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Town of Rothesay

Salmon Brook Watershed – Flood Reduction Study

Final Report

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CBCL LIMITED
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Chapter 1 Introduction

1.1 Background

On Saturday and Sunday, September 6th and 7th 2008, the Saint John area, including Rothesay, received significant amounts of rainfall from Tropical Storm Hanna. The storm caused flooding in the upper end of Monaco Drive as well as in the low areas of Sierra Avenue following the event, leading to complaints from local residents. To address the issue, the Town commissioned CBCL Limited to study the cause of the flooding and to investigate possible means to reduce flood risks.

As the study was beginning, the Town held a meeting with interested residents which was attended by several residents that were flooded. Following the meeting, attempts were made to visit the residents that flooded to obtain the following information:

- Maximum flood levels on each property;
- How the flooding occurred.

In addition to review of information on existing drainage systems, site visits and surveys were conducted to obtain more detail in key locations in the system. This included survey of cross sections in the channels through the affected sub-division.

Following the information gathering process, assessments were completed to understand the process of runoff generation in the tributary areas as well as the hydraulics of the flow of this runoff through the existing drainage system. Once the systems were understood, the process of evaluating various methods to reduce flooding was undertaken. This report summarizes the process and describes alternatives that might be considered for flood reduction, including their costs.

Chapter 2 Data Collection

2.1 Data Collection

2.1.1 Site Visits

Site visits were made to the areas where flooding was reported to observe existing conditions and indications of flooding. The study area is highlighted in Figure 1, a plan of the Salmon Brook Watershed.

On Thursday, September 11th 2008, an initial site visit was conducted as part of the proposal development. Observations from the site visit included:

- Size and configuration of existing culverts in the main drainage system from the Hampton Road to the railway culvert adjacent the Gondola Point Road. The main system in the area of the reported flooding is open channels with twin 1200 mm diameter corrugated metal pipe CMP road (driveway) crossing culverts. Conditions observed included:
  - Sections of some channels have abundant vegetation as well as deposition of fine material;
  - There is some accumulation of debris and sediment upstream of some culverts, including driveway cross culverts;
- Inlet conditions for the culverts in the system through the Monaco Drive area are beveled inlets protruding from the road embankments. Some are misshaped at the inlets, partially blocking the inlets;
- Erosion where the drainage system was topped on Seville Road, flows went around the timber headwall on the driveway culvert and spilled onto Seville Road;
- High water or flood lines in the open drainage systems. These were indicated by bent foliage and appeared below the cross road elevations at most locations. Most buildings along the drainage system appeared above the flood elevations, the exception was the flooded area at the upper end of Monaco Drive;
- Potential for basement flooding in the properties adjacent the main drainage system in the upper Monaco Drive area as well as local drainage. The area appears relatively flat while the conveyance system sizes appear consistent with downstream systems. This area appears to have potential to be capacity limiting for the main drainage system;
- Recent commercial development on the Hampton Road, including a newly constructed strip mall and a dental office on either side of Oakville Lane.

On Monday, November 10th 2008, a second site visit was conducted to obtain additional survey data and to talk to residents that experienced property flooding. Information collected included the following:

- Maximum flood levels on the properties adjacent the upper end of Monaco Drive at Oakville Lane;
- Descriptions of flooding during the September 2008 event.

The information collected is summarized in Figure 2.

