South Campus Stormwater Detention Facility Design Report

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University of British Columbia

CIVL 446

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University of British Columbia:
South Campus Stormwater Detention Facility
Design Report

Client:

University of British Columbia – Social Ecological
Economic Development Studies Sustainability Program

UNLIMITED LTD.
A TEAM 10 ENGINEERING COMPANY

Project Team Members:

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Friday, April 8, 2016

Executive Summary

Stormwater management is a recurring issue in the South Campus catchment area of the University of British Columbia's (UBC) Point Grey campus. Significant flooding occurs in the event of extreme storms that can potentially cause damage to UBC assets, surrounding riparian habitats, and results in cliff erosion or failure. With only one stormwater detention facility for the south catchment, Unlimited Ltd. has been assigned the task to determine an innovative and eco-friendly solution to mitigate the stormwater problem.

The main objectives of this project is to address the issues surrounding flooding and erosion problems in the UBC south campus catchment. The design is intended to mitigate the flood and erosion effects of a 10 and 100-year rainstorm event from the South Campus at UBC.

Unlimited Ltd. prepared an analysis on three conceptual designs and considered a dry pond retention design as the optimal solution. The dry pond is located at the intersection of Wesbrook Mall and SW Marine Drive and has a maximum capacity of 5450 m^3. The dry pond will create a welcoming cornerstone to Wesbrook Village and the UBC campus. A detailed description of the following categories will be included in this report: detailed design, construction work plan, cost analysis, environmental impact, scheduling, maintenance requirements and constraints involved with the dry pond project.

As discussed in further detail in the report the design items of the dry pond facility that have been undertaken by the design team included the following actions: determined

soil properties and materials for creating the dry pond, determined the inlet and outlet pipe details, determined the filter specifications and details, as well as a completed stormwater system modelling analysis to ensure system function. Following the detailed design of the dry pond Unlimited Ltd. determined, a detailed cost estimate as well as a projected construction schedule that is included in the appendix of this report.

If necessary Unlimited Ltd. is willing to discuss with the client any changes to the design until a satisfactory design is determined. All of the information used in the determination of the dry pond detention facility has been accumulated and sourced in the appendix for the convenience of any further research or design if so required. Please feel free to contact Unlimited Ltd. if there are any questions, concerns, or change orders to the scope of this project. Unlimited Ltd. is looking forward working with the University of British Columbia on the unique and challenging project as well as getting feedback on the detailed design.

Table of Contents

1 Introduction

This final South Campus Stormwater Detention Facility Design Report will explain all major design components, issues, and constraints of the Dry Pond solution to the UBC Point Grey campus stormwater management issues. The design components discussed in this report are as follows:

- Project Objectives
- Project Constraints
- Project Catchment
- Project Location
- Dry Pond Design Components
- Design Criteria
- Standards and Software Used
- Environmental impact
- Risk Management
- Stakeholder Management
- Construction Plan
- Project Schedule
- Cost Estimate

UBC has made the Stormwater Quality a requirement for achieving LEED Gold for the buildings on campus; therefore the highest level of environmentally sustainable practices have been taken into consideration through the entire design process.

The following table describes each of group member’s contributions toward this report.

Name	Tasks
David Leo	Key components (Oil/Grit separator), Dry Pond sizing and performance modeling, Dry Pond Design criteria, Water quality.
Zhiguang Liang	Technical consideration, Report formatting, Report Assembly.
Shu-Hao Hsu	Cost estimation, project scheduling.
Zhanslu Davletyarova	Risk Management, stakeholder management, public impact.
Elliot Seifried	Executive summary, introduction, project objectives, project constraints, catchment area, project location, flooding issues, construction plan, conclusion, final continuity edit.
Emmanuel Mutegyeki	Key components (Dry Pond), standards and software packages, erosion control, land usage and future land usability.

Table 1 Member's Contribution Summary

2 Project Objectives

The main objective of the UBC South Campus Stormwater Detention Facility Project is a Dry Pond that manages both 10-year and 100-year storm flow events. The detention facility must be able to hold a minimum of 2550 cubic meter of water and reintroduce this water safely back into the environment by utilizing a water treatment system. Another major objective to be mitigated by this detention facility is the erosion issues involved when rapid, heavy rain causes high stream flows through the lower sections of the catchment. Erosion problems will be mitigated by using a controlled small outlet volume pipe that will reintroduce water into the environment at an acceptable flow rate. To coincide with UBC's sustainability guidelines the dry pond will meet all environmentally sustainable guidelines and create a green space to be enjoyed by the public. The water detention facility has been designed to safely manage 100-year storm flows, reintroduce clean water into the system, and follow all UBC sustainability guidelines while creating a welcoming environment to stand as a cornerstone to the Westbrook Village and UBC campus.

2.1 Project Constraints

The constraints of the South Campus Stormwater Detention Facility project include the limited storage capacity of the existing storm sewers, limited land availability, the need to prevent flooding in lower elevated areas, minimization of cliff erosion surrounding UBC, as well as protecting water quality. The limited storage capacity of existing storm sewers on campus results in low lying areas of the south catchment to flood, such as the intersection of Wesbrook Mall and SW Marine Drive. Based on the data provided by the UBC Stormwater Model System Analysis, Detention Analysis and System

Optimization Report by GeoAdvice Engineering Inc. the approximate volume of water that is expected at this intersection from a 100-year storm flow event is approximately 2650 m^3. This volume of water can cause severe erosion at the nearby cliff when the water overtops the roadways and banks, as well as contributing to slope failure that jeopardizes SW Marine Drive as a main access to the UBC Campus. Since the water that is collected in the storm sewer system is urban runoff from roadways and paved surfaces around campus, it also contains suspended solids and oils which lower water quality. In order to address this, a treatment system is needed to improve and conserve water quality before it is discharged to the environment. One of the biggest project constraints of this project is the limited land availability at UBC. Since limited land is available, the stormwater detention facility should minimize land usage and the restrictions it implements on future land development in the area. For construction and maintenance purposes it is important that the water detention facility be located on UBC property.

2.2 Project Catchment Area

During major storm events flooding issues are occurring over the entire UBC campus. This project is designed to focus only on the UBC South Catchment flooding issues as this area has been analyzed to be of greatest concern with the largest floodwater volumes. The south catchment area extends along South West Marine Drive to 16th Ave and includes everything from Westbrook Village to the UBC Village. The catchment also encapsulates several large developments including the Doug Mitchell Thunderbird Sports Center, Rashpal Dhillon Track & Field Oval, and several student housing complexes. The rapid development of the UBC campus over the last 20 years has increased the amount of stormwater runoff that the campus' stormwater system has to handle. The flows have increased to the point where the existing discharge locations and stormwater storage piping are under capacity during large storm events. The UBC South catchment can be seen in the Figure 1 below and is highlighted in purple.

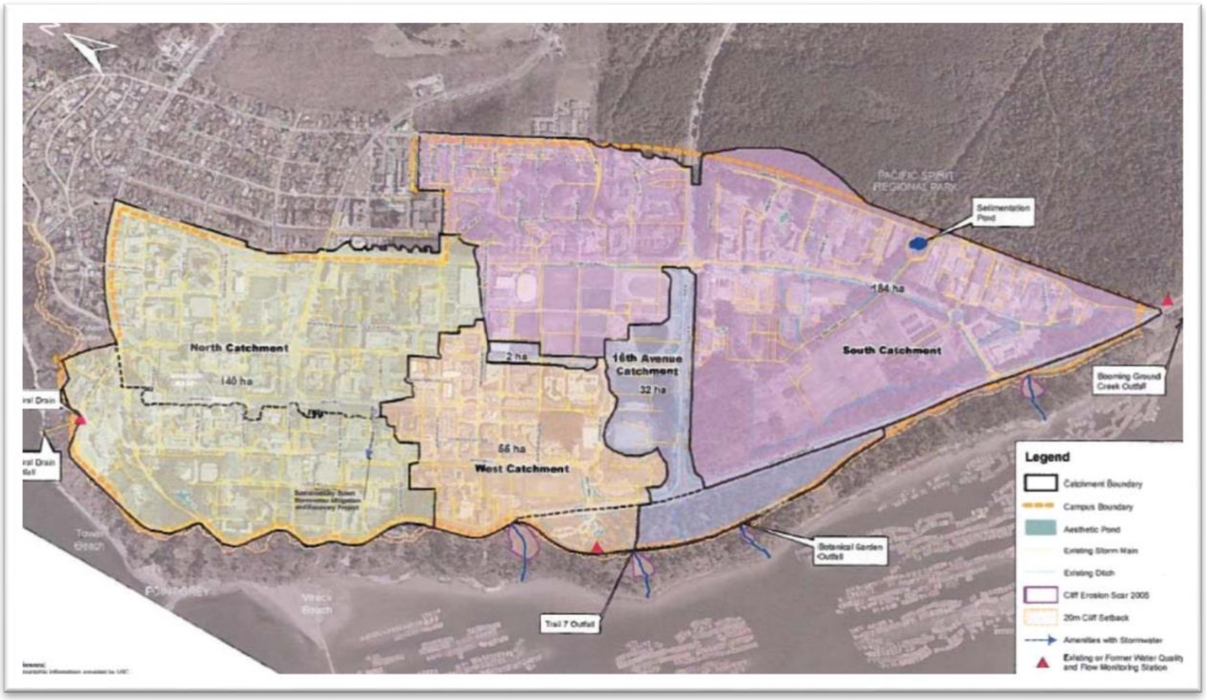


Figure 1 UBC Campus South Catchment

The South Catchment is the largest basin on the UBC campus and therefore has the largest stormwater flows. This catchment directs large volumes of water towards the ocean via the existing stormwater system along Westbrook Mall. The figure below shows areas along south marine drive that suffer from severe erosion issues when this system is overloaded. The red tones shown on the image indicate the areas that have suffered from more than 1m of bank erosion.

