STEELES AVENUE

C1

C2

C3

C5

C6

C7

100
89.3 ha

110-0
4.04 ha

120
5.72 ha

125
24.5 ha

130
25.6 ha

105-0
703 ha

REACH 13 TRIBUTARY

16 MILE CREEK MIDEAST REACH 13 MAIN

TRAFALGAR ROAD

LEGEND

- DRAINAGE BOUNDARY
- PROPOSED CULVERT
- PROPOSED STORM SEWER
- FLOW DIRECTION
- C1 — CULVERT ID
- B1 — BRIDGE ID
- 255 / 29.4 ha — CATCHMENT ID / CATCHMENT AREA

Metric Scale
150m 0 300m
Horizontal

MMM GROUP

PROPOSED CONDITIONS DRAINAGE MOSAIC

TRAFALGAR ROAD EA, FROM STEELES AVENUE TO HIGHWAY 7

EXHIBIT
16

LEGEND

- DRAINAGE BOUNDARY
- PROPOSED CULVERT
- PROPOSED STORM SEWER
- FLOW DIRECTION
- C1 — CULVERT ID
- B1 — BRIDGE ID
- 255 / 29.4 ha — CATCHMENT ID / CATCHMENT AREA

Metric Scale
25m 0 50m
Horizontal

16 MILE CREEK MIDEAST REACH 13 MAIN

16 MILE CREEK MIDEAST REACH 13 TRIBUTARY

STEELES AVENUE

0+000

ENHANCED GRASSED SWALES AND BIO-SWALE FOR QUALITY TREATMENT ON THE WEST SIDE

0+100

0+200

0+300

0+400

C1

ENHANCED GRASSED SWALES FOR QUALITY TREATMENT ON THE WEST SIDE

0+500

0+600

0+700

TRAFALGAR ROAD

0+800

0+900

1+000

1+100

BIO-SWALES FOR QUALITY TREATMENT ON THE WEST SIDE

POND – 2S
GRASSED LINEAR DRY SWM FACILITY
FOR QUANTITY AND QUALITY CONTROL
100-YEAR STORAGE VOLUME = 565 m³

C2

100 / 89.3 ha

105-3 / 2.30 ha

105-0 / 703 ha

MMM GROUP

PROPOSED CONDITIONS DRAINAGE MOSIAC

TRAFALGAR ROAD EA, FROM STEELES AVENUE TO HIGHWAY 7

EXHIBIT 17

POND – 2N
WET SWM FACILITY FOR QUANTITY AND QUALITY CONTROL
PERMANENT POOL VOLUME = 1160 m³
100–YEAR STORAGE VOLUME = 1890 m³

HORNBY ROAD

TRAFALGAR ROAD

1+500

1+600

1+700

1+800

1+900

2+000

2+100

2+200

2+300

1+300

1+200

675 mm DIAMETER CULVERT REQUIRED TO DIRECT RUNOFF TO SWM FACILITY

825 mm DIAMETER CULVERT REQUIRED TO DIRECT RUNOFF TO SWM FACILITY

BIO–SWALES FOR QUALITY TREATMENT ON THE WEST SIDE

16 MILE CREEK MIDEAST REACH 13 MAIN

105-0
703 ha

105-1
6.42 ha

105-2
1.65 ha

LEGEND

- DRAINAGE BOUNDARY
- PROPOSED CULVERT
- PROPOSED STORM SEWER
- FLOW DIRECTION
- C1 — CULVERT ID
- B1 — BRIDGE ID
- 255 / 29.4 ha — CATCHMENT ID / CATCHMENT AREA

Metric Scale
25m 0 50m
Horizontal

MMM GROUP

PROPOSED CONDITIONS DRAINAGE MOSIAC

TRAFALGAR ROAD EA, FROM STEELES AVENUE TO HIGHWAY 7

EXHIBIT 18

LEGEND

- DRAINAGE BOUNDARY
- PROPOSED CULVERT
- PROPOSED STORM SEWER
- FLOW DIRECTION
- C1 — CULVERT ID
- B1 — BRIDGE ID
- 255 / 29.4 ha — CATCHMENT ID / CATCHMENT AREA

Metric Scale
25m 0 50m
Horizontal

POND – 3N
DRY SWM FACILITY FOR
QUANTITY CONTROL
100–YEAR STORAGE
VOLUME = 1290 m³

GRASSED SWALES FOR
QUALITY TREATMENT ON
THE WEST SIDE

ENHANCED GRASSED SWALES
AND BIO–SWALES FOR QUALITY
TREATMENT ON THE WEST SIDE

C3

2+400 2+500 2+600 2+700 2+800 2+900 3+000 3+100 3+200 3+300 3+400 3+500

110-1
1.69 ha

110-2
0.90 ha

TRAFALGAR ROAD

5 SIDEROAD

110-0
4.04 ha

105-0
703 ha

MMM GROUP

PROPOSED CONDITIONS DRAINAGE MOSIAC

TRAFALGAR ROAD EA, FROM STEELES AVENUE TO HIGHWAY 7

EXHIBIT

19

115
0.82 ha

120
5.72 ha

125
24.5 ha

105-0
703 ha

ENHANCED GRASSED SWALES FOR QUALITY TREATMENT ON THE WEST SIDE

ENHANCED GRASSED SWALES AND BIO–SWALES FOR QUALITY TREATMENT ON THE WEST SIDE

TRAFALGAR ROAD

3+500 3+600 3+700 3+800 3+900 4+000 4+100 4+200 4+300 4+400 4+500 4+600

C5 C6

Metric Scale
25m 0 50m
Horizontal

LEGEND

- DRAINAGE BOUNDARY
- PROPOSED CULVERT
- PROPOSED STORM SEWER
- FLOW DIRECTION
- C1 — CULVERT ID
- B1 — BRIDGE ID
- 255 / 29.4 ha — CATCHMENT ID / CATCHMENT AREA

MMM GROUP

PROPOSED CONDITIONS DRAINAGE MOSIAC

TRAFALGAR ROAD EA, FROM STEELES AVENUE TO HIGHWAY 7

EXHIBIT
20

125
24.5 ha

130
25.6 ha

ENHANCED GRASSED SWALES AND BIO–SWALES FOR QUALITY TREATMENT ON THE WEST SIDE

135-0
9.3 ha

4+700 4+800 4+900 C7 5+000 5+100 5+200 5+300 5+400 5+500 5+600 5+700 5+800

TRAFALGAR ROAD

LEGEND

- DRAINAGE BOUNDARY
- PROPOSED CULVERT
- PROPOSED STORM SEWER
- FLOW DIRECTION
- C1 — CULVERT ID
- B1 — BRIDGE ID
- 255 / 29.4 ha — CATCHMENT ID / CATCHMENT AREA

Metric Scale
25m 0 50m
Horizontal

105-0
703 ha

MMM GROUP

PROPOSED CONDITIONS DRAINAGE MOSAIC

TRAFALGAR ROAD EA, FROM STEELES AVENUE TO HIGHWAY 7

EXHIBIT
21

LEGEND

- DRAINAGE BOUNDARY
- PROPOSED CULVERT
- PROPOSED STORM SEWER
- FLOW DIRECTION
- C1 — CULVERT ID
- B1 — BRIDGE ID
- 255 / 29.4 ha — CATCHMENT ID / CATCHMENT AREA

Metric Scale
25m 0 50m
Horizontal

135-0
9.3 ha

140-0
28.0 ha

ENHANCED GRASSED SWALES AND BIO–SWALES FOR QUALITY TREATMENT ON THE WEST SIDE

ENHANCED GRASSED SWALES AND BIO–SWALES FOR QUALITY TREATMENT ON THE WEST SIDE

ENHANCED GRASSED SWALES AND BIO–SWALES FOR QUALITY TREATMENT ON THE WEST SIDE

5+900 6+000 6+100 6+200 C8 6+300 6+400 6+500 6+600 6+700 6+800 C9 6+900 7+000

TRAFALGAR ROAD

10 SIDEROAD

135-1
2.9 ha

POND – 8S
GRASSED LINEAR DRY SWM FACILITY
FOR QUANTITY AND QUALITY CONTROL
100–YEAR STORAGE VOLUME = 630 m³

140-1
1.30 ha

OGS

POND– 9S
GRASSED LINEAR DRY SWM FACILITY
FOR QUANTITY AND QUALITY CONTROL
100–YEAR STORAGE VOLUME = 455 m³

MMM GROUP

PROPOSED CONDITIONS DRAINAGE MOSIAC

TRAFALGAR ROAD EA, FROM STEELES AVENUE TO HIGHWAY 7

EXHIBIT

22

145-0
45.0 ha

140-0
28.0 ha

150-0
133.9 ha

16 MILE CREEK MIDEAST REACH 1 NORTH

ENHANCED GRASSED SWALES AND BIO–SWALES FOR QUALITY TREATMENT ON THE WEST SIDE

ENHANCED GRASSED SWALES AND BIO–SWALES FOR QUALITY TREATMENT ON THE WEST SIDE

750 mm DIAMETER CULVERT REQUIRED TO DIRECT RUNOFF TO SWM FACILITY

C10

C11

7+000 7+100 7+200 7+300 7+400 7+500 7+600 7+700 7+800 7+900 8+000 8+100

TRAFALGAR ROAD

OGS

140-2
0.90 ha

145-1
1.40 ha

POND – 10N
GRASSED LINEAR DRY SWM FACILITY
FOR QUANTITY AND QUALITY CONTROL
100–YEAR STORAGE VOLUME =500 m^3

POND – 11N
GRASSED LINEAR DRY SWM FACILITY
FOR QUANTITY AND QUALITY CONTROL
100–YEAR STORAGE VOLUME = 500 m^3

LEGEND

- DRAINAGE BOUNDARY
- PROPOSED CULVERT
- PROPOSED STORM SEWER
- FLOW DIRECTION
- C1 — CULVERT ID
- B1 — BRIDGE ID
- 255 / 29.4 ha — CATCHMENT ID / CATCHMENT AREA

Metric Scale
25m 0 50m
Horizontal

MMM GROUP

PROPOSED CONDITIONS DRAINAGE MOSAIC

TRAFALGAR ROAD EA, FROM STEELES AVENUE TO HIGHWAY 7

EXHIBIT
23

150-0
133.9 ha

155-0
37.4 ha

ENHANCED GRASSED SWALES
AND BIO–SWALES FOR QUALITY
TREATMENT ON THE WEST SIDE

ENHANCED GRASSED SWALES
AND BIO–SWALES FOR QUALITY
TREATMENT ON THE WEST SIDE

8+200 8+300 8+400 8+500 8+600 C12 8+700 8+800 8+900 9+000 9+100 9+200 9+300

TRAFALGAR ROAD

150-1
2.1 ha

155-1
1.90 ha

OGS

POND– 12N
GRASSED LINEAR DRY SWM FACILITY
FOR QUANTITY AND QUALITY CONTROL
100–YEAR STORAGE VOLUME = 580 m³

LEGEND

- DRAINAGE BOUNDARY
- PROPOSED CULVERT
- PROPOSED STORM SEWER
- FLOW DIRECTION
- C1 — CULVERT ID
- B1 — BRIDGE ID
- 255 / 29.4 ha — CATCHMENT ID / CATCHMENT AREA

Metric Scale
25m 0 50m
Horizontal

MMM GROUP

PROPOSED CONDITIONS DRAINAGE MOSAIC

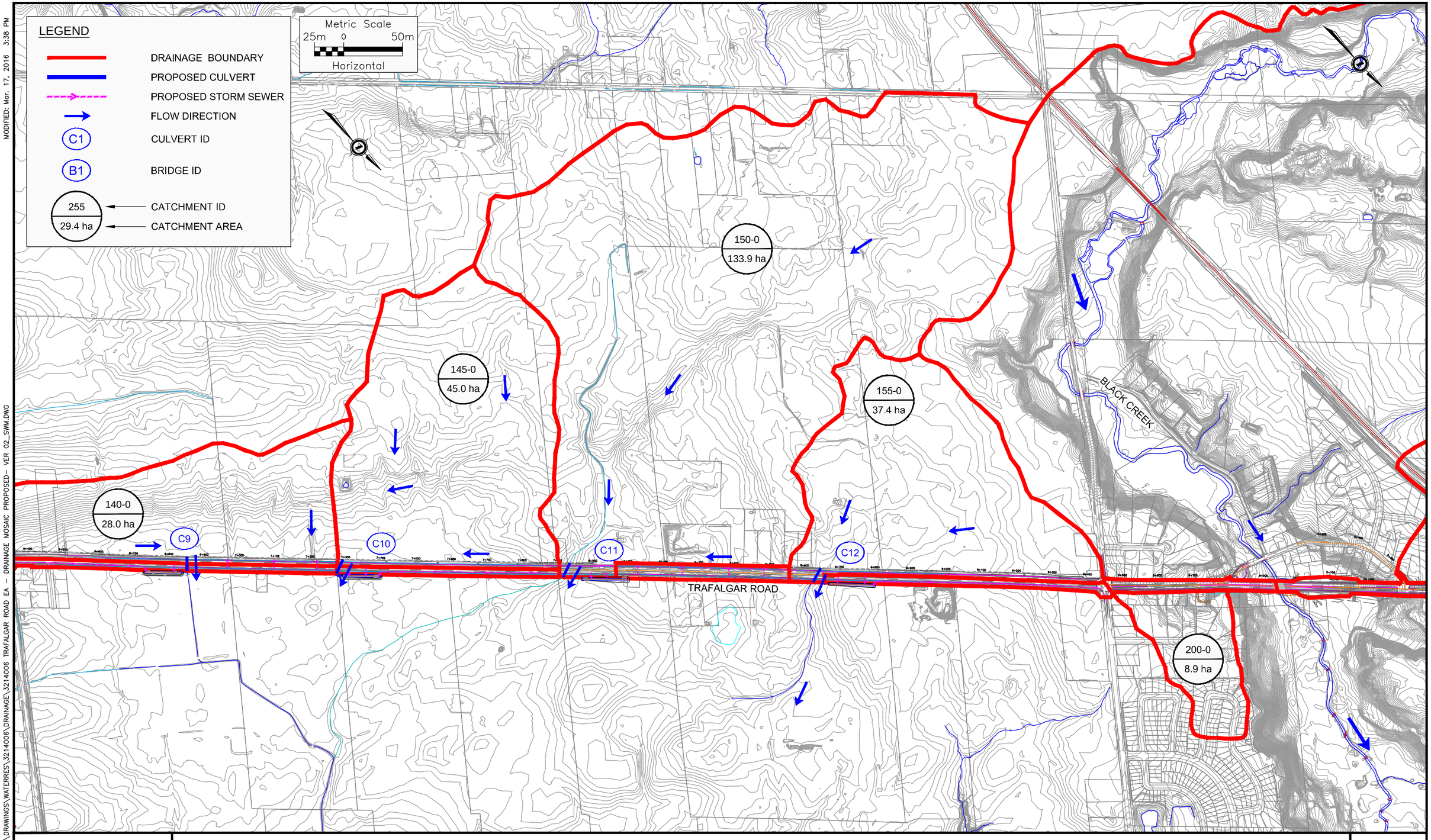
TRAFALGAR ROAD EA, FROM STEELES AVENUE TO HIGHWAY 7

EXHIBIT
24

LEGEND

- DRAINAGE BOUNDARY
- PROPOSED CULVERT
- PROPOSED STORM SEWER
- FLOW DIRECTION
- C1 — CULVERT ID
- B1 — BRIDGE ID
- 255 / 29.4 ha — CATCHMENT ID / CATCHMENT AREA

Metric Scale
25m 0 50m
Horizontal



MMM GROUP

PROPOSED CONDITIONS DRAINAGE MOSIAC

TRAFALGAR ROAD EA, FROM STEELES AVENUE TO HIGHWAY 7

EXHIBIT

25

BLACK CREEK

STEWARTTOWN ROAD SOUTH

STEWARTTOWN ROAD NORTH

TRAFALGAR ROAD

15 SIDEROAD

200-1
1.60 ha

200-0
8.9 ha

210
4.70 ha

B1

OUTLET POOL

OGS

OUTLET POOL

OGS

BLACK CREEK BRIDGE
30m OPENING SINGLE
SPAN STRUCTURE

EXISTING STORMSEWER
OUTLET

BLACK CREEK

9+400 9+500 9+600 9+700 9+900 0+300 0+400 0+500 2+100 10+100 10+200 10+400

Metric Scale
25m 0 50m
Horizontal

LEGEND

- DRAINAGE BOUNDARY
- PROPOSED CULVERT
- PROPOSED STORM SEWER
- FLOW DIRECTION
- C1 — CULVERT ID
- B1 — BRIDGE ID
- 255 / 29.4 ha — CATCHMENT ID / CATCHMENT AREA

MMM GROUP

PROPOSED CONDITIONS DRAINAGE MOSIAC

TRAFALGAR ROAD EA, FROM STEELES AVENUE TO HIGHWAY 7

EXHIBIT
26

220
21.0 ha

215
10.6 ha

230
0.81 ha

235
55.2 ha

205
3.21 ha

225
2.65 ha

THOMPSON DRIVE

17 SIDEROAD

MAPLE AVENUE

TRAFALGAR ROAD

PRINCESS ANNE DRIVE

CNR

BLACK CREEK TRIB 1

BLACK CREEK TRIB 1

C14

DI

10+500
10+600
10+700
10+800
10+900
11+000
11+100
11+200
11+300
11+400
11+500
11+600

ENHANCED GRASSED SWALES AND BIO–SWALES FOR QUALITY TREATMENT ON THE WEST SIDE

FACILITY – 14S
PIPE STORAGE FACILITY FOR QUANTITY CONTROL QUALITY TREATMENT WILL BE PROVIDED BY OGS
100–YEAR STORAGE VOLUME =510 m^3

LEGEND

- DRAINAGE BOUNDARY
- PROPOSED CULVERT
- PROPOSED STORM SEWER
- FLOW DIRECTION
- C1 — CULVERT ID
- B1 — BRIDGE ID
- 255 / 29.4 ha — CATCHMENT ID / CATCHMENT AREA

Metric Scale
25m 0 50m
Horizontal

MMM GROUP

PROPOSED CONDITIONS DRAINAGE MOSIAC

TRAFALGAR ROAD EA, FROM STEELES AVENUE TO HIGHWAY 7

EXHIBIT
27

MODIFIED: Mar. 17, 2016 1:40 PM

DRAWING NAME: I:\DRAWINGS\WATERRES\3214006\DRAINAGE\3214006 TRAFALGAR ROAD EA – DRAINAGE MOSAIC PROPOSED–PROPOSED– VER 02_SWM.DWG

LEGEND

- DRAINAGE BOUNDARY
- PROPOSED CULVERT
- PROPOSED STORM SEWER
- FLOW DIRECTION
- C1 — CULVERT ID
- B1 — BRIDGE ID
- 255 / 29.4 ha — CATCHMENT ID / CATCHMENT AREA

240 / 40.3 ha

245 / 9.0 ha

255 / 29.4 ha

250 / 1.12 ha

260 / 71.5 ha

270 / 18.3 ha

251 / 0.56 ha

265 / 1.50 ha

275 / 0.40 ha

ENHANCED GRASSED SWALES AND BIO–SWALES FOR QUALITY TREATMENT ON THE WEST SIDE

ENHANCED GRASSED SWALES AND BIO–SWALES FOR QUALITY TREATMENT ON THE WEST SIDE

BIO–SWALES FOR QUALITY TREATMENT ON THE WEST SIDE

TRAFALGAR ROAD

11+800 C15 11+900 12+000 12+100 12+200 S1 12+300 12+400 12+500 12+600 12+700

C18 20+100 20 SIDEROAD 20+000 20+300 20+400 20+500 20+600 20+700 20+800 20+900 21+000 21+100 21+200

C16 C17

OGS

TO EXISTING STORM SEWER

BERTON BOULEVARD

GEXR

LINDSAY COURT

HIGHWAY 7

BLACK CREEK TRIBUTARY 2

Metric Scale
25m 0 50m
Horizontal

MMM GROUP

PROPOSED CONDITIONS DRAINAGE MOSAIC

TRAFALGAR ROAD EA, FROM STEELES AVENUE TO HIGHWAY 7

EXHIBIT 28

MODIFIED: Mar. 17, 2016 10:56 AM

DRAWING NAME: I:_DRAWINGS\WATERRES\3214006\DRAINAGE\3214006 TRAFALGAR ROAD EA – DRAINAGE MOSAIC PROPOSED– VER 02_SWM.DWG

235
55.2 ha

240
40.3 ha

255
29.4 ha

260
71.5 ha

215
10.6 ha

220
21.0 ha

245
9.0 ha

270
18.3 ha

C14

C15

C16

C17

C18

S1

TRAFALGAR ROAD

HIGHWAY 7

LEGEND

- DRAINAGE BOUNDARY
- PROPOSED CULVERT
- PROPOSED STORM SEWER
- FLOW DIRECTION
- C1 — CULVERT ID
- B1 — BRIDGE ID
- 255 / 29.4 ha — CATCHMENT ID / CATCHMENT AREA

Metric Scale
100m 0 200m
Horizontal

MMM GROUP

PROPOSED CONDITIONS DRAINAGE MOSIAC

TRAFALGAR ROAD EA, FROM STEELES AVENUE TO HIGHWAY 7

EXHIBIT

29

3.4 Proposed Conditions Hydrologic Modelling

The proposed conditions drainage mosaics (Exhibits 16 to 29) vary slightly compared to the existing conditions drainage mosaics. A SWMHYMO hydrologic model was developed to estimate runoff from the roadway and external areas under proposed conditions, based on the 24-hour SCS storm distribution. The results of the hydrologic modelling are summarized in Table 4 and Table 5, which provides the proposed conditions flows at each culvert.

The proposed hydrologic modelling schematics, hydrologic modelling parameters, and SWMHYMO summary output files are included in Appendix B.

3.5 Comparison of Flows

The comparison of flows between existing and proposed conditions in CH and CVC jurisdiction is presented in Table 4 and Table 5 respectively.

From Steeles Avenue to 15 Side Road – CH Jurisdiction:

- Flows through Culverts C1 increase by less than 0.3% due to minor increase in imperviousness. No peakflow control is required.
- Uncontrolled flow at Culvert C2 increases significantly. Two SWM facilities are provided for peak flow control. The controlled flows are less than existing conditions flows by up to 2%. No peak flow control will be provided in Catchments 120 (Culvert C5), 125 (Culvert C6) and 130 (Culvert C7), since these are subcatchments drain to Culvert C2.
- Controlled flows through Culvert C3 decrease by up to 5% with the exception of the Regional Storm that increases by 29%. This can be reviewed during detailed design phase to provide addition control for the Regional Storm.
- Controlled flows through Culverts C8, C9 and C11 decrease for all storm events.
- Controlled flows through Culvert C10 increase for the 2-year event by 0.7%.
- Controlled flows through Culvert C12 increase for the 2-year and 5-year storm events by approximately 1% and 0.4%, respectively, but decrease for all other storm events.

From 15 Side Road to Highway 7 – CVC Jurisdiction:

- Quantity control of runoff discharging into Black Creek is not feasible due to the steep grade of Trafalgar Road and land constraints. The increases in flows in Black Creek are 0.272 m^3/s for the 2-year to 0.582 m^3/s for the 100-year and 0.053 m^3/s for the Regional Storm. Comparing these flow increases with the flows of Black Creek, the increases will be only 4.5% for the 2-year to 1.6% for the 100-year and 0.04% for the Regional Storm.
- Peak flow control for CNR underpass area will be provided by pipe storage facility. Except for the 2-year flow, peak flows for other storm events decrease from 0.3% to 10%. This pipe storage facility

will provide over-control of flows to balance the uncontrolled flows from Culvert C14. Flows from both Culvert C14 and underpass area drain to Tributary 1 of Black Creek. At Tributary 1, there are no increases in flows for the 25-year, 50-year and 100-year; however, there are minor increases in flows for the 2-year, 5-year and 10-year of 3.3%, 1.7% and 0.9%, respectively. This can be further reviewed in detailed design phase to balance the flows by adjusting the control features.

- There are no increases in flows at Culvert C15, storm inlet S1, Culvert C16, Culvert C17 and Culvert C18. As such peak flow controls at these locations are not required.

Table 4: Peak Flow Comparison - CH Jurisdiction

Culvert ID / Node	Hydro ID	Drainage Area (ha)	Condition	24-hour SCS Storm Distribution Flows (m^3/s)						Regional (Hazel)	Comments
				2-year	5-year	10-year	25-year	50-year	100-year		
C1	100	89.3	Existing	1.83	2.708	3.405	4.299	5.031	5.585	9.185	Negligible increases in flows; no peak flow control is required.
			Proposed (Uncontrolled)	1.835	2.713	3.41	4.304	5.035	5.589	9.185	
			Difference (Pr. Un. - Ex)	0.005	0.005	0.005	0.005	0.004	0.004	0.00	
			%	0.27%	0.18%	0.15%	0.12%	0.08%	0.07%	0.0%	
C2	505	770.6	Existing	7.209	10.926	13.925	17.815	21.033	23.482	55.203	Peak flow control is provided by wet Pond 2N and linear facility Pond 2S.
			Proposed (Uncontrolled)	8.092	12.107	15.315	19.451	22.852	25.433	56.684	
			Difference (Pr. Un. - Ex)	0.883	1.181	1.39	1.636	1.819	1.951	1.481	
			Proposed (Controlled)	7.063	10.734	13.702	17.555	20.742	23.167	54.748	
			Difference (Pr. Con. - Ex)	-0.146	-0.192	-0.223	-0.260	-0.291	-0.315	-0.455	
			%	-2.03%	-1.76%	-1.60%	-1.46%	-1.38%	-1.34%	-0.82%	
C3	110 515	5.73	Existing	0.246	0.364	0.457	0.574	0.670	0.741	0.761	Peak flow control is provided by dry Pond 3N.
			Proposed (Uncontrolled)	0.329	0.469	0.594	0.752	0.896	1.026	0.740	
			Difference (Pr. Un. - Ex)	0.083	0.105	0.137	0.178	0.226	0.285	-0.021	
			Proposed (Controlled)	0.244	0.346	0.447	0.572	0.668	0.741	0.982	
			Difference (Pr. Con. - Ex)	-0.002	-0.018	-0.010	-0.002	-0.002	0.000	0.221	
			%	-0.81%	-5.0%	-2.2%	-0.35%	-0.30%	0.00%	29%	
C4		Remove culvert in proposed conditions.									

Culvert ID / Node	Hydro ID	Drainage Area (ha)	Condition	24-hour SCS Storm Distribution Flows (m^3/s)						Regional (Hazel)	Comments
				2-year	5-year	10-year	25-year	50-year	100-year		
C5	120	5.72	Existing	0.153	0.236	0.304	0.393	0.468	0.525	0.706	Subcatchment of C2. Peak flow control provided at Culvert C2.
			Proposed (Uncontrolled)	0.173	0.262	0.335	0.430	0.509	0.569	0.722	
			Difference (Pr. Un. - Ex)	0.020	0.026	0.031	0.037	0.041	0.044	0.016	
			%	13.07%	11.02%	10.20%	9.41%	8.76%	8.38%	2.27%	
C6	125	24.5	Existing	0.460	0.704	0.902	1.162	1.379	1.545	2.644	Subcatchment of C2. Peak flow control provided at Culvert C2.
			Proposed (Uncontrolled)	0.487	0.741	0.947	1.216	1.439	1.610	2.673	
			Difference (Pr. Un. - Ex)	0.027	0.037	0.045	0.054	0.060	0.065	0.029	
			%	5.87%	5.26%	4.99%	4.65%	4.35%	4.21%	1.10%	
C7	130	25.6	Existing	0.497	0.760	0.975	1.256	1.489	1.668	2.793	Subcatchment of C2. Peak flow control provided at Culvert C2.
			Proposed (Uncontrolled)	0.499	0.762	0.976	1.257	1.491	1.670	2.793	
			Difference (Pr. Un. - Ex)	0.002	0.002	0.001	0.001	0.002	0.002	0.000	
			%	0.40%	0.26%	0.10%	0.08%	0.13%	0.12%	0.00%	
C8	135 / 520	12.2	Existing	0.272	0.427	0.555	0.725	0.867	0.977	1.453	Peak flow control is provided by linear facility Pond 8S.
			Proposed (Uncontrolled)	0.328	0.504	0.648	0.837	0.994	1.114	1.500	
			Difference (Pr. Un. - Ex)	0.056	0.077	0.093	0.112	0.127	0.137	0.047	
			Proposed (Controlled)	0.271	0.420	0.545	0.706	0.858	0.976	1.428	
			Difference (Pr. Con. - Ex)	-0.001	-0.007	-0.010	-0.019	-0.009	-0.001	-0.025	
			%	-0.37%	-1.6%	-1.8%	-2.6%	-1.0%	-0.1%	-1.7%	

Culvert ID / Node	Hydro ID	Drainage Area (ha)	Condition	24-hour SCS Storm Distribution Flows (m^3/s)						Regional (Hazel)	Comments
				2-year	5-year	10-year	25-year	50-year	100-year		
C9	140 / 525	30.2	Existing	0.735	1.129	1.448	1.864	2.208	2.471	3.523	Peak flow control is provided by interim linear facility Pond 9S.
			Proposed (Uncontrolled)	0.830	1.254	1.593	2.031	2.391	2.665	3.569	
			Difference (Pr. Un. - Ex)	0.095	0.125	0.145	0.167	0.183	0.194	0.046	
			Proposed (Controlled)	0.716	1.083	1.381	1.768	2.088	2.333	3.446	
			Difference (Pr. Con .- Ex)	-0.019	-0.046	-0.067	-0.096	-0.120	-0.138	-0.077	
			%	-2.59%	-4.07%	-4.63%	-5.15%	-5.43%	-5.58%	-2.19%	
C10	145 / 530	46.4	Existing	0.869	1.317	1.680	2.155	2.548	2.849	4.934	Peak flow control is provided by interim linear facility Pond 10N.
			Proposed (Uncontrolled)	0.869	1.320	1.680	2.160	2.550	2.850	4.930	
			Difference (Pr. Un. - Ex)	0.000	0.003	0.000	0.005	0.002	0.001	-0.004	
			Proposed (Controlled)	0.875	1.314	1.669	2.132	2.521	2.816	4.930	
			Difference (Pr. Con. - Ex)	0.006	-0.003	-0.011	-0.023	-0.027	-0.033	-0.004	
			%	0.69%	-0.23%	-0.65%	-1.07%	-1.06%	-1.16%	-0.08%	
C11	150 / 535	136	Existing	1.402	2.154	2.769	3.579	4.255	4.774	11.005	Peak flow control is provided by interim linear facility Pond 11N.
			Proposed (Uncontrolled)	1.454	2.225	2.854	3.678	4.365	4.891	11.081	
			Difference (Pr. Un. - Ex)	0.052	0.071	0.085	0.099	0.110	0.117	0.076	
			Proposed (Controlled)	1.398	2.142	2.751	3.552	4.220	4.733	10.982	
			Difference (Pr. Con. - Ex)	-0.004	-0.012	-0.018	-0.027	-0.035	-0.041	-0.023	
			%	-0.29%	-0.56%	-0.65%	-0.75%	-0.82%	-0.86%	-0.21%	
C12	155 / 540	39.3	Existing	0.633	0.975	1.255	1.624	1.931	2.167	4.047	Peak flow control is provided by interim linear facility Pond 12N.
			Proposed (Uncontrolled)	0.711	1.082	1.383	1.776	2.102	2.351	4.142	
			Difference (Pr. Un .- Ex)	0.078	0.107	0.128	0.152	0.171	0.184	0.095	
			Proposed (Controlled)	0.639	0.979	1.252	1.604	1.898	2.124	4.040	
			Difference (Pr. Con .- Ex)	0.006	0.004	-0.003	-0.020	-0.033	-0.043	-0.007	
			%	0.95%	0.41%	-0.24%	-1.23%	-1.71%	-1.98%	-0.17%	

Table 5: Peak Flow Comparison - CVC Jurisdiction

Culvert ID / Node	Hydro ID	Drainage Area (ha)	Condition	24-hour SCS Storm Distribution Flows (m^3/s)						Regional (Hazel)	Comments
				2-year	5-year	10-year	25-year	50-year	100-year		
C13		No culvert in proposed conditions, a storm sewer is proposed for the railway underpass									
Existing STM Outlet	520	36.3	Existing	0.639	1.019	1.146	1.388	1.584	1.695	2.288	Existing storm sewer will be maintained to drain the runoff from Catchments 210, 215 and 220. No increase in flow.
			Proposed (Uncontrolled)	0.639	1.019	1.146	1.388	1.584	1.695	2.288	
			Difference (Pr. Un. - Ex)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
			%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
B1 Black Creek	525	50.01	Existing	0.763	1.203	1.596	2.322	2.886	3.268	3.156	Sum of flows from North and South of the bridge. Peakflow control cannot be provided due to steep road grade and land constraints.
			Proposed (Uncontrolled)	1.035	1.498	2.033	2.808	3.434	3.850	3.209	
			Difference (Pr. .Un - Ex)	0.272	0.295	0.437	0.486	0.548	0.582	0.053	
			%	35.6%	24.5%	27.4%	20.9%	18.9%	17.8%	1.7%	
			Flow in Black Creek	6.10	12.10	16.70	25.20	31.40	37.10	117.9	
			% increase with respect to Black Creek Flow	4.5%	2.4%	2.6%	1.9%	1.7%	1.6%	0.04%	
CNR Underpass	530 / 805	3.46	Existing	0.240	0.336	0.417	0.531	0.630	0.698	0.465	Peak flow control is provided by pipe storage facility 14S.
			Proposed (Uncontrolled)	0.397	0.529	0.636	0.777	0.897	0.982	0.484	
			Difference (Pr. Un - Ex)	0.157	0.193	0.219	0.246	0.267	0.284	0.019	
			Proposed (Controlled)	0.250	0.335	0.403	0.494	0.567	0.652	0.466	
			Difference (Pr. Con - Ex)	0.010	-0.001	-0.014	-0.037	-0.063	-0.046	0.001	
			%	4.2%	-0.30%	-3.4%	-7.0%	-10.0%	-6.6%	0.22%	
C14	235	55.2	Existing	0.481	0.759	0.991	1.300	1.562	1.765	4.421	Flow increased due to increase in drainage area. Pipe storage facility 14S will provide over-control to balance the flows.
			Proposed (Uncontrolled)	0.495	0.779	1.017	1.334	1.602	1.810	4.529	
			Difference (Pr. Un - Ex)	0.014	0.020	0.026	0.034	0.040	0.045	0.108	
			%	2.9%	2.6%	2.6%	2.6%	2.5%	2.5%	2.4%	

Culvert ID / Node	Hydro ID	Drainage Area (ha)	Condition	24-hour SCS Storm Distribution Flows (m^3/s)						Regional (Hazel)	Comments
				2-year	5-year	10-year	25-year	50-year	100-year		
Tributary 1 of Black Creek	235+530 / 235+805	58.66	Existing	0.721	1.095	1.408	1.831	2.192	2.463	4.886	Peak flow control is provided by pipe storage facility 14S.
			Proposed (Uncontrolled)	0.880	1.290	1.629	2.079	2.461	2.749	4.906	
			Difference (Pr. Un - Ex)	0.159	0.195	0.221	0.248	0.269	0.286	0.020	
			Proposed (Controlled)	0.745	1.114	1.420	1.828	2.169	2.462	4.995	
			Difference (Pr. Con - Ex)	0.024	0.019	0.012	-0.003	-0.023	-0.001	0.109	
			%	3.3%	1.7%	0.85%	-0.16%	-1.1%	-0.04%	2.2%	
C15	240	40.3	Existing	0.583	0.912	1.183	1.543	1.845	2.078	4.143	Part of roadway area is directed to C14. No increase in flows due to decrease in drainage area.
			Proposed (Uncontrolled)	0.573	0.896	1.163	1.517	1.814	2.042	4.072	
			Difference (Pr. Un - Ex)	0.002	0.002	0.003	0.003	0.002	0.002	0.000	
			%	-1.72%	-1.75%	-1.70%	-1.70%	-1.68%	-1.73%	-1.71%	
S1	245	9.0	Existing	0.236	0.373	0.487	0.638	0.765	0.864	1.239	No increase in flows due to reduction in drainage area.
			Proposed (Uncontrolled)	0.224	0.352	0.459	0.600	0.718	0.809	1.121	
			Difference (Pr. Un - Ex)	-0.012	-0.021	-0.028	-0.038	-0.047	-0.055	-0.118	
			%	-5.08%	-5.63%	-5.75%	-5.96%	-6.14%	-6.37%	-9.52%	
C18	535	100.9	Existing	1.149	1.842	2.429	3.220	3.894	4.419	9.982	No increase in flows.
			Proposed (Uncontrolled)	1.149	1.842	2.429	3.220	3.894	4.419	9.982	
			Difference (Pr. Un. - Ex)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
			%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

Culvert ID / Node	Hydro ID	Drainage Area (ha)	Condition	24-hour SCS Storm Distribution Flows (m^3/s)						Regional (Hazel)	Comments
				2-year	5-year	10-year	25-year	50-year	100-year		
C16	540 / 545	104.5	Existing	1.172	1.878	2.474	3.276	3.959	4.491	10.232	No increase in flows.
			Proposed (Uncontrolled)	1.178	1.880	2.474	3.274	3.955	4.486	10.202	
			Difference (Pr. Un - Ex)	0.006	0.002	0.000	-0.002	-0.004	-0.005	-0.030	
			%	0.51%	0.11%	0.00%	-0.06%	-0.10%	-0.11%	-0.29%	
C17	545 / 270	18.3	Existing	0.338	0.538	0.706	0.932	1.124	1.274	2.153	Drainage area decreased from 18.7 ha to 18.3 ha. No increase in flows.
			Proposed (Uncontrolled)	0.333	0.531	0.698	0.922	1.113	1.261	2.148	
			Difference (Pr. Un - Ex)	-0.005	-0.007	-0.008	-0.010	-0.011	-0.013	-0.005	
			%	-1.48%	-1.30%	-1.13%	-1.07%	-0.98%	-1.02%	-0.23%	

3.6 Flows for Black Creek HEC-RAS modelling

The flows for HEC-RAS modelling of Black Creek are provided in Table 6. The flows were extracted from Table 3.23 of the Black Creek Hydrology Study Report, as discussed in the teleconference with CVC. Table 3.23 of the Black Creek Hydrology Study provides the summary of flows at different location within the watershed based on GAWSER simulation model with 2031 land use scenario. Table 6 summarizes the flows that are applicable for the HEC-RAS Model.

Table 6: Summary of Flows for Black Creek Hydraulic Modelling

#	River	Reach	HEC-RAS River Sta.	Flows (m^3/s)							Flow Location
				Reg.	100-year	50-year	25-year	10-year	5-year	2-year	
1	Beeney Cr.	TR2B004	11390.4	46.5	18.0	14.9	11.8	7.8	5.4	2.6	End of Catchments 14 and 16 on 5th Line.
2	Beeney Cr.	TR2B004	8908.7	50.9	19.4	16.1	12.7	8.4	5.8	2.8	U/s of Hwy 7 Structure, end of Catchment 18
3	Beeney Cr.	TR2B004	6430.1	54.9	21.5	18.3	14.9	10.0	6.8	3.1	U/s of 5th Line Structure, d/s of Catchment 13
4	Beeney Cr.	TR2B004	1319.6	62.8	24.7	21.0.0	17	11.3	7.8	3.6	Just u/s of 20 Side Road & CN Structures, i.e. u/s of confluence of Black Creek
5	Black (TR2)	TR2B002	9211.2	20.9	5.0	3.9	2.7	1.2	0.9	0.4	D/s of Junction 7(Fairy Lake Outlet)
6	Black (TR2	TR2B002	6024.2	23.2	6.7	4.1	5.0	2.6	2.1	1.5	U/s of CNR and3rd Line structures, end of Catchment 3
7	Black (TR2	TR2B002	4765	37.0	13.5	9.9	9.8	5.9	4.6	2.9	U/s of 4th Line Structure
8	Black (TR2	TR2B002	2299.8	61.6	22.8	19.6	16.2	11.5	8.3	4.8	U/s of 5th Line Structure, i.e. u/s of confluence of Beeney Creek
9	Black (TR2)	TR2B001	7230.3	111.9	34.5	29.2	23.4	15.4	10.9	5.2	D/s of Junction 23, (Junction of Beeney and Black)
10	Black (TR2)	TR2B001	2368.9*	117.9	37.1	31.4	25.2	16.7	12.1	6.1	U/s of Stewarttown Rd Bridge
11	Black (TR2)	TR2B001	1585.7*	122.7	39.3	33.2	26.6	17.8	13.1	7.0	D/s of Catchment 7, at tributary - Black Creek confluence
12	Black (TR2)	TR2B001	515.9	127.5	41.4	35	28	18.9	14.1	7.8	U/s of 8th Line Structure
* Note: Flows for River Stations 2368.9 and 1585.7 were estimated based on the drainage areas at the river station point.											

4.0 HYDRAULIC ASSESSMENT

4.1 Overview

A hydraulic assessment was performed for the culverts and one bridge within the study limits.

Hydraulic assessments of Culverts C1, C2, and C11 and the Black Creek Bridge B1 were analyzed using the Hydraulic Engineering Center's River Analysis System modelling software (HEC-RAS). Bentley's CulvertMaster hydraulic model was used to analyze the hydraulic performance of the other culverts.

The design standards for the hydraulic assessment of culverts are based on the "MTO Highway Drainage Design Standards (HDDS) (February 2008)", discussed in Section 2.1.1. The CulvertMaster hydraulic model was used to estimate headwater depth elevation and assess the hydraulic performance of each culvert within the study area. The CulvertMaster model was selected for the following reasons:

- Evaluates inlet and outlet controlled headwater depths;
- Simulates the hydraulic performance of culverts based on user-specified flows;
- Considers variable tailwater depths based on either outlet channel geometry or user specified depth discharge rating curves; and
- Incorporates an extensive database of standard culvert sizes, shapes and materials, and allows for the addition of custom culvert types and sizes.

Under existing conditions, there are eighteen (18) crossing culverts and one (1) bridge within the study limits. Fourteen (14) culverts are proposed to be replaced, two (2) culverts are proposed to be removed, two (2) culverts are proposed to be extended, and one (1) bridge is proposed to be replaced. In addition a third cell will be added at Culvert C2. These proposed changes are summarized in Table 7.

Table 7: Status of Crossing Structures from Existing to Proposed Conditions

Sixteen Mile Creek Watershed		Black Creek Watershed	
Structure ID	**Status**	**Structure ID**	**Status**
C1	Extend from 28.1 m to 36 m	B1	Replace
C2	Extend from 36.4 m to 53.7 m and add 1 cell	C13	Remove
C3	Replace	C14	Replace
C4	Remove	C15	Replace
C5	Replace	C16	Replace
C6	Replace	C17	Replace
C7	Replace	C18	Replace
C8	Replace		
C9	Replace		
C10	Replace		
C11	Replace		
C12	Replace		

In addition to the 18 crossing structures mentioned above, three (3) additional culverts are required for stormwater management purpose. Two (2) pipe culverts are required to direct the roadway runoff to Pond 2N and one pipe culvert is required to direct the roadway runoff to Pond 11N.

4.2 Road Classification and Design Flows

Trafalgar Road will become a semi-urban / urban arterial road through some sections and will remain rural on some areas. A. According to the MTO HDDS for an urban arterial road, for structures with spans less than or equal to 6.0 m, the design flow is the 50-year storm flow; and for span greater than 6.0 m, the design flow is the 100-year storm flow.

- All culverts located on Trafalgar Road have spans of less than 6.0 m; therefore, the design flow for the culverts is the 50-year flow.
- The Black Creek Bridge has a span greater than 6.0 m. The design flow for the Black Creek Bridge is the 100-year flow.
- 20 Side Road is classified as a local road; therefore the design flow is the 10-year flow.
- Highway 7 is classified as a rural arterial road. The design flow for the culvert crossing Highway 7 is the 25-year flow.
- Trafalgar Road is considered to be a critical transportation corridor within the Region of Halton. Therefore, Conservation Halton recommends that it be designed as an emergency route such that the roadway would be flood free under Regional Storm conditions.

4.3 Hydraulic Modelling and Impact Assessments

The hydraulic performance of the existing structures was analyzed using HEC-RAS for Culverts C1, C2, and C11 and for Bridge B1. These are regulated watercourses and HEC-RAS models were available and provided by CH and CVC. For the remaining culvert crossings where HEC-RAS model are not available, CulvertMaster hydraulic model was used.

4.3.1 HEC-RAS Hydraulic Modelling for Culverts C1, C2 and C11

The HEC-RAS cross-section locations and the Regional Storm flood lines for the watercourses crossing Culverts C1, C2 and C11 for both existing and proposed conditions are provided in Exhibits 30 and 31.

Culvert C1

Culvert C1 at Trafalgar Road Station 0+400 (north of Steeles Avenue) is located on Sixteen Mile Creek Mideast Reach 13 Tributary. The HEC-RAS model for this reach was provided by Conservation Halton. Two Sections 576 and 616.5, culvert size, inverts, road profile and flows were updated in the model.

Under existing conditions, Culvert C1 is a 28.1 m long concrete box culvert with a 3.05 m x 2.45 m opening. The road low point elevation for this crossing is 205.31 m. The available freeboard for the existing culvert is 3.01 m for the 50-year design flow, which meets the minimum requirement of 1.0 m. The 100-year and the Regional Storm flows do not overtop Trafalgar Road.

Under proposed conditions, Culvert C1 will be extended to approximately 36 m long maintaining the same 3.05 m x 2.45 m opening. The road low point elevation for this crossing is 205.38 m. The available freeboard for the proposed culvert is 3.04 m for the 50-year design flow, which meets the minimum requirement of 1.0 m. The 100-year and the Regional Storm flows do not overtop Trafalgar Road. Immediately upstream of the culvert, the Regional Storm water level increased by 0.02 m, the 100-year water level increased by 0.03 m and 50-year water level increased by 0.04 m. These increases are considered small and are within modelling tolerance. There is no increase in water level for the other storm events.

Table 8 provides a comparison of the existing and proposed conditions HEC-RAS hydraulic modelling for Culvert C1.

Table 8: Comparison of HEC-RAS Modelling Results for Culvert C1

River Station	Storm Event	Existing Conditions			Proposed Conditions		
		Flow	Water Surface Elevation	Channel Velocity	Water Surface Elevation	Difference	Channel Velocity
		(m^3/s)	(m)	(m/s)	(m)	(m)	(m/s)
576	Regional	9.19	202.18	2.27	202.18	0.0	2.27
576	100-year	5.59	202.03	1.67	202.03	0.0	1.67
576	50-year	5.03	202.00	1.57	202.00	0.0	1.57
576	25-year	4.30	201.95	1.47	201.95	0.0	1.47
576	10-year	3.41	201.78	1.62	201.78	0.0	1.62
576	5-year	2.71	201.72	1.48	201.72	0.0	1.48
576	2-year	1.83	201.60	1.39	201.60	0.0	1.39
594.5		Culvert C1					
616.5	Regional	9.19	202.91	1.64	202.93	0.02	1.60
616.5	100-year	5.59	202.41	1.79	202.44	0.03	1.72
616.5	50-year	5.03	202.30	1.95	202.34	0.04	1.83
616.5	25-year	4.30	202.19	2.12	202.19	0.0	2.12
616.5	10-year	3.41	202.12	1.97	202.12	0.0	1.97
616.5	5-year	2.71	202.07	1.85	202.07	0.0	1.85
616.5	2-year	1.83	201.98	1.67	201.98	0.0	1.67
635.2526	Regional	9.19	203.21	1.97	203.21	0.0	1.97
635.2526	100-year	5.59	203.07	1.80	203.07	0.0	1.80
635.2526	50-year	5.03	203.04	1.77	203.04	0.0	1.77
635.2526	25-year	4.30	203.01	1.68	203.01	0.0	1.68
635.2526	10-year	3.41	202.96	1.63	202.96	0.0	1.63
635.2526	5-year	2.71	202.91	1.57	202.91	0.0	1.57
635.2526	2-year	1.83	202.83	1.47	202.83	0.0	1.47

Culvert C2

Culvert C2 at Trafalgar Road Station 1+080 is located on Sixteen Mile Creek Mideast Reach 13 Main. The HEC-RAS model for this reach was provided by Conservation Halton. Three Sections 2594.387, 2571 and 2510.996 were updated based on current survey. In addition, the culvert size, culvert inverts, road profile and flows were updated in the model.

Under existing conditions, Culvert C2 is a 36.4 m long twin cell concrete box culvert with openings measuring 2.75 m x 2.25 m. The road low point elevation at this crossing is 203.03 m. The available freeboard for the existing culvert is 1.08 m for the 50-year design flow, which meets the minimum requirement of 1.0 m. The 100-year flow does not overtop Trafalgar Road; however, the Regional Storm flow overtops Trafalgar Road by 0.40 m.

Under proposed conditions, the existing twin cell culverts will be extended to approximately 53 m. A 3.0 m x 2.4 m open footing culvert (i.e. third cell) will be added to provide additional capacity to avoid overtopping of Trafalgar Road under the Regional Storm flow condition. The road low point elevation at this crossing is 203.07 m. With the addition of one culvert, the total opening exceeds 6.0 m, and the design flow increases to the 100-year flow. The available freeboard is 1.30 m for the 100-year design flow which meets the minimum requirement of 1.0 m. The Regional Storm flow does not overtop Trafalgar Road, and the available freeboard for the Regional Storm flow is 0.37 m. The water levels on the upstream side are lower than the existing conditions water levels for all storm events.

Table 9 provides a comparison of the existing and proposed conditions HEC-RAS hydraulic modelling for Culvert C2.

Table 9: Comparison of HEC-RAS Modelling Results for Culvert C2

River Station	Storm Event	Existing Conditions			Proposed Conditions		
		Flow	Water Surface Elevation	Channel Velocity	Water Surface Elevation	Difference	Channel Velocity
		(m^3/s)	(m)	(m/s)	(m)	(m)	(m/s)
2511.00	Regional	55.2	202.55	4.21	201.89	-0.66	2.9
2511.00	100-year	23.5	201.80	3.18	201.58	-0.22	1.48
2511.00	50-year	21.0	201.73	3.05	201.58	-0.15	1.33
2511.00	25-year	17.8	201.63	2.89	201.54	-0.09	1.16
2511.00	10-year	13.9	201.55	2.53	201.45	-0.1	0.96
2511.00	5-year	10.9	201.47	2.19	201.36	-0.11	0.8
2511.00	2-year	7.21	201.36	1.70	201.22	-0.14	0.59
594.50		Culvert C2					

River Station	Storm Event	Existing Conditions			Proposed Conditions		
		Flow	Water Surface Elevation	Channel Velocity	Water Surface Elevation	Difference	Channel Velocity
		(m^3/s)	(m)	(m/s)	(m)	(m)	(m/s)
2571.00	Regional	55.2	203.43	0.52	202.70	-0.73	2.12
2571.00	100-year	23.5	202.02	3.10	201.77	-0.25	1.46
2571.00	50-year	21.0	201.95	2.98	201.72	-0.23	1.34
2571.00	25-year	17.8	201.85	2.82	201.65	-0.20	1.2
2571.00	10-year	13.9	201.72	2.62	201.52	-0.20	1.02
2571.00	5-year	10.9	201.61	2.46	201.41	-0.20	0.86
2571.00	2-year	7.21	201.42	2.25	201.25	-0.17	0.65
2594.39	Regional	41.1	203.44	0.42	202.99	-0.45	0.63
2594.39	100-year	16.2	202.66	0.39	202.06	-0.60	1.68
2594.39	50-year	14.5	202.55	0.42	202.03	-0.52	1.66
2594.39	25-year	12.3	202.40	0.48	202.00	-0.40	1.61
2594.39	10-year	9.62	202.21	0.60	201.72	-0.49	2.41
2594.39	5-year	7.55	202.06	0.77	201.62	-0.44	2.29
2594.39	2-year	4.98	201.85	1.02	201.45	-0.40	2.11
2640.57	Regional	41.1	203.42	1.17	202.96	-0.46	1.84
2640.57	100-year	16.2	202.65	1.07	202.27	-0.38	2.04
2640.57	50-year	14.5	202.54	1.14	202.25	-0.29	1.89
2640.57	25-year	12.3	202.39	1.25	202.22	-0.17	1.72
2640.57	10-year	9.62	202.21	1.39	202.24	0.03	1.31
2640.57	5-year	7.55	202.10	1.37	202.13	0.03	1.29
2640.57	2-year	4.98	201.98	1.18	201.95	-0.03	1.23
2685.01	Regional	41.1	203.46	0.78	203.09	-0.37	1.29
2685.01	100-year	16.2	202.71	1.09	202.57	-0.14	1.55
2685.01	50-year	14.5	202.61	1.26	202.52	-0.09	1.6
2685.01	25-year	12.3	202.48	1.49	202.45	-0.03	1.61
2685.01	10-year	9.62	202.36	1.50	202.37	0.01	1.49
2685.01	5-year	7.55	202.28	1.39	202.29	0.01	1.38
2685.01	2-year	4.98	202.15	1.17	202.14	-0.01	1.2
2740.57	Regional	41.1	203.45	1.71	203.06	-0.39	2.12
2740.57	100-year	16.2	202.76	1.68	202.73	-0.03	2.1
2740.57	50-year	14.5	202.70	1.63	202.70	0.00	2.04
2740.57	25-year	12.3	202.65	1.50	202.65	0.00	1.98
2740.57	10-year	9.62	202.57	1.34	202.57	0.00	1.83
2740.57	5-year	7.55	202.48	1.21	202.48	0.00	1.87
2740.57	2-year	4.98	202.33	1.03	202.33	0.00	1.81

Culvert C11

Culvert C11 at Trafalgar Road Station 7+927 (south of 15 Side Road) is located on Sixteen Mile Creek Mideast Reach 1 North tributary. The HEC-RAS model for this reach was provided by Conservation Halton. Four Sections 4199.265, 4178, 4140 and 4105.245 were updated based on current survey. In addition, the culvert size, culvert inverts, road profile and flows were updated in the model.

Under existing conditions, Culvert C11 is a 25.5 m long CSP with HDPE pipe lining. The HDPE pipe has a 750 mm diameter. The road low point elevation at this crossing is 257.38 m. Only the 2-year flow passes through the culvert, while Trafalgar Road is overtopped from the 5-year to the Regional Storm flows.

Under proposed conditions, Culvert C11 will be replaced with a 44.0 m long concrete open footing culvert with an opening of 3.05 m x 1.53 m. A low flow channel is recommended at the culvert. The road low point elevation at this crossing is 257.45 m. The available freeboard for the proposed culvert is 1.29 m for the 50-year design flow, which meets the minimum requirement of 1.0 m. The 100-year and the Regional Storm flows do not overtop Trafalgar Road. Upstream water levels are lowered by 1.24 m for the 2-year flow to 0.68 m for the Regional Storm flow.

Table 10 provides the comparison of the existing and proposed conditions HEC-RAS hydraulic modelling for Culvert C11.

Table 10: Comparison of HEC-RAS Modelling Results for Culvert C11

River Station	Storm Event	Existing Conditions			Proposed Conditions		
		Flow	Water Surface Elevation	Channel Velocity	Water Surface Elevation	Difference (Pr. – Ex)	Channel Velocity
		(m^3/s)	(m)	(m/s)	(m)	(m)	(m/s)
4105.25	Regional	11.01	255.08	0.64	255.08	0.0	0.64
4105.25	100-year	4.77	254.93	0.49	254.93	0.0	0.49
4105.25	50-year	4.26	254.92	0.47	254.92	0.0	0.47
4105.25	25-year	3.58	254.90	0.44	254.9	0.0	0.44
4105.25	10-year	2.77	254.87	0.4	254.87	0.0	0.4
4105.25	5-year	2.15	254.85	0.37	254.85	0.0	0.37
4105.25	2-year	1.40	254.81	0.32	254.81	0.0	0.32
4140.00	Regional	8.44	256.13	3.11	255.82	-0.31	2.54
4140.00	100-year	3.66	255.71	2.36	255.54	-0.17	1.93
4140.00	50-year	3.26	255.67	2.27	255.51	-0.16	1.86
4140.00	25-year	2.74	255.61	2.13	255.47	-0.14	1.75
4140.00	10-year	2.12	255.54	1.96	255.42	-0.12	1.61
4140.00	5-year	1.65	255.48	1.81	255.38	-0.10	1.47
4140.00	2-year	1.08	255.40	1.58	255.33	-0.07	1.28
4158.16		Culvert C11					

River Station	Storm Event	Existing Conditions			Proposed Conditions		
		Flow	Water Surface Elevation	Channel Velocity	Water Surface	Difference (Pr. – Ex)	Channel Velocity
		(m^3/s)	(m)	(m/s)	(m)	(m)	(m/s)
4178.00	Regional	8.44	257.52	1.30	256.89	-0.63	0.98
4178.00	100-year	3.66	257.58	0.55	256.23	-1.35	0.69
4178.00	50-year	3.26	257.59	0.49	256.16	-1.43	0.66
4178.00	25-year	2.74	257.59	0.41	256.07	-1.52	0.61
4178.00	10-year	2.12	257.59	0.32	255.95	-1.64	0.54
4178.00	5-year	1.65	257.60	0.25	255.86	-1.74	0.48
4178.00	2-year	1.08	256.97	0.22	255.73	-1.24	0.39
4199.27	Regional	8.44	257.65	0.10	256.97	-0.68	0.16
4199.27	100-year	3.66	257.61	0.04	256.26	-1.35	0.18
4199.27	50-year	3.26	257.61	0.04	256.19	-1.42	0.18
4199.27	25-year	2.74	257.61	0.03	256.1	-1.51	0.18
4199.27	10-year	2.12	257.60	0.03	255.98	-1.62	0.19
4199.27	5-year	1.65	257.60	0.02	255.88	-1.72	0.19
4199.27	2-year	1.08	256.98	0.02	255.74	-1.24	0.21
4300.00	Regional	8.44	257.65	0.52	257.12	-0.53	1.80
4300.00	100-year	3.66	257.61	0.25	256.96	-0.65	1.46
4300.00	50-year	3.26	257.61	0.23	256.94	-0.67	1.43
4300.00	25-year	2.74	257.60	0.19	256.91	-0.69	1.38
4300.00	10-year	2.12	257.60	0.15	256.87	-0.73	1.31
4300.00	5-year	1.65	257.60	0.12	256.84	-0.76	1.25
4300.00	2-year	1.08	256.97	0.40	256.79	-0.18	1.15
4400.00	Regional	8.44	257.68	0.71	257.55	-0.13	0.88
4400.00	100-year	3.66	257.62	0.34	257.33	-0.29	0.62
4400.00	50-year	3.26	257.61	0.31	257.31	-0.3	0.59
4400.00	25-year	2.74	257.61	0.26	257.27	-0.34	0.55
4400.00	10-year	2.12	257.61	0.20	257.22	-0.39	0.50
4400.00	5-year	1.65	257.6	0.16	257.18	-0.42	0.45
4400.00	2-year	1.08	257.09	0.43	257.11	0.02	0.39
4500.00	Regional	8.44	258.22	1.55	258.22	0.0	1.55
4500.00	100-year	3.66	258.07	1.39	258.07	0.0	1.39
4500.00	50-year	3.26	258.06	1.34	258.06	0.0	1.34
4500.00	25-year	2.74	258.03	1.28	258.03	0.0	1.28
4500.00	10-year	2.12	258.00	1.22	258	0.0	1.22
4500.00	5-year	1.65	257.98	1.14	257.98	0.0	1.14
4500.00	2-year	1.08	257.94	1.04	257.94	0.0	1.04

The existing and proposed conditions HEC-RAS summary outputs for Culverts C1, C2 and C11 are provided in Appendix C.

199.00 / 199.00 — 1832.318 — 200.19 / 200.19 — 2005.93

198.70 / 198.70 — 1768.168

2147.764 — 200.39 / 200.39 — 2240.565 — 200.90 / 200.90 — 2340.565 — 201.46 / 201.46

2393.286 — 201.61 / 201.61

2844.895 — 203.69 / 203.75

16 MILE CREEK MIDEAST
REACH 13 MAIN

TRAFALGAR ROAD

201.94 / 201.94 — 2467.864

198.44 / 198.44 — 71.14858

202.55 / 201.89 — 2510.996

1900.724 — 199.70 / 199.70

2740.565 — 203.45 / 203.06

198.69 / 198.69 — 150.1236

2571 — 203.43 / 202.70

2685.007 — 203.46 / 203.09

635.2526 — 203.21 / 203.21

16 MILE CREEK MIDEAST
REACH 13 TRIBUTARY

203.44 / 202.99 — 2594.387

2640.565 — 203.42 / 202.96

3038.216 — 204.59 / 204.59

199.58 / 199.58 — 280.0153

744.7111 — 204.18 / 204.18

2945.253 — 204.22 / 204.21

STEELES AVENUE

200.54 / 200.54 — 397.8328

824.9669 — 204.59 / 204.59 — 983.0944 — 205.77 / 205.77

877.2101 — 205.15 / 205.15

201.5 / 201.5 — 500.6567

1059.089 — 205.98 / 205.98

STEELES AVE

202.18 / 202.18 — 576

202.91 / 202.93 — 616.5

Metric Scale
50m 0 100m
Horizontal

LEGEND

- HEC-RAS SECTION LINE
- PROPOSED REGIONAL FLOODLINE
- EXISTING REGIONAL FLOODLINE
- 260.64 / 260.64 — 4800 — EXISTING REGIONAL FLOOD ELEVATION / SECTION NUMBER / PROPOSED REGIONAL FLOOD ELEVATION

MMM GROUP

HEC-RAS SECTION LOCATIONS AND FLOOD LINES - 16 MILE CREEK MIDEAST REACH 13

TRAFALGAR ROAD EA, FROM STEELS AVENUE TO HIGHWAY 7

EXHIBIT

30

LEGEND

- HEC-RAS SECTION LINE
- PROPOSED REGIONAL FLOODLINE
- EXISTING REGIONAL FLOODLINE
- FLOODPLAIN
- 260.64 / 260.64 — 4800 — EXISTING REGIONAL FLOOD ELEVATION / SECTION NUMBER / PROPOSED REGIONAL FLOOD ELEVATION

Metric Scale
50m 0 100m
Horizontal

16 MILE CREEK MIDEAST REACH 1 NORTH

TRAFALGAR ROAD

4800 260.64 / 260.64
4705.956 260.06 / 260.06
4600 259.12 / 259.12
4500 258.22 / 258.22
4400 257.68 / 257.55
4300 257.65 / 257.12
4178 257.52 / 256.89
4140 256.13 / 255.82
4105.245 255.08 / 255.08
3900 254.82 / 254.82
3799.999 254.34 / 254.34
4199.265 257.65 / 256.97

MMM GROUP

HEC-RAS SECTION LOCATIONS AND FLOOD LINES - 16 MILE CREEK MIDEAST REACH 1 NORTH

TRAFALGAR ROAD EA, FROM STEELS AVENUE TO HIGHWAY 7

EXHIBIT
31

4.3.2 HEC-RAS Hydraulic Modelling for Black Creek Bridge B1

Bridge B1 at Trafalgar Road Station 9+940 crosses over Black Creek, north of 15 Side Road. The HEC-RAS model for Black Creek was provided by Credit Valley Conservation. The existing conditions model has outdated flows. As advised by CVC, the flows for the HEC-RAS model was updated as provided in Table 6 in Section 3.6. The updated flows were based on the GAWSER model and were extracted from Table 3.23 of the Black Creek Hydrology Study Report. The road profile was also updated in the existing conditions model.

Under existing conditions, Bridge B1 has a 9.25 m span skew opening structure which provides an 8.80 m of clear perpendicular opening. The existing bridge length is 13 m. The road low point elevation is 240.31 m and the lowest point of the soffit has an elevation of 240.65 m. The available freeboard for the 100-year design flow is 0.52 m and the soffit vertical clearance for the design flow is 0.86 m. The existing bridge does not meet the minimum freeboard and soffit (vertical) clearance requirements. The roadway overtops by 1.01 m under the Regional Storm flow, approximately 135 m of roadway length would be flooded.

Under proposed conditions, Bridge B1 will be replaced by a 33.0 m span skew opening structure which provides a 30.0 m clear perpendicular opening. The new bridge length is approximately 30 m. Reach lengths were adjusted based on the new bridge length. The new road profile was also raised and was updated for the proposed conditions modelling. The channel section on the north side will be re-graded above the 2-year water level to span the bridge and to provide more capacity for higher storm flows. The proposed road low point is 243.14 m and the lowest soffit elevation is 241.08 m. The hydraulic modelling results provided in Table 11 shows that the proposed bridge meets all hydraulic requirements. The structure has a freeboard of 3.42 m and a soffit vertical clearance of 1.36 m for the 100-year design flow. The roadway will not be overtopped and will be free from flooding during the Regional Storm flow. Immediately upstream of the bridge, the Regional Storm water level decreases by 0.27 m.

The HEC-RAS cross-section locations and the Regional Storm flood lines for the Black Creek for both existing and proposed conditions is provided in Exhibit 32. Table 11 provides a comparison of the existing and proposed conditions HEC-RAS hydraulic modelling for Bridge B1.

Table 11: Comparison of HEC-RAS Modelling Results for Black Creek Bridge B1

River Station	Storm Event	Flow	Existing Conditions		Proposed Conditions 30 m clear opening		
			W.S. Elevation	Channel Velocity	W.S. Elevation	Differenc (Pr. - Ex)	Channel Velocity
		(m^3/s)	(m)	(m/s)	(m)	(m)	(m/s)
2197.6	Regional	117.9	239.96	3.61	239.96	0.00	3.61
2197.6	100 Year	37.1	239.35	3.11	239.35	0.00	3.11
2197.6	50 Year	31.4	239.27	2.87	239.27	0.00	2.87
2197.6	25 Year	25.2	239.16	2.63	239.16	0.00	2.63
2197.6	10 Year	16.7	238.95	2.27	238.95	0.00	2.27
2197.6	5 Year	12.1	238.78	2.08	238.78	0.00	2.08
2197.6	2 Year	6.1	238.54	1.52	238.54	0.00	1.52

River Station	Storm Event	Flow	Existing Conditions		Proposed Conditions 30 m clear opening		
			W.S. Elevation	Channel Velocity	W.S. Elevation	Differenc (Pr. - Ex)	Channel Velocity
		(m^3/s)	(m)	(m/s)	(m)	(m)	(m/s)
2230.6	Regional	117.9	240.67	3.15	240.51	-0.16	3.23
2230.6	100 Year	37.1	239.49	2.74	239.57	0.08	2.16
2230.6	50 Year	31.4	239.41	2.43	239.48	0.07	1.95
2230.6	25 Year	25.2	239.32	2.07	239.36	0.04	1.71
2230.6	10 Year	16.7	239.14	1.57	239.14	0.00	1.36
2230.6	5 Year	12.1	238.98	1.29	238.97	-0.01	1.15
2230.6	2 Year	6.1	238.68	0.87	238.66	-0.02	0.80
2231	Bridge at Trafalgar Road						
2250.1	Regional	117.9	241.32	1.93	241.05	-0.27	3.04
2250.1	100 Year	37.1	239.79	2.79	239.72	-0.07	2.18
2250.1	50 Year	31.4	239.62	2.60	239.60	-0.02	2.03
2250.1	25 Year	25.2	239.51	2.24	239.45	-0.06	1.85
2250.1	10 Year	16.7	239.20	1.86	239.20	0.00	1.56
2250.1	5 Year	12.1	239.04	1.55	239.02	-0.02	1.38
2250.1	2 Year	6.1	238.74	1.08	238.70	-0.04	1.08
2293.3	Regional	117.9	241.45	3.94	241.45	0.00	3.94
2293.3	100 Year	37.1	240.30	3.34	240.30	0.00	3.34
2293.3	50 Year	31.4	240.18	3.23	240.18	0.00	3.23
2293.3	25 Year	25.2	240.04	3.03	240.04	0.00	3.03
2293.3	10 Year	16.7	239.79	2.77	239.79	0.00	2.77
2293.3	5 Year	12.1	239.61	2.61	239.61	0.00	2.61
2293.3	2 Year	6.1	239.36	2.09	239.36	0.00	2.09
2317.1	Regional	117.9	242.27	3.76	242.27	0.00	3.76
2317.1	100 Year	37.1	240.91	4.04	240.91	0.00	4.04
2317.1	50 Year	31.4	240.77	3.80	240.77	0.00	3.80
2317.1	25 Year	25.2	240.59	3.53	240.59	0.00	3.53
2317.1	10 Year	16.7	240.32	3.11	240.32	0.00	3.11
2317.1	5 Year	12.1	240.15	2.80	240.15	0.00	2.80
2317.1	2 Year	6.1	239.88	2.25	239.88	0.00	2.25
2317.5	Bridge at Stewarttown Road						
2337.3	Regional	117.9	242.39	3.30	242.39	0.00	3.30
2337.3	100 Year	37.1	241.61	2.37	241.61	0.00	2.37
2337.3	50 Year	31.4	241.41	2.58	241.41	0.00	2.58
2337.3	25 Year	25.2	241.24	2.27	241.24	0.00	2.27
2337.3	10 Year	16.7	240.69	2.20	240.69	0.00	2.20
2337.3	5 Year	12.1	240.48	1.93	240.48	0.00	1.93
2337.3	2 Year	6.1	240.14	1.44	240.14	0.00	1.44

The existing and proposed conditions HEC-RAS summary outputs for Black Creek Bridge B1 are provided in Appendix C.

MODIFIED: May. 25, 2016 11:31 AM

DRAWING NAME: I:\DRAWINGS\WATERRES\3214006\HEC-RAS AND FLOOD MAPS\3214006-BLACK CREEK-REGIONAL FLOOD LINES.DWG

2806.3 | 244.97 / 244.97

2693.1 | 244.94 / 244.94

2607.6 | 244.91 / 244.91

2448.1 | 242.73 / 242.73

2337.3 | 242.39 / 242.39

2317.1 | 242.27 / 242.27

2293.3 | 241.45 / 241.45

2524.1 | 244.57 / 244.57

2502.3 | 242.78 / 242.78

2368.9 | 242.58 / 242.58

2250.1 | 241.32 / 241.05

2230.6 | 240.67 / 240.51

2197.9 | 239.96 / 239.96

2017.9 | 238.80 / 238.80

1817.4 | 237.04 / 237.04

BLACK CREEK

STEWARTTOWN ROAD NORTH

STEWARTTOWN ROAD NORTH

CNR

TRAFALGAR ROAD

15 SIDEROAD

17 SIDEROAD

MAPLE AVENUE

Metric Scale

50m 0 100m

Horizontal

LEGEND

- HEC-RAS SECTION LINE
- PROPOSED REGIONAL FLOODLINE
- EXISTING REGIONAL FLOODLINE
- EXISTING REGIONAL FLOOD ELEVATION
- SECTION NUMBER
- PROPOSED REGIONAL FLOOD ELEVATION

237.04 / 1817.4 / 237.04

MMM GROUP

HEC-RAS SECTION LOCATIONS AND FLOOD LINES - BLACK CREEK

TRAFALGAR ROAD EA, FROM STEELS AVENUE TO HIGHWAY 7

EXHIBIT

32

4.3.3 Hydraulic Assessment of Culverts using CulvertMaster

The CulvertMaster hydraulic model was used to determine the upstream headwater elevations (HWL) for Culverts C3, C5, C6 to C10, C12, and C14 to C18. The input characteristics of the culverts include size, length, type, material and invert elevations. The locations of the culverts are shown in Exhibit 2 to Exhibit 15. Culverts C3 to C12 are located within the Sixteen Mile Creek watershed (i.e. south of 15 Side Road and within CH jurisdiction) and Culverts C14 to C18 are located within the Black Creek watershed (i.e. north of 15 Side Road and within CVC jurisdiction).

Peak flows obtained from the 24-hour SCS storm distribution were used for the assessments. The hydraulic assessment was carried out for flows of the design storm, 100-year storm and Regional Storm (Hurricane Hazel). Tailwater elevations (TWL) were determined based on the downstream channel geometry of each culvert where a channel was present. Otherwise, a constant tailwater was used. The computed HWLs were compared to the road low point elevation to determine if freeboard was available.

4.3.3.1 Existing Conditions Assessments

Although Trafalgar Road is a rural arterial road under existing condition, it will become an urban arterial road under proposed conditions where the design storm flow is the 50-year flow. Therefore, the 50-year storm flow was considered as the design flow for the existing culverts, so that upstream water levels can be compared with the proposed conditions.

Table 12 provides the results of the existing conditions hydraulic assessments of the culverts located within the Sixteen Mile Creek watershed. The results show that:

- Culvert C3 does not meet the freeboard requirement for the 50-year design flow. The roadway is overtopped during the design, 100-year, and Regional Storm flows by 0.04 m, 0.05 m and 0.05 m, respectively.
- Culvert C4 will be eliminated under proposed conditions. No assessment was carried out.
- Culvert C5 meets all hydraulic requirements. The flows do not overtop Trafalgar Road during the 100-year and the Regional Storm flows. Due to poor conditions of the culvert, replacement of the culvert is recommended.
- Culvert C6 does not meet the freeboard requirement. The Regional Storm flow overtops Trafalgar Road by 0.14 m.
- Culvert C7 does not meet the freeboard criterion. The Regional Storm flow overtops Trafalgar Road by 0.09 m.
- Culvert C8 does not meet the freeboard requirement. The roadway is overtopped during the design, 100-year, and Regional Storm flows by 0.11 m, 0.12 m and 0.16 m, respectively.
- Culvert C9 does not meet the freeboard criterion. The roadway is overtopped during the design, 100-year, and Regional Storm flows by 0.06 m, 0.06 m and 0.09 m respectively.
- Culvert C10 does not meet the freeboard requirement. The 50-year to the Regional Storm flows spill from the driveway toward Culvert C9.

- Culvert C12 does not meet the freeboard requirement. The roadway is overtopped during the design, 100-year, and Regional Storm flows by 0.11 m, 0.15 m, and 0.26 m, respectively.

Table 13 provides the results of the existing conditions hydraulic assessments of the culverts located within the Black Creek watershed. The results show that:

- Culvert C13 will be eliminated under proposed conditions due to CNR underpass. No assessment was carried out.
- Culvert C14 does not meet the freeboard requirement. The roadway is overtopped during the design, 100-year, and Regional Storm flows by 0.17 m, 0.19 m and 0.35 m respectively.
- Culvert C15 does not meet the freeboard criterion. The roadway is overtopped during the design, 100-year, and Regional Storm flows by 0.05 m, 0.11 m and 0.26 m respectively.
- Culvert C16 meets the freeboard criterion for the 50-year design flow. The roadway is overtopped during the Regional Storm flow by 0.10 m.
- Culvert C17 does not meet the freeboard requirement for the 25-year design flow. The roadway is overtopped during the Regional Storm flow by 0.20 m.
- Culvert C18 meets the freeboard requirement for the 10-year design flow. The roadway is overtopped during the Regional Storm flows by 0.38 m.

4.3.3.2 Proposed Conditions Assessments

While undertaking the assessments to determine the sizes of the culverts under proposed conditions, the following guidelines were taken into consideration:

- No increase of upstream headwater elevations compared to the existing conditions;
- No overtopping of the roadway during the 100-year and the Regional Storm flows; and
- Consideration of geomorphic interest.

Table 14 provides the results of the proposed conditions hydraulic assessments of the culverts located within the Sixteen Mile Creek watershed. The results show that:

- Culvert C3 will be replaced by a 750 mm diameter concrete pipe. The culvert meets the freeboard requirement for the 50-year design flow and Trafalgar Road does not overtop during the Regional Storm flow.
- Culvert C5 will be replaced by a 600 mm diameter concrete pipe. The culvert meets the freeboard requirement for the 50-year design flow and the Regional Storm flow does not overtop the roadway.
- Culvert C6 will be replaced by a 975 mm diameter concrete pipe. The culvert meets the freeboard requirement for the 50-year design flow and the roadway does not overtop during the Regional Storm flow.

- Culvert C7 will be replaced by a 2130 mm x 1220 mm concrete box culvert which includes a 300 mm embedment. The culvert meets the freeboard requirement for the 50-year design flow and the Regional Storm flow does not overtop Trafalgar Road.
- Culvert C8 will be replaced by a 1530 mm x 1220 mm concrete box culvert which includes a 500 mm embedment due to cover constraint. The culvert will have a freeboard of 0.67 m for the 50-year design flow which does not meet the requirement; however, the culvert will have a 0.39 m freeboard during the Regional Storm flow. The culvert has cover constraints and a higher culvert would not be technically feasible; therefore, it is not proposed.
- Culvert C9 will be replaced by an 1830 mm x 1220 mm concrete culvert. This structure will be an open footing structure due to geomorphic interest. The culvert meets the freeboard requirement for the 50-year design flow and the Regional Storm flow does not overtop the roadway.
- Culvert C10 will be replaced by a 2130 mm x 1220 mm concrete box culvert which includes a 300 mm embedment. The culvert meets the freeboard requirement for the 50-year design flow and Trafalgar Road does not overtop during the Regional Storm flow.
- Culvert 12 will be replaced by a 2130 mm x 1220 mm concrete culvert. This structure will be an open footing structure due to geomorphic interest. The culvert meets the freeboard requirement for the 50-year design flow. Trafalgar Road does not overtop during the Regional Storm flow.

Table 15 provides the results of the proposed conditions hydraulic assessments of the culverts located within the Black Creek watershed. The results show that:

- Culvert 14 will be replaced by a 2130 mm x 1220 mm concrete culvert. This structure will be an open footing structure due to geomorphic interest. The culvert meets the freeboard requirement for the 50-year design flow and the Regional Storm flow does not overtop the roadway.
- Culvert 15 will be replaced by a 1520 mm x 910 mm concrete culvert. This structure will be an open footing structure due to geomorphic interest. The culvert meets the freeboard requirement for the 50-year design flow and the roadway does not overtop during the Regional Storm flow.
- Culvert 16 will be replaced by a 3050 mm x 1520 mm concrete culvert. This structure will be an open footing structure due to geomorphic interest. The culvert meets the freeboard requirement for the 50-year design flow and the Regional Storm flow does not overtop Trafalgar Road.
- Culvert 17, located on Highway 7, will be replaced by a 975 mm concrete culvert. The culvert meets the freeboard requirement for the 25-year design flow and the Regional Storm flow does not overtop Highway 7.
- Culvert 18, located in 20 Side Road, will be replaced by a 3050 mm x 1520 mm concrete culvert. This structure will be an open footing structure due to geomorphic interest. The culvert meets the freeboard requirement for the 10-year design flow and the Regional Storm flow overtops 20 Side Road by 0.14 m which is less than 0.30 m, hence, acceptable. The Regional Storm does not overtop Trafalgar Road.

The CulvertMaster output files for both existing and proposed conditions assessments are included in Appendix D.

Table 12: Hydraulic Assessments of Existing Culverts located within Sixteen Mile Creek Watershed

Culvert ID	Size (mm)	Length (m)	Drainage Area (ha)	Type / Material	U/S Invert (m)	D/S Invert (m)	Road Low Point Elevation (m)	Ditch Spill Elevation (m)	Events	Flow (m^3/s)	TWL (m)	Computed HWL (m)	HW/D	Freeboard (m)	Meets Requirements?		
															Freeboard	HW/D	Overtopping?
C3	500 mm diameter	21.7	5.7	Circular, CSP	233.260	232.210	234.710	n/a	50-year	0.670	232.20	234.75	2.98	-0.04	No	No	Overtopping
									100-year	0.741	232.19	234.76	n/a	-0.05	n/a	n/a	Overtopping
									Regional	0.761	232.19	234.76	n/a	-0.05	n/a	n/a	Overtopping
C4	600 mm diameter	18.5	0.81	Circular, CSP	244.060	244.020	245.440	n/a	This culvert will be eliminated under proposed conditions.								
C5	600 mm diameter	20.6	5.7	Circular, CSP	241.240	240.930	243.260	n/a	50-year	0.468	239.15	242.07	1.36	1.19	Yes	Yes	No
									100-year	0.525	239.16	242.24	n/a	1.02	n/a	n/a	No
									Regional	0.706	239.18	242.93	n/a	0.33	n/a	n/a	No
C6	900 mm diameter	23.3	24.5	Circular, CSP	241.070	240.420	243.300	243.210	50-year	1.379	240.23	242.41	1.46	0.89	No	Yes	No
									100-year	1.545	240.24	242.56	n/a	0.74	n/a	n/a	No
									Regional	2.644	240.29	243.44	n/a	-0.14	n/a	n/a	Overtopping
C7	1400 x 900	26.5	25.6	Arc CSP	245.390	245.270	246.820	246.530	50-year	1.489	245.50	246.37	1.01	0.45	No	Yes	No
									100-year	1.668	245.51	246.45	n/a	0.37	n/a	n/a	No
									Regional	2.793	245.56	246.91	n/a	-0.09	n/a	n/a	Overtopping
C8	600 mm diameter	21.0	12.2	Circular, CSP	253.590	253.520	254.510	n/a	50-year	0.867	253.79	254.62	1.70	-0.11	No	No	Overtopping
									100-year	0.977	253.79	254.63	n/a	-0.12	n/a	n/a	Overtopping
									Regional	1.453	253.79	254.67	n/a	-0.16	n/a	n/a	Overtopping
C9	900 mm diameter	22.9	30.2	Circular, CSP	251.000	250.830	253.020	n/a	50-year	3.950*	251.24	253.08	2.27	-0.06	No	No	Overtopping
									100-year	4.508*	251.24	253.08	n/a	-0.06	n/a	n/a	Overtopping
									Regional	7.633*	251.24	253.11	n/a	-0.09	n/a	n/a	Overtopping
C10	700 mm diameter	26.5	46.4	Circular, CSP	252.320	252.240	254.360	253.920	50-year	2.548	252.56	254.00	2.40	0.36	No	No	No
									100-year	2.849	252.56	254.01	n/a	0.35	n/a	n/a	No
									Regional	4.934	252.56	254.05	n/a	0.31	n/a	n/a	No
C12	900 mm diameter	26.4	39.3	Circular, CSP	260.740	260.420	262.470	n/a	50-year	1.931	245.52	262.58	2.02	-0.11	No	No	Overtopping
									100-year	2.167	245.53	262.62	n/a	-0.15	n/a	n/a	Overtopping
									Regional	4.047	245.60	262.73	n/a	-0.26	n/a	n/a	Overtopping

Note: Flows from C10 spill into C9. Spilled flows from C10 are added to C9 flows.
U/S = Upstream D/S = Downstream TWL = Tailwater elevation HWL = Headwater elevation HW/D = Headwater to depth ratio

Table 13: Hydraulic Assessments of Existing Culverts located within Black Creek Watershed

Culvert ID	Size (mm)	Length (m)	Drainage Area (ha)	Type / Material	U/S Invert (m)	D/S Invert (m)	Road Low Point Elevation (m)	Ditch Spill Elevation (m)	Events	Flow (m^3/s)	TWL (m)	Computed HWL (m)	HW/D	Freeboard (m)	Meets Requirements?		
															Freeboard	HW/D	Overtopping?
C13	525 mm diameter	24.1	53.9	Circular, HDPE	238.41	238.25	n/a	n/a	This culvert will be eliminated under proposed conditions.								
C14	900 mm diameter	24.1	53.9	Circular, CSP with HDPE Liner	267.920	267.640	268.790	n/a	50-year	1.562	267.76	268.96	1.14	-0.17	No	Yes	Overtopping
									100-year	1.765	267.78	268.98	n/a	-0.19	n/a	n/a	Overtopping
									Regional	4.420	267.92	269.14	n/a	-0.35	n/a	n/a	Overtopping
C15	600 mm diameter	28.3	41.0	Circular, CSP with HDPE Liner	269.670	268.680	274.040	n/a	50-year	1.845	268.90	274.09	7.26	-0.05	No	No	Overtopping
									100-year	2.078	268.92	274.15	n/a	-0.11	n/a	n/a	Overtopping
									Regional	4.140	269.05	274.30	n/a	-0.26	n/a	n/a	Overtopping
C16	1800 mm diameter	50.2	104.0	Circular, CSP	269.480	269.290	273.000	n/a	50-year	3.959	269.92	271.16	0.92	1.84	Yes	Yes	No
									100-year	4.491	269.96	271.30	n/a	1.70	n/a	n/a	No
									Regional	10.230	270.26	273.10	n/a	-0.10	n/a	n/a	Overtopping
C17 (Highway 7)	900 mm diameter	65.5	18.7	Circular, CSP	274.460	273.500	276.240	n/a	25-year	0.932	273.93	275.47	1.10	0.96	No	Yes	No
									100-year	1.274	273.95	275.68	n/a	0.75	n/a	n/a	No
									Regional	2.150	274.08	276.63	n/a	-0.20	n/a	n/a	Overtopping
C18 (20 Side Road)	1800 mm diameter	49.2	100.9	Circular, CSP	270.500	270.000	272.750	n/a	25-year	3.220	270.98	272.00	0.82	0.75	No	Yes	No
									100-year	4.419	271.30	272.29	n/a	0.46	n/a	n/a	No
									Regional	9.980	273.10	273.13	n/a	-0.38	n/a	n/a	Overtopping

Notes: Inverts of Culvert C18 were estimated. No survey Information was available for this culvert.
U/S = Upstream D/S = Downstream TWL = Tailwater elevation HWL = Headwater elevation HW/D = Headwater to depth ratio

Table 14: Hydraulic Assessments of Proposed Culverts located within Sixteen Mile Creek Watershed

Culvert ID	Size (mm)	Length (m)	Drainage Area (ha)	Type / Material	U/S Invert (m)	D/S Invert (m)	Road Low Point Elevation (m)	Ditch Spill Elevation (m)	Events	Flow (m^3/s)	TWL (m)	Computed HWL (m)	HW/D	Freeboard (m)	Meets Requirements?		
															Freeboard	HW/D	Overtopping?
C3	750 mm diameter	40.5	5.7	Circular, Concrete	233.000	232.210	234.840	n/a	50-year	0.668	232.19	233.84	1.10	1.00	Yes	Yes	No
									100-year	0.741	232.21	233.90	n/a	0.94	n/a	n/a	No
									Regional	0.982	232.23	234.11	n/a	0.73	n/a	n/a	No
C5	600 mm diameter	40.6	5.72	Circular, Concrete	241.240	240.930	243.370	n/a	50-year	0.809	239.15	242.05	1.33	1.32	Yes	Yes	No
									100-year	0.569	239.17	242.14	n/a	1.23	n/a	n/a	No
									Regional	0.722	239.18	242.49	n/a	0.88	n/a	n/a	No
C6	975 mm diameter	40.6	24.5	Circular, Concrete	241.070	240.420	243.420	243.210	50-year	1.439	240.22	242.25	1.21	1.17	Yes	Yes	No
									100-year	1.610	240.24	242.35	n/a	1.07	n/a	n/a	No
									Regional	2.670	240.29	243.39	n/a	0.03	n/a	n/a	No
C7	2130 x 1220 mm 300 mm embedded	50.8	25.6	Box, Concrete	245.400	245.250	246.870	246.530	50-year	1.491	245.48	245.87	0.73	1.00	Yes	Yes	No
									100-year	1.670	245.51	245.92	n/a	0.95	n/a	n/a	No
									Regional	2.790	245.56	246.21	n/a	0.66	n/a	n/a	No
C8	1530 x 1220 mm 500 mm embedded	40.6	12.2	Box, Concrete	253.450	253.350	254.730	n/a	50-year	0.858	253.79	254.06	0.88	0.67	No	Yes	No
									100-year	0.976	253.79	254.11	n/a	0.62	n/a	n/a	No
									Regional	1.430	253.79	254.34	n/a	0.39	n/a	n/a	No
C9	1830 x 910 mm	39.0	30.2	Open Footing, Concrete	251.000	250.830	253.090	n/a	50-year	2.088	251.24	251.92	1.08	1.17	Yes	Yes	No
									100-year	2.333	251.24	251.99	n/a	1.10	n/a	n/a	No
									Regional	4.270*	251.24	253.00	n/a	0.09	n/a	n/a	No
C10	2130 mm x 1220 mm 300 mm embedded	43.3	46.4	Box, Concrete	252.320	252.240	254.460	253.920	50-year	2.521	252.56	253.30	1.07	1.16	Yes	Yes	No
									100-year	2.816	252.56	253.37	n/a	1.09	n/a	n/a	No
									Regional	4.930	252.56	253.97	n/a	0.49	n/a	n/a	No
C12	2130 x 910 mm	43.5	39.3	Open Footing, Concrete	260.740	260.420	262.570	n/a	50-year	1.898	245.53	261.48	0.81	1.09	Yes	Yes	No
									100-year	2.124	245.53	261.54	n/a	1.03	n/a	n/a	No
									Regional	4.040	245.60	262.33	n/a	0.24	n/a	n/a	No

Note: Regional flows from C10 spill into C9. Spilled flows from C10 were added to C9 flows for the hydraulic analysis.

U/S = Upstream D/S = Downstream TWL = Tailwater elevation HWL = Headwater elevation HW/D = Headwater to depth ratio

Table 15: Hydraulic Assessments of Proposed Culverts located within Sixteen Mile Creek Watershed

Culvert ID	Size (mm)	Length (m)	Drainage Area (ha)	Type / Material	U/S Invert (m)	D/S Invert (m)	Road Low Point Elevation (m)	Ditch Spill Elevation (m)	Events	Flow (m^3/s)	TWL (m)	Computed HWL (m)	HW/D	Freeboard (m)	Meets Requirements?		
															Freeboard	HW/D	Overtopping?
C14	2130 mm x 1220 mm	46.0	55.2	Open Footing Concrete	267.450	267.200	269.410	n/a	50-year	1.602	267.77	268.13	0.56	1.28	Yes	Yes	No
									100-year	1.810	267.78	268.19	n/a	1.22	n/a	n/a	No
									Regional	4.529	267.92	268.81	n/a	0.60	n/a	n/a	No
C15	1520 mm x 910 mm	43.5	40.3	Open Footing Concrete	269.670	268.680	272.180	n/a	50-year	1.814	268.89	270.89	1.00	1.29	Yes	Yes	No
									100-year	2.042	268.91	270.96	n/a	1.22	n/a	n/a	No
									Regional	4.072	269.05	271.48	n/a	0.70	n/a	n/a	No
C16	3050 mm x 1520 mm	78.0	104.5	Open Footing Concrete	269.400	269.200	271.860	n/a	50-year	3.955	269.92	270.43	0.68	1.43	Yes	Yes	No
									100-year	4.486	270.52	270.52	n/a	1.34	n/a	n/a	No
									Regional	10.200	270.26	271.43	n/a	0.43	n/a	n/a	No
C17 (Highway 7)	975 mm diameter	65.5	18.3	Circular, Concrete	274.460	273.500	276.430	n/a	25-year	0.922	273.93	275.35	0.92	1.08	Yes	Yes	No
									100-year	1.261	273.95	275.54	n/a	0.89	n/a	n/a	No
									Regional	2.148	274.08	276.19	n/a	0.24	n/a	n/a	No
C18 (20 Side Road)	3050 mm x 1520 mm	22.0	100.9	Open Footing Concrete	270.000	269.800	271.700	n/a	10-year	2.429	270.16	270.69	0.56	1.01	Yes	Yes	No
									100-year	4.419	270.52	271.03	n/a	0.67	n/a	n/a	No
									Regional	9.982	271.43	271.84	n/a	-0.14	n/a	n/a	Overtopping

Notes: U/S = Upstream D/S = Downstream TWL = Tailwater elevation HWL = Headwater elevation HW/D = Headwater to depth ratio

5.0 FLUVIAL GEOMORPHOLOGY

A fluvial geomorphic assessment was conducted to describe the existing conditions of the various watercourses within the study area, to assess the possible impacts of the proposed works on the watercourses and to provide preliminary design recommendations for the proposed watercourse crossings. A brief overview of the assessment is provided below. The detailed geomorphology assessment will be provided in a separate volume and will be appended in Appendix E of this report.

Site visits were conducted on December 2 and 3, 2015 as well as on February 3, 2016. Existing reach characteristics are summarized in Table 16. Most of the watercourse crossings are headwater features with small drainage areas on the order of 1km^2 or less. These are typically swales or ditches with minimal ongoing geomorphic processes.

The most significant watercourses within the study area are Hornby Tributary (Sixteen Mile Creek Mideast Reach 13) to Middle Sixteen Mile Creek (C2) and Black Creek (B1), which have drainage areas of 7.1 km^2 and 73.2 km^2 respectively. These crossings were examined in detail. A Tributary to Black Creek located downstream of C14 was also assessed in detail because the future road alignment will be shifted toward the creek valley as part of the CN Rail grade separation.

The proposed works include replacement of all watercourse crossings included in the geomorphology assessment, excluding Culverts C1 and C2 which will be extended. A third cell will be added to the existing Culvert C2, which will also be an open footing structure with a low flow channel. Minor channel realignment on both upstream and downstream side will be necessary to convey the low flow through the added open footing cell of Culvert C2. All the replacement crossings which are included in the fluvial geomorphological assessment will be open-foot structures to allow sediment transport processes to occur unimpeded. Wherever applicable, replacement structures will meet both hydraulic and geomorphic criteria. In particular, the existing 8.8 m wide bridge at Black Creek will be replaced with a 30 m wide clear span structure. The proposed spans are considered sufficient to maintain ongoing geomorphic processes and will be an improvement over existing conditions. The proposed works are summarized in Table 21 Summary Matrix.

Preliminary design recommendations are provided in the Geomorphology Assessment Report and will be included in Appendix E.

Table 16: Summary of Reach Characteristics

	Culvert No.	Drainage Area (km^2)	Bankfull Width (m)	Planform Geometry	Description
Sixteen Mile Creek Watershed (Conservation Halton)	C1	0.89	1	Meandering	Small meandering channel upstream. Downstream, multiple flow paths through grassy area. Loose silt and clay bed.
	C2	7.10	5	Straight	Bankfull width modified (over-widened). Channel previously straightened, straight planform persists. Cobble-gravel bed. Poorly developed bedforms, silt and alga-covered bed.
	C9	0.30	Swale	Straight	No defined channel downstream of roadside ditch.
	C11	1.36	Ditch	Straight	Ditch is 2.5m wide, no natural bankfull indicators. Erosion present at outlet due to undersized culvert.
	C12	0.39	Swale	Straight	No defined channel outside of roadside ditches.
Black Creek Subwatershed / Silver Creek Watershed (Credit Valley Conservation)	B1	73.20	6-9	Straightened reach in meandering system	Black Creek has been straightened near Trafalgar Road. Partial bank protection present, limited bank erosion. Cobble-gravel bed with riffle-run morphology. Reach is located downstream of Stewarttown Road Bridge.
	C14	0.54	1.3	Straight	Upstream is a wetland with no defined channel. Downstream channel is modified.
	Downstream of C14	n/a	1.7-2.5	Meandering	CN rail culvert outlet is perched. Downstream, channel is sinuous within confined valley. Active erosion on banks. Ongoing lateral adjustment and incision. Cobble-gravel bed.
	C15	0.41	Swale	Straight	Swale flowing on forest floor. No defined channel in Trafalgar Road ROW.
	C16	1.00	Swale	Straight	No defined channel upstream. Straightened channel downstream. Vegetated, fine gravel substrate.
	C18	1.00	2	Straight	No defined channel.

6.0 STORMWATER MANAGEMENT

6.1 Screening of Alternatives

The preferred alignment of Trafalgar Road is located inside the watersheds of Sixteen Mile Creek and Black Creek. A list of stormwater best management practices (BMPs) was screened, with consideration of the general advantages and disadvantages, experience, and practical feasibility for the site specific conditions.

It was determined at the start of the study that the "do nothing" alternative is not an acceptable course of action. The increase in pavement areas and the associated potential increase in pollutant loading to the receiving watercourses would result in negative effects such as reduced stream water quality, degraded aquatic habitat, flooding, and in-stream erosion, which necessitate provision of appropriate mitigation measures.

The MOECC has identified a broad range of stormwater management practices (SWMPs) that may be considered for the proposed roadway corridor. The recommended practices that can be implemented as part of this project are:

- Wet ponds providing quality treatment, quantity control and erosion control;
- Vegetative, dry linear facilities providing quantity control and a measure of quality treatment;
- Storage pipe systems providing quantity control;
- Enhanced vegetated grassed swales providing quality treatment;
- Special SWMPs such as oil and grit separators (OGSs) to provide quality treatment; and
- LID measures such as bio-retention areas (bio-swales), tree pits, and infiltration galleries/trenches.

Storage SWMPs such as wet ponds, dry ponds, and linear SWM facilities, can be effective in providing combined quality treatment and/or quantity control where drainage areas are sufficient and land is available. Storage pipe systems can be effective for small drainage areas and in the case where land is not available. Vegetative SWMPs such as Enhanced grassed swales, bio-swales, etc. provide water quality treatment primarily by filtering out fine sediments and promoting infiltration, but can also be used to provide erosion control. Filtering of roadway pavement runoff can also be accomplished with vegetative embankments. Enhanced grassed swales are primarily designed to provide water quality control by limiting flow velocities and increasing the wetted perimeter, and can include grassed berms to detain water during small events and/or wider flat bottoms to increase storage and flow contact. Vegetative SWMPs can be readily applied to roads and highways, and are relatively inexpensive and particularly effective for small catchment areas. Infiltration measures such as bio-retention areas (bio-swales), tree pits, and infiltration galleries/trenches are effective for water balance and low impact development (LID) measures.

Within the study area, runoff from the proposed roadway will ultimately discharge to permanent watercourses via ditches and storm sewers. The roadway areas result in an increase in impervious area which eventually may result in an increase potential for erosion, flood risk, and water quality degradation

along the receiving watercourses. Therefore, road runoff needs to be treated as far as possible both in terms of quantity and quality treatment before discharging into the receiving watercourses.

Where appropriate, extension detention will be provided to reduce/mitigate the erosion impacts to the receiving watercourses during the detailed design.

Planting of native, non-rare species around the proposed SWM facilities will be reviewed during the detailed design phase in consultation with Landscape Architect.

6.2 Impact of the Proposed Improvement of Road Corridor

The proposed improvements of Trafalgar Road include the widening from a 2 to 4 lane roadway with the provision of active transportation facilities with a combination of urban section and semi-urban section. Two grade separations will also be provide – one at the CN crossing north of 17 Side Road and one at the Metrolinx crossing north of 20 Side Road. The roadway stretch with semi-urban section will have urban section on the east side and rural section on the west side. The proposed roadway improvement will lead to an increase in impervious areas thereby increasing the peak flow rates. Several SWM facilities are proposed to address flows from the increased impervious areas

Table 17 provides a comparison of impervious areas under existing and proposed conditions at each Node or point of interest due to the proposed road alignment. The table also shows the uncontrolled 100-year peak flow increases due to increase in impervious areas.

Table 17: Comparison of Impervious Areas

Node / Outlet	Existing Conditions			Proposed Conditions			Increase from Existing	
	Drainage Area (ha)	Impervious Area		Drainage Area (ha)	Impervious Area			
		Ha.	%		Ha.	%	Impervious Area	100-year Flow
Sixteen Mile Creek Watershed								
C1	89.3	3.16	3.5%	89.3	4.40	4.9%	1.4%	0.07%
C2	771	9.76	1.3%	769	15.7	2.0%	0.8%	8.30%
C3	5.73	0.80	14.0%	7.45	2.33	31.3%	17.3%	38.5%
C5	5.72	0.35	6.1%	5.72	0.65	11.4%	5.2%	7.70%
C6	24.5	0.50	2.0%	24.5	0.99	4.0%	2.0%	4.00%
C7	25.6	1.11	4.3%	25.6	1.57	6.1%	1.8%	0.10%
C8	12.2	1.29	10.6%	12.2	1.74	14.3%	3.7%	14.0%
C9	30.2	2.54	8.4%	30.2	3.50	11.6%	3.2%	7.90%
C10	46.4	0.78	1.7%	46.4	1.73	3.7%	2.0%	3.30%
C11	136	1.10	0.8%	136	2.11	1.6%	0.7%	2.50%
C12	39.3	1.80	4.6%	39.3	2.83	7.2%	2.6%	8.50%

Node / Outlet	Existing Conditions			Proposed Conditions			Increase from Existing	
	Drainage Area (ha)	Impervious Area		Drainage Area (ha)	Impervious Area			
		Ha.	%		Ha.	%	Impervious Area	100-year Flow
Black Creek Watershed								
Existing Storm Outlet	36.3	3.02	8.3%	36.3	3.02	8.3%	0.0%	0.0%
B1	50.1	4.90	9.8%	50.1	7.21	14.4%	4.6%	17.8%
Underpass Area	3.46	1.09	31.4%	3.46	1.97	56.9%	25.5%	40.7%
C14	53.9	5.20	9.6%	55.2	5.85	10.6%	1.0%	2.5%
Tributary 1	57.4	6.29	11.0%	58.7	7.82	13.3%	2.4%	13.4%
C15	41.0	1.39	3.4%	40.3	1.60	4.0%	0.6%	-1.73%
S1	10.0	0.57	5.7%	9.00	0.50	5.6%	-0.1%	-6.4%
C16	104.0	2.34	2.3%	104.5	3.69	3.5%	1.3%	-0.1%
C17	18.7	1.42	7.6%	18.3	1.37	7.5%	-0.1%	-1.0%

The table illustrates that there is significant increase in flows at Culverts C2, C3, C5, C6, C8, C9, C10, C11, B1, CNR Underpass area, and Tributary 1. Therefore, to reduce the impacts of sediment loading as well as increased peak flows to the receiving watercourses, storm water management measures are required for runoff quality and quantity control. The proposed measures are addressed in the following section.

6.3 Proposed Stormwater Management Strategy

The stormwater management strategy for the Trafalgar Road corridor involves a two stage approach which consists of interim SWM facilities and ultimate SWM facilities.

- **Interim SWM Approach**: A suitable temporary SWM approach will be proposed in the area of future Vision Georgetown Subdivision development site (i.e. between 10 Side Road and 15 Side Road, on the east side of Trafalgar Road). After the development of the Subdivision in the area, the interim SWM facilities will be integrated into the Subdivision's SWM plan. The Region, Town and the developer should have an agreement for the ultimate conditions SWM plan.
- **Ultimate SWM Approach**: In the areas where there are no future development plans, ultimate SWM approach are proposed.

Under this approach, a total of nine (9) SWM facilities are proposed for the runoff quality and quantity control. There will be one (1) wet pond and seven (7) grassed lined, dry SWM facilities and one (1) pipe storage facility. In addition, there will be Enhanced grassed swales and bio-swales to provide quality treatment as well as water balance. Oil and grit separators (OGSs) will be provided at seven (7) locations where the roadway runoff is conveyed by storm sewers. The treatment goals for different SWM facilities are:

- SWM wet pond will provide quality treatment, quantity control and erosion control.
- Vegetative dry linear facility will provide peak flow control and a measure of quality control.
- Enhanced grassed swales, bio-swales and other grassed swales/ditch will provide quality treatment and water balance.

- OGSs will provide quality treatment.

Where feasible, a treatment train approach has been provided as per the MOECC guidelines.

Table 18 summarizes the details of the SWM component proposed for the Trafalgar Road corridor within the Sixteen Mile Creek watershed.

Table 18: Proposed SWM Components within Sixteen Mile Creek Watershed(CH Jurisdiction)

Station		Length (m)	SWM Component	Purpose
From	To			
0+100	0+250	150	Enhanced grassed swale on west side	Quality control
0+250	0+400	150	Bio-swales on west side	Quality control and water balance
0+400	0+550	150	Enhanced grassed swale on west side	Quality control
0+600	0+850	250	Enhanced grassed swale on west side	Quality control
0+820	0+970	150	Grassed linear facility - Pond 2S	Quality and quantity control
0+970	1+050	80	Bio-swales on west side	Quality control and water balance
1+050	1+100	100	Grassed ditch on west side	Limited water quality control
1+100	1+360	260	Bio-swales on west side	Quality control and water balance
1+380	1+460	80	SWM wet facility - Pond 2N	Quality and quantity control
1+460	2+600	1140	Grassed ditch on both sides	Limited water quality control
2+780	2+880	100	Dry SWM facility – Pond 3N	Quantity control
2+880	3+100	220	Grassed ditch on west side	Limited water quality control
3+100	3+200	100	Bio-swales on west side	Quality control and water balance
3+200	3+500	300	Enhanced grassed swale on west side Grassed ditch on east side	Quality control
3+500	3+900	400	Grassed ditch on both sides	Limited water quality control
3+900	4+050	150	Enhanced grassed swale on west side Grassed ditch on east side	Quality control
4+050	4+300	250	Grassed ditch on both sides	Limited water quality control
4+300	4+500	200	Bio-swale on west side Grassed ditch on east side	Quality control and water balance
4+500	4+800	300	Enhanced grassed swale on west side Grassed ditch on east side	Quality control
4+800	4+980	180	Grassed ditch on both sides	Limited water quality control
4+980	5+200	220	Bio-swale on west side Grassed ditch on east side	Quality control and water balance
5+200	5+700	500	Grassed ditch on both sides	Limited water quality control

Station		Length (m)	SWM Component	Purpose
From	To			
5+700	5+950	250	Enhanced grassed swale on west side	Quality control
5+950	6+120	170	Bio-swales on west side	Quality control and water balance
6+120	6+300	180	Grassed linear facility – Pond 8S	Quality and quantity control
6+300	6+500	200	Storm sewer on NBL toward Pond 9S Grassed ditch on west side	Quality control
6+500	6+700	200	Storm sewer on NBL toward Pond 9S (Interim) on east side Enhanced grassed swale on west side	Quality control
6+700	6+850	150	Storm sewer, OGS and grassed linear facility Pond 9S Bio-swale on west side	Quality control, quantity control and water balance
6+850	7+000	150	Bio-swale on west side	Quality control and water balance
0+700	7+200	6500	Enhanced grassed swale on west side	Quality control
7+300	7+450	150	OGS and grassed linear facility 10N (interim)on east side Bio-swale on west side	Quality control, quantity control and water balance
7+450	7+900	450	Storm sewer on NBL toward Pond 10N Enhanced grassed swale on west side	Quality control
7-975	8+100	125	Grassed linear facility Pond 11N (interim) on the east side	Quality and control
8+060	8+300	240	Bio-swale on west side	Quality control and water balance
8+300	8+500	200	Enhanced grassed swale on west side	Quality control
8+500	8+650	150	Grassed ditch	Limited water quality control
8+650	8+800	150	OGS and grassed linear facility Pond 12N (interim) on east side Bio-swale on west side	Quality control, quantity control and water balance
8+800	9+300	500	Enhanced grassed swale on west side	Quality control
9+300	9+450	150	Grassed ditch on west side	Limited water quality control

Where appropriate, extension detention / erosion control measures will be provided during the detailed design phase. The possibility of other LID measures such as bio-retention areas (bio-swales), tree pits, infiltration galleries/trenches, etc. will be reviewed during the detailed design phase. Consultation with Landscape Architect will be carried out to refine the LID options

Table 19 summarizes the details of the SWM component proposed for the Trafalgar Road corridor within the Black Creek watershed.

Table 19: Proposed SWM Components within Black Creek Watershed (CVC Jurisdiction)

Station		Length (m)	SWM Component	Purpose
From	To			
9+450	9+920	470	Storm sewer, OGS and outlet pool	OGS for quality treatment and outlet pool for erosion control
9+980	10+680	700	Storm sewer, OGS , outlet pool and grassed swale	OGS and grassed swale for quality treatment and outlet pool for erosion control
10+700	11+125	425	Storage pipe facility 14S and OGS	Quality and quantity control
11+125	11+400	275	Bio-swales on west side	Quality control and water balance
11+400	11+750	350	Enhanced grassed swale on west side	Quality control
11+750	11+850	100	Bio-swales on west side	Quality Control and water balance
11+850	11+950	100	Ditch with rip-rap	Riprap for erosion control
11+950	12+100	150	Bio-swales on west side	Quality control and water balance
12+100	12+300	200	Enhanced grassed swale on west side	Quality control
12+300	12+420	120	Storm sewer and OGS on the east side Bio-swales on west side	Quality control and water balance
12+500	12+720	220	Grassed ditch on west side	Limited water quality control

Table 20 summarizes the characteristics and overall performance of each SWM facility.

Table 20: Characteristics of Proposed SWM Facilities

Facility ID.	Type	Design Stage	Draiange Area	Permanent Pool [1]	Active Storage [2]	100-yr Peak Inflow	100-yr Peak Outflow	% Reduction in 100-yr Peak Flow
			(ha)	(m^3)	(m^3)	(m^3/s)	(m^3/s)	
2S	Grassed linear dry SWM facility	Ultimate	2.30	--	565	0.572	0.242	58%
2N	Wet SWM facility	Ultimate	6.42	1160	1890	1.345	1.105	18%
3N	Dry SWM facility	Ultimate	3.41	--	1290	0.98	0.218	78%
8S	Grassed linear dry SWM facility	Ultimate	2.90	--	630	0.728	0.503	31%
9S	Grassed linear dry SWM facility	Interim	1.30	--	455	0.390	0.088	77%
10N	Grassed linear dry SWM facility	Interim	1.40	--	500	0.406	0.169	58%
11N	Grassed linear dry SWM facility	Interim	2.10	--	505	0.595	0.239	60%
12N	Grassed linear dry SWM facility	Interim	1.90	--	580	0.481	0.266	45%
14S	Pipe storage facility	Ultimate	3.46	--	510	0.982	0.652	34%

Notes:
1) Permanent Pool is based on Table 3.2 of the MOECC Stormwater Planning and Design Manual.
2) Active Storage refers to the maximum volume used during the 100-year 24-hr SCS Storm.

The location of Enhanced grassed swales, bio-swales and other stormwater management BMPs are shown in Exhibits 16 to 29. The stage-discharge-storage information for each stormwater management facility is provided in Appendix F. Additional details for each SWM facility are provided in the following texts.

Pond 2S:

- It is a grassed linear SWM facility located at Station 0+900 on the west side of Trafalgar Road.
- The facility will service 2.3 ha of the roadway (Catchment 105-3) from Station 0+580 to 0+960. The layout plan of this linear facility is shown in Exhibit 17.
- The pond will have 2.5:1 side slopes and a bottom elevation of 202.70 m. At the bottom of the facility, its size will be approximately 150 m long and 2.5 m wide. The 100-year storage volume for this pond will be approximately 565 m^3.
- Outflows from the SWM facility will discharge to the 80 m long Enhanced grassed swale and then ultimately to the downstream side of Culvert C2.
- The Enhanced grassed swale, vegetative linear facility and bio-swale in series provide a water quality treatment train.

Pond 2N:

- It is a wet SWM facility located at Station 1+400 on the west side of Trafalgar Road.
- The facility will service 6.42 ha of the roadway right-of-way (Catchment 105-1) from approximately Station 1+400 to 2+600. The layout plan of this facility is shown in Exhibit 18.
- The pond will have 3:1 side slopes from the bottom of the pond to the permanent pool level and 4:1 side slopes from permanent pool level to the top of the pond. The bottom elevation of the pond will be 202.00 m. The permanent pool volume of the pond will be 1160 m^3 at an elevation of 203.80 m. The 100-year storage volume for this pond will be approximately 1890 m^3.
- Outflows from the SWM facility will discharge to the bio-swale followed by an Enhanced grassed swale and then ultimately to the downstream side of Culvert C2.
- The SWM wet pond, bio-swale and Enhanced grassed swale together will provide an Enhanced level of quality treatment of the runoff and maintaining a treatment train approach.

Pond 3N:

- It is a dry SWM facility located at Station 2+800 on the west side of Trafalgar Road.
- The facility will service 3.41 ha of the roadway (Catchments 110-1, 110-2 and 115) from approximately Station 2+800 to 3+700. The layout plan of this linear facility is shown in Exhibit 19.
- The pond will have 3:1 side slopes and a bottom elevation of 232.50 m. At the bottom of the facility, its size will be approximately 90 m long and 11 m wide. The 100-year storage volume for this pond will be approximately 1290 m^3.

- Before discharging into this SWM facility, roadway runoff will be conveyed by Enhanced grassed swale, bio-swale and flat bottom grassed ditch. Outflows from the SWM facility will discharge to the downstream side of Culvert C3.
- The Enhanced grassed swale, bio-swale, flat bottom grassed ditch and SWM facility together will provide quality treatment of the runoff and maintaining a treatment train approach.

Pond 8S:

- It is a grassed linear SWM facility located at Station 6+200 on the west side of Trafalgar Road.
- The facility will service 2.9 ha of the roadway corridor (Catchment 135-1) from approximately Station 5+500 to 6+250. The layout plan of this linear facility is shown in Exhibit 22.
- The pond will have 3:1 side slopes and a bottom elevation of 254.0 m. At the bottom of the facility, its size will be approximately 125 m long and 2.5 m wide. The 100-year storage volume for this pond will be approximately 630 m^3.
- Before discharging into this SWM facility, roadway runoff will be conveyed by Enhanced grassed swale and bio-swale. Outflows from the SWM facility will discharge to the upstream side of Culvert C8.
- The Enhanced grassed swale, bio-swale and vegetative linear facility maintain a treatment train to provide quality treatment of the runoff.

Pond 9S:

- It is a grassed linear SWM facility located at Station 6+800 on the east side of Trafalgar Road.
- This facility is considered an interim facility until such time when the future SWM facility of 'Vision Georgetown" is constructed.
- The facility will service 1.3 ha of the roadway corridor (Catchment 140-1) from approximately Station 6+300 to 6+820. The layout plan of this linear facility is shown in Exhibit 22.
- The pond will have 3:1 side slopes and a bottom elevation of 251.0 m. At the bottom of the facility, its size will be approximately 100 m long and 3 m wide. The 100-year storage volume for this pond will be approximately 455 m^3.
- Roadway runoff will be conveyed by storm sewers and an OGS is provided for quality treatment before discharging to the grassed linear facility. Outflows from the SWM facility will discharge to the downstream side of Culvert C9.
- The OGS and vegetative linear facility together will provide quality treatment of the runoff and maintaining a treatment train approach.

Pond 10N:

- It is a grassed linear SWM facility located at Station 7+350 on the east side of Trafalgar Road.
- This facility is considered as an interim facility until such time when the future SWM facility of 'Vision Georgetown" is constructed.
- The facility will service 1.4 ha of the roadway corridor (Catchment 145-1) from approximately Station 7+300 to 7+900. The layout plan of this linear facility is shown in Exhibit 22.

- The pond will have 3:1 side slopes and a bottom elevation of 252.60 m. At the bottom of the facility, its size will be approximately 100 m long and 2.5 m wide. The 100-year storage volume for this pond will be approximately 500 m^3.
- Roadway runoff will be conveyed by storm sewers and an OGS is provided for quality treatment before discharging to the grassed linear facility. Outflows from the SWM facility will discharge to the downstream side of Culvert C10.
- The OGS and vegetative linear facility together will provide quality treatment of the runoff and maintaining a treatment train approach.

Pond 11N:

- It is a grassed linear SWM facility located at Station 8+150 on the east side of Trafalgar Road.
- This facility is considered as an interim facility until such time when the future SWM facility of 'Vision Georgetown" is constructed.
- The facility will service 2.1 ha of the roadway corridor (Catchment 150-1) from approximately Station 8+080 to 8+560. The layout plan of this linear facility is shown in Exhibit 23.
- The pond will have 3:1 side slopes and a bottom elevation of 256.30 m. At the bottom of the facility, its size will be approximately 125 m long and 2 m wide. The 100-year storage volume for this pond will be approximately 500 m^3.
- Before discharging into this SWM facility, roadway runoff will be conveyed by grassed ditch, Enhanced grassed swale and bio-swale on the west side of the roadway and through a 750 mm diameter culvert, the storm runoff is directed to the SWM facility on the east side. Outflows from the SWM facility will be conveyed by approximately 50 m long ditch to Culvert C11.
- The grassed ditch, Enhanced grassed swale, bio-swale, vegetative linear facility and grassed ditch together in series will provide quality treatment of the runoff and maintaining a treatment train approach.

Pond 12N:

- It is a grassed linear SWM facility located at Station 8+750 on the east side of Trafalgar Road.
- This facility is considered as an interim facility until such time when the future SWM facility of 'Vision Georgetown" is constructed.
- The facility will service 1.9 ha of the roadway corridor (Catchment 155-1) from approximately Station 8+680 to 9+450. The layout plan of this linear facility is shown in Exhibit 24.
- The pond will have 3:1 side slopes and a bottom elevation of 261.50 m. At the bottom of the facility, its size will be approximately 125 m long and 2 m wide. The 100-year storage volume for this pond will be approximately 580 m^3.
- Before discharging into this SWM facility, roadway runoff will be conveyed by storm sewers and an OGS is provided for quality treatment before discharging to the grassed linear facility. Outflows from the SWM facility will discharge to the downstream side of Culvert C12.

- The OGS and vegetative linear facility together will provide quality treatment of the runoff and maintaining a treatment train approach.

SWM Facility 14S:

- It is a Super Pipe (pipe storage system) design located within the CNR underpass area.
- The facility will service the runoff of a 3.46 ha area of Catchments 225 and 230 from approximately Station 10+680 to 11+120. The layout plan of this facility is shown in Exhibit 27.
- Outflows from the SWM facility will discharge to Tributary 1 of Black Creek via storm sewers and an OGS will be provided for quality treatment before discharging the runoff into the watercourse.
- The Super Pipe system will be used to provide over control of the peak flows to balance the uncontrolled flows from Catchment 235 discharging to Tributary 1 of Black Creek.
- The storage pipe system will be extended 150 m long on each side of the sag, thus providing a total length of 300 m. The storage pipe system consists of 1830 mm x 910 mm concrete box at a slope of 0.65% from one end to the sag point. The invert elevation of the storage pipe facility at its outlet is 256.80 m. The 100-year storage volume for this facility is approximately 510 m^3.

6.4 Water Balance and Low Impact Development Measures

For the water balance and low impact development (LID) measures the following steps were considered:

- Maximum exposure of roadway runoff into the pervious areas;
- Implementation of Enhanced grassed swales; and
- Implementation of bio-swales.

This will allow both quality treatment of the roadway runoff and infiltration into the ground to provide water balance requirement. Table 18 and Table 19 list the locations where Enhanced grassed swales and bio-swales are proposed along the Trafalgar Road corridor. A comprehensive review of these water balance and LID measure will be carried out during the detailed design phase. Consultation with Landscape Architect will be carried out to refine the LID option.

6.5 Erosion and Sediment Control

At each watercourse crossing structure, erosion and sediment control best practices will be applied during construction to prevent sediment-laden runoff from entering the water course.

Two outlet pools will be provided at the proposed storm sewer outlets on the south side and north side of the Black Creek Bridge for erosion control.

The detailed design of outlet pools and other erosion and sediment control measures will be carried out during the detailed design phase.

7.0 CONCLUSIONS AND SUMMARY MATRIX

Based on the preceding assessments, the following conclusions can be made:

a) The Trafalgar Road Transportation Corridor Improvements study area is from Steeles Avenue to Highway 7 and it is located within the Sixteen Mile Creek watershed (Steeles Avenue to south of 15 Side Road) and Black Creek watershed (15 Side Road to Highway 7), under the jurisdiction of CH and CVC, respectively. The existing land use on both sides of Trafalgar Road is transition from mainly agriculture with some forest, meadow, and rural residential features in the south to semi-urban environment through Stewarttown and Georgetown. The predominant soil types in the study area are mostly sandy loam and silty loam and clay loam.

b) There are eighteen (18) culverts (Culverts C1 to C18) and one (1) bridge (Bridge B1) within the study area. Culverts C1 through C12 are located within CH jurisdiction (Steeles Avenue to south of 15 Side Road). Culverts C13 through C18 are located within CVC jurisdiction (15 Side Road to Highway 7). The majority of the culverts drain from west to east with the exception of Culverts C1 and C3 that drain from east to west and Culvert C2 that drains from north to south.

c) Trafalgar Road is proposed to be widened to four lanes from Steeles Avenue to Highway 7 with a 3 m wide multi-use path on the east side, sidewalk will be provided on the east side between 15 Side Road and Trafalgar Sports Park. On road bike lane (urban section) or paved shoulders (rural section) are provided for cyclists. Trafalgar Road would be a combination of urban-urban, urban-rural and rural-rural sections depending on existing and future adjacent land uses. Typical section is an urban section on the east side and a rural section on the west side.

d) Hydrologic Analysis:

- The hydrologic analysis was carried out using SWMHYMO hydrologic modelling.
- The rainfall hyetographs for 12-hour Chicago, 24-hour Chicago, 24-hour SCS, and the Regional Storm (Hurricane Hazel) were prepared from the rainfall IDF values provided in the Black Creek Hydrology Study Report. Approval was obtained from both CH and CVC for the use of the hyetographs.
- The 24-hour SCS storm distribution generated the highest flows at most culvert locations. Therefore, the flows obtained from the 24-hour SCS storm distribution were carried forward for the hydraulic analysis of the culverts. The hydrologic assessments, results and recommendation were reviewed by CVC and approval was obtained from CVC to use the 24-hour SCS storm distribution flows for hydraulic analysis.
- The flows for the Black Creek hydraulic modelling was provided in the Black Creek Hydrology Study Report obtained from CVC.

e) Hydraulic Analysis:

- Hydraulic modeling was undertaken using HEC-RAS for Culverts C1, C2, and C11 within the Sixteen Mile Creek watershed and Bridge B1 within the Black Creek watershed. The HEC-RAS hydraulic models were provided by CH for Culverts C1, C2 and C11 and by CVC for Bridge B1.
- CulvertMaster hydraulic modelling was used for the remaining crossing culverts.
- The hydraulic performance of existing and proposed crossing structures is summarized in Table 21 Summary Matrix.

f) Stormwater Management Strategy

- The stormwater management strategy for the Trafalgar Road corridor involves a two stage approach which consists of interim SWM facilities and ultimate SWM facilities.
  - **Interim SWM Approach**: A suitable temporary SWM approach was proposed in the area of the future Vision Georgetown Subdivision development site (between 10 Side Road and 15 Side Road, on the east side of Trafalgar Road). After the development of the Subdivision in the area, the interim SWM facilities should be integrated into the Subdivision's SWM plan. The Region, Town and the developer should have an agreement for the ultimate conditions SWM plan.
  - **Ultimate SWM Approach**: In the areas where there are no future development plans, ultimate SWM approach are proposed.
- A total of nine (9) SWM facilities are proposed to provide quality and quantity control for the roadway runoff. One (1) wet pond, seven (7) grassed lined, dry linear SWM facilities and one (1) pipe storage facility are proposed. In addition, Enhanced grassed swales and bio-swales are proposed for quality treatment as well as water balance. Oil and grit separators will be provided to provide quality treatment at seven (7) locations where roadway runoff will be conveyed by storm sewers.
- Three pipe culverts are required for the stormwater management. Two pipe culverts are required to direct the roadway runoff to Pond 2N and one pipe culvert is required to direct the roadway runoff to Pond 11N.
- Tables 18 and 19 provide the list of the proposed SWM components; Table 20 provides the characteristics of each SWM facility. The proposed SWM components are also summarized in Table 21 Summary Matrix.

g) Summary Matrix

Table 21 is a Summary Matrix. The Summary Matrix provides the characteristics of the existing culverts and their hydraulic performance, proposed culverts and their hydraulic performance and lists the SWM components, functions and characteristics proposed for the roadway runoff.

Table 20: Summary Matrix

Culvert ID	Station	Drainage Area (ha)	Existing Conditions					Proposed Conditions						
			Size (mm)	Type / Material	U/S Invert (m)	D/S Invert (m)	Hydraulic Criteria	Status	Size (mm)	Type / Material	U/S Invert (m)	D/S Invert (m)	Hydraulic Criteria / SWM Notes	Fluvial Interest
16 Mile Creek Watershed, Conservation Halton Jurisdiction														
C1	0+400	89.3	3050 x 2450	Single cell box culvert	201.360	201.240	- Meets freeboard. - No overtopping.	Needs to extend from 28.1 m to 36 m	3050 x 2450	Box Culvert Concrete	201.370	201.200	- Meets freeboard. - No overtopping during the Regional Storm flow. - Runoff quantity control is not required. - Runoff quality control by Enhanced grassed swale and bio-swale.	**Yes**
C2	1+080	714.0	2750 x 2250 (x2)	Double cell box culvert	200.060	199.960	- Meets freeboard. - Trafalgar Rd. overtops by 0.40 m during the Regional flow.	Needs to extend from 36.4 m to 53.7 m. To avoid overtopping, an addition cell of size 3.0 m span x 2.4 m rise open footing structure is proposed. Inverts be lowered by 0.15m for low flow .	2750 x 2250 (x2) Additional cell of size 3000 mm x 2400 mm, open footing	Concrete Box culvert (Existing) and Concrete Open Footing for new cell	200.100	199.900	- Meets freeboard. - No overtopping during the Regional Storm flow after the addition of another cell The added cell will be an open footing structure with low flow channel. - Runoff quantity control by two SWM facilities - 2N and 2S - Runoff quality control by two SWM facilities and Enhanced grassed swale and bio-swale. - Two pipe culverts are required to direct the storm runoff to Pond 2N.	**Yes**
C3	2+755	5.73	500 mm diameter	Circular, CSP	233.260	232.210	- Fails to meet freeboard. - Overtops road during the design, 100-year, and Regional Storm flows.	Replace	750 mm diameter	Circular, Concrete	233.000	232.210	- Meets freeboard. - No overtopping during the Regional Storm flow. - Runoff quantity control by dry SWM facility 3N. - Runoff quality control by Enhanced grassed swales and bio-swale.	**No**
C4	3+506	0.82	600 mm diameter	Circular, CSP	244.060	244.020	n/a	C4 will be eliminated under proposed conditions						
C5	4+068	5.72	600 mm diameter	Circular, CSP	241.240	240.930	- Meets freeboard. - No overtopping.	Replace (Existing culvert is corroded and face damaged)	600 mm diameter	Circular, Concrete	241.240	240.930	- Meets freeboard. - No overtopping during the Regional Storm flow. - Runoff quality control by Enhanced grassed swales and bio-swale. - Quantity control for the tributary is achieved via SWM Pond 2N.	**No**
C6	4+228	24.5	900 mm diameter	Circular, CSP	241.070	240.420	- fails to meet freeboard - Overtops road during the Regional Storm flow by 0.14 m.	Replace	975 mm diameter	Circular, Concrete	241.070	240.420	- Meets freeboard. - No overtopping during the Regional Storm flow. - Runoff quality control by Enhanced grassed swales and bio-swale. - Quantity control for the tributary is achieved via SWM Pond 2N.	**No**
C7	4+950	25.6	1400 x 900	Arch CSP	245.390	245.270	- Fails to meet freeboard. - Overtops road during the Regional Storm flow by 0.09 m.	Replace	2130 x 1220 mm (300 mm embedded)	Box, Concrete	245.400	245.250	- Meets freeboard. - No overtopping during the Regional Storm flow. - Runoff quality control by Enhanced grassed swales and bio-swale. - Quantity control for the tributary is achieved via SWM Pond 2N.	**No**
C8	6+266	12.2	600 mm diameter	Circular, CSP	253.590	253.520	- Fails to meet freeboard. - Overtops road during the design, 100-year, and Regional Storm flows.	Replace	1530 mm x 1220 mm (500 mm needs to embed to maintain cover)	Box, Concrete	253.450	253.350	- Available freeboard is 0.67 m for the design flow. - No overtopping during the Regional Storm flow. A 0.39 m of freeboard still available for the Regional storm flow. - Runoff quantity control by a linear SWM facility 8S. - Runoff quality control by grassed linear facility, Enhanced grassed swales and bio-swale.	**No**
C9	6+852	30.2	900 mm diameter	Circular, CSP	251.000	250.830	- Fails to meet freeboard - Overtops road during the design, 100-year, and Regional Storm flows.	Replace	1830 x 910 mm Open Footing structure	Concrete, Open Footing	251.000	250.830	- Meets freeboard. - No overtopping during the Regional Storm flow. - Runoff quantity control by a linear SWM facility 9S. - Runoff quality control by grassed linear facility, Enhanced grassed swales, bio-swale and OGS. - Consideration to integrate with the future SWM pond of Vision Georgetown.	**Yes**
C10	7+285	46.4	700 mm diameter	Circular, CSP	252.320	252.240	- Fails to meet freeboard requirement. - No overtopping of Trafalgar Rd. - Spills from drive way and flows toward C9.	Replace	2130 mm x 1220 mm (300 mm embedded)	Box, Concrete	252.320	252.240	- Meets freeboard. - No overtopping during the Regional Storm flow. - Runoff quantity control by a linear SWM facility 10N - Runoff quality control by grassed linear facility, Enhanced grassed swales, bio-swale and OGS. - Consideration to integrate with the future SWM pond of Vision Georgetown.	**No**

Table 20: Summary Matrix

Culvert ID	Station	Drainage Area (ha)	Existing Conditions					Proposed Conditions						
			Size (mm)	Type / Material	U/S Invert (m)	D/S Invert (m)	Hydraulic Criteria	Status	Size (mm)	Type / Material	U/S Invert (m)	D/S Invert (m)	Hydraulic Criteria / SWM Notes	Fluvial Interest
C11	7+927	136.0	750 mm diameter	Circular, CSP with HDPE Liner	255.490	255.310	- Fails to meet freeboard. - Overtops road during the 5-year to the Regional Storm flows.	Replace	3050 mm x 1530 mm Open Footing structure	Concrete, Open Footing	255.000	254.900	- Meets freeboard. - No overtopping during the Regional Storm flow. - Runoff quantity control by a linear SWM facility 11N - one pipe culverts is required to direct the storm runoff to Pond 11N - Runoff quality control by grassed linear facility and Enhanced grassed swale and bio-sale. - Consideration to integrate with the future SWM pond of Vision Georgetown.	**Yes**
C12	8+635	39.3	900 mm diameter	Circular, CSP	260.740	260.420	- Fails to meet freeboard. - Overtops road during the design, 100-year and Regional Storm flows.	Replace	2130 x 910 mm Open Footing structure	Concrete, Open Footing	260.740	260.420	- Meets freeboard. - No overtopping during the Regional Storm flow. - Runoff quantity control by a linear SWM facility 12 N - Runoff quality control by grassed linear facility, Enhanced grassed swales, bio-swale and OGS. - Consideration to integrate with the future SWM pond of Vision Georgetown.	**Yes**
Black Creek Watershed, Credit Valley Conservation Jurisdiction														
B-1	9+940	7320	8.8 m opening	Bridge, Single span	n/a	n/a	- Fails to meet freeboard. - Fails to meet soffit clearance. - Overtops roadway by 0.93 m during the Regional Storm flow. - Length of roadway under the Regional flood is 133 m.	Replace	30 m clear opening	Bridge, Single span	n/a	n/a	- Meets freeboard requirement. - Meets soffit clearance requirement. - No overtopping during the Regional Storm flow. - Upstream water level under proposed conditions are lower than existing conditions. - No quantity control. - Quality treatment by two OGS on south- and north side of bridge. - Erosion control at storm sewer outlets by outlet pools.	**Yes**
C13	11+020	0.81	525 mm diameter	Circular, HDPE Liner	266.840	266.370	n/a	C13 will be eliminated under proposed conditions						
C14	11+145	53.9	900 mm diameter	Circular, CSP with HDPE Liner	267.920	267.640	- Fails to meet freeboard. - Overtops road during the design, 100-year and Regional Storm flows.	Replace	2130 mm x 1220 mm Open Footing structure	Concrete, Open Footing	267.450	267.200	- Meets freeboard. - No overtopping during the Regional Storm flow. - Quantity control not required. Flow balanced by providing over control in pipe storage facility proposed in underpass area. - Runoff quality control by Enhanced grassed swales and bio-swale. - Runoff quality control for the underpass area is provided by OGS.	**Yes**
C15	11+880	41.0	600 mm diameter	Circular, CSP with HDPE Liner	269.670	268.680	- Fails to meet freeboard. - Overtops road during the design, 100-year and Regional Storm flows.	Replace	1520 mm x 910 mm Open Footing structure	Concrete, Open Footing	269.670	268.680	- Meets freeboard. - No overtopping during the Regional Storm flow. - Quantity control not required., as runoff from the part of the roadway is directed to C14. - Runoff quality control by Enhanced grassed swales and bio-swale	**Yes**
S1	12+245	25.6	750 mm dia. Storm inlet	Circular, HDPE	272.090	n/a	n/a	Extend existing pipe by 20 m.	Maintained existing conditions flow or less.					**No**
C16	12+460	104.0	1800 mm diameter	Circular, CSP	269.480	269.290	- Existing culvert is in poor conditions. - Meets freeboard. - Overtops Trafalgar Road during the Regional Storm flow by 0.10m.	Replace	3050 mm x 1520 mm Open Footing structure	Concrete, Open Footing	269.400	269.200	- Meets freeboard. - No overtopping during the Regional Storm flow. - Quantity control not required. No flow increase. - Runoff quality control by grassed swales, bio-swales and OGS.	**Yes**
C17	12+780 **(Highway 7)**	18.7	900 mm diameter	Circular, CSP	274.460	273.500	- Fails to meet freeboard. - Overtops road during the Regional Storm flow by 0.20 m.	Replace	975 mm diameter	Circular, Concrete	274.460	273.500	- Meets freeboard. - No overtopping during the Regional Storm flow.	**No**
C18	20+100 **(20 Side Road)**	100.9	1800 mm diameter	Circular, CSP	270.500	270.000	- Existing culvert is in poor conditions. - Meets 0.30 m freeboard for the 10-yr design flow. - Overtops 20 Side Road during the Regional Storm flow by 0.39m.	Replace	3050 mm x 1520 mm Open Footing structure	Concrete, Open Footing	270.000	269.800	- Meets freeboard for the 10-year design flow. - Overtops 20 Side Road by 0.14 m only during the Regional Storm flow which is less than 0.30 m, therefore, acceptable.	**Yes**

8.0 RECOMMENDATION

Based on the preceding assessments and conclusion, the following implementations are recommended to support the Trafalgar Road Corridor Improvements at the detailed design stage:

- Culvert C1 be extended to approximately 36 m with the same 3050 mm x 2450 mm size;
- The existing twin cells of Culvert C2 be extended to approximately 54 m with same size. An additional 3000 mm x 2400 mm concrete open footing culvert is proposed to convey the Regional Storm flow without overtopping;
- Culvert C3 be replaced with a 750 mm diameter concrete pipe;
- Existing Culvert C4 be eliminated;
- Culvert C5 be replaced with a 600 mm diameter concrete pipe;
- Culvert C6 be replaced with a 975 mm diameter concrete pipe;
- Culvert C7 be replaced with a 2130 mm x 1220 mm concrete box culvert with 300 mm embedment;
- Culvert C8 be replaced with a 1530 mm x 1220 mm concrete box culvert with 500 mm embedment;
- Culvert C9 be replaced with an 1830 mm x 910 mm concrete open footing structure.
- Culvert C10 be replaced with a 2130 mm x 1220 mm concrete box culvert with 300 mm embedment;
- Culvert C11 be replaced with a 3050 mm x 1530 mm concrete open footing structure with a low flow channel;
- Culvert 12 will replaced with a 2130 mm x 910 mm concrete open footing structure;
- The Black Creek Bridge B1 be replaced with a single span bridge of 30 m clear perpendicular opening.
- Existing Culvert C13 be eliminated;
- Culvert 14 be replaced with a 2130 mm x 1220 mm concrete open footing structure;
- Culvert 15 be replaced with a 1520 mm x 910 mm concrete open footing structure;
- Culvert 16 be replaced with a 3050 mm x 1520 mm concrete open footing structure;
- Culvert 17 be replaced with a 975 mm concrete pipe culvert;
- Culvert 18 be replaced with a 3050 mm x 1520 mm concrete open footing structure;
- A total of nine (9) SWM facilities consisting of one (1) wet pond, seven (7) grassed lined, dry linear SWM facilities, and one (1) pipe storage facility be implemented to provide quality and quantity control for the roadway runoff;

- Enhanced grassed swales and bio-swales be implemented for additional quality treatment as well as water balance at different locations as provided in Tables 18 and 19;
- Oil and grit separators be provided at seven (7) locations to provide quality treatment where the roadway runoff is conveyed by storm sewers; and
- Two outlet pools be provided at new storm sewer outlet locations immediately north and south side of Black Creek Bridge.

All of which is respectfully submitted,

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