University of British Columbia

Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

UBC Groundwater Emergency Water Supply Project

Prepared by: Kaede Durrant, Andrew Nickel, Andrew Miller, Natalie McRae, Anha Nubaira, Xiaoying Qin

Prepared for:

Course Code: CIVL 446

University of British Columbia

Date: 16 April 2021

UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

UBC Groundwater Emergency Water Supply Project

Kaede Durrant *Andrew Nickel* *Andrew Miller*

Natalie McRae *Anha Nubaira* *Xiaoying Qin*

University of British Columbia

CIVL 446

April 2021

Executive Summary

The University of British Columbia (UBC) Point Grey Campus is located within the region known as the Cascadia Subduction Zone. Scientists have indicated that a large magnitude earthquake is likely to occur in this region. When this earthquake happens the potable water supply mains going through the University Endowment Lands (UEL) may be cut off. The UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program has been exploring ways to provide water to the residents in such an event, so as to improve their resiliency under trying times. A leading option in their search is to utilize the water found in aquifers that are located below UBC, in the Quadra Sand layer. This final design report explains in detail how this will be achieved and also provides final detailed drawing sets.

There are two aquifers in the Quadra Sand layer, containing about 5 and 15 metres of available water, respectively. During an emergency, there is enough water in these aquifers to provide potable water for the UBC residents for a period of about seven days. The main objective was determining what flow could be produced from a well installed in these aquifers. It was determined from our analysis that a well installed at a suitable location could produce around 15 litres per second. The next objective considered was understanding the demand flow rate. From analyzing the current usage some important areas came to the forefront: residential, academic research, and the hospital. Accommodating these and reducing in areas such as irrigation and laundry, brought the average demand to around 67 litres per second.

Wells were located based on the thickness of the aquifer and available surface space. Additionally, drawing water from one well can impact the available water at a nearby well. This calculation was done and it was determined there will be enough water for all the wells to draw continually for the 7-day emergency period. Also of importance for well location was the thickness of till cover at the surface, as excess till can cause delays in drilling. It was decided to use the existing water network to transport the well water to the residents, however, the well water would need to be treated before entering the network. The location for the treatment plant, storage reservoir, and pump station was based on proximity to the entrance of the two existing pressure zones, in order to minimize water main installation costs.

The well water will first arrive at a treatment plant to receive filtration and chlorination, before proceeding to a storage reservoir. The inclusion of a 4,500 cubic metre storage reservoir helps balance the daily peaking demands and provides the campus with a source of water, ready to be used immediately after the onset of an emergency. This combination will provide an average flow rate of 67 litres per second. The treated well water in the storage reservoir will be sent to the two existing pressure zones from the pump station. This system has been designed for reliability and to have a service life of 50 years, thereby meeting the needs of current and future residents.

The first month of this project was spent researching wells, aquifers, precedent structures, campus demand and reservoirs. This collaborative process involved sharing ideas, walking through explanations, and documenting rationale behind decisions. After the initial research, a technical analysis was performed for the soil geology, the hydraulics, the environmental impact, the cost, the schedule and for the construction planning. The project is scheduled to start construction on May 1, 2021, completing on November 23, 2021. The final project cost is $6.5 million, as determined in the attached class A, cost estimate.This final detail design for the emergency water system will provide a seamless transition from a broken water supply main, to a treated well water supply system.

Table of Contents

List of Figures

List of Tables

1.0 Introduction

This report presents the final design of a groundwater emergency water supply system for UBC's Point Grey Campus. The system is designed to provide the campus with potable water in case of a major emergency leading to failure of the Metro Vancouver water supply. UBC currently receives water from Metro Vancouver via two water mains running through the UEL. In the event that these mains fail, UBC would be left with no water. A backup water supply system which uses wells on campus to access groundwater from the Quadra Sand layer aquifers was designed.

The Quadra Sand layer aquifers stretch beneath the entire UBC Point Grey campus with the upper layer being approximately 5 m deep, and the lower sands approximately 15 m deep. The lower aquifer is approximately 90 m below ground. To access these aquifers, wells will have to be drilled on campus and the water will be pumped to the surface. The water will then be stored, treated, and distributed to campus residents. Analysis of the aquifer indicated that a single well will yield approximately 15 L/s.

The first design step was determining demand. It was decided that it was imperative to provide water for residential, academic, and hospital uses. This led to an average demand of 67 L/s. The next step was determining how to supply this water. Due to fluctuations in demand throughout the day, a storage reservoir was necessary. It was then decided to prefill this storage reservoir with treated water from the UEL mains. The stored water will be used in conjunction with four wells to provide an average flow of 67 L/s for exactly one week following a UEL water disruption event. To ensure that the stored water does not grow stale, a water main from the UEL will be rerouted through the tank to continually refresh the water supply. The final design step was creating a distribution and treatment system. The team decided to use the existing water distribution system, and pump water from the reservoir back into the UEL mains. Treatment will be accomplished before the well water enters the reservoir, using chlorine. Inflow into the storage reservoir after treatment will be controlled with a check valve.

Table 1: Team Contribution Breakdown

Member Number	Team Member	Contributions	Review
1	Kaede Durrant	● Storage reservoir calculations and design ● Storage reservoir drawings ● Storage reservoir construction specifications ● Design Criteria	Xiaoying Qin
2	Natalie McRae	● Pipe system calculation and design ● Pipe system drawings ● Pipe system construction specifications ● Well pump selection EPANET model ● Standards and Software Packages	Anha Nubaira
3	Andrew Miller	● Design of Pump Station for Preliminary Stage ● Overview map & Reservoir Sump CAD drawing ● Formatting Final Design Drawing set ● Material Handling Construction Specifications	Kaede Durrant
4	Andrew Nickel	● Construction schedule ● Concrete construction specifications ● Service Life Maintenance Plan	Natalie McRae
5	Anha Nubaira	● Draft Construction Work Plan ● Cost Estimate ● Project and Site Overview	Andrew Nickel
6	Xiaoying Qin	● Well calculations and design ● Well drawings ● Well and General Requirements construction specifications ● Geotechnical model	Andrew Miller

2.0 Project and Site Overview

The UBC groundwater emergency water supply project is designed to be an alternative water source for campus activities in the event of an emergency such as an earthquake, power failure, pump failure, transmission main failure, valve seizure, contamination, or any combination of the above. In such a crisis, the two existing water mains along Pacific Spirit Park which supply the UBC Point Grey campus with water from Metro Vancouver may no longer be a reliable water source. The client - UBC SEEDS (Social Ecological Economic Development Studies) Sustainability Program - intends for the project to help establish UBC as a resilient institution in the case of service interruptions. Utilizing the Quadra Sand layer underneath UBC, the groundwater emergency supply should be able to service the peak campus population of 55,000 people each day with potential to increase service to 70,000 by 2030.

The project team aims to deliver a sustainable groundwater supply solution to UBC's emergency water problem, taking into consideration the triple bottom line (financial, social and environmental accountability) to ensure stakeholder satisfaction. The design will provide water for peak campus populations for one week in the event of a crisis, covering both residential water demands and research/academic needs. The new system will connect to the existing water mains to ensure that a reliable on-campus water supply is constantly available. All relevant bylaws, criterias and policies for land/water use and building design were strictly adhered to. The UBC emergency groundwater supply will provide water for the UBC Point Grey Campus which includes residential communities and all UBC campus buildings, spanning approximately 4 km^2. The Point Grey Campus is a part of the UEL that contains additional residential areas and the Pacific Spirit Regional Park.

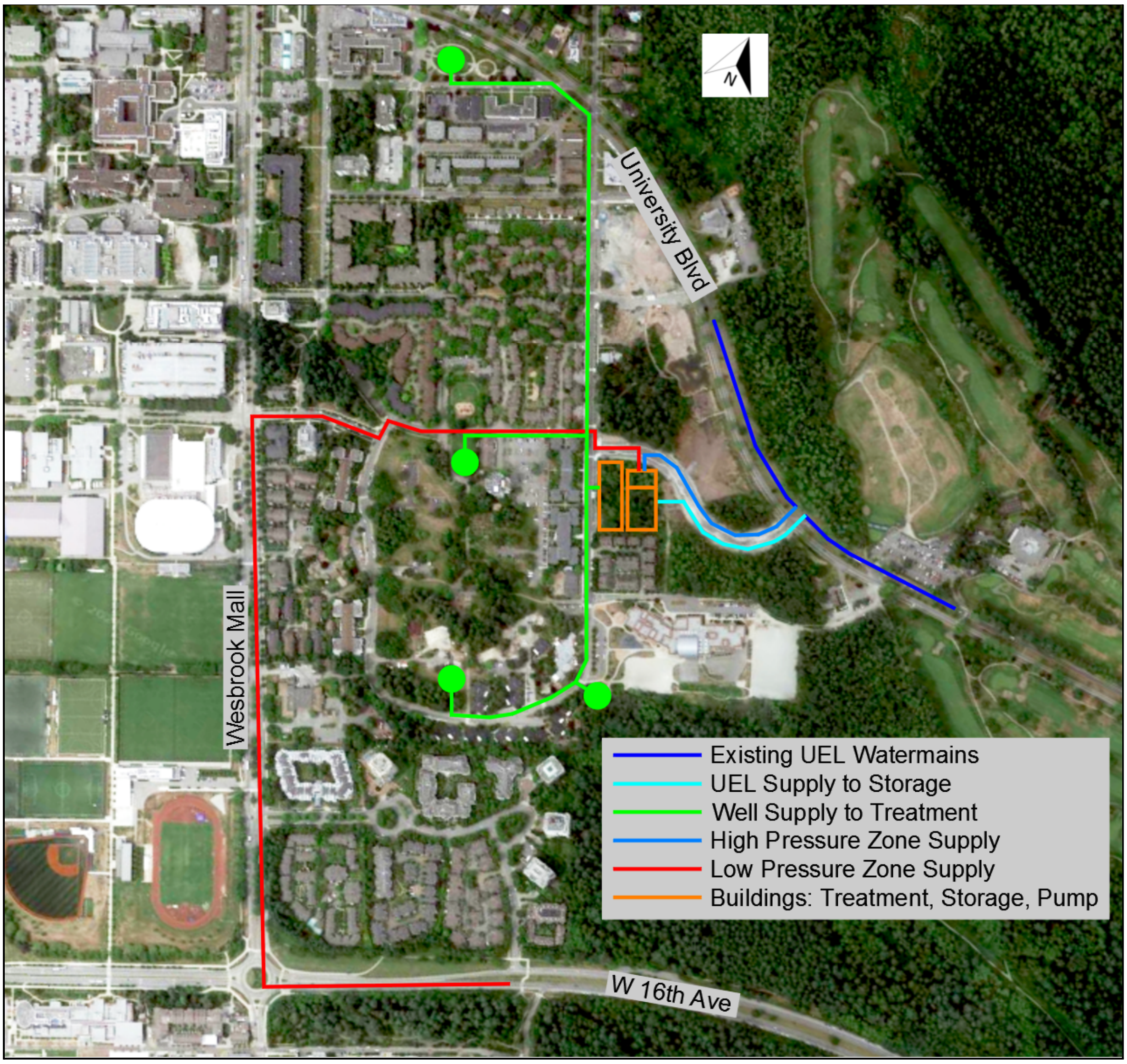


Figure 1: The UBC Point Grey Campus Project Overview Map

3.0 Design Criteria

Design and analysis were based on a 2,475-year return period “design event” earthquake along the Pacific Plate. This return period was selected as it corresponds to an event with a magnitude that would have the capacity to break water mains, which is our primary concern. The analysis includes a maintenance plan which includes yearly checks of systems and cleaning where necessary, with an intended total design life of 50 years. Regular upkeep of chlorine for the treatment system will also be required, as it would be the main emergency treatment mechanism for the emergency system.

The design loading for the system was based on analysis of UBC’s water use breakdown. The analysis showed the average demand during an emergency to be 67 L/s, and the peak anticipated flow in the event of an emergency to be 182 L/s.Subsequently, from our calculations of a 15 L/s well production rate, a required well quantity of 4 was determined to meet selected demand.

4.0 Key Components & Technical Design Considerations

The emergency water supply design provides water to UBC residents at about two thirds the existing rate. Four wells provide water to a treatment station; which outputs to a storage reservoir. The storage reservoir acts as a buffer during the high and low demand periods, allowing the pumps to run at a constant rate. A pump station draws treated water from the reservoir and increases the pressure to the current level, while sending it to both the existing water networks (the high pressure and low pressure zones). During non-emergency times, the UEL supply is re-routed through the reservoir and pump station and joins back to the UEL supply water main at the same pressure.

4.1 Wells

The well system of the emergency water supply consists of 4 individual wells, each capable of supplying a 15 L/s flow rate. Each well taps into both the upper and lower aquifer of the Quadra Sands underneath UBC. Installation will be conducted by a BC registered well driller and well pump installer as per provincial guidelines. The well locations will follow Canadian health hazard regulations, and be located 6 m from any private dwelling.

4.1.1 Structural System

At the surface of the well system, the well head will extend 0.70 m above the ground elevation, capped with a watertight vented well cap. Each well will be registered with the BC Ministry of Environment and labeled with a well identification plate. A 0.2 m depth surface clay soil backfill will be installed with a slope facing away from the wellhead to prevent surface water infiltration. A pitless adapter extrudes the casing at a 0.9 m depth for connection to the pipe system. Below the backfill, a 0.5 m deep cement grout base encompasses the well casing, extending a 1 m radius around the casing diameter.

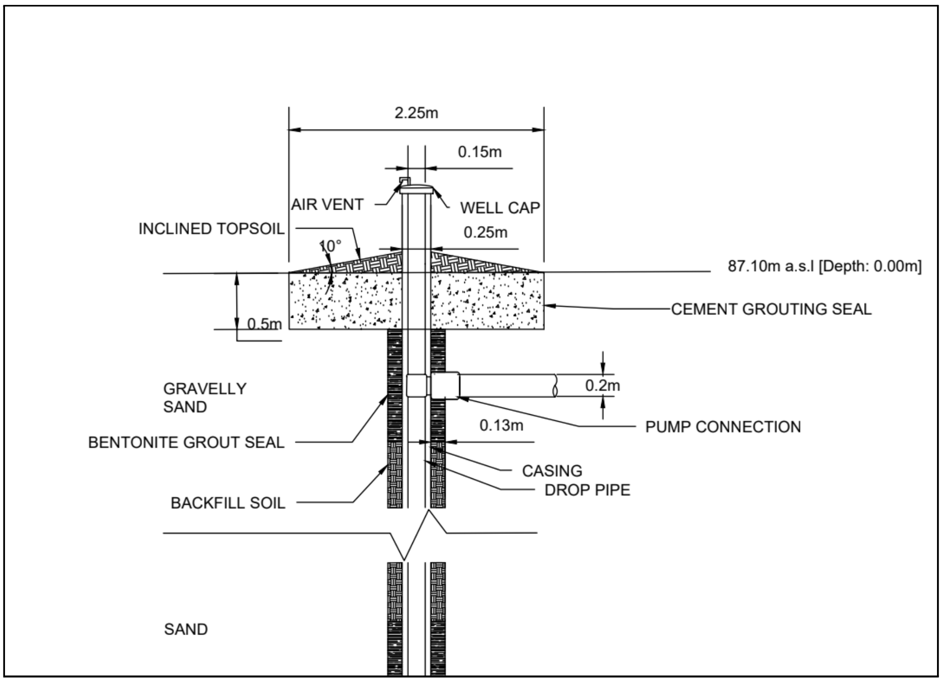


Figure 2: Well Design Overview

Underneath the cement grout, the well extends 90 m to reach both the upper and lower aquifer sands. The cross section of the well consists of a 0.152 m (6 inch) diameter steel inner drop pipe with a wire wrap screen intake at the bottom of the pipe. The 0.254 m (10 inch) diameter stainless steel casing will encompass the drop pipe, allowing ample space for water intake and flow. A 30 HP 9 stage submersible pump will be installed in each well to extract water from the aquifers. Each submersible pump would be connected to a 30HP motor. A Variable Frequency Drive will be used to control pump flow rates in case lower flow is required.

At elevations [19.20 m - 21.3 m] and [3.58 m - (-4.52) m] where the well draws water from the upper and lower aquifers, the well casing is replaced by pipe based wire wrap screens for water intake. The wire wrap screens have 0.15 mm slits to filter sands and gravel from the exterior aquifer water source. Outside of the screens, a 12.7 cm or 5 inch thick layer of gravel pack will provide additional water filtration and prevent screen clogging.

Above/below each gravel pack, there is a 1 m layer of bentonite clay grouting. In the geotechnical analysis, a potential organics layer is expected to be present at elevation [12.88 m - 13.79 m] posing a contamination risk. In response, 2.91 m of bentonite clay grouting will be used to fill the casing exterior [0.91 m at organics + 1 m above/below organics]. Due to the magnitude of the well depth, the gravel pack and bentonite clay will be supplemented only at the specified depths for cost saving reasons. For the majority of the casing, the exterior will be backfilled.

For detailed, close-up drawings of the well, please refer to the Appendix.

4.1.2 Pump Selection

Several conditions pertaining to pump selection had to be met. The goals included:

1. Pumps must provide sufficient head to meet system demands
2. Overpumping must be avoided (pumps cannot operate above 15 L/s)
3. Backflow into the wells must be prevented

Hydraulic analysis was performed to calculate the approximate head that the pumps would need to supply. An appropriate pump capable of meeting the flow rate and requirements was then selected. The pumps are all required to supply approximately 110 m of head at 15 L/s. A good pump choice would be Flint and Walling's 30 HP 9 stage submersible pump, paired with a variable frequency drive. This pump can supply a flow of approximately 15 L/s and 113 m of head at it's best efficiency point. Assuming that a VFD will be used to limit the flow rate from each pump to 15 L/s (the well's production limit), the system was analyzed using EPANET. The system was modeled to ensure that the well pumps would be fully capable of extracting water from the wells and transporting the water to the treatment and pump station. The EPANET model can be found in Appendix B. Pressure reducing valves were modelled before each node to equalize the incoming pressures. Figure 3 below shows the pump and system curves created for each well. The intersection represents the pump operating point. The pump curve data was taken from the manufacturer website. The system curve uses head drops across pressure reducing valves calculated by EPANET, assuming that the pump has been set to operate at 15 L/s. Detailed calculations can be found in the Appendix A. Further description of the EPANET software can be found in Section 5.0.

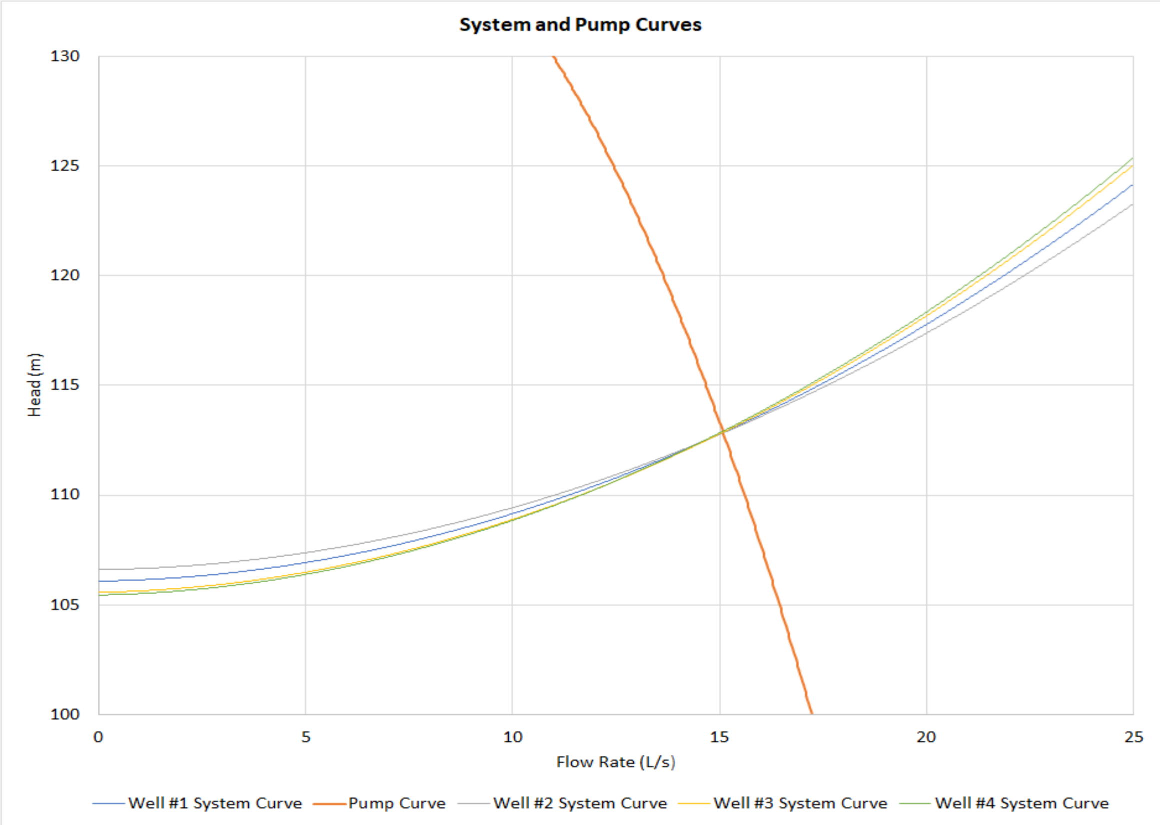


Figure 3: System and Pump Curves

4.1.3 Materials

As the well system will need to be reliable in the case of an emergency, materials chosen for the well construction were selected based on durability and serviceability. The following table highlights the dimensions and materials chosen for each well component.

Table 2: Well Components, Pump Components and Specified Materials

Well Component	Materials and Specifications
Well Cap	Water-tight vented 6” diameter cast iron well cap.
Piping	A 92 m length 0.152 m (6”) diameter stainless steel pipe
Casing	A 91.3 m length 0.254 m (10”) diameter stainless steel casing with embedded screens at the upper + lower aquifers. Casing will be capped with a 0.05 m thick steel bottom plate.
Screens	Pipe based wire wrap screen with 0.15 mm slit size [D_{40} of sample soil grain size] For Upper Aquifer: 3.00 m depth For Lower Aquifer: 10.80 m depth
Gravel Pack	Well rounded clean river/ocean sand with a nominal diameter of 0.2mm. Must be uniformly graded.
Sealing + Contamination Prevention	Cement grout at surface of the well to prevent surface contamination. Bentonite clay will be used above/below organics to prevent potential contamination.
Pump Component	**Materials and Specifications**
Pumps	4x Flint and Walling 30 HP 9 stage submersible pump
Motor	4x 3 Phase 30 HP motor
Variable Frequency Drive	4x 30 HP Variable Frequency Drive
Pressure Reducing Valves	6x Singer 106-PR-C Pressure Reducing and Check Valve

4.1.4 Rationale

A concern for the placement of wells was balancing the cost of piping to connect the wells to storage and ensuring the wells do not debilitate nearby wells’ water intake capacity. The closest wells of concern are well 3 and well 4, with 301 m spacing in between the placements. Using the Theis equation and superimposing drawdown curves, a 12.54 m drawdown depth (out of 13.8 m original aquifer depth) will be experienced at equidistance between well 3 and 4 at the end of a 7 day draw period. This is a significant drawdown; however the system is intended to operate for at a maximum of 7 days and aquifer depletion by the end of this emergency period is considered to be acceptable for the project. For assumptions and detailed calculations, refer to the Appendix.

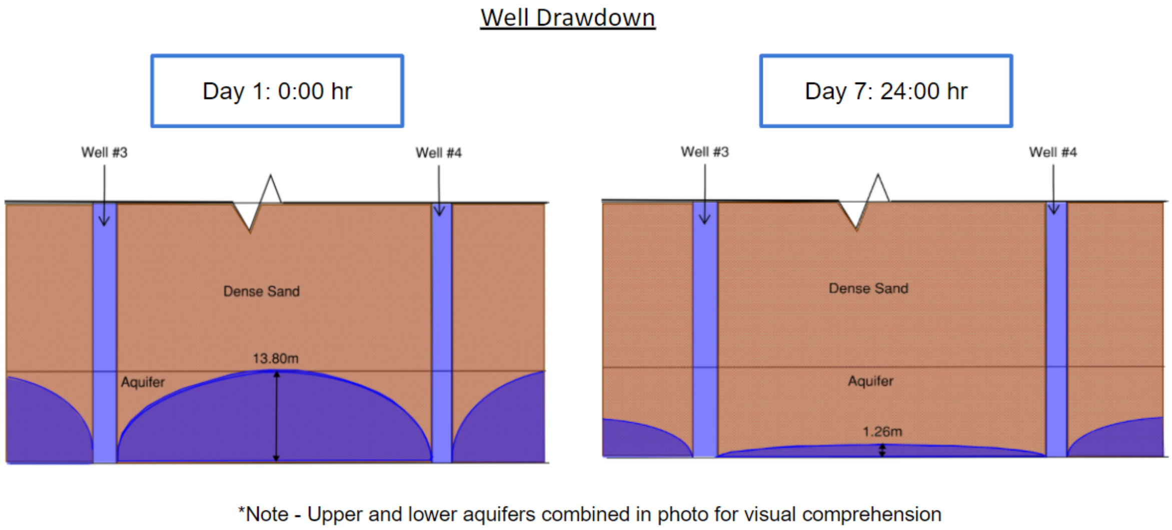


Figure 4: Drawdown Depth Influence

The two major challenges faced in well design were contamination prevention and durability of the well to withstand and outlast emergency situations.

Contamination is a significant hazard in well systems because surface contamination infiltration oftentimes penetrates deep depths by flowing along the well casing surface. The well cap is watertight to prevent contamination from accessing the well water from inside the drop pipe or casing. The ground surrounding the pipe will also be backfilled with a slope facing away from the wellhead. This ensures water does not accumulate around the well and infiltrate due to hydrostatic head from precipitation build-up. Additional grouting measures are taken at the surface and along the casing of the well. At the ground surface, cement grout will deflect any surface infiltration away from the well, reducing flow running down the casing length and encouraging water to be naturally filtered by soil. Bentonite grout is used along the length of the casing above/below the gravel packs at aquifer levels, as well as in replacement of the organics layer. The bentonite will swell up and behave like a plug to discourage vertical contamination infiltration, and ensure the intake water is composed of clean aquifer groundwater.

The durability of the well is of concern for seismic loads as well as service life/maintenance requirements. As the well is designed to be used in emergency circumstances such as in post-earthquake situations, the resiliency of the system is important. Stainless steel metal casing and drop pipes will be used due to their ductility and ability to continue service with minor damages. The long-term serviceability of the well largely depends on the water intake screens, as groundwater sediments can quickly build up and clog the screens. A pipe-based wire wrap screen will be used as the wires produce a 'v-shape' opening which discourages sediment trapping. The 0.15 mm slit screen will be capable of filtering out coarse-fine grained sands as well as all gravel. The 0.20 mm gravel pack surrounding the screen will be uniform in diameter and 'round' in grain shape (clean river/ocean sand) to sieve aquifer sands during water intake and reduce clogging.

4.2 Pipe System

4.2.1 Structural System

Water will be transmitted from the storage reservoir to the existing UBC water distributions system via two transmission mains. The transmission mains will be Polyvinyl Chloride Pressure (PVC) with a diameter of 300mm. Exact material specifications can be found in Section 6.0 of the report. The transmission mains will be installed along existing rights of way. Installation and construction specifications can be found in Section 6.0 of the report. Contractors will adhere to UBC's Technical Guidelines (2020) and UBC Energy and Water Services standards when installing the transmission mains. A Utility Service Connection Application and a Plumbing Permit prior to construction will be required.

The high pressure zone transmission main will be approximately 256 m long and transmit water from the storage reservoir to the UBC high pressure zone water main on University Boulevard. It will run along the unnamed corridor shown below in Figure 5. The low pressure zone transmission main will be approximately 1644 m long and transmit water from the storage reservoir to the UBC low pressure zone water main on West 16th Ave. It will run along Fairview Place and Thunderbird Boulevard to Wesbrook Mall, and then run along Wesbrook Mall to West 16th Ave. It will connect to the existing low pressure water main on West 16th Ave. just downstream of the existing check valve station. Figure 5 below shows the approximate paths of the transmission mains. Construction drawings with detailed system layouts can be found in Appendix F. For detailed drawings of fittings, elbows, and valves refer to the manufacturer catalogue. For detailed trenching drawings and specifications refer to the UBC Technical Standards.

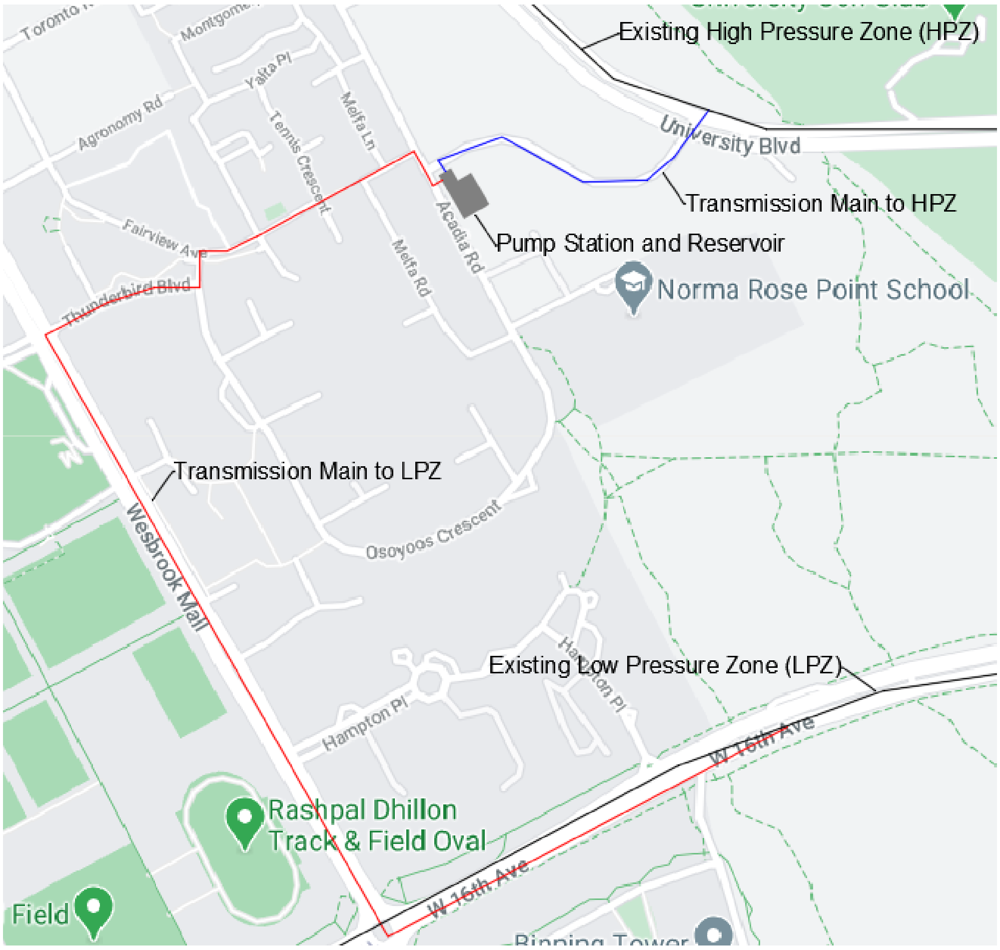


Figure 5: Transmission Main Map

4.2.2 Materials

Material choice was guided by the hydraulic requirements of the system and applicable guidelines and standards. PVC piping was selected for its durability and resistance to corrosion, as specified in the UEL water main replacement program. All materials meet the relevant American Water Works Association (AWWA) standards and Canadian Standards Association (CSA) standards. Further specifications can be found in Section 6.0. The following tables summarizes the components of the transmission main system:

Table 3: Transmission Main Materials

Transmission Main Component:	Material:
Pipes	1900 m of 300 mm Pressure Class 200 Polyvinyl Chloride Pressure Pipe
Valves	2 x Watts Series 774 300 mm Double Check Valve Backflow Prevention Assemblies
Fittings	6 x 300 mm Pressure Class 235 IPEX Blue Brute Series 90 degree angles 3 x 300 mm Pressure Class 235 IPEX Blue Brute Series 45 degree angles 3 x 300 mm Pressure Class 235 IPEX Blue Brute Series 22.5 degree angles 3 x 300 mm Pressure Class 235 custom 17 degree angle 2 x 300 mm x 300 mm x 300 mm Pressure Class 235 IPEX Blue Brute Series tees
Joint Restraints	19 x Stargrip Series 4100P Wedge Action Joint Restraints
Trench Fill	19 mm combined crushed aggregate fill
Pipe Bedding	19 mm combined crushed aggregate fill

4.2.3 Rationale

Transmission main materials were selected for durability and reliability. Stragrip, IPEX, and Watt products are frequently used in water main infrastructure projects in multiple municipalities, and have been proven to meet the applicable AWWA and CSA standards described in Section 6.0. Construction drawings were produced in accordance with the UBC Technical Guidelines and City of Vancouver Standards.

