UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

UBC Stormwater Detention: UBC Centre for Comparative Medicine (CCM) Multiple Use Stormwater Detention Project

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University of British Columbia

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Executive Summary

Our team has created this final design report for the UBC CCM Multiple Use Stormwater Detention Project for the University of British Columbia SEEDS Sustainability Program. Enclosed are the outline, design components, design considerations, cost estimate, construction schedule, and detailed drawings/specifications for the project. The UBC Integrated Stormwater Management Plan (ISMP) has established the UBC South Campus area as a critical section that is prone to flooding during heavy storm events and erosion of the surrounding Point Grey cliffs. The primary goals of the UBC ISMP were implemented in the design process.

The enclosed project recommends a stormwater detention pond beside the UBC CCM building that will receive and detain the 100-year rainfall event from the UBC south catchment basin. The stormwater detention pond was designed with a natural systems design approach that would be minimally invasive to the surrounding area while acting as a multiple use area. The existing site is a densely forested area that is the point of lowest elevation and the most feasible area to collect stormwater for the south catchment basin.

Stormwater runoff will be redirected to the pond by a culvert tie-in to the existing storm sewers on Wesbrook Mall road. An oil and grit separator will remove pollutants and debris from the stormwater before it enters the pond. The stormwater detention pond is designed to detain the 100-year storm runoff volume of 3000 cubic metres. A unique control structure located on the opposite side of the pond releases the runoff at a greatly reduced flow rate to decrease scouring and erosion downstream. Once exiting the storm pond, the runoff enters a series of bioswales

along SW Marine Drive that naturally filter and clean the runoff before entering Booming Ground Creek which feeds into the Pacific Ocean.

Our team recommends the project be constructed over the summer months of May to August, 2019, in order to mitigate risk of construction impacts during the busy school year. A final construction schedule has been created that begins with site mobilization on May 1, 2019 and conclude with final commissioning during the middle of August, 2019. After performing a Class D cost estimate, the client can expect to budget $794,750.00 for the construction of all aspects of the stormwater detention pond with an annual maintenance cost of $23,800.00.

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1.0 Introduction

The UBC Integrated Stormwater Management Plan (ISMP) recommends a new design for stormwater management to replace and enhance the current system. The objective of this project is to build a multi-use integration between stormwater infrastructure and environment, also achieving the flow control to address the erosion concerns. It includes the exploration of features that can serve not only as a piece of critical infrastructure but also benefit the surrounding community. The Wetland Stormwater Detention Area is a man-made excavated pond with membrane lined for seepage prevention, passive flow control structure, oil and grit separator, bioswales for quality treatment, and ties in to existing UBC stormwater lines. The project's construction is expected to start in May 2019 and complete in August 2019.

2.0 Design Components

2.1 Existing Site

The existing site is a moderately wooded 3 hectare lot bounded by UBC Centre for Comparative Medicine, Wesbrook Mall, Southwest Marine Drive and the UBC Farm as shown in **Figure 1.**

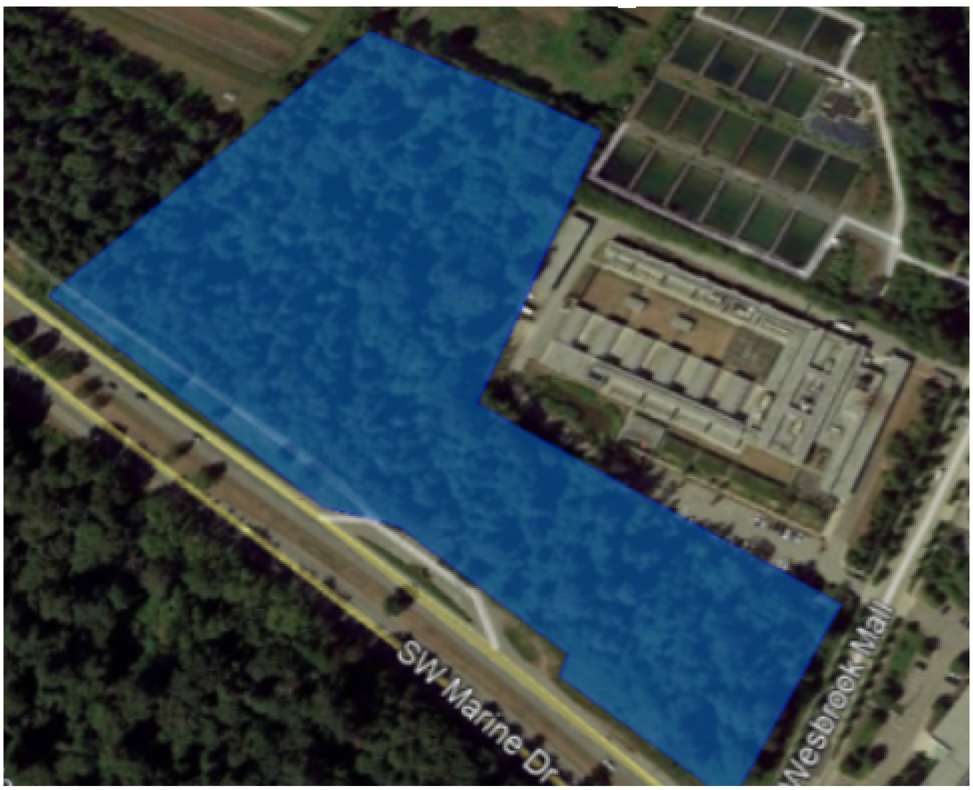


Figure 1: Aerial view of existing site.

The UBC campus is split into five different catchment basins as depicted in **Figure 2.** Outflows from the South Campus Catchment area are released directly into the Strait of Georgia via Booming Ground Creek which is fed through a network of unlined roadside ditches and corrugated steel pipe.

Figure 2: Illustration of catchment basins at UBC [2].

Across SW Marine Drive from the existing site is the area of Pacific Spirit Regional Park. Any access or disturbance to this area will require communication with and permission from Metro Vancouver. This project must take into special consideration during construction and operation the sandstone cliffs which flank the southern shoulder of SW Marine Drive. These landforms are highly susceptible to erosion and must be protected. Significant loss of land and collapse of an arterial road would occur if these cliffs were to wash out.

Open air academic research ponds, The Centre for Comparative Medicine, and The National Research Council are all in the immediate vicinity of this site. Adequate dust protection measures must be in place to prevent contamination of these facilities. Unnecessary noise is to be limited as much as reasonably achievable to prevent disturbance to building occupants. Road bound traffic must also be cautious of private vehicles regularly entering and exiting these facilities.

2.2 Influent Tie-In

The influent tie-in structure along Wesbrook Mall will use similar pipe to the existing system at 1050mm diameter. Diversion of influent from the two main storm sewer lines for the southeast catchment will happen in such a way that the pond may be gravity fed. Lines downstream of the diversion points will be severed and capped but kept active for catchment not covered by the pond. Careful attention has been paid to minimizing disruption to the UBC Research Ponds and UBC Farm, both of which the new system will skirt. Only one new manhole will have to be added to the system adjacent to the UBC Research Ponds, others will only require alteration to existing manholes. The City of Surrey Design Criteria requiring sewers of this diameter to have a slope of at least 0.1% was considered, but most areas had a greater slope due to connection of existing manholes.

2.3 Oil and Grit Separator

The oil and grit separator will provide effective pretreatment of the stormwater entering the pond. The separator will remove debris, free oils and suspended solids from the storm water to increase water quality as well as improving pond health. Effective pre-treatment is essential for pond health. Suspended solids in the water increase turbidity downstream which blocks the sunlight from reaching plants below the water surface, therefore inhibiting photosynthesis. The resulting reduction of oxygen levels in the water is damaging for wildlife populations. Additionally, suspended solids absorb sunlight and increase water temperatures which further degrades the wildlife environment. Nutrients like nitrogen and phosphorus are often attached to suspended solids and it it a know benefit to have these nutrients removed from the water system. These nutrients can cause significant eutrophication of the pond if they are not appropriately mitigated.

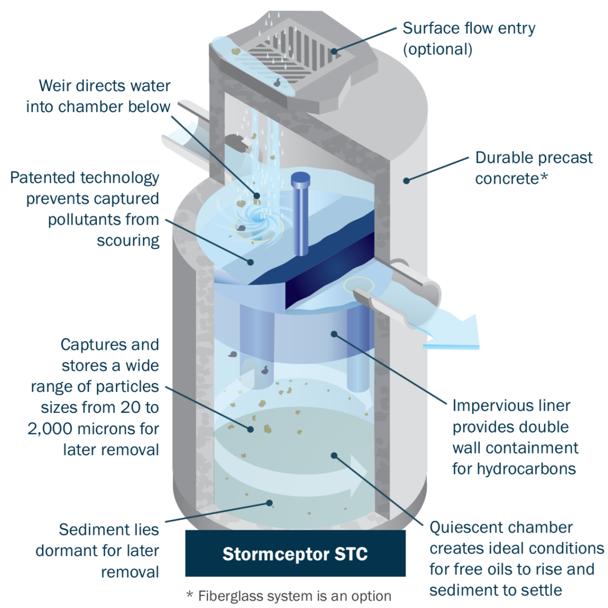


Figure 3: Oil and Grit Separator

The selected oil and grit separator, as seen in **Figure 3** is compliant with the UBC Technical Guidelines Section 33 49 00 Storm Drainage. The specified Oil and Grit separator will be a Imbrium Stormceptor STC model. The oil and grit separator will require maintenance and regular inspection to ensure proper operation. To determine the required maintenance schedule it is recommended that separator storage capacity be monitored weekly until buildup rates for the system have been determined. For maintenance, only a vacuum truck will be required to remove debris and oils.

2.4 Pond

The stormwater detention pond was designed to handle the 100-year storm surge, a volume of 3000 m^3. As seen in the right side of **Figure 4**, the pond is depicted at its normal pond volume elevation of 59.40 m relative to sea level and the full storm surge volume at an elevation of 60.45 m. The pond was designed with a balanced cut and fill to reduce project expenses. There is a 16 m^3 difference between cut and fill, meaning only 16 m^3 of new fill will be required for this project. The outside slopes were designed at 5:1, primarily to allow for proper maintenance such as lawn mowing. The slope just below normal pond elevation was increased to a steeper slope in order to achieve a depth that will help reduce algae growth. The inflow and outflow locations of the stormwater were designed in such a way to allow for sediment to settle to the pond bottom before entering the control structure. The pond is also designed to have a walking and biking path around its perimeter. This provides the functionality of a multi-use space.

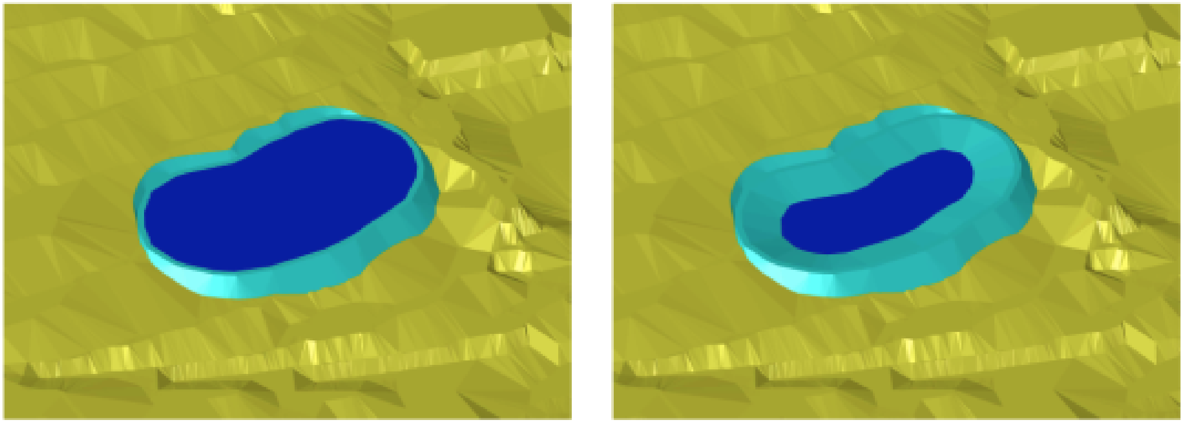


Figure 4: Full 100-year storm pond volume and normal pond elevation.

2.5 Geotextile

The suitable geotextile will be impermeable to prevent erosion of the water sensitive clay cliffs adjacent to the site and to allow for the pond to maintain its normal water level. The clay cliffs are sensitive to water and a saturated condition could cause them to become unstable and put them at risk of erosion or trigger a landslide. The area of campus where the pond will be located is at risk of serious flooding in a major storm event, making it important that the geomembrane is in place and working so the design measures in place can convey the flood off campus and to the ocean.

The geotextile membrane must be laid out just below the ground surface of the pond and in areas where the effluent is not otherwise prevented from infiltration . A compacted clay layer for seepage control was considered but would require more performance testing to ensure its impermeability, therefore it is not recommended. The specified geotextile is a linear low density polyethylene (LLDPE) geomembrane made by GSE [3]. This membrane will have the required flexibility to follow the contours of the pond. Correct installation is important to ensure the membrane does not float up, and that it is impermeable to prevent erosion of the clay cliffs.

2.6 Flow Control Structure

The flow control structure for the stormwater detention pond regulates the outflow rate of the pond and maintains a regular pond water elevation. An elevation view of the control structure and details is found in **Figure 5.** The pipes were sized using the City of Surrey Design Manual [1] and Manning's formula with a roughness coefficient of 0.013 for PVC and the concrete pipe. As seen in Appendix A.1, the reverse sloped outflow pipe is 154 mm (inside diameter) PVC and the overflow pipe is 525 mm (533 mm inside diameter) Concrete Pipe [4]. The small diameter reverse sloped pipe will maintain the pond's standard elevation and release the 3000 m³ storm surge at a maximum rate of 0.037 m³/s. The slower release rate will drain the 3000 m³ storm surge in 22 hours which greatly reduces stress on the existing infrastructure. The slow release rate is intended to reduce scouring and erosion of the downstream systems. This will give the bioswales adequate retention time to naturally filter the water and reduce the flow volume that will occur over the cliff outflow.

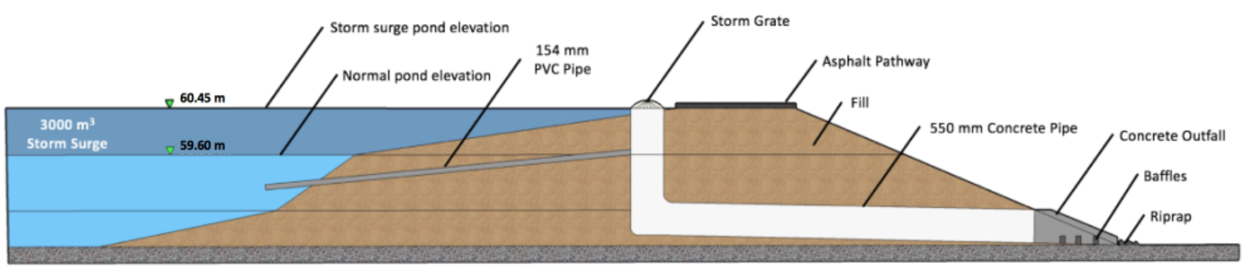


Figure 5: Elevation view of pond control structure.

The concrete headwall will include baffles, leading into riprap which will reduce the hydraulic energy of the water entering the bioswales and provide scour protection [5]. The baffles are a prefabricated unit available from the Langley Concrete Group [6]. The specific unit is the 11-13 Headwall Structure w/ Energy Dissipators and the section view of the baffle is seen in **Figure 6** below. The concrete headwall will introduce water to the bioswale in a distributed sheet flow which is best practice for bioswale design.

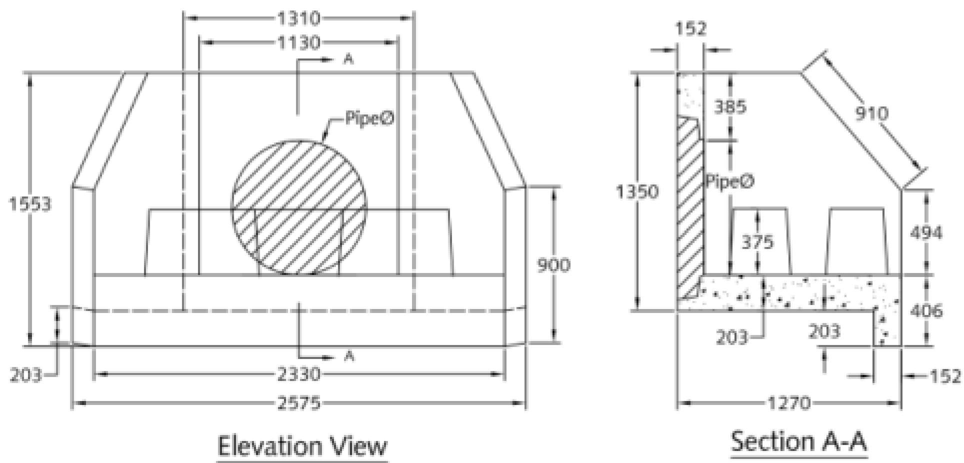


Figure 6 : Prefabricated Concrete Headwall Unit [6].

2.7 Bioswales

The outflow from the storm detention pond will travel approximately 200 metres alongside SW Marine Drive before it crosses the road and flows over the cliff in Booming Ground Creek. The purpose of the bioswales is to naturally improve the storm runoff water quality before entering the ocean. This will help mitigate pollutants entering the ocean from UBC's storm runoff.

Figure 7: Location of bioswale system along SW Marine Drive.

Due to the interruption of a road pullout and Wesbrook Mall road crossing the bioswale, a series of 600 mm HDPE culverts will be installed to connect the bioswales as seen in **Figure 7**. Using the City of Victoria Rainwater Management Standard, a bioswale with a bottom 100 mm perforated PVC pipe will be installed to direct the pond outflow to Booming Ground Creek [5]. Since the longitudinal slope between bioswale sections is less than 2%, there it is not necessary to include rock weirs along the length of the bioswales.

Since the bioswales are located within 300 metres of the cliffs, no ground water penetration is allowed; therefore, an impermeable membrane is recommended to line the bioswale trench. After the trench excavation, the impermeable membrane will be installed over 200 mm of sand with 600 mm minimum overlap at all joints. The bioretention growing medium must be a properly graded mix of gravels, sands, silts, and organics to facilitate adequate retention while providing a fertile base for vegetation to grow. Shrub, grass, and perennial species that are resilient and native to the Pacific Northwest coast should be chosen to vegetate the bioswales. For construction sequencing, it is important to leave construction of the bioswale to the end of the overall construction timeline to avoid soil compaction and contamination due to construction runoff. Storm runoff should also be diverted away from the bioswale until the plant material has has adequate time in situ.

2.8 Vegetation and Plant Selection

The role that the plants play is to decorate the pond in a visually appealing way and to sustain the aquatic environment. Various plants are selected for the pond design. Pickerel, Horsetail and Cardinal Flower are selected to be placed at the bottom of the pond with an overall height ranging from 2 to 5 feet. As for the edge of the pond, Creeping Jenny and Blue Iris are chosen because they provide easy management and resistance to animals. Vegetation will help with overall slope stability of the pond and bioswale structures. They will also provided a filtering effect for runoff and water making its way through the pond.

2.9 Perimeter Walkway

The pond had been design to incorporate a walkway surrounding its perimeter. The walkway will connect to the existing walkway that is running parallel to SW Marine drive. It has been designed according to the City of Surrey Design guidelines [1]. The walkway is incorporated to achieve the projects goal of being a multi use area. A typical cross section of the walkway structure can be found in the attached drawings.

2.10 Information Board

Education and awareness are key values to expanding sustainable infrastructure throughout UBC. Our team recommends that a permanent information board be installed on the perimeter walkway for the general public to understand the purpose of the stormwater detention pond. This project is a perfect opportunity to educate the public around sustainable stormwater runoff practices and enable UBC to further its reputation as a leader in sustainability. Stakeholders of UBC appreciate understanding how their money has been spent and an information board has the ability to do so while also educating the public.

3.0 Design Considerations

3.1 Adherence to UBC's Integrated Stormwater Management Plan (ISMP)

The following goals of UBC's ISMP were acknowledged in the design process of the stormwater detention pond:

- Reduce flows of water off campus
- Reduce impacts through water detention
- Enhance water quality leaving campus
- Protect campus assets from flooding
- Safeguard human life
- Incorporate a natural systems approach.

Our team strived to achieve all of these goals while keeping a low cost and practical design approach in mind. The projected land use for the south campus area is not expected to see a large growth in public or residential facets, so a low cost design option that could achieve storm runoff performance requirements was chosen.

3.2 Expected Flows

From EPA SWMM analysis and the ISMP projection, the 100-year storm surge volume for the UBC south campus catchment was calculated to be 3000 m^3. The critical path in design is the culvert crossing SW Marine Drive which has a maximum flow capacity of 1.2 m^3/s. The storm detention pond will release at a much slower 0.037 m^3/s over a 22 hour period.

3.3 Budget

It is recommended that the project goes ahead with a total budget of $794,750 as per the detailed cost estimate summarized in Section 4, as well as an annual allowance of $23,800 for the lifetime of the project.

3.4 Standards

The following list of applicable standards and design manuals were used:

- 2016 City of Surrey - Design Criteria Manual [1]
- 2018 Lafarge Concrete Pipe Catalogue [2]
- 2015 City of Victoria Rainwater Management Standards [3]

3.5 Draft Plan of Construction Work

There are 4 stages in total during the construction: mobilization on site, site grading and landscaping, installation of stormwater discharge control system, and sewer work. Project management will be implemented throughout the construction.

3.6 Maintenance Plan

The maintenance plan will be implemented annually. The plan includes components such as testing, cleanup and other maintenance. The testing crew will be hired to evaluate the whole water system. If any issue is found during the testing, specific maintenance groups will be hired to resolve the problem respectively. Also, the cleanup process is to clean the dead vegetation and replace some soil if needed. Mowing the lawn and doing routine site maintenance checks will also be necessary for proper maintenance of the area.

4.0 Cost Estimate

The total cost of the project is estimated at $794,750 initially with $23,800 annual operating expenses. This detailed cost estimate differs from the preliminary cost estimate primarily in that construction costs were no longer estimated using weighted location indices and cost multipliers, but instead calculated as per the actual design. Further changes and adjustments were made to ensure an accurate cost estimate, including a revised method for calculating contingencies.. The cost components of the project are summarized below in Table 4.1.

Table 1: Cost Estimate Summary

Cost Component	Initial Cost $	Annual Cost $
Design	101,000	-
Permitting	1,000	-
Construction	620,500	-

Operational	-	21,600
Contingency	72,250	2,20
Total Project Cost	**794,750**	**23,800**

4.1 Design Cost

Our team estimates the total cost for consulting services for the design of the project at $101,000. The calculated rates for consulting work are as per the Consulting Engineers Fee Guideline 2016, for 10 weeks of consulting work.

Table 2: Consulting Services Cost Estimate

Service	Hourly Rate $	Hours Per Week	Cost $
Engineer-in-Training	123	12	1476
Assistant Project Engineer	144	12	1728
Project Engineer	162	2	324
Supervisory Engineer	199	2	398
Specialist Engineer	199	2	398
Management Engineer	227	2	454
Advanced Specialist Engineer	227	2	454
Senior Management Engineer	276	2	552
		Sub-Total	5784
Technician	103	10	1030
Technician/Technologist (Drawings)	113	10	1130
Technician/Technologist (Field)	135	6	810
		Sub-Total	2970
Disbursements			
Minor Disbursement			463
Other Disbursement			875
		Sub-Total	1338
		Total Weekly Cost	10092
		Total	**101000**

4.2 Permitting Cost

The permitting costs associated with this project are related to tree removal, and include hiring a surveyor as well as acquiring the tree removal permit. The total permitting cost is estimated at $1,000.

Table 3: Permitting Costs

Component	Cost $
Surveying (G.C.)	500
Documentation & Permit Fee	500
Total	**1000**

4.3 Construction Cost

The total construction cost for the project is estimated at $620,500. The table below summarizes all costs for labour, equipment and project management.

Table 4: Construction Cost Summary

Component	Hourly Rate	Total Hours	Cost $
Arborist (Site Grading Contractor)	200	40	8000
Excavation (G.C. Labour Crew)	400	120	48000
Traffic Management Crew	100	130	13000
Concrete (G.C. Labor Crew)	400	100	40000
Asphalt (G.C. Labor Crew)	200	20	4000
Pipes (Plumbing Contractor)	300	70	21000
		Labour Sub-Total	134000
Cement Truck Hire	100	100	10000
Excavator Hire	100	110	11000
Bulldozer Hire	100	50	5000
Dump Truck Hire	150	80	12000
		Equipment Sub-Total	38000
Project Management (G.C.)	200	120	10000

		Sub-Total	**182000**

The table below summarizes all costs for materials and installed components.

Table 5: Material Cost Summary

Component	Unit Price $	Quantity	Cost $)
Concrete (Control Structure)	250 / m^3	200 m^3	50000
525 mm PVC Pipe	100 / m	600 m	60000
154 mm PVC Pipe	50 / m	20 m	1000
Asphalt (Footpath)	150 / m^2	200 m^2	30000
Bioswales	20 / m^2	200 m^2	2000
Geotextile	20 / m^2	13000 m^2	260000
Vegetation	10 each	500	5000
Oil & Grit Separator	30,000 each	1	30000
Information Board	500 each	1	500
		Sub-Total	**438500**

4.4 Operational Cost

The operational cost consists of testing, cleaning, and general maintenance. Testing is to be performed annually, with a total of 10 labour hours annually. Cleaning is to be performed quarterly, with a total of 40 hours annually. General maintenance is to be performed annually, with a total of 8 labour hours. The total operational cost is estimated at $21,600 annually.

Table 6: Operational Cost Summary

Component	Hourly Rate $	Hours Annually	Cost $
Testing	400	10	4000
Cleanup	400	40	16000
General Maintenance	200	8	1600
		Total (Annually)	**21600**

4.5 Contingencies

The total contingency cost is calculated based on a 10% factor, which includes all unforeseen additional costs. The total contingency costs are $72,250 initially and $2,200 annually.

5.0 Conclusion

Our team has designed the UBC CCM Stormwater Detention Facility in accordance with data and studies provided by The University of British Columbia's Campus and Community Planning Department. This design has capacity to detain and release in a controlled manner the rainwater flows associated with a 100-year storm event as estimated by the provided EPA SWMM Model. The stormwater detention pond incorporates comprehensive design elements including a membrane lining for seepage prevention, a passive flow control structure to ensure flow control during the 100-year event, an oil and grit separator for water ensuring adequate influent quality, and bioswales for ensuring adequate effluent quality. Construction is expected to begin in May 2019 and to be complete in August 2019 at a total cost of $794,750. Our team Consulting would like to thank UBC CCP for their support on this project and look forward to provide continued supervision and expertise in its implementation.

References

[1] City of Surrey Engineering Department, “Design Criteria Manual”, Surrey, Canada. Pg. 46-48. January 2016.

[2] UBC Campus and Community Planning, “Stormwater Management Infrastructure at UBC”, Vancouver, BC, 2019. [Online]. Available: https://planning.ubc.ca/vancouver/projects-consultations/consultations-engagement/integrated-stormwater-management-plan/Infrastructure. [Accessed Feb 2, 2019].

[3] GSE Environmental Solmax, “LLDPE Smooth Geomembranes”, United States, 2019. [Online]. Available: http://www.gseworld.com/Products/Geomembranes/LLDPE-Smooth/ . [Accessed Feb 16, 2019].

[4] Lafarge Precast Stormwater & Wastewater Solutions, “Concrete Pipe Catalogue”, Calgary Pipe Plant, Canada. 2018.

[5] City of Victoria, “City of Victoria Stormwater Utility - Rainwater Management Standards”, Victoria, Canada. Pg. 40-49. June 2015.

[6] The Langley Concrete Group - Technical Drawings, “11-13 Headwall Structure w/ Energy Dissipator”, 2019. [Online]. Available: http://www.langleyconcrete.calls.net/index.php?page=tech-drawings#headwalls. [Accessed Jan. 14, 2019].

[7] "Guidelines by Specification Division." Guidelines by Specification Division - UBC Technical Guidelines. Accessed April 03, 2019. http://www.technicalguidelines.ubc.ca/technical/divisional_specs.html.

Appendix A: Design Details and Calculations

A.1 Control Structure

The pipe sizing for the control structure is based off Manning's formula in the Surrey Design Criteria [1]. A standard size PVC pipe was selected and the concrete pipe size was selected using the Lafarge Concrete Pipe Catalogue [4].

Outflow - Reverse Sloped Pipe Diameter

Q	Pipe flow	0.037	m3/s
A	Cross sectional area of pipe	0.019	m2
R	hydraulic radius	0.039	m
D	diameter of pipe	0.154	m
S	slope of energy grade line	0.053	m/m
n	Manning roughness coefficient	0.013	-
h	height above datum	0.950	m
l	length of pipe	20.000	m
HGL	hydraulic grade line	1.052	m

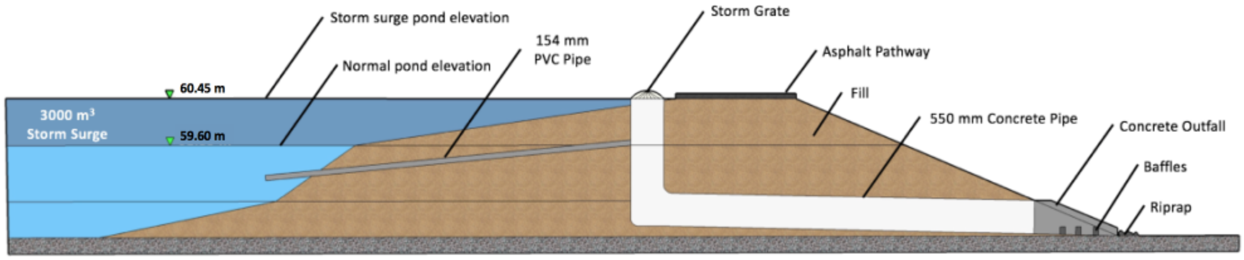
Use PVC Pipe with inside diameter of:	**154**	**mm**
Time to drain 3000 m3 storm surge volume	22.24	hours

Outflow - Concrete Pipe to Handle 1.2 m3/s

Q	Pipe flow	0.838	m3/s
A	Cross sectional area of pipe	0.223	m2
R	hydraulic radius	0.133	m
D	inside diameter of pipe	0.533	m
S	slope of energy grade line	0.035	m/m
n	Manning roughness coefficient	0.013	-
h	height above datum	0.950	m
l	length of pipe	30.000	m
HGL	hydraulic grade line	1.052	m

Use Concrete Pipe with inside diameter of:	**533**	**mm**

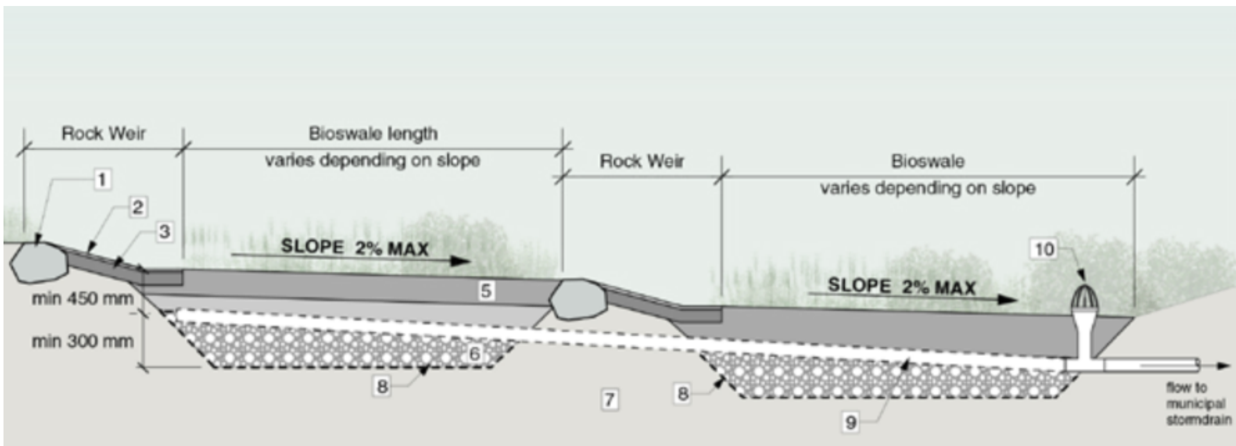
Illustration of Control Structure



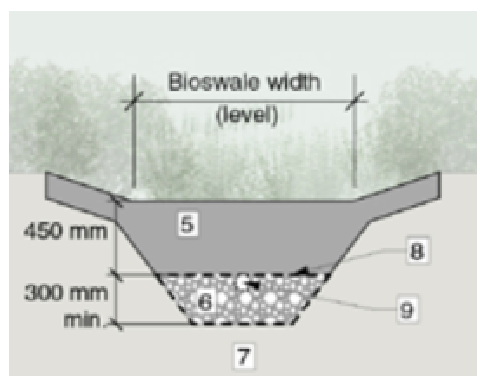
A.2 Bioswale Design

The locations of the bioswales are depicted below in the shaded red area with culverts connecting them in areas to be topped with concrete.

This typical bioswale design was taken from the City of Victoria Professional Rainwater Management Standards [5]. Weirs structures may be installed to slow runoff and allow adequate infiltration. The storm grate will provide overflow capabilities in storm surge events.



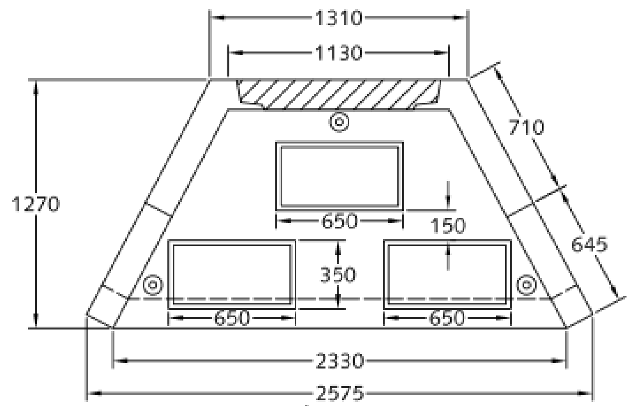
Bioswale Materials:



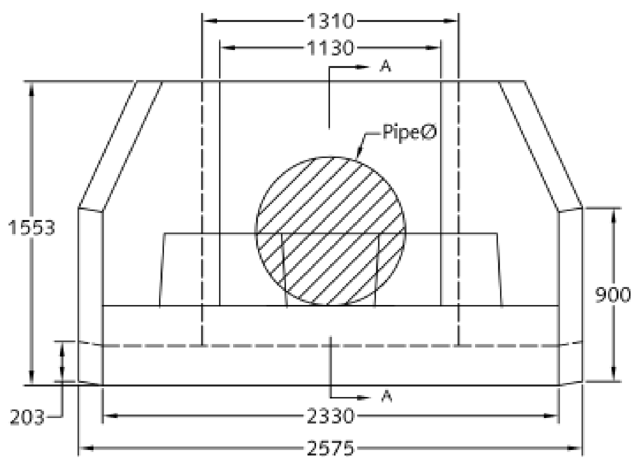
1) Rock weir (300 – 400 mm dia)
2) 25 mm dia drain rock, 25 mm depth
3) 50 – 75 mm dia drain rock, 100 mm depth min
4) Composted mulch, 50 – 70 mm depth
5) Bio-retention growing medium, 450 mm min
6) Reservoir, min 300 mm depth
7) Existing subgrade/native material
8) Non-woven geotextile on bottom sides
9) 100 mm diameter (min) perforated pipe
10) Overflow drain, 200 mm domed grate and adapter

A.3 Concrete Headwall

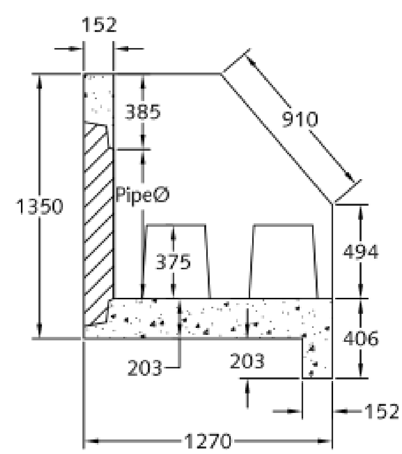
The concrete headwall that connects the pond outflow culvert to the bioswales is a prefabricated unit by the Langley Concrete Group [6]. The specific unit is the 11-13 Headwall Structure w/ Energy Dissipators, section details are listed below.



Plan View



Elevation View



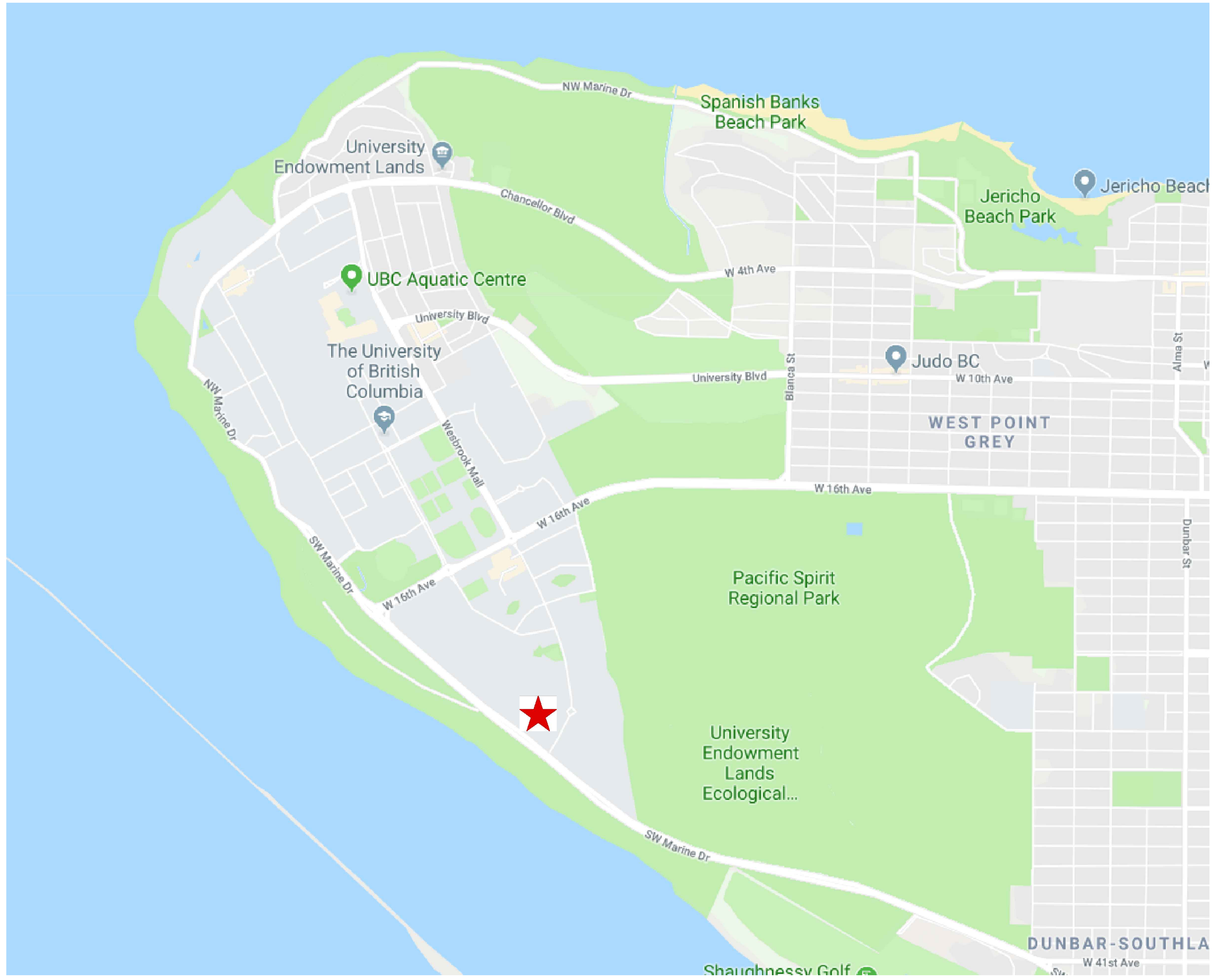
Section A-A

Appendix B: Technical Drawings For Construction

Attached below.

UBC CCM Multiple Use Stormwater Detention Project

Project Location:
Scale: NTS



DRAWING INDEX	
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STORM SEWER PLAN	1-3
BIOSWALE TYPICAL SECTION	CS - 001 TO CS - 003
CONTROL STRUCTURE TYPICAL SECTION	CS - 004
WALKWAY CROSS SECTION	CS - 005
PIPE TRENCH CROSS SECTION	CS - 006
POND BOTTOM SECTION	CS - 007
ISOMETRIC FULL & NORMAL POND	ISO - 001
CUT & FILL DEPTHS	CF - 001

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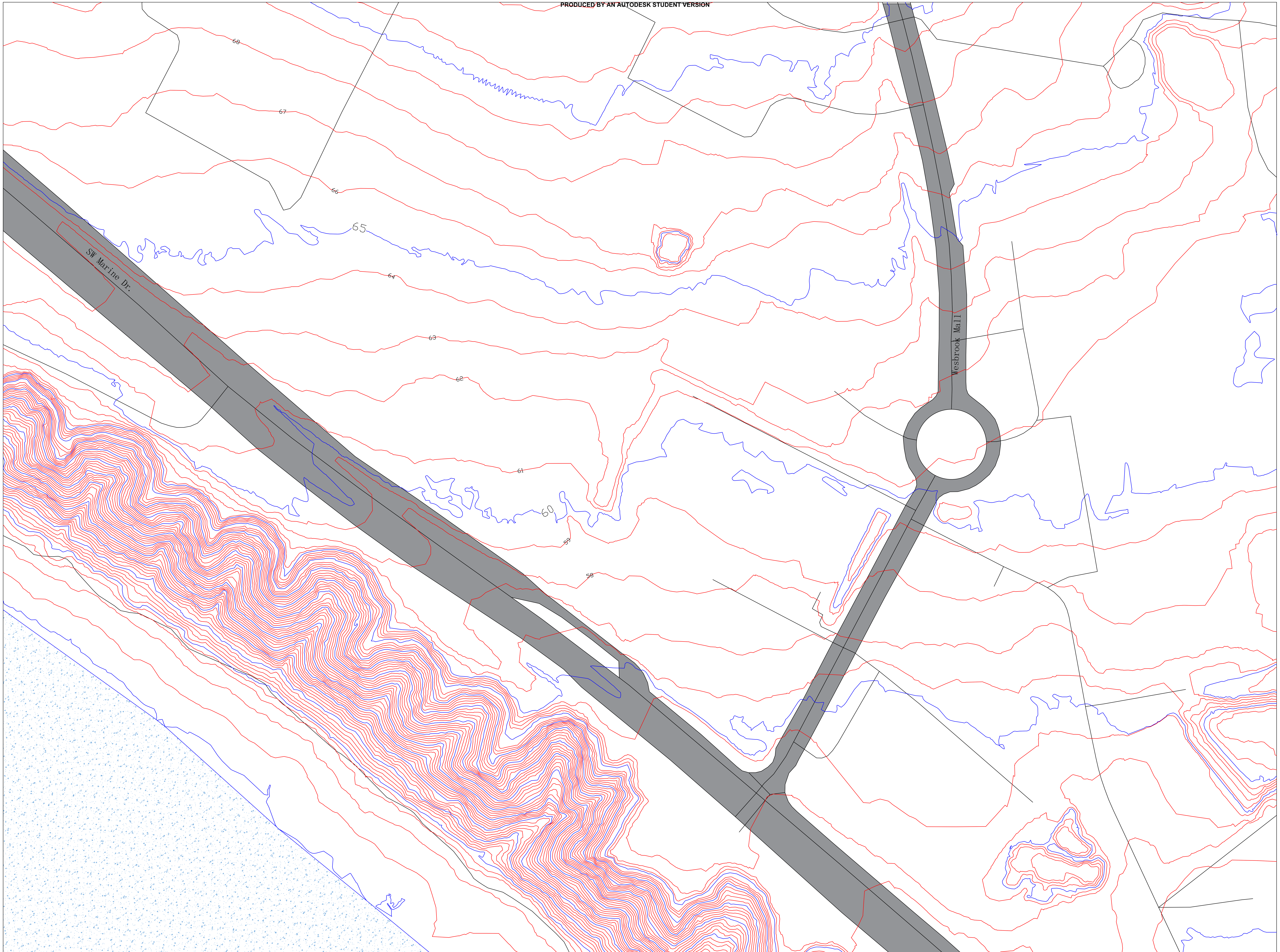


Drawing Title: Existing Site

Sheet Size: Arch E1 30x24

Scale: 1:409

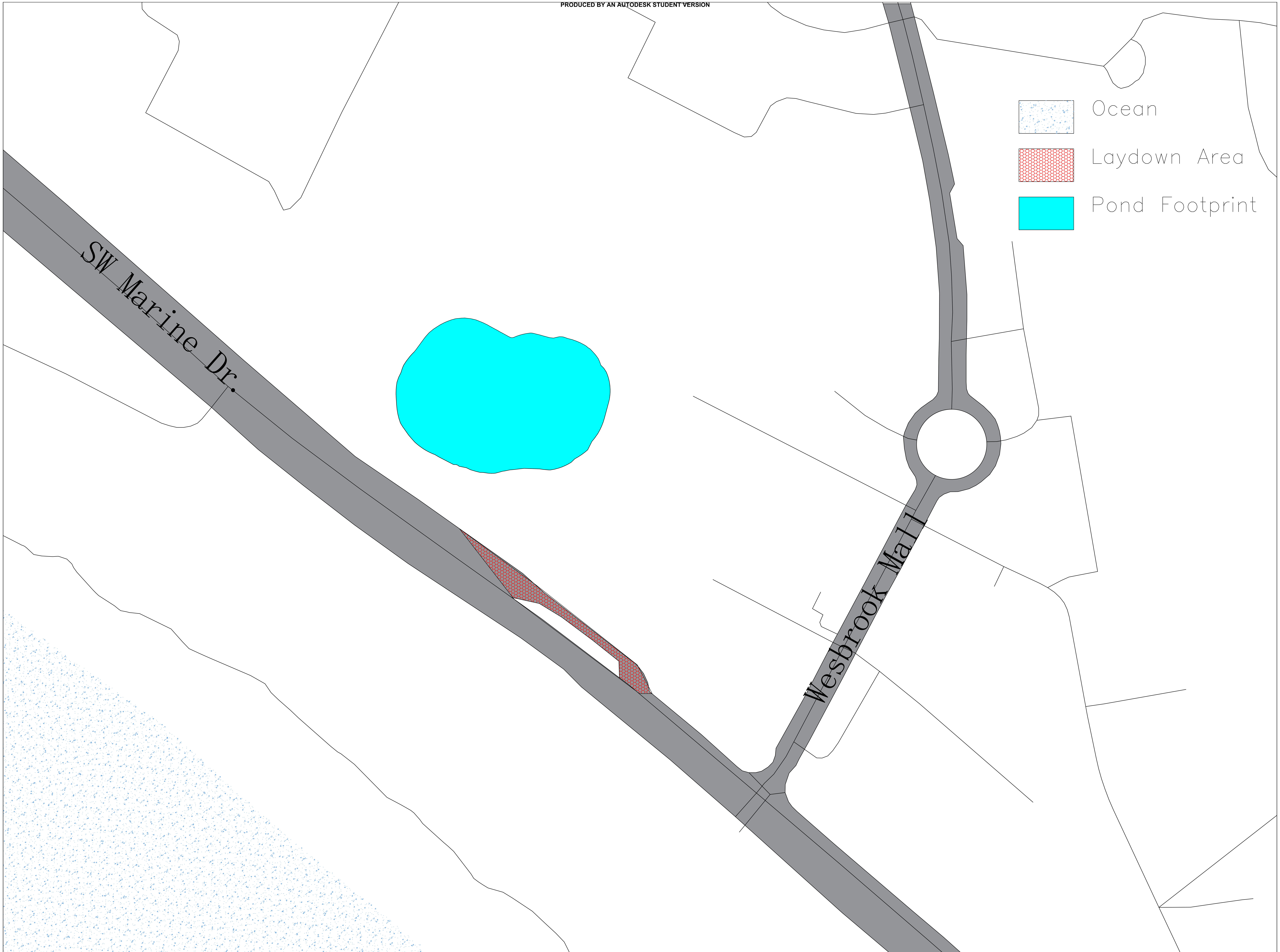
Drawing Set: General

Sheet Number: 1 of 5

Issue: C

Revision History

Rev. #	Date	Author
0	02/22/2019	Luke Burrows



Drawing Title: Site Layout	Sheet Size: Arch E1 30x24	Scale: 1:409
Drawing Set: General	Sheet Number: 2 of 5	Issue: C

Revision History

Rev. #	Date	Author
0	03/02/2019	Luke Burrows

PRODUCED BY AN AUTODESK STUDENT VERSION
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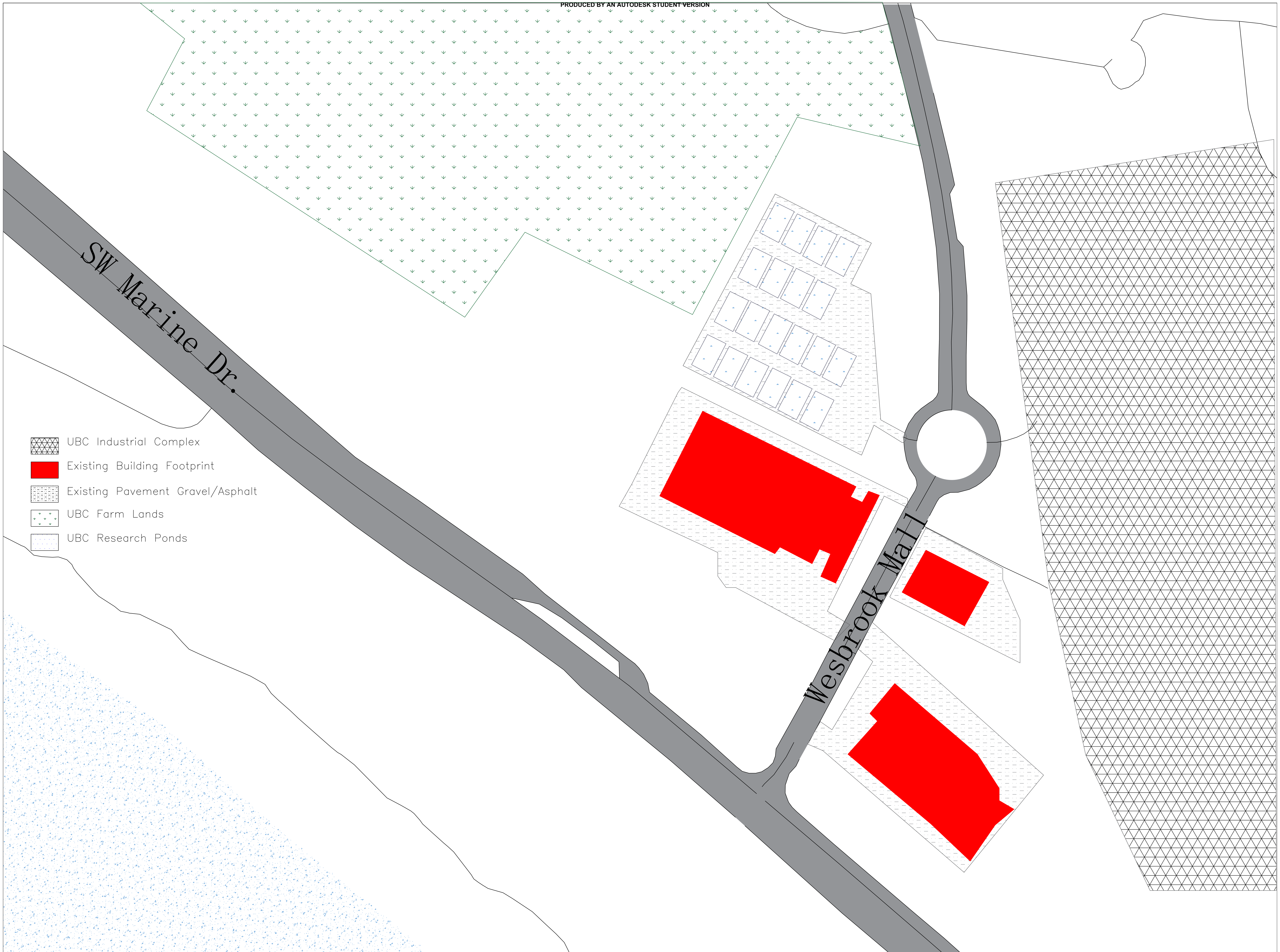


Drawing Title: Existing Structures

Drawing Set: General

Sheet Size: Arch E1 30x24

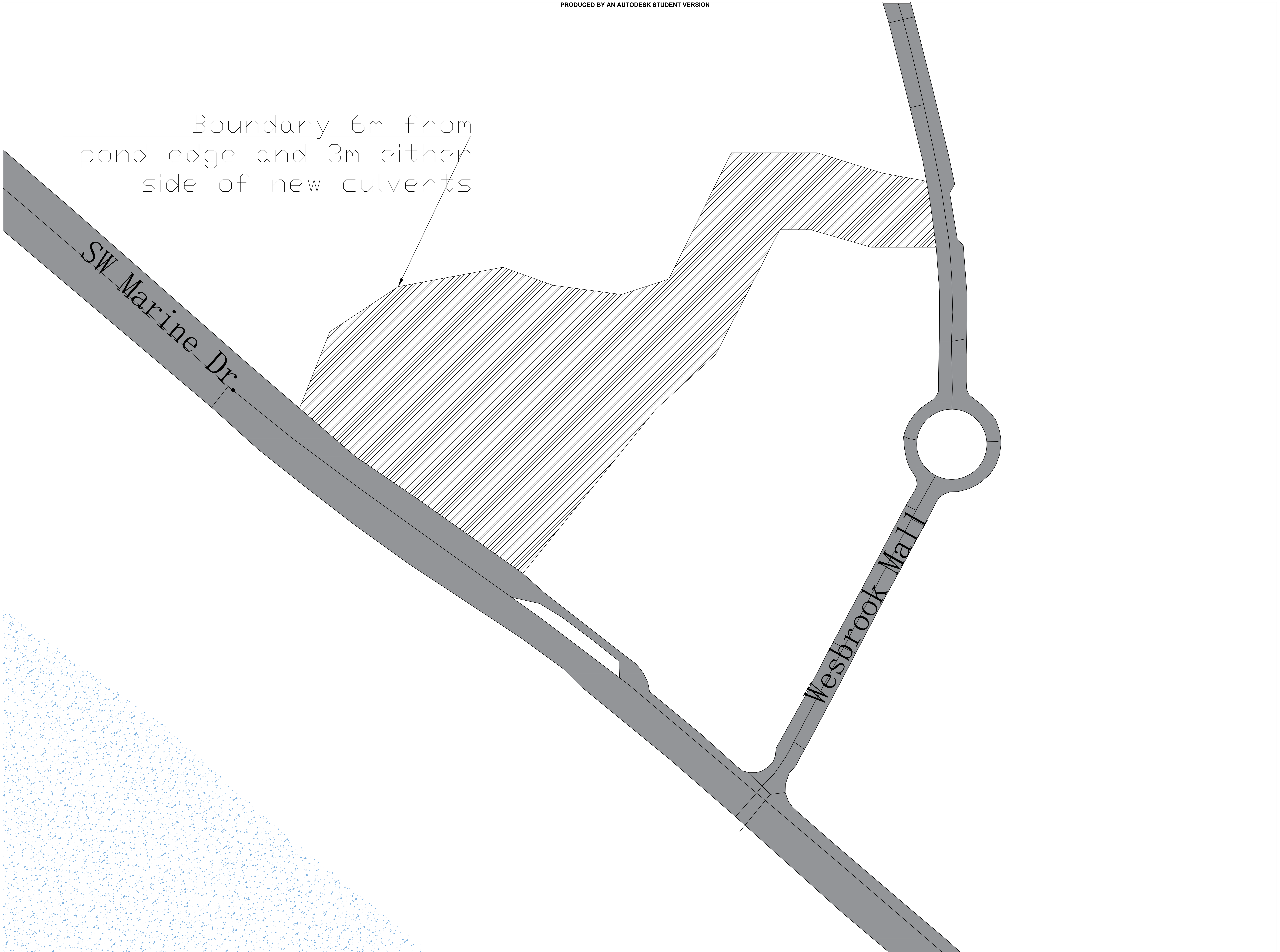
Sheet Number: 3 of 5

Scale: 1:409

Issue: C

Revision History

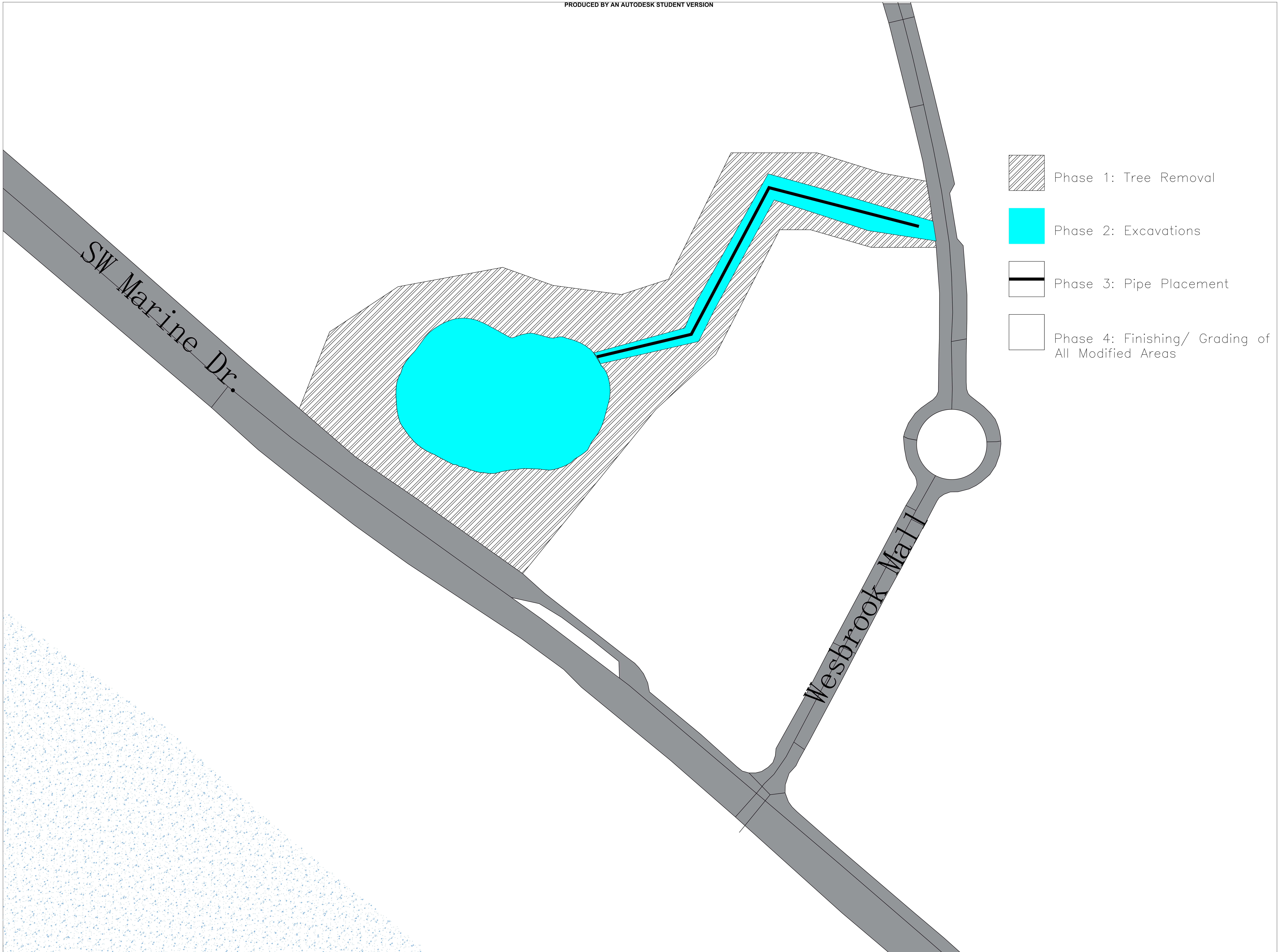
Rev. #	Date	Author
0	03/19/2019	Luke Burrows



Drawing Title: Tree Removal Area	Sheet Size: Arch E1 30x24	Scale: 1:409	
Drawing Set: General	Sheet Number: 4 of 5	Issue: C	

Revision History

Rev. #	Date	Author
0	02/22/2019	Luke Burrows



Drawing Title: Construction Phases	Sheet Size: Arch E1 30x24	Scale: 1:409	
Drawing Set: General	Sheet Number: 5 of 5	Issue: C	

Revision History

Rev. #	Date	Author
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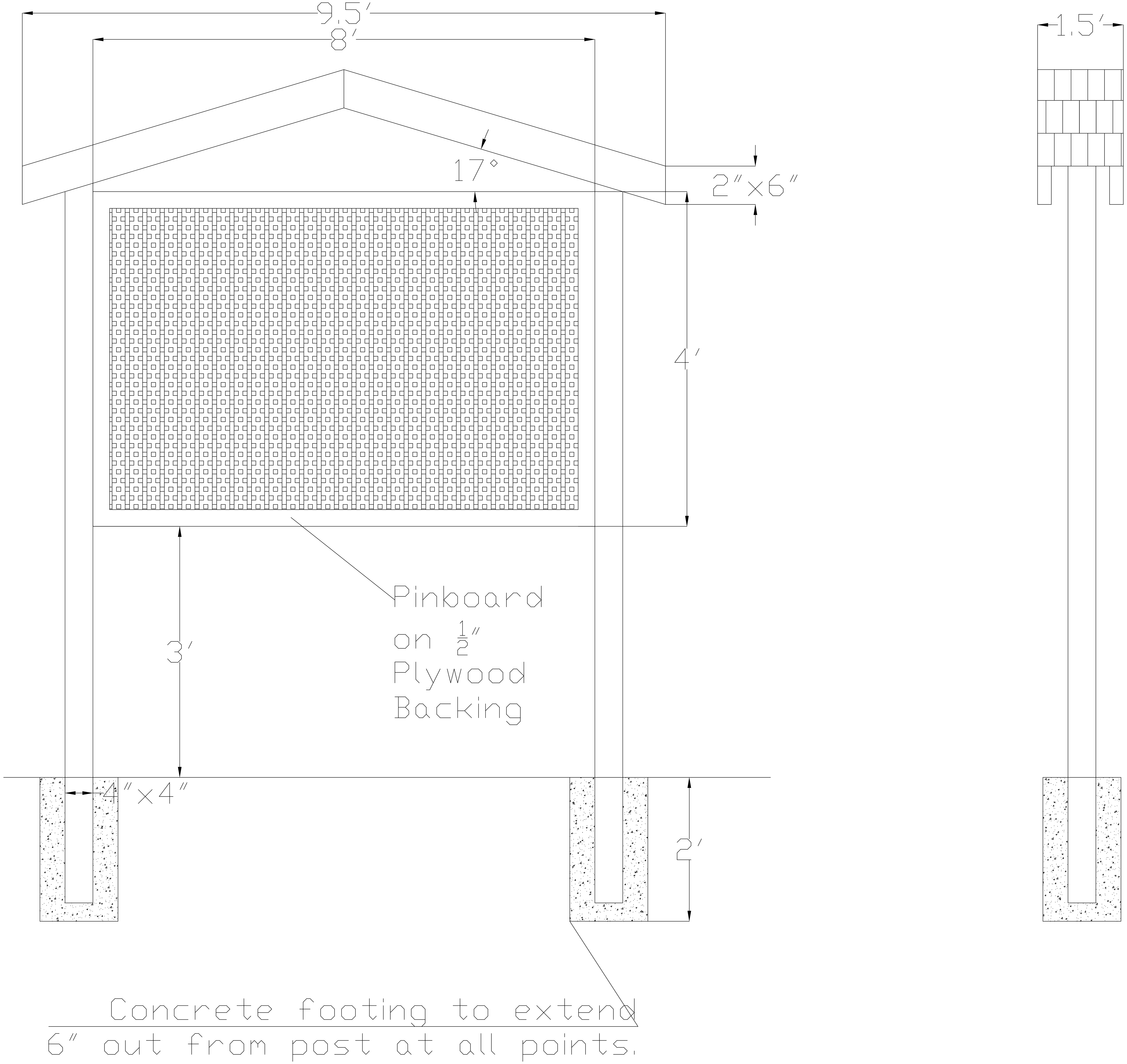

Drawing Title: Signage	Sheet Size: Arch E1 30x24	Scale: 1:12	Revision History		
			Rev. #	Date	Author
Drawing Set: Landscape	Sheet Number: 1 of 2	Issue: C	0	04/02/2019	Luke Burrows

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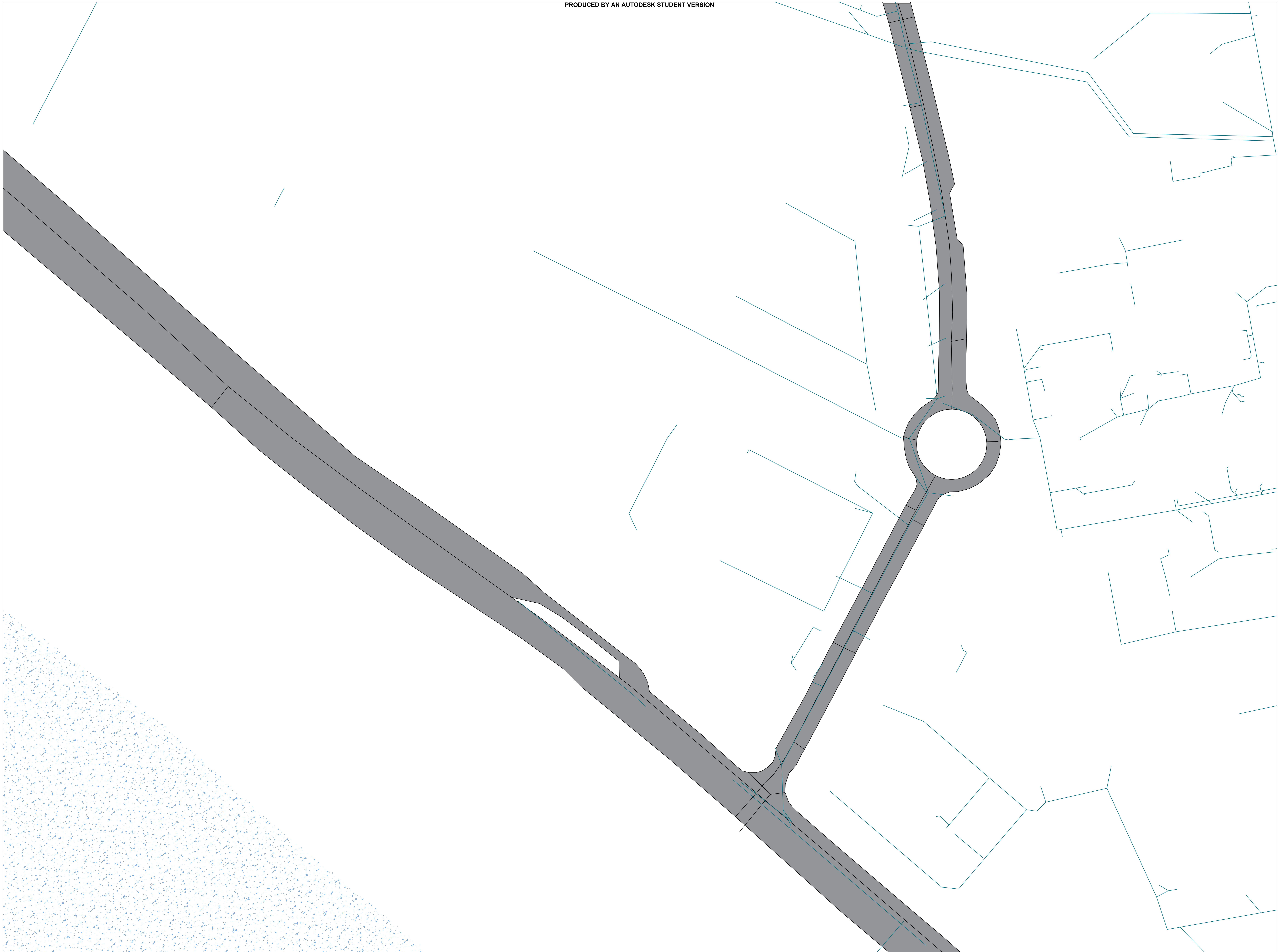
PRODUCED BY AN AUTODESK STUDENT VERSION

Drawing Title: Walkway Plan View	Sheet Size: Arch E1 30x24	Scale: 1:409	Revision History
Drawing Set: Landscape	Sheet Number: 2 of 2	Issue: C	

Rev #	Date	Author
0		



Drawing Title: Existing Stormwater Conveyance	Sheet Size: Arch E1 30x24	Scale: 1:409
Drawing Set: Storm Sewers	Sheet Number: 1 of 3	Issue: C

Revision History

Rev. #	Date	Author
0	03/19/2019	Luke Burrows

PRODUCED BY AN AUTODESK STUDENT VERSION
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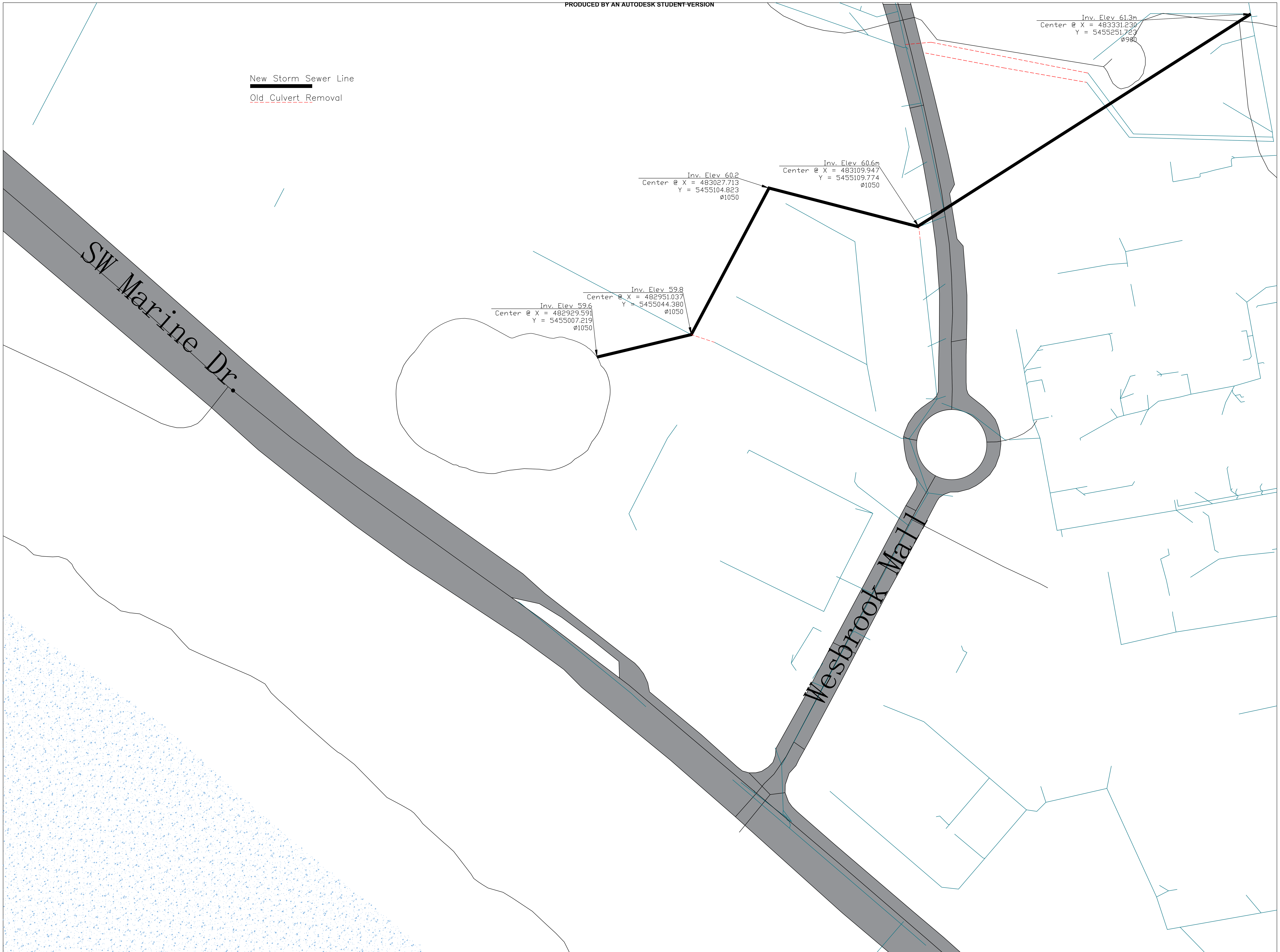
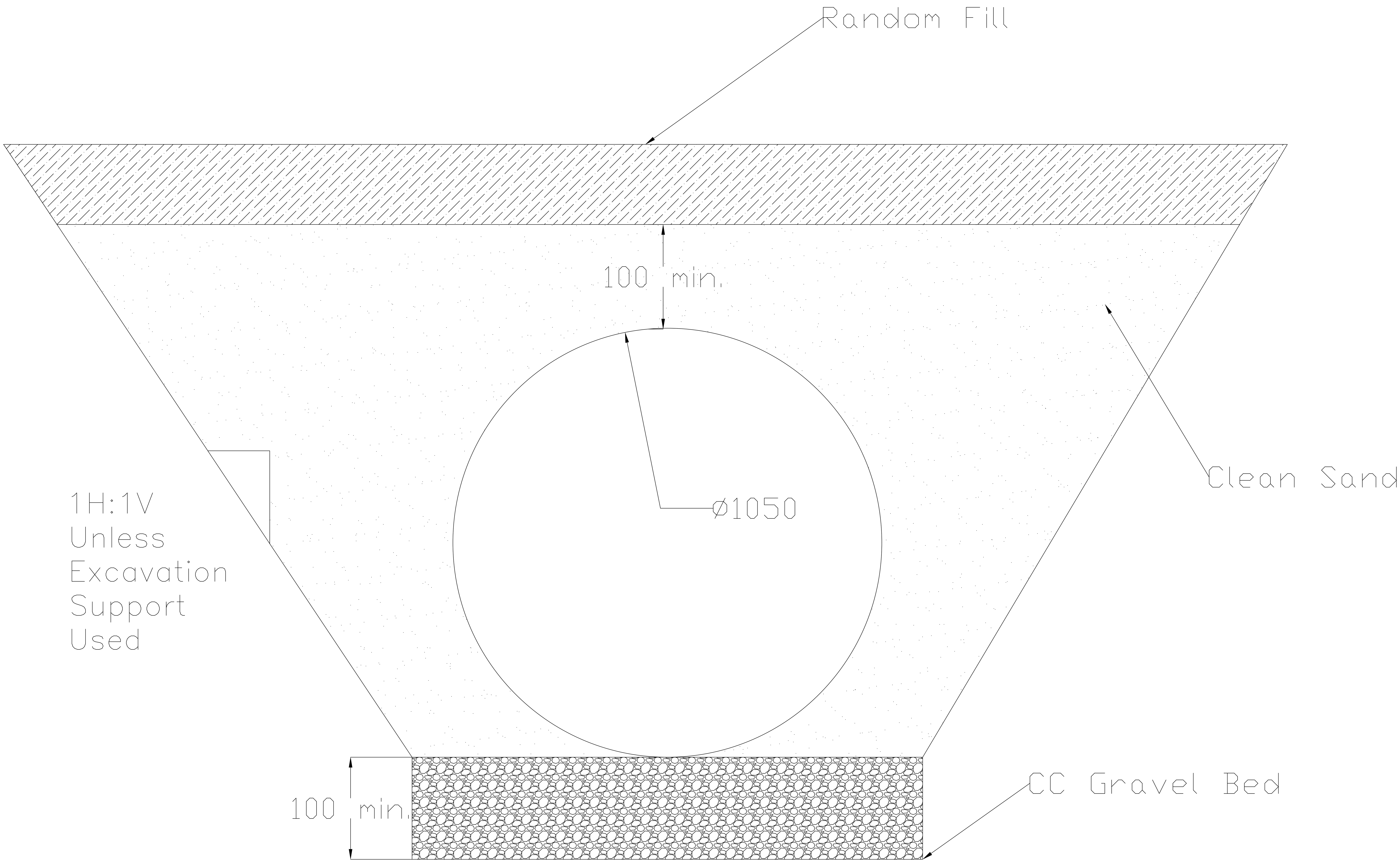


Drawing Title: Conveyance System Alterations	Sheet Size: Arch E1 30x24	Scale: 1:114
Drawing Set: Storm Sewers	Sheet Number: 2 of 3	Issue: C

Revision History

Rev. #	Date	Author
0	02/22/2019	Luke Burrows

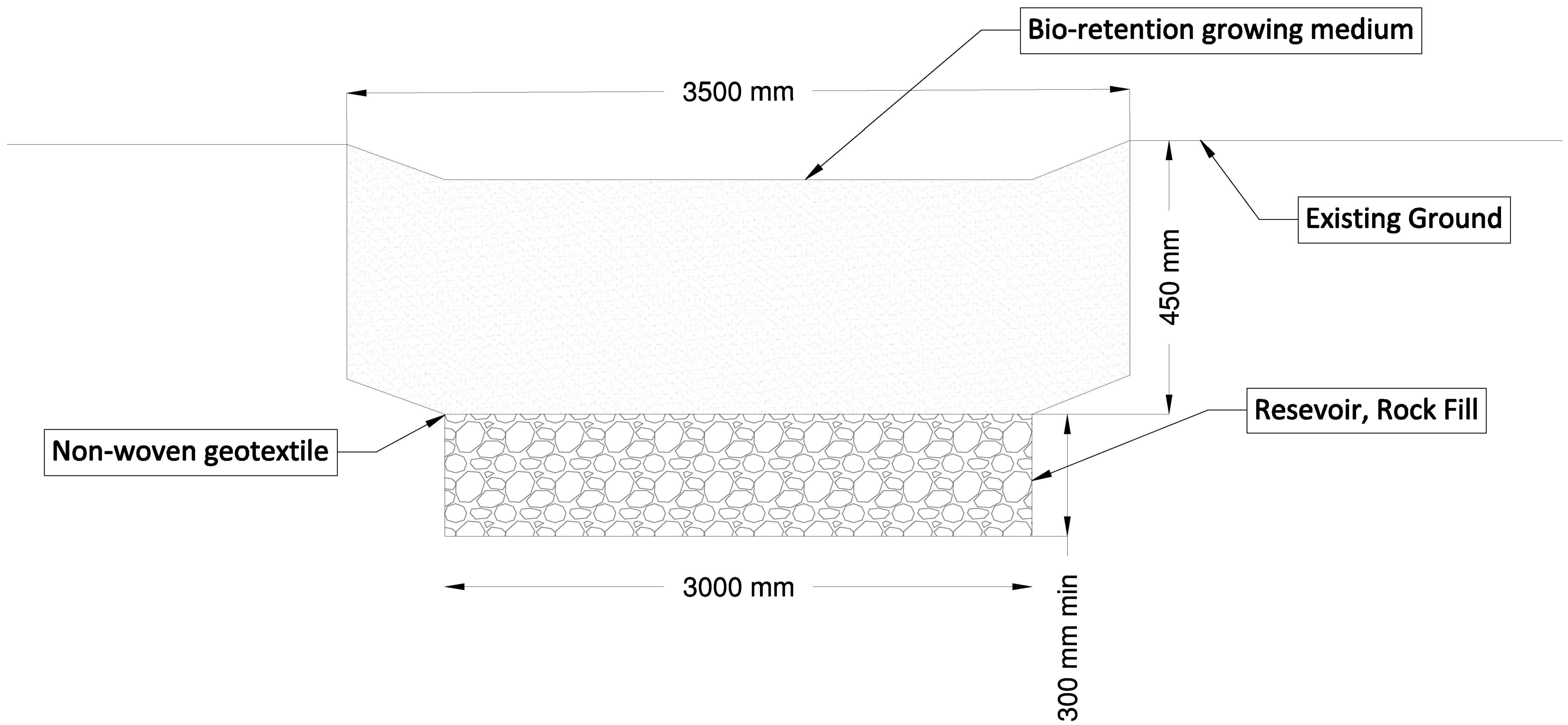


Drawing Title: Inlet Storm Sewer Section	Sheet Size: Arch E1 30x24
Drawing Set: Storm Sewers	Sheet Number: 3 of 3

Scale: NTS	Issue: C

Revision History

Rev. #	Date	Author
0	04/05/2019	Luke Burrows



TYPICAL SECTION BIOSWALE

SCALE: NTS

PRODUCED BY AN AUTODESK STUDENT VERSION

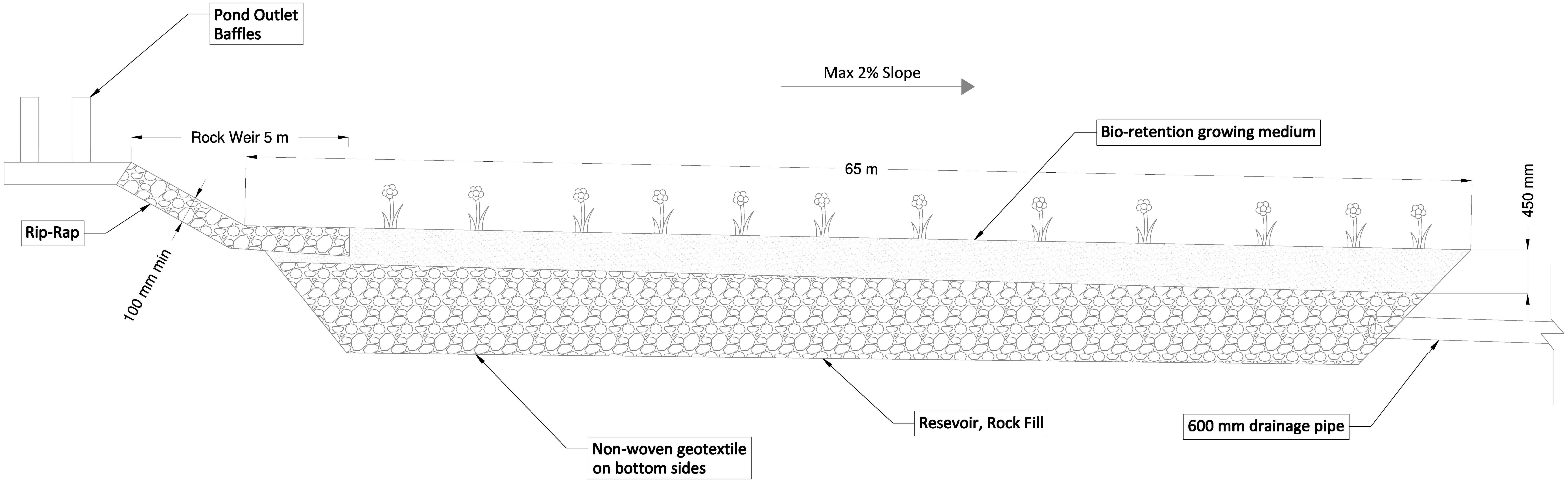
PRODUCED BY AN AUTODESK STUDENT VERSION

Drawing Title: BioSwale Typical Sections	CS - 001	
Drawing Set: Civil Works	Sheet Number: 1 of 7	Issue: C

Revision History

Rev. #	Date	Author
0	02/22/2019	Mike Shannon

PRODUCED BY AN AUTODESK STUDENT VERSION



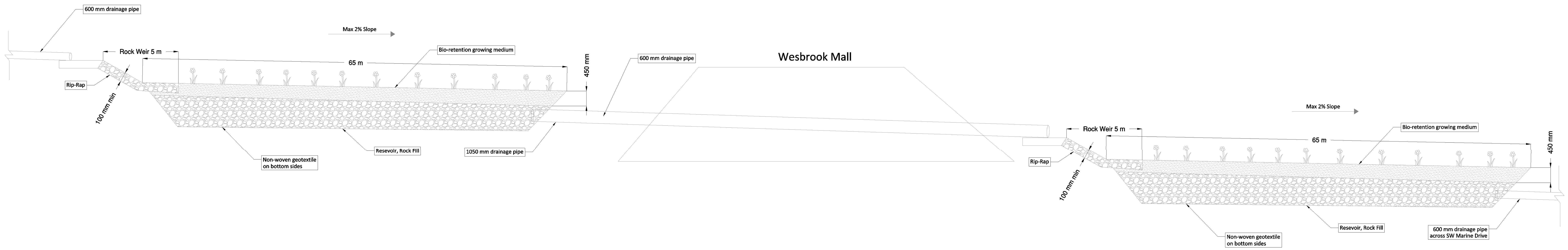
TYPICAL SECTION BIOSWALE

SCALE: NTS

Drawing Title: BioSwale Typical Sections	CS - 002		
Drawing Set: Civil Works	Sheet Number: 2 of 7	Issue: C	

Revision History

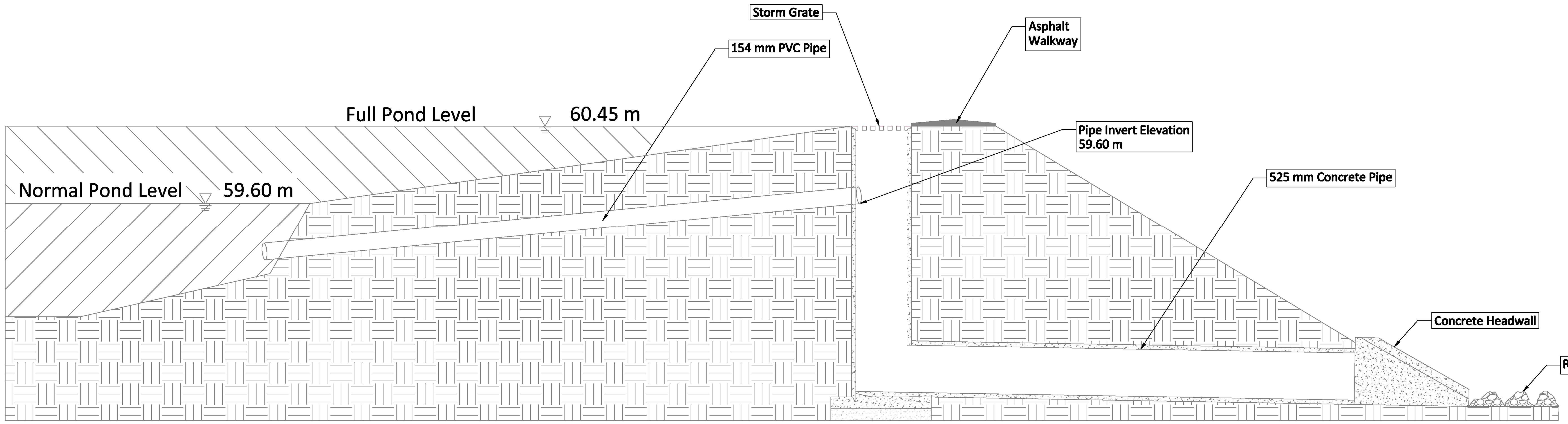
Rev. #	Date	Author
0	03/28/2019	Mike Shannon



TYPICAL SECTION
BIOSWALE

SCALE: NTS

Drawing Title: BioSwale Typical Section	CS - 003		Revision History		
			Rev. #	Date	Author
Drawing Set: Civil Works	Sheet Number: 3 of 7	Issue: C	0	03/28/2019	Mike Shannon



CROSS SECTION OUTLET STRUCTURE

SCALE: NTS

Drawing Title: Control Structure Cross Section

CS - 004

Drawing Set: Civil Works

Sheet Number: 4 of 7

Issue: C

Revision History

Rev. #	Date	Author
0	04/03/2019	Mike Shannon

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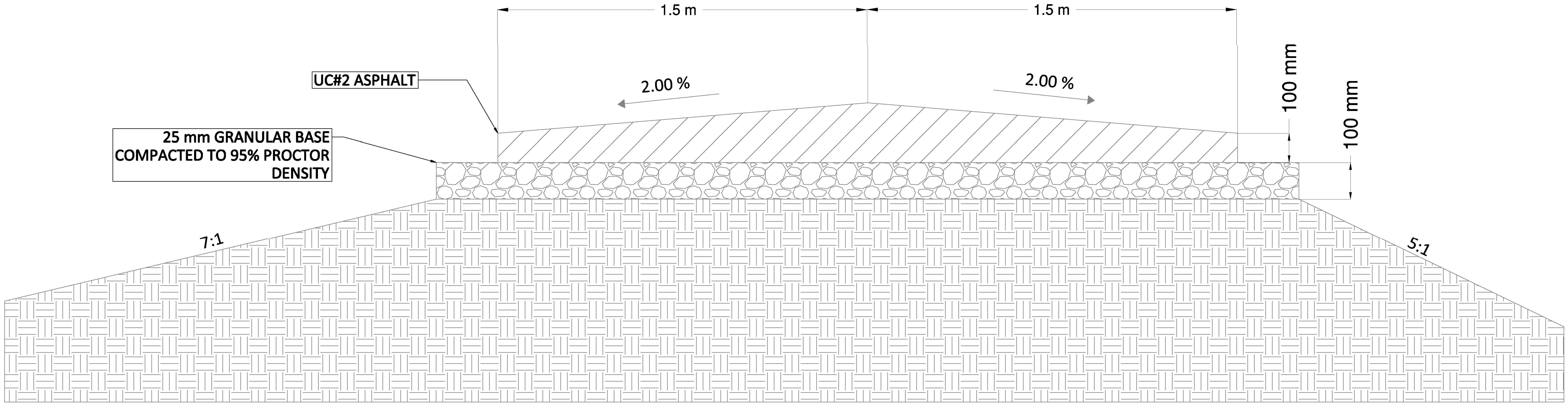
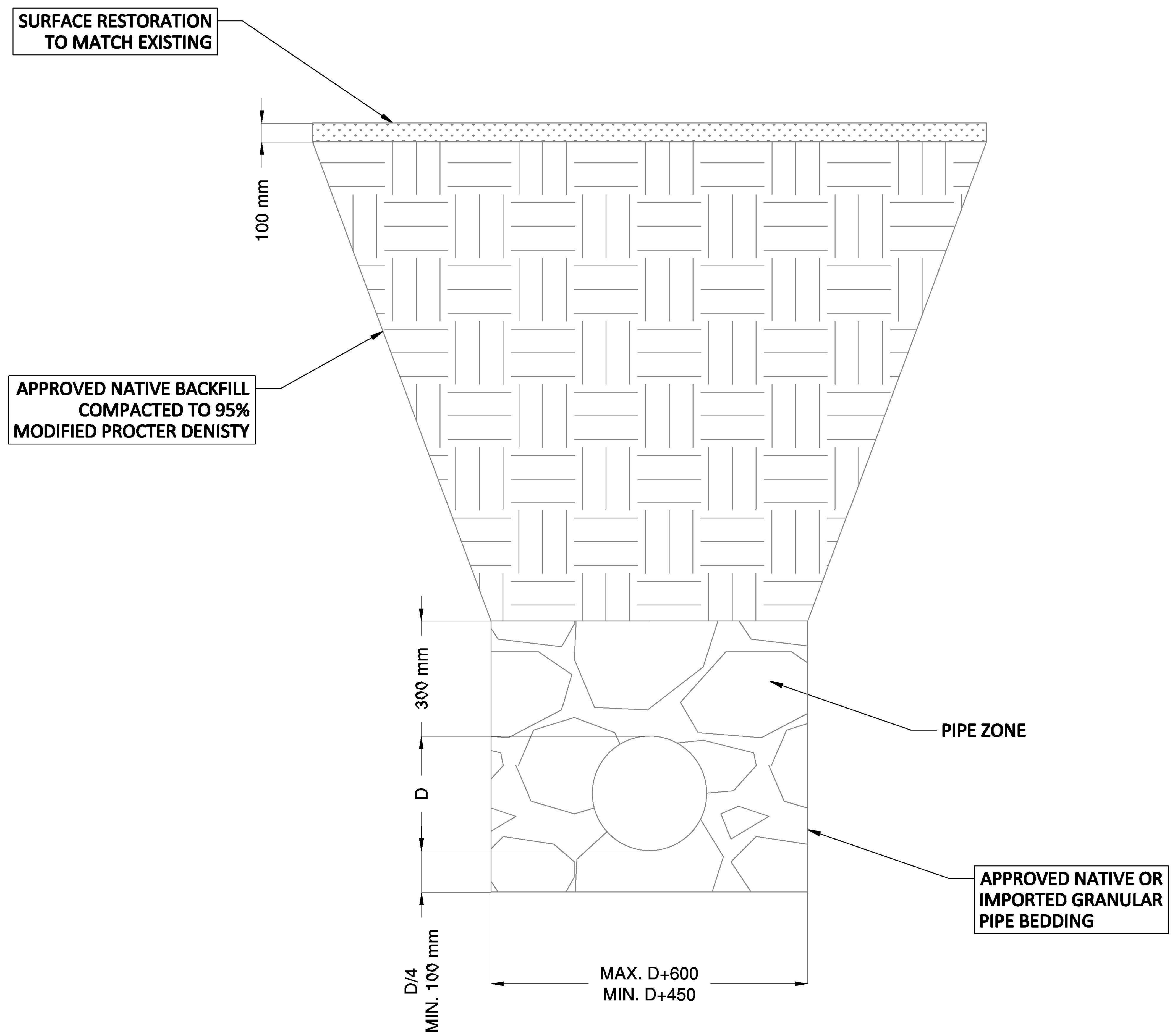


CROSS SECTION
WALKING PATH

SCALE: NTS

Drawing Title: Walking Path Cross Section	CS - 005		Revision History		
			Rev. #	Date	Author
			0	04/03/2019	Mike Shannon
Drawing Set: Civil Works	Sheet Number: 5 of 7	Issue: C			

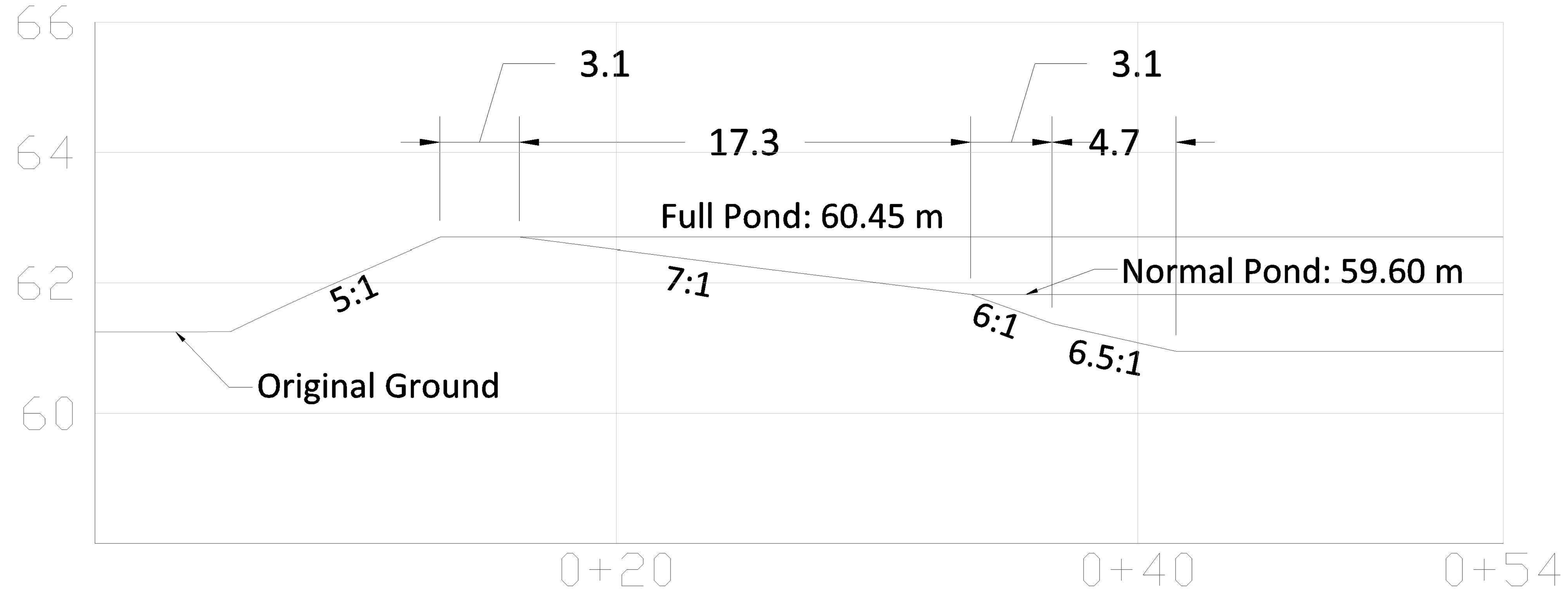


CROSS SECTION
PIPE TRENCH

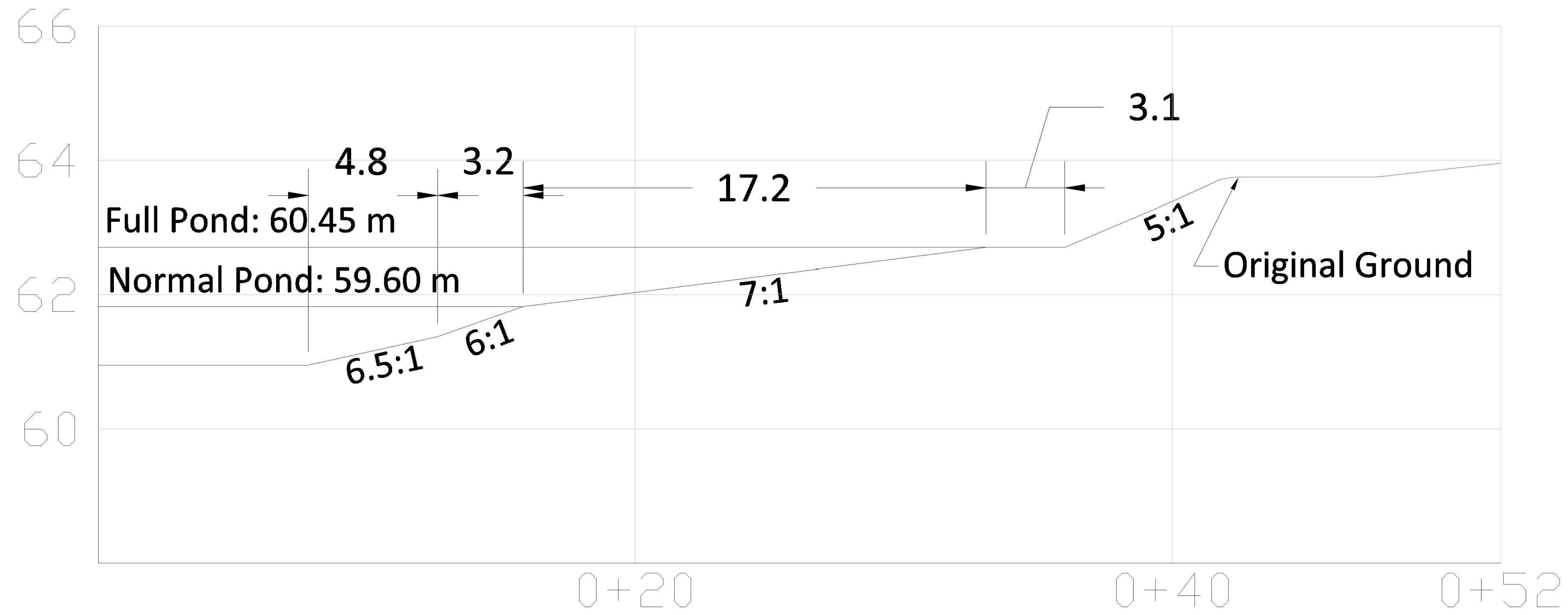
SCALE: NTS

Drawing Title: Pipe Trench Cross Section	CS - 006		Revision History		
			Rev. #	Date	Author
			0	04/05/2019	Mike Shannon
Drawing Set: Civil Works	Sheet Number: 6 of 7	Issue: C			

Pond Bottom Section



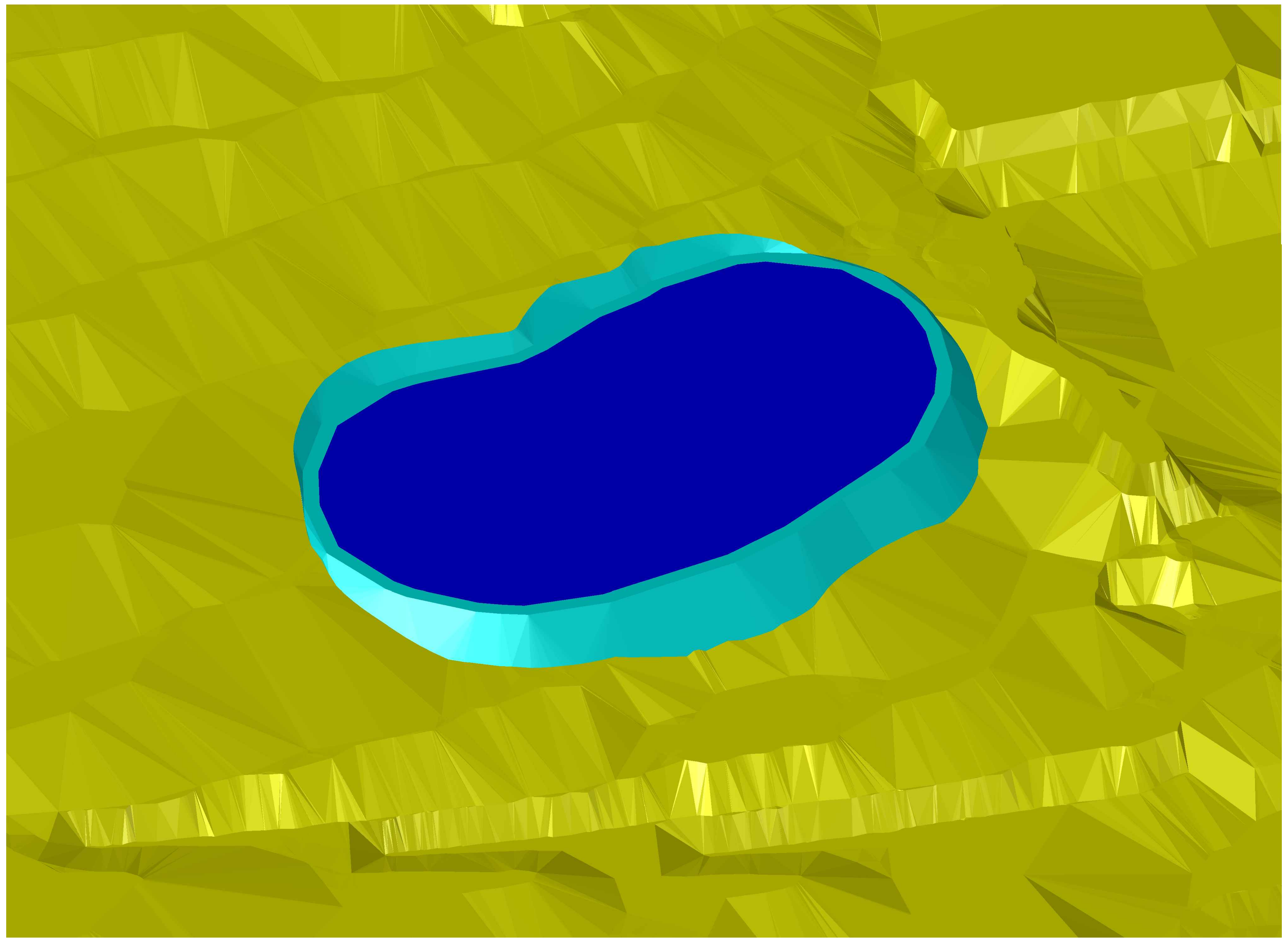
Pond Bottom Section

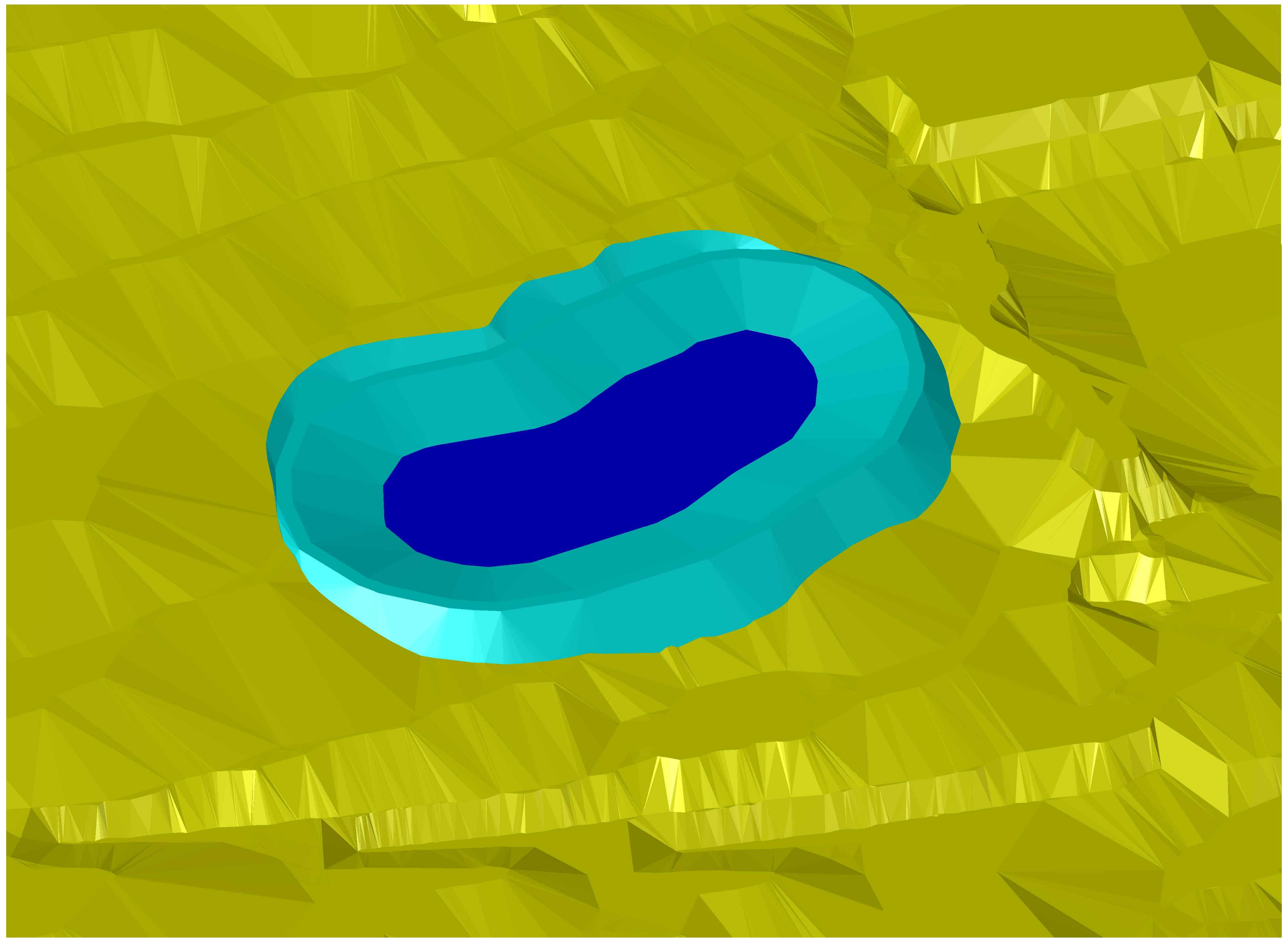


Drawing Title: Pond Bottom Sections	CS - 007		
Drawing Set: Civil Works	Sheet Number: 7 of 7	Issue: C	

Revision History

Rev. #	Date	Author
0	02/22/2019	Mike Shannon

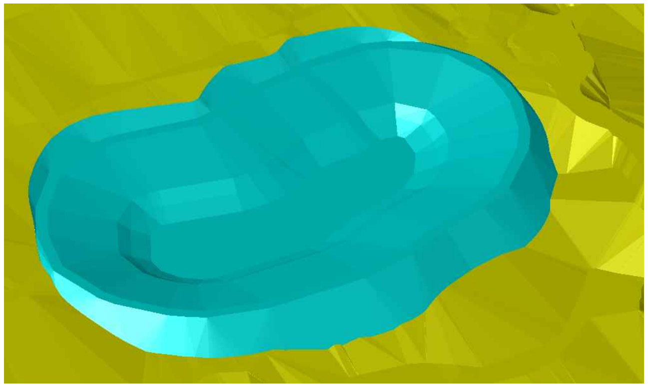




Drawing Title: Full & Normal Pond	ISO - 001		
Drawing Set: Civil Works	Sheet Number: 1 of 1	Issue: C	

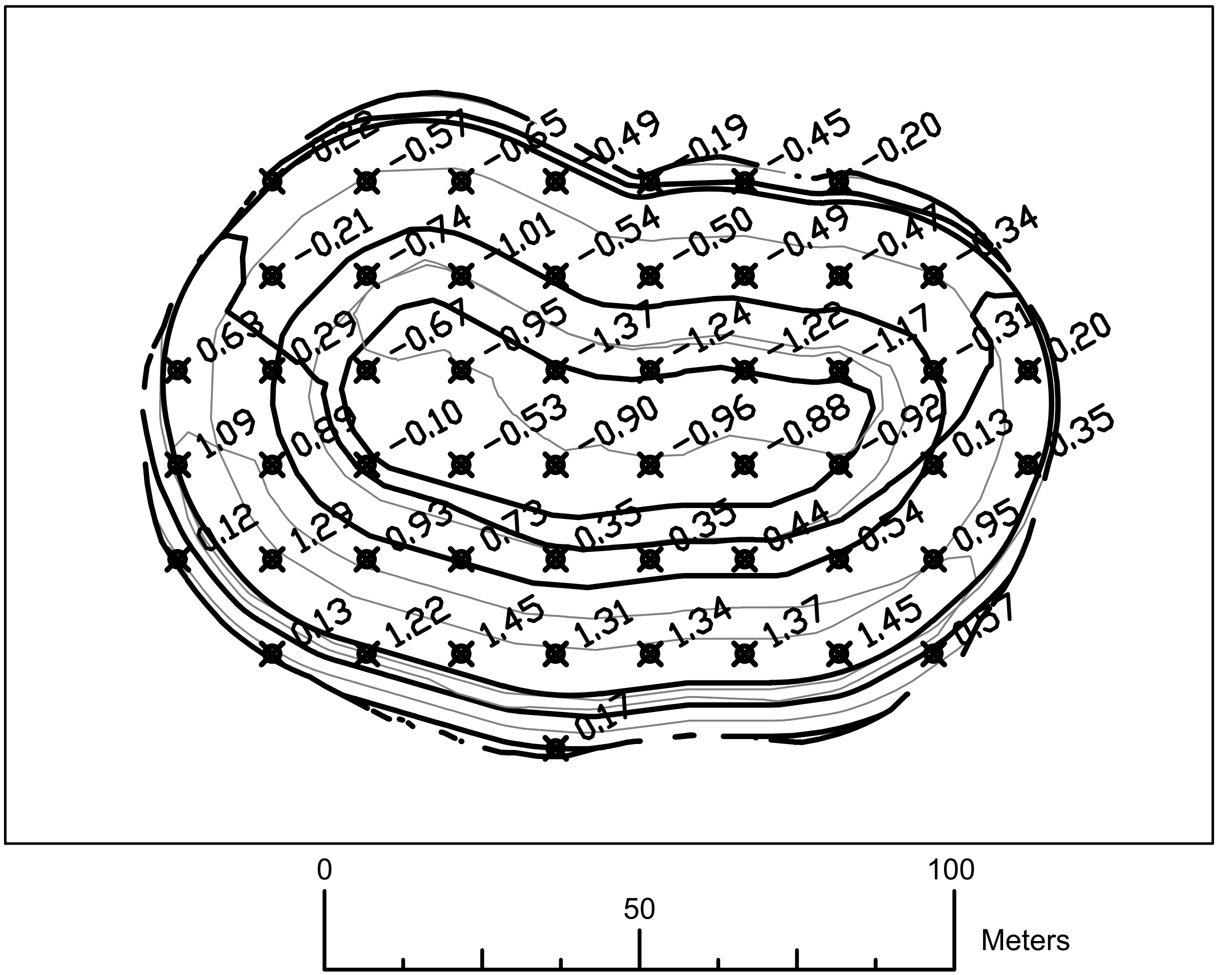
Revision History

Rev. #	Date	Author
0	02/22/2019	Mike Shannon



Cut/Fill Summary

Name	Cut Factor	Fill Factor	2d Area	Cut	Fill	Net
Cut n Fill	1.000	1.000	11820sq.m	4086 Cu. M.	4102 Cu. M.	16 Cu. M.<Fill>
100 Year Volume	1.000	1.000	3497sq.m	0 Cu. M.	3060 Cu. M.	3060 Cu. M.<Fill>
Normal Pond Volume	1.000	1.000	3497sq.m	0 Cu. M.	2316 Cu. M.	2315 Cu. M.<Fill>
Totals			18815sq.m	4086 Cu. M.	9478 Cu. M.	5392 Cu. M.<Fill>



Drawing Title: Cut & Fill Depths	CF - 001		Revision History		
			Rev. #	Date	Author
			0	02/22/2019	Mike Shannon
Drawing Set: Civil Works	Sheet Number: 1 of 1	Issue: C			

Appendix C: Technical Specifications For Construction

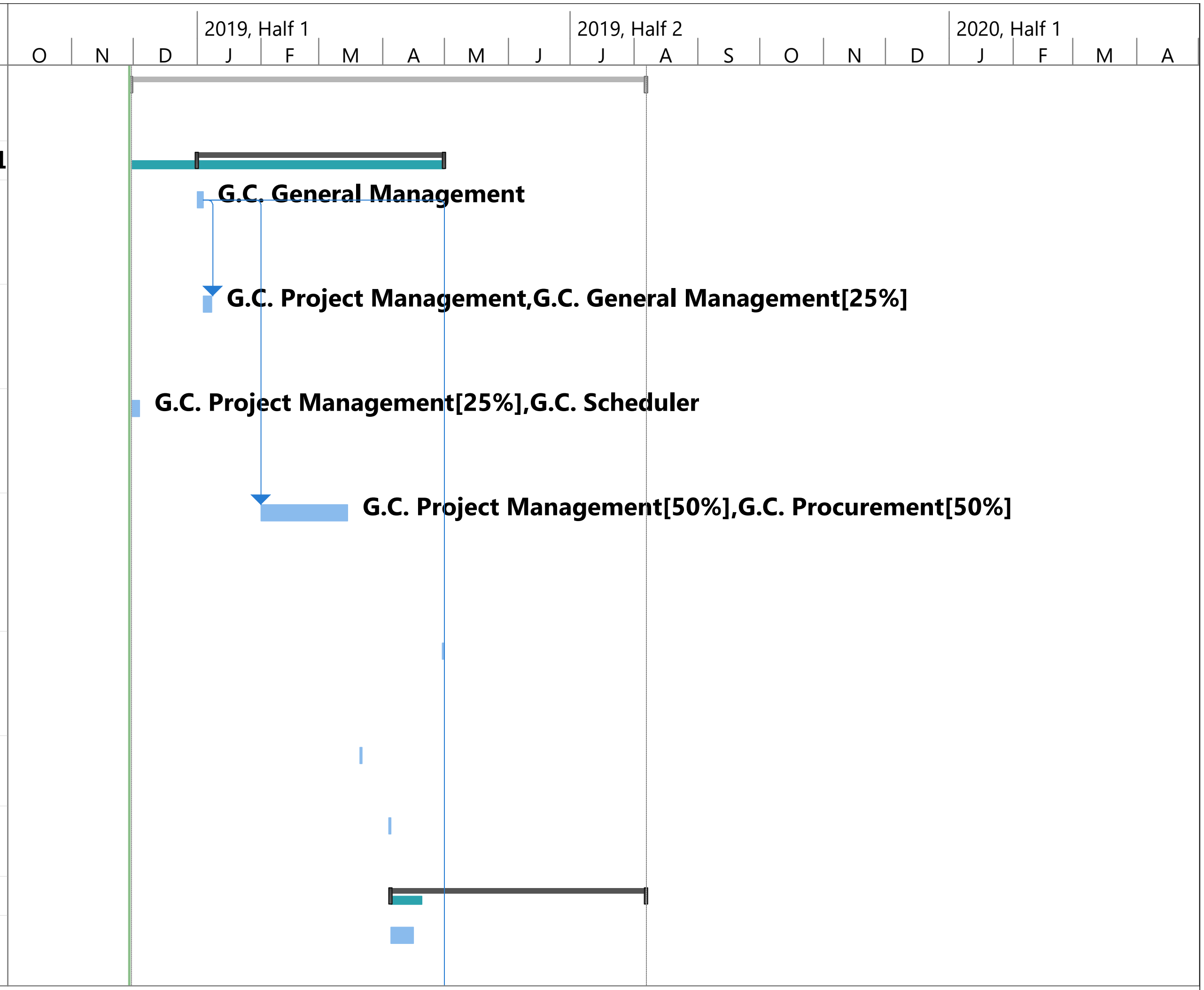
The technical specifications for construction for this project are attached as a separate document titled “Team17-FinalDesignReport-AppendixC.pdf”.

UBC Technical Guidelines were used as a reference in the development of the specifications. Any construction at UBC must abide by these guidelines, so compiling the relevant sections was deemed to be the most realistic representation of an appropriate specification document. Design choices covered throughout the report abide by these specifications. Additionally, notes on the drawings are to be used in conjunction with these specifications.

Appendix D: Construction Schedule

Attached below.

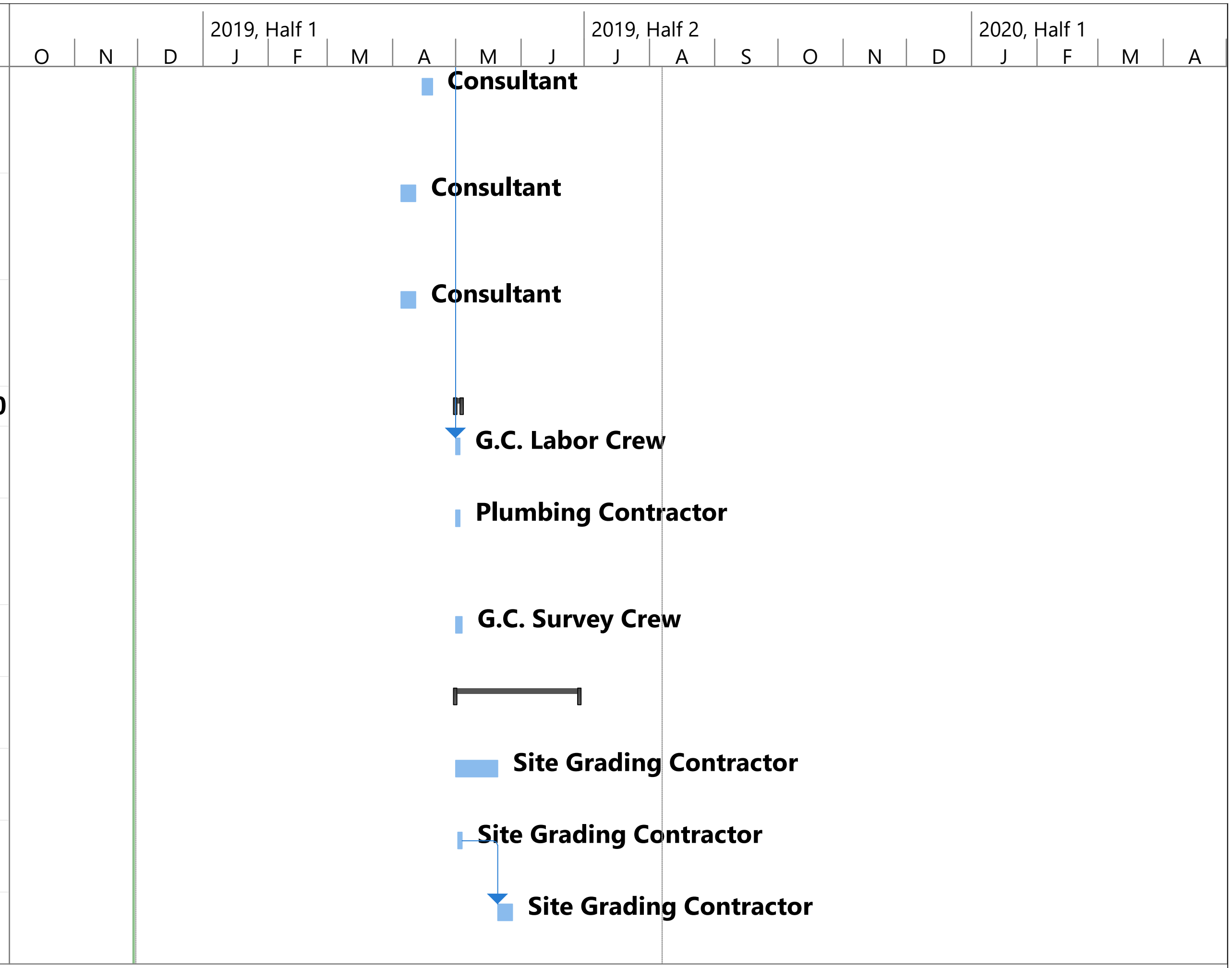
ID	Task Name	Duration	Start
0	**UBC CCM Stormwater**	**178 days**	**Fri 18-11-30**
1	**General Conditions**	**86 days**	**Tue 19-01-01**
2	Receive notice to proceed and sign contract	3 days	Tue 19-01-01
3	Submit bond and insurance documents	2 days	Fri 19-01-04
4	Prepare and submit project schedule	2 days	Fri 18-11-30
5	Obtain environmental and tree removal permits	30 days	Fri 19-02-01
6	Submit monthly requests for payment	1 day	Tue 19-04-30
7	Final design review	1 day	Thu 19-03-21
8	Submittal of final design	1 day	Thu 19-04-04
9	**Reviewals**	**88 days**	**Fri 19-04-05**
10	Review tree removal plan	7 days	Fri 19-04-05



Project: UBC CCM Stormwater D
Date: Thu 18-11-29

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

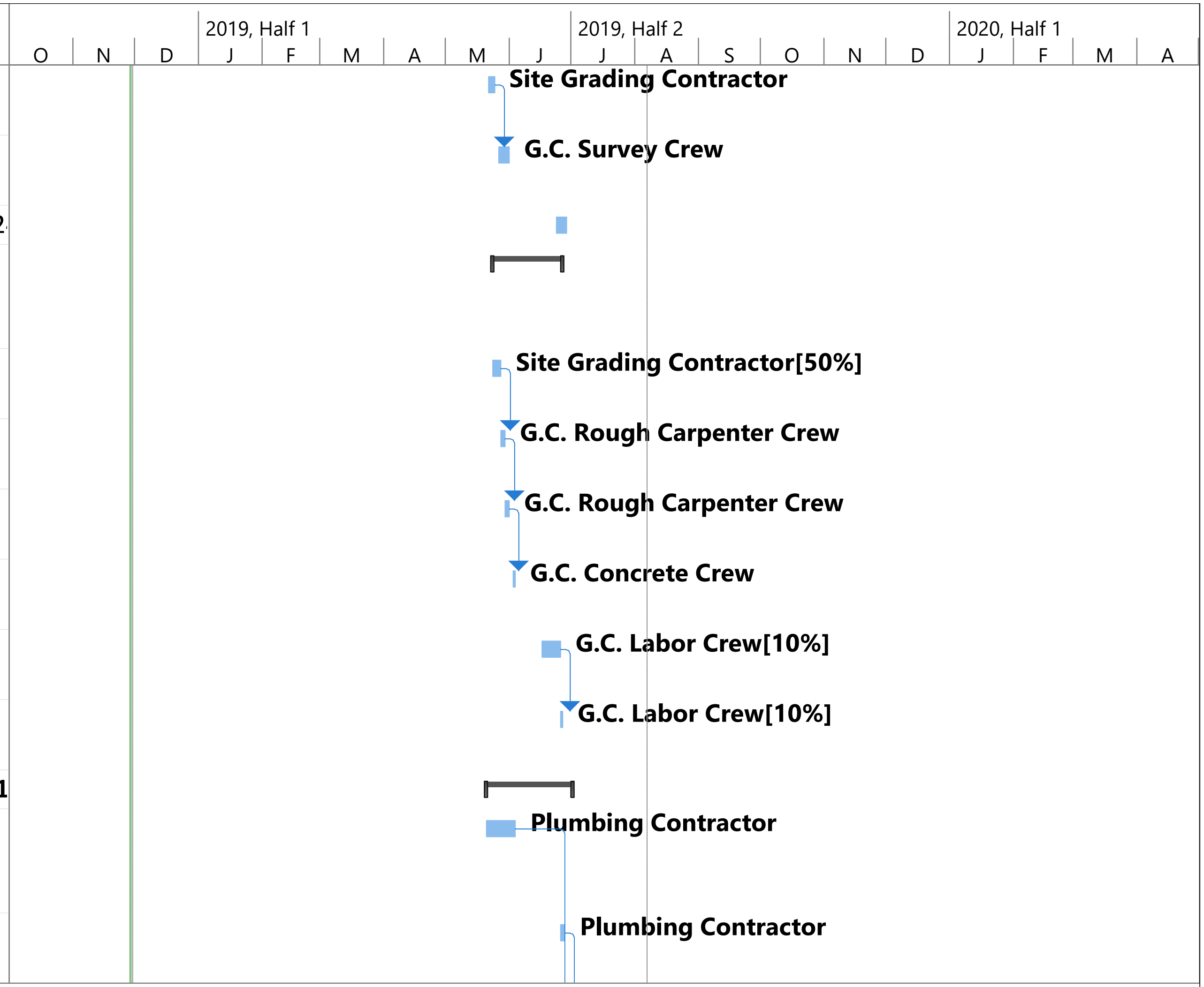
ID	Task Name	Duration	Start
11	Review shop drawings - geomembrane	1 wk	Mon 19-04-15
12	Review shop drawings - reinforcing steel	1 wk	Fri 19-04-05
13	Review shop drawings - sewer systems	1 wk	Fri 19-04-05
14	**Mobilize on Site**	**3 days**	**Wed 19-05-0**
15	Setup laydown area	2 days	Wed 19-05-01
16	Install silt fences along existing ditches	2 days	Wed 19-05-01
17	Set line and grade	3 days	Wed 19-05-01
18	**Site Grading and Landscaping**	**43 days**	**Wed 19-05-01**
19	Tree removal	14 days	Wed 19-05-01
20	Stone site access	2 days	Thu 19-05-02
21	Rough excavations	1 wk	Tue 19-05-21



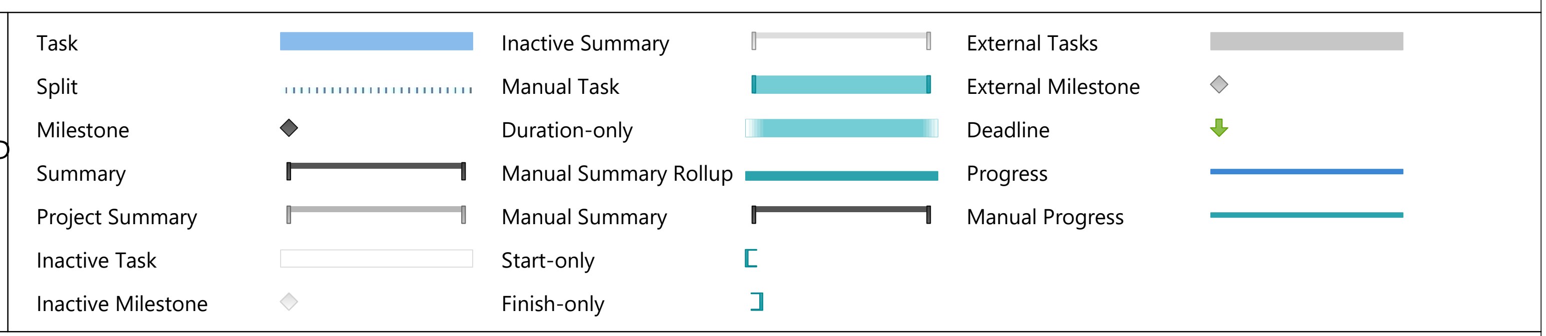
Project: UBC CCM Stormwater D
Date: Thu 18-11-29

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

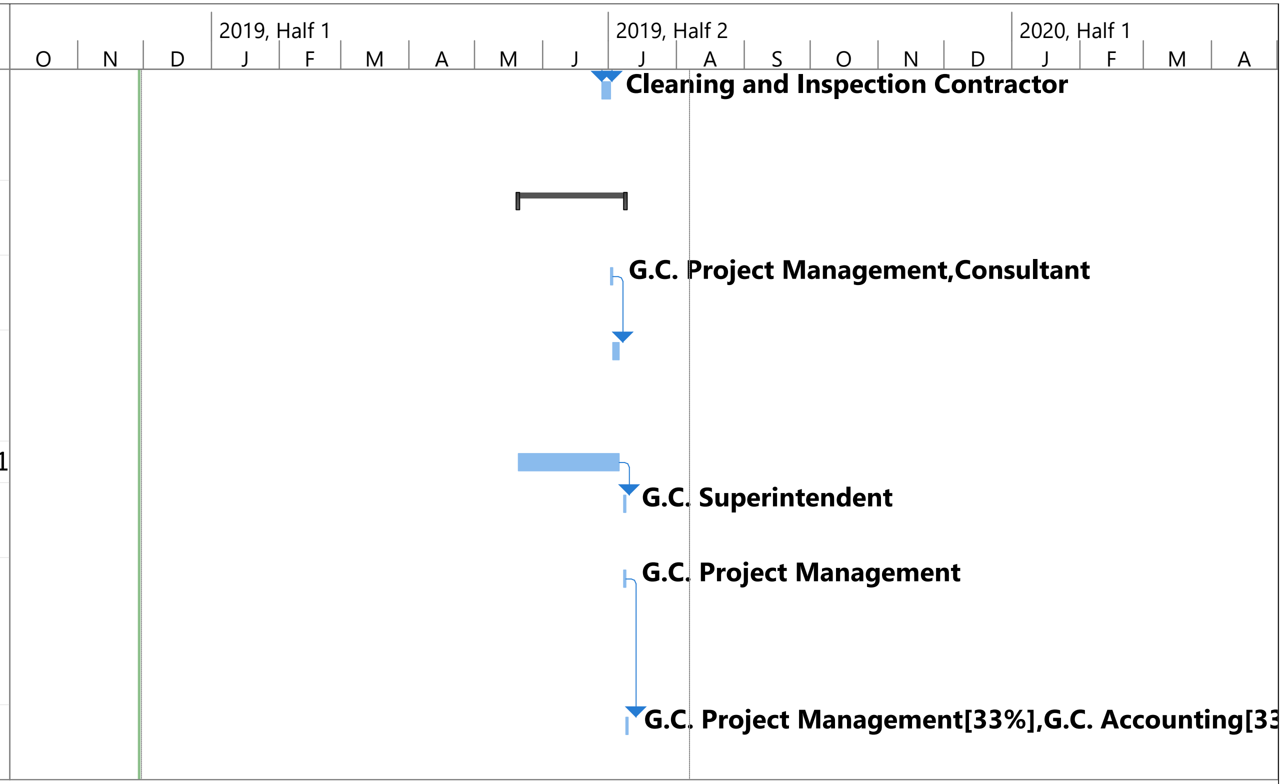
ID	Task Name	Duration	Start
22	Placement of geomembrane	3 days	Wed 19-05-22
23	Final site grading	5 days	Mon 19-05-27
24	Seeding/Planting	5 days	Mon 19-06-2
25	**Stormwater Discharge Control System**	**24 days**	**Fri 19-05-24**
26	Excavate foundations	2 days	Fri 19-05-24
27	Form control structure	2 days	Tue 19-05-28
28	Set reinforcing steel	2 days	Thu 19-05-30
29	Pour control structure	1 day	Mon 19-06-03
30	Cure control structure	7 days	Mon 19-06-17
31	Strip control structure forms	1 day	Wed 19-06-26
32	**Sewer Work**	**30 days**	**Tue 19-05-21**
33	Rough in connection to existing lines	2 wks	Tue 19-05-21
34	Install sewer connections	2 days	Wed 19-06-26



Project: UBC CCM Stormwater D
Date: Thu 18-11-29



ID	Task Name	Duration	Start
35	Cleaning and camera inspection of	2 days	Fri 19-06-28
36	**Final Clean-up and Occupancy**	**35 days**	**Tue 19-05-21**
37	Substantial completion	1 day	Tue 19-07-02
38	Complete deficiency punchlist	3 days	Wed 19-07-03
39	Site demobilizatic	34 days	Tue 19-05-21
40	Substantial completion date	1 day	Mon 19-07-08
41	Issue final completion documents including	1 day	Mon 19-07-08
42	Issue final request for payment	1 day	Tue 19-07-09



Project: UBC CCM Stormwater D
Date: Thu 18-11-29

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