Manuel de critères de conception pour les services municipaux

....

Design Criteria Manual for Municipal Services

JANVIER / JANUARY

2022

DISCLAIMER

The Town of Shediac would like to acknowledge the cooperation of the City of Moncton for providing the Town with an electronic copy of their document to facilitate the creation of this document.

The purpose of this document is to provide guidance for designers in the design of standard municipal services offering an acceptable level of service while constructing sustainable infrastructure to be owned and operated by the Town of Shediac.

The material presented in this text was carefully researched and presented. However, no warranty expressed or implied is made on the accuracy of the contents or their extraction from reference to publications; nor shall the fact of distribution constitute responsibility by the Town of Shediac or any researchers or contributors 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, rather it is intended to standardize the materials, design criteria, and method of construction to be utilized in the installation of standard municipal services.

The design of Municipal Services, when submitted to the Town of Shediac for review and acceptance, must bear the seal of a Professional Engineer licenced or registered with the Association of Professional Engineers and Geoscientists (APEGNB).

The acceptance by the Town of Shediac of the design of proposed municipal service systems shall not relieve the Consultant of the responsibility of proper design, and hence the Consultant will retain full responsibility and liability for their work as a Professional Engineer.

TABLE OF CONTENTS

PAGE

LIST OF FIGURES

PAGE

LIST OF TABLES

1 INTRODUCTION

The guidelines, recommendations, and design standards presented herein have been prepared for use as a guideline of:

- minimum standards to be met in the design and construction of standard municipal services within the Town of Shediac,
- limiting values for items upon which an evaluation of such designs will be made by the reviewing authority,
- establishment, as far as practicable, of uniformity of design and construction within the Town of Shediac.

A complete documentation of all parameters relating to the design and construction of municipal services is beyond the scope of this manual. 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 Shediac.

Standard municipal services covered in this manual include water distribution systems and storm drainage systems. Sanitary sewerage systems are as per the Greater Shediac Sewerage Commission.

The purpose of this document is to provide guidance for designers in the design of standard municipal services offering an acceptable level of service while constructing sustainable infrastructure to be owned and operated by the Town of Shediac. The design of standard municipal services, when submitted to the Town of Shediac must bear the seal of a Professional Engineer licensed or registered to practice with the New Brunswick Association of Professional Engineers and Geoscientists.

This document is not intended to eliminate the necessity for detailed design by a professional engineer, rather it is intended to standardize the materials, design criteria, and method of construction to be utilized in the installation of standard municipal services. The design of Municipal Services, when submitted to the Town of Shediac for review and acceptance, must bear the seal of a Professional Engineer licenced or registered with the Association of Professional Engineers and Geoscientists of New Brunswick (APEGNB).

Further, it is not the intention of the Town of Shediac to stifle innovation. Where, in the judgement of the Consultant, variations from this document are justified or required, and where the Consultant can show that alternate approaches can produce the desired results, such approaches will be considered for approval. In considering requests for variations from these design criteria, the Consultant shall take into consideration such factors as safety, nuisance, system maintenance, operational costs, life cycle costs, environmental issues, natural topography, configuration of the bulk land, etc. Designs will be accompanied by statements of certification by the Consultant to the effect that designs have been completed in accordance with these guidelines. Where the designer uses standards other than those outlined in this document, they shall clearly indicate in all appropriate documents and plans those areas of difference. The acceptance by the Town of Shediac of the design of proposed municipal service systems shall not relieve the Consultant of the responsibility of proper design, and hence the Consultant will retain full responsibility and liability for their work as a Professional Engineer.

In any case where these specifications require expansion or clarification, the latest revisions of the following documents may be used for reference:

- American Water Works Association Standards

The experience of other agencies, authorities, and commissions have been freely referred to in the preparation of this manual. The following is a listing of reference documents:

- Manual of Water Supply Practices, American Water Works Association
- AWWA Standards, American Water Works Association
- Manual of Practice No. 9, Water Pollution Control Federation
- Recommended Standards for Water and Sewer Projects, Association of Professional Engineers of New Brunswick
- Standards for Sewage Works, Ontario Water Resources Commission

- Recommended Standards for Water Works, Great Lakes Upper Mississippi River Board of State Public Health and Environmental Managers
- NBDELG Guidelines for the Collection and Treatment of Wastewater
- Halifax County Municipality Municipal Service Systems General Specification

These documents have been carefully reviewed and those standards and guidelines appropriate for conditions in the Town of Shediac have been adopted.

Other Town of Shediac Publications related to Subdivision Development, Site Development and Acceptable Construction Practices include the following:

- Subdivision Development – Procedures, Standards and Guidelines
- Standard Municipal Specifications for Municipal Services

For works relating to sanitary sewer:

- Greater Shediac Sewerage Commission Standard Specifications

2 DEFINITION OF TERMS

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

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

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.

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 Municipal Operations appointed by Council to oversee all public works of the Town of Shediac Municipal Operations Department, or their designated representative.

Feeder Main: A large diameter watermain which typically receives flow from transmission mains or from pressure control facilities, which supplies water to several small diameter branch mains. The feeder main provides a significant flow capacity to a large area.

Floodplain: The relatively flat or lowland area adjacent to a river, stream, watercourse, ocean, lake, or other body of water which 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) The quantity of ground water which enters into a sanitary sewerage system through cracks and defective joints.
(3) The entrance of water from the ground into a sewer or drain through breaks, defective joints, or porous walls.
(4) 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 $100^{(+20\%)}$ years (1% probability of being equalled or exceeded in any year).

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 $100^{(+20\%)}$ 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.

Municipal Service Systems: Municipal service systems include all sanitary sewerage systems, storm drainage systems, water distribution systems, streets, sidewalks and miscellaneous appurtenances within the Town of Shediac which are owned, operated, and maintained by the Town.

NBDELG: The central office of the New Brunswick Department of Environment and Local Government.

NBDTI: The central office of the New Brunswick Department of Transportation and Infrastructure.

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 member or license to practice 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 which reaches stream channels.

Sanitary Service Lateral: A pipe that conveys sanitary sewage from the inner side of the wall through which the pipe exits the building to the sanitary sewer.

Sanitary Sewage: The wastewater from a community consisting of liquid conveying solids from residential, commercial, and industrial development excluding stormwater inflow and ground water infiltration.

Sanitary Sewerage System: A system receiving, conveying, and controlling wastewater discharge from residential, commercial, and industrial sources. Such systems consist of mainline sewers, lateral sewers, service lateral lines, underground storage chambers, pumping facilities, and treatment facilities.

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: That part of the precipitation which is concentrated and conveyed as overland flow.

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.

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.

Town: The Office of the Director of Municipal Operations appointed by Council to oversee all public works of the Town of Shediac Municipal Operations Department, or their designated representative.

Trench Drainage Relief System: A pipe system designed to collect groundwater from sewerage main trenches and lower the hydraulic gradeline of the groundwater below the invert of the sewerage main.

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 Environment Act – Revised Statutes of New Brunswick.

Water Distribution System: A system receiving, conveying, and controlling potable water for residential, commercial, industrial, and fire protection demands. Such systems consist of transmission mains, feeder mains, distribution mains, lateral lines, fittings and appurtenances, pumping facilities, treatment facilities, pressure control facilities, and storage facilities.

Water Service Lateral: A pipe that conveys water from a watermain to the inner side of the wall through which the pipe enters the building.

3 SUBMISSION REQUIREMENTS

3.1 Scope

The submission requirements presented in this section outline the requirements of the Town of Shediac for the purposes of the review of engineering design only. This section pertains to subdividers who have already obtained *Tentative Subdivision Plan Approval*.

A subdivider proposing to subdivide an area of land must submit to the Town of Shediac for approval all plans, design briefs, and supplementary calculations required by that office, as outlined herein.

Additional copies of any plans, technical briefs, and supplementary calculations as deemed necessary by the Town of Shediac for any government department, public utility, or Crown Corporation may be required.

Approval by the Town of Shediac does not relieve the Consultant of the responsibility of proper design, nor does it imply that the Town of Shediac has checked the plans, technical briefs, and supplementary calculations for compliance with this document.

3.2 Municipal Infrastructure

If the subdivision requires the installation or upgrading of any municipal infrastructure, the following additional information must be provided.

Two (2) copies of the Sanitary Schematic Servicing Plan prepared in accordance with Subsection 3.6. (to be submitted to the Greater Shediac Sewerage Commission)

Two (2) copies of the Water Distribution Schematic Servicing Plan prepared in accordance with Subsection 3.7.

Two (2) copies of the Storm Schematic Servicing Plan prepared in accordance with Subsection 3.8.

Two (2) copies of the Engineering Design Drawings prepared in accordance with Subsection 3.9 through Subsection 3.12.

Two (2) copies of the Grading and Drainage Plans prepared in accordance with Subsection 3.14.

Additional copies of any plans, design briefs, or supplementary calculations as deemed necessary by the Town of Shediac for any government department, public utility, or Crown Corporation.

A digital coordinate database of all key infrastructure to the Town of Shediac at the construction plan approval phase. The coordinate database will contain point number, northing, easting, elevation, and description information in an electronic format suitable for updates to the geographic information System (GIS).

Acceptable electronic formats include space-delimited ASCII files, tab-delimited ASCII files, or comma-delimited ASCII files with the following electronic structure.

Point Number, Northing, Easting, Elevation, Description

If abbreviated feature codes are used, a feature code legend with full descriptions must also be provided.

Key features to be located and included in the coordinate database include, but are not limited to, the following:
manhole cover locations
catchbasin and/or sluicebox grate locations
valve box locations
curb stop locations
chamber cover locations

hydrant locations

3.3 Subdivision Plans

The following information must be submitted in support of the Application for Subdivision Agreement:

A copy of any overall Master Plan outlining the long term development scheme, if available and deemed necessary;

A copy of the Tentative Subdivision Plan as approved by the Southeast Regional Service Commission and the Town of Shediac to be conforming to the *Community Planning Act and Regulations*. Proof of application for said approval may be acceptable.

3.4 Drawing Requirements

3.4.1 General

All Schematic Servicing Plans, Engineering Design Drawings, Grading and Drainage Plans, and As-Built Drawings 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).

3.4.2 Units

All Schematic Servicing Plans, Engineering Design Drawings, Grading Plans, and As-Built Drawings must be submitted in SI units on standard size drawing sheets.

3.5 Schematic Servicing Plans

3.5.1 Scale

Wherever possible, Schematic Servicing Plans are to be drafted in one of the following standard metric ratios:

1 : 500
1 : 1,000
1 : 2,000

The Schematic Servicing Plan scale, and a graphic bar scale are to be provided on all plans.

3.6 Sanitary Schematic Servicing Plan

As per the requirements of the Greater Shediac Sewerage Commission.

3.7 Water Distribution Schematic Servicing Plan

Water Distribution Schematic Servicing Plans, in addition to the requirements of Subsection 3.4 and Subsection 3.5, must include the following in either graphic and/or tabular form:

- the location of the subdivision within the total topographic drainage area;
- site layout including proposed streets, lots and approximate location of proposed structures;
- pre-development contours at an interval not exceeding 1 m;

- hydraulic grade line, or pressure zone;
- location and layout of the water distribution system including hydrants and hydrant laterals, valves, chambers, storage facilities, pumping facilities, and water main indicating pipe material, and diameter;
- location of connections to existing systems;
- any additional information deemed necessary by the Town of Shediac.

3.7.1 Supplementary Calculations

In addition to the above requirements, the applicant must submit to the Town of Shediac computational sheets, and related model output used to determine:

- minimum residual pressure;
- minimum residual pressure under fire flow conditions.

3.8 Storm Schematic Servicing Plan

Storm Schematic Servicing Plans, in addition to the requirements of Subsection 3.4 and Subsection 3.5, must include the following in either graphic and/or tabular form:

- the location of the subdivision within the total topographic drainage area;
- 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 and wetlands indicating direction of flow;

- location and layout of the minor storm drainage system including manholes, catchbasins, and storm sewer indicating pipe material, diameter, slope, and direction of flow;

- boundaries of catchment and subcatchment areas tributary to each set of catchbasins, and/or pipes indicating the area, runoff coefficients;

- size and location of any proposed post-development storage facilities;

- predominant direction of surface flow including the flow route of the major storm drainage system;

- location of outfalls, or connection to existing systems, for both the minor storm drainage system, and the major storm drainage system;

- any additional information deemed necessary by the Town of Shediac.

3.8.1 Supplementary Calculations

In addition to the above requirements, the applicant must submit to the Town of Shediac computational sheets, and related model output used to determine:

- Manning's capacity analysis
- hydraulic grade line analysis
- major drain depth and spread of flow

3.9 Engineering Design Drawings

3.9.1 Scale

Wherever possible, Engineering Design Drawings are to be drafted in the following standard metric ratios:

horizontal	1 : 500
vertical	1 : 50
details	1 : 50, 1 : 25, 1 : 10

The horizontal and vertical scale, and a graphic bar scale are to be provided on all plans.

3.9.2 Composition

Engineering Design Drawings are to be composed of the following components:

- plan(s)
- profile(s)
- cross section(s) as required
- detail(s) as required

3.10 Engineering Design Plans

The plan component of the Engineering Design Drawings, in addition to the requirements of Subsection 3.4 and Subsection 3.9, must include the following:

- plans are to be drawn with chainage increasing from left to right regardless of north arrow orientation with the plan and profile orientation being in agreement

- the street name, classification and its dimension;
- the boundary lines of each lot;
- centreline chainage along streets and easements including:
  - 20m station labels;
  - 10m station ticks;
  - Street and easement intersection locations;
  - beginning and ending of all horizontal curves;
  - beginning and ending of all vertical curves.
- any control monuments and bench marks that are within the coverage of the plan, or used to reference the plan;
- limits of the street indicating proposed street name, classification and dimension;
- the existing and proposed location of the sanitary sewerage system, the storm drainage system, the water distribution system, and all appurtenances;
- the existing and proposed location of sanitary, storm, and water service laterals from the mainline to the property line;
- the existing and proposed location of all other municipal services and their appurtenances including underground natural gas, power, cable, and telecommunications systems;
- the existing and proposed location of all curbs, gutters, and sidewalks;
- the existing and proposed location of all catchbasins, inlet pipes, and outlet pipes;
- the existing and proposed utility poles and street lighting system;

- at least two points of known chainage on the street centreline are to be related to the New Brunswick Coordinate Control System.

3.11 Engineering Design Profiles

The profile component of the Engineering Design Drawings, in addition to the requirements of Subsection 3.4 and Subsection 3.9, must include the following:

- profiles are to be drawn with chainage increasing from left to right regardless of north arrow orientation with the profile and plan orientation being in agreement

- existing ground profile along centreline for all streets and easements;

- proposed finished ground profile along centreline for all streets and easements;

- the sanitary sewerage system, the storm drainage system, the water distribution system, and all appurtenances indicating material, diameter, length, and slope where applicable;

- all other municipal services and their appurtenances including underground natural gas, power, cable, and telecommunications systems;

- the soil profile and water table where they may affect proposed services

- the location of bore holes, or test pits, if required by the Town of Shediac in order to determine appropriate type of bedding for burred municipal infrastructure.

3.12 Engineering Design Cross Sections (As Required)

The cross section component of the Engineering Design Drawings, in addition to the requirements of Subsection 3.4 and Subsection 3.9, must include the following:

- existing ground
- proposed finished ground
- existing and proposed services

In the case of urban development, or development involving full curb and gutter construction, a typical cross section meeting the above criteria must be provided, or referenced.

In the case of rural development, or development involving open ditch construction, cross sections at 20m intervals meeting the above criteria must be provided.

3.13 Supplementary Calculations

In addition to the above requirements, the subdivider must submit to the Town of Shediac the following:

- construction cost estimates in the standard format used by the Town of Shediac contract documents.

3.14 Grading and Drainage Plans

3.14.1 Scale

Wherever possible, Grading and Drainage Plans are to be drafted in the following standard metric ratios:

1 : 250
1 : 500

The Grading and Drainage Plan scale, and a graphic bar scale are to be provided on all plans.

3.14.2 General

Grading and Drainage Plans, in addition to the requirements of Subsection 3.4, must include the following:

- site layout including proposed streets, lots and approximate location of proposed structures;
- pre-development contours at an interval not exceeding 1 m;
- proposed landscaping features on each lot including driveways, parking lots, and grassed areas;
- proposed finished grade elevations at the following locations:
- centreline of streets
- corners of all lots and easements
- proposed foundation wall elevation
- minimum basement floor elevation

- pattern and direction of post-development surface drainage including lots, swales, and major storm drainage system;
- location and layout of the minor storm drainage system including manholes, catchbasins, and storm sewer.

3.15 Sedimentation and Erosion Control Plans

3.15.1 Introduction

Erosion is the removal of soil by the action of wind, rainfall and surface runoff. The deposition of the eroded particles is called sedimentation. Construction activities can accelerate erosion dramatically, mainly by exposing large areas of soil to rain and running water. If runoff is not properly controlled and treated, the outcome can lead to sedimentation of nearby watercourses and degradation of fish and wildlife habitat.

Drainage and erosion control should be considered in the initial planning phase of a project and an erosion and sediment control plan should be developed before any earth-moving activity takes place. The intent of the erosion and sediment control plan is to reduce the impact of construction on water quality.

Erosion is primarily affected by four factors: climate, soil type, topography and vegetation. The selection of the best soil erosion and sediment control measures for your site will be based on the characteristics of the site and the nature of the construction activity. In order to select the right control measures, a site investigation must be conducted to clearly identify existing conditions. It is important that the sediment and erosion control plan be designed specifically for the subject site.

A comprehensive erosion and sediment control plan should first focus on preventing erosion by minimizing the disturbed area, stabilizing exposed soil and re-vegetating slopes. The next thing to consider is sediment control measures, which focus on intercepting sediment-laden runoff that has escaped the erosion control measures. Sediment control measures include silt fences, check dams, sediment traps and sediment basins.

The Fisheries Act prohibits the deposit or release of a deleterious substance, including sediments, to fish-bearing waters or any place where the deleterious substance may enter such water. Implementing an erosion and sediment control plan is good engineering practice and it will also reduce environmental risk and liability.

The following sections describe the information which should be included in an erosion and sediment control plan, the format in which the information should be presented, best management practices, a list of accepted erosion and sediment control measures, monitoring and maintenance requirements and runoff water quality requirements.

3.15.2 The Erosion And Sediment Control Plan Format

The erosion and sediment control plan must be an integral part of the site development plan and prescribe all the necessary steps, including scheduling, to assure proper erosion and sediment control during all phases of construction. The plan should include a narrative report and a site plan.

1) The narrative report must include:

- A project description;
- Scheduling of major land-disturbing activities;
- A brief analysis of local drainage factors and potential problems posed by stormwater runoff on downstream areas;
- A description of erosion and sediment control measures to be used during construction (purpose, type, location, dimensions and design considerations);
- A description of the inspection and maintenance program and schedule.

2) The erosion and sediment control plan should be an integral part of any site plan, grading plan or drainage plan or construction drawing and must include:

- Topographic features including environmentally sensitive areas located in proximity of the project area such as streams, lakes, ponds, wetlands, drainage ditches, flood plains and wells;
- Available soil information (such as major soil types and depth);
- The proposed alteration of the area including project boundary limits, limits of clearing and grubbing, areas of cut and fill, proposed slopes and location of stockpiles and excess fill;
- Erosion and sediment control measures to be used during construction (type, location, dimensions and design considerations).

3.15.3 Erosion And Sediment Control Best Management Practices

The following principles should be utilized as much as possible on all construction projects.

1) Minimize the amount of disturbed soil and limit the time the disturbed area is exposed.

- Adjust the activity to natural site features (topography, soils, waterways, and natural vegetation).
- When possible, minimize the grade change on the site, which will decrease the amount of disturbed soil and the amount of erosion that can occur.
- Only clear and grub the portions of the site where it is necessary for construction and retain existing vegetation wherever feasible.
- When feasible, stage the project so that only a small portion of the site will be disturbed at any one time.
- If there are disturbed areas of the site that will not be re-disturbed for a long period, then these areas should be stabilized with temporary seeding, mulching or matting.

2) Prevent offsite runoff from flowing across disturbed areas.

- Divert surface runoff from the construction site and exposed areas using dikes, berms, drainage swales or ditches. The method of choice depends on the size of the drainage area and the steepness of the slope (further discussed in the Drainage and Sediment Control section).

3) Reduce the velocity of the runoff traveling across the site.

- Steeper slopes result in faster moving runoff, which results in greater erosion. Grade change should be as gradual as possible.
- Cover erodible soils and sloped areas with mulch, vegetation, matting or riprap. Vegetative covers increase the surface roughness, which reduces the velocity of the surface runoff.
- Runoff concentrated into swales or channels can be slowed by reducing the slope, increasing the channel width, constructing check dams and by establishing a vegetative cover.

4) Remove the sediment from onsite runoff before it leaves the site.

- Since it may take several weeks to establish a grass cover to control erosion, it is important that measures which can remove sediment from runoff before it flows off of the construction site be installed.

- Sediment control devices include check dams, gravel filter berms, sediment control fences, straw bale filter barriers, sediment traps and sediment control ponds. The selection of the best measure depends on a number of criteria including the size of the disturbed area, the type of runoff (concentrated or sheet-flow) and the volume of runoff.

- The sediment control devices must remain in place until permanent vegetation has been established or the site is otherwise stabilized.

5) Develop and implement a thorough monitoring and maintenance program.

- Conduct a routine check, including after each rain event, to ensure that all control measures are working properly for the duration of the project.
- Additional preparation may be required if heavy rain is predicted.
- Keep an inventory of erosion and sediment control materials throughout construction.

3.15.4 Selection Of Erosion And Sediment Control Measures

Both stabilization and drainage control measures can be used to control erosion and sedimentation. Stabilization measures are used to stabilize the soil to prevent erosion. Structural drainage and sediment control measures are implemented to trap sediment-laden runoff before it leaves the site. A combination of both erosion and sediment control measures should be implemented for the plan to be effective. The selection of the best combination of measures is site specific and a site investigation must be conducted before selecting appropriate measures.

3.15.5 Surface Stabilization And Erosion Control

Surface stabilization measures will help prevent erosion of soils and should therefore be given primary attention. The following are some common accepted surface stabilization and erosion control measures:

3.15.5.1 Surface Roughening

Surface roughening is a temporary measure and it can help reduce runoff velocity, increase infiltration and trap sediment. It helps protect exposed soil until a vegetative cover is established and should be done as soon as possible after existing vegetation has been removed.

The soil surface can be roughened by the creation of horizontal grooves or depressions that run parallel to the contour of the land (can be created by dozer treads or other heavy equipment).

Can be used in combination with other stabilization measures such as seeding and mulching.

Re-vegetation

3.15.5.2 Seeding

Seeding can be a temporary or long-term erosion control measure. An immediate plant cover will not be established, unless hydroseeding is conducted.

Seeding is most appropriate in flat areas and on slopes less than 3H:1V. It should take place as soon as possible after the land has been disturbed.

The surface soil must be loosened for water to infiltrate and roots to penetrate. Seedbed preparation may require the application of a fertilizer.

The selection of vegetation mixture is dependant upon site conditions. Grasses and legumes are commonly used in seed mixtures.

Mulch should be used as it helps conserve moisture and increases the odds of successful re-vegetation.

3.15.5.3 Hydroseeding

Hydroseeding, where a slurry of seed, fertilizer, mulch, binder and water is sprayed on a prepared surface, is an acceptable process.

Hydroseeding should not be applied to compacted soils, eroded surfaces or areas where ponding has occurred. The soil should be loosened and free of roots, branches, weeds, rocks, ruts and ridges.

Hydroseeding should not be neglected until the end of a project. It should be completed in stages as construction progresses. It should not be conducted during periods of heavy rain, strong winds, or immediately prior to forecasted heavy rain.

3.15.5.4 Sodding

Sodding is appropriate for graded areas where a permanent cover is required.
Will provide immediate cover and erosion control.

Sodding should be done as soon as possible after the area has been cleared and should include a prepared topsoil bed.

The sod should be rolled out horizontally across the slope with joints staggered.
Sod should not be installed during very hot or wet weather or on frozen ground.

3.15.5.5 Mulching

Mulch, commonly consisting of hay or straw, is applied to the ground surface as a temporary erosion prevention measure. It also aids in plant growth and re-vegetation as it helps conserve moisture.

Mulching can provide immediate, effective, and inexpensive erosion control.
Mulching can be used together with seeding or planting. Straw is the mulch most commonly used in conjunction with seeding.

Mulch can be applied by hand or with a mulch blower.
A tackifier, which is a bonding agent that helps secure the mulch to the soil, may be applied with the mulch. The supplier should be consulted for the application rate and ratio.

On steep slopes and critical areas such as waterways, mulch matting should be used with netting or anchoring to hold it in place.

3.15.5.6 Matting

Matting or erosion control blankets are used to protect slope surfaces, channels or newly seeded soil from eroding. Erosion control blankets are commonly made of mulch, wood fibre or synthetics. The selection of the mat is dependent upon the availability and the length of time protection is required.

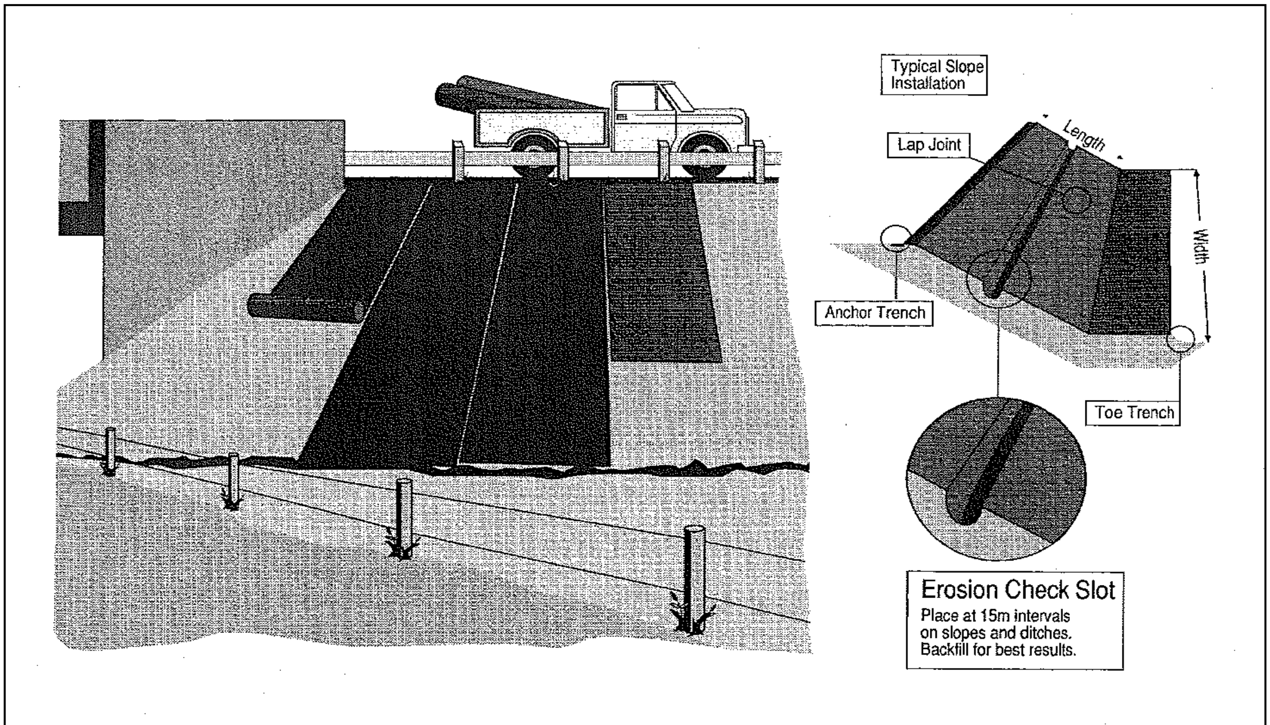
Most applicable for steep slopes, generally greater than 3H:1V, and where high velocity runoff or severe erosion problems are anticipated.

The effectiveness of matting increases when used in conjunction with hydroseeding or mulching. It provides protection against surface runoff, allowing vegetation to properly establish and preventing washing away of seeds.

The ground surface should be prepared, graded and large rocks or debris removed. It is important that the mat be in continuous contact with the underlying soil.
The following are some important installation guidelines:

- Fertilize and seed the area as required.
- Lay out the mats starting from the up-slope end of the site. The adjacent edges of adjoining mats shall be overlapped by a minimum of 10 cm .
- Using U-shaped wire staples, staple the upper upslope edge of the mat into a 15 cm deep trench. Then backfill and firmly pack the trench.

- If two mat lengths are used end-to-end, the down-slope mat should be overlapped a minimum of 10 cm by the up-slope length. The down-slope mat should be stapled into a trench.
- Staples should be placed 45 cm apart along overlaps and 60 cm apart along outer edges, making sure the mat is in contact with the soil.
- Erosion check slots shall be made in highly erodible areas or where slopes exceed 4H:1V to prevent water from accumulating underneath the mat. On slopes more than 15m long, there should be an erosion check slot at the midpoint. On slopes and ditches more than 30m long, there should be a check slot at 15m intervals. The check slots are trenches about 100 mm deep and 100 mm wide dug across the slope or ditch.
- Consider installing a diversion ditch at the top of the slope to further control the amount of stormwater that may flow over an area.



Source: Nova Scotia Department of the Environment, Erosion and Sedimentation Control Handbook for Construction Sites

3.15.5.7 Geotextiles

A geotextile, another form of erosion protection blanket, is a porous filter fabric, usually made from synthetic materials.

Geotextiles can be used to stabilize channel floors or to protect seeding on planted slopes until they become established. It can also be used to separate soil and riprap to prevent the soil from being eroded from beneath the riprap.

3.15.5.8 Rock Riprap

Riprap is typically used on long steep slopes where it is difficult to establish vegetation due to high flow and surface runoff velocities. It can also be used to provide stream bank protection where vegetation alone is insufficient to prevent erosion.

The stone gradation should be mixed so that voids between large stones are filled with smaller stones. The predominant stone size should be determined based upon the overland flow velocity.

Filter fabric (geotextile) should be used to prevent fines from being washed out from underlying soil. To protect the fabric a layer of coarse gravel can be placed on top of the fabric, below the riprap.

Riprap should be applied at a thickness of at least 1.5 times the maximum stone size and not less than 30 cm thick.

3.15.5.9 Buffer Zones

A buffer zone is a strip of dense vegetation that is used to minimize the erosion potential. They are often used to delineate disturbed areas, sensitive areas and property boundaries and to protect stream banks. It is normally used as a temporary measure where the area has not been finally graded.

The buffer zone can be an area of natural vegetation that is left undisturbed during construction or it can be newly planted or seeded.

The buffer strip should be wider for steeper slopes or areas exhibiting excessive runoff.

Vegetation strips should be oriented perpendicular to the flow direction.

The selection of vegetation depends on the site conditions and the intended use of the buffer strip. May consist of grasses, legumes, shrubs and trees.

3.15.6 Drainage And Sediment Control Structures

Runoff, which passes over disturbed soil, should pass through sediment control structures before it flows off of the construction site. To remove sediments from sheet-flow run-off, a filtration device such as a sediment control fence should be installed on the perimeter of the disturbed area. For concentrated flow, a diversion device such as a drainage swale or dike should be constructed and carry the runoff to a sediment basin or sediment trap. Inlet protection for catch basins and curb inlets, which receive flow from a disturbed area, should be constructed to remove the sediments from the runoff before it flows into the inlet. The following are some common sediment control measures:

3.15.6.1 Earth Dike

An earth dike or interceptor dike is a ridge or ridge and channel combination used to divert upslope runoff from construction areas towards sediment basins or sediment traps. They can also be constructed near the perimeter of the construction area to prevent sediment-laden runoff from leaving the site.

The dike can be constructed with compacted soil and stone, riprap, or vegetation.

3.15.6.2 Drainage Swale

Often referred to as interceptor swale, interceptor ditch, diversion channel or diversion ditch. The swale can be parabolic, V-shaped or trapezoidal.

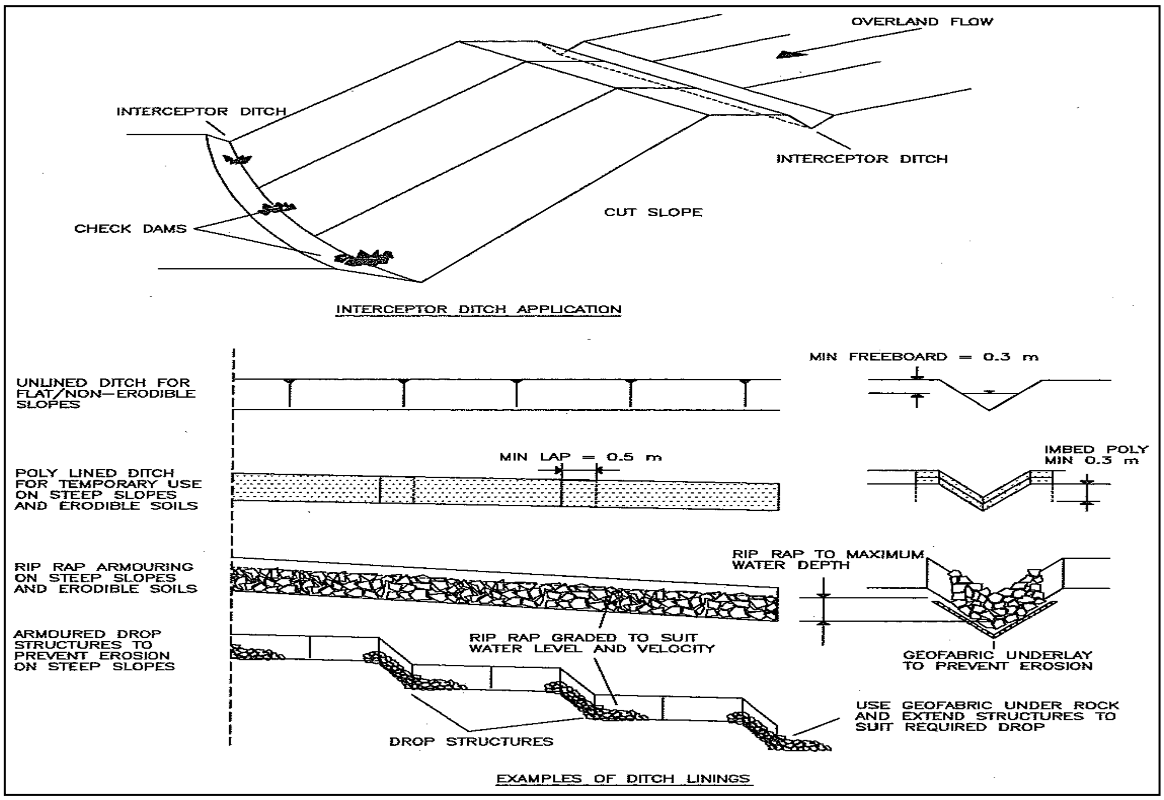
They are used to reduce slope lengths and to intercept and divert water away from construction sites or other erodible areas to a suitable outlet point such as a sediment trap or sediment control pond. They are usually built around the perimeter of the site or along the upslope perimeter of a disturbed area.

They should be built before any major soil disturbing activity takes place on site.

Depending on the soil type and the velocity and volume of the anticipated runoff, it may be necessary to line the swale with a geotextile and/or stabilize the bottom and sides of the channel with vegetation, rock or other type of stabilization. If the soil is silt, sand, sand and gravel or organic, it is recommended to line the swale with polyethylene or other geotextile and construct a number of check dams within it. Bedrock or hard glacial till subgrade can remain unlined. Steep gradient and/or swales carrying a large volume of water may require full rock armouring to design water levels to prevent bank erosion.

Grassed swales are broad, shallow, gently-sloping channels stabilized by suitable vegetation, which can increase infiltration of runoff and sediment removal. Until turf becomes established it will be necessary either to (i) divert runoff via an alternative route (ii) line the channel with a temporary protective lining, and mulch the shoulders thoroughly, or (iii) lay sod over the channel.

There should be no dips or low points in the swale where storm water can collect.



Source: Fisheries and Oceans Canada, Land Development Guidelines for the Protection of Aquatic Habitat

3.15.6.3 Gravel or Stone Filter Berm

A filter berm is a temporary ridge constructed of loose gravel, stone, or crushed rock. It slows and filters flow, diverting it from an exposed traffic area to a stabilized outlet.

This method is appropriate where roads and other right-of-ways under construction accommodate vehicular traffic.

Berms should only be used in gently sloping areas. The spacing of the berms will depend on the steepness of the slope. They should be placed closer together as the slope increases.

Berm material must be well-graded gravel or crushed rock.

3.15.6.4 Sediment Control Fences

A sediment control fence, commonly referred to as silt fence or filter fabric barrier, is used to remove sediment from overland sheet flow runoff. It is not intended to handle concentrated channel flow or high velocities.

Sediment fences are installed perpendicular to the flow to intercept runoff, trapping the sediment. A sediment fence should be used in the following locations:

(i) To delineate buffer zones;
(ii) Along the contours of exposed slopes;
(iii) At the downslope perimeter of cut or fill slopes or disturbed areas;
(iv) Adjacent to streams and along the bank of a watercourse;
(v) At the outer boundary of the work area.

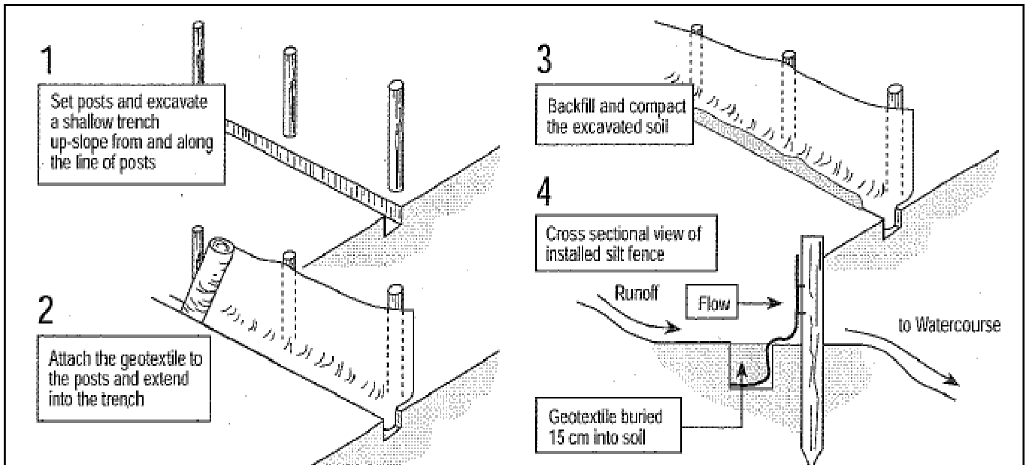
The fence should be erected before there is any soil disturbed on the site.

Should be used where the size of the drainage area is not more than 0.1 ha/30m of silt fence length or in small swales where 1 ha is the maximum contributing drainage area.

Prefabricated sediment control fences shall be installed as per the manufacturer's instructions.

The following are some sediment control fence installation guidelines:

- The geotextile fabric shall be erected to a height of approximately 0.75m above the ground surface (so that at least 0.15m is left as a bottom flap for burying) and secured to wood or steel posts.
- Reinforcement of the fabric, using a wire fence, may be necessary.
- Support posts should not be over 2.5m apart. Extra strength filter fabric may be used without wire fence backing if posts are not over 2.0m apart.
- Fabric joints should be lapped at least 0.15m and stapled. The filter fabric should be stapled to the upstream side of the wooden stakes.
- The lower edge of the fence should be buried in a trench at least 0.15m to 0.30m deep and covered with backfill to prevent flow under the fence.
- The sediment control fence should be inspected frequently, especially prior to and after rain events. Sediment should be removed when it reaches about half of the height of the fence, and shall be disposed of at a location at least 30m from any watercourse and such that it cannot wash into a watercourse.



Silt Fence Construction

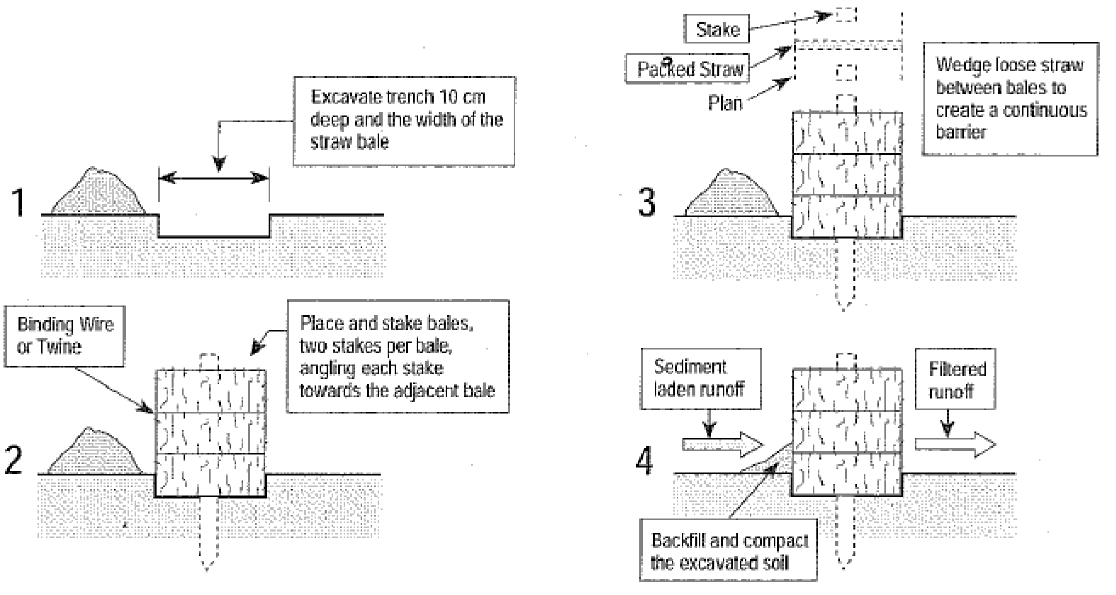
Source: Government of New Brunswick, Department of the Environment, Watercourse Alteration Technical Guidelines

3.15.6.5 Straw Bale Filter Barriers

Straw bale barriers can be placed around the downslope perimeter of a disturbed area or along the bank of a watercourse in order to intercept runoff, trapping the sediment before it reaches a watercourse.
They are a short-term measure and only effective to treat runoff from small drainage areas.

They should be bound with wire or string, placed lengthwise in a trench, staked, and backfilled. There should be at least 2 stakes per bale. The first stake in each bale should be driven toward the previously laid bale to force the bales together.

Straw bale barriers should be checked regularly and immediately after each rainfall. Straw bales can deteriorate in 30 to 60 days. Sediment control fences are stronger and have a higher filtering capacity than straw bale barriers.



Cross sectional view of Straw Bale Barrier Installation

Source: Government of New Brunswick, Department of the Environment, Watercourse Alteration Technical Guidelines

3.15.6.6 Check Dams

A check dam is a small dam constructed across a drainage ditch, swale or channel. It is used to trap sediments by reducing the flow velocity and allowing sediments to settle out before discharge to a watercourse, to minimize channel scour and to hold moisture in underlying soil, thereby facilitating the establishment of vegetation.

The drainage area of the ditch or swale should not be greater than 4 hectares (10 acres). The check dams should be installed before drainage is allowed to flow through the ditch.

Several check dams, not over 40 cm high, are preferable to a few larger dams. Check dams should be placed between 15 to 200 metres apart depending on the slope of the ditch and erodibility of the soil. The top of the check dam should be as high as the base of the one upstream.

The center of the dam should be at least 15 cm lower than the ends of the dam. This can be accomplished with a notch at the center of the dam.

Each end of the dam should be risen by 45 cm or more to protect the bank.

A protective apron should be placed at the foot of the dam, extending 1m beyond the main spillway and on both banks of the ditch.

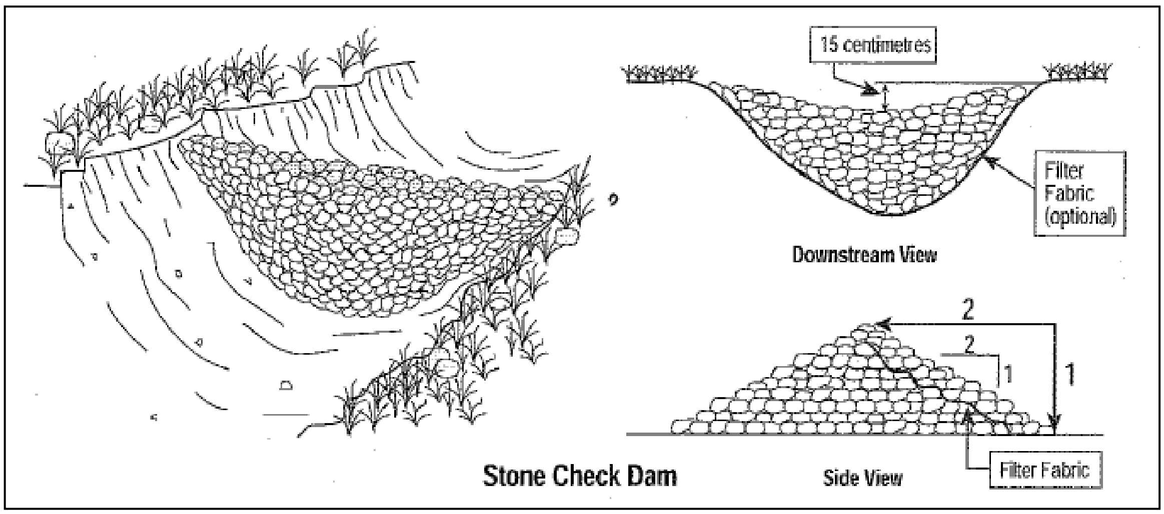
A small area should be excavated just upstream of the check dam to provide some capacity for trapping sediment.

Regular inspections are necessary to ensure that sediment does not accumulate to an elevation of more than half of the height of the dam at which point the accumulated sediment should be removed.
The type of check dam used will depend on the volume and velocity of the runoff, the required life expectancy of the dam and on whether the check dam is to be temporary or permanent.

(i) Stone Check Dams

- Used in ditches of low to moderate slope (1-8%), having a small drainage area.
- The size of stone should be selected base on the anticipated velocity of runoff.
- They are usually constructed with stone having a minimum size of 50 mm. If available, a gradation of stone size of at least 100-150 mm should be used. If 25-50 mm rock is used, the centre and backside of the dam should be protected with 100 mm rock

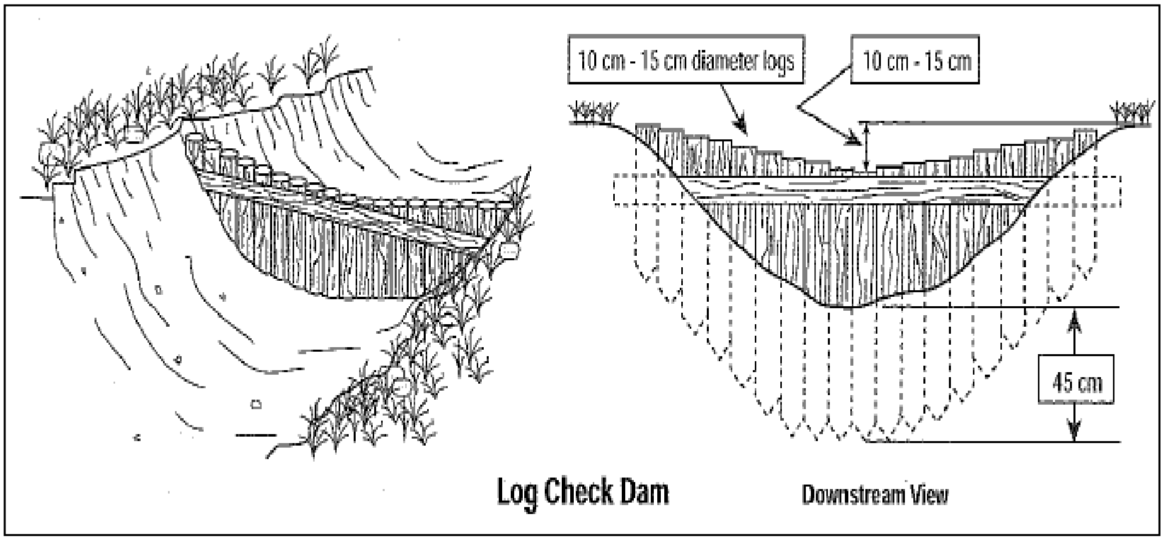
- A geotextile filter should be placed under the stones to provide a stable foundation, to facilitate the removal of the stones and to prevent the finer soil particles from washing away.
- The side slopes should be approximately 2H:1V.
- Stone check dams vary in height up to 1.0 metre depending on the size and drainage area of the ditch and should be placed such that the elevation of the toe of the upstream dam is the same elevation as the top of the downstream dam.



Source: Government of New Brunswick, Department of the Environment, Watercourse Alteration Technical Guidelines

(ii) Log Check Dams

- Should be constructed with logs of 10 cm to 15 cm diameter salvaged from clearing operations if possible.
- The logs should be embedded at least 45 cm into the soil.
- The center of the check dam should be approximately 15 cm lower than the outer edges.



Source: Government of New Brunswick, Department of the Environment, Watercourse Alteration Technical Guidelines

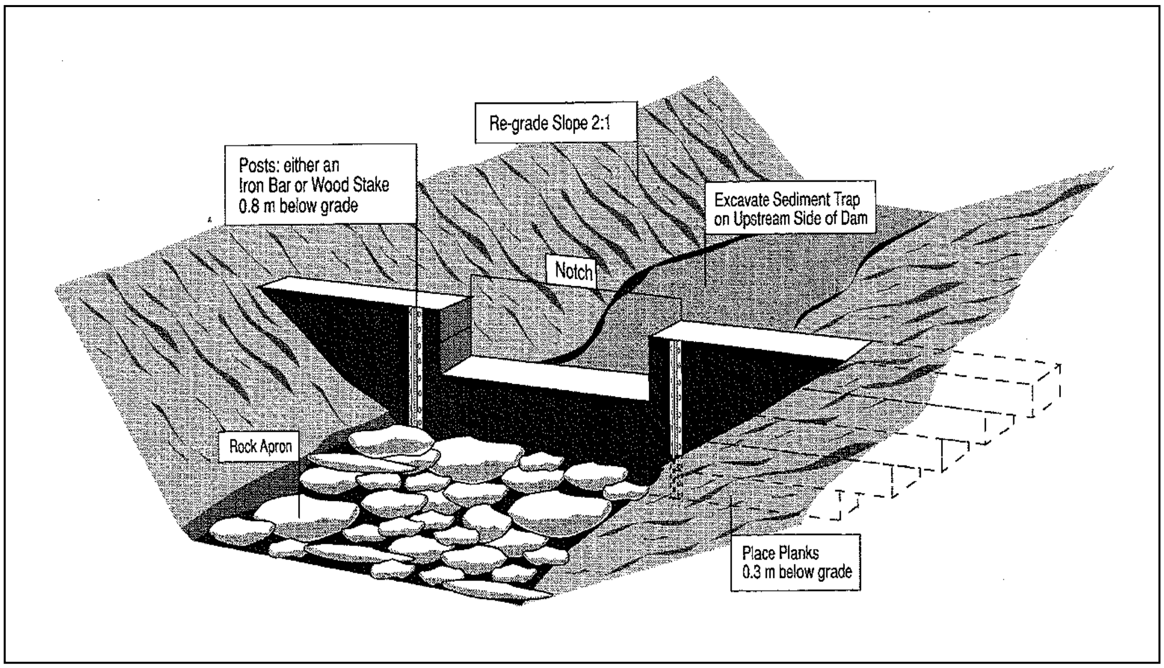
(iii) Gabion Basket Check Dam

- Gabion baskets are fabricated from wire mesh and filled with rock.
- May be used in channels or ditches of moderate slope, having a small to medium size drainage area, and where a source of rock is available.
- The bottom of the wire baskets should be set approximately 300 mm below the bottom of the ditch.
- Placing a layer of straw at the bottom of the gabion can improve the sediment trapping efficiency.
- A rock apron should be placed down-stream of the baskets and extend 1m from the gabion.
- The channel sides should be stabilized by sodding, seeding, mulching or gravelling immediately after construction.

(iv) Plank Dam

- Plank dams can be used in channels with small to medium drainage areas and when a durable check dam is required.

- Posts are set at a depth of approximately 1m in a straight line across the channel (on each side of the spillway).
- A 30 cm deep trench should be dug along the upstream side to permit placing the bottom plank and a thin layer of straw or grass as a seal. The trench should be backfilled and well compacted with earth.
- Planks are nailed to the posts with the ends of the planks set well into the banks.
- A spillway notch shall be cut in the center of the dam and a rock apron installed.



Source: Nova Scotia Department of the Environment, Erosion and Sedimentation Control Handbook for Construction Sites

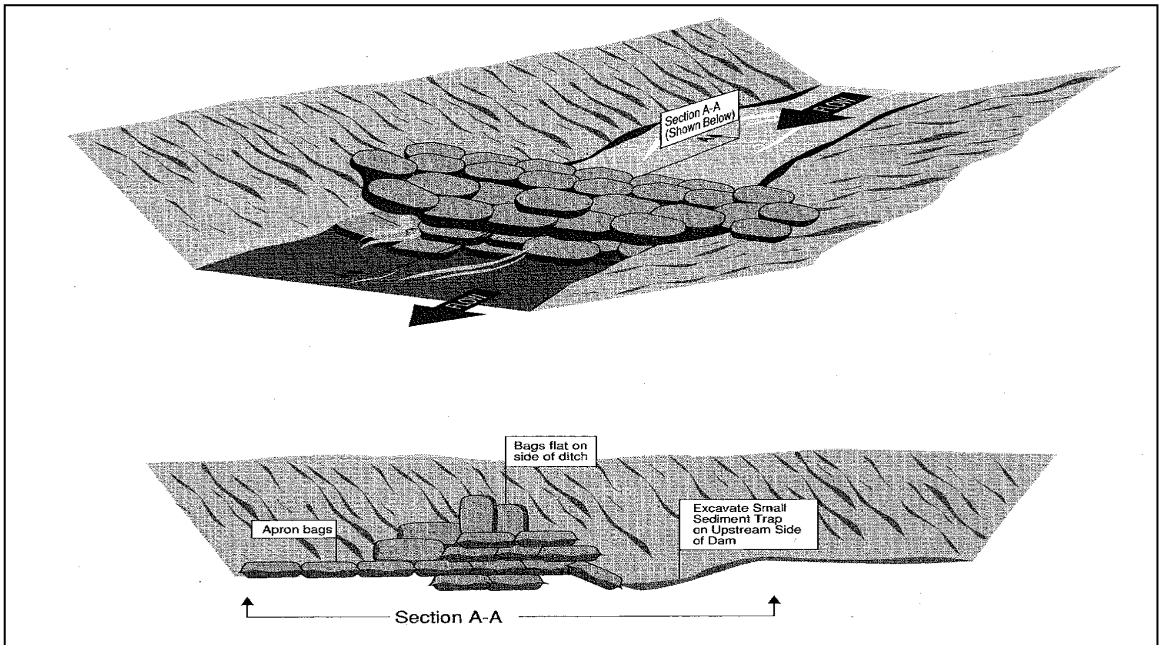
(v) Straw Bale Check Dams

- Straw bales are often used as check dams in channels or ditches. They should not be used in channels with drainage areas greater than 0.8 hectares.
- Straw bales must be secured into the channel and staked with two stakes angled towards the adjacent bale.

- Additional details on straw bale check dams are provided under item (ix), Straw Bale Erosion Control Structure - NBDTI Type C.

(vi) Sandbag Dam

- Sandbag dams can be used in channels with small drainage areas and a low runoff velocity.
- A trench is excavated to a depth of 25 cm across the channel or ditch.
- Sandbags are laid in a row across the channel at least two bags high. The bags should be overlapped.
- Sandbags can be used to create an apron below the spillway. Sandbags should extend a minimum of 1m downstream.
- The sides of the channel should be stabilized by sodding, seeding, mulching or gravelling immediately after construction.

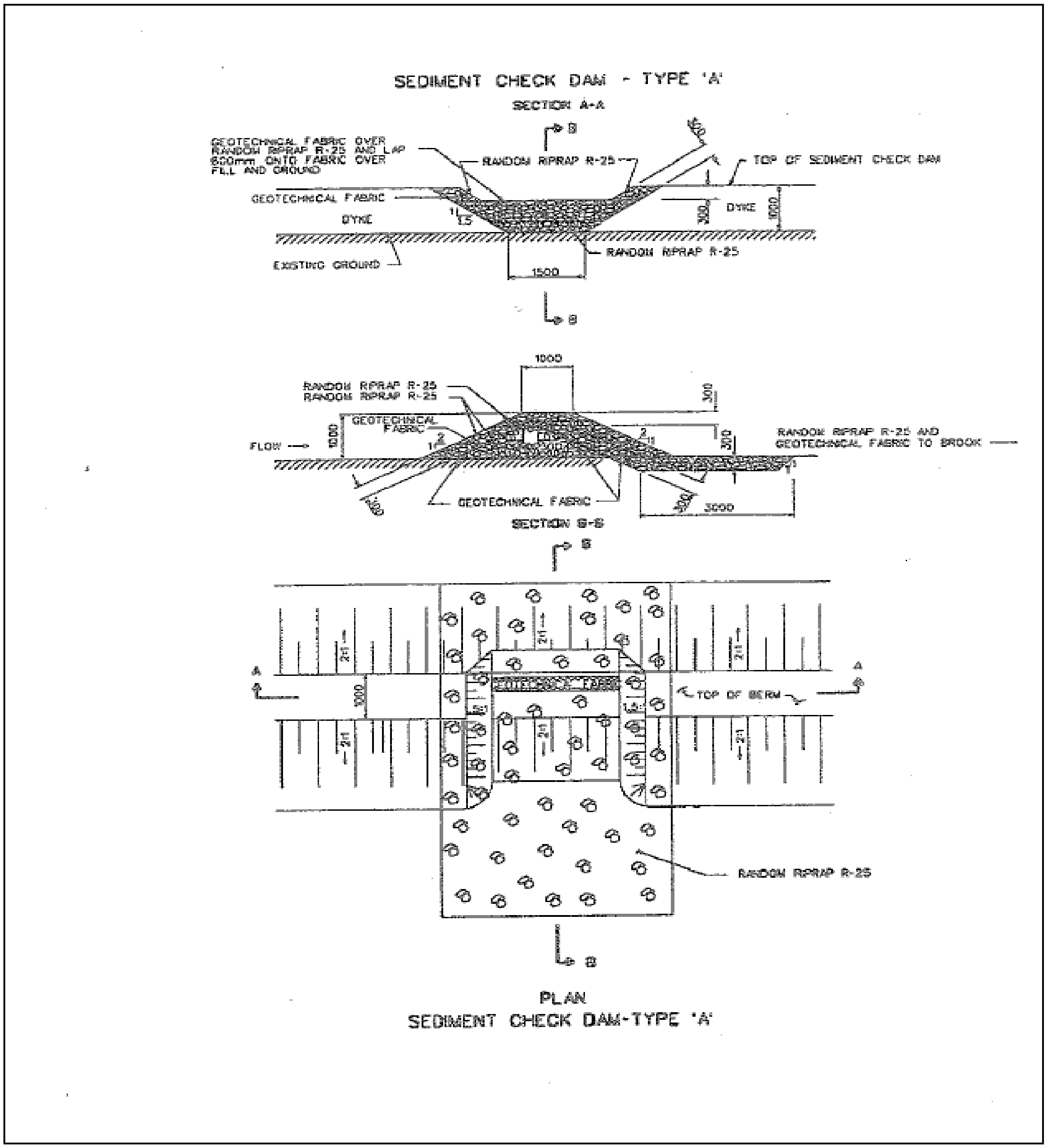


Source: Nova Scotia Department of the Environment, Erosion and Sedimentation Control Handbook for Construction Sites

The New Brunswick Department of Transportation and Infrastructure (NBDTI) adopted standardized erosion control structures. These erosion control structures, or check dams, are categorized as Type A, Type B and Type C and are described below. Additional details can be found in NBDTI's Environmental Management Manual (https://www2.gnb.ca/content/dam/gnb/Departments/trans/pdf/en/RoadsHighways/EnvironmentalManagementManual.pdf).

(vii) Spillway Structure for Sediment Pond Dykes - NBDTI (New Brunswick Department of Transportation and Infrastructure) Type A

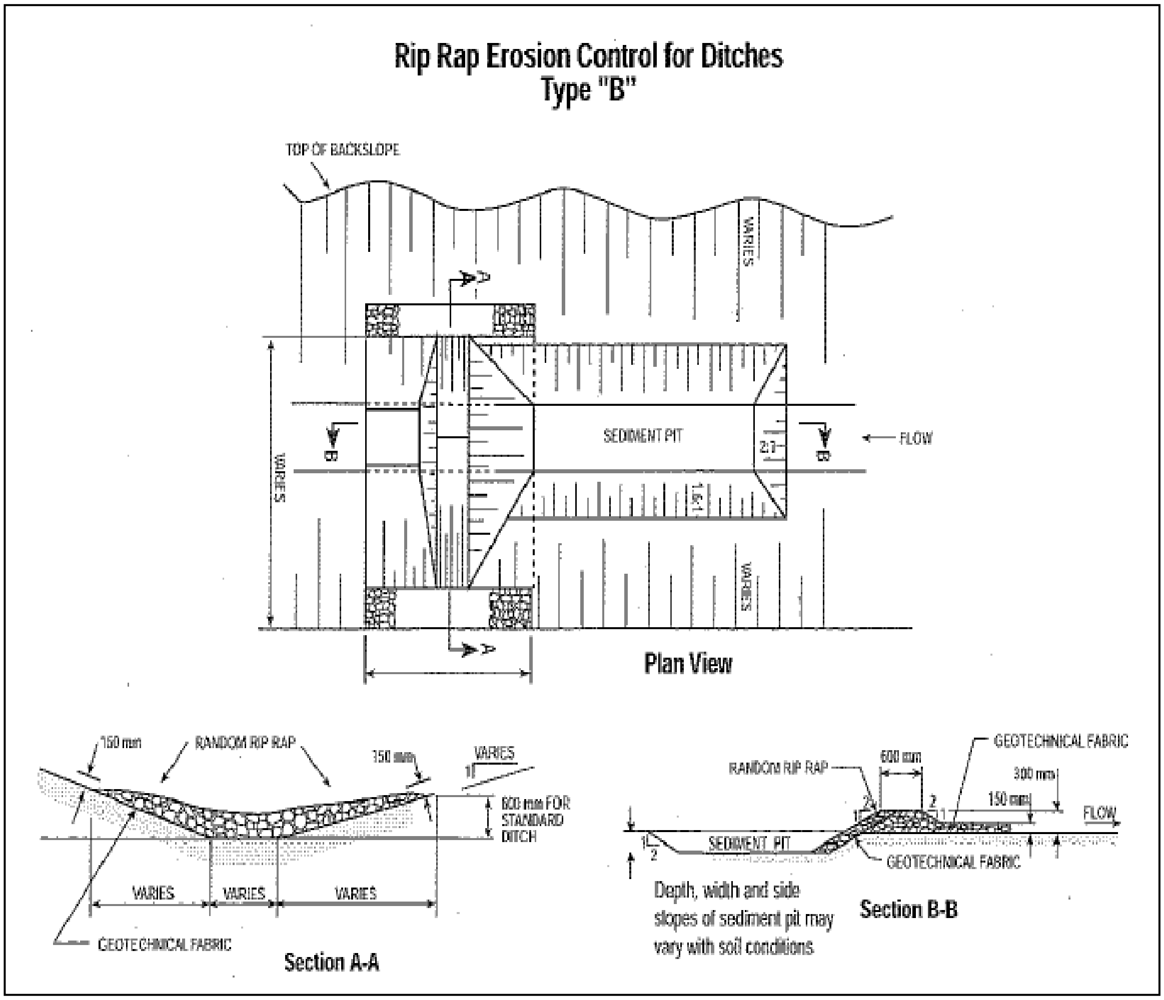
- They are used in conjunction with sediment ponds to retain water and allow suspended particles to settle out. The discharge from the ponding area is filtered by riprap, which lines the outlet. They are built to pond runoff from ditches or from grubbed areas, or at the end of a cut where runoff leaves the ditch to flow down a natural slope.
- Sediment should be removed when it accumulates to a level equal to half of the design depth of the trap or prior to the level of sedimentation reaching a point within 300 mm of the crest of the spillway.



Source: New Brunswick Department of Transportation and Infrastructure (NBDTI), Environmental Management Manual, January 2010.

(viii) Riprap Erosion Control Structure for Ditches – NBDTI Type B

- Typically installed in rock ditches where stakes required for Type C and D structures cannot be driven.
- A small ponding area is excavated behind the dam where the runoff is detained before discharging.
- They are usually used in channels having grades steeper than 8% with heavy flows or in rock ditches where stakes cannot be driven.
- They should be constructed of geotextile fabric and random riprap “R-5”. The outlet consists of rock with an impermeable membrane sandwiched between the rocks.
- Sediment deposits shall be removed when the level of sedimentation is within 100 mm of the top of the structure, or as directed by the Engineer.

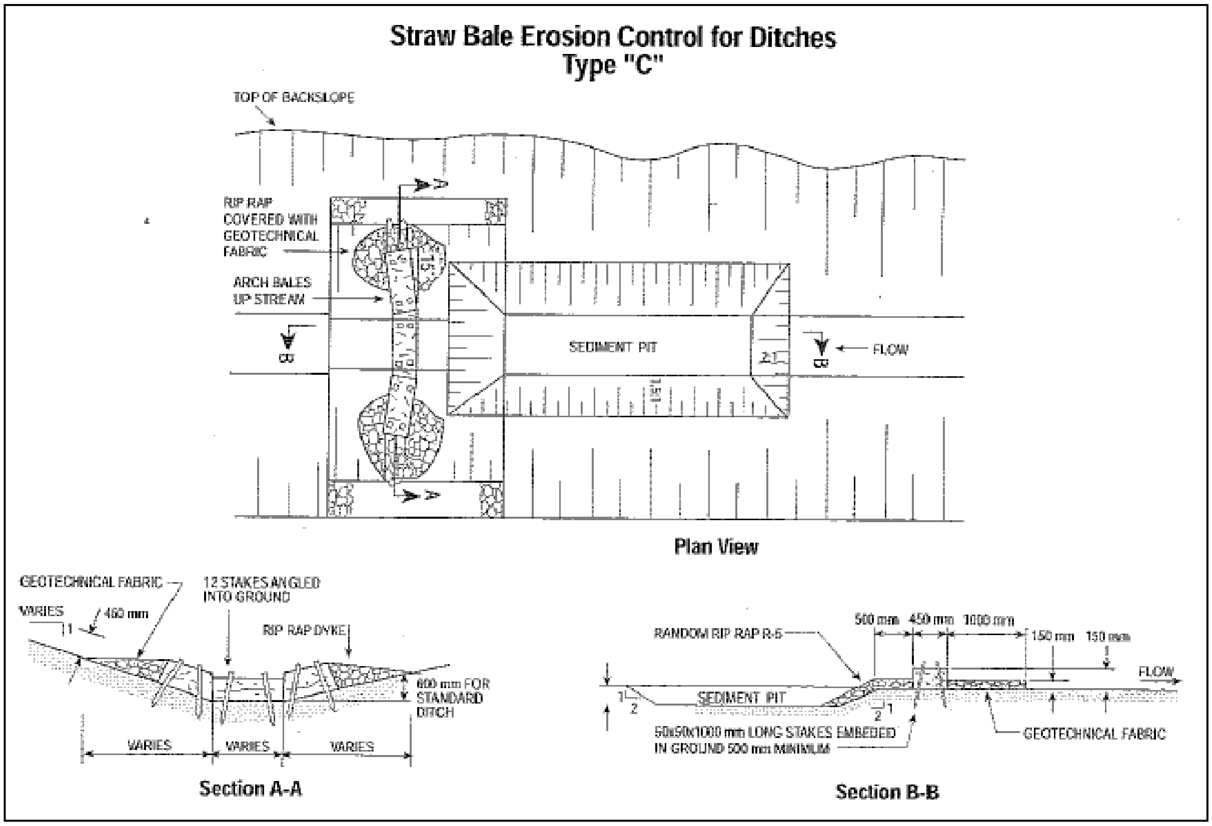


Source: Government of New Brunswick, Department of the Environment, Watercourse Alteration Technical Guidelines

(ix) Straw Bale Erosion Control Structure for Ditches – NBDTI Type C

- Consists of a small dam made of geotextile fabric, straw bales and riprap constructed across a ditch. A small ponding area is excavated behind the dam where the runoff is detained before discharging.
- They can be used in channels or ditches and along side of waterways or property boundaries. They are most effective for treating small drainage areas (less than 0.6 to 0.8 hectares) for a short period of time.

- Generally used in ditches having grades up to 8 % with low to medium flows.
- A trench the width of a straw bale and the length of the proposed barrier should be excavated to a minimum depth of 100-150 mm below the surface.
- The bales are placed on their sides tightly together in the trench.
- Two wooden or steel stakes need to be driven through each bale. The first stake in each bale should be driven toward the previously laid bale to force the bales together.
- Loose straw should be wedged between any cracks to seal openings.
- The excavated soil should be backfilled and lightly compacted up to a depth of 100 mm against the upslope side of the barrier and to ground level on the down-slope side.
- A sediment trap should be excavated on the upslope side of the barrier.
- Sediment deposits shall be removed when the level of sediment is about halfway to the top of the structure or prior to the level of sedimentation reaching a point within 100 mm of the crest of the notch.
- Straw bales must be checked on a regular basis and rafter each rainstorm. Straw bales can deteriorate in 30 to 60 days.



Source: Government of New Brunswick, Department of the Environment, Watercourse Alteration Technical Guidelines

3.15.6.7 Sediment Control Ponds

Runoff from a disturbed area can be intercepted and directed to a sediment control pond, also referred to as sediment basin or siltation pond, where runoff is detained long enough to allow most of the sediments to settle out.

A sediment pond differs from a sediment trap with respect to the contributing drainage area it services. Ponds are generally constructed for larger disturbed areas or where the volume of water to be treated is expected to be high. They are usually designed for disturbed areas larger than 2 hectares (5 acres).

The pond should be located at the lowest practical point in the catchment area,below construction activities, and should be large enough to handle the maximum expected amount of runoff. It should be constructed before any land disturbing activity occurs on the site. Multiple ponds may be designed for a large development.

The pond design should include an outlet riser pipe and a spillway or gravel outlet to prevent scour. It may be necessary to use filter fabric on the spillway.

The sediment pond should be inspected periodically and after each rain event. The pond should be cleaned out when sediment have filled about half of the volume. The accumulated sediments shall not be disposed within 30m of a wetland or waterway or where it could re-enter the basin.

The pond should remain in operation until the site is permanently stabilized by vegetation and/or permanent measures are in place.

The sediment pond should be designed by a qualified engineer. The following are some design guidelines for sediment control ponds:

- Identify the contributing drainage area, the anticipated runoff volume and the soil type. Larger ponds may be required if soil is clay or silt as they take more time to settle.
- In general, the pond should be sized for a minimum storage volume of 250 m3/ha.
- The average pond depth should be at least 1.2m to lessen the clean out frequency.
- Average hydraulic retention time: Minimum of 40 minutes.

- Length to width ratio should be a minimum of 2:1, preferably 4:1, in order to increase the amount of time in which settling may occur.

- Minimum sediment storage depth: 0.5 meters

- Minimum freeboard: 0.6 meters

- Interior side slopes should not exceed: 2H:1V

- Exterior side slopes should not exceed: 3H:1V

    - Additional design guidelines are included in the Fisheries and Oceans Canada's Land Development Guidelines for the Protection of Aquatic Habitat: http://www.dfo-mpo.gc.ca/Library/165353.pdf.

3.15.6.8 Sediment Traps

- Overland flow runoff from a disturbed area can be directed to a sediment trap, which operates like a small sediment control pond. The trap retains the runoff long enough to allow most of the sediments to settle out.

- The sediment trap is formed by excavating a pond or by placing an earthen embankment across a low area or drainage swale.

- Sediment traps are suitable for small drainage areas, usually less than 2 hectares (5 acres). The trap should be large enough to allow the sediments to settle and should have the capacity to store the sediments until removed.

- In general, sediment traps should be sized for a minimum storage volume of 150 m3/ha over the contributing drainage area.
- Side slopes should not exceed 2H:1V.

- Traps should be inspected periodically and after each rainfall. The trap should be cleaned out when sediment have filled about half of the design volume. The trap should remain in operation until the site area is permanently stabilized by vegetation and/or other permanent measures.

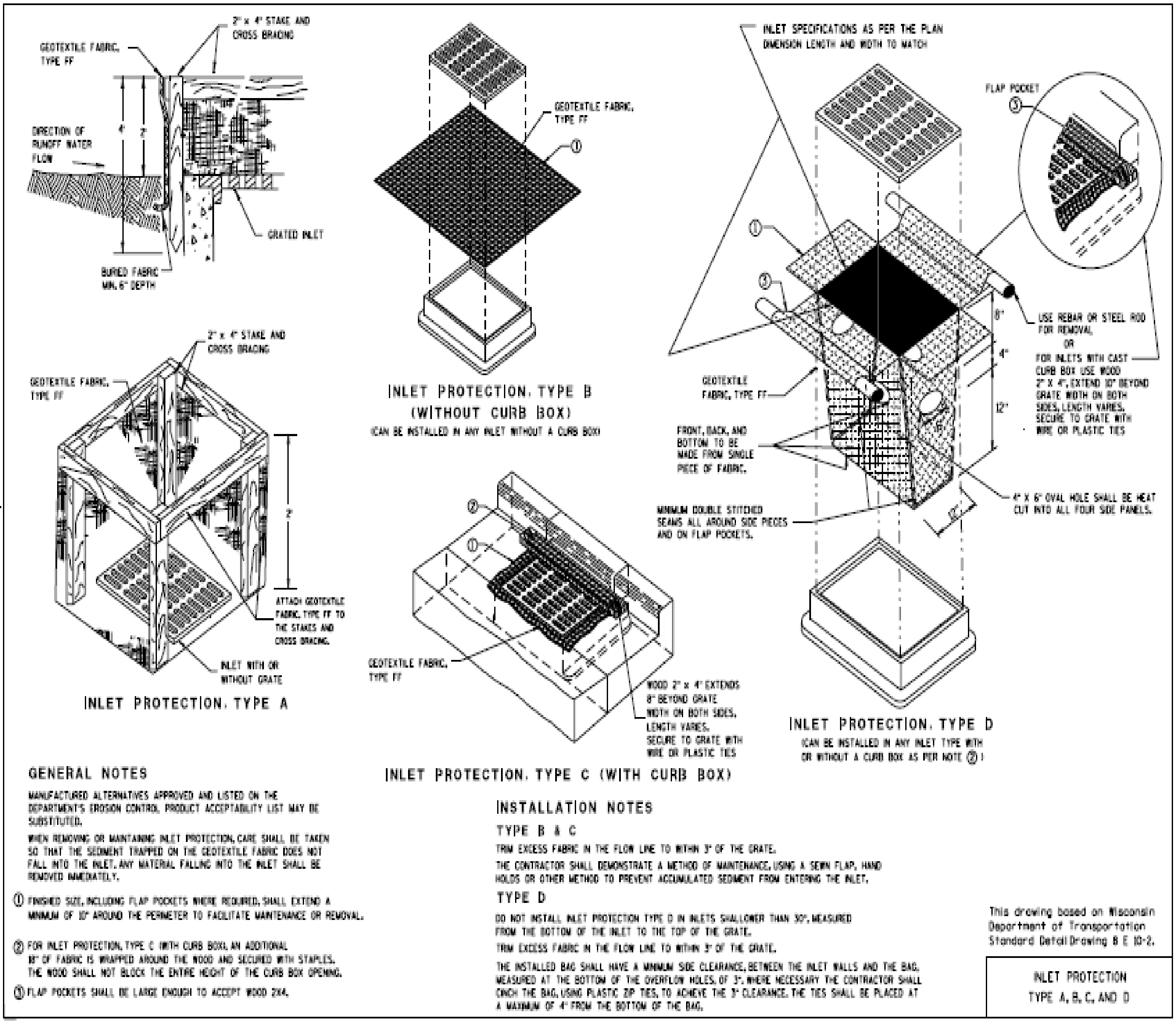
3.15.6.9 Storm Drain Inlet Protection

- Drain inlet protection will prevent sediment from entering the underground storm pipe system prior to stabilization of the disturbed area. Drain or curb inlet protection should be used where storm inlets are operational prior to permanent stabilization of the disturbed area.

- Storm drain inlet protection is a filtering measure placed around any inlet or drain to trap sediment. Inlet protection can be formed using gravel or stone, sod, straw bales or filter fabric, which trap the sediment before it enters the system. Filter fabric is used when storm water flows are relatively small with low velocities. Gravel filters can be used where velocities are higher.

- This type of protection is appropriate for small drainage areas, generally not exceeding 0.4 hectares (1 acre) and where storm drain inlets will be operational prior to permanent stabilization.

- The following figure illustrates some examples of storm drain inlet protection measures that can be implemented at a construction site.

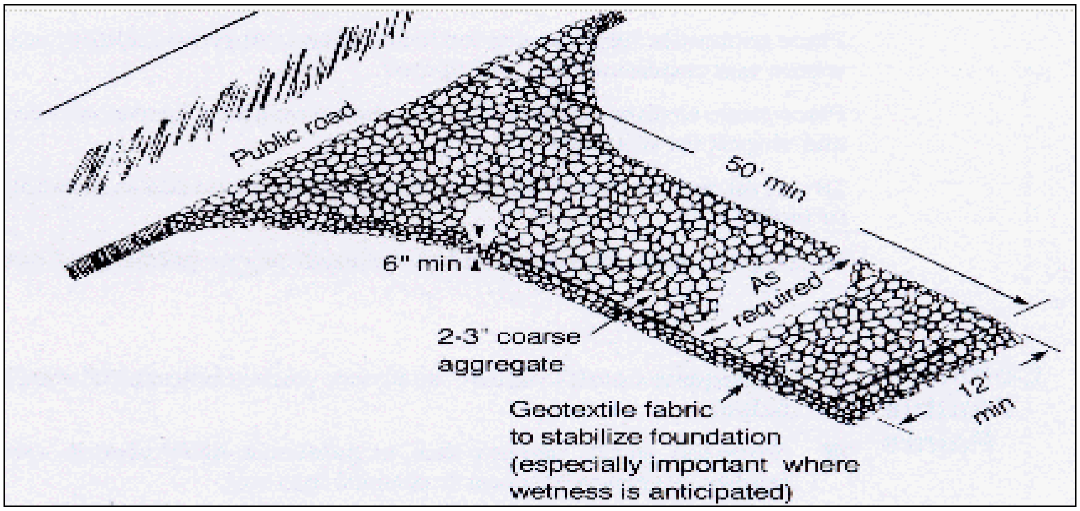


Source: Wisconsin Department of Natural Resources, Conservation Practice Standard, Storm Drain Inlet Protection for Construction Sites.

3.15.6.10 Stabilized Construction Entrance/Exit

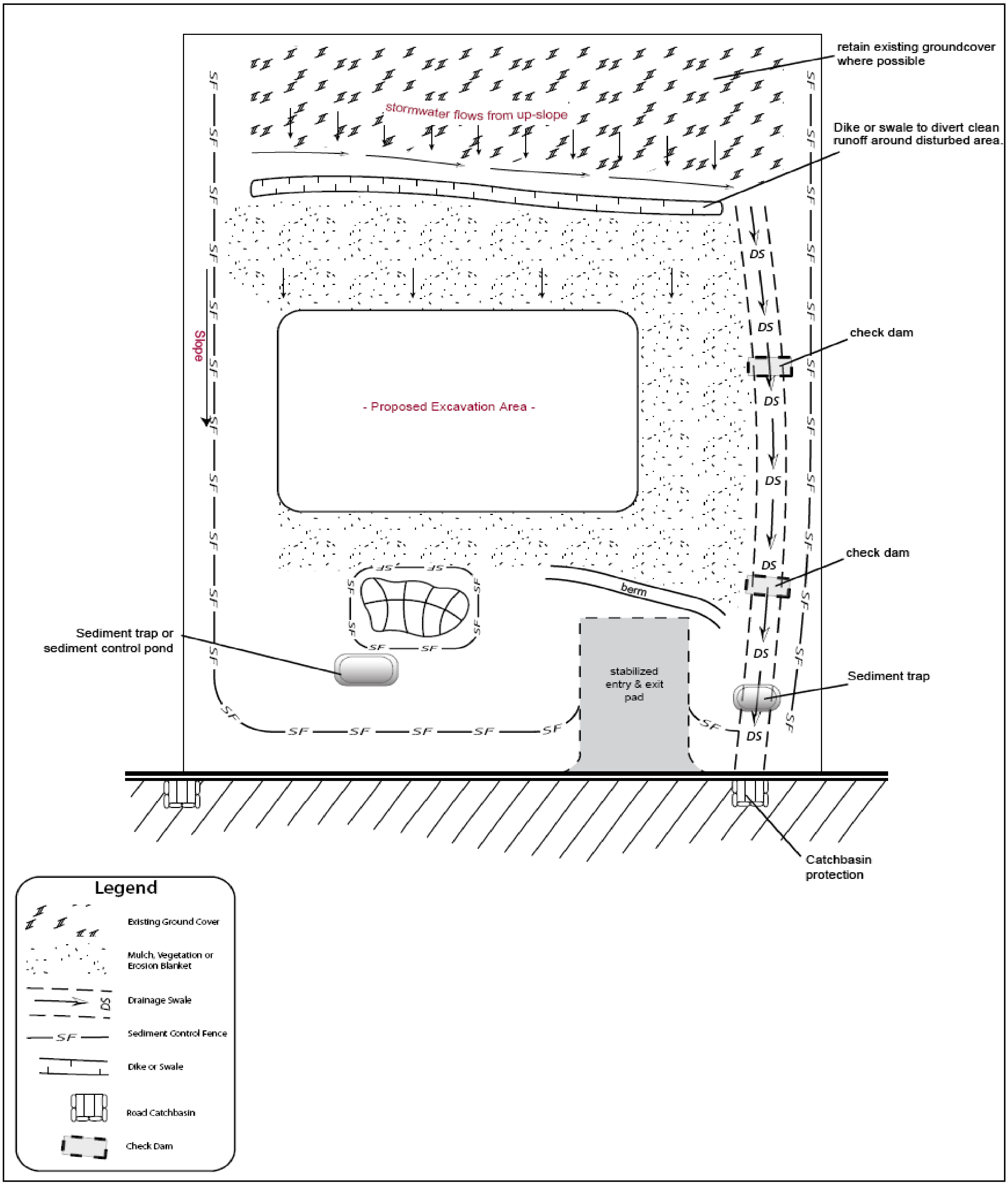
- A temporary sediment removal device can be installed at the approach from an unpaved construction site to a public roadway where there is risk of transporting mud or sediment onto paved roads.
- Installing a pad of gravel, especially over filter cloth, can help stabilize a construction entrance. Rumble strips and tire washing devices can also be added.
- Stabilize all entrances to a site before construction and further site disturbance begins. Make sure the stabilized site entrances are long and wide enough to allow the largest construction vehicle that will enter the site to fit through with room to spare.
- Install stone or gravel at a depth of at least 15 cm for the entire length and width of the stabilized construction entrance. Make sure stone and gravel are large enough so that they are not carried offsite by vehicles. Monitor and replace gravel as needed.

Example of a Stabilized Entrance at a Construction Site:



Source: Gaston County Natural Resources Department, NC.

The following figure illustrates some examples of the implementation of erosion and sediment control measures at a construction site.


retain existing groundcover where possible
stormwater flows from up-slope
Dike or swale to divert clean runoff around disturbed area.
check dam
Slope
- Proposed Excavation Area -
check dam
berm
Sediment trap or sediment control pond
stabilized entry & exit pad
Sediment trap
Catchbasin protection
Legend
Existing Ground Cover
Mulch, Vegetation or Erosion Blanket
Drainage Swale
Sediment Control Fence
Dike or Swale
Road Catchbasin
Check Dam

3.15.7 Monitoring And Maintenance

A maintenance program must be implemented throughout construction activities. The maintenance program should include daily routine checks, repairs, replacements and an inventory of control materials. All control measures shall be inspected periodically and after each rainfall event.

Ensuring that erosion and sediment control structures are properly maintained will also prevent or limit mosquito breeding. Some maintenance principles include cleaning out the temporary sediment traps and basins, maintaining ditches to ensure positive drainage and removing grass cutting and other debris.

The sediment and erosion control devices must remain in place and be maintained in functional condition until permanent vegetation has been established or the site is otherwise stabilized.

Prior to winter shutdown, site conditions must be evaluated and specific requirements for erosion control to be implemented prior to spring runoff should be identified.

3.15.8 Runoff Water Quality Requirements

The Fisheries Act prohibits the deposit or release of a deleterious substance to fish-bearing waters. In high concentrations, sediment is recognized as a deleterious substance.

Fisheries and Oceans' Land Development Guidelines for the Protection of Aquatic Habitat indicate that runoff water from the development site should contain less than 25 mg/liter of suspended solids above the back-ground suspended solids levels of the receiving waters during normal dry weather operation and less than 75 mg/liter of suspended solids above background levels during design storm events. The

Department of Fisheries and Oceans or the Provincial Department of the Environment should be contacted for additional questions regarding the normal dry weather storm background level.

It is also stated in the Land Development Guidelines that where spawning areas are situated in the receiving waters, the runoff water should not, at any time, increase the level of suspended solids above the background level in the receiving waters. Background suspended solids levels are the natural instream suspended solids.

3.15.9 Applicable Legislation

3.15.9.1 Provincial Legislation

The New Brunswick Watercourse Alteration Regulation, which falls under the Clean Water Act, is administered by the Department of the Environment and Local Government. The Regulation states that any person working within 30 metres of a watercourse is required to obtain a watercourse and wetland alteration permit. One of the mandates of the Watercourse Alteration Program is to prevent sedimentation of watercourses by requiring that control measures be taken during construction phases of the project.

The need for a Watercourse and Wetland Alteration permit should be assessed prior to any land disturbing activities taking place within 30 metres of a watercourse. Additional information on Watercourse and Wetland Alteration permits can be found in the New Brunswick Department of Environment and Local Government Watercourse Alterations Technical Guidelines https://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Water-Eau/WatercourseAlterations.pdf.

Relevant sections and keys points from the Clean Water Act are presented in the following table.

Legislation	Relevant Section	Key Points	Fines
Clean Water Act	Section 12(1)	No person shall directly or indirectly release a contaminant into or upon water if to do so would or could (a) affect the natural, physical, chemical or biological quality of constitution water (b) endanger the health, safety or comfort of a person or the health of animal life (c) cause damage to property or plant life or (d) interfere with visibility, the normal conduct of transport or business or the enjoyment of life or property.	-Min of $500 and max. of $50,000 (for an individual) -Min. of $1,000 and max. of $1,000,000 (for a person other than an individual)
	Section 15(1)	A person planning a hydro-electric power project, a control dam, a river diversion, a drainage diversion or another project or structure that alters a watercourse or a wetland or diverts all or part of a watercourse or the water flowing in a watercourse or a wetland, shall, before undertaking or proceeding with the project (a) provide the Minister with copies of the plans and such other documents or information as the Minister may require and (b) subject to subsection (1.1) obtain a permit issued by the Minister.	

3.15.9.2 Federal Legislation

As discussed in the previous section, the Fisheries Act, which is administered by Fisheries and Oceans, prohibits the deposit or release of a deleterious substance to fish-bearing waters. Relevant sections and key points found in the Act are presented in the following table.

Legislation	Relevant Sections	Key Points	Fines
Fisheries Act http://laws-lois.justice.gc.ca/eng/F-14	Section 35 (1)	No person shall carry on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat.	-Up to $300,000 (first offence) -Up to $300,000 and/or up to 6 months imprisonment (subsequent offences) -Up to $1,000,000 (first indictable offence) -Up to $1,000,000 and/or up to 3 years imprisonment (subsequent indictable offences)
	Section 35 (2)	No person contravenes subsection(1) by causing the alteration, disruption or destruction of fish habitat by any means or under any conditions authorized by the Minister or under regulations made by the Governor in Council under this Act.	
	Section 36 (3)	Subject to subsection (4), no person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions where the deleterious substance or any other deleterious substance that results from the deposit of the deleterious substance may enter any such water.	
	Section 38 (4), (5) & (6)	(4) Duty to report deposits of deleterious substance, (5) Duty to take all reasonable measures to prevent the deposit of a deleterious substance (6) Inspectors may order to take remedial measures.	-Up to $200,000 (first offence) -Up to $200,000 and/or up to 6 months imprisonment (subsequent offences)
	Section 95	Releases of toxic substances must be reported, prevented and mitigated to prevent any danger to the environment or hum life or health.	

Note: Legislation is subject to change. The applicable bylaw, act or regulation should be consulted for accuracy.

3.16 Engineering Design Brief

In an effort to facilitate the review and approval of proposed subdivision plans, the applicant is required to submit to the Town of Shediac an Engineering Design Brief which outlines and summarizes design assumptions and approaches contained within the subdivision submission.

In general, the Engineering Design Brief should provide commentary on the sanitary sewerage system design, the water distribution system design, the storm drainage system design, and the street design.

The Engineering Design Brief should clearly identify where design assumptions and approaches are consistent with recommendations set forth in the Town of Shediac *Standard Specification for Municipal Services*, and the Town of Shediac *Design Criteria Manual for Municipal Services*. The Engineering Design Brief must clearly identify where design assumptions and approaches have deviated from the recommendations set forth in the *Standard Specifications for Municipal Services*, and the *Design Criteria Manual for Municipal Services*, along with supporting documentation and test results to justify the deviations from the established recommendations.

3.17 Engineering As-Built Drawings

3.17.1 Scale

Wherever possible, Engineering As-Built Drawings are to be drafted in the following standard metric ratios:

horizontal	1 : 500
vertical	1 : 50
details	1 : 50, 1 : 25, 1 : 10

The horizontal and vertical scale, and a graphic horizontal scale are to be provided on all plans.

3.17.2 Engineering As-Built Drawing Cover Sheet

The cover sheet of the Engineering As-Built Drawing set must include the following general project information including:

- project name
- project number
- sheet description (cover, plan & profile, detail)
- location plan
- subdivider name
- consultant name
- contractor name
- foreman name
- inspector name
- construction period
- date of substantial performance
- names of substantial inspection/acceptance attendees

3.17.3 Engineering As-Built Drawing Plan and Profile Sheets

The plan and profile sheets of the Engineering As-Built Drawing set must include the following specific information including:

- drawing symbol legend consistent with those approved by Town of Shediac
- material manufacturer name, model name, and model number
- sanitary sewer, forcemain, watermain, and storm sewer size, material, and class
- sanitary sewer distance between manholes and flow direction

- sanitary service lateral distance from mainline to property line
- sanitary service lateral invert at property line
- forcemain distance between fittings
- watermain distance between fittings
- hydrant lead distance from isolation valve to mainline
- water service lateral distance from curb stop to mainline
- water service lateral distance from curb stop to property line
- water service lateral curb stop swing-tie information
- water service lateral invert at property line
- storm sewer distance between manholes and flow direction
- storm sewer distance between catchbasin and mainline
- storm service lateral distance from mainline to property line
- storm service lateral invert at property line

3.17.4 Digital Coordinate Database

In addition to the Engineering As-Built Drawing set requirements outlined above, the subdivider is to provide a digital coordinate database of all key features to the Town of Shediac. The coordinate database will contain point number, northing, easting, elevation, and description information in an electronic format.

Acceptable electronic formats include space-delimited ASCII files, tab-delimited ASCII files, or comma-delimited ASCII files with the following electronic structure.

Point Number, Northing, Easting, Elevation, Description

If abbreviated feature codes are used, a feature code legend with full descriptions must also be provided.

Key features to be located and included in the coordinate database include, but are not limited to, the following:

- manhole cover locations
- catchbasin and/or sluicebox grate locations
- valve box locations
- curb stop locations
- chamber cover locations
- hydrant locations
- power pole locations

3.17.5 Engineering As-Built Drawing Submission Deadline

Engineering As-Built Drawings and the Digital Coordinate Database are to be submitted to the Town of Shediac prior to Final Acceptance.

4 SANITARY SEWERAGE SYSTEM

A sanitary sewerage system is a system intercepting, conveying, and controlling wastewater discharge from residential, commercial, and industrial sources. Such systems consist of mainline sewers, trunk sewers, service laterals, underground storage chambers, pumping facilities, and treatment facilities. Sanitary sewage is defined as the wastewater from a community consisting of liquid conveying solids from residential, commercial and industrial facilities excluding stormwater inflow and groundwater infiltration.

The sanitary sewerage system shall be as per the requirements of the Greater Shediac Sewerage Commission.

In addition to the requirements of the Greater Shediac Sewerage Commission, all sanitary sewerage systems must conform to any requirements established by New Brunswick Department of Environment and Local Government (NBDELG). No systems must be constructed until the design has been approved by the Greater Shediac Sewerage Commission and by the NBDELG.

5 WATER DISTRIBUTION SYSTEM

5.1 Scope

A water distribution system is a system conveying, and controlling potable water for residential, commercial, industrial, and fire protection demands. Such systems consist of mainlines, lateral lines, fittings and appurtenances, pumping facilities, treatment facilities, pressure control facilities, and storage facilities. Water supply and water quality is monitored and maintained by the Town of Shediac and water distribution systems must be designed such that the water quality is maintained while being distributed at adequate flows and pressures.

In addition to these design criteria, all water distributions systems must conform to the latest edition of the Town of Shediac *Standard Municipal Specifications*, and the following:

- *Water Supply for Public Fire Protection – A Guide to Recommended Practice* as prepared by the Fire Underwriter's Survey (FUS) in conjunction with the Insurers' Advisory Organisation (IAO)
- National Fire Protection Association (NFPA)
- American Water Works Association (AWWA)
- Hydraulic Institute Standards (HIS)
- Canadian Standards Association (CSA)
- National Building Code (NBC)
- Canadian Plumbing Code (CPC)
- Underwriters Laboratories of Canada (ULC)

Additionally, water distribution systems must conform to any requirements established by NBDELG. No system must be constructed until the design has been approved by the Town of Shediac and by NBDELG.

Extension of or connection to an existing water distribution system must be carried out in conformance with a Master Plan prepared for the Water Service District in which the extension is to take place. The Master Plan shall identify major infrastructure such as large diameter transmission mains, reservoir size, location and capacity, system size, location and capacity, pressure control facilities, flow control facilities, and operations and maintenance information. The responsibility for the preparation of the Master Plan for each Water Service District lies with the Engineer.

In the event that a Developer in a Water Service District requests an extension of, or connection to an existing water distribution system prior to the preparation of a Master Plan by the Engineer, then responsibility for the preparation of the Master Plan for the Water Service District shall be borne by the Developer. The Master Plan shall be submitted to the Engineer for review and approval. Approval of the Master Plan by the Engineer is required prior to implementation.

The Engineer may enter into an agreement with the Developer in order to:

- ensure that the Master Plan is developed considering all infrastructure components which are necessary to provide for the long-term, ultimate service requirements for the Water Service District under consideration. Upsizing of water mains to accommodate the water supply requirements of future developments may be required by the Engineer to satisfy infrastructure requirements.

- ensure that the Master Plan complies with an implementation plan and scheduling, approved by the Engineer. The implementation plan and scheduling shall provide for the installation of key infrastructure components within prescribed timeframes.

- ensure that the amount of capital cost contribution due from the Developer in order to finance the required infrastructure works be determined and identified in the Master Plan.

5.2 System Design

5.2.1 Design Water Demands

Water distribution systems must be designed to accommodate the greater of either of the following demands:

- Maximum Daily Demand plus Fire Flow (where Fire Flow is to be provided);
- Maximum Hourly Demand;

unless otherwise approved by the Engineer.

Fire Flow demand must be established by the Engineer in accordance with the latest requirements contained in the publication *Water Supply for Public Fire Protection - A Guide to Recommended Practice*, as prepared by the Fire Underwriter's Survey (FUS) in conjunction with the Insurers' Advisory Organisation (IAO).

Domestic flow demands must be established in accordance with the following:

- Average Daily Demand:410 litres per capita per day;
- Maximum Daily Demand:680 litres per capita per day;
- Maximum Hourly Demand:1,025 litres per capita per day.

Domestic flow demands should be based upon a gross population density of 45 persons per hectare. In developments where the anticipated population exceeds, or is anticipated to exceed, the population density of 45 persons per hectare, or in areas of commercial, industrial, or institutional development, the domestic demand shall be adjusted accordingly. Typical water demands for commercial, industrial, and institutional development are presented in Table 5.1.

Table 5.1 presents typical water demands for commercial, industrial, and institutional development.

Table 5.1 - Typical Water Demands for Commercial, Industrial, and Institutional Development

Development	Water Demand	Unit
Shopping Centre	2,500 – 5,000	L / 1,000m^2 / day
Hospital	900 – 1,800	L / bed / day
School	70 – 140	L / student / day
Recreational Vehicle Park – without hook-ups	340	L/ site / day
Recreational Vehicle Park – with hook-ups	800	L / site / day
Campground	225 – 570	L / site / day
Manufactured Home Park	1,000	L / site / day
Motel	150 – 200	L / bed space / day
Hotel	225	L / bed space / day

Adapted from *Guidelines for the Design of Water Distribution Systems*, OMEE – Environmental Approvals and Project Engineering Branch, July 1985.

The design population or assumed domestic demand must be clearly specified in the calculations submitted for review and approval.

5.2.2 Design Horizon

Water distribution systems must be designed to accommodate projected population and development patterns based upon the Town of Shediac municipal plan. Water distribution systems have useful life expectancies that greatly exceed this design pattern, therefore longer design Horizons should be considered if financial considerations permit. Shorter design Horizons may be permitted where works are short term, and will undergo upgrades or replacement in the foreseeable future at the discretion of the Engineer.

5.2.3 Minimum Pressures

Water distribution systems must be designed and sized in order to provide and maintain a minimum residual pressure of 275 kPa, measured at the main, at all points along the distribution system during Maximum Hourly Demand conditions. Under special conditions, if full and justifiable reasons are given, minimum residual pressure of 210 kPa, measured at the main, at all points along the distribution system during Maximum Hourly Demand conditions may be acceptable for small isolated areas.

Water distribution systems must be designed and sized in order to provide and maintain a minimum residual pressure of 150 kPa at all points along the distribution system during Maximum Daily Demand plus Fire Flow conditions.

Hydraulic analysis of the water distribution system must be conducted by the Consultant using the hydraulic grade line for that particular Water Service District as established by the Engineer. Design calculations and analysis are to be submitted by the Consultant in the form of a Design Brief at the time that the Application for Final Approval for the extension of, or connection to, an existing water distribution system is made.

As a result of differences in ground elevations, or distance from the source of supply, isolated areas may require increasing the pressure of the water system to adequately meet minimum pressure requirements. In order to accomplish this, a water booster station may be required to adequately service a specific area within the Water Service District. Such areas, or Pressure Zones, are generally isolated from the remainder of the water distribution system.

In the event that the number of dwellings or structures affected by inadequate domestic flow and pressure within a Pressure Zone is minimal, or does not warrant a water booster station, the Engineer may permit alternative measures to be employed. Alternative measures shall be consistent with the Canadian Plumbing Code, and must increase the available pressure as close as possible to the 275 kPa requirement. Alternative measures may include, but are not limited to, the following:

- provision of increased diameter service laterals and increased diameter residential plumbing to provide a system hydraulically equivalent to a 275 kPa static pressure system serviced through standard diameter service laterals, and minimum diameter residential plumbing;
- provision of individual residential booster pumps within each serviced dwelling or structure to increase the available pressure as close as possible to the 275 kPa requirement.

Calculations to determine residual water pressure must be based on the hydraulic gradeline of the water distribution system as established by the Engineer.

5.2.4 Maximum Pressures

Water distribution systems must be designed and sized in order to operate under a normal range of pressures from 275 kPa to 600 kPa under Maximum Daily Demand conditions.

The maximum pressure in the water distribution system should not exceed 700 kPa in order to avoid damage to residential plumbing systems, fixtures, and appurtenances.

As a result of differences in ground elevations, or distance from the source of supply, isolated areas may require decreasing the pressure of the water system to adequately meet maximum pressure requirements. In order to accomplish this, a pressure reducing valve may be required to adequately service a specific area within the Water Service District. Such areas, or Pressure Zones, are generally isolated from the remainder of the water distribution system.

In the event that the number of dwellings or structures affected by excessive pressure within a Pressure Zone is minimal, or does not warrant a mainline pressure reducing valve, the Engineer may permit individual domestic pressure reducing valves to be employed. Individual domestic pressure reducing valves shall be consistent with the Canadian Plumbing Code, and shall decrease the available pressure to be within the 275 kPa to 600 kPa requirement.

5.2.5 Maximum Velocities

Water distribution systems must be designed and sized such that the maximum velocity in the pipe must not exceed the following:

- 1.5 m/s during Maximum Hourly Demand;
- 2.4 m/s during Fire Flow.

5.2.6 Hazen-Williams Roughness Coefficient (C_{HW})

Water distribution systems must be designed and sized assuming an ultimate pipe friction will be attained over long term operation. Table 5.2 presents Hazen-Williams roughness coefficients (C_{HW}) that shall be applied regardless of the pipe material.

Table 5.2 presents Hazen-Williams roughness coefficients (C_{HW}) that must be applied regardless of the pipe material.

Table 5.2 - Hazen-Williams Roughness Coefficients (C_{HW})

Pipe Diameter	C_{HW}
NPS-6	100
NPS-8 to NPS-10	110
NPS-12 to NPS-24	120
NPS-24 and greater	130

Adapted from *Guidelines for the Design of Water Distribution Systems*, OMEE – Environmental Approvals and Project Engineering Branch, July 1985

5.2.7 Materials

All water distribution system piping, fittings, and appurtenances are to be as per the Town of Shediac *Standard Municipal Specifications*.

5.2.8 Minimum Diameter

Water distribution systems must be designed and sized to meet all of the criteria outlined above, but under no circumstances shall be less than 200 mm in diameter.

5.2.9 Minimum Cover

All water mains must be designed with a minimum cover of 1.8m as measured from the finished grade to the top of the pipe.

5.2.10 Maximum Cover

The cover as measured from the finished grade to the top of the pipe may be increased to a suitable depth to prevent freezing of either the water main or the services, but under no circumstances shall the cover exceed 2.4 m.

5.2.11 Location

In the case of separate trench installations, the water main must be laid adjacent to the sanitary sewer with a minimum horizontal separation of 3m from the sanitary main.

In the case of common trench installations, the water main must be laid adjacent to the sanitary sewer with a minimum 0.5m horizontal separation, and a minimum 0.3m vertical separation, with the water main being located above the sanitary sewer.
All water main and appurtenances must be located within the street right-of-way owned by the Town of Shediac or the New Brunswick Department of Transportation

and Infrastructure. In the case of off-street servicing, all water main and appurtenances must be located within a 6.0m wide municipal service easement granted to the Town of Shediac. Contingent upon the length and location of the municipal service easement, the Engineer may require a suitable travelled way to be provided within the easement for operations and maintenance purposes.

In the case of curb and gutter street design, all water main and appurtenances must be located within the travelled way and no closer than 1.8m of the curb line.

In the case of open ditch street design, all water main and appurtenances may be located in the gravel shoulder.

In the case of municipal service easement installations, all water main and appurtenances must be located as close as possible to the centreline of the easement.

Where a need is identified to accommodate future development on adjacent lands, municipal service easements must be provided from the edge of the street right-of-way to the property boundary of the subdivision.

5.2.12 Grid Design and Looping

The layout of water distribution systems must be based on a grid design of closed loops wherever possible. Municipal service easements must be provided in order to provide closed loops where the street right-of-way does not.

The occurrence of dead-end water mains should be minimized, or eliminated. Where dead-end water mains cannot be avoided, they should be provided with a fire hydrant, or acceptable blow-off to provide the opportunity for disinfection and flushing.

Additional looping may be required to increase the reliability of the system at the discretion of the Engineer.

5.2.13 Isolation Valves

All connections to an existing water distribution system must provide an isolation valve so that the connection can be isolated from the existing water distribution system. The Engineer cannot guarantee leak-proof operation of existing valves, therefore, it is recommended that a new valve be installed when connecting to existing mains.

The connection to an existing water distribution system must be coordinated by the Consultant with the Town of Shediac Department of Municipal Operations. Any such connection is to be witnessed by the Consultant and the Town of Shediac. All tapping of existing water distribution systems for such connections must be conducted and inspected with the existing water distribution system operating under working pressure.

Isolation valves must be provided on water distribution systems to satisfy the following conditions:

- A sufficient number of isolation valves must be provided at intersections to permit isolation of any section by operating not more than three valves;
- A sufficient number of isolation valves must be provided to allow for shut-down of any section without putting more than 30 customers out of service at any time;
- A sufficient number of isolation valves must be provided so that a break or other failure will not affect more than 150m of water distribution system in commercial districts, or 250m of water distribution system in residential districts;
- Where water distribution systems serve customers located on large rural lots, and where future development is not expected, isolation valve spacing must not exceed 425 m.

5.2.14 Butterfly Valves

For water distribution systems exceeding 300 mm in diameter, butterfly valves may be used at the discretion of the Engineer. Butterfly valves must close clockwise and have a square operating nut on an underground rated operating housing. Butterfly valves must not leak at rated pressures with flow in either direction. Butterfly valves must be equipped with actuators designed to operate the valve against maximum design flow rates in either direction through the valve.

For water distribution systems exceeding 400 mm in diameter, valves must be located in insulated valve chambers.

5.2.15 Automatic Combination Air Relief and Vacuum Valves

Automatic combination air relief and vacuum valves must be installed in an appropriate insulated manhole structure at all significant high points in the distribution system, and at other locations as required by sound engineering judgement, or at the discretion of the Engineer.

5.2.16 Drain Valves

Water distribution systems exceeding 300 mm in diameter must be equipped with drain valves located at low points to permit drainage during maintenance and repairs to the system.

Water distribution systems less than 300 mm in diameter must be equipped with hydrants located at low points to permit draining through pumping or compressed air during maintenance and repair to the system.

5.2.17 Fire Hydrants

Fire hydrants must be provided at a recommended spacing in accordance with the latest requirements contained in the publication *Water Supply for Public Fire Protection - A Guide to Recommended Practice*, as prepared by the Fire Underwriter's Survey (FUS) in conjunction with the Insurers' Advisory Organisation (IAO). Under no circumstances shall the maximum fire hydrant spacing exceed 150 m.

The following are desirable fire hydrant locations:

- Fire hydrants should be located at localized high points in the water distribution system, unless an automatic combination air release and vacuum valve is required at that location;

- Fire hydrants should be located at localized low points in the water distribution system, unless a drain valve is required at that location;

- Fire hydrants should be located at intersections of roads;

- Fire hydrants should be located near the middle of long blocks;

- Fire hydrants should be located at the end of dead-end streets or cul-de-sacs.

5.2.18 Fittings

Any horizontal or vertical change in direction exceeding the manufacturer's recommended maximum deflection tolerance at a pipe joint must require a suitable bend.

5.2.19 Joint Restraint

Calculation of thrust forces on pipe joints and fittings should account for normal operating pressure plus pressure transients induced at peak flow velocity plus dynamic thrust if the peak flow velocity is excessive.

Joint restraint must be provided for the following fittings and appurtenances:

- caps and plugs;
- tees and wyes;
- reducers and enlargers;
- horizontal and vertical bends;
- valves;
- hydrants.

Thrust blocks must be provided at fittings and appurtenances requiring joint restraint and shall consider the soil bearing capacity of the in-situ material that the thrust block bears against. The Consultant should exercise sound engineering judgement in order to account for reduced bearing capacity associated with shallow trench installations.

In the case of vertical bends, the thrust block must be located below the fitting and must be connected to the water main through the use of stainless steel tie rods securely embedded in the concrete.

Mechanical joint restraint systems may be used in lieu of thrust blocks at the discretion of the Engineer. The Consultant should exercise sound engineering judgement in the design of mechanical joint restraint systems recognizing that not only the fittings and appurtenances require restraint, but adjacent pipe sections require restraint in order to develop adequate skin friction equal to the restraint offered by the thrust block. The number of restrained joints and number of restrained pipe runs should be clearly identified on plan and profile drawings.

5.2.20 Corrosion Protection

Corrosion protection of all metal pipe, fittings, and appurtenances is to be provided in accordance with the Town of Shediac *Standard Municipal Specifications*.

5.2.21 Trench Drainage Relief System

The Consultant shall assess the possibility of groundwater migration, caused by an elevated water table, through pervious bedding and backfill material, and shall be responsible for the design of corrective measures to prevent flooding as a result of this groundwater migration.

Water distribution systems installed in a separate trench, or installed in areas where sanitary sewer mains and/or storm sewer mains are not installed must require a trench drainage relief system to lower the elevated water table in the trench below the invert of the water main.

5.2.22 Service Laterals

All water service laterals must be designed with a minimum cover of 1.8m as measured from the finished grade to the top of the lateral including the goose neck.

All water service laterals from the water main to the property line must be provided by the Developer.

For single-family residential lots, a single water service lateral is to be supplied to each residential lot or potential future residential lot that could potentially be created under the zoning in effect at the time of the installation of the water distribution system. Whenever possible, water service laterals should not be installed in private driveways unless a self-leveling cover is provided.

For semi-detached residential lots, two single water service lateral are to be supplied to each semi-detached lot or potential future semi-detached lot that could potentially be created under the zoning in effect at the time of the installation of the water distribution system. Whenever possible, water service laterals should not be installed in private driveways unless a self-leveling cover is provided.

For commercial, industrial, institutional and multi-unit residential development, a single water service lateral is to be supplied to each lot or potential future lot that could potentially be created under the zoning in effect at the time of the installation of the water distribution system for potable supply. In instances where a sprinkler system is required, a separate fire service lateral is to be supplied to each lot or potential future lot that could potentially be created under the zoning in effect at the time of the installation of the water distribution system for potable supply. Whenever possible, water service laterals should not be installed in private driveways unless a self-leveling cover is provided.

In order to avoid high friction losses in water service laterals, the maximum length of any 19 mm diameter water service lateral must be limited to 55m from the curb stop to the dwelling or structure. Water services laterals longer than 55m must be a minimum of 25 mm in diameter.

For water service laterals longer than 20 m, the number of compression couplings used shall be kept to a minimum. Compression couplings must not be used within 1.5m of the foundation of any dwelling or serviced structure.

5.2.23 Backflow Prevention Devices

Backflow prevention devices are required on new commercial, industrial, institutional and multi-unit residential development services if there is a risk of contamination of the potable water supply. Premises which require backflow prevention devices include, but are not limited to, the following:

- commercial, industrial and institutional development;
- multi-unit residential development;
- fire protection laterals

5.2.24 Custody Transfer Vaults

In some instances, commercial, industrial, institutional and multi-unit residential development may require a custody transfer vault containing a water meter, backflow prevention device(s) and isolation valves.

5.3 Pumped Systems

5.3.1 General Requirements

As a result of differences in ground elevations, or distance from the source of supply, isolated areas may require increasing the pressure of the water system to adequately meet minimum pressure requirements.

In order to accomplish this, a water booster station may be required to adequately service a specific area within the Water Service District. Such areas, or Pressure Zones, are generally isolated from the remainder of the water distribution system.

Water booster stations may incorporate either ground storage reservoirs or elevated storage reservoirs into their design and operation. The incorporation of such storage is normally done in order to supply extreme demand requirements such as Maximum Hourly Demand or Fire Flow.

5.3.2 Design Water Demands

Design water demands will vary considerably from one location to another. For the purposes of design, the Consultant shall review existing records in order to determine the following:

- Maximum Hourly Demand (A.M.) when commercial and industrial demands are normally at their highest;
- Maximum Hourly Demand (P.M.) when residential demands, including lawn watering, are normally at their highest;
- Minimum Hourly Demand (Night) when commercial, industrial, and residential demands are at their lowest and reservoirs are normally filling;
- Fire Flow Demand which can occur at any time.

In the absence of existing records, the Consultant shall revert to the following criteria:

- Average Daily Demand – As per Section 5.1;
- Maximum Daily Demand - As per Section 5.1;
- Maximum Hourly Demand - When residential demands, including lawn watering, are normally at their highest, a minimum of 0.1 L/s per dwelling should be used;
- Fire Flow Demand - Fire Flow demand shall be established by the Engineer in accordance with the latest requirements contained in the publication *Water Supply for Public Fire Protection - A Guide to Recommended Practice*, as prepared by the Fire Underwriter's Survey (FUS) in conjunction with the Insurers' Advisory Organisation (IAO).

5.3.3 Minimum Pressure

Water booster stations must be designed and sized in order to provide and maintain a minimum residual pressure of 275 kPa at all points along the distribution system during Maximum Hourly Demand conditions.

Water booster stations must be designed and sized in order to provide and maintain a minimum residual pressure of 150 kPa at all points along the distribution system during Maximum Daily Demand plus Fire Flow Demand conditions.

5.3.4 Maximum Pressure

Water booster stations must be designed and sized in order to operate under a normal range of pressures from 350 kPa to 550 kPa under Minimum Hourly Demand conditions.

The maximum pressure in the water distribution system should not exceed 700 kPa in order to avoid damages to residential plumbing systems, fixtures, and appurtenances.

5.3.5 Floating Storage

Water booster stations, without floating storage, must be designed and sized in order to supply the extreme water demand conditions outlined in Section 5.2.2.

In the case of small pressure zones within the Water Service District that do not have ground storage or elevated storage available, the necessity to meet Fire Flow Demand is the most critical.

In the case of large pressure zones within the Water Service District that do not have ground storage or elevated storage available, the necessity to meet the extreme water demands directly from the water booster station may become cost prohibitive.

Floating storage facilities become economically viable for large pressure zones and shall be incorporated into the system at the discretion of the Engineer.

Water booster stations, with floating storage, must be designed and sized in order to supply the Maximum Hourly Demand as outlined in Section 5.2.2. Floating storage must be available for water balancing and Fire Flow Demand conditions.

5.3.6 Pump System Capacity

Water booster stations, without floating storage, must be designed and sized with a minimum of one lead and two lag domestic pumps. Domestic pumps must be designed and sized such that the capacity of the pumping station with the two largest pumps out of service must provide a minimum of 80% of the peak demand of the serviced area when completely developed.

Water booster stations, with floating storage, must be designed and sized with a minimum of one lead and two lag domestic pumps. The domestic pumps must be designed and sized such that the capacity of the pumping station with the largest pump out of service must provide a minimum of 80% of the peak demand of the serviced area when completely developed.

The lead pump must provide a maximum of 25% of the peak demand and provide an adequate supply during normal periods of domestic demand.

The lag pumps must provide a maximum of 55% of the peak demand and provide an adequate supply during maximum periods of domestic demand.

The fire pump must have adequate capacity to supply the necessary fire flow demand.

The use of variable speed pumps is preferred to compensate for the demand variations.

5.3.7 Domestic Pumps and Fire Pumps

Domestic pumps, fire pumps, and all fittings and appurtenances including system capacity, system sizing, system layout, control facilities, installation, and testing, must meet all applicable and relevant standards and codes.

5.3.8 System Head Curves

A single system head curve cannot be developed due to fluctuations in water demands within the system. Therefore, projected points of operating head and flow for at least the following conditions shall be developed:

- Average Daily Demand;
- Maximum Daily Demand;
- Maximum Hourly Demand (A.M.);
- Maximum Hourly Demand (P.M.);
- Minimum Hourly Demand (Night).

Pumps that adequately operate over the anticipated range of demands at the station from a minimum total dynamic head to a maximum total dynamic head shall be selected. Generally, the pumps must be capable of meeting the following criteria:

- the rated point corresponding to the Maximum Daily Demand condition;
- the rated point corresponding to the maximum efficiency;
- the rated point corresponding to the minimum total dynamic head and the maximum total dynamic head;

- the minimum submergence level for a vertical turbine unit;

- the available NPSH for a horizontal centrifugal unit;

In general, pumps operate at a total dynamic head considerably less than the manufacturer's ultimate rated point. Therefore, the maximum efficiency point shall be specified as that point at which the pump will normally run. The rated point shall be selected as the point at which the pump will overcome the greatest amount of head for a specified flow rate.

Pumps shall be selected in order to avoid the following conditions:

- pumps subjected to low total dynamic head may be prone to destructive cavitation under high flow conditions;

- pumps subjected to high total dynamic head may be prone to high power consumption under low flow conditions;

- noise and vibration levels that are audible beyond the immediate station vicinity.

5.3.9 Site Considerations

5.3.9.1 Site Access

Vehicle access to the water booster station must be provided in order to accommodate the need for maintenance and service personnel and vehicles.

A paved access driveway shall be provided to access the building. The access driveway shall be a minimum of 3.5m in width and a minimum of 7.5m in length. The access driveway shall be constructed on a suitable prepared subgrade with a minimum lift of 375mm of granular material, a minimum lift of 50mm Type 'B' Base

Course asphaltic concrete, and a minimum lift of 25mm Type 'D' Surface Course asphaltic concrete.

Adequate access hatchways and doorways must be provided. All locks must be keyed alike to the Town of Shediac standard.

5.3.9.2 Site Ownership

All structures, fittings, and appurtenances associated with the water booster station must be located on property outside of the street right-of-way in an appropriate area. The ownership of this property must be deeded to the Town of Shediac.

5.3.9.3 Flooding

Water booster stations and appurtenances should be protected from flooding and flood related damage due to the 1 in $100^{(+20\%)}$ year storm.

Water booster stations and appurtenances should remain operational in the 1 in $100^{(+20\%)}$ year storm.

Water booster station land must be graded such that ponding of water does not occur. All exposed areas must be sodded.

5.3.9.4 Site Location

All structures and appurtenances associated with the booster station must be located off the street right-of-way in an appropriate area specifically designated for that purpose. The ownership of this property must be deeded to the Town of Shediac.

5.3.9.5 Equipment Removal

All water booster stations must be equipped with acceptable devices for the removal and maintenance of pumps, motors, controls, and auxiliary power equipment.

5.3.10 Civil

The pump house building must be of adequate size to accommodate the pumps, pump motors, control panel, auxiliary power supply, oil tank, and other accessories. These items must be located in the building taking into consideration safety for operators and convenient access for maintenance.

The pump house building design and construction must meet the requirements of the latest edition of the National Building Code. Exterior wall assembly shall be 200 mm split face concrete block with a minimum of R-10 insulation. There shall be no windows in any exterior wall.

Adequate ventilation for all mechanical equipment must be provided by vandal-resistant, heavy duty type steel intake and exhaust louvres. Engine emissions must be directed away from the building so as not to create a ventilation "short-circuit". Provisions must be made to support wall-mounted equipment inside the building. The building shall have a hip roof with a minimum slope of 12 horizontal to 6 vertical and have a minimum of R-20 insulation.

The building floor must be a minimum 150 mm above the external ground surface and any potential flood level. Pump-house floors must be poured reinforced concrete and sloped towards the access door. All interior wall surfaces, doors, and trims should be painted to a colour scheme as approved by the Engineer. A non-metallic coloured hardener shall be added to the concrete floors during the finishing process to a colour scheme as approved by the Engineer.

Lifting devices of a type approved by the Engineer should be incorporated into the design of the structure so that pumps and/or motors can easily be transferred from their location within the station to an access door.

All locks must be keyed alike to the Town of Shediac standard system.

5.3.11 Electrical & Miscellaneous

The pumping station must be provided with a three phase power supply. Design and installation of the power supply system must meet all applicable and relevant standards and codes.

Full standby power supply must be provided utilizing a standby diesel generator set. The power generating system must be capable of providing continuous electric power during any interruption of the normal power supply. The standby power unit must be designed with adequate capacity to operate fire and domestic pumps, control and monitoring systems, and heating and lighting systems within the pump house.

The generating system must include the following items:

- diesel engine;
- alternator;
- control panel;
- automatic change-over equipment;
- automatic ventilation system;
- battery charger and battery;
- fuel supply unit.

Pumping station equipment must be equipped with control systems, compatible with the pumping station monitoring system. The control system must be capable of providing:

- uninterrupted fully automatic operation of the pumping station to meet the various demand requirements of the area being serviced;

- protection against equipment damage or failure during extreme hydraulic or electrical conditions.

Each pump shall be operated by an energy efficient electric motor capable of operating the pump over the full range of load conditions. Motors should be located such that they cannot be flooded should a pipe failure occur.

All electrical apparatus shall be located in an accessible location above grade with a clear access of 1.0m around all pumps and motors. All panels and controls must be moisture-resistant.

Pump house must contain at least the following:

- electric unit heaters with individual built-in thermostats;
- adequate vapour proof lighting;
- a single photo-cell activated outside vandal proof security light adjacent to or over the access door;
- a weather-proof switch and electrical outlet inside the pump-house immediately adjacent to the access door;
- adequate lightning arrestors;
- a fire extinguisher;
- sufficient ventilation to ensure that heat generated from the electrical equipment is sufficiently dissipated.

5.3.12 Mechanical

Suction and discharge piping must be designed and arranged to provide easy access for maintenance. All piping and tubing, 100 mm diameter and smaller, must be stainless steel, Type 316 or 316L, Schedule 40, unless otherwise approved by the Engineer. All ductile iron piping within the station must be Class 54, cement lined.

Threaded flanges must be used for all joints, fittings and connections within the station.

All piping within the pumping station must be properly supported and must be designed with appropriate fittings to allow for expansion and contraction, thrust restraint, etc. All exposed surfaces and pipes, other than stainless steel, must be finished, treated, and painted to prevent rusting. Colour scheme and paint types shall be approved by the Engineer.

A self-closing check valve must be incorporated in the discharge of each unit in the pumping station. It must be designed in such a way that if pump flow is lost, the valve will close automatically. The type and arrangement of check valves and discharge valves is dependent on the potential hydraulic transients that might be experienced in the pumping station.

An adequate number of isolation valves must be provided to allow maintenance of pumps and/or control valves.

In an in-line booster pumping station, the pressure on the suction side of the pump must not be allowed to drop below 150 kPa when there are service connections on the suction side water main.

5.3.13 Pressure Transients

Water distribution systems must be designed and sized in order to withstand maximum operating pressures plus pressure transients. Pressure transients, or surges, result from sudden changes in flow velocity within the water distribution system. These sudden changes in velocity are most often the result of rapid valve operation, pump start-up and shut-down, sudden demand fluctuations, and power failures.

Pipe and pipe joints must be able to minimally withstand the pressure transient created by the instantaneous stoppage of a water column travelling at 0.6 m/s. The magnitude of the pressure transient will vary as a function of pipe diameter, pipe wall thickness, and pipe wall material.

Celerity values expressed in many texts and manufacturer's catalogues for flexible pipe are for the unrestrained condition. Flexible pipe, when buried, often exhibits an effective celerity much higher than published values. The Consultant should exercise sound engineering judgement to account for this increased effective celerity. A rule of thumb approach is to assume an effective celerity twice that of the published value for flexible pipe.

Typical methods of surge protection that can be used to protect the booster station and equipment include the following:

- surge anticipator systems that dissipate over-pressure from the discharge lines;
- slow closing and opening control valves on pump discharges;
- hydro-pneumatic surge tanks on discharge headers;
- variable speed pumping units.

5.3.14 Safety Precautions

The pumping station and appurtenances must be designed in such a manner as to ensure the safety of operators, in accordance with all applicable Municipal, Provincial, and Federal regulations including the Occupational Health & Safety Act of the province of New Brunswick.

- All moving equipment must be covered with suitable guards and shields to prevent accidental contact by operations and maintenance personnel;

- All self-starting equipment must be labelled with suitable warning signage to ensure that operations and maintenance personnel are aware of this situation;

- All equipment must be equipped with lock-outs to ensure that the equipment is completely out of service when operations and maintenance personnel are working on the system.

5.3.15 Pumping Station Monitoring

Pumping station functions must be monitored using an integrated Supervisory Control and Data Acquisition (SCADA) system to ensure that the station is performing satisfactorily. Monitoring signals and alarms are normally transmitted to the central monitoring station located at the Water Treatment Plant on Breaux Bridge Street. All software is to be fully compatible with the Town of Shediac central SCADA system. The SCADA unit must have two extra digital points and two extra analog points and must be capable of transmitting the following signals and alarms to the central monitoring location:

Signals

- station flow;
- station suction pressure;
- station discharge pressure.

Domestic Booster Pump Alarms

- pump status (On/Off);
- low discharge pressure alarm;
- high discharge pressure alarm;
- motor current overload alarm;
- motor temperature overload;
- surge valve alarm.

Fire Booster Pump Alarms

- pump status (On/Off);
- low discharge pressure alarm;
- high discharge pressure alarm;
- motor current overload alarm;
- motor temperature overload alarm.

Standby Power Unit Alarms

- power failure alarm;
- generator status (On/Off);
- hand-off automatic selector switch status (On/Off);
- battery status (charged/charging);
- fuel tank level (diesel only);
- fuel tank pressure (propane only);
- generator current overload alarm;
- generator temperature overload alarm.

Building Alarms

- panic alarm;
- building fire alarm;
- illegal entry alarm;
- building temperature alarm;
- building flood alarm.

A flow meter, approved by the Engineer, must be installed in the pumping station. Pressure gauges, complete with isolation valves, must be installed on the suction side and on the discharge side of the pumps.

5.3.16 Operation and Maintenance Manual

Three copies of the pumping station operation and maintenance manual must be prepared in a form acceptable to the Engineer, and provided to the Engineer prior to acceptance of the pumping station. This manual must contain at least the following:

- system description;
- design parameters, system hydraulics and design calculation;
- as constructed civil, mechanical, and electrical drawings;
- pump literature, pump curves, and operating instructions;
- manufacturers' operation and maintenance instructions for all equipment;
- name, address, and telephone number of all equipment suppliers and installers;
- information on guarantees/warranties for all equipment.

All special tools and standard spare parts for all pumping station equipment is to be provided by the contractor prior to acceptance of the system by the Town of Shediac.

6 STORM DRAINAGE SYSTEM

6.1 Scope

A storm drainage system is a system receiving, conveying, and controlling discharges in response to precipitation and snow melt. Such systems consist of ditches, culverts, swales, subsurface interceptor drains, roadways, curb and gutters, catchbasins, manholes, pipes, detention ponds, service lateral lines.

All storm drainage systems within the Town of Shediac 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 snow melt 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.

In the Town of Shediac, storm drainage systems are owned, operated, and maintained by either the Town of Shediac, private landowners, or a combination of both.

The management and control of stormwater is a mixture of art and science, and like all other municipal services, storm drainage systems must be carefully designed, reviewed, and approved before construction proceeds. In addition to design criteria, all storm drainage systems shall conform to any requirements established by the New Brunswick Department of Environment and Local Government (NBDELG). No system shall be constructed until the design has been reviewed and approved by the Town of Shediac and by NBDELG, if applicable.

6.2 Engineering Responsibilities

The design of municipal storm drainage systems requires knowledge of two basic fields:

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 which convey storm water.

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, hydrologic and hydraulic modelling is required for the design of piped storm drainage systems, overland storm drainage systems, and stormwater detention facilities.

6.3 Design Approach

6.3.1 Storm Drainage System Types

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).

6.3.2 Dual Storm Drainage System Design

Design of storm drainage systems shall include consideration of both a minor storm drainage system and a major storm drainage system. The design of the dual storm drainage system, including the minor system and the major system, shall be carried out to ensure that no proposed or existing structure shall be damaged by the runoff generated by any storm up to the 1 in $100^{(+20\%)}$ year return period storm. This requires proper care in the design of streets, curb and gutters, catchbasins, pipes, open channels, grading of lots and road profiles, setting of elevations or openings into buildings, foundation drains, roof drains, or other “off-street” connections.

In the event that the Consultant identifies a existing structure that may be damaged by the runoff generated by any storm up to the 1 in $100^{(+20\%)}$ year return period storm, the Consultant shall notify the Engineer so that the situation may be reviewed and resolved on an individual basis.

When adequate downstream capacity does not exist, one option is to upgrade downstream infrastructure, however this is not the only option. The Developer and/or Consultant may reduce peak flow through the use of storage. A “zero-net increase” covenant may be implemented that will limit post-development peak discharge to the existing pre-development peak discharge. It is the responsibility of the Developer and/or Consultant to ensure that the proposed development does not create a downstream flooding problem, or aggravate an existing downstream flooding problem.

Further, it is the responsibility of the Developer and/or Consultant to exercise innovative engineering design solutions including various methods of on-site storage to mitigate the detrimental effects of their development by any storm up to the 1 in $100^{(+20\%)}$ year return period storm.

6.3.2.1 Minor Storm Drainage 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. The minor storm drainage system shall consist of the following components:

- 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.

6.3.2.2 Major Storm Drainage System

The major storm drainage system shall be designed to convey stormwater runoff from the 1 in $100^{(+20\%)}$ 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. The major storm drainage system shall consist of the following components:

- 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;

- ditches, open drainage channels, swales, roadways, watercourses, floodplains, canals, ravines, gullies, springs, and creeks in those areas where an open channel 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 1 in $100^{(+20\%)}$ 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 up to and including the 1 in $100^{(+20\%)}$ 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.

6.3.3 Storm Drainage System Outfall

The dual storm drainage system consisting of the minor storm drainage system and the major drainage system shall be extended to discharge to an existing downstream storm drainage system, or natural watercourse.

6.3.4 Existing Storm Drainage System Outfall

The downstream storm drainage system shall have adequate capacity to capture and convey discharge from the proposed storm drainage system in addition to its own base flow rate of discharge. Any adverse impact, such as flooding or erosion, as a result of the combined rate of discharge, on the downstream storm drainage system shall be investigated. Such investigation shall be carried out from the outfall location of the proposed storm drainage system to a location in the downstream watercourse where the peak rate of discharge from the proposed storm drainage system is 10% of the combined peak rate of discharge in the watercourse at that location.

The extent of any adverse impacts will be assessed by the Town of Shediac based on this investigation. Depending upon the nature of any adverse impacts, the Town of Shediac may require mitigative measures to be provided to the storm drainage system to prevent or alleviate such adverse impacts.

6.3.5 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.

6.3.6 Developed Areas

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.

6.3.7 Undeveloped Areas

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.

6.3.8 Long Duration

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

6.4 Stormwater Management

Sound stormwater management requires skillful integration of the planning and design of piped stormwater systems, overland stormwater systems, and stormwater detention facilities recognizing and accounting for the effects of urbanization and climate change in terms of stormwater quantity and stormwater quality.

6.4.1 Climate Change

The effects of climate change are to be accommodated in the design of drainage infrastructure in the Town of Shediac. Major risks that threaten municipal storm drainage systems need to be recognized and accommodated in planning and design. Two major risks are the effects of increased precipitations and sea level rising.

6.4.1.1 Increased Precipitation

The effects of increased precipitation resulting from climate change are to be accommodated in the design of dual storm drainage systems. The recommended approach consists of:

1. incorporation of allowances to accommodate the effects of increased precipitation in the planning and design of overland storm drainage systems for major storm events;

2. continuing to use historic precipitation data in the planning and design of piped storm drainage systems for minor storm events.

This approach will minimize development costs associated with construction of the piped storm drainage system while providing the flexibility to marginally increase the capacity of the overland storm drainage system.

6.4.1.2 Sea Level Rise

The effects of sea level rise resulting from climate change are to be accommodated in the design of dual storm drainage systems. The recommended approach consists of:

1. ensuring that all overland storm drainage systems are constructed above the minimum geodetic elevation for habitable space as published in the Community Planning Act;

2. ensuring that all piped storm drainage systems are constructed above the minimum geodetic elevation for habitable space as published in the Community Planning Act, or ensuring that approved mechanisms to prevent the inundation of sea water are employed.

This approach will ensure that new development is constructed above the high water elevation associated with storm surges and extreme high tides and that additional measures are employed in high risk areas.

6.4.2 Zero-Net Increase Development

In recognition of the environmental impacts of urbanization, the effects of climate change, and the need to reduce the risk of property damage resulting from localized flooding, the Town of Shediac has introduced a requirement for zero-net increase development in terms of stormwater management. The objective of this requirement is to ensure that the peak rate of stormwater discharge from a development does not exceed that of the pre-developed condition. That is, there is a zero-net increase in stormwater discharge resulting from development.

This requirement must be met for the broad spectrum of high-frequency, low-intensity storm events, as well as low-frequency, high-intensity storm events. Confirmation of pre-development and post-development peak stormwater discharge rates will assessed for the 2, 5, 10, 25, 50 and $100^{(+20\%)}$-year design storm events as published by the Atmospheric Environment Service (AES) of Environment Canada.

6.4.2.1 Pre-Development Condition

For the pre-developed condition, hydrologic analysis should be based on the land parcel in its natural wooded pervious condition. The time concentration (T_c) should be based on natural flow patterns. Runoff hydrographs must be prepared for the 2, 5, 10, 25, 50 and $100^{(+20\%)}$-year design storm events for the pre-developed condition.

6.4.2.2 Post-Developed Condition

For the post-developed condition, hydrologic analysis should be based on the land parcel in its altered impervious condition. The time concentration (T_c) should be based on altered flow patterns. Runoff hydrographs must be prepared for the 2, 5, 10, 25, 50 and $100^{(+20\%)}$-year design storm events for the post developed condition.

Adequate detention storage must be provided within the development to ensure that the post-developed hydrographs, after routing through the detention storage, do not exceed the pre-developed hydrographs.

6.5 Meteorological Data

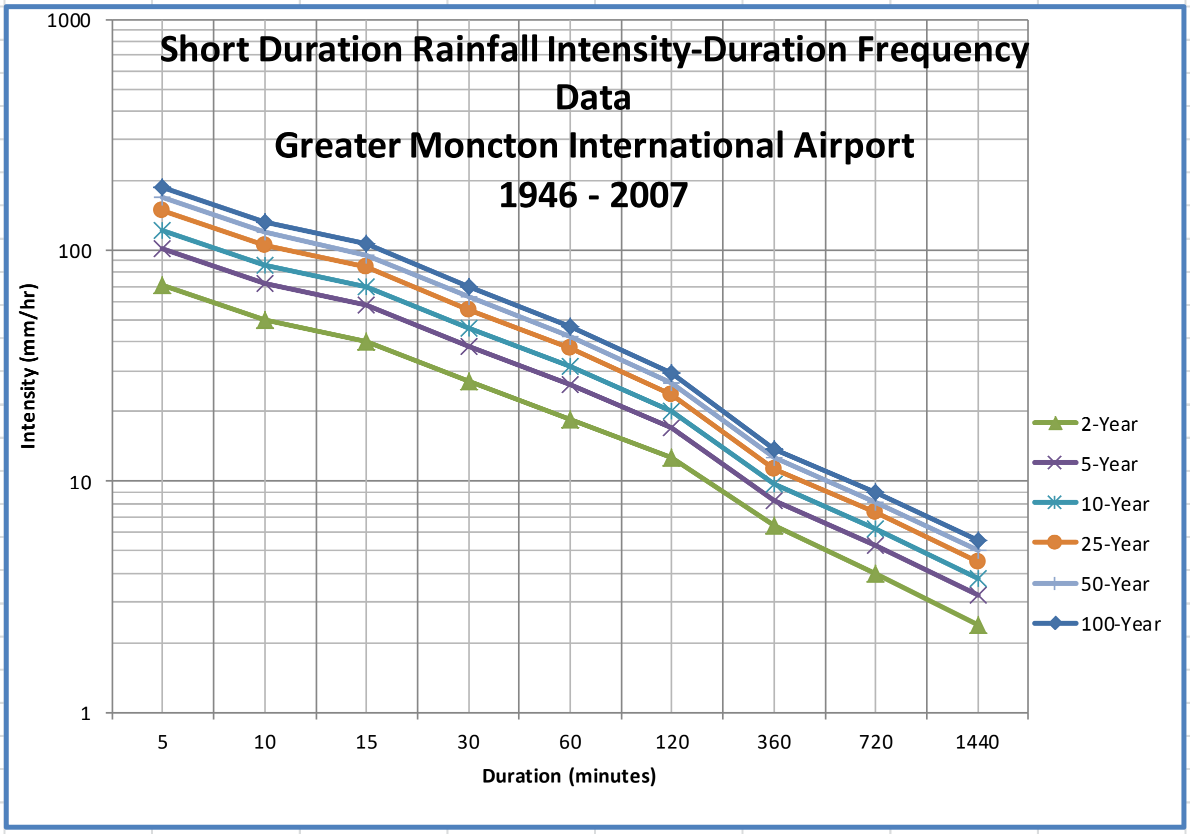
Rainfall data is used in a variety of forms including intensity-duration-frequency curves, synthetic design storms, historical design storms, and historical long-term rainfall records.

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 be noted that the climatic information presented in this section does not contain any allowances for climate change. As presented in Section 6.4.1.1, allowances for climate change are required for the design of the major storm drainage system and detention facilities.

6.5.1 Rainfall Intensity – Duration – Frequency Curve

Figure 6.1 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.

Figure 6.1 - Short Duration Rainfall Intensity-Duration Frequency Data



Return Period (years)	Coefficient A	Exponent B	Interpolation Equation	
				$R = At^B$
2-Year	17.5	-0.595		
5-Year	24.4	-0.612	R =	Rainfall Rate (mm/hr)
10-Year	29.0	-0.618	A =	Coefficient
25-Year	34.7	0.624	t =	Time (hrs)
50-Year	39.0	-0.628	B =	Exponent
100-Year	43.3	-0.630		

6.5.2 Synthetic Design Storm

Advanced procedures for the design of storm drainage systems requires the input of rainfall hyetographs or unit hyetographs, which specify rainfall intensities for successive time increments during a storm event. For this purpose, it is standard practice to use both synthetic and historical design storm hyetographs, or unit hyetographs. Synthetic design storm hyetographs are intended to represent some of the long statistical properties of recorded rainfall. The Chicago Storm distribution shall be used to derive synthetic design storm hyetographs from rainfall intensity-duration-frequency (IFD) curves. Figure 6.2 through Figure 6.7 present the 2-hour Chicago Storm distribution for the 2, 5, 10, 25, 50 and $100^{(+20\%)}$ -year return periods.

Figure 6.2 - 2-Year Return Period - 2-Hour Chicago Storm Distribution

Time (min)	Rainfall (mm)
0-5	0.39
5-10	0.41
10-15	0.44
15-20	0.46
20-25	0.50
25-30	0.54
30-35	0.59
35-40	0.66
40-45	0.75
45-50	0.90
50-55	1.15
55-60	1.79
60-65	6.40
65-70	1.79
70-75	1.15
75-80	0.90
80-85	0.75
85-90	0.66
90-95	0.59
95-100	0.54
100-105	0.50
105-110	0.46
110-115	0.44
115-120	0.41
120-125	0.39

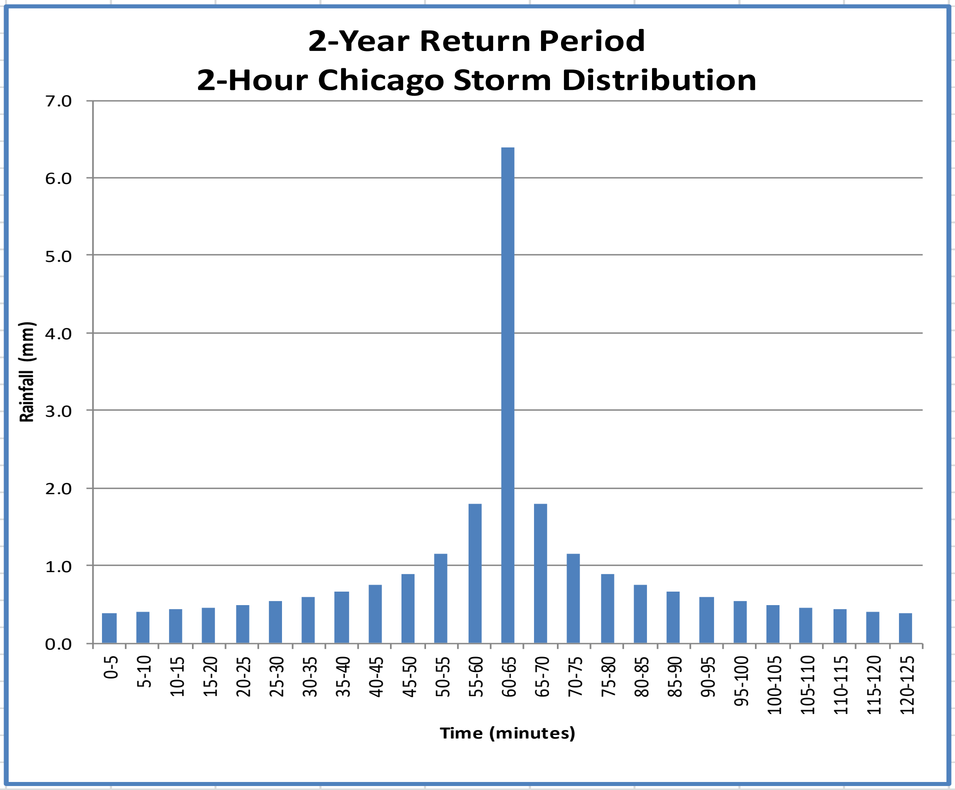


Figure 6.3 - 5-Year Return Period - 2-Hour Chicago Storm Distribution

Time (min)	Rainfall (mm)
0-5	0.52
5-10	0.54
10-15	0.58
15-20	0.62
20-25	0.66
25-30	0.72
30-35	0.79
35-40	0.88
40-45	1.01
45-50	1.21
50-55	1.56
55-60	2.47
60-65	9.30
65-70	2.47
70-75	1.56
75-80	1.21
80-85	1.01
85-90	0.88
90-95	0.79
95-100	0.72
100-105	0.66
105-110	0.62
110-115	0.58
115-120	0.54
120-125	0.52

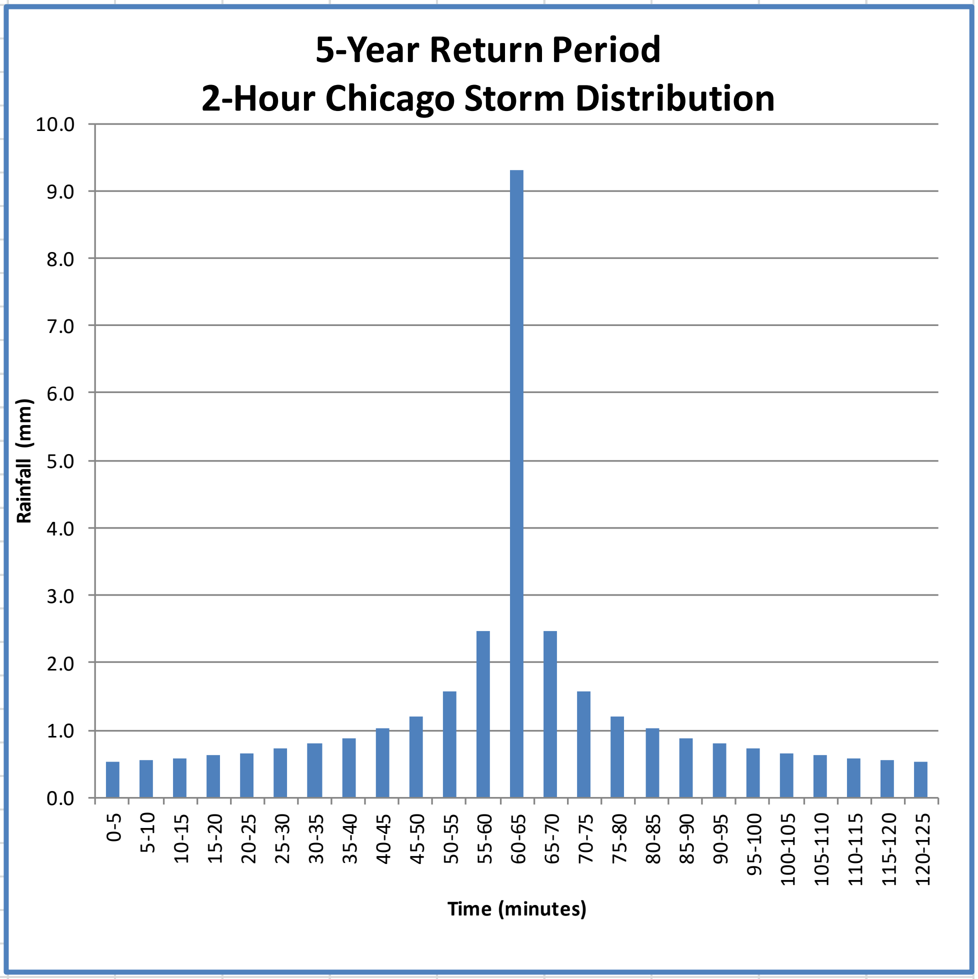


Figure 6.4 - 10-Year Return Period - 2-Hour Chicago Storm Distribution

Time (min)	Rainfall (mm)
0-5	0.60
5-10	0.63
10-15	0.67
15-20	0.72
20-25	0.77
25-30	0.84
30-35	0.92
35-40	1.04
40-45	1.19
45-50	1.42
50-55	1.84
55-60	2.93
60-65	11.22
65-70	2.93
70-75	1.84
75-80	1.42
80-85	1.19
85-90	1.04
90-95	0.92
95-100	0.84
100-105	0.77
105-110	0.72
110-115	0.67
115-120	0.63
120-125	0.60

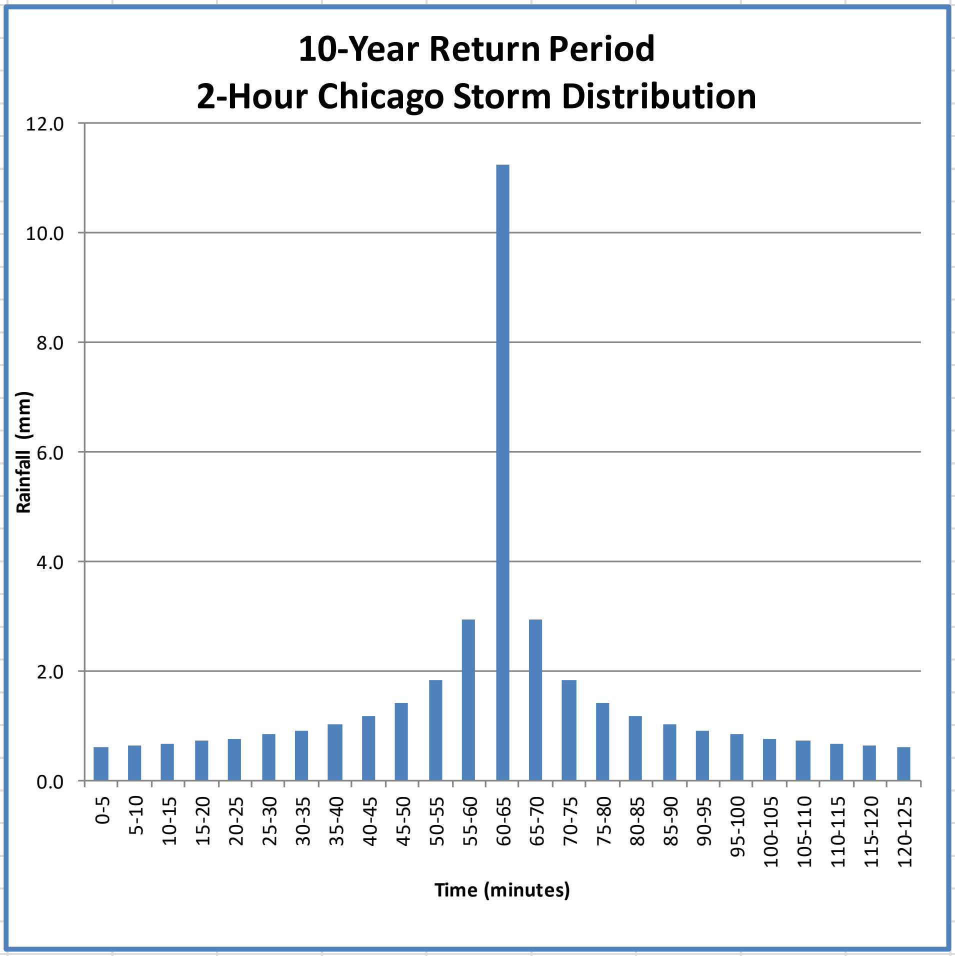


Figure 6.5 - 25-Year Return Period - 2-Hour Chicago Storm Distribution

Time (min)	Rainfall (mm)
0-5	0.71
5-10	0.75
10-15	0.79
15-20	0.84
20-25	0.91
25-30	0.99
30-35	1.09
35-40	1.22
40-45	1.40
45-50	1.68
50-55	2.18
55-60	3.49
60-65	13.63
65-70	3.49
70-75	2.18
75-80	1.68
80-85	1.40
85-90	1.22
90-95	1.09
95-100	0.99
100-105	0.91
105-110	0.84
110-115	0.79
115-120	0.75
120-125	0.71

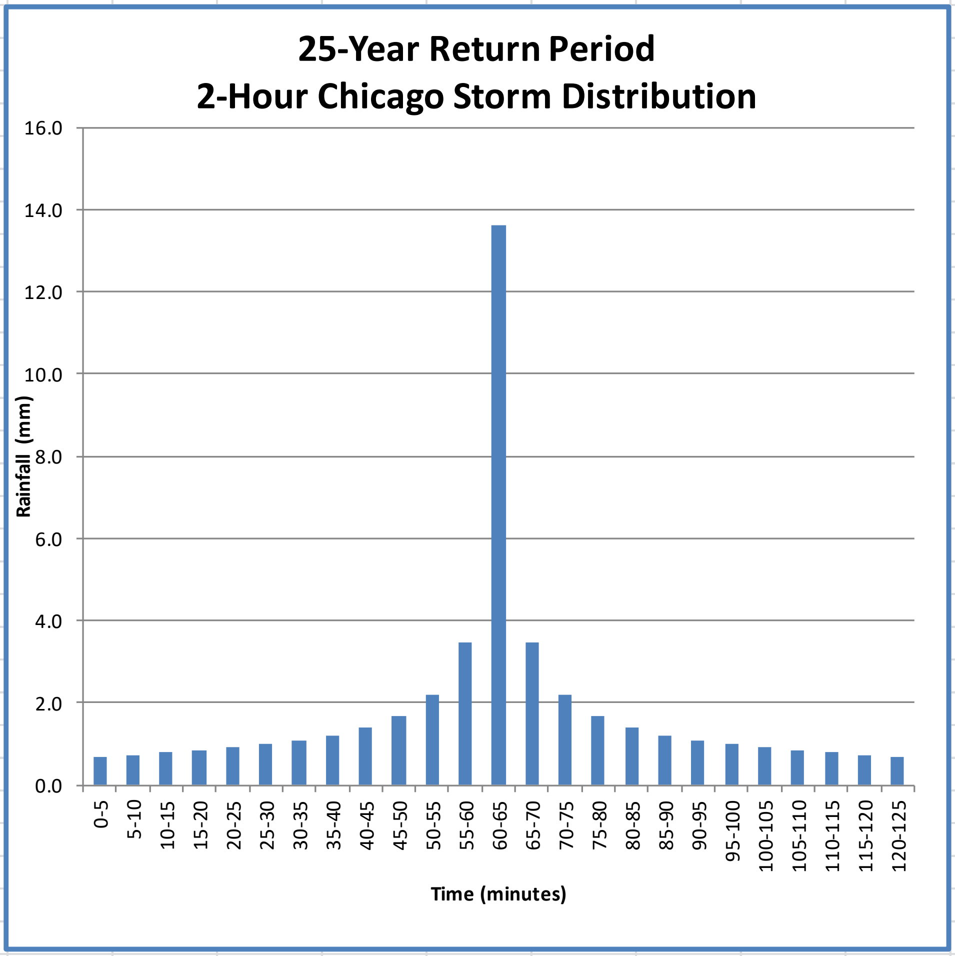


Figure 6.6 - 50-Year Return Period - 2-Hour Chicago Storm Distribution

Time (min)	Rainfall (mm)
0-5	0.78
5-10	0.83
10-15	0.88
15-20	0.94
20-25	1.01
25-30	1.10
30-35	1.21
35-40	1.36
40-45	1.56
45-50	1.88
50-55	2.44
55-60	3.91
60-65	15.47
65-70	3.91
70-75	2.44
75-80	1.88
80-85	1.56
85-90	1.36
90-95	1.21
95-100	1.10
100-105	1.01
105-110	0.94
110-115	0.88
115-120	0.83
120-125	0.78

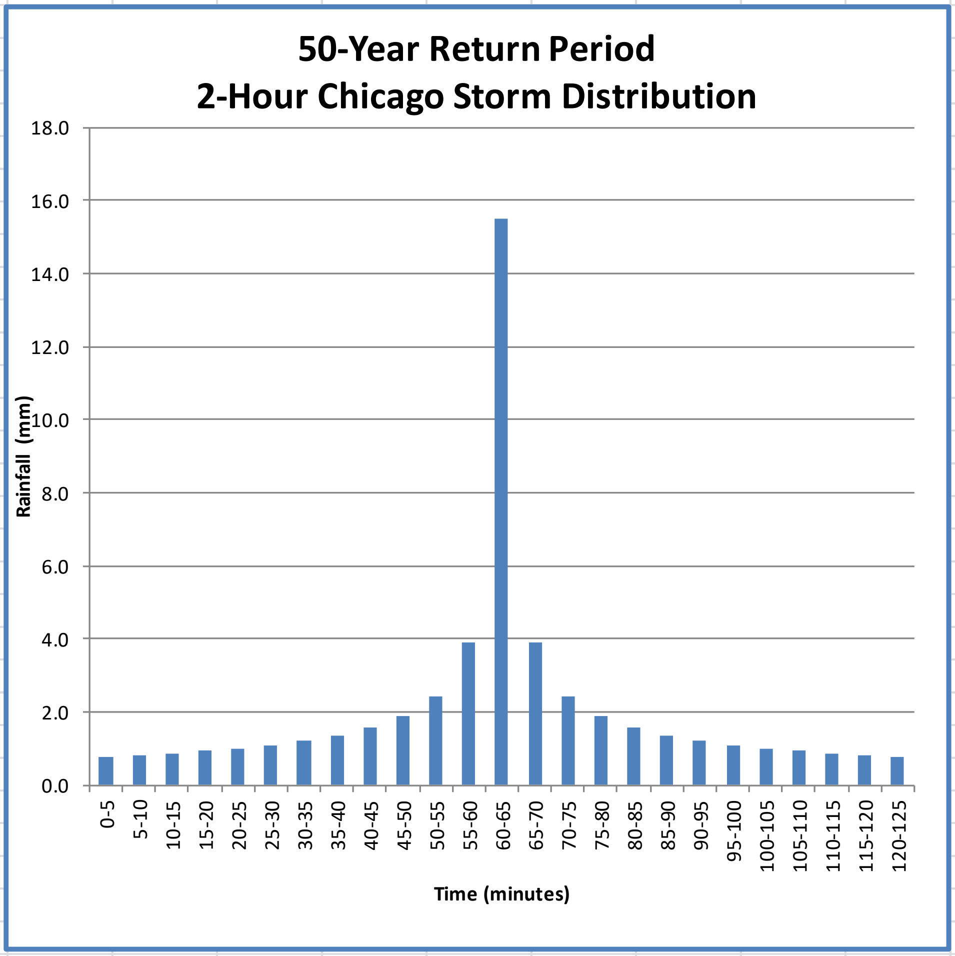
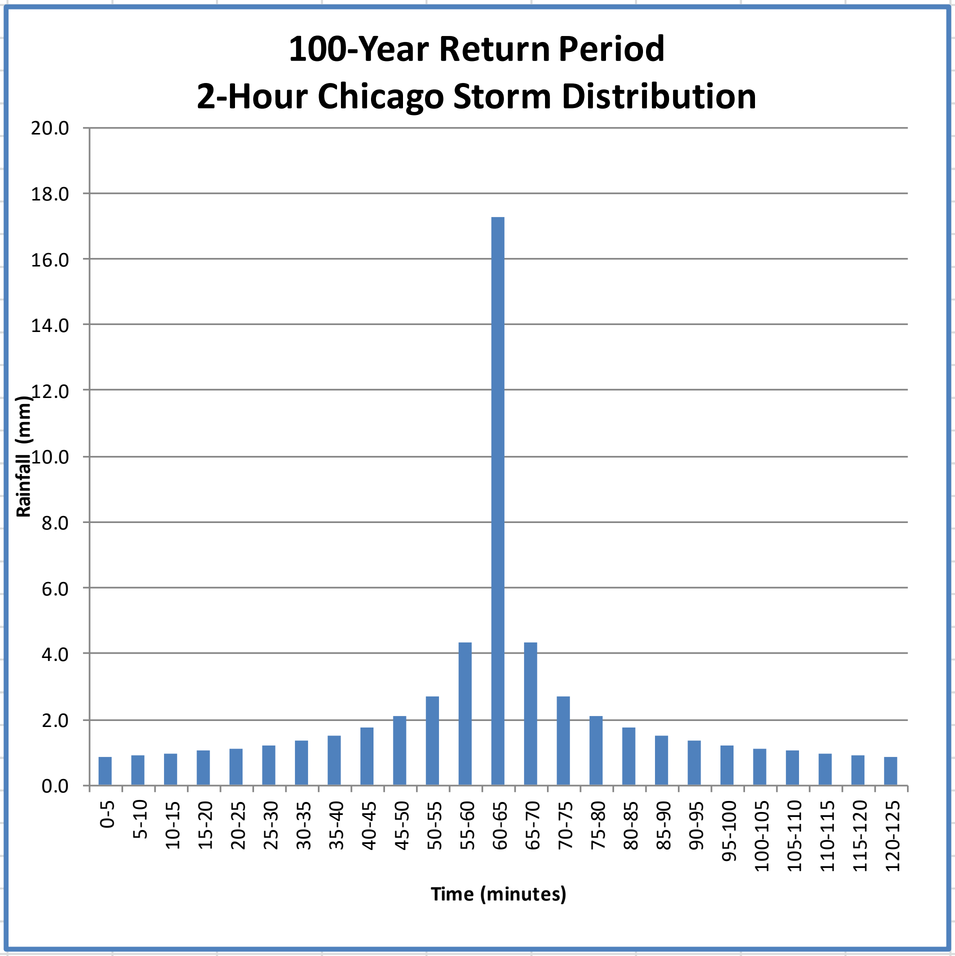


Figure 6.7 - 100-Year Return Period - 2-Hour Chicago Storm Distribution

Time (min)	Rainfall (mm)
0-5	0.86
5-10	0.91
10-15	0.97
15-20	1.03
20-25	1.11
25-30	1.21
30-35	1.34
35-40	1.50
40-45	1.73
45-50	2.08
50-55	2.70
55-60	4.33
60-65	17.27
65-70	4.33
70-75	2.70
75-80	2.08
80-85	1.73
85-90	1.50
90-95	1.34
95-100	1.21
100-105	1.11
105-110	1.03
110-115	0.97
115-120	0.91
120-125	0.86



6.5.3 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.

6.6 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 list of computational methods is not to be considered complete and comprehensive. Its intention is to provide general comments on several of the methods accepted by the Town of Shediac.

6.6.1 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.

6.6.2 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.

6.6.3 SWMM

The United States Environmental Protection Agency (USEPA), Storm Water Management Model (SWMM) and other third-party developed interfaces for the SWMM model including MIKE-SWMM, OTT-SWMM and PC-SWMM for example, may be used for design of piped systems, modelling overland flow in a major system and modelling contaminant transport.

6.6.4 HYMO

The Hydrologic Model (HYMO) and other third-party developed interfaces for the HYMO model including OTT-HYMO for example, may be used for modelling overland flow in a major system, design of storage facilities and stream channel routing.

6.6.5 HEC

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

Methods other than those listed above may be used if their use is justified by the Consultant and approved by the Town of Shediac.

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

6.7 Hydrologic Design Criteria

6.7.1 Rational Method

6.7.1.1 Summer Runoff Coefficients

Table 6.1 and Table 6.2 present Rational method runoff coefficients appropriate for various land uses and surface types. Selection of values from Table 6.1 and Table 6.2 shall be based on impervious area, lot size, soil conditions, and other relevant considerations. For residential, commercial or industrial land uses, rainfall intensities from Figure 6.1 shall be used with coefficients for summer ground conditions.

Table 6.1 presents a range of summer Rational method runoff coefficients commonly associated with a general character of area.

Table 6.1 - 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 6.2 presents a range of summer Rational method runoff coefficients commonly associated with a general character of surface.

Table 6.2 - 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.

6.7.1.2 Winter Runoff Coefficients

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 6.3 and rainfall intensities from Figure 6.1 accounting for snowmelt contributions. 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 $100^{(+20\%)}$ year design storm, and the time of concentration (T_c) shall be adjusted to reflect flow over frozen ground.

Table 6.3 presents the winter Rational method runoff coefficients commonly associated with areas and surfaces with summer Rational method runoff coefficients less than or equal to 0.80.

Table 6.3 - 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

6.7.1.3 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.

The summer runoff coefficients presented in Table 6.1 and Table 6.2 are suitable for analysis of storm events up to the 1:5 year design storm event. The summer runoff coefficients should be increased to account for saturated soil conditions for analysis of storm events including the 1:100$^{(+20\%)}$ year design storm event. Table 6.4 presents Rational method runoff coefficients for use in the 1:100$^{(+20\%)}$ year design storm event.

Table 6.4 presents the increased Rational method runoff coefficient for the 100$^{(+20\%)}$ Year Return Period.

Table 6.4 - 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

Table 6.1 and Table 6.2 provide a general guideline to tunoff coefficients for various area characterixitics and various pervios and impervios grpoundcovers. However, a deteiled calculation of the composite rational method ruunoff coeffient should be made for exisitng and propsd delopment as per the exaples provided in Figure 6.8 and Figure 6.9.

Figure 6.8 - Composite Ration Runoff Coefficient – Single-Family Dwelling

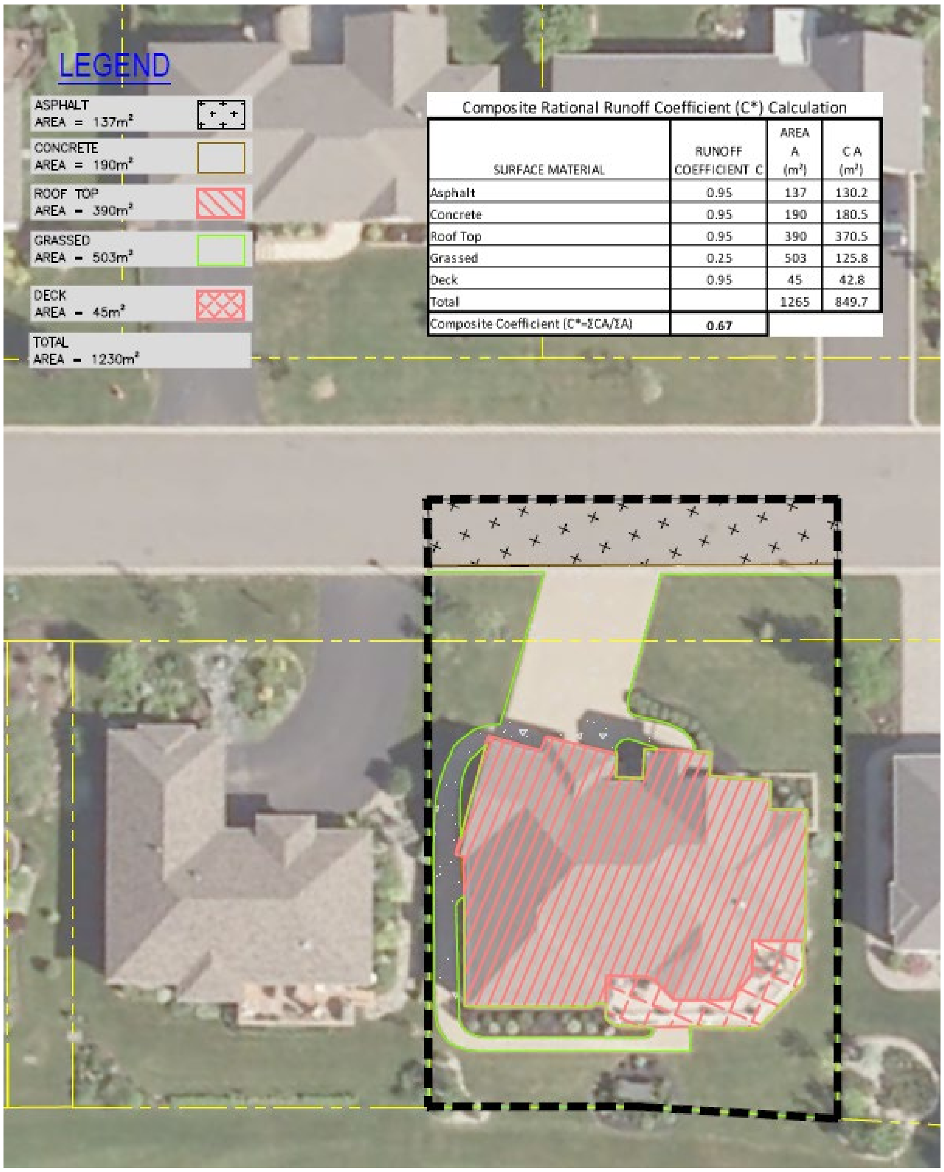
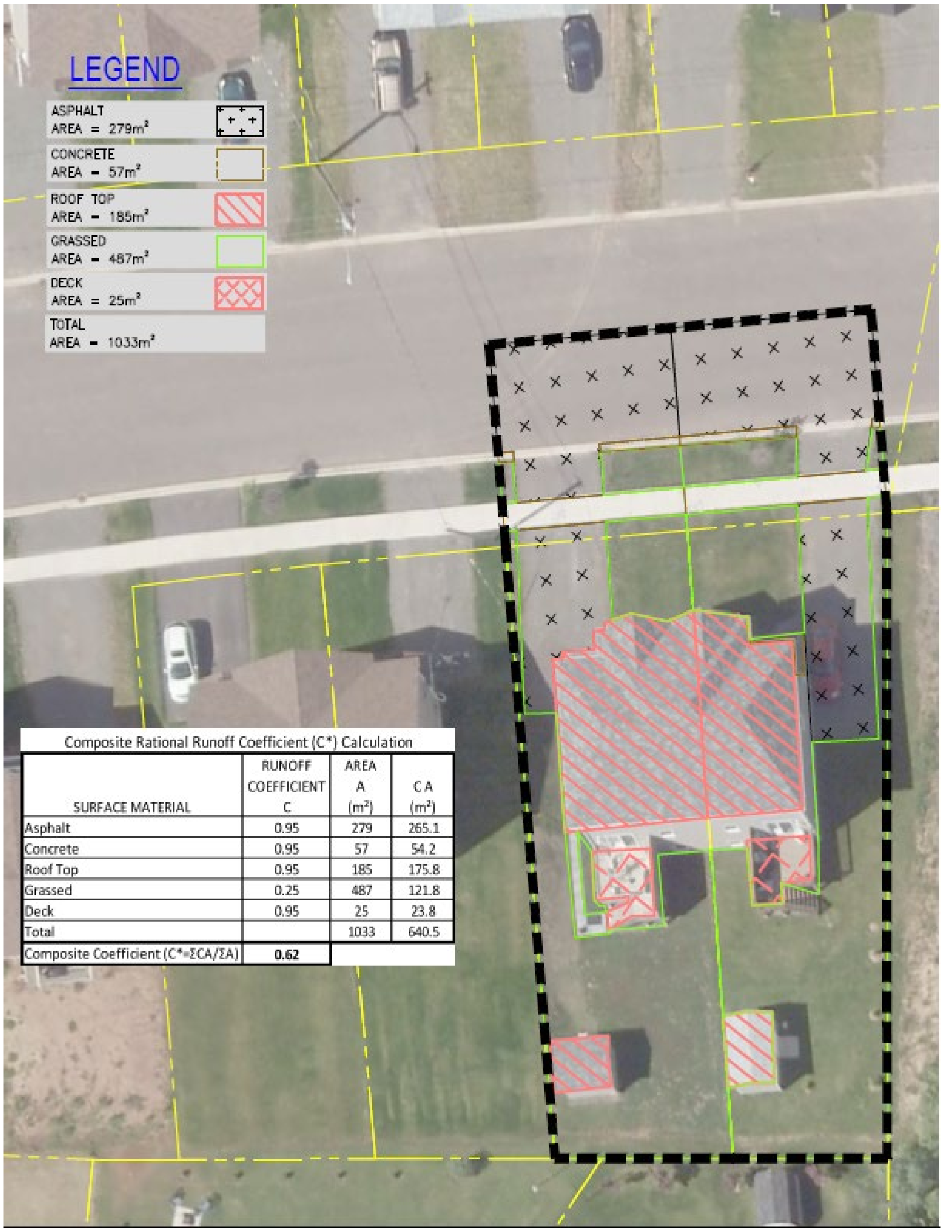


Figure 6.9 - Composite Ration Runoff Coefficient – Semi-Detached Dwelling



Composite Rational Runoff Coefficient (C*) Calculation

SURFACE MATERIAL	RUNOFF COEFFICIENT C	AREA A (m²)	C A (m²)
Asphalt	0.95	279	265.1
Concrete	0.95	57	54.2
Roof Top	0.95	185	175.8
Grassed	0.25	487	121.8
Deck	0.95	25	23.8
Total		1033	640.5
Composite Coefficient (C*=ΣCA/ΣA)	**0.62**		

6.7.1.4 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:

Time of Concentration (T_C) = 1.7 x Lag Time (T_L) [6.1]

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.

6.7.2 United States Soil Conservation Service (USSCS) Method

6.7.2.1 USSCS Curve Numbers

Table 6.5 presents USSCS method curve numbers for various land uses and hydrologic conditions. Selection of values from Table 6.5 shall be based on impervious area, lot size, soil condition, and other relevant considerations. The curve numbers presented in Table 6.5 are intended for general guidance only, and the curve numbers of all development shall be calculated using the values of pervious and impervious surfaces shown in Table 6.5.

For ordinary residential, industrial, or commercial land uses, rainfall data from Figure 6.2 through Figure 6.5 shall be used with curve numbers for summer ground conditions. Where runoff from an area that includes 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 6.1 through Figure 6.7 accounting for snowmelt contribution.

Table 6.5 - USSCS Method Curve Numbers

Character of Area	Hydrologic Condition	Average Impervious Area	US SCS 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

6.7.2.2 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 6.6 presents USSCS hydrologic soil groups. Generally, in lieu of detailed soil analysis, the Consultant should select USSCS curve numbers consistent with Table 6.5 assuming hydrologic soil group "D"

Table 6.6 presents USSCS hydrologic soil group definitions.

Table 6.6 - 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)

6.8 Storm Drainage Report

A storm drainage report shall be prepared and included as part of the submission for any subdivision to examine the effect of the development on the receiving watercourses and downstream drainage systems.

The storm drainage report shall include a Storm Servicing Schematic consistent with the submission requirements outlined in Subsection 3.4, Subsection 3.5, and Subsection 3.7.

6.9 Minor Storm Drainage System

6.9.1 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 (ICD's) to limit the quantity of stormwater runoff that gets into the minor storm drainage system. 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.

6.9.2 Minimum Velocity

Under peak design flow (PDF) conditions from the tributary area, when fully developed, stormwater flow velocities must be a minimum of 0.6 m/s.

6.9.3 Maximum Velocity

Under peak design flow (PDF) conditions from the tributary area, when fully developed, stormwater flow velocities must be a maximum of 4.0 m/s.

6.9.4 Minimum Diameter

Storm sewer main diameter shall not be less than 300 mm.

Catchbasin lead diameters shall not be less than 150 mm.

6.9.5 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.

6.9.6 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.**

6.9.7 Minimum Depth

The depth of storm sewer mains, measured from the design grade of the finished surface to the top of the pipe must be a minimum of 1.5 m.

However, in order to service full residential basements, the depth of storm sewer lateral must be a minimum of 2.5m at the property line. In order to achieve this, the depth of storm sewer mains, measured from the design grade of the finished surface to the top of the pipe must be a minimum of 3.0m.

6.9.8 Maximum Depth

The depth of storm sewer mains, measured from the design grade of the finished surface to the top of the pipe must be a maximum of 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 depth to the crown of the pipe at any manhole location shall not exceed 8.0 m.

6.9.9 Location

Wherever possible, all storm sewer mains and appurtenances shall be located within the street right-of-way or a Municipal Service Easement (MSE) in favour of the Town of Shediac. All storm drainage outfalls shall be located within a Municipal Service Easement (MSE) in favour of the Town of Shediac.

Municipal Service Easements shall be of sufficient width to allow safe excavation of the sanitary sewer in accordance with the requirements of Worksafe NB. Depending upon the length and location of the Municipal Service Easement (MSE), the Department of Engineering and Environmental Services 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 (MSE) 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. However, the actual width shall depend upon the depth and size of any sanitary sewer contained therein such that safe excavation to the sanitary sewer is possible.

6.9.10 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 1,500 mm in diameter.

Where a storm sewer main diameter is less than 1,500 mm, manhole spacing shall not exceed 120 m. Where a storm sewer main diameter is equal to or greater than 1,500 mm, manhole spacing will be determined in consultation with the Town of Shediac.

The following criteria 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 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 1,050 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.

6.9.11 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 Shediac;
- For semi-detached lots, one storm drainage service lateral is required;

- The storm drainage lateral shall be laid at a minimum grade of 1.5% to the limit of the street right-of-way;

  The depth of storm drainage laterals shall not be less than 2.5m within the street right-of-way. In order to service full-depth residential basements. In areas where this requirement cannot be met, the Subdivision Grading and Drainage Plan must reflect half-depth residential basements, or slab-on-grade foundations.

6.9.12 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.

6.9.13 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 1 in $100^{(+20\%)}$ 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 0.5m 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.

6.9.14 Roof Drains

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 250m^2, shall be directly connected to the storm drainage system, depending on the capacity of the downstream system.

Commercial/Industrial roof drains, where the roof area to be drained exceeds 250m^2, may be discharged overland and incorporated into the overall on-site storm water management plan.

6.9.15 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 120 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 for open channel flow conditions for the 1 in 5 year return period storm, the actual flows captured by the catchbasins during the 1 in 100$^{(+20\%)}$ year return period storm shall be determined.

6.9.16 Inlet Control Devices

Inlet control devices (ICD's) 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 6.7. Detailed ICD sizing requirements and theory are provided in Appendix C.

Table 6.7 presents typical inlet control device (ICD) sizes for medium density residential development.

Table 6.7 - 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

Table 6.7 is based on a Rational Method runoff coefficient (C = 0.50) for medium density residential development.
Table 6.7 is based on an inlet time (T_i = 5 min) for medium density residential development.
Table 6.7 is based on a head of 1.13 m.

6.9.17 Inlets

Inlets to piped storm drainage systems shall, for pipes 300 mm in diameter or larger, require a concrete headwall, wingwalls and apron complete with a grate 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.

6.9.18 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 a concrete headwall, wingwalls and apron complete with a grate 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.

6.9.19 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 Shediac *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.

$$D_{load} = \frac{(W_e + W_l + W_s)}{B_f \cdot D} \qquad [6.1]$$

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

6.10 Major Storm Drainage System

6.10.1 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.

6.10.2 Major Storms

For barrier-type curb applications, storm drainage design shall provide that the depth and spread of flow in a 1 in $100^{(+20\%)}$ 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 (MSE) 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 Municipal Service Easement (MSE) 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.

6.10.3 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.

6.10.4 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 drawing No. 28 of the Town of Shediac *Standard Municipal Specifications*. Ditches shall be designed with adequate capacity to carry the flow expected from the 1 in $100^{(+20\%)}$ year return period storm.

6.10.5 Maximum Velocity

To prevent erosion, maximum velocities in a 1 in $100^{(+20\%)}$ year return period storm in ditches or open channels that convey stormwater runoff shall not exceed values set forth in Table 6.8 unless the channel is lined or acceptable energy dissipation facilities are provided.

Table 6.8 presents maximum permissible mean channel velocities for swales, ditches, open channels, and drainage courses.

Table 6.8 - 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

6.11 Culverts

6.11.1 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.

6.11.2 Minimum Depth

Minimum cover for culverts under roadways is 500 mm.

6.11.3 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.

6.11.4 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 Shediac.

Culverts located in drainage courses or natural watercourses are to be designed to accommodate the 1 in 100$^{(+20\%)}$ year return period storm, unless otherwise directed by the Town of Shediac.

6.11.5 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 6.9 and Table 6.10 present entrance loss coefficients (k_e) for reinforced concrete pipe (RCP) and corrugated steel pipe (CSP)

Table 6.9 presents entrance loss coefficients (k_e) for reinforced concrete pipe (RCP) culverts under inlet control. The values presented in Table 6.9 should be used for the determination of required headwater from the energy equation, or a nomograph solution of the energy equation.

Table 6.9 - 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
Bevelled ring	6	0.25

Table 6.10 - 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

6.11.6 Inlet Design

All culverts under roadways are to be equipped with a concrete headwall, wingwalls and apron or some other form of embankment stabilization and erosion control.

6.11.7 Outlet Design

All culverts under roadways are to be equipped with a concrete headwall, wingwalls and apron or some other form of embankment stabilization and erosion control.

6.11.8 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 6.2.

$$D_{mean} = 0.019 \cdot V^2 \qquad [6.2]$$

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 6.8.

6.11.10 Inlet and Outlet Grates

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

Culverts longer than 25m 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.

6.11.11 Culvert Materials

Culverts under driveways shall be as per the Town of Shediac *Standard Municipal Specification*.

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

6.12 Guidelines for On-Site Stormwater Quality Management

The Town of Shediac recognises the need to reduce the environmental impacts of urban development on natural watercourses through the implementation of on-site stormwater quality management practices. This section contains Guidelines for On-Site Stormwater Quality Management documenting the policies and practices that have been applied in the region on urban development for the past several years. This section will assist with the selection and sizing of the necessary on-site stormwater quality management (SQM) technology to meet the current stormwater quality objectives.

It must be recognized stormwater quality objectives are not static. As more and more municipalities implement ever more stringent stormwater quality objectives, vendors are developing and marketing a wider range of SQM devices to address the needs of this emerging market. The Town of Shediac will consider SQM devices and technologies provided they meet the stormwater quality objectives.

6.12.1 Land Use, Zoning and Parking Requirements

It is recognised that certain types of development generate higher concentrations of stormwater contaminants than others. In the case of urban development, stormwater contaminants are primarily associated with the operation and maintenance of parking facilities. Stormwater contaminants are deposited on parking facilities where they accumulate and concentrate until a rainfall or snowmelt event washes them from the parking facility conveying them to the storm drainage system. Eventually the stormwater contaminants will outfall to a natural watercourse. For this reason, the size and use of a parking facility will determine whether a development requires on-site stormwater quality management.

The Town of Shediac Zoning By-Law contains a vast number of zoning descriptions, allowable land use descriptions associated with each zone, and parking requirements. The combination of zoning, land use and parking requirements will determine whether a development requires on-site stormwater quality management.

To assist the Developer/Engineer in determining whether on-site stormwater quality management is a requirement of their development, commercial development and industrial development are all candidates.

6.12.2 Stormwater Quality Pollutants

Stormwater runoff from urban development contains a myriad of pollutants including gross debris, total suspended sediments (TSS), metals, free oil and grease (FOG), dissolved substances, nutrients, herbicides and pesticides and micro-organisms. Current technology allows the removal of many, but not all of these stormwater pollutants.

Current technology allows for the removal of gross debris, suspended sediments, and free oil and grease. However, by removing suspended sediments, many metals are also removed as smaller particles adhere to larger particles and are trapped in the sediments load.

It is a requirement that all on-site SQM devices be capable of removing and retaining both TSS and FOG.

6.12.3 First Flush Capture

Stormwater contaminants are deposited on parking facilities where they accumulate between rainfall events. After a brief period of initial rainfall, surface depressions on the parking facility will be filled and sheet flow will wash stormwater contaminants from the parking facility to the storm drainage system. This phenomena is known as the first flush and is responsible for washing the majority of stormwater contaminants (TSS and FOG) from the parking facility. Overall stormwater quality, with removal of the first flush, greatly improves as higher intensity rainfall continues to flow over a nearly clean parking facility.

In order to effectively capture the first flush of stormwater contaminants, an on-site SQM device must be capable of capturing and retaining the first 10 mm of rainfall that falls within the first hour of a rainfall event, or be capable of retaining a flow rate of up to 10 mm/hr.

6.12.4 Total Suspended Solids (TSS) Removal

The particle size distribution found in the total suspended solids (TSS) accumulated on an urban parking facility range in size from grit sized particles (1,000 microns), to silt sized particles (100 microns), to clay sized particles (10 microns). Current technology makes it cost prohibitive to remove clay sized particles.
It is a requirement that all on-site SQM devices be capable of removing and retaining TSS greater than 100 microns.

6.12.5 Total Suspended Solids (TSS) Retention

It is required that an on-site SQM device not only be capable of removing TSS from the first flush of a rainfall event, but it must be capable of retaining the captured TSS for the duration of the rainfall event. More importantly, it is required that the on-site SQM device capable of additional capture and additional retention of TSS for subsequent rainfall events throughout the year.

In order to meet this stormwater quality objective, an on-site SQM device must be sized to capture and retain the anticipated TSS loading for a period of one year.

6.12.6 Free Oil and Grease (FOG) Removal

Trace hydrocarbon connections, as low as 1 mg/L or 1 ppm, in the form of free oil and grease (FOG) can have a detrimental effect on stormwater quality.

It is a requirement that all on-site SQM devices be capable of removing and retaining 80% of FOG.

6.12.7 Free Oil and Grease (FOG) Retention

It is required that an on-site SQM device not only be capable of removing FOG from the first flush of a rainfall event, but it must be capable of retaining the captured FPG for the duration of the rainfall event. More importantly, it is required that the on-site SQM device capable of additional capture and additional retention of FOG for subsequent rainfall events throughout the year.

In order to meet this stormwater quality objective, an on-site SQM device must be sized to capture and retain the anticipated FOG loading for a period of one year.

6.12.8 Treatment Area and Roof Drain Laterals

In general, urban development consists of mostly impervious area with little, or no pervious area. Stormwater that falls on any impervious area is generally conveyed away from the building to the storm drainage system. Any stormwater conveyed to the storm drainage system contains stormwater pollutants and must be managed by an on-site stormwater treatment device. The treatment area is generally the sum of all impervious area for a given development.

In the case of urban development, stormwater contaminants are primarily associated with the operation and maintenance of parking facilities. It is recognised that the background concentration of airborne pollutants that fall on a rooftop are no greater than that which falls upon the natural watercourse being protected.

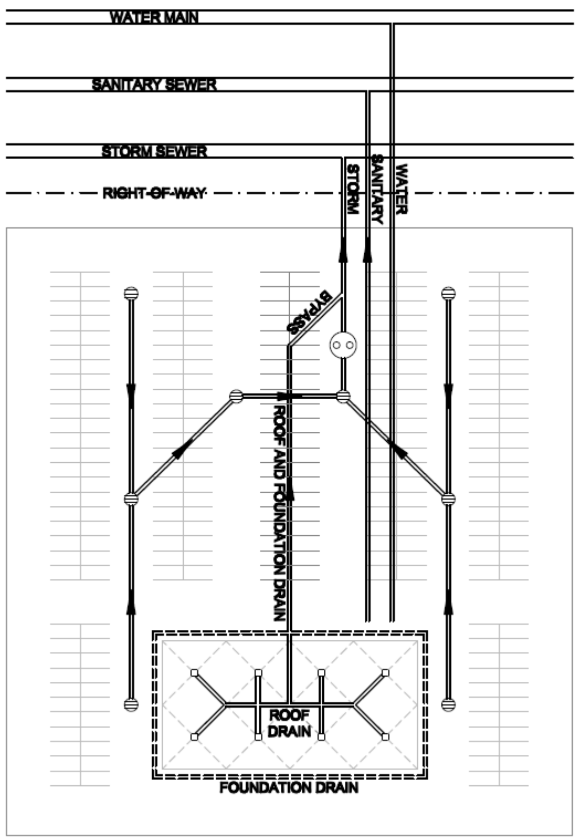
The objective of on-site stormwater quality management is to target TSS and FOG from the parking facility and not from the rooftop. By removing the rooftop area from the treatment area, often significant savings can be realised by not unnecessarily oversizing an on-site SQM device to include the rooftop area.

- In the case of buildings **without a piped rooftop drainage system**, stormwater runoff is shed from the rooftop onto the parking facility where it flushes stormwater contaminants to the storm drainage system. In such instances, the rooftop area must be included in the treatment area.

- In the case of buildings **with a piped rooftop drainage system**, a separate storm drainage lateral may be provided that connects the rooftop drainage system and the foundation drain to the storm sewer lateral a location downstream of the on-site stormwater treatment device. This effectively removes the rooftop area from the treatment area. In such instances, the rooftop area may be excluded from the treatment area.

Figure 6.4 illustrates a typical roof drain/foundation drain bypass lateral configuration that may be provided by the Developer/Engineer in order to reduce the size and cost of the on-site SQM device.

Figure 6.10 – Typical Roof Drain/Foundation Drain Bypass Lateral



6.12.9 <u>On-Site SQM Device Database</u>

During the plan review and approval process associated with the Development Permit and Building Permit application process, the Town of Shediac will review and approve the Developer's/Engineer's proposed on-site SQM device selection and sizing. Assuming that the proposed on-site SQM device meets the stormwater quality objectives, the Owner, location, device manufacturer and device model will be added to the Town of Shediac on-site SQM device database for the purposes of tracking and confirming operation and maintenance of the on-site SQM device.

6.12.10 On-Site SQM Device Operation and Maintenance

As with any mechanical device, on-site SQM devices require periodic inspection and maintenance. Over a period of time, failure to provide periodic inspection and maintenance will decrease the pollutant removal capability of the device.

The particular inspection and maintenance requirements of a given on-site SQM device vary from vendor to vendor. However, generally an on-site SQM device requires inspection, cleaning and disposal of captured pollutants.

6.12.11 On-Site SQM Device Operation and Maintenance Compliance Monitoring

In addition to any specific vendor recommendations for a given on-site SQM device, the Owner shall provide proof of:

- Annual inspection for physical defect
- Removal and disposal of captured gross debris
- Removal and disposal of captured FOG
- Removal and disposal of captured TSS

Compliance monitoring of annual inspection and maintenance of on-site SQM devices will be managed by the Town of Shediac. An annual letter will be provided to each device Owner registered in the On-Site SQM Device Database reminding them of the annual inspection and maintenance requirements.

The Owner will retain the services of local service provide to provide the necessary inspection and maintenance on an annual basis. The Owner will provide a proof of inspection and maintenance on an annual basis.

6.13 Downstream Effects

6.13.1 Other Considerations

Explicit consideration shall be given to public safety, NBDELG regulations, NBDTI 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.

6.13.2 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 storage facility for stormwater runoff control. If a determination is made that a storage 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 storage facilities shall be designed to control the peak runoff conditions for multi-storm events up to the $100^{(+20\%)}$ year return period storm.

6.13.3 Storm Drainage Municipal Service Easement

No storm drainage is to be carried onto, thru, 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 Shediac in the following cases:

- Excavated ditches or storm sewers within the boundary of the subdivision;
- Where a need is identified by the Town of Shediac 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 (MSE) 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 (MSE) 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 Shediac must be provided by the owners affected;
- Natural watercourses shall not normally be carried in roadside ditches or minor storm drainage systems.

6.13.4 Discharge to Adjacent Properties

All storm drainage is to be self-contained within the subdivision limits, except for natural drainage associated with runoff from undeveloped areas. However, runoff from within the subdivision may be directed to a natural stream, watercourse, or storm drainage system owned by the Town of Shediac.

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.

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.

6.14 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 Shediac. 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 Shediac, the following procedure shall be followed in doing so.

6.14.1 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, the simple instantaneous peak flow will not be adequate to analyse storage facilities. In determining the stormwater runoff or hydrographs, the methods as described in Subsection 6.4 shall be used.

In preparing the 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 1 in 100$^{(+20\%)}$ year return period storm shall be checked for the points of interest.

6.14.2 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 Shediac for determining the hydraulic capacity of storm drainage structures.

6.14.3 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 Subsection 6.4. Also to be considered in these calculations is the water surface elevation at the outlet of the ditch, watercourse, or channel.

6.14.4 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.

6.14.5 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 6.11. The ratio of the 1 in 5 year design flow (Q_5) to full flow pipe capacity (Q_{cap}) should not exceed 80%.

$$\frac{Q_5}{Q_{cap}} \leq 0.80$$

[6.3]

where:

Q_5 1 in 5 year design flow (L/s)

Q_{cap} 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 1 in 100$^{(+20\%)}$ year return period should be conducted assuming the actual captured flow (Q_c) is some percentage of the 1 in 100$^{(+20\%)}$ 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 1 in 100$^{(+20\%)}$ 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.

6.15 Stormwater Detention Basins

The following sections apply to stormwater detention basins that are to be owned and operated by the Town of Shediac.

In cases where stormwater detentions basins are to be owned and operated by private owners, the same principles apply, however individual design criteria requirements may be omitted.

6.15.1 Design Volume

Stormwater detention basins should be sized in order to provide adequate storage volume necessary to limit post-development peak discharge rates to pre-development peak discharge rates for the 2, 5, 10, 25, 50 and $100^{+20\%}$ design storm events.

An additional volume allowance should be made to ensure that a 300mm freeboard is available for the $100^{+20\%}$ design storm event.

6.15.2 Inlet Requirements

All piped inlets to stormwater detention basins must be fitted with a reinforced concrete headwall, wingwalls and apron acceptable to the Town of Shediac.

All reinforced concrete headwalls are to be fitted with a grate acceptable to the Town of Shediac.

In some instances, fencing, safety rail or additional protective measures may be required in order to ensure public safety.

Energy dissipation measures should be employed to reduce velocities through the basin and reduce the likelihood or re-suspending settled solids.

6.15.3 Outlet Requirements

All piped outlets from stormwater detention basins must be fitted with a reinforced concrete headwall, wingwalls and apron acceptable to the Town of Shediac.

All reinforced concrete headwalls are to be fitted with a grate acceptable to the Town of Shediac.

In some instances, fencing or additional protective measures may be required in order to ensure public safety.

6.15.4 Flow Control Structures

Typical flow control structures currently in use in the region include large diameter manholes with a concrete bulkhead separating the inlet and outlet sides of the structure. A series of circular orifices and weirs are arranged in the bulkhead to restrict peak discharge rates to pre-development levels.

An access manhole frame and cover or an access hatch must be provided on both the inlet and the outlet sides of the flow control structure in order to facilitate inspection and maintenance.

6.15.5 Low Flow Channel

Low flow channels serve two purposes. Firstly, a low flow channel prevents erosion as runoff enters the stormwater detention basins during a storm event. Secondly, a low flow channel conveys the last remaining runoff to the outlet control structure ensuring that the basin dries completely.

Stormwater detention basins must provide a low flow channel from the inlet structure to the flow control structure, or the outlet structure. Low flow channels may consist of a concrete channel, half-pipe, perforated pipe/granular drain, or other means acceptable to the Town of Shediac.

6.15.6 Emergency Spillway

Stormwater detention basins must have an emergency spillway to manage excess flows that may exceed the 1 in $100^{+20\%}$ design storm event, or manage overflows in the event that the outlet structure fails.

The emergency spillway elevation should be set at 300mm above the 1 in $100^{+20\%}$ flood elevation in order the meet minimum freeboard requirements.

The emergency spillway must be integrated into the major drain system so that nor property damage results from an overflow event.

6.15.7 Drawdown Time

Stormwater detention basins should empty within 48 hours of the design storm event to avoid creating vector breeding habitat.

6.15.8 Maximum Side Slope

Stormwater detention basins must be constructed with maximum side slope of 3:1 (H:V). Side slopes of 4:1 (H:V) or 5:1 (H:V) are preferred where condition permit.

6.15.9 Minimum Floor Slope

Stormwater detention basins must be constructed with minimum floor slope of 1.0% to ensure positive drainage from the basin margins to the low flow channel.

6.15.10 Under Drains

In some instances, the excavation of the stormwater detention basin may intercept the groundwater table. In such instances, seepage into the basin may become problematic if no additional means are employed to address the issue.

In areas of with a high groundwater table, or in areas of high seepage potential, under drains consisting of perforated pipes and granulars may be required to intercept seepage from within the stormwater detention basins and direct it to the low flow channel.

6.15.11 Access Road

An access road must be provided so that a sewer flusher truck can access all areas of the stormwater detention basin including all inlet structures, outlet control structures and emergency spillway structures.

The access road must have a minimum drivable surface of width of 4.0m and be constructed to Rural Minor classification standards. In some instances, additional drivable surface width must be provided if sharp turns are to be negotiated.

If a full loop road is not proposed, a turning circle, or a turning-tee must be provided so that maintenance vehicles may exit the facility without requiring reverse manoeuvres. Turning movement analysis may be required in support of the proposed access road.

6.15.12 Fencing

In general, stormwater detention basins do not require fencing. Construction using maximum sideslopes of 3:1 (H:V), and preferably 4:1 (H:V) or 5:1 (H:V) where conditions permit should allow for safe egress from the stormwater detention basin. However, fencing may be required at inlet structures and outlet control structures in some instances.

Select planting and other landscaping features are a preferred deterrent to access and a means of providing natural screening of the stormwater detention basin.

Contingent upon location and proximity to private properties or lands for public purposes, fencing may be required as a matter of public safety.

In instances where fencing is required, fencing shall be as per the requirements contained in the *Standard Municipal Specifications for Municipal Services*.

6.15.13 Standard Operating Procedure

A *Standard Operating Procedure* must be provided to the Town of Shediac as an appendix to the *Engineering Design Brief*. The *Standard Operating Procedure* should address all recommended inspection and maintenance for the stormwater detention basin.

6.15.14 Hydraulic Grade Line Effects

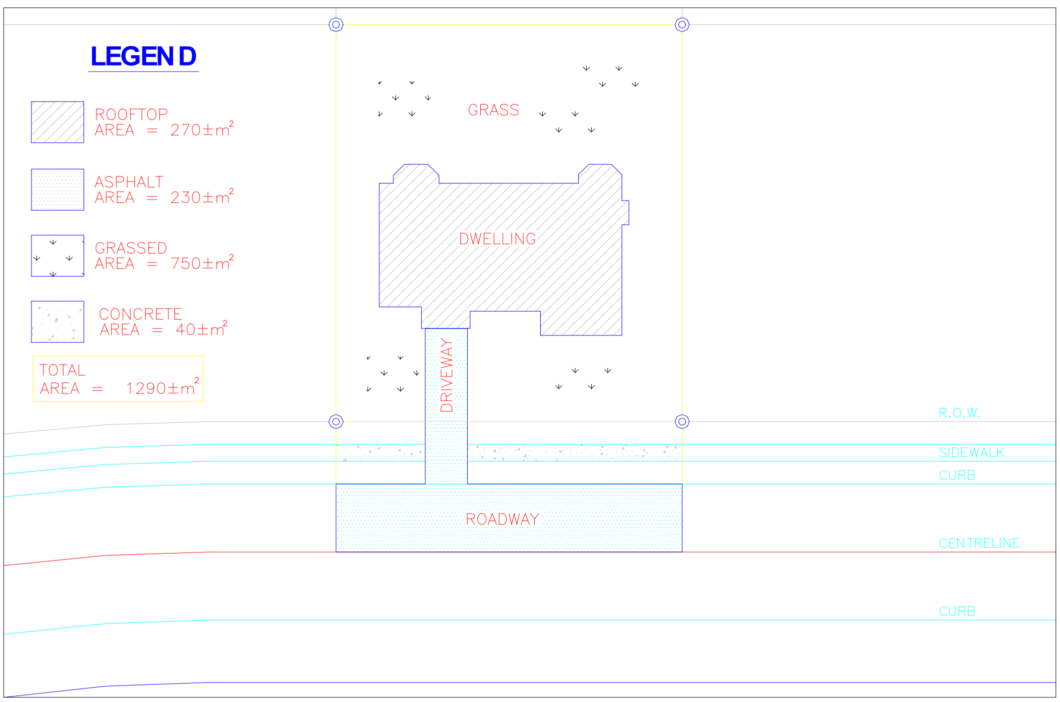
The water elevation in the stormwater detention basin will directly influence the hydraulic grade line in the upstream piped storm drainage system. Typically, piped storm drainage systems are subjected to hydraulic grade lines associated with the 1:5 year design storm. With the piped storm drainage system discharging to a stormwater detention basin, the piped storm drainage system will be subjected to hydraulic grade lines associated with the $1{:}100^{+20\%}$ design storm.

Elevated hydraulic grade lines in the piped storm drainage system for the $100^{+20\%}$ design storm must be taken into consideration when setting minimum basement floor elevations on Subdivision Grading and Drainage Plans. As a result, dwellings within close proximity to stormwater detention basins may only be able to accommodate a half-basement, or a slab-on-grade foundation design.

7 APPENDIX A

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

Figure 7.1 - Typical Single Family Residential Lot



Example 7.1(a)

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

<u>*Given:*</u>Figure 7.1 presents surface materials and surface areas for a typical single-family residential lot.

<u>*Determine:*</u> Determine the composite Rational runoff coefficient (*C**).

<u>Step 1:</u>The composite Rational runoff coefficient (*C**) may be determined by the

following equation:

$$C^* = \frac{\sum C \cdot A}{\sum A} \qquad [7.1]$$

where:

*C** composite Rational runoff coefficient

C Rational runoff coefficient (from Table 5.2)

*A*area (m^2)

Table 7.1 was created using the surface material and surface areas presented in Figure 7.1, and the Rational runoff coefficients presented in Table 6.2. The composite Rational runoff coefficient was determined from Equation [7.1].

Table 7.1 - 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 7.1(b)

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

*Given:*Figure 7.1 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:

$$CN^* = \frac{\sum CN \cdot A}{\sum A} \quad [7.2]$$

where:

*CN** composite USSCS curve number
CN USSCS curve number (from Table 6.5)
A area (m^2)

Table 7.2 was created using the surface material and surface areas presented in Figure 7.1, and the USSCS curve numbers presented in Table 6.5. The composite USSCS curve number was determined from Equation [7.2].

Table 7.2 - 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**		

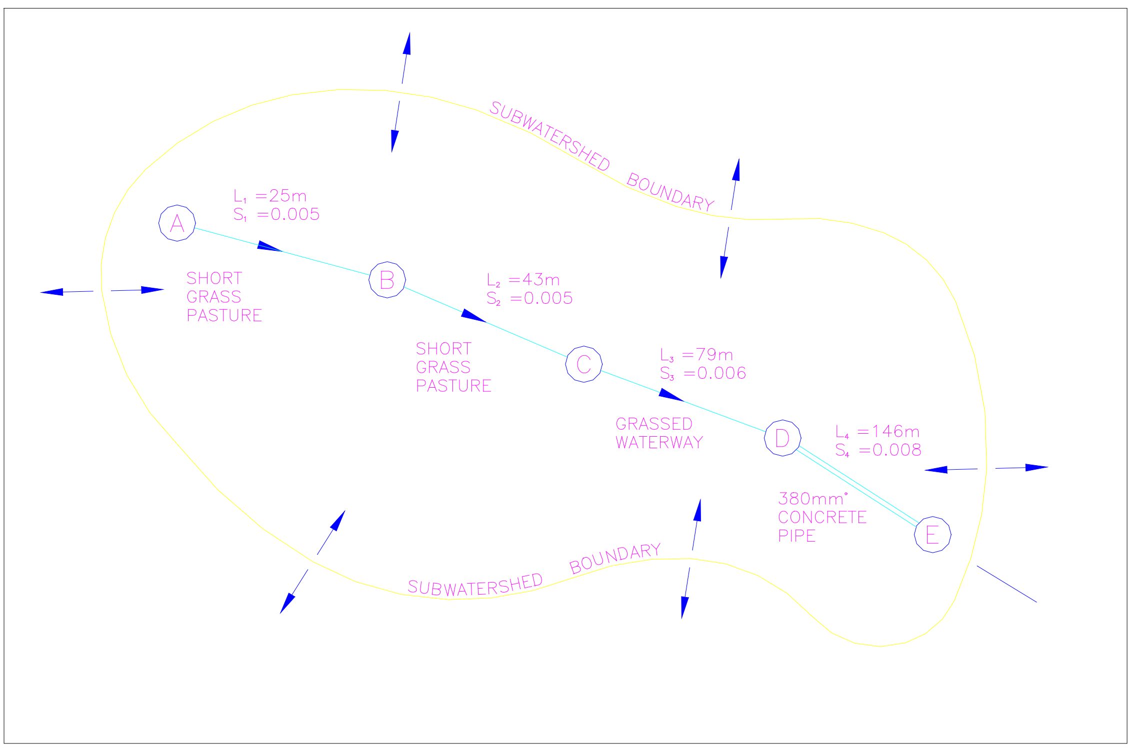
7 APPENDIX B

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

Example 7.1

Calculation of Travel Time (T_t) Through a Subwatershed

Figure 7.2 - Overland Flow Through a Typical Watershed



Stormwater runoff is conveyed through a subwatershed by a natural progression of overland flow. Stormwater runoff initiates as overland sheet flow in the most upstream portions of a subwatershed. As overland sheet flow is concentrated into rills and gullies, stormwater runoff is conveyed as shallow concentrated flow. Eventually shallow concentrated flow will further concentrate until it is conveyed to an open channel, or piped system.

A number of methodologies exist for the determination of flow velocity for overland sheet flow, shallow concentrated flow and open channel and piped flow. The United States Soil Conservation Service (USSCS) methodology is presented below.

Overland Sheet Flow

Sheet flow occurs over plane surfaces in the upper reaches of a subwatershed. Sheet flow is normally considered to be limited to a depth of 25 mm, and a flow length of as little as 25 m, and as much as 100 m. The travel time may be determined by a simplification of the Manning kinematic wave equation expressed as:

$$T_t = \frac{K_c}{I^{0.4}} \cdot \left(\frac{n \cdot L}{\sqrt{S}} \right)^{0.6} \qquad [7.3]$$

where:

T_t	travel time (min)
n	effective Manning roughness coefficient (see Table 7.3)
L	flow length (m)
I	rainfall intensity (mm/hr)
S	slope (m/m)
K_c	coefficient = 6.943

The roughness coefficient expressed in Equation [7.3] 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 7.3 presents effective Manning roughness coefficients for various surface conditions suitable for use in Equation [7.3].

Table 7.3 - 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:

$$V = k \cdot \sqrt{S} \quad [7.4]$$

where:

*V*velocity (m/s)
*k*slope/velocity intercept coefficient (see Table 7.4)
*S*slope, (%)

Table 7.4 - 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:

$$V = \frac{1}{n} \cdot R^{\frac{2}{3}} \cdot S^{\frac{1}{2}} \qquad [7.5]$$

where:

V velocity (m/s)
n Manning roughness coefficient for open channel flow (see Table 6.5)
R hydraulic radius (m)
S slope (m/m)

The hydraulic radius (R) presented in Equation [7.5] is defined as the flow area (*A*) divided by the wetted perimeter (*P*) and may be expressed as:

$$R = \frac{A}{P} \qquad [7.6]$$

where:

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

Table 7.5 - 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:

$$T_t = \frac{L}{60 \cdot V} \qquad [7.7]$$

where:

T_{ti} 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 individual travel tim

$$T_c = T_t = T_{t1} + T_{t2} + \ldots + T_{tn} \qquad [7.8]$$

where:

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

Example 7.2

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 25m of overland flow in the subwatershed occurs as overland sheet flow.

From Table 7.3 for short grass pasture, n=0.15.

From Equation 7.3

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

T_{t1} = 14.6 min

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

From Table 6.4 for short grass pasture, k=0.213.

From Equation 7.4

$V_2 = (0.213)\ (0.5)^{0.5}$

$V_2 = 0.15$ m/s

From Equation 7.7

$T_{t2} = (43) / (60 \times 0.15)$

$T_{t2} = 4.8$ min

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

From Table 6.4 for grassed waterway, k=0.457.

From Equation 7.4

$V_3 = (0.457)\ (0.6)^{0.5}$

$V_3 = 0.35$ m/s

From Equation 7.7

$T_{t3} = (79) / (60 \times 0.35)$

$T_{t3} = 3.7$ min

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

From Table 6.5 for concrete pipe, n=0.013.

From Equation 7.6

$R = [\pi \times (0.380/2)^2] / [2\pi \times (0.380/2]$

$R = 0.095$ m

From Equation 7.5

V_4 = [1/(0.013)] x $(0.095)^{2/3}$ x $(0.008)^{1/2}$

V_4 = 1.4 m/s

From Equation 7.7

T_{t4} = (146) / (60 x 1.4)

T_{t4} = 1.7 min

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

From Equation 7.8

T_c = 14.6 + 4.8 + 3.7 + 1.7

T_c = 24.8 min

7 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 pressurised 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 catch basin 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.

$$Q = C \cdot A \cdot \sqrt{2 \cdot g \cdot (H - r)} \qquad [7.9]$$

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)

8 References

American Concrete Pipe Association 1980. Concrete Pipe Design Manual. American Concrete Pipe Association, Vienna, VA, 486 pp.

American Concrete Pipe Association 1980. Concrete Pipe Handbook. American Concrete Pipe Association, Vienna, VA.

American Iron and Steel Institute 1984. Handbook of Steel Drainage & Highway Construction Products, Canadian Edition. American Iron and Steel Institute, Washington, DC, 413 pp.

American Society of Civil Engineers 1970. WPCF Manual of Practice No. 9, ASCE Manuals and Reports on Engineering Practice No. 37, Design and Construction of Sanitary and Storm Sewers. Water Pollution Control Federation, Washington, D.C., 332 pp.

Brown, S.A., Stein, S.M., & Warner, J.C. 1996. Urban Drainage Design Manual, Hydraulic Engineering Circular 22. U.S. Department of Transportation, Federal Highway Administration, FHWA-SA-96-078, 478 pp.

Chow V.T., Maidment D.R., and Mays L.W. 1988. Applied Hydrology. McGraw-Hill Book Company, New York, NY, 572 pp.

Chow, V.T. 1959. Open-Channel Hydraulics. McGraw-Hill Book Company, New York, 680 pp.

City of Halifax. *Standard Procedure No. 11-041*.

Cronshey R., et al. 1986 Urban Hydrology for Small Watersheds. United States Department of Agriculture, United States Soil Conservation Service, Technical Release 55, 2nd Edition.

Environment Canada 1982. Canadian Climate Normals – Volume 3 – Precipitation, 1951-1980. Environment Canada, Atmospheric Environment Service, Canadian Climate Program, Ottawa, ON, 601 pp.

Environment Canada 1993. Canadian Climate Normals - 1961-1990 – Atlantic Provinces. Environment Canada, Atmospheric Environment Service, Canadian Climate Program, 105 pp.

Fisheries and Oceans Canada 1993. *Land Development Guidelines for the Protection of Aquatic Habitat.*

Greater Shediac Sewerage Commission Standard Specifications

Haestad Methods, Inc. 1997. 1997 Practical Guide to Hydraulics and Hydrology. Haestad Press, Waterbury, CT, 216 pp.

Halifax County Storm Drainage Task Force 1982. *Recommendations and Stormwater Policy*.

Halifax County Storm Drainage Task Force 1982. *Design Criteria Manual*.

Henderson F.M. 1966. Open Channel Flow. MacMillan Publishing Co., Inc., New York, NY, 552 pp.

Hogg W.D., and Carr D.A. 1985. Rainfall Frequency Atlas for Canada. Environment Canada, Atmospheric Environment Service, Ottawa, ON.

Marshal Macklin Monaghan Limited 1994. Stormwater Management Practices Planning and Design Manual. Ontario Ministry of Environment and Energy, Environmental Services & Standards Development Branch, Toronto, ON, 260 pp.

National Research Council Canada 1976. *Drainage and Erosion at Construction Sites*.

New Brunswick Department of Transportation 1996. *A Guide to the Minimum Standards for the Construction of Subdivision Roads & Streets.* New Brunswick Department of Transportation, Planning and Land Management Branch, Fredericton, NB.

New Brunswick Department of Transportation 2010. *Environmental Management Manual*.

New Brunswick Department of Transportation and Infrastructure *Standard Specifications*.

Nova Scotia Department of the Environment 1988. *Erosion and Sedimentation Control Handbook for Construction Sites*.

Smith C.D. 1985. Hydraulic Structures. University of Saskatchewan Printing Services, Saskatoon, SK, 357 pp.

Town of Shediac *Standard Municipal Specifications*

Townshend D.R., Wisner P.E., and Moss D.J. 1980. *Inlet Control Devices for Stormsewer Catchbasins: A Laboratory Study.* University of Ottawa, Faculty of Science and Engineering, Department of Civil Engineering, Ottawa, ON.

Uni-Bell PVC Pipe Association 1991. Handbook of PVC Pipe Design and Construction, Uni-Bell PVC Pipe Association, Dallas, TX, 474 pp.

United States Environmental Protection Agency 1992. *Stormwater Management for Construction Activities, Chapter 3-Sediment and Erosion Control*.

United States Environmental Protection Agency 2006. *Construction Entrances*.

Walski T.M., Chase D.V., and Savic D.A. 2001. Water Distribution Modeling, Haestad Press, Waterbury, CT, 441 pp.

Watt W.E., et al. 1989. Hydrology of Floods in Canada – A Guide to Planning and Design, National Research Council of Canada, Associate Committee on Hydrology, Ottawa, ON, 245 pp.

Whipple W., et al 1983. Stormwater Management in Urbanising Areas. Prentice-Hall, Inc., New Jersey, 234 pp.

Wisner P.E. 1990. *Protection of Basements Against Flooding – Trends and Impact of Drainage Regulations*, Canada Mortgage and Housing Corporation, External Research Program.