UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program
Student Research Report

Intersection Redesign: UBC Chancellor Boulevard and Wesbrook Mall

Authors:
Barry (Junyu) Qiu
Charmaine Leung
Johnson (Jiongshen) Liu
Lucy Chu
Marcus Chan
Virginia Kam

University of British Columbia

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Executive Summary

The existing Wesbrook Mall and Chancellor Boulevard intersection is inefficient for the growing traffic flows to and from UBC, and is unsafe for pedestrians and cyclists. The lack of crosswalks, sidewalks, and bike lanes results in a hostile access to the intersection for pedestrians and cyclists. Moreover, with the high volume of vehicles utilizing the intersection, numerous delays and traffic congestion during peak hour occurs. In order to improve the traffic efficiency and safety of the intersection, a redesign is imperative to accommodate the increasing traffic demands and encourage sustainable travels.

Three options were considered for the redesign of the intersection - a roundabout, slanted intersection, and slanted signal operated intersection. To determine the preferred option, weighted criteria were applied to evaluate the options. Criteria included, but not limited to, the safety, sustainability, traffic capacity, feasibility, and familiarity to the users.

The roundabout was the chosen option as it offers a minimized walking distance for pedestrians, controls traffic speeds entering the intersection, and encourages sustainability through the rain garden situated on the roundabout island. In addition, the design includes a landmark that serves as a gateway into UBC. The roundabout design focuses on improving the safety and sustainability at the intersection. To encourage a sustainable and user-friendly intersection, all approaches to the intersection have pedestrian crosswalks and proper bike lanes. The roundabout island is 9 meters in radius with two circulatory road lanes that are 9 meters in width. The gateway feature located at the centre of the island consists of two totem poles connected by a galvanized steel truss acting as an arch. Upon the truss is a Musqueam carved Thunderbird with polished steel

lettering of "UBC" bolted onto the chest. The totem poles stand at a height of 10 meters and have a diameter of 1 meter.

Construction is expected to commence in May 2017 and complete by August 2017 and will be broken down into three phases to better facilitate and monitor traffic and are broken down as follows:

Phase 1 – Pedestrian Walkways and utilities

Phase 2 – Rain Garden, Roundabout, Gateway

Phase 3 – Install Lighting and Finishes

Considering the Wesbrook Mall and Chancellor Boulevard intersection is a major entrance to UBC that is located on land shared by many stakeholders, site and stakeholder management is necessary to facilitate construction. Stakeholder management plans involve constant communication with the surrounding community, UBC, and the Ministry of Transportation to ensure those who are affected by the construction agree with the methods, changes and the construction schedule. Construction management plans consider to the environmental disturbances, as well as the movement of personnel, equipment and materials on site.

The construction will last five months and cost $4.1 million to construct and maintain for 30 years. This report provides results and recommendations derived from thorough analyses and evaluations of the designed transportation features, gateway design, and storm water management plan.

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Table of Contents

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Table of Figures

Table of Tables

1.0 Introduction

The existing intersection at Chancellor Boulevard and Wesbrook Mall is currently inefficient, does not fully support sustainable travel modes, and is inconsistent with the provincial governments 10-Year Transportation Plan. A redesign is proposed with the goal to create a design that meets the projected transportation demands, encourage active transportation and improve safety and mobility for vehicles, cyclists and pedestrians. A roundabout is deemed the safest intersection design as it slows down traffic when vehicles must yield to traffic and pedestrians. The island in the centre of the roundabout serves as a protection point for pedestrians while crossing the intersection. Proper bike lanes will be implemented to reduce confusion and chance of collision. As a result, safety levels of the intersection will be increased, thus promoting sustainable travels for pedestrians and cyclists. In addition, a gateway incorporated at the centre of the roundabout will be the focal point of the intersection and provide a more functional and inviting intersection.

1.1 Purpose

The purpose of this report is to outline the design and safety considerations of the project, as well as the specific design features of the intersection design and to provide an overview of the design considerations during the detailed design process.

This report provides details on the transportation features, analysis on the structured gateway, and a storm water management plan. The detailed project cost estimate has been updated as well as a schedule of the construction phases. Also, recommended amendments, and pertinent design calculations undertaken during the detailed design phase are provided.

1.2 Site Overview

The intersection at Chancellor Boulevard and Wesbrook Mall is located at the boundary of University Endowment Lands (UEL) and University of British Columbia (UBC). The intersection provides access to UBC from W 4th avenue. The site is within the boundary of the UEL and the Southwest corner of the intersection is within the UBC property lines.

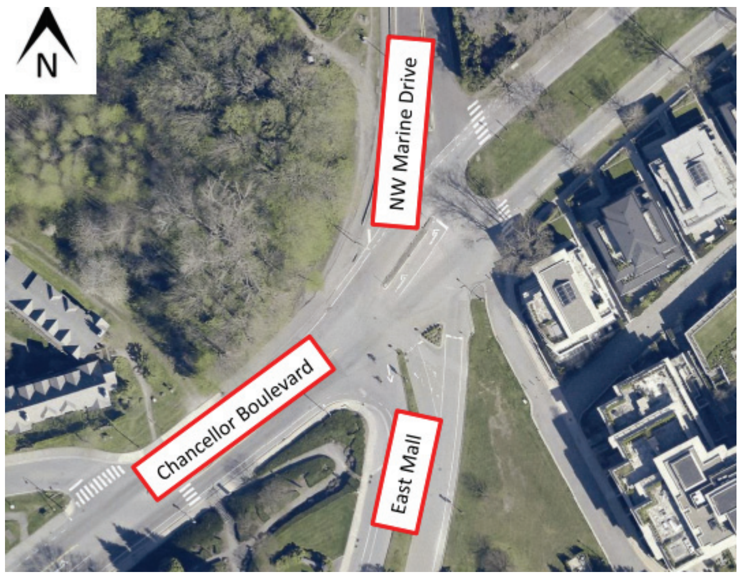

Figure 1. Aerial View of Chancellor Boulevard and Wesbrook Mall

Table 1. Task Member Contributions

Group Member		Task Description
Barry Qiu	**Role:**	Structural Consultant
	Task:	Structural Analysis – Size steel members, generate SAP2000 model and gateway structure design.
		Modeler – Produce plans and sections drawings of gateway, storm water and intersection using AutoCAD. Model existing and new intersection with SketchUp.
Charmaine Leung	**Role:**	Construction and Cost Consultant
	Task:	Construction Cost Estimate – Modified the preliminary cost, developed and verified the detailed final cost estimate for the project.
		Environmental Considerations – Developed the environmental protection plan for construction phase in accordance to guidelines and bylaws.
Johnson Liu	**Role:**	Transportation Consultant
	Task:	Geometric Design – Designed the road geometry and performed sight distance calculations based on roundabout design guidelines.
		Transportation Infrastructure Design – Researched and designed the transportation infrastructures that promotes sustainable travel modes and safety.
Lucy Chu	**Role:**	Environmental Consultant
	Task:	Water Sensitive Urban Design – Designed bioretention trees along the intersection to tie into the storm water management plan and to offset ecological footprint using Best Management Practices.

Group Member		Task Description
Marcus Chan	**Role:**	Transportation Consultant
	Task:	Transportation Analysis – Created models using Synchro Studio and conducted traffic analysis for current and future traffic demands.
		Traffic Management Plan – Planned alternative routes for public transportation and detours for private vehicles to facilitate construction.
Virginia Kam	**Role:**	Project Manager
	Task:	Project Managing – Oversees the progress and changes of each team member's responsibilities. Held meetings and consultations with team members on design decisions. Ensured the project met with the client's requests.
		Rain Garden Design – Researched and developed the management, sizing, and design of inflow to the storm system through the use of the City guidelines.
		Construction Schedule – Developed detailed and progress task and construction sequence for the whole project using MS Project from project initiation to completion.

2.0 Transportation

A detailed design of the intersection at Chancellor Boulevard and Wesbrook Mall is discussed, with the focus on the safety, accessibility and traffic mitigation. The roundabout features a number of infrastructures that improve the safety and accessibility of its users. Road geometry of the intersection is designed in accordance to the Geometric Design Guidelines for B.C. Roads of BC Ministry of Transportation (Section 740 – Roundabouts). Traffic analysis has proven that the roundabout can handle the traffic demands within its intended service life of 30 years. A traffic management plan is also included for each phase of the construction.

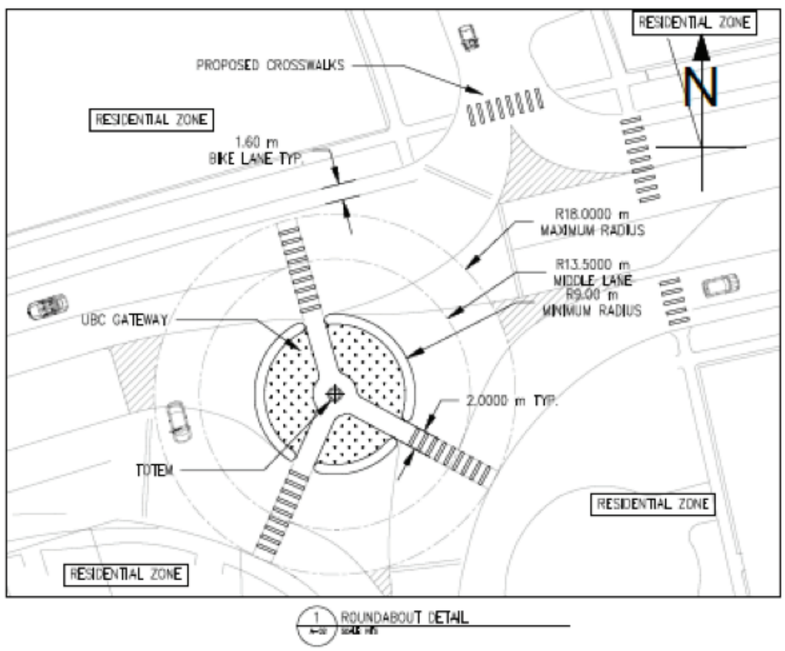

Figure 2. Roundabout Detail

2.1 Road Infrastructures

The intersection features a two-lane roundabout with a radius of 9 meters. Pedestrian-friendly walkways are put on the central island to shorten the walking distance across the intersection. The design improves the intersection's accessibility, and reduces the time for cars to stop and yield for pedestrians and cyclists. At the entrance onto the roundabout island crosswalk, bicycle dismount gates and road markings will be placed to ensure the safety of pedestrians. Lights will be installed at the edge of the central island to increase visibility and safety for vehicles and pedestrians.

2.2 Road Geometry

The road geometry of the roundabout is designed in accordance to the roundabouts design guideline by BC Ministry of Transportation. The designed width of the road is 3.35m with a maximum flared width of 4.5m at the entrance. As shown in figure 1, islands are modified and installed to help guide drivers across the roundabout. A conventional bike lane with a width of 1.8m to the curb is defined by road markings. Sight distance evaluations are undertaken to ensure a clear sight for drivers before entering the roundabout (Appendix B).

2.3 Traffic Analysis

Traffic analysis was conducted for this intersection design using Synchro Studio 6. The software was used to create a representative model and analyse the roundabout's design performance. The analysis results show that the roundabout intersection will uphold a satisfactory performance throughout its intended service life of 30 years.

2.3.1 Analysis Inputs and Assumptions

The intersection is modelled as a 2-laned, 3-approach roundabout, with the North approach omitted in traffic analysis because of its insignificant vehicle flow compared to the other traffic directions. The model's base year inputs are drawn from A.M. peak traffic counts done by Creative Transportation Solutions Ltd during the fall of 2015, and the Kam & Associates' engineers validated the data with their own traffic counts conducted in October 2017. Growth factors are projected using BC population information from Statistic BC, UBC student information and staff information. The resulting annual growth factor is 1.3%, and calculation details can be found in Appendix B**.** Only A.M. peak conditions will be analysed in this report since it presents the most stress to traffic.

2.3.2 Performance Output

The analysis is broken down into increments of 10 years and it outputs the intersection's performance during a snapshot of time in year 2017, 2027, 2037, and 2047. Two major criteria, level of service and average delays/vehicles, were used to represent the roundabout's performance. The table below outlines the model outputs to their corresponding years and Appendix C has the detailed traffic loading report for every ten years.

Table 2. Traffic Analysis - Traffic Loading Over Design Life

Year	Growth Factor	Level of Service	Delay/ Vehicle (s)
2017	1.00	A	6.2
2027	1.14	B	9.1
2037	1.29	C	9.9
2047	1.47	C	17.7

2.4 Traffic Management Plan

Traffic management will span across phase 1 and phase 2 of construction, but most traffic changes will only be implemented in phase 2. Phase 3 of construction will require little to no traffic management.

<u>Phase 1: (May – June)</u>

During the phase 1, storm water management, lighting, pedestrian and cycling facilities will be upgraded. For most of phase 1, these activities occur on the side of the roadway, which will leave space for normal vehicle to travel through the intersection. This also means the pedestrian walkway and cycling path will be closed during this period. For the safety of drivers and construction personnel however, a speed limit of 30km/hr will be imposed on roadways near the site and barricades between work area and roadway will be erected.

Phase 2&3: (June – August)

Phase 2 of construction will require this intersection to be closed off as most of the activities are happening on the intersection and roadways will be excavated. Traffic that normally pass through this intersection will be directed to other roadways. Proper services will be provided to those who are impacted by this closure.

Chancellor Boulevard will be regulated as "local-only" and be closed off to non-resident vehicles. Residents around the UBC campus will be provided with permits for entering through Chancellor Boulevard to reduce disruptions to their travel patterns. Suggested detours to enter UBC are University Boulevard and W 16th Avenue. Furthermore, the roadways next to the intersections will be closed off during this phase and local traffic will be redirected through Walter Gage Road. Figure 2 is the traffic management plan for phase 2 and shows the "local-only" section of Chancellor Boulevard, the recommended detour, and the restricted area.

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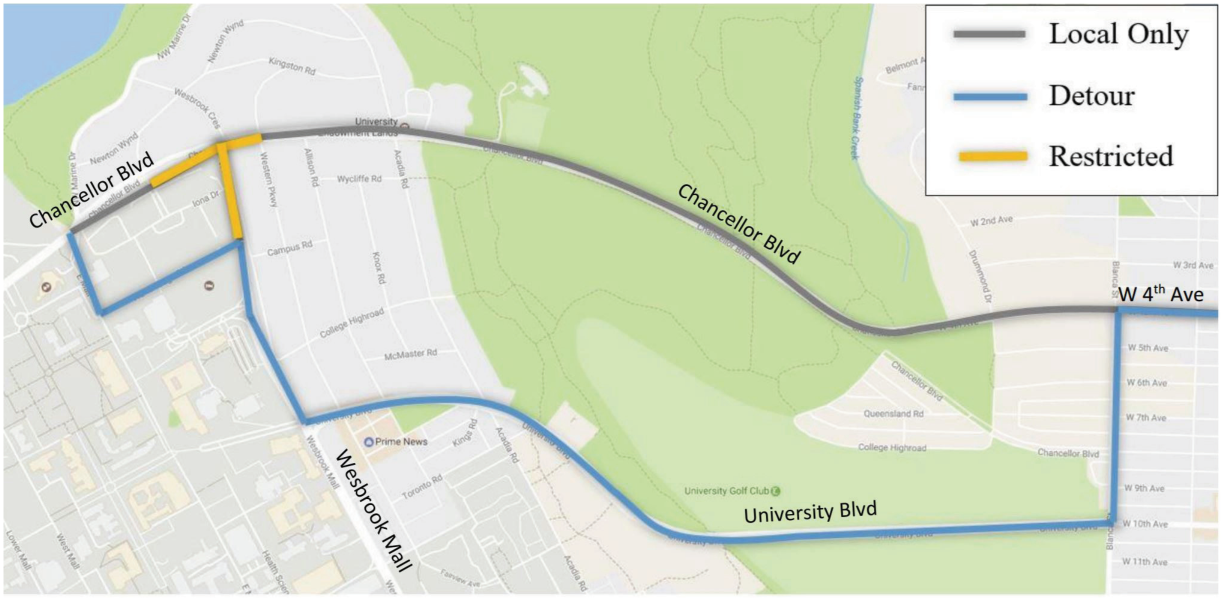

Figure 3. Traffic Management Plan - Phase 2

Bus 84 and 44, traveling to and from downtown Vancouver and UBC through Chancellor Boulevard will be redirected to University Boulevard at the intersection of W 4thAvenue and Blanca Street. Four bus stops servicing 84 and 44 along Chancellor Boulevard will cease service until construction is complete. UBC community shuttles, C18 and C20, will be rerouted to pick up passengers in the vicinity from the University Endowment Lands at a temporary bus stop at the intersection of Chancellor Blvd and Acadia Road. The shuttles will allow passengers from those stops to reach UBC bus loop and transition to other bus routes. Figure 3 shows the existing and proposed routes for bus 84, 44 and the proposed temporary route for shuttles C18, C20.

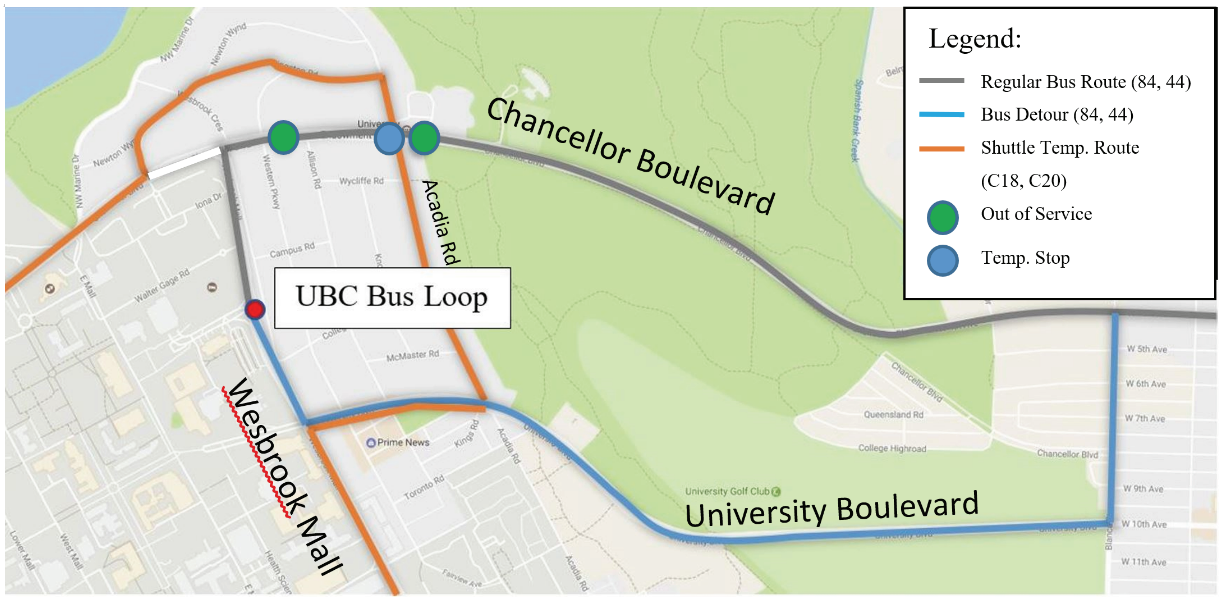

Figure 4. Bus and Community Shuttle Reroutes

3.0 Structural

The structural component of the gateway is carefully analysed with hand calculations and SAP2000 shown in Appendix D. The overall capacity of each member will exceed the load going through each element with a safety factor.

