



**STORMWATER MANAGEMENT
CONSIDERATIONS
FOR THE
TOWN OF BERWICK**

Department:	Public Works
Adopted:	8 September 2026
Revised Date:	N/A

1. Purpose

This document provides information relating to:

- Stormwater modelling within the Town of Berwick
 - Watershed characteristics
 - Rainfall data
 - Climate change projections
- Modelling results for known areas prone to overland stormwater accumulation
- Flood mitigation options
- Overall Recommendations

This document serves to inform the following as they relate to stormwater collection, retention, and conveyance:

- Land Use and Planning
- Infrastructure Capital Upgrades
- Repairs and Maintenance to existing stormwater components

This document contains a Stormwater Management Report produced by CBCL for the Town of Berwick with funding support from the Provincial Capital Assistance Program (PCAP) and should be viewed as an information report.

The modelling and mapping contained herein is for information purposes only and may not represent the long-term capital plans or priorities for the Town of Berwick.

This document should not be viewed as Policy or as a formal Capital Plan.

2. Scope

This document applies to the stormwater ditches, culverts, buried infrastructure, and overland flow paths that service or impact the lands and areas within the Town of Berwick.

3. Roles and Responsibilities

1.1. Mayor and Council

Council shall establish the Town's overall direction for stormwater management, and make the necessary policies and financial decisions.

Responsibilities:

- Adopt this Stormwater Management Considerations document as an information report.
- Establish priorities as they pertain to Stormwater Management, based on:
 - Public safety

- Protection of property
 - Accessibility, including emergency access
 - Development needs
 - Cost and funding
 - Climate resilience
- Approve capital expenditures
- Approve municipal policy and regulatory changes
- Support the protection of major drainage corridors, including overland flow paths
 - Establish easements

1.2. Chief Administrative Officer (CAO)

The CAO shall implement the decisions of council as they relate to Stormwater Management.

Responsibilities:

- Coordinate with the Planning and Development, and Public Works Staff as needed
- Work with property owners to establish easements for existing and future stormwater systems

1.3. Planning & Development Staff

Planning and Development Staff shall ensure that future development within the Town of Berwick does not make existing stormwater problems worse.

Responsibilities:

- Incorporate this Municipal Information Report into development review
- Understand and protect overland flow paths
- Apply stormwater quantity controls
 - post-development peak flows should not exceed pre-development conditions for 1- through 100-year design storms.
- Apply volume controls
 - The first 15 mm of runoff should be captured through on-site retention or infiltration where practical.
- Protect flood-risk areas during development review
- Work with developers to assure that proposed development shall not:
 - increase downstream peak flows
 - block overland flow paths
 - impact adjacent properties
 - overload existing municipal infrastructure
 - create new ponding or flooding problems
- Coordinate with Public Works for development review

1.4. Public Works Staff

The Public Works Staff shall operate, maintain, inspect, and implement stormwater infrastructure.

Responsibilities:

- Establish a formal stormwater inspection program for:
 - Culverts
 - Open ditches
 - Channels
 - Catch basins
 - Stormwater ponds
 - Detention areas
 - Outfalls
 - Overland flow paths
- Maintain drainage capacity through preventative maintenance
- Maintain an accurate stormwater asset inventory with condition assessments
 - Culvert locations, diameter, material, invert elevations,
 - Ditch dimensions, invert elevations
 - Catch basins
 - Outfalls
 - Ponds, detention sites
 - Drainage structures
- Identify deficiencies and feed them into the Capital Plan
- Respond and document flood events
- Maintain easements and access

APPENDIX 1: Definitions

Term	Definition
1:5-Year Storm	A storm with approximately a 20% annual exceedance probability. In the Berwick modelling, 1:5-year rainfall is also used in combination with high Cornwallis River water levels.
1:100-Year Storm	A storm with a 1% annual exceedance probability for the specified rainfall characteristic. The report uses the 1:100-year event extensively to evaluate major flood risk.
1D Stormwater Model	A model that represents flow primarily along defined drainage routes such as pipes, culverts, ditches and channels. The CBCL Report developed a 1D model of the major drainage system.
Active Storage Volume	The volume of water that can actively be stored and subsequently released from a detention facility during a storm.
Backwater	Water that backs up into an upstream drainage system because downstream water levels or restrictions prevent water from freely discharging.
Backwater Effect	The hydraulic influence of elevated downstream water levels on upstream drainage.
Baseline Period	A historical period against which future climate projections are compared. The CBCL Report uses 1981–2010 as its baseline for the CMIP5 projections.
Berm	An elevated earth or structural embankment used to prevent floodwater from entering a protected area.
Boundary Condition	A specified condition at the edge of a hydraulic model that controls how water enters or leaves the model. In Berwick, downstream Cornwallis River water levels were used as boundary conditions.
Calibration	The process of adjusting model parameters so that model results better represent observed real-world conditions.
Catch Basin	A drainage structure that collects surface water and directs it into a pipe or drainage system.
Channel Diversion	Constructing or modifying a drainage channel so that some or all flow follows a new route.

Term	Definition
Channel Roughness	A measure of resistance to flow within a ditch or channel. Vegetation, sediment, debris and channel material can increase resistance and reduce conveyance.
Channel Storage	Temporary storage of stormwater within a widened or modified drainage channel.
Check Dam	A small structure constructed across a channel to slow flow and create localized storage.
Clausius-Clapeyron Approach	A method for estimating changes in extreme precipitation based on projected temperature increases. The report applies an approximate relationship of 7% increase in precipitation intensity for each degree of warming.
Climate Change Projection	An estimate of future climate conditions produced using climate models and an assumed emissions/socioeconomic scenario.
Climate Model	A computer representation of atmospheric, oceanic and other physical processes used to project future climate conditions.
Climate Model Ensemble	A collection of climate model projections used together to represent a range of possible future conditions.
CMIP5	Fifth Coupled Model Intercomparison Project, a major international collection of climate model simulations.
CMIP6	Sixth Coupled Model Intercomparison Project, the subsequent generation of coordinated international climate model simulations.
Conceptual Design	An early-stage design developed sufficiently to evaluate feasibility, impacts and approximate costs, but not yet suitable for construction.
Constructability	The practical feasibility of physically constructing a proposed improvement given terrain, property, utilities, access, existing infrastructure and other constraints.
Conveyance	The ability of a ditch, channel, culvert or pipe to carry water. An undersized or obstructed drainage feature has insufficient conveyance capacity.
Conveyance Capacity	The maximum flow that a drainage feature can carry under specified conditions.

