VALDOR ENGINEERING INC.
Municipal • Land Development • Water Resources
Site Development • Project Management • Contract Administration
Consulting Engineers - est. 1992

741 Rowntree Dairy Road, Suite 2
Woodbridge, Ontario L4L 5T9
TEL (905) 264-0054
FAX (905) 264-0069
info@valdor-engineering.com
www.valdor-engineering.com

Unionville SPA 2D Study and Floodplain Mapping Update

APPENDICES 'A' to 'F'

Toronto and Region Conservation Authority
City of Markham

February 2019 (FINAL)

Prepared By:

Valdor Engineering Inc.

Prepared For:

The Toronto and Region Conservation Authority

File: **18123**

Toronto and Region Conservation Authority

VALDOR WATER RESOURCES

s:\projects\2018\18123\reports\2d modelling and floodplain rep-feb 2019\final report - feb 2019\18123 - final - unionville spa 2d modelling study and floodplain mapping update - feb 2019.doc

APPENDIX 'A'

Completed Survey and Structure Inventory

Unionville SPA 2D Modelling Study and Floodplain Mapping Update

Toronto and Region Conservation Authority

Appendix 'A' Contents:

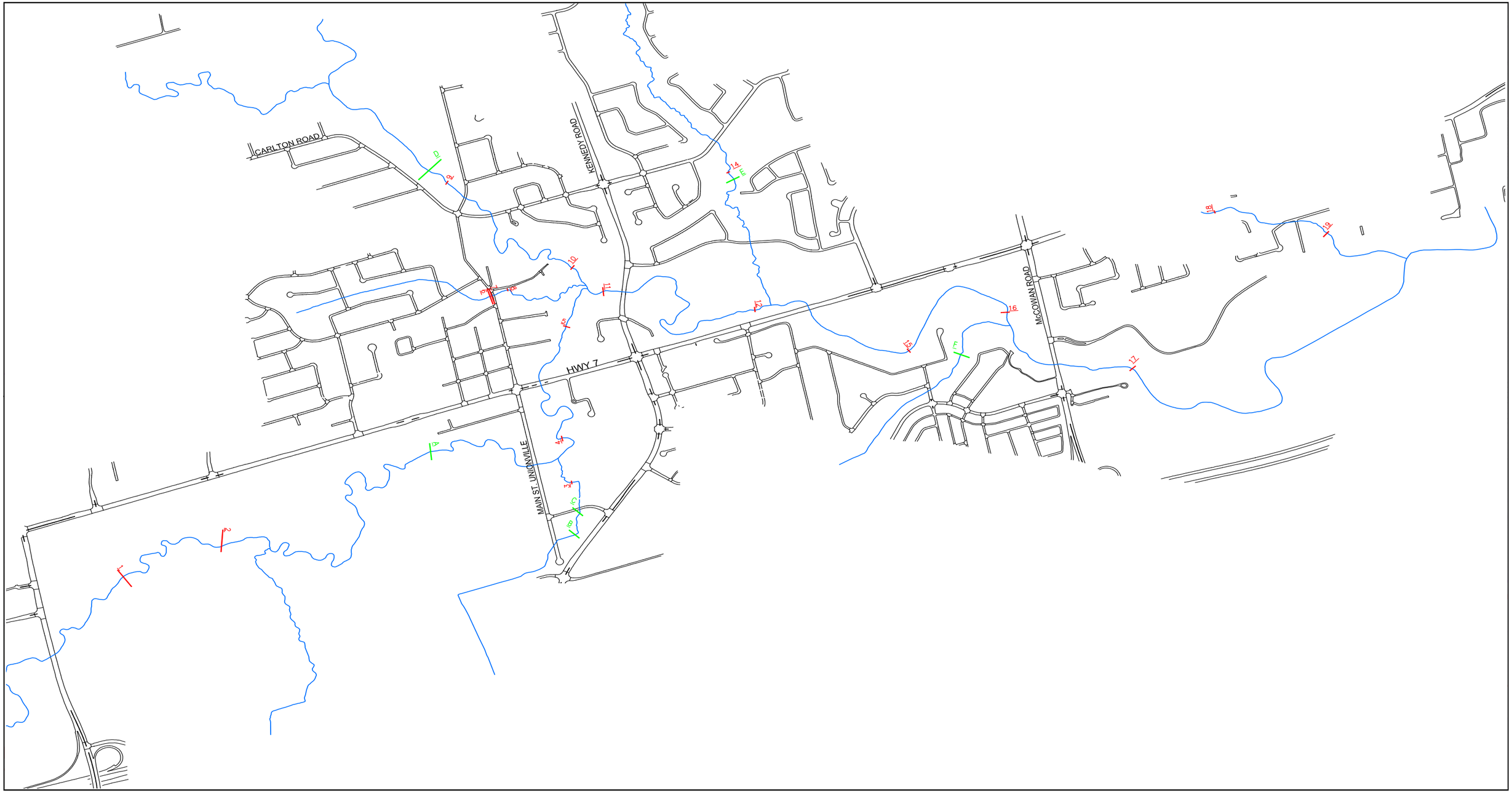

Figure A.1

Location Plan for Field Surveys

18 December 2018

LEGEND

1 — TRCA CHANNEL SURVEY SECTION

A — VALDOR STRUCTURE SURVEY SECTION

N

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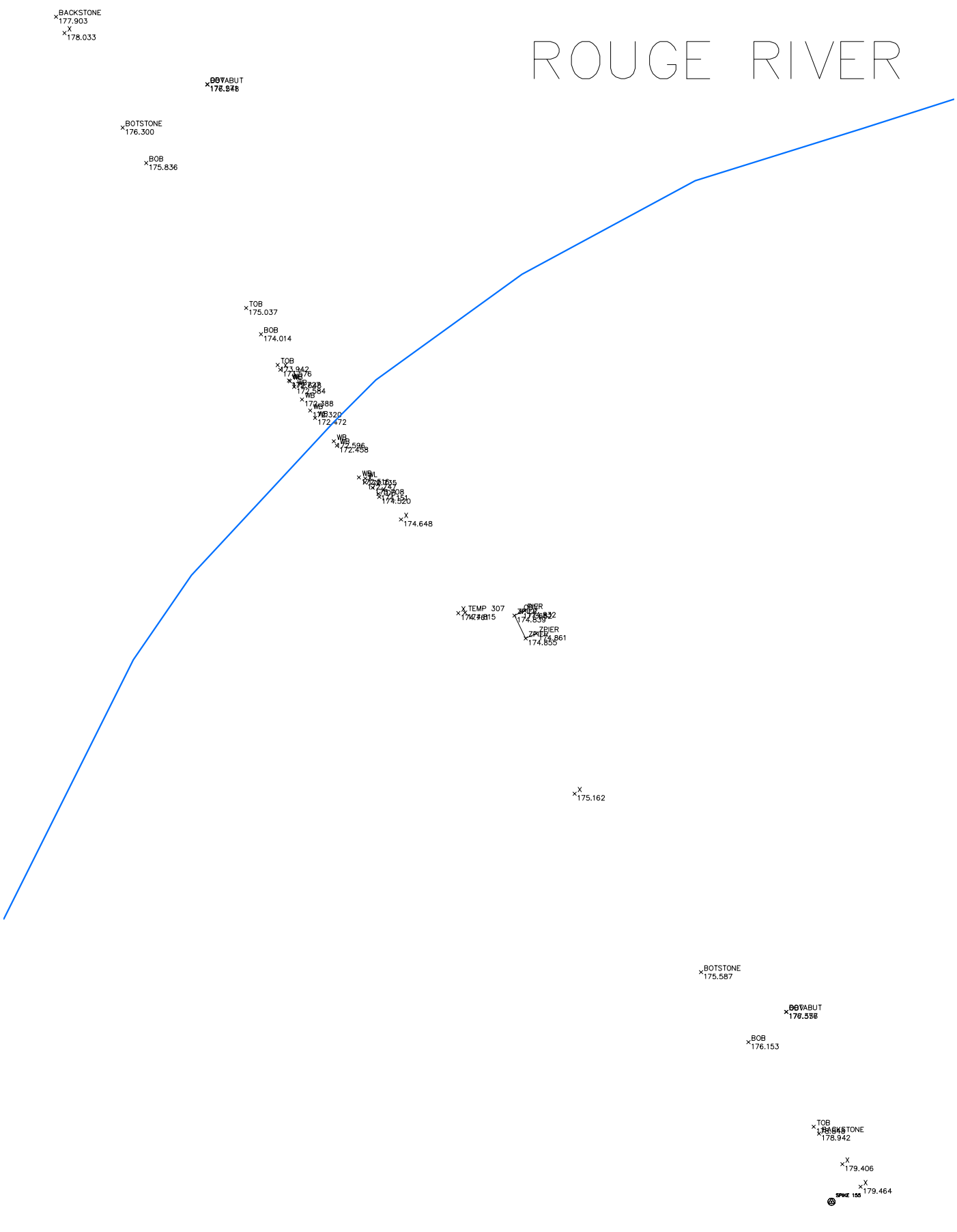

FIGURE A1.a
TRCA CHANNEL CROSS-SECTION SURVEY DATA

CHANNEL SURVEY LOCATION 1

N

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UNIONVILLE SPA 2D MODELLING STUDY AND FLOODPLAIN MAPPING UPDATE

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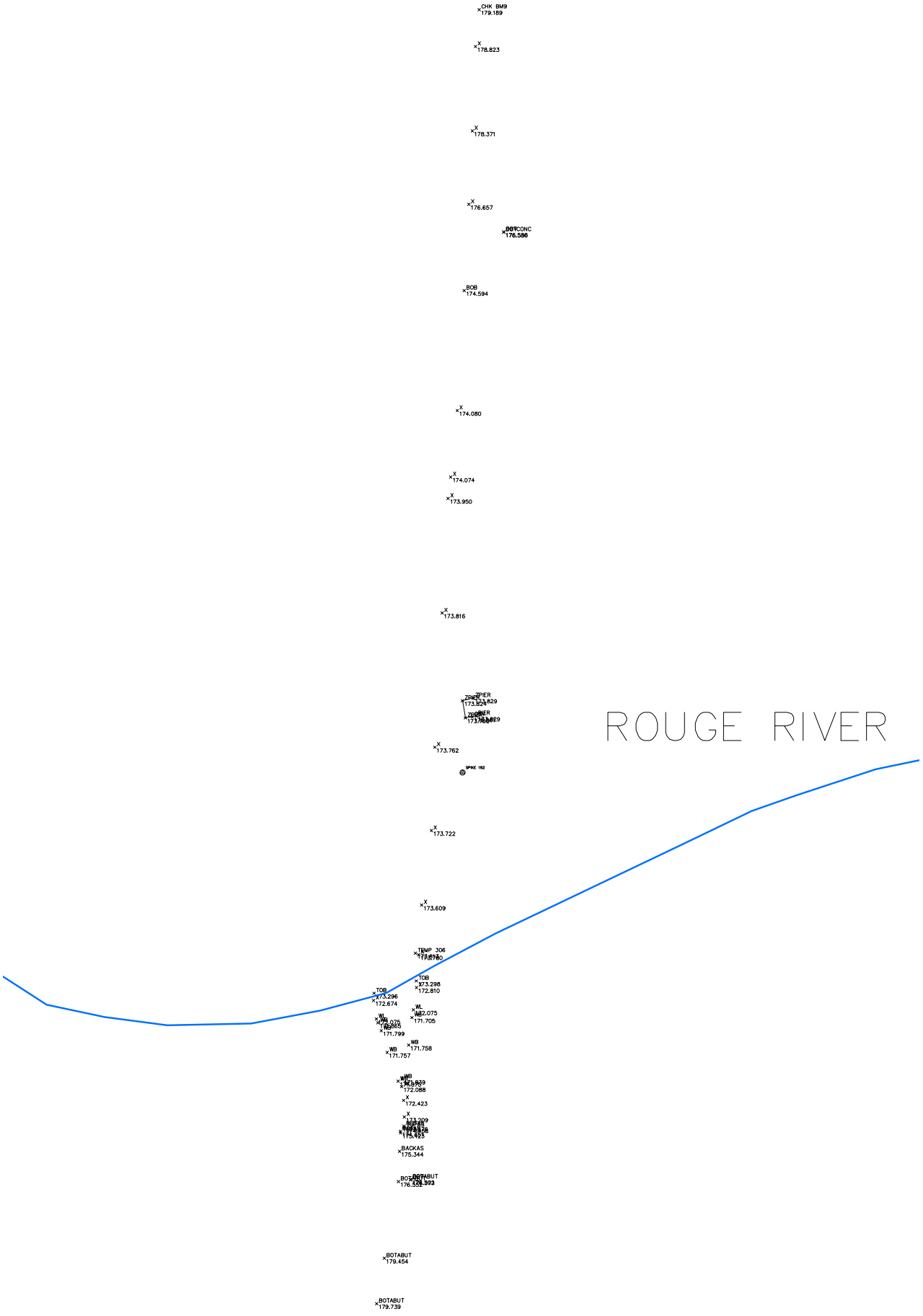

FIGURE A1.b
TRCA CHANNEL CROSS-SECTION SURVEY DATA

CHANNEL SURVEY LOCATION 2

N

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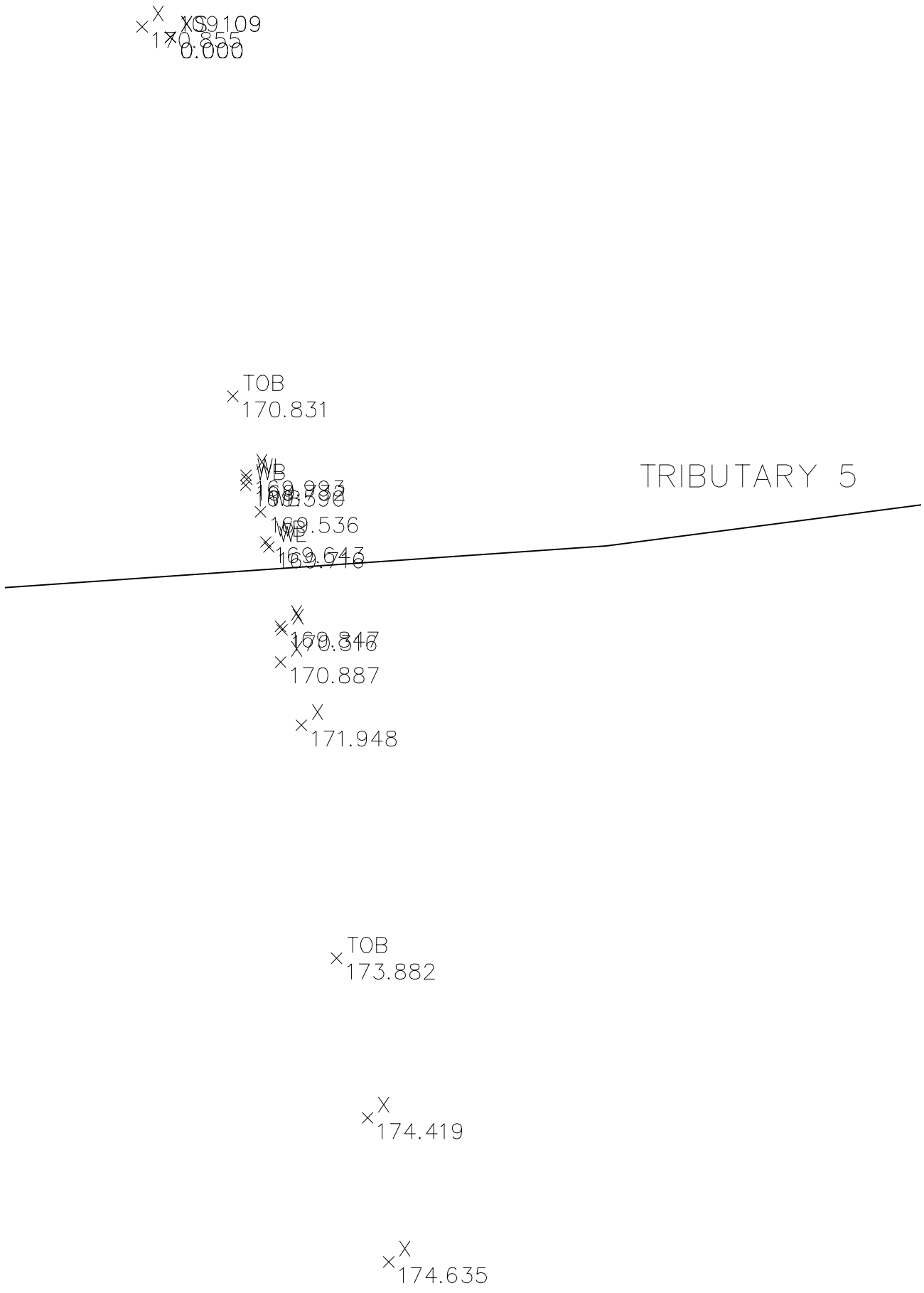

FIGURE A1.c
TRCA CHANNEL CROSS-SECTION SURVEY DATA

CHANNEL SURVEY LOCATION 3

N

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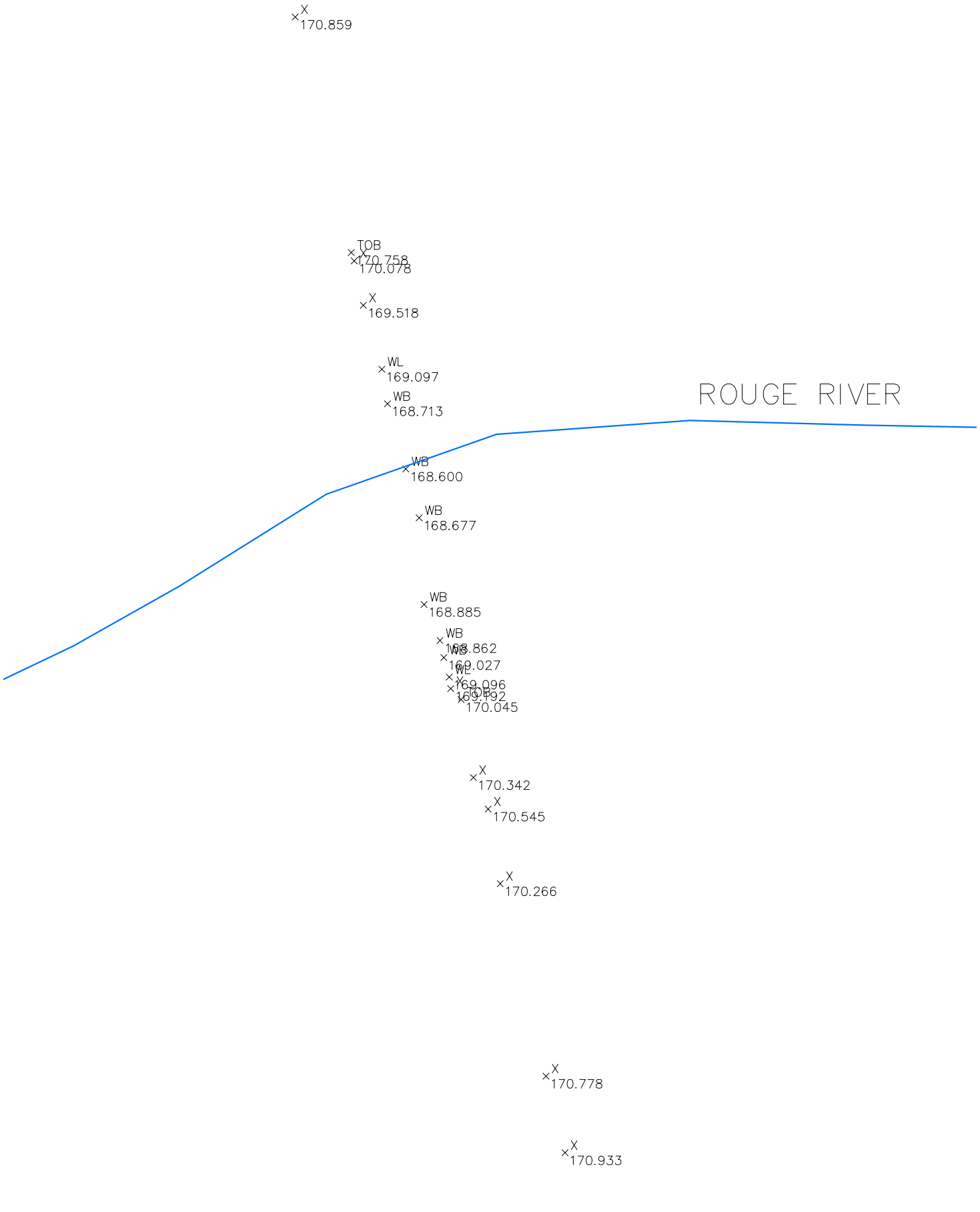

FIGURE A1.d
TRCA CHANNEL CROSS-SECTION SURVEY DATA

CHANNEL SURVEY LOCATION 4

N

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UNIONVILLE SPA 2D MODELLING STUDY
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FIGURE A1.e
TRCA CHANNEL CROSS-SECTION SURVEY DATA

CHANNEL SURVEY LOCATION 5

N

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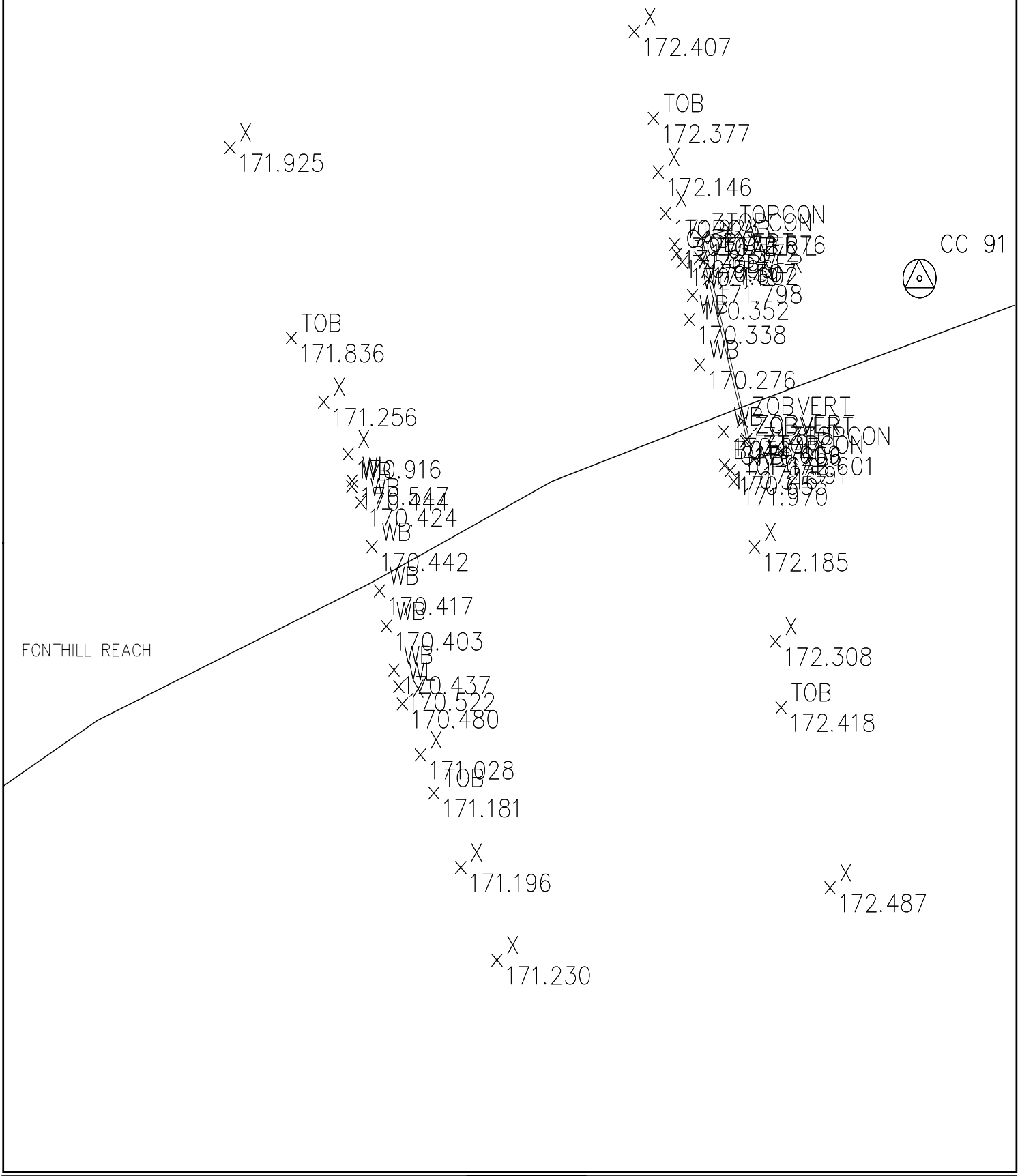

FIGURE A1.f
TRCA CHANNEL CROSS-SECTION SURVEY DATA

CHANNEL SURVEY LOCATION 6 and 7

N

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UNIONVILLE SPA 2D MODELLING STUDY
AND FLOODPLAIN MAPPING UPDATE

Toronto and Region Conservation Authority

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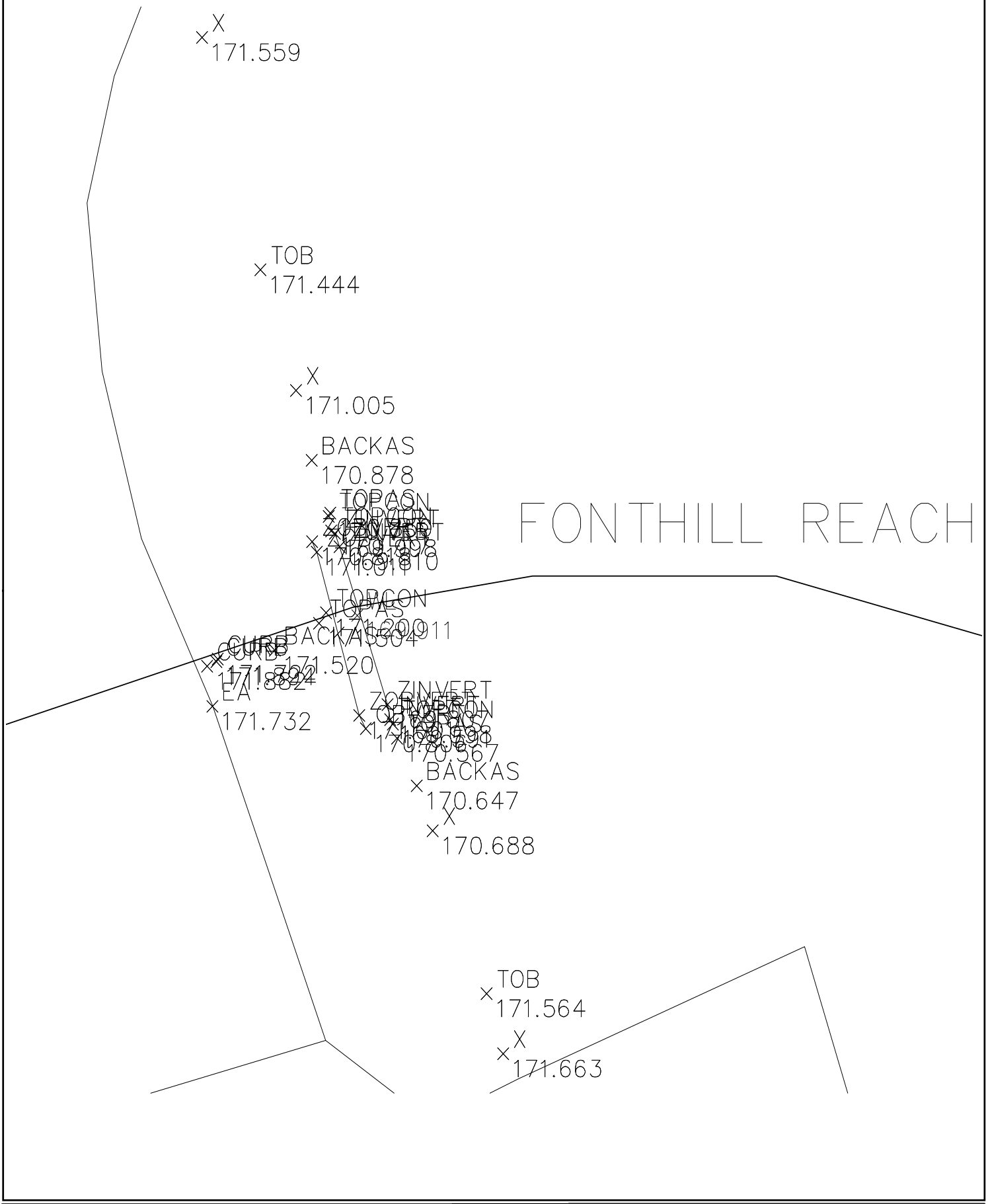

FIGURE A1.g
TRCA CHANNEL CROSS-SECTION SURVEY DATA

CHANNEL SURVEY LOCATION 8

N

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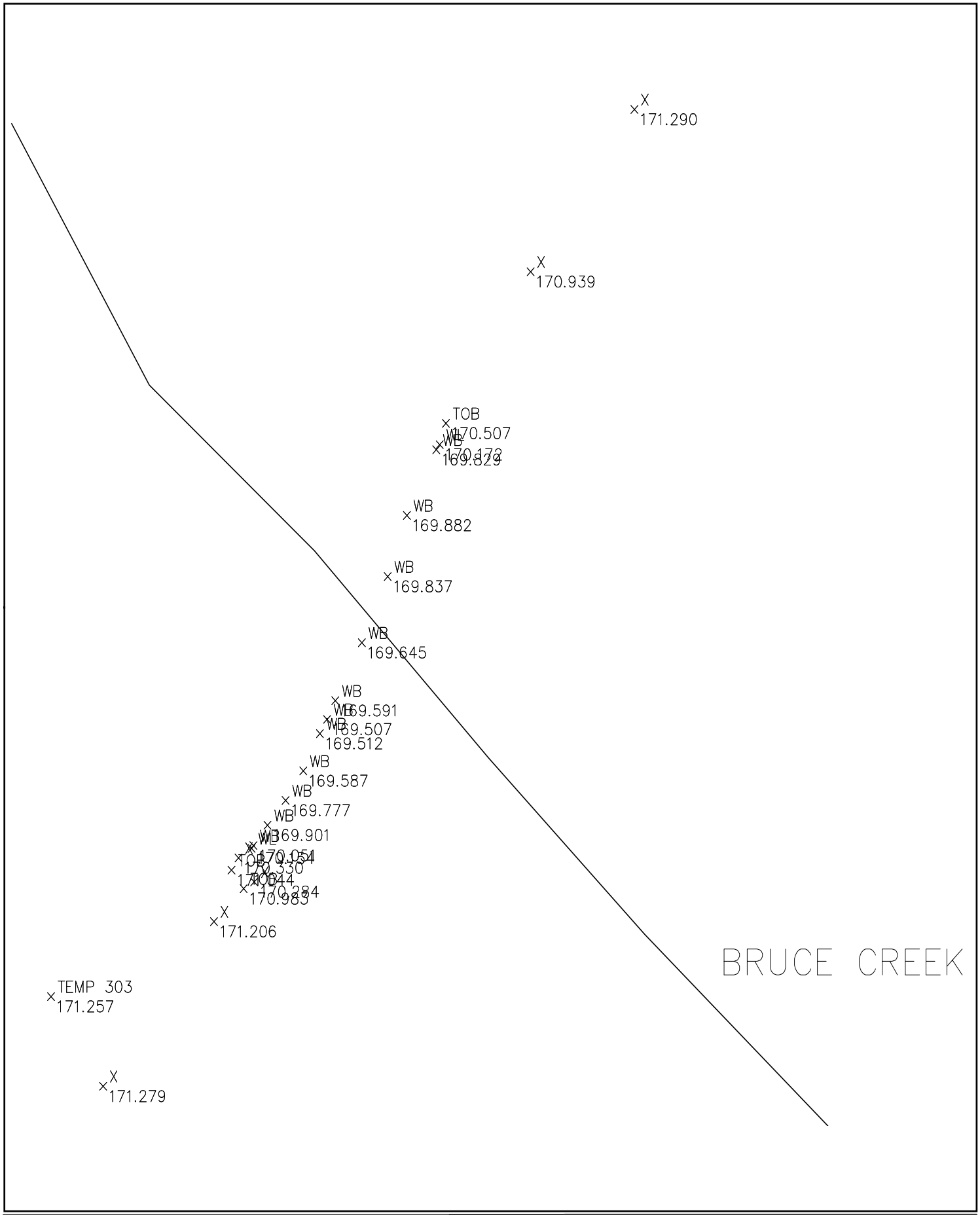

FIGURE A1.h
TRCA CHANNEL CROSS-SECTION SURVEY DATA

CHANNEL SURVEY LOCATION 9

N

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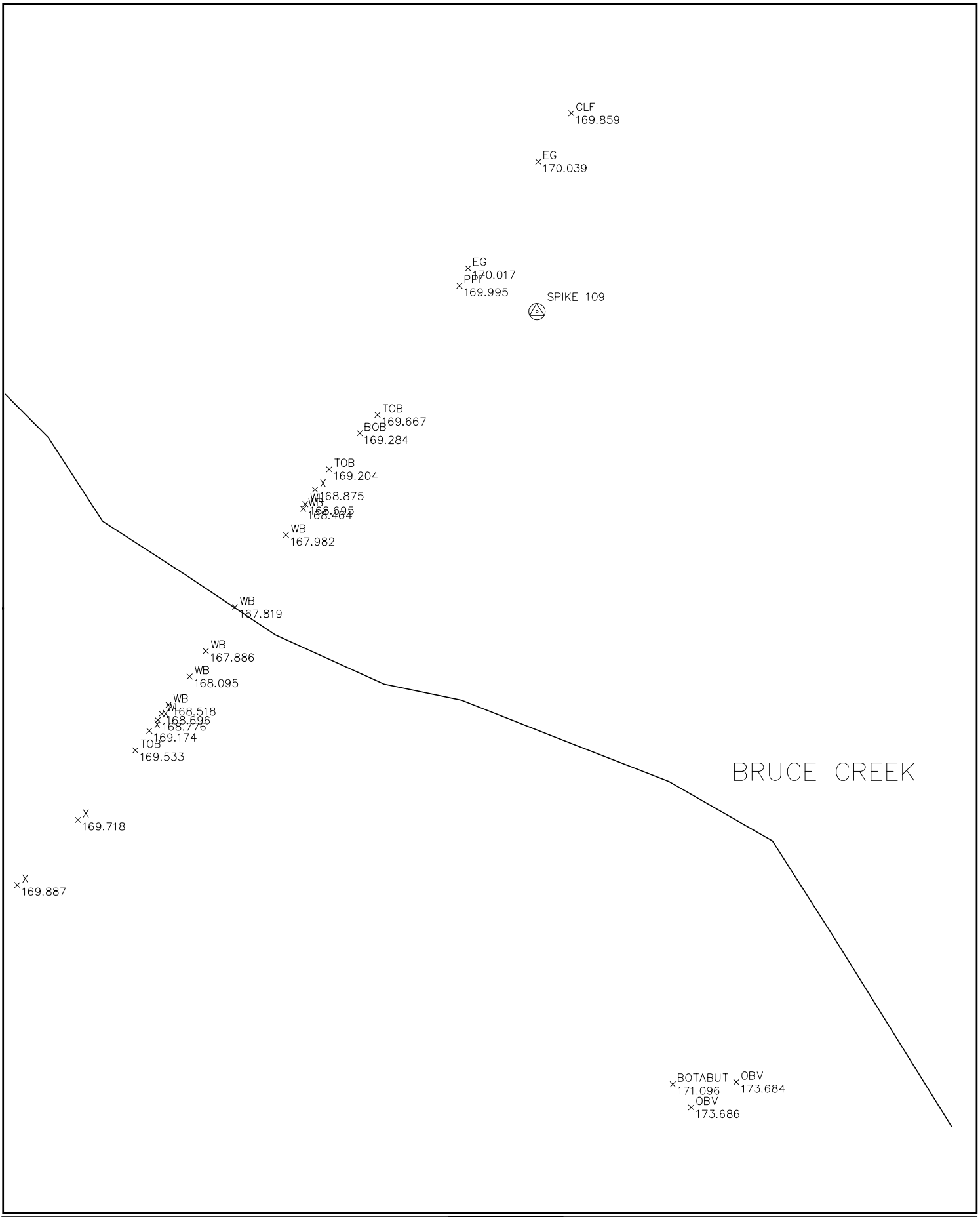

FIGURE A1.i
TRCA CHANNEL CROSS-SECTION SURVEY DATA

CHANNEL SURVEY LOCATION 10

N

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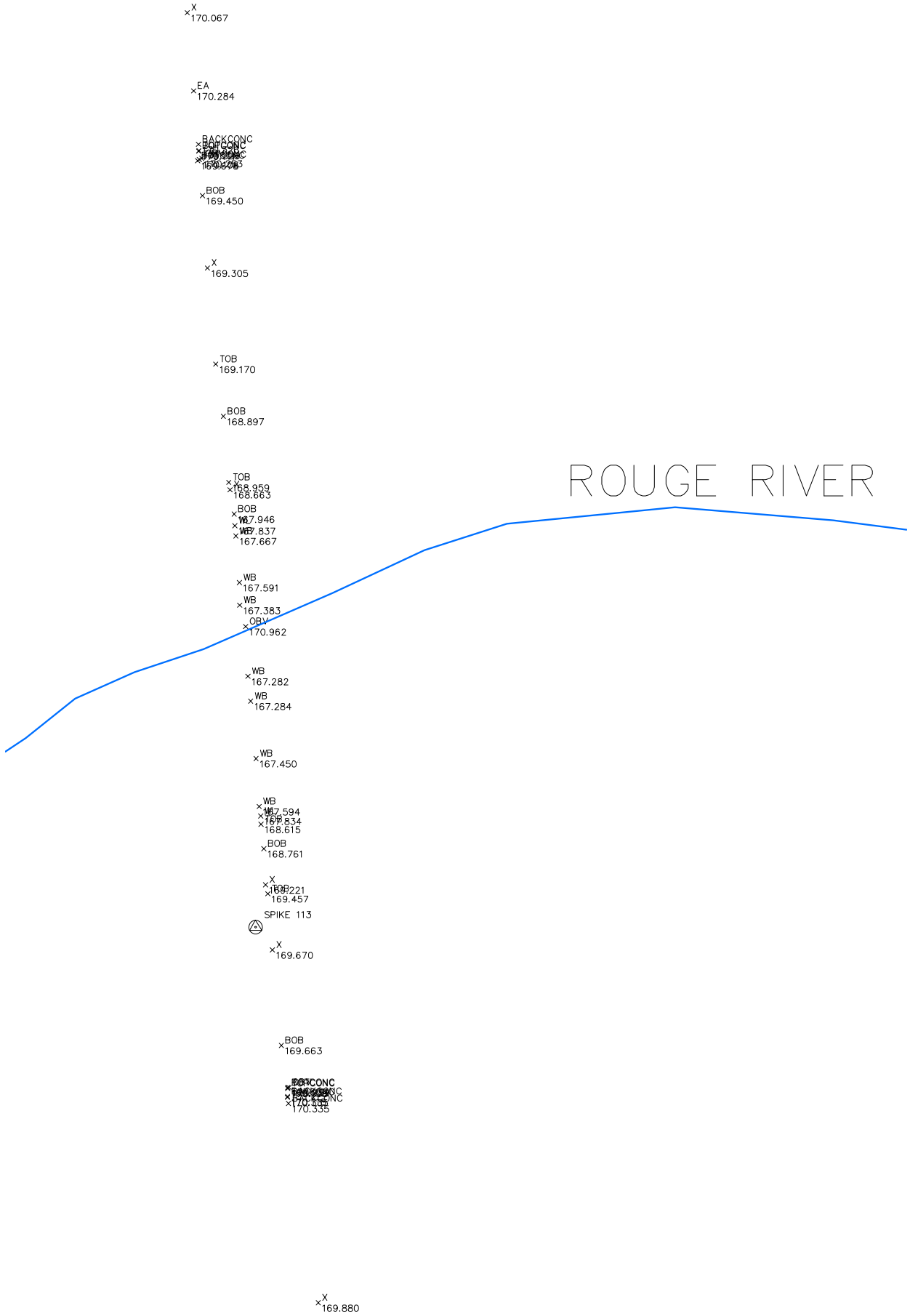

FIGURE A1.j
TRCA CHANNEL CROSS-SECTION SURVEY DATA

CHANNEL SURVEY LOCATION 11

N

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TORONTO AND REGION CONSERVATION AUTHORITY

UNIONVILLE SPA 2D MODELLING STUDY
AND FLOODPLAIN MAPPING UPDATE

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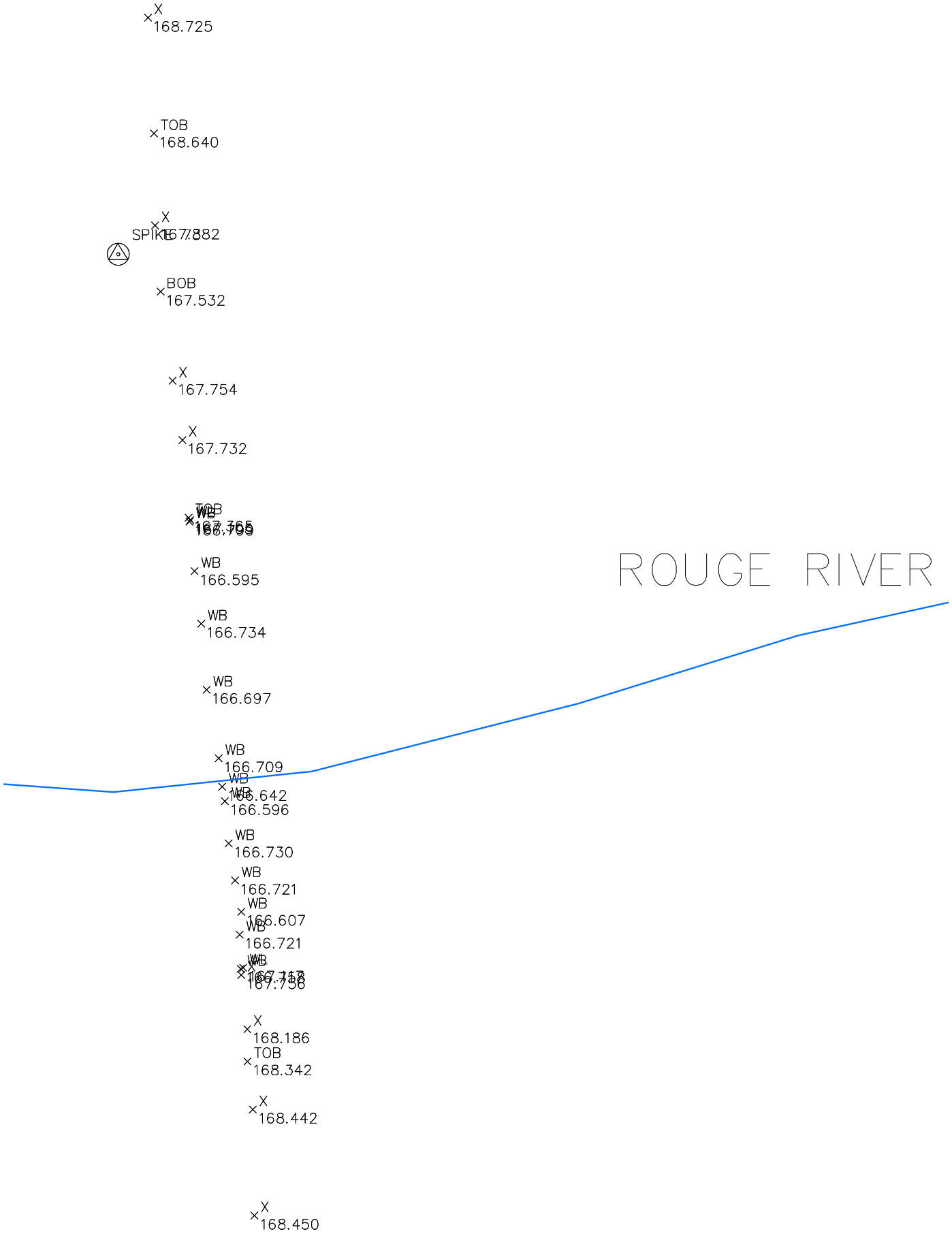

FIGURE A1.k
TRCA CHANNEL CROSS-SECTION SURVEY DATA

CHANNEL SURVEY LOCATION 12

N

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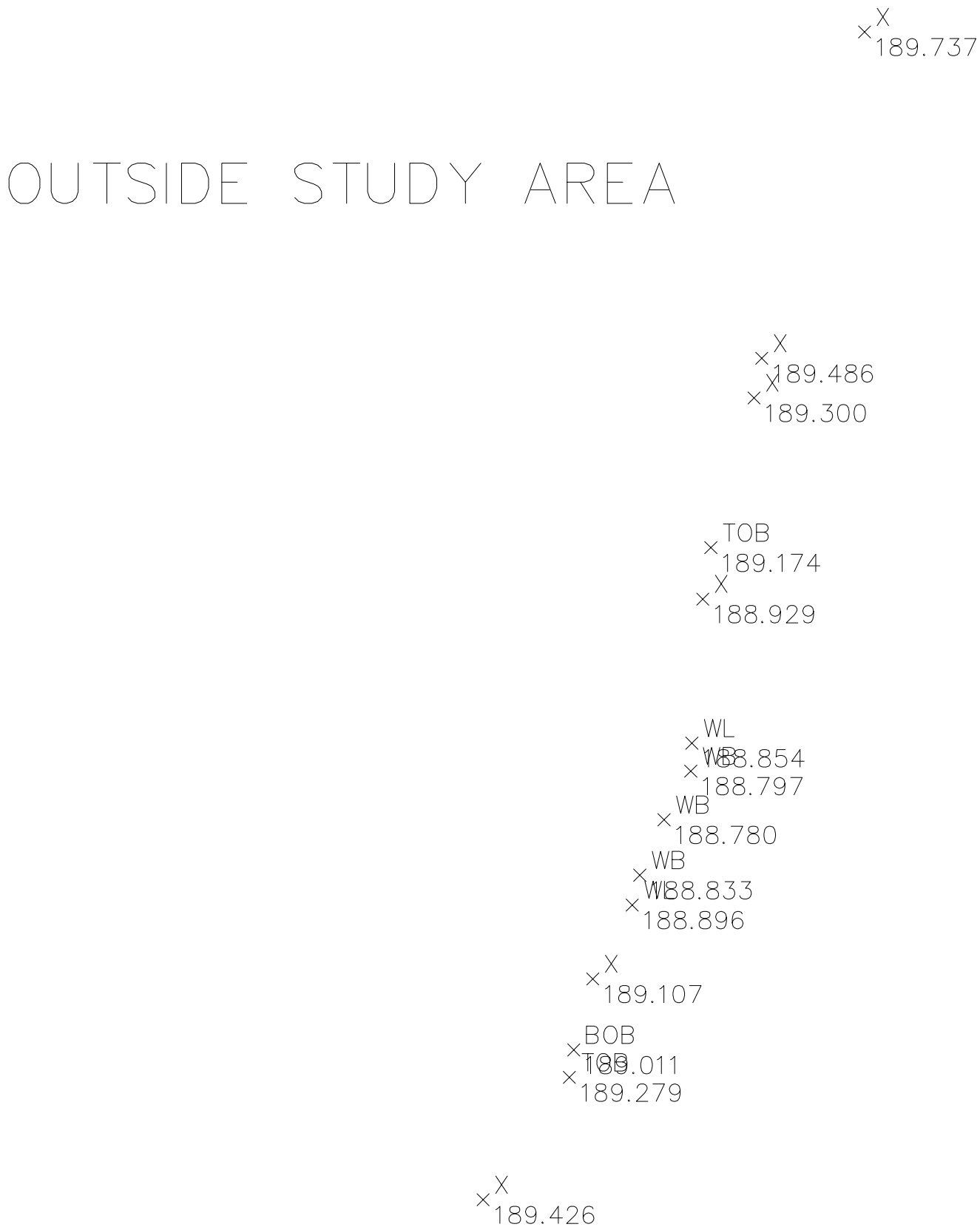

FIGURE A1.I
TRCA CHANNEL CROSS-SECTION SURVEY DATA

CHANNEL SURVEY LOCATION 13

N

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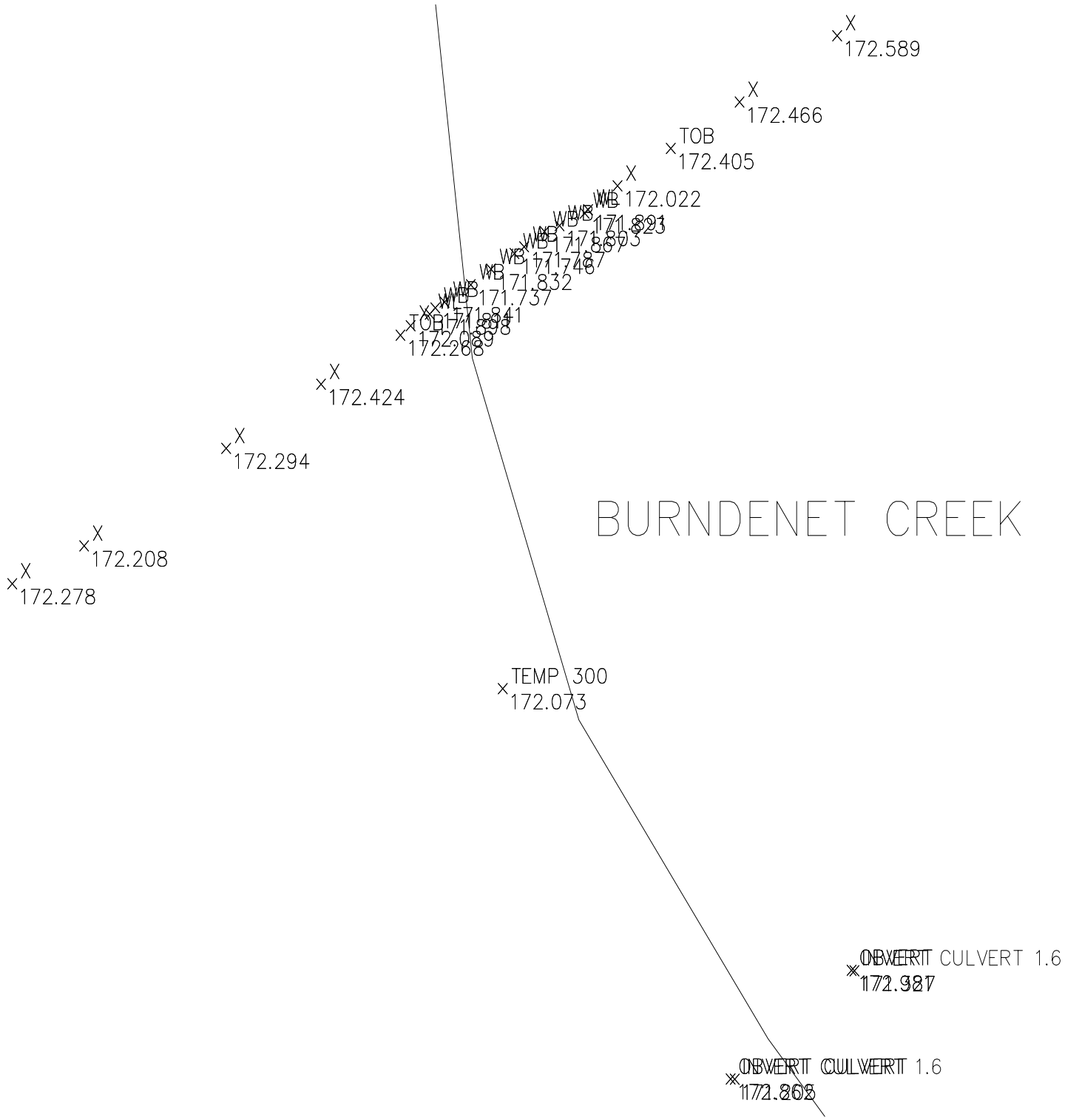

FIGURE A1.m
TRCA CHANNEL CROSS-SECTION SURVEY DATA

CHANNEL SURVEY LOCATION 14

N

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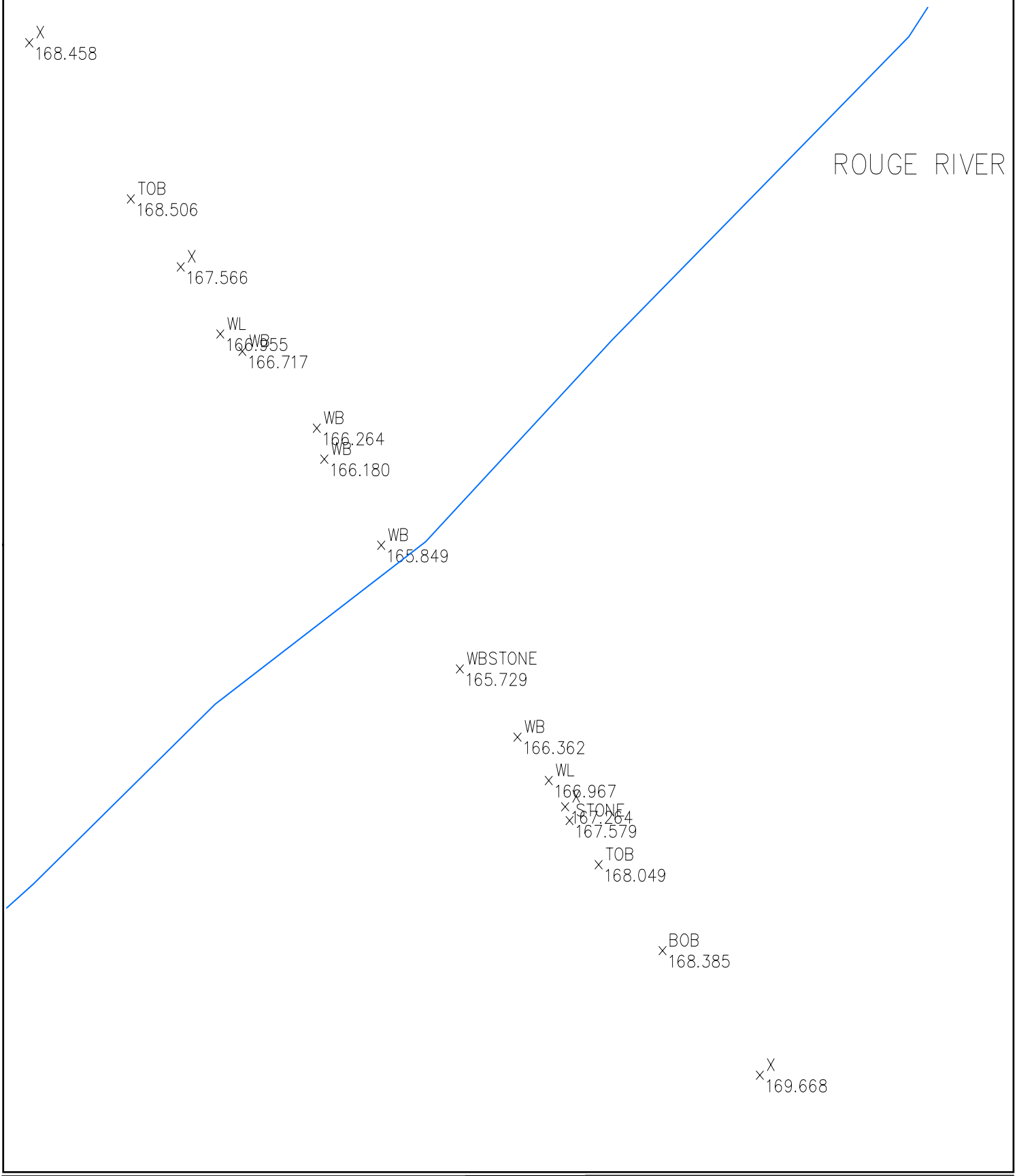

FIGURE A1.n
TRCA CHANNEL CROSS-SECTION SURVEY DATA

CHANNEL SURVEY LOCATION 15

N

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FIGURE A1.o
TRCA CHANNEL CROSS-SECTION SURVEY DATA

CHANNEL SURVEY LOCATION 16

N

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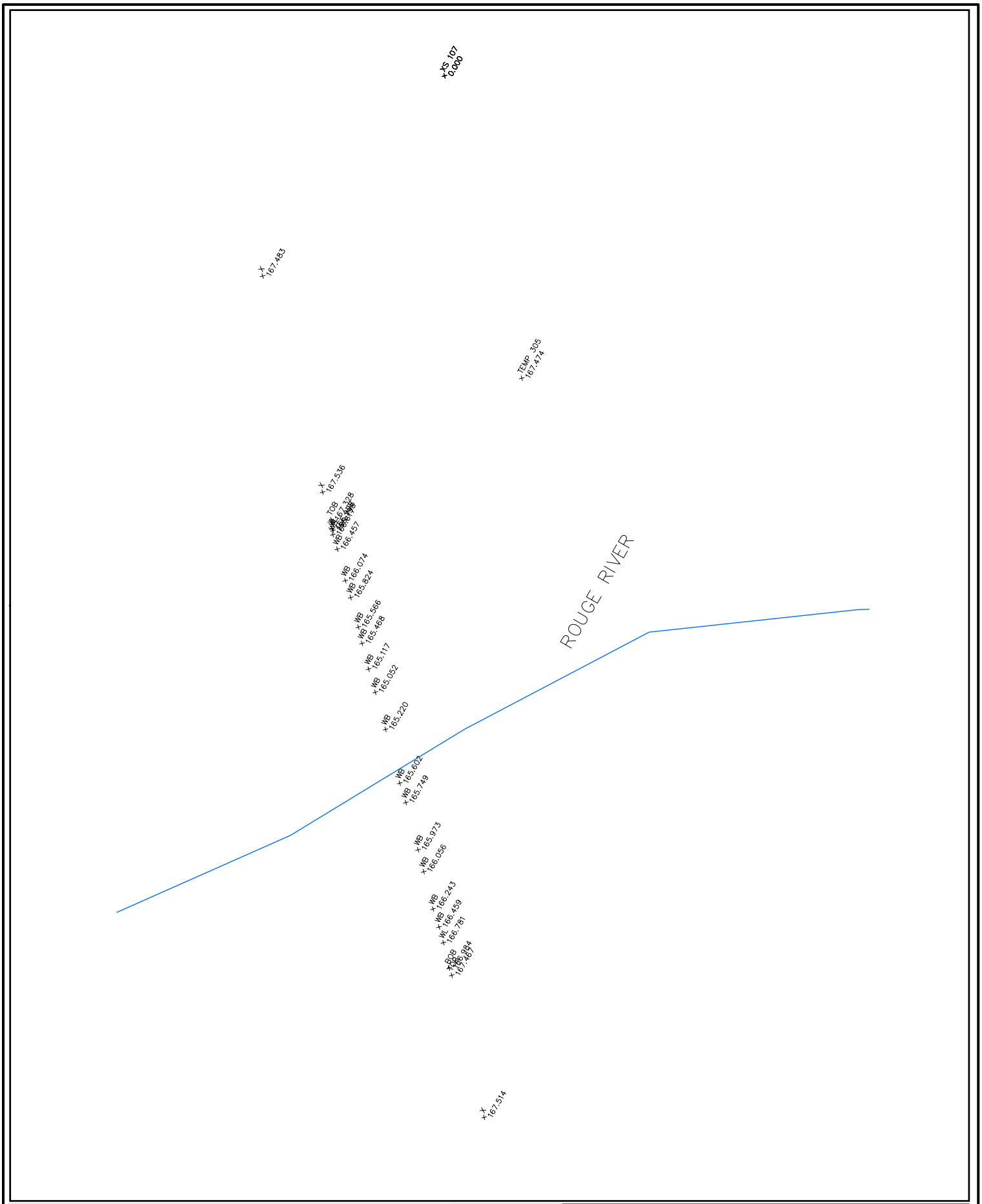

FIGURE A1.p
TRCA CHANNEL CROSS-SECTION SURVEY DATA

CHANNEL SURVEY LOCATION 17

18 December 2018

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FIGURE A1.q
TRCA CHANNEL CROSS-SECTION SURVEY DATA

CHANNEL SURVEY LOCATION 18

N

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FIGURE A1.r
TRCA CHANNEL CROSS-SECTION SURVEY DATA

CHANNEL SURVEY LOCATION 19

N

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FIGURE A1.s
TRCA LIDAR SURVEY DATA

TOO GOOD POND LIDAR SURVEY

N

18 December 2018

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UNIONVILLE SPA 2D MODELLING STUDY
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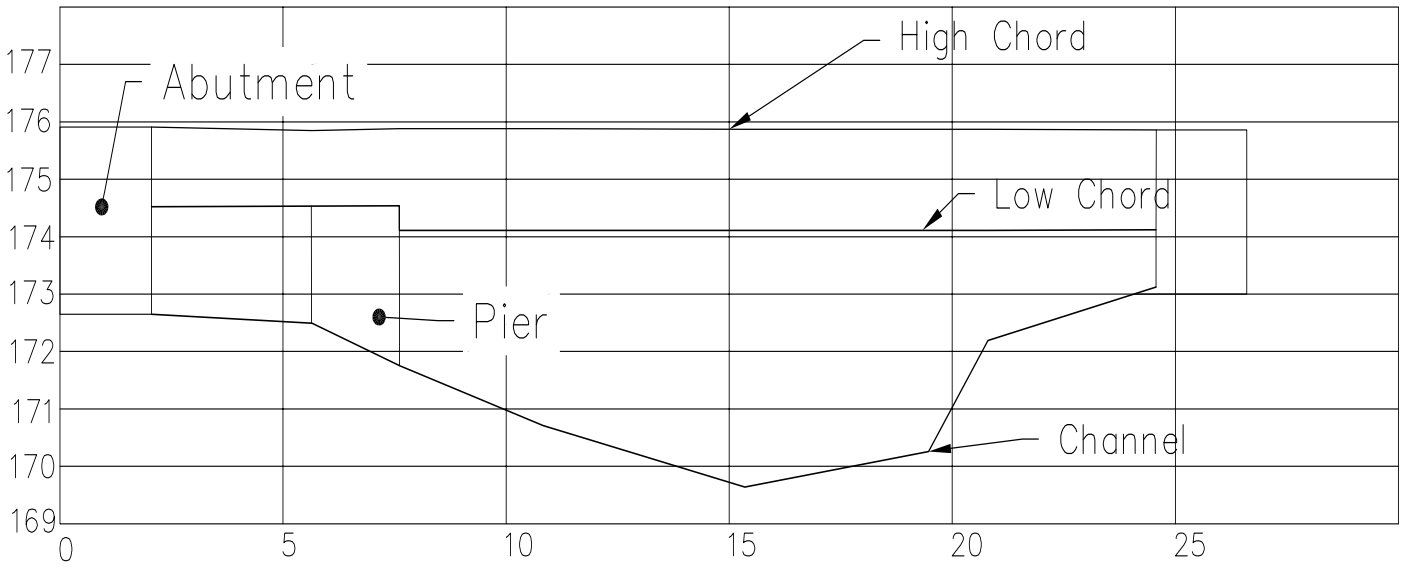

Figure A.1t
S8 - Rouge at CNR and HWY 7 U/S Face

Survey Location A

Scale: N.T.S

TORONTO AND REGION CONSERVATION AUTHORITY

UNIONVILLE SPA 2D MODELLING STUDY AND FLOODPLAIN MAPPING UPDATE

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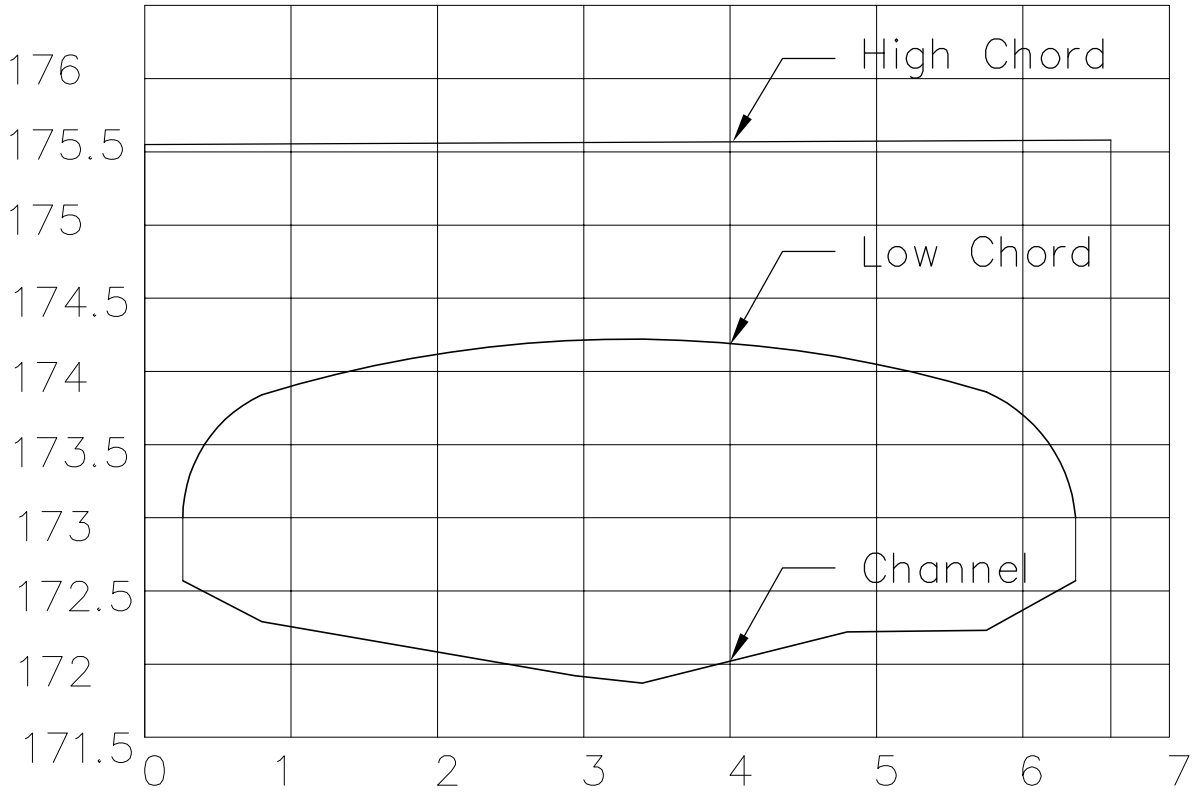

Figure A.1u
S13 - Trib. 5 U/S of Unionville Gate

Survey Location B

Scale: N.T.S

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UNIONVILLE SPA 2D MODELLING STUDY
AND FLOODPLAIN MAPPING UPDATE

Toronto and Region Conservation Authority

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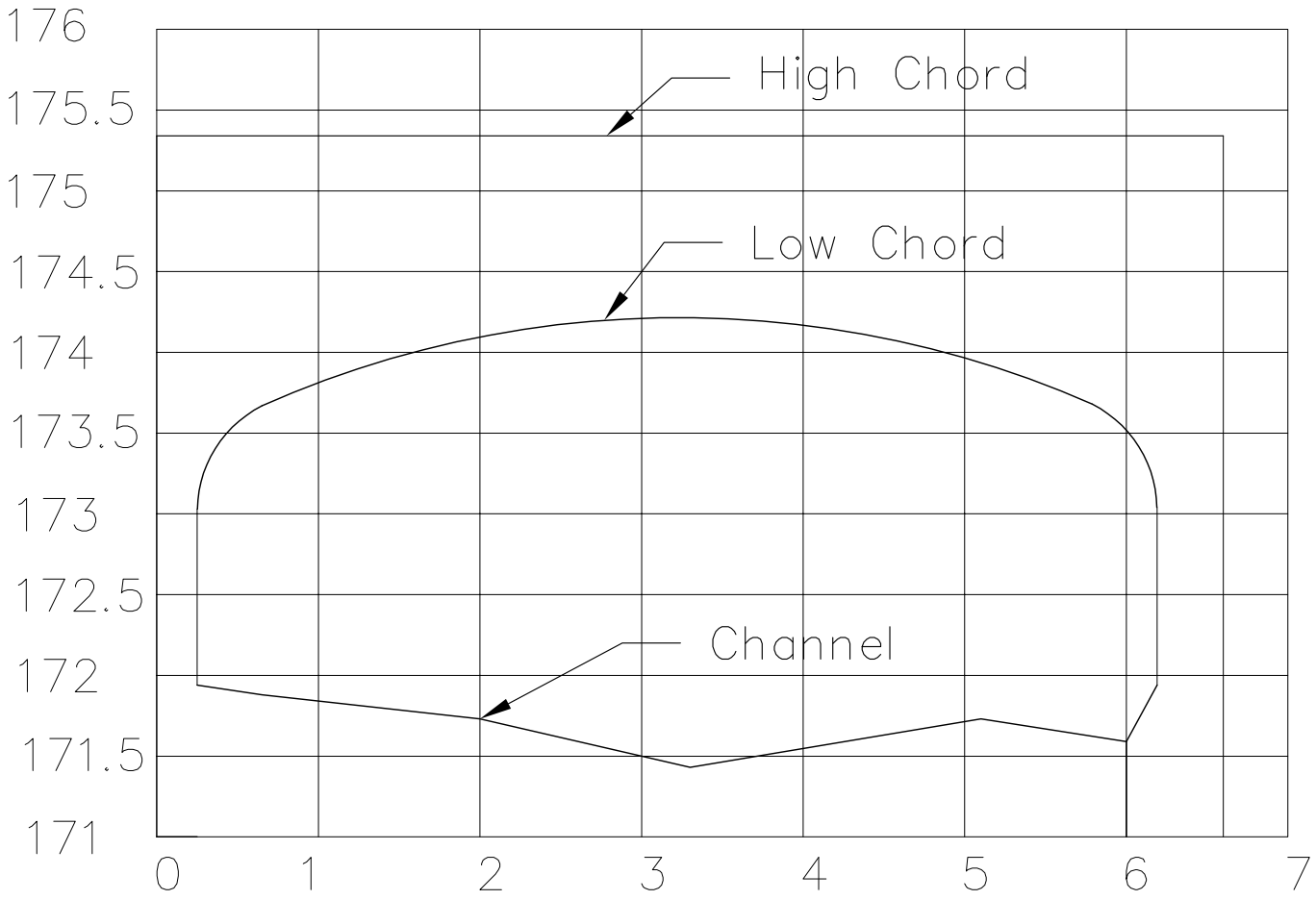

Figure A.1v
S14 - Trib. 5 Immediately U/S of Unionville Gate
Survey Location C

Scale: N.T.S

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UNIONVILLE SPA 2D MODELLING STUDY
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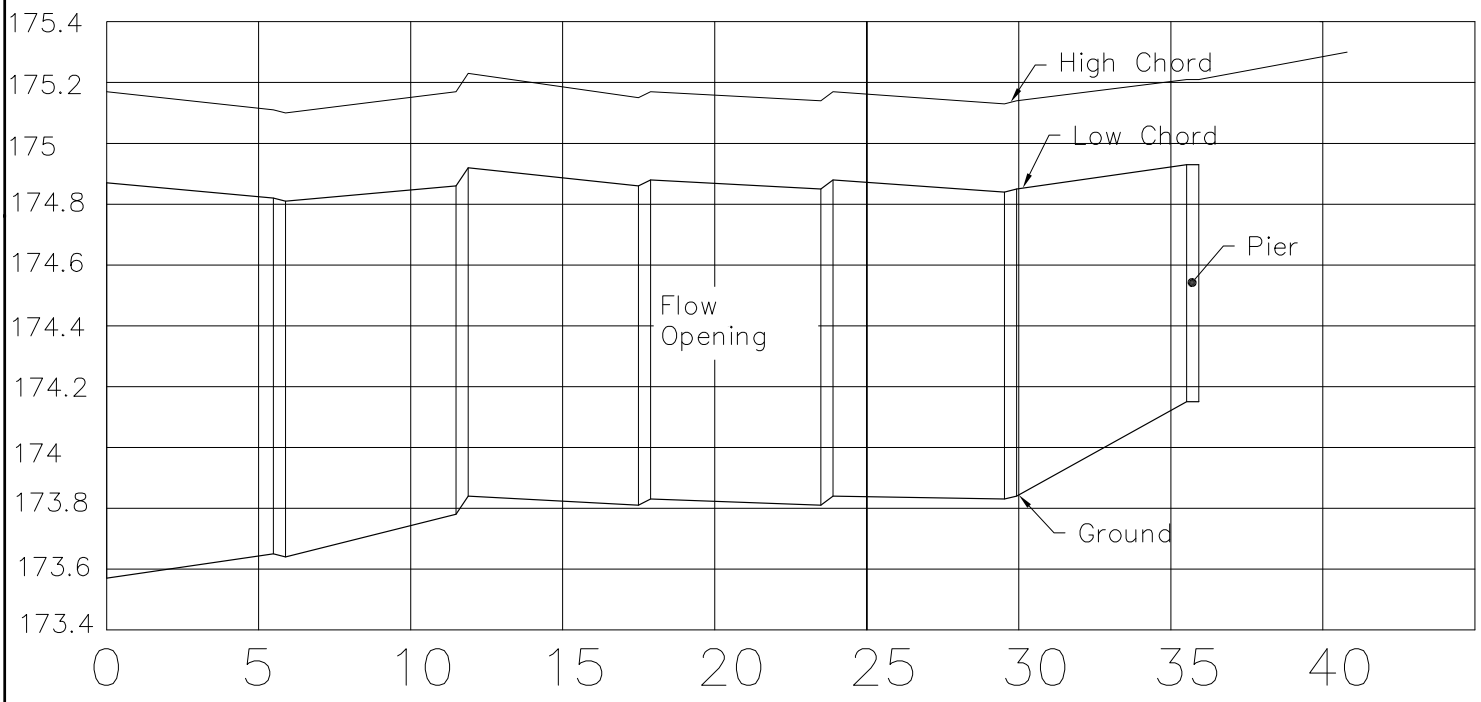

Figure A.1w
S31 - Too Good Pond Dam U/S Face, Right Side
Survey Location D

Scale: N.T.S

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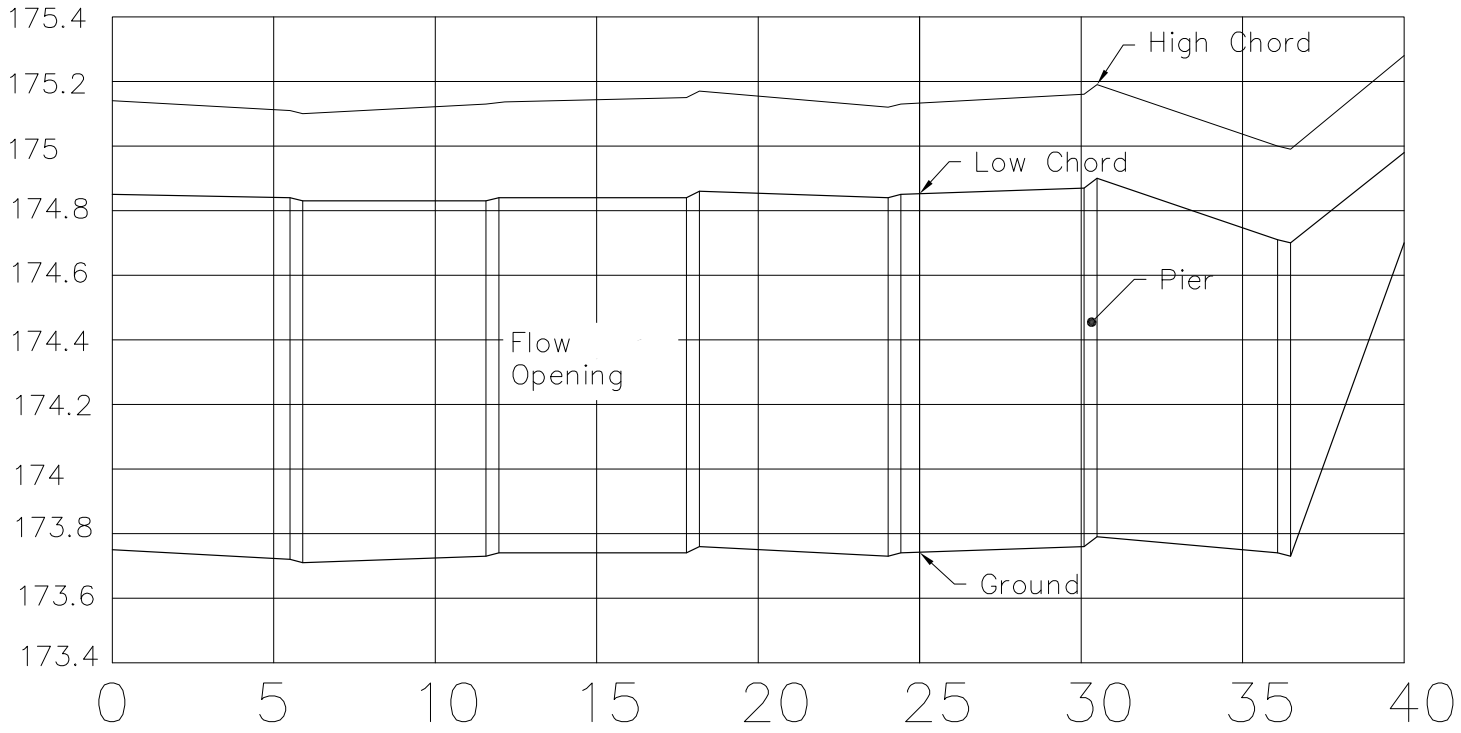

Figure A.1x

S31 - Too Good Pond Dam U/S Face, Left Side

Survey Location D

Scale: N.T.S

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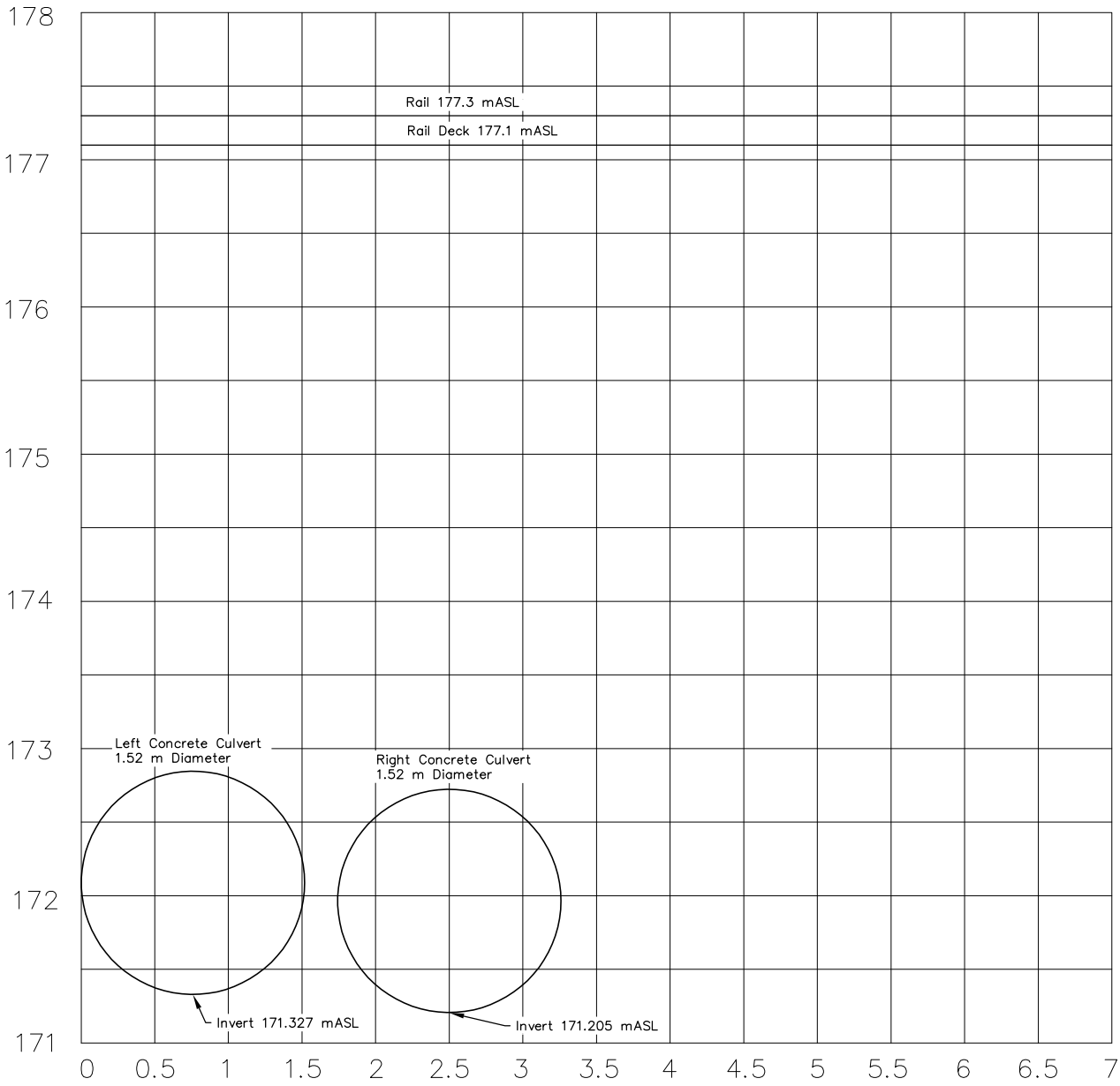