3.1 Gateway Structure

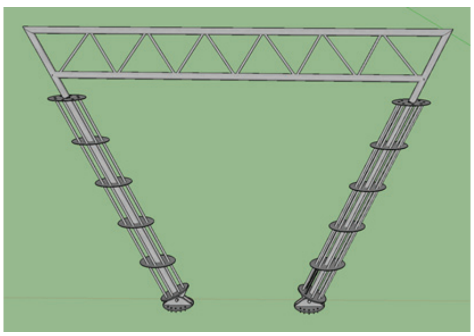

Figure 5. Structure Overview

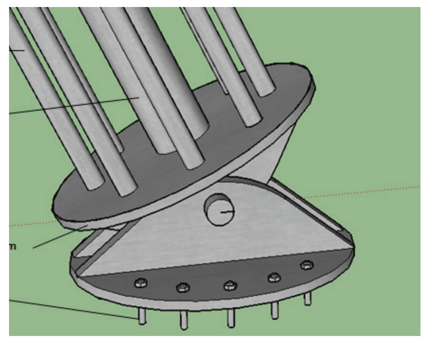

Figure 6. Base Support

The steel structure is the core of the gateway structure that holds up the wood totems and is designed using the NBCC guidelines (Figure 4). SAP2000 was used to analyse the steel structure with a load combination of 1.25DL+1.4W. The structure is subjected to a wind load of 35 m/s (735 Pa) and a dead load of 119 kN on the truss. The model involves a 6x0.375” Round HSS as the core, and 8 - 1.9x0.125” Round HSS surrounding the core as the truss members. The ultimate tensile strength (UTS) and shear strength of ASTM A500C steel are found to be 427 MPa and 320 MPa respectively.

3.2 Foundation

Pin-pin supports in one direction are used for the columns to prevent exerting moment at the footing, and are fixed in the other direction to prevent overturning (Figure 5). There are no stirrups required according to the calculations in Appendix B, but longitudinal reinforcements are needed.

3.3 Overall Design

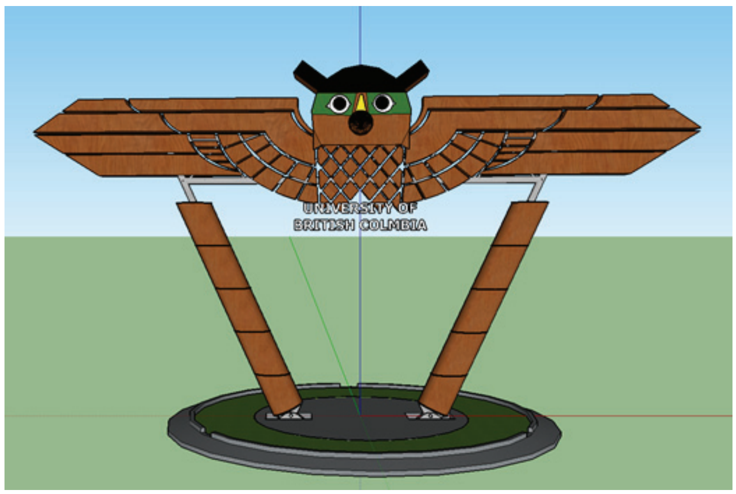

Figure 7. Overall Gateway Design

Figure 6 depicts the overall design of the gateway structure for the Chancellor Boulevard and Westbrook Mall intersection. The totem segments will be pre-drilled with holes, and slotted in during construction. The elliptical plates will then be welded on to prevent buckling. The Musqueam community will design the angled wooden totem columns shown in figure 6. The Thunderbird is the mascot of UBC and represents the university's close relationship with their Aboriginal culture.

4.0 Storm Water Management

With the upgrade of the intersection, the storm water system will simultaneously receive modifications. New gutters with a larger catch basin will be connected to the storm water main along the road and rain gardens on the median of the road in order to prevent pooling of water in the bike lanes, and reduce the overall rain inflow into the system respectively. A discussion on the type of plants used to restore the ecosystem of the intersection and assist with efficient infiltration of rainwater into the ground is provided.

4.1 Rain Gardens

Rain gardens will be installed at the east and west median islands of the intersection to reduce flow into the storm sewers (Figure 7). There will be openings at the curb connecting the island to the road spacing at 1m apart to ensure proper drainage off the road surface into the garden. The grate above the curb opening is designed to prevent leaves from congesting the opening. The rain garden base will be filled with a 200mm layer of absorbent topsoil and a 200mm layer of gravel below to encourage quick infiltration to native soils.

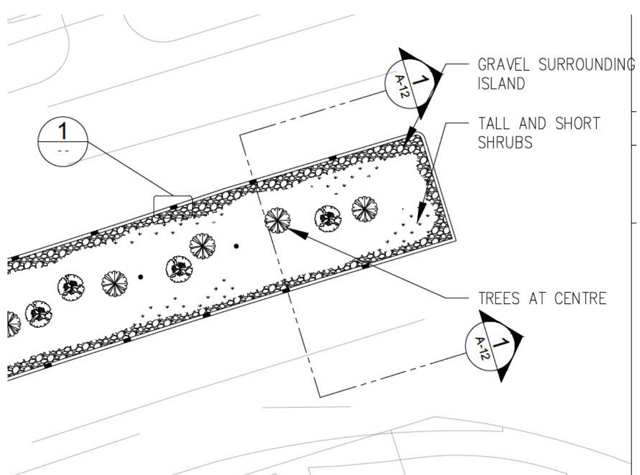

Figure 8. Rain Garden Location

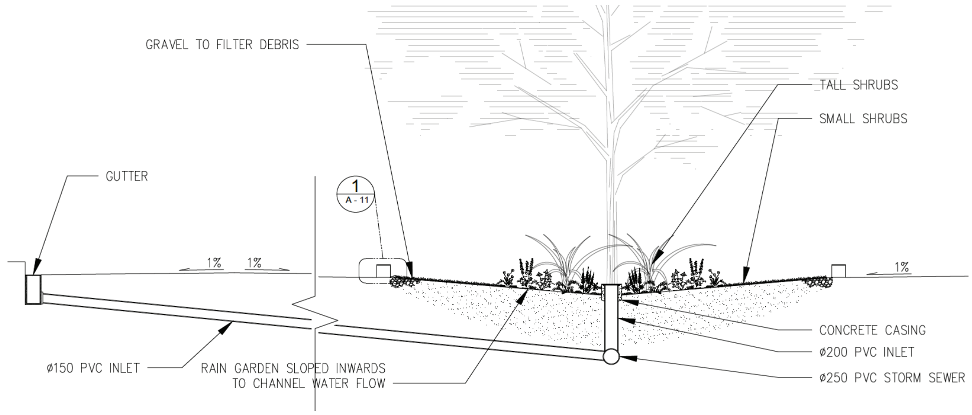

Figure 9. Rain Garden Plan View

Hidden amongst the plants growing at the centre of the rain garden is an overflow inlet that connects to the underground storm sewer (Figure 8). The overflow inlet is only necessary when the rain garden floods due to an oversaturation of soil. The water received by the rain garden will not backflow into the road since the overflow inlet is placed below the road level by 0.5m, and is designed to drain the excessive amount of water into the storm sewer.

Considering the rain garden is sloped inwards and densely populated with plants, it will not be suitable for pedestrians to cross over, thus serving as a deterrent to pedestrians from crossing the intersection without the use of the provided crosswalks. The rain garden will also increase the visual aesthetic of the intersection, and will be self-sustaining since water will always gravitate towards the middle where the plants are.

Gutters on the road will still be used along the sidewalks to ensure thorough drainage of water for cyclists and vehicles, especially when not all the rainwater will drain to the rain garden. The location of the current storm sewer will remain the same, but the size of the storm sewer will increase to 250mm to accommodate for future flows, and connections to the overflow inlet will be included.

Considering bike lane space is required along the side of the roads, rain gardens along the sidewalks will not be implemented due to lack in space. As a result, gutters spaced at 1m apart with catch basins below will be installed, and the catch basin outlets will be connected to the storm sewer at the centre of the road.

4.2 Urban Sensitive Water Design

For the implementation of the roundabout design, Water Sensitive Urban Design (WSUD) was also focused upon for the streetscape (Shaw and Schmidt, 2011). The main objective is to utilize best management practices (BMP) to improve absorbance of landscape and reduce runoff from landscape. The intersection will be enhanced with the addition of bioretention street trees that will be integrated into the road. Incorporating trees into the bioretention system will:

- Reduce the pollutant loads to the storm water systems by reducing the total suspended solids (TSS) and total phosphorous (TP) and total nitrogen (TN).
- Improve the landscape of the intersection to enhance the community.

Figure 10. Bioretention Trees Example

From further research, urban forest trees species have been proved to be the most effective in intercepting rainfall, therefore cottonwood trees will be planted in concrete box planters and hydraulically connected using underdrains that discharge excess water to the catch basins. The concrete box planters are installed in the sidewalk zone and adjacent to the curb as shown in in Figure 11**.** The planter boxes are 1m wide and will lodge a series of connected trees planted together in a row. There will be a bioretention soil mix layer below the planting soil and 4-inch perforated underdrains. The surface of the planting area will be composed of a grate on top to separate the leaves, mulch to filter out undesirable grit and chemical runoff, and below the soil grade, there will be coarse rocks for efficient water infiltration.

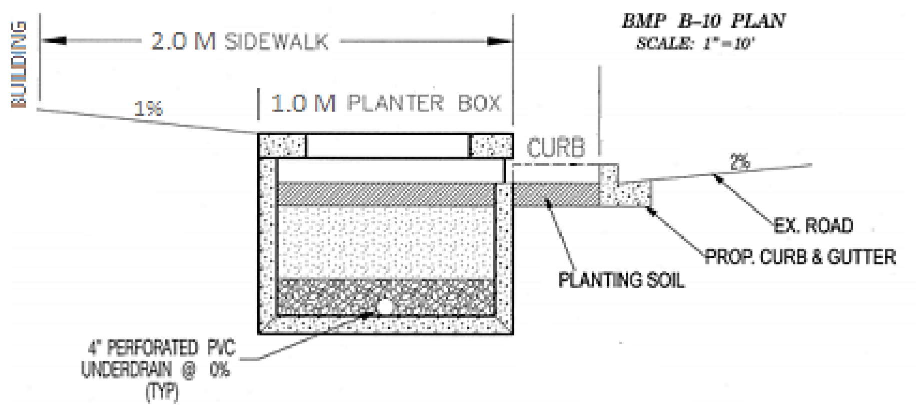

Figure 11. Cross Section of Bio Retention Trees

With the incorporation of bioretention trees to the storm water system, runoff will be reduced through rainfall interception and evapotranspiration. Also, enhanced soil infiltration will provide soil stabilization and the trees will increase the aesthetic appeal of the intersection and provide ample shading for the summer seasons.

5.0 Technical Details

This section discusses about the technical details of the project, including the project schedule and cost estimate. A benefit-cost analysis was conducted to verify the feasibility and cost-effectiveness of our design. Additionally, environmental concerns and the corresponding mitigations are explored.

5.1 Construction Schedule

The project schedule from conceptual design to project completion started on September 6, 2016 with an expected finish date of August 2017. Permits and bidding have begun with the final design at the time of this report. The schedule has been further developed after more design details were finalized.

Construction is expected to commence in May 2017 and complete by August 2017. Materials will be prefabricated off-site prior to construction in order to achieve the short schedule that minimizes the impact to road users. A Gantt Chart is provided in Appendix F for further details regarding the project schedule.

Construction will be split into 3 phases as follows:

- Phase 1 (early May to late June) involves the upgrades of pedestrian walkways and utilities;
- Phase 2 (late June to early August) involves the installation of the newly designed rain gardens, the roundabout, and the gateway structure;
- Phase 3 (late June to mid-August) involves the installation of finishes, such as lighting fixtures.

5.2 Cost Estimate

Unit pricing method is used for the cost elements, permitting, construction and maintenance. Contingency for this project varies for each cost element, ranging from 10% to 20%. These percentages are determined based on the variation of material and labour costs.

Traffic management during construction is one of the key components of the estimate. The project involves temporary works such as detours and pedestrian barriers, and the estimated cost for temporary traffic control itself is $300,000. A detailed cost breakdown can be found in Appendix E.

The total construction cost for the roundabout intersection is estimated to be $4.1 million, including the maintenance required for the expected service life of 30 years. The approximate cost breakdown for each component is as follows:

Table 3. Cost Breakdown

Item	**Cost (Million)**	
Roundabout	$	1.7
Gateway	$	0.9
Roadwork	$	1.3
Maintenance	$	0.2
Total	$	4.1

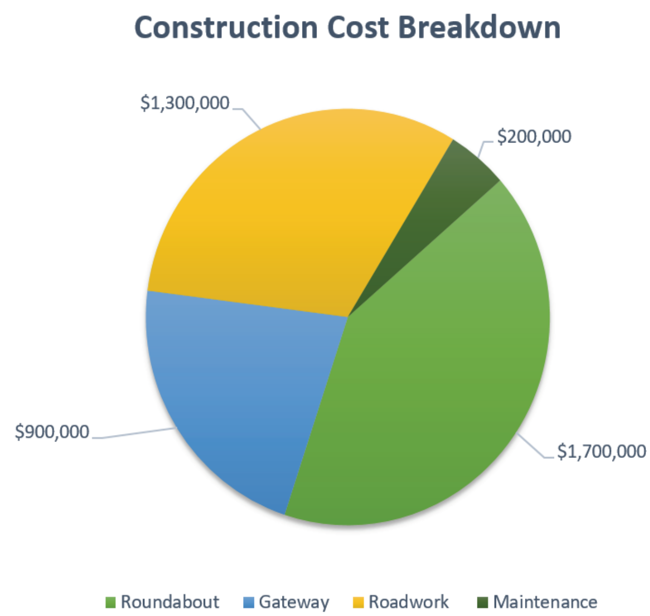

Figure 12. Construction Cost Breakdown Chart

Benefit-cost analysis (BCA) is a project evaluation method widely used for construction projects. Many benefits and costs, such as time, noise and air pollution, and disruption to traffic, are intangible. Therefore, accident reduction factors for left turn (1.0) and angle collisions (0.5) were used to determine the benefit cost for our intersection. After conducting BCA for our design, the benefit cost is found to be 2.79. Detailed calculations can be found in Appendix B.

5.3 Environmental Concerns

This section provides specifications and guidelines to minimize adverse impacts on the community and the environment during construction phase. Mitigations for waste, noise and dust are explored. A revegetation and rehabilitation plan will be carried out after construction phase of the roundabout.

5.3.1 Waste Management

Construction waste will not be dumped or burnt onsite, but removed to an approved location for treatment prior to disposal. Hazardous wastes, such as oils, paints, and lubricants, will be disposed in compliance with the British Columbia Hazardous Waste Regulation.

5.3.2 Noise and Vibration Management

Construction will follow the Noise Control Bylaw 6555 of the City of Vancouver, which states street construction can only be carried out between 7A.M. and 8P.M. from Monday to Saturday, and between 10A.M. and 8P.M on Sundays and holidays. Construction is permitted outside of the designated hours with the noise bylaw exception permit. Application will be sent through to the City of Vancouver for approval.

Day of the week	
Monday to Friday	
Private property	7:30am -8:00pm
City streets, lanes, and boulevards	7:00am - 8:00pm
Saturday	
Private property	10:00am - 8:00pm
City streets, lanes, and boulevards	7:00am - 8:00pm
Sunday	
Private property	*No* construction-related noise permitted
City streets, lanes, and boulevards	10:00am - 8:00pm
Holidays	
Private property	*No* construction-related noise permitted
City streets, lanes, and boulevards	10:00am - 8:00pm

Figure 13. Construction Hours

During construction, quieter models of equipment will be used to lower the noise level of the source. On the other hand, sound control panels and barriers will be installed around the noisy equipment to limit the noise transmission.

5.3.3 Air Quality and Dust Control

To lower fugitive dust levels, speed limit signs will be erected to regulate and reduce vehicle speeds to 30 km/h. Dust control measures such as watering and spraying of the road during excavation, or covering groundwork fill material will be conducted onsite. Minimizing engine idling and setting speed limits for diesel equipment on site can reduce odours, greenhouse gases emissions, and increase the air quality standards for the health of the workers onsite.

5.3.4 Revegetation and Rehabilitation Plan

Trees and shrubs will be removed during construction due to the modifications in sidewalk design. Self-sustaining rain gardens will be installed in the median islands, and bioretention shrubs and grass will be planted to restore the ecosystem function.

6.0 Conclusion and Recommendations

Kam & Associates design and construction plan for the Chancellor Boulevard and Wesbrook Mall intersection reveals a roundabout that has a service life of 30 years, a steel and wood gateway structure that displays Musqueam carvings, and a sustainable rain garden that minimizes rain inflow into the storm water system.

The roundabout features shortened pedestrian crossing distances due to the designed pedestrian crosswalks on the roundabout island, and cyclists are provided with comfortably spaced cycling lanes along the road. From the analysis conducted with an increase in population around UBC, the roundabout has a minimum level of service of C by the end of its 30-year service life. Traffic management plans developed for each phase of construction ensures minimal traffic disruptions to the community and UBC operations.

A gateway has been designed to greet road users who are entering UBC, and a steel and wooden Musqueam totem structure has been chosen. The design has been confirmed to be structurally stable, even against vehicle collisions as well as earthquakes. Moreover, the material used is locally obtained, and is designed to withstand natural decay and erosion.

To avoid pooling of water along the road which would endanger cyclists and vehicles during heavy rainfall seasons, rain gardens have been designed to reduce the overland flood probability. In addition, plants that are more adsorbent efficient are used to assist with rainwater adsorption along the sidewalk.

The next steps that the University of British Columbia is recommended to take is confirm the construction dates with subcontractors who will conduct the work for the site, and confirm that the construction details are compliant with the contract awarded. Moreover, affirmation with the pre-fabricators on the progress of the material for construction is necessary to ensure the construction schedule is not delayed. Delays in the project are likely to cause monetary damage to the project and are ill advised. Furthermore, permits and construction drawings require several reviews to certify the completeness and constructability before the construction begins. Kam & Associates firmly believe that the designs provided to the University of British Columbia complies with the objectives of the Social Ecological Economic Development Studies Sustainability Program, and is highly likely to benefit the community with its implementation.

