APPENDIX A

NASSCO PACP Condition Grading System Code Matrix

NASSCO PACP Condition Grading System
Code Matrix

Family	Group	Descriptor	Modifier	Code	Structural Grade	O&M Grade
Structural	Crack (C)	Circumferential (C)		CC	1	
		Longitudinal (L)		CL	2	
		Multiple (M)		CM	3	
		Spiral (S)		CS	2	
Structural	Fracture (F)	Circumferential (C)		FC	2	
		Longitudinal (L)		FL	3	
		Multiple (M)		FM	4	
		Spiral (S)		FS	3	
Structural	Pipe Failures (Silent)	Broken (B)		B	1 clock pos – 3.2 clock pos – 4 >=3 clock pos – 5	
		Broken (B)	Soil Visible (SV)	BSV	5	
		Broken (B)	Void Visible (VV)	BVV	5	
		Hole (H)		H	1 clock pos – 3.2 clock pos – 4, >=3 clock pos – 5	
		Hole (H)	Soil Visible (SV)	HSV	5	
		Hole (H)	Void Visible (VV)	HVV	5	
Structural	Collapse (X)	Pipe (P)		XP	5	
		Brick (B)		XB	5	
Structural	Deformed (D)	(Pipe) (P)		D	<=10% - 4.>10% - 5	
		Brick (B)	Horizontally (H)	DH	5	
		Brick (B)	Vertically (V)	DV	5	
Structural	Joint (J)	Offset (displaced) (O)	Med (M)	JOM	1	
			Large (L)	JOL	2	
		Separated (open) (S)	Med (M)	JSM	1	
			Large (L)	JSL	2	
		Angular (A)	Med (M)	JAM	1	
			Large (L)	JAL	2	
	Surface Damage Chemical (S)	Roughness Increased (R)	C	SRIC	1	
		Surface Spalling (SS)	C	SSSC	2	
		Aggregate Visible (AV)	C	SAVC	3	
		Aggregate Projecting (AP)	C	SAPC	3	
		Aggregate Missing (AM)	C	SAMC	4	
		Reinforcement Visible (RV)	C	SRVC	5	
		Reinforcement Corroded (RC)	C	SRCC	5	
		Missing Wall (MW)	C	SMWC	5	
		Other (Z)	C	SZC		

NASSCO PACP Condition Grading System
Code Matrix

Family	Group	Descriptor	Modifier	Code	Structural Grade	O&M Grade
	Surface Damage Mechanical (M)	Roughness Increased (R)	M	SRIM	1	
		Surface Spalling (SS)	M	SSSM	2	
		Aggregate Visible (AV)	M	SAVM	3	
		Aggregate Projecting (AP)	M	SAPM	3	
		Aggregate Missing (AM)	M	SAMM	4	
		Reinforcement Visible (RV)	M	SRVM	5	
		Reinforcement Corroded (RC)	M	SRCM	5	
		Missing Wall (MW)	M	SMWM	5	
		Other (Z)	M	SZM	N/A	
	Surface Damage Not Evident (Z)	Roughness Increased (R)	Z	SRIZ	1	
		Surface Spalling (SS)	Z	SSSZ	2	
		Aggregate Visible (AV)	Z	SAVZ	3	
		Aggregate Projecting (AP)	Z	SAPZ	3	
		Aggregate Missing (AM)	Z	SAMZ	4	
		Reinforcement Visible (RV)	Z	SRVZ	5	
		Reinforcement Corroded (RC)	Z	SRCZ	5	
		Missing Wall (MW)	Z	SMWZ	5	
		Other (Z)	Z	SZZ	N/A	
Structural	Surface Damage (Metal Pipes)	Corrosion (CP)		SCP	3	
	Lining Failure (LF)	Detached (D)		LFD	3	
		Defective End (DE)		LFDE	3	
		Blistered (B)		LFB	3	
		Service Cut Shifted (CS)		LFCS	3	
		Abandoned Connection (AC)		LFAC		
		Overcut Service (OC)		LFOC	3	
		Undercut Service (UC)		LFUC	3	
		Buckled (BK)		LFBK	3	
		Wrinkled (W)		LFW	3	
		Other (Z)		LFZ		
Structural	Weld Failure (WF)	Circumferential (C)		WFC	2	
		Longitudinal (L)		WFL	2	
		Multiple (M)		WFM	3	
		Spiral (S)		WFS	2	
Structural	Point Repair (RP)	Localized Lining (L)		RPL		
		Localized Lining (L)	Defective (D)	RPLD	4	
		Patch Repair (P)		RPP		

NASSCO PACP Condition Grading System
Code Matrix

Family	Group	Descriptor	Modifier	Code	Structural Grade	O&M Grade
		Patch Repair (P)	Defective (D)	RPPD	4	
		Pipe Replaced (R)		RPR		
		Pipe Replaced (R)	Defective (D)	RPRD	4	
		Other (Z)		RPRZ		
		Other (Z)		RPRZD		
Structural	Brickwork (Silent)	Displaced (DB)		DB	3	
		Missing (MB)		MB	4	
		Dropped Invert (DI)		DI	5	
			Slight	MMS	2	
			Medium	MMM	3	
			Large	MML	3	
O&M	Deposits Attached (DA)	Encrustation (E)		DAE		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Grease (G)		DAGS		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Ragging (R)		DAR		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Other (Z)		DAZ		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
	Deposits Settled (DS)	Hard/Compacted (C)		DSC		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Fine (F)		DSF		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Gravel (G)		DSGV		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Other (Z)		DSZ		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
	Deposits Ingress (DN)	Fines silt/sand (F)		DNF		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Gravel (GV)		DNGV		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Other (Z)		DNZ		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
O&M	Roots (R)	Fine (F)	Barrel (B)	RFB		2
			Lateral (L)	RFL		1
			Connection (C)	RFC		1
	Roots (R) at a Joint		N/A	RF		1
		Tap (T)	Barrel (B)	RTB		3

NASSCO PACP Condition Grading System
Code Matrix

Family	Group	Descriptor	Modifier	Code	Structural Grade	O&M Grade
			Lateral (L)	RTL		2
			Connection (C)	RTC		2
	Roots (R) at a Joint		N/A	RT		2
		Medium (M)	Barrel (B)	RMB		4
			Lateral (L)	RML		3
			Connection (C)	RMC		3
	Roots (R) at a Joint		N/A	RM		3
		Ball (B)	Barrel (B)	RBB		5
			Lateral (L)	RBL		4
			Connection (C)	RBC		4
	Roots (R) at a Joint		N/A	RB		4
O&M	Infiltration (I)	Weeper (W)		IW		2
		Dripper (D)		ID		3
		Runner (R)		IR		4
		Gusher (G)		IB		5
O&M	Obstacles/Obstructions (OB)	Brick or Masonry (B)		OBB		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Pipe Material in Invert (M)		OBM		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Object Protruding Thru Wall (I)		OBI		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Object Wedged in Joint (J)		OBJ		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Object Thru Connection (C)		OBC		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		External Pipe or Cable in Sewer (P)		OBP		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Built into Structure (S)		OBS		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Construction Debris (N)		OBN		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Rocks (R)		OBR		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Other Objects (Z)		OBZ		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
O&M	Vermin (V)	Rat (R)		VR		2
		Cockroach (C)		VC		1
		Other (Z)		VZ		1
Construction Features	Tap (T)	Factory Made (F)		TF		

NASSCO PACP Condition Grading System
Code Matrix

Family	Group	Descriptor	Modifier	Code	Structural Grade	O&M Grade
			Capped (C)	TFC		
			Defective (D)	TFD		2
			Intruding (I)	TFI		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
			Active (A)	TFA		
		Break-In/Hammer (B)		TB		
			Capped (C)	TBC		2
			Defective (D)	TBD		3
			Intruding (I)	TBI		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
			Active (A)	TBA		
		Saddle (S)		TS		
			Capped (C)	TSC		
			Defective (D)	TSD		2
			Intruding (I)	TSI		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
			Active (A)	TSA		
Construction Features	Intruding Seal Material (IS)			IS		
		Sealing Ring (SR)		ISSR		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
			Hanging	ISSRH		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
			Broken	ISSRB		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Grout (GT)		ISGT		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Other (Z)		ISZ		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
Construction Features	Line (L)	Left (L)		LL		<=10 Deg – 1, <=20 Deg 2, >20 Deg – 4
		Left/Up (LU)		LLU		<=10 Deg – 1, <=20 Deg 2, >20 Deg – 4
		Left/Down (LD)		LLD		<=10 Deg – 1, <=20 Deg 2, >20 Deg – 4
		Right (R)		LR		<=10 Deg – 1, <=20 Deg 2, >20 Deg – 4
		Right/Up (RU)		LRU		<=10 Deg – 1, <=20 Deg 2, >20 Deg – 4
		Right/Down (RD)		LRD		<=10 Deg – 1, <=20 Deg 2, >20 Deg – 4

NASSCO PACP Condition Grading System
Code Matrix

Family	Group	Descriptor	Modifier	Code	Structural Grade	O&M Grade
		Up (U)		LU		<=10 Deg – 1, <=20 Deg 2, >20 Deg – 4
		Down (D)		LD		<=10 Deg – 1, <=20 Deg 2, >20 Deg – 4
Construction Features	Access Points (A)	Cleanout (CO		ACO		
			Mainline (M)	ACOM		
			Property (P)	ACOP		
			House (H)	ACOH		
		Discharge Point (DP)		ADP		
		Junction Box (JB)		AJB		
		Meter (M)		AM		
		Manhole (MH)		AMH		
		Other Special Chamber (OC)		AOC		
		Tee Connection (TC		ATC		
		WW Access Device (WA)		AWA		
		Wet Well (WW)		AWW		
Other	Miscellaneous (M)	Camera Underwater (CU)		MCU		4
		Dimension/Diam/Shape Change (SC)		MSC		
		General Observation (GO)		MGO		
		General Photograph (GP)		MGP		
		Material Change (MC)		MMC		
		Lining Change (LC)		MLC		
		Joint Length Change (JL)		MJL		
		Survey Abandoned (SA)		MSA		
		Water Level (WL)		MWL		
		Water Level (WL)	(S)	MWLS		<=30% - 2, <=50% - 3, >50% - 4
		Water Mark (WM)		MWM		>=50% 4, >=75% 5
		Dye Test (Y)		MY		
			Visible (V)	MYV		5
			Not Visible (N)	MYN		3

APPENDIX B

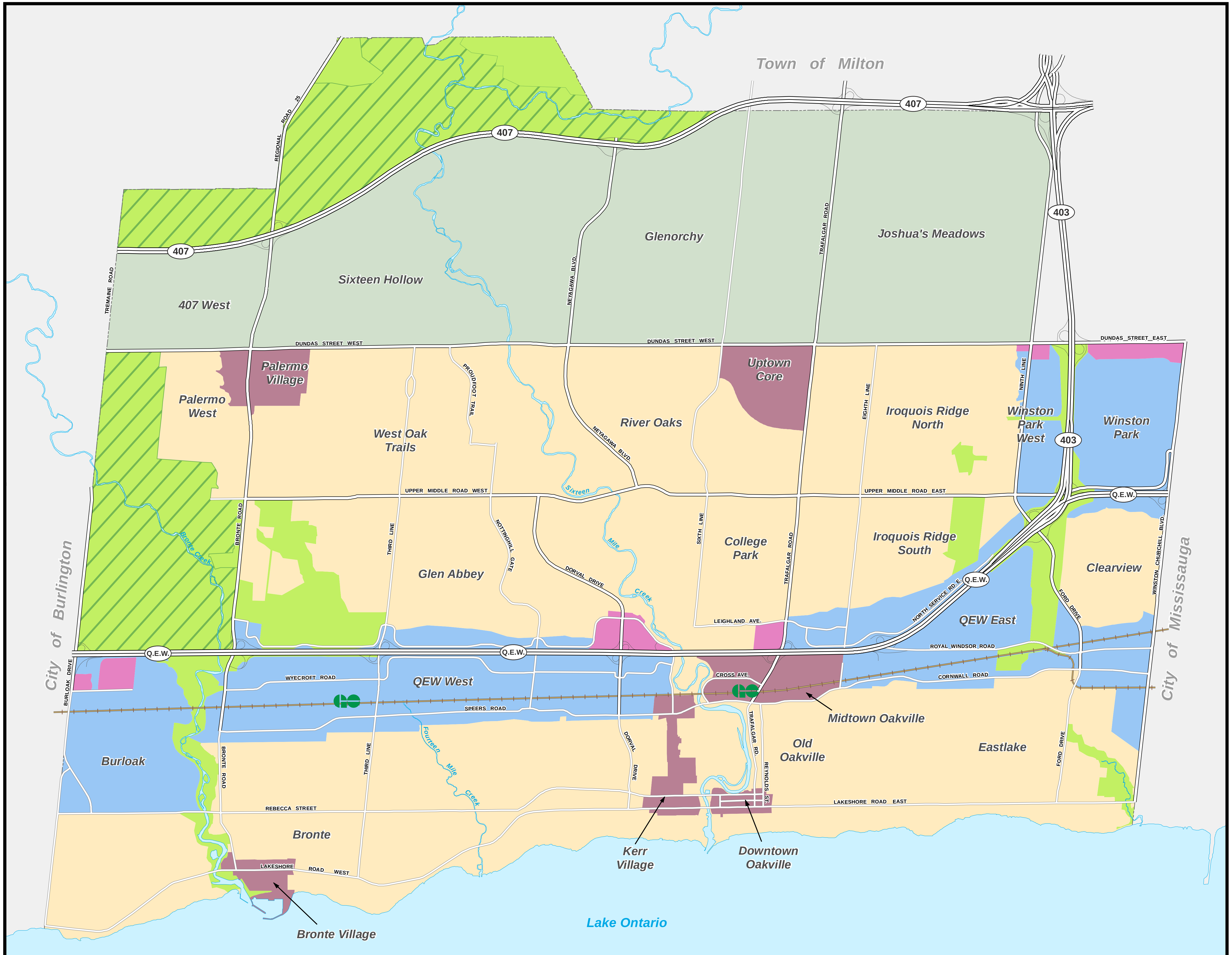
Town of Oakville Official Land Use Plan

Legend:
Urban Residential
Mixed Use
Employment
Commercial (excluding most NCC and CCC designations)
Central Business District and Uptown Business Core
Urban Special Study Area
Institutional
Parkland (over 6ha)
Private Open Space
Natural Area
Agricultural
Parkway Belt
Former Sanitary Landfill Site/ Waste Disposal Assessment Area
Interchange
NOTE: This figure forms part of the Official Plan and must be read together with the text and the accompanying tables at the front of this document.
FIGURE B
GENERAL LAND USE
Town of Oakville Official Plan
Planning Services Department
Technical Services Business Unit
September 2006
0 500 1000 1500 2000 2500
SCALE IN METRES
NORTH
TOWN OF MILTON
CITY OF BURLINGTON
CITY OF MISSISSAUGA
Lake Ontario
BRONTE CREEK PROVINCIAL PARK
LOWER BASE LINE
HWY. 407
BURNHAMTHORPE ROAD WEST
BURNHAMTHORPE ROAD EAST
DUNDAS STREET WEST
DUNDAS STREET EAST
UPPER MIDDLE ROAD
Q.E.W.
SPEERS ROAD
WYECROFT ROAD
C.N.R.
REBECCA STREET
LAKESHORE ROAD WEST
LAKESHORE ROAD EAST
CORNWALL ROAD
ROYAL WINDSOR DRIVE
TRAFALGAR ROAD
NEYAGAWA BLVD.
SIXTH LINE
EIGHTH LINE
NINTH LINE
TREMAINE ROAD
REGIONAL ROAD 25
THIRD LINE
FOURTH LINE
DORVAL DRIVE
KERR STREET
CHARTWELL ROAD
MORRISON ROAD
MAPLE GROVE DR.
FORD DRIVE
WINSTON CHURCHILL BLVD.
Sixteen Mile Creek
Bronte Creek
Joshua's Creek
R2

APPENDIX C

Schedule A1 to Liveable Oakville Plan

SCHEDULE A1
URBAN STRUCTURE



NOTE: This Schedule does not represent land use designations

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September 7, 2012

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APPENDIX D

Surveyed Storm Sewer Outfalls

Outfalls		Measurments				Photos	Elevations				Inverts	Comments
Pipe No.	Type	Ø Dia.	Width	Height	Type	Photo No.	Elev. 1	Type (1)	Elev. 2	Type (2)	Invert	Comments
30	Outfall	1.200			C.S.P.	1					75.23	
25	Outfall	0.600			Concrete	2					83.24	
6239	D.I.M.H.					3; 4	99.88	T/G			95.53	
22	Outfall	1.050			Concrete	5					88.51	
6240	Outfall	1.820			Concrete	6	93.68	H.W.			91.23	
6241	Outfall	1.540			Concrete	7	93.23	H.W.			91.05	
8415	Outfall					8					91.28	O/F #8415,16,17 Only 1 pipe found @ south end of pond. Photo is of south invert.
13217	Outfall	1.360			Concrete	9	92.02	H.W.			90.14	Southwest end of pond
13216	Outlet	1.050			Concrete	10; 11	93.14	Top	91.03	Weir	89.76	See photo or diagram form notes
2960	Outfall	0.700			Concrete	12	90.62	Top			89.30	
2959	Outfall	0.700			Concrete	13	90.48	H.W.			89.18	
19 a	Outfall	1.220			Concrete	14					104.06	See photo or diagram form notes for outfall configuration
19 b	Outfall	2.140			Concrete	14					103.84	See photo or diagram form notes for outfall configuration
19 c	Outfall	1.240			Concrete	14					103.95	See photo or diagram form notes for outfall configuration
18	Outfall	1.220			Concrete	74					102.45	
17	Outfall	1.200			Concrete	75					102.39	
15	Outfall		2.340	3.050	Conc. Box	15	114.39	Top			111.94	
34	Outfall		2.240	1.160	Conc. Box	16	78.21	Top			76.30	
11615	Outfall	0.450			PVC	17					79.62	
26	Outfall		2.440	1.240	Conc. Box	18	84.01	Top			82.06	
6623	Outfall		3.100	1.520	Conc. Box	19	83.40	Top			81.12	
28	Outfall	1.050			Concrete	20	83.35	Top			81.71	
29	Outfall	0.450			Concrete	21	81.46	Top			80.48	
11297	Outfall	1.200			Concrete	22					77.27	
31	Outfall	0.600			Concrete	23					-	
32	Outlet	0.450			Concrete	24					76.10	
48	Outfall	1.800			Concrete	25					75.31	
45	Outfall	0.300			Concrete	27	88.21	Top			87.31	
2961	Outfall	0.900			C.S.P.	26	88.68	Top			-	Vertical C.S.P. (Locked)
46	Outfall	0.750			Concrete	28	76.53	Top			75.13	
41	Outfall	0.700			C.S.P.	29					74.95	
42	Outfall	0.600			C.S.P.	31					76.00	
40	Outfall	1.500			Concrete	30	76.93	H.W.			75.02	
50	Outfall					32; 33					-	Not Found. Possible location buried. See Photos.
43	Outfall	0.600			C.S.P.	34	86.01	M/H L/D			75.91	
35	Outfall	0.600			Concrete	35			82.96	T.B.M.	-	
49	Outfall		2.000	1.000	Conc. Oval	36					89.12	
2320	Outfall		2.000	1.200	Conc. Oval	37	90.46	Top			88.28	
5535	Outfall	1.200			Concrete	38	108.28	Top			105.98	
6847	Outfall	1.200			Concrete	39	112.12	H.W.			110.44	
51	Outfall	0.450			Concrete	40	105.27	Top			104.12	
5855	Outfall	1.500			Steel	41	102.82	Top	106.51	T.B.M.	101.05	

Outfalls		Measurments				Photos	Elevations				Inverts	Comments
Pipe No.	Type	Ø Dia.	Width	Height	Type	Photo No.	Elev. 1	Type (1)	Elev. 2	Type (2)	Invert	Comments
299	Outfall	0.300			Big 'O'	42			108.23	T.B.M.	101.20	
300	Outfall	0.900			C.S.P.	43					102.18	
301	Outfall	0.450			Concrete	44					102.06	
302	Outfall	0.450			Concrete	45	102.43	Top			101.42	
7151	Outfall	1.200			Concrete	47					98.66	
303	Outfall	1.400			Concrete	46			98.07	T.B.M.	94.79	
44	Outfall	0.300			Concrete	48					76.13	
35	Outfall	0.600			Concrete	49			82.96	T.B.M.	79.91	
36	Outfall	0.600			C.S.P.	50					75.82	
37	Outfall	0.200			C.S.P.	51					78.45	Only pipe visable, see photo.
4258	Dutch Inlet	0.450			PVC	52					105.70	
329	Outfall	0.550			Concrete	53			85.32	T.B.M.	81.59	
328	Outfall	0.900			Concrete	54					80.70	
331	Outfall	1.800			Concrete	55					81.56	
3297	Outlet					56					-	Outlet not found See Photo for Location
3298	Outfall	0.370			PVC	57					87.45	
335	Outfall		1.800	1.050	Conc. Oval	58					90.50	
338	Outfall	0.800			Concrete	59					95.30	
6831	Outfall	0.750			Concrete	60					77.67	
39	Outfall	0.250			PVC	61					75.41	
316	Outfall	0.400			Concrete	62					76.51	
317	Outfall	0.450			C.S.P.	63					76.70	
318	Outfall		2.120	1.340	Conc. Oval	64	77.19	Top			75.44	See Photo to Confirm type of pipe
319	Outfall	0.600			Concrete	65					75.51	East of #318
321	Outfall	0.350			Big 'O'	66					75.69	
320	Outfall	0.850			Concrete	67					75.23	
314	Outfall	0.900			Concrete	68					75.47	
315	Outfall	0.450			C.S.P.	69					75.71	
313	Outfall		1.200	1.000	Conc. Box	70					77.02	See Photo
4256	Outfall	0.650			Concrete	71					82.96	
308	Outfall		1.700	1.040	C.S.P.A.	72					84.80	
323	Outfall	0.750			Concrete	73					77.70	
311	Outfall	0.450			Big 'O'	76					80.87	
312	Outfall					-					-	Only 1 pipe found
399	Outfall	0.400			PVC	77					80.21	
310	Outfall	0.450			Concrete	78					86.02	
307	Outfall	0.900			C.S.P.	79					90.26	
306	Outfall	0.600			C.S.P.	80					90.50	
309	Outfall	0.700			Concrete	81					88.21	
3295	Outfall	1.200			Concrete	82					82.61	
327	Outfall	0.450			Concrete	83					81.85	
324	Outfall	0.450			Concrete	84					78.11	

Outfalls		Measurments				Photos	Elevations				Inverts	Comments
Pipe No.	Type	Ø Dia.	Width	Height	Type	Photo No.	Elev. 1	Type (1)	Elev. 2	Type (2)	Invert	Comments
5231	Outfall	0.450			PVC	85					109.03	
229	Outfall					86					-	No outlet found, c.basin @ corner of property line. See Photo.
3938	Outfall					87					-	No outlet found @ south end of Dorval Road, See Photo
234	Outfall	0.250			PVC	88					85.14	
1375	Outfall	0.375			PVC	89					85.85	
334	Outfall	0.840			Concrete	90					82.85	
11616	Outfall	0.650			Concrete	91					81.61	
4575	Outfall	0.300			Concrete	92					77.30	
4576	Outfall					93					-	No outlet found at bend in road. See Photo. Must connect to new DW4 culvert
332	Outfall					94					-	With #333. Not found. New Devepolement present. See Photo.
333	Outfall					94					-	With #332. Not found. New Devepolement present.See Photo.
2976	Outfall	0.600			Concrete	96					79.53	With #2977. 2 outlets @ south side of road inlet north side.
2977	Outfall	1.220			Concrete	95					79.57	With #2976. 2 outlets @ south side of road inlet north side.
11	Outfall	1.220			Concrete	97					126.84	
4895	Outfall	0.300			PVC	98					79.21	
4896	Outfall	0.400			Concrete	99					79.00	
222	Outfall					100					-	Not Found (Buried?) Possible Location, see photo.
223	Outfall	1.220			Concrete	101					79.42	
226	Outfall	1.220			Concrete	102					77.65	
227	Outfall	0.600			Concrete	103					77.69	
228	Outfall	1.220			Concrete	104					-	
12	Outfall	1.220			Concrete	105					76.75	
133	Outfall	0.450			PVC	106; 108					75.55	(Ice/Snow). Looks like flow has been diverted to here, see photo 108.
134	Outfall	1.220			Concrete	107					75.02	
157	Outfall	1.200			Concrete	109					98.67	May be oval (iced over). Height and witdh = ±1.200

APPENDIX E

Climate Change Synopsis

Appendix E

Climate Change Synopsis

Subject: **Town of Oakville Storm Sewer Master Plan**
Discussion Paper for Climate Change Assessment

Introduction

The Town of Oakville, like other Municipalities across the Province, has recognized climate change as an emerging issue which could potentially affect the design of new and performance of existing Municipal infrastructure.

Town staff has worked with ICLEI (Local Governments for Sustainability) since 2011 to create and implement a town-wide Climate Change Adaptation Strategy through ICLEI's Canada's Changing Climates, Changing Communities municipal climate change adaptation program. This effort has resulted in the Town's Climate Change Strategy[1] (the "Strategy") published in September 2014.

The Strategy seeks to build the Town's resiliency to the impacts of a changing climate by:

1. increasing the Town's capacity to protect against and respond to projected climate change impacts;
2. educating through effective and efficient means of communication; and,
3. monitoring the implementation of adaptation actions and goals in order to make continuous operational improvements.

Consequently, as a component of Objective #1 above, an assessment has been included in this report (i.e. Town of Oakville Storm Sewer Master Plan Phase 1 Report), to evaluate the performance of the existing Municipal storm sewers under the influence of climate change. To further the discussion regarding the approaches toward assessing the influence of climate change in the planning and design of Municipal storm infrastructure, the following information has been prepared to summarize the direction provided by the Province of Ontario, and AMEC's experience with the practices of other Provinces and Municipalities in addressing this emerging issue, as specifically related to storm infrastructure to convey and control runoff.

[1] Available via http://www.oakville.ca/assets/general%20-20environment/FINAL_Climate_Change_Strategy.pdf

<u>CANADIAN</u>

National Municipal Adaptation Project (NMAP)
(abstracted from http://www.localadaptation.ca/)

- NMAP is a university-based research group that works to assess the state of planning for adaptation and resiliency in Canadian local governments, develop case studies, and generate applied knowledge that can help advance adaptation planning.
- NMAP recently facilitated a survey of Canadian municipal governments to obtain a broad image of the state of municipal adaptation planning in Canada; some details are offered as follows:
    - Prolonged high temperature and extreme rainfall causing flooding ranked highest amongst a variety of weather related events municipalities have had to deal with over the past 10 years
    - About 70% of respondents do not have a community adaptation plan or are only now beginning to discuss formation of a plan
    - Adaptation planning by Ontario local governments has included the following:
        - campaigns to provide public information and improve public knowledge about adaptation
        - community engagement planning processes
        - seeking new internal and external revenue sources for adaptation
        - planning for new and improving existing public infrastructure
        - land use zoning changes
        - bylaws aimed at changing public behaviour (for example, water use restrictions)
        - risk management/risk assessment
        - examining insurance costs and other potential liabilities

Province of Ontario

- Various initiatives have been undertaken by the Ontario Ministry of the Environment and Climate Change (MOECC) and Ministry of Natural Resources and Forestry (MNRF) related to climate change.
- Papers and reports have been prepared regarding policy conformance and impacts to ecology and biota.
- Web-based tools have been developed by the MTO and MNRF which, respectively, provide updated IDF relationships using the latest Environment Canada data, and IDF curves which incorporate projected climate change impacts.
- To-date, no consistent standard has been provided by the Province to account for the potential influence of climate change in the planning and design of Municipal storm infrastructure.

- The Provincial Policy Statement (June 2014) now includes requirements for incorporating climate change into natural hazards assessments stating that “Planning authorities shall consider the potential impacts of climate change that may increase the risk associated with natural hazards.”
- The Water Opportunities Act will require that municipalities evaluate water infrastructure risks in light of climate change. Specifically, the Water Opportunities Act provides the Province with the authority to make regulations requiring municipalities to prepare Municipal Water Sustainability Plan that may require the development of asset management plans and an assessment of risks that may impact future delivery of municipal service, including climate change.

Province of Newfoundland and Labrador

- The Department of Environment and Conservation is tasked with preparation of flood plain mapping in the Province. The Department began incorporating climate change projections into flood risk mapping in 2008/2009.
- Floodline mapping is delineated for the 1:20 year and 1:100 year annual exceedence probability (AEP) using the current IDF relationships in order to establish current flood risk.
- In the early projects, projected IDF relationships were developed for the years 2020, 2050, and 2080 based upon Global Climate Model results and statistical modelling of extreme precipitation events; the projected IDF relationships were then used to estimate the 1:20 and 1:100 year AEP for the 2020, 2050, and 2080 scenarios, to assess the potential influence of climate change.
- The Province recently developed a suite of climate change datasets for the entire Province. One of these datasets is projected IDF data for 12 hour and 24 hour rainfall events. The Province has also recently concluded that projected future rainfall peaks in 2050 and sees reductions thereafter. As such, presently floodplain mapping assignments focus only on 2050 for representation of future flood risk.
- The Province has also developed policies for land development which use the future flood risk assessments to inform placement of critical infrastructure.

City of Welland – Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol

- The PIEVC Protocol was applied by the City of Welland to identify those components of the City’s wastewater and stormwater collection systems that are at risk of failure, damage and/or deterioration from extreme climatic events or significant changes to baseline climate design values.
- Anticipated impacts to infrastructure were determined based upon estimates of probable climate change effects and professional judgement to determine likely effects on individual components of the infrastructure.

- IDF relationships for future scenarios corresponding to projected 2020 and 2050 conditions were developed using changes in temperature and precipitation from 112 GCM runs and a statistical model of extreme precipitation was run against each of these adjusted records to obtain estimates of climate-impacted extreme precipitation intensities.
- The projected IDF relationships were used to update synthetic design storms and hydrologic modelling was completed to assess the performance of a stormwater management facility under projected climate change conditions and re-design of the stormwater management facility under future conditions.
- A similar assessment was also completed for two examples of Welland's storm sewer infrastructure (associated with residential developments) to assess performance of these systems under future projected rainfall conditions and the construction cost implications had the systems been designed based on future projected rainfall conditions. It was concluded that the cost implications were low to moderate (in the range of 10% to 25%).
- The assessments were completed to assist the City in the decision to adopt a new IDF relationship for design of municipal infrastructure.

City of Cambridge IDF Update

- As part of the City of Cambridge Stormwater Management Master Plan, additional rainfall data were collected to update the City's IDF relationships.
- The rainfall dataset from the nearest Environment Canada station (Waterloo Wellington) was extended using data collected locally within the City of Cambridge, since it was observed that the Waterloo Wellington station did not capture the formative events which occurred in the City in recent years.
- The comparison of the updated IDF relationships with the previous IDF relationships indicated a shift in storm frequency, whereby higher depth storms would be anticipated to occur more frequently.

City of Markham Standards

- The City of Markham Design Storms have been established using the IDF relationships for the Bloor Street Gauge, rather than the nearby Buttonville Airport Gauge.
- Analyses completed by City staff indicate that the depths generated by both relationships suggest that the depths for the Bloor Street gauge are up to 30% greater than those for the Buttonville Airport gauge
- The City of Markham thus concluded that the current IDF relationships provide a "buffer" against uncertainties in rainfall conditions, including those resulting from climate change.

City of Barrie

- The City's current "Storm Drainage and Stormwater Management Policies and Design Guidelines" (November 30 2009) identify that stormwater management facilities should be designed based on the most current IDF tables developed by Environment Canada for Barrie including a 15% increase in rainfall intensity data to account for impacts due to climate change.

City of Sarnia

- The City's current "Site Plan Approval, Policy Guidelines and Standards" (October 2013) identifies that all rainfall runoff analysis should be completed using the City's climate change Modified Return Period Rainfall Amounts. It is not explicitly noted in the guidelines as to what modifications were made to the IDF relationship, however, it is indicated that the modified IDF data is applicable over the period from 2012 to 2042.

Lake Simcoe Region Conservation Authority

- As documented in the current LSRCA Technical Guidelines for Stormwater Management Submissions (April 26, 2013): "The Province of Ontario set up a committee in 2008 led by the Ministry of Environment to review stormwater management in light of climate change. The objective is to make recommendations on whether legislation, or regulations or policies need to be written to regulate SWM practices to account for climate change. Some changes could also be made to the MOE SWM manual as a result of this review. This work is ongoing. When changes are made to provincial guidance, then the LSRCA technical guidelines can be modified accordingly."

City of Halifax, Nova Scotia
(abstracted from http://www.halifax.ca/climate/)

- In its Climate Change Risk Management Strategy, completed in December 2007 and released in April 2008, the Halifax Regional Municipality (HRM) identified a wide range of climate change vulnerabilities and prioritized them based on the probability of their occurrence and the severity of the likely impact.
- Climate SMART is the HRM's Integrated Strategy for Climate Change Mitigation and Impact & Adaptation Preparedness and Planning - the Climate **S**ustainable **M**itigation and **A**daptation **R**isk **T**oolkit.
- HRM partnered with all levels of government and the private sector to develop Climate SMART, a fully integrated planning approach that addresses the impacts of climate change.
- Climate SMART is the first initiative of its kind at the municipal level that integrates and mainstreams greenhouse gas emission reduction and climate change impacts and adaptation considerations into its overall corporate-decision making process.

- The goal of Climate SMART is to help municipalities integrate "greenhouse gas" emission reduction and climate change impact and adaptation issues into the decision-making process for policy makers, practitioners and vulnerable communities. With HRM as the prototype municipality, lessons learned can be replicated in other municipalities across Canada and overseas. Climate SMART is helping HRM and its partners to develop management and planning tools to prepare for climate change impacts, and to develop strategies to reduce practices that contribute to global warming through the reduction of greenhouse gas emissions.
- Climate SMART is reinforcing HRM's leadership on climate change priorities on the ground and helping fulfill Nova Scotia's commitment to address climate change adaptation and support the Federal and Provincial Governments' Climate Change priorities. Further, it is a framework for an enabling environment to leverage Federal-Provincial mitigation and adaptation funding for integrated climate change actions.
- Climate SMART is a public-private initiative which addresses mitigation and adaptation opportunities from a cost-benefit perspective, with special consideration given to the long-term sustainability of the measures to be implemented. The plan encompasses all of HRM's corporate and community assets and activities, and includes a series of tools that are used to incorporate climate change information into its municipal decision-making processes. Climate SMART was formally launched in March, 2004 and includes several key deliverables:
    1. Vulnerability assessments and sustainability analyses
    2. Cost-benefit assessments
    3. Emissions management and mitigation tool
    4. Climate change risk management plan
    5. An emissions management and adaptation methodology, which includes methodologies for each sector of the community
    6. Communications and outreach

City of London, Ontario

- The municipality has a two-phase (short term and long term) Climate Change Adaptation Strategy
    - Phase 1 - Short-term Strategy:
        - Review Ontario municipalities practices and standards
        - Update the City’s current IDF curves, using data from London Airport
        - Develop rainfall IDF Curves incorporating changing climate
            - Difference between Environment Canada IDF curves and the projected IDF curves ranged from 11% to 35%

    - City adopted an upward shift of 21% (applied to current IDF curves) to represent future rainfall conditions
  - Conduct general risk and consequence analyses across the City
    - Based on flood risk assessment using the 100 year and 250 year design events
    - Climate change postulated to increase flood damages resulting from a 250 year flood by approximately 70%
- Phase 2 - Long-term Strategy:
  - Update key elements of London's Subwatershed studies
    - Preliminary estimate of direct increase on SWM footprint is 10-15% assuming IDF increases of 21%
  - Develop Green Infrastructure Plan fundamental principles
  - Develop a Stormwater Adaptation Strategy to Climate Change

INTERNATIONAL
(abstracted from http://insideclimatenews.org/news/20130620/6-worlds-most-extensive-climate-adaptation-plans)

New York City, New York, USA

- The City's $19.5 billion plan to adapt to climate change may be the world's most ambitious
- The plan, initiated in June 2013, was developed in response to Superstorm Sandy.
- The report "A Stronger, More Resilient New York,"[2] proposes more than 250 initiatives to reduce the city's vulnerability to coastal flooding and storm surge. About 80 percent of the $19.5 billion plan will go to repairing homes and streets damaged by Sandy, retrofitting hospitals and nursing homes, elevating electrical infrastructure, improving ferry and subway systems and fixing leaky drinking water systems. Other initiatives will focus on building and researching floodwalls, restoring swamplands and sand dunes, and other coastal flood protections.

London, England (UK)

- The adaptation strategy was developed in response to rising concerns about persistent flooding, drought and extreme heat waves in the city; adopted in October 2011.
- The final report, "Managing Risks and Increasing Resilience"[3], analyzes the threat of global warming impacts to the city and identifies the residents and infrastructure that are

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[2] Available via http://www.nyc.gov/html/sirr/html/report/report.shtml

[3] Available via http://www.london.gov.uk/priorities/environment/publications/managing-risks-and-increasing-resilience-the-mayor-s-climate

most vulnerable. It also proposes 34 initiatives to protect and strengthen the city, including three key actions: managing the risk of surface water flooding, increasing the amount of parks and vegetation in the city, and retrofitting more than one million homes by 2015 to improve water and energy efficiency.

- London's adaptation plan is based on national climate change projections developed in 2009 by the UK Hadley Center.

Chicago, Illinois, USA

- The "Chicago Climate Action Plan"[4] (2008) is mainly a mitigation strategy for the city, though one chapter is devoted to adaptation.
- The adaptation chapter outlines nine initiatives for dealing with intensely hot summers, thick smog, flooding and heavy rains—though most proposals call for further study rather than actual projects. By 2010, however, significant adaptation work was underway on green buildings, storm water management projects, tree planting and green roof installations. Overall, the city developed more than 450 mitigation and adaptation initiatives in the first two years of the climate plan.

Rotterdam, Netherlands

- "Rotterdam Climate Proof"[5], initiated in 2009, aims to make the city "fully" resilient to climate change impacts by 2025.
- The adaptation strategy contains five themes: flood management, accessibility for ships and passengers, adaptive buildings, urban water systems, and quality of life within the city.
- The city set aside about $40 million for implementation of the plan’s near-term projects.
- By 2010 the initiative was making "full progress" toward its initiatives and broader goals. Perhaps the most notable project to come from the plan is Rotterdam's trio of floating pavilions. The bubble-shaped domes are anchored off the city’s waterfront and measure a total of 12,000 square feet. The project is a pilot for future floating urban districts that will be able to rise with the changing sea levels.

Quito, Ecuador

- Development of the Climate Change Strategy started in 2007 and formally approved in October 2009.
- The climate change strategy includes both mitigation and adaptation initiatives.

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[4] Available at http://www.chicagoclimateaction.org/

[5] Available at http://www.rotterdamclimateinitiative.nl/documents/RCP/English/RCP_adaptatie_eng.pdf

- Its adaptation component focuses on five key sectors: ecosystems and biodiversity, drinking water supplies, public health, infrastructure and power production, and climate risk management.
- It has been noted that Quito has successfully moved climate adaptation into the city's main development agenda.

Durban, South Africa

- Development of the climate change strategy was initiated in 2004 with a timeline to 2020
- Durban has implemented adaptation initiatives in stages under the Municipal Climate Protection Program.
- The program began assessing the local impacts of climate change—namely hotter average temperatures, intense rainfalls and coastal erosion.
- The city also created a Headline Adaptation Strategy to study the vulnerability of each municipal agency to such impacts.
- In 2008, development of specific adaptation plans began for the health, water and disaster management agencies.
- The environmental planning department is tasked with monitoring the implementation of the agencies' plans on a quarterly basis.
- A 2010 report[6] outlines the dozens of initiatives underway.
- Funding implementation efforts is an on-going issue.

Norway

Municipalities play an important role regarding guidance and coordination in relation to municipal and regional climate change adaptation plans. The revised Planning and Building Act (2008) strengthens county municipalities' role as planning authorities. The municipalities are in the frontline in carrying out climate change adaptation measures. The Planning and Building Act and the Civil Protection Act obligate the municipalities to carry out risk and vulnerability assessments. These assessments can be important in clarifying issues and areas of risk relevant to each municipality and in recommending initiatives for various players in order to reduce vulnerability.

Copenhagen, Denmark

The initial work on climate adaptation was done with the drafting of the City of Copenhagen

[6] Available at http://www.durban.gov.za/City_Services/development_planning_management/environmental_planning_climate_protection/Publications/Documents/Durbans%20Municipal%20Climate%20Protection%20Programme_Climate%20Chan.pdf

Climate Plan[7] in 2009, where the principal challenges and five initiatives were identified as essential to climate-adapting the City, namely:

1. Development of methods to discharge during heavy downpours
2. Establishment of green solutions to reduce the risk of flooding
3. Increased use of passive cooling of buildings
4. Protection against flooding from the sea
5. Preparation of a combined climate adaptation strategy which co-ordinates the other elements of this plan.

Climate adaptation is planned by continuously assessing potential risk and opportunities. The aim is to achieve the greatest possible synergy with other plans and projects.

Detailed investigation related to initiative #1 has led to the development of the Cloudburst Management Plan[8] (2012). This Plan outlines the methods, priorities, and measures recommended for climate adaptation to mitigation potential flooding associated with extreme rainfall. It is estimated that the plan will required an implementation period of about 20 years.

Copenhagen is targeting a level of resilience which limits potentially damaging floods from extreme rainfall events to the type which, statistically, occurs only once every 100 years. In Copenhagen, flood damages begin (typically) when water levels in streets reach about 10 cm depth, yet sewerage systems are only required to handle 10-year rainfall events and there are no systems able to handle the extensive flooding caused by an extreme rainfall event.

- Adaptive measures must combine solutions which make the city more green and blue by draining off rainwater at ground level. Tunnel solutions will only be used in those parts of the city where no opportunities exist for drainage solely at ground level.
- Adaptive measures need to be put in order of priority taking into account both the risk of flooding and the scope for synergies with other projects such as road renovation, urban development etc. A "cloudburst" tool box of urban interventions, such as cloudburst boulevards, cloudburst parks, cloudburst plazas, provided the basis for a dynamic and multifunctional system.
- Estimated construction costs up to 2033 amount to a total of DKK 3.8 bn (~$725 million CAN) in present-day prices.

AF/PN/af

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[7] Available at http://subsite.kk.dk/sitecore/content/Subsites/CityOfCopenhagen/SubsiteFrontpage/LivingInCopenhagen/ClimateAndEnvironment/ClimateAdaptation/~/media/9FC0B33FB4A6403F987A07D5332261A0.ashx

[8] Available at http://kk.sites.itera.dk/apps/kk_pub2/pdf/1019_81lSkHGSvS.pdf

APPENDIX F

Drainage Requirements for Redevelopment and Infill Development

Drainage Requirements for Re-development and Infill Development

1. Sump pumps

a) Sump pumps shall discharge via pipe directly to a storm sewer.

b) Where a storm sewer does not exist along the frontage or flankage of a property, discharge via pipe shall be directly to the back slope of a municipal ditch.

c) Where a basement excavation is lower than the Static Water Level, sump/s may run continuously therefore discharge to a dry-well (see section 4) located on private property minimum 5.0m from all buildings with an overflow pipe to the back slope of a municipal ditch is required.

d) Sump pump discharge to a side yard swale is not acceptable.

2. Roof water downspouts

a) Downspouts shall discharge to grade via concrete splash pads, directed away from the building to prevent erosion and percolation to the weeping tile. Rainwater harvesting is permitted, provided any overflow pipes or overflows meet the requirements of **Roof water downspouts** drainage section.

b) Houses located on corner lots shall have roof leader(s) at the corners of the house, closest to the street lines.

c) Downspouts shall not be piped to a mutual property line and allowed to discharge onto another property.

d) Downspouts shall not be directed towards an adjacent property where there is no property line intercept swale; or the volume / velocity may impact that property or interfere with access or pose a safety issue.

e) For high density developments, downspouts may be connected to a municipal storm sewer with special permission from the Town in its sole discretion.

f) Roof leader downspout locations are to be indicated on all plot plans, site grading and site plans.

3. Lot grading and drainage

a) Grading and drainage shall provide positive surface drainage directed away from any buildings towards lot line swales.

b) Drainage shall be self-contained and outlet to an approved location. Where Split or Front-to-Back grading design is utilized to outlet surface drainage; and runoff will or is likely to drain onto another property, a private rear lot catchbasin or other approved method is required to collect the water and outlet it to the storm sewer or municipal ditch.

c) Where required by site plan or as determined by the Town, in its sole discretion, a Stormwater Management Report/ Brief is required.

4. Dry-wells

a) Dry-wells do not work in all soil types. Should a dry-well be proposed, a report and detail drawing/s, stamped, signed and dated by a qualified professional engineer must accompany the proposal. The report shall provide data indicating that the soils are suitable and the sizing is correct for the development.

b) An overflow route from a dry-well may be required, where deemed necessary, in the Town's opinion.

5. Grading Certification

Upon completion of the development works, the owner shall supply the Town a Lot Grading Certification, stamped by a Civil Engineer (P.Eng.), Landscape Architect (OALA) or an Ontario Land Surveyor (OLS); certifying that the grading conforms to the approved grading plan/s and that there are no adverse impacts on neighbouring properties.

APPENDIX G

Flow Monitoring Data

TOWN OF OAKVILLE STORM SEWER MASTER PLAN - FLOW MONITORING SUMMARY

Round	Period	Site ID	Site Description	Type	UTM X	UTM Y
1	Sept-Dec 2011	3	Yolanda Drive	Open Channel	604003	4806455
	Sept-Dec 2011	16	South Service Road	Open Channel	606846	4812585
	Sept-Dec 2011	19	Ford Drive	Open Channel	609709	4815263
2	Oct-Dec 2012	15B	Sarah Lane	Storm Sewer	605154	4806245
	Oct-Dec 2012	27A	Patricia Drive	Storm Sewer	605900	4809206
	Oct-Dec 2012	47B	Arbour Drive	Storm Sewer	610257	4814297

Round 1 Monitoring Site – Yolanda Drive

Yolanda Drive Monitoring Site looking downstream – September 6, 2011

Round 1 Monitoring Site – South Service Road

South Service Road Monitoring Site looking downstream – September 6, 2011

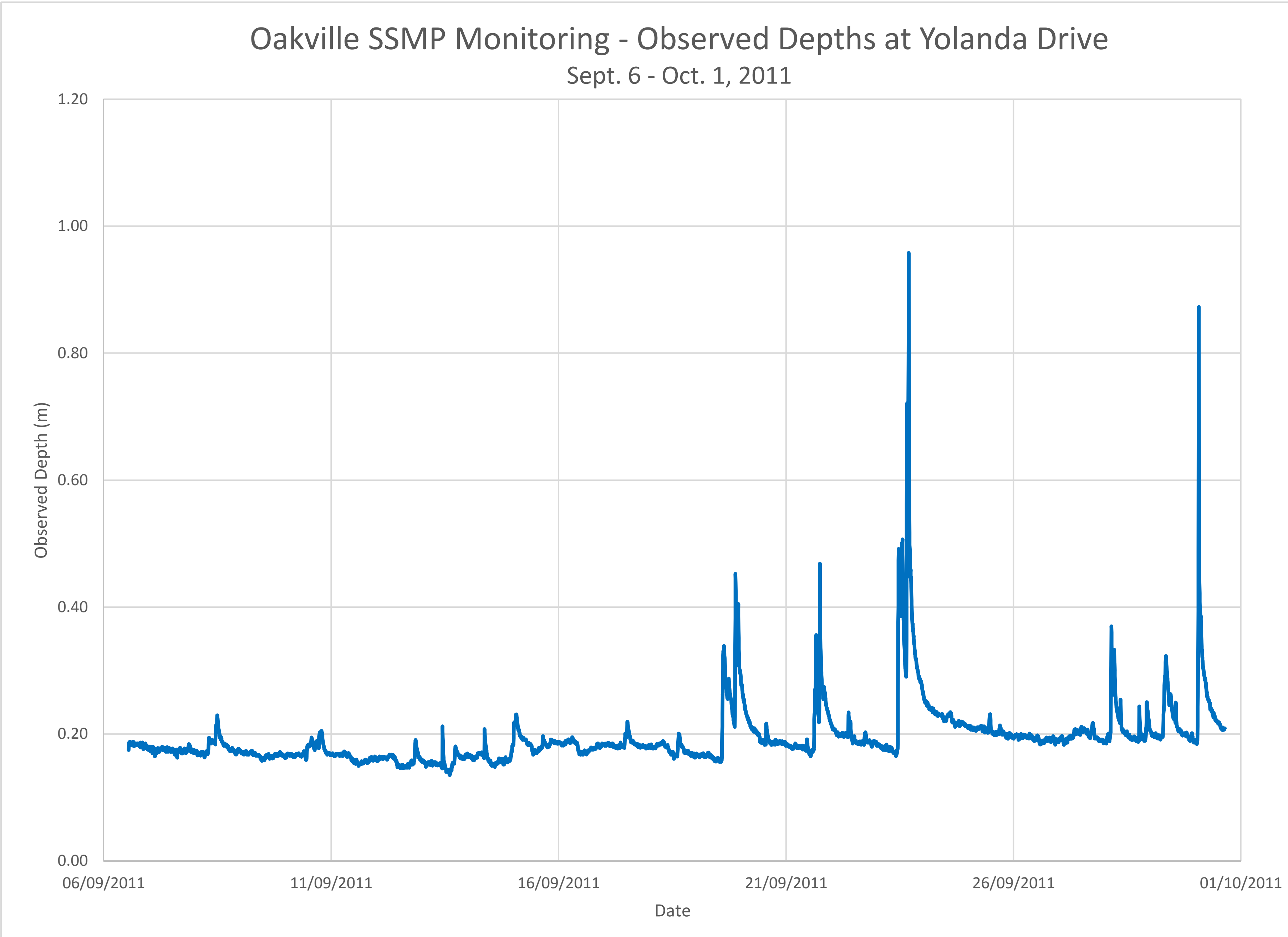

Round 1 Monitoring Site – Ford Drive

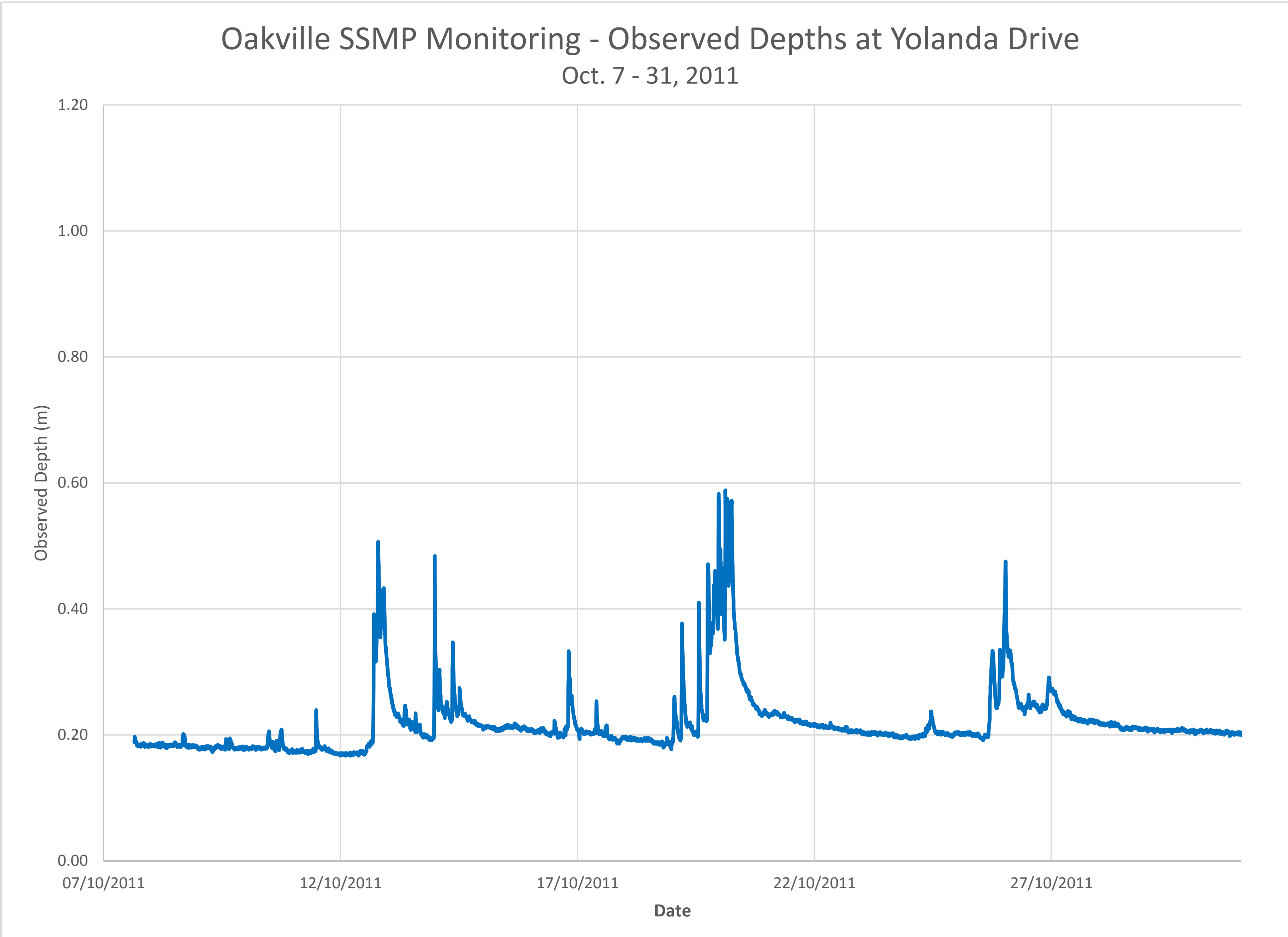

Ford Drive Monitoring Site looking downstream – September 6, 2011

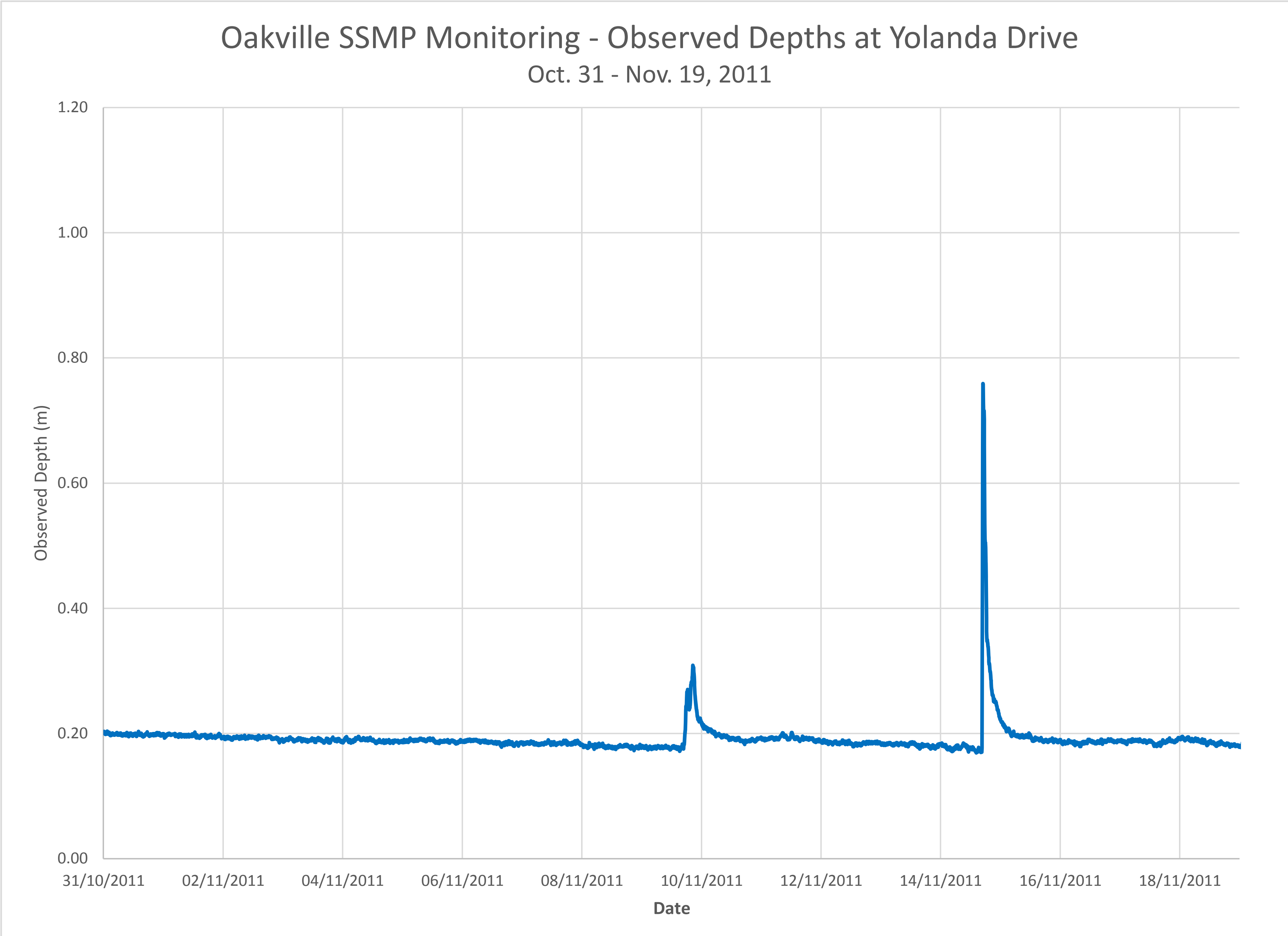
Round 2 Monitoring Site – Sarah Lane

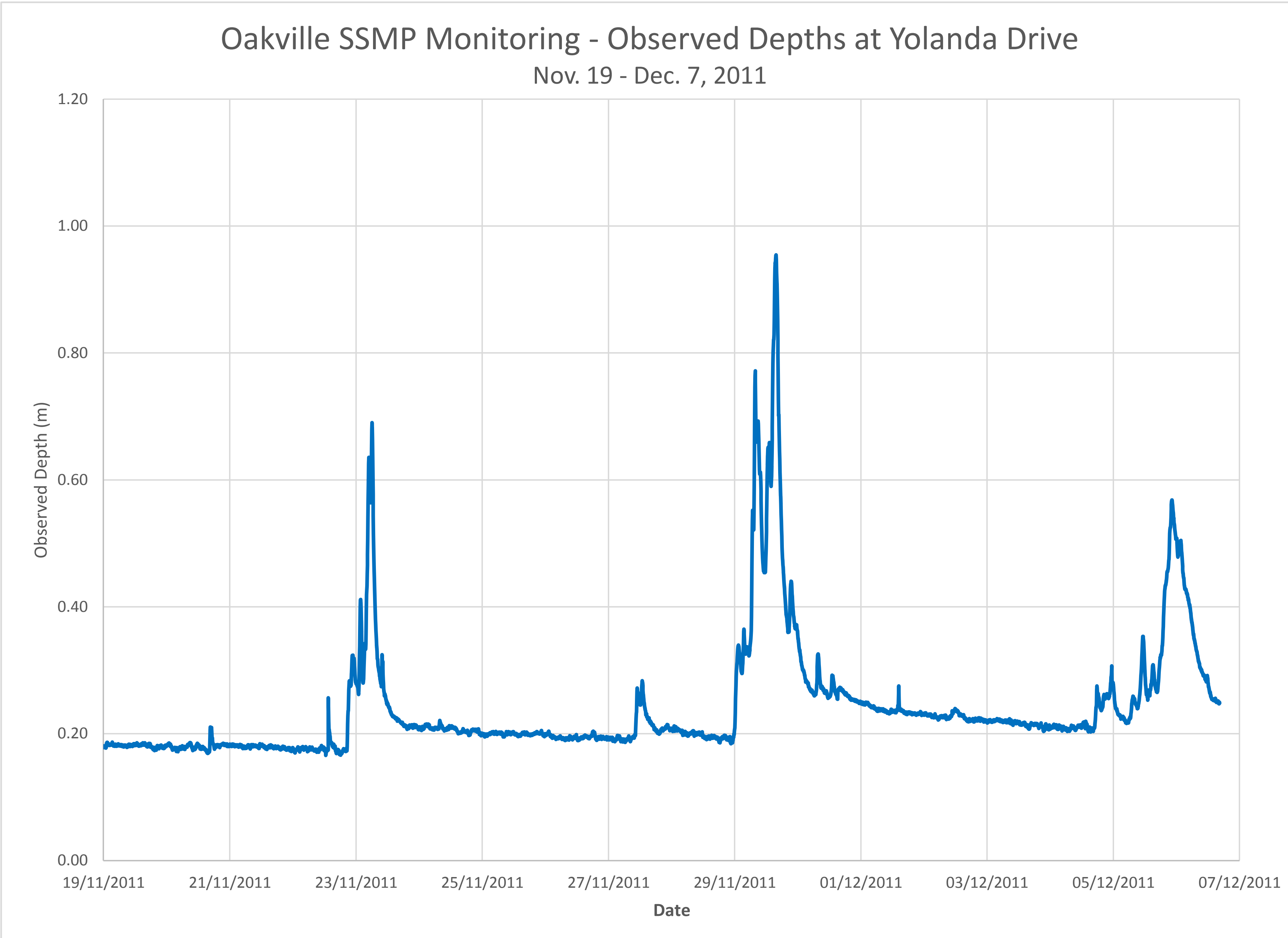
Round 2 Monitoring Site – Patricia Drive

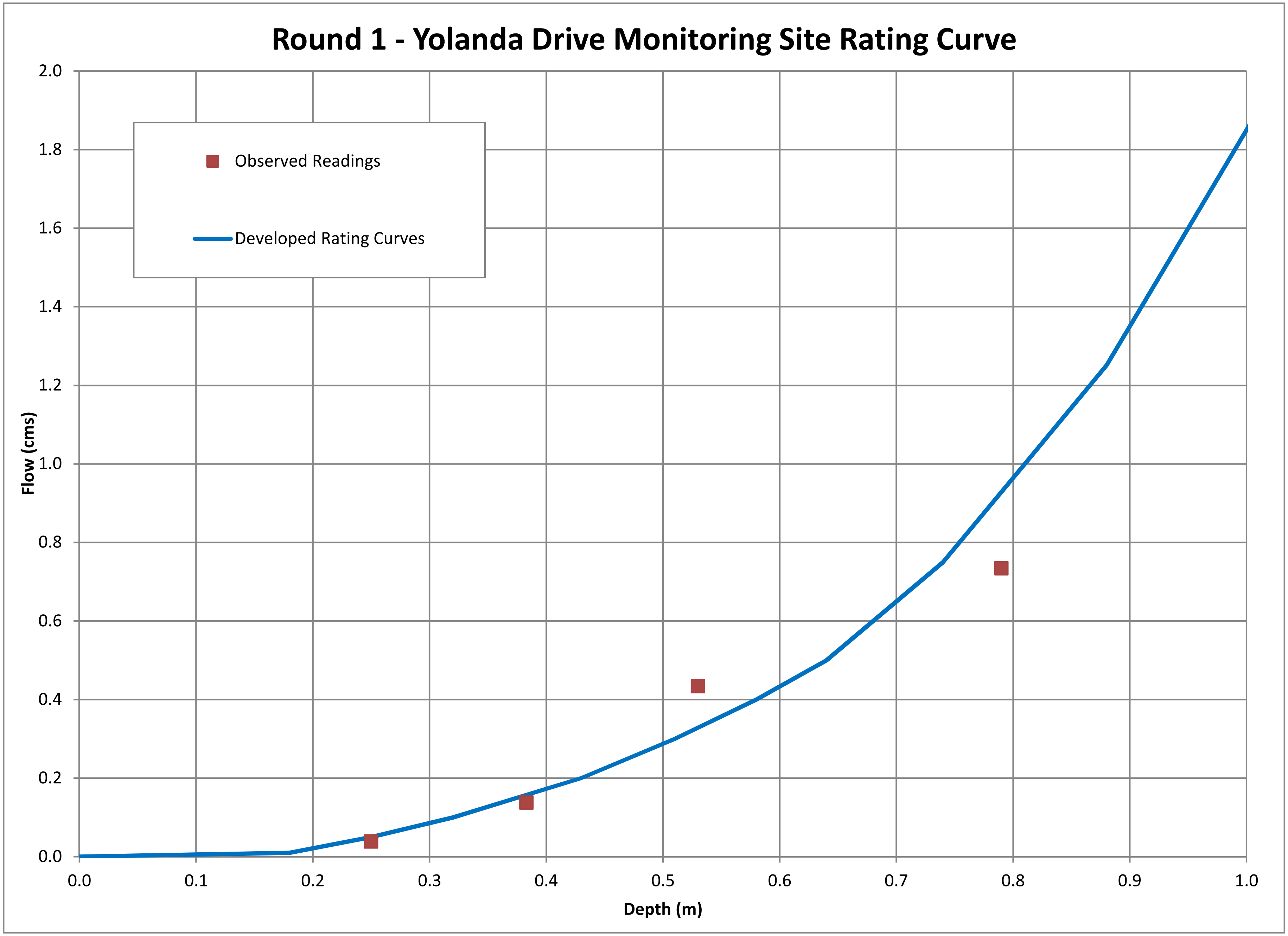
Round 2 Monitoring Site – Arbour Drive


Oakville SSMP Monitoring - Observed Depths at Yolanda Drive
Sept. 6 - Oct. 1, 2011
Observed Depth (m)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
06/09/2011
11/09/2011
16/09/2011
21/09/2011
26/09/2011
01/10/2011
Date

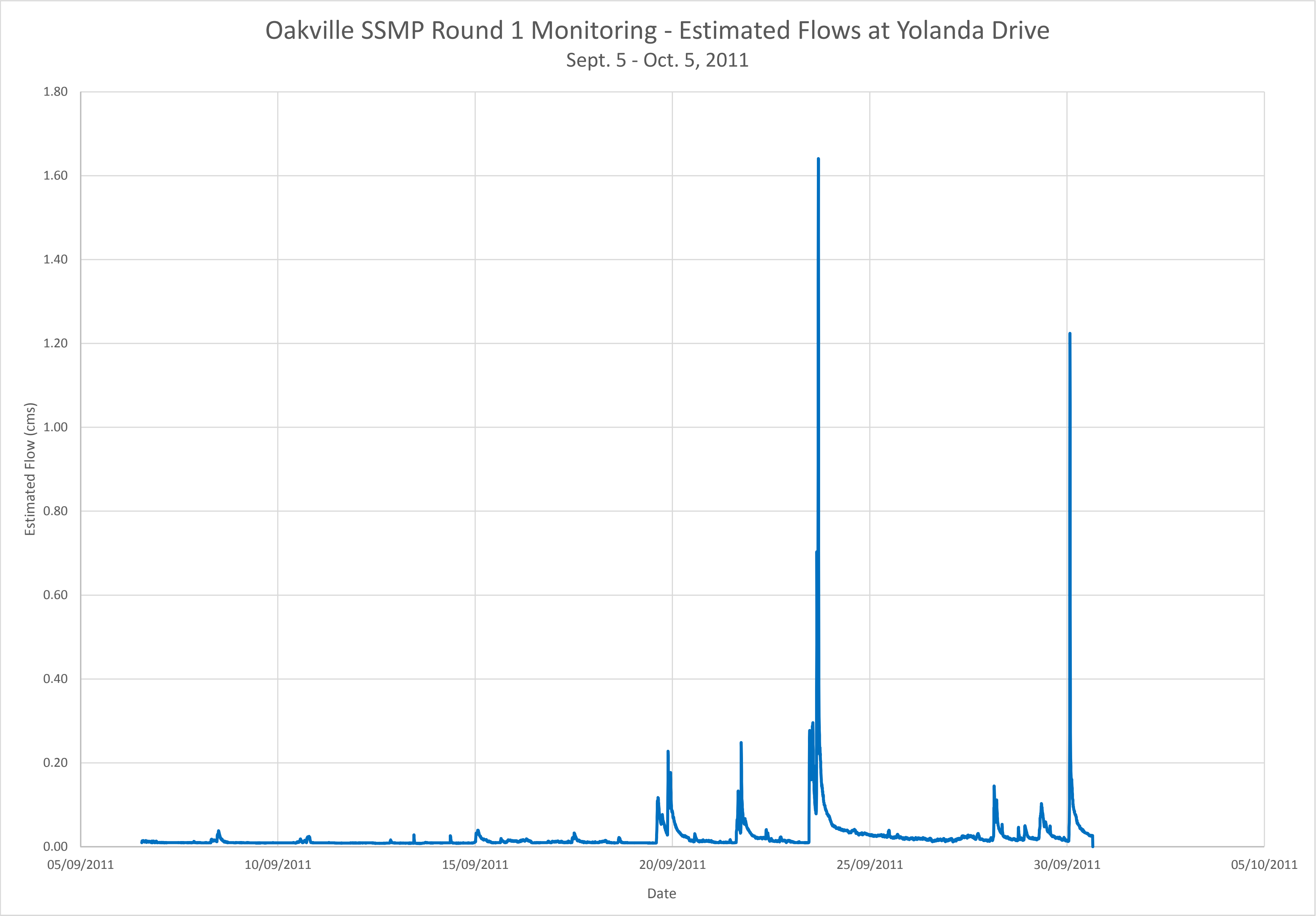

Oakville SSMP Monitoring - Observed Depths at Yolanda Drive
Oct. 7 - 31, 2011
Observed Depth (m)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
07/10/2011
12/10/2011
17/10/2011
22/10/2011
27/10/2011
Date

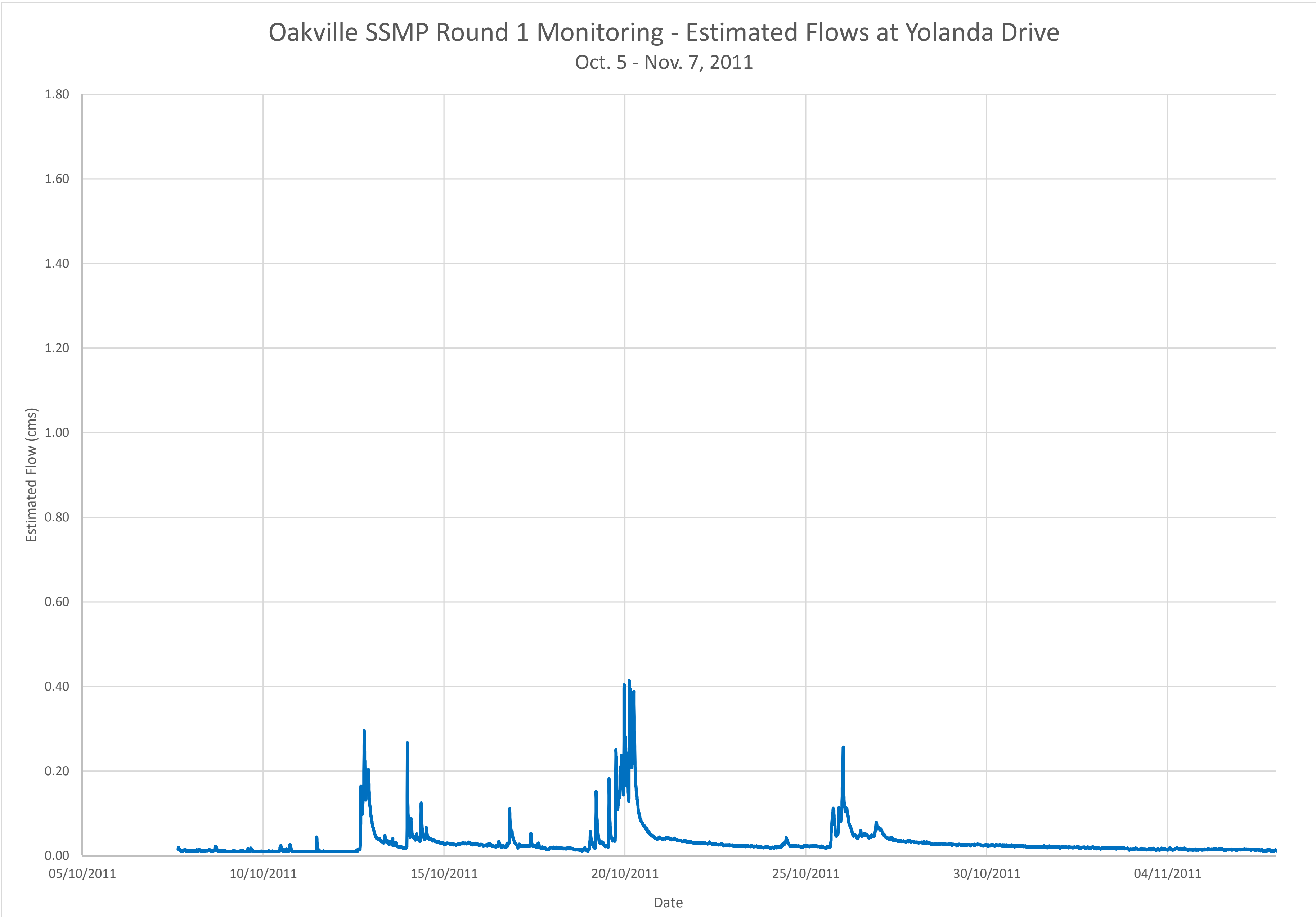

Oakville SSMP Monitoring - Observed Depths at Yolanda Drive
Oct. 31 - Nov. 19, 2011
Observed Depth (m)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
31/10/2011
02/11/2011
04/11/2011
06/11/2011
08/11/2011
10/11/2011
12/11/2011
14/11/2011
16/11/2011
18/11/2011
Date

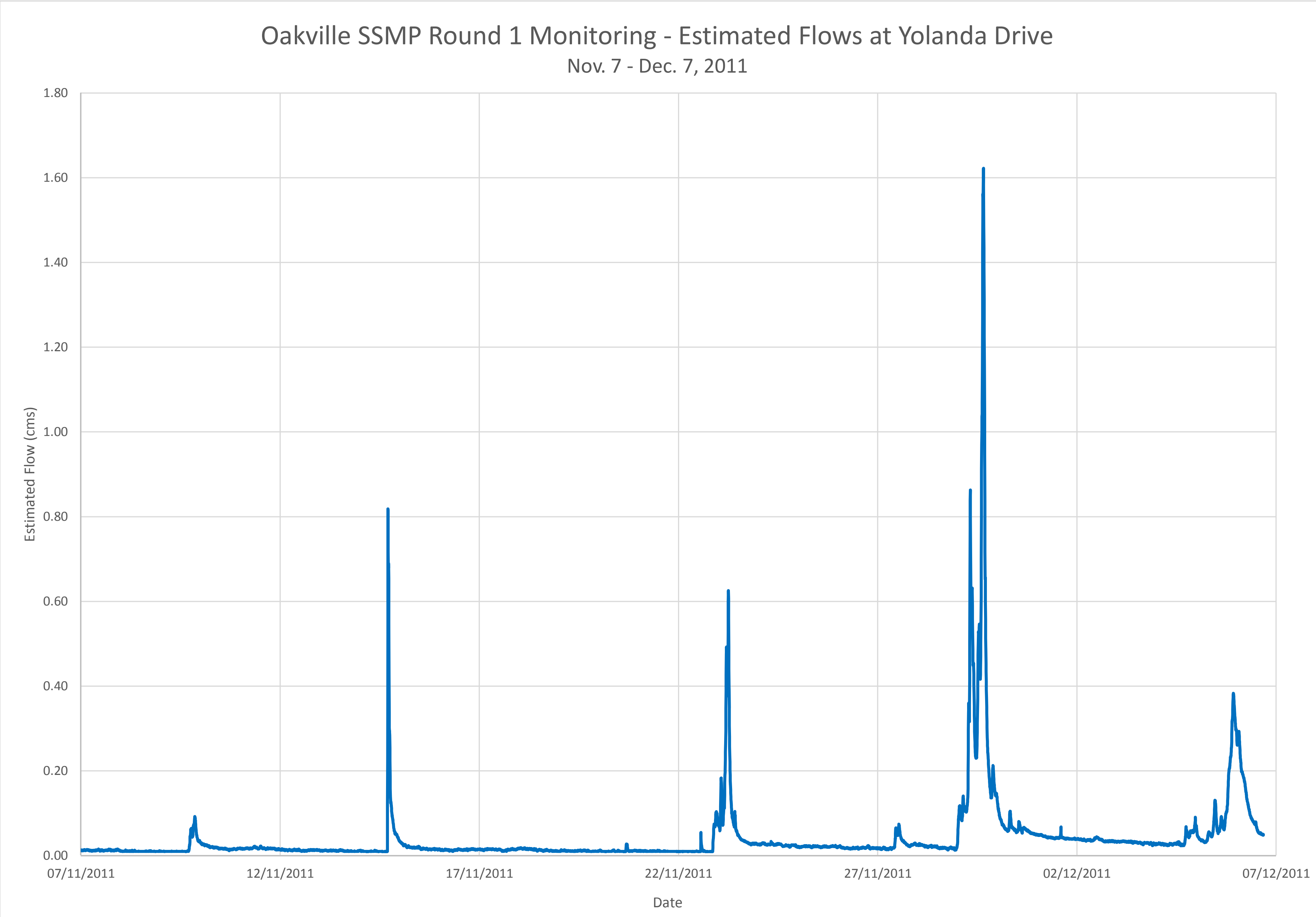

Oakville SSMP Monitoring - Observed Depths at Yolanda Drive
Nov. 19 - Dec. 7, 2011
Observed Depth (m)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
19/11/2011
21/11/2011
23/11/2011
25/11/2011
27/11/2011
29/11/2011
01/12/2011
03/12/2011
05/12/2011
07/12/2011
Date

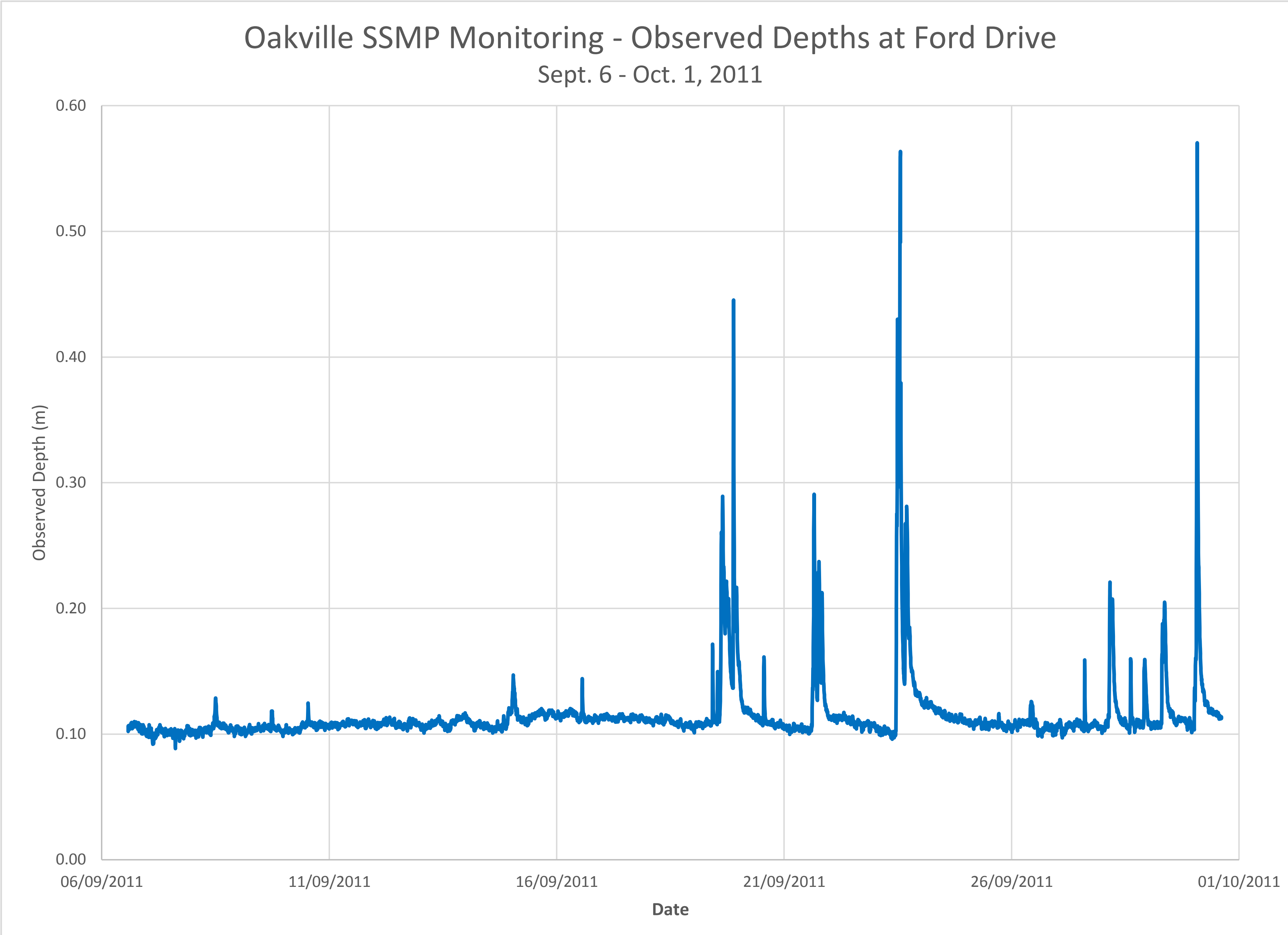


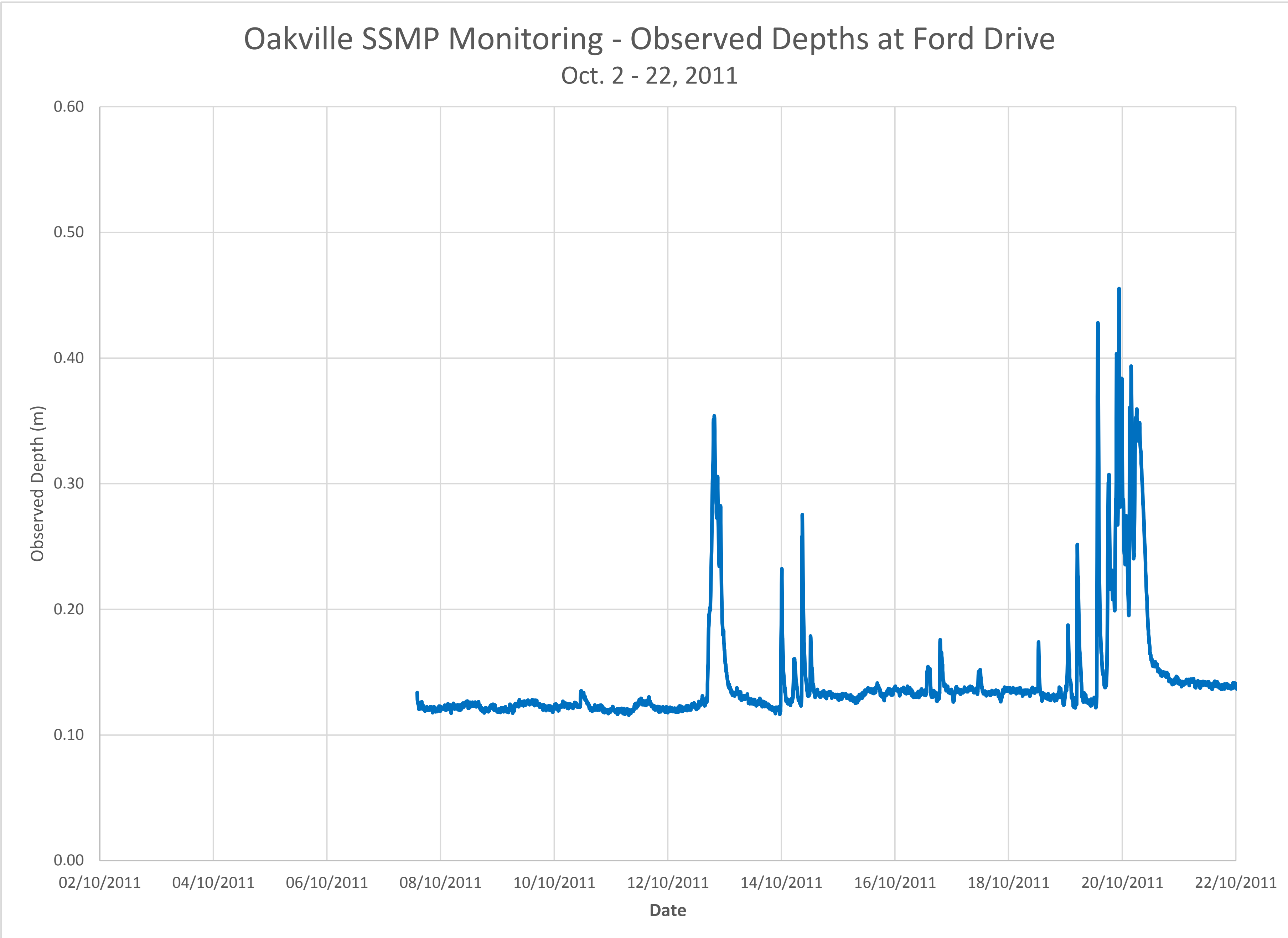
Round 1 - Yolanda Drive Monitoring Site Rating Curve
Observed Readings
Developed Rating Curves
Flow (cms)
Depth (m)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0


Oakville SSMP Round 1 Monitoring - Estimated Flows at Yolanda Drive
Sept. 5 - Oct. 5, 2011
Estimated Flow (cms)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
05/09/2011
10/09/2011
15/09/2011
20/09/2011
25/09/2011
30/09/2011
05/10/2011
Date

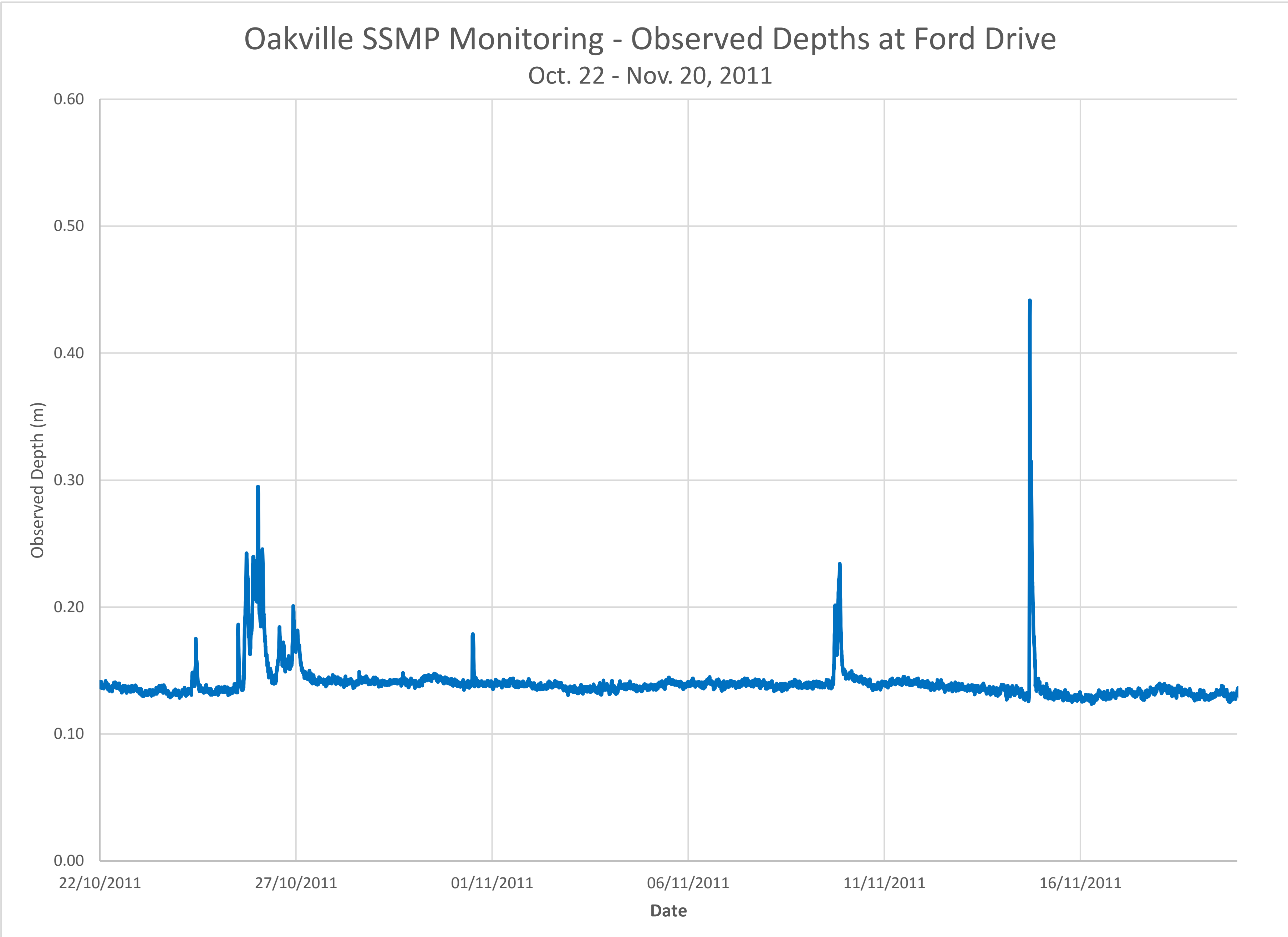

Oakville SSMP Round 1 Monitoring - Estimated Flows at Yolanda Drive
Oct. 5 - Nov. 7, 2011
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Estimated Flow (cms)
05/10/2011
10/10/2011
15/10/2011
20/10/2011
25/10/2011
30/10/2011
04/11/2011
Date

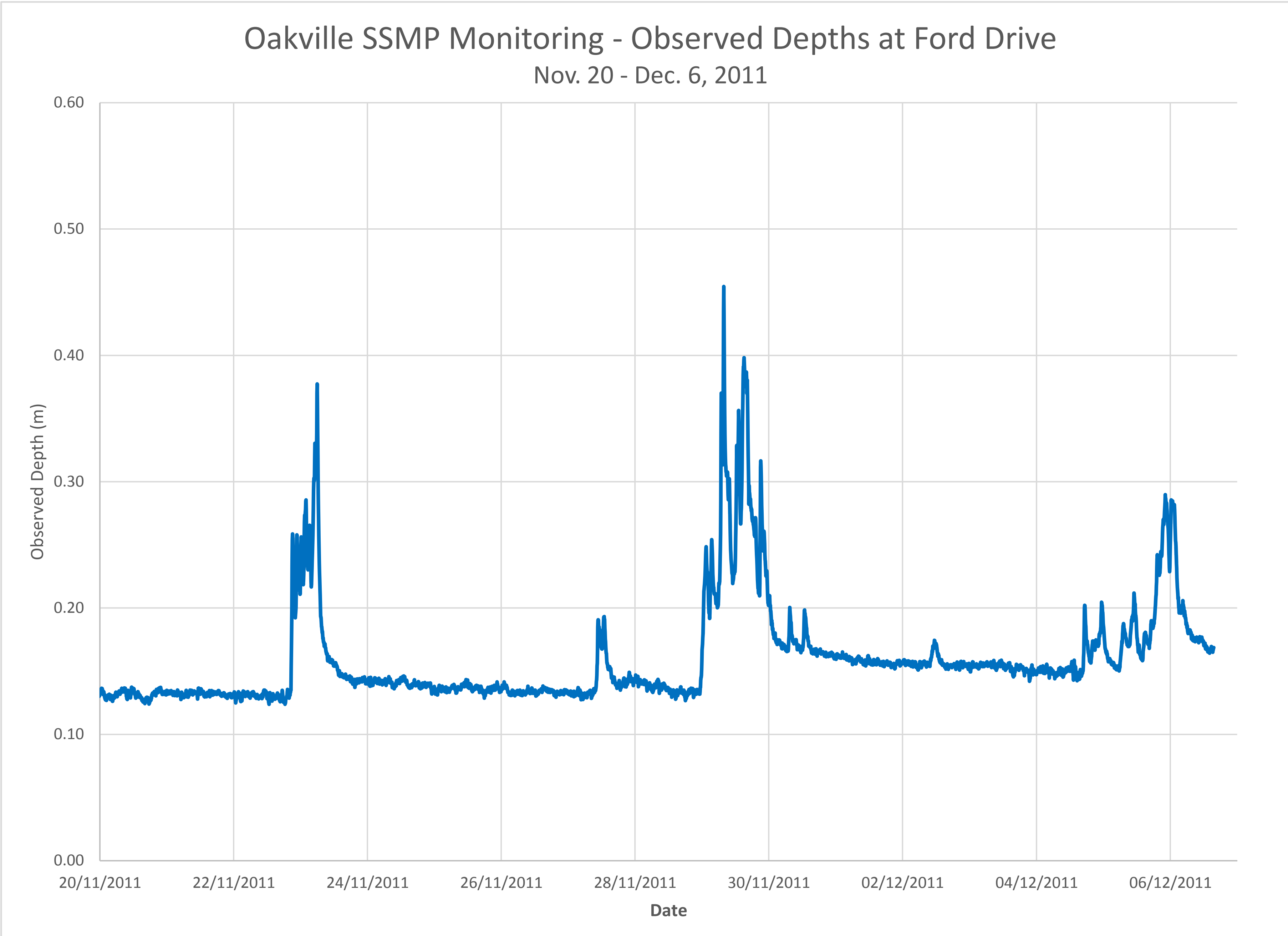

Oakville SSMP Round 1 Monitoring - Estimated Flows at Yolanda Drive
Nov. 7 - Dec. 7, 2011
Estimated Flow (cms)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
07/11/2011
12/11/2011
17/11/2011
22/11/2011
27/11/2011
02/12/2011
07/12/2011
Date

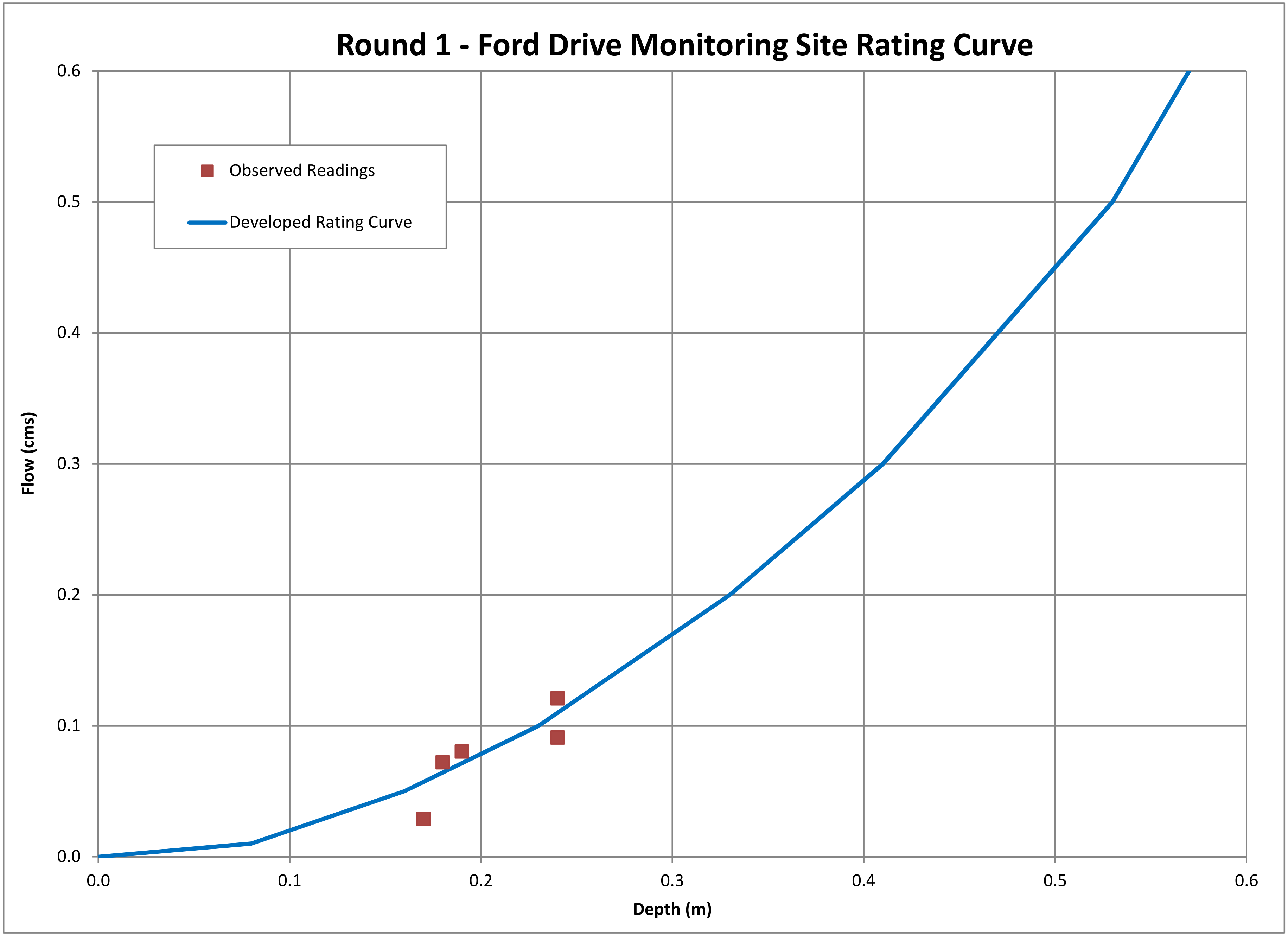

Oakville SSMP Monitoring - Observed Depths at Ford Drive
Sept. 6 - Oct. 1, 2011
Observed Depth (m)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
06/09/2011
11/09/2011
16/09/2011
21/09/2011
26/09/2011
01/10/2011
Date



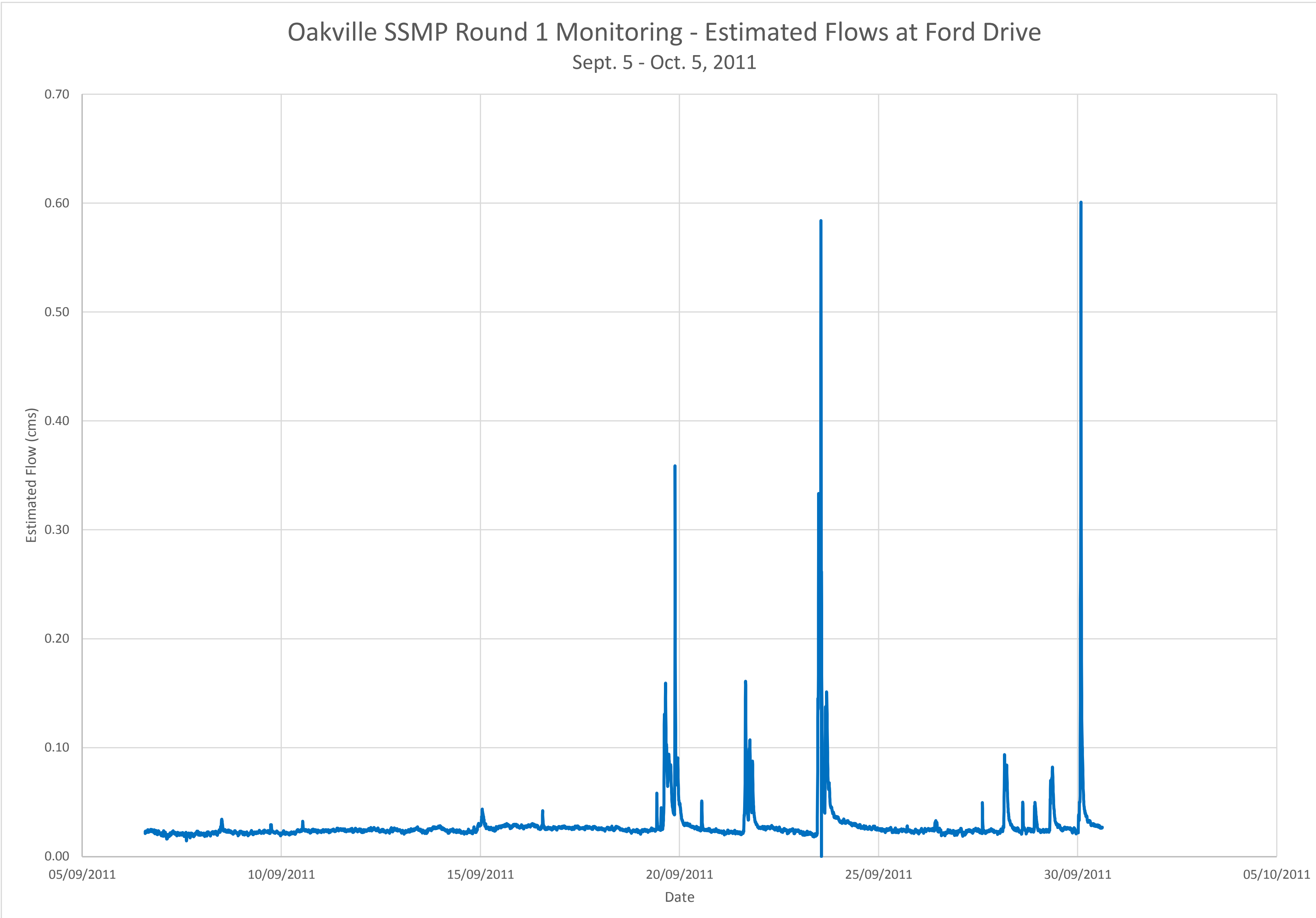
Oakville SSMP Monitoring - Observed Depths at Ford Drive
Oct. 2 - 22, 2011
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Observed Depth (m)
02/10/2011
04/10/2011
06/10/2011
08/10/2011
10/10/2011
12/10/2011
14/10/2011
16/10/2011
18/10/2011
20/10/2011
22/10/2011
Date


Oakville SSMP Monitoring - Observed Depths at Ford Drive
Oct. 22 - Nov. 20, 2011
Observed Depth (m)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
22/10/2011
27/10/2011
01/11/2011
06/11/2011
11/11/2011
16/11/2011
Date

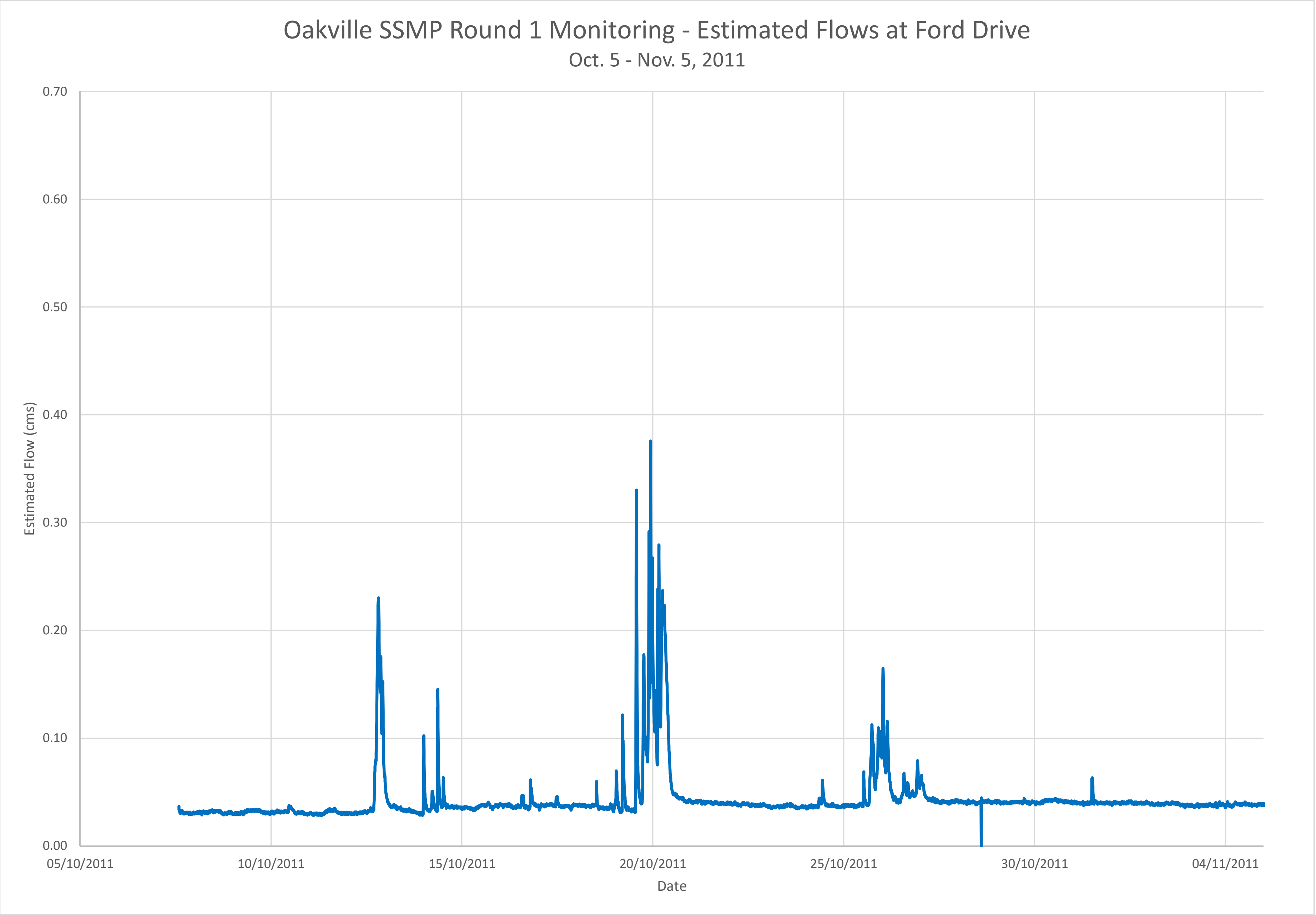

Oakville SSMP Monitoring - Observed Depths at Ford Drive
Nov. 20 - Dec. 6, 2011
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Observed Depth (m)
20/11/2011
22/11/2011
24/11/2011
26/11/2011
28/11/2011
30/11/2011
02/12/2011
04/12/2011
06/12/2011
Date

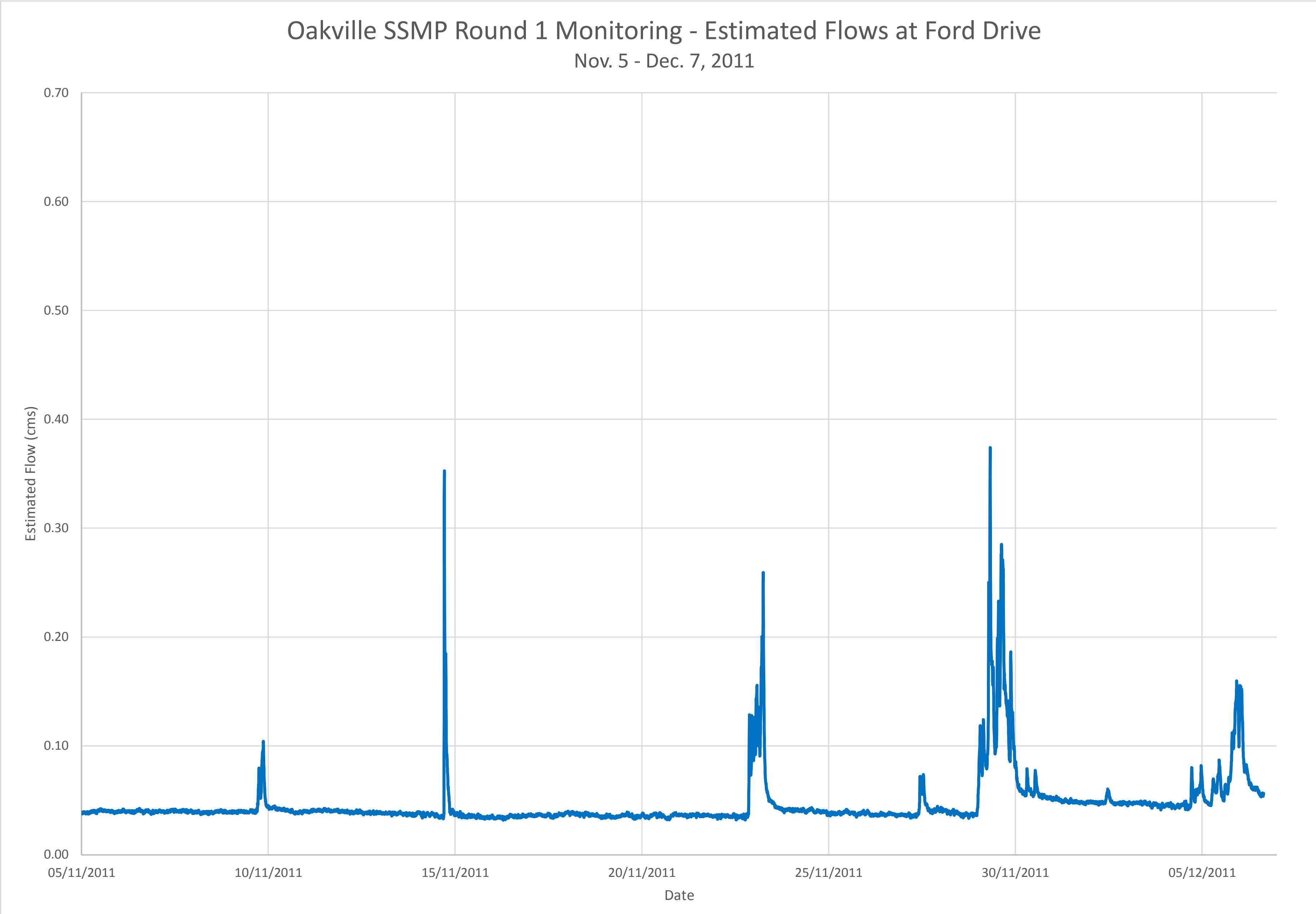


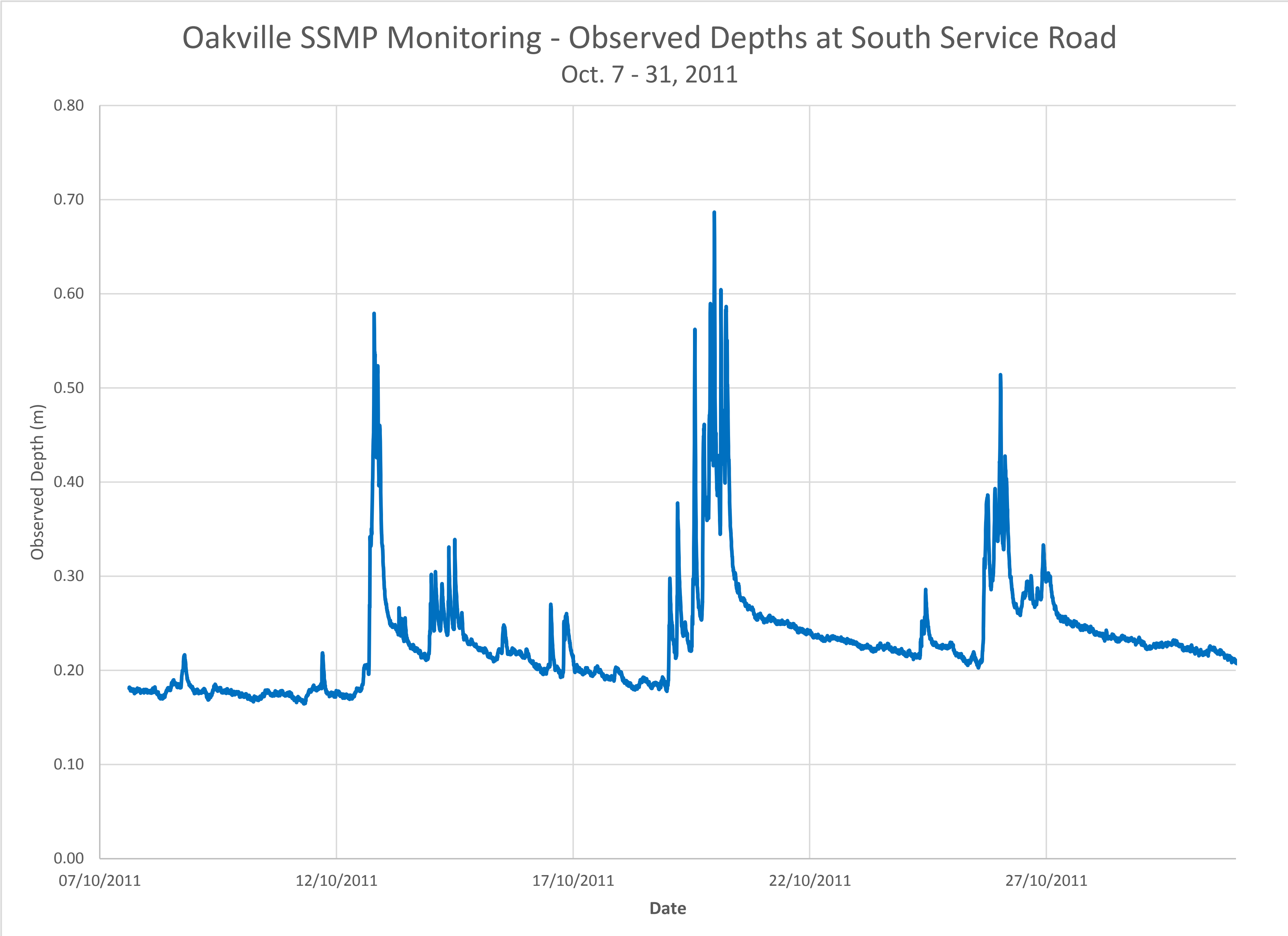
Round 1 - Ford Drive Monitoring Site Rating Curve
Observed Readings
Developed Rating Curve
Flow (cms)
Depth (m)
0.0
0.1
0.2
0.3
0.4
0.5
0.6



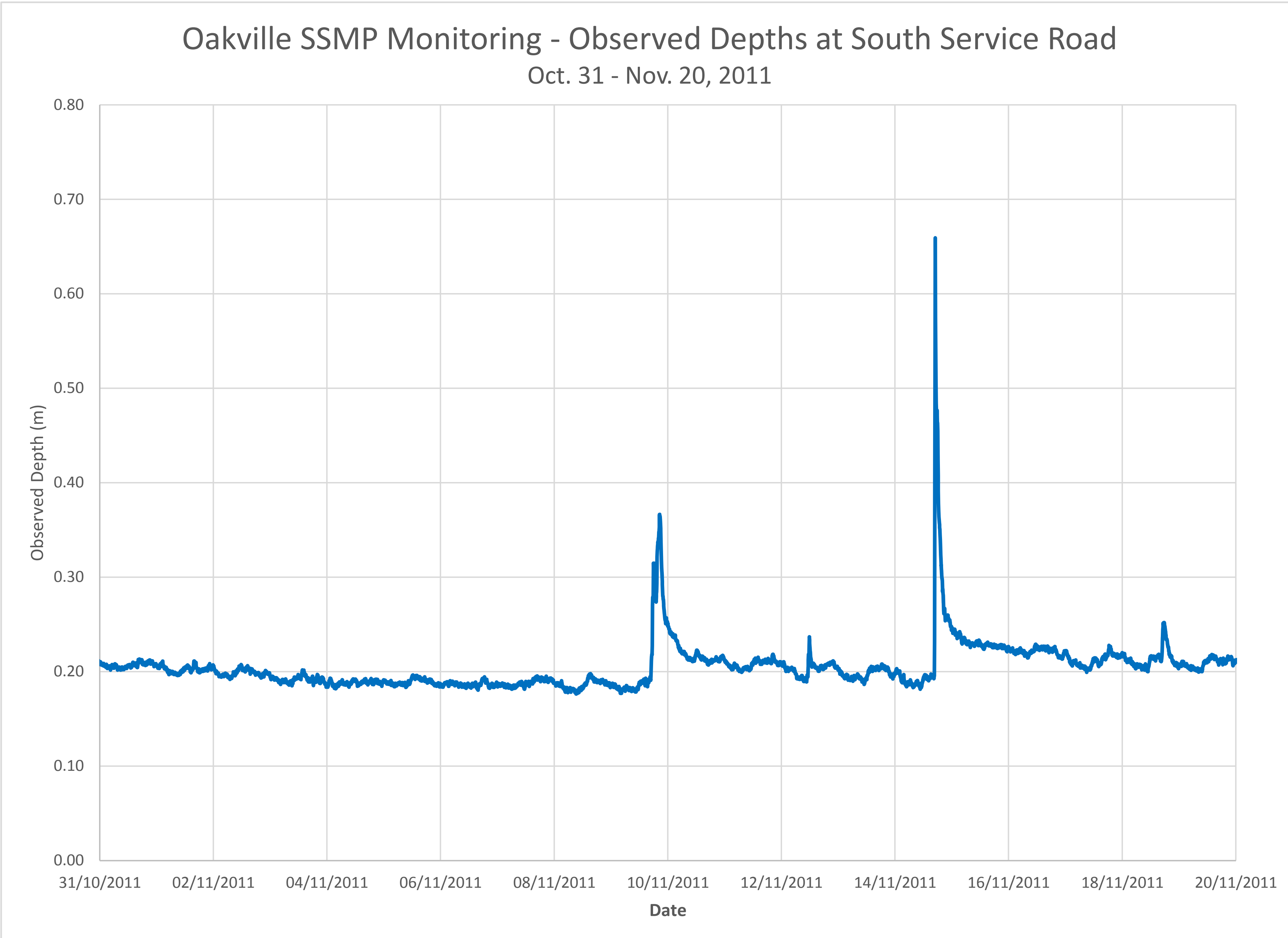
Oakville SSMP Round 1 Monitoring - Estimated Flows at Ford Drive
Sept. 5 - Oct. 5, 2011
Estimated Flow (cms)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
05/09/2011
10/09/2011
15/09/2011
20/09/2011
25/09/2011
30/09/2011
05/10/2011
Date

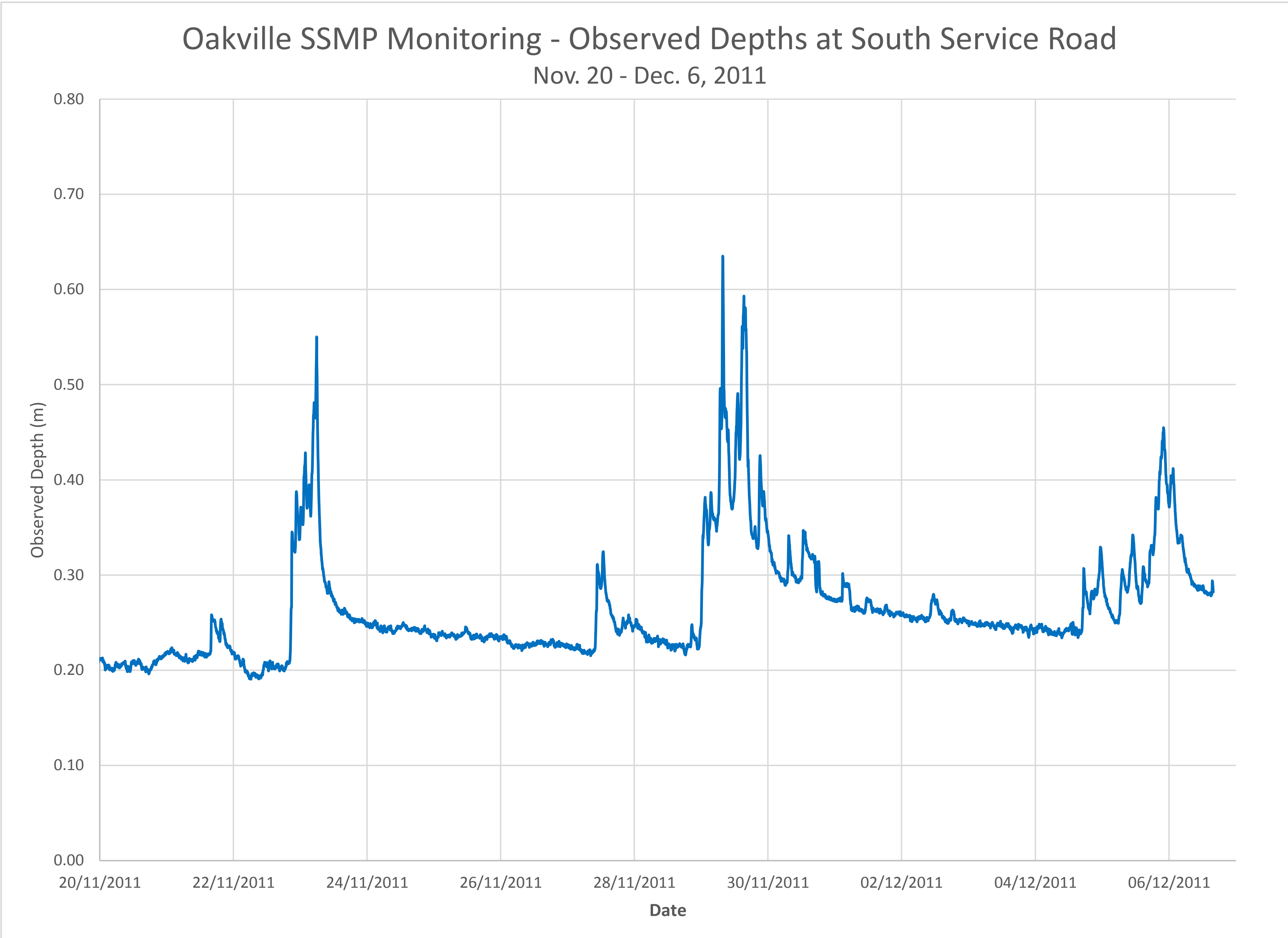

Oakville SSMP Round 1 Monitoring - Estimated Flows at Ford Drive
Oct. 5 - Nov. 5, 2011
Estimated Flow (cms)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
05/10/2011
10/10/2011
15/10/2011
20/10/2011
25/10/2011
30/10/2011
04/11/2011
Date

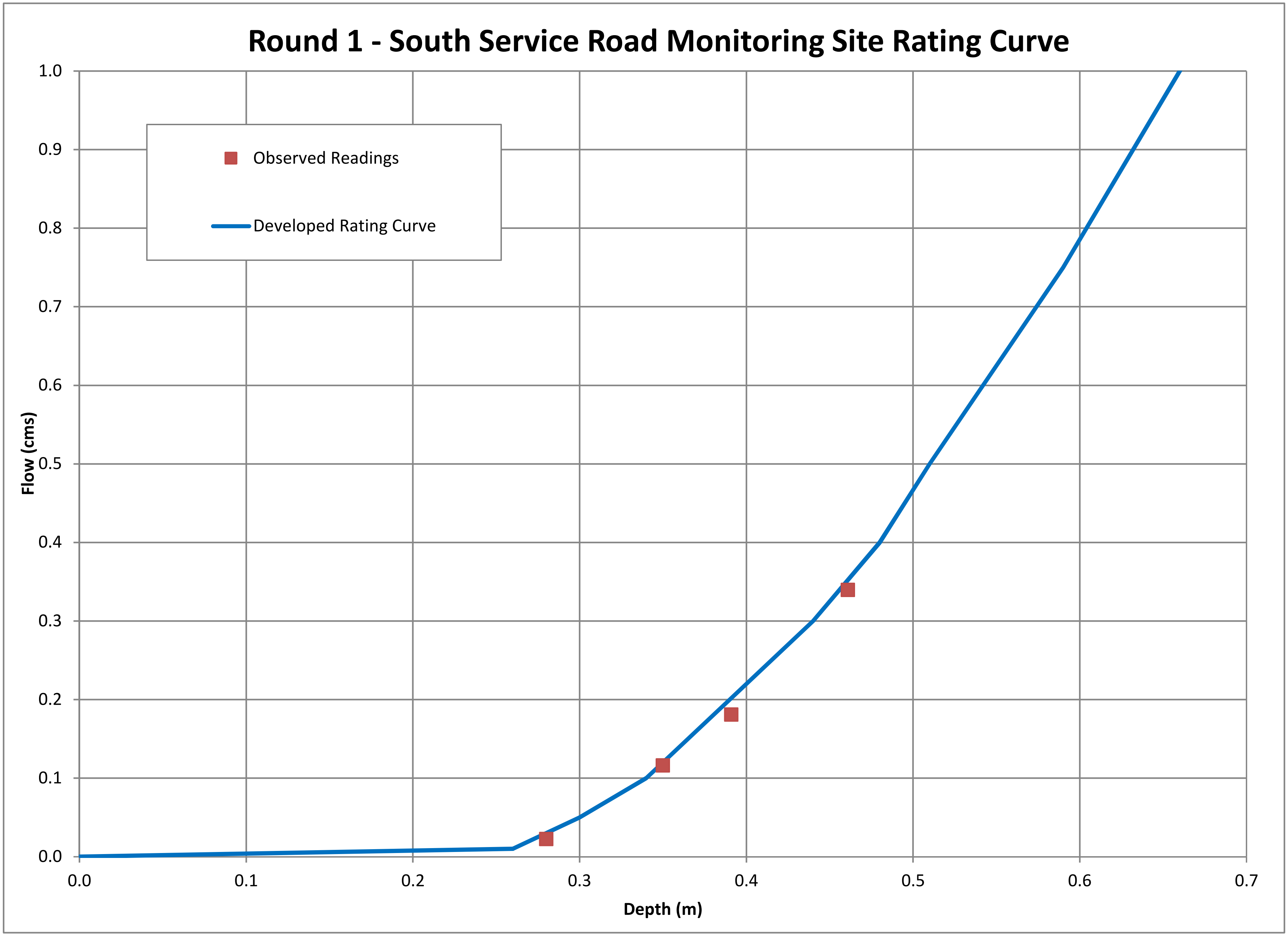

Oakville SSMP Round 1 Monitoring - Estimated Flows at Ford Drive
Nov. 5 - Dec. 7, 2011
Estimated Flow (cms)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
05/11/2011
10/11/2011
15/11/2011
20/11/2011
25/11/2011
30/11/2011
05/12/2011
Date

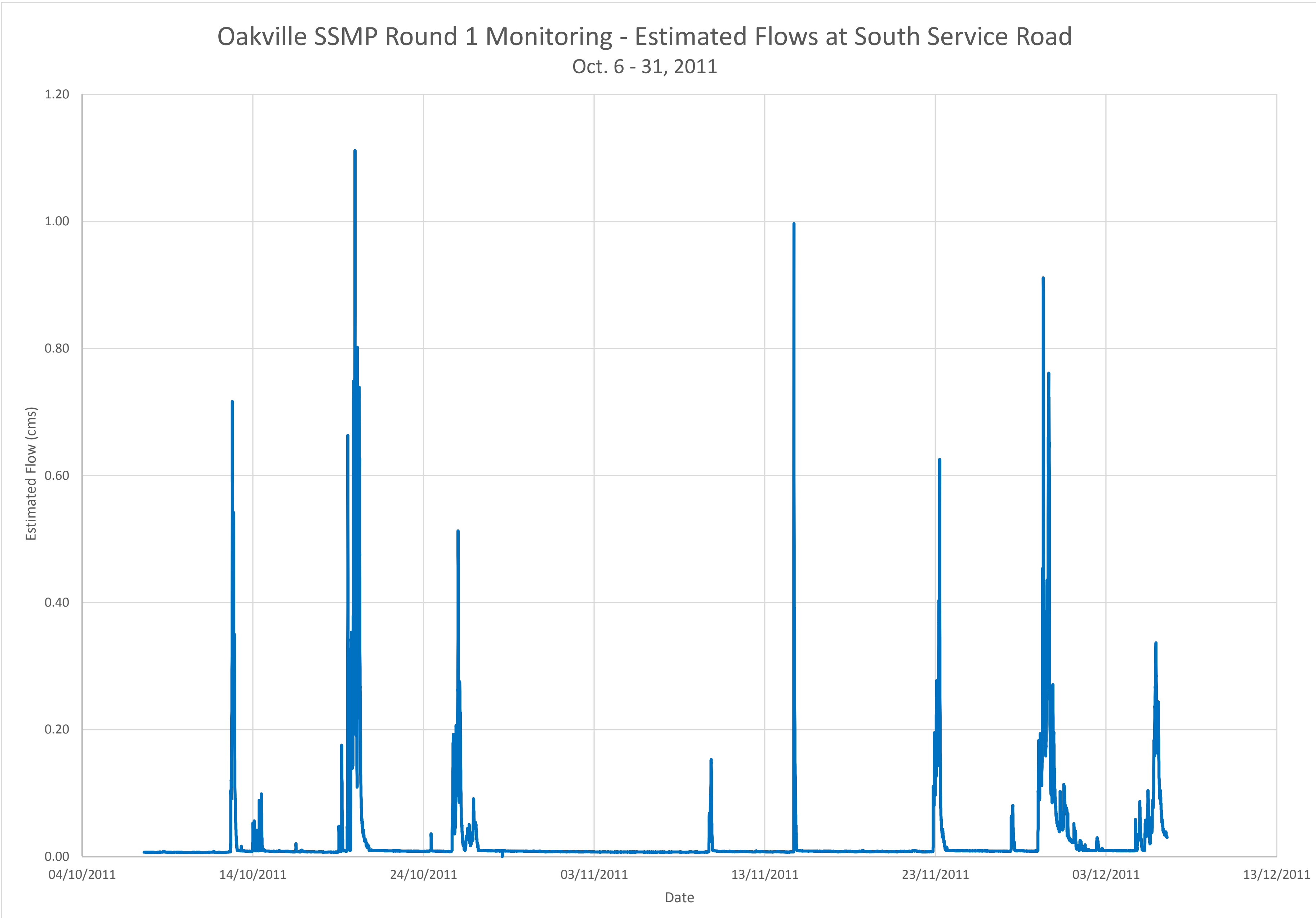


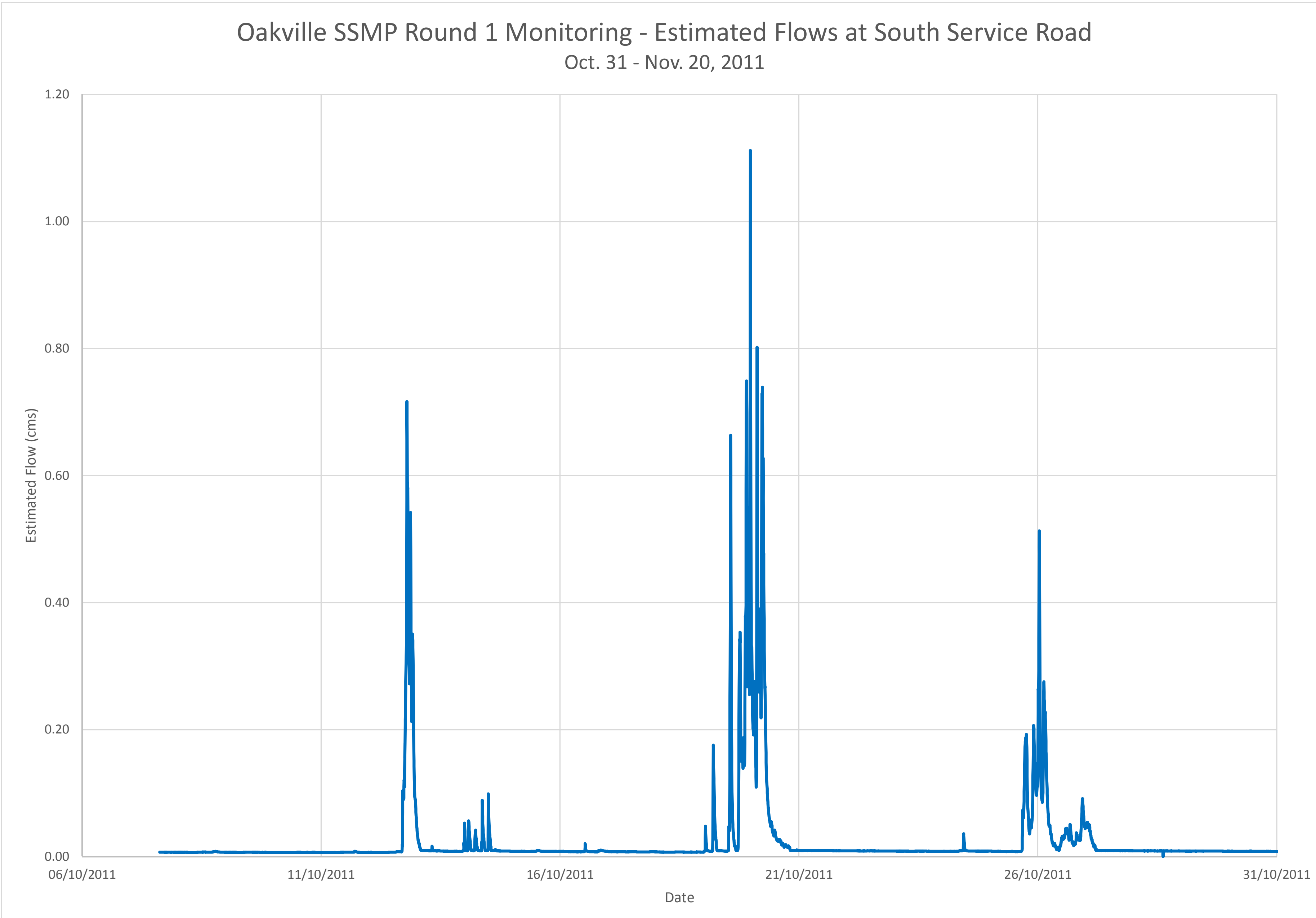
Oakville SSMP Monitoring - Observed Depths at South Service Road
Oct. 7 - 31, 2011
Observed Depth (m)
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
07/10/2011
12/10/2011
17/10/2011
22/10/2011
27/10/2011
Date

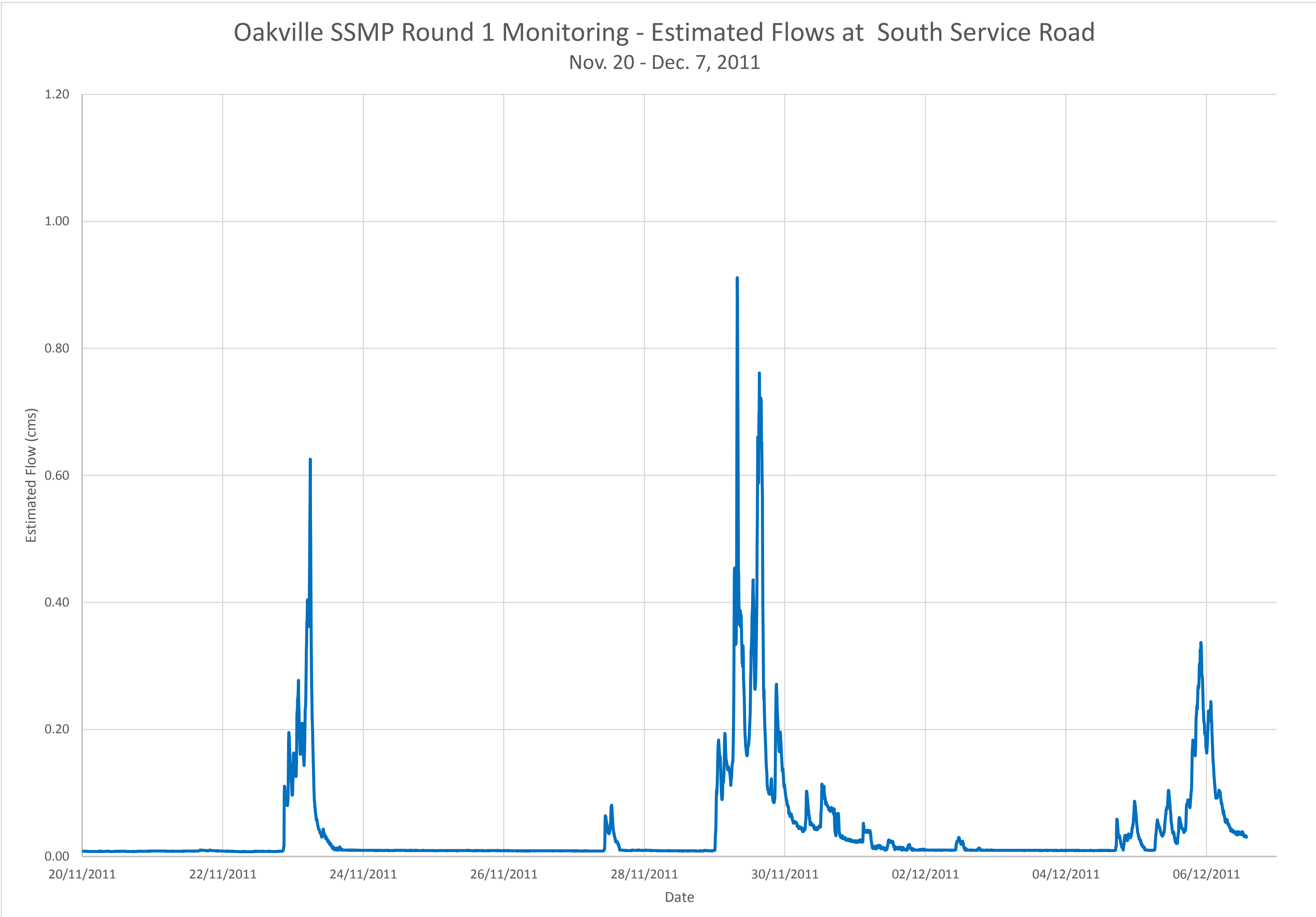

Oakville SSMP Monitoring - Observed Depths at South Service Road
Oct. 31 - Nov. 20, 2011
Observed Depth (m)
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
31/10/2011
02/11/2011
04/11/2011
06/11/2011
08/11/2011
10/11/2011
12/11/2011
14/11/2011
16/11/2011
18/11/2011
20/11/2011
Date

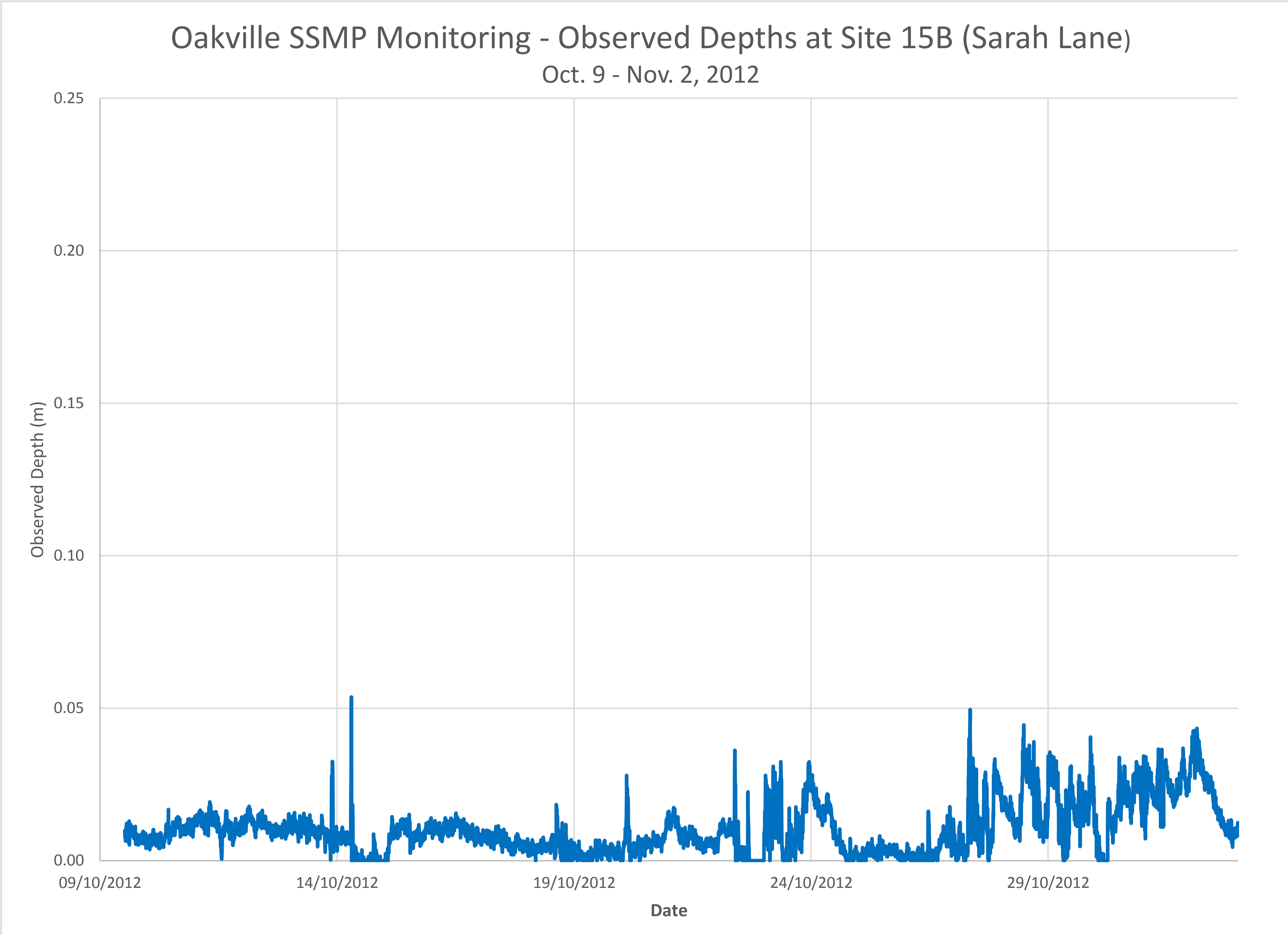

Oakville SSMP Monitoring - Observed Depths at South Service Road
Nov. 20 - Dec. 6, 2011
Observed Depth (m)
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
20/11/2011
22/11/2011
24/11/2011
26/11/2011
28/11/2011
30/11/2011
02/12/2011
04/12/2011
06/12/2011
Date

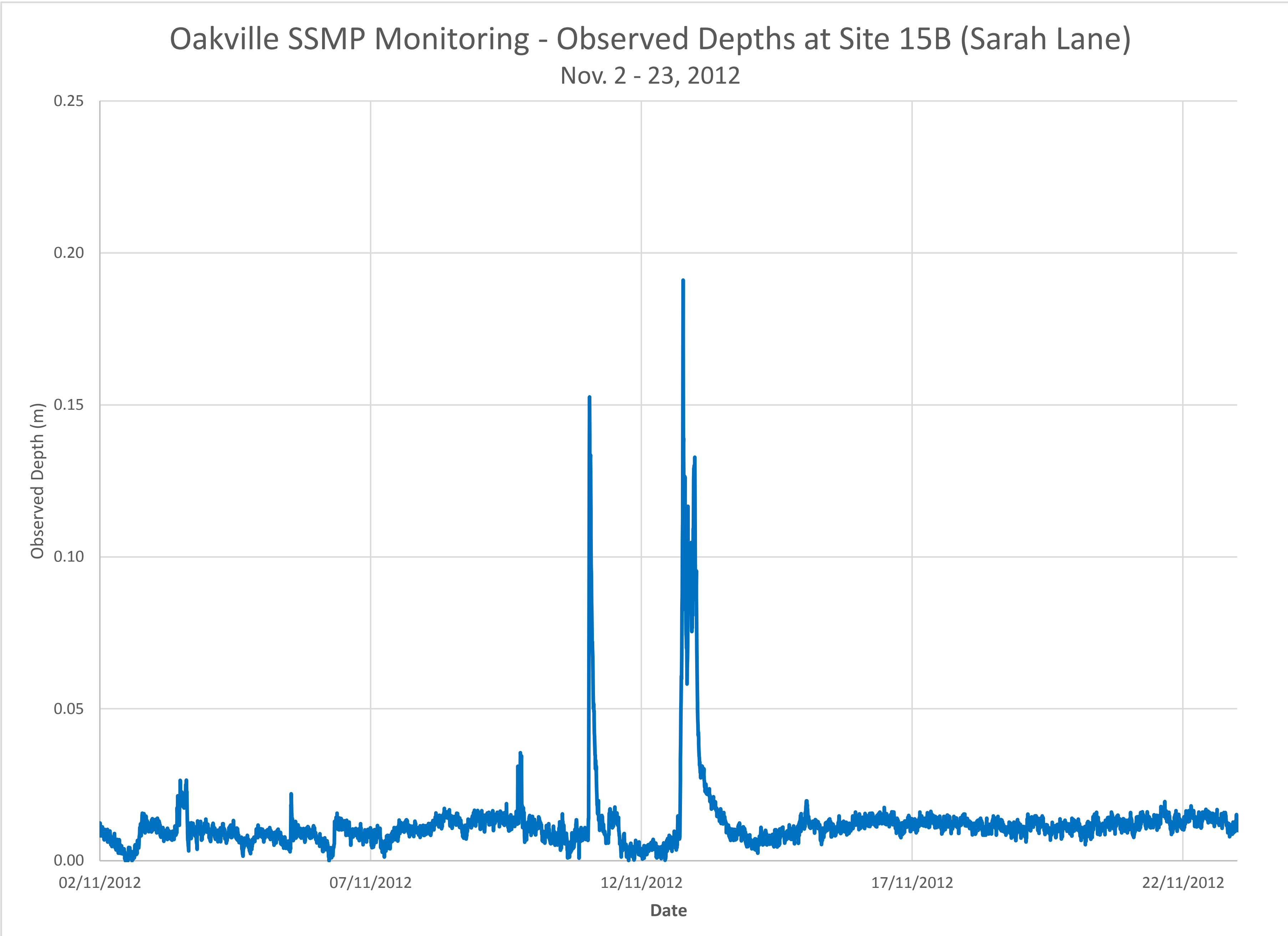

Round 1 - South Service Road Monitoring Site Rating Curve
Observed Readings
Developed Rating Curve
Flow (cms)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Depth (m)

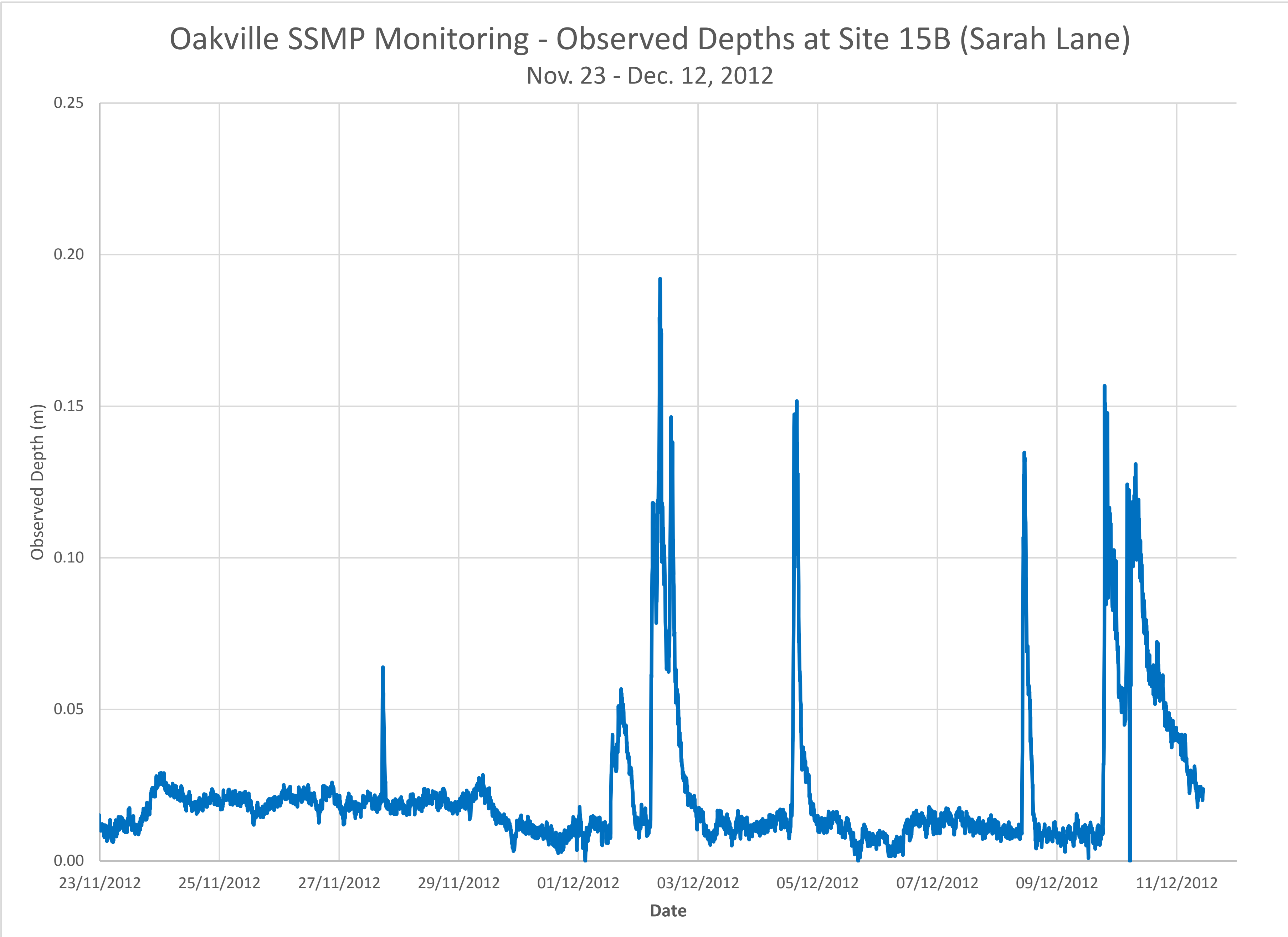

Oakville SSMP Round 1 Monitoring - Estimated Flows at South Service Road
Oct. 6 - 31, 2011
Estimated Flow (cms)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
04/10/2011
14/10/2011
24/10/2011
03/11/2011
13/11/2011
23/11/2011
03/12/2011
13/12/2011
Date


Oakville SSMP Round 1 Monitoring - Estimated Flows at South Service Road
Oct. 31 - Nov. 20, 2011
Estimated Flow (cms)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
06/10/2011
11/10/2011
16/10/2011
21/10/2011
26/10/2011
31/10/2011
Date

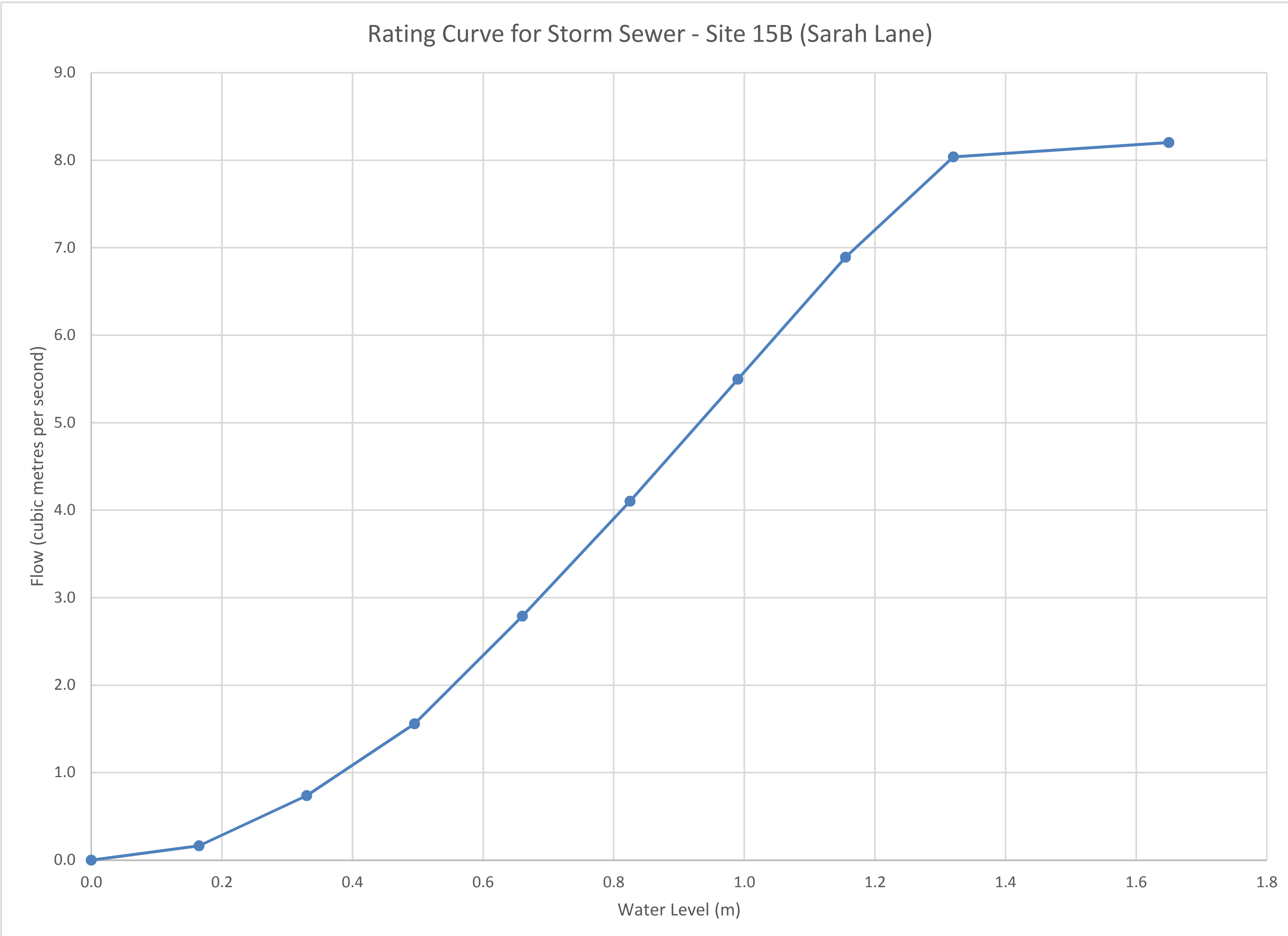

Oakville SSMP Round 1 Monitoring - Estimated Flows at South Service Road
Nov. 20 - Dec. 7, 2011
Estimated Flow (cms)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
20/11/2011
22/11/2011
24/11/2011
26/11/2011
28/11/2011
30/11/2011
02/12/2011
04/12/2011
06/12/2011
Date

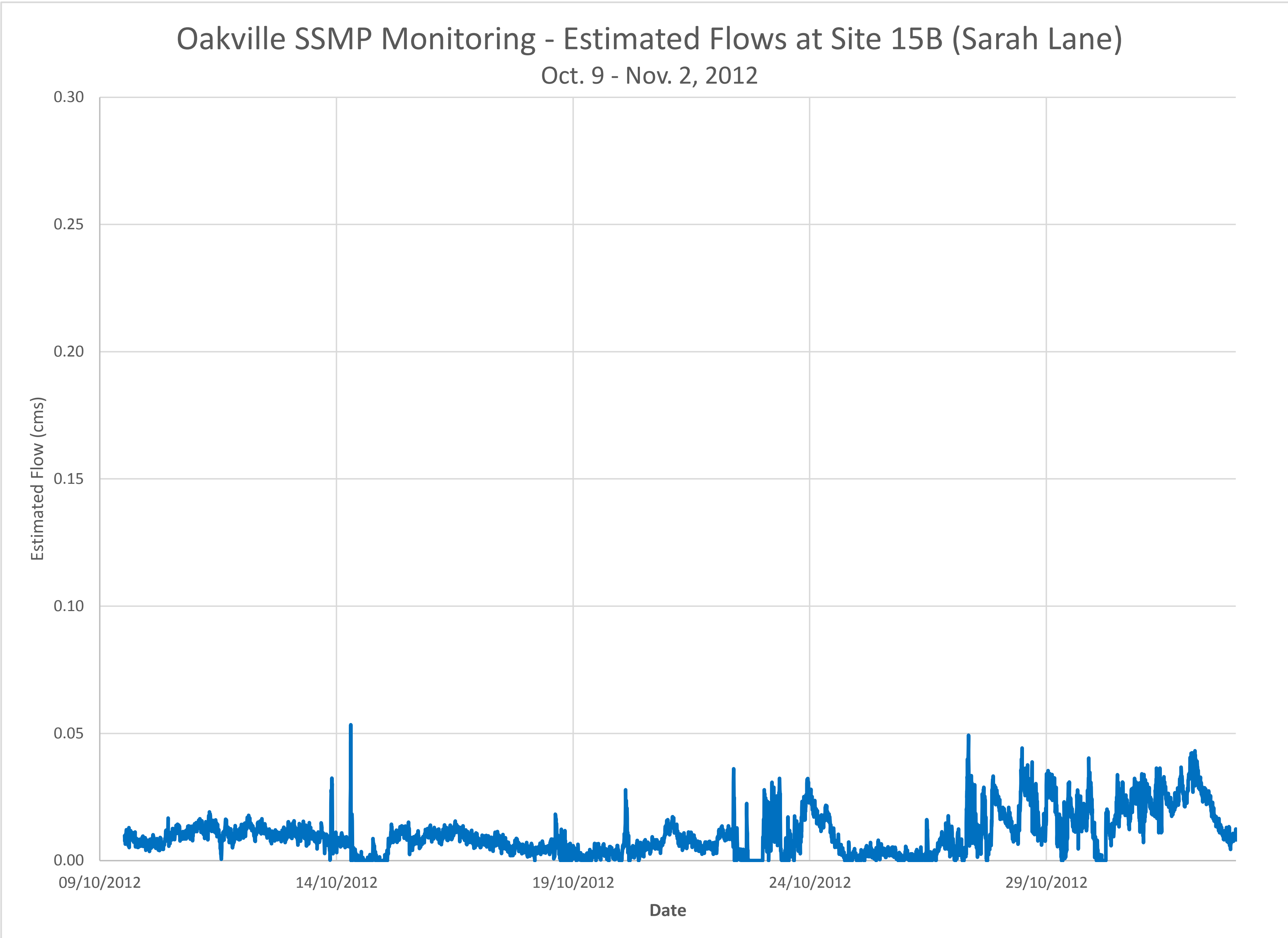

Oakville SSMP Monitoring - Observed Depths at Site 15B (Sarah Lane)
Oct. 9 - Nov. 2, 2012
Observed Depth (m)
0.25
0.20
0.15
0.10
0.05
0.00
09/10/2012
14/10/2012
19/10/2012
24/10/2012
29/10/2012
Date

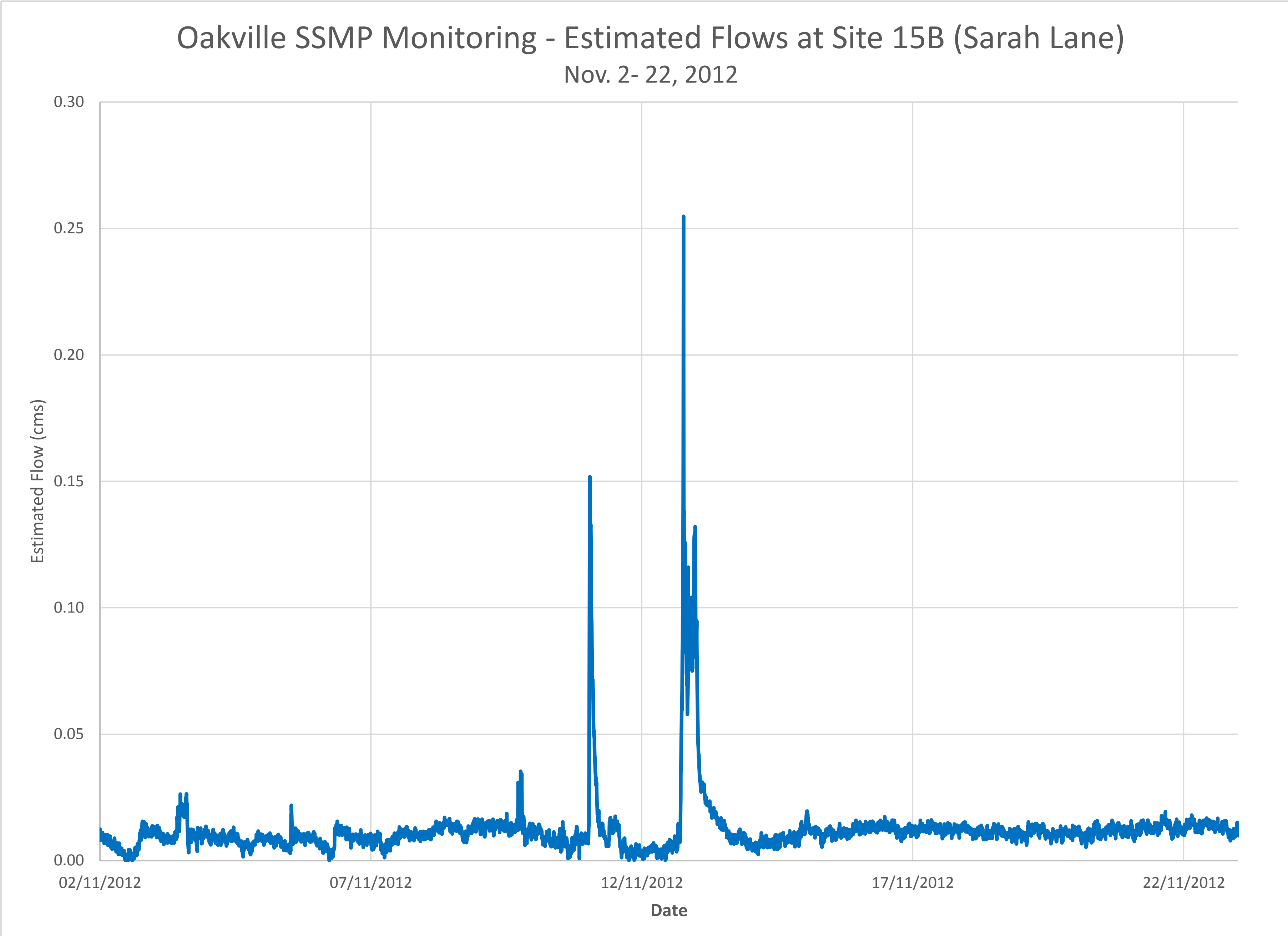

Oakville SSMP Monitoring - Observed Depths at Site 15B (Sarah Lane)
Nov. 2 - 23, 2012
Observed Depth (m)
0.25
0.20
0.15
0.10
0.05
0.00
02/11/2012
07/11/2012
12/11/2012
17/11/2012
22/11/2012
Date

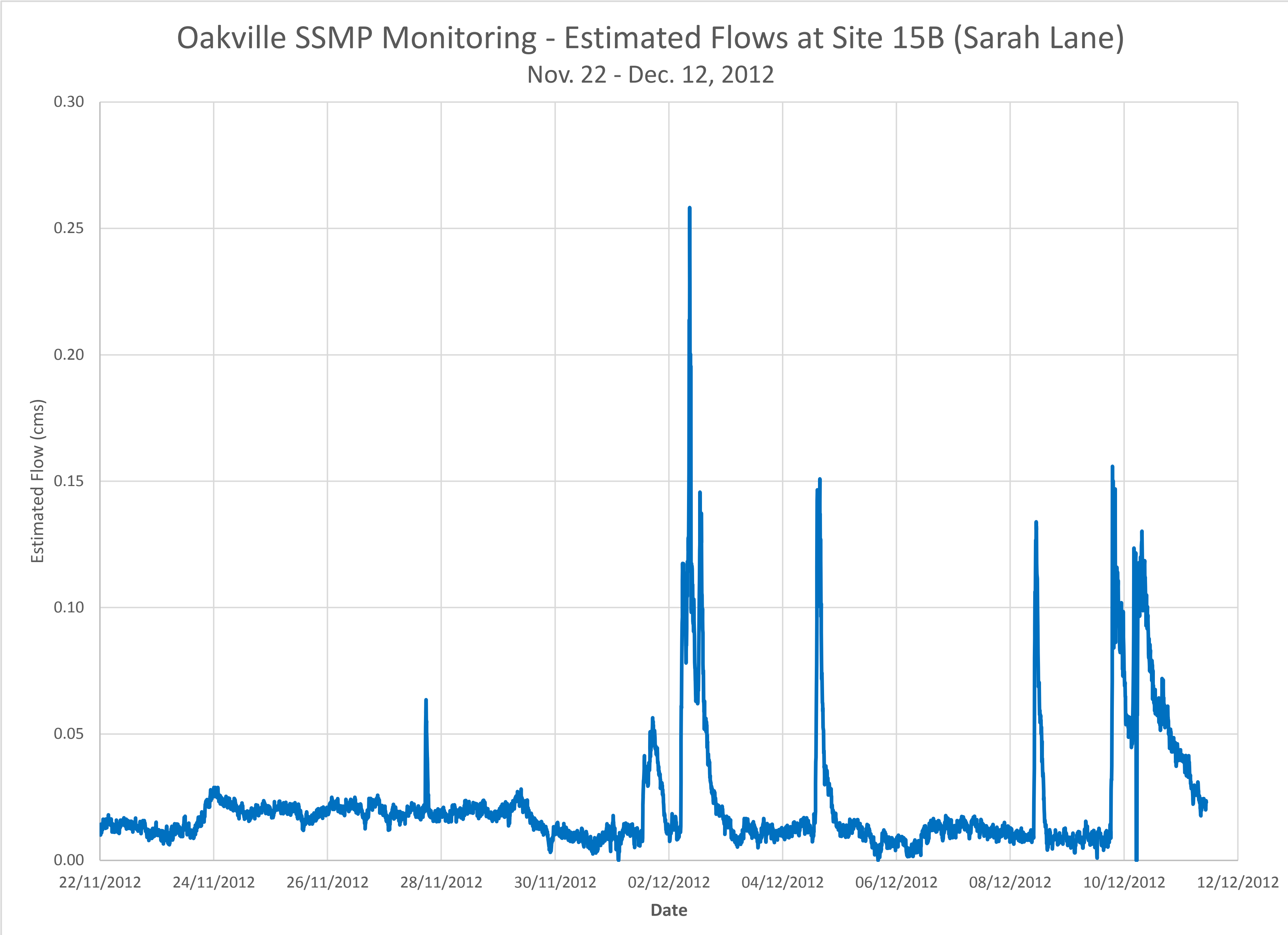


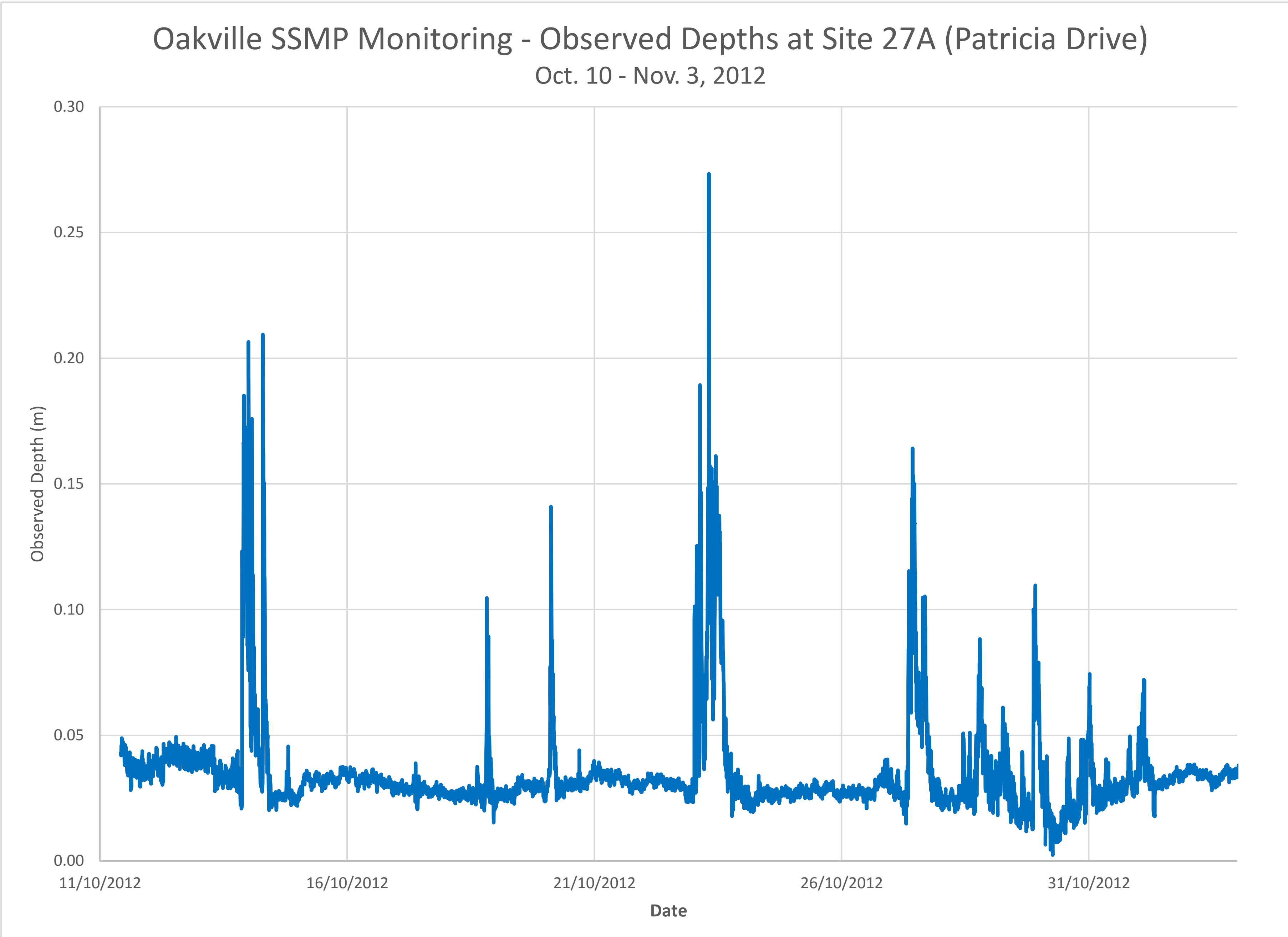
Oakville SSMP Monitoring - Observed Depths at Site 15B (Sarah Lane)
Nov. 23 - Dec. 12, 2012
Observed Depth (m)
0.25
0.20
0.15
0.10
0.05
0.00
23/11/2012
25/11/2012
27/11/2012
29/11/2012
01/12/2012
03/12/2012
05/12/2012
07/12/2012
09/12/2012
11/12/2012
Date


Rating Curve for Storm Sewer - Site 15B (Sarah Lane)
Flow (cubic metres per second)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Water Level (m)

