UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

# Redesign of 16th Avenue / SW Marine Drive Intersection Detailed Design Report


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**University of British Columbia**


**CIVL 446**

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# Executive Summary

The intersection of Southwest Marine Drive (SW Marine Dr.) at 16th Avenue (16th Ave.) is a major car-oriented entry gateway to the University of British Columbia (UBC). Due to the rapid development of residential buildings nearby, the necessity of an intersection redesign has been further emphasized as a result of the increase in active transportation. The original intersection was not capable of handling the active transportation of the time, let alone the increased volume of today and the future.

The objectives for this redesign are as follows:

- ➢ Prioritize the safety of active modes of transportation,
- ➢ Reduce the speeds of motor vehicles entering the intersection,
- ➢ Minimize land usage requirements while not encroaching on preoccupied property,
- ➢ Effectively retain stormwater on site,
- ➢ Act as an entry gateway to welcome travelers to the campus.

Our team followed relevant codes and standards in the geometric design of the intersection, analyzing it in SIDRA based on traffic flow data collected during the PM peak hours of a regular weekday. AutoCAD, Civil 3D, and ArcGIS were used to develop drawings while Sketchup was used to develop 3D renders of the final design.

The proposed intersection design features a 55 m diameter roundabout with a truck apron. The westbound right-turn slip lane was removed to maintain four lanes of traffic on each leg, with horizontal deflection on the northbound approach to calm traffic. The pedestrian crossing and crossride across 16th Ave. and the crossride across SW Marine Dr. at the north-end of the intersection are equipped with Rectangular Rapid Flashing Beacons (RRFBs). An underground stormwater detention tank and an entry gateway structure rests in the centre roundabout island.

The cost of the project is estimated to be $6.7 million, with a construction start date of May 2024 and completion date in November 2024. For detailed design drawings, refer to Appendix A.

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# 1.0 Introduction

The following section will provide context to the project by providing some background on the reasons for the redesign, providing an overview of the site, describing the scope of the project, concluding with details regarding softwares used and member contributions.

## 1.1 Project Background

The intersection of SW Marine Dr. and 16th Ave. serves as a crucial entrance to the UBC campus for university faculty, students, and local residents. Despite years of significant growth in the UBC student enrolment and adjacent residential areas as outlined in the UBC Transportation Plan, the intersection design has remained unchanged. With the increase in active transportation, the existing road and intersection configuration presents many challenges for cyclists and pedestrians. Recognizing the need for improvement, UBC Campus and Community Planning (CCP) seeks to explore an intersection redesign that facilitates a safe and welcoming entrance to the campus, while aligning with BC Ministry of Transportation and Infrastructure (BC MOTI) requirements. Additionally, all design work should be based on the standards and guidelines of the B.C. Supplement to the Transportation Association of Canada (TAC) Geometric Design Guide 2019, the B.C. TAC Geometric Design Guide for Canadian Roads, and the B.C. Active Transportation Design Guide. This report showcases our team's detailed design work for the proposed design of the intersection.

## 1.2 Site Overview

The intersection is situated at the southern end of campus, residing on University Endowment Lands. It neighbours the Botanical Gardens and serves as a point of traffic control for people entering and exiting the campus. The intersection is also the entry point for the TransLink R4 bus line. There are pedestrian crossings across 16th Ave. that connect the existing pedestrian walkways by the food garden and Pacific Spirit Regional Park.

Both SW Marine Dr. and 16th Ave. have two traffic lanes heading in each direction. The intersection is currently signalized and consists of two protected right turn slip lanes north and south of 16th Ave. The westbound right-turn slip lane remains as a third travel lane between Stadium Rd. and 16th Ave., transitioning into a right-turn lane at Stadium Rd. As SW Marine Dr. was originally designed as a freeway, the intersection features approaches with wide shoulders and medians, and posted speed limits of 60 km/h and 50 km/h along the SW Marine Dr. and 16th Ave. approaches respectively. Catch basins are located adjacent to the median islands throughout the intersection. As it stands, there is currently no signage or gateway structure on site that welcomes the local community to UBC. Safety and accessibility for active transportation modes are compromised by the absence of designated bike lanes and excessive speeding of vehicles approaching the intersection. See Figure 1-1 for an overview of the current intersection conditions.

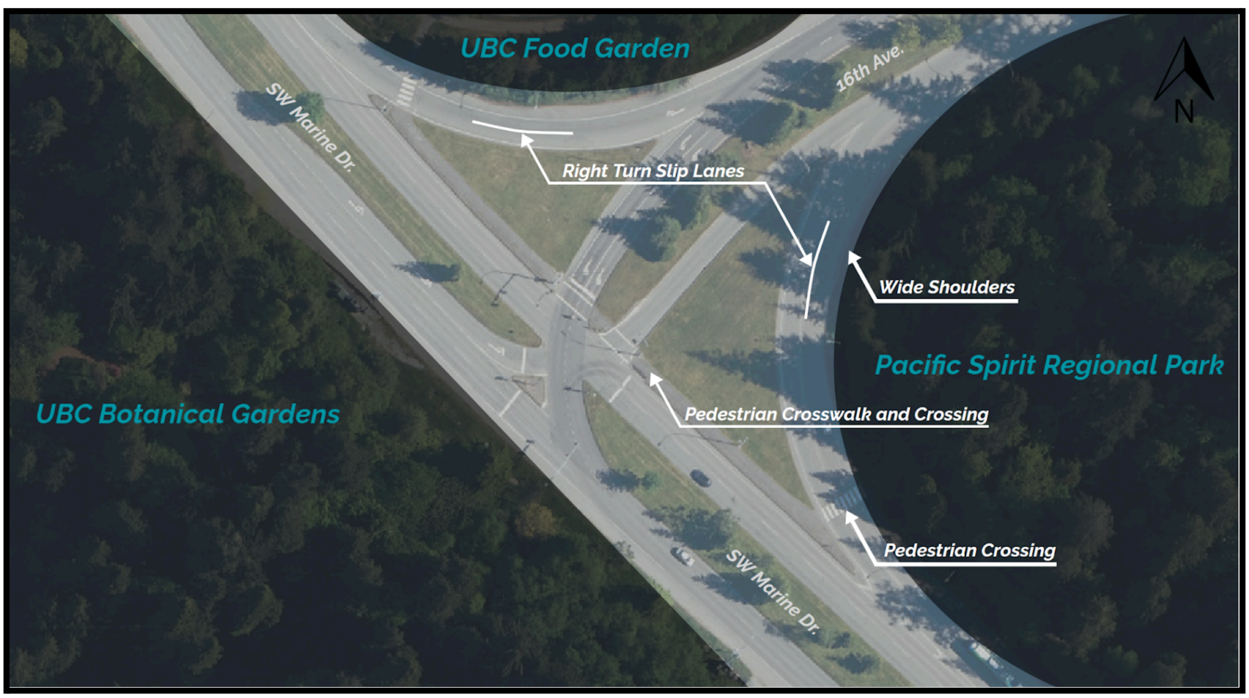


Figure 1-1: SW Marine Dr. and 16th Ave. Overview

(Background Photo Credit: Google Earth, 2021)

## 1.3 Project Scope

The scope of the project is to redesign the existing intersection on SW Marine Dr. and 16th Ave. in accordance with the relevant codes and standards. Transportation, structural, geotechnical, and construction components are encompassed within the intersection redesign. Economic, societal, and environmental considerations were explored, to ensure sustainability and resilience.

In addition to the intersection redesign, the following tasks will be completed:

- ➢ Site investigations and PM peak period intersection count
- ➢ Design of a stormwater management system
- ➢ Design of a gateway structure and necessary footing
- ➢ Class A cost estimate and construction schedule of project milestones
- ➢ Construction planning and sequencing for the installation of the new intersection

## 1.4 Project Management Documentation

Table 1-1 presents a summary list of computer modelling software used.

Table 1-1: List of Computer Modelling Software Used

| Software | Usage |
|---|---|
| Civil 3D/AutoCAD | Geometric Design & Detailed Design Drawings |
| SIDRA | Feasibility and Traffic Analysis |
| ArcGIS | Determination of Storm Catchment Area |
| Bluebeam | Construction and Traffic Management Plans |
| Excel | Design Calculations, Schedule, and Cost Estimates |
| Sketchup | 3D Modelling |

Civil 3D and AutoCAD were used in the drafting of the geometric design elements, placement of active transportation elements, and the signage and pavement markings; with the end goal to produce drawings used for construction. The roundabout analysis program SIDRA was used to test the viability of different lane and road configurations based on traffic data collected. Bluebeam was used to illustrate the construction plan and traffic management plan. ArcGIS was used to determine the stormwater catchment area and the contours of the site. Excel was used to perform design calculations for structural elements such as the gateway and stormwater detention tank, while also being used for the schedule and cost estimate. Sketchup was used to model the final design of the intersection. Table 1-2 presents the contributions of each team member to the development of the detailed design and report.

Table 1-2: Description of Member Contributions

| Member | Contributions |
|---|---|
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| | |

# 2.0 Project Objectives

The objective of the project is to redesign the existing intersection on SW Marine Dr. and 16th Ave. with a design life of 25 years to align with UBC's SEEDS sustainability initiatives. This includes prioritizing public transit and active transportation modes by designing the intersection to be safe and accessible for pedestrians and cyclists. Additionally, the new design should aim to:

- Reduce the speeds of motor vehicles entering the intersection,
- Minimize land usage requirements while not encroaching on preoccupied property,
- Effectively retain stormwater on site,
- Act as an entry gateway to welcome travelers to the campus.

## 2.1 Key Issues and Criteria

This section describes the key issues and criteria identified.

### 2.1.1 Technical

Key technical issues include the need to address the current road alignment which enables vehicle speeding. The anticipated surge of the population traveling to the campus in 2050 requires our design to manage increased demand and capacity. The design must accommodate higher volumes of traffic while prioritizing safety and active transportation.

### 2.1.2 Economic

Although decisions were not limited by budget constraints, our team understands the importance of fiscal responsibility. We have incorporated cost-mitigating measures throughout the project to avoid overbuilding the intersection. This includes utilizing affordable and durable materials, as well as exploring innovative and economical traffic management solutions.

### 2.1.3 Construction Planning

During the construction phase, the work zone must not encroach on preoccupied property boundaries (UBC Food Garden, Pacific Spirit Regional Park, and Botanical Garden), respecting boundaries and minimizing disruptions to surrounding areas. Effective construction staging planning is necessary to streamline workflow while also maintaining a continuous flow of traffic to prevent the closure of the intersection.

### 2.1.4 Regulatory

The design of the intersection has to follow all relevant codes and standards concerning roadway design, stormwater design, and structural design. Relevant codes and guidelines include:

- ➢ BC Supplement to TAC Geometric Design Guide (2019)
- ➢ Geometric Design Guide for Canadian Roads (1999)
- ➢ The British Columbia Active Transportation Design Guide (2019)
- ➢ BC Stormwater Management Guidebook (2002)
- ➢ UBC Integrated Stormwater Management Plan (2017)
- ➢ British Columbia Building Code (2018)
- ➢ CSA A23.3 Design of Concrete Structures (2019)
- ➢ BC MoTI Standard Specifications for Highway Construction (2020)

### 2.1.5 Environmental

While designing the intersection, Our team complied with a set of environmental constraints that reflect our commitment to sustainable practices. This includes occupying minimal space within the project area and prioritizing the preservation or restoration of greenery. In alignment with UBC CCP project objectives, efforts have been made to preserve as many trees as possible. The environmental impact from necessary tree removal will be offset by planting a new tree on-site for each one that is removed. Another environmental challenge is managing stormwater runoff; achieved through the integration of strategically placed ditches and a detention tank. Additionally, the importance of establishing a buffer zone between our work area and the UBC Botanical Gardens property is recognized.

### 2.1.6 Societal

The design places a strong emphasis on improving the local community by creating a vibrant, safe, and sustainable transportation route to the campus. In addition to improving the overall aesthetics of the intersection, ensuring everyone can safely and efficiently reach their destinations is crucial. This includes pedestrians, cyclists, and motor vehicles traveling to and from the UBC campus.

# 3.0 Detailed Design

This section describes the detailed design. Shown in Figure 3-1 is an overview of the final roundabout design. This section will discuss the key components and parameters, design rationale, and the construction specifications.

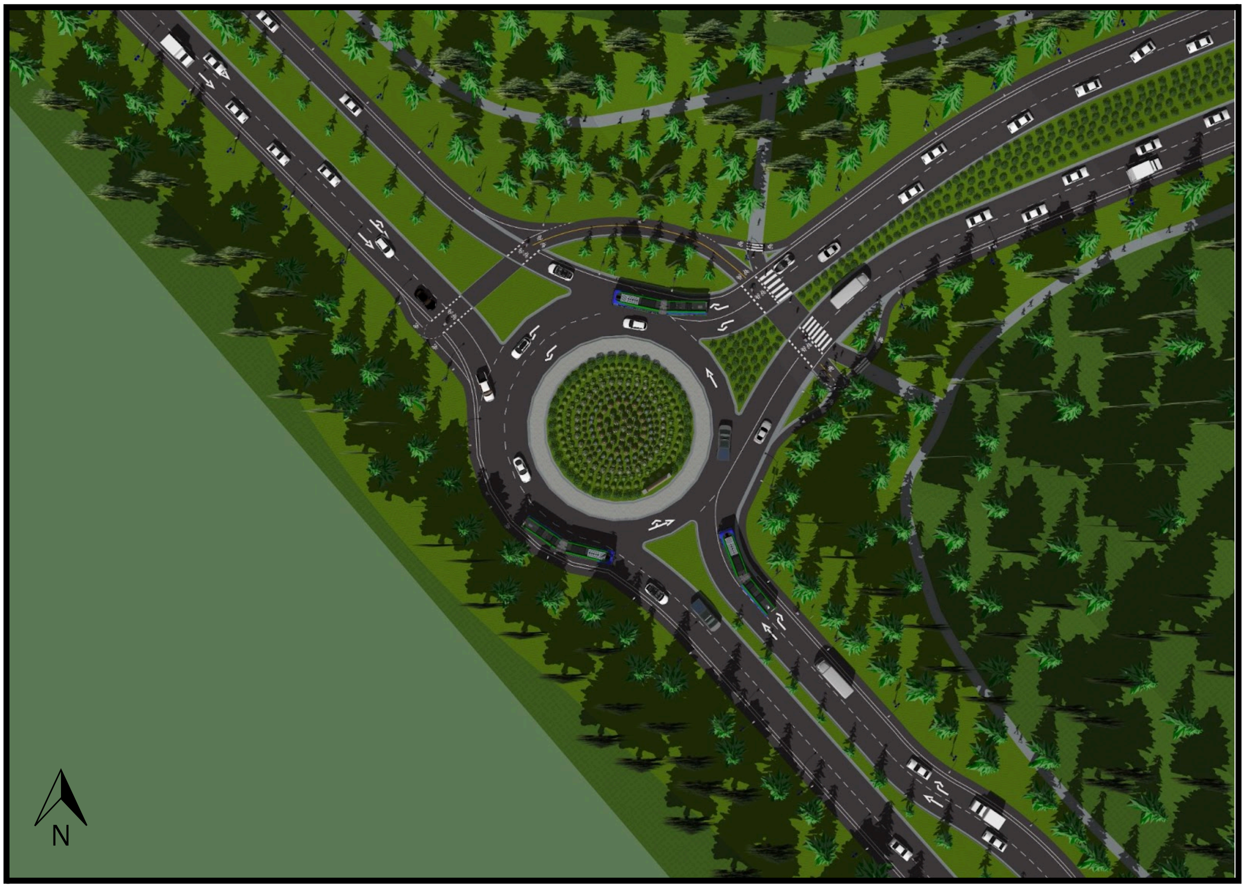



Figure 3-1: Overview of the Detailed Design Roundabout

## 3.1 Key Components and Parameters

The detailed design for the roundabout incorporates key design components and parameters including geometric design elements, pedestrian and bicycle infrastructure, a stormwater management plan, and an entry gateway structure.

### 3.1.1 Geometric Design Elements

The proposed roundabout is designed to the standards and guidelines of the BC Supplement to TAC Geometric Design Guide, 2019. The roundabout features two lanes of traffic on all approaches and exits except for the northbound exit leg onto SW Marine Dr., which has only one exit lane. Two circulating lanes are provided to facilitate westbound traffic from 16th Ave. onto SW Marine Dr. One circulating lane is used for all other traffic movements.

The roundabout is designed to accommodate a WB-20 truck, which is the largest vehicle that is expected to regularly use the roundabout. A truck apron is proposed to provide additional space for the design vehicle within a compact roundabout layout.

Pedestrian splitter islands, along with new medians are proposed near the roundabout, but eventually tie back into the existing 11.2 m wide median using a 12:1 taper. Figure 3-1 shows the proposed chicane along the south leg of SW Marine Drive.

Figure 3-2: Proposed Chicane Along the South Leg of SW Marine Drive

The rationale for the geometric design elements are discussed in Section 3.2.2. Figure 3-3 illustrates the geometric design of the roundabout and Table 3-1 summarises the geometric design elements below.

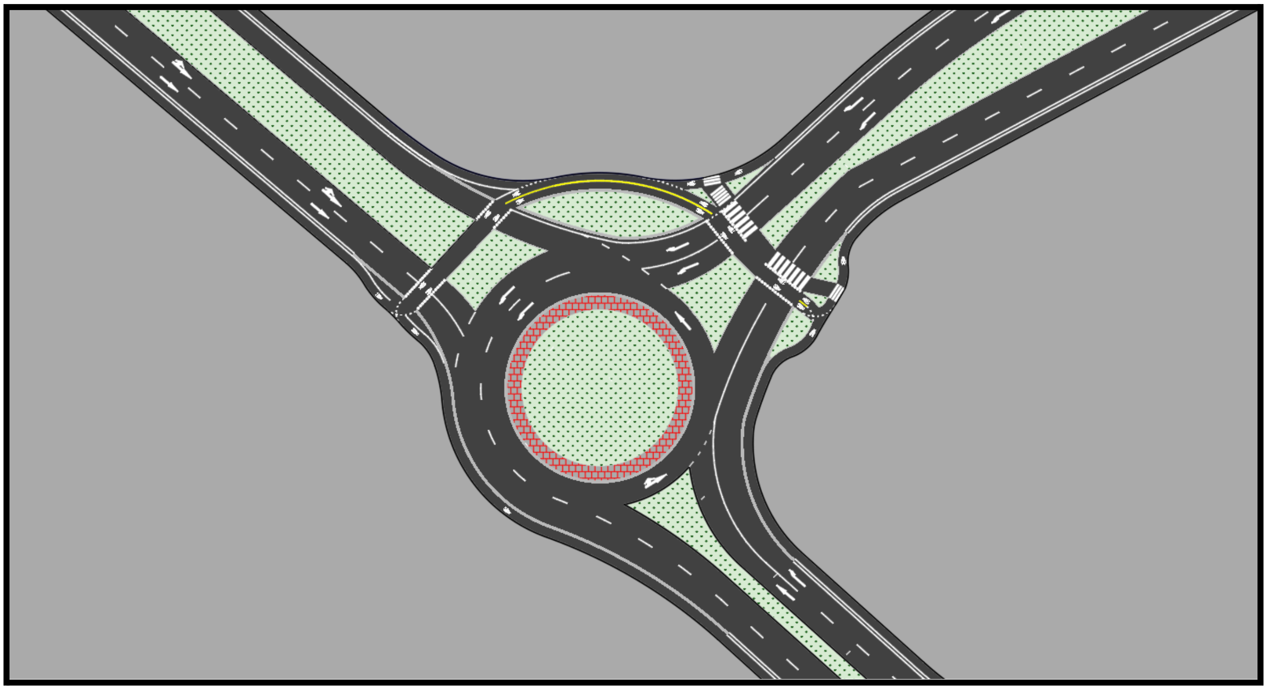


Figure 3-3: Geometric Design of the Roundabout

Table 3-1: Geometric Design Elements of Roundabout

| Geometric Design Elements (Proposed Criteria) | SW Marine Drive South Leg | SW Marine Drive North Leg | W 16th Ave East Leg |
|---|---|---|---|
| Design Classification of Approach Road | Primary Artierial Road/Highway | Primary Artierial Road/Highway | Primary Arterial Road |
| Posted Speed of Approach Road (km/h) | 60 | 40 | 50 |
| No. of Lanes | 2 | 2 | 2 |
| Angle of Intersecting Roads (°) | 84.46 | 84.46 | 95.54 |
| Inscribed Circle Diameter (m) | 54.9 | 54.9 | 54.9 |
| Circulatory Roadway (m) | 4.45 | 9.45 | 4.48 |
| Apron Width (m) | 2.6 | 2.6 | 2.6 |
| Entry Width (m) | 9.87 | 8.74 | 9.35 |
| Entry Radius (m) | 30 | 30 | 30 |
| Exit Width (m) | 8.98 | 5.34 | 9.18 |
| Exit Radius (m) | 100 | 100 | 100 |

### 3.1.2 Active Transportation Infrastructure

Encouraging and supporting active transportation stands as a primary focus in the design. As such, the design incorporates the following pedestrian and bicycle infrastructure:

- At-grade 3.0 m wide bidirectional crossrides for cyclists to safely make left-turns from SW Marine Dr. and 16th Ave. respectively.
- At-grade crosswalks for pedestrians crossing 16th Ave.
- A direct tie-in from the existing sidewalk along 16th Ave. to the location of the proposed crosswalks.
- Rapid Rectangular Flashing Beacons at each crosswalk and crossride.
- 1.8 m bike lanes with an additional 0.6 m pavement marking buffer or physical separation at all sections with proposed bike lanes.
- A 3.0 m wide bidirectional bike lane along the northeast corner connecting the north and east legs of the roundabout.

Figure 3-4 gives a plan view of the key active transportation infrastructure.

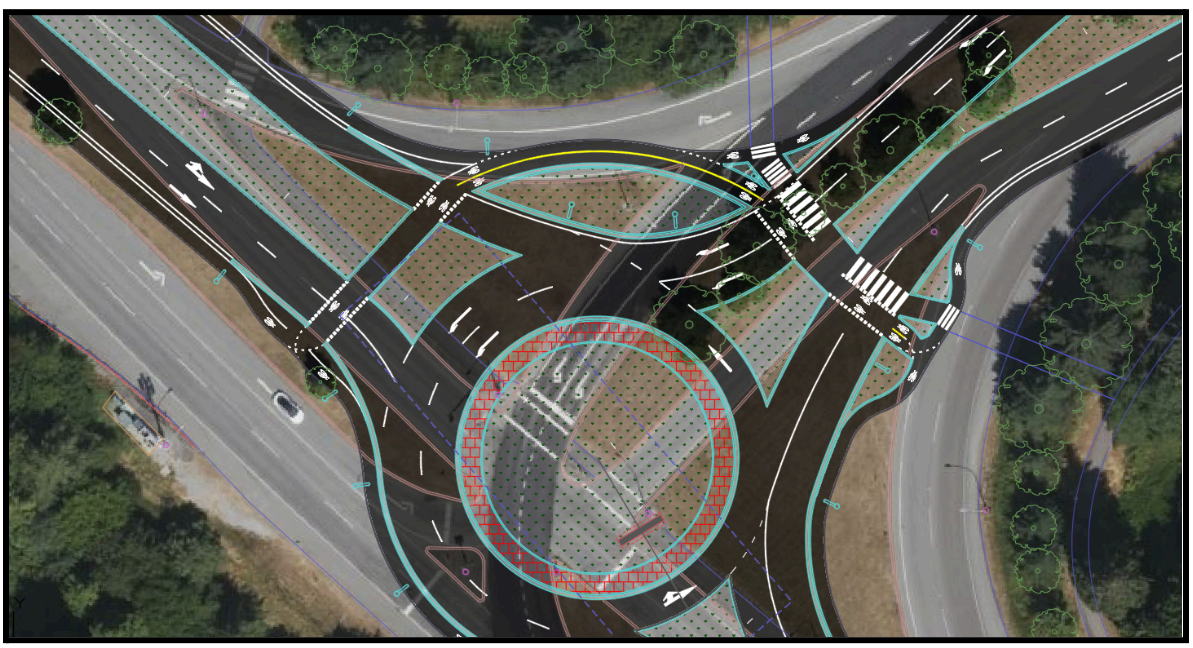


Figure 3-4: Plan View of Key Active Transportation Infrastructure

### 3.1.3 Stormwater Design

The preferred stormwater management plan is an underground detention tank. Collection ditches and catch basins running along the outer edges of the legs of the intersection will direct stormwater to 0.3 m diameter central gravity collection pipes, which flow into the detention tank. The detention tank will be constructed using reinforced concrete and placed 0.75 m below the surface near the centre of the roundabout with a width of 20.4 m, length of 65.4 m, and height of 4.8 m. The tank contains separate detention and discharge chambers, allowing for any collected solids to settle before water is discharged to the west of the intersection through a new 0.3 m diameter gravity outfall pipe. The robust two-chamber system also prevents overflowing during extreme storm events, minimizing flooding in the intersection, as well as runoff at the cliffside. An estimated 3000 $m^3$ of water can be stored inside the detention chamber, which can be used for irrigation purposes in dry seasons or pumped to the outfall to be discharged during regular maintenance. A stormwater plan diagram can be seen in Figure 3-5.

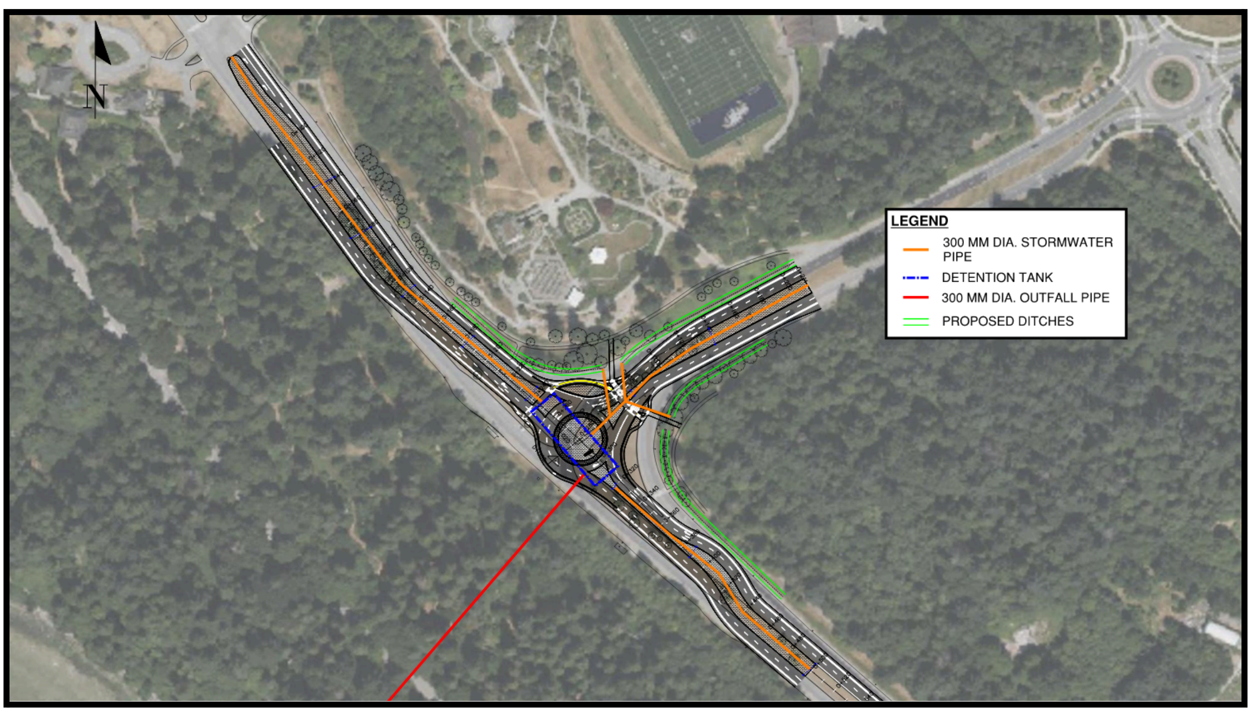



Figure 3-5: Stormwater Management Plan

### 3.1.4 Gateway Structure

Figure 3-6: 3D Model of Gateway Structure

Located at the southeast end of the central roundabout island, this gateway structure serves as a welcome sign for visitors traveling westbound on SW Marine Dr. A 3D model of the gateway structure is shown above in Figure 3-6. The centrepiece is a panel made of cedar, intended to showcase indigenous artwork. The panel is connected with steel rods to a reinforced concrete pedestal. The concrete is decorated with stone veneer, and topped with a protective cement cover slab. The entire structure rests on a concrete base, securely embedded in a reinforced footing beneath the surface, ensuring stability and durability. The total span and height of the gateway structure are 6.3 m and 3.2 m respectively, with a width of 0.85 m. The footing has an identical span of 6.3 m, but with an increased width of 1.7m and thickness of 0.3 m.

## 3.2 Design Rationale

Throughout the decision-making process, our team took deliberate steps to optimize the design and achieve the project objectives. This section will discuss the rationale behind key design decisions made, as outlined in Section 3.1.

### 3.2.1 Traffic Analysis

With SW Marine Dr. and 16th Ave. being a BC MOTI owned intersection, their preferred method of intersection control is a roundabout. SIDRA was used to model a roundabout design to confirm that a roundabout was feasible. A site investigation and traffic count were conducted to observe and collect data, which was then inputted into SIDRA for analysis. The volume data and results of the SIDRA analysis by our team are found in Appendix E. The detailed design modelled on SIDRA is presented in Figure 3-7.

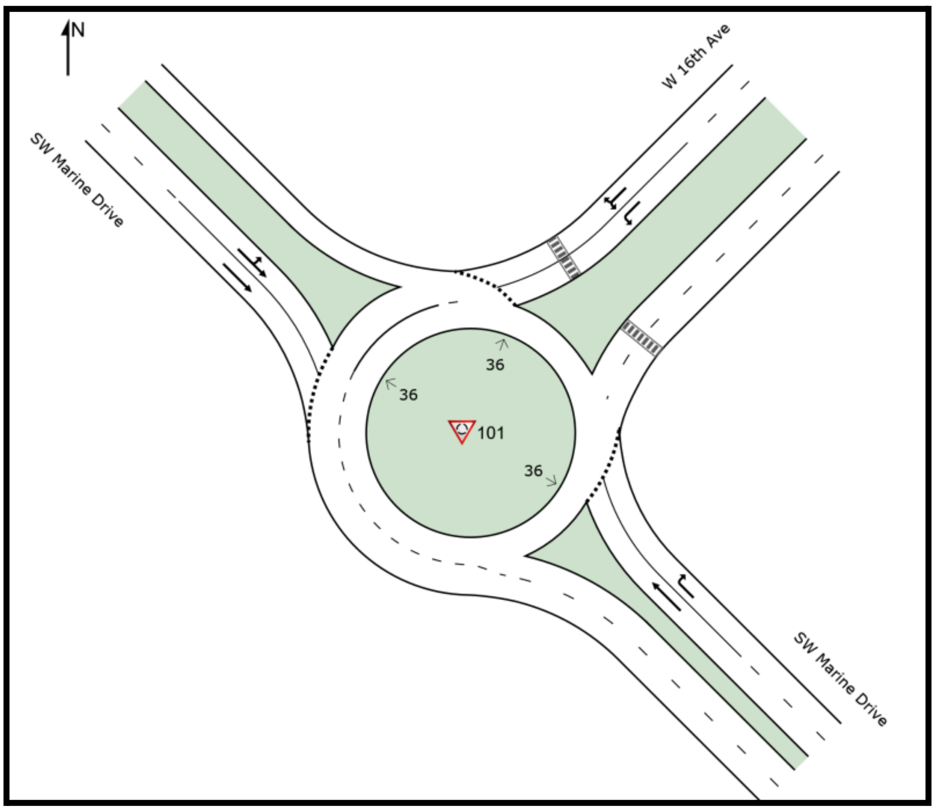



Figure 3-7: SIDRA Detailed Design Roundabout

As mentioned in Section 3.1.1, the south and east legs contain one lane each within the circulatory road width. The low volume of southbound vehicles turning left and northbound vehicles traveling straight permits the reduction to one circulating lane on each leg. This reduction results in increased green space and enables the safe use of the roundabout for cyclists and pedestrians. Overall, the roundabout received a level of service (LOS) of B. This indicates that the roundabout balances vehicle convenience with active transportation accessibility. Therefore, the roundabout is not overbuilt and creates a calm environment for active transportation.

Two lanes are available for vehicles approaching the intersection on 16th Ave. The left lane is exclusive for left turn movements and the right lane permits both left and right movements in the roundabout. The collected data indicates that there is currently a low volume of vehicles turning right from 16th Ave. at the existing intersection. The low volume, combined with an emphasis on accessibility, enabled the removal of the existing right turn slip lane on 16th Ave. With one less crossing to face, pedestrians and cyclists will travel more conveniently. A notable aspect of the curb lane is that the left turn movements are only permitted for buses. Lane disciplines that were created on SIDRA for the 16th Ave. approaches are displayed in Figure 3-8. The decision to permit buses to use the right lane to complete left turn movements simultaneously alleviates congestion in the left lane and prioritizes public transit.

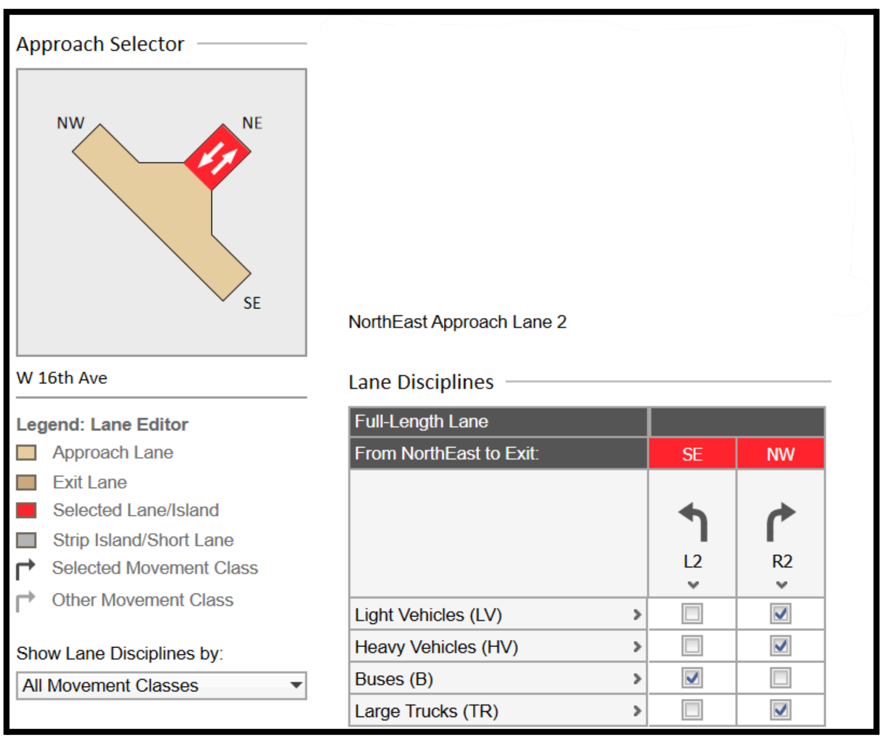



Figure 3-8: Lane Disciplines of 16th Ave. Right Lane Approach

### 3.2.2 Geometric Design

The rationale for the geometric design elements in the roundabout are described in this section.

Design Vehicle:

As outlined by BC Supplement to TAC Geometric Design Guide 2019, the recommended design vehicle of the roundabout is a WB-20 truck, meaning that all smaller vehicles, such as articulated buses, can traverse the intersection. As outlined in the TAC Design Vehicle Dimensions for Use in Geometric Design, the dimensions for a WB-20 truck and an articulated bus are shown in Figure 3-9 below.

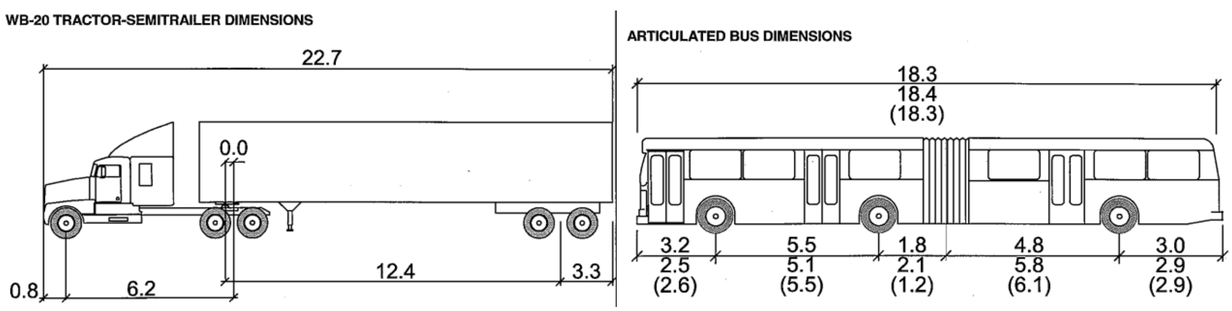



Figure 3-9: Dimensions of the WB-20 Truck and Articulated Bus

Truck Apron:

A recommended truck apron of 2.6 m is designed to further accommodate the design vehicle of the WB-20 truck. This is to ensure that the roundabout is not overbuilt and designed to allow the rear tires of larger vehicles, such as the WB-20 truck, to mount the truck apron during their turn. As outlined by the TAC Design Guide, the minimum width for a mountable truck apron is 2.0 m and is met by our design. It should be noted that the truck apron has a higher vertical elevation of 0.075 m above the road with a 2% grade sloping outwards to deter smaller vehicles and trucks from using the truck apron and provide drainage away from the central island. The truck apron is also coloured red and tile textured to clearly identify that the truck apron is not a sidewalk for pedestrians. Figure 3-10 illustrates the described truck apron.

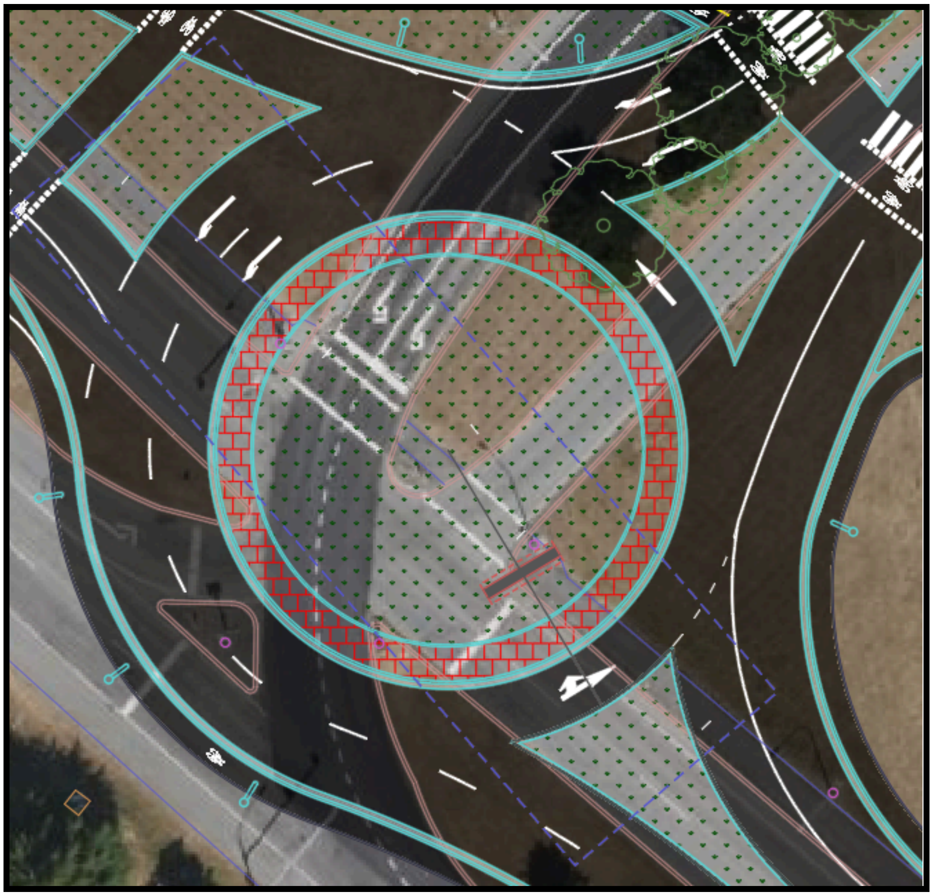


Figure 3-10: Mountable Truck Apron (Background Photo Credit: Google Earth, 2021)

Horizontal Alignment:

The horizontal alignment of the roundabout is recommended to be offset left, which is preferred over the design of a radial alignment as shown in Figure 3-11. This is because an offset left approach reduces vehicular entry speeds by horizontally deflecting vehicles entering the roundabout. As traffic calming is a critical project objective, the alignment of the northbound approach along SW Marine Dr. is offset left, which achieves lower entry speeds and increases safety for all road users. To accommodate the existing road curvature conflicts, the alignment for 16th Ave. is slightly offset to the left. This design choice ensures there are no abrupt curves prior to entering the roundabout. This adjustment is evident in the intersection angles: the east leg approach features an angle of 95.54°, while the north and south leg approaches have angles of 84.46°.