Glossary

Terms	Definition
Benefit-Cost Analysis (BCA)	A project evaluation method widely used for public-sector projects.
Best Management Practices (BMP)	A plan that evaluates the potential sources of sediment and other pollutants at the construction site and put controls in place that will effectively prevent pollutant discharges to surface.
CoV	City of Vancouver.
Delay/ Vehicle	A quantitative measurement that shows the typical delay each driver will experience at this intersection.
Level of Service (LoS)	A qualitative measurement that relates the quality of traffic service to a given flow rate and it is ranked from A to F, with A denoting the best quality of service and F denoting the worst.
Revegetation	The process of replanting and rebuilding the soil and plants that were disturbed by construction.
Total Nitrogen (TN)	The sum of nitrate (NO_3), nitrite (NO_2), organic nitrogen and ammonia in the rainwater.
Total Phosphorus (TP)	The sum of reactive, condensed and organic phosphorous in rainwater that can be removed through sedimentation or filtration.
Total Suspended Solids (TSS)	The quantity of solids in suspension within the rainwater.

Terms	Definition
UBC	University of British Columbia.
UEL	University Endowment Lands
Ultimate Tensile Strength (UTS)	The capacity of a material or structure to withstand loads tending to elongate.
Water Sensitive Urban Design (WSUD)	A land planning and engineering design approach which integrates the urban water cycle into urban design to minimise environmental degradation and improve aesthetic and recreational appeal.

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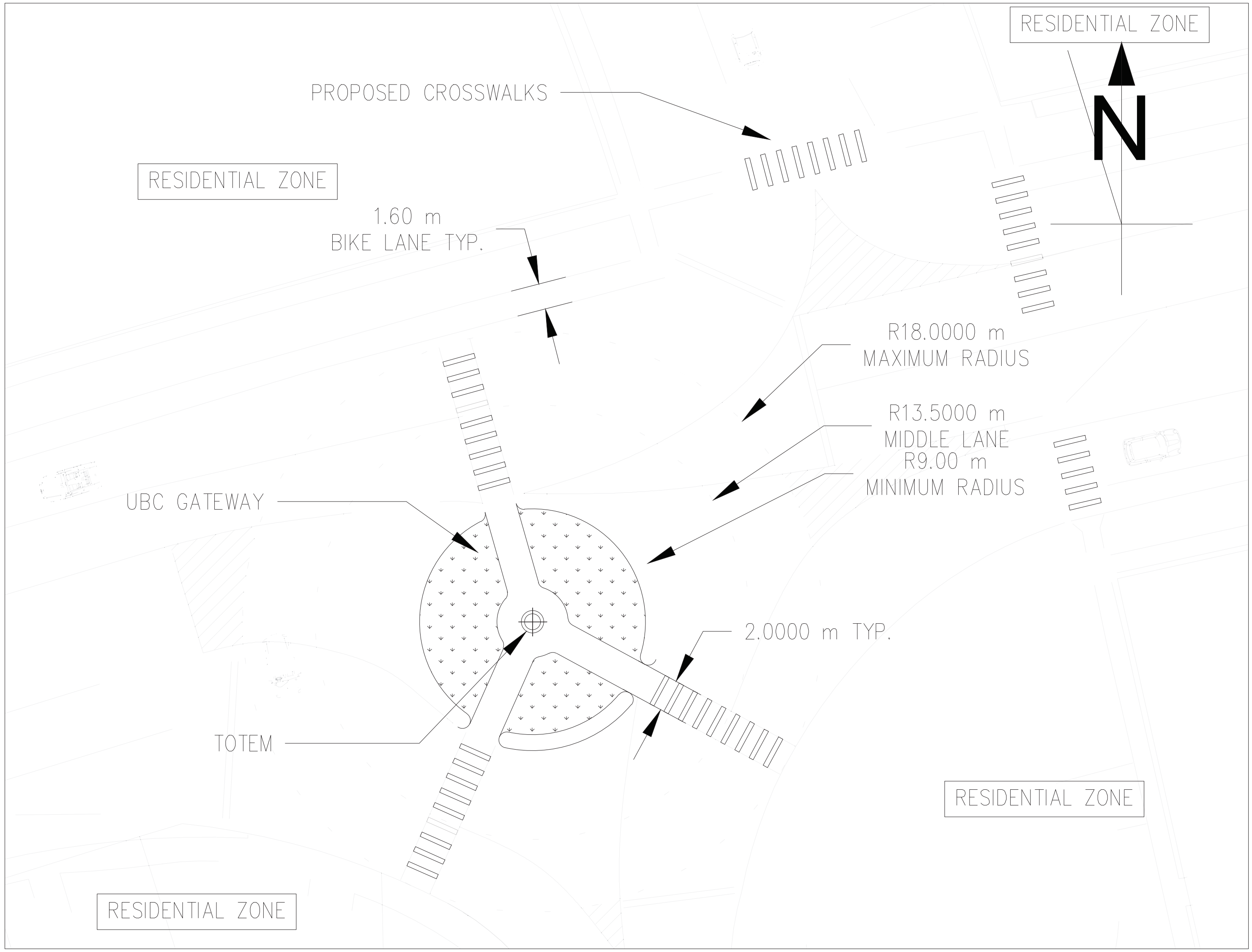
Appendix A: Design Drawings



1 A-02 ROUNDABOUT DETAIL
SCALE: NTS

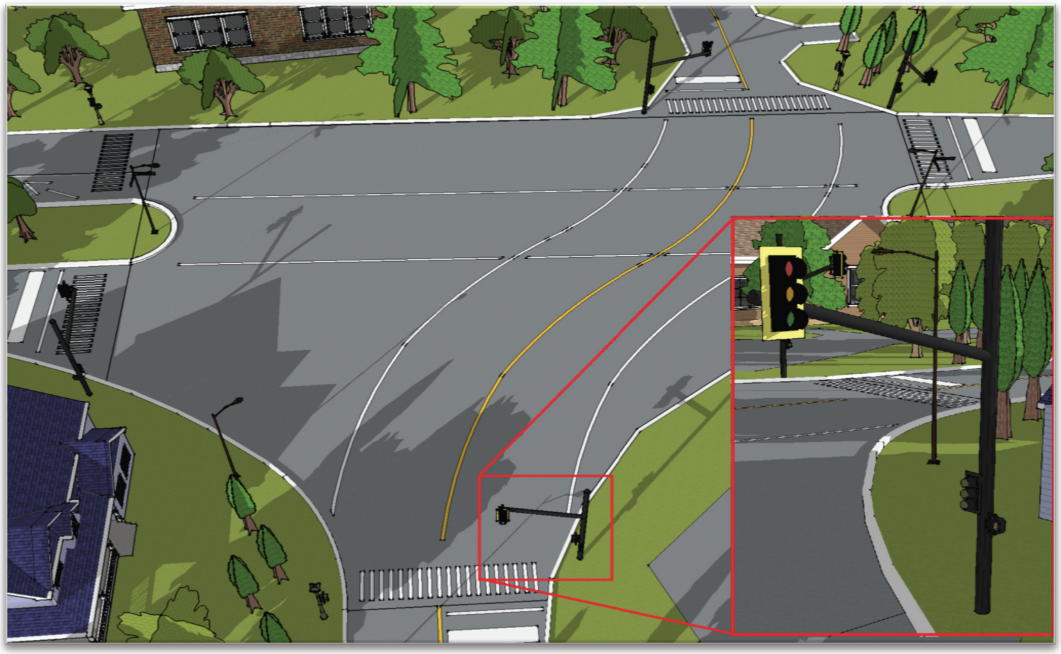
REV. #	DATE	NOTES:
1	3/19/17 LANES CHANGED	TWO-LANE ROUNDABOUT
		ALL LANE WIDTH ARE 3.35 m
		MAX. WIDTH 4.50 m
		ALL ARC MIN. RADIUS 30.48 m

K&A
KAM & ASSOCIATES

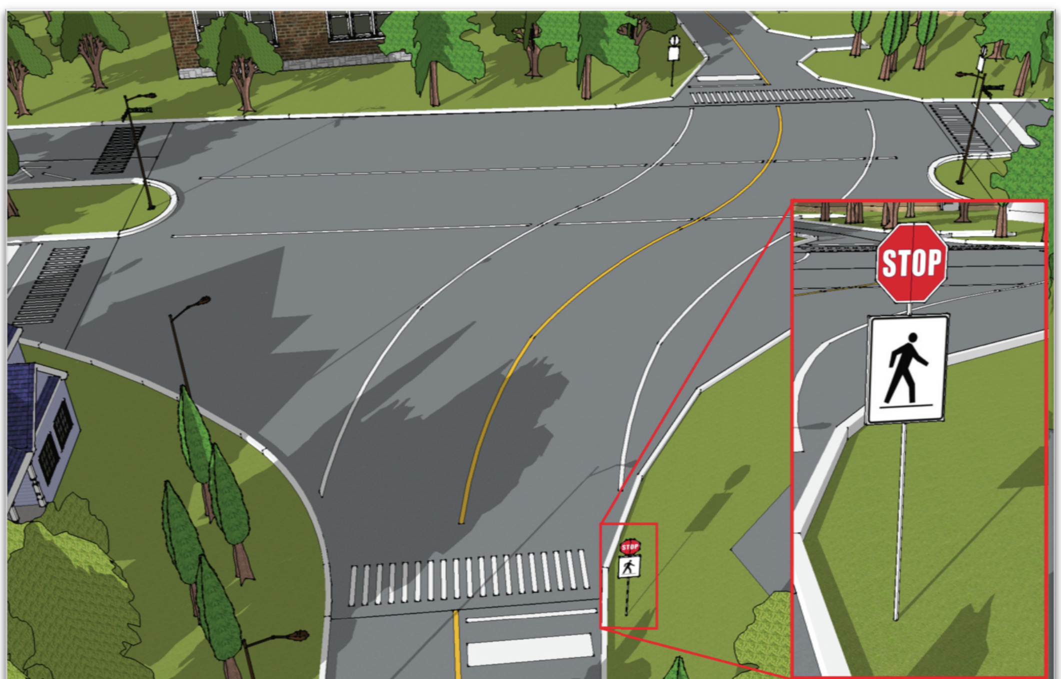
ROUNDABOUT DETAIL

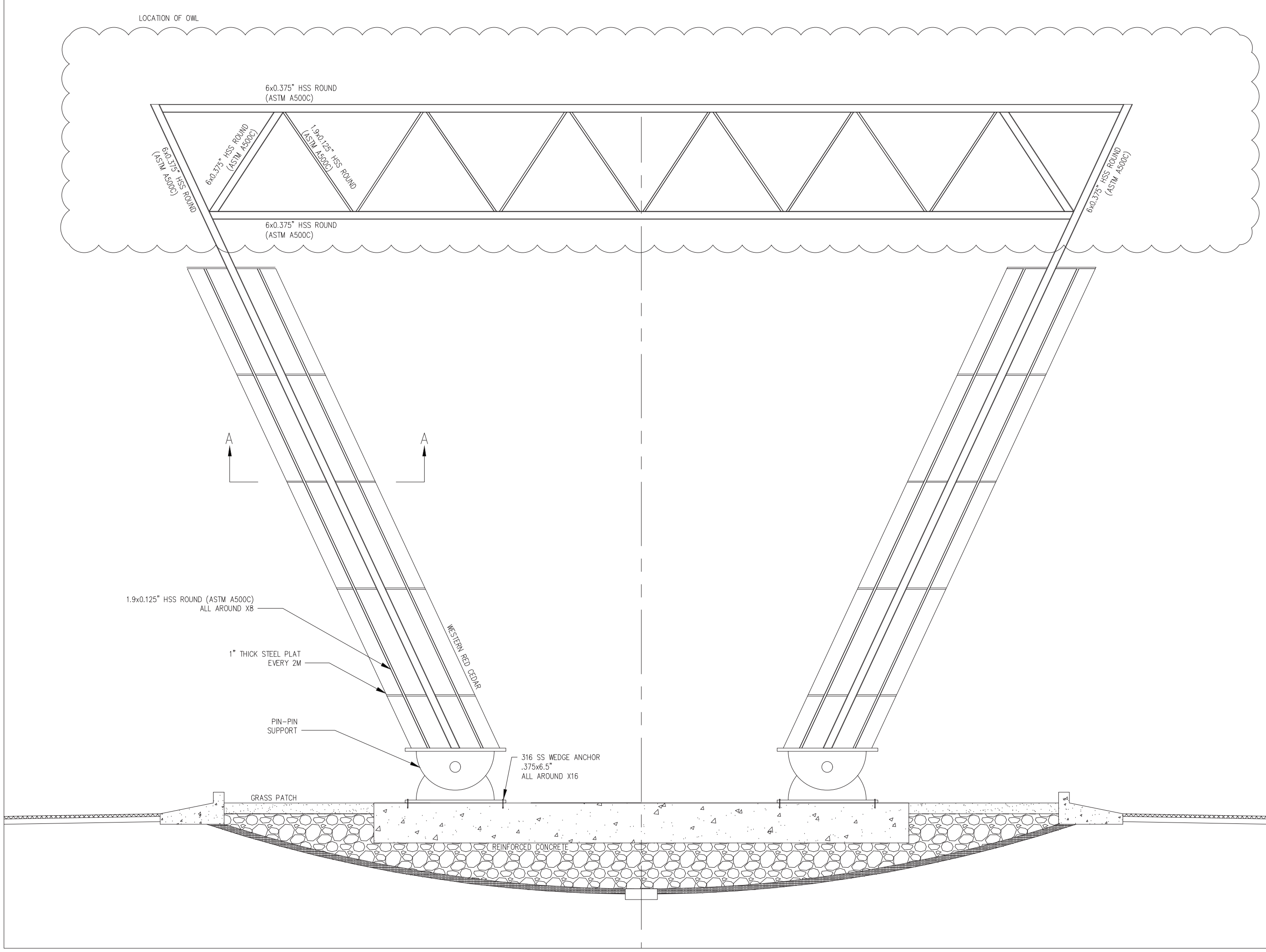
DRAWN BY	BQ
DATE	NOV 26, 2016
SCALE	NTS
PAGE	A – 03

A.1.2 Design Option 2 – Signalized Intersection

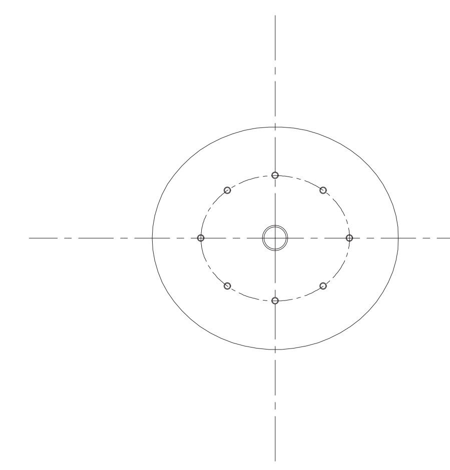


A.1.3 Design Option 3 – Unsignalized Intersection





1 S-01 STEEL LAYOUT
SCALE: NTS



1 S-01 SECTION A-A
SCALE: NTS

REV. #	DATE	NOTES:

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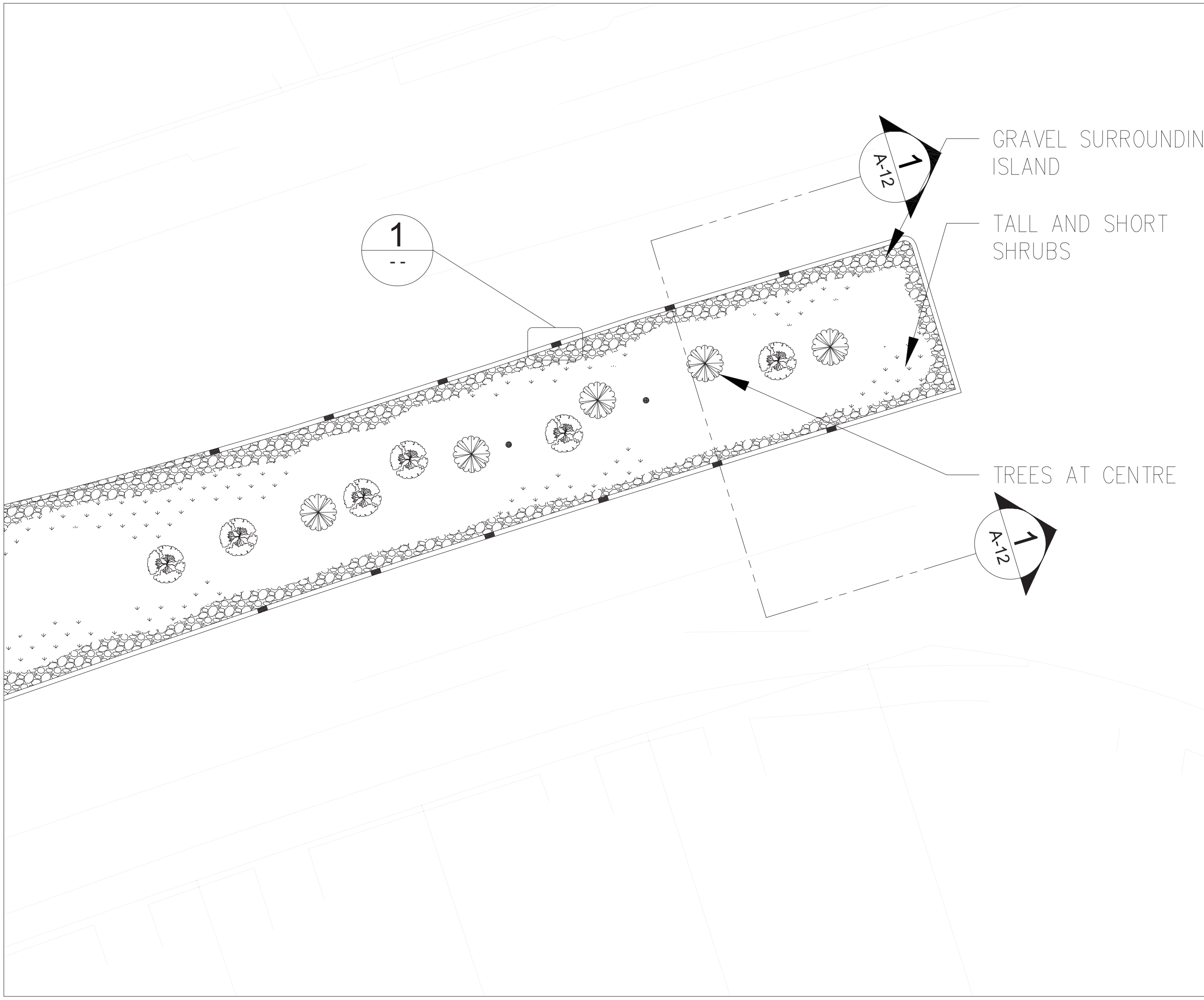
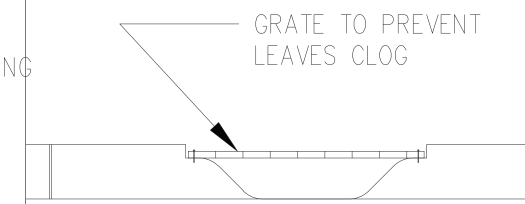
STEEL DESIGN

