UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Secure Water Supply for UBC Vancouver Campus - Team 11

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University of British Columbia

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Themes: Water, Community, Land

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FINAL DESIGN REPORT

SECURE WATER SUPPLY FOR UBC VANCOUVER CAMPUS

University of British Columbia - UBC SEEDS Sustainability Program

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Executive Summary

The Iron Head Ltd. (IHL) has been contracted with SEEDS (Social Ecological Economic Development Studies) Sustainability Program to work towards a better water supply system. The design includes a 450mm ductile iron water main underneath University Boulevard; two 600mm ductile iron pipe underneath Wesbrook Mall; and two storage tanks that have a total combined volume of 12,600 m^3.

This report summarizes the design progress and critical outcomes after the preliminary design. Some of the highlights are as follows: total flow in the distribution system is 153 L/s; the highest and lowest pressure in distribution system is at 205.5 psi and 49 psi respectively; the structure system of the concrete storage tank consists of a slab-beam-column system with walls. More details about our design can be found in the attached report.

The new cost estimation of the whole project is $15,198,386, which includes $13,923,961 for the storage and auxiliary facility construction, and $1,274,425 for the pipeline replacement. The project construction will commence on May 1st, 2018, and the substantial completion will be achieved on Feb. 12th, 2019, with the full operation coming up on Mar. 26th, 2019.

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1.0 INTRODUCTION

This design summary report is prepared on behalf of the Iron Head Ltd. (IHL) and will present the final design solution to the UBC SEEDS Water Supply Improvement Project. The main objective of our design is to scope and design a new water storage and supply system for UBC Point Grey campus in the event of Metro Vancouver water system failure. The secondary objective is to establish collaboration between the new systems with existing supply line to accommodate growing water demand.

In brief, this report will present detailed information of design components, design inputs, and cost estimate of the project. Detailed Issued for Construction (IFC) drawings, cost estimate, and sample calculations are included in the Appendices.

1.1 TASK DISTRIBUTION

The table below indicates the group contribution:

TABLE 1: TEAM LIST & TASK DISTRIBUTION

Team Member	Report Contribution
Team Member 1	Reservoir Control System Design SketchUp Modeling (Reservoir) & Cost Estimate (Reservoir) Yard Piping Drawings, Coordination & Formatting
Team Member 2	Environmental Impact, Maintenance Specifications and Plans Site Descriptions
Team Member 3	Design Criteria & Technical Consideration (Reservoir) Drawings of Design Component
Team Member 4	Executive Summary & Introduction Cost Estimate (Pipe) & Schedule Water Main Design & Drawings
Team Member 5	Stakeholder Engagement Reservoir Section, Base/Top Slab Structural Drawings, and Chamber Detail Drawings
Team Member 6	Reservoir Construction Plan & Structural Design Reservoir Control System Analysis

1.2 Site Description

The project site is located in 272 – 6081 University Blvd, named Arthur Lord Field and Frank Buck Field on the southwest side of Wesbrook Mall with total land size 130m x 100m, which currently used as rugby fields for public and UBC student clubs. These two grassy areas were constructed in 1963 and elevation upgraded in 2015.

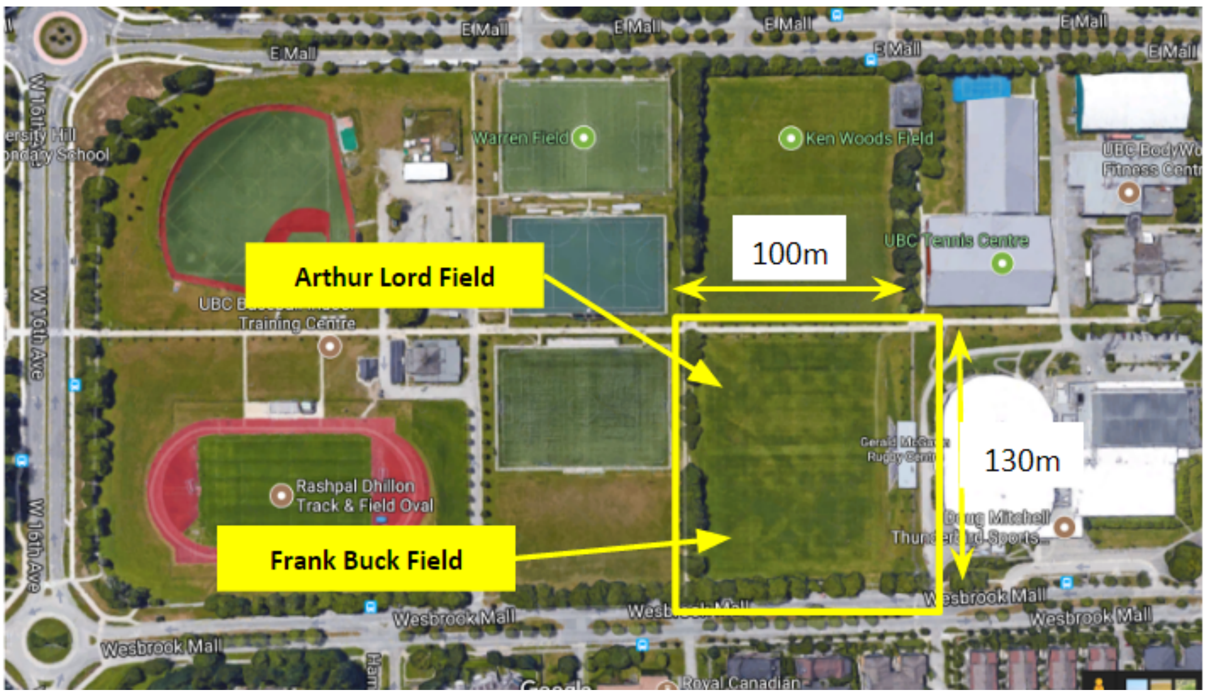

FIGURE 1 – SITE OVERVIEW

The project scope also includes three new water mains on University Boulevard and Wesbrook Mall and another backup line on Wesbrook Mall. In addition, the inflow supply water main is connected to the existing main at W 16th Ave from Sasamat Reservoir. All three roads are prominent gateway for both cars and bikes entering and exiting UBC campus which are extremely busy during rush hours.

2.0 Design Overview

The complete design consists of two parts: an improved distribution system and water storage tanks.

The proposed distribution system includes three new water mains on University Boulevard and Wesbrook Mall and another backup line on Wesbrook Mall. The water main on University Boulevard connects to a distribution main on Tolmie Street which supplies water to the UBC campus. The other two mains on Wesbrook Mall are two dedicated water mains delivering water into the storage tanks and out of the storage tanks to the existing pump house. A backup line will supply water to low pressure zone in case of the Sasamat Reservoir failed. Slight changes to the existing system are required. Major improvements include a new valve to shut off a transmission line in Pacific Spirit Park, and pipe connection modifications on Wesbrook Mall and University Boulevard.

The storage system consists of two separate tanks. Each rectangular storage tank has the same dimension and structure system, with a maximum storage capacity of 25,200 m^3, and a minimum storage of 9,400 m^3 for disaster portable water supply. The gravitational system is designed as a slab-beam-column system. The lateral system is designed as a moment frame with walls. The control system of each tank is independent, which can improve the ease of maintenance and minimize the impact in case of leakage and tank contamination.

To supply water to the main storage tanks under sport fields, a secondary water main will be added to the distribution system to deliver water to the new storage tanks. This water main will connect to the City of Vancouver transmission main on Tolmie St. and tie-in to the existing water main under University Boulevard where it meets Cleveland Trail. The water main will be under the centre boulevard.

3.0 Design Criteria and Constraints

In order to finalize the design of water storage system and new water supply network, the design team has identified the criteria and constraints for the project by considering design capacity, economic impact, environmental impact, sustainability, and stakeholder engagement based on the requirements of clients and potential impacts to the local communities.

3.1 Design Capacity

The capacity should be the first priority for the design of the new water supply system. It is critical to determine the level of service of water supply during the crisis period with considerations of current water consumption of the campus, future population growth, seasonal variability of water demand, and water supply for refuge during large disasters. To satisfy the requirement of the clients and UBC land development plan, the construction site of the storage reservoir should be reasonably large for the design; In addition, the new system must be able to provide safe potable water at all times; a proper treatment system should be designed within the storage facility if required to ensure the water safety. Moreover, the proposed water supply network and pump stations in the new storage system need to be compatible with the existing distribution system.

3.2 Economic

Costs will escalate from incidents such as design changes, inaccurate cost estimation, or low efficiency due to technical difficulties of the project. Therefore, in order to minimize unnecessary cost associated with the above issues, the following actions need to be taken. The engineering design team should meet with the general contractor to go through the design and check for constructability in the early stage. The review meeting can identify obstacles before the construction starts and therefore, reduce the chance of scope creep at later stages. Also, the development of water storage and water mains should try to avoid conflicts with existing infrastructure since it will be very inefficient to re-implement the interrupted sections of the network. In order to control project cost, it is necessary to establish the engineering cost estimate as well as project budget and cost control management plan. To address to the concern of exceeding the budget, advanced cost control method such as Earned Value Management (EVM) will be introduced to measure cost performance during the construction to ensure that the budget is under control. Last but not least, it is mandatory for the estimator to check each critical stage to ensure the project is on the right track and also find out errors and omissions from complex work process.

3.3 Construction Planning

As the construction of the new system will be within the core part of campus area, the selection of construction methods and sequencing need to be a prime consideration at the final design stage so that the impact on public sectors can be minimized during construction. Consequently, the construction method for the water main and water storage system should try to prevent or minimize the adverse social, economic and environmental impact to the surrounding neighborhood, existing infrastructure and underground utilities.

3.4 Environmental Consideration

Potential negative environmental impacts to the local communities are always needed to take into considerations before the implementation stage of the project. The project team is dedicated to finding out the best solution on reducing carbon footprint and disruptions to the environment. The selection of building material and construction methods are major concerns throughout the process. The material used for building the storage system needs to be environmentally friendly. Environmental controls' method such as noise control should be implemented in order to minimize disruption to adjacent buildings and local environment.

3.5 Sustainability Approach

Sustainability performance of the proposed infrastructure is one of the key criteria for stakeholders to evaluate whether the project is environmentally friendly, socially responsible and energy efficient. In general, environmental controls such as dust control will minimize disruption to adjacent buildings and local environment. In addition, advanced technologies such as efficient piping systems that are leak-free should be implemented in both of the pump station and proposed water mains. Also, the well-insulated concrete foundation for the storage system can increase the reliability and reduce waste of water due to leakage. Additionally, occupational health and safety management plan should be established based on the standards of UBC SEEDS sustainability program; interdependencies of landscape and flexibility in urban planning should also be considered during the design stage.

3.6 Stakeholder Engagement

Every successful project requires a high degree of collaboration with multiple parties and stakeholders who will be involved in the project. In general, the overall principles of successful engagements are the followings: be respectful during the engagement; be open minded and transparent in decision making; be willing to adapt the public suggestions if possible; and also, be willing to listen to the public.

A stakeholder engagement analysis will be performed before conceptual design stage to ensure that the stakeholder interests are under consideration. The design team will discuss with the stakeholders about the critical design criteria and provide appropriate correspondence to address the potential future impacts. Moreover, substantive discussion and reasonable changes of the design needs to be considered in order to accommodate the concerns of local communities. It is critical to communicate with relevant stakeholders during the planning and execution phases, so that the public concerns can be addressed promptly. In addition, since underground construction might be required for this project, potential road closures will impact access to certain areas. The contractor is obligated to inform the public about the purpose of the project and how the project will affect the local communities during construction phase. Therefore, a public hearing for the final design is needed to ensure all stakeholders are well informed.

4.0 PROPOSED NEW WATER MAIN

Three new water mains are proposed to be built for the new water distribution system. The Figure 2 is showing a schematic of the new pipe layout.

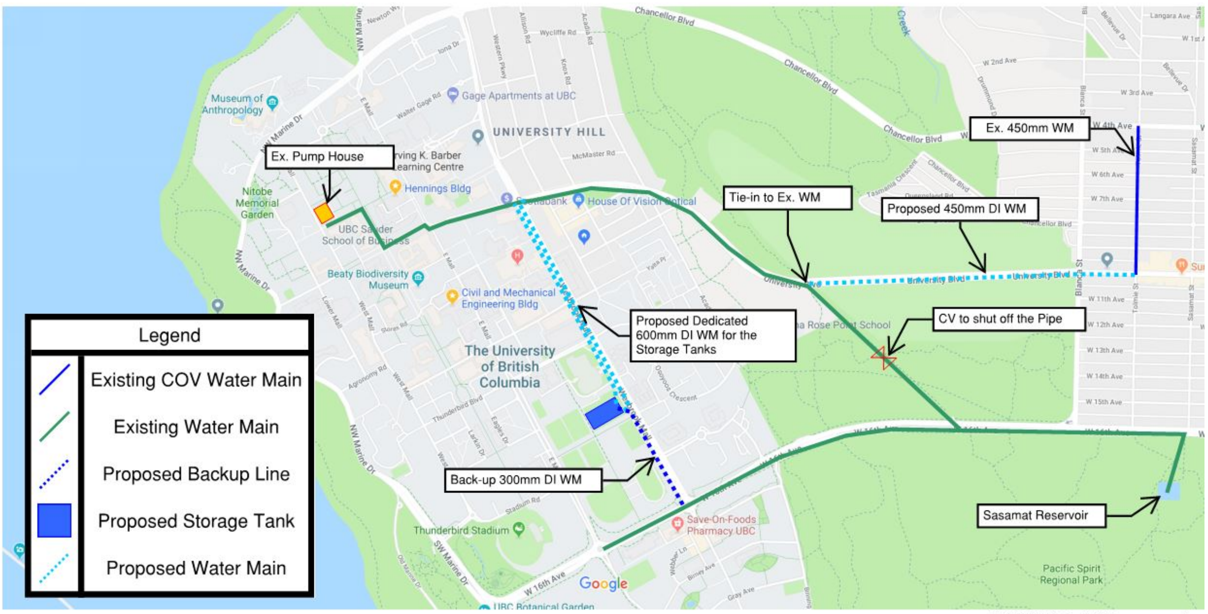

FIGURE 2 – PROPOSED DISTRIBUTION SYSTEM LAYOUT

4.1 450MM WM UNDER UNIVERSITY BOULEVARD

A 450mm Ductile Iron water main is proposed to be built under the University Boulevard.

4.1.1 PROPOSED DESIGN

The proposed water main is to be 450mm ductile iron pipes. The total length of the pipe is approximately 1300 lm. The pipes shall be Class 50 ductile iron pipe manufactured to AWWA C151; cement mortar lined to AWWA C104 and coated 1 mil. thick asphalt. Joints are to be single rubber gasket for push-on bell and spigot type joints to AWWA C111. Fittings are to be ductile to AWWA C110 suitable for pressure rating of 2,415 kPa. Cement mortar lined to AWWA C104. Minimum design pressure for piping 1,210 kPa. Minimum cover of the pipe shall be 1.0m and trench details shall as per MMCS section 02666 (UBC, 2017). For detailed drawings, please refer to University Boulevard Water Main drawings in the Appendix A.

4.1.2 Design Rationale

The addition of this pipe is to improve the number of transmission line that can deliver water to UBC Point Grey campus. At the moment, all UBC water supply is coming from the Sasamat water reservoir on the 16th Ave. The water to the reservoir is supplied by a single pipe running along the 16th Ave. The reservoir is responsible to provide water for both high pressure and low-pressure zones in UBC. If the transmission line on the 16th Ave. failed or the Sasamat reservoir is contaminated, there will be no back-up water transmission line to provide potable water for both institutions and households. Therefore, a secondary water transmission is proposed to be implemented and connect to a different transmission line from City of Vancouver. The old pipe under Cleveland Trail in the Pacific Spirit Park will be shut off and the new water main under University Boulevard will be tie-in to the existing water main which is delivering water to the pump house in UBC. With the pipe size of 450mm and pressure of 73 psi from the COV transmission line (Vancouver GIS, 2018), the simulation in EPANET indicates that the proposed line can provide a maximum flow of approximate 140L/s, which can satisfy our projected future water demand for UBC and UEL areas.

4.1.3 Design Implementation/Construction

Please refer to construction drawings for location and layout of the pipes. The pipe should be installed as per MMCD section 02666. The water pipe should be kept a minimum 3m horizontal space from sanitary and storm sewer. A minimum 750mm clearance is required from all other services. Valves and thrust blocks shall be installed as per MMCD Section 02666. Thrust blocks shall be placed between valves, tees, wyes, plugs caps, bends and undisturbed ground as shown on the drawings. Notify the consultants if there are any utility crossings during construction. To prevent damage to existing utilities, excavate the last 300mm over utility by hand. Hot taps to tie-in the pipes may be requested in writing and done only with prior written permission from the manager, Mechanical Distribution Services, UBC Energy & Water Services (UBC, 2018).

4.2 600mm WM Under Wesbrook Mall

Two 600mm Ductile Iron pipes will be install and run parallel under Wesbrook Mall and are responsible to deliver water in and out of the storage tanks.

