UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Stadium Neighbourhood Underground Parkades and Water Storage

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University of British Columbia

CIVL 446

Themes: Water, Climate, Land

April 8th, 2019

Executive Summary

Stormside Consulting Limited has prepared this report at the request of the University of British Columbia (UBC) as a solution to stormwater management and increasing parking capacities in the Stadium Neighbourhood. The detailed design is a mixed solution including a parkade to suit growing parking needs and a water detention facility to store stormwater runoff and gradually release it back into the stormwater mains to avoid environmental damages. The parkade has been designed under the National Building Code of Canada and Concrete Code to provide sufficient strength to support all stadium attendees and vehicles. The detention tank and drainage network have been designed to effectively store, manage, treat, and release stormwater.

Two key objectives of the project are to meet the communities' new parking demands and to hold the equivalent stormwater runoff from a 1-in-100 year storm. The design solution covers an area 110m by 110m, with a depth of 10m, all underneath the location of the new stadium. The structure is designed with two parking levels with a capacity of 700 parking stalls, including disability parking spaces and electric vehicle charging spaces. The water detention facility beneath the second parking level consists of 3 retention tanks holding a total volume of over 36,300 cubic meters. In addition to the detention tanks a natural dry pond is designed with an area covering 15,000m^2 at a depth of 1.5m. The design holds water in the detention facility until it is safe to release the treated water back into the city's sewer network via pumps directing flow to SW Marine Drive. Improving stormwater runoff quality is done through filtration systems with the use of outdoor bio swales. The underground parkade and detention facility have a total project cost of $18,486,000, with implementation planning and construction spanning 7 months beginning February 4th, 2019.

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1.0 Introduction

The Stadium Neighbourhood redevelopment project at the University of British Columbia (UBC) will increase commercial and living spaces that will require additional infrastructure upgrades to meet the demands of the growing community. Through the development of infrastructure projects, the regions impermeable areas will increase, raising concerns of environmental damages from excess storm water runoff. Stormwater modeling has identified the neighbourhood is susceptible to flooding as the current storm sewer mains are incapable of storing and transporting runoff in the event of a major storm. The main objective of this project is to design a mixed-use parkade and water detention facility to hold storm water runoff from a 1-in-100-year storm event in the southwest catchment area of UBC, while meeting the stadium capacity for parking spaces.

This report examines the detailed design of the parkade and stormwater detention reservoir. Key components of the project are evaluated based on their respective design criteria as per structural, technical, regulatory, communal, and environmental considerations. Construction specifications are incorporated through detailed drawings, work schedules, and a cost estimate. Independent contributions by members of the Stormside consulting team are illustrated in Table 1 below.

Table 1: Contributions from Each Member

Tasks	Tanvir	Brenna	Colin	Gabriel	Peggy	Nicole
Executive Summary	✓					
Table of Contents				✓		
Introduction	✓					
Project Overview	✓					
Pipe Network Design					✓	
Detention Tank Design					✓	
Stormwater Management Methods			✓	✓	✓	✓
Pump System Design			✓			
Parkade Structure Design	✓	✓		✓		✓
Standards and Modelling Software			✓		✓	✓
Traffic Flow						✓
Stakeholder Engagement						✓
Construction Schedule		✓				
Construction Workplans		✓				✓
Cost Estimate	✓	✓				
Service-Life Maintenance Plan				✓		
Conclusion	✓					
Detailed Designs	✓			✓	✓	
Formatting			✓	✓	✓	

2.0 Project Overview

2.1 Design Requirements to Address Key Issues

The design is required to meet the goals outlined in UBC's Integrated Stormwater Management Plan, as well as those determined by the client: the UBC SEEDS Sustainability Program. The parkade must have the capacity to meet the demand for stadium and commercial areas, while having entrance and exit locations easily accessible to minimize traffic flow disturbances on West 16th Avenue and East Mall. One of the main stormwater management requirements is to prevent further erosion of the nearby cliffs and minimize disruption to the surrounding habitat. It is also important to minimize flooding in the new neighborhood, roads, and nearby botanical garden. This can be achieved by ensuring that the storage tanks are able to hold the full volume of water from a 1-in-100 year storm event. This has been calculated using past data in the form of an EPA SWMM Model in relation to the catchment area determined in the project scope. The water captured in the storage tanks requires treatment to meet acceptable standards before being discharged off campus. The design must also have a focus on sustainability, and ideally incorporate natural stormwater solutions and potential water reuse. Finally, human safety should be held paramount, both in the usage and construction of the facility.

2.2 Regulatory Requirements

As this is a mixed-use project on UBC campus grounds, there are a number of regulations that must be followed. Stormwater management requirements fall under four different Acts; two from the BC Provincial government and two from Canada's federal government. These are the federal Fisheries Act and Canadian Environmental Protection Act, and the provincial Water Act and Environmental Management Act. They provide restrictions on water discharge quality for fish habitat protection and pollution prevention, water diversion, and waste management respectively. UBC has also committed to providing a water quality similar to that outlined in Metro Vancouver's Integrated Liquid Waste

Management and Resource Plan. The construction process should also adhere to Occupational Health and Safety Guidelines enforced by WorkSafe BC.

2.3 Stadium Neighbourhood

The project site is located within the Stadium Neighbourhood on the southwest corner of UBC's Point Grey Campus. The location of the site was selected through UBC's Land Use Plan which consists of detailed guides for future developments for each of UBC's six neighbourhoods. The plans are prepared by UBC's administration, receiving input from the community of students, residents, staff, stakeholders and partners. The guiding principles for this plan include building long-term value, creating a community, enhancing ecology, and environmental sustainability. The Stadium Neighbourhood redevelopment will consist of the new stadium, residential housing, and commercial spaces all within the boundaries outlined below in red, Figure 1.

Figure 1: Stadium Road Neighbourhood Redevelopment at UBC

2.4 Site Overview

The site for the parkade and detention tank is located on the corner of West 16th Avenue and East Mall enclosed in red in Figure 2. The entire Stadium Neighbourhood is 22 acres while the location of the parkade is approximately 2.5 acres. The new stadium and bleachers will be constructed on top of the parkade structure which will have three levels, the top two levels for parking and the bottom level serving as the detention tank for stormwater runoff. UBC's Botanical Gardens are adjacent to the site which will receive treated water leaving the detention tank for water reclamation efforts. Leading down West 16th Avenue to the West are the steep cliffs that currently direct overflowing stormwater to the ocean. Presently the site is occupied with vegetation which will be replanted to the West of the site. The site is on a mild slope allowing for the use of gravity-fed piping networks and catch basins. With UBC's campus built on Musqueam territory Indigenous stakeholder engagement will continue through public consultation, from the early design phases to the completion of construction.

Figure 2: Project Site Location

3.0 Design Summary

3.1 Pipe Network and Detention Tanks

3.1.1 Design Criteria

City of Vancouver Utilities Design & Construction Manual was used as a guideline for designing the drainage system. All gravity pipes will have a minimum grade of 2%, as per the manual. Pipes will have a minimum depth cover of 2m, higher than the 1.5m minimum, to ensure safety. The minimum vertical clearance between stormwater pipes and any utilities will be 0.5m. The detention tanks will be constructed of concrete under the parkade. See section 3.4.1 for structural design criteria.

3.1.2 Technical Considerations

Mains in the existing network will be upgraded if they do not have the capacity to handle 1-in-100 year storm events. Pipes were sized using the rational method for the catchment area. In order to control pipe flow, valves will need to be installed, so existing concrete pipe should be replaced with ductile iron. The inlet pipes will need to clear the parkade ramp while maintaining sufficient grade for a gravity system. They will need to be the same size as the storm main, as only one valve will be open until the tank 1 fills up, followed by tanks 2 and 3. Outlet pipes will use a smaller diameter, as they will part of a pressurized system. The pipes after the pump will require pressure reducing valves, bringing flow to the channel and to the 16th Avenue main.

The total capacity of the detention tanks was estimated using the rational method. This was done with 1-in-100 year storm intensity using Metro Vancouver's 2009 IDF curve, using the contour lines to find the approximate catchment area, calculating the time of concentration with the longest flow path, and approximating runoff coefficients. The storage tanks are primary means of stormwater management in this design and are located underneath the parking lot, which provide a convenient place to reduce the overall system's land use footprint.

3.1.3 Design Components

The upgraded pipe network will consist mainly of ductile iron (DI) pipe. The existing storm main on East Mall is a 300mm concrete pipe with flow heading SE. This will be replaced with 300mm DI, along which valves and wyes can be installed. Three 300mm DI pipes will be installed connecting the proposed East Mall main to the inlets of each of the detention tanks. The same pipe size was used as only one tank will be filled at a time, with valves closed for the other two. Gate valves will be installed on each inlet pipe at the wye and at the 45-degree elbow at the wall of the tank to control the flow.

Tank 3 will be filled first, followed by tank 2 and tank 1 during high intensity storm events. The tanks will each have two outlet connections, one to the outfall, via the W 16th Ave main, and one to the channel. All outlet pipes will be 200mm DI, as these pipes will be pressurized. For the channel system, one outlet pipe from each tank will tie into another pipe, via 90-degree elbows, and flow will reach the pump system. Flow will then be pumped up to the surface. A pressure reducing valve (PRV) will be installed to bring the pressure down to allow the system to transition back to a gravity system in the channel, before flow reaches the dry pond. A similar configuration of outlet pipes, pumps, and a PRV will be installed for the outfall system. The PRV be upstream of the existing 300mm RC storm main tying into W 16^{th} Avenue. This system will also return to a gravity system.

Sensors will be installed to determine current water level. Once the tanks have reached 80% capacity, channel valves will be opened and pumps turned on. If the water level continues to rise and reaches 90% capacity, discharge into the outfall will begin. Both systems will use two pumps, installed in parallel, to bring water to surface level.

Detention tanks will be constructed under the parking levels to minimize damage caused by a leakage and to reduce inlet pipe size with increased grade. The tank depth will be 3m, based on an estimated catchment area of 1.5 km^2. The total volume of the tanks will be approximately 36,300 m^3. The inner

walls of the tank will have waterproof lining to prevent water and moisture from deteriorating the structural integrity of concrete.

3.2 Pump System

3.2.1 Design Criteria

System curves have the following design factors: elevation head, friction and minor losses, as well as demand flows. Pump selection must take these criteria into consideration in order to design the most effective pump system.

3.2.2 Technical Considerations

High and low operating scenarios were developed based on the major and minor head losses from pipe network characteristics, pipe fittings, as well as required conveyance elevations. The dynamic head requirements for both operating scenarios are relatively low. High flows are required to safely discharge flow from the tanks during the durations where capacity reaches the maximum during high intensity rain events. Running a system of pumps can consume large quantities of energy; selection pumps required consideration of impeller diameter, operations speed and pump efficiency are factors when determining total power input into the system.

3.2.3 Design Components

The pump room will be located southwest of the storage tanks and 2 m below the bottom of the storage tanks. The system configuration includes 2 sets of twin low head high flow pumps of 7.5 inch impeller diameter, run in parallel, and joining at a single discharge pipe for each set. This system adds redundancy during maintenance and is convenient for when a higher or lower flow is desired. One set will be used to convey water from the detention tanks up to the channel flowing into the dry pond. The other set will be used for emergencies where flow into detention tanks exceeds the rate of pump flow out of the detention tank into the channel. The outlet for this emergency set will be tied-in to the existing outfall adjacent to W

16th Ave. All pipes connected to the pumps system have been designed with a Hazen Williams coefficient of 140.

The system high operating system was created based on the low upstream tank elevation head and two pumps running in parallel for a large storm event. During this scenario, the most head losses are experienced as water is drawn from all 3 detention tanks and through the highest number of pipe fittings and longest pipe lengths. Head losses for one set of two pumps in this scenario come from 9 gate valves, 4 90 degree bends, and 102 m of pipe. The operating point for the system during this scenario is 0.073 m3/s of flow with 13.2 m of total dynamic head. When the emergency set of pumps is running an additional 0.073 m3/s of flow will be available for total of 0.146 m3/s. The 100% speed of these pumps is 1750 RPM and consume 9.3 Horsepower at 70% efficiency. At 0.073 m3/s of flow a retention time of 114 hours is need to convey the full tanks storage and 57 hours during 0.146 m3/s of flow.

The system low operating scenarios consists of only a single pump running and will be used during common rain events. Water is drawn from only tank 1 and flows through 5 gate valves and 2 90 degree bends. The system operating point is 0.051 m3/s and 11.9 m of total dynamic head.

3.3 Stormwater Management Methods

3.3.1 Design Criteria

The design of stormwater management systems was developed based on the goals and planning practices outlined in the UBC's Integrated Stormwater Management Plan, 20 Year Sustainability Strategy, and UBC Vancouver's Campus Plan. The design seeks to follow the three main objectives of the UBC Integrated Stormwater Management Plan: reduce the flow of water off-campus, reduce impacts of flow off campus, and maintain or enhance water quality at boundaries of the campus.

3.3.2 Technical Considerations

A major technical consideration for managing the excess stormwater is capturing as much overland flow as possible in the catchment area and releasing this water in a slow and gradual manner. When these flows cannot be captured subcritical flows should be maintained in all control structures to avoid flow leading to cliff erosion, and soil material movement. As pollutants, such as oils and heavy metals, from road surfaces are picked up and washed along with overland flows, consideration for re-release of these waters must include cleaning to ensure the health of surrounding ecosystems.

3.3.3 Design Components

During heavy rainfall events, water will first be pumped to a terraced bioswale channel leading to a grassy dry pond. Once the dry pond has reached capacity, the emergency outfall valves will be opened and pumps turned on to direct additional flow to the cliffs. The outfall pipe will be installed along W 16th Ave. for accessibility during maintenance and repairs. A smaller pipe diameter can be used as the outfall pipes will only be used when the dry pond and tanks are full. Release rates will be controlled as well. The pipe will be 300mm RC for the entire run as grade will increase and no other pipes will be discharging into it.

Additional pipes will be installed to direct water to the Botanical Garden sections east and west of SW Marine Drive. These pipes will be installed downstream of the pumps and will divert flow to the garden.

The existing football field site will be converted into the dry pond for the overflow situations during heavier events. This pond is sized with the similar dimensions to the field. The area of the pond is 15,000 m2 and will hold at least an undrained water level of 1.5 m during extreme storm events with additional storage within the permeable soils below the grassy surface. A sample cross section of the dry pond is presented in Figure 3 below.

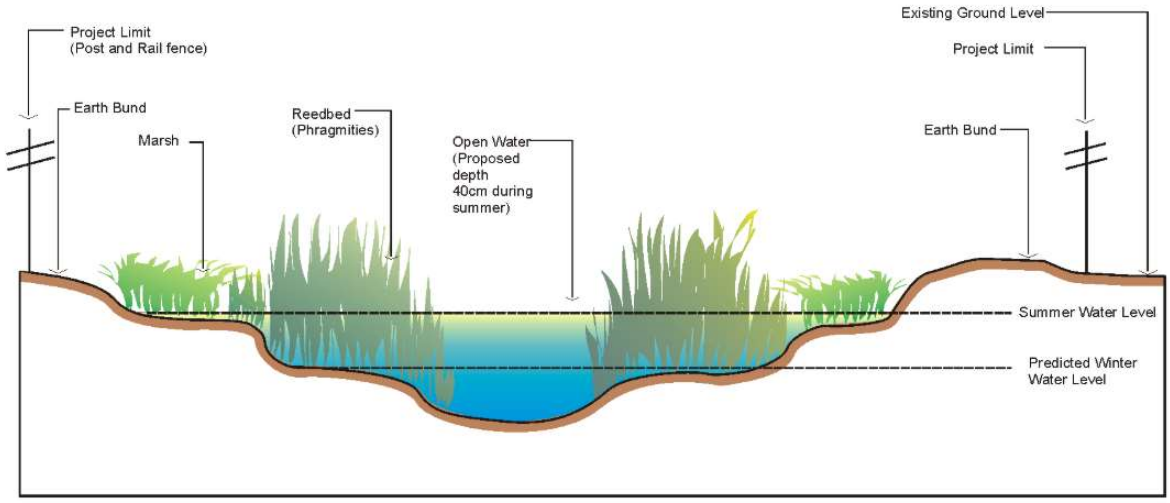

Figure 3: Typical Detention Pond

The bioswale terraced channel is designed similar to the existing University Boulevard water feature to a smaller scale. Through the terraced channel pools, oxygenation of the stagnant water from the detention tanks will allow for healthier discharge into the surround environment. The terraced channel will be bedded with 1 to 3 inch diameter river drain rock to prevent scour of channel of permeable infill. As water flows through the connecting channel, the discharged water will be cleaned and treated through biofiltering flora. Native species such as Western Sloughgrass, Softstem bulrush and Bur reed are able to provide biofiltration at depths up to 0.3 m. A typical channel pool cross section can be seen in Figure 4.

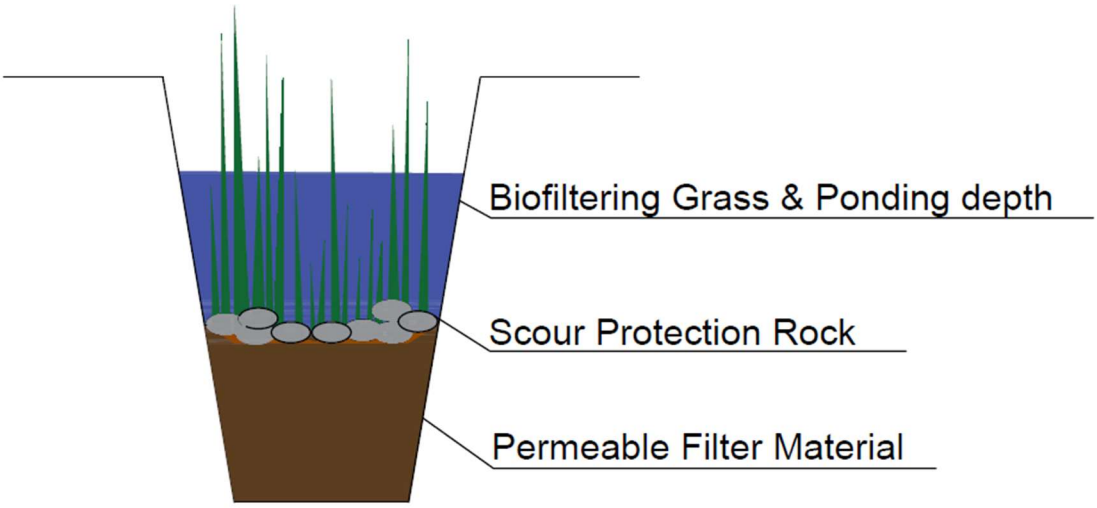

Figure 4: Terraced Channel Cross Section

The channel includes 3 terrace pools sized 5 m long each and a distribution box for a total length of 18.2m. Total depth of the channel pools is 0.4 m and the depth of water inside the channel depends on the flow from discharge from the pumping system. To maintain subcritical conditions through the maximum pumped flow of 0.076 m3/s, the peak pool water level is sized 0.3 m in height with 0.3 m width. Flow from pool to pool will be controlled by overflow weirs when peak water levels are reached. The flow path from the tanks to the dry pond through the channel is shown below in Figure 5.

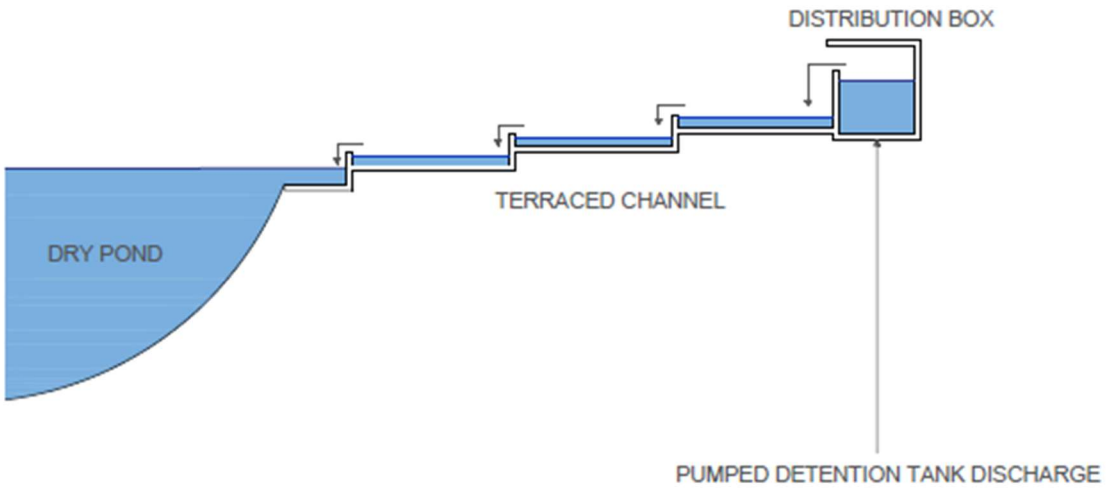

Figure 5: Conceptual Profile Drawing of a Terraced Channel

3.4 Parkade

3.4.1 Design Criteria

The parkade design adheres to the 2015 NBCC (National Building Code of Canada) and all relevant CSA (Canadian Standards Association) codes. The ultimate and serviceability limit state designs were followed in the design process. The reinforced concrete structures meet the minimum requirements followed in CSA A23.3-14 code of design of concrete structures. The CSA S413-14 code of parking structures was also referenced and reviewed.

In particular for loading scenarios, load cases in the NBCC were followed to calculate live, dead, and snow loads. All designs were done to sustain the governing load case. As each floor contained various loadings, they were split up into loads for each separate level. A factored load combination was used for each floor, which then became the basis for Limit States design.

In regard to the geotechnical aspects, the geotechnical report completed for Wesbrook Dr. and W 16th Ave was used to obtain allowable bearing pressures and general foundation requirements to ensure pressure limits on the soil are not exceeded.

3.4.2 Design Components

The parkade covers a 110m by 110m area with approximately 700 parking stalls in total (350 stalls per level). There will be two parking levels, with one level of stormwater detention tanks below the parkade. Rebar reinforced concrete slabs, beams, and columns all construct of the structure.

3.4.2.1 Concrete Mix Design

The concrete mix design will have a 30MPa concrete yield strength with a water to cementing materials ratio of 0.45 due to the exposure to sulphates from the surrounding soil. Supplementary cementing materials (SCM), particularly fly ash, will be used to reduce the amount of CO_2 released and to increase strength. Concrete materials include cement, SCM, aggregates (fine and coarse), and water. Corrosion-inhibiting admixtures will be added to slow the corrosion of the steel reinforcement, as well as a waterproofing admixture to make the cement more water resistant. Type HS (high sulphate) cement will be used due to soil being expose to sulphate and an approximate density of 2400kg/m^3. The range in air content in coarse aggregate is 4-7% when using 14-20mm nominal sized aggregates, with a unit weight of 1700kg/m^3.

The 30MPa structural mix material proportions are as follows (Table 1):

Table 2: Ingredients of Concrete Mixture

Water (kg/m^3)	Cement (kg/m^3)	Coarse Aggregate (kg/m^3)	Fine Aggregate (kg/m^3)	Supplementary Cementing Materials (kg/m^3)
190	355	1122	576	68

3.4.2.2 Structural Loading

All portions are constructed to sustain the shear and flexural forces from dead and live loads. A live load of 2.4kPa and 1.9kPa for snow load is specified to be the minimum for the structure. An assumed dead load of 50kPa includes the soil load, people load, and self-weight (includes concrete density of $2400kg/m^3$ and rebar). This dead load is for parkade level 2. The columns, beams, and slabs on level 1 will only take the live load, snow load, and a dead load of 25kPa. The level 1 dead load accounts for the self-weight and soil load on the concrete structures. Though Figure 6 describes the 4^{th} level loading to be on top of the parkade instead of describing the 1^{st} level, the figure is meant to describe the total/maximum loading on the parkade.

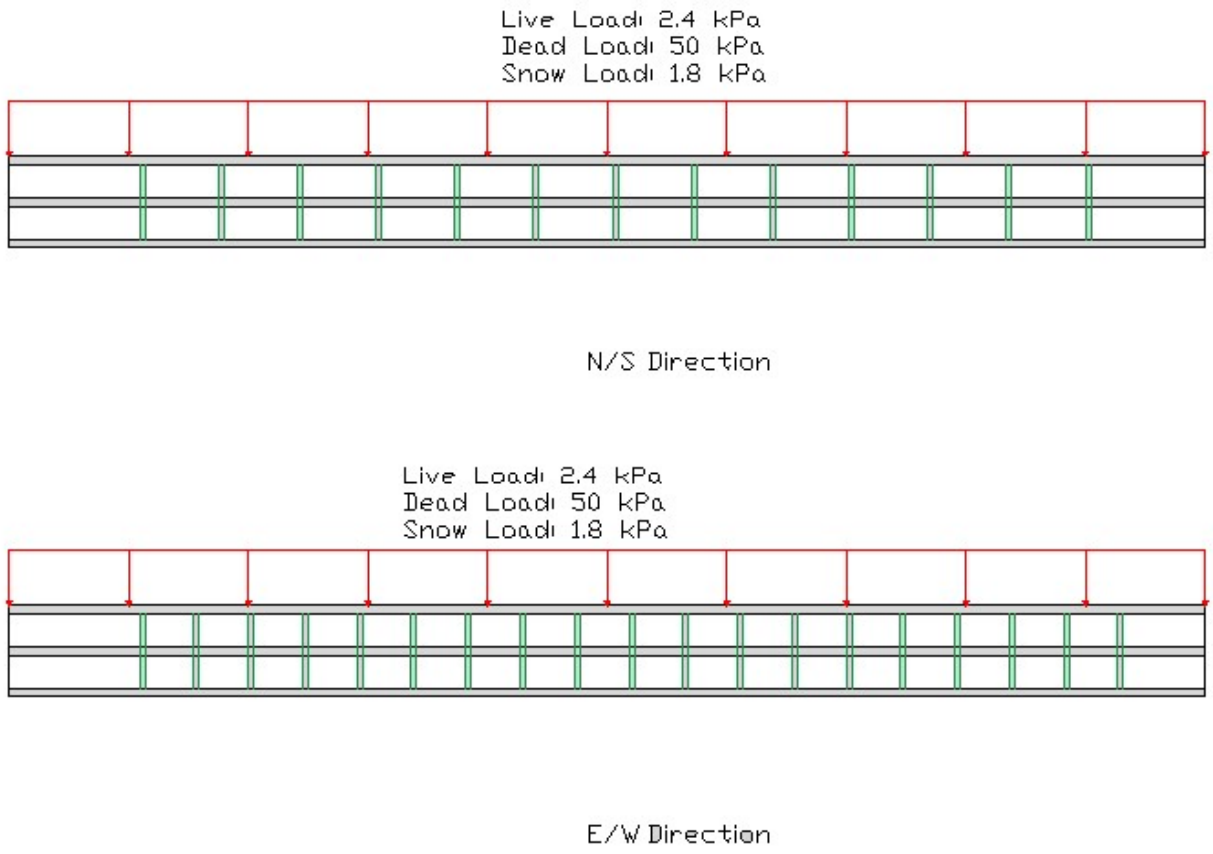

Figure 6: Side View and Total Loading of Parkade

The geotechnical report completed for Wesbrook Dr. and W 16th Ave is used to obtain allowable bearing pressures and general foundation requirements to ensure we do not exceed pressure limits on the soil. Due to the soil type of the area, the maximum pressure allowed is 150kPa. As each floor contained various loadings, they were split up into loads for each separate level. A factored load combination was used for each floor, which then became the basis for Limit States design.

3.4.2.3 Column and Foundation

The columns are designed as squares of 0.5m in width and 3m in height for each floor. They are evenly spaced 5m in the north-south direction and 10m in the east-west direction on each floor. The axial demand for each column increases as it descends through the floors, as the column takes on more load, with a maximum loading at the bottom of the detention tank. Hence, all columns are designed equally to match the demand of the base column, with increased rebar

reinforcements the lower the floor. The parkade level one columns are reinforced with 4-30M bars, the parkade level two columns are reinforced with 4-30M and 4-25M bars, and tank level are reinforced with 8-45M bars.

The spread footing capacity for each of the interior columns is required to meet the design demands for the live and dead loads from the levels above and distribute over the soil below. With the columns designed as 3m high, 500mm squares for each of the 3 floors the centric load is uniformly distributed over the foundation. The isolated footings as seen in Drawing SRN-001-D8 are designed with a square 7 x 7 grid of 35M rebars underlaid with 70mm spacers to achieve an adequate concrete cover. The 35M rebar cage is assembled with each rebar spaced at 450mm with a 75mm concrete cover at each end. Connected to the rebar cage are the 4-30M column rebars bent in 90°, acting as a column 'shoe', to have an evenly distributed transfer of the above loads. The rebar cage is then used to resist shear forces and bending moments from the effects of upward soil pressures. Footings are designed to a height of 700mm, which form a 3100mm square after the concrete pour.

3.4.2.4 Slabs and Beams

The one-way slab T-beams span across the 110m length of the parkade and are spaced 5m in the north south direction and 10m in the east west direction. The beams are 800mm in height, 300mm in thickness of the slab portion, and 500mm wide in the web. T-beams in the north south direction are reinforced for negative moments with 6-20M @250mm at the column supports, where the beam and column intersect, and 20M @50mm between the columns. For tension reinforcement, the T-beams that are not connect to the walls are reinforced with a total of 10-35M bars with the two layers of reinforcement. T-beams that are connected to the walls are reinforced with 5-35M bars with two layers of reinforcement. T-beams in the east west direction have reinforcement identical to the north south direction at the columns and have positive reinforcement of 5-20M

@65mm where no column supports exist. For tension reinforcement, the T-beams that are not connect to the walls are reinforced with a total of 5-20M bars with the one layer of reinforcement. T-beams that are connected to the walls are reinforced with 3-20M bars with one layer of reinforcement. The T-beams in mid spans where no columns are present there have positive reinforcements of 20M @85mm installed.