Transmission main sizing was based on the predicted well flow rate and emergency requirements. In the case of an emergency all UBC campus water would flow through the transmission mains. The pump station will be designed to supply 75 psi (517 kPa) to the high pressure zone and 60 psi (414 kPa) to the low pressure zones. The combined flow rate through the pipes will be 67 L/s. It is imperative that the transmission mains are capable of sustaining high flow rates at high pressures for prolonged periods of time. For this reason the mains were designed to have a diameter of 300 mm to accommodate high flow rates, and all materials were specified to a high pressure rating. Head loss calculations were performed using the Hazen Williams equation, assuming a roughness coefficient of 150 and accounting for minor losses. It was assumed that at peak flow approximately 33.5 L/s of water would flow through each pipe. Table 4 below summarizes the results. Sample calculations can be found in Appendix A.

Table 4: Transmission Main Losses

Transmission Main	Main to HPZ	Main to LPZ
Major Losses	1.68 kPa	11.75 kPa
Minor Losses	1.08 kPa	0.54 kPa
Total:	2.76 kPa	12.29 kPa

Based on these calculations, the pump station must provide at least 519.8 kPa of pressure at the inlet of the high pressure zone transmission main, and 426.3 kPa of pressure at the inlet of the low pressure zone transmission main.

Transmission mains were routed to minimize cost and time of construction. Where possible, only standard sized angles and fittings were used, to minimize the cost of custom fabrication. All mains were routed down existing rights that UBC has already designated as utility corridors to avoid lengthy construction delays. Where possible, transmission main cover was kept to 0.9 m. This is the optimal depth to avoid electrical, communications, and natural gas lines, which are typically buried with 0.6 m of cover, and storm and sanitary sewers, which are typically buried with 1.5-3.0 m of cover. Based on this information, it was assumed that conflicts between the new transmission mains and existing utilities would not occur. It is incumbent on the contractor to confirm the location of all existing utilities and report any design conflicts to the engineer.

4.3 Treatment

After being drawn from the wells, the water may need to be treated. Treatment would occur at a water treatment station directly adjacent to the storage reservoir and pump station. Water from the well network would be processed in the treatment station before entering the storage reservoir, from which it would be distributed using the existing pipe system.

4.3.1 Structural System

Water enters the treatment station through a 200 mm PVC pipe. The treatment station itself will be housed below ground within a reinforced concrete foundation. The above ground structure will be constructed using prefabricated steel and will provide easy access to the treatment area. Once the water has entered the station, it will be piped into a series of cylindrical completely stirred tank reactors. A conservative chlorine contact time of 36 minutes for a free chlorine dosage of 0.5 mg/L was calculated for the system, which gives a total reactor volume of 130 m^3. These tanks will be constructed using marine grade aluminum and will be continuously stirred by electric central motor systems. The system will also have a chlorine residual analyzer to ensure chlorine is kept at acceptable levels. The exact design of such a structure is left to the subcontractor.

4.3.2 Materials

Below is a summary of the materials that will be used in the construction of the treatment station. Material selection was based on a number of factors, including price, resiliency, and serviceability.

Table 5: Treatment Station Materials

Treatment Station Component:	Material:
Pipes	200 mm PVC
Structure	20ga Steel Prefabricated Building
Slab	30M Reinforced Concrete
Tanks	Marine Grade Aluminum
Pipe Fittings	200 mm PVC fittings
Chlorine Analyzer	CL17sc Colorimetric Chlorine Analyzer
Mixing Motors	NEMA 140 Frame 3-Phase NEMA Frame General Purpose AC Motors

4.3.3 Rationale

The treatment system for this project was selected on the basis of several federal and provincial drinking water guidelines. Much of this is dependent on the results of a Groundwater at Risk of Containing Pathogens (GARP) assessment. In British Columbia, water must be treated by a distributor only if it is from a surface source or if a groundwater source fails the GARP assessment (in accordance with the B.C. Drinking Water Regulation section 5.2). This assessment is to be performed by a drinking water officer (DWO) and will inform the degree of treatment that must be performed on the water. The above water treatment station plans were designed for the event that this system fails the DWO's GARP assessment. Notably, this treatment system must have 4-log removal of viruses, 3-log removal of protozoa, maintain less than 1 NTU effluent turbidity, and have no detectable E. coli or fecal coliforms. Based on these requirements, it was determined that the ideal system would be one that uses chlorine for treatment purposes. Some of the factors that influenced this decision are listed hereafter. When using a groundwater system, the process of the water travelling through the soil provides a significant degree of filtration. This is also in accordance with provincial recommendations of using both filtration and chemical treatment. As such, the level of chlorination needed to remove pathogens is significantly reduced. Additionally, the cost of chlorine treatment is generally lower than the cost of other treatment methods such as UV. However, chlorine does require replacement at semi-regular intervals. The method for implementing this treatment was selected to be a completely stirred tank reactor, as it allows a constant inflow and outflow of water.

4.4 Storage Reservoir

The storage reservoir is a single cell cast-in-place underground chamber. The on-line storage system is constantly refreshed by the incoming UEL water supply to ensure that the reservoir is active and water is refreshed at all times. A valve chamber encloses the inlet and outlet valves connected to the reservoir for ease of access.. In the event of an emergency, the inlet path from the UEL water supply closes, and the inlet path from the well supply and treatment facility will be opened. This system allows water to be supplied to the UBC community with minimal interruption while the water source is transitioned over to the groundwater supply that is able to service the campus for 7 days. The reservoir also serves as an equalization tank to ensure that no groundwater is wasted. The following sections outline the structural system and materials selected based on guidelines published by Vancouver Coastal Health, the Government of BC, and local municipalities.

4.4.1 Structural System

The underground 4,500m^3 storage reservoir is sized and designed to adequately supply the UBC community during emergency situations. The structure is a watertight structure with fully operational mechanical equipment and SCADA equipment, as outlined in the construction specifications. The reinforced concrete structure of the storage reservoir contains 40 reinforced columns (500 mm by 500 mm) that redistribute the load from the roof of the storage reservoir to the ground. The roof of the storage reservoir is designed for a uniformly distributed live load equivalent to an “assembly area”, which provides a myriad of possibilities for creative use of the space above the reservoir, if the community desires to do so. The thickness of the walls and roof are well above the minimum corrosion cover requirement outlined in the latest BC building code. Freeze thaw requirements as well as other specific structural design considerations shall be examined and approved by the structural subcontractor prior to start of construction. Detailed design drawings for the storage reservoir and all associated calculations are shown in the appendices.

Design features for the storage reservoir, as required by provincial and regional authorities, are outlined in the following table:

Table 6: Storage Reservoir Design Features

Design Features	
● One 4,500 m^3 cell ● Inlet path from treatment facility ● Inlet path from UEL supply ● 2 outlets to pump station ● Overflow drain ● Drain outlet at floor ● Roof access hatch (manway) ● Downturned ventilation pipe ● Lighting, locks, and alarms	● Sloped reservoir floor ● Minimum 1 m x 1 m x 0.4 m drain sump ● Wall ladder and railings ● SCADA equipment incl. leakage monitoring

Further, The storage reservoir's structural stability was checked with the preliminary geotechnical model to ensure it meets bearing capacity limits. As the soil stratigraphy underneath the storage reservoir consists of over 65 m of well graded dense sands, settlement is not of concern. Preliminary calculations can be found in the appendix, however, detailed analysis and final approval shall be subcontracted. In lieu of a washdown connection, the operational plan shall include services by a portable servicing truck.

4.4.2 Materials

Material selection was based upon review of guidance documents from various Canadian municipalities. The table below provides a summary of the storage reservoir components and materials that will be used in the design.

Table 7: Storage Reservoir Materials

Storage Reservoir Component	Material
• Internal piping	PVC
• Storage cell - Walls, base, and roof • Structural supporting columns • Sump chamber • Valve chamber	Reinforced concrete
• Access hatches • Overflow drain • Wall ladder • Floor drain • Downturned vents • All metal parts within storage reservoir (bolts, nuts, screws, anchors)	Stainless Steel or other NSF61 approved material

*All materials will meet ANSI/NSF61 standards for safety.

As outlined in the Design Guidelines for Rural Residential Community Water Systems by the Government of BC, completed reservoirs should be cleaned and disinfected in accordance with current AWWA standards prior to the start of operation.

4.4.3 Rationale

Storage size was calculated based on best practices adopted by various jurisdictions in BC. The concrete storage reservoir cell holds up to 4500 m^3 of water for immediate use, and acts as a buffer for peak demands. The total storage volume was determined by the summation of balancing volume, emergency supply volume, and fire flow supply volume.Water main connections to the existing UEL water distribution system will be able to provide 67 L/s ADD and 186 L/s PHD design flows for resident consumption, assuming a population of 55,000 students and residents. The demands throughout the day were estimated using a diurnal pattern with a steady base flow as described in the UBC Water Action Plan (2019). Detailed calculations can be found in the appendix.

Rationale for key design features are summarized in the table below:

Table 8: Storage Reservoir Design Rationale

Key Storage Reservoir Design Features & Rationale	
Single cell "on-line" reservoir	For equalization capacity of pumped groundwater supply during emergencies, and to ensure minimal interruption in water supply in the event of an emergency.
Overflow drain	For emergency overflow. Sized to handle overflow equivalent to design inflow.
Roof access hatch	For maintenance and temporary ventilation.
Ventilation pipe	For intake and exhaust air columns for filling and draining the reservoir.
Wall ladder	For ease of access. Designed with attachment points for fall arrest equipment.
Sloped reservoir floor towards floor drain	For ease of draining for maintenance.
Minimum 1 m x 1 m x 0.4 m drain sump	For draining.

4.5 Pump Station

The final design for this project will require a pump station. This is because we are including a reservoir to store a back-up supply of water that can be used immediately in the event of failure. However, since the pump station falls outside of the primary scope for this project, we will provide the basic requirements and criteria and allow the sub-contractor to make the full design.

4.5.1 Primary Criteria

The pump station will need to be built for continual and reliable operation. In this final design, the UEL water mains get rerouted to fill the storage reservoir. From the storage reservoir the pump station brings the water back to the same flow and pressure that the UEL had originally provided. The pump stations connect back to the existing continuation of the UEL supply water mains. The high pressure zone operates at 75 psi and uses an average day demand of 124 L/s. The pipes used to exit the pump station will be 300 mm PVC. The pump station would need to be designed for these numbers. Refer to section 4.2 for more details about head loss in the water supply network.

4.5.2 Additional Criteria

The low pressure zone on the southern portion of UBC Point Grey campus, operates at 60 psi. This pressure is achieved through using a pressure reducing valve (PRV) from the high pressure zone. Therefore no extra requirements are placed on the pump station.

The building itself needs to be built for a lifetime of 50 years. It will be likely located underground and needs to be readily accessible and spacious enough for easy servicing and maintenance. It must be built in accordance with the standards laid out in section 5.0. Additionally, since this system is being made to provide water after a major earthquake, the building must be made strong enough to continue functioning after such an earthquake. The electrical power for the pump station will come from the grid during regular operation. However the building must be able to switch over to emergency back-up power provided by a nearby building's back-up generator system.

4.6 Seismic Considerations

Almost the entirety of this project is predicated on the fact that a high-magnitude earthquake could damage the water mains running to UBC. As such, it is of utmost importance that the system be resistant to seismic effects. When examining the system as a whole, the areas most at risk are the pipe system and the storage reservoir. The latter is to be designed to the standards of the BCBC and ACI guidelines. Although there are load cases that utilize the effect of earthquakes within these guidelines, their final value is less than that of the factored dead load combination. This is in large part due to the relatively short stature of the building, reducing the effects of compounding acceleration. Another effect that must be considered for both the storage reservoir and the pipe system, however, is liquefaction. In order for liquefaction to occur, the following conditions must be met:

- Cohesionless soil
- Loose
- Undrained conditions
- Saturated
- Strong ground shaking

Based on the available geological data, the only sections of the soil stratigraphy that could potentially meet these requirements are the saturated sand layers of the upper and lower aquifer. However, the layers seem to have a sufficient amount of drainage to prevent any liquefaction from occurring. Additionally, any potential liquefaction in these layers would have a minimal effect on the pipe system, which will be quite close to the ground surface. Precautions must still be put in place, however. The relative flexibility of PVC (in contrast to a material such as asbestos concrete) allows it to weather moderate levels of wave propagation with little damage. Instead, much of the failures in such a pipe system would be due to pulled joints. Thus, it is important that the pipe joints throughout the system be installed with a high degree of precision and potentially extra reinforcement.

4.7 Geological Assessment

A geological assessment was conducted to ensure the success of well, storage reservoir and piping installation. As the designed well will be drawing water from both the upper and lower aquifers, the pre-existing ground investigation data available was limited due to the depth of analysis required. The closest and most complete set of borehole data was determined to be TH01-02_70 from the Piteau Hydro-Geo Study completed in 2002. A summary of the soil stratigraphy found in the investigation along with project-relevant concerns are presented below.

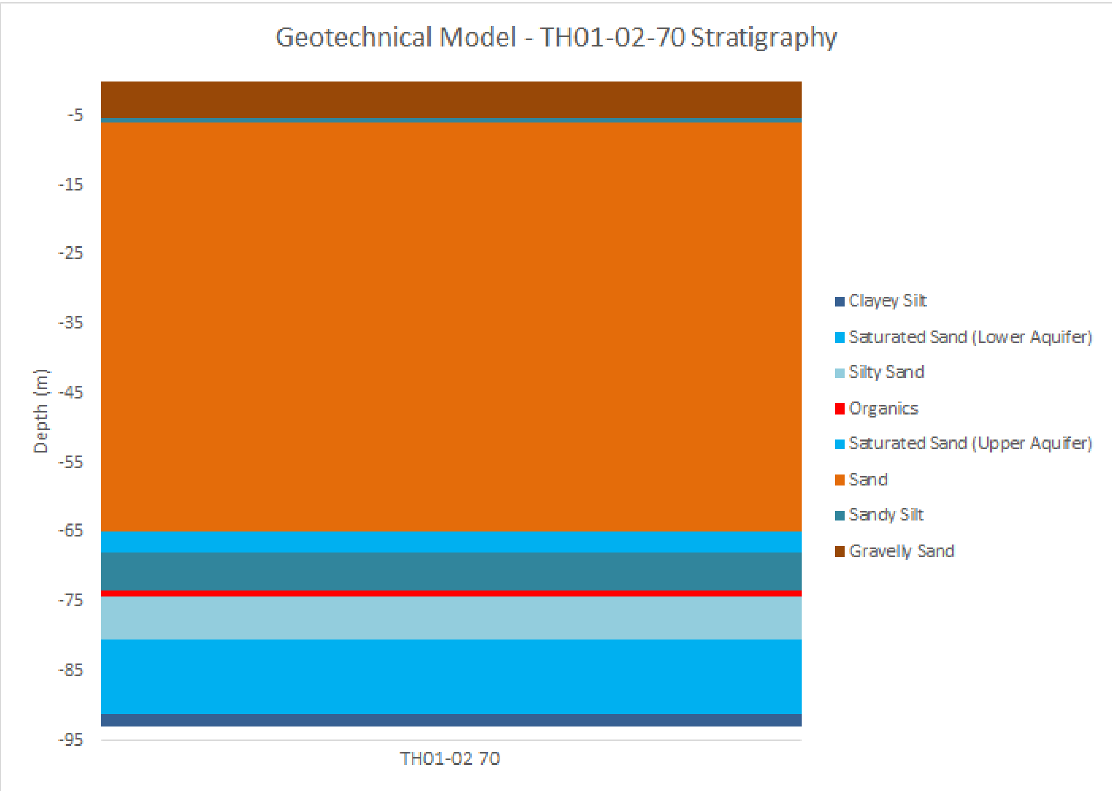


Figure 6: Predicted soil stratigraphy - borehole TH-01-02_70

Table 9: Predicted soil stratigraphy - borehole TH-01-02_70

Elevation [m]	Depth Below Surface [m]	Soil Type/Conditions
87.10 – 81.90	0.00 – 5.20	Gravelly Sand ● At 2.70 m depth the sampled soil composition was: ○ 99% Sand, with the majority being 'medium' grain size ○ 1% Gravel ○ Hazen Approximation: K = 8.1 *10^-5 m/s

		● The upper gravelly layer is known to consist of glacial till material. It is known that some till materials can contain high sulphate content which degrades concrete. Additional research in sulphate content should be conducted and a higher concrete exposure class is required. As the gravelly sand is well graded, there is little bearing capacity concern in this layer.
81.90 – 81.20	5.20 – 5.90	Sandy Silt ● Silty sands may experience dilatancy and is often weak. Due to the relatively thin layer and low bearing capacity demands, there is no recommended action.
81.20 – 22.20	5.90 – 64.90	Sand ● At 7.0 m depth the sampled soil composition was: ○ 79% Sand, well graded grain size ○ 21% Gravel, ‘fine’ – ‘medium’ grain size ○ 13% Silts ○ Hazen Approximation: K < 8.1 * 10^-5 m/s ● At 16.8 m depth the sampled soil composition was: ○ 99.5% Sand, ‘medium’ – ‘fine’ grained ○ 49.5% Silts/Fines ○ 0.5% Gravel ○ Hazen Approximation: K< 8.1 * 10^-5 m/s ● Well graded, dense sand zones pose low settlement/liquefaction concern
22.20 – 19.20	64.90 – 67.90	Saturated Sand (Upper Aquifer) ● Poorly graded sand with pockets of clayey silt ● Additional screen considerations for well design is required to prevent silt/clay build-up.
19.20 – 13.79	67.90 – 73.31	Sandy Silt
13.79 – 12.88	73.31 – 74.22	Organics ● Too deep in the soil stratigraphy for structural concern. ● Additional considerations for well design is required to ensure no organic contamination will affect well water.
12.88 – 6.28	74.22 – 80.50	Silty Sand
6.28 – -4.52	80.50 – 91.30	Saturated Sand (Lower Aquifer) ● Fine-medium grained loose sands with imbedded silt pockets ● Additional screen considerations for well design is required to prevent silt/clay build-up.
-4.52 – -6.22	91.30 – 93.00	Clayey Silt Clay/silt material is prone to variability (swelling, shrinking) due to moisture content. However since the soil is below the lower aquifer and below sea level, it is assumed that the clay's constantly saturated and the moisture content does not fluctuate throughout the year. As a result, this layer is not of immediate concern.

To assess the structural stability of our design on the ground, soil parameters used will be as recommended in the Piteau report and summarized as follows:

Table 10: Summary of Soil Parameters

	Density [kg/m^3]	Cohesion (kPa)	Friction Angle (◦)	Shear Modulus (MPa)	Bulk Modulus (MPa)
Gravelly Sand	2000	0	38	200	2000
Sand	2080	0	44	260	2600
Silt	1900	200-600	0	100-300	1000-3000

Borehole TH01-02_70 is approximately 1.1 km away from the chosen storage reservoir/treatment station location, and therefore variations are to be expected at the exact site location. Additional CPT investigations are planned in the pre-construction phase of this project to confirm the following soil stratigraphy - any deviations from TH-01-02 will require additional analysis.

5.0 Standards and Software Packages

5.1 Codes and Standards

The following codes and standards will be used to aid in design. Specific criteria for different project components are outlined in Section 6.0.

- City of Vancouver Engineering Design Manual (2018)
- City of Burnaby Engineering Design Criteria Manual (2019)
- BC Design Guidelines for Rural Residential Water Systems (2012)
- Canadian Standards Association (CSA)
- American National Standards Institute NSF 61 Standard (ANSI/NSF61)
- American Water Works Association Standards (AWWA)

5.2 Regulatory Requirements

The project design will comply with all regulatory requirements of the UBC Board of Governors, British Columbia Provincial Government, and Canadian Federal Government. The design will also adhere to WHO recommendations regarding safe water supply in emergencies. Compliance with the policies listed below will be monitored and enforced through all project phases. The policies and standards listed here cover encompass project design, construction, operations, and maintenance. It must also be ensured that the relevant construction and operational permits are obtained for the water system. The following regulations will be adhered to:

Table 11: Important Regulations to be Considered

Land and Groundwater Protection Policies:	
UBC Environmental Protection Policy (Policy No. SC4)	Non-negotiable - Project will adhere to all environmental guidelines for projects on UBC land.
UBC Land Use Policy (Policy No. UP12)	Non-negotiable - Project will adhere to UBC's long-term land use objectives.
BC Groundwater Protection Regulation Under BC Water Sustainability Act (2016)	Non-negotiable - Act will be used to regulate well water supply, as well as groundwater access methods,well installation, and water treatment system.
BC Water Sustainability Act (2016)	Non-negotiable - Project will adhere to all guidelines and restrictions for well construction, proof of qualifications, and well operations and analysis. The project will also obtain necessary water licenses for non-domestic use of water from groundwater sources.
Canadian Environmental Quality Guidelines (2020)	Negotiable/voluntary - Project will aim to meet goals and standards for the quality of aquatic/ terrestrial ecosystems.
Design and Construction Policies	
BC Drinking Water Protection Regulation under BC Drinking Water Protection Act (2001)	Non-negotiable - Project will adhere to relevant criteria regarding the safe design, construction, and operation of water supply systems in the province of British Columbia.
BC Building Code (2018)	Non-negotiable - Project will adhere to all applicable rules and regulations outlined in the BC Building Code regarding structural

	design.
WorkSafe BC Standards	Non-negotiable - Project will adhere to all applicable worksafe BC regulations, in particular those relevant to construction, operations, and maintenance of facilities.
Emergency Water Volume Policies:	
World Health Organization (WHO) Technical Notes on Drinking-Water, Sanitation and Hygiene in Emergencies (2013)	Negotiable/voluntary - Project will strive to provide estimated necessary water requirements for survival, basic hygiene and basic cooking needs (measured in lpd/person).
City of Vancouver Building By-law (2018)	Non-negotiable - Project will adhere to all regulations established in this By-law, in particular those pertaining to the minimum fire flow required to maintain fire-fighting capabilities in the community.

5.2 Software Packages

The pipe system pressures and head losses were modelled using EPANET software. EPANET utilizes a parameter called nodes to represent locations with junctions or changes in pipe properties. Links are used to represent pipe segments. The team input all relevant node and pipe parameters and used EPANET to calculate all pipe segment head losses and all pipe junction pressures. The EPANET software provides several options for calculating head losses. The Hazen-Williams equation was chosen to calculate head losses for this project. The necessary pump curves were calculated using manufacturer data and Excel, and then the data was inputted into EPANET to model the system's pumping operations. Pressure reducing valves were also modelled. While EPANET does not explicitly provide tools to model wells, we chose to represent them in the system by using a reservoir with a negative head, followed by a flow restricting valve to limit the flow to the well's production limits, followed by a pump. All EPANET input values and the output results for this project can be found in Appendix E.

6.0 Construction Specifications

Complete Construction Specifications outlining various requirements for the system are appended to this report.

7.0 Draft Construction Work Plan

Construction work for the project will be split up into eight sections, based on pre-construction testing, construction of the key components, and project close-out. Key requirements for all construction work are presented below.

Table 12: Construction Work Draft Plan

Construction Work Draft Plan - Key Requirements:	
Pre-construction	● Site Condition Borehole Drilling: A minimum of 8 Cone Penetration Tests (CPTs) will be conducted at predetermined well locations near Acadia Road
Well Construction	● Borehole drilling to required depths ● Installation of casings and screens ● Gravel pack float-in for filtering ● Grouting to prevent contamination ● Construction of concrete pads around the wells ● Installation of pitless adapters ● Attachment of piping to wells ● Disinfection, sealing checks and installation of well ID
Reservoir Construction:	● Site Preparation: Clearing, Fencing ● Excavation to grade using cut-and-fill ● Installation of concrete tank components (floors, slabs, ceiling, columns and chambers) on site using the cast-in-place method ● Use of rebar that is chosen prior and shipped to site for the tank components ● Installation of internal piping and mechanical valve components ● Installation of prefabricated stainless-steel components: hatches, ladders, drains, vents, structural connectors ● Installation of SCADA equipment for monitoring and alarms ● Disinfection, inspections and checks
Pump Station Construction:	● Site Preparation: Clearing, Fencing ● Excavation using cut-and-fill ● Installation of the reinforced concrete station: Concrete slabs, walls, ceiling and stairs will be cast-in-place and installed on site. 25M rebar will be chosen prior and shipped to site for use ● Installation of pumps, motors, valves, fittings and steel pipes ● Inspections and checks
Treatment Centre Construction:	● Site Preparation: Clearing, Fencing ● Excavation using cut-and-fill ● Installation of reinforced concrete foundation and slabs using the cast-in-place method

	● Installation of the above-ground prefabricated steel building: Components will be prefabricated and shipped to site ● Installation of the cylindrical tank reactors, PVC pipes, pipe fittings, chlorine analyzers and mixing motors ● Inspections and checks
Pipe System Construction	● Site Preparation: Clearing, Fencing ● Continual excavation to required grade as piping installation advances, using the cut-and-fill method ● Installation and connection of well pipes, valves, fittings and motors to the main line junctions ● Installation of main line piping, valves, motors and fittings along Wesbrook Mall ● Installation of piping, valves, motors and fittings to connect the main line to the treatment station and reservoir ● Backfill and compaction ● Checks and inspections
Existing Pipe System Modifications:	● Site Preparation: Clearing, Fencing ● Excavation to required grade using the cut-and-fill method ● Installation of piping and fittings between the UEL high pressure water main on University Boulevard and the storage reservoir, and between new pipelines and the UEL low pressure water main on West 16th Ave. New piping will be attached to the existing water main systems. ● Backfill and compaction ● Checks and inspections
Project Close-out	● Final inspections ● Site clean-up

The construction sequence includes work done for different components simultaneously, with varying timelines. This is outlined in the project schedule, discussed in Section 9.0 and Appendix C. Anticipated construction issues for the project include the large amount of concrete casting required in uncertain weather conditions, which may lead to delays. Water main connection to the existing Low Pressure Zone has asbestos concrete pipes, which are old and structurally not as strong. Tie-in to these pipes may provide a challenge.

8.0 Cost Estimate

The Class A Project Cost Estimate was determined based on the analysis of key project requirements. Costs were determined for pre-construction requirements, project management, project components in scope (wells, pipe system and storage reservoir), project components to be contracted out (pump station and treatment system), project close-out, and maintenance. This analysis led to an estimated total project cost of $7,185,712.

It is to be noted that all costs were calculated to be within 5% to 10% of the estimated prices to account for contingencies, with the exception of the pump station and treatment system which are to be contracted out for additional details. The costs for these two components were calculated to be within 10% to 15% of the estimated prices for contingency considerations. A detailed breakdown of the cost estimate is provided in Appendix D.

9.0 Schedule

Through the consultation of industry standard construction times and previous project data, a final construction schedule was produced. This schedule assumes that all work that can be completed concurrently will be, requiring the use of multiple different crews. With this information, the project is expected to be completed in 6 months and 10 days. Given a start date of May 1, 2021, this results in a completion date of November 10, 2021. The gantt chart is included in Appendix C.

10.0 Service Life Maintenance Plan

This emergency water supply system will have a complete operational guidelines created. The general maintenance and operation practices are outlined for a few of the key system elements. These are in compliance with BC Groundwater Protection Regulation, the AWWA Standard A100-06, AWWA Manual M21, and the BC Design Guidelines for Rural Residential Community Water Systems.

10.1 General Operation and Maintenance Guidelines

During non-emergency time, the wells, supply pipelines, and treatment plant will be operated and inspected on a monthly basis to ensure proper functioning in time of need. The storage reservoir and pump station will be in continual, year-round use. All components of the entire proposed well water system will be inspected, cleaned, maintained, and replaced when necessary, according to the individual component's guidelines.

10.2 Emergency Actions

Should an emergency event occur causing a break of the supplying water mains, certain operational steps will be taken to facilitate transition to the well water system. The first step is to close the valves on the two incoming supply lines to prevent fouled water from entering the supply. The next step is to locate any local breaks and isolate those areas by closing the surrounding valves. Now the water in the reservoir can be the source of water and continue to supply the network. The well pumps will then be turned on to ensure the reservoir is continually filled.

10.3 Wells

The wells are designed to operate at a constant 15 L/s. This can be achieved through use of a storage reservoir to accommodate changing levels of use. However, the reservoir will have a redundant monitoring system, so that in the event it reaches capacity, a signal will be sent to the well pumps to turn off.

10.4 Treatment Station

The treatment station is designed to receive, treat, and output a constant 60 L/s. In the event that the treatment station needs to stop operating, a signal will be sent to the well pumps to turn off. Maintaining and ordering a reliable chlorine supply will be clearly outlined.

10.5 Storage Reservoir

The storage reservoir will have a monitoring and control system with five levels of redundancy. The reservoir actively monitors the water level and, when at capacity, will signal the inlet valves (or well pumps, during emergency) to be closed, thus preventing overfilling of the reservoir. Conversely, in the event that the reservoir reaches a critical low level, the monitoring system will signal the well pumps to turn on to help meet the temporary higher demand. The reservoir will also have the ability to be fully drained for in-chamber maintenance. In lieu of a washdown connection, a servicing truck will be used to provide washdown.

10.6 Pump Station

The pump station is designed for continual year-round use. The four main components that will have regular maintenance checks are the pumps, motors, variable frequency drive units, and the pressure reducing valve. The design includes two pumps; one duty and one standby. The actual pumps will rotate between the duty and standby roles to ensure that they both remain functional.

10.7 Transmission Mains

The transmission mains will be Polyvinyl Chloride Pressure Pipe, which has a service life of approximately 100 years. The double check valve backflow prevention assemblies will be subject to regular maintenance checks. Prior to use mains will be flushed and disinfected in accordance with AWWA C605-13 and AWWA C651 standards.

