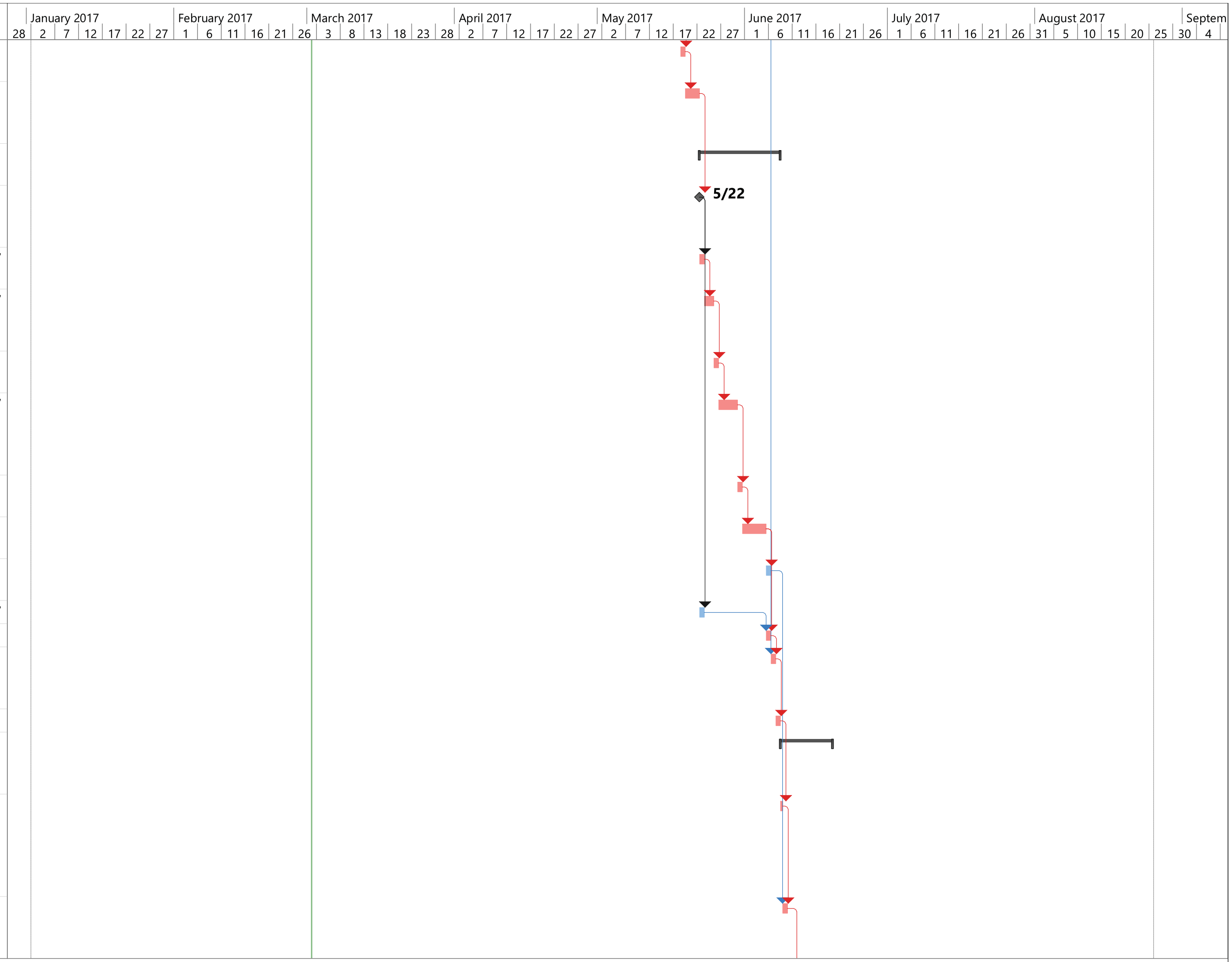
ID	Task Name	Duration	Start	Finish
21	Set up flaggers, work perimeter, temp signs	0 days	Tue 5/2/17	Tue 5/2/17
22	Remove existing island and truck out debris	1 day	Wed 5/3/17	Wed 5/3/17
23	Fill to grade with road base	1 day	Thu 5/4/17	Thu 5/4/17
24	**3 - SE Island Demo**	**2 days**	**Thu 5/4/17**	**Mon 5/8/17**
25	Set up flaggers, work perimeter, temp signs	0 days	Thu 5/4/17	Thu 5/4/17
26	Remove existing island and truck out debris	1 day	Fri 5/5/17	Fri 5/5/17
27	Fill to grade with road base	1 day	Mon 5/8/17	Mon 5/8/17
28	**3.5 -Temporary Bus**	**2 days**	**Mon 5/8/17**	**Wed 5/10/17**
29	Set up flaggers, work perimeter, temp signs	0 days	Mon 5/8/17	Mon 5/8/17
30	Cut back curbs on next	1.5 days	Tue 5/9/17	Wed 5/10/17
31	Fill to grade with road base	0.5 days	Wed 5/10/17	Wed 5/10/17
32	**4 - NE Median Construction**	**7.5 days**	**Thu 5/11/17**	**Mon 5/22/17**
33	Mob additional fence; set up flaggers, work perimeter, temp signs	0.5 days	Thu 5/11/17	Thu 5/11/17
34	Cut back on extg island	1 day	Thu 5/11/17	Fri 5/12/17
35	Formwork on new curbs on	1.5 days	Thu 5/11/17	Fri 5/12/17
36	Excavate/trench to relocate extg drainage pipe	1.5 days	Fri 5/12/17	Mon 5/15/17
37	Backfill drainage pipe	0.5 days	Tue 5/16/17	Tue 5/16/17
38	Excavate/trench to install new electrical boxes	2 days	Tue 5/16/17	Thu 5/18/17



Project: Roundabout Construct
Date: Thu 3/2/17

Task | Milestone | Summary | Critical

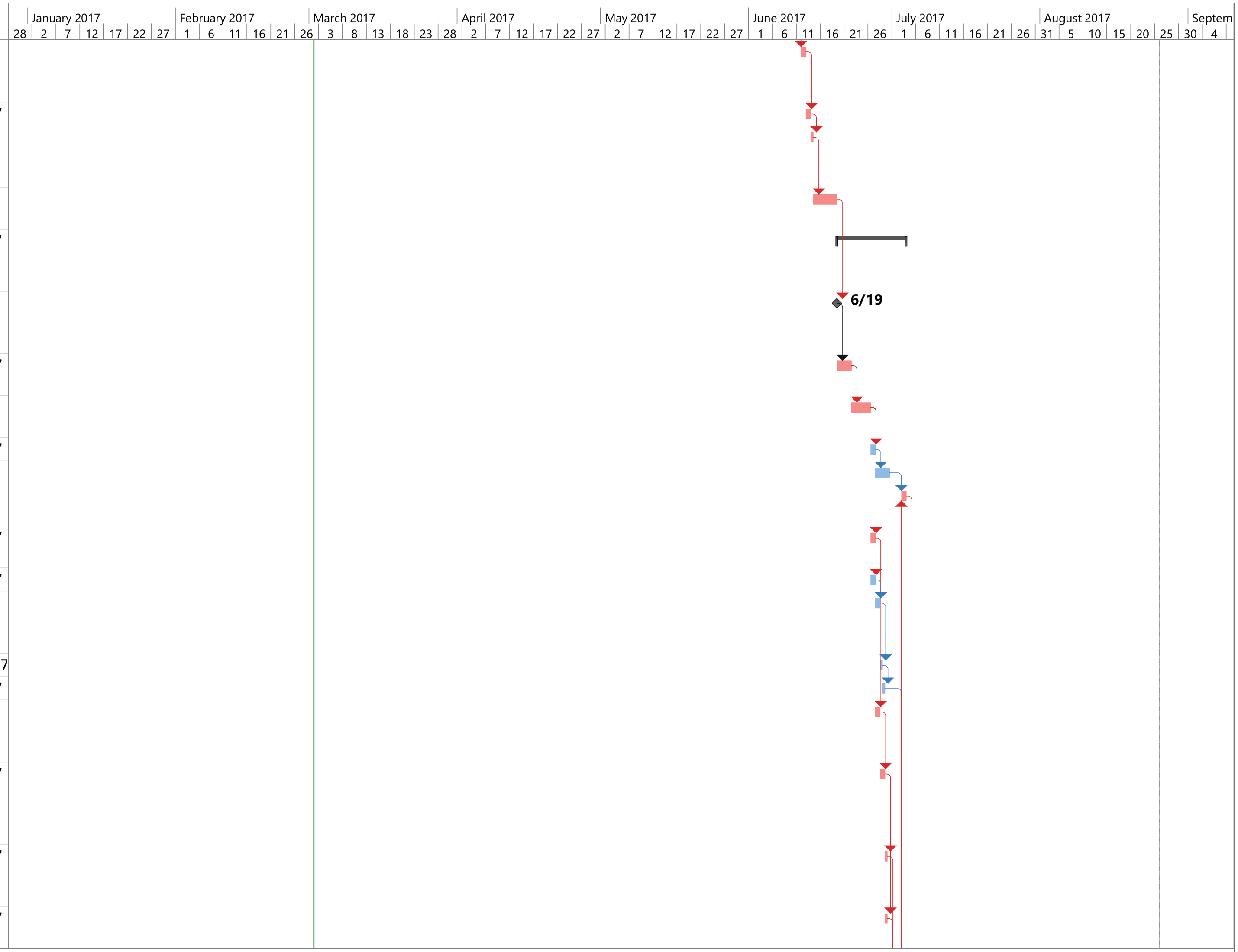
ID	Task Name	Duration	Start	Finish
39	Backfill electrical boxes	1 day	Thu 5/18/17	Fri 5/19/17
40	Fill cut island to grade with road base	1 day	Fri 5/19/17	Mon 5/22/17
41	**5 - NW Median Construction**	**13 days**	**Mon 5/22/17**	**Thu 6/8/17**
42	Set up flaggers, work perimeter, temp signs	0 days	Mon 5/22/17	Mon 5/22/17
43	Cut back on extg island	1 day	Mon 5/22/17	Tue 5/23/17
44	Excavate/trench to relocate extg electrical box	2 days	Tue 5/23/17	Thu 5/25/17
45	Backfill electrical box	1 day	Thu 5/25/17	Fri 5/26/17
46	Excavate/trench to install new stormwater and electrical	2 days	Fri 5/26/17	Tue 5/30/17
47	Backfill to grade with road base	1 day	Tue 5/30/17	Wed 5/31/17
48	Excavate for new westbound	3 days	Wed 5/31/17	Mon 6/5/17
49	Backfill to grade with road base	1 day	Mon 6/5/17	Tue 6/6/17
50	Formwork prep	1 day	Mon 5/22/17	Tue 5/23/17
51	Formwork install	1 day	Mon 6/5/17	Tue 6/6/17
52	Pour curbs on phase 4 and 5 islands	1 day	Tue 6/6/17	Wed 6/7/17
53	Strip curbs	1 day	Wed 6/7/17	Thu 6/8/17
54	**6 - Northern Roundabout Construction**	**7 days**	**Thu 6/8/17**	**Mon 6/19/17**
55	Mob additional fence; set up flaggers, work perimeter, temp signs	0.5 days	Thu 6/8/17	Thu 6/8/17
56	Excavate for new northern half of	1 day	Fri 6/9/17	Fri 6/9/17



Project: Roundabout Construct
Date: Thu 3/2/17

Task | Milestone | Summary | Critical

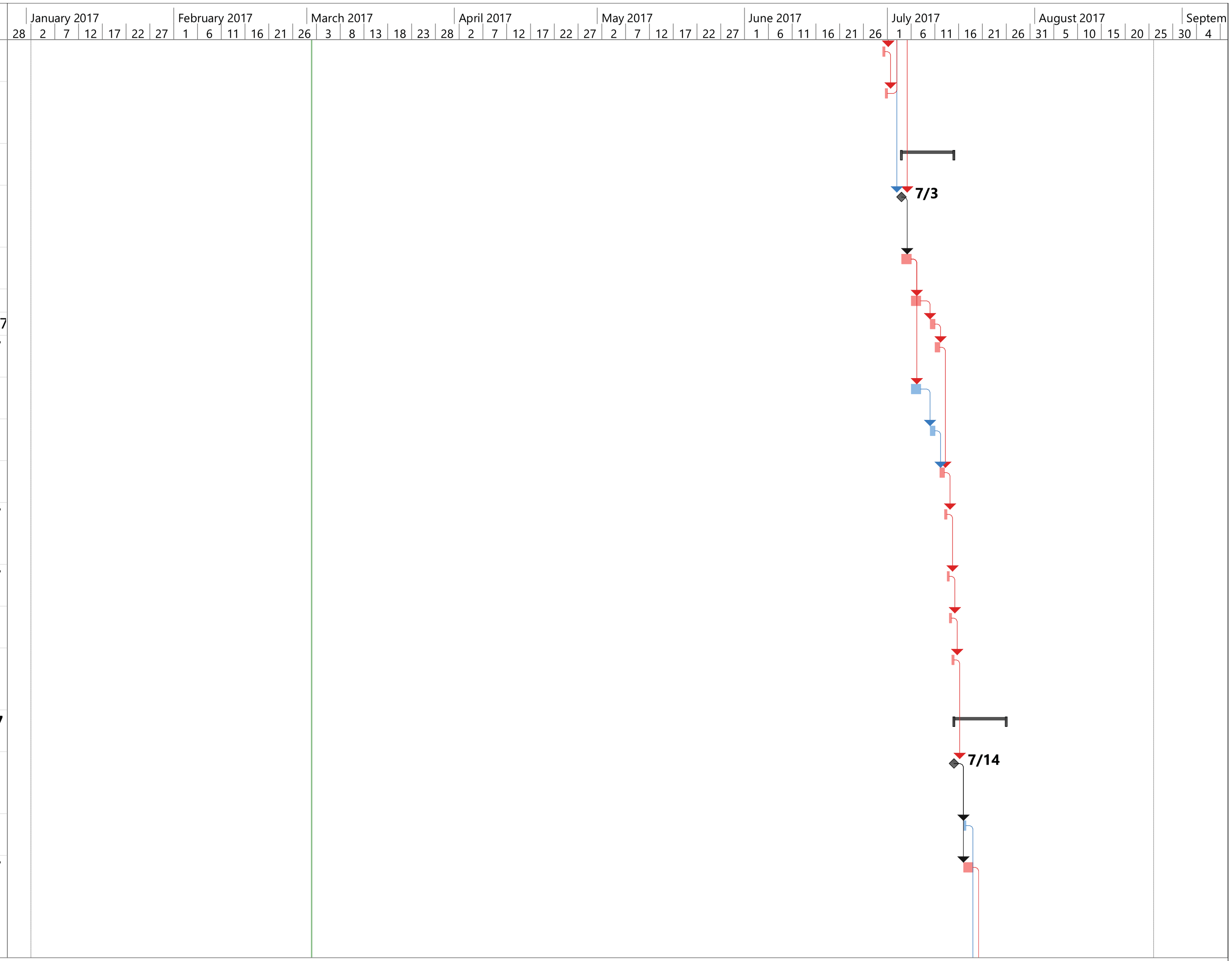
ID	Task Name	Duration	Start	Finish
57	Fill roundabout to grade with road base	1 day	Mon 6/12/17	Mon 6/12/17
58	Excavate for new	1 day	Tue 6/13/17	Tue 6/13/17
59	Fill new island to grade with road base	0.5 days	Wed 6/14/17	Wed 6/14/17
60	Milling top coat for new asphalt	3 days	Wed 6/14/17	Mon 6/19/17
61	**7 - Southern Roundabout Construction**	**10.5 days**	**Mon 6/19/17**	**Mon 7/3/17**
62	Set up flaggers, work perimeter, temp signs	0 days	Mon 6/19/17	Mon 6/19/17
63	Milling top coat for new asphalt	3 days	Mon 6/19/17	Thu 6/22/17
64	Excavate and trench south	2 days	Thu 6/22/17	Mon 6/26/17
65	Tie in electrical	1 day	Mon 6/26/17	Tue 6/27/17
66	Tie in drainage	3 days	Tue 6/27/17	Fri 6/30/17
67	Backfill to grade with road base	1 day	Mon 7/3/17	Mon 7/3/17
68	Excavate for new sidewalk	1 day	Mon 6/26/17	Tue 6/27/17
69	Formwork prep	1 day	Mon 6/26/17	Tue 6/27/17
70	Formwork install and pack on new curbs	1 day	Tue 6/27/17	Wed 6/28/17
71	Pour sidewalk	0.5 days	Wed 6/28/17	Wed 6/28/17
72	Strip sidewalk	0.5 days	Thu 6/29/17	Thu 6/29/17
73	Excavate for new southern half of	1 day	Tue 6/27/17	Wed 6/28/17
74	Backfill roundabout to grade with road base	1 day	Wed 6/28/17	Thu 6/29/17
75	Excavate for channelized island addition	0.5 days	Thu 6/29/17	Thu 6/29/17
76	Curb formwork prep	0.5 days	Thu 6/29/17	Thu 6/29/17



Project: Roundabout Construct
Date: Thu 3/2/17

Task | Milestone | Summary | Critical

ID		Task Name	Duration	Start	Finish
77		Curb formwork install	0.5 days	Fri 6/30/17	Fri 6/30/17
78		Backfill island to grade with road base	0.5 days	Fri 6/30/17	Fri 6/30/17
79		**8 - Electrical Trenching**	**9 days**	**Mon 7/3/17**	**Fri 7/14/17**
80		Set up flaggers, work perimeter, temp signs	0 days	Mon 7/3/17	Mon 7/3/17
81		Excavate and trench west	2 days	Tue 7/4/17	Wed 7/5/17
82		Tie in drainage	2 days	Thu 7/6/17	Fri 7/7/17
83		Tie in electrical	1 day	Mon 7/10/17	Mon 7/10/17
84		Backfill to grade with road base	1 day	Tue 7/11/17	Tue 7/11/17
85		Excavate and trench east road	2 days	Thu 7/6/17	Fri 7/7/17
86		Tie in electrical for east road	1 day	Mon 7/10/17	Mon 7/10/17
87		Backfill to grade with road base	1 day	Wed 7/12/17	Wed 7/12/17
88		Excavate for channelized island addition	0.5 days	Thu 7/13/17	Thu 7/13/17
89		Curb formwork prep	0.5 days	Thu 7/13/17	Thu 7/13/17
90		Curb formwork install	0.5 days	Fri 7/14/17	Fri 7/14/17
91		Backfill island to grade with road base	0.5 days	Fri 7/14/17	Fri 7/14/17
92		**9 - Roundabout Construction**	**8 days**	**Fri 7/14/17**	**Tue 7/25/17**
93		Set up flaggers, work perimeter, temp signs	0 days	Fri 7/14/17	Fri 7/14/17
94		Scrape top layer of roundabout	0.5 days	Mon 7/17/17	Mon 7/17/17
95		Form Prep for roundabout, north channelized island, and temp	2 days	Mon 7/17/17	Tue 7/18/17



Project: Roundabout Construct
Date: Thu 3/2/17

Task | Milestone | Summary | Critical

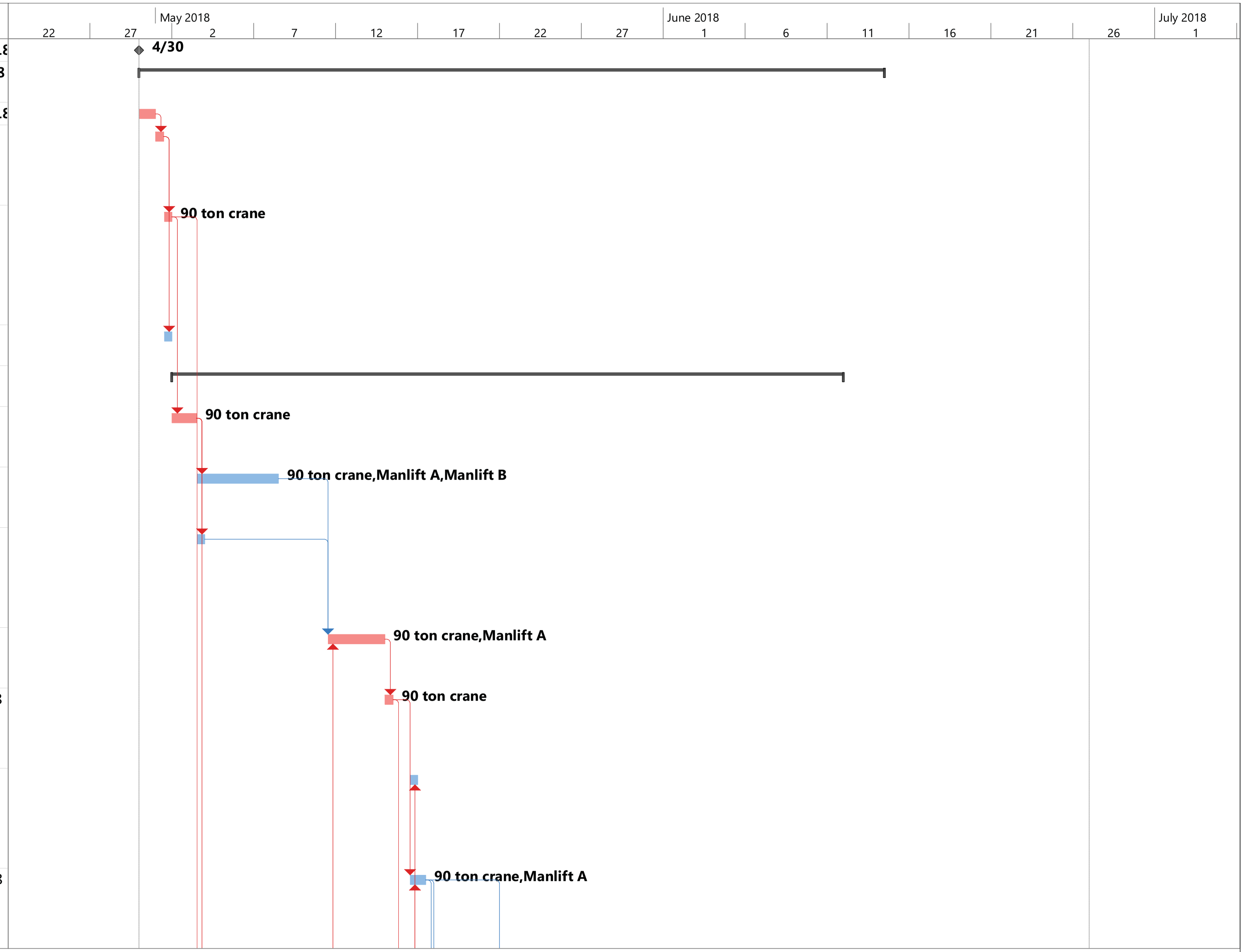
ID		Task Name	Duration	Start	Finish
96		Form install on roundabout	1 day	Wed 7/19/17	Wed 7/19/17
97		Form install on channelized	1 day	Thu 7/20/17	Thu 7/20/17
98		Form install on temp bus accommodation	1 day	Fri 7/21/17	Fri 7/21/17
99		Pour remaining structures	1 day	Sat 7/22/17	Sat 7/22/17
100		Strip formwork	2 days	Mon 7/24/17	Tue 7/25/17
101		**10 - Paving and Painting**	**11 days**	**Tue 7/25/17**	**Wed 8/9/17**
102		Set up flaggers, work perimeter, temp signs	0 days	Tue 7/25/17	Tue 7/25/17
103		Paving milled road surface	5 days	Wed 7/26/17	Tue 8/1/17
104		Backfill with soil to grade and plant grass on new islands	5 days	Wed 8/2/17	Tue 8/8/17
105		Painting crosswalk, bike lanes, lane	3 days	Wed 8/2/17	Fri 8/4/17
106		Area cleanup	1 day	Wed 8/9/17	Wed 8/9/17
107		**11 - Demobilizatior**	**2 days**	**Thu 8/10/17**	**Fri 8/11/17**
108		**2.0 - Project Close-ou**	**10 days**	**Mon 8/14/17**	**Fri 8/25/17**
109		Utilities commissioning	5 days	Mon 8/14/17	Fri 8/18/17
110		Prepare and submit O&M	10 days	Mon 8/14/17	Fri 8/25/17
111		**END**	**0 days**	**Fri 8/25/17**	**Fri 8/25/17**

Project: Roundabout Construct
Date: Thu 3/2/17

Task | Milestone | Summary | Critical

Appendix J –Construction Schedule: Phase 2 - Gateway

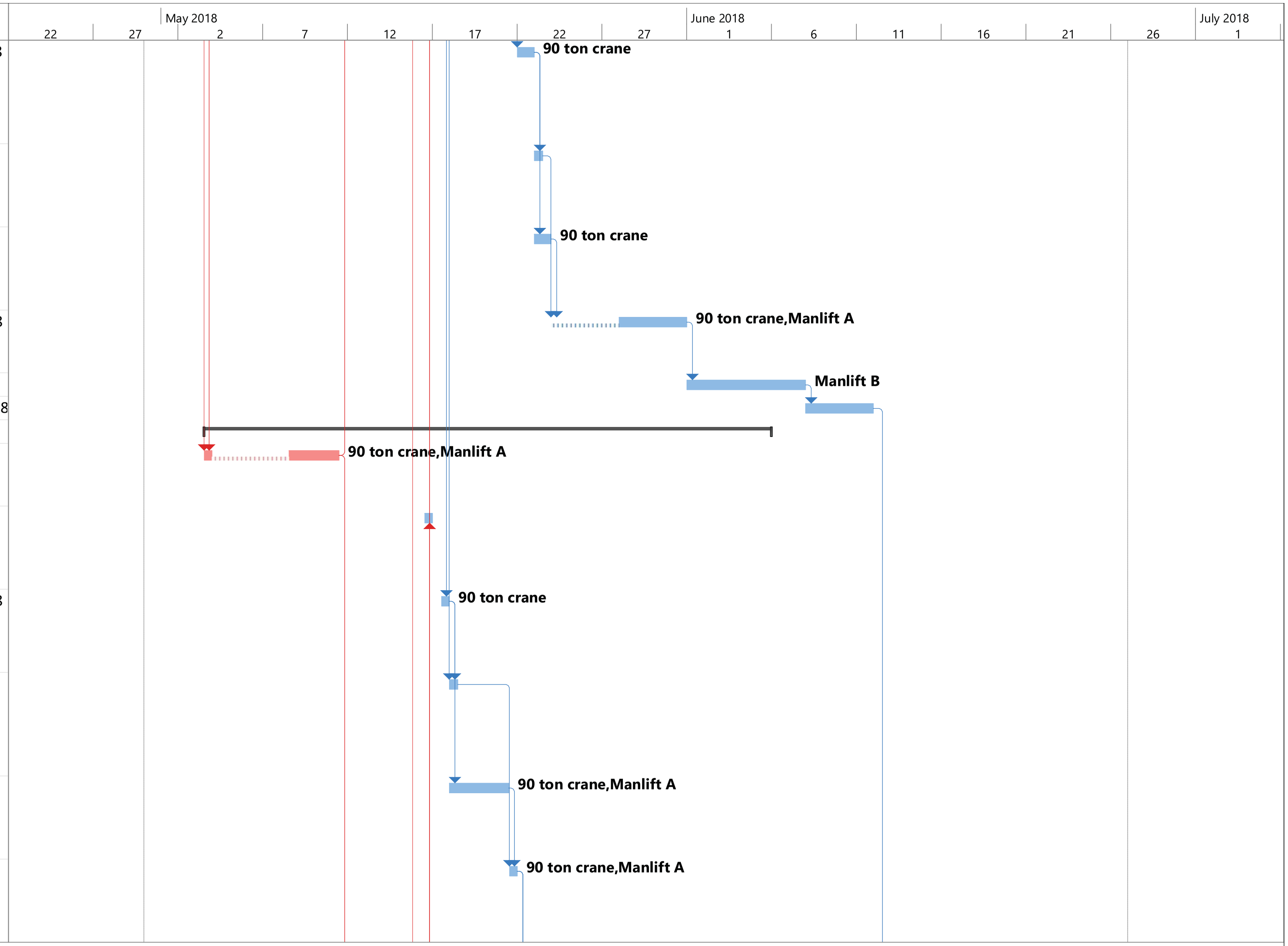
ID	Task Name	Duration	Start	Finish
1	**START**	**0 days**	**Mon 4/30/18**	**Mon 4/30/18**
2	**1.0 - GATEWAY CONSTRUCTION**	**33.5 days**	**Mon 4/30/18**	**Thu 6/14/18**
3	**Site Mobilization**	**1 day**	**Mon 4/30/18**	**Mon 4/30/18**
4	Set up flaggers, work perimeter, temp signage; mob 150 ton crane	0.5 days	Tue 5/1/18	Tue 5/1/18
5	Receive precast columns, HSS columns & bracing delivery and stage on east median island	0.5 days	Tue 5/1/18	Tue 5/1/18
6	Receive bracing for precast columns	0.5 days	Tue 5/1/18	Tue 5/1/18
7	**1.1 - Observation Deck**	**29 days**	**Wed 5/2/18**	**Mon 6/11/18**
8	Erect Dfir columns and bolt to footings	1.5 days	Wed 5/2/18	Thu 5/3/18
9	Erect X-bracing between Dfir columns	3 days	Thu 5/3/18	Tue 5/8/18
10	Receive and stage obs deck steel framing and decking on roundabout	0.5 days	Thu 5/3/18	Thu 5/3/18
11	Erect obs deck CLT slab; complete	1.5 days	Fri 5/11/18	Mon 5/14/18
12	Receive and stage obs deck OSB decking on roundabout	0.5 days	Tue 5/15/18	Tue 5/15/18
13	Receive and stage glulam columns for obs deck roof & guardrails on	0.5 days	Wed 5/16/18	Wed 5/16/18
14	Erect obs deck OSB decking and complete connections	1 day	Wed 5/16/18	Thu 5/17/18



Project: Gateway Construction
Date: Fri 3/24/17

Task | Milestone | Summary | Critical

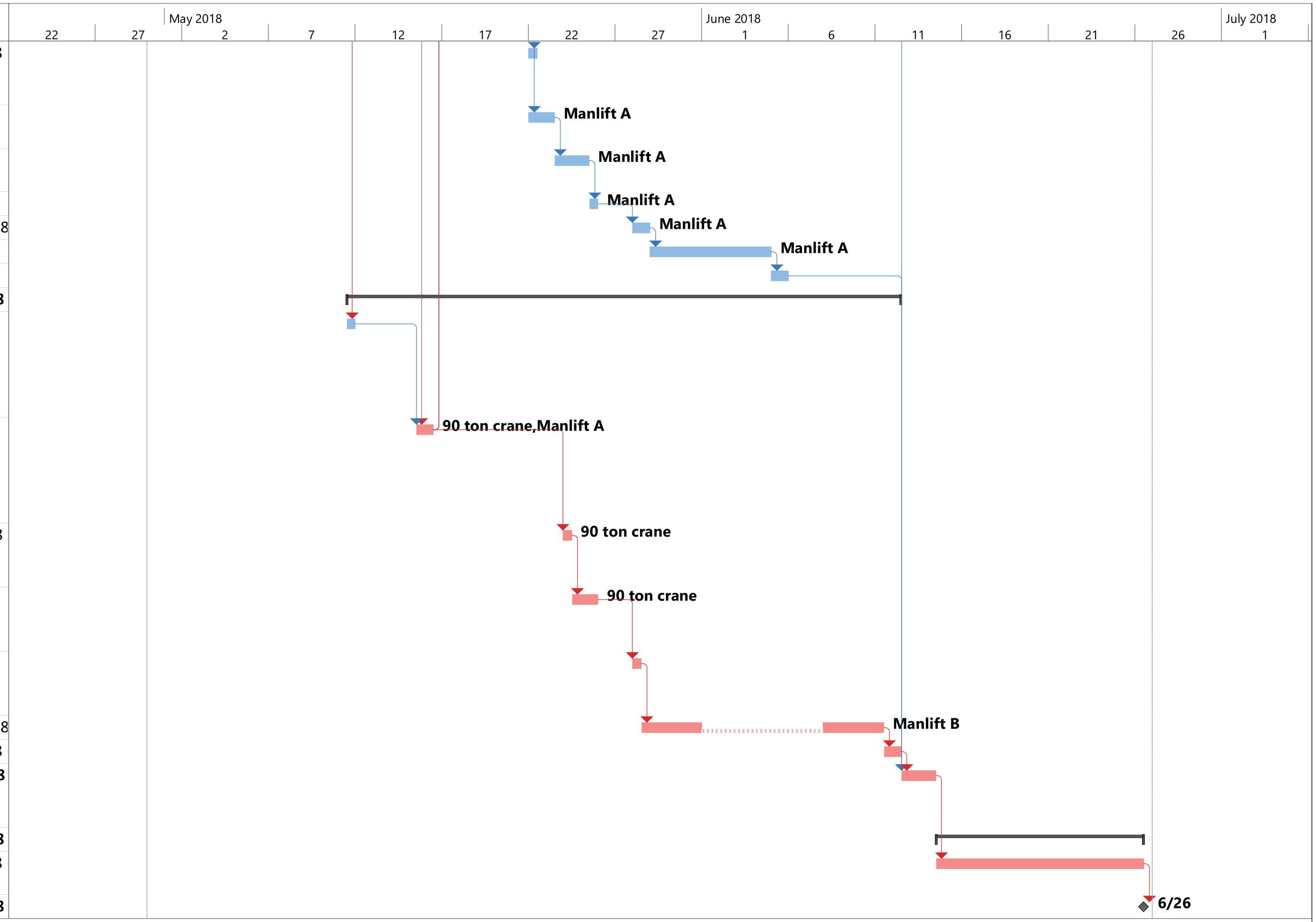
ID	Task Name	Duration	Start	Finish
15	Erect glulam columns for obs deck and secure; transfer guardrails to obs	1 day	Tue 5/22/18	Tue 5/22/18
16	Receive and stage obs deck signage and flashing on west	0.5 days	Wed 5/23/18	Wed 5/23/18
17	Receive and erect roof structure and secure to glulam	1 day	Wed 5/23/18	Wed 5/23/18
18	Install obs deck signage and flashing	4 days	Wed 5/23/18	Thu 5/31/18
19	Guardrail install	5 days	Fri 6/1/18	Thu 6/7/18
20	Final touchups	2 days	Fri 6/8/18	Mon 6/11/18
21	**1.2 - Walkway**	**23.5 days**	**Thu 5/3/18**	**Tue 6/5/18**
22	Erect HSS columns & bracing and bolt	3.5 days	Thu 5/3/18	Fri 5/11/18
23	Receive and stage walkway lateral members on east median	0.5 days	Wed 5/16/18	Wed 5/16/18
24	Receive and erect walkway girders and secure to HSS	0.5 days	Thu 5/17/18	Thu 5/17/18
25	Receive and stage walkway corrugated steel decking with rebar on	0.5 days	Fri 5/18/18	Fri 5/18/18
26	Erect walkway lateral members and complete connections	1.5 days	Fri 5/18/18	Mon 5/21/18
27	Erect walkway corrugated decking and secure to girders	0.5 days	Mon 5/21/18	Mon 5/21/18



Project: Gateway Construction
Date: Fri 3/24/17

Task | Milestone | Summary | Critical

ID	Task Name	Duration	Start	Finish
28	Receive and stage walkway guardrails on	0.5 days	Tue 5/22/18	Tue 5/22/18
29	Walkway formwork and	1.5 days	Tue 5/22/18	Wed 5/23/18
30	Walkway pour and cure	2 days	Wed 5/23/18	Fri 5/25/18
31	Walkway strip	0.5 days	Fri 5/25/18	Fri 5/25/18
32	Walkway finishin	1 day	Mon 5/28/18	Mon 5/28/18
33	Guardrail install	5 days	Tue 5/29/18	Mon 6/4/18
34	Final touchups	1 day	Tue 6/5/18	Tue 6/5/18
35	**1.3 - Stairway**	**22 days**	**Fri 5/11/18**	**Tue 6/12/18**
36	Receive and stage stairway landing steel framing and deck on east	0.5 days	Fri 5/11/18	Fri 5/11/18
37	Erect stairway landing steel framing and deck; complete connections	1 day	Tue 5/15/18	Wed 5/16/18
38	Receive and stage stairways on east median	0.5 days	Thu 5/24/18	Thu 5/24/18
39	Erect stairways and connect to landing,	1.5 days	Thu 5/24/18	Fri 5/25/18
40	Receive and stage guardrails on east median	0.5 days	Mon 5/28/18	Mon 5/28/18
41	Guardrail install	5 days	Mon 5/28/18	Mon 6/11/18
42	Final touchups	1 day	Mon 6/11/18	Tue 6/12/18
43	**Demobilization of crane and manlifts, area**	**2 days**	**Tue 6/12/18**	**Thu 6/14/18**
44	**2.0 - Project Close-ou**	**8 days**	**Thu 6/14/18**	**Tue 6/26/18**
45	Prepare and submit O&M	8 days	Thu 6/14/18	Tue 6/26/18
46	**END**	**0 days**	**Tue 6/26/18**	**Tue 6/26/18**