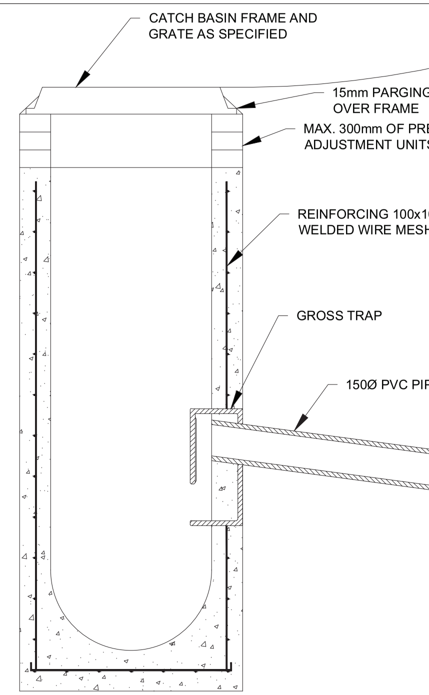
DRAWN BY	BQ
DATE	APR 1, 2017
SCALE	NTS
PAGE	S - 01



1 A-11 RAIN GARDEN
SCALE: NTS



1 A-11 CURB DETAIL
SCALE: NTS



2 A-11 GUTTER DETAIL
SCALE: NTS

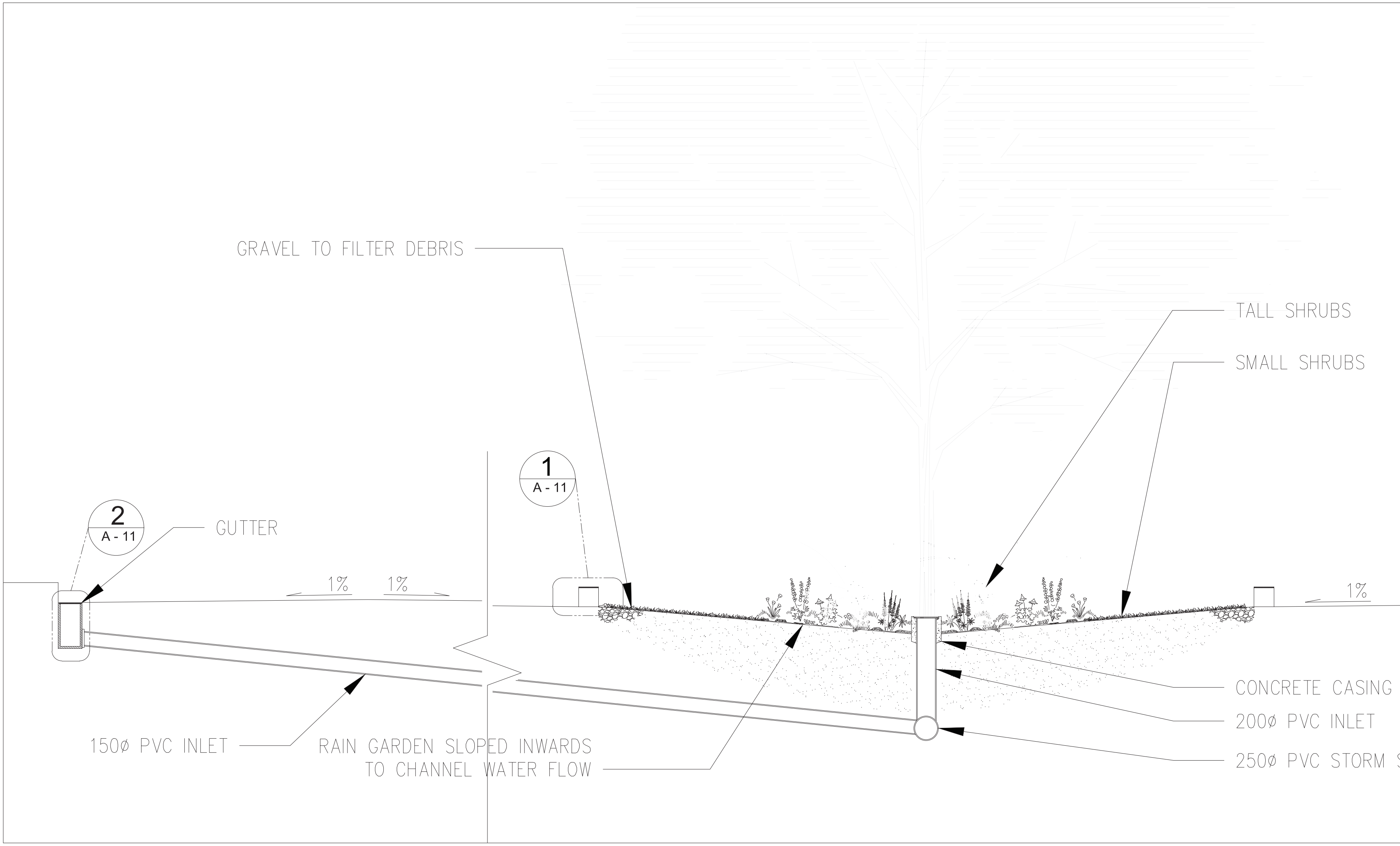
REV. #	DATE

NOTES:

KAM & ASSOCIATES

SECTIONS

DRAWN BY	BQ
DATE	NOV 26, 2016
SCALE	NTS
PAGE	A – 11



1 A-07 RAIN GARDEN SECTION
SCALE: NTS

REV. #	DATE	NOTES:

K&A
KAM & ASSOCIATES

SECTIONS	
DRAWN BY	BQ
DATE	NOV 26, 2016
SCALE	NTS
PAGE	A – 12

Appendix B: Sample Calculations

B.1 Sight Distance Analysis

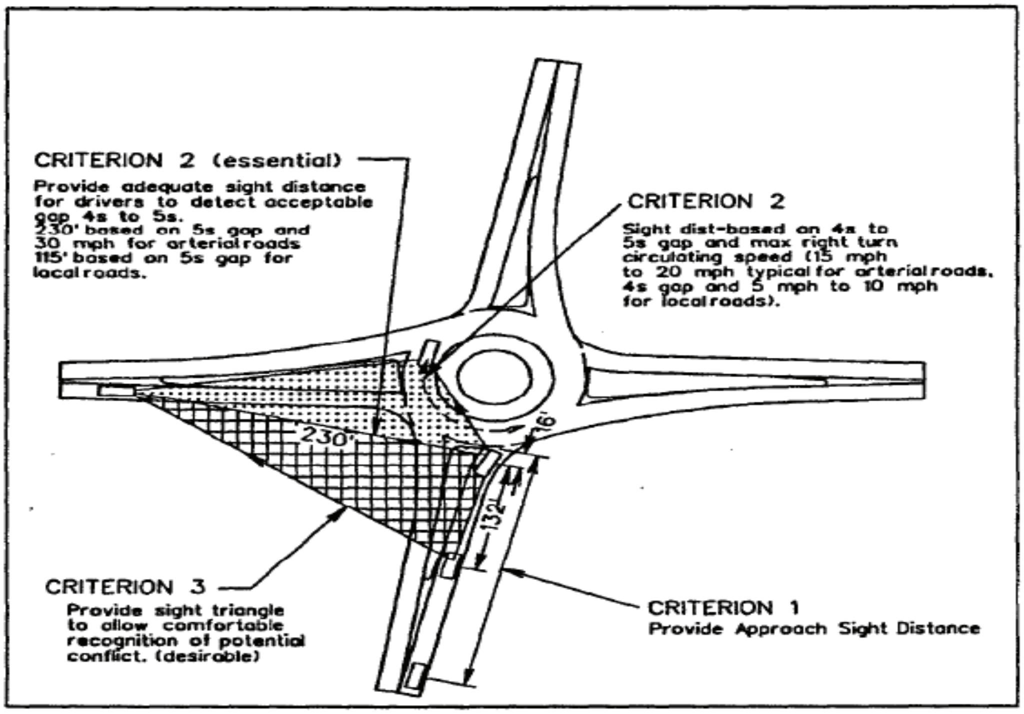


Figure 14. Site Distance Criterions

Sight distance analysis is performed to ensure the above criteria are met in the geometry design of the roundabout.

B.2 Gateway Structure Calculations

The capacity was calculated using the formula Tr=φFtA for tension and Vr=φFsA where φ is 0.9, F is the strength and A is the gross area.

As an example, the area of 6x0.375” HSS is 0.0047 m^2 and the UTS is 427 MPa, so the tension capacity of that member is Tr = 0.9x427x0.0047 = 1806.21 kN. for bolt sizing.

B.3 Foundation Calculations

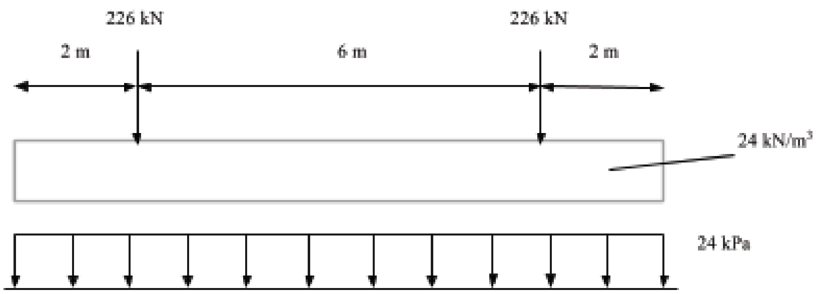


Figure 15. Concrete Foundation

Round Pad Footing:

Radius = 5 m
Depth = 0.75 m
Area = πr^2 = 78.54 m^2
Volume = Area × Depth =58.90 m^3
Density = 24 kN/m^3
Weight = Volume × Density = 1413.7 kN
Weight + Load = 1413.72 kN + 2 × 226.04 kN = 1865.80 kN
Stress = $\frac{Weight+Load}{Area}$ = 23.76 kPa

$$N_q = \frac{e^{2\pi(0.75-\phi'/360)\tan\phi'}}{2\cos^2(45+\phi'/2)}$$

$$N_\gamma = \frac{2(N_q+1)\tan\phi'}{1+0.4\sin 4\phi'}$$

$$q_{ult} = 1.3c'N_c + \sigma'_{zD}N_q + 0.3\gamma' BN_\gamma$$

N_q = 41.44
N_y = 47.28
q_{ult} = 1563.96 kPa

Soil (Gravel with Sand)

Density = 1922 kg/m^3
Unit Weight = 18.85 kN/m^3
GWT = 0 m
Effective Stress at Base = 6.78 kPa
Effective Friction Angle = 35 degrees = 0.61 radian
Effective Unit Weight = 9.04 kN/m^3
Cohesion (c') = 0
Bearing Capacity = 200 kPa

B.4 Reinforced Concrete Design

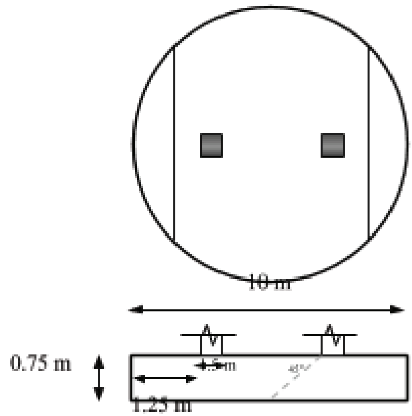


Figure 16. Reinforced Concrete

$$V_c = \varphi_c \lambda \beta \sqrt{f_c'} b_w d_w$$

$$\varphi_c = 0.65$$

$$A = 1$$

$$\beta = \frac{230}{1000 + d_v} = 0.131$$

$$f_c' = 25\ MPa$$

$$b_w = 10\ m$$

$$d_w = 0.75$$

$$V_c = 3193\ kN$$

$$V_f = q_f b_w (1.25 - d)$$

$$l = 10\ m$$

$$t = 1.5\ m$$

$$d = 0.75\ m$$

$$q_f = 128\ kPa$$

$$V_f = 640\ kN \text{ per slanted column}$$

$$V_f = 640\ kN < V_r = 3193\ kN$$

$$\therefore \text{No stirrups required}$$

B.5 Reinforcement Configuration

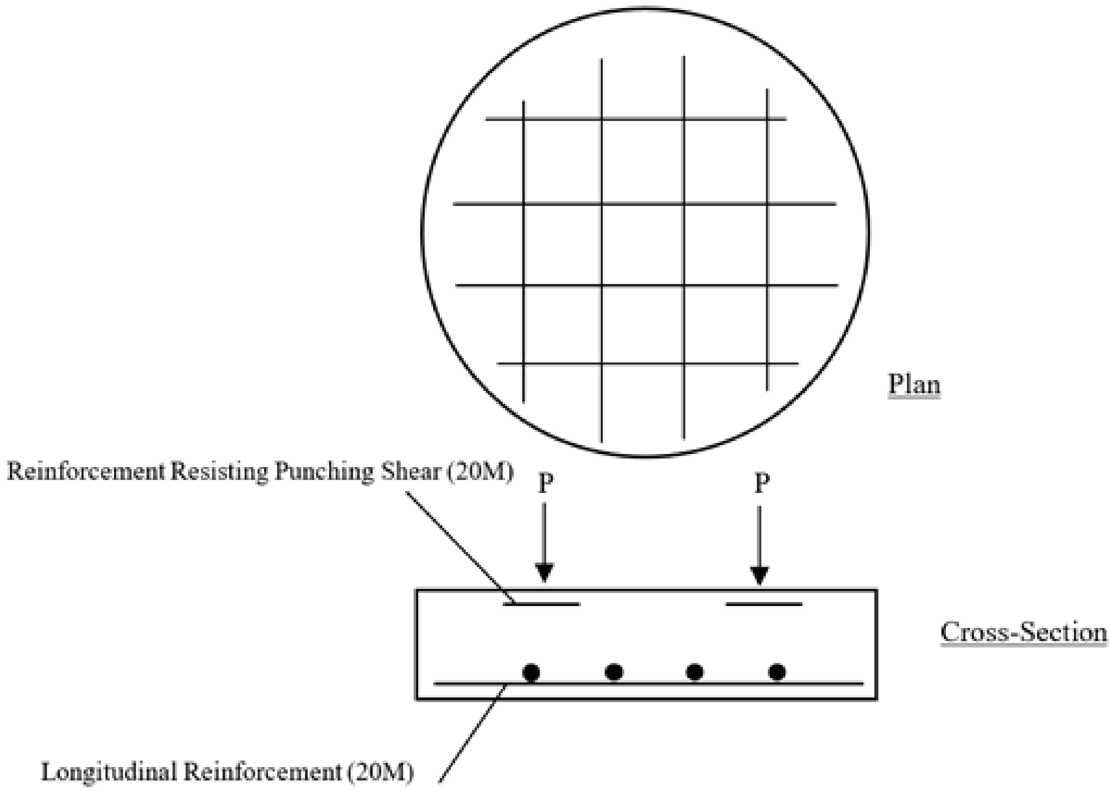


Figure 17. Reinforcement Configuration

B.6 BCA Calculations

Type of Collision	Estimated Accident Experience	Accident Reduction Factor	Average Accident Cost (assume injury collisions)	Forecasted Reduction	First Years Benefit
Angle	2.5	0.5	60500	1.25	75625
Left Turn	11.2	1	60500	11.2	677600
Total				**12.45**	**753225**

Service Life	CRF	Initial Cost	EUAC
30	0.089	4100000	364900

Variables	
j (annual % inc in traffic)	0.03
I (interest rate)	0.08
N (service life)	30
CRF	0.089

Summary	
Forecasted Reduction	12.45
EUAC	364900
EUAB	1017334
Benefit Cost	**2.79**

Numbers were extracted from the Roundabout Design Guidelines of the State of Maryland.

B.7 Traffic Demand Projection

Year	Student/ Staff Count	% Increase
2008	45,179.00	0.00
2009	46,933.00	3.88
2010	47,450.00	1.10
2011	48,285.00	1.76
2012	49,238.00	1.97
2013	49,896.00	1.34
2014	51,041.00	2.29
Average % Increase		2.06

Source	% Increase	Weight	Weighted %
UBC	2.06	0.3	0.618
BC-STAT	0.96	0.7	0.672
		Result:	1.29

Year	BC Population	% Increase
2017	4,740.10	0.00
2018	4,801.20	1.29
2019	4,861.30	1.25
2020	4,920.50	1.22
2021	4,979.30	1.20
2022	5,037.31	1.17
2023	5,094.40	1.13
2024	5,151.80	1.13
2025	5,208.60	1.10
2026	5,264.80	1.08
2027	5,320.10	1.05
2028	5,374.50	1.02
2029	5,427.90	0.99
2030	5,480.10	0.96
2031	5,531.10	0.93
2032	5,580.40	0.89
2033	5,628.90	0.87
2034	5,676.50	0.85
2035	5,721.60	0.79
2036	5,765.20	0.76
2037	5,808.00	0.74
2038	5,849.30	0.71
2039	5,889.30	0.68
2040	5,928.00	0.66
2041	5,965.60	0.63
Average % Increase		0.96

Appendix C: Traffic Analysis Report

Summary of All Intervals

Start Time	6:57
End Time	7:10
Total Time (min)	13
Time Recorded (min)	10
# of Intervals	2
# of Recorded Intvls	1
Vehs Entered	190
Vehs Exited	198
Starting Vehs	25
Ending Vehs	17
Denied Entry Before	0
Denied Entry After	0
Travel Distance (km)	83
Travel Time (hr)	2.4
Total Delay (hr)	0.3
Total Stops	40
Fuel Used (l)	22.2

Interval #0 Information Seeding

Start Time	6:57
End Time	7:00
Total Time (min)	3

Volumes adjusted by Growth Factors.

No data recorded this interval.

Interval #1 Information Recording

Start Time	7:00
End Time	7:10
Total Time (min)	10

Volumes adjusted by Growth Factors.

Vehs Entered	190
Vehs Exited	198
Starting Vehs	25
Ending Vehs	17
Denied Entry Before	0
Denied Entry After	0
Travel Distance (km)	83
Travel Time (hr)	2.4
Total Delay (hr)	0.3
Total Stops	40
Fuel Used (l)	22.2

2: c & w Performance by movement

Movement	EBT	EBR	WBL	WBT	NBL	NBR	All
Total Delay (hr)	0.0	0.0	0.1	0.1	0.0	0.0	0.2
Delay / Veh (s)	4.2	4.0	3.9	4.4	3.3	3.2	4.0
Fuel Used (l)	0.9	0.9	4.5	3.0	0.2	1.0	10.4
HC Emissions (g)	1	1	5	3	0	1	11
CO Emissions (g)	53	32	243	157	11	38	534
NOx Emissions (g)	4	2	18	12	1	3	41
Vehicles Entered	14	10	77	58	6	25	190
Vehicles Exited	14	11	79	61	7	24	196
Hourly Exit Rate	84	66	474	366	42	144	1176
Denied Entry Before	0	0	0	0	0	0	0
Denied Entry After	0	0	0	0	0	0	0

Total Network Performance

Total Delay (hr)	0.3
Delay / Veh (s)	6.2
Fuel Used (l)	22.2
HC Emissions (g)	20
CO Emissions (g)	1053
NOx Emissions (g)	74
Vehicles Entered	190
Vehicles Exited	198
Hourly Exit Rate	1188
Denied Entry Before	0
Denied Entry After	0

Intersection: 2: c & w

Movement	EB	WB	NB
Directions Served	UTR	ULT	ULR
Maximum Queue (m)	3.7	23.5	16.7
Average Queue (m)	0.7	4.7	3.3
95th Queue (m)	3.2	20.2	14.4
Link Distance (m)	255.6	192.4	108.2
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (m)			
Storage Blk Time (%)			
Queuing Penalty (veh)			

Nework Summary

Network wide Queuing Penalty: 0

Summary of All Intervals

Start Time	6:57
End Time	7:10
Total Time (min)	13
Time Recorded (min)	10
# of Intervals	2
# of Recorded Intvls	1
Vehs Entered	232
Vehs Exited	226
Starting Vehs	11
Ending Vehs	17
Denied Entry Before	0
Denied Entry After	0
Travel Distance (km)	99
Travel Time (hr)	3.0
Total Delay (hr)	0.6
Total Stops	81
Fuel Used (l)	34.8

Interval #0 Information Seeding

Start Time	6:57
End Time	7:00
Total Time (min)	3

Volumes adjusted by Growth Factors.