Figure A.1y
S44 - Burndenet Creek at C.N.R U/S Face
Survey Location E

Scale: N.T.S

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UNIONVILLE SPA 2D MODELLING STUDY
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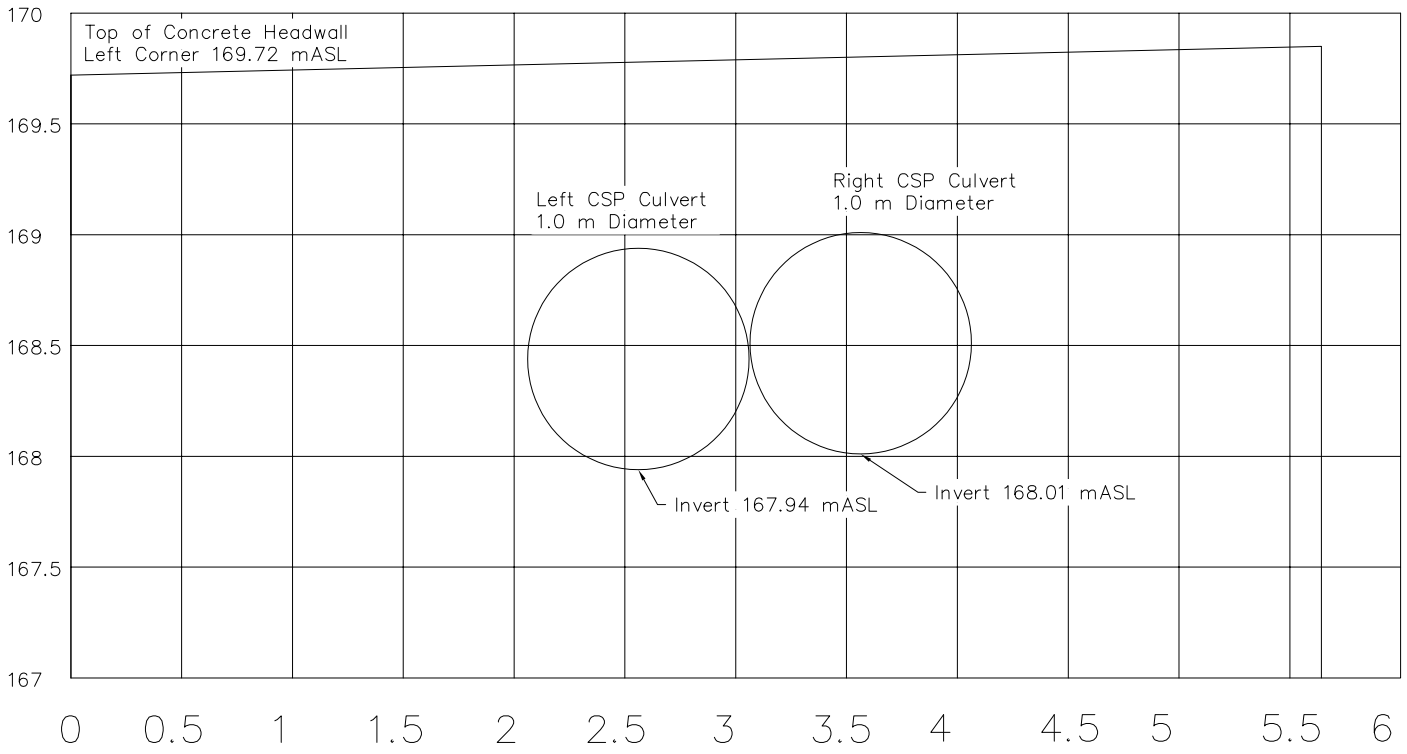

Figure A.1z
S52 - South Unionville Pond Trib. and Campbell Ct.

Survey Location F

Scale: N.T.S

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UNIONVILLE SPA 2D MODELLING STUDY
AND FLOODPLAIN MAPPING UPDATE

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VALDOR

Valdor Engineering Inc.
File:18123
Date: August 2018

Legend:

	Structure included in MIKE FLOOD Model
	Structure excluded from MIKE FLOOD Model

Table A.1 - Available Structures in Modelled Area

Struct. ID	As-Built Folder-ID	Locations (Reach, Road Names)	Type of Structure	Source of Data				Recommended Data Source /Remarks	Reason for Exclusion from Model
				TRCA Survey	As-Built	HEC-RAS	Notes in HEC-RAS Model		
S1		Rouge at Warden	Concrete Bridge			6320.095	Information supplied by TRCA, Survey, Sept., 18, 2001	HEC-RAS	
S2		Rouge at Verdale Crossing	Concrete Bridge	Available	Available			TRCA survey	
S3	B048	Rouge at Birchmount	Concrete Bridge	Partial information available	Only SWM plan is Illegible			TRCA survey, but no information on north abutment. Valdor field measurements required for location of abutments and pier, and pier width	
S4	C106	Trib. 4 at Enterprise	Triple Arch Culvert		Available			As-built	
S5		Rouge at downstream confluence with West Trib.	No Access; structure is on a private property					Modeling not required	Within wide floodplain, not hydraulically significant. Based on review parcel fabric and TRCA ownership mapping, it appears that the structure is privately owned and may have been constructed without a permit. TRCA may want to investigate further the legality of the structure and whether it should be removed.
S6		Rouge between C.N.R. and downstream confluence with West Trib.	No Access; structure is on a private property					Modeling not required	Within wide floodplain, not hydraulically significant. Based on review parcel fabric and TRCA ownership mapping, it appears that the structure is privately owned and may have been constructed without a permit. TRCA may want to investigate further the legality of the structure and whether it should be removed.
S7		Driveway Crossing upstream of CNR at HWY 7	U/S Side of Railway Crossing Bridge		NA	6319.107	Crossing and Ground Information from HEC-2	Modeling not required.This structure does not Exist (confirmed at field)	Structure has been removed

Struct. ID	As-Built Folder-ID	Locations (Reach, Road Names)	Type of Structure	Source of Data				Recommended Data Source /Remarks	Reason for Exclusion from Model
				TRCA Survey	As-Built	HEC-RAS	Notes in HEC-RAS Model		
S8		Rouge at C.N.R. at HWY. 7	Railway Crossing	No survey	SWM plan only (Illegible)	6319.095	CNR. Opening information from TRCA field measurements	Surveyed By Valdor Field Staff	
S9	B038	Rouge at Main St. Unionville, south of HWY. 7	Concrete Bridge		Available	6319.015	Crossing information supplied by TRCA from survey completed on Sept. 18, 2001	As-built, use inverts from HEC-RAS	
S9A		Trib. 5 Immediately U.S of HWY 407	Twin Circular CSP Culvert						
S9B		Trib. 5 Parking lot culvert	Twin Circular CSP Culvert						
S9C		Trib. 5 Under YMCA Blvd.	Twin Circular CSP Culvert						
S10		Trib. 5 at Rivis Road and YMCA Blvd.	Twin Circular CSP culvert		Available			Available, PAN AM Centre Hydraulic Study Fig (TRCA)	
S11		Trib. 5 at Main St. Unionville south of Enterprise (South end)	CSP Arch Culvert		Available			Available, PAN AM Centre Hydraulic Study Fig (TRCA)	
S12		Trib. 5 at Main St. Unionville, upstream of Unionville Gate	CSP Arch Culvert		Available			Available, PAN AM Centre Hydraulic Study Fig (TRCA)	
S13		Trib. 5 upstream of Unionville Gate between Kennedy & Main St. Unionville	Concrete Bridge		Empty Folder			Surveyed By Valdor Field Staff	
S14		Trib. 5 immediately upstream of Unionville Gate, between Main St. Unionville & Kennedy Rd.	Concrete Bridge		Empty Folder			Surveyed By Valdor Field Staff	
S15	B038	Trib. 5 at Unionville Gate	Conc. Box Culvert		Available			As-built	

Struct. ID	As-Built Folder-ID	Locations (Reach, Road Names)	Type of Structure	Source of Data				Recommended Data Source /Remarks	Reason for Exclusion from Model
				TRCA Survey	As-Built	HEC-RAS	Notes in HEC-RAS Model		
S15-A		Pedestrian Walkway off Main St. Unionville, north of Unionville Gate	Steel Pedestrian Bridge with Wooden Deck, Open Railing					Modeling not Required	Within wide floodplain, not hydraulically significant
S16		Rouge and Highway 7, east of Main St. Unionville	Concrete Bridge		NA (Water main only)	6316.105	Opening info from HEC-2 file. Road profile from topo. Opening verified by TRCA field survey	Extract Info from available water main drawings	
S17		Rouge at Eckardt Ave. Pedestrian Extension	Steel Pedestrian Bridge with Wooden Deck, Open Railing					Modeling not Required	Within wide floodplain, not hydraulically significant
S18	C068	Fonthill Reach at Rycroft Boulevard	Concrete Bridge		Available	7317.285	Source: Original HEC2 data, Sep. 2003. Top of Road From actual topography.	As-built	
S19	C037	Fonthill Reach at Fonthill Boulevard	Concrete Bridge		Available	7317.215	Source: TOWN OF MARKHAM DESIGN DRAWING August 1996	As-built	
S20	C036	Fonthill Reach and Fred Varley Road	Concrete Bridge		Available	7317.165	Source: TOWN OF MARKHAM DESIGN DRAWING	As-built	
S21	C042	Fonthill Reach and Main St. Unionville	Concrete Box Culv.	Available	Grading/ Servicing dwg only	7317.115	Source: Original HEC2 data Sep. 2003 Top of Road From actual topography	TRCA survey	
S22		Fonthill Reach at Private Crossing	Concrete Box Culv.		NA	7317.095	Source: Original HEC2 data Sep. 2003	HEC-RAS	
S23		Fonthill Reach at Victoria Avenue	Concrete Box Culvert	Available	NA (Grading/Servicing dwg only)	7317.075	Source: Original HEC2 data Sep. 2003	TRCA survey. Measure length of culvert	
S24		Fonthill Reach at C.N.R.	Railway Crossing (Concrete Box Culvert)		NA (Empty Folder)	7200.02	Original HEC 2 Model Top of Road from topo., 2003 Oct. 2003	HEC-RAS (HEC-Xsec combined with S37 on Bruce), confirm HEC-RAS structure dimensions	
S25		Bruce Creek downstream of 16th Avenue	Steel Pedestrian Bridge with Wooden Deck					Modeling not Required	Within wide floodplain, outside of study area, not hydraulically significant

Struct. ID	As-Built Folder-ID	Locations (Reach, Road Names)	Type of Structure	Source of Data				Recommended Data Source /Remarks	Reason for Exclusion from Model
				TRCA Survey	As-Built	HEC-RAS	Notes in HEC-RAS Model		
S26		Bruce Creek between Normandale Road and Milestone Court	Steel Pedestrian Bridge with Wooden Deck, Open Railing					Modeling not Required	Within wide floodplain, outside of study area, not hydraulically significant
S27		Bruce Creek at Sidewalk Extension off southside Normandale Rd.	Steel Pedestrian Bridge with Wooden Deck, Open Railing					Modeling not Required	Within wide floodplain, outside of study area, not hydraulically significant
S28		Bruce Creek north of Pennock Cres. immediately upstream of confluence	Steel Pedestrian Bridge with Wooden Deck, Open Railing					Modeling not Required	Within wide floodplain, outside of study area, not hydraulically significant
S29		Bruce Creek Trib. east of Ritter Cres.	Steel Pedestrian Bridge with Wooden Deck, Open Railing					Modeling not Required	Within wide floodplain, outside of study area, not hydraulically significant
S30		Bruce immediately upstream of Too Good Pond	Wooden Pedestrian Bridge					Modeling not Required	Within wide floodplain, not hydraulically significant
S31		Bruce immediately downstream of Too Good Pond	Dam		Only Civil dwg, No Structure dwg	NA		Surveyed By Valdor Field Staff	
S32	B029	Bruce at Main St. Unionville	Concrete Bridge		Servicing/Grading dwg only	7200.165	Main St. Unionville	HEC-RAS	
S33		Bruce at Park Structure, upstream of Carlton Road, downstream of Main St. Unionville	Steel Pedestrian Bridge with Wooden Deck					Modeling not Required	Within wide floodplain, not hydraulically significant
S34	B034	Bruce at Carlton Road	Concrete Bridge		Grading, SWM dwg only, no structures	7200.115	Carlton Road	HEC-RAS	
S35		Bruce at Pedestrian Bridge upstream of Victoria Avenue	Steel Pedestrian Bridge with Wooden Deck, Open Railing					Modeling not Required	Within wide floodplain, not hydraulically significant
S36	P043	Bruce Creek at Victoria Avenue	Pedestrian Bridge		Available	7200.065	Victoria Avenue	Modeling not Required	Within wide floodplain, not hydraulically significant
S37		Bruce at C.N.R.	Railway Crossing	Limited (5 Points)	NA (Illegible)	7200.02*		HEC-RAS (HEC-Xsec combined with S24), confirm HEC-RAS structure dimensions	

Struct. ID	As-Built Folder-ID	Locations (Reach, Road Names)	Type of Structure	Source of Data				Recommended Data Source /Remarks	Reason for Exclusion from Model
				TRCA Survey	As-Built	HEC-RAS	Notes in HEC-RAS Model		
S38	P035	Rouge at immediately upstream of Kennedy Road	Pedestrian Bridge	Limited data	NA (SSG Only)	NA		Modeling not Required	Within wide floodplain, not hydraulically significant
S39		Rouge at Kennedy Road	Concrete Bridge		Limited structural info. Mostly servicing.	6315.105	Opening coded using design info and verified from field measurements by TRCA (GF).	HEC-RAS	
S40		Rouge at Pedestrian Structure downstream of Kennedy road	Steel Pedestrian Bridge with Wooden Deck, Open Railing					Modeling not Required	Within wide floodplain, not hydraulically significant
S41		Rouge east of Second Street and north of Hwy 7	No Access; structure is on private property behind a house					Modeling not Required	Within wide floodplain, not hydraulically significant. Based on review parcel fabric and TRCA ownership mapping, it appears that the structure is privately owned and may have been constructed without a permit. TRCA may want to investigate further the legality of the structure and whether it should be removed.
S42		Burndenett Creek west of Burndenford Cres.	Steel Pedestrian Bridge with Wooden Deck, Open Railing					Modeling not Required	Outside of the study area. No significant impact on the study area result
S43	C019	Burndenett Creek at Raymerville Dr.	Concrete Box Culvert		Available	NA		As-built	
S44		Burndenett Creek at C.N.R.	Twin Circular Concrete Culverts	obvert, invert info only	Folder not found	NA		Surveyed By Valdor Field Staff	
S45	C018	Burndenett Creek at Austin Drive	CSP Arch Cuvlert		Available	NA		As-built	
S46		Burndenett Creek at Waldon Pond	Steel Pedestrian Bridge with Wooden Deck, Open Railing					Modeling not Required	Within wide floodplain, not hydraulically significant
S47	P010	Rouge at HWY 7, downstream of Waldon Pond	Concrete Bridge		NA (Water main)	6313.165	Crossing information from TRCA field measurements (GF). Outside opening, top of road from new topographic mapping.	HEC-RAS	

Struct. ID	As-Built Folder-ID	Locations (Reach, Road Names)	Type of Structure	Source of Data				Recommended Data Source /Remarks	Reason for Exclusion from Model
				TRCA Survey	As-Built	HEC-RAS	Notes in HEC-RAS Model		
S48		Rouge immediately north of River bend road east end	Steel Pedestrian Bridge					Modeling not Required	Within wide floodplain, not hydraulically significant
S49		Rouge south of Mcowan and HWY 7 Commercial Plazas	Steel Pedestrian Bridge					Modeling not Required	Within wide floodplain, not hydraulically significant
S50		South Unionville Pond Trib. at upstream of Piera Gardens Rd.	Steel Pedestrian Bridge with Wooden Deck, Open Railing					Modeling not Required	Located within a SWM pond storage area
S51	C238	South Unionville Pond Trib. at Piera Gardens Rd.	SWM Pond Outlet Structure		SWM Pond desgn- Q vs H available	NA		Use available Q.vs.H. Valdor will verify structure at field to match SWM Pond Outlet Design	
S52		Driveway off South Unionville Pond Trib. at Campbell CT. Sidewalk (Private Driveway)	Twin Circular CSP Culvert		NA	NA		Surveyed By Valdor Field Staff	
S53		South Unionville Pond Trib. at Sidewalk upstream of Piera Gardens Rd.	Steel Pedestrian Bridge					Modeling not Required. New bridge replaces old csp culvert	Within wide floodplain, not hydraulically significant
S54		Rouge immediately downstream of confluence with South Unionville Pond Tributary	Steel Pedestrian Bridge					Modeling not Required	Within wide floodplain, not hydraulically significant
S55		Rouge at Mcowan at South Unionville Road	Concrete Bridge		Water main , illegible, insufficient	6312.19	Crossing information from: The Regional Municipality of York Engineering.	HEC-RAS	
S56	C066	Milne Reach at Drakefield Road	Concrete Pipe Culvert		Half of Culvert info missing	NA		As-built for half length of culvert is available; use constant slope and size for the other half	
S57		Milne Dam	Dam		NA	NA		Rating Curve Q.vs.H Available	

Table A.2 Hydraulic Structure Details

ID	Location	Opening Width (m)	Opening Depth (m)	Bridge/ Culvert Length Along Channel (m)	U/S Invert (m)	D/S Invert (m)	Type of Structure	Remarks
S1	Rouge at Warden	13.3	3.1	40	173.4	173.3	Concrete Bridge	HEC-RAS (Surveyed by TRCA) Length by Valdor
S2	Rouge at Verdale Crossing	68.5	4.71	23.80	172.12	172.1	Concrete Bridge	As-Build (verified by field measurements)
S3	Rouge at Birchmount	78.34	5.57	27.81	171.83	171.81	Concrete Bridge	Valdor Survey + TRCA Survey
S4	Trib. 4 at Enterprise	L = 4.65 Mid = 10.8 R = 4.7	L = 2.5 Mid = 3.82 R= 2.38	37.39	174.873	174.888	Triple Arch Culvert	Valdor Survey and As-Build (depth taken from field survey, width from as-build)
S8	Rouge at C.N.R. at HWY. 7	L = 3.6 R = 16.95	4.37	4.78	169.74	169.73	Railway Crossing	Valdor Survey
S9	Rouge at Main St. Unionville, south of HWY. 7	16.8	4.11	20.20	168.83	168.85	Concrete Bridge	HEC-RAS (Verified by Valdor field measurements)
S9A	Trib. 5 Immediately U.S of HWY 407	L = 1.75 R = 1.75	1.25	20.02	176.99	176.86	Twin Circular CSP Culvert	Varies from HEC-RAS (1.2 m dia. Circular CMP)
S9B	Trib. 5 Parking lot culvert	L = 1.5 R = 1.5	1.5	12.02	175.95	175.79	Twin Circular CSP Culvert	HEC RAS
S9C	Trib. 5 Under YMCA Blvd.	L = 1.5 R = 1.5	1.5	41.88	175.59	175.42	Twin Circular CSP Culvert	HEC RAS
S10	Trib. 5 at Rivis Road and YMCA Blvd.	L = 1.2 R = 1.2	1.2	40.00	174.84	174.741	Twin Circular CSP Culvert	As Build (verified by field measurements)
S11	Trib. 5 at Main St. Unionville south of Enterprise (South end)	2.16	1.52	18.00	173.75	173.7	CSP Arch Culvert	Valdor Field Measurements
S12	Trib. 5 at Main St. Unionville, upstream of Unionville Gate	2.16	1.52	71.00	173.15	172.95	CSP Arch Culvert	As Build (modified according to Valdor Field measurements)
S13	Trib. 5 upstream of Unionville Gate between Kennedy & Main St. Unionville	6.1	2.35	13.66	172.2	172.1	Concrete Bridge	Valdor Survey

ID	Location	Opening Width (m)	Opening Depth (m)	Bridge/ Culvert Length Along Channel (m)	U/S Invert (m)	D/S Invert (m)	Type of Structure	Remarks
S14	Trib. 5 immediately upstream of Unionville Gate, between Main St. Unionville & Kennedy Rd.	5.94	2.79	16.00	171.742	171.741	Concrete Bridge	Valdor Survey
S15	Trib. 5 at Unionville Gate	2	1.8	38.37	171.741	171.2	Conc. Box Culvert	As Build (verified by field measurements)
S16	Rouge and Highway 7, east of Main St. Unionville	18.5	4.72	25.94	168.35	168.29	Concrete Bridge	Valdor Survey + HEC-RAS
S18	Fonthill Reach at Rycroft Boulevard	6.28	2.09	35.00	171.87	171.81	Concrete Bridge	As-Build, HEC-RAS, LiDAR and Valdor Survey
S19	Fonthill Reach at Fonthill Boulevard	8.5	2.13	30.00	170.77	170.71	Concrete Bridge	HEC-RAS + Valdor Survey
S20	Fonthill Reach and Fred Varley Drive	9.775	2.44	28.87	170.651	170.564	Concrete Bridge	As Build (verified by field measurements)
S21	Fonthill Reach and Main St. Unionville	2.135	1.5	16.72	170.48	170.49	Concrete Box Culv.	TRCA Survey
S22	Fonthill Reach at Private Crossing	3.35	1.98	3.30	170.46	170.4	Concrete Box Culv.	HEC-RAS + Valdor Survey
S23	Fonthill Reach at Victoria Avenue	2.33	1.194	9.52	169.99	169.95	Concrete Box Culvert	TRCA Survey
S24	Fonthill Reach at C.N.R.	2.4	2.38	13.70	170	169.91	Railway Crossing (Concrete Box Culvert)	HEC-RAS + Valdor Survey
S31	Bruce immediately downstream of Too Good Pond	23	2.5	5.3 (Main Dam) 1.75 (Spillway)	172.5	172.4	Dam	Valdor Survey + TRCA Info
S32	Bruce at Main St. Unionville	12.85	2.79	13.40	169.53	169.54	Concrete Bridge	HEC-RAS (Verified by Valdor field measurements)
S34	Bruce at Carlton Road	14	3.43	15.07	168.99	168.95	Concrete Bridge	HEC-RAS (Verified by Valdor field measurements)
S37	Bruce at C.N.R.	M = 17.65	5.76	4.04	167.997	167.699	Railway Crossing	HEC-RAS (Verified by Valdor field measurements)
S39	Rouge at Kennedy Road	28.96	4.31	18.4	167.36	167.33	Concrete Bridge	HEC-RAS (Verified by TRCA field measurements)

ID	Location	Opening Width (m)	Opening Depth (m)	Bridge/ Culvert Length Along Channel (m)	U/S Invert (m)	D/S Invert (m)	Type of Structure	Remarks
S43	Burndenet Creek at Raymerville Dr.	4.5	2.5	24.70	173.44	173.4	Conc. Box Culvert	As Build (Verified by field measurements)
S44	Burndenet Creek at C.N.R.	L = 1.52 R = 1.52	1.52	16.10	171.327	171.1	Twin Circular Conc. Culv	Valdor Survey (Detailed)
S45	Burndenet Creek at Austin Drive	3.4	2.01	36.00	169.95	169.81	CSP Arch Culvert	As Build (Verified by field measurements)
S47	Rouge at HWY 7, downstream of Waldon Pond	33	4.9	21.5	166.87	166.77	Concrete Bridge	HEC-RAS (Verified by TRCA field measurements)
S51	South Unionville Pond Trib. at Piera Gardens Rd.	L = 3 R = 3	1.8	55.00	168.59	168.59	SWM Pond Outlet Structure	As-Build and Valdor Survey
S52	Driveway off South Unionville Pond Trib. at Campbell CT. Sidewalk (Private Driveway)	L = 0.92 R = 0.92	1	6.03	168.37	168.32	Twin Circular CSP Culvert	Valdor Survey
S55	Rouge at Mcowan at South Unionville Road	24.42	4	18.80	165.2	165.26	Concrete Bridge	HEC-RAS (Except Width, which is taken from Valdor Field Measurements)
S56	Milne Reach at Drakefield Road	2.134	2.134	109.78	170.2	168.26	Concrete Pipe Culvert	Valdor Survey
S57	Milne Dam						Dam	Q vs H

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S1)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : October 16, 2018	Structure Type : Concrete Bridge		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staff	No. of Openings/Culverts: 1	Footing: Open Bottom with Abutments	Approx. Depth (m): 0.34 m
Watershed Name: Rouge	Materials: Concrete Structure to Support Road		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 3.1 m; Max. opening width along the structure face is 15.2 m. Perpendicular Width is 13.3 m		Upstream Erosion (Y/N): N
Tributary Name: Rouge River	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 69	Length: 40 m	Total bridge span: 13.3 m	Additional Flow Information:
Cross-section Range: 6320.09 to 6320.105	Road Deck: Varies from the lowest elevation of 177.53 m and the highest 177.85 m. Solid Railing Elevation between 178.74 and 178.42		Structure skew exists relative to river.
Municipality: City of Markham			
Location: Rouge River at Warden Avenue	Low chord/obvert: Elevation varies between 176.16 and 176.48		
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 173.4 m; d/s inv. of 173.3 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S2)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : October 16, 2018	Structure Type : Concrete Span Bridge		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 2	Footing: Open Bottom w. Conc. Pier	Approx. Depth (m): 0.3
Watershed Name: Rouge	Materials: Concrete		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 4.71 m; Max. opening width is 50.4 m		Upstream Erosion (Y/N): N
Tributary Name: Rouge River	Pier Dimension: 1 m Diameter		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 69	Length: 23.8 m	Total bridge span: 68.5 m	Additional Flow Information:
Cross-section Range: 6320.04 to 6320.03	Road Deck: Paved surface elevation varies between the highest 179.95 m to the lowest 179.11 m. Solid Railing Elevation between 180.92 to 179.87		
Municipality: City of Markham			
Location: Rouge River at Verdale Crossing	Low chord/obvert: Elevation varies between 176.83 m to 176.42 m		
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 172.12 m; d/s inv. of 172.1 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S3)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : October 16, 2018	Structure Type : Concrete Bridge, Paved Road		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 2	Footing: Open Bottom w. Conc. Pier	Approx. Depth (m): 0.35
Watershed Name: Rouge	Materials: Concrete		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 5.57 m; Max. opening width is 38.94 m		Upstream Erosion (Y/N): N
Tributary Name: Rouge River	Pier Dimension: 1 m Diameter		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 69	Length: 27.81 m	Total bridge span: 78.34 m	Additional Flow Information:
Cross-section Range: 6320.02 to 6320.00	Road Deck: Road surface elevation varies between the highest 179.73 m to the lowest 178.59 m. Top of Solid Railing Elevation 180.82 to 179.72		
Municipality: City of Markham			
Location: Rouge River at Birchmount Rd.	Low chord/obvert: Elevation varies between 176.7 m to 177.378 m		
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 171.83 m; d/s inv. of 171.81 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S4)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : October 16, 2018	Structure Type : Concrete Bridge		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 3	Footing: Open Bottom	Approx. Depth (m): 0.15
Watershed Name: Rouge	Materials: Concrete		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 3.82 m; Max. opening width is 10.8 m		Upstream Erosion (Y/N): N
Tributary Name: Tributary 4	Pier Dimension: 2 piers, 0.7 m wide each		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 69	Length: 37.39 m	Total structure span: 21.5 m	Additional Flow Information:
Cross-section Range: 6320.00 to 6319.23	Road Deck: Road surface elevation varies between the highest 181.44 m to the lowest 181.20 m		
Municipality: City of Markham			
Location: Tributary 4 and Enterprise Blvd.	Low chord/obvert: Center Obvert Elevation 178.708 m		
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 174.873 m; d/s inv. of 174.888 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S8)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : September 14, 2018	Structure Type : Railway Crossing		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 2	Footing: Open Bottom, Conc. Pier	Approx. Depth (m):0.69
Watershed Name: Rouge	Materials: Steel Deck, Concrete Abutment and Pier		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 4.37 m; Max. opening width is 16.95 m		Upstream Erosion (Y/N): Y
Tributary Name: Rouge River	Pier Dimension: 1.97 m wide		Downstream Erosion (Y/N): Y
Floodplain Map Sheet No.: 53	Length: 4.78 m	Total bridge span: 22.52 m	Additional Flow Information:
Cross-section Range: 6319.08 to 6319.105	Road Deck: Railway Crossing surface elevation between the highest 175.91 m to the lowest 175.79 m		
Municipality: City of Markham			
Location: Rouge River at CNR and HWY 7.	Low chord/obvert: Elevation varies between 174.52 m to 174.11 m		
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 169.74 m; d/s inv. of 169.73 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S9)

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date : September 12, 2018	Structure Type : Concrete Bridge Crossing	Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1 | Footing: Open Bottom	Approx. Depth (m): 0.4
Watershed Name: Rouge	Materials: Concrete	Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 4.11 m; Max. opening width is 16.8 m	Upstream Erosion (Y/N): N
Tributary Name: Rouge River	Pier Dimension: No pier	Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 53	Length: 20.2 m | Total bridge span: 16.8 m	Additional Flow Information:
Cross-section Range: 6319.00 to 6319.03	Road Deck: Surface elevation varies between the highest 174.17 m to the lowest 173.89 m. Solid Railing Elevation 175.30 to 175.49	
Municipality: City of Markham		
Location: Rouge River and Main Street Unionville, south of HWY. 7	Low chord/obvert: Elevation varies between 172.96 m to 172.94 m	
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 168.83 m; d/s inv. of 168.85 m	

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S9A)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : September 14, 2018	Structure Type : Twin Circular CSP Culverts		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 2	Footing:	Approx. Depth (m):
Watershed Name: Rouge	Materials: Corrugated Steel		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 1.25 m; Max. opening width is 1.75 m		Upstream Erosion (Y/N): N
Tributary Name: Tributary 5	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.:	Length: 20.02 m	Total structure span: 3.75 m	Additional Flow Information:
Cross-section Range:	Road Deck: Road surface elevation varies between the highest 178.32 m to the lowest 178.28 m		
Municipality: City of Markham			
Location: Tributary 5 immediately u/s of HWY 407	Low chord/obvert: Elevation u/s 178.24 m and d/s 178.11m		
	Invert: u/s inv. of 176.99 m; d/s inv. of 176.86 m		

Additional Field Notes:

Site Sketch:

Upstream of CSP Culvert

Downstream of CSP Culvert

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S9B)

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date : September 14, 2018	Structure Type : Twin Circular CSP Culverts	Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 2 | Footing:	Approx. Depth (m):
Watershed Name: Rouge	Materials: Corrugated Steel	Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 1.5 m; Max. opening width is 1.5 m	Upstream Erosion (Y/N): N
Tributary Name: Tributary 5	Pier Dimension: No pier	Downstream Erosion (Y/N): N
Floodplain Map Sheet No.:	Length: 12.02 m | Total structure span:	Additional Flow Information:
Cross-section Range:	Road Deck: Road surface elevation varies between the highest 177.70 m to the lowest 177.37 m	
Municipality: City of Markham		
Location: Tributary 5 Parking Lot Culvert	Low chord/obvert: Elevation obv. u/s 177.45 m; obv d/s 177.29	
	Invert: u/s inv. of 175.95 m; d/s inv. of 175.79 m	

Additional Field Notes:

Site Sketch:

Upstream of CSP Culvert

Downstream of CSP Culvert

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S9C)

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date : September 14, 2018	Structure Type : Twin Circular CSP Culverts	Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 2 | Footing:	Approx. Depth (m):
Watershed Name: Rouge	Materials: Corrugated Steel	Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 1.5 m; Max. opening width is 1.5 m	Upstream Erosion (Y/N): N
Tributary Name: Tributary 5	Pier Dimension: No pier	Downstream Erosion (Y/N): N
Floodplain Map Sheet No.:	Length: 41.88 m | Total structure span: 3.2	Additional Flow Information:
Cross-section Range:		
Municipality: City of Markham	Road Deck: 2-D Surface from LiDAR	
Location: Tributary 5 under YMCA Blvd.	Low chord/obvert: u/s obv. 177.09 m d/s obv. 176.92m	
	Invert: u/s inv. of 175.59 m; d/s inv. of 175.42 m	

Additional Field Notes:

Site Sketch:

Upstream of CSP Culvert

Downstream of CSP Culvert

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S10)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : August 29, 2018	Structure Type : Twin Circular CSP Culvert		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 2	Footing: Open Bottom	Approx. Depth (m):
Watershed Name: Rouge	Materials: Corrugated Steel Pipe		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 1.2 m; Max. opening width is 1.2 m		Upstream Erosion (Y/N): N
Tributary Name: Tributary 5	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.:	Length: 40.0m	Total span:	Additional Flow Information:
Cross-section Range:			
Municipality: City of Markham	Road Deck: 2-D Surface From LiDAR		
Location: Tributary 5 at Rivis Road and YMCA Blvd.	Low chord/obvert: u/s obv. 176.04 m d/s obv. 175.941 m		
	Invert: u/s inv. of 174.84 m; d/s inv. of 174.741 m		

Additional Field Notes:

Site Sketch:

Upstream of Culverts

Downstream of Culverts

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S11)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : August 28, 2018	Structure Type : CSP Arch Culvert		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1	Footing:	Approx. Depth (m):
Watershed Name: Rouge	Materials: Corrugated Steel		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 1.52 m; Max. opening width is 2.16 m		Upstream Erosion (Y/N): N
Tributary Name: Tributary 5	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.:	Length: 18 m	Total bridge span: 2.16	Additional Flow Information:
Cross-section Range:	Road Deck: Road surface elevation between the highest 176.10 m to the lowest 176.02 m		
Municipality: City of Markham			
Location: Trib. 5 at Main St. Unionville South of Enterprise Blvd.	Low chord/obvert: u/s obv. 175.27 m; d/s obv. 175.22		
	Invert: a u/s inv. of 173.75 m; d/s inv. of 173.7 m		

Additional Field Notes:

Site Sketch:

Upstream of CSP Culvert

Downstream of CSP Culvert

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S12)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : August 28, 2018	Structure Type : CSP Arch Culvert		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1	Footing:	Approx. Depth (m):
Watershed Name: Rouge	Materials: Corrugated Steel		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 1.52 m; Max. opening width is 2.16 m		Upstream Erosion (Y/N): N
Tributary Name: Tributary 5	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 53	Length: 71.00 m	Total structure span: 2.16	Additional Flow Information:
Cross-section Range:			
Municipality: City of Markham	Road Deck: 2-D Surface from LiDAR		
Location: Tributary 5 at Main St. Unionville upstream of Unionville Gate	Low chord/obvert: u/s obv. 174.67 m d/s obv. 174.47		
	Invert: u/s inv. of 173.15 m; d/s inv. of 172.95 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S13)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : August 28, 2018	Structure Type : Concrete Bridge		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1	Footing: Open Bottom	Approx. Depth (m): 0.17
Watershed Name: Rouge	Materials: Concrete		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 2.35 m; Max. opening width is 6.1 m		Upstream Erosion (Y/N): N
Tributary Name: Tributary 5	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 53	Length: 13.66 m	Total bridge span: 6.1 m	Additional Flow Information:
Cross-section Range:	Road Deck: Road surface elevation varies between the highest 175.18 m to the lowest 175.07 m. Top of Solid Railing elevation between 175.58 to 175.07		
Municipality: City of Markham			
Location: Trib. 5 upstream of Unionville Gate between Kennedy & Main St. Unionville	Low chord/obvert: Elevation varies between 174.55 m to 173.9 m		
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 172.2 m; d/s inv. of 172.1 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S14)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : August 28, 2018	Structure Type : Concrete Bridge Crossing		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1	Footing: Open Bottom	Approx. Depth (m):0.16
Watershed Name: Rouge	Materials: Concrete		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 2.79 m; Max. opening width is 5.94 m		Upstream Erosion (Y/N): N
Tributary Name: Tributary 5	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 53	Length: 16 m	Total bridge span: 5.94 m	Additional Flow Information:
Cross-section Range: 6319.03 to 6319.00	Road Deck: Road surface elevation varies between the highest 175.28 m to the lowest 175.06 m. Top of solid railing elevation 175.34 m		
Municipality: City of Markham			
Location: Tributary 5 Immediately upstream of Unionville Gate, Between Main St. Unionville and Kennedy Road.	Low chord/obvert: Elevation varies between 174.532 m to 173.352 m		
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 171.742 m; d/s inv. of 171.741 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S15)

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date : August 28, 2018	Structure Type : Concrete Box Culvert	Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1 | Footing:	Approx. Depth (m):
Watershed Name: Rouge	Materials: Concrete	Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 1.8 m; Max. opening width is 2 m	Upstream Erosion (Y/N): N
Tributary Name: Tributary 5	Pier Dimension: No pier	Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 53	Length: 38.37 m | Total bridge span: 2 m	Additional Flow Information:
Cross-section Range: 6319.03 to 6319.00		
Municipality: City of Markham	Road Deck: 2D Surface From LiDAR	
Location: Tributary 5 at Unionville Gate	Low chord/obvert: Elevation u/s 173.514 and d/s 173	
	Invert: u/s inv. of 171.741 m; d/s inv. of 171.2 m	

Additional Field Notes:

Site Sketch:

Upstream of Concrete Box Culvert

Downstream of Concrete Box Culvert

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S16)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : September 12, 2018	Structure Type : Concrete Bridge		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1	Footing: Open Bottom	Approx. Depth (m): 0.35
Watershed Name: Rouge	Materials: Concrete Bridge		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 4.72 m; Max. opening width is 18.5 m		Upstream Erosion (Y/N): N
Tributary Name: Rouge	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 53	Length: 25.94 m	Total bridge span: 18.5 m	Additional Flow Information:
Cross-section Range: 6316.12 to 6316.09	Road Deck: Road surface elevation varies between the highest 174.26 m to the lowest 174.13 m. Solid Railing Elevation from 175.19 to 175.10 .		
Municipality: City of Markham			
Location: Rouge and Highway 7 East of Main St. Unionville	Low chord/obvert: Elevation varies between 173.07 m to 172.57 m		
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 168.35 m; d/s inv. of 168.29 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S18)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : September 04, 2018	Structure Type : Concrete Bridge		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staff	No. of Openings/Culverts: 1	Footing: Open Bottom	Approx. Depth (m): 0.11
Watershed Name: Rouge	Materials: Concrete		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 2.09 m; Max. opening width is 6.28 m		Upstream Erosion (Y/N): Y
Tributary Name: Fonthill	Pier Dimension: No pier		Downstream Erosion (Y/N): Y
Floodplain Map Sheet No.: 54	Length: 35.00 m	Total bridge span: 6.28 m	Additional Flow Information:
Cross-section Range: 7317.30 to 7317.27	Road Deck: Road surface elevation varies between the highest 174.89 m to the lowest 174.85 m		
Municipality: City of Markham			
Location: Fonthill Reach at Rycroft Dr.	Low chord/obvert: Elevation varies along low chord arc. Obv. Elev. 173.46 m		
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 171.87 m; d/s inv. of 171.81 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S19)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : September 04, 2018	Structure Type : Concrete Bridge		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1	Footing: Open Bottom	Approx. Depth (m): 0.13
Watershed Name: Rouge	Materials: Concrete		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 2.13 m; Max. opening width is 8.5 m		Upstream Erosion (Y/N): N
Tributary Name: Fonthill	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 54	Length: 30.00 m	Total bridge span: 8.5 m	Additional Flow Information:
Cross-section Range: 7317.22 to 7317.19	Road Deck: Road surface elevation between the highest 173.83 m to the lowest 173.78 m		
Municipality: City of Markham			
Location: Fonthill Reach at Fonthill Blvd.	Low chord/obvert: Elevation varies along the low chord arc. u/s obv. Elevation 172.95 m.		
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 170.77 m; d/s inv. of 170.71 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S20)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : August 31, 2018	Structure Type : Concrete Bridge		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1	Footing: Open Bottom	Approx. Depth (m):
Watershed Name: Rouge	Materials: Concrete		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 2.44 m; Max. opening width is 9.775 m		Upstream Erosion (Y/N): N
Tributary Name: Fonthill	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 54	Length: 28.87m	Total bridge span: 9.775 m	Additional Flow Information:
Cross-section Range: 7317.15 to 7317.18	Road Deck: Road surface elevation varies between the highest 174.1 m to the lowest 174.02 m		
Municipality: City of Markham			
Location: Fonthill reach at Fred Varley Dr.	Low chord/obvert: Elevation varies along arc. u/s obv. elevation 173.091		
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 170.651 m; d/s inv. of 170.564 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S21)

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date : August 31, 2018	Structure Type : Concrete Box Culvert	Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1 | Footing:	Approx. Depth (m): 0.1
Watershed Name: Rouge	Materials: Concrete and Brick	Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 1.5 m; Max. opening width is 2.135 m	Upstream Erosion (Y/N): N
Tributary Name: Fonthill Reach	Pier Dimension: No pier	Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 54	Length: 16.72 m | Total bridge span: 2.135 m	Additional Flow Information:
Cross-section Range: 7317.13 to 7317.11	Road Deck: Road surface elevation varies between the highest 172.48 m to the lowest 172.38 m	
Municipality: City of Markham		
Location: Fonthill Reach at Main St. Unionville.	Low chord/obvert: u/s obv. elevation 171.98 m	
	Invert: u/s inv. of 170.48 m; d/s inv. of 170.49 m	

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S22)

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date : September 04, 2018	Structure Type : Concrete Box Culvert	Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1 | Footing:	Approx. Depth (m): 0.55
Watershed Name: Rouge	Materials: Wooden Deck, Concrete Bottom and Side Walls	Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 1.98 m; Max. opening width is 3.35 m	Upstream Erosion (Y/N): N
Tributary Name: Fonthill Reach	Pier Dimension: No pier	Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 54	Length: 3.30 m | Total bridge span: 3.35 m	Additional Flow Information:
Cross-section Range: 7200.05 to 7317.11	Road Deck: Road surface elevation varies between the highest 172.06 m to the lowest 171.99 m	
Municipality: City of Markham		
Location: Fonthill Reach at Private Crossing	Low chord/obvert: Elevation 172.44 m	
	Invert: u/s inv. of 170.46 m; d/s inv. of 170.40 m	

Additional Field Notes:

Site Sketch:

Upstream of Concrete Box Culvert

Downstream of Concrete Box Culvert

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S23)

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date : September 04, 2018	Structure Type : Concrete Box Culvert	Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1 | Footing:	Approx. Depth (m): 0.25
Watershed Name: Rouge	Materials: Concrete	Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 1.194 m; Max. opening width is 2.33 m	Upstream Erosion (Y/N): N
Tributary Name: Fonthill	Pier Dimension: No pier	Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 54	Length: 9.52 m | Total bridge span: 2.33 m	Additional Flow Information:
Cross-section Range: 7317.11 to 7200.05	Road Deck: Road surface elevation varies between the highest 171.70 m to the lowest 171.62 m	
Municipality: City of Markham		
Location: Fonthill Reach at Victoria Avenue	Low chord/obvert: Elevation 171.184 m	
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 169.99 m; d/s inv. of 169.95 m	

Additional Field Notes:

Site Sketch:

Upstream of Concrete Box Culvert

Downstream of Concrete Box Culvert

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S24)

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date : September 13, 2018	Structure Type : Concrete Box Culvert Railway Crossing	Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1 | Footing:	Approx. Depth (m): 0.15
Watershed Name: Rouge	Materials: Concrete	Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 2.38 m; Max. opening width is 2.4 m	Upstream Erosion (Y/N): Y
Tributary Name: Fonthill	Pier Dimension: No pier	Downstream Erosion (Y/N): Y
Floodplain Map Sheet No.: 54	Length: 13.70m | Total bridge span: 2.4 m	Additional Flow Information:
Cross-section Range: 7200.03 to 7200.01	Road Deck: Rail deck elevation varies between the highest 175.27 m to the lowest 175.24 m	
Municipality: City of Markham		
Location: Fonthill Reach at CNR	Low chord/obvert: Elevation 172.38 m	
	Invert: u/s inv. of 170.00 m; d/s inv. of 169.91 m	

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S31)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : September 13, 2018	Structure Type : Concrete Dam		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 19	Footing:	Approx. Depth (m): 0.3
Watershed Name: Rouge	Materials: Concrete Deck, Piers and Steel open handrail		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 2.5 m; Max. opening width is 5.84 m		Upstream Erosion (Y/N): N
Tributary Name: Bruce Creek	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 54	Length: 5.30 m	Total bridge span: 23.0 m	Additional Flow Information:
Cross-section Range: 7200.23 to 7200.20	Road Deck: Right Deck elevation varies between the highest 175.34 m to the lowest 175.05 m.		
Municipality: City of Markham			
Location: Bruce Creek and Too Good Pond Dam	Low chord/obvert: Elevation varies between 175.00 m to 174.9 m		
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 172.5 m; d/s inv. of 172.4 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S32)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : September 04, 2018	Structure Type : Concrete Bridge		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1	Footing: Open Bottom	Approx. Depth (m): 0.33
Watershed Name: Rouge	Materials: Concrete		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 2.79 m; Max. opening width is 12.00 m (perpendicular)		Upstream Erosion (Y/N): N
Tributary Name: Bruce Creek	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 54	Length: 13.4 m	Total bridge span: 12.85 m (skewed)	Additional Flow Information:
Cross-section Range: 7200.17 to 7200.16	Road Deck: Road surface elevation varies between the highest 173.36 m to the lowest 172.95 m. Solid Railing Elevation 174.36 to 173.99 m.		Structure Skewed Relative to River.
Municipality: City of Markham			
Location: Bruce creek at Main St. Unionville	Low chord/obvert: Elevation varies between 172.71 m to 172.51 m		
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 169.53 m; d/s inv. of 169.54 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S34)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : September 04, 2018	Structure Type : Concrete Bridge		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1	Footing: Open Bottom	Approx. Depth (m): 0.36
Watershed Name: Rouge	Materials: Concrete		Approximate Velocity (m/s):
Subcatchment Area No.:	Max. Opening Height is 3.43 m; Max. opening width is 14.00 m		Upstream Erosion (Y/N): N
Tributary Name: Bruce Creek	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 54	Length: 15.07 m	Total bridge span: 14.00 m	Additional Flow Information:
Cross-section Range: 7200.12 to 7200.11	Road Deck: Road surface elevation varies between the highest 173.33 m to the lowest 172.75 m. Solid Railing Elevation between 174.33 to 173.76		
Municipality: City of Markham			
Location: Bruce Creek at Carlton Road	Low chord/obvert: Elevation varies between 172.41 m to 172.01 m		
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 168.99 m; d/s inv. of 168.95 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S37)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : September 04, 2018	Structure Type : Steel Pedestrian Bridge with Wooden Deck		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 3	Footing: Open Bottom	Approx. Depth (m): 0.69
Watershed Name: Rouge	Materials: Wooden Deck, Concrete Beams to support walkway		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 5.76 m; Max. opening width is 17.65 m		Upstream Erosion (Y/N): N
Tributary Name: Bruce Creek	Pier Dimension: 1.9 m		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 54	Length: 4.04 m	Total bridge span: 29.6 m	Additional Flow Information:
Cross-section Range: 7200.03 to 7200.01	Road Deck: Railway surface elevation varies between the highest 175.45 m to the lowest 175.29 m		
Municipality: City of Markham			
Location: Bruce Creek and CNR	Low chord/obvert: Elevation 173.76 m		
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 167.997 m; d/s inv. of 167.699 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert 39)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : August 31, 2018	Structure Type : Concrete Bridge		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1	Footing: Open Bottom	Approx. Depth (m): 0.54
Watershed Name: Rouge	Materials: Concrete		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 4.31 m; Max. opening width is 28.96 m		Upstream Erosion (Y/N): N
Tributary Name: Rouge River	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 54	Length: 18.4 m	Total bridge span: 28.96 m	Additional Flow Information:
Cross-section Range: 6315.12 to 6315.09	Road Deck: Road surface elevation varies between the highest 172.88 m to the lowest 172.29 m		
Municipality: City of Markham			
Location: Rouge River at Kennedy Rd.	Low chord/obvert: Elevation varies between 171.67 m to 171.03 m		
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 167.36 m; d/s inv. of 167.33 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S43)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : September 12, 2018	Structure Type : Concrete Box Culvert		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1	Footing: Open Bottom	Approx. Depth (m):
Watershed Name: Rouge	Materials: Concrete		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 2.5 m; Max. opening width is 4.5 m		Upstream Erosion (Y/N): N
Tributary Name: Burndenet Creek	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 50	Length: 24.70 m	Total bridge span: 4.5 m	Additional Flow Information:
Cross-section Range: 6330.17 to 6330.165	Road Deck: Road surface elevation varies between the highest 176.68 m to the lowest 176.57 m. Top of Solid Railing Elevation 177.63 m to 177.57 m.		
Municipality: City of Markham			
Location: Burndenet Creek at Raymerville Dr.	Low chord/obvert: u/s obv. 175.94 m and d/s obv. 175.9 m		
	Invert: u/s inv. of 173.44 m; d/s inv. of 173.4m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S44)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : September 14, 2018	Structure Type : Twin Concrete Culverts		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 2	Footing:	Approx. Depth (m):
Watershed Name: Rouge	Materials: Concrete		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 1.52 m; Max. opening width is 1.52 m		Upstream Erosion (Y/N): N
Tributary Name: Burndenet Creek	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 50	Length: 16.1 m	Total span: 3.15 m	Additional Flow Information:
Cross-section Range: 6330.13 to 6330.12	Road Deck: Railway surface elevation varies between the highest 177.18 m to the lowest 177.12 m		
Municipality: City of Markham			
Location: Burndenet Creek at C.N.R	Low chord/obvert: u/s obv. 172.847 m and d/s obv. 172.62 m		
	Invert: u/s inv. 171.327 m; d/s inv. of 171.1 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Culverts

Downstream of Concrete Culverts

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S45)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : September 14, 2018	Structure Type : CSP Arch Culvert		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1	Footing: Open Bottom	Approx. Depth (m):
Watershed Name: Rouge	Materials: Corrugated Steel Pipe, Seated in Concrete		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 2.01 m; Max. opening width is 3.4 m		Upstream Erosion (Y/N): N
Tributary Name: Burndenet Creek	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 50	Length: 36 m	Total culvert span: 3.4 m	Additional Flow Information:
Cross-section Range: 6330.065 to 6330.062	Road Deck: Road surface elevation varies between the highest 173.42 m to the lowest 173.24 m		
Municipality: City of Markham			
Location: Burndenet Creek at Austin Drive	Low chord/obvert: u/s obv.171.96 m d/s obv. 171.82 m		
	Invert: u/s inv. of 169.95 m; d/s inv. of 169.81 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S47)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : September 12, 2018	Structure Type : Concrete Bridge		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 2	Footing: Open Bottom w. Conc. Pier	Approx. Depth (m): 0.6
Watershed Name: Rouge	Materials: Concrete		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 4.9 m; Max. opening width is 20.9 m		Upstream Erosion (Y/N): N
Tributary Name: Rouge River	Pier Dimension: 1.1 m		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 53	Length: 21.5 m	Total bridge span: 33 m	Additional Flow Information:
Cross-section Range: 6313.15 to 6315.00	Road Deck: Road surface elevation varies between the highest 173.05 m to the lowest 172.85 m; Solid Railing Elevation 173.65 to 173.48		
Municipality: City of Markham			
Location: Rouge at HWY 7 downstream of Walton Pond	Low chord/obvert: u/s obv. 171.77 d/s obv 171.67		
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 166.87 m; d/s inv. of 166.77 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S51)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : September 12, 2018	Structure Type : Twin Concrete Box Culverts		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 2	Footing:	Approx. Depth (m):
Watershed Name: Rouge	Materials: Concrete with steel grate covers		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 1.8 m; Max. opening width is 3.0 m		Upstream Erosion (Y/N): N
Tributary Name: South Unionville Tributary	Pier Dimension:		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 49	Length: 55.00	Total bridge span: 6.1 m	Additional Flow Information:
Cross-section Range: 6313.05 to 6313.04			
Municipality: City of Markham	Road Deck: 2D Surface from LiDAR		
Location: South Unionville Pond Tributary at Piera Gardens Road	Low chord/obvert: Elevation 170.39		
	Invert: u/s inv. of 168.59 m; d/s inv. of 168.59 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Box Culvert

Downstream of Concrete Box Culvert

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S52)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : September 14, 2018	Structure Type : Twin CSP Culverts		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 2	Footing:	Approx. Depth (m):
Watershed Name: Rouge	Materials: CSP culverts in concrete seating		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 1 m; Max. opening width is 0.92 m		Upstream Erosion (Y/N): N
Tributary Name: South Unionville Tributary	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 49	Length: 6.03 m	Total span: 1.85 m	Additional Flow Information:
Cross-section Range: 6313.05 to 6313.04	Road Deck: Driveway surface elevation varies between the highest 169.72 m to the lowest 169.61 m		
Municipality: City of Markham			
Location: South Unionville Pond Tributary at Campbell Court Sidewalk (Private Driveway Crossing)	Low chord/obvert: u/s obv. 169.37 and 169.32 m		
	Invert: u/s inv. of 168.37 and 168.32 m;		

Additional Field Notes:

Site Sketch:

Upstream of CSP Culverts

Downstream of CSP Culverts

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S55)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : September 14, 2018	Structure Type : Concrete Bridge		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1	Footing: Open Bottom	Approx. Depth (m): 1.36
Watershed Name: Rouge	Materials: Concrete		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 4.0 m; Max. opening width is 24.42 m		Upstream Erosion (Y/N): N
Tributary Name: Rouge River	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 49	Length: 18.8 m	Total bridge span: 24.42 m	Additional Flow Information:
Cross-section Range: 6312.20 to 6312.17	Road Deck: Road surface elevation varies between the highest 170.82 m to the lowest 170.67 m		
Municipality: City of Markham			
Location: Rouge at McCowan Road.	Low chord/obvert: Elevation varies between 169.8 m to 169.68 m		
	Invert: Elevations on the irregular natural channel vary across and along the bridge section having a u/s inv. of 165.2 m; d/s inv. of 165.26 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Bridge

Downstream of Concrete Bridge

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S56)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : September 14, 2018	Structure Type : Circular Concrete Pipe Culvert		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts: 1	Footing:	Approx. Depth (m):
Watershed Name: Rouge	Materials: Concrete		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height is 2.134 m; Max. opening width is 2.134 m		Upstream Erosion (Y/N): N
Tributary Name: Milne Reach	Pier Dimension: No pier		Downstream Erosion (Y/N): N
Floodplain Map Sheet No.: 48	Length: 109.78 m	Total bridge span: 2.134 m	Additional Flow Information:
Cross-section Range:			
Municipality: City of Markham	Road Deck: 2-D Surface from LiDAR		
Location: Milne Reach at Drakefield Road	Low chord/obvert: u/s obv. 172.334 m to 170.394m		
	Invert: u/s inv. of 170.2 m; d/s inv. of 168.26 m		

Additional Field Notes:

Site Sketch:

Upstream of Concrete Pipe

Downstream of Concrete Pipe

Description of Photograph:

HYDRAULIC STRUCTURE INVENTORY SHEET (Bridge / Culvert S57)

Watershed and Location Information	Structure Configuration and Dimensions		Current Flow Information
Date : August 19, 2018	Structure Type : Dam		Flow Present (Y/N): Y
Field Crew: Valdor Engineering Inc Staffs	No. of Openings/Culverts:	Footing:	Approx. Depth (m):
Watershed Name: Rouge	Materials:		Approximate Velocity(m/s):
Subcatchment Area No.:	Max. Opening Height		Upstream Erosion (Y/N):
Tributary Name: Rouge	Pier Dimension:		Downstream Erosion (Y/N):
Floodplain Map Sheet No.: 48	Length:	Total bridge span:	Additional Flow Information:
Cross-section Range:			Will be modeled using rating curve
Municipality: City of Markham	Road Deck:		
Location: Milne Dam	Low chord/obvert:		
	Invert:		

Additional Field Notes:

Site Sketch:

Description of Photograph:

APPENDIX 'B'

Supporting Technical Information - Bathymetry and Roughness

Unionville SPA 2D Modelling Study and Floodplain Mapping Update

Toronto and Region Conservation Authority

Appendix 'B' Contents:

Figure B.1a

Water Edge Lines and Bathymetry Adjustment Polygons

0 12.5 25 50 Meters

18 December 2018

N

TORONTO AND REGION CONSERVATION AUTHORITY
UNIONVILLE SPA 2D MODELLING STUDY AND FLOODPLAIN MAPPING UPDATE

Toronto and Region Conservation Authority

VALDOR Est. 1992

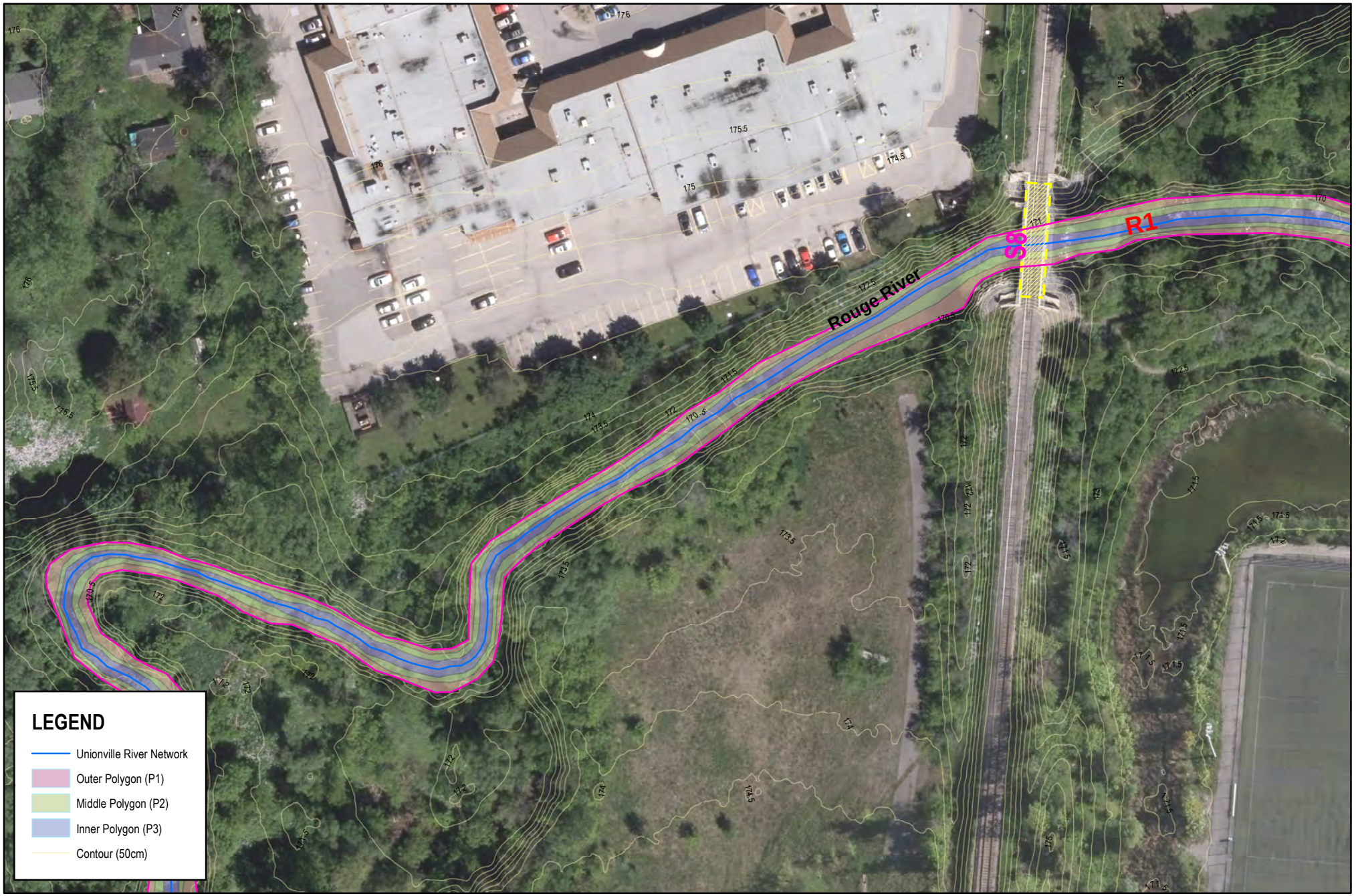


Figure B.1b

Water Edge Lines and Bathymetry Adjustment Polygons

18 December 2018

TORONTO AND REGION CONSERVATION AUTHORITY

UNIONVILLE SPA 2D MODELLING STUDY AND FLOODPLAIN MAPPING UPDATE

Toronto and Region Conservation Authority

VALDOR Est. 1992

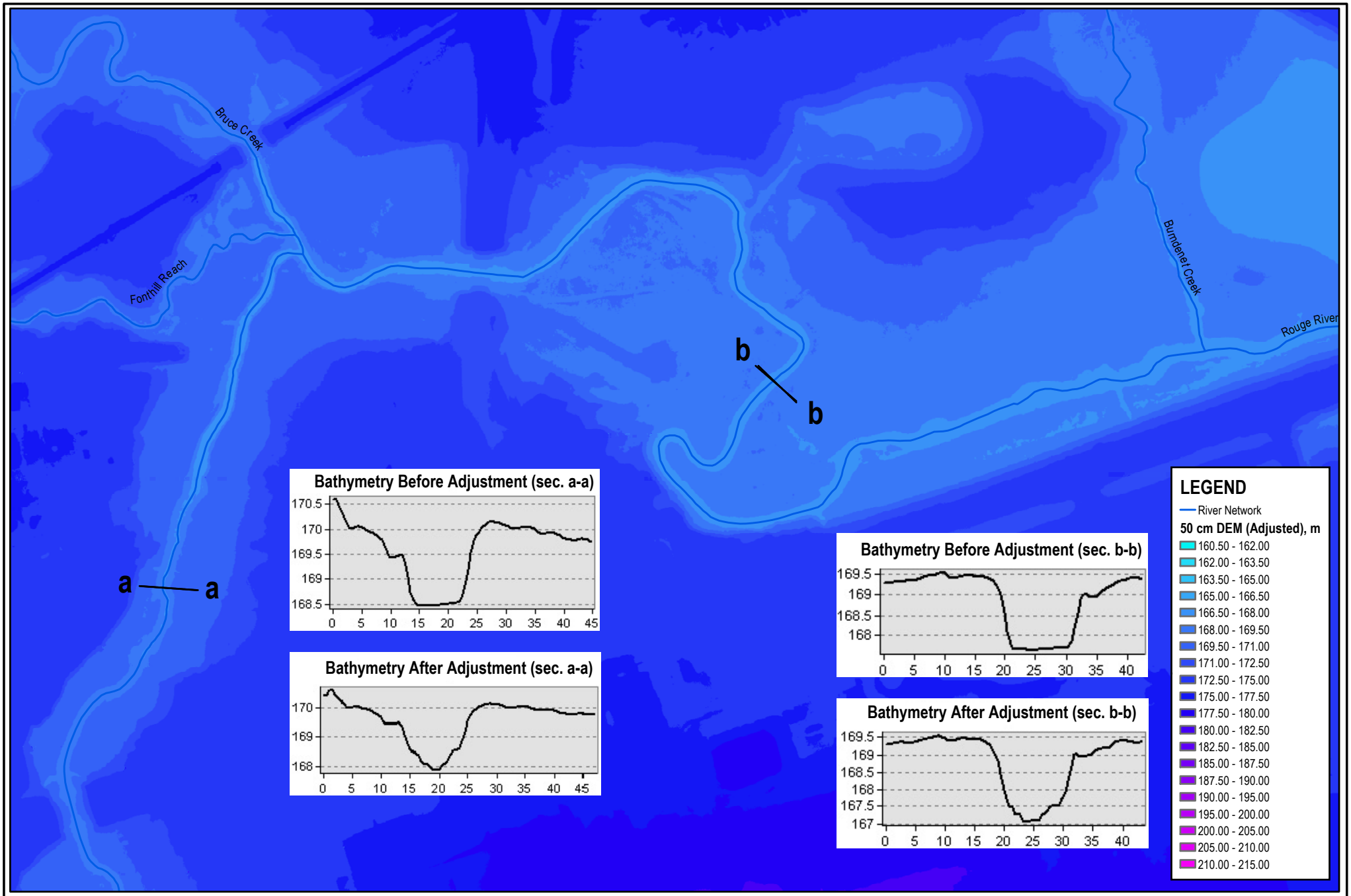


Figure B.2

50 CM RASTER DEM WITH ADJUSTED UNDERWATER GROUND ELEVATIONS

0 37.5 75 150 Meters

N

18 December 2018

TORONTO AND REGION CONSERVATION AUTHORITY

UNIONVILLE SPA 2D MODELLING STUDY
AND FLOODPLAIN MAPPING UPDATE

Toronto and Region Conservation Authority

VALDOR Est. 1992

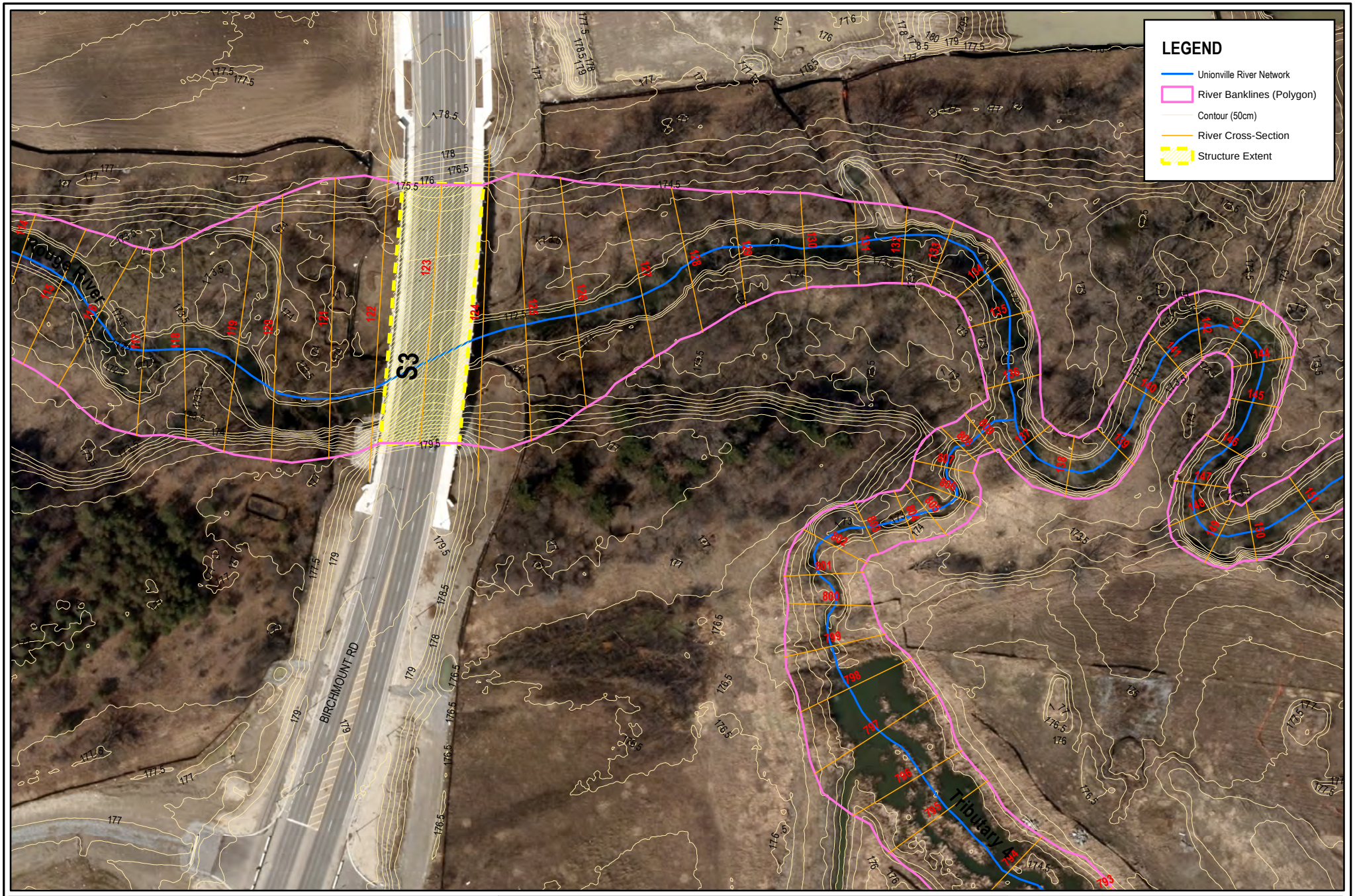


Figure B.3a

MIKE HYDRO River Network, Banklines, Cross-Sections

0 12.5 25 50 Meters

18 December 2018

N

TORONTO AND REGION CONSERVATION AUTHORITY
UNIONVILLE SPA 2D MODELLING STUDY AND FLOODPLAIN MAPPING UPDATE

Toronto and Region Conservation Authority

VALDOR Est. 1992

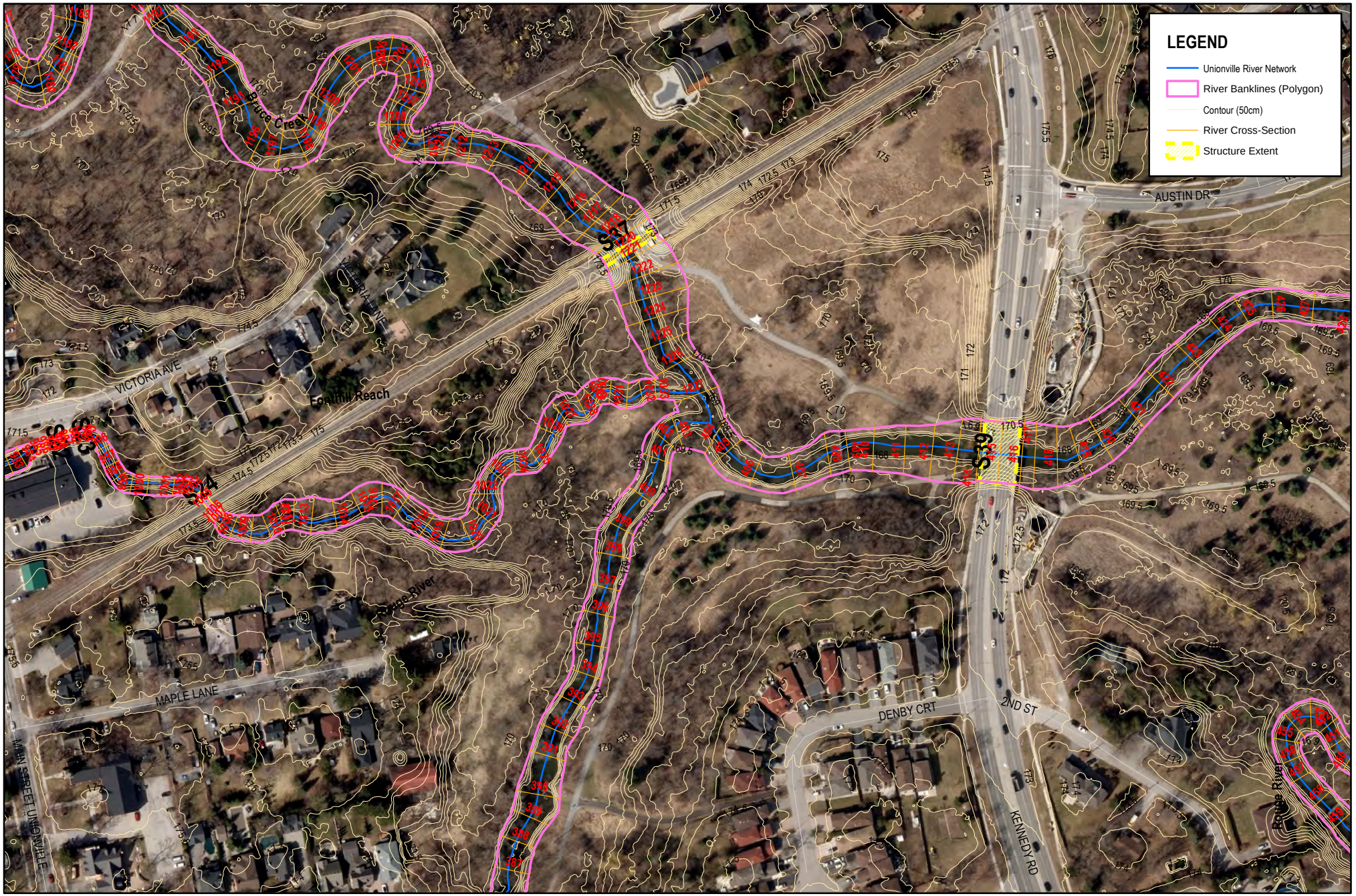


Figure B.3b

MIKE HYDRO River Network, Banklines, Cross-Sections

0 25 50 100 Meters

18 December 2018

N

TORONTO AND REGION CONSERVATION AUTHORITY

UNIONVILLE SPA 2D MODELLING STUDY AND FLOODPLAIN MAPPING UPDATE

Toronto and Region Conservation Authority

VALDOR

Figure B.3c

MIKE HYDRO River Network, Banklines, Cross-Sections

0 25 50 100 Meters

N

18 December 2018

TORONTO AND REGION CONSERVATION AUTHORITY
UNIONVILLE SPA 2D MODELLING STUDY AND FLOODPLAIN MAPPING UPDATE

Toronto and Region Conservation Authority

VALDOR Est. 1992

S39

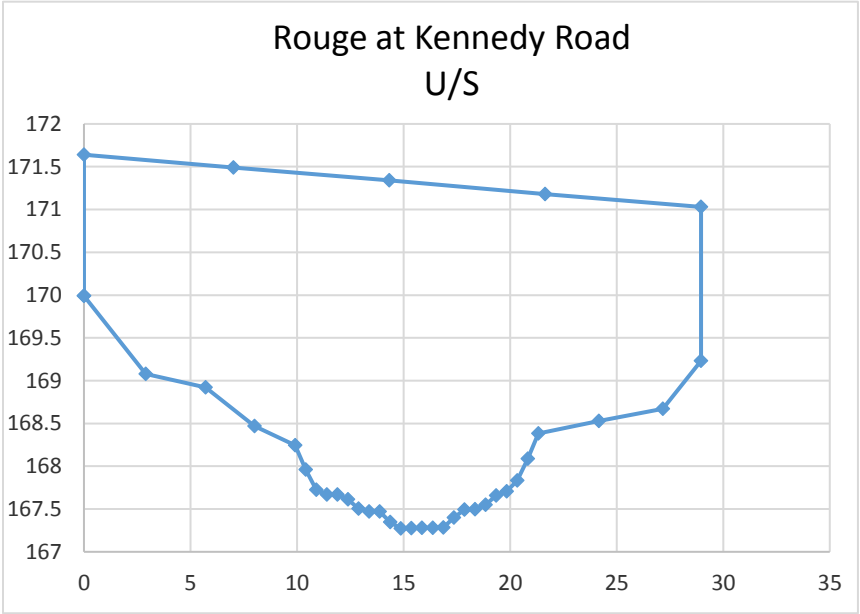
Project: 18123 - Unionville 2D

Location: Rouge River at Kennedy Road

Figure B.4a Example Showing Survey Data as Converted into Mike 11 Structure Opening

Corrected Horizontal Distance (m)	Elevation (masl)	Corrected Vertical Distance (m)
0	169.99	2.7162
2.9	169.08	1.8062
5.7	168.92	1.6462
8	168.47	1.1962
9.915997	168.2436	0.9698
10.4118	167.9593	0.6855
10.9076	167.7249	0.4511
11.4034	167.6679	0.3941
11.8992	167.6704	0.3966
12.395	167.6128	0.339
12.8908	167.5031	0.2293
13.3866	167.4702	0.1964
13.8824	167.4708	0.197
14.3782	167.3455	0.0717
14.87399	167.2738	0
15.36979	167.2762	0.0024
15.86559	167.279	0.0052
16.36139	167.2818	0.008
16.85719	167.2849	0.0111
17.35299	167.4009	0.1271
17.84879	167.4924	0.2186
18.34459	167.4963	0.2225
18.84039	167.549	0.2752
19.33619	167.6591	0.3853
19.83199	167.7078	0.434
20.32779	167.8318	0.558
20.82359	168.0884	0.8146
21.31939	168.3847	1.1109
24.16	168.53	1.2562
27.16	168.67	1.3962
28.96	169.23	1.9562
28.96	171.03	3.7562
21.64	171.18	3.9062
14.33	171.34	4.0662
7.01	171.49	4.2162
0	171.64	4.3662
0	169.99	2.7162

Depth (m)	Width (m)
0	0.75
0.6	6.5
0.98	8.5
1.15	9.1
1.7	11.3
1.9	13.039
2	15.168
2.15	19.5
2.2	20.14
2.35	21.56
2.76	28.96
3.7	28.96
3.85	21.64
4.01	14.33
4.16	7.01
4.31	0



TORONTO AND REGION CONSERVATION AUTHORITY
UNIONVILLE SPA 2D MODELING STUDY
AND FLOODPLAIN MAPPING UPDATE

Toronto and Region Conservation Authority

Est. 1992
VALDOR

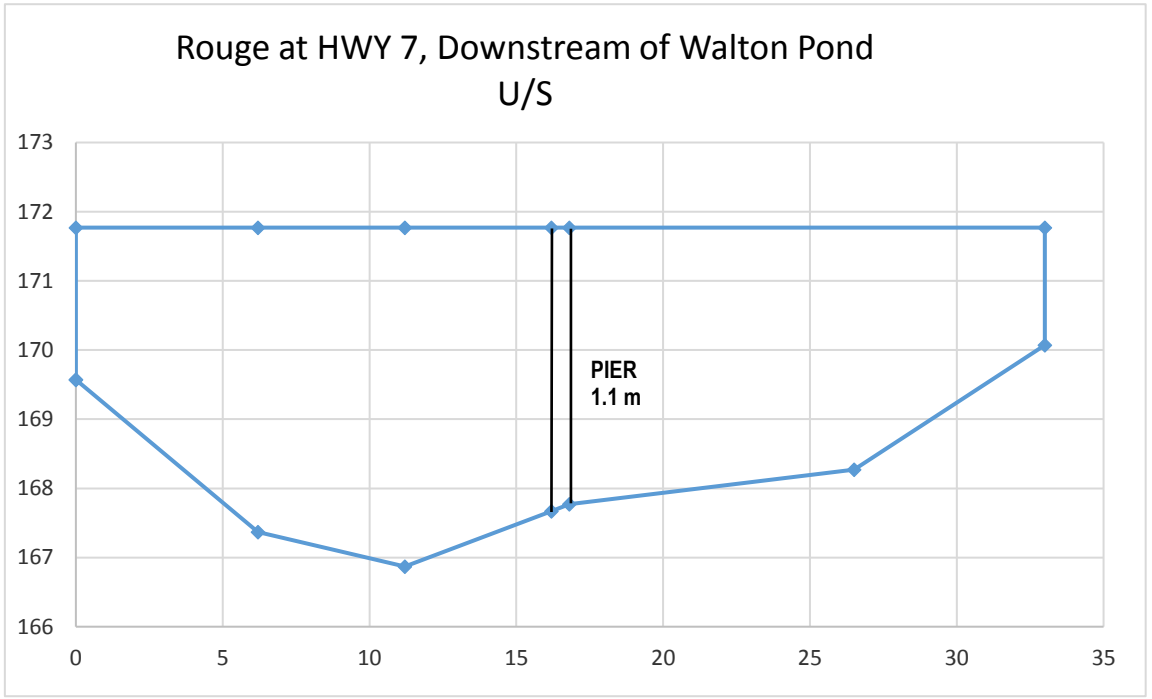
S47

Project: 18123 - Unionville 2D

Location: Rouge River at HWY 7

Figure B.4b Example Showing Survey Data as Converted into Mike 11 Structure Opening

Station (m)	Corrected Horizontal Distance (m)	Elevation (masl)	Corrected Vertical Distance (m)
1170.84	0	169.57	2.7
1177.04	6.2	167.37	0.5
1182.04	11.2	166.87	0
1187.04	16.2	167.67	0.8
1187.64	16.8	167.77	0.9
1197.34	26.5	168.27	1.4
1203.84	33	170.07	3.2
1203.84	33	171.77	4.9
1187.64	16.8	171.77	4.9
1187.04	16.2	171.77	4.9
1182.04	11.2	171.77	4.9
1177.04	6.2	171.77	4.9
1170.84	0	171.77	4.9
1170.84	0	169.57	2.7



Depth (m)	Width (m)
0	0
0.5	8.141
0.8	9.8
0.9	10.75
1.4	21.778
2.7	30.032
3.2	31.9
4.9	31.9

Table B.1 Land Use and Mike Flood Roughness

Surface	Roughness (n-value)	MIKE Flood Roughness (M-value)
Natural Area	0.08	12.5
Urban Pervious	0.05	20
Paved Surface	0.025	40
Water Body	0.035	28.57
Building	0.0001	10000

Table B.2 Roughness for Bridge, Culvert and Weir

Bridge / Culvert	Roughness Surface	Length (m)	Weighted Average n Value
S1	Natural Channel, Concrete	Natural Channel =14.139 Concrete = 16.234	0.023
S2	Natural Channel, Concrete	Natural Channel = 69.504 Concrete = 74.854	0.024
S3	Natural Channel, Concrete	Natural Channel = 79.941 Concrete = 85.46	0.024
S4	Natural Channel, Concrete	Natural Channel = 19.507 Concrete = 33.91	0.021
S8	Natural Channel, Steel, Bricked Concrete	Natural Channel = 24.252 Steel = 20.496 Bricked Concrete = 2.613	0.026
S9	Natural Channel, Concrete	Natural Channel = 17.346 Concrete = 22.37	0.023
S10	Corrugated Steel Pipe	Corrugated Steel Pipe = 40	0.024
S11	Corrugated Steel Pipe	Corrugated Steel Pipe = 18	0.024
S12	Corrugated Steel Pipe	Corrugated Steel Pipe = 71	0.024
S13	Natural Channel, Concrete	Natural Channel = 6.334 Concrete = 8.047	0.023
S14	Natural Channel, Concrete	Natural Channel = 6.231 Concrete = 9.036	0.022
S15	Concrete	Concrete = 7.6	0.013
S16	Natural Channel, Concrete	Natural Channel = 18.78 Concrete = 24.39	0.023
S18	Natural Channel, Concrete	Natural Channel = 6.67 Concrete = 9.721	0.022
S19	Natural Channel, Concrete	Natural Channel = 8.517 Concrete = 10.918	0.023
S20	Natural Channel, Concrete	Natural Channel = 9.792 Concrete = 12.35	0.023
S21	Concrete	Concrete = 7.46	0.013
S22	Concrete	Concrete = 10.66	0.013
S23	Concrete	Concrete = 7.048	0.013
S24	Concrete	Concrete = 9.56	0.013
S31-C1	Natural Channel, Concrete	Natural Channel = 10.319 Concrete = 16.998	0.021
S31-C2	Natural Channel, Concrete	Natural Channel = 5.612 Concrete = 26.704	0.017
S31-C3	Natural Channel, Concrete	Natural Channel = 5.674 Concrete = 27.874	0.017
S31-C4	Natural Channel, Concrete	Natural Channel = 5.848 Concrete = 27.943	0.017
S31-C5	Natural Channel, Concrete	Natural Channel = 5.81 Concrete = 27.81	0.017
S31-C6	Natural Channel, Concrete	Natural Channel = 5.674 Concrete = 27.87	0.017
S31-C7	Natural Channel, Concrete	Natural Channel = 5.508 Concrete = 27.701	0.017
S31-C8	Concrete	Concrete = 12.92	0.013
S31-C9	Concrete	Concrete = 14.6	0.013
S31-C10	Concrete	Concrete = 14.64	0.013
S31-C11	Concrete	Concrete = 10.4	0.013
S31-C12	Concrete	Concrete = 14.4	0.013

S31-C13	Natural Channel, Concrete	Natural Channel = 5.48 Concrete = 30.203	0.016
S31-C14	Natural Channel, Concrete	Natural Channel = 5.61 Concrete = 28.132	0.017
S31-C15	Natural Channel, Concrete	Natural Channel = 5.6 Concrete = 26.932	0.017
S31-C16	Natural Channel, Concrete	Natural Channel = 5.604 Concrete = 26.508	0.017
S31-C17	Natural Channel, Concrete	Natural Channel = 5.64 Concrete = 26.154	0.017
S31-C18	Natural Channel, Concrete	Natural Channel = 6.392 Concrete = 23.547	0.018
S31-C19	Natural Channel, Concrete	Natural Channel = 1.97 Concrete = 3.77	0.021
S32	Natural Channel, Concrete	Natural Channel = 13.118 Concrete = 16.02	0.023
S34	Natural Channel, Concrete	Natural Channel = 14.084 Concrete = 16.02	0.023
S37	Natural Channel, Concrete	Natural Channel = 20.714 Concrete = 29.805	0.022
S39	Natural Channel, Concrete	Natural Channel = 29.941 Concrete = 32.246	0.024
S43	Concrete	Concrete = 24.7	0.013
S44	Concrete	Concrete = 16.1	0.013
S45	Corrugated Steel Pipe	Corrugated Steel Pipe = 42.5	0.024
S47	Natural Channel, Concrete	Natural Channel = 33.697 Concrete = 36.76	0.024
S51	SWM Pond Outlet Structure	Concrete = 55.38	0.013
S52	Corrugated Steel Pipe	Corrugated Steel Pipe = 55.38	0.024
S55	Natural Channel, Concrete	Natural Channel = 25.42 Concrete = 28.674	0.023
S56	Concrete	Concrete = 109.78	0.013
S57	Concrete Dam		

Roughness:

Natural Channel = 0.035

Concrete = 0.013

Corrugated Steel Pipe = 0.024

Bricked Concrete = 0.05

Sample Calculations

$$\textbf{Length Weighted Roughness of Structure} = \frac{\mathbf{L1 * N1 + L2 * N2 + \cdots + Ln * Nn}}{\mathbf{L1 + L2 + \cdots + Ln}}$$

$$\mathbf{nS1} = \frac{\mathbf{14.139 * 0.035 + 16.234 * 0.013}}{\mathbf{14.139 + 16.232}} = \mathbf{0.023}$$

$$\mathbf{nS2} = \frac{\mathbf{69.504 * 0.035 + 74.854 * 0.013}}{\mathbf{69.504 + 74.845}} = \mathbf{0.024}$$

Table B.3

Unionville 2D: Comparison of Survey Point Elevations vs LiDAR Elevations

Checking Point	Locations	Survey Elevations (m)	LiDAR Elevations (m)	Differences (m)
1	Left of U/S Face of Rouge at Birchmount	178.823	178.806	-0.017
2	Rouge West of Denby Crt.	170.288	170.301	0.013
3	Rouge U/S of Kennedy Road	169.880	169.887	0.007
4	Bruce D/S of Too Good Pond	171.279	171.311	0.032
5	Rouge U/S of Burndenet Creek Confluence	168.725	168.712	-0.013
6	Burndenet Creek U/S of C.N.R.	172.589	172.595	0.006
7	Rouge U/S of Burndenet Confluence	168.458	168.469	0.011
8	Rouge U/S of South Unionville Tributary Confluence	170.884	170.853	-0.031
9	Rouge D/S of McCowan Road	167.483	167.485	0.002

Table B.4 Underwater Channel Elevation Adjustment Depth

Reach	Segment Location	Adjustment Polygon Extent	Adjustment Depth Range (m)
R1 (Rouge River)	U/S Rouge to U/S CNR	Outer, Middle, Inner	0.12 – 0.36
	U/S CNR to D/S Main St. Unionville	Outer, Middle, Inner	0.18 – 0.55
	D/S Main St. Unionville to D/S HWY 7	Outer, Middle, Inner	0.20 – 0.60
	D/S HWY 7 to U/S of South Unionville Trib.	Outer, Middle, Inner	0.5 – 1.5
	U/S of South Unionville Trib. to U/S Milne Pond	Outer, Middle, Inner	0.58 – 1.75
R2 (Tributary 4)	Tributary 4	Outer, Inner	0.05 – 0.1
R3 (Tributary 5)	Tributary 5	Outer, Inner	0.05 – 0.14
R4 (Fonthill Reach)	Fonthill Reach	Outer, Inner	0.16 – 0.31
R5 (Bruce Creek)	U/S Bruce to U/S Too Good Pond	Outer, Inner	0.15 – 0.30
	U/S Too Good Pond to Rouge Confluence	Outer, Inner	0.34 – 0.67
R6 (Bruce Tributary)	Bruce Tributary	Outer, Inner	0.1 – 0.2
R7 (Burndenet Creek)	Burndenet Creek	Single Polygon	0.16
R8 (South Unionville Tributary)	South Unionville Trib.	Single Polygon	0.05
R9 (Milne Reach)	Milne Reach	Single Polygon	0.49

APPENDIX 'C'

Flow Data and MIKE FLOOD Boundaries

Unionville SPA 2D Modelling Study and Floodplain Mapping Update

Toronto and Region Conservation Authority

Appendix 'C' Contents:

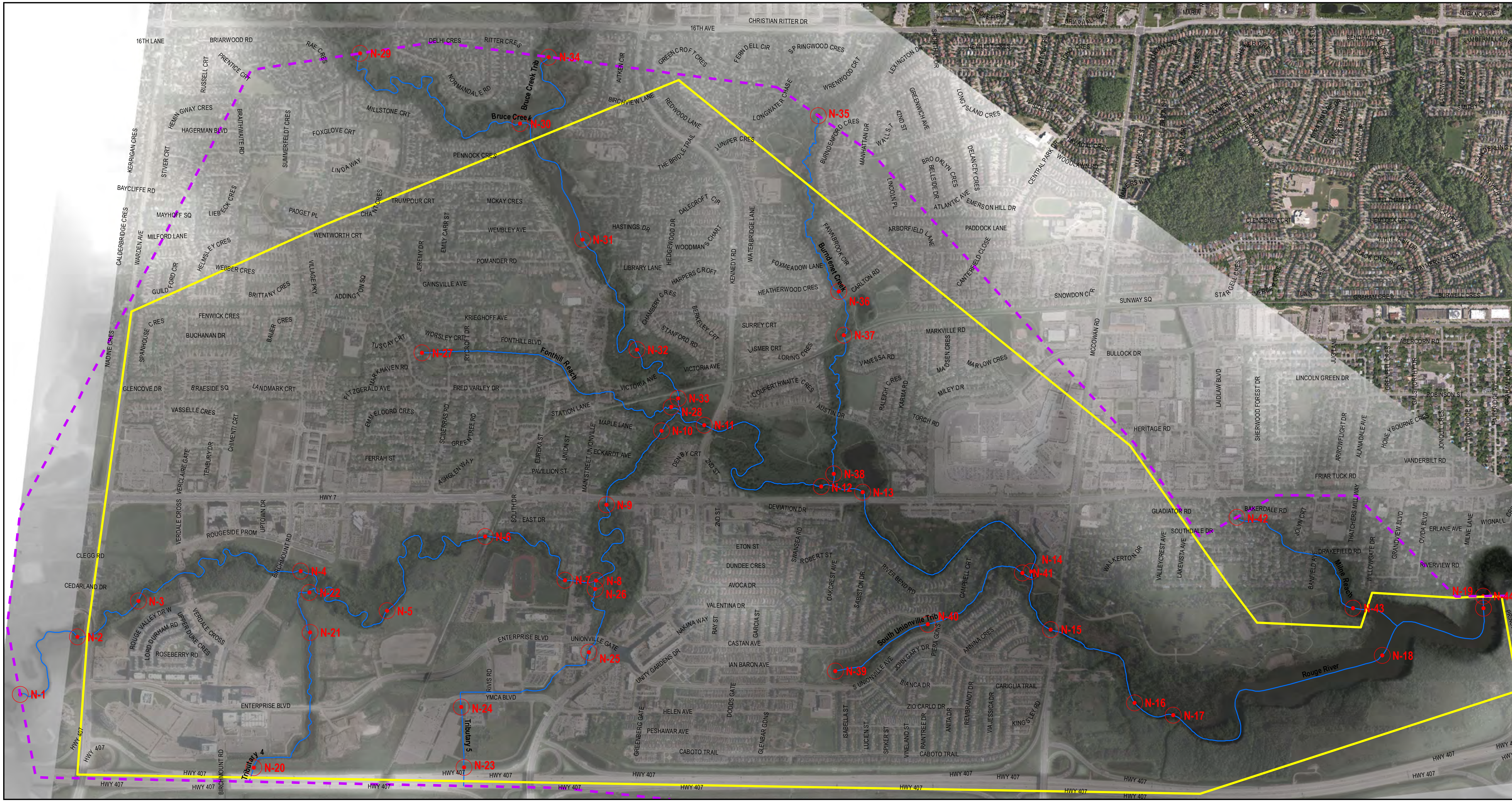


Figure C.1

MIKE FLOOD INFLOW INPUT AND BOUNDARY LOCATIONS

0 250 500 1,000 Meters

18 December 2018

LEGEND

- Study Area
- 2D Model Extent
- River Network (in MIKE FLOOD)
- Flow Input and Boundary Locations

N

TORONTO AND REGION CONSERVATION AUTHORITY

UNIONVILLE SPA 2D MODELLING STUDY AND FLOODPLAIN MAPPING UPDATE

Toronto and Region Conservation Authority

Est. 1992 VALDOR

Elevation (m)	Total Discharge (m^3/s)
163.4	0
163.6	0
163.6	1.2
163.7	1.9
163.8	2.5
163.9	2.9
164.0	3.2
164.1	3.6
164.2	3.9
164.3	4.2
164.4	4.4
164.5	4.7
164.6	4.9
164.7	5.1
164.8	5.4
164.9	5.6
165.0	5.7
165.2	6.2
165.5	6.7
165.9	7.2
166.0	7.4
166.2	7.7
166.5	8.1
166.8	8.5
167.0	8.8
167.1	8.9
167.4	24.6
167.7	53.1
168.0	91.1
168.3	133.8
168.6	183.6
168.9	238.7
169.0	257.4
169.2	298.7
169.5	363.4
169.8	432.5
170.0	475.9
170.1	505.6
170.4	582.8
170.7	663.7
171.0	748.3
171.3	836.5
171.6	1039
172.0	1194
172.3	1326.1
172.6	1498.6
172.9	1685.4
173.0	1771.6
173.2	1884.7
173.5	2095.5
173.8	2317
174.0	2482.7
174.1	2548.5
174.4	2789.6
174.7	3039.7
175.0	3298.5
175.3	3565.6

Table C.1 Milne Dam Q-H Boundary

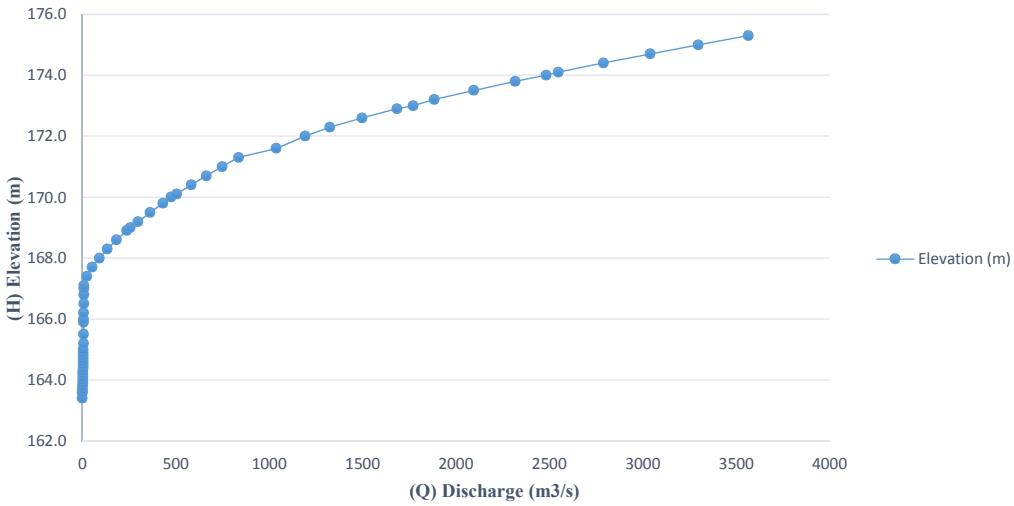


Table C.1
Q-H Boundary at Milne Dam

UNSTEADY INFLOW HYDROGRAPH (HURRICANE HAZEL)

N

18 December 2018

TORONTO AND REGION CONSERVATION AUTHORITY

UNIONVILLE SPA 2D MODELLING STUDY
AND FLOODPLAIN MAPPING UPDATE

Toronto and Region Conservation Authority

VALDOR

Elevation (m)	Total Discharge (m^3/s)
168.75	0
168.45	0
169.52	0.21
169.55	0.36
169.6	0.67
169.65	1.06
169.7	1.51
169.75	2.03
169.8	2.61
169.84	3.12
169.9	3.96
169.95	4.3
170.03	5
170.21	8
170.36	11
170.5	14
170.64	17
170.81	20
171	23
171.21	25

Table C.2 Control Structure Q-H Curve

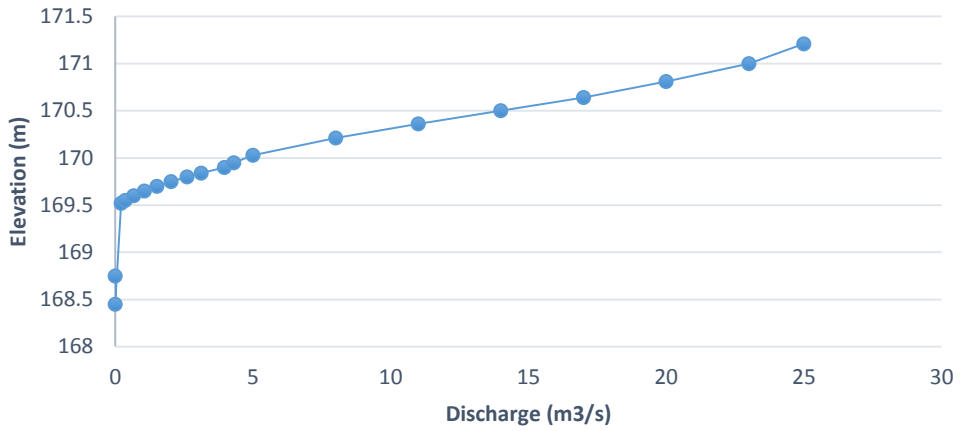


Table C.2
Control Structure Rating Curve
- South Unionville SWM Pond
UNSTEADY INFLOW HYDROGRAPH (HURRICANE HAZEL)

N

18 December 2018

TORONTO AND REGION CONSERVATION AUTHORITY
UNIONVILLE SPA 2D MODELLING STUDY
AND FLOODPLAIN MAPPING UPDATE

Toronto and Region Conservation Authority

VALDOR

Toronto and Region Conservation for The Living City®

TO:	Ying Qiao	DATE:	March 7, 2019
FROM:	Wilfred Ho	CFN:	*TBD*
RE:	*2018 Unionville SPA 2D Study and Floodplain Mapping Update* Development of Flow Input		
CC:			

Background:

Toronto and Region Conservation Authority (TRCA) uses calibrated and validated watershed-scale hydrologic modelling to provide flow data in support of regulatory floodplain mapping. Updates to such modelling exercises typically occur on an approximate 10-year cycle, depending on available information (e.g. significant rainfall events) and watershed needs (e.g. SWM criteria for subwatershed planning). For the Rouge River watershed, the most recent hydrology update was finalized in December of 2018, which superseded the previous work completed in 2002. With updated watershed hydrologic information, as well as the availability of newer basemapping and other geographic information products, it is typical practice to update the respective floodplain maps and supporting hydraulic modelling. In June of 2018, TRCA retained Valdor Engineering Ltd. to update the floodplain mapping for the Unionville Special Policy Area (SPA) in the City of Markham; the study area is highly urbanized, roughly bounded by Warden Avenue to the west, 16th Avenue to the north, Highway 7 to the south, and the eastern boundary falls between McCowan Road and Main Street Markham (**Figure 1**, below)

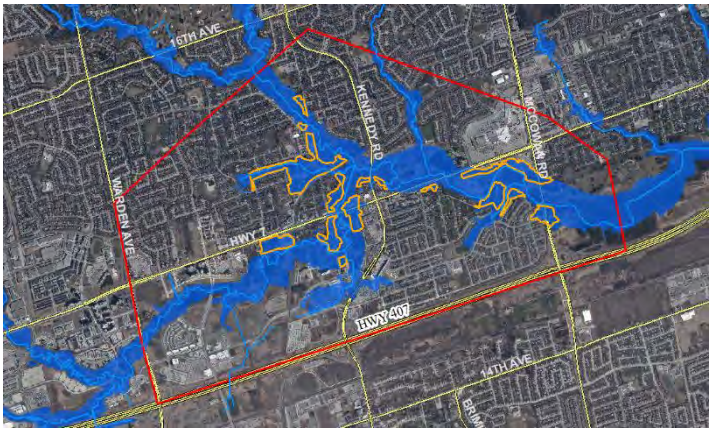


Figure 1 - Unionville SPA 2D modelling and floodplain mapping update study area

Introduction:

The study area terminates at the control structure of the Milne Dam, which has an upstream drainage area of approximately 152km^2 (nearly half of the entire watershed) and contains the confluence of several large tributaries over a short distance. The Bruce and Berczy Creeks join southwest of 16th Avenue and Kennedy Road (thereafter referred to as Bruce Creek), this reach then travels about 1.5km before joining with Fonthill Creek followed by Beaver Creek a short distance after (<30m downstream). TRCA staff decided that floodplain mapping using the 2-dimensional MIKE modelling platform would be the best option for navigating the potential hydraulic complexities of this system, thereby replacing the current 1-dimensional, steady-state HEC-RAS modelling.

MIKE Model Development:

The model set-up applies time series flow data to coupled LiDAR-derived 2D floodplain bathymetry and 1D channel cross-sections. In maintaining the steady flow assumption typical of floodplain mapping practice in TRCA jurisdiction, initial runs of the MIKE model applied pseudo-steady flow hydrographs to specific points along the watercourse; total discharge hydrographs were applied at inflow boundaries and point source hydrographs were used to represent lateral flow contributions from adjacent catchments. In contrast to applying an instantaneous peak flow value from the hydrologic model that is the procedure for the current HEC-RAS modelling, a pseudo-steady hydrograph applies an arbitrary 1-hour “ramp-up” to the peak flow value (**Figure 2**, below); this prevents instabilities associated with the sudden “wetting” of 2D model elements. The peak is then held steady for the remainder of the simulation period.

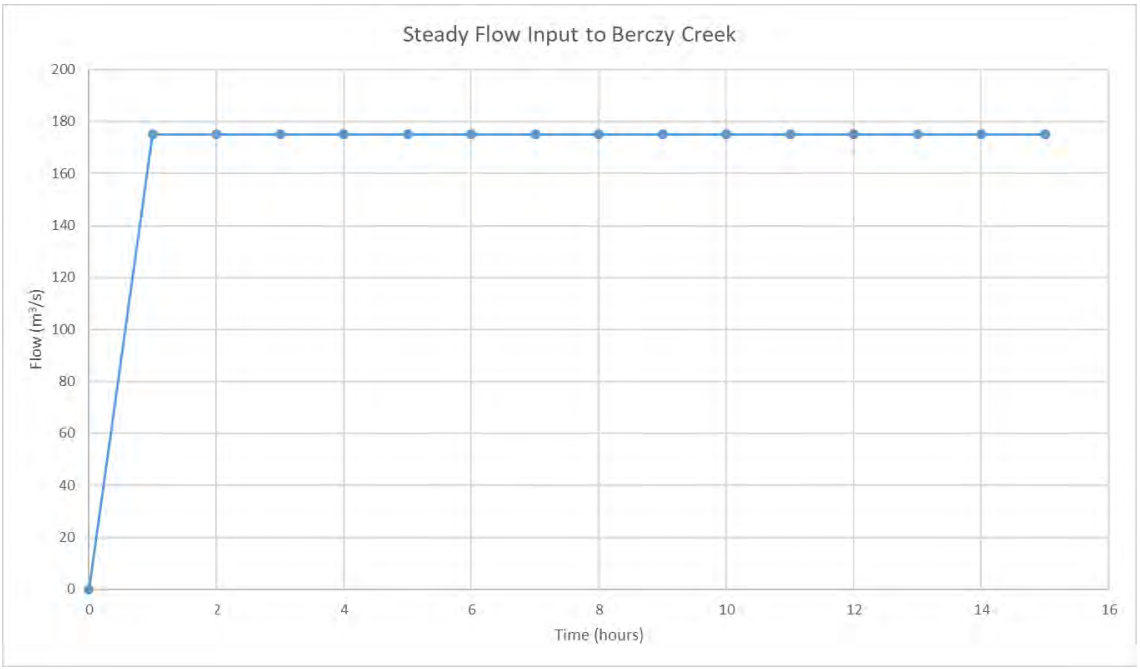


Figure 2 - A pseudo-steady state hydrograph for use in a coupled 1D-2D MIKE model

Steady-State Assumption versus Hydrologic Routing:

During initial runs of the model, TRCA and Valdor staff (i.e. project team) encountered issues

with reconciling outflows from the MIKE model with those from the equivalent hydrologic nodes for the same storm event. Specifically, the application of pseudo-steady state hydrographs does not account for hydrologic routing and therefore the peak flows stack on top of each other rather than reflect the watershed response predicted by the hydrologic modelling. From **Figure 3**, below, it can be seen that peak timing is a critical characteristic not captured by the pseudo-steady state approach, which instead exhibits linearity of flow increase with reach distance.

Figure 3 - Comparison of peak flows from hydrology nodes to pseudo-steady state hydrographs

By overlaying orthographic imagery with the watercourse centreline, it can be seen that multiple small tributaries laterally connect urbanized subcatchments to the main branch. Given the hydrologic assumption of a uniformly distributed design storm, it is a reasonable expectation that the small urban subcatchments would drain quickly relative to the upstream drainage area contributing to the main branch. In short, the hydrologic response of the study area is more realistically reflected as a series of staggered hydrograph peaks rather than holding all flow contributing areas in a steady state and allowing the peaks to accumulate. This can be demonstrated using hydrograph outputs from the hydrologic model. **Figure 4** (below) compares the hydrographs of individual tributaries (Bruce, Fonthill and Beaver Creeks) with the hydrograph from the confluence point; for demonstrative purposes, hydrographs from simulation of the 100-year design storm were plotted. **Figure 5** is the location map for the confluence of the aforementioned tributaries.

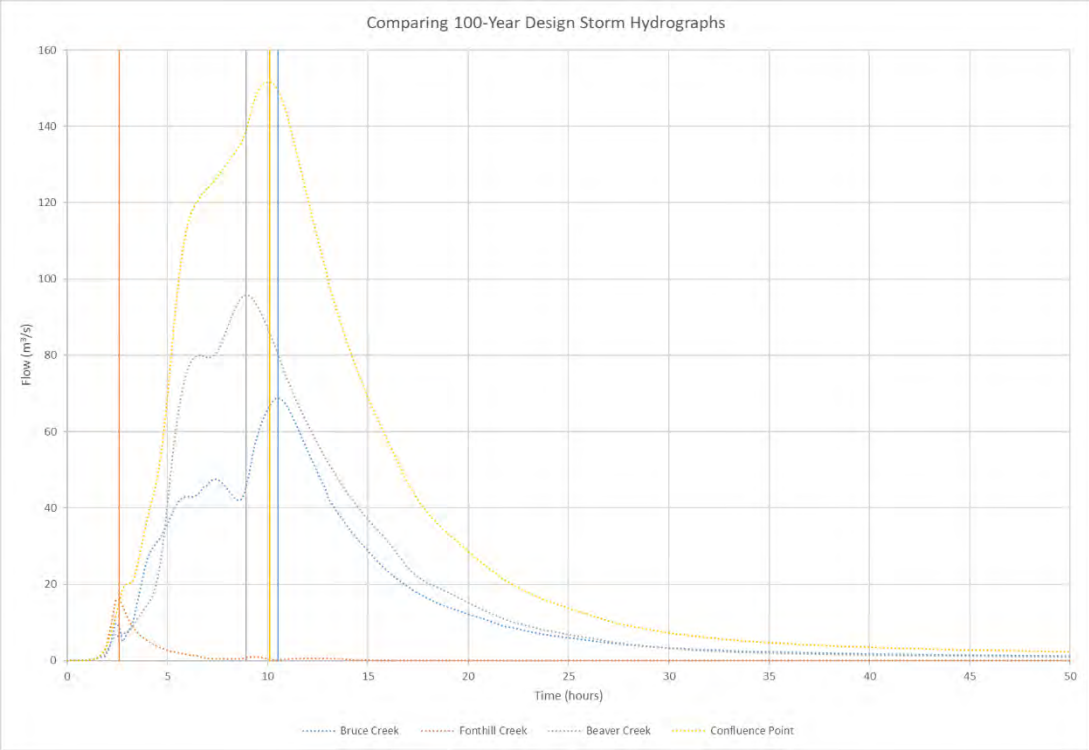


Figure 4 - Staggered peak timing due to hydrologic routing

Figure 5 - Location map for the confluence of the Bruce, Fonthill and Beaver Creeks

The stacking of hydrograph peaks irrespective of hydrologic routing has ramifications for floodplain mapping. The accumulated flows start to exceed channel capacity more rapidly than the modelled hydrologic response, generating greater floodplain extents for the same design

event. To illustrate this issue, MIKE simulations were run with two sets of flow information from the Regional storm hydrologic model. The first set of information preserves the peak hydrologic response by applying negative flow values throughout the system such that outflow from the study area matches that from its respective hydrologic node; the second set of information used the pseudo-steady state hydrograph approach. **Figure 6** (below) gives an example of applying negative flow values to a stacked hydrograph in order to generate a resultant hydrograph that matches the hydrologic peak. The basis for applying negative flow is that as a flood wave is observed at a confluence point and routes through the drainage network without lateral contributions, the hydrograph may broaden and the peak flow observed at a distal downstream node may be lower; going in the downstream direction, the difference between peaks at the two observation points would be negative.

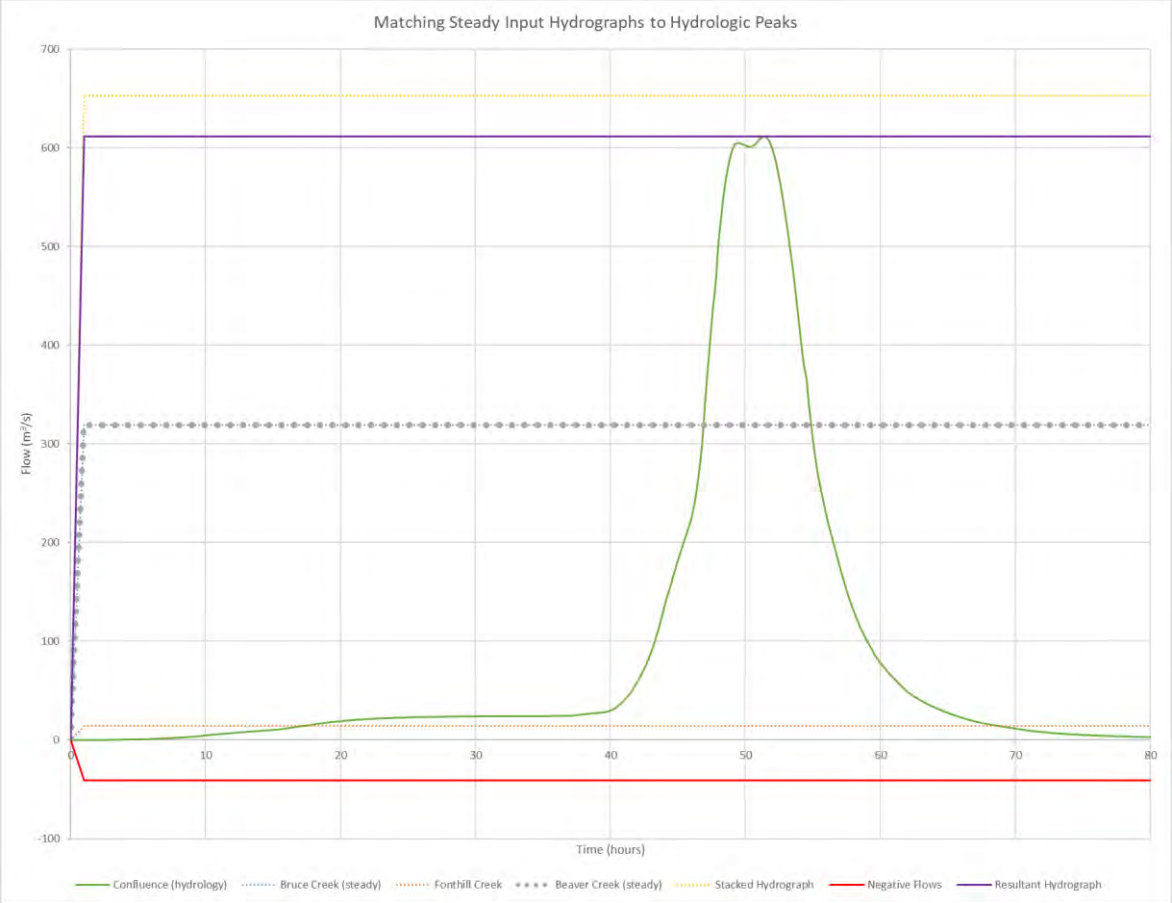


Figure 6 - Applying negative flow values to a stacked hydrograph in order to match the hydrologic peak

Results from the simulations were plotted on a grid along with building footprints and the current regulatory floodplain delineation (**Figure 7**, below). It is evident that the same basic flow information from hydrologic modelling can produce different flood extents depending on how the hydrologic response is interpreted in the hydraulic model framework, which in turn has regulatory implications and also how the 2D model results will tie into the 1D model results downstream of the study area. While the application of negative flow values was able to reconcile the steady-state assumption underpinning the hydraulic model with hydrologic routing and produce a more reasonable estimate of floodplain extents than using pseudo-steady state flow input, there is no physical basis for doing so. Conversely, applying the steady-state

assumption to the 2D modelling framework disregards the hydrologic response from the network of small, urbanized tributaries in the study area. However, the effect of momentum exchange on floodplain extents as flow moves through the tight network of crossings and the confluence of the Bruce, Fonthill and Beaver Creeks was not explicitly analyzed using the previous energy-based 1D approach. After testing the validity of a pseudo-steady state approach and that of applying negative flows, the project team agrees that there is sufficient rationale for applying hydrograph information from the hydrologic modelling, running the hydraulic simulations with the assumption of unsteady state, and plotting the maximum flood extents within the simulation period as the regulatory floodline for the Unionville SPA.

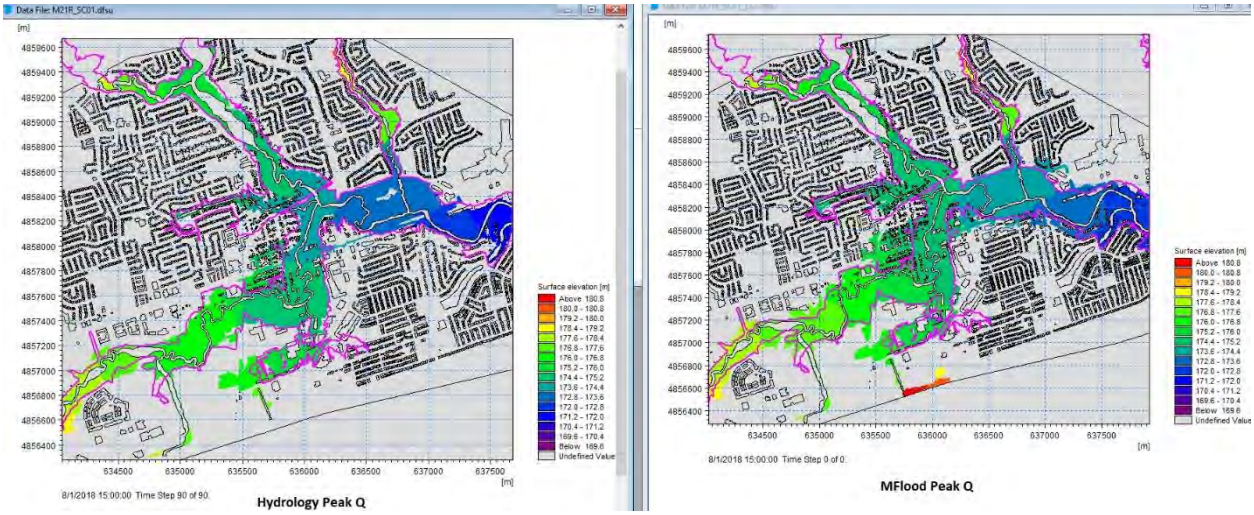


Figure 7 - Floodplain extents based on hydrologic peaks (left) and stacked hydrograph peaks (right) compared to current regulatory floodplain

Developing Input Hydrographs for Unsteady State Simulations

The updated Rouge hydrology is highly discretized (**Figure 8**, below); in the model space, small (~35ha) catchments are connected laterally to junctions, which connect segments of conceptual routing elements (i.e. cross-sectional geometry) into an idealized channel network. Routing losses are computed based on the so-called “dampened” dynamic wave routine, a variation of the Saint-Venant equation in which the inertial terms are gradually ignored as the Froude Number approaches a value of 1. Junctions convolute the runoff hydrograph(s) with routed upstream flows, then the resultant hydrograph is routed downstream to the next node until downstream boundary of the model domain (i.e. outfall to Lake Ontario).

Input hydrographs for MIKE simulations were initially extracted based two categories, total flows (i.e. inflow boundary data from closest hydrologic node) and lateral flows (i.e. runoff hydrographs from catchments). This approach resulted in 53 input hydrographs. Since a number of lateral flows can also be distributed along the channel in MIKE, TRCA staff aggregated 16 input hydrographs into 6 based on proximity of respective nodes and flow volume. These extraction points are common to Regional and Design storm hydrologic model builds. In order to account for the Areal Reduction Factors (ARFs) applied to Regional storm hydrologic model, TRCA staff extracted hydrographs from two major areas: the upstream study area limit to Kennedy Road, which has a ARF of 0.954, and from Kennedy Road to the downstream limit of the study area, which has a ARF of 0.948; note that these ARFs were maintained for extracting/aggregating lateral flow hydrographs.

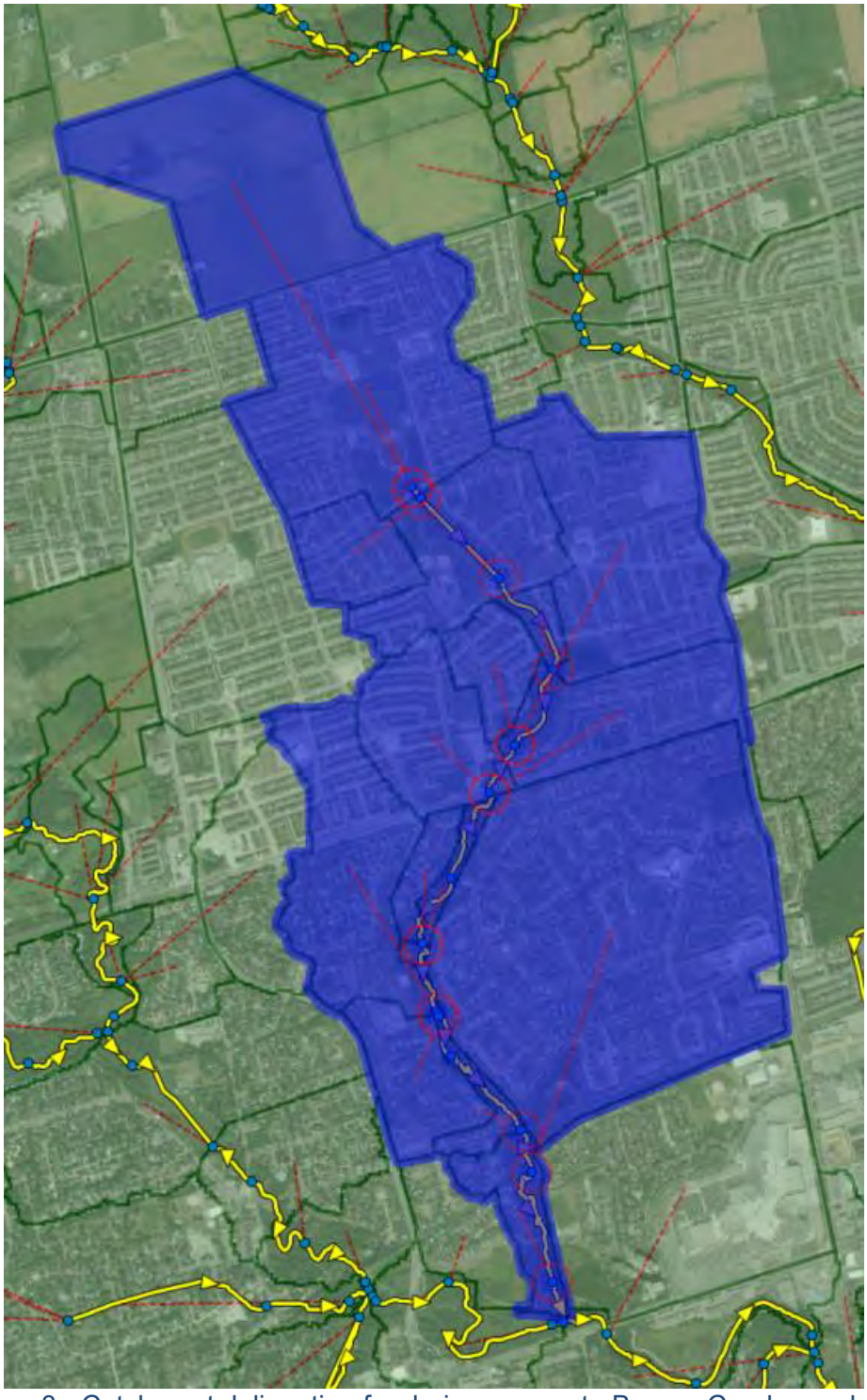


Figure 8 - Catchment delineation for drainage area to Beaver Creek, reach 4-1

Fonthill Creek

Between the 2002 and recent hydrology update, the peak response to the Regional storm at Fonthill Creek decreased 46% from 26.573m^3/s to 14.308m^3/s. Furthermore, a transposed peak flow value of 23.470 m^3/s was used in the previous floodplain mapping exercise. Using the

updated flow information, the initial unsteady simulation produced a significantly narrower Regulatory flood extent than currently mapped (similar to **Figure 7**, left pane). Given the consistent rainfall input and ARF between the previous and recent hydrology update, as well as the limited opportunities for increasing imperviousness in the upstream drainage area due to landuse planning, TRCA staff investigated potential reasons for the observed reduction in peak flow value.

The most significant change with the recent hydrology update is the catchment area delineation. **Figure 9** (below) shows a 28% decrease in total catchment area from 295.46ha in the previous model to 213.18ha currently and imperviousness has changed slightly from 40% to 47%. Moreover, catchment connectivity and routing are conceptually different.

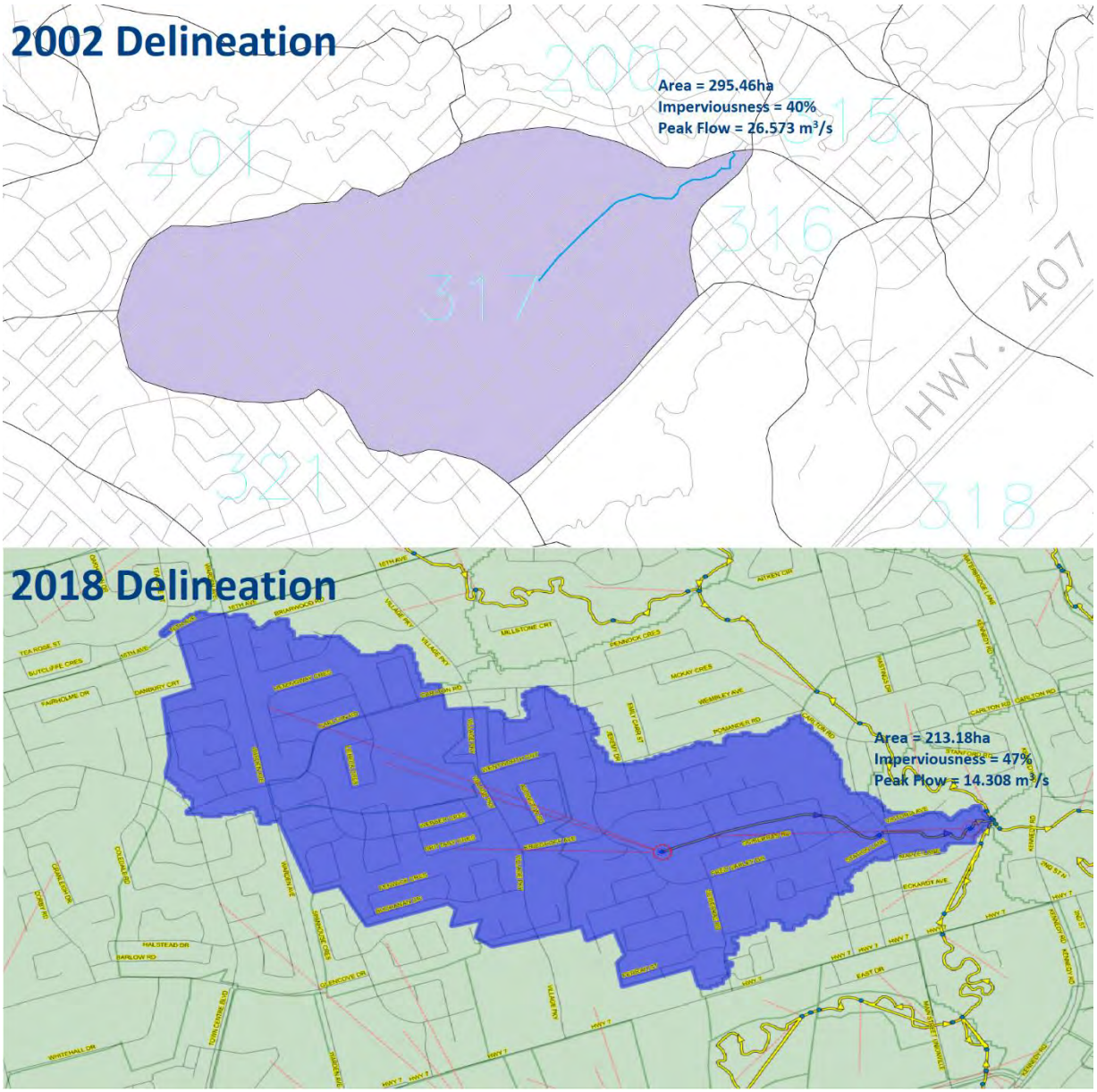


Figure 9 - Change in delineation of catchment area to Fonthill Creek

The 2002 hydrology conceptualized the drainage area to Fonthill Creek as a large, homogenous catchment connected to one node, whereas the 2018 update conceptualizes the drainage area as four catchments, three of which are connected to one node the top of Fonthill Creek and routed downstream to the join the fourth catchment at another node. Furthermore, the former approach estimated an overland flow length of 1403m on a large catchment while the estimates for overland flow length in the latter approach range from 739m to 4285m on smaller catchments; this affects peak timing and therefore the resultant hydrographs at nodes. To test the effect of catchment connectivity, all four catchments in the 2018 were connected to the same downstream node while maintaining the respective flow lengths. **Figure 10** (below) compares the hydrographs for the 2002 hydrology, 2018 update, and the 2018 update with the four catchments connected to the same node.

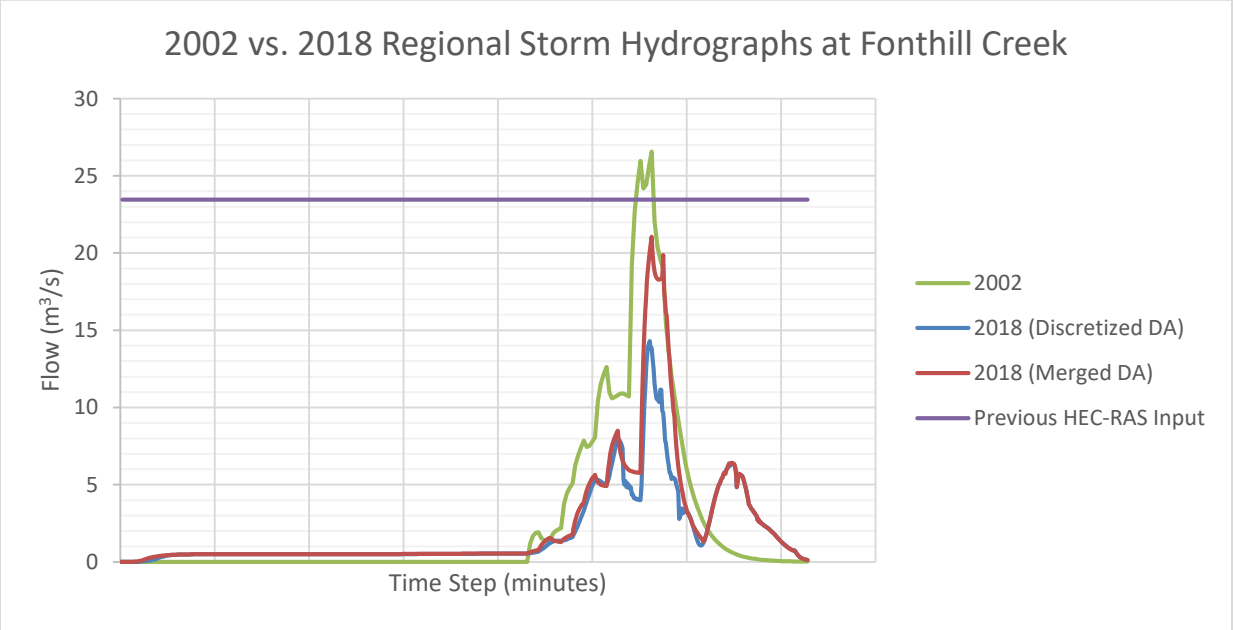


Figure 10 - Comparison of 2002 and 2018 hydrographs at Fonthill Creek

Connecting the four catchments contributing to Fonthill Creek in the 2018 model provides a comparable model schematic to that used in 2002; this resulted in a peak flow value of 21.051m^3/s. To relate this result to imperviousness, **Table 1** (below) compares the impervious area unitary peak flow; connecting the four catchments to one node in the 2018 model produced a virtually identical impervious area unitary peak flow value to the 2002 model.

Table 1 - Impervious area unitary flows for 2002 and 2018 hydrologic models

Scenario	Total Drainage Area (ha)	Imperviousness	Peak (m^3/s)	Unitary Flow (m^3/s per impervious hectare)
2002	295.46	40%	26.573	0.22
Previous HEC-RAS	250.38 (estimated)[1]	40%	23.470	0.23
2018	213.18	47%	14.308	0.14
2018 (one node)	213.18	47%	21.051	0.21

[1] Transposition area back-calculated using MTO flood transposition equation from ratio of 2002 hydrologic output and previous HEC-RAS input.

Lastly, the dynamic wave loss routine applied in the 2018 update was tested for the sensitivity of the inertial terms. The approved update “dampens” the inertial terms, as discussed in a previous section, and produces a peak value of 14.308m^3/s. Keeping the inertial terms produced a peak flow value of 14.311m^3/s, while ignoring them (i.e. diffusive wave variation of the Saint-Venant equation) produced a peak flow value of 14.286 m^3/s. With a standard deviation of 0.01m^3/s, the variation of the dynamic wave routing routine has an insignificant effect on the peak flow value in Fonthill Creek.

Conclusions

After several attempts to reconcile the conventional steady state assumption with the routing effects predicted by the hydrologic model, the project team is in agreement that the most reasonable compromise for balancing the need for conservatism in floodplain mapping with modelling the hydraulic complexities of the Unionville SPA is to run unsteady MIKE simulations and map the maximum flood extents. The unsteady flow information was extracted from key locations for total and lateral flow in the most recent hydrologic model; for the Regional storm, two major areas were identified wherein ARFs were considered. Initial runs of the unsteady model based on the updated flow information produced a significantly different delineation of the floodplain at Fonthill Creek due to a significant decrease in flow compared to the previous hydrologic model. Further investigation revealed that the major factors contributing to this decrease in the updated hydrologic model are 1) smaller total drainage area; 2) finer discretization with longer average overland flow length; and 3) change in conceptualization of catchment connectivity and routing.

Should there be further questions or concerns, please do not hesitate to contact me.

Wilfred Ho

Extension 5738