STORM WATER DESIGN
CRITERIA MANUAL
FOR MUNICIPAL SERVICES

ENGINEERING AND
PUBLIC WORKS DEPARTMENT

MAY 24, 2011

DISCLAIMER

The purpose of this document is to provide guidance to designers of stormwater drainage systems in the Town of Riverview. Generally, stormwater drainage and management systems should be designed considering the lowest possible overall installation, operation, and maintenance costs required to provide an acceptable level of service without significant adverse effects on the environment.

No warranty is expressed or implied concerning the accuracy of the material presented in this text. Distribution of the guidelines does not constitute responsibility by the Town of Riverview Engineering and Public Works Department or other contributors to these guidelines for omissions, errors, or possible misrepresentations that may result from use or interpretation of the material herein contained.

This document is not intended to eliminate the necessity for detailed design by a Professional Engineer, nor is it intended to stifle innovation. The guidelines do not relieve the Designer of their responsibility and liability for their design work as a Professional Engineer.

TABLE OF CONTENTS

DEFINITION OF TERMS

Approval: The approval of the Engineer. The Engineer's decision will be final and binding in matters of design and construction.

Town: The Office of the Director of Engineering and Public Works appointed by Council to oversee all public works of the Town of Riverview Engineering and Public Works Department, or their designated representative.

Consultant: A member, or Licence to practice member, of the Association of Professional Engineers and Geoscientists of New Brunswick (APEGNB).

Developer: The owner of the area of land proposed for developed, or their designated representative.

Development: Development includes any erection, construction, addition, alteration, replacement, or relocation of or to any building or structure and any change or alteration in land use, buildings, or structures.

Drainage Area: (1) The area tributary to a single drainage basin, expressed in units of area. The drainage area may also be referred to as the catchment area, subcatchment area, watershed, subwatershed, drainage basin, or drainage subbasin.
(2) The area served by a drainage system receiving storm sewer discharge and surface water runoff.
(3) The area tributary to a watercourse.

Drainage Master Plan: The compilation of data and mapping that delineates watersheds, indicates routes of the major and minor drainage systems, defines floodplains, indicates constraints associated with water quality and quantity, indicates erosion and bank stability problems, and indicates specific flood control and environmental objectives in the watershed.

Engineer: The Office of the Director of Engineering and Public Works appointed by Council to oversee all public works of the Town of Riverview Engineering and Public Works Department, or their designated representative.

Flood Hazard Area: An area adjacent to a river, stream, watercourse, ocean, lake, or other body of water that has been, or may be, temporarily covered with floodwater during storms of specified frequency.

Hydrograph: A graph showing the discharge of water with respect to time for a given point within a subwatershed.

Hyetograph: A graph showing average rainfall, rainfall intensity, or rainfall volume with respect to time within a subwatershed.

Impervious: A term applied to a material through which water cannot pass, or through which water passes with great difficulty over a prolonged duration of time.

Infiltration: (1) The migration of water through the interstices or pores of a soil or other porous medium.
(2) Absorption of liquid water by the soil, either as it falls as precipitation, or from a stream flowing over the surface.

Intensity: The rate of precipitation derived from the quantity of precipitation expressed per unit of time.

Major Storm: The storm used for design purposes – the runoff from which is used for design and sizing the major storm drainage system. The frequency of such a storm is 1 in 100 years (1% probability of being equalled or exceeded in any year). Please note that the Town of Riverview requires an allowance in the magnitude of this design storm to accommodate the anticipated effects of climate change (see Section 4.2).

Major Storm Drainage System: The storm drainage system which water will follow in a major storm when the capacity of the minor system is exceeded. The major system usually includes many features such as streets, curb and gutter systems, swales, and major drainage channels. Minor storm drainage systems may reduce the flow in many parts of the major storm drainage system by storing and conveying water underground. Design of a major system is based on a storm frequency of 1 in 100 years.

Minor Storm: The storm used for design purposes – the runoff from which is used for design and sizing the minor storm drainage system. The frequency of such a storm is 1 in 5 years (20% probability of being equalled or exceeded in any year).

Minor Storm Drainage System: That storm drainage system which is designed to eliminate or minimize inconveniences or disruption of activity as a result of runoff from the more frequent, less intense storms. The minor storm drainage system is sometimes termed the "convenience system", or "initial system". The minor system may include many features ranging from curbs and gutters to storm sewer pipes and open drainage ways. Design of a minor system is based on a storm frequency of 1 in 5 years.

NBDOE: The central office of the New Brunswick Department of Environment.

NBDOT: The central office of the New Brunswick Department of Transportation.

Overland Flow: The concentration and conveyance of stormwater runoff over the ground surface.

Pervious: A term applied to a material through which water passes relatively freely over a short duration of time.

Precipitation: Any moisture that falls from the atmosphere, including snow, sleet, rain, and hail.

Professional Engineer: A registered or licensed member, in good standing, of the Association of Professional Engineers and Geoscientists of New Brunswick.

Runoff (Direct): The total amount of surface runoff and subsurface storm runoff that reaches stream channels.

Storm Drainage System: A system receiving, conveying, and controlling discharges in response to precipitation and snowmelt. Such systems consist of ditches, culverts, swales, subsurface interceptor drains, roadways, curb and gutters, catchbasins, manholes, pipes, detention ponds, and service lateral lines.

Stormwater Runoff Storage: The detention or retention of overland flow from a storm event allowing it to be released at a set rate during or after the storm event.

Detention Storage: Precipitation that is detained on the surface during a storm and does not become runoff until sometime after the storm has ended.

Depression Storage: Precipitation that is retained in small depressions and surface irregularities and does not become part of the stormwater runoff.

Storm Service Lateral: A pipe that conveys foundation drain water from the inner side of the wall through which the pipe exits the building to the storm sewer.

Stormwater Runoff: The stormwater resulting from precipitation falling onto and running off of the surface of a subwatershed during and immediately following a period of rain.

Subdivision: The division of any area of land into two or more parcels, including a resubdivision or a consolidation of two or more parcels.

Surcharge: The flow condition occurring in closed conduits when the hydraulic gradeline is above the conduit crown, or the transition from open channel flow to pressurised flow.

Time of Concentration: The time required for stormwater runoff to concentrate and convey from the hydraulically most remote point of a subwatershed to the outlet or point under consideration. Time of concentration is not a constant, but varies with depth of flow, slope, and hydraulic condition of the subwatershed.

Watercourse: The bed and shore of every river, stream, lake, creek, pond, spring, lagoon, or other natural body of water, and the water therein, within the jurisdiction of the Province, whether is contains water or not, and all groundwater, in accordance with The Clean Environment Act – Revised Statutes of New Brunswick.

1.0 INTRODUCTION

A storm drainage system is a system receiving, conveying, and controlling stormwater runoff in response to precipitation and snowmelt. Such systems include: ditches, culverts, swales, subsurface interceptor drains, roadways, curb and gutters, catch basins, manholes, pipes, attenuation ponds and service lateral lines. In the Town of Riverview, storm drainage systems are owned, operated, and maintained either by the Town, private landowners, or a combination of both.

These Storm Water Design Criteria shall be used for all residential, commercial, and industrial developments.

All storm drainage systems within the Town of Riverview shall be designed to achieve the following objectives:

- to prevent loss of life and to protect structures and property from damage due to flood events;
- to provide safe and convenient use of streets, lot areas, and other improvements during and following precipitation and snowmelt events;
- to adequately convey stormwater runoff from upstream sources;
- to mitigate the adverse effects of stormwater runoff, such as flooding and erosion, onto downstream properties;
- to preserve designated natural watercourses and natural designated wetland environment;
- to minimize the long-term effects of development on the receiving surface water and groundwater regimes from both a quantity and quality perspective.

The guidelines, recommendations, and design standards presented in these design criteria are intended to promote uniformity of the design and construction of drainage systems within the Town of Riverview. Like all municipal services, storm drainage systems must be carefully designed in accordance with municipal and provincial technical guidelines and standards. In addition to the specifications for drainage infrastructure in the Town of Riverview (as presented in this document), all storm drainage systems shall conform to any applicable requirements established by the New Brunswick Department of Environment (NBDOE). Furthermore, no system shall be constructed until the design has been accepted by the Town and reviewed and approved by NBDOE, if applicable. These specifications for drainage infrastructure can be used in the evaluation of drainage system designs by the Town and regulatory authorities.

A complete description and documentation of all parameters relating to the design and construction of stormwater systems is beyond the scope of this document. However, an attempt has been made to define the parameters of greatest importance, and to present the policies and accepted methods of the Town of Riverview's Engineering and Public Works Department. Designs submitted to the Town of Riverview's Engineering and Public Works Department for approval should be accompanied by a written statement that the designs have been completed in accordance with these guidelines, or a technical report by a qualified professional engineer providing justification for departure from these guidelines (see Section 2.0).

2.0 ENGINEERING RESPONSIBILITIES

The planning and design of urban stormwater drainage systems requires knowledge of two basic fields:

- Engineering Hydrology, which is the estimation of runoff produced from rainfall and/or snowmelt, and understanding the factors which influence it, and
- Hydraulics, which is the determination of water flow characteristics in the channels, pipes, streams, ponds, and rivers that convey stormwater.

The selection of the method(s) best suited for a design requires a qualified Professional Engineer. Proposed storm drainage works must be based on sound engineering design with due consideration of potential environmental impacts. For stormwater design work, good quality hydrologic and hydraulic modelling is often required.

This document is not intended to eliminate the necessity for detailed design by a Professional Engineer. The design of municipal services, when submitted to the Town of Riverview's Engineering and Public Works Department for approval, must bear the seal of a Professional Engineer licensed or registered to practice with the Association of Professional Engineers and Geoscientists of New Brunswick (APEGNB). The acceptance by the Town of Riverview's Engineering and Public Works Department of a drainage infrastructure design does not relieve the Professional Engineer of the responsibility for proper design. The Designer will retain full responsibility and liability for their work as a Professional Engineer.

This document is not intended to stifle innovation, and alternate approaches will be considered for approval. If an engineering consultant deems variations from this document to be justified or required, and the Designer can show that alternate approaches can produce acceptable results, such approaches will be considered satisfactory. In considering requests for variations from these specifications for drainage infrastructure, the Designer shall take into consideration such factors as safety, nuisance, system maintenance, operational costs, life-cycle costs, environmental issues, natural topography, and land configuration. Where the Designer uses standards other than those outlined in this document, they shall be clearly indicated in all appropriate documents and plans.

The Consultant has the responsibility of supplying the Developer with adequate information as needed to make decisions concerning the proposed project, and the Contractor with detailed plans and specifications as needed to construct the stormwater drainage system. The Town of Riverview requires that work that becomes part of the Town of Riverview system, and which will be maintained by the Town of Riverview, will be inspected by a consultant approved by the Director.

3.0 EFFECTS OF URBAN DEVELOPMENT

The preservation of the natural hydrologic cycle, to the greatest extent possible, will reduce the potential for flooding and erosion, maintain base flows in urban streams, and reduce the size and cost of stormwater systems. Urbanization alters natural conditions by increasing impervious area and by creating new pathways of stormwater flow. This results in an increase in direct runoff and decreases in infiltration and evapotranspiration. The net effect of development on the hydrologic regime of receiving streams could include an increase in the frequency of runoff events of all magnitudes, a greater proportion of annual flow as surface runoff rather than base flow or interflow, and increased flow velocity during storms. The decrease in infiltration that occurs with urbanization also reduces soil moisture replenishment and groundwater recharge.

Urban floods and major runoff events differ from those in natural basins in the shape of their hydrographs (they tend to be more intense and have a shorter duration), the magnitude of the peak flow, and times of occurrence during the year. The imperviousness of urban areas along with the greater hydraulic efficiency of urban drainage infrastructure causes more rapid stream responses and greater peak flows. Infiltration and evapotranspiration during the summer are less for developed areas than for undeveloped areas.

Stream channels in urban areas respond and adjust to the altered hydrologic regime that accompanies urbanization. The severity and extent of stream adjustment is a function of the stream’s characteristics and the hydrologic changes. Stream adjustments could include adjustments to channel size and shape (channel degradation, scour and erosion) to accommodate higher flows, modification of the streambed (typically a change in the size of stream bed material), and changes in stream alignment or sinuosity. Research results imply that a threshold for urban stream stability exists at approximately 10% to 15% imperviousness of a watershed, beyond which unstable and eroding channels would result. A stable stream and channel system should be an aim of stormwater management.

Urban stormwater runoff may contain contaminants such as suspended solids, nutrients, bacteria, heavy metals, oil and grease, and pesticides. A priority of stormwater management with respect to water quality has been avoidance of elevated levels of suspended solids, as suspended solids may interfere with photosynthetic activity and fish feeding by reducing light penetration in the receiving watercourse, or transport or store contaminants.

Temperature may be a concern in regard to fish and their habitat, especially where discharge is to a cold water stream. Urbanization generally causes temperature increases in stormwater, and ponds can compound this increase in water temperature since open water will tend to acclimate with the ambient air temperature. Where temperature is a significant concern, it is recommended that the designer consult with the federal Department of Fisheries and Oceans (Fisheries and Habitat Management) during the design process.

The ecology of aquatic habitat can be altered by major shifts in hydrology, in channel morphology, and in water quality that may accompany the development process. The health and diversity of fish, plant, animal, and aquatic insect communities in urban watercourses could be affected. In Riverview, developers should attempt to minimize the potential for adverse effects of development on aquatic habitat by using best practices with respect to subdivision design and construction. Riparian buffers and springs along urban streams shall be preserved. Urban drainage systems shall be designed to reduce major changes in the hydrologic and water quality regimes of receiving watercourses (both urban streams and wetlands). In Riverview, stormwater management and the design of drainage infrastructure should aim to preserve the ecology of urban streams.

4.0 STORMWATER MANAGEMENT

4.1. Planning for Stormwater Management

Planning for stormwater management should be done considering the entire upstream drainage area, including basin characteristics (size, vegetation, land use and topography), runoff conditions (the rate and amount of runoff, and water quality), existing and future development, actual and proposed alterations to natural drainage patterns and return flows to streams. The design of drainage infrastructure within the Town of Riverview should conform to the stormwater management plans that have been designated by the Town for selected areas within town limits. Prior to initiating design of drainage infrastructure within the Town of Riverview, it is recommended that the Engineering and Public Works Department be consulted to determine the existence of a stormwater management plan, and assess the potential impact of this plan on the proposed development. The need for in-ground stormwater infrastructure and measures to control stormwater quality and quantity should be assessed considering both the incremental and total effects of changes in development on the drainage basin. New developments within urban areas shall be serviced by a dual drainage system consisting of both a minor storm drainage system (piped system) and a major storm drainage system (overland system), which as discussed in more detail in Subsection 4.5.

Since the 1990's, a number of Canadian cities (i.e. Edmonton, Winnipeg, Hamilton, Toronto, Ottawa, Montreal, etc.) have attempted to manage storm water quality and quantity through a wide range of Best Management Practices (BMPs), such as extended detention ponds, infiltration basins and trenches, porous pavement, sand filters, water quality inlets, and the use of vegetation. BMPs can be implemented at either the lot level or at the “end of pipe” before entering a stream. Lot level BMPs include: rooftop storage, parking lot storage, reduced lot grading, roof leader discharge to soakaway pits and vegetation along channel banks; while end-of-pipe facilities include such measures as wet ponds, constructed wetlands, dry ponds, infiltration basins and oil/grit separators. These existing BMPs are valuable and practical tools for the management of stormwater, and the vast majority of these BMPs can be adapted for use in the Town of Riverview. Designers should however take care that appropriate allowances are made to accommodate the soil conditions in the Riverview area, the local climate conditions, the unique drainage dynamics of the low-lying marshlands, the effects of ice in the local drainage courses and waterways, and the tidal water level fluctuations in the Petitcodiac River, and its tributaries.