No data recorded this interval.

Interval #1 Information Recording

Start Time	7:00
End Time	7:10
Total Time (min)	10

Volumes adjusted by Growth Factors.

Vehs Entered	232
Vehs Exited	226
Starting Vehs	11
Ending Vehs	17
Denied Entry Before	0
Denied Entry After	0
Travel Distance (km)	99
Travel Time (hr)	3.0
Total Delay (hr)	0.6
Total Stops	81
Fuel Used (l)	34.8

2: c & w Performance by movement

Movement	EBT	EBR	WBL	WBT	NBL	NBR	All
Total Delay (hr)	0.0	0.0	0.1	0.1	0.0	0.0	0.3
Delay / Veh (s)	4.9	4.7	5.0	5.8	3.9	3.1	5.0
Fuel Used (l)	1.4	1.7	8.3	3.7	0.5	0.9	16.5
HC Emissions (g)	1	1	6	3	0	1	12
CO Emissions (g)	51	44	250	161	21	44	570
NOx Emissions (g)	4	3	23	14	2	4	50
Vehicles Entered	16	11	96	78	12	19	232
Vehicles Exited	18	10	95	76	13	19	231
Hourly Exit Rate	108	60	570	456	78	114	1386
Denied Entry Before	0	0	0	0	0	0	0
Denied Entry After	0	0	0	0	0	0	0

Total Network Performance

Total Delay (hr)	0.6
Delay / Veh (s)	9.1
Fuel Used (l)	34.8
HC Emissions (g)	24
CO Emissions (g)	1121
NOx Emissions (g)	92
Vehicles Entered	232
Vehicles Exited	226
Hourly Exit Rate	1356
Denied Entry Before	0
Denied Entry After	0

Intersection: 2: c & w

Movement	EB	WB
Directions Served	UTR	ULT
Maximum Queue (m)	21.0	14.7
Average Queue (m)	4.2	5.4
95th Queue (m)	18.1	16.3
Link Distance (m)	255.6	192.4
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (m)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Nework Summary

Network wide Queuing Penalty: 0

Summary of All Intervals

Start Time	6:57
End Time	7:10
Total Time (min)	13
Time Recorded (min)	10
# of Intervals	2
# of Recorded Intvls	1
Vehs Entered	271
Vehs Exited	268
Starting Vehs	16
Ending Vehs	19
Denied Entry Before	0
Denied Entry After	0
Travel Distance (km)	116
Travel Time (hr)	3.6
Total Delay (hr)	0.7
Total Stops	108
Fuel Used (l)	39.6

Interval #0 Information Seeding

Start Time	6:57
End Time	7:00
Total Time (min)	3

Volumes adjusted by Growth Factors.
No data recorded this interval.

Interval #1 Information Recording

Start Time	7:00
End Time	7:10
Total Time (min)	10

Volumes adjusted by Growth Factors.

Vehs Entered	271
Vehs Exited	268
Starting Vehs	16
Ending Vehs	19
Denied Entry Before	0
Denied Entry After	0
Travel Distance (km)	116
Travel Time (hr)	3.6
Total Delay (hr)	0.7
Total Stops	108
Fuel Used (l)	39.6

2: c & w Performance by movement

Movement	EBT	EBR	WBL	WBT	NBL	NBR	All
Total Delay (hr)	0.1	0.0	0.1	0.2	0.0	0.0	0.4
Delay / Veh (s)	5.6	4.1	5.0	8.2	4.4	4.0	5.9
Fuel Used (l)	2.3	0.9	8.4	3.9	0.9	1.1	17.6
HC Emissions (g)	3	1	5	4	1	1	14
CO Emissions (g)	151	50	233	149	32	26	641
NOx Emissions (g)	10	3	23	14	4	4	58
Vehicles Entered	35	14	98	82	18	24	271
Vehicles Exited	33	14	98	81	18	24	268
Hourly Exit Rate	198	84	588	486	108	144	1608
Denied Entry Before	0	0	0	0	0	0	0
Denied Entry After	0	0	0	0	0	0	0

Total Network Performance

Total Delay (hr)	0.7
Delay / Veh (s)	9.9
Fuel Used (l)	39.6
HC Emissions (g)	27
CO Emissions (g)	1285
NOx Emissions (g)	108
Vehicles Entered	271
Vehicles Exited	268
Hourly Exit Rate	1608
Denied Entry Before	0
Denied Entry After	0

Intersection: 2: c & w

Movement	EB	WB	WB
Directions Served	UTR	UL	ULT
Maximum Queue (m)	16.1	13.3	28.4
Average Queue (m)	6.3	4.4	17.8
95th Queue (m)	19.1	13.6	34.2
Link Distance (m)	255.6	192.4	192.4
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (m)			
Storage Blk Time (%)			
Queuing Penalty (veh)			

Nework Summary

Network wide Queuing Penalty: 0

Summary of All Intervals

Start Time	6:57
End Time	7:10
Total Time (min)	13
Time Recorded (min)	10
# of Intervals	2
# of Recorded Intvls	1
Vehs Entered	304
Vehs Exited	298
Starting Vehs	22
Ending Vehs	28
Denied Entry Before	0
Denied Entry After	0
Travel Distance (km)	130
Travel Time (hr)	4.6
Total Delay (hr)	1.5
Total Stops	252
Fuel Used (l)	42.5

Interval #0 Information Seeding

Start Time	6:57
End Time	7:00
Total Time (min)	3

Volumes adjusted by Growth Factors.

No data recorded this interval.

Interval #1 Information Recording

Start Time	7:00
End Time	7:10
Total Time (min)	10

Volumes adjusted by Growth Factors.

Vehs Entered	304
Vehs Exited	298
Starting Vehs	22
Ending Vehs	28
Denied Entry Before	0
Denied Entry After	0
Travel Distance (km)	130
Travel Time (hr)	4.6
Total Delay (hr)	1.5
Total Stops	252
Fuel Used (l)	42.5

2: c & w Performance by movement

Movement	EBT	EBR	WBL	WBT	NBL	NBR	All
Total Delay (hr)	0.0	0.0	0.4	0.5	0.0	0.0	0.9
Delay / Veh (s)	5.1	3.8	11.7	16.8	3.6	3.8	11.0
Fuel Used (l)	2.1	1.3	7.5	4.9	0.8	1.3	17.8
HC Emissions (g)	2	1	5	4	1	1	14
CO Emissions (g)	126	68	196	171	32	36	629
NOx Emissions (g)	8	4	18	16	3	5	55
Vehicles Entered	35	16	108	100	19	26	304
Vehicles Exited	32	15	110	97	20	26	300
Hourly Exit Rate	192	90	660	582	120	156	1800
Denied Entry Before	0	0	0	0	0	0	0
Denied Entry After	0	0	0	0	0	0	0

Total Network Performance

Total Delay (hr)	1.5
Delay / Veh (s)	17.7
Fuel Used (l)	42.5
HC Emissions (g)	30
CO Emissions (g)	1387
NOx Emissions (g)	116
Vehicles Entered	304
Vehicles Exited	298
Hourly Exit Rate	1788
Denied Entry Before	0
Denied Entry After	0

Intersection: 2: c & w

Movement	EB	EB	WB	WB	NB
Directions Served	UT	UTR	UL	ULT	ULR
Maximum Queue (m)	10.3	11.0	48.5	68.8	17.2
Average Queue (m)	4.0	4.4	32.8	41.0	3.4
95th Queue (m)	12.0	13.2	51.0	73.9	14.7
Link Distance (m)	255.6	255.6	192.4	192.4	108.2
Upstream Blk Time (%)					
Queuing Penalty (veh)					
Storage Bay Dist (m)					
Storage Blk Time (%)					
Queuing Penalty (veh)					

Nework Summary

Network wide Queuing Penalty: 0

KAM
And Associates

Appendix D: SAP2000 Model Output

D.1 Frame Check

HSS Check	Max Shear (kN)	Max Axial (kN)	Area (m^2)	Shear Capacity (kN)	Axial Capacity (kN)
6x0.375"	43.676	482.996	0.008836	2544.684959	3395.563992
1.9x0.125"	43.676	168.24	0.000931	268.1495979	357.8121197
ASTM-A500C					
UTS	427	MPa			
Shear	320	MPa			
Phi	0.9				

***Note: All the individual frame loads are not shown here due to massive output data's, but will provide if requested.*

D.2 Base Reactions

TABLE: Joint Reactions								
Joint	**OutputCase**	**CaseType**	**F1**	**F2**	**F3**	**M1**	**M2**	**M3**
Text	Text	Text	KN	KN	KN	KN-m	KN-m	KN-m
9	COMB1	Combination	-102.707	-17.763	226.043	214.3771	0	85.8896
18	COMB1	Combination	102.707	-17.763	226.052	214.3771	0	-85.8896
			x	y	z	x-x	y-y	z-z

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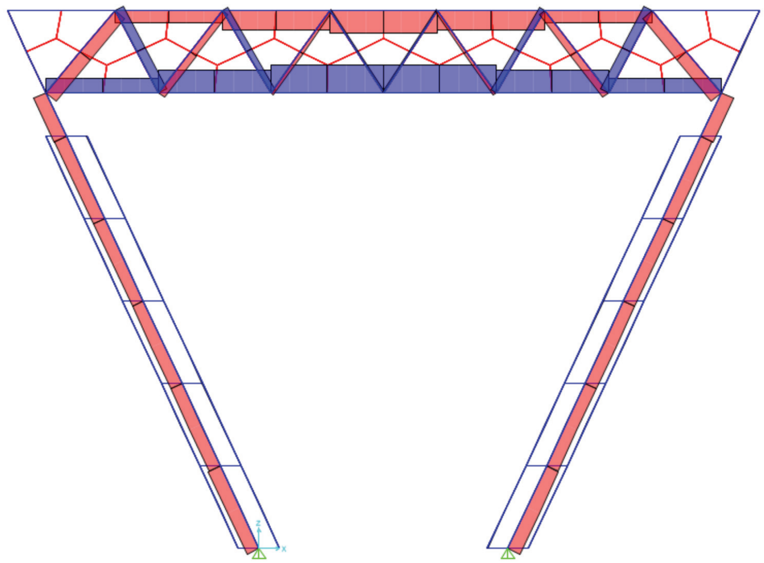
D.3 Axial Force Diagram



Appendix E: Costs

CIVL 446 - Detailed Design Cost Estimate

Created On: January 22, 2017
Edited on: April 2, 2017

Item	Personnel	Unit	Unit Cost	# Units	Duration	ontingency (%	Total Cost
Approval							
	Permitting Documentation	LS	$ 10,420	1	1	20%	$ 12,504.00
	Permit Approval Personnel	hrs	$ 50	1	80	20%	$ 4,800.00
Sub Total							$ 17,304.00
Equipment/Supplies							
	Pipe Laying	foot	$ 200	40	1	15%	$ 9,200.00
	Fences w/ dirt screens (100ft)	day	$ 2,500	1	150	15%	$ 431,250.00
	Temporary Light Tower 6KW	days	$ 145	10	150	15%	$ 250,125.00
	Excavator	hrs	$ 250	1	10	15%	$ 2,875.00
	Asphalt Compactor	hrs	$ 140	1	28	15%	$ 4,508.00
	Asphalt Pavers	hrs	$ 800	1	28	15%	$ 25,760.00
	Power Generator 70 KVA	day	$ 260	4	150	15%	$ 179,400.00
	Sewage waste truck	day	$ 800	1	150	15%	$ 138,000.00
Sub Total							$ 1,041,118.00
Labour							
	Superintendent	hrs	$ 100	1	800	12%	$ 89,600.00
	Excavation Workers	hrs	$ 70	2	15	12%	$ 2,352.00
	Asphalt Pourers	hrs	$ 70	3	24	12%	$ 5,644.80
	Gateway Installers	hrs	$ 70	3	40	15%	$ 9,660.00
	Roundabout Installers	hrs	$ 70	3	20	15%	$ 4,830.00
	Rain Garden Installers	hrs	$ 100	3	20	15%	$ 6,900.00
	Structural Inspectors	hrs	$ 120	1	8	12%	$ 1,075.20
	Traffic Controllers	hrs	$ 70	5	800	12%	$ 313,600.00
	Carver (Musquem)	hrs	$ 100	1	5	15%	$ 575.00
	Steel Work	hrs	$ 70	2	16	12%	$ 2,508.80
	Piping	hrs	$ 120	3	20	12%	$ 8,064.00
	Electrical	hrs	$ 120	3	20	12%	$ 8,064.00
	Landscaper	hrs	$ 120	3	16	12%	$ 6,451.20
	Road Paint Eradicator	hrs	$ 100	1	8	12%	$ 896.00
	Road Painter	hrs	$ 70	2	8	12%	$ 1,254.40
	Surveyor	hrs	$ 50	4	8	12%	$ 1,792.00
Sub Total							$ 463,267.40
Fabrication							
	Supervisor	hrs	$ 70	3	480	15%	$ 115,920.00
	Fabricators (Concrete, Gateway, Totem)	hrs	$ 50	9	480	15%	$ 248,400.00
Sub Total							$ 364,320.00
Materials							
	Concrete	cbm	$ 191	20		15%	$ 4,393.00
	Asphalt	sq m	$ 70	1100		15%	$ 88,550.00
	Gateway Structure						
	Totem Carvings	ft	$ 3,000	16		15%	$ 55,200.00
	Steel Truss	ft	$ 200	80		15%	$ 18,400.00
	Lamp Post	unit	$ 500	2		15%	$ 1,150.00
	Stormwater System						
	250 PVC Storm sewer	m	$ 180	500		15%	$ 103,500.00
	Filter Material	cbm	$ 100	20		15%	$ 2,300.00
	Gravel	cbm	$ 40	20		15%	$ 920.00
	Catch basins	unit	$ 4,000	10		15%	$ 46,000.00
	Landscaping	sq m	$ 250	250		15%	$ 71,875.00
	Temporary Traffic Control						
	Pedestrian Control Barriers	unit	$ 80	50		15%	$ 4,600.00
	Arrow Boards	unit	$ 4,000	5		15%	$ 23,000.00
	Signs (Aluminum, 3 Diamond Grade)	sq m	$ 300	16		15%	$ 5,520.00
Sub Total							$ 392,288.00
Management							
	Engineers (K&A)	hrs	$ 120	6	1280	15%	$ 921,600.00
	Specialists (Structural, Geotechnical, Transportation Management)	hrs	$ 150	6	80	15%	$ 72,000.00
Sub Total							$ 993,600.00
Sub Total							$ 3,271,897.40
25% Markup							$ 817,974.35
Capital Cost							$ 4,089,871.75
Maintenance							
	Gardeners	Yr	$ 800	1	30	15%	$ 27,600.00
	Road Painters	Yr	$ 1,000	1	30	15%	$ 34,500.00
	Pavement Repair	Yr	$ 4,000	1	30	15%	$ 138,000.00
Sub Total							$ 200,100.00

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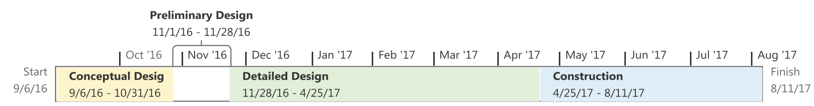
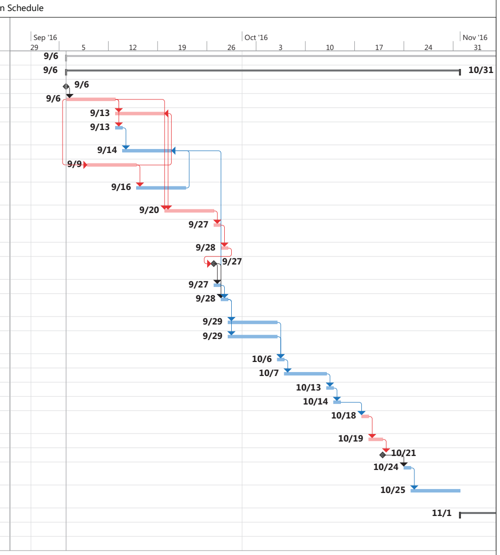
Appendix F: Schedule



CIVL 446 - Detailed Design Schedule

ID	ID	Task Mode	Task Name	Duration	Start	Finish
0	**0**		**CIVL 446 - Detailed Design Schedule**	**243 days**	**Tue 9/6/16**	**Fri 8/11/17**
1	**1**		**1 Conceptual Design**	**40 days**	**Tue 9/6/16**	**Mon 10/31/16**
2	2		1.1 Project Initiation	0 days	Tue 9/6/16	Tue 9/6/16
3	3		1.2 Review client requests, project objectives, and codes	5 days	Tue 9/6/16	Mon 9/12/16
4	4		1.3 Acquire geotechnical reports for intersection soil condition	5 days	Tue 9/13/16	Mon 9/19/16
5	5		1.4 Meeting with team to discuss feedback of clients and develop project plan and approaches	1 day	Tue 9/13/16	Tue 9/13/16
6	6		1.5 Brainstorm period for team to come up with intersection solutions	5 days	Wed 9/14/16	Tue 9/20/16
7	7		1.6 Select structural and geotechnical engineers to conduct analysis on gateway design and ground conditions	5 days	Fri 9/9/16	Thu 9/15/16
8	8		1.7 Development of design to satisfies both UBC and Musquem requirements for gateway (Conceptual)	5 days	Fri 9/16/16	Thu 9/22/16
9	9		1.8 Develop Proposal for client and stakeholders on project deliverables	5 days	Tue 9/20/16	Mon 9/26/16
10	10		1.9 Meeting with client and stakeholders on clarification of scope and additional requests	1 day	Tue 9/27/16	Tue 9/27/16
11	11		1.10 Meeting with team to review and modify Proposal prior to submission	1 day	Wed 9/28/16	Wed 9/28/16
12	12		1.11 Submit Proposal to client and stakeholders for project deliverables and commitments	0 days	Tue 9/27/16	Tue 9/27/16
13	13		1.12 Meeting with client to review Proposal submission	1 day	Tue 9/27/16	Tue 9/27/16
14	14		1.13 Meeting with team to discuss brainstormed ideas and decide on three intersection options to develop	1 day	Wed 9/28/16	Wed 9/28/16
15	15		1.14 Develop options further for chosen three options	5 days	Thu 9/29/16	Wed 10/5/16
16	16		1.15 Develop decision matrix, cost estimate, stakeholder engagement plan for three options for Conceptual Design report	5 days	Thu 9/29/16	Wed 10/5/16
17	17		1.16 Meeting with team to present to each other developed three options	1 day	Thu 10/6/16	Thu 10/6/16
18	18		1.17 Modify three options with suggestions from team meeting	4 days	Fri 10/7/16	Wed 10/12/16
19	19		1.18 Meeting with team to re-present modified three options	1 day	Thu 10/13/16	Thu 10/13/16
20	20		1.19 Modify smaller details regarding three options	1 day	Fri 10/14/16	Fri 10/14/16
21	21		1.20 Meeting with client to present three options and obtain feedback before submission of conceptual design	1 day	Tue 10/18/16	Tue 10/18/16
22	22		1.21 Modify three options with suggestions from client meeting	2 days	Wed 10/19/16	Thu 10/20/16
23	23		1.22 Submit to client and stakeholders Conceptual Design report	0 days	Fri 10/21/16	Fri 10/21/16
24	24		1.23 Present three options and recommended option to pursue to stakeholders and clients	1 day	Mon 10/24/16	Mon 10/24/16
25	25		1.24 Receive feedback from stakeholders and clients on submitted and presented Conceptual Design	5 days	Tue 10/25/16	Mon 10/31/16
26	**26**		**2 Preliminary Design**	**20 days**	**Tue 11/1/16**	**Mon 11/28/16**
41	**41**		**3 Detailed Design**	**107 days**	**Mon 11/28/16**	**Tue 4/25/17**
183	**1...**		**4 Construction**	**77 days**	**Tue 4/25/17**	**Fri 8/11/17**