Shear reinforcement in the north south direction are reinforced with 10M@450mm starting from 4m from the web of the beam to 3.2m from the web of the beam. From 3.2m to the web of the beam requires shear reinforcement of 10M@100mm. No shear reinforcement is required in the east west direction because the concrete shear resistance is larger than the maximum shear force.

3.4.2.5 Retaining Wall and Foundation

The parkade walls are designed to withstand horizontal loading from the soil and stored water at the base of the parkade. The walls are 360mm thick and have a 10.4m height from the base of the footing. From the footing to the top of the wall, rebar reinforcements are laid in both horizontal and vertical directions. Specifically, horizontal shear reinforcement of 15M @275mm and vertical flexure reinforcement of 15M@200mm will be used. The square footings at the walls and column bases are designed for flexure and two-way shear, which are 3.1m in width and 700mm in height. The positive reinforcement used is 7-35M @450mm.

Foundation solutions designed for the exterior retaining walls as strip footings are illustrated in Drawing SRN-001-D7. The strip footing is designed similar to the spread footing with a grid of 35M rebars placed for flexural resistance in the traverse direction and reinforcement in the longitudinal direction to distribute the concentrated loads over the entire footing. Dimensions of the wall footing are similar to the spread footing with a height of 700mm and width of 3500mm, while the retaining wall itself is 360mm wide. The strip footing has a toe length of 1300mm

designed as a cantilever to support the wall, with the critical moments at the front face of the toe. The wheel of the footing supports the weight of the backfill material, and has a length of 1840mm to balance overturning moments of the wall due to lateral earth pressure, combined with pore water pressure. A sufficient bond strength is developed by using the required development and lap lengths.

3.4.2.6 Waterproofing

Waterproofing membrane will be applied to the exterior concrete surfaces of the parkade, bottom of the slab on grade, and the detention tank interior. On the top of the parkade, the slab will have a 2% slope to prevent any pooling of water on the membrane. In addition to waterproofing membrane, PVC water stops will be installed within the concrete slabs and walls. This is a plastic sheet that prevents the flow of liquids through the whole concrete depth, and is commonly used throughout various construction projects. As mentioned in the concrete mix design section (Section 0), a waterproofing admixture will be added to the concrete mix for added water resistance.

3.4.3 Technical Considerations

Reinforced concrete was the primary material chosen for construction of the underground parkade and stormwater storage facility. As concrete parkades are a common and robust construction method, it increases both the quality of contractor bids and construction progression. Abundance of field expertise on concrete construction and easily accessible building materials will expedite procurement and construction.

3.4.3.1 Column and Foundation

Interior square columns are reinforced with rebar that stretches through three floors of the parkade structure, which connects to a spread footing at the foundation. Rebar cages give strength to the footing, and rebar of sufficient development length connects the column and footing for

strong bond and flexural strength. Sufficient shear reinforcement provides resistance to any shear propagations at the column-beam interface.

A square spread footing foundation was utilized to support the underground parkade, with the footings planted below the columns on the underside of the slab on grade. With the apparent load path travelling straight down columns on each parkade floor, the footing could be properly designed to uphold the entirety of the column load. As the parkade has equal width and length, proportionality in the footing dimensions would make for better symmetry and load distribution. The addition of strap beams to connect each spread footing evenly distributes the load by alleviating point load pressure on the below subgrade soil.

3.4.3.2 Slabs and Beams

One-way reinforced concrete T-beam slabs were chosen due to their predictable load path that can be used to identify deficiencies and provide adequate reinforcement where necessary. Concrete columns were also designed to have a square cross section to provide symmetry in all directions and an evenly distributed load transfer from slab to column to footing.

The slab on grade has been designed to control cracking via volume changes in concrete, drying shrinkage, and cooling contraction by implementing joints in the slab. Control (contraction) joints are used to control tensile stresses in the slab and isolation (expansion) joints are used to separate the slab from adjacent walls and columns. The underside of the slab will also be laid with a polyethylene moisture barrier and appropriate depth of gravel to prevent contact of moisture with the concrete.

3.4.3.3 Retaining Wall and Foundation

The exterior retaining wall contains longitudinal and transverse rebar formation to sustain moments in two directions. The spread footings below have similar dimensions and rebar

structure to column spread footings. Again, sufficient bond strength is developed by using the required development length. To give extra stability to the surrounding soil, reinforced concrete anchors with a free length and bond length portion can be drilled into the soil through the exterior retaining walls. This is a provisional item that offers more stability to the parkade and ground, though is not necessary. Details can be seen in Drawing SRN-001-D7.

3.4.3.4 Waterproofing

In order to protect concrete surfaces from moisture exposure, preventative measures of water stops and waterproof membranes were implemented. This is to ensure that the reinforced concrete operates at full capacity with minimal corrosion via contact with water or moisture. As the concrete tanks will be holding water as well, possibilities of leakage are to be minimized. Propagation of water flow through the concrete walls will result in negative effects to its structural integrity and possible contamination in the surrounding backfill and natural soils.

4.0 Modelling Software

4.1 Topographical Mapping

ArcGIS Pro was used to create a topographical map of the project site and the UBC campus based on the supplied data from the client. Elevations for key project components were based on this map and elevation profiles for the parkade structure were generated in AutoCAD. The catchment area and flow path were also found using this topographical map.

4.2 Stormwater Estimates

The EPA SWMM Model provided by the client was used to extract stormwater data for both 1-in-100 and 1-in-10 year storms. The average runoff coefficient based on the imperviousness of ground and roof surfaces is 0.77.

In the 1-in-100 year storm model, the 24 hour total rainfall at the provided rain gauge was 129 mm. The combined total runoff volume for all subcatchments over the entire campus was 380,000 m^3. The primary outfall for the Thunderbird Stadium area experienced a total discharge volume of 55,000 m^3 at an average flow rate of 0.713 m^3/s.

There was 92 mm of rainfall over 24 hours in the 1 in 10 year model. The total rainfall volume over the entire campus was 255,000 m^3. The total discharge volume was 37,000 m^3 at the primary outfall for the Thunderbird Stadium area with an average flow rate of 0.482 m^3/s.

4.3 Design Software

AutoDesk AutoCAD 2019 was the primary software used to draw plan and profile views of the parkade levels, tank, and pipe network. Surrounding roads, surface elevations, and depth of excavation are also shown in the AutoCAD drawings. A full set of detailed, issued-for-construction drawings can be found in Appendix 1 of this report.

5.0 Traffic Flow

The traffic and people flow to, from, and within the parkade are designed to minimize the impact on the current traffic network and for the efficiency of the users. The entrance and exit of the parkade are located on East Mall where there is a lighter traffic flow than the adjacent W 16 Ave. The parkade was designed in accordance to the Canadian Parking Association Standards and allows cars to move effectively through the structure. There are staircases and elevators located in three corners of the parkade to transport users up to the stadium and commercial areas, as seen in Figure 7 below. Signs will be placed both inside and outside the structure to effectively facilitate the flow of users and vehicles.

Figure 7: Traffic Flow in Parkade

6.0 Stakeholder Engagement

6.1 Stakeholder Identification

A number of stakeholders have been identified for the project. These stakeholders are people, groups, or organizations that will be impacted by or have interest in the design outcome. The main identified stakeholders are as follows:

- UBC SEEDS Sustainability Program
- UBC Environmental Services Facility
- UBC Students, Staff and Faculty
- Future Neighbourhood Residents
- Metro Vancouver
- UBC Botanical Gardens
- UBC Thunderbirds
- UBC Campus and Community Planning

These stakeholders would most likely all be affected by a storm event in the south campus area and would benefit from a well-designed stormwater solution. Each of the UBC organizations would be closely involved in the planning of the design and will be consulted for information on the best direction for the project. The UBC students, staff, faculty, Thunderbirds, and future residents would be likely to make use of the stadium and parkade. Metro Vancouver would be involved in the routing of water off campus and control of water quality. UBC Botanical Gardens also desires for a design that reduces flooding in their area, and possibility to use gathered water for irrigation.

6.2 Stakeholder Consultation

Stakeholder consultation is necessary in order to find a design that most benefits all members that will be affected by the project, and is a way to ensure that all voices are heard, and listened to. The main stakeholder consultation would be in the form of public consultation events, where members of the public

are invited to come and weigh in on different design options, make suggestions, and voice their comments and concerns. There may also be focus groups with some of the UBC organizations to make sure that all project goals are being addressed, and to get valuable information from members who have worked on other similar projects on campus. Flyers and signs will also be distributed and posted throughout the implementation process to give notice of project progress and upcoming milestones. This can also serve as an opportunity to once again allow stakeholders to voice their concerns.

6.3 Stakeholder Implementation

Stakeholder engagement is a way to get valuable suggestions and information about the best direction for the project, and will be treated as such. The stakeholder engagement will be one of the main factors in choosing an optimal design, which benefits everyone that will be using the facilities. Experts in UBC land use, stormwater management, and environmental services will be consulted for their expertise in the respective areas, and groups such as the Botanical Gardens will be worked with to find opportunities for sustainable solutions that include water reuse. The engagement should ensure that the project is safe, efficient, environmentally beneficial, and meets all requirements that the UBC SEEDS Sustainability Program has put in place.

6.4 Indigenous Stakeholders

The project will be built on the traditional, ancestral, and unseeded territory of the Musqueam people and it is very important to have close consultations with the group throughout the design and construction of the facility. Similar to other stakeholders, they will be invited to join public consultations with focus groups present to obtain feedback and suggestions for the project. During the excavation phase, there will be an archaeological assessment to ensure that the site is clear of cultural significant remains within site boundaries, as the parkade will be located at a lower elevation than has been previously excavated in that area. Lastly, the Chance Find method training will be required of all on-site workers during excavation and construction to guarantee proper procedures are adhered to if archaeological material is to be found.

7.0 Construction Work Plan

7.1 Construction Requirements

The project is required to be completed on time and on budget, with construction taking place over the spring and early summer months so that the stormwater system is operational for the coming Fall of 2019. Laydown areas on site will be in convenient locations to maximize efficiency on the job site. During construction there will be traffic management to minimize disruption to W 16th Avenue and East Mall. A change management protocol will be put in place to smoothly implement any changes that may be incurred due to unforeseen problems and conditions during construction. There should also be weekly project review meetings held to discuss issues and generate solutions. To ensure quality, inspections will be held at regular intervals for all aspects of the project. All completed work should be photo documented and filed to be easily accessible in the future. At all times, safety should be held in the highest regard, with all workers understanding and abiding by the WorkSafeBC safety regulations.

7.2 Construction Sequence

Construction work is scheduled to maximize efficiency on the jobsite. It is created around the decision that the project is more schedule-controlled than cost-controlled; therefore, the construction plan is more focused on completing tasks on time.

Demolition is not within the scope of this project; therefore, the field should be ready to begin construction on May 1, 2019. Due to the arterial roads surrounding the construction site, a gravel area shall be created so concrete and material-transport trucks have clear and easy access to the site. This will reduce the traffic, traffic safety issues, and traffic control personnel due to construction. Additionally, during the construction of the parkade and the detention tanks, Thunderbird Stadium cannot be used. Any practices or games that require a field shall be held at Warren Field. Extra bleachers shall be set up on game days for spectators.

Temporary fencing shall be installed for jobsite control. This shall occur directly after the site clearance. Coordination will ensure they will not interfere with construction work. Locations of material storage areas, work office trailers, fenced-in construction site, and parkade/detention tank location are shown in Figure 8. This figure does not include the construction work/demolition of Thunderbird Stadium; the figure only focuses on the detention tank and parkade construction site.

Figure 8: Construction Site

Surveying shall occur to determine all control points for grading after excavation. Grading allows proper placement of the detention tank foundation. Formwork placement will start at the highest elevation and

proceed to the lower elevation. A temporary rainwater drainage system shall be installed after survey work has been completed. After the formation of the detention tank, inspections shall occur to check waterproofing and structural components before the construction of the parkade. Following after inspections, the parkade construction shall begin with parkade formwork being placed, with the level 2 being constructed first, then level 1.

7.3 Anticipated Issues

There are a number of issues that may arise during construction. Though borehole soil investigations will be conducted, there is always uncertainty with underground soil conditions. There may also be issues that result in changes to the scope or design of the project, which will be dealt with as stated above by a change management protocol. Weather issues could possibly delay construction; however, measures will be taken by the project manager to ensure that the project stays on track. There is also the possibility of archaeological objects being found, which will be responded to promptly following the Archaeological Impact Assessment Guidelines.

8.0 Service-Life Maintenance Plan

8.1 Operation and Maintenance Plan

The design service life of the underground parkade and detention facility is estimated to be 100 years. Maintenance and inspection requirements are listed in Table 3. A more detailed maintenance duration and description of specific parts of the facility are detailed in Table 4. A cost estimate for these maintenance components are further detailed in Section 10.

Table 3: Maintenance and Inspection Requirements

General Component	Maintenance Period	Description
Washing and Cleaning Maintenance	Annual	Clear parkade and tank of any debris, and clean out collected dust and surface contaminants via pressure washing.
Safety Inspection	2 Years	Inspect all emergency response equipment and procedures, and ensure they adhere to UBC's policies

Table 4: Component Specific Maintenance

Facility Component	Maintenance Period	Description
Detention Tank	Monthly or After Extreme Storm Event	Inspect physical state, pipe system, and pumps, as well as cleaning the tank to maintain standards. This includes cleaning and checking for residual water, grit cloggers, and sedimentation
Pipe Network	Every 5 years or when attention is needed	CCTV inspections for all the pipes will be conducted every 5 years. Repairs will be made if CCTV reports indicate damages.
Pumps	Semi-Annual	Pumps in the channel system will be expected to be in use much more frequently than those in the outfall system, and will be inspected semi-annually and repaired as necessary. Pumps in the outfall system will only be use during high intensity storm events, so for an average year, will not be expected to be in use at all. These pumps will be run twice a year and inspected.
Parkade – Structural Concrete and Rebar	Monthly	Inspection and repairs of waterproof membrane, corrosion inhibitors for corroding rebar/concrete, grout/fill any cracks
Parkade – Painting and Coating	Annual	Repaint worn out traffic and parking stall paints. Inspect for wearing down of fireproofing coating and replace as needed

Mechanical Systems	Bi-Annual or Post Failure of System	Inspect for wearing or creep of any mechanical parts, especially of elevators and ventilation system. Ensure installation of new parts do not inhibit the structural capacity of the parkade
Electrical Systems	Bi-Annual or Post Failure of System	Inspect for broken fluorescent light tube or bulbs, as well as electrical wiring and conduits that require repairs

8.2 Emergency Response Plan

The Emergency Response Plan (ERP) outlines emergency management planning procedures that addresses risk assessments developed for the project. WorkSafe BC shall be notified of any incidents with potentially significant impacts on people or environment off site, in addition to notifying the University of British Columbia and project team. This plan will operate alongside the Health and Safety Plan and Traffic Management Plan developed by the contractor.

Emergency contact lists shall be located within the project office during construction, and within several locations of the parkade (especially the service rooms). This should include emergency contacts to the local emergency assistance agencies, including 911, ICBC, FortisBC, BC Hydro, etc.

Flash and issue reports shall also be used to provide operation and maintenance members of the facility with notifications of validated information of a serious event. They act as a communication tool between management and frontline supervision to investigate the event, and will be separated by the severity of the event.

The general evacuation response procedure and on-site injury response procedure produced according to the standards of the University of British Columbia shall be adhered to evacuate all staff and facility users, as well as treating any injuries according to its severity. Other response plans that should be developed by the owner include:

- Environmental Spills
- Site Security
- Dangerous Goods/Hazardous Substance Incident
- Vehicular Collision
- Excavation Instability and Collapse
- Utility Damage and Release

As the owner will be operating and maintaining the facility, they should have site evacuation routes, emergency equipment, and designated First Aiders in place in case of any emergencies.

9.0 Construction Schedule

The Stadium Underground Parkade and Water Storage Management Plan will commence on Monday, February 2, 2019 and finish on Monday, September 11, 2019. Construction begins on May 1, 2019, with bidding, permitting, procurement, pre-construction work, and mobilization all completed before this date. With limited disruptions in construction schedule due to lighter traffic and bystanders in the summer, faster project progression is estimated. The schedule consists of standard 5-day work weeks from Monday to Friday, barring any statutory holidays. Work days on-site have been estimated to begin at 08:00 and ending at 17:00, accounting for a one-hour lunch break and two fifteen-minute breaks. The full proposed schedule can be found in Appendix 1: Project Management Schedule.

The schedule is separated by its major tasks: Project Start Up, Pre-Construction, Site Works, Detention Tank Construction, Pipe System Construction, Parkade Construction, Mechanical & Electrical Systems, Stormwater Features, and Finishing. Subtasks to construct its corresponding system or structure are listed below the major task, resulting in some repeated subtasks. Two separate crews will be working simultaneously for efficiency; one on the detention tanks and the other on the water pipe system. Both crews will work together as one on the parkade.

A simplified timeline can be seen in Figure 9, showing the number of days predicted for each major task.

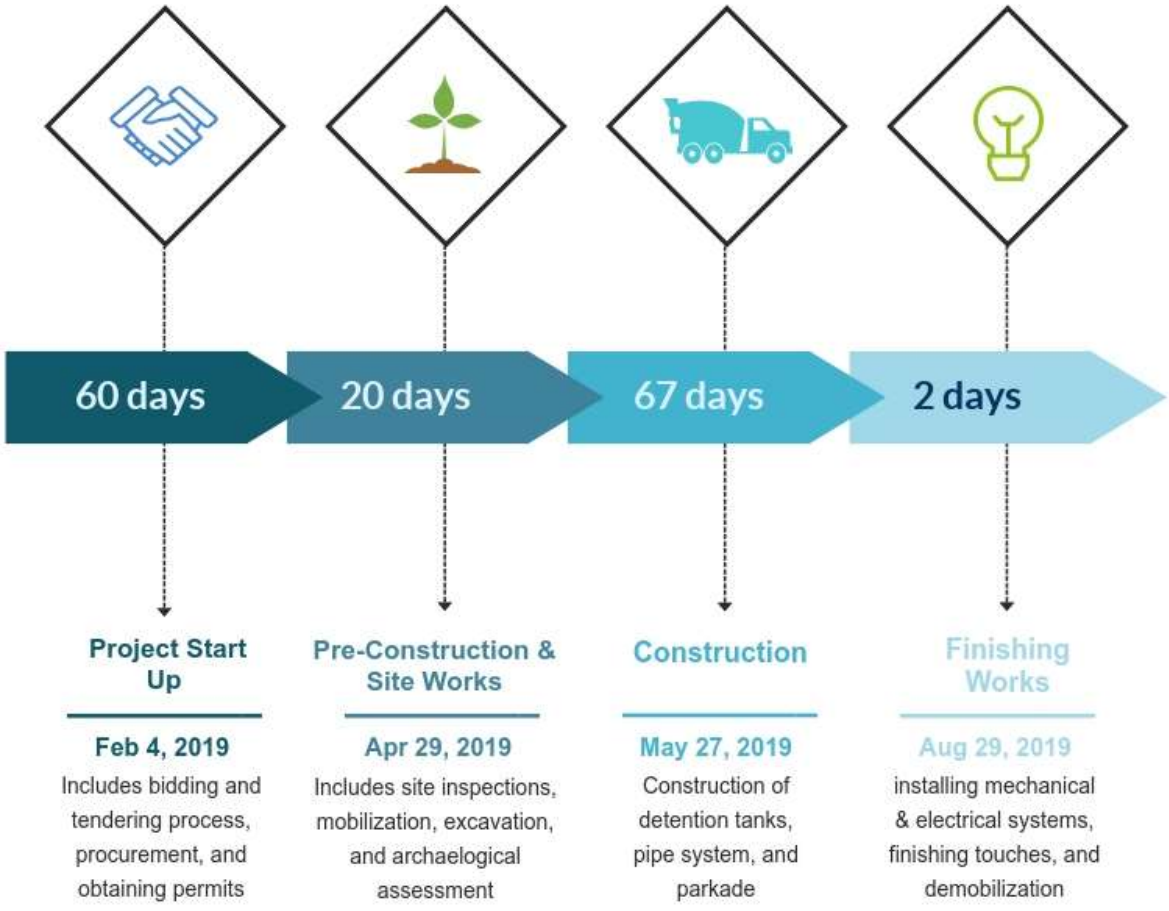

Figure 9: Project Timeline

Procurement and permit approvals should occur immediately after contracts are signed. Permits and environmental assessments are taken during the tendering process. Detention tanks and the pipe system shall be constructed simultaneously with parkade construction taking place immediately after the formwork of the detention tanks is removed. The pipe system also needs to be finished before the parkade construction because there are pipes connecting the detention tank to the water system. Furthermore, slab formwork shall be removed four days after concrete pouring and curing to ensure the slab has properly set. Additionally, implementation of the mechanical and electrical systems, along with landscaping, should start immediately after parkade inspections. The finishing tasks, such as installing signage and paint jobs, should start while the mechanical and electrical systems are being installed.

The site hazard assessment and field review shall commence before excavation or mobilization occurs by the Project Manager. Formal site inspections are not included in the schedule as they will be taken at random by a health and safety executive of work to ensure accurate assessment of the site. Informal inspections shall be conducted by all supervisors when they are out on site. Formal site inspections will be scheduled at random by the worker health and safety representative. Special inspections shall be made if a malfunction or incident occurs on site. Archaeological assessments shall take place as excavation occurs to ensure assessments are done as soon as an archaeological object is found. Since the landscape is being altered on the traditional, ancestral, and unseeded territory of the Musqueam people, excavation may potentially harm archaeological sites. If an archaeological object is found, a formal process shall take place, following the Archaeological Impact Assessment Guidelines.

10.0 Cost Estimate

The detailed design was used in the Class B cost estimate for the parkade and stormwater management mix solution. The estimated cost to implement this design is $18.5M, which only includes construction costs and project management costs. Due to the magnitude of this project, contingency is set at 15% of the total project cost, reduced from the preliminary contingency of 20%.

The cost estimate is split into three sections: Construction, Project Management, and Operating and Maintenance costs. The first section includes costs related to implementing the design through obtaining permits, consuming building materials, equipment rentals, activity specific labourers, and additional construction-related costs. The second section consists of costs related to Project Management and professional personnel, such as engineers, additional construction labourers, and technicians. The third section details the annual operating and maintenance costs to maintain the projected facilities and provides an estimated 5-year operating and maintenance cost plan. A cost summary of each section can be seen in Table 2.

The following assumptions were made to complete the cost estimate:

- Costs for each item were calculated based on the values referenced in the RSMeans cost database which accounts for site location and the 2019 construction year
- Costs not found in the RSMeans were based off of similar precedent project costs
- Profit mentioned in the RSMeans means the estimated profit for Stormside Consultants

Table 5: Summary of Underground Parkade and Water Storage Project Cost Estimate

Cost Type	**Cost**
Construction	$17,326,000
Project Management	$1,165,000

Total Project Cost	$18,486,000
Operations and Maintenance Cost	**$2,441,000**

10.1 Construction Cost Estimate

The construction cost estimate section is divided into separate phases to show the cost of each portion: general, permitting, detention tanks, stormwater sustainable solutions, parkade, and dry pond. The general phase includes but is not limited to temporary facilities, litigation, equipment, and machines. Stormwater sustainable solutions also includes the terraced channel, permeable pavement, bioswales, and tree trenches. The detention tank phase, parkade phase, and dry pond phase include the construction materials as well as labour, overhead, and profit. Contingency is 15% of the total construction cost. The expected construction cost is $17,376,000. Provided below in Table 3 is a summary of the construction cost estimate.

Table 6: Summary of Construction Cost Estimate

Phase	**Cost**
General	$1,230,000
Permitting	$183,000
Detention Tank	$7,178,000
Stormwater Sustainable Solutions	$50,000
Underground Parkade	$6,305,000
Dry Pond	$127,000.00
Contingency	$2,253,000
Total Construction Cost	**$17,376,000**

10.2 Project Management Cost Estimate

Different rates and quantities were applied depending on the profession (Table XX). The rates include labour, overhead, and profit. The project manager, plus the structural, stormwater management, and geotechnical engineers, are needed during the entire project process and periodically onsite during the construction phase. The environmental engineer, landscapers, and archaeological subconsultants are only needed for certain portions of the project, resulting in a lower overall cost. CAD technicians are only necessary pre-construction, while the field technicians, construction workers, site superintendent, and first aid attendants are only required during the construction phase. The expected project management cost is $1,161,000. In Table 4 is a summary of the project management cost estimate.

Table 7: Summary of Project Management Cost Estimate

Phase	**Cost**
Engineers	$433,000.00
Construction Management	$130,000.00
On-site Workers	$446,000.00
Contingency	$152,000
Total Project Management Cost	**$1,161,000**

10.3 Operating and Maintenance Cost Estimate

Proper maintenance and inspections ensure that the detention tank can perform during a 1-in-100 year storm during its entire lifespan and that the parkade can function accordingly. An estimated 5-year operating and maintenance cost plan was created to include crucial tasks that are not needed annually. An operational checklist will be created to ensure the structures are in a proper state. Logging records of inspections and maintenance will be kept for each session to allow management to be fully aware of the structure's current state. Further details of each item are described in Section 8.1.

The 5-year operating and maintenance cost plan is estimated at $2,441,000 with its cost summary shown in Table 5. This estimate and maintenance plan will be reviewed and revised in 5 years depending on a number of factors including the condition of the system and the estimated storm impact in the future based on new data, as well as the state of the economy.

Table 8: Summary of 5-Year Operating & Maintenance Cost Plan

Phase	**Cost**
Detention Tank	$106,000.00
Mechanical & Electrical	$34,000.00
Parkade	$178,000.00
Administration	$1,805,000.00
Contingency	$318,000.00
Total 5-year Operating & Maintenance cost	**$2,441,000**

11.0 Conclusion

Through a comprehensive analysis the above solution prepared by Stormside Consulting Limited for the Stadium Neighbourhood provides a detailed proposal for stormwater management and parkade infrastructure. Stormwater modelling for a 1-in-100-year storm using EPA SWMM Model provided the necessary quantity of water required to size the detention tanks. The three tanks are sized to accommodate a total of 36,300m^3, in addition to the dry pond capable of storing 22,500m^3 of stormwater runoff. This will mitigate environmental damages and prevent overflowing of the existing stormwater mains. The two levels of parking provide a total of 700 stalls meeting the requirement for the Stadium Neighbourhood based on stadium capacity and expected users of the commercial spaces. The quantity of parking stalls takes into consideration the transportation initiatives set by UBC to reduce the total number of trips taken by individual vehicle's to only one third of the total. The project begins on February 4th, 2019 lasting 148 days until the completion of construction on August 29th, 2019. The total cost for the construction and management of the project is set at $18,486,000 with a contingency of 15%. The 5-year maintenance and operations plan will cost $2,441,000 to operate and will be revised after the first 5 years of service.

12.0 References

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Appendix 1: Issued-for-Construction Drawings

a place of mind

THE UNIVERSITY OF BRITISH COLUMBIA

STADIUM ROAD NEIGHBOURHOOD UNDERGROUND PARKADES AND WATER STORAGE FACILITY PROJECT

STORMSIDE PROJECT NUMBER: SRN-001

STORMSIDE CONSULTING LTD.

THE UNIVERSITY OF BRITISH COLUMBIA	LEGEND	SRN UNDERGROUND PARKADES AND WATER STORAGE
		DATE: April 5, 2019
		DRAWING: SRN-001-COVER

GENERAL NOTES:

1. ALL ISSUED-FOR-CONSTRUCTION DRAWINGS ARE TO BE READ ALONG WITH ALL CONTRACT DOCUMENTS AND SPECIFICATIONS
2. THE CONTRACTOR MUST BE FAMILIAR WITH SITE CONDITIONS AND PHYSICAL FEATURES THAT IMPACT THEIR WORK
3. THE CONTRACTOR MUST KEEP THE SITE CLEAN AND DEBRIS FREE DURING CONSTRUCTION, AND MUST REMEDIATE THE SITE BY REMOVING ALL CONSTRUCTION SCRAPS AND DEBRIS
4. THE CONSULTANT MUST FIRST APPROVE ANY CONSTRUCTION DEVIATIONS FROM THE ATTACHED DRAWINGS. ALL REVISIONS SHALL BE RECORDED
5. ALL CONSTRUCTION ACTIVITY MUST CONFORM TO THE MOST RECENT OCCUPATIONAL HEALTH AND SAFETY PLAN, WORKSAFE BC REGULATIONS, AND THE NATIONAL BUILDING CODE OF CANADA
6. DISCREPANCIES SHOWN ON THE ATTACHED DRAWINGS MUST BE BROUGHT TO THE ENGINEER OF RECORD FOR REVIEW AND APPROVAL BEFORE PROCEEDING CONSTRUCTION
7. THE ATTACHED DRAWINGS ARE NOT TO BE SCALED
8. LOCATIONS OF EXISTING UTILITIES SHOWN ON THE DRAWINGS ARE APPROXIMATE. THE CONTRACTOR MUST VERIFY THEIR EXACT LOCATIONS ON SITE

GENERAL MATERIALS:

1. MATERIALS SHALL BE DELIVERED TO SITE IN DRY CONDITIONS AND KEPT CLEAN UNTIL USE
2. BACKFILL WITH GRANULAR MATERIAL IN 0.3M LIFTS AND COMPACTED TO 95% COMPACTION
3. EXCAVATION AND DISPOSAL OF ANY EXCAVATED MATERIAL SHALL ADHERE TO ENVIRONMENTAL REGULATIONS. ANY CONTAMINATED MATERIALS EXCAVATED SHALL FOLLOW THE UNIVERSITY'S DISPOSAL PROCEDURES

PIPE NETWORK:

EAST MALL MAIN REPLACEMENT:

1. M-SCOPE TO LOCATE UTILITIES.
2. HAND DIG TO EXPOSE ALL UTILITIES.
3. ALL MANHOLE BARRELS TO BE 1050ø UNLESS NOTED OTHERWISE.
4. INSTALL 3 300X300X300 WYES.
5. INSTALL 6 GATE VALVES ON CONNECTIONS AT INLET AND WYE.
6. LEAVE 150 STM FOR ALL LOTS AND 200 STM CATCH BASIN LEADS. MATCH EXISTING CONNECTION DIAMETER IF LARGER.
7. MEASURE WYE DISTANCES OF ALL CONNECTIONS FROM THE DOWNSTREAM MANHOLE.
8. TIE EXISTING CONNECTIONS & CB'S TO PROPOSED STORM SEWER.
9. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT PEGGY CHEN AT 604-000-0000.

OUTFALL CONNECTION:

1. INSTALL 3 200MM DI AT OUTLET OF EACH TANK.
2. INSTALL GATE VALVE AT EACH OUTLET, BETWEEN TANK OUTLETS, AND BEFORE PUMP CONFIGURATION.
3. INSTALL 2 190MM IMPELLER CENTRIFUGAL PUMPS IN PARALLEL, CONNECTED BY 200MM DI. INSTALL BYPASS VALVES BETWEEN PUMPS.
4. INSTALL 200MM DI VERTICAL UNTIL EX 300 STM ELEVATION.
5. INSTALL PRV AND CONNECT TO EX 300 STM.
6. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT COLIN PHANG AT 604-000-0000.

CHANNEL:

1. INSTALL 3 200MM DI AT OUTLET OF EACH TANK.
2. INSTALL GATE VALVE AT EACH OUTLET, BETWEEN TANK OUTLETS, AND BEFORE PUMP CONFIGURATION.
3. INSTALL 2 190MM IMPELLER CENTRIFUGAL PUMPS IN PARALLEL, CONNECTED BY 200MM DI. INSTALL BYPASS VALVES BETWEEN PUMPS.
4. INSTALL 200MM DI VERTICAL UNTIL CHANNEL ELEVATION.
5. INSTALL PRV AND CONNECT TO CHANNEL
6. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT COLIN PHANG AT 604-000-0000.

PIPE QUANTITIES ESTIMATE:

- 300mm DI
- 200mm DI
- 300mm RC

FOUNDATION:

1. EXCAVATION SHALL HAVE A 2H:1V SIDE SLOPE
2. REFER TO THE GEOTECHNICAL REPORT FOR OTHER SPECIFIC DESIGN AND CONSTRUCTION REQUIREMENTS FOR FOOTINGS, SOIL SLOPES, FROST PROTECTION, MINIMUM COVER, AND MORE
3. SPREAD FOOTINGS ARE TO BE CENTERED BELOW THE COLUMN AND STRIP FOOTINGS CENTERED BELOW THE WALL
4. TO ACCOMMODATE MECHANICAL OR ELECTRICAL SERVICES, FOOTINGS MAY NEED TO BE LOWERED. REFER TO MECHANICAL AND ELECTRICAL DRAWINGS FOR ELEVATIONS TO ENSURE NO UNDERMINING OF FOOTINGS
5. BEARING SURFACES MUST HAVE FROST PROTECTION BEFORE AND AFTER POURING OF FOOTING
6. SOIL SUBGRADE SHALL BE PROOF ROLLED AND INSPECTED BY GEOTECHNICAL ENGINEER FOLLOWING STRIPPING AND COMPLETION OF EXCAVATION.

CONCRETE:

1. ALL CEMENT TO BE PORTLAND CEMENT CONCRETE WITH A WATER TO CEMENT RATIO OF 0.5.
2. CONCRETE MIX DESIGN SHALL HAVE A YIELD STRENGTH OF 30MPa
3. AIR CONTENT RANGE IN COARSE AGGREGATE IS FROM 4% TO 7% USING 14MM TO 20MM SIZED AGGREGATES
4. EXPOSURE CLASS OF CONCRETE IS C-4
5. ALL CAST-IN-PLACE CONCRETE MUST ADHERE TO THE CSA STANDARD A23.1. HOT OR COLD WEATHER PROTECTION SHALL ALSO BE PROVIDED AS SPECIFIED IN A23.1
6. ALL EXPOSED NON-FORMED SURFACES MUST BE KEPT CONTINUOUSLY MOIST FOR A MINIMUM OF SEVEN CONSECUTIVE DAYS POST PLACEMENT
7. ALL CONCRETE POURS MUST BE VIBRATED AND FREE OF HONEY COMBING, SUCH THAT NO SEGREGATION OCCURS
8. ENSURE GOOD CLEANLINESS OF REBAR AND SECURED IN CORRECT LOCATION DURING PLACEMENT
9. CURING COMPOUND SHALL BE A WATER BASED MEMBRANE FORMING AND OF A TYPE APPROVED BY THE ENGINEER

CONCRETE FORMWORK:

1. FORMWORK AND SHORING DESIGN, AS WELL AS FIELD REVIEW AND CONSTRUCTION, ARE RESPONSIBILITIES OF THE CONTRACTOR ANY
2. NO SLAB OR BEAM FORMS CAN BE REMOVED PRIOR TO CONCRETE REACHING 75% OF ITS 28 DAY STRENGTH
3. NO COLUMN OR WALL FORMS CAN BE REMOVED PRIOR TO CONCRETE REACHING 8MPa

REINFORCING STEEL:

1. ALL REINFORCING STEEL SHALL BE IN ACCORDANCE WITH CAN/CSA-G30-18
2. ALL REINFORCEMENT SHALL BE ADEQUATELY SUPPORTED AND SECURED AGAINST DISPLACEMENT BEFORE AND DURING CONCRETE POURING. DISPLACEMENT TOLERANCES MUST BE MET AS PER THE LATEST CSA A23.1 STANDARD
3. MINIMUM CONCRETE COVER TO REINFORCEMENT IS 60MM FOR ALL CONCRETE STRUCTURES (UNLESS NOTED OTHERWISE)
4. NOTIFY CONSULTANT FOR REVIEW OF SITE FOR REINFORCEMENT 24 HOURS BEFORE POURING OF CONCRETE
5. ALL REINFORCING BARS WITH HOOKED ENDS SHALL HAVE STANDARD HOOK LENGTHS, UNLESS NOTED OTHERWISE

MASONRY:

1. PROVIDE ALL LABOUR, MATERIALS, EQUIPMENT, AND SERVICES TO COMPLETE ALL MASONRY WORK SPECIFIED IN THE DRAWINGS
2. ALL WORK MUST CONFORM TO CSA STANDARD S304.1 FOR MASONRY DESIGN FOR BUILDINGS, AS WELL AS CSA STANDARD A370 FOR CONNECTORS FOR MASONRY
3. MORTAR USED MUST CONFORM TO CSA STANDARD A179
4. CLEAN MASONRY BY:
   - 4.1. RAKING AND REPLACING DEFECTIVE MORTAR JOINTS
   - 4.2. REMOVE EXCESS MORTAR, SMEARS, AND STAINS ON COMPLETION
   - 4.3. SCRUB SURFACES TO BE CLEANED WITH SUITABLE NON-ACID CLEANING SOLUTIONS
   - 4.4. FINISHED PRODUCT SHALL HAVE A UNIFORM CLEAN APPEARANCE

TRAFFIC MANAGEMENT:

1. THE CONTRACTOR IS RESPONSIBLE FOR THE TRAFFIC MANAGEMENT PLAN AND ALL TEMPORARY TRAFFIC CONTROL ON STREETS REQUIRED FOR COMPLETION OF WORK
2. TRAFFIC MANAGEMENT PLANS SHALL BE SUBMITTED FOR REVIEW BY THE ENGINEER TWO WEEKS PRIOR TO COMMENCEMENT OF CONSTRUCTION, AND SHALL MEET REQUIREMENTS NOTED IN THE TECHNICAL SPECIFICATIONS

DRAWING LIST

ISSUED FOR CONSTRUCTION

THE UNIVERSITY OF BRITISH COLUMBIA

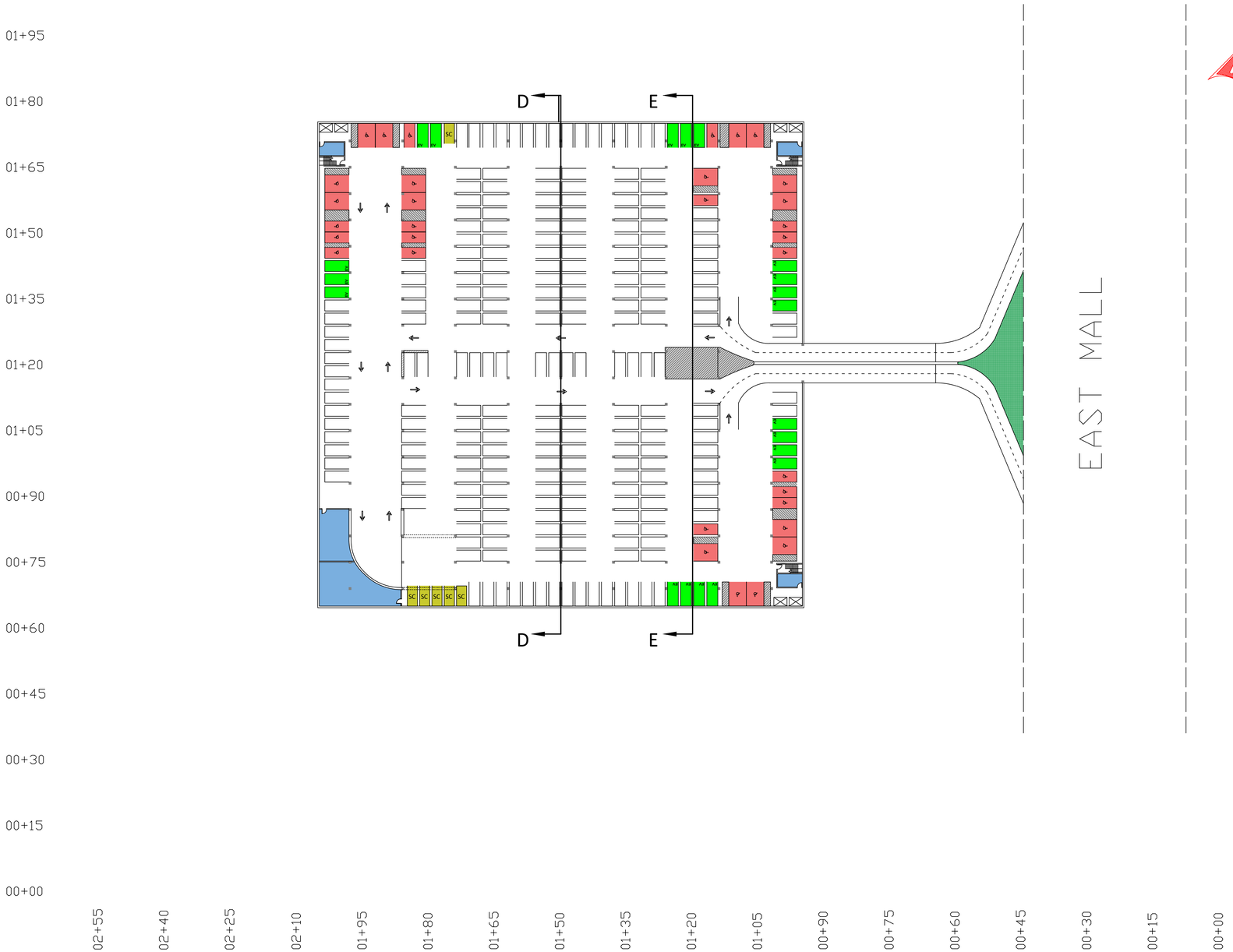
LEGEND

SRN UNDERGROUND PARKADES AND WATER STORAGE

DATE: April 5, 2019

DRAWING: SRN-001-00

GENERAL NOTES



NOTES:

1. FOR GENERAL NOTES SEE DRAWING SRN–001–00

SURVEYOR NOTES:

1. EXPOSE XXX WATERMAIN PRIOR TO CONSTRUCTION. REPORT ELEVATION TO ENGINEER.
2. EXPOSE XXXX NONAME ST SERVICE CONNECTION PRIOR TO CONSTRUCTION. REPORT ELEVATION TO ENGINEER.
3. PIPE MATERIALS OPTIONS AVAILABLE. PLEASE RECORD PIPE MATERIALS USED ON DRAWING.

STORM NETWORK NOTES:

1. M–SCOPE TO LOCATE UTILITIES.
2. HAND DIG TO EXPOSE ALL UTILITIES.
3. ALL MANHOLE BARRELS TO BE 1050ø UNLESS NOTED OTHERWISE.
4. SEE SEWERS PERMIT xxxxxxxB FOR SERVICE LOCATION AND ACCOUNT NUMBERS.
5. LEAVE 150 STM/100 SAN WYES FOR ALL LOTS. MATCH EXISTING CONNECTION DIAMETER IF LARGER.
6. MEASURE WYE DISTANCES OF ALL CONNECTIONS FROM THE DOWNSTREAM SANITARY MANHOLE AND NOTE ON ATTACHED WYE SHEET. INDICATE IF CONNECTION IS FUTURE OR REHOOK.
7. SUBMIT COMPLETED WYE SHEET TO SEWER OPS SUPERINTENDENT.
8. TIE EXISTING COMBINED CONNECTIONS & CB'S TO PROPOSED STORM SEWERS.
9. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT JIM BURNETT AT 604–763–3602.

PIPE QUANTITIES ESTIMATE:
- 150mm SDR 28 PVC
- 200mm SDR 35 PVC

ACCOUNT NUMBERS: (FOR MAIN EXTENSION ONLY)
WBS:
CESD SEWERS:
CESD STREETS:
CESD OTHERS:

COST ESTIMATE (LESS STREET REPAIRS:)$

ORIGINAL BC ONE CALL TICKET NUMBER: NUMBER (CALL DATE)

PARKADE CONSTRUCTION NOTES:

1. EXCAVATION, FORMWORK, AND REINFORCED CONCRETE CONSTRUCTION WORK FOLLOW TYPICAL CONSTRUCTION STANDARDS, UNLESS NOTED OTHERWISE.
2. QA/QC REVIEWS OF CONCRETE MIX, MORTAR, AGGREGATES AND ENGINEERED FILL SHALL BE CARRIED OUT DAILY BY THE SITE SUPERINTENDENT, AND WEEKLY BY THE ENGINEER OF RECORD, UNLESS OTHERWISE SPECIFIED
3. MECHANICAL AND ELECTRICAL SYSTEMS DESIGN AND INSTALLATION SHALL BE CARRIED OUT BY SUBCONTRACTORS HIRED BY THE GENERAL CONTRACTOR
4. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ADHERENCE TO THE PROVIDED GEOMETRIC DESIGN.
5. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ROADWAY AND ALL PARKADE PAINTING. PAINTING MATERIALS AND EQUIPMENT MUST BE CHECKED BY THE ENGINEER OF RECORD PRIOR TO INSTALLATION, AND MUST FOLLOW GUIDELINES SET OUT IN CSA S413 DESIGN OF PARKING STRUCTURES.
6. ALL WATERPROOFING METHODS SHALL BE DECIDED BY THE CONTRACTOR. APPROVAL MUST BE OBTAINED FROM ENGINEER OF RECORD BEFORE PROCEEDANCE

ISSUED FOR CONSTRUCTION

THE UNIVERSITY OF BRITISH COLUMBIA

LEGEND

- DISABILITY PARKING STALL
- EV PARKING STALL
- SMALL CAR PARKING STALL
- NO PARKING AREA
- SERVICE ROOM
- COLUMN

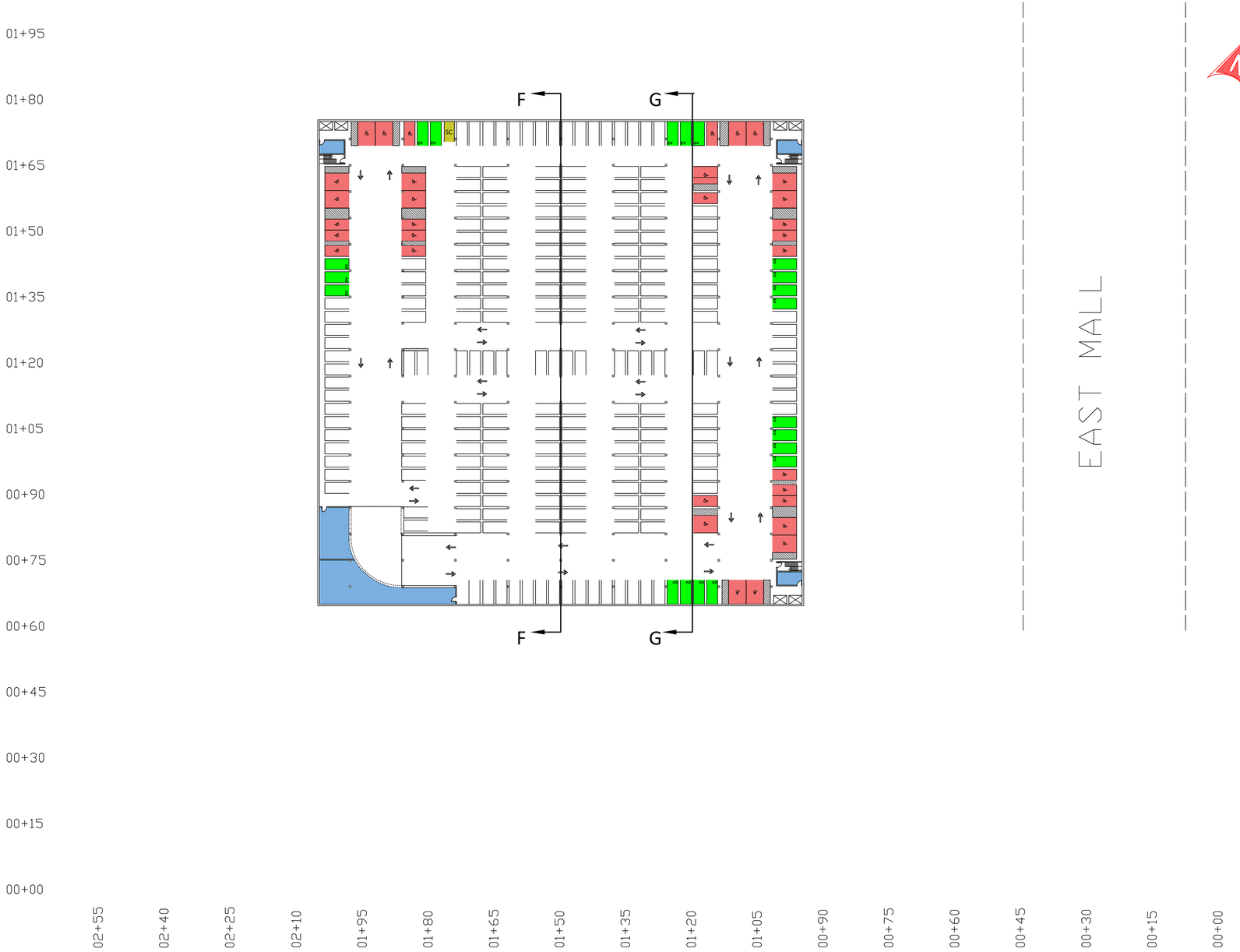
SRN UNDERGROUND PARKADES AND WATER STORAGE

DATE: April 5, 2019

DRAWING: SRN-001-01

PLAN VIEW - PARKADE P1

PRODUCED BY AN AUTODESK STUDENT VERSION



NOTES:

1. FOR GENERAL NOTES SEE DRAWING SRN–001–00

SURVEYOR NOTES:

1. EXPOSE XXX WATERMAIN PRIOR TO CONSTRUCTION. REPORT ELEVATION TO ENGINEER.
2. EXPOSE XXXX NONAME ST SERVICE CONNECTION PRIOR TO CONSTRUCTION. REPORT ELEVATION TO ENGINEER.
3. PIPE MATERIALS OPTIONS AVAILABLE. PLEASE RECORD PIPE MATERIALS USED ON DRAWING.

STORM NETWORK NOTES:

1. M–SCOPE TO LOCATE UTILITIES.
2. HAND DIG TO EXPOSE ALL UTILITIES.
3. ALL MANHOLE BARRELS TO BE 1050ø UNLESS NOTED OTHERWISE.
4. SEE SEWERS PERMIT xxxxxxxB FOR SERVICE LOCATION AND ACCOUNT NUMBERS.
5. LEAVE 150 STM/100 SAN WYES FOR ALL LOTS. MATCH EXISTING CONNECTION DIAMETER IF LARGER.
6. MEASURE WYE DISTANCES OF ALL CONNECTIONS FROM THE DOWNSTREAM SANITARY MANHOLE AND NOTE ON ATTACHED WYE SHEET. INDICATE IF CONNECTION IS FUTURE OR REHOOK.
7. SUBMIT COMPLETED WYE SHEET TO SEWER OPS SUPERINTENDENT.
8. TIE EXISTING COMBINED CONNECTIONS & CB'S TO PROPOSED STORM SEWERS.
9. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT JIM BURNETT AT 604–763–3602.

PIPE QUANTITIES ESTIMATE:
- 150mm SDR 28 PVC
- 200mm SDR 35 PVC

ACCOUNT NUMBERS: (FOR MAIN EXTENSION ONLY)
WBS:
CESD SEWERS:
CESD STREETS:
CESD OTHERS:

COST ESTIMATE (LESS STREET REPAIRS:)$

ORIGINAL BC ONE CALL TICKET NUMBER: NUMBER (CALL DATE)

PARKADE CONSTRUCTION NOTES:

1. EXCAVATION, FORMWORK, AND REINFORCED CONCRETE CONSTRUCTION WORK FOLLOW TYPICAL CONSTRUCTION STANDARDS, UNLESS NOTED OTHERWISE.
2. QA/QC REVIEWS OF CONCRETE MIX, MORTAR, AGGREGATES AND ENGINEERED FILL SHALL BE CARRIED OUT DAILY BY THE SITE SUPERINTENDENT, AND WEEKLY BY THE ENGINEER OF RECORD, UNLESS OTHERWISE SPECIFIED
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5. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ROADWAY AND ALL PARKADE PAINTING. PAINTING MATERIALS AND EQUIPMENT MUST BE CHECKED BY THE ENGINEER OF RECORD PRIOR TO INSTALLATION, AND MUST FOLLOW GUIDELINES SET OUT IN CSA S413 DESIGN OF PARKING STRUCTURES.
6. ALL WATERPROOFING METHODS SHALL BE DECIDED BY THE CONTRACTOR. APPROVAL MUST BE OBTAINED FROM ENGINEER OF RECORD BEFORE PROCEEDANCE

ISSUED FOR CONSTRUCTION

THE UNIVERSITY OF BRITISH COLUMBIA

LEGEND

- DISABILITY PARKING STALL
- SMALL CAR PARKING STALL
- SERVICE ROOM
- EV PARKING STALL
- NO PARKING AREA
- COLUMN

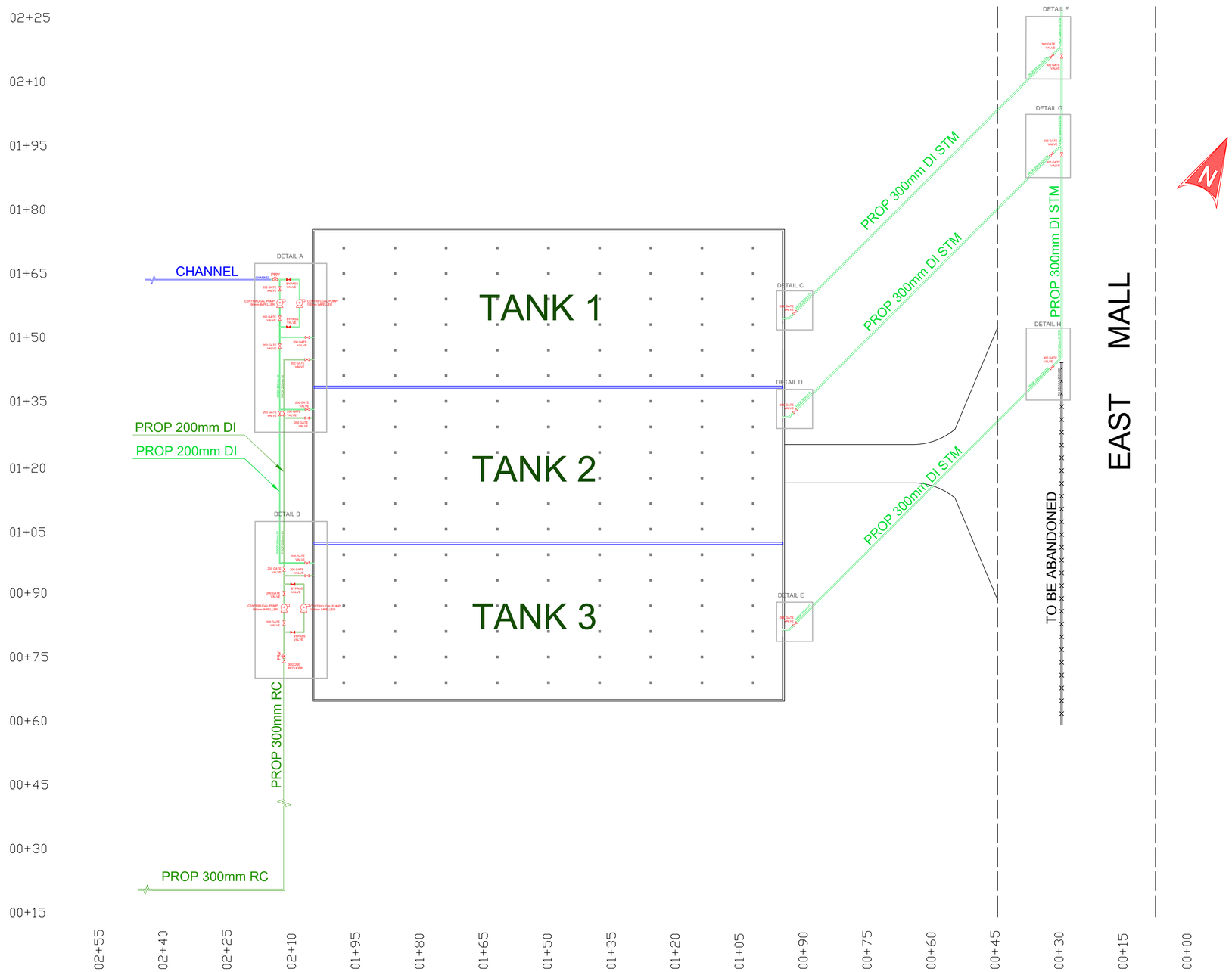
SRN UNDERGROUND PARKADES AND WATER STORAGE

DATE: April 5, 2019

DRAWING: SRN-001-02

PLAN VIEW - PARKADE P2

PRODUCED BY AN AUTODESK STUDENT VERSION



NOTES:

EAST MALL MAIN REPLACEMENT:
1. M–SCOPE TO LOCATE UTILITIES.
2. HAND DIG TO EXPOSE ALL UTILITIES.
3. ALL MANHOLE BARRELS TO BE 1050ø UNLESS NOTED OTHERWISE.
4. INSTALL 3 300X300X300 WYES.
5. INSTALL 6 GATE VALVES ON CONNECTIONS AT INLET AND WYE.
6. LEAVE 150 STM FOR ALL LOTS AND 200 STM CATCH BASIN LEADS. MATCH EXISTING CONNECTION DIAMETER IF LARGER.
7. MEASURE WYE DISTANCES OF ALL CONNECTIONS FROM THE DOWNSTREAM MANHOLE.
8. TIE EXISTING CONNECTIONS & CB'S TO PROPOSED STORM SEWER.
9. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT PEGGY CHEN AT 604–000–0000.

OUTFALL CONNECTION:
1. INSTALL 3 200MM DI AT OUTLET OF EACH TANK.
2. INSTALL GATE VALVE AT EACH OUTLET, BETWEEN TANK OUTLETS, AND BEFORE PUMP CONFIGURATION.
3. INSTALL 2 190MM IMPELLER CENTRIFUGAL PUMPS IN PARALLEL, CONNECTED BY 200MM DI. INSTALL BYPASS VALVES BETWEEN PUMPS.
4. INSTALL 200MM DI VERTICAL UNTIL EX 300 STM ELEVATION.
5. INSTALL PRV AND CONNECT TO EX 300 STM.
6. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT COLIN PHANG AT 604–000–0000.

CHANNEL:
1. INSTALL 3 200MM DI AT OUTLET OF EACH TANK.
2. INSTALL GATE VALVE AT EACH OUTLET, BETWEEN TANK OUTLETS, AND BEFORE PUMP CONFIGURATION.
3. INSTALL 2 190MM IMPELLER CENTRIFUGAL PUMPS IN PARALLEL, CONNECTED BY 200MM DI. INSTALL BYPASS VALVES BETWEEN PUMPS.
4. INSTALL 200MM DI VERTICAL UNTIL CHANNEL ELEVATION.
5. INSTALL PRV AND CONNECT TO CHANNEL
6. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT COLIN PHANG AT 604–000–0000.