The design criteria of different BMPs have been established in a number of guidelines (e.g. Ontario Ministry of the Environment or MOE) and their effectiveness and appropriate application have also been discussed (eg. Ontario MOE, US EPA). Limited information related to capital and operating costs for sample BMP projects are available for comparative purposes (Chapter 7 of the Ontario MOE guidelines). Effects of BMPs on peak flow reduction are well documented and can be adapted to local conditions with little change. The more prominent and practical sources of stormwater management BMPs are presented in Section 16.0 (References).

4.2. Climate Change

The effects of climate change are to be accommodated in the design of drainage infrastructure in the Town of Riverview. The recommended approach consists of the incorporation of allowances to accommodate the effects of climate change in the planning and design of the major system, while continuing to use historic climatic data for the design of the minor system. This recommendation will minimize the up-front costs associated with accommodating the effects of climate change on drainage infrastructure, while providing the flexibility to adjust the capacity of the overall dual drainage system to prevent changing climate conditions from resulting in unacceptable flood related damages.

Return period (or recurrence interval) is the average time between occurrences of an event with a given magnitude, e.g. a 10-year-return-period flood means that a flood with a similar or larger magnitude would occur once every ten years, given a long period and assuming hydro-climatic conditions do not change. The return period is based on past records, usually available only for a relatively short period (10 to 30 years). Probability is the inverse of return period; e.g. a 10 year storm event has a 10% chance of occurring in any year. The choice of a return period for the design of drainage infrastructure depends on what is considered to be an acceptable risk to property and public safety, and the desired level of service.

The minor storm drainage system shall be designed to convey stormwater runoff from the 5-year-return-period storm, without surcharging. Surcharging of the minor system can be prevented by either increasing the size of minor system components, or (following approval of the Engineering and Public Works Department) reducing the magnitude of the flow entering the minor system by directing more flow towards the major (overland) storm drainage system.

The major storm drainage system shall be designed to convey stormwater runoff from the major storm event (the future 100-year-return-period storm or 1.2 times the historic 100-year-return-period storm), thereby preventing loss of life and protecting structures and property from damage. The meteorological data presented in Section 5.3 of this document is based on historic information and does not contain an implicit allowance for the effects of climate change. **The magnitudes/volumes of the meteorological data presented in this section will thus have to be multiplied by 1.2 to accommodate the anticipated effects of climate change.** The capacity of the major storm drainage system shall be adequate to carry the discharge from a major storm event when the capacity of the minor storm drainage system is exceeded. The design of the major system shall include measures to limit the degree of surcharging of the minor system during a major storm event. These measures may include inlet control devices and flow relief to the major system. The degree of minor system surcharging during major storm events shall be controlled so as to prevent flooding of properties connected to the minor system.

4.3. Flooding

High runoff rates following major precipitation and/or snowmelt events, poor drainage and to some degree high tide levels have been causes of flood events.

Flood avoidance is the preferred means of reducing the risk of potential future flood damage. This means that development generally should not be undertaken in identified and mapped flood hazard / flood risk areas or in areas where past flooding is known to have occurred. If development in such areas is carried out, adequate flood proofing measures must be incorporated in the planning, design and construction of the development.

A stormwater management scheme and stormwater drainage system design may not be approved by the Town of Riverview Engineering and Public Works Department if there is a transfer of the flood risk from the developer to other people or a potential transfer of liability for future flood damages to the Town of Riverview.

The Town Engineer therefore reserves the right to require that additional measures be taken in areas mapped and designated as flood prone areas.

4.4. Quality Control

The Town of Riverview expects developers to consider the treatment train approach when developing plans for stormwater management. The treatment train approach involves a series of structural and non-structural water-quality-management measures aimed at minimizing stormwater pollution wherever possible through appropriate reductions of pollutants at their source, during transit, and if necessary in receiving waters. Controlling stormwater pollution at its source could include controls on construction site runoff, better land use practices, the construction of litter traps, and on-site detention and treatment. Stormwater contaminants at the source can be minimized if more of an area being developed is kept vegetated. In-transit elements of the treatment train approach can include pollutant traps, filters, infiltration systems, and treatment wetlands. Treatment at receiving water bodies could include gross pollutant traps and floating booms.

Floatable pollutants such as oil, debris, and scum can be removed with separator structures. Other methods of pollutant removal include sedimentation/settling, filtration, plant uptake, ion exchange, adsorption, and bacterial decomposition. Within these processes, there are generally three levels of treatment: (1) primary treatment: screening of gross pollutants, sedimentation of coarse particles, (2) secondary treatment: sedimentation of fine particulates, filtration, and (3) tertiary treatment: enhanced sedimentation and filtration, biological uptake.

Pollutants in urban stormwater may include suspended sediment (e.g., sand, silt) and other suspended solids, metals (e.g., copper, lead, and zinc), nutrients (e.g., nitrogen and phosphorous), bacteria and viruses, and organics (e.g., petroleum hydrocarbons and pesticides). The water quality parameters that are regulated by the Town of Riverview consist of:

1. Total Suspended Solids (TSS), and
2. Hydrocarbons.

Details regarding the specific parameters, limits of these parameters and the type of development to which they apply are presented in the following sub-sections.

4.4.1. Total Suspended Solids

Total Suspended Solids concentrations in the stormwater discharge from any type of development, either during or following construction, shall not exceed 25 mg/L. The effective opening size of the sieve or filter medium that is to be used in determining this concentration is 1.0 µm.

Commercial and industrial development with a property size in excess of 0.5 acres (approximately 2023 m^2) and impervious areas in excess of 50% of the property, shall have stormwater treatment facilities that will trap all particles with a diameter in excess of 75 µm during a flow that equals the magnitude of 30% of the two (2) year return period flow event. This requirement may be waived, at the discretion of the Director, for development with a low traffic turnover.

4.4.2. Hydrocarbons

Commercial and industrial development with a property size in excess of 1.5 acres (approximately 6070 m^2) is required to have stormwater treatment facilities that will limit the discharge of hydrocarbons (expressed as total hydrocarbons) to less than 1 ppm or 1 mg/L.

Selected methods of stormwater quality control are addressed elsewhere in this document: oil and grit separators (Section 12.0); infiltration trenches (Section 9.6), and buffer areas (Section 9.7); while other methods of stormwater quality control can be found in technical literature including Environment Australia (2002), Alberta Environmental Protection (1999) and Ontario Ministry of the Environment (2003), as presented in the Section 16.0 References.

4.5. Quantity Control

Controlling the quantity of stormwater implies reductions in the total amount and/or the rate of runoff. Control of the rate of runoff (peak stormwater flow) from areas of new development will be required. For all development, peak post-development flows should not exceed pre-development flows for all storms up to the major drainage system design storm.

Specific methods of stormwater quantity control are addressed elsewhere in this document: attenuation ponds (Section 13.2) and infiltration trenches (Section 9.6), Other methods of stormwater quantity control can be found in technical literature, the more prominent of which are listed in Section 16.0 (References) and include: Alberta Environmental Protection (1999), City of Calgary (2000) and Ontario Ministry of the Environment (2003).

4.6. Dual Drainage Systems

4.6.1. Dual Drainage Concept

Stormwater drainage systems have historically consisted of an underground network of pipes and associated structures designed to transport flows for relatively minor or low intensity storms, as a matter of convenience. Although this works well for minor storms, it is unable to accommodate major storm events. Since little or no consideration was given to controlling runoff from major storm events, flooding due to inadequate drainage capacity could occur.

The solution to these past problems was to make allowances for these major storm events in the planning and design of new developments. The division of the urban drainage system into major and minor systems became known as the “Dual Drainage Concept”. The minor system provides a basic level of service by conveying flows from the more common (low intensity, more frequent) storm events. The major system conveys runoff from the extreme (high intensity, less frequent) storm events that produce runoff in excess of what the minor system can handle. Good planning and design are critical to successful stormwater management. **All areas of new development within the Town of Riverview shall be designed using the Dual Drainage Concept (Minor/ Major systems) to achieve specific levels of service**.

4.6.2. Minor System

The minor storm drainage system shall be designed to convey stormwater runoff from the 1 in 5 year return period storm, thereby providing safe and convenient use of streets, lot areas, and other areas. Components of the minor storm drainage system could include:

- swales, subsurface interceptor drains, curb and gutters, catchbasins, manholes, pipes or conduits and service lateral lines in those areas where a piped storm drainage system is required.

4.6.3. Major System

The major storm drainage system shall be designed to convey stormwater runoff from the future 1 in 100 year return period storm, thereby preventing loss of life and protecting structures and property from damage. The capacity of the major storm drainage system shall be adequate to carry the discharge from a major storm event when the capacity of the minor storm drainage system is exceeded. Components of the major storm drainage system could include:

- ditches, open drainage channels, swales, roadways, detention ponds, watercourses, floodplains, canals, ravines, gullies, springs, and creeks in those areas where a piped storm drainage system is required for the minor drainage system;

For the storms up to and including the 1 in 5 year return period storm, the Consultant must ensure that a travelled way of adequate width is maintained to ensure the safe passage of all vehicles in both directions for all road classifications.

For storms up to and including the future 1 in 100 year return period storm, the Consultant must ensure that the depth and spread of flow does not exceed the curb height and absolutely does not exceed the right-of-way width for residential streets and local collector streets.

In addition to the above criteria, for storm events up to and including the future 1 in 100 year return period storm, the Consultant must ensure that a travelled way of adequate width is maintained to ensure the safe passage of vehicles in both directions for major collector streets and arterial streets.

4.6.4. Dual System

New development shall be serviced by a dual drainage system consisting of both a minor storm drainage system (primarily a piped system) and a major storm drainage system (primarily an overland system). The capacity of the major storm drainage system shall be adequate to carry the discharge from a major storm event when the capacity of the minor storm drainage system is exceeded. The design of a dual drainage system shall be carried out to ensure that no proposed or existing structure shall be damaged by the runoff generated by the major design storm (1.2 times the historic 100-year-return-period storm). In the event that the Designer identifies an existing structure that may be damaged by the runoff generated by the major design storm, the Designer shall notify the Director of Engineering and Public Works so that the specific situation may be reviewed and resolved.

4.6.5. Basis of Design

Design of the dual storm drainage system shall be based on the state of development anticipated to exist for both the subwatershed under design and upstream subwatershed when both areas are completely developed in accordance with the land-use zoning in place at the time of design. Except as indicated below, design flows for residential, commercial, or industrial land uses shall be based on summer rainfall data and corresponding runoff coefficients for summer conditions.

When the area under design includes a significant proportion of undeveloped land, peak design flows shall be the largest of flows estimated for both winter and summer conditions.

When the area under design requires calculation of flows for storms with durations greater than 6 hours, design flows shall be the largest of the flows estimated for both winter and summer conditions.

4.6.6. System Discharge

The dual storm drainage system shall discharge to an existing storm drainage system, or to a natural watercourse. It is the responsibility of the Designer and the Developer to ensure that the proposed development does not create a new, or aggravate an existing, downstream flooding problem. To this end, the Town of Riverview no longer allows increases in peak flows due to new development. More specifically, new development shall not result in an increase in peak flows for all storm events up to and including the peak runoff from a storm event with a 100-year-return-period. This stormwater peak flow requirement may be satisfied by either integrating new development into Town of

Riverview stormwater management plans (which attempt to control the drainage and management of stormwater through the use of regional measures for selected sections of the town), or through the use of development-specific stormwater management measures and controls (e.g. lot-based or development-based stormwater quantity best management practices).

If connecting to an existing storm drainage system, the downstream storm drainage system must have adequate capacity to convey the discharge from both the existing and proposed storm drainage systems (see Section 14.0). The potential for adverse impacts (such as flooding or erosion) from the combined discharges on the downstream storm drainage system must be considered. When downstream capacity in the existing stormwater drainage systems is inadequate, downstream infrastructure must be upgraded or peak flow to the downstream systems reduced with stormwater retention and storage.

If discharging to a natural watercourse, water quantity and quality impacts on the receiving water body shall be assessed by the Consultant. Depending upon the nature and severity of potential adverse impacts, the Town of Riverview's Engineering and Public Works Department may require the implementation of measures to prevent or alleviate these potential adverse impacts.

4.7. On-Lot Stormwater Management

4.7.1. Lot Grading

Carefully controlled lot grading can be a tool in good stormwater management. In Riverview, if properties drain front-to-back (away from the street), a designed stormwater collection channel or natural watercourse has to be present along the back of each property.

Reduced lot grading can be implemented in areas that have more permeable soil types (a minimum infiltration rate of 15 mm/hr or greater is recommended). In these cases, the grading can be flattened to 0.5% to promote greater depression storage and natural infiltration, except within 2 m to 4 m of buildings where a 2% minimum grade away from the building should be maintained and soils should be well compacted in order to avoid foundation drainage problems. The proposed finished elevations of the front lot corners shall be between 0.1 and 0.3 metres above the finished grade of the street.

A lot grading plan (scale 1:1000) is a requirement for subdivision approval (see Section 15.0, Design Documentation). The plan should show the drainage pattern for individual lots, the limits of the entire development as well as the immediate surrounding areas.

4.7.2. On-Lot Storage

On-lot retention of runoff reduces downstream flooding and erosion, and includes rooftop and surface storage. For rooftop storage, drains on flat roofs are raised to allow ponding of stormwater on the roof. Rooftop storage is only deemed suitable for commercial, industrial, and institutional sites, and a maximum depth of 10 mm is allowed before water can flow through the roof drains. Structural supports must be adequate to support the additional weight of the ponded water, and the design of rooftop storage requires a qualified Professional Engineer.

Surface storage can be utilized for residential as well as industrial and commercial development, and is one of the most cost effective ways of stormwater management. Surface storage areas (or ponding areas) in residential development can consist of depressions created in yards where stormwater can be collected to infiltrate, evaporate or drain slowly. The maximum depression depth of ponding areas on residential lots is 150 mm. For depths greater than, overland escape routes would be necessary, if egress from the property is affected. Ponding areas should be located a minimum of 4 m away from buildings.

Surface storage areas in commercial, industrial or institutional development should not interfere with access to, and egress from, these developments. Storage of stormwater on parking lots should not result in water depths in excess of 200 mm.

Depending on the type of On-Lot storage proposed, the Engineering and Public Works Department may require a deposit to ensure final construction conforms to the design and the receipt of associated recorded information (see Section 15.0).

5.0 METEOROLOGICAL DATA

Rainfall data is used in a variety of forms including intensity-duration-frequency curves, synthetic design storms, historical design storms, and historical long-term rainfall records. Selection of the proper form depends upon the type of computational procedure to be used, contingent upon the type of problem to be solved and the level of analysis required. It should however be noted that the climatic information presented in this section does not contain any allowances for climate change. As presented in Section 4.2, allowances for climate change are required for the design of the major storm drainage system.

5.1. Rainfall Intensity – Duration – Frequency Curve

Figure 5.1 contains rainfall intensity – duration – frequency curves which are based on annual rainfall at the Greater Moncton International Airport (GMIA) weather station. Additional detailed historical rainfall information is available through the Atmospheric Environment Service (AES) of Environment Canada.

