Appendix E.7
Drainage and Stormwater Management Report

Region of Peel

Highway 50 and Mayfield Road Class EA Drainage and Stormwater Management Report

Peel Region, ON

June 2012

Region of Peel

Highway 50 and Mayfield Road Class EA Drainage and Stormwater Management Report

Peel Region, ON

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HDR | iTRANS
144 Front Street West, Suite 655
Toronto, ON M5J 2L7
Tel: (416) 847-0005
Fax: (905) 882-1557
www.hdrinc.com
www.itransconsulting.com

Project # 4956

HDR | iTRANS Project Team

Principal / Project Manager	Stephen Keen, P.Eng
Technical Team	Anthony Reitmeier, P.Eng. Larry Lamontagne, Dipl. T.

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1. INTRODUCTION

1.1 Study Area

As part of the Region of Peel's Capital Works Program, the Region is undertaking a Class Environmental Assessment for the Highway 50 widening from Castlemore Road / Rutherford Road to Mayfield Road / Albion-Vaughan Road, and Mayfield Road between Highway 50 and Coleraine Drive. The Study Area is shown in **Exhibit 1-1.**

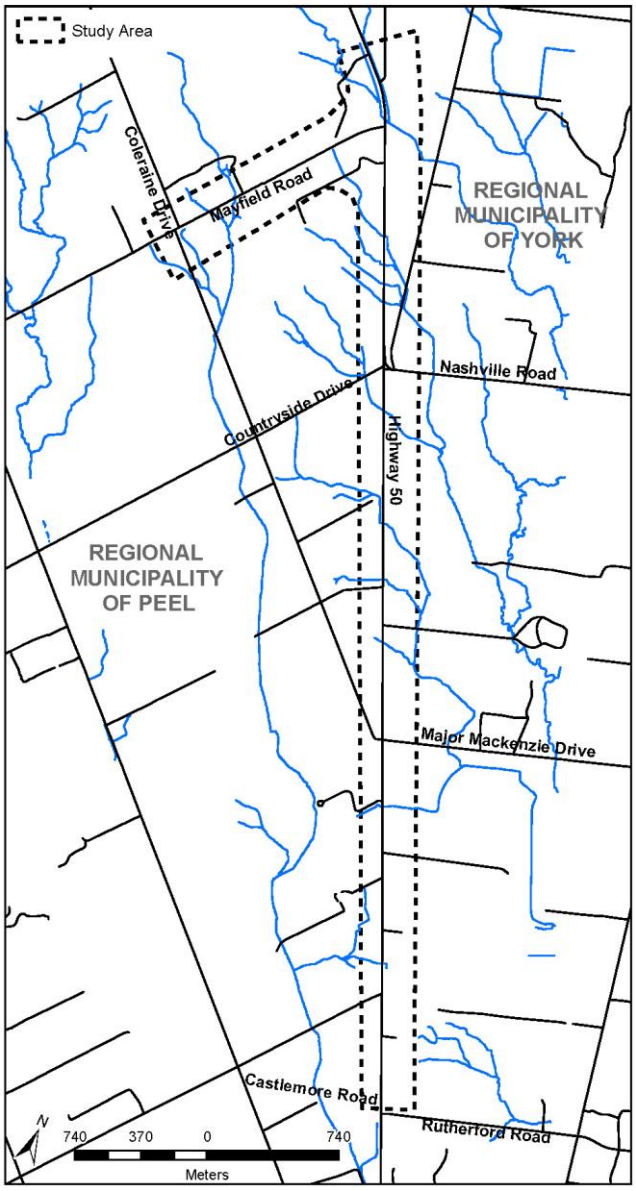


Exhibit 1-1: Key Plan

1.2 Background

The roadway improvements under investigation include widening Highway 50 to three lanes in each direction with a raised median, and widening Mayfield Road to two lanes in each direction with a centre median. This would be accomplished by adding an additional lane along the outside of each existing traffic lane for both roads. An urban roadway cross section with curb and gutter, sidewalk and boulevard will be provided given property and environmental constraints, and Regional practices.

The purpose of this Drainage and Stormwater Management Study is to develop a stormwater management plan for the Highway 50 and Mayfield Road widening Class Environmental Assessment project that will address both water quantity and quality issues by incorporating Best Management Practices (BMPs). In essence, the Stormwater Management Study was carried out with the view of minimizing the potential impacts of the proposed road widening on the natural environment, while ensuring an adequate roadway drainage system is incorporated as part of the overall improvements.

1.3 Objectives of Drainage and SWM Study

The objectives of the stormwater management study are to develop a strategy for the project that will:

- Identify potential stormwater runoff (quality and quantity) impacts to the receiving watercourses from the proposed new paved area.
- Address concerns from the review agencies including the Region of Peel, City of Brampton, City of Vaughan, Toronto and Region Conservation Authority (TRCA), Ministry of Natural Resources (MNR), as well as the development community, and any public interest groups.
- Provide an appropriate pavement drainage system for roadway operation and safety.

2. BACKGROUND INFORMATION

2.1 Background Information

A field investigation with the participation of TRCA, Peel Region, LGL and HDR | iTRANS staff was conducted on December 3, 2009 to identify watercourse crossings along Highway 50 and Mayfield Road. In addition, previous studies and reports relating to hydrology, hydraulics, stormwater management and adjacent development plans were obtained from the appropriate sources and reviewed, and are listed as follows:

Reference Documents for Drainage and Stormwater Study

MacViro Consultants Inc. & R.J. Burnside & Associates Limited

- Drainage and Stormwater Management Report for Regional Road 50 Widening Class Environmental Assessment from Steeles Avenue to Castlemore Road, Regional Municipalities of Peel and York, March 2005.

A.M. Candaras Associates Inc.

- Functional Study Report for Regional Road 50 & Mayfield Road Business Park, Bolton, Town of Caledon, December, 2005.

Candevcon Limited

- Stormwater Management Report, Application for Site Plan Approval for Automotive Dealership Facility, Highway 50 and Albion-Vaughan Road Part of Lot 1, Concession 7, Bolton, Ontario, February, 2004.

Chisholm, Fleming and Associates

- Mayfield Road / Albion-Vaughan Road and Highway 50 Intersection Improvement, Environmental Study Report-Class EA Schedule 'B', prepared November 2007.
- Storm Water Management Report, Commuter Parking Lot, Highway 50 and Mayfield Road, Brampton / Caledon, prepared July 2008.
- HEC-RAS model, updated September 2008
- Email conversation regarding assessment of major and minor storms on the Roadway and Commuter Parking Lot, January 2009.

LGL Limited, Environmental Research Associates

- Natural Heritage Report Existing Conditions, Highway 50 from Castlemore Road to Mayfield Road, Mayfield Road from Highway 50 to Coleraine Drive, Municipal Class Environmental Assessment Study, January 2010.

Marshall Macklin Monaghan Limited

- Plan of Survey of Part of Broken Lot 17, Concession 12 Northern Division, Drawing No. 20-09-042-001, October 2009.

Read, Voorhees & Associates

- Regional Road 50 / Mayfield Road, Carpool & Transit Lot, prepared by Read, Voorhees & Associates, February 2008.

Stantec Consulting Limited

- Bolton / Brampton Sanitary Trunk Sewer Twinning Environmental Study Report, December 2005.

Toronto Region Conservation Authority (TRCA)

- TRCA Floodplain and Regulation Limit mapping, Sheets 150, 151, 152, 154, 155, and 157, June 2006.
- HEC-RAS model, updated April 2008.

2.2 Land Use

The existing land use in the vicinity of the study area is primarily agricultural, rural residential, and industrial / commercial.

Previous studies indicate an increase in residential, business and industrial developments within the general study area, resulting in traffic growth pressures.

2.3 Watershed Descriptions

The study area is located in the Humber River watershed (Main Humber River subwatershed, Rainbow Creek and Robinson Creek secondary subwatersheds; TRCA 2008). The watercourses within the study limits are tributaries of Robinson Creek and Rainbow Creek which fall under the jurisdiction of the Toronto and Region Conservation Authority (TRCA) and the Ministry of Natural Resources (MNR) Aurora District.

2.3.1 Rainbow Creek

The Rainbow Creek Watershed is located within the Regional Municipalities of Peel and York, and is within the jurisdiction of the TRCA.

West Rainbow Creek originates in the Mayfield Road / Coleraine Drive area. The watercourse is a culturally influenced, second order tributary of Rainbow Creek that flows across primarily agricultural lands. Woody riparian cover is sparse and scattered. Substrates tend to include larger materials such as gravel and cobble.

East Rainbow Creek originates in the Coleraine Drive area just south of Countryside Drive. It is a culturally influenced, second order tributary of Rainbow Creek that flows across primarily agricultural lands. The watercourse appears to have been modified (straightened) in some reaches, and has been significantly realigned and straightened around the CPR

Vaughan Intermodal Facility south of Major Mackenzie Drive. Woody riparian cover is sparse and scattered.

2.3.2 Robinson Creek

The Robinson Creek Watershed is primarily located within York Region whereas the upper part of West Robinson Creek originates in the Region of Peel, and is within the jurisdiction of the TRCA. This watercourse has numerous first order headwater streams that generally coalesce between Nashville Road and Major Mackenzie Drive to form West Robinson Creek. Robinson Creek merges with Rainbow Creek at Rainbow Creek Park in Woodbridge, north of Regional Road 7 and east of Martin Grove Road. According to the mapping presented in the Humber River Fisheries Management Plan (OMNR & TRCA 2005), three first order streams cross Mayfield Road on either side of the Highway 50 intersection (two in the northwest and one in the northeast) and converge approximately 75 m to the south where the watercourse flows in a generally south-easterly direction.

2.4 Fisheries

The watercourses in this project's study area are considered to be small riverine warmwater habitat, and are managed for darter species (OMNR & TRCA 2005). No fish species at risk have been reported from the watercourses within the study area. The habitat in the vicinity of the intersection supports a warmwater baitfish community.

2.4.1 Rainbow Creek

The main stem of Rainbow Creek commences at the confluence of West and East Rainbow Creeks just east of Huntington Road between Langstaff Road and Rutherford Road. This intermittent watercourse has retained its natural channel form and the TRCA regards it as warmwater habitat.

2.4.2 Robinson Creek

The main stem of Robinson Creek commences at the confluence of West and East Robinson Creeks just west of Regional Road 27 and south of Rutherford Road. This intermittent watercourse contains Darter Species and the TRCA regards it as a warmwater habitat.

2.4.3 Species at Risk

No aquatic species at risk are known to inhabit the watercourses within this study area. However, all watercourses / drainage features located within the study area (with the exception of Site 1) convey flows to Redside Dace habitat downstream, a fact that should be considered when designing erosion and sediment controls to protect downstream habitats during construction. Redside Dace are ranked as 'Endangered' both provincially and federally. This species is regulated as 'Endangered' under the Ontario *Endangered Species*

Act, 2007. Federally, Redside Dace is designated as 'Endangered' by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), but is regulated as 'Special Concern' (Schedule 3) under the federal *Species at Risk Act*. The MNR manages fish habitat, in concert with the TRCA under Fisheries Management Plans, and provides direction in the classification of watercourses as warmwater, coldwater and / or Redside Dace habitat.

3. HIGHWAY 50 AND MAYFIELD ROAD SURFACE DRAINAGE SYSTEM

3.1 Existing Drainage Conditions

The study area covers a distance of approximately 5.0 km of Highway 50 from Castlemore Road / Rutherford Road to Mayfield Road / Albion-Vaughan Road, and another 1.4 km on Mayfield Road between Highway 50 and Coleraine Drive. Within this corridor, the existing Highway 50 consists of two lanes in each direction with a continuous center left turn lane and a combination of granular and paved shoulders. Highway 50 is classified as a rural arterial road. Mayfield Road is also classified as a rural arterial road with one lane in each direction with granular shoulders.

The existing Highway 50 and Mayfield Road drainage system consists primarily of open roadside ditches, cross culverts and local storm sewer systems that convey runoff into the receiving watercourses. All watercourses within the Study Area are part of the Humber River watershed, which is under the jurisdiction of the TRCA.

There are a total of 19 transverse crossing culverts including 4 intersection culverts. There exists an additional 40 entrance culverts within the study limits. The location of the transverse culverts is shown schematically on **Exhibits 3-1** to **3-9**. **Exhibits 3-10** to **3-13** represent the external areas draining to all Highway 50 transverse culverts..These external drainage areas are based on delineations done on a 1:10,000 scale Ontario Base Mapping in combination with contour mapping. Figure 4 from the Master Environmental Servicing Plan illustrates the external drainage areas tributary to the three Mayfield Road crossings (Crossings 15-17). This figure can be found in **Appendix A**

The existing drainage conditions for Highway 50 and Mayfield Road are summarized below in **Tables 3-1** and **3-2** respectively.

Table 3-1: Summary of Existing Drainage Conditions for Highway 50

Location and Roadway Drainage Limits	Particulars
Culvert#1 Hwy 50 Sta. (7+104) Station 6+870 to Station 7+830	▪ NBL drainage drains southerly via open ditches; outlets to a 750 mm diameter CSP cross culvert. ▪ The 750 mm diameter CSP culvert also conveys external flows from east of Highway 50. ▪ The hydraulic assessment of the culvert shows that under the 50 year design storm, the 750 mm diameter CSP culvert does not meet the 1.0 m. freeboard requirement; Solution would be to upgrade the culvert to meet the hydraulic criteria, or reduce subcatchment area by diverting flows.

Location and Roadway Drainage Limits	Particulars
Culvert#2 Hwy 50 Sta. (7+810) Station 7+830 to Station 8+000	▪ SBL drainage drains southerly via open ditches; outlets to an 800 mm diameter CSP cross culvert. ▪ The 800 mm diameter CSP culvert also conveys external flows from west of Highway 50. ▪ The 800 mm diameter CSP culvert should be flushed / cleaned and the ends should be re-shaped.
Culvert#3 Hwy 50 Sta. (7+980) Station 8+000 to Station 8+360	▪ SBL drainage from station 8+360 drains southerly via open ditches; outlets to a 600mm diameter CSP culvert and then into an 800 mm diameter CSP cross culvert. ▪ The 800 mm diameter CSP culvert also conveys external flows from west of Highway 50. ▪ The 800 mm diameter CSP culvert appears in good condition; however, the culvert should be flushed / cleaned.
Culvert#4 Hwy 50 Sta. (8+333) Station 8+360 to Station 8+900	▪ SBL drainage from station 8+900 drains southerly via open ditches and a series of smaller CSP entrance culverts; outlets to a 1.3 x 1.85 m box culvt. ▪ The 1.3 x 1.85 m box culvert also conveys external flows from west and east of Highway 50. ▪ The 1.3 x 1.85 m box culvert appears in good condition; however, the culvert should be flushed / cleaned.
Culvert#5 Hwy 50 Sta. (8+632) Station 8+900 to Station 8+810	▪ NBL drainage from station 8+810 drains southerly via open ditches; outlets to an 800 mm CSP cross culvert. ▪ The 800 mm CSP culvert also conveys external flows from east of Highway 50. ▪ The 800mm CSP culvert appears in good condition; however, the culvert should be flushed / cleaned.
Culvert#6 Hwy 50 Sta. (8+895) Station 8+900 to Station 9+270	▪ SBL drainage from station 9+270 drains southerly via open ditches; outlets to a 1.0m CSP cross culvert. ▪ The 1.0m CSP culvert also conveys external flows from west of Hwy 50. ▪ The 1.0m CSP culvert appears in good condition, however, the culvert should be flushed / cleaned.
Culvert#7 Hwy 50 Sta. (9+249) Station 9+270 to Station 9+580	▪ SBL drainage from station 9+580 drains southerly via open ditches; outlets to a 0.8 x 1.85 m box culvert. ▪ The 0.8 x 1.85m box culvert also conveys external flows from west of Highway 50. ▪ The 0.8 x 1.85m box culvert appears in good condition; however, the culvert should be flushed / cleaned.
Culvert#8 Hwy 50 Sta. (9+562) Station 9+580 to Station 10+200	▪ SBL drainage from 10+200 drains southerly via open ditches; outlets to 0.8 x 1.85 m box culvert. ▪ The 0.8 x 1.85 m box culvert also conveys external flows from west of Highway 50. ▪ The hydraulic assessment of the culvert shows that under the 50 year design storm, the 0.8 x 1.85 m box culvert marginally fails to meet the 1.0 m freeboard requirement; Solution would be to upgrade the culvert to meet the hydraulic criteria, reduce subcatchment area by diverting flows or

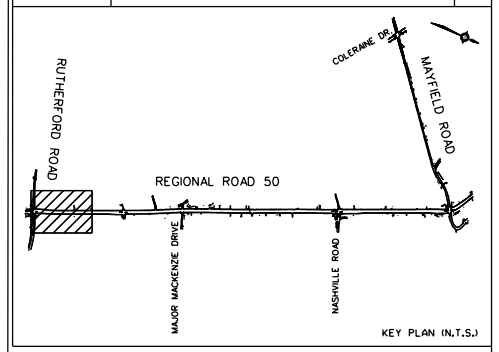
Location and Roadway Drainage Limits	Particulars
	accept the marginal freeboard deficiency. ▪ The box culvert appears in good condition; however, the culvert should be flushed / cleaned.
Culvert#9 Hwy 50 Sta. (10+197) Station 10+200 to Station 10+630	▪ SBL drainage from 10+630 drains southerly via open ditches; outlets to twin 1.35 m diameter CSP culvert. ▪ The twin 1.35m diameter CSP culvert also conveys external flows from west of Highway 50. ▪ The twin 1.35 m CSP culvert appears in good condition.
Culvert#10 Hwy 50 Sta. (10+798) Station 10+630 to Station 10+900	▪ SBL drainage from station 10+900 drains southerly via open ditches; outlets to a twin 700 mm diameter CSP culvert located at station 10+825. ▪ The twin 700 mm CSP culvert also conveys external flows from west of Highway 50. ▪ The ends of the 700 mm twin CSP culvert is severely rusted and have eroded away. ▪ The hydraulic assessment of the culverts show that under the 50 year design storm, the twin 700 mm diameter CSP culvert does not meet the 1.0 m freeboard requirement; Solution would be to upgrade the culvert to meet the hydraulic criteria, or reduce subcatchment area by diverting flows.
Culvert#11 Hwy 50 Sta. (10+905) Station 10+900 to Station 11+040	▪ SBL drainage from station 11+030 drains southerly via open ditches; outletting to a twin 600 mm diameter CSP culvert located at stn 10+930. ▪ The twin 600 mm CSP culvert also conveys external flows from west of Highway 50. ▪ The ends of the 600 mm twin CSP culvert is severely rusted and have eroded away. ▪ The hydraulic assessment of the culverts show that under the 50yr design storm, the twin 600 mm diameter CSP culvert does not meet the 1.0m freeboard requirement; Solution would be to remove the culvert and replace with a larger size, or reduce subcatchment area by diverting flows.
Culvert#12 Hwy 50 Sta. (11+012) Station 11+040 to Station 11+200	▪ SBL drainage from station 11+200 drains southerly via open ditches; outlets to a twin 700 mm diameter CSP culvert located at station 11+030. ▪ The twin 700 mm CSP culvert also conveys external flows from west of Highway 50. ▪ The twin 700 mm CSP culvert appears in good condition, however, the culvert should be flushed / cleaned.
Culvert#13 Hwy 50 Sta. (11+132) Station 11+200 to Station 11+635	▪ SBL drainage from station 11+635 drains southerly via open ditches; outlets to a twin 0.9 x 1.4 m elliptical CSP culvert located at station 11+200. ▪ The twin 0.9 x 1.4 m elliptical CSP culvert also conveys external flows from west of Highway 50. ▪ The twin 0.9 x 1.4 m elliptical CSP culvert appears in good condition; however, the culvert should be flushed / cleaned.
Culvert#14 Hwy 50 Sta. (11+832)	▪ An existing 1.5 x 3.5 m box culvert conveys flows from both the road and external upstream areas. ▪ The 1.5 x 3.5 m box culvert appears to be in good condition.

Table 3-2: Summary of Existing Drainage Conditions for Mayfield Road

Location	Particulars
Culvert#15 Mayfield Rd. Sta. (20+218)	▪ EBL drainage drains westerly via open ditches; outlets through a 900 mm CSP located at a central location. ▪ Under the 50 year design storm, the CSP culvert fails to meet the 1.0 m freeboard requirement; Solution would be to replace the culvert with a larger one, or by providing a relief culvert adjacent to the existing culvert.
Culvert#16 Mayfield Rd. Sta. (20+367)	▪ EBL drainage drains westerly via open ditches; outlets through a 1200 mm CSP located at a central location. ▪ Under the 50 year design storm, the CSP culvert fails to meet the 1.0 m freeboard requirement; Solution would be to replace the culvert with a larger one, or by providing a relief culvert adjacent to the existing culvert.
Culvert#17 Mayfield Rd. Sta. (20+984)	▪ EBL drainage drains westerly via open ditches; outlets through a 1200 mm CSP located at a central location at station 20+982. ▪ Under the 50 year design storm, the CSP culvert fails to meet the 1.0 m freeboard requirement; Solution would be to replace the culvert with a larger one, or by providing a relief culvert adjacent to the existing culvert.
Culvert#18 Mayfield Rd. Sta. (21+340)	▪ An existing 1.25 x 2.5 m box culvert conveys flows from both the road and external upstream areas. ▪ Under the 50 year design storm the box culvert fails to meet the 1.0 m freeboard requirement.
Culvert#19 Mayfield Rd. Sta. (21+387)	▪ An existing 1.5 x 4.5 m box culvert conveys flows from both the road and external upstream areas and provides a 1.15 m freeboard for the 50 year design storm.

SERVICE DATA					
SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN SEWERS			GAS MAINS		
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS		
DATE	DETAILS	INIT.



KEY PLAN (N.T.S.)

CASTLEMORE

CASTLEMORE DRIVE

CULVERT 1
0.750Ø CULVERT
INV=206.73

INV=206.94

HIGHWAY 50

HIGHWAY 50

RUTHERFORD ROAD

1A
3.19

REFER TO EXHIBIT 3.11 FOR
DRAINAGE CATCHMENT BOUNDARY

LEGEND

1A
5.5 — CULVERT/CATCHMENT ID; AREA (ha)

EXISTING DITCH

EXISTING CULVERT

FLOW DIRECTION

10m 0 10 20 30m HORIZONTAL SCALE

Region of Peel
Working for you

REGIONAL ROAD 50

EXISTING DRAINAGE CONDTIONS
FROM CASTLEMORE DR TO MAYFIELD RD
FROM STA. 6+400 TO STA. 7+150

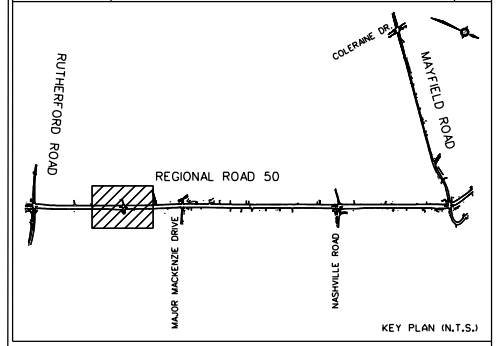
CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 3-1

SERVICE DATA

SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN SEWERS			GAS MAINS		
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS

DATE	DETAILS	INIT.



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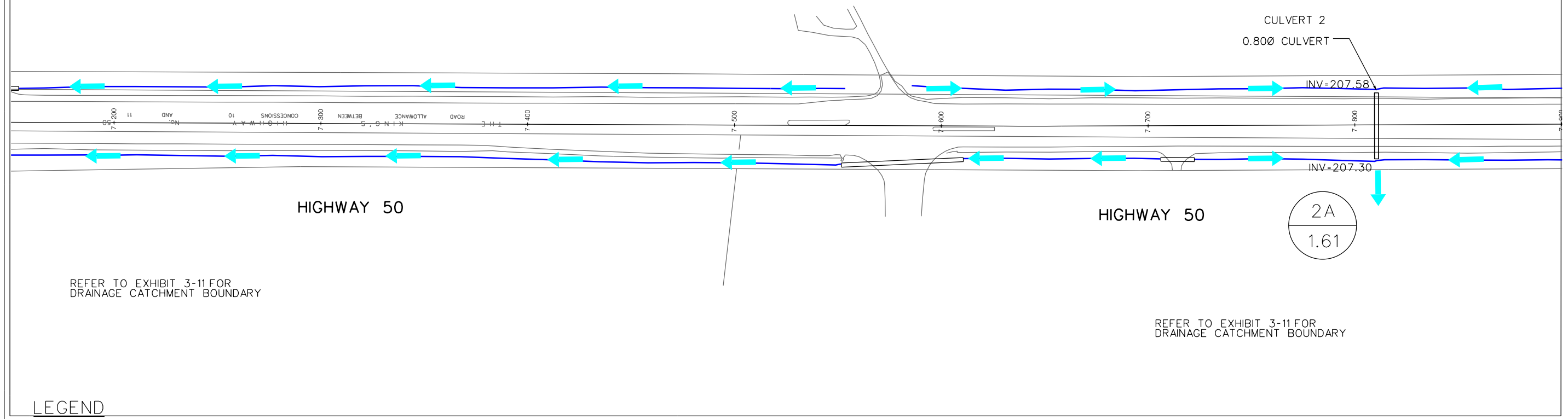

LEGEND

1A / 5.5 — CULVERT/CATCHMENT ID; AREA (ha)

EXISTING DITCH

EXISTING CULVERT

FLOW DIRECTION

10m 0 10 20 30m HORIZONTAL SCALE

Region of Peel
Working for you

REGIONAL ROAD 50

EXISTING DRAINAGE CONDTIONS
FROM CASTLEMORE DR TO MAYFIELD RD
FROM STA. 7+150 TO STA. 7+900

CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	Plan No. EXHIBIT 3-2
Date MARCH 2011	Sheet	

SERVICE DATA					
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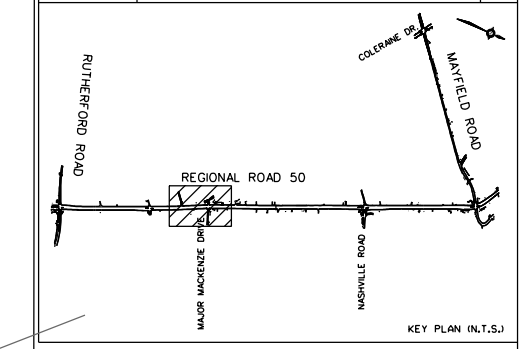
SAN SEWERS			GAS MAINS		
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS		
DATE	DETAILS	INIT.



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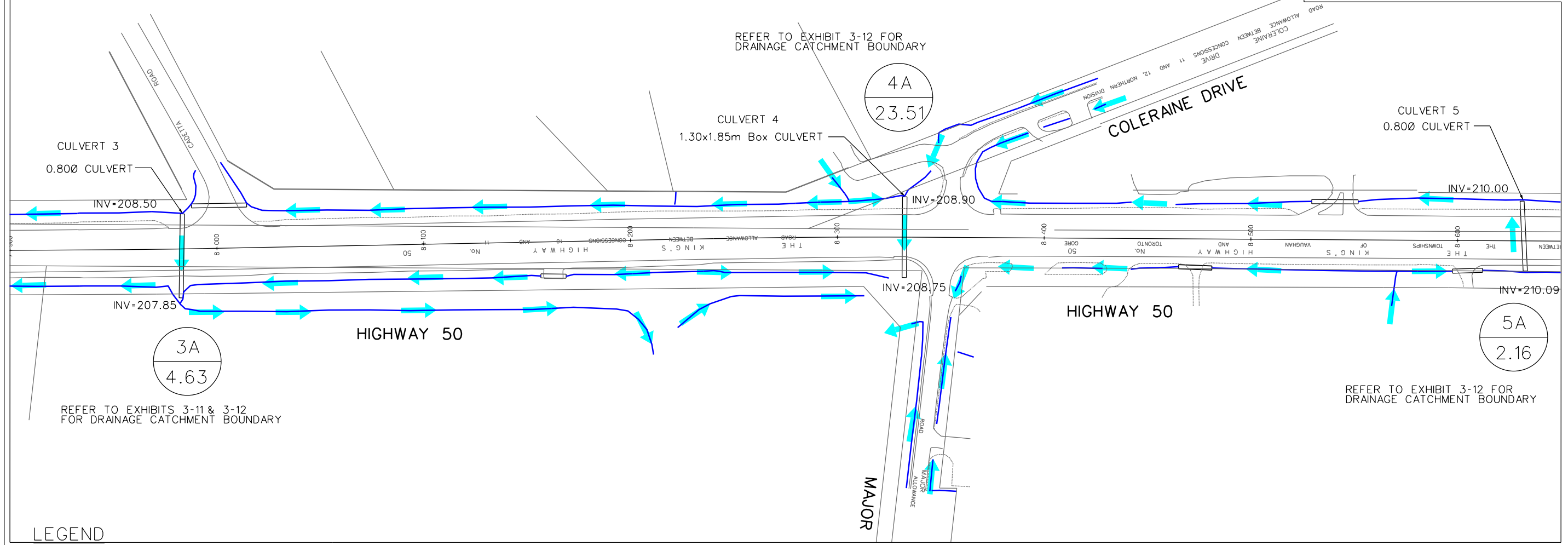

LEGEND

1A / 5.5 — CULVERT/CATCHMENT ID / AREA (ha)

EXISTING DITCH

EXISTING CULVERT

FLOW DIRECTION

10m 0 10 20 30m HORIZONTAL SCALE

Region of Peel
Working for you

REGIONAL ROAD 50

EXISTING DRAINAGE CONDTIONS
FROM CASTLEMORE DR TO MAYFIELD RD
FROM STA. 7+900 TO STA. 8+650

CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 3-3

SERVICE DATA					
SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
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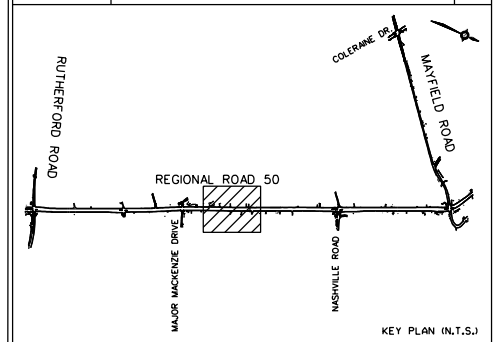
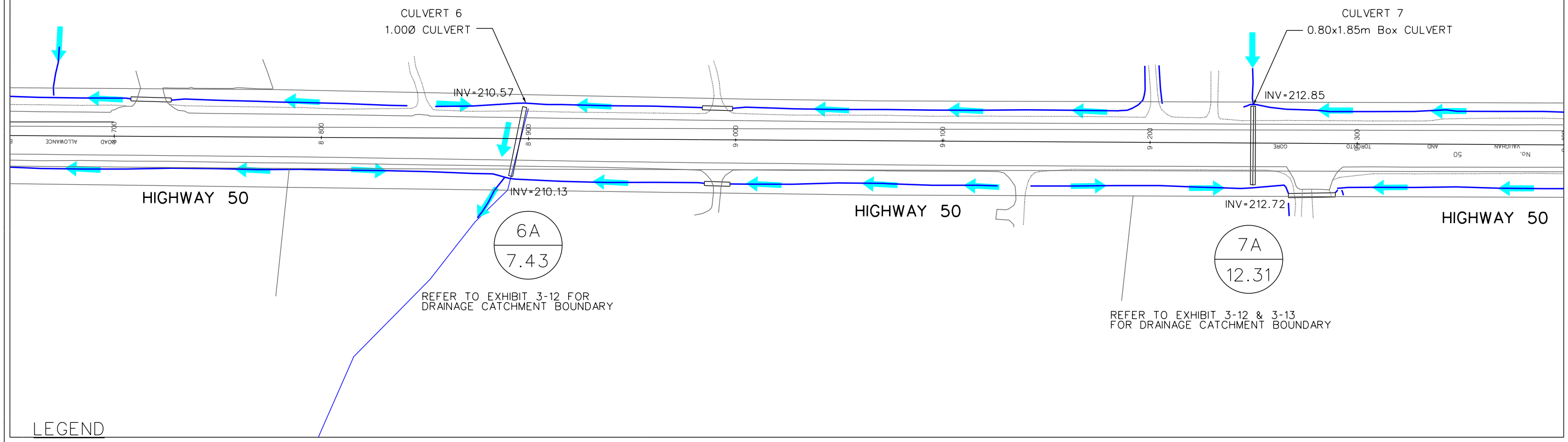
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS		
DATE	DETAILS	INIT.



KEY PLAN (N.T.S.)



LEGEND

1A / 5.5 — CULVERT/CATCHMENT ID; AREA (ha)

EXISTING DITCH

EXISTING CULVERT

FLOW DIRECTION

10m 0 10 20 30m HORIZONTAL SCALE

Region of Peel
Working for you

REGIONAL ROAD 50

EXISTING DRAINAGE CONDTIONS
FROM CASTLEMORE DR TO MAYFIELD RD
FROM STA. 8+650 TO STA. 9+400

CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 3-4

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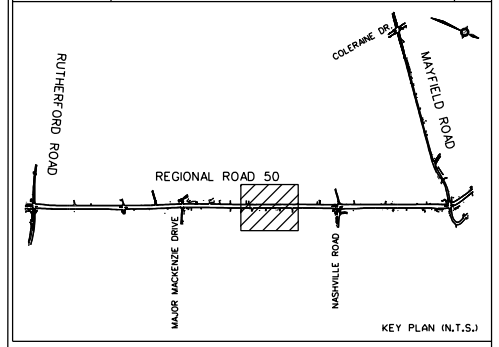
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS		
DATE	DETAILS	INIT.



KEY PLAN (N.T.S.)

LEGEND

1A / 5.5 — CULVERT/CATCHMENT ID; AREA (ha)

EXISTING DITCH

EXISTING CULVERT

FLOW DIRECTION

10m 0 10 20 30m HORIZONTAL SCALE

Region of Peel
Working for you

REGIONAL ROAD 50

EXISTING DRAINAGE CONDTIONS
FROM CASTLEMORE DR TO MAYFIELD RD
FROM STA. 9+400 TO STA. 10+150

CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 3-5

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STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS		
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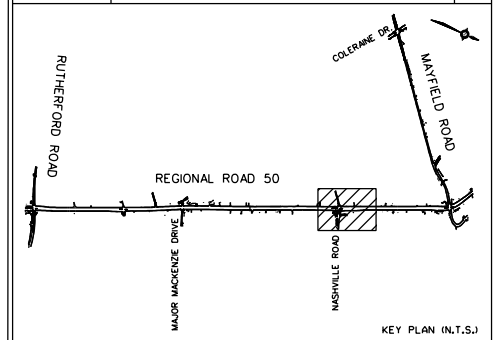


KEY PLAN (N.T.S.)

LEGEND

1A / 5.5	CULVERT/CATCHMENT ID
	AREA (ha)
	EXISTING DITCH
	EXISTING CULVERT
	FLOW DIRECTION

10m 0 10 20 30m HORIZONTAL SCALE

Region of Peel
Working for you

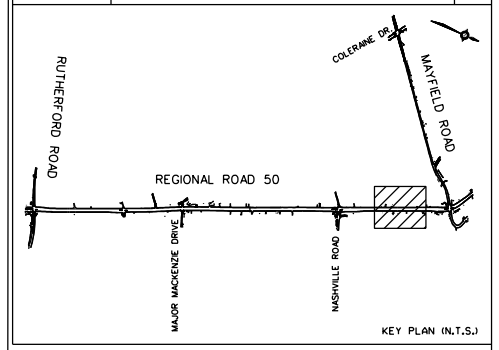
REGIONAL ROAD 50

EXISTING DRAINAGE CONDTIONS
FROM CASTLEMORE DR TO MAYFIELD RD
FROM STA. 10+150 TO STA. 10+900

CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 3-6

SERVICE DATA					
SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN SEWERS			GAS MAINS		
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS		
DATE	DETAILS	INIT.

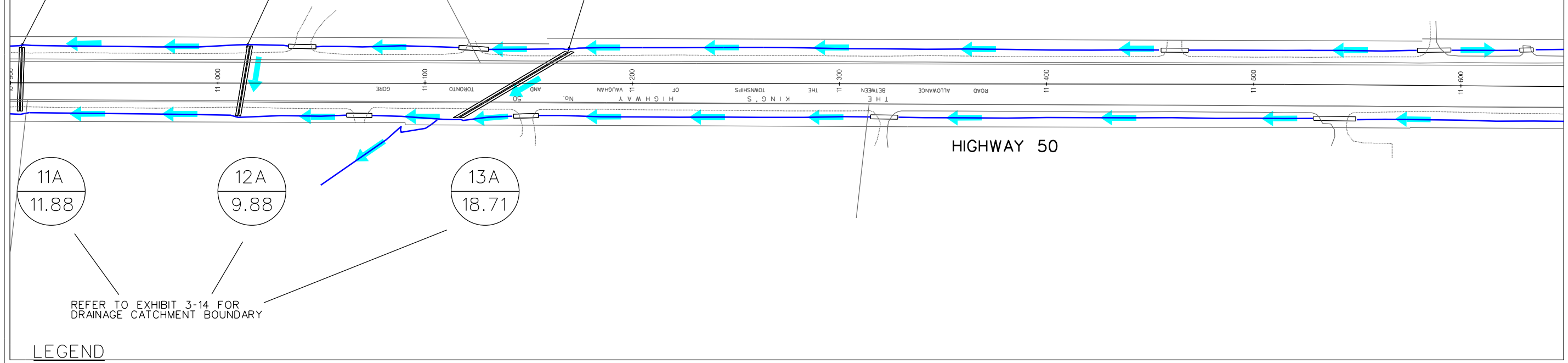


KEY PLAN (N.T.S.)

CULVERT 11
TWIN 0.60m CSP CULVERT

CULVERT 12
TWIN 0.70m CSP CULVERT

CULVERT 13
TWIN 0.9x1.4m OVAL CSP CULVERT



11A
11.88

12A
9.88

13A
18.71

REFER TO EXHIBIT 3-14 FOR
DRAINAGE CATCHMENT BOUNDARY

LEGEND

1A
5.5
CULVERT/CATCHMENT ID
AREA (ha)

EXISTING DITCH

EXISTING CULVERT

FLOW DIRECTION

10m 0 10 20 30m
HORIZONTAL SCALE

Region of Peel
Working for you

REGIONAL ROAD 50

EXISTING DRAINAGE CONDTIONS
FROM CASTLEMORE DR TO MAYFIELD RD
FROM STA. 10+900 TO STA. 11+650

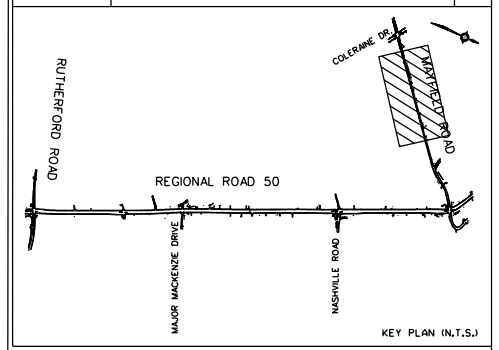
CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 3-7

SERVICE DATA

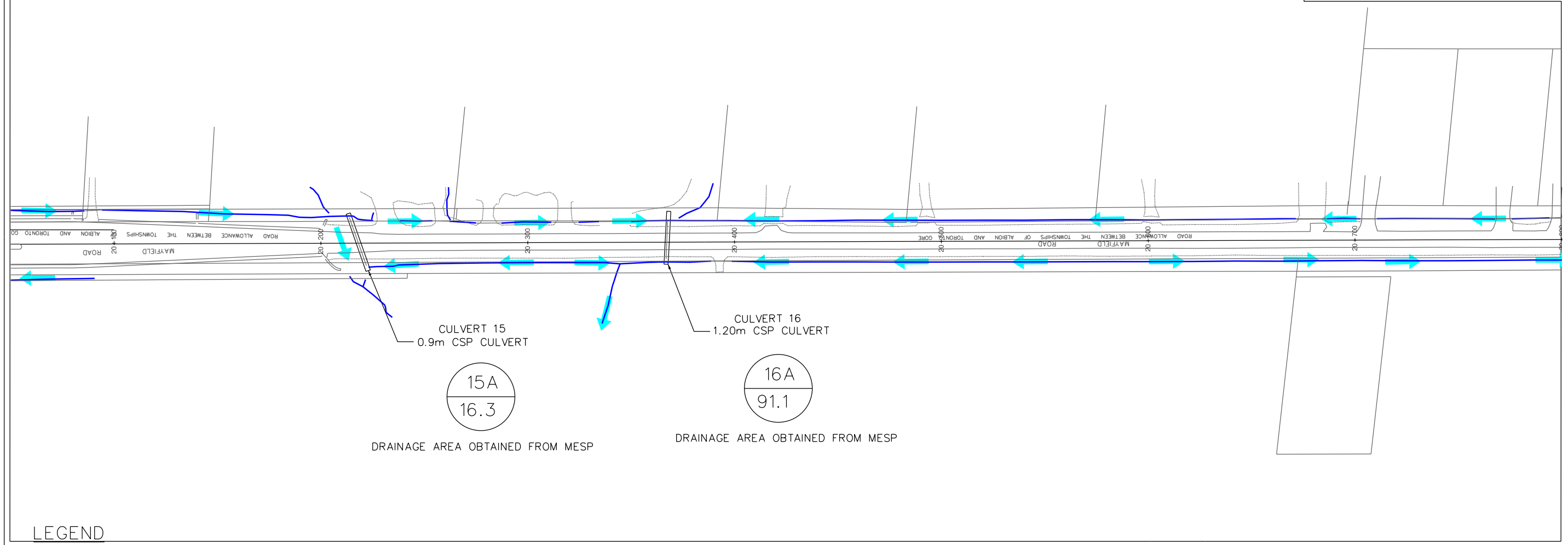
SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN SEWERS			GAS MAINS		
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS

DATE	DETAILS	INIT.



KEY PLAN (N.T.S.)



15A / 16.3

DRAINAGE AREA OBTAINED FROM MESP

16A / 91.1

DRAINAGE AREA OBTAINED FROM MESP

LEGEND

1A / 5.5 — CULVERT/CATCHMENT ID; AREA (ha)

EXISTING DITCH

EXISTING CULVERT

FLOW DIRECTION

10m 0 10 20 30m HORIZONTAL SCALE

Region of Peel
Working for you

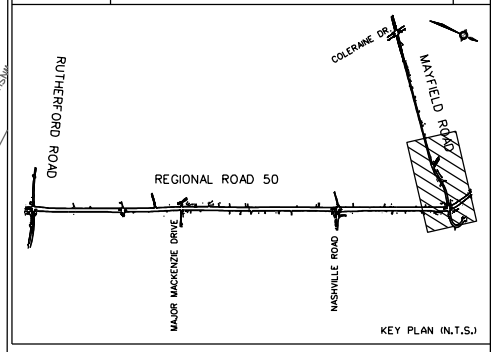
MAYFIELD ROAD

EXISTING DRAINAGE CONDTIONS
FROM COLERAINE DR. TO HWY 50
FROM STA. 20+050 TO STA. 20+800

CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 3-8

SERVICE DATA					
SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN SEWERS			GAS MAINS		
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS		
DATE	DETAILS	INIT.



KEY PLAN (N.T.S.)

18A

18A

CULVERT 18
2.5x1.25m BOX CULVERT

MAYFIELD ROAD

14A

CULVERT 14
3.5x1.5m BOX CULVERT

19A

ALBION-VAUGHAN ROAD

4.5x1.5m BOX CULVERT
CULVERT 19

CULVERT 17
1.20m CSP CULVERT

17A
22.0

DRAINAGE AREA OBTAINED FROM MESP

14A

HIGHWAY 50

LEGEND

1A / 5.5	CULVERT/CATCHMENT ID AREA (ha)
	EXISTING DITCH
	EXISTING CULVERT
	FLOW DIRECTION

10m 0 10 20 30m HORIZONTAL SCALE

Region of Peel
Working for you

MAYFIELD RD.

EXISTING DRAINAGE CONDTIONS
FROM COLERAINE DR. TO HWY 50
FROM STA. 20+800 TO STA. 21+550

CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 3-9

3.2 Future Drainage Conditions

It is intended to widen the portion of Highway 50 from Castlemore Road / Rutherford Road to Mayfield Road / Albion-Vaughan Road, and Mayfield Road between Highway 50 and Coleraine Drive.

The preferred configuration of Highway 50 is based on a 6 lane urban section with a continuous 6.0 m wide raised median. For Mayfield Road, the preferred configuration would consist of a 4 lane urban section with a similar 6.0 m wide raised median. The horizontal and vertical profile of Highway 50 and Mayfield Road will remain unchanged from existing conditions, with the exception of a profile adjustment on Mayfield Road, west of Highway 50. The future drainage conditions will remain similar to existing, maintaining the same drainage patterns.

Since the proposed widening of Highway 50 and Mayfield Road will consist of an urban cross section, the existing driveway culverts running parallel to Highway 50 will be removed and the cross culverts will need to be extended to the required length.

Should land adjacent to the proposed widening develop in the future, those developments have the potential to alter the drainage patterns external to Highway 50 and Mayfield Road. The drainage analysis associated with the future widening has considered that all external drainage areas will remain as currently exists and that all culverts crossing Highway 50 and Mayfield Rd. will be required to convey the external drainage beyond the road right-of-way.

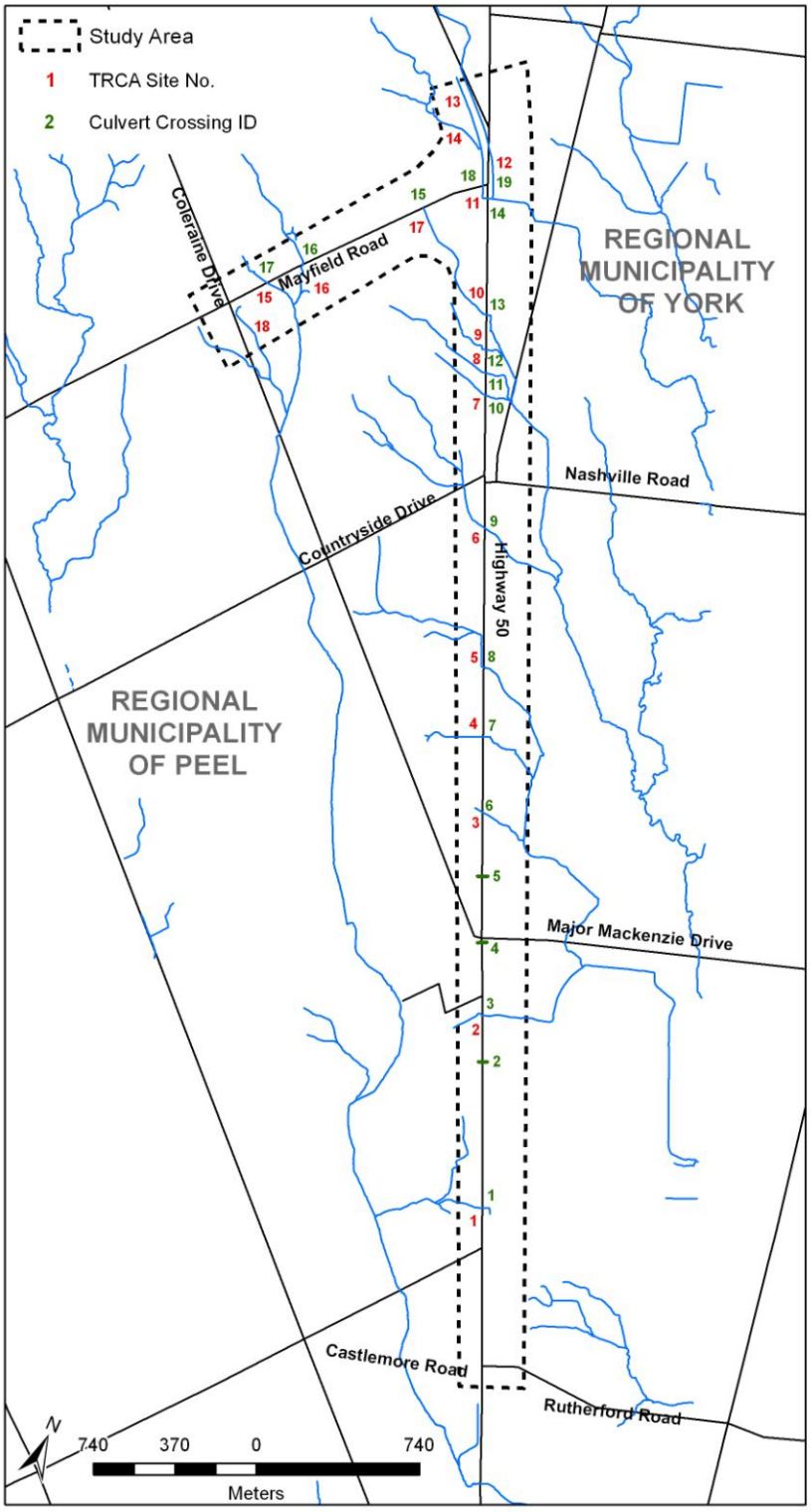
3.3 Transverse Drainage Crossings

3.3.1 Field Investigations

There are 19 transverse drainage crossings within the project area. Field investigations were undertaken to assess the overall condition of the existing drainage infrastructure within the project limits. This investigation included major crossing culverts, as well as other points of interest along the outside shoulders of both the northbound and southbound lanes for Highway 50, as well as the westbound and eastbound lanes for Mayfield Road. Specifically, inspections were conducted at the inlet and outlet ends of all major watercourse crossing culverts. Field staff located the feature of interest, reviewed the condition of the existing structure, and inspected upstream and downstream ditch lines.

Tables 3-1 and **3-2** summarize the condition of all existing crossing culverts under existing conditions within the project limits. The ends of Culverts1 and 2 on Highway 50 need to need to be reshaped and the culvert must be flushed, also culverts 10 and 11 on Highway 50 are heavily rusted and eroded away. Culvert 16 on Mayfield Road will require realignment. The location of each culvert crossing and associated culvert identification number is depicted on **Exhibit 3-10**. This exhibit also identifies the TRCA Site Crossing numbers for cross-reference.

Exhibit 3-10: Watercourse/Culvert Crossing Locations



3.3.2 Culvert Design Criteria

Both Highway 50 and Mayfield Road are currently classified as rural arterial roads. However, it is expected that with the proposed improvements, both roadway will become urban arterial roads.

The Region of Peel has, in practice, adopted the Ministry of Transportation Directive B-100 (MTO, October 16, 1980) which requires that all hydraulic crossings be designed to allow the specified freeboard between the edge of travelled way and the upstream water surface elevation for specified storm events. Under the urban arterial classification, culverts with a total span up to 6m are designed for the 50 year design storm event and must provide a minimum of a 1.0 m freeboard from the edge of the travelled lane.

All culverts within the study limits fit these criteria; therefore they have been assessed under the 50 year design storm event while using the 100 year storm event as a safety check.

In addition, since Highway 50 is an important north-south route, particularly during emergencies, maintaining it flood-free to the extent possible, or at least passable by emergency vehicles during a Regional storm, is an important aspect that must be regarded.

3.4 Hydrologic Analysis

An analysis of the hydrologic response of the upstream external drainage areas and the Highway 50 and Mayfield Road drainage systems was undertaken to assess the impact on the transverse drainage crossings and the downstream watercourses. If future peak flows are significantly different from the existing flow rates, mitigation measures will be required to control the discharge under future conditions.

For drainage catchments that are considered relatively small, the Rational Method was used to generate the peak flow rates. This includes Culvert crossings 1 to 13 and 15 to 17.

Hydrologic analyses were not performed for Culverts 14, 18 and 19 as there is an existing backwater (HEC-RAS) model for these reaches of West Robinson Creek. Peak flows for Culvert crossings 14, 18 with storm return periods up to the 100 year event at these crossings were obtained from the approved MESP which is referenced in the "Functional Servicing Report for Regional Road No. 50 & Mayfield Road Business Park, Town of Caledon, prepared by A.M. Candaras Associates Inc, 2005"and used in the HEC-RAS analysis for these crossing locations. Regional Storm peak flow rates for Culvert crossings 14, 18 and 19 as well as the 1:50 and 1:100 year peak flows at Culvert 19 were obtained directly from the approved HEC-RAS model provided by the Toronto Region Conservation Authority.

3.4.1 Rational Method Calculations

The Rational Method was used to compute the peak flow for the 50 and 100 year design storm events for Culverts 1 to 13 along Highway 50, and Culverts 15 to 17 along Mayfield Road.

All paved and non-paved areas within the ROW were calculated from the current base plan and survey information, while characteristics of the external drainage areas were obtained from the delineated 1: 10,000 OBMs. The delineations are found in **Exhibits 3-11** to **3-14**.

The design rainfall data used for the current analysis is the City of Vaughan Rainfall Intensity Duration Frequency (IDF) Curve.

Time of concentration was calculated using the Airport Formula for catchment areas with a runoff coefficient less than 0.4 and the Bransby Williams Formula for catchments with a runoff coefficient greater than 0.4, as outlined in the MTO Drainage Manual (1997). The Airport Formula is expressed as follows:

$$\mathbf{Tc = 0.057 * L / (S_w^{0.2} * A^{0.1})}$$ where:

Tc = time of concentration, min
L = watershed length, m
S_w = watershed slope, %
A = watershed area, ha

The Bransby Williams formula is expressed as follows:

$$\mathbf{Tc = [3.26 * (1.1-C) * L^{0.5}] / S_w^{0.33}}$$ where:

Tc = time of concentration, min
C = runoff coefficient
S_w = watershed slope, %
L = watershed length, L

The time of concentration estimates are summarized on **Table 3-3.**

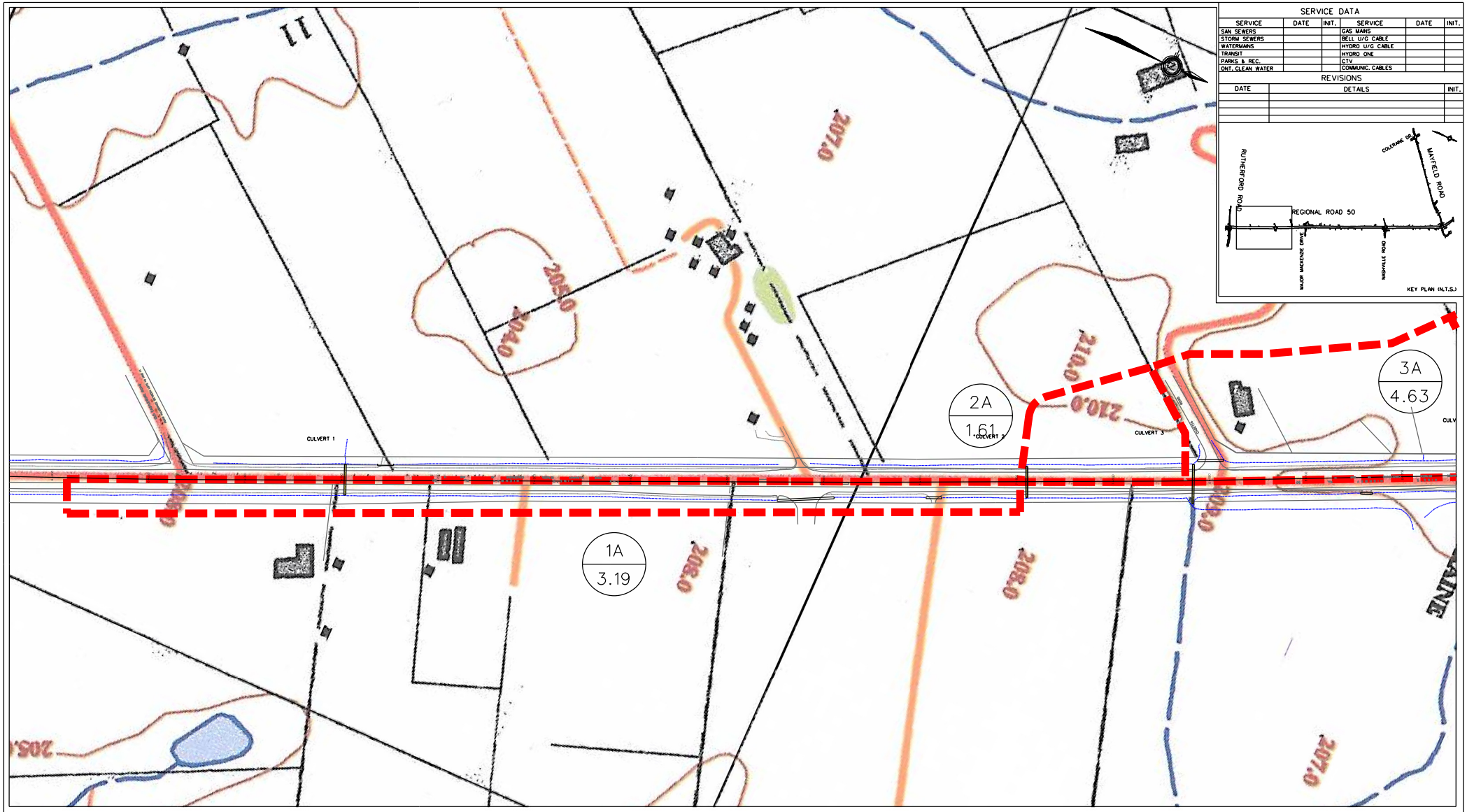
Table 3-3 summarizes the calculated peak flows at each watercourse crossing location. All paved areas within the subwatershed assumed a runoff coefficient of 0.9 while all pervious surfaces assumed a runoff coefficient of 0.25. A weighted runoff coefficient was then determined for each catchment based on the runoff coefficient values and corresponding catchment areas.

All 1:50 and 1:100 year peak flow rates calculated as described above were adjusted by safety factors of 20% for the 1:50 year event and by 25% for the 1:100 year event to arrive at the final peak flow rate.

Table 3-3: Peak Flow Summary

PEAK FLOW																										
HIGHWAY 50																										
		Watershed Parameters				Existing Condition											Proposed Condition										
From		Invert	High Point	Watershed Length	Slope (%)	Drainage Area to Crossing (ha)	Area ouside of E/P (ha)	Length of Road (m)	C	A*C	Cummul. Tc (TL= 15min)	I 50 (mm/hr)	Q 50 (m3/s)	I 100 (mm/hr)	Q 100 (m3/s)	Q Reg (m3/s)	Drainage Area to Crossing (ha)	Area ouside of E/P (ha)	Length of Road (m)	C	A*C	Cummul. Tc (TL= 15min)	I 50 (mm/hr)	Q 50 (m3/s)	I 100 (mm/hr)	Q 100 (m3/s)	Q Reg (m3/s)
Culvert ID	Sta.																									
1	7+104	206.94	210.50	955	0.37%	3.19	2.18	955	0.45	1.45	59.06	52.62	0.25	59.18	0.30	-	3.19	1.83	955	0.53	1.68	59.06	52.62	0.29	59.18	0.35	-
2	7+810	207.58	210.00	180	1.35%	1.61	1.43	170	0.32	0.52	31.02	85.26	0.15	95.85	0.17	-	1.61	1.36	170	0.35	0.56	29.99	87.39	0.16	98.22	0.19	-
3	7+990	208.50	213.25	340	1.40%	4.63	4.27	340	0.30	1.39	43.32	66.55	0.31	74.89	0.36	-	4.63	4.15	340	0.32	1.47	42.35	67.69	0.33	76.17	0.39	-
4	8+333	208.90	216.00	1065	0.67%	23.51	17.82	510	0.41	10.27	48.01	61.59	2.11	69.31	2.47	-	23.51	17.63	510	0.41	10.44	48.01	61.59	2.14	69.31	2.51	-
5	8+832	210.09	211.50	230	0.61%	2.16	1.92	225	0.32	0.69	45.53	64.10	0.15	72.14	0.17	-	2.16	1.84	225	0.35	0.75	44.05	65.73	0.16	73.96	0.19	-
6	8+895	210.57	216.00	585	0.93%	7.43	7.03	387	0.29	2.12	66.22	48.20	0.34	54.18	0.40	-	7.43	6.88	387	0.30	2.22	65.19	48.79	0.36	54.85	0.42	-
7	9+249	212.85	220.00	700	1.02%	12.31	11.99	305	0.27	3.29	71.79	45.30	0.50	50.90	0.58	-	12.31	11.88	305	0.27	3.36	71.27	45.55	0.51	51.18	0.60	-
8	9+562	213.50	229.00	1245	1.24%	43.45	42.79	535	0.26	11.29	90.44	37.88	1.43	42.50	1.67	-	43.45	42.54	535	0.26	11.45	90.05	38.01	1.45	42.64	1.70	-
9	10+197	216.19	229.00	975	1.31%	25.04	24.58	430	0.26	6.55	78.46	42.29	0.92	47.50	1.08	-	25.04	24.42	430	0.27	6.66	78.07	42.46	0.94	47.68	1.10	-
10	10+798	221.36	228.00	670	0.99%	17.35	17.06	275	0.26	4.53	71.46	45.46	0.69	51.08	0.80	-	17.35	16.96	275	0.26	4.59	71.13	45.62	0.70	51.26	0.82	-
11	10+905	221.64	229.00	755	0.97%	11.88	11.75	125	0.26	3.06	76.60	43.09	0.44	48.39	0.51	-	11.88	11.70	125	0.26	3.09	76.37	43.19	0.44	48.51	0.52	-
12	11+012	221.82	230.00	760	1.08%	9.88	9.74	135	0.26	2.56	74.19	44.16	0.38	49.61	0.44	-	9.88	9.69	135	0.26	2.60	73.90	44.30	0.38	49.76	0.45	-
13	11+132	222.27	230.00	590	1.31%	18.71	18.21	470	0.27	5.00	60.69	51.53	0.86	57.95	1.01	-	18.71	18.04	470	0.27	5.11	60.25	51.82	0.88	58.28	1.03	-
14	11+832	223.13	DEFINED IN MESP and/or OBTAINED from TRCA HEC-RAS model										1.40		1.71	13.33	DEFINED IN MESP and/or OBTAINED from TRCA HEC-RAS model							1.40		1.71	13.33
MAYFIELD ROAD / ALBION VAUGHAN ROAD																										
15	20+218	228.37	234.00	700.00	0.80%	16.30	16.14	233.00	0.26	4.177229	78.68	42.20	0.59	47.39	0.69	-	16.30	15.95	332.77	0.26	4.30	77.96	42.50	0.61	47.73	0.71	-
16	20+367	228.11	241.00	1867.00	0.69%	91.10	90.78	470.00	0.25	22.98121	155.00	24.85	1.90	27.72	2.21	-	91.10	90.96	131.69	0.25	22.86	135.97	27.54	2.10	30.78	2.44	-
17	20+984	226.96	234.00	715.00	0.98%	22.00	21.74	386.00	0.26	5.669358	74.25	44.13	0.83	49.58	0.98	-	22.00	21.37	597.28	0.27	5.91	73.30	44.58	0.88	50.08	1.03	-
18	21+340	223.44	DEFINED IN MESP and/or OBTAINED from TRCA HEC-RAS			69.81	DEFINED IN MESP and/or OBTAINED from TRCA HEC-RAS model						1.40		1.71	13.33	DEFINED IN MESP and/or OBTAINED from TRCA HEC-RAS model							1.40		1.71	13.33
19	21+387	223.97				60.80							7.50		8.40	15.46								7.50		8.4	15.46

NOTES:
Safety factor of 20% for 50yr and 25% for 100yr applied to all peak flow values
External Drainage area for culverts 15, 16, 17 obtained from Figure 4 of the Master Environmental Servicing Report (1999, R.J. Burnside). Refer to Appendix A.
The design rainfall data used for the current analysis is the City of Vaughan Rainfall Intensity Duration Frequency (IDF) Curve.
50 and 100 Year Peak Flow values for Culvert No.'s 14, 18 obtained from the MESP referenced in the Functional Servicing Report prepared by A.M. Candaras 2005
50 and 100 Year Peak Flow values for Culvert 19 obtained from Toronto Region Conservation Authority approved HEC-RAS model.
Regional Storm peak flows for Culverts 14, 18 and 19 obtained from Toronto Region Conservation Authority approved HEC-RAS model.
Bransby Williams Method used to calculate Time of Concentration



SERVICE DATA

SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN SEWERS			GAS MAINS		
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS

DATE	DETAILS	INIT.

KEY PLAN (N.T.S.)

LEGEND

- 1A / 5.5 — CULVERT/CATCHMENT ID, AREA (ha)
- EXISTING DITCH
- EXISTING CULVERT
- SUBWATERSHED

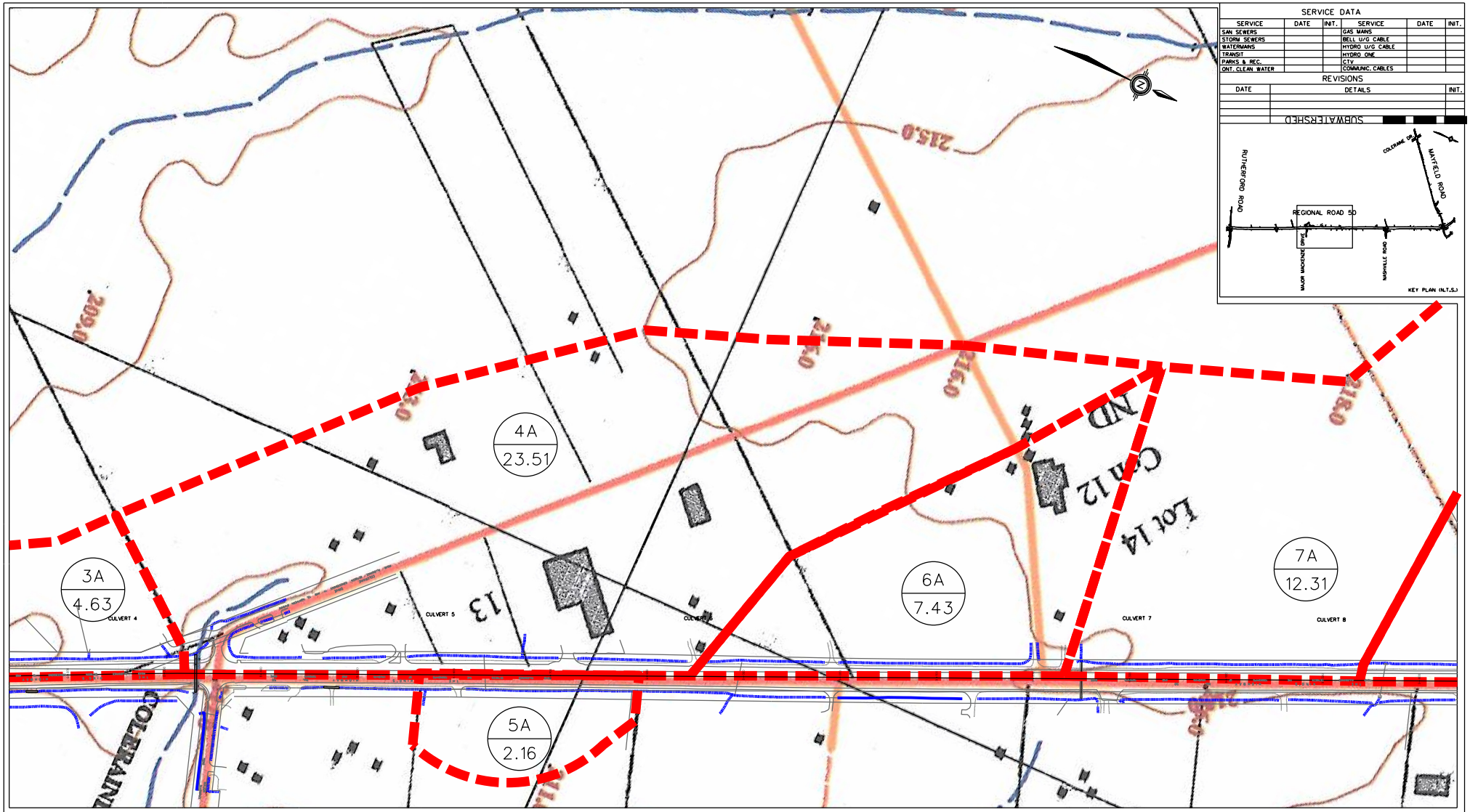
10m 0 10 20 30m HORIZONTAL SCALE

Region of Peel
Working for you

REGIONAL ROAD 50 AND MAYFIELD ROAD

DRAINAGE CATCHMENT BOUNDARY

CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 3-11



SERVICE DATA

SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN SEWERS			GAS MAINS		
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS

DATE	DETAILS	INIT.

SUBWATERSHED

LEGEND

- 1A / 5.5 — CULVERT/CATCHMENT ID, AREA (ha)
- EXISTING DITCH
- EXISTING CULVERT
- SUBWATERSHED

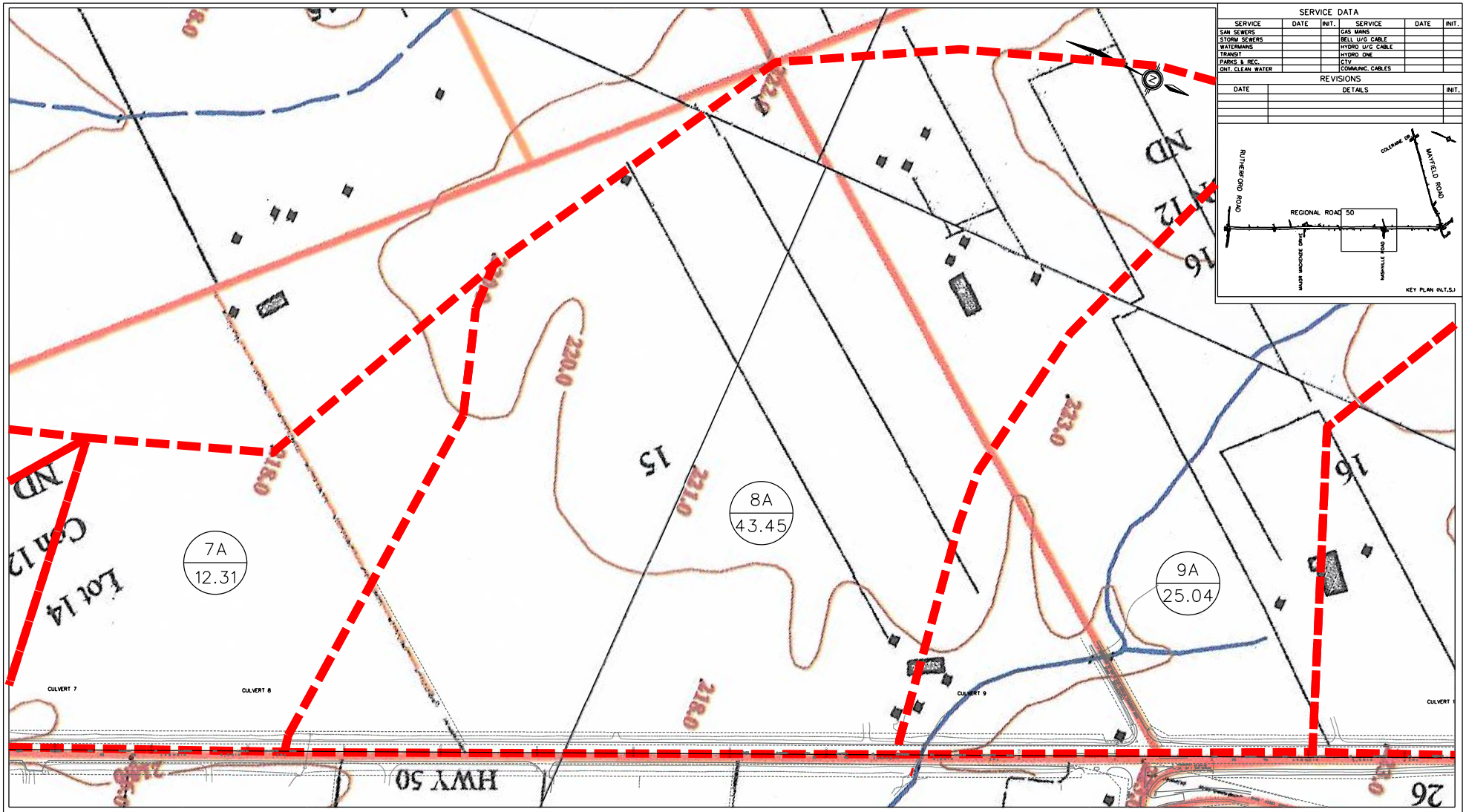
10m 0 10 20 30m HORIZONTAL SCALE

Region of Peel
Working for you

REGIONAL ROAD 50 AND MAYFIELD ROAD

DRAINAGE CATCHMENT BOUNDARY

CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 3-12



SERVICE DATA

SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN SEWERS			GAS MAINS		
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS

DATE	DETAILS	INIT.

LEGEND

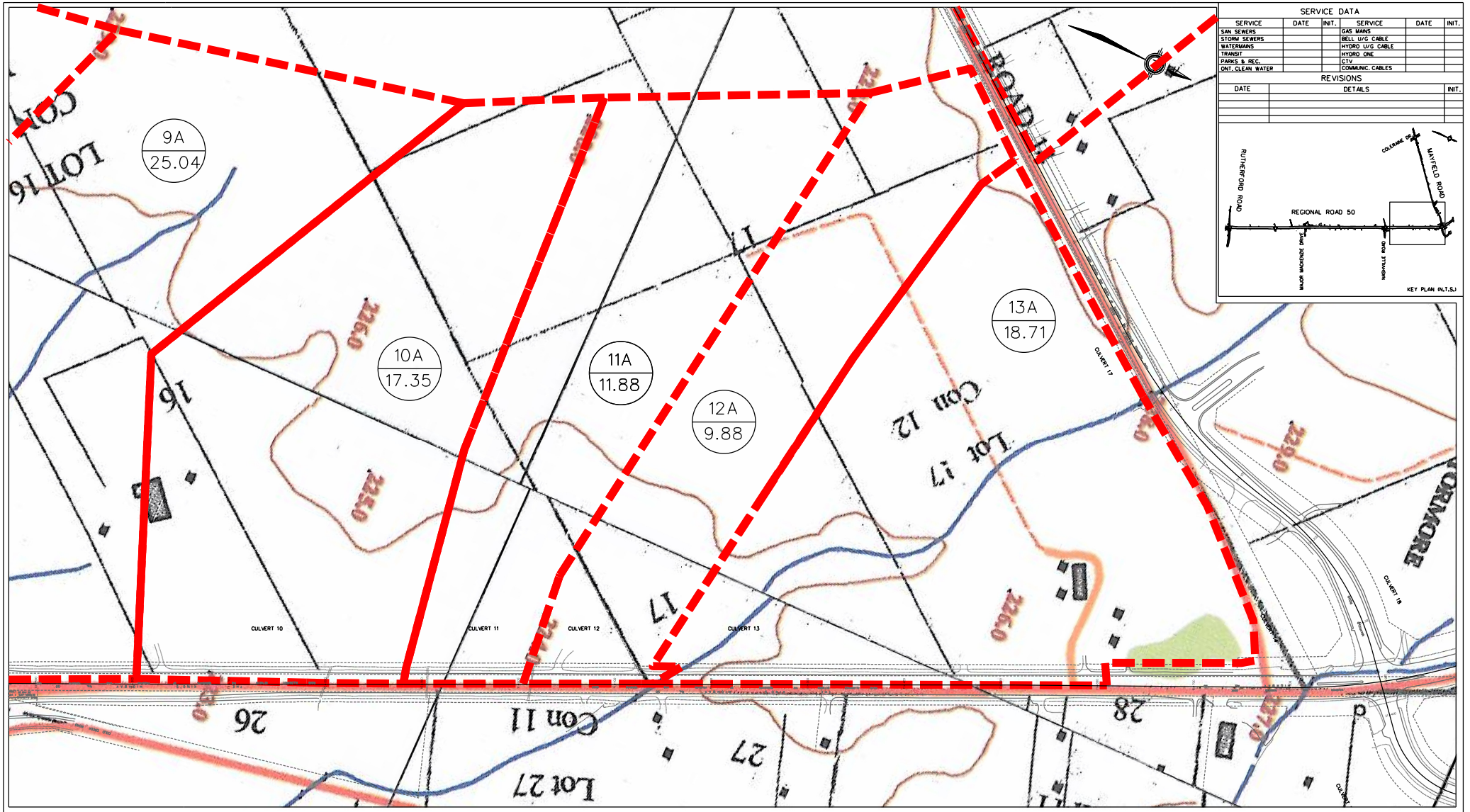
- 1A / 5.5 — CULVERT/CATCHMENT ID, AREA (ha)
- EXISTING DITCH
- EXISTING CULVERT
- SUBWATERSHED

Region of Peel
Working for you

REGIONAL ROAD 50 AND MAYFIELD ROAD

DRAINAGE CATCHMENT BOUNDARY

CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 3-13



LEGEND

1A / 5.5 — CULVERT/CATCHMENT ID, AREA (ha)

EXISTING DITCH

EXISTING CULVERT

SUBWATERSHED

Region of Peel
Working for you

REGIONAL ROAD 50 AND MAYFIELD ROAD
DRAINAGE CATCHMENT BOUNDARY

CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 3-14

3.5 Hydraulic Analysis of Transverse Culverts

The existing culverts were analyzed using the Culvert Master software and HEC RAS backwater model. The design flows as shown in **Table 3-3** were used in the Culvert Master and HEC-RAS models to compute the headwater levels associated with the 50 year and 100 year design storm events.

3.5.1 Existing Conditions

As seen in **Table 3-4**, for the design storm event (50 year), the existing culvert freeboard from edge of pavement elevations are less than 1.0 m for Culverts 1, 8, 10 and 11 on Highway 50, and Culverts 15, 16, 17 and 18 on Mayfield Road. The Culvert Master Output is presented in **Appendix A.** These culverts may require upgrades in order to meet the hydraulic criteria. Consideration for culvert replacement may include a larger diameter/box section or culvert twinning at these crossing locations.

The hydraulic results for Culvert 14 on Highway 50 and Culverts 18 on Mayfield Road and Culvert 19 on Albion-Vaughan Road were originally conducted by Chisholm Fleming and Associates Inc. as part of the Regional Carpool Lot development using the HEC-RAS model. This model was updated by HDR | iTRANS to reflect more up-to-date peak flow values as outlined in the approved MESP, including extensive cross-section modifications upstream of culvert 18 to reflect the Robinson Creek channel realignment undertaken as part of the industrial developments north and west of the Highway 50 and Mayfield Road intersection.

As noted above, Culvert 18 does not meet the required hydraulic criteria for passage of design flows with a minimum 1.0 metre freeboard. As such, consideration for hydraulic improvements or roadway vertical profile adjustments is recommended at this crossing location.

Culverts 14, 18 and 19 were also assessed for possible flooding concerns on Highway 50, Mayfield Road and Albion-Vaughan Road. The Region of Peel has confirmed Highway 50 as a designated Emergency Route. The Adaptive Management of Stream Corridors in Ontario – Flooding Hazard Limit Technical Guide (Ministry of Natural Resources, 2001) provides information on culvert performance during a Regional storm for those crossings with drainage areas exceeding 125 ha. It specifies that depths of overtopping less than 1.2 metres (maximum) and velocities less than 4.5 m/s would be adequate to allow the passage of emergency vehicles, and depth of overtopping less than 0.3 m (maximum) and velocities less than 3.0 m/s would be adequate to allow for the passage of private vehicles. These standards have been adopted for this project.

Based on the results of the HEC-RAS analysis for Culvert 14, 18 and 19, overtopping occurs at Mayfield Road Culvert crossing 14 and 18 under Regional Storm conditions only. The results are presented on **Table 3-5**. The HEC-RAS model output is provided in **Appendix B.**

Table 3-4: Summary of Culvert Assessments for Existing Conditions

EXISTING CONDITION HYDRAULIC SUMMARY

HIGHWAY 50

Culvert Characteristics										Hydraulic Assessment										
Culvert ID	Station	Stream	Type	Diameter	Dimensions	Length	Invert		Slope	Flow (m3/s)		50yr Critical Depth	100yr Critical Depth	50 yr Tailwater Elevation	100 yr Tailwater Elevation	Edge of Pavement Elevation	Headwater Elevation		Freeboard	
				(m)	(m)	(m)	U/S (m)	D/S (m)	%	50yr	100yr						50yr	100yr	50yr	100yr
1	7+104	West Rainbow	CSP	0.75	-	31.93	206.94	206.73	0.66%	0.25	0.30	0.31	0.34	207.26	207.28	208.25	207.46	207.52	0.79	0.73
2	7+810	East Rainbow	CSP	0.80	-	31.96	207.58	207.30	0.87%	0.15	0.17	0.23	0.24	207.81	207.82	209.26	207.95	207.97	1.31	1.29
3	7+980	East Rainbow	CSP	0.80	-	40.69	208.50	207.85	1.60%	0.31	0.36	0.33	0.36	208.42	208.43	210.13	209.07	209.12	1.06	1.01
4	8+333	East Rainbow	Conc. Box	n/a	1.3 x 1.85	39.23	208.90	208.75	0.38%	2.11	2.47	0.51	0.57	209.66	209.69	211.66	209.86	209.95	1.80	1.71
5	8+632	East Rainbow	CSP	0.80	-	33.81	210.09	210.00	0.27%	0.15	0.17	0.23	0.24	210.52	210.52	212.03	210.57	210.58	1.46	1.45
6	8+895	East Rainbow	CSP	1.00	-	34.02	210.57	210.13	1.29%	0.34	0.40	0.32	0.35	210.79	210.81	212.30	211.12	211.17	1.18	1.13
7	9+249	East Rainbow	Conc. Box	n/a	0.8 x 1.85	37.91	212.85	212.72	0.34%	0.50	0.58	0.20	0.22	213.27	213.28	214.72	213.30	213.31	1.42	1.41
8	9+562	East Rainbow	Conc. Box	n/a	0.8 x 1.85	35.90	213.50	213.39	0.31%	1.43	1.67	0.40	0.44	213.99	214.01	215.12	214.15	214.21	0.97	0.91
9	10+197	West Robinson	twin CSP	1.35	-	42.54	216.19	215.83	0.85%	0.92	1.08	0.35	0.38	216.68	216.70	219.20	216.78	216.82	2.42	2.38
10	10+798	West Robinson	twin CSP	0.70	-	32.35	221.36	220.95	1.27%	0.69	0.80	0.36	0.39	221.48	221.50	222.82	221.98	222.04	0.84	0.78
11	10+905	West Robinson	twin CSP	0.60	-	30.71	221.64	221.48	0.52%	0.44	0.51	0.30	0.33	221.93	221.95	223.04	222.18	222.23	0.86	0.81
12	11+012	West Robinson	twin CSP	0.70	-	33.97	221.82	221.39	1.27%	0.38	0.44	0.27	0.29	221.88	221.89	223.41	222.27	222.30	1.14	1.11
13	11+132	West Robinson	twin CSP oval	n/a	0.9 x 1.4	62.15	222.27	221.85	0.68%	0.86	1.01	0.31	0.33	222.46	222.47	224.18	222.71	222.75	1.47	1.43
14	11+832	West Robinson	Conc. Box	n/a	1.5 x 3.5	56.86	223.13	222.84	0.50%	1.40	1.71					225.75	224.70	224.77	1.05	0.98
MAYFIELD ROAD / ALBION VAUGHAN ROAD																				
15	20+218	West Robinson	CSP	0.90	-	24.81	228.37	227.92	1.81%	0.59	0.69	0.45	0.49	228.60	228.62	229.91	229.15	229.22	0.76	0.69
16	20+367	West Robinson	CSP	1.20	-	18.44	228.11	228.21	-0.54%	1.90	2.21	0.75	0.82	229.19	229.22	229.64	229.62	229.79	0.02	-0.15
17	20+984	West Robinson	CSP	1.20	-	27.17	226.96	226.22	2.72%	0.83	0.98	0.49	0.53	227.07	227.09	228.35	227.80	227.88	0.55	0.47
18	21+340	West Rainbow	Conc. Box	n/a	1.25 x 2.5	41.87	223.44	223.33	0.26%	1.40	1.71					225.05	224.71	224.79	0.34	0.26
19	21+387	West Rainbow	Conc. Box	n/a	1.5 x 4.5	38.87	223.97	223.42	1.41%	7.50	8.40					226.60	225.38	225.47	1.22	1.13

NOTES:

Headwater elev. Taken from Culvert Master
Tailwater Elevation = (critical depth + culv. Dia.) / 2
Critical Depth calc. from Flow Master
Edge of Pavement = Crown of Road - 2% cross fall

hydraulic deficiency
physical condition deficiency
deficiency both physical and hydraulic

Table 3-5: Summary of Existing Flooding Conditions at Highway 50 / Mayfield Road Intersection

Culvert Crossing	Regional Flow over Roadway (m^3/s)	Regional Flow Depth over Roadway (Max)[1] (m)	Regional Storm Velocity[1] (m/s)	100 year Flow Depth over Roadway (Max)[2] (m)	100 Year Storm Velocity[2] (m/s)
14 (Highway 50)	1.09	0.06	.30	0.0	0.0
18 (Mayfield Road)	12.53	1.01	0.27	0.0	0.0

Note: 1. Allowable flow depth of 1.2m and velocity of 4.5 m/s for safe passage of emergency vehicles
2. Allowable flow depth of 0.3m and velocity of 3.0 m/s for safe passage of private vehicles

The results presented in **Table 3-6** indicate that adequate flow depths and velocities can be attained to allow for the safe passage of emergency vehicles under Regional storm conditions (i.e. flow depths are less than 1.2 metres and velocities are less than 4.5 m/s) as well as for the safe passage of private vehicles under 100 year storm conditions.

3.5.2 Future Conditions

Under the future condition scenario, to accommodate the road widening along Highway 50 and Mayfield Road, culvert extensions were required at each culvert crossing location.

As seen in **Table 3-6**, for the design storm event (50 year), the future culvert freeboard from edge of pavement elevations are less than 1.0 m for Culverts 3, 8, 10 and 11 on Highway 50, and Culverts 15, 16 and 17 on Mayfield Road. The freeboard from edge of pavement elevations is more than 1.0m for all remaining culverts. The Culvert Master Output is presented in **Appendix A.**

Although not all culverts satisfy the 1.0m freeboard criteria, it is not considered necessary to replace these culverts, as most culverts provide more than 0.5 m freeboard. The exceptions include Culverts 10 and 11 which require replacement due to structural deficiencies and Culvert 16 which has a freeboard of only 0.2 m. Culverts 1 and 2 will be abandoned or removed since drainage to these culverts will now be collected by new storm sewers.

Robinson Creek Tributaries at Highway 50 and Mayfield Road Intersection

Through discussions held with Toronto Region Conservation Authority, it was agreed that roadway widening at the Highway 50 and Mayfield Road intersection should be concentrated on the west side of the right-of-way, to avoid potential disruption of aquatic habitat along the Robinson Creek tributary which parallels Highway 50 on the east side of the roadway. At Albion Vaughan Road, the existing 4.5m x 1.5m box culvert needs to be extended to accommodate the intersection improvements.

Consequently, the tributary on the west side of Highway 50 requires the enclosure of the watercourse within the reach between Highway 50 and Mayfield Road. This can be achieved

by linking the existing box culverts at Highway 50 and Mayfield Road with a similar size box culvert section.

The modifications to culvert geometry along both the "east" and "west' tributaries of Robinson Creek were conducted using the HEC-RAS model. Culvert 19, which crosses Albion-Vaughan Road on the "east" tributary continues to provide adequate hydraulic capacity. There is very little change in regional floodlevels, despite the 30 metre culvert extension. No overtopping of the roadway occurs at this location.

On the "west" tributary, the enclosure of a part of the watercourse results in a single, 149 metre long culvert from the east side of Highway 50 to upstream of Mayfield Road. For the purposes of the assessment, a 2.5m x 1.5m box culvert was modelled for the entire 149m length, which represents the smaller hydraulic opening corresponding to Culvert 18. Hydraulic capacity and freeboard criteria are met with this configuration, and although regional flows overtop the roadway, the flows are relatively minor (3.78 m^3/s). As such, flooding conditions are reduced within the Highway 50/Mayfield Road intersection over existing conditions as a result of the vertical profile correction of Mayfield Road as well as the reduced amount of overflow.

During detailed design, the HEC-RAS model should be revised/updated to reflect the final culvert configuration (i.e. dimensions, length etc) based on final design recommendations.

The results of the HEC-RAS analysis are included in **Appendix B**. The location of cross-sections used in the HEC-RAS analysis under both the existing and future condition scenarios is also included in **Appendix B.**

Table 3-6: Summary of Culvert Assessments for Future Conditions

PROPOSED CONDITION HYDRAULIC SUMMARY																				
HIGHWAY 50																				
Culvert Characteristics										Hydraulic Assessment									Freeboard	
Culvert ID	Station	Stream	Type	Diameter	Dimensions	Length	Invert		Slope	Flow (m3/s)		50yr Critical Depth	100yr Critical Depth	50 yr Tailwater Elevation	100 yr Tailwater Elevation	Edge of Pavement Elevation	Headwater Elevation			
				(m)	(m)	(m)	U/S (m)	D/S (m)	%	50yr	100yr						50yr	100yr	50yr	100yr
1	Culvert 1 to be removed and replaced with storm sewer.																			
2	Culvert 2 to be removed and replaced with storm sewer.																			
3	7+980	East Rainbow	CSP	0.80	n/a	48.19	208.56	207.79	1.60%	0.31	0.36	0.33	0.36	208.36	208.37	210.12	209.13	209.18	0.99	0.94
4	8+333	East Rainbow	Conc. Box	n/a	1.3 x 1.85	46.73	208.91	208.74	0.38%	2.11	2.47	0.51	0.57	209.64	209.67	211.65	209.86	209.95	1.79	1.70
5	8+632	East Rainbow	CSP	0.80	n/a	41.31	210.10	209.99	0.27%	0.15	0.17	0.23	0.24	210.50	210.51	212.03	210.56	210.59	1.47	1.44
6	8+895	East Rainbow	CSP	1.00	n/a	41.52	210.62	210.08	1.29%	0.34	0.40	0.32	0.35	210.74	210.76	212.29	211.17	211.22	1.12	1.07
7	9+249	East Rainbow	Conc. Box	n/a	0.8 x 1.85	45.41	212.86	212.71	0.34%	0.50	0.58	0.20	0.22	213.26	213.27	214.72	213.29	213.31	1.43	1.41
8	9+562	East Rainbow	Conc. Box	n/a	0.8 x 1.85	43.40	213.51	213.38	0.31%	1.43	1.67	0.40	0.44	213.98	214.00	215.12	214.16	214.22	0.96	0.90
9	10+197	West Robinson	twin CSP	1.35	n/a	50.04	216.22	215.80	0.85%	0.92	1.08	0.35	0.38	216.65	216.66	219.19	216.79	216.83	2.40	2.36
10	10+798	West Robinson	Twin Alum.	0.75	n/a	39.85	221.41	220.90	1.27%	0.69	0.80	0.36	0.39	221.46	221.47	222.82	222.03	222.08	0.79	0.74
11	10+905	West Robinson	Twin Alum.	0.68	n/a	38.21	221.66	221.46	0.52%	0.44	0.51	0.29	0.31	221.94	221.95	223.04	222.16	222.20	0.88	0.84
12	11+012	West Robinson	twin CSP	0.70	n/a	41.47	221.87	221.34	1.27%	0.38	0.44	0.27	0.29	221.83	221.84	223.41	222.32	222.35	1.09	1.06
13	11+132	West Robinson	twin CSP oval	n/a	0.9 x 1.4	69.65	222.30	221.82	0.68%	0.86	1.01	0.31	0.33	222.43	222.44	224.17	222.74	222.76	1.43	1.41
14	11+832	West Robinson	Conc. Box	n/a	1.5 x 3.5	149.00	223.52	222.84	0.46%	1.4	1.71					226.67	224.71	224.79	1.96	1.88
MAYFIELD ROAD / ALBION VAUGHAN ROAD																				
15	20+218	West Robinson	CSP	0.90	n/a	32.31	228.44	227.85	1.81%	0.59	0.69	0.45	0.49	228.53	228.55	230.10	229.22	229.29	0.88	0.81
16	20+367	West Robinson	Twin Alum.	1.00	n/a	25.94	228.09	228.00	0.35%	1.90	2.21	0.56	0.60	228.78	228.80	229.98	229.10	229.20	0.88	0.78
17	20+984	West Robinson	CSP	1.20	n/a	34.67	227.06	226.12	2.72%	0.83	0.98	0.49	0.53	226.96	226.98	228.68	227.90	227.98	0.78	0.70
18	21+340	West Rainbow	Conc. Box	n/a	1.25 x 2.5	Culvert 18 is combined with Culvert 14 as one single length culvert (refer to Culvert 14 above)														
19	21+387	West Rainbow	Conc. Box	n/a	1.5 x 4.5	72.00	224.35	223.33	1.42%	7.5	8.4					226.6	225.39	225.49	1.21	1.11

NOTES:
Headwater elev. Taken from Culvert Master
Tailwater Elevation = (critical depth + culv. Dia.) / 2
Critical Depth calc. from Flow Master
Edge of Pavement = Crown of Road - 2% cross fall

Table 3-7 summarizes the water surface elevations along the Robinson Creek "east" and "west" tributaries under the 50 year and Regional Storm frequencies including the corresponding changes in flood elevations at the various section locations.

Table 3-7: Flood Elevation Comparison – Hwy 50 and Mayfield Road Crossings of Robinson Creek

Event		Regional			50 Year		
Tributary	**Condition**	**Existing (m)**	**Proposed (m)**	**Diff. (m)**	**Existing (m)**	**Proposed (m)**	**Diff. (m)**
West Tributary							
	37.91964	225.50	225.50	0.0	224.69	224.69	0.0
Culvert 14	80	226.04	-	-	224.70	-	-
	81	226.04	-	-	224.70	-	-
Culvert 18	103	226.05	-	-	224.71	-	-
	201	226.42	226.42	0.0	224.85	224.71	-0.14
U/S	202	226.44	226.44	0.0	224.86	224.73	-0.13
East Tributary							
	35.77466	225.44	225.44	0.0	224.74	224.74	0.0
	100.2409	225.74	225.74	0.0	225.31	225.30	-0.01
Culvert 19	105	226.02	226.02	0.0	225.38	225.39	0.01
	258.4349	226.09	226.09	0.0	225.75	225.76	0.01
U/S	390	227.28	227.28	0.0	226.89	226.89	0.00

Note: Refer to Appendix B for stream cross-section locations.

4. HYDROGEOLOGICAL ASSESSMENT

A Hydrogeological Investigation was undertaken for the Highway 50 and Mayfield Road Improvements by Trow Associates Incorporated (***Hydrogeological Investigation, Hwy 50 Road Improvements from Castlemore Road to Mayfield Road, Mayfield Road from Hwy 50 to Coleraine Drive, Region of Peel Ontario, Draft, June 2010)***. The following is an excerpt of the background conditions and hydrogeological setting as obtained from the above report:

The subject property is located in the physiographic region known as the Peel plain (Chapman and Putnam, 1984), characterized by level to undulating tracts of land consisting primarily of clay soils. Surficial soils are typically sandy silt and clayey silt deposits associated with the Peel Ponds. Surficial sediments are underlain by Paleozoic Upper Ordivician Queenstone shale, limestone, dolostone and siltstone bedrock.

The project area is located within the West Humber River sub watershed. The site contains numerous 1st and 2nd order streams; these streams are generally in a northwest to southeast alignment and mostly flow intermittently toward the south.

Below 0.7 to 2.4 metres of fill, the site is generally underlain by silt till. The silt till contains clay layers and wet sand seams. A layer of organic silt occurs beneath the fill in BH-2, 3, 4A, 7, 14 and 16 (located throughout the study area), suggesting the fill was placed on top of the original topsoil horizon. Soil generally changes from brown to grey at 4.0 metres below ground surface. In the vicinity of BH-13 and BH-14 (located in the south portion of the study area), a fine sand layer is present at 5.5 and 3.9 metres below ground surface respectively. The sand layer extends to the maximum investigated depth.

Based on available borehole logs, the dominant soil at the Site is silt till. The till formation contains some sand seams which may produce varying amounts of water depending on the size and frequency of the sand seams.

Regional groundwater flow in the area is expected to be south, towards Lake Ontario. Water level monitoring undertaken during the project indicates that the groundwater flow on the Site is south towards Lake Ontario.

5. SURFACE AND GROUNDWATER MANAGEMENT

5.1 Drainage and Stormwater Management Criteria

5.1.1 General Criteria

In accordance with Regions of Peel and York Policy, the stormwater management plan should conform to the following documents:

1. MOEE Stormwater Management Practices Planning and Design Manual, March 2003;
2. Region of Peel drainage design standards and criteria;
3. Region of York drainage design standards and criteria;
4. Toronto Region Conservation Authority Valley and Stream Corridor Management program (TRCA 1994).

5.1.2 Pavement Drainage Criteria

Minor System

The storm sewer system draining the pavement for the ultimate roadway configuration is to be designed to the 10 year design storm standard.

Major System

The major drainage system for the roadway is to be designed to convey overland flow to the adjacent watercourse in a safe manner.

5.1.3 Flooding and Erosion Control Criteria

Toronto and Region Conservation Authority generally requires that new development control the 2-year through 100-year storm post development flows to pre development levels. This criterion does not apply to drainage areas that are less than 5 hectares. However, Toronto and region Conservation Authority encourages the proponent to practice quantity control to the extent feasible.

Potential stream erosion impacts are to be dealt with through stormwater management. Stormwater management facilities are to control the increased runoff from the new pavement of the roadways.

The provision of detention storage to control the runoff from a 25mm rainfall event is typically selected as the design criteria for erosion control.

5.1.4 Water Quality Control Criteria

Toronto region Conservation Authority requires water quality controls commensurate with the maximum downstream habitat type. In this case, all watercourses tributary to the Humber River requires "Enhanced" protection (Level 1). Level 1 protection is to be provided, as a minimum for a pavement area equivalent to the new pavement area.

The MOEE Stormwater Management Practices and Planning Manual, March 2003, provides guidance for the selection of appropriate levels of stormwater quality protection for enhanced habitats, based on removal of total suspended solids (TSS).

5.2 Potential Groundwater Impacts

5.2.1 Seepage Rates for Open-Cut Trenches

As part of the hydrogeological investigation conducted by Trow Associates, estimates of seepage rates were determined to identify the expected volume of dewatering that will be required for the installation of culverts and other sub-surface infrastructure using open-cut construction practices. The average hydraulic conductivity (K) of the different soil formations was found to be 6.25×10^{-7} m/s. This K value was used to estimate dewatering rates. Based on a 50 metre long excavation, the estimated groundwater seepage into the excavation is estimated to be 45 m^3/day.

5.2.2 Dewatering Impacts

Based on water well records obtained by Trow Associates from the Ministry of Environment water well database, 85 wells are present within a 500 metre radius of the Site. Nineteen of these wells are situated within 50 metres from Hwy 50 and Mayfield Roads. Three of the nineteen wells are relatively shallow (less than 10 metres) and are located approximately 40 m to 50 m away from the roadway. No dewatering effects on these shallow wells are therefore anticipated.

Due to the presence of a considerable number of water wells in the area, a groundwater monitoring program prior to, during and after construction dewatering is recommended to determine any dewatering related impacts on the water wells.

5.2.3 Permit to Take Water

The dewatering rate required for a 50 metre long section of the proposed culvert/sewer installation was estimated to be approximately 45 m^3/day (refer to Section 5.2.1). In terms of the requirements for a Permit to Take water Application (PTTW), Trow Associates suggests increasing the dewatering rate by 50% to account for the uncertainties on the hydraulic properties of the geologic formations and increased seepage rates under the transient

hydraulic conditions. The anticipated dewatering rate is expected to be between 60 m^3/day and 75 m^3/day.

A PTTW from the MOE is required if groundwater dewatering exceeds 50 m^3/day.

5.3 Stormwater Management Options

5.3.1 List of Options

"Do Nothing" Alternative

The proposed roadways widening will increase the pavement area within the study limit. The increase in paved area will increase the quantity of runoff and the amount of pollutants draining to the receiving watercourses. If nothing is done to mitigate these effects, the receiving watercourses may be negatively affected with the potential for reduced stream quality, degraded aquatic habitat, and in-stream erosion. Since there are potential negative consequences associated with a "do nothing" alternative it cannot be considered a reasonable or acceptable course of action. Hence, some form of mitigation must be undertaken to manage the stormwater runoff from the proposed roadway improvement.

The list of stormwater management water quality measures that may be considered include:

1. Water Quality Inlets
2. Vegetative Facilities
    - Filter strips
    - Enhanced grassed swales
3. Infiltration Facilities
    - Infiltration basins
    - Infiltration trenches
    - Soak-away pits
4. Detention Facilities
    - Extended detention wet ponds
    - Extended detention dry ponds
    - Extended detention wetlands

Each of these types of treatment was reviewed for application to this project.

5.3.2 Water Quality Inlets

Water quality inlets, also known as oil/grit separators, combine storage chambers for sediment trapping and oil separation with drainage inlets or inflow sewers for intercepting or receiving roadway stormwater runoff. Oil/grit separators are capable of removing up to 80%

of the annual sediment load when properly applied as a source control for small areas. This type of SWMP was considered feasible for this study.

5.3.3 Vegetative Facilities

Vegetative facilities treat runoff through filtration and sedimentation. With appropriate site condition, they can provide effective treatment of sediment. They have limited effectiveness for controlling peak flows and downstream erosion.

Filter Strips

Filter Strips operate through a combination of sedimentation and infiltration. Shallow flows are routed over grassed filter strips, which slow down runoff to enhance both the retention of the particulate matter and the infiltration of the runoff with its dissolved constituents. Filter strips are applicable to a rural road cross section where there are at least several meters of grassed shoulder on the side of the roadway in addition to the standard shoulder and ditch. They may also be applicable where there are high vegetated embankments at deep valley crossing. Vegetated filter strips were not considered to be a water quality treatment option for Regional Road 50 and Mayfield Road widening since the roadways will be designed with an urban cross-section.

Enhanced Grassed Swales

Enhanced grassed swales are formed by widening the roadway ditches and installing small, porous check dams to retard the flow. The check dams slow down and detain the flow which increase the degree of sedimentation and infiltration that occurs. The enlarged ditches provide additional storage capacity for flow retention and sediment accumulation. Due to the limited storage capacities in ditches, the degree of flow control may be small. However, they are relatively more effective at controlling runoff from smaller, more frequent events which results in some erosion control benefit. The sediment storage capacity is also relatively small and may require more frequent clean out than a detention pond. For the enhanced grassed swales to be effective at providing the desired treatment for runoff, they should be designed with maximum flow of 0.15 m^3/s for the 25 mm Chicago type storm distribution and a maximum flow velocity of 0.5 m/s. Enhanced grassed ditches can be created by relatively minor modifications to the standard ditches in a rural roadway section. Enhanced grassed swales were considered to be a feasible water quality treatment option for Regional Road 50.

5.3.4 Infiltration Facilities

Infiltration facilities capture runoff for infiltration to groundwater. This reduces the rates of runoff to the streams and provides a high level of treatment through the capture of both particulate and dissolved constituents. These types of facilities reduce water temperature impacts and enhance stream base flows through groundwater recharge. Since the volume of runoff to the receiving streams is reduced, these facilities also contribute to controlling downstream erosion and peak flow increases.

The disadvantage of these types of facilities is that they tend to become clogged by sediment wash-off from the roadway. As a result, the maintenance of an infiltration facility may be more frequent and more costly than other types of stormwater management. A second disadvantage is the need to protect the groundwater from contamination from chlorides and other constituents of road runoff. In addition to the above, infiltration facilities are effective only when the native soil column is permeable enough to allow the runoff from the infiltration basin to percolate through. As noted in Section 5.2.1, the hydraulic conductivity of the native soil along the study corridor is 6.25×10^{-7} m/s, which is not adequate for infiltration purposes. For these reasons, infiltration facilities were not considered further.

5.3.5 Stormwater Management Detention Facilities

Detention facilities operate on the basis of temporary storage of runoff to promote the removal of pollutants through sedimentation. They are generally effective at removing particulate constituents such as sediments and metals but ineffective at removing dissolved constituents such as salt. Extended detention wet ponds and constructed wetlands are considered to be effective at achieving an enhanced level of treatment for roadway runoff. Extended detention dry ponds generally do not provide this level of treatment. Detention facilities are also effective for erosion and peak flow (flood) control.

The disadvantage of these facilities is their large land requirement. For this project, there is a space constraint within the right-of-way that would not accommodate the construction of detention facilities.

5.4 Feasible SWM Options

Based on the screening of stormwater management options, oil grit separators and enhanced grassed swales are considered to be feasible for the Regional Road 50 widening project.

It is possible however, that drainage from Mayfield Road and Highway 50 can be collected by urban drainage networks (conveyance and stormwater management systems) associated with new development in the City of Brampton. It is anticipated that future development on the west side of Highway 50 and south of Mayfield Road (Secondary Plan 47) could potentially provide opportunities to intercept Highway 50 and Mayfield Road right-of-way drainage and convey these flows to future stormwater management facilities where appropriate water quality control can be provided. The implementation of this alternative is almost entirely dependant on the timing of construction of both the development lands and Highway 50/Mayfield Road. Other factors such as technical feasibility and cost-sharing arrangements must also be considered.

5.5 Proposed Stormwater Management Plan

The proposed stormwater management plan for the project has been developed by examining the opportunities and constraints within the entire project area. The proposed plan consists of an urban roadway section for Regional Road 50. Runoff from the paved roadway area will be conveyed by new storm sewers, new ditches and existing culverts.

The existing ditch system on the west side of Highway 50 will be relocated further west and will continue to function to collect and convey drainage from external lands west of the Highway 50 corridor to the respective culvert crossing locations.

As mentioned in section 5.4, the Secondary Plan 47 will need to drain a portion of the development lands to the Regional Road 50 right-of-way under future conditions. On an interim basis the external drainage from the undeveloped lands can continue to be conveyed through the crossing culverts under Regional Road 50. However, from our preliminary investigations it has been determined that it will not be possible to capture and treat all of the drainage from future subdivisions using the Regional Road 50 cross culverts. It will be possible to convey some post development external drainage at levels equal to current levels for each existing cross culvert.

Therefore the proposed drainage and stormwater management presented in this report maintains all culverts currently crossing Regional Road 50. In the future, some of those culverts may not be necessary and could be abandoned. However, until the lands west of Regional Road 50 are developed, those culverts will be required to convey external drainage.

Two options for stormwater management quality control were considered.

Oil/Grit Separator Option

Oil/grip separators could be installed at storm sewer outlets to control stormwater quality originating on the roadway. The oil-grit separator unit generally has two design requirements and limitations:

1. A 25 mm and 75 mm drop from inlet to outlet must occur for one and two inlet configurations respectively
2. A minimum of 450 mm of cover is required from the crown of the pipe to ground level.

Enhanced Grassed Swale Option

Enhanced grassed swales could be constructed at the downstream end of storm sewer outlets, where appropriate. The grassed swales require a minimum length of 60 metres for effective water quality treatment and should have contributing drainage areas of less than 2 hectares. However, most of the outlets have space constraints. For the most part, this option will

require property acquisition to accommodate the construction of enhanced grassed swales; otherwise retaining walls will be required to confine this BMP within the existing ROW.

Recommendation

For the Highway 50 and Mayfield Road widening project, it is recommended that oil-grit separators (OGS) be included into the roadway drainage system to provide the necessary Enhanced Level protection required to meet water quality control criteria.

Table 5-1 presents a summary of the Highway 50 and Mayfield Road pavement area for both existing and proposed conditions as well as the proposed OGS treatment at each of the watercourse crossing locations.

A total of twenty-four (24) oil-grit separators are proposed for installation throughout the project limits. The locations of the proposed OGS units are illustrated on **Exhibits 5-1 to 5-9,** including catchment area limits for each separator unit which range in area from 0.33 ha to 2.6 ha. The sizing of the OGS units will be undertaken during detailed design.

The stormwater management strategy recommended for this project will provide water quality treatment to 25.0 hectares of pavement area which exceeds the additional pavement area (10.8 hectares) and represents 231% of the overall pavement area.

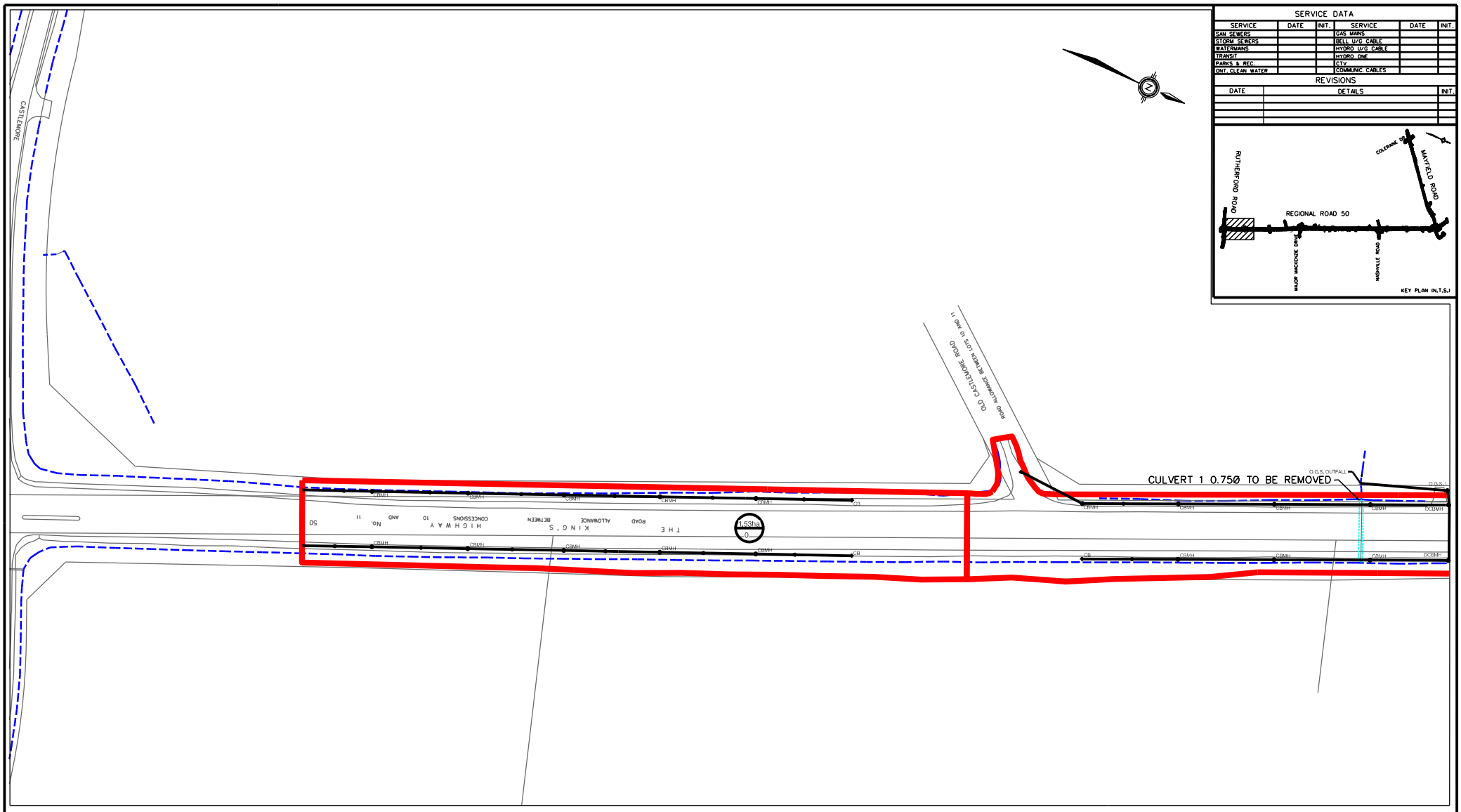
As noted in Section 5.4, there is a possibility that drainage from Mayfield Road and Highway 50 can be integrated with urban drainage systems associated with future development west of Highway 50 and south of Mayfield Road (Secondary Plan 47). The above water quality control strategy (i.e. use of OGS) should be incorporated only if the widening of Highway 50/Mayfield Road occurs prior to the development of the Secondary Plan 47 lands.

The Region of Peel will pursue opportunities to have Highway 50/Mayfield Road storm runoff discharge to future stormwater management facilities by way of the land development process (e.g. through conditions of draft plan approval, subdivision agreements etc). In addition, during detail design, provisions can be made for future storm sewer connections from the roadway to future drainage systems by extending these systems to the roadway right-of-way and temporarily plugging the storm sewers.

As such, it is anticipated that ultimately, runoff from the Highway 50/Mayfield Road corridor will be treated through a combination of future stormwater management facilities within the Secondary Plan 47 area as well as Oil-grit Separator systems within the Highway 50/Mayfield Road drainage systems.

Table 5-1: Pavement Area and Treatment Summary - Hwy 50 and Mayfield Road

								Oil- Grit Separator		
Roadway	Starting station (m)	Ending station (m)	Length of Road (m)	Total Drainage Area (m^2)	Existing paved Area (m^2)	Proposed Paved Area (Incl. Sidewalks) (m^2)	New Paved Area (+ sidewalk) (m^2)	Total Pavement Treated (m^2)	Total Pavement Treated (%)	Total Pavement Treated as % of New Pvmt
Hwy 50	6550	6900	350	15275	8116	11845	3729	11845	100	146
Hwy 50	6900	7500	600	25690	13055	20845	7790	20845	100	160
Hwy 50	7500	7720	220	9570	5410	7546	2136	7546	100	139
Hwy 50	7720	7987	267	12225	5402	9145	3743	9145	100	169
Hwy 50	7987	8505	518	30550	11770	26013	14243	26013	100	221
Hwy 50	8505	8630	125	5625	2835	4830	1995	4830	100	170
Hwy 50	8630	8897	267	11005	5667	9105	3438	9105	100	161
Hwy 50	8897	9250	353	14478	7245	12020	4775	12020	100	166
Hwy 50	9250	9387	137	5630	3008	4670	1662	4670	100	155
Hwy 50	9387	9563	176	7245	3617	6011	2394	6011	100	166
Hwy 50	9563	10196	633	25976	13075	21578	8503	21578	100	165
Hwy 50	10196	10660	464	24175	12819	20532	7713	20532	100	160
Hwy 50	10660	10808	148	6260	3289	5195	1906	5195	100	158
Hwy 50	10808	10907	99	4065	2011	3367	1356	3367	100	167
Hwy 50	10907	11011	104	4306	2162	3587	1425	3587	100	166
Hwy 50	11011	11136	125	4982	2700	4283	1583	4283	100	159
Hwy 50	11136	11675	539	22145	10935	18375	7440	18375	100	168
Hwy 50	11675	11820	145	5953	3650	4896	1246	4896	100	134
Hwy 50	11820	12214	394	19545	11380	17857	6477	17857	100	157
Mayfield	20085	20219	134	5415	2116	4278	2162	4278	100	202
Mayfield	20219	20367	148	5678	1196	4387	3191	4387	100	367
Mayfield	20367	20572	205	7606	1649	5859	4210	5859	100	355
Mayfield	20572	20977	405	15730	3548	11133	7585	11133	100	314
Mayfield	20977	21322	345	15244	5480	12589	7109	12589	100	230



SERVICE DATA

SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN SEWERS			GAS MAINS		
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS

DATE	DETAILS	INIT.

LEGEND

- 1A / 5.5 — O.G.S. CATCHMENT ID / AREA (ha)
- EXISTING DITCH
- EXISTING CULVERT
- DRAINAGE AREA BOUNDARY
- CB — STORM SEWER

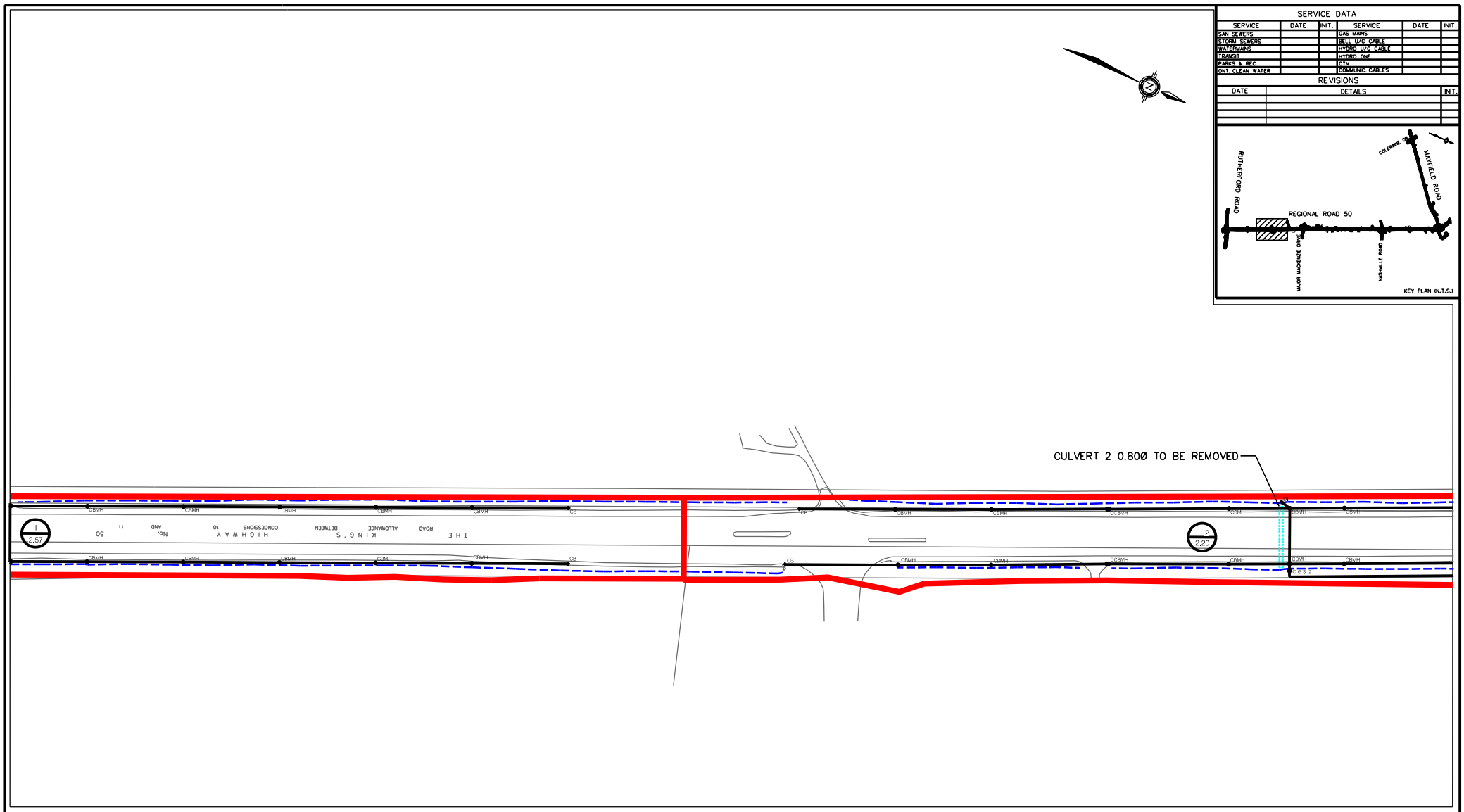
10m 0 10 20 30m HORIZONTAL SCALE

Region of Peel
Working for you

REGIONAL ROAD 50

PROPOSED DRAINAGE PLAN
FROM CASTLEMORE DR TO MAYFIELD RD
FROM STA. 6+400 TO STA. 7+150

CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 5-1



SERVICE DATA

SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN SEWERS			GAS MAINS		
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS

DATE	DETAILS	INIT.

LEGEND

- 1A / 5.5 — O.G.S. CATCHMENT ID / AREA (ha)
- EXISTING DITCH
- EXISTING CULVERT
- DRAINAGE AREA BOUNDARY
- CB — STORM SEWER

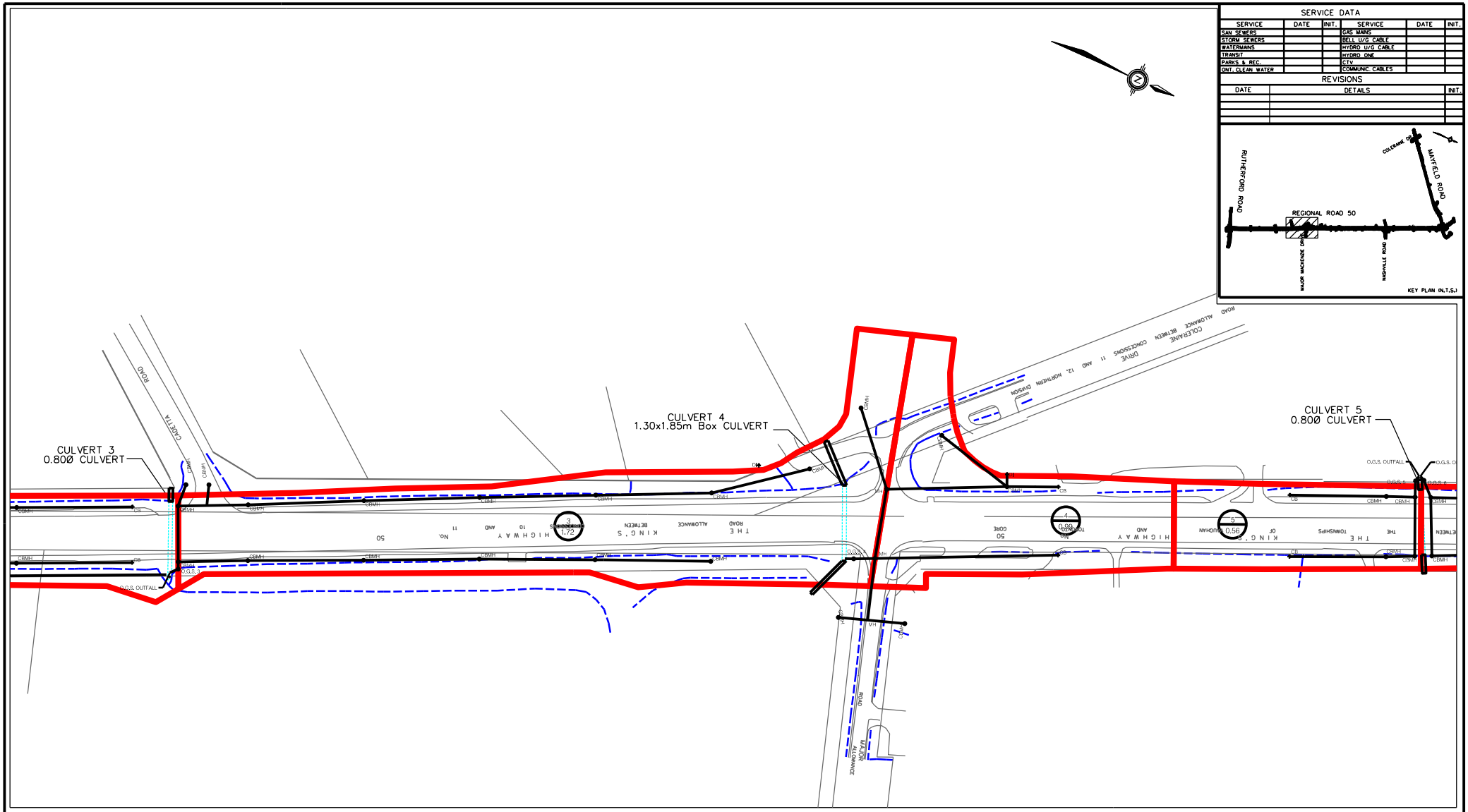
10m 0 10 20 30m HORIZONTAL SCALE

Region of Peel
Working for you

REGIONAL ROAD 50

PROPOSED DRAINAGE PLAN
FROM CASTLEMORE DR TO MAYFIELD RD
FROM STA. 7+150 TO STA. 7+900

CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 5-2



SERVICE DATA

SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN SEWERS			GAS MAINS		
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS

DATE	DETAILS	INIT.

LEGEND

- 1A / 5.5 — O.G.S. CATCHMENT ID / AREA (ha)
- EXISTING DITCH
- EXISTING CULVERT
- DRAINAGE AREA BOUNDARY
- CB — STORM SEWER

10m 0 10 20 30m HORIZONTAL SCALE

Region of Peel
Working for you

REGIONAL ROAD 50

PROPOSED DRAINAGE PLAN
FROM CASTLEMORE DR TO MAYFIELD RD
FROM STA. 7+900 TO STA. 8+650

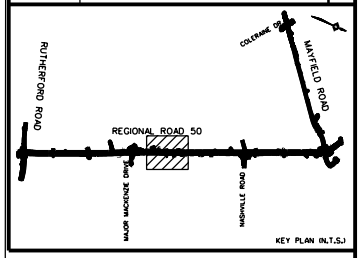
CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 5-3

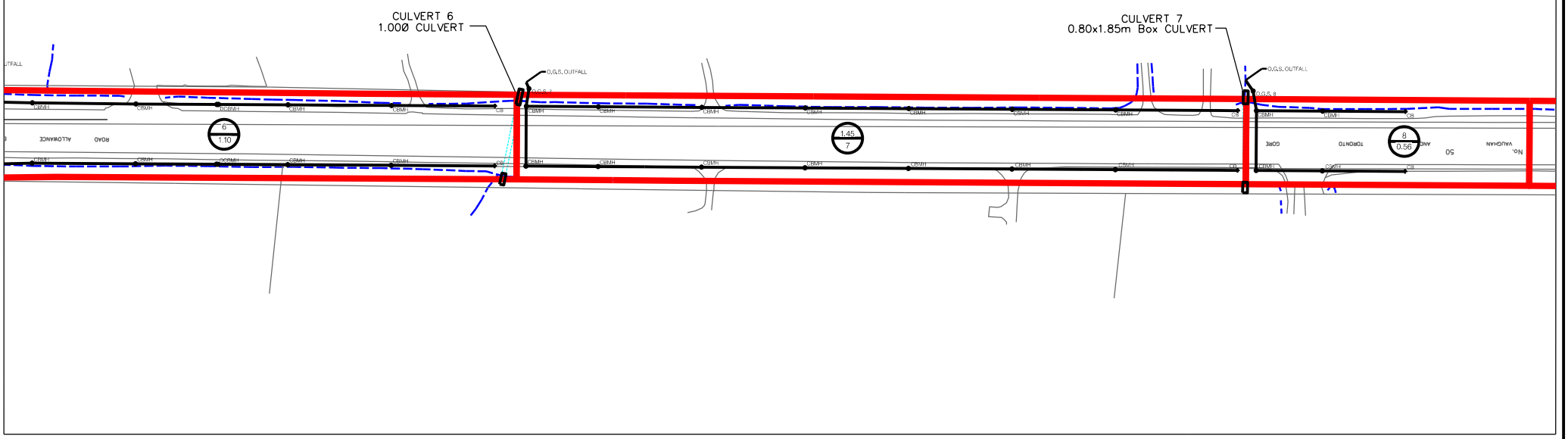
SERVICE DATA

SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN SEWERS			GAS MAINS		
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS

DATE	DETAILS	INIT.





LEGEND

- 1A / 5.5 — O.G.S. CATCHMENT ID, AREA (ha)
- EXISTING DITCH
- EXISTING CULVERT
- DRAINAGE AREA BOUNDARY
- STORM SEWER (CB)

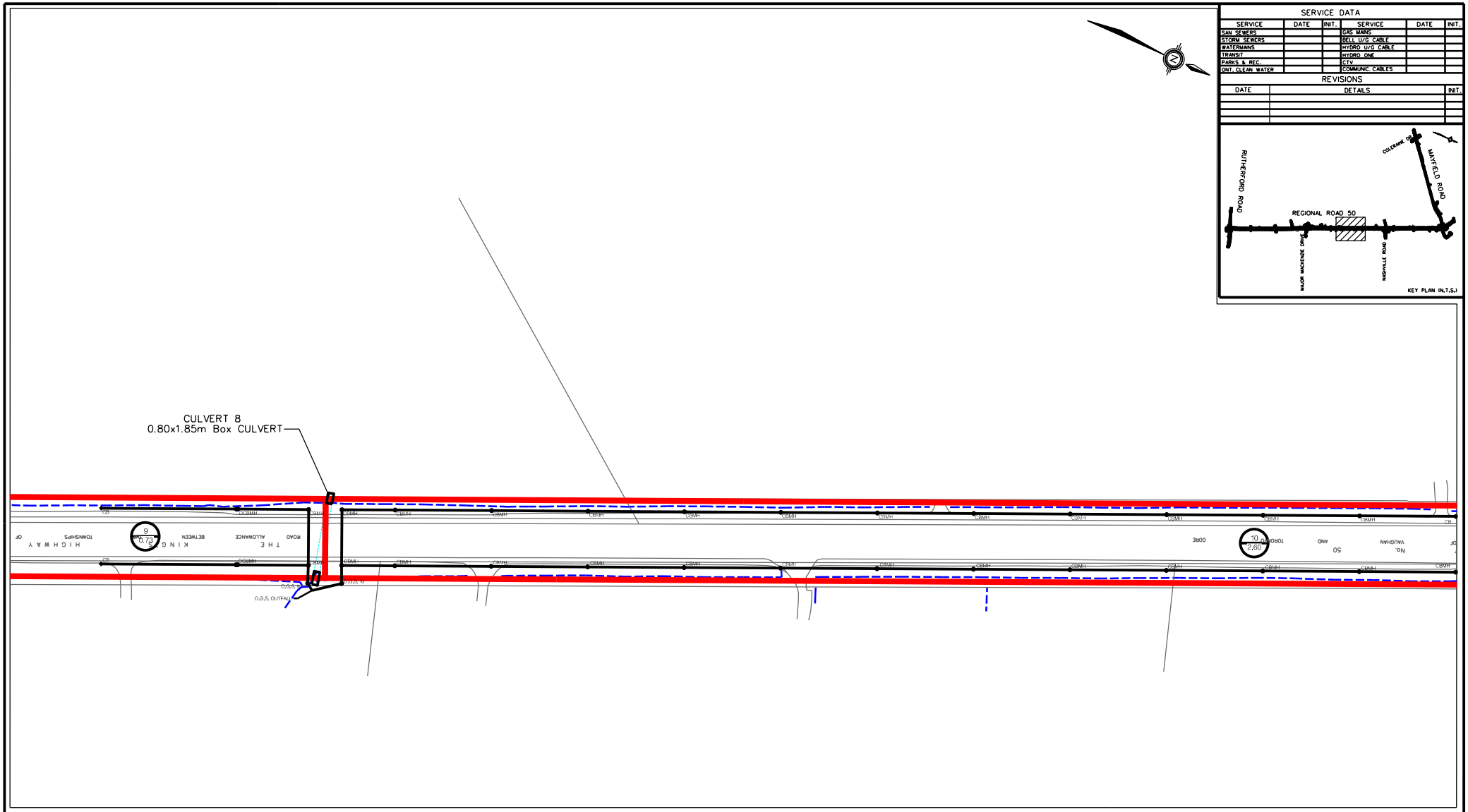
10m 0 10 20 30m HORIZONTAL SCALE

Region of Peel
Working for you

REGIONAL ROAD 50

PROPOSED DRAINAGE PLAN
FROM CASTLEMORE DR TO MAYFIELD RD
FROM STA. 8+650 TO STA. 9+400

CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 5-4



SERVICE DATA

SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN SEWERS			GAS MAINS		
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS

DATE	DETAILS	INIT.

LEGEND

- 1A / 5.5 — O.G.S. CATCHMENT ID / AREA (ha)
- EXISTING DITCH
- EXISTING CULVERT
- DRAINAGE AREA BOUNDARY
- CB — STORM SEWER

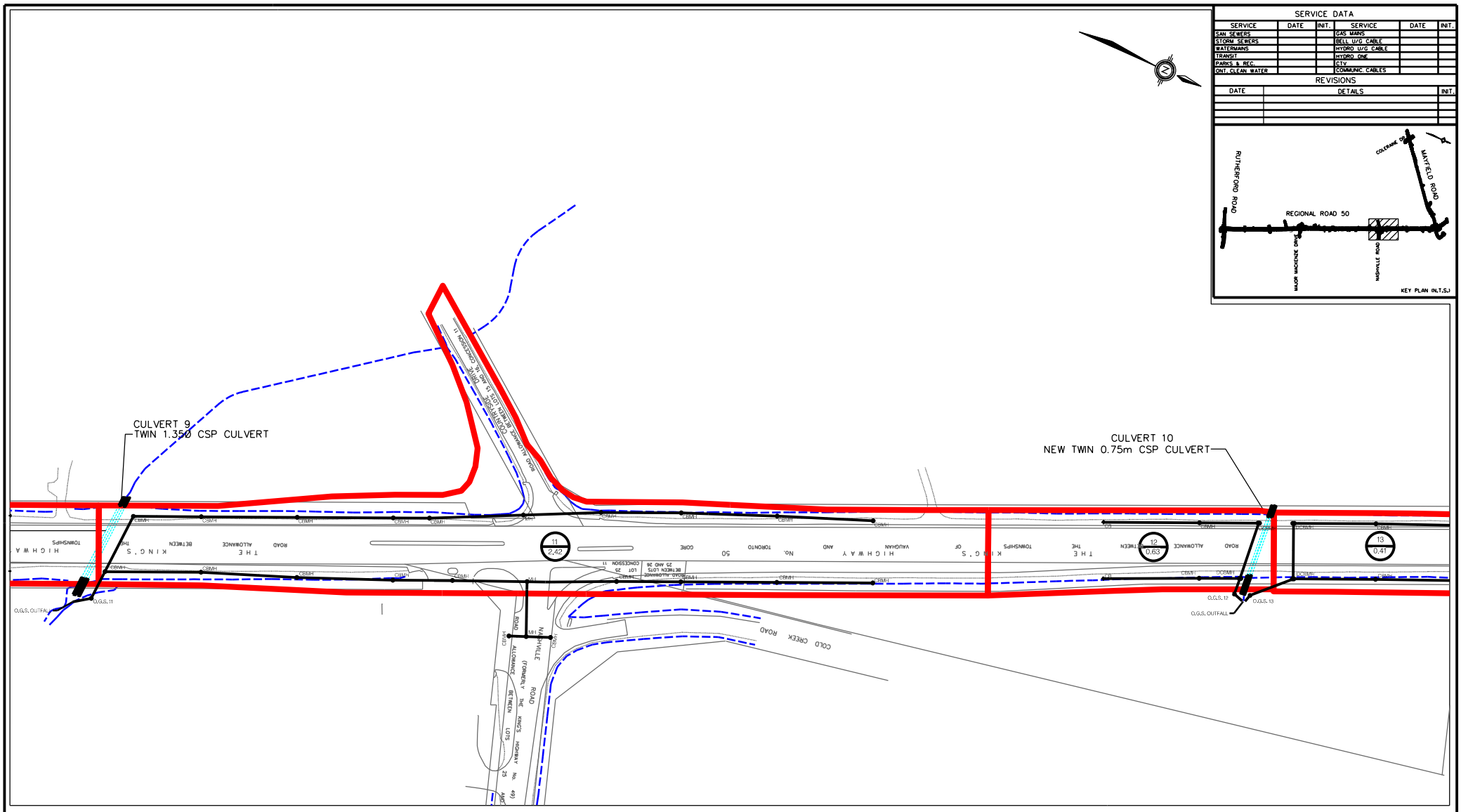
10m 0 10 20 30m HORIZONTAL SCALE

Region of Peel
Working for you

REGIONAL ROAD 50

PROPOSED DRAINAGE PLAN
FROM CASTLEMORE DR TO MAYFIELD RD
FROM STA. 9+400 TO STA. 10+150

CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 5-5



SERVICE DATA

SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN SEWERS			GAS MAINS		
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS

DATE	DETAILS	INIT.

LEGEND

- 1A / 5.5 — O.G.S. CATCHMENT ID / AREA (ha)
- EXISTING DITCH
- EXISTING CULVERT
- DRAINAGE AREA BOUNDARY
- STORM SEWER (CB)

10m 0 10 20 30m HORIZONTAL SCALE

Region of Peel
Working for you

REGIONAL ROAD 50

PROPOSED DRAINAGE PLAN
FROM CASTLEMORE DR TO MAYFIELD RD
FROM STA. 10+150 TO STA. 10+900

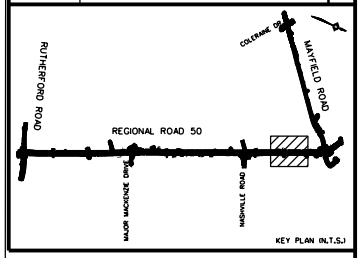
CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 5-6

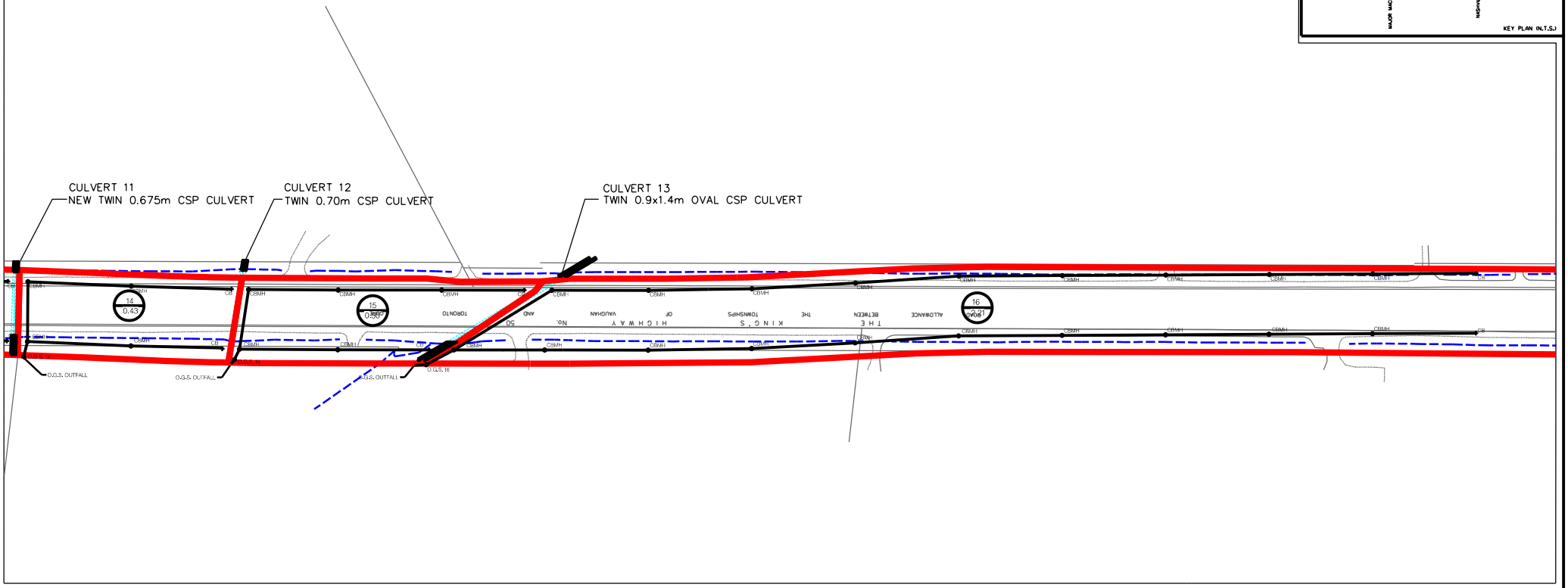
SERVICE DATA

SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN SEWERS			GAS MAINS		
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS

DATE	DETAILS	INIT.





LEGEND

- 1A / 5.5 — O.G.S. CATCHMENT ID, AREA (ha)
- EXISTING DITCH
- EXISTING CULVERT
- DRAINAGE AREA BOUNDARY
- STORM SEWER
- CB

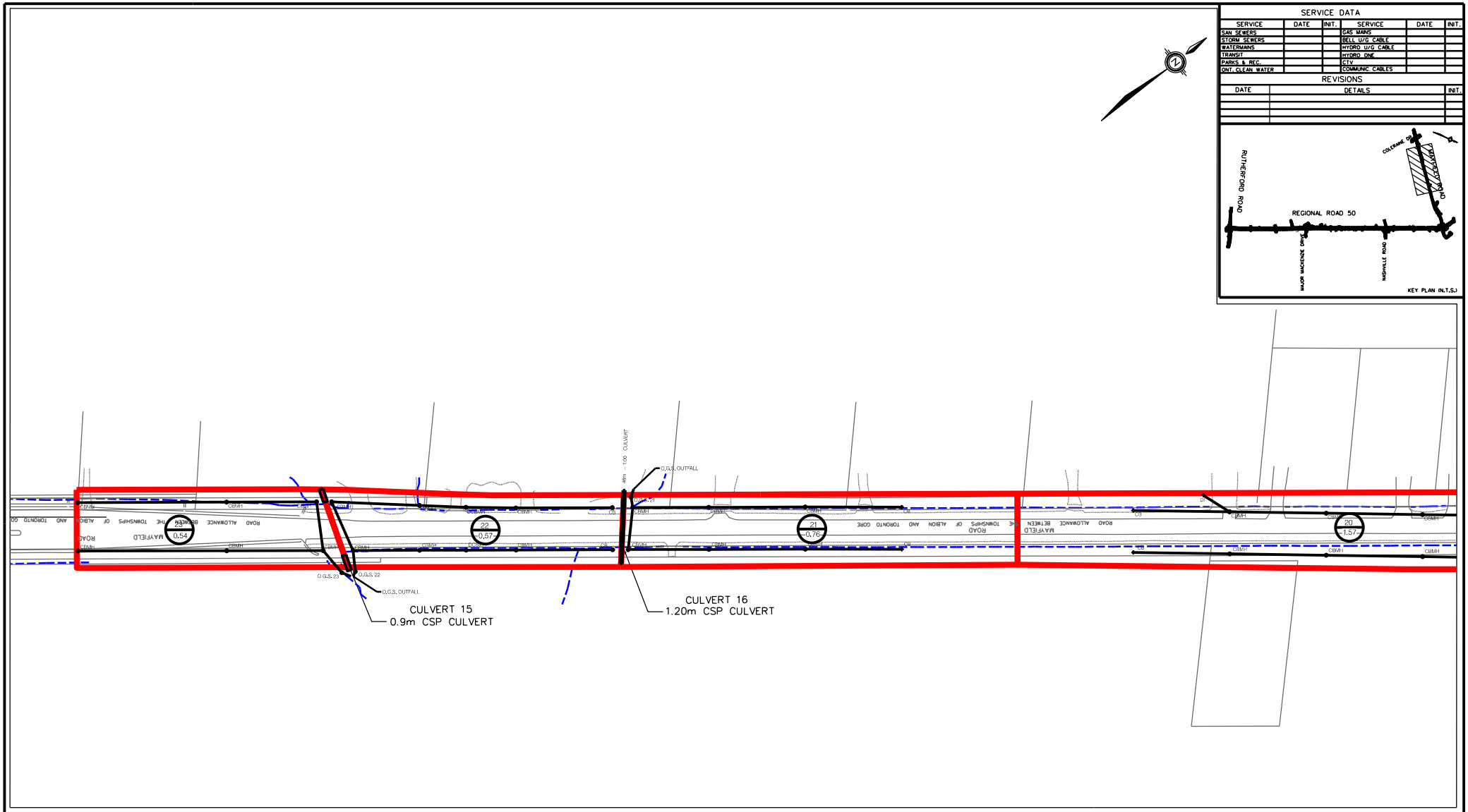
10m 0 10 20 30m HORIZONTAL SCALE

Region of Peel
Working for you

REGIONAL ROAD 50

PRPOSED DRAINAGE PLAN
FROM CASTLEMORE DR TO MAYFIELD RD
FROM STA. 10+900 TO STA. 11+650

CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 5-7



SERVICE DATA

SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN SEWERS			GAS MAINS		
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS

DATE	DETAILS	INIT.

LEGEND

- 1A / 5.5 — O.G.S. CATCHMENT ID / AREA (ha)
- EXISTING DITCH
- EXISTING CULVERT
- DRAINAGE AREA BOUNDARY
- CB — STORM SEWER

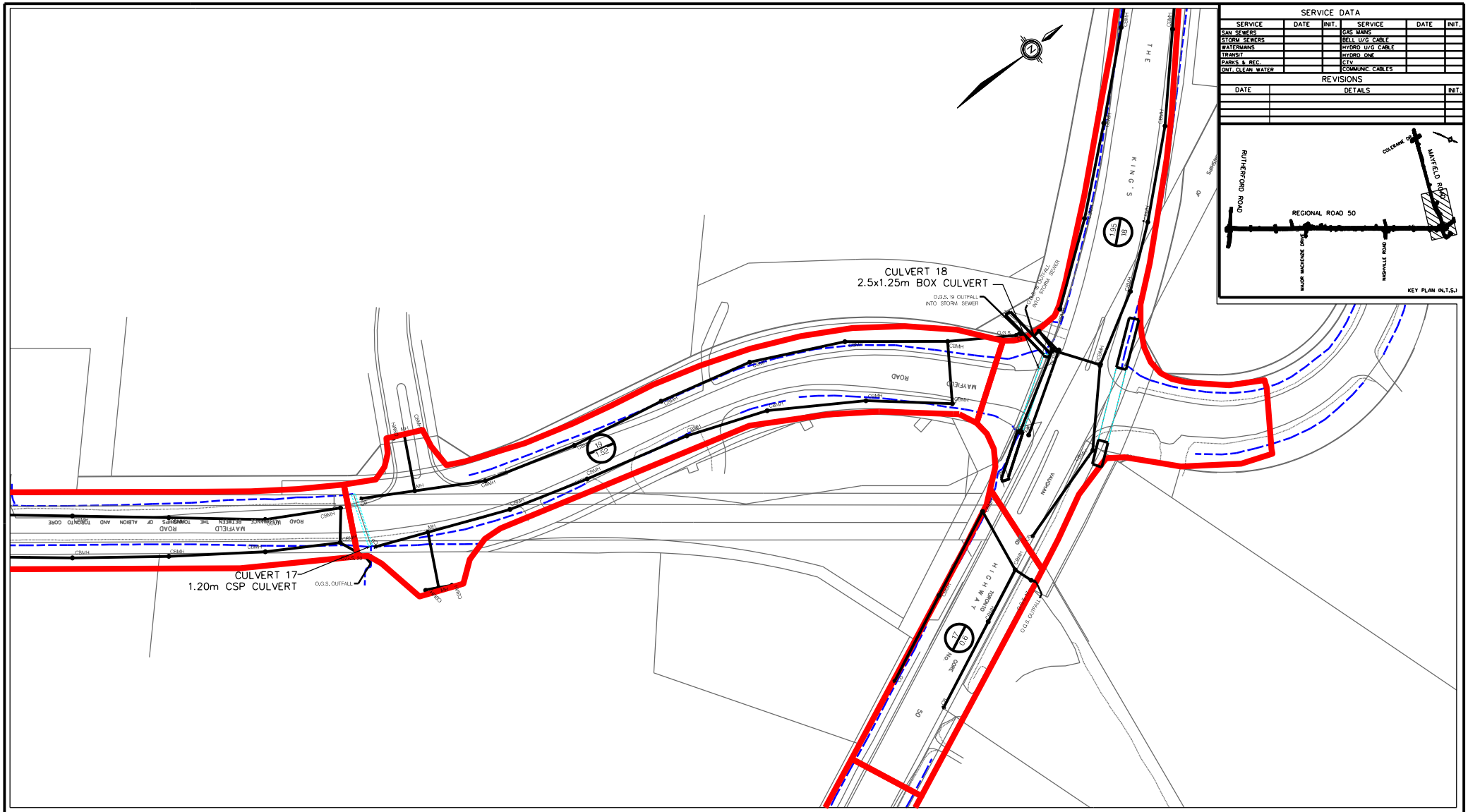
10m 0 10 20 30m HORIZONTAL SCALE

Region of Peel
Working for you

MAYFIELD ROAD

PROPOSED DRAINAGE PLAN
FROM COLERAINE DR. TO HWY 50
FROM STA. 20+050 TO STA. 20+800

CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 5-8



SERVICE DATA

SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN SEWERS			GAS MAINS		
STORM SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
TRANSIT			HYDRO ONE		
PARKS & REC.			CTV		
ONT. CLEAN WATER			COMMUNIC. CABLES		

REVISIONS

DATE	DETAILS	INIT.

LEGEND

- 1A / 5.5 — O.G.S. CATCHMENT ID / AREA (ha)
- EXISTING DITCH
- EXISTING CULVERT
- DRAINAGE AREA BOUNDARY
- CB — STORM SEWER

10m 0 10 20 30m HORIZONTAL SCALE

Region of Peel
Working for you

MAYFIELD RD.

PROPOSED DRAINAGE PLAN
FROM COLERAINE DR. TO HWY 50
FROM STA. 20+800 TO STA. 21+550

CAD Area	Area	Project No. 4956
Checked by TR	Drawn by LPL	
Date MARCH 2011	Sheet	Plan No. EXHIBIT 5-9

6. EROSION AND SEDIMENT CONTROL DURING CONSTRUCTION

6.1 Erosion and Sediment Control Measures

Erosion and sediment control measures should be implemented and monitored through the construction period. Construction activity should be conducted during periods that are least likely to result in in-stream impacts to fish habitat.

Detailed erosion and sediment control plans will be required as part of the detailed design component for all phases of the construction. The erosion and sediment control plans will be subject to review and approval by the various external agencies involved in the project. These would include the Region of Peel, Region of York and Toronto Region Conservation Authority. The erosion and sediment control plans shall be prepared in accordance with the **TRCA's Erosion and Sediment Control Guidelines (December 2006)** and shall adhere to the criteria contained within the guideline document.

During construction, disturbances to watercourse riparian vegetation should be minimized. If riparian vegetation is removed or disturbed, erosion and sediment control measures such as silt fences, rock flow check dams and sedimentation ponds should be utilized to provide a maximum protection of local and downstream aquatic resources. These measures should be maintained during construction and until disturbed areas have been stabilized with seed and mulch. Additionally, topsoil should not be stockpiled close to the watercourses, and water should not be withdrawn from these sensitive streams for construction purposes.

The site engineer and contractor will be responsible for delineating work areas, and ensuring that erosion and sediment control measures are functional. In addition, the engineer will ensure that provisions related to fisheries and watercourse protection is met and that fish habitat compensation measures are implemented in accordance with the terms and conditions of the Fisheries Act Authorization.

7. SUMMARY AND CONCLUSIONS

A summary of the study recommendations is provided below:

1. The preliminary stormwater management plan presented in this report addresses the potential impacts that widening Regional Road 50 and Mayfield Road may have on the receiving surface water features. The proposed stormwater management plan is designed to prevent impacts from the future six lane roadway configuration. The plan maximizes the use of available technologies and opportunities taking into consideration the site constraints, thus to achieving the highest degree of control possible.
2. Some sections of Highway 50 contain very mild longitudinal gradients. In addition, several existing culvert crossings that convey external drainage across Highway 50 and Mayfield Road are very shallow (i.e. close to the existing surface grade). The combination of these two factors will require mild storm sewer gradients which may affect the size of the storm sewer pipes. To minimize the storm sewer sizes, a dual-line storm sewer collection is proposed throughout the project limits. The proposed sewer configuration will also minimize traffic staging and detouring requirements during the sewer construction phase.
3. Storm sewers will be provided for conveyance of all pavement areas. Storm sewers shall be sized to convey the 10 year design storm as per Region of Peel requirements. Major system (overland) flows will be conveyed along the road surface within the roadway right-of-way in a safe manner.
4. A total of three (3) transverse culverts will need to be replaced either due to physical deterioration or lack of hydraulic capacity. These include the following:
    - Culvert crossing 10 (Station 10+798) New twin 750 mm diameter culverts
    - Culvert Crossing 11 (Station 10+905) New twin 675 mm diameter culverts
    - Culvert Crossing 16 (Station 20+367) New twin 1000 mm diameter culverts
5. Existing transverse culvert crossings need to be extended to accommodate the roadway widening.
6. Flooding conditions at the Highway 50 and Mayfield Road intersection will be improved as a result of the vertical profile adjustment on Mayfield Road.
7. Ditches will be provided on the west side of the Highway 50 right-of-way to collect external drainage from adjacent lands and convey the flow to the respective transverse culvert crossings.
8. Wherever feasible, stormwater treatment will be provided at storm sewer outlets. Storm water quality treatment is to be provided by oil-grit separators. A total of 24 OGS units are proposed throughout the study corridor.

   Where possible and depending on the timing of development of lands west of Highway 50 and south of Mayfield Road, opportunities to integrate Highway 50 and Mayfield Road drainage with storm drainage systems from adjacent developments should be

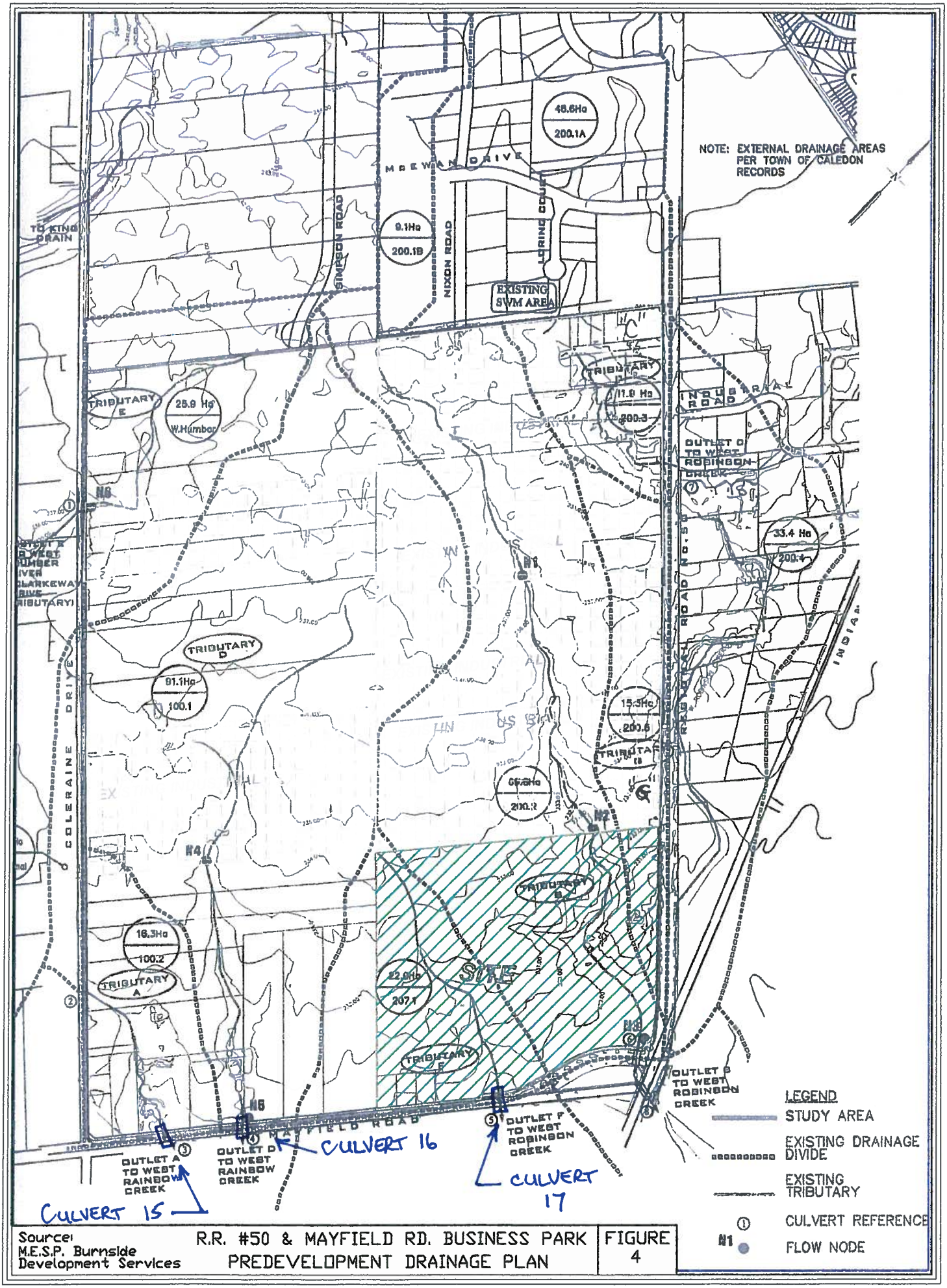
pursued. Provisions for future storm connections from Highway 50 and Mayfield Road to future storm systems within the future development lands should also be considered during detail design.

9. Erosion and sediment control measures should be implemented and monitored through the construction period. Construction activity should be conducted during periods that are least likely to result in in-stream impacts to fish habitat.

Appendix A

Culvert Master Model Output

Existing Condition Culvert Master Output



Source:
M.E.S.P. Burnside
Development Services

R.R. #50 & MAYFIELD RD. BUSINESS PARK
PREDEVELOPMENT DRAINAGE PLAN

FIGURE 4

Culvert Calculator Report
Crossing 1 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	208.25 m	Headwater Depth/Height	0.74
Computed Headwater Elevation	207.46 m	Discharge	0.2500 m³/s
Inlet Control HW Elev.	207.40 m	Tailwater Elevation	207.26 m
Outlet Control HW Elev.	207.46 m	Control Type	Outlet Control

Grades			
Upstream Invert	206.94 m	Downstream Invert	206.73 m
Length	31.93 m	Constructed Slope	0.006577 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.53 m
Slope Type	Mild	Normal Depth	0.39 m
Flow Regime	Subcritical	Critical Depth	0.31 m
Velocity Downstream	0.79 m/s	Critical Slope	0.015048 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.71 m
Section Size	700 mm	Rise	0.71 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	207.46 m	Upstream Velocity Head	0.05 m
Ke	0.90	Entrance Loss	0.05 m

Inlet Control Properties			
Inlet Control HW Elev.	207.40 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	0.4 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 1 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	208.25 m	Headwater Depth/Height	0.82
Computed Headwater Elevation	207.52 m	Discharge	0.3000 m³/s
Inlet Control HW Elev.	207.46 m	Tailwater Elevation	207.28 m
Outlet Control HW Elev.	207.52 m	Control Type	Outlet Control

Grades			
Upstream Invert	206.94 m	Downstream Invert	206.73 m
Length	31.93 m	Constructed Slope	0.006577 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.55 m
Slope Type	Mild	Normal Depth	0.44 m
Flow Regime	Subcritical	Critical Depth	0.34 m
Velocity Downstream	0.91 m/s	Critical Slope	0.015488 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.71 m
Section Size	700 mm	Rise	0.71 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	207.52 m	Upstream Velocity Head	0.06 m
Ke	0.90	Entrance Loss	0.05 m

Inlet Control Properties			
Inlet Control HW Elev.	207.46 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	0.4 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 2 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	209.26 m	Headwater Depth/Height	0.45
Computed Headwater Elevation	207.95 m	Discharge	0.1500 m³/s
Inlet Control HW Elev.	207.90 m	Tailwater Elevation	207.81 m
Outlet Control HW Elev.	207.95 m	Control Type	Outlet Control

Grades			
Upstream Invert	207.58 m	Downstream Invert	207.30 m
Length	31.96 m	Constructed Slope	0.008761 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.51 m
Slope Type	Mild	Normal Depth	0.26 m
Flow Regime	Subcritical	Critical Depth	0.23 m
Velocity Downstream	0.44 m/s	Critical Slope	0.013818 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.81 m
Section Size	800 mm	Rise	0.81 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	207.95 m	Upstream Velocity Head	0.05 m
Ke	0.90	Entrance Loss	0.04 m

Inlet Control Properties			
Inlet Control HW Elev.	207.90 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	0.5 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 2 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	209.26 m	Headwater Depth/Height	0.48
Computed Headwater Elevation	207.97 m	Discharge	0.1700 m³/s
Inlet Control HW Elev.	207.92 m	Tailwater Elevation	207.82 m
Outlet Control HW Elev.	207.97 m	Control Type	Outlet Control

Grades			
Upstream Invert	207.58 m	Downstream Invert	207.30 m
Length	31.96 m	Constructed Slope	0.008761 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.52 m
Slope Type	Mild	Normal Depth	0.27 m
Flow Regime	Subcritical	Critical Depth	0.24 m
Velocity Downstream	0.49 m/s	Critical Slope	0.013804 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.81 m
Section Size	800 mm	Rise	0.81 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	207.97 m	Upstream Velocity Head	0.05 m
Ke	0.90	Entrance Loss	0.05 m

Inlet Control Properties			
Inlet Control HW Elev.	207.92 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	0.5 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 3 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	210.13 m	Headwater Depth/Height	0.70
Computed Headwater Elevation	209.07 m	Discharge	0.3100 m³/s
Inlet Control HW Elev.	208.99 m	Tailwater Elevation	208.42 m
Outlet Control HW Elev.	209.07 m	Control Type	Entrance Control

Grades			
Upstream Invert	208.50 m	Downstream Invert	207.85 m
Length	40.69 m	Constructed Slope	0.015974 m/m

Hydraulic Profile			
Profile	CompositeS1S2	Depth, Downstream	0.57 m
Slope Type	Steep	Normal Depth	0.32 m
Flow Regime	N/A	Critical Depth	0.33 m
Velocity Downstream	0.80 m/s	Critical Slope	0.014196 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.81 m
Section Size	800 mm	Rise	0.81 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	209.07 m	Upstream Velocity Head	0.12 m
Ke	0.90	Entrance Loss	0.11 m

Inlet Control Properties			
Inlet Control HW Elev.	208.99 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	0.5 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 3 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	210.13 m	Headwater Depth/Height	0.76
Computed Headwater Elevation	209.12 m	Discharge	0.3600 m³/s
Inlet Control HW Elev.	209.03 m	Tailwater Elevation	208.43 m
Outlet Control HW Elev.	209.12 m	Control Type	Entrance Control

Grades			
Upstream Invert	208.50 m	Downstream Invert	207.85 m
Length	40.69 m	Constructed Slope	0.015974 m/m

Hydraulic Profile			
Profile	CompositeS1S2	Depth, Downstream	0.58 m
Slope Type	Steep	Normal Depth	0.35 m
Flow Regime	N/A	Critical Depth	0.36 m
Velocity Downstream	0.91 m/s	Critical Slope	0.014463 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.81 m
Section Size	800 mm	Rise	0.81 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	209.12 m	Upstream Velocity Head	0.14 m
Ke	0.90	Entrance Loss	0.12 m

Inlet Control Properties			
Inlet Control HW Elev.	209.03 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	0.5 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 4 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	211.66 m	Headwater Depth/Height	0.79
Computed Headwater Elevation	209.86 m	Discharge	2.1100 m^3/s
Inlet Control HW Elev.	209.77 m	Tailwater Elevation	209.66 m
Outlet Control HW Elev.	209.86 m	Control Type	Outlet Control

Grades			
Upstream Invert	208.90 m	Downstream Invert	208.75 m
Length	39.23 m	Constructed Slope	0.003824 m/m

Hydraulic Profile			
Profile	S1	Depth, Downstream	0.91 m
Slope Type	Steep	Normal Depth	0.51 m
Flow Regime	Subcritical	Critical Depth	0.51 m
Velocity Downstream	1.27 m/s	Critical Slope	0.003750 m/m

Section			
Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	1.83 m
Section Size	1830 x 1220 mm	Rise	1.22 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	209.86 m	Upstream Velocity Head	0.12 m
Ke	0.70	Entrance Loss	0.08 m

Inlet Control Properties			
Inlet Control HW Elev.	209.77 m	Flow Control	N/A
Inlet Type	0° wingwall flares	Area Full	2.2 m^2
K	0.06100	HDS 5 Chart	8
M	0.75000	HDS 5 Scale	3
C	0.04230	Equation Form	1
Y	0.82000		

Culvert Calculator Report
Crossing 4 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	211.66 m	Headwater Depth/Height	0.86
Computed Headwater Elevation	209.95 m	Discharge	2.4800 m³/s
Inlet Control HW Elev.	209.87 m	Tailwater Elevation	209.69 m
Outlet Control HW Elev.	209.95 m	Control Type	Outlet Control

Grades			
Upstream Invert	208.90 m	Downstream Invert	208.75 m
Length	39.23 m	Constructed Slope	0.003824 m/m

Hydraulic Profile			
Profile	S1	Depth, Downstream	0.94 m
Slope Type	Steep	Normal Depth	0.57 m
Flow Regime	Subcritical	Critical Depth	0.57 m
Velocity Downstream	1.44 m/s	Critical Slope	0.003816 m/m

Section			
Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	1.83 m
Section Size	1830 x 1220 mm	Rise	1.22 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	209.95 m	Upstream Velocity Head	0.15 m
Ke	0.70	Entrance Loss	0.10 m

Inlet Control Properties			
Inlet Control HW Elev.	209.87 m	Flow Control	N/A
Inlet Type	0° wingwall flares	Area Full	2.2 m²
K	0.06100	HDS 5 Chart	8
M	0.75000	HDS 5 Scale	3
C	0.04230	Equation Form	1
Y	0.82000		

Culvert Calculator Report
Crossing 5 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	212.03 m	Headwater Depth/Height	0.59
Computed Headwater Elevation	210.57 m	Discharge	0.1500 m³/s
Inlet Control HW Elev.	210.52 m	Tailwater Elevation	210.52 m
Outlet Control HW Elev.	210.57 m	Control Type	Outlet Control

Grades			
Upstream Invert	210.09 m	Downstream Invert	210.00 m
Length	33.81 m	Constructed Slope	0.002662 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.52 m
Slope Type	Mild	Normal Depth	0.35 m
Flow Regime	Subcritical	Critical Depth	0.23 m
Velocity Downstream	0.43 m/s	Critical Slope	0.013818 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.81 m
Section Size	800 mm	Rise	0.81 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	210.57 m	Upstream Velocity Head	0.01 m
Ke	0.90	Entrance Loss	0.01 m

Inlet Control Properties			
Inlet Control HW Elev.	210.52 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	0.5 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 5 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	212.03 m	Headwater Depth/Height	0.61
Computed Headwater Elevation	210.58 m	Discharge	0.1700 m³/s
Inlet Control HW Elev.	210.52 m	Tailwater Elevation	210.52 m
Outlet Control HW Elev.	210.58 m	Control Type	Outlet Control

Grades			
Upstream Invert	210.09 m	Downstream Invert	210.00 m
Length	33.81 m	Constructed Slope	0.002662 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.52 m
Slope Type	Mild	Normal Depth	0.38 m
Flow Regime	Subcritical	Critical Depth	0.24 m
Velocity Downstream	0.49 m/s	Critical Slope	0.013804 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.81 m
Section Size	800 mm	Rise	0.81 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	210.58 m	Upstream Velocity Head	0.02 m
Ke	0.90	Entrance Loss	0.01 m

Inlet Control Properties			
Inlet Control HW Elev.	210.52 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	0.5 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 6 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	212.30 m	Headwater Depth/Height	0.54
Computed Headwater Elevation	211.12 m	Discharge	0.3400 m³/s
Inlet Control HW Elev.	211.03 m	Tailwater Elevation	210.79 m
Outlet Control HW Elev.	211.12 m	Control Type	Entrance Control

Grades			
Upstream Invert	210.57 m	Downstream Invert	210.13 m
Length	34.02 m	Constructed Slope	0.012934 m/m

Hydraulic Profile			
Profile	CompositeS1S2	Depth, Downstream	0.66 m
Slope Type	Steep	Normal Depth	0.32 m
Flow Regime	N/A	Critical Depth	0.32 m
Velocity Downstream	0.61 m/s	Critical Slope	0.012825 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	1.02 m
Section Size	1000 mm	Rise	1.02 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	211.12 m	Upstream Velocity Head	0.12 m
Ke	0.90	Entrance Loss	0.11 m

Inlet Control Properties			
Inlet Control HW Elev.	211.03 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	0.8 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 6 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	212.30 m	Headwater Depth/Height	0.59
Computed Headwater Elevation	211.17 m	Discharge	0.4000 m³/s
Inlet Control HW Elev.	211.08 m	Tailwater Elevation	210.81 m
Outlet Control HW Elev.	211.17 m	Control Type	Entrance Control

Grades			
Upstream Invert	210.57 m	Downstream Invert	210.13 m
Length	34.02 m	Constructed Slope	0.012934 m/m

Hydraulic Profile			
Profile	CompositeS1S2	Depth, Downstream	0.68 m
Slope Type	Steep	Normal Depth	0.35 m
Flow Regime	N/A	Critical Depth	0.35 m
Velocity Downstream	0.69 m/s	Critical Slope	0.012888 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	1.02 m
Section Size	1000 mm	Rise	1.02 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	211.17 m	Upstream Velocity Head	0.13 m
Ke	0.90	Entrance Loss	0.12 m

Inlet Control Properties			
Inlet Control HW Elev.	211.08 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	0.8 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 7 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	214.72 m	Headwater Depth/Height	0.49
Computed Headwater Elevation	213.30 m	Discharge	0.5000 m³/s
Inlet Control HW Elev.	213.27 m	Tailwater Elevation	213.27 m
Outlet Control HW Elev.	213.30 m	Control Type	Outlet Control

Grades			
Upstream Invert	212.85 m	Downstream Invert	212.72 m
Length	37.91 m	Constructed Slope	0.003429 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.55 m
Slope Type	Mild	Normal Depth	0.20 m
Flow Regime	Subcritical	Critical Depth	0.20 m
Velocity Downstream	0.50 m/s	Critical Slope	0.003695 m/m

Section			
Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	1.83 m
Section Size	1830 x 910 mm	Rise	0.91 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	213.30 m	Upstream Velocity Head	0.02 m
Ke	0.20	Entrance Loss	0.00 m

Inlet Control Properties			
Inlet Control HW Elev.	213.27 m	Flow Control	N/A
Inlet Type	90° headwall w 45° bevels	Area Full	1.7 m²
K	0.49500	HDS 5 Chart	10
M	0.66700	HDS 5 Scale	2
C	0.03140	Equation Form	2
Y	0.82000		

Culvert Calculator Report
Crossing 7 - 100yr

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	214.72	m	Headwater Depth/Height	0.51	
Computed Headwater Elevation	213.31	m	Discharge	0.5800	m³/s
Inlet Control HW Elev.	213.28	m	Tailwater Elevation	213.28	m
Outlet Control HW Elev.	213.31	m	Control Type	Outlet Control	

Grades					
Upstream Invert	212.85	m	Downstream Invert	212.72	m
Length	37.91	m	Constructed Slope	0.003429	m/m

Hydraulic Profile					
Profile	M1		Depth, Downstream	0.56	m
Slope Type	Mild		Normal Depth	0.22	m
Flow Regime	Subcritical		Critical Depth	0.22	m
Velocity Downstream	0.57	m/s	Critical Slope	0.003663	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	1.83	m
Section Size	1830 x 910 mm		Rise	0.91	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	213.31	m	Upstream Velocity Head	0.03	m
Ke	0.20		Entrance Loss	0.01	m

Inlet Control Properties					
Inlet Control HW Elev.	213.28	m	Flow Control	N/A	
Inlet Type	90° headwall w 45° bevels		Area Full	1.7	m²
K	0.49500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	2	
C	0.03140		Equation Form	2	
Y	0.82000				

Culvert Calculator Report
Crossing 8 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	215.12 m	Headwater Depth/Height	0.71
Computed Headwater Elevation	214.15 m	Discharge	1.4300 m³/s
Inlet Control HW Elev.	214.12 m	Tailwater Elevation	213.99 m
Outlet Control HW Elev.	214.15 m	Control Type	Outlet Control

Grades			
Upstream Invert	213.50 m	Downstream Invert	213.39 m
Length	35.90 m	Constructed Slope	0.003064 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.60 m
Slope Type	Mild	Normal Depth	0.42 m
Flow Regime	Subcritical	Critical Depth	0.40 m
Velocity Downstream	1.30 m/s	Critical Slope	0.003647 m/m

Section			
Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	1.83 m
Section Size	1830 x 910 mm	Rise	0.91 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	214.15 m	Upstream Velocity Head	0.12 m
Ke	0.20	Entrance Loss	0.02 m

Inlet Control Properties			
Inlet Control HW Elev.	214.12 m	Flow Control	N/A
Inlet Type	90° headwall w 45° bevels	Area Full	1.7 m²
K	0.49500	HDS 5 Chart	10
M	0.66700	HDS 5 Scale	2
C	0.03140	Equation Form	2
Y	0.82000		

Culvert Calculator Report
Crossing 8 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	215.12 m	Headwater Depth/Height	0.78
Computed Headwater Elevation	214.21 m	Discharge	1.6700 m³/s
Inlet Control HW Elev.	214.19 m	Tailwater Elevation	214.01 m
Outlet Control HW Elev.	214.21 m	Control Type	Outlet Control

Grades			
Upstream Invert	213.50 m	Downstream Invert	213.39 m
Length	35.90 m	Constructed Slope	0.003064 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.62 m
Slope Type	Mild	Normal Depth	0.47 m
Flow Regime	Subcritical	Critical Depth	0.44 m
Velocity Downstream	1.47 m/s	Critical Slope	0.003679 m/m

Section			
Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	1.83 m
Section Size	1830 x 910 mm	Rise	0.91 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	214.21 m	Upstream Velocity Head	0.15 m
Ke	0.20	Entrance Loss	0.03 m

Inlet Control Properties			
Inlet Control HW Elev.	214.19 m	Flow Control	N/A
Inlet Type	90° headwall w 45° bevels	Area Full	1.7 m²
K	0.49500	HDS 5 Chart	10
M	0.66700	HDS 5 Scale	2
C	0.03140	Equation Form	2
Y	0.82000		

Culvert Calculator Report
Crossing 9 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	219.20 m	Headwater Depth/Height	0.43
Computed Headwater Elevation	216.78 m	Discharge	0.9200 m³/s
Inlet Control HW Elev.	216.68 m	Tailwater Elevation	216.68 m
Outlet Control HW Elev.	216.78 m	Control Type	Outlet Control

Grades			
Upstream Invert	216.19 m	Downstream Invert	215.83 m
Length	42.54 m	Constructed Slope	0.008463 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.85 m
Slope Type	Mild	Normal Depth	0.38 m
Flow Regime	Subcritical	Critical Depth	0.35 m
Velocity Downstream	0.48 m/s	Critical Slope	0.011652 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	1.37 m
Section Size	1350 mm	Rise	1.37 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	216.78 m	Upstream Velocity Head	0.04 m
Ke	0.90	Entrance Loss	0.04 m

Inlet Control Properties			
Inlet Control HW Elev.	216.68 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	3.0 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 9 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	219.20 m	Headwater Depth/Height	0.46
Computed Headwater Elevation	216.82 m	Discharge	1.0800 m³/s
Inlet Control HW Elev.	216.72 m	Tailwater Elevation	216.70 m
Outlet Control HW Elev.	216.82 m	Control Type	Outlet Control

Grades			
Upstream Invert	216.19 m	Downstream Invert	215.83 m
Length	42.54 m	Constructed Slope	0.008463 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.87 m
Slope Type	Mild	Normal Depth	0.41 m
Flow Regime	Subcritical	Critical Depth	0.38 m
Velocity Downstream	0.55 m/s	Critical Slope	0.011601 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	1.37 m
Section Size	1350 mm	Rise	1.37 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	216.82 m	Upstream Velocity Head	0.05 m
Ke	0.90	Entrance Loss	0.05 m

Inlet Control Properties			
Inlet Control HW Elev.	216.72 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	3.0 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 10 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	222.82 m	Headwater Depth/Height	0.87
Computed Headwater Elevation	221.98 m	Discharge	0.6900 m³/s
Inlet Control HW Elev.	221.93 m	Tailwater Elevation	221.48 m
Outlet Control HW Elev.	221.98 m	Control Type	Outlet Control

Grades			
Upstream Invert	221.36 m	Downstream Invert	220.95 m
Length	32.35 m	Constructed Slope	0.012674 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.53 m
Slope Type	Mild	Normal Depth	0.39 m
Flow Regime	Subcritical	Critical Depth	0.36 m
Velocity Downstream	1.09 m/s	Critical Slope	0.015961 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.71 m
Section Size	700 mm	Rise	0.71 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	221.98 m	Upstream Velocity Head	0.12 m
Ke	0.90	Entrance Loss	0.11 m

Inlet Control Properties			
Inlet Control HW Elev.	221.93 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	0.8 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 10 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	222.82 m	Headwater Depth/Height	0.95
Computed Headwater Elevation	222.04 m	Discharge	0.8000 m³/s
Inlet Control HW Elev.	221.99 m	Tailwater Elevation	221.50 m
Outlet Control HW Elev.	222.04 m	Control Type	Outlet Control

Grades			
Upstream Invert	221.36 m	Downstream Invert	220.95 m
Length	32.35 m	Constructed Slope	0.012674 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.55 m
Slope Type	Mild	Normal Depth	0.43 m
Flow Regime	Subcritical	Critical Depth	0.39 m
Velocity Downstream	1.21 m/s	Critical Slope	0.016626 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.71 m
Section Size	700 mm	Rise	0.71 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	222.04 m	Upstream Velocity Head	0.13 m
Ke	0.90	Entrance Loss	0.12 m

Inlet Control Properties			
Inlet Control HW Elev.	221.99 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	0.8 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 11 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	223.04 m	Headwater Depth/Height	0.88
Computed Headwater Elevation	222.18 m	Discharge	0.4400 m³/s
Inlet Control HW Elev.	222.11 m	Tailwater Elevation	221.93 m
Outlet Control HW Elev.	222.18 m	Control Type	Outlet Control

Grades			
Upstream Invert	221.64 m	Downstream Invert	221.48 m
Length	30.71 m	Constructed Slope	0.005210 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.45 m
Slope Type	Mild	Normal Depth	0.44 m
Flow Regime	Subcritical	Critical Depth	0.30 m
Velocity Downstream	0.95 m/s	Critical Slope	0.016562 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.61 m
Section Size	600 mm	Rise	0.61 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	222.18 m	Upstream Velocity Head	0.05 m
Ke	0.90	Entrance Loss	0.04 m

Inlet Control Properties			
Inlet Control HW Elev.	222.11 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	0.6 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 11 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	223.04 m	Headwater Depth/Height	0.97
Computed Headwater Elevation	222.23 m	Discharge	0.5100 m³/s
Inlet Control HW Elev.	222.16 m	Tailwater Elevation	221.95 m
Outlet Control HW Elev.	222.23 m	Control Type	Outlet Control

Grades			
Upstream Invert	221.64 m	Downstream Invert	221.48 m
Length	30.71 m	Constructed Slope	0.005210 m/m

Hydraulic Profile			
Profile	M2	Depth, Downstream	0.47 m
Slope Type	Mild	Normal Depth	0.51 m
Flow Regime	Subcritical	Critical Depth	0.33 m
Velocity Downstream	1.06 m/s	Critical Slope	0.017166 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.61 m
Section Size	600 mm	Rise	0.61 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	222.23 m	Upstream Velocity Head	0.05 m
Ke	0.90	Entrance Loss	0.05 m

Inlet Control Properties			
Inlet Control HW Elev.	222.16 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	0.6 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 12 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	223.41 m	Headwater Depth/Height	0.63
Computed Headwater Elevation	222.27 m	Discharge	0.3800 m³/s
Inlet Control HW Elev.	222.21 m	Tailwater Elevation	221.88 m
Outlet Control HW Elev.	222.27 m	Control Type	Outlet Control

Grades			
Upstream Invert	221.82 m	Downstream Invert	221.39 m
Length	33.97 m	Constructed Slope	0.012658 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.49 m
Slope Type	Mild	Normal Depth	0.28 m
Flow Regime	Subcritical	Critical Depth	0.27 m
Velocity Downstream	0.65 m/s	Critical Slope	0.014635 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.71 m
Section Size	700 mm	Rise	0.71 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	222.27 m	Upstream Velocity Head	0.09 m
Ke	0.90	Entrance Loss	0.08 m

Inlet Control Properties			
Inlet Control HW Elev.	222.21 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	0.8 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 12 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	223.41 m	Headwater Depth/Height	0.68
Computed Headwater Elevation	222.30 m	Discharge	0.4400 m³/s
Inlet Control HW Elev.	222.24 m	Tailwater Elevation	221.89 m
Outlet Control HW Elev.	222.30 m	Control Type	Outlet Control

Grades			
Upstream Invert	221.82 m	Downstream Invert	221.39 m
Length	33.97 m	Constructed Slope	0.012658 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.50 m
Slope Type	Mild	Normal Depth	0.30 m
Flow Regime	Subcritical	Critical Depth	0.29 m
Velocity Downstream	0.74 m/s	Critical Slope	0.014821 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.71 m
Section Size	700 mm	Rise	0.71 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	222.30 m	Upstream Velocity Head	0.10 m
Ke	0.90	Entrance Loss	0.09 m

Inlet Control Properties			
Inlet Control HW Elev.	222.24 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	0.8 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 13 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	224.18 m	Headwater Depth/Height	0.51
Computed Headwater Elevation	222.71 m	Discharge	0.8600 m³/s
Inlet Control HW Elev.	222.69 m	Tailwater Elevation	222.46 m
Outlet Control HW Elev.	222.71 m	Control Type	Outlet Control

Grades			
Upstream Invert	222.27 m	Downstream Invert	221.85 m
Length	62.15 m	Constructed Slope	0.006758 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.61 m
Slope Type	Mild	Normal Depth	0.35 m
Flow Regime	Subcritical	Critical Depth	0.31 m
Velocity Downstream	0.59 m/s	Critical Slope	0.011624 m/m

Section			
Section Shape	Horizontal Ellipse	Mannings Coefficient	0.024
Section Material	Concrete	Span	1.35 m
Section Size	860 x 1350 mm	Rise	0.86 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	222.71 m	Upstream Velocity Head	0.08 m
Ke	0.20	Entrance Loss	0.02 m

Inlet Control Properties			
Inlet Control HW Elev.	222.69 m	Flow Control	Unsubmerged
Inlet Type	Groove end projecting (horizontal ellipse)	Area Full	1.9 m²
K	0.00450	HDS 5 Chart	29
M	2.00000	HDS 5 Scale	3
C	0.03170	Equation Form	1
Y	0.69000		

Culvert Calculator Report
Crossing 13 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	224.18 m	Headwater Depth/Height	0.56
Computed Headwater Elevation	222.75 m	Discharge	1.0100 m³/s
Inlet Control HW Elev.	222.73 m	Tailwater Elevation	222.47 m
Outlet Control HW Elev.	222.75 m	Control Type	Outlet Control

Grades			
Upstream Invert	222.27 m	Downstream Invert	221.85 m
Length	62.15 m	Constructed Slope	0.006758 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.62 m
Slope Type	Mild	Normal Depth	0.38 m
Flow Regime	Subcritical	Critical Depth	0.33 m
Velocity Downstream	0.69 m/s	Critical Slope	0.011530 m/m

Section			
Section Shape	Horizontal Ellipse	Mannings Coefficient	0.024
Section Material	Concrete	Span	1.35 m
Section Size	860 x 1350 mm	Rise	0.86 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	222.75 m	Upstream Velocity Head	0.09 m
Ke	0.20	Entrance Loss	0.02 m

Inlet Control Properties			
Inlet Control HW Elev.	222.73 m	Flow Control	N/A
Inlet Type	Groove end projecting (horizontal ellipse)	Area Full	1.9 m²
K	0.00450	HDS 5 Chart	29
M	2.00000	HDS 5 Scale	3
C	0.03170	Equation Form	1
Y	0.69000		

Culvert Calculator Report
Mayfield: Crossing 15 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	229.90 m	Headwater Depth/Height	0.85
Computed Headwater Elevation	229.15 m	Discharge	0.5900 m³/s
Inlet Control HW Elev.	229.05 m	Tailwater Elevation	228.60 m
Outlet Control HW Elev.	229.15 m	Control Type	Entrance Control

Grades			
Upstream Invert	228.37 m	Downstream Invert	227.92 m
Length	24.81 m	Constructed Slope	0.018138 m/m

Hydraulic Profile			
Profile	CompositeS1S2	Depth, Downstream	0.68 m
Slope Type	Steep	Normal Depth	0.42 m
Flow Regime	N/A	Critical Depth	0.45 m
Velocity Downstream	1.13 m/s	Critical Slope	0.014377 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.91 m
Section Size	900 mm	Rise	0.91 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	229.15 m	Upstream Velocity Head	0.17 m
Ke	0.90	Entrance Loss	0.16 m

Inlet Control Properties			
Inlet Control HW Elev.	229.05 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	0.7 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Mayfield: Crossing 15 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	229.90 m	Headwater Depth/Height	0.93
Computed Headwater Elevation	229.22 m	Discharge	0.6900 m³/s
Inlet Control HW Elev.	229.13 m	Tailwater Elevation	228.62 m
Outlet Control HW Elev.	229.22 m	Control Type	Entrance Control

Grades			
Upstream Invert	228.37 m	Downstream Invert	227.92 m
Length	24.81 m	Constructed Slope	0.018138 m/m

Hydraulic Profile			
Profile	CompositeS1S2	Depth, Downstream	0.70 m
Slope Type	Steep	Normal Depth	0.46 m
Flow Regime	N/A	Critical Depth	0.49 m
Velocity Downstream	1.28 m/s	Critical Slope	0.014923 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.91 m
Section Size	900 mm	Rise	0.91 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	229.22 m	Upstream Velocity Head	0.19 m
Ke	0.90	Entrance Loss	0.17 m

Inlet Control Properties			
Inlet Control HW Elev.	229.13 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	0.7 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Mayfield: Crossing 16 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	229.91 m	Headwater Depth/Height	1.24
Computed Headwater Elevation	229.62 m	Discharge	1.9000 m³/s
Inlet Control HW Elev.	229.47 m	Tailwater Elevation	229.19 m
Outlet Control HW Elev.	229.62 m	Control Type	Outlet Control

Grades			
Upstream Invert	228.11 m	Downstream Invert	228.21 m
Length	18.44 m	Constructed Slope	-0.005423 m/m

Hydraulic Profile			
Profile	CompositeA2PressureProfile	Depth, Downstream	0.98 m
Slope Type	Adverse	Normal Depth	N/A m
Flow Regime	Subcritical	Critical Depth	0.75 m
Velocity Downstream	1.89 m/s	Critical Slope	0.015027 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	1.22 m
Section Size	1200 mm	Rise	1.22 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	229.62 m	Upstream Velocity Head	0.14 m
Ke	0.90	Entrance Loss	0.12 m

Inlet Control Properties			
Inlet Control HW Elev.	229.47 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	1.2 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Mayfield: Crossing 16 - 100yr

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	229.91	m	Headwater Depth/Height	1.38	
Computed Headwater Elevation	229.79	m	Discharge	2.2100	m³/s
Inlet Control HW Elev.	229.62	m	Tailwater Elevation	229.22	m
Outlet Control HW Elev.	229.79	m	Control Type	Outlet Control	

Grades					
Upstream Invert	228.11	m	Downstream Invert	228.21	m
Length	18.44	m	Constructed Slope	-0.005423	m/m

Hydraulic Profile					
Profile	CompositeA2PressureProfile		Depth, Downstream	1.01	m
Slope Type	Adverse		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	0.82	m
Velocity Downstream	2.14	m/s	Critical Slope	0.016227	m/m

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	1.22	m
Section Size	1200 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	229.79	m	Upstream Velocity Head	0.18	m
Ke	0.90		Entrance Loss	0.16	m

Inlet Control Properties					
Inlet Control HW Elev.	229.62	m	Flow Control	Unsubmerged	
Inlet Type	Projecting		Area Full	1.2	m²
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Culvert Calculator Report
Mayfield: Crossing 17 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	229.91 m	Headwater Depth/Height	0.69
Computed Headwater Elevation	227.80 m	Discharge	0.8300 m³/s
Inlet Control HW Elev.	227.67 m	Tailwater Elevation	227.07 m
Outlet Control HW Elev.	227.80 m	Control Type	Entrance Control

Grades			
Upstream Invert	226.96 m	Downstream Invert	226.22 m
Length	27.17 m	Constructed Slope	0.027236 m/m

Hydraulic Profile			
Profile	CompositeS1S2	Depth, Downstream	0.85 m
Slope Type	Steep	Normal Depth	0.40 m
Flow Regime	N/A	Critical Depth	0.49 m
Velocity Downstream	0.96 m/s	Critical Slope	0.012358 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	1.22 m
Section Size	1200 mm	Rise	1.22 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	227.80 m	Upstream Velocity Head	0.18 m
Ke	0.90	Entrance Loss	0.16 m

Inlet Control Properties			
Inlet Control HW Elev.	227.67 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	1.2 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Mayfield: Crossing 17 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	229.91 m	Headwater Depth/Height	0.75
Computed Headwater Elevation	227.88 m	Discharge	0.9800 m³/s
Inlet Control HW Elev.	227.75 m	Tailwater Elevation	227.09 m
Outlet Control HW Elev.	227.88 m	Control Type	Entrance Control

Grades			
Upstream Invert	226.96 m	Downstream Invert	226.22 m
Length	27.17 m	Constructed Slope	0.027236 m/m

Hydraulic Profile			
Profile	CompositeS1S2	Depth, Downstream	0.87 m
Slope Type	Steep	Normal Depth	0.43 m
Flow Regime	N/A	Critical Depth	0.53 m
Velocity Downstream	1.10 m/s	Critical Slope	0.012600 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	1.22 m
Section Size	1200 mm	Rise	1.22 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	227.88 m	Upstream Velocity Head	0.20 m
Ke	0.90	Entrance Loss	0.18 m

Inlet Control Properties			
Inlet Control HW Elev.	227.75 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	1.2 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Future Condition Culvert Master Output

Culvert Calculator Report
Crossing 3 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	210.13 m	Headwater Depth/Height	0.70
Computed Headwater Elevation	209.13 m	Discharge	0.3100 m³/s
Inlet Control HW Elev.	209.05 m	Tailwater Elevation	208.36 m
Outlet Control HW Elev.	209.13 m	Control Type	Entrance Control

Grades			
Upstream Invert	208.56 m	Downstream Invert	207.79 m
Length	48.19 m	Constructed Slope	0.015978 m/m

Hydraulic Profile			
Profile	CompositeS1S2	Depth, Downstream	0.57 m
Slope Type	Steep	Normal Depth	0.32 m
Flow Regime	N/A	Critical Depth	0.33 m
Velocity Downstream	0.80 m/s	Critical Slope	0.014196 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.81 m
Section Size	800 mm	Rise	0.81 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	209.13 m	Upstream Velocity Head	0.12 m
Ke	0.90	Entrance Loss	0.11 m

Inlet Control Properties			
Inlet Control HW Elev.	209.05 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	0.5 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 3 - 100yr

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	210.13	m	Headwater Depth/Height	0.76	
Computed Headwater Elevation	209.18	m	Discharge	0.3600	m³/s
Inlet Control HW Elev.	209.09	m	Tailwater Elevation	208.37	m
Outlet Control HW Elev.	209.18	m	Control Type	Entrance Control	

Grades					
Upstream Invert	208.56	m	Downstream Invert	207.79	m
Length	48.19	m	Constructed Slope	0.015978	m/m

Hydraulic Profile					
Profile	CompositeS1S2		Depth, Downstream	0.58	m
Slope Type	Steep		Normal Depth	0.35	m
Flow Regime	N/A		Critical Depth	0.36	m
Velocity Downstream	0.91	m/s	Critical Slope	0.014463	m/m

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	0.81	m
Section Size	800 mm		Rise	0.81	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	209.18	m	Upstream Velocity Head	0.14	m
Ke	0.90		Entrance Loss	0.12	m

Inlet Control Properties					
Inlet Control HW Elev.	209.09	m	Flow Control	Unsubmerged	
Inlet Type	Projecting		Area Full	0.5	m²
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Culvert Calculator Report
Crossing 4 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	211.66 m	Headwater Depth/Height	0.78
Computed Headwater Elevation	209.86 m	Discharge	2.1100 m³/s
Inlet Control HW Elev.	209.78 m	Tailwater Elevation	209.64 m
Outlet Control HW Elev.	209.86 m	Control Type	Outlet Control

Grades			
Upstream Invert	208.91 m	Downstream Invert	208.74 m
Length	46.73 m	Constructed Slope	0.003638 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.90 m
Slope Type	Mild	Normal Depth	0.52 m
Flow Regime	Subcritical	Critical Depth	0.51 m
Velocity Downstream	1.28 m/s	Critical Slope	0.003750 m/m

Section			
Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	1.83 m
Section Size	1830 x 1220 mm	Rise	1.22 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	209.86 m	Upstream Velocity Head	0.12 m
Ke	0.70	Entrance Loss	0.09 m

Inlet Control Properties			
Inlet Control HW Elev.	209.78 m	Flow Control	Unsubmerged
Inlet Type	0° wingwall flares	Area Full	2.2 m²
K	0.06100	HDS 5 Chart	8
M	0.75000	HDS 5 Scale	3
C	0.04230	Equation Form	1
Y	0.82000		

Culvert Calculator Report
Crossing 4 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	211.66 m	Headwater Depth/Height	0.85
Computed Headwater Elevation	209.95 m	Discharge	2.4700 m³/s
Inlet Control HW Elev.	209.88 m	Tailwater Elevation	209.67 m
Outlet Control HW Elev.	209.95 m	Control Type	Outlet Control

Grades			
Upstream Invert	208.91 m	Downstream Invert	208.74 m
Length	46.73 m	Constructed Slope	0.003638 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.93 m
Slope Type	Mild	Normal Depth	0.58 m
Flow Regime	Subcritical	Critical Depth	0.57 m
Velocity Downstream	1.45 m/s	Critical Slope	0.003815 m/m

Section			
Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	1.83 m
Section Size	1830 x 1220 mm	Rise	1.22 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	209.95 m	Upstream Velocity Head	0.16 m
Ke	0.70	Entrance Loss	0.11 m

Inlet Control Properties			
Inlet Control HW Elev.	209.88 m	Flow Control	Unsubmerged
Inlet Type	0° wingwall flares	Area Full	2.2 m²
K	0.06100	HDS 5 Chart	8
M	0.75000	HDS 5 Scale	3
C	0.04230	Equation Form	1
Y	0.82000		

Culvert Calculator Report
Crossing 5 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	212.03 m	Headwater Depth/Height	0.58
Computed Headwater Elevation	210.56 m	Discharge	0.1500 m³/s
Inlet Control HW Elev.	210.50 m	Tailwater Elevation	210.50 m
Outlet Control HW Elev.	210.56 m	Control Type	Outlet Control

Grades			
Upstream Invert	210.09 m	Downstream Invert	210.00 m
Length	33.81 m	Constructed Slope	0.002662 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.50 m
Slope Type	Mild	Normal Depth	0.35 m
Flow Regime	Subcritical	Critical Depth	0.23 m
Velocity Downstream	0.45 m/s	Critical Slope	0.013818 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.81 m
Section Size	800 mm	Rise	0.81 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	210.56 m	Upstream Velocity Head	0.01 m
Ke	0.90	Entrance Loss	0.01 m

Inlet Control Properties			
Inlet Control HW Elev.	210.50 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	0.5 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 5 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	212.03 m	Headwater Depth/Height	0.60
Computed Headwater Elevation	210.59 m	Discharge	0.1700 m³/s
Inlet Control HW Elev.	210.51 m	Tailwater Elevation	210.51 m
Outlet Control HW Elev.	210.59 m	Control Type	Outlet Control

Grades			
Upstream Invert	210.10 m	Downstream Invert	209.99 m
Length	41.31 m	Constructed Slope	0.002663 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.52 m
Slope Type	Mild	Normal Depth	0.38 m
Flow Regime	Subcritical	Critical Depth	0.24 m
Velocity Downstream	0.49 m/s	Critical Slope	0.013804 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.81 m
Section Size	800 mm	Rise	0.81 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	210.59 m	Upstream Velocity Head	0.02 m
Ke	0.90	Entrance Loss	0.01 m

Inlet Control Properties			
Inlet Control HW Elev.	210.51 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	0.5 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 6 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	212.30 m	Headwater Depth/Height	0.54
Computed Headwater Elevation	211.17 m	Discharge	0.3400 m³/s
Inlet Control HW Elev.	211.08 m	Tailwater Elevation	210.74 m
Outlet Control HW Elev.	211.17 m	Control Type	Entrance Control

Grades			
Upstream Invert	210.62 m	Downstream Invert	210.08 m
Length	41.52 m	Constructed Slope	0.013006 m/m

Hydraulic Profile			
Profile	CompositeS1S2	Depth, Downstream	0.66 m
Slope Type	Steep	Normal Depth	0.32 m
Flow Regime	N/A	Critical Depth	0.32 m
Velocity Downstream	0.61 m/s	Critical Slope	0.012825 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	1.02 m
Section Size	1000 mm	Rise	1.02 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	211.17 m	Upstream Velocity Head	0.12 m
Ke	0.90	Entrance Loss	0.11 m

Inlet Control Properties			
Inlet Control HW Elev.	211.08 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	0.8 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 6 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	212.30 m	Headwater Depth/Height	0.59
Computed Headwater Elevation	211.22 m	Discharge	0.4000 m³/s
Inlet Control HW Elev.	211.13 m	Tailwater Elevation	210.76 m
Outlet Control HW Elev.	211.22 m	Control Type	Entrance Control

Grades			
Upstream Invert	210.62 m	Downstream Invert	210.08 m
Length	41.52 m	Constructed Slope	0.013006 m/m

Hydraulic Profile			
Profile	CompositeS1S2	Depth, Downstream	0.68 m
Slope Type	Steep	Normal Depth	0.35 m
Flow Regime	N/A	Critical Depth	0.35 m
Velocity Downstream	0.69 m/s	Critical Slope	0.012888 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	1.02 m
Section Size	1000 mm	Rise	1.02 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	211.22 m	Upstream Velocity Head	0.13 m
Ke	0.90	Entrance Loss	0.12 m

Inlet Control Properties			
Inlet Control HW Elev.	211.13 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	0.8 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 7 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	214.72 m	Headwater Depth/Height	0.47
Computed Headwater Elevation	213.29 m	Discharge	0.5000 m³/s
Inlet Control HW Elev.	213.26 m	Tailwater Elevation	213.26 m
Outlet Control HW Elev.	213.29 m	Control Type	Outlet Control

Grades			
Upstream Invert	212.86 m	Downstream Invert	212.71 m
Length	45.41 m	Constructed Slope	0.003303 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.55 m
Slope Type	Mild	Normal Depth	0.20 m
Flow Regime	Subcritical	Critical Depth	0.20 m
Velocity Downstream	0.50 m/s	Critical Slope	0.003695 m/m

Section			
Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	1.83 m
Section Size	1830 x 910 mm	Rise	0.91 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	213.29 m	Upstream Velocity Head	0.02 m
Ke	0.20	Entrance Loss	0.00 m

Inlet Control Properties			
Inlet Control HW Elev.	213.26 m	Flow Control	Unsubmerged
Inlet Type	90° headwall w 45° bevels	Area Full	1.7 m²
K	0.49500	HDS 5 Chart	10
M	0.66700	HDS 5 Scale	2
C	0.03140	Equation Form	2
Y	0.82000		

Culvert Calculator Report
Crossing 7 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	214.72 m	Headwater Depth/Height	0.49
Computed Headwater Elevation	213.31 m	Discharge	0.5800 m³/s
Inlet Control HW Elev.	213.27 m	Tailwater Elevation	213.27 m
Outlet Control HW Elev.	213.31 m	Control Type	Outlet Control

Grades			
Upstream Invert	212.86 m	Downstream Invert	212.71 m
Length	45.41 m	Constructed Slope	0.003303 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.56 m
Slope Type	Mild	Normal Depth	0.22 m
Flow Regime	Subcritical	Critical Depth	0.22 m
Velocity Downstream	0.57 m/s	Critical Slope	0.003663 m/m

Section			
Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	1.83 m
Section Size	1830 x 910 mm	Rise	0.91 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	213.31 m	Upstream Velocity Head	0.03 m
Ke	0.20	Entrance Loss	0.01 m

Inlet Control Properties			
Inlet Control HW Elev.	213.27 m	Flow Control	Unsubmerged
Inlet Type	90° headwall w 45° bevels	Area Full	1.7 m²
K	0.49500	HDS 5 Chart	10
M	0.66700	HDS 5 Scale	2
C	0.03140	Equation Form	2
Y	0.82000		

Culvert Calculator Report
Crossing 8 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	215.12 m	Headwater Depth/Height	0.71
Computed Headwater Elevation	214.16 m	Discharge	1.4300 m³/s
Inlet Control HW Elev.	214.13 m	Tailwater Elevation	213.98 m
Outlet Control HW Elev.	214.16 m	Control Type	Outlet Control

Grades			
Upstream Invert	213.51 m	Downstream Invert	213.38 m
Length	43.40 m	Constructed Slope	0.002995 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.60 m
Slope Type	Mild	Normal Depth	0.42 m
Flow Regime	Subcritical	Critical Depth	0.40 m
Velocity Downstream	1.30 m/s	Critical Slope	0.003647 m/m

Section			
Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	1.83 m
Section Size	1830 x 910 mm	Rise	0.91 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	214.16 m	Upstream Velocity Head	0.13 m
Ke	0.20	Entrance Loss	0.03 m

Inlet Control Properties			
Inlet Control HW Elev.	214.13 m	Flow Control	Unsubmerged
Inlet Type	90° headwall w 45° bevels	Area Full	1.7 m²
K	0.49500	HDS 5 Chart	10
M	0.66700	HDS 5 Scale	2
C	0.03140	Equation Form	2
Y	0.82000		

Culvert Calculator Report
Crossing 8 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	215.12 m	Headwater Depth/Height	0.78
Computed Headwater Elevation	214.22 m	Discharge	1.6700 m³/s
Inlet Control HW Elev.	214.20 m	Tailwater Elevation	214.00 m
Outlet Control HW Elev.	214.22 m	Control Type	Outlet Control

Grades			
Upstream Invert	213.51 m	Downstream Invert	213.38 m
Length	43.40 m	Constructed Slope	0.002995 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.62 m
Slope Type	Mild	Normal Depth	0.47 m
Flow Regime	Subcritical	Critical Depth	0.44 m
Velocity Downstream	1.47 m/s	Critical Slope	0.003679 m/m

Section			
Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	1.83 m
Section Size	1830 x 910 mm	Rise	0.91 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	214.22 m	Upstream Velocity Head	0.16 m
Ke	0.20	Entrance Loss	0.03 m

Inlet Control Properties			
Inlet Control HW Elev.	214.20 m	Flow Control	Unsubmerged
Inlet Type	90° headwall w 45° bevels	Area Full	1.7 m²
K	0.49500	HDS 5 Chart	10
M	0.66700	HDS 5 Scale	2
C	0.03140	Equation Form	2
Y	0.82000		

Culvert Calculator Report
Crossing 9 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	219.20 m	Headwater Depth/Height	0.41
Computed Headwater Elevation	216.79 m	Discharge	0.9200 m³/s
Inlet Control HW Elev.	216.70 m	Tailwater Elevation	216.65 m
Outlet Control HW Elev.	216.79 m	Control Type	Outlet Control

Grades			
Upstream Invert	216.22 m	Downstream Invert	215.80 m
Length	50.04 m	Constructed Slope	0.008393 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.85 m
Slope Type	Mild	Normal Depth	0.38 m
Flow Regime	Subcritical	Critical Depth	0.35 m
Velocity Downstream	0.48 m/s	Critical Slope	0.011652 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	1.37 m
Section Size	1350 mm	Rise	1.37 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	216.79 m	Upstream Velocity Head	0.06 m
Ke	0.90	Entrance Loss	0.05 m

Inlet Control Properties			
Inlet Control HW Elev.	216.70 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	3.0 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 9 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	219.20 m	Headwater Depth/Height	0.45
Computed Headwater Elevation	216.83 m	Discharge	1.0800 m³/s
Inlet Control HW Elev.	216.75 m	Tailwater Elevation	216.66 m
Outlet Control HW Elev.	216.83 m	Control Type	Outlet Control

Grades			
Upstream Invert	216.22 m	Downstream Invert	215.80 m
Length	50.04 m	Constructed Slope	0.008393 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.86 m
Slope Type	Mild	Normal Depth	0.41 m
Flow Regime	Subcritical	Critical Depth	0.38 m
Velocity Downstream	0.55 m/s	Critical Slope	0.011601 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	1.37 m
Section Size	1350 mm	Rise	1.37 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	216.83 m	Upstream Velocity Head	0.07 m
Ke	0.90	Entrance Loss	0.06 m

Inlet Control Properties			
Inlet Control HW Elev.	216.75 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	3.0 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 10 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	222.82 m	Headwater Depth/Height	0.81
Computed Headwater Elevation	222.03 m	Discharge	0.6900 m³/s
Inlet Control HW Elev.	221.95 m	Tailwater Elevation	221.46 m
Outlet Control HW Elev.	222.03 m	Control Type	Entrance Control

Grades			
Upstream Invert	221.41 m	Downstream Invert	220.90 m
Length	39.85 m	Constructed Slope	0.012798 m/m

Hydraulic Profile			
Profile	CompositeS1S2	Depth, Downstream	0.56 m
Slope Type	Steep	Normal Depth	0.26 m
Flow Regime	N/A	Critical Depth	0.36 m
Velocity Downstream	0.96 m/s	Critical Slope	0.003761 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.012
Section Material	Aluminum	Span	0.76 m
Section Size	750 mm	Rise	0.76 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	222.03 m	Upstream Velocity Head	0.14 m
Ke	0.90	Entrance Loss	0.12 m

Inlet Control Properties			
Inlet Control HW Elev.	221.95 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	0.9 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 10 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	222.82 m	Headwater Depth/Height	0.89
Computed Headwater Elevation	222.08 m	Discharge	0.8000 m³/s
Inlet Control HW Elev.	222.01 m	Tailwater Elevation	221.47 m
Outlet Control HW Elev.	222.08 m	Control Type	Entrance Control

Grades			
Upstream Invert	221.41 m	Downstream Invert	220.90 m
Length	39.85 m	Constructed Slope	0.012798 m/m

Hydraulic Profile			
Profile	CompositeS1S2	Depth, Downstream	0.57 m
Slope Type	Steep	Normal Depth	0.28 m
Flow Regime	N/A	Critical Depth	0.39 m
Velocity Downstream	1.09 m/s	Critical Slope	0.003876 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.012
Section Material	Aluminum	Span	0.76 m
Section Size	750 mm	Rise	0.76 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	222.08 m	Upstream Velocity Head	0.15 m
Ke	0.90	Entrance Loss	0.14 m

Inlet Control Properties			
Inlet Control HW Elev.	222.01 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	0.9 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 11 - 50yr

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	223.04	m	Headwater Depth/Height	0.73	
Computed Headwater Elevation	222.16	m	Discharge	0.4400	m³/s
Inlet Control HW Elev.	222.07	m	Tailwater Elevation	221.94	m
Outlet Control HW Elev.	222.16	m	Control Type	Entrance Control	

Grades					
Upstream Invert	221.66	m	Downstream Invert	221.46	m
Length	38.21	m	Constructed Slope	0.005234	m/m

Hydraulic Profile					
Profile	CompositeS1S2		Depth, Downstream	0.48	m
Slope Type	Steep		Normal Depth	0.27	m
Flow Regime	N/A		Critical Depth	0.29	m
Velocity Downstream	0.80	m/s	Critical Slope	0.003792	m/m

Section					
Section Shape	Circular		Mannings Coefficient	0.012	
Section Material	Corrugated HDPE (Smooth Interior)		Span	0.69	m
Section Size	675 mm		Rise	0.69	m
Number Sections	2				

Outlet Control Properties					
Outlet Control HW Elev.	222.16	m	Upstream Velocity Head	0.11	m
Ke	0.90		Entrance Loss	0.10	m

Inlet Control Properties					
Inlet Control HW Elev.	222.07	m	Flow Control	Unsubmerged	
Inlet Type	Groove end projecting		Area Full	0.7	m²
K	0.00450		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	3	
C	0.03170		Equation Form	1	
Y	0.69000				

Culvert Calculator Report
Crossing 11 - 100yr

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	223.04	m	Headwater Depth/Height	0.79	
Computed Headwater Elevation	222.20	m	Discharge	0.5100	m³/s
Inlet Control HW Elev.	222.10	m	Tailwater Elevation	221.95	m
Outlet Control HW Elev.	222.20	m	Control Type	Entrance Control	

Grades					
Upstream Invert	221.66	m	Downstream Invert	221.46	m
Length	38.21	m	Constructed Slope	0.005234	m/m

Hydraulic Profile					
Profile	CompositeS1S2		Depth, Downstream	0.49	m
Slope Type	Steep		Normal Depth	0.29	m
Flow Regime	N/A		Critical Depth	0.31	m
Velocity Downstream	0.90	m/s	Critical Slope	0.003870	m/m

Section					
Section Shape	Circular		Mannings Coefficient	0.012	
Section Material	Corrugated HDPE (Smooth Interior)		Span	0.69	m
Section Size	675 mm		Rise	0.69	m
Number Sections	2				

Outlet Control Properties					
Outlet Control HW Elev.	222.20	m	Upstream Velocity Head	0.12	m
Ke	0.90		Entrance Loss	0.11	m

Inlet Control Properties					
Inlet Control HW Elev.	222.10	m	Flow Control	Unsubmerged	
Inlet Type	Beveled ring, 33.7° bevels		Area Full	0.7	m²
K	0.00180		HDS 5 Chart	3	
M	2.50000		HDS 5 Scale	B	
C	0.02430		Equation Form	1	
Y	0.83000				

Culvert Calculator Report
Crossing 12 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	223.41 m	Headwater Depth/Height	0.63
Computed Headwater Elevation	222.32 m	Discharge	0.3800 m³/s
Inlet Control HW Elev.	222.26 m	Tailwater Elevation	221.83 m
Outlet Control HW Elev.	222.32 m	Control Type	Outlet Control

Grades			
Upstream Invert	221.87 m	Downstream Invert	221.34 m
Length	41.47 m	Constructed Slope	0.012780 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.49 m
Slope Type	Mild	Normal Depth	0.28 m
Flow Regime	Subcritical	Critical Depth	0.27 m
Velocity Downstream	0.65 m/s	Critical Slope	0.014635 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.71 m
Section Size	700 mm	Rise	0.71 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	222.32 m	Upstream Velocity Head	0.09 m
Ke	0.90	Entrance Loss	0.08 m

Inlet Control Properties			
Inlet Control HW Elev.	222.26 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	0.8 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 12 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	223.41 m	Headwater Depth/Height	0.68
Computed Headwater Elevation	222.35 m	Discharge	0.4400 m³/s
Inlet Control HW Elev.	222.29 m	Tailwater Elevation	221.84 m
Outlet Control HW Elev.	222.35 m	Control Type	Outlet Control

Grades			
Upstream Invert	221.87 m	Downstream Invert	221.34 m
Length	41.47 m	Constructed Slope	0.012780 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.50 m
Slope Type	Mild	Normal Depth	0.30 m
Flow Regime	Subcritical	Critical Depth	0.29 m
Velocity Downstream	0.74 m/s	Critical Slope	0.014821 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.71 m
Section Size	700 mm	Rise	0.71 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	222.35 m	Upstream Velocity Head	0.10 m
Ke	0.90	Entrance Loss	0.09 m

Inlet Control Properties			
Inlet Control HW Elev.	222.29 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	0.8 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Crossing 13 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	224.18 m	Headwater Depth/Height	0.51
Computed Headwater Elevation	222.74 m	Discharge	0.8600 m³/s
Inlet Control HW Elev.	222.72 m	Tailwater Elevation	222.43 m
Outlet Control HW Elev.	222.74 m	Control Type	Outlet Control

Grades			
Upstream Invert	222.30 m	Downstream Invert	221.82 m
Length	69.65 m	Constructed Slope	0.006892 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	0.61 m
Slope Type	Mild	Normal Depth	0.35 m
Flow Regime	Subcritical	Critical Depth	0.31 m
Velocity Downstream	0.59 m/s	Critical Slope	0.011624 m/m

Section			
Section Shape	Horizontal Ellipse	Mannings Coefficient	0.024
Section Material	Concrete	Span	1.35 m
Section Size	860 x 1350 mm	Rise	0.86 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	222.74 m	Upstream Velocity Head	0.08 m
Ke	0.20	Entrance Loss	0.02 m

Inlet Control Properties			
Inlet Control HW Elev.	222.72 m	Flow Control	Unsubmerged
Inlet Type	Groove end projecting (horizontal ellipse)	Area Full	1.9 m²
K	0.00450	HDS 5 Chart	29
M	2.00000	HDS 5 Scale	3
C	0.03170	Equation Form	1
Y	0.69000		

Culvert Calculator Report
Crossing 13 - 100yr

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	224.18	m	Headwater Depth/Height	0.56	
Computed Headwater Elevation	222.78	m	Discharge	1.0100	m³/s
Inlet Control HW Elev.	222.76	m	Tailwater Elevation	222.44	m
Outlet Control HW Elev.	222.78	m	Control Type	Outlet Control	

Grades					
Upstream Invert	222.30	m	Downstream Invert	221.82	m
Length	69.65	m	Constructed Slope	0.006892	m/m

Hydraulic Profile					
Profile	M1		Depth, Downstream	0.62	m
Slope Type	Mild		Normal Depth	0.38	m
Flow Regime	Subcritical		Critical Depth	0.33	m
Velocity Downstream	0.69	m/s	Critical Slope	0.011530	m/m

Section					
Section Shape	Horizontal Ellipse		Mannings Coefficient	0.024	
Section Material	Concrete		Span	1.35	m
Section Size	860 x 1350 mm		Rise	0.86	m
Number Sections	2				

Outlet Control Properties					
Outlet Control HW Elev.	222.78	m	Upstream Velocity Head	0.09	m
Ke	0.20		Entrance Loss	0.02	m

Inlet Control Properties					
Inlet Control HW Elev.	222.76	m	Flow Control	Unsubmerged	
Inlet Type	Groove end projecting (horizontal ellipse)		Area Full	1.9	m²
K	0.00450		HDS 5 Chart	29	
M	2.00000		HDS 5 Scale	3	
C	0.03170		Equation Form	1	
Y	0.69000				

Culvert Calculator Report
Mayfield: Crossing 15 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	229.90 m	Headwater Depth/Height	0.85
Computed Headwater Elevation	229.22 m	Discharge	0.5900 m³/s
Inlet Control HW Elev.	229.12 m	Tailwater Elevation	228.53 m
Outlet Control HW Elev.	229.22 m	Control Type	Entrance Control

Grades			
Upstream Invert	228.44 m	Downstream Invert	227.85 m
Length	32.31 m	Constructed Slope	0.018261 m/m

Hydraulic Profile			
Profile	CompositeS1S2	Depth, Downstream	0.68 m
Slope Type	Steep	Normal Depth	0.42 m
Flow Regime	N/A	Critical Depth	0.45 m
Velocity Downstream	1.13 m/s	Critical Slope	0.014377 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.91 m
Section Size	900 mm	Rise	0.91 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	229.22 m	Upstream Velocity Head	0.17 m
Ke	0.90	Entrance Loss	0.16 m

Inlet Control Properties			
Inlet Control HW Elev.	229.12 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	0.7 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Mayfield: Crossing 15 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	229.90 m	Headwater Depth/Height	0.93
Computed Headwater Elevation	229.29 m	Discharge	0.6900 m³/s
Inlet Control HW Elev.	229.20 m	Tailwater Elevation	228.55 m
Outlet Control HW Elev.	229.29 m	Control Type	Entrance Control

Grades			
Upstream Invert	228.44 m	Downstream Invert	227.85 m
Length	32.31 m	Constructed Slope	0.018261 m/m

Hydraulic Profile			
Profile	CompositeS1S2	Depth, Downstream	0.70 m
Slope Type	Steep	Normal Depth	0.46 m
Flow Regime	N/A	Critical Depth	0.49 m
Velocity Downstream	1.28 m/s	Critical Slope	0.014923 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.91 m
Section Size	900 mm	Rise	0.91 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	229.29 m	Upstream Velocity Head	0.19 m
Ke	0.90	Entrance Loss	0.17 m

Inlet Control Properties			
Inlet Control HW Elev.	229.20 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	0.7 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Mayfield: Crossing 16 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	229.91 m	Headwater Depth/Height	0.99
Computed Headwater Elevation	229.10 m	Discharge	1.9000 m³/s
Inlet Control HW Elev.	228.97 m	Tailwater Elevation	228.78 m
Outlet Control HW Elev.	229.10 m	Control Type	Outlet Control

Grades			
Upstream Invert	228.09 m	Downstream Invert	228.00 m
Length	25.94 m	Constructed Slope	0.003470 m/m

Hydraulic Profile			
Profile	M2	Depth, Downstream	0.78 m
Slope Type	Mild	Normal Depth	N/A m
Flow Regime	Subcritical	Critical Depth	0.56 m
Velocity Downstream	1.42 m/s	Critical Slope	0.014638 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	1.02 m
Section Size	1000 mm	Rise	1.02 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	229.10 m	Upstream Velocity Head	0.09 m
Ke	0.90	Entrance Loss	0.08 m

Inlet Control Properties			
Inlet Control HW Elev.	228.97 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	1.6 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Mayfield: Crossing 16 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	229.91 m	Headwater Depth/Height	1.09
Computed Headwater Elevation	229.20 m	Discharge	2.2100 m³/s
Inlet Control HW Elev.	229.07 m	Tailwater Elevation	228.80 m
Outlet Control HW Elev.	229.20 m	Control Type	Outlet Control

Grades			
Upstream Invert	228.09 m	Downstream Invert	228.00 m
Length	25.94 m	Constructed Slope	0.003470 m/m

Hydraulic Profile			
Profile	M2	Depth, Downstream	0.80 m
Slope Type	Mild	Normal Depth	N/A m
Flow Regime	Subcritical	Critical Depth	0.60 m
Velocity Downstream	1.61 m/s	Critical Slope	0.015409 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	1.02 m
Section Size	1000 mm	Rise	1.02 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	229.20 m	Upstream Velocity Head	0.11 m
Ke	0.90	Entrance Loss	0.10 m

Inlet Control Properties			
Inlet Control HW Elev.	229.07 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	1.6 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Mayfield: Crossing 17 - 50yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	229.91 m	Headwater Depth/Height	0.69
Computed Headwater Elevation	227.90 m	Discharge	0.8300 m³/s
Inlet Control HW Elev.	227.77 m	Tailwater Elevation	226.96 m
Outlet Control HW Elev.	227.90 m	Control Type	Entrance Control

Grades			
Upstream Invert	227.06 m	Downstream Invert	226.12 m
Length	34.67 m	Constructed Slope	0.027113 m/m

Hydraulic Profile			
Profile	CompositeS1S2	Depth, Downstream	0.84 m
Slope Type	Steep	Normal Depth	0.40 m
Flow Regime	N/A	Critical Depth	0.49 m
Velocity Downstream	0.97 m/s	Critical Slope	0.012358 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	1.22 m
Section Size	1200 mm	Rise	1.22 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	227.90 m	Upstream Velocity Head	0.18 m
Ke	0.90	Entrance Loss	0.16 m

Inlet Control Properties			
Inlet Control HW Elev.	227.77 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	1.2 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
Mayfield: Crossing 17 - 100yr

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	0.00 m	Headwater Depth/Height	0.75
Computed Headwater Elevation	227.98 m	Discharge	0.9800 m³/s
Inlet Control HW Elev.	227.85 m	Tailwater Elevation	226.98 m
Outlet Control HW Elev.	227.98 m	Control Type	Entrance Control

Grades			
Upstream Invert	227.06 m	Downstream Invert	226.12 m
Length	34.67 m	Constructed Slope	0.027113 m/m

Hydraulic Profile			
Profile	CompositeS1S2	Depth, Downstream	0.86 m
Slope Type	Steep	Normal Depth	0.43 m
Flow Regime	N/A	Critical Depth	0.53 m
Velocity Downstream	1.11 m/s	Critical Slope	0.012600 m/m

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	1.22 m
Section Size	1200 mm	Rise	1.22 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	227.98 m	Upstream Velocity Head	0.20 m
Ke	0.90	Entrance Loss	0.18 m

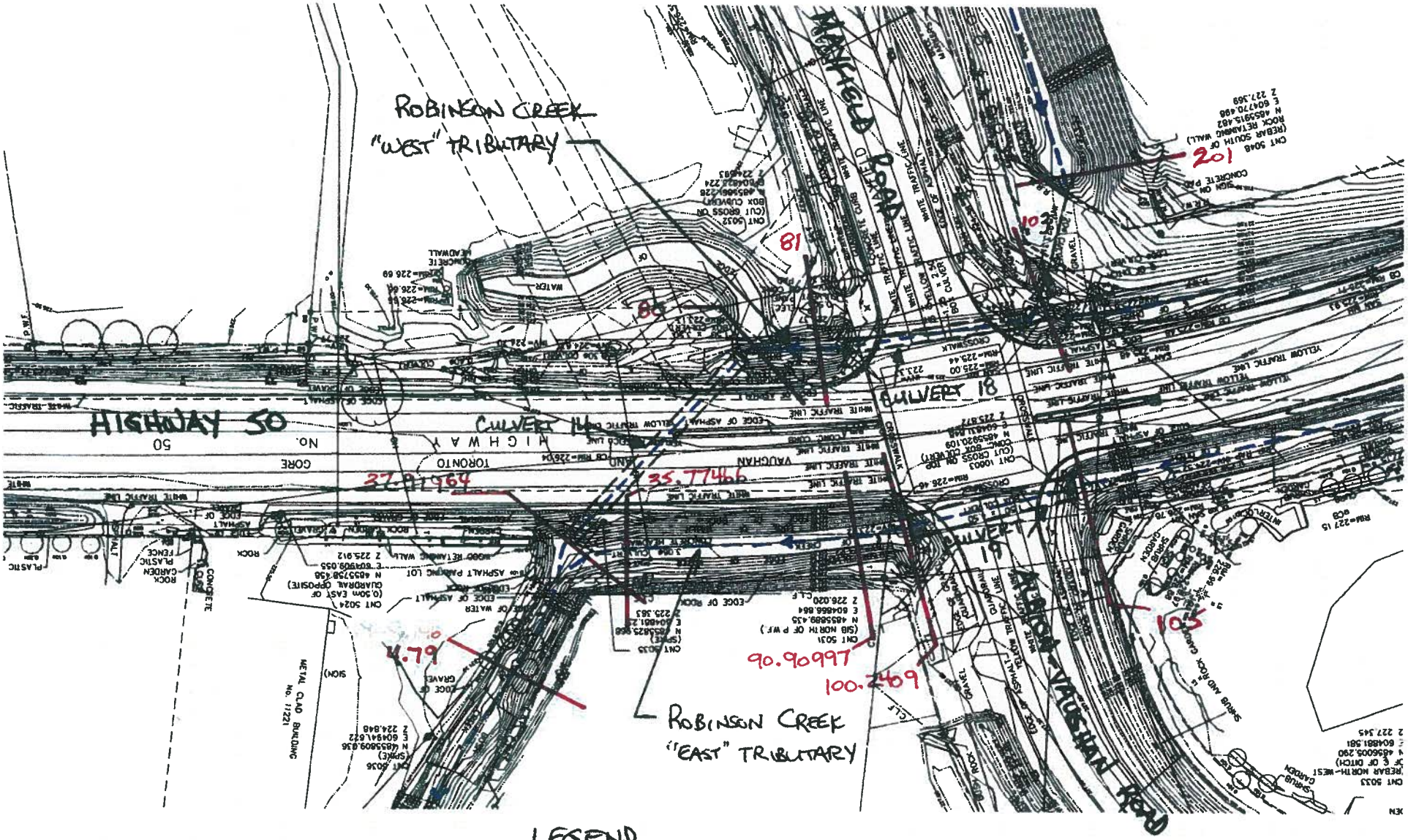
Inlet Control Properties			
Inlet Control HW Elev.	227.85 m	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	1.2 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Appendix B

HEC-RAS Model Output

Existing Condition HEC-RAS Cross-Sections and Model Output

HEC-RAS CROSS-SECTION LOCATIONS
EXISTING CONDITION



LEGEND

80 CROSS-SECTION AND I.D. NUMBER

Existing Condition, Robinson Creek - Tributary on East Side of HWY 50 Crossing 19

HEC-RAS Plan: Existing-Jun2012 Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Rainbow_22_North	22 North	1929.146	50-yr	7.50	237.48	238.41		238.42	0.000326	0.35	21.38	38.06	0.15
Rainbow_22_North	22 North	1929.146	100-yr	8.40	237.48	238.43		238.44	0.000368	0.38	22.18	38.49	0.16
Rainbow_22_North	22 North	1929.146	Regional	15.46	237.48	238.56		238.58	0.000676	0.56	27.39	41.22	0.22
Rainbow_22_North	22 North	1890.405	50-yr	7.50	237.17	238.41		238.41	0.000087	0.22	33.59	43.74	0.08
Rainbow_22_North	22 North	1890.405	100-yr	8.40	237.17	238.43		238.43	0.000101	0.24	34.48	44.17	0.09
Rainbow_22_North	22 North	1890.405	Regional	15.46	237.17	238.55		238.56	0.000222	0.38	40.24	46.83	0.13
Rainbow_22_North	22 North	1816.953	50-yr	7.50	238.04	238.37		238.39	0.003458	0.60	12.54	60.46	0.41
Rainbow_22_North	22 North	1816.953	100-yr	8.40	238.04	238.39		238.41	0.003432	0.62	13.55	61.39	0.42
Rainbow_22_North	22 North	1816.953	Regional	15.46	238.04	238.49		238.52	0.003617	0.79	19.82	67.46	0.45
Rainbow_22_North	22 North	1751.419	50-yr	7.50	237.77	238.02		238.05	0.008387	0.77	9.75	61.17	0.61
Rainbow_22_North	22 North	1751.419	100-yr	8.40	237.77	238.03		238.07	0.008679	0.80	10.53	64.17	0.63
Rainbow_22_North	22 North	1751.419	Regional	15.46	237.77	238.11		238.16	0.009380	0.94	16.75	98.73	0.67
Rainbow_22_North	22 North	1743.342	50-yr	7.50	237.60	237.86	237.86	237.93	0.028170	1.13	6.62	57.74	1.07
Rainbow_22_North	22 North	1743.342	100-yr	8.40	237.60	237.87	237.87	237.94	0.029550	1.19	7.08	59.71	1.10
Rainbow_22_North	22 North	1743.342	Regional	15.46	237.60	237.94	237.94	238.04	0.023134	1.39	11.33	68.87	1.04
Rainbow_22_North	22 North	1677.011	50-yr	7.50	236.02	236.74		236.76	0.000812	0.57	13.25	23.28	0.24
Rainbow_22_North	22 North	1677.011	100-yr	8.40	236.02	236.78		236.80	0.000844	0.60	14.15	23.83	0.24
Rainbow_22_North	22 North	1677.011	Regional	15.46	236.02	237.07		237.09	0.000892	0.75	21.46	27.92	0.26
Rainbow_22_North	22 North	1626.705	50-yr	7.50	235.50	236.56		236.66	0.006743	1.42	5.31	11.64	0.65
Rainbow_22_North	22 North	1626.705	100-yr	8.40	235.50	236.57		236.70	0.007933	1.56	5.45	11.84	0.71
Rainbow_22_North	22 North	1626.705	Regional	15.46	235.50	236.80	236.68	236.97	0.008786	1.87	8.55	15.72	0.77
Rainbow_22_North	22 North	1499.526	50-yr	7.50	234.93	235.31	235.29	235.36	0.017073	1.02	7.35	51.41	0.86
Rainbow_22_North	22 North	1499.526	100-yr	8.40	234.93	235.33	235.30	235.38	0.013704	0.99	8.48	52.51	0.79
Rainbow_22_North	22 North	1499.526	Regional	15.46	234.93	235.39	235.38	235.48	0.015903	1.28	12.07	56.93	0.89
Rainbow_22_North	22 North	1414.097	50-yr	7.50	233.14	233.72	233.72	233.80	0.019711	1.24	6.04	35.07	0.95
Rainbow_22_North	22 North	1414.097	100-yr	8.40	233.14	233.72	233.72	233.82	0.025560	1.40	5.98	34.99	1.08
Rainbow_22_North	22 North	1414.097	Regional	15.46	233.14	233.82	233.82	233.95	0.020136	1.61	9.71	41.95	1.03
Rainbow_22_North	22 North	1335.243	50-yr	7.50	232.31	232.77		232.81	0.004699	0.83	9.00	32.33	0.50
Rainbow_22_North	22 North	1335.243	100-yr	8.40	232.31	232.79		232.82	0.005105	0.88	9.50	33.29	0.53
Rainbow_22_North	22 North	1335.243	Regional	15.46	232.31	232.91		232.97	0.005990	1.09	14.24	41.31	0.59
Rainbow_22_North	22 North	1223.936	50-yr	7.50	231.73	232.27		232.31	0.004090	0.83	9.04	29.47	0.48
Rainbow_22_North	22 North	1223.936	100-yr	8.40	231.73	232.31		232.34	0.003770	0.84	10.05	30.54	0.46
Rainbow_22_North	22 North	1223.936	Regional	15.46	231.73	232.55		232.58	0.002178	0.81	20.96	57.38	0.38

Crossing 19, Existing Condition, "East Tributary"

Revised Jun 2012

HEC-RAS Plan: Existing-Jun2012 Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Rainbow_22_North	22 North	1219.626	50-yr	7.50	231.73	232.26		232.29	0.003765	0.80	9.43	30.81	0.46
Rainbow_22_North	22 North	1219.626	100-yr	8.40	231.73	232.30		232.33	0.003410	0.80	10.57	33.89	0.44
Rainbow_22_North	22 North	1219.626	Regional	15.46	231.73	232.54		232.57	0.001889	0.77	22.64	62.68	0.35
Rainbow_22_North	22 North	1216.997	50-yr	7.50	231.73	232.25	232.10	232.28	0.003368	0.78	9.66	30.14	0.44
Rainbow_22_North	22 North	1216.997	100-yr	8.40	231.73	232.29	232.12	232.32	0.003037	0.78	10.78	30.90	0.42
Rainbow_22_North	22 North	1216.997	Regional	15.46	231.73	232.53	232.23	232.57	0.001890	0.81	19.03	35.90	0.36
Rainbow_22_North	22 North	1214.147	50-yr	7.50	231.73	232.24		232.27	0.004012	0.82	9.10	29.57	0.47
Rainbow_22_North	22 North	1214.147	100-yr	8.40	231.73	232.28		232.31	0.003455	0.82	10.28	30.22	0.45
Rainbow_22_North	22 North	1214.147	Regional	15.46	231.73	232.53		232.56	0.001927	0.85	18.35	34.54	0.36
Rainbow_22_North	22 North	1137.895	50-yr	7.50	231.47	232.21		232.22	0.000223	0.29	25.70	45.28	0.12
Rainbow_22_North	22 North	1137.895	100-yr	8.40	231.47	232.25		232.26	0.000227	0.31	27.50	45.90	0.13
Rainbow_22_North	22 North	1137.895	Regional	15.46	231.47	232.50		232.51	0.000256	0.39	39.53	49.87	0.14
Rainbow_22_North	22 North	1092.066	50-yr	7.50	231.47	232.19		232.20	0.000731	0.41	18.24	46.92	0.21
Rainbow_22_North	22 North	1092.066	100-yr	8.40	231.47	232.23		232.24	0.000677	0.42	20.12	47.75	0.21
Rainbow_22_North	22 North	1092.066	Regional	15.46	231.47	232.48		232.50	0.000486	0.47	32.81	52.32	0.19
Rainbow_22_North	22 North	973.9172	50-yr	7.50	230.87	231.73	231.73	231.95	0.016403	2.05	3.66	8.56	1.00
Rainbow_22_North	22 North	973.9172	100-yr	8.40	230.87	231.77	231.77	232.00	0.016676	2.12	3.96	8.90	1.01
Rainbow_22_North	22 North	973.9172	Regional	15.46	230.87	232.02	232.02	232.30	0.014996	2.37	6.52	11.42	1.00
Rainbow_22_North	22 North	861.5114	50-yr	7.50	230.07	230.74		230.78	0.002766	0.88	9.53	27.21	0.42
Rainbow_22_North	22 North	861.5114	100-yr	8.40	230.07	230.77		230.81	0.002818	0.91	10.51	29.39	0.43
Rainbow_22_North	22 North	861.5114	Regional	15.46	230.07	231.01		231.04	0.003111	0.83	22.12	65.27	0.43
Rainbow_22_North	22 North	856.1116	50-yr	7.50	229.60	230.49	230.49	230.73	0.015193	2.24	4.15	13.38	0.97
Rainbow_22_North	22 North	856.1116	100-yr	8.40	229.60	230.59	230.59	230.77	0.011972	2.01	5.63	16.50	0.86
Rainbow_22_North	22 North	856.1116	Regional	15.46	229.60	230.88	230.88	231.00	0.012026	1.76	14.23	56.55	0.85
Rainbow_22_North	22 North	847.7188	50-yr	7.50	229.34	229.94	229.94	230.14	0.017064	1.97	3.80	9.78	1.01
Rainbow_22_North	22 North	847.7188	100-yr	8.40	229.34	229.98	229.98	230.19	0.016377	2.00	4.19	10.20	1.00
Rainbow_22_North	22 North	847.7188	Regional	15.46	229.34	230.20	230.20	230.47	0.015237	2.30	6.74	13.11	1.00
Rainbow_22_North	22 North	734.1218	50-yr	7.50	227.87	228.67		228.70	0.003023	0.85	8.77	21.77	0.43
Rainbow_22_North	22 North	734.1218	100-yr	8.40	227.87	228.72		228.75	0.002756	0.85	9.86	22.97	0.41
Rainbow_22_North	22 North	734.1218	Regional	15.46	227.87	229.03		229.07	0.001645	0.86	18.35	33.34	0.34
Rainbow_22_North	22 North	623.445	50-yr	7.50	227.84	228.55		228.56	0.000678	0.39	19.48	52.98	0.20
Rainbow_22_North	22 North	623.445	100-yr	8.40	227.84	228.64		228.65	0.000420	0.34	24.56	58.15	0.16

HEC-RAS Plan: Existing-Jun2012 Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Rainbow_22_North	22 North	623.445	Regional	15.46	227.84	229.00		229.01	0.000200	0.34	48.93	75.09	0.12
Rainbow_22_North	22 North	531.735	50-yr	7.50	227.21	228.55		228.55	0.000036	0.14	53.21	70.64	0.05
Rainbow_22_North	22 North	531.735	100-yr	8.40	227.21	228.64		228.64	0.000033	0.14	59.91	75.36	0.05
Rainbow_22_North	22 North	531.735	Regional	15.46	227.21	229.00		229.00	0.000036	0.17	89.31	88.15	0.05
Rainbow_22_North	22 North	513.7729	50-yr	7.50	226.84	228.53	227.35	228.54	0.000192	0.53	14.16	35.83	0.13
Rainbow_22_North	22 North	513.7729	100-yr	8.40	226.84	228.62	227.38	228.64	0.000201	0.56	14.96	38.01	0.14
Rainbow_22_North	22 North	513.7729	Regional	15.46	226.84	228.99	227.63	229.00	0.000099	0.30	50.97	46.32	0.09
Rainbow_22_North	22 North	513		Culvert									
Rainbow_22_North	22 North	510	50-yr	7.50	226.66	228.47	227.19	228.47	0.000079	0.24	31.61	34.46	0.08
Rainbow_22_North	22 North	510	100-yr	8.40	226.66	228.54	227.22	228.54	0.000081	0.25	34.17	36.14	0.08
Rainbow_22_North	22 North	510	Regional	15.46	226.66	228.94	227.49	228.95	0.000101	0.31	50.53	45.69	0.09
Rainbow_22_North	22 North	480.6141	50-yr	7.50	226.80	228.29		228.45	0.006588	1.76	4.27	5.73	0.65
Rainbow_22_North	22 North	480.6141	100-yr	8.40	226.80	228.35		228.52	0.006685	1.82	4.62	5.96	0.66
Rainbow_22_North	22 North	480.6141	Regional	15.46	226.80	228.49	228.47	228.89	0.014515	2.83	5.46	6.48	0.98
Rainbow_22_North	22 North	473.4928	50-yr	7.50	226.76	228.30		228.40	0.003040	1.36	5.52	5.77	0.44
Rainbow_22_North	22 North	473.4928	100-yr	8.40	226.76	228.36		228.47	0.003237	1.43	5.87	5.93	0.46
Rainbow_22_North	22 North	473.4928	Regional	15.46	226.76	228.51	228.23	228.77	0.009126	2.24	6.89	8.01	0.77
Rainbow_22_North	22 North	443.5518	50-yr	7.50	227.12	228.31		228.33	0.001015	0.65	11.73	29.04	0.27
Rainbow_22_North	22 North	443.5518	100-yr	8.40	227.12	228.38		228.40	0.000915	0.65	14.31	43.13	0.26
Rainbow_22_North	22 North	443.5518	Regional	15.46	227.12	228.60		228.63	0.001009	0.83	24.85	52.86	0.28
Rainbow_22_North	22 North	409.9739	50-yr	7.50	226.40	227.84	227.84	228.20	0.018950	2.68	2.80	3.90	1.01
Rainbow_22_North	22 North	409.9739	100-yr	8.40	226.40	227.94	227.94	228.28	0.015042	2.59	3.47	8.94	0.92
Rainbow_22_North	22 North	409.9739	Regional	15.46	226.40	228.39	228.39	228.55	0.005573	2.11	19.09	67.83	0.60
Rainbow_22_North	22 North	391.374	50-yr	7.50	226.31	227.24	226.92	227.36	0.003866	1.55	4.85	7.11	0.52
Rainbow_22_North	22 North	391.374	100-yr	8.40	226.31	227.31	226.97	227.44	0.003714	1.60	5.26	7.31	0.52
Rainbow_22_North	22 North	391.374	Regional	15.46	226.31	227.82	227.29	228.01	0.003048	1.92	8.04	8.75	0.51
Rainbow_22_North	22 North	391		Culvert									
Rainbow_22_North	22 North	390	50-yr	7.50	225.97	226.89	226.59	227.02	0.004263	1.57	4.77	6.62	0.54
Rainbow_22_North	22 North	390	100-yr	8.40	225.97	226.94	226.64	227.08	0.004419	1.66	5.05	6.74	0.55
Rainbow_22_North	22 North	390	Regional	15.46	225.97	227.28	226.95	227.54	0.005276	2.24	6.90	7.52	0.64
Rainbow_22_North	22 North	258.4349	50-yr	7.50	224.85	225.75	225.75	226.01	0.016399	2.24	3.34	6.67	1.01

HEC-RAS Plan: Existing-Jun2012 Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Rainbow_22_North	22 North	258.4349	100-yr	8.40	224.85	225.80	225.80	226.07	0.015808	2.28	3.69	7.00	1.00
Rainbow_22_North	22 North	258.4349	Regional	15.46	224.85	226.09	226.09	226.43	0.014918	2.60	5.95	8.87	1.01
Rainbow_22_North	22 North	105	50-yr	7.50	224.05	225.38	224.58	225.41	0.000558	0.78	9.59	16.51	0.22
Rainbow_22_North	22 North	105	100-yr	8.40	224.05	225.47	224.62	225.50	0.000556	0.82	10.27	18.31	0.22
Rainbow_22_North	22 North	105	Regional	15.46	224.05	226.02	224.86	226.07	0.000593	1.06	16.65	77.20	0.25
Rainbow_22_North	22 North	104		Culvert	(ALBION-VAUGHAN ROAD CROSSING #19)								
Rainbow_22_North	22 North	100.2409	50-yr	7.50	223.33	225.31	223.92	225.32	0.000160	0.49	15.43	15.45	0.12
Rainbow_22_North	22 North	100.2409	100-yr	8.40	223.33	225.38	223.96	225.39	0.000174	0.52	16.08	16.75	0.13
Rainbow_22_North	22 North	100.2409	Regional	15.46	223.33	225.74	224.22	225.77	0.000312	0.79	19.48	23.19	0.18
Rainbow_22_North	22 North	90.90997	50-yr	7.50	223.50	225.27		225.31	0.002038	0.84	8.94	16.30	0.36
Rainbow_22_North	22 North	90.90997	100-yr	8.40	223.50	225.35		225.38	0.001872	0.82	10.21	18.10	0.35
Rainbow_22_North	22 North	90.90997	Regional	15.46	223.50	225.73		225.77	0.001320	0.83	19.10	40.00	0.31
Rainbow_22_North	22 North	35.77466	50-yr	7.50	223.49	224.74	224.66	225.04	0.015249	2.45	3.07	3.97	0.89
Rainbow_22_North	22 North	35.77466	100-yr	8.40	223.49	224.79	224.73	225.12	0.015682	2.54	3.30	4.12	0.91
Rainbow_22_North	22 North	35.77466	Regional	15.46	223.49	225.44		225.60	0.008087	1.81	8.73	15.84	0.71

HEC-RAS Plan: Existing-Jun2012 Locations: User Defined

River	Reach	River Sta		Profile	Culv Inv El Up	Culv Inv El Dn	E.G. US.	W.S. US.	W.S. DS	E.G. IC	E.G. OC	Min El Weir Flow	Q Culv Group	Q Weir	Delta WS	Culv Vel US	Culv Vel DS
					(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m3/s)	(m3/s)	(m)	(m/s)	(m/s)
Rainbow_22_North	22 North	513	Culvert #1	50-yr	226.84	226.66	228.54	228.53	228.47	227.87	228.54	228.70	7.50		0.06	1.04	1.04
Rainbow_22_North	22 North	513	Culvert #1	100-yr	226.84	226.66	228.64	228.62	228.54	227.96	228.64	228.70	8.40		0.08	1.17	1.17
Rainbow_22_North	22 North	513	Culvert #1	Regional	226.84	226.66	229.00	228.99	228.94	228.52	229.00	228.70	8.49	8.97	0.05	0.90	0.90
Rainbow_22_North	22 North	391	Culvert #1	50-yr	226.31	225.97	227.38	227.24	226.89	227.34	227.38	228.15	7.50		0.35	2.54	1.81
Rainbow_22_North	22 North	391	Culvert #1	100-yr	226.31	225.97	227.44	227.31	226.94	227.43	227.44	228.15	8.40		0.37	2.64	1.92
Rainbow_22_North	22 North	391	Culvert #1	Regional	226.31	225.97	228.01	227.62	227.28	227.99	228.01	228.15	15.48		0.54	3.23	4.29
Rainbow_22_North	22 North	104	Culvert #1	50-yr	224.05	223.33	225.41	225.38	225.31	225.08	225.41	225.96	7.50		0.07	1.34	1.11
Rainbow_22_North	22 North	104	Culvert #1	100-yr	224.05	223.33	225.50	225.47	225.38	225.17	225.50	225.96	8.40		0.09	1.40	1.24
Rainbow_22_North	22 North	104	Culvert #1	Regional	224.05	223.33	228.07	228.02	225.74	225.73	228.07	225.96	13.86	1.60	0.28	2.05	2.05

ALBION-VAUGHAN ROAD CULVERT CROSSING 19

Existing Condition

Robinson Creek - Tributary on East side of HWY 50

"East tributary"

"West Tributary" Revised Jun 2012

HEC-RAS Plan: Existing-Jun2012 River: Rainbow_22_South Reach: 22 South

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
22 South	203	50-yr	1.40	224.00	224.87		224.87	0.000084	0.19	7.43	11.92	0.08
22 South	203	100-yr	1.71	224.00	225.02		225.02	0.000066	0.18	9.35	13.14	0.07
22 South	203	Regional	13.33	224.00	226.45		226.45	0.000108	0.37	35.78	24.82	0.10
22 South	202	50-yr	1.40	224.00	224.86		224.86	0.000085	0.19	7.39	11.90	0.08
22 South	202	100-yr	1.71	224.00	225.02		225.02	0.000067	0.18	9.32	13.13	0.07
22 South	202	Regional	13.33	224.00	226.44		226.45	0.000109	0.37	35.70	24.78	0.10
22 South	201	50-yr	1.40	223.52	224.85	223.79	224.85	0.000103	0.35	3.99	7.87	0.10
22 South	201	100-yr	1.71	223.52	225.00	223.84	225.01	0.000107	0.38	4.45	8.47	0.10
22 South	201	Regional	13.33	223.52	226.42	224.78	226.44	0.000155	0.54	32.25	36.99	0.12
22 South	200		Culvert									
22 South	103	50-yr	1.40	223.25	224.71	223.63	224.72	0.000125	0.34	4.09	7.50	0.09
22 South	103	100-yr	1.71	223.25	224.79	223.67	224.80	0.000153	0.39	4.35	7.82	0.10
22 South	103	Regional	13.33	223.25	226.05	224.61	226.06	0.000142	0.50	56.94	70.18	0.11
22 South	82		Culvert									
22 South	81	50-yr	1.40	223.25	224.70	223.58	224.70	0.000022	0.33	4.25	7.45	0.09
22 South	81	100-yr	1.71	223.25	224.77	223.62	224.78	0.000028	0.38	4.48	7.74	0.10
22 South	81	Regional	13.33	223.25	226.04	224.56	226.06	0.000041	0.62	56.38	70.61	0.14
22 South	80	50-yr	1.40	223.13	224.70	223.77	224.70	0.000124	0.22	6.44	10.77	0.09
22 South	80	100-yr	1.71	223.13	224.77	223.83	224.78	0.000133	0.23	7.30	11.52	0.09
22 South	80	Regional	13.33	223.13	226.04	224.62	226.06	0.000175	0.55	28.69	190.49	0.13
22 South	38		Culvert									
22 South	37.91964	50-yr	1.40	222.84	224.69	223.22	224.69	0.000006	0.08	18.21	18.21	0.02
22 South	37.91964	100-yr	1.71	222.84	224.77	223.25	224.77	0.000008	0.09	19.40	18.84	0.03
22 South	37.91964	Regional	13.33	222.84	225.50	223.81	225.51	0.000137	0.35	38.35	35.54	0.11
22 South	4.790982	50-yr	1.40	223.32	224.69		224.69	0.000262	0.23	5.97	15.72	0.12
22 South	4.790982	100-yr	1.71	223.32	224.76		224.77	0.000237	0.24	7.18	17.18	0.12
22 South	4.790982	Regional	13.33	223.32	225.49		225.50	0.000364	0.54	34.78	71.08	0.17

Existing Condition, Robinson Creek - Tributary on west side of HWY 50 Crossings 14 & 18

"West tributary"

Revised Jun 2012

HEC-RAS Plan: Existing-Jun2012 River: Rainbow_22_South Reach: 22 South

Reach	River Sta	Profile	Culv Inv El Up	Culv Inv El Dn	E.G. US.	W.S. US.	W.S. DS	E.G. IC	E.G. OC	Min El Weir Flow	Q Culv Group	Q Weir	Delta WS	Culv Vel US	Culv Vel DS
			(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m3/s)	(m3/s)	(m)	(m/s)	(m/s)
22 South	200 Culvert #1	50-yr	223.52	223.45	224.85	224.85	224.71	224.47	224.85	226.00	1.40		0.14	1.24	1.24
22 South	200 Culvert #1	100-yr	223.52	223.45	225.01	225.00	224.79	224.61	225.01	226.00	1.71		0.21	1.51	1.51
22 South	200 Culvert #1	Regional	223.52	223.45	226.44	226.42	226.05	226.39	226.44	226.00	2.28	11.05	0.37	2.02	2.02
22 South	82 Culvert #1	50-yr	223.44	223.33	224.72	224.71	224.70	223.96	224.72	225.20	1.40		0.01	0.45	0.45
22 South	82 Culvert #1	100-yr	223.44	223.33	224.80	224.79	224.77	224.03	224.80	225.20	1.71		0.02	0.55	0.55
22 South	82 Culvert #1	Regional	223.44	223.33	226.06	226.05	226.04	226.06	226.06	225.20	0.80	12.53	0.01	0.26	0.26
22 South	38 Culvert #1	50-yr	223.13	222.84	224.70	224.70	224.69	223.53	224.70	226.00	1.40		0.00	0.27	0.27
22 South	38 Culvert #1	100-yr	223.13	222.84	224.78	224.77	224.77	223.59	224.78	226.00	1.71		0.01	0.33	0.33
22 South	38 Culvert #1	Regional	223.13	222.84	226.06	226.04	225.50	224.98	226.06	226.00	12.42	1.09	0.54	2.36	2.36

HWY 50, Culvert Crossing 14

Mayfield Road culvert crossing 18

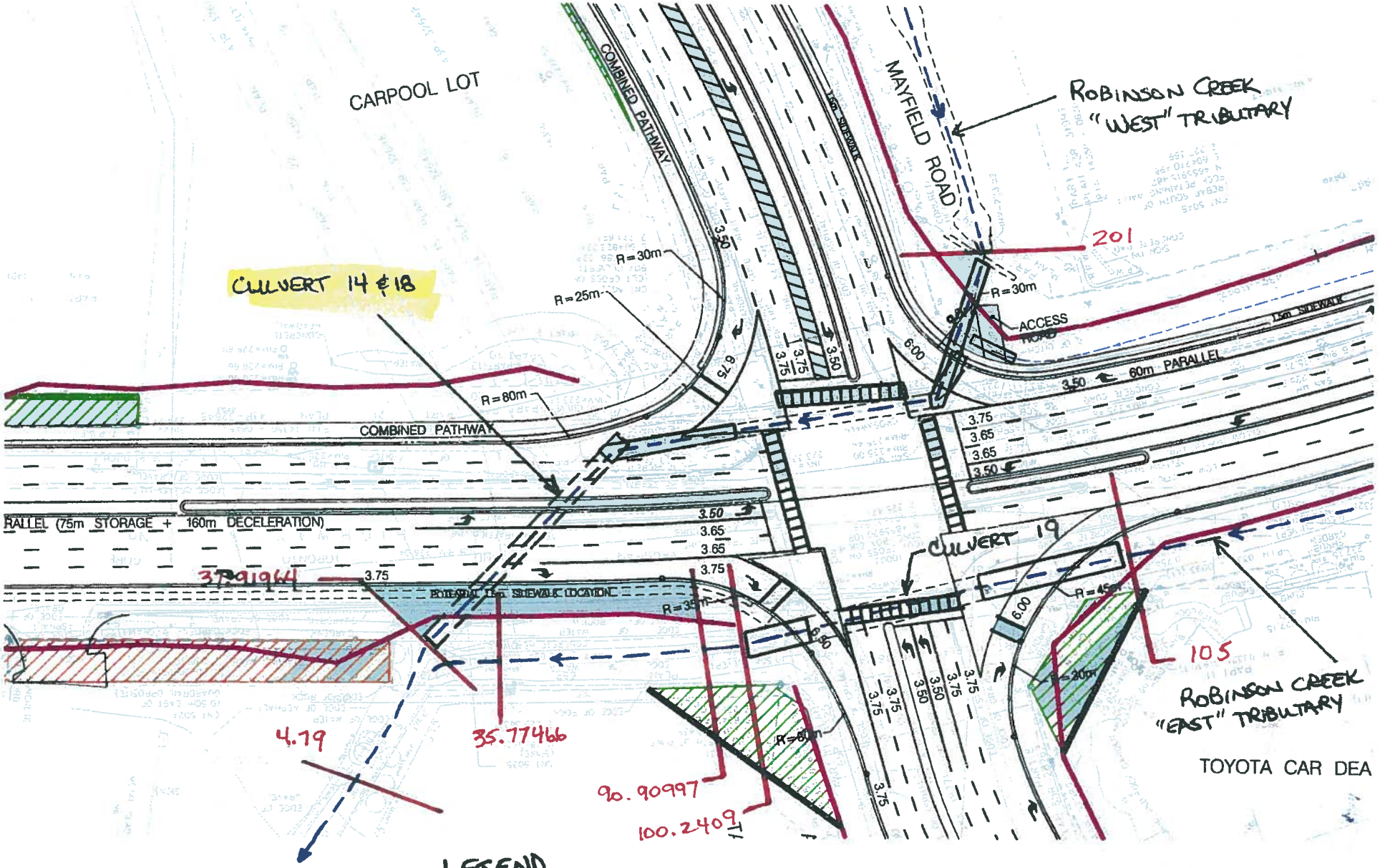
Robinson Creek - Tributary on West side of HWY 50

Existing condition

Future Condition HEC-RAS Cross-Sections and Model Output

HEC-RAS CROSS-SECTION LOCATIONS

FUTURE CONDITION



Future Condition, Robinson Creek - Tributary on East Side of HWY 50

"East Tributary"

Revised Jun 12

HEC-RAS Plan: Rev-Jun2012 Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Rainbow_22_North	22 North	1929.146	50-yr	7.50	237.48	238.41		238.42	0.000326	0.35	21.39	38.06	0.15
Rainbow_22_North	22 North	1929.146	100-yr	8.40	237.48	238.43		238.44	0.000368	0.38	22.18	38.50	0.16
Rainbow_22_North	22 North	1929.146	Regional	15.46	237.48	238.56		238.58	0.000676	0.56	27.39	41.22	0.22
Rainbow_22_North	22 North	1890.405	50-yr	7.50	237.17	238.41		238.41	0.000087	0.22	33.59	43.74	0.08
Rainbow_22_North	22 North	1890.405	100-yr	8.40	237.17	238.43		238.43	0.000101	0.24	34.48	44.17	0.09
Rainbow_22_North	22 North	1890.405	Regional	15.46	237.17	238.55		238.56	0.000222	0.38	40.24	46.82	0.13
Rainbow_22_North	22 North	1816.953	50-yr	7.50	238.04	238.37		238.39	0.003458	0.60	12.54	60.46	0.41
Rainbow_22_North	22 North	1816.953	100-yr	8.40	238.04	238.39		238.41	0.003432	0.62	13.55	61.39	0.42
Rainbow_22_North	22 North	1816.953	Regional	15.46	238.04	238.49		238.52	0.003617	0.79	19.82	67.46	0.45
Rainbow_22_North	22 North	1751.419	50-yr	7.50	237.77	238.02		238.05	0.008387	0.77	9.75	61.17	0.61
Rainbow_22_North	22 North	1751.419	100-yr	8.40	237.77	238.03		238.07	0.008679	0.80	10.53	64.17	0.63
Rainbow_22_North	22 North	1751.419	Regional	15.46	237.77	238.11		238.16	0.009380	0.94	16.75	98.73	0.67
Rainbow_22_North	22 North	1743.342	50-yr	7.50	237.60	237.86	237.86	237.93	0.028170	1.13	6.62	57.74	1.07
Rainbow_22_North	22 North	1743.342	100-yr	8.40	237.60	237.87	237.87	237.94	0.029550	1.19	7.08	59.71	1.10
Rainbow_22_North	22 North	1743.342	Regional	15.46	237.60	237.94	237.94	238.04	0.023134	1.39	11.33	68.87	1.04
Rainbow_22_North	22 North	1677.011	50-yr	7.50	236.02	236.74		236.76	0.000812	0.57	13.25	23.28	0.24
Rainbow_22_North	22 North	1677.011	100-yr	8.40	236.02	236.78		236.80	0.000844	0.60	14.15	23.83	0.24
Rainbow_22_North	22 North	1677.011	Regional	15.46	236.02	237.07		237.09	0.000892	0.75	21.46	27.92	0.26
Rainbow_22_North	22 North	1626.705	50-yr	7.50	235.50	236.56		236.66	0.006746	1.42	5.31	11.64	0.65
Rainbow_22_North	22 North	1626.705	100-yr	8.40	235.50	236.57		236.70	0.007933	1.56	5.45	11.84	0.71
Rainbow_22_North	22 North	1626.705	Regional	15.46	235.50	236.80	236.68	236.97	0.008786	1.87	8.55	15.72	0.77
Rainbow_22_North	22 North	1499.526	50-yr	7.50	234.93	235.31	235.29	235.36	0.017074	1.02	7.35	51.41	0.86
Rainbow_22_North	22 North	1499.526	100-yr	8.40	234.93	235.33	235.30	235.38	0.013704	0.99	8.48	52.51	0.79
Rainbow_22_North	22 North	1499.526	Regional	15.46	234.93	235.39	235.38	235.48	0.015903	1.28	12.07	56.93	0.89
Rainbow_22_North	22 North	1414.097	50-yr	7.50	233.14	233.72	233.72	233.80	0.019711	1.24	6.04	35.07	0.95
Rainbow_22_North	22 North	1414.097	100-yr	8.40	233.14	233.72	233.72	233.82	0.025560	1.40	5.98	34.99	1.08
Rainbow_22_North	22 North	1414.097	Regional	15.46	233.14	233.82	233.82	233.95	0.020136	1.61	9.71	41.95	1.03
Rainbow_22_North	22 North	1335.243	50-yr	7.50	232.31	232.77		232.81	0.004699	0.83	9.00	32.33	0.50
Rainbow_22_North	22 North	1335.243	100-yr	8.40	232.31	232.79		232.83	0.005104	0.88	9.50	33.29	0.53
Rainbow_22_North	22 North	1335.243	Regional	15.46	232.31	232.91		232.97	0.005990	1.09	14.24	41.31	0.59
Rainbow_22_North	22 North	1223.936	50-yr	7.50	231.73	232.27		232.31	0.004090	0.83	9.03	29.47	0.48
Rainbow_22_North	22 North	1223.936	100-yr	8.40	231.73	232.31		232.34	0.003770	0.84	10.05	30.54	0.46
Rainbow_22_North	22 North	1223.936	Regional	15.46	231.73	232.55		232.58	0.002178	0.81	20.96	57.38	0.38

Crossing 19, Future Condition

Jun 2012

HEC-RAS Plan: Rev-Jun2012 Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Rainbow_22_North	22 North	1219.626	50-yr	7.50	231.73	232.26		232.29	0.003765	0.80	9.43	30.81	0.46
Rainbow_22_North	22 North	1219.626	100-yr	8.40	231.73	232.30		232.33	0.003410	0.80	10.57	33.89	0.44
Rainbow_22_North	22 North	1219.626	Regional	15.46	231.73	232.54		232.57	0.001889	0.77	22.64	62.68	0.35
Rainbow_22_North	22 North	1216.997	50-yr	7.50	231.73	232.25	232.10	232.28	0.003368	0.78	9.66	30.14	0.44
Rainbow_22_North	22 North	1216.997	100-yr	8.40	231.73	232.29	232.12	232.32	0.003037	0.78	10.78	30.90	0.42
Rainbow_22_North	22 North	1216.997	Regional	15.46	231.73	232.53	232.23	232.57	0.001890	0.81	19.03	35.90	0.36
Rainbow_22_North	22 North	1214.147	50-yr	7.50	231.73	232.24		232.27	0.004012	0.82	9.10	29.57	0.47
Rainbow_22_North	22 North	1214.147	100-yr	8.40	231.73	232.28		232.31	0.003455	0.82	10.28	30.22	0.45
Rainbow_22_North	22 North	1214.147	Regional	15.46	231.73	232.53		232.56	0.001927	0.85	18.35	34.54	0.36
Rainbow_22_North	22 North	1137.895	50-yr	7.50	231.47	232.21		232.22	0.000223	0.29	25.70	45.28	0.12
Rainbow_22_North	22 North	1137.895	100-yr	8.40	231.47	232.25		232.26	0.000227	0.31	27.50	45.90	0.13
Rainbow_22_North	22 North	1137.895	Regional	15.46	231.47	232.50		232.51	0.000256	0.39	39.53	49.87	0.14
Rainbow_22_North	22 North	1092.066	50-yr	7.50	231.47	232.19		232.20	0.000731	0.41	18.24	46.92	0.21
Rainbow_22_North	22 North	1092.066	100-yr	8.40	231.47	232.23		232.24	0.000677	0.42	20.12	47.75	0.21
Rainbow_22_North	22 North	1092.066	Regional	15.46	231.47	232.48		232.50	0.000486	0.47	32.81	52.32	0.19
Rainbow_22_North	22 North	973.9172	50-yr	7.50	230.87	231.73	231.73	231.95	0.016403	2.05	3.66	8.56	1.00
Rainbow_22_North	22 North	973.9172	100-yr	8.40	230.87	231.77	231.77	232.00	0.016676	2.12	3.96	8.90	1.01
Rainbow_22_North	22 North	973.9172	Regional	15.46	230.87	232.02	232.02	232.30	0.014996	2.37	6.52	11.42	1.00
Rainbow_22_North	22 North	861.5114	50-yr	7.50	230.07	230.74		230.78	0.002766	0.88	9.53	27.21	0.42
Rainbow_22_North	22 North	861.5114	100-yr	8.40	230.07	230.77		230.81	0.002818	0.91	10.51	29.39	0.43
Rainbow_22_North	22 North	861.5114	Regional	15.46	230.07	231.01		231.04	0.003111	0.83	22.12	65.27	0.43
Rainbow_22_North	22 North	856.1116	50-yr	7.50	229.60	230.49	230.49	230.73	0.015193	2.24	4.15	13.38	0.97
Rainbow_22_North	22 North	856.1116	100-yr	8.40	229.60	230.59	230.59	230.77	0.011972	2.01	5.63	16.50	0.86
Rainbow_22_North	22 North	856.1116	Regional	15.46	229.60	230.88	230.88	231.00	0.012026	1.76	14.23	56.55	0.85
Rainbow_22_North	22 North	847.7188	50-yr	7.50	229.34	229.94	229.94	230.14	0.017064	1.97	3.80	9.78	1.01
Rainbow_22_North	22 North	847.7188	100-yr	8.40	229.34	229.98	229.98	230.19	0.016379	2.00	4.19	10.20	1.00
Rainbow_22_North	22 North	847.7188	Regional	15.46	229.34	230.20	230.20	230.47	0.015241	2.30	6.74	13.11	1.00
Rainbow_22_North	22 North	734.1218	50-yr	7.50	227.87	228.67		228.70	0.003023	0.85	8.77	21.77	0.43
Rainbow_22_North	22 North	734.1218	100-yr	8.40	227.87	228.72		228.75	0.002756	0.85	9.86	22.97	0.41
Rainbow_22_North	22 North	734.1218	Regional	15.46	227.87	229.03		229.07	0.001645	0.86	18.35	33.34	0.34
Rainbow_22_North	22 North	623.445	50-yr	7.50	227.84	228.55		228.56	0.000678	0.39	19.48	52.98	0.20
Rainbow_22_North	22 North	623.445	100-yr	8.40	227.84	228.64		228.65	0.000420	0.34	24.56	58.15	0.16

HEC-RAS Plan: Rev-Jun2012 Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Rainbow_22_North	22 North	623.445	Regional	15.46	227.84	229.00		229.01	0.000200	0.34	48.93	75.09	0.12
Rainbow_22_North	22 North	531.735	50-yr	7.50	227.21	228.55		228.55	0.000036	0.14	53.21	70.64	0.05
Rainbow_22_North	22 North	531.735	100-yr	8.40	227.21	228.64		228.64	0.000033	0.14	59.91	75.36	0.05
Rainbow_22_North	22 North	531.735	Regional	15.46	227.21	229.00		229.00	0.000036	0.17	89.31	88.15	0.05
Rainbow_22_North	22 North	513.7729	50-yr	7.50	226.84	228.53	227.35	228.54	0.000192	0.53	14.16	35.83	0.13
Rainbow_22_North	22 North	513.7729	100-yr	8.40	226.84	228.62	227.38	228.64	0.000201	0.56	14.96	38.00	0.14
Rainbow_22_North	22 North	513.7729	Regional	15.46	226.84	228.99	227.63	229.00	0.000099	0.30	50.97	46.32	0.09
Rainbow_22_North	22 North	513		Culvert									
Rainbow_22_North	22 North	510	50-yr	7.50	226.66	228.47	227.19	228.47	0.000079	0.24	31.61	34.46	0.08
Rainbow_22_North	22 North	510	100-yr	8.40	226.66	228.54	227.22	228.54	0.000081	0.25	34.17	36.14	0.08
Rainbow_22_North	22 North	510	Regional	15.46	226.66	228.94	227.49	228.95	0.000101	0.31	50.53	45.70	0.09
Rainbow_22_North	22 North	480.6141	50-yr	7.50	226.80	228.29		228.45	0.006588	1.76	4.27	5.73	0.65
Rainbow_22_North	22 North	480.6141	100-yr	8.40	226.80	228.35		228.52	0.006685	1.82	4.62	5.96	0.66
Rainbow_22_North	22 North	480.6141	Regional	15.46	226.80	228.49	228.47	228.89	0.014522	2.83	5.46	6.47	0.98
Rainbow_22_North	22 North	473.4928	50-yr	7.50	226.76	228.30		228.40	0.003040	1.36	5.52	5.77	0.44
Rainbow_22_North	22 North	473.4928	100-yr	8.40	226.76	228.36		228.47	0.003237	1.43	5.87	5.93	0.46
Rainbow_22_North	22 North	473.4928	Regional	15.46	226.76	228.51	228.23	228.77	0.009123	2.24	6.89	8.01	0.77
Rainbow_22_North	22 North	443.5518	50-yr	7.50	227.12	228.31		228.33	0.001015	0.65	11.73	29.04	0.27
Rainbow_22_North	22 North	443.5518	100-yr	8.40	227.12	228.38		228.40	0.000915	0.65	14.31	43.14	0.26
Rainbow_22_North	22 North	443.5518	Regional	15.46	227.12	228.60		228.63	0.001010	0.83	24.84	52.86	0.28
Rainbow_22_North	22 North	409.9739	50-yr	7.50	226.40	227.84	227.84	228.20	0.018950	2.68	2.80	3.90	1.01
Rainbow_22_North	22 North	409.9739	100-yr	8.40	226.40	227.94	227.94	228.28	0.015040	2.59	3.47	8.94	0.92
Rainbow_22_North	22 North	409.9739	Regional	15.46	226.40	228.39	228.39	228.55	0.005572	2.11	19.09	67.83	0.60
Rainbow_22_North	22 North	391.374	50-yr	7.50	226.31	227.24	226.92	227.36	0.003866	1.55	4.85	7.11	0.52
Rainbow_22_North	22 North	391.374	100-yr	8.40	226.31	227.31	226.97	227.44	0.003714	1.60	5.26	7.31	0.52
Rainbow_22_North	22 North	391.374	Regional	15.46	226.31	227.82	227.29	228.01	0.003049	1.92	8.04	8.75	0.51
Rainbow_22_North	22 North	391		Culvert									
Rainbow_22_North	22 North	390	50-yr	7.50	225.97	226.89	226.59	227.02	0.004299	1.58	4.75	6.61	0.54
Rainbow_22_North	22 North	390	100-yr	8.40	225.97	226.95	226.64	227.09	0.004390	1.66	5.06	6.74	0.55
Rainbow_22_North	22 North	390	Regional	15.46	225.97	227.28	226.95	227.54	0.005315	2.24	6.89	7.51	0.64
Rainbow_22_North	22 North	258.4349	50-yr	7.50	224.85	225.76	225.76	226.01	0.016076	2.23	3.37	6.69	1.00

HEC-RAS Plan: Rev-Jun2012 Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Rainbow_22_North	22 North	258.4349	100-yr	8.40	224.85	225.80	225.80	226.07	0.016149	2.30	3.66	6.97	1.01
Rainbow_22_North	22 North	258.4349	Regional	15.46	224.85	226.09	226.09	226.43	0.014637	2.58	5.99	8.90	1.00
Rainbow_22_North	22 North	105	50-yr	7.50	224.35	225.39	224.86	225.44	0.001231	0.99	7.55	16.77	0.32
Rainbow_22_North	22 North	105	100-yr	8.40	224.35	225.49	224.90	225.54	0.001148	1.02	8.25	18.56	0.31
Rainbow_22_North	22 North	105	Regional	15.46	224.35	226.02	225.15	226.09	0.001012	1.25	14.46	77.16	0.31
Rainbow_22_North	22 North	104		Culvert	(ALBION-VAUGHAN ROAD CROSSING 19)								
Rainbow_22_North	22 North	100.2409	50-yr	7.50	223.33	225.30	223.92	225.32	0.000161	0.49	15.41	15.44	0.12
Rainbow_22_North	22 North	100.2409	100-yr	8.40	223.33	225.37	223.96	225.39	0.000175	0.52	16.06	16.70	0.13
Rainbow_22_North	22 North	100.2409	Regional	15.46	223.33	225.74	224.22	225.77	0.000314	0.79	19.45	23.13	0.18
Rainbow_22_North	22 North	90.90997	50-yr	7.50	223.50	225.27		225.31	0.002038	0.84	8.94	16.30	0.36
Rainbow_22_North	22 North	90.90997	100-yr	8.40	223.50	225.35		225.38	0.001872	0.82	10.21	18.10	0.35
Rainbow_22_North	22 North	90.90997	Regional	15.46	223.50	225.73		225.77	0.001320	0.83	19.10	40.00	0.31
Rainbow_22_North	22 North	35.77466	50-yr	7.50	223.49	224.74	224.66	225.04	0.015249	2.45	3.07	3.97	0.89
Rainbow_22_North	22 North	35.77466	100-yr	8.40	223.49	224.79	224.73	225.12	0.015682	2.54	3.30	4.12	0.91
Rainbow_22_North	22 North	35.77466	Regional	15.46	223.49	225.44		225.60	0.008087	1.81	8.73	15.84	0.71

"East tributary"

Jun 2012

HEC-RAS Plan: Rev-Jun2012 Locations: User Defined

River	Reach	River Sta	Profile	Culv Inv El Up	Culv Inv El Dn	E.G. US.	W.S. US.	W.S. DS	E.G. IC	E.G. OC	Min El Weir Flow	Q Culv Group	Q Weir	Delta WS	Culv Vel US	Culv Vel DS
				(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m3/s)	(m3/s)	(m)	(m/s)	(m/s)
Rainbow_22_North	22 North	513 Culvert #1	50-yr	226.84	228.66	228.54	228.53	228.47	227.87	228.54	228.70	7.50		0.06	1.04	1.04
Rainbow_22_North	22 North	513 Culvert #1	100-yr	226.84	228.66	228.64	228.62	228.54	227.96	228.64	228.70	8.40		0.08	1.17	1.17
Rainbow_22_North	22 North	513 Culvert #1	Regional	226.84	228.66	229.00	228.99	228.94	228.52	229.00	228.70	6.49	8.97	0.05	0.90	0.90
Rainbow_22_North	22 North	391 Culvert #1	50-yr	228.31	225.97	227.36	227.24	226.89	227.34	227.36	228.15	7.50		0.35	2.54	1.81
Rainbow_22_North	22 North	391 Culvert #1	100-yr	228.31	225.97	227.44	227.31	226.95	227.43	227.44	228.15	8.40		0.37	2.64	1.91
Rainbow_22_North	22 North	391 Culvert #1	Regional	228.31	225.97	228.01	227.82	227.28	227.99	228.01	228.15	15.46		0.54	3.23	4.29
Rainbow_22_North	22 North	104 Culvert #1	50-yr	224.35	223.33	225.45	225.39	225.30	225.38	225.45	225.96	7.50		0.09	1.91	1.11
Rainbow_22_North	22 North	104 Culvert #1	100-yr	224.35	223.33	225.54	225.49	225.37	225.47	225.54	225.96	8.40		0.11	1.95	1.24
Rainbow_22_North	22 North	104 Culvert #1	Regional	224.35	223.33	226.09	226.02	225.74	225.99	226.09	225.96	13.12	2.34	0.28	1.94	1.94

ALBION-VAUGHAN ROAD CULVERT CROSSING (19)

Future condition

Robinson Creek - Tributary on East Side of HWY 50.

"West Tributary" Revised Jun 2012

HEC-RAS Plan: Rev-Jun2012 River: Rainbow_22_South Reach: 22 South

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
22 South	203	50-yr	1.40	224.00	224.73		224.74	0.000158	0.24	5.92	10.87	0.10
22 South	203	100-yr	1.71	224.00	224.82		224.82	0.000156	0.25	6.87	11.54	0.10
22 South	203	Regional	13.33	224.00	226.44		226.45	0.000109	0.37	35.61	24.73	0.10
22 South	202	50-yr	1.40	224.00	224.73		224.73	0.000162	0.24	5.87	10.83	0.10
22 South	202	100-yr	1.71	224.00	224.81		224.82	0.000159	0.25	6.81	11.50	0.10
22 South	202	Regional	13.33	224.00	226.44		226.44	0.000111	0.38	35.54	24.85	0.10
22 South	201	50-yr	1.40	223.52	224.71	223.80	224.72	0.000151	0.39	3.56	7.31	0.12
22 South	201	100-yr	1.71	223.52	224.79	223.84	224.80	0.000180	0.45	3.80	7.63	0.13
22 South	201	Regional	13.33	223.52	226.42	224.78	226.43	0.000157	0.54	31.97	36.81	0.12
22 South	38		Culvert									
22 South	37.91964	50-yr	1.40	222.84	224.69	223.22	224.69	0.000006	0.08	18.01	18.21	0.02
22 South	37.91964	100-yr	1.71	222.84	224.77	223.25	224.77	0.000007	0.09	19.11	18.84	0.03
22 South	37.91964	Regional	13.33	222.84	225.50	223.80	225.51	0.000137	0.35	38.35	35.54	0.11
22 South	4.790982	50-yr	1.40	223.32	224.69		224.69	0.000262	0.23	5.97	15.72	0.12
22 South	4.790982	100-yr	1.71	223.32	224.76		224.77	0.000237	0.24	7.18	17.18	0.12
22 South	4.790982	Regional	13.33	223.32	225.49		225.50	0.000364	0.54	34.78	71.08	0.17

Future Condition, Robinson Creek - Tributary on West side of HWY 50

Crossings 14 + 18 (combined)

HEC-RAS Plan: Rev-Jun2012 River: Rainbow_22_South Reach: 22 South

Reach	River Sta	Profile	Culv Inv El Up	Culv Inv El Dn	E.G. US.	W.S. US.	W.S. DS	E.G. IC	E.G. OC	Min El Weir Flow	Q Culv Group	Q Weir	Delta WS	Culv Vel US	Culv Vel DS
			(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m3/s)	(m3/s)	(m)	(m/s)	(m/s)
22 South	38 Culvert #1	50-yr	223.52	222.84	224.72	224.71	224.69	224.02	224.72	226.25	1.40		0.01	0.48	0.37
22 South	38 Culvert #1	100-yr	223.52	222.84	224.80	224.79	224.77	224.09	224.80	226.25	1.71		0.02	0.54	0.46
22 South	38 Culvert #1	Regional	223.52	222.84	226.43	226.42	225.50	226.05	226.43	226.25	9.46	3.78	0.91	2.52	2.52

- HWY 50 culvert crossings 14+18 (combined)

Robinson Creek - Tributary on west side of HWY 50

Future condition