4.2.1 Overview

The two 600mm DI pipe will be running under Wesbrook Mall and are dedicated to deliver water to the storage tank, and out of the storage tank to the pump house. The existing 600mm pipe will be temporarily shut off and reconnect to the new proposed 600mm water main and storage tanks.

4.2.2 Proposed Design

The proposed water mains are to be 600mm ductile iron pipes. The total length of the pipes is approximately 1,700 lm. The pipes will be installed under Wesbrook Mall from the intersection of University Boulevard and Wesbrook Mall, and Frank Buck Field on Westbrook Mall. The pipes shall be Class 50 ductile iron pipe manufactured to AWWA C151; cement mortar lined to AWWA C104 and coated 1 mil. thick asphalt. Joints are to be single rubber gasket for push-on bell and spigot type joints to AWWA C111. Fittings are to be ductile to AWWA C110 suitable for pressure rating of 2,415 kPa. Cement mortar lined to AWWA C104. Minimum design pressure for piping 1,210 kPa. Minimum cover of the pipe shall be 1.0m and trench details shall as per MMCS section 02666 (UBC, 2017). For detailed drawings, please refer to University Boulevard Water Main drawings in the Appendix A.

4.2.3 Design Rationale

These two pipes are dedicated pipe to deliver water to the storage tanks. The existing pipe that delivering water to booster pump house for high pressure zone is a nominal 600mm pipe. To minimize the pressure disturbance to the existing pump station and still be able to supply adequate amount of water, a 600mm is selected to deliver water from transmission main to storage tank. The other outflow 600mm pipe in conjunction with the pump house that will be built with the storage tank will keep the inflow pressure to the pump house the same. This is to avoid any potential operational risks due to pressure changes. From the simulation in the EPANET model, it indicates that the high pressure in the high-pressure zone will increase from 197.5 psi to 205.5 psi.

4.2.4 Design Implementation/Construction

Please refer to construction drawings for location and layout of the pipes. The pipe should be installed as per MMCD section 02666. The water pipe should be kept a minimum 3m horizontal space from sanitary and storm sewer. A minimum 750mm clearance is required from all other services. Valves and thrust blocks shall be installed as per MMCD Section 02666. Thrust blocks shall be placed between valves, tees, wyes, plugs caps, bends and undisturbed ground as shown on the drawings. Notify the consultants if there are any utility crossings during construction. To prevent damage to existing utilities, excavate the last 300mm over utility by hand. Hot taps to tie-in the pipes may be requested in writing and done only with prior written permission from the manager, Mechanical Distribution Services, UBC Energy & Water Services (UBC, 2018).

4.3 Computer Simulation

We used EPANET to simulate the system status under loadings. With the EPANET model provided on connect, we modified the pipe layout to reflect our new proposed design. The result from model shows us that our design can fully function under UBC peak day water demand. Figure 3 shows the simulation result with colored pressure nodes at each junction

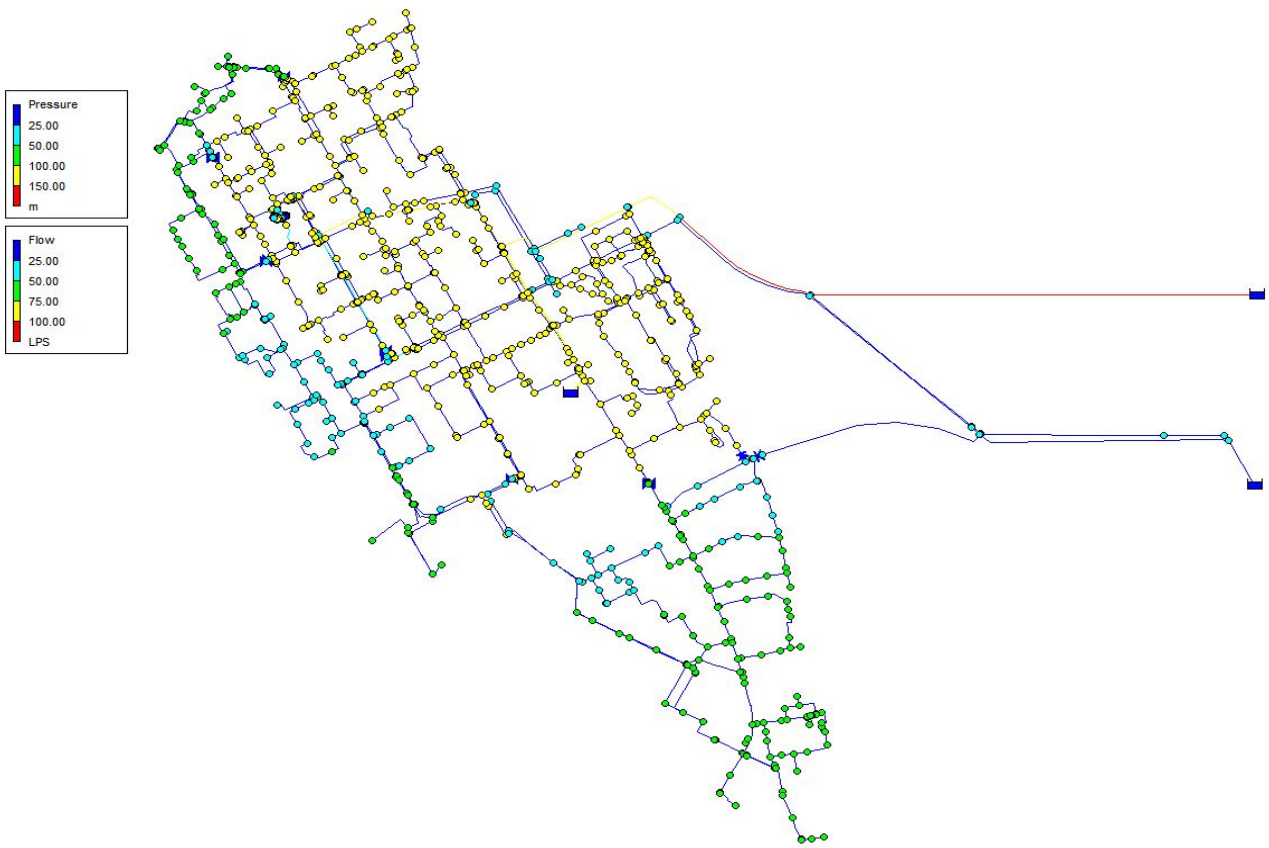

FIGURE 3 – EPANET SIMULATION

As we can see in the simulation result, the UBC remains the same pressure zoning as before and pressure fluctuation is very minimal. Table 2 is a summary table of the important simulation results.

TABLE 2: EPANET MODEL SIMULATION RESULTS

	Existing	Proposed
Total Flow (LPS)	149.3 L/s	153 L/s
Highest Demand (LPS)	37.3 L/s	38.7L/s
High Pressure (m / psi)	138.9m / 197.5 psi	144.5m / 205.5 psi
Low Pressure (m / psi)	29m / 41 psi	35m / 49 psi

4.4 Construction Plan of Water Main

The water main replacement will first start on University Boulevard. Phase 1 is the proposed 450mm water main. It will start on Blanca St. and will be installed from East to West and join at the existing water main on University Boulevard. but not tie-in to the water main. Phase 2 is the proposed 600mm water main underneath the Wesbrook Mall. The two parallel pipes will be laid down at the same time and connect to the pump chamber in the water storage tank. Phase 3 is tie-in the two water mains on university boulevard. Phase 4 is to tie-in the 450mm water main to transmission main on Tolmie St. Phase 5 is to to connect the 600mm lines to the existing system after the water storage tanks are commissioned. The valve at the WM under the Imperial Trial shall be closed after the system is in commissioned. The water main construction is expecting to take total of 92 business days.

5.0 PROPOSED RESERVOIR

The proposed reservoir is located on the southbound of Wesbrook Mall and consists of a twin concrete tank equipped with separated control systems. The following section illustrates the design approach and detailed parameters of the twin-tank system.

5.1 METHODOLOGY

5.1.1 STORAGE CAPACITY

The storage capacity of the reservoir is determined based on the future maximum daily demand of the campus, fire protection flow requirement, and emergency storage demand. The maximum daily demand (MDD) is predicted based on the previous MDD and population data from the Water Consumption Statistic Report produced by Metro Vancouver from 2013 to 2016. These three storage components are summed proportionally with a total required storage capacity of 21,600 m^3. There are numerous risks associated with a single underground concrete tank with a volume over 20,000 m^3, such as seismic design issue, leakage and contamination issues, and maintenance issue. To mitigate these risks, we have proposed a twin-tank storage system.

5.1.2 SOFTWARE PACKAGE USED

SAP2000 is used as the modeling and static analysis of underground storage tank. Four load cases adopted from the ACI code will be tested to find out the flexural, shear and torsional demand of the critical section of the system. The main sources of gravitational loading are from water, soil, and concrete. Then the amount of reinforcement can be determined based on the result of the structural analysis. Earthquake analysis is also performed to check whether the system satisfy the minimum requirements as stated on the National Building Code of Canada.

5.1.3 Regulatory Provisions

The project is held under the regulations of UBC SEEDS Sustainability Program and should follow all rules set by the UBC Infrastructure and Service Planning as well as UBC Campus and Community Planning. For the construction of water storage system, all structures are mandatory to meet or exceed minimum requirements for infrastructure design in the Nation Building Code of Canada. Specific requirements regarding local geotechnical or climatic condition should follow the standard of British Columbia Building Code and City of Vancouver By-laws. In addition, water supply is provided by Metro Vancouver and therefore, water pressure is set by Metro Vancouver. During the construction of the new water main, all design criteria and construction methods should meet the requirements of Metro Vancouver and conflicts should be avoided with existing underground facility. The Design standards of the distribution system and water storage system will follow the standards set by UBC Sustainability Development Policy#5, American Water Works Association, and CSA Standards as applicable.

5.1.4 Technical Consideration

This section will mainly discuss the technical consideration for the underground storage tank from the environmental, geotechnical, structural and construction perspective.

- **Environmental**
  - **Sediment Erosion**

    The construction of the underground storage tank will require a large scale of excavation. In fact, the exposure of clear soil surfaces, and the temporary storage of excavated topsoil entail a high risk of sediment erosion during the rainy season. Erosion and sediment control have to take place to minimize the impact to the construction site.

- **Noise Pollution**

  Noise nuisance from operation of construction equipment, tracked excavator and vehicles are inevitable. Excessive noise on site can disrupt the daily operation of the campus and the living of local communities. Therefore, the contractor need to make sure all machine is well maintained and perform in a suitable noise level; no work is carried out between 6pm to 7am during the construction period.

- **Air Quality**

  Local air pollution can be caused by exhaust emission from the operation of construction equipment. Due to the heavy excavation and openness of the field, dust pollution will very likely take place in the construction site. To address this issue, contractor can control the on-site dust emissions by spraying water while excavating.

- **Geotechnical (foundation)**

  Underground soil should have adequate bearing capacity to support the storage system; the site should have minimal impact on its surrounding areas and underground utilities. (Assessment, 2002) Given the current design of the underground storage tank, the soil properties under the Arthur Lord Field need to be further investigated to ensure the performance of the foundation. In addition, the whole system will be very heavy after the tank is filling up with water; pile foundations are being considered since the it can effectively transfer to load to a deeper layer of soil which is stronger enough to support the heavy structure.

- **Material Selection**

  Water leakage is one of the expected problems given the design of underground storage system. In fact, it is very likely to have the leakage problem for concrete tanks that continuously have water in storage. It is also difficult and costly to repair the leakage spot especially in the underground environment. Waterproofing concrete can increase the longevity of the concrete tanks. Water stopper and hydrophobic coating spray can also help the layer to repel water.

- **Structural**

  We also anticipate some challenges associated with the underground water storage design. To make the concrete storage tank structurally sound, the largest load combination scenario needs to be analyzed in order to determine the governing loading. Flexural, shear, and torsional strength of each individual components in the system need to be checked by the CSA concrete code. Also, in order to balance the heavy bending moment at the corner of the storage tank, special design of footing need to be considered.

- **Contamination**

  Since the storage tank has high volumes of water, it should be monitored more often due to its vulnerability of development of stagnated water. Stagnation can lead to water contamination because potential hosts such as files and water fleas can bring bacteria to the water body. Mixing system can help eliminate the problem by mixing the denser layer of water from the bottom to the less dense surface water to avoid stagnation. In addition, having two separated tanks with a bypass connection can also lower the risk of contamination of all storage water.

5.2 Structural Design of the Tank

As it was mentioned earlier, the design and installation of the underground storage tank was a challenge because of insufficient record on the UBC area as well as technical difficulties. The technical difficulties include first, the design of the gravitational system of the storage tank. Since the tank is significant in volume, a large amount of load is due to water and it will have to be transferred to foundation, the slab-beam-column system has to be designed to have enough capacity to sustain the loading. The second difficulty is to design for lateral loading from soil and water. The third technical difficulty is to design for sloshing effect and earthquakes.

5.2.1 Materials and Tank Dimensions

The major materials used for the storage tank is concrete and steel rebar. Each storage tank has a dimension of 120 m in length, 30 m in width, and 4 m in depth, with a maximum storage capacity of 12,600 m^3. The maximum water level is 3.5 m and the minimum water level is 1.3 m. The top slab has a thickness of 150 mm and the bottom slab has a thickness of 450 mm. The walls have a thickness of 250 mm. The beam cross section has a dimension of 500 mm x 800 mm. The column cross section has a dimension of 500 mm x 500 mm. Table 3 summarizes the structure components of the design.

TABLE 3: RESERVOIR SECTION PROPERTIES OF STRUCTURAL COMPONENTS

Component	Width	Height	Rebar Sizing	# of rebar
Beam	500 mm	800 mm	30M	15
Column	500 mm	500 mm	30M	16
Top Slab	1000 mm	150 mm	15M	5
Bottom Slab	1000 mm	450 mm	15M	5

5.2.2 Design Loadings

Design loads are obtained from structure analysis by using SAP2000. The design bending moment is 1800 kNm and the design shear is 500 kN for beam. The design compression load for column is 1200 kN.

5.3 Construction Plan of Storage Tank

The construction of the tank will start on July 19th, 2018. The first phase of the construction involves excavation and preparation on site. The second phase of the construction will be building the foundations and constructing the side walls of the tank. Onto the next phase, the walls will be finished, and the support columns will be under construction. Next phase will be constructing the formwork and concreting of the roof. For the final phase, manhole will be constructed, and an overall inspection will be done.

6.0 STAKEHOLDER ENGAGEMENT

6.1 STAKEHOLDER IDENTIFICATION

The water supply system upgrade is associated with large-scale construction. During the construction, there is a potential of occupying the public facilities for a relatively long period of time. For pipeline renovating, the road above will be excavated and closed. And for concrete storage, the sports field above will be unavailable during construction. It is crucial to consider all impacted stakeholders and get their support in order to move on smoothly. A general way to achieve that is to give out enough information and follow up to their concerns. The different interests of the stakeholders give good reason to identify the stakeholder parties and develop engagement plan for them respectively.

The following tables list the identified stakeholders and summarize the interests and the importance of them.

TABLE 4: IDENTIFIED INTERNAL STAKEHOLDERS

Internal stakeholders	Interest	Importance
UBC	Ensure functionality of campus and invest in a new system with quality to meet future need.	High
Consultant	Interest	Medium
Project contractor	Interest	Medium

TABLE 5: IDENTIFIED EXTERNAL STAKEHOLDERS

External stakeholders	Interest	Importance
First nation community	Good protection of the aboriginal lands and the culture.	Medium
Local residents	Live in a convenient and comfortable environment.	High
School staff and students	Unaffected access to school and normal usage of the utilities.	High
Visitors and business owners	Easy access from outside to the destinations and enjoyable environment around the service.	Medium
Sports field users	Suitable facilities for sports activities	Low

6.2 Engagement Plan

An engagement plan for each party is suggested based on the preliminary stakeholder analysis presented above.

UBC

- Update the design with the Campus administrator; provide detailed information of the project progress on a weekly basis.
- Hold bi-weekly meeting to communicate important problems with the campus representatives and get their feedback.

Consultant

- We as the consultant are responsible for planning the engagement activities and carrying out analysis on the engagement outcomes. The consultant should schedule weekly meeting inside the team to discuss feedback from other stakeholders and improve the engagement process.

Project Contractors

- Assign engineers to the construction site for solving urgent technical issues and performing quality control.
- Schedule weekly meeting with consultant to update construction timeline and report construction quality.

First Nation Community

- Identify the involved first nation community with the database tool and build connection with their representatives at the first phase of the project.
- Hold workshop to explain the project and possible impact and seek for any input.
- Establish analysis of the feedback and continuously keep track of the first nations' needs.

Local Residents

- Contact the local resident communities before project starts to setup public workshops that outline the construction timeline and process.
- Gather major concerns from the residents; identify the residents with different concerns and invite them to form group that represent themselves.
- Address concerns respectively from each group and communicate decisions regarding their interests monthly.

School Staff and Students

- Work with the university to notify the ongoing project on campus and encourage input from the staff and students.
- Hold open houses on campus to introduce the benefit of the project and the temporary impact on the existing facilities.
- Give estimation on the affected services and the duration of shutoff. Update the estimate status as the construction goes on.

Visitors and Business Owners

- Consult the campus transportation department and plan for alternative routes to keep the traffic functional.
- Distribute information at the major transportation destinations including UBC hospital, Thunderbird sports centre, and Westbrook Village to give notice to the visitors and business owners.
- Hold one-on-one meeting with the local business and service institution to make accommodations to special requirements.
- Deploy appropriate signage and traffic control team around construction site to organize and guide the traffic.

Sports Field Users

- Communicate with sports field users and estimate the demand on the sports field.
- Work with the university to invite the users to use the other facilities in the vicinity and help with the transfer or refund of the memberships.

7.0 ENVIRONMENTAL IMPACT

7.1 Erosion & Sedimentation Process

Erosion is a natural process of soil detachment that can be accelerated by construction activities and sediment is the eroded material suspended in water or wind. In general, over 80% of the erosion problems on construction sites are a result of raindrop impacts, which becomes extremely critical during Winter time in Vancouver.

7.2 Erosion and Sediment Control

Climate can affect erosion rate; human activities like construction can also affect erosion rate. According to the studies done by ESCA BC (Erosion and Sediment Control Association of British Columbia), accelerated erosion from construction can be up to 1000 times greater than the natural rate of erosion. Sedimentation is another construction consequence that can impact infrastructure and involve costly cleanup such as clogged storm sewer systems and local flooding. For our project, erosion and sedimentation can greatly impact the repairing cost and construction delays, as well as the profitability. No matter how minimal one impact is, our team considered the cumulative effect of multiple impacts that can affect our natural environment.

In the following section, potential environmental impacts during construction and the control measures we used to prevent and eliminate those impacts will be discussed.

7.3 Water Erosion Control

Erosion and Sediment Control, which short as ESC, is a rapidly changing field. The key factors in water erosion control are to intercept and manage off and on-site runoff. This limits the potential for soils to be eroded and form sediments in surface runoff. In addition to the traditional approaches such as sedimentation pond and retention pond, a host of new approaches and practices will be considered by our team for this project.

Based on our construction schedule, different ESC methods and plans will be used for different construction phase. In the beginning, all stockpiles created by field excavation will be covered using qualified stockpile cover, and any other erodible surfaces will be covered using polythene covers. As the construction moving forward, space will be a problem for sedimentation pond and retention pond. As such, flocculation tank and dewatering bags will be used to replace ponds. Although the cost for flocculation tank can be as high as $5,000 CAD per month, it is a must-have investment which included in our final cost estimation.

Because of our 4-meter-deep tank height, few relatively steep slopes will be created by excavation. To protect these steep slopes during construction, the long slope will be break up into several shorter ones and the flow off slope will be directed. By doing so, the potential of erosion for our site can be reduced by 55%.

FIGURE 4 – DEWATERING BAG

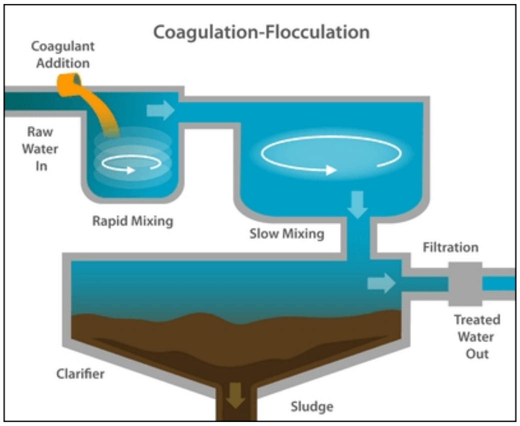

FIGURE 5 – FLOCCULATION TANK

7.4 Wind Erosion Control

Due to the low humidity and low precipitation in Vancouver's summer, wind erosion control is particularly important for our site. Because of the dry weather condition, fugitive dust will be formed once there is wind or other air flow caused by construction vehicles and equipment. In addition, Wesbrook mall has very busy traffic during rush hours, which makes more dynamic air flows than other sites. Although it is hard to eliminate wind erosion from its source, method like silt fence, wind barrier and water spraying will be used during construction to minimize dust. Usually, dust control requires staying ahead of the problem, thus, for our project, control methods and equipment will be implemented before the construction start to meet government's regulations.

FIGURE 6 – SILT FENCE

7.5 Factors That Influence Erosion

Soil type is one of the biggest factors that influence erosion rate. Different soil types have different characteristics regarding to the potential of being eroded. For example, sandy soil is easily to be detached by flowing water, however, clay soil has lower potential to be eroded. In general, the soil erodibility is decided by the composition percentage of sand, silt clay and organics. As the percentage of sand and silt increases, the erodibility goes up; and as the percentage of organics and clay increases, the erodibility goes down.

Due to the complex relationship between soil type and erodibility, our team will have the soil sample from the site examined before construction start. After determining the composition of the site soil, specific control method can be applied in addition to those general control methods.

7.6 Regulations

According to federal fisheries Act, no person shall disrupt or destroy fish habitat and no deleterious substance shall be deposited in habitat area. In addition, different municipal governments have different

BY-LAW regarding to Erosion and Sediment Control. For example, the BY-LAW NO.16138 of City of Surrey states that the TSS (Total suspension Solid) discharged into the sewage system cannot exceed 75mg/L *(CITY OF SURREY BY-LAW NO. 16138)*. For our project, although UBC or City of Vancouver does not have a specific BY-LAW for Erosion and Sediment Control, due to our diligence of being civil engineers, we use the highest requirement among all other municipalities' regulation as our reference, which is 25 NTU in Winter and 20 NTU in Summer.

7.7 Inspections

Base on BC-CESCL creed, a paper trail that documents compliance with all permit conditions throughout the life of the project is needed, and the ESC Plan should detail the inspection procedures including time, location, personnel and method used.

In addition, the importance of maintenance has been supported by a survey of BMPs (Best Management Practices) by the King County Conservation District *(Manual of Best Management Practices for Maintenance of Agricultural Waterways in King County)*. The results indicate that the major reason for BMP failure is poor maintenance. Therefore, BMPs should be inspected regularly, particularly before, during, and after a major storm *(Greater Vancouver Regional District Best Management Practices Guide for Storm Water).*

To make sure the inspections will be done on time and under the city regulations, a site inspection company will be hired to do the job, which take the responsibility of recording, inspecting and reporting.

8.0 MAINTENANCE SPECIFICATIONS AND PLANS

The three major components of our design are pipe distribution system, pump station and twin concrete tank. Every one of them needs a different maintenance method and plan.

Detecting and repairing leaks will be the most cost-effective way we planned to maintain the two underground water tanks. Unnoticed leaks are costly occurrences in underground water tanks, and many may only be found when they become visible at the surface. However, leaks detected and repaired early will only incur minor costs. The way we planned to make sure leaks do not go unnoticed is to get the tank inspected regularly and monitor the distribution carefully. If the system has experienced a noticeable drop in water pressure, an unexplained sudden increase in water use, or water loss greater than 10%, then a leak may be found, and priority attention is required. To reduce operating costs and conserve, all the data including water pressure and water usage will be monitored through system 24 hours a day, 7 days a week, and annual inspection and cleaning will be done on time. Besides, Documentation will be accurate, consistent, current, and accessible to be a useful tool in deciding priorities and establishing an emergency plan. Each tank has separate control valves including a valve chamber, a flowmeter chamber, and a drain chamber. Inspection on the reservoir will be performed on a monthly basis in summer and every three months in other seasons.

For distribution pipeline system, all equipment along a pipeline will be carefully inspected and maintained, both inside and outside. The method we used to inspected pipeline is called inspection gauges, also known as smart pigs. They are highly sophisticated machines equipped with GPS tracking and sensors. These smart pigs will travel inside the pipe to identify and locate anything out of the ordinary, like small cracks or corrosion *(Smart Pigs)*. When a smart pig inspection detects a defects, pipeline inspector will conduct an integrity dig, which involves excavating a section of buried pipeline. Integrity digs give pipeline inspector a clearer view of the pipeline to determine if it needs repair or replacement.

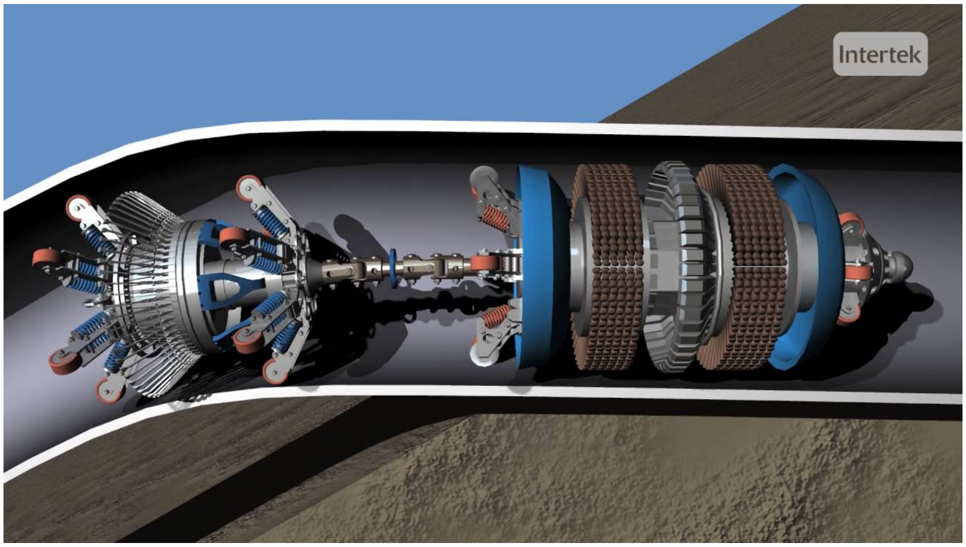

FIGURE 7 – SMART PIG

Two steps are designed to maintain the Pumps. The first step is to clean out the cooling fans. The debris and dust may build up around cooling fans to create overheating issues. The second step is to spray anti-corrosion product on exposed steel. Anti-corrosion spray can extend the life of a pump and make a real difference to the smooth running of a pump. In addition, regular checking will be scheduled annually for wear and tear.

9.0 CONSTRUCTION SCHEDULING & COST ESTIMATE

9.1 Construction Milestones

We drafted a high-level construction plan for the entire project. A summary of the construction milestone dates is as follow:

- Start of WM on University Boulevard: May 1, 2018
- Finish of WM on University Boulevard: June 25, 2018
- Start of WM on Wesbrook Mall: June 26, 2018
- Finish of WM on Wesbrook Mall: September 5, 2018
- Start of Reservoir Construction: May 1, 2018
- Underground Piping Start: July 5, 2018
- Underground Piping Finish: July 18, 2018
- Reservoir Concrete Structure Start: July 19, 2018
- Reservoir Main Structure Finish: January 11, 2019
- System Commissioning: April 19, 2019

The total construction days from start to finish are expected to be 254 days. A detailed schedule can be found in Appendix B.

9.2 Cost Estimate

Based on the final design detailed in the previous section, a Class B project cost estimate was prepared. The total cost of the project is comprised of the first costs, including permitting, project management, construction, 15% of contingency, PST (7%), and the annual operating and maintenance fees. A breakdown of these costs is summarized in Table 6 below.

TABLE 6: COST ESTIMATE SUMMARY

	Capital Cost	Operation & Maintenance	Total Cost
Distribution System	$1,247,813	$ 26,612	$1,274,425
Storage System	$ 13,794,361	$ 129,600	$ 13,923,961
Total Cost Over 1-Year Period			**$ 15,198,386**

Changes from the preliminary cost estimate include the change from single underground concrete tank to twin-tank with separated control system, and a change to the contingency allowance arising from the upgrade from a "Class C" estimate to "Class B". A detailed estimate can be found in Appendix C.

9.1 Estimate of Capital Cost

Table 7 and 8 summarize the contractor costs to fully implement the proposed design of the reservoir and distribution system. The costs are broken into major divisions as per specified in the Master Municipal Construction Documents (MMCD), 2009 edition. All estimates are exclusive of PST (7%), GST (5%), and contingency.

TABLE 7: CONSTRUCTION COST OF RESERVOIR

Code	Scopes	Cost Estimate
01 00 00	General Conditions	$368,891
02 00 00	Site Construction	$3,768,811
03 00 00	Concrete	$3,982,689
16 00 00	Electrical	$1,278,791
22 00 00	Plumbing	$818,045
33 00 00	Utilities	$162,000
N/A	Miscellaneous	$831,214
	Total	**$11,210,371**

TABLE 8: CONSTRUCTION COST OF DISTRIBUTION SYSTEM

Code	Scopes	Cost Estimate
01 00 00	General Conditions	$139,779
02 00 00	Site Construction	$276,122
33 00 00	Utilities	$598,169
	Total	**$1,014,070**

9.2 Estimate of Operating and Maintenance Costs

Regular maintenance and examination are highly required for underground water supply system to prevent leakage and contaminant issues. The lifespan for each project component is anticipated to be 50 years for the concrete reservoir and 75 years for the proposed water main system. Therefore, the operating and maintenance costs are estimated based on the approximate costs per square meter and per linear meter on a one-year span, respectively. Table 9 lists the detailed estimates of each component.

TABLE 9: MAINTENANCE & OPERATIONAL COST SUMMARY

Maintenance Category	Quantity	Unit	Rate	Price
Concrete Reservoir	7,200	m^2	18	$129,600
Pump Station	1	N/A	25,000	$25,000
Water Main	3.1	km	520	$1,612
			Total:	**$156,212**

It should be noted that a one-year warranty will be provided by the contractor after project substantial completion. Thus, the values above exclude any costs to correct major performance deficiencies that would fall under warranty conditions.

10.0 References

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2. Best Management Practices Guide for Stormwater [PDF]. (1999, October). Vancouver: Greater Vancouver Sewerage and Drainage District.
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4. Manual of Best Management Practices for Maintenance of Agricultural Waterways in King County [PDF]. (2012, April). King County: Department of Natural Resources and Parks April 2012 Water and Land Resources Division.
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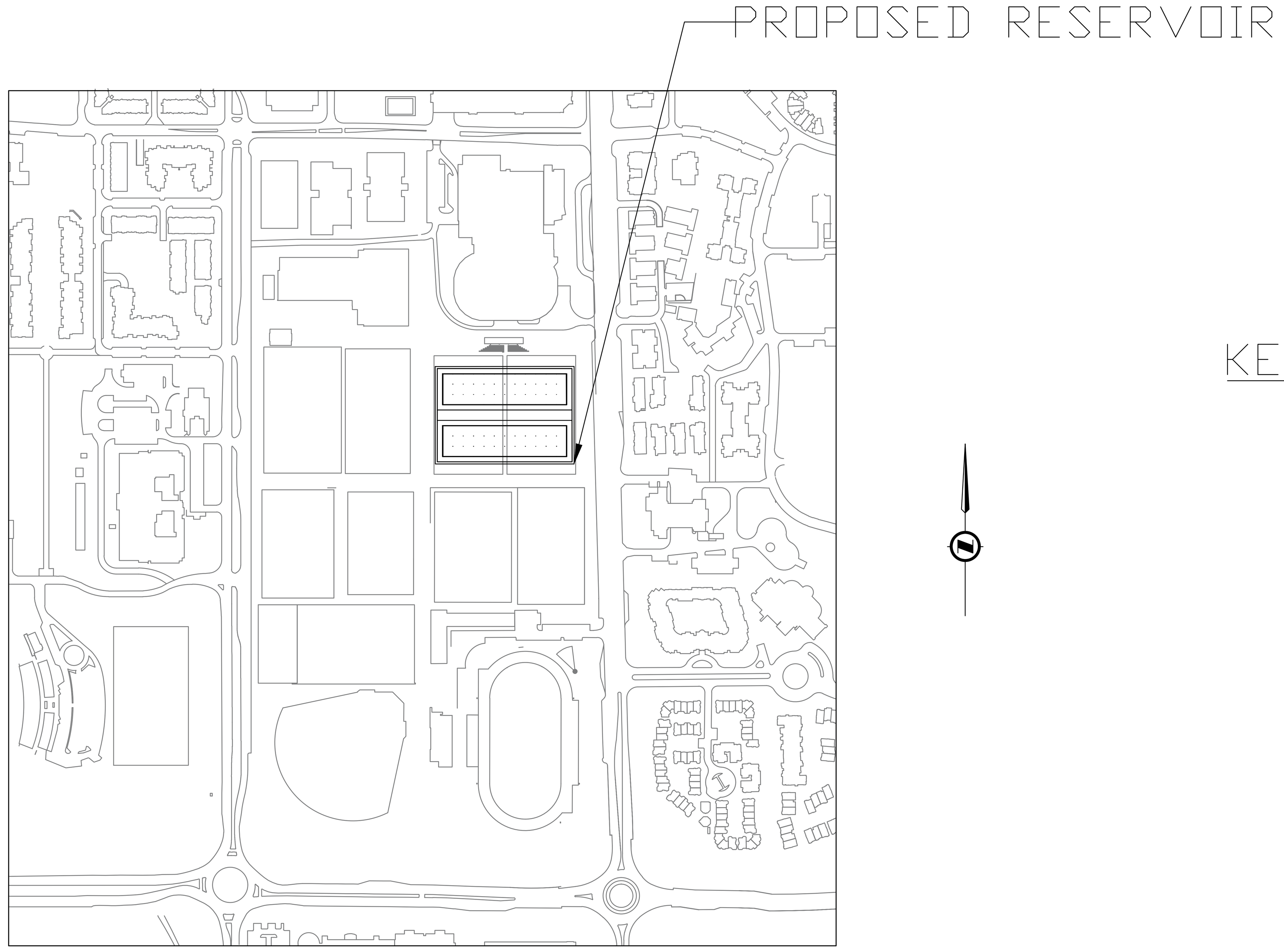
14. UBC Properties Trust (2002, September) Hydrogeological and Geotechnical Assessment of Northwest Area UBC Campus, Vancouver. Retrieved from Connect UBC

15. UBC Properties Trust (2015, June 2) Land Use Plan for The University of British Columbia Point Grey Campus. Retrieved from Connect UBC

Appendix A – Issued for Construction Drawings



KEY PLAN

GENERAL CONSTRUCTION NOTES:

1. CONTACT & NOTIFY ALL HOMEOWNERS AFFECTED BY WORKS 4 WEEKS PRIOR TO CONSTRUCTION.
2. ALL CONSTRUCTION AND MATERIALS SHALL CONFORM TO MMCD PLATINUM EDITION & UBC SUPPLEMENTARY SPECIFICATIONS AND DRAWINGS UNLESS OTHERWISE NOTED IN THE CONTRACT SPECIFICATIONS OR ON THIS DRAWING.
3. REPAIR AND/OR REPLACE ALL INFRASTRUCTURE/PRIVATE PROPERTY DAMAGED OR REMOVED DURING CONSTRUCTION, TO BETTER THAN, OR EQUAL TO PRE-CONSTRUCTION CONDITION.
4. CONTACT MUNICIPALITY PARKS DEPARTMENT PRIOR TO WORKING IN AND AROUND TREES.
5. ENSURE THE CURRENT MUNICIPAL O.H.&S. GROUND DISTURBANCE PRACTICE AND PROCEDURES ARE FOLLOWED. CONTACT BC1 AT 1-800-474-6886 FOR EXTERNAL UTILITY LOCATIONS AT LEAST 72 HOURS PRIOR TO THE START OF CONSTRUCTION.
6. CONFIRM LOCATION AND ELEVATION OF EXISTING UTILITIES AT ALL CROSSINGS AND CONNECTIONS PRIOR TO CONSTRUCTION.
7. ENSURE ALL EXISTING SERVICES STAY IN OPERATIONAL CONDITION DURING CONSTRUCTION.
8. SUBMIT SITE EXCAVATION PLAN FOR REVIEW.

ENVIRONMENTAL NOTES:

USE BEST MANAGEMENT PRACTICES DURING CONSTRUCTION. ADJUST WORK ACTIVITIES DURING PERIODS OF HEAVY RAIN TO MINIMIZE SEDIMENTS ENTERING THE STORM DRAINAGE SYSTEM. SOME BEST MANAGEMENT PRACTICES TO CONSIDER:

1. CHECK ALL EQUIPMENT FOR FLUID LEAKS PRIOR TO ENTERING THE WORK AREA.
2. NO EQUIPMENT RE-FUELING TO OCCUR IN THE WORK AREA UNLESS SPILL PROTECTION MEASURES ARE IN PLACE.
3. A SPILL KIT IS TO BE MAINTAINED ON SITE THROUGHOUT THE CONSTRUCTION PERIOD.
4. SURFACE WATER IS TO BE MANAGED WITHIN THE WORK AREA AND TREATED BEFORE DISCHARGED. THIS MAY INCLUDE ONSITE DETENTION AND/OR CULVERT FILTRATION.
5. COVER EXPOSED SOILS IN INCLEMENT WEATHER ie TARP, HYDRO SEED OR ORGANIC LEAF MULCH.
6. STOCKPILE SOILS AWAY FROM CULVERT INLETS AND ENSURE THEY ARE COVERED IF LEFT FOR MORE THAN 48 HOURS.
7. PLACE DRAIN ROCK AND FILET FABRIC AT THE INLET OF CULVERT.
8. SURROUND PROTECTED TREES WITH SNOW FENCING AT DRIP LINE OR CRITICAL ROOT ZONE OF TREE DURING CONSTRUCTION. CONTACT MUNICIPAL ARBORIST PRIOR TO BEGINNING CONSTRUCTION. INSTALL SILT FENCING.
9. ADHERE TO ALL CONDITIONS OF THE PROJECT ENVIRONMENTAL CONSULTANT.
10. AVOID WORKING WITHIN OR CONTAMINATION OF THE STAR CREEK TRIBUTARY ADJACENT TO THE SITE.
11. SUBMIT SEDIMENT AND EROSION CONTROL PLAN FOR REVIEW IN ACCORDANCE WITH UBC STANDARDS AND THE CONTRACT DOCUMENTS.
12. SUBMIT TREE CLEARING SUBMITTAL INCLUDING REQUIRED PERMIT.

LEGEND

EXISTING — PROPOSED

CONCRETE CURB
RETAINING WALL
PROPERTY BOUNDARY
CONTOUR - MAJOR 1m
CONTOUR - MINOR 0.5m
1.8m HIGH CHAIN LINK FENCE
3.0m HIGH CHAIN LINK FENCE
DRAIN
DRAIN MANHOLE
DRAIN CLEANOUT
DRAIN CATCHBASIN SIDE INLET
SWALE
TOP OF BANK
CULVERT
WATER MAIN
WATER MAIN BLOWOFF
WATER VALVE
FIRE HYDRANT
WATER REDUCER
WATER TEE
WATER CAP
WATER ROBAR COUPLING
WATER BEND FITTING
UNDERGROUND ELECTRICAL LINE
ELECTRICAL GROUNDING ROD
ELECTRICAL POLE
TREE - CONIFEROUS
TREE - DECIDUOUS

General Notes

1. ALL WORK SHALL MEET OR EXCEED MINIMUM REQUIREMENTS OF THE CURRENT EDITION OF THE BRITISH COLUMBIA BUILDING CODE 2012, ASSOCIATED STANDARDDS REFERENCED IN THAT CODE, AND LOCAL STANDARS AND BYLAW AS APPLICABLE.

2. CONFIRM SIZE AND LOCATIONS OF OPENINGS WITH MECHANICAL AND ELECTRICAL CONTRACTORS. REPORT ANY DESCREPANCIES TO CONSULTANT BEFORE PROCEEDING WITH WORK.

No.	Revision/Issue	Date
1	ISSUED FOR CONSTRUCTION	07/04

Firm Name and Address

IRON HEAD CONSULTING LTD
2205 LOWER MALL. VANCOUVER, BC

Project Name and Address

SECURE WATER SUPPLY FOR UBC VANCOUVER CAMPUS

272 - 6081 UNIVERSITY BLVD.

Project: CIVL446-011
Date: APR-07-2018
Scale:
Sheet: C-001 COVER SHEET

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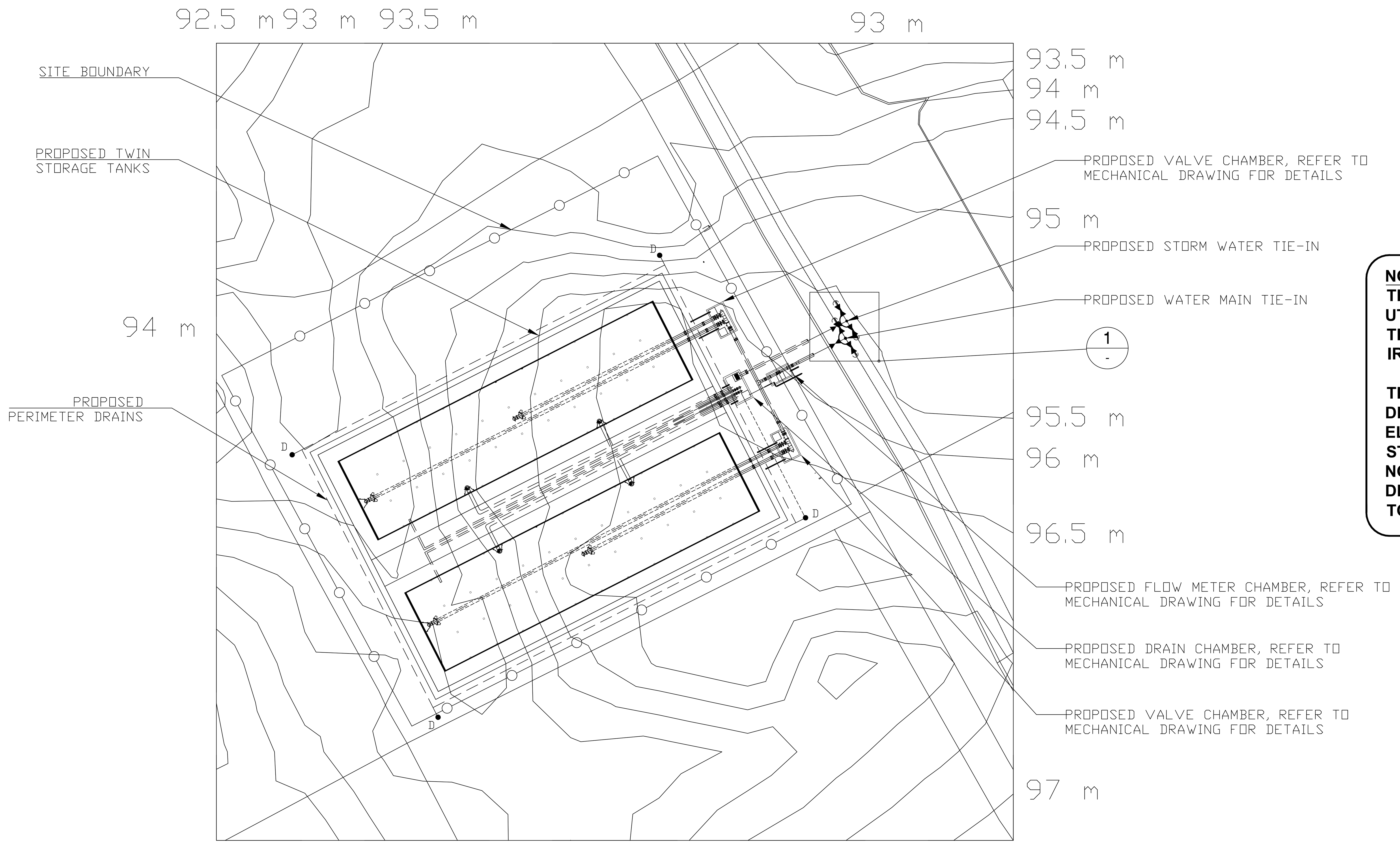

PLAN
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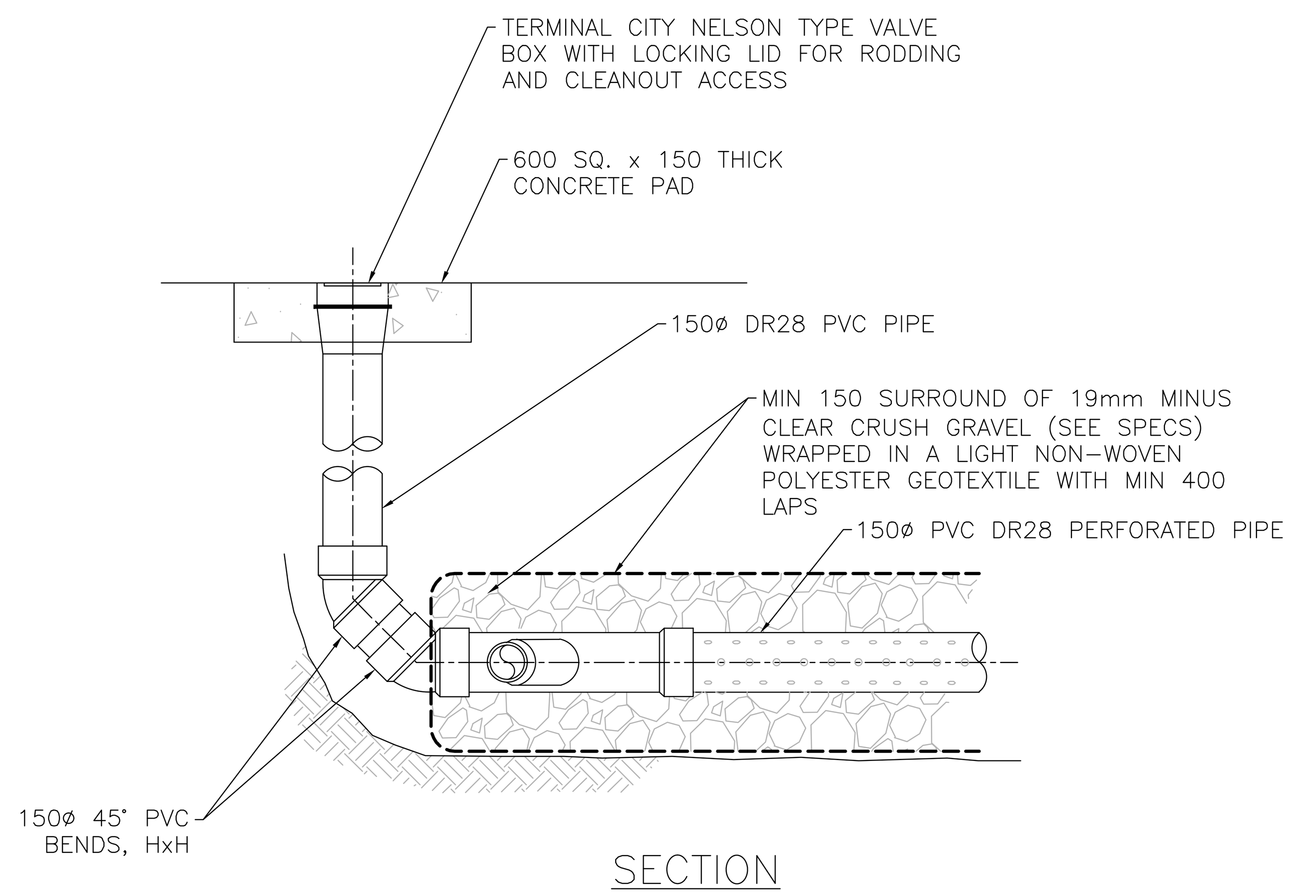
0m 20m 60m

NOTICE:
THE EXISTENCE, LOCATION AND ELEVATION OF UTILITIES AND/OR CONCEALED STRUCTURES AT THE PROJECT SITE ARE NOT GUARANTEED BY IRON HEAD CONSULTING LTD.

THE CONTRACTOR IS RESPONSIBLE FOR DETERMINING THE EXISTENCE, LOCATION AND ELEVATION OF ALL SUCH UTILITIES AND/OR STRUCTURES AND IS RESPONSIBLE FOR NOTIFYING THE APPROPRIATE COMPANY, DEPARTMENT OR PERSON(S) OF ITS INTENTION TO CARRY OUT ITS OPERATIONS.



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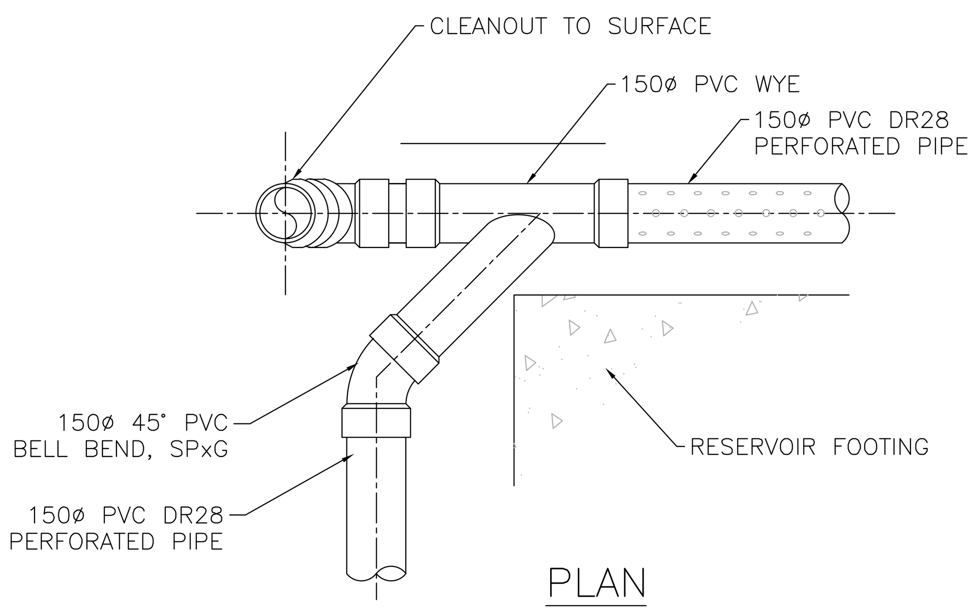

PLAN

PERIMETER DRAIN CLEANOUT DETAIL
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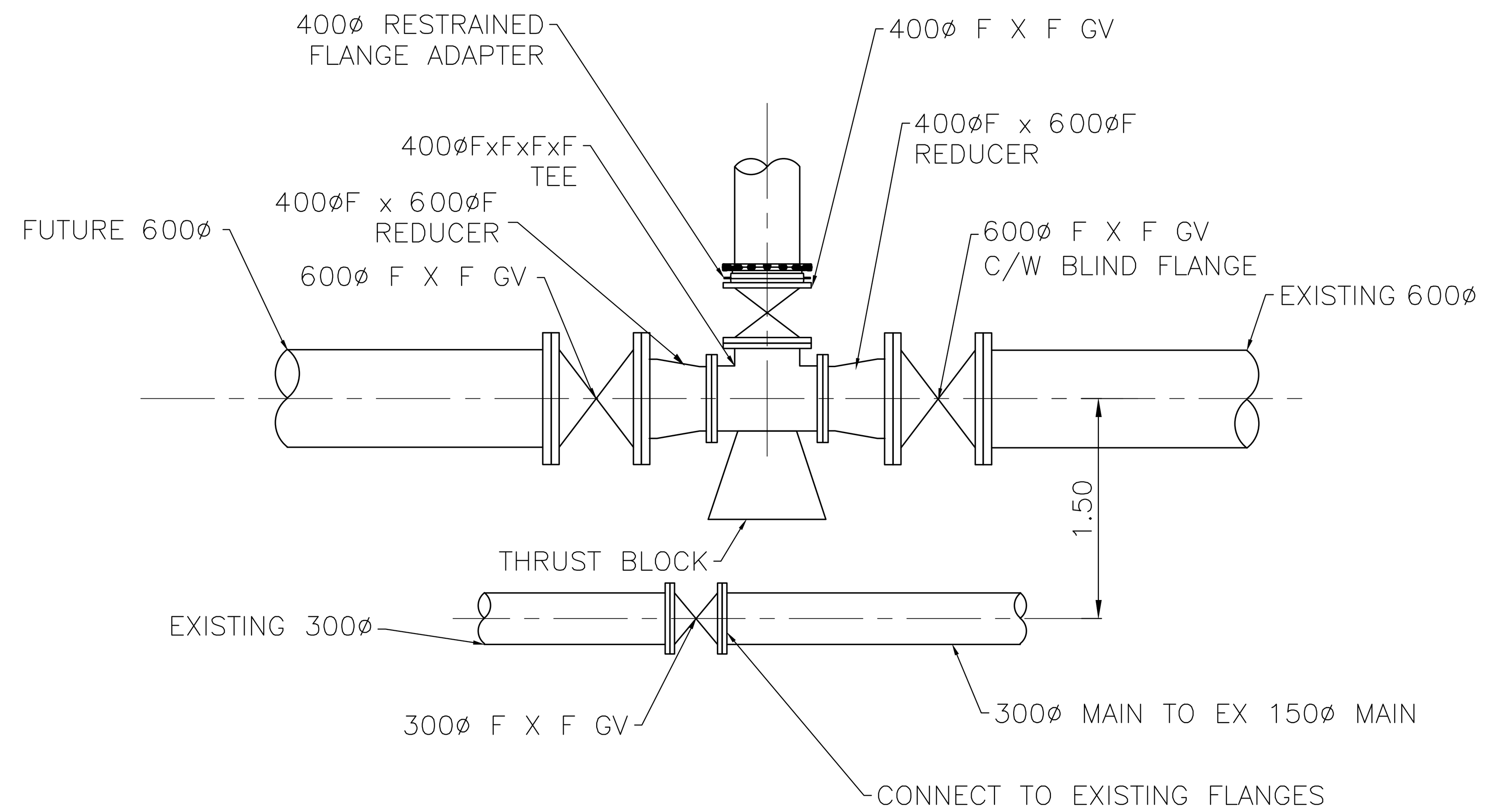

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General Notes

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No.	Revision/Issue	Date
1	ISSUED FOR CONSTRUCTION	07/04

Firm Name and Address

IRON HEAD CONSULTING LTD
2205 LOWER MALL. VANCOUVER, BC

IRON HEAD

Project Name and Address

SECURE WATER SUPPLY FOR UBC VANCOUVER CAMPUS
272 - 6081 UNIVERSITY BLVD.

Project: CIVL446-011
Date: APR-07-2018
Scale
Sheet: C-002
GENERAL ARRANGEMENT

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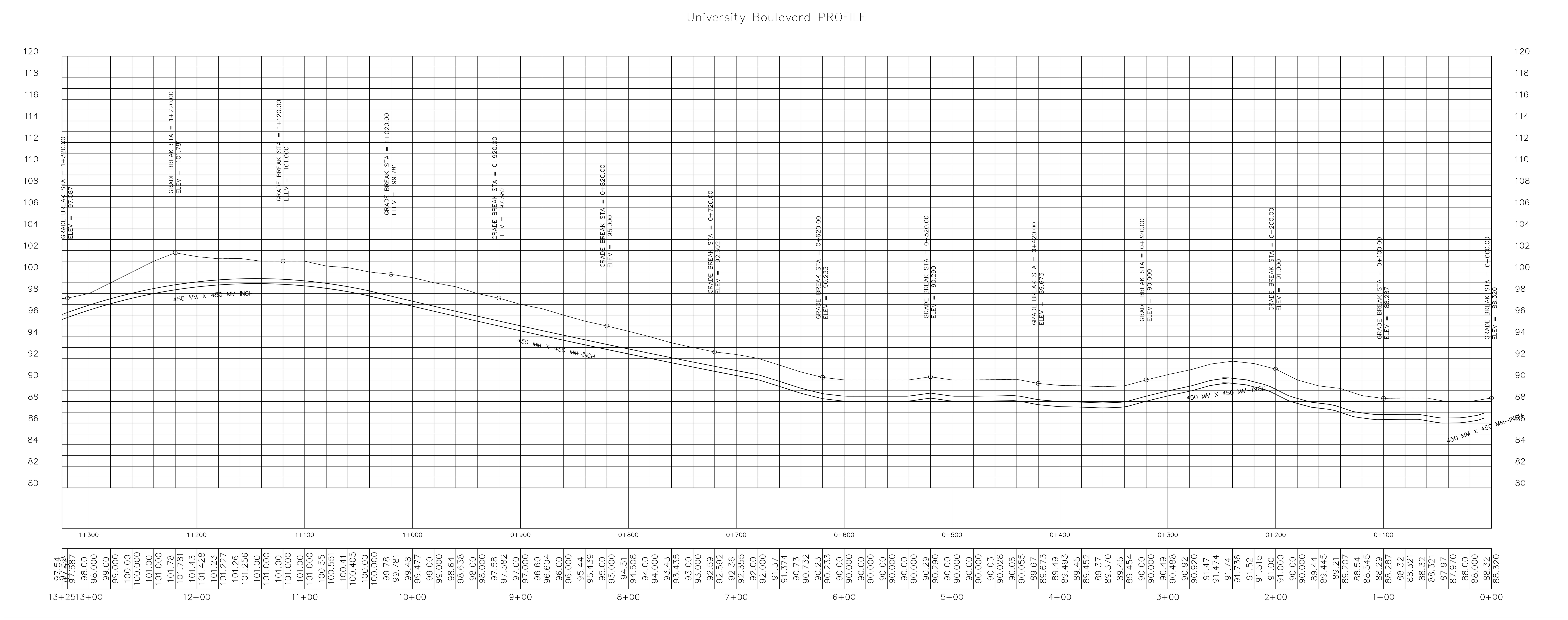

General Notes

1. Pipe shall be Class 50 ductile iron pipe manufactured to AWWA C151; cement mortar lined to AWWA C104 and coated 1 mil. thick asphalt.
2. Copper, up to 75 mm diameter, type K, joints brazed only.
3. Joints shall be single rubber gasket for push-on bell and spigot type joints to AWWA C111, Tyton or approved equal.
4. Fittings shall be ductile to AWWA C110 suitable for pressure rating of 2415 kPa. Cement, mortar lined to AWWA C104. Minimum design pressure for piping 1,210 kPa.
5. Bolts shall be medium carbon steel or Martensitic steel, ASTM A325 heavy hex finished, hot-dip galvanized to ASTM A153. Coarse threads shall have Class 2A tolerance before galvanizing. Bolt sizes to AWWA110.
6. Gate Valves shall be manufactured to AWWA C509, ductile iron body, resilient seated, nonrising steam, hub or flanged ends
7. Stem seal shall be O-ring type. Valves to be complete with 50 mm square nut for underground operation. Manufacturer shall be Clow, or equal approved by Building Operations.
8. Circular valve boxes shall be Nelson-type as manufactured by Terminal City or Dobney Foundry. Valve box riser pipe to be 150 mm diameter PVC DR35.
9. Fire Hydrants to be 150 mm diameter Terminal City type C-71-P hydrants subjected to hydrostatic pressure test of 2070 kPa in compliance with AWWA C502.
10. For hydrant installation requirements see standard dwg. 1140-UT-02FireHydrantDetail.dwg.
11. For pipe bedding use clean granular pipe bedding, graded gravel, 19 mm (-), MMS type 1. Bottom thickness shall be a quarter of pipe diameter, or minimum 100 mm thick. Top shall be minimum 300 mm thick. Sides shall be minimum 225 mm to maximum 300 mm thick.
12. Place granular bedding (sand) material across full with of trench bottom in uniform layers to 100 mm depth.
13. Utility Separation: A minimum 3 m horizontal clearance is required from either sanitary sewer or storm sewer piping, when they run parallel to water main. If this clearance cannot be met, water piping can be installed closer with prior approval from UBC Energy & Water Services. Refer to MMCD Design Guideline Manual Section 1.4, and Vancouver Coastal Health's Water Supply System Construction Permit Guidelines and Application Form (see 2.1.4 this section). Installation may be approved provided water pipe is installed above sanitary or storm sewer piping with minimum vertical clearance 0.5 m and water main joints are wrapped. When crossing sanitary sewers at 90° angle, the water pipe shall be encased with 20 MPa concrete of minimum thickness 150 mm. If concrete is not desirable, joints of the water main can be wrapped with heat shrink plastic or packed with compound and wrapped with petroleum tape in accordance with the latest version of the AWWA Standards C217, and C214 or C209.

No.	Revision/Issue	Date
1	ISSUED FOR CONSTRUCTION	07/04

Firm Name and Address

Project Name and Address

University Boulevard Water Main Replacing
4665 W 10th Ave.
Vancouver
V6R 2J4

Project: UBC Water Improvement

Date: 06.04.2018

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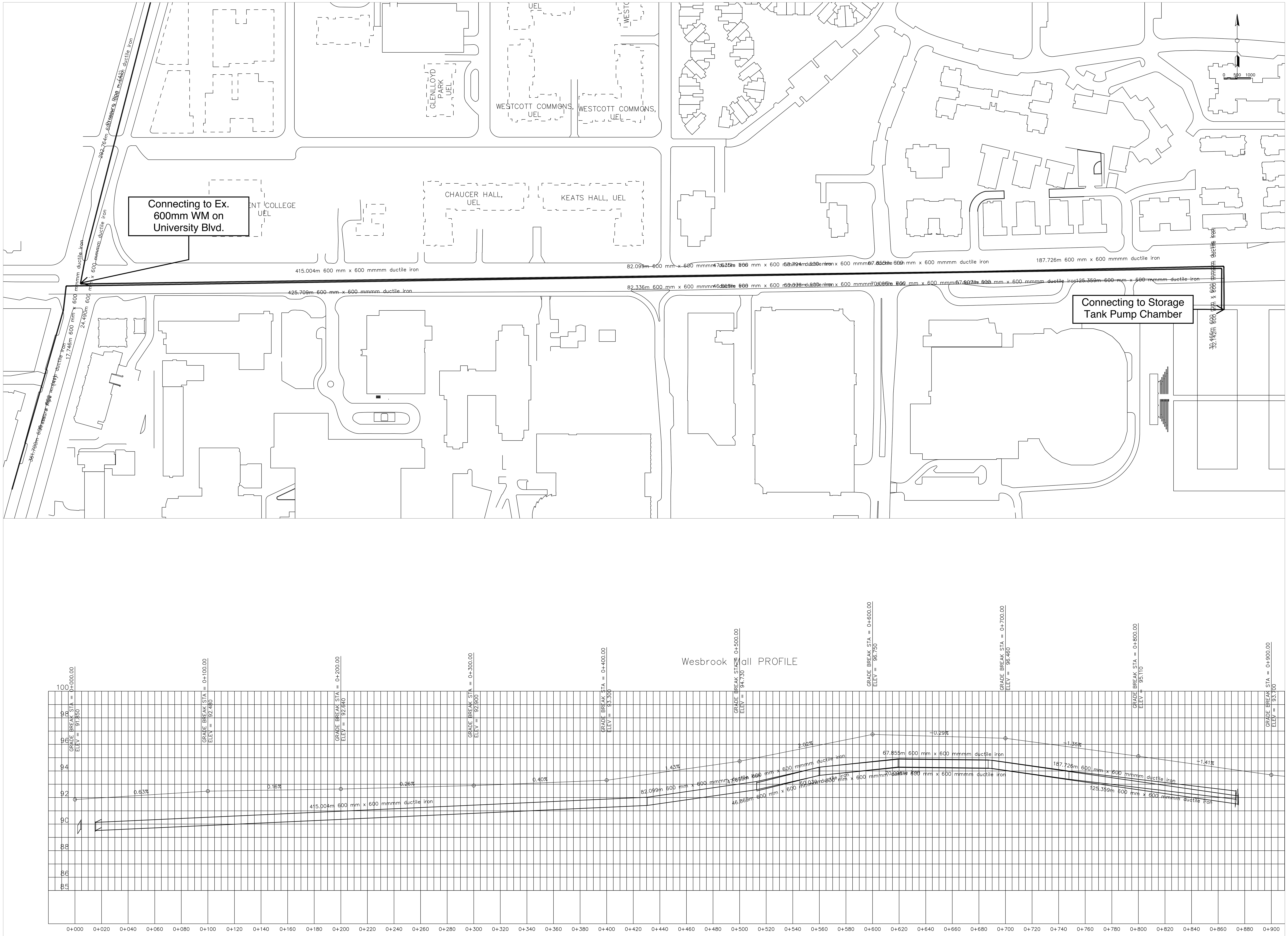

Wesbrook Mall.dwg

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7. Stem seal shall be O-ring type. Valves to be complete with 50 mm square nut for underground operation. Manufacturer shall be Clow, or equal approved by Building Operations.
8. Circular valve boxes shall be Nelson-type as manufactured by Terminal City or Dobney Foundry. Valve box riser pipe to be 150 mm diameter PVC DR35.
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No.	Revision/Issue	Date
1	ISSUED FOR CONSTRUCTION	07/04

Firm Name and Address

Project Name and Address
Wesbrook Mall WM
5800 University Boulevard

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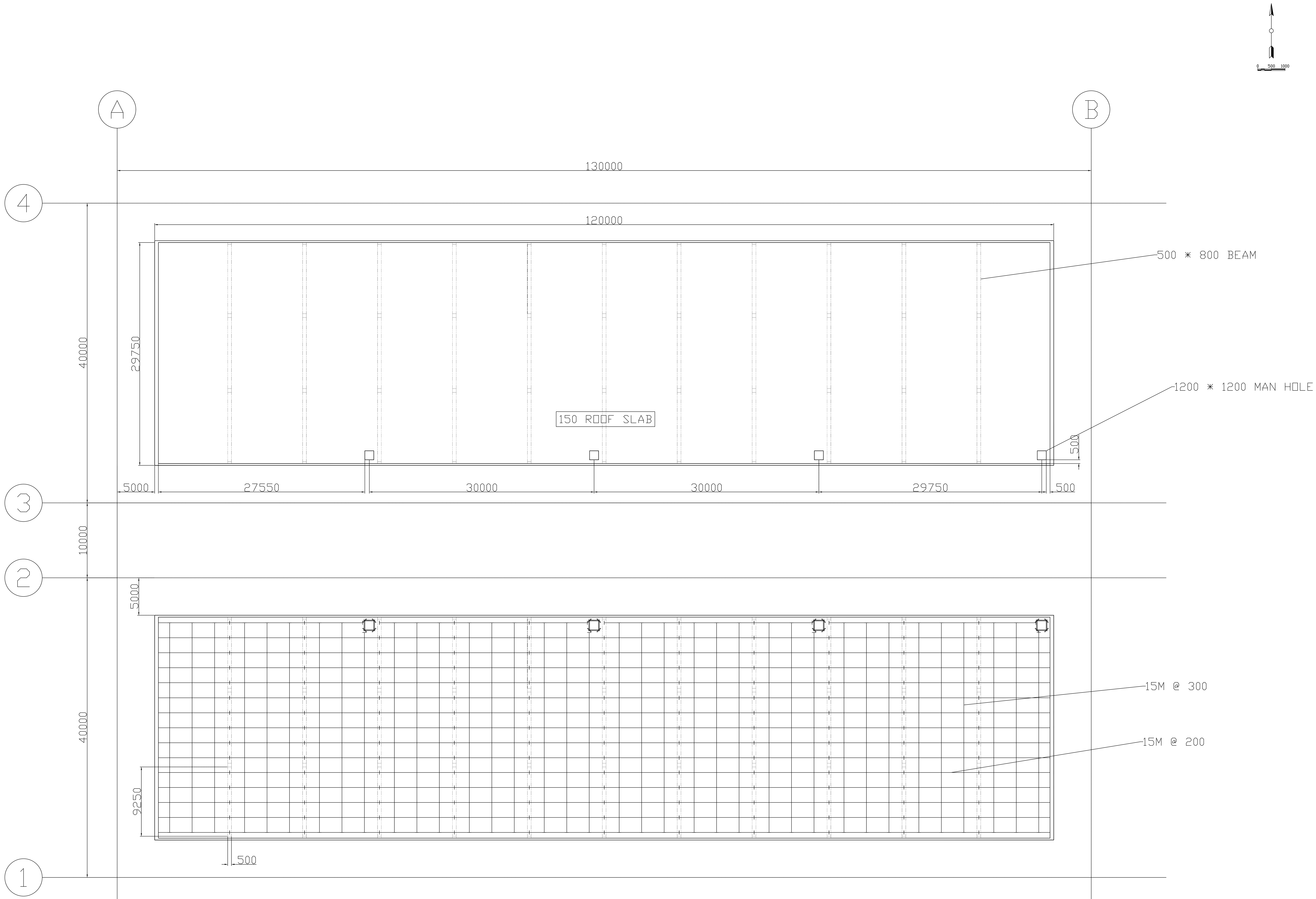

RESERVOIR ROOF SLAB PLAN
SCALE 1:100

General Notes

1. ALL WORK SHALL MEET OR EXCEED MINIMUM REQUIREMENTS OF THE CURRENT EDITION OF THE BRITISH COLUMBIA BUILDING CODE 2012, ASSOCIATED STANDARDDS REFERENCED IN THAT CODE, AND LOCAL STANDARS AND BYLAW AS APPLICABLE.

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No.	Revision/Issue	Date
1	ISSUED FOR CONSTRUCTION	07/04

Firm Name and Address

IRON HEAD CONSULTING LTD
2205 LOWER MALL. VANCOUVER, BC

IRON HEAD

Project Name and Address

SECURE WATER SUPPLY FOR UBC VANCOUVER CAMPUS

272 - 6081 UNIVERSITY BLVD.

Project: CIVL446-011
Date: APR-07-2018
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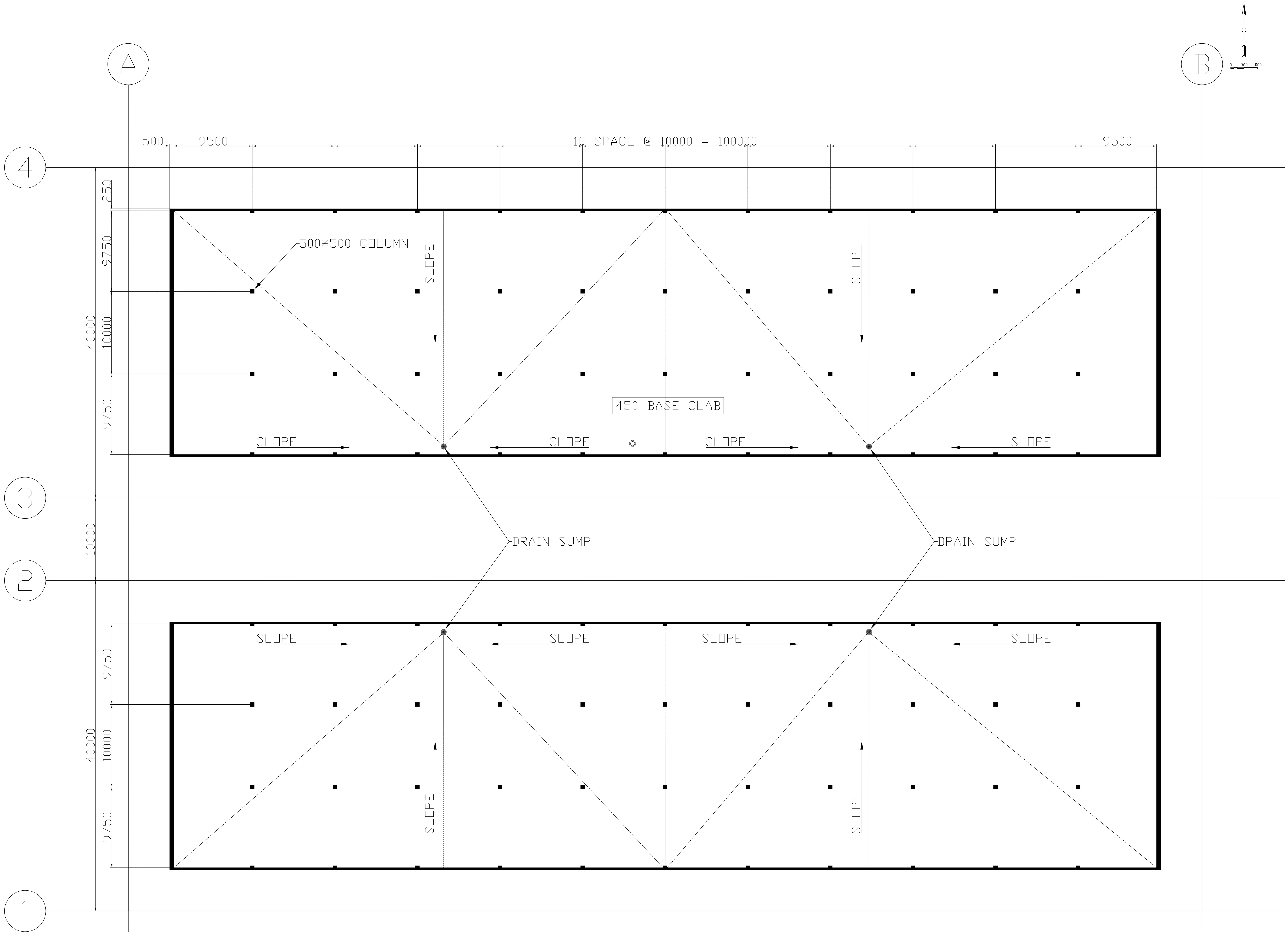

RESERVOIR BASE SLAB PLAN
SCALE 1:100

General Notes

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No.	Revision/Issue	Date
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Firm Name and Address

IRON HEAD CONSULTING LTD
2205 LOWER MALL. VANCOUVER, BC

IRON HEAD

Project Name and Address

SECURE WATER SUPPLY FOR UBC VANCOUVER CAMPUS

272 - 6081 UNIVERSITY BLVD.

Project	Sheet
CIVL446-011	S-002 BASE PLAN
Date: APR-07-2018	
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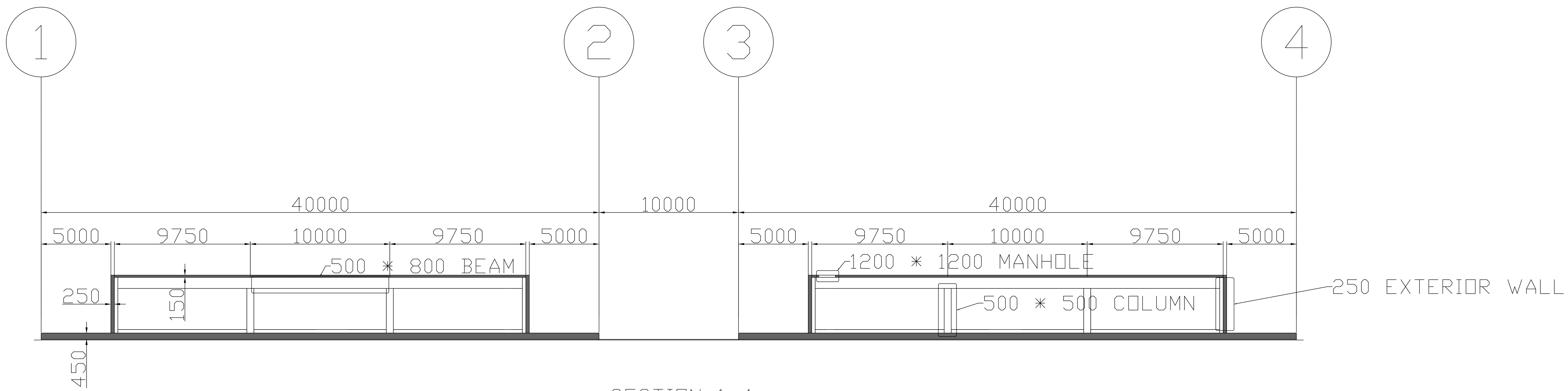

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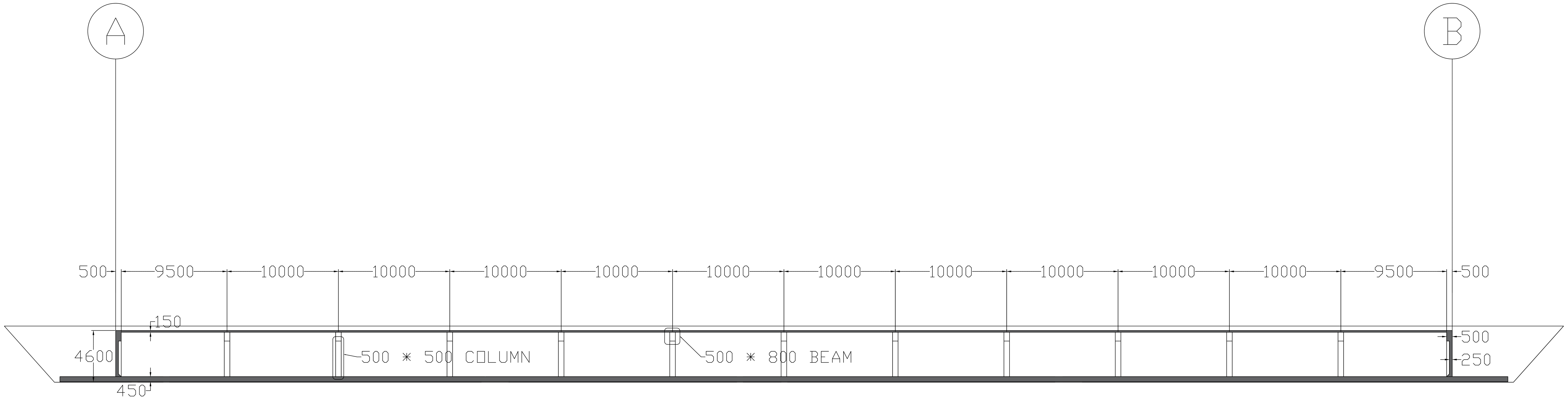


SECTION A-B
SCALE 1:100

General Notes

1. ALL WORK SHALL MEET OR EXCEED MINIMUM REQUIREMENTS OF THE CURRENT EDITION OF THE BRITISH COLUMBIA BUILDING CODE 2012, ASSOCIATED STANDARDDS REFERENCED IN THAT CODE, AND LOCAL STANDARS AND BYLAW AS APPLICABLE.

2. CONFIRM SIZE AND LOCATIONS OF OPENINGS WITH MECHANICAL AND ELECTRICAL CONTRACTORS. REPORT ANY DESCREPANCIES TO CONSULTANT BEFORE PROCEEDING WITH WORK.

No.	Revision/Issue	Date
1	ISSUED FOR CONSTRUCTION	07/04

Firm Name and Address

IRON HEAD CONSULTING LTD
2205 LOWER MALL, VANCOUVER, BC

IRON HEAD

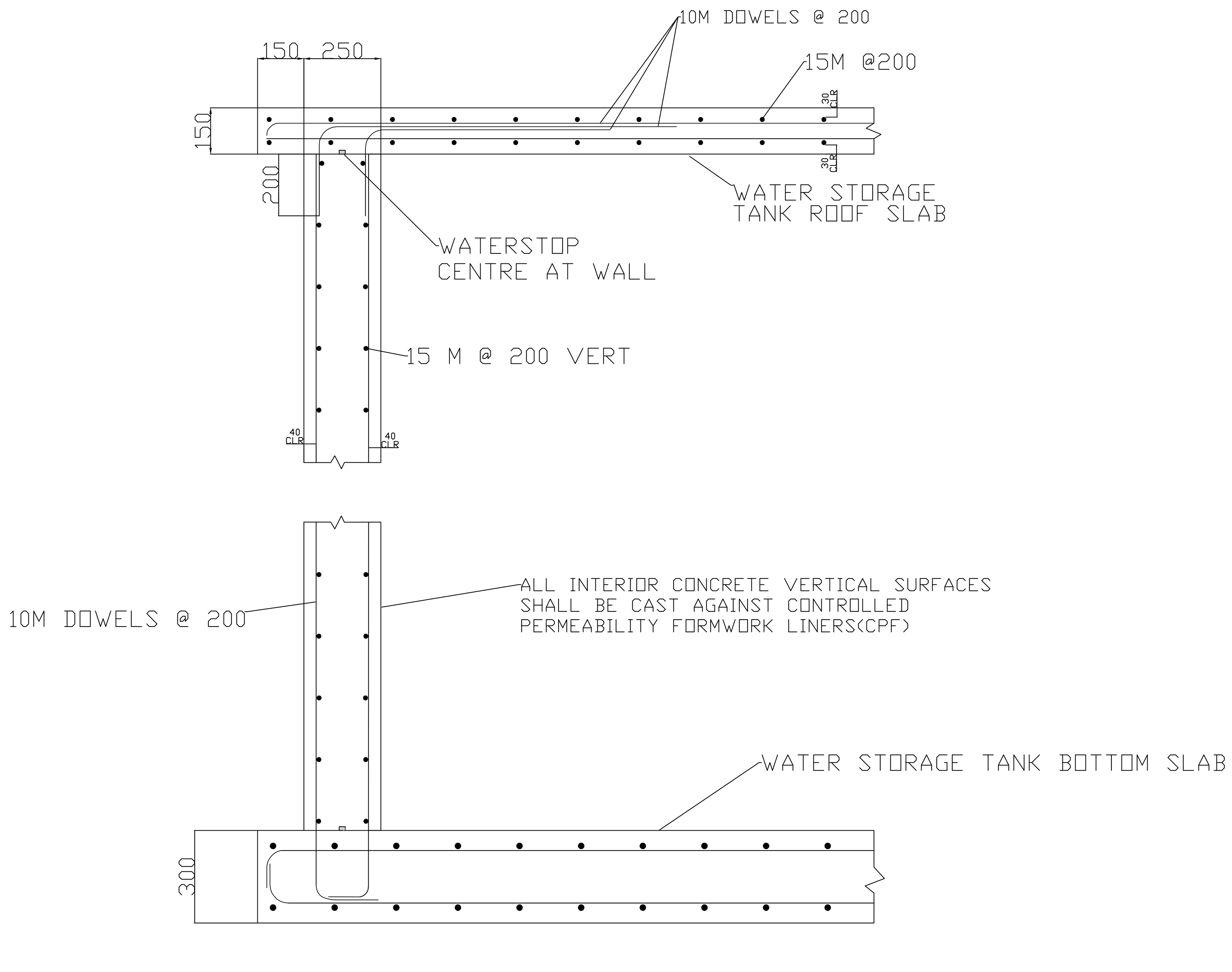
Project Name and Address

SECURE WATER SUPPLY FOR UBC VANCOUVER CAMPUS

272 - 6081 UNIVERSITY BLVD.

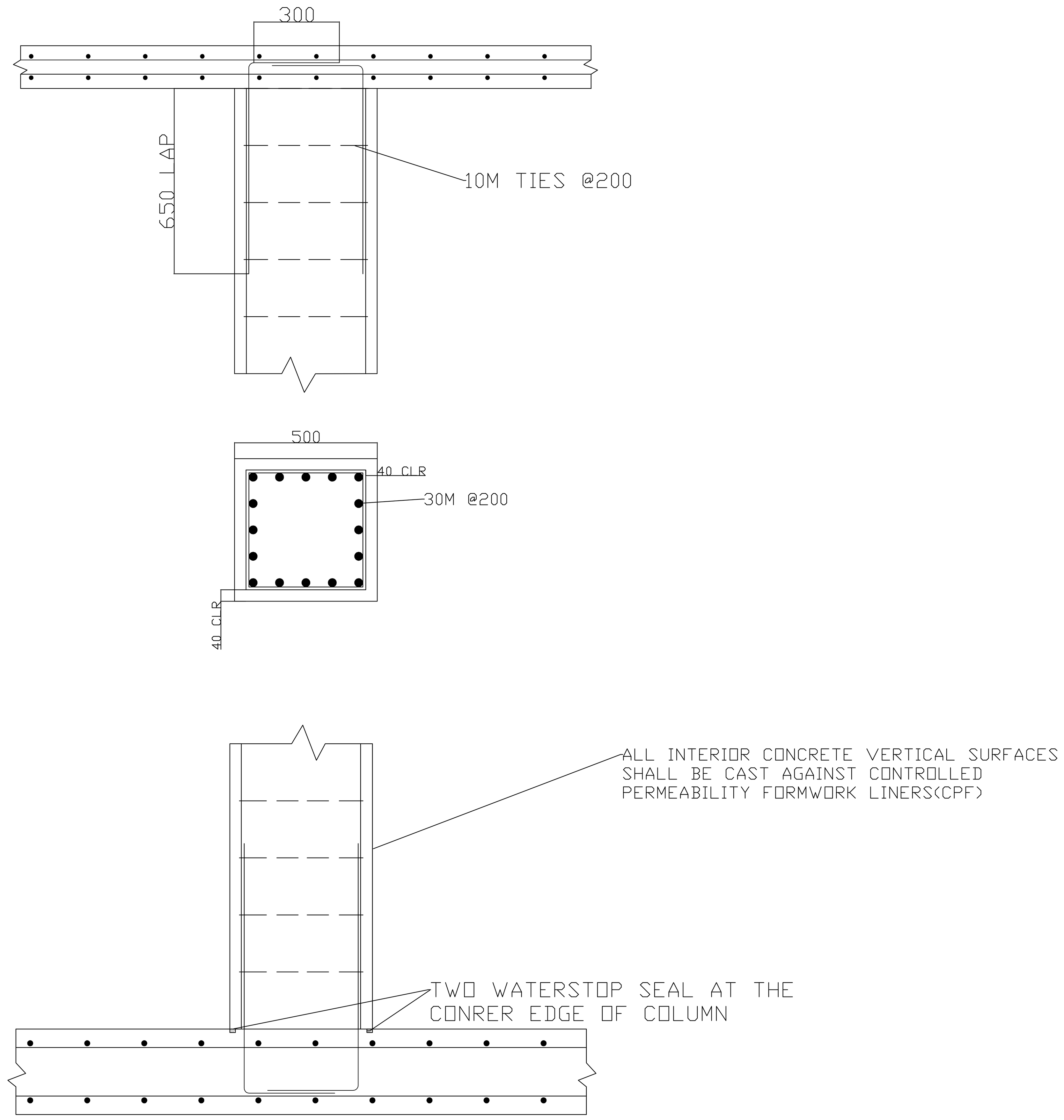
Project: CIVL446-011
Date: APR-07-2018
Scale: 1:100
Sheet: S-003 ELEVATIONS

section 1-4.dwg



250 EXTERIOR WALL

Scale: 1:10



500 * 500 COLUMN DETAIL

Scale: 1:10

General Notes

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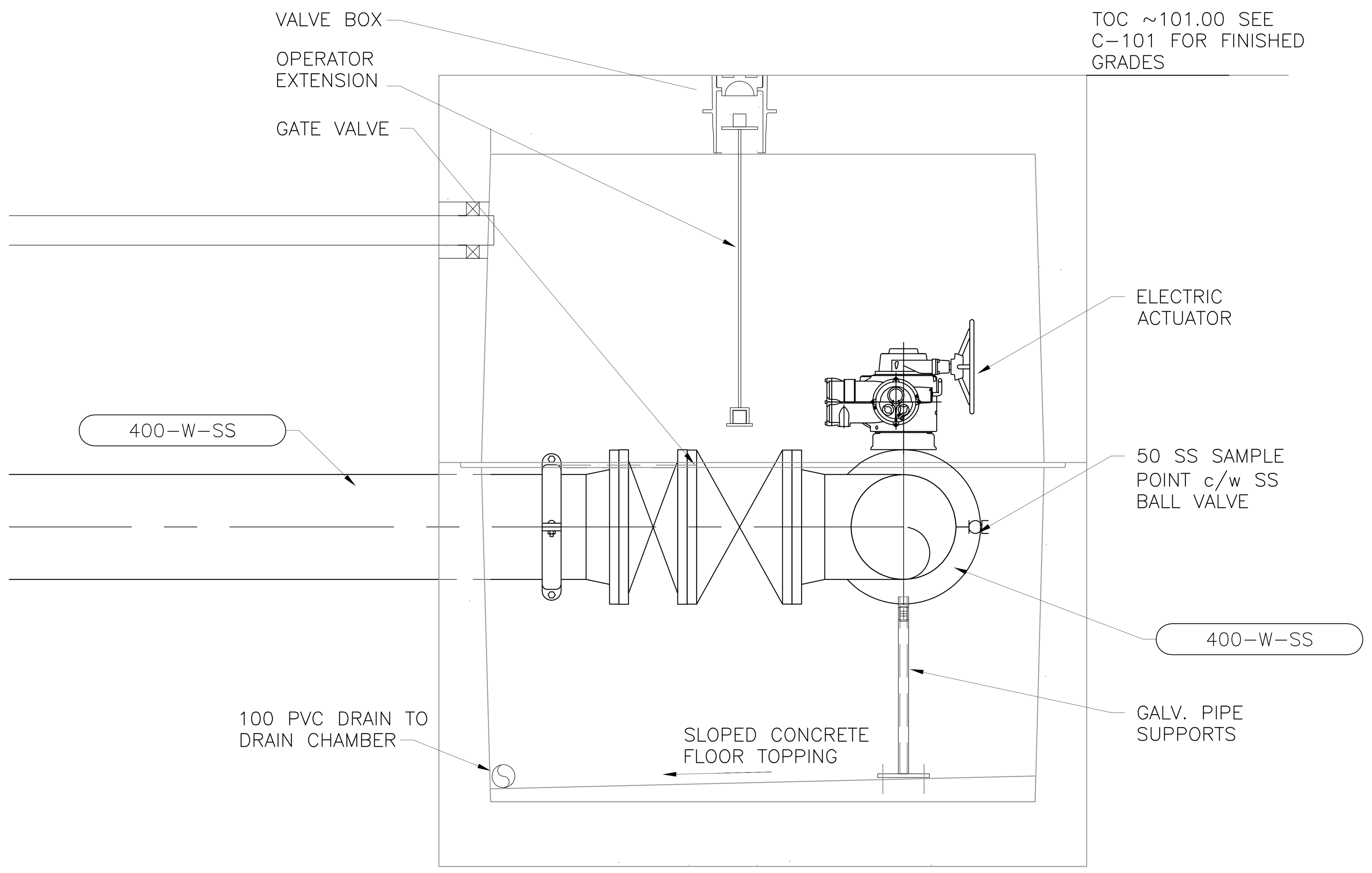
272 - 6081 UNIVERSITY BLVD.

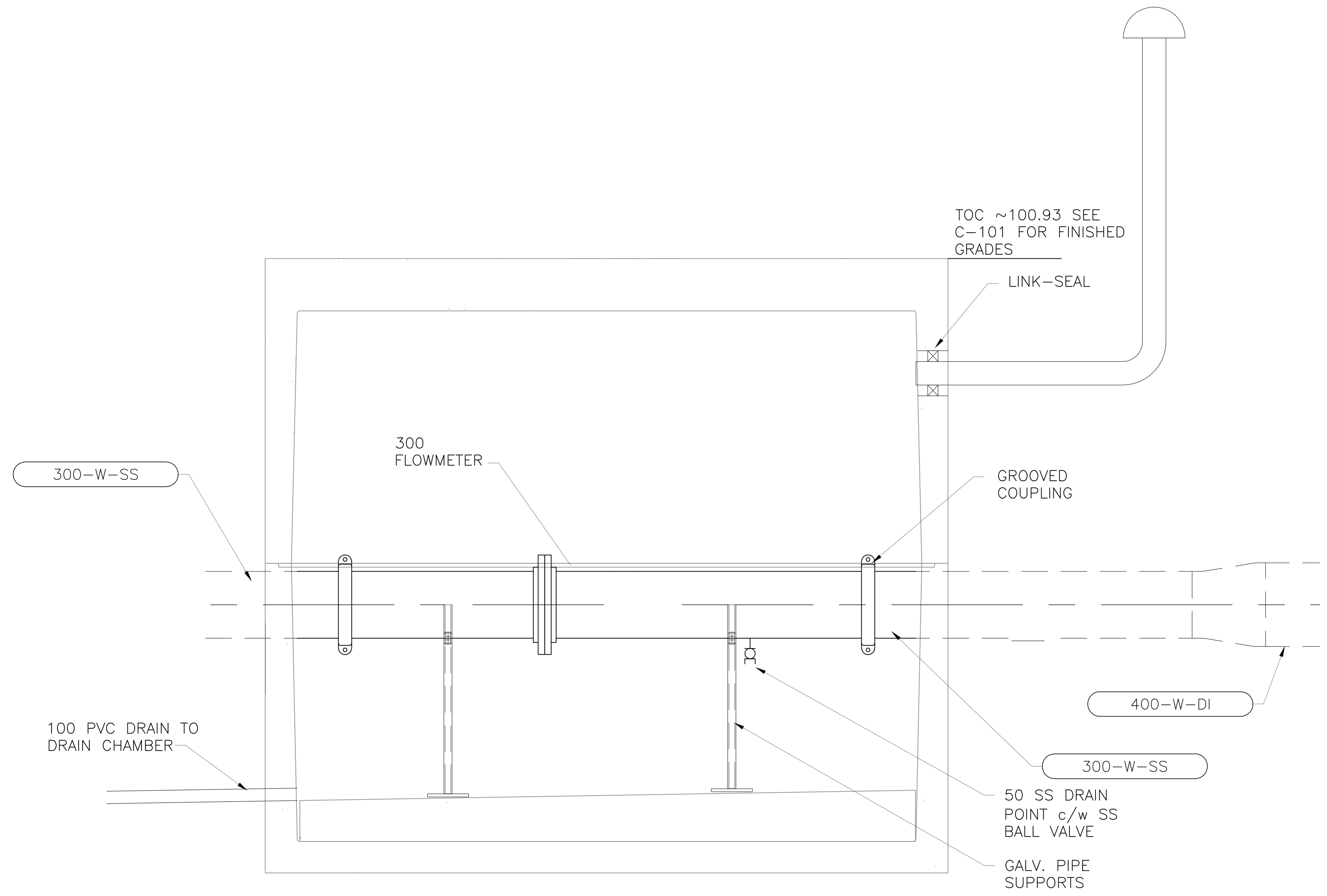
Project: CIVL446-011
Date: APR-07-2018
Scale: 1:10
Sheet: S-004 SECTION DETAILS

Component.dwg



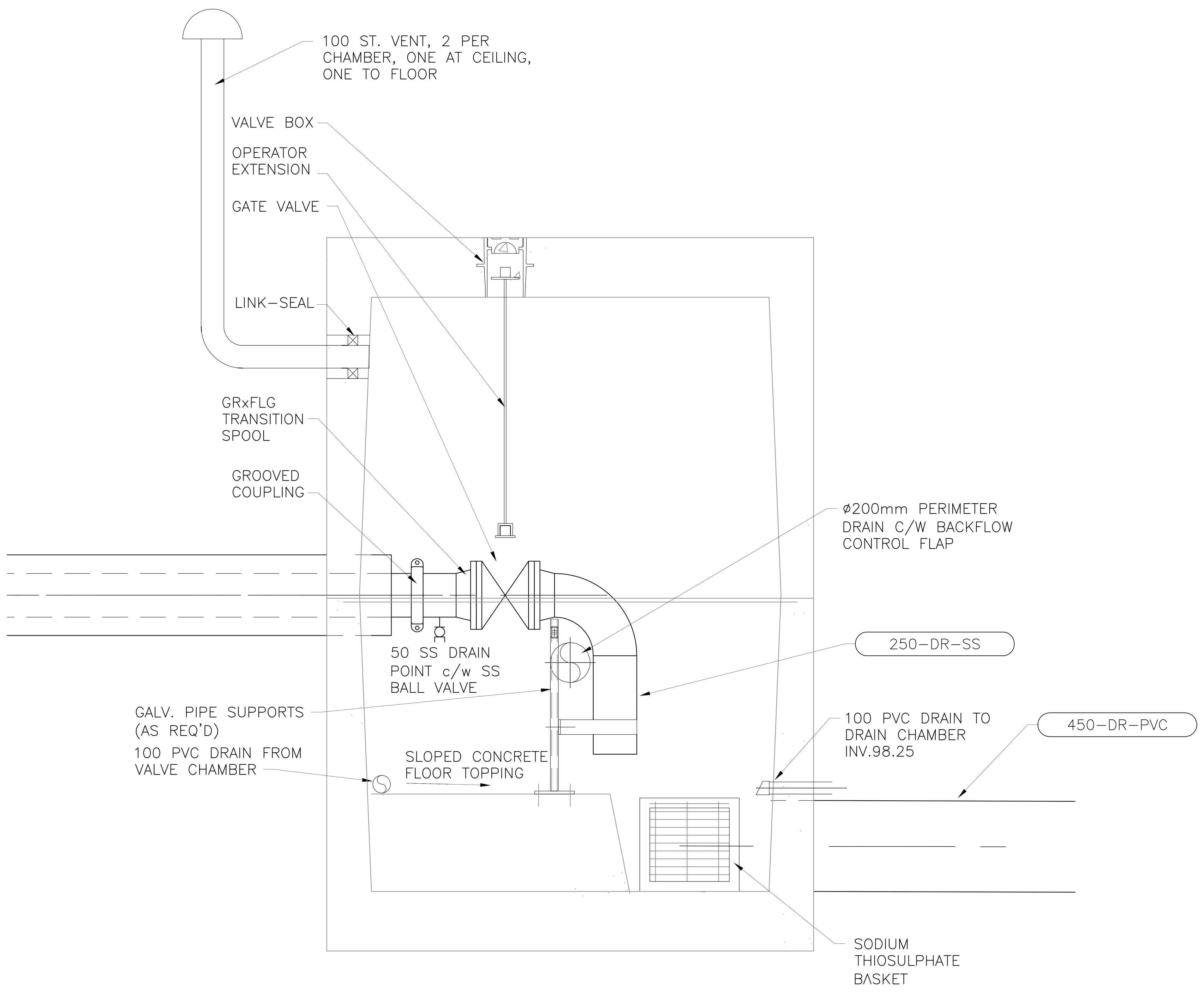
VALVE CHAMBER

Scale: 1:30



FLOWMETER CHAMBER

Scale: 1:30



DRAIN CHAMBER

Scale: 1:30

0 500 1000

General Notes

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2205 LOWER MALL. VANCOUVER, BC

Project Name and Address

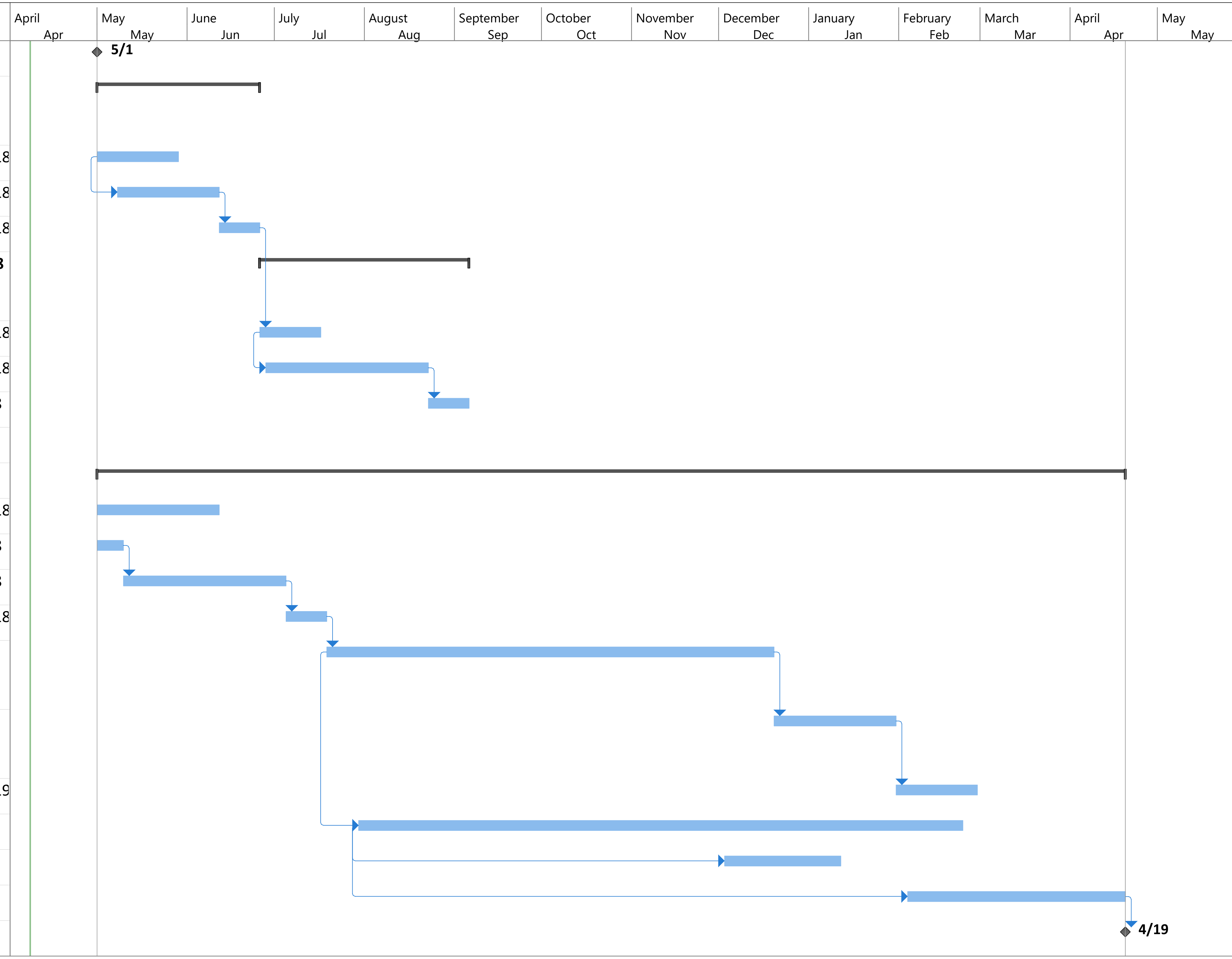
SECURE WATER SUPPLY FOR UBC VANCOUVER CAMPUS
272 - 6081 UNIVERSITY BLVD.

Project: CIVL446-011
Date: APR-07-2018
Scale: 1:10
Sheet: M-001 CHAMBER DETAILS

Chamber details.dwg

Appendix B – Construction Schedule

ID	Task Mode	Task Name	Duration	Start	Finish
1		Start	0 days	Tue 5/1/18	Tue 5/1/18
2		**Water Main on University Blvd.**	**40 days**	**Tue 5/1/18**	**Mon 6/25/18**
3		Trench Excavation	20 days	Tue 5/1/18	Mon 5/28/18
4		Piping	25 days	Tue 5/8/18	Mon 6/11/18
5		Landscape	10 days	Tue 6/12/18	Mon 6/25/18
6		**Water Main Construction Wesbrook Mall**	**52 days**	**Tue 6/26/18**	**Wed 9/5/18**
7		Trench Excavation	15 days	Tue 6/26/18	Mon 7/16/18
8		Piping	40 days	Thu 6/28/18	Wed 8/22/18
9		Landscape & Paving	10 days	Thu 8/23/18	Wed 9/5/18
10					
11		**Reservoir & Pump Stati**	**254 days**	**Tue 5/1/18**	**Fri 4/19/19**
12		Procurement	30 days	Tue 5/1/18	Mon 6/11/18
13		Mobolization & Layo	7 days	Tue 5/1/18	Wed 5/9/18
14		Bulk Excavation	40 days	Thu 5/10/18	Wed 7/4/18
15		Underground Piping	10 days	Thu 7/5/18	Wed 7/18/18
16		Reservoir & Pump Station Concrete Pour	110 days	Thu 7/19/18	Wed 12/19/18
17		Reservoir & Pump Station Backfill	30 days	Thu 12/20/18	Wed 1/30/19
18		Landscaping	20 days	Thu 1/31/19	Wed 2/27/19
19		Process & Mechanica	150 days	Mon 7/30/18	Fri 2/22/19
20		Electrical Installation	30 days	Mon 12/3/18	Fri 1/11/19
21		Comissioning	55 days	Mon 2/4/19	Fri 4/19/19
22		Finish	0 days	Fri 4/19/19	Fri 4/19/19



Project: Water Main & Pump Stat
Date: Sun 4/8/18

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

APPENDIX C – COST ESTIMATE

SECURE WATER SUPPLY FOR UBC VANCOUVER CAMPUS

UBC SEEDS

April 08, 2018

Code	Description	Item	Labour		Material			Equipment			Subcontract		Total
			Man Hr	Rate	Qty	Unit	Rate	Qty	Unit	Rate	Qty	Rate	
Water Main on University Blvd.													
01 - General Conditions													
01 43 00	Office & Site Staff		259	$ 75.00							1	$ 1,500	$ 20,925
01 55 00	Traffic Control										1	$ 10,000	$ 10,000
01 59 50	Temporary Facilities	Temporary Toilets, Offices, Drinking Water									1	$ 25,000	$ 25,000
												Subtotal:	**$ 55,925**
02 - Site Construction													
02 07 00	Sitework Demolition & Removal	Topsoil Removal	86	$ 30.00				1	ea	$ 24,876			$ 27,450
02 33 00	Trench Excavation	Excavation	172	$ 46.00				86	hr	$ 250			$ 29,362
		Disposal									1	$ 20,780	$ 20,780
02 51 00	Asphalt Paving	Asphalt Restore									1	$ 7,000	$ 7,000
02 90 00	Landscaping										1	$ 50,000	$ 50,000
												Subtotal:	**$ 134,592**
33 - Utilities													
N/A	Pipe Placement			$ 17,333			$ 105,338.00			$ 72,800.00	1	$ 7,000	$ 195,471
N/A	Disinfection										1	$ 17,000	$ 17,000
												Subtotal:	**$ 212,471**
												University Blvd. Water Main Total:	**$ 402,988**
Water Main on Wesbrook Mall													
01 - General Conditions													
01 43 00	Office & Site Staff		360	$ 75.00							1	$ 1,500	$ 28,500
01 55 00	Traffic Control										1	$ 15,000	$ 15,000
01 59 50	Temporary Facilities	Temporary Toilets, Offices, Drinking Water									1	$ 30,000	$ 30,000
												Subtotal:	**$ 73,500**
02 - Site Construction													
02 07 00	Sitework Demolition & Removal	Topsoil Removal	90	$ 30.00				1	ea	$ 25,800			$ 28,500
02 33 00	Trench Excavation	Excavation	180	$ 46.00				90	hr	$ 250			$ 30,780
		Disposal									1	$ 21,797	$ 21,797
02 51 00	Asphalt Paving	Asphalt Restore									1	$ 20,000	$ 20,000
02 90 00	Landscaping										1	$ 20,000	$ 20,000
												Subtotal:	**$ 121,077**

IRON HEAD

SECURE WATER SUPPLY FOR UBC VANCOUVER CAMPUS

UBC SEEDS

April 08, 2018

Code	Description	Item	Labour		Material			Equipment			Subcontract		Total
			Man Hr	Rate	Qty	Unit	Rate	Qty	Unit	Rate	Qty	Rate	
33 - Utilities													
N/A	Pipe Placement			$ 27,000			$ 183,989.00			$ 113,400.00	1	$ 7,000	$ 324,389
N/A	Disinfection										1	$ 17,000	$ 17,000
												Subtotal:	**$ 341,389**
												Wesbrook Mall Water Main Total:	**$ 535,966**
												Water Main Total:	**$ 938,954**
												Water Main Contingency (15%)	**$ 140,843**
												Total Water Main Construction Cost (incl. O&P, PST)	**$ 1,247,813**

IRON HEAD

SECURE WATER SUPPLY FOR UBC VANCOUVER CAMPUS

UBC SEEDS

April 08, 2018

Code	Description	Item	Labour		Material			Equipment			Subcontract		Total
			Man Hr	Rate	Qty	Unit	Rate	Qty	Unit	Rate	Qty	Rate	
Underground Rectangular Concrete Reservoir													
01 - General Conditions													
01 10 50	Surveying		24	$ 145.00							1	$ 1,500	$ 4,980
01 33 01	Project Record Documents										1	$ 2,000	$ 2,000
01 41 00	Material Testing	Soil Compaction & Concrete Testing	116	$ 200.00							2	$ 3,000	$ 29,186
01 43 10	Project Manager		1600	$ 60.00									$ 96,000
01 43 20	Project Coordinator		1600	$ 35.00									$ 56,000
01 43 50	Safety Officer		80	$ 60.00									$ 4,800
01 44 00	Site Superintendent		1600	$ 65.00									$ 104,000
01 51 10	Temporary Power	Design, Install, and Consumption			10	MO	$ 350.00				1	$ 8,000	$ 11,500
01 55 00	Traffic Control										1	$ 8,000	$ 8,000
01 59 50	Temporary Facilities	Temporary Toilets, Offices, Drinking Water			10	MO	$ 100.00	12	MO	$ 1,550.00	1	$ 1,500	$ 21,100
01 71 00	Waste Management	Container Rental, Cleaning	40	$ 40.00				12	MO	$ 200.00			$ 4,000
												Subtotal:	**$ 341,566**
02 - Site Construction													
02 07 00	Sitework Demolition & Removal	16,800 m2 Demolition	78	$ 38.05	5,040	m3	$ 13.50	78	hr	$ 160.00			$ 83,396
02 15 00	Sedimentation & Erosion Control	Silt Fence	97	$ 33.50	387	m	$ 10.00						$ 7,111
		Cleaning	160	$ 33.50	10	MO	$ 500.00	10	MO	$ 850.00			$ 18,860
	Piling	Pile Setup									7	$ 6,000	$ 42,000
		Pile Driver									105	$ 75	$ 7,875
02 22 30	Excavation, Trenching, and Backfilling	Ecavation	1069	$ 37.50	80,185	m3	$ 13.50	1069	hr	$ 160.00			$ 1,293,651
		Backfilling	988	$ 37.50	44,445	m3	$ 30.00	988	hr	$ 205.00			$ 1,572,858
		Trenching	12	$ 34.00	596	m		12	hr	$ 225.00			$ 3,087
02 66 80	Yard Piping										1	$ 350,000	$ 350,000
02 90 00	Landscaping	Topsoil Placement, Hydro Seeding			16,800	sqm	$ 6.00				1	$ 10,000	$ 110,800
												Subtotal:	**$ 3,489,639**

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SECURE WATER SUPPLY FOR UBC VANCOUVER CAMPUS

UBC SEEDS

April 08, 2018

Code	Description	Item	Labour		Material			Equipment			Subcontract		Total
			Man Hr	Rate	Qty	Unit	Rate	Qty	Unit	Rate	Qty	Rate	
03 - Concrete													
03 10 00	Concrete Forming	Forman	640	$ 50.00	12,753	sqm							$ 32,000
		Labour	12,753	$ 41.45	12,753	sqm	$ 20.00						$ 783,652
03 20 00	Concrete Reinforcement	Materials & Off Loading			592,552	kg	$ 2.25						$ 1,333,243
03 30 00	Cast-in-Place Concrete	Materials & Pouring	6,956	$ 40.98	6,956	m3	$ 150.00				1	$ 40,000	$ 1,368,412
		Pumping			6,956	m3	$ 4.00	366.09287	hr	$ 180.00			$ 93,720
03 35 05	Concrete Finishes							30,633	sqm	$ 2.50			$ 76,584
												Subtotal:	**$ 3,687,611**
22 - Plumbing													
22 11 13	Process Piping	400mm dia. SS Pipe	368	$ 37.50	724	lm	$ 58.53	724	lm	$ 1.12			$ 56,987
		400mm SS 90 deg. Elbow	2	$ 37.50	10	ea	$ 99.79						$ 1,073
		400mm T	4	$ 37.50	14	ea	$ 99.79						$ 1,547
		400mm BV	2	$ 44.50	2	ea	$ 6,260.00						$ 12,609
		400mm Gate Valve	4	$ 44.50	4	ea	$ 15,727.00						$ 63,086
		150mm dia. SS Pipe	82	$ 37.50	204	lm	$ 60.34	204	lm	$ 1.03			$ 15,594
		150mm SS 90 deg. Elbow	3	$ 37.50	10	ea	$ 10.89						$ 221
		150mm T	1	$ 37.50	2	ea	$ 10.99						$ 59
		150mm Gate Valve	2	$ 44.50	2	ea	$ 1,850.00						$ 3,789
	Miscellaneous										1	$ 350,000	$ 350,000
	Contingency	50%									1	$ 252,483	$ 252,483
												Subtotal:	**$ 757,449**
16 - Electrical													
16 00 00	Electrical										1	$ 1,184,065	$ 1,184,065
												Subtotal:	**$ 1,184,065**
33 - Utilities													
33 44 01	Manholes & Catchbasins										1	$ 150,000	$ 150,000
												Subtotal:	**$ 150,000**

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SECURE WATER SUPPLY FOR UBC VANCOUVER CAMPUS

UBC SEEDS

April 08, 2018

Code	Description	Item	Labour		Material			Equipment			Subcontract		Total
			Man Hr	Rate	Qty	Unit	Rate	Qty	Unit	Rate	Qty	Rate	
Miscellaneous													
05 00 00	Metals										1	$ 355,220	$ 355,220
06 00 00	Wood & Plastics										1	$ 59,203	$ 59,203
07 00 00	Thermal & Moisture Control										1	$ 177,610	$ 177,610
08 00 00	Doors & Windows										1	$ 59,203	$ 59,203
09 00 00	Finishes										1	$ 118,407	$ 118,407
												Subtotal:	**$ 769,643**
												Reservoir Total:	**$10,379,973**
												Reservoir Contingency (15%)	**$ 1,556,996**
												Total Reservoir Construction Cost (incl. O&P, PST)	**$13,794,361**

APPENDIX D – SAMPLE CALCULATION

										H	L	W	water lvl		
Depth of soil on top		2.5	m					dimension of tank		5	120	30	4		
Sands, loamy sands		1.8	g/cm^3							Top	Bottom	Walls			
		1800	kg/m^3					Shell properties		0.15	0.3	0.25			
Dead load	4710150	kg	1308.375	kg/m^2	12830.78	N/m^2		Volume of conc		1960.113	m^3	u/w concrete		2403	kg/m^3
Live load	900000	kg	250	kg/m^2	2451.663	N/m^2		volume of water		14101	m^3	u/w water		1000	kg/m^3
water	14101000	kg	3916.944	kg/m^2	38412.1	N/m^2									
soil	16200000	kg	4500	kg/m^2	44129.93	N/m^2		top/bottom slab		3600	m^2				
uplift	12600000		3500		34323.28										
Load combination								Lateral:		Water		Soil			
1	83264	N/m^2													
2	159641	N/m^2						Wall Long		9417600	N	15892200	N		
3	101291	N/m^2						Wall short		2354400	N	3973050	N		
4	17849	N/m^2													
5	28219	N/m^2													
Reinforcement in Flexure				1.3U		207533	N/m^2								
Direct Tension/hoop reinforcement				1.6U		255426	N/m^2								
Excess shear				1.3U		207533	N/m^2								
Compression+flexure				1.0U		159641	N/m^2								

Property of Concrete					Design Factors					MSA	20	mm			
f'c	25	Mpa	2.50E+07	N/m^2	\phi_s	0.85									
Density of Concrete	1800	kg/m^3	\rho_b	0.022727	\phi_c	0.65									
	17640	N/m^3			\alpha_1	0.8125									
Ec	16200.66572	Mpa	16200665722	N/m^2	\beta_1	0.9075	0.9075								
Property of Steel					Cover	40	mm	0.04							
fy	400	Mpa	400000000	N/m^2											
					Cross Section of Beam					Deflection Control			Cross Section of Column		
Property of Rebar			Area(mm^2)		b	500	mm	0.5	m	h_min	452.381		b	500	mm
Stirrup	10	M	100		h	800	mm	0.8	m	h>h_min?	YES		h	500	mm
	15	M	200		L	10000	mm	10	m						
	20	M	300		d	730	mm	h-70							
	25	M	500		d'	70	mm								
	30	M	700												

Design Beam Check										mm				
Flexural Resistance		kNm	Tension at bottor	1800			Spacing of longitudinal reinforcement			42	1.4db		Maximum number of bars per layer:	
Mr(from Sap2000)	962.9031818	kNm	Tension on Top	655						28	1.4MSA		#of Rebars	5
As from Direct Method	4638.548519	mm^2	Asb	9090.909	mm^2	Steel Failure				30			Rebar Size	30
				# of rebars	Actual As(mm^2)				Spacing:	42			If section fits?	YES
Longitudinal	10	M	100	47	4700									
	15	M	200	24	4800		Compression Steel							
	20	M	300	16	4800		a	421.575	mm	Total As	8011.219	mm^2		
	25	M	500	10	5000		Mrb	1604.83864	kNm	# of tension steel	10			
	30	M	700	7	4900		Mr1	962.903182	kNm	# of compression steel	5			
Actual Mr							Mr2	837.096818	kNm				Two layers of 5	Tension
a	257.5147929	mm					Cr2	1146.70797	kN				One layer of 5	Compression
Mr	1022.112426	kNm	If capacity>loading				A's	3372.6705	mm^2				30M	
			YES				As2	3372.6705	mm^2				The water table is at 3m	

Shear Resistance	Shear from Sap2000	500	kN				
dv	657	mm					
beta	0.18	min reinforcement					
	0.138805069	no reinforcement		*For being conservative, choose beta with no reinforcement.*			
Vc	148.1917622	kN					
Vs	351.8082378	kN			Check if the section is ok:		
s	181.5951792	mm			maxVr	1334.531	OK
s_max	600						
s	533.3333333	mm					
governing s	181.5951792	mm	180	mm			

Column Check	M1 from Sap2000	0	kNm	Pf	1200	kN			Assume non-sway but may not actually be the case.
	M2 from Sap2000	400	kNm	*M1 should always be smaller than M2.*					Real case should have k somewhere between pinned and fixed.
Slenderness Check	Lu	4	m	4000	mm				
Fixed k	0.5		kLu/r	13.85641					
Pinned k	1			27.71281					
			from loading	57.05443					
		Can slenderness be ignored? YES							
Moment Maginification									
cm	0.6								
\beta_d	0.75	From assumption, may or may not be valid.							
EI	1.92865E+13	N*mm^2							
Pc-fixed	47587.54813	kN		Check if min eccentricity satisfie			YES		
Pc-pinned	11896.88703	kN		use \rho_t	0.03				
Magnification Factor-fixe	0.620875216				7500	mm^2	# of rebars	15	
MF-pinned	0.693232061			\gamma	0.7			5 rebars on each side	
Design Mr	277.2928244								