5.2. Synthetic Design Storm

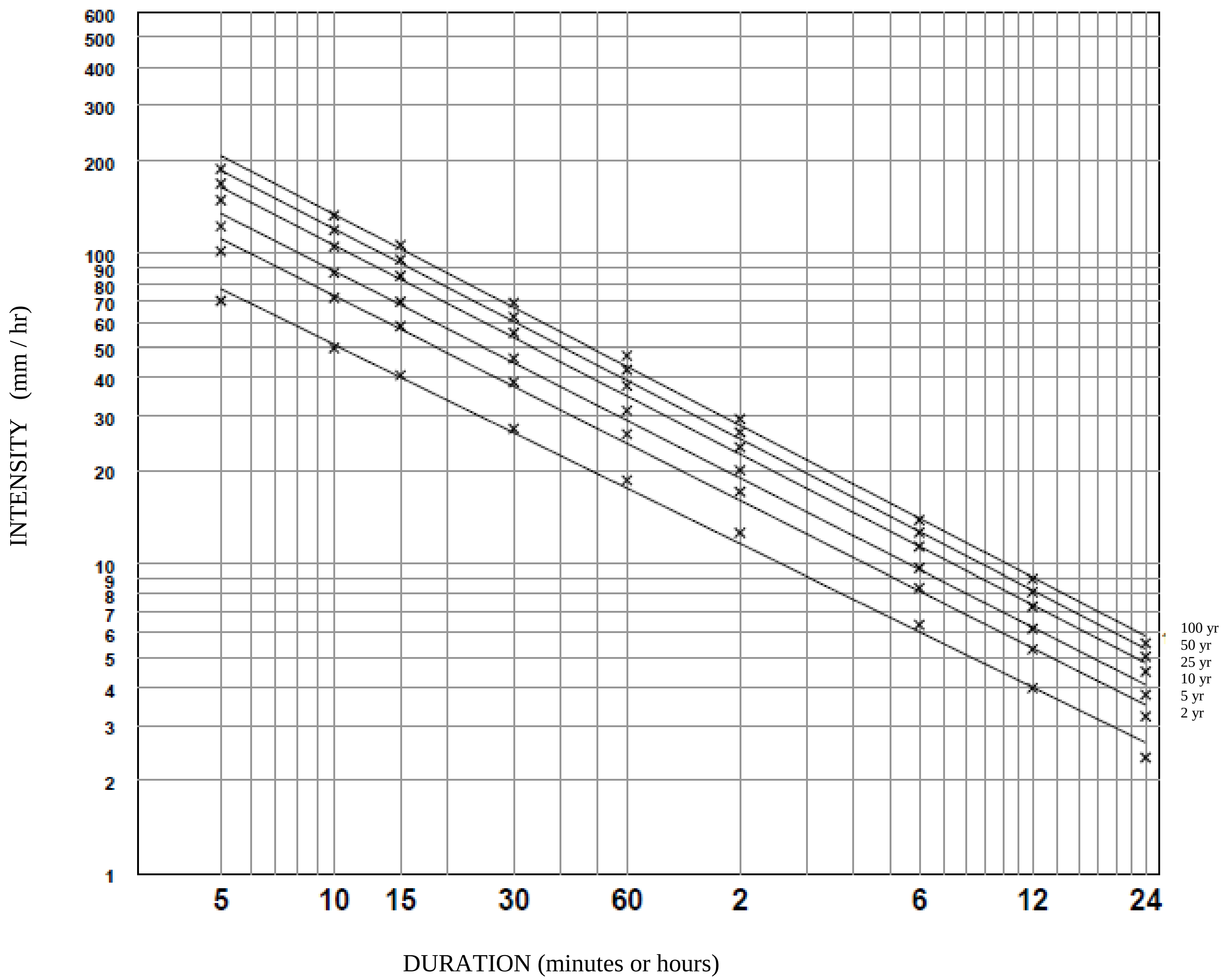
Advanced procedures for the design of storm drainage systems require the input of rainfall hyetographs, which specify rainfall intensities for successive time increments during a storm event. For this purpose, it is standard to use both synthetic and historical design storms hyetographs. Synthetic design storm hyetographs are intended to represent some of the long term statistical properties of recorded rainfall. The Chicago type distribution shall be used to derive synthetic design storm hyetographs from rainfall intensity - duration - frequency curves. Figure 5.2 through Figure 5.5 present 2 hour and 24 hour duration Chicago type distributions for the 1 in 5 year, and 1 in 100 year return periods.

5.3. Historical Design Storm

In some instances the design of storm drainage systems requires the input of historical design storms. Historical design storm hyetographs are intended to represent a specific recorded rainfall. Additional detailed historical rainfall information is available through the Atmospheric Environment Service (AES) of Environment Canada.

Figure 5.1

ANNUAL RAINFALL INTENSITY - DURATION FREQUENCY CURVES FOR MONCTON
BASED ON ENVIRONMENT CANADA ATMOSPHERIC ENVIRONMENT SERVICE DATA
1946 - 2007



R = A * T ^ B

	A	B
2 yr	17.3	-0.607
5 yr	24.3	-0.626
10 yr	29.0	-0.634
25 yr	34.9	-0.641
50 yr	39.2	-0.644
100 yr	43.6	-0.647

Where :
R - mm/hr
A - coefficient
T - hr
B - coefficient

FIGURE 5.2

5 YEAR ANNUAL HYETOGRAPH FOR MONCTON
BASED ON ENVIRONEMNT CANADA ATMOSPHERIC ENVIRONMENT SERVICE DATA 1946-1997

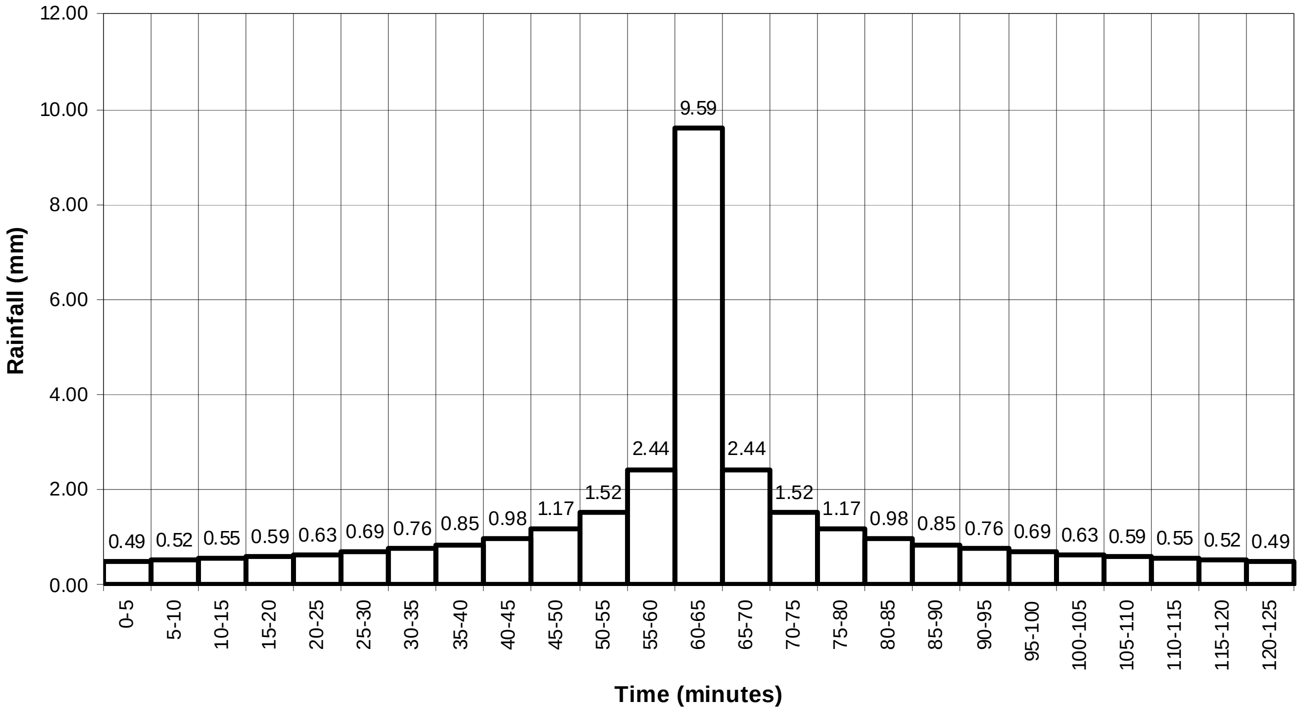


FIGURE 5.3

100 YEAR ANNUAL HYETOGRAPH FOR MONCTON
BASED ON ENVIRONEMNT CANADA ATMOSPHERIC ENVIRONMENT SERVICE DATA 1946-1997

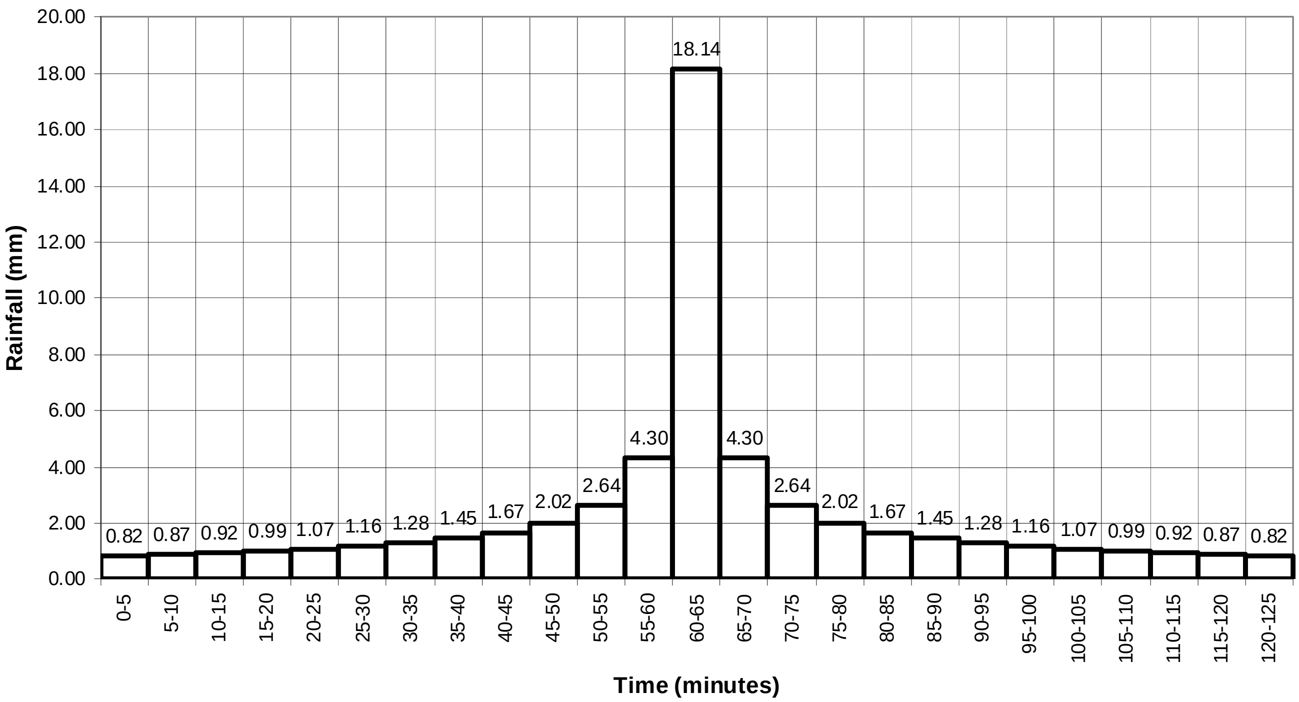


FIGURE 5.4

5 YEAR ANNUAL HYETOGRAPH FOR MONCTON
BASED ON ENVIRONMENT CANADA ATMOSPHERIC ENVIRONMENT SERVICE DATA 1946-1997

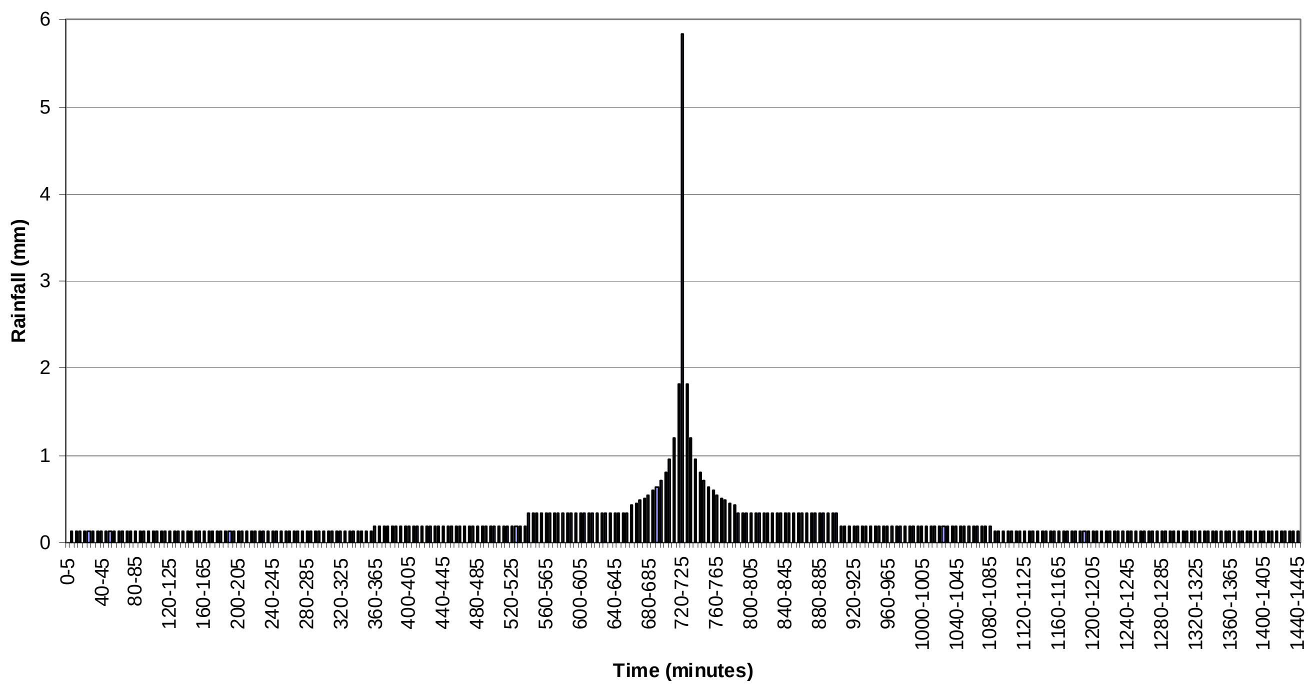
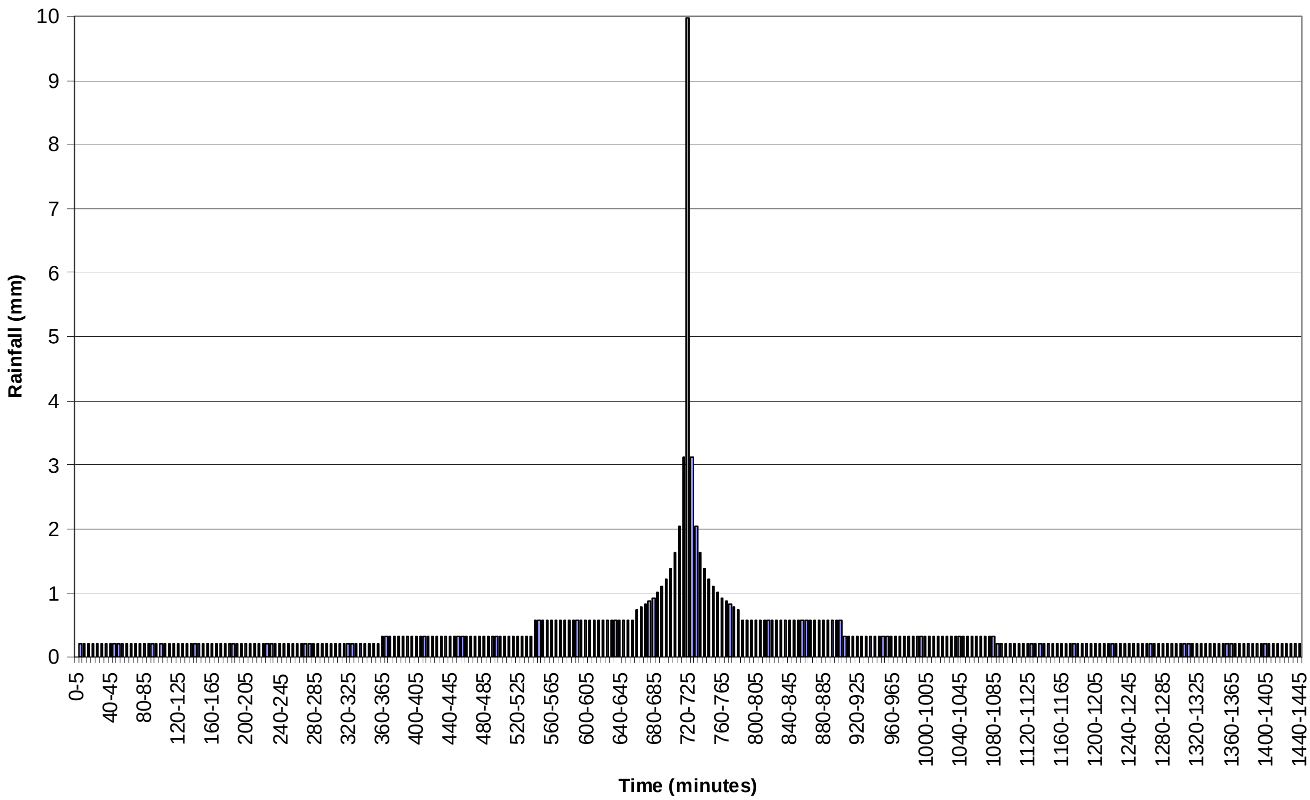