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Page 1

CIVL 446 - Detailed Design Schedule

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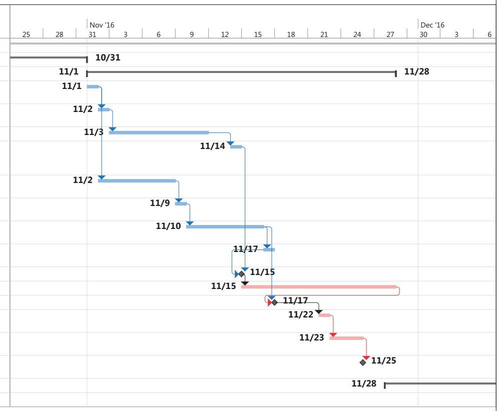
1	**1**		**1 Conceptual Design**	**40 days**	**Tue 9/6/16**	**Mon 10/31/16**
26	**26**		**2 Preliminary Design**	**20 days**	**Tue 11/1/16**	**Mon 11/28/16**
27	27		2.1 Meeting with client to request clarifications on feedback for the Conceptual Design	1 day	Tue 11/1/16	Tue 11/1/16
28	28		2.2 Meet with client, stakeholders and FN on the gateway skeleton design	1 day	Wed 11/2/16	Wed 11/2/16
29	29		2.3 Modify structural design of gateway skeleton	7 days	Thu 11/3/16	Fri 11/11/16
30	30		2.4 Regroup with clients and stakeholders to ensure material cost and structural stability of gateway structure with hypothetical dead loads included	1 day	Mon 11/14/16	Mon 11/14/16
31	31		2.5 Modify and develop further schedule, cost estimates, design and planning of intersection project	5 days	Wed 11/2/16	Tue 11/8/16
32	32		2.6 Meeting with team to present to each other responsible sections	1 day	Wed 11/9/16	Wed 11/9/16
33	33		2.7 Modify Preliminary Design report parts in response to feedback from team members	5 days	Thu 11/10/16	Wed 11/16/16
34	34		2.8 Meeting with client to review progress of Preliminary Design report draft	1 day	Thu 11/17/16	Thu 11/17/16
35	35		2.9 Submit project plan to FN for review (Preliminary)	0 days	Tue 11/15/16	Tue 11/15/16
36	36		2.10 FN review project plan	10 days	Tue 11/15/16	Mon 11/28/16
37	37		2.11 Submit Preliminary Design report draft to client for review	0 days	Thu 11/17/16	Thu 11/17/16
38	38		2.12 Meeting with client to get feedback on Preliminary Design draft report	1 day	Tue 11/22/16	Tue 11/22/16
39	39		2.13 Modify Preliminary Design draft report according to feedback from client	3 days	Wed 11/23/16	Fri 11/25/16
40	40		2.14 Submit Preliminary Design Report to client and stakeholder for approval to go for tender	0 days	Fri 11/25/16	Fri 11/25/16
41	**41**		**3 Detailed Design**	**107 days**	**Mon 11/28/16**	**Tue 4/25/17**
183	**1...**		**4 Construction**	**77 days**	**Tue 4/25/17**	**Fri 8/11/17**



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Page 1

CIVL 446 - Detailed Design Schedule

ID	ID	Task Mode	Task Name	Duration	Start	Finish
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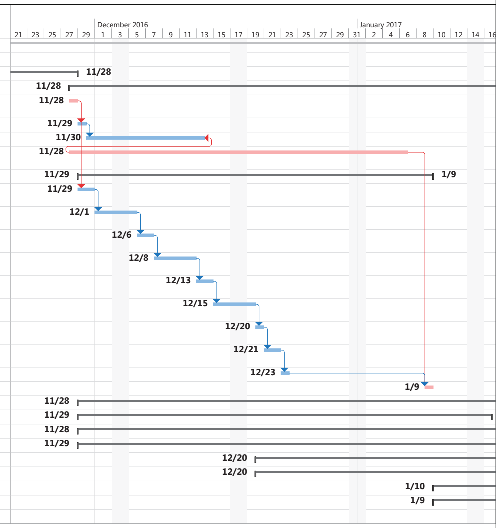
1	**1**		**1 Conceptual Design**	**40 days**	**Tue 9/6/16**	**Mon 10/31/16**
26	**26**		**2 Preliminary Design**	**20 days**	**Tue 11/1/16**	**Mon 11/28/16**
41	**41**		**3 Detailed Design**	**107 days**	**Mon 11/28/16**	**Tue 4/25/17**
42	42		3.1 Meeting with client and stakeholders to discuss modifications to Preliminary Design Report	1 day	Mon 11/28/16	Mon 11/28/16
43	43		3.2 Open house for the community	1 day	Tue 11/29/16	Tue 11/29/16
44	44		3.3 Obtain feedback from community	10 days	Wed 11/30/16	Tue 12/13/16
45	45		3.4 Develop tender package including project scope, recommended approach to project, contracting details, scheduled milestones,	30 days	Mon 11/28/16	Fri 1/6/17
46	**46**		**3.5 Develop design permit and tender drawings**	**30 days**	**Tue 11/29/16**	**Mon 1/9/17**
47	47		3.5.1 Review construction feasibility with structural, electrical and transportation planning team members	2 days	Tue 11/29/16	Wed 11/30/16
48	48		3.5.2 Modify Preliminary Design drawings according to feedback acquired from construction feasibility meeting	3 days	Thu 12/1/16	Mon 12/5/16
49	49		3.5.3 Review safety by construction with structural, electrical and transportation planning team members	2 days	Tue 12/6/16	Wed 12/7/16
50	50		3.5.4 Modify Preliminary Design drawings for design permit and tendering	3 days	Thu 12/8/16	Mon 12/12/16
51	51		3.5.5 Meeting with engineers and operation & management staff on safety by construction designs	2 days	Tue 12/13/16	Wed 12/14/16
52	52		3.5.6 Modify design according to safety by construction review meeting	3 days	Thu 12/15/16	Mon 12/19/16
53	53		3.5.7 Meeting with value engineering group and review permit and tender drawings	1 day	Tue 12/20/16	Tue 12/20/16
54	54		3.5.8 Modify design permit and tender drawings according to value engineering meeting	2 days	Wed 12/21/16	Thu 12/22/16
55	55		3.5.9 Meeting with client and stakeholders on design changes	1 day	Fri 12/23/16	Fri 12/23/16
56	56		3.5.10 Finalize permit and tender drawings	1 day	Mon 1/9/17	Mon 1/9/17
57	**57**		**3.6 Acquisition**	**106 days**	**Mon 11/28/16**	**Tue 4/25/17**
58	**58**		**3.6.1 Documents/Agreement to Musquem Community (FN)**	**35 days**	**Tue 11/29/16**	**Tue 1/17/17**
70	**70**		**3.6.2 Documents/Permits to City of Vancouver (CoV)**	**75 days**	**Mon 11/28/16**	**Mon 3/13/17**
83	**83**		**3.6.3 Project Construction Contractor Acquisition**	**106 days**	**Tue 11/29/16**	**Tue 4/25/17**
110	**1...**		**3.6.4 Pre-Cast Concrete Acquisition**	**23 days**	**Tue 12/20/16**	**Thu 1/19/17**
117	**1...**		**3.6.5 Utility, Trades Services, Equipment Acquisition**	**88 days**	**Tue 12/20/16**	**Thu 4/20/17**
152	**1...**		**3.6.6 Documents/Permits to UBC**	**40 days**	**Tue 1/10/17**	**Mon 3/6/17**
179	**1...**		**3.6.7 Documents/Permits to Ministry of Transportation (MoT)**	**30 days**	**Mon 1/9/17**	**Mon 2/20/17**
183	**1...**		**4 Construction**	**77 days**	**Tue 4/25/17**	**Fri 8/11/17**



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Page 1

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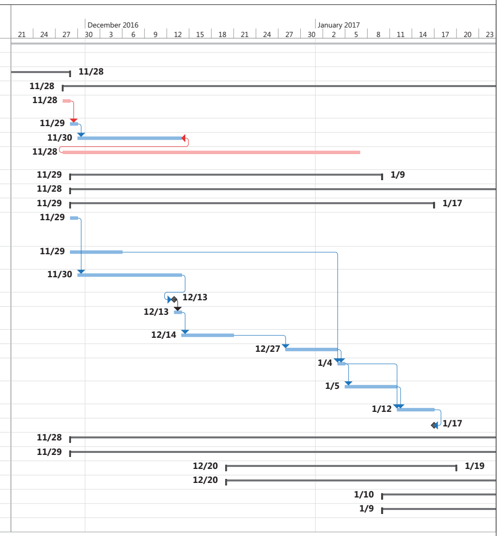
0	0		CIVL 446 - Detailed Design Schedule	243 days	Tue 9/6/16	Fri 8/11/17
1	1		1 Conceptual Design	40 days	Tue 9/6/16	Mon 10/31/16
26	26		2 Preliminary Design	20 days	Tue 11/1/16	Mon 11/28/16
41	41		3 Detailed Design	107 days	Mon 11/28/16	Tue 4/25/17
42	42		3.1 Meeting with client and stakeholders to discuss modifications to Preliminary Design Report	1 day	Mon 11/28/16	Mon 11/28/16
43	43		3.2 Open house for the community	1 day	Tue 11/29/16	Tue 11/29/16
44	44		3.3 Obtain feedback from community	10 days	Wed 11/30/16	Tue 12/13/16
45	45		3.4 Develop tender package including project scope, recommended approach to project, contracting details, scheduled milestones,	30 days	Mon 11/28/16	Fri 1/6/17
46	46		3.5 Develop design permit and tender drawings	30 days	Tue 11/29/16	Mon 1/9/17
57	57		3.6 Acquisition	106 days	Mon 11/28/16	Tue 4/25/17
58	58		3.6.1 Documents/Agreement to Musquem Community (FN)	35 days	Tue 11/29/16	Tue 1/17/17
59	59		3.6.1.1 Open house for FN to discuss modifications and opinions on how to design gateway totem and carvings for thunderbird statue	1 day	Tue 11/29/16	Tue 11/29/16
60	60		3.6.1.2 Meeting with different age groups of FN to discuss opinion on project	5 days	Tue 11/29/16	Mon 12/5/16
61	61		3.6.1.3 Modify intersection and gateway design according to FN opinion and suggestions	10 days	Wed 11/30/16	Tue 12/13/16
62	62		3.6.1.4 Submit to FN changed project plan details (Detailed)	0 days	Tue 12/13/16	Tue 12/13/16
63	63		3.6.1.5 Meeting with FN to see if any more changes needed to be made for project plan	1 day	Tue 12/13/16	Tue 12/13/16
64	64		3.6.1.6 Modify design once again with FN's comments	5 days	Wed 12/14/16	Tue 12/20/16
65	65		3.6.1.7 Submit final designs	5 days	Tue 12/27/16	Tue 1/3/17
66	66		3.6.1.8 Agreement with FN on design and representation of FN at intersection	1 day	Wed 1/4/17	Wed 1/4/17
67	67		3.6.1.9 Acquire quotation for material, construction and supervision costs	5 days	Thu 1/5/17	Wed 1/11/17
68	68		3.6.1.10 Evaluate quotation for services, equipment, schedule	3 days	Thu 1/12/17	Mon 1/16/17
69	69		3.6.1.11 Agreement with Musquems on pricing	0 days	Tue 1/17/17	Tue 1/17/17
70	70		3.6.2 Documents/Permits to City of Vancouver (CoV)	75 days	Mon 11/28/16	Mon 3/13/17
83	83		3.6.3 Project Construction Contractor Acquisition	106 days	Tue 11/29/16	Tue 4/25/17
110	1...		3.6.4 Pre-Cast Concrete Acquisition	23 days	Tue 12/20/16	Thu 1/19/17
117	1...		3.6.5 Utility, Trades Services, Equipment Acquisition	88 days	Tue 12/20/16	Thu 4/20/17
152	1...		3.6.6 Documents/Permits to UBC	40 days	Tue 1/10/17	Mon 3/6/17
179	1...		3.6.7 Documents/Permits to Ministry of Transportation (MoT)	30 days	Mon 1/9/17	Mon 2/20/17
183	1...		4 Construction	77 days	Tue 4/25/17	Fri 8/11/17



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44	44		3.3 Obtain feedback from community	10 days	Wed 11/30/16	Tue 12/13/16
45	45		3.4 Develop tender package including project scope, recommended approach to project, contracting details, scheduled milestones,	30 days	Mon 11/28/16	Fri 1/6/17
46	46		3.5 Develop design permit and tender drawings	30 days	Tue 11/29/16	Mon 1/9/17
57	57		3.6 Acquisition	106 days	Mon 11/28/16	Tue 4/25/17
58	58		3.6.1 Documents/Agreement to Musquem Community (FN)	35 days	Tue 11/29/16	Tue 1/17/17
70	70		3.6.2 Documents/Permits to City of Vancouver (CoV)	75 days	Mon 11/28/16	Mon 3/13/17
71	71		3.6.2.1 CoV Business License	15 days	Mon 11/28/16	Mon 12/19/16
72	72		3.6.2.1.1 Submit business license to conduct construction CoV	0 days	Mon 11/28/16	Mon 11/28/16
73	73		3.6.2.1.2 CoV review business license	15 days	Tue 11/29/16	Mon 12/19/16
74	74		3.6.2.1.3 Approval from CoV on business license	0 days	Mon 12/19/16	Mon 12/19/16
75	75		3.6.2.2 CoV Construction Permit	30 days	Mon 1/9/17	Mon 2/20/17
76	76		3.6.2.2.1 Submit construction permits to the CoV	0 days	Mon 1/9/17	Mon 1/9/17
77	77		3.6.2.2.2 CoV review construction permits	30 days	Tue 1/10/17	Mon 2/20/17
78	78		3.6.2.2.3 Approval from CoV on construction permits	0 days	Mon 2/20/17	Mon 2/20/17
79	79		3.6.2.3 CoV Sidewalk and Landscaping Permit	15 days	Mon 2/20/17	Mon 3/13/17
80	80		3.6.2.3.1 Submit Sidwalk and Landscaping permit to CoV	0 days	Mon 2/20/17	Mon 2/20/17
81	81		3.6.2.3.2 CoV review Sidewalk and Landscaping permit	15 days	Tue 2/21/17	Mon 3/13/17
82	82		3.6.2.3.3 Approval from CoV on Sidewalk and Landscaping permits	0 days	Mon 3/13/17	Mon 3/13/17
83	83		3.6.3 Project Construction Contractor Acquisition	106 days	Tue 11/29/16	Tue 4/25/17
110	1...		3.6.4 Pre-Cast Concrete Acquisition	23 days	Tue 12/20/16	Thu 1/19/17
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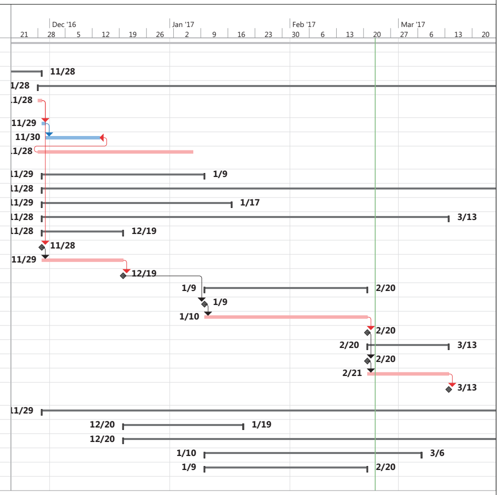