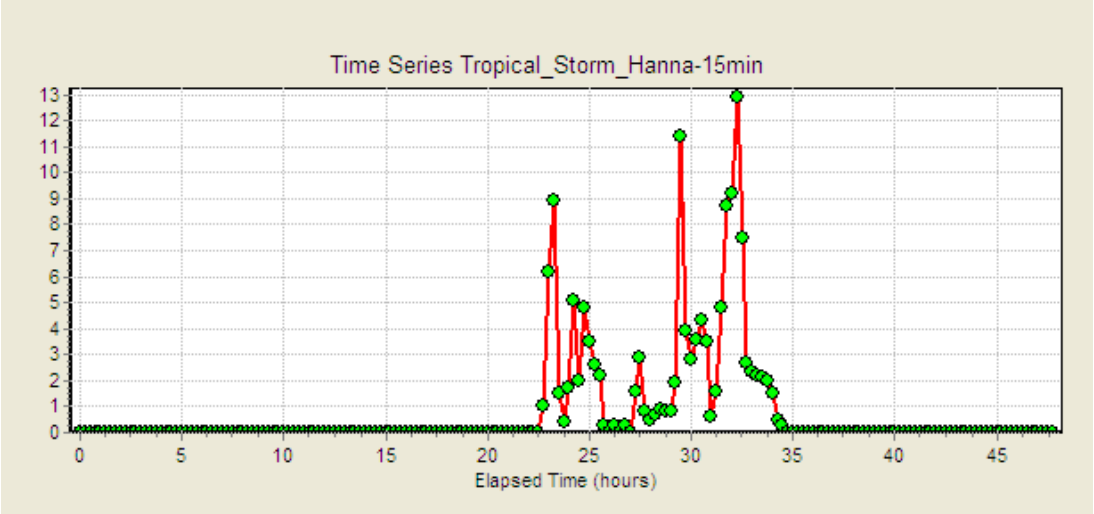
2.1.2 Rainfall Data

Tropical Storm Hanna

Rainfall records from the event were obtained from the closest operating monitoring station, Environment Canada's station at Lepreau. Records from the station indicate that 140.7 mm of rain fell in approximately 12 hours. The majority of the rain was informally reported to have fallen in the final 3 hours of the event on Sunday morning from 7 to 10 am. This was a significant rainfall event with a relatively low probability of occurrence.

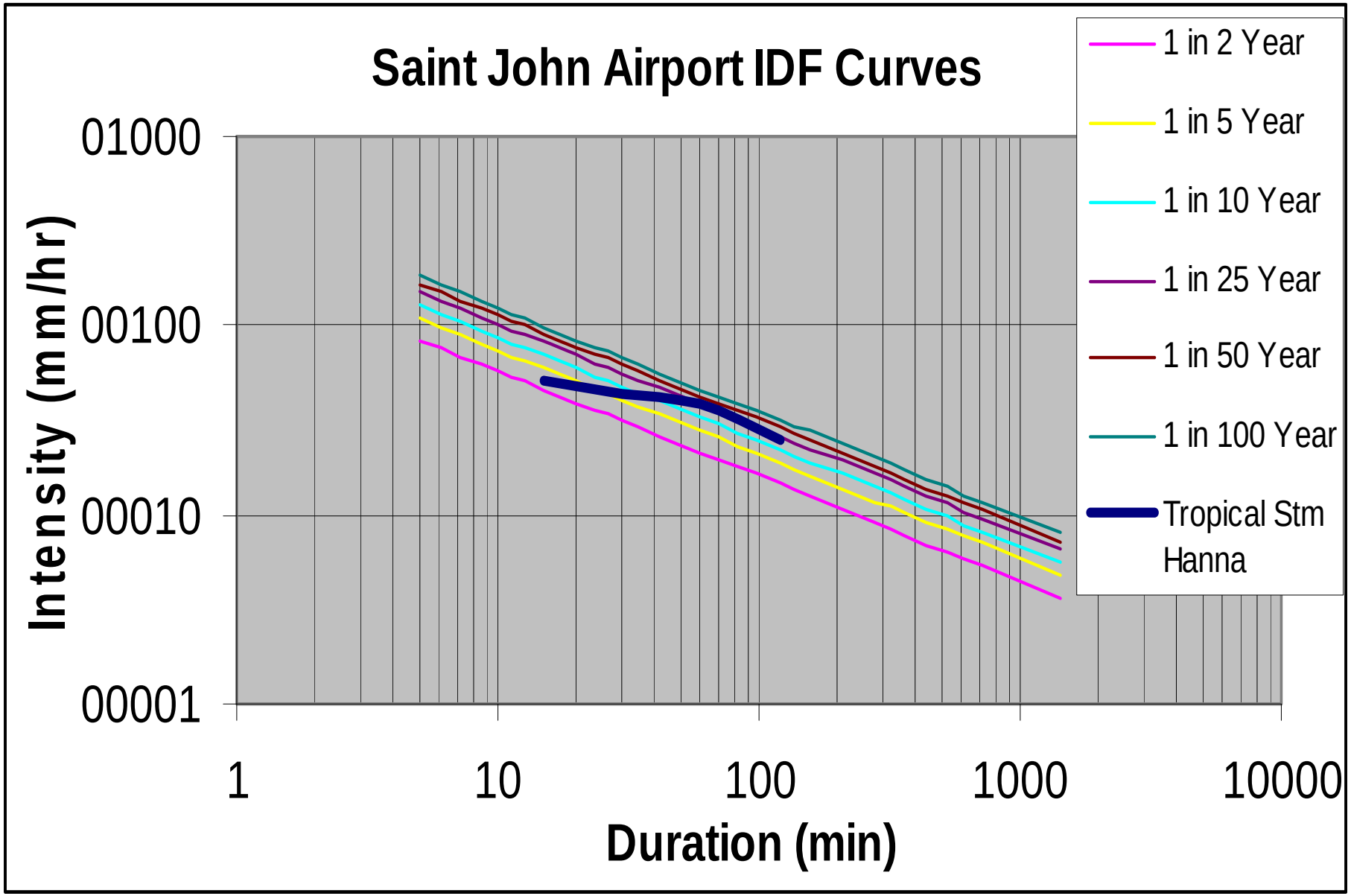
Recorded data is summarized in the following chart, a plot of rainfall volume (in millimeters of rain in 15 minute intervals) verses time from midnight on September 6th 2008:

Chart 1: Tropical Storm Hanna Rainfall Time Series



Assessment of the data from this event in relation to infrequent rainfall events measured between 1960 and 1997 at the Saint John Airport (a former rainfall monitoring site operated by Environment Canada) are shown on the Intensity Duration Frequency (IDF) plot for the former station. This plot indicates that the range of intensities between 1 hour and 2 hours observed on September 7th were relatively infrequent, with a recurrence period in the order of 1 in 25 years.

Chart 2: Saint John Airport IDF Curves

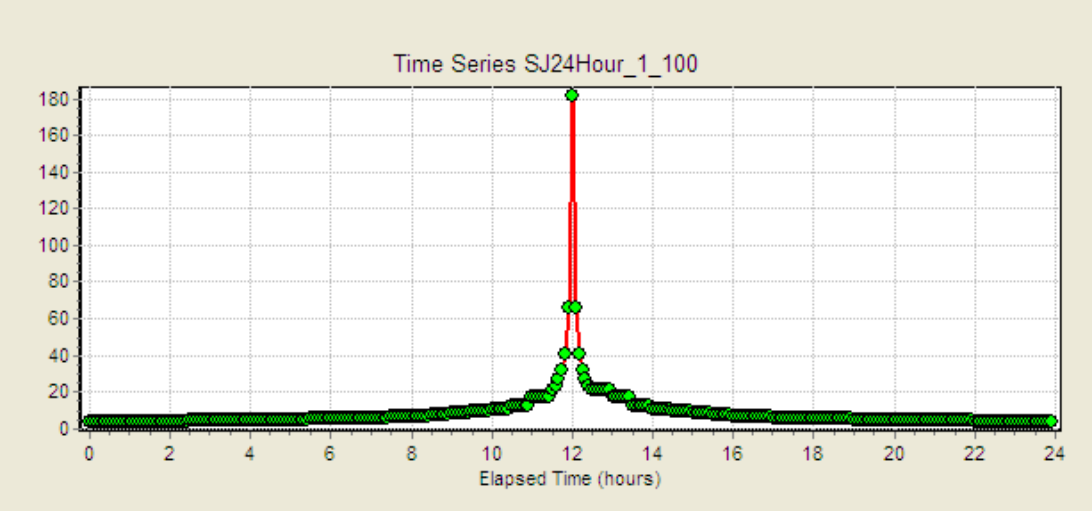


1 in 100 Year Design Rainfall Event

The major drainage systems were assessed based on their performance with runoff generated by 1 in 25 and 1 in 100 year design rainfall events. This event is based on the IDF Curve for the closest rain gauge station. The former station at the Saint John Airport was selected as there is record of approximately 35 years available. The design event is not an actual event but is generated based on rainfall intensities with a recurrence period of 1 in 100 years for a range of durations from 5 minutes to 24 hours. Its intent is to subject all watersheds or sub-watersheds of varying sizes to its most critical rainfall intensity.

A plot of the design event follows. The plot is peak intensities (in millimeters per hour) versus time (hours) since the beginning of the 24 hour rainfall event.

Chart 3: 1 in 100 Year Design Event Rainfall Time Series



Chapter 3 Analysis

3.1 Analysis of Data

Data collected was used as input to a computer based hydrologic and hydraulic model of the Salmon Brook Watershed, the areas included in the model are shown in Figure 1. The watershed was divided into 4 main sub-watersheds based on:

- The areas tributary to the two main tributaries south of the Hampton Road;
- Tributary areas for Ritchie Lake and it's connection to the Main Channel;
- Areas tributary to the main channel between the Hampton Road and the outlet near the lagoon.

It was determined that most of the tributary areas for the system are currently developed or in the process of being developed. It is a mix of medium density residential with ½ acres lots as well as commercial in the upper reaches of the watershed, along Millennium Drive, the Marr Road and the Hampton Road.

In addition, the main drainage system was identified including:

- The two main tributaries south of the Hampton Road;
  - The tributary through the Monaco Drive area as well as the system up Campbell Drive;
  - The system adjacent the Marr Road up to the retention basin near the Super Store;
- The main channel between the Hampton Road and the outlet near the lagoon.

Profiles along the canter-lines of the main channel and the two main tributaries are shown in Figure 3.

Information about the piped systems was taken from previous reports and assessments while information on the main channel was taken from topographic mapping of the system. Site surveys were conducted through the study area to define channel cross sections and culvert inverts. Most of the system in the developed areas is open channel earth lined swales and ditches with culverts at street and driveway crossings. The main channel from the Hampton Road to the Gondola Point Road is mostly natural, a main channel that conveys most frequently occurring flows and a floodplain.

The collected data was compiled in an input file for SWMM5, from the USEPA, a model commonly used for simulation and prediction of urban

hydrology and hydraulics. This model was calibrated to the extent possible using information collected from residents for the 7th September 2008 event.

Estimated maximum water levels resulting from the 1 in 100 year design rainfall event are also shown on Figure 3. Accuracy of the estimates is best in the sections where site survey data was used in the calculations as indicated in the Figure. These flood elevations were used to produce the flood delineation mapping shown in Figure 4 for existing development and drainage configurations.

The model was then used to assess possible means to reduce flooding in the Monaco Drive area. The model of existing conditions was modified to simulate flooding conditions with potential flood reduction measures considered.

3.2 Opportunities for Reduction of Existing Flood Risks

Reduction of existing flooding may be achieved by a number of methods including the following:

- Drainage system upgrades to increase conveyance capacity – Drainage system components that are identified as under capacity in the model of existing conditions are modified to increase their capacity;
- Runoff reduction:
  - Decreased overall runoff volume – Development tends to create impermeable surfaces that limit the amount of infiltration that can occur. To reduce runoff requires creation of facilities to re-establish infiltration in the watershed to predevelopment conditions. While there is opportunity to maintain current runoff generation by incorporating measures into new development, this is a difficult task in areas that are currently developed;
  - Reduction of peak flows - Detention storage may be created to reduce peak flows resulting from rainfall events. In a watershed that is mostly developed such as this one, the opportunities for creating large detention basins are limited. There are opportunities however to create the required storage on a smaller scale, including on-site storage for individual properties.

3.3 Increased Capacity of the Drainage System

3.3.1 Upgrade the Existing System

Opportunities to increase conveyance system capacity through the Monaco Drive system include:

- Excavation of the existing open channel sections, complete with re-stabilization of the channels, to make wider – deeper sections, possibly at steeper grades;
- Improve inlet capacity of the existing culverts with shaped headwalls as well as providing new larger culverts and/or additional culverts.

To reduce existing flooding requires replacement of the culverts from the upper end of Monaco Drive to the cross culvert at Seville. The sizes of the new culverts determine the reduction in peak flood levels achievable. A range of sizes were evaluated. The analysis indicates that the most significant reductions are achieved with increased depth in the main channels and culverts. Capacity increases and resulting lower flood levels can be achieved by lowering the main channel by 600 mm and replacing the existing twin 1200 mm diameter corrugated steel pipes with concrete box culverts. A minimum box culvert size of 2400 mm by 1800 mm is required to achieve flood levels equivalent to the top of the banks of the existing channels near the properties between Monaco Drive and Aries Court.

Advantages of this strategy include:

- The existing alignment is in the natural low areas so excavation is minimal;
- Siting of new culverts and channels is not necessary;

Concerns with this approach include:

- Disturbance of well established drainage systems through private property will bring complaints from residents, particularly in areas where there is currently minimal flood risk;
- Larger and deeper channels that may pose other risks to the community;
- Negative impacts on the downstream system resulting from larger downstream flows. Implementing such measures and increasing capacity will increase flood flows on the downstream system and increase downstream flood levels (maximum water level in the main channel downstream of Monaco Drive at Seville is estimated to increase by 0.100 metres and the maximum flow in the main channel, is estimated to increases by as much as 38 percent).

3.3.2 Diversion Channels

Alternatively, the additional capacity may be achieved by providing additional drainage systems or diversion channels. Several scenarios were considered, including:

- Between the properties on Monaco Drive and Hampton Road – This alternative intercepts the major flows from the tributary storm sewers at the end of Campbell Drive and diverts them directly to the main

channel before they enter the flood prone area at the upper end of Monaco Drive. One major culvert is required at the Oakville Lane crossing. Inlets to the channel would be provided at either end of the culvert to receive flows conveyed down Oakville Lane under high flow conditions, preventing them from entering the flood prone area as well. The minimum dimensions of the channel and culverts required to convey flows from the 1 in 100 year design rainfall event are 2400 mm wide and 1800 mm deep.

- Along Monaco Drive – New channels would be required on one or both sides of the road, if both sides are used the size of the channel and driveway culverts can be reduced. There is a high point of land to pass through as well as many large driveway culverts to construct; however, if the channels are lined they can be constructed in the street Right of Way (ROW).
- Between the properties on Monaco Drive and Aries – This alternative supplements the capacity of the culvert under Aries and provides an opportunity to significantly reduce flood levels with minor impact on the existing channels. While there are no new culverts to construct along the diversion alignment, the channel will be deep where it passes through a high point of land;
- Along Aries from the Aries culverts to Seville – the biggest concern for this alternative is the depth of the cut and the impact on Aries.

It should be noted that the most effective alignment is the alignment between Hampton Road and Monaco Drive; it has the capability of capturing all or a portion of the upstream flows and directing them away from the problem areas. Alignments further into the system require these large flows to pass through current flood prone areas and do not specifically address the issue of flows entering the system from Oakville Lane.

The main advantage of these diversion alternatives is the opportunity to take flows away from the existing drainage system and reduce the need for major changes to this system.

The main concerns with these alternatives include:

- Routing proposed channels in limited spaces, on suitable alignments so that the majority of flows are intercepted. This can be limited by lining the channel walls with gabions or concrete blocks to achieve near vertical sides. This can greatly reduce the required alignment width but at a significant capital cost;
- Access to major drainage channels located between private properties;
- As with the other conveyance system upgrades considered, these alternatives make the drainage system more effective and as a result increase peak flows and flood levels in the downstream system.

3.4 Runoff Reduction

3.4.1 Peak Flow Reduction

To maintain downstream peak flows and flooding at current levels while alleviating flooding within the Monaco Drive system requires reduction in runoff generation and development of additional storage in the existing tributary areas.

It was estimated that approximately 60,000 cubic metres of storage is required to achieve this objective. A potential site, currently undeveloped, near the intersection of Pettingill Road and Hampton Road was investigated in conjunction with Diversion Channel Option 1. There is a height of land along the proposed alignment with a maximum depth of 6 metres above the require channel bottom. To make the diversion channel feasible would require a deep excavation for an open channel or a piped section, both costly alternatives.

3.4.2 Diversion Channel with Storage

A modified version of the original diversion concept, presented in Figure 5, considered the following:

- Constructing a berm upstream of the existing culverts under Monaco Drive with a culvert through it to allow some flow to continue to the existing system;
- The berm height would need to be high enough to elevate the water level above the height of land where a much shallower diversion channel could be constructed (near elevation 26 metres);
- Under low flow conditions, all flows would pass through the culvert in the berm and carry on downstream with minimal depth of water in the detention pond;
- Under rainfall conditions, when the capacity of the culvert in the berm was exceeded, the water level in the pond would rise, taking advantage of the available storage to a maximum level in the order of 27 metres, below the elevation of the Pettingill Road and the tributary storm sewers. It is estimated that this could create in the order of 54,000 cubic metres of storage. Excess flows would pass to the diversion channel.
- After the rainfall event the pond would drain to the existing channel system and supplement normal dry weather flows in the system.

Construction of the berm and diversion channel would include:

- Clearing of the low area and excavation to produce a low flow channel through the area. Alternatively, it could be excavated deeper than the outlet culvert and planted with wetland plants to create a wet pond for water quality improvements;

- Construction of a significant berm structure with a base near elevation 23 metres and a top elevation of 27.5 metres;
- Construction of a diversion channel from the detention pond to the main channel, on steep slopes, in a built-up area. Some newer buildings are close to the back property lines between Hampton Road and Monaco Dr.

Figure 6 shows the flood delineation resulting with the proposed diversion and Monaco Drive retention pond. The flooding in the flat area adjacent Monaco Drive and Aries Court is moved to the proposed retention pond without increasing the current flooding adjacent the main channel.

3.5 Cost Estimates

Order of magnitude costs for the alternatives and options considered have been developed based on unit costs of similar works. The exception is the cost of supply for the concrete box culverts. Estimates of cost were developed based on discussions with potential suppliers of the pipe. They provided unit costs for supply on-site. As well, discussions were held with representatives of the local construction industry to assess current installation costs for culverts.

Capital cost estimates are presented in Table 1. These include 25 percent contingency and engineering costs but do not include H.S.T.

Table 1: Summary of Costs of Alternatives Considered

Section	Alternative	Peak Flow in Main Channel for 1 in 100 year Rainfall	Maximum Flood Level at Node 2025	Estimated Cost
		(m3/s)	(m)	
	Existing Conditions	13.5	22.6	-
3.3.1	Culvert Replacement and Lower Channels	18	22	$1,715,000
3.3.2	Diversion Channel - Option1	18	21.7	$2,070,000
	Diversion Channel - Option2			$1,735,000
	Diversion Channel - Option3			$1,495,000
	Diversion Channel - Option4			$1,665,000
3.4.2	Diversion Channel - Option1 with Storage	15.5	21.1	$1,695,000
	Diversion Culvert - Option1 with Storage			$2,505,000

Note: ***Node 2025*** is located along the existing channel, between the properties on Monaco and Aries, at the bend upstream of the Aries culverts

Chapter 4 Other Measures

4.1 Planning

It is recommended that the Town take the lead on stormwater management planning in the Salmon Brook watershed to ensure that:

- Runoff generated in the tributary areas within the Town's jurisdiction is limited to current peak flows as a minimum. Measures to reduce current peak flows should be investigated, policies should be adopted by the Town that place restrictions on peak flows from future development of currently undeveloped areas (Post – development flows should be equal to or less than Pre – development peak flows);
- Plans include runoff peak flows from lands not under the Town's jurisdiction. It is in the Town's best interest to negotiate with administrators of these lands to try to achieve upper limits in peak flows from these lands as well;
- An adequate drainage system is in place to convey peak runoff flows from all tributary areas without causing flooding problems. Measures must be taken to reduce current flooding and accommodate all flows from future development without causing unplanned flooding.

This study is the first major step in the process, current flood levels have been identified through the system for existing conditions and measures have been evaluated for reducing current levels.

4.2 Floodplain Mapping

Another measure that can be taken to reduce the risk of flooding that causes damage to properties is to produce floodplain mapping identifying flood prone areas. The process includes the following:

- Identification of flood plains in areas that are not currently developed, particularly in the floodplain adjacent the main channel from the Hampton Road to the Gondola Point Road and in the vicinity of potential retention basins;
- Areas that are or will be prone to flooding should be identified on land-use mapping and zoned to restrict further development in these areas.

Restrictions should include:

- A buffer of zero development adjacent the main channel, the buffer should be a minimum of 30 metres (or the current minimum required by the Department of Environment if it changes in the future, whichever is greater) on either side of main channel or associated wetlands;
- No filling of the floodplain as identified in the floodplain mapping;

- Any development that does take place should not be affected by flooding, typically this limits development to recreational uses etc.;
- Basement elevations on lands adjacent the floodplain should be above the expected flood levels.

Floodplain mapping produced in this study should be considered preliminary as it was developed based on available contour mapping. It should be confirmed using more detailed and accurate topographic information prior to zoning changes.

4.3 Additional Diversions

Currently, flows in excess of the piped system on Campbell Drive flow in a roadside ditch on the north side of the road. During extreme events, the ditch overflows to the Hampton Road and is conveyed on the road to Oakville Lane. The proposed diversion will intercept flows on Oakville Lane and divert them to the main channel.

It is understood that the Town plans to construct a small detention pond near Anoka Avenue. It is estimated that a pond with 1300 cubic metres of storage could reduce the peak flow from area 2-4 from 4.8 m^3/s to 3.9 m^3/s. Additional plans include new inlets to the 750 mm diameter storm sewer from area 2-4 as well as from the channel upstream of the current end of the storm sewer (servicing areas 2-1, 2-2 and 2-3). It is estimated that these measures should increase the hydraulic efficiency of the inlets and the portion of the peak runoff flows that enter the stormsewer system from 15% of current peak flows to 40 percent.

Rather than allow flood flows to be conveyed on the Hampton Road, a second diversion could be constructed from the upstream side of the Campbell Drive intersection to the proposed retention pond. A 2400 mm by 1800 mm box culvert is required to divert all of the flows from Campbell Drive to the Monaco Drive retention pond at an estimated cost of $1,000,000. This could be extended to the end of the roadside ditches on Campbell Drive to minimize flows on Campbell Drive for an additional $1,200,000. The following sketch illustrates preliminary alignment of an additional diversion.

This would provide the following benefits:

- Some attenuation of peak flows to the main channel;
- Reduction in flood hazard on Hampton Road and properties immediately adjacent.

4.4 Upgrade Priorities

Implementation priorities of the measures considered are as follows:

1. Obtain the land needed for the proposed Monaco Dive retention pond. Start negotiations with current land owners as soon as possible;
2. Co-ordinate the stormwater management plan for the watershed with the Town of Quispamsis, as it has jurisdiction over a significant portion of the lands tributary to the main drainage system as well as part of the land that will form the Monaco Drive retention pond.
3. Discuss the plan with local residents, particularly those immediately adjacent the planned works, to get their input and buy-in;
4. Depending on the outcome of these discussions, the plan may need to be modified;
5. Agree on and implement a policy regarding peak runoff flows from proposed development in the Town;
6. Identify floodplains – use the delineation in this report as a starting point and improve it over time as the need arises;

7. Design and construct the following components:
    a. The main diversion channel or culvert from Oakville Lane to the main channel;
    b. The Monaco Drive retention pond and overflow channel to Oakville Lane;
    c. The Anoka Lane retention pond and stormsewer inlet upgrades;
    d. The flow diversion from Hampton Road at Campbell Drive to the Monaco Drive retention basin
    e. The flow diversion along Campbell Drive.