FIGURE 5.5

100 YEAR ANNUAL HYETOGRAPH FOR MONCTON
BASED ON ENVIRONMENT CANADA ATMOSPHERIC ENVIRONMENT SERVICE DATA 1946-1997



6.0 RUNOFF METHODOLOGY

There are numerous techniques and models available to the Consultant for use in the determination of stormwater runoff. Selection of an appropriate method must be based on an understanding of the principles and assumptions underlying the method and of the problem under consideration. It is, therefore, essential that appropriate techniques and models be selected and used by experienced engineers.

The following computational methods provide general comments on several of the methods accepted by the Town of Riverview Engineering and Public Works Department.

6.1. The Rational Method

The Rational method is the most widely used empirical equation for predicting instantaneous peak discharge from a small subwatershed. The peak discharge is assumed to occur at a rainfall duration equal to the time of concentration. The Rational method may be used for the determination of instantaneous peak runoff, in the design of storm drainage systems up to 20 hectares in area, for preliminary design of systems serving larger areas, and as a check on flows determined by other methods. This method cannot be used to determine the size or hydraulic performance of storage facilities.

6.2. The USSCS Method

Methods described in the United States Soil Conservation Service (USSCS) Technical Report No. 20 and No. 55 may be used to determine peak flow and volume for rural areas, to determine urbanization impacts, and to evaluate the performance of storage facilities.

6.3. SWMM and OTTSWMM

United States Environmental Protection Agency (USEPA), Storm Water Management Model (SWMM), and the University of Ottawa version of the model may be used for design of piped systems and to model overland flow in a major system.

6.4. HYMO and OTTHYMO

The HYMO (Hydrologic Model) and the University of Ottawa version of the model may be used for the development of storm drainage Master Plans, in the analysis of stormwater management proposals for new development. The model includes capability for storage calculations and stream channel routing.

6.5. HEC

The United States Army Corps of Engineers (USACE) HEC model may be used for modelling overland storm drainage systems, natural watercourses and determining the extent of floodplains.

Methods other than those listed above may be used if the Consultant justifies their use and approved by the Town of Riverview Engineering and Public Works Department.

Results may need to be verified by checking with a second method, or calibration based on flow measurement.

7.0 HYDROLOGIC DESIGN CRITERIA

7.1. Rational Method

7.1.1. Runoff Coefficients

Table 7.1 and Table 7.2 present Rational Method runoff coefficients appropriate for various land uses and surface types. Selection of values from Table 7.1 and Table 7.2 shall be based on impervious area, lot size, soil conditions, and other relevant considerations. The runoff coefficients presented in Table 7.1 are intended for general guidance only, and the runoff coefficients of all development shall be calculated using the values for impervious and pervious surfaces shown in Table 7.2. In lieu of detailed soil analysis, the Consultant should select runoff coefficients from Table 7.2 that are consistent with the soil conditions of the area.

For residential, commercial or industrial land uses, rainfall intensities from Figure 7.1 shall be used with coefficients for summer ground conditions. Where runoff from an area that includes a significant proportion of undeveloped land is to be determined, a comparison shall be made between summer and winter ground conditions using winter runoff coefficients from Table 7.3 and rainfall intensities from Figure 7.1 accounting for snowmelt contributions. For winter or year-round runoff calculations, the coefficients from Tables 7.1, 7.2, and 7.3 shall be increased according to Table 7.4 for the 1 in 100 year return period.

Table 7.1 Rational Method Runoff Coefficients for Various Areas for the Summer Condition

Character of Area	Description of Area	Runoff Coefficient
Industrial	Light	0.50 to 0.80
	Heavy	0.60 to 0.90
Commercial	Downtown	0.70 to 0.95
	Neighbourhood	0.50 to 0.70
Residential	Single-Family	0.30 to 0.50
	Detached Multi-Unit	0.40 to 0.60
	Attached Multi-Unit	0.60 to 0.75
	Suburban	0.25 to 0.40
	Apartment	0.50 to 0.70
Other	Park, Cemetery	0.10 to 0.25
	Playground	0.20 to 0.40
	Railroad Yard	0.20 to 0.40
	Unimproved/Vacant Lands	0.10 to 0.30

Table 7.2 Rational Method Runoff Coefficients for Various Surfaces for the Summer Condition

Character of Surface	Description of Surface	Runoff Coefficient
Impervious	Asphalt	0.70 to 0.95
	Concrete	0.80 to 0.95
	Brick	0.70 to 0.85
	Rooftop	0.75 to 0.95
Pervious	Lawn, Sandy Soil, < 2%	0.05 to 0.10
	Lawn, Sandy Soil, 2%-7%	0.10 to 0.15
	Lawn, Sandy Soil, > 7%	0.15 to 0.20
	Lawn, Clayey Soil, <2%	0.13 to 0.17
	Lawn, Clayey Soil, 2%-7%	0.18 to 0.22
	Lawn, Clayey Soil, >7%	0.25 to 0.35

Note: Higher values than those presented in Table 6.2 are required to account for steeply sloped areas, longer duration events, and longer return periods to account for decreased infiltration and other losses.

Table 7.3 Rational Method Runoff Coefficients for the Winter Condition

Character of Area/Surface	Return Period	Runoff Coefficient
All areas/surfaces with Summer coefficient < 0.80	5 year	0.80
All areas/surfaces with Summer coefficient < 0.80	100 year	1.00

Table 7.4 Rational Method Runoff Coefficients for the 100 Year Return Period

Runoff Coefficient for 5 to 10 Year Return Period	Corresponding Runoff Coefficient for 100-Year Return Period
0.10	0.20
0.20	0.35
0.30	0.50
0.40	0.65
0.50	0.80
0.60	0.90
0.70 to 1.00	1.00

7.1.2. Winter Runoff

Where calculation of winter runoff is required, frozen ground shall be simulated by assuming the area to be 80% paved in a 1 in 5 year design storm and 100% paved in a 1 in 100 year design storm, and the time of concentration (T_c) shall be adjusted to reflect flow over frozen ground.

7.1.3. Snowmelt

Estimation of snowmelt contribution is a complex process dependent on a number of variables, often not published for a given region. In lieu of available data, estimated snowmelt of 1.5 mm per hour shall be added to winter rainfall intensity as determined above.

7.2. Time of Concentration and Lag Time

Time of concentration (T_c) for a storm drainage system should include both inlet time (T_i) and the travel time (T_t) to the point at which peak flow is to be estimated. Travel time (T_t) and time of concentration (T_c) for overland flow may be estimated by methods described by the USSCS presented in Appendix B. For runoff methods that use Lag Time (T_L) rather than Time of Concentration (T_C), the following accepted conversion shall be used:

$$\text{Time of Concentration } (T_C) = 1.7 \text{ times Lag Time } (T_L) \qquad [7.1]$$

For most piped systems in medium density urban areas, it is expected that a minimum five minute inlet time (T_i) will be used. Travel times (T_t) in piped systems should be based on velocities at peak design flow.

7.3. United States Soil Conservation Service (USSCS) Method

7.3.1. USSCS Curve Numbers

Table 7.5 presents USSCS method curve numbers for various land uses and hydrologic conditions. Selection of values from Table 7.5 shall be based on impervious area, lot size, soil condition, and other relevant considerations. The curve numbers presented in Table 7.5 are intended for general guidance only, and the curve numbers of all development shall be calculated using the values for impervious and pervious surfaces shown in Table 7.5.

For ordinary residential, industrial, or commercial land uses, rainfall data from Figure 7.2 through Figure 7.5 shall be used with curve numbers for summer ground conditions. Where runoff from an area that includes a significant portion of undeveloped land is to be determined, a comparison shall be made between summer and winter ground conditions using curve numbers to account for frozen ground, and rainfall data from Figure 7.2 through Figure 7.5 accounting for snowmelt contribution.

7.3.2. Hydrologic Soil Group (HSG)

The USSCS categorizes soils into one of four hydrologic soil groups (HSG) contingent upon its surface infiltration rate, and subsurface permeability rate. Table 7.6 presents USSCS hydrologic soil groups. Generally, in lieu of detailed soil analysis, the Consultant should select USSCS curve numbers consistent with Table 7.5 assuming hydrologic soil group "D".

Table 7.5 USSCS Method Curve Numbers

Character of Area	Hydrologic Condition	Average Impervious Area	USSCS Curve Numbers For Hydrologic Soil Group			
		(%)	A	B	C	D
Pervious Areas (Open Space, Lawn, Park)	Poor (grass cover <50%)		68	79	86	89
	Fair (grass cover 50%-75%)		49	69	79	84
	Good (grass cover > 75%)		39	61	74	80
Impervious Areas			98	98	98	98
Roadways	Paved with curb and gutter		98	98	98	98
	Paved with open ditch		83	89	92	93
	Gravel with open ditch		76	85	89	91
	Dirt with open ditch		72	82	87	89
Industrial		72	81	88	91	93
Commercial		85	89	92	94	95
Residential	1/8 Acre or Less	65	77	85	90	92
	1/4 Acre	38	61	75	83	87
	1/3 Acre	30	57	72	81	86
	1/2 Acre	25	54	70	80	85
	1 Acre	20	51	68	79	84
	2 Acre	12	46	65	77	82
Newly Graded	No Vegetation		77	86	91	94
Meadow	Good (grass cover > 75%)		30	58	71	78
Woods	Poor (grazed and burned)		45	66	77	83
	Fair (grazed not burned)		36	60	73	79
	Good (not grazed or burned)		25	55	70	77
Farmsteads			59	74	82	86

Table 7.6 USSCS Hydrologic Soil Group (HSG) Classification

USSCS Hydrologic Soil Group (HSG)	Description
A	• Very low runoff potential • Very high infiltration rate (consistent with well drained sand and gravel)
B	• Moderate runoff potential • Moderate infiltration rate (consistent with silt and sand)
C	• High runoff potential • Low infiltration rate (consistent with clay and silt)
D	• Very high runoff potential • Very low infiltration rate (consistent with saturated clays and high water tables)

8.0 MINOR STORM DRAINAGE SYSTEM

8.1. Design Requirements

Minor storm drainage systems shall be designed to convey, without surcharge, the 1 in 5 year return period storm.

The capacity of a proposed storm sewer system or an existing storm sewer system shall be checked by accounting for the headloss through the pipe system and through any junctions including manholes and bends. As a preliminary check on the capacity of a piped storm system, the Manning's equation can be used. This will be particularly useful for sizing the pipes in the first instance; however, a more detailed analysis of the system as a whole will be required. This analysis will determine the hydraulic gradeline (HGL) when the storm system is conveying the 1 in 5 year flows, and will take into account losses at manholes and other junctions, the headloss through the pipes, and any backwater conditions at the outlet of the storm sewer system.

To ensure that the minor storm drainage system is not subjected to flows greater than its design capacity, it is required that the Consultant check the total inlet capacity for the entire system. It is likely that this analysis will determine that during a major storm, flows greater than that of a 1 in 5 year return period storm will enter the storm sewer system, and the Consultant will likely need to specify inlet control devices (ICDs) to limit the quantity of stormwater runoff that gets into the minor storm drainage system (Section 8.16 and Appendix C). To streamline the design process, it may be advisable to calculate the 1 in 5 year flows to each catchbasin using the appropriate hydrologic methods, specifying an inlet control device for each catchbasin which limits the flow to approximately that design flow for the 1 in 5 year storm, and apply the flow that the ICD will allow into the system at each catchbasin, and then calculate the hydraulic gradeline. Contingent upon the results of hydraulic gradeline analysis, it may be necessary to revise some of the junctions, or revise some of the storm sewer main diameters to ensure that the hydraulic gradeline is below the top of the pipe.

8.2. Minimum Velocity

Under peak design flow conditions from the tributary area, when fully developed, stormwater flow velocities must not be less than 0.6 m/s.

8.3. Maximum Velocity

Under peak design flow conditions from the tributary area, when fully developed, stormwater flow velocities must not exceed 4.0 m/s.

8.4. Minimum Diameter

Storm sewer main diameter shall not be less than 300 mm.
Catchbasin lead diameters shall not be less than 200 mm.

8.5. Changes in Diameter

Storm sewer main diameter must not decrease in the downstream direction. Manholes are to be provided where the storm sewer main diameter changes.

8.6. Minimum Slope

The minimum pipe slope for storm sewer mains is 0.4%. The minimum slope for storm sewer mains on a permanent dead-end is 0.6%. **Under special conditions, if full and justifiable reasons are given, slopes less than 0.4% and 0.6% may be permitted provided that self-cleansing velocities under full flow conditions are maintained.**

8.7. Minimum Depth

The minimum depth of storm sewer mains, measured from the design grade of the finished surface to the top of the pipe, shall not be less than 1.5 m.

8.8. Maximum Depth

The maximum depth of storm sewer mains, measured from the design grade of the finished surface to the top of the pipe, shall not exceed 6.0 m. However, under special conditions, if full and justifiable reasons are given, the maximum depth of storm sewer mains may be increased such that the maximum permissible depth to the crown of the pipe at any manhole location is 8.0 m.

8.9. Location

Wherever possible, all storm sewer mains and appurtenances shall be located within the street right-of-way or a municipal service easement owned by the Town of Riverview, as per the Town of Riverview Standard Municipal Specifications. All storm drainage outfalls shall be located within a municipal service easement owned by the Town of Riverview. Municipal service easements shall be of sufficient width to allow safe access to the pipe line in accordance with the requirements of the Occupational Health and Safety Act for the Province of New Brunswick. Depending upon the length and location of the municipal service easement, the Town of Riverview Engineering and Public Works Department may require a travel way to be provided within the municipal service easement for access and maintenance purposes.

Where Master Planning indicates a need to accommodate future upstream lands naturally tributary to the drainage area, a municipal service easement shall be provided from the edge of the street right-of-way to the upstream limit of the subdivision.

The minimum width of a municipal service easement shall be 6.0 m. The actual width shall depend upon the depth and size of any pipe contained therein such that safe access to the pipe is possible.

8.10. Manholes

A manhole must be provided on a storm sewer main at any change in diameter, material, horizontal alignment, vertical alignments, pipe main intersections, at the end of a pipe, and where a catchbasin is to be connected to a storm sewer main less than 1500 mm in diameter.

Where a storm sewer main diameter is less than 1500 mm, manhole spacing shall not exceed 90 m. Where a storm sewer main diameter is equal to or greater than 1500 mm, manhole spacing will be determined in consultation with the Town of Riverview Engineering and Public Works Department.

The criteria below shall be used for pipe elevation and alignment in storm drainage manholes to account for energy losses through the manhole.

- An invert drop equal to the difference in pipe diameter shall be provided unless a different drop is determined by means of appropriate calculations;
- The crown of a downstream pipe shall not be higher than the crown of an upstream pipe;
- An internal drop manhole shall be constructed where the vertical drop between pipe inverts in the manhole exceeds 1.0 m;
- The Consultant shall take into consideration energy losses at manholes during peak flow conditions to ensure that surcharging of the system does not occur;
- The minimum internal diameter of a manhole shall be 1050 mm. The consultant shall ensure that the internal diameter is adequate to accommodate all pipe and appurtenances in accordance with manufacturer's recommendations. Manhole ladders are not required.

8.11. Service Laterals

All service laterals shall be installed according to the following provisions:

- For single-family lots, one storm drainage service lateral is to be supplied to each existing lot or potential future lot which could be created under the zoning in effect at the time of approval by the Town of Riverview Engineering and Public Works Department;
- For semi-detached lots, one storm drainage service lateral is required;
- The storm drainage lateral shall be laid at a minimum grade of 2% to the limit of the street right-of-way;
- The depth of storm drainage laterals shall not be less than 1.5 m within the street right-of-way.

8.12. Groundwater Migration

The Consultant shall assess the possibility of groundwater migration through mainline, lateral, and service lateral trenches resulting from the use of pervious bedding material. Corrective measures, including provision of impermeable collars or plugs, to reduce the potential for basement flooding resulting from groundwater migration should be employed.

8.13. Foundation Drains

Foundation drains will normally be connected by gravity to the minor storm drainage system unless the Consultant determines that surcharging of the system in a future 1 in 100 year design storm will result in basement flooding or foundation damage. The elevation of the lateral at the property line should be established at least 300 mm to 500 mm above the elevation of the obvert of the storm sewer main at the point of connection.

Where a minor storm drainage system does not exist, other options are permitted as specified in the National Building Code. In using other alternatives, Subdivision 9.14 of the National Building Code shall be applicable.

Foundation drains shall not be permitted to discharge to ground surface in such a way as to direct stormwater runoff to the street surface, walkway, or adjacent private property.

8.14. Roof Drains

Residential roof drains shall not be connected to storm drains, but shall discharge onto splash pads at the ground surface a minimum of 600 mm from the foundation wall in a manner that will carry water away from the foundation wall.

Commercial / Industrial roof drains where the roof area to be drained exceeds 250 square metres, shall be directly connected to a storm drainage system, depending on the capacity of the downstream system.

Commercial / Industrial roof drains could be discharged overland if the overland flow can be directed to attenuation ponds. Other options could include roof storage and/or onsite storage.

8.15. Catchbasins

Catchbasins shall be installed at the curb of the street and shall be adequately spaced to prevent excessive water from flowing in the travelled lanes during storm events corresponding to the design of the minor system. In no case shall the spacing of catchbasins exceed 100 m.

At intersections, catchbasin locations shall be dependent upon the slopes of intersecting streets and the alignment of the intersection.

It is vital that the interception capacity of the system of catchbasins be completely compatible with the design capacity of the storm drainage system. While the storm drainage mains will be designed to accommodate open channel flow resulting from the 1 in 5 year return period storm, the actual flows captured by the catchbasins during the future 1 in 100 year return period storm shall be determined.

8.16. Inlet Control Devices

Inlet control devices (ICDs) must be provided where there is a risk of surcharging the minor storm drainage system by storm events that exceed the 1 in 5 year return period. Typical ICD sizing requirements for medium density residential development are provided in Table 8.1. Detailed ICD sizing requirements and theory are provided in Appendix C.

Table 8.1 Typical Inlet Control Device (ICD) Sizes

Catchbasin Tributary Area (ha)	ICD Limiting Flow (L/s)	ICD Diameter (mm)
0.1	16	85
0.2	32	120
0.3	48	150
0.4	64	170

Note: Based on a Rational Method runoff coefficient (C = 0.50) for medium density residential development, an inlet time (T_i = 5 min) and a head of 1.13 m.

8.17. Inlets

Inlets to piped storm drainage systems shall, for pipes 300 mm in diameter or larger, require grates to prevent entry. The orientation of the bars on the grate shall be vertical. The design of the inlet shall take into consideration the effect of the grating on restriction of flow into the pipe.

8.18. Outfalls

Design of outfalls from piped storm drainage systems into any receiving body of water shall take into consideration such factors as public safety, erosion control, and aesthetics.

Outfalls from piped storm drainage systems of 300 mm in diameter and larger shall require grates to prevent entry. The orientation of the bars on the grate shall be horizontal. Inverts of outfall pipes should be installed above the normal winter ice level in the receiving stream wherever possible.

8.19. Required Pipe Strength

Pipe, when installed within the street right-of-way, or a municipal service easement, shall be either reinforced concrete pipe (RCP) manufactured to conform to CAN/CSA A257.2, Polyvinyl Chloride Pipe (PVC) pipe to conform to CAN/CSA B192.1, or as per the *Town of Riverview Standard Municipal Specifications.*

Required pipe strength should determined using the Marston and Spangler equations, or by nomograph method as published by the American Concrete Pipe Association for reinforced concrete pipe or the Uni-Bell PVC Pipe Association for PVC pipe.

Imposed loads should consider the effects of earth load (W_e), live load (W_l), surcharge load (W_s), bedding factor (B_f), and pipe diameter (D). A factor of safety (FS) of 1.5 should be applied when determining required pipe strength.

$$D_{load} = \frac{(W_e + W_l + W_s)}{B_f \cdot D}(FS) \qquad [8.1]$$

Where:

D_{load}	required pipe strength
W_e	earth load
W_l	live load
W_s	surcharge load
B_f	bedding factor
D	pipe diameter
FS	factor of safety

9.0 MAJOR STORM DRAINAGE SYSTEM

9.1. Minor Storms

In storms corresponding to the basis of design of the minor drainage system, it is expected that roadways will remain free of water other than that accumulated between inlets.

9.2. Major Storms

For barrier-type curb applications, storm drainage design shall provide that the depth and spread of flow in a future 1 in 100 year return period storm shall be contained within the right-of-way.

For mountable-type curb applications, the area located directly behind the curb must be graded in order that there be no overflow discharged from the right-of-way except at municipal service easements designed to convey the overland flow.

All low points in the roadway profile must be designed to collect and convey stormwater runoff off the roadway via a drainage easement designed to convey the overland flow.

Provision shall be made to remove runoff into drainage channels, watercourses, and pipe systems at low points and at intervals that will assure that this criteria is observed.

9.3. Off-Street Drainage

In order to avoid seepage and icing problems on the street caused by groundwater seeping over the top of the curb, the Consultant shall provide a perforated curb drainage system.

9.4. Ditches and Open Channels

Roadway ditches, where curb and gutter systems are not required, shall be designed to conform to the typical cross section for rural roads as detailed in the *Town of Riverview Standard Municipal Specifications*. Ditches shall be designed with adequate capacity to carry the flow expected from the future 1 in 100 year return period storm.

9.5. Maximum Velocity

To prevent erosion, maximum velocities in a future 1 in 100 year return period storm in ditches or open channels that convey stormwater runoff shall not exceed values set forth in Table 9.1 unless the channel is lined or acceptable energy dissipation facilities are provided.

Table 9.1 Maximum Permissible Mean Channel Velocity

Channel Material	Maximum Permissible Mean Channel Velocity (m/s)
Fine Sand	0.45
Coarse Sand	0.75
Fine Gravel	1.85
Earth – Sandy Silt	0.60
Earth – Silty Clay	1.05
Earth – Clay	1.20
Bermuda Grass Lined – Earth – Sandy Silt	1.85
Bermuda Grass Lined – Earth – Silty Clay	2.45
Kentucky Blue Grass Lined – Earth – Sandy Silt	1.50
Kentucky Blue Grass Lined – Earth – Silty Clay	2.15
Sedimentary Bedrock – Poor	3.05
Sedimentary Bedrock – Sandstone	2.45
Sedimentary Bedrock – Shale	1.05
Igneous Bedrock	6.10
Metamorphic Bedrock	6.10

9.6. Infiltration trenches

This section is intended to provide limited guidance on the use of infiltration trenches within the Town of Riverview. Details regarding the design and use of infiltration trenches can be found in technical literature, the more prominent of which are listed in Section 16.0 (References) and include: Alberta Environmental Protection (1999), City of Calgary (2000) and Ontario Ministry of the Environment. (2003).

9.6.1. Hydrotechnical Considerations

A Professional Engineer with experience in stormwater management shall do the design of an infiltration trench.

The designer should consider specific site conditions, such as soil type, depth of water table, topography, and contributing area conditions.
The designer should aim to improve the quality of stormwater runoff by removing both particulate and soluble pollutants by means of the infiltration trenches. Effective removal of sediment, phosphorus, nitrogen, trace metals, coliforms, and organic matter is accomplished through adsorption by soil particles, and biological and chemical conversion in the soil. Rates of pollutant removal are affected by the type of soil.

Infiltration trenches and basins should reduce runoff volumes normally directed toward minor drainage systems.

Infiltration trenches and basins should be designed to collect and temporarily store surface runoff and to promote subsequent infiltration, considering the volume of stormwater from a 5-year-return- period storm.

Infiltration basins should drain within 72 hours to maintain aerobic conditions (which favour bacteria that aid in pollutant removal) and to ensure there is capacity to receive the next storm.

9.6.2. Location

Infiltration trenches can be used as recharge devices for compact residential developments (less than 2 ha). Infiltration trenches differ from on-lot infiltration systems in that they are generally constructed to manage stormwater flow from a number of lots in a developed area, not a single property.

Infiltration trenches should only be used where the soil is porous and can absorb the required quantity of stormwater.

Potential contamination of groundwater should be considered when examining runoff quality directed to an infiltration trench or basin.

Infiltration trenches and basins are not recommended for use in commercial or industrial areas because of the potential for high-contaminant loads or spills that may result in groundwater contamination.

Infiltration trenches and basins should not be built under parking lots or other multiuse areas, within 2.0 m (measured vertically) of bedrock, near a septic field, on fill material, where the underlying soils have a low percolation rate (<1.3 mm) when fully saturated, or where runoff is likely to be highly polluted.

9.6.3. Construction and Maintenance

Only clean stone and other materials should be used in the construction of an infiltration trench.

Regular inspections and maintenance including the cleaning of inlets to prevent clogging is required to maintain proper operation, and to prevent the nuisances of insect infestations, odours, and soggy ground.

9.7. Buffer and Filter Strips

Buffer and filter strips are practical and low-cost measures that provide rudimentary stormwater quality control. The following is intended to provide limited guidance on the use of buffer and filter strips within the Town of Riverview. Details regarding the design and use of buffer and filter strips (as well as other Best Management Practices) can be found in technical literature, the more prominent of which are listed in Section 16.0 (References) and include: Alberta Environmental Protection (1999), City of Calgary (2000) and Ontario Ministry of the Environment. (2003).

Buffer strips remove pollutants from overland runoff due to the fact that vegetation promotes pollutant filtration and infiltration of stormwater.

- Whenever possible, natural buffer strips should be maintained within 30 metres of the natural boundary of a wetland or the banks of a watercourse. Within the buffer strip, land should not be disturbed, vegetation removed, soil removed, or materials deposited.

Filter strips are bands of close-growing vegetation, usually grass, planted between a source area and receiving watercourse, to provide a degree of stormwater quality control. The filtering action of the vegetation, sediment deposition, and infiltration of pollutant-carrying water reduces pollution to watercourses from sediment, organic matter, and trace metals, but are not considered reliable for the removal of soluble pollutants. Filter strips are used primarily in residential areas around streams or ponds, where runoff does not tend to be heavily polluted.

- When planning a stormwater management system for a drainage area, all filter strips should be considered ineffective for runoff velocities greater than 0.75 m/s, and for runoff volumes greater than that produced from a two-hectare catchment during a 25-year-return-period, 24 hour duration storm.
- The actual width of the filter strip should be determined considering topography, the characteristics of the upstream development, and the types of soil and vegetation at the site, with 10 m considered the minimum practical width.
- The ongoing maintenance of filter strips should be arranged as a critical component of stormwater quality control. Filter strips require periodic repair, such as re-seeding and the removal of dead vegetation.

9.8. Grassed Swales

9.8.1. Hydrotechnical Considerations

Grassed swales should be designed as open channels using the Manning Equation, using a Manning's coefficient of 0.022 or greater.

The maximum velocity in a swale should be 0.5 m/s. Where velocities are greater than 0.5 m/s, the use of check dams can avoid uncontrolled channel scour.

9.8.2. Dimensions and Layout

A minimum bottom width of 1.0 m should be maintained.

A minimum depth of 1.0 m should be maintained.

Side slopes should be no greater than 2.5 horizontal to 1 vertical, but are optimally less than 4 horizontal to 1 vertical.

Swales should be designed with longitudinal slopes that maintain conveyance and prevent flooding and local ponding in the swale.

9.8.3. Location

Grassed swales are typically used in more rural areas with rolling or relatively flat land. Grassed swales can be considered as an enhancement to stormwater curb and gutter system, but are not permissible as replacements for curb and gutter systems in commercial and high-density residential areas.

Since many particulates are effectively filtered by grassed swales, they should be considered for use at sites where contamination from suspended solids might occur. Grassed swales are not considered effective in filtering contaminants such as organic nitrogen, phosphorus, and bacteria.

9.8.4. Construction and Maintenance

Grass should be local species or standard turf grass where a more manicured appearance is required.

The grass should be allowed to grow higher than 75 mm so that suspended solids can be filtered effectively.

10.0 STREETS

10.1. Roadway Drainage

Provision shall be made to remove runoff from streets into drainage channels, watercourses, and pipe systems at low points and at intervals that will assure that ponding of stormwater on streets does not occur for long durations.

The maximum depth of stormwater flow on any street shall not exceed 0.3 m, with a maximum flow velocity of 2 m/s.

For storms greater than the design storm of the minor drainage system (i.e. a storm event with a return period in excess of 5 years), streets could be designed to temporarily convey flow as part of the major drainage system. The flow conveyance capacity of street shall be determined using the Manning Equation, with a Manning's resistance coefficient of 0.013 (asphalt surfaces) or 0.015 (concrete surfaces).

For storms up to and including the 5-year-return-period storm, the Designer must ensure that, for all roads, a travelled way of adequate width is maintained to ensure the safe passage of all vehicles in both directions.

For residential streets and local collector streets, the Designer must ensure that during storms up to and including the major design storm (1.2 times the 100-year-return-period storm), the depth and spread of flow does not exceed the curb height and does not exceed the right-of-way width.

For major collector streets and arterial streets (emergency access routes), the Designer must ensure that during storms up to and including the major design storm (1.2 times the 100-year-return-period storm), a travelled way of adequate width is maintained to ensure the safe passage of vehicles in both directions.

For designated highways within the Town of Riverview, the more stringent of the New Brunswick Department of Transportation design criteria or the Town of Riverview specifications for drainage infrastructure shall apply.

10.2. Curbs and Gutters

Curbs and gutters are usually installed along town streets. The gutter should be hydraulically efficient with a smooth surface texture and a minimum grade of 0.5%, which is generally the same longitudinal grade as the pavement surface. Gutter flow can be determined using a modified version of the Manning Equation:

$$Q = (0.375 \;\; S_o^{0.5} \; d^{2.667}) \,/ (n * S_x) \qquad [10.1]$$

Where:

Q the gutter flow in m^3/s,

S_o the longitudinal slope, m/m,

d the depth of flow at the curb, m,

n Manning's resistance coefficient, and

S_x cross slope over the pavement area, m/m.

In applying the equation, allowance should be made for changes in the gutter cross section if the slope of the gutter is depressed near the curb.

The depth and spread of flow during the major design storm (1.2 times the 100-year-return-period storm) shall be contained within the right-of-way if the curb acts as a barrier, or discharged from the right-of-way into municipal service easements designed to convey the overland flow if the curb can be overtopped.

For storms with a magnitude less than or equal the design storm of the minor drainage system, i.e. the 5-year-return-period storm, roadways should remain free of water, except for water accumulated between inlets. The maximum spread of water across a street as measured from the curb should not exceed 3 m or one half of the width of the traffic lane closest to the curb, whichever is less. The calculation of maximum stormwater spread should be based on a road crown of 3.0%, in accordance with the Town of Riverview general specifications for road and street design.

The spacing between two consecutive inlets shall be such that the immediate spread upstream of the downstream inlets shall be less than the maximum permissible spread (as specified above), or 120 m, whichever is less.

Inlets along streets should also be provided at:

- sag points in the gutter grade, upstream of major street intersections and pedestrian cross walks, and along median barriers,
- upstream and downstream of bridges, and
- upstream of the starting point of a horizontal curve where there are major changes in cross (transverse) and longitudinal slope.

10.3. Roadway Ditches

Roadway ditches shall be designed as a trapezoidal open channel with a minimum bottom width of 1.0 m and maximum side slopes of 3 horizontal to 1 vertical.

Ditches shall be designed with adequate capacity to carry the flow expected from the major design storm (1.2 times the 100-year-return-period storm).

The minimum grade of a ditch shall be 0.5%.

The maximum velocity in an unlined ditch shall be in accordance with Table 9.1.

11.0 CULVERTS

11.1. Minimum Diameter

Minimum culvert diameter is 450 mm for circular culverts. Minimum culvert width by height is 450 mm x 450 mm for rectangular culverts. No downstream decrease in culvert sizing is permitted.

11.2. Minimum Depth

Minimum cover for culverts under roadways is 500 mm.

11.3. Maximum Depth

The Consultant may be required to submit pipe strength calculations including earth loading, line loading, and induced loading, accounting for site conditions and construction practices.

11.4. Hydraulic Capacity

Culverts are to be sized to convey instantaneous peak flows with a headwater depth (*HW*) to culvert diameter (*D*) ratio of 1.0 accounting for both inlet control and outlet control.

Culverts located under driveways and roadways are to be designed to accommodate the 1 in 5 year return period storm, unless otherwise directed by the Town of Riverview Engineering and Public Works Department.

Culverts located in drainage courses or natural watercourses are to be designed to accommodate the future 1 in 100 year return period storm, unless otherwise directed by the Town of Riverview Engineering and Public Works Department.

11.5. Maximum Headwater Depth

Maximum headwater elevation (*HW*) for both inlet control and outlet control should be checked relative to adjacent ground surface and adjacent structures for compatibility. The Consultant may reduce maximum headwater elevations (*HW*) for culverts under inlet control by improving inlet hydraulics. Table 11.1 and Table 11.2 present entrance loss coefficients (k_e) for reinforced concrete pipe (RCP) and corrugated steel pipe (CSP).

Table 11.1 Entrance Loss Coefficients (k_e) for Reinforced Concrete Pipe (RCP) Culverts Under Inlet Control

Inlet Geometry	Inlet Type	Entrance Loss Coefficient (k_e)
Projecting from fill (bell end)	1a	0.2
Projecting from fill (square cut end)	1b	0.5
Mitered to conform to slope	2	0.7
Headwall or headwall and wingwalls (bell end)	3a	0.2
Headwall or headwall and wingwalls (square cut end)	3b	0.5
Flared inlet conforming to slope	4	0.5
Headwall or headwall and wingwalls (rounded edge)	5	0.1

Table 11.2 Entrance Loss Coefficients (k_e) for Corrugated Steel Pipe (CSP) Culverts Under Inlet Control

Inlet Geometry	Inlet Type	Entrance Loss Coefficient (k_e)
Projecting from fill	1	0.9
Mitered to conform to slope	2	0.7
Headwall or headwall and wingwalls (square edge)	3	0.5
Flared inlet conforming to slope	4	0.5
Headwall or headwall and wingwalls (rounded edge)	5	0.2
Bevelled ring	6	0.25

11.6. Inlet Design

All culverts under roadways are to be equipped with an inlet headwall, or some other form of embankment stabilization and erosion control.

11.7. Outlet Design

All culverts under roadways are to be equipped with an outlet headwall, or some other form of embankment stabilization and erosion control.

11.8. Outlet Velocity

The maximum culvert outlet velocity is 4.0 m/s. A rip rap splash pad and apron must be designed to transition the culvert outlet velocity to the mean downstream channel velocity. Rip rap should be sized in accordance with Equation 11.1.

$$D_{mean} = 0.019 \cdot V^2 \qquad [11.1]$$

Where:

D_{mean} equivalent spherical diameter of rip rap (m)

V culvert outlet velocity (m/s)

Culvert outlet velocities must not exceed the maximum permissible mean channel velocities for a given channel material as presented in Table 9.1.

11.9. Inlet and Outlet Grates

Culverts under driveways and roadways less that 25 m in length shall not normally require inlet and outlet grates.

Culverts longer than 25 m shall be equipped with inlet and outlet grates.

Inlet grates shall be constructed of vertically oriented bars. Outlet grates shall be constructed of horizontally oriented bars. Design and sizing of inlet and outlet grates must account for the restriction in flow created by the grate and blockage. Under no circumstances shall a culvert be equipped with an outlet grate and no inlet grate. Generally, the cross sectional area of the grate should be 5 to 10 times the cross sectional area of the pipe. Placement of the grate should be at least one pipe diameter from the end of the pipe.

11.10. Culvert Materials

Culverts under driveways shall be as per the Town of Riverview Standard Municipal Specifications.

Culverts under roadways must be reinforced concrete pipe (RCP), or approved equal.

12.0 OIL AND GRIT SEPARATORS (OSG)

12.1. Design Considerations

Oil and grit separators are intended to remove sediment, debris and hydrocarbons (oil and grease) from stormwater, and may consist of commercial in-ground structures (such as Stormceptor® or CDS units), custom-designed structures, ponds, or other BMPs.

The cases where oil and grit separators are required are described in Section 4.3 of these specifications.

The oil and grit separators should be designed such that high flows from infrequent rainfall events do not result in the re-suspension of contaminants in the separator and the discharge of these contaminants into the receiving environment or the storm sewer system.

The design of oil and grit separators or the selection of commercially available oil and grit separators should be done by a Professional Engineer with experience in stormwater management. The designer should consider specific site conditions, such as soil type, depth of water table, topography, the expected types and amounts of pollutants, and overall stormwater management for the catchment.

Oil and grit separators should be designed and constructed to the following performance standards:

- A total Suspended Solids concentration in the stormwater discharge is not to exceed 25 mg/L. The effective opening size of the sieve or filter medium that is to be used in determining this concentration is 1.0 µm.
- All particles with a diameter in excess of 75 µm shall be removed during a flow that equals the magnitude of 30% of the two (2) year return period flow event.
- The total hydrocarbon concentration in stormwater shall be less than 1ppm or 1 mg/L.

12.2. Location

Oil and grit separator structures should generally be installed underground as a component of the minor drainage system. Oil and grit separator ponds or other non-structural BMPs should generally be installed within the property boundaries of the development that it services, and should generally be installed in the most downstream portion of a property.

Oil and grit separators can be installed as stand-alone devices in less developed portions of the Town of Riverview, provided that they are designed and constructed so that they could be tied into the minor drainage system at a future time.

Oil and grit separators should be located so as to allow the collection of all runoff from a property and prevent the discharge of contaminant runoff into the minor stormwater system or receiving watercourses.

Oil and grit separators are particularly well suited to capture particulates and hydrocarbons from loading/parking areas at commercial facilities, and gas stations (CMHC, Alternative Stormwater Management Practices for Residential Projects). Their major environmental benefit comes in the form of improved downstream water quality as part of a treatment train.

12.3. Maintenance

Oil and grit separators should be designed and constructed to ensure easy access for inspection and cleaning.

Oil and grit separators should be cleaned of sediment, accumulated oils and grease, debris and other pollutants as needed to ensure the continued proper operation of the system. The maintenance of oil and grease separators shall be discussed with the Town of Riverview’s Engineering and Public Works Department prior to their adoption and installation.

13.0 DOWNSTREAM EFFECTS

13.1. Other Considerations

Explicit consideration shall be given to public safety, NBDOE regulations, NBDOT regulations, nuisance, and maintenance implications of ditches, open channels, and drainage courses. Attempts shall be made to limit the number of partial enclosures of a ditch, open channel, or drainage course by driveways, roadways, and other crossings.

13.2. Stormwater Control Facilities

Investigation of requirements to mitigate the downstream effects of a proposed development shall be carried out to determine the requirements for and feasibility of the utilization of a facility for stormwater runoff control through attenuation. If a determination is made that an attenuation facility is required, its design shall be carried out using appropriate methods and sound engineering principles. The design shall take into consideration various factors including, but not limited to, watercourse protection, erosion and sediment control, impact on adjacent property, maintenance requirements, public safety, access, liability, and nuisance. Such attenuation facilities shall be designed to control the peak runoff conditions for multi-storm events up to the 100 year return period storm.

Details regarding the design and use of stormwater attenuation ponds can be found in technical literature, the more prominent of which are listed in Section 16.0 (References) and include: Alberta Environmental Protection (1999), City of Calgary (2000) and Ontario Ministry of the Environment. (2003).

Stormwater attenuation ponds can include wet ponds and dry ponds. Wet ponds have a permanent standing body of water. Dry ponds only contain water immediately following a storm event. Wet ponds provide better breeding habitat for insects than dry ponds (and thereby increase the spread of biting insect-borne diseases such as the West-Nile virus) and have a greater potential than dry ponds to increase water temperature to levels lethal to aquatic life. The Town of Riverview's Engineering and Public Works Department prefers the use of dry ponds over wet ponds.

The purpose of a dry pond is to temporarily store stormwater runoff in order to restrict peak discharge to pre-development conditions and reduce the potential of downstream flooding and erosion. Dry ponds are not considered effective for volume reduction, although some evaporation may occur. As a detention facility, a dry pond should flatten and spread the inflow hydrograph, thus lowering the peak discharge.

Because dry ponds have no permanent pool of water, the removal of stormwater contaminants in dry ponds is a function of the pond's drawdown time. Dry ponds operating in a batch mode are considered more effective than a dry pond operating in a continuous mode.

During the design process, the Designer should generate a hydrograph to assess the performance of the stormwater pond. Other design considerations include ease of maintenance and use of the dry pond. In addition, the Designer could consider alternate means, including fabricated storm drainage detention facilities, to reduce peak flows.

13.2.1. Hydrotechnical Considerations

The emergency spillway of the pond should be designed for a major design storm (1.2 times the 100-year-return-period). Snowmelt should be included in the estimate of runoff.

The pond should be designed to empty completely within 72 hours following the termination of stormwater inflow.

13.2.2. Dimensions and Layout

In order to maximize the water quality benefits from a stormwater attenuation pond, the ratio of effective pond length to width should exceed 3 to 1, and the inlet should be located as far away from the outlet as possible.

The bottom of dry ponds shall be graded to drain properly all areas after operation. The minimum bottom slope is 1.0%. The recommended bottom slope is 2.0%.

In consideration of public safety, the maximum allowable active retention storage depth for a dry pond is 1.5 m.

The maximum embankment slopes of stormwater retention ponds are 4 horizontal to 1 vertical for interior (inward facing) slopes, and 3 horizontal to 1 vertical for exterior (outward facing) slopes.

The minimum pond freeboard is 1.0 m.

13.3. Storm Drainage Municipal Service Easement

No storm drainage is to be carried onto, through, or over private property, within a subdivision, other than by a natural watercourse, excavated ditch, or minor storm drainage system. To ensure access to storm drainage systems, a municipal service easement of adequate width shall be deeded to the Town of Riverview in the following cases:

- Excavated ditches or storm sewers within the boundary of the subdivision.
- Where a need is identified by the Town of Riverview Engineering and Public Works Department to accommodate future upstream drainage, a municipal service easement shall be provided from the roadway to the upstream limits of the subdivision.
- A municipal service easement may be required for excavated ditches or minor storm drainage systems that are adjacent to and immediately downstream of the subdivision that are required to ensure proper functioning of the subdivision storm drainage system. A municipal service easement will not normally be required for a natural watercourse.
- Where subdivision stormwater runoff flows from the subdivision onto adjacent properties other than in a natural watercourse, a municipal service easement in favour of the Town of Riverview must be provided by the owners affected.

Natural watercourses shall not normally be carried in roadside ditches or minor storm drainage systems.

13.4. Discharge to Adjacent Properties

All storm drainage is to be self-contained within the limits of the subdivision, except for natural drainage associated with runoff from undeveloped areas. In all cases, concentration and conveyance of stormwater to adjacent properties outside the subdivision limits is prohibited unless the developer obtains permission from the adjacent property owners, and unless private drainage or service easements are provided.

The grading along the limits of the subdivision shall be carefully controlled to avoid disturbance of adjacent properties or an increase in the discharge of stormwater to those properties. Drainage may be prevented from entering a property by constructing a barrier to overland flow, provided this does not interfere with natural drainage or impacts neighbouring properties (i.e. natural drainage may not be “cut-off” and the construction of hydraulic controls may not cause off-property flooding).

Runoff from within the subdivision, however, may be directed to a natural stream, watercourse, or storm drainage system owned by the Town of Riverview.

The lot grading design shall provide for drainage from adjacent properties where no other alternative exists.

The lot grading design shall provide for temporary drainage of all blocks of land within the subdivision that are intended for future development.

During the design of storm drainage systems, provision must be made for accommodating natural drainage from adjacent properties by means of an interceptor swale or other system component.

Where a drainage channel to service one property is to be constructed on an adjacent property, written permission from the adjacent property owner(s) for such construction shall be required. A copy of the document which grants said approval shall be submitted to the Town of Riverview Engineering and Public Works Department.

14.0 ANALYSIS OF EXISTING STORM DRAINAGE SYSTEMS

In the absence of existing Master Planning, it may be necessary to analyze the capacity of existing storm drainage systems, including storm sewer systems within the Town of Riverview. This may be required due to the fact that a proposed development is going to increase stormwater runoff to an existing system, and the existing system needs to be analyzed to ensure that it will convey the additional flows without any problems. It may also be necessary to analyze an existing system due to complaints of flooding or problems in the system. Where consultants are required to analyze an existing storm drainage system within the Town of Riverview, the following procedure shall be followed.

14.1. Hydrologic Analysis

Where existing systems are being analysed, it is crucial to determine the peak stormwater runoff to a given point in a system caused by severe rainfall events and snowmelt events. Where storage facilities are included in the study, it may be necessary to determine the hydrograph of the stormwater runoff to a particular point; that is, instantaneous peak flow will not be adequate for the evaluation of storage facilities. In determining the stormwater runoff or hydrographs, the methods as described in Section 6.0 shall be used.

In preparing a hydrologic and hydraulic model, it may be necessary to determine the drainage area to each individual storm manhole and each individual storm catchbasin. This information should be compiled on a master drawing of the area being studied with appropriate labels for the areas, manholes, and catchbasins such that calculations can be easily compared to the plan. For minor storm drainage systems, ie. storm sewers and catchbasins, the 1 in 5 year return period storm shall be checked for the points of interest. For open channels, watercourses, and major drains on streets, the future 1 in 100 year return period storm shall be checked for the points of interest.

14.2. Hydraulic Analysis

For each component of the existing storm drainage system such as a storm sewer main, open channel, watercourse, or culvert, the hydraulic capacity of that portion of the system needs to be determined and compared to the flow determined from the hydrologic calculations. The following procedures are accepted by the Town of Riverview

Engineering and Public Works Department for determining the hydraulic capacity of storm drainage structures.

14.3. Open Ditches, Channels, and Watercourses

To determine the capacity of open channels, ditches, and watercourses, the Manning equation may be used where grades are relatively steep, greater than 1%. Where grades are less than 1%, it may be necessary to account for backwater effects using the energy equation and the direct-step or standard-step methodologies. This may be accomplished with a water surface profile model as per Section 6.0. Also to be considered in these calculations is the water surface elevation at the outlet of the ditch, watercourse, or channel.

14.4. Culverts

To calculate the hydraulic capacity of a culvert, the inlet capacity of the culvert and the outlet capacity should be checked taking into consideration maximum tailwater elevation at the outlet of the culvert. Also to be checked is the barrel capacity of the culverts using the Manning equation. In general, the inlet capacity of the culvert will be the limiting factor in determining the capacity.

14.5. Minor Storm Sewer System

Minor storm sewer systems consist of storm sewer mains, manholes, catchbasins, and various inlets and outlets. The capacity of a storm sewer system shall be checked as follows:

- Preliminary sizing of pipe diameter assuming full flow conditions for each pipe in the minor storm drainage system using the Manning equation for the 1 in 5 year return period storm. Manning's roughness coefficients (n) have been tabulated in Table 14.1. The ratio of the 1 in 5 year design flow (Q_5) to full flow pipe capacity (Q_{cap}) should not exceed 80%.

$$\frac{Q_5}{Q_{cap}} \leq 0.80 \quad [14.1]$$

Where:

Q5 1 in 5 year design flow (L/s)

Qcap full flow pipe capacity (L/s)

- A determination of the hydraulic gradeline (HGL) for the 1 in 5 year return period storm should be conducted assuming the actual captured flow (Q_c) is 100% of the 1 in 5 year design flow (Q_5). Analysis should account for pipe friction losses, junction and bend losses, outlet tailwater elevation, and capacity constraints of the downstream system. HGL profiles may be determined by the standard-step method, the direct-step method, or acceptable energy equation principles. The HGL profile should be plotted on the plan and profile drawing to ensure that the water surface profile is contained the pipe. An elevated HGL may require a pipe diameter larger than that which is determined by the Manning equation in order to avoid surcharging of the minor storm sewer system.

- A determination of the hydraulic gradeline (HGL) for the future 1 in 100 year return period should be conducted assuming the actual captured flow (Q_c) is some percentage of the future 1 in 100 year design flow (Q_{100}). The actual captured flow should be the lesser of the maximum catchbasin inlet capacity, the maximum catchbasin lead capacity, or the future 1 in 100 year design flow (Q_{100}). Analysis should account for pipe friction losses, junction and bend losses, outlet tailwater elevation, and capacity constraints of the downstream system. HGL profiles may be determined by the standard-step method, the direct-step method, or acceptable energy equation principles. The HGL profile should be plotted on the plan and profile drawing to ensure that the water surface profile is at an acceptable level. The elevated HGL profile should not threaten back-up into service laterals, or basements.

- Provision of inlet control devices (ICDs), as presented in Appendix C, is an acceptable means of limiting the actual captured flow (Q_c) by the minor system in storm events that exceed the design capacity of the minor storm sewer system.

Design capacity (Q_{des}) of the major storm drainage system must account for any additional flow restricted from entering the minor storm drainage system.

14.6. Stormwater Detention Structures

Components of a storm drainage system may include ponds, lakes, or man-made storm drainage detention facilities to reduce the peak flow downstream. The following procedures shall be used to check the performance of a storm drainage detention facility:

- A future 1 in 100 year return period, 24-hour duration, storm shall be applied to the watershed, using one of the applicable models in Section 6.0, and a hydrograph should be generated to assess the stormwater runoff detention facility performance.

- The storage indication method shall be used to calculate the outflow from this pond, taking into consideration the outlet condition (that is, the hydraulic outlet structure of the pond). The maximum flood elevation of this facility shall be calculated as part of this work. Where the watershed is mostly urban or developed land, it is likely that a summer storm will be adequate to check this facility; however, if a large portion of the watershed is forested or open fields, it may be necessary to check the facility using a winter storm with snowmelt included in the runoff.

Table 14.1 Manning Roughness Coefficient (n) *for Open Channel Flow and Piped Flow*

Material	Description	Manning Roughness Coefficient (*n*)
Closed Conduits	Asbestos-Cement Pipe	0.011 to 0.015
	Brick	0.013 to 0.017
	Cast Iron Pipe (Cement Lined)	0.011 to 0.015
Concrete	Concrete (monolithic)	0.012 to 0.014
	Reinforced Concrete Pipe (RCP)	0.011 to 0.015
Corrugated Steel Pipe	Corrugated Metal Pipe (plain)	0.022 to 0.026
	Corrugated Metal Pipe (paved invert)	0.018 to 0.022
	Corrugated Metal Pipe (spun asphalt lined)	0.011 to 0.015
Plastic Pipe PVC/HDPE	Ribbed	0.010 to 0.012
	Plain	0.009 to 0.011
Vitrified Clay	Vitrified Clay Pipe	0.011 to 0.015
	Vitrified Clay Liner Plate	0.013 to 0.017
Lined Channels	Asphalt	0.013 to 0.017
	Brick	0.012 to 0.018
	Concrete	0.011 to 0.020
	Rubble or Rip Rap	0.020 to 0.035
	Vegetal	0.030 to 0.400
Excavated Channels	Earth, straight and uniform	0.020 to 0.030
	Earth, curved and uniform	0.025 to 0.040
	Rock	0.030 to 0.045
	Unmaintained	0.050 to 0.140
Natural Channels	Regular section	0.03 to 0.07
	Irregular section with pools	0.04 to 0.10

15.0 DESIGN DOCUMENTATION

15.1. General Submissions Requirements

A detailed design must be performed for each stormwater system that is to be built in the Town of Riverview. The Designer must retain a copy of all design information supplied to the Developer. Upon request, the Designer will submit to the Town of Riverview Engineering and Public Works Department computational sheets, and related model output used to determine design flows, hydraulic capacity of components of the drainage systems and the entire drainage system, and estimates of the depth and extent of flow in open channels.

A Developer must supply in a timely manner to the Town of Riverview Engineering and Public Works Department all required technical briefs and reports, design drawings and supplementary calculations as may be required by that office. Development is not to proceed until the Director has received and accepted the requested information.

Acceptance of design documents by the Town of Riverview Engineering and Public Works Department does not relieve the Designer of the responsibility for proper design, nor does it imply that the Town of Riverview Engineering and Public Works Department has checked the plans, technical briefs, and supplementary calculations for compliance with this document. Additional copies of any plans, technical briefs, and supplementary calculations as deemed necessary by the Director may be required.

In order to facilitate the overall management of stormwater within the Town of Riverview, any development that involves the installation or upgrading of municipal stormwater infrastructure requires that two (2) copies of a **Drainage Plan** (also referred to as the dual drainage plan) and two (2) copies of a **Drainage Design Report** be submitted along with the **Lot Grading Plan** and other required documentation to the Town of Riverview (contact the Engineering and Public Works Department for a complete list of submission requirements).

If On-Lot storage is proposed as part of a development, the Town of Riverview Engineering and Public Works Department may require a deposit to ensure final construction conforms to the design and ensure the receipt of associated record information. The need for this deposit is a function of the type of On-Lot storage, and is at the discretion of the Director.

All Drainage Plans and Drainage Design Reports must be prepared under the direct supervision of, and be signed and sealed by a member, or a Licence to Practice member, of the Association of Professional Engineers and Geoscientists of New Brunswick (APEGNB). The requirements of the Drainage Plans and the Drainage Design Report are presented in the following sub-sections.

15.2. Drainage Plans

The intent of the Drainage Plan is to provide a graphical representation of new or upgraded drainage infrastructure, and the manner in which it affects the drainage of, or is affected by the drainage from, surrounding land. The Drainage Plan is to be prepared at a scale of 1:1000 and must include the following in either graphic and/or tabular form:

- the location of the development within the total topographic drainage area;
- the boundary limit of a delineated flood hazard area (or designated flood risk area) if within the limits of the developments or if crossed by a drainage system that would convey flow from the development during the design storm event,
- site layout including proposed streets, lots and approximate location of proposed structures;
- pre-development contours at an interval not exceeding 1 m;
- all existing watercourses including ponds, swamps and wetlands indicating direction of flow;
- boundaries of catchment and sub-catchment areas tributary to each: set of catch basins, infiltration pond, or drainage channel, indicating the direction of flow, drainage area, and where appropriate, runoff coefficients;
- the location and layout of the proposed storm drainage system including manholes, catch basins, and storm sewers indicating pipe material, diameter, slope, and direction of flow;
- the size and location of any proposed post-development stormwater storage and retention facilities; and
- the location of outfalls, or connections to existing systems.

The requirements for the preparation of Lot Grading Plans are presented below.

- Existing elevations at all lot corners. Existing elevations should be checked outside of the development boundary to determine the effects on and of the surrounding areas.
- Proposed finished grades at all lot corners.
- Proposed finished ground elevations at house foundations.
- Lot Number.
- Proposed finish grade at change of slope between lot corners.
- Finished centreline grade of street at intersections and 40 m intervals.

Where there are differences between the information presented above and the information presented in the Standard Municipal Specifications, the Standard Municipal Specifications for Municipal Services shall govern.

15.3. Drainage Design Reports

The intent of the Drainage Design Report is to summarize all of the relevant design information associated with the installation or upgrading of municipal stormwater infrastructure. These reports will facilitate to overall management of stormwater within the Town of Riverview, and the integration of stormwater drainage infrastructure. All drainage design reports shall include:

- A description of the design methodology used. This shall include the computational methods or computer model(s) and the design storms used.
- For all of the drainage infrastructure and discharge points from a property, a summary shall be provided of: drainage area, percentage impervious area, runoff coefficient or curve number, design flows and hydraulic design data.
- Model results including outflow hydrographs and hydraulic grade lines associated with the minor and major design flows.
- Design calculations on all downstream drainage facilities confirming excess capacity is available. Where excess capacity is not available the report shall include specific recommendations on downstream improvements to be made to accommodate the additional drainage.

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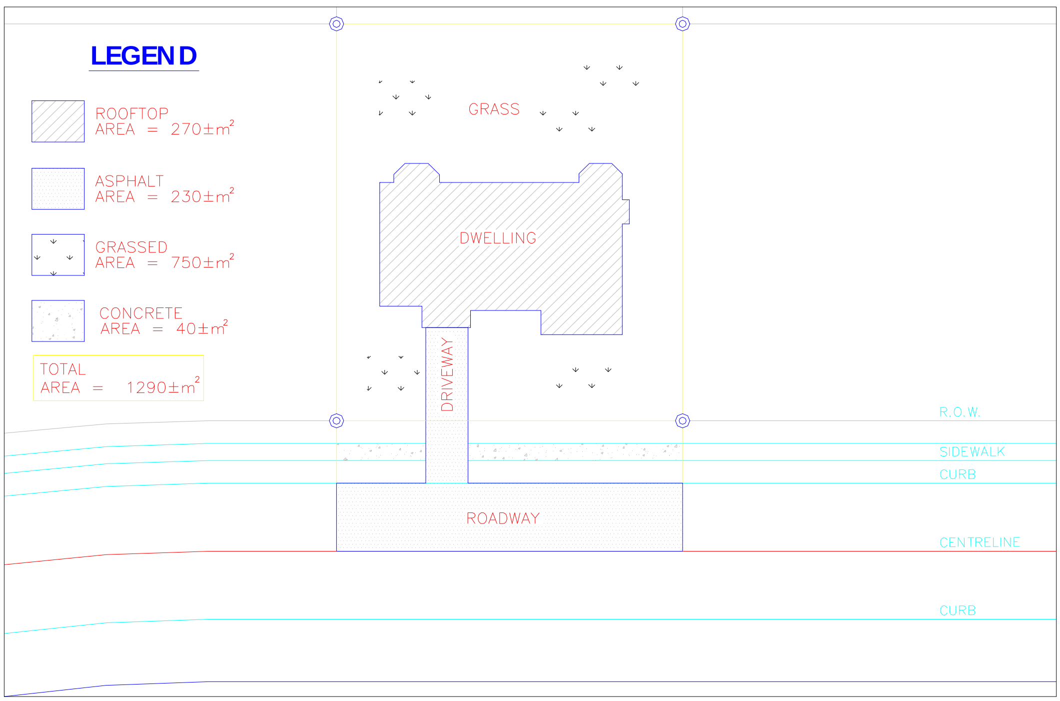
APPENDIX A

Calculation of Composite Rational Runoff Coefficient (*C**) and Composite USSCS Curve Number (*CN**)

Figure A.1 - Typical Single Family Residential Lot



Example A.1(a)

Calculation of Composite Rational Runoff Coefficient (*C)**

Given: Figure A.1 presents surface materials and surface areas for a typical single-family residential lot.

Determine: Determine the composite Rational runoff coefficient (*C**).

Step 1: The composite Rational runoff coefficient (*C**) may be determined by the following equation:

$$C^* = \frac{\sum C \cdot A}{\sum A} \quad [A.1]$$

Where:

*C** composite Rational runoff coefficient
C *Rational runoff coefficient (from Table 6.2)*
A *area (m2)*

Table A.1 was created using the surface material and surface areas presented in Figure A.1, and the Rational runoff coefficients presented in Table 7.2. The composite Rational runoff coefficient was determined from Equation [A.1].

Table A.1 Composite Rational Runoff Coefficient (C) Calculation*

Surface Material	**Runoff Coefficient C**	**Area A (m^2)**	***C A* (m^2)**
Rooftop	0.95	270	256.5
Asphalt	0.95	230	218.5
Grass	0.17	750	127.5
Concrete	0.95	40	38.0
Total		1290	640.5
Composite Coefficient ($C^*=\sum CA/\sum A$)	**0.50**		

Example A.1(b)

Calculation of Composite USSCS Curve Number (*CN)**

Given: Figure A.1 presents surface materials and surface areas for a typical single-family residential lot.

Determine: Determine the composite USSCS curve number (CN^*).

Step 1: The composite USSCS curve number (CN^*) may be determined by the following equation:

$$CN^* = \frac{\sum CN \cdot A}{\sum A} \qquad [A.2]$$

Where:

*CN** *composite USSCS curve number*
CN *USSCS curve number (from Table 6.5)*
A *area (m2)*

Table A.2 was created using the surface material and surface areas presented in Figure A.1, and the USSCS curve numbers presented in Table 7.5. The composite USSCS curve number was determined from Equation [A.2].

Table A.2 Composite USSCS Curve Number (CN) Calculation*

Surface Material	**Curve Number CN**	**Area A (m^2)**	***CN A*** **(m^2)**
Rooftop	98	270	26,460
Asphalt	98	230	22,540
Grass	80	750	60,000
Concrete	98	40	3920
Total		1290	112,920
Composite Curve Number ($CN^*=\sum CNA/\sum A$)	**88**		

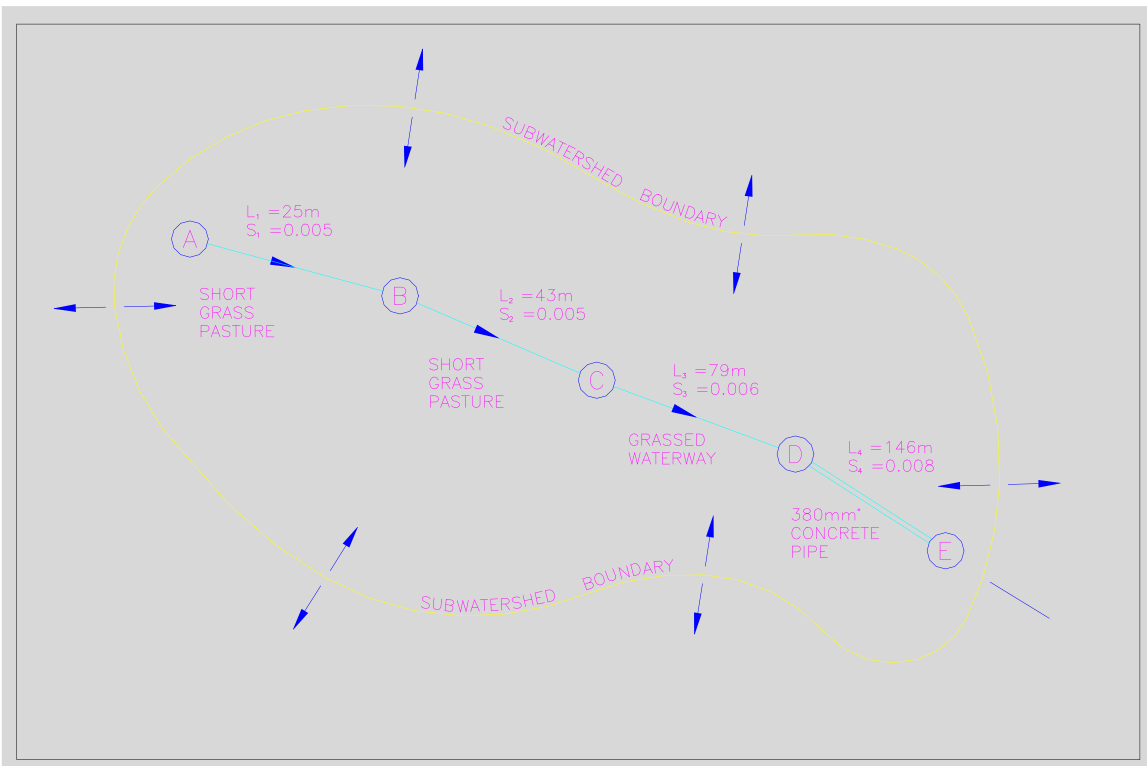
APPENDIX B

Computation of Travel Time (T_t) and Time of Concentration (T_c)

Example B.1

Calculation of Travel Time (T_t) Through a Subwatershed

Figure B.1 Overland Flow Through a Typical Watershed



$$T_t = \frac{Kc}{I^{0.4}} \bullet \left(\frac{nL}{\sqrt{S}} \right)^{0.6} \qquad \text{[B.1]}$$

kinematic wave equation expressed as:

Where:

T_t travel time (min)

n	effective Manning roughness coefficient (see Table B.1)
L	flow length (m)
I	rainfall intensity (mm/hr)
S	slope (m/m)
K_c	coefficient = 6.943

The roughness coefficient expressed in Equation [B.1] is the effective Manning roughness coefficient for sheet flow. The effective roughness coefficient accounts for the effects of raindrop impact, drag, surface irregularities, obstacles, and sediment transport. Table B.1 presents effective Manning roughness coefficients for various surface conditions suitable for use in Equation [B.1].

Table B.1 Effective Manning Roughness Coefficient (n) for Overland Sheet Flow	
Surface Condition	**Effective Manning Roughness Coefficient (*n*)**
Smooth asphalt	0.011
Smooth Concrete	0.012
Ordinary Concrete Lining	0.013
Good Wood	0.014
Brick with Cement Mortar	0.014
Vitrified Clay	0.015
Cast Iron	0.015
Corrugated Metal Pipe (CSP)	0.024
Cement Rubble Surface	0.024
Fallow – no residue	0.05
Cultivated Soils – residue ≤ 20%	0.06
Cultivated Soils – residue > 20%	0.17
Range – natural	0.13
Grass – Short Grass Prairie	0.15
Grass – Dense Grasses	0.24
Grass – Bermuda Grass	0.41
Woods[1] – Light Underbrush	0.40
Woods[1] – Dense Underbrush	0.80

Note: [1]*Only ground cover to a height of approximately 30 mm that impedes overland sheet flow should be considered when selecting the effective Manning roughness coefficient.*

Shallow Concentrated Flow

Shallow concentrated flow normally occurs as sheet flow is concentrated into rills and gullies of increasing proportion. The velocity may be determined by:

$$V = k \cdot \sqrt{S} \qquad [B.2]$$

Where:

V velocity (m/s)
k slope/velocity intercept coefficient (see Table B.2)
S slope, (%)

Table B.2 Slope/Velocity Intercept Coefficient (k) for Shallow Concentrated Flow

Surface Condition	**Slope/Velocity Intercept Coefficient (*k*)**
Forest with Heavy Ground Litter, Meadow	0.076
Woodland, Trash Fallow, Minimum Tillage Cultivation	0.152
Short Grass Pasture	0.213
Cultivated Straight Row	0.274
Nearly Bare and Untilled, Alluvial Fans	0.305
Grassed Waterway	0.457
Unpaved	0.491
Paved, Small Upland Gullies	0.619

Open Channel Flow Velocity and Piped Flow Velocity

Open channel flow and piped flow normally occurs as shallow concentrated flow from rills and gullies is concentrated. The velocity of open channel flow or piped flow may be determined by the Manning equation:

$$V = \frac{1}{n} \cdot R^{\frac{2}{3}} \cdot S^{\frac{1}{2}} \qquad [B.3]$$

Where:

V velocity (m/s)
n Manning roughness coefficient for open channel flow (see Table B.3)
R hydraulic radius (m)
S slope (m/m)

The hydraulic radius (R) presented in Equation [B.4] is defined as the flow area (*A*) divided by the wetted perimeter (*P*) and may be expressed as:

$$R = \frac{A}{P} \qquad [B.4]$$

where:

R hydraulic radius (m)
A flow area (m^2)
P wetted perimeter (m)

Table B.3 Manning Roughness Coefficient (n) *for Open Channel Flow and Piped Flow*

Material	Description	Manning Roughness Coefficient (*n*)
Closed Conduits	Asbestos-Cement Pipe	0.011 to 0.015
	Brick	0.013 to 0.017
	Cast Iron Pipe (Cement Lined)	0.011 to 0.015
Concrete	Concrete (monolithic)	0.012 to 0.014
	Reinforced Concrete Pipe (RCP)	0.011 to 0.015
Corrugated Steel Pipe	Corrugated Metal Pipe (plain)	0.022 to 0.026
	Corrugated Metal Pipe (paved invert)	0.018 to 0.022
	Corrugated Metal Pipe (spun asphalt lined)	0.011 to 0.015
Plastic Pipe PVC/HDPE	Ribbed	
	Plain	0.011 to 0.015
Vitrified Clay	Vitrified Clay Pipe	0.011 to 0.015
	Vitrified Clay Liner Plate	0.013 to 0.017
Lined Channels	Asphalt	0.013 to 0.017
	Brick	0.012 to 0.018
	Concrete	0.011 to 0.020
	Rubble or Rip Rap	0.020 to 0.035
	Vegetal	0.030 to 0.400
Excavated Channels	Earth, straight and uniform	0.020 to 0.030
	Earth, curved and uniform	0.025 to 0.040
	Rock	0.030 to 0.045
	Unmaintained	0.050 to 0.140
Natural Channels	Regular section	0.03 to 0.07
	Irregular section with pools	0.04 to 0.10

Computation of Travel Time (T_t) and Time of Concentration (T_c)

The travel time (T_t) through a subwatershed, or the time of concentration of a subwatershed (T_c), is the sum of the travel times for each individual sequential segment contained within the flow path.

The travel time (T_t) for an individual flow segment of a subwatershed may be determined by:

$$T_t = \frac{L}{60 \cdot V} \quad \text{[B.5]}$$

Where:

T_t travel time for segment *i* (min)
L flow length for segment *i* (m)
V average velocity for segment *i* (m/s)

The travel time (T_t), or the time of concentration (T_c) may be determined by the sum of all the travel times for each segment.

$$T_c = T_t = T_{t1} + T_{t2} + \ldots + T_{tn} \quad \text{[B.6]}$$

Where:

T_c time of concentration (min)
T_t travel time (min)
T_{tn} travel time for flow segment n

Example B.2

Calculation of Travel Time (T_t) Through a Subwatershed

Given: The following flow segment characteristics:

Flow Segment	Length (m)	Slope (m/m)	Segment Description
1	25	0.005	short grass pasture
2	43	0.005	short grass pasture
3	79	0.006	grassed waterway
4	146	0.008	380 mm concrete pipe

Determine The travel time (T_t) for each flow segment, and the travel time (T_t) through the subwatershed for a rainfall intensity (I) of 60 mm/hr.

Step 1: Determine the travel time (T_t) for each flow segment.

Segment 1: The first 25 m of overland flow in the subwatershed occurs as overland sheet flow.

From Table B.1 for short grass pasture, n=0.15.

From Equation B.1

$T_{t1} = (6.943 / 60^{0.4})\ [(0.15 \times 25) / 0.05^{0.5}]^{0.6}$

T_{t1} = 14.6 min

Segment 2: The next 43 m of overland flow in the subwatershed occurs as shallow concentrated flow.

From Table B.2 for short grass pasture, k=0.213.

From Equation B.2

V2 = (0.213) (0.5)0.5

V2 = 0.15 m/s

From Equation B.5

Tt2 = (43) / (60 x 0.15)

Tt2 = 4.8 min

Segment 3: The next 79 m of flow in the subwatershed occurs as shallow concentrated flow.

From Table B.2 for grassed waterway, *k*=0.457.

From Equation B.2

V3 = (0.457) (0.6)0.5

V3 = 0.35 m/s

From Equation B.5

Tt3 = (79) / (60 x 0.35)

Tt3 = 3.7 min

Segment 4: The next 146 m of flow in the subwatershed occurs as piped flow.

From Table B.3 for concrete pipe, *n*=0.013.

From Equation B.4

R = [π x (0.380/2)2] / [2π x (0.380/2]

R = 0.095 m

From Equation B.3

V4 = [1/(0.013)] x (0.095)2/3 x (0.008)1/2

V4 = 1.4 m/s

From Equation B.5

Tt4 = (146) / (60 x 1.4)

Tt4 = 1.7 min

Step 2: Determine the time of concentration (T_c) for the subwatershed.

From Equation B.6

Tc = 14.6 + 4.8 + 3.7 + 1.7

Tc = 24.8 min

APPENDIX C

Provision and Design of Inlet Control Devices (ICD)

Minor storm sewer mains are typically designed to accommodate the 1 in 5 year design event. Catchbasin grate capacity and catchbasin lead capacity are typically designed to accommodate flows in excess of the 1 in 5 year design event.

In a major storm, or any storm event that exceeds the 1 in 5 year design event, catchbasin grates and leads attempt to capture and convey more stormwater runoff to the storm sewerage mains than the mains were originally designed to accommodate. As the excess capacity that is naturally designed into storm sewerage mains is used up, the hydraulic gradeline, or the water surface profile under open channel conditions, elevates and approaches a surcharged condition.

Under surcharged, or pressurized conditions, energy losses due to pipe friction and irregularities at manholes are greatly increased over that of open channel conditions. This phenomena further elevates the hydraulic gradeline. In extreme cases, elevated hydraulic gradelines may backflow into basements resulting in flooding complaints, and may even damage the storm sewerage system.

In order to minimize, or even eliminate, the potential for surcharging in the storm sewerage system, it is necessary to provide a flow control device capable of conveying the 1 in 5 year design flow, yet restrict any additional flow. An inlet control device (ICD) is a flow restriction device designed with this purpose in mind.

Typical ICD configurations are in the form of caps, or plugs designed to fit onto the catchbasin lead, restricting flow from the catchbasin to the storm sewer main. The premise of ICD design is to limit the open area available to flow to a size that will convey only the maximum desired design flow. Given that the ICD may function as a weir, or as an orifice, contingent upon the depth of available head, and that the capacity of the ICD is also contingent upon the depth of available head, proper sizing may be difficult.

For the purposes of design, the ICD should be sized to accommodate the 1 in 5 year design flow under its maximum available head. For the purposed of design, the maximum available head should be considered to be the depth from the top of the catchbasin grate to the ICD plus the additional 150 mm of depth that is allowed to flow in the gutter in a major storm event. It should be noted that restricting flow into the minor storm system and diverting it to the major storm system should be considered in the design and sizing of the major storm system.

A number of proprietary ICD designs and suppliers are available. However, the Consultant may propose an alternative design and sizing complete with supporting calculations, material and construction specifications for consideration.

In the case of a circular ICD design, when the maximum available head (*H*) exceeds 1.5 times the orifice diameter (*D*), the orifice equation may be used to determine the correct orifice diameter for the 1 in 5 year design flow given the maximum available head.

$$Q = C \cdot A \cdot \sqrt{2 \cdot g \cdot (H - r)}$$ [C.1]

Where:

Q	capacity (m^3/s)
C	discharge coefficient (*C*=0.6)
A	open area (m^2)
g	gravitational acceleration (9.806 m/s^2)
H	head above invert (m)
r	radius (m)