Stantec

PROPOSED HAZELDEAN ROAD MUNICIPAL DRAINAGE WORKS A TECHNICAL BACKGROUND REPORT

Engineers Report for the Hazeldean Road Municipal Drain

June 2010

Table of Contents

List of Tables

1.0 Background

Stantec Consulting Ltd has been appointed under **Section 8** and **10** of the *Drainage Act* to complete an Engineer's Report for the Hazeldean Road Municipal Drain, as provided under separate cover. This technical report has been completed in support of the Engineer's Report, in particular as it pertains to the recommended improvements within the Drain. Specifically, the objective of this technical report is to assess the hydraulic impact of removing a beaver dam, located at approximate station 5+500, and its effect on peak flow and flood levels downstream. An analysis of the existing conditions and proposed improvements for the Hazeldean Municipal Drain has been completed in support of the Engineer's Report for this area. The drain itself stretches from Highway 7, crosses Hazeldean Avenue and continues on easterly beyond West Ridge Avenue.

It should be noted that flow monitoring data was not available for the subject reach of drain in question and, therefore, the analysis presented herein is not calibrated. As such, the results from this analysis should not be used for the purpose of designing future works, or to validate or calibrate future models. The results from this analysis are meant to show the relative changes between existing and future conditions only.

2.0 Field Investigations

A topographic survey of the drain to obtain cross-sections and culvert details was completed in order to complement the available topographic mapping. Of note, the flooded area north of the Trans Canada Trail (TCT) was not accessible due to restrictive site conditions.

There is currently a beaver dam located approximately 300m downstream (~5+500) from the culvert crossing at the TCT. The top of this beaver dam was surveyed and is located at an elevation of approximately 124.12m. The presence of this beaver dam is suspected to be the cause of the upstream flooding between Hazeldean Road and the TCT, and the cause of the submerged condition present at the TCT culvert.

3.0 Modeling & Analysis

A combination of SWMHYMO modeling and spreadsheet calculations was used to analyze the drain. Two scenarios were considered:

Existing Conditions: 1390x970 arch culvert at TCT[(1)] with beaver dam.

Post Conditions: 1390x970 arch culvert at TCT with beaver dam removed.

The existing 1160x1160mm concrete box Trans Canada Trail culvert crossing is structurally deficient and for safety reasons is to be replaced by the City with an equivalent sized 1390x970 arch culvert. A 7m 1390mm x 970mm pipe arch culvert with upstream invert of 123.40m and downstream invert of 123.30m has been proposed to replace the existing culvert.

3.1 DRAINAGE AREAS CHARACTERISTICS

The total drainage area for the reach of interest was further subdivided as shown in Figure 1. An SCS runoff curve number (CN value) of 63 was assumed to apply to all catchments except for catchment A0. A CN value of 75 was used for A0 since highway 7 passes through this catchment. The CN value of 63 was estimated by using the average value for Soil Groups B & C for Brush with Fair conditions. The CN value of 75 was calculated by using an average value for Soil Groups B & C for Open Space-Fair and Streets/Roads-Open Ditches based on the City of Ottawa Sewer Design Guidelines suggested values. A value of 4.67mm was used as the initial abstraction value for this analysis as suggested by the City of Ottawa Sewer Design Guidelines.

The time of concentration for each of these subcatchments was estimated using the Uplands Method nomograph as well as the approximate drainage path lengths and subcatchment slopes. Line "A – Overland Flow: Forest (heavy litter) & hay meadow" was selected as the appropriate category for the study area other than for catchment A0. Line "G – Small Upland Gullies & Paved Areas" was selected for catchment A0. The time of concentration was then used to calculate the time to peak for each catchment. **Table 1** is provided as a summary of the drainage area characteristics used in the analysis.

Table 1 Subcatchment Properties.

Subcatchment	Area (ha)	Slope (%)	Drainage Length (m)	Velocity (m/s)	Time of Concentration (hr)	Time to Peak (hr)
A0	134.1	0.57%	1400	0.45	0.9	0.5
A1	73.8	0.50%	600	0.06	2.8	1.7
A2	108.3	0.64%	1100	0.06	5.0	3.0
A3	127.5	0.42%	2400	0.05	13.3	8.0
A4	41.6	0.33%	900	0.05	5.6	3.3
A5	147.3	0.65%	1850	0.06	8.4	5.1
A6	19.1	0.46%	650	0.05	3.6	2.2
A7	12.9	1.14%	350	0.12	0.8	0.5
A8	41.2	0.61%	1650	0.06	7.6	4.6
A9	49.7	1.00%	1100	0.08	4.1	2.4
A10	20.6	0.57%	350	0.06	1.6	1.0
A11	35.0	0.46%	650	0.05	3.6	2.2
A12	24.8	0.88%	800	0.07	3.2	1.9
S1	38.1	0.04%	1200	0.01	33.3	20.0
S2	8.7	0.24%	425	0.04	3.1	1.9

3.1.1 Typical Cross-Sections & Roughness Values

Field data was used to establish typical cross-sections for the reaches from highway 7 to the beaver dam downstream. Survey data was not obtainable for the flooded area immediately upstream of the culvert and beaver dam due to restrictive site conditions. An approximated cross-section was assumed for this area, as illustrated in **Figure 1**.

Roughness values varying from 0.030-0.060 were used for flow routing during the analysis. These values were selected based on photographs taken during field work. The roughness values selected are defined as presented in **Table 2.**

Table 2 Roughness Values & Descriptions.

Description	Roughness
Pasture, no brush – Short Grass	0.030
Pasture, no brush – High Grass	0.035
Cultivated Area – Mature Field Crop	0.040
Brush – Light brush and trees (summer)	0.060

3.1.2 Rainfall Events

Generic 24hr SCS type II rainfall hyetographs were run through the SWMHYMO model under existing and future conditions. These synthetic rainfall events were run to show the relative difference between the existing and future conditions. The recent storm event that occurred in the City of Ottawa between July 23rd and 26th, 2009 caused significant flooding within the Poole Creek Watershed. Rain gauge data from the Maple Grove station was obtained from the City of Ottawa and has also been modeled. **Table 3** is provided as a summary of the events considered in the analysis.

Table 3 Rainfall Event Summary.

Description	Total Volume (mm)	Max Intensity (mm/hr)
2 year 24hr SCS II	48	20.5
5 year 24hr SCS II	62	26.7
10 year 24hr SCS II	72	30.8
25 year 24hr SCS II	84	35.9
50 year 24hr SCS II	95	40.1
100 year 24hr SCS II	104	44.2
July 23-26 2009 Event	115	88.8

3.1.3 Hydraulic Analysis

SWMHYMO's *Route Channel* command was used to convey the flow up to the culvert at the TCT crossing. A SWMHYMO schematic showing the flow chart for the addition and routing of the input hydrographs is provided as Figure 2 to this report. Channel lengths and slopes were estimated from the contours provided and shown in Figure 1.

Storage area "S1" is located in an area where limited topographic detail is available, due to the long-term flooding. A typical 1m wide and 1m deep main channel with 1:1 side slopes was assumed for the length of the storage area. A depth of 1.5m was estimated considering the proposed upstream culvert invert is specified to be 123.4m and the surveyed centre line of road from the bicycle pathway was surveyed and identified as 125.25m. **Table 4** provided below is provided as a summary of the storage characteristics upstream of the TCT crossing as assumed during the analysis.

Table 4 Storage Area Characteristics.

Elevation (m)	Depth (m)	Area (m^2)	Volume (ha-m)
123.4	0.0	0.00	0.00
123.5	0.1	0.11	0.01
123.6	0.2	0.24	0.03
123.7	0.3	0.39	0.04
123.8	0.4	0.56	0.06
123.9	0.5	0.75	0.09
124.0	0.6	0.96	0.11
124.1	0.7	1.19	0.14
124.2	0.8	1.44	0.17
124.3	0.9	1.71	0.20
124.4	1.0	2.00	0.23
124.5	1.1	7.77	0.89
124.6	1.2	24.48	2.82
124.7	1.3	52.13	5.99
124.8	1.4	90.72	10.43
124.9	1.5	140.25	16.13
125.0	1.6	200.72	23.08

3.1.4 Existing Conditions (Beaver Dam In)

The beaver dam is located approximately 300m downstream of the TCT crossing. Its elevation was surveyed to be 124.12m. For the purpose of this analysis, it has been assumed that this crossing acts as a broad crested weir with a width of 10m (from survey). Due to the proximity of the dam to the crossing, the tail water for the culvert analysis was assumed to be equivalent to the head water required to pass flow over the beaver dam using Equation (1).

$$Q = 1.67W\sqrt{H}$$

(1) Where *W* is the width of the weir in meters

H is the head above the weir in meters

Q is the flow in cubic meters.

The head-discharge characteristics as described by Equation (1) were used to produce **Table 5**, which was in turn used to interpolate the tail water elevations for the culvert analysis.

Table 5 Beaver Dam Head-Discharge Characteristics.

Tail Water Surface Elevation (m)	Head (m)	Flow (m^3/s)
124.12	0	0
124.20	0.08	0.38
124.30	0.18	1.28
124.40	0.28	2.47
124.50	0.38	3.91
124.60	0.48	5.55
124.70	0.58	7.38
124.80	0.68	9.36
124.90	0.78	11.50

The HydroCulv v2.0 spreadsheet was used to analyze the proposed culvert considering the tail waters calculated shown in **Table 5** and based on the beaver dam/weir analysis. A roughness value of 0.025 was used for the culvert analysis (corrugated metal – storm drain). Results from the culvert analysis were used to estimate the storage-discharge relationship for this scenario. This storage-discharge relationship was then used in the SWMHYMO modeling to calculate the flow and storage details caused by the culvert-beaver dam system (see **Tables 6 and 8**).

Table 6 Existing Conditions Storage-Discharge Relationship.

Flow (m^3/s)	Tail Water Surface Elevation (m)	Head Water Surface Elevation (m)	Volume (ha-m)
0.25	124.18	124.19	0.50
0.50	124.21	124:24	0.53
1.00	124.26	124.38	0.63
1.50	124.30	124.59	4.83
2.00	124.34	124.86	15.10
2.50	124.39	125.19	27.75

3.1.5 Future Conditions (Beaver Dam Removed)

Removing the beaver dam essentially lowers the tail water affecting the TCT culvert. During the analysis it became apparent that the drain bed itself is reverse sloped between the TCT crossing and the beaver dam. This reverse grade acts as a restriction in the drain and results in elevated tail water even after the removal of the beaver dam.

The surveyed drain inverts immediately upstream and downstream of the beaver dam were used to estimate the channel characteristics. A summary of the depth-conveyance details of this section assuming a roughness of 0.045 (clean, winding, some pools, shoals, weeds and stones) and a slope of 0.38% (based on a cross-section to cross-section distance of 230m) is provided in **Table 7**.

Table 7 Beaver Dam Removed Depth-Conveyance Details.

Tail Water Elevation (m)	Depth (m)	Area (m^2)	Wetted Perimeter (m)	Conveyance (m^3/s)
123.6	0.0	0.0	0.0	0.0
123.7	0.1	0.1	1.4	0.0
123.8	0.2	0.3	2.8	0.1
123.9	0.3	0.6	4.2	0.2
124.0	0.4	1.1	5.7	0.5
124.1	0.5	1.8	7.1	0.9
124.2	0.6	2.3	7.4	1.5
124.3	0.7	2.9	7.8	2.0
124.4	0.8	3.4	8.2	2.6

Tail Water Elevation (m)	Depth (m)	Area (m^2)	Wetted Perimeter (m)	Conveyance (m^3/s)
124.5	0.9	4.0	8.6	3.3
124.6	1.0	4.6	8.9	4.0
124.7	1.1	5.1	9.3	4.7
124.8	1.2	5.7	9.7	5.5

Table 8 Future Conditions Storage-Discharge Relationship.

Flow (m^3/s)	Tail Water Surface Elevation (m)	Head Water Surface Elevation (m)	Volume (ha-m)
0.25	123.83	123.86	0.27
0.50	123.94	124.00	0.37
1.00	124.11	124.27	0.55
1.50	124.24	124.54	2.80
2.00	124.34	124.87	15.78
2.50	124.41	125.24	29.87

4.0 Results

The rating curves for both existing and future conditions were developed to represent the hydraulic interaction between the upstream storage, TCT culvert and beaver dam. These were then modeled using the SWMHYMO *Route Reservoir* routine to attenuate the hydrographs generated from the upstream catchments. **Tables 9 and 10** are provided as a summary of the results.

Table 9 Existing Scenario Results (Beaver Dam In).

Event	Flow through Culvert / Beaver Dam		Storage Used (ha-m)	Water Surface Elevation (m)
	Upstream (m^3/s)	Downstream (m^3/s)		
2 year 24hr SCS II	2.35	1.19	1.72	124.54
5 year 24hr SCS II	3.93	1.50	4.35	124.60
10 year 24hr SCS II	5.20	1.63	6.83	124.66
25 year 24hr SCS II	6.79	1.80	10.40	124.75
50 year 24hr SCS II	8.30	1.97	13.83	124.83
100 year 24hr SCS II	9.54	2.10	16.86	124.90
July 2009 Event	11.02	2.23	20.37	124.99

Table 10 Future Scenario Results (Beaver Dam Out).

Event	Flow through Culvert		Storage Used (ha-m)	Water Surface Elevation (m)
	Upstream (m^3/s)	Downstream (m^3/s)		
2 year 24hr SCS II	2.35	1.31	1.56	124.53
5 year 24hr SCS II	3.93	1.56	3.92	124.59
10 year 24hr SCS II	5.20	1.66	6.48	124.65
25 year 24hr SCSII	6.79	1.81	10.14	124.74
50 year 24hr SCS II	8.30	1.94	13.68	124.83
100 year 24hr SCS II	9.54	2.06	16.79	124.90
July 2009 Event	11.02	2.19	20.34	124.99

5.0 Discussion & Conclusions

The results obtained from the SWMHYMO modeling indicate that removing the beaver dam has negligible impact on the storage volume and head water elevation at the TCT crossing. Throughout all modeled events the differences between the scenarios are minimal.

It is expected that much of the available storage is due primarily to the gradation of the drain, and that the beaver dam is not solely responsible for the head water elevation upstream. The downstream flooding, conveyance and erosion impacts of the proposed drainage works are discussed as follows:

5.1 FLOODING

By removing the beaver dams the available storage volume for the less frequent flood events is increased. For these events it is the channel hydraulics not the beaver dams that control flow rates. Thus, the channel response to these larger events (i.e. 10 year to 100 year events) closely simulates existing conditions and the added storage volume may potentially reduce peak flows that contribute to flooding.

5.2 CONVEYANCE CAPACITY

At West Ridge Drive, the culverts have been sized to provide conveyance capacity that results in 100 year regulatory flood levels, and a flow of 22.4m^3/s. Downstream of the West Ridge culvert, the channel was modeled (by others), for a range of flows between 10.4m^3 to 22.4m^3/s. These flows are 7 to 14 times greater than the estimated 5 year flow rate of 1.56m^3/s. From a review of the HEC-RAS model results, (see Appendix B), and from a visual inspection of the drain, the estimated small increase in 2 year to 5 year flows of 10% and 4% respectively will not exceed the channel conveyance capacity. Thus, the proposed West Ridge Culvert provides good and sufficient outlet for the proposed drainage works.

5.3 EROSION

Stream erosion is a natural feature of any water course and the rate of erosion is related to the rate and duration of flow in the channel. It is noted that, the proposed drainage works do not include for any landuse changes that would increase the net volume of runoff. Thus any increase in peak flow rate is offset by a reduction in flow duration and vice versa. From a review of the HEC-RAS model results, (see Appendix B), and from a visual inspection of the drain, the estimated 10% increase in the less than 2 year flows will not increase the channel erosion.

It is again noted that none of the results presented herein originate from a calibrated model. As such, the results from this analysis should not be used for the purpose of designing future works, or to validate or calibrate future models.

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