11.0 Conclusion & Recommendations

This final detailed design report provides a solution to the two primary design questions. What demand will the UBC population require during an emergency? The population will require 67 L/s over the emergency period of about seven days. And, what supply can be provided from the aquifers using a well system? Each well can provide about 15 L/s, using four wells and depleting the fully stocked reservoir results in 67 L/s thereby meeting the population demand. This report has a fully specified design to be implemented that will achieve the aforementioned targets and have a service life of 50 years.

We recommend operating the wells during emergency times only. Operating them continually during non-emergency times will deplete the aquifers, and therefore defeat the purpose of an emergency supply system. To be noted, the maintenance plan includes drawing small amounts from the wells on a scheduled basis to ensure they are in functioning order. Additionally, we recommend conducting cone penetration tests (CPT) in selected areas to help provide more information about the aquifer and which areas would be more favourable for installing a well.

12.0 References

All Disciplines Sustainability APEGBC Professional Practices Guidelines V1.1. (n.d.). Retrieved from https://www.egbc.ca/getmedia/91beda29-ad6f-4a6f-b302-ac60de0bab40/APEGBC-Sustainability-Guidelines.pdf.aspx

American Water Works Association. (n.d.). Find the Standrd You Need. Retrieved from American Water Works Association: https://www.awwa.org/Publications/Standards/Standards-List

A Guide to Water Well Casing and Screen Selection. (n.d.). Retrieved November 14 from http://roscoemoss.com/wp-content/uploads/publications/ggwc.pdf

BC Publications. (n.d.). Retrieved from free.bcpublications.ca website: http://free.bcpublications.ca/civix/content/public/bcbc2018/?xsl=/templates/browse.xsl

CITY OF BURNABY ENGINEERING DEPARTMENT DESIGN CRITERIA MANUAL. (2019). Retrieved from https://www.burnaby.ca/Assets/our+city+hall/city+departments/engineering/Engineering+Design+Criteria.pdf

City of Toronto. (2014, March). City of Toronto. Retrieved from Material Specifications: https://www.toronto.ca/wp-content/uploads/2017/11/90f3-ecs-specs-matspec-Chapter_6_Material_Specifications_March2014.pdf

City of Vancouver. (2019). Engineering Design Manual. https://vancouver.ca/files/cov/engineering-design-manual.PDF

City of Vancouver. (2018, September). Standard Detail Drawings. Retrieved from Standard Detail Drawings: https://bids.vancouver.ca/bidopp/RFA/Documents/PS20181461-CityofVancouver-StandardDetailDrawingsFirstEdition2018.PDF

City of Vancouver. (2019, November). Construction Specifications. Retrieved from Construction Specifications: https://vancouver.ca/files/cov/engineering-construction-specifications.PDF

Concrete Prices. Concretenetwork.com. Retrieved 28 November 2020, from: https://www.concretenetwork.com/concrete-prices.html

Cotterman. (n.d.). Fixed Ladders. Retrieved from Cotterman: https://www.cotterman.com/products/fixed-ladders

Design Guidelines for Rural Residential Community Water Systems 2012. (n.d.). Retrieved from https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/water-rights/water-utilities/design_guidelines_rural_residential_water_mar2012.pdf

Drinking Water Protection Act (2020) Retrieved November 29, 2020 from https://www.bclaws.ca/civix/document/id/complete/statreg/01009_01#part4

Engineering Design Manual. (n.d.). Retrieved from https://vancouver.ca/files/cov/engineering-design-manual.PDF

EPA Region 8 Drinking Water Unit Tech Tips Sanitary Protection of Drinking Water Storage Tanks: Vents. (n.d.). Retrieved from https://www.epa.gov/sites/production/files/2016-06/documents/tech_tip_tank_vents.pdf

Flint and Walling. (2020, November 27). 6" Cast Iron T Series. Retrieved November 28, 2020, from Flint & Walling website: https://www.flintandwalling.com/en-na/products/submersible-pumps/turbine/6-inch-t#technical-support

Global Industrial. (n.d.). Baldor-Reliance General Purpose Motor. Retrieved from Global Industrial:

https://www.globalindustrial.ca/p/motors/ac-motors-2-phase/premium-efficiency-motors/general-purpose-motor-230-460-v-30-hp-1770-rpm-3-ph-286tc-opsb?infoParam.campaignId=T9F&gclid=CjwKCAjw6qqDBhB-EiwACBs6x-jKhBPefQdZcsDXIzVJX5abu4lsTd537xjNmaWzzca5Yqye8xWL

Grainger. (n.d.). Dual Check Valve. Retrieved from Grainger: https://www.grainger.ca/en/product/p/WWG46A961?cm_mmc=PPC:+Google+PLA&ef_id=CjwKCAjw6qqDBhB-EiwACBs6xx4DsQKPdDXmc_Pma6ko-91jXR2o6AEH20i4TpC7Suj7Y_w9fwRLrBoCFhoQAvD_BwE:G:s&s_kwcid=AL!3645!3!303439923572!!!g!538298254449!&gclid=CjwKCAjw6qqDBhB-EiwACBs6xx4D

Gravel Filter Pack. (n.d.). Retrieved November 14 from https://www.lifewater.ca/drill_manual/Section_8.htm

Greater Vancouver Water District. (2015, May 20). Greater Vancouver Water District General Requirements, Measurement & Payments, Specifications and Standards for Queensborough Main No.2. Retrieved from Greater Vancouver Water District: https://www.newwestcity.ca/database/files/library/Item_10__Supplemental_GVWD_to_ITT_NWIT_15_09_Combined_Rev_1___May20_2015_Addendum_3.pdf

Groundwater Wells and Aquifers|Search for a Well Driller or Well Pump Installer. (n.d.) Retrieved November 14 from:https://apps.nrs.gov.bc.ca/gwells/registries/

Groundwater Wells Design. (n.d.). Retrieved November 14 from http://www.hwe.org.ps/Education/Birzeit/GroundwaterEngineering/Chapter%205%20-%20Groundwater%20Well%20Design.pdf

HomeAdvisor. (n.d.). How Much Does Construction Clean Up Cost? Retrieved from https://www.homeadvisor.com/cost/cleaning-services/clean-construction-site/#:~:text=Construction%20cleanup%20costs%20%24445%20on,for%20per%20site%20cleanup%20pass

Housing Foundations and Geotechnical Challenges (n.d.). Retrieved November 16, 2020, from http://bchousing.org/residential-design-construction/

Howmuch.net. (n.d.). Install Plumbing. Retrieved from https://howmuch.net/costs/plumbing

How much does a plumber charge to install a pressure reducing valve?. Findanyanswer.com. Retrieved 28 November 2020, from: https://findanyanswer.com/how-much-does-a-plumber-charge-to-install-a-pressure-reducing-valve#:~:text=How%20much%20does%20a%20plumber%20charge%20to%20install%20a%20pressure%20reducing%20valve%3F,-Asked%20By%3A%20Luscinda&text=It%20costs%20about%20%241%2C000%20to%20%241%2C500%20to%20have%20the%20valve%20installed.

HydroSOLVE (2016). Hydraulic Properties: Aquifer Testing 101. Retrieved from Aqtesolv.com website: http://www.aqtesolv.com/aquifer-tests/aquifer_properties.htm

Is a VFD a Cost-Effective Option for Your Application? Pumps and Systems Magazine. Retrieved 28 November 2020, from https://www.pumpsandsystems.com/vfd-cost-effective-option-your-application#:~:text=Typical%20installed%20costs%20of%20VFD,%24500%20per%20horsepower%20(HP).

KompareIT. (n.d.). Cost of Site Preparation and Land Clearing. Retrieved from KonpareIT: kompareit.com/homeandgarden/developers-engineers-land-prep.html

Learn how much it costs to Install a Backflow Preventer. Homeadvisor.com. Retrieved 28 November 2020, from: https://www.homeadvisor.com/cost/plumbing/install-replace-backflow-preventer/#:~:text=Expect%20to%20pay%20between%20%2470,comprehensive%20double%2Dvalve%20preventer%20system

Learn how much it costs to Install Drainage. Homeadvisor.com. Retrieved 28 November 2020, from https://www.homeadvisor.com/cost/landscape/install-drainage/.

Lee County, Southwest Florida. (2000, 10 2). Lee County Utilities. Retrieved from Lee County :

https://www.leegov.com/utilities/Documents/New%20Development/Technical%20Specifications/L-02623%20-%20POLYVINYL%20CHLORIDE%20(PVC)%20WATER%20MAIN%20PIPE.pdf

Margulis, S.A.M (2017). Introduction to Hydrology (2017A ed.) [E-book]. https://books.apple.com/us/book/introduction-to-hydrology/id1272471780

Ministry of Municipal Affairs and Housing. (July 2019). University Endowment Lands 2019 Drinking Water Quality Monitoring Report. http://www.universityendowmentlands.gov.bc.ca/library/2019%20UEL%20Water%20Quality%20Report.pdf

NSF International. (n.d.). NSF/ANSI/CAN 61. https://www.nsf.org/testing/water/municipal-water-systems/nsf-ansi-can-61

Office Trailers. Western Container Sales. Retrieved 27 November 2020, from https://westerncontainersales.com/jobsite-rentals/office-trailers/.

Plumley, T. (n.d.). Engineering of Water Systems – Water Well Journal. Retrieved November 28, 2020, from https://waterwelljournal.com/engineering-of-water-systems-3/

Soil and Foundation Challenges | Ground Improvement Techniques. (n.d.). Retrieved November 28, 2020, from GEOSOLV website: https://geosolv.ca/soil-types/

"Source Drinking Water Quality Guidelines ." Government of British Columbia, 2020.

Sprigg, S. Water Tanks Cost and Pricing Guide. Agriculture.coerco.com.au. Retrieved 28 November 2020, from https://agriculture.coerco.com.au/agriculture-blog/water-tanks-cost-and-pricing-guide.

Stainless Pipe. Metalsdepot.com. (2020). Retrieved 28 November 2020, from: https://www.metalsdepot.com/stainless-steel-products/stainless-steel-pipe.

Stainless Steel Screens. Rjbwholesale.com. (2020). Retrieved 28 November 2020, from: http://www.rjbwholesale.com/catalog/salesCat/id/11/root/22.

Submersible Well Pumps. Homedepot.ca. (2020). Retrieved 28 November 2020, from: https://www.homedepot.com/b/Plumbing-Water-Pumps-Well-Pumps-Submersible-Well-Pumps/N-5yc1vZbqja

UBC Campus Aerial Image. Retrieved 29 November, 2020, from: https://www.ubc.ca/our-campuses/vancouver/

University of British Columbia. (n.d.). UBC Technical Guidelines. Retrieved from Technical Specifications for Architects & Engineers: http://www.technicalguidelines.ubc.ca/

University of British Columbia. (June 2019). Water Action Plan. https://planning.ubc.ca/sites/default/files/2019-11/PLANS_UBC_WaterActionPlan.pdf

Versa Hatch. (n.d.). Versa Hatch. Retrieved from Versa Hatch Advanced Designs - Superior Performance: https://www.versahatch.com/aluminium-hatch-dl-long.html

Water Supply System Construction Permit Guidelines and Application Form. (n.d.). Retrieved from http://www.vch.ca/Documents/Water-system-construction-permit.pdf

Water Sustainability Act (2014), SBC 2014

Well Design and Wellhead Protection. (n.d.). Retrieved November 14 from https://www.agr.gc.ca/eng/agriculture-and-the-environment/agricultural-practices/agriculture-and-water/wells-and-groundwater/well-design-and-wellhead-protection/?id=1371564950593

Well Protection Toolkit Files. (n.d.). Retrieved November 14 from http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/wells/well_protection/acrobat.html

Well Caps and Well seals, Cast iron, pvc, Regulation. Thewaterguy.ca. Retrieved 28 November 2020, from: *https://www.thewaterguy.ca/catalog/well-caps-and-seals-89-1.htm*.

Well Drilling Cost. Homeguide.com. Retrieved 28 November 2020, from: *https://homeguide.com/costs/well-drilling-cost*

Well-Sealing Grants - CRWD. CRWD. Retrieved 28 November 2020, from *https://www.capitolregionwd.org/grants/well-sealing-grants/#:~:text=How%20to%20seal%20a%20well,four%2Dinch%20diameter%20domestic%20well*.

Well Pump Switch Replacement Costs. Costimates.com. (2020). Retrieved 28 November 2020, from *https://www.costimates.com/costs/plumbing-plumbers/well-pump-pressure-switch/*.

Appendix A - Calculations

Wells

Well Drawdown:

Water intake per well:

Q = 15 L/s = 0.015 m^3/s

Distance between well 3 and well 4:

r = 301 m

From the Hazen approximation of the Piteau report, the conductivity of the aquifer sands is given as:

K = 8.1 *10^{-5} m/s

Storativity (S) is estimated using Domenico and Mifflin [1965] as reported in Batu [1998]:

Dense Sand = 1.97 * 10^{-4} m^{-1}

Transmissivity (assume upper and lower aquifer as one unit since we are drawing from both):

$$T = K * h = 8.1 * 10^{-5} \frac{m}{s} * 13.8m$$

$$T = 1.12 * 10^{-3} \frac{m^2}{s}$$

The Theis well function u, [unitless] is given as:

$$u = \frac{S*r^2}{4*T*t} = \frac{1.97*10^{-4} m^{-1}*(\frac{301}{2})m^2}{4*1.12*10^{-3} \; m^2/s*604800s}$$

$$u = 1.6468 * 10^{-3}$$

Using table 9.1 – Values of well function W(u) as a function of the non-dimensional parameter u. from Intro to Hydrology [Margulis, Steven A.].

TABLE 9.1. VALUES OF WELL FUNCTION $W(u)$ AS A FUNCTION OF THE NON-DIMENSIONAL PARAMETER u

u	1	2	3	4	5	6	7	8	9
× 1	0.219	0.049	0.013	3.8 × 10^{-3}	1.1 × 10^{-3}	3.6 × 10^{-1}	1.2 × 10^{-4}	3.8 × 10^{-5}	1.2 × 10^{-5}
× 10^{-1}	1.82	1.22	0.91	0.7	0.56	0.45	0.37	0.31	0.26
× 10^{-2}	4.04	3.35	2.96	2.68	2.47	2.3	2.15	2.03	1.92
× 10^{-3}	6.33	5.64	5.23	4.95	4.73	4.54	4.39	4.26	4.14

W = 5.88 (interpolated)

Using Theis equation for drawdown depth:

$$s = \frac{Q}{4*\pi*T} * W = \frac{0.015 \frac{m^3}{s}}{4*\pi*1.12*10^{-3} \frac{m^2}{s}} * 5.88$$

$$s = 6.27m$$

$Combined\ [Superimposed]Well\ Drawdown = 6.27m + 6.27m = 12.54m$

$12.54m\ Drawdown > 13.8\ Total\ Aquifer\ Depth$

Pump Choice

Calculations completed in Excel for other pumps. Sample calculation provided for Pump #1 at a flow rate of 15L/s.

Bernoulli Equation:

$$H + z_1 + \frac{P_1}{\gamma} + \frac{v_1^2}{2g} = z_2 + \frac{P_2}{\gamma} + \frac{v_2^2}{2g} + h_L$$

H = Pump head (m)

z = Elevation (m)

P= Pressure (Pa)

V= Velocity (m/s)

γ= 9810 N/m^3

g = 9.81 m/s^2

h_L= Head loss (m)

$$Pump\ \#1\ Head\ Loss = Segment\ \#1\ h_L + Segment\ \#2\ h_L + Segment\ \#3\ h_L = 6.68\ m$$

$$Pump\ \#1\ Head = z_2 + \frac{P_2}{\gamma} + \frac{v_2^2}{2g} + h_L - (z_1 + \frac{P_1}{\gamma} + \frac{v_1^2}{2g})$$

Required head for pump #1:

$$H = 0m + \frac{140\ 000\ kPa}{9810\frac{N}{m^3}} + \frac{\left(\frac{0.015m^3}{s}\right) * 4}{2g} + 6.68\ m - (-90\ m + 0kPa + 0kPa) = 110.1m$$

Other required pump heads found in Excel:

Pump	Flow (L/s)	Head (m)
1	15	110.9
2	15	110.4
3	15	111.5
4	15	110.7

Pump chosen will provide 113 m of head at 15 L/s.

Piping System

Calculations completed in Excel for different flow rates and pipe segments. Sample calculation provided for Main to High Pressure Zone.

1.) Friction loss in Pipe Segment:

Friction Losses (Hazen-Williams Equation):

$$h_f = (10.58 * L * Q^{1.85})/(C^{1.85} * d^{4.87})$$

H = Head loss due to friction (m)
L = Pipe length (m)
Q = Flow rate (m^3/s)
C = Hazen Williams Coefficient
d = Pipe diameter (m)

$$Segment\ \#1\ Friction\ Losses = 10.85 * 256m * \frac{(0.0335\ m^3/s)^{1.85}}{150^{1.85} * 0.3\ m^{4.87}} = 0.17m = 1.68\ kPa$$

2.) Minor Loss in Pipe Segment:

Minor Loss Equation:

$$h_m = K\frac{v^2}{2g}$$

K = Minor Loss Coefficient
V = Flow Velocity (m/s)
G = 9.81 m/s2
Flow Velocity:

$$v = \frac{4Q}{\pi d^2}$$

Q = Flow rate (m3/s)
D = Pipe Diameter (m)

$$Segment\ \#1\ Velocity = \frac{4(0.0335\ m^3/s)}{\pi * 0.3\ m^{\ 2}} = 0.474m/s$$

$$Segment\ \#1\ Minor\ Losses = \frac{9.65 * \frac{0.531m^2}{s}}{2 * \frac{9.81m}{s^2}} = 0.11\ m = 1.1kPa$$

Storage Reservoir

- Storage Reservoir Size

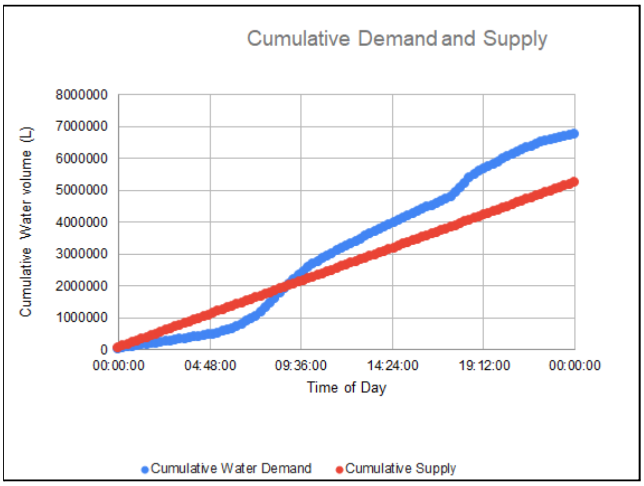
$$Storage\ Reservoir\ =\ 1.\ Balancing\ Storage\ +\ 2.\ Emergency\ Storage\ +\ 3.\ Fire\ Storage$$

1. Balancing Storage

Summary of calculated ADD, fh, PHD:

ADD (L/s)	84
fh (Assumed pop=55,000)	2.22
PHD (L/s)	186.5

Cumulative Demand and Supply Plot (to right):



The maximum volume deviation above the water supply, plus the maximum volume deviation below the water supply were used to find the balancing volume. $Balancing\ Volume\ =\ |-\ 163054\ L| +\ 699840\ L\ =\ 2330m^3$

2. Emergency Storage

   $Emergency\ Storage\ =\ 0.15\ *\ ADD\ =\ 0.15\ *\ 84\ =\ 677m^3$

3. Fire Storage

   Assuming 2hr fire duration requirement:

   $Fire\ Storage\ =\ 200L/s\ *\ 2hr\ =\ 1440\ m^3$

$Storage\ Reservoir\ =\ 2330\ m^3\ +\ 677\ m^3\ +\ 1440\ m^3\ \approx\ 4500m^3$

$Balancing\ Volume\ =\ |-\ 163054\ L| +\ 699840\ L\ =\ 2330m^3$

4. Emergency Storage

   $Emergency\ Storage\ =\ 0.15\ *\ ADD\ =\ 0.15\ *\ 84\ =\ 677m^3$

5. Fire Storage

   Assuming 2hr fire duration requirement:

   $Fire\ Storage\ =\ 200L/s\ *\ 2hr\ =\ 1440\ m^3$

$Storage\ Reservoir\ =\ 2330\ m^3\ +\ 677\ m^3\ +\ 1440\ m^3\ \approx\ 4500m^3$

- Storage Reservoir Slab

Assume f'c=40MPa
Unit width = 1000mm
Thickness = 300mm
Rebar Size = 25M at 250mm spacing
Ls = 5.5m
L=6m
Min cover = 75mm
d=300mm-75mm-25/2mm=212.5 = 213mm
As=2000mm2

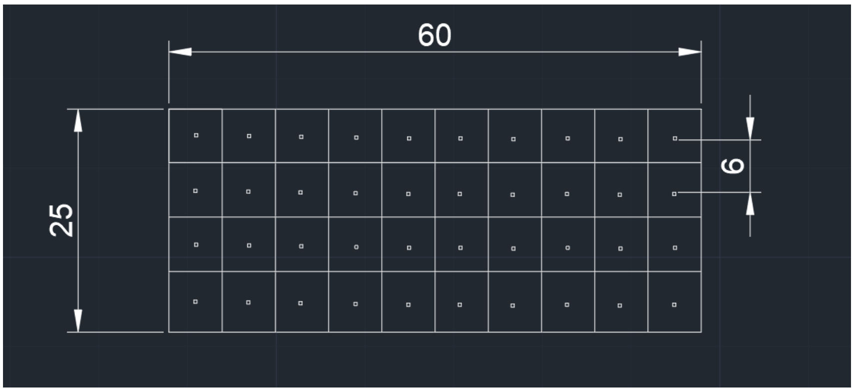
Assuming Steel yields,
T=ϕ$s\ *\ fy\ *\ As\ =\ 0.85\ *\ 400\ *\ 2000$ =680kN
C=α1(ϕ$c\ *\ fc\ *$ β1$c)b\ =\ 0.8\ *\ 0.65\ *\ 40\ *$ β1$c\ *\ 1000$=20.8β1c
T=C at cracking -> β1c=33mm

c≤0.64d **- OK - Yield Confirmed**

Mr=T*(d-β1c/2)=680000*(213-33/2)= 133.62kNm
$M_{max}\ =\ \frac{wl^2}{8}$
w=$1069/6^2\ =\ 29.69kN/m$**-OK**

* This thickness value also meets the minimum wall thickness requirements outlined by the American Concrete Institute (ACI) 350/350R: Code Requirements for Environmental Engineering Concrete Structures, and Commentary.
*Stirrups and shear failure check will be completed in the detailed design stage

- Storage Reservoir Columns



Tributary Area for each column = $37.5 m^2$
vertical reinforcement = 6
Rebar size = 25M
Live Load = $4.8 kPa * 37.5 = 180 kN$
Dead Load = $23.5 kN/m^3 * 37.5 m^2 * 0.3 m = 264\ kN$

Factored Load (Pf)= 1.25L+1.5D = 621kN

Maximum factored axial load resistance (Pr,max)
→ since h>=300mm, Pr,max = 0.8 Pr,o
$Pr, max = 0.8(\alpha * \phi_c * f'c * Ac + \phi_s * fy * As)$

$=0.8 * (0.805 * 0.65 * 30 * 250000 + 0.85 * 400 * 3000)$
= 3956 kN

Where $\rho = 1.2\%$, $A_c = 250000 mm^2$, $A_s = 3000 mm^2$, $\phi_c = 0.65$, $f'c = 30 MPa$, $fy = 400 MPa$, ϕ_s =0.85

Pf≤Pr,max → acceptable.

- Soil Conditions Under Storage Reservoir

Storage Tank Load Calculation:

$*\ Assume\ the\ concrete\ foundation\ evenly\ distributes\ load$

$*\ Assume\ 23.5\frac{kN}{m^3} density\ reinforced\ concrete$

$Water = 4500\ m^3 * 997\frac{kg}{m3} = 4486500 kg$

$Concrete = Surface\ Area * thickness = 3510\ m^2 * 0.5\ m = 1755\ m^3$

$1755\ m^3 * 23.5\frac{kg}{m^3} = 41242.5\ kg$

$$\frac{(4486500\ kg + 41242.5\ kg)*9.8\frac{m}{s^2}}{1500\ m^2} = 29.6\ kPa$$

Bearing Capacity Calculation:

$Variables: \varphi = 38°,\ N_r = 77.5,\ N_q = 61.5,\ N_\gamma = 82.3,\ B = 25m,\ \gamma' = 20\frac{kN}{m^3},\ \sigma'_D = 29.6\ kPa$

$For\ Strip\ \left(\frac{B}{L} = 0\right)$

$$qult = \sigma'_D * Nq + 0.5 * \gamma' * B * N_\gamma = 29.6 * 61.5 + 0.5 * 20 * 25 * 82.3 = 22395\ kPa$$

$$For\ Square\left(\frac{B}{L} = 1\right)$$

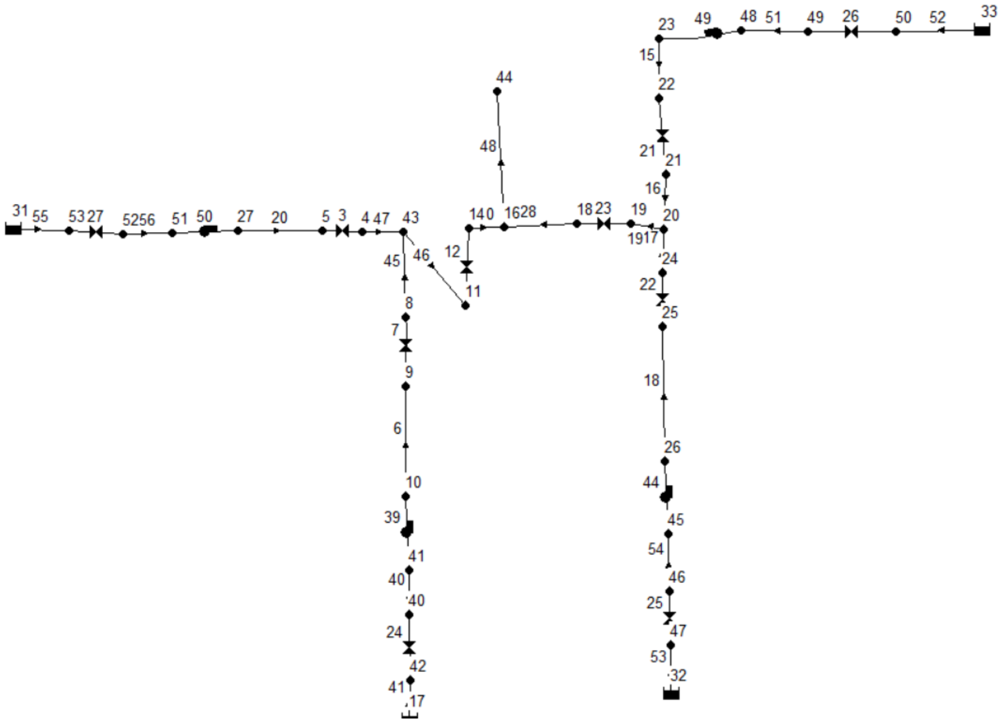
$$qult = \sigma'_D * Nq + 0.5 * \gamma' * B * N_\gamma = 29.6 * 61.5 + 0.4 * 20 * 25 * 82.3 = 18280\ kPa$$

$$For\ Rectangular\left(\frac{B}{L} = \frac{25}{60} = 0.4167\right) Interpolate$$

$$qult = 22395 - 0.4167 * (22395 - 18280) = 20683\ kPa$$

$$q_{allowable} = \frac{qult}{FOS} = \frac{20683}{4} = 5170\ kPa \gg 29.6\ kPa$$

Appendix B - EPANET



Network Table- Nodes

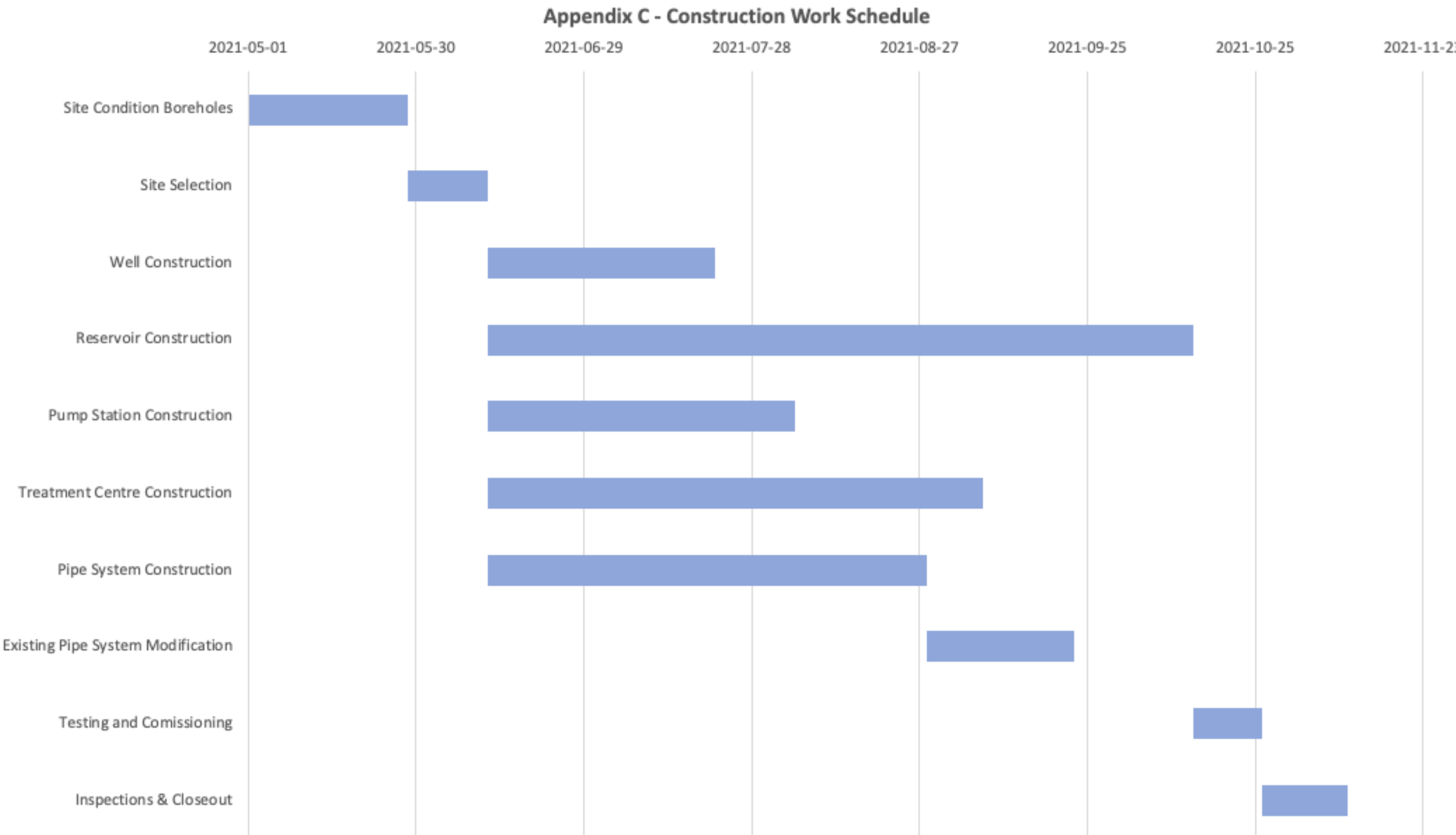
	Demand	Head	Pressure
Node ID	LPS	m	m
Junc 4	0	18.9	18.9
Junc 5	0	19.14	19.14
Junc 8	0	18.9	18.9
Junc 9	0	19.66	19.66
Junc 10	0	20	20
Junc 11	0	18.28	18.28
Junc 14	0	16.8	16.8
Junc 16	0	16.8	16.8
Junc 18	0	16.8	16.8
Junc 19	0	17.08	17.08
Junc 20	0	18.9	18.9
Junc 21	0	18.9	18.9
Junc 22	0	19.83	19.83
Junc 23	0	20	20
Junc 24	0	18.9	18.9
Junc 25	0	19.71	19.71
Junc 26	0	20	20

Junc 27	0	20	20
Junc 40	0	-93	-93
Junc 41	0	-93	-93
Junc 42	0	-93	-93
Junc 43	0	18.9	18.9
Junc 44	60	14.37	14.37
Junc 45	0	-93	-93
Junc 46	0	-93	-93
Junc 47	0	-93	-93
Junc 48	0	-93	-93
Junc 49	0	-93	-93
Junc 50	0	-93	-93
Junc 51	0	-93	-93
Junc 52	0	-93	-93
Junc 53	0	-93	-93
Resvr 17	-15	-93	0
Resvr 31	-15	-93	0
Resvr 32	-15	-93	0
Resvr 33	-15	-93	0

Network Table- Links

	Flow	Velocity	Unit Headloss	Friction Factor
Link ID	LPS	m/s	m/km	
Pipe 6	15	0.48	1.69	0.029
Pipe 10	30	0.95	3.83	0.016
Pipe 15	15	0.48	3.38	0.058
Pipe 16	15	0.48	1.06	0.018
Pipe 17	15	0.48	1.06	0.018
Pipe 18	15	0.48	2.13	0.037
Pipe 19	30	0.95	5.28	0.023
Pipe 20	15	0.48	1.27	0.022
Pipe 28	30	0.95	3.83	0.016
Pipe 40	15	0.48	1.02	0.018
Pipe 41	15	0.48	1.12	0.019
Pipe 45	15	0.48	1.06	0.018
Pipe 46	30	0.95	24.63	0.106
Pipe 47	15	0.48	1.06	0.018
Pipe 48	60	1.91	97.03	0.104

Pipe 51	15	0.48	1.02	0.018
Pipe 52	15	0.48	1.12	0.019
Pipe 53	15	0.48	1.12	0.019
Pipe 54	15	0.48	1.02	0.018
Pipe 55	15	0.48	1.12	0.019
Pipe 56	15	0.48	1.02	0.018
Pump 39	15	0	-113	0
Pump 44	15	0	-113	0
Pump 49	15	0	-113	0
Pump 50	15	0	-113	0
Valve 3	15	0.48	0.24	0
Valve 7	15	0.48	0.76	0
Valve 12	30	0.95	1.48	0
Valve 21	15	0.48	0.93	0
Valve 22	15	0.48	0.81	0
Valve 23	30	0.95	0.28	0
Valve 24	15	0.48	0	0
Valve 25	15	0.48	0	0
Valve 26	15	0.48	0	0
Valve 27	15	0.48	0	0



Appendix C - Construction Work Schedule
2021-05-01
2021-05-30
2021-06-29
2021-07-28
2021-08-27
2021-09-25
2021-10-25
2021-11-23
Site Condition Boreholes
Site Selection
Well Construction
Reservoir Construction
Pump Station Construction
Treatment Centre Construction
Pipe System Construction
Existing Pipe System Modification
Testing and Comissioning
Inspections & Closeout

Appendix D - Cost Estimate

Task	Description	Material Cost			Equipment Costs			Skilled Labour Cost			GC Project Management Costs			Consultant Cost			Subcontractor Costs	Other Costs	Tax	Total Fee
		Cost/Unit	Units	Total	Cost/Hour	Hours	Total	Cost/Hour	Hours	Total	Cost/Hour	Hours	Total	Cost/Hour	Hours	Total	Total	Total	(GST + PST)	
	Project Management - Progress/Strategy Meetings																			
	Project Management Review Meetings			0.00			0.00			0.00	144.00	72.00	10368.00	144.00	72.00	10368.00			$2,488.32	$23,224.32
	Project Management Strategy Meetings			0.00			0.00			0.00	227.00	40.00	9080.00	227.00	40.00	9080.00			$2,179.20	$20,339.20
	Subtotal																			**$43,563.52**
1.0	**Pre-Construction Site Investigation & Preparation**																			
1.1	Project Team Kick-off Meeting - Owners, consultants and general contractor team (project			0.00			0.00			0.00	144.00	24.00	3456.00			0.00			$414.72	$3,870.72
1.2	Obtain Permits			0.00			0.00			0.00	144.00	40.00	5760.00			0.00		2000	$931.20	$8,691.20
1.3	Set Up Site Trailer	8000.00	1.00	8000.00	400.00	6.00	2400.00	40.00	12.00	480.00			0.00			0.00			$1,305.60	$12,185.60
1.4	Survey and Mark Underground Utilities			0.00			0.00			0.00	100.00	8.00	800.00			0.00			$96.00	$896.00
1.5	Drill Investigative Boreholes (CPT x 8) at Well Locations			0.00			0.00			0.00			0.00			0.00	24000		$2,880.00	$26,880.00
1.6	Evaluate Borehole Data and Finalize Well Site			0.00			0.00			0.00	144.00	6.00	864.00	144.00	10.00	1440.00			$276.48	$2,580.48
	Subtotal																			**$55,104.00**
Project Components - Detailed Design within scope																				
2.0	**Well Installation**																			
2.1	Prep site for construction (delineators, fencing, tree clearing)	500.00	1.00	500.00			0.00			0.00			0.00			0.00	8655.00		$1,098.60	$10,253.60
2.2	Drill well holes			0.00	750.00	32.00	24000.00	40.00	32.00	1280.00	144.00	32.00	4608.00			0.00			$3,586.56	$33,474.56
2.3	Install well			0.00	500.00	20.00	10000.00	40.00	20.00	800.00	144.00	20.00	2880.00			0.00			$1,641.60	$15,321.60
	i. 6 " Cast Iron Well Cap	80.00	4.00	320.00			0.00			0.00			0.00			0.00			$38.40	$358.40
	ii. Stainless Steel Piping	18920.00	4.00	75680.00			0.00			0.00			0.00			0.00			$9,081.60	$84,761.60
	iii. Casing + bottom plate	10500.00	4.00	42000.00			0.00			0.00			0.00			0.00			$5,040.00	$47,040.00
	iv. Screens	650.00	8.00	5200.00			0.00			0.00			0.00			0.00			$624.00	$5,824.00
	iv. Gravel Pack	500.00	4.00	2000.00			0.00			0.00			0.00			0.00			$240.00	$2,240.00
	v. Sealing and Contamination Prevention	700.00	4.00	2800.00			0.00			0.00			0.00			0.00			$336.00	$3,136.00
	vi. Pumps	29000.00	4.00	116000.00			0.00			0.00			0.00			0.00			$13,920.00	$129,920.00
	vii. Motor	5715.00	4.00	22860.00			0.00			0.00			0.00			0.00			$2,743.20	$25,603.20
	viii. Variable Frequency Drive (VFD)	10400.00	4.00	41600.00			0.00			0.00			0.00			0.00			$4,992.00	$46,592.00
	ix. PRV	440.00	6.00	2640.00			0.00			0.00			0.00			0.00			$316.80	$2,956.80
	x. Switch + Electrical Wiring	960.00	4.00	3840.00			0.00			0.00			0.00			0.00			$460.80	$4,300.80
2.4	QA/QC Checks + Inspections	600.00	4.00	2400.00			0.00			0.00	144.00	12.00	1728.00			0.00			$495.36	$4,623.36
	Subtotal																			**$416,405.92**
3.0	**Pipe System Installation**																			
3.1	Prep site for construction (delineators, fencing, clearing)	2500.00	1.00	2500.00			0.00			0.00			0.00			0.00	14600.00		$2,052.00	$19,152.00
3.2	Excavate to grade			0.00			0.00			0.00			0.00			0.00	720000		$86,400.00	$806,400.00
3.3	Install Piping			0.00			0.00			0.00			0.00			0.00	128750		$15,450.00	$144,200.00
	i. Pipes	342870.00	1.00	342870.00			0.00			0.00			0.00			0.00			$41,144.40	$384,014.40
	ii. Valves	2900.00	2.00	5800.00			0.00			0.00			0.00			0.00			$696.00	$6,496.00
	iii. Fittings	650.00	17.00	11050.00			0.00			0.00			0.00			0.00			$1,326.00	$12,376.00
	iv. Joint Restraints	567.00	19.00	10773.00			0.00			0.00			0.00			0.00			$1,292.76	$12,065.76
	v. Trench Fill and Pipe Bedding	46.28	1900.00	87932.00			0.00			0.00			0.00			0.00			$10,551.84	$98,483.84
3.4	Backfill and compaction			0.00			0.00			0.00			0.00			0.00	35660.00		$4,279.20	$39,939.20
3.5	QA/QC Checks + Inspections	2000.00	1.00	2000.00			0.00			0.00	144.00	16.00	2304.00			0.00			$516.48	$4,820.48
	Subtotal																			**$1,527,947.68**
4.0	**Storage Reservoir Installation**																			
4.1	Prep site for construction (delineators, fencing, tree clearing)	500.00	1.00	500.00			0.00			0.00			0.00			0.00	27470.00		$3,356.40	$31,326.40
4.2	Excavate to grade						0.00			0.00			0.00			0.00	484400.00		$58,128.00	$542,528.00
4.3	Install reinforced concrete tank (Storage cell, columns and chambers)			0.00			0.00			0.00			0.00			0.00	1600000.00		$192,000.00	$1,792,000.00
4.4	Install internal PVC piping	35000.00	1.00	35000.00			0.00			0.00			0.00			0.00	46440.00		$9,772.80	$91,212.80
4.5	Install Stainless Steel Components						0.00			0.00			0.00			0.00	39600.00		$4,752.00	$44,352.00
	i. Hatches	9000.00	1.00	9000.00			0.00			0.00			0.00			0.00			$1,080.00	$10,080.00
	ii. Drains	18000.00	2.00	36000.00			0.00			0.00			0.00			0.00			$4,320.00	$40,320.00
	iii. Vents	7000.00	1.00	7000.00			0.00			0.00			0.00			0.00			$840.00	$7,840.00
	iv. Other metal parts (ladder,bolts, screws, nuts, anchors)	42000.00	1.00	42000.00			0.00			0.00			0.00			0.00			$5,040.00	$47,040.00
4.6	Install electrical and SCADA monitoring system	80000.00	1.00	80000.00						0.00			0.00			0.00	32000.00		$13,440.00	$125,440.00
4.7	QA/QC Checks + Inspections	2000.00	1.00	2000.00			0.00			0.00	144.00	6.00	864.00			0.00	2000.00		$583.68	$5,447.68
	Subtotal																			**$2,737,586.88**
5.0	**Project Close Out/Demobilization**																			
5.1	Site Clean up			0.00	180.00	40.00	7200.00	40.00	40.00	1600.00			0.00			0.00	3348.00		$1,457.76	$13,605.76
5.2	Delivery of documents/project handover			0.00			0.00			0.00	144.00	24.00	3456.00	144.00	24.00	3456.00			$829.44	$7,741.44
	Subtotal																			**$21,347.20**
6.0	**Maintenance + Operation (50 years)**																			
6.1	Monthly Well Tests			0.00			0.00	80.00	2400.00	192000.00			0.00			0.00			$23,040.00	$215,040.00
6.2	Water treatment filter + chlorine replacement	2000.00	50.00	100000.00			0.00			0.00			0.00			0.00			$12,000.00	$112,000.00
6.3	Energy Costs	7000.00	50.00	350000.00			0.00			0.00			0.00			0.00			$42,000.00	$392,000.00
6.4	Storage Reservoir Checks			0.00			0.00	40.00	1200.00	48000.00			0.00			0.00			$5,760.00	$53,760.00
6.5	Pump Station Checks			0.00			0.00	40.00	1200.00	48000.00			0.00			0.00			$5,760.00	$53,760.00
6.6	General monthly operation checks (Pipelines)			0.00			0.00	40.00	2400.00	96000.00			0.00			0.00			$11,520.00	$107,520.00
6.7	Emergency Action			0.00			0.00	40.00	10.00	400.00			0.00			0.00			$48.00	$448.00
	Subtotal																			**$934,080.00**
Project Components to be contracted out																				
7.0	**Pump Station Installation**																			
7.1	Prep site for construction	500.00	1.00	500.00			0.00			0.00			0.00			0.00	10360.00		$1,303.20	$12,163.20
7.2	Install Pump Station			0.00			0.00			0.00			0.00	144.00	400.00	57600.00	32000.00		$10,752.00	$100,352.00
	i. Walls, ceilings, floors, stairs (Reinforced Concrete)			0.00			0.00			0.00			0.00			0.00	55000.00		$6,600.00	$61,600.00
	ii. Pumps	7000.00	2.00	14000.00			0.00			0.00			0.00			0.00	4800.00		$2,256.00	$21,056.00
	iii. Motors	27000.00	2.00	54000.00			0.00			0.00			0.00			0.00	4800.00		$7,056.00	$65,856.00
	iv. VFDs	27000.00	2.00	54000.00			0.00			0.00			0.00			0.00	4800.00		$7,056.00	$65,856.00
	v. PRV	3000.00	1.00	3000.00			0.00			0.00			0.00			0.00	4800.00		$936.00	$8,736.00
	vi. Steel Pipes	600.00	12.00	7200.00			0.00			0.00			0.00			0.00	10240.00		$2,092.80	$19,532.80
7.3	QA/QC Checks + Inspections	2000.00	1.00	2000.00			0.00			0.00	144.00	6.00	864.00			0.00	1800.00		$559.68	$5,223.68
	Subtotal																			**$360,375.68**
8.0	**Water Treatment Plant Installation**																			
8.1	Prep site for construction	500.00	1.00	500.00			0.00			0.00			0.00			0.00	13650.00		$1,698.00	$15,848.00
8.2	Install Water Treatment Station			0.00			0.00			0.00			0.00	144.00	800.00	115200.00	64000.00		$21,504.00	$200,704.00
	i. Pipes	30000.00	1.00	30000.00			0.00			0.00			0.00			0.00	6400.00		$4,368.00	$40,768.00
	ii. Structure						0.00			0.00			0.00			0.00	95000.00		$11,400.00	$106,400.00
	iii. Slab						0.00			0.00			0.00			0.00	23000.00		$2,760.00	$25,760.00
	iv. Tank	25000.00	1.00	25000.00			0.00			0.00			0.00			0.00	5120.00		$3,614.40	$33,734.40
	v. Pipe fittings	3000.00	1.00	3000.00			0.00			0.00			0.00			0.00	5120.00		$974.40	$9,094.40
8.3	QA/QC Checks + Inspections	2000.00	1.00	2000.00			0.00			0.00	144.00	6.00	864.00			0.00	480.00		$401.28	$3,745.28
	Subtotal																			**$436,054.08**
																			Total Project Costs	**$ 6,532,464.96**
																			Contingencies (10%)	**$ 653,246.50**
																			Total	**$ 7,185,711.46**

Key	
(blue)	**Detailed Design within scope (5% to 10% cost contingency)**
(green)	**Additional Details to be contracted out (10% to 15% cost contingency)**

Appendix E - Construction Specifications

Section 01 10 00 - General Requirements

---

1. General Requirements

1.1 Scope

1.1.1 This section covers the general contractual requirements and clauses which are not contained or not fully contained elsewhere in the contract documents.

1.2 Submittals

1.2.1 Within seven days of award of contract, submit to the corporation engineer a general construction schedule detailing proposed work and sequence of operations.

1.2.2 Provide the corporation engineer with a minimum of forty-eight hours notice prior to mobilization and/or de-mobilization to the work site.

1.2.3 Before commencing construction, provide the corporation engineer with a list of at least two persons who have authority to act on behalf of the contractor in times of emergency.

1.2.4 Provide a list of contact information of all key staff and subcontractors to the corporation engineer prior to start of construction.

1.2.5 Within seven days of work completion, submit to the corporation engineer the completed marked-up set of drawings showing all as-constructed changes.

1.2.6 Within thirty days of award of contract, submit an Environmental Management Plan (EPP) prior to commencement of construction activities. The plan must be prepared and approved by a Qualified Environmental Professional (QEP). The corporation engineer must give written approval of the EPP prior to construction start.

1.2.7 Prior to construction start, the contractor must apply for and submit all approved permits (refer to 1.4.3) to the corporation engineer.

1.3 Permits & Working Space

1.3.1 Regulations affecting construction work is imposed by:

.1 University of British Columbia (UBC)

.2 University Endowment Lands (UEL)

.3 BC Ministry of Environment (BC MoE)

.4 Metro Vancouver

.5 Worker's Compensation Board of B.C. (WorkSafe BC)

.6 All other applicable utility or stakeholders

1.3.2 The corporation has obtained all the following permits listed below. It is the responsibility of the contractor to obtain additional required permits.

.1 UBC: Work Authorization Permit

.2 UBC: Building Permit

1.3.3 The contractor is required to apply for and receive approval for the following permits at no additional cost to the corporation.

.1 Hydrant Use Permit

.2 Water Service Relocation Permit

.3 Excavation/shoring Permit

.4 Soil Deposit/Removal Permit

.5 Erosion and Sediment Control Permit

.6 Tree Removal Permit

.7 Obtain any other permits or approvals necessary for construction

1.4 Fencing & Site Traffic Management

1.4.1 Due to anticipated high pedestrian traffic, temporary cordoning of the construction site is required. Modu-Loc fencing and/or engineer approved equivalent must be set up along site perimeters.

1.4.2 Provide adequate barricades, lighting, and warning/detour signs for vehicular, bicycle and pedestrian traffic.

1.4.3 The contractor shall have a copy of and adhere to the current "Traffic Control Manual for Work on Roadways" (TMM) on site at all times.

1.4.4 The contractor must contact the governing authority for the impacted roadways during construction after the Notice of Award to ensure traffic management procedures are approved prior to commencing work.

1.4.5 Complete closure of public roads is not permitted.

1.5 Drainage Works

1.5.1 During construction, provide and maintain the means and devices to promptly remove and dispose of water entering excavation sites or other water-sensitive site locations. Intercept and divert precipitation and surface water using means such as cutoffs, dikes, ditches, pipes, sumps or other means accepted by the corporation engineer.

1.5.2 Make provisions to maintain dewatering during:

.1 Power outages.

.2 Holidays, weekends, and/or between work shifts.

1.5.3 Ensure dewatering of the site does not remove native soils/fines.

1.5.4 Settle and/or filter collected water in a settling tank or equivalent system prior to discharge if native soils/fines are present in drainage water.

1.6 Earthworks

1.6.1 Reference Standards to be adhered to include:

.1 ASTM D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil using Modified Effort

.2 ASTM D2488, Standard Practice for Description and Identification of Soils

.3 Ministry of Transportation and Infrastructure of British Columbia: Open Cut Requirements

.4 WorkSafeBC: Occupational Health and Safety Regulations (OHSR)

1.6.2 Obtain all necessary permits from the governing authority prior to any earthworks. Access to existing utilities (hydrants, valves, manholes etc.) must be maintained throughout construction.

1.6.3 Prior to excavation, a certified British Columbia Land Surveyor (BCLS) must locate and label all nearby underground utilities. Hand excavation will be carried out when necessary to avoid damaging utilities.

1.6.4 Excavation collapse prevention will be the contractor's responsibility. Precautions include but not limited to shoring, groundwater control, and limiting open trench length. Excavate slope at stable gradients and adhere to applicable WorkSafeBC regulations.

1.6.5 Existing adjacent structures such as utilities, adjacent structures, curbs, sidewalks, landscaping etc. will not be disturbed or damaged. The contractor must ensure they are protected and replace/repair them if damage occurs.

1.6.6 Backfill only after the corporation engineer has inspected and approved installations. Only backfill after concrete has achieved sufficient strength (seven days).

1.6.7 When backfilling, place loose material in 200 mm depths and compact each layer to ASTM D1557 standards (bedding = 90%, pipe zone = 92%) prior to placing successive layers.

1.6.8 Soils classified under ASTM D2488 fall under Peat, OH, CH, MH, or OL contain high moisture contents and cannot be used as backfill until dried.

1.7 Environmental Protection

1.7.1 The contractor must submit an Environmental Management Plan (EMP) prepared by a Qualified Environmental Professional (QEP) prior to commencing work. The plan must cover but is not limited to the following:

.1 Dewatering plan for each work including drainage, stormwater management, sediment and erosion control.

.2 Spill prevention and emergency response plan.

.3 Solid waste handling (work site garbage, waste disposal etc.)

.4 Air quality and dust control plan.

1.7.2 Ensure water routing on site deters sedimentation of water flow to eliminate the release of concrete leachate, debris, and other contaminant substances into storm drains.

1.7.3 The QEP must visit the work site twice a month until project finish to ensure the EMP is strictly adhered to.

1.7.4 Store environmentally harmful products such as fuels, cement, paints, clearance etc. in a way to minimize potential leakage or spillage. Ensure a recovery plan is in place for each harmful product. Harmful products must be labeled according to the Workplace Hazardous Material Information System (WHMIS).

1.7.5 Paints and stains must be dried prior to burial to minimize leaching into groundwater.

1.7.6 If wild animal nests are located at the work site, contact a qualified removal personnel. Destroying of bird nests is prohibited under the Wildlife Act [1996].

1.8 Preservation and Protection of Trees

1.8.1 The contractor must receive approval from the corporation engineer prior to excavation of trees or root systems.

1.8.2 Trees adjacent to the work site must not be harmed and must be surrounded by a protective barrier. The Critical Root Zone [area of land surrounding the trunk with radius equal to diameter at breast height (DBH) of tree multiplied by 18, or drip line, greater of] must be protected with temporary fencing. High visibility (orange snow) fencing is recommended.

1.8.3 Any root/branch pruning must be completed by a Certified Arborist or Tree Surgeon under supervision of the engineer.

1.8.4 Under a Certified Arborist's direction, trees disturbed by excavations/construction must be thoroughly watered and fertilized to regenerate lost roots/foliage.

1.8.5 Tree removal on site must adhere to UBC's tree removal application process and receive written approval.

End of Section

Section 01 20 00 - Water Supply

---

2. Water Supply

2.1 Scope

2.1.1 This section covers the contractual requirements regarding water supply material specifications, water supply installation standards and water supply related deliverables.

2.2 Related Sections

2.2.1 Section 01 30 00 Concrete Works

2.2.2 Section 01 40 00 Handling & Storage of Materials

2.3 Submittals

2.3.1 For contractor supplied materials and products, all manufacturers' product data documentation must be submitted to and approved by engineer prior to installation

2.3.2 Shop drawings for all contractor fabricated works must be submitted to and approved by engineer prior to installation

2.3.3 Catalogue data and assembly drawings for contractor provided valves must be submitted to and approved by engineer prior to installation

2.4 Water Supply Pipeworks

2.4.1 All water mains shall be Pressure Class 200 Polyvinyl Chloride Pressure Pipe (PVC), with a diameter of 300 mm

2.4.2 All pipes shall conform to ANSI/NSF Standard 14 regarding basic material requirements, manufactured quality, and dimensional tolerance

2.4.3 All pipes shall be CSA-certified to meet the standards of CAN / CSA B137.3.1

2.4.4 Materials used in the PVC pipes shall be CSA-certified to have a cell classification of 12454B as defined in ASTM D1784

2.4.5 Minimum cover over water mains shall be 0.9 m

2.4.6 Pipes shall have a minimum horizontal clearance of 3 m and a minimum vertical clearance of 1

m from storm and sanctuary sewer mains

2.4.7 All pipes with less than 3 m horizontal or 1 m vertical clearance from storm and sanitary sewers whall be wrapped with heat shrink plastic adhering to AWWA C209

2.4.8 Following installation pipes must be pressure tested, flushed, and disinfected in accordance with AWWA C605-13 and AWWA C651 standards

2.4.9 Pipe bedding and backfill shall be be comprised of combined crushed aggregate fill with a maximum particle size of 19 mm

2.4.10 Pipe bedding and backfill shall be compacted in layers not greater than 300 mm to 95% modified proctor density

2.4.11 Density tests shall be performed on fill in accordance with CSA A23.2-10A standards at a minimum of every 1000 mm

2.4.12 Use caution when excavating near existing utilities

2.4.13 Cap pipe at open ends to prevent groundwater, dirt, or foreign materials from entering pipe during construction in accordance with AWWA C651

2.4.14 If contamination of pipe occurs during construction, pipes must be flushed, chlorinated, and tested in accordance with AWWA C651

2.5 Fittings

2.5.1 All vertical bends shall be restrained by a wedge action joint restraint, Stargrip series 4100P or equivalent

2.5.2 All horizontal bends shall be restrained by a wedge action joint restraint, Stargrip series 4100P or equivalent

2.5.3 All pipe joints shall be wedge action joint restrained, Star series 1100G2 or equivalent

2..5.4 All PVC pipe bends shall be Pressure Class 235 PSI 300 mm IPEX Blue Brute Series elbows

2.5.6 All fabricated fittings for PVC pipes shall conform to AWWA C900-16 standards and shall be certified to CSA B137.2-05

2.5.7 All PVC fittings shall be supplied with push on rubber gasketed joints conforming to ASTM F277

2.5.8 All PVC pipe joints shall adhere to ASTM D3139 standards

2.5.9 Joint deflection shall adhere to AWWA C605, but shall not exceed 3˚ or maximum joint deflection recommended by the pipe manufacturer

2.6 Valves

2.6.1 All double check valve backflow prevention assemblies shall adhere to AWWA C510-17 standards

2.6.2 Double check valve backflow prevention assemblies from the Watt series 774 or equivalent shall be installed at all connections to existing water mains

End of Section

Section 01 30 00 - Concrete Works

---

3. Concrete Works

3.1 Scope

3.1.1 This section relates to the composition and placement of concrete features throughout the system.

3.2 Related Sections

3.2.1 Section 01 20 00 Water Supply

3.2.2 Section 01 40 00 Handling & Storage of Materials

3.2.3 Section 01 50 00 Wells

3.2.4 Section 01 60 00 Storage Reservoir

3.3 Submittals

3.3.1 Within 30 days of each concrete pour, submit to the consulting engineer the concrete testing results for approval.

3.3.2 Shop drawings of all precast concrete structural elements are to be submitted to the owner before completion of the project

3.4 Composition

3.4.1 All concrete structural components shall be designed in accordance with CSA A23.3 standards.

3.4.2 All concrete elements shall have a composition in conformance with CSA A23.1 standards.

3.4.3 All concrete is to be proportioned and mixed at an approved mixing plant unless otherwise directed by the consulting engineer

3.4.4 Structural elements in contact with water from the distribution system shall be of City of Vancouver Mix 2828C

3.5 Placement

3.5.1 Concrete formwork shall be constructed on site.

3.5.2 Formwork shall remain in place until structure has achieved sufficient strength, as specified by the consulting engineer (approximately 24 hours).

3.5.3 Protect freshly finished concrete from dust, rain or frost by using tarpaulins or other suitable protective coverings after final set.

3.5.4 Concrete is not to be poured at a temperature less than 5 degrees celsius unless sufficient heating and hoarding measures have been put in place to maintain an adequate temperature. Additionally, concrete is not to come in contact with any surface below 5 degrees during pouring.

3.5.5 Concrete is not to be poured at a temperature greater than 25 degrees celsius unless the surface can be protected from direct sunlight or through fogging. Subgrade surfaces should also be dampened prior to placement.

3.5.6 Concrete should not be poured during periods that have a high probability of rain or snow, or should otherwise be protected from such weather conditions.

3.5.7 A vibrator is to be used during the pouring process to reduce the quantity of entrapped air in the mix.

3.5.8 Primary concrete curing will take place over 7 days and will consist of either regularly applying water to the concrete surfaces or covering them with non-permeable material.

.1 Viable methods for applying water include ponding, fogging, and application of saturated materials such as burlap.

.2 Viable non-permeable materials include plastic and reinforced paper sheeting.

3.5.9 Concrete surfaces are to be sealed after curing to reduce potential for water damage. The type of sealant used is left to the discretion of the consulting engineer

End of Section

Section 01 40 00 - Handling and Storage of Materials

---

4. Handling and Storage of Materials

4.1 Scope

4.1.1This section applies to the Handling and Storage of Materials required for the construction of the wells, the storage reservoir, and for the water mains connecting to the existing water distribution system.

4.1.2 For Construction Specifications relating to the construction of the water mains connecting the wells to the treatment station, the treatment station, and the pump station, please refer to the documents provided by the sub-contractor.

4.2 Related Sections

4.2.1 Section 01 20 00 Water Supply

4.2.2 Section 01 30 00 Concrete Works

4.3 Submittals

4.3.1 All deliveries and usage of materials will be documented to match to corresponding records.

4.3.2 An inventory will be maintained so as to make sure that when certain projects are ready to begin, it is known that all the required materials are available.

4.4 General Guidelines

4.4.1 Safety is the priority for all storage and handling of materials. All WorkSafe BC standards will be followed. This includes adherence to having the correct PPE in place.

4.4.2 Unnecessary handling and movement of materials should be reduced.

4.4.3 Materials to be stored in a manner to allow for unit loading based on the requirements of the loading machinery.

4.4.4 Material lay down area to be kept organized and clean.

4.4.5 Handle and store materials in a manner to reduce damage to them.

4.4.6 Use a system for handling site waste.

4.4.7 A site security assessment will be conducted. If needed a security guard will be hired to monitor the area outside of construction hours.

4.5 Material - Concrete

4.5.1 All concrete shall be stored in accordance with the material provider's specifications.

4.5.2 Precast concrete items will have assigned locations in the lay-down area. These locations will meet their needs in terms of soil strength, protection from weather and other damaging forces. Further, they will be secured to ensure they are stable in position and will not shift.

4.5.3 All concrete batched and mixed on site will be performed and stored in accordance with the City of Vancouver Building By-Law and the BC Building Code. This includes preparation, execution, usage, and clean-up.

4.5.4 All concrete batches and mixes made on site will conform to the specification outlined in Section 01 30 00 – Concrete works or as otherwise specified in the Final Design package.

4.5.5 Precast concrete pieces will be moved in accordance with the material manufacturer. This includes sufficient base foundation and strapping to support any weaker sections when lifted.

4.5.6 Concrete that is cast-in-place will be transported by specified vehicle appropriate for the weight and use.

4.5.7 Large and heavy vehicles used for handling materials, such as a concrete pumping truck, shall be properly supported to the ground below.

4.5.8 Both precast and cast-in-place concrete will be inspected to ensure they are being built to the specified standards. This includes testing upon arrival as well as testing while being installed.

4.6 Material – Other

4.6.1 Other materials include but are not limited to the following. Stainless steel well piping, stainless steel well casing, well filter screens, well pumps, other well fittings. Water main PVC piping, pressure reducing valves, and other water main fittings. Reservoir reinforcing steel bars, and other reservoir fittings. Gravels, sands, soils.

4.6.2 These other materials shall be stored and handled in accordance with their material provider's specifications.

4.6.3 These other materials shall be transported by appropriate vehicles and in amounts that are within the limits of the vehicle.

End of Section

Section 01 50 00 - Wells

5. Wells

5.1 Scope

5.1.1 This section covers the contractual requirements regarding well material specifications, well installation standards and well related deliverables.

5.2 Related Sections

5.2.1 Section 01 30 00 Concrete Works

5.2.2 Section 01 40 00 Handling & Storage of Materials

5.3 Submittals

5.3.1 Prior to construction start, the contractor must provide the British Columbia Groundwater Act (BCGWA) registered well driller/well pump installer and their registration number to the corporation engineer. Approval must be received to begin work.

5.3.2 The clean river/ocean sand gravel pack supplier sieve analysis particle size distribution curve must be provided to the corporation engineer and approved prior to use.

5.3.3 The cement grout and bentonite clay mix design mix must be submitted to and approved by the engineer prior to installation.

5.3.4 The contractor must submit a well yield test report promptly following the well installation written by the BCGWA registered well driller to the corporation engineer.

5.3.4 The contractor must submit the well identification number and any relevant documentation to the corporation engineer within seven days of well installation completion.

5.4 Well Materials

5.4.1 The well cap used must be a water-tight vented 0.152 m (6”) diameter cast iron well cap.

5.4.2 The well drop pipe used must be 0.152 m (6”) diameter stainless steel pipe adhering to ASTM A589 specifications.

5.4.3 The well casing used must be a 0.254 m (10”) diameter stainless steel casing adhering to ASTM A1097-16 specifications.

5.4.3 The well screen used must be 0.15 mm slit screen pipe based wire wrap.

5.4.4 The gravel pack surrounding water intake areas must be well rounded clean river or ocean sand with a nominal diameter of 0.2mm. Supplier sieve analysis particle size distribution curve must be provided and approved by the engineer prior to installation.

5.4.5 The cement grout and bentonite clay design mix must be approved by the engineer prior to pour.

5.4.6 All well materials used should arrive to site the day of installation or the day prior. Avoid storing well materials on site for an extended period of time to avoid risk of damage. Refer to section 01 40 00 Handling & Storage of Materials for further details.

5.5 Well Installation

5.5.1 Under the Groundwater Act (GWA), the well driller/well pump installer must be a registered installer with the BCGWA and be able to provide their registration number.

5.5.2 All well installation activities must comply with the British Columbia Water Sustainability Act Groundwater Protection Regulation.

5.5.3 Promptly following the well installation a disinfection of the groundwater in the well must be conducted to destroy any micro-organisms introduced by the activity and avoid contaminating the aquifer water supply.

5.5.4 The well diller/installer must conduct a well yield test and produce a summary report to be submitted to the corporation engineer.

5.5.5 A pump test must be performed following the installation.

5.5.6 The contractor must ensure and pay for a well identification plate to be installed securely and in a visible location on the well-head by the driller. The identification plate placement must not interfere with well operations.

End of Section

Section 01 60 00 - Storage Reservoir

---

6. Storage Reservoir

6.1 Scope

6.1.1 This section includes specifications for the appurtenances and general structure of the storage reservoir.

6.2 Related Sections

6.2.1 Section 01 30 00 - Concrete Works

6.2.2 Section 01 40 00 - Handling and Storage of Materials

6.3 Submittals

6.3.1 Within 30 days of each concrete pour, submit to the consulting engineer the concrete testing results for approval.

6.3.2 Electrical, SCADA, Mechanical submittals to and from the subcontractors must also be submitted to the consulting engineer for approval in a timely manner.

6.4 Electrical & SCADA

6.4.1 All electrical and SCADA (monitoring and control) design and installation shall be completed by a subcontracted party. The design shall be reviewed and discussed with the consultant and client prior to start of construction.

6.4.2 The reservoir shall be equipped with sensors that actively monitor the water level. When at capacity, a signal shall be sent to the inlet and outlet valves (or well pumps, during emergency) to prevent reservoir overflow.

6.4.3 The overflow, vent, and drain sump shall be equipped with sensors, locks, and alarm systems that notify operators in the event of an overflow, leakage, or any unusual activity in the storage reservoir.

6.4.4 The electrical design shall include consideration for adequate lighting for the reservoir. Design for the lighting location shall be submitted to the consulting engineer for approval.

6.5 Mechanical

6.5.1 All mechanical components of the storage reservoir must be reviewed and approved by a subcontracted party prior to start of construction.

6.5.2 Inlet and outlet valves shall be equipped with manual operating methods in addition to the remotely controllable system.

6.6 Geotechnical

6.6.1 In addition to the preliminary geotechnical analysis that the consultant has completed, a subcontracted party must review the soil conditions under the storage reservoir and provide guidance and approval for ground preparation prior to start of construction.

6.4 Access Hatch

6.4.1 The access hatch shall be the model specified below. In the case that the exact model is not available, the replacement access hatch must be approved by the consulting engineer.

VERSA STEEL WATER RESERVOIR HATCH, 84 x 120, DUAL LEAF. Assembly No. VSH-150-A-84-120-DT-GS.

6.5 Downturned Vent

6.5.1 The downturned vent shall be custom made by the contractor’s preferred supplier, according to the dimensions and materials provided in the detailed design drawings. The specifications shall be submitted to the consulting engineer for approval prior to ordering.

6.6 Overflow

6.6.1 The overflow shall be custom made by the contractor’s preferred supplier, according to the dimensions and materials provided in the detailed design drawings and report. The specifications shall be submitted to the consulting engineer for approval prior to ordering.

6.6.2 Overflow protection walls shall be cast with the same concrete material in the specified dimensions as per the design drawings.

6.6.3 Metal grating shall be provided over the overflow area to keep the ground surface uniform and prevent injury by falling.

6.6.4 Drainage away from the overflow shall be provided through a PVC pipe or culvert type structure, but shall not connect directly to any storm sewer main.

6.7 Wall Ladder

6.7.1 The wall ladder shall be the model specified below. In the case that the exact model is not available, the replacement wall ladder must be approved by the consulting engineer.

COTTERMAN 8 RUNG FIXED STEEL LADDER, Part No. F10S Item No.3570210

6.8 Drain & Drain Sump

6.8.1 The drain cover and drain sump shall be custom made by the contractor’s preferred supplier, according to the dimensions and materials provided in the detailed design drawings and report. The specifications shall be submitted to the consulting engineer for approval prior to ordering.

6.8.2 The reservoir floor shall be sloped at 2% grade to enable efficient drainage to the drain and drain sump.

6.9 Valve Chamber

6.9.1 The valve chamber shall be custom made by the contractor’s preferred supplier, according to the dimensions and materials provided in the detailed design drawings and report. The specifications shall be submitted to the consulting engineer for approval prior to ordering.

6.10 Disinfection

6.10.1 The reservoir and all appurtenances within it must be cleaned and disinfected in accordance with the current AWWA standards prior to the start of operation.

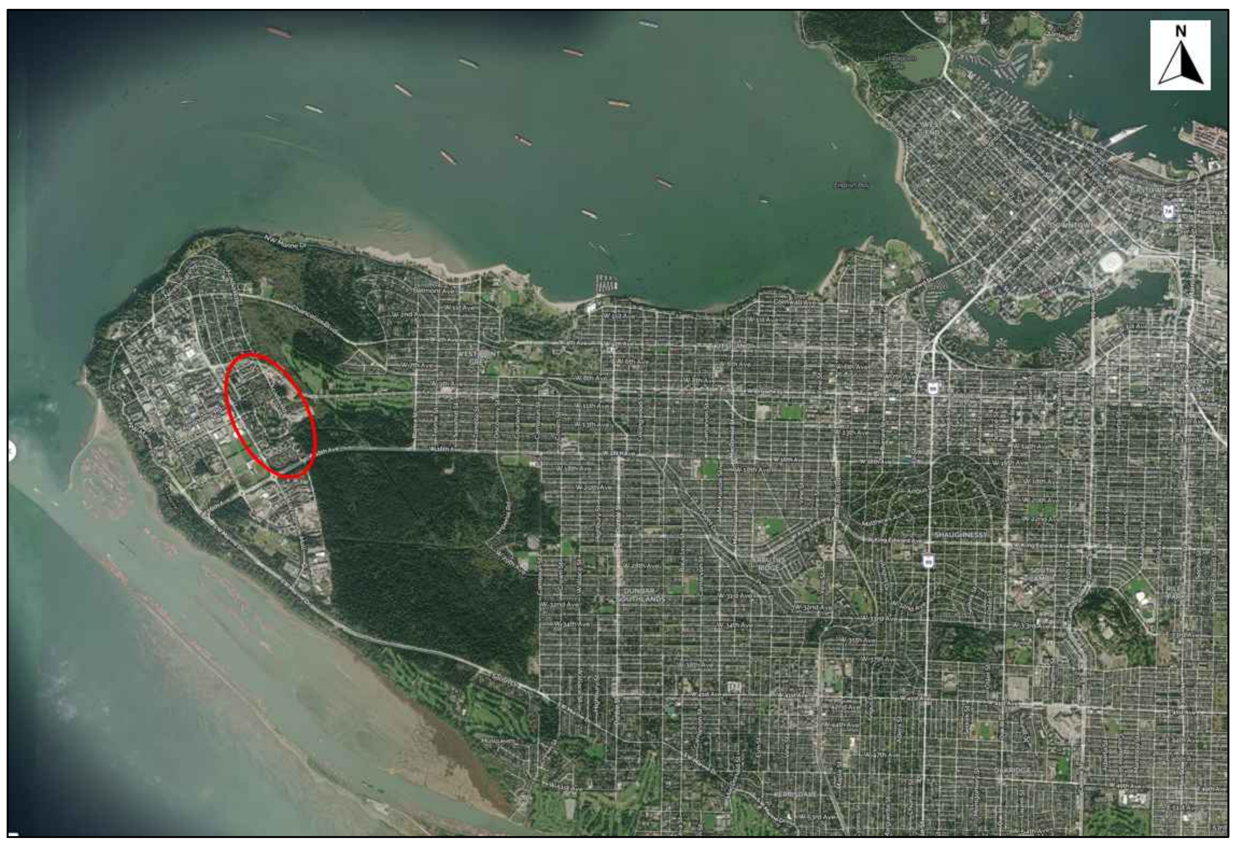
End of Section

Appendix F - Detailed Design Drawings

UNIVERSITY OF BRITISH COLUMBIA

SOCIAL ECOLOGICAL ECONOMIC DEVELOPMENT STUDIES (SEEDS) SUSTAINABILITY PROGRAM

UBC GROUNDWATER EMERGENCY WATER SUPPLY DETAILED DESIGN DRAWINGS - ISSUED FOR CONSTRUCTION



VICINITY MAP

SHEET LIST TABLE

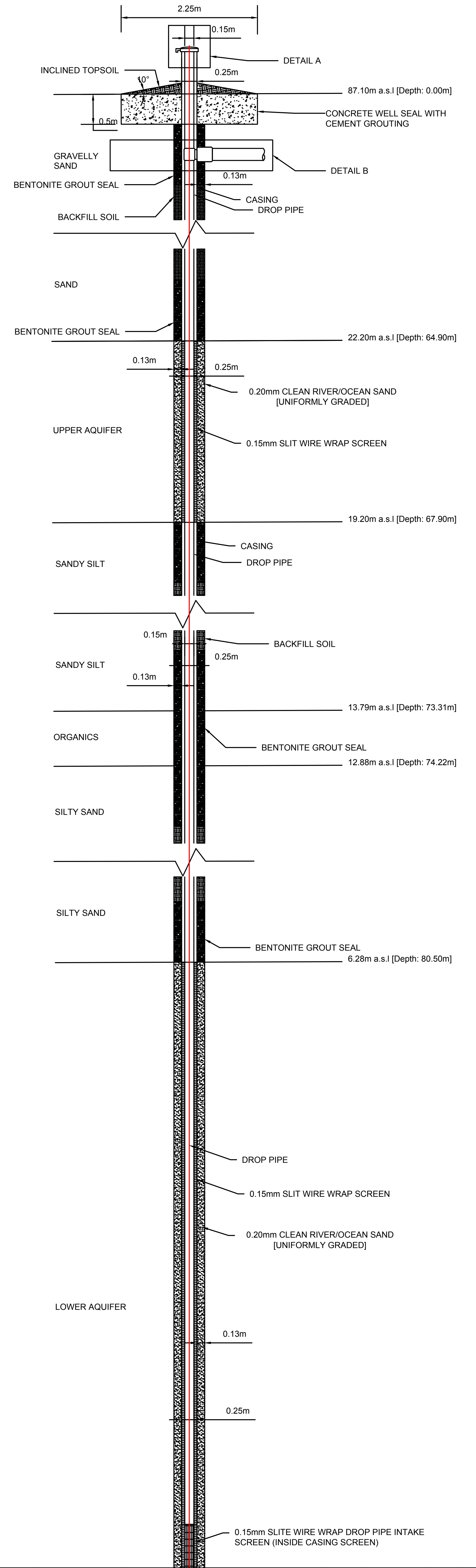
SHEET #	DRAWING #	SHEET TITLE
WELLS		
01	01-WELL-01	WELL HEAD
02	02-WELL-02	WELL HEAD
03	03-WELL-03	UPPER AQUIFER AND ORGANICS LAYER
04	04-WELL-04	LOWER AQUIFER
05	05-WELL-05	WELL CAP
06	06-WELL-06	PITLESS ADAPTER
STORAGE RESERVOIR		
07	07-STOR-01	STORAGE RESERVOIR BASE SLAB & COLUMN
08	08-STOR-02	STORAGE RESERVOIR CROSS SECTION
09	09-STOR-03	STORAGE RESERVOIR ROOF, VENTS & OVERFLOWS
10	10-STOR-04	STORAGE RESERVOIR VENT, OVERFLOW, VALVE CHAMBER DETAILS
11	11-STOR-05	SUMP PUMP PROFILE
WATER SUPPLY PIPES		
12	12-PIPE-01	FAIRVIEW PLACE WATER MAIN
13	13-PIPE-02	WESBROOK MALL WATER MAIN
14	14-PIPE-03	WEST 16TH AVE WATER MAIN
15	15-PIPE-04	WATER MAIN TO HIGH PRESSURE ZONE
16	16-PIPE-05	WATER MAIN DETAILS

PREPARED BY

KAEDE DURRANT
NATALIE MCRAE
ANDREW MILLER
ANDREW NICKEL
ANHA NUBAIRA
XIAOYING QIN

APRIL 14, 2021

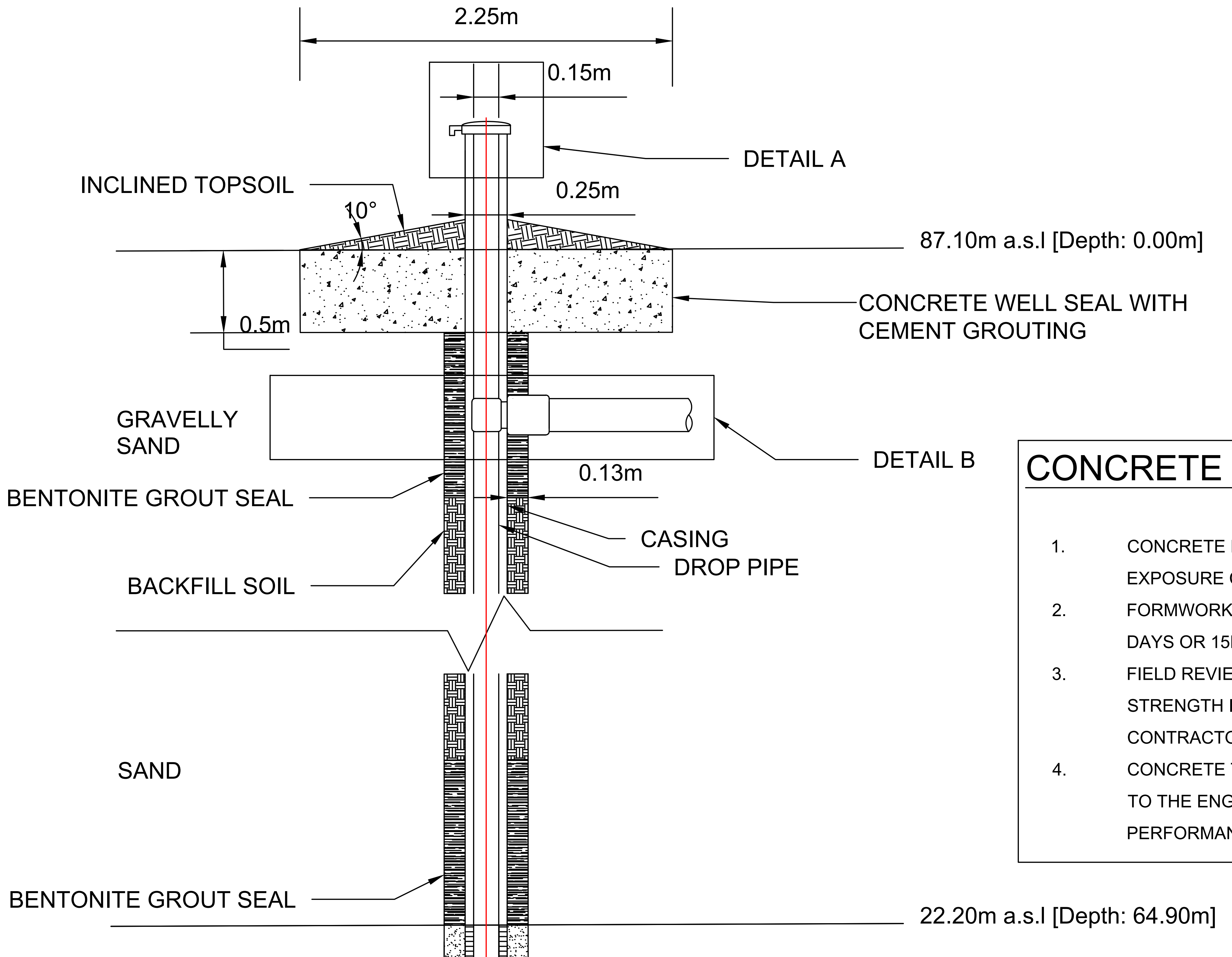
ISSUED FOR CONSTRUCTION



CIVL 446 - UBC GROUNDWATER EMERGENCY WATER SUPPLY PROJECT		CLIENT	NOTES:	REV.:	DATE: (yyyy-mm-dd)	BY:	APPROVED:	SIGN & SEAL
DRAWING NAME:	WELL HEAD	UBC SEEDS	• DIMENSIONS IN METRES UNLESS OTHERWISE SPECIFIED • DO NOT MEASURE FROM THIS DRAWING • REPORT ANY DISCREPANCIES TO THE ENGINEER OF RECORD	01-IFC	2021-04-14	XQ	XQ	
DRAWING NO.:	01-WELL-01							
SCALE:	-							

PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION

ISSUED FOR CONSTRUCTION

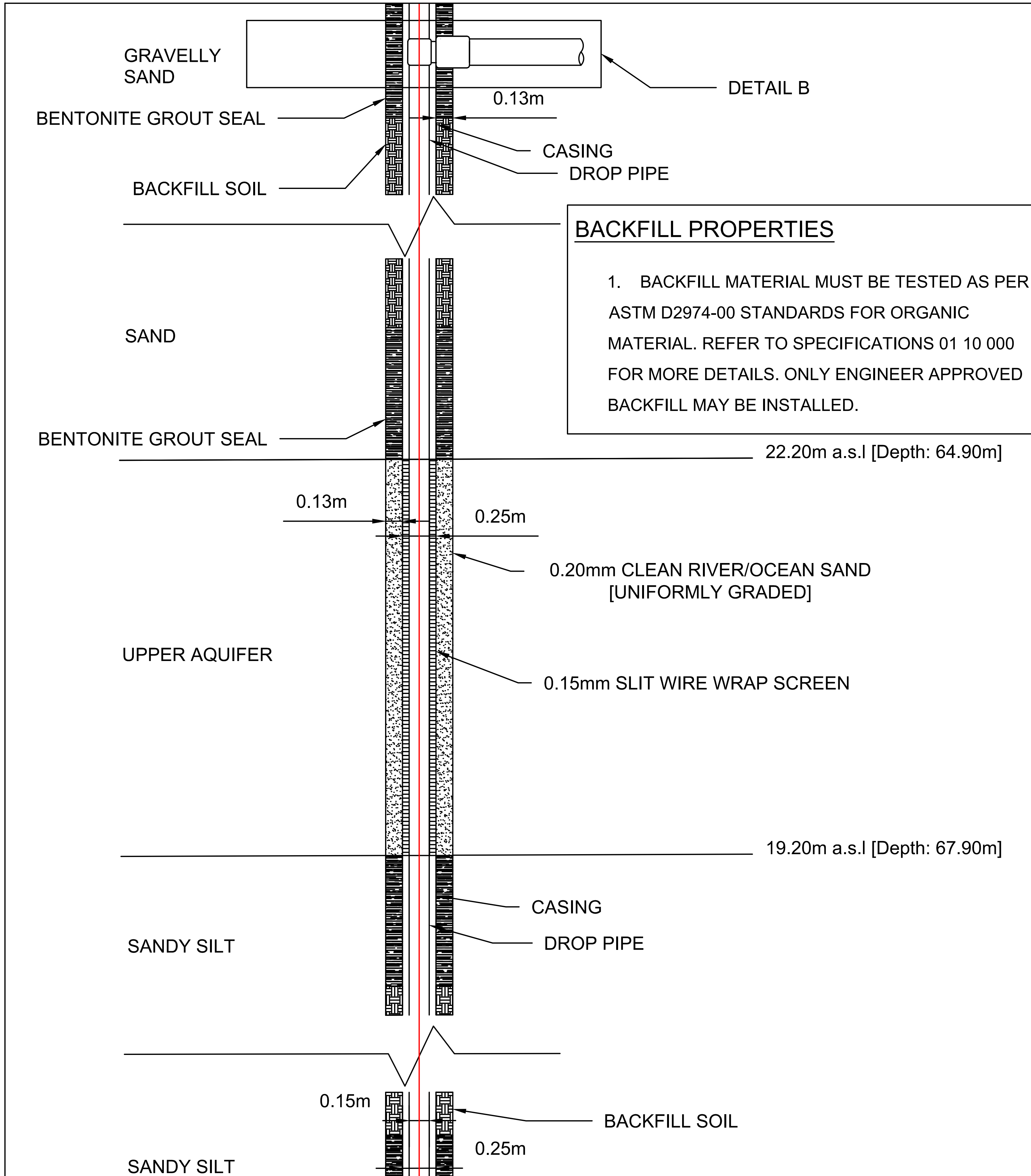


CONCRETE PROPERTIES

1. CONCRETE MUST BE 25 MPa AND ADHERE TO C-2 EXPOSURE CLASS STANDARDS.
2. FORMWORK MUST NOT BE REMOVED BEFORE 7 DAYS OR 15MPa STRENGTH IS REACHED.
3. FIELD REVIEW OF FORMWORK, AND CONCRETE STRENGTH IS THE RESPONSIBILITY OF THE CONTRACTOR.
4. CONCRETE TEST RESULTS MUST BE SUBMITTED TO THE ENGINEER WITHIN 5 WORK DAYS OF PERFORMANCE.

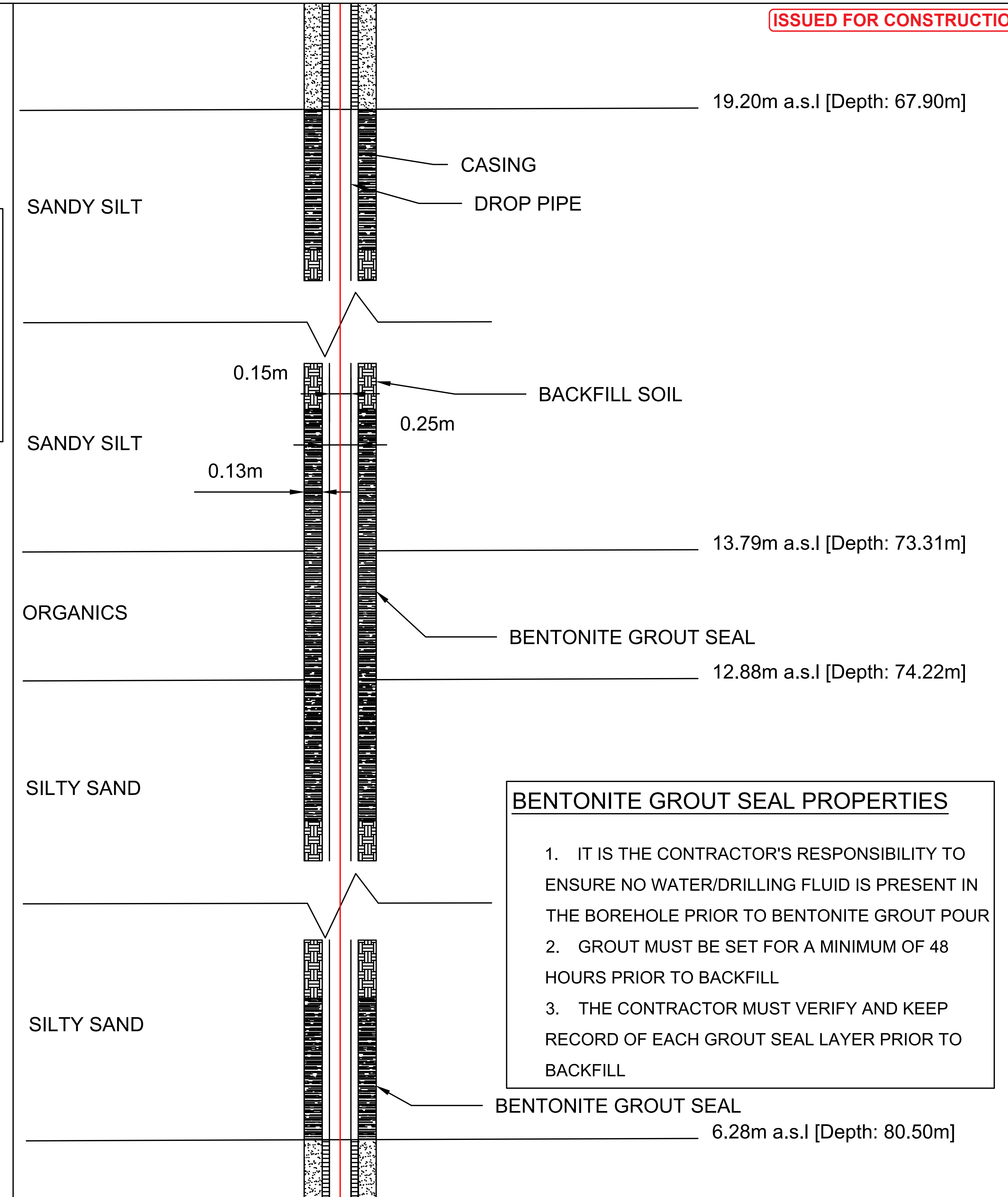
CIVL 446 - UBC GROUNDWATER EMERGENCY WATER SUPPLY PROJECT		CLIENT	NOTES:	REV.:	DATE: (yyyy-mm-dd)	BY:	APPROVED:	SIGN & SEAL
DRAWING NAME:	WELL HEAD	UBC SEEDS	• DIMENSIONS IN METRES UNLESS OTHERWISE SPECIFIED • DO NOT MEASURE FROM THIS DRAWING • REPORT ANY DISCREPANCIES TO THE ENGINEER OF RECORD	01-IFC	2021-04-14	XQ	XQ	
DRAWING NO.:	02-WELL-02							
SCALE:	-							

ISSUED FOR CONSTRUCTION



BACKFILL PROPERTIES

1. BACKFILL MATERIAL MUST BE TESTED AS PER ASTM D2974-00 STANDARDS FOR ORGANIC MATERIAL. REFER TO SPECIFICATIONS 01 10 000 FOR MORE DETAILS. ONLY ENGINEER APPROVED BACKFILL MAY BE INSTALLED.



BENTONITE GROUT SEAL PROPERTIES

1. IT IS THE CONTRACTOR'S RESPONSIBILITY TO ENSURE NO WATER/DRILLING FLUID IS PRESENT IN THE BOREHOLE PRIOR TO BENTONITE GROUT POUR
2. GROUT MUST BE SET FOR A MINIMUM OF 48 HOURS PRIOR TO BACKFILL
3. THE CONTRACTOR MUST VERIFY AND KEEP RECORD OF EACH GROUT SEAL LAYER PRIOR TO BACKFILL

CIVL 446 - UBC GROUNDWATER EMERGENCY WATER SUPPLY PROJECT		CLIENT	NOTES:	REV.:	DATE: (yyyy-mm-dd)	BY:	APPROVED:	SIGN & SEAL
DRAWING NAME:	UPPER AQUIFER AND ORGANICS LAYER	UBC SEEDS	• DIMENSIONS IN METRES UNLESS OTHERWISE SPECIFIED • DO NOT MEASURE FROM THIS DRAWING • REPORT ANY DISCREPANCIES TO THE ENGINEER OF RECORD	01-IFC	2021-04-14	XQ	XQ	
DRAWING NO.:	03-WELL-03							
SCALE:	-							

PRODUCED BY AN AUTODESK STUDENT VERSION

ISSUED FOR CONSTRUCTION

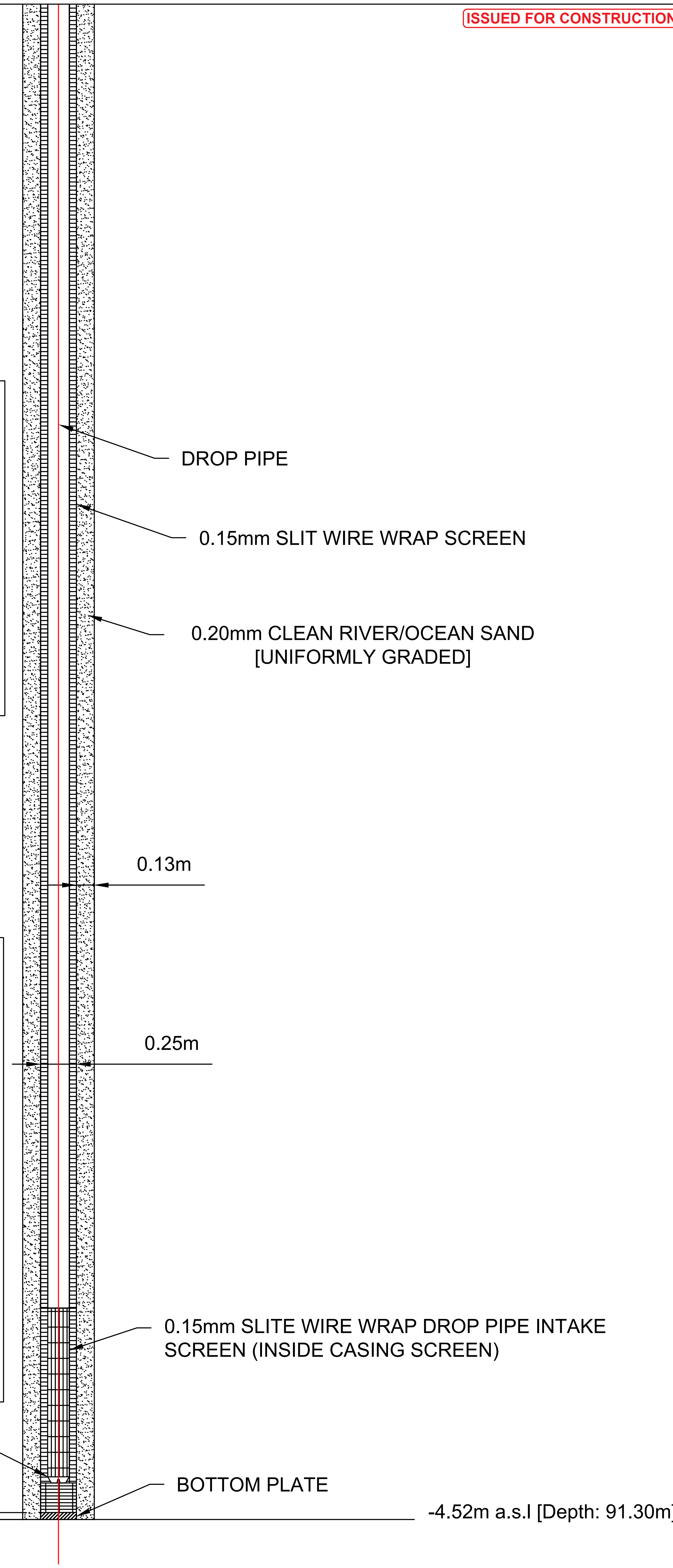
CLEAN SAND NOTES

1. CLEAN RIVER/OCEAN SAND MUST HAVE 90% OF ALL PARTICLES FALL WITHIN THE D50 OF THE PARTICLE SIZE DISTRIBUTION CURVE.
2. IT IS THE CONTRACTORS'S RESPONSIBILITY TO WASH SAND PRIOR TO INSTALLATION AND ENSURE NO SILTS OR DUST ARE PRESENT.
3. THE CONTRACTOR MUST SUBMIT A THIRD-PARTY SAND GRADATION CURVE AND RECEIVE APPROVAL FROM THE ENGINEER PRIOR TO INSTALLATION.

LOWER AQUIFER

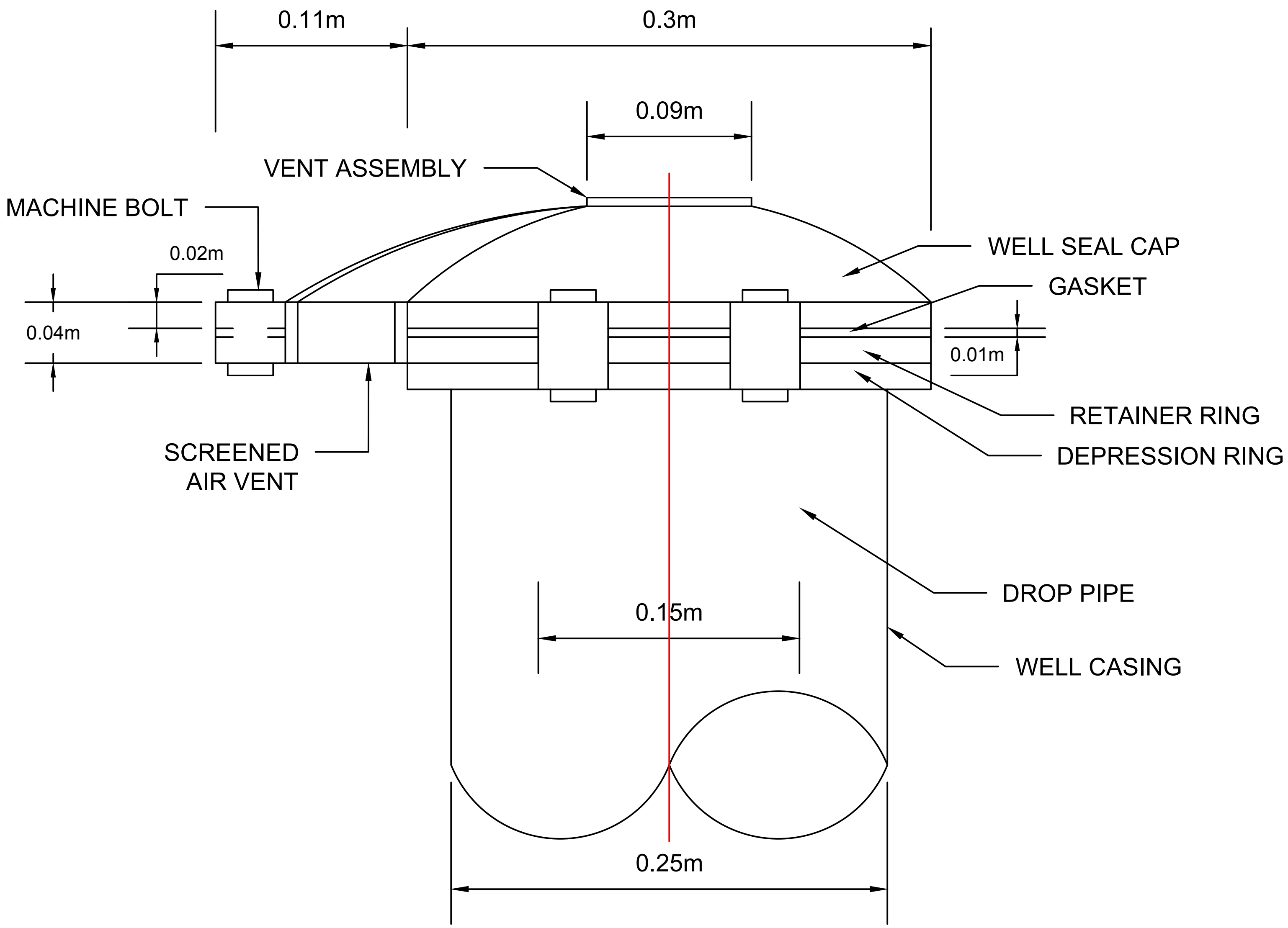
PUMP NOTES

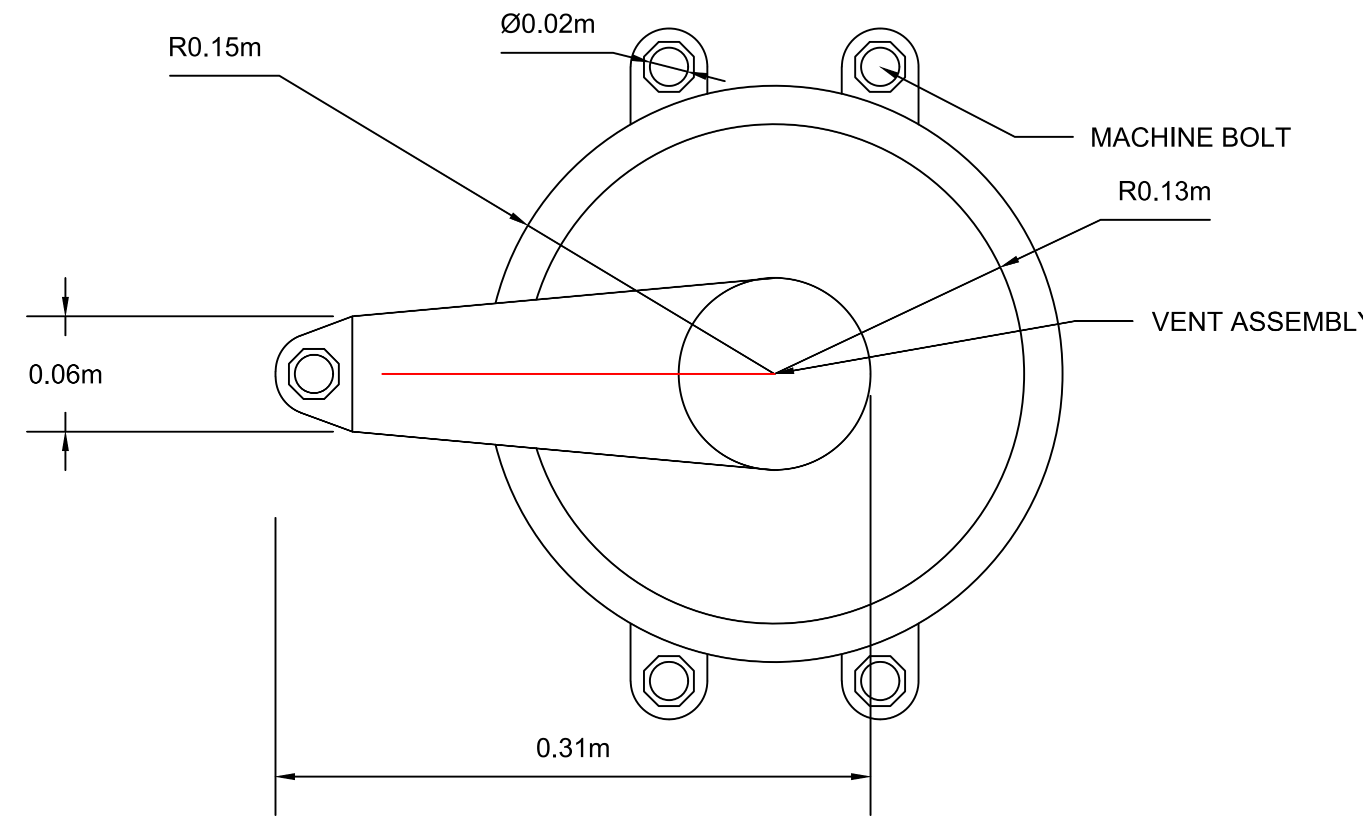
1. PUMP MUST BE A 30 HP 9 STAGE SUBMERSIBLE PUMP CAPABLE OF SUPPLYING A MINIMUM OF 110M OF HEAD AT 15 L/s.
2. PUMP SETS MUST COMPLY WITH CURRENT I.S.O STANDARDS.
3. IT IS THE CONTRACTOR'S RESPONSIBILITY TO ENSURE THE PUMP CABLE CONNECTION IS IN WORKING CONDITION PRIOR TO INSTALLATION.
4. THE CONTRACTOR MUST SUBMIT THE PUMP MANUFACTURER'S AUTHORIZATION LETTER AND PUMP CERTIFICATE TO THE ENGINEER AS WELL AS RECEIVE THE ENGINEER'S APPROVAL PRIOR TO PUMP INSTALLATION.



CIVL 446 - UBC GROUNDWATER EMERGENCY WATER SUPPLY PROJECT		CLIENT	NOTES:	REV.:	DATE: (yyyy-mm-dd)	BY:	APPROVED:	SIGN & SEAL
DRAWING NAME:	LOWER AQUIFER	UBC SEEDS	• DIMENSIONS IN METRES UNLESS OTHERWISE SPECIFIED • DO NOT MEASURE FROM THIS DRAWING • REPORT ANY DISCREPANCIES TO THE ENGINEER OF RECORD	01-IFC	2021-04-14	XQ	XQ	
DRAWING NO.:	04-WELL-04							
SCALE:	-							

ISSUED FOR CONSTRUCTION





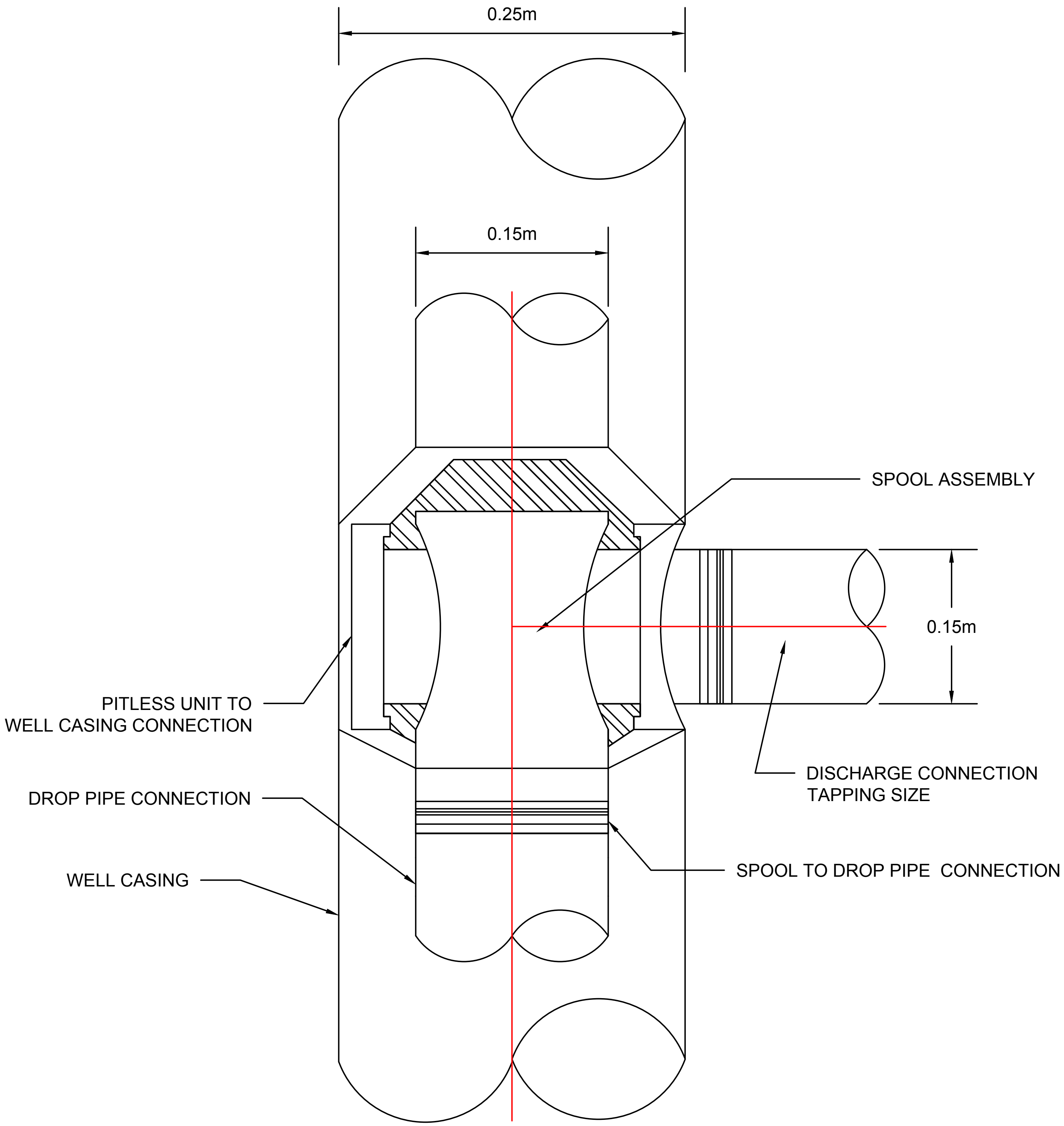
WELL CAP DETAILS:

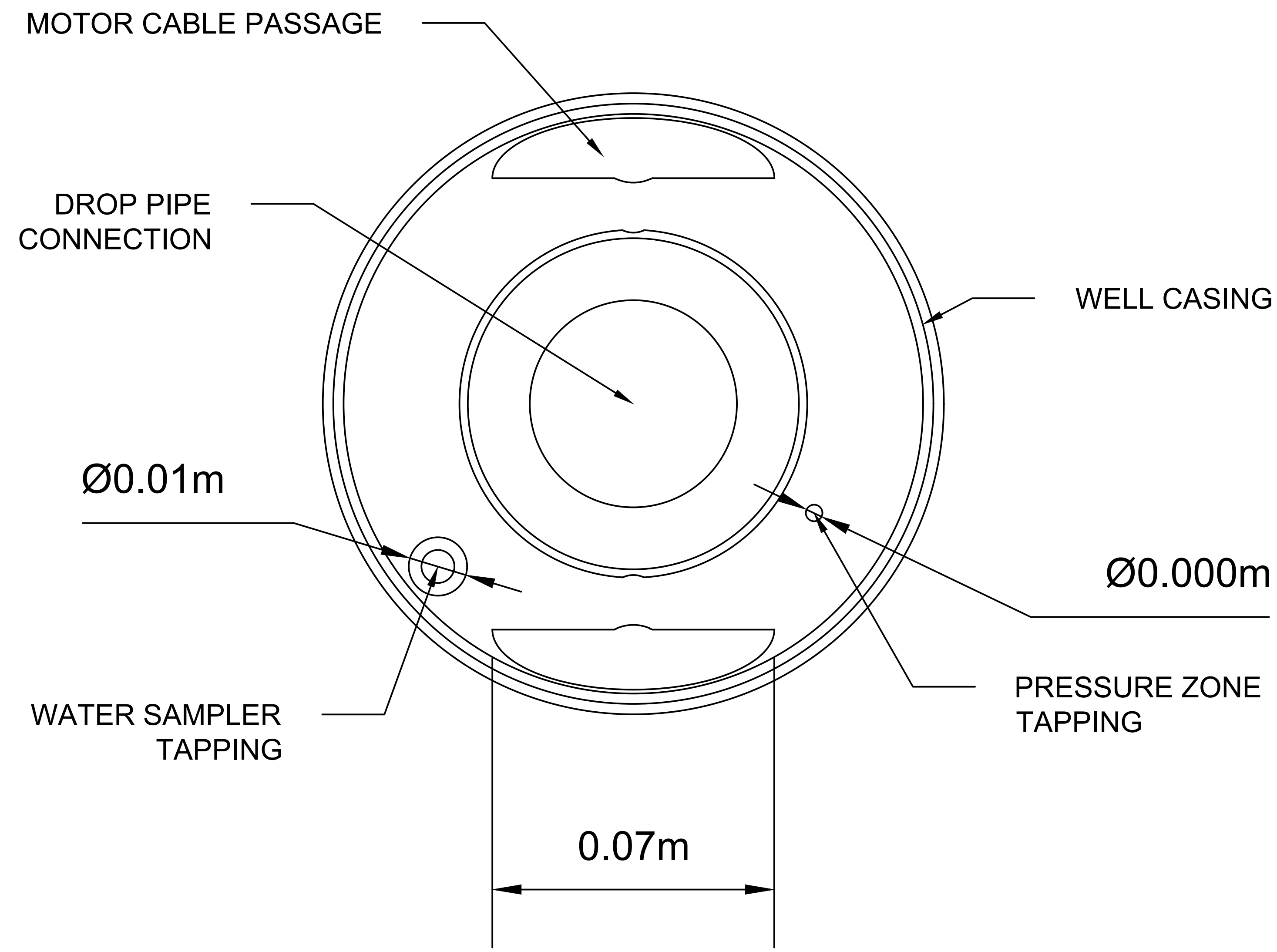
1. THE WELL CAP MUST BE WATERTIGHT AND INSTALLED WITH A COMPRESSION SEAL RING AND SCREENED WELL VENT.
2. THE WELL IDENTIFICATION PLATE MUST BE SECURED ONTO THE WELL CAP IN A VISIBLE LOCATION.

CIVL 446 - UBC GROUNDWATER EMERGENCY WATER SUPPLY PROJECT		CLIENT	NOTES:	REV.:	DATE: (yyyy-mm-dd)	BY:	APPROVED:	SIGN & SEAL
DRAWING NAME:	WELL CAP	UBC SEEDS	• DIMENSIONS IN METRES UNLESS OTHERWISE SPECIFIED • DO NOT MEASURE FROM THIS DRAWING • REPORT ANY DISCREPANCIES TO THE ENGINEER OF RECORD	01-IFC	2021-04-14	XQ	XQ	
DRAWING NO.:	05-WELL-05							
SCALE:	-							

PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION

ISSUED FOR CONSTRUCTION





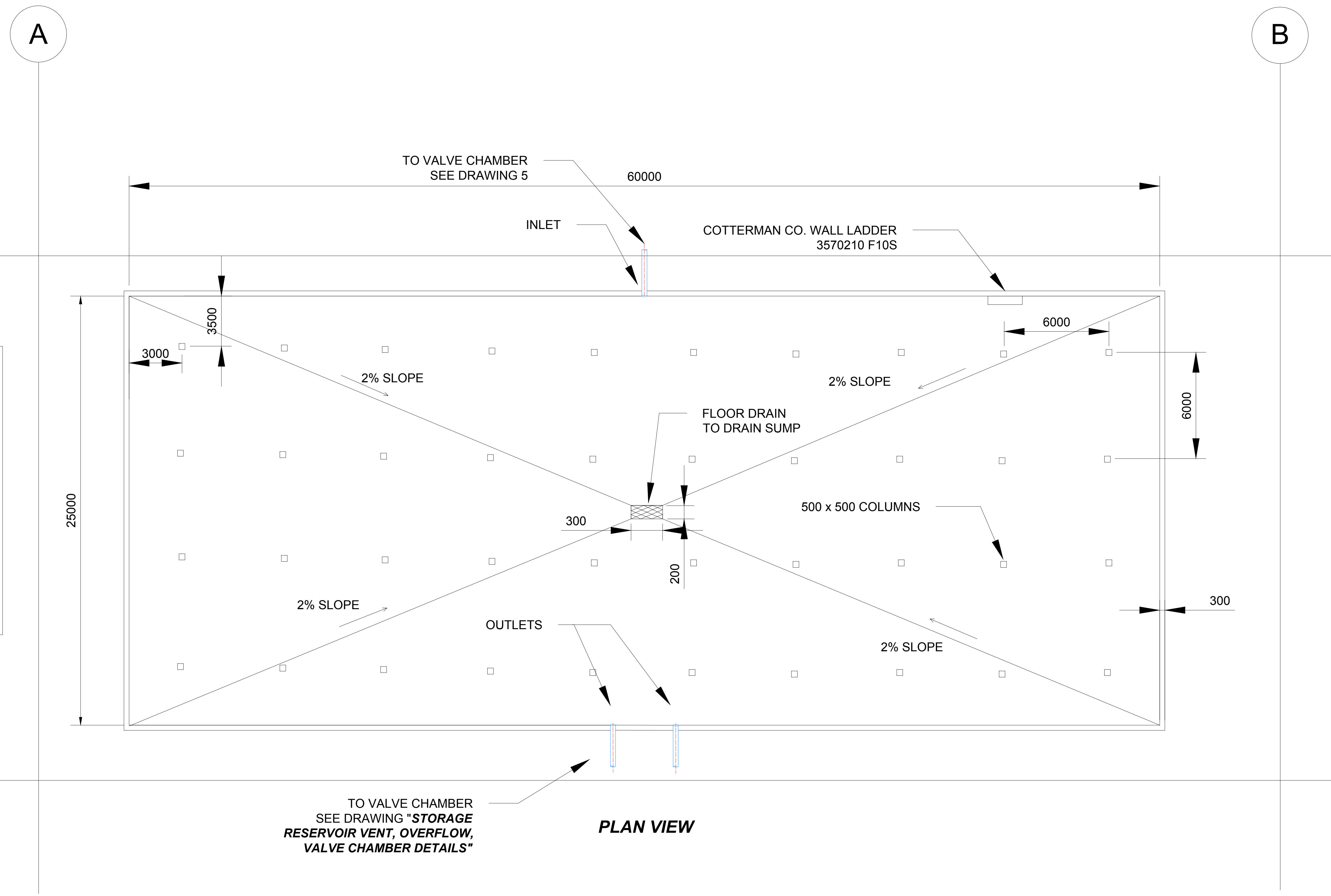
PITLESS ADAPTER DETAILS:

1. THE PITLESS ADAPTOR AND WELL CASING CONNECTION MUST BE BUTT WELDED BY A CERTIFIED WELDER REGISTERED WITH THE CANADIAN WELDING BUREAU (CWB). THE CONTRACTOR MUST PROVIDE WELDER QUALIFICATIONS AND SEEK THE ENGINEER'S APPROVAL PRIOR TO COMMENCING THE WELD.
2. THE PITLESS ADAPTOR MUST BE RATED CAPABLE OF CONDUCTING 100m OF HEAD PRESSURE DISCHARGE.

CIVL 446 - UBC GROUNDWATER EMERGENCY WATER SUPPLY PROJECT		CLIENT	NOTES:	REV.:	DATE: (yyyy-mm-dd)	BY:	APPROVED:	SIGN & SEAL
DRAWING NAME:	PITLESS ADAPTER	UBC SEEDS	• DIMENSIONS IN METRES UNLESS OTHERWISE SPECIFIED • DO NOT MEASURE FROM THIS DRAWING • REPORT ANY DISCREPANCIES TO THE ENGINEER OF RECORD	01-IFC	2021-04-14	XQ	XQ	
DRAWING NO.:	06-WELL-06							
SCALE:	-							

PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION

ISSUED FOR CONSTRUCTION



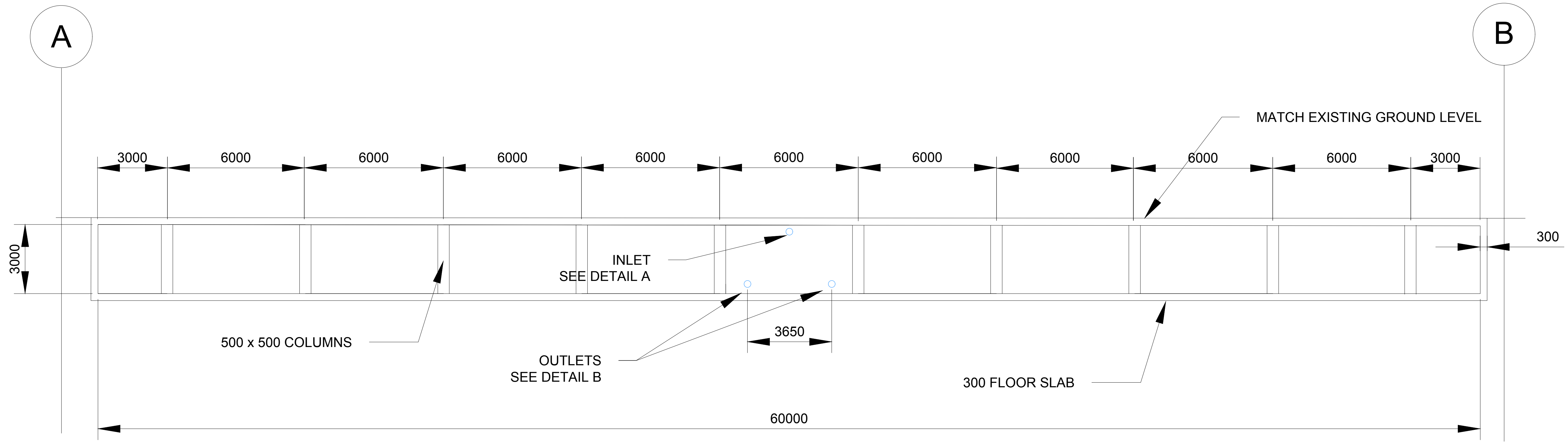
PLAN VIEW

NOTES:

1. ***ALL DIMENSIONS IN MILLIMETERS UNLESS SPECIFIED***
2. ***SEE CONSTRUCTION SPECIFICATIONS FOR LADDER DETAILS***
3. ***STRUCTURAL DETAILS OF CONCRETE CASTING OF WALLS AND COLUMNS SHALL BE CONFIRMED WITH STRUCTURAL DESIGNER***
4. ***SEE CONSTRUCTION SPECIFICATIONS AND MANUFACTURER DRAWINGS FOR WALL LADDER***
5. ***VALVE CHAMBER DETAILS ON DRAWING "STORAGE RESERVOIR VENT, OVERFLOW, VALVE CHAMBER DETAILS"***

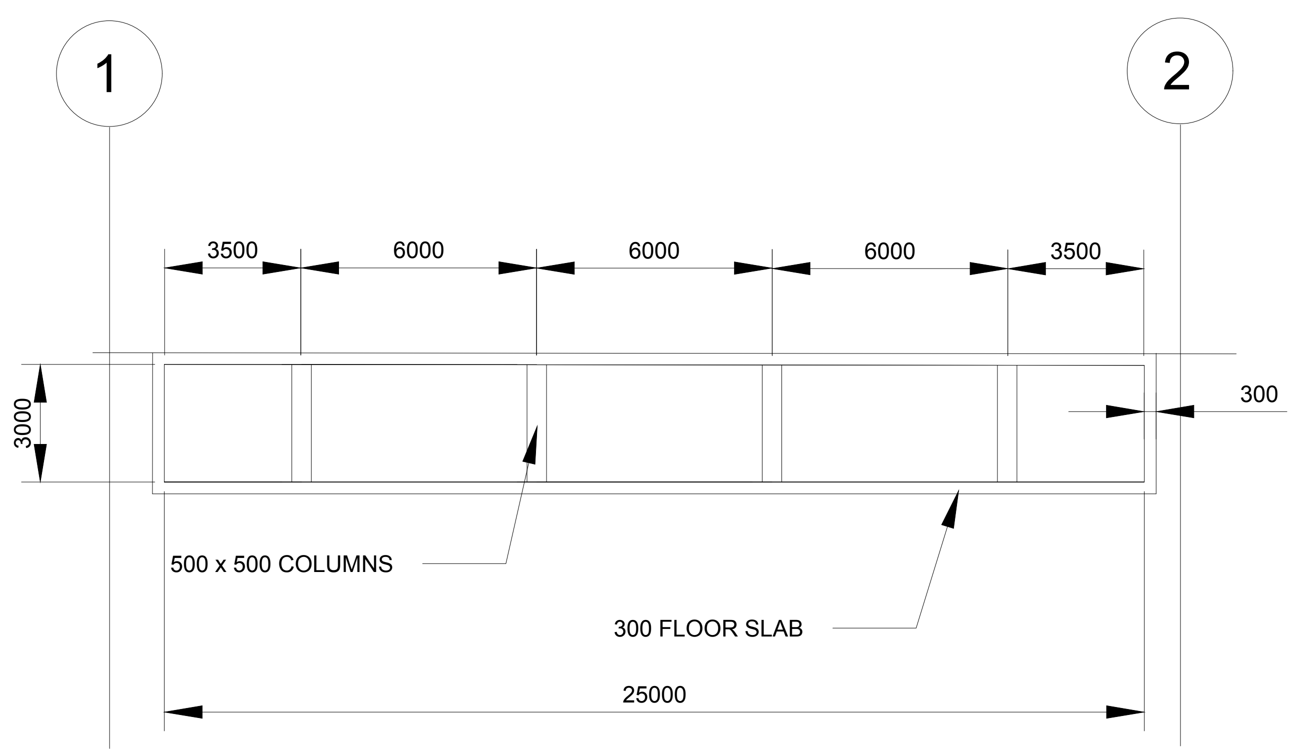
CIVL 446 - UBC GROUNDWATER EMERGENCY WATER SUPPLY PROJECT		CLIENT	NOTES:	REV.:	DATE: (yyyy-mm-dd)	BY:	APPROVED:	SIGN & SEAL
DRAWING NAME:	STORAGE RESERVOIR BASE SLAB & COLUMN	UBC SEEDS	• DIMENSIONS IN METRES UNLESS OTHERWISE SPECIFIED • DO NOT MEASURE FROM THIS DRAWING • REPORT ANY DISCREPANCIES TO THE ENGINEER OF RECORD	01-IFC	2021-04-14	KD	KD	
DRAWING NO.:	07-STOR-01							
SCALE:	-							

ISSUED FOR CONSTRUCTION

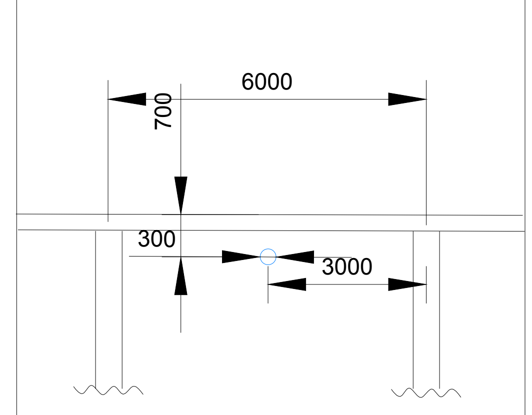


ELEVATION VIEW

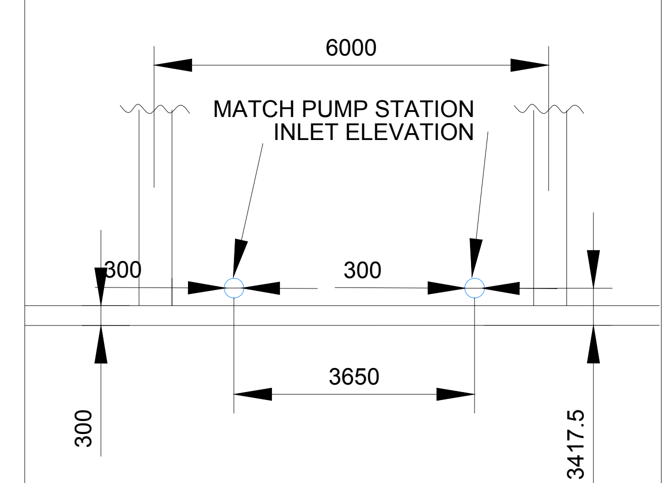
NOTES:
1. ALL DIMENSIONS IN MILLIMETERS UNLESS SPECIFIED
2. MAINS, VENT, LADDER AND OVERFLOW ARE NOT SHOWN IN THIS DRAWING FOR CLARITY



PROFILE VIEW



DETAIL A



DETAIL B

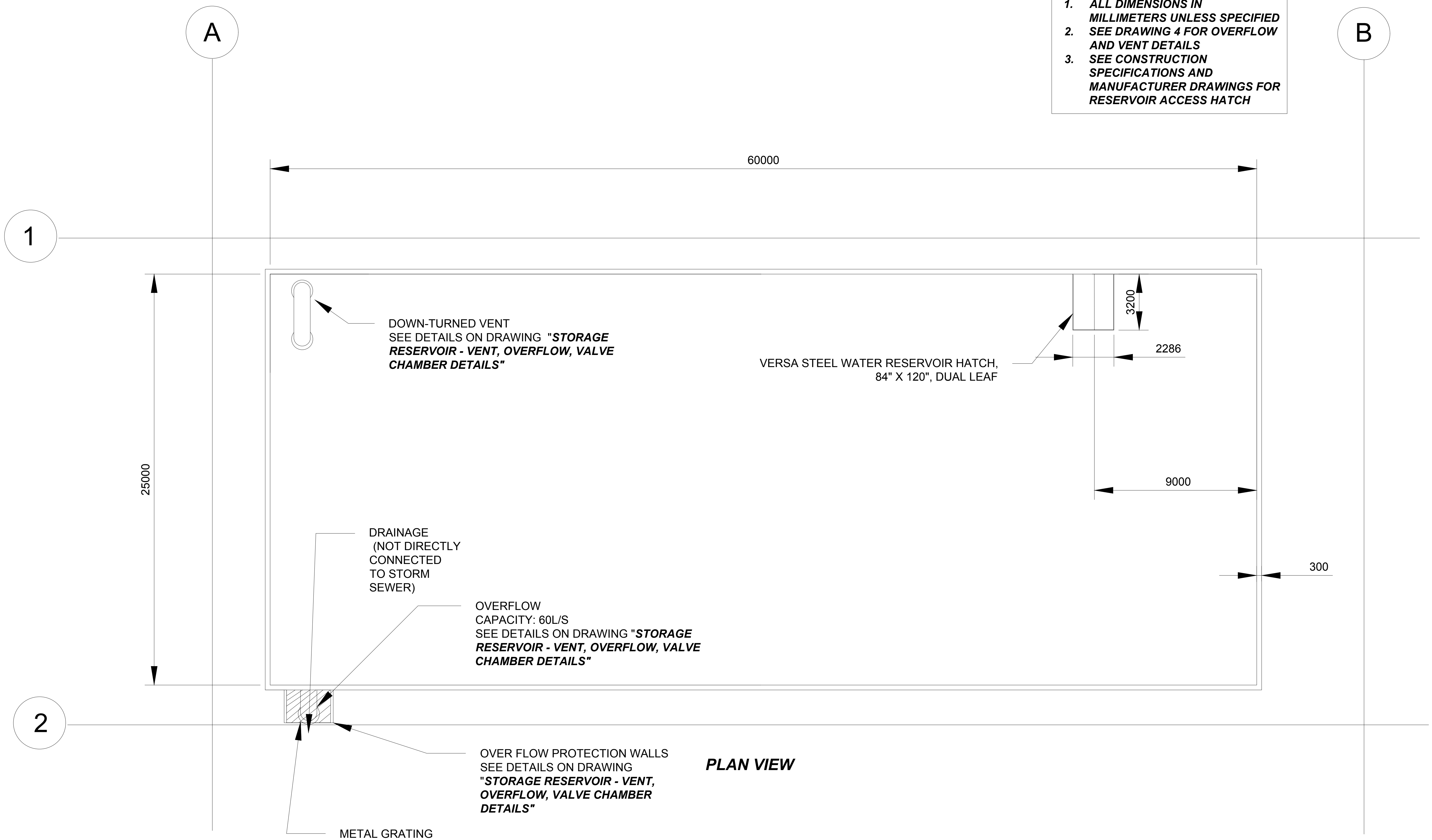
CIVL 446 - UBC GROUNDWATER EMERGENCY WATER SUPPLY PROJECT		CLIENT	NOTES:	REV.:	DATE: (yyyy-mm-dd)	BY:	APPROVED:
DRAWING NAME:	STORAGE RESERVOIR CROSS SECTION	UBC SEEDS	• DIMENSIONS IN METRES UNLESS OTHERWISE SPECIFIED • DO NOT MEASURE FROM THIS DRAWING • REPORT ANY DISCREPANCIES TO THE ENGINEER OF RECORD	01-IFC	2021-04-14	KD	KD
DRAWING NO.:	08-STOR-02						
SCALE:	-						

SIGN & SEAL

PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION

ISSUED FOR CONSTRUCTION

NOTES:
1. ALL DIMENSIONS IN MILLIMETERS UNLESS SPECIFIED
2. SEE DRAWING 4 FOR OVERFLOW AND VENT DETAILS
3. SEE CONSTRUCTION SPECIFICATIONS AND MANUFACTURER DRAWINGS FOR RESERVOIR ACCESS HATCH



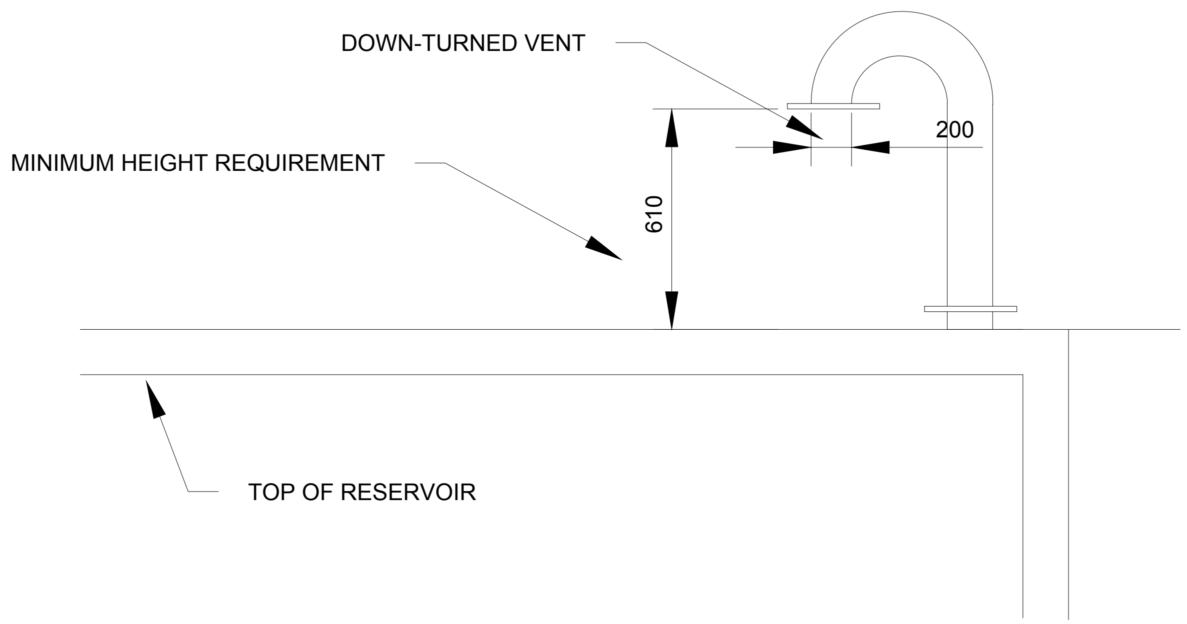
PLAN VIEW

CIVL 446 - UBC GROUNDWATER EMERGENCY WATER SUPPLY PROJECT		CLIENT	NOTES:	REV.:	DATE: (yyyy-mm-dd)	BY:	APPROVED:	SIGN & SEAL
DRAWING NAME:	STORAGE RESERVOIR ROOF, VENTS & OVERFLOWS	UBC SEEDS	• DIMENSIONS IN METRES UNLESS OTHERWISE SPECIFIED • DO NOT MEASURE FROM THIS DRAWING • REPORT ANY DISCREPANCIES TO THE ENGINEER OF RECORD	01-IFC	2021-04-14	KD	KD	
DRAWING NO.:	09-STOR-03							
SCALE:	-							

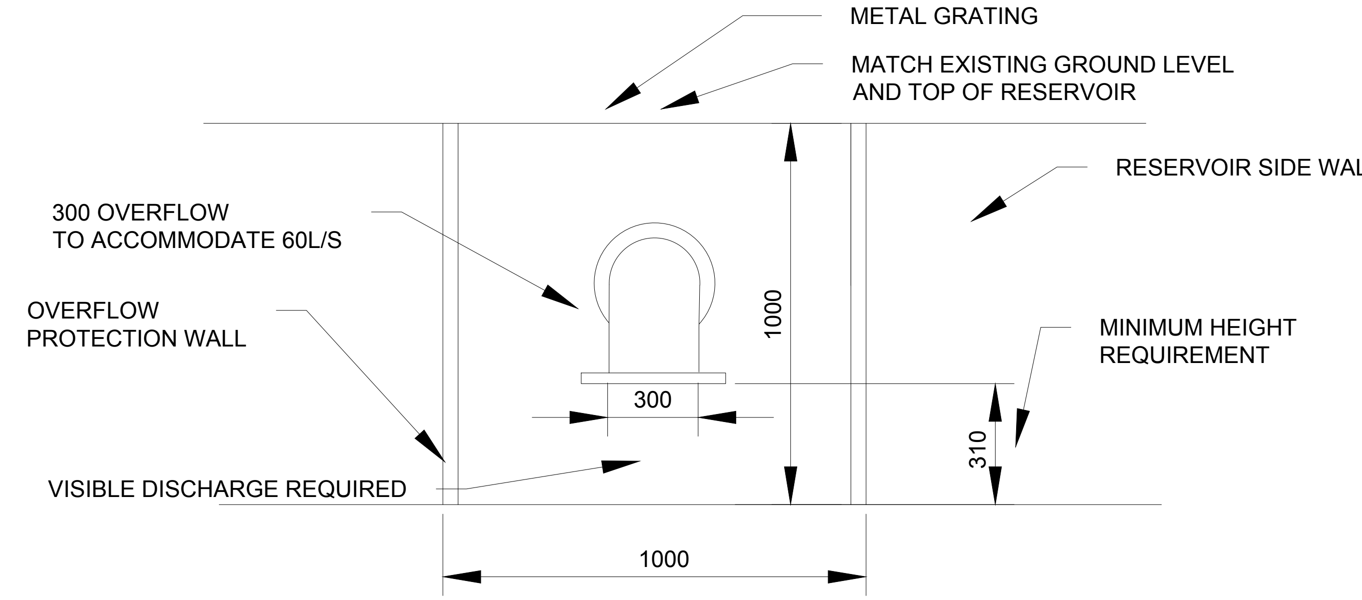
PRODUCED BY AN AUTODESK STUDENT VERSION

ISSUED FOR CONSTRUCTION

DOWN-TURNED VENT



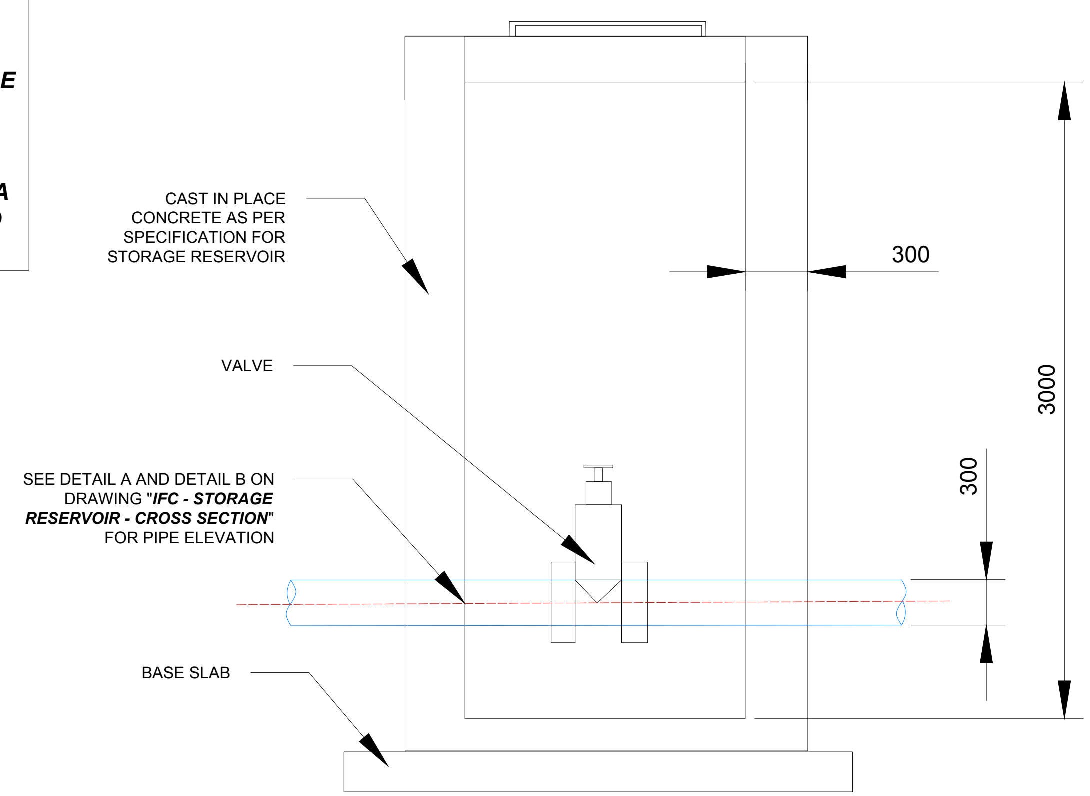
OVERFLOW - FRONT



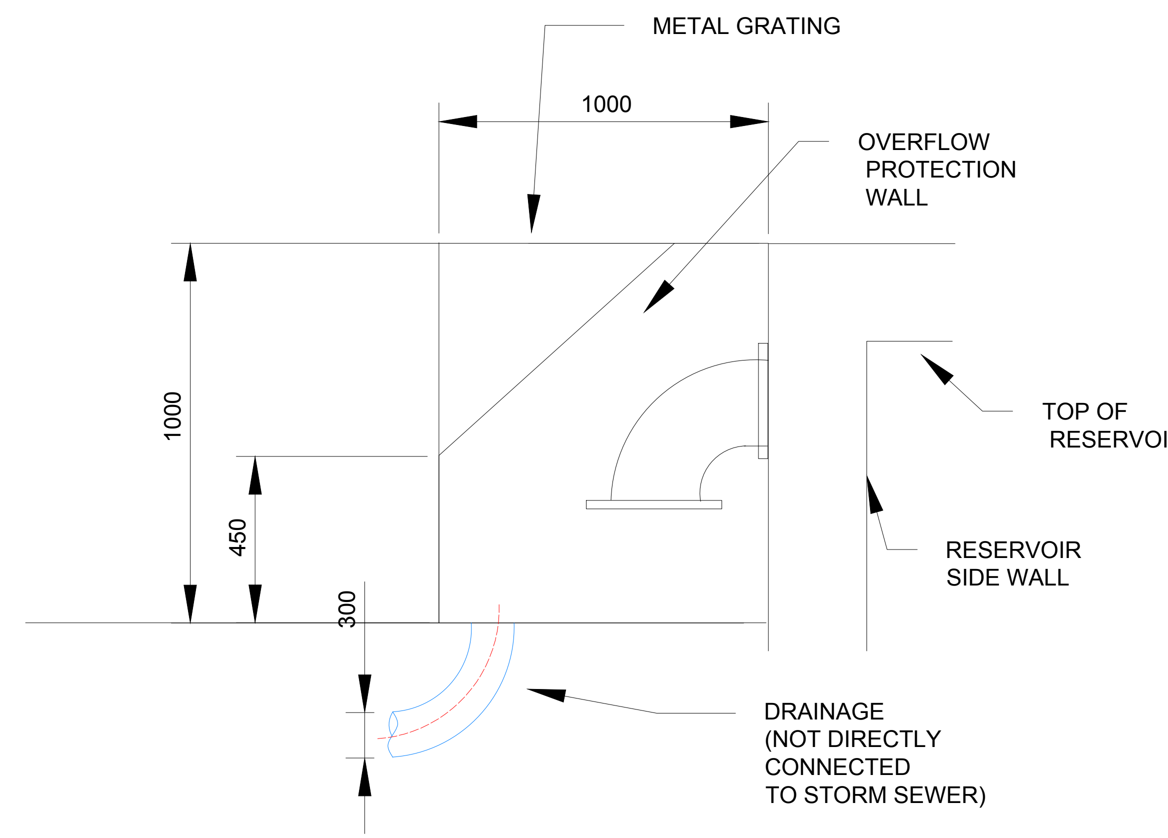
NOTES:

1. **ALL DIMENSIONS IN MILLIMETERS UNLESS SPECIFIED**
2. **VENT AND OVERFLOW MATERIALS SHALL MEET ANSI/NSF61 REQUIREMENTS**
3. **VALVE CHAMBER DRAWING CAN BE APPLIED TO THE INLET AND TWO OUTLETS**
4. **VALVE AND VALVE CHAMBER DESIGN SHALL BE APPROVED BY A MECHANICAL ENGINEER PRIOR TO CONSTRUCTION**

VALVE CHAMBER



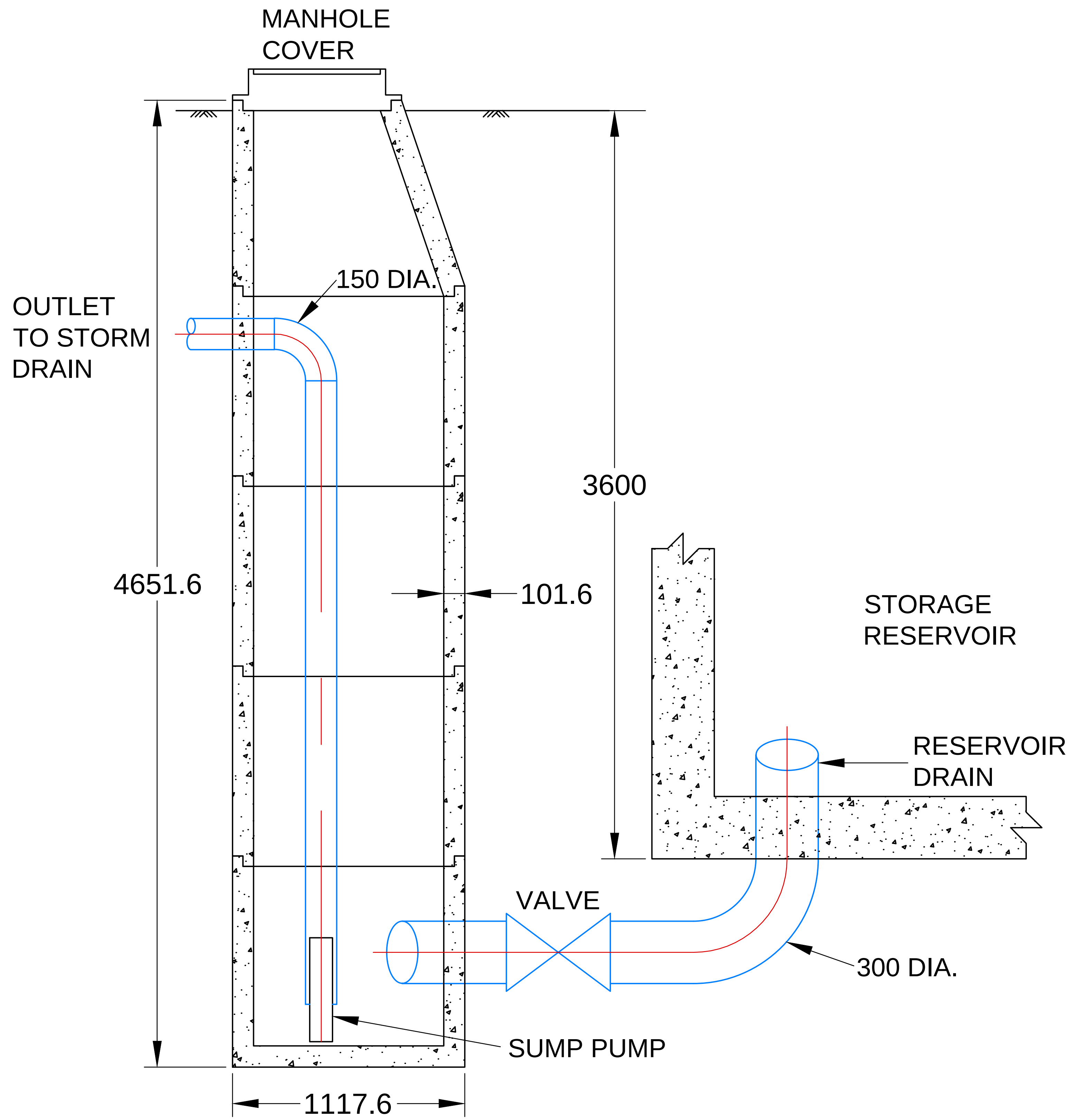
OVERFLOW - SIDE



CIVL 446 - UBC GROUNDWATER EMERGENCY WATER SUPPLY PROJECT		CLIENT	NOTES:	REV.:	DATE: (yyyy-mm-dd)	BY:	APPROVED:	SIGN & SEAL
DRAWING NAME:	STORAGE RESERVOIR VENT, OVERFLOW, VALVE CHAMBER DETAILS	UBC SEEDS	• DIMENSIONS IN METRES UNLESS OTHERWISE SPECIFIED • DO NOT MEASURE FROM THIS DRAWING • REPORT ANY DISCREPANCIES TO THE ENGINEER OF RECORD	01-IFC	2021-04-14	KD	KD	
DRAWING NO.:	10-STOR-04							
SCALE:	-							

PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION

ISSUED FOR CONSTRUCTION

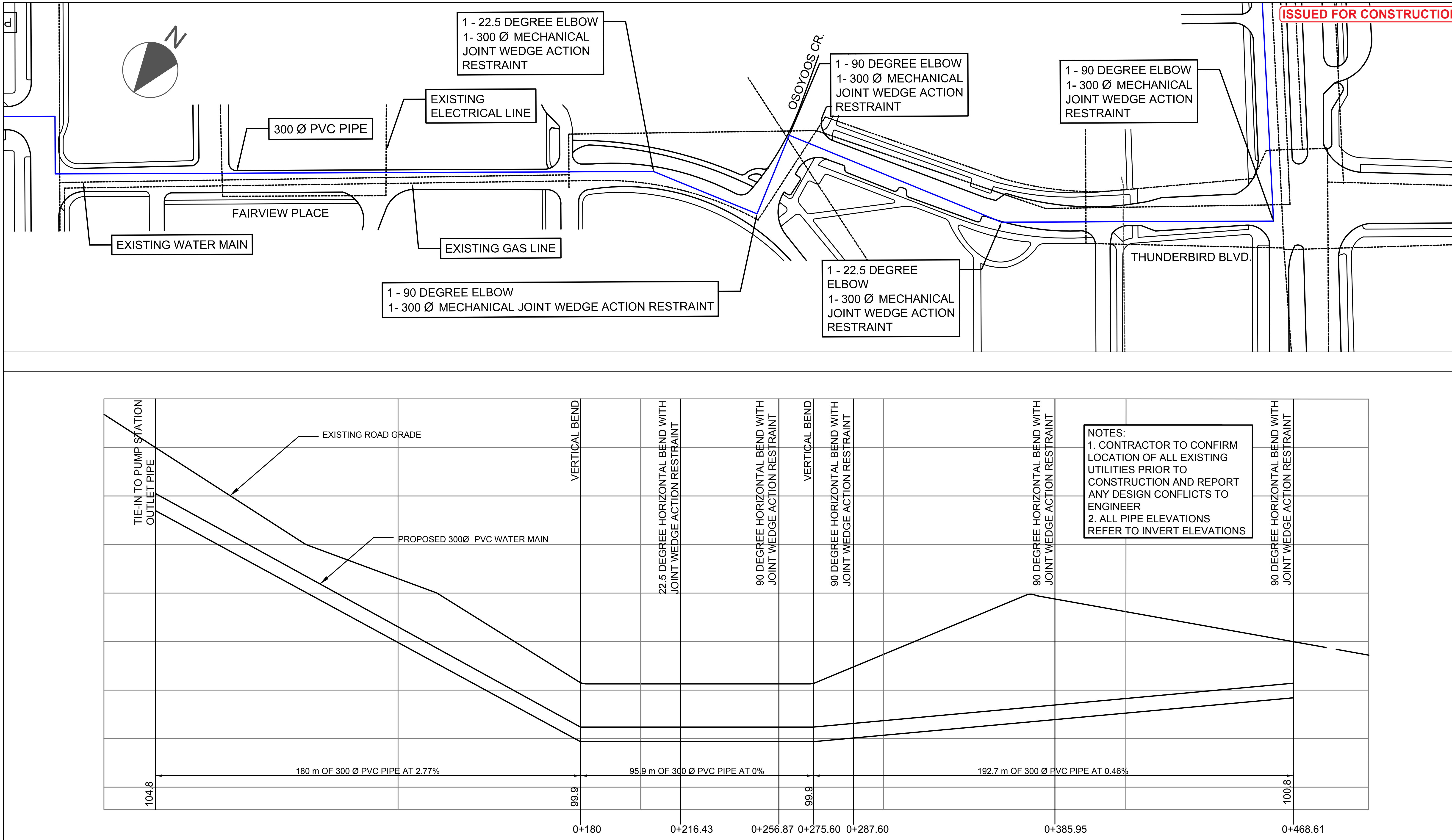


CIVL 446 - UBC GROUNDWATER EMERGENCY WATER SUPPLY PROJECT		CLIENT	NOTES:	REV.:	DATE: (yyyy-mm-dd)	BY:	APPROVED:	SIGN & SEAL
DRAWING NAME:	SUMP PUMP PROFILE	UBC SEEDS	• DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE SPECIFIED • DO NOT MEASURE FROM THIS DRAWING • REPORT ANY DISCREPANCIES TO THE ENGINEER OF RECORD	01	2021-04-14	AM	AM	
DRAWING NO.:	11-STOR-05							
SCALE:	-							

PRODUCED BY AN AUTODESK STUDENT VERSION

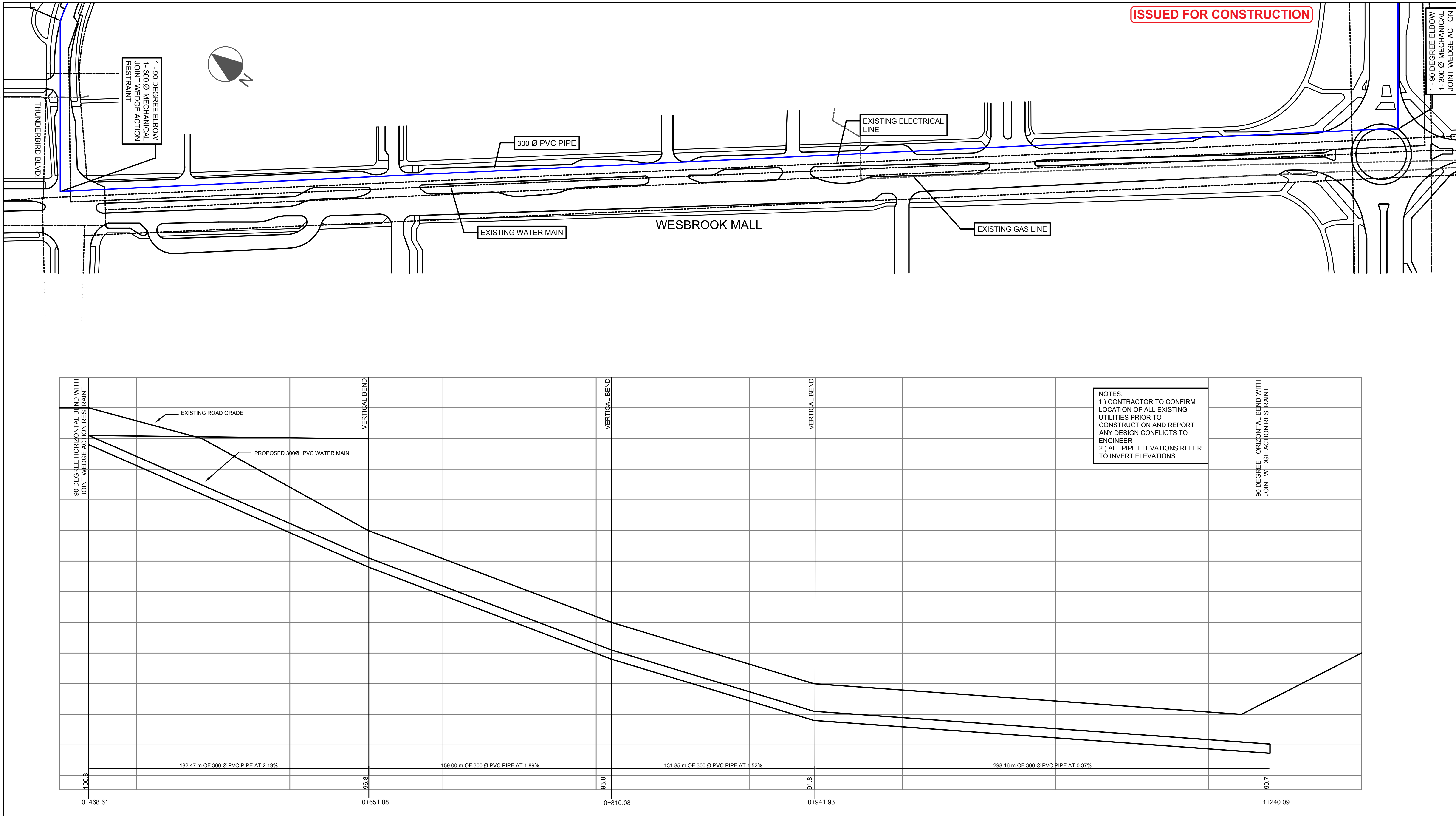
PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION



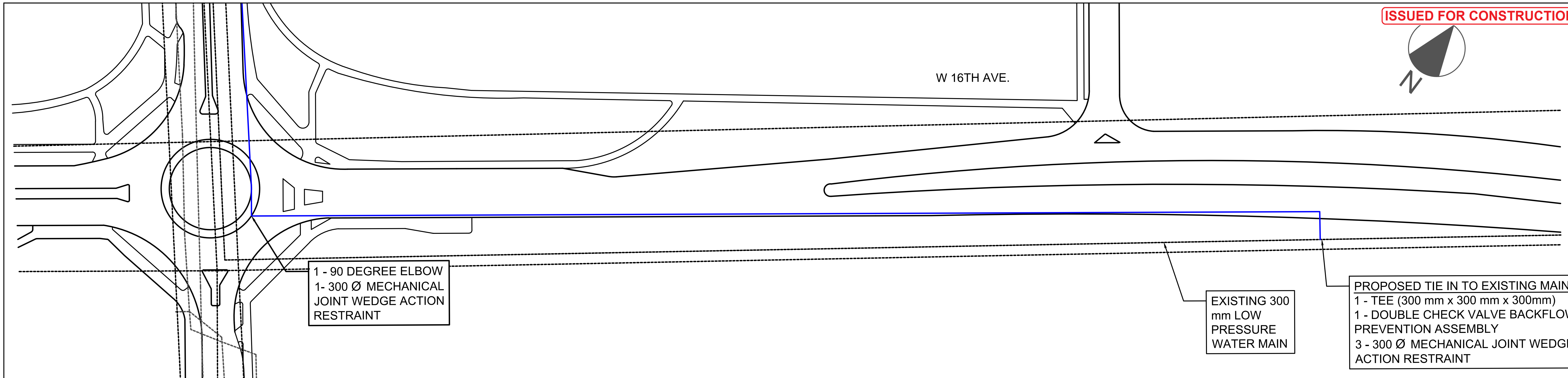
CIVL 446 - UBC GROUNDWATER EMERGENCY WATER SUPPLY PROJECT		CLIENT	NOTES:	REV.:	DATE: (yyyy-mm-dd)	BY:	APPROVED:	SIGN & SEAL
DRAWING NAME:	FAIRVIEW PLACE WATER MAIN	UBC SEEDS	• DIMENSIONS IN METRES UNLESS OTHERWISE SPECIFIED • DO NOT MEASURE FROM THIS DRAWING • REPORT ANY DISCREPANCIES TO THE ENGINEER OF RECORD	01	2021-04-14	NM	NM	
DRAWING NO.:	12-PIPE-01							
SCALE:	-							

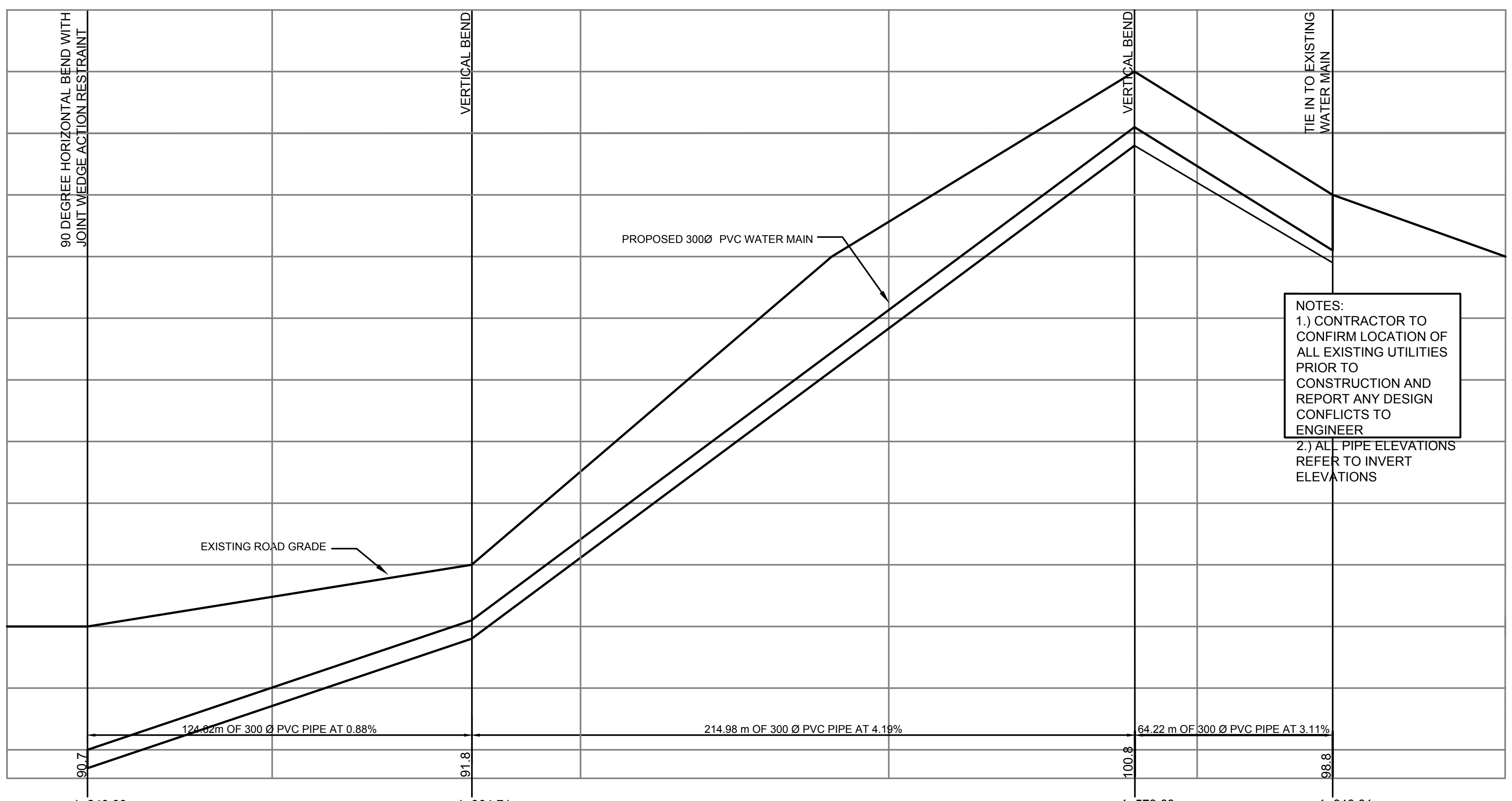
ISSUED FOR CONSTRUCTION



CIVL 446 - UBC GROUNDWATER EMERGENCY WATER SUPPLY PROJECT		CLIENT	NOTES:	REV.:	DATE: (yyyy-mm-dd)	BY:	APPROVED:	SIGN & SEAL
DRAWING NAME:	WESBROOK MALL WATER MAIN	UBC SEEDS	• DIMENSIONS IN METRES UNLESS OTHERWISE SPECIFIED • DO NOT MEASURE FROM THIS DRAWING • REPORT ANY DISCREPANCIES TO THE ENGINEER OF RECORD	01	2021-04-14	NM	NM	
DRAWING NO.:	13-PIPE-02							
SCALE:	-							

ISSUED FOR CONSTRUCTION

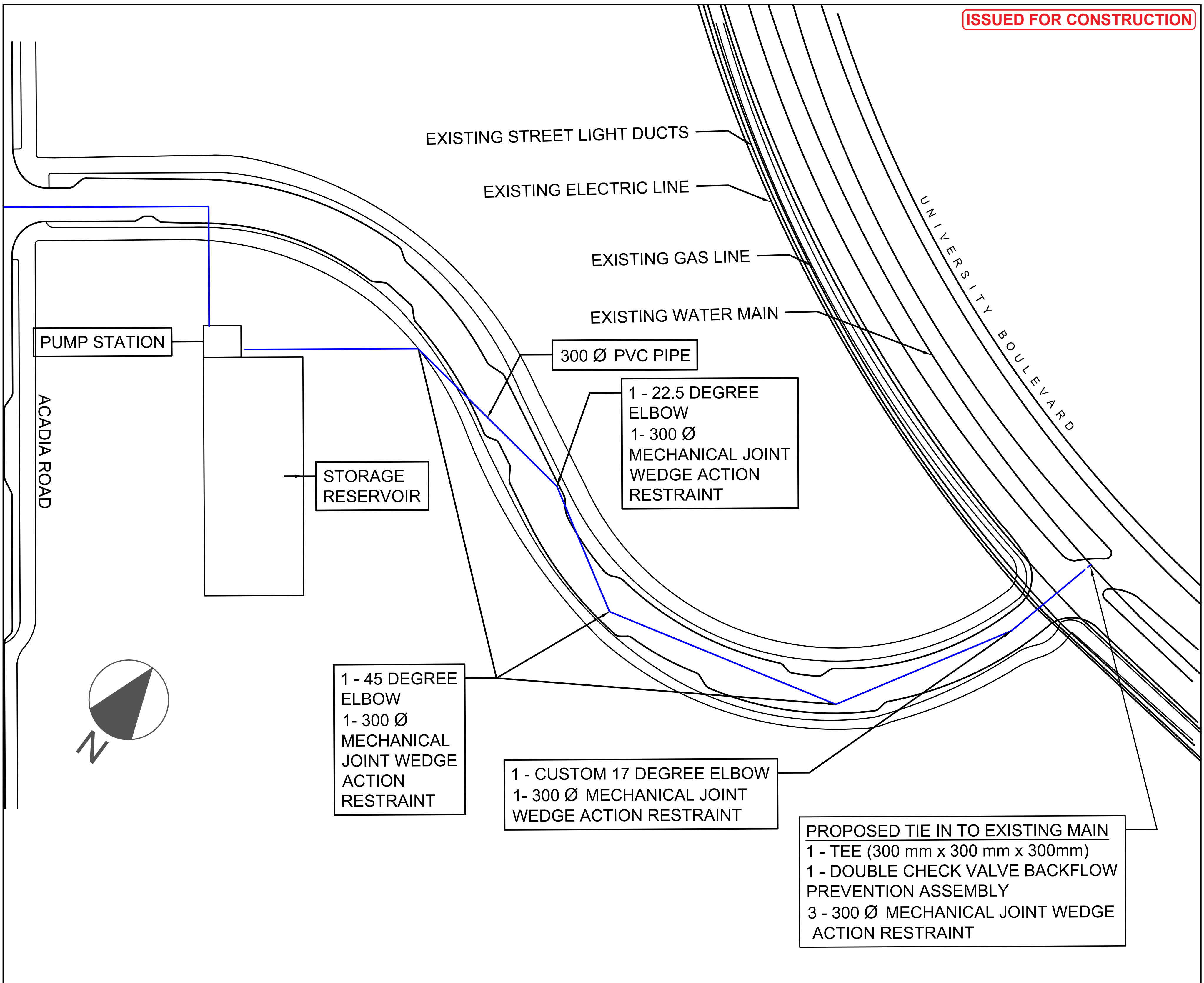


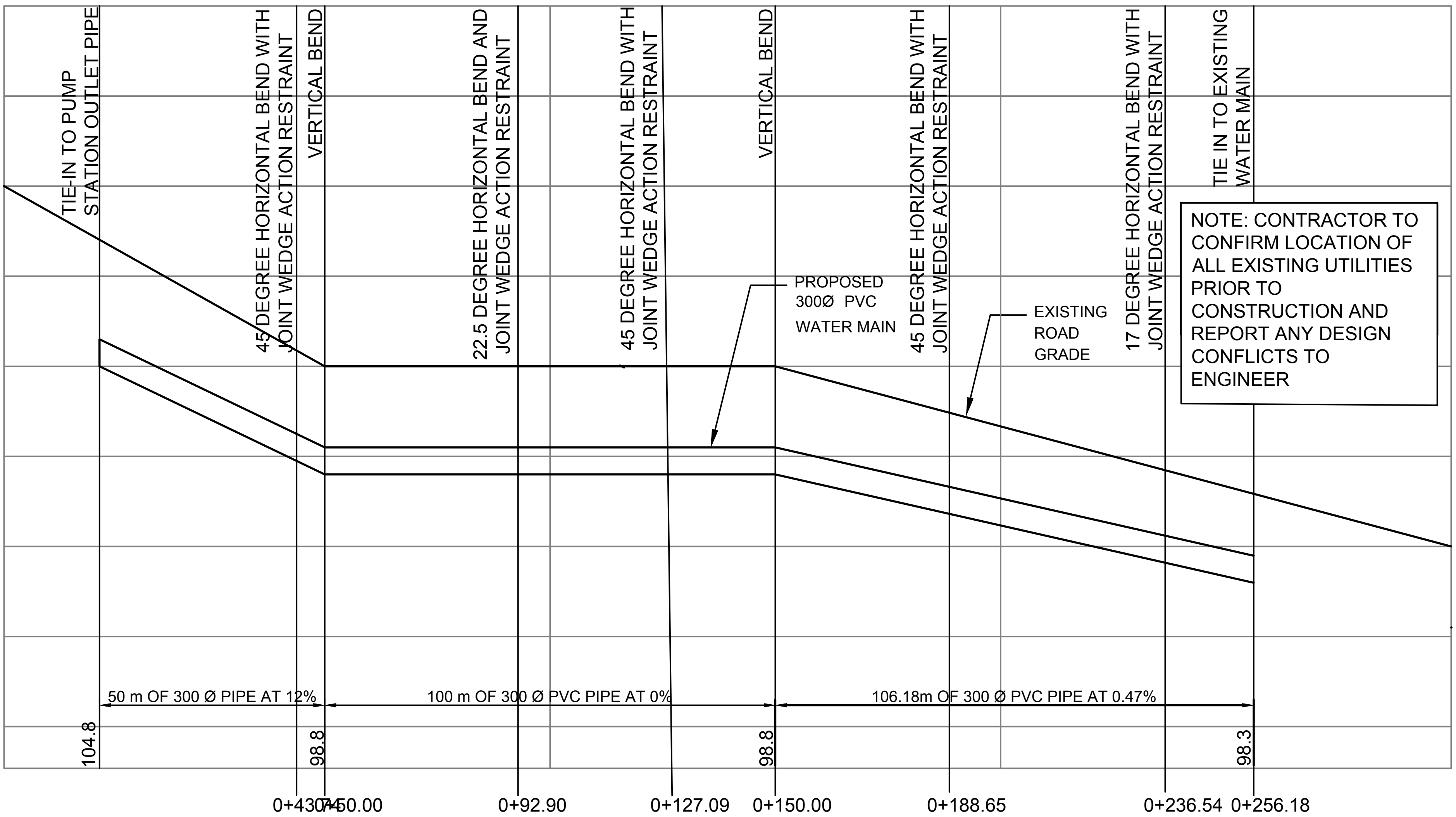


NOTES:
1.) CONTRACTOR TO CONFIRM LOCATION OF ALL EXISTING UTILITIES PRIOR TO CONSTRUCTION AND REPORT ANY DESIGN CONFLICTS TO ENGINEER
2.) ALL PIPE ELEVATIONS REFER TO INVERT ELEVATIONS

CIVL 446 - UBC GROUNDWATER EMERGENCY WATER SUPPLY PROJECT		CLIENT	NOTES:	REV.:	DATE: (yyyy-mm-dd)	BY:	APPROVED:	SIGN & SEAL
DRAWING NAME:	WEST 16TH AVE WATER MAIN	UBC SEEDS	• DIMENSIONS IN METRES UNLESS OTHERWISE SPECIFIED • DO NOT MEASURE FROM THIS DRAWING • REPORT ANY DISCREPANCIES TO THE ENGINEER OF RECORD	01	2021-04-14	NM	NM	
DRAWING NO.:	14-PIPE-03							
SCALE:	-							

ISSUED FOR CONSTRUCTION

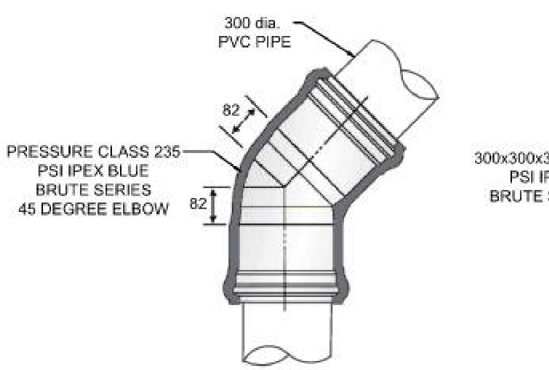




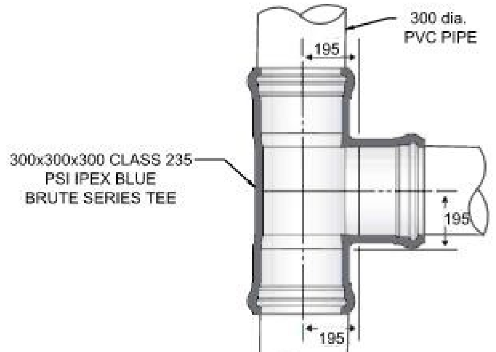
CIVL 446 - UBC GROUNDWATER EMERGENCY WATER SUPPLY PROJECT		CLIENT	NOTES:	REV.:	DATE: (yyyy-mm-dd)	BY:	APPROVED:	SIGN & SEAL
DRAWING NAME:	WATER MAIN TO HIGH PRESSURE ZONE	UBC SEEDS	• DIMENSIONS IN METRES UNLESS OTHERWISE SPECIFIED • DO NOT MEASURE FROM THIS DRAWING • REPORT ANY DISCREPANCIES TO THE ENGINEER OF RECORD	01	2021-04-14	NM	NM	
DRAWING NO.:	15-PIPE-04							
SCALE:	-							

PRODUCED BY AN AUTODESK STUDENT VERSION

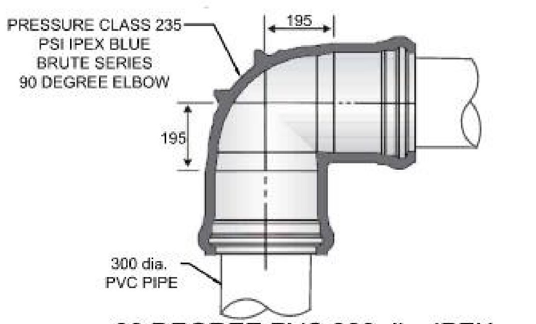
ISSUED FOR CONSTRUCTION



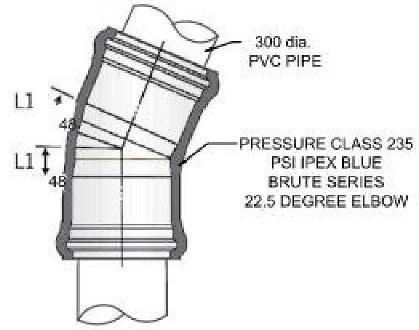
45 DEGREE PVC 300 dia. IPEX BLUE BRUTE SERIES ELBOW DETAIL
N.T.S.



IPEX BLUE BRUTE SERIES TEE DETAIL
N.T.S.



90 DEGREE PVC 300 dia. IPEX BLUE BRUTE SERIES ELBOW DETAIL
N.T.S.



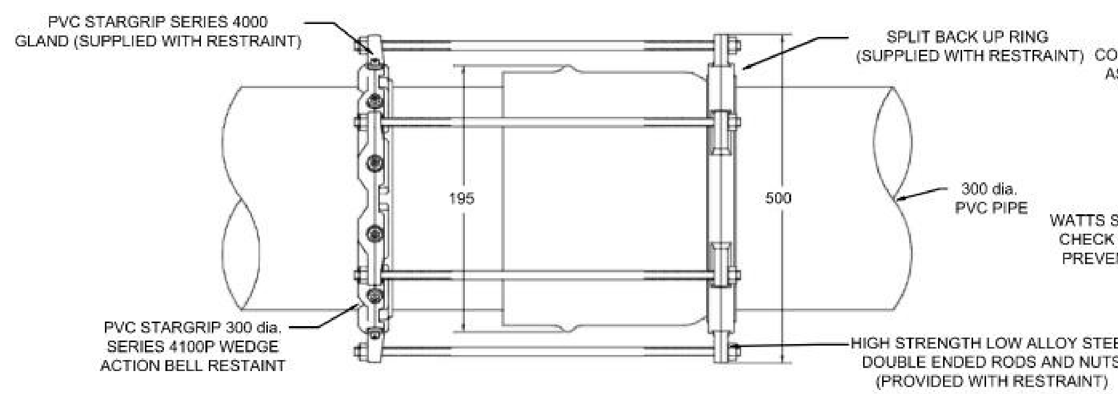
22.5 DEGREE PVC 300 dia. IPEX BLUE BRUTE SERIES ELBOW DETAIL
N.T.S.

WATER MAIN NOTES

1.) ALL DIMENSIONS IN MILLIMETERS
2.) CONTRACTOR SHALL USE RESTAINED COUPLINGS AS REQUIRED WHEN TYING IN TO EXISTING MAINS.
3.) CONTRACTOR SHALL RESTORE ALL ROADWAYS TO ORIGINAL CONDITIONS.
4.) CONTRACTOR SHALL COMPLY WITH ALL CITY OF VANCOUVER ENGINEERING DEPARTMENT REQUIREMENTS REGARDING PAVEMENT RESTORATION.

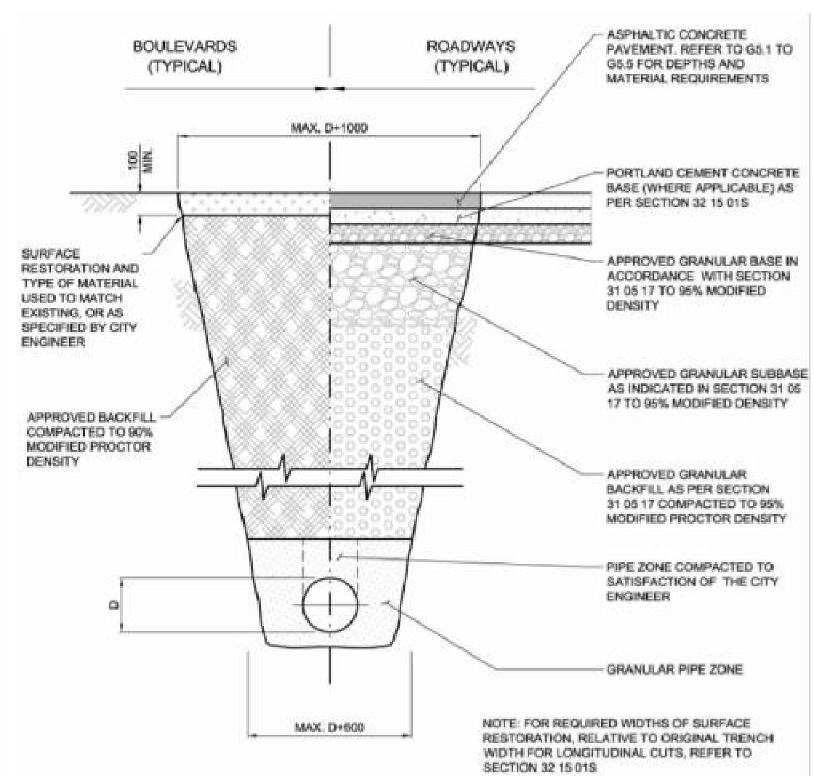
PIPE FITTINGS NOTES

1.) ALL PVC PIPES AND BLUE BRUTE SERIES FITTINGS ARE MANUFACTURED WITH CAST IRON OUTSIDE DIAMTER (CIOD).
2.) PIPE SHALL HAVE CAST IRON OUTSIDE DIAMETERS.
3.) PIPE LAYING LENGTHS SHALL BE 6.1 M.
4.) WHEN JOINING PIPES AND FITTINGS BELL AND SPIGOT SHALL BE CLEAN AND FREE OF DEBRIS BEFORE APPROVED LUBRICANT IS APPLIED. SPIGOT SHALL BE PUSHED INTO BELL TO THE DEPTH LINE MARKED ON SPIGOT BY MANUFACTURER.
5.) IF PIPES ARE CUT IN FIELD ALL ENDS SHALL BE SQUARED AND BEVELED TO A 15 DEGREE CHAMFER. INSERTION LINES SHALL BE REDRAWN.
6.) IPEX NON-TOXIC, WATER SOLUBLE LUBRICANT SHALL BE USED AT ALL PIPE JOINTS AND FITTINGS



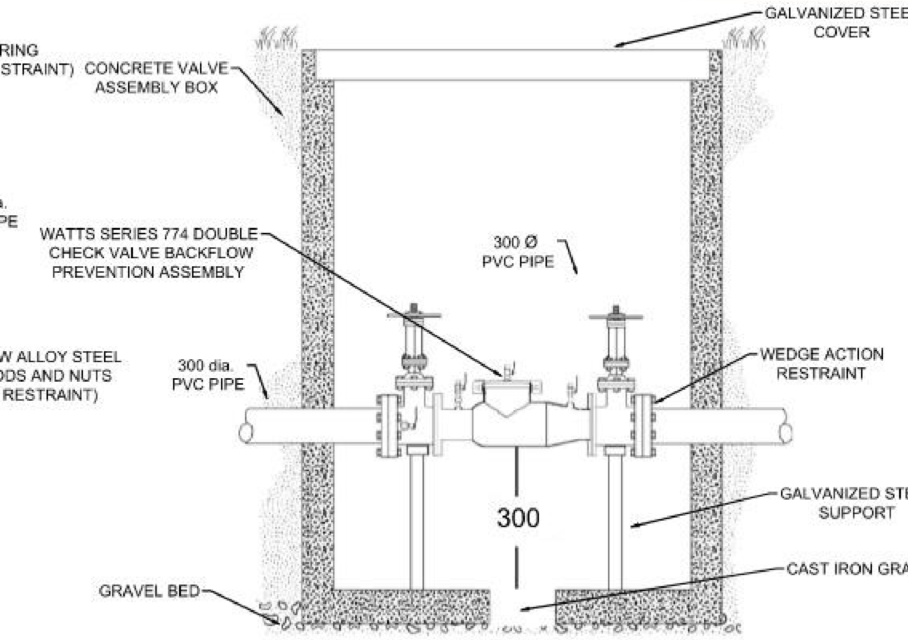
1.) CONTRACTOR SHALL ENSURE THAT STARGRIP RESTRAINTS ARE ADEQUATELY WRAPPED AND PROTECTED
2.) CLAMPING BOLTS ON SPLIT BACK UP RING SHALL BE TIGHTENED TO 120 NEWTON METERS.
3.) PROVIDE SUFFICIENT ROOM ON DOUBLE ENDED RODS TO FULLY ENGAGE NUTS, WITH SEVERAL THREADS VISIBLE
4.) ENSURE THAT PVC SERIES 4000 RESTRAINT GLAND IS PULLED FULLY AWAY FROM JOINT SO THAT THERE IS NO SLACK IN THE RODS.
5.) TIGHTEN TORQUE LIMITING TWIST-OFF NUTS UNTIL ALL TORQUE-LIMITING TWIST-OFF BOLT HEADS HAVE BEEN TWISTED OFF.

PVC PUSH ON PIPE BELL FITTING - WEDGE ACTION RESTRAINT (PVC PIPE SPIGOT TO PVC FITTING BELL)
N.T.S.



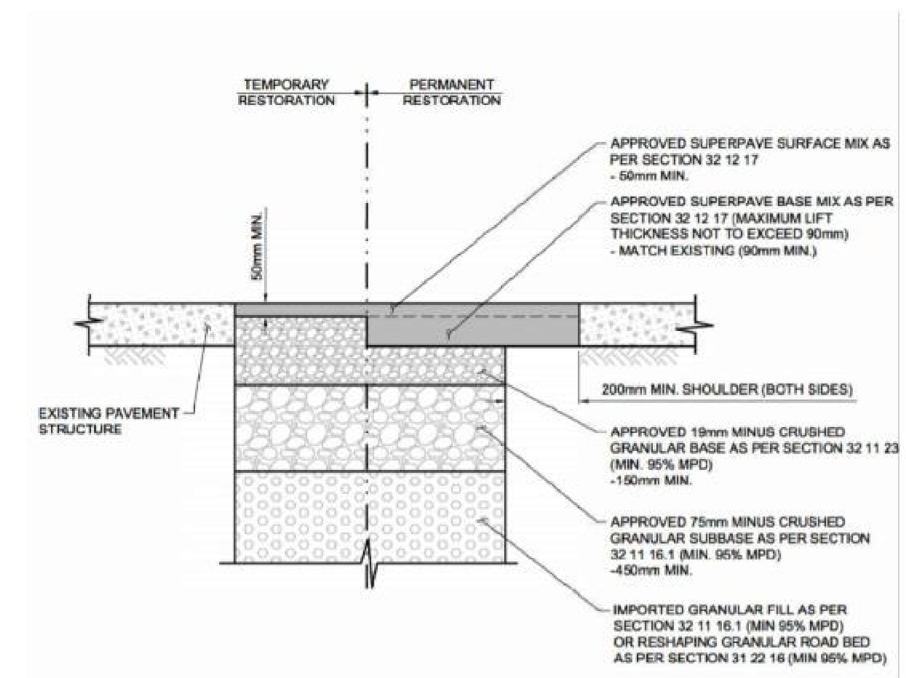
NOTES:
1.) 'D' REFERS TO NOMINAL OUTSIDE DIAMETER OF PIPE (300 mm)
2.)CONTRACTOR MUST COMPLY WITH ALL CITY OF VANCOUVER SPECIFICATIONS REGARDING PAVEMENT RESTORATION, AND APPROVED GRANULAR BASE AND SUB-BASE UNDER ROADWAYS

TYPICAL TRENCH SECTION DETAIL (CITY OF VANCOUVER STANDARD DETAIL DRAWING G4.1)
N.T.S.



NOTES:
1.) INSTALL STRAINER APPROVED BY ENGINEER PRIOR TO INSTALLING DOUBLE CHECK VALVE BACKFLOW PREVENTER ASSEMBLY
2.) DOUBLE CHECK VALVE BACKFLOW PREVENTION ASSEMBLY SHALL BE INSTALLED IN VALVE ASSEMBLY BOX WHICH MEETS ALL AWWA C500 STANDARDS
3.) VALVE ASSEMBLY BOX CONCRETE SHALL HAVE MINIMUM STRENGTH OF 28 MPA AT 28 DAYS

VALVE BOX ASSEMBLY DETAIL
N.T.S.



SURFACE RESTORATION DETAIL (CITY OF VANCOUVER STANDARD DETAIL DRAWING G5.2)
N.T.S.

CIVL 446 - UBC GROUNDWATER EMERGENCY WATER SUPPLY PROJECT		CLIENT	NOTES:	REV.:	DATE: (yyyy-mm-dd)	BY:	APPROVED:
DRAWING NAME:	WATER MAIN DETAILS	UBC SEEDS	• DIMENSIONS IN METRES UNLESS OTHERWISE SPECIFIED • DO NOT MEASURE FROM THIS DRAWING • REPORT ANY DISCREPANCIES TO THE ENGINEER OF RECORD	01	2021-04-14	NM	NM
DRAWING NO.:	16-PIPE-05						
SCALE:	-						

PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION