TECHNICAL MEMO

To Helen Lockhart, P.Eng	**From** Jack McKee, P.Eng Ian Whitehead, P. Eng.
Company City of Colwood	**MCSL Branch** 2243 - Victoria
Re Stormwater Master Plan Phase 2 – Triangle Mountain Assessment	**Date** March 14th, 2019 **File Number** 2243-18045-00

1. INTRODUCTION

McElhanney Consulting Services Limited (McElhanney) was retained by the City of Colwood (City) to develop an updated Stormwater Master Plan (SWMP). As outlined by the City, the SWMP was to be broken into two phases.

- Phase 1 – Development of the SWMP Report; and
- Phase 2 – Two site-specific areas of particular concern, namely:
    - An assessment of the Triangle Mountain area and Patterson Pit / Ridley Pit drainage conditions.
    - An assessment of the Latoria Rd and Veterans Memorial Parkway [VMP] wetland preservation and enhancement.

The SWMP Report provides guidance to the City in the development of new stormwater infrastructure as well as identifying locations where existing stormwater infrastructure upgrades are required on a City-wide scale. Phase 1 was completed with the submission of the Stormwater Master Plan Report (McElhanney, 2018) on September 21, 2018.

This Phase 2 technical memo provides an assessment of current Triangle Mountain area drainage conditions, and runoff toward the ‘Patterson Pit’ / ‘Ridley Pit’ areas. The Latoria / VMP wetland assessment is provided under separate cover.

The City has endured long standing challenges with respect to storm drainage in the Patterson Pit / Ridley Pit region. The lack of overland drainage routes within / from the Patterson Pit / Ridley Pit area has resulted in the surface ponding of runoff and subsequent flooding of adjacent properties on a frequently occurring basis. The City has been dealing with the issues of flooding in the region since incorporation in 1985 and has commissioned a number of studies intended to deal with the localized drainage issues. The purpose of this Technical Memorandum is to summarize the work completed with respect to this issue in the past, outline current drainage conditions, to identify potential mitigation options and to recommend a solution.

1.1. Scope of Work

The goal of this portion of project assignment Phase 2 is to assess the current drainage situation within the Patterson Pit / Ridley Pit region - currently having no overland drainage route. Based on the objectives of Phase 2 (assessment of Patterson / Ridley Pit drainage) as outlined by the City, the scope of the project is summarized as follows:

1. Review all relevant background material including Computer Aided Design (CAD) drawings, record drawings, Geographic Information System (GIS) data, previously completed reports, etc.;

2. Review of drainage basin boundaries for the Patterson Pit / Ridley Pit region and establish these graphically;

3. Identify drainage issues within the region;

4. Provide conceptual mitigation options to be explored; and develop recommendations for implementation of a solution, complete with estimated costs.

5. Summarize the findings and recommendations in a Technical Memorandum.

2. BACKGROUND

The Triangle Mountain area is located west of Wishart Road and north of Latoria Road. The Patterson / Ridley Pits are located east of Veterans Memorial Parkway, north of Cairndale Road, west of Wishart Road and South of Sooke Road. As shown in **Figure 1**, there are two stormwater management ponds within the Patterson Pit / Ridley Pit (Mary Anne Crescent Pond and Cairndale Road Pond).

Engineering, planning and feasibility reports have previously been completed both by the City and by private consultants with respect to drainage issues in the Triangle Mountain region. McElhanney has reviewed these existing documents to gain a better understanding of the City's stormwater servicing and system constraints. Some of the key background documents reviewed can be found in **Table 1**. **Section 2.1** provides a summary of the key findings from each document.

Table 1: Background Reports Reviewed

REPORT	AUTHOR	DATE
The City of Colwood Sanitary & Storm Sewer Study for the Triangle Mountain, Colwood Corners and Lagoon Area of Colwood	Duncan & Associates Engineering LTD.	1992
Colwood Creek Drainage Basin Study	1st Team Engineering Limited	1998
Triangle Mountain Trunk Drain & Wetlands Treatment Facility Preliminary Engineering Report	Reid Crowther & Partners Ltd.	1999
Triangle Mountain Drainage - Update	City of Colwood	2001
Millstream Connector/Triangle Mountain Drainage/Hydraulic Modeling	City of Colwood	2001
Millstream Connector Hydraulic Analysis Update – Colwood Creek	Associated Engineering	2002
Triangle Mountain Drainage Engineering Analysis of Potential to Route Flows Contributory to Pondco 1 through Proposed Royal Bay Storm System	1st Team Engineering	2008

2.1. Summary of Previous Reports

The City of Colwood Sanitary & Storm Sewer Study for the Triangle Mountain, Colwood Corners and Lagoon Area of Colwood (Duncan & Associated, 1992)

The report examines the storm and sanitary sewer requirements for varying future population projections, to determine the development cost charges for servicing the Triangle Mountain development, Colwood Corners development and Lagoon areas in the City of Colwood.

The study estimated stormwater runoff from the proposed developments based on City design criteria.