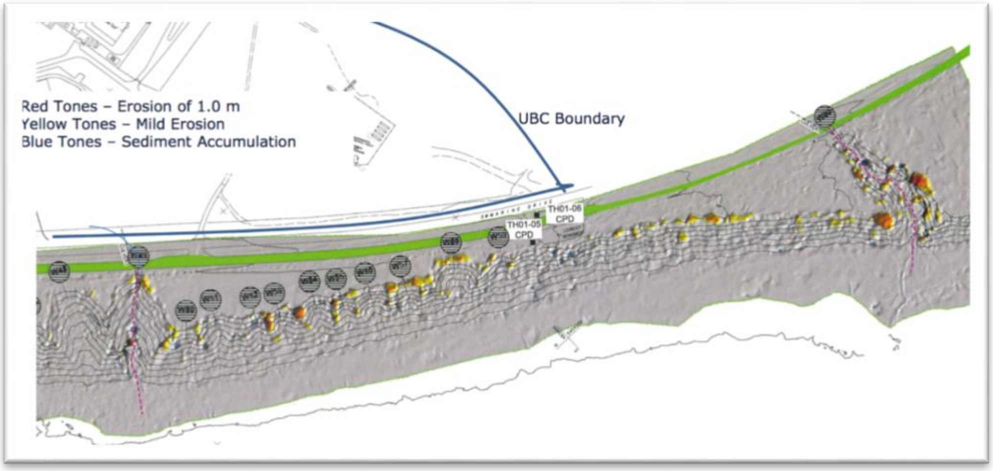


Figure 2 Erosion Area

2.3 Flooding Issue

The most severe flooding locations on the UBC campus occur in the south catchment, and more specifically at the intersection of South Marine Drive and Westbrook Mall where approximately 2600 m^3 of excess stormwater can accumulate. Figure 3 below shows the locations of severe and minor flooding that occurs during a 100-year storm event. The major flooding locations are at South Marine drive with minor flooding at the TRIUMF center and along Osoyoos crescent an area of student residency.

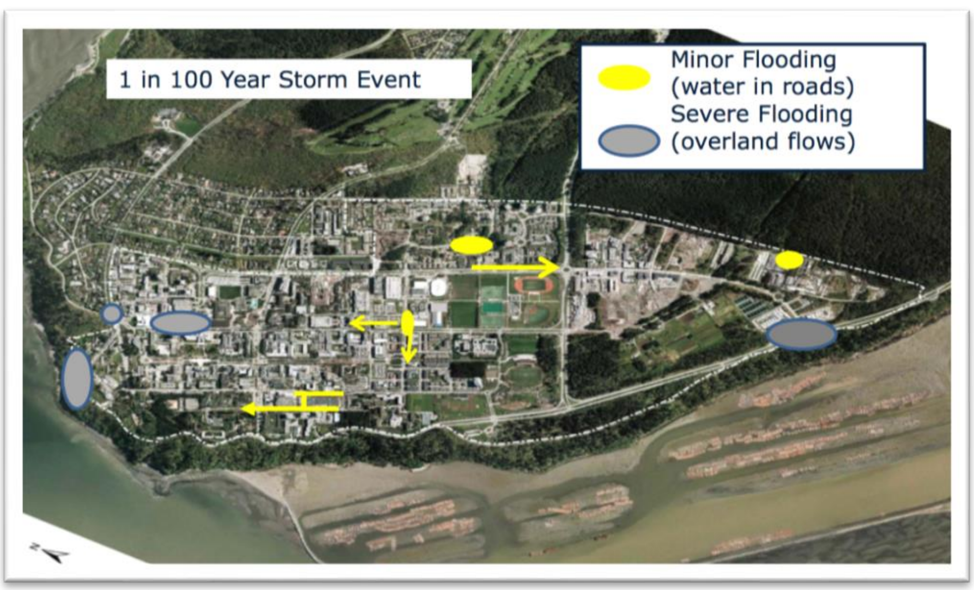


Figure 3 Flooding Issues during 100-Year Strom Event

During a 10-year storm event only minor flooding occurs in the South Catchment and is illustrated in Figure 4 below. A 10-year storm event is expected to produce 430 m^3 of excess stormwater at the intersection of South West Marine Drive and Westbrook Mall as well as 202 m^3 and 43 m^3 around the intersection of West 16th Ave and Wesbrook Mall.

Figure 4 Flooding Issues during 10-Year Strom Event

3 Design Description

3.1 Site Overview

To optimize the function and maximize the volume of captured stormwater flows the Dry Pond will be located on the corner of Westbrook Mall and South West Marine Drive. As can be seen in Figure 5 below, the system is designed to utilize the existing 1000 mm stormwater system along Wesbrook Mall as the inlet source and the 1950 mm stormwater system along Marine drive as the outlet system. This location is optimum because it is in close proximity and capable of operating alongside of an existing storm sewer storage tank with a 515 m^3 capacity in event of overflow.

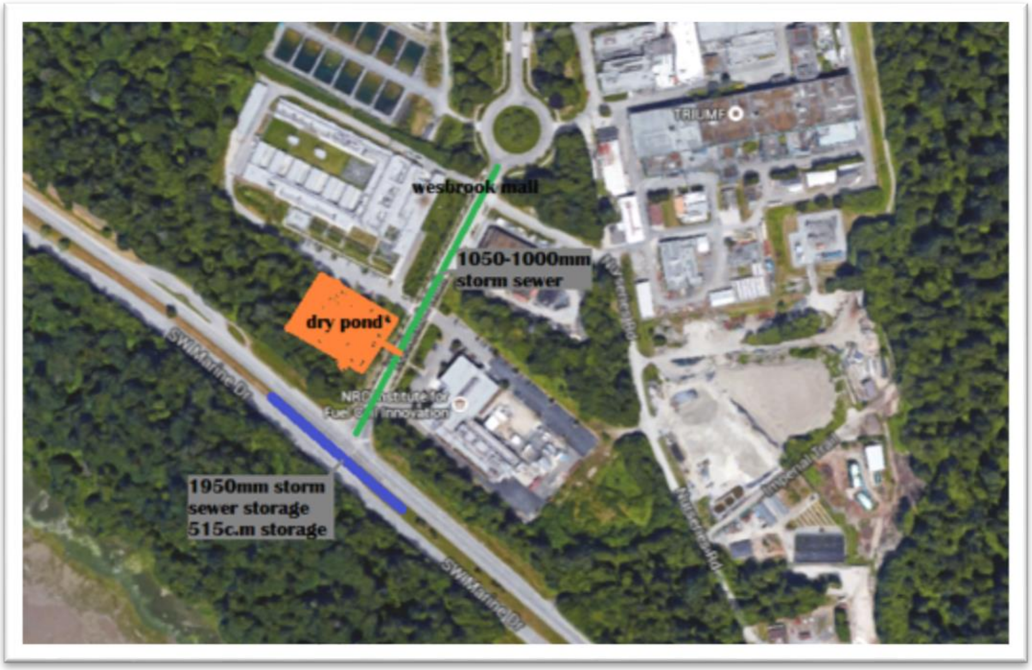


Figure 5 Dry Pond Site Location

The site location is in a remote area of this highly trafficked subdivision and would therefore allow for minimal public disturbance during and after construction. This project is located in a highly sensitive environment so the highest level of sustainable design methods have been incorporated; however since usable UBC land is scarce this location requires tree removal. Figure 6 below shows the overgrowth of brush and trees that would be removed in the construction process. This tree removal will create a more appealing cornerstone to the Westbrook Village as well as provide space for the construction process including material storage. The majority of trees required to be removed as shown below are poplar trees with a lower environmental significance than the native cedar trees in the surrounding area.

Figure 6 Existing Site View

The intersection of South West Marine Drive and Westbrook Mall is the ideal location for a dry pond detention facility as it allows for the largest volume of collected water while having a minimal negative impact of the environment and neighbouring subdivision traffic.

3.2 Key Components

3.2.1 Dry Pond

The dry pond is designed to temporarily detain excess stormwater runoff and thereby reduce the peak outflow rates to the connected stormwater system. The Dry Pond is designed to be 1.5 meter deep, 50 meters by 100 meters grassed basin with 1:4 sloped walls and a 0.5% sloped base capable of holding a maximum of 5450 cubic meters of water. A grated 1m diameter concrete pipe on the east end of the basin serves as both the outlet and inlet. When the system is past capacity, the pipe allows surcharged water into the dry pond and then drains the pond when surcharging ceases. The design volume (5450m3) is dictated by the maximum depth of a pond with the aforementioned parameters in the event of a 100yr storm event when modelled in EPA SWMM.