PIPE QUANTITIES ESTIMATE:
- 300mm DI
- 200mm DI
- 300mm RC

ISSUED FOR CONSTRUCTION

THE UNIVERSITY OF BRITISH COLUMBIA

LEGEND

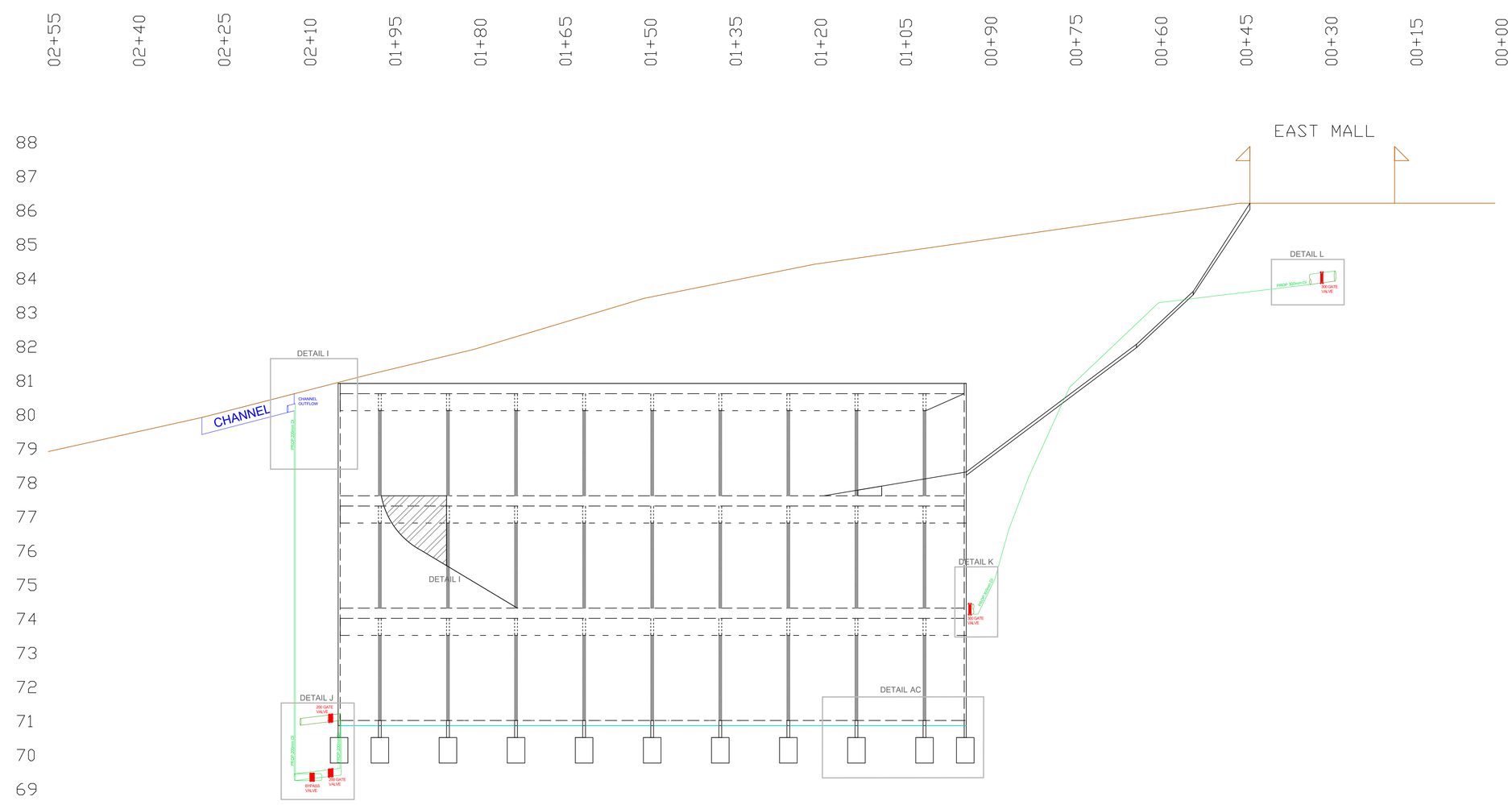
PUMP
VALVE
DI PIPE
300MM RC PIPE
TANK PARTITION
COLUMN

SRN UNDERGROUND PARKADES AND WATER STORAGE

DATE: April 5, 2019

DRAWING: SRN-001-03

PLAN VIEW - DETENTION TANK



NOTES:

1. FOR GENERAL NOTES SEE DRAWING SRN–001–00

EAST MALL MAIN REPLACEMENT:
1. M–SCOPE TO LOCATE UTILITIES.
2. HAND DIG TO EXPOSE ALL UTILITIES.
3. ALL MANHOLE BARRELS TO BE 1050ø UNLESS NOTED OTHERWISE.
4. INSTALL 3 300X300X300 WYES.
5. INSTALL 6 GATE VALVES ON CONNECTIONS AT INLET AND WYE.
6. LEAVE 150 STM FOR ALL LOTS AND 200 STM CATCH BASIN LEADS. MATCH EXISTING CONNECTION DIAMETER IF LARGER.
7. MEASURE WYE DISTANCES OF ALL CONNECTIONS FROM THE DOWNSTREAM MANHOLE.
8. TIE EXISTING CONNECTIONS & CB'S TO PROPOSED STORM SEWER.
9. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT PEGGY CHEN AT 604–000–0000.

OUTFALL CONNECTION:
1. INSTALL 3 200MM DI AT OUTLET OF EACH TANK.
2. INSTALL GATE VALVE AT EACH OUTLET, BETWEEN TANK OUTLETS, AND BEFORE PUMP CONFIGURATION.
3. INSTALL 2 190MM IMPELLER CENTRIFUGAL PUMPS IN PARALLEL, CONNECTED BY 200MM DI. INSTALL BYPASS VALVES BETWEEN PUMPS.
4. INSTALL 200MM DI VERTICAL UNTIL EX 300 STM ELEVATION.
5. INSTALL PRV AND CONNECT TO EX 300 STM.
6. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT COLIN PHANG AT 604–000–0000.

CHANNEL:
1. INSTALL 3 200MM DI AT OUTLET OF EACH TANK.
2. INSTALL GATE VALVE AT EACH OUTLET, BETWEEN TANK OUTLETS, AND BEFORE PUMP CONFIGURATION.
3. INSTALL 2 190MM IMPELLER CENTRIFUGAL PUMPS IN PARALLEL, CONNECTED BY 200MM DI. INSTALL BYPASS VALVES BETWEEN PUMPS.
4. INSTALL 200MM DI VERTICAL UNTIL CHANNEL ELEVATION.
5. INSTALL PRV AND CONNECT TO CHANNEL
6. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT COLIN PHANG AT 604–000–0000.

PIPE QUANTITIES ESTIMATE:
- 300mm DI
- 200mm DI
- 300mm RC

PARKADE CONSTRUCTION NOTES:
1. EXCAVATION, FORMWORK, AND REINFORCED CONCRETE CONSTRUCTION WORK FOLLOW TYPICAL CONSTRUCTION STANDARDS, UNLESS NOTED OTHERWISE.
2. QA/QC REVIEWS OF CONCRETE MIX, MORTAR, AGGREGATES AND ENGINEERED FILL SHALL BE CARRIED OUT DAILY BY THE SITE SUPERINTENDENT, AND WEEKLY BY THE ENGINEER OF RECORD, UNLESS OTHERWISE SPECIFIED
3. MECHANICAL AND ELECTRICAL SYSTEMS DESIGN AND INSTALLATION SHALL BE CARRIED OUT BY SUBCONTRACTORS HIRED BY THE GENERAL CONTRACTOR
4. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ADHERENCE TO THE PROVIDED GEOMETRIC DESIGN,
5. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ROADWAY AND ALL PARKADE PAINTING. PAINTING MATERIALS AND EQUIPMENT MUST BE CHECKED BY THE ENGINEER OF RECORD PRIOR TO INSTALLATION, AND MUST FOLLOW GUIDELINES SET OUT IN CSA S413 DESIGN OF PARKING STRUCTURES.
6. ALL WATERPROOFING METHODS SHALL BE DECIDED BY THE CONTRACTOR. APPROVAL MUST BE OBTAINED FROM ENGINEER OF RECORD BEFORE PROCEEDANCE

ISSUED FOR CONSTRUCTION

THE UNIVERSITY OF BRITISH COLUMBIA

LEGEND

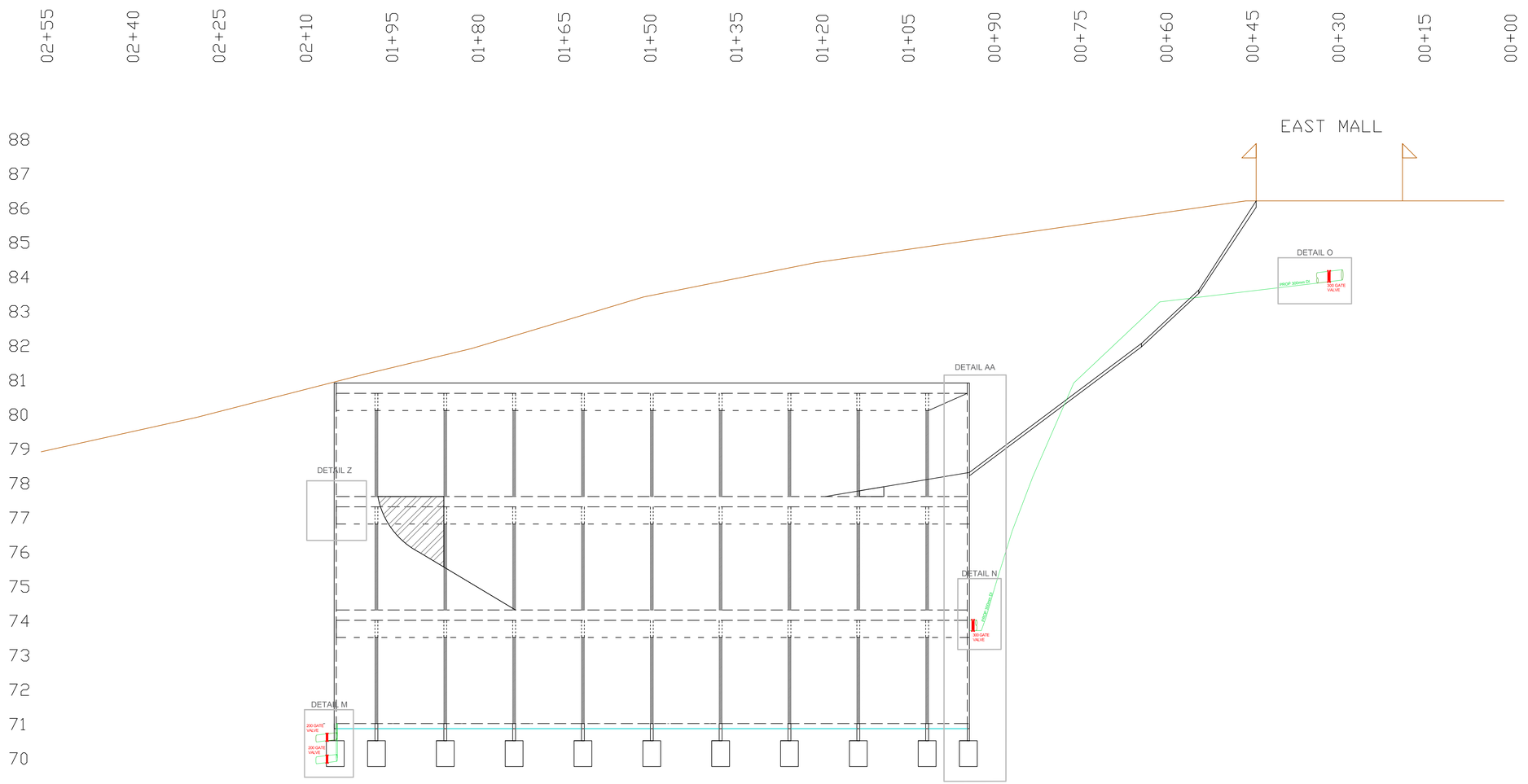
PUMP
VALVE
DI PIPE
300MM RC PIPE
POLYETHYLENE MEMBRANE
OPEN CHANNEL

SRN UNDERGROUND PARKADES AND WATER STORAGE

DATE: April 5, 2019

DRAWING: SRN-001-04

PROFILE VIEW - from W 16th Ave
DETENTION TANK 1



NOTES:

1. FOR GENERAL NOTES SEE DRAWING SRN–001–00

EAST MALL MAIN REPLACEMENT:
1. M–SCOPE TO LOCATE UTILITIES.
2. HAND DIG TO EXPOSE ALL UTILITIES.
3. ALL MANHOLE BARRELS TO BE 1050ø UNLESS NOTED OTHERWISE.
4. INSTALL 3 300X300X300 WYES.
5. INSTALL 6 GATE VALVES ON CONNECTIONS AT INLET AND WYE.
6. LEAVE 150 STM FOR ALL LOTS AND 200 STM CATCH BASIN LEADS. MATCH EXISTING CONNECTION DIAMETER IF LARGER.
7. MEASURE WYE DISTANCES OF ALL CONNECTIONS FROM THE DOWNSTREAM MANHOLE.
8. TIE EXISTING CONNECTIONS & CB'S TO PROPOSED STORM SEWER.
9. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT PEGGY CHEN AT 604–000–0000.

OUTFALL CONNECTION:
1. INSTALL 3 200MM DI AT OUTLET OF EACH TANK.
2. INSTALL GATE VALVE AT EACH OUTLET, BETWEEN TANK OUTLETS, AND BEFORE PUMP CONFIGURATION.
3. INSTALL 2 190MM IMPELLER CENTRIFUGAL PUMPS IN PARALLEL, CONNECTED BY 200MM DI. INSTALL BYPASS VALVES BETWEEN PUMPS.
4. INSTALL 200MM DI VERTICAL UNTIL EX 300 STM ELEVATION.
5. INSTALL PRV AND CONNECT TO EX 300 STM.
6. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT COLIN PHANG AT 604–000–0000.

CHANNEL:
1. INSTALL 3 200MM DI AT OUTLET OF EACH TANK.
2. INSTALL GATE VALVE AT EACH OUTLET, BETWEEN TANK OUTLETS, AND BEFORE PUMP CONFIGURATION.
3. INSTALL 2 190MM IMPELLER CENTRIFUGAL PUMPS IN PARALLEL, CONNECTED BY 200MM DI. INSTALL BYPASS VALVES BETWEEN PUMPS.
4. INSTALL 200MM DI VERTICAL UNTIL CHANNEL ELEVATION.
5. INSTALL PRV AND CONNECT TO CHANNEL
6. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT COLIN PHANG AT 604–000–0000.

PIPE QUANTITIES ESTIMATE:
- 300mm DI
- 200mm DI
- 300mm RC

PARKADE CONSTRUCTION NOTES:
1. EXCAVATION, FORMWORK, AND REINFORCED CONCRETE CONSTRUCTION WORK FOLLOW TYPICAL CONSTRUCTION STANDARDS, UNLESS NOTED OTHERWISE.
2. QA/QC REVIEWS OF CONCRETE MIX, MORTAR, AGGREGATES AND ENGINEERED FILL SHALL BE CARRIED OUT DAILY BY THE SITE SUPERINTENDENT, AND WEEKLY BY THE ENGINEER OF RECORD, UNLESS OTHERWISE SPECIFIED
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6. ALL WATERPROOFING METHODS SHALL BE DECIDED BY THE CONTRACTOR. APPROVAL MUST BE OBTAINED FROM ENGINEER OF RECORD BEFORE PROCEEDANCE

ISSUED FOR CONSTRUCTION

THE UNIVERSITY OF BRITISH COLUMBIA

LEGEND

PUMP
VALVE
DI PIPE
300MM RC PIPE
POLYETHYLENE MEMBRANE
OPEN CHANNEL

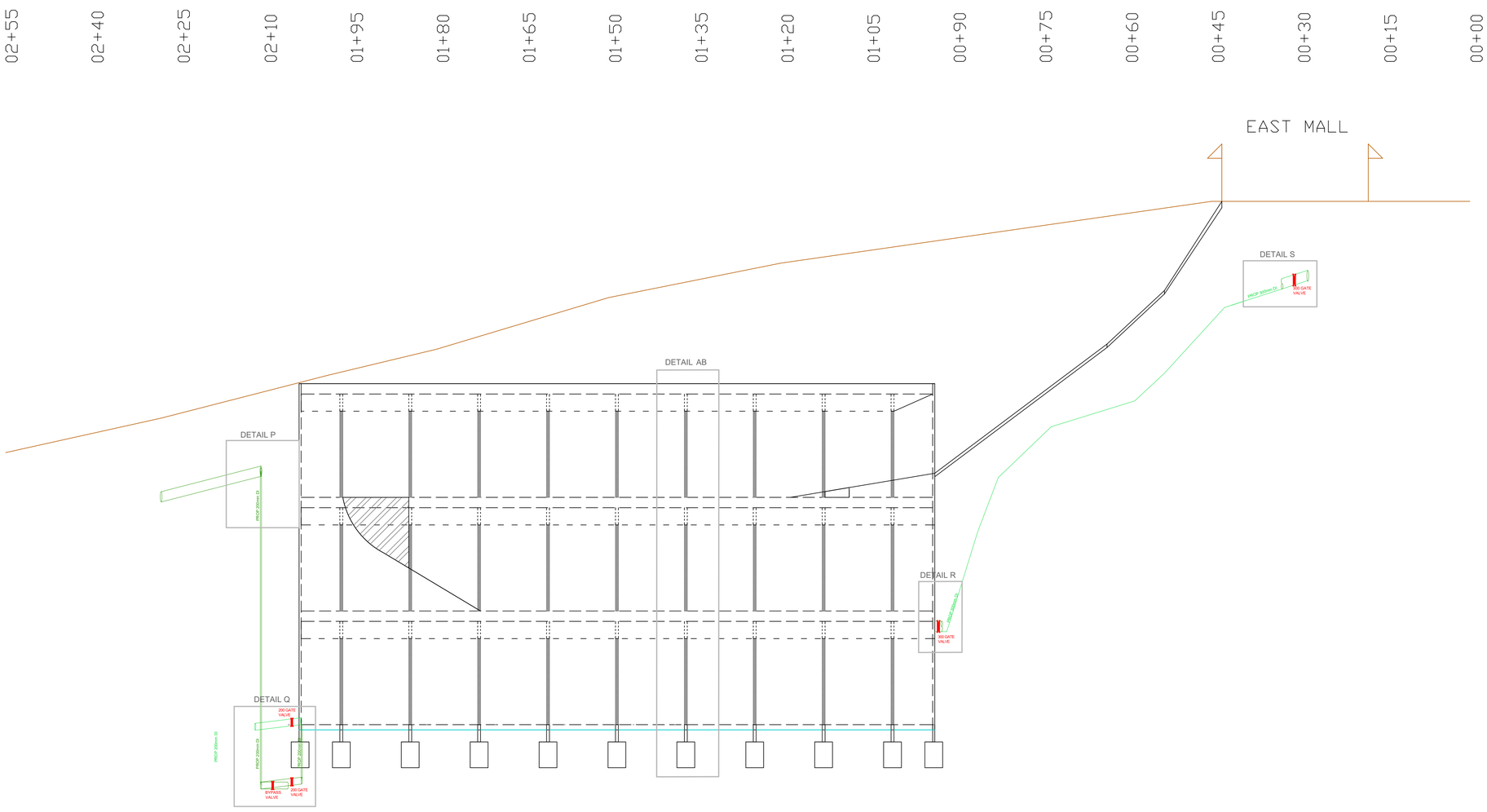
SRN UNDERGROUND PARKADES AND WATER STORAGE

DATE: April 5, 2019

DRAWING: SRN-001-05

PROFILE VIEW - from W 16th Ave
DETENTION TANK 2

PRODUCED BY AN AUTODESK STUDENT VERSION



NOTES:

1. FOR GENERAL NOTES SEE DRAWING SRN–001–00

EAST MALL MAIN REPLACEMENT:
1. M–SCOPE TO LOCATE UTILITIES.
2. HAND DIG TO EXPOSE ALL UTILITIES.
3. ALL MANHOLE BARRELS TO BE 1050ø UNLESS NOTED OTHERWISE.
4. INSTALL 3 300X300X300 WYES.
5. INSTALL 6 GATE VALVES ON CONNECTIONS AT INLET AND WYE.
6. LEAVE 150 STM FOR ALL LOTS AND 200 STM CATCH BASIN LEADS. MATCH EXISTING CONNECTION DIAMETER IF LARGER.
7. MEASURE WYE DISTANCES OF ALL CONNECTIONS FROM THE DOWNSTREAM MANHOLE.
8. TIE EXISTING CONNECTIONS & CB'S TO PROPOSED STORM SEWER.
9. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT PEGGY CHEN AT 604–000–0000.

OUTFALL CONNECTION:
1. INSTALL 3 200MM DI AT OUTLET OF EACH TANK.
2. INSTALL GATE VALVE AT EACH OUTLET, BETWEEN TANK OUTLETS, AND BEFORE PUMP CONFIGURATION.
3. INSTALL 2 190MM IMPELLER CENTRIFUGAL PUMPS IN PARALLEL, CONNECTED BY 200MM DI. INSTALL BYPASS VALVES BETWEEN PUMPS.
4. INSTALL 200MM DI VERTICAL UNTIL EX 300 STM ELEVATION.
5. INSTALL PRV AND CONNECT TO EX 300 STM.
6. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT COLIN PHANG AT 604–000–0000.

CHANNEL:
1. INSTALL 3 200MM DI AT OUTLET OF EACH TANK.
2. INSTALL GATE VALVE AT EACH OUTLET, BETWEEN TANK OUTLETS, AND BEFORE PUMP CONFIGURATION.
3. INSTALL 2 190MM IMPELLER CENTRIFUGAL PUMPS IN PARALLEL, CONNECTED BY 200MM DI. INSTALL BYPASS VALVES BETWEEN PUMPS.
4. INSTALL 200MM DI VERTICAL UNTIL CHANNEL ELEVATION.
5. INSTALL PRV AND CONNECT TO CHANNEL
6. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT COLIN PHANG AT 604–000–0000.

PIPE QUANTITIES ESTIMATE:
- 300mm DI
- 200mm DI
- 300mm RC

PARKADE CONSTRUCTION NOTES:
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ISSUED FOR CONSTRUCTION

THE UNIVERSITY OF BRITISH COLUMBIA

LEGEND

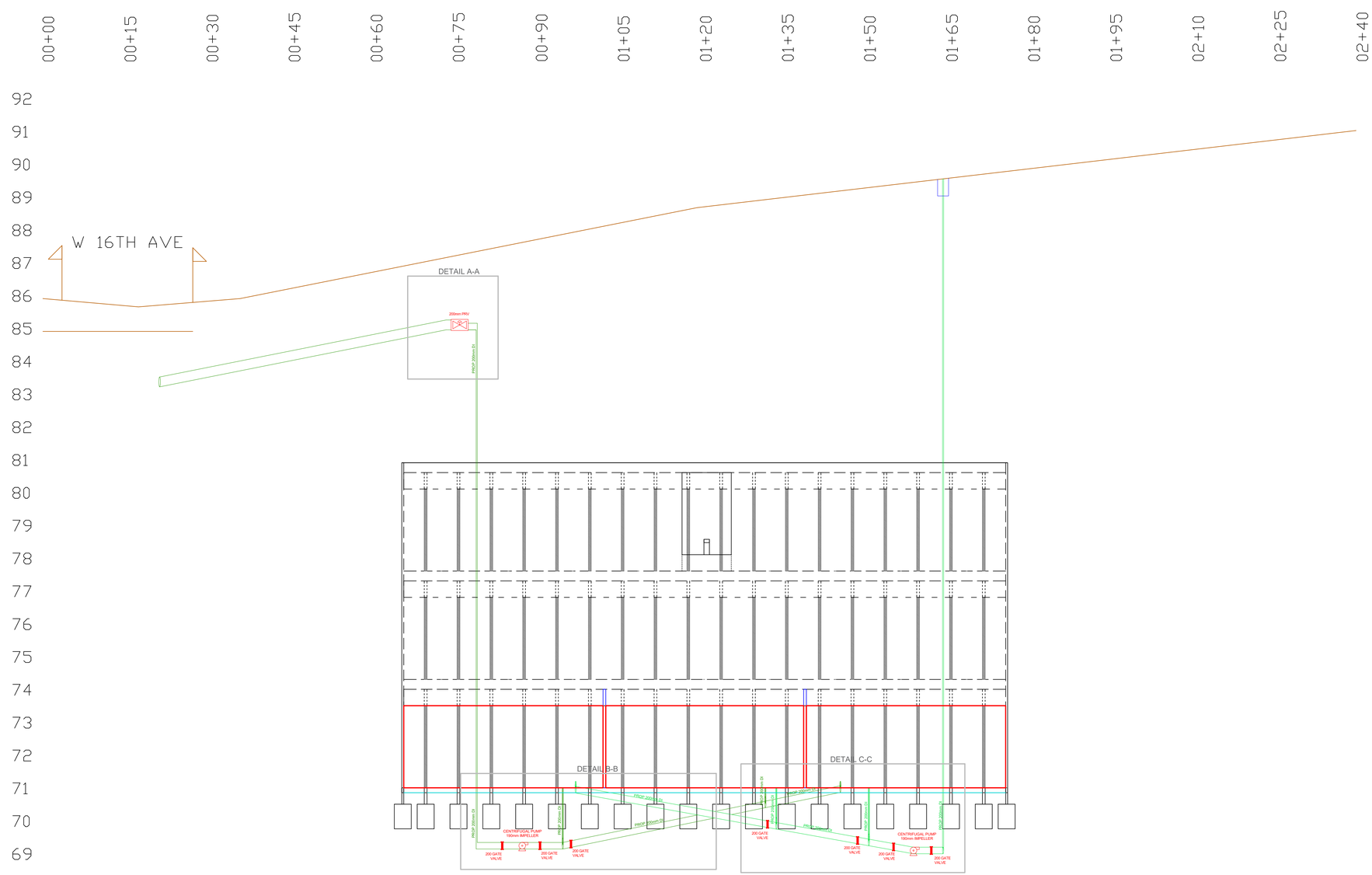
PUMP
VALVE
DI PIPE
300MM RC PIPE
POLYETHYLENE MEMBRANE
OPEN CHANNEL

SRN UNDERGROUND PARKADES AND WATER STORAGE

DATE: April 5, 2019

DRAWING: SRN-001-06

PROFILE VIEW - from W 16th Ave
DETENTION TANK 3



NOTES:

1. FOR GENERAL NOTES SEE DRAWING SRN–001–00

EAST MALL MAIN REPLACEMENT:
1. M–SCOPE TO LOCATE UTILITIES.
2. HAND DIG TO EXPOSE ALL UTILITIES.
3. ALL MANHOLE BARRELS TO BE 1050ø UNLESS NOTED OTHERWISE.
4. INSTALL 3 300X300X300 WYES.
5. INSTALL 6 GATE VALVES ON CONNECTIONS AT INLET AND WYE.
6. LEAVE 150 STM FOR ALL LOTS AND 200 STM CATCH BASIN LEADS. MATCH EXISTING CONNECTION DIAMETER IF LARGER.
7. MEASURE WYE DISTANCES OF ALL CONNECTIONS FROM THE DOWNSTREAM MANHOLE.
8. TIE EXISTING CONNECTIONS & CB'S TO PROPOSED STORM SEWER.
9. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT PEGGY CHEN AT 604–000–0000.

OUTFALL CONNECTION:
1. INSTALL 3 200MM DI AT OUTLET OF EACH TANK.
2. INSTALL GATE VALVE AT EACH OUTLET, BETWEEN TANK OUTLETS, AND BEFORE PUMP CONFIGURATION.
3. INSTALL 2 190MM IMPELLER CENTRIFUGAL PUMPS IN PARALLEL, CONNECTED BY 200MM DI. INSTALL BYPASS VALVES BETWEEN PUMPS.
4. INSTALL 200MM DI VERTICAL UNTIL EX 300 STM ELEVATION.
5. INSTALL PRV AND CONNECT TO EX 300 STM.
6. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT COLIN PHANG AT 604–000–0000.

CHANNEL:
1. INSTALL 3 200MM DI AT OUTLET OF EACH TANK.
2. INSTALL GATE VALVE AT EACH OUTLET, BETWEEN TANK OUTLETS, AND BEFORE PUMP CONFIGURATION.
3. INSTALL 2 190MM IMPELLER CENTRIFUGAL PUMPS IN PARALLEL, CONNECTED BY 200MM DI. INSTALL BYPASS VALVES BETWEEN PUMPS.
4. INSTALL 200MM DI VERTICAL UNTIL CHANNEL ELEVATION.
5. INSTALL PRV AND CONNECT TO CHANNEL
6. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT COLIN PHANG AT 604–000–0000.