Colwood Creek Drainage Basin Study (1st Team Engineering Limited, 1998)

The Colwood Creek drainage plan was developed to assess the condition of the watershed, estimate various return period flows / water levels within Colwood Creek and determine the impact of long term development plans within the watershed on flows / water levels. Key findings related to the development of Triangle Mountain include:

- Indication that development of the Triangle Mountain and the Patterson / Ridley pit would result in a doubling of runoff to Colwood Creek (assuming that under current conditions the runoff reaches Colwood Creek, which it did not at the time of the study).

- Identification of the need for flow attenuation for runoff directed from the Triangle Mountain developments to Colwood Creek. Suggested that without attenuation, future 200-year depths at Colwood Creek Park would increase by approximately 0.5 m as a result of the Triangle Mountain runoff, and the construction of the storm sewer along Veterans Memorial Parkway.

- Recommended that the Mary Anne Crescent Pond be maintained to attenuate flows.

Triangle Mountain Trunk Drain & Wetlands Treatment Facility Preliminary Engineering Report (Reid Crowther & Partners Ltd., 1999)

The report provided stormwater designs for drainage servicing to the Patterson / Ridley Pit area, which had no drainage routes at the time of the study. Therefore, any development of the catchment was thought to result in worsening of the flooding situation. The following are key findings from the report:

- The study notes that continued development of the Triangle Mountain catchment area, combined with the backfilling of the Patterson / /Ridley Pits has resulted in increased levels of ponding. The ponding is affecting the existing residences surrounding the pit.

- The study noted that preliminary studies established that a deep storm drain discharging northerly across Sooke Road to Colwood Creek, represented the most feasible solution to the problem. This drainage concept was then included in the design of Veterans Memorial Highway.

- An engineered wetland was also proposed to reduce pollutant loading on the receiving Colwood Creek.

- Based on the previously calculated design flows, it was noted that runoff from the Triangle Mountain developments are relatively high compared to the receiving creek design flows. Therefore, any design efforts should examine ways to attenuate and / or reduce these flows either through detention or ground absorption or a combination of methods (Diversion alternatives involving the entire catchments were abandoned due to high cost).

- Several conceptual alternatives were analyzed to reduce ponding within the Patterson / Ridley Pits including:

    - Collecting all water in the Pit area and discharging it to the ground through a rapid infiltration basin.

    - Diverting the Triangle Mountain drainage (from south of Cairndale Road), south through the Royal Bay development site.

    - Establishing facilities for stormwater control and treatment in the pit area.

    - Splitting the control and treatment facilities by locating detention ponds in the pit area and wetland treatment in the Colwood Creek Park area.

- As part of the study the public input was solicited to determine perception on the construction of a wetland in Colwood Creek Park. A majority of nearby residents disapproved of the wetland proposal in Colwood Creek Park at the time of the study.

- It was proposed to construct a storm drain to intercept drainage from Triangle Mountain, the two Pondco Ponds (Mary Anne Crescent Pond and Cairndale Road Pond), Veterans Memorial Parkway and the gravel pit lands. The preliminary design covered 1400 m of conveyance from Pondco Pond #1 (Mary Anne Crescent Road Pond) through the Paterson Pit, across Ridley Pit and Sooke Rd to Colwood Creek. The pipe increases from 450 mm to 1200 mm diameter at depths of 8.6 m (at Sooke Road). The storm drain design relied on 'in-pit' detention to moderate the 25-year design flows. This design was adopted in the design of Veterans Memorial Parkway.

- Levelton completed a geotechnical assessment and noted that it should not be assumed the infiltration basin could discharge through the floor of the pit, due to the depth of the backfill that has occurred with fine grained materials. Rather, any rapid infiltration basin should be designed to exfiltrate horizontally into the pit wall.

- Based on the Levelton assessment, the groundwater table at the pit is at approximately El. 60m and is believed to flow southeasterly towards Esquimalt Lagoon, not towards Colwood Creek.

Triangle Mountain Drainage – Update (City of Colwood, 2001)

The report was created to update Council on the drainage conditions within the Triangle Mountain Region. The following key items were included in the report.

- Breaks down the cost of installing a cut off storm sewer to convey flows east to Colwood Creek.

- Recommends the installation of a soak away facility within the Patterson / Ridley Pits with an overflow north to Colwood Creek.

Millstream Connector/Triangle Mountain Drainage/Hydraulic Modeling (City of Colwood, 2001)

The report provides a summary of the hydraulic modeling completed in the drainage design for Veterans Memorial Parkway.

Millstream Connector Hydraulic Analysis Update – Colwood Creek (Associated Engineering, 2002)

The report provides an update on the drainage design of Veterans Memorial Parkway. The report summarizes an analysis completed to determine the impact of additional runoff on Colwood Creek water levels.

Triangle Mountain Drainage Engineering Analysis of Potential to Route Flows Contributory to Pondco 1 through Proposed Royal Bay Storm System (1st Team Engineering, 2008)

The document summarizes the assessment completed to determine the impact on design and construction costs associated with re-routing flows which currently drain to Cairndale Pond through the Royal Bay development to the south. Key points from the assessment include:

- The study assessed the possibility of re-routed flows that currently drain to the Cairndale Pond through the proposed Royal Bay development. The Cairndale pond would be abandoned and the flows would drain through the Royal Bay developments, eventually discharging into the Strait of Juan de Fuca.

- Based on the assessment, it was determined that the additional flow would result in an increase in pipe sizes within the Royal bay development. Therefore, it was determined that there would be a significant cost increase associated with accommodating the additional runoff through the Royal Bay Development.

The above reports were used to develop our understanding of the current drainage conditions within the Patterson and Ridley Pits.

3. ISSUE UNDERSTANDING

The Patterson Pit and Ridley Pit are located within an area of historically high infiltration potential (soils composed of gravels and sands). The pits are located within a natural depression immediately east of Triangle Mountain. The pits are a part of the Colwood Creek watershed; however, the area is a localized natural low point where historically, runoff from a 77.4 ha of Triangle Mountain drained and ponded. It is thought that only during extreme rainfall events would water overflow this natural depression and drain to Colwood Creek.

The Patterson Pit is located in a region where steep mountain slopes (10 – 15%) shallow out and change to moderate lowland slopes (1 – 3%). As shown in **Figure 1** there is a ridge-line located east of Patterson and Ridley Pit along Galloway Drive. It is presumed that as the Patterson Pit and Ridley Pit were excavated for gravel extraction, naturally well drained soils were removed, therefore exacerbating the flooding. The Patterson and Ridley Pits have no system of public drains or evidence of an overland drainage outlet.

Immediately east of the Patterson Pit is a series of properties fronting Galloway Road. Based on the review completed and discussion with the City, these properties experience flooding within the backyards annually as well as occasional flooding of basements (in the order of every 5 years). Based on a review of topography, the Patterson Pit has a low point adjacent to the flooded properties. The low point has a base elevation of 67 m and a spill elevation of approximately 71 m. As shown in **Figure 1** at the spill elevation of 71 m, the flooded properties are within the area of inundation.

Based on discussion with the City, the flooding has been aggravated by development within Triangle Mountain. To try and mitigate the problem, a cut off storm sewer line was installed in 2008 along Veterans Memorial Parkway to capture surface runoff from Triangle Mountain west of Veterans Memorial Parkway (reducing the catchment contributing surface runoff to the lowlands by 51.66 ha). The runoff from the cut off storm sewer is directed to Mary Anne Crescent Pond, located at the north end of the Patterson Pit. The pond then discharges runoff north to a storm sewer along Veterans Memorial Parkway which directs the flow to Colwood Creek.

Following the installation of the cut off storm sewer in 2008, residents still noted the flooding of backyards annually. The cut off storm sewer currently captures surface runoff from Triangle Mountain; however, subsurface flow may still continue east and contribute to surface ponding within the pits. An analysis of hydrogeological conditions would be required to substantiate this supposition and to determine the impact of groundwater on drainage conditions in the region.

Catchment ‘C1’ drains to Mary Anne Crescent Pond. The catchment is approximately 45.6 ha and contains all of the contributing area west of Veterans Memorial Parkway. The catchment is primarily composed of single family residential development. Runoff is captured and conveyed northward along Veterans Memorial Parkway to Mary

Anne Crescent Pond. Flow is then discharged from the pond to a storm sewer along Veterans Memorial Parkway, thence discharging into Colwood Creek.

The City could consider installation of permeable rock check dams within the roadside ditches located in Catchment C1. The check dams will slow the runoff velocity and cause some modest proportion of total runoff-water to pool in this upstream catchment during larger rainfall events. The reduction in runoff velocity will promote infiltration, reducing the contributing runoff volume downstream. Using permeable rock check dams, the water can pass through the permeable block during lower flows or following the rainfall event. These check dams will require some on-going maintenance, to avoid plugging/clogging. The absolute magnitude of the runoff reduction resulting has not been modeled, but it is though, at this stage, likely to be modest. This said, reductions in flows downgradient will reduce the size of infrastructure under the options 1 through 4 as discussed below.

Catchment ‘C2’ drains to Cairndale Pond. The catchment is approximately 11.4 ha and composed of single family residential development. The runoff is conveyed through a series of roadside ditches and storm sewers to the Cairndale Pond. The Cairndale pond discharges to the Patterson Pit, where the runoff then ponds at the low point. Design efforts were made, considering the feasibility of a connection between the Cairndale Pond and the Mary Anne Crescent Pond, via a ditch - intended to reduce area contributing flow to the Patterson Pit low point. However, due to issues with land acquisition, the connecting ditch was never installed. Therefore, the catchment continues to contribute runoff to the low point within Patterson Pit.

Catchment ‘C3’ drains to the Mary Anne Crescent Pond. The catchment comprises approximately 5.1 ha, containing several residential properties and the western half of the Patterson Pit. The runoff is captured and conveyed to the Mary Anne Crescent Pond. The runoff is then discharged from the pond to a storm sewer along Veterans Memorial Parkway thence flowing into Colwood Creek.

Catchment ‘C4’ drains to the Patterson Pit low point. The catchment area is approximately 15.3 ha in area, containing some residential developments and the eastern half of the Patterson Pit. The catchment has no overland flow route out. The runoff drains to the low point identified in **Figure 1** where the water ponds and then either infiltrates or evaporates.

Catchment ‘C5’ drains to an infiltration manhole located on the City of Colwood Public Works Yard. The catchment is approximately 28.1 ha and contains a mixture of residential and institutional land uses. The infiltration manhole fully infiltrates all runoff and no recent instances of surface flooding have been noted by City staff.

Catchment ‘C6’ drains to the Ridley Pit low point. The catchment is approximately 35.4 ha and contains residential properties as well as the Ridley Pit. The catchment has no overland flow route out. Water ponds within the low point and infiltrates / evaporates. No instances of flooding from the Ridley pit have been identified by the City.

We note the Colwood Creek Drainage Basin Study (1st Team Engineering Limited, 1998) indicated that additional runoff from the Triangle Mountain area will have a significant impact on water levels within Colwood Creek. Therefore, we caution that any alterations to the flow regime in Colwood Creek - as a result of changing the contributing catchment - needs to be analyzed in detail, including hydraulic modelling of the Creek and completing an environmental assessment.

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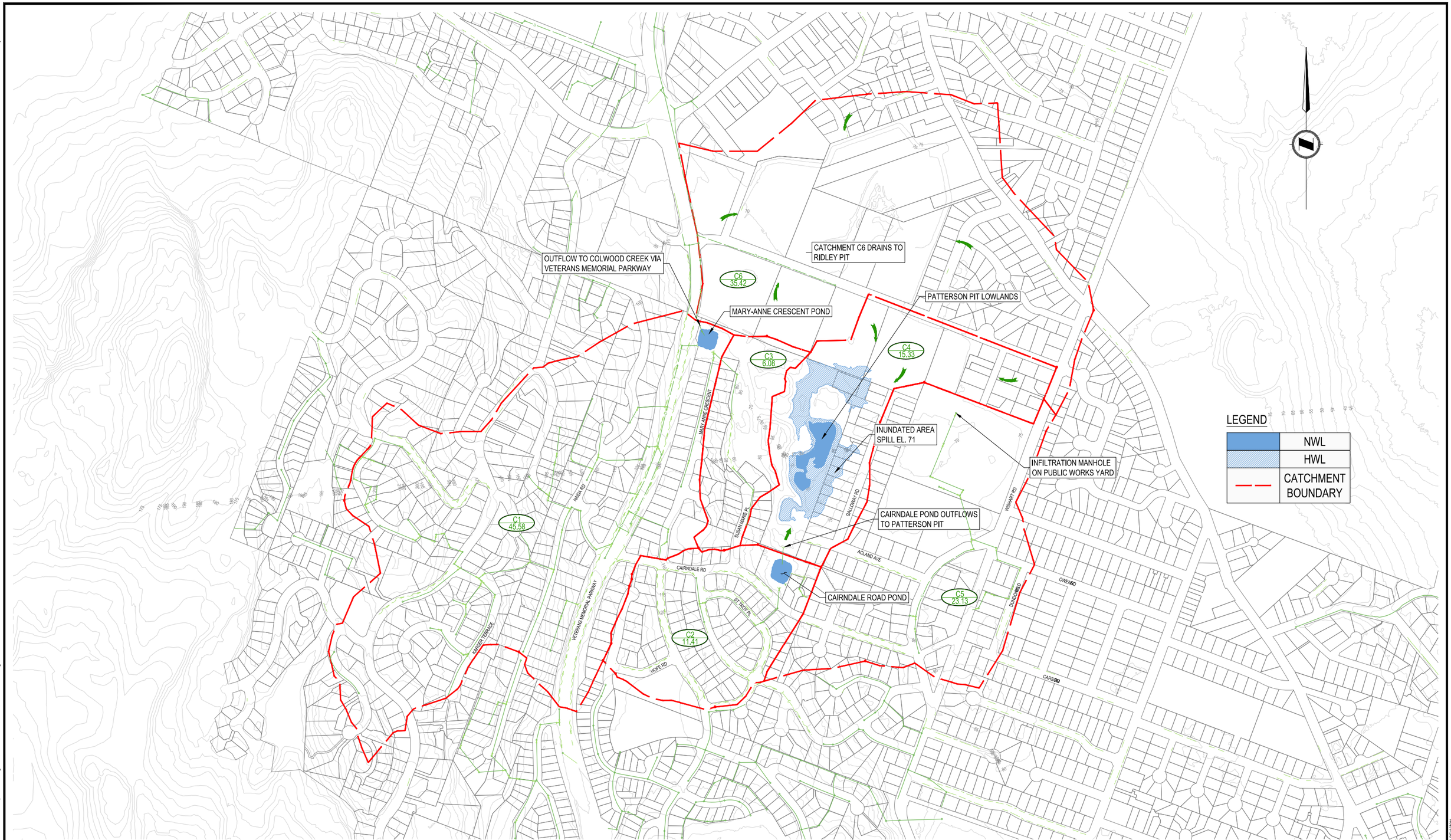

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COLWOOD STORM WATER MASTER PLAN STUDY AREA

Drawing No.