Project: Gateway Construction
Date: Fri 3/24/17

Task | Milestone ◆ | Summary | Critical

Appendix K –Traffic Management Plan Checklist

Table 3.1: Initial Project Category Assessment

Traffic Consideration	Value	✓	Point Value	Score
Posted or Statutory Speed Speed limit of the roadway.	≤ 50 km/hr.	☑	1 point	1
	60 - 70 km/hr.	☐	3 points	
	≥ 80 km/hr.	☐	4 points	
Traffic Volume Traffic volume (in both directions) in peak hours.	< 1,000 vehicles/hr.	☐	1 point	3
	1,000 to 3,000 vehicles/hr.	☑	3 points	
	> 3,000 vehicles/hr.	☐	4 points	
Lanes Number of lanes in both directions.	2 lanes.	☑	1 point	1
	3 lanes.	☐	3 points	
	4 lanes or more.	☐	4 points	
Encroachment Location of work.	Off roadway.	☐	0 point	4
	Shoulder work/partial lane closure.	☐	3 points	
	Full lane closure, ramp closure, or intersection closure.	☑	4 points	
Detours	No detour.	☐	0 point	4
	Detour traffic on temporary roadway next to work zone.	☐	3 points	
	Route takes traffic off regular route away from work zone; requires detour signing.	☑	4 points	
Duration of Work	Short-duration work (no more than one day-time shift).	☐	1 point	4
	Long-duration work (less than 2 weeks).	☐	2 points	
	Long-duration work (more than two weeks).	☑	4 points	
Allowable Delays Delay time plus time to travel through work zone in minutes.	< 20 minutes.	☑	1 point	1
	≥ 20 minutes.	☐	3 points	
	No allowable delay.	☐	4 points	

Traffic Consideration	Value	✓	Point Value	Score
Time of Day Time of day that work will occur.	Day-time only work (DT).	☐	1 point	3
	Active day-time work, with traffic control devices in place at night (DTN).	☑	3 points	
	Active night-time work (NT).	☐	4 points	
Vertical Alignment	Flat terrain.	☑	0 point	0
	Rolling terrain.	☐	1 point	
	Mountainous terrain.	☐	2 point	
Horizontal Alignment	Work zone and approaches on tangent.	☑	0 point	0
	Curve in work zone; no reduced speed advisory for curve.	☐	1 point	
	Curve in work zone with reduced speed advisory.	☐	2 point	
Signalization	No signal in work zone.	☑	0 point	0
	Signal in work zone with left- or right-turn arrows.	☐	1 point	
	Signal in work zone with left- and right-turn arrows.	☐	4 points	
Runaway Lanes	No runaway lanes in work zone.	☑	0 point	0
	Runaway lanes within or near work zone; they will not be blocked at any time during course of work.	☐	1 point	
	Runaway lanes within or near work zone; they may be blocked by work or queues during course of work.	☐	4 points	
Pedestrians and Cyclists	No pedestrians or cyclists in work zone.	☐	0 point	3
	Pedestrians and cyclists could be in/near work zone.	☐	2 point	
	Designated cycle route or multi-use pathway in work zone.	☑	3 points	

Traffic Consideration	Value	✓	Point Value	Score
Roundabout	No roundabout in work zone.	☑	0 point	**0**
	Single lane roundabout in work zone.	☐	2 point	
	Multilane roundabout in work zone.	☐	4 points	
HOV or Bus Lane	No HOV or bus lane in work zone.	☑	0 point	**0**
	HOV or bus lane in work zone.	☐	4 points	
Counter-Flow Lane	No counter-flow lane within work zone.	☑	0 point	**0**
	Counter-flow lane within work zone (CF).	☐	4 points	
			Total Score	**24**
			Category 1	< 16
			Category 2	16 to 25
			Category 3	> 25
			Initial Project Category	**2**

3.3.2 Project Risk Analysis

A project risk analysis is the process of reviewing site-specific characteristics and considering the likelihood and consequence of each item listed. It is able to highlight potential hazards that are not captured in the Initial Project Category Assessment.

Each project has a unique combination of site-specific characteristics, and the risk analysis considers potential hazards associated with the specific project and/or location.

Table 3.2: Project Risk Analysis on the following pages is used to determine whether each potential hazard creates a low, medium, or high risk for the project and location.

The total point value calculated at the end of Table 3.2 indicates that the project is assessed as a low-risk, medium-risk, or high-risk project.

Combining the results of the initial project category assessment and the risk analysis will determine the final project category (see *Section 3.3.3: Final Project Category Determination*).

Table 3.2: Project Risk Analysis

Item	Risk	Definition	✓	Point Value	Score
Falling object	Low	Potential of falling object through course of work (i.e., overhead works, slung loads, or equipment boom/bucket work).	☑	1 point	**1**
	Medium	Working within a known avalanche or rock fall area; no recent evidence of activity.	☐	2 points	
	High	Recent evidence of rock or material entering work site or overhead work that may impact travelling public or worker safety (i.e., overhead structures). Vehicle queues may back into a rock fall or avalanche area.	☐	3 points	
Nature of work activity	Low	Work activity is not expected to create a significant hazard.	☐	1 point	**2**
	Medium	Work activity will create excessive dirt, dust, or gravel on the road surface, and will thereby create a potential hazard.	☑	2 points	
	High	Work activity such as blasting, scaling, or excavation < 2 metres from active travelling lanes will create a potential hazard.	☐	3 points	
Removal of safety devices	Low	No removal of safety devices.	☐	1 point	**2**
	Medium	Removal of safety devices such as pavement markings, signage, traffic signal, or reflectors.	☑	2 points	
	High	Removal of containment devices, such as barrier, guard rail, crash attenuators, fencing, etc.	☐	3 points	
Equipment movement through work zone	Low	Minimal conflict with traffic (e.g., work commencing off travelled roadway).	☐	1 point	**2**
	Medium	Conflict with normal traffic flow; no queuing or traffic stoppages.	☑	2 points	
	High	Conflicts with normal traffic; may create queuing and require traffic stoppages. Difficult for equipment to enter and exit site.	☐	3 points	

Item	Risk	Definition	✓	Point Value	Score
Roadway surface condition during construction	Low	Roadway surface is maintained.	☐	1 point	**2**
	Medium	Roadway surface, such as milling and grinding (consistent surface), creates a hazard for road users.	✓	2 points	
	High	Roadway surface is inconsistent, with multiple changes or work tasks (manholes, culvert installation, etc.).	☐	3 points	
Storage of equipment and material	Low	Stored outside clear zone.	✓	1 point	**1**
	Medium	Stored within clear zone but outside travelled roadway.	☐	2 points	
	High	Stored on shoulder but encroaching on travelled roadway.	☐	3 points	
Load restrictions as a result of construction	Low	No load restrictions.	✓	1 point	**1**
	Medium	Narrow lanes restrict wide loads	☐	2 points	
	High	Overweight/overheight vehicles restricted (may result in structural damage).	☐	3 points	
Lane widths	Low	Maintain existing lane widths.	☐	1 point	**3**
	Medium	n/a	-	n/a	
	High	Lane width not maintained throughout work zone, or Single-lane alternating traffic.	✓	3 points	
Work zone or queues block access (active or inactive site)	Low	None.	✓	1 point	**1**
	Medium	Side street or business access.	☐	2 points	
	High	Major public facility and/or major secondary roadway.	☐	3 points	
Transit access	Low	No transit or school bus stops.	☐	1 point	**3**
	Medium	Community shuttle or school bus stops.	☐	2 points	
	High	Express transit or major bus route.	✓	3 points	
Impacts of special events	Low	No known event.	✓	1 point	**1**
	Medium	Moderate public event with attendance under 5,000.	☐	2 points	
	High	Major public event with attendance over 5,000 or moderate public event (under 5,000) with no alternative access or route.	☐	3 points	

Item	Risk	Definition	✓	Point Value	Score
Overlapping work	Low	No overlapping work.	☐	1 point	**2**
	Medium	Another work site within 3 km; traffic control for the projects could impact one another.	✓	2 points	
	High	Work sites adjacent or overlapping.	☐	3 points	
Emergency facility access	Low	No emergency facility near work site.	✓	1 point	**1**
	Medium	24-hour manned emergency facility.	☐	2 points	
	High	Volunteer-staffed emergency facility; consider responder access to facility and emergency response.	☐	3 points	

Total Score	**22**
Low Risk	< 23
Medium Risk	23 to 28
High Risk	> 28
Project Risk	**Low**

Note: If significant project-specific hazards are not included in the risk analysis above, the Evaluator may consider increasing the final risk rating. This modification and the justification for it should be documented.

All high-risk, project-specific hazards should be addressed and mitigated in the Traffic Management Plan.

3.3.3 Final Project Category Determination

The matrix in *Table 3.3: Final Project Category Determination* should be used to make the final project category determination.

It combines the initial project category assessment with the results of the risk analysis to identify a final project category based on roadway and traffic characteristics and risks.

It may be appropriate to increase the final category level for high-risk projects to reflect the complexity or hazards associated with the work.

Table 3.3: Final Project Category Determination

		Initial Project Category Assessment		
		1	**2**	**3**
Project Risk	**Low**	**Category 1**	**Category 2**	**Category 3**
	Medium	**Category 1**	**Category 2**	**Category 3**
	High	**Category 2**	**Category 3**	**Category 3**

The final project category determination should be used to identify required and recommended sub-plans and special conditions addressed in the Traffic Management Plan. This process is a guide and may not capture all components of the project which should be considered when determining the Project Category.

Appendix L –Cost Estimate

Pre-Construction Consultation Costs	Rate	Hours	Cost
Preliminary Design:			$95,600
Project Engineer (E3)	$159	160	$25,440
Traffic Specialist Engineer (E4)	$195	160	$31,200
Management Engineer (E5)	$223	80	$17,840
CAD Technician/Technologist (T3)	$132	160	$21,120
Surveying:			$20,400
Lead Surveyor (T4)	$144	80	$11,520
Assistant Surveyor (T2)	$111	80	$8,880
Geotechnical Evaluation			$34,960
Geotechnical Engineer (E4)	$195	80	$15,600
Engineer-in-Training (E1)	$121	160	$19,360
Detailed Design:			$60,820
Project Engineer (E3)	$159	80	$12,720
Traffic Specialist Engineer (E4)	$195	40	$7,800
Management Engineer (E5)	$223	20	$4,460
CAD Technician/Technologist (T3)	$132	80	$10,560
Structural EIT (E1)	$121	80	$9,680
Structural Engineer (E4)	$195	80	$15,600
Contractor Selection and Preparation			$42,950
Project Engineer (E3)	$159	200	$31,800
Management Engineer (E5)	$223	50	$11,150
Total:			**$254,730**

Roundabout Construction		
Division	**Description**	**Cost**
1	General Requirements	$ 366,334.94
2	Site Construction	$ 270,521.31
3	Concrete	$ 68,977.60
15	Electrical	$ 60,000.00
16	**Sum**	**$ 765,833.85**
	Fee @ 10%	$ 76,583.38
	Contingency @ 5%	$ 38,291.69
	Total	**$ 880,708.93**

Gateway Construction		
Division	**Description**	**Cost**
1	General Requirements	$ 186,555.35
2	Site Construction	$ 10,790.00
3	Concrete	$ 173,493.50
5	Metals	$ 103,518.79
6	Wood and Plastics	$ 46,398.03
7	Thermal and Moisture Pr	$ 8,000.00
8	Doors and Windows	$ 50,160.00
	Sum	**$ 578,915.67**
	Fee @ 10%	$ 57,891.57
	Contingency @ 5%	$ 28,945.78
	Total	**$ 665,753.02**

ROUNDABOUT ESTIMATE BREAKDOWN

Description	Quantity	Unit Cost	UoM	(Sub)Contract	Labour	Labour Qty	Labour Unit Cost	Hours/Day	Days	Subtotal
Div 1 General Expenses (Indirects)									Division Total	$ 366,334.94
Permitting										
Excavation allowance	1	$ 2,000.00	LS							$ 2,000.00
Electrical	1	$ 1,985.00	EA							$ 1,985.00
Tree removal	0	$ 66.00	EA							$ -
Signage permit	1	$ 93.00	EA							$ 93.00
Noise bylaw	1	$ 148.00	EA							$ 148.00
UBC Parking Permit x 20	3	$ 1,895.00	MO							$ 5,685.00
Mobilization and Demobilization										
Phase 1										
Washroom mob	1	$ 300.00	EA	SC						$ 300.00
Trailer mob	1	$ 300.00	EA	SC						$ 300.00
Trash bin mob	1	$ 300.00	EA	SC						$ 300.00
Excavator mob	1	$ 300.00	EA	SC						$ 300.00
Fencing mob	1	$ 300.00	EA	SC						$ 300.00
Phase 4										
Fencing mob	1	$ 300.00	EA	SC						$ 300.00
Phase 6										
Fencing mob	1	$ 300.00	EA	SC						$ 300.00
Phase 9										
Fencing demob	1	$ 300.00	EA	SC						$ 300.00
Phase 11										
Washroom demob	1	$ 300.00	EA	SC						$ 300.00
Trailer demob	1	$ 300.00	EA	SC						$ 300.00
Trash bin demob	1	$ 300.00	EA	SC						$ 300.00
Excavator demob	1	$ 300.00	EA	SC						$ 300.00
Fencing demob	1	$ 300.00	EA	SC						$ 300.00

Description	Quantity	Unit Cost	UoM	(Sub)Contract	Labour	Labour Qty	Labour Unit Cost	Hours/Day	Days	Subtotal
Rentals										
Fencing										
Phase 1 - 3.5	113		LM							
10 days	0.3225806		MO							
		$ 7.00	/LM/MO							$ 255.16
Phase 4 - 5	260		LM							
30 days	0.9677419		MO							
		$ 7.00	/LM/MO							$ 1,761.29
Phase 6 - 8	370		LM							
38 days	1.2258065		MO							
		$ 7.00	/LM/MO							$ 3,174.84
Phase 9 - 11	130		LM							
30 days	0.9677419		MO							
		$ 7.00	/LM/MO							$ 880.65
Washroom x 1	3	$ 300.00	MO	SC					76	$ 900.00
8 x 24 Trailer x 1	3	$ 300.00	MO	SC					76	$ 900.00
12YD Trash bin x 1	3	$ 200.00	MO	SC					76	$ 600.00
1CY Bucket Excavator x 1	76	$ 312.00	DAYS	SC	Operator	1	$ 90.00	4	76	$ 51,072.00
5kW Generator x 1	3	$ 800.00	MO	SC					76	$ 2,400.00
20kW Generator x 1	3	$ 1,500.00	MO	SC					76	$ 4,500.00
Project Staff										
Project Manager	1	$ -	EA	SP		1	$ 120.00	4	76	$ 36,480.00
Superintendent	1	$ -	EA	SP		1	$ 130.00	8	76	$ 79,040.00
Safety Coordinator	1	$ -	EA	SP		1	$ 80.00	4	76	$ 24,320.00
Surveyor	1	$ -	EA	SP		1	$ 60.00	4	76	$ 18,240.00
Subcontractors										
Flaggers										
Phase 1 - 5	2	$ -	EA	SC		2	$ 50.00	8	25	$ 20,000.00
Phase 6 - 11	4	$ -	EA	SC		4	$ 50.00	8	51	$ 81,600.00
Flagging work truck x 1	76	$ 150.00	DAYS	SC						$ 11,400.00
Signage allowance	1	$ 5,000.00	LS	SP						$ 5,000.00
O&M Manual										
Allowance	1	$ 10,000.00	LS							$ 10,000.00

Description	Quantity	Unit Cost	UoM	(Sub)Contract	Labour	Labour Qty	Labour Unit Cost	Hours/Day	Days	Subtotal
Div 2 Site Construction									Division Total	$ 270,521.31
Site Preparation										
Pavement removal to subgrade		$ 32.29	M2	SC						$ -
Excavation	1130.3	$ 60.00	M3	SC						$ 67,818.51
Trench box	1.0	$ 10,000.00	LS	SC						$ 10,000.00
Pavement milling 50mm deep										$ -
Phase 6	611.0	$ 7.85	M2	SC						$ 4,794.95
Phase 7	1517.0	$ 7.85	M2	SC						$ 11,904.97
Truck and Transfer	1.0	$ 10,000.00	LS	SC						$ 10,000.00
Backfill										
Road Base 19mm Minus	1426.2	$ 12.00	TON	SC						$ 17,114.34
Density		1654	KG/M3							
Volume		862.3	M3							
Mass		1426.195209	TON							
Sub-base 75mm Minus	425.4	$ 11.50	TON	SC						$ 4,891.83
Density		1587	KG/M3							
Volume		268.0	M3							
Mass		425.3765071	TON							
Drain Rock 20mm Fractured	60.7	$ 17.30	TON	SC						$ 1,050.12
Density		1670	KG/M3							
Volume		36.3	M3							
Mass		60.700325	TON							
Soil Testing	1.0	$ 10,000.00	LS	SC						$ 10,000.00
Landscaping										
Grass	729	$ 9.00	M2	SC						$ 6,561.00
Soil	583.2	$ 8.00	M3	SC						$ 4,665.60
Soil Install by Subcontractor	5	$ 312.00	DAYS	SC	Labourer	3	$ 60.00	8	5	$ 8,760.00
1CY Bucket Excavator x 1					Operator	1	$ 75.00	8	5	$ 3,000.00
					Foreman	1	$ 85.00	8	5	$ 3,400.00
Paving										
Paving	2128.0	$ 20.00	M2	SC						$ 42,560.00
Stormwater										
Allowance	1	$ 60,000.00	LS	SC						$ 60,000.00
Painting										
Allowance	1	$ 4,000.00	LS	SC						$ 4,000.00

Description	Quantity	Unit Cost	UoM	(Sub)Contract	Labour	Labour Qty	Labour Unit Cost	Hours/Day	Days	Subtotal
Div 3 Concrete									Division Total	$ 68,977.60
Curbs										
Formwork										
Phase 4	61	$ -	LM	SC						$ -
Phase 5	160	$ -	LM	SC						$ -
Phase 8	82	$ -	LM	SC						$ -
Phase 9	153	$ -	LM	SC						$ -
Curb Pour										$ -
Phase 5	211	$ 17.00	LM	SC						$ 3,587.00
Phase 9	180	$ 17.00	LM	SC						$ 3,060.00
Strip	847	$ -	LM	SC						$ -
Roundabout										
Formwork										
Phase 9 - truck apron	33.67	$ 32.29	M2	SP	Carpenters	3	60	8	3	$ 5,407.16
Concrete										
Phase 9 - truck apron	62.5	$ 600.00	M3	SC	Carpenters	2	60	4	1	$ 37,980.00
Strip	0	$ -	M2	SP	Carpenters	2	60	8	2	$ 1,920.00
Sidewalk										
Formwork										
Phase 7	25.5	$ 32.29	M2	SP	Carpenters	2	60	4	1	$ 1,303.44
Curb Pour										
Phase 7	24.6	$ 600.00	M3	SC	Carpenters	2	60	4	1	$ 15,240.00
Strip	25.5	$ -	M2	SP	Carpenters	2	60	4	1	$ 480.00
Div 16 Electrical									Division Total	$ 60,000.00
Electrical	1	$ 60,000.00	LS	SC						$ 60,000.00

GATEWAY ESTIMATE BREAKDOWN

Description	Quantity	Unit Cost	UoM	(Sub)Contract	Labour	Labour Qty	Labour Unit Cost	Hours/Day	Days	Subtotal
Div 1 General Expenses (Indirects)									Division Total	$ 186,555.35
Permitting										
Signage permit	1	$ 93.00	EA							$ 93.00
Noise bylaw	1	$ 148.00	EA							$ 148.00
UBC Parking Permit x 20	2	$ 1,895.00	MO							$ 3,790.00
Mobilization and Demobilization										
Washroom mob	1	$ 300.00	EA	SC						$ 300.00
Trailer mob	1	$ 300.00	EA	SC						$ 300.00
Trash bin mob	1	$ 300.00	EA	SC						$ 300.00
Excavator mob	1	$ 300.00	EA	SC						$ 300.00
Fencing mob	1	$ 300.00	EA	SC						$ 300.00
90 ton crane mob	1	$ 500.00	EA	SC						$ 500.00
Washroom demob	1	$ 300.00	EA	SC						$ 300.00
Trailer demob	1	$ 300.00	EA	SC						$ 300.00
Trash bin demob	1	$ 300.00	EA	SC						$ 300.00
Excavator demob	1	$ 300.00	EA	SC						$ 300.00
Fencing demob	1	$ 300.00	EA	SC						$ 300.00
90 ton crane mob	1	$ 500.00	EA	SC						$ 500.00
Rentals										
Fencing										
During gateway construction	130		LM							
32 days	1.0322581		MO							
		$ 7.00	/LM/MO							$ 939.35
Washroom x 1	2	$ 300.00	MO	SC					33.5	$ 600.00
8 x 24 Trailer x 1	2	$ 300.00	MO	SC					33.5	$ 600.00
12YD Trash bin x 1	2	$ 200.00	MO	SC					33.5	$ 400.00
5kW Generator x 1	2	$ 800.00	MO	SC					33.5	$ 1,600.00
20kW Generator x 1	2	$ 1,500.00	MO	SC					33.5	$ 3,000.00
90 ton mobile hydraulic crane	268	$ 150.00	HOUR	SC	Operator	1	$ 80.00	8	33.5	$ 61,640.00
Genie Boom Lift Z45' 4x4 (Manlift A)	5	$ 1,200.00	WK	SC						$ 6,000.00
Genie Boom Lift Z45' 4x4 (Manlift B)	5	$ 1,200.00	WK	SC						$ 6,000.00
Project Staff										
Project Manager	1	$ -	EA	SP		1	$ 120.00	2	33.5	$ 8,040.00
Superintendent	1	$ -	EA	SP		1	$ 130.00	8	33.5	$ 34,840.00
Surveyor	1	$ -	EA	SP		1	$ 60.00	4	33.5	$ 8,040.00
Subcontractors										
Flaggers										
During gateway construction	3	$ -	EA	SC		2	$ 50.00	8	33.5	$ 26,800.00
Flagging work truck x 1	33.5	$ 150.00	DAYS	SC						$ 5,025.00
Signage allowance	1	$ 5,000.00	LS	SP						$ 5,000.00

Description	Quantity	Unit Cost	UoM	(Sub)Contract	Labour	Labour Qty	Labour Unit Cost	Hours/Day	Days	Subtotal
O&M Manual										
Allowance	1	$ 10,000.00	LS							$ 10,000.00
Div 2 Site Construction									**Division Total**	**$ 10,790.00**
Grass protection										
GPM12 GROUND PROTECTION MATS	15	$ 162.00	EA							$ 2,430.00
install and remove					Carpenters	2	60	8	2	$ 1,920.00
					Foreman	1	90	8	2	$ 1,440.00
Grass rehab allowance	1	$ 5,000.00	LS							$ 5,000.00
Div 3 Concrete									**Division Total**	**$ 173,493.50**
Walkway										
Formwork & Rebar										
Fdn fmwk & rebar	57.12	$ 32.29	M2	SP	Carpenters	3	60	8	1.5	$ 4,004.50
					Foreman	1	90	8	1.5	$ 1,080.00
Walkway pour										
L	14		LM							
W	2		LM							
D	0.04		LM							
no. of walkways	1		EA							
Volume	1.12	$ 600.00	M3		Carpenters	2	60	4	1	$ 1,152.00
					Foreman	1	90	4	1	$ 360.00
Strip	57.12	$ -	M2	SP	Carpenters	2	60	4	1	$ 480.00
					Foreman	1	90	4	1	$ 360.00
Precast Rebar										
Rebar to conc ratio	0.7692308									
Conc density	2400		KG/M3							
Fdn Conc weight	2688		KG							
Fdn Rebar weight	2067.6923		KG							
Fdn Rebar cost	4558.4812	$ 0.80	LBS							$ 3,646.78
Gateway Foundations										
1.1 Observation Deck										
Formwork & Rebar										
Fdn fmwk & rebar	32	$ 32.29	M2	SP	Carpenters	3	60	8	1	$ 2,473.34
					Foreman	1	90	8	1	$ 720.00
Concrete Fdn SOG										
L	2		LM							
W	2		LM							
D	1		LM							
No. of fdns	4		EA							
Volume	16	$ 600.00	M3	SC	Carpenters	2	60	6	1	$ 10,320.00
					Foreman	1	90	6	1	$ 540.00
Strip	32	$ -	M2	SP	Carpenters	2	60	4	1	$ 480.00
					Foreman	1	90	4	1	$ 360.00

Description	Quantity	Unit Cost	UoM	(Sub)Contract	Labour	Labour Qty	Labour Unit Cost	Hours/Day	Days	Subtotal
1.2 Walkway										
Formwork & Rebar										
Fdn fmwk & rebar	16	$ 32.29	M2	SP	Carpenters	3	60	8	1	$ 1,956.67
					Foreman	1	90	8	1	$ 720.00
Concrete Fdn SOG										
L	2		LM							
W	1		LM							
D	1		LM							
No. of fdns	2		EA							
Volume	4	$ 600.00	M3	SC	Carpenters	2	60	4	1	$ 2,880.00
					Foreman	1	90	4	1	$ 360.00
Strip	16	$ -	M2	SP	Carpenters	2	60	4	1	$ 480.00
					Foreman	1	90	4	1	$ 360.00
1.3 Stairway										
Formwork & Rebar										
Fdn fmwk & rebar	48	$ 32.29	M2	SP	Carpenters	3	60	8	1	$ 2,990.00
					Foreman	1	90	8	1	$ 720.00
Stairway fdn pour										
L	6		LM							
W	3		LM							
D	1		LM							
No. of fdns	1		EA							
Volume	18	$ 600.00	M3	SC	Carpenters	2	60	8	1	$ 11,760.00
					Foreman	1	90	8	1	$ 720.00
Strip	48	$ -	M2	SP	Carpenters	2	60	4	1	$ 480.00
					Foreman	1	90	4	1	$ 360.00
Fdn Rebar										
Rebar to conc ratio	0.7692308									
Conc density	2400		KG/M3							
Fdn Conc weight	91200		KG							
Fdn Rebar weight	70153.846		KG							
Fdn Rebar cost	154662.76	$ 0.80	LBS							$ 123,730.20

Description	Quantity	Unit Cost	UoM	(Sub)Contract	Labour	Labour Qty	Labour Unit Cost	Hours/Day	Days	Subtotal
Div 5 Metals									Division Total	$ 103,518.79
Gateway Structure										
Steel cost/lb		$ 2.76	KG	SC						
1) Deck Girder (GL B, 3-4)										
W360x134	2		EA							
L	14		LM							
Load/m	1.31		kN/LM							
Load	36.68		kN							
steel weight	3742.8571	$ 2.76	KG	SC						$ 10,316.25
2) Deck Span Bracing (Lateral Stability and Torsional Stiffness)										
Brace length	2		LM							
Spacing @	3		LM							
Deck Span	14		LM							
W360x33	5		EA							
L	10		LM							
Load/m	0.321		kN/LM							
Load	16.05		kN							
steel weight	1637.7551	$ 2.76	KG	SC						$ 4,514.06
3) Steel Column (B3) Supporting Steel Deck										
HSS 89x89x6.4	2		EA							
L	6		LM							
Load/m	0.153		kN/LM							
Load	1.836		kN							
steel weight	187.34694	$ 2.76	KG	SC						$ 516.38
4) Steel Column (A1 A2 B1 B2) Supporting Landing										
HSS 89x89x6.4	4		EA							
L	3.5		LM							
Load/m	0.153		kN/LM							
Load	2.142		kN							
steel weight	218.57143	$ 2.76	KG	SC						$ 602.44
5) Staircase Landing Beam										
W360x33	2		EA							
L	2		LM							
Load/m	0.321		kN/LM							
Load	1.284		kN							
steel weight	131.02041	$ 2.76	KG	SC						$ 361.13
6) Observation Deck X-bracing										
L76x76x7.9	8		EA							
L	8.5		LM							
Load/m	0.0883		kN/LM							
Load	6.0044		kN							
steel weight	612.69388	$ 2.76	KG	SC						$ 1,688.74

Description	Quantity	Unit Cost	UoM	(Sub)Contract	Labour	Labour Qty	Labour Unit Cost	Hours/Day	Days	Subtotal
7) Connections, walkway decking, plates, staircase										
Total steel weight	6530.2449		KG							
Factor for connections and decking	7836.2939		KG							
Weight of misc steel	1306.049	$ 2.76	KG	SC						$ 3,599.80
Erection Staff										
ironworkers					ironworkers	3	70	8	29	$ 48,720.00
steel foreman					foreman	1	100	8	29	$ 23,200.00
Steel painting	1	$ 10,000.00	LS	SC						$ 10,000.00
Div 6 Wood and Plastics									**Division Total**	**$ 46,398.03**
Observation Deck										
1) CLT Slab				SP						
L	7.2		LM							
W	7.2		LM							
D	0.175		LM							
V	9.072		M3							
V	320.37466	$ 25.00	CF							$ 8,009.37
Install					Carpenters	2	60	8	1.5	$ 1,440.00
					Foreman	1	90	8	1.5	$ 1,080.00
2) Foundation Columns supporting slab										
D.Fir-L 24EX 215x190										
L	8.5		IN							
W	7.5		IN							
L	0.7083333		FT							
W	0.625		FT							
H	19.685039		FT							
Count	4		EA							
V	34.858924		CF							
Boardfoot of material	418.30709	$ 25.60	BF	SP						$ 10,708.66
Fdn columns - Erection Staff										
ironworkers					ironworkers	3	70	8	1.5	$ 2,520.00
steel foreman (ironworkers installing since bracings are steel, and Dfir column to bracing connection is also steel)					foreman	1	100	8	1.5	$ 1,200.00
3) Glulam columns				SP						
L	1		LF							
W	1		LF							
D	10		LF							
no. of columns	4		EA							
total length	40	$ 76.00	LF							$ 3,040.00
					Carpenters	2	60	8	1	$ 960.00
					Foreman	1	90	8	1	$ 720.00
UBC Signage	1	$ 10,000.00	LS	SC						$ 10,000.00
				SP	Carpenters	2	60	8	4	$ 3,840.00
				SP	Foreman	1	90	8	4	$ 2,880.00

Description	Quantity	Unit Cost	UoM	(Sub)Contract	Labour	Labour Qty	Labour Unit Cost	Hours/Day	Days	Subtotal
Div 7 Thermal and Moisture Protection									**Division Total**	**$ 8,000.00**
Roofing Structure										
Allowance	1	$ 5,000.00	LS							$ 5,000.00
Flashing										
Allowance	1	$ 3,000.00	LS							$ 3,000.00
Div 8 Doors and Windows									**Division Total**	**$ 50,160.00**
Glazed guardrail										
Glazed guardrail	83.6	$ 600.00	LF							$ 50,160.00

Appendix M –Presentation Poster

REDESIGN OF CHANCELLOR BOULEVARD / WESBROOK MALL INTERSECTION

Nishchhal Gautam, Ryan Li, Jason Wen, Jeffrey Chun, Nathan Chan & Jessica Francis
The University of British Columbia – Civil Engineering

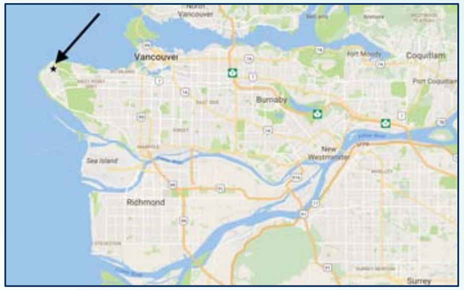
a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA
Faculty of Applied Science

Project Background

UBC Campus and Community Planning has identified the Chancellor Boulevard and Wesbrook Mall intersection as the site for a redesign. The project objectives are:

- Accommodate safe travel for all modes of transportation
- Perform with minimal delays for future traffic volume
- Provide a "gateway" to the northern part of UBC Vancouver campus

The Project site can be seen below:



The existing intersection is a three way stop and yield control intersection that does not have pedestrian crossings. The existing layout can be seen below:

After completing traffic analysis for the existing intersection, a traffic light, and a roundabout it was determined to be the best solution based on the below criteria:

- Safety of pedestrians, cyclists, and vehicles
- Sustainability and aesthetics
- Intersection capacity
- Cost and construction schedule

Key Design Features

Intersection Safety

- Crosswalks and a boulevard for bicycles have been integrated
- Electrical connections for LED lighting at crosswalks
- Roundabouts facilitate slower speeds, minimizing chance of collision and reducing severity of collisions, collisions are also not head on
- There is a concrete apron within the roundabout that allows for heavy vehicles safely as well as maintenance for landscaping

Economic Performance

- The increase in traffic capacity can reduce future costs and collateral effects such as increasing the traffic demand of other entrances.
- The construction of the roundabout is phased to allow for traffic flow in the area

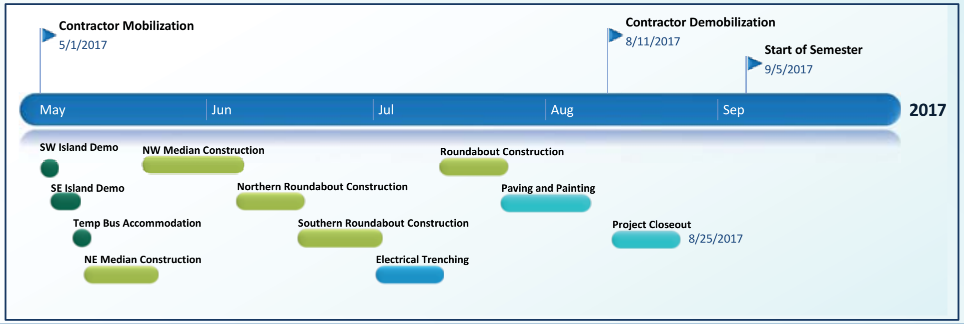
Traffic Capacity

- Under current traffic volumes, the roundabout is expected to perform well with an average delay per vehicle of less than 5 seconds; the remaining scenarios operate with an average anticipated delay of approximately 10 seconds per vehicle
- Under 2040 projected traffic volumes, the roundabout performs significantly better than the alternatives

Project Sustainability

- Overall there is a net gain of green space for the project site which improves storm water

Construction Schedule

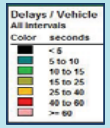


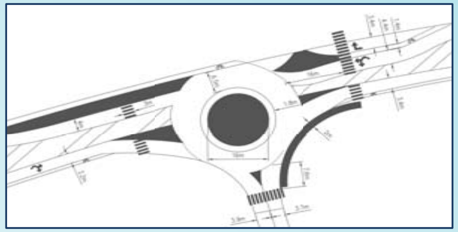
Traffic Analysis

Intersection Configuration	Approach	Delays (s) Current AM Conditions	Delays (s) 2040 AM Conditions
Existing	East	5-10	40-60
	South	5-10	5-10
	West	5-10	5-10
Roundabout	East	<5	5-10
	South	<5	<5
	West	<5	5-10

Modelling

- 2040 AM Peak – Existing Intersection and Roundabout Design





Cost Estimate

DESIGN			**TOTAL: $254,750**
Preliminary Design	$95,600		
Detailed Design	$116,200		
Contract Administration and Construction Reviews	$42,950		
CONSTRUCTION			**TOTAL: $976,360**
General Contractor	$310,670	Gateway Structure	$119,770
Subcontracts	$457,170	Fee	$88,760
ADDITIONAL BUDGETS			
Contingency		$44,380	
Maintenance		$15,300 per year	
			TOTAL: $1,275,470