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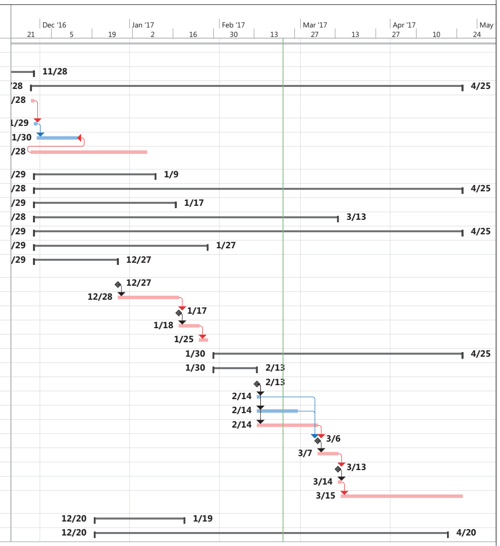
57	**57**		**3.6 Acquisition**	**106 days**	**Mon 11/28/16**	**Tue 4/25/17**
58	**58**		**3.6.1 Documents/Agreement to Musquem Community (FN)**	**35 days**	**Tue 11/29/16**	**Tue 1/17/17**
70	**70**		**3.6.2 Documents/Permits to City of Vancouver (CoV)**	**75 days**	**Mon 11/28/16**	**Mon 3/13/17**
83	**83**		**3.6.3 Project Construction Contractor Acquisition**	**106 days**	**Tue 11/29/16**	**Tue 4/25/17**
84	**84**		**3.6.3.1 Qualify Contractors for Project**	**44 days**	**Tue 11/29/16**	**Fri 1/27/17**
85	**85**		**3.6.3.1.1 Develop Request for Qualifications (RFQ) Specifications and Documents**	**21 days**	**Tue 11/29/16**	**Tue 12/27/16**
90	90		3.6.3.1.2 RFQ Opens	0 days	Tue 12/27/16	Tue 12/27/16
91	91		3.6.3.1.3 Acquire RFQ	15 days	Wed 12/28/16	Tue 1/17/17
92	92		3.6.3.1.4 RFQ Closes	0 days	Tue 1/17/17	Tue 1/17/17
93	93		3.6.3.1.5 Evaluation of RFQs	5 days	Wed 1/18/17	Tue 1/24/17
94	94		3.6.3.1.6 Create short list of contractors from evaluated RFQs	3 days	Wed 1/25/17	Fri 1/27/17
95	**95**		**3.6.3.2 Tender/Bid Project**	**62 days**	**Mon 1/30/17**	**Tue 4/25/17**
96	**96**		**3.6.3.2.1 Develop Tender Specifications and Documents**	**11 days**	**Mon 1/30/17**	**Mon 2/13/17**
101	1...		3.6.3.2.2 Bid Opens on BCBids	0 days	Mon 2/13/17	Mon 2/13/17
102	1...		3.6.3.2.3 Site Visit for contractors	1 day	Tue 2/14/17	Tue 2/14/17
103	1...		3.6.3.2.4 Q & A period for contractos	10 days	Tue 2/14/17	Mon 2/27/17
104	1...		3.6.3.2.5 Acquire Request for Proposal (RFP) for project construction	15 days	Tue 2/14/17	Mon 3/6/17
105	1...		3.6.3.2.6 Bid Closes	0 days	Mon 3/6/17	Mon 3/6/17
106	1...		3.6.3.2.7 Evaluation of Proposals for project construction	5 days	Tue 3/7/17	Mon 3/13/17
107	1...		3.6.3.2.8 Award project to qualified contractor	0 days	Mon 3/13/17	Mon 3/13/17
108	1...		3.6.3.2.9 Meet with contractors to discuss construction and subcontr	1 day	Tue 3/14/17	Tue 3/14/17
109	1...		3.6.3.2.10 Review and edit costs, supply list, schedules and subcontractors and their qualifications	30 days	Wed 3/15/17	Tue 4/25/17
110	**1...**		**3.6.4 Pre-Cast Concrete Acquisition**	**23 days**	**Tue 12/20/16**	**Thu 1/19/17**
117	**1...**		**3.6.5 Utility, Trades Services, Equipment Acquisition**	**88 days**	**Tue 12/20/16**	**Thu 4/20/17**



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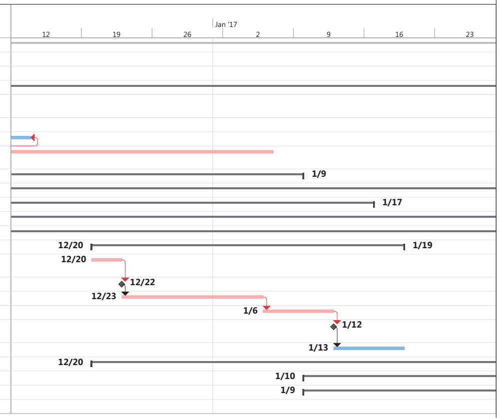
Page 1

CIVL 446 - Detailed Design Schedule

ID	ID	Task Mode	Task Name	Duration	Start	Finish
0	**0**		**CIVL 446 - Detailed Design Schedule**	**243 days**	**Tue 9/6/16**	**Fri 8/11/17**
1	**1**		**1 Conceptual Design**	**40 days**	**Tue 9/6/16**	**Mon 10/31/16**
26	**26**		**2 Preliminary Design**	**20 days**	**Tue 11/1/16**	**Mon 11/28/16**
41	**41**		**3 Detailed Design**	**107 days**	**Mon 11/28/16**	**Tue 4/25/17**
42	42		3.1 Meeting with client and stakeholders to discuss modifications to Preliminary Design Report	1 day	Mon 11/28/16	Mon 11/28/16
43	43		3.2 Open house for the community	1 day	Tue 11/29/16	Tue 11/29/16
44	44		3.3 Obtain feedback from community	10 days	Wed 11/30/16	Tue 12/13/16
45	45		3.4 Develop tender package including project scope, recommended approach to project, contracting details, scheduled milestones,	30 days	Mon 11/28/16	Fri 1/6/17
46	**46**		**3.5 Develop design permit and tender drawings**	**30 days**	**Tue 11/29/16**	**Mon 1/9/17**
57	**57**		**3.6 Acquisition**	**106 days**	**Mon 11/28/16**	**Tue 4/25/17**
58	**58**		**3.6.1 Documents/Agreement to Musquem Community (FN)**	**35 days**	**Tue 11/29/16**	**Tue 1/17/17**
70	**70**		**3.6.2 Documents/Permits to City of Vancouver (CoV)**	**75 days**	**Mon 11/28/16**	**Mon 3/13/17**
83	**83**		**3.6.3 Project Construction Contractor Acquisition**	**106 days**	**Tue 11/29/16**	**Tue 4/25/17**
110	**1...**		**3.6.4 Pre-Cast Concrete Acquisition**	**23 days**	**Tue 12/20/16**	**Thu 1/19/17**
111	1...		3.6.4.1 Research of pre-cast concrete companies that make roundabout/road installment features	3 days	Tue 12/20/16	Thu 12/22/16
112	1...		3.6.4.2 Issue Bid Proposal for pre-cast concrete services	0 days	Thu 12/22/16	Thu 12/22/16
113	1...		3.6.4.3 Acquire proposals for pre-cast concrete services	10 days	Fri 12/23/16	Thu 1/5/17
114	1...		3.6.4.4 Evaluation of proposals for pre-cast concrete services	5 days	Fri 1/6/17	Thu 1/12/17
115	1...		3.6.4.5 Award pre-cast concrete services to qualitified contractors	0 days	Thu 1/12/17	Thu 1/12/17
116	1...		3.6.4.6 Schedule for pre-cast concrete supplies and services	5 days	Fri 1/13/17	Thu 1/19/17
117	**1...**		**3.6.5 Utility, Trades Services, Equipment Acquisition**	**88 days**	**Tue 12/20/16**	**Thu 4/20/17**
152	**1...**		**3.6.6 Documents/Permits to UBC**	**40 days**	**Tue 1/10/17**	**Mon 3/6/17**
179	**1...**		**3.6.7 Documents/Permits to Ministry of Transportation (MoT)**	**30 days**	**Mon 1/9/17**	**Mon 2/20/17**
183	**1...**		**4 Construction**	**77 days**	**Tue 4/25/17**	**Fri 8/11/17**



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Page 1

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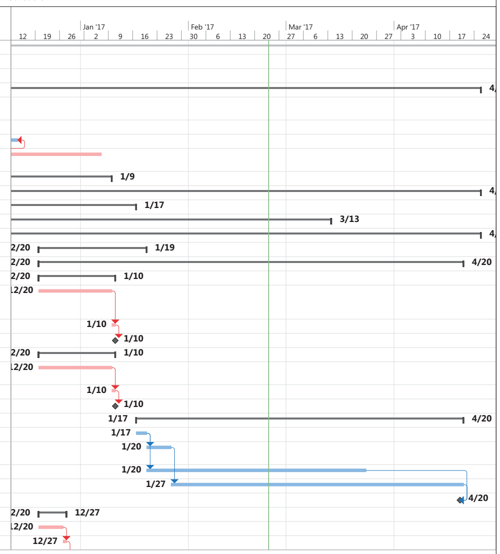
ID	ID	Task Mode	Task Name	Duration	Start	Finish
0	**0**		**CIVL 446 - Detailed Design Schedule**	**243 days**	**Tue 9/6/16**	**Fri 8/11/17**
1	**1**		**1 Conceptual Design**	**40 days**	**Tue 9/6/16**	**Mon 10/31/16**
26	**26**		**2 Preliminary Design**	**20 days**	**Tue 11/1/16**	**Mon 11/28/16**
41	**41**		**3 Detailed Design**	**107 days**	**Mon 11/28/16**	**Tue 4/25/17**
42	42		3.1 Meeting with client and stakeholders to discuss modifications to Preliminary Design Report	1 day	Mon 11/28/16	Mon 11/28/16
43	43		3.2 Open house for the community	1 day	Tue 11/29/16	Tue 11/29/16
44	44		3.3 Obtain feedback from community	10 days	Wed 11/30/16	Tue 12/13/16
45	45		3.4 Develop tender package including project scope, recommended approach to project, contracting details, scheduled milestones,	30 days	Mon 11/28/16	Fri 1/6/17
46	**46**		**3.5 Develop design permit and tender drawings**	**30 days**	**Tue 11/29/16**	**Mon 1/9/17**
57	**57**		**3.6 Acquisition**	**106 days**	**Mon 11/28/16**	**Tue 4/25/17**
58	**58**		**3.6.1 Documents/Agreement to Musquem Community (FN)**	**35 days**	**Tue 11/29/16**	**Tue 1/17/17**
70	**70**		**3.6.2 Documents/Permits to City of Vancouver (CoV)**	**75 days**	**Mon 11/28/16**	**Mon 3/13/17**
83	**83**		**3.6.3 Project Construction Contractor Acquisition**	**106 days**	**Tue 11/29/16**	**Tue 4/25/17**
110	**1...**		**3.6.4 Pre-Cast Concrete Acquisition**	**23 days**	**Tue 12/20/16**	**Thu 1/19/17**
117	**1...**		**3.6.5 Utility, Trades Services, Equipment Acquisition**	**88 days**	**Tue 12/20/16**	**Thu 4/20/17**
118	**1...**		**3.6.5.1 Rain Garden Contractor**	**16 days**	**Tue 12/20/16**	**Tue 1/10/17**
119	1...		3.6.5.1.1 Acquire quotation of certified rain garden design specialists to install underground cistern, develop a sand and bog filtration system and install drip irrigation	15 days	Tue 12/20/16	Mon 1/9/17
120	1...		3.6.5.1.2 Evaluate quotation for services, equipment, schedule	1 day	Tue 1/10/17	Tue 1/10/17
121	1...		3.6.5.1.3 Award contract for work	0 days	Tue 1/10/17	Tue 1/10/17
122	**1...**		**3.6.5.2 Stormwater System Contractor**	**16 days**	**Tue 12/20/16**	**Tue 1/10/17**
123	1...		3.6.5.2.1 Acquire quotation for shoring and tapping in to stormwater drainage system at UBC	15 days	Tue 12/20/16	Mon 1/9/17
124	1...		3.6.5.2.2 Evaluate quotation for services, equipment, schedule	1 day	Tue 1/10/17	Tue 1/10/17
125	1...		3.6.5.2.3 Award contract for work	0 days	Tue 1/10/17	Tue 1/10/17
126	**1...**		**3.6.5.3 Musquem Gateway Structure**	**68 days**	**Tue 1/17/17**	**Thu 4/20/17**
127	1...		3.6.5.3.1 Send structural design to metal fabrication company	3 days	Tue 1/17/17	Thu 1/19/17
128	1...		3.6.5.3.2 Send structural design to Musquem group to start carving totem structure and Thunderbird statue	5 days	Fri 1/20/17	Thu 1/26/17
129	1...		3.6.5.3.3 Prefabrication of structural elements	45 days	Fri 1/20/17	Thu 3/23/17
130	1...		3.6.5.3.4 Prefabrication of totem and Thunderbird carvings	60 days	Fri 1/27/17	Thu 4/20/17
131	1...		3.6.5.3.5 Prefabrication of steel and Musquem parts complete	0 days	Thu 4/20/17	Thu 4/20/17
132	**1...**		**3.6.5.4 Landscape Contractors**	**6 days**	**Tue 12/20/16**	**Tue 12/27/16**
133	1...		3.6.5.4.1 Acquire quotation from UBC used landscape contractors	5 days	Tue 12/20/16	Mon 12/26/16
134	1...		3.6.5.4.2 Evaluate quotation for services, equipment, schedule	1 day	Tue 12/27/16	Tue 12/27/16



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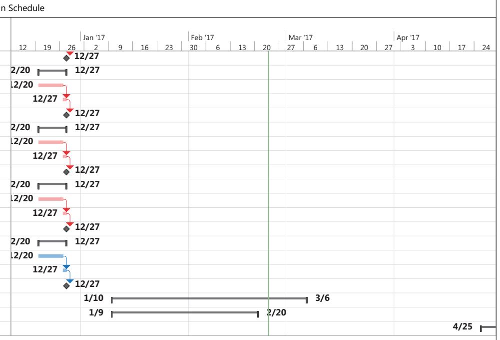
Page 1

CIVL 446 - Detailed Design Schedule

ID	ID	Task Mode	Task Name	Duration	Start	Finish
135	1...		3.6.5.4.3 Award contract for work	0 days	Tue 12/27/16	Tue 12/27/16
136	**1...**		**3.6.5.5 Lamp Post Installers**	**6 days**	**Tue 12/20/16**	**Tue 12/27/16**
137	1...		3.6.5.5.1 Acquire quotation from UBC used campus lighting contractc	5 days	Tue 12/20/16	Mon 12/26/16
138	1...		3.6.5.5.2 Evaluate quotation for services, equipment, schedule	1 day	Tue 12/27/16	Tue 12/27/16
139	1...		3.6.5.5.3 Award contract for work	0 days	Tue 12/27/16	Tue 12/27/16
140	**1...**		**3.6.5.6 Pedestrian Cross Walk Lighting Infrastructure Contractor**	**6 days**	**Tue 12/20/16**	**Tue 12/27/16**
141	1...		3.6.5.6.1 Acquire quotation from UBC used pedestrian sidewalk lighti	5 days	Tue 12/20/16	Mon 12/26/16
142	1...		3.6.5.6.2 Evaluate quotation for services, equipment, schedule	1 day	Tue 12/27/16	Tue 12/27/16
143	1...		3.6.5.6.3 Award contract for work	0 days	Tue 12/27/16	Tue 12/27/16
144	**1...**		**3.6.5.7 Line Painting Contractor**	**6 days**	**Tue 12/20/16**	**Tue 12/27/16**
145	1...		3.6.5.7.1 Acquire quotation from UBC used line paint contractors	5 days	Tue 12/20/16	Mon 12/26/16
146	1...		3.6.5.7.2 Evaluate quotation for services, equipment, schedule	1 day	Tue 12/27/16	Tue 12/27/16
147	1...		3.6.5.7.3 Award contract for work	0 days	Tue 12/27/16	Tue 12/27/16
148	**1...**		**3.6.5.8 Surveyors**	**6 days**	**Tue 12/20/16**	**Tue 12/27/16**
149	1...		3.6.5.8.1 Acquire quotation from CoV and UBC used surveyors	5 days	Tue 12/20/16	Mon 12/26/16
150	1...		3.6.5.8.2 Evaluate quotation for services, equipment, schedule	1 day	Tue 12/27/16	Tue 12/27/16
151	1...		3.6.5.8.3 Award contract for work	0 days	Tue 12/27/16	Tue 12/27/16
152	**1...**		**3.6.6 Documents/Permits to UBC**	**40 days**	**Tue 1/10/17**	**Mon 3/6/17**
179	**1...**		**3.6.7 Documents/Permits to Ministry of Transportation (MoT)**	**30 days**	**Mon 1/9/17**	**Mon 2/20/17**
183	**1...**		**4 Construction**	**77 days**	**Tue 4/25/17**	**Fri 8/11/17**



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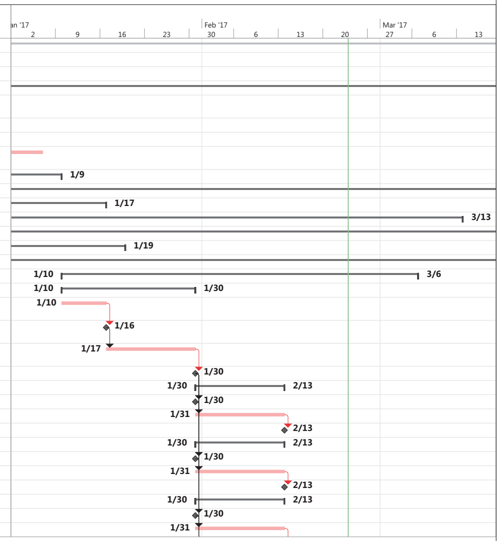
Page 2

CIVL 446 - Detailed Design Schedule

ID	ID	Task Mode	Task Name	Duration	Start	Finish
0	**0**		**CIVL 446 - Detailed Design Schedule**	**243 days**	**Tue 9/6/16**	**Fri 8/11/17**
1	**1**		**1 Conceptual Design**	**40 days**	**Tue 9/6/16**	**Mon 10/31/16**
26	**26**		**2 Preliminary Design**	**20 days**	**Tue 11/1/16**	**Mon 11/28/16**
41	**41**		**3 Detailed Design**	**107 days**	**Mon 11/28/16**	**Tue 4/25/17**
42	42		3.1 Meeting with client and stakeholders to discuss modifications to Preliminary Design Report	1 day	Mon 11/28/16	Mon 11/28/16
43	43		3.2 Open house for the community	1 day	Tue 11/29/16	Tue 11/29/16
44	44		3.3 Obtain feedback from community	10 days	Wed 11/30/16	Tue 12/13/16
45	45		3.4 Develop tender package including project scope, recommended approach to project, contracting details, scheduled milestones,	30 days	Mon 11/28/16	Fri 1/6/17
46	**46**		**3.5 Develop design permit and tender drawings**	**30 days**	**Tue 11/29/16**	**Mon 1/9/17**
57	**57**		**3.6 Acquisition**	**106 days**	**Mon 11/28/16**	**Tue 4/25/17**
58	**58**		**3.6.1 Documents/Agreement to Musquem Community (FN)**	**35 days**	**Tue 11/29/16**	**Tue 1/17/17**
70	**70**		**3.6.2 Documents/Permits to City of Vancouver (CoV)**	**75 days**	**Mon 11/28/16**	**Mon 3/13/17**
83	**83**		**3.6.3 Project Construction Contractor Acquisition**	**106 days**	**Tue 11/29/16**	**Tue 4/25/17**
110	**1...**		**3.6.4 Pre-Cast Concrete Acquisition**	**23 days**	**Tue 12/20/16**	**Thu 1/19/17**
117	**1...**		**3.6.5 Utility, Trades Services, Equipment Acquisition**	**88 days**	**Tue 12/20/16**	**Thu 4/20/17**
152	**1...**		**3.6.6 Documents/Permits to UBC**	**40 days**	**Tue 1/10/17**	**Mon 3/6/17**
153	**1...**		**3.6.6.1 UBC Board of Governors - Recommendation Report**	**15 days**	**Tue 1/10/17**	**Mon 1/30/17**
154	1...		3.6.6.1.1 Develop Recommendation Report to UBC Board of Governors	5 days	Tue 1/10/17	Mon 1/16/17
155	1...		3.6.6.1.2 Submit Recommendation Report to UBC Board of Governors	0 days	Mon 1/16/17	Mon 1/16/17
156	1...		3.6.6.1.3 UBC Board of Governors review project recommendations	10 days	Tue 1/17/17	Mon 1/30/17
157	1...		3.6.6.1.4 Approval from UBC Board of Governors	0 days	Mon 1/30/17	Mon 1/30/17
158	**1...**		**3.6.6.2 UBC Construction Permit**	**10 days**	**Mon 1/30/17**	**Mon 2/13/17**
159	1...		3.6.6.2.1 Submit construction permits to UBC	0 days	Mon 1/30/17	Mon 1/30/17
160	1...		3.6.6.2.2 UBC review construction permit	10 days	Tue 1/31/17	Mon 2/13/17
161	1...		3.6.6.2.3 Approval of construction permit from UBC	0 days	Mon 2/13/17	Mon 2/13/17
162	**1...**		**3.6.6.3 UBC Street and Landscape Permit**	**10 days**	**Mon 1/30/17**	**Mon 2/13/17**
163	1...		3.6.6.3.1 Submit Streen and Landscape permit to UBC	0 days	Mon 1/30/17	Mon 1/30/17
164	1...		3.6.6.3.2 UBC review Street and Landscape permit	10 days	Tue 1/31/17	Mon 2/13/17
165	1...		3.6.6.3.3 Approval of Street and Landscape permit	0 days	Mon 2/13/17	Mon 2/13/17
166	**1...**		**3.6.6.4 UBC Noise Regulation Variance Application**	**10 days**	**Mon 1/30/17**	**Mon 2/13/17**
167	1...		3.6.6.4.1 Submit Noise Regulation Variance Application to UBC	0 days	Mon 1/30/17	Mon 1/30/17
168	1...		3.6.6.4.2 UBC review Noise Regulation Variance Application	10 days	Tue 1/31/17	Mon 2/13/17



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Page 1

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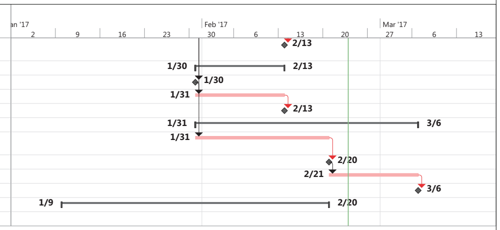
ID	ID	Task Mode	Task Name	Duration	Start	Finish
169	1...		3.6.6.4.3 Approval of Noise Regulation Variance Application from UBC	0 days	Mon 2/13/17	Mon 2/13/17
170	**1...**		**3.6.6.5 UBC Energy and Water Utility Plan**	**10 days**	**Mon 1/30/17**	**Mon 2/13/17**
171	1...		3.6.6.5.1 Submit energy and water utility plan to UBC	0 days	Mon 1/30/17	Mon 1/30/17
172	1...		3.6.6.5.2 UBC review energy and water utiliy plan	10 days	Tue 1/31/17	Mon 2/13/17
173	1...		3.6.6.5.3 Approval of energy and water utility plan	0 days	Mon 2/13/17	Mon 2/13/17
174	**1...**		**3.6.6.6 UBC Traffic Control Plan of Goods**	**25 days**	**Tue 1/31/17**	**Mon 3/6/17**
175	1...		3.6.6.6.1 Develop traffic control plans for delivery of equipment and supplies for project	15 days	Tue 1/31/17	Mon 2/20/17
176	1...		3.6.6.6.2 Submit traffic control plans to UBC	0 days	Mon 2/20/17	Mon 2/20/17
177	1...		3.6.6.6.3 UBC review traffic control plans	10 days	Tue 2/21/17	Mon 3/6/17
178	1...		3.6.6.6.4 Approval from UBC on traffic control plans	0 days	Mon 3/6/17	Mon 3/6/17
179	**1...**		**3.6.7 Documents/Permits to Ministry of Transportation (MoT)**	**30 days**	**Mon 1/9/17**	**Mon 2/20/17**
183	**1...**		**4 Construction**	**77 days**	**Tue 4/25/17**	**Fri 8/11/17**



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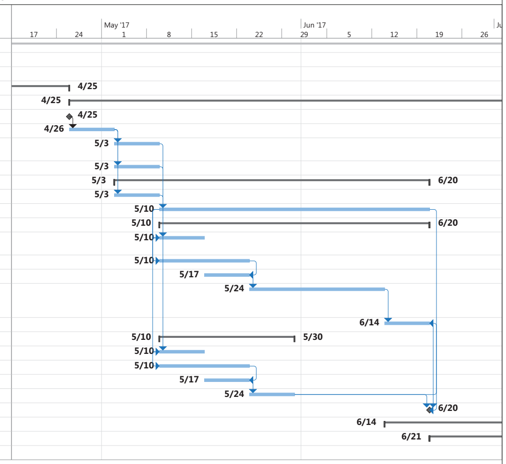
Page 2

CIVL 446 - Detailed Design Schedule

ID	ID	Task Mode	Task Name	Duration	Start	Finish
0	**0**		**CIVL 446 - Detailed Design Schedule**	**245 days**	**Tue 9/6/16**	**Mon 8/14/17**
1	**1**		**1 Conceptual Design**	**40 days**	**Tue 9/6/16**	**Mon 10/31/16**
26	**26**		**2 Preliminary Design**	**20 days**	**Tue 11/1/16**	**Mon 11/28/16**
41	**41**		**3 Detailed Design**	**107 days**	**Mon 11/28/16**	**Tue 4/25/17**
183	**1...**		**4 Construction**	**79 days**	**Tue 4/25/17**	**Mon 8/14/17**
184	1...		4.1 Commence Construction	0 days	Tue 4/25/17	Tue 4/25/17
185	1...		4.2 Mobilize construction crew and project staff trailers	5 days	Wed 4/26/17	Tue 5/2/17
186	1...		4.3 Rain Garden material arrive (cistern, drip irrigation piping, stormwater connection piping, sand, bog material, filter membrane)	5 days	Wed 5/3/17	Tue 5/9/17
187	1...		4.4 Light Fixture material arrive (Lamp posts, electrical conduits)	5 days	Wed 5/3/17	Tue 5/9/17
188	**1...**		**4.5 Phase 1 - Sidewalks, Bike Lanes, Electrical Routing**	**35 days**	**Wed 5/3/17**	**Tue 6/20/17**
189	1...		4.5.1 Put signage to warn road users of scheduled construction	5 days	Wed 5/3/17	Tue 5/9/17
190	1...		4.5.2 Reroute traffic for Phase 1 installation of sidewalks and bike lanes	30 days	Wed 5/10/17	Tue 6/20/17
191	**1...**		**4.5.3 P1 - Sidewalk, Bike Lane, Rain Garden**	**30 days**	**Wed 5/10/17**	**Tue 6/20/17**
192	1...		4.5.3.1 Excavate for access to sewage system for stormwater garden on sidewalk	5 days	Wed 5/10/17	Tue 5/16/17
193	1...		4.5.3.2 Shoring activity to prevent soil from sliding back into excavated	10 days	Wed 5/10/17	Tue 5/23/17
194	1...		4.5.3.3 Tap into stormwater system to help facilitate better drainage	5 days	Wed 5/17/17	Tue 5/23/17
195	1...		4.5.3.4 Install localized rain garden between sidewalk and bike lanes (plastic piping to allow water to filter into stormwater system, sand filter, local vegetation)	15 days	Wed 5/24/17	Tue 6/13/17
196	1...		4.5.3.5 Pave sidewalk and bike lanes	5 days	Wed 6/14/17	Tue 6/20/17
197	**1...**		**4.5.4 P1 -Sidewalk Lamps**	**15 days**	**Wed 5/10/17**	**Tue 5/30/17**
198	1...		4.5.4.1 Excavate for access to power supply for light fixtures	5 days	Wed 5/10/17	Tue 5/16/17
199	1...		4.5.4.2 Shoring activity to prevent soil from sliding back into excavated	10 days	Wed 5/10/17	Tue 5/23/17
200	2...		4.5.4.3 Pull power cables from UBC source	5 days	Wed 5/17/17	Tue 5/23/17
201	2...		4.5.4.4 Erect street light posts and power	5 days	Wed 5/24/17	Tue 5/30/17
202	2...		4.5.5 Phase 1 Complete - Open sidewalks for use by public	0 days	Tue 6/20/17	Tue 6/20/17
203	**2...**		**4.6 Phase 2 - Roundabout**	**38 days**	**Wed 6/14/17**	**Fri 8/4/17**
238	**2...**		**4.7 Phase 3 - Finishes**	**39 days**	**Wed 6/21/17**	**Mon 8/14/17**
244	2...		4.8 Construction Complete	0 days	Fri 8/11/17	Fri 8/11/17



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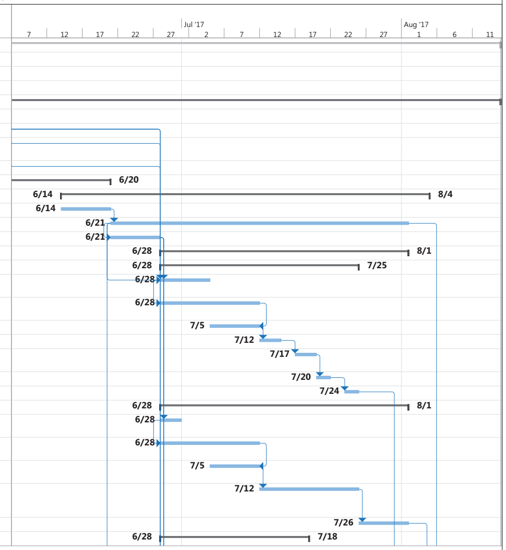
Page 1

CIVL 446 - Detailed Design Schedule

ID	ID	Task Mode	Task Name	Duration	Start	Finish
0	**0**		**CIVL 446 - Detailed Design Schedule**	**245 days**	**Tue 9/6/16**	**Mon 8/14/17**
1	**1**		**1 Conceptual Design**	**40 days**	**Tue 9/6/16**	**Mon 10/31/16**
26	**26**		**2 Preliminary Design**	**20 days**	**Tue 11/1/16**	**Mon 11/28/16**
41	**41**		**3 Detailed Design**	**107 days**	**Mon 11/28/16**	**Tue 4/25/17**
183	**1...**		**4 Construction**	**79 days**	**Tue 4/25/17**	**Mon 8/14/17**
184	1...		4.1 Commence Construction	0 days	Tue 4/25/17	Tue 4/25/17
185	1...		4.2 Mobilize construction crew and project staff trailers	5 days	Wed 4/26/17	Tue 5/2/17
186	1...		4.3 Rain Garden material arrive (cistern, drip irrigation piping, stormwater connection piping, sand, bog material, filter membrane)	5 days	Wed 5/3/17	Tue 5/9/17
187	1...		4.4 Light Fixture material arrive (Lamp posts, electrical conduits)	5 days	Wed 5/3/17	Tue 5/9/17
188	**1...**		**4.5 Phase 1 - Sidewalks, Bike Lanes, Electrical Routing**	**35 days**	**Wed 5/3/17**	**Tue 6/20/17**
203	**2...**		**4.6 Phase 2 - Roundabout**	**38 days**	**Wed 6/14/17**	**Fri 8/4/17**
204	2...		4.6.1 Put signage to warn road users of scheduled construction	5 days	Wed 6/14/17	Tue 6/20/17
205	2...		4.6.2 Reroute traffic for Phase 2 removal of intersection islands	30 days	Wed 6/21/17	Tue 8/1/17
206	2...		4.6.3 Remove intersection islands (center and roadway medians)	5 days	Wed 6/21/17	Tue 6/27/17
207	**2...**		**4.6.4 P2 - Rain Garden**	**25 days**	**Wed 6/28/17**	**Tue 8/1/17**
208	**2...**		**4.6.4.1 Roundabout Rain Garden**	**20 days**	**Wed 6/28/17**	**Tue 7/25/17**
209	2...		4.6.4.1.1 Excavate ground to access sewage system for stormwater cistern overflow	5 days	Wed 6/28/17	Tue 7/4/17
210	2...		4.6.4.1.2 Shoring activity to prevent soil from sliding back into excavated pit	10 days	Wed 6/28/17	Tue 7/11/17
211	2...		4.6.4.1.3 Install rain garden cistern system and drip irrigation piping	5 days	Wed 7/5/17	Tue 7/11/17
212	2...		4.6.4.1.4 Install filter membrane around drip irrigation piping	3 days	Wed 7/12/17	Fri 7/14/17
213	2...		4.6.4.1.5 Install settling gauge to measure changes in ground movement during operation	3 days	Mon 7/17/17	Wed 7/19/17
214	2...		4.6.4.1.6 Install bog filtration system	2 days	Thu 7/20/17	Fri 7/21/17
215	2...		4.6.4.1.7 Install sand filtration system	2 days	Mon 7/24/17	Tue 7/25/17
216	**2...**		**4.6.4.2 Roadway Median Rain Garden**	**25 days**	**Wed 6/28/17**	**Tue 8/1/17**
217	2...		4.6.4.2.1 Excavate for access to sewage system for stormwater garden	3 days	Wed 6/28/17	Fri 6/30/17
218	2...		4.6.4.2.2 Shoring activity to prevent soil from sliding back into excavated pit	10 days	Wed 6/28/17	Tue 7/11/17
219	2...		4.6.4.2.3 Tap into stormwater system to help facilitate better drainage	5 days	Wed 7/5/17	Tue 7/11/17
220	2...		4.6.4.2.4 Install localized rain garden (plastic piping to allow water to filter into stormwater system, sand filter, local vegetation)	10 days	Wed 7/12/17	Tue 7/25/17
221	2...		4.6.4.2.5 Pave sidewalk	5 days	Wed 7/26/17	Tue 8/1/17
222	**2...**		**4.6.5 P2 - Sidwalk Lamps**	**15 days**	**Wed 6/28/17**	**Tue 7/18/17**



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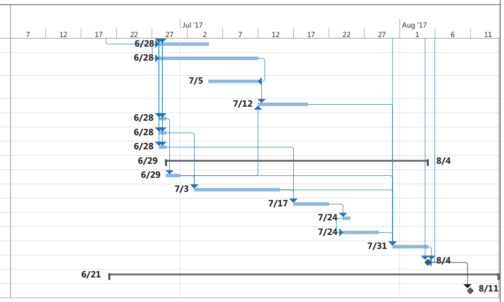
Page 1

CIVL 446 - Detailed Design Schedule

ID	ID	Task Mode	Task Name	Duration	Start	Finish
223	2...		4.6.5.1 Excavate ground to access power supply for light fixtures	5 days	Wed 6/28/17	Tue 7/4/17
224	2...		4.6.5.2 Shoring activity to prevent soil from sliding back into excavated pit	10 days	Wed 6/28/17	Tue 7/11/17
225	2...		4.6.5.3 Install power supply connections for pedestrian island edge lights	5 days	Wed 7/5/17	Tue 7/11/17
226	2...		4.6.5.4 Install pedestrian island edge light fixtures	5 days	Wed 7/12/17	Tue 7/18/17
227	2...		4.6.6 Pre-Cast concrete roundabout island material arrives	1 day	Wed 6/28/17	Wed 6/28/17
228	2...		4.6.7 Musquem Totem pole arrives	1 day	Wed 6/28/17	Wed 6/28/17
229	2...		4.6.8 UBC Concrete Gateway signage arrives	1 day	Wed 6/28/17	Wed 6/28/17
230	**2...**		**4.6.9 P2- Roundabout Parts Install**	**27 days**	**Thu 6/29/17**	**Fri 8/4/17**
231	2...		4.6.9.1 Install pre-cast concrete roundabout	2 days	Thu 6/29/17	Fri 6/30/17
232	2...		4.6.9.2 Install Gateway steel structure and foundation	10 days	Mon 7/3/17	Fri 7/14/17
233	2...		4.6.9.3 Install Musquem totem poles and Thunderbird statue	5 days	Mon 7/17/17	Fri 7/21/17
234	2...		4.6.9.4 Install bike dismount barriers	1 day	Mon 7/24/17	Mon 7/24/17
235	2...		4.6.9.5 Pave sidewalk	5 days	Mon 7/24/17	Fri 7/28/17
236	2...		4.6.9.6 Landscape/plant self sustaining local plants	5 days	Mon 7/31/17	Fri 8/4/17
237	2...		4.6.10 Phase 2 Complete	0 days	Fri 8/4/17	Fri 8/4/17
238	**2...**		**4.7 Phase 3 - Finishes**	**39 days**	**Wed 6/21/17**	**Mon 8/14/17**
244	2...		4.8 Construction Complete	0 days	Fri 8/11/17	Fri 8/11/17



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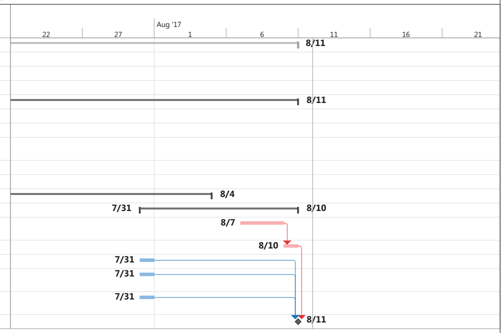
Page 2

CIVL 446 - Detailed Design Schedule

ID	ID	Task Mode	Task Name	Duration	Start	Finish
0	**0**		**CIVL 446 - Detailed Design Schedule**	**243 days**	**Tue 9/6/16**	**Fri 8/11/17**
1	**1**		**1 Conceptual Design**	**40 days**	**Tue 9/6/16**	**Mon 10/31/16**
26	**26**		**2 Preliminary Design**	**20 days**	**Tue 11/1/16**	**Mon 11/28/16**
41	**41**		**3 Detailed Design**	**107 days**	**Mon 11/28/16**	**Tue 4/25/17**
183	**1...**		**4 Construction**	**77 days**	**Tue 4/25/17**	**Fri 8/11/17**
184	1...		4.1 Commence Construction	0 days	Tue 4/25/17	Tue 4/25/17
185	1...		4.2 Mobilize construction crew and project staff trailers	5 days	Wed 4/26/17	Tue 5/2/17
186	1...		4.3 Rain Garden material arrive (cistern, drip irrigation piping, stormwater connection piping, sand, bog material, filter membrane)	5 days	Wed 5/3/17	Tue 5/9/17
187	1...		4.4 Light Fixture material arrive (Lamp posts, electrical conduits)	5 days	Wed 5/3/17	Tue 5/9/17
188	**1...**		**4.5 Phase 1 - Sidewalks, Bike Lanes, Electrical Routing**	**35 days**	**Wed 5/3/17**	**Tue 6/20/17**
203	**2...**		**4.6 Phase 2 - Roundabout**	**38 days**	**Wed 6/14/17**	**Fri 8/4/17**
238	**2...**		**4.7 Phase 3 - Finishes**	**9 days**	**Mon 7/31/17**	**Thu 8/10/17**
239	2...		4.7.1 Line painting for whole intersection (pedestrian crosswalks, bike lanes, vehicle lane markings)	3 days	Mon 8/7/17	Wed 8/9/17
240	2...		4.7.2 Install reflective pieces on ground for lanes and island	1 day	Thu 8/10/17	Thu 8/10/17
241	2...		4.7.3 Install speed limit signs	1 day	Mon 7/31/17	Mon 7/31/17
242	2...		4.7.4 Install warning signs indicating pedestrian crossin and bike path	1 day	Mon 7/31/17	Mon 7/31/17
243	2...		4.7.5 Install tactile paving at edges of sidewalk and roundabout island	1 day	Mon 7/31/17	Mon 7/31/17
244	2...		4.8 Construction Complete	0 days	Fri 8/11/17	Fri 8/11/17



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Page 1