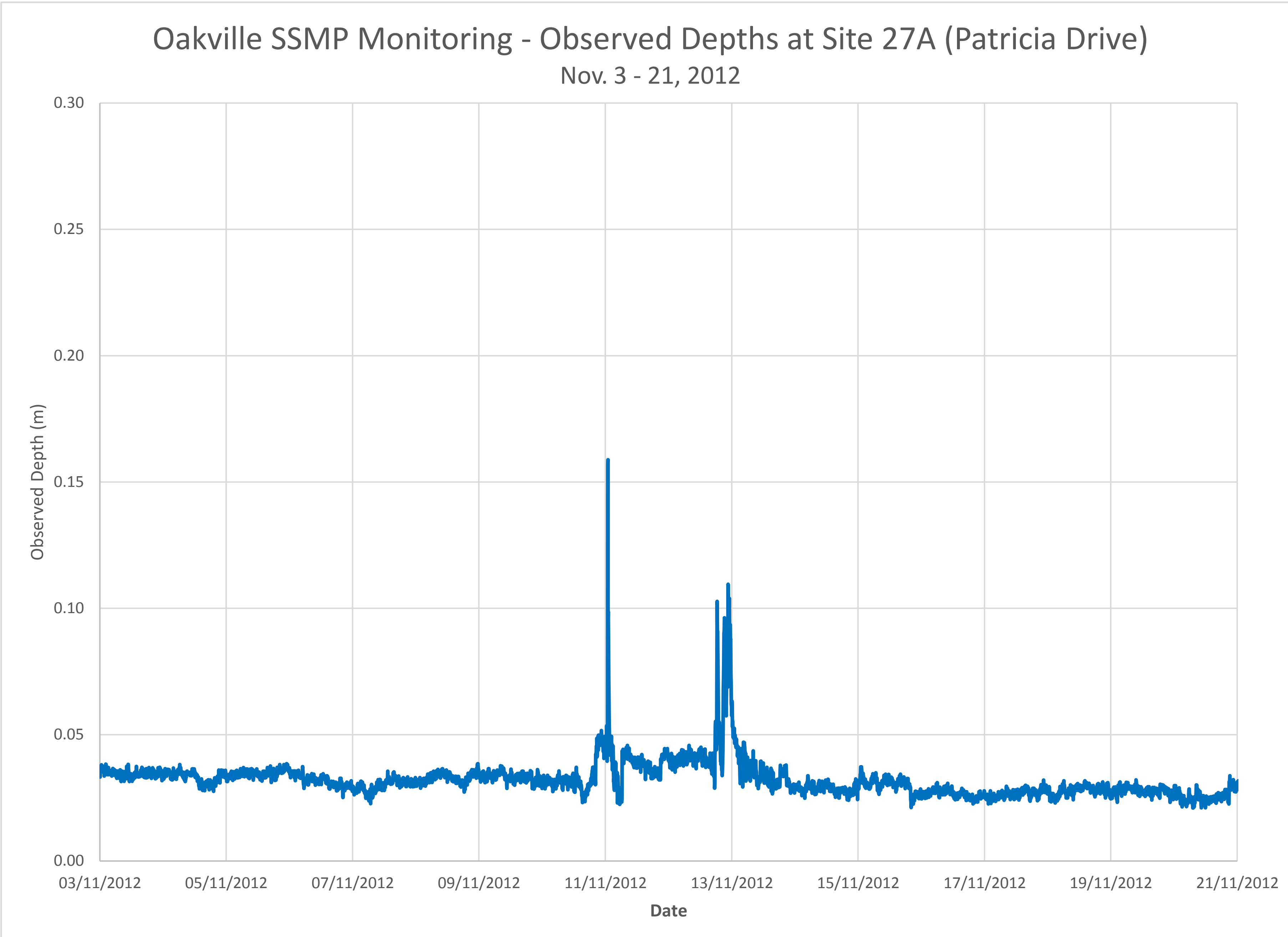

Oakville SSMP Monitoring - Estimated Flows at Site 15B (Sarah Lane)
Oct. 9 - Nov. 2, 2012
Estimated Flow (cms)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
09/10/2012
14/10/2012
19/10/2012
24/10/2012
29/10/2012
Date

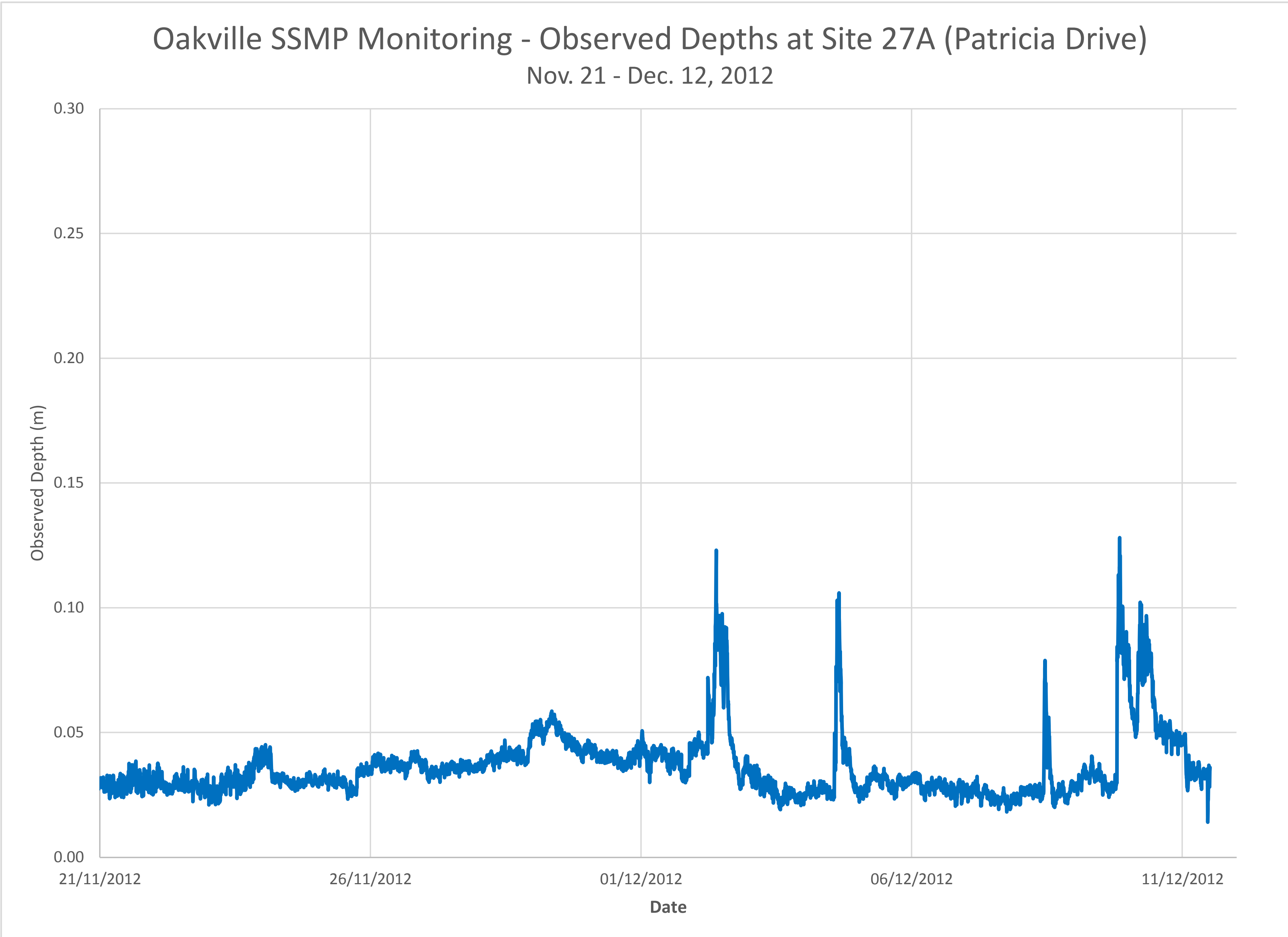

Oakville SSMP Monitoring - Estimated Flows at Site 15B (Sarah Lane)
Nov. 2- 22, 2012
Estimated Flow (cms)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
02/11/2012
07/11/2012
12/11/2012
17/11/2012
22/11/2012
Date

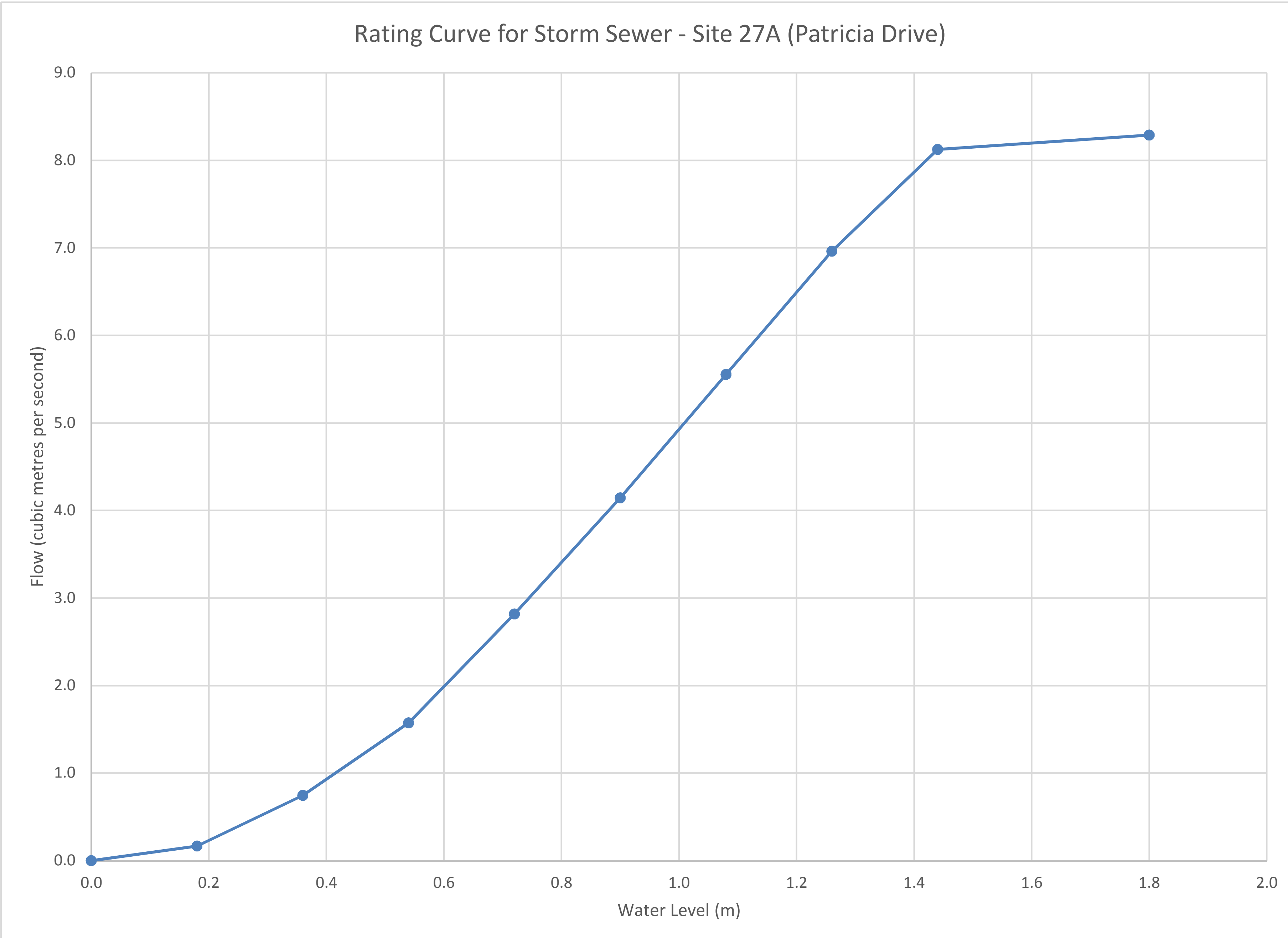

Oakville SSMP Monitoring - Estimated Flows at Site 15B (Sarah Lane)
Nov. 22 - Dec. 12, 2012
Estimated Flow (cms)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
22/11/2012
24/11/2012
26/11/2012
28/11/2012
30/11/2012
02/12/2012
04/12/2012
06/12/2012
08/12/2012
10/12/2012
12/12/2012
Date

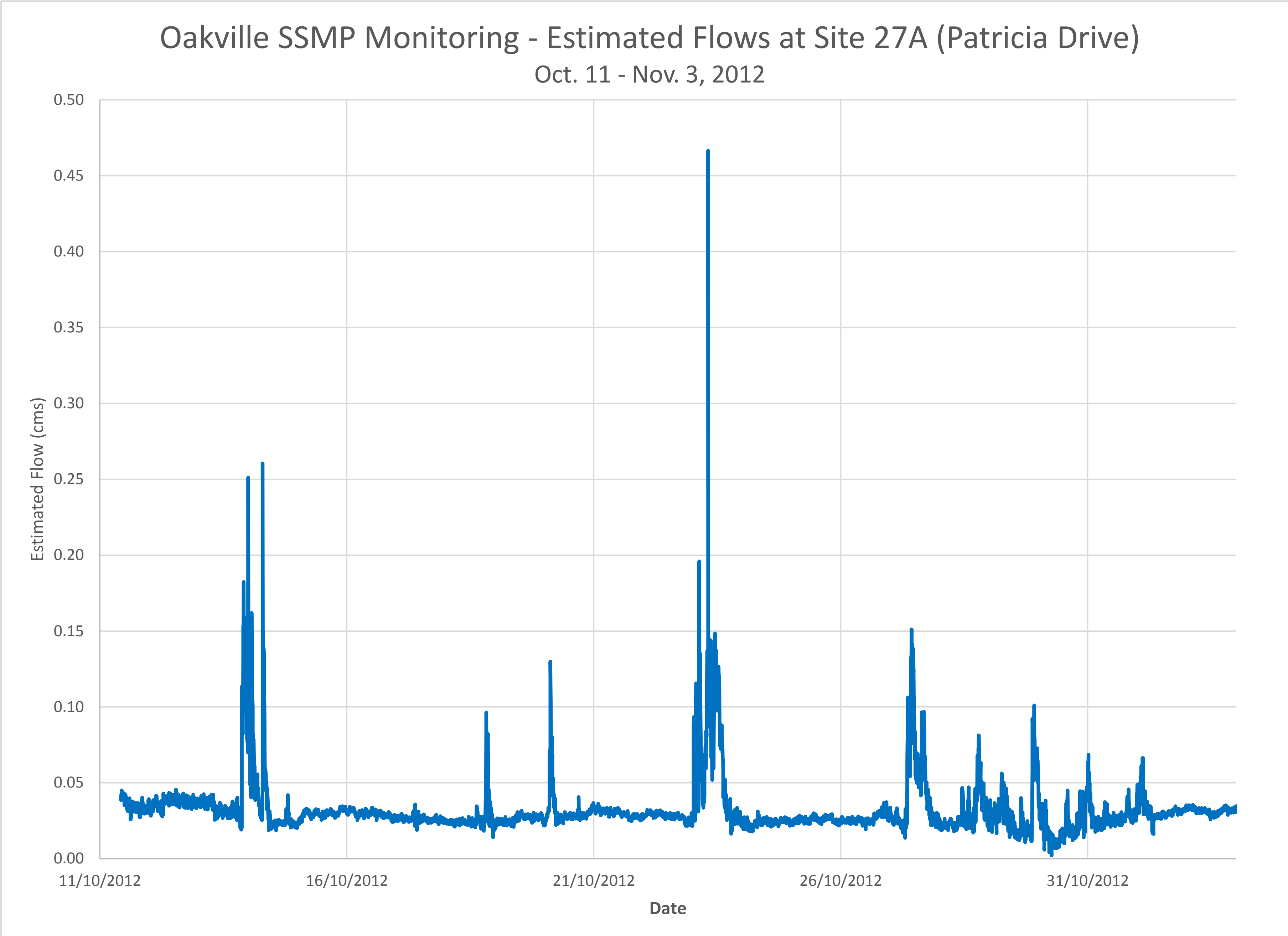


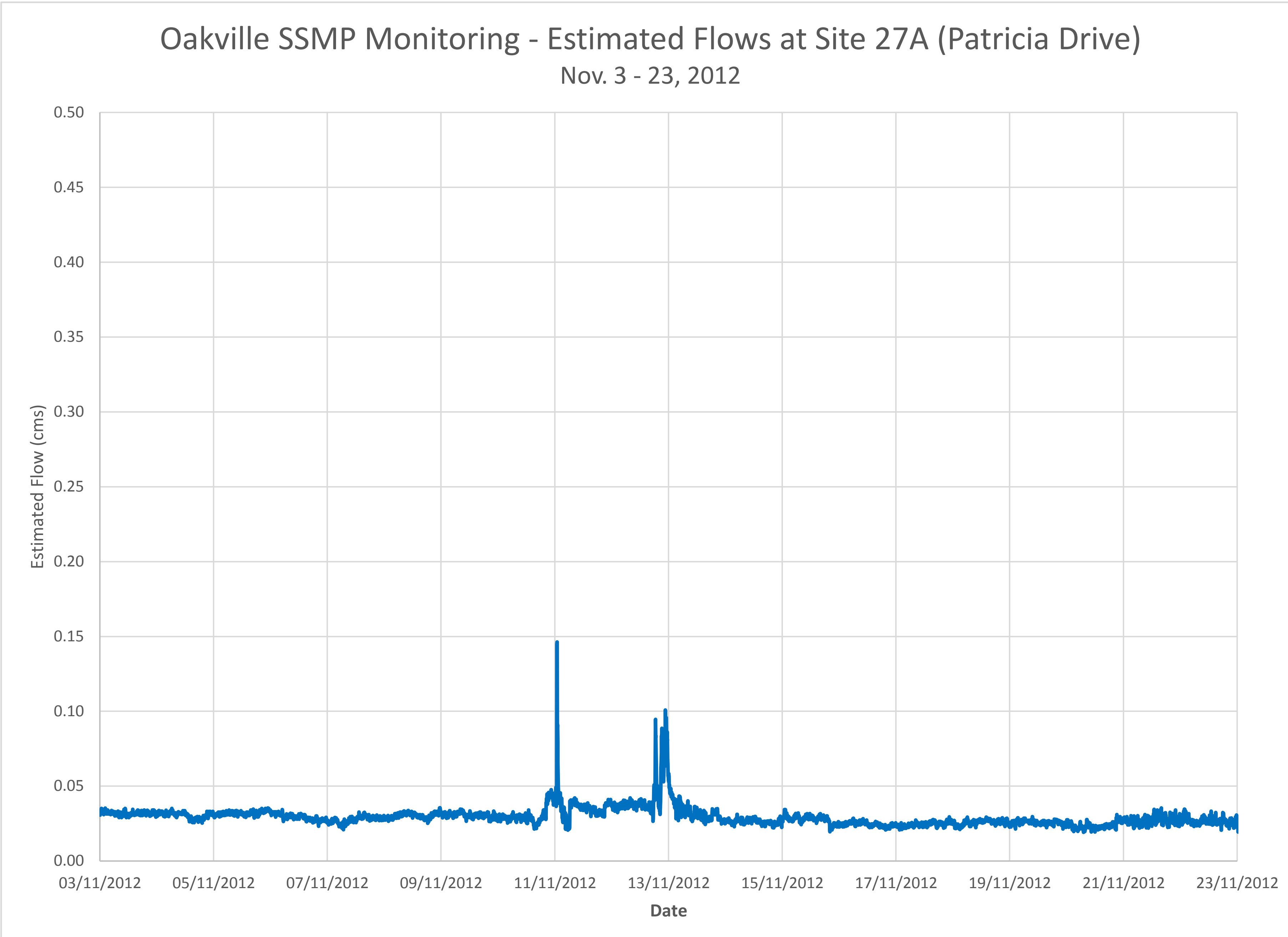
Oakville SSMP Monitoring - Observed Depths at Site 27A (Patricia Drive)
Oct. 10 - Nov. 3, 2012
Observed Depth (m)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
11/10/2012
16/10/2012
21/10/2012
26/10/2012
31/10/2012
Date

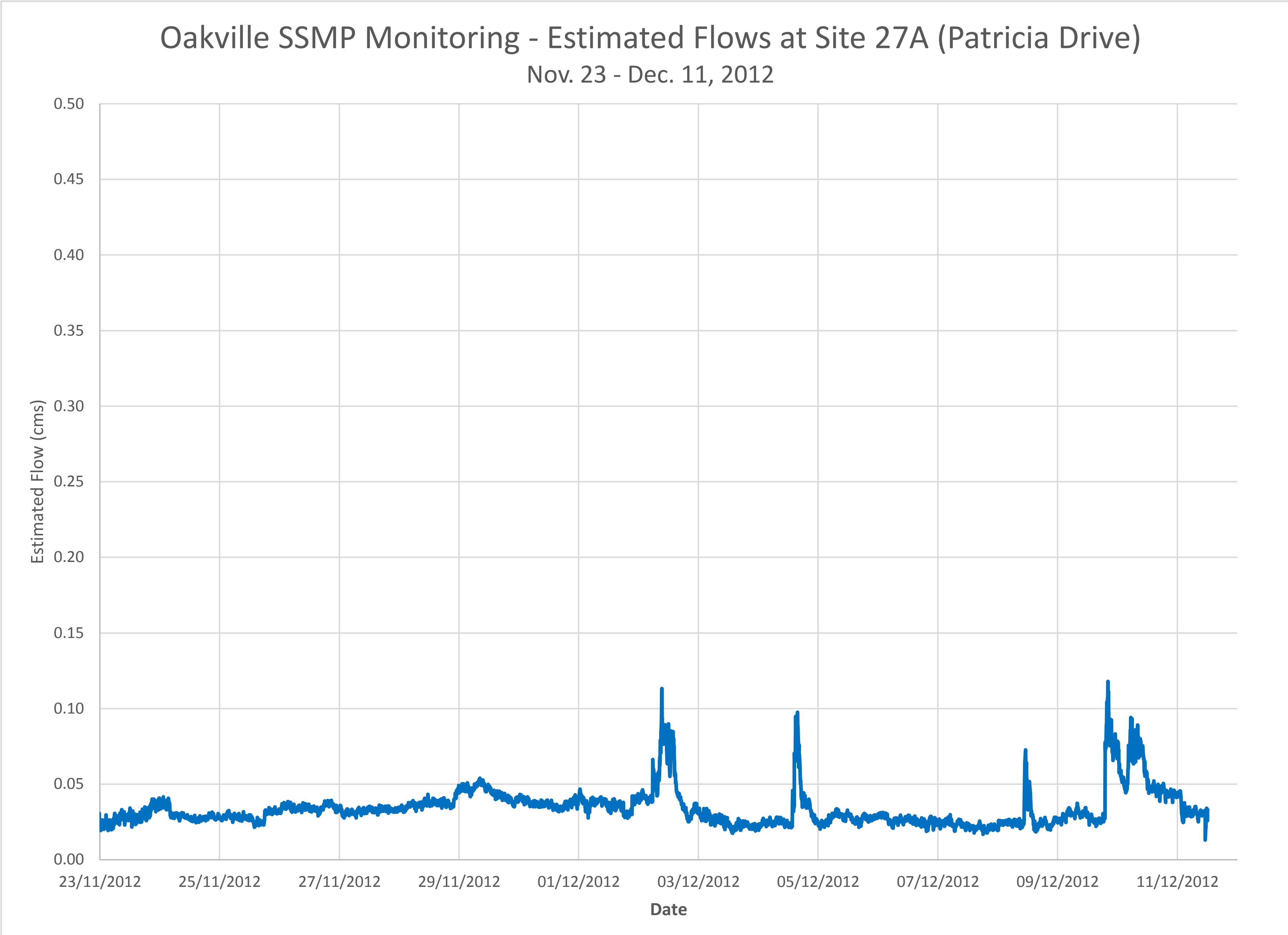

Oakville SSMP Monitoring - Observed Depths at Site 27A (Patricia Drive)
Nov. 3 - 21, 2012
Observed Depth (m)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
03/11/2012
05/11/2012
07/11/2012
09/11/2012
11/11/2012
13/11/2012
15/11/2012
17/11/2012
19/11/2012
21/11/2012
Date


Oakville SSMP Monitoring - Observed Depths at Site 27A (Patricia Drive)
Nov. 21 - Dec. 12, 2012
Observed Depth (m)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
21/11/2012
26/11/2012
01/12/2012
06/12/2012
11/12/2012
Date

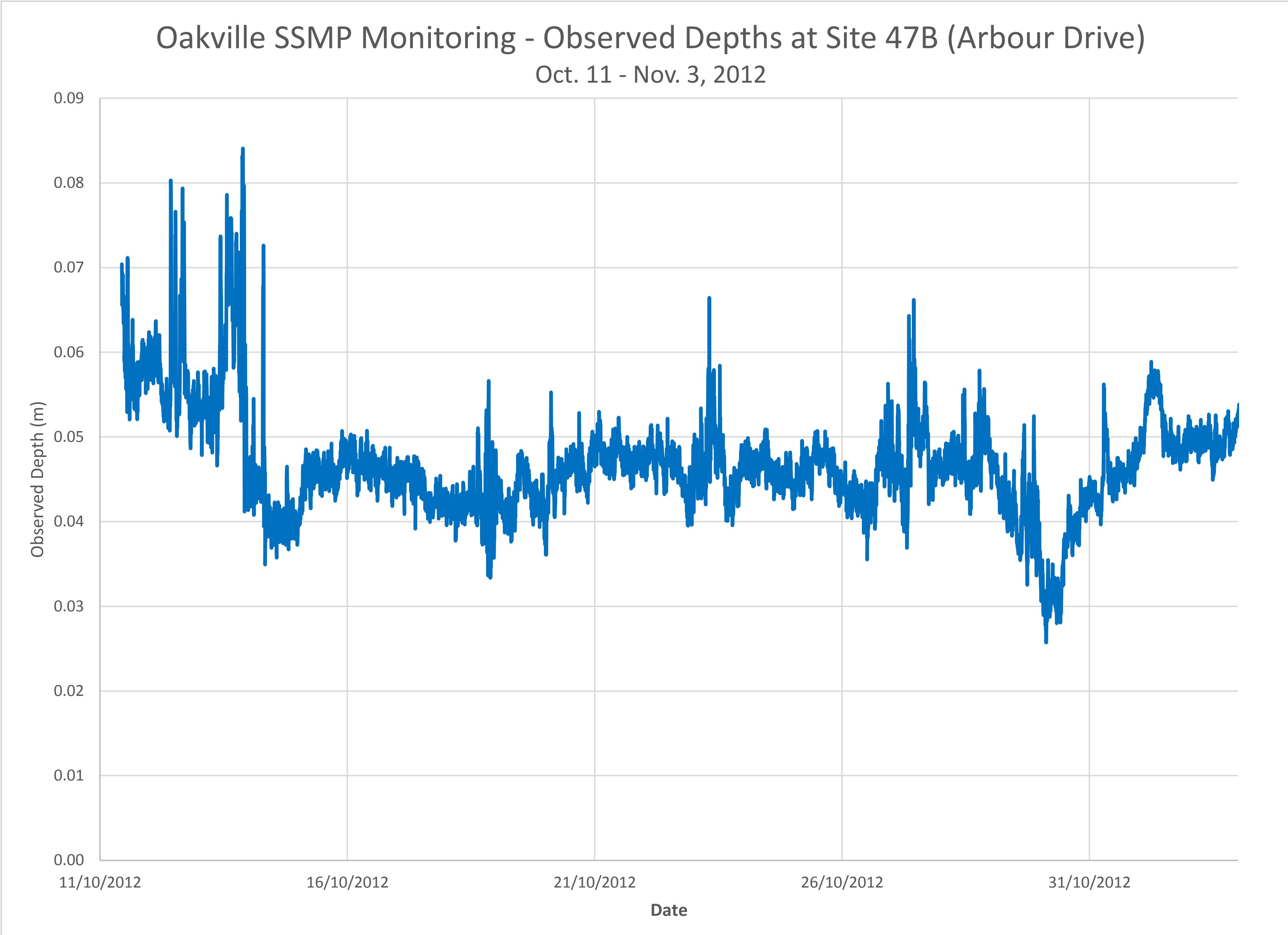

Rating Curve for Storm Sewer - Site 27A (Patricia Drive)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Flow (cubic metres per second)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Water Level (m)