Term	Definition
Culvert	A pipe or enclosed structure that conveys water beneath a road, driveway, railway or other obstruction. Culverts are a major component of Berwick's stormwater system.
Data Gap	Missing, incomplete or uncertain information needed to accurately represent the drainage system.
Design Event	The combination of rainfall and downstream water levels selected for evaluating mitigation options. In the report, the design event generally combines 1:100-year rainfall with 1:5-year Cornwallis River water levels.
Design Storm	A standardized rainfall event used to assess drainage infrastructure and flood risk. The Berwick report describes design rainfall events as standardized benchmarks for infrastructure design and flood mapping.
Detention Area	An area designed to temporarily store stormwater during a rainfall event and release it at a controlled rate.
Digital Elevation Model (DEM)	A digital representation of ground elevations used to understand terrain, drainage patterns and flow paths. The CBCL Report uses a 1 m DEM supplemented by survey data.
Distributed Storage	Multiple smaller areas of stormwater storage distributed throughout a drainage system rather than one large storage facility.
Drainage Catchment	An area of land from which stormwater drains toward a common outlet or drainage point.
Driveway Culvert	A culvert installed beneath a driveway to maintain drainage connectivity across the driveway.
Easement	A legal right allowing infrastructure access or use of part of a property for a specified purpose.
Exceedance Probability	The probability that a specified rainfall magnitude will be equaled or exceeded in any given year.
Flood Extent	The geographic area covered by floodwater under a particular modelled scenario.
Flood Mitigation	Actions intended to reduce the likelihood, extent or consequences of flooding.

Term	Definition
Flood Risk Area	In the CBCL Report, an area where overland flow during the 1:100-year rainfall event could pose a flood risk. The report notes that these areas are not defined by provincial legislation but are intended to inform development decisions within Berwick.
Floodplain	Land adjacent to a watercourse that is susceptible to flooding.
Floodway	The portion of a river floodplain required to convey flood flows. In the CBCL Report's discussion of Nova Scotia Municipal Flood Line Mapping, the Floodway corresponds to the 1:20-year river-induced flood extent.
Floodway Fringe	The portion of the flood-prone area outside the Floodway but within the mapped 1:100-year river-induced flood extent.
Flow Diversion	Redirecting stormwater away from an existing drainage route toward another flow path, channel or outlet.
Freeboard	The vertical distance between the design water level and the elevation of a structure or protective feature.
Headwater	The water level immediately upstream of a culvert or other hydraulic structure. Higher headwater generally indicates greater hydraulic resistance or insufficient downstream capacity.
High-Water Level (HWL)	A specified high-water elevation used to assess flooding. The Public Works site, for example, is affected by high Cornwallis River water levels rather than inadequate local drainage capacity.
Hydraulics	The study of how water moves through pipes, culverts, channels and other drainage systems.
Hydraulic Grade Line (HGL)	A calculated representation of the water surface/energy elevation within a hydraulic system. In the Bezanson Drive example, rising hydraulic grade can cause upstream ponding and potentially reverse flow through the culvert.
Hydraulic Model	A computer model that calculates how water flows through drainage infrastructure and across the landscape.
Hydrograph	A graph showing how flow changes over time during a rainfall/runoff event.

Term	Definition
Hydrologic Model	A computer model that estimates how rainfall becomes runoff within a drainage area.
Hydrologic Simulation	The process of using a hydrologic model to calculate runoff resulting from a particular rainfall event.
Hydrology	The study and modelling of rainfall, runoff, infiltration and the movement of water through a watershed.
Hyetograph	A representation of rainfall intensity over time. The Berwick design storms use 24-hour hyetographs with rainfall intensities represented at five-minute intervals.
IDF Curve	Intensity-Duration-Frequency curve. A statistical relationship showing rainfall intensity for different storm durations and frequencies/return periods.
Impervious Area	A surface that does not readily allow water to infiltrate into the ground, such as pavement, roofs and other hard surfaces. Increased imperviousness generally produces more and faster runoff.
Infiltration	The process by which water enters the soil from the ground surface. The model uses soil information to establish infiltration parameters.
Inundation	The covering of land, roads, buildings or other areas by water.
Invert Elevation	The elevation of the bottom inside a pipe, culvert or channel. Invert elevations are critical when determining how water flows through drainage infrastructure.
Junction	A location in a SWMM model where drainage elements connect or where an elevation/flow point is represented. The Berwick model contains 304 junctions.
LiDAR	Light Detection and Ranging, a remote-sensing technology commonly used to obtain detailed ground elevation information.
Lifecycle Renewal	Replacing or upgrading infrastructure as part of its normal renewal cycle while taking the opportunity to improve its capacity or resilience.
Low-Flow Channel	A smaller channel within a larger detention or drainage area that maintains drainage during smaller, more frequent events and helps prevent prolonged standing water.

Term	Definition
Major Stormwater System	The drainage system intended to manage larger storm events, including overland flow paths, major channels, street curbs, and culverts.
Minor Stormwater System	The smaller-scale drainage infrastructure intended to handle more frequent rainfall events.
Mitigation Scenario	A proposed combination of infrastructure changes or drainage modifications that is modelled to determine its potential effectiveness.
Model Uncertainty	The unavoidable uncertainty associated with input data, assumptions, model parameters and computational methods. The CBCL Report identifies uncertainty in topography, infiltration, roughness, rainfall, water levels, seasonal conditions and climate projections.
Normal Flow Boundary Condition	A model condition where downstream flow is assumed to behave under normal hydraulic conditions rather than being controlled by an elevated downstream water level.
Oil-Grit Separator (OGS)	A stormwater treatment device that removes sediment/grit and oil from runoff before discharge.
Open Channel	A drainage channel in which water has a free surface exposed to the atmosphere.
Open Ditch	An open channel used to collect and convey stormwater. Berwick relies extensively on open ditches.
Orifice	A controlled opening used to restrict the rate at which water leaves a storage facility.
Outfall	The point where a drainage pipe, ditch or other stormwater system discharges into a receiving watercourse or other downstream location.
Overland Flow	Stormwater flowing across the ground surface rather than through a buried pipe.
Overland Flow Path	The route water naturally follows across the ground surface during a rainfall event.
PCSWMM	Stormwater modelling software used by CBCL to develop the Berwick hydrologic and hydraulic model.

Term	Definition
Peak Flow	The highest flow rate occurring during a storm event. Reducing peak flow is one of the principal objectives of detention facilities.
Percentile	A statistical measure indicating where a result falls within a range of model projections. For example, the 90th percentile represents a more extreme projection than the 50th percentile.
Ponding	The accumulation of water in a low-lying area when drainage cannot remove water quickly enough.
Pre-Treatment	Treatment of stormwater before it enters a downstream drainage or treatment system, such as removing sediment and oil.
Projection Horizon	The future period for which climate conditions are being estimated. The CBCL Report focuses on conditions representing approximately 2100, using the 2070–2100 period.
Quantity Control	Measures intended to control the amount and rate of stormwater runoff. The CBCL Report recommends that post-development peak flows not exceed pre-development conditions for the 1- to 100-year design storms.
Rainfall Duration	The length of time over which rainfall occurs. Different durations can produce different drainage responses.
Rainfall-Induced Flooding	Flooding caused primarily by rainfall-generated runoff exceeding the capacity of local drainage infrastructure or natural flow paths.
Rainfall Intensity	The rate at which rain falls, generally expressed in mm/hour.
RCP	Representative Concentration Pathway. A climate-change scenario describing a particular trajectory of greenhouse-gas concentrations.
Return Period	A statistical way of describing the frequency of a rainfall or flood event. A 100-year event has a 1% annual exceedance probability; it does not mean the event occurs only once every 100 years.

Term	Definition
Riverine Flooding	Flooding caused by a river or watercourse exceeding its channel capacity or having elevated water levels. This is distinct from flooding caused primarily by local rainfall runoff.
Road Overtopping	The condition where water flows over the roadway surface because the drainage system or roadway drainage path cannot contain the flow.
Runoff	Rainfall or snowmelt that does not infiltrate into the ground and instead flows over the land surface or through drainage infrastructure.
Runoff Coefficient	A value representing the proportion of rainfall that becomes runoff for a particular area. In the Berwick model, rural/vegetated areas generally have coefficients below 0.4, residential areas approximately 0.4–0.6, and denser developed areas approximately 0.6–0.8 or higher.
Spill Point	A location where water overtops the local terrain and begins flowing toward another drainage area.
SSP	Shared Socioeconomic Pathway. A scenario framework used to represent possible future socioeconomic and greenhouse-gas trajectories.
SSP5-8.5	A high-emissions climate scenario used for stress-testing critical infrastructure. The CBCL Report presents results using the 90th percentile of SSP5-8.5 projections.
Storage Node	A model element representing an area where water can temporarily accumulate, such as a pond or detention area. The Berwick model contains 30 storage nodes.
Storm Sewer	A buried pipe system designed to collect and convey stormwater.
Stormwater	Water originating from rainfall or snowmelt that flows over or through land and drainage infrastructure.
Stormwater Drainage System	The network of natural and constructed features that collect and convey stormwater, including ditches, culverts, pipes, channels, storage areas, and outfalls.
Stormwater Pond Stormwater Management	A constructed or naturalized area that stores stormwater. The planning, design, operation, and maintenance of systems that control stormwater quantity, flow paths and water quality.

Term	Definition
Subcatchment	A smaller drainage area represented separately in the stormwater model. The Berwick model within the CBCL Report contains 287 subcatchments, ranging in size up to approximately 28 ha.
Surface Roughness	A representation of how easily water moves across a surface. Vegetation, pavement and other surface characteristics affect the speed of overland flow.
SWMM	Stormwater Management Model, the modelling engine underlying the stormwater simulations.
Tailwater	The water level downstream of a drainage structure or outlet. High tailwater can restrict the ability of upstream drainage infrastructure to discharge. The Cornwallis River is a major tailwater influence in Berwick.
Temperature Scaling	An approach in which projected temperature increases are used as a proxy for changes in precipitation intensity rather than directly modelling future precipitation.
Time to Peak	The time between the beginning of a rainfall event and the occurrence of peak flow. The report notes that the Cornwallis River watershed and Berwick's urban drainage areas have significantly different times to peak.
Trapezoidal Channel	A channel with a flat or relatively flat bottom and sloped sides.
Undersized Culvert	A culvert whose hydraulic capacity is insufficient for the required design flow.
Validation	The process of comparing model results with observed or independently available information to assess whether the model reasonably represents actual conditions. The CBCL Report was checked against historical flooding and the 11 July 2024 rainfall event.
Volume Control	Measures intended to retain, infiltrate or otherwise manage a specified volume of runoff on site. The CBCL Report recommends capturing the first 15 mm of runoff through on-site retention or infiltration.
Water Level (WL)	The elevation of the water surface at a particular location or under a particular flood condition.
Water Quality Control	Measures intended to reduce pollutants carried by stormwater, such as sediment and oils.

Term	Definition
Watershed	A larger area of land that drains toward a common receiving watercourse or outlet. The report uses watershed characteristics to establish model parameters such as slope, infiltration and surface roughness.
Weir	A structure that controls or measures water flow by allowing water to pass over a defined crest.

APPENDIX 2: CBCL Report



Berwick Stormwater Management Plan

Final Report



251083.00 • April 2026

02	Final Report	A. Ehrenholz	2-Apr-2026	N. Mohammadzadeh
01	Issued for DRAFT Review	A. Ehrenholz	23-Feb-2026	N. Mohammadzadeh
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Project No. 251083.00



April 2, 2026

Aaron Dondale
Director of Public Works
Town of Berwick
236 Commercial Street
Berwick, NS B0P 1E0

Dear Mr. Dondale:

RE: Town of Berwick – Stormwater Management Plan

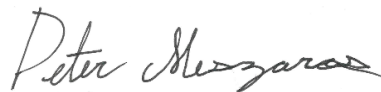
CBCL Limited is pleased to provide this Stormwater Management Plan for Berwick for your consideration. This report contains a summary of the project background, the stormwater management modelling methodology and results, and recommendations for flood mitigation options and climate resiliency along with high-level cost estimates. Should you have any questions or comments, please do not hesitate to contact the undersigned.

Yours very truly,

CBCL Limited



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Executive Summary

The Town of Berwick (the Town) experiences recurring flooding during large rainfall events, particularly along Main Street and in low-lying areas and areas adjacent to the Cornwallis River. The Town's stormwater system relies primarily on overland flow paths, open ditches, and culverts, and much of this aging infrastructure does not have sufficient capacity to convey increased stormwater flows associated with climate change and increased development. The Town retained CBCL Limited (CBCL) to prepare a Stormwater Management Plan to better understand existing drainage system performance, identify flood risk areas, and develop feasible mitigation strategies that improve flood resilience while supporting future development, with a focus on deficient municipal infrastructure.

The study focused on the Town's major stormwater system, comprised of overland flow paths, open channels, and culverts. A detailed hydrologic and hydraulic model was developed in PCSWMM using a combination of LiDAR-based topography, targeted field surveys, Town-provided GIS data, and input from community members and residents collected from a public consultation session. The model represents over 300 system nodes, 40 culverts, and nearly 300 subcatchments, and was validated against known historical flooding locations. Climate change impacts were also incorporated using federal guidance with an overall projected rainfall increase of approximately 67% by 2100.

Through modelling results, several flooded areas of interest were identified. The suitability and priority for mitigation were established for each area based on the cause and impacts of flooding, which helped direct the focus of mitigation design onto high-impact infrastructure upgrades. Six mitigation scenarios representing large capital projects were implemented into the model; the viable, high-impact scenarios are as follows:

- ▶ **Baseline mitigation (scenario 1):** Foster Street at Main Street culvert upgrades and Centennial Park detention area:
 - The existing triple-barrel 600mm culvert under Main Street was upsized to a twin 1050mm culvert. The existing 900mm outlet pipe downstream, and the upstream driveway culvert, were also upsized.
 - The surface of Centennial Park was lowered to create stormwater storage, reducing peak flows downstream.
- ▶ **Horsburgh Drive channel diversion (scenarios 5 and 6):** The existing ditch south of Horsburgh Drive was formalized, and a flow diversion reduces flow to the existing, over-capacity ditches. In scenario 5, the channel discharges straight to a ditch inlet catchbasin; in scenario 6, the channel discharges into an additional proposed stormwater detention area.

- ▶ **Public Works site:** Floodproofing options include berming with on-site storage and pumping, or long-term site raising and building replacement.
- ▶ **Lifecycle renewal opportunities:** Culverts in the Gravenstein Drive at Spartan Avenue, Brown Street at Front Street, Lawrence Avenue, and Main Street at Cottage Street were upsized to increase their conveyance capacity and reduce flood extents.

Other general recommendations in addition to the infrastructure concept designs include:

- ▶ Establishing drainage easements to enable legal access to key pieces of stormwater infrastructure.
- ▶ Implementation of a proactive inspection and maintenance program for existing stormwater infrastructure to ensure that current assets are providing maximum value.
- ▶ Expanding municipal stormwater management design standards to include clear and specific stormwater quantity and quality control requirements.

This Stormwater Management Plan provides the Town of Berwick with a defensible, data-driven framework to address existing flooding challenges and prepare for future climate conditions. While further detailed design and additional data collection will be required prior to construction, the recommended stormwater management strategies represent practical, scalable steps toward improved flood resilience and long-term infrastructure sustainability.

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List of Terms and Acronyms

Acronym / Abbreviation	Full Term
CMIP5	Fifth Coupled Model Intercomparison Project
CSP	Corrugated steel pipe
DEM	Digital Elevation Model
ECCC	Environment and Climate Change Canada
HDPE	High-density polyethylene
HWL	High-water level
IDF curve	Intensity-duration-frequency curve
IPCC	Intergovernmental Panel on Climate Change
MFLM	Nova Scotia Municipal Flood Line Mapping
OGS	Oil-grit separator
PCSWMM	A stormwater management modeling software, which CBCL used for the project
RCPs	Representative concentration pathways
SSPs	Shared socioeconomic pathways
SWMM	Stormwater management model
The Town	The Town of Berwick
WL	Water level

1 Project Overview

1.1 Introduction

The Town of Berwick (herein referred to as “the Town”), located in the centre of Kings County within the Annapolis Valley, is currently subject to flooding during larger rainfall events. Flooding is especially frequent on properties along Main Street due to their close proximity to the Cornwallis River. The Town’s stormwater management infrastructure is comprised of both buried pipes and open ditches. It is also aging and is no longer able to adequately convey the higher stormwater flows associated with a changing climate and development of the Town.

This draft stormwater management plan includes the following:

- ▶ Description of the stormwater management modelling methodology.
- ▶ Discussion of the existing model results showing where there are deficiencies in the existing major stormwater system including culverts, ponds and overland flow paths.
- ▶ Description of proposed capital works projects to alleviate existing flooding issues, along with modelling results showing their effectiveness and high-level cost estimates.

1.2 Project Objectives

The primary objective of the project is to provide mitigation strategies to alleviate historical flooding issues caused by deficient municipal infrastructure and allow for future development within the Town. The Town does not have an extensive storm sewer system, and the majority of the flooding issues have been a result of overland flow in large storm events. The focus of the project was therefore on the major overland flow system and the sewer / culvert connections, where they are conveying major flow. The defined major overland flow system for the Town of Berwick is shown below in Figure 1-1, is the focus of the study.



Figure 1-1: Limits of the Study Area

This overall objective was completed in three stages:

- ▶ Stage 1: Data Collection:
 - Existing data provided by the Town was reviewed.
 - Public outreach and documentation of the locations within the study area that experience flooding.
 - Surveys of the local topography and existing major stormwater infrastructure were conducted for areas that were identified as either lacking accuracy in the Town's existing QGIS database or key flow paths requiring higher accuracy.
- ▶ Stage 2: Data Processing & Model Development:
 - Review of previous PCSWMM models developed by CBCL for the area along Foster Street and Cottage Street.
 - Development of a 1D stormwater model to assess how the existing major drainage system in the Town responds to various rainfall scenarios.
- ▶ Stage 3: Analysis and Reporting:
 - Identification of critical deficiencies in the existing stormwater infrastructure.
 - Developing and modelling concept-level designs for mitigation strategies to accommodate sustainable development.
 - Reporting and cost estimation.

2 Stormwater Model

The following chapter summarizes the data collection, PCSWMM model development, climate change projections, model calibration and validation for the Town's major stormwater collection system.

2.1 Hydrologic Background

The Town is situated along the Cornwallis River, and the Town's runoff discharges into the river either via Morris Brook to the east or via smaller tributaries to the north and west. During high tide events within the Minas Basin, the flow from the Cornwallis River is impeded. This creates a cascading effect that impacts upstream areas, including the Town, resulting in localized flooding on various streets and properties.

The Town's drainage system is predominately reliant on overland flow paths and culverts to convey flow to the Cornwallis River or Morris Creek. There are points where the open ditch system and culverts lack sufficient capacity to convey flows and there are parts of the Town where the lack of capacity has created flood risks to private property and municipal infrastructure. Furthermore, during winter the Town primarily uses sand and minimizes the use of road salt to improve road traction. Based on on-site observations, sand accumulation has contributed to capacity restrictions in the system due to sedimentation in culverts and open channels. Salt is not used as potable water use is from private wells and there is a concern that salt could impact the quality of the water supply. In some of the open channel sections dense vegetative growth has reduced capacity and restricted CBCL's field observations and surveying.

CBCL has considered these issues in the development of the stormwater management strategy to provide recommendations to the Town on potential upgrades for the overland flow network and presentation of flood risk mitigation options.

2.2 Data Collection

External background data was reviewed and supplemented by collected data to support the development of the stormwater system model. The following information was utilized in the storm sewer model development:

- ▶ The modified digital elevation model (DEM) generated using the 1m DEM obtained from GeoNova, combined with surface elevation survey points at critical locations to determine overland flow paths, storm catchment topography and rim elevations for structures with missing elevation information.
- ▶ Culvert information including size, material and inlet and outlet invert elevations.
- ▶ Ditch information at key locations including width, bottom and top elevations.
- ▶ Downstream water levels extracted from the “PS21-18 Berwick Hydraulic Study” prepared by WSP for the Department of Nova Scotia Transportation and Active Transit in October 2021.
- ▶ Anecdotal information collected from residents during the open house on March 24, 2025.

While the survey data and Town-provided information aided the modelling process, there are still unknown connections and missing data in the major stormwater collection system. Reasonable assumptions about the culvert sizes, and invert elevations were made where needed to support the development of the stormwater system model. Please refer to Section 2.3 for a list of modelling assumptions.

There is a minor storm sewer system servicing parts of the Town. Survey information, as built or design drawings, were not available for extensive sections of the minor system. This information was available for a small section on Cottage Street between Foster Street and Commercial Street as well as on Foster Street, between Cottage Street and Main Street that were extracted from a previous project completed by CBCL and incorporated into the model. The remaining parts of the model focuses on the major overland flow system in large 1:100-year rainfall events where the minor system would be operating beyond capacity and surcharged.

CBCL also engaged in a public consultation session on March 24, 2025, to collect anecdotal information from residents regarding flood locations during specific rain events. This information, summarized and discussed in detail later in Section 2.4, was used both to calibrate the stormwater model and identify specific areas in the Town with insufficient stormwater management infrastructure.

2.3 Model Development

The PCSWMM modelling software was used to create a hydrologic and hydraulic model of the existing stormwater collection system for the Town of Berwick.

The 1m-DEM was downloaded from GeoNOVA and combined with the survey point elevations to create a large surface with targeted areas of high accuracy. Culverts size, roughness, inlet and outlet elevations, were extracted from the survey where available. Width, bottom and top elevation of ditches at key locations were obtained from field surveys where available or extracted from the DEM where vegetation prevented field data collection.

In total, the model is comprised of a total of 304 junctions (including culvert inlet and outlet nodes, elevation points along ditches, major flow paths or watercourses), 10 outfalls, and 30 storage nodes, identified using the DEM and storage creator tool in PCSWMM. 287 sub catchments of various extents up to 28 ha, are modelled. There are 40 culverts in the model, of which 29 culverts were accessible and surveyed, while the remaining 11 culverts were assumed to exist based on the DEM, engineering judgments, and aerial imagery.

As mentioned in Section 0, data gaps were present in the provided data and various assumptions had to be made during model development to rectify those gaps. Following key assumptions were made in developing the hydraulic model. Spatial locations of assumptions made for model development are shown on Figure 2-1:

1. It is assumed that the open channel just downstream of the culvert north of the Berwick Electric Commission office has a water depth of 500mm. This depth is used to calculate the junctions invert elevation based on the DEM-derived water surface elevation.
2. The driveway culvert (C132_6) located west of Main Street and the Cottage Street is assumed to be a 375mm diameter corrugated steel pipe (CSP) culvert.
3. It is assumed that the culvert under Horsburgh Drive (C128_3) has a diameter of 300mm.
4. Two culverts are modelled near the intersection of Main Street and Commercial Street. The required information for the eastern culvert (C187) was obtained from the survey. For the western culvert (C135), the inlet location, pipe size, and material were identified during the survey; however, the outlet could not be verified. It is assumed that both culverts drain to a point north of Main Street.
5. Two culverts are modelled beneath Foster Street near the intersection of Mill Street. The northern culvert (C173_1) was surveyed; however, its size and material could not be confirmed and were recorded in the survey as an unknown culvert. For modelling purposes, C173_1 was assumed to be a 300 mm diameter culvert based on the surveyed diameter of the nearby culvert (C55_3), which has a similar alignment and function. The downstream culvert (C55_1) could not be surveyed due to dense vegetation limiting site access and was assumed to be 450 mm in diameter. This diameter was assumed based on upstream drainage connectivity, and consistency with standard municipal culvert sizes.
6. The newly constructed ditch located east of Beckwith Drive was surveyed, and the ditch cross sections were entered into the model based on the survey data. However, some assumptions were made on future topography as the most recent DEM surface is not representative of the latest grading in the development.

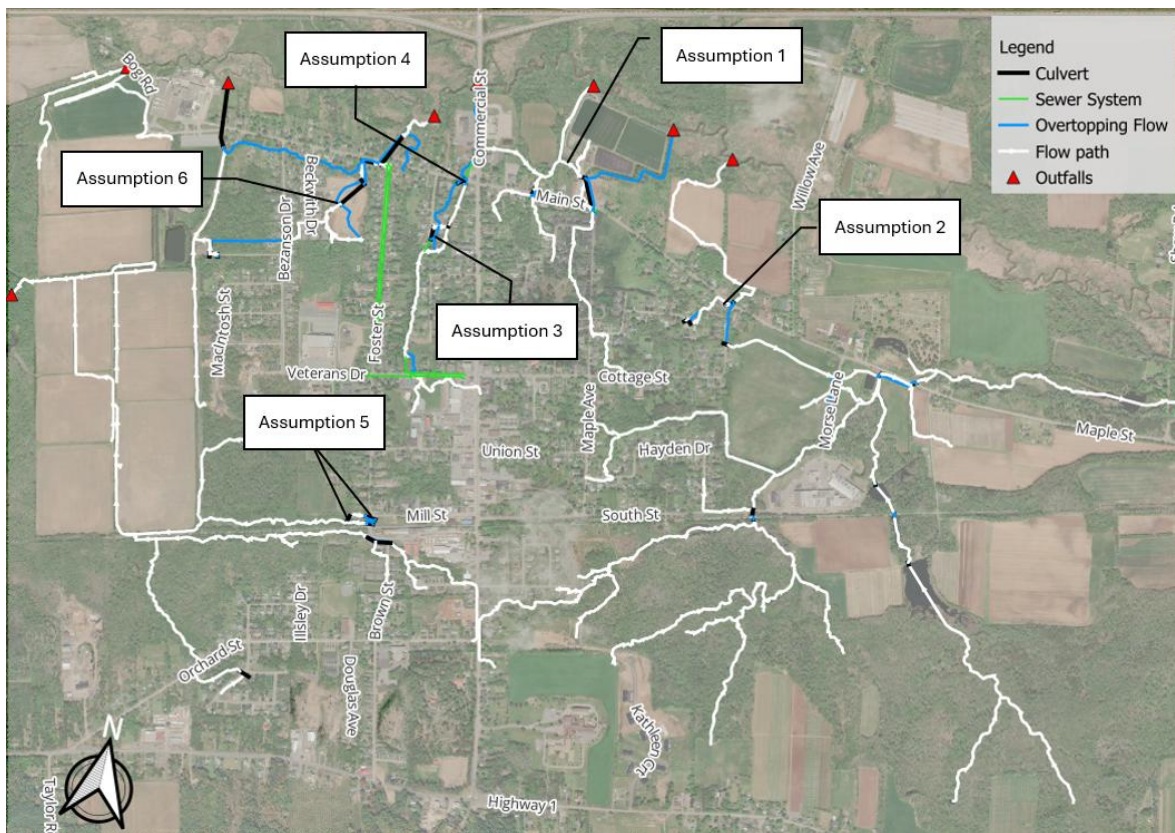


Figure 2-1: Spatial Location of Assumptions Applied During Model Development

2.3.1 Watershed Characteristics

Stormwater drainage catchments were delineated based on the modified DEM. Watershed characteristics were assigned to each individual sub-catchment. The average slope across each catchment was calculated along the maximum overland flow path based on the DEM elevation profile. Soil mapping from Agriculture and Agri-food Canada was used to define infiltration parameters for Green-Ampt model. Provincial land cover was refined using the buildings and roads shapefiles as well as satellite imagery to assign sub catchments roughness parameters.

Maximum flow lengths were initially derived from the DEM and later adjusted during model validation. The width parameter in the SWMM simulation engine is representative of the width of overland sheet flow before the flow channelizes. It is typical that overland sheet flow naturally channelizes after 150m; therefore, width parameters were adjusted to ensure a maximum flow length of 150m for urban sub catchments.

2.3.2 Rainfall Analysis

Hydrological modelling requires rainfall time series (hyetographs) as inputs to generate the runoff response. Rainfall timeseries were generated based on the Intensity-Duration-Frequency (IDF) data obtained from a representative nearby climate station.

IDF data is the result of statistical analysis of historical rainfall intensities. Environment and Climate Change Canada (ECCC) is the primary organization that publishes IDF data in Canada. The IDF data can be used to generate synthetic hyetographs (e.g., the Chicago storm distribution) that represent specific exceedance probability storm events (i.e., return periods).

ECCC climate stations with published IDF data near the study area were reviewed for direct use in generating storm hyetographs, which are shown on a map relative to the Town in Figure 2-2. A comparison of the IDF stations relevant to the study area is provided in Table 2-1.

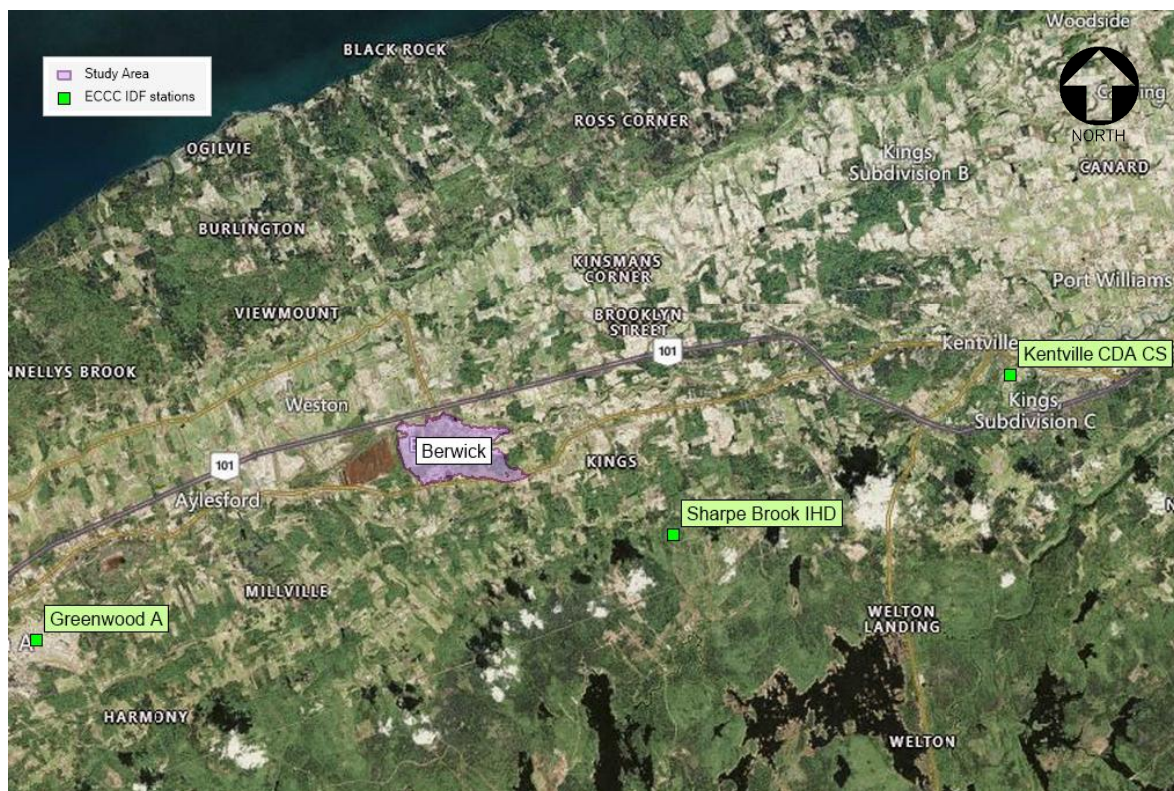


Figure 2-2: Nearby IDF Stations Location

Table 2-1: Regional ECCC Stations with IDF Data

Station Name	Years of Record	Record Length	Station Elevation (m)	1:100 Year, 24 hr. Rainfall Depth (mm)	Record Comments
GREENWOOD A	1964-2016	48	28	117.5	Does not reflect the recent rainfall events.
KENTVILLE CDA CS	1960-2021	51	48	123.6	Long years of record, up to date, higher 1:100-year daily rainfall compared to Greenwood A.
SHARPE BROOK IHD	1968-1977	10	137	169.6	Very high elevation, short years of record, and outdated.

A minimum of 20 years of data is generally recommended to produce reliable IDF curves. The Sharp Brook IHD station has a short record, is located at a much higher elevation, and the data is outdated, therefore, it cannot be considered as a reliable source for IDF data. Both Greenwood A and Kentville CDA CS stations have sufficiently long records, with Kentville CDA CS providing more recent data and slightly higher 1:100-year rainfall amounts for 24-hour duration. The Kentville CDA CS station was therefore selected for generating design storm timeseries.

2.3.3 Design Storms

The IDF curves from Kentville CDA CS station were then used to produce design rainfall events (or hyetograph), which are standardized benchmarks for evaluating the impact of rainfall events. They are the standard events used to produce flood maps and to support design of infrastructure.

The design hyetographs consist of 24-hour duration events with 5-minute interval intensities based on the Chicago storm distribution. Figure 2-3 shows the generated timeseries for the 1:2-year, 1:5-year and 1:100-year events.

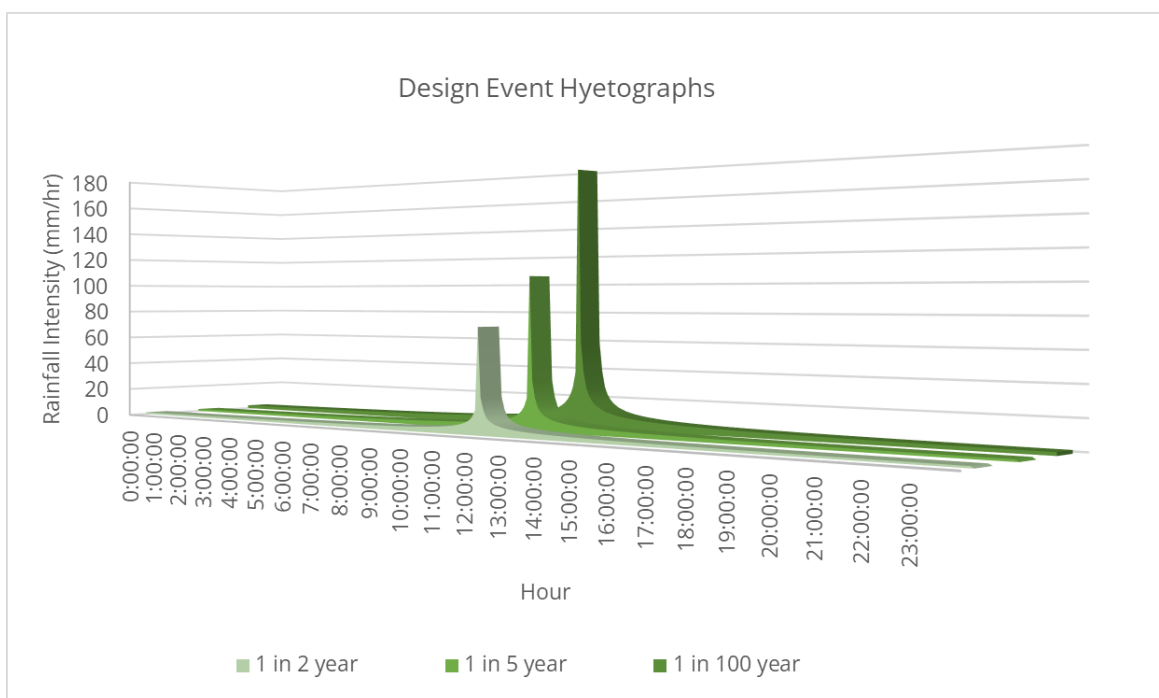


Figure 2-3: Design Event Hyetographs for Current Climate Conditions

2.3.4 Climate Change Projections

Climate change is expected to cause an increase in extreme precipitation, primarily due to the ability of warmer air to hold more moisture. Therefore, it is not appropriate to use IDF data based on historical information alone for long-term planning. Instead, estimates of future changes in extreme precipitation must be obtained.

To project future changes in extreme precipitation, climate models and emission scenarios are used. A climate model is a computer representation of atmospheric, oceanic, and other processes. Climate models use greenhouse gas emission scenarios as inputs to project climate into the future. The Intergovernmental Panel on Climate Change (IPCC) has established future emission scenarios, including Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs).

Climate models use approximations in their mathematical formulations and can overestimate or underestimate the actual climate. Therefore, climate projections are best obtained from an ensemble of models that cover the range of possibilities (to the extent that they can be modelled). Projections are thus reported as a percentile of the model ensemble (e.g., 10th, 50th, 90th).

2.3.4.1 General Approach

Climate change projections for this study are based on the Clausius-Clapeyron approach, which uses projected temperature increases as a proxy for precipitation changes rather than projecting precipitation directly. With this “temperature scaling” approach, each

degree of warming is taken to result in an approximately 7% increase in precipitation intensity (Westra et al. 2014).

This approach aligns with federal recommendations: the Clausius-Clapeyron method is considered scientifically defensible by authoritative sources such as CSA PLUS 4013:19 and Cannon et al. (2020), the ECCC report that will inform climate change updates to the building and bridge codes.

Although the general relationship between warming and extreme precipitation is robust, it is noted that the scaling rate may vary significantly around the approximate value of 7% (Cannon et al. 2020). There is also some evidence to suggest a doubling of the Clausius-Clapeyron scaling rate for shorter (i.e., sub-daily) precipitation event durations; however, there is no clear guidance to apply this at present (CSA 2019) and thus this has not been applied for this project.

2.3.4.2 Scenario Choice

Best practices in climate risk assessment emphasize the importance of considering multiple climate change scenarios due to the high degree of uncertainty in projections. Scenario selection should be guided by the project's tolerance for risk. For example, infrastructure with a higher tolerance for risk—such as a sports field—may rely on a "most likely" or moderate scenario rather than a more extreme one.

While the IPCC does not assign formal likelihoods to scenarios, there is a growing consensus in the scientific literature that SSP5-8.5 represents a low-likelihood pathway. As such, SSP5-8.5 is best suited for analyzing critical infrastructure with a low risk tolerance. This is particularly true when considering high percentiles (e.g., 90th or 95th) of the model ensemble, which reflect more extreme projections.

It is relevant to note that the Provincial Government, through the Nova Scotia Municipal Flood Line Mapping (MFLM) program, is gradually moving toward using the SSP5-8.5 90th percentile as its climate change scenario. The rationale for the MFLM is that the climate change scenario is intended for informational and stress-testing purposes only and is not currently used to guide policy. Although this project for the Town of Berwick is not directly connected to the MFLM program, this remains relevant for context and comparison.

For this project, results under the SSP5-8.5 90th percentile are presented and was used in the development of the stormwater management plan.

2.3.4.3 Methodology

The application of the method is described by CSA (2019). In general, temperature projections were obtained and then converted to a precipitation projection using a simplified equation. In addition to scenario choice discussed above, key decision points for the methodology include:

- ▶ **Generation of Climate Model Ensemble:** Two datasets were used. The first is the Fifth Coupled Model Intercomparison Project (CMIP5), bias-corrected/downscaled with the BCCAQv2 (Cannon et al. 2015) method. The second is the Sixth Coupled Model Intercomparison Project (CMIP6), bias-corrected/downscaled with a multivariate method (Cannon et al. 2018). These datasets are available on ClimateData.ca and the PAVICS data portal.
- ▶ **Baseline:** The temperature projections were compared to a baseline of 1981-2010 (the standard baseline for CMIP5 projections).
- ▶ **Projection horizons:** Projection horizons are defined based on the planning needs of the project. In this case, the focus was 2100. The best practice for projection horizons is to use 30-year time periods, to account for natural variability in the earth's system. Thus, the year range used was 2070-2100. Note that CMIP5 climate model outputs are not readily available past the year 2100. Thus, the 2100 projection is centered around the 2080s and may be an underestimate of projections for 2100.

2.3.4.4 Climate Model Comparison

Results were obtained for a range of climate change scenarios and are presented below in Table 2-2. These results are generally in line with the expected value for changes in extreme precipitation in Atlantic Canada. Precipitation projections for SSP5-8.5 indicate a greater increase in intensity compared to RCP8.5 and SSP3-7.0.

If the **90th percentile of SSP5-8.5 projections** is to be used in this study, this corresponds to an approximate **67% increase** in precipitation intensity for the 30-year period representing **2100**.

The percentage increases can be applied to the historical hyetograph used for hydrological/hydraulic modelling to approximate the effects of climate change on future flows. It is important to consider the uncertainty – i.e., the differences between scenarios and the range of results from the climate model ensemble—when interpreting the resulting flows.

Table 2-2: Comparison of CMIP5 and CMIP6 Precipitation Intensity Projections

	2050			2100		
	CMIP5 RCP8.5	CMIP6 SSP3-7.0	CMIP6 SSP5-8.5	CMIP5 RCP 8.5	CMIP6 SSP3-7.0	CMIP6 SSP5-8.5
50 th Percentile	22%	21%	27%	38%	36%	46%
90 th percentile	31%	28%	36%	55%	44%	67%
95 th Percentile	31%	38%	43%	56%	62%	79%

Figure 2-4 illustrates the resulting rainfall timeseries used for hydrologic and hydraulic modelling to approximate the effects of climate change on future rainfall intensities.

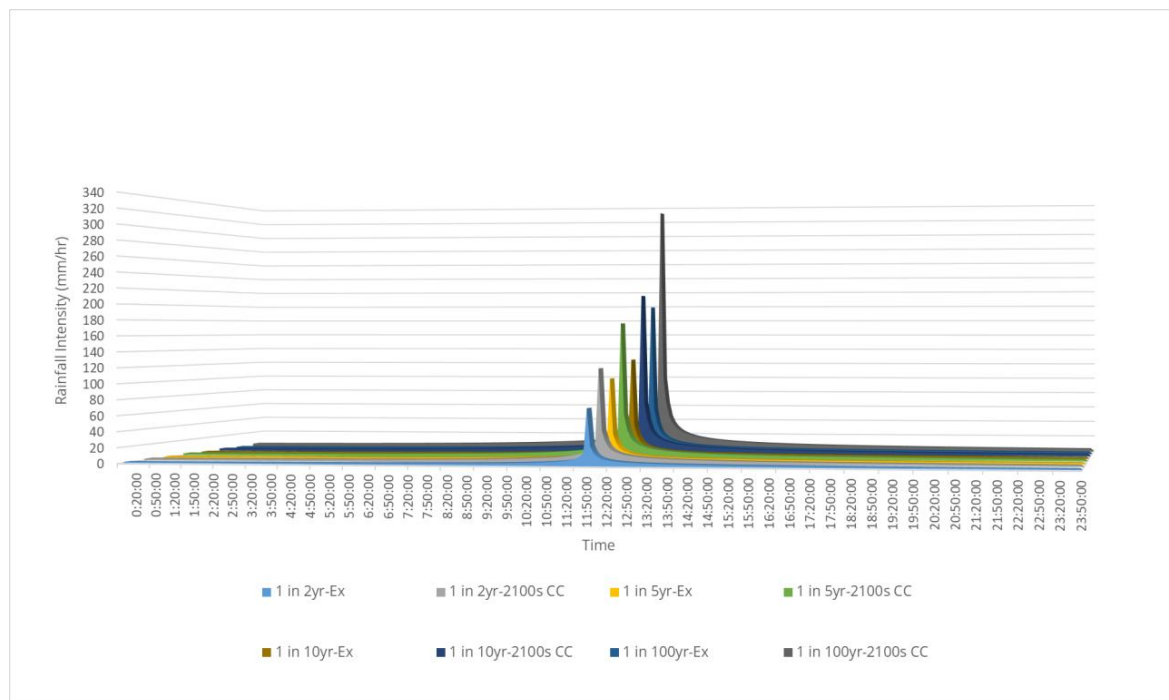


Figure 2-4: Hyetographs of 1: 2-year, 1: 5-year, 1: 10-year, and 1: 100-year events for Existing and Future Climate Change Conditions

2.3.5 Boundary Conditions

To define the downstream boundary conditions in the PCSWMM model, CBCL reviewed two previous studies for the study area, as provided by the client, and listed below:

1. Gaspereau Primary Watershed Flood Line Mapping (Final Report), 2023. Prepared by Dillon Consulting Limited for the Town of Kentville.
2. PS21-18 Berwick Hydraulic Study, 2021. Prepared by WSP Canada Inc. for the Department of Nova Scotia Transