University of British Columbia

Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Emergency Water Supply for the UBC Vancouver Campus

Prepared by: Yekta Kaya, Mengyang Liu, Davis Philps, Daryl Roldan, Matt Senior

Prepared for:

Course Code: CIVL 446

University of British Columbia

Date: 16 April 2021

SEEDS Sustainability Program

UBC sustainability

UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Emergency Water Supply for the UBC Vancouver Campus

Author/s:

Yekta Kaya

Mengyang Liu

Davis Philps

Daryl Roldan

Matt Senior

University of British Columbia

CIVL 446

April 16, 2021

EXECUTIVE SUMMARY

In the event of a failure of the main water supply to the UBC Vancouver Campus, an alternative source of water must be relied on. To address this need, Team 22 completed a final technical design for an emergency groundwater supply that provides a safe, sustainable, and resilient source of water for UBC's population during an emergency.

The final design consists of ten groundwater wells that will draw water from the aquifer located in the Quadra Sand Layer beneath the UBC campus. Both the wells and storage structures are in the Arthur Lord, Frank Buck, and Wolfson East fields in the southern section of campus, just east of Thunderbird stadium. The design makes use of a high production rate for a quick provision of water and minimal pump usage. The multiple wells provide ample resilience to the system allowing it to be confidently relied upon in an emergency. Due to the permanent underground storage tank, it will also allow UBC to use it for regular operation and lower their reliance upon Metro Vancouver. The design was evaluated based on criteria concerning economic, environmental, and social aspects to fully evaluate the designs sustainability.

Team 22 has estimated the total cost of the project to be $2.66 million, including costs for the construction of the wells and storage tank, as well as operations and maintenance of the system. Construction of the project will take part in three main phases: well construction, storage construction, and project finalisation. It is expected to begin in May 2021 and last for 38 days. Detailed breakdown of the construction schedule and cost estimate are provided in the body of the report.

Table of Contents

List of Figures

List of Tables

1.0 Introduction

As a large academic and living community, UBC and its surrounding residential areas need to accommodate many students, professors, staff, and residents. To ensure their normal study, work and living needs, an adequate water supply is essential. Although UBC's current water supply system meets the requirements of daily water demands; emergencies, such as water system failure or water pollution could prevent the flow of normal water supply system. To avoid any inconvenience caused by the interruption of the water system, Team 22 was tasked to design an emergency water supply plan for UBC Vancouver Campus and the surrounding area.

The design ideas will be introduced in three main sections in the report. The key components will be explained in detail in the first section, which includes the quality and quantity of daily water demand. Secondly, the design scheme of each component in the water supply system are explained and illustrated. And finally, the construction schedule and cost estimate will be presented thereafter to provide more information about details needed for project onset.

2.0 Summary of Key Concepts

The following sections outlines and gives and overview of the key components of the project and the site of construction.

2.1 Project Overview

For this project, Team 22 determined UBC's requirements for water in the event of an emergency and assessed the feasibility of sourcing the water through means such as the use of groundwater wells, an emergency storage system, or a combination of both.

UBC has a peak population of 72,000 people per day and anticipates an increase in population to 80,000 by 2030. If an emergency occurs when UBC is at its peak occupancy, all these people need to be included in the anticipated water demand. Currently, water is provided to the UBC area by Metro Vancouver through two water mains that flow along 16th Ave. This presents a significant risk to UBC's water supply due to a lack of redundancy. An interruption of service to the water supply to UBC would cause the campus to face many challenges. Therefore, a key consideration of this project would be to make the campus' water supply more resilient.

One of the challenges making UBC's water system resilient is the campus' location along the Cascadia Subduction Zone. This location presents a high likelihood of seismic events and thus, there is a significant risk to the traditional water main infrastructure system. It also means there is a higher likelihood for an emergency event to occur and cause a service interruption to UBC's current water infrastructure.

2.2 Site Overview

UBC is located roughly 10km west of Downtown Vancouver. It is situated on the Quadra Sand Layer. Multiple aquifers reside in the sand layer and could possibly be tapped to provide water to the campus. The Quadra Sand Layer is currently being used to provide water for the City of White Rock and thus presents a viable option for the UBC campus.

Additionally, the Sasamat Reservoir is already present at UBC and could be retrofitted to work in unison with the water well developments. Finally, there are two pre-existing water mains that are currently used to provide water to UBC from Metro Vancouver.

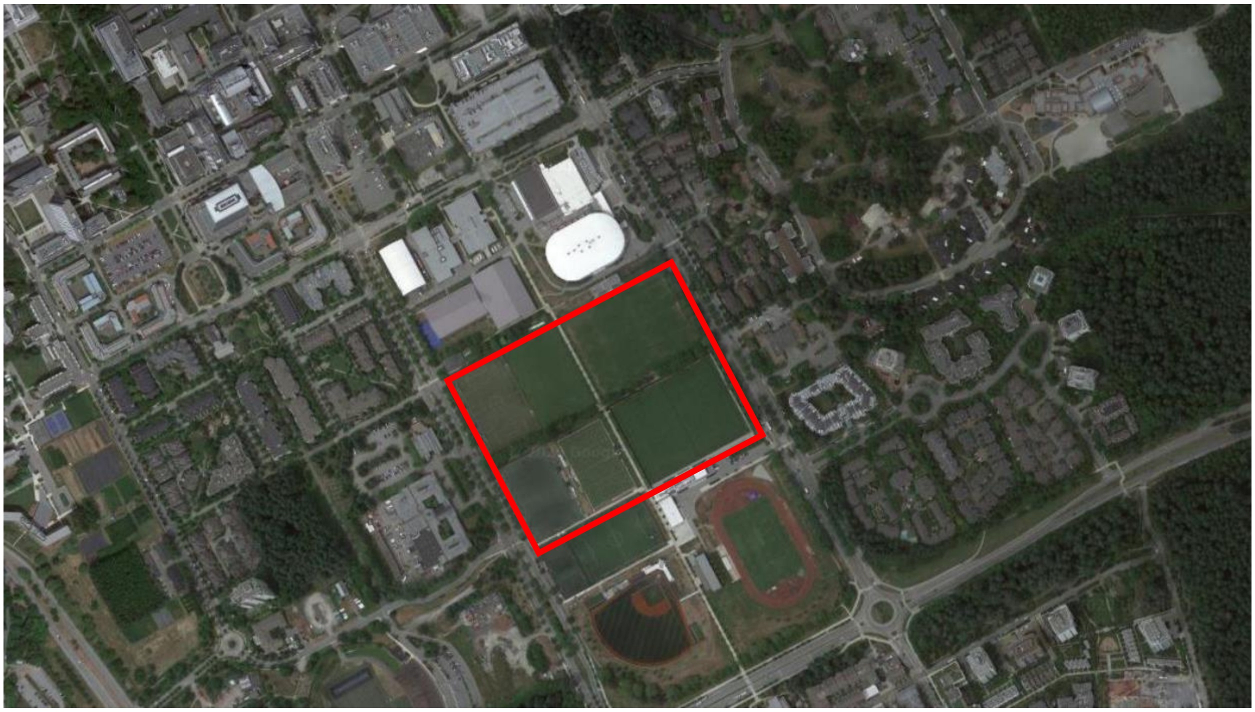


Figure 1. Aerial View of the Site

3.0 Design Criteria

This section explains significant design parameters and criteria and is divided into four sections: population estimation, water demand calculation, social benefits, and design constraints.

3.1 Population Estimation

A detailed emergency water supply plan requires a population estimation to determine the water demand. The surrounding areas of UBC is assumed to be affected when an emergency occurs and is considered in the population estimation. Therefore, the population estimation includes UBC students and staff as well as residents of the Point

Grey area. Based on the UBC 2019 – 2020 Annual Overview and Facts report, the UBC Vancouver campus has 45,611 undergraduate students, 10,379 graduate students, 5,711 faculty members, and 10,736 staff and the population growth rate has remained at roughly 2.5% per year. (University of British Columbia, 2020) . According to the census report from the City of Vancouver, the West Point Grey area had a population of 13,065 in 2016 and a population growth rate of 2.1% over 5 years (City of Vancouver, 2021). By using the population estimation formula, the population will approximately increase to 82,500 by 2030. The detailed calculation result is shown in Appendix C.

3.2 Water Demand Calculation

Daily water consists of many components: personal water needs, irrigation, and industrial and experimental uses. The primary objective of the project is to meet the daily water needs of the residents and provide essential water for medical use during the emergency period. Irrigation, industrial, and experimental water use are not counted in this calculation, and they will be explained in the constraint section. The population estimated in Section 2.1 will be used to determine the water demand for each person per day to obtain the overall daily water demand.

Generally, daily domestic water consumption in Canada is 190 /cap, which consists of 66 L of bathing water, 57 L for toilet flushing, 38 L for laundry, 10 L for cleaning and waste, and 19 L for drinking and cooking water. In the project, unnecessary daily water supply will be reduced during the emergency period. To maintain proper health and hygiene, the daily drinking water supply is maintained at 19 L/cap and the daily toilet water is maintained at 57 L/cap. Other daily water consumption is reduced to 50% of the original number; the bathing, laundry, and cleaning water is 33 L/cap, 19 L/cap, and 5 L/cap, respectively. The overall adjusted water supply plan is 133 L/cap/day for the Point Grey and UBC residents. For the students, professors and staff who are not living on campus, the water supply plan provides half a day of drinking and toilet water services. Therefore, the final water demand for these people is 38 L/cap.

Once the population estimation and the water supply plan are determined, the water demand for residential use can be calculated to be 4,453,000 L/day.

The plan also needs to address the medical water demand. Since the water for medical use has a direct impact on people's health, the project will not reduce the water supply for this aspect. According to the World Health Organisation statistics, the average medical water use in Canada is 1,350 L/bed/day, and the UBC hospital has 332 beds for patients (World Health Organization, 2021). Therefore, the total daily water demand for medical use is 448,200 L/day.

The total amount of residential and medical water demand for the UBC campus and surrounding West Point Grey area is 5,040,000 L/day. The detailed water demand calculation is shown in Appendix C.

3.3 Design Constraints

The irrigation and experimental water use are a large portion of UBC's normal water use. During the emergency period UBC must ensure that the water supply for experimental and irrigation use is limited. Therefore, when the emergency water supply plan is initiated, UBC should quickly inform all students, professors, staff, and surrounding residents of the emergency water supply situation and delay experimental and irrigation water use until the main water system is restored.

Secondly, although the project scope does not include a complete water disinfection system, the design of a treatment system for contaminants of concern is to be contracted out (details provided in Section 4.1). The groundwater will also be tested regularly to confirm that the selected water source meets the requirements of the Fisheries Act, Canadian Environmental Assessment Act, Environment Canada, and BC Water Sustainability Act, and all other related acts and guidelines.

Other constraints and assumptions include:

- Emergency water supply is not including laboratory and irrigation use.
- The groundwater resources meet the requirements of Canadian drinking water quality.
- The emergency water supply plan can address interruption for 5 to 7 days.
- Some surrounding trees and facilities will need to be removed.

4.0 Water Quality and Treatment System

Water quality testing will be carried out (detailed in Section 6.3) to ensure the following guidelines from the BC Health Act and Regulations are met:

- 4-log removal of viruses
- 3-log reduction in parasites
- 2-Pathogen Reduction Barriers
- <1 NTU of turbidity

The emergency groundwater supply draws from the Quadra Sand Layer, which for the purposes of water quality will be considered a seasonally stable, confined source (no hydraulic surface interactions). The source is classified as "low risk" of containing pathogens, therefore does not require disinfection to be considered potable. Potential contaminants of concern include material leached from soil and gases from anaerobic organisms. The maximum allowable concentrations according to the BC Source Drinking Water Quality Guidelines for major contaminants of concern are as follows:

Table 1. Max Allowable Concentration for Contaminants

Contaminant	Max Allowable Concentration (MAC)
Arsenic	0.01 mg/L
Lead	0.005 mg/L
Manganese	0.12 mg/L

The full list of contaminants can be found in the Source Drinking Water Quality Guidelines. The two most effective methods of removing the above contaminants in the context of our supply include an ozone injection system and media filtration. The detailed design of these components is to be contracted to a suitable engineering consultant.

5.0 Detailed Design

5.1 Design Parameters and Load

System demands are based on a reduced personal water demand of 133 L/cap/day for the Point Grey and UBC residents and 38 L/cap/day for the students, professors and staff who reside off-campus. A total daily medical water demand of 448,200 L/day was included. Total daily demands for the UBC Vancouver campus were then estimated to be 5,030,000 L/day (58.2 L/s).

Water quality will be monitored and treated as necessary according to BC Source Drinking Water Quality Guidelines (refer to Section 4.1).

5.2 Storage Tank

The storage tank will be constructed of reinforced concrete for the top and bottom slabs and retaining walls, with dimensions of 50 m x 50 m x 10 m for a total storage volume of 25000 m^3. The tank is to be lined with a waterproof membrane. The storage tank was designed as a concrete structure in accordance with CSA A23.3-14.

The storage tank was sized to provide water supply for maximum of 7 days during an emergency event occurring at UBC. The tank will be filled up to 90% of its volume capacity, storing 22,500 m^3 of water before being discharged. Once the storage tank reaches this capacity volume, the sensors installed in the storage tank should alert the system and pumps should stop working. After the emergency state is over and water is supplied to UBC through the regular distribution system, it takes approximately 7 days to fill up the tank. The system is designed for the well pumps to operate 20 hours/day and a detailed operating schedule should be prepared by the operator. Figure 2 below shows the tank volume modelled against 14 days, where the first 7 days emergency water is supplied and the water volume in the tank is decreasing each day. The tank water storage capacity is reached after the next 7 days:

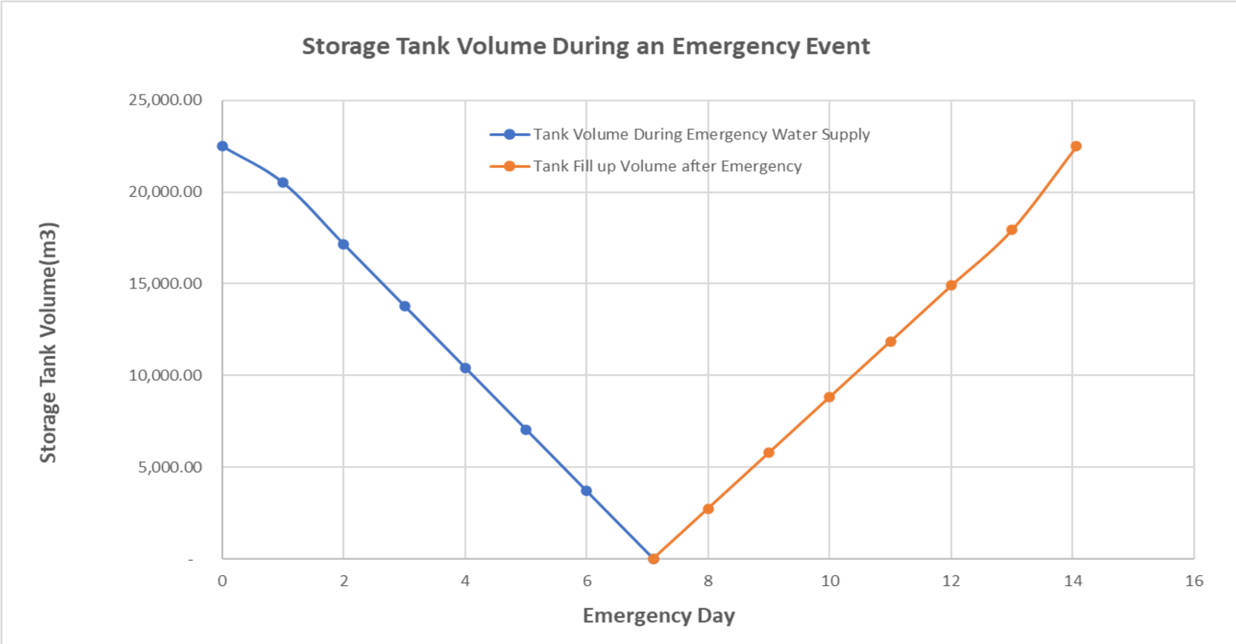


Figure 2. Storage Tank Volume during Emergency Event

5.3 Well Design

The locations of the wells were determined so that the minimum distance between them was 15 m, to avoid cones of depression, per the BC Groundwater Protection Regulation. All wells are assumed to have a lower aquifer and a well depth of 100 m below ground elevation; however, this may slightly vary based on the exact location.

All wells were designed in accordance with Regulation 903 amended under the *Ontario Water Resources Act 1990,* as it was assumed that the B.C. regulations would be similar in content. Each well has a diameter of 12'' and will have an 18" stainless steel casing to comply with annular spacing requirements. For a drilled well, a fluid based flushing method must be used. Water will be used as it is the simplest fluid to acquire and will be adequate in this situation. The steel casing will be lowered into the borehole as it is drilled, and the segments of the casing will be welded together due to its large diameter to create watertight seals. Grout and gravel will be poured into the annular space to affix the casing in place. The well screen will be installed using the open hole - double string method where the screen is inserted as part of the casing when the well is being drilled. This minimizes the risk associated with heaving but does not significantly reduce the column strength of the well, which is important due to its depth.

5.4 Pump Design

The pumps are designed to have a gravity feeding system, where the water is supplied from the storage tank to the existing pump house station West Mall without the use of additional pumps. Each well has a Grundfos SP215-8-AA model submersible well pump shown in Figure 3, pumping out the groundwater in the lower aquifer through 8'' PVC pipes through a 20 m x 20 m Pump House Station and supplying it to the underground storage tank through a 300 mm diameter Ductile Iron pipe.

Figure 3. Grundfos SP 215-8-AA submersible well pump.

The pumps provide a head of 187.1m (see Appendix C for calculations) to the system and the total head in the storage tank is 180m. There is 95 m static difference due to well depth, plus the friction losses in the PVC pipe that are accounted for. The Hydraulic Grade Line (HGL) Curve of the system is shown in Figure 4 below.

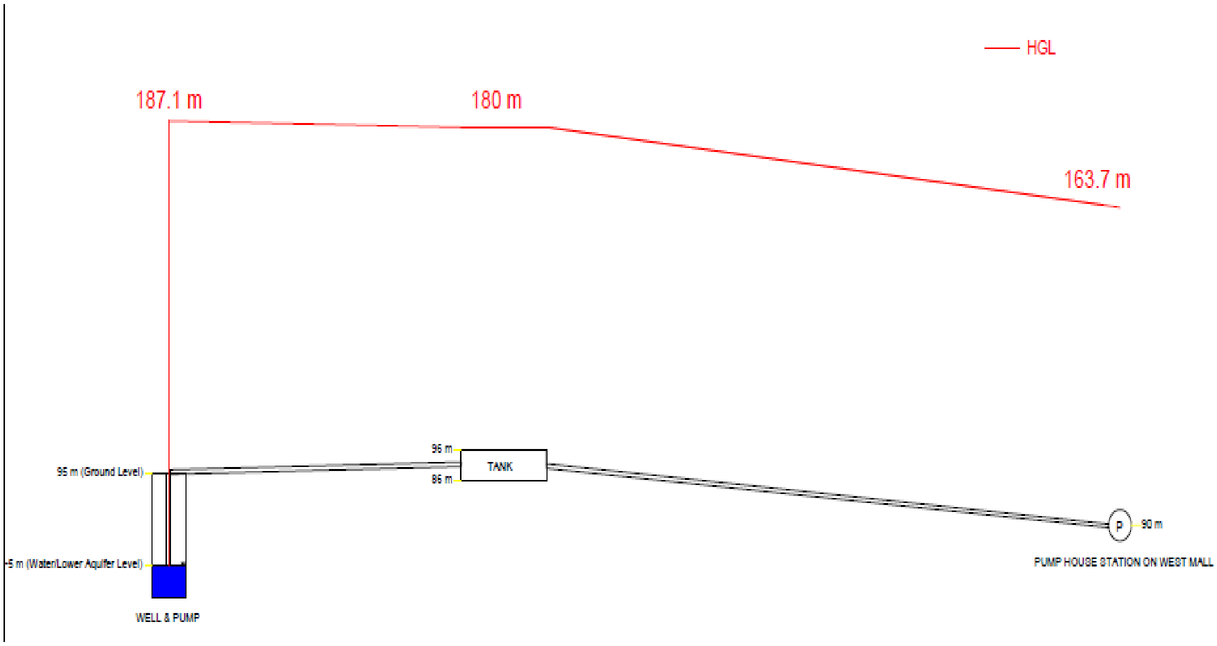


Figure 4. HGL Curve of the System

Having a 180 m head in the tank for water distribution allows a velocity between 0.8 m/s - 2 m/s in the pipes, and a pressure between 28-105 m at each node, meeting the *2016 Surrey Design Criteria requirements*. These requirements are tested and validated through an EPAnet model (the results of the model can be found in Appendix D).

The pumps will operate at a flow of 61.2 L/s, which is slightly higher than the daily demand of 58.2 L/s during an emergency event. In addition, pumps will operate at an efficiency of 82%, each consuming 156.4 kW power while operating at a full speed of 2900 rpm. Sensors should be installed in the pump and the storage tank, so that the pumps stop working when the tank is full. The pump performance curves showing the head provided by the pump and the power consumption & efficiencies for different flow rates, obtained from Grundfos, is shown in Figure 5 below:

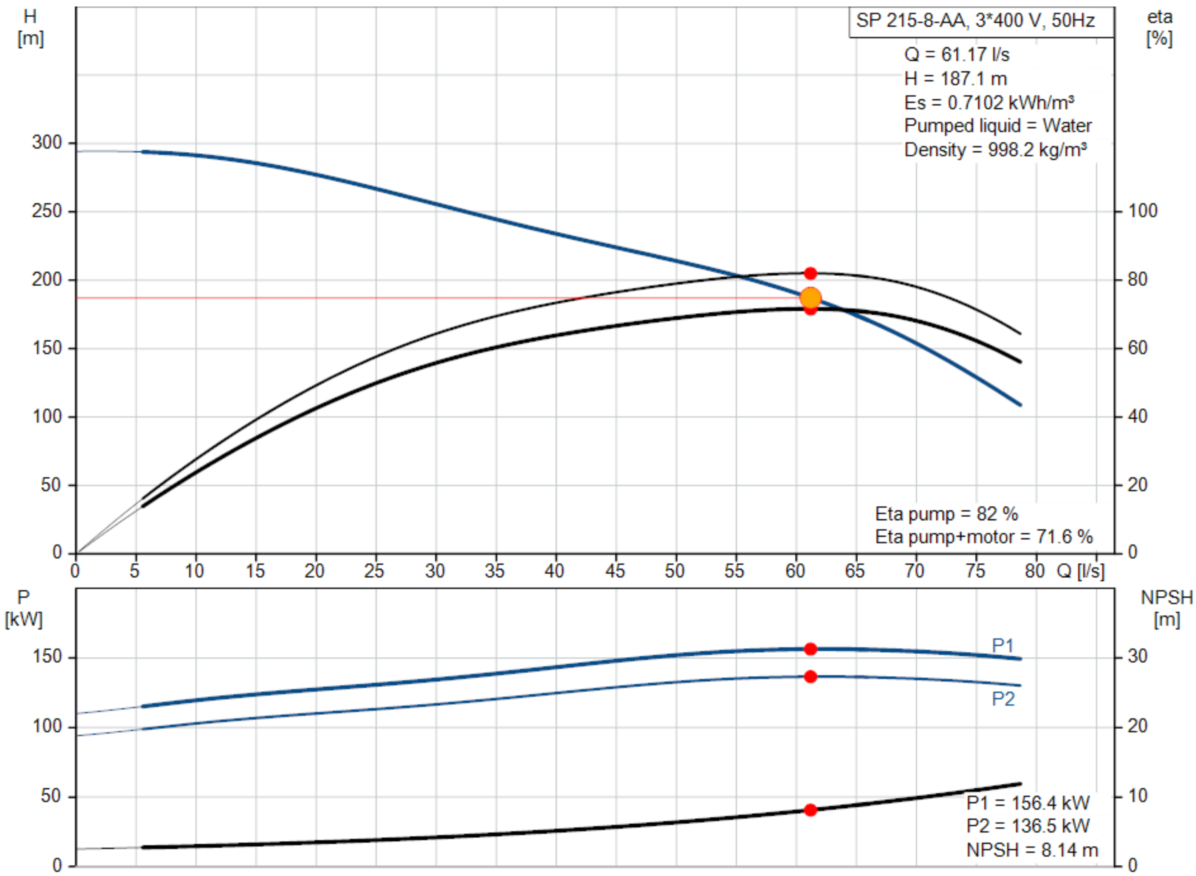


Figure 5. Pump Performance Curve

The detailed properties of the pump, specifications and motor performance curves can be found in Appendix D.

5.5 Pipe Distribution System

The distribution system consists of 1320 m of 2" PVC pipe delivering the pumped-out groundwater to the storage tank and 1450 m of Ductile Iron pipe supplying the water from the tank to the existing Pump House Station on West Mall to be connected to the existing network. The location of gate valves is provided in the design drawings (see Appendix B). For the installation and location of gate valves, refer to the *City of Vancouver - Waterworks Standard Detailed Drawings W3.1 and W3.2*. For 45 degrees elbow connections and pipe fittings, refer to *W1.2 Standard Detailed Drawing*

6.0 Service-Life Maintenance Plan

The service-life maintenance plan for the water supply system proposed by Team 22 is described in the following sections. An operations and maintenance manual will be transferred over to the clients that is included in the project hand-off. This will include more detailed information about steps and procedures in the upkeep and preservation of the system.

6.1 Storage Tank

According to various tank manufacturers and consultants, it is imperative that maintenance of the storage tank is done properly for the benefit of a healthy water supply. Because concrete is a porous material, it will be vulnerable to leaks and cracks over time. A contractor will be hired to ensure that proper maintenance and repair will be included in the service provided. For instance, SUEZ in North America will be retained as the concrete water tank repair contractor as they offer various solutions and innovative technology to different industries, including water resources, in Canada. Their main goal is repair, clean, and apply high-performance coatings to water storage tanks to extend the service life and prevent water quality issues.

Annual inspections will include detailed reports and assessments that review safety, sanitary, security, substrate, and coatings condition of the tank. Their reports will determine the following rehabilitation/maintenance need. They have a guarantee that the materials and coatings utilized by their team are ANSI/NSF Standard 61-approved and meet AWWA standards. While the cost might seem to be excessive, these services have a value to the project. Being able to maintain the underground storage tank can extend the service life of the tank, maintains the value of the system, which is a better alternative than the replacement after a few years. These maintenance services will also enable the tank to be compliant to safety and sanitary regulations, which can take the burden off UBC SEEDS. The coatings also come with a lifetime warranty, which can span the longevity of the project life.

6.2 Pumping Test

A pumping test is required in one of the well locations to ensure that the designed well conditions and criteria are met. This work is to be subcontracted to an experienced and verified well driller or well pumping tester in accordance with *Section 50 of the Water Sustainability Act.* The water should be pumped at a constant rate and the drawdown rate should be noted by the tester. An observation well should be placed near the pumped well to examine the effects of pumping on nearby groundwater. The following items should be measured by the tester:

- Maximum yield from the well
- Impacts on neighbouring wells and water bodies. Cone of depression
- Aquifer properties; permeability and boundary conditions
- Aquifer's ability to store and transmit water.

The measurements should continue after the pump has stopped working, to examine the effects when water is not withdrawn. Prior to testing, proper consideration should be taken on the well diameter, desired pumping rate and power source etc. The planning, measurements and testing should meet the *Water Sustainability Act* and best management practices should be applied. The *Guide to Conducting Pumping Tests* provided by the Province of British Columbia can be used as a guidance. The results must be shared with the consultant, to examine the results verifying that the well performance indicators meet design expectations.

6.3 Water Quality & Testing

In accordance with Metro Vancouver and their water quality testing approach, Team 22 proposes a multi-barrier approach to the testing of the emergency water distribution system. A monitoring program will be implemented so that the system can be safe and clean from contaminants. Since water must comply with health standards set out in the BC Drinking Water Regulation, testing stations within the distribution system will be set up. Frequent testing is recommended in these stations and the frequency will be determined after the initial quality testing done by the water engineer.

Guidelines and standards that will be looked for in these tests include the following:

- Temperature (Degree C) < 15
- Turbidity (NTU) < 1
- Free Chlorine (mg/L) > 0.2
- pH: 7.0-10.5
- E. coli (cfu/100ml) = 0

7.0 Construction Management

Team 22 will handle management of the construction phase with the team focusing on works and practices meeting the following standards and regulations:

- BC Building Codes and Standards
- Occupational Health and Safety Regulations
- Master Municipal Construction Documents Manual (MMCD)
- UBC Technical Guidelines

General contractors and subcontractors will be required to present all proper certifications and requirements as directed by client and the team.

The following section will describe the construction methods and schedules that will be followed throughout the construction phase.

7.1 Construction Method

Due to the geological composition of the proposed well sites, the most efficient method is to drill the wells. Other methods would be too slow or unable to reach the large depth required. For 18” well casing we will use a 24” bore hole to comply with requirements regarding annular space. Water will be used as a flushing method as this works best with the sand and clay soil present. The steel casing will be lowered into the oversized hole as it is drilled, and the smaller segments of steel will be welded together using three passes to form watertight joints. Grout and gravel will be poured into the annular space to affix the casing in place. The well screen will be installed using the open hole - double string method where the screen is inserted as part of the casing when the well is being drilled. This minimizes the risk associated with heaving but does not significantly reduce the column strength of the well, which is important due to its depth.

The underground storage tank located under the field will be excavated using machine excavators. The steel reinforcement will then be laid, and a concrete boom pump will be used to pump the concrete into the forms. Utility trenches will be excavated where piping will be laid to connect the storage to the main water lines. The lines will then be laid in place, thrust blocks created, and then the trenches filled. After construction, the sod on the field will be resodded so the remainder of the fields can be utilised.

The size of above ground water tanks necessary for this project are too large to be bought pre-built. Thus, the materials will be acquired separately, and the tanks will be assembled and installed onsite.

7.2 Construction Schedule

A schedule for the construction of the project was prepared. It is anticipated that the project will have a total duration of 38 workdays. Shown in Figure 6 is a timeline of the anticipated project schedule. The project was divided into three sections and the longest section to construct is the construction of the underground storage tank. With an expected start date of May 3rd, 2021, construction is expected to conclude on June 19th, 2021, and the system to be fully functional by June 25th, 2021.

As the treatment facility design will be outsourced, its duration in the construction schedule is only a preliminary estimate, however it should not be a critical item in the finish date of the project as the start date is not dependent on any other component and could be moved forward if necessary.

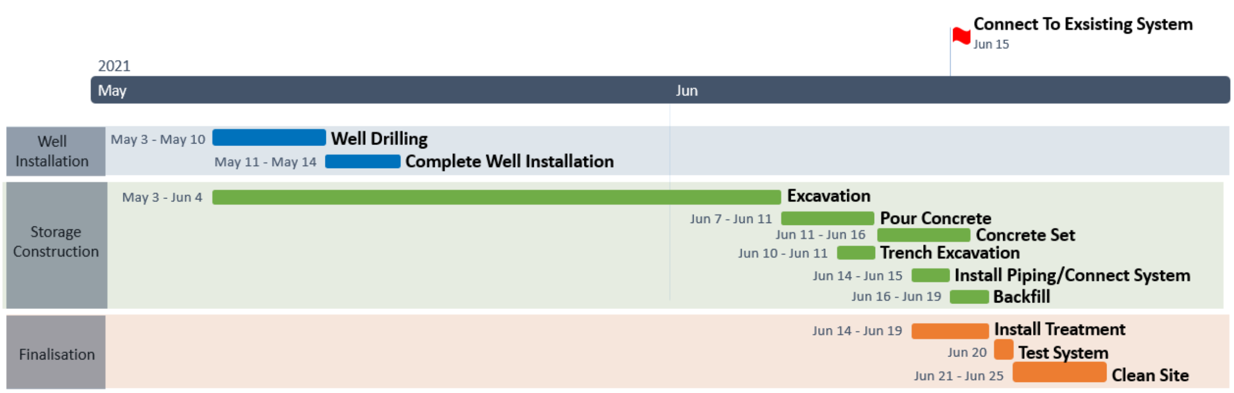


Figure 6. Project Construction Timeline

7.3 Anticipated Issues

Issues are guaranteed to happen on a construction project, especially with a large one as this one. The following are anticipated issues that may or may not cause negative impacts and it is efficient to come up with a contingency plan before any of them occur:

- Coordination with existing utilities and active construction (detailed Traffic Management required)
- Excavation risks (shoring collapse, soil erosion, sedimentation)
- Poor soil conditions
- Delays due to human errors.

8.0 Cost Estimate

The cost of the project is anticipated to be $2,662,000. The Class A cost estimate was created by determining the individual components from the design drawings and assembling the individual costs. Project management costs were taken to be 7% of the total construction costs of the project due to its large scale. An additional 10% contingency was added to account for any unexpected costs or incidents that occur during construction. A summary of the cost of each component is presented in Table 2 and a detailed estimate is available in Appendix B.

Table 2. Cost Estimate

Project Costs	**$167,500**
Wells	$1,410,000
Storage	$512,000
Piping	$141,300
Other Construction Costs	$192,500
Total (incl. contingency)	**$2,662,000**

The system is anticipated to cost $14,000 per year to operate due to electricity and maintenance costs. This value includes regular maintenance and electricity usage.

References

City of Surrey. (2021, January 15). *Design Criteria Manual.* Retrieved from https://www.surrey.ca/sites/default/files/media/documents/DesignCriteriaManualApril2020.pdf

City of Vancouver. (2021, November 01). *About Vancouver*. Retrieved from Population: https://vancouver.ca/news-calendar/population.aspx#:~:text=The%202016%20Census%20population%20for,home%20and%2016%25%20speak%20Chinese.

City of Vancouver. (n.d.). *Drinking Water Monitoring and Results*. Retrieved April 01, 2021, from https://vancouver.ca/home-property-development/drinking-water-monitoring-and-results.aspx#:~:text=Once%20water%20enters%20Vancouver's%20distribution,does%20not%20contain%20lead%20pipes.

Government of British Columbia. (2021, November 01). *Groundwater Protection Regulation*. Retrieved from British Columbia: https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/laws-rules/groundwater-protection-regulation

Government of British Columbia. (2021, April 01). *Guide to Conducting Pump Tests.* Retrieved from https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/water-wells/guide_to_conducting_pumping_tests.pdf

Government of British Columbia. (2021, November 01). *Source Drinking Water Quality Guidelines.* Retrieved from Water Quality Guideline Series:

https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/approved-wqgs/drinking-water-and-recreation/source_drinking_water_quality_guidelines_bcenv.pdf

Government of British Columbia. (2021, November 01). *Water Sustainability Regulation.* Retrieved from Water Sustainability Act: https://www.bclaws.gov.bc.ca/civix/document/id/crbc/crbc/36_2016

Government of Ontario. (2021, November 01). *Ontwario Water Resources Act, R.S.O. 1990.* Retrieved from Laws: https://www.ontario.ca/laws/statute/90o40

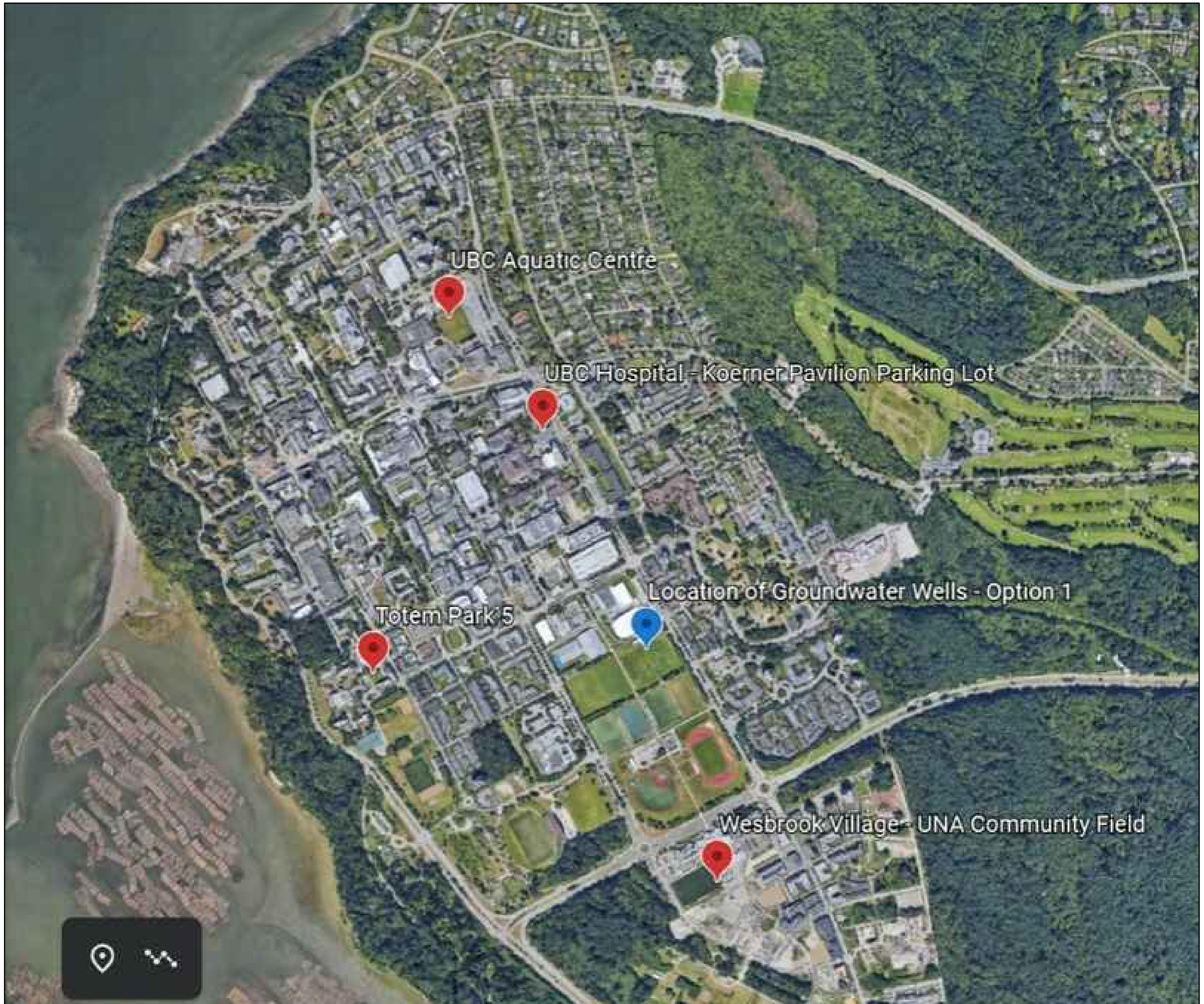
SUEZ in North America. (n.d.). *SUEZ in North America*. Retrieved April 01, 2021, from https://www.suez-na.com/en-us

University of British Columbia. (2020, November 01). *UBC Overview & Facts*. Retrieved from The University of British Columbia: https://www.ubc.ca/about/facts.html

World Health Organization. (2021, November 01). *Water, Sanitation, and Hygiene (WASH).* Retrieved from https://www.who.int/health-topics/water-sanitation-and-hygiene-wash

Appendix A: IFC Drawing Set

EMERGENCY WATER SUPPLY FOR UBC VANCOUVER



General Notes

No.	Revision/Issue	Date

Firm Name and Address

TEAM 22

Project Name and Address

EMERGENCY WATER SUPPLY FOR UBC VANCOUVER

Project #17532	Sheet COVER
Date MAR 5, 2020	
Scale NTS	

General Notes

No.	Revision/Issue	Date

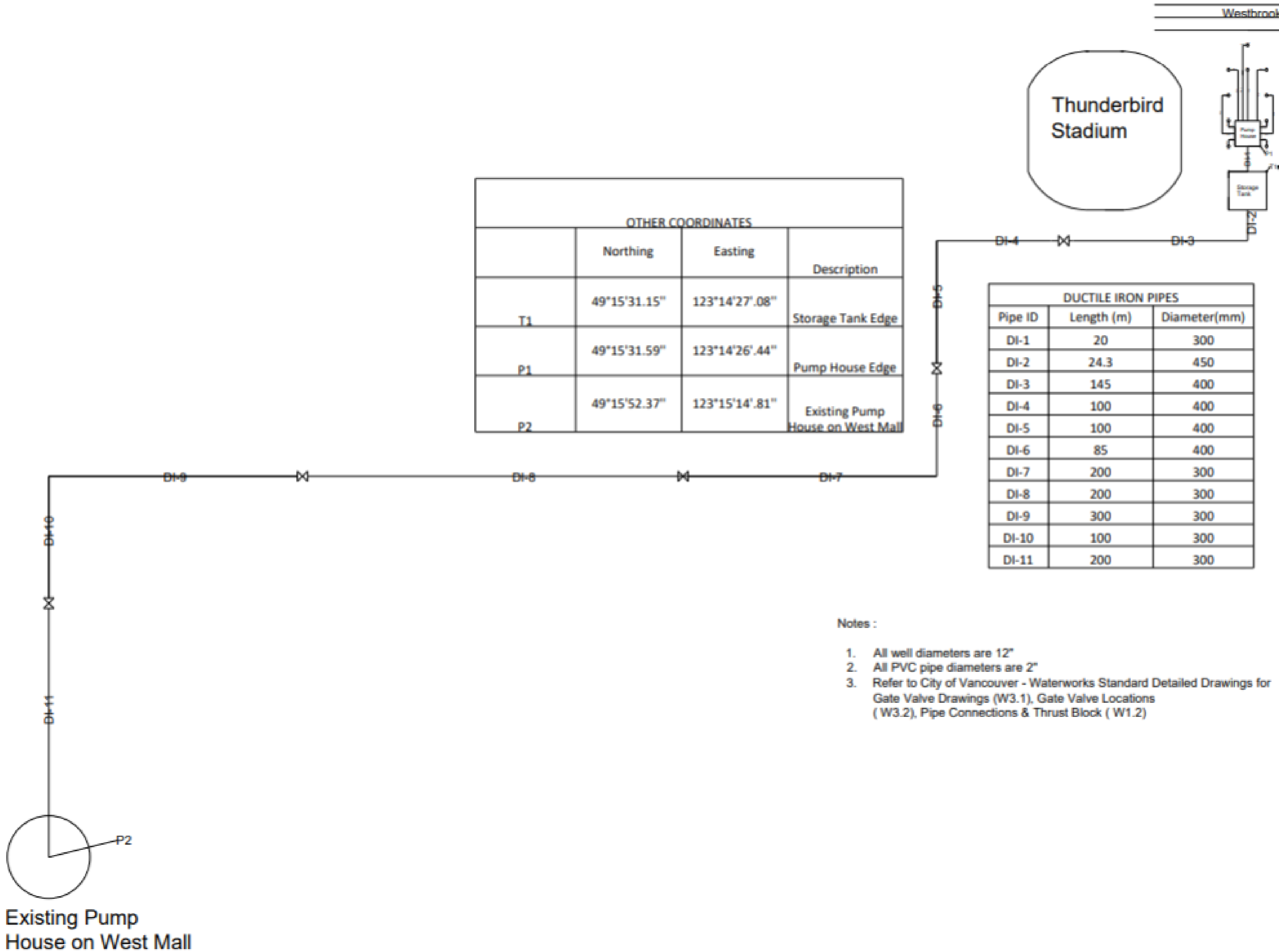
Firm Name and Address

TEAM 22

Project Name and Address

EMERGENCY WATER SUPPLY
FOR UBC VANCOUVER

Project #17532	Sheet SITE PLAN
Date MAR 5, 2020	
Scale NTS	



Well I.D	Top Elevation(m)	Tip Elevation(m)	CP Northing	CP Easting
W1	96.5	-3.5	49°15'31.42"	123°14'26'.23"
W2	96.4	-3.6	49°15'32.31"	123°14'26'.90"
W3	95.9	-4.1	49°15'31.77"	123°14'25'.49"
W4	96	-4	49°15'32.62"	123°14'26'.08"
W5	95.6	-4.4	49°15'32.08"	123°14'23'.74"
W6	95.7	-4.3	49°15'32.94"	123°14'25'.23"
W7	95.4	-4.6	49°15'32.39"	123°14'23'.74"
W8	95.4	-4.6	49°15'33.25"	123°14'24'.40"
W9	95.2	-4.8	49°15'32.83"	123°14'24'.00"
W10	95	-5	49°15'33.04"	123°14'23'.44"

OTHER COORDINATES

	Northing	Easting	Description
T1	49°15'31.15"	123°14'27'.08"	Storage Tank Edge
P1	49°15'31.59"	123°14'26'.44"	Pump House Edge
P2	49°15'52.37"	123°15'14'.81"	Existing Pump House on West Mall

DUCTILE IRON PIPES

Pipe ID	Length (m)	Diameter(mm)
DI-1	20	300
DI-2	24.3	450
DI-3	145	400
DI-4	100	400
DI-5	100	400
DI-6	85	400
DI-7	200	300
DI-8	200	300
DI-9	300	300
DI-10	100	300
DI-11	200	300

PVC PIPES

Pipe ID	Length (m)
P1.1	5
P1.2	4
P2.1	5
P2.2	4
P3.1	4
P3.2	5
P4.1	4
P4.2	5
P5.1	4
P5.2	30
P5.3	10
P6.1	4
P6.2	30
P6.3	10
P7.1	6.5
P7.2	40
P8.1	6.5
P8.2	40
P9.1	39
P10.1	2.75
P10.2	60

Notes :

1. All well diameters are 12"
2. All PVC pipe diameters are 2"
3. Refer to City of Vancouver - Waterworks Standard Detailed Drawings for Gate Valve Drawings (W3.1), Gate Valve Locations (W3.2), Pipe Connections & Thrust Block (W1.2)

General Notes

No.	Revision/Issue	Date

Firm Name and Address

TEAM 22

Project Name and Address

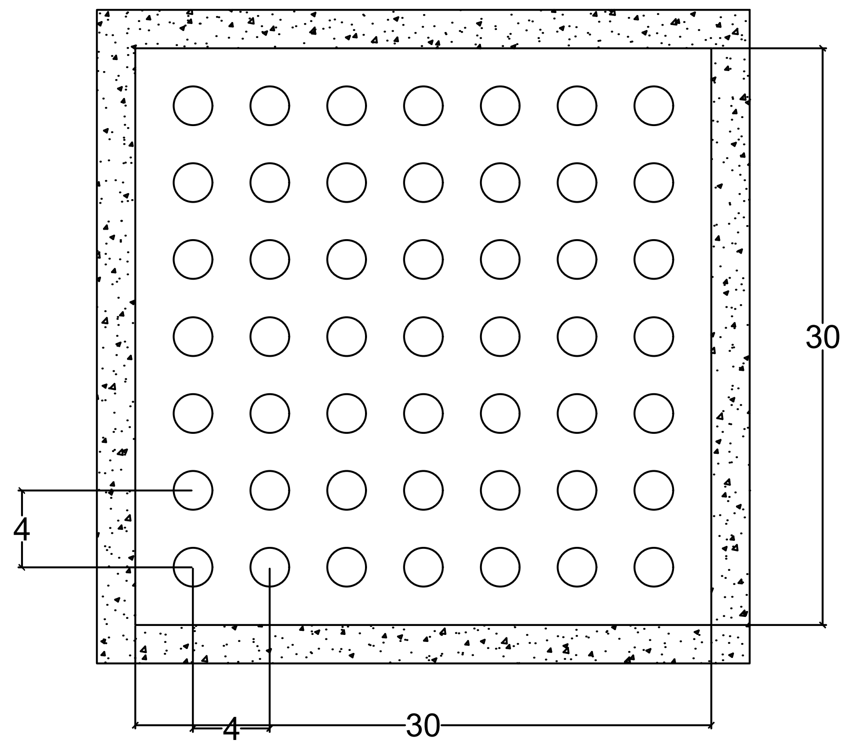
EMERGENCY WATER SUPPLY FOR UBC VANCOUVER

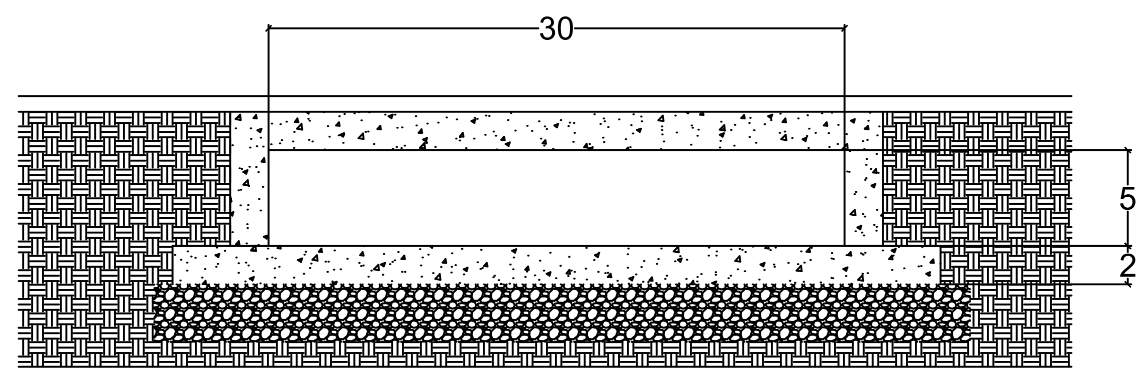
Project #17532

Date MAR 5, 2020

Scale NTS

Sheet SITE LOCATION





General Notes

No.	Revision/Issue	Date

Firm Name and Address

TEAM 22

Project Name and Address

EMERGENCY WATER SUPPLY
FOR UBC VANCOUVER

Project #17532	Sheet UNDER GROUND TANK
Date MAR 5, 2020	
Scale NTS	

Appendix B: Class A Cost Estimate

Item	Quantity	Unit	Unit Rate	Subtotal ($)	Total ($)
Project Costs					
Project Management	1	% Total	7.00%	$ 157,689.00	
Permiting	1		Lump	$ 10,000.00	$ 167,689.00
Construction					
Site Clearing and Preperation	700	m^2	$ 10.00	$ 7,000.00	
Well Drilling	10 x 550	ft	$ 137.00	$ 753,500.00	
Electrical	10 x 550	ft	$ 39.00	$ 214,500.00	
Pump	10	Pump	$ 1,500.00	$ 15,000.00	
Casing	10 x 550	ft	$ 65.00	$ 357,500.00	
Other Costs	10	Well	$ 6,000.00	$ 60,000.00	
Tank Excavation	9800	m^3	$ 18.00	$ 176,400.00	
Tank Concrete	1500	m^3	$ 190.00	$ 285,000.00	
Tank Rebar	10000	m	$ 5.00	$ 50,000.00	
Service Trench Excavation	2795	m	$ 10.00	$ 27,950.00	
Utility Pipe PVC	1320	m	$ 30.00	$ 39,600.00	
Utility Pipe Steel	1475	m	$ 50.00	$ 73,750.00	
					$ 2,060,200.00
Extraneous Labour					
Low Cost Labour	10000	hours	$ 13.00	$ 130,000.00	
High Cost Labour	2500	hours	$ 25.00	$ 62,500.00	$ 192,500.00
Subtotal					$ 2,420,389.00
Contingency			10%		$ 242,000.00
Total					**$ 2,662,000.00**

Item	Quantity	Unit	Unit Rate	Subtotal ($)	Total ($)
Operating Costs per Year					
Electricity	72445	kWh	$ 0.13	$ 9,417.88	
Pump Maintence	10	Pump	$ 240.00	$ 2,400.00	
Other Maintence	1		Lump	$ 2,000.00	$ 13,817.88
Subtotal					$ 13,817.88
Total (Annually)					**$ 14,000.00**

Appendix C: Sample Calculations

Head Required by Pump

Apply Bernoulli's equation from the tank's exit (3) to the top of the tank (2):

$$\cancel{\frac{v_2^2}{2g}} + \frac{P_2}{\rho g} + z_2 = \cancel{\frac{v_3^2}{2g}} + \frac{P_3}{\rho g} + z_3 = 180m$$

$$\frac{P_2}{2g} + z_2 = \frac{P_3}{2g} + z_3 = 180\ m$$

Apply Bernoulli's equation from the well's aquifer surface (1) to the top of the tank (2):

$$\cancel{\frac{v_1^2}{2g}} + \cancel{\frac{P_1}{\rho g}} + z_1 + H_{pump} = \cancel{\frac{v_2^2}{2g}} + \frac{P_2}{\rho g} + z_2 + H_{L,PVC}$$

The ground elevation for the wells is 90m and the lower aquifer is located 95 m beneath the ground surface based on the hydrogeological studies in the area. This gives a well aquifer elevation, z_1, of -5 m.

The friction lost from the PVC Pipe connecting the water from the aquifer to the tank is calculated using the Hazen-Williams equation, with the length of PVC pipe being the well from the furthest location (length of P10.2 above ground + pipe from ground to lower elevation of well):

$$-5\ m + H_{pump} = 180\ m + \frac{10.67 * L_{PVC} * Q^{1.85}}{D^{4.87} * C^{1.85}}$$

$$where\ L = total\ pipe\ length, Q = flow\ rate\ , D = PVC\ pipe\ diameter, C = Hazen - Willaims\ coefficent$$

The flow rate, Q, is the desired operating flow rate, which was determined to be 61.8 L/s, slightly higher than the emergency water supply demand of 58.2 L/day

$$H_{pump} = 185\ m + \frac{10.67 * 155\ m * (0.0618\ {}^{m^3}/_{s})^{1.85}}{(0.203\ m)^{4.87} * 150^{1.85}}$$

$$H_{pump} = 187.1$$

System Curve (Well to Tank)

$$H_{system} = 185\ m + \frac{10.67 * L_{PVC} * Q^{1.85}}{D^{4.87} * C^{1.85}}$$

$$H_{system} = 185\ m + 410.7\ Q^{1.85}$$

Storage Volume

$$Tank\ Volume = Tank\ Height\ x\ Tank\ Width\ x\ Tank\ Length$$

$$= 50\ m\ x\ 50m\ x\ 10m = 25000\ m3$$

$$Tank\ Storage\ Capacity = 0.9\ x\ Tank\ Volume$$

$$Tank\ Storage\ Capacity = 0.9\ x\ 25000\ m3 = 22500\ m3$$

$$Total\ Well\ Yield\ Per\ Day$$

$$= Well\ Yield\ Rate\ x\ \#of\ Wells\ x\ Operating\ Well\ Hours\ Per\ Day$$

$$= 3.52\ \frac{L}{s}\ x\ 3600\ \frac{s}{hr}\ x\ 10\ (\ wells) x\ 20 \frac{hr}{day} = 2{,}534{,}400\ \frac{L}{day}$$

Population Estimate

Population Growth Rate Formula
P = Total population after year t
P int = Initial population
r = Growth rate per year
t = number of years
P = P int * e^(r*t)

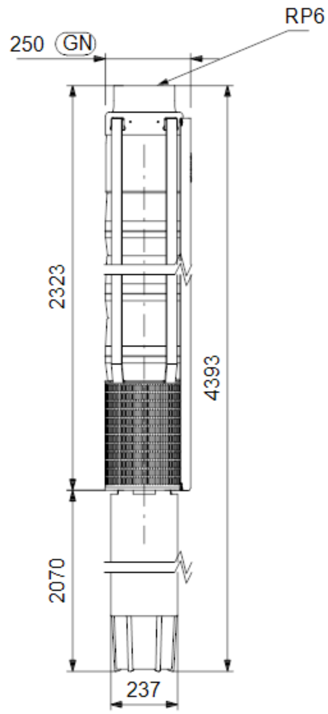
UBC Population (Vancouver Campus)	
Undergradeuate student	45611
Graduate Student	10379
Facutly member (Professor or researcher)	5711
Staff	10736
Total	72437
Student Increase rate /year	2.50%
Faculty & Staff Population increase rate/ye	0.50%
Assuming 2 years future campus populatio	75436
Ubc resident	14500
Point Grey Resident	7800
Non resident	60036
Total Population (Vancouver Campus)	
82336	

Water Demand Calculation

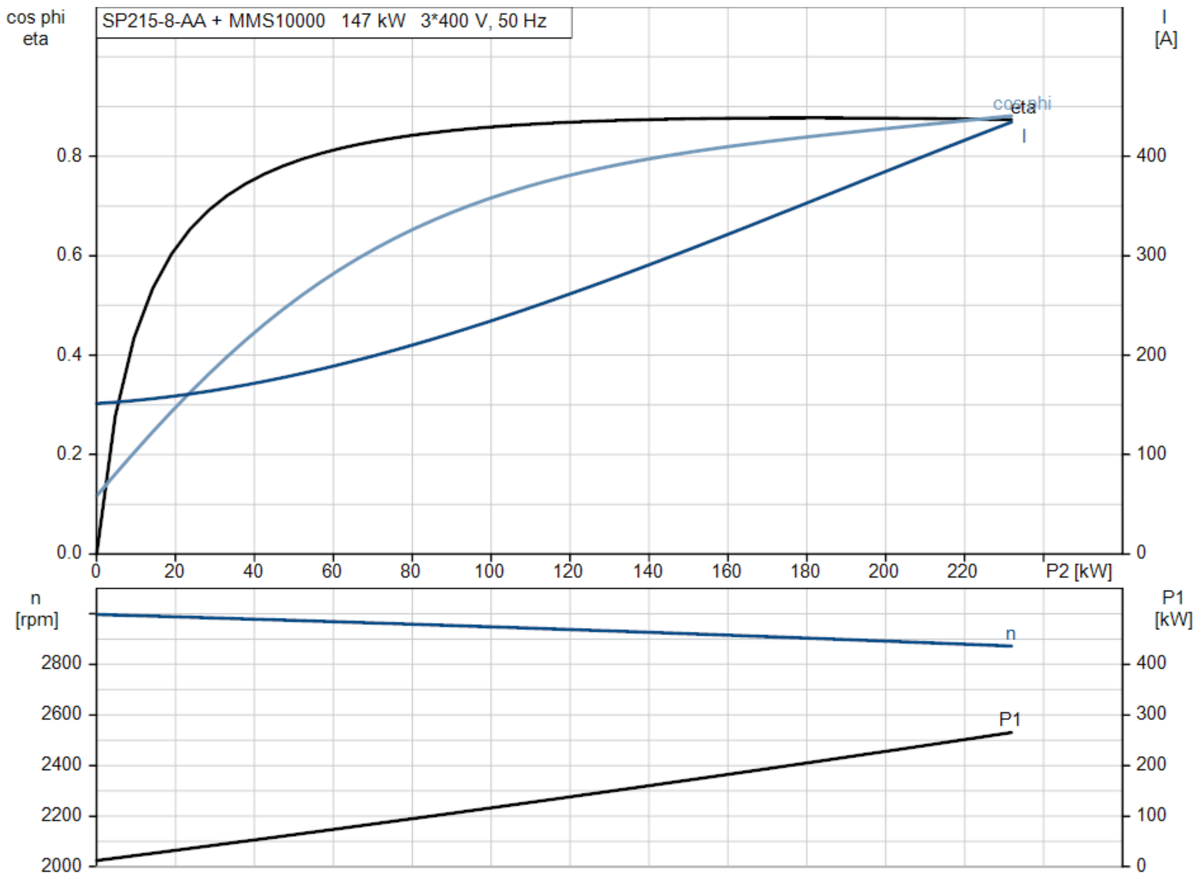
1	**Water Demand per capita per day**			
2	General Water Demand L/(capita*day)			Water Type
3	Bathing,Showers and Lavatory	66	35%	Non-Potable Water
4	Toliet Flushing	57	30%	Non-Potable Water
5	Laundry	38	20%	Non-Potable Water
6	Misc Cleaning	10	5%	Non-Potable Water
7	Drinking Water including Cooking & Cleani	19	10%	Potable Water
8	Total	190	100%	10% Potable Water and 90% Potable Water
9				
10	Emergency Water Supply Plan L/(capita*day)			
11	Bathing,Showers and Lavatory	33	32%	Non-Potable Water
12	Toliet Flushing	28.5	27%	Non-Potable Water
13	Laundry	19	18%	Non-Potable Water
14	Misc Cleaning	5	5%	Non-Potable Water
15	Drinking Water including Cooking & Cleani	19	18%	Potable Water
16	Total	104.5	100%	12% Potable Water & 88% Non Potable Water
17	Note: For the emergency water supply plan. We 100% satisfy people potable water demand and cut down the non-potable water to 50% compare the normal water demand			
18				
19	**Water Demand for Resident (L/Day)**			
20	Total			4592455
21	Note:We must to satisfy the all day water demand for resident & half day drink water and toliet flushing water demand for non resident			
22				
23	**UBC Hospital Wter Using L/Day**			
24	Annual water using per bed	328500	657000	average 492750
25	Total Bed	332		
26	Total water using per day	448200		
27				
28	**Irrigation**			
29	water using	20.55 L/s		1775520L /day
30				
31	**Waste and others**			
32	Water using	9.6L/s		829400L/day
33				
34	**Total Water Using (L/Day)**			
35	5040655			

Appendix D: Pump Design

Pump Detailed Drawing (provided by the manufacturer)



Motor Performance Curve



Pump Specifications

Specifications

Product name	SP 215-8-AA
Product No	18AT06B8
EAN number	5700394659154

TECHNICAL

Pump speed on which pump data are based	2900 rpm
Actual calculated flow	61.17 l/s
Resulting head of the pump	187.1 m
Stages	8
Impeller reduc.	AA
Shaft seal for motor	CER/CARBON
Curve tolerance	ISO9906:2012 3B
Model	C
Valve	YES
Motor version	T30

MATERIALS

Pump	Stainless steel
	EN 1.4301
	AISI 304
Impeller	Stainless steel
	EN 1.4301
	AISI 304
Motor	Cast iron
	DIN W.-Nr. 0.6025
	ASTM 35-40

INSTALLATION

Pump outlet	RP6
Motor diameter	10 inch

LIQUID

Pumped liquid	Water
Maximum liquid temperature	30 °C
Max liquid t at 0.15 m/sec	25 °C
Max liquid t at 0.5 m/sec	30 °C

ELECTRICAL DATA

Motor type	MMS10000
Applic. motor	GRUNDFOS
Rated power - P2	147 kW
Power (P2) required by pump	147 kW
Mains frequency	50 Hz
Rated voltage	3 x 380-400-415 V
Rated current	315-315-320 A
Requested voltage	400 V
Rated current at this voltage	315 A
Starting current	580-620-630 %
Cos phi - power factor	0.85-0.81-0.77
Rated speed	2920-2920-2930 rpm
Start. method	direct-on-line
Enclosure class (IEC 34-5)	IP68
Motor protec	NONE
Thermal protec	external
Built-in temp. transmitter	no
Motor No	96430681
Windings	PVC

OTHERS

Minimum efficiency index, MEI ≥	-.--
ErP status	EuP Standalone/Prod.
Net weight	626 kg
Gross weight	714 kg
Shipping volume	0.973 m^3

EPAnet Model Results

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Friction Factor	Reaction Rate mg/L/d	Quality	Status
Pipe 1	291.00	1.83	5.62	0.015	0.00	0.00	Open
Pipe 2	232.80	1.85	6.60	0.015	0.00	0.00	Open
Pipe 3	174.60	1.39	3.87	0.016	0.00	0.00	Open
Pipe 4	116.40	1.65	7.42	0.016	0.00	0.00	Open
Pipe 5	58.21	0.82	2.06	0.018	0.00	0.00	Open

Node ID	Demand LPS	Head m	Pressure m	Quality
Junc 2	58.20	179.86	84.86	0.00
Junc 3	58.20	178.25	81.25	0.00
Junc 4	58.20	177.53	81.53	0.00
Junc 5	58.20	172.34	85.34	0.00
Junc 6	58.20	171.72	81.72	0.00
Resvr 1	-291.00	180.00	0.00	0.00