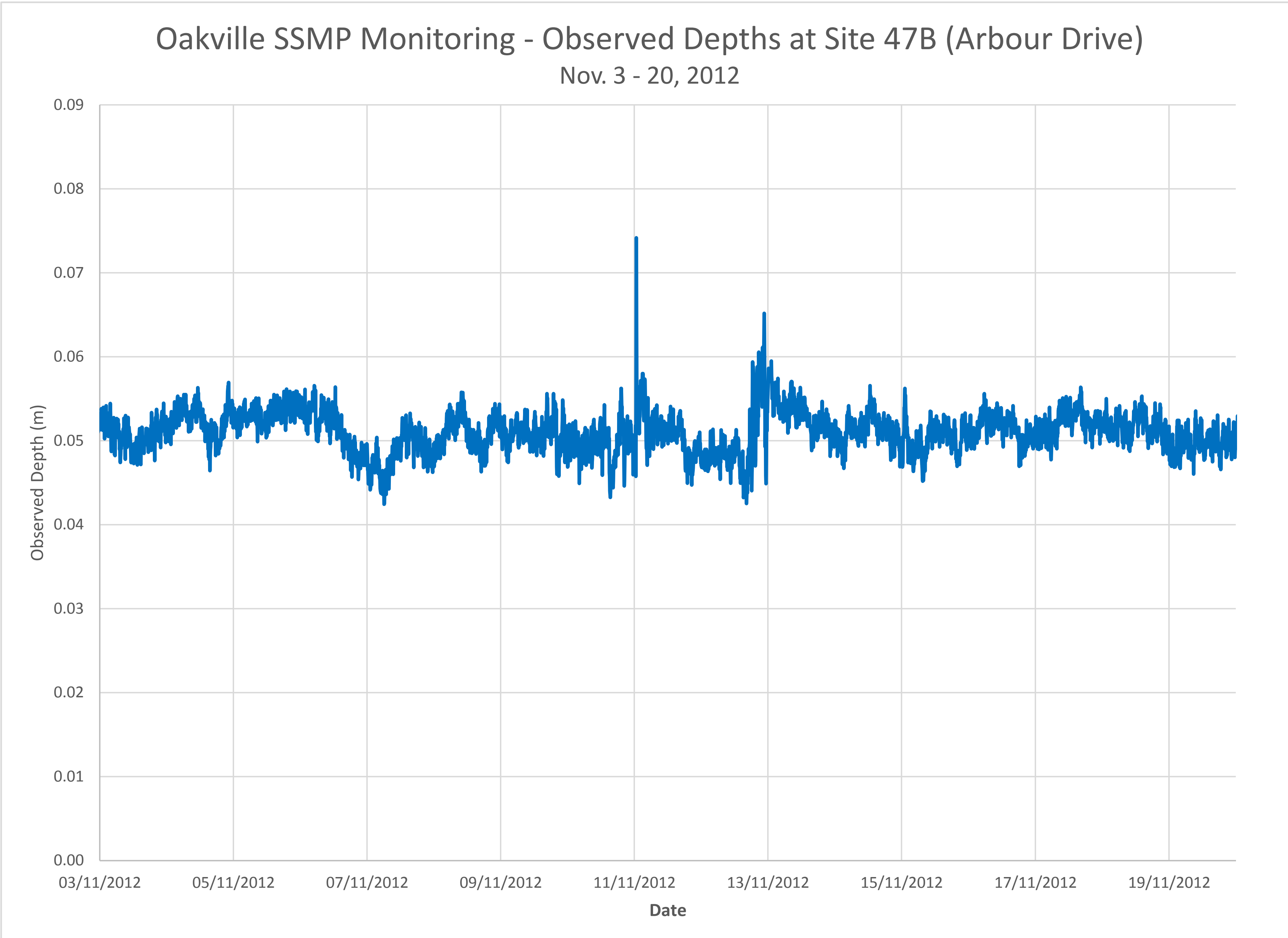

Oakville SSMP Monitoring - Estimated Flows at Site 27A (Patricia Drive)
Oct. 11 - Nov. 3, 2012
Estimated Flow (cms)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
11/10/2012
16/10/2012
21/10/2012
26/10/2012
31/10/2012
Date


Oakville SSMP Monitoring - Estimated Flows at Site 27A (Patricia Drive)
Nov. 3 - 23, 2012
Estimated Flow (cms)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
03/11/2012
05/11/2012
07/11/2012
09/11/2012
11/11/2012
13/11/2012
15/11/2012
17/11/2012
19/11/2012
21/11/2012
23/11/2012
Date

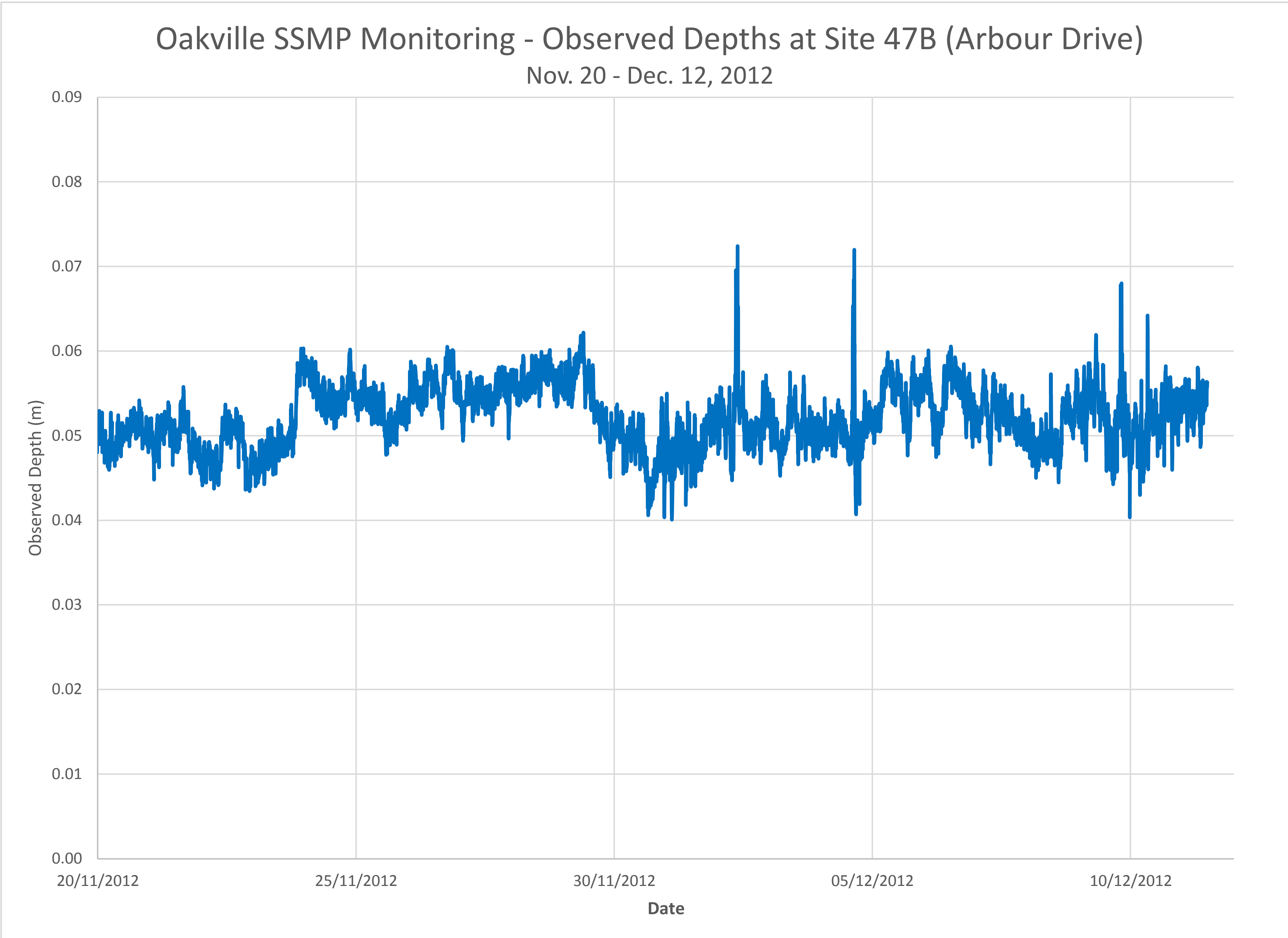


Oakville SSMP Monitoring - Estimated Flows at Site 27A (Patricia Drive)
Nov. 23 - Dec. 11, 2012
Estimated Flow (cms)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
23/11/2012
25/11/2012
27/11/2012
29/11/2012
01/12/2012
03/12/2012
05/12/2012
07/12/2012
09/12/2012
11/12/2012
Date

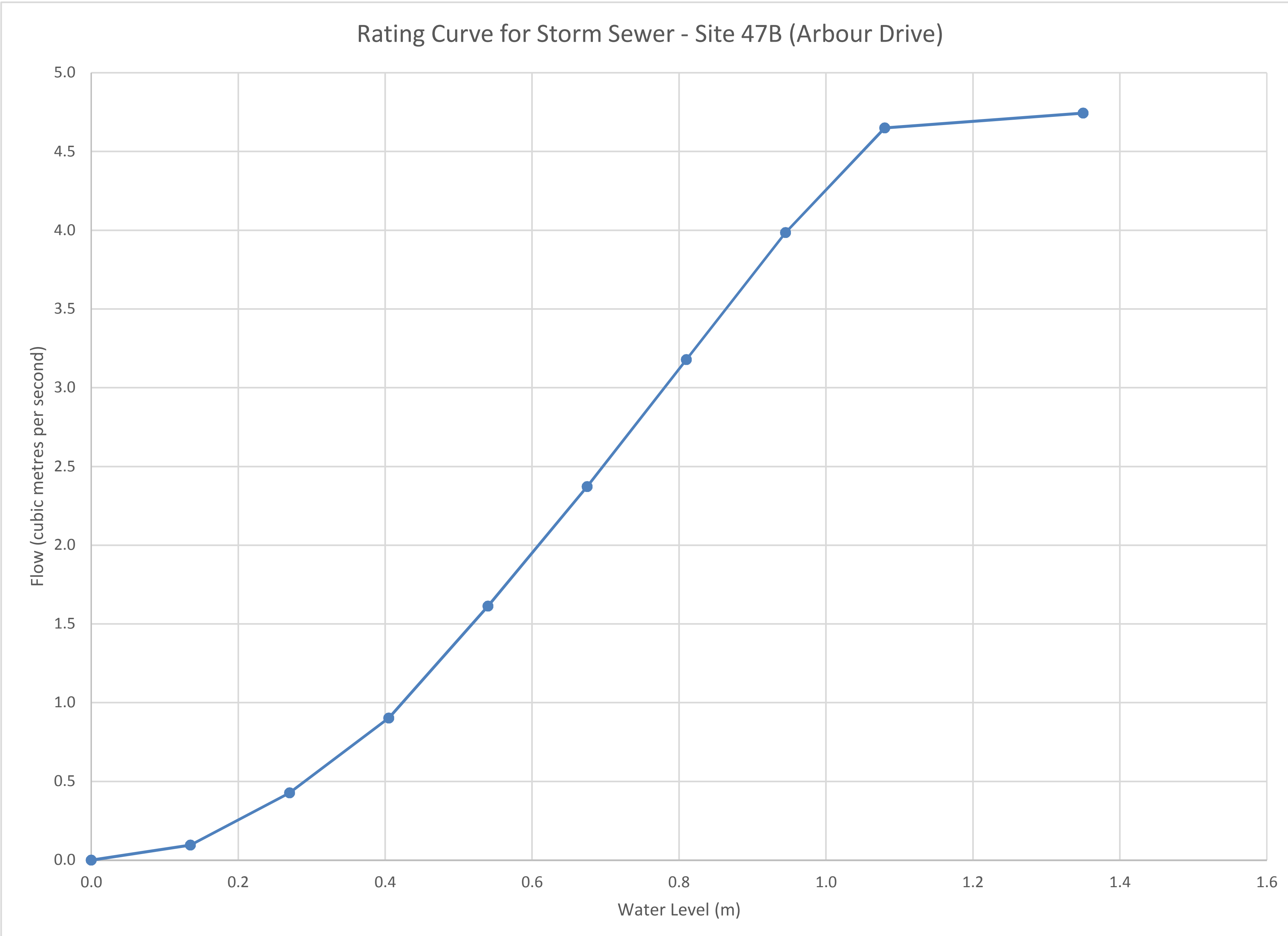

Oakville SSMP Monitoring - Observed Depths at Site 47B (Arbour Drive)
Oct. 11 - Nov. 3, 2012
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Observed Depth (m)
11/10/2012
16/10/2012
21/10/2012
26/10/2012
31/10/2012
Date

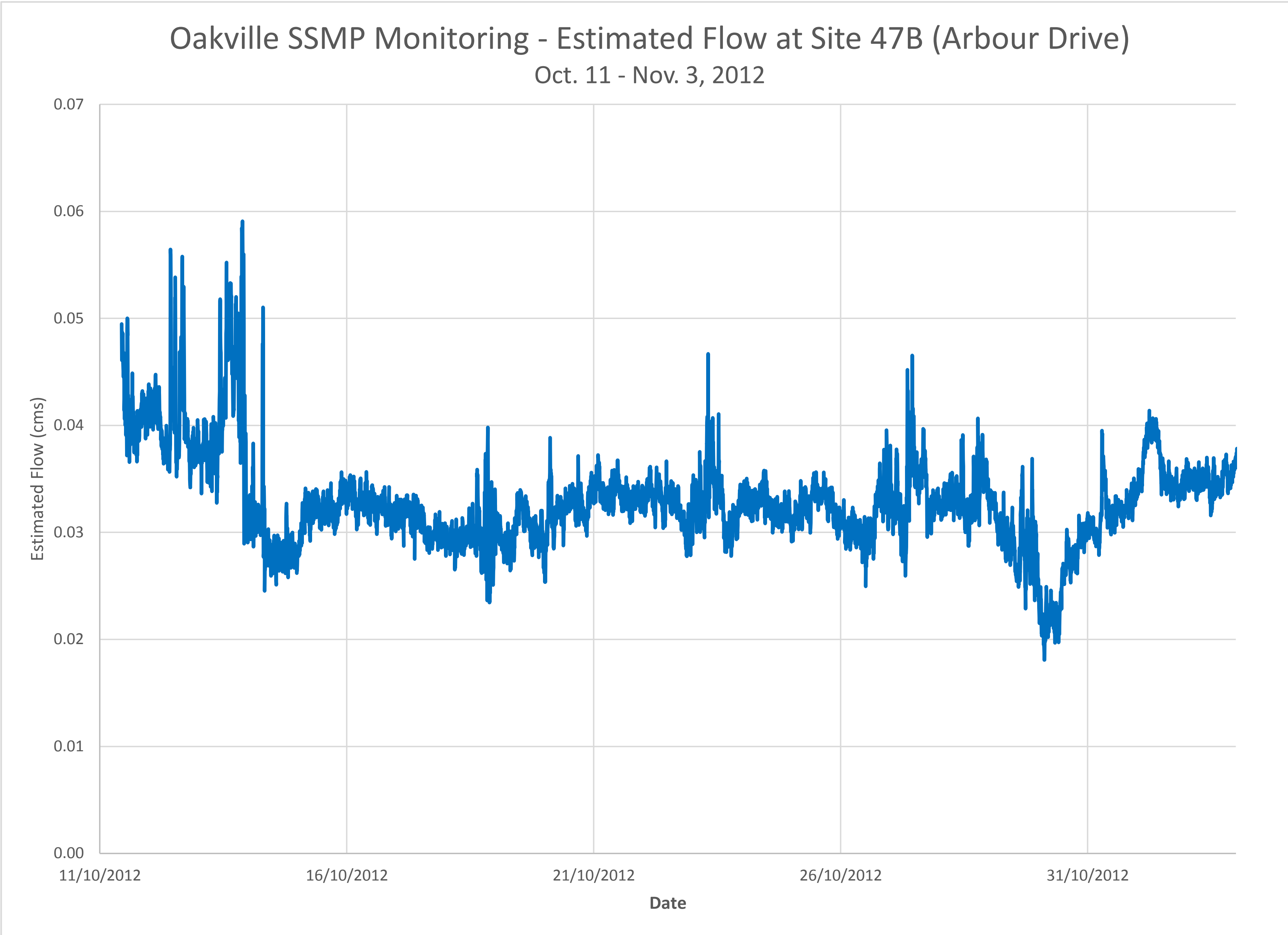


Oakville SSMP Monitoring - Observed Depths at Site 47B (Arbour Drive)
Nov. 3 - 20, 2012
Observed Depth (m)
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
03/11/2012
05/11/2012
07/11/2012
09/11/2012
11/11/2012
13/11/2012
15/11/2012
17/11/2012
19/11/2012
Date

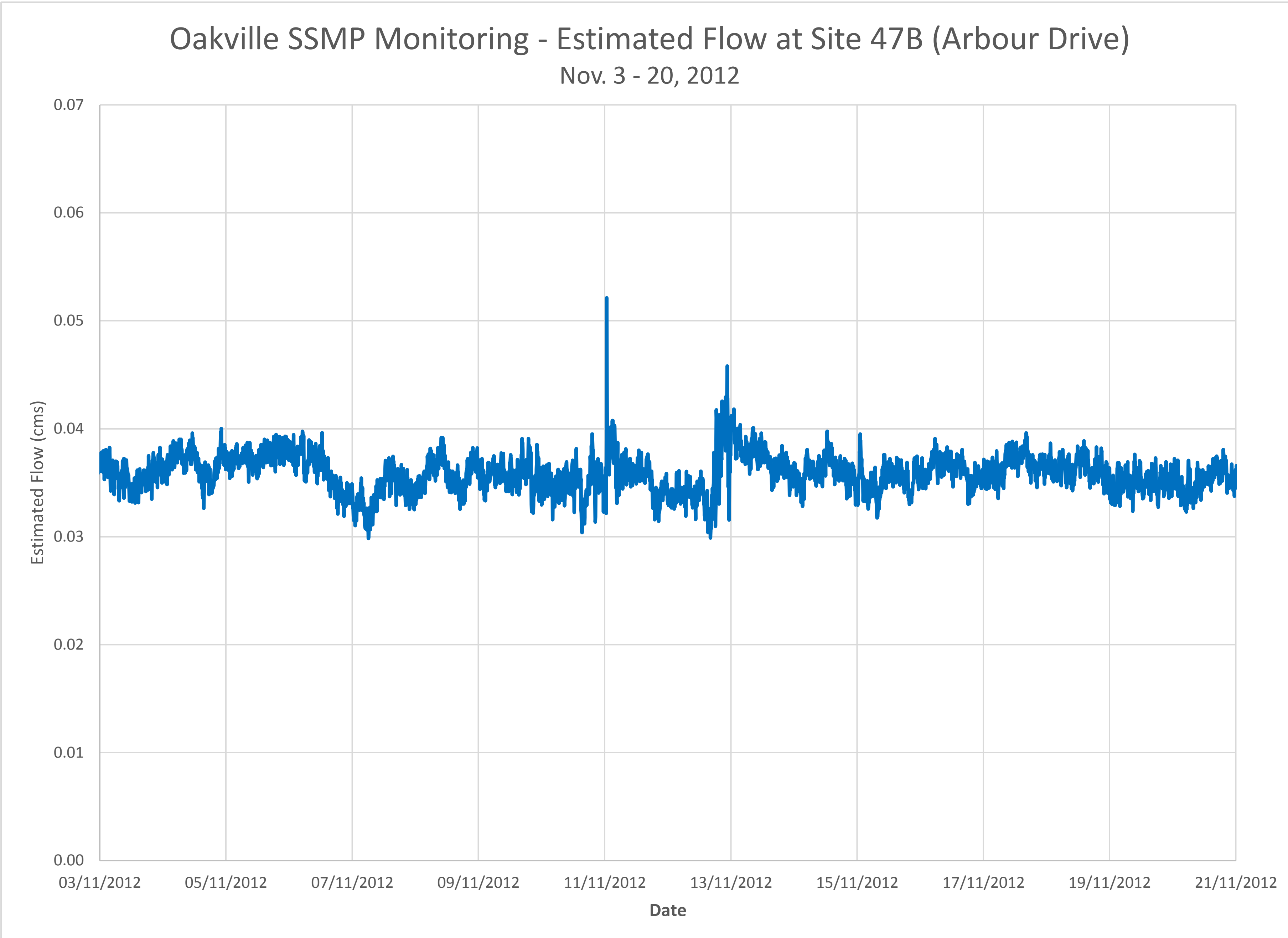


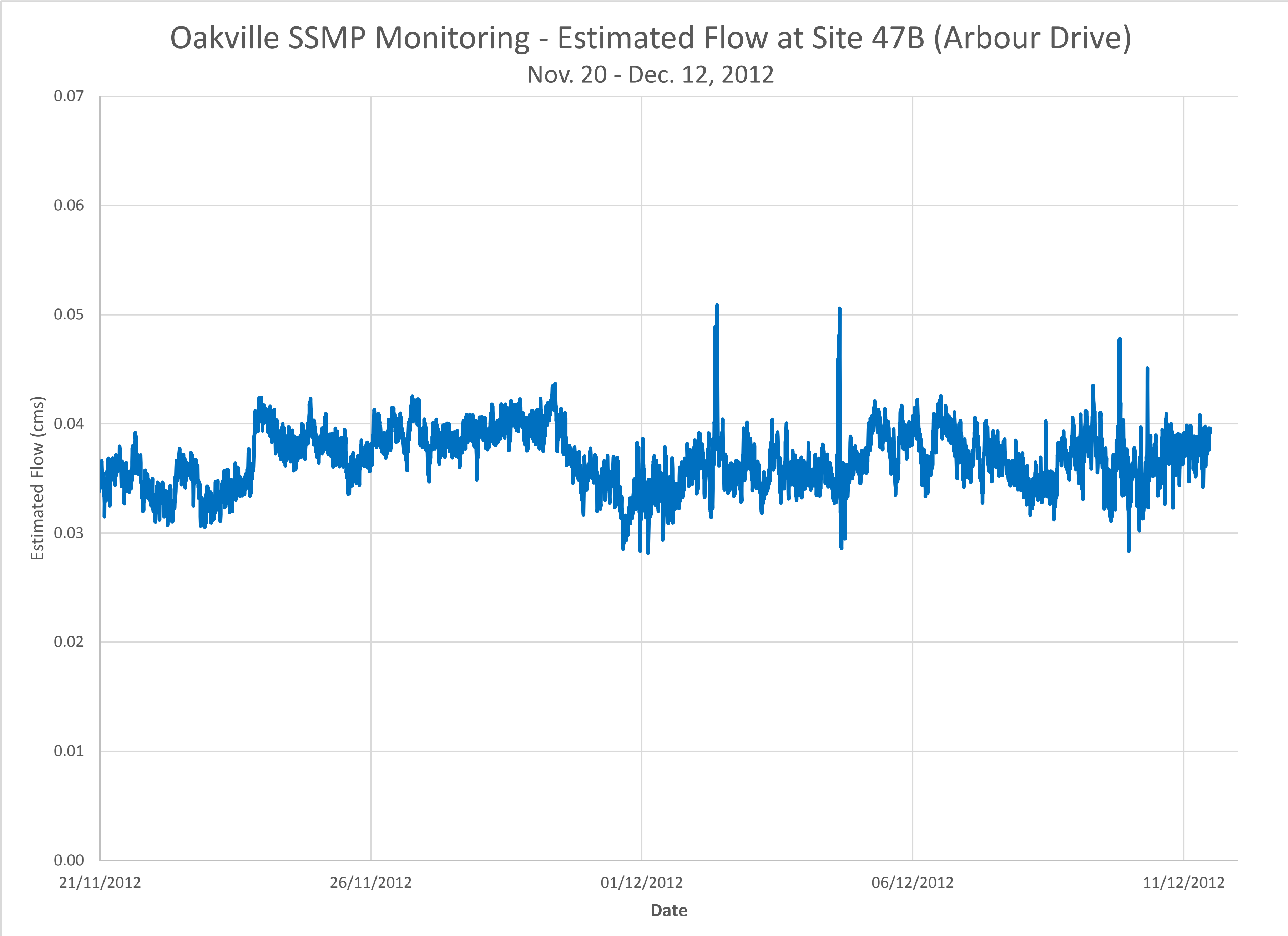
Oakville SSMP Monitoring - Observed Depths at Site 47B (Arbour Drive)
Nov. 20 - Dec. 12, 2012
Observed Depth (m)
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
20/11/2012
25/11/2012
30/11/2012
05/12/2012
10/12/2012
Date


Rating Curve for Storm Sewer - Site 47B (Arbour Drive)
Flow (cubic metres per second)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
Water Level (m)



Oakville SSMP Monitoring - Estimated Flow at Site 47B (Arbour Drive)
Oct. 11 - Nov. 3, 2012
Estimated Flow (cms)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
11/10/2012
16/10/2012
21/10/2012
26/10/2012
31/10/2012
Date


Oakville SSMP Monitoring - Estimated Flow at Site 47B (Arbour Drive)
Nov. 3 - 20, 2012
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Estimated Flow (cms)
03/11/2012
05/11/2012
07/11/2012
09/11/2012
11/11/2012
13/11/2012
15/11/2012
17/11/2012
19/11/2012
21/11/2012
Date



Oakville SSMP Monitoring - Estimated Flow at Site 47B (Arbour Drive)
Nov. 20 - Dec. 12, 2012
Estimated Flow (cms)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
21/11/2012
26/11/2012
01/12/2012
06/12/2012
11/12/2012
Date

APPENDIX H

Cost Estimate

Cost Estimates Capital Works, Maintenance Practices and Monitoring of Storm Sewer Pipes						
	5 Year Cost			10 Year Cost		
Network	Replacement Based on Structural Condition	Maintenance	Monitoring	Replacement Based on Structural Condition	Maintenance	Monitoring
1	$37,806	$0	$10,656	$114,954	$0	$10,440
2	$0	$0	$7,110	$165,100	$0	$6,798
3	$0	$6,998	$11,169	$0	$3,580	$11,298
4	$0	$0	$21,798	$130,008	$0	$21,513
5	$0	$0	$7,203	$0	$12,508	$6,792
6	$0	$0	$2,013	$16,760	$2,309	$1,791
7	$0	$2,784	$3,168	$0	$11,767	$2,904
8	$13,241	$14,369	$13,887	$45,252	$15,696	$13,506
9	$0	$5,875	$10,290	$0	$6,201	$10,272
10	$0	$2,988	$153	$0	$0	$285
11	$0	$1,494	$3,807	$0	$0	$3,873
12	$0	$0	$1,170	$0	$0	$1,170
13	$0	$27,687	$23,859	$9,936	$153,374	$23,190
14	$12,989	$47,802	$46,791	$297,249	$151,182	$46,698
15	$84,638	$36,557	$26,580	$83,128	$28,368	$26,802
16	$0	$0	$1,047	$0	$0	$1,047
17	$0	$0	$4,185	$72,147	$0	$3,816
18	$18,673	$11,511	$13,461	$44,709	$10,764	$13,332
19	$0	$21,908	$6,063	$54,320	$5,746	$5,607
20	$29,245	$2,716	$18,579	$403,496	$245,684	$17,184
21	$0	$0	$4,674	$46,913	$0	$4,452
22	$0	$0	$1,515	$0	$0	$1,515
23	$0	$0	$5,649	$0	$0	$5,649
24	$0	$7,877	$8,976	$305,731	$16,608	$8,601
25	$0	$12,934	$8,721	$0	$14,685	$8,727
26	$0	$4,142	$4,080	$0	$37,787	$3,801
27	$140,875	$28,207	$25,995	$1,683,680	$12,313	$24,369
28	$0	$0	$5,433	$0	$25,197	$4,632
29	$20,310	$3,974	$5,694	$29,876	$6,029	$5,466
30	$52,272	$0	$19,389	$129,019	$9,600	$18,879

Cost Estimates Capital Works, Maintenance Practices and Monitoring of Storm Sewer Pipes						
Network	5 Year Cost			10 Year Cost		
	Replacement Based on Structural Condition	Maintenance	Monitoring	Replacement Based on Structural Condition	Maintenance	Monitoring
31	$0	$0	$4,002	$36,034	$4,604	$3,642
32	$0	$0	$4,653	$218,588	$33,668	$4,191
33	$0	$6,966	$10,617	$34,024	$13,663	$10,122
34	$0	$41,914	$15,900	$30,216	$0	$16,272
35	$3,395	$8,895	$14,307	$7,469	$11,907	$14,166
36	$0	$5,435	$16,467	$32,253	$59,976	$15,135
37	$0	$10,340	$12,258	$31,006	$37,089	$12,219
38	$0	$2,241	$6,474	$15,084	$5,098	$6,288
39	$0	$24,500	$10,536	$10,879	$42,223	$9,735
40	$0	$0	$4,338	$0	$3,327	$4,191
41	$0	$3,658	$5,085	$26,481	$4,228	$4,809
42	$0	$4,616	$6,198	$0	$0	$6,345
43	$0	$0	$4,683	$0	$0	$4,683
44	$0	$8,971	$11,940	$25,249	$28,563	$11,628
45	$107,952	$11,984	$11,256	$0	$0	$12,042
46	$1,004,402	$0	$24,237	$768,490	$107,622	$22,569
47	$0	$6,383	$23,382	$248,544	$213,942	$20,919
48	$0	$2,377	$9,558	$0	$3,802	$9,495
49	$0	$46,350	$17,220	$0	$121,832	$17,994
50	$0	$0	$11,838	$37,291	$34,797	$11,007
51	$0	$28,279	$5,514	$0	$8,846	$6,348
52	$0	$25,229	$69,414	$104,035	$83,658	$68,625
53	$71,438	$23,001	$24,243	$235,513	$12,905	$23,280
54	$0	$6,566	$38,007	$161,007	$29,788	$37,062
55	$103,422	$6,111	$16,920	$449,781	$3,944	$14,358
56	$0	$91,207	$38,907	$182,821	$10,605	$39,309
Grand Total	**$1,700,656**	**$604,845**	**$741,069**	**$6,287,038**	**$1,645,486**	**$720,843**