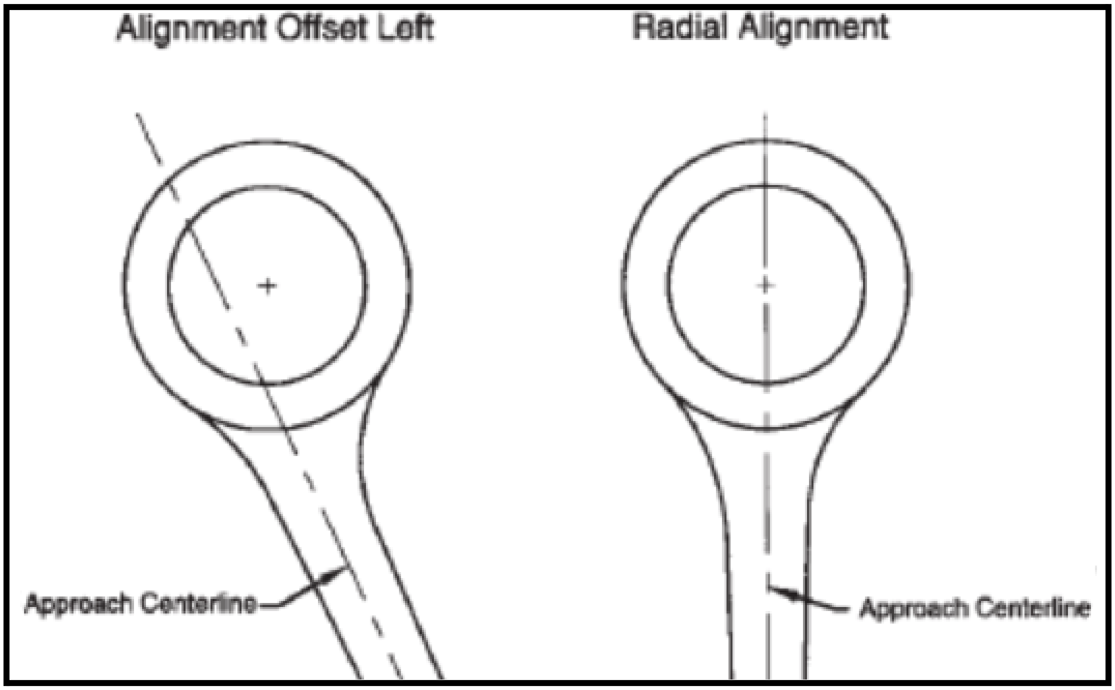



Figure 3-11: Left Offset and Radial Alignment (Photo Credit: Transoft Solutions Inc.)

<u>Inscribed Circle Diameter and Circulatory Roadway Width:</u>

The recommended inscribed circle diameter (ICD) of the roundabout is 54.9 m. The ICD is large enough to accommodate the design vehicle while not larger than necessary. This ensures that the circulating speeds in the roundabout are reduced as smaller ICDs will result in lower speeds. The recommended total circulatory roadway width is 9.45 m for dual lane sections. As outlined by the TAC Guide, the inner circulatory roadway width is designed to be 4.45 m with the outer circulatory roadway taking the remaining width of 5.0 m where dual circulating lanes exist. Moreover, camel-backs are recommended to be avoided in the roundabout to create a smooth transition from the entry and exit paths and are illustrated in Figure 3-12.

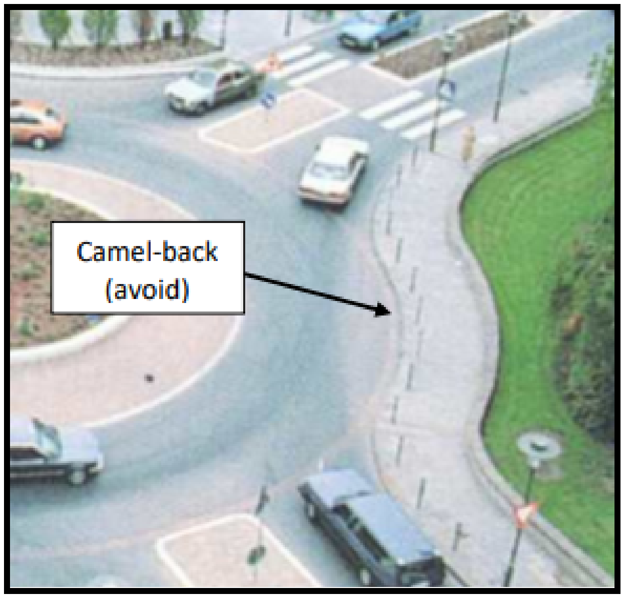



Figure 3-12: Camel-back in Roundabout (Photo Credit: BC Supplement to TAC, 2019)

Entry Width & Exit Width:

The recommended entry width of the roundabout is 9.87 m for the south leg, 8.74 m for the north leg, and 9.35 m for the east leg. These entry widths are recommended to maintain optimal vehicle capacity within the roundabout while prioritizing safety without impeding turning movements for the design vehicle. The recommended exit width of the roundabout is 8.98 m for the south leg, 5.34 m for the north leg, and 9.18 m for the east leg. This guarantees ample width for vehicles exiting the roundabout, preventing any delays that could be caused by a narrow exit width.

Entry Radius & Exit Radius:

The recommended entry radius of the roundabout is 30 m and the recommended exit radius is 100 m for all three legs. The smaller entry radius allows for vehicles to reduce their speeds, but is large enough that the turning movements are not impaired. The larger exit radius allows for vehicles to have a smoother exit out of the roundabout, to prevent potential delays from circulating vehicles and stopped vehicles, and to increase capacity in the roundabout.

Medians:

The recommended minimum median width of the roundabout is 3.0 m and is provided near the roundabout, and ties back into the existing median of 11.2 m using a 12:1 taper. Medians help reduce head-on collisions and provide pedestrians an area of refuge when crossing the roundabout, ensuring shorter walking distances. Smaller medians are used to provide a smaller and tighter roundabout while still being able to separate the directions of traffic effectively.

Entry Speed:

As outlined in the US Department of Transportation Geometric Design Guide shown in Figure 3-13, the recommended entry speed is 40 kph for an urban double-lane roundabout. This allows vehicles approaching the roundabout to slow down before entering. The entry speed correlates directly with entry width and entry radius, as these parameters make up the entry deflection of the roundabout. A fastest path analysis is needed to determine the actual entry speed of the roundabout, according to the TAC guidelines.

Recommended maximum entry design speeds for roundabouts at various intersection site categories are provided in Exhibit 6-4.

**Exhibit 6-4.** Recommended maximum entry design speeds.

| Site Category | Recommended Maximum Entry Design Speed |
|---|---|
| Mini-Roundabout | 25 km/h (15 mph) |
| Urban Compact | 25 km/h (15 mph) |
| Urban Single Lane | 35 km/h (20 mph) |
| Urban Double Lane | 40 km/h (25 mph) |
| Rural Single Lane | 40 km/h (25 mph) |
| Rural Double Lane | 50 km/h (30 mph) |

Figure 3-13: Recommended Maximum Entry Design Speeds for Roundabouts

(Photo Credit: U.S. DOT FHWA Geometric Design)

Chicanes:

Chicanes are commonly used as a speed reduction measure on a race track environment; however, the same principle can be applied to this intersection and many urban applications throughout the province.

There are numerous studies available online to support this conclusion. One study performed by John C. Marek and Shauna Walgren, a traffic engineer and transportation planner respectively of Seattle Transportation, was conducted on numerous residential streets and showed that chicanes "have been very effective at reducing high-end speeders and [reducing] mid-block speeds".

An example of the use of a chicane at a roundabout can be found at the intersection of Highway (Hwy) 8 and Hwy 22 to the west of Calgary where chicanes are implemented for the major freeway approaches to a roundabout intersection.

The curvature in the road was designed based on the TAC guidelines and the chicane is designed off of the proposed alignment using a travel speed of 60 kph and radius of 65 m to match the existing speed limit.

Tie-ins to Existing Roads:

The tie-ins to the existing infrastructure are designed to be smooth transitions with minimal changes required. As the right-turn slip lane from 16th Ave. to SW Marine Dr. is being removed, the right-turn lane between the roundabout and Stadium Rd. will also be removed to ensure a smooth tie-in to the existing road. For the south side of the roundabout, the road is tied in before the approach of the right-turn lane as the slip lane from SW Marine Dr. to 16th Ave. is being removed.

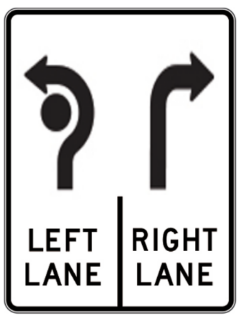
### 3.2.3 Signage and Pavement Markings

The detailed plans for signage and pavement markings related to detailed design are enclosed in Appendix A. Although the majority of the plan aligns with the guidelines outlined in the BC MOTI Traffic Signs and Pavement Markings manual, this section explains our design approach and rationale behind certain unique applications of traffic signs and pavement markings in order to accommodate our design problem.

<u>16th Avenue - Westbound Left-Turn Restriction from Curb Lane with Exemption for Buses:</u>

To clearly communicate the left-turn restriction for non-transit vehicles discussed in Section 3.2.1, a signage plan was designed to clearly convey this restriction. Table 3-2 summarizes the signage used to indicate the left-turn restriction from the westbound curb lane on 16th Ave.

Table 3-2: Proposed Signage for 16th Ave. Left-Turn from Curb Lane Restriction

<table>
<tr><th>Sign Code</th><th>Description</th></tr>
<tr><td>



**RB-R-510**</td><td>

**<u>Roundabout Double Lane Use Diagram</u>**

This regulatory sign indicates the available lane use options in the left and right lane as drivers approach the roundabout.

A left-turn arrow is intentionally not shown in the right-lane option to mitigate potential for non-transit vehicles making the restricted turn instead.

This sign will be positioned at the top of the signpole above the following signs.</td></tr>
<tr><td>



**RB-082-R2**</td><td>

**<u>Right Lane Must Turn Right</u>**

This regulatory sign clearly indicates that drivers in the curb lane must make a right turn at the roundabout.

This sign will be positioned in between the RB-R-510 and the RB-009 signs.</td></tr>
<tr><td>



**RB-009**</td><td>

**<u>Bus Exemption Tab</u>**

This regulatory sign alerts transit vehicles that they are exempt from the RB-082-R2 right-turn only restriction.

This sign will be positioned at the bottom of the signpole below the previous signs.</td></tr>
</table>

Wayfinding Signage for Approaches to the Roundabout:

It is important for clear wayfinding signage to be provided for drivers approaching and traveling in the roundabout. Custom RB-G-503 series signs from the BC MOTI will be shoulder mounted and installed 120 m from the entrance of each of the roundabout approaches. To maintain consistency with the existing wayfinding signage approaching the 16th Ave. and East Mall roundabout, a blue background rather than the traditional green will be used on our proposed sign. Figure 3-14 shows an example of the existing sign on the west leg of the 16th Ave. and East Mall roundabout.


Figure 3-14: Existing Roundabout Wayfinding Sign at 16th Ave. and East Mall

## 3.2.4 Active Transportation Infrastructure

At-grade crosswalks equipped with RRFBs are provided across 16th Ave. With the proposed crosswalk layout, there is a two-lane reduction in total crossing distance for pedestrians travelling across 16th Ave. compared to the existing signalized intersection. This is due to the removal of the right-turn slip lane on both directions of 16th Ave. which leads to a safer crossing environment for pedestrians and cyclists alike. To minimize land impacts, the existing sidewalk will be retained and an asphalt sidewalk extension is provided directly at the location of the crosswalks. Consistent with the existing intersection, crosswalks are not provided across SW Marine Dr. as there is no destination of interest for pedestrians on the west side.

Figure 3-15: Aerial View of Active Transportation Infrastructure

With special permission from the BC MOTI, crossrides are proposed across both SW Marine Dr. and 16th Ave. Unlike pedestrians, cyclists require a safe way to travel between the bike lane along the west side of SW Marine Dr. and the bike lanes along 16th Ave. As outlined in the BC Active Transportation Design Guide, crossrides are effective at locations where motorists yielding behaviour can be expected, and appropriate signage and motorist sightlines are present. As motorists are expected to yield to circulating traffic and pedestrians when entering the roundabout and pedestrians when exiting the roundabout already, a crossride will be an effective crossing treatment across SW Marine Dr. and 16th Ave. The crossrides are preferred as they avoid the need for cyclists to share the space with motor vehicle traffic and travel within the roundabout to complete a left-turn. Instead, cyclists travel along a bidirectional bike path protected by a landscaping buffer on the northeast corner of the roundabout to travel between 16th Ave. and SW Marine Dr. Similar to the crosswalks, RRFBs will be installed at the crossrides to enhance cyclist conspicuity.

Additionally, as the crosswalks and crossrides are at the same elevation as the road, accessibility is improved for all modes of transportation due to the removal of unnecessary grade changes at the median refuges. This is also preferred for wheelchair users who may previously have had trouble accessing the raised median refuge.

The proposed bike lanes along SW Marine Dr. and 16th Ave. will be accompanied by a 0.6 m buffer area on the approaches to the roundabout and a form of physical separation at the roundabout itself. The buffer area provides a future option to install physical separation ranging from plastic delineator posts to concrete barriers. As cyclists enter the roundabout, curb separation is provided at a minimum, and cyclists are encouraged to use the crossride to avoid travel within the roundabout, promoting a safer cycling environment.

### 3.2.5 Stormwater

A detention tank below ground was chosen as the technique to manage storm events as it prevents runoff reaching the erosion-prone cliff to the west of the intersection. The possibility of draining the stormwater into the underground aquifer was considered, but was determined to be unfeasible, based on the recommendations in the University Endowment Lands Integrated Stormwater Management Plan. The detention tank was initially sized to fully capture a 24-hour duration 1-in-100 year storm event, in line with the guidelines set forth by the UBC Integrated Stormwater Management Plan. While the TAC recommends that freeways should be designed for 1-in-200 year storms, considering the design lifecycle of this intersection, our team deemed it to be excessively conservative, and permission was granted to design for the 1-in-100 year storm scenario. IDF curves and data were sourced from a study conducted on Metro Vancouver Climate Stations by BGC Engineers Inc. An additional 20% was added to the total precipitation volume in accordance with the Impacts of Climate Change on Precipitation and Stormwater Management Technical Brief for the 2050 moderate climate change scenario. The runoff coefficient was estimated based on the TAC's guidelines, in consideration of the grade profile, amount of impermeable asphalt, and amount of vegetated land. The total required storage volume of the tank was calculated using these parameters.

Figure 3-16: Project Site Drainage Area (Photo Credit: ESRI, 2023)

Shown in Figure 3-16 above is the drainage area for the intersection. The catchment area was determined based on the construction boundaries and raster elevation data, and the area was calculated using ESRI ArcGIS.

Based on the required storage volume, an initial estimate was made for the dimensions of the tank. Reinforced concrete was selected as the construction material due to its high compressive strength. Structural calculations were completed according to CSA guidelines to determine the sizing and spacing of the various concrete members required to resist the soil and surcharge loads. The tank dimensions were then fine-tuned to account for the loss of internal storage volume caused by supporting concrete members, and divided into a detention and discharge chamber. Though the storage volume is reduced as a result, the design prevents overflowing almost entirely, even in continuous heavy rainfall. In addition, the operations and maintenance costs are significantly reduced, since the design eliminates the need for frequent monitoring and maintenance. The discharge chamber also improves the ease of access for maintenance purposes, acting as a dry chamber for maintenance staff to enter and exit through. Maintenance will be carried out on an annual basis in the summer months when rainfall and traffic volumes at the intersection are low, in order to remove trapped solids and check for damage or blockages. Detailed drawings for the detention tank can be found in Appendix A.

Ditches and catch basins are the preferred collection method for stormwater as they can be placed anywhere around the intersection and the approaches. As the catchment area for this intersection includes SW Marine Dr. and a portion of 16th Ave., there are catch basins at all approaches. Underground PVC pipes were selected instead of overland flow paths to transport the collected stormwater into the central detention tank, as they prevent interference with traffic in the intersection. Pipes were sized based on assumed values for slope and roughness, as well as the TAC's recommendations for flow velocities.

The collected stormwater will be discharged through a gravity-fed outfall pipe at the side of the cliff. The outflow pipe diameter was selected to be the same as the collection pipes to reduce project costs. The selected diameter also provides a flow velocity in the lower range of the TAC's recommended values, reducing erosion. This simple design is ideal, as it reduces potential failure modes, construction cost, and time, due to decreased complexity. As the location of the existing outfall pipe is unknown, the decision was made to install a new outfall pipe. Calculations for the stormwater design can be found in Appendix D.

### 3.2.6 Gateway Structure

The minimalistic design of the gateway structure provides an opportunity to showcase indigenous art. The artwork will be placed on the cedar panel to accentuate UBC's environmental heritage. The pedestal holding the cedar panel was chosen to be made of concrete and stone to exude a feeling of coexistence between modern civilization and its ecological roots. Additionally, the muted colours of the stone and concrete shift the attention of the audience to the bright cedar panel displaying indigenous artwork.

After analyzing the structure, a footing was required. Due to the significant span-to-width ratio of the concrete base, a reinforced wall footing was designed. The associated calculations and dimensions of the footing can be found in Appendix D.

### 3.2.7 Additional Infrastructure

Spanning around the outside of the roundabout and along the perimeter of the approaching roads, tall street lights with UBC banners hanging on the sides are incorporated. Additionally, a large flower bed made of Vancouver native flowers is located adjacent to the gateway structure on the centre roundabout island. These additional features are displayed in Figure 3-17.

Our team increased the number of street lights on SW Marine Dr. due to the poor lighting conditions at night along SW Marine Dr. This will help drivers and cyclists traverse the intersection and chicanes more safely in the dark. Additionally, the blue banners hanging from the street lights and the decorative flower beds aim to add to the overall university aesthetic of the intersection, adding colour to the site and giving visitors a warm welcome to the beautiful UBC Campus.

Figure 3-17: Streetlights and Decorative Landscape

# 4.0 Construction Plan

This section will discuss the potential risks that may result from the project, the maintenance plan, construction staging, traffic management plan, anticipated site issues, concluding with an overview of the construction specifications.

## 4.1 Risk Analysis and Hazard Log

To assist with developing the construction plans, a risk analysis of various hazards was performed. The identified hazards were separated into three categories; Existing, Installation, and Operation & Maintenance. Each entry was scored based on the likelihood and severity of the associated consequence, with a higher score being more likely/severe. Table 4-1 and Table 4-2 below display a qualitative representation of each score.

Table 4-1: Likelihood of Risks Occurring

| Likelihood of Occurrence | | |
|---|---|---|
| **Qualitative Definition** | **Meaning** | **Score** |
| Frequent | Likely to occur many times (has occurred frequently) | 5 |
| Occasional | Likely to occur sometimes (has occurred infrequently) | 4 |
| Remote | Unlikely to occur but possible (has occurred rarely) | 3 |
| Improbable | Very unlikely to occur (not known to have occurred) | 2 |
| Extremely Improbable | Almost inconceivable that the event will occur | 1 |

Table 4-2: Severity of Risk Consequences

| Severity of Consequences | | |
|---|---|---|
| **Qualitative Definition** | **Meaning** | **Score** |
| Catastrophic | Results in an accident, death or equipment destroyed | 5 |
| Hazardous | Serious injury or major equipment damage | 4 |
| Major | Serious incident or injury | 3 |
| Minor | Results in a minor incident | 2 |
| Negligible | Nuisance of little consequence | 1 |

After assigning each hazard a level of risk, risk responses were explored to try to lower the likelihood and severity. After noting risk responses for each hazard, new scores were allocated, with a new score of less than 6 being deemed acceptable. This risk analysis allowed our team to investigate all the hazards associated with the construction and operation of our design, and develop the necessary construction plans accordingly. See Appendix F for the risk analysis of our intersection redesign.

## 4.2 Maintenance Plan

Maintenance of the intersection will involve two major components: stormwater, and road components. Costs for each component will not be discussed in this section; however, they will be broken down into sub-components as shown in Table 4-3 and Table 4-4. Road maintenance is projected to require a significant portion of the allotted maintenance budget and as such is budgeted accordingly in the cost estimate; however, costs vary significantly year-to-year based on worker salaries, and the amount of work required to be performed. As a result, the budget may not be accurately representative of the actual costs depending on the year.

Table 4-3: Breakdown of Stormwater-Related Maintenance Items

| Item | Details | Frequency |
|---|---|---|
| **Ditch Landscaping** | Clearing and removal of excessive shrubbery to allow for stormwater to flow more easily into ditches for collection. | Annually (moist months) |
| **Pumping of Tank** | The tank requires excess water to be pumped out for sufficient volume to be available for future storms. | Annually (dry months) |
| **Tank Inspection** | Inspection of concrete internals to ensure that cracking, honeycombing, etc. are minimal or nonexistent. | Annually (dry months) |

Table 4-4: Breakdown of Road Component-Related Maintenance Items

| Item | Details | Frequency |
|---|---|---|
| **Road Surface** | Potholes, cracks, and other similar deficiencies in the roads due to temperature, weather, and other similar effects must be fixed to ensure safety for all road users | As Necessary |
| **Snow and Ice** | Roads must be cleared of snow and salted to prepare for winter snowfall and mitigate ice buildup. | Annually |
| **Landscaping** | Vegetation including trees, shrubbery, and grass must be managed to maintain a well-kept appearance as well as to prevent overgrowth that could endanger road users. | Annually, with ditches |
| **Traffic Controls** | Signage and pavement markings must be maintained and redrawn to ensure the safety of road users. | As Necessary |
| **Gateway** | The gateway must be inspected to ensure that it does not collapse and pose a danger to road users. | Annually |
| **Network Management** | Highway patrols and maintenance crews should be allocated to the intersection to ensure the safety of road users. | As Necessary |

## 4.3 Anticipated Site Issues

Some of the anticipated issues related to the specific site conditions include safety issues, space constraints, and uncertainties in soil conditions. As safety is paramount, the importance of safety considerations during ongoing construction should be acknowledged. Safety must always take precedence over site factors.

Undergoing construction requires lane closures and lane width reductions. These modifications will confine the space available for vehicles traveling through the intersection. While design measures will be in place, caution must be exercised by vehicles throughout the construction zones. In cases of emergency, it is necessary to ensure that police, fire, and ambulance services can navigate through or around the construction site without delay.

Moreover, there is uncertainty of the current ground and soil conditions of the site as many of the past geotechnical reports are outdated and the conditions may be different. Inaccurate reports are anticipated and further geotechnical and auger testing should be completed to confirm the findings of the past report. The aforementioned site issues require establishing coordination with the University Endowment Lands to help identify and relocate underground utilities and services.

## 4.4 Construction Staging

The construction of the roundabout will be completed through 6 total stages. Figure 4-1 displays Stages 1 to 4, and Figure 4-2 displays Stage 5. Each stage is described in detail below.

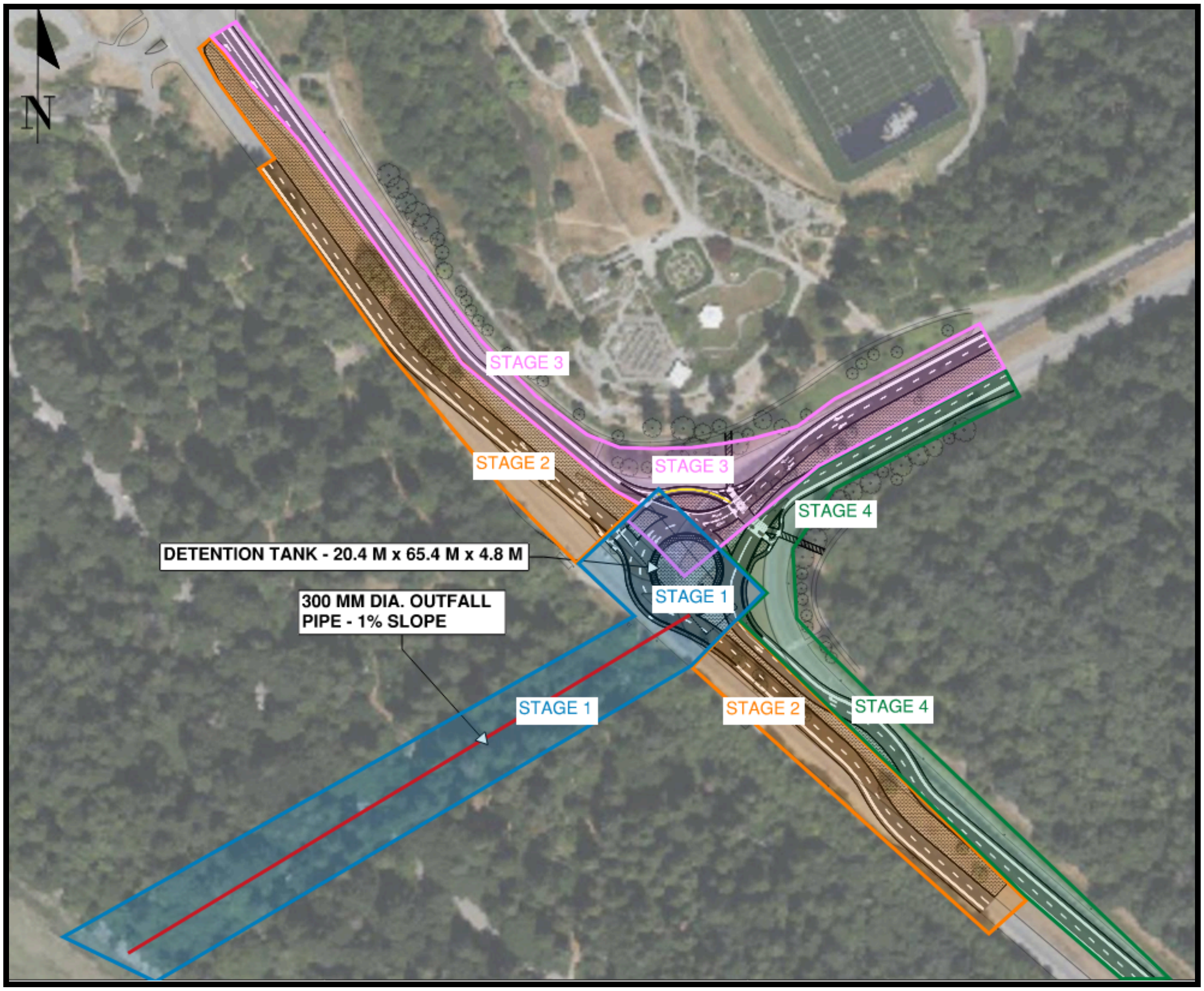



Figure 4-1: Construction Staging Plan for Stages 1-4


Figure 4-2: Construction Staging Plan for Stage 5

**Stage 0: Mobilization**

The initial stage acts as a mobilization period, requiring the closure of one southbound lane on Marine Dr. to facilitate the mobilization of equipment in the area. Additionally, clearing and grubbing operations will be conducted to remove all medians. Removal of medians is crucial to prepare for subsequent stages, as temporary routes will have to be created.

**Stage 1: Installation of Outfall Pipe and Detention Tank**

Vehicle traffic is shifted to the northbound side of Marine Dr. to create a temporary T-intersection. Work will be conducted to install both the outfall pipe and detention tank.

Backfilling will commence after installation is complete. Additionally, the bottom half of the central island and truck apron will be isolated for construction.

**Stage 2: Construction of the West and South Sections**

Minor changes are made to the temporary T-intersection created in Stage 1. Stormwater pipes will be installed and backfilled along the median on Marine Dr. Once the pipes are installed, repaving will occur along the west and south side of Marine Dr.

**Stage 3: Construction of Northeast Section**

Vehicle traffic will shift to the southbound side of Marine Dr. and the eastbound side of 16th Ave. The other half of 16th Ave. will shut down for stormwater pipes and connections to be installed along the median on 16th Ave and close to the detention tank. The top half of the central island will be isolated for construction. Once the pipes are installed and backfilled, repaving will occur.

**Stage 4: Construction of Southeast Section**

Vehicle traffic will shift to the northbound side of Marine Dr. and the westbound side of 16th Ave. The other half of 16th Ave. will shut down for stormwater pipes and connections to be installed close to the detention tank. Once the pipes are installed and backfilled, repaving will occur.

**Stage 5: Final Details and Landscaping**

In the final stage, the remaining portion of the central island will be fully constructed. Moreover, the splitter islands and medians will be finalized, as seen with the red shading in Figure 4-2. Any remaining portion of old pavement will be removed, while temporary pavement will be repaved. Additionally, curb and gutter installation will finalize the asphalt structure of the project site. The Gateway Structure shall be constructed on the finalized central island. Finally, to complete the construction process, landscaping will be conducted on all medians and islands.

## 4.5 Traffic Management Plan (TMP)

Stages 1 to 4 are accompanied by detailed TMPs and are attached in Appendix G. The TMPs were designed in accordance with the 2020 Traffic Manual for Work on Roadways of BC MoTI. Each TMP provides a view of the signage, intersection control, traffic diversions, work activity areas, and direction of traffic within the stages. Lane closures and median crossovers are the main traffic alterations for the construction period. Each TMP displays a modified T-intersection for each stage. Each version of the intersection is controlled and the location varies for each TMP. In each stage, at least one lane of bi-directional traffic remains open. This design optimizes safety, and avoids transforming the site into single-lane alternating traffic. For areas outside of the project scope, any traffic management must be designed in accordance with the 2020 Traffic Manual for Work on Roadways.

## 4.6 Construction Specifications

The intersection is designed based on the construction specifications found in Appendix H. It is imperative that all specifications are followed to ensure that construction is successful. The specifications include:

- Lighting Specifications
- Environmental Specifications
- Roadworks Specifications
- Site Earthworks and Engineered Fill Specifications
- Reinforced Cast-In-Place Concrete Specifications
- Storm Sewer Specifications
- Concrete Reinforcement Specifications
- Signage and Pavement Markings Specifications

# 5.0 Detailed Construction Schedule

A construction schedule for the detailed design has been created. Table 5-1 shows a simplified version of the construction schedule by illustrating the durations of key milestones. The expected start date of the construction phase is set to begin May 1, 2024 and the estimated complete date is November 20, 2024. A detailed construction schedule can be found in Appendix B.

Table 5-1: Simplified Detailed Construction Schedule

| Task | Duration | April | May | June | July | August | September | October | November |
|---|---|---|---|---|---|---|---|---|---|
| **Phase 1: Permitting** | 30 | | | | | | | | |
| **Phase 2: Mobilization** | 2 | | | | | | | | |
| **Phase 3: Construction Stage 1** | 37 | | | | | | | | |
| **Phase 4: Construction Stage 2** | 34 | | | | | | | | |
| **Phase 5: Construction Stage 3** | 31 | | | | | | | | |
| **Phase 6: Construction Stage 4** | 31 | | | | | | | | |
| **Phase 7: Construction Stage 5** | 39 | | | | | | | | |
| **Phase 8: Inspections** | 25 | | | | | | | | |
| **Phase 9: Demobilization** | 2 | | | | | | | | |

The construction schedule has been created under the assumption of an accelerated permitting process to ensure construction can commence on May 1, 2024. The construction schedule has been tailored to operate on a 6-day work week, with an exclusion of Sundays and statutory holidays from the working calendar. Furthermore, the schedule has been divided into distinct phases. Each phase focuses on a specific aspect of the construction process, allowing for strategic implementation without the need for a complete closure.

# 6.0 Class A Cost Estimate

A cost estimate is completed for the detailed design of the roundabout. Table 6-1 shows a simplified Class A cost estimate with a total cost of **$6,678,000**. A detailed Class A cost estimate can be found in Appendix C.

Table 6-1: Simplified Cost Estimate

| Simplified Cost Estimate | | |
|---|---|---|
| Client: UBC Campus and Community Planning | | |
| Project: Redesign of 16th Avenue / SW Marine Drive Intersection | | |
| | | |
| **Item No.** | **Description of Work and Materials** | **Total** |
| | | |
| 1 | General Construction Items | $180,000.00 |
| 2 | Engineering & Permitting | $428,000.00 |
| 3 | Clearing, Grubbinng & Demolition Items | $735,000.00 |
| 4 | Road Construction | $2,848,000.00 |
| 5 | Storm Drainage | $555,000.00 |
| 6 | Gateway Feature | $20,000.00 |
| 7 | Signals & Lighting | $50,000.00 |
| 8 | Landscape & Restoration | $741,000.00 |
| 9 | Operations & Maintenance | $250,000.00 |
| | | |
| | **SUBTOTAL** | **$5,807,000.00** |
| | **Contingency 15%** | $871,000.00 |
| | **TOTAL ESTIMATE** | **$6,678,000.00** |

The cost estimate includes first costs, the construction of the design of the roundabout, and the annual operating and maintenance costs. First costs include general construction items, such as project and construction management, as well as the necessary engineering and permitting. The pre-construction costs include clearing, grubbing, and demolition of the existing intersection, and the work and materials needed to complete construction. The construction elements, included in items 4 to 8 in Table 6-1, consider road construction, storm drainage components, the gateway structure, signals and lighting, and landscaping and restoration needed in the final stages. Lastly, annual operating and maintenance costs are included for the lifetime of the roundabout, assuming a 25 year lifespan. A contingency of 15% is applied to account for uncertainties and risks.

# 7.0 Conclusion

Our team is proud to present our redesign of the Southwest Marine Dr. and 16th Ave. intersection located on UBC's Vancouver campus. Our design features a multi-lane roundabout with two lanes of traffic at all approaches. Active transportation is encouraged through bi-directional bike lanes spanning all directions, with RRFBs installed at new crossrides and crosswalks. A gateway structure decorated with indigenous artwork and stone veneer is found on the southeast end of the centre roundabout island. The sign faces northbound travelers who must first pass through a speed-reducing chicane along the southwest intersection leg. Lastly, along the outskirts of the roundabout are sloped ditches to feed stormwater into a detention tank residing beneath the centre island.

Encompassed within the many features of the design, our roundabout achieves the following project objectives:

- Prioritizes the safety and accessibility for all active modes of transportation
- Reduces motor vehicles speeds prior to entering the intersection
- Stays within designated property and minimizes land usage
- Effectively retains stormwater on-site
- Serves as a gateway to welcome travelers to the campus

The next steps for our team include acquiring the necessary permits, informing the public, and proceeding with the first stages of construction. Our team looks forward to working alongside UBC SEEDS in ensuring the successful installation of the redesigned Southwest Marine Dr. and 16th Ave intersection.

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# Appendix A: Drawings

UBC CAMPUS + COMMUNITY PLANNING

# 16TH AVENUE & SW MARINE DRIVE INTERSECTION REDESIGN



| REV. | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 02 | 24-04-10 | ISSUED FOR CONSTRUCTION | |
| 01 | 23-12-07 | ISSUED FOR PRELIMINARY DESIGN | |

CONSULTANT

CLIENT
**UBC CAMPUS + COMMUNITY PLANNING**
CIRS, 2210 WEST MALL VANCOUVER,
B.C., CANADA V6T 1Z4

TITLE 16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
DRAWING INDEX

SEAL

SCALE: HOR. VERT.
DESIGNED
DRAWN
REVIEWED

DATE (YYYY.MM.DD) 2024.04.10
CONSULTANT PROJ. NO. CIVL 446
DWG. NO. 00
REV. 1

DRAWING TYPE
DRAWING INDEX

GENERAL NOTES:

1. All construction and materials shall be in accordance with:
   - The Master Municipal Construction Document and Standard Detail Drawings (MMCD–Platinum Edition);
   - BC MOTI 2020 Standard Specifications for Highway Construction
   - BC MOTI Electrical and Traffic Engineering Manual
   - For construction contract drawings as per the form of agreement – signed & sealed by Professional Engineer
   - Applicable contract documents and all specifications.
   - Ministry of Transportation "B.C. Traffic Control Manual for Work on Roadways", latest edition;
   - WorkSafeBC, latest edition.

   The Contractor shall maintain on site copies of the above documents and shall ensure that all trades are thoroughly familiar with the applicable sections of the documents.
2. The Contractor shall register a BC One Call before start of construction.
3. Before commencing construction, the Ministry will schedule a pre–construction meeting.
4. The Contractor shall expose and verify the location and elevation of all existing services in the field prior to construction and notify the contract administrator of any discrepancies, conflicts or omissions prior to construction.
5. Figured dimension shall govern over scaled dimensions.
6. The Contractor shall ensure that all approvals required for the proposed works have been obtained from all authorities and agencies prior to commencing the work.
7. The Contractor shall contact the appropriate personnel at least 72 hours prior to the work. Scheduling and other construction constraints imposed by these works shall be taken into account.
8. Residents directly affected by construction of these works and services shall be given 48 hours written notice of the proposed start of construction.
9. The Contractor shall repair or replace any existing streets, services, landscaping, private landscaping or private improvements that may be damaged as a result of construction. Repairs to existing Ministry services such as water, sanitary sewer, storm sewer and street or traffic lighting shall be made by the Ministry at cost to the Contractor.
10. As part of the project, the Contractor is responsible for conducting all necessary tests, inspections, and approvals outlined in the contract documents. Before issuing the Substantial Completion Certificate, the Contractor must provide the contract administrator with copies of all test results. Additionally, reports and test results must be submitted to the Ministry's site inspector as the work progresses or upon request. The cost of all testing is included in the contract.
11. The Contractor will submit a traffic and pedestrian safety control plan prior to the pre–construction meeting.
12. The Contractor bears sole responsibility for ensuring construction safety at the work site, complying with relevant construction safety legislation, regulations, and codes, including but not limited to the Workers Compensation Act and associated regulations, as well as adhering to good construction practices.

DRAWING NOTES – ENVIRONMENTAL

1. Tree protection barriers shall be installed around the drip line of each tree to be retained, before any site activities, in such a manner that its branches, root systems and trunk will not be damaged by any site activity.
2. The contractor shall comply with the provisions of any provincial or local government enactments that may apply to the impacts on nesting birds of removing trees.
3. Construction and operational activities on the site (including management of rain water) should respect aquifer water quantity and quality (e.g. no leaking machinery, appropriate machinery refueling practices, prompt spill clean–up, proper waste management during construction, preparation of operational spill response plans, etc.).

DRAWING NOTES – EARTHWORKS & GRADING

1. In areas with setbacks, and discharges to creeks, streams, and watercourses, approval from federal and provincial authorities may be necessary. The Contractor is responsible for engaging a certified environmental professional to conduct essential studies and secure any required permits and approvals before commencing construction.
2. Geotechnical consultant to assess and authorize the natural subgrade before initiating the placement of fill.
3. Geotechnical consultant to review and approve fill material before initiating the material use.
4. Before introducing structural fill, clear vegetation, remove organic material, and eliminate any unsuitable substances as needed.
5. Conform to MMCD specifications by compacting all earth fills and granular material layers.
6. Ensure that all proposed grading aligns with the existing ground elevations, unless specified otherwise.
7. Proof rolling should involve at least four passes of a vibratory smooth drum roller (eg. minimum 8 tonne deadweight) for the detection of unstable or "soft" areas.

DRAWING NOTES – ROADWORKS

GEOMETRICS

1. Implement smooth vertical and horizontal curves to shape changes in grade and direction.
2. Execute earthworks according to the contract documents, which involve tasks such as removing loose or detrimental materials, addressing soft spots, compacting, and grading slopes.
3. Construct embankments in accordance with the standards and specifications outlined in the contract documents, ensuring proper placement, shaping, compaction, and protection.
4. In instances where existing ditches need infilling or services are established in fill sections, utilize granular material for filling, ensuring it is supplied, placed, and compacted in accordance with MMCD specifications.
5. Adhere to MMCD specifications for all sub–base road and granular base materials.
6. Extend the road sub–base and base a minimum of 0.3 meters beyond the road edge or curb and gutter.
7. Ensure compliance with the specifications outlined in the MMCD specifications and detail drawings when placing asphalt pavement and concrete.
8. Unless approved otherwise, asphaltic concrete for roadwork must be applied in two lifts.
9. Connect to existing pavement by cutting back to sound material as required to create a tidy vertical face.
10. Ensure that all new pavement is graded to prevent ponding, with a minimum cross slope of 2% on any new or overlain road surface.
11. Adjust all valve boxes, manholes, etc., within the paved surface of the roadway to the finished course elevation before applying the finish course paving.
12. Concrete barrier curbs must adhere to the MOTI standard drawing SP582–01.04 and combined curb and gutters must adhere to the MOTI standard drawing SP582–01.01. Mountable concrete curb and gutter must adhere to the MOTI standard drawing SP582–01.02.

ASPHALT

1. Ensure compliance with the specifications outlined in the MMCD specifications and detail drawings when placing asphalt pavement and concrete.
2. Unless approved otherwise, asphaltic concrete for road work must be applied in two lifts.
3. Asphalt mix must be in compliance with Section 952 of the 2020 Standard Specification for Highway Construction Volume 1.
4. Quality control, inspection, and testing of asphalt pavement must be conducted and recorded according to Section 952.02 of the 2020 Standard Specification for Highway Construction Volume 1.
5. Sourced aggregates for paving must be compliant with Section 502.06.05 of the 2020 Standard Specification for Highway Construction Volume 1.
6. Asphalt mixes are the responsibility of the contractor to design and cost as outlined in Section 502.08 of the 2020 Standard Specification for Highway Construction Volume 1.

DRAWING NOTES – STORM SEWER

PVC PLASTIC DRAINAGE PIPE

1. All storm sewer main and catchbasin lead material to be PVC.
2. The pipe shall be homogenous throughout and free from visible cracks, flaws, foreign inclusion, or other injurious defects. The pipe shall be uniform in colour, opacity and other physical properties.
4. The minimum pipe stiffness when tested in accordance with SS 318.10.02 and ASTM D2412 shall be 320 kPa.
5. There shall be no evidence of splitting, cracking or breaking when the pipe is tested in accordance with SS 318.10.03.
6. The pipe stiffness shall be determined at 5% deflection of the initial inside diameter in accordance with ASTM D2412. Three specimens, each with a length equal to one pipe diameter shall be tested; all shall meet the required stiffness.

STORM DRAINAGE

1. The Contractor is responsible for performing tie–ins and connections to existing storm sewers under the supervision and direction of the Ministry. Costs associated with this task are incidental to the relevant item in the schedule of quantities and prices. A minimum of 72 hours' notice must be provided for any tie–in activities.
2. New sewer lines connecting to existing lines must be plugged until they undergo testing and flushing.
3. All drain pipe shall be of first quality, sound, true in form and free from defects of all kinds.
4. Catch basins shall be constructed, where shown and as required in the Drawings or as the Ministry Representative may direct, in accordance with the intent of SS Drawings SP582–02.01 through SP582–02.05.
5. Storm drains shall be constructed where shown on Drawings, or as directed by the Ministry Representative, and in accordance with the Drawings and specifications covering the various types and as attached herewith. The trench and other preparatory work shall be approved by the Ministry Representative before actual placing starts.
4. Ensure a minimum slope of 0.5% on catch basin leads.
5. Prevent the entry of deleterious materials into the Ministry's sewer system.
6. Utilize manufactured wyes or approved alternatives for all service connections to storm mains.
7. Include inspection chambers for completeness in storm service connections.
8. Grout between precast sections and donuts for all manholes and catch basins.

DRAWING NOTES – CONCRETE REINFORCEMENT

1. Compliance to the following sections in the BC MoTI 2020 Standard Specifications for Highway Construction shall apply for Concrete Reinforcement Specifications. Refer to Section 412 – Concrete Reinforcement for detailed construction specifications.
2. Galvanized reinforcement steel shall conform to the requirements of ASTM A767M–Class II Coating, as per Section 412.11.03.
3. Reinforcement bars shall be cut and bent to the shapes shown on the drawings, and shall be bent cold unless otherwise permitted, as per Section 412.31
4. Unless otherwise shown on the drawings, hooks and bend dimensions shall conform the requirements of Section 412.31.01.
5. Reinforcing bars shall be stored on platforms, skids or other suitable supports clear of the ground, as per Section 412.32
6. Placing and fastening of reinforcement shall conform to the requirements of Section 412.33.
7. Tolerances for placing reinforcement shall, unless otherwise specified, be as shown in Table 412–D of Section 412.33.01.
8. Concrete cover for reinforcing steel shall be in accordance with Section 412.33.03 and the Ministry "Bridge Standards and Procedure Manual –Supplement to CHBDC S6".
9. Special requirements for splicing, such as particular locations for splices, use of overlength bars or special lap lengths, shall be as shown on the Drawings, as per Section 412.34
10. Splices in bars larger than 35M shall be mechanical coupler splices or welded. The detail of such splices shall be subject to acceptance by the Ministry Representative.

DRAWING NOTES – REINFORCED CAST–IN–PLACE CONCRETE

1. Concrete supplied under this Specification will be specified in accordance with CSA A23.3:19
2. Fine aggregate shall meet the grading requirements of C CSA A23.3:19, be graded uniformly and not more than 3% shall pass a 75 um sieve.
3. The maximum nominal size of coarse aggregate shall be 20 mm and meet the grading requirements of CSA A23.3:19. Coarse aggregate shall be uniformly graded and not more than 1% shall pass a 75 um sieve.
4. Cementitious materials shall conform to the requirements of CSA A23.3:19 and shall be free from lumps.
5. Water to be used for mixing and curing concrete or grout and saturating the substrate shall be potable, shall conform to the requirements of CSA A23.3:19
6. Forms for exposed surfaces shall be made of good quality plywood in "like–new" condition and uniform in thickness, with or without a form liner.
7. All concrete shall be mixed thoroughly until it is uniform in appearance, with all ingredients uniformly distributed.
8. The maximum time allowed for all types of concrete to be delivered to the site of the Work, including the time required to discharge, shall not exceed 90 minutes after batching.
9. The design, fabrication, erection, and use of concrete formwork shall conform to the requirements of CSA A23.3:19.
10. The operation of the pump shall produce a continuous flow of concrete without air pockets.
11. Sampling of concrete shall be carried out in accordance with CSA A23.3:19
12. The structure shall not be opened to traffic until the concrete has attained a minimum compression strength of 100% of the design strength.

DRAWING NOTES – PAVEMENT MARKINGS & SIGNAGE PLAN

1. All signage recommendations should be complemented by Reference to Specifications for Standard Highway Sign Materials, Fabrication and Supply by the Ministry of Transportation and Infrastructure.
2. All pavement marking recommendations should be complemented by reference to Pavement Marking Service Agreement 2008 by the Ministry of Transportation and Infrastructure.
3. Preserve all currently installed signs, remove any surplus signs upon completion of the work, and return them to the Ministry.
4. The Ministry is responsible for installing temporary and permanent street, traffic, and advisory signs, as well as pavement markings not explicitly depicted on the drawings.
5. The Ministry is responsible for removing existing conflicting pavement markings.
6. All signage must be retro–reflective to show the same colour, shape and message at night as they appear in daytime.
7. Signs shall be clearly and permanently labeled (using durable, weather resistant material) or engraved with an identification coding.
8. Edges of all substrate material shall be deburred to provide a smooth finished edge.
9. Sheeting Material cannot contain air pockets and shall not have holes, tears,scrapes, compressed cells, or patches.
10. Utilize extruded thermoplastic for all permanent pavement markings.
11. White paint must conform to US Federal specification 595b White 17886.
12. Yellow paint must conform to US Federal specification 595b Yellow 33538.
13. The Ministry is responsible for removing all existing conflicting pavement markings.

DRAWING NOTES – STREETLIGHTING

1. LED lighting to be used at all new lighting installations. Refer to Section 504 of the MOTI Electrical and Signing Material Standards for the materials specification for LED roadway luminaires.
2. Due to the rapid evolution of LED lighting, material suppliers and equipment specifications may change at any time. The designer shall reference the most current version of the ministry's Recognized Products List and Procurement Services Corporate Supply Arrangement to ensure that the latest equipment is used for new designs.

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| 02 | 24-04-10 | ISSUED FOR CONSTRUCTION | |
| 01 | 23-12-07 | ISSUED FOR PRELIMINARY DESIGN | |

CONSULTANT

CLIENT
UBC CAMPUS + COMMUNITY PLANNING
CIRS, 2210 WEST MALL VANCOUVER,
B.C., CANADA V6T 1Z4

TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
GENERAL NOTES

SEAL

SCALE: HOR. 1:1000 VERT. -
DESIGNED
DRAWN
REVIEWED

DATE (YYYY.MM.DD) 2024.04.10
CONSULTANT PROJ. NO. CIVL446
DWG. NO. 01
REV. 1

DRAWING TYPE
GENERAL NOTES


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CIRS, 2210 WEST MALL VANCOUVER,
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TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
SITE PLAN

SEAL

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REVIEWED

DATE (YYYY.MM.DD)
2024.04.10

CONSULTANT PROJ. NO.
CIVL446

DWG. NO.
02

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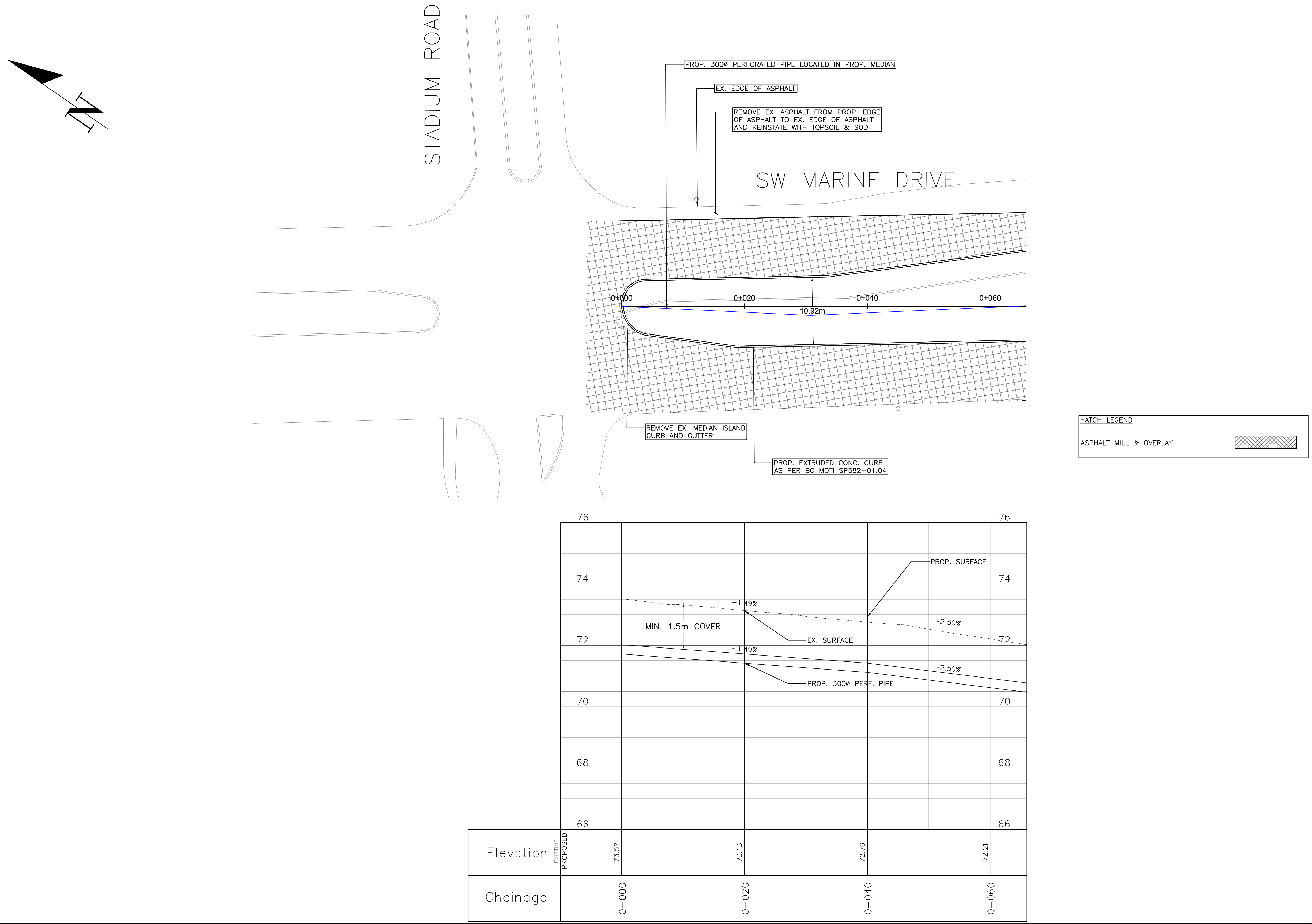
DRAWING TYPE
SITE PLAN

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TITLE

16th AVENUE & SW MARINE DRIVE

INTERSECTION REDESIGN

PLAN & PROFILE

SEAL

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DATE (YYYY.MM.DD) 2024.04.10

CONSULTANT PROJ. NO. CIVL446

DWG. NO. 03

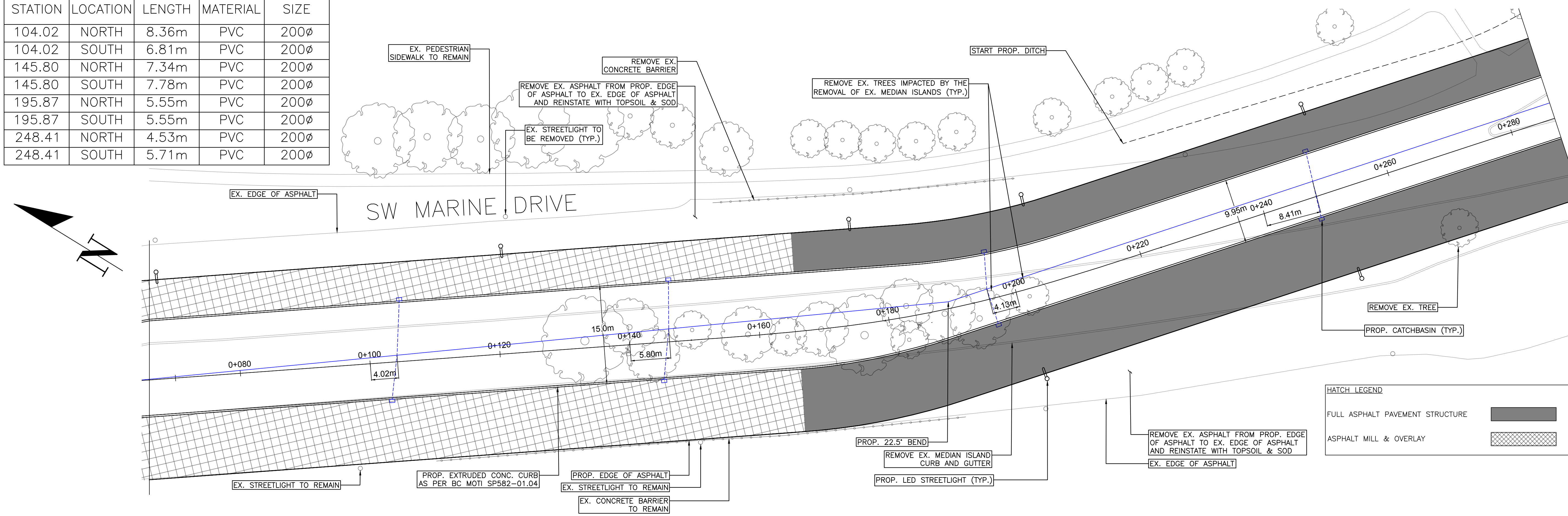
REV. 1

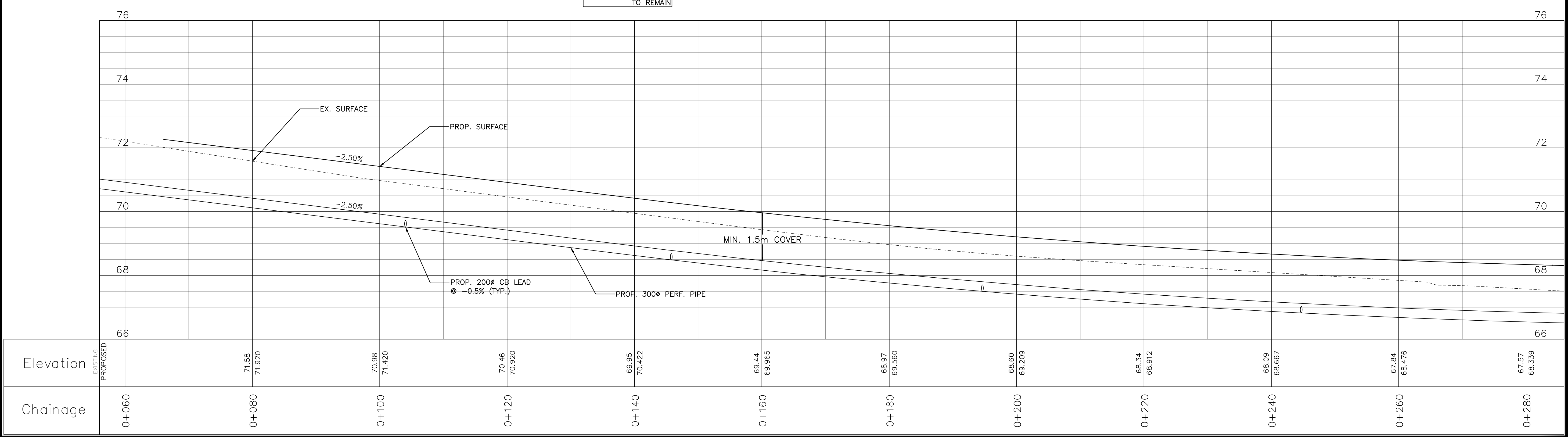
DRAWING TYPE

ROADWORKS PLAN & PROFILE

## CB LEAD DETAILS

| STATION | LOCATION | LENGTH | MATERIAL | SIZE |
|---|---|---|---|---|
| 104.02 | NORTH | 8.36m | PVC | 200ø |
| 104.02 | SOUTH | 6.81m | PVC | 200ø |
| 145.80 | NORTH | 7.34m | PVC | 200ø |
| 145.80 | SOUTH | 7.78m | PVC | 200ø |
| 195.87 | NORTH | 5.55m | PVC | 200ø |
| 195.87 | SOUTH | 5.55m | PVC | 200ø |
| 248.41 | NORTH | 4.53m | PVC | 200ø |
| 248.41 | SOUTH | 5.71m | PVC | 200ø |

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CIRS, 2210 WEST MALL VANCOUVER, B.C., CANADA V6T 1Z4

TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
PLAN & PROFILE

SEAL

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DATE (YYYY.MM.DD) 2024.04.10
CONSULTANT PROJ. NO. CIVL446
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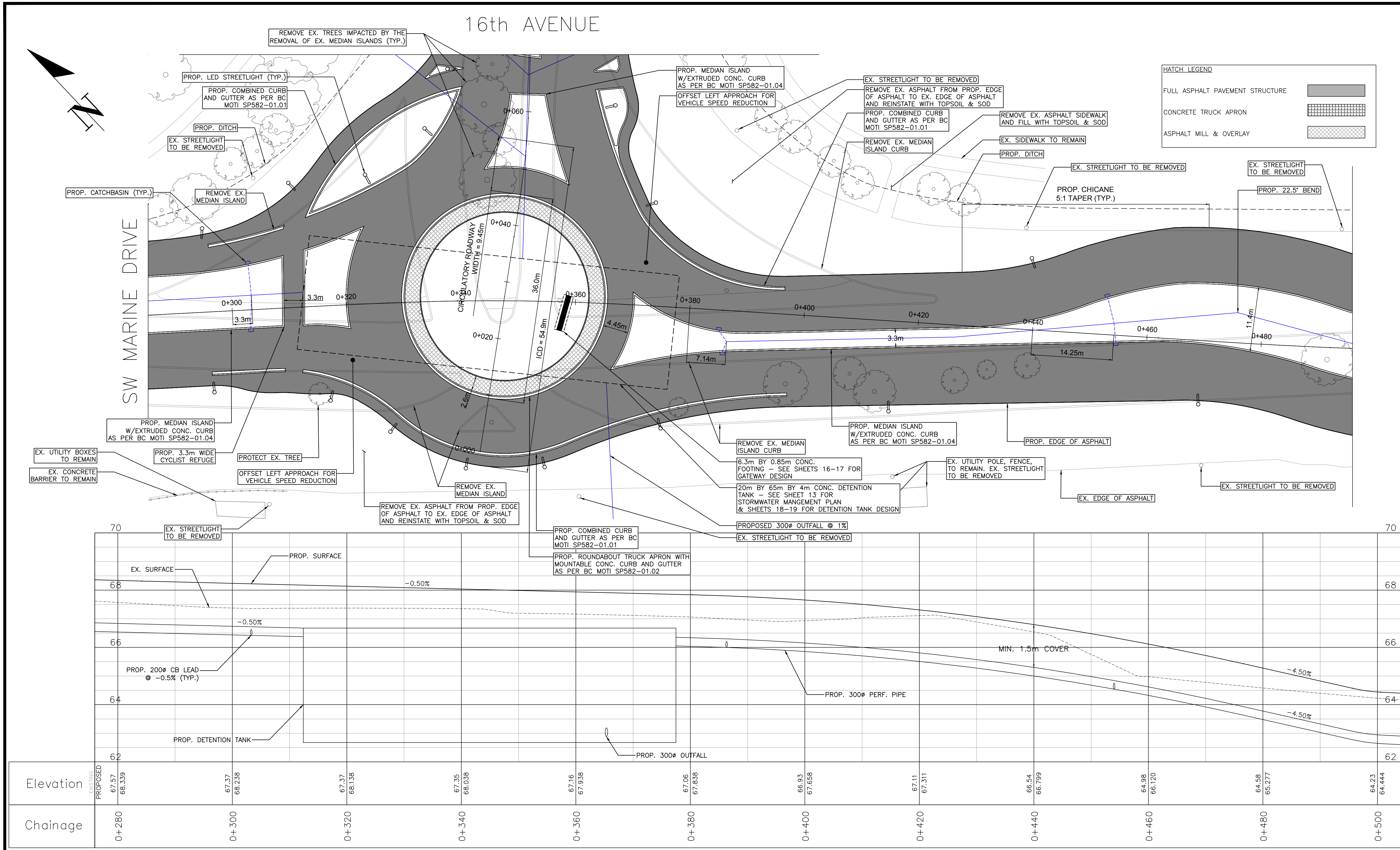
ROADWORKS PLAN & PROFILE

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TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
PLAN & PROFILE

SEAL

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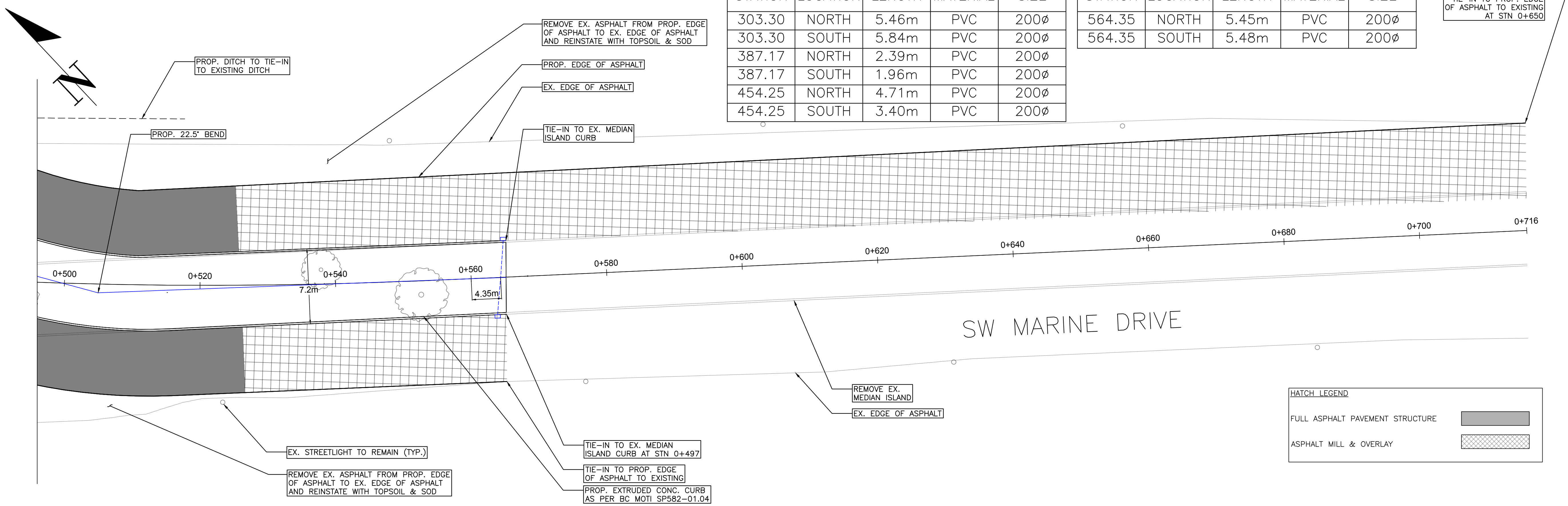
DRAWING TYPE
ROADWORKS PLAN & PROFILE

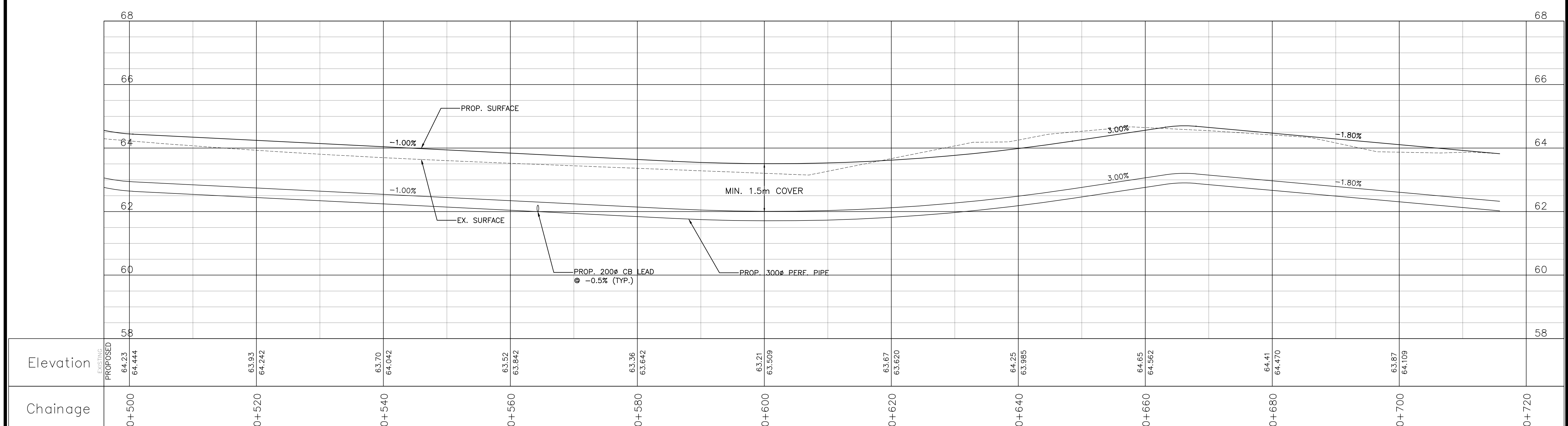
## CB LEAD DETAILS (DWG 05)

| STATION | LOCATION | LENGTH | MATERIAL | SIZE |
|---|---|---|---|---|
| 303.30 | NORTH | 5.46m | PVC | 200ø |
| 303.30 | SOUTH | 5.84m | PVC | 200ø |
| 387.17 | NORTH | 2.39m | PVC | 200ø |
| 387.17 | SOUTH | 1.96m | PVC | 200ø |
| 454.25 | NORTH | 4.71m | PVC | 200ø |
| 454.25 | SOUTH | 3.40m | PVC | 200ø |

## CB LEAD DETAILS (DWG 06)

| STATION | LOCATION | LENGTH | MATERIAL | SIZE |
|---|---|---|---|---|
| 564.35 | NORTH | 5.45m | PVC | 200ø |
| 564.35 | SOUTH | 5.48m | PVC | 200ø |

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TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
PLAN & PROFILE

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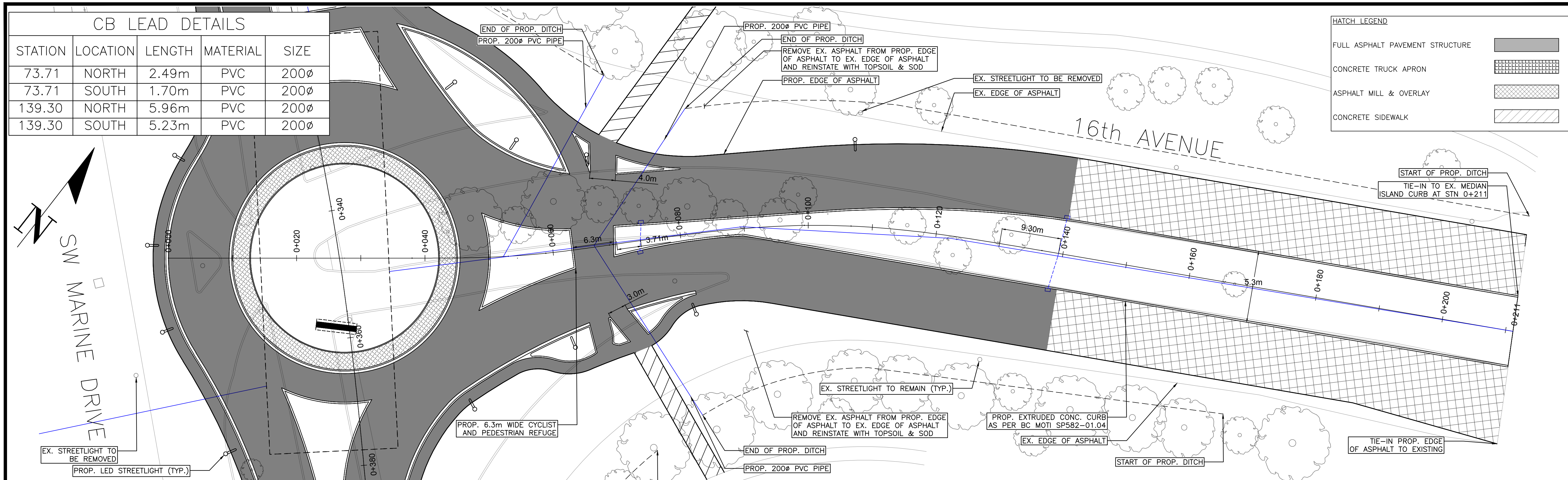
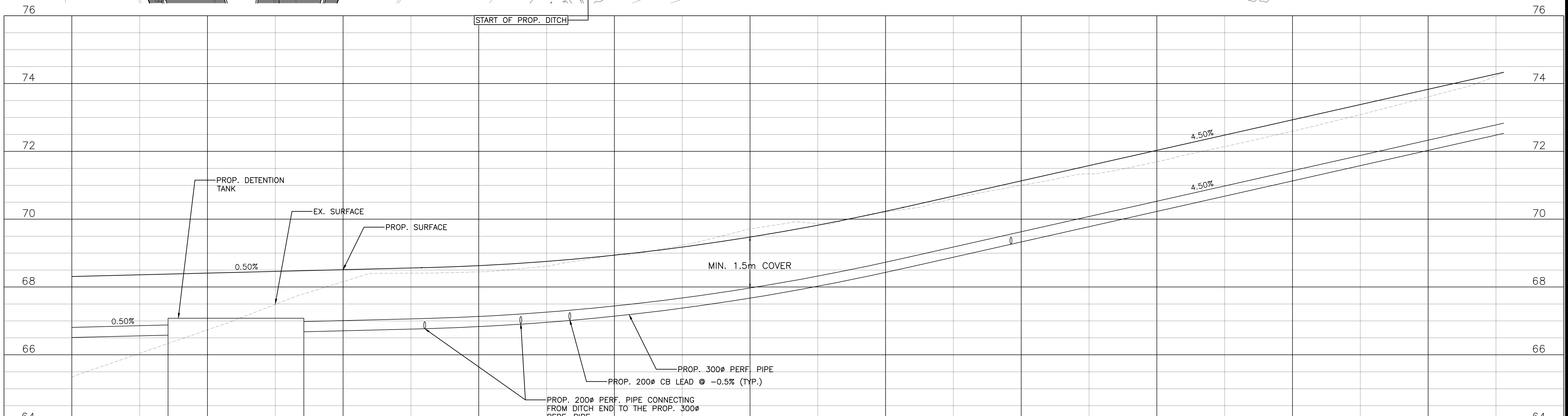
## CB LEAD DETAILS

| STATION | LOCATION | LENGTH | MATERIAL | SIZE |
|---|---|---|---|---|
| 73.71 | NORTH | 2.49m | PVC | 200ø |
| 73.71 | SOUTH | 1.70m | PVC | 200ø |
| 139.30 | NORTH | 5.96m | PVC | 200ø |
| 139.30 | SOUTH | 5.23m | PVC | 200ø |




| Chainage | 0+000 | 0+020 | 0+040 | 0+060 | 0+080 | 0+100 | 0+120 | 0+140 | 0+160 | 0+180 | 0+200 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Elevation EXISTING | 65.35 | 66.74 | 68.16 | 68.45 | 68.95 | 69.71 | 70.22 | 71.00 | 71.69 | 72.60 | 73.61 |
| Elevation PROPOSED | 68.310 | 68.410 | 68.510 | 68.631 | 68.939 | 69.472 | 70.231 | 71.130 | 72.030 | 72.931 | 73.831 |

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TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
PLAN & PROFILE

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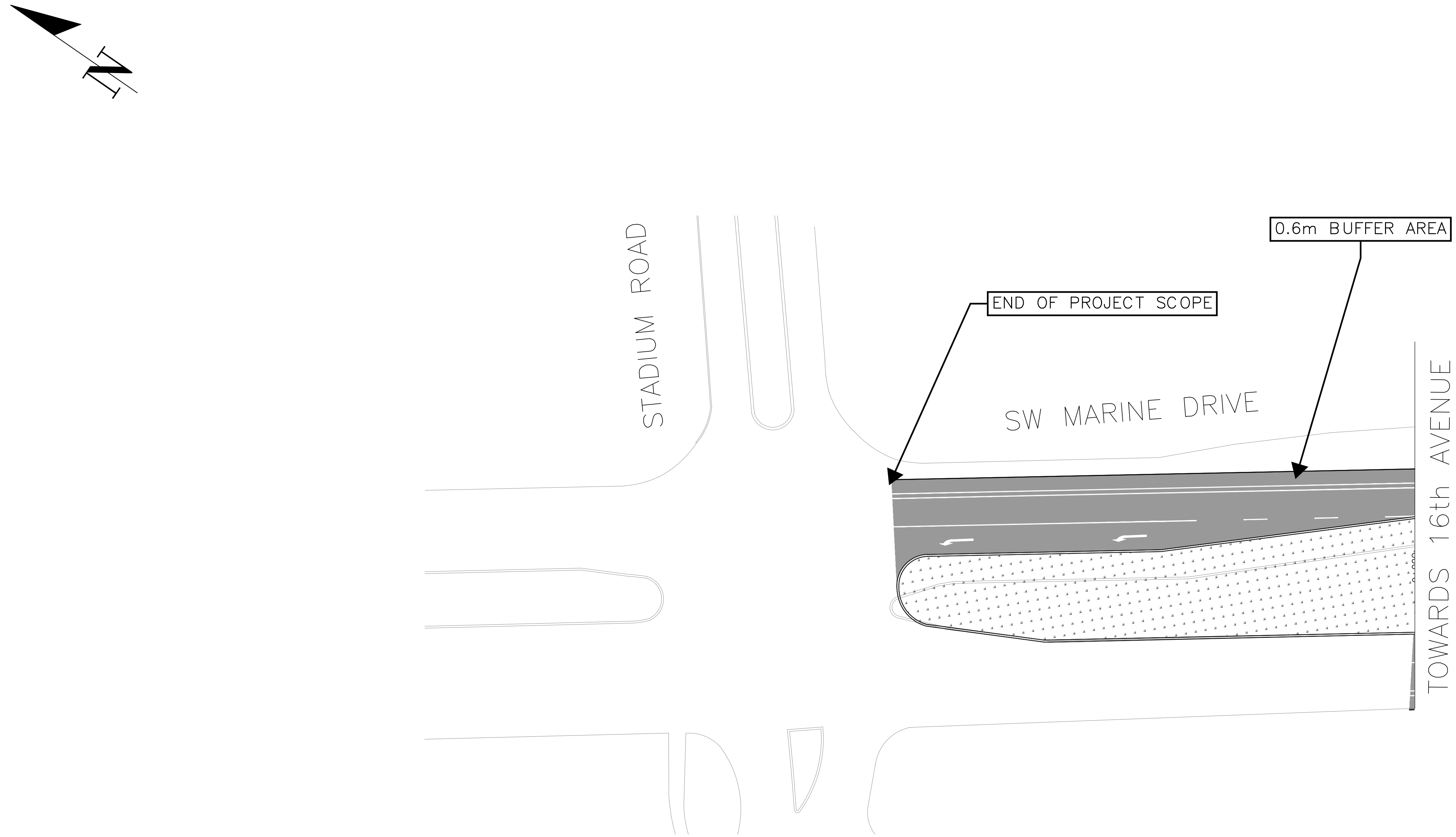


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TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
PLAN & PROFILE

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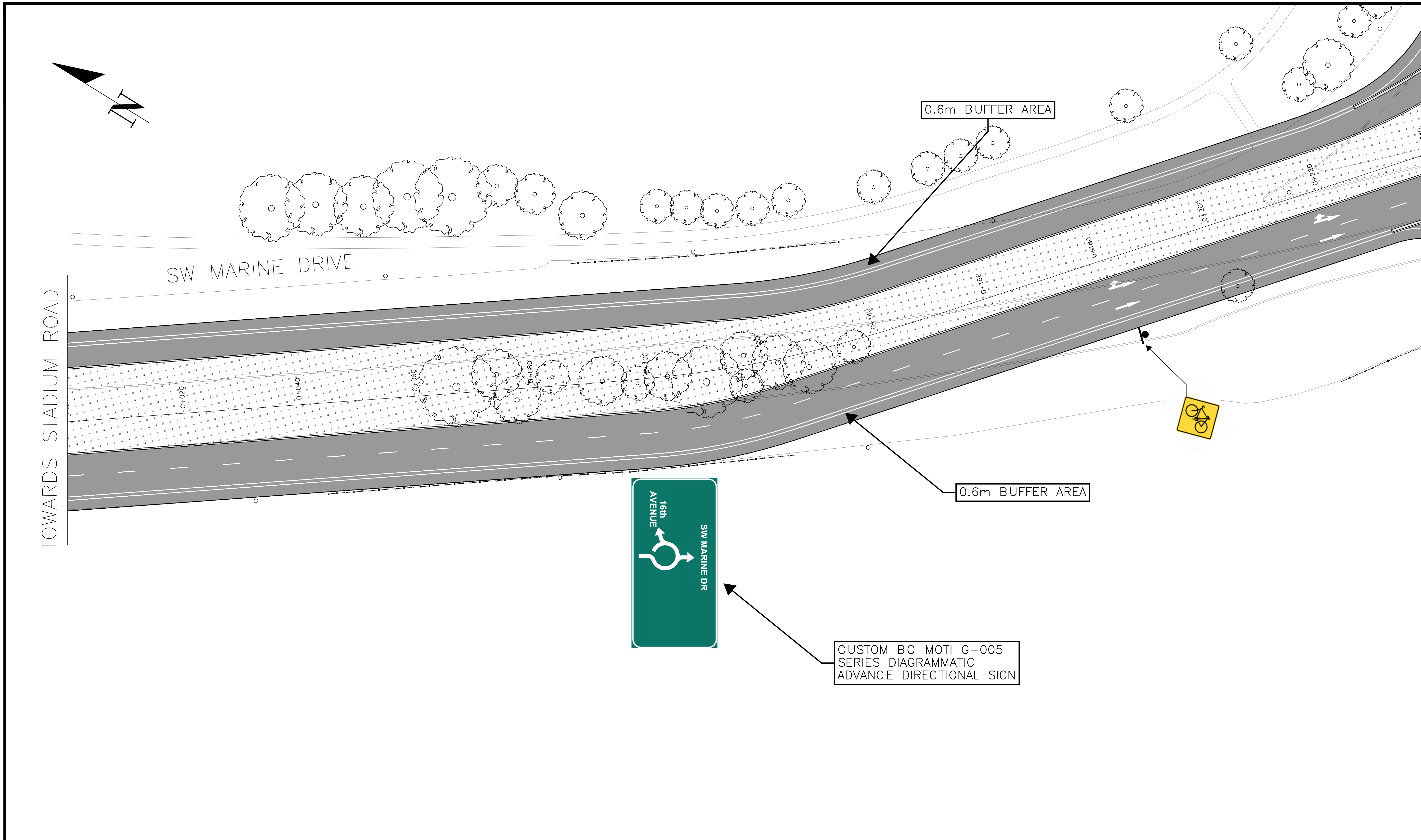
PLAN & PROFILE

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CIRS, 2210 WEST MALL VANCOUVER, B.C., CANADA V6T 1Z4

TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
PAVEMENT MARKING & SIGNS

SEAL

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CONSULTANT PROJ. NO. CIVL446
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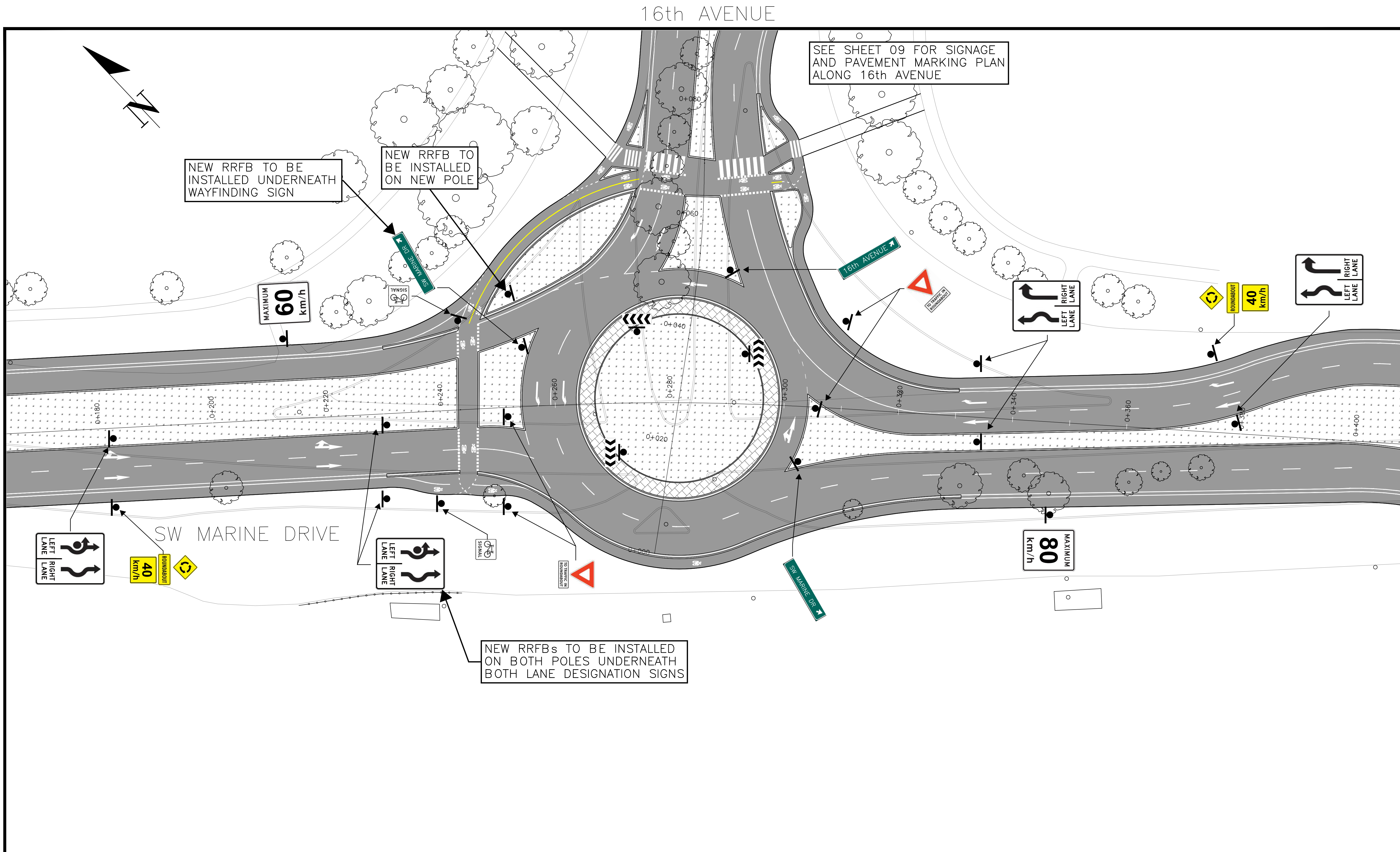
REV. 1

DRAWING TYPE
PAVEMENT MARKING
SIGNAGE

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CONSULTANT

CLIENT
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CIRS, 2210 WEST MALL VANCOUVER, B.C.,
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TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
PAVEMENT MARKING & SIGNS

SEAL

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DATE (YYYY.MM.DD) 2024.04.10
CONSULTANT PROJ. NO. CIVL446
DWG. NO. 10
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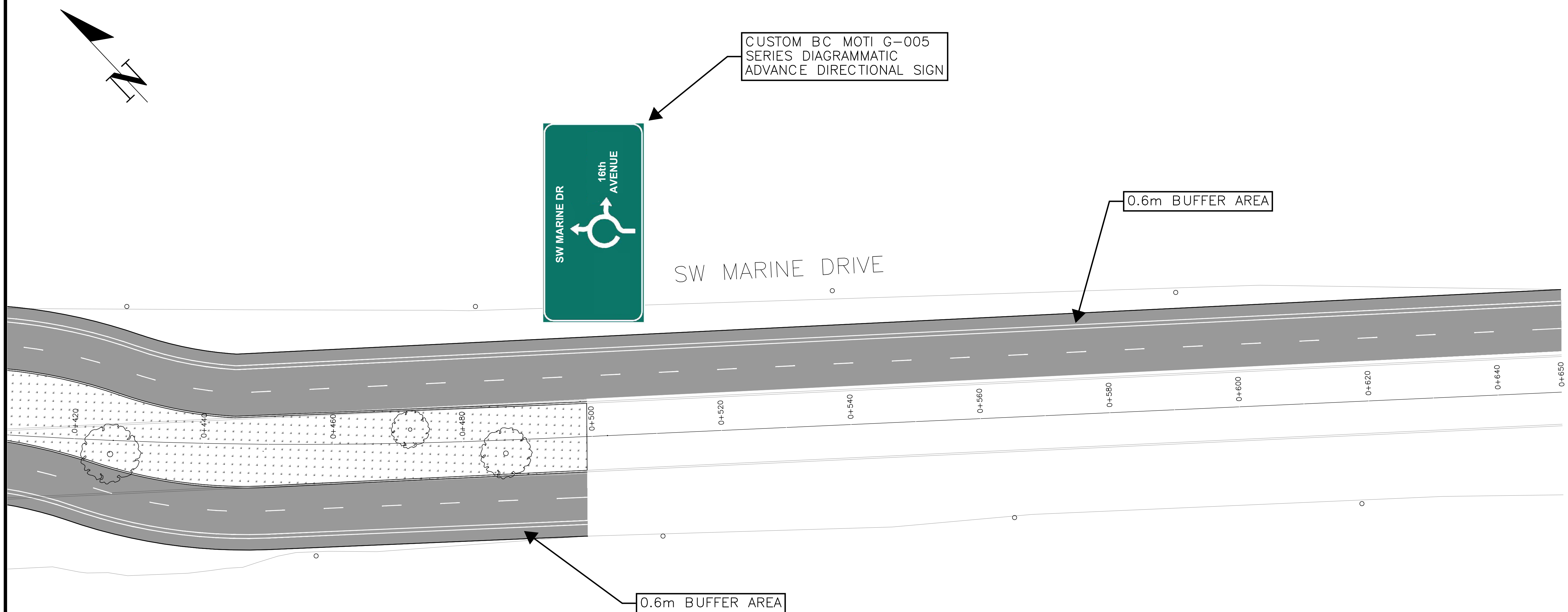
DRAWING TYPE
PAVEMENT MARKING
SIGNAGE

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CLIENT

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CIRS, 2210 WEST MALL VANCOUVER, B.C.,
CANADA V6T 1Z4

TITLE

16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
PAVEMENT MARKING & SIGNS

SEAL

SCALE: HOR. 1:300 VERT. -

DESIGNED

DRAWN

REVIEWED

DATE (YYYY.MM.DD) 2024.04.10

CONSULTANT PROJ. NO. CIVL446

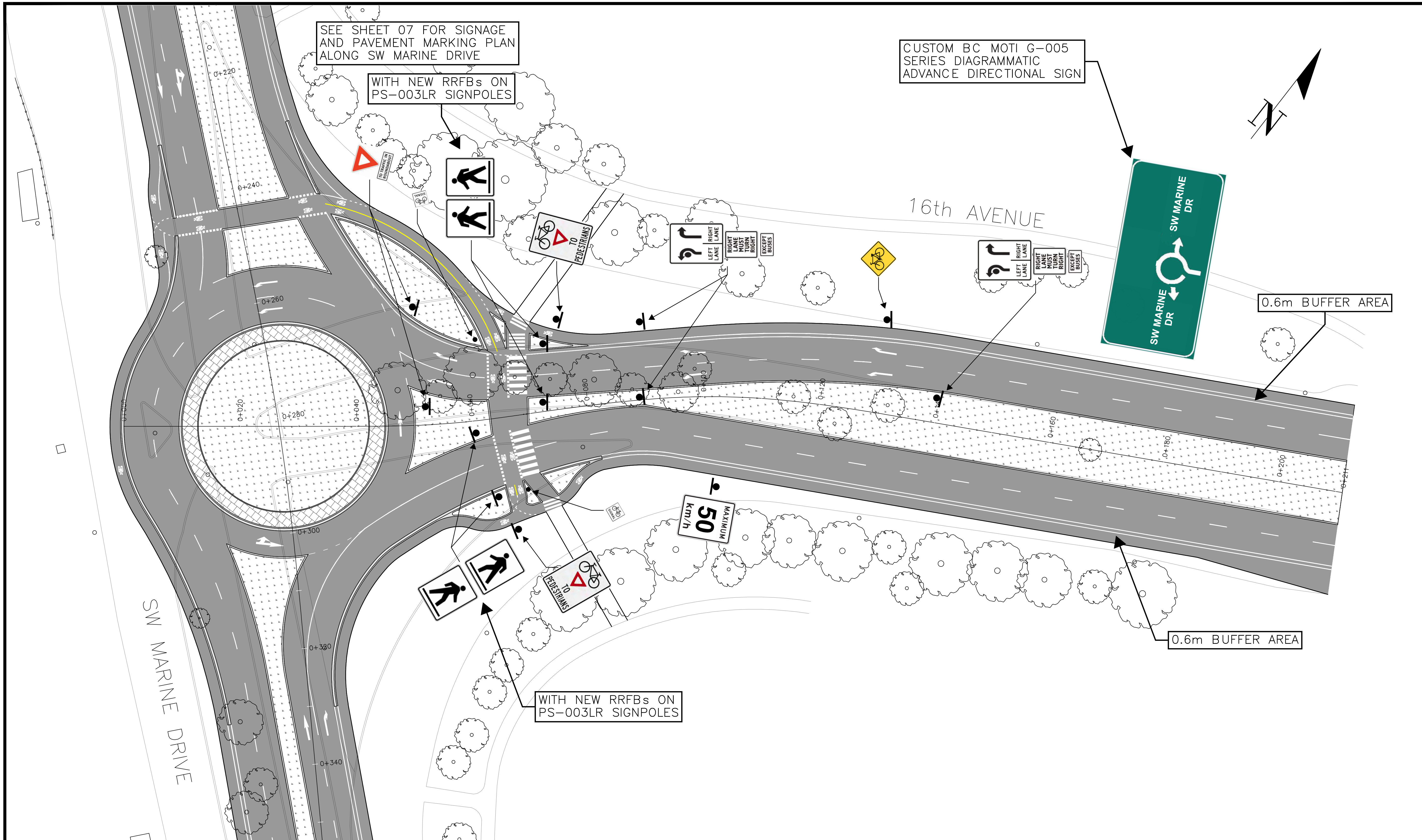
DWG. NO. 11

REV. 1

DRAWING TYPE

PAVEMENT MARKING

SIGNAGE

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CONSULTANT

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**UBC CAMPUS + COMMUNITY PLANNING**
CIRS, 2210 WEST MALL VANCOUVER, B.C., CANADA V6T 1Z4

TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
PAVEMENT MARKING & SIGNS

SEAL

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CONSULTANT PROJ. NO. CIVL446
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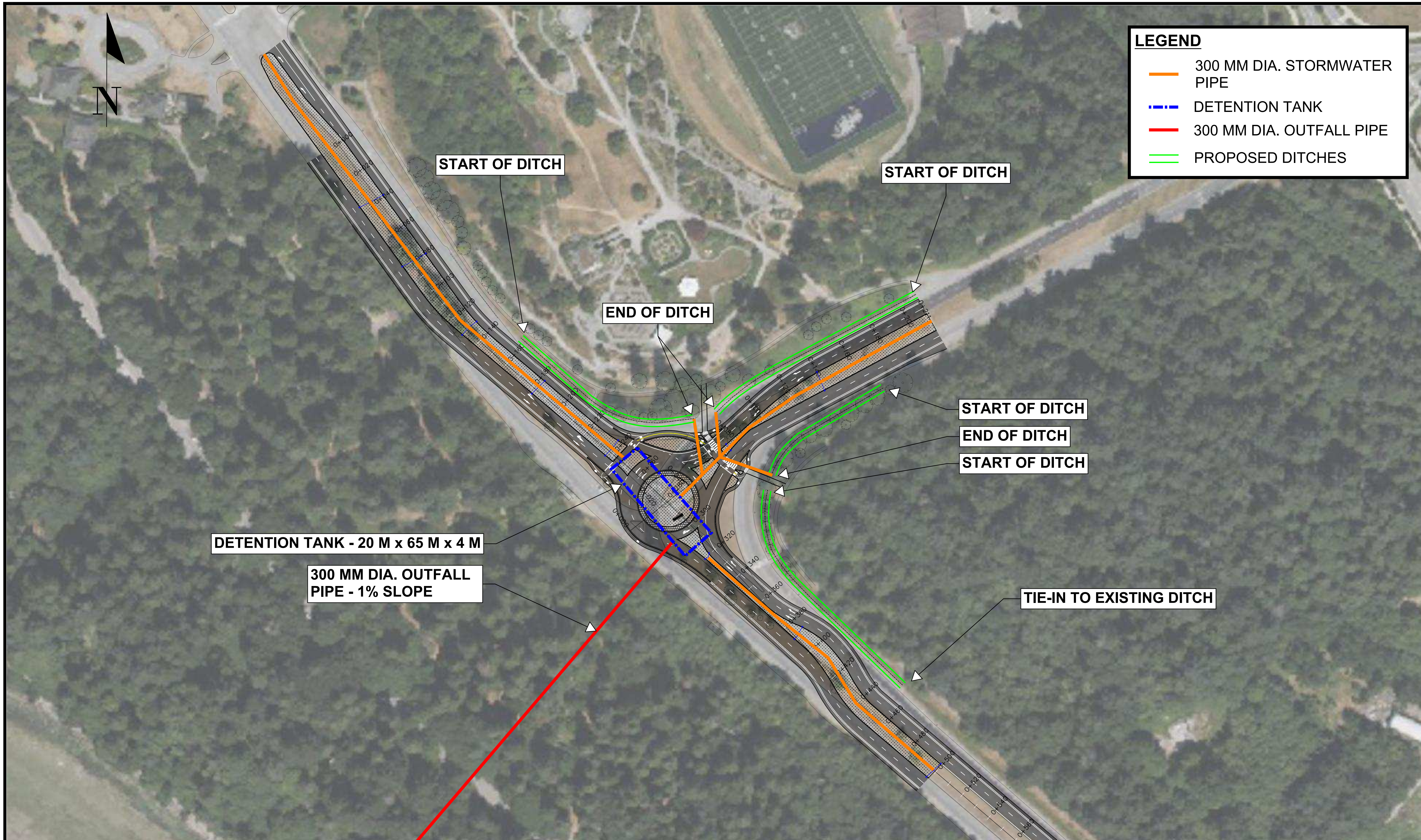
REV. 1

DRAWING TYPE
PAVEMENT MARKING
SIGNAGE

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**UBC CAMPUS + COMMUNITY PLANNING**
CIRS, 2210 WEST MALL VANCOUVER,
B.C., CANADA V6T 1Z4

TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
STORMWATER MANAGEMENT PLAN

SEAL

SCALE: HOR. 1:1000 VERT. -

DESIGNED

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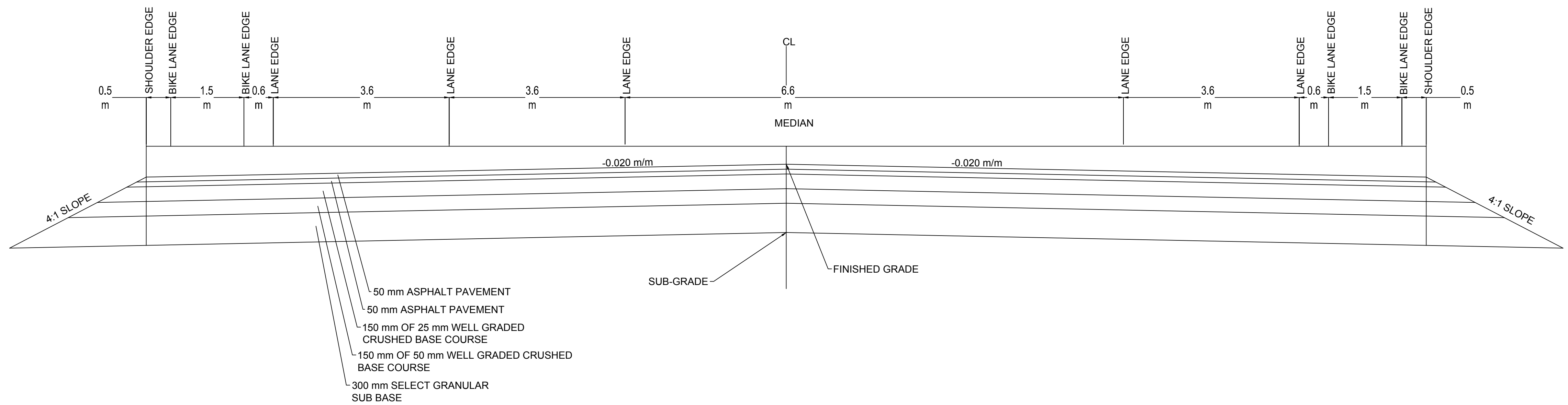
DATE (YYYY.MM.DD) 2024.04.10

CONSULTANT PROJ. NO. CIVL446

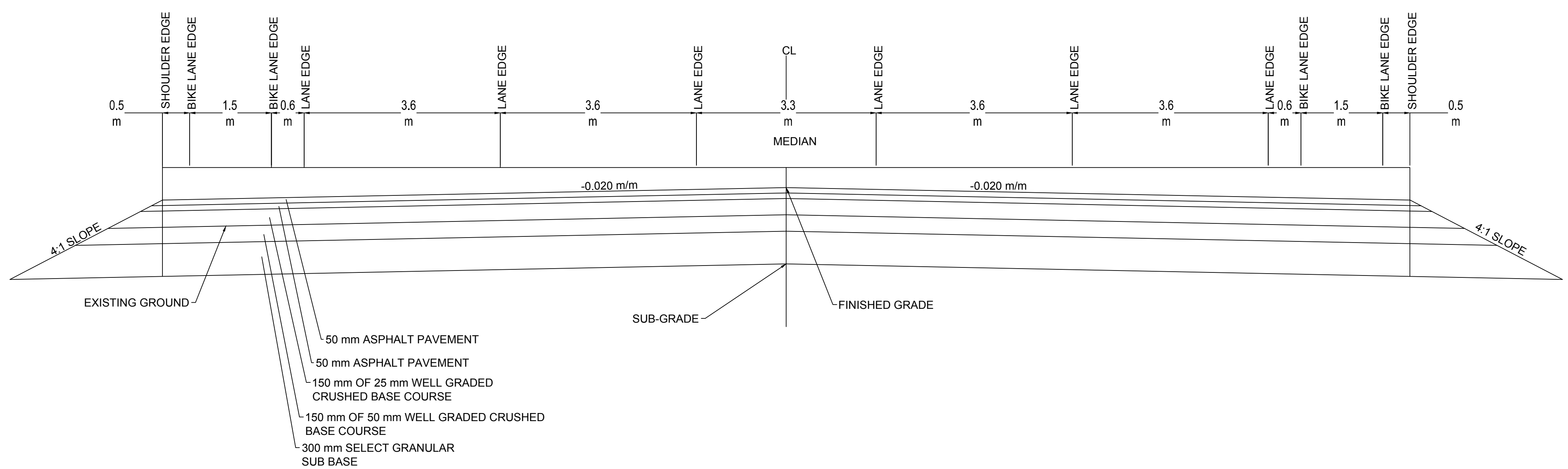
DWG. NO. 13

REV. 1

DRAWING TYPE
STORMWATER MANAGEMENT PLAN




TYPICAL SECTION: SW MARINE DR (NORTH)
SCALE 1:50




TYPICAL SECTION: SW MARINE DR (SOUTH)
SCALE 1:50

| REV. | DATE | DESCRIPTION | BY |
|---|---|---|---|
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| | | | |
| 02 | 24-04-10 | ISSUED FOR CONSTRUCTION | |
| 01 | 23-12-07 | ISSUED FOR PRELIMINARY DESIGN | |

CONSULTANT

CLIENT
**UBC CAMPUS + COMMUNITY PLANNING**
CIRS, 2210 WEST MALL VANCOUVER, B.C., CANADA V6T 1Z4

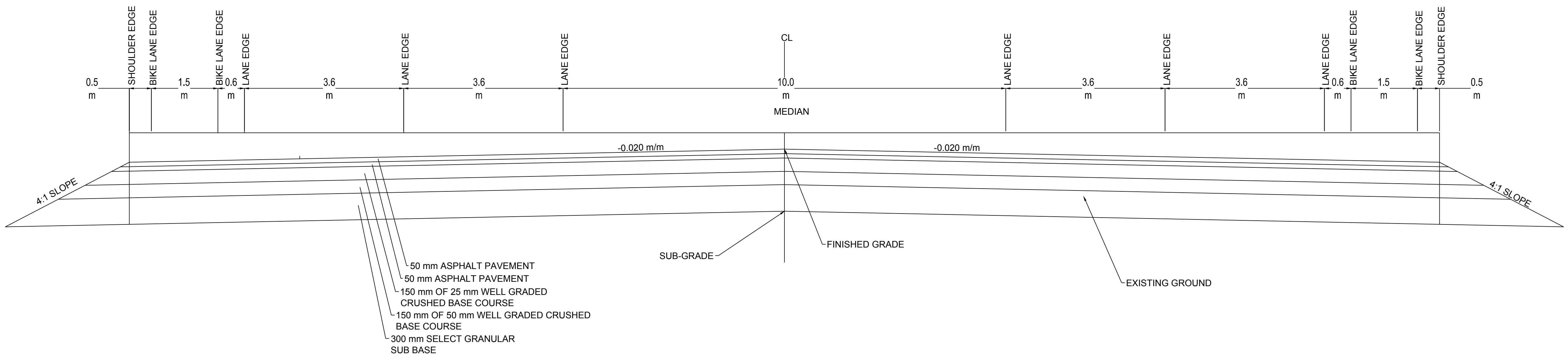
TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
TYPICAL SECTIONS & DETAILS

SEAL

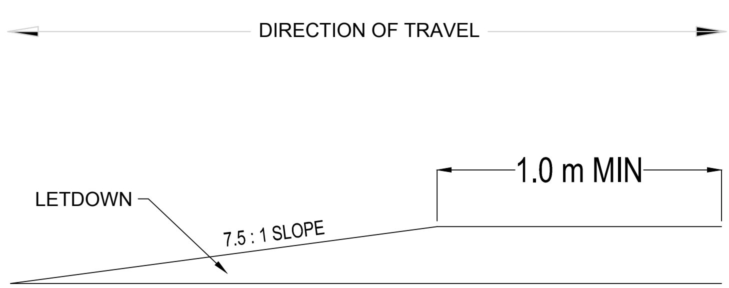
SCALE: HOR. VARIES VERT. -
DESIGNED
DRAWN
REVIEWED

DATE (YYYY.MM.DD) 2024.04.10
CONSULTANT PROJ. NO. CIVL446
DWG. NO. 14
REV. 1

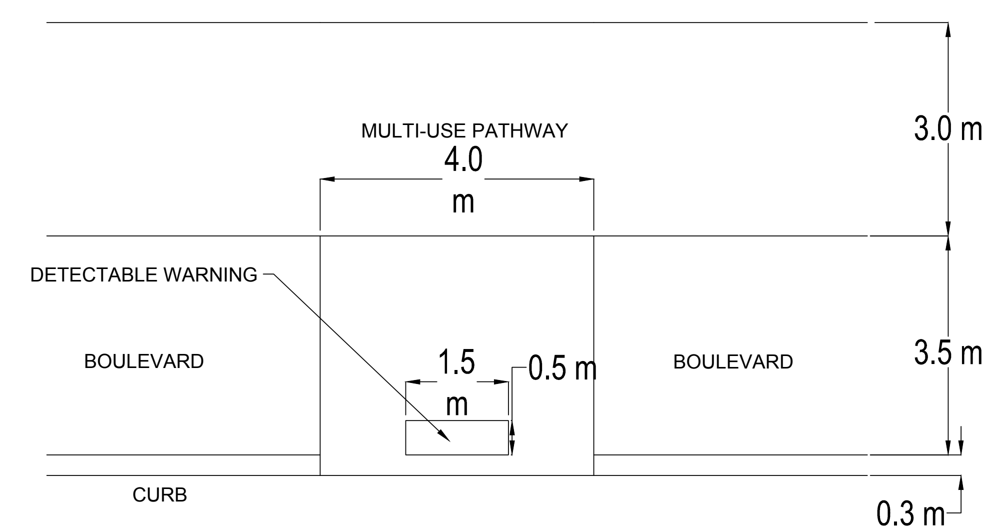
DRAWING TYPE
TYPICAL DRAWINGS




TYPICAL SECTION: 16th AVENUE
SCALE 1:50




TYPICAL LETDOWN DETAIL
ELEVATION VIEW
SCALE 1:25




TYPICAL LETDOWN DETAIL
PLAN VIEW
SCALE 1:25

| REV. | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 02 | 24-04-10 | ISSUED FOR CONSTRUCTION | |
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CLIENT
**UBC CAMPUS + COMMUNITY PLANNING**
CIRS, 2210 WEST MALL VANCOUVER, B.C., CANADA V6T 1Z4

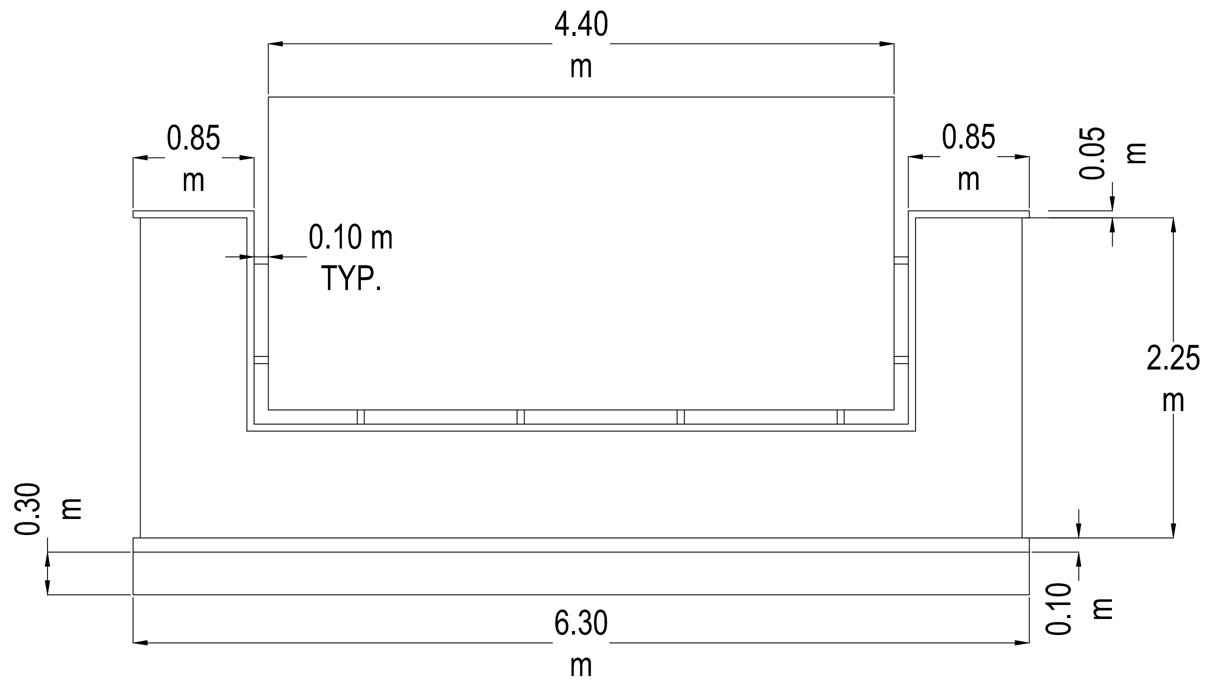
TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
TYPICAL SECTIONS & DETAILS

SEAL

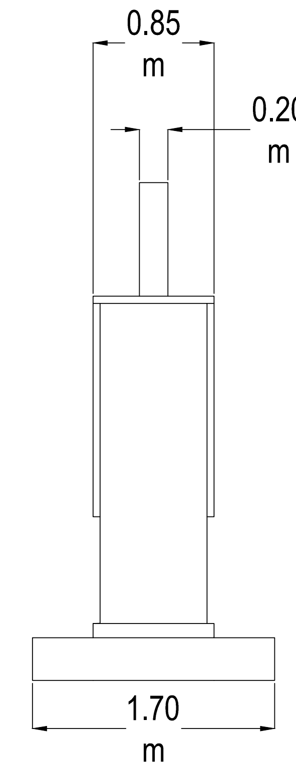
SCALE: HOR. VARIES VERT. -
DESIGNED
DRAWN
REVIEWED

DATE (YYYY.MM.DD) 2024.04.10
CONSULTANT PROJ. NO. CIVL446
DWG. NO. 15
REV. 1

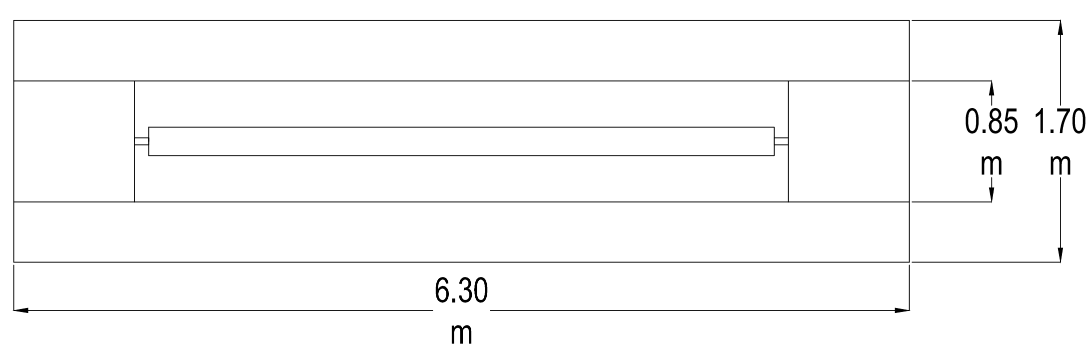
DRAWING TYPE
TYPICAL DRAWINGS




VISUAL GATEWAY FRONT ELEVATION DETAIL
SCALE 1:25




VISUAL GATEWAY SIDE ELEVATION DETAIL
SCALE 1:25




VISUAL GATEWAY PLAN VIEW DETAIL
SCALE 1:25

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**UBC CAMPUS + COMMUNITY PLANNING**
CIRS, 2210 WEST MALL VANCOUVER, B.C.,
CANADA V6T 1Z4

TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
VISUAL GATEWAY - STRUCTURAL DRAWINGS

SEAL

SCALE: HOR. VARIES
VERT. -

DESIGNED

DRAWN

REVIEWED

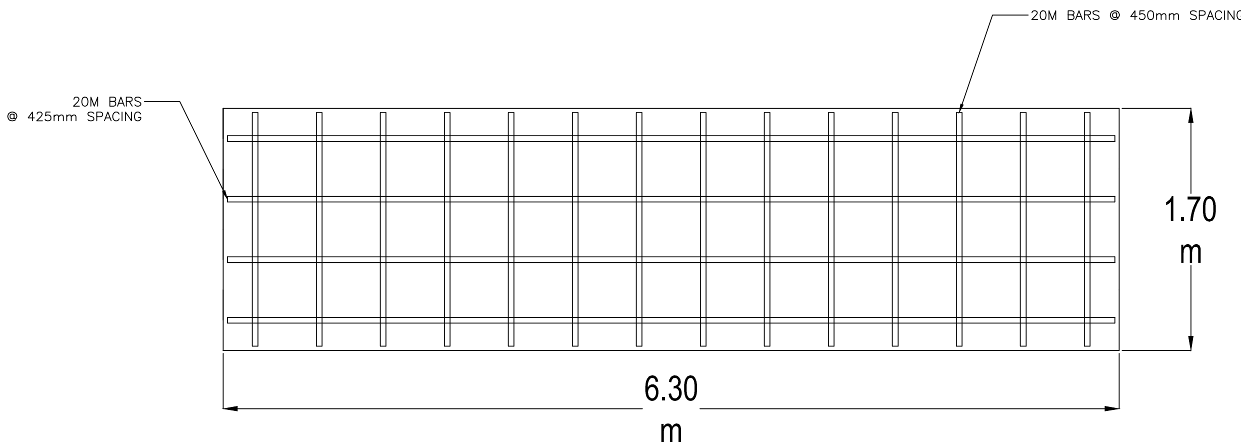
DATE (YYYY.MM.DD) 2024.04.10

CONSULTANT PROJ. NO. CIVL446

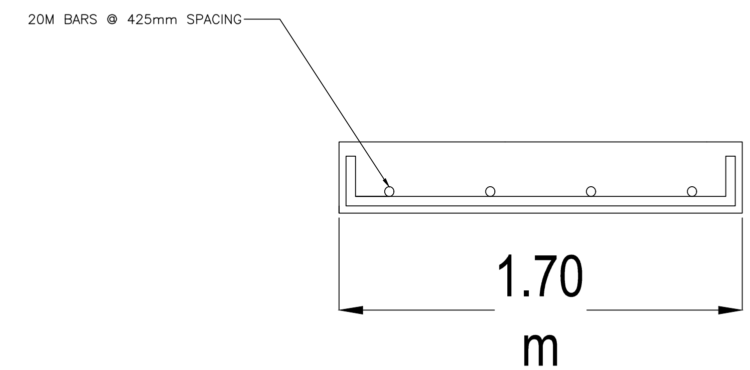
DWG. NO. 16

REV. 1

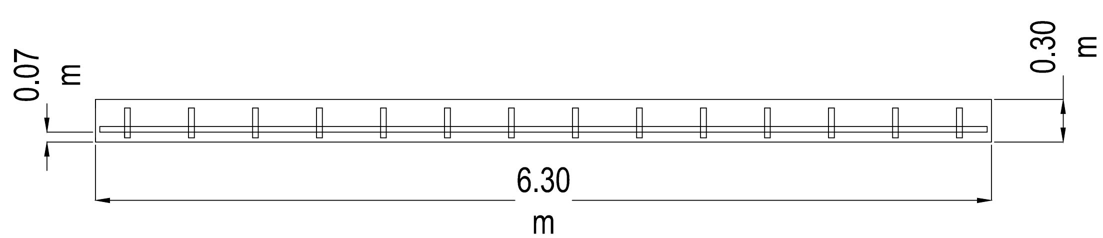
DRAWING TYPE
TYPICAL DRAWINGS




VISUAL GATEWAY FOOTING – PLAN VIEW
SCALE: NTS




VISUAL GATEWAY FOOTING – CROSS SECTION
SCALE: NTS




VISUAL GATEWAY FOOTING – FRONT ELEVATION
SCALE: NTS

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CONSULTANT

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**UBC CAMPUS + COMMUNITY PLANNING**
CIRS, 2210 WEST MALL VANCOUVER, B.C.,
CANADA V6T 1Z4

TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
VISUAL GATEWAY - STRUCTURAL DRAWINGS

SEAL

SCALE: HOR. VARIES
VERT. -

DESIGNED

DRAWN

REVIEWED

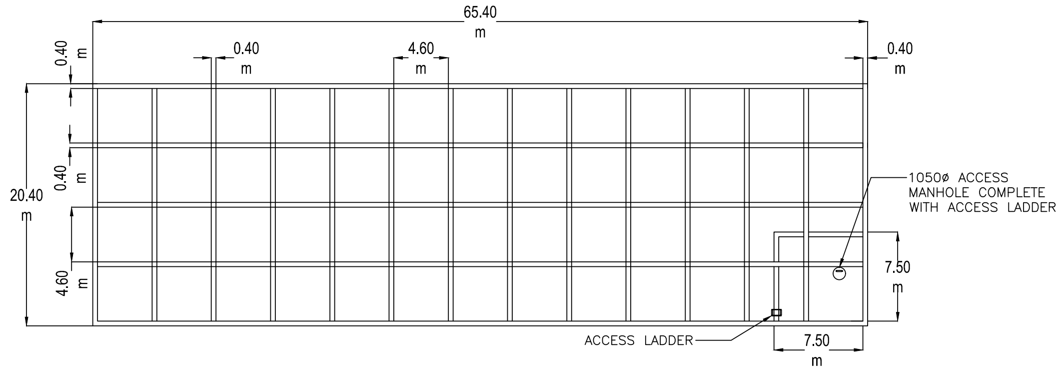
DATE (YYYY.MM.DD) 2024.04.10

CONSULTANT PROJ. NO. CIVL446

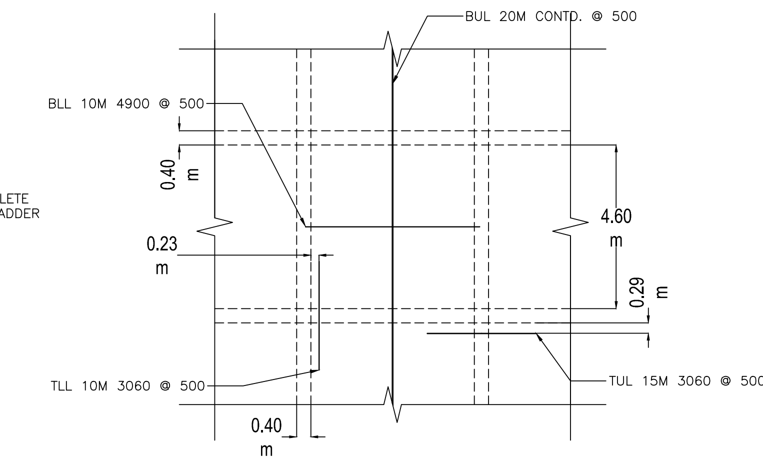
DWG. NO. 17

REV. 1

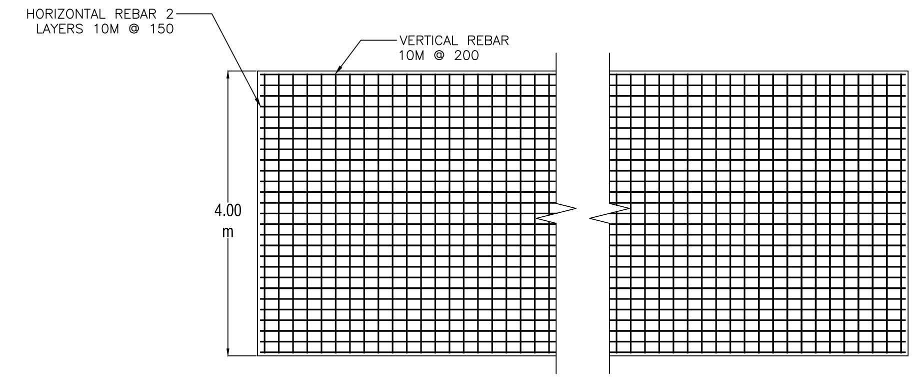
DRAWING TYPE
STRUCTURAL DRAWINGS



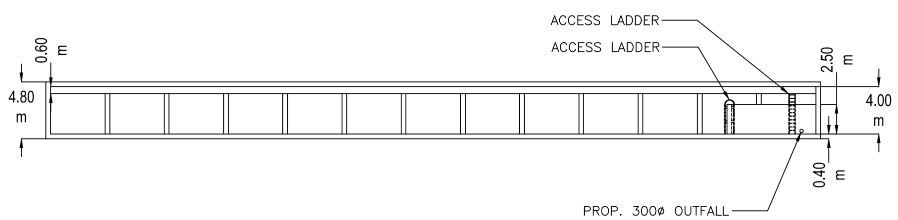

DETENTION TANK – PLAN VIEW
SCALE: 1:300



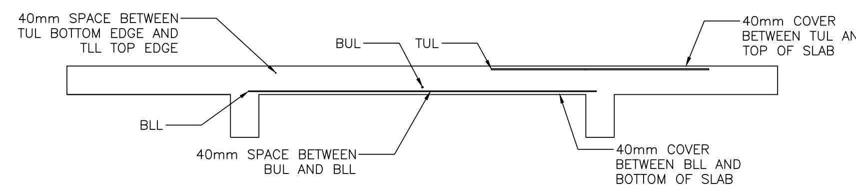

DETENTION TANK SLAB – PLAN VIEW
SCALE: 1:100



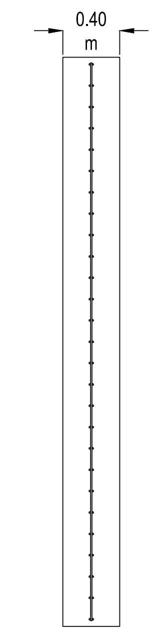

DETENTION TANK WALL – LONGITUDINAL VIEW
SCALE: 1:50




DETENTION TANK – LONGITUDINAL VIEW
SCALE: 1:300

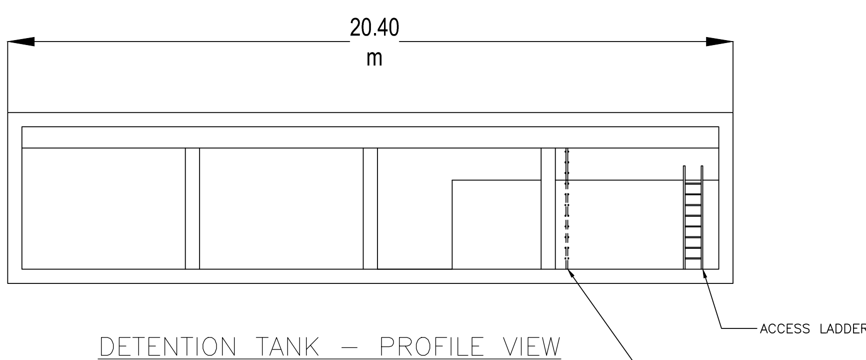



DETENTION TANK SLAB – LONGITUDINAL VIEW
SCALE: 1:50

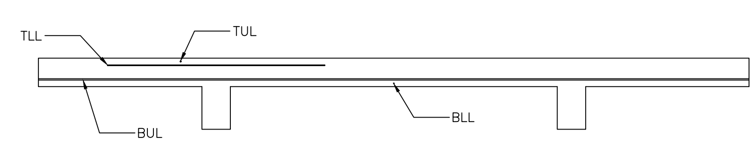



DETENTION TANK WALL – PROFILE VIEW
SCALE: 1:25

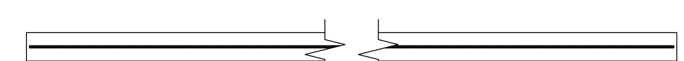
ACCESS LADDER DIMENSIONS
–LADDER RUNGS 0.1m WIDE X 0.45m LONG X 0.03m TALL
–RUNGS SPACED @ 0.3m CENTER TO CENTER
–LADDER RAILS 0.05m X 0.05m SQUARE




DETENTION TANK – PROFILE VIEW
SCALE: 1:100




DETENTION TANK SLAB – PROFILE VIEW
SCALE: 1:50



DETENTION TANK WALL – PLAN VIEW
SCALE: 1:50

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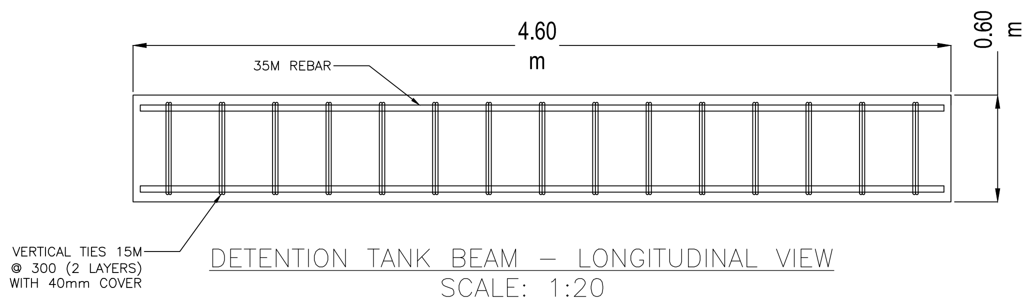
CONSULTANT

CLIENT
**UBC CAMPUS + COMMUNITY PLANNING**
CIRS, 2210 WEST MALL VANCOUVER, B.C.,
CANADA V6T 1Z4

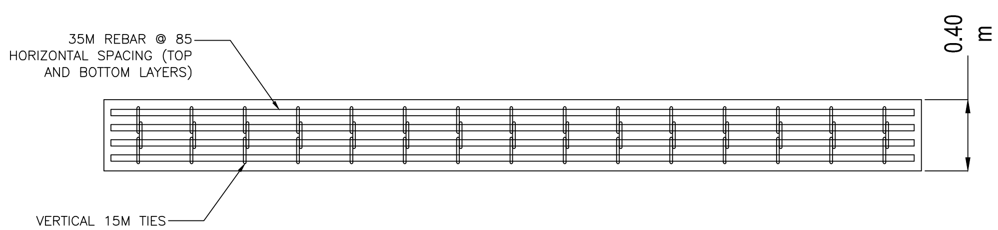
TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
DETENTION TANK - STRUCTURAL DRAWINGS

SEAL

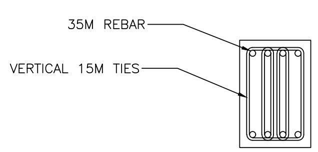
SCALE: HOR. VARIES VERT. -
DESIGNED
DRAWN
REVIEWED
DATE (YYYY.MM.DD) 2024.04.10
CONSULTANT PROJ. NO. CIVL446
DWG. NO. 18
REV. 1
DRAWING TYPE
STRUCTURAL DRAWINGS



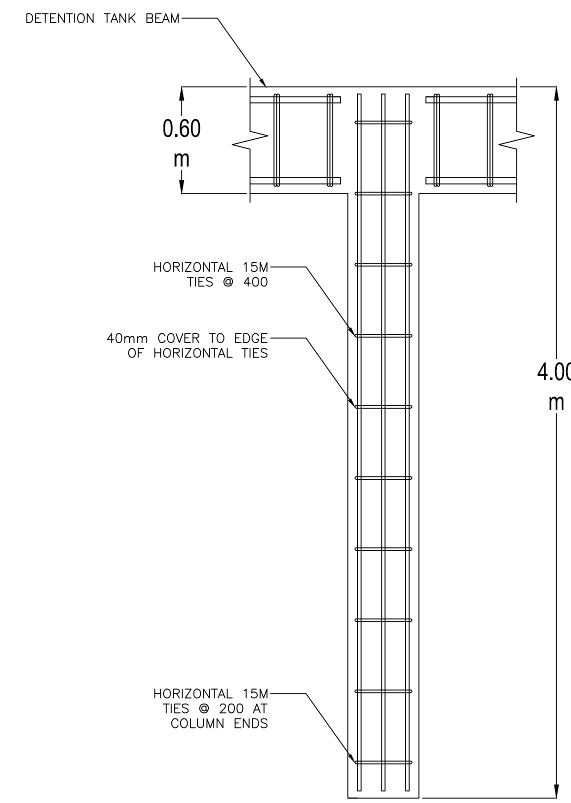

DETENTION TANK BEAM — LONGITUDINAL VIEW
SCALE: 1:20



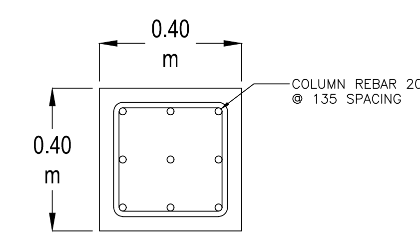

DETENTION TANK BEAM — PLAN VIEW
SCALE: 1:20




DETENTION TANK BEAM — PROFILE VIEW
SCALE: 1:20




DETENTION TANK COLUMN — PLAN VIEW
SCALE: 1:20




DETENTION TANK COLUMN — PLAN VIEW
SCALE: 1:10

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**UBC CAMPUS + COMMUNITY PLANNING**
CIRS, 2210 WEST MALL VANCOUVER, B.C.,
CANADA V6T 1Z4

TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
DETENTION TANK - STRUCTURAL DRAWINGS

SEAL

SCALE: HOR. VARIES VERT. -
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DRAWN
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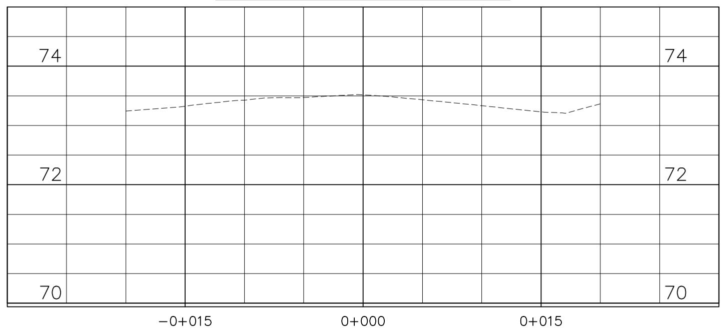
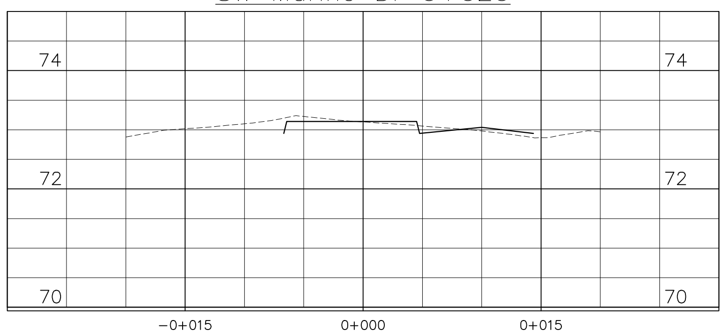
DATE (YYYY.MM.DD) 2024.04.10
CONSULTANT PROJ. NO. CIVL446
DWG. NO. 19
REV. 1

DRAWING TYPE
STRUCTURAL DRAWINGS

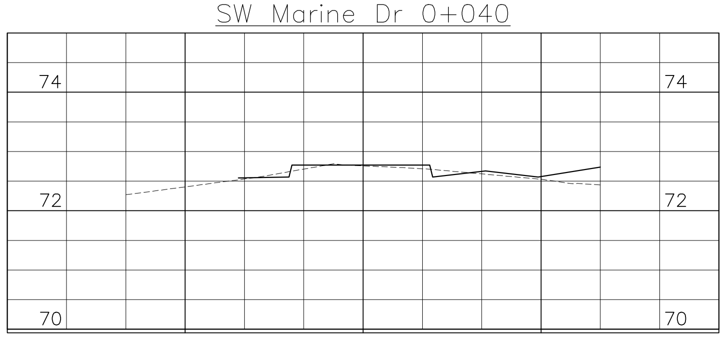
SW Marine Dr 0+000



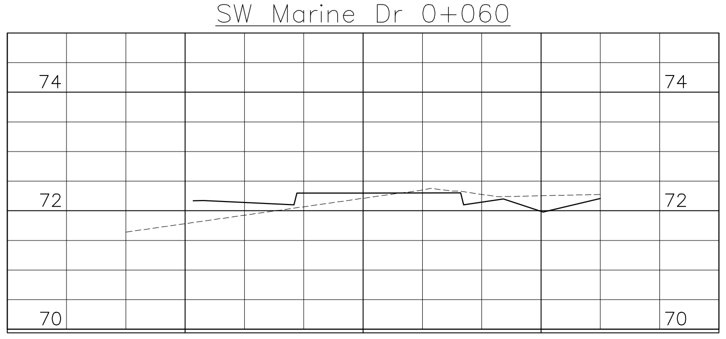

SW Marine Dr 0+020



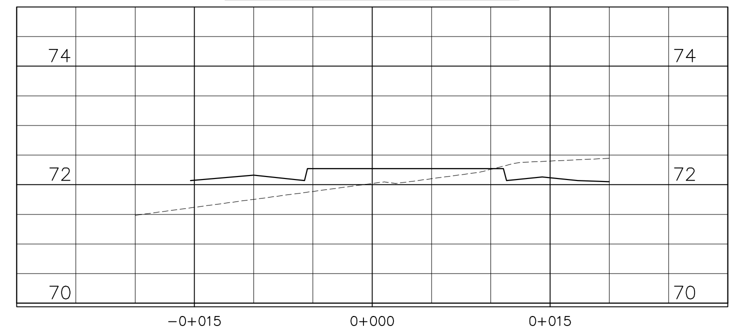

SW Marine Dr 0+040



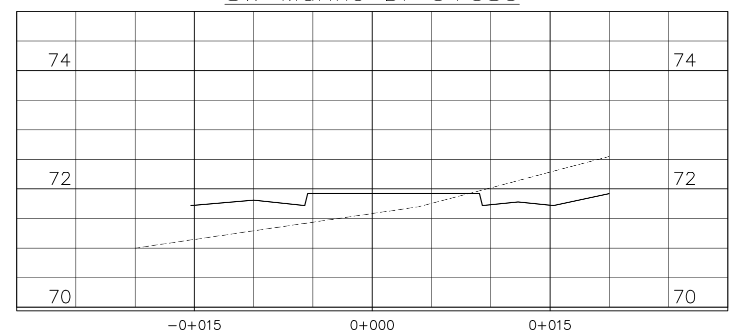

SW Marine Dr 0+060



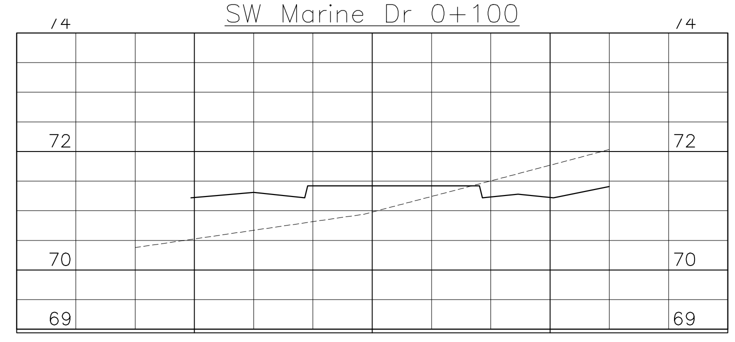

SW Marine Dr 0+065



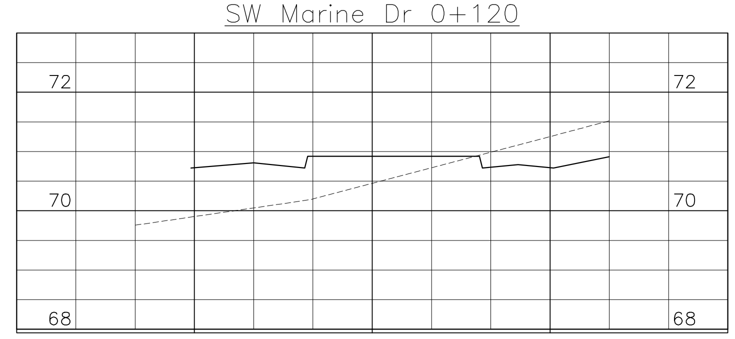

SW Marine Dr 0+080



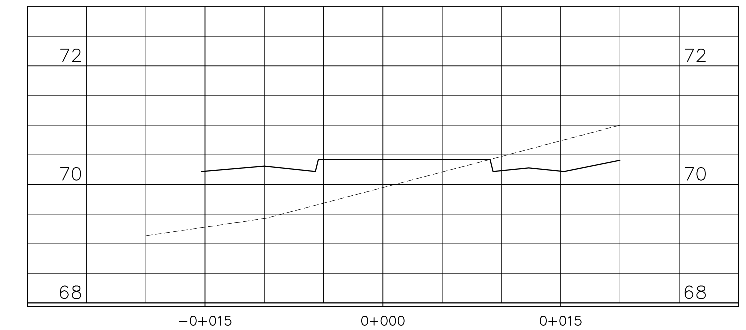

SW Marine Dr 0+100



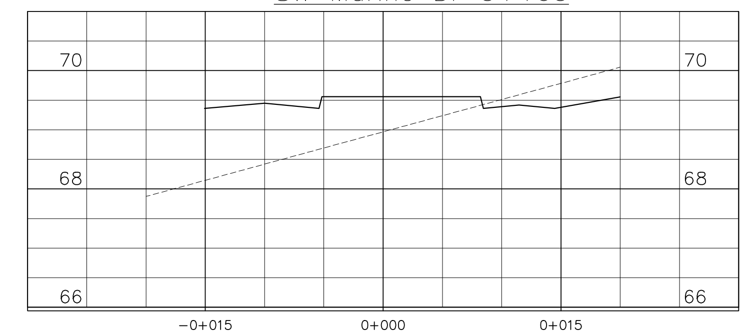

SW Marine Dr 0+120



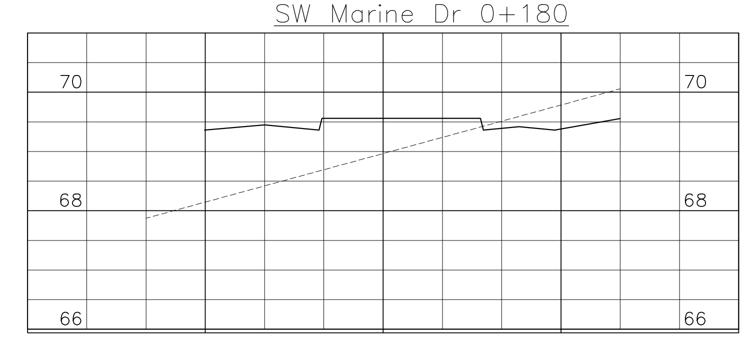

SW Marine Dr 0+140



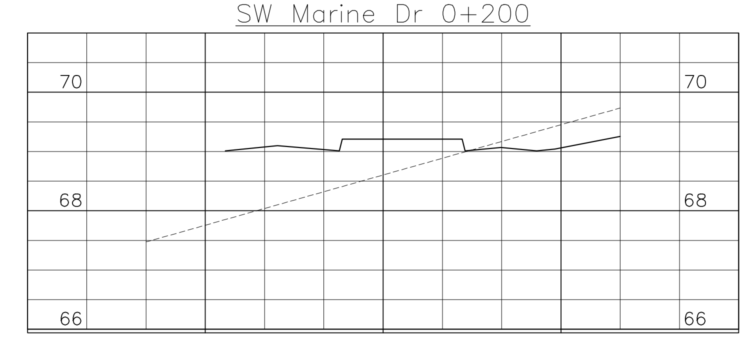

SW Marine Dr 0+160




SW Marine Dr 0+180




SW Marine Dr 0+200

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CONSULTANT

CLIENT
**UBC CAMPUS + COMMUNITY PLANNING**
CIRS, 2210 WEST MALL VANCOUVER, B.C.,
CANADA V6T 1Z4

TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
CROSS SECTIONS

SEAL

SCALE: HOR. VARIES
VERT. -

DESIGNED

DRAWN

REVIEWED

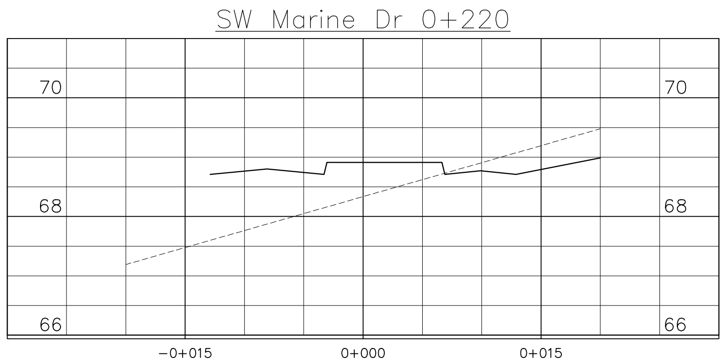
DATE (YYYY.MM.DD) 2024.04.10

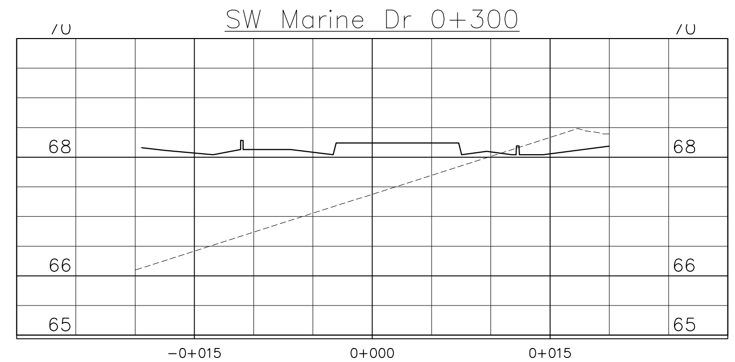
CONSULTANT PROJ. NO. CIVL446

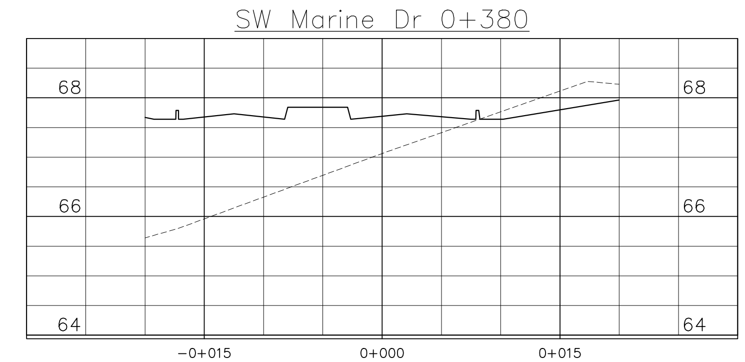
DWG. NO. 20

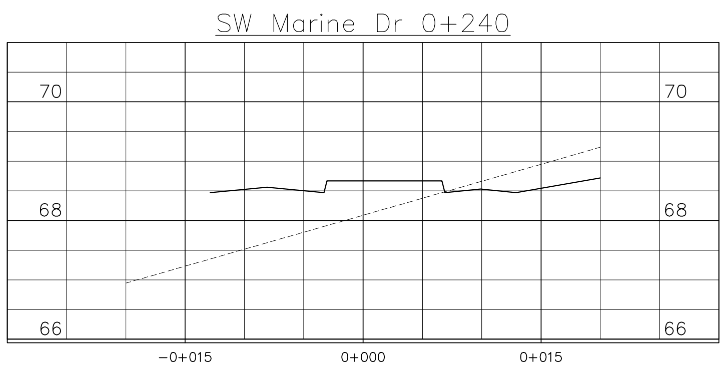
REV. 1

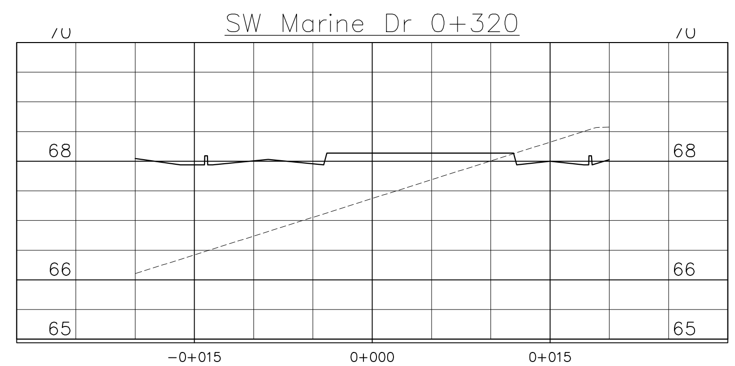
DRAWING TYPE
CROSS SECTIONS

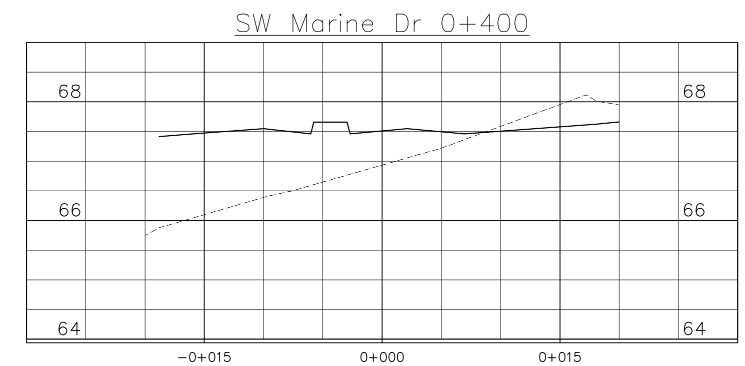


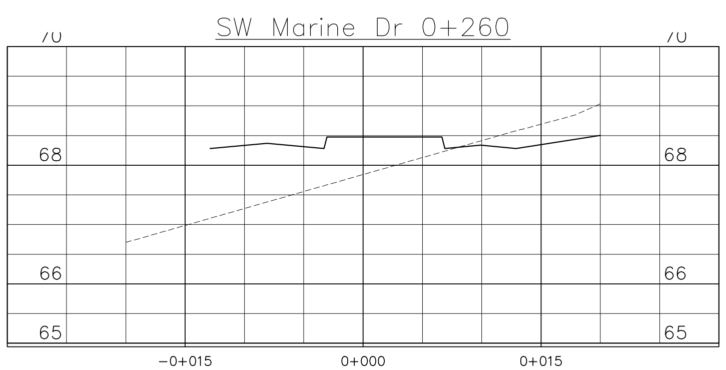



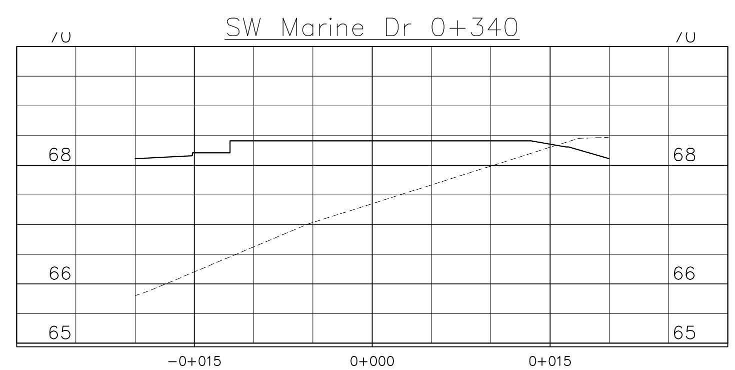



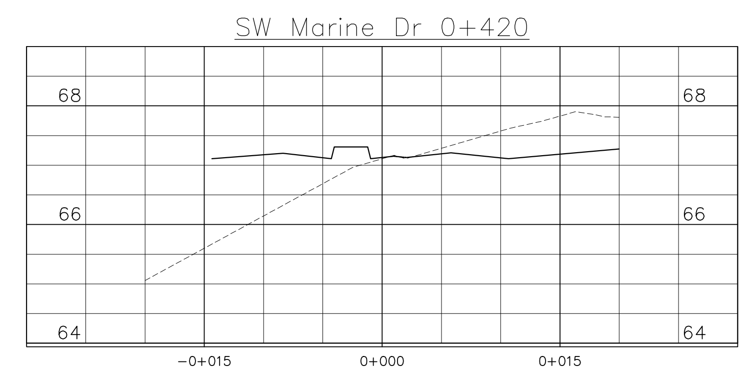



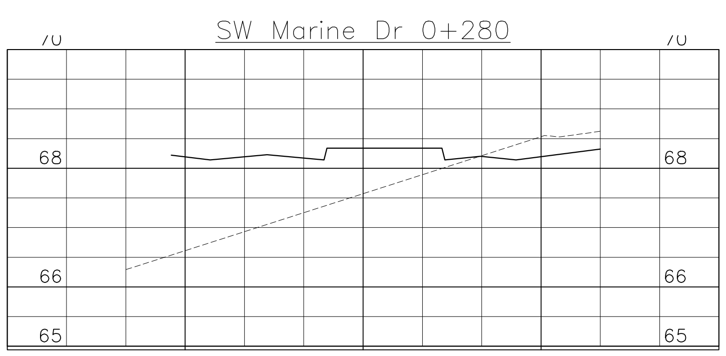



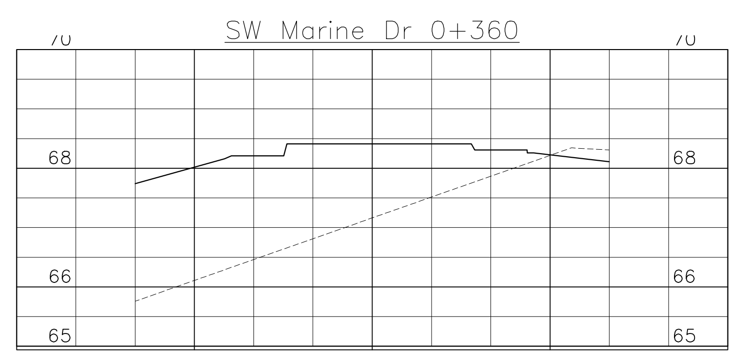



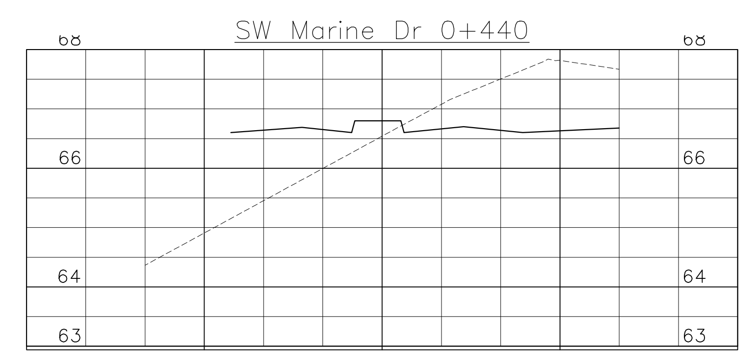

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CONSULTANT

CLIENT
**UBC CAMPUS + COMMUNITY PLANNING**
CIRS, 2210 WEST MALL VANCOUVER, B.C., CANADA V6T 1Z4

TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
CROSS SECTIONS

SEAL

SCALE: HOR. VARIES VERT. -
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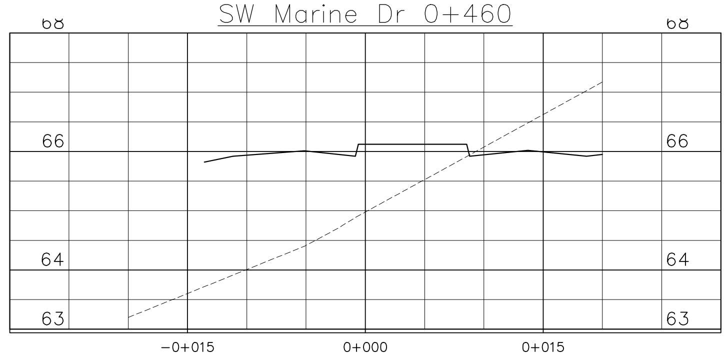
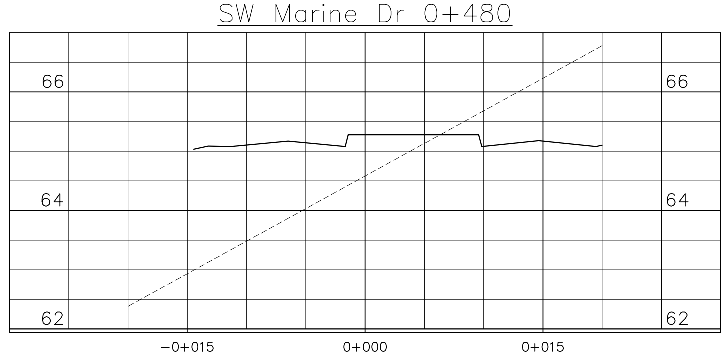
DATE (YYYY.MM.DD) 2024.04.10
CONSULTANT PROJ. NO. CIVL446
DWG. NO. 21
REV. 1

DRAWING TYPE
CROSS SECTIONS

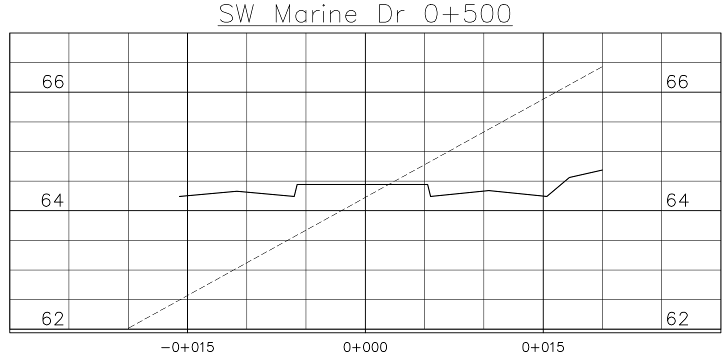
SW Marine Dr 0+460



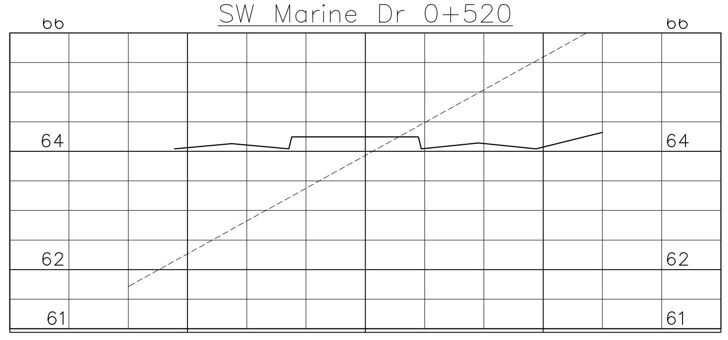

SW Marine Dr 0+480




SW Marine Dr 0+500




SW Marine Dr 0+520

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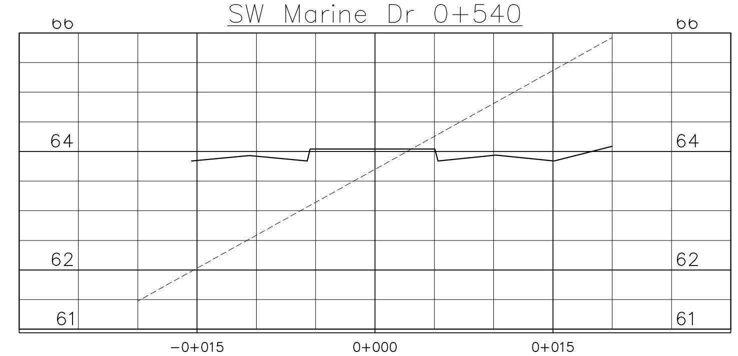


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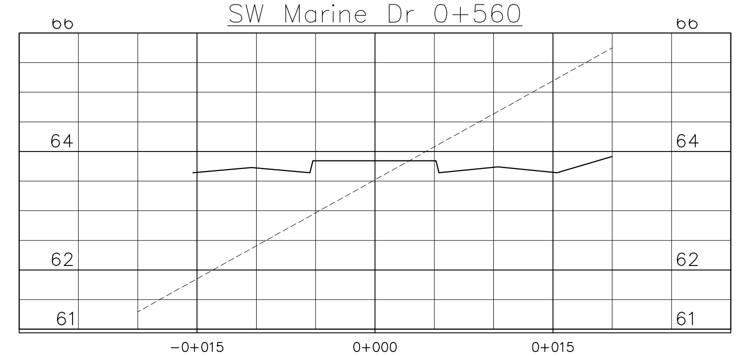


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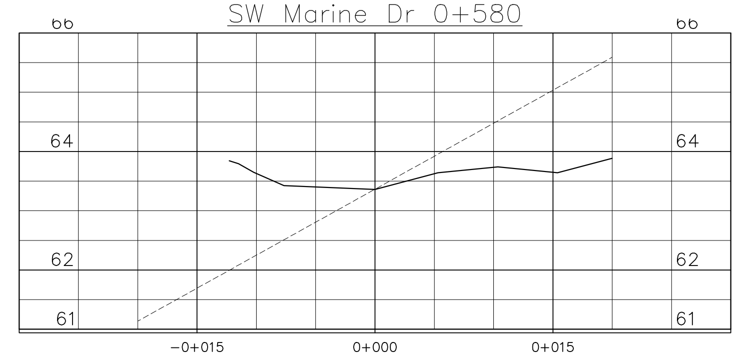


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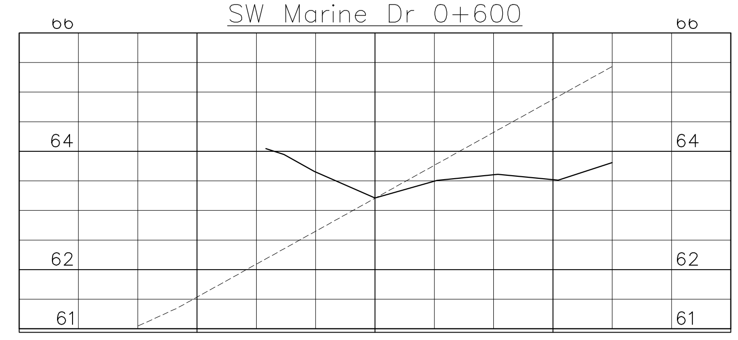


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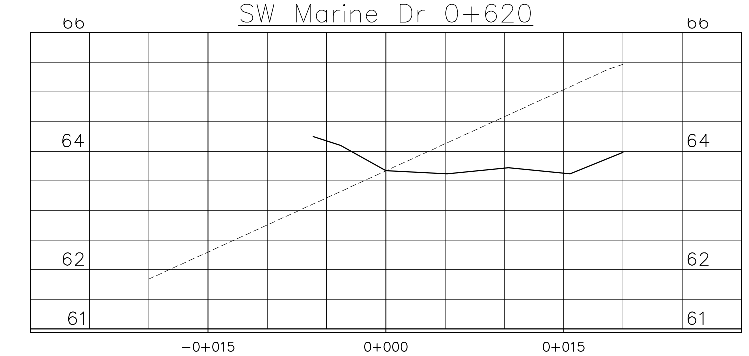


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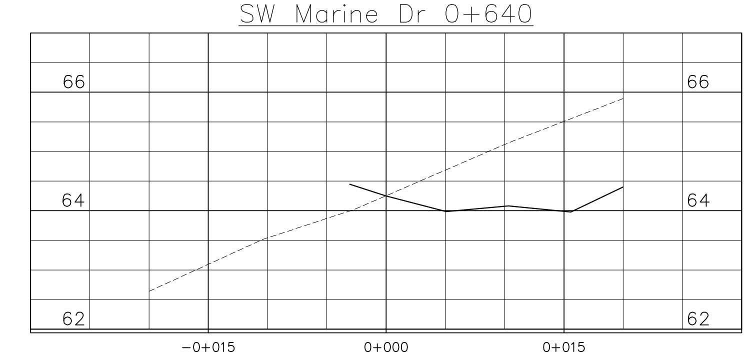


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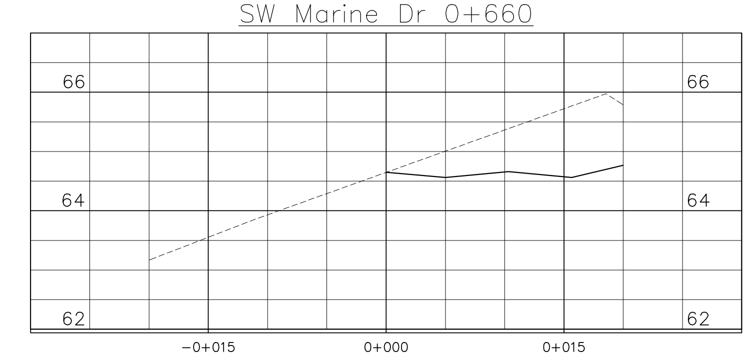


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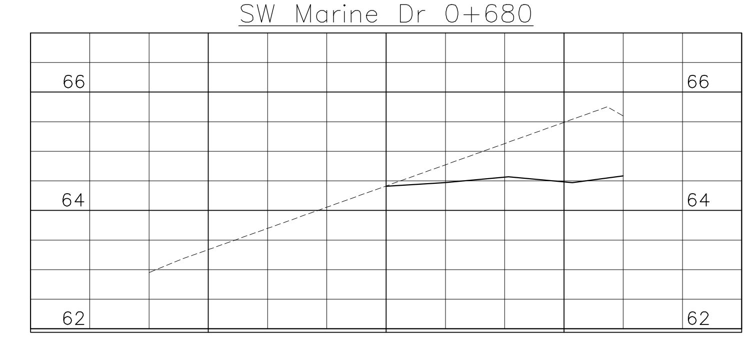


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| 02 | 24-04-10 | ISSUED FOR CONSTRUCTION | |
| 01 | 23-12-07 | ISSUED FOR PRELIMINARY DESIGN | |

CONSULTANT

CLIENT
**UBC CAMPUS + COMMUNITY PLANNING**
CIRS, 2210 WEST MALL VANCOUVER, B.C.,
CANADA V6T 1Z4

TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
CROSS SECTIONS

SEAL

SCALE: HOR. VARIES VERT. -
DESIGNED
DRAWN
REVIEWED

DATE (YYYY.MM.DD) 2024.04.10
CONSULTANT PROJ. NO. CIVL446
DWG. NO. 22
REV. 1

DRAWING TYPE
CROSS SECTIONS

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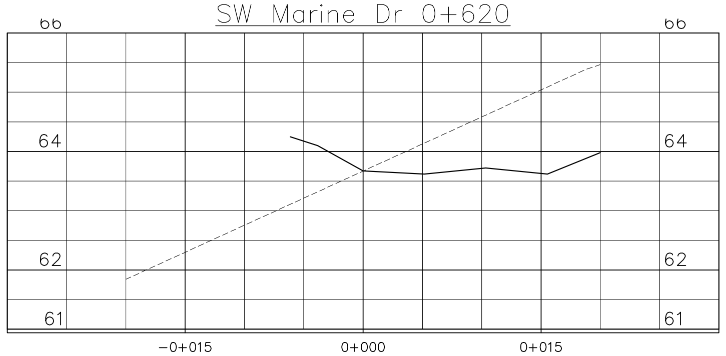


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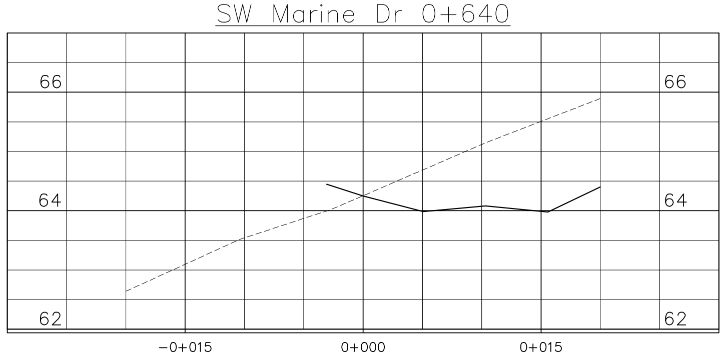


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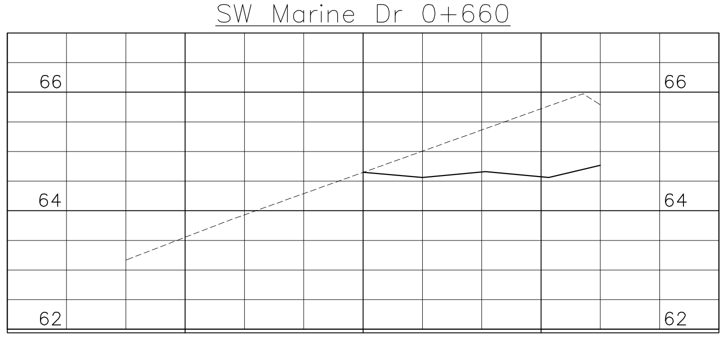


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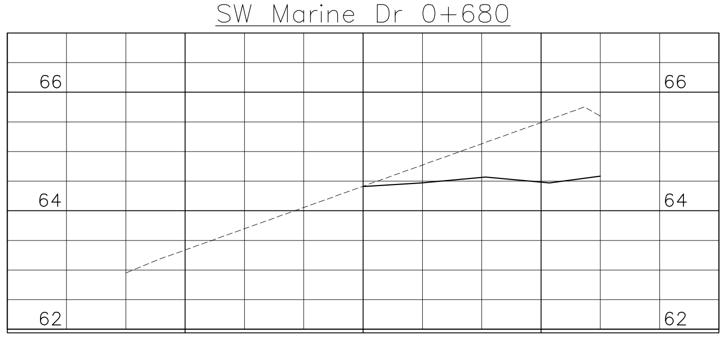


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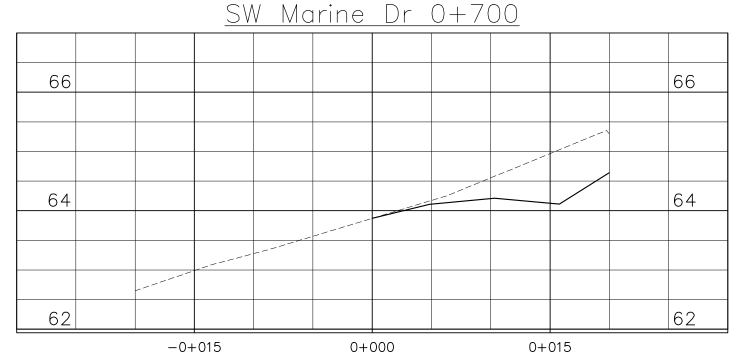


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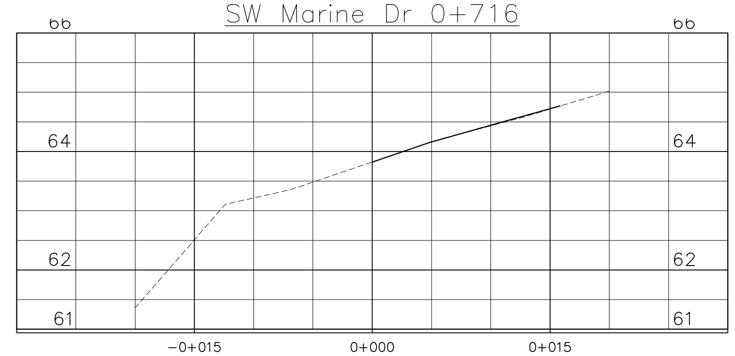


| REV. | DATE | DESCRIPTION | BY |
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| 02 | 24-04-10 | ISSUED FOR CONSTRUCTION | |
| 01 | 23-12-07 | ISSUED FOR PRELIMINARY DESIGN | |

CONSULTANT

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**UBC CAMPUS + COMMUNITY PLANNING**
CIRS, 2210 WEST MALL VANCOUVER, B.C.,
CANADA V6T 1Z4

TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
CROSS SECTIONS

SEAL

SCALE: HOR. VARIES
VERT. -

DESIGNED

DRAWN

REVIEWED

DATE (YYYY.MM.DD) 2024.04.10

CONSULTANT PROJ. NO. CIVL446

DWG. NO. 23

REV. 1

DRAWING TYPE
CROSS SECTIONS

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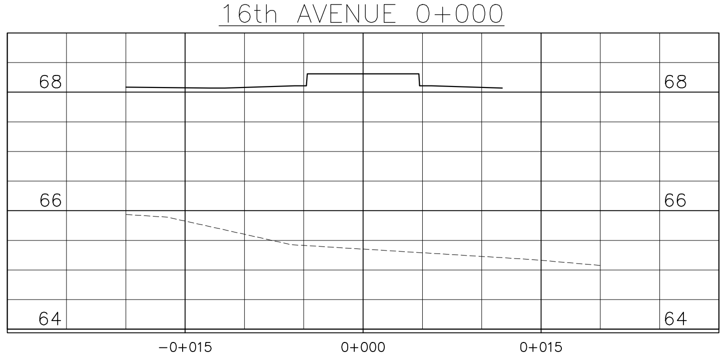


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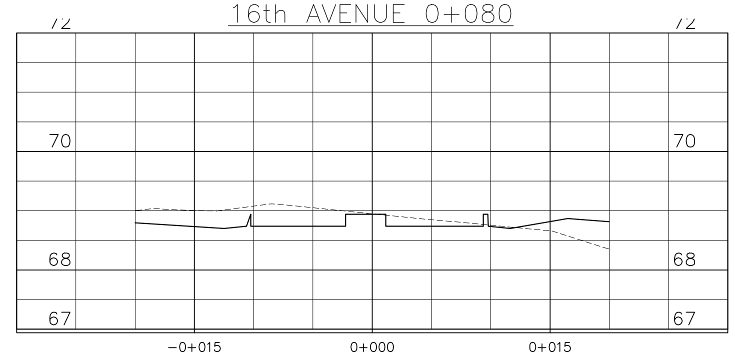


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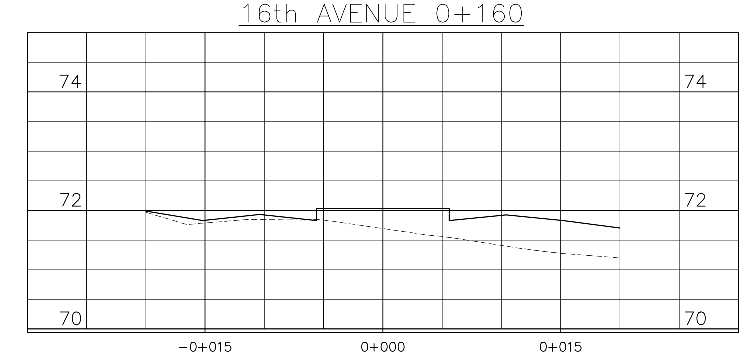


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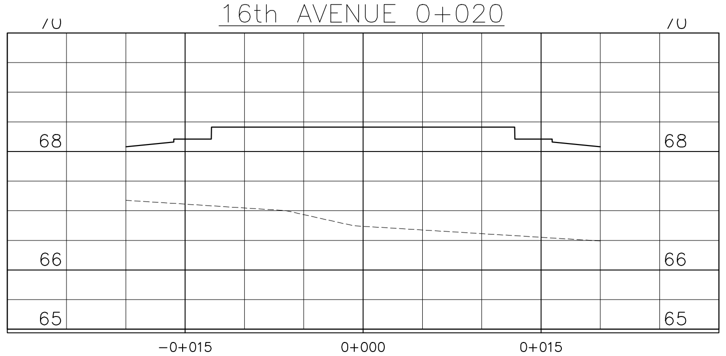


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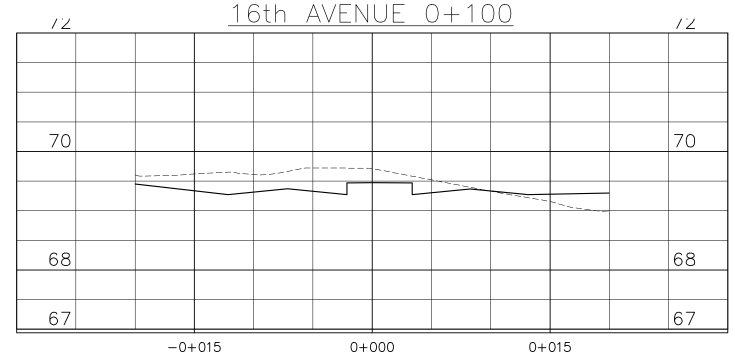


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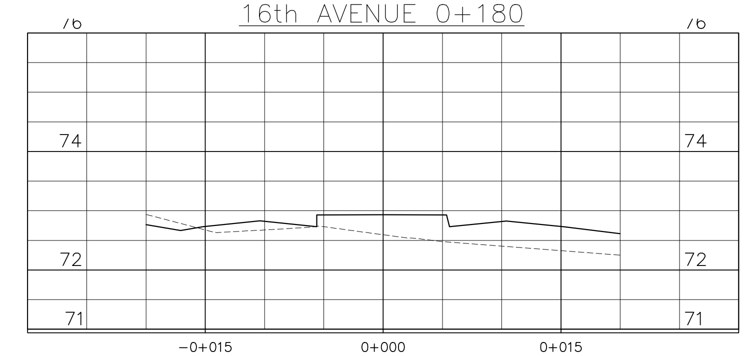


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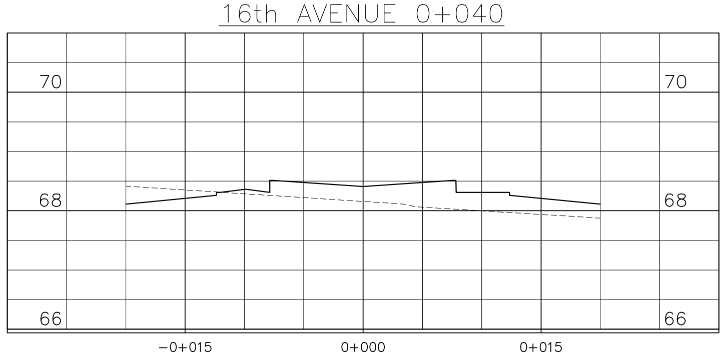


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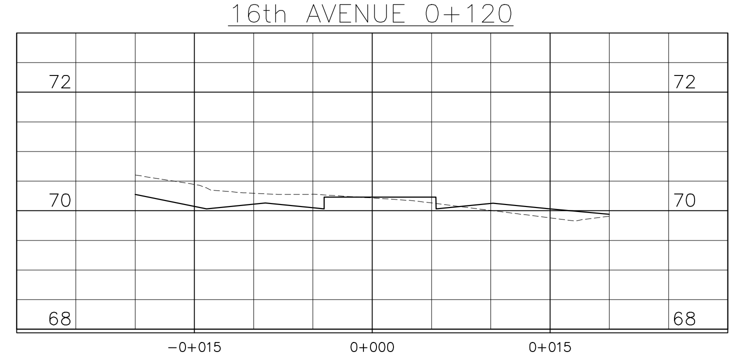


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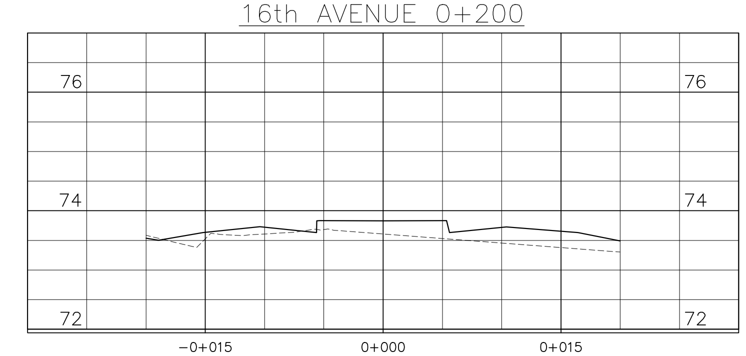


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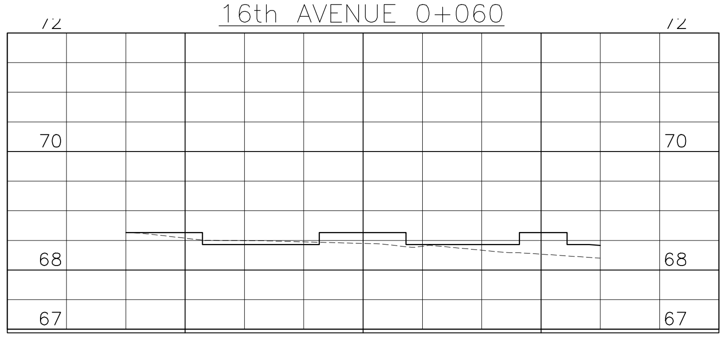


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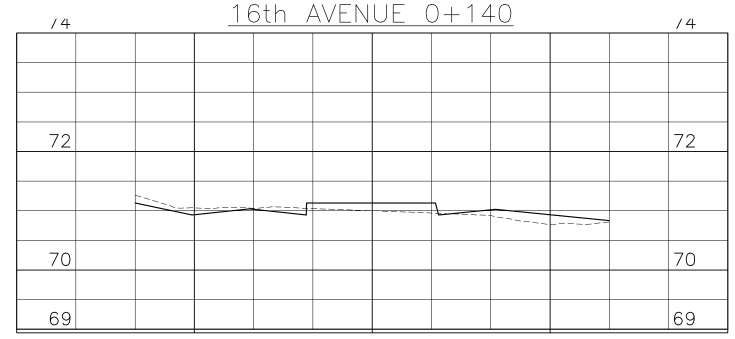


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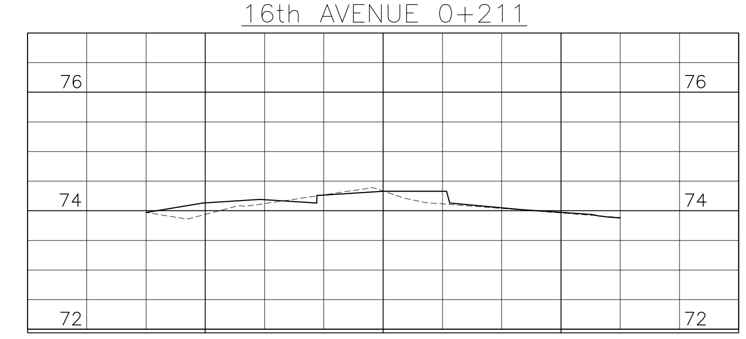


| REV. | DATE | DESCRIPTION | BY |
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| | | | |
| 02 | 24-04-10 | ISSUED FOR CONSTRUCTION | |
| 01 | 23-12-07 | ISSUED FOR PRELIMINARY DESIGN | |

CONSULTANT

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**UBC CAMPUS + COMMUNITY PLANNING**
CIRS, 2210 WEST MALL VANCOUVER, B.C., CANADA V6T 1Z4

TITLE
16th AVENUE & SW MARINE DRIVE
INTERSECTION REDESIGN
CROSS SECTIONS

SEAL

SCALE: HOR. VARIES VERT. -

DESIGNED

DRAWN

REVIEWED

DATE (YYYY.MM.DD) 2024.04.10

CONSULTANT PROJ. NO. CIVL446

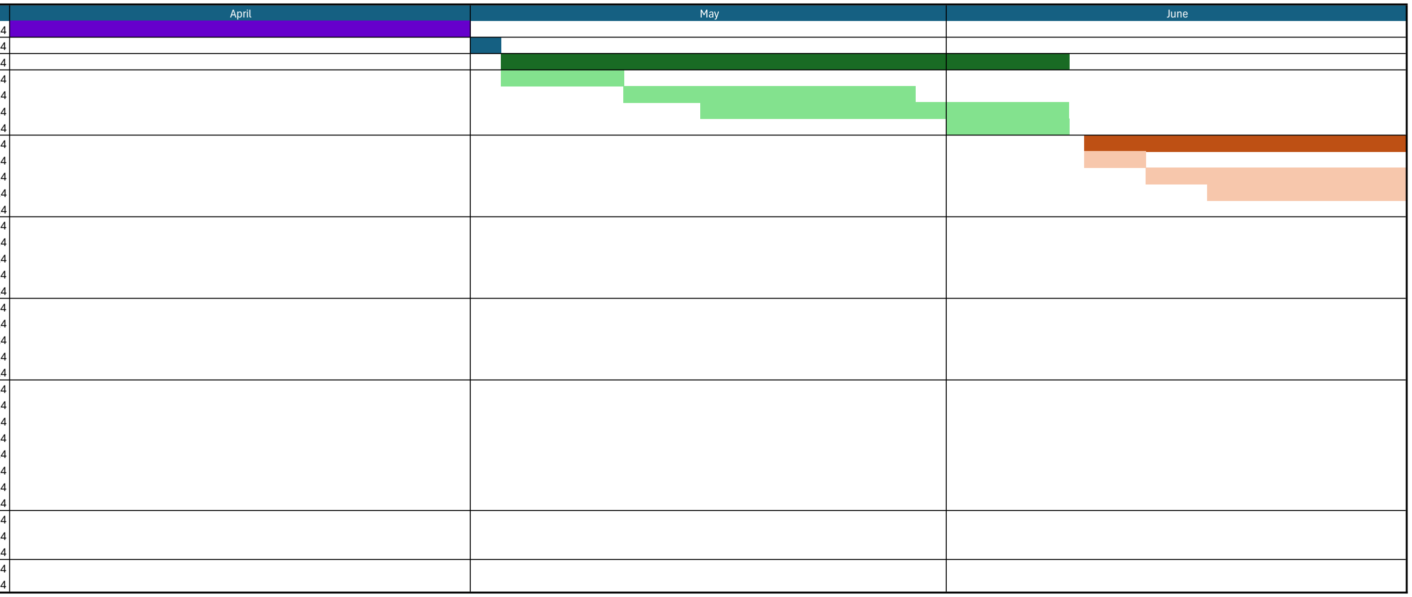
DWG. NO. 24

REV. 1

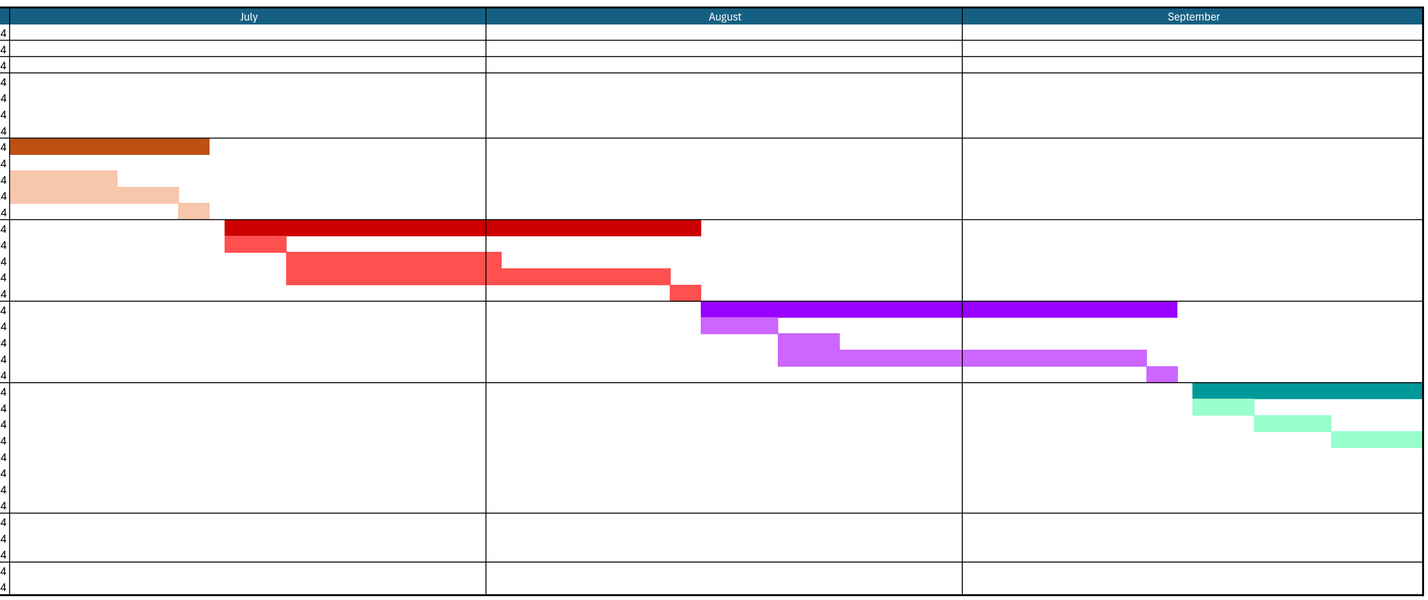
DRAWING TYPE
CROSS SECTIONS

# Appendix B: Detailed Schedule

| ID | Task | Duration | Start | Finish |
|---|---|---|---|---|
| 1 | **Phase 1: Permitting** | 30 | 01-Apr-24 | 30-Apr-24 |
| 2 | **Phase 2: Mobilization and Site Preparation** | 2 | 01-May-24 | 02-May-24 |
| 3 | **Phase 3: Retention Tank Install (Stage 1)** | 37 | 03-May-24 | 08-Jun-24 |
| 4 | Milling, Removal and Detour Road Construction | 7 | 03-May-24 | 10-May-24 |
| 5 | Installation of Stormwater Detention Tank | 15 | 11-May-24 | 29-May-24 |
| 6 | Installation of Outfall Pipe | 20 | 16-May-24 | 08-Jun-24 |
| 7 | Backfilling, Grading, and Constructing Temporary Pavement | 7 | 01-Jun-24 | 08-Jun-24 |
| 8 | **Phase 4: Southwest and Northwest Side of Roundabout (Stage 2)** | 34 | 10-Jun-24 | 13-Jul-24 |
| 9 | Milling, Removal and Detour Road Construction | 4 | 10-Jun-24 | 13-Jun-24 |
| 10 | Installation of Stormwater Collection Pipes | 20 | 14-Jun-24 | 07-Jul-24 |
| 11 | Construction of Southwest and Northwest Sides of Roundabout | 20 | 18-Jun-24 | 11-Jul-24 |
| 12 | Backfilling, Grading, and Constructing Temporary Pavement | 2 | 12-Jul-24 | 13-Jul-24 |
| 13 | **Phase 5: North Side of Roundabout (Stage 3)** | 31 | 15-Jul-24 | 14-Aug-24 |
| 14 | Milling, Removal and Detour Road Construction | 4 | 15-Jul-24 | 18-Jul-24 |
| 15 | Installation of Stormwater Collection Pipes | 12 | 19-Jul-24 | 01-Aug-24 |
| 16 | Construction of North Side of Roundabout | 20 | 19-Jul-24 | 12-Aug-24 |
| 17 | Backfilling, Grading, and Constructing Temporary Pavement | 2 | 13-Aug-24 | 14-Aug-24 |
| 18 | **Phase 6: East Side of Roundabout (Stage 4)** | 31 | 15-Aug-24 | 14-Sep-24 |
| 19 | Milling, Removal and Detour Road Construction | 4 | 15-Aug-24 | 19-Aug-24 |
| 20 | Installation of Stormwater Collection Pipes | 4 | 20-Aug-24 | 23-Aug-24 |
| 21 | Construction of East Side of Roundabout | 20 | 20-Aug-24 | 12-Sep-24 |
| 22 | Backfilling, Grading, and Constructing Temporary Pavement | 2 | 13-Sep-24 | 14-Sep-24 |
| 23 | **Phase 7: Median, Central Island and Landscaping (Stage 5)** | 39 | 16-Sep-24 | 24-Oct-24 |
| 24 | Milling, Removal and Detour Road Construction | 4 | 16-Sep-24 | 19-Sep-24 |
| 25 | Installation of Footing for Gateway | 4 | 20-Sep-24 | 24-Sep-24 |
| 26 | Median and Cental Island Construction | 10 | 25-Sep-24 | 07-Oct-24 |
| 27 | Installation of Gateway Struture | 4 | 03-Oct-24 | 07-Oct-24 |
| 28 | Backfilling and Grading | 2 | 08-Oct-24 | 09-Oct-24 |
| 29 | Lane Markings and Signage | 4 | 10-Oct-24 | 15-Oct-24 |
| 30 | Landscaping | 10 | 12-Oct-24 | 24-Oct-24 |
| 31 | **Phase 8: Inspections** | 25 | 25-Oct-24 | 18-Nov-24 |
| 32 | Defiencies Inspection | 20 | 25-Oct-24 | 18-Nov-24 |
| 33 | Defiencies Correction | 15 | 31-Oct-24 | 18-Nov-24 |
| 34 | **Phase 9: Demobilization** | 2 | 19-Nov-24 | 20-Nov-24 |
| 35 | Final Cleanup and Demobilization | 2 | 19-Nov-24 | 20-Nov-24 |




| ID | Task | Duration | Start | Finish |
|---|---|---|---|---|
| 1 | **Phase 1: Permitting** | 30 | 01-Apr-24 | 30-Apr-24 |
| 2 | **Phase 2: Mobilization and Site Preparation** | 2 | 01-May-24 | 02-May-24 |
| 3 | **Phase 3: Retention Tank Install (Stage 1)** | 37 | 03-May-24 | 08-Jun-24 |
| 4 | Milling, Removal and Detour Road Construction | 7 | 03-May-24 | 10-May-24 |
| 5 | Installation of Stormwater Detention Tank | 15 | 11-May-24 | 29-May-24 |
| 6 | Installation of Outfall Pipe | 20 | 16-May-24 | 08-Jun-24 |
| 7 | Backfilling, Grading, and Constructing Temporary Pavement | 7 | 01-Jun-24 | 08-Jun-24 |
| 8 | **Phase 4: Southwest and Northwest Side of Roundabout (Stage 2)** | 34 | 10-Jun-24 | 13-Jul-24 |
| 9 | Milling, Removal and Detour Road Construction | 4 | 10-Jun-24 | 13-Jun-24 |
| 10 | Installation of Stormwater Collection Pipes | 20 | 14-Jun-24 | 07-Jul-24 |
| 11 | Construction of Southwest and Northwest Sides of Roundabout | 20 | 18-Jun-24 | 11-Jul-24 |
| 12 | Backfilling, Grading, and Constructing Temporary Pavement | 2 | 12-Jul-24 | 13-Jul-24 |
| 13 | **Phase 5: North Side of Roundabout (Stage 3)** | 31 | 15-Jul-24 | 14-Aug-24 |
| 14 | Milling, Removal and Detour Road Construction | 4 | 15-Jul-24 | 18-Jul-24 |
| 15 | Installation of Stormwater Collection Pipes | 12 | 19-Jul-24 | 01-Aug-24 |
| 16 | Construction of North Side of Roundabout | 20 | 19-Jul-24 | 12-Aug-24 |
| 17 | Backfilling, Grading, and Constructing Temporary Pavement | 2 | 13-Aug-24 | 14-Aug-24 |
| 18 | **Phase 6: East Side of Roundabout (Stage 4)** | 31 | 15-Aug-24 | 14-Sep-24 |
| 19 | Milling, Removal and Detour Road Construction | 4 | 15-Aug-24 | 19-Aug-24 |
| 20 | Installation of Stormwater Collection Pipes | 4 | 20-Aug-24 | 23-Aug-24 |
| 21 | Construction of East Side of Roundabout | 20 | 20-Aug-24 | 12-Sep-24 |
| 22 | Backfilling, Grading, and Constructing Temporary Pavement | 2 | 13-Sep-24 | 14-Sep-24 |
| 23 | **Phase 7: Median, Central Island and Landscaping (Stage 5)** | 39 | 16-Sep-24 | 24-Oct-24 |
| 24 | Milling, Removal and Detour Road Construction | 4 | 16-Sep-24 | 19-Sep-24 |
| 25 | Installation of Footing for Gateway | 4 | 20-Sep-24 | 24-Sep-24 |
| 26 | Median and Cental Island Construction | 10 | 25-Sep-24 | 07-Oct-24 |
| 27 | Installation of Gateway Struture | 4 | 03-Oct-24 | 07-Oct-24 |
| 28 | Backfilling and Grading | 2 | 08-Oct-24 | 09-Oct-24 |
| 29 | Lane Markings and Signage | 4 | 10-Oct-24 | 15-Oct-24 |
| 30 | Landscaping | 10 | 12-Oct-24 | 24-Oct-24 |
| 31 | **Phase 8: Inspections** | 25 | 25-Oct-24 | 18-Nov-24 |
| 32 | Defiencies Inspection | 20 | 25-Oct-24 | 18-Nov-24 |
| 33 | Defiencies Correction | 15 | 31-Oct-24 | 18-Nov-24 |
| 34 | **Phase 9: Demobilization** | 2 | 19-Nov-24 | 20-Nov-24 |
| 35 | Final Cleanup and Demobilization | 2 | 19-Nov-24 | 20-Nov-24 |



| ID | Task | Duration | Start | Finish | October | November |
|---|---|---|---|---|---|---|
| 1 | **Phase 1: Permitting** | 30 | 01-Apr-24 | 30-Apr-24 | | |
| 2 | **Phase 2: Mobilization and Site Preparation** | 2 | 01-May-24 | 02-May-24 | | |
| 3 | **Phase 3: Retention Tank Install (Stage 1)** | 37 | 03-May-24 | 08-Jun-24 | | |
| 4 | Milling, Removal and Detour Road Construction | 7 | 03-May-24 | 10-May-24 | | |
| 5 | Installation of Stormwater Detention Tank | 15 | 11-May-24 | 29-May-24 | | |
| 6 | Installation of Outfall Pipe | 20 | 16-May-24 | 08-Jun-24 | | |
| 7 | Backfilling, Grading, and Constructing Temporary Pavement | 7 | 01-Jun-24 | 08-Jun-24 | | |
| 8 | **Phase 4: Southwest and Northwest Side of Roundabout (Stage 2)** | 34 | 10-Jun-24 | 13-Jul-24 | | |
| 9 | Milling, Removal and Detour Road Construction | 4 | 10-Jun-24 | 13-Jun-24 | | |
| 10 | Installation of Stormwater Collection Pipes | 20 | 14-Jun-24 | 07-Jul-24 | | |
| 11 | Construction of Southwest and Northwest Sides of Roundabout | 20 | 18-Jun-24 | 11-Jul-24 | | |
| 12 | Backfilling, Grading, and Constructing Temporary Pavement | 2 | 12-Jul-24 | 13-Jul-24 | | |
| 13 | **Phase 5: North Side of Roundabout (Stage 3)** | 31 | 15-Jul-24 | 14-Aug-24 | | |
| 14 | Milling, Removal and Detour Road Construction | 4 | 15-Jul-24 | 18-Jul-24 | | |
| 15 | Installation of Stormwater Collection Pipes | 12 | 19-Jul-24 | 01-Aug-24 | | |
| 16 | Construction of North Side of Roundabout | 20 | 19-Jul-24 | 12-Aug-24 | | |
| 17 | Backfilling, Grading, and Constructing Temporary Pavement | 2 | 13-Aug-24 | 14-Aug-24 | | |
| 18 | **Phase 6: East Side of Roundabout (Stage 4)** | 31 | 15-Aug-24 | 14-Sep-24 | | |
| 19 | Milling, Removal and Detour Road Construction | 4 | 15-Aug-24 | 19-Aug-24 | | |
| 20 | Installation of Stormwater Collection Pipes | 4 | 20-Aug-24 | 23-Aug-24 | | |
| 21 | Construction of East Side of Roundabout | 20 | 20-Aug-24 | 12-Sep-24 | | |
| 22 | Backfilling, Grading, and Constructing Temporary Pavement | 2 | 13-Sep-24 | 14-Sep-24 | | |
| 23 | **Phase 7: Median, Central Island and Landscaping (Stage 5)** | 39 | 16-Sep-24 | 24-Oct-24 | | |
| 24 | Milling, Removal and Detour Road Construction | 4 | 16-Sep-24 | 19-Sep-24 | | |
| 25 | Installation of Footing for Gateway | 4 | 20-Sep-24 | 24-Sep-24 | | |
| 26 | Median and Cental Island Construction | 10 | 25-Sep-24 | 07-Oct-24 | | |
| 27 | Installation of Gateway Struture | 4 | 03-Oct-24 | 07-Oct-24 | | |
| 28 | Backfilling and Grading | 2 | 08-Oct-24 | 09-Oct-24 | | |
| 29 | Lane Markings and Signage | 4 | 10-Oct-24 | 15-Oct-24 | | |
| 30 | Landscaping | 10 | 12-Oct-24 | 24-Oct-24 | | |
| 31 | **Phase 8: Inspections** | 25 | 25-Oct-24 | 18-Nov-24 | | |
| 32 | Defiencies Inspection | 20 | 25-Oct-24 | 18-Nov-24 | | |
| 33 | Defiencies Correction | 15 | 31-Oct-24 | 18-Nov-24 | | |
| 34 | **Phase 9: Demobilization** | 2 | 19-Nov-24 | 20-Nov-24 | | |
| 35 | Final Cleanup and Demobilization | 2 | 19-Nov-24 | 20-Nov-24 | | |

# Appendix C: Class A Cost Estimate

| Class A Cost Estimate | | | | | |
|---|---|---|---|---|---|
| Client: UBC Campus and Community Planning | | | | | |
| Project: Redesign of 16th Avenue / SW Marine Drive Intersection | | | | | |
| Item No. | Description of Work and Materials | Measurement Unit | Quantity | Unit Price | Total |
| | **General Items** | | | | |
| 1 | Project Management | L.S. | 1 | $50,000.00 | $50,000.00 |
| 2 | Construction Management | L.S. | 1 | $35,000.00 | $35,000.00 |
| 3 | Mobilization / Demobilization | L.S. | 1 | $95,000.00 | $95,000.00 |
| | **Engineering & Permitting** | | | | |
| 4 | Preliminary Design | L.S. | 1 | $94,362.00 | $94,362.00 |
| 5 | Detailed Design Services | L.S. | 1 | $228,849.00 | $228,849.00 |
| 6 | Quality Assurance | L.S. | 1 | $45,000.00 | $45,000.00 |
| 7 | Permitting | L.S. | 1 | $60,000.00 | $60,000.00 |
| | **Clearing, Grubbinng & Demolition Items** | | | | |
| 8 | Clearing & Grubbing (incl. trees) | sq. m | 21725.7 | $21.52 | $467,537.06 |
| 9 | Removal of Curbs | lin. m | 1380 | $137.19 | $189,322.20 |
| 10 | Removal of Pole Barriers | L.S. | 1 | $10,000.00 | $10,000.00 |
| 11 | Removal of Structures & Obstructions | L.S. | 1 | $68,000.00 | $68,000.00 |
| | **Road Construction** | | | | |
| 12 | Pavement Removal 100mm deep | sq. m | 15386.2 | $21.52 | $331,111.02 |
| 13 | Roadway Excavation 600mm deep | sq. m | 15386.2 | $6.63 | $102,010.51 |
| 14 | SGSB Granular Fill - 300mm | sq. m | 15386.2 | $28.00 | $430,813.60 |
| 15 | WGB Granular Fill - 300mm | sq. m | 15386.2 | $33.60 | $516,976.32 |
| 16 | Level 3, HMAC Mixture, 50mm thick (Asphalt) | sq. m | 15386.2 | $33.24 | $511,437.29 |
| 17 | Level 3, HMAC Mixture, Overlay, 50mm thick (Asphalt) | sq. m | 15386.2 | $27.35 | $420,812.57 |
| 18 | Concrete Curb and Gutter- Extruded | lin. m | 1774 | $140.00 | $248,360.00 |
| 19 | Concrete Standard Curb | lin. m | 252 | $120.00 | $30,240.00 |
| 20 | Pavement Markings - Paintlines (100 mm wide) | lin. m | 4528.9 | $12.00 | $54,346.80 |
| 21 | Crosswalk Markings | sq. m | 32.7 | $36.00 | $1,177.20 |
| 22 | Painting Bike Route Symbol Markings | each | 13 | $375.00 | $4,875.00 |
| 23 | Roadway Signing | L.S. | 1 | $10,000.00 | $10,000.00 |
| 24 | Temporary Asphault - Construction Staging | sq. m | 9231.72 | $20.15 | $186,019.16 |
| | **Storm Drainage** | | | | |
| 25 | 300mm dia. Storm Drain Pipe (SDR 35 PVC) | lin. m | 950 | $121.00 | $114,950.00 |
| 26 | Culvert - Supply and Install (600 mm dia. C.S.P) | m | 14 | $274.74 | $3,846.36 |
| 27 | Detention Tank - 1584.58 m^3 concrete | each | 1 | $435,760.00 | $435,760.00 |
| | **Gateway Feature** | | | | |
| 28 | Material Costs | L.S. | 1 | $20,000.00 | $20,000.00 |
| | **Signals & Lighting** | | | | |
| 29 | Removal & Relocation of Existing Light Poles | L.S. | 1 | $25,000.00 | $25,000.00 |
| 30 | Traffic Signal Removal | L.S. | 1 | $25,000.00 | $25,000.00 |
| | **Landscape & Restoration** | | | | |
| 31 | Slope Stabilization | L.S. | 1 | $15,000.00 | $15,000.00 |
| 32 | Center Island Landscaping | L.S. | 1 | $10,000.00 | $10,000.00 |
| 33 | Landscape Restoration | sq. m | 6339.5 | $112.98 | $716,236.71 |
| | **Operations & Maintenance** | | | | |
| 34 | Stormwater Operations and Maintenance (Lifetime Cost) | L.S. | 1 | $75,000.00 | $75,000.00 |
| 35 | Roadwork Operations and Maintenance (Lifetime Cost) | L.S. | 1 | $100,000.00 | $175,000.00 |
| | **SUBTOTAL** | | | | **$5,807,042.80** |
| | Contingency 15% | L.S. | 1 | $871,056.42 | $871,056.42 |
| | **TOTAL ESTIMATE** | | | | **$6,678,099.22** |

# Appendix D: Calculations

| | | |
|---|---|---|
| Project | **Intersection Redesign of Southwest Marine Drive & 16th Avenue** | |
| Subject | **Stormwater Design** | |
| Calculated by | | |
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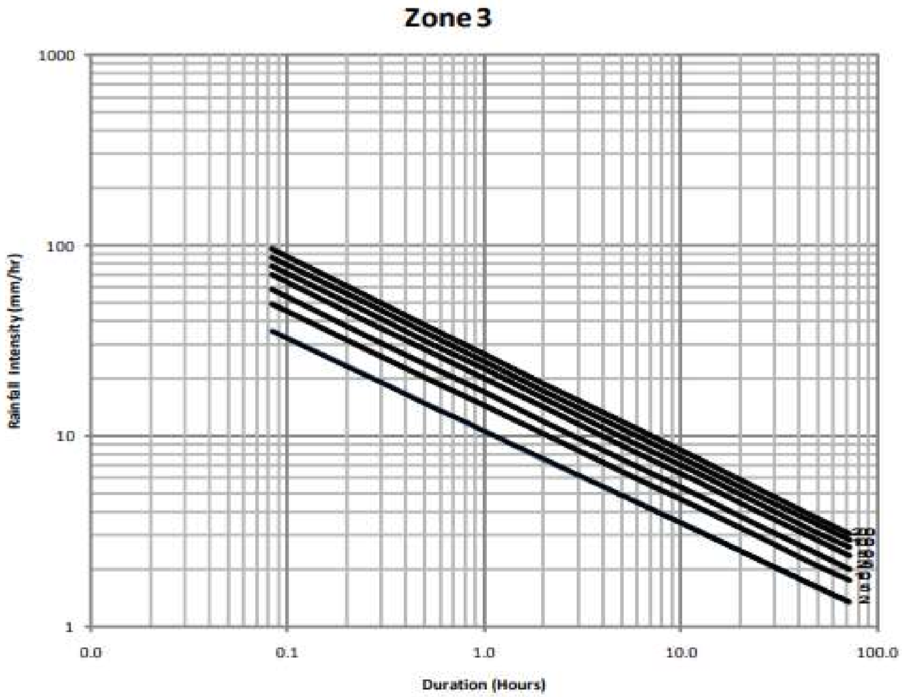
Rainfall Inflow Rate




| Duration | 2 year | 5 year | 10 year | 25 year | 50 year | 100 year | 200 year |
|---|---|---|---|---|---|---|---|
| 5 min | 35.3 | 49.2 | 58.3 | 69.7 | 78.2 | 86.6 | 95.0 |
| 15 min | 20.7 | 28.6 | 33.7 | 40.2 | 44.9 | 49.7 | 54.4 |
| 30 min | 14.8 | 20.3 | 23.9 | 28.4 | 31.7 | 35.0 | 38.3 |
| 1 h | 10.6 | 14.4 | 16.9 | 20.0 | 22.3 | 24.6 | 26.9 |
| 2 h | 7.6 | 10.2 | 12.0 | 14.1 | 15.7 | 17.3 | 18.9 |
| 6 h | 4.5 | 5.9 | 6.9 | 8.1 | 9.0 | 9.9 | 10.8 |
| 12 h | 3.2 | 4.2 | 4.9 | 5.7 | 6.4 | 7.0 | 7.6 |
| 24 h | 2.3 | 3.0 | 3.5 | 4.1 | 4.5 | 4.9 | 5.4 |
| 48 h | 1.6 | 2.1 | 2.5 | 2.9 | 3.2 | 3.5 | 3.8 |
| 72 h | 1.3 | 1.7 | 2.0 | 2.3 | 2.6 | 2.8 | 3.1 |

***The design storm scenario is a 1-in-100 year storm with a 24-hour duration.**

| | | | |
|---|---|---|---|
| C | 0.85 | | Runoff Coefficient (best estimate) |
| i' | 4.9 | mm/hr | Design Storm Rainfall Intensity |
| i | 5.88 | mm/hr | Climate Change Adjusted Intensity (+20%) |
| A | 41961 | m^2 | Drainage Area |

$$Q = CiA$$

| | | | |
|---|---|---|---|
| Q | 209.7 | m^3/hr | Design Flow Rate |

| | | |
|---|---|---|
| Project | **Intersection Redesign of Southwest Marine Drive & 16th Avenue** | |
| Subject | **Stormwater Design** | |
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## Stormwater Retention Tank Dimensions

| | | | |
|---|---|---|---|
| Q | 209.7 | m^3/hr | Design Flow Rate |
| t | 24 | hr | Storm Duration |

$$V = Qt$$

| | | | |
|---|---|---|---|
| V | 5033.3 | m^3 | Total Design Storm Rainfall Volume |

| | | | |
|---|---|---|---|
| L | 65 | m | Length of Tank |
| W | 20 | m | Width of Tank |
| H | 4 | m | Height of Tank |

$$V = LWH$$

| | | | |
|---|---|---|---|
| V | 5200 | m^3 | Stormwater Retention Tank Storage Volume |

## Collection Pipe & Outfall Diameter

| | | | |
|---|---|---|---|
| C | 0.85 | | Runoff Coefficient |
| i' | 49.2 | mm/hr | Pipe Design Storm Rainfall Intensity |
| i | 59.04 | mm/hr | Climate Change Adjusted Intensity (+20%) |
| A | 41961 | m^2 | Drainage Area |

***The pipe design storm scenario is a 1-in-5 year storm with a 5-minute duration.**

$$Q = CiA$$

| | | | |
|---|---|---|---|
| Q | 2105.8 | m^3/hr | Pipe Design Flow Rate |

| | | | |
|---|---|---|---|
| q | 351.0 | m^3/hr | Flow Rate per Inflow Pipe |

***Assumed that total flow is evenly distributed among the 6 inflow pipes**

| | | | |
|---|---|---|---|
| n | 0.012 | | Manning's Roughness Coefficient |
| S | 0.01 | | Slope |

$$d = \left(\frac{Qn}{0.31S^{0.5}}\right)^{0.375}$$

| | | | |
|---|---|---|---|
| d | 0.293 | m | Minimum Pipe Diameter |
| D | 0.3 | m | Design Pipe Diameter |

***Assumed that outfall pipe is the same diameter, as the discharge rate is not critical to design**

| | | |
|---|---|---|
| Project | **Intersection Redesign of Southwest Marine Drive & 16th Avenue** | |
| Subject | **Stormwater Design** | |
| Calculated by | | |
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## Pipe Flow Velocity

| | | |
|---|---|---|
| R | 0.075 m | Hydraulic Radius |

***R is taken as one quarter of the pipe diameter**

| | | |
|---|---|---|
| n | 0.012 | Manning's Roughness Coefficient |
| S | 0.01 | Slope |

$$v = \frac{R^{0.67} S^{0.5}}{n}$$

| | | |
|---|---|---|
| v | 1.47 m/s | Velocity |

| | | |
|---|---|---|
| Project | **Intersection Redesign of Southwest Marine Drive & 16th Avenue** | |
| Subject | **Detention Tank Structural Design** | |
| Calculated by | | |
| Reviewed by | | |
| Date | Mar 14, 2023 |  |

## Detention Tank Soil Loads

| | | | |
|---|---|---|---|
| γs | 24.2 | kg/m^3 | Unit Weight of Soil |

***Estimated based on typical values**

| | | | |
|---|---|---|---|
| γw | 9.8 | kg/m^3 | Unit Weight of Water |
| ka | 0.27 | | Active Pressure Coefficient |
| Hw | 5 | m | Height of Tank |

***Height estimated as conservative assumption**

| | | | |
|---|---|---|---|
| Hs | 1 | m | Height of Soil Above Tank |

## Shear Wall Lateral Soil Loads

$$\gamma H K_a$$

| | | | |
|---|---|---|---|
| Vs | 6.56 | kN/m | Top Soil Lateral Load Per 1m of Shear Wall |
| Vw | 13.28 | kN/m | Surcharge Lateral Load Per 1m of Shear Wall |
| Vsmax | 32.79 | kN/m | Max Active Lateral Soil Load Per 1m of Wall |
| Fs | 9.18 | kN/m | Factored Top Soil Lateral Load Per 1m |
| Fw | 18.59 | kN/m | Factored Surcharge Lateral Load Per 1m |
| Fsmax | 45.91 | kN/m | Factored Max Active Lateral Soil Load Per 1m |

***Factored load case taken as 1.4DL**

| | | | |
|---|---|---|---|
| UDLmin | 27.77 | kN/m | Minimum UDL Per 1m of Wall (top of tank) |
| UDLmax | 73.68 | kN/m | Maximum UDL Per 1m of Wall (bottom of tank) |
| Rxtop | 107.68 | kN/m | Reaction Force Per 1m of Wall (top of tank) |
| Rxbottom | 145.94 | kN/m | Reaction Force Per 1m of Wall (bottom of tank) |
| Mmax | 159.4 | kNm | Maximum Moment Per 1m of Wall |

***Max moment calculated using double integral of applied UDL and confirmed using structural analyzer**

| Project | **Intersection Redesign of Southwest Marine Drive & 16th Avenue** | |
|---|---|---|
| Subject | **Detention Tank Structural Design** | |
| Calculated by | | |
| Reviewed by | | |
| Date | Mar 14, 2023 |  |

## Shear Wall Vertical Soil Loads

| | | | |
|---|---|---|---|
| γc | 23.5 | kg/m^3 | Unit Weight of Reinforced Concrete |

***Based on typical values**

| | | | |
|---|---|---|---|
| X | 65 | m | Top Slab X Dimension |
| Y | 20 | m | Top Slab Y Dimension |
| Z | 0.5 | m | Top Slab Z Dimension |

***Based on initial tank sizing**

| | | | |
|---|---|---|---|
| Psl | 11.75 | kN/m^2 | Weight of Top Slab |
| Pw | 9.8 | kN/m^2 | Surcharge Weight |
| Ps | 24.2 | kN/m^2 | Soil Weight |
| Pf | 64.05 | kN/m^2 | Total Factored Vertical Load |

***Factored load case taken as 1.4 DL**

| | | | |
|---|---|---|---|
| Pft | 4163.25 | kN/m | Total Factored Vertical Load Per 1m of Wall |

## Shear Wall Structural Design

| | | | |
|---|---|---|---|
| f'c | 30 | MPa | Concrete Strength |
| fy | 350 | MPa | Steel Strength |
| Hw | 4 | m | Shear Wall Height |
| Tw | 0.4 | m | Shear Wall Thickness |
| Ww | 1 | m | Shear Wall Design Width |

***Shear wall designed per 1m of wall**

| | | | |
|---|---|---|---|
| Ag | 400000 | mm^2 | Gross Area |

## Axial Design

| | | |
|---|---|---|
| a1 | 0.805 | |
| k | 0.8 | Coefficient for Walls Fixed on Both Ends |

$$P_r = \frac{2}{3} \times \alpha_1 \times \phi_c \times f_c' \times A_g \times \left[1 - \left(\frac{k \times h_u}{32 \times t}\right)^2\right]$$

| | | | |
|---|---|---|---|
| Pr | 3824.38 | kN/m | Axial Resistance Per 1m of Wall |

| Project | Intersection Redesign of Southwest Marine Drive & 16th Avenue | |
|---|---|---|
| Subject | **Detention Tank Structural Design** | |
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## Axial Design

| | | | |
|---|---|---|---|
| Pfs | 2134.26 | kN/m | Axial Load Per 1m of Wall |

***Total axial load shared by two walls, therefore Pfs = Pft/2**

***Pr > Pfs, therefore adequate axial design**

## Reinforcement Design

$$A_{h,\min} = 0.002 \times A_g$$

| | | | |
|---|---|---|---|
| Ah min | 800 | mm^2 | Minimum Area for Horizontal Reinforcement |

***Since Tw > 210mm, 2 layers of reinforcement required**

***Select 10M bars @ 150 mm**

$$A_{v,\min} = 0.0015 \times A_g$$

| | | | |
|---|---|---|---|
| Av min | 600 | mm^2 | Minimum Area for Vertical Reinforcement |
| Ab | 100 | mm^2 | Design Rebar Area (10M) |

***Select 10M bars @ 200 mm**

## Shear Design

$$V_c = \phi_c \times \lambda \times \beta \times \sqrt{f_c'} \times b_w \times d_v$$

| | | | |
|---|---|---|---|
| dv | 0.8 | m | Effective Depth |
| B | 0.18 | | |
| Vr | 205.07 | kN/m | Shear Resistance Per 1m of Wall |
| Vfmax | 145.94 | kN/m | Max Applied Shear Per 1m of Wall |

***Vr > Vfmax, therefore adequate shear design**

## Flexural Design

$$\alpha = \frac{P_f}{\phi_c \times f_c' \times l_w \times t}$$

a 0.00027

$$\omega = \frac{\phi_s \times A_{vt} \times f_y}{\phi_c \times f_c' \times l_w \times t}$$

w 0.019

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## Flexural Design

$$\frac{c}{l_w} = \frac{\omega + \alpha}{2 \times \omega + \alpha_1 \times \beta_1}$$

| | | | |
|---|---|---|---|
| c/lw | 0.025 | | |

$$M_r = 0.5 \times \phi_s \times A_{tv} \times f_y \times l_w \times \left(1 + \frac{P_f}{\phi_s \times A_{tv} \times f_y}\right)\left(1 - \frac{c}{l_w}\right)$$

| | | | |
|---|---|---|---|
| Mr | 73518.4 | kNm | Moment Resistance Per 1m of Wall |
| Mmax | 159.4 | kNm | Max Applied Moment Per 1m of Wall |

***Mr > Mmax, therefore adequate flexural design**

***Reinforcement design adequate for all checks**

## Slab Design

| | | | |
|---|---|---|---|
| W | 1 | m | Width of Slab (designed per 1m of slab) |
| Span | 5 | m | Assumed Span Between Supporting Beams |
| Ln | 4.6 | m | Assumed Clear Span Between Supporting Beams |
| fyc | 350 | MPa | Concrete Yield Strength |
| fys | 400 | MPa | Steel Yield Strength |
| f'c | 30 | MPa | Concrete Strength |
| Wf | 64.05 | kN/m^2 | Factored Load Per 1m of Slab |

Mf+ = wL^2/24

| | | | |
|---|---|---|---|
| Mf+ | 56.47 | kNm | Factored Moment at Midspan |

Mf- = wL^2/12

| | | | |
|---|---|---|---|
| Mf- | 112.94 | kNm | Factored Moment at Supports |

Hmin = Ln/28

| | | | |
|---|---|---|---|
| Hmin | 0.25 | m | Minimum Slab Thickness |
| Hdesign | 0.4 | m | Design Slab Thickness |

| | | |
|---|---|---|
| Project | **Intersection Redesign of Southwest Marine Drive & 16th Avenue** | |
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## Slab Shear Design

Vfmax = wL/2

| | | | |
|---|---|---|---|
| Vfmax | 147.3 | kN | Max Applied Shear |
| dv | 310.5 | mm | Effective Depth |

$$V_r = V_c = \phi_c \, \beta \sqrt{f_c'} \; b_w d_v$$

| | | | |
|---|---|---|---|
| B | 0.21 | | |
| Vr | 232.14 | kN | Shear Resistance |

***Vr > Vfmax, therefore adequate shear design**

## BUL Design

| | | | |
|---|---|---|---|
| Ag | 1840000 | mm^2 | Gross Area |

As/Ag => 0.002

| | | | |
|---|---|---|---|
| As min | 3680 | mm^2 | Minimum BUL Reinforcement Area |
| Smax | 500 | mm | Maximum Spacing |

***Select 20M bars @ 500 mm**

## BLL Design

| | | | |
|---|---|---|---|
| Ag | 400000 | mm^2 | Gross Area |

As/Ag => 0.002

| | | | |
|---|---|---|---|
| As min | 800 | mm^2 | Minimum BLL Reinforcement Area |
| Smax | 500 | mm | Maximum Spacing |

***Select 10M bars @ 500 mm**

L = Ln + 0.3m

| | | | |
|---|---|---|---|
| L | 4900 | mm | BLL Reinforcement Length |

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## Flexural Capacity at Midspan

$$M_r = \phi_s f_y A_s \cdot (d - \beta_1 c/2)$$

$$\beta_1 c = \frac{\phi_s f_y A_s}{\alpha_1 \phi_c f_c' \, b}$$

| | | | |
|---|---|---|---|
| dv | 310.5 | mm | Effective Depth |
| B1c | 15.16 | | |
| Mr+ | 82.39 | kNm | Flexural Capacity at Midspan |
| Mf+ | 56.47 | kNm | Applied Moment at Midspan |

***Mr+ > Mf+, therefore adequate flexural design at midspan**

## TUL Design

| | | | |
|---|---|---|---|
| Ag | 400000 | mm^2 | Gross Area |

As/Ag => 0.003

| | | | |
|---|---|---|---|
| As min | 1200 | mm^2 | Minimum TUL Reinforcement Area |
| Smax | 500 | mm | Maximum Spacing |

***Select 15M bars @ 500 mm**

L = 2 * 0.3Ln + 0.3 m

| | | | |
|---|---|---|---|
| L | 3060 | mm | TUL Reinforcement Length |

## TLL Design

| | | | |
|---|---|---|---|
| Ag | 92000 | mm^2 | Gross Area |

As/Ag => 0.004

| | | | |
|---|---|---|---|
| As min | 369 | mm^2 | Minimum TLL Reinforcement Area |
| Smax | 500 | mm | Maximum Spacing |

***Select 10M bars @ 500 mm**

L = 2 * 0.3Ln + 0.3 m

| | | | |
|---|---|---|---|
| L | 3060 | mm | TLL Reinforcement Length |

## Flexural Capacity at Supports

$$M_r = \phi_s f_y A_s \cdot (d - \beta_1 c/2)$$

$$\beta_1 c = \frac{\phi_s f_y A_s}{\alpha_1 \phi_c f_c' \, b}$$

| | | | |
|---|---|---|---|
| dv | 310.5 | mm | Effective Depth |
| B1c | 22.74 | | |
| Mr- | 122.04 | kNm | Flexural Capacity at Supports |
| Mf- | 112.94 | kNm | Applied Moment at Supports |

***Mr- > Mf-, therefore adequate flexural design at supports**

## Beam Design

| | | | |
|---|---|---|---|
| W | 0.4 | m | Assumed Beam Width |
| Ln | 4.6 | m | Assumed Beam Clear Span |

dmin = Ln/20

| | | | |
|---|---|---|---|
| dmin | 0.23 | m | Minimum Beam Depth |
| d | 0.6 | m | Design Beam Depth |
| Wsl | 47 | kN/m | Weight of Slab Per 1m of Beam |
| Ww | 49 | kN/m | Weight of Surcharge Per 1m of Beam |
| Ws | 121 | kN/m | Weight of Soil Per 1m of Beam |
| Wb | 5.64 | kN/m | Weight of Beam Per 1m of Beam |
| Wf | 311.7 | kN/m | Total Factored Load Per 1m of Beam |

***Factored load case taken as 1.4DL**

## Flexural Design

As min = 0.0027 * b * h

| | | | |
|---|---|---|---|
| As min | 648 | mm^2 | Minimum Longitudinal Reinforcement Area |

jd = 0.7 * h

| | | | |
|---|---|---|---|
| jd | 420 | mm | Internal Lever Arm |

| | | |
|---|---|---|
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## Flexural Design

Mf+ = Wf * L/24

| | | | |
|---|---|---|---|
| Mf+ | 324.68 | kNm | Applied Moment at Midspan |

Mf- = Wf * L/12

| | | | |
|---|---|---|---|
| Mf- | 649.37 | kNm | Applied Moment at Supports |

T = Mf / jd

| | | | |
|---|---|---|---|
| Ti+ | 773.1 | kN | Estimate for Required Tension Force at Midspan |
| Ti- | 1546.1 | kN | Estimate for Required Tension Force at Supports |

As = T / 340

| | | | |
|---|---|---|---|
| As+ | 2273.7 | mm^2 | Estimate for Required Reinforcement at Midspan |
| As- | 4547.4 | mm^2 | Estimate for Required Reinforcement at Supports |

***Select 8 35M bars in 2 layers (4 bars per layer) for both midspan and supports**

| | | | |
|---|---|---|---|
| dv+ | 520 | mm | Effective Depth at Midspan |

jd = 0.8 * d

| | | | |
|---|---|---|---|
| jd+ | 416 | mm | Revised Internal Lever Arm at Midspan |
| T+ | 780.49 | kN | Revised Tension Estimate at Midspan |
| As+ | 2295.6 | mm^2 | Revised Required Reinforcement at Midspan |

$$\beta_1 c = \frac{\phi_s f_y A_s}{\alpha_1 \phi_c f_c' \, b}$$

| | |
|---|---|
| B1c | 433.2 |

$$M_r = \phi_s f_y A_s \cdot (d - \beta_1 c/2)$$

| | | | |
|---|---|---|---|
| Mr+ | 825.26 | kNm | Flexural Capacity at Midspan |
| Mf+ | 324.68 | kNm | Applied Moment at Midspan |

***Mr+ > Mf+, therefore adequate flexural design at midspan**

| Project | **Intersection Redesign of Southwest Marine Drive & 16th Avenue** | |
|---|---|---|
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## Flexural Design

| | | | |
|---|---|---|---|
| dv- | 505 | mm | Effective Depth at Supports |

jd = 0.8 * d

| | | | |
|---|---|---|---|
| jd- | 404 | mm | Revised Internal Lever Arm at Supports |
| T- | 1607.34 | kN | Revised Tension Estimate at Supports |
| As- | 4727.48 | mm^2 | Revised Required Reinforcement at Supports |

$$\beta_1 c = \frac{\phi_s f_y A_s}{\alpha_1 \phi_c f_c' \, b}$$

| | |
|---|---|
| B1c | 433.2 |

$$M_r = \phi_s f_y A_s \cdot (d - \beta_1 c/2)$$

| | | | |
|---|---|---|---|
| Mr- | 784.46 | kNm | Flexural Capacity at Supports |
| Mf- | 649.37 | kNm | Applied Moment at Supports |

***Mr- > Mf-, therefore adequate flexural design at supports**

## Shear Design

Vfmax = wL/2

| | | | |
|---|---|---|---|
| Vfmax | 779.24 | kN | Maximum Applied Shear Force |
| f'c | 30 | MPa | Concrete Strength |
| fy | 400 | MPa | Steel Yield Strength |
| dv- | 454.5 | mm | Effective Depth at Midspan |

Smax = min (0.7 * dv, 600)

| | | | |
|---|---|---|---|
| Smax | 318 | mm | Maximum Stirrup Spacing |
| Sdesign | 300 | mm | Design Stirrup Spacing |

***Select 15M bars @ 300 mm**

| | | | |
|---|---|---|---|
| Ab | 200 | mm^2 | Stirrup Area Per Leg |

***Use 3 stirrups, Av = Ab * 6 since there are 6 legs**

| | | | |
|---|---|---|---|
| Av | 1200 | mm^2 | Total Stirrup Area |

| | | |
|---|---|---|
| Project | **Intersection Redesign of Southwest Marine Drive & 16th Avenue** | |
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## Shear Design

$$V_c = \phi_c \, \beta \sqrt{f_c'} \; b_w d_v$$

$$V_s = \phi_s f_y A_v \cdot {}^{d_v \cot\theta}/_{s}$$

$$V_r = V_c + V_s \leq 0.25 \phi_c f_c' b_w d_v$$

| | | | |
|---|---|---|---|
| B | 0.18 | | |
| θ | 35° | | |
| Vc+ | 120 | kN | Concrete Shear Resistance at Midspan |
| Vs+ | 909 | kN | Steel Shear Resistance at Midspan |
| Vr+ | 1029 | kN | Total Shear Resistance at Midspan |

***Vr+ > Vfmax, therefore adequate shear design at midspan**

| | | | |
|---|---|---|---|
| Vc- | 116.5 | kN | Concrete Shear Resistance at Supports |
| Vs- | 882.8 | kN | Steel Shear Resistance at Supports |
| Vr- | 999.3 | kN | Total Shear Resistance at Supports |

***Vr- > Vfmax, therefore adequate shear design at supports**

## Column Design

| | | | |
|---|---|---|---|
| W | 0.4 | m | Assumed Width of Column |
| L | 0.4 | m | Assumed Length of Column |
| H | 4 | m | Assumed Height of Column |
| Ag | 160000 | mm^2 | Gross Area |

As min = 0.01 * Ag

| | | | |
|---|---|---|---|
| As min | 1600 | mm^2 | Minimum Vertical Reinforcement Area |

***Select 8 20M bars**

| | | | |
|---|---|---|---|
| Ab | 300 | mm^2 | Area of Rebar |
| As | 2400 | mm^2 | Total Vertical Reinforcement Area |

***Select 15M ties @ 400 mm (200 mm at ends)**

| | | |
|---|---|---|
| Project | **Intersection Redesign of Southwest Marine Drive & 16th Avenue** | |
| Subject | **Detention Tank Structural Design** | |
| Calculated by | | |
| Reviewed by | | |
| Date | Mar 14, 2023 | Page 11 of 11 |

## Axial Design

| | | | |
|---|---|---|---|
| Wsl | 235 | kN | Weight of Slab |
| Wb | 51.9 | kN | Weight of Beam |
| Wc | 15.04 | kN | Weight of Column (self weight) |
| Ws | 605 | kN | Weight of Soil |
| Ww | 245 | kN | Weight of Surcharge |
| Pf | 1612.7 | kN | Total Factored Load |

***Factored load case taken as 1.4DL**

$$P_{r,max} = 0.80\left(\alpha_1 \phi_c f_c' A_c + \phi_s f_y A_s\right)$$

| | | | |
|---|---|---|---|
| a1 | 0.805 | | |
| f'c | 30 | MPa | Concrete Strength |
| fy | 400 | MPa | Steel Yield Strength |
| Ac | 157600 | mm^2 | Area of Concrete |
| Prmax | 2631.94 | kN | Maximum Factored Axial Resistance |

***Prmax > Pf, therefore adequate axial design**

***Assumed no moment acting on column**

| | | |
|---|---|---|
| Project | **Intersection Redesign of Southwest Marine Drive & 16th Avenue** | |
| Subject | **Gateway Footing** | |
| Calculated by | | |
| Reviewed by | | |
| Date | Dec 1st, 2023 | Page 1 of 2 |

## Gateway Structure Self-weight

| | | | |
|---|---|---|---|
| V_concrete | 6.987 | m^3 | Volume of Concrete Components |
| V_wood | 1.936 | m^3 | Volume of Wood Components |
| V_steel | 0.002 | m^3 | Volume of Steel Components |
| y_concrete | 23.5 | kN/m^3 | Unit Weight of Reinforced Concrete |
| y_wood | 3.3 | kN/m^3 | Unit Weight of Cedar Wood |
| y_steel | 77 | kN/m^3 | Unit Weight of Steel |

$$D = V_{concrete} * y_{concrete} + V_{wood} * y_{wood} + V_{steel} * y_{steel}$$

| | | | |
|---|---|---|---|
| D | 170.74 | kN | Dead load of Gateway Structure |

$$F = 1.4D$$

| | | | |
|---|---|---|---|
| F | 239.0 | kN | Factored Load |

## Footing Dimensions

| | | | |
|---|---|---|---|
| f_allow | 185 | kPa | Soil Bearing Stress |
| h | 0.3 | m | Tested Footing Depth |
| f_l | 7.05 | kPa | Footing Line Load |

$$A_{min} = \frac{D}{f_{allow} - f_l}$$

| | | | |
|---|---|---|---|
| A_min | 0.96 | m^2 | Minimum Footing Cross-section |

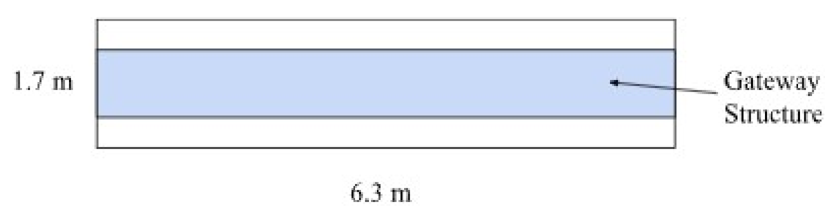
***Since the minimum area is less than the gateway structure base area, a wall-footing was designed.**

| | | | |
|---|---|---|---|
| w | 6.3 | m | Footing Width |
| l | 1.7 | m | Footing Length |
| d | 0.3 | m | Footing Depth |

$$f_{footing} = \frac{F}{w * l}$$

| | | | |
|---|---|---|---|
| f_footing | 22.3 | kPa | Footing Stress |

*** Footing stress is less than the soil bearing stress, therefore the footing dimensions are adequate.**



| Project | **Intersection Redesign of Southwest Marine Drive & 16th Avenue** | |
|---|---|---|
| Subject | **Gateway Footing** | |
| Calculated by | | |
| Reviewed by | | |
| Date | Dec 1st, 2023 |  |

## One-way Shear Check

| | | | |
|---|---|---|---|
| d | 0.3 | m | Footing Depth |
| dv | 0.1765 | m | Shear Depth |
| l_w | 1.7 | | Footing Length |
| b_w | 0.85 | | Structure Length |

$$y = \frac{l_w - b_w}{2} - d_v$$

| | | | |
|---|---|---|---|
| y | 0.2495 | m | Footing Length in Shear |

$$V_f = f_{footing} * w * y$$

| | | | |
|---|---|---|---|
| V_f | 35.05 | kN | Shear Demand |

$$V_r = V_c = \phi_c \beta \sqrt{f_c'}\ b_w d_v \qquad \beta = \frac{230}{(1000 + d_v)}$$

| | | | |
|---|---|---|---|
| f'c | 30.0 | MPa | Concrete Strength |
| V_r | 121.9 | kN | Shear Resistance |

***Since the shear resistance is greater than the demand, the footing is adequate for shear demands.**

## Flexural Design Check

$$M_f = \frac{f_{footing} * w * (\frac{l_w - b_w}{2})^2}{2}$$

| | | | |
|---|---|---|---|
| M_f | 12.69 | kNm | Bending Moment Demand |

***The moment capacity of the footing will depend on the amount of reinforcement in it**

$$As_{min,y} = 0.002ld$$

| | | | |
|---|---|---|---|
| As_min,y | 1020 | mm^2 | Minimum Reinforcement Area in y-direction |

*** Select 4 20M bars, with a total As of 1200 mm^2, and spacing of 425 mm**

$$As_{min,x} = 0.002wd$$

| | | | |
|---|---|---|---|
| As_min,x | 3780 | mm^2 | Minimum Reinforcement Area in x-direction |

*** Select 14 20M bars, with a total As of 4200 mm^2, and spacing of 450 mm**

$$M_r = \phi_s f_y A_s \cdot (d - \beta_1 c/2) \qquad \beta_1 c = \frac{\phi_s f_y A_s}{\alpha_1 \phi_c f_c' b}$$

| | | | |
|---|---|---|---|
| fy | 350 | MPa | Steel Strength |
| Mr | 60.5 | kNm | Bending Moment Resistance |

***Since the moment resistance is greater than the demand, the footing is adequate for flexural demands.**

# Appendix E: SIDRA Analysis

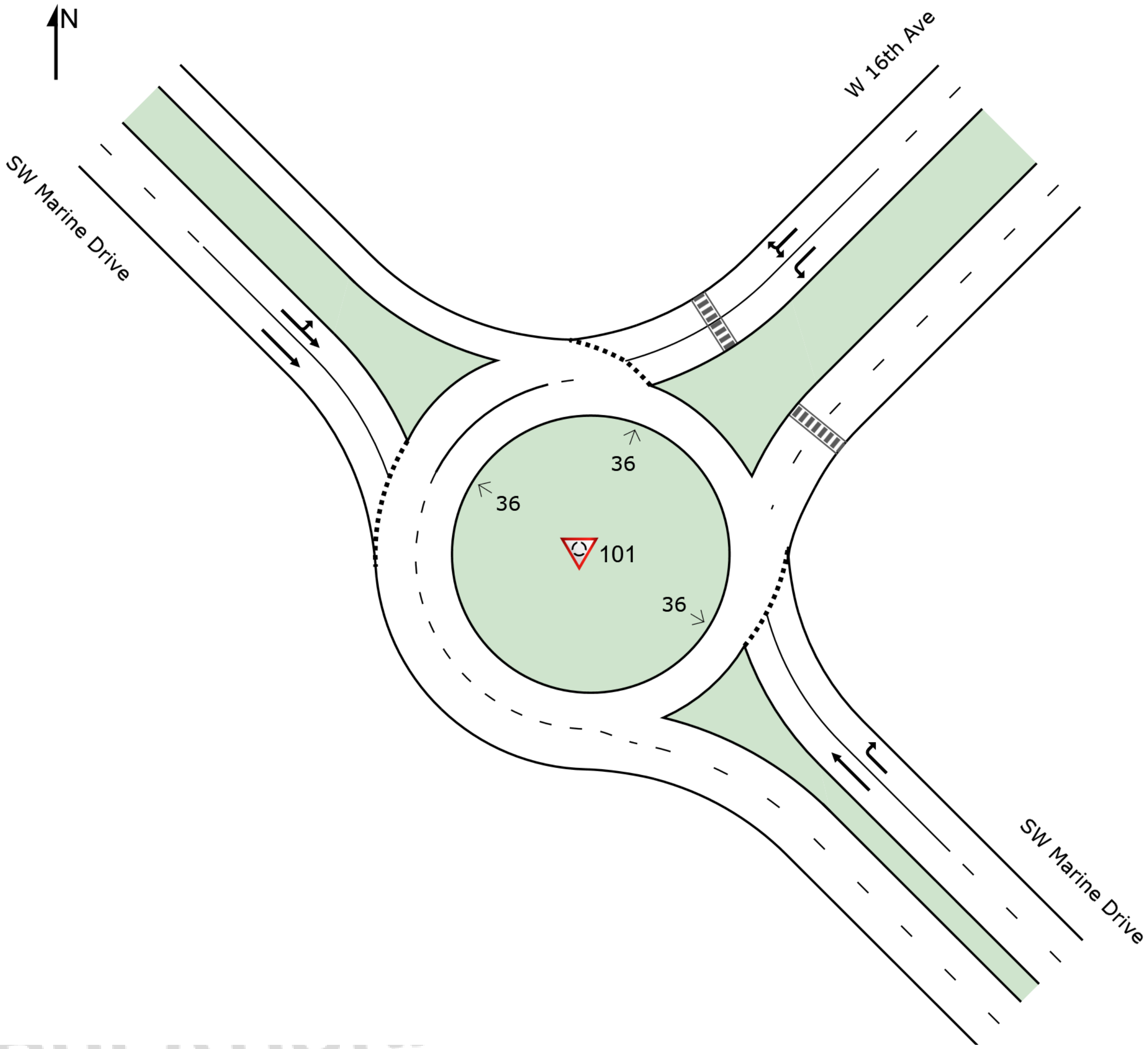
# SITE LAYOUT

## Site: 101 [SW Marine Dr and W 16th Ave (Site Folder: General)]

New Site
Site Category: Proposed Design 1
Roundabout



Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



# LANE LEVEL OF SERVICE

## Lane Level of Service

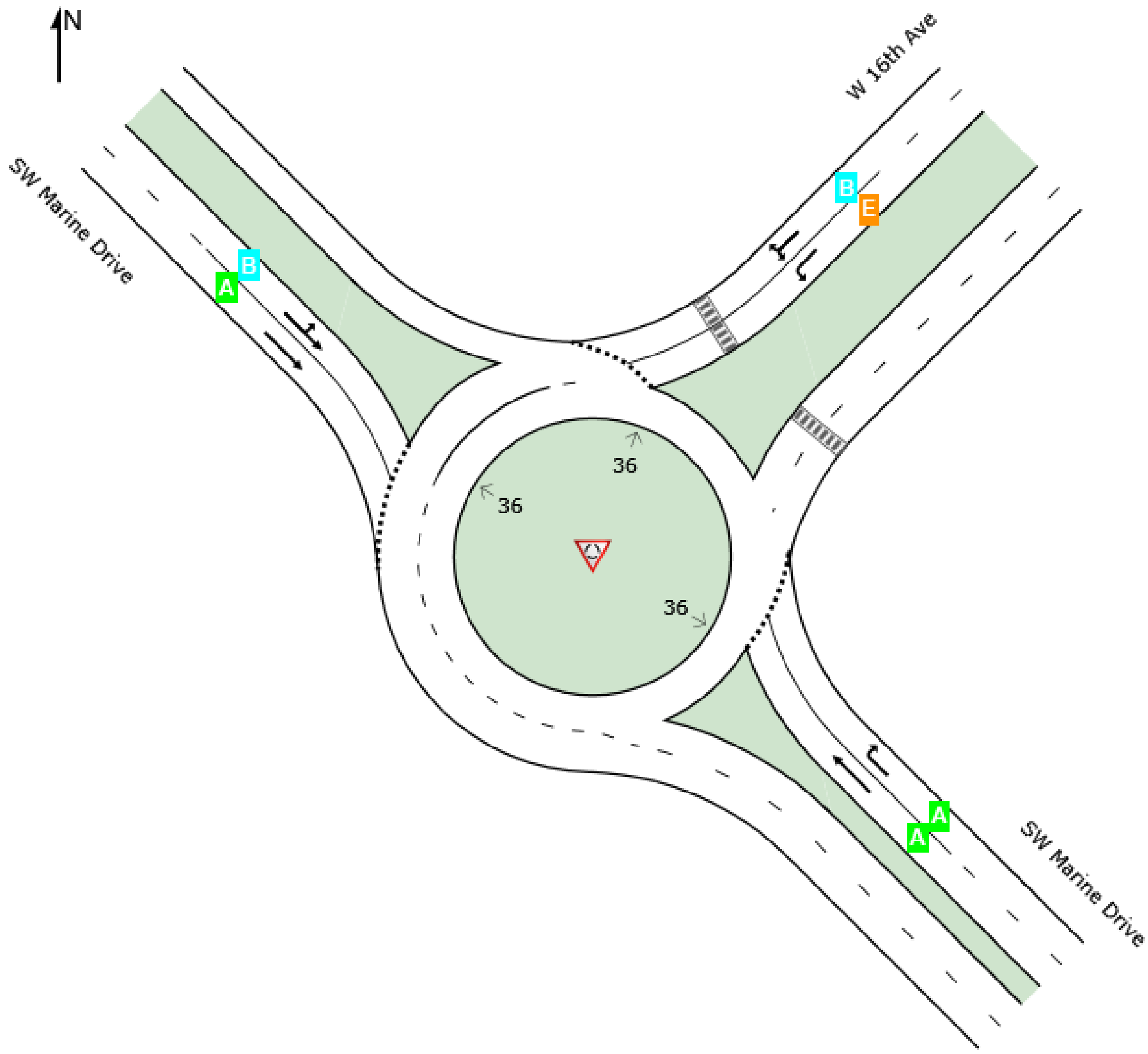
### Site: 101 [SW Marine Dr and W 16th Ave (Site Folder: General)]

**Output produced by SIDRA INTERSECTION Version: 9.1.5.224**



New Site
Site Category: Proposed Design 1
Roundabout

| | Approaches | | | Intersection |
|---|---|---|---|---|
| | Southeast | Northeast | Northwest | |
| LOS | A | E | B | B |




Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Lane LOS values are based on average delay per lane.
Intersection and Approach LOS values are based on average delay for all lanes.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).

# DEGREE OF SATURATION

**Ratio of Arrival Flow to Capacity, v/c ratio per movement**

## Site: 101 [SW Marine Dr and W 16th Ave (Site Folder: General)]

**Output produced by SIDRA INTERSECTION Version: 9.1.5.224**

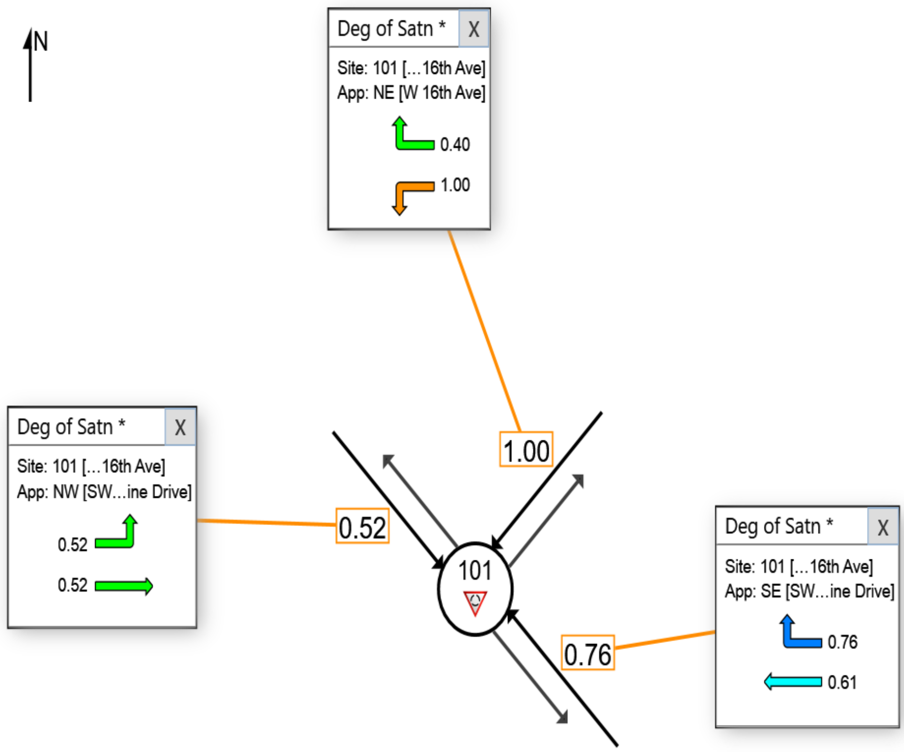


New Site
Site Category: Proposed Design 1
Roundabout

Use the button below to open or close all popup boxes. Click value labels to open selected ones.
Click and drag popup boxes to move to preferred positions.

Close All Popups

### All Movement Classes (*)




Colour code based on Degree of Saturation

| [ < 0.6 ] | [ 0.6 – 0.7 ] | [ 0.7 – 0.8 ] | [ 0.8 – 0.9 ] | [ 0.9 – 1.0 ] | [ > 1.0 ] | NA |
|---|---|---|---|---|---|---|

NA: The movement only runs in short lanes and these are not included in determining Queue Storage Ratio, or the movement has zero volume for the selected Movement Class.

# MOVEMENT FLOWS FOR SITE (DEMAND)

**Approach movement demand flow rates by movement class (veh/h)**

## Site: 101 [SW Marine Dr and W 16th Ave (Site Folder: General)]

**Output produced by SIDRA INTERSECTION Version: 9.1.5.224**

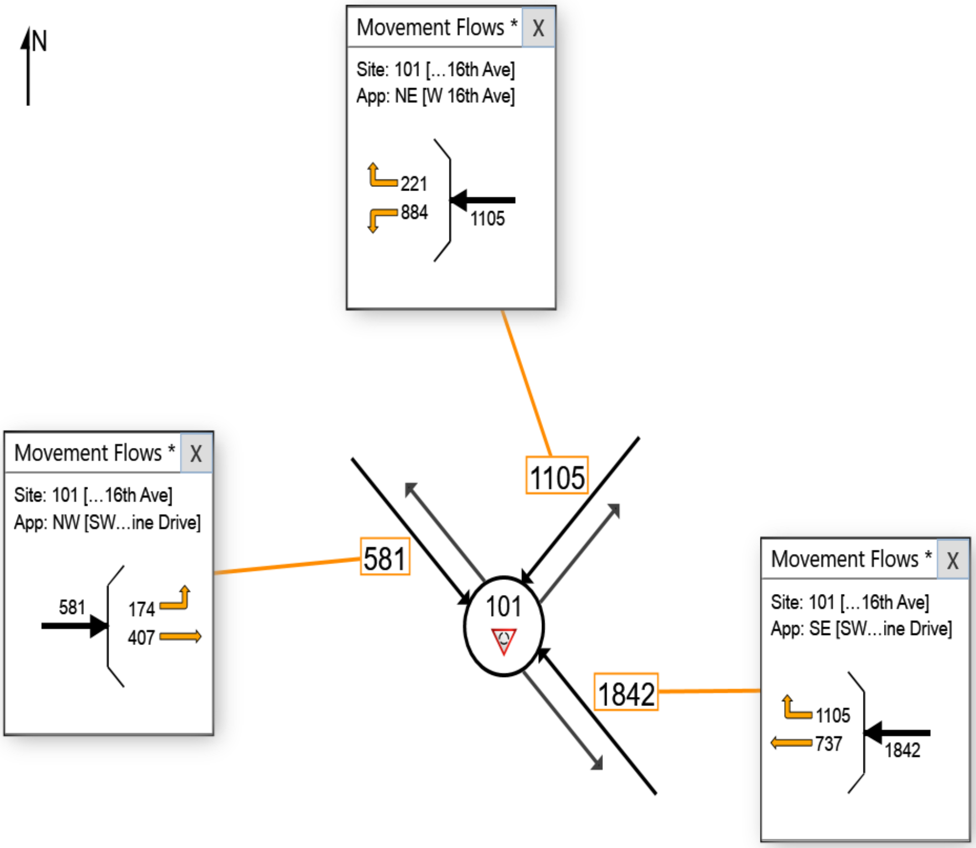


New Site
Site Category: Proposed Design 1
Roundabout

Use the button below to open or close all popup boxes. Click value labels to open selected ones.
Click and drag popup boxes to move to preferred positions.

Close All Popups

### All Movement Classes (*)



# LANE SUMMARY

## Site: 101 [SW Marine Dr and W 16th Ave (Site Folder: General)]

**Output produced by SIDRA INTERSECTION Version: 9.1.5.224**



New Site
Site Category: Proposed Design 1
Roundabout

**Lane Use and Performance**

| | Demand Flows [ Total veh/h | Demand Flows HV ] % | Arrival Flows [ Total veh/h | Arrival Flows HV ] % | Cap. veh/h | Deg. Satn v/c | Lane Util. % | Aver. Delay sec | Level of Service | 95% Back Of Queue [ Veh | 95% Back Of Queue Dist ] m | Lane Config | Lane Length m | Cap. Adj. % | Prob. Block. % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SouthEast: SW Marine Drive** | | | | | | | | | | | | | | | |
| Lane 1 | 737 | 4.0 | 737 | 4.0 | 1202 | 0.613 | 100 | 3.1 | LOS A | 6.2 | 46.7 | Full | 500 | 0.0 | 0.0 |
| Lane 2 [d] | 1105 | 6.0 | 1105 | 6.0 | 1459 | 0.758 | 100 | 3.8 | LOS A | 10.0 | 76.1 | Full | 500 | 0.0 | 0.0 |
| Approach | 1842 | 5.2 | 1842 | 5.2 | | 0.758 | | 3.5 | LOS A | 10.0 | 76.1 | | | | |
| **NorthEast: W 16th Ave** | | | | | | | | | | | | | | | |
| Lane 1 [d] | 867 | 4.1 | 867 | 4.1 | 868 | 0.998 | 100 | 61.4 | LOS E | 41.3 | 309.1 | Full | 500 | 0.0 | 0.0 |
| Lane 2 | 239 | 11.1 | 239 | 11.1 | 594 | 0.402 | 100 | 10.3 | LOS B | 2.9 | 22.7 | Full | 500 | 0.0 | 0.0 |
| Approach | 1105 | 5.6 | 1105 | 5.6 | | 0.998 | | 50.4 | LOS E | 41.3 | 309.1 | | | | |
| **NorthWest: SW Marine Drive** | | | | | | | | | | | | | | | |
| Lane 1 | 263 | 4.0 | 263 | 4.0 | 508 | 0.519 | 100 | 15.2 | LOS B | 3.9 | 29.2 | Full | 500 | 0.0 | 0.0 |
| Lane 2 [d] | 318 | 4.0 | 318 | 4.0 | 612 | 0.519 | 100 | 9.8 | LOS A | 4.2 | 31.7 | Full | 500 | 0.0 | 0.0 |
| Approach | 581 | 4.0 | 581 | 4.0 | | 0.519 | | 12.3 | LOS B | 4.2 | 31.7 | | | | |
| All Vehicles | 3528 | 5.1 | 3528 | 5.1 | | 0.998 | | 19.6 | LOS B | 41.3 | 309.1 | | | | |

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Lane LOS values are based on average delay per lane.
Intersection and Approach LOS values are based on average delay for all lanes.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

d Dominant lane on roundabout approach

**Approach Lane Flows (veh/h)**

**SouthEast: SW Marine Drive**

| Mov. From SE To Exit: | T1 NW | R2 NE | Total | %HV | Cap. veh/h | Deg. Satn v/c | Lane Util. % | Prob. SL Ov. % | Ov. Lane No. |
|---|---|---|---|---|---|---|---|---|---|
| Lane 1 | 737 | - | 737 | 4.0 | 1202 | 0.613 | 100 | NA | NA |
| Lane 2 | - | 1105 | 1105 | 6.0 | 1459 | 0.758 | 100 | NA | NA |
| Approach | 737 | 1105 | 1842 | 5.2 | | 0.758 | | | |

**NorthEast: W 16th Ave**

| Mov. From NE To Exit: | L2 SE | R2 NW | Total | %HV | Cap. veh/h | Deg. Satn v/c | Lane Util. % | Prob. SL Ov. % | Ov. Lane No. |
|---|---|---|---|---|---|---|---|---|---|
| Lane 1 | 867 | - | 867 | 4.1 | 868 | 0.998 | 100 | NA | NA |
| Lane 2 | 18 | 221 | 239 | 11.1 | 594 | 0.402 | 100 | NA | NA |
| Approach | 884 | 221 | 1105 | 5.6 | | 0.998 | | | |

| NorthWest: SW Marine Drive | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Mov. From NW To Exit: | L2 NE | T1 SE | Total | %HV | Cap. veh/h | Deg. Satn v/c | Lane Util. % | Prob. SL Ov. % | Ov. Lane No. |
| Lane 1 | 174 | 89 | 263 | 4.0 | 508 | 0.519 | 100 | NA | NA |
| Lane 2 | - | 318 | 318 | 4.0 | 612 | 0.519 | 100 | NA | NA |
| Approach | 174 | 407 | 581 | 4.0 | | 0.519 | | | |

| | Total | %HV | Deg.Satn (v/c) |
|---|---|---|---|
| All Vehicles | 3528 | 5.1 | 0.998 |

Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

## Merge Analysis

| | Exit Lane Number | Short Lane Length m | Percent Opng in Lane % | Opposing Flow Rate veh/h pcu/h | Critical Gap sec | Follow-up Headway sec | Lane Flow Rate veh/h | Capacity veh/h | Deg. Satn v/c | Min. Delay sec | Merge Delay sec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| There are no Exit Short Lanes for Merge Analysis at this Site. | | | | | | | | | | | |

## Variable Demand Analysis

| | Initial Queued Demand veh | Residual Queued Demand veh | Time for Residual Demand to Clear sec | Duration of Oversatn sec |
|---|---|---|---|---|
| SouthEast: SW Marine Drive | | | | |
| Lane 1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Lane 2 | 0.0 | 0.0 | 0.0 | 0.0 |
| NorthEast: W 16th Ave | | | | |
| Lane 1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Lane 2 | 0.0 | 0.0 | 0.0 | 0.0 |
| NorthWest: SW Marine Drive | | | | |
| Lane 1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Lane 2 | 0.0 | 0.0 | 0.0 | 0.0 |

# Appendix F: Risk Analysis

## Appendix F: Risk Analysis

| Hazard Number | Hazard Category | Identified Hazard | Description of Hazard | Associated Risk (consequence) | Likelihood | Severity | Current Level of Risk | Type of Risk Response | Description of Risk Response | Likelihood | Severity | New Level of Risk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Existing | Pedestrian-cyclist-vehicle conflict | Pedestrians, cyclists and vehicles failing to follow signage and road right-of-ways | Collisions leading to fatal injuries | 3 | 5 | 15 | Mitigation | Redesigning the intersection | 1 | 5 | 5 |
| 2 | Installation | Excavation | Loose debris and accidents related to excavation work and construction machinery | Fatal injuries to workers, environment, and community | 2 | 5 | 10 | Mitigation | - Follow proper construction plans and wear applicable PPE<br>- Create applicable signage to deter community from interference | 2 | 3 | 6 |
| 3 | Installation | Pedestrian-cyclist-vehicle conflict | Pedestrians, cyclists and vehicles failing to follow construction detouring and road right-of-ways | Collisions leading to fatal injuries | 4 | 5 | 20 | Mitigation | - Follow proper construction plans and wear applicable PPE<br>- Create applicable signage to deter community from interference | 2 | 3 | 6 |
| 4 | Installation | Material Handling | Misuse or misplacement of raw materials | Fatal injuries to workers and community. Pollution to local environment | 2 | 4 | 8 | Mitigation | - Follow proper construction plans and wear applicable PPE<br>- Create applicable signage to deter community from interference | 2 | 3 | 6 |
| 5 | Installation | Utlity Conflicts | Construction process conflicting with nearby utilities | Damage to underground utility lines during activity | 3 | 3 | 9 | Elimination | - Identify all nearby utility lines<br>- Follow proper construction plans to avoid confliction | 1 | 3 | 3 |
| 6 | Installation | Traffic Hazards | Lane closures leading to increased traffic congestion | Disruption of traffic leading to increased likelihood of collisions | 5 | 3 | 15 | Mitigation | - Create traffic management plan to direct all traffic<br>- Signage and reduced speed limits | 2 | 3 | 6 |
| 7 | Operation/Maintenance | Pedestrian-cyclist-vehicle conflict | Pedestrians, cyclists and vehicles failing to follow signage and road right-of-ways | Collisions leading to fatal injuries | 2 | 5 | 10 | Mitigation | - Ensure new signage and road alignment is visible<br>- Ensure proper installation of all new intersection components | 1 | 5 | 5 |
| 8 | Operation/Maintenance | Stormwater detention maintenance | Overflowing of stormwater detention tank | Destruction of nearby environment and disruption to traffic | 3 | 3 | 9 | Elimination | - Have routine maintenace plans and access to monitor stormwater detention tank volumes and operation | 1 | 3 | 3 |
| 9 | Operation/Maintenance | Road and landscape maintenance | Excessive growth and damage on the roadway and landscape around the intersection | Collisions and accidents leading to major injuries or further destruction of roadways | 3 | 3 | 9 | Mitgation | - Have routine maintenace plans to manage roadways and surrounding landscape | 1 | 3 | 3 |

# Appendix G: Traffic Management Plans


N
C-018-1A
C-130-Ta
C-130-R
C-132
C-053
WORK ACTIVITY AREA
C-130-L
C-030-14
LEFT TWO LANES CLOSED

# STAGE 1 TMP


# STAGE 2 TMP

OUT OF SCOPE -
FURTHER TRAFFIC
MANAGEMENT NEEDED
N
WORK
ACTIVITY
AREA
C-053
C-132
C-130-R
C-130-R
X00 m
C-130-Ta


# STAGE 3 TMP

N
WORK ACTIVITY AREA
OUT OF SCOPE - FURTHER TRAFFIC MANAGEMENT NEEDED
C-132
C-053
C-130-L
C-130-R


# STAGE 4 TMP

# Appendix H: Construction Specifications

## Lighting Specifications

1. Recommended design values for roundabout lighting to follow requirements outlined by IESNA DG-19 as per MOTI Electrical and Traffic Engineering Manual Section 304.3.4.1.
2. Recommended design values for crosswalk lighting to follow requirements outlined by IESNA RP-8 as per MOTI Electrical and Traffic Engineering Manual Section 304.3.2.1.
3. Recommended lighting design values for continuous roadway lighting to follow requirements outlined by IESNA RP-8 as per MOTI Electrical and Traffic Engineering Manual Section 304.3.1.1.
4. Recommended lighting design values for pedestrian walkways and bikeways to follow requirements outlined by IESNA DG-19 as per MOTI Electrical and Traffic Engineering Manual Section 304.3.6.1.
5. LED lighting to be used at all new lighting installations. Refer to Section 504 of the MOTI Electrical and Signing Material Standards for the materials specification for LED roadway luminaires.
6. Due to the rapid evolution of LED lighting, material suppliers and equipment specifications may change at any time. The designer shall reference the most current version of the ministry's Recognized Products List and Procurement Services Corporate Supply Arrangement to ensure that the latest equipment is used for new designs.

## Environmental Specifications

Compliance to the following sections in the BC MoTI 2020 Standard Specifications for Highway Construction shall apply for Environmental Specifications. Refer to *Section 145 - General Requirements for Highway, Bridge and Marine Construction* and *Section 165 - Protection of the Environment* for detailed construction specifications.

1. **145.28.06 Protection and Restoration of Property and Environment** - The Contractor shall not enter upon private property for any purpose without first obtaining permission of the owner of that property and shall be responsible for the preservation of public property along and adjacent to the Work, and shall use every reasonable precaution necessary to prevent damage or injury thereto.
2. **165.02 Environmental Monitor** - The Contractor shall retain the services of an Environmental Monitor. The Environmental Monitor shall be suitably experienced in, and responsible for:
   - The preparation and implementation of environmental protection plans, including the CEMP;
   - Preparing environmental monitoring reports;
   - proactive sediment and erosion control; and
   - sampling, analysis and monitoring of water quality.
3. **165.02.01 Planning and Scheduling** - The Contractor shall carefully plan and schedule construction activities in a manner that ensures the avoidance or absolute minimization of environmental damage. The Contractor shall be familiar with and be able to identify those areas and times which present environmental problems and shall prepare schedules and work methods accordingly.
4. **165.02.02 Construction Environmental Management Plan** - The Contractor shall provide to the Ministry a Construction Environmental Management Plan (CEMP), prepared and/or signed and accepted by an Appropriately Qualified Professional.
5. **165.03.03 Temporary Pollution Control** - The Contractor shall be responsible for implementation of any temporary environmental protection measures, such as pollution control measures.
6. **165.03.04 Responsibility for Damage to Environment** - The Contractor shall bear sole responsibility for any direct or indirect damage to the environment which occurs as a result of failure to comply with environmental legislation, Environmental Approvals, these Specifications, the Special Provisions, and/or the directions of the Ministry Representative or recommendations of the Environmental Monitor.
7. **165.04 Erosion, Sediment, and Drainage Control** - All works shall be undertaken in a manner that avoids or absolutely minimizes erosion problems and the discharge of siltation or other deleterious substances into any Watercourse.
8. **165.04.01 Erosion and Sediment Control Plan (ESCP)** - The Contractor is responsible for preparing and implementing an ESCP for the project in accordance with the methodology of the "National Guide to Erosion and Sediment Control on Roadway Projects", Transportation Association of Canada 2005.
9. **165.04.03 Sediment Control Ponds** - The Contractor shall construct sediment control ponds where necessary to prevent the release of unavoidably entrained sediments in runoff from the construction site, and shall construct stormwater detention ponds for the temporary and/or permanent control and discharge of stormwater runoff.
10. **165.04.04 Maintenance of Drainage Patterns** - Except where interceptor ditches or berms are required to divert sediment laden runoff from the site to a sediment control pond or filtration area, original drainage patterns shall be maintained throughout construction operations.

11. **165.04.05 Storm Drainage Systems** - In order to minimize siltation, the Contractor may be required to block storm drain inlets, or to activate inlets by means of sandbags, berms or swales, as circumstances require, or at the direction of the Ministry Representative. Berms shall be constructed of clean, non-erodible granular material.
12. **165.05 Clearing and Grubbing Plan (CGP)** - The Contractor shall obtain acceptance for this plan from the Ministry Representative. The Contractor shall also obtain any necessary tree removal permits from the Ministry of Forests, Lands and Natural Resource Operations prior to initiating any clearing
13. **165.05.01 Limits for Clearing and Grubbing** - Clearing and/or grubbing shall extend only to the Designated limits, as defined in the Contract Drawings and marked on site. Prior to clearing or grubbing, marked limits will be inspected by the Ministry Representative, who may amend them.
14. **165.05.02 Protection of Vegetation** - The Contractor shall protect all vegetation growing outside of the Designated and marked areas for clearing and grubbing, as specified in SS 769 "Protection and Retention of Vegetation", with the exception of danger trees, which must be hand-felled and removed with minimum disturbance to retained vegetation.
15. **165.05.03 Clearing Activities** - Any trees or large pieces of woody debris that accidentally fall into a Watercourse and require removal shall be removed in a manner that minimizes the disturbance of the Watercourse and adjacent banks, and is approved by the Ministry Representative.
16. **165.06.01 Exposure of Erodible Earth** - In areas where erosion or siltation is anticipated, the duration of exposure of erodible earth material shall be minimized.
17. **165.06.02 Placement of Stripped Material** - The Contractor shall avoid placement of stripped materials on lands within the Agricultural Land Reserve and in areas adjacent to Watercourses or other Environmentally Sensitive Areas. Erosion and sediment control measures must be taken prior to and after placement of stockpiles of stripped material in areas where natural drainage or storm water could erode the stockpile and thereby transport pollutants to surface waters.
18. **165.07.01 Excavation and Disposal of Waste or Surplus Material** - The creation and use of any site on Crown or private lands for the placement and disposal of waste or surplus material requires prior approval from the Ministry Representative and may require the approval of the Agricultural Land Commission or representatives of other provincial Environmental Agencies.
19. **165.08 Borrow and Sand / Gravel Pits** - All Borrow and Sand/Gravel pit locations, operations, reclamation and revegetation shall comply with the Ministry of Energy and Mines / the Ministry of Transportation and Infrastructure / Natural Resources Canada joint publication "Reclamation and Environmental Protection Handbook for Sand, Gravel and Quarry Operations in British Columbia".
20. **165.08.01 Control of Drainage** - Prior to borrow excavation, or quarry, sand or gravel pit development, the Contractor shall prepare an Erosion and Sediment Control Plan (see SS 165.04.01) prior to the creation and/or operation of any borrow excavations or quarry, sand or gravel pit development sites. The Contractor shall also prepare a Reclamation Plan.
21. **165.08.02 Location and Development of Borrow and Sand/Gravel Pits** - Clearing for borrow and sand/gravel pits shall comply with SS 165.05 – Clearing and Grubbing. All organic strippings topsoil shall be stockpiled for future reclamation.
22. **165.09.01 Design, Construction and Operation of Access Roads** - Any temporary access, detour and/or haul roads, including associated lay-down or staging areas, associated with the project shall be constructed to accommodate all required uses and maintained throughout the course of construction.
23. **165.09.02 Drainage and Erosion Control** - Drainage structures shall be incorporated into and maintained for the duration of the project along all detour, access and haul roads to minimize erosion and maintain drainage patterns.
24. **165.10.02 Management of Water Discharges** - During preparation of stream diversions, culvert installations and other operations involving dewatering where drainage could readily reach a Designated Watercourse, all effluent and silt-laden water shall be discharged to a sediment control pond or a vegetated area acceptable to the Ministry Representative and the Environmental Monitor for removal of silt prior to its release into that Watercourse.
25. **165.10.06 Culvert Installations** - Unless otherwise approved by the Ministry Representative, culvert installation in Watercourses shall involve an appropriate method of isolating the work site from the stream, such as the diversion of the stream around the culvert site, and the placement of the culvert in the "dry".
26. **165.11 Ditch Maintenance** - To reduce the risk of damage to aquatic habitat and sensitive life stages of fish and other aquatic organisms, the Contractor shall ensure that the excavation and maintenance of ditches is conducted in an environmentally sound manner.
27. **165.13.01 Transport of Materials** - The Contractor shall use equipment and containers that are capable of safely transporting petroleum products and/or hazardous materials in compliance with Section 7.33.1 of the Federal "Transport of Dangerous Goods Regulations" for bulk containers, and Sections 7.21 and 7.23 of the same regulations for materials in packages or small containers.

28. **165.13.04 Equipment Operation in Environmentally Sensitive Areas** - Construction equipment shall be operated only within the Designated construction site and access roads. Equipment operators shall not be allowed to damage or destroy vegetation or streambanks outside of this area.
29. **165.16.01 Noise and Emissions** - All activities, equipment, processes and work operated or performed by the Contractor in accomplishing the specified construction shall be in strict accordance with Federal, Provincial and local regulations governing noise levels and air emission standards.
30. **165.16.03 Dust Control** - Application and handling of the any dust palliative, with the exception of water, shall be in compliance with the Ministry documents as given in "Dust Management Environmental Best Practice for Highway Maintenance Activities" and "Maintenance Guidelines for Dust Palliatives and Gravel Road Stabilization".
31. **165.18.02 Decommissioning of Sites** - Upon completion of construction, all temporary support facilities and camp infrastructure, including buildings, equipment, lumber, refuse, surplus materials, fencing and other such items shall be removed.
32. **165.19.01 Protection of Livestock and Wildlife** - Harassment of livestock or wildlife in and adjacent to the project site is prohibited. The presence of livestock or wildlife in or adjacent to the project site, field office trailers or construction camp shall not be encouraged by feeding.
33. **165.20 Archaeological and Paleontological Discoveries** - In the event that any item of archaeological, heritage, historical, cultural or scientific interest is found on the project site, the Chance Find Procedure in this section shall apply.

## **Roadworks Specifications**

Geometrics

1. Implement smooth vertical and horizontal curves to shape changes in grade and direction
2. Execute earthworks according to the contract documents, which involve tasks such as removing loose or detrimental materials, addressing soft spots, compacting, and grading slopes.
3. Construct embankments in accordance with the standards and specifications outlined in the contract documents, ensuring proper placement, shaping, compaction, and protection.
4. In instances where existing ditches need infilling or services are established in fill sections, utilize granular material for filling, ensuring it is supplied, placed, and compacted in accordance with MMCD specifications.
5. Adhere to MMCD specifications for all sub-base road and granular base materials. Refer to earthworks specifications for details.
6. Extend the road sub-base and base a minimum of 0.3 meters beyond the road edge or curb and gutter.
7. Connect to existing pavement by cutting back to sound material as required to create a tidy vertical face.
8. Ensure that all new pavement is graded to prevent ponding, with a minimum cross slope of 2% on any new or overlain road surface.
9. Adjuse all valve boxes, manholes, etc., within the paved surface of the roadway to the finished course elevation before applying the finish course paving.
10. Concrete barrier curbs must adhere to the MOTI standard drawing SP582-01.04 and combined curb and gutters must adhere to the MOTI standard drawing SP582-01.01. Mountable concrete curb and gutter must adhere to the MOTI standard drawing SP582-01.02.

Asphalt

11. Ensure compliance with the specifications outlined in the MMCD specifications and detail drawings when placing asphalt pavement and concrete.
12. Unless approved otherwise, asphaltic concrete for road work must be applied in two lifts.
13. Asphalt mix must be in compliance with Section 952 of the 2020 Standard Specification for Highway Construction Volume 1.
14. Quality control, inspection, and testing of asphalt pavement must be conducted and recorded according to Section 952.02 of the 2020 Standard Specification for Highway Construction Volume 1.
15. Sourced aggregates for paving must be compliant with Section 502.06.05 of the 2020 Standard Specification for Highway Construction Volume 1.
16. Asphalt mixes are the responsibility of the contractor to design and cost as outlined in Section 502.08 of the 2020 Standard Specification for Highway Construction Volume 1.
17. Construction practices must comply with the specifications outlined in Section 502.20 through Section 502.27.08 of the 2020 Standard Specification for Highway Construction Volume 1.

18. All surface treatments must comply with Section 531 of the 2020 Standard Specification for Highway Construction Volume 1.

## Site Earthworks and Engineered Fill Specifications

### Earthworks

All site earthworks recommendations should be complemented by reference to SS 2020 202. Any deleterious or contaminated filling should be stripped and disposed of in accordance with the recommendation provided in our environmental report. The exposed subgrade should be proof rolled, any existing uncontrolled filling and rubble be removed and replaced with engineered fill as specified below. Engineered fill is to be used to backfill batters and to raise the site level where required.

Where clays are exposed at subgrade level, they will undergo substantial loss in strength when wet and may even become untraversable. Therefore, it is important to provide good and effective drainage during construction. The principal aim of the drainage is to promote run-off towards designated sumps by cross-falls and to reduce ponding.

Following the stripping and completion of the proposed excavations, it is recommended that the soil subgrade be proof rolled and inspected by an experienced geotechnical engineer.

Subgrade heaving may occur during proof rolling in areas where the clays may have become "saturated". Heaving areas should be locally removed to a "stiff" base and replaced with engineered fill as defined below. Depending on the extent and depth of the heaving areas, it may be necessary to provide a bridging layer. If the insitu clays exhibit shrinkage cracking, then the surface should be watered and rolled until the shrinkage cracks are no longer evident. **Engineered fill** should also be used where it is proposed to raise the levels.

### Engineered Fill

Engineered fill should comprise well-graded granular material (sands, ripped or crushed sandstone), free of deleterious substances and having a maximum particle size of 50 mm. Excavated sands from the site may be reused as fill provided that any unsuitable material (organic clays) and any building rubble or deleterious material is excluded. The engineered fill, and any excavation backfill where subgrade support is required, should be compacted in layers of not greater than 300 mm loose thickness, to a density ratio of 98% of Standard Maximum Dry Density (SMDD) or to a minimum of 95% Density Index.

Density tests should be regularly carried out on the fill in accordance of SS 2020 204.04.02 standard to confirm the above specifications are achieved. The frequency of density testing should be at least one test per layer per 1000 $m^2$.

## Reinforced Cast-In-Place Concrete Specifications

The Work shall consist of:

- Supplying of materials and the mixing and placing of reinforced cast-in-place concrete as shown and described on the Drawings and in this Specification, including placing, vibrating, finishing and curing;
- Supplying, fabricating, constructing, maintaining and removing temporary works, including falsework and formwork;
- Heating and cooling concrete, if necessary;
- Developing concrete mix design(s) that meets the performance requirements, including trial batches;
- The quality control (QC) testing of all materials; and
- Supplying and installing water seals and joint fillers (when applicable).

Concrete supplied under this Specification will be specified in accordance with CSA A23.3:19

1. All concrete plant, equipment, and truck mixers comply with the requirements of CSA A23.3:19 and this Specification;
2. All materials to be used in the concrete comply with the requirements of CSA A23.3:19 and this Specification;
3. All the concrete mix design(s) satisfy the requirements of CSA A23.3:19 and this Specification;
4. Production and delivery of concrete will meet the requirements of CSA A23.3:19 and this Specification;

Contractor's Performance Criteria

The submission shall include the Contractor's performance criteria for each mix design including:

- Placeability (i.e. pumping, buggies, truck chute, etc.)
- Workability
- Proposed slump and slump retention time
- Set time

**References and Related Specifications**

All reference standards and related specifications shall be current issue or the latest revision at the date of tender advertisement.

References

- ASTM D 75, Standard Practice for Sampling Aggregates
- ASTM D 516, Standard Test Method for Sulfate Ion in Water
- ASTM C 494, Standard Specification for Chemical Admixtures for Concrete

**Materials**

**1. Fine Aggregate**
Fine aggregate shall meet the grading requirements of C CSA A23.3:19, be graded uniformly and not more than 3% and shall pass a 75 um sieve.

**2. Coarse Aggregate**
The maximum nominal size of coarse aggregate shall be 20 mm and meet the grading requirements of CSA A23.3:19. Coarse aggregate shall be uniformly graded and not more than 1% shall pass a 75 um sieve.

**3. Cementitious Materials**
Cementitious materials shall conform to the requirements of CSA A23.3:19 and shall be free from lumps. Normal portland cement, Type GU or GUb, or sulphate resistant, Type HS or HSb, shall be supplied unless otherwise specified on the Drawings.

**4. Water**
Water to be used for mixing and curing concrete or grout and saturating the substrate shall be potable, shall conform to the requirements of CSA A23.3:19 and shall be free of oil, alkali, acidic, organic materials or deleterious substances.

**5. Formwork**
Forms for exposed surfaces shall be made of good quality plywood in "like-new" condition and uniform in thickness, with or without a form liner.

**Construction Method**

**1. Mixing Concrete**

All concrete shall be mixed thoroughly until it is uniform in appearance, with all ingredients uniformly distributed. In no case shall the mixing time per batch be less than one minute for mixers of one cubic metre capacity or less. The "batch" is considered as the quantity of concrete inside the mixer. This figure shall be increased by 15 seconds for each additional half cubic metre capacity or part thereof. The mixing period shall be measured from the time all materials are in the mixer drum.

**2. Time of Hauling**

The maximum time allowed for all types of concrete to be delivered to the site of the Work, including the time required to discharge, shall not exceed 90 minutes after batching. Batching of all types of concrete is considered to occur when any of the mix ingredients are introduced into the mixer, regardless of whether or not the mixer is revolving. For concrete that includes silica fume, this requirement is reduced to 60 minutes.

**3. Falsework and Formwork**

The design, fabrication, erection, and use of concrete formwork shall conform to the requirements of CSA A23.3:19. All forms shall be oiled or otherwise treated to facilitate stripping. For narrow walls and columns, where the bottom of the form is inaccessible, or wherever necessary, removable panels shall be provided in the bottom form panel to enable cleaning out of extraneous material immediately before placing the concrete. Falsework shall conform to CSA A23.3:19, Falsework for Construction Purposes. All falseworks shall be designed and constructed to provide the necessary rigidity and to support the loads without appreciable settlement or deformation.

**4. Pumping of Concrete**

When the Contractor chooses to pump the concrete, the operation of the pump shall produce a continuous flow of concrete without air pockets. The equipment shall be arranged such that vibration is not transmitted to the freshly placed concrete that may damage the concrete. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients.

**Cold Weather Precautions**

**1. General**

When the ambient temperature falls below 5°C or when there is a probability of it falling below 5°C within 24 hours of placing the concrete, the Contractor shall make provisions for heating the water, aggregates and freshly deposited concrete.

**2. Aggregates**

Aggregates shall be heated to a temperature of not more than 65°C. For concrete containing silica fume, the aggregate shall not be heated to more than 40°C. The heating apparatus and the housing for the aggregates shall be sufficient to heat the aggregates uniformly without the possibility of the occurrence of hot spots which may burn the materials.

**3. Water**

The water shall be heated to a temperature of not more than 65°C. For concrete containing silica fume, the water shall not be heated to more than 40°C.

**4. Concrete**

The temperature of the mixed concrete shall not be less than 15°C and not more than 25°C at the time of placing in the forms. Temperature requirements for concrete containing silica fume shall be between 10°C and 18°C at the time of placing in the forms. Sufficient stand-by heating equipment must be available to allow for any sudden drop in outside temperatures and any breakdowns that may occur in the equipment.

**5. Curing Requirements**

Water curing of concrete shall be terminated at least 12 hours before the end of the protection period during periods of freezing weather.

The curing compound shall be water based membrane forming and of a type approved by the Engineer. It shall conform to the requirements of ASTM C-309 and be applied as directed by the Manufacturer. The rate of each application shall not be less than the rate specified by the Manufacturer of the compound. If rain falls on the newly coated concrete before the film has dried sufficiently to resist damage, or if the film is damaged in any other manner during the curing period, a new coat of solution shall be applied to the affected portions equal in curing value to that specified above.

All superstructure concrete with a specified exposure class of C-XL or C-1 shall be wet cured for a minimum period of 7 days at a minimum temperature of 15°C and for the time necessary to attain 50% of the specified compressive strength.

**6. Quality Control**

Sampling of concrete shall be carried out in accordance with CSA A23.3:19. When a concrete pump is used to place concrete, sampling shall be at the end of the discharge hose. Making and curing concrete test cylinders shall be carried out in accordance with CSA A23.3:19, except that the time for cylinders to reach the testing laboratory shall be between 20 and 48 hours. The test cylinders shall be cast by the Contractor in standard CSA approved moulds.

**7. Open to Traffic**

The structure shall not be opened to traffic until the concrete has attained a minimum compression strength of 100% of the design strength. The Contractor shall be responsible for all costs associated with any additional testing that may be required to satisfy the strength requirement.

## Storm Sewer Specifications

Section 318 - PVC PLASTIC DRAINAGE PIPE

1. 318.03 Materials – The pipe shall be made of PVC plastic having a cell classification of 12454, or 12364, as defined in ASTM D1784. The fittings shall be made of PVC plastic and shall have a cell classification of 12454, or 13343, as defined in ASTM D1784. Elastomeric gaskets shall comply with the requirements of ASTM F477.
2. 318.04 Quality of Work – The pipe shall be homogenous throughout and free from visible cracks, flaws, foreign inclusion, or other injurious defects. The pipe shall be uniform in colour, opacity and other physical properties.
3. 318.06.01 Length – Laying length shall be 4 m or 6 m for all diameters unless otherwise specified by the Purchase Order, Work Order or Drawings. A tolerance of 25 mm on the nominal laying length will be permitted.
4. 318.08.02 Pipe Stiffness – The minimum pipe stiffness when tested in accordance with SS 318.10.02 and ASTM D2412 shall be 320 kPa.
5. 318.08.03 Pipe Flattening – There shall be no evidence of splitting, cracking or breaking when the pipe is tested in accordance with SS 318.10.03.
6. 318.09 Marking – All pipe shall be clearly marked at intervals of no more than 1.5 m with 5 mm or larger letters with the following information:
   • Manufacturer's name or trademark
   • Nominal diameter
   • Material designation and cell class: PVC-12454 or 12364
   • The word "Drainage" or similar
   • The class: PS320
   • The applicable specification designation (ASTM D3034 or ASTM F794)
   • Date of manufacture and plant designation

The marking on perforated pipe shall be 180º from a point equidistant between the bottom row of holes as shown in Table 318-C of the MOTI 2020 Standard Specifications for Highway Construction Volume 1.

7. 318.10.02 Pipe Stiffness – The pipe stiffness shall be determined at 5% deflection of the initial inside diameter in accordance with ASTM D2412. Three specimens, each with a length equal to one pipe diameter shall be tested; all shall meet the required stiffness. Perforated samples shall be positioned as shown in Figure 1 of the MOTI 2020 Standard Specifications for Highway Construction Volume 1.

Section 582 - CONCRETE CURB AND GUTTER AND STORM DRAINAGE

8. 582.11 Drain Pipe – All drain pipe shall be of first quality, sound, true in form and free from defects of all kinds.
9. 582.12 Manufacture of Precast Concrete Storm Drainage Products – For all contracts awarded after December 31, 2021, all concrete pipe, box culverts, manholes, catch basins, precast concrete endwalls and associated precast concrete products shall be supplied from a manufacturer that is certified by an independent third party certification agency to produce these products according to applicable CSA and ASTM manufacturing standards.

10. 582.12.01 Certified Manufacturer – For all contracts awarded after December 31, 2021, the manufacturer shall be certified under at least one for the following quality assurance programs: (a) The Canadian Precast Concrete Quality Assurance (CPCQA) Certification Program. (b) The CSA Group Testing & Certification Inc. (CSA) Certification Program (c) QCAST Certification Program by the American Concrete Pipe Association for Precast Products. (d) National Precast Concrete Association (NPCA) Plant Certification. (e) Other certification organizations acceptable to the Ministry Representative that are accredited by the Standards Council of Canada for the certification of manufacturers for these products.
11. 582.12.01 Product Markings – All products shall be marked with the certification body's logo confirming that the production of the product is in accordance with the quality and requirements of the specified standards for the products.
12. 582.15.03 Covers and Frames – Catch basin and manhole covers and frames shall be cast iron and meet the requirements of ASTM A48. Catch basin and manhole covers and frames shall be designed for highway loading in accordance with either of the following: (a) AASHTO M 306 using the H-20 or HS-20 proof load testing with the proof load of 178 kN; or (b) The design live load in accordance with the Ministry Supplement to the CHBDC S6, including the dynamic impact allowance, with the wheel load application distributed over an area of 250 mm x 250 mm.
13. 582.32 Catch Basins – Catch basins shall be constructed, where shown and as required in the Drawings or as the Ministry Representative may direct, in accordance with the intent of SS Drawings SP582-02.01 through SP582-02.05 of the MOTI 2020 Standard Specifications for Highway Construction Volume 1.
14. 582.33 Manholes – Manholes shall be constructed at the locations and to invert levels shown in Drawings or as the Ministry Representative may direct in accordance with the intent of SS Drawings SP582-03.01 through SP582-03.08 of the MOTI 2020 Standard Specifications for Highway Construction Volume 1.
15. 582.34 Storm Drains – Storm drains shall be constructed where shown on Drawings, or as directed by the Ministry Representative, and in accordance with the Drawings and specifications covering the various types and as attached herewith. The trench and other preparatory work shall be approved by the Ministry Representative before actual placing starts.
16. 582.35.04 General – Pipes shall be accurately set and laid to even gradients, concentric and in straight lines between manholes.

## Concrete Reinforcement Specifications

Compliance to the following sections in the BC MoTI 2020 Standard Specifications for Highway Construction shall apply for Concrete Reinforcement Specifications. Refer to *Section 412 - Concrete Reinforcement* for detailed construction specifications.

1. **412.11.03 Galvanized Reinforcing Steel** - Hot dipped galvanized reinforcing bars shall conform to the requirements of ASTM A767M – Class II Coating. Only CSA G30.18 Grade W bars shall be galvanized. All bent bars shall be heat treated for stress relief prior to galvanizing. Stress relief shall be at a temperature from 480°C to 560°C for 1 hour per 25 mm of bar diameter as per ASTM A-767M. Galvanized reinforcing bars shall not be placed in contact with uncoated reinforcing bars. Wire ties for galvanized reinforcing steel shall be zinc coated or stainless steel.
2. **412.31 Bending** – Reinforcement bars shall be cut and bent to the shapes shown on the Drawings. Bending shall be sufficiently accurate that the placing tolerances (specified in SS 412.33.01) can be met. All bars shall be bent cold, unless otherwise permitted. Bars partially embedded in concrete shall not be field bent except as shown on the Drawings or where specifically permitted. Field bending of galvanized steel reinforcing bar and fibre reinforced polymer reinforcing bar is not allowed. Field bending of stainless steel reinforcing bar is only allowed upon prior written approval from the Ministry's Representative. Stainless steel reinforcement shall only be bent using equipment specifically designed for that purpose.
3. **412.31.01 Hooks and Bend Dimensions** – Unless otherwise shown on the Drawings, hooks shall have the following dimensions
   - 180° bend plus extension of at least 4 bar diameters, but not less than 60 mm.
   - 90° bend plus extension of at least 12 bar diameters.
   - for stirrups and ties only, either a 90° or a 135° bend plus extension of at least 6 bar diameters at the free end of the bar.
   - Minimum inside diameters of bends shall be as shown in Table 412-C. For stainless steel reinforcing bars #8 and smaller, the minimum bend diameters shall be six times the bar diameter. Minimum bend diameters for #9 through #12 stainless steel reinforcing shall be eight times the bar diameter. Minimum bend diameters for #13 and larger stainless steel reinforcing shall be ten times the bar diameter.

Exceptions:

- Minimum inside diameters of bends and 90º and 135º hooks for stirrups and ties shall be 4 bar diameters for uncoated and stainless steel bars and 8 bar diameters for epoxy-coated bars.

- Minimum inside diameters of bends in welded wire fabric, plain or deformed, for stirrups and ties shall not be less than 4 wire diameters for deformed wire larger than 7 mm and two wire diameters for all other wires, except that bends with an inside diameter of less than 8 wire diameters shall be not less than 4 wire diameters from the nearest welded intersection

Note: Galvanized reinforcing bars shall be pre-bent before galvanizing.

4. **412.32 Handling and Storage –** Reinforcing bars shall be stored on platforms, skids or other suitable supports clear of the ground and shall be protected as practicable from mechanical injury and surface deterioration caused by exposure to conditions producing rust. When placed in the Work, reinforcement shall be free from dirt, loose rust or scale, mortar, paint, grease, oil, or other materials that would reduce bond.
5. **412.33 Placing and Fastening** – Before any concrete is placed, the placing and securing of reinforcing steel including dowels, within the area of concrete placement shall be complete. Tying in place of all dowels projecting from the area of concrete placement shall be subject to acceptance by the Ministry Representative before any concrete is placed. The reinforcing steel shall be free from dirt, detrimental rust, loose scale, paint, oil or other foreign material. Steel reinforcement - other than stainless steel reinforcing bars - with rust, mill scale, or a combination of both shall be acceptable, provided the minimum physical properties including height of deformations and mass of a wire brushed test specimen are not less than the applicable specification requirements.

Reinforcement shall be placed in the positions shown on the Drawings, within the tolerances specified below, adequately supported and secured against displacement. All splices of adjacent bars shall be securely tied together. Tying 100% of the bar intersections is required where the bar spacing centres are 300 mm or greater. Tying of 50% of the bar intersections is required when the bar spacing centres are less than 300 mm.

The locations of the top reinforcing steel in bridge decks shall be checked by running a full deck-width template along the longitudinal screeds. The lower edge of the template shall be set at the cover dimension (as specified or noted in the Drawings) plus any anticipated deflection of the screed rail support system below the level of the deck surface. No steel shall touch the template nor be more than 6 mm distant from it. Any discrepancies outside of these limits shall be corrected by the Contractor to the satisfaction of the Ministry Representative.

The location of reinforcing steel near deck joint anchors shall be adjusted so that there will be no interference with the deck joint anchors.

Tack welding of reinforcement for cage assembly or securing of reinforcement will be permitted only in the following circumstances:

(a) on bars provided by the Contractor that are additional to design requirements, except that no additional shear stirrups or tensile reinforcement bars will be permitted, as they may adversely affect structural performance.

(b) at the ends of bars where the Contractor provides additional length that is in excess of design requirements and this additional length is detailed on bar bend sheets or shop drawings, with notes indicating the purpose of the additional length. Such bar bend sheets or shop drawings shall have written acceptance by the Ministry Representative prior to welding taking place.

(c) with the written acceptance of the Ministry Representative, in which case, welding shall be in accordance with SS 412.34.02.

6. **412.33.01 Tolerances** – Tolerances for placing reinforcement shall, unless otherwise specified, be as shown in Table 412-D
7. **412.33.03 Concrete Cover** – Concrete cover for reinforcing steel shall be in accordance with the Ministry “Bridge Standards and Procedure Manual – Supplement to CHBDC S6”.
8. **412.34 Splicing of Bars** – Special requirements for splicing, such as particular locations for splices, use of overlength bars or special lap lengths, shall be as shown on the Drawings.

Splices in bars larger than 35M shall be mechanical coupler splices or welded. The detail of such splices shall be subject to acceptance by the Ministry Representative.

## Signage and Pavement Markings Specifications

**Signage**

All signage recommendations should be complemented by reference to Specifications for Standard Highway Sign Materials, Fabrication and Supply by the Ministry of Transportation and Infrastructure.

All signage must be retro-reflective to show the same colour, shape and message at night as they appear in daytime. Signage may be fabricated using sheet aluminum or extruded aluminum, conforming to the requirements of ASTM B209M and ASTM B221M.

The signs shall be clearly and permanently labeled (using durable, weather resistant material) or engraved with an identification coding. Sheeting material shall be correctly applied in accordance with the manufacturer's recommendations and accepted quality practice. The edges of all substrate material shall be deburred to provide a smooth finished edge. Sheeting material cannot contain air pockets and shall not have holes, tears, scrapes, compressed cells, or patches.

Preserve all currently installed signs, remove any surplus upon completion of the work, and return them to the Ministry. The Ministry is responsible for installing temporary and permanent street, traffic, and advisory signs not explicitly depicted on the drawings.

**Pavement Markings**

All pavement marking recommendations should be complemented by reference to Pavement Marking Service Agreement 2008 by the Ministry of Transportation and Infrastructure.

The Ministry is responsible for installing pavement markings not explicitly depicted on the drawings. The Ministry is also responsible for removing all existing conflicting pavement markings.

Must utilize extruded thermoplastics for all permanent pavement markings. Traffic paint and thermoplastic material must be in accordance with the Recognized Products List. White paint must conform to US Federal specification 595b White 17886 and yellow paint must conform to US Federal specification 595b Yellow 33538.