APPENDIX E

Alternative Solution Details

APPENDIX E1

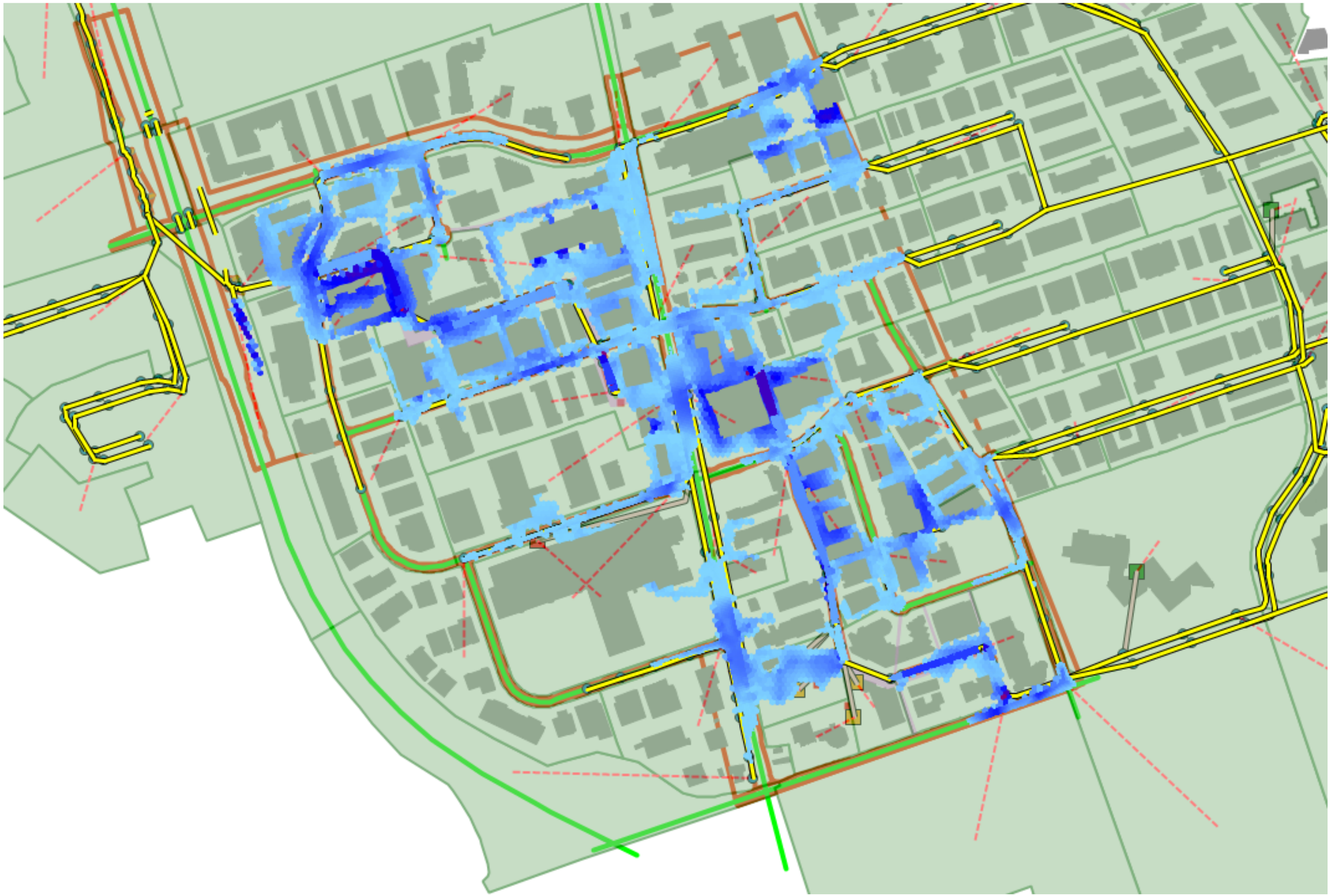
Enhanced Channel Maintenance

2 Yr Channel Maintenance

5 Yr Channel Maintenance

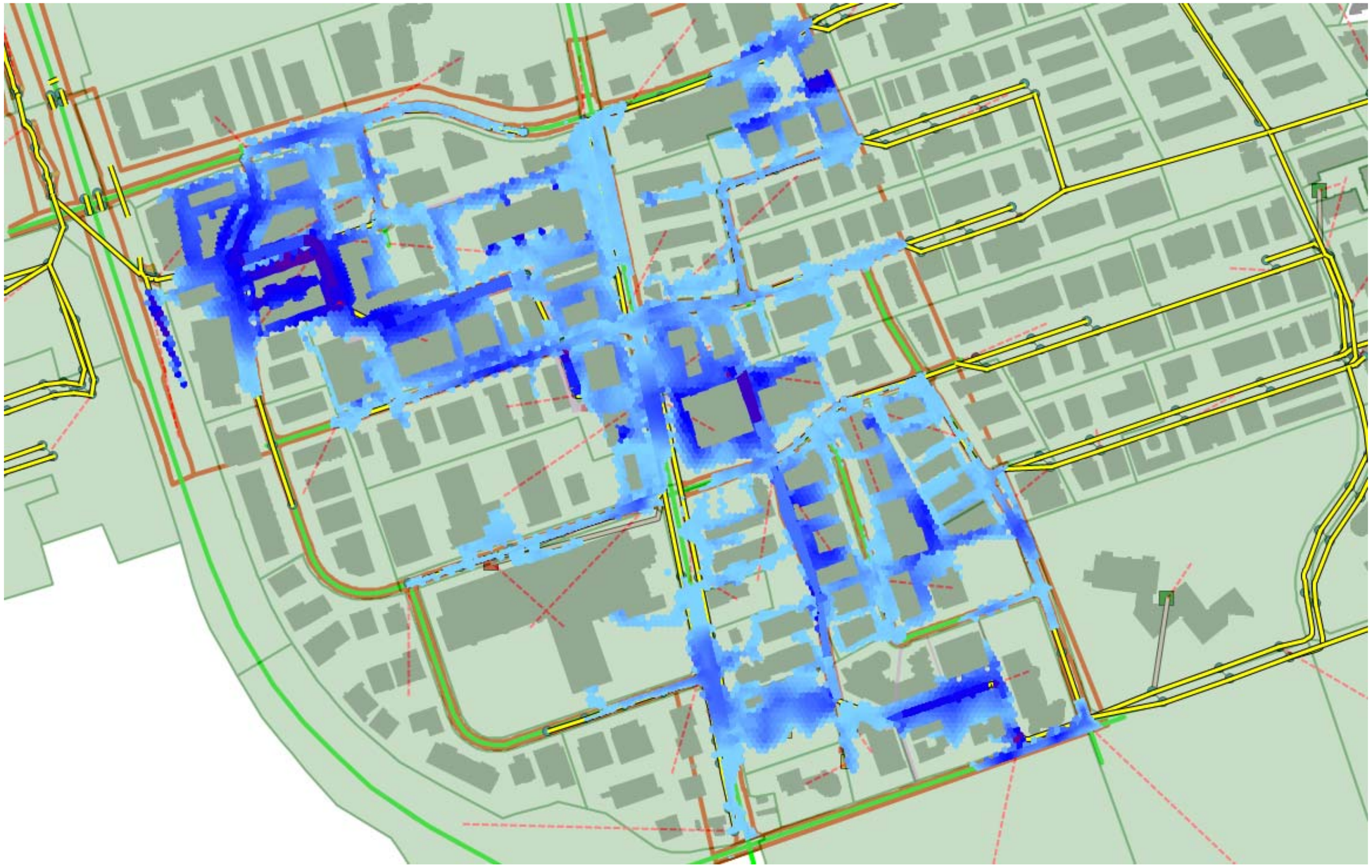
10 Yr Channel Maintenance

25 Yr Channel Maintenance



50 Yr Channel Maintenance

100 Yr Channel Maintenance



APPENDIX E2

Channel Widening with Culvert Improvements

Extent of flooding not plotted for Channel Widening alternative
All riverine flows are contained in the widened Don Mills Channel corridor for up to the 100 year storm event.

City of Markham
Don Mills Channel Flood Reduction Study

TMIG

Cost Estimate
Channel Widening Alternative

Project Component	Unit	Estimated Quantity	Unit Price	Total Price	Notes
Property Acquisition	property	24	varies	$213,300,000	Based on property cost estimates from City of Markham legal department
Building demolition and site preparation	property	24	varies	$21,330,000	Estimated as 10% of property cost
Channel construction and restoration	m	2,200	$5,500	$12,100,000	Includes excavation, grading, naturalized bankfull channel and planting
Steelcase Road East culvert replacement	m	33	$42,000	$1,386,000	based on 12.8 m Conspan culvert over 33 m ROW
Woodbine Avenue culvert replacement	m	29	$42,000	$1,197,000	based on 12.8 m Conspan culvert over 29 m ROW
Denison Street culvert replacement	m	34	$42,000	$1,407,000	based on 12.8 m Conspan culvert over 34 m ROW
Steelcase Road West culvert replacement	m	32	$42,000	$1,323,000	based on 12.8 m Conspan culvert over 32 m ROW
Sub-Total				**$252,043,000**	
Soft Costs and Contingencies (40%)				$100,817,200	
Total Cost				**$352,860,200**	

APPENDIX E3

Acquisition of Flood Prone Properties

Don Mills Channel Flood Reduction Study

Flood Damage Estimates

Property Acquisition

Storm Event	Probability	Buildings within Area of Flooding	Buildings Impacted by Flooding (Flood elevation > finished floor elevation)	Assessed Value of Properties where Buidlings Impacted by Flooding (from MPAC)	Flood Damage Estimate (10% of Assessed Value)
2	0.50	7	0	$ -	$ -
5	0.20	34	0	$ -	$ -
10	0.10	36	4	$ 24,793,221	$ 2,479,322
25	0.04	44	6	$ 46,840,472	$ 4,684,047
50	0.02	53	7	$ 53,081,222	$ 5,308,122
100	0.01	58	8	$ 60,519,973	$ 6,051,997
AVERAGE ANNUALIZED FLOOD DAMAGE ESTIMATE					**$ 495,589**

City of Markham
Don Mills Channel Flood Reduction Study

Cost Estimate

Property Acquisition

Project Component	Unit	Estimated Quantity	Unit Price	Total Price	Notes
Property Acquisition	property	16	varies	$163,000,000	Based on property cost estimates from City of Markham legal department
Building demolition and site preparation	property	16	varies	$16,300,000	Estimated as 10% of property cost
Sub-Total				**$179,300,000**	
Soft Costs and Contingencies (40%)				$71,720,000	
Total Cost				**$251,020,000**	

APPENDIX E4

Underground Flood Control Storage

2 Yr Onsite Flood Control Storage

5 Yr Onsite Flood Control Storage

10 Yr Onsite Flood Control Storage

25 Yr Onsite Flood Control Storage

50 Yr Onsite Flood Control Storage

100 Yr Onsite Flood Control Storage

Don Mills Channel Flood Reduction Study

Flood Damage Estimates

Underground Flood Control Storage

Storm Event	Probability	Buildings within Area of Flooding	Buildings Impacted by Flooding (Flood elevation > finished floor elevation)	Assessed Value of Properties where Buidlings Impacted by Flooding (from MPAC)	Flood Damage Estimate (10% of Assessed Value)
2	0.50	0	0	$ -	$ -
5	0.20	0	0	$ -	$ -
10	0.10	34	4	$ 11,036,251	$ 1,103,625
25	0.04	44	15	$ 83,832,724	$ 8,383,272
50	0.02	53	16	$ 89,092,725	$ 8,909,273
100	0.01	58	18	$ 103,233,976	$ 10,323,398
AVERAGE ANNUALIZED FLOOD DAMAGE ESTIMATE					**$ 608,877**

City of Markham
Don Mills Channel Flood Reduction Study

TMIG

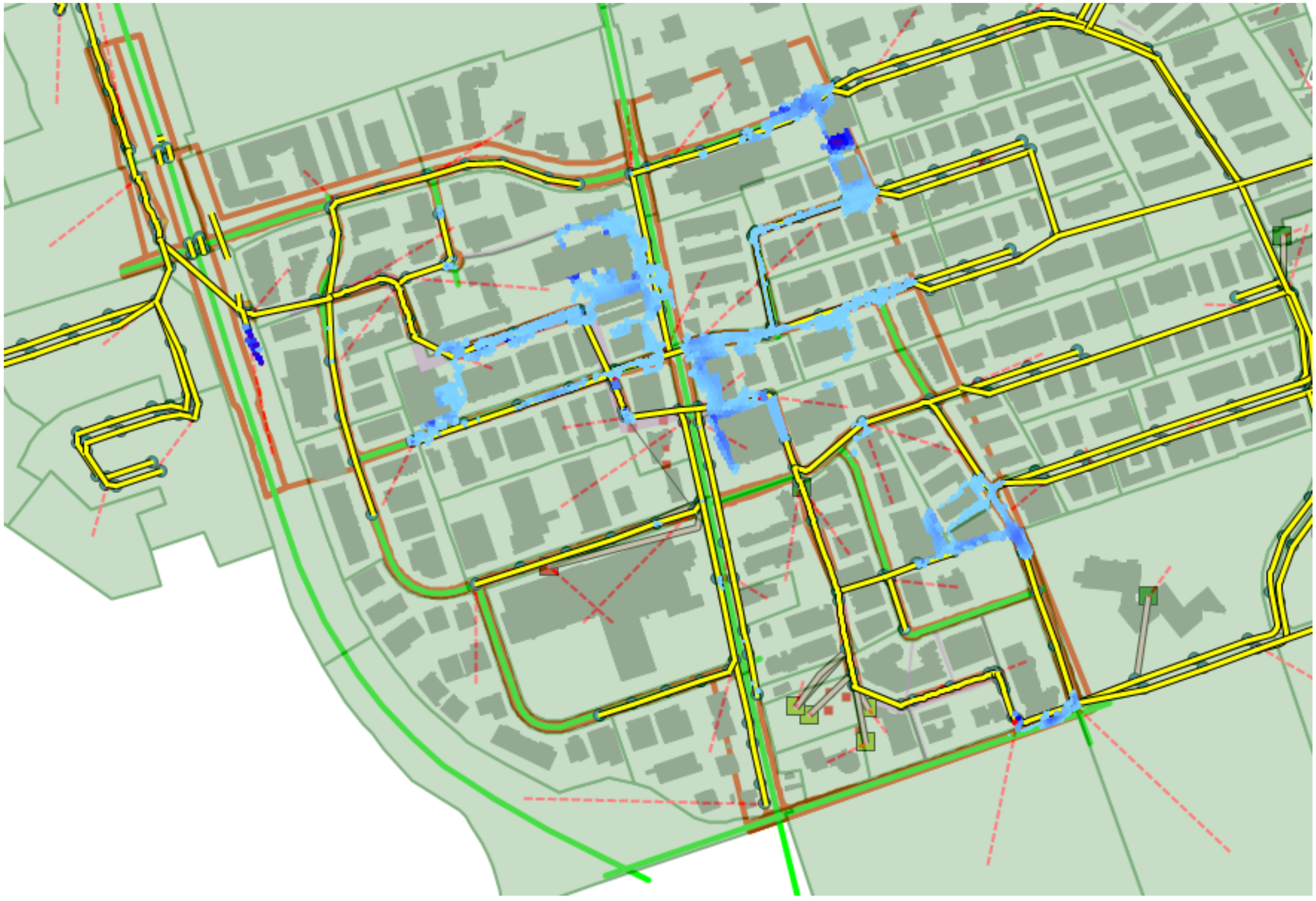
Cost Estimate
On-Site Flood Control Storage

Project Component	Unit	Estimated Quantity	Unit Price	Total Price	Notes
Underground storage facilities	m^3	40,000	$1,000	$40,000,000	based on commercial underground storage units (i.e. Cultec, Stormtrap)
Compensation for Property Impacts	m^2	40,000	$400	$16,000,000	based on 1 m high tanks, compensation based on 50% of average property value
Sub-Total				**$56,000,000**	
Soft Costs and Contingencies (40%)				$22,400,000	
Total Cost				**$78,400,000**	

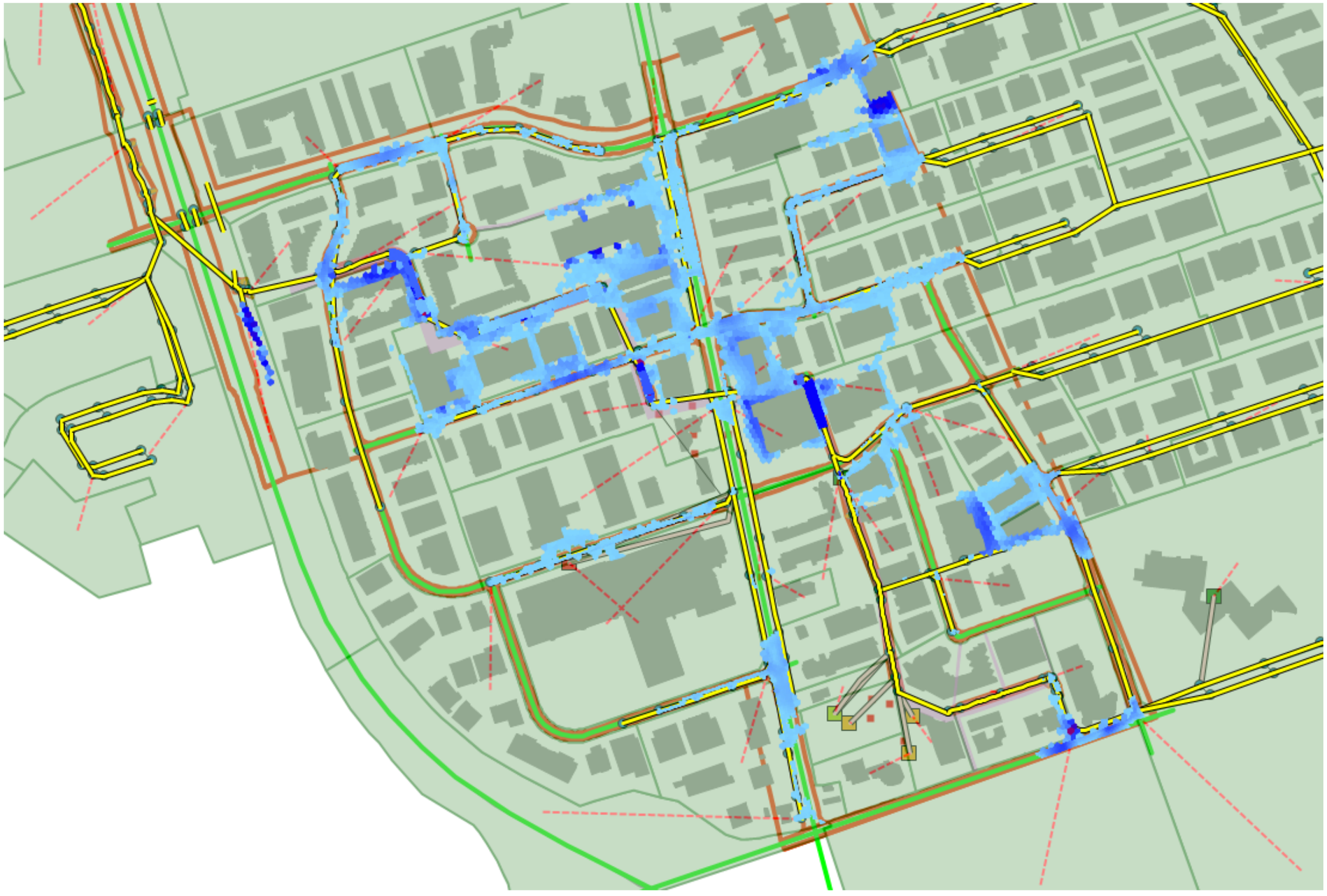
APPENDIX E5

Central Municipal Flood Control Storage

2 Yr Centralized Municipal Flood Control Storage



5 Yr Centralized Municipal Flood Control Storage



10 Yr Centralized Municipal Flood Control Storage

25 Yr Centralized Municipal Flood Control Storage

50 Yr Centralized Municipal Flood Control Storage

100 Yr Centralized Municipal Flood Control Storage

Don Mills Channel Flood Reduction Study

Flood Damage Estimates

Centralized Municipal Flood Control Storage

Storm Event	Probability	Buildings within Area of Flooding	Buildings Impacted by Flooding (Flood elevation > finished floor elevation)	Assessed Value of Properties where Buidlings Impacted by Flooding (from MPAC)	Flood Damage Estimate (10% of Assessed Value)
2	0.50	10	0	$ -	$ -
5	0.20	26	3	$ 18,699,421	$ 1,869,942
10	0.10	33	4	$ 28,270,921	$ 2,827,092
25	0.04	43	7	$ 41,073,222	$ 4,107,322
50	0.02	48	12	$ 76,388,223	$ 7,638,822
100	0.01	48	13	$ 92,741,224	$ 9,274,122
AVERAGE ANNUALIZED FLOOD DAMAGE ESTIMATE					**$ 925,402**

City of Markham
Don Mills Channel Flood Reduction Study

Cost Estimate

Centralized Municipal Flood Control Storage

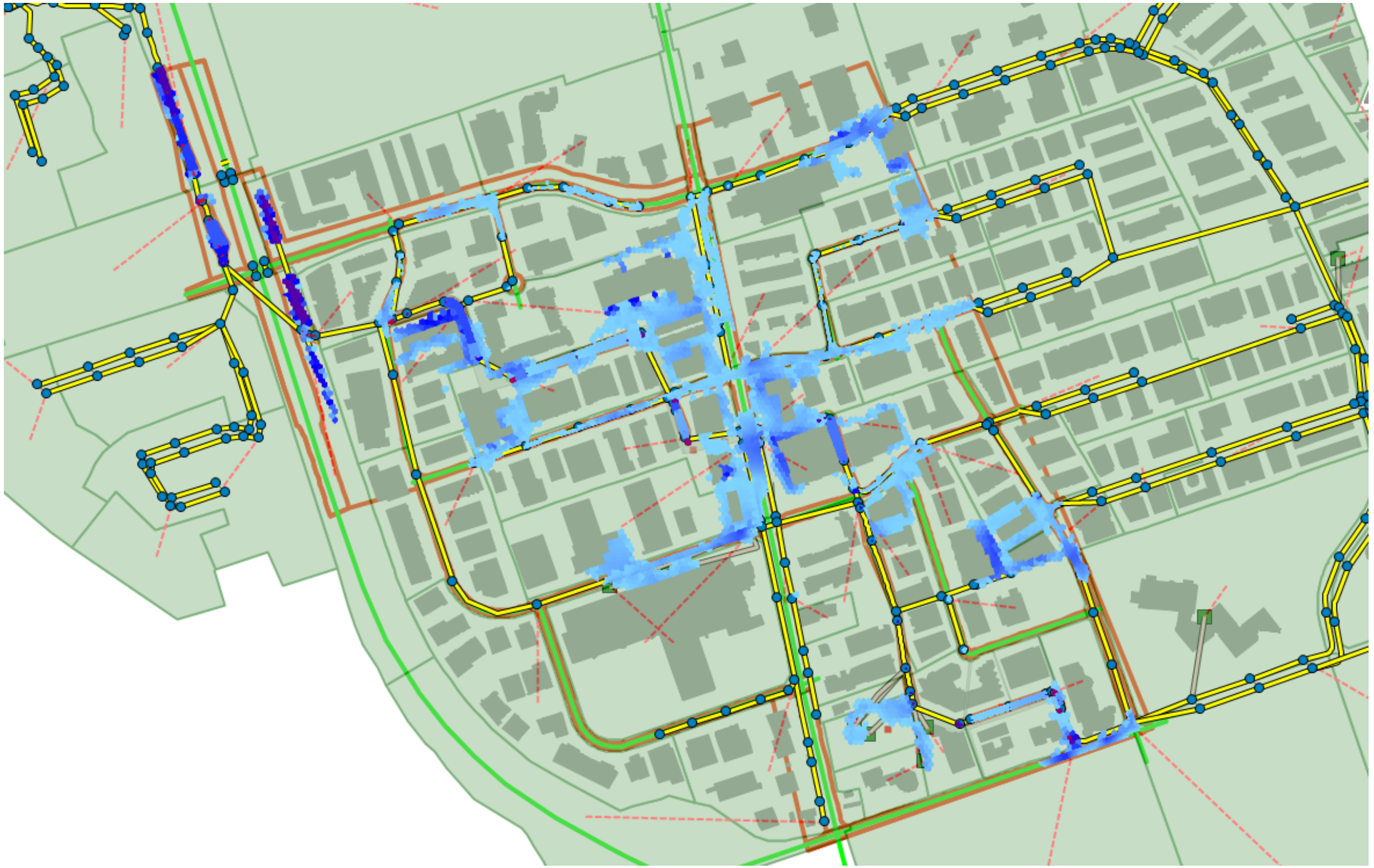
Project Component	Unit	Estimated Quantity	Unit Price	Total Price	Notes
Property Acquisition	property	4	varies	$18,993,600	Based on property cost estimates from City of Markham legal department
Building demolition and site preparation	property	4	varies	$1,899,360	Estimated as 10% of property cost
Excavation and off-site disposal	m^3	33,000	$25	$825,000	
Storage facility contruction and restoration	ha	2.1	$500,000	$1,050,000	includes grading, control structure and landscaping
Sub-Total				**$22,767,960**	
Soft Costs and Contingencies (40%)				$9,107,184	
Total Cost				**$31,875,144**	

APPENDIX E6

Flow Diversion

2 yr Flood Diversion

5 yr Flood Diversion



10 yr Flood Diversion

25 yr Flood Diversion

50 yr Flood Diversion

100 yr Flood Diversion

Flood Damages for the Flow Diversion alternative were not calculated, as the impacts on flooding of Highway 404 prevent this alternative from being selected to reduce flooding from the Don Mills Channel through the study area

City of Markham
Don Mills Channel Flood Reduction Study

Cost Estimate
Flow Diversion

Project Component	Unit	Estimated Quantity	Unit Price	Total Price	Notes
Sewer Installation	m	1,360	$5,620	$7,643,200	based on 3 m x 1.8 m concrete box sewer
Maintenance Holes	unit	14	$50,000	$700,000	based on 100 m spacing between maintenance holes
Culvert Replacement	m	126	$45,000	$5,670,000	replacement of the Steelcase Road West culvert with a Conspan structure
Sub-Total				**$14,013,200**	
Soft Costs and Contingencies (40%)				$5,605,280	
Total Cost				**$19,618,480**	

APPENDIX E7

Flood Proofing and Education

Don Mills Channel Flood Reduction Study

Flood Damage Estimates

Flood Proofing and Education

Storm Event	Probability	Buildings within Area of Flooding	Buildings Impacted by Flooding (Flood elevation > finished floor elevation)	Assessed Value of Properties where Buidlings Impacted by Flooding (from MPAC)	Flood Damage Estimate (10% of Assessed Value)
2	0.50	7	0	$ -	$ -
5	0.20	34	0	$ -	$ -
10	0.10	36	11	$ 52,651,973	$ 5,265,197
25	0.04	44	15	$ 83,832,724	$ 8,383,272
50	0.02	53	16	$ 89,092,725	$ 8,909,273
100	0.01	58	18	$ 103,233,976	$ 10,323,398
AVERAGE ANNUALIZED FLOOD DAMAGE ESTIMATE					**$ 941,803**

assumes that all buildings will be flood proofed to the 5 year storm, no change to existing flood damages for the 10 year to 100 year storms

City of Markham
Don Mills Channel Flood Reduction Study

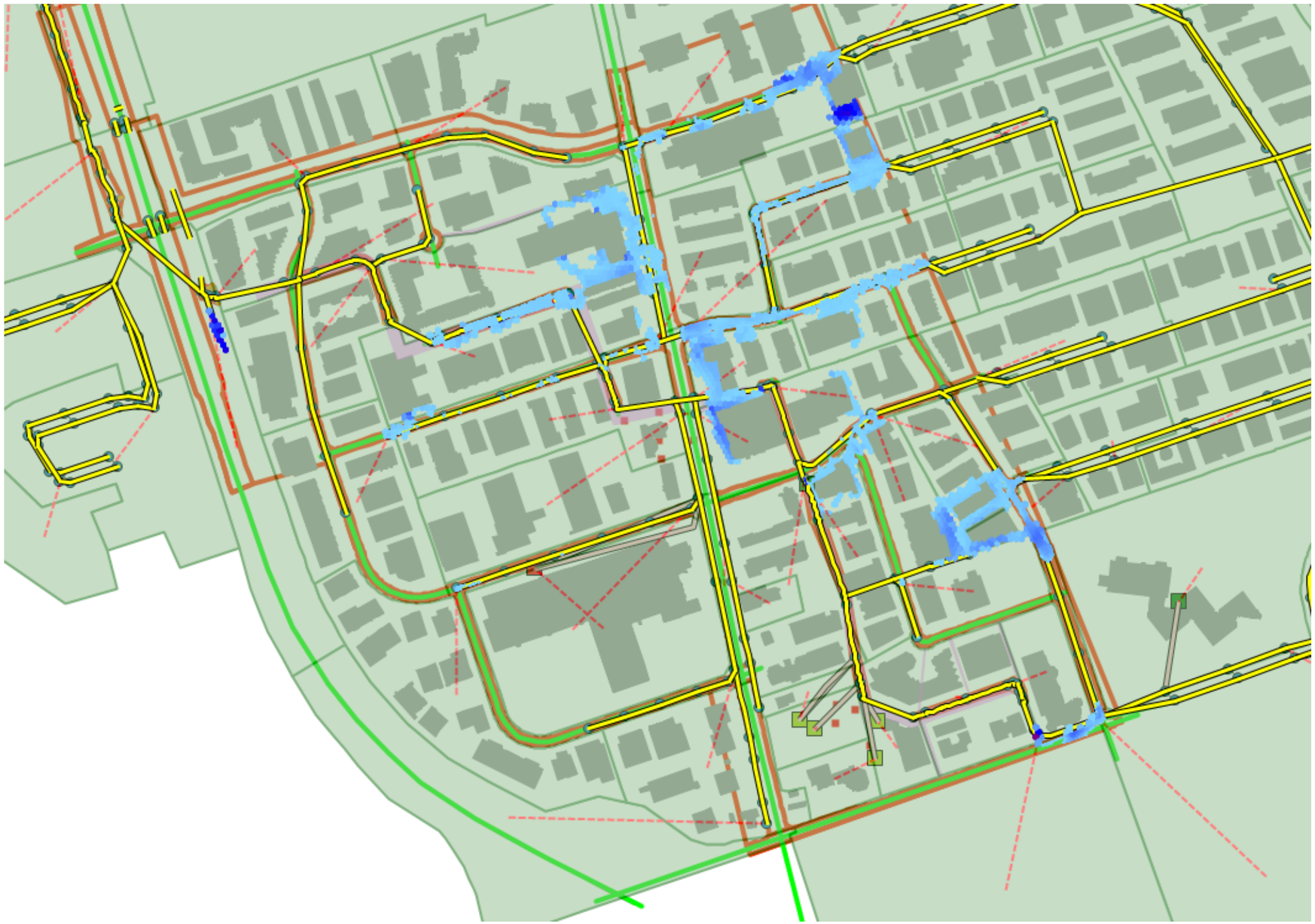
Cost Estimate
Flood Proofing

Project Component	Unit	Estimated Quantity	Unit Price	Total Price	Notes
Site specific flood proofing measures	property	8	varies	$1,500,000	pro-rated from actual site costs based on building size and flood depth
Sub-Total				**$1,500,000**	
Soft Costs and Contingencies (40%)				$600,000	
Total Cost				**$2,100,000**	

APPENDIX E8

Combined Alternative

2 yr Combined Alternative



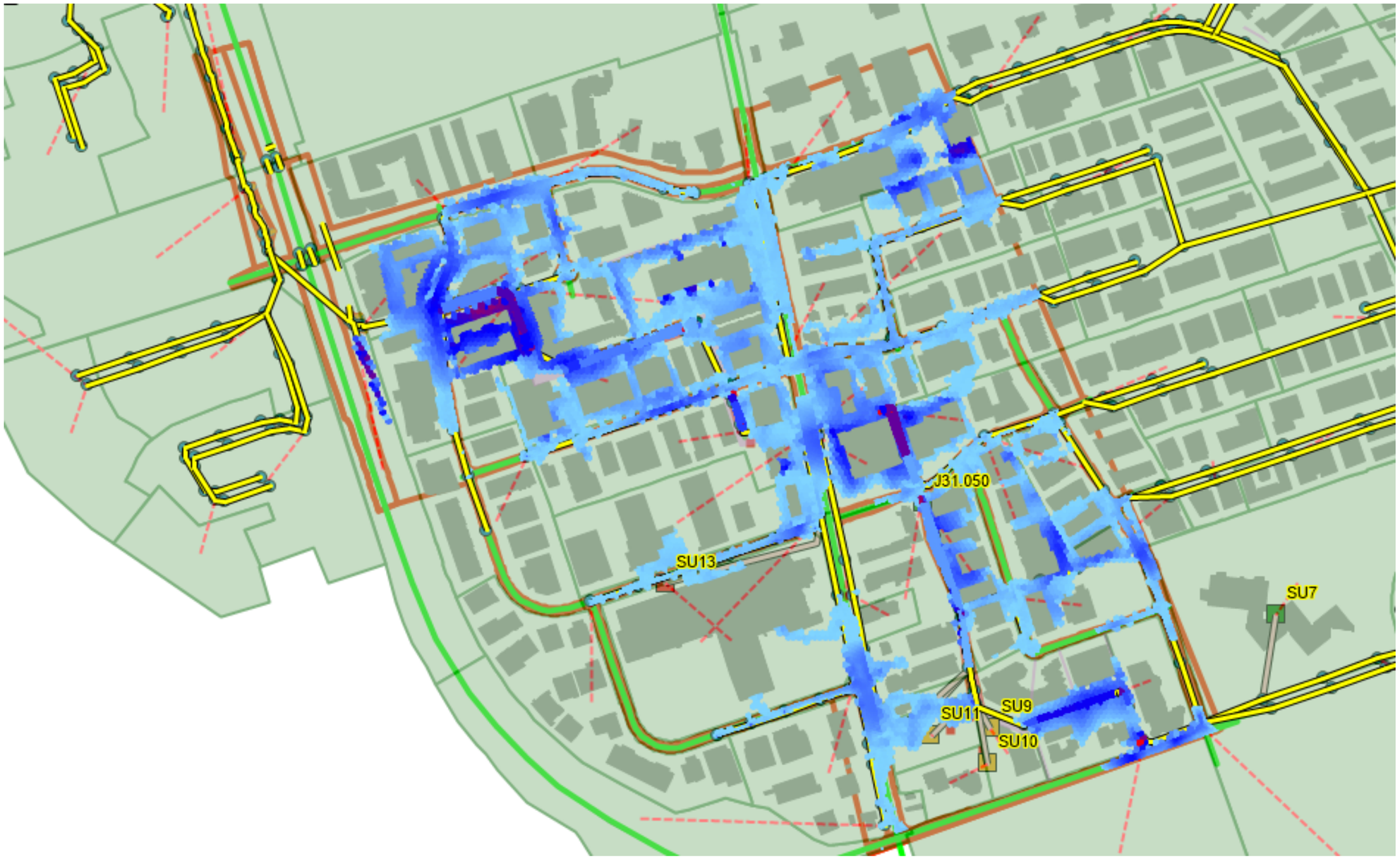
5 yr Combined Alternative

10 yr Combined Alternative

25 yr Combined Alternative

50 yr Combined Alternative

100 yr Combined Alternative



Don Mills Channel Flood Reduction Study

Flood Damage Estimates

Combination Alternative

Storm Event	Probability	Buildings within Area of Flooding	Buildings Impacted by Flooding (Flood elevation > finished floor elevation)	Assessed Value of Properties where Buidlings Impacted by Flooding (from MPAC)	Flood Damage Estimate (10% of Assessed Value)
2	0.50	9	0	$ -	$ -
5	0.20	24	0	$ -	$ -
10	0.10	24	0	$ -	$ -
25	0.04	37	3	$ 17,062,800	$ 1,706,280
50	0.02	47	8	$ 34,982,052	$ 3,498,205
100	0.01	48	12	$ 64,273,803	$ 6,427,380
AVERAGE ANNUALIZED FLOOD DAMAGE ESTIMATE					**$ 152,861**

City of Markham
Don Mills Channel Flood Reduction Study

TMIG

Cost Estimate
Combined Alternative

Project Component	Unit	Estimated Quantity	Unit Price	Total Price	Notes
Property Acquisition	property	4	varies	$18,993,600	Based on property cost estimates from City of Markham legal department
Building demolition and site preparation	property	4	varies	$1,899,360	Estimated as 10% of property cost
Excavation and off-site disposal	m^3	33,000	$25	$825,000	
Storage facility contruction and restoration	ha	2.1	$500,000	$1,050,000	includes grading, control structure and landscaping
Steelcase Road East culvert replacement	m	33	$42,000	$1,386,000	based on 12.8 m Conspan culvert over 33 m ROW
Woodbine Avenue culvert replacement	m	267	$42,000	$11,214,000	based on 12.8 m Conspan culvert over entire length, 35 m in Regional ROW
Denison Street culvert replacement	m	153	$42,000	$6,426,000	based on 12.8 m Conspan culvert over entire length, 23 m in City ROW
Steelcase Road West culvert replacement	m	156	$45,000	$7,020,000	based on 14.6 m Conspan culvert over entire length, 28 m in City ROW
Site specific flood proofing measures	property	2	varies	$470,000	pro-rated from actual site costs based on building size and flood depth
Sub-Total				**$49,283,960**	
Soft Costs and Contingencies (40%)				$19,713,584	
Total Cost				**$68,997,544**	

APPENDIX E9

Culvert Staging Analysis

THE MUNICIPAL INFRASTRUCTURE GROUP LTD.
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Vaughan, Ontario L4K 0C5 F 905.738.0065
www.tmig.ca

MEMORANDUM

DATE	October 10, 2017
TO	**Rob Grech, P.Eng**
CC	FILE
SUBJECT	Don Mills Channel Flood Reduction Study Analysis of Phasing for Culvert Replacements
FROM	Steve Hollingworth
PROJECT NUMBER	15160

Background and Introduction

The preferred solution to reduce flooding and flood damages from the Don Mills Channel is to construct a centralized municipal flood control facility along the channel upstream (south) of Steelcase Road East, and to replace the existing culverts at Steelcase Road East, Woodbine Avenue, Denison Street and Steelcase Road West.

The analyses completed for the development and evaluation of this alternative was based on all works being in place. However, budget limitations will require the implementation of the recommended works over a period of several years. It is assumed that the centralized municipal flood storage facility will be constructed in advance of the culvert replacements, as this facility will reduce flow rates and flooding throughout the study area.

Culvert replacements will follow, but cannot all be constructed at the same time. Logically, the culverts should be replaced starting with the most downstream culvert and progress upstream, such that increasing the conveyance capacity does not worsen flooding at a downstream unimproved culvert. However, a number of factors will influence the timing and order of culvert replacements, including structural condition and remaining lifespan for culverts, planned road construction projects and future re-development of sites containing culvert extensions.

Additional analyses have therefore been completed to determine if and how the order of culvert replacements impacts flooding from the Don Mills Channel through the study area.

Culvert Properties

The locations of the four culverts recommended for replacement are shown in Figure 1, and the properties of the existing and proposed culverts are summarized in Table 1.

Table 1: Existing and Proposed Culvert Properties

Culvert Location	Existing Culvert Size	Existing Culvert Condition	Proposed Replacement Culvert
Steelcase Road West (CU3)	4.27 m x 2.44 m concrete box + 5.5 m x 3.05 m CSP Arch extension	Good condition, rehabilitated in 2011	14.6 m x 3.0 m Conspan or equivalent
Dennison Street (CU5)	4.35 m x 2.9 m CSP Arch	Fair condition, estimated remaining service life of 10 years in 2013 condition assessment	12.8 m x 2.7 m Conspan or equivalent
Woodbine Avenue (CU6)	3.9 m x 2.7 m CSP Arch	Fair condition, estimated remaining service life of 10 years in 2013 condition assessment	12.8 m x 2.7 m Conspan or equivalent
Steelcase Road East (CU7)	2.2 m x 3.4 m concrete ellipse	Good condition, rehabilitated in 2014	12.8 m x 2.4 m Conspan or equivalent

Modelling and Results

The PCSWMM 2D model developed for the Don Mills Channel was used to assess the impacts of individual culvert replacements on existing flood levels in the channel. For each analysis, it was assumed that the centralized flood storage facility was already constructed and operational, but that all culverts remained in their existing condition with the exception of the culvert assumed to be replaced.

Tables 2 and 3 compare the flood levels from each of the culvert replacement scenarios for the 5 year and 100 year storm events, respectively. For context, the tables also include the flood levels under existing conditions, with the centralized flood storage facility constructed but no culvert replacements, and with all culverts replaced.

The analyses show that replacing some culverts in isolation may result in a minor increase in flood levels at the next (unimproved) culvert downstream for the 5 year storm event, but in all cases the flood levels remain well below existing conditions (prior to construction of the centralized flood storage facility). Individual culvert replacements will not increase downstream flood depths during the 100 year storm.

Table 2: Maximum Flood Depth Comparison – 5 Year Storm

Scenario	Maximum Flood Depth (m) Upstream of				
	Steelcase Rd. E. (J31.051)	Woodbine Ave. (J31.047)	Denison St. (J31.041)	Steelcase Rd. W. (J31.030)	Highway 404 (J31.026)
Existing Conditions	4.16	4.31	3.39	3.52	3.68
Municipal Flood Storage Facility Only	1.91	2.10	2.37	3.22	3.45
Steelcase Road West Culvert Replacement	1.87	2.06	2.24	2.99	3.52
Denison Street Culvert Replacement	1.82	1.99	2.19	3.28	3.49
Woodbine Avenue Culvert Replacement	1.80	1.97	2.29	3.16	3.36
Steelcase Road East Culvert Replacement	1.91	2.14	2.28	3.18	3.42
All Culvert Replacements	1.71	1.84	1.98	2.86	3.39

Increase in flood depth relative to centralized municipal flood storage facility only

Table 3: Maximum Flood Depth Comparison – 100 Year Storm

Scenario	Maximum Flood Depth (m) Upstream of				
	Steelcase Rd. E. (J31.051)	Woodbine Ave. (J31.047)	Denison St. (J31.041)	Steelcase Rd. W. (J31.030)	Highway 404 (J31.026)
Existing Conditions	8.55	8.41	6.81	7.11	7.34
Municipal Flood Storage Facility Only	3.56	4.07	4.87	6.46	6.85
Steelcase Road West Culvert Replacement	3.51	3.93	4.70	6.21	6.78
Denison Street Culvert Replacement	3.47	4.02	4.80	6.45	6.83
Woodbine Avenue Culvert Replacement	3.41	3.86	4.58	6.22	6.63
Steelcase Road East Culvert Replacement	3.58	3.75	4.66	6.31	6.72
All Culvert Replacements	3.34	3.56	4.17	5.65	6.18

Conclusion

Upon completion of the centralized flood storage facility upstream of Steelcase Road East, it is recommended that the Steelcase Road West culvert be replaced first, followed by the Denison Street culvert, Woodbine Avenue culvert and Steelcase Road East culvert.

It is recognized that culverts may require replacement at any time due to structural condition, scheduled road rehabilitation or re-development of sites containing culvert extensions. The additional PCSWMM analyses demonstrate that replacing any culvert in isolation may increase flood levels slightly during the 5 year storm, but will not increase flood levels during a 100 year storm. Note also that despite the slight increases in flood levels at some locations during the 5 year storm, flood levels remain well below existing conditions, prior to construction of the centralized flood storage facility.

It is therefore concluded that, while it is preferred to replace culverts starting at the downstream end of the study area and proceeding upstream, any culvert can be safely replaced at any time with negligible impacts on downstream flooding.

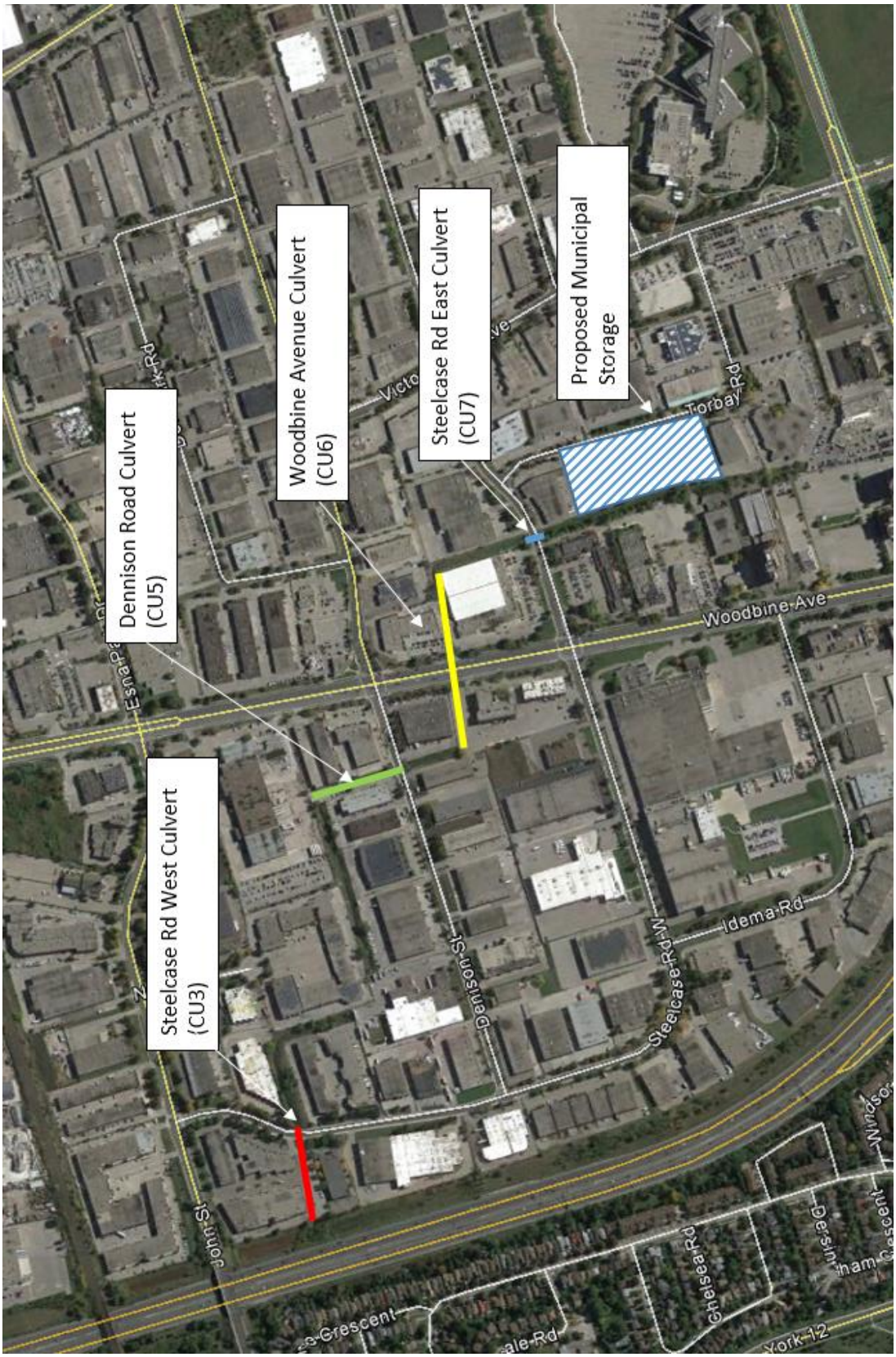

Figure 1 Culvert Location Plan