Figure 1

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4. OPTIONS DISCUSSION

Following a review of current drainage conditions within the Patterson / Ridley Pits, four mitigation options have been developed; intended to help in reducing the frequency of surface ponding / flooding in the subject residential area. These options are based on the desk top study completed herein.

4.1. Option 1

Option 1 involves conveying runoff from the low point within Patterson Pit to the Mary Anne Crescent pond. Due to topography, this will involve the installation of a pump station at the low point within Patterson Pit. As shown in **Figure 2,** runoff would be pumped from the Patterson Pit low point to a ditch located immediately north of Susan Marie Place. The runoff would then be conveyed via a ditch and storm sewer to Mary Anne Crescent Pond and eventually to Colwood Creek - through the existing storm sewer along Veterans Memorial Parkway.

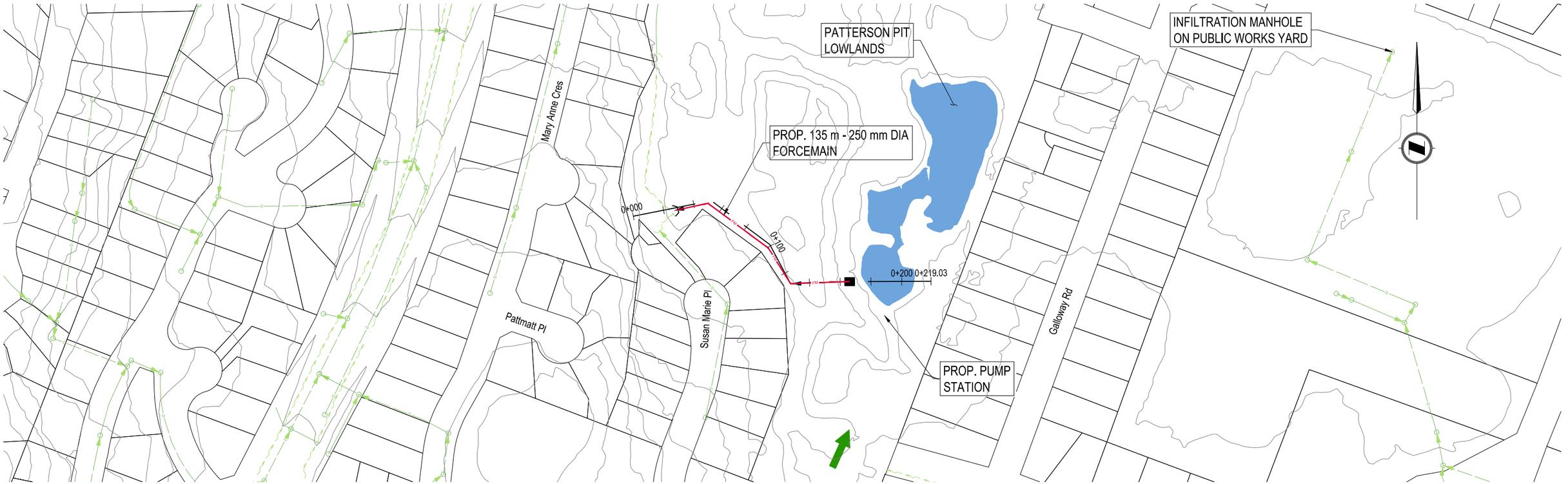
This option involves the construction of 135 m of forcemain and a pump station. A hydrological / hydraulic assessment is required to determine the required peak pump rate and size the forcemain. Advantages / disadvantages of pumping runoff from the Patterson Pit low point to the Mary Anne Crescent Pond are as follows:

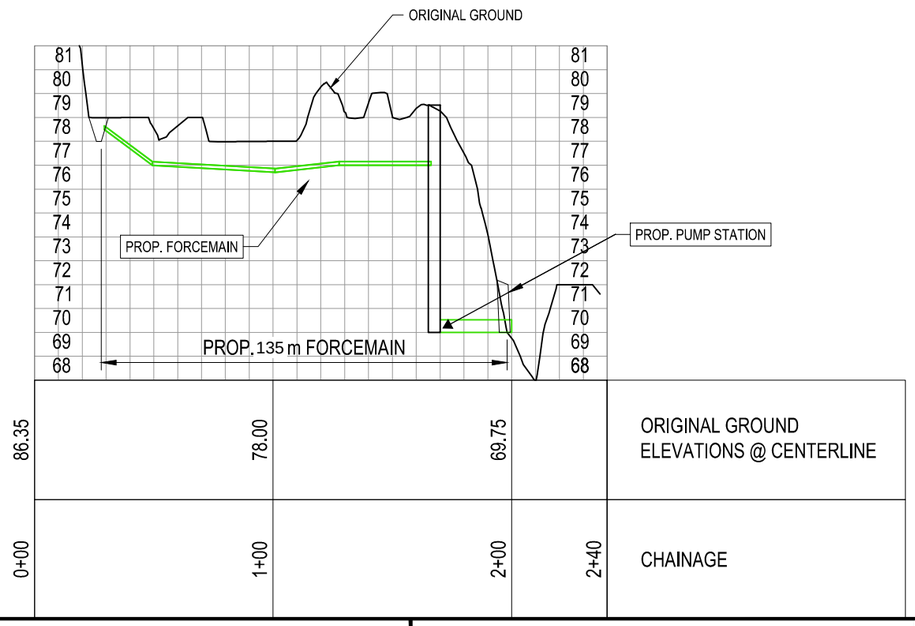
Advantages

- Reduces ponding within the Patterson Pit.
- May result in the elimination of need for the Cairndale Pond.

Disadvantages

- Would increase the contributing area to Mary Anne Crescent Pond and Colwood Creek. Need to assess the impact on each of these systems as noted above.
- Requires a statutory right of way through Patterson Pit for the forcemain - and likely for the pumping station.
- Involves the construction of a significant pumping station.
- Ongoing operations and maintenance costs of a pump / pump station.
- Increases flow rates within Colwood Creek, potentially resulting in the required increase in culvert sizes along Colwood Creek.





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COLWOOD STORM WATER MASTER PLAN
OPTION 1

Drawing No.
Figure 2

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4.2. Option 2

Option 2 involves the construction of a gravity storm sewer to convey runoff from the Patterson Pit low point to Colwood Creek. As shown in **Figure 3,** the gravity storm sewer would convey flows north to Allandale Road. The storm sewer would then follow the alignment of the existing storm sewer on Allandale Road north to Veterans Memorial Parkway and then east to Colwood Creek Park. Due to topography, the proposed gravity storm sewer would be considerably deeper than the existing storm sewer along both Allandale Road and Veterans Memorial Parkway. Therefore, roughly a 415 m section of the Veterans Memorial Parkway storm sewer would need to be replaced.

The storm sewer shown in **Figure 3** has been preliminarily indicated with a constant minimum slope of 0.2%. Based on a minimum slope of 0.2%, the proposed gravity storm would meet grade and tie into the existing storm sewer approximately 150 m north of the intersection of Veterans Memorial Parkway and Sooke Road. Therefore, option 2 involves the construction of approximately 1,160 m of new storm sewer at a maximum depth of 11.5 m. Advantages / disadvantages of installing a gravity main to drain the Patterson Pit low point north to Colwood Creek are noted below:

Advantages

- Reduces ponding within the Patterson Pit.
- May result in the elimination of the Cairndale Pond.
- Does not require pumping.

Disadvantages

- Would increase the contributing area to Mary Anne Crescent Pond and Colwood Creek. Need to assess the impact on each of these systems.
- Requires an SRW through Patterson Pit for gravity sewer.
- Requires the construction of a 11.5 m deep 1,050 mm diameter storm sewer which will be very costly and technically challenging.
- Requires new storm drain construction along Veterans Memorial Parkway which is an existing arterial roadway.

Based on the depths required for construction of the gravity sewer, this option does not appear to be cost effective. Directional drilling could be used for the installation of the deep section of storm sewer, however, the typically accepted minimum grade for directional drilling is 1.0%. Therefore, directional drilling would increase the length of sewer required by approximately 175 m, before the proposed sewer can tie into the existing pipe. Geotechnical investigations would be needed to verify the opportunity for use of trenchless technology.

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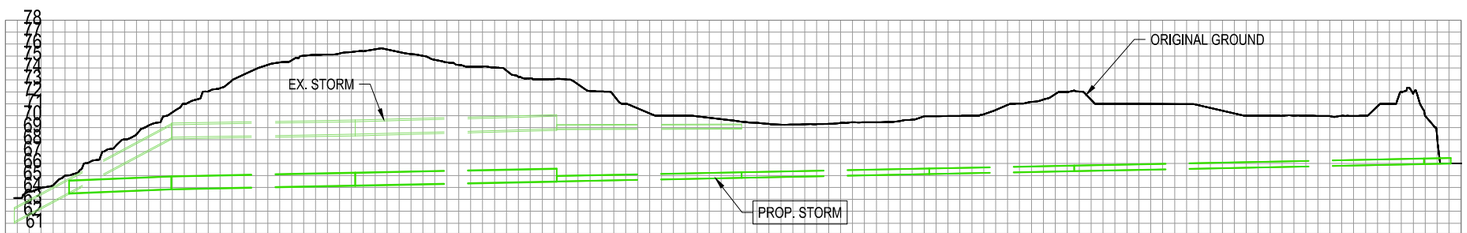

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COLWOOD STORM WATER MASTER PLAN
OPTION 2

Drawing No.
Figure 3

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4.3. Option 3

Option 3 involves the construction of a gravity storm sewer to convey runoff from the Patterson Pit low point to a new infiltration gallery, to be constructed within the Ridley Pit. As shown in **Figure 4,** the gravity storm sewer would convey runoff from the Patterson pit low point northward, following the eastern property line to an infiltration gallery to be constructed within the Ridley Pit. The size of the infiltration gallery shown in **Figure 4** is for illustration/discussion purposes only, as a hydrogeological investigation is required to confirm feasibility and then to properly size the infiltration gallery. We understand that surface ponding has not been evident in the past within the Ridley Pit, therefore soils may be favorable to infiltration. A geotechnical investigation should be completed to verify existing soil conditions and to determine sustainable infiltration rates.

This option would involve the construction of 550 m of storm sewer at a maximum depth of 9.5 m. Advantages / disadvantages of installing a gravity main to drain the Patterson Pit low point, north to infiltration gallery located within the Ridley Pit are outlined below:

Advantages

- Reduces ponding within the Patterson Pit.
- May result in the elimination of the Cairndale Pond.
- Does not require pumping.
- Does not add directly contributing surface runoff area to Colwood Creek.
- Relies on infiltration - mimicking the natural hydrology of the area.

Disadvantages

- Requires an SRW through Patterson Pit for the gravity sewer and the purchase of land [or SRW acquisition] within the Ridley Pit - for the infiltration gallery.
- Requires the construction of a 9.5 m deep storm sewer which will be very costly and technically challenging, requiring a tiered or benched excavation.
- May result in a large infiltration gallery on what is presently private property.
- Requires hydrogeological and geotechnical assessments.

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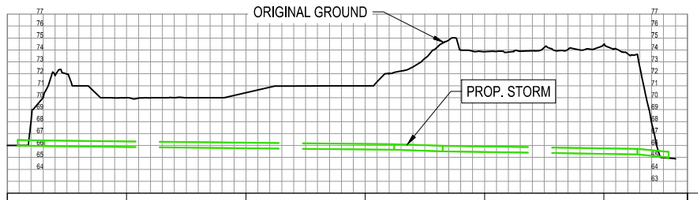

67.00	70.99	71.42	72.00	74.86	75.47		ORIGINAL GROUND ELEVATIONS @ CENTERLINE
0+00	1+00	2+00	3+00	4+00	5+00	5+70	CHAINAGE

Rev	Date	Description	Drawn	Design	App'd
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0 H1:5000 250
0 V1:500 25

ORIGINAL DWG SIZE: ANSI B (11" x 17")

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Tel 604 683 8521

THE CITY OF COLWOOD
3300 WISHART ROAD, VICTORIA, BC, V9C 1R1, CANADA

COLWOOD STORM WATER MASTER PLAN
OPTION 3

Drawing No.
Figure 4

Project Number	Rev.
2243-18045-00	----

DATE: 2019-09-14, 10:28 FILE: x:\2243\19-0045 colwood storm water master plan\10.0 drawings\civil 3d files\02 sketch\SK002-18045-CIV-000 Phase 2 Option 3.dwg
DESTROY ALL PRINTS BEARING PREVIOUS REVISION

4.4. Option 4

Option 4 involves conveying runoff from the Patterson Pit low point to an infiltration gallery within the City of Colwood Public Works Yard. There is currently an infiltration manhole located within the public works yard which infiltrates runoff from a 23.1 ha residential catchment. There have been no reports of ponding or flooding at this manhole location. The infiltration manhole is located within an area of high infiltration potential as per the Capital Region Wide Infiltration Mapping Project (Synetric Consulting Group & Hillcrest Geographics, 2016).

As shown in **Figure 5,** flow would be conveyed from the Patterson Pit low point by a gravity storm sewer. The storm sewer would convey flows northerly, along the eastern property line and then eastward at the north extent of Galloway Road to the City of Colwood Public Works Yard. It is presumed the infiltration gallery at the public works yard would then be expanded to accommodate this additional runoff.

This option would involve the construction of 355 m of storm sewer at a maximum depth of 5.5 m. Advantages / disadvantages of installing a gravity main to drain the Patterson Pit low point, east to an infiltration gallery in the City of Colwood Public Works Yard are as follows:

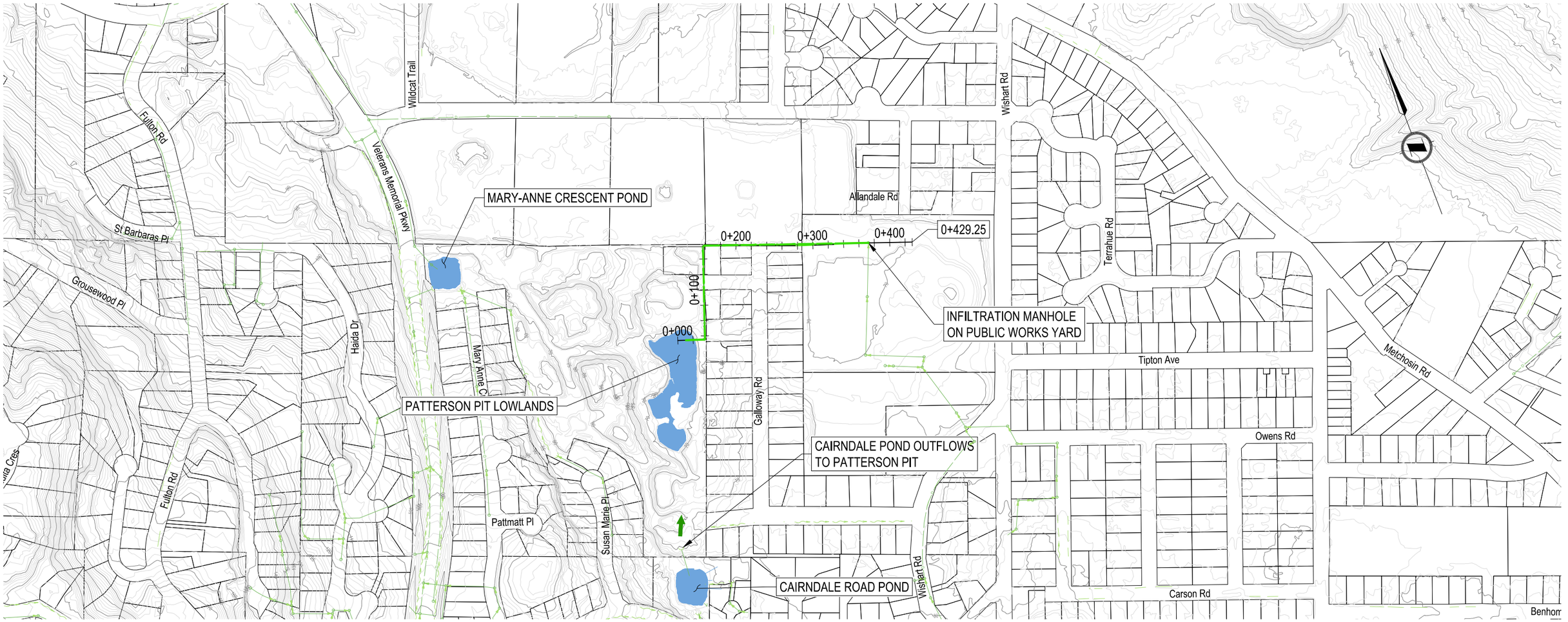
Advantages

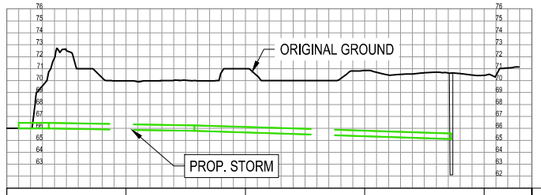
- Reduces ponding within the Patterson Pit.
- May result in the elimination of the Cairndale Pond.
- Does not require pumping.
- Does not add directly contributing area to Colwood Creek.
- Relies on infiltration - mimicking the natural hydrology of the area.
- Infiltration gallery would be installed on land already owned by the City.

Disadvantages

- Requires an SRW through Patterson Pit for the gravity sewer.
- May result in a large infiltration gallery.
- Requires favorable hydrogeological and geotechnical assessments before proceeding further with the concept.
- Requires the construction of a 5.5 m deep storm sewer.

McElhanney ANSI B - 2018-09-11





67.00	70.99	72.00	71.85	71.44		ORIGINAL GROUND ELEVATIONS @ CENTERLINE
0+00	1+00	2+00	3+00	4+00	4+40	CHAINAGE

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ORIGINAL DWG SIZE: ANSI B (11" x 17")

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COLWOOD STORM WATER MASTER PLAN
OPTION 4

Drawing No.
Figure 5

Project Number	Rev.
2243-18045-00	----

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DESTROY ALL PRINTS BEARING PREVIOUS REVISION

4.5. RECOMMENDATIONS

Option 1 requires the installation of a pumping station and forcemain across private property. The lifecycle costs associated with this option will be considerable.

Options 2 and 3 require the installation of very deep new storm drains. It is recommended that these options be eliminated, unless fatal flaws are revealed in either Option1 or Option 4.

Option 4 likely represents the least capital cost solution and does not involve on-going pumping of stormwater. We recommend the City pursue Option 4 as the preferred solution.

Prior to the selection and implementation of any of the design options, further field investigation and analysis must be conducted - to confirm feasibility – both in terms of constructability and in the longer-term hydro-geologic impacts. It is vital that the City be made aware of the sub-surface routing and likely point[s] of breakout for surface water re-introduced to the ground, per Option 4.

The following engineering / planning tasks are recommended, in order to further refine the feasibility of the preferred option, and to enable defensible capital cost estimates to be generated.

- Topographic survey and CADD base plan mapping, as needed to allow modelling of the existing ponds and hydrology of the area, and thus, the design peak runoff flows to be conveyed.
    - $4,500
- Refine the hydrological / hydraulic model developed for the Colwood SWMP, to determine an estimate of runoff rates and volumes for the Patterson / Ridley Pit areas.
    - $5,000
- Complete a hydrogeological assessment to determine groundwater depth and infiltration potential, as well as the expected infiltration pit expansion as needed to accommodate the preferred Option 4 solution.
    - $20,000
- Complete a geotechnical investigation, complete with test pitting and reporting, to confirm soil conditions and infiltration potential.
    - $15,000

5. CLOSING

We trust the above provides the necessary investigation and recommendation required to allow the City to move forward with Option 4. We would like to thank the City for the opportunity to be of service and we look forward to assisting in carrying the recommended solution forward, if the City wishes.

Sincerely,

Prepared by:

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Water Resources Engineer
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Reviewed by:

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Vice President
iwhitehead@mcelhanney.com