CITY OF STRATFORD

STRATFORD WEST
SECONDARY PLAN

FLOOD PLAIN AND STORM WATER MANAGEMENT

COURT DRAIN AND MCNAMARA DRAIN

MCCORMICK RANKIN CORPORATION
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1.0 INTRODUCTION

1.1 Purpose

McCormick Rankin Corporation (MRC) carried out a storm water and flood plain management analysis for the McNamara Drain and a portion of the Court Drain as part of the West Secondary Plan for the City of Stratford (City) and developed a storm water management strategy for future developments in the northern portion of the Planning Area. The northwestern portion of the West Secondary Planning Area drains to the McNamara Drain, which is tributary to the Court Drain. The northeastern portion of the West Secondary Planning Area drains to the Court Drain. A portion of the northeastern West Secondary Planning Area drains to existing City storm sewers along Greenwood Drive, Norwood Court, and the Nethercott/Greenwood/McCarthy storm sewer system. The southern portion of the Planning Area drains to the Roadhouse Drain, which is a tributary of the Avon River. A Master Drainage Plan was prepared by MRC for the Roadhouse Drain as part of the West Secondary Planning Study for the City, and is documented under separate cover.

The McNamara Drain flows through agricultural lands towards the southeast before crossing O'Loane Avenue near Quinlan Road. It continues through agricultural lands and small wooded areas, and confluences with the Court Drain.

The Court Drain was studied previously as part of the Court Drain Subwatershed Study (CDSWS), which was prepared by Aquafor Beech Limited in 2002. The CDSWS identifies storm water management (SWM) criteria for the watershed as well as preliminary locations for future SWM facilities. The CDSWS identified opportunities to free up some flood plain lands adjacent to the Court Drain and McNamara Drain for development, however the preliminary assessment did not result in firm recommendations. The original drainage-related work plan for the West Secondary Plan was focused on SWM requirements for future developments. As the project developed, the need to revisit preliminary flood plain management alternatives became evident.

The purpose of the storm water and flood plain management analyses is to provide a comprehensive understanding of the hydrologic and hydraulic aspects of the Court Drain and McNamara Drain, an understanding of the system as a whole, to refine the flood plain limits, to develop a storm water management strategy for future developments, to evaluate flood plain management alternatives, and to provide implementation recommendations. The limits of the West Secondary Planning Area are presented on Exhibit 1.

1.2 Background Information

Relevant background information was collected and reviewed to develop an understanding of the Court Drain and McNamara Drain and tributary lands. The following information was examined:

- 1:10,000 Ontario Base Maps;
- 1 m contour interval topographic maps from the City;
- Aerial photography;

- City storm sewer layout and storm sewer subcatchment areas;
- Report No. 15 of the Ontario Soil Survey, *The Soils of Perth County* (1952);
- Court Drain Subwatershed Plan Study (Phases 1 to 5) (Aquafor Beech Limited, 2002); and
- City of Stratford City-Wide Storm System Master Plan (Dillon Consulting, 2004).

2.0 PUBLIC AND AGENCY CONSULTATION

The storm water and flood plain management analysis was carried out in conjunction with the Municipal Class Environmental Assessment (Class EA) for the McCarthy Road extension and water / wastewater servicing, as part of the overall City of Stratford West Secondary Plan. The storm water and flood plain management analysis was undertaken following the Master Planning Process identified in the Municipal Class Environmental Assessment (Municipal Engineers Association, June 2000). As stated therein, work undertaken in preparation of Master Plans "should recognize the planning and design process of the Class EA, and should incorporate the key principles of successful environmental assessment planning, including consultation with affected parties early in and throughout the process, consideration of a reasonable range of alternatives, and identification and consideration of the effects of each alternative on all aspects of the environment, systematic evaluation of alternatives in terms of their advantages and disadvantages, to determine their net environmental effects, and provision of clear and complete documentation of the planning process followed, to allow "traceability" of decision-making with respect to the project."

The storm water and flood plain management analysis involved consultation with the City of Stratford, the Upper Thames River Conservation Authority (UTRCA), and the public. Consultation with the City and the UTRCA was ongoing throughout the Study process. This included attendance at several Steering Committee meetings which included a representative of the UTRCA, and regular correspondence with City and UTRCA staff. The City also provided background information, and co-ordinated communication between MRC and a number of stakeholders (property owners) and developers.

During development of the storm water and flood plain management analysis, the UTRCA reviewed the technical analyses that formed the basis for the storm water management strategy and recommended flood plain management works. MRC submitted the hydrologic and hydraulic modelling for the Court Drain and McNamara Drain to the UTRCA as preliminary findings for their review and comments. MRC staff also attended a technical meeting with UTRCA staff. Comments were received from the UTRCA on February 2, 2007, and were addressed in a response letter dated February 14, 2007. Documentation of the correspondence with the UTRCA is provided in Appendix A. Additional comments were received from the UTRCA and from the City of Stratford subsequent to the submittal of the Draft report. The comments were addressed in a response letter dated December 20, 2007.

Information was prepared by MRC for presentation at the Public Information Centres (PICs) that were held throughout the overall study. MRC provided input for the first two PIC's in May 2006 and November 2006, including work completed to date, and work yet to be completed. MRC presented a summary of the storm water and flood plain management analysis during a formal presentation at the March 2007 PIC, including the purpose of the storm water and flood plain management analysis, storm water management requirements, flood plain management alternatives and recommendations, and requirements for implementation.

3.0 EXISTING CONDITIONS

The McNamara Drain receives flows from agricultural lands west of the West Secondary Planning Area. These lands flow easterly and ultimately to the upper reaches of the McNamara Drain. These mainly agricultural lands include depression areas with imperfect natural drainage. An existing tile drain discharges at the upstream limit of the South Branch of the McNamara Drain just west of O'Loane Avenue. Lands from the northwest portion of the West Secondary Planning Area including areas bounding Quinlan Road, discharge to the McNamara Drain which continues to flow easterly. The agricultural lands drain to the adjacent McNamara Drain just upstream of its confluence with the Court Drain. Just downstream of the confluence, the adjacent agricultural lands flow overland to the Court Drain. The soils within the West Secondary Planning Area consist of mainly Perth Silt Loam soils, classified as hydrologic soil group B. The existing conditions are presented on Exhibit 2.

3.1 Site Reconnaissance and Survey

A site reconnaissance was carried out in August and November 2005, and April 2006 to establish a better understanding of the existing conditions along the McNamara Drain and Court Drain within the West Secondary Planning Area, including areas beyond the West Secondary Planning Area. The Court Drain and McNamara Drain and adjacent tributary lands were observed, and are discussed in further detail in the following section. Conditions observed during the site reconnaissance were documented with photographs, which are included in Appendix B of this report.

A detailed field survey was carried out in October 2006 to generate the data necessary to complete the backwater and floodway analyses. The detailed survey included a geodetic survey of numerous points, including cross-sections along the McNamara Drain and Court Drain, and all structures along both Drains. All points and sections were surveyed geodetically with horizontal and vertical control in order to tie into existing base mapping.

3.2 McNamara Drain and Court Drain Characteristics

The upper McNamara Drain at the west end of the West Secondary Planning Area flows through agricultural lands. The channel in this area is a trapezoidal grassed channel. During the August 2005 site visit, it was noted that the upper portion of the McNamara Drain showed virtually no signs of flow, but contained standing water. It crosses O'Loane Avenue through a CSP culvert, and continues downstream crossing a series of farm lanes through CSP culverts. The trapezoidal channel continues through agricultural lands and small wooded areas. During the August 2005 site visit, no flow was observed along the Drain at the confluence with the Court Drain and the channel was dry. Upstream of Quinlan Road the Court Drain flows through a densely vegetated and wooded area. The Court Drain meanders northeasterly and crosses Quinlan Road through a concrete box culvert. The Court Drain has a natural cross-section and channel morphology. Some signs of bank erosion were evident along the section of the Court Drain downstream of Quinlan Road. Further downstream, the Court Drain crosses Mornington Street through a box culvert, and ultimately crosses the abandoned railway to the west of Romeo Street.

3.3 Hydrologic Characterization

The SWMHYMO hydrologic model was used to estimate the runoff contribution to the drains. The Court Drain Subwatershed Study prepared in 2002 presented hydrologic and hydraulic analyses for the Court Drain, including previously completed hydrologic modelling. Hydrologic modelling data from the Visual Otthymo model was converted and used in the SWMHYMO hydrologic model to model the upstream contributing drainage areas outside of the West Secondary Planning Area. The original hydrologic modelling was also used as a comparison for the updated hydrologic modelling prepared for this study.

The existing conditions hydrologic model for the Court Drain and McNamara Drain within the West Secondary Planning Area was developed based on catchment parameters determined by MRC using aerial photography, topographic mapping and survey information. Rainfall parameters were obtained from the City of Stratford City-Wide Storm System Master Plan, which were updated subsequent to the City of Stratford rainfall parameters used in the CDSWS. The hydrologic modelling prepared for the Court Drain Subwatershed Plan Study included an in-depth comparison of the hydrologic modelling with actual flow data. The analysis found that using an N value of 1.3 (where N is the number of linear reservoirs used for the derivation of the Nash unit hydrograph) resulted in a calibrated model. MRC has applied the calibrated parameter to the hydrologic modelling.

Of particular note is the subcatchment boundary between the Roadhouse Drain and the McNamara Drain. The subcatchment drainage divide determined by MRC based on the topographic information, including additional recent survey information, correlates to the drainage divide established by the City of Stratford City-Wide Storm System Master Plan. This includes MRC's subcatchments 111 and 120 as part of the Roadhouse Drain subwatershed as shown on Exhibit 2. The City-Wide Plan also presented the subwatershed boundary established by the Court Drain Subwatershed Study, which showed MRC's subcatchment 120 as draining north to the McNamara Drain instead of to the Roadhouse Drain, and MRC's subcatchment 111 draining south to the Roadhouse Drain. As shown in Exhibit 2, the southeastern corner of the West Secondary Planning Area is part of the Rec Centre lands, which drain to an on-site SWM pond.

Although MRC's subcatchment 208 does not discharge to the Court Drain, it has been included in this study as it falls within the West Secondary Planning Area, and is proposed for development as part of the Community Plan. Under existing conditions, subcatchment 208 drains southerly to the existing storm sewers to the Iddington Creek outlet systems, as per the City-Wide Storm System Master Plan. Specifically, three existing storm sewers receive flows from subcatchment 208. These include two Iddington Creek/Glastonbury/Greenwood sewers which run along Greenwood Drive and another along Norwood Court. The third is the Nethercott/Greenwood/McCarthy sewer system which has several branches and ultimately runs along Nethercott Drive. These sewers are presented on Exhibit 2.

A summary of the calculated existing conditions flows are included in Table 1. Existing conditions catchment parameters and modelling files are included in Appendix C. Hydrologic modelling files in electronic format are provided in Appendix F.

Table 1 – Existing Conditions Flow Summary									
Subcatchment[1]		**Chicago 4-hour Storm Flows (m^3/s) (SWM Facility Design)**							**Chicago 24-hour Storm Flows (m^3/s) (Regulatory Flood Delineation)**
MRC ID	**CDSWS ID**	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**	**250-yr**	**250-yr**
202	430 (partial)	0.04	0.09	0.13	0.18	0.23	0.27	0.34	0.45
-	440	0.18	0.36	0.49	0.66	0.80	0.94	1.13	1.42
-	450	0.05	0.11	0.16	0.22	0.28	0.33	0.41	0.53
-	460	0.45	0.88	1.20	1.62	1.96	2.30	2.76	3.49
203	420B	0.08	0.18	0.25	0.36	0.44	0.53	0.65	0.85
201	420A	0.05	0.11	0.16	0.22	0.27	0.32	0.40	0.52
204	410	0.12	0.24	0.33	0.45	0.54	0.64	0.77	0.95
205	400A	0.05	0.10	0.15	0.20	0.25	0.30	0.37	0.48
210	-	0.04	0.09	0.13	0.18	0.23	0.27	0.33	0.43
211	-	0.06	0.12	0.17	0.24	0.29	0.35	0.42	0.54
206&207	400B	0.07	0.15	0.22	0.30	0.37	0.45	0.55	0.71
209	-	0.11	0.24	0.33	0.46	0.57	0.68	0.83	1.04
208	-	0.19	0.40	0.56	0.76	0.93	1.11	1.36	1.66

Note: 1) MRC ID indicates MRC subcatchment ID, CDSWS ID indicates CDSWS subcatchment ID

3.4 Hydraulic Analysis and Flood Plain Mapping

Flood plain mapping was presented in the CDSWS. MRC refined the flood plains based on more detailed topographic information developed from detailed survey information. As previously noted in Section 3.3, MRC generated subcatchment boundaries based on the most recent survey information. MRC's subcatchment boundaries show subcatchment 120 discharging to the Roadhouse Drain rather than to the McNamara Drain as previously presented in the CDSWS. As such, MRC's flows to the McNamara Drain are decreased, and the floodlines also decreased, as compared to the CDSWS results. MRC also defined floodlines for the South Branch of the McNamara Drain, which was not previously defined.

The flood plains along the McNamara Drain and Court Drain under existing conditions are presented on Exhibit 4, for the updated existing 250-year floodline, as well as the CDSWS 250-year floodline. As shown, the updated existing 250-year floodline expands upstream of O'Loane Avenue, due to the insufficient capacity of the existing culvert crossing O'Loane Avenue (culvert S6). The updated existing floodplain mapping includes floodlines for the McNamara South Branch, which was previously only estimated. Downstream of O'Loane Avenue, the flood plain broadens over agricultural lands, not deviating significantly from the CDSWS floodlines. Further downstream, the flood plain downstream has a variable width, and is significantly reduced from the CDSWS floodlines, based on the refined topography. The refined floodlines based on the more detailed topography shows that there is no spill to storm sewers along McCarthy Road at Greenwood Drive and at Deacon Street. Downstream of the confluence of the McNamara Drain with the Court Drain, the Court Drain flood plain expands into low-lying areas, somewhat narrower than the CDSWS floodlines, although not deviating significantly from the CDSWS floodlines.

4.0 FUTURE CONDITIONS HYDROLOGY AND PROPOSED STORM WATER MANAGEMENT STRATEGY

4.1 Future Conditions Hydrology and Potential Impacts

The SWMHYMO hydrologic model was used to estimate the runoff contribution for the various catchment areas contributing to the Court Drain and McNamara Drain following development in the West Secondary Planning Area. Catchment areas were refined to account for future drainage, and future possible SWM pond locations. Various community plans were developed by GSP Group, comprised of various residential developments, school blocks, industrial development areas, and various alignments of the future McCarthy Road.

The recommended community plan was utilized to develop the future conditions hydrologic modelling parameters. It should be noted that undeveloped lands outside of the existing City Limits were modelled as undeveloped under future conditions. Based on our analysis of these areas, it was concluded that flow control and water quality treatment could be provided for these areas in conjunction with future development such that the current SWM targets could be met with additional facilities located on these lands. In other words, any development beyond the current City Limits would not require SWM facilities within the current City Limits. The future conditions drainage mosaic is presented on Exhibit 3. Future conditions catchment parameters and modelling input and output files are included in Appendix D.

4.2 Storm Water Management Objectives and Criteria

The storm water management objectives for future developments within the McNamara Drain and Court Drain subwatersheds are:

- to maintain or reduce peak flows along the McNamara Drain and Court Drain up to and including the 250-year storm;
- to maintain or reduce erosion potential along the McNamara Drain and Court Drain;
- to maintain or improve water quality; and
- to ensure no adverse impacts to existing developments and their storm drainage systems.

The following specific criteria were identified in order to meet these objectives:

- Maintain or reduce peak flows on a catchment-by-catchment basis for the 4 hour 2-year to 250 year Chicago design storms and the 24 hour 250 year Chicago design storm;
- Apply the “Simplified Approach” to erosion control as outlined in the Ministry of the Environment’s (MOE) Stormwater Management Planning and Design Manual and the Court Drain Subwatershed Study;
- Provide MOE “Normal” level of protection with respect to water quality (formerly Level 2);

- Control the 4-hour duration post development flows up to and including the 250-year storm event, to the 4-hour duration 5-year existing flow rates (i.e. overcontrol) where developments will drain to existing storm sewers.

Through the hydrologic modelling, it was found that if peak flows are maintained on a catchment-by-catchment basis, peak flows along the McNamara Drain and Court Drain will also be maintained. The need for overcontrol for areas draining to existing sewers was identified in the City of Stratford City-Wide Storm System Master Plan and was based on a review of the capacity of the sewer system.

4.3 Storm Water Management Strategy

The overall strategy that was developed to meet the storm water management criteria includes the provision of a number of storm water management (SWM) facilities. SWM facility locations were initially based on 'proposed' and 'alternate' SWM basin locations as presented in the 2004 City of Stratford City-Wide Storm System Master Plan and the CDSWS. Locations were refined based on topography, existing features, and consolidation of previously proposed SWM facilities to reduce the overall number of facilities required. The feasibility of each of the proposed SWM facility locations was analyzed based on the need for sufficient fall to achieve surface drainage from the contributing drainage areas to the SWM facilities, while at the same time accounting for sufficient gradient to allow for discharge to the receiving watercourse/storm sewer.

The SWM facilities were designed to be wet ponds, and were sized to provide a Normal (Level 2) level of protection, as required by the MOE's Stormwater Management Planning and Design Manual. For a wet pond with a 55 percent impervious contributing area, 70 m^3/ha of permanent pool volume, and 40 m^3/ha of extended detention volume are required for a Normal level of protection. The percent impervious value for future developments was estimated based on the recommended West Stratford Community Plan.

The Distributed Runoff Control (DRC) Simplified Approach for erosion control was applied to the SWM facility design, as per the procedure as outlined in the CDSWS. Application of the Simplified Approach to erosion control resulted in the need for 225 m^3/ha of extended detention volume. Thus the extended detention zones of the SWM facilities must include this volume; the 40 m^3/ha of extended detention volume required for water quality control is included in the 225 m^3/ha volume. In addition to the volume calculation procedure as demonstrated in Section 7.2.2 of the CDSWS (Figure 7.2), the detailed design of the outlet rating curves for the facilities must follow the proposed rating curve development procedure as outlined in Section 7.2.2 of the CDSWS (Figure 7.3). Excerpts of the procedures from the CDSWS are included in Appendix E.

An additional peak flow attenuation volume of 200 m^3/ha was determined to be required to control discharge rates to existing discharge rates for storm events up to and including the 250-year storm. It should be noted that the SWM facilities are also required to be designed to operate acceptably up to the 24-hour duration 250-year Chicago design storm.

4.3.1 SWM Facility Design Criteria

Criteria for the conceptual design of the SWM facilities are as follows:

- Permanent pool depth of 1.0 m;
- Maximum total pond depth of 3.0 m (3.3 m to top of freeboard); and
- Pond side slopes of 5:1.

With the exception of Pond 13, the SWM facilities were sized such that the design discharges not exceed the existing conditions peak flow rates. A freeboard of 0.3 m must also be provided above the required storage volume. MRC also calculated the SWM pond size required to meet the discharge criteria. As shown on Exhibit 3, the SWM block sizes include SWM basin active storage volumes determined based on modelling results, and permanent pool volumes calculated based on requirements for water quality control. SWM block sizes included a 15 percent additional area to allow for grading and pond access for maintenance purposes. Actual SWM block sizes will be established during detailed design. It should be noted that if during detailed design it is found that existing condition flows overtop the roadway, then flows must be overcontrolled in the SWM pond to prevent roadway overtopping during future conditions. A summary of the conceptual SWM facility requirements including target flow rates and SWM block areas is presented in Table 2.

4.3.2 Proposed SWM Facilities

Pond 6 is located in catchment 202, and will discharge to the McNamara Drain at O'Loane Avenue. It should be noted that if the chosen flood plain management alternative (see Section 5.0) involves realignment of the Upper McNamara Drain corridor south of the existing building west of O'Loane Avenue and south of Quinlan Road as shown on Exhibit 4, Pond 6 will have to be reconfigured as two ponds on either side of the realigned Drain. The peak flow comparison location for this pond was downstream of subcatchment 202.

Pond 7 is located in subcatchment 203, and will discharge to the South Branch of the McNamara Drain. The peak flow comparison location was downstream of subcatchment 203.

Pond 8 is located in subcatchment 205 and will receive flows from subcatchments 204 and 205. The pond is proposed to discharge to the portion of the McNamara Drain flowing easterly, located south of Quinlan Road. The peak flow comparison location was downstream of subcatchment 205.

Pond 9 is located in subcatchment 210, and will discharge to the McNamara Drain upstream of the confluence with the Court Drain. The peak flow comparison location was downstream of subcatchment 210. Ponds 9 and 10 are shown as two separate ponds (previously shown as one pond in the City-Wide Storm System Master Plan and the CDSWS), due to the existing property on Quinlan Road which divides subcatchments 210 and 211.

Pond 10 is located within subcatchment 211, and will discharge to the McNamara Drain upstream of its confluence with the Court Drain. The peak flow comparison location for this pond was downstream of subcatchment 211.

Pond 12 is proposed to be located in the general area as shown on Exhibit 3, in the vicinity of intersection of subcatchments 207 and 209. Pond 12 will receive flows from subcatchments 206, 207, and 209. Pond 12 will discharge to the Court Drain downstream of its confluence with the McNamara Drain. The peak flow comparison location for this pond was downstream of subcatchment 209.

Pond 13 is located within subcatchment 208, and will discharge to the existing Greenwood Drive storm sewer located on McCarthy Road. The peak flow comparison location for this pond was downstream of subcatchment 208. The subcatchments contributing to Pond 13 currently belong to the City and A. J. Jackson Developments Limited. It should be noted that the Jackson and City properties within subcatchments 207 and 208 may in future be subdivided. An alternative to Pond 13 consists of providing on-site over-controls for the properties with on-site controls discharging to the existing storm sewers along Greenwood Drive, Norwood Court, or the Nethercott/Greenwood/McCarthy sewer system. Future severance of lands may result in many viable drainage options through more detailed analysis, provided that all SWM criteria are met during detailed design.

Exhibit 3 presents the proposed SWM pond locations and sizes, and Table 2 presents the proposed SWM basin sizes as well as the target peak flow rates and the designed peak flow rates. The pond sizes as shown include additional allowance above the required storage volume to account for grading and pond access. The additional area also accounts for 0.3 m of freeboard.

The location of the proposed SWM ponds were based on proposed future land use, proposed drainage, and in some cases discharge restrictions, as mentioned above. The proposed SWM pond locations and sizes are preliminary and conceptual only, and are somewhat flexible. Further refinements on a site by site basis may be applicable during development stages. The SWM ponds are to be located outside of the flood plain.

4.3.3 Effectiveness of Quantity Control Criterion

In order to demonstrate that the control of peak flows on a catchment-by-catchment basis will control peak flows along the McNamara Drain and Court Drain, the proposed conditions model was set up with the conceptual SWM facilities and run for the full range of design storms. Comparisons of the existing and future controlled peak flows along the McNamara Drain and Court Drain are provided in Table 3. As shown, the future controlled peak flows are very close to the existing flows. Although a slight increase in peak flows is shown at the confluence of the McNamara Drain and the Court Drain, the increase in flow is very minimal, and as presented on Exhibit 4, does not result in any adverse effects on the proposed floodlines as there is sufficient capacity to convey the small increase in peak flows.

4.4 Storm Water Management Implementation

All storm water management facilities should be constructed prior to any development within their future tributary area. Construction phasing plans and cost-sharing agreements will be required for ponds that will service more than one development (different landowners). As part of the Draft Plan and Final Approval process, a storm water management report and detailed design drawings for the storm water management facilities will be required. The hydrologic model developed for this storm water and flood plain management analysis should be utilized in development of the storm water management report. Model refinements should be made to reflect any catchment area refinements and catchment parameters should be refined to reflect more detailed development plans. Each update to the model should be returned to the City / UTRCA so that it may be provided to the next proposed development. The report should include the following:

- Demonstration that the storm water management criteria (water quality and quantity) identified in this storm water and flood plain management analysis will be met. This should include a comparison of existing and future controlled peak flows along the McNamara Drain and Court Drain. Where there are downstream flow constraints, such as those associated with the existing sewers downstream of Pond 13, the report should demonstrate that there will be no adverse impacts to the receiving drainage system and tributary developments.
- Detailed stage-storage-discharge curve for the proposed storm water management pond and details regarding grading, maintenance access and emergency overflow spillways.
- Assessment of the proposed drainage system for the development to demonstrate that both major and minor flows will be directed to the SWM pond(s). A SWM pond may need to overcontrol tributary flows to compensate for any areas that cannot be drained to the pond.
- Results of geotechnical investigations to confirm the suitability of the pond site in terms of soils, bedrock and groundwater elevations. The pond may need to be lined to prevent interaction with groundwater if the soils are not sufficiently impermeable to retain water or the groundwater table is high.
- Landscaping design / thermal mitigation. The storm water management ponds should be designed as aesthetically appealing features that enhance its surroundings. Shade plantings should be utilized to help reduce temperature increases of the ponded water. Where feasible, consideration should be given to thermal mitigation measures such as cooling trenches at the outlet and/or bottom-draw outlets.
- Erosion and sediment control plan detailing the proposed staging of works and proposed erosion and sediment controls measures to protect the receiving waters during construction.

Table 2 – Conceptual SWM Facility Characteristics

SWM Basin I.D.	Catchment I.D.	Catchment Area (ha)[2]	SWM Basin Volume (m^3)				SWM Block Area (ha)		4hr Target Flows (m^3/s)[5]					24hr	Modelled Flows (m^3/s)				
			Permanent Pool [1]	Extended Detention	Flow Attenuation Storage	Total Volume	Estimated Area[3]	Modelled Area[4]	Ext. Det.	2 yr	5 yr	100 yr	250 yr	250 yr	2 yr	5 yr	100 yr	4hr – 250yr	24hr – 250 yr
6	202	7.80	546	1,755	6,308	6,854	0.5	0.6	0.02	0.04	0.09	0.27	0.34	0.45	0.02	0.07	0.25	0.33	0.43
7	203	29.60	2,072	6,660	26,320	28,392	2.1	2.0	0.08	0.08	0.18	0.53	0.65	0.85	0.07	0.14	0.53	0.62	0.74
8	204&205	32.70	2,289	7,358	27,070	29,359	2.3	2.0	0.09	0.17	0.34	0.93	1.13	1.42	0.08	0.25	0.87	1.10	1.35
9	210	13.30	931	2,993	11,600	12,531	0.9	0.9	0.04	0.04	0.09	0.27	0.33	0.43	0.03	0.07	0.27	0.33	0.43
10	211	12.30	861	2,768	9,512	10,373	0.9	0.8	0.03	0.06	0.12	0.35	0.42	0.54	0.03	0.09	0.33	0.41	0.53
12	206 & 207 & 209	30.20	2,114	6,795	21,290	23,404	2.1	1.6	0.08	0.16	0.34	0.98	1.20	1.55	0.06	0.17	0.95	1.18	1.45
13[6]	208	8.70	609	1,958	7,640	8,249	0.6	0.7	0.02	0.19	0.40	-	-	-	0.01	0.01	0.18	0.25	0.38

Notes:

1) Protection level *Normal (formerly Level 2)*.
2) Based on the proposed land use plan, an impervious level of 55% was used for the conceptual pond designs.
3) 'Estimated' SWM Block area calculated assuming a SWM Block size of 7 percent of the contributing drainage area.
4) 'Modelled' SWM Block area based on additional 15 percent added to modelled SWM facility size to account for grading and maintenance access (modelled size achieves target flow rates).
5) Target flow rates based on existing conditions peak flows.
6) Basin 13 oversized to control 250-year peak flow to at or below the 5-yr existing peak flow as preliminary pond design accounted for possible discharge to an existing storm sewer system(Greenwood Drive, Norwood Court, or the Nethercott/Greenwood/McCarthy sewer system).

Table 3 - Summary of Flows at Key Points of Interest along McNamara Drain and Court Drain

Point of Interest	Location Description	Area (ha)	Drainage Catchment Number[1]	Hec-Ras Section Locations		Peak Flows (m^3/s)													
						2-Year		5-Year		10-Year		25-Year		50-Year		100-Year		250-Year	250-Year
				From	To	Existing 4-hour	Future 4-hour	Existing 4-hour	Future 4-hour	Existing 4-hour	Future 4-hour	Existing 4-hour	Future 4-hour	Existing 4-hour	Future 4-hour	Existing 4-hour	Future 4-hour	Existing 4-hour	Future 4-hour	Existing 24-hour	Future 24-hour
1 (culvert S6)	O'Loane Avenue (sum 5A)	175	202	1577.4	2031	0.71	0.70	1.42	1.41	1.96	1.95	2.64	2.64	3.21	3.21	3.78	3.78	4.56	4.56	5.72	5.75
2 (culvert S5)	McNamara at confluence (sum 3A)	222	204	1214	1450	0.85	0.81	1.71	1.66	2.36	2.33	3.21	3.20	3.92	3.91	4.62	4.62	5.60	5.57	7.08	7.08
3 (culvert S3)	Catchment 205 (sum 400)	280	205	613	1268	1.10	0.94	2.23	2.03	3.07	2.94	3.99	3.86	4.74	4.62	5.73	5.61	7.04	6.88	9.09	8.88
4 (culvert S1)	Confluence at Court Drain (sum 5B)	311	207	14	438	1.21	1.00	2.47	2.20	3.39	3.31	4.38	4.38	5.23	5.29	6.31	6.41	7.77	7.92	10.04	10.25
5	McNamara South Branch	65.5 ha	201, 203, (204)[2]	82	415	0.26	0.15	0.53	0.38	0.74	0.62	1.02	0.91	1.25	1.16	1.49	1.40	1.81	1.72	2.32	2.23

Note:

1) Flow downstream of catchment number.

2) South Branch receives flows from catchments 201, 203, and 204 under existing conditions. Under proposed conditions South Branch receives controlled flows from catchments 201 and 203 (routed through Pond 7). Catchment 204 is routed to Pond 8 and discharges to McNamara Drain downstream of South Branch.

5.0 FLOODPLAIN MANAGEMENT ALTERNATIVES

5.1 Description of Alternatives

MRC investigated various flood plain management alternatives to refine the previous flood plain management work presented in the CDSWS, and to make a recommendation of a preferred flood plain management alternative. The flood plain management alternatives were carried out in conjunction with development of the storm water management strategy to improve the function of the existing McNamara Drain and Court Drain, and to free up existing flood plain areas for development. Opportunities were identified to increase conveyance, to increase the efficiency of storage within the adjacent flood plain, and to better connect the channel with the flood plain. The alternatives were comprised of a combination of improvements including culvert upgrades, channel regrading, and creation of flood plain corridors through cut/fill works. All cut/fill locations will be within open space flood plain areas only, and not in any vegetated areas.

The following alternatives were investigated to improve the function of the existing Drains. Hydraulic modelling is provided on CD in Appendix F.

5.1.1 Alternative 1 – Do Nothing

As part of the Class EA or Master Planning process, the Do Nothing alternative must be considered as a bench mark comparison for all alternatives.

5.1.2 Alternative 2 – Enlarge or Twin Mornington Street Culvert

Alternative 2 consists of enlarging or twinning the culvert located at Mornington Street to increase its conveyance capacity, and to reduce the flood risk of developments near the upstream end of the culvert.

5.1.3 Alternative 3 – Enlarge or Twin Quinlan Road Culvert

Alternative 3 consists of enlarging or twinning the culvert located at Quinlan Road to increase its conveyance capacity, and to reduce flood elevations upstream of Quinlan Road.

5.1.4 Alternative 4 – Enlarge or Twin both Mornington Street and Quinlan Road Culverts

Alternative 4 consists of enlarging or twinning both the Mornington Street and the Quinlan Road culvert, to increase their conveyance capacity, thereby reducing the flood risk of developments upstream of the Mornington Street culvert, and to reduce flood elevations upstream of Quinlan Road.

5.1.5 Alternative 5 – Cut and Fill Within Court Drain Flood Plain (variable corridor width)

Alternative 5 consists of cutting and filling within the Court Drain flood plain, creating a corridor of a variable width. All cut/fill works will be within open space flood plain areas only, and with no cut/fill works to take place in vegetated areas. Excavation is proposed along the McNamara Drain immediately upstream its confluence with the Court Drain, and along the north side of the Court Drain (south of Quinlan Road) immediately downstream of its confluence with the McNamara Drain.

5.1.6 Alternative 6 – Cut and Fill Within McNamara Drain Flood Plain (30 m and 74 m corridor sections)

Alternative 6 consists of cutting and filling within the McNamara Drain flood plain, and creating a 30 m corridor along the Upper McNamara Drain west of O'Loane Avenue to approximately 120 m east of O'Loane Avenue, and a 74 m corridor from approximately 120 m east of O'Loane Avenue to Quinlan Road.

5.1.7 Alternative 7 – Combination of Alternatives 5 and 6

Alternative 7 consists of cutting and filling within the Court Drain flood plain creating a variable width corridor, and cutting and filling within the McNamara Drain flood plain and creating a 30 m corridor along the Upper McNamara Drain west of O'Loane Avenue to approximately 120 m east of O'Loane Avenue, and a 74 m corridor from approximately 120 m east of O'Loane Avenue to Quinlan Road.

The analyses and evaluation of the alternatives are discussed in the following sections, including the recommended flood plain management works and the implementation requirements. A summary of the analysis and evaluation of the alternatives is presented in Table 4.

5.2 Analysis of Alternatives

The impacts of each of the proposed alternatives were analysed based on the following factors:

- Aquatic habitat impacts including direct loss of habitat, habitat quality, and barriers to fish passage;
- Impacts to vegetation/terrestrial habitat and wildlife movement such as direct loss of vegetation, habitat quality, and impacts of wildlife movement;
- Impacts to flood plain storage/flood risk, such as change in flood plain storage/risk of increased peak flows downstream;
- Impacts to flood elevations/flood risk including change in regulatory flood elevations, and change in flood risk of existing developments;
- Impacts to erosion potential;
- Increases in developable lands within the City;
- Requirements for implementation including Municipal Drain implications, Municipal Class EA requirements, agency approvals, and phasing requirements/considerations; and
- Comparative construction costs.

5.2.1 Alternative 1 – Do Nothing

The Do Nothing alternative results in no loss or change to aquatic habitat, and vegetation terrestrial habitat and wildlife movement. There is no change in flood plan storage, flood elevations, or flood risk, and no change in erosion potential. There is also no increase in developable lands. One additional storm water management facility would be required due to the close proximity of the existing floodline to Deacon Street. Implementation requires that the City either continues to manage the Court and McNamara Municipal Drains on City lands in accordance with the Drainage Act, or abandons the Drains under the Drainage Act. The

Table 4 – Summary of Analysis and Evaluation of Flood Plain Management Alternatives

Analysis Factors	Factor Indicators	Alternative 1 Do Nothing (Maintain Existing Flood Plain and Conveyance System Characteristics)	Alternative 2 Enlarge or Twin Mornington Street Culvert	Alternative 3 Enlarge or Twin Quinlan Road Culvert	Alternative 4 Enlarge or Twin Both Mornington Street and Quinlan Road Culverts	Alternative 5 Cut & Fill within Court Drain Flood Plain (variable corridor width)	Alternative 6 Cut & Fill within McNamara Drain Flood Plain (30m & 74m corridor sections)	Alternative 7 Combination of Alternatives 5 and 6 [RECOMMENDED]
Aquatic Habitat Impacts	Direct loss of habitat Habitat quality Barriers to fish passage	No loss or change	Opportunity to incorporate aquatic habitat enhancements within new culvert Temporary disturbance during culvert construction	Opportunity to incorporate aquatic habitat enhancements within new culvert Temporary disturbance during culvert construction	Opportunity to incorporate aquatic habitat enhancements within new culverts Temporary disturbance during culvert construction	No loss or change	No loss of habitat Potential for habitat quality improvements with channel bank plantings and possibly in-channel works such as pool creation	No loss or change along Court Drain McNamara Drain - No loss of habitat Potential for habitat quality improvements with channel bank plantings and possibly in-channel works such as pool creation
Vegetation / Terrestrial Habitat and Wildlife Movement	Direct loss of vegetation Habitat quality Impacts of wildlife movement	No loss or change	No loss of vegetation or impacts to habitat quality Wildlife movement may be enhanced with larger/additional culvert	Some loss of vegetation in vicinity of culvert Potential to restore area with plantings Wildlife movement may be enhanced with larger/additional culvert	Some loss of vegetation in vicinity of Quinlan Road culvert – potential to restore area with plantings Wildlife movement may be enhanced with larger/additional culverts	Loss of habitat in fill areas is associated with cultural meadow and agricultural fields Opportunity to enhance habitat in cut areas with diverse riparian plantings	Loss of habitat in fill areas is associated with cultural meadow and agricultural fields Opportunity to enhance habitat in cut areas with diverse riparian plantings	Loss of habitat in fill areas is associated with cultural meadow and agricultural fields Opportunity to enhance habitat in cut areas with diverse riparian plantings
Flood Plain Storage / Flood Risk	Change in flood plain storage / Risk of increased peak flows downstream	No change	Not applicable	Not applicable	Not applicable	Minor increase in flood plain storage	Some storage reduction, loss of approximately 7 percent	Maintains overall flood plain storage along Court Drain and McNamara Drain
Flood Elevations / Flood Risk	Change in Regulatory flood elevations Change in flood risk of existing developments	No change	Reduces flood elevations from 0.15 to 0.43 metres along Court Drain from Mornington Street to McNamara Drain Reduces flood risk of developments near upstream end of Mornington Street culvert	Reduces flood elevations by a maximum of 0.04 metres upstream of Quinlan Road	Reduces flood elevations along Court Drain from 0.27 to 0.42 metres from Mornington Street to McNamara Drain and along approximately 200 metres of lower McNamara Drain Reduces flood risk of developments near upstream end of Mornington Street culvert Reduces flood risk associated with flows over Quinlan Road	No change	Reduces flood elevations from approximately 0.1 to 0.8 metres along McNamara Drain from approximately 400 metres upstream of Court Drain to City Limit	Reduces flood elevations from approximately 0.1 to 0.8 metres along McNamara Drain from approximately 400 metres upstream of Court Drain to City Limit

Table 4 – Summary of Analysis and Evaluation of Flood Plain Management Alternatives

Analysis Factors	Factor Indicators	Alternative 1 Do Nothing (Maintain Existing Flood Plain and Conveyance System Characteristics)	Alternative 2 Enlarge or Twin Mornington Street Culvert	Alternative 3 Enlarge or Twin Quinlan Road Culvert	Alternative 4 Enlarge or Twin Both Mornington Street and Quinlan Road Culverts	Alternative 5 Cut & Fill within Court Drain Flood Plain (variable corridor width)	Alternative 6 Cut & Fill within McNamara Drain Flood Plain (30m & 74m corridor sections)	Alternative 7 Combination of Alternatives 5 and 6 [RECOMMENDED]
Erosion Potential	Change in erosion potential	No change	No change	No change	No change	No change	Flow velocities reduced in channel due to reduced depth of channel and more frequent use of flood plain during storm events – reduced risk of bed and bank erosion	No change along Court Drain McNamara Drain - Flow velocities reduced in channel due to reduced depth of channel and more frequent use of flood plain during storm events – reduced risk of bed and bank erosion
Future Development	Increase in developable lands within City Compatibility with future storm water management	No increase in developable lands One additional storm water management facility required due to close proximity of existing floodline to Deacon Street	Approximately 1.3 hectare increase in developable lands	Minor increase in developable lands	Approximately 1.5 hectare increase in developable lands	Approximately 2.3 hectare increase in developable lands	Approximately 7.0 hectare increase in developable lands	Approximately 9.3 hectare increase in developable lands
Requirements for Implementation	Municipal Drain implications Municipal Class EA requirements Agency approvals Phasing requirements/ considerations	City either continues to manage the Court and McNamara Municipal Drains on City lands in accordance with the Drainage Act or abandons the Drains under the Drainage Act	Drainage Engineer's report required in accordance with Drainage Act If Drain is abandoned under Drainage Act, Municipal EA requirements for Schedule 'B' activity must be fulfilled Additional approvals required from DFO, UTRCA, MOE	Drainage Engineer's report required in accordance with Drainage Act If Drain is abandoned under Drainage Act, Municipal EA requirements for Schedule 'B' activity must be fulfilled Additional approvals required from DFO, UTRCA, MOE	Drainage Engineer's report required in accordance with Drainage Act If Drain is abandoned under Drainage Act, Municipal EA requirements for Schedule 'B' activity must be fulfilled Additional approvals required from DFO, UTRCA, MOE	Drainage Engineer's report required in accordance with Drainage Act If Drain is abandoned under Drainage Act, Municipal EA requirements for Schedule 'B' activity must be fulfilled Approval required from UTRCA	Drainage Engineer's report required in accordance with Drainage Act If Drain is abandoned under Drainage Act, Municipal EA requirements for Schedule 'B' activity must be fulfilled Approval required from UTRCA Additional approvals required for any in-stream works from DFO and MOE Preferred staging of works is from downstream to upstream, need to maintain sufficient flood plain storage during interim stages	Drainage Engineer's report required in accordance with Drainage Act If Drain is abandoned under Drainage Act, Municipal EA requirements for Schedule 'B' activity must be fulfilled Approval required from UTRCA Additional approvals required for any in-stream works from DFO and MOE Preferred staging of works is from downstream to upstream, need to maintain sufficient flood plain storage during interim stages
Cost	Estimated construction cost	$75,000 associated with need for two stormwater management facilities instead of one near the north end of Deacon Street	$300,000 for culvert and restoration works	$400,000 for culvert and restoration works	$700,000 for culvert and restoration works	$350,000 for cut/fill and restoration of cut areas	$1,300,000 for corridor works and O'Loane culvert upgrade (channel realignment costs associated with Upper McNamara and South Branch options not included)	$1,650,000 for corridor works and O'Loane culvert upgrade (channel realignment costs associated with Upper McNamara and South Branch options not included)

Notes: **Costs are approximate and for comparison only**

associated cost for the requirement of two SWM facilities instead of one near the north end of Deacon Street is estimated to be $75,000.

5.2.2 Alternative 2 – Enlarge or Twin Mornington Street Culvert

Alternative 2 results in an opportunity to incorporate aquatic habitat enhancements within the new culvert, despite temporary disturbance during culvert construction. No loss of vegetation or impacts to habitat quality would result from the proposed works, and wildlife movement may be enhanced with the larger/twinned culvert. The proposed works would reduce flood elevations from 0.15 to 0.43 m along Court Drain from Mornington Street to McNamara Drain, and reduce flood risk of developments near the upstream end of the Mornington Street culvert.

No change in erosion potential results from this alternative, however it would result in an increase of approximately 1.3 ha of developable lands. Implementation requires that the City either continues to manage the Court and McNamara Municipal Drains on City lands in accordance with the Drainage Act, or abandons the Drains under the Drainage Act. A Drainage Engineer's report is required in accordance with the Drainage Act. If the Drain is abandoned under the Drainage Act, the Municipal EA requirements for a Schedule 'B' activity must be fulfilled. Approvals would be required from the DFO, UTRCA, and MOE. The estimated cost for the culvert and restorations works is $300,000.

5.2.3 Alternative 3 – Enlarge or Twin Quinlan Road Culvert

Alternative 3 results in an opportunity to incorporate aquatic habitat enhancements within the new culverts, despite temporary disturbance during culvert construction. Some loss of vegetation in the vicinity of the culvert may result, although there is the potential to restore the area with plantings. Wildlife movement may be enhanced with the larger/twinned culvert. The proposed works would reduce flood elevations by a maximum of 0.04 m upstream of Quinlan Road, which would result in only a minor increase in developable lands.

No change in erosion potential results from this alternative. Requirements for implementation include a Drainage Engineer's report in accordance with the Drainage Act. If the Drain is abandoned under the Drainage Act the Municipal EA requirements for a Schedule 'B' activity must be fulfilled. Approvals would be required from the DFO, UTRCA, and MOE. The estimated cost for the culvert and restorations works is $400,000.

5.2.4 Alternative 4 – Enlarge or Twin both Mornington Street and Quinlan Road Culverts

Alternative 4 provides the opportunity to incorporate aquatic habitat enhancements within the new culverts. The culvert construction would result in a temporary disturbance. Some loss of vegetation in the vicinity of the Quinlan Road culvert would result, although there would be the potential to restore the area with plantings. Wildlife movements may be enhanced with the larger/twinned culvert.

The proposed works would reduce the flood elevations along the Court Drain from 0.27 m to 0.42 m from Mornington Street to the McNamara Drain and along approximately 200 m of the lower McNamara Drain. The reduced flood elevations would reduce the flood risk of developments near the upstream end of the Mornington Street Culvert, and reduces the flood risk associated with flows over Quinlan Road.

No change in erosion potential results form this alternative. An increase in developable lands of approximately 1.5 ha would result. Requirements for implementation include a Drainage Engineer's report prepared in accordance with the Drainage Act. If the Drain is abandoned under the Drainage Act the Municipal EA requirements for a Schedule 'B' activity must be fulfilled. Approvals would be required from the DFO, UTRCA, and MOE. The estimated cost for the culvert and restorations works is $700,000.

5.2.5 Alternative 5 – Cut and Fill Within Court Drain Flood Plain (variable corridor width)

Alternative 5 would result in no loss or change to aquatic habitat. Loss of terrestrial habitat in fill areas would be associated with cultural meadow and agricultural fields. There would be an opportunity to enhance habitat in cut areas with diverse riparian plantings. The proposed works would result in a minor increase in flood plain storage, and no change in flood elevations or flood risk.

This alternative results in no change in the erosion potential, and an increase in developable land of approximately 2.3 ha. Requirements for implementation include a Drainage Engineer's report prepared in accordance with the Drainage Act. If the Drain is abandoned under the Drainage Act the Municipal EA requirements for a Schedule 'B' activity must be fulfilled. Approvals would be required from the DFO, UTRCA, and MOE. The estimated cost for the restoration works is $350,000.

5.2.6 Alternative 6 – Cut and Fill Within McNamara Drain Flood Plain (30 m and 74 m corridor sections)

Alternative 6 would result in no loss of habitat, with a potential for habitat quality improvements with channel bank plantings and possibly in-channel works such as pool creation. The loss of terrestrial habitat in fill areas is associated with cultural meadow and agricultural fields. There would be an opportunity to enhance habitat in cut areas with diverse riparian plantings. The proposed works would result in some flood plain storage reduction, with a loss of approximately 7 percent. Flood elevations would be reduced from approximately 0.1 to 0.8 m along the McNamara Drain from the City Limit to approximately 400 m upstream of the Court Drain confluence.

Reduced flow velocities in the channel resulting from reduced depth of channel and more frequent use of flood plain during storm events result in a reduced risk of bend and bank erosion. There would be an increase in developable lands of approximately 7.0 ha.

Requirements for implementation include a Drainage Engineer's report prepared in accordance with the Drainage Act. If the Drain is abandoned under the Drainage Act the Municipal EA requirements for a Schedule 'B' activity must be fulfilled. Approval would be required from the UTRCA, and additional approvals would be required for any in-stream works form the DFO and MOE. Preferred staging of the works is from downstream to upstream, with flood plain storage maintained during the interim stages. The estimated cost for the proposed works is $1,300,000 for corridor works and the O'Loane culvert upgrade. Channel realignment costs associated with the Upper McNamara and South Branch options are not included in this estimate.

5.2.7 Alternative 7 – Combination of Alternatives 5 and 6

The final alternative results in no loss or change in aquatic habitat along the Court Drain or McNamara Drain. There would be a potential for habitat quality improvements with channel bank plantings and possibly in-channel works such as pool creation. Loss of terrestrial habitat in fill areas is associated with cultural meadow and agricultural field. The works would provide an opportunity to enhance terrestrial habitat in cut areas with diverse riparian plantings.

The proposed works would reduce flood elevations from approximately 0.1 to 0.8 m along the McNamara Drain from the City Limit to approximately 400 m upstream of the Court Drain confluence. No change in erosion potential would occur along the Court Drain. Flow velocities would be reduced in the McNamara Drain due to reduced depth of channel and more frequent use of flood plain during storm events, resulting in reduced risk of bed and bank erosion. The proposed works would result in an increase in developable lands of approximately 9.3 ha.

Requirements for implementation include a Drainage Engineer's report prepared in accordance with the Drainage Act. If the Drain is abandoned under the Drainage Act the Municipal EA requirements for a Schedule 'B' activity must be fulfilled. Approval would be required from the UTRCA, and additional approvals would be required for any in-stream works form the DFO and MOE. Preferred staging of the works is from downstream to upstream, with flood plain storage maintained during the interim stages. The estimated cost for the proposed works is $1,6500,000. Channel realignment costs associated with the Upper McNamara and South Branch options are not included in this estimate.

5.3 Recommended Works and Implementation

5.3.1 Recommended Flood Plain Management Works

The recommended flood plain management works are those associated with Alternative 7:

- Cutting of the Court Drain downstream of its confluence with the McNamara Drain and filling within the Court Drain flood plain (within open space flood plain areas only) and creating a variable corridor width, and

- Cutting and filling within the McNamara Drain flood plain, creating 30 m and 74 m corridor sections.

This alternative results in the greatest benefits, aquatic habitat enhancements, reduction in flood elevations along the McNamara Drain, reduction in flood risk, maintenance of flood plain storage, and the greatest increase in developable lands. It should be noted that for the South Branch of the McNamara Drain, there is some flexibility for the proposed corridor, which does not have to have its width centred on the Drain.

5.3.2 Staging of Corridor Works

The staging of the proposed works must be scheduled and executed to ensure that interim stages do no result in adverse impacts to the Drains and adjacent lands. Sufficient flood plain storage will need to be maintained as the works proceed to ensure no increase in flood risk to adjacent and downstream lands. The Jackson property located in subcatchments 207 and 208 can be cut/filled independent of fill on the adjacent east property. The remainder of the lower

McNamara works should be implemented simultaneously. Various alignments of the Upper McNamara and South Branch are presented on Exhibit 4. The proposed realignments would improve the hydraulics of the system by eliminating the 90 degree bends, and providing some flexibility in the drain realignment at the O'Loane Avenue crossing. Realignment of the South Branch could result in areas more easily discharged to Pond 8. The South Branch realignment option results in a shorter South Branch, which would allow for a steeper gradient. The entire South Branch and the entire Upper McNamara works can be implemented independently at any time, provided that the various landowners/developers develop an agreement on the proposed realignment.

5.4 Municipal Drain Process

The McNamara Drain and Court Drain are both Municipal Drains, and as such are subject to the Municipal Drain Process outlined in the Drainage Act. Some of the works/improvements to the Drains may require the preparation of a drainage report by a registered engineer. In cases such as improvements in relation to road works (e.g. culvert replacements), or channel regrading, a drainage report is not required. For works such as realignments, drain abandoning, removal of existing drop structures, then a drainage report prepared by a registered engineer is required. As stated in the CDSWS, a Municipal Drain may be abandoned if they service relatively small drainage areas, and if they are located in future growth areas which will ultimately be urbanized and serviced by storm sewers. This situation may exist on the south branch of the McNamara Drain.

Although there are benefits to existing developments that will be removed from the flood plain following the works, the works are only necessary to facilitate future developments and as such, it is recommended that the costs for the works and preparation of the drainage report be shared by the City and land developers.

5.4.1 Approvals

It is anticipated that approvals will be required from a number of agencies including:

- City of Stratford
- Upper Thames River Conservation Authority (UTRCA)
- Department of Fisheries and Oceans (DFO)
- Ministry of the Environment (MOE)

Early consultation with these agencies should be undertaken to confirm approval requirements.

6.0 MONITORING PLAN

Monitoring is an important component to the implementation of the storm water management strategy. Monitoring should be undertaken to assess conditions of the Court Drain and McNamara Drain over time and to assess the effectiveness of the storm water management strategy. Results of the monitoring should be reviewed in order to determine if changes need to be made to the implementation of the strategy or to the stormwater management criteria.

It is recommended that the Monitoring Plan focus on assessing channel erosion and sedimentation, water temperature and base flows. The recommended Monitoring Plan consists of the following:

1. Establish baseline conditions prior to any development (minimum one year):
   - Conduct a spring runoff and late summer (dry period) assessment of the Drains along two reaches; one upstream of the O'Loane Avenue crossing, and one upstream of the Quinlan Road crossing
   - Collect water temperatures and baseflow measurements
   - Conduct a rapid geomorphic assessment (sediment and erosion)

2. Monitor during construction
   - Continue with above data collection
   - Assess other channel reaches if significant impacts become evident
   - Assess data to determine if any significant changes are problematic and could be related to on-going developments
   - Make recommendations for further action if necessary such as inspection of the operation of storm water management ponds, inspection of temporary erosion and sediment controls, revisiting the storm water management criteria

3. Post-construction monitoring (minimum 2 years)
   - Continue with above data collection
   - Assess other channel reaches if significant impacts become evident
   - Make recommendations for further action if necessary such as inspection of the operation of storm water management ponds or revisiting the designs of storm water management ponds to determine if modification are necessary

It is recommended that a specialist in fluvial geomorphology be retained to implement the Monitoring Plan. It should be noted that this Monitoring Plan does not cover the monitoring of storm water management facilities by developers prior to them being assumed by the City or monitoring that may be required by the UTRCA and/or DFO in conjunction with the flood plain management works.

7.0 SUMMARY OF FINDINGS AND RECOMMENDATIONS

MRC carried out a storm water and flood plain management analysis for the McNamara Drain and a portion of the Court Drain as part of the West Secondary Plan for the City of Stratford (City) and developed a storm water management strategy for future developments in the northern portion of the Planning Area. A Master Drainage Plan was prepared by MRC for the Roadhouse Drain as part of the West Secondary Planning Study for the City, and is documented under separate cover. The purpose of the storm water and flood plain management analyses is to provide a comprehensive understanding of the hydrologic and hydraulic aspects of the Court Drain and McNamara Drain, an understanding of the system as a whole, to refine the flood plain limits, to develop a storm water management strategy for future developments, to evaluate flood plain management alternatives, and to provide implementation recommendations.

The following summarizes the key findings which are presented in this storm water and flood plain management analysis:

- Under existing conditions, the results of the hydraulic modelling indicated that the existing 250-year floodline expands upstream of O'Loane Avenue, due to the insufficient capacity of the existing culvert crossing O'Loane Avenue;
- Downstream of O'Loane Avenue, the flood plain broadens over agricultural lands, and is contained within steep banks immediately south of an existing rural residential property located on Quinlan Road; and
- Further downstream, the Court Drain flood plain expands into low-lying areas, and flows spill over Quinlan Road continuing northeasterly towards the Bannerman Drain.

Future development within the West Secondary Planning Area was accounted for in the hydrologic modelling carried out as part of this storm water and flood plain management analysis. Storm water management objectives for future developments are as follows:

- to maintain or reduce peak flows along the McNamara Drain and Court Drain up to and including the 250-year storm;
- to maintain or reduce erosion potential along the McNamara and Court Drain;
- to maintain or improve water quality; and
- to ensure no adverse impacts to existing developments and their storm drainage systems.

The following specific criteria were identified in order to meet these objectives:

- Maintain or reduce peak flows on a catchment-by-catchment basis for the 4 hour 2-year to 250 year Chicago design storms and the 24 hour 250 year Chicago design storm;
- Apply the "Simplified Approach" to erosion control as outlined in the Ministry of the Environment's (MOE) Stormwater Management Planning and Design Manual and the Court Drain Subwatershed Study;

- Provide MOE "Normal" level of protection with respect to water quality (formerly Level 2);

- Control the 4-hour duration post development flows up to and including the 250-year storm event, to the 4-hour duration 5-year existing flow rates (i.e. overcontrol) where developments will drain to existing storm sewers.

The hydrologic modelling results indicate that if peak flows are maintained on a catchment-by-catchment basis, peak flows along the Drains will also be maintained.

The SWM criteria was met by developing an overall strategy that included the provision of a number of SWM facilities that were designed to be wet ponds. The location of the proposed SWM facilities were based on proposed future land use, and proposed drainage. Conceptual designs were developed based on the above criteria and a number of assumptions. It should be noted that the proposed SWM facility locations and designs are conceptual only, and are somewhat flexible. Changes may be made provided that the SWM objectives and targets are met. Further refinements on a site-by-site basis are anticipated during subsequent design stages.

The storm water and flood plain management analysis included the analysis of numerous flood plain management alternatives. The recommended alternative includes the following:

- Cutting of the Court Drain downstream of its confluence with the McNamara Drain and filling within the Court Drain flood plain (within open space flood plain areas only) and creating a variable corridor width, and

- Cutting and filling within the McNamara Drain flood plain, creating 30 m and 74 m corridor sections.

This alternative results in the greatest benefits, aquatic habitat enhancements, reduction in flood elevations along the McNamara Drain, reduction in flood risk, maintenance of flood plain storage, and the greatest increase in developable lands. As the Court Drain and McNamara Drain are Municipal Drains, they are subject to the Municipal Drain process as outlined in the Drainage Act. It is anticipated that approvals will be required from the City of Stratford, UTRCA, DFO, and MOE. The estimated cost for the channel works associated with the preferred alternative is approximately $1,650,000.

The staging of the proposed works must be scheduled and executed to ensure that interim stages do no result in adverse impacts to the Drains and adjacent lands. Sufficient flood plain storage will need to be maintained as the works proceed to ensure no increase in flood risk to adjacent and downstream lands. The Jackson property located in subcatchments 207 and 208 can be cut/filled independent of fill on the adjacent east property, and the remainder of the lower McNamara works should be implemented simultaneously. The entire South Branch and the entire Upper McNamara works can be implemented independently at any time, provided that the various landowners/developers develop an agreement on the proposed realignment.

A Monitoring Plan was developed in order to provide a means to assess conditions of the Drains over time and to assess the effectiveness of the storm water management strategy. Results of the monitoring should be reviewed in order to determine if changes need to be made to the implementation of the strategy or to the stormwater management criteria.

Exhibit 1 - Study Area

Exhibit 2 - Existing Conditions Drainage Mosaic

Exhibit 3 - Future Conditions Drainage Mosaic and Proposed SWM Pond Locations

Exhibit 4 – McNamara Drain and Court Drain 250-year Floodlines and Flood Plain Management Alternatives

APPENDIX A

Agency Correspondence

APPENDIX B

Photographic Inventory

APPENDIX C

Hydrologic Model Input Parameters And Output Files – Existing Conditions

APPENDIX D

Hydrologic Model Input Parameters And Output Files –Future Conditions

APPENDIX E

Distributed Runoff Control – Simplified Approach Procedures (Excerpts from Court Drain Subwatershed Study)

APPENDIX F

Hydraulic Modelling Output Files
(available on CD)