3.2.2 Oil Grit Separator

The oil/grit separator is a key component of the design's objective to meet *UBC's Sustainability Guidelines* to improve water quality. It is manufactured by **Rainwater Management Ltd.**, based locally out of *Port Coquitlam, BC*. The oil grit separator uses their patented *Continuous Deflective Separation Technologies* or *(CDS Technologies)* to trap floatable materials, including oil, as well as neutrally buoyant materials. The oil/grit separator is capable to settle out denser silt and grit materials that are suspended in the collected stormwater, thereby improving water quality.

Based on performance test reports performed by the *Washington State Department of Ecology*, the oil/grit separator is able to treat up to *708 L/s*, and bypass up to *1416 L/s* without reintroducing previously collected materials. The flows expected from the system has been modeled to discharge 786 L/s at its peak flow during a 100-year storm event at the UBC Campus, meaning the oil grit separator is able to successfully handle these flows to improve discharged water quality. See Appendix H for the design drawing of the Oil/Grit Separator.

3.3 Design Criteria

There were several design criteria that were considered when designing the dry pond for this project. No design standards were previously established by the client, and design standards for the City of Vancouver could not be found. Several other design standards were considered, such as Oregon State, City of Edmonton, and City of Surrey design standards. There were several similarities among them all, but due to proximity of the location, City of Surrey design standards were chosen. (See Appendix F and G for the design standards)

An important design criteria taken into consideration was the hydraulic grade line, which is to be at least 0.3m below the rim of manholes and catchbasins. The energy grade line was also considered so that it did not exceed the rim of the manholes. This ensures that during surcharge conditions, pressurized flows and increased velocity head does not result the manhole and catchbasin covers to blow off during operation. Manhole and catchbasin blow offs is a hazard to the public and needs to be avoided at all cost.

The elevation of the existing system and the new dry pond facility was also considered. Elevation is important to ensure that the system can operate with gravity flows, which reduces the system complexity and operating costs associated with installing pumps to obtain desired performance.

Another important design consideration is the maximum flow rate the oil/grit separator can handle. Flow rates through the oil/grit separator need to be low enough to filter all flows, but not restricting so much that it overloads the upstream dry pond facility. Flow velocity was also taken into account when designing the system in order to ensure that erosion is minimized at the outfall points.

3.4 Technical Considerations

Pollutant removal efficiency is one of the major technical considerations when designing a stormwater detention system. Dry detention pond has limited level of efficiency of removing the pollutant by itself. In this design, we install the oil/grit separator to improve the discharge water quality and ensure to meet the UBC's sustainability guidelines.

The second technical consideration is the slope. The side slope is recommended to be lower than 18 degree to ensure soil stabilization and prevent soil erosion. A strong growth of vegetation on the side slope can improve the safety and reduce the effectiveness of a dry pond with respect to water quality. On the other hand, dry detention pond should not be located immediately above or below a steep slope or grade, because impounded water may create slope stability problems; however, there should be enough elevation drop between the pond inlet and outlet to ensure that flow can move through the detention system.

Last but not least, we need to consider the soil characteristics on site. Even though dry ponds can be used in almost all kind of soils and geology. It is suggested to design with an impermeable liner to prevent groundwater contamination or sinkhole formation.

3.5 Standards and Software Packages

A few design standards and guidelines were followed during the development of this design solution. The City of Surrey Design Criteria Manual was used to guide the design process as it is the most descriptive guideline on dry pond design within proximity to the proposed design site that was available to the team. The City of Vancouver Stormwater/ Drainage Specifications and requirements were considered and met as well.

Besides Microsoft office, a variety of specialized software were used to develop the design. The table below summarizes the software used their respective function:

Software	Function
AutoCAD	Conceptual development, preliminary modelling
Sigma	Cost database for cost estimate
EPA SWMM	Storage modelling and Storm event simulation

Table 2 Software Package

4 Environmental Impact

4.1 Water Quality

The Dry Pond design includes the installation of an Oil/Grit Separator Manhole, which improves water quality. The current stormwater system doesn't involve any improvement to water quality and the contaminated stormwater is directly piped into the discharge creek where it could affect sensitive riparian habitats and other wildlife. With the implementation of the Oil/Grit Separator, oil and other floatable materials, such as plastics and refuse that may be washed into the storm system, are collected and separated from the stormwater. Grit materials, such as sand and silt, that may be suspended in the storm water are also separated and settled, resulting in discharged storm water that has a significant reduction in oil and suspended solids. This improves water quality, and improves the environment downstream of the outlet. Compared to conditions prior to the implementation of this project, contaminants such as oil and grit will be retained in the stormwater system before discharge meeting all UBC's sustainability guidelines.

4.2 Erosion Control

By providing a temporary storage, the dry pond increases the capacity of the existing stormwater system allowing for less surface runoff and a more controlled release of stormwater. The reduction in surface runoff significantly decreases surface erosion and sedimentation into surrounding riparian habitats.

4.3 Land Usage and Future Land Usability

The dry pond occupies a 5000 m^2 area of prime land, as such the probable usability of the land is important. A major advantage of this design is its simplicity. The shallow depression is dry most of the year and is therefore accessible as an open social space. Secondly, the design consists of minimal construction materials and as such the land is easily reclaimable at a later time in the event that the land can be better utilized.

5 Risk Management

The detailed Risk analysis is described in Appendix E. This section contains information about the risks that may affect the project and ways to respond to those risks.

5.1 Major Risks

5.1.1 Design Errors

During the project there might be changes required due to errors or by the request of the owner. The success will depend on how the new changes will integrate into already established design. The project schedule will be changed and cost may increase due to extra fees of consultants.

5.1.2 Different geological conditions

Due to specifics of geological research, the actual conditions of soil may be different from the geological reports. This situation will affect schedule and may affect cost of the project significantly. Also, it may cause legal issues between subcontractor and general contractor.

5.1.3 Unanticipated Rainfalls

In case the actual 100-year storm will exceed the estimated amount the flooding of the surrounding area may happen. To avoid the risk of the event of severe rainfall during the construction process, interruption to the existing stormwater system will be conducted at the end of construction.

5.1.4 Shortage of Workers

The reason for this risk is deeply economical and will have various consequences as the project length and cost may increase.

5.1.5 Project cost Overrun

This risk happens due to different reasons. All the risk described in the Appendix E are affecting the project cost overrun. It more consequence of the different risks rather than a separate risk itself.

5.2 Responses to Risks

Although each risk requires an individual solution, the following common approach can be used. The main solution is set an insurance value of each risk based on the probability of it happening. The risk cost are included in the total cost of the project. From the management point of view the risks should be identified and managed at early stage.

6 Stakeholder Management

One of the crucial analyses for the project is stakeholder management. The goal of this is to identify key groups that are involved in the project execution and manage interaction between them. There are several parties involved each having its role. Setting a clear responsibility between each party will prevent miscommunication and, each party has different level of involvement and responsibility which is described in more details in the table 3.

Stakeholder Group	Role in project	Level of Involvement	Communication Plan
The owner: UBC Properties Trust	Provides funding, assistance and Management Approves changes in the project	High	Manage closely
Project Management Team	Manages interaction between architect, engineers and the owner	High	Manage closely
Musqueam Indian Band	Consult on land use as well as historical and cultural value	Medium	Consult
Environmental Design	Does the landscape design	High	Manage closely
Engineer Design	Design all the specifications	High	Manage closely
Users	Use the developed space	Low	Keep informed
Maintenance Operators	Conduct maintenance Clean filter annually	High	Manage closely

Table 3 Stakeholder Management

7 Public Impact

Public impact of the dry pond storage system is minimal because of its location off the road in unused land. The construction process will take from May until the end of August but since the site is located off the roadway it will not block any existing roads or flow of traffic. The construction site will require access for heavy trucks to remove excavated material and a traffic management plan will be required for these times. Since the start of construction is set for May 2016 and will continue through the first few weeks of summer the effect of construction on UBC students commuting to campus will be minimized.

The dry pond will benefit surrounding neighbourhood by serving as a leisure space as described earlier in the report. This leisure space will benefit UBC and the growing Wesbrook Village neighbourhood as continues to be developed.

8 Project Schedule

The project schedule is based on the following major milestones and three construction phases: General, Earthwork, and Accessory. The first phase "General" has 80 working days in duration, which will began on January 11th, 2016 and shall be completed by April 29th, 2016. The second phase "Earthwork" has 110 working days in duration, which will begin on May 2nd, 2016 and shall be completed by September 30th, 2016. The third and final phase "Accessory" has 20 working days in duration, which will begin on September 26th, 2016 and shall be completed by October 28th, 2016. During earthwork and building stages, there will be some time periods that will affect the local community's transportation. The estimated duration is approximately 105 working days.

As estimated, the dry pond project will take approximately 10 and a half months for completion, from the start of construction to project finishing. The major milestone of the project, as well as the estimated project delivery period of this project, are as follows:

- Project Approval and Starting: January 11th, 2016
- Expected Contract Release Date: April 8th, 2016
- Dry Pond completion: September 30th, 2016
- Substantial Completion: October 21th, 2016
- Project Closing: October 28rd, 2016

The project schedule, as can be found in Appendix A has been provided to allow flexibility for the owner to make key decisions.

9 Construction Work Plan

All construction processes should take the public effects as top priority and minimize these effects accordingly. Anticipated construction process that will require a traffic and public management plan are site access, site runoff, and tree removal.

With the ideal site location at the intersection of SW Marine Drive and Westbrook Mall the effects of the construction process on UBC, Westbrook Village, and all through traffic is minimal; however certain construction processes will intrude of the flow of traffic and require a traffic management plan. The major construction process that will intrude on the flow of traffic is the site preparation phase including tree removal as well as the initial construction phase that will requires high volumes of soil removed from the site location. Single lane closure of the west bound traffic along SW Marine Drive is predicted for the tree removal process. All other construction processes including soil excavation and soil removal will require temporary traffic interruptions to allow for an ease of site access for any site traffic including dump trucks and material delivery.

Being located in such a highly sensitive environment the contractor is expected to hold the highest level of site runoff protection. Any clay or silt must be detained on site by the use of berms or approved methods the contractor has. It is expected that all neighbouring manholes will be protected with silt protectors and maintained to ensure they work effectively.

Tree removal will be conducted by a certified and approved arborist and requires a traffic management and safety plan be submitted prior to any construction.

10 Cost Estimation

Total cost of this project is approximately 3.25 million of Canadian dollar. The cost can separate in following catalogues, and the further details could find in the Appendix B.

10.1 Design Fees

The project design fee cost is based on a design team of 6 engineers working for 120 hours per person. The total design and consultant fee is $120,000.00 that combining the cost on-site inspection analysis, three solutions researching, designing, modeling, simulation, scheduling, estimating.

10.2 Construction Cost

The major component of construction is tree removal, land clearing and excavation. The total cost of the construction is $2,300,000.00 that including all the labor, equipment and material cost.

10.3 Taxes

The tax is combining the 7% provincial tax and 5% federal tax that in total of

$ 2,700,000.00.

10.4 Risk Allowances

The risk allowances were estimating 15% of construction cost, which is $ 340,000.00.

The further details are in Appendix E.

10.5 Maintenance cost

The maintenance cost is $17,000.00 annually with taxes included.

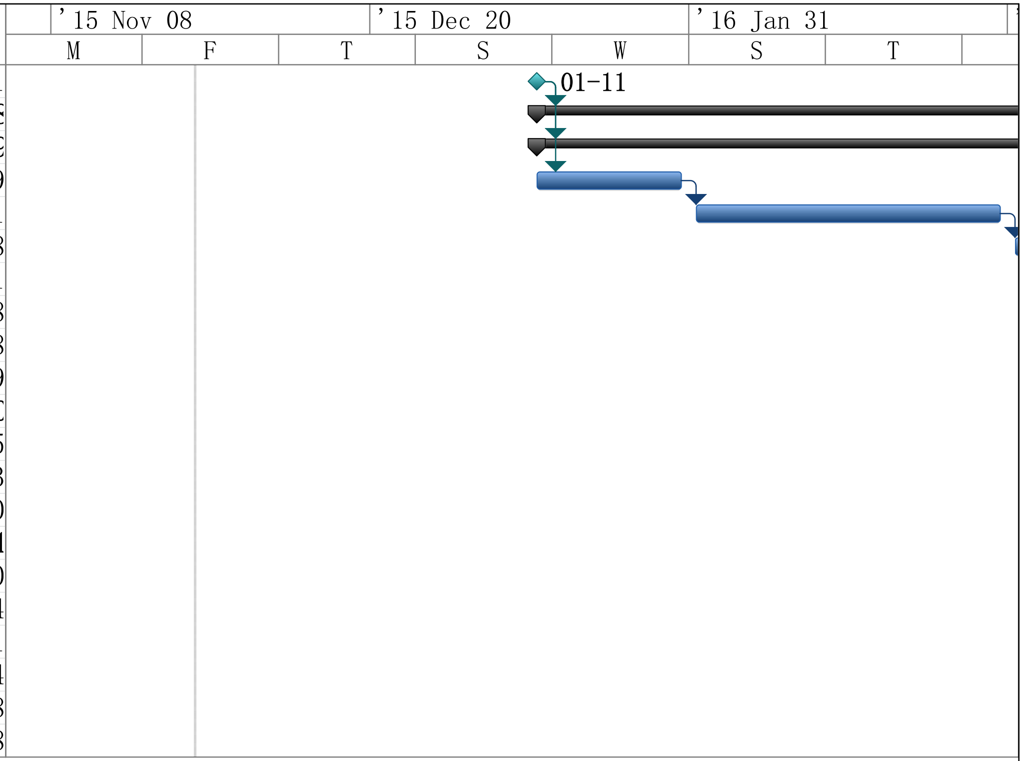
11 Conclusion

The Dry Pond retention facility design by Unlimited Ltd. is intended to mitigate all negative effects involved in the 10 and 100-year rainstorm events in the UBC South Catchment basin. The dry pond is located at the intersection of Wesbrook Mall and SW Marine Drive and has a maximum capacity of 5450 m^3. The Dry Pond will create a welcoming cornerstone to Wesbrook Village and the UBC campus. UBC has made the Stormwater Quality a requirement for achieving LEED Gold for the buildings on campus; therefore the highest level of environmentally sustainable practices have been taken into consideration through the entire design process. Please feel free to contact Unlimited Ltd. If there are any further question or concerns surrounding our design.

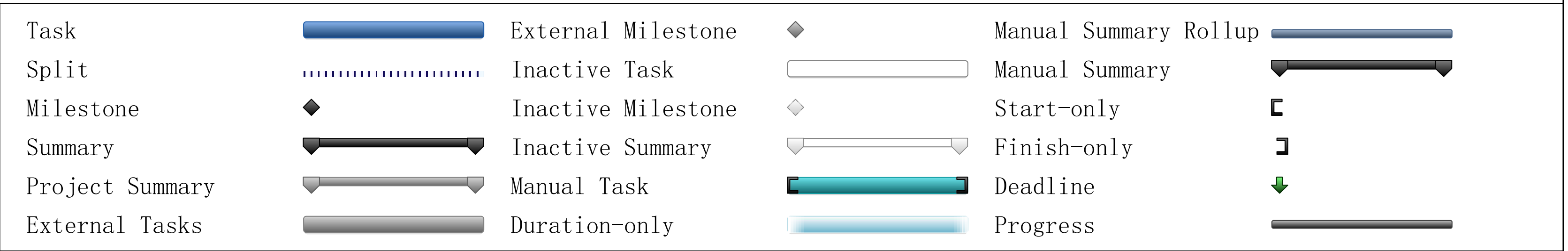
Appendix A – Project Schedule

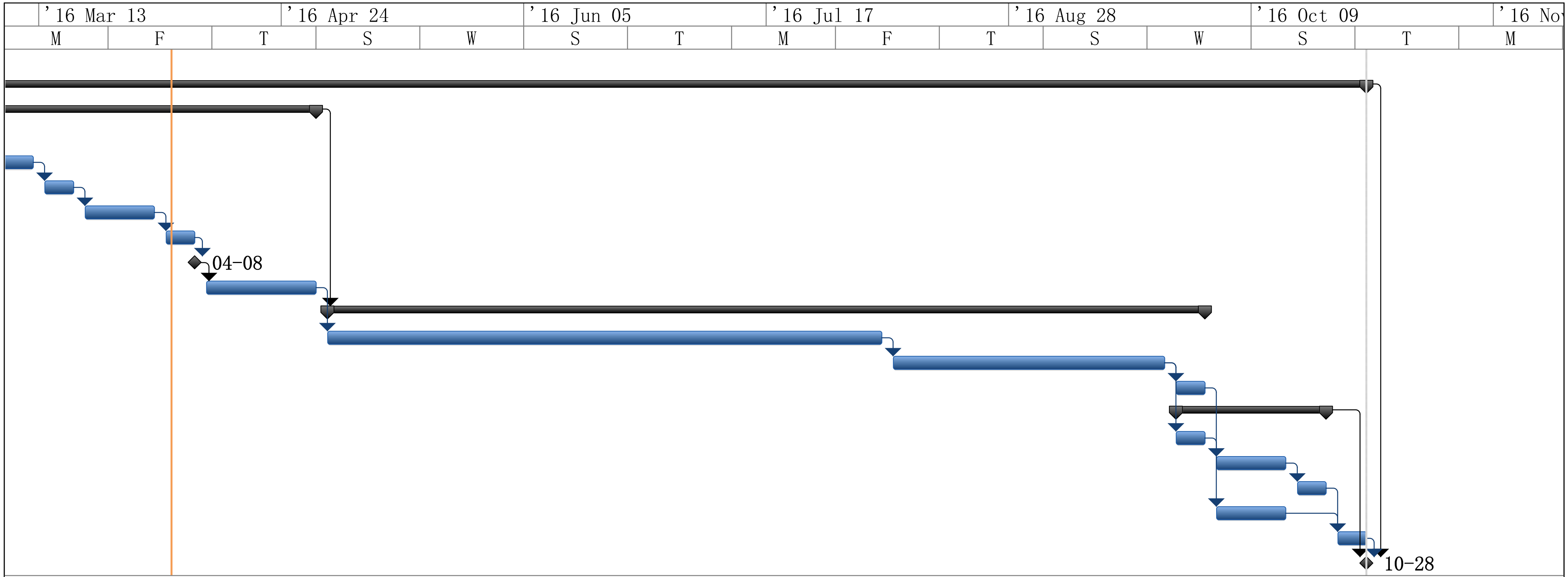
Task Name	Duration	Start	Finish
Project begin	0 days	Mon 16-01-11	Mon 16-01-11
UBC Stormwater Upgrading	**210 days**	**Mon 16-01-11**	**Fri 16-10-28**
General	**80 days**	**Mon 16-01-11**	**Fri 16-04-29**
Design stage	15 days	Mon 16-01-11	Fri 16-01-29
Development Permit and document approval	30 days	Mon 16-02-01	Fri 16-03-11
Project Tender Release	5 days	Mon 16-03-14	Fri 16-03-18
Bid Period	10 days	Mon 16-03-21	Fri 16-04-01
Contract and Negotiate	5 days	Mon 16-04-04	Fri 16-04-08
Excepted Contract Release Date	0 days	Fri 16-04-08	Fri 16-04-08
Building Permit approval	15 days	Mon 16-04-11	Fri 16-04-29
Earthwork	**110 days**	**Mon 16-05-02**	**Fri 16-09-30**
Working area tree removal	70 days	Mon 16-05-02	Fri 16-08-05
Working area excavation	35 days	Mon 16-08-08	Fri 16-09-23
Geotechnical material fill and treatment	5 days	Mon 16-09-26	Fri 16-09-30
Accessory	**20 days**	**Mon 16-09-26**	**Fri 16-10-21**
Filter system installation	5 days	Mon 16-09-26	Fri 16-09-30
Discharge pipeline setup	10 days	Mon 16-10-03	Fri 16-10-14
Pipeline trench backfill	5 days	Mon 16-10-17	Fri 16-10-21
Landscaping	10 days	Mon 16-10-03	Fri 16-10-14
Inspection	5 days	Mon 16-10-24	Fri 16-10-28
Project Closing	0 days	Fri 16-10-28	Fri 16-10-28

ID	Task Mode	Task Name	Duration	Start	Finish
1		Project begin	0 days	Mon 16-01-11	Mon 16-01-11
2		**UBC Stormwater Upgradi**	**210 days**	**Mon 16-01-11**	**Fri 16-10-28**
3		**General**	**80 days**	**Mon 16-01-11**	**Fri 16-04-29**
4		Design stage	15 days	Mon 16-01-11	Fri 16-01-29
5		Development Permi	30 days	Mon 16-02-01	Fri 16-03-11
6		Project Tender Re	5 days	Mon 16-03-14	Fri 16-03-18
7		Bid Period	10 days	Mon 16-03-21	Fri 16-04-01
8		Contract and Nego	5 days	Mon 16-04-04	Fri 16-04-08
9		Excpected Contrac	0 days	Fri 16-04-08	Fri 16-04-08
10		Building Permit a	15 days	Mon 16-04-11	Fri 16-04-29
11		**Earthwork**	**110 days**	**Mon 16-05-02**	**Fri 16-09-30**
12		Working area tree	70 days	Mon 16-05-02	Fri 16-08-05
13		Working area excav	35 days	Mon 16-08-08	Fri 16-09-23
14		Geotechnic materia	5 days	Mon 16-09-26	Fri 16-09-30
15		**Building**	**20 days**	**Mon 16-09-26**	**Fri 16-10-21**
16		Filter system inst	5 days	Mon 16-09-26	Fri 16-09-30
17		Discharge pipeline	10 days	Mon 16-10-03	Fri 16-10-14
18		Pipline trench bac	5 days	Mon 16-10-17	Fri 16-10-21
19		Landscaping	10 days	Mon 16-10-03	Fri 16-10-14
20		Inspection	5 days	Mon 16-10-24	Fri 16-10-28
21		Project Cloing	0 days	Fri 16-10-28	Fri 16-10-28



Project: phase2projectschedule
Date: Tue 16-04-05





Project: phase2projectschedule
Date: Tue 16-04-05

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

Appendix B – Project Cost Estimation

Item	Quantity	Unit Price	Cost
Tree Removal	1000	$ 1,000.00/Each	$ 1,000,000.00
Temporary Fencing	340	$ 17.14/m	$ 5,827.68
Topsoil stripping	1000	$ 4.56/m^3	$ 4,560.00
Excavation	8950	$ 26.58/m^3	$ 237,909.95
Backfill	4309	$ 66.12/m^3	$ 284,911.08
Surplus	7326	$ 87.71/m^3	$ 642,585.01
Manhole 3000mm	1	$ 22,000.00/Each	$ 22,000.00
Manhole excavation	150	$ 26.58/m^3	$ 3,987.32
Manhole backfill	55	$ 66.12/m^3	$ 3,636.60
Manhole installation	1	$ 2,000.00/Each	$ 2,000.00
Filter system installation	1	$ 4,000.00/Each	$ 4,000.00
Surplus	140	$ 87.71/m^3	$ 12,279.81
Pipe 1050mm	25	$ 600.00/m	$ 15,000.00
Pipe excavation	90	$ 26.58/m^3	$ 2,392.39
Pipe backfill	27	$ 66.12/m^3	$ 1,785.24
Surplus	90	$ 87.71/m^3	$ 7,894.16
Pipe installation	25	$ 100.00/m	$ 2,500.00
Spread topsoil	1000	$ 7.03/m^3	$ 7,027.76
Landscaping	1000	$ 22.00/m^3	$ 22,000.00
Subtotal			$ 2,282,297.01
Contingency		15%	$ 342,344.55
General fee			$ 120,000.00
Profit		10%	$ 228,229.70
GST		5%	$ 114,114.85
PHT		7%	$ 159,760.79
Total cost			$ 3,246,746.90

Appendix C – Maintenance Cost Estimation

Items	Quantity	Unit Price	Cost
Semi-annual inspection	2/yr	$500/Each	$ 1,000.00
Annual inspection	1/yr	$1,000/Each	$ 1,000.00
Landscaping	6/yr	$1,500/Each	$ 9,000.00
Sediment removal (pipe)	0.2/yr	$10,000/Each	$ 2,000.00
Sediment removal (pond)	0.02/yr	$100,000/Each	$ 2,000.00
Subtotal			$15,000.00
GST		5%	$ 750.00
PHT		7%	$ 1,050.00
Annual maintenance fee			$16,800.00

Appendix D – Design Fee

Engineer Service Charge			$ 108,000
Supervisory Engineer ($195/hr)			
David Leo	120	hours	$ 23,400
Assistant Project Engineer ($141/hr)			
Emmanuel Mutegyeki	120	hours	$ 16,920
Zhanslu Davletyarova	120	hours	$ 16,920
Zhi Guang Liang	120	hours	$ 16,920
Shu-Hao Hsu	120	hours	$ 16,920
Elliot Seifried	120	hours	$ 16,920
Travel expense			$ 330
Sub Total			$ 108,330
GST (5%)			$ 5,416.5
PST (7%)			$ 7,583.1
Total Cost			$ 121,329.6

Appendix E – Risk Assessment

Risk Allocation (Retained, Shared, Transferred)	Risk ID Number	Risk Category	Risk	Timing of Risk Event (Planning, Design, Construction, Operations)	Description & Source of Risk	Consequence	Risk Treatment (Avoid, Transfer, Mitigate, Accept)	Cost Base	Probability of Occurrence	Cost of Consequence	Expected Value of Risk Event
Transferred	1	Force majeure	Seismic event	All	Major natural events of severity greater than that the structure is designed for	Destruction causes delay in project delivery or excessive cost	Transfer: the unpredictable associated with the insurance that the project will be insured against the natural events	$ 1,500,000.00	2%	$ 750,000.00	$ 15,000.00
Transferred	2	Force majeure	Major wind event	Construction	Major wind event during construction	Causing major damage and injury to workers, major repair costs, 10 days' delay, 20% project budge cost	Transfer: the unpredictable associated with the insurance that the project will be insured against the natural events	$ 1,000,000.00	2%	$ 200,000.00	$ 4,000.00
Retained	3	Volume	Flooding event	Operation	Under estimated design for the unexpected rainwater	Causing flooding to Marine Drive, and increasing erosion on cliff	Avoid: design with safety factor	$ 1,500,000.00	5%	$ 750,000.00	$ 37,500.00
Retained	4	Cost	Poor conceptual estimate under values the project cost when bids are received	Planning	In planning stage, wrong estimation of the project budgets	Delay in project works commencement or completion and cost increases	Accepted: any over budget cost necessary for the project continuing processing must be undertaken	$ 2,300,000.00	10%	$ 500,000.00	$ 50,000.00
Semi-shared	5	Reputation	Union Issues experienced by the contractor	Construction	Employees feel wrongly treated	Slow the project down by low productivity and increase cost	Mitigate: hire reputable companies that have reputation for treating their employees fair	$ 2,300,000.00	5%	$ 300,000.00	$ 15,000.00
Retained	6	Reputation	Builders lien from major	Construction	Poor reception from UBC	S/C force legal fees, delays	Mitigate: require GC to submit statutory declaration with invoices	$ 3,250,000.00	0.05%	$ 1,000,000.00	$ 5,000.00
Transferred	7	Maintenance	Failures of maintenance	Operation	Poor performance from the maintenance contractor	Stressing of the maintained budget	Mitigate: the contractor should guarantee the quality or functionality of the essential service for a period of time	$ 15,000.00	5%	$ 15,000.00	$ 750.00

Risk Allocation (Retained, Shared, Transferred)	Risk ID Number	Risk Category	Risk	Timing of Risk Event (Planning, Design, Construction, Operations)	Description & Source of Risk	Consequence	Risk Treatment (Avoid, Transfer, Mitigate, Accept)	Cost Base	Probability of Occurrence	Cost of Consequence	Expected Value of Risk Event
Transferred	8	Inflation	Inflation rates can induce considerable pressure on the project with the budge. It can also cause a degrading effect on the funding of project.	All	Global economic turbulence may impact the inflation rates.	The unforeseen increase in inflation could lead to cost overrun	Transfer: the unpredictable associated with the insurance that the project will be insured against the inflation	$ 3,250,000.00	5%	$ 65,000.00	$ 3,250.00
Transferred	9	HSE	Lost time incident	Construction	High risk areas around construction site	Leads to OH&S sight shut down the site 5 days	Mitigate: provide the safety equipment and follows safety regulations	$ 2,300,000.00	10%	$ 300,000.00	$ 30,000.00
Retained	10	Design	Poor engineering details	Design	Poor engineering details lead to construction error during major interface point in project	Trades are delayed	Mitigate: build 3D modeling, listing all the details on blueprint, section detail	$ 2,300,000.00	10%	$ 500,000.00	$ 50,000.00
Transferred	11	Design	Design error in existing stormwater system	Design	Design error in existing stormwater system causes contractor delay and redesign charges	Re-engineering charges, late charges, delay charges	Mitigate: build 3D modeling, listing all the details on blueprint, section detail	$ 50,000.00	10%	$ 25,000.00	$ 2,500.00
Retained	12	Planning	Poor quality pre-tender estimate	Planning	Poor quality pre-tender estimate	Forces additional consultant time redesigning the project scope	Mitigate: require a Class A estimate prepared prior to tendering	$ 3,250,000.00	10%	$ 650,000.00	$ 65,000.00

Appendix F – Dry Pond Design Criteria – City of Surrey

5.8.5 Dry Pond Design Details

The design details should follow those given for wet ponds with specific modifications as outlined below.

5.8.5.1 Frequency of Operation

All dry ponds will consist of off-line storage areas designed to temporarily detain excess runoff and thereby reduce the peak outflow rates to the connected downstream system. These facilities may be subject to prolonged inundation during winter months.

5.8.5.2 Side Slopes and Depth

Side slopes within the limits to inundation (e.g. upon filling of the dry pond) will have a maximum slope of 4 (horizontal) to 1 (vertical) within public property, as shown on the *Standard Drawings*.
The maximum live storage depth in a dry pond is 3.0m for the 100-year event and 1.5m for the 5-year event, as measured from the invert elevation of the outlet pipe.

5.8.5.3 Bottom Grading and Drainage

The dry pond will be graded to properly drain all areas after its operation. The dry pond bottom will have a minimum slope of 0.5%, however, a slope of 0.7% or greater is recommended. Lateral slopes for the pond bottom will be 0.5% or greater. French drains or similar means may be required where it is anticipated that these slopes will not properly drain the dry pond bottom, or where the land dedicated for the dry pond is used by others when the pond is not activated (e.g. as a recreational field), or other special considerations.

5.8.5.4 Safety Provisions at Inlets and Outlets

All inlet and outlet structures associated with dry ponds will have grates installed over their openings to restrict access and prevent entry into sewers. A maximum clear bar spacing of 0.15m will be used for gratings. Grated outlet structures will be designed with a hydraulic capacity of at least twice the required capacity to allow for possible blockage and plugging. Further, the arrangement of the structures and the location of the grating will be such that the velocity of the flow passing through the grating will not exceed 1.0 m/s. Appropriate fencing and guard-rails will be provided to restrict access.

5.8.6 Maintenance and Service Manual

The *Consultant* will prepare an Operation and Maintenance (O&M) Manual for the storage facility along with As-Constructed drawings following construction.

Two (2) complete copies of the manual and a consolidated digital copy (PDF) are to be provided to the *Engineer* prior to the time when the operation responsibility of the facility is transferred to the *City*. A digital copy of the manual and As-Constructed drawings will also be provided. This manual will include a complete list of equipment; the manufacturer’s operation,

Appendix G – Piping Design Criteria – City of Surrey

5.4 Design of Storm Sewer Components

5.4.1 General

In general, storm sewers will be designed as the minor system with a conveyance capacity to a minimum of the 1:5-year return period storm under free flow conditions, to minimize inconvenience of frequent surface runoff, and there shall be designed of a major system with a conveyance capacity up to the 1:100-year return period storm, to provide safe conveyance of flows and to minimize damage to life and property.

5.4.1.1 Major Flow Conveyance Conditions

All habitable areas of buildings, including basements, will be above the 100-year HGL, except where specific flood proofing measures to eliminate backwater effects from the downstream HGL have been taken.

In special circumstances, or where lower building elevation is desired, such as for basements, the minor system may be enlarged or supplemented to accommodate the major flow (100 year). As such, the sewer system will be designed with adequate inlets to accommodate introduction of the major flow.

The proportion of flow to be carried along the major routing will be the total major flow less the flow carried in the minor system.

In conjunction with the piped system, a surface overflow route will be provided from all potential surface ponding locations along the major flow route.

5.4.1.2 Surcharged Sewers

Surcharged sewers to convey the design flows are permitted only as exceptions under the following conditions:

a. Where temporary discharge to an existing ditch with a submerged outlet is required to allow for a future extension of the sewer at an adequate depth; and
b. Where flow will surcharge the outlet sewers into detention ponds during storm events and until the pond is drained down to the normal water level.

Surcharged sewers will have the 5-year hydraulic grade line shown on the drawings. In addition, in cases where the CB inlets and the sewers are designed to carry the 100-year flows, the 100-year hydraulic grade line will also be shown.

In all such cases, it must be clearly demonstrated that the projected highest hydraulic grade line is at least 300mm below the MBE of all of the serviced properties.

5.4.2 Storm Sewers

5.4.2.1 Size

Minimum sewer sizes are:

a. 200mm diameter –for all catch basin leads;

b. 250mm diameter–for all zones and land-uses; and

c. 375mm diameter – where ditches discharge directly into a storm sewer.

5.4.2.2 Location

Sewers will be located, as shown on the *Standard Drawings* in a *Highway*. All non-standard utility off-sets are to be supported by a typical cross-section showing all utilities and the ultimate road section.

Where not technically feasible, as determined by the *Engineer*, sewers may be approved in side yard and rear yard rights-of-way if:

a. The right-of-way minimum width meets the requirements set out in Section 2.5.8;

b. The right-of-way is capable of supporting the intended maintenance vehicles in all weather conditions;

c. Within the rights-of-way, there are no *Service Connections* or manholes and the sewer alignment must be straight; and

d. The right-of-way includes an all-weather road surface for service or maintenance.

5.4.2.3 Depth

Sewer depth will be sufficient to provide appropriate gravity *Service Connections* to all properties tributary to the sewer. Unless approved by the *Engineer*, sewers will be installed at a nominal depth between 1.5m and 3.0m, from finished ground surface to pipe invert.

Pipe cover less than 1.5m but more than 1.0m above the outside crown of the pipe may be permitted if the location of the sewer is outside the roadway and driveways.

Unless approved by the *Engineer*, no *Service Connections* will be installed on sewers greater than 4.5m depth, and if permitted then a second main at maximum depth of 3.5m must be installed to facilitate *Service Connections*.

Where a new sewer will service existing buildings and existing vacant properties, the crown of the sewer will shall be designed to achieve the requirements outlined in Section 5.4.6.

5.4.2.4 Curvilinear Sewers

Curvilinear sewers are only permitted under special circumstances and must be approved by the *Engineer*.

When permitted, pipes between two consecutive manholes may be installed on a defined curve, provided that the maximum joint deflection does not exceed 1/2 the deflection recommended by the pipe manufacturer. Only one vertical or one horizontal defined curve is permitted between any two manholes. Curvilinear sewer designs will include proposed elevations at 5m stations for vertical curves and sufficient data for setting out of horizontal curves and detailing as-built construction record information.

PVC pipes shall not be bent (between the pipe joint ends) to form curves. Manufactured long bends or PVC high deflection stops coupling shall be used to achieve curves, when curvilinear sewers are permitted.

5.4.2.5 Pipe Grades

Sewers are to be designed with a constant grade and at the minimum slopes indicated in **Table 5.4.1**.

Table 5.4.1: Minimum Pipe Slopes

Sewer Size	Minimum Slope
CB leads (200&250)	1.00%
300mm	0.22 %
375mm	0.15 %
450mm	0.12 %
525mm and larger	0.10 %

The minimum slope will be 0.4% for the most upstream leg of any storm sewer system (e.g. between the *Terminal* manhole and the first manhole downstream) unless approved by the *Engineer*.

Where pipe slopes less than 0.4% are used, the *Consultant* will confirm that the proposed system meets the minimum velocity requirements.

Pipes with grades at 15 % or greater must have an anchoring system approved by the *Engineer*, and designed with special attention to scour velocities and potential damage to the pipe structure. Proposed pipe protection systems to prevent pipe invert damage must be approved by the *Engineer*.

5.4.2.6 Velocity Requirements

All storm sewers shall be designed to achieve a velocity of 1.0 m/s, however if this cannot be achieved a velocity of at least 0.6 m/s, based on Manning's Equation full pipe flow, will be achieved.

Where design velocities are supercritical or in excess of 3.0 m/s, special provisions shall be made to protect against sewer displacement. The *Consultant* will provide appropriate analysis and justification and make provisions in the design to ensure that structural stability and durability concerns are addressed. Flow throttling or energy dissipation measures to prevent scour will be required to control the flow velocity or to accommodate the transition back to subcritical flow.

5.4.2.7 Pipe Joints

All concrete pipe joints will be open except where the pipe is temporarily or permanently designed to act under head, when bedding material is river sand, or where infiltration from surrounding soils is not desirable. Appropriately designed sealed pipe joints will be used where the design flow HGL rises above the pipe obvert, or where the pipe backfill may be subject to soil piping.

Where "Open Joints" are used, bedding will be 19mm crushed gravel as per the *Supplementary Specifications*, designed to prevent piping conditions.

5.4.2.8 Recharge

In general, storm sewers will be designed to provide low flow exfiltration to the pipe bedding / backfill and contribute to groundwater recharge.

Where groundwater recharge has been designated as desirable and existing surficial and pipe area soils are identified as suitable by a Geotechnical *Consultant*, additional site specific designed exfiltration systems will be provided.

Conversely, seepage collars or clay plugs will be provided where groundwater may adversely affect steep sewers.

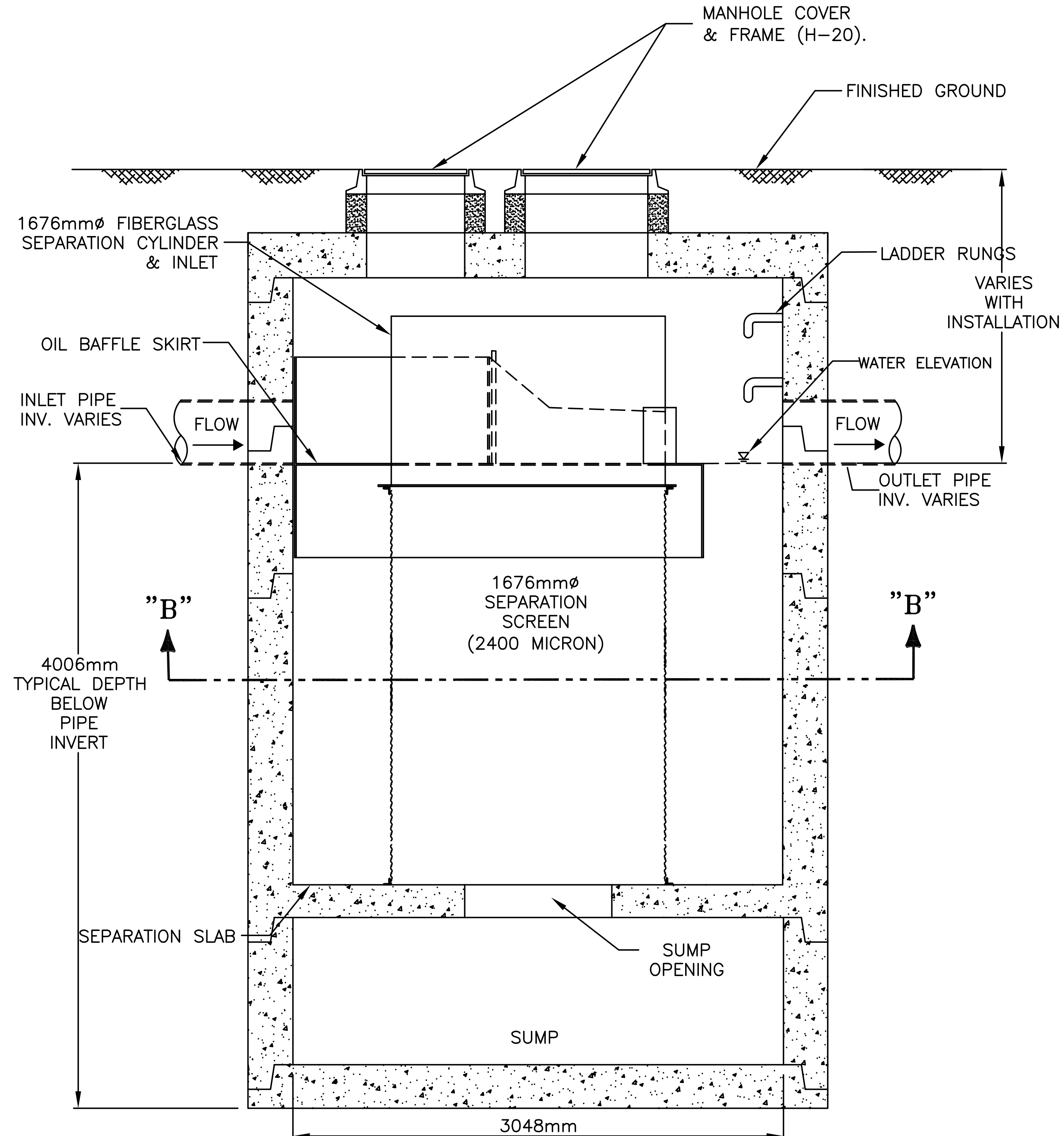
5.4.3 Subsurface Drains

Subsurface drains will be used where supported by a soils report carried out by a qualified Geotechnical *Consultant*.

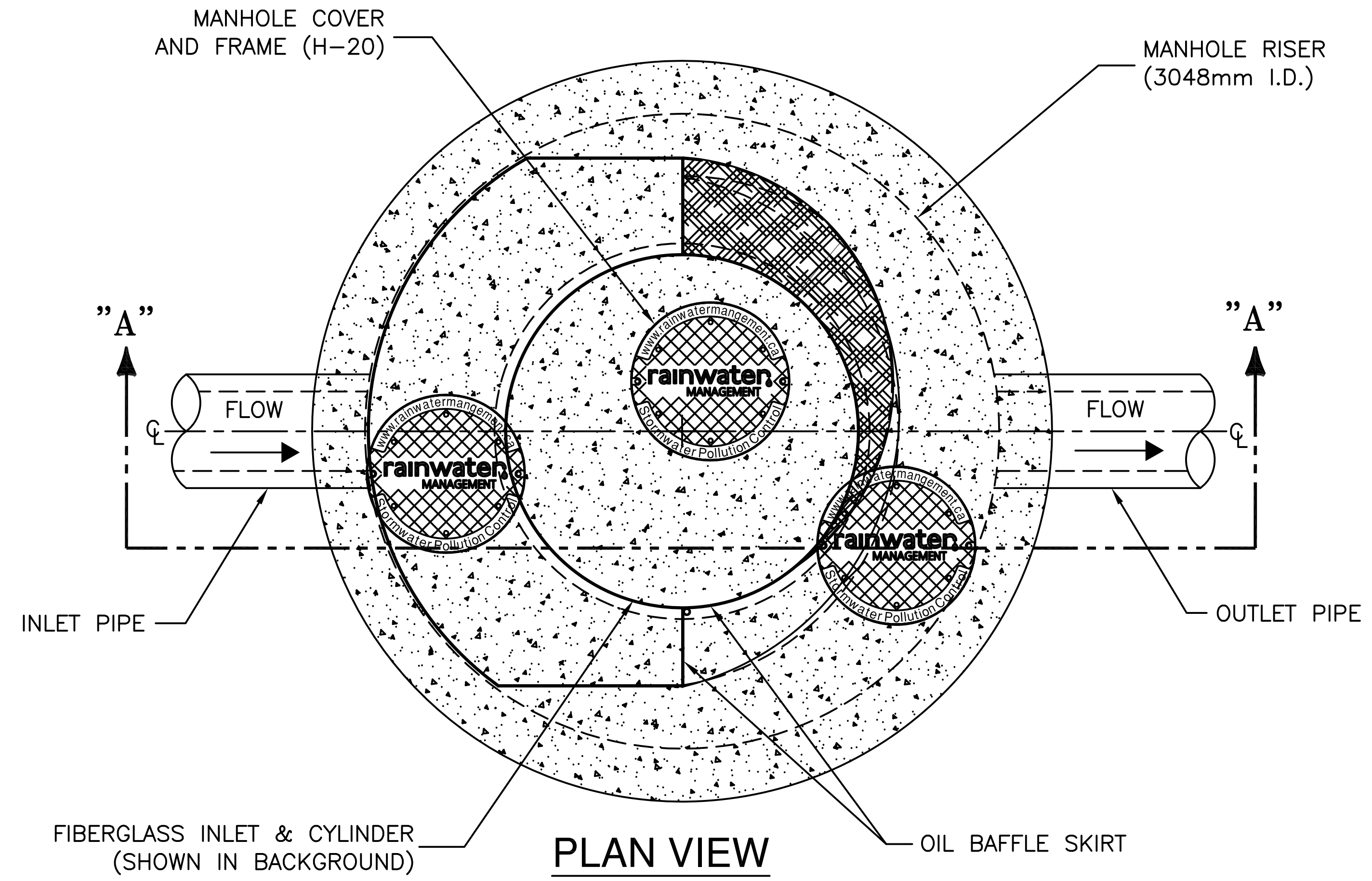
Subsurface drains located adjacent to roads will be extended well below the road base. The material for subsurface drains will be clear round drain rock in an envelope of approved filter material. A minimum 100mm PVC perforated pipe will be placed at the bottom of the trench.

Appendix H – Oil/Grit Separator Design Drawing

ELEVATION VIEW
"A"-"A"
NOT TO SCALE



CONTECH STORMWATER SOLUTIONS
CDS



PLAN VIEW
"B"-"B"
NOT TO SCALE

DESIGN NOTES

1. THE STANDARD CDS5678 CONFIGURATION IS SHOWN. ALTERNATE CONFIGURATIONS ARE AVAILABLE, PLEASE CONTACT RAINWATER MANAGEMENT. SOME CONFIGURATIONS MAY BE COMBINED TO SUIT SITE REQUIREMENTS.
2. THE CDS UNIT CAN HANDLE MULTIPLE INLET PIPES,TOP INLET AND CAN ACCOMODATE INLET PIPES AT AN ANGLE TO THE OUTLET.

GENERAL NOTES

1. RAINWATER MANAGEMENT TO PROVIDE ALL MATERIALS UNLESS NOTED OTHERWISE.
2. ALL DIMENSIONS ARE SHOWN IN MILLIMETERS.
3. FOR FABRICATION DRAWINGS WITH DETAILED STRUCTURE DIMENSIONS AND WEIGHTS, PLEASE CONTACT YOUR RAINWATER MANAGEMENT PRODUCTS REPRESENTATIVE. www.rainwatermanagement.ca
4. CDS WATER QUALITY STRUCTURE SHALL BE IN ACCORDANCE WITH ALL DESIGN DATA AND INFORMATION CONTAINED IN THIS DRAWING.
5. STRUCTURE AND CASTINGS SHALL MEET HS20 LOAD RATINGS, ASSUMING GROUNDWATER ELEVATION AT, OR BELOW THE OUTLET PIPE INVERT ELEVATION. ENGINEER OF RECORD TO CONFIRM ACTUAL GROUNDWATER ELEVATION.
6. MANHOLE MANUFACTURED TO ASTM 478 SPECIFICATIONS.

INSTALLATION NOTES

1. ANY SUB-BASE, BACKFILL DEPTH, AND/OR ANTI-FLOTATION PROVISIONS ARE SITE-SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY THE ENGINEER OF RECORD.
2. CONTRACTOR TO PROVIDE EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE CDS MANHOLE STRUCTURE (LIFTING CLUTCHES PROVIDED). HEAVIEST LIFT TO PLAN FOR IS 17,500kg.(THIS CAN BE REDUCED)
3. CONTRACTOR TO ADD GASKETS OR JOINT SEALANT (PROVIDED) BETWEEN ALL STRUCTURE SECTIONS, AND ASSEMBLE STRUCTURE.
4. CONTRACTOR TO PROVIDE, INSTALL, AND GROUT PIPES, MATCH PIPE INVERTS WITH ELEVATIONS SHOWN.
5. CONTRACTOR TO TAKE APPROPRIATE MEASURES TO ASSURE UNIT IS WATER TIGHT, HOLDING WATER TO FLOWLINE INVERT MINIMUM. IT IS SUGGESTED THAT ALL JOINTS BELOW PIPE INVERTS ARE GROUTED.

SITE SPECIFIC DATA REQUIREMENTS FOR CDS5678

STRUCTURE ID		PIPE DATA:	I.E.	MATERIAL	DIAMETER
WATER QUALITY FLOW RATE (L/S)	*	INLET PIPE 1	*	*	*
PEAK FLOW RATE (L/S)	*	INLET PIPE 2	*	*	*
RETURN PERIOD OF PEAK FLOW (YRS)	*	OUTLET PIPE	*	*	*
SCREEN APERTURE (2400)	*	RIM ELEVATION			*

ANIT-FLOTATION BALLAST	WIDTH	HEIGHT
	*	*

NOTES / SPECIAL REQUIREMENTS

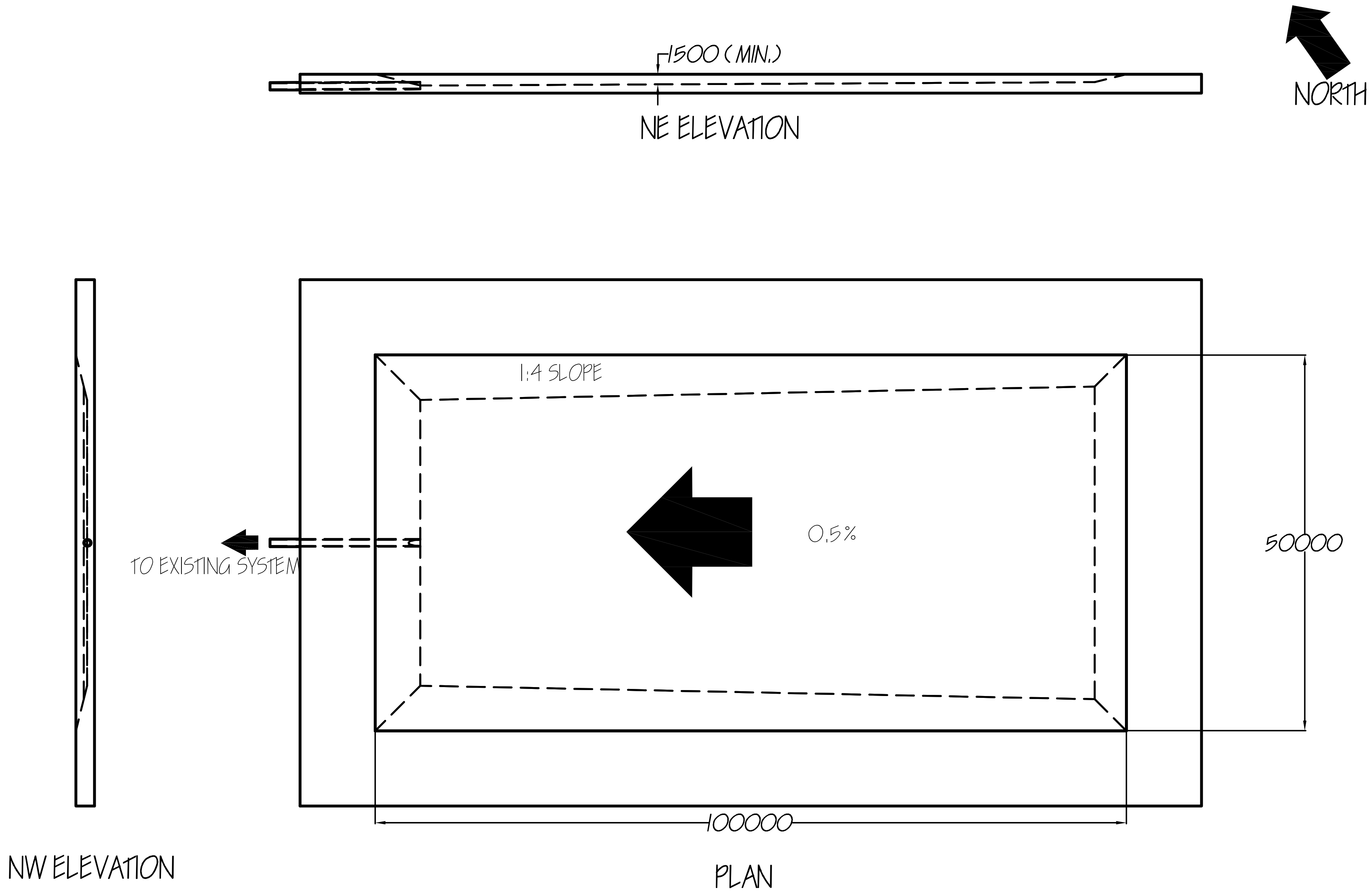
* PER ENGINEER OF RECORD

rainwater MANAGEMENT
www.rainwatermanagement.ca
TEL : 604-944-9265

CDS5678
INLINE CDS
STANDARD DETAIL

Plotted:

Appendix I – Dry Pond Design Drawing



PROPERTIES:

MAX. CAPACITY: 5477 c.m

SURFACE AREA: 5000 s.m

PIPE DIAMETER:1.0 m

**ALL UNITS IN MM*

UNIVERSITY OF BRITISH COLUMBIA	SCALE: 1:750	CIVL 446
DRY POND ELEVATIONS	DATE: 26/ 02/ 2016	TEAM 10
		PG. 1 OF 2