PIPE QUANTITIES ESTIMATE:
- 300mm DI
- 200mm DI
- 300mm RC

PARKADE CONSTRUCTION NOTES:
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6. ALL WATERPROOFING METHODS SHALL BE DECIDED BY THE CONTRACTOR. APPROVAL MUST BE OBTAINED FROM ENGINEER OF RECORD BEFORE PROCEEDANCE

ISSUED FOR CONSTRUCTION

THE UNIVERSITY OF BRITISH COLUMBIA

LEGEND

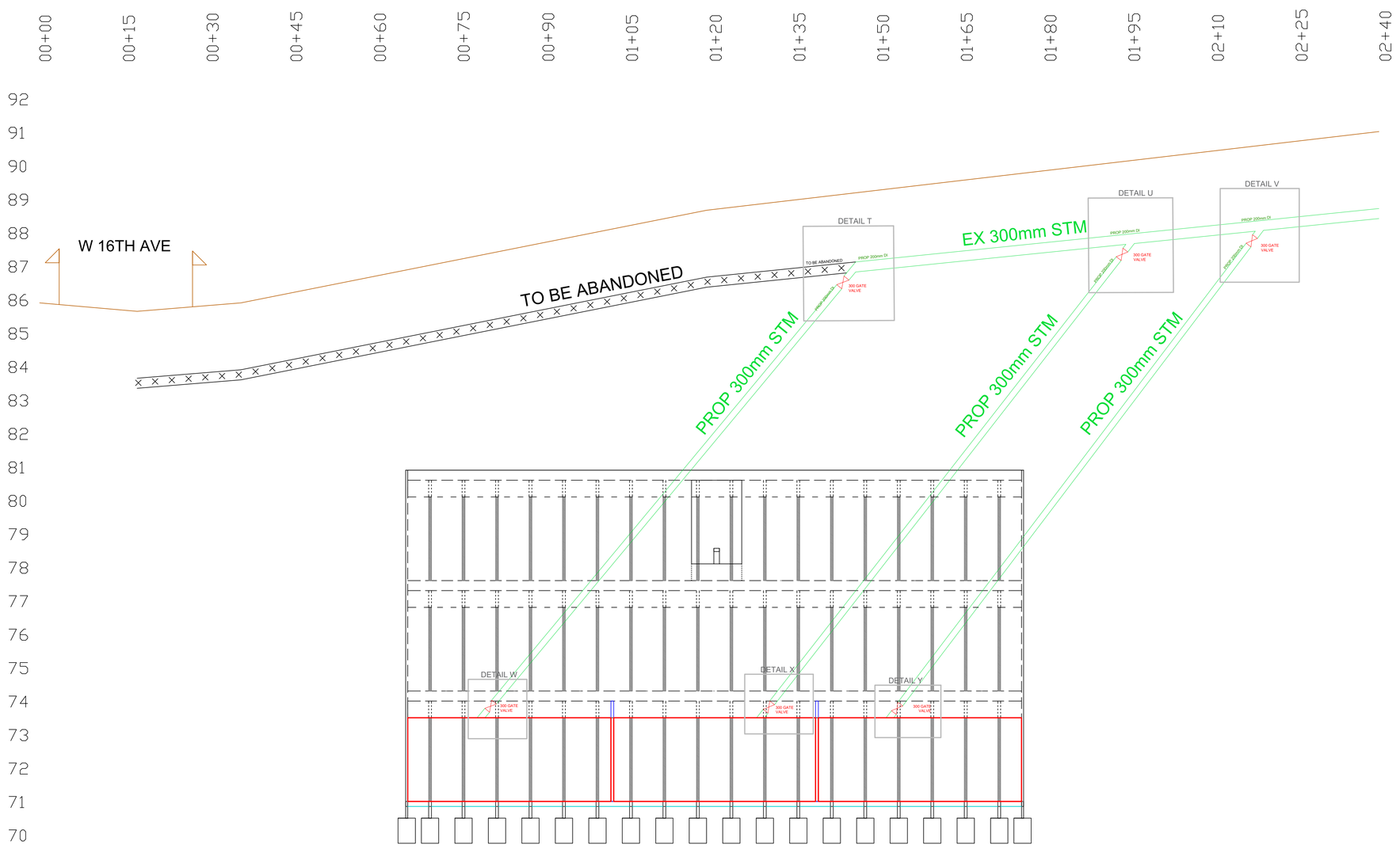
PUMP
VALVE
DI PIPE
300MM RC PIPE
POLYETHYLENE MEMBRANE
OPEN CHANNEL

SRN UNDERGROUND PARKADES AND WATER STORAGE

DATE: April 5, 2019

DRAWING: SRN-001-07

PROFILE VIEW - from EAST MALL
WEST WALL



NOTES:

1. FOR GENERAL NOTES SEE DRAWING SRN–001–00

EAST MALL MAIN REPLACEMENT:
1. M–SCOPE TO LOCATE UTILITIES.
2. HAND DIG TO EXPOSE ALL UTILITIES.
3. ALL MANHOLE BARRELS TO BE 1050ø UNLESS NOTED OTHERWISE.
4. INSTALL 3 300X300X300 WYES.
5. INSTALL 6 GATE VALVES ON CONNECTIONS AT INLET AND WYE.
6. LEAVE 150 STM FOR ALL LOTS AND 200 STM CATCH BASIN LEADS. MATCH EXISTING CONNECTION DIAMETER IF LARGER.
7. MEASURE WYE DISTANCES OF ALL CONNECTIONS FROM THE DOWNSTREAM MANHOLE.
8. TIE EXISTING CONNECTIONS & CB'S TO PROPOSED STORM SEWER.
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OUTFALL CONNECTION:
1. INSTALL 3 200MM DI AT OUTLET OF EACH TANK.
2. INSTALL GATE VALVE AT EACH OUTLET, BETWEEN TANK OUTLETS, AND BEFORE PUMP CONFIGURATION.
3. INSTALL 2 190MM IMPELLER CENTRIFUGAL PUMPS IN PARALLEL, CONNECTED BY 200MM DI. INSTALL BYPASS VALVES BETWEEN PUMPS.
4. INSTALL 200MM DI VERTICAL UNTIL EX 300 STM ELEVATION.
5. INSTALL PRV AND CONNECT TO EX 300 STM.
6. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT COLIN PHANG AT 604–000–0000.

CHANNEL:
1. INSTALL 3 200MM DI AT OUTLET OF EACH TANK.
2. INSTALL GATE VALVE AT EACH OUTLET, BETWEEN TANK OUTLETS, AND BEFORE PUMP CONFIGURATION.
3. INSTALL 2 190MM IMPELLER CENTRIFUGAL PUMPS IN PARALLEL, CONNECTED BY 200MM DI. INSTALL BYPASS VALVES BETWEEN PUMPS.
4. INSTALL 200MM DI VERTICAL UNTIL CHANNEL ELEVATION.
5. INSTALL PRV AND CONNECT TO CHANNEL
6. IF THERE ARE ANY QUESTIONS, PLEASE CONTACT COLIN PHANG AT 604–000–0000.

PIPE QUANTITIES ESTIMATE:
- 300mm DI
- 200mm DI
- 300mm RC

PARKADE CONSTRUCTION NOTES:
1. EXCAVATION, FORMWORK, AND REINFORCED CONCRETE CONSTRUCTION WORK FOLLOW TYPICAL CONSTRUCTION STANDARDS, UNLESS NOTED OTHERWISE.
2. QA/QC REVIEWS OF CONCRETE MIX, MORTAR, AGGREGATES AND ENGINEERED FILL SHALL BE CARRIED OUT DAILY BY THE SITE SUPERINTENDENT, AND WEEKLY BY THE ENGINEER OF RECORD, UNLESS OTHERWISE SPECIFIED
3. MECHANICAL AND ELECTRICAL SYSTEMS DESIGN AND INSTALLATION SHALL BE CARRIED OUT BY SUBCONTRACTORS HIRED BY THE GENERAL CONTRACTOR
4. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ADHERENCE TO THE PROVIDED GEOMETRIC DESIGN.
5. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ROADWAY AND ALL PARKADE PAINTING. PAINTING MATERIALS AND EQUIPMENT MUST BE CHECKED BY THE ENGINEER OF RECORD PRIOR TO INSTALLATION, AND MUST FOLLOW GUIDELINES SET OUT IN CSA S413 DESIGN OF PARKING STRUCTURES.
6. ALL WATERPROOFING METHODS SHALL BE DECIDED BY THE CONTRACTOR. APPROVAL MUST BE OBTAINED FROM ENGINEER OF RECORD BEFORE PROCEEDANCE

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LEGEND

PUMP
VALVE
DI PIPE
300MM RC PIPE
POLYETHYLENE MEMBRANE
TANK PARTITION

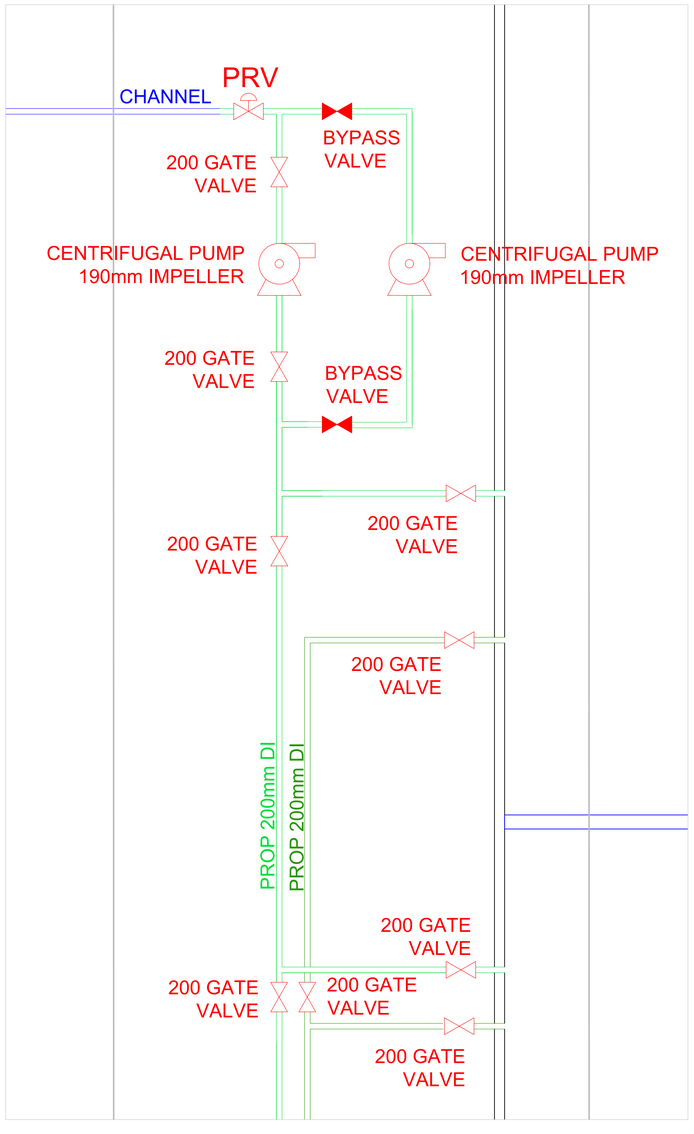
SRN UNDERGROUND PARKADES AND WATER STORAGE

DATE: April 5, 2019

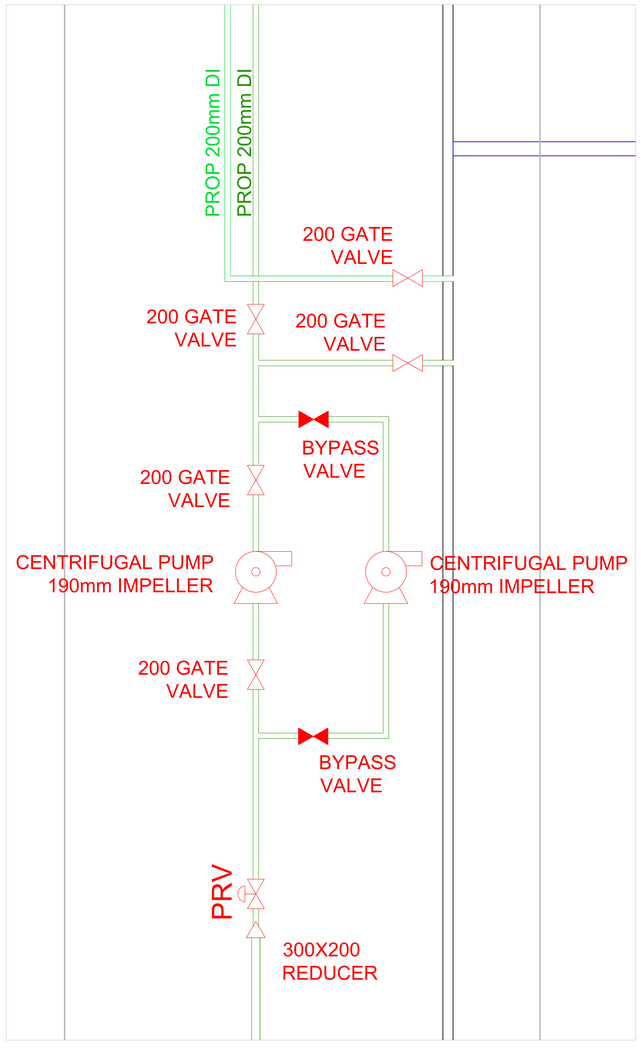
DRAWING: SRN-001-08

PROFILE VIEW - from EAST MALL
EAST WALL

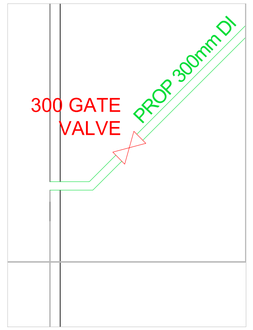
DETAIL A
PLAN VIEW
SCALE 10:1



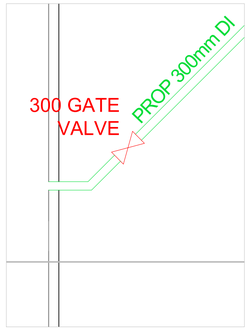
DETAIL B
PLAN VIEW
SCALE 10:1



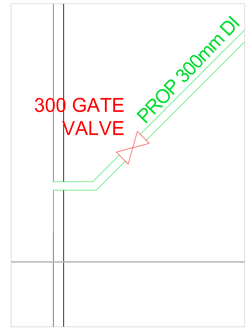
DETAIL C
PLAN VIEW
SCALE 10:1



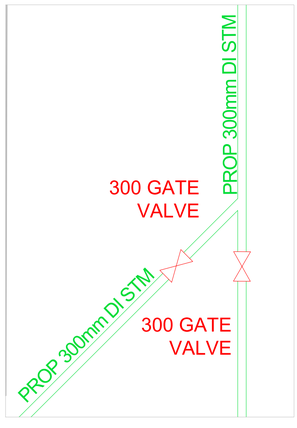
DETAIL D
PLAN VIEW
SCALE 10:1



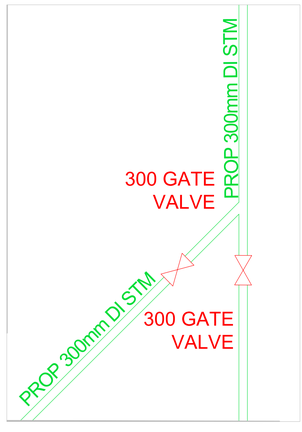
DETAIL E
PLAN VIEW
SCALE 10:1



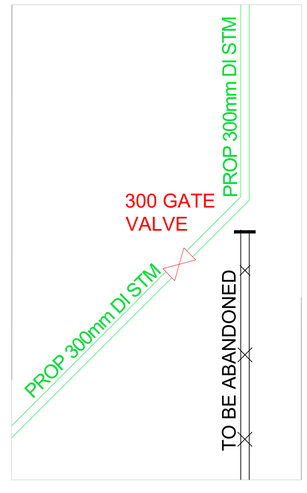
DETAIL F
PLAN VIEW
SCALE 10:1



DETAIL G
PLAN VIEW
SCALE 10:1



DETAIL H
PLAN VIEW
SCALE 10:1



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LEGEND

SRN UNDERGROUND PARKADES AND WATER STORAGE

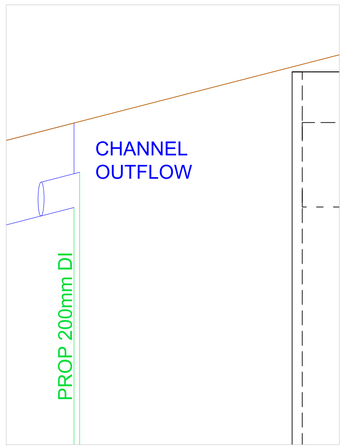
DATE: April 5, 2019

DRAWING: SRN-001-D1

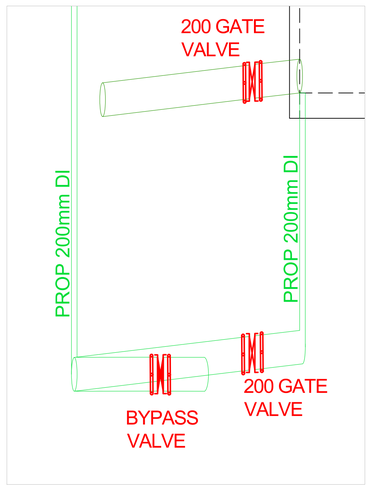
PLAN VIEW - DETENTION TANK
DETAILS AND SECTIONS

Tank 1

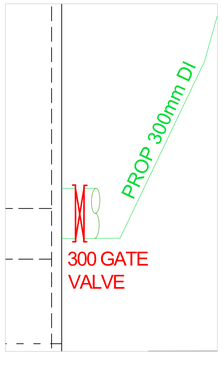
DETAIL I
PROFILE VIEW
SCALE 10:1



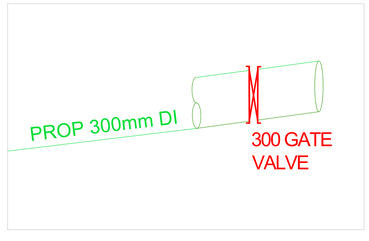
DETAIL J
PROFILE VIEW
SCALE 10:1



DETAIL K
PROFILE VIEW
SCALE 10:1

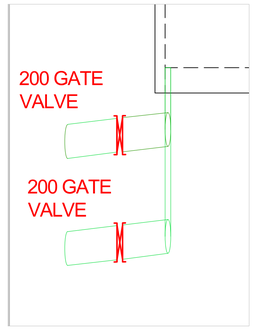


DETAIL L
PROFILE VIEW
SCALE 10:1

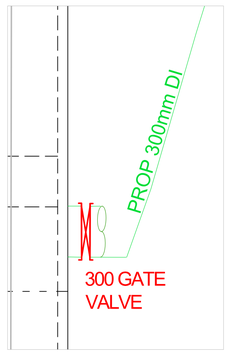


Tank 2

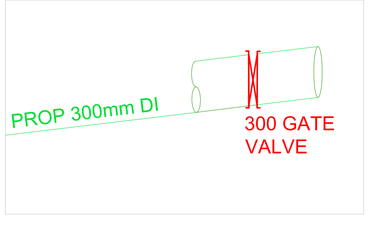
DETAIL M
PROFILE VIEW
SCALE 10:1



DETAIL N
PROFILE VIEW
SCALE 10:1

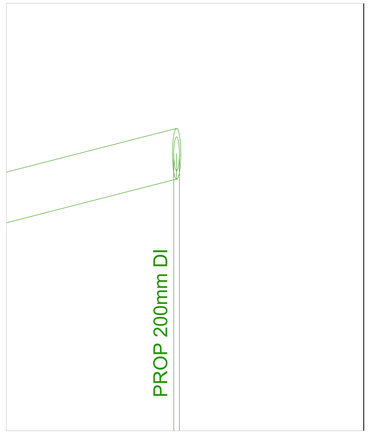


DETAIL O
PROFILE VIEW
SCALE 10:1

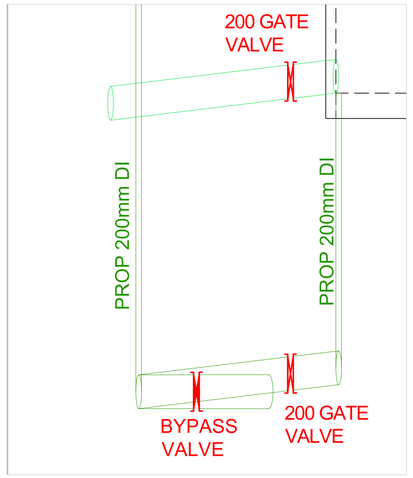


Tank 3

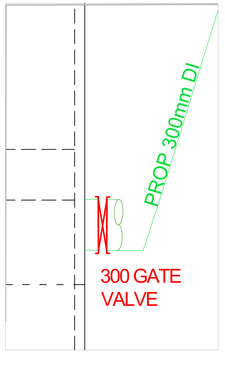
DETAIL P
PROFILE VIEW
SCALE 10:1



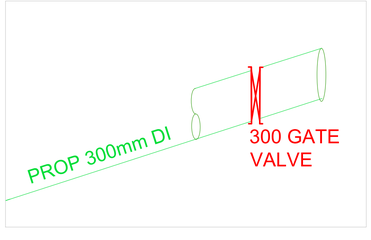
DETAIL Q
PROFILE VIEW
SCALE 10:1



DETAIL R
PROFILE VIEW
SCALE 10:1



DETAIL S
PROFILE VIEW
SCALE 10:1



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THE UNIVERSITY OF BRITISH COLUMBIA

LEGEND

SRN UNDERGROUND PARKADES AND WATER STORAGE

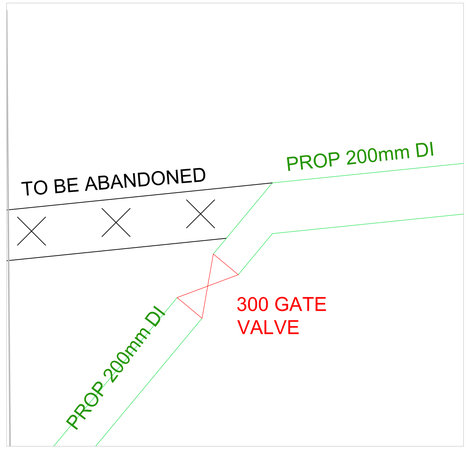
DATE: April 5, 2019

DRAWING: SRN-001-D2

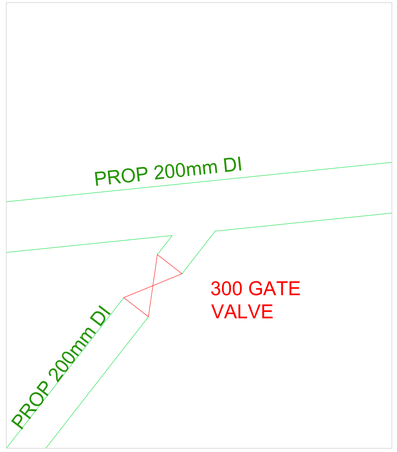
PROFILE VIEW - from W 16th Ave
DETAILS AND SECTIONS

PRODUCED BY AN AUTODESK STUDENT VERSION

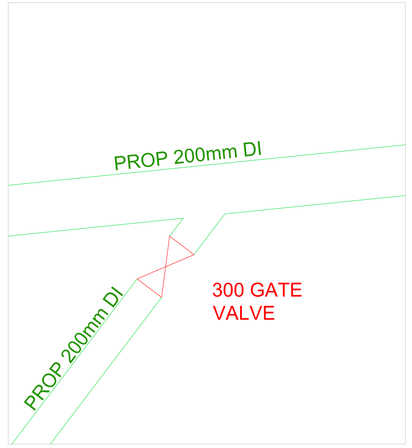
DETAIL T
PROFILE VIEW
SCALE 10:1



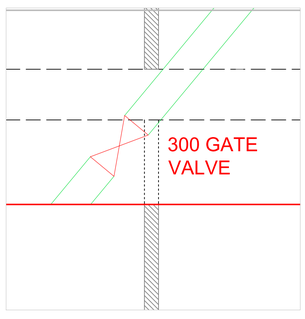
DETAIL U
PROFILE VIEW
SCALE 10:1



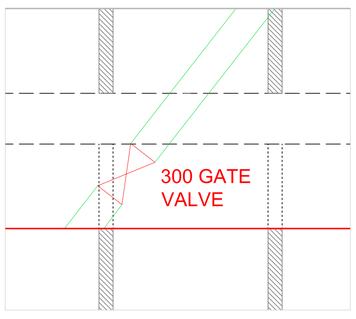
DETAIL V
PROFILE VIEW
SCALE 10:1



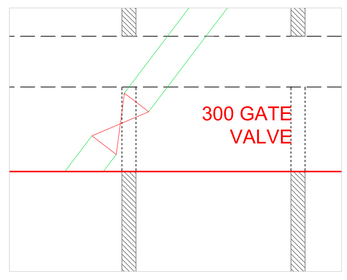
DETAIL W
PROFILE VIEW
SCALE 10:1



DETAIL X
PROFILE VIEW
SCALE 10:1



DETAIL Y
PROFILE VIEW
SCALE 10:1



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THE UNIVERSITY OF BRITISH COLUMBIA

LEGEND

SRN UNDERGROUND PARKADES AND WATER STORAGE

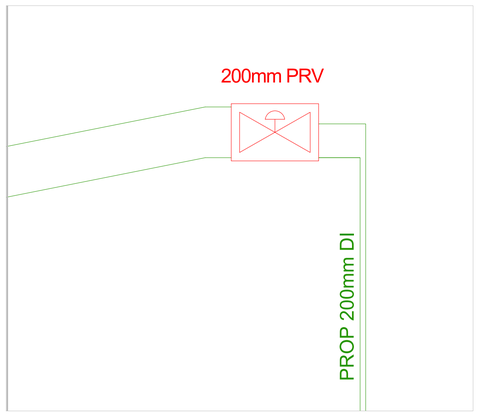
DATE: April 5, 2019

DRAWING: SRN-001-D3

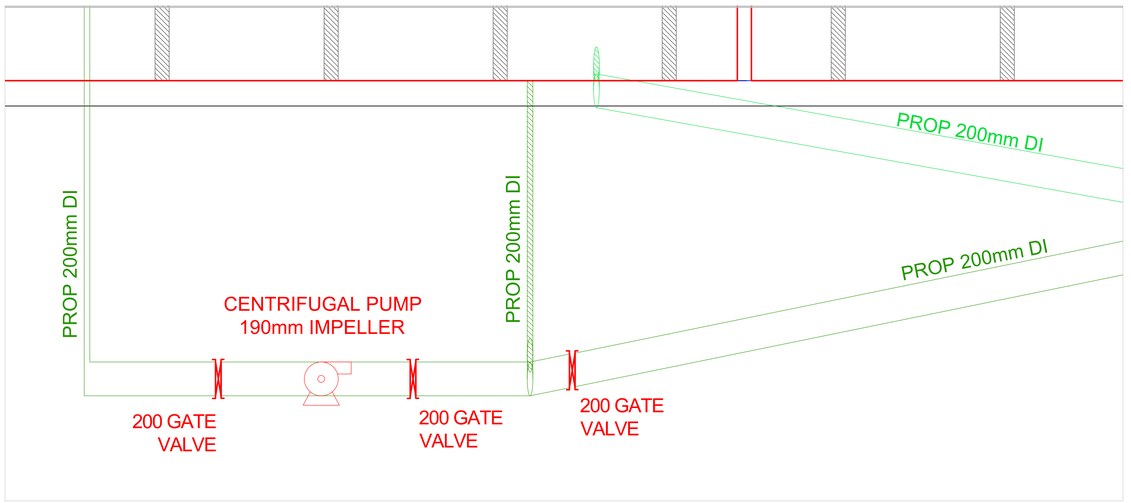
PROFILE VIEW - from EAST MALL
EAST WALL - DETAILS AND SECTIONS

PRODUCED BY AN AUTODESK STUDENT VERSION

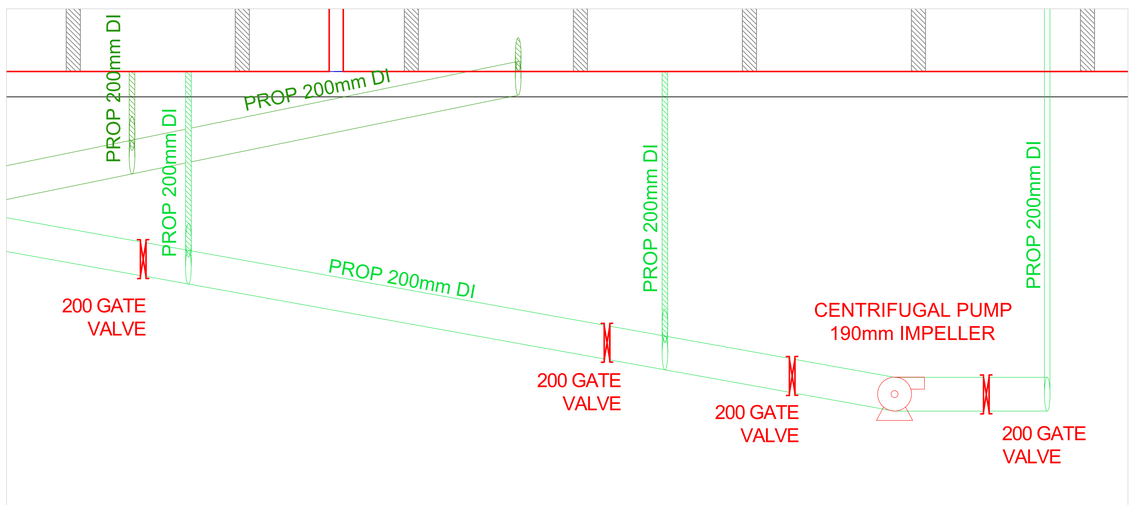
DETAIL A-A
PROFILE VIEW
SCALE 10:1



DETAIL B-B
PROFILE VIEW
SCALE 10:1



DETAIL C-C
PROFILE VIEW
SCALE 10:1



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THE UNIVERSITY OF BRITISH COLUMBIA

LEGEND

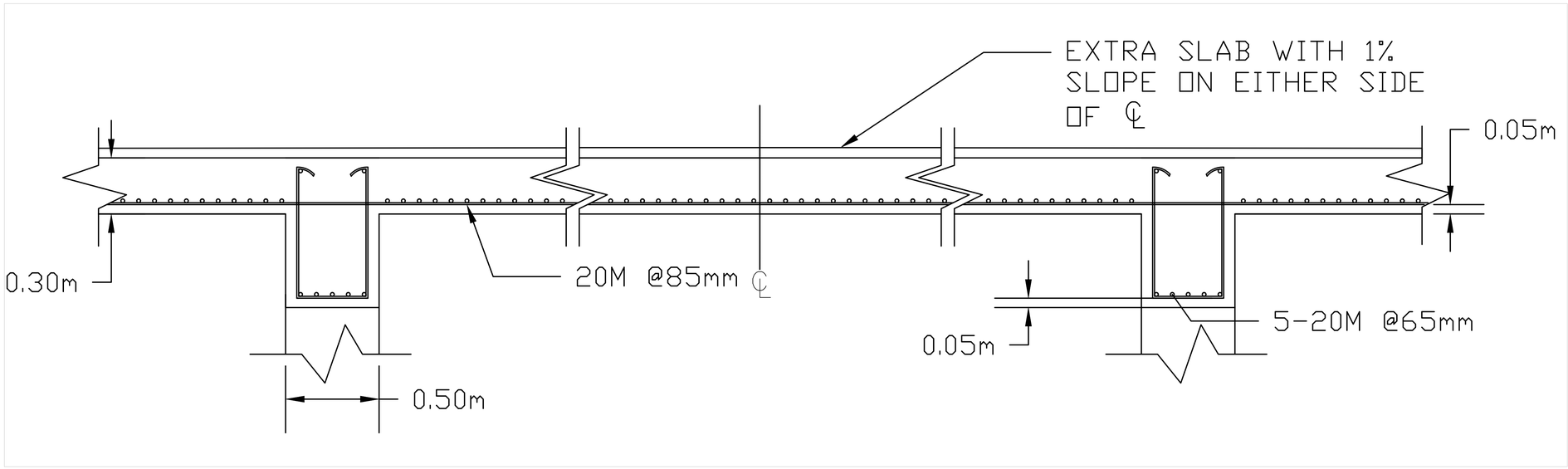
SRN UNDERGROUND PARKADES AND WATER STORAGE

DATE: April 5, 2019

DRAWING: SRN-001-D4

PROFILE VIEW - from EAST MALL
DETAILS AND SECTIONS

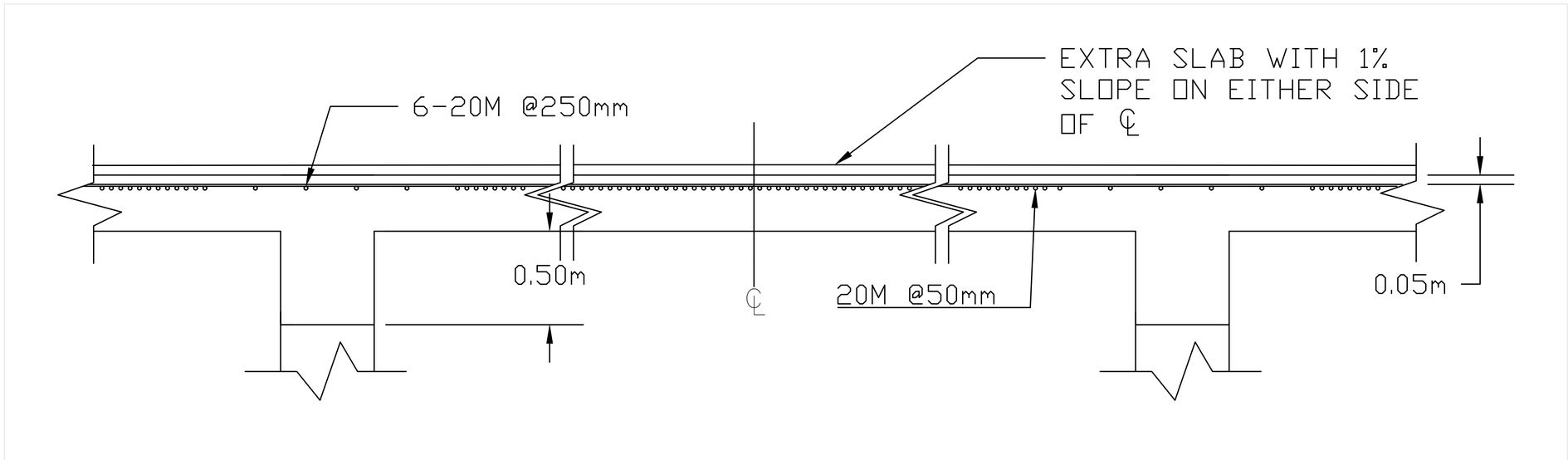
DETAIL D-D
PROFILE VIEW
SCALE 80:1



NOTES:

1. SHEAR STIRRUPS SHALL BE PLACED IN BEAMS IN NORTH SOUTH DIRECTION ONLY. 10M@450MM SHALL BE USED FROM 1M TO 1.8M AWAY FROM COLUMN SUPPORT. 10M@1000MM SHALL BE USED FROM 1.8M ONWARD.
2. ALL LONGITUDINAL REINFORCEMENT SHALL HAVE A TOP AND BOTTOM LAYER, FORMING A CAGE THAT IS SUPPORTED BY STIRRUPS. ONLY THE REINFORCEMENT LAYER OF STRUCTURAL INTEREST IS SHOWN IN DETAILS. TOP AND BOTTOM LAYERED REINFORCEMENT SETUP SHALL BE USED DURING CONSTRUCTION.

DETAIL E-E
PROFILE VIEW
SCALE 80:1



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LEGEND

SRN UNDERGROUND PARKADES AND WATER STORAGE

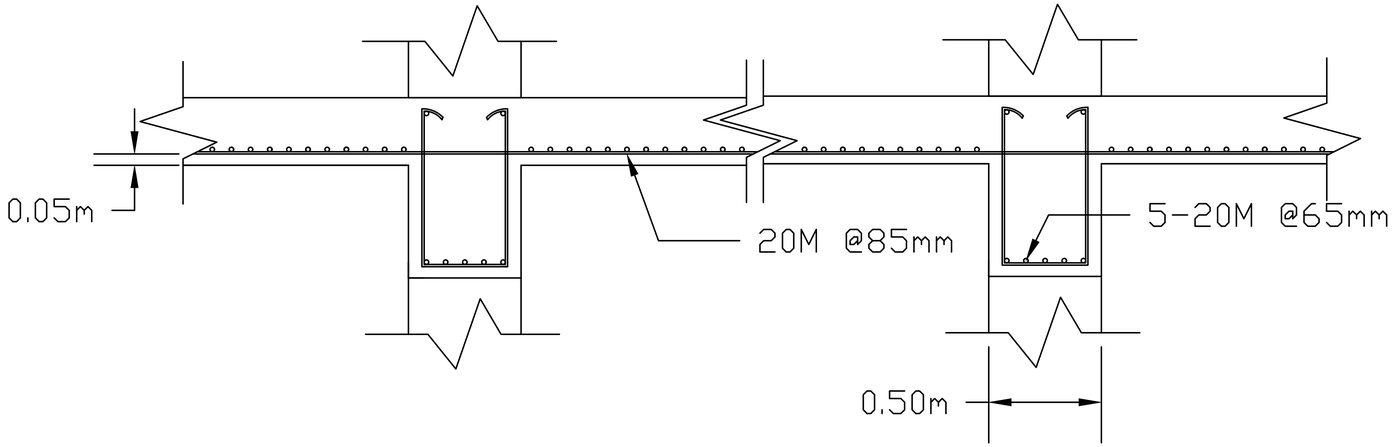
DATE: April 5, 2019

DRAWING: SRN-001-D5

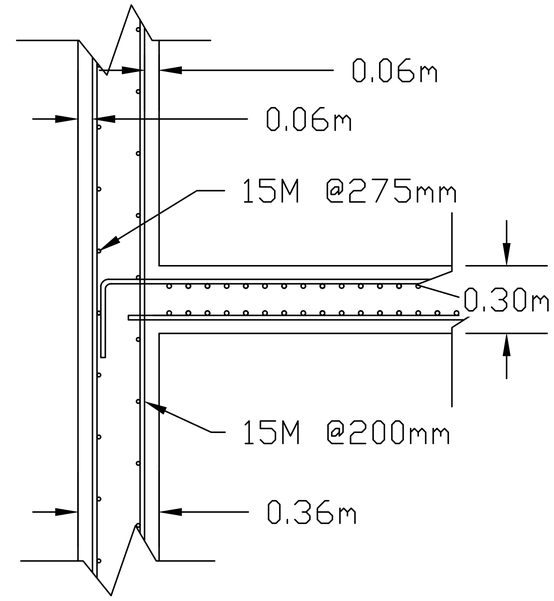
PARKADE - SLAB
DETAILS AND SECTIONS

PRODUCED BY AN AUTODESK STUDENT VERSION

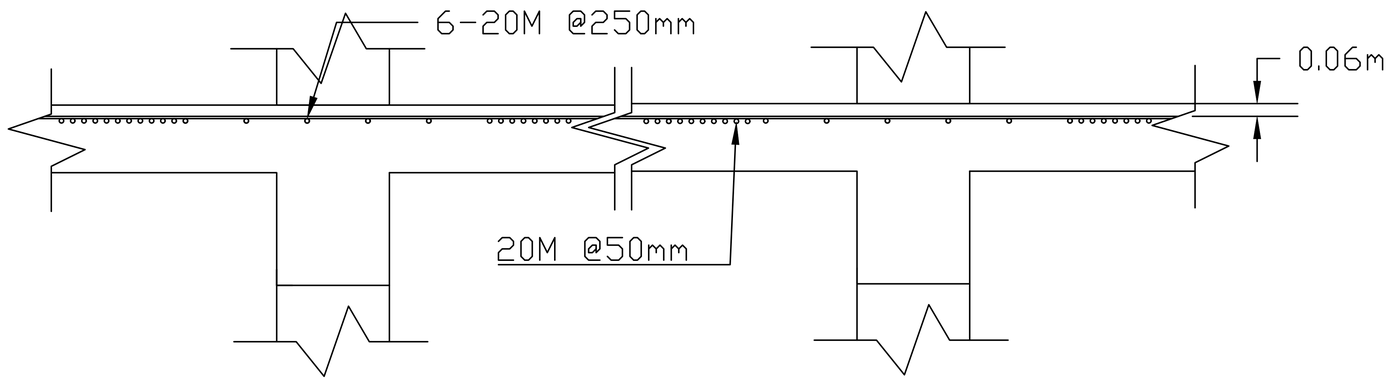
DETAIL F-F
PROFILE VIEW
SCALE 80:1



DETAIL Z
PROFILE VIEW
SCALE 80:1



DETAIL G-G
PROFILE VIEW
SCALE 80:1



NOTES:

1. SHEAR STIRRUPS SHALL BE PLACED IN BEAMS IN NORTH SOUTH DIRECTION ONLY. 10M@450MM SHALL BE USED FROM 1M TO 1.8M AWAY FROM COLUMN SUPPORT. 10M@1000MM SHALL BE USED FROM 1.8M ONWARD.
2. ALL LONGITUDINAL REINFORCEMENT SHALL HAVE A TOP AND BOTTOM LAYER, FORMING A CAGE THAT IS SUPPORTED BY STIRRUPS. ONLY THE REINFORCEMENT LAYER OF STRUCTURAL INTEREST IS SHOWN IN DETAILS. TOP AND BOTTOM LAYERED REINFORCEMENT SETUP SHALL BE USED DURING CONSTRUCTION.

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LEGEND

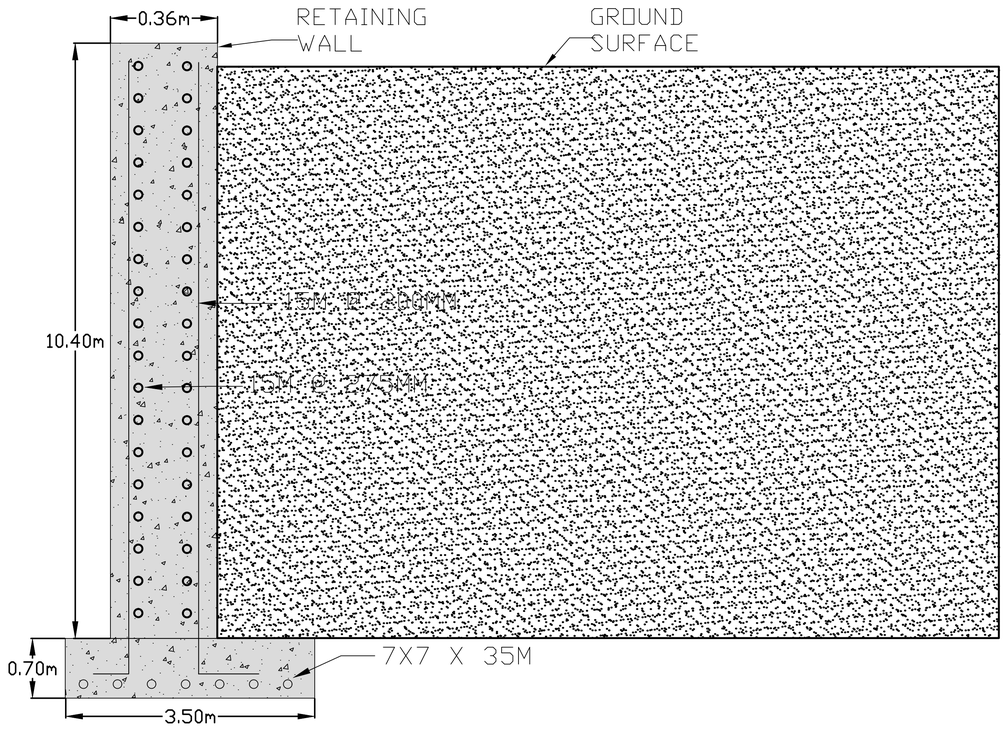
SRN UNDERGROUND PARKADES AND WATER STORAGE

DATE: April 5, 2019

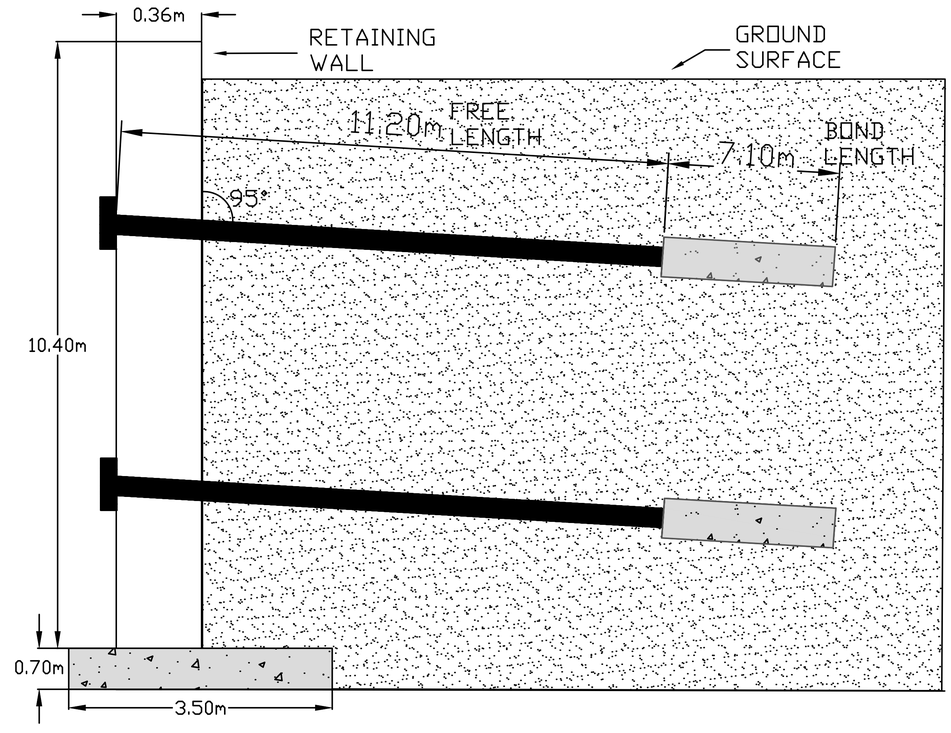
DRAWING: SRN-001-D6

PARKADE - SLAB
DETAILS AND SECTIONS

DETAIL AA
PROFILE VIEW
SCALE 3:1



DETAIL AA (WITH ANCHORS)
PROFILE VIEW
SCALE 3:1



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THE UNIVERSITY OF BRITISH COLUMBIA

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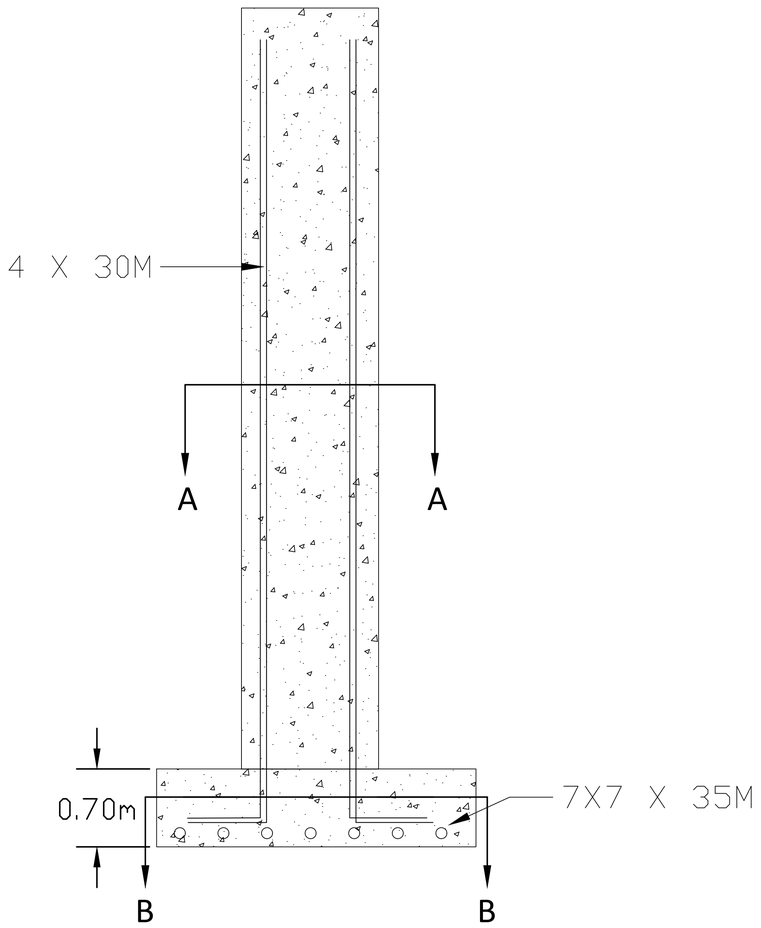
SRN UNDERGROUND PARKADES AND WATER STORAGE

DATE: April 5, 2019

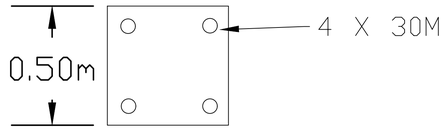
DRAWING: SRN-001-D7

PARKADE - FOUNDATIONS
DETAILS AND SECTIONS

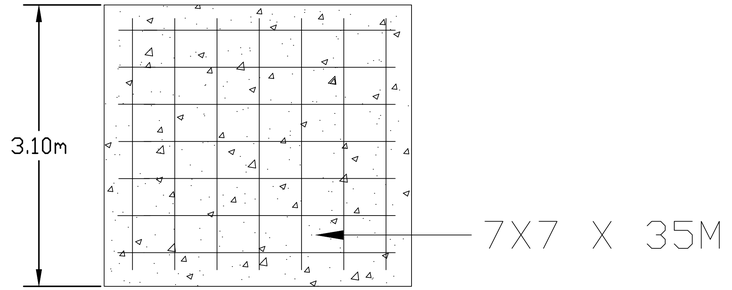
DETAIL AB
PROFILE VIEW
SCALE 40:1



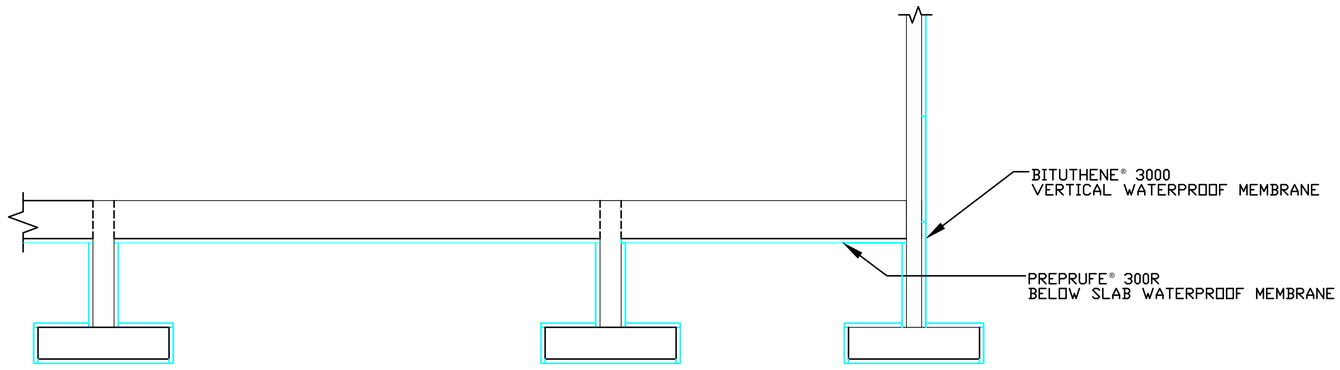
DETAIL AB (A-A SECTION)
PLAN VIEW
SCALE 80:1



DETAIL AB (B-B SECTION)
PLAN VIEW
SCALE 30:1



DETAIL AC
PROFILE VIEW
SCALE 15:1



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LEGEND

SRN UNDERGROUND PARKADES AND WATER STORAGE

DATE: April 5, 2019

DRAWING: SRN-001-D8

PARKADE - COLUMNS & WATERPROOF MEMBRANE DETAILS AND SECTIONS

PRODUCED BY AN AUTODESK STUDENT VERSION

Appendix 2: Cost Estimate and Quantity Takeoffs

Construction Costs

Phase	Item	Detailed Description	Unit	Quantity Needed	Labour + Overhead + Profit	Phase Cost
General	Liability Insurance		Percentage		0.64%	$ 93,822.05
General	Traffic Management	Flaggers, Standard TTC Signs, Speed display trailers, warning lights	Day	110	$ 750.00	$ 82,500.00
General	Site vehicles	Pickup Truck 4x4 2018 Ford. 1/2 Ton	Months	4	$ 1,500.00	$ 6,000.00
General	Sit offices/storage	Rent Office Trailer 9.6m x 2.4m	Months	4	$ 323.12	$ 1,292.48
General	Temporary power facilities	Power for lighting and utilities 85MJ per month	Months	4	$ 0.41	$ 1.64
General	Temporary lights/HVAC	Lights/HVAC	Months	4	$ 206.57	$ 826.28
General	Temporary Drinking Water	2xCooler Rental/10xWater Jugs	Week	16	$ 175.00	$ 2,800.00
General	Temporary restrooms	Toilet/Sink	Week	16	$ 200.00	$ 3,200.00
General	Signage	General Construction Signage	Lump Sum	1	$ 2,000.00	$ 2,000.00
General	Fences and barriers	Rented Chain Link Fencing 6ft high	Linear Foot	2400	$ 6.12	$ 14,688.00
General	Site office equipment	Office Equipment	Months	4	$ 261.96	$ 1,047.84
General	Site office supplies	Office Supplies	Months	4	$ 107.90	$ 431.60
General	Site communication (phone, fax, etc.)	Telephone bill	Months	4	$ 110.21	$ 440.84
General	Temporary Sidewalk	sidewalk 2x(2x12 planks)w/ plywood	Sqft	300	$ 2.79	$ 837.00
General	Small tools	Small Tools used by General Labourers	Monthly	4	$ 10,000.00	$ 40,000.00
General	Waste Management	Dump Truck Rental 9 m3 payload	Day	110	$ 498.00	$ 54,780.00
General	Mobilization/ demobilization	Mobilization/ demobilization delivery charge, hauled 18 MT capacity	Lump Sum	4	$ 886.54	$ 3,546.16
General	Main Office Documentation	Preliminary/Construction/As-Built Drawings for projects upto $8Million	Percentage		5.6%	$ 820,942.92
General	First aid station and supplies	First aid station and supplies	Lump Sum	1	$ 6,000.00	$ 6,000.00
General	Site security	Uniformed Security Guard	Hr	2640	$ 28.93	$ 76,375.20
General	Environmental Assessment		Lump Sum	1	$ 4,000.00	$ 4,000.00
General	Floodlights	Floodlights with Generator 300W	Months	4	$ 974.76	$ 3,899.04
General	Personal Protective Equipment	Eye protection, gloves, hardhats, ear protection, safety vests, coveralls	Lump Sum	1	$ 10,000.00	$ 10,000.00
General Phase Total						$ 1,229,431.05
Permitting	Permitting	Building/Stormwater Discharge/Demolition Permits	Percentage		1.25%	$ 183,246.19
Detention Tank	Offsite earthworks removal		m^3	145200	$ 18.00	$ 2,613,600.00
Detention Tank	Earth Auger	For fence/sign posts, boring, monitoring underground water	Months	4	$ 5,869.88	$ 23,479.52
Detention Tank	Leveling	Aggregate spreader 3.7m wide	Months	4	$ 352.90	$ 1,411.60
Detention Tank	Aerial lift	Aerial lift, scissor type up to 9m	Months	4	$ 860.92	$ 3,443.68
Detention Tank	Crane	Crane, 30m jib, 2700kg capacity	Week	10	$ 7,613.05	$ 76,130.50
Detention Tank	Excavator	Rent diesel hydraulic crawler .764 cubic meters capacity	Week	2.5	$ 2,988.30	$ 7,470.75
Detention Tank	Backfill	Engineering Fill	m^3	96800	$ 18.00	$ 1,742,400.00
Detention Tank	Leveling	compaction and leveling	m^3	6050	$ 24.00	$ 145,200.00
Detention Tank	Retaining wall		m^3	160	$ 271.00	$ 43,360.00
Detention Tank	Formwork	Scaffolding and Formwork, Crew of 4 for Entire Pit	m^2	5280	$ 24.73	$ 130,574.40
Detention Tank	Strip footings		m^3	1408	$ 271.00	$ 381,568.00
Detention Tank	Tank walls	Walls Seperating Tanks	m^3	330	$ 271.00	$ 89,430.00

Detention Tank	Top slab	Slab above tanks	m^3	4373	$	271.00	$	1,185,083.00
Detention Tank	Columns Concrete	All columns	m^3	364.5	$	385.00	$	140,332.50
Detention Tank	45M Rebar	All columns	m	11600	$	15.00	$	174,000.00
Detention Tank	300mm DI Pipe	Connection between mainline and tank	m	600	$	148.85	$	89,311.02
Detention Tank	200mm DI Pipe	Connection between tank and dry pond/outfall	m	360	$	101.05	$	36,377.95
Detention Tank	300mm RC Pipe	Connection between tank and dry pond/outfall	m	990	$	93.00	$	92,065.30
Detention Tank	200mm Gate Valve	Pipe Network	Lump Sum	14	$	1,575.00	$	22,050.00
Detention Tank	300mm Gate Valve	Pipe Network	Lump Sum	8	$	3,122.00	$	24,976.00
Detention Tank	8" Bypass Valve	Pipe Network	Lump Sum	4	$	750.00	$	3,000.00
Detention Tank	8" PRV	Pipe Network	Lump Sum	1	$	1,000.00	$	1,000.00
Detention Tank	Trash rack	Tank Filtering	Lump Sum	2	$	4,500.00	$	9,000.00
Detention Tank	Weir wall	Tank Filtering	Lump Sum	1	$	9,000.00	$	9,000.00
Detention Tank	Chemical protective coatings	Water based polymer coating	m^2	1320	$	16.37	$	21,608.40
Detention Tank	Pumps	7.5" Impeller Diameter Centrifugal	Each	4	$	1,230.00	$	4,920.00
Detention Tank	Oil/Grit seperator	Water Filtration system	Each	3	$	35,000.00	$	105,000.00
Detention Tank	Riprap outlet		Lump Sum	1	$	2,000.00	$	2,000.00
Detention Tank Phase Total							$	7,177,792.63
Stormwater Management	Terraced Channel		Lump Sum	1	$	30,000.00	$	30,000.00
Stormwater Management	Permeable Pavement		Lump Sum	1	$	10,000.00	$	10,000.00
Stormwater Management	Bioswales		Lump Sum	1	$	5,000.00	$	5,000.00
Stormwater Management	Tree Trenches		Lump Sum	1	$	5,000.00	$	5,000.00
Stormwater Management Phase Total							$	50,000.00
Underground Parkade	Wall perimeter	Wall encapsulating parkade	m^3	1430	$	271.00	$	387,530.00
Underground Parkade	Bottom slab	Slab above parking lot 2	m^3	4373	$	271.00	$	1,185,083.00
Underground Parkade	Top slab	Slab above parking lot 1	m^3	4373	$	271.00	$	1,185,083.00
Underground Parkade	20M Rebar	Rebar in all slabs	m	80000	$	12.00	$	960,000.00
Underground Parkade	15M Rebar	Rebar in all footings vertical	m	30000	$	10.00	$	300,000.00
Underground Parkade	35M Rebar	Rebar in all footings horizontal	m	3080	$	13.00	$	40,040.00
Underground Parkade	Lighting	Interior Lighting, ceiling mounted 300mm by 1200mm	Each	520	$	158.90	$	82,628.00
Underground Parkade	Electrical wiring and surge protector		Lump Sum	1	$	52,000.00	$	52,000.00
Underground Parkade	Backup generator		Lump Sum	2	$	12,000.00	$	24,000.00
Underground Parkade	Emergency lighting system	Emergency lighting system	m^2	24200	$	2.85	$	68,970.00
Underground Parkade	signage		Lump Sum	1	$	4,500.00	$	4,500.00
Underground Parkade	air ventilation system		Lump Sum	1	$	25,000.00	$	25,000.00
Underground Parkade	Waterproof membrane system	Membrane waterproofing on slab, glass fibre fabric 2ply mopped on	m^2	26840	$	46.03	$	1,235,445.20
Underground Parkade	Protective coatings	Paints and protective coating on slab, sprayed	m^2	26840	$	4.31	$	115,680.40
Underground Parkade	Paint job (stalls, direction arrows, etc.)	Paint and labour for ground and directions, crew of 2	Day	2	$	463.00	$	926.00
Underground Parkade	Safety system (fire alarms, sprinklers, etc.)	Fire Systems	Lump Sum	1	$	38,000.00	$	38,000.00
Underground Parkade	Parkade gates	Security Gates. 3.048m wide, frame, hardware, and labour	Lump Sum	4	$	4,829.00	$	19,316.00
Underground Parkade	Stairwell (formwork, concrete, railing, etc.)	18 step stairs. 2 per floor	Lump Sum	4	$	6,800.00	$	27,200.00

Underground Parkade	Elevator	Elevator installation, material, service inspection	Lump Sum	1	$	36,000.00	$	36,000.00
Underground Parkade	Security installations (CCTV, booth, intercom system, etc.)		Lump Sum	1	$	42,000.00	$	42,000.00
Underground Parkade	Parking meters		Lump Sum	9	$	1,000.00	$	9,000.00
Underground Parkade	Testing and Inspecting	Concrete Building Testing	Lump Sum	1	$	5,470.40	$	5,470.40
Underground Parkade	Concrete Batch Testing	4 batches testing	Per Truck Load	20	$	215.66	$	4,313.20
Underground Parkade	Soil Testing	Atterberg Limits, liquid/plastic limits	Each	10	$	68.38	$	683.80
Underground Parkade	Groundcover/landscaping	compacting and leveling	m^2	13000	$	24.00	$	312,000.00
Underground Parkade	Cathodic Protection System		Lump Sum	1	$	15,000.00	$	15,000.00
Underground Parkade	Anchors		m	455	$	262.47	$	119,422.57
Underground Parkade	Grout		Lump Sum	1	$	10,000.00	$	10,000.00
Underground Parkade Phase Total							$	6,305,291.57
Dry Pond	Soil Excavation		m^3	360	$	150.00	$	54,000.00
Dry Pond	Landscaping	compaction and leveling	m^2	3000	$	24.00	$	72,000.00
Dry Pond	Engineering Fill		m^3	20	$	18.00	$	360.00
Dry Pond Total							$	126,360.00
	Contingency	of total cost	%	15%	N/A		$	2,253,318.22
First Cost Total							$	17,325,439.65

Project Management Costs

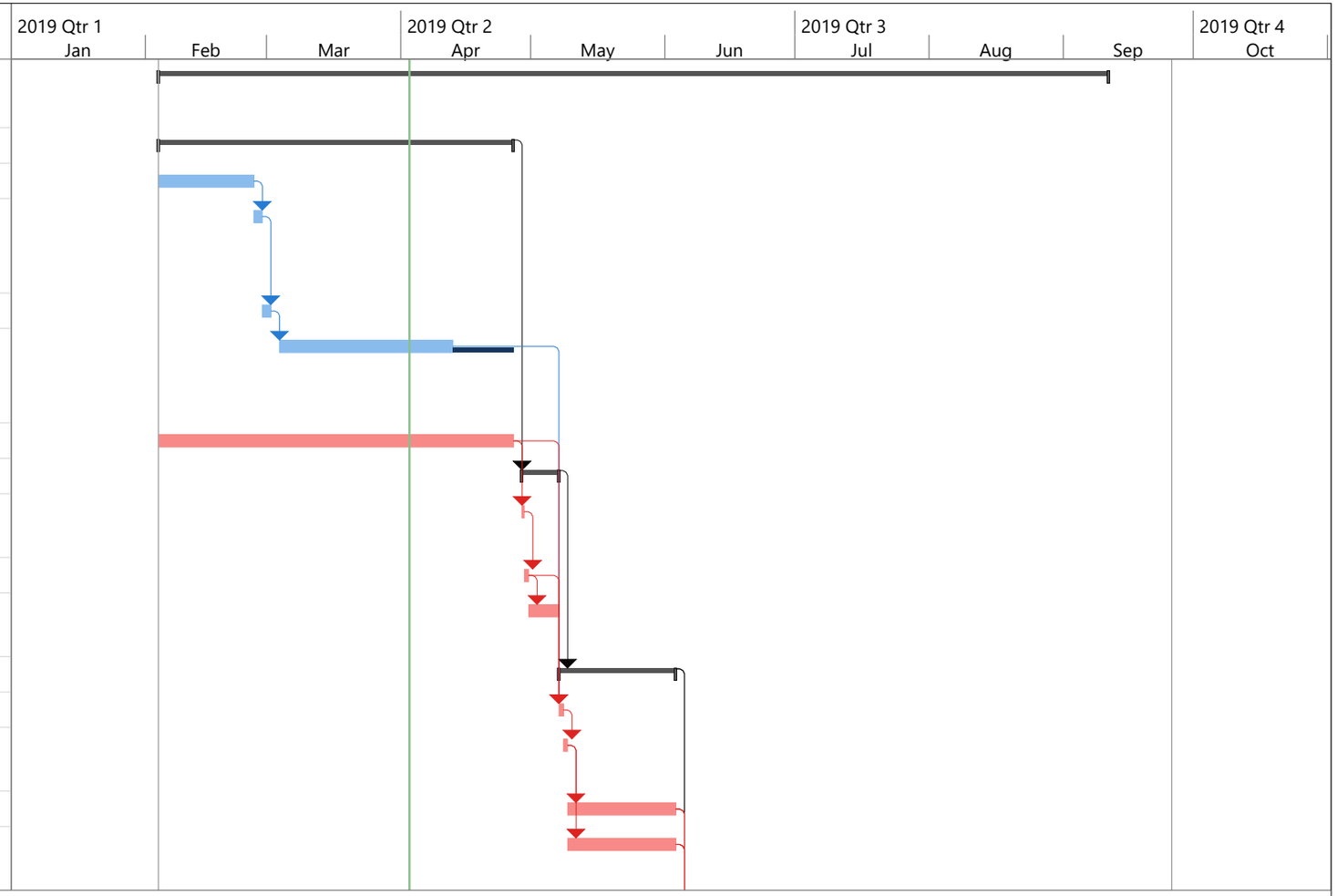
Item	Unit	Quantity	Rate (includes overhead+profit)	Total Phase Cost
Structural Engineer	Week	40	$ 2,650.00	$ 106,000.00
Stormwater Management Engineer	Week	40	$ 2,650.00	$ 106,000.00
Geotechnical engineer	Week	25	$ 2,650.00	$ 66,250.00
Project Manager	Week	40	$ 2,900.00	$ 116,000.00
Environmental Engineer	Week	40	$ 2,325.00	$ 93,000.00
Archaelogical Subconsultant	Week	5	$ 2,300.00	$ 11,500.00
CAD/Field Technician	Week	40	$ 1,250.00	$ 50,000.00
General Purpose Labourer	hour	8480	$ 40.00	$ 339,200.00
Site Superintendent	Week	40	$ 350.00	$ 14,000.00
First Aid	hour	1060	$ 35.00	$ 37,100.00
Landscapers	hour	2000	$ 20.00	$ 40,000.00
Clerk	Week	40	$ 750.00	$ 30,000.00
Contingency Conceptual stage	percentage		30%	$ 302,715.00
Contingency schematic stage	percentage		25%	$ 252,262.50
Contingency preliminary stage	percentage		20%	$ 201,810.00
Contingency Final drawing stage	percentage		15%	$ 151,357.50
		Total Preliminary Project Management Cost Estimate		$ 1,160,407.50

Operating and Maintence: 5 Year Plan

Phase	Item	Unit	Quantity	Unit Price	Item Cost	Phase Cost
Detention Tanks	Water Detention Cleaning	Seasonal	15	800	$ 12,000.00	$ 106,000.00
	Water Detention Pump Maintenace	Seasonal	15	1000	$ 15,000.00	
	Water Detention General Maintenace/Upkeep	Seasonal	15	1200	$ 18,000.00	
	Structural/Concrete Inspections	Month	60	150	$ 9,000.00	
	Detention Tank Inspections (ie. checking for clogging, residual water, infestation, etc.)	Month	60	150	$ 9,000.00	
	Waterproofing (includes joint repairs, crack sealing, etc.)	3 years	1.67	25800	$ 43,000.00	
Mechanical/Electrical	Security CCTV Monitoring Hardware Costs	Annual	5	5000	$ 25,000.00	$ 33,700.00
	Elevator Inspection & Maintenance	Bi-annual	10	150	$ 1,500.00	
	Lighting Maintenance	Bi-annual	10	150	$ 1,500.00	
	Ventilation System Inspection & Maintenance	Bi-annual	10	570	$ 5,700.00	
Parkade	Structural/Concrete Inspections	Month	60	500	$ 30,000.00	$ 177,533.33
	Coatings, paint jobs, etc.	5 years	1	200	$ 200.00	
	Materials Testing	5 years	1	4000	$ 4,000.00	
	Waterproofing (includes joint repairs, crack sealing, etc.)	3 years	1.67	86000	$ 143,333.33	
Administration	Parking Ticket Reference	Lump Sum	N/A	200	$ 200.00	$ 1,805,200.00
	Personnel (includes parkade management, security guards, parking ticket attendants, etc.)	Month	60	30000	$ 1,800,000.00	
	Maintenance Approvals	Bi-annual	10	500	$ 5,000.00	
	Contingency	%	N/A	15	$ 424,486.67	$ 318,365.00
					Total 5 year cost	$ 2,440,798.33

Appendix 3: Construction Schedule

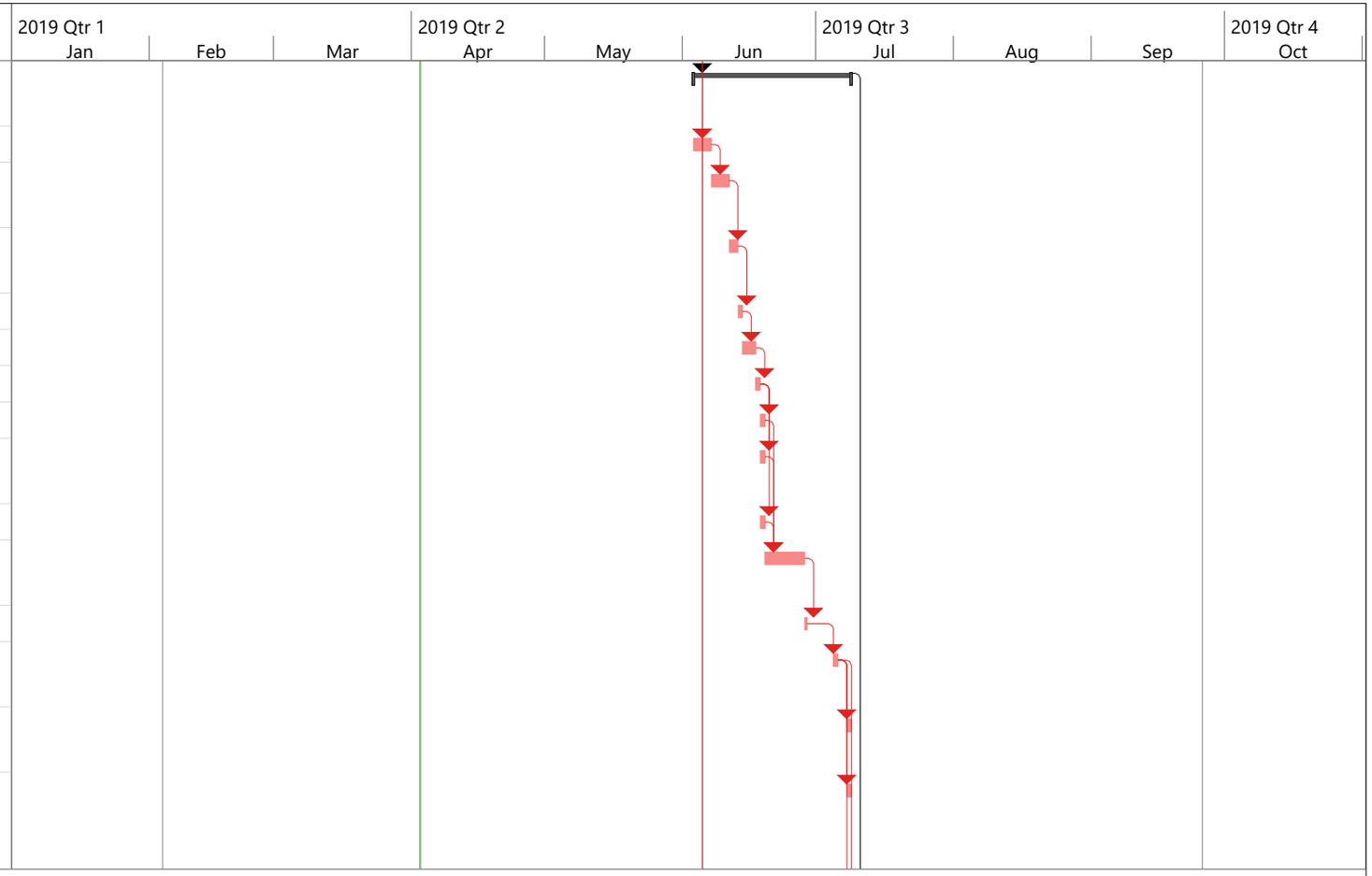
ID	Task Name	Duration	Start	Finish
1	**UBC Stormwater Management Plan**	**157.5 days**	**Mon 19-02-04**	**Wed 19-09-11**
2	**Project Start Up**	**60 days**	**Mon 19-02-04**	**Fri 19-04-26**
3	Bidding	16 days	Mon 19-02-04	Mon 19-02-25
4	Tender and award to contractor	2 days	Tue 19-02-26	Wed 19-02-27
5	Sign Contracts	2 days	Thu 19-02-28	Fri 19-03-01
6	Procurement of Materials and Equipment	30 days	Mon 19-03-04	Fri 19-04-12
7	Obtain permits	60 days	Mon 19-02-04	Fri 19-04-26
8	**Pre-Construction**	**6.5 days**	**Mon 19-04-29**	**Tue 19-05-07**
9	Site Inspections	0.5 days	Mon 19-04-29	Mon 19-04-29
10	Surveying	1 day	Mon 19-04-29	Tue 19-04-30
11	Borehole testing	5 days	Tue 19-04-30	Tue 19-05-07
12	**Site Works**	**19 days**	**Tue 19-05-07**	**Mon 19-06-03**
13	Mobilization	1 day	Tue 19-05-07	Wed 19-05-08
14	Site Preparation	1 day	Wed 19-05-08	Thu 19-05-09
15	Excavation	17 days	Thu 19-05-09	Mon 19-06-03
16	Archaeological Assessment	17 days	Thu 19-05-09	Mon 19-06-03



Project: Schedule
Date: Wed 19-04-03

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

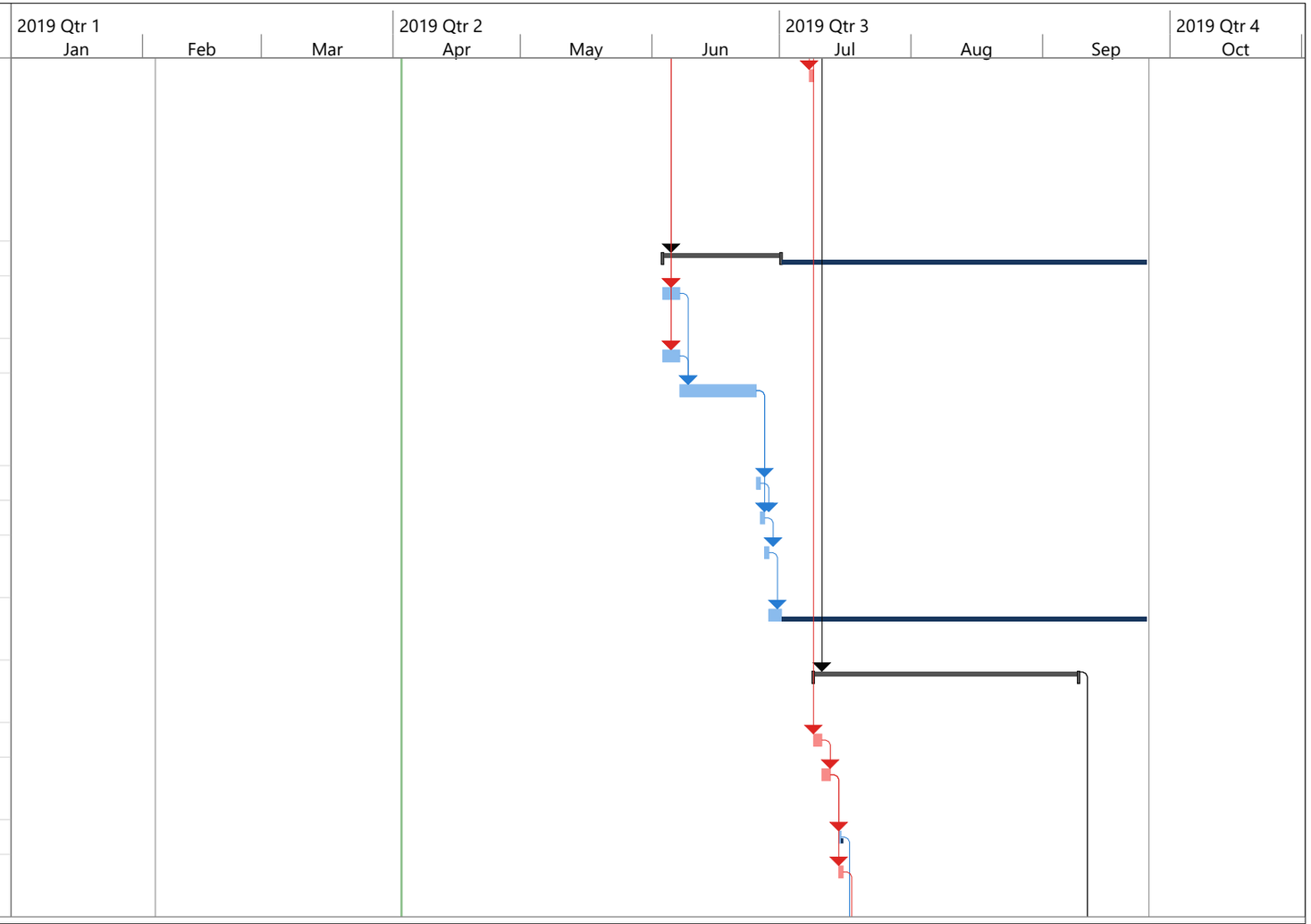
ID	Task Name	Duration	Start	Finish
17	**Detention Tanks Construction**	**25.5 days**	**Mon 19-06-03**	**Mon 19-07-08**
18	Trenching	4 days	Mon 19-06-03	Fri 19-06-07
19	Install pipes from tank	2 days	Fri 19-06-07	Tue 19-06-11
20	Install retaining walls	2 days	Tue 19-06-11	Thu 19-06-13
21	Formwork	1 day	Thu 19-06-13	Fri 19-06-14
22	Strip footings	1 day	Fri 19-06-14	Mon 19-06-17
23	Place rebar	1 day	Mon 19-06-17	Tue 19-06-18
24	Pour SOG	1 day	Tue 19-06-18	Wed 19-06-19
25	Form tank walls	1 day	Tue 19-06-18	Wed 19-06-19
26	Form columns	1 day	Tue 19-06-18	Wed 19-06-19
27	Concrete curing	7 days	Wed 19-06-19	Fri 19-06-28
28	Form top slab	0.5 days	Fri 19-06-28	Fri 19-06-28
29	Formwork removal	1 day	Fri 19-07-05	Fri 19-07-05
30	Structural inspections	1 day	Mon 19-07-08	Mon 19-07-08
31	Install filtration system	1 day	Mon 19-07-08	Mon 19-07-08



Project: Schedule
Date: Wed 19-04-03

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

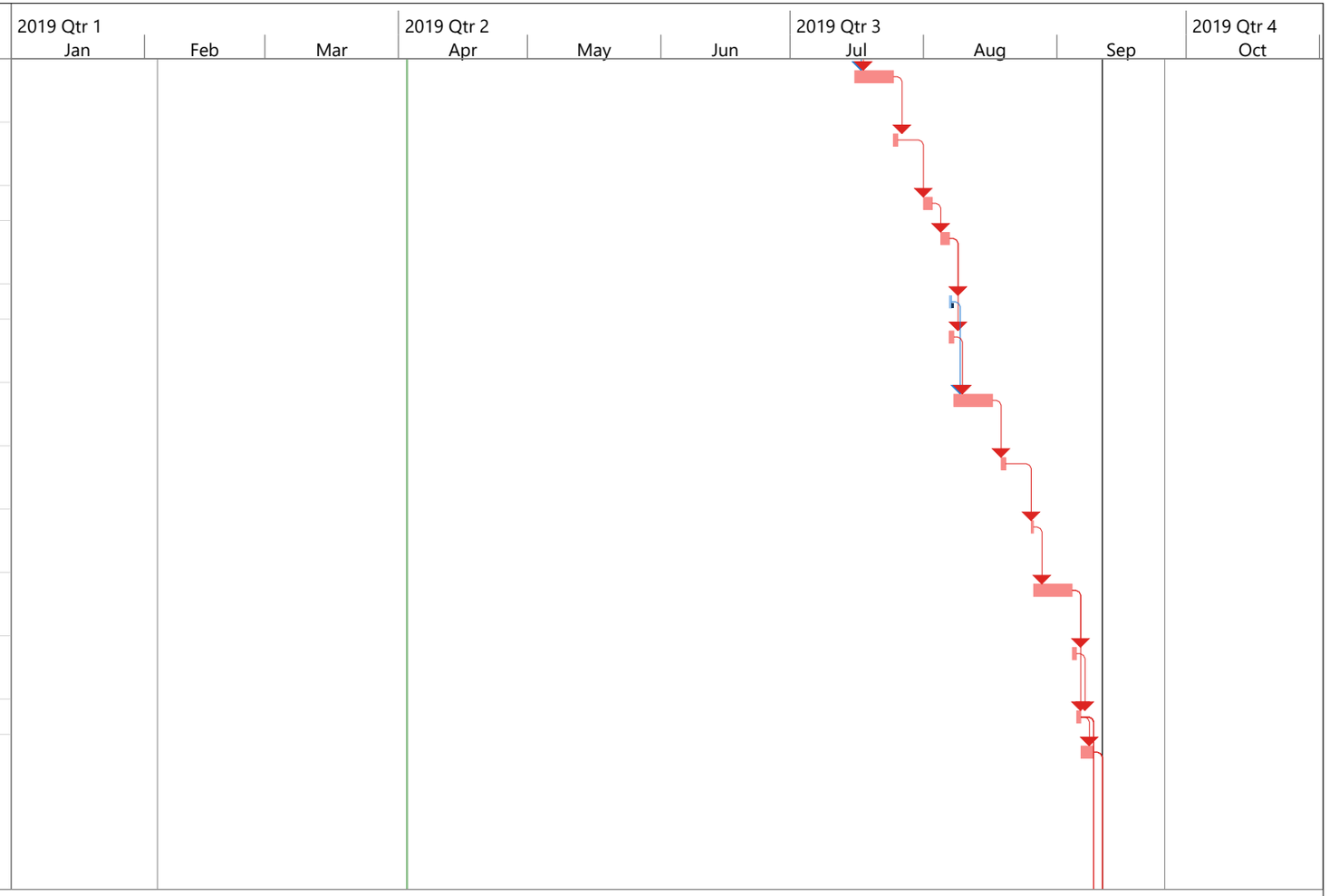
ID	Task Name	Duration	Start	Finish
32	Installing chemical protection (e.g. corrosion protection, coatings, etc.)	1 day	Mon 19-07-08	Mon 19-07-08
33	**Pipe Work**	20 days	**Mon 19-06-03**	**Mon 19-07-01**
34	Pipe excavation	4 days	Mon 19-06-03	Fri 19-06-07
35	Trenching	4 days	Mon 19-06-03	Fri 19-06-07
36	Lay pipework and install pumps	12 days	Fri 19-06-07	Tue 19-06-25
37	Install valves	1 day	Tue 19-06-25	Wed 19-06-26
38	Backfilling	1 day	Wed 19-06-26	Thu 19-06-27
39	Levelling & Grading	1 day	Thu 19-06-27	Fri 19-06-28
40	Landscaping & clean up	1 day	Fri 19-06-28	Mon 19-07-01
41	**Parkade Construction**	**44.5 days**	**Tue 19-07-09**	**Mon 19-09-09**
42	P2 Formwork	2 days	Tue 19-07-09	Wed 19-07-10
43	Place P2 Rebar	2 days	Thu 19-07-11	Fri 19-07-12
44	Pour P2 Slab	0.5 days	Mon 19-07-15	Mon 19-07-15
45	Form walls and columns	1 day	Mon 19-07-15	Mon 19-07-15



Project: Schedule
Date: Wed 19-04-03

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

ID	Task Name	Duration	Start	Finish
46	Concrete curing	7 days	Tue 19-07-16	Wed 19-07-24
47	Formwork Removal	1 day	Thu 19-07-25	Thu 19-07-25
48	P1 Formwork	2 days	Thu 19-08-01	Fri 19-08-02
49	Place P1 Rebar	2 days	Mon 19-08-05	Tue 19-08-06
50	Pour P1 Slab	0.5 days	Wed 19-08-07	Wed 19-08-07
51	Form walls and columns	1 day	Wed 19-08-07	Wed 19-08-07
52	Concrete curing	7 days	Thu 19-08-08	Fri 19-08-16
53	Formwork Removal	1 day	Mon 19-08-19	Mon 19-08-19
54	Pour ground level slab	0.5 days	Mon 19-08-26	Mon 19-08-26
55	Concrete curing	7 days	Mon 19-08-26	Wed 19-09-04
56	Structural inspections	1 day	Wed 19-09-04	Thu 19-09-05
57	Backfilling	1 day	Thu 19-09-05	Fri 19-09-06
58	Preparation for installing stormwater features & clean up	1 day	Fri 19-09-06	Mon 19-09-09



Project: Schedule
Date: Wed 19-04-03

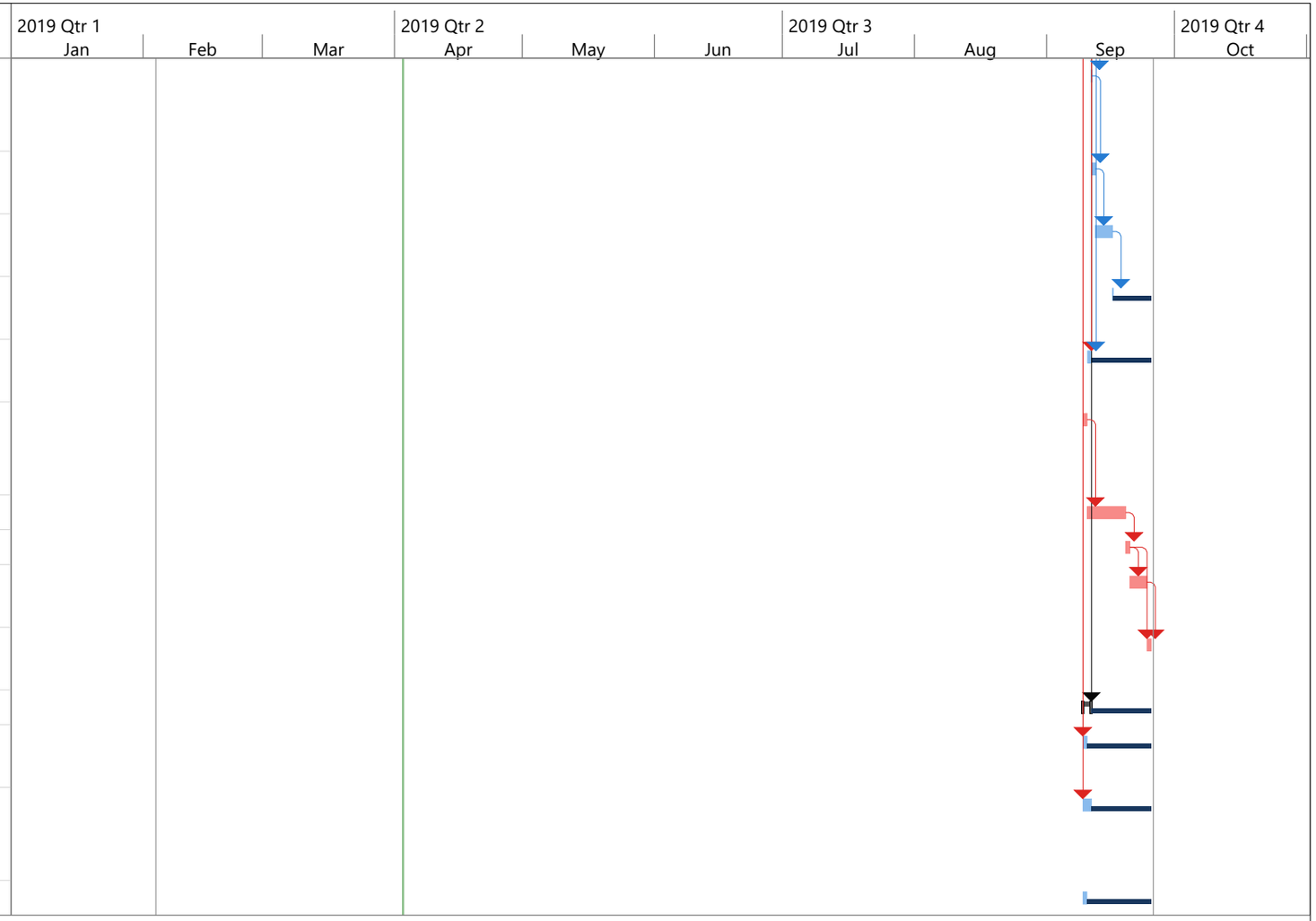
Task	Inactive Milestone	Start-only	Critical Split
Split	Inactive Summary	Finish-only	Progress
Milestone	Manual Task	External Tasks	Manual Progress
Summary	Duration-only	External Milestone	Slack
Project Summary	Manual Summary Rollup	Deadline	
Inactive Task	Manual Summary	Critical	

ID	Task Name	Duration	Start	Finish
59	**Mechanical & Electrical Systems**	**2 days**	**Mon 19-09-09**	**Wed 19-09-11**
60	Install wiring	1 day	Mon 19-09-09	Tue 19-09-10
61	Install ventilation ductwork	2 days	Mon 19-09-09	Wed 19-09-11
62	Install lighting	2 days	Mon 19-09-09	Wed 19-09-11
63	Install security system	1 day	Mon 19-09-09	Tue 19-09-10
64	**Stormwater features**	**12 days**	**Mon 19-09-09**	**Wed 19-09-25**
65	Place geotextile fabric for tree trench	0.25 days	Mon 19-09-09	Mon 19-09-09
66	Fill with stone/gravel	0.25 days	Mon 19-09-09	Mon 19-09-09
67	Plant trees	0.5 days	Tue 19-09-10	Tue 19-09-10
68	Place gravel for permeable pavement	0.25 days	Mon 19-09-09	Mon 19-09-09
69	Install geotextile	0.25 days	Tue 19-09-10	Tue 19-09-10
70	Install first rock layer and compact	0.5 days	Tue 19-09-10	Wed 19-09-11

Project: Schedule
Date: Wed 19-04-03

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

ID	Task Name	Duration	Start	Finish
71	Install second rock layer and compact	0.5 days	Wed 19-09-11	Wed 19-09-11
72	Pour pea gravel as bedding layer	0.5 days	Wed 19-09-11	Thu 19-09-12
73	Lay pavement stones	2 days	Thu 19-09-12	Mon 19-09-16
74	Install side restraints	0.5 days	Mon 19-09-16	Mon 19-09-16
75	Planting for bioswale	0.5 days	Tue 19-09-10	Wed 19-09-11
76	Place formwork for stormwater channel feature	1 day	Mon 19-09-09	Tue 19-09-10
77	Concrete curing	7 days	Tue 19-09-10	Thu 19-09-19
78	Placing plants	1 day	Thu 19-09-19	Fri 19-09-20
79	Testing of features	2 days	Fri 19-09-20	Tue 19-09-24
80	Landscaping & clean up	1 day	Tue 19-09-24	Wed 19-09-25
81	**Finishing**	**2 days**	**Mon 19-09-09**	**Wed 19-09-11**
82	Install parking signs	1 day	Mon 19-09-09	Tue 19-09-10
83	Paint parking spot lines and arrows	2 days	Mon 19-09-09	Wed 19-09-11
84	Demobilization	0.75 days	Mon 19-09-09	Tue 19-09-10



Project: Schedule
Date: Wed 19-04-03

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

Appendix 4: Pump System Details

Thunderbird Stadium Neighbourhood SWM
Pump Selection

High Head

Pumps Operating	1	
Flow	76.0	L/s
Discharge HGL=	8.00	m
Suction HGL=	0.00	m
Hazen-Williams C Value	140.00	

Flow in L/s, head in m

	No. of Pumps				
	13.70	1	2	3	4
Flow	0	8	8	8	8
(L/s)	10	8	8	8	8
	20	8	8	8	8
	30	9	8	8	8
	40	10	9	8	8
	50	11	9	9	8
	60	12	9	9	9
	70	13	10	9	9
	80	14	10	9	9
	90	16	11	10	10
	100	18	12	10	10
	110	20	12	11	10
	120	22	13	11	11
	130	24	14	12	11
	140	26	15	12	12
	150	29	16	13	12
	160	32	17	14	13

	Element	Dia (nom) in	I.D. mm	Total Flow L/s	Flow in Element L/s	Length m	"C"	"K"	"CV"	Velocity m/s	Delta H m
T1	Square Entrance		200	76	76.00			0.50		2.42	0.15
	Discharge elbow		200	76	76.00			0.05			
	Pipe		200	76	76.00	21.5	140			2.42	0.52
	Gate valve		200	76	76.00			0.30		2.42	0.09
	Gate valve		200	76	76.00			0.30		2.42	0.09
	90 degree bend		200	76	76.00			0.60		2.42	0.18
T2	Square Entrance		200	76	76.00			0.50		2.42	0.15
	Pipe		200	76	76.00	8	140			2.42	0.19
	Pipe		200	76	76.00	17	140			2.42	0.41
	Gate valve		200	76	76.00			0.30		2.42	0.09
	Gate valve		200	76	76.00			0.30		2.42	0.09
	90 degree bend		200	76	76.00			0.60		2.42	0.18
T3	Square Entrance		200	76	76.00			0.50		2.42	0.15
	Pipe		200	76	76.00	8	140			2.42	0.19
	Pipe		200	76	76.00	37	140			2.42	0.90
	Gate valve		200	76	76.00			0.30		2.42	0.09
	Gate valve		200	76	76.00			0.30		2.42	0.09
	90 degree bend		200	76	76.00			0.60		2.42	0.18
PH	Gate valve		200	76	76.00			0.30		2.42	0.09
	Gate valve		200	76	76.00			0.30		2.42	0.09
	Pipe		200	76	76.00	11	140			2.42	0.27
	Swing check valve		200	76	76.00				4600	2.42	0.05
	90 degree bend		200	76	76.00			0.60		2.42	0.18
	Gate valve		200	76	76.00			0.30		2.42	0.09
	Exit		200	76	76.00			1.00		2.42	0.30
T1	Square Entrance		300	76	76.00			0.50		1.08	0.03
	Discharge elbow		300	76	76.00			0.05			
	Pipe		300	76	76.00	21.5	140			1.08	0.07
	Gate valve		300	76	76.00			0.30		1.08	0.02
	Gate valve		300	76	76.00			0.30		1.08	0.02
	90 degree bend		300	76	76.00			0.60		1.08	0.04
T2	Square Entrance		300	76	76.00			0.50		1.08	0.03
	Pipe		300	76	76.00	8	140			1.08	0.03
	Pipe		300	76	76.00	17	140			1.08	0.06
	Gate valve		300	76	76.00			0.30		1.08	0.02
	Gate valve		300	76	76.00			0.30		1.08	0.02
	90 degree bend		300	76	76.00			0.60		1.08	0.04
T3	Square Entrance		300	76	76.00			0.50		1.08	0.03
	Pipe		300	76	76.00	8	140			1.08	0.03
	Pipe		300	76	76.00	37	140			1.08	0.12
	Gate valve		300	76	76.00			0.30		1.08	0.02
	Gate valve		300	76	76.00			0.30		1.08	0.02
	90 degree bend		300	76	76.00			0.60		1.08	0.04
PH	Gate valve		300	76	76.00			0.30		1.08	0.02
	Gate valve		300	76	76.00			0.30		1.08	0.02
	Pipe		300	76	76.00	11	140			1.08	0.04
	Swing check valve		300	76	76.00				4600	1.08	0.05
	90 degree bend		300	76	76.00			0.60		1.08	0.04
	Gate valve		300	76	76.00			0.30		1.08	0.02
	Pipe		300	76	76.00	60.5	140			1.08	0.20
	Exit		300	76	76.00			1.00		1.08	0.06

Total Head Losses (m) **5.70**
Static Head 8.00
Total Dynamic Head (m) 14

Thunderbird Stadium Neighbourhood SWM
Pump Selection

Low Head

Pumps Operating	1	
Flow	51.0	L/s
Discharge HGL=	11.00	m
Suction HGL=	0.00	m
Hazen-Williams C Value	140.00	

Flow in L/s, head in m

	No. of Pumps				
	11.90	1	2	3	4
Flow (L/s)	0	11	11	11	11
	10	11	11	11	11
	20	11	11	11	11
	30	11	11	11	11
	40	12	11	11	11
	50	12	11	11	11
	60	12	11	11	11
	70	13	12	11	11
	80	13	12	12	11
	90	14	12	12	12
	100	14	12	12	12
	110	15	13	12	12
	120	16	13	12	12
	130	17	13	12	12
	140	17	13	13	12
	150	18	14	13	13
	160	19	14	13	13

Element	Dia (nom) in	I.D. mm	Total Flow L/s	Flow in Element L/s	Length m	"C"	"K"	"CV"	Velocity m/s	Delta H m
Discharge elbow		200	51	51.00			0.05			
PVC Pipe		200	51	51.00	21.5	140			1.62	0.25
Gate valve		200	51	51.00			0.30		1.62	0.04
Gate valve		200	51	51.00			0.30		1.62	0.04
90 degree bend		200	51	51.00			0.60		1.62	0.08
Gate valve		200	51	51.00			0.30		1.62	0.04
Gate valve		200	51	51.00			0.30		1.62	0.04
PVC Pipe		200	51	51.00	11	140			1.62	0.13
Swing check valve		200	51	51.00				4600	1.62	0.02
90 degree bend		200	51	51.00			0.60		1.62	0.08
Gate valve		200	51	51.00			0.30		1.62	0.04
Exit		200	51	51.00			1.00		1.62	0.13

Total Head Losses (m) **0.90**
Static Head 11.00
Total Dynamic Head (m) 12

March 31, 2019

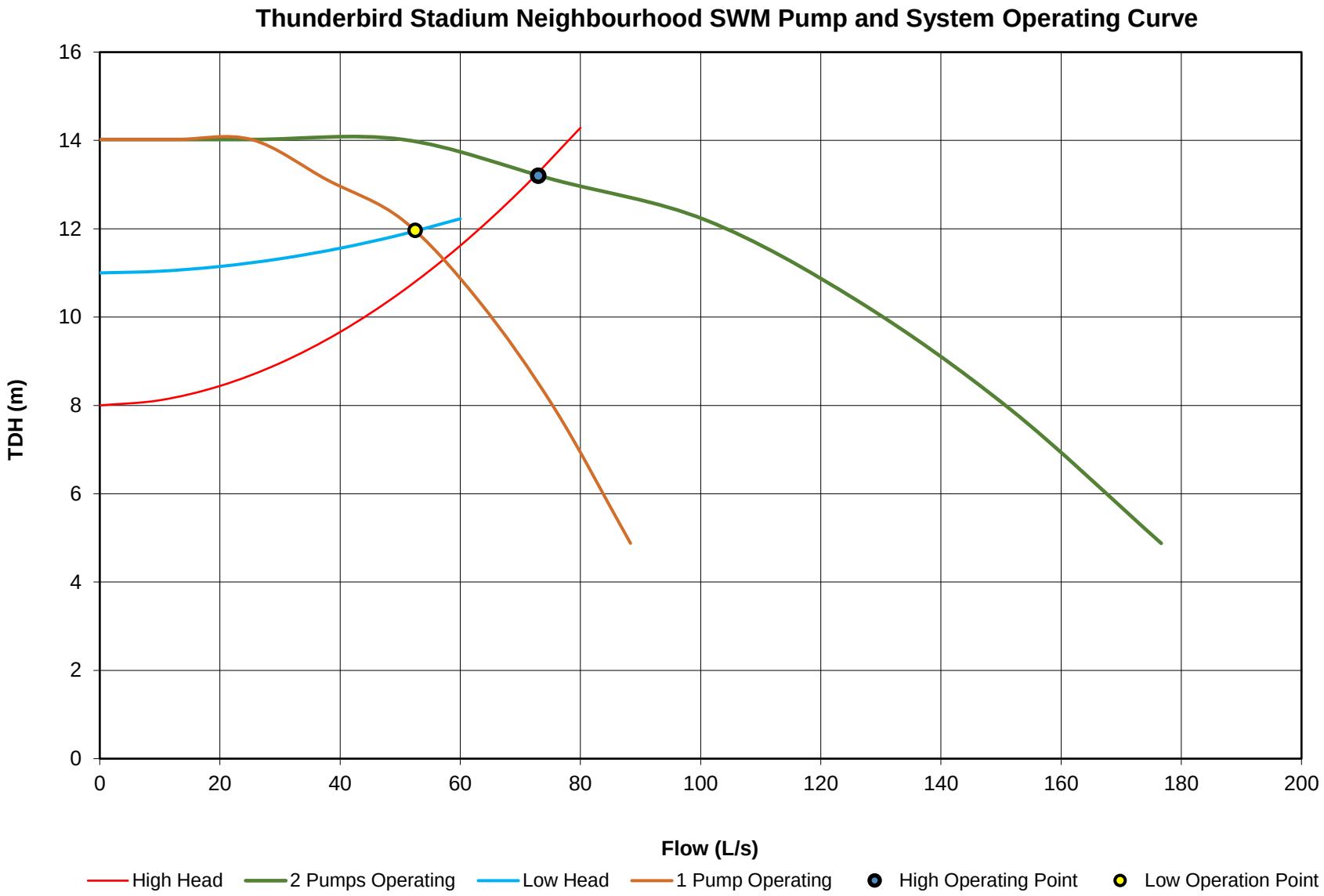
Thunderbird Stadium Neighbourhood SWM
Pump Curve

Full Speed										
1,750	RPM	100% Speed								
1	Stages									
1	Pump Operating						2	Pumps Op.	3	Pumps Op.
Flow (USgpm)	TDH (ft/stage)	TDH (ft)	Eff (%)	Flow (L/s)	TDH (m)	Power (HP)	Flow (L/s)	TDH (m)	Flow (L/s)	TDH (m)
0	46.0	46.0		0	14.0		0	14.0	0	14.0
200	46	46.0	64.0%	13	14.0	3.6	25	14.0	38	14.0
400	46	46.0	64.0%	25	14.0	7.3	50	14.0	76	14.0
600	43	43.0	70.0%	38	13.1	9.3	76	13.1	114	13.1
800	40	40.0	74.0%	50	12.2	10.9	101	12.2	151	12.2
1000	34	34.0	81.0%	63	10.4	10.6	126	10.4	189	10.4
1200	26	26.0	85.0%	76	7.9	9.3	151	7.9	227	7.9
1400	16	16.0	82.0%	88	4.9	6.9	177	4.9	265	4.9

Reduced Speed										1400 RPM - 80%
1400	RPM	80% Speed								
1	Pump Operating						2	Pumps Op.	3	Pumps Op.
		Eff (%)	Flow (L/s)	TDH (m)	Power (HP)		Flow (L/s)	TDH (m)	Flow (L/s)	TDH (m)
		0.0%	0	9.0			0	9.0	0	9.0
		64.0%	10	9.0	1.9		20	9.0	30	9.0
		64.0%	20	9.0	3.7		40	9.0	61	9.0
		70.0%	30	8.4	4.8		61	8.4	91	8.4
		74.0%	40	7.8	5.6		81	7.8	121	7.8
		81.0%	50	6.6	5.4		101	6.6	151	6.6
		85.0%	61	5.1	4.7		121	5.1	182	5.1
		82.0%	71	3.1	3.5		141	3.1	212	3.1

Reduced Speed										1610 RPM - 92%
1610	RPM	92% Speed								
1	Pump Operating						2	Pumps Op.	3	Pumps Op.
		Eff (%)	Flow (L/s)	TDH (m)	Power (HP)		Flow (L/s)	TDH (m)	Flow (L/s)	TDH (m)
1		0.0%	0	11.9			0	11.9	0	11.9
2		64.0%	12	11.9	2.8		23	11.9	35	11.9
3		64.0%	23	11.9	5.6		46	11.9	70	11.9
4		70.0%	35	11.1	7.2		70	11.1	104	11.1
5		74.0%	46	10.3	8.5		93	10.3	139	10.3
6		81.0%	58	8.8	8.2		116	8.8	174	8.8
7		85.0%	70	6.7	7.2		139	6.7	209	6.7
8		82.0%	81	4.1	5.4		163	4.1	244	4.1

Reduced Speed										1558 RPM - 89%
1558	RPM	89% Speed								
1	Pump Operating						2	Pumps Op.	3	Pumps Op.
		Eff (%)	Flow (L/s)	TDH (m)	Power (HP)		Flow (L/s)	TDH (m)	Flow (L/s)	TDH (m)
1		0.0%	0	11.1			0	11.1	0	11.1
2		64.0%	11	11.1	2.6		22	11.1	34	11.1
3		64.0%	22	11.1	5.1		45	11.1	67	11.1
4		70.0%	34	10.4	6.6		67	10.4	101	10.4
5		74.0%	45	9.7	7.7		90	9.7	135	9.7
6		81.0%	56	8.2	7.5		112	8.2	168	8.2
7		85.0%	67	6.3	6.5		135	6.3	202	6.3
8		82.0%	79	3.9	4.9		157	3.9	236	3.9


Thunderbird Stadium Neighbourhood SWM Pump and System Operating Curve
TDH (m)
16
14
12
10
8
6
4
2
0
0
20
40
60
80
100
120
140
160
180
200
Flow (L/s)
High Head
2 Pumps Operating
Low Head
1 Pump Operating
High Operating Point
Low Operation Point

Appendix 5: Sample Calculations

1.0 Rainfall and Catchment

Catchment Area: $A = 956460\ m^2$

Elevation at start of run: $z_i = 101.25m$

Elevation at end of run: $z_f = 88.75m$

Change in elevation: $\Delta z = z_i - z_f = 101.25m - 88.75m = 12.5m$

Run length:

Metric: $L = 1424m$

Imperial: $L = 1424m * \frac{3.28084ft}{1m} = 4671.9ft$

Average grade: $S = \frac{\Delta z}{L} = \frac{12.5m}{1424m} = 0.009$

Time of Concentration (Kirpich Method):

$$t_c = 0.0078\left(\frac{L^{0.77}}{S^{0.385}}\right) = 0.0078\left(\frac{4671.9^{0.77}}{0.009^{0.385}}\right) = 32.0min$$

Rainfall intensity (for 100 year event, TOC=32min) :

$$i = 35mm/hr$$

Runoff Coefficient (estimate): $C = 0.79$

Flow rate (Rational Method):

$$Q = CiA = 0.79 * 35\frac{mm}{hr} * \frac{1m}{1000mm} * \frac{1hr}{60min} * 956460m^2 = 441m^3/min$$

Required volume of storage tanks:

$$V_0 = Q * t = \frac{418m^3}{min} * 32min = 14{,}105m^3$$

Factor of Safety: $FS = 1.5$

Required volume with FS applied:

$$V = FS * V_0 = 1.5 * 14{,}105 = 21{,}157m^3$$

2.0 Pipe Network

Minimum grade (used): 2%

Minimum depth cover (used): 2m

Minimum vertical clearance: 0.5m

Minimum depth of invert below ground for 300mm pipe:

$$2m + 0.3m = 2.3m$$

Grade of outfall pipe upstream of pump:

$$\frac{1.865m - 0m}{50.73m} = 0.0368 = 3.68\%$$

Depth of invert of channel outlet at tank 2 (m below tank bottom): 1.231m

Maximum depth (below tank bottom) of outfall outlet at tank 2:

$$1.231m - 0.5m = 0.731m$$

Pipe Roughness (PVC): $e = 0.0015\ mm$

Pipe Diameter: $D = 200\ mm$

Relative Roughness: $\frac{e}{D} = \frac{1.65mm}{200mm}$

Friction Factor (derived from Moody Diagram): $f = 0.012$

Equivalent Pipe Length:

$$Leq = \frac{D\sum k}{f} = \frac{(0.2m)(1 + 0.39 + 0.39 + 1)}{0.012}$$

Resistance Coefficient (Darcy-Weisbach):

$$R = \frac{8f(L + Leq)}{\pi^2 g D^5} = \frac{8(0.012)(9m + 43m)}{\pi^2(9.81\frac{m^2}{s})(0.2m)^5} = 161.1$$

System Demand Curve $Hp = Hs + RQ^2 = 9m + 161.1Q^2$

3.0 Parkade Design

3.1 T-Beam Design

Calculate factored load, then factored moment:

$$w_f = 1.25DL + 1.5LL$$

Estimated the slab thickness by basing it on A23.3 C1.9.8.2.1, which depends on the clear span of the slab

Effective slab depth (d): $d = h - cover - \frac{d_b}{2}$ assuming there is only one layer of reinforcement. d_b is the diameter of the rebar chosen.

Calculate required area of tension reinforcement (mm^2) using factored moment:

$$A_s{}' = \frac{\alpha_1\phi_c f_c{}' b}{\phi_s f_y}(d - \sqrt{d^2 - \frac{2M_r}{\alpha_1\phi_c f_c{}' b}})$$

Where $\alpha_1 = 0.8$, $\phi_c = 0.65$, $\phi_s = 0.85$, M_r is in Nmm, b is in mm, d is in mm, and $f_c{}'$ is in MPa

Determined actual rebar area by choosing from nominal bar sizes

For bar spacing: $s \le A_b\frac{1000}{A_s}$

Check if provided area of reinforcement is greater than or equal to the required amount of reinforcement:

$$A_s = A_b\frac{1000}{s} \ge A_s{}'$$

Check reinforcement requirements:

$$\rho = \frac{A_s}{bd} \quad where\ \rho \le \rho_b \qquad \rho_b = \frac{A_{sb}}{bd}$$

$$A_{smin} = 0.002A_g = 0.002bh$$

$$A_{min} = \min(A_{smin}\ or\ A_s')$$

$$A_s \ge A_{min}$$

Determine actual effective depth (following equation is for one layer of reinforcement:

$$d = h - cover - \frac{d_b}{2}$$

Confirm maximum bar spacing requirement satisfies Code A23.3 C1.7.4.1.2:

$$s_{max} = \min(3h\ or\ 500mm)$$

$$s_{max} \geq s$$

Calculate the moment resistance and confirm strength requirement satisfies Code A23.3 C1.8.1.3:

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

$$M_r \geq M_f$$

Check crack control parameter, that it meets the CSA A23.3 cracking requirements for an exterior exposure:

$$d_s = d_c = h - d$$

$$A = s(d_s)$$

$$f_s = 0.6 f_y$$

$$z = f_s \sqrt[3]{d_c A}$$

Design the shrinkage and temperature reinforcement:

$$A_{smin} = 0.002 A_g = 0.002 bh$$

$$s_{max} = \min(5h \; or \; 500mm)$$

$$s \leq A_b \frac{1000}{A_{smin}}$$

$$A_s = A_b \frac{1000}{s}$$

A_b is the area of a single rebar using the chosen nominal rebar size.

3.2 Slab Design

Calculate factored load, then factored moment:

$$w_f = 1.25DL + 1.5LL$$

Estimate beam web width (b_w) and overall depth (h) using Code A23.3 C1.9.8.2.1 which is based on the clear space. The depth is rounded up to the nearest 100mm

$$b_w = 0.5h \; or \; \frac{h}{1.5}$$

Estimate the effective beam depth (d):

For 1 layer of reinforcement: $d = h - 70mm$

For 2 layers of reinforcement: $d = h - 110mm$

Calculate the effective flange width (b_f) based on A23.3 C1.10.3.3 and 10.3.4 using the clear span and the clear distance between adjacent webs.

$$b_f = b_w + 2b_T$$

Where b_w is the web width and b_T is the overhanging flange width

Calculate required area of tension reinforcement (mm^2) using factored moment:

$$A_s' = \frac{\alpha_1 \phi_c f_c' b}{\phi_s f_y} (d - \sqrt{d^2 - \frac{2M_r}{\alpha_1 \phi_c f_c' b}})$$

Where $\alpha_1 = 0.8$, $\phi_c = 0.65$, $\phi_s = 0.85$, M_r is in Nmm, b=b_f is in mm, d is in mm, and f_c' is in MPa

*since the T-beam is under positive bending, it is reasonable to assume that the neutral axis is located within the flange

Determined actual rebar area (A_s) by choosing from nominal bar sizes and check if it meets the requirements:

$$A_s \geq A_s'$$

Confirm the maximum tension reinforcement requirement satisfies the Code A23.3 C1.10.5.2:

$$\rho = \frac{A_s}{bd} \quad where \; \rho \leq \rho_b \quad \rho_b = \frac{A_{sb}}{bd}$$

Determine actual effective depth (d) by determining concrete cover requirements (CSA A23.1), the minimum required bar spacing, and the number of bars in each layer:

$$s_{min} = \max(1.4d_b, 1.4a_{max}, 30\text{mm})$$

$$b_{min} = (\#\ of\ rebar\ in\ 1\ layer) \times d_b + (\#\ of\ rebar\ in\ 1\ layer - 1) \times s_{min} + 2d_s + 2cover$$

Determine actual effective depth and confirm minimum reinforcement requirement is satisfied (A23.3 C1.10.5.1.1 and 10.5.1.2)

$$A_{smin} = \frac{0.2\sqrt{f_c'}}{f_y} b_t h$$

$$A_s > A_{smin}$$

$$a = \frac{\phi_s f_y A_s}{\alpha_1 \phi_c f_c' b}$$

Ensure that $a < h_f$ so that the neutral axis located in the flange

Confirm strength requirement satisfied Code A23.3 C1.8.1.3

$M_r = \phi_s f_y A_s (d - \frac{\phi_s f_y A_s}{2\alpha_1 \phi_c f_c' b})$; $M_r \geq M_f$

Check crack control parameter, that it meets the CSA A23.3 cracking requirements for an exterior exposure:

$$d_s = d_c = h - d$$

$$A_e = b_w(2d_s)$$

$$A = \frac{A_e}{N}$$

$$f_s = 0.6 f_y$$

$$z = f_s \sqrt[3]{d_c A}$$

3.3 Column Design

Calculated the areas of longitudinal reinforcement (A_{st}) and concrete with the number of bars given and the rebar size given.

Calculate maximum axial load resistance (P_{rmax})

$$P_{ro} = \alpha_1 \phi_c f_c' (A_g - A_{st}) \phi_s f_y A_{st}$$

$$P_{rmax} = 0.8 P_{ro}$$

3.4 Basement Wall Design

Reinforced concrete wall subject to 40kN/m DL and 20kN/m LL, and lateral soil pressure.

$\gamma_s = 20kN/m^3$ $K_o = 0.5$ $f_c' = 25MPa$ $f_y = 400MPa$ $\phi_c = 0.65$ $\phi_s = 0.85$ b=1000mm

Determine wall height:

Consider as pin-pin so use h_w = 3m

Determine the magnitude of the lateral soil pressure:

$$\gamma_0 = K_0 \gamma_s; \quad p_0 = h_w \gamma_0; \quad p_{of} = 1.5\, p_0$$

Determine the factored bending moment:

$$w_f = \frac{p_{of}}{2} \qquad M_f = \frac{w_f {h_w}^2}{8}$$

Determine the factored shear force as a simply supported beam with a triangular load distribution:

$$V_f = \frac{p_{of} h_w}{3}$$

Determine wall thickness:

According to A23.3 CI.14.3.6.1 thickness> $h_u/25$ = 120mm or 190mm

Use t=200mm

Determine factored axial load: $P_f = 12.5DL + 1.5LL$

Determine effective depth:

$d = h - cover - \frac{d_b}{2}$ assuming there is only one layer of reinforcement. d_b is the diameter of the rebar chosen.

Determine area of tension reinforcement:

$$A_s = 0.0015 f_c' b\left(d - \sqrt{d^2 - \frac{3.85 M_r}{f_c' b}}\right)$$

Determine required bar spacing: $s \leq = A_b \frac{1000}{A_s}$

Check reinforcement ratio: $\rho = \frac{A_s}{bd}$

Design for shear:

Determine effective shear depth:

$$d_v > 0.9d \text{ or } 0.72t \quad Use\ d_v = 153mm$$

Determine β: $\beta = \frac{230}{1000 + d_v}$

Determine V_c: $V_c = \emptyset_c \lambda \beta \sqrt{f_c'} b_w d_v$

3.5 Slab on Grade Design

From geotech report, floor lab underlain by polyethylene moisture barrier, 100mm of ¾ inch gravel.

K = 54MPa/m → gravelly soils, well-graded sands

$f_c' \geq 20Mpa \;\; Use\ f_c' = 25Mpa$

t=100-150mm

Assume slab to be 110mx110mx150mm.

Temperature + Shrinkage Reinforcement:

$$f_s A_s = \left(\frac{wL}{2}\right) F \qquad A_s = \frac{44.7mm^2}{unit} slab\ width$$

$$f_s = 0.67 f_y = (0.67)(400); F = 1.5$$

$$w = (2400kg/m^3)(0.15m)(9.81m/s^2) = 3532N/m^2$$

$$L = length\ between\ joints = 4.5m\ for\ 20mm\ aggregate\ size$$

$$A_{s_{min}} = 0.001 A_g = 150mm^2/unit\ slab\ width > 44.7mm^2$$

$$A_s = 150mm^2$$

Use 2-10M deformed bars/unit slab width in both directions.

Reinforcement should be 1/3 below slab surface.

3.6 Spread Footing Foundation Design

Square-shaped footing supporting a 500mm square concrete column. DL=1000kN and LL=1000kN. Maximum aggregate size is 20mm.

q_{all} = 250kPa f_c' = 25MPa f_y = 400MPa ϕ_c = 0.65 ϕ_s = 0.85

Determine footing plan dimensions: $A \geq \frac{P_s}{q_{all}} = \frac{DL+LL}{q_{all}}; \;\; b = \sqrt{A}$

Determine factored soil pressure:

$P_f = 1.25DL + 1.5LL; \qquad q_f = \frac{P_f}{A}$

Determine concrete shear resistance:

$v_c = 0.38\lambda \emptyset_c \sqrt{f_c'}; \qquad V_c = v_c b_o d$

Determine shear perimeter: $b_o = 4(t + d)$

Check v_c criteria:

$$v_c = \left(1 + \frac{2}{\beta_c}\right) 0.19 \lambda \emptyset_c \sqrt{f_c'}$$

$$v_c = \left(\frac{\alpha_s d}{b_o} + 0.19\right) \lambda \emptyset_c \sqrt{f_c'}$$

Determine footing thickness: $h = d + cover + \frac{d_b}{2}$

Determine factored shear force: $V_f = q_f b\left(\frac{b-2}{t} - d\right)$

Determine effective shear depth:

$$d_v > 0.9d \text{ or } 0.72t \quad Use\ d_v = 500mm$$

Determine β: $\beta = \frac{230}{1000 + d_v}$

Determine V_c: $V_c = \emptyset_c \lambda \beta \sqrt{f_c'} b_w d_v$

Determine factored bending moment resistance:

$$M_f = q_f \left(\frac{b-t}{2}\right)\left(\frac{b-t}{4}\right) b$$

Determine area of flexural reinforcement:

$$A_s = 0.0015 f_c' b\left(d - \sqrt{d^2 - \frac{3.85 M_r}{f_c' b}}\right)$$

Check development length for flexural reinforcement:

$l_d = 0.45 k_1 k_2 k_3 k_4 \frac{f_y}{\sqrt{f_c'}} d_b$ where $k_1 = k_2 = k_3 = k_4 = 1.0$

$$l = \frac{b-t}{2}$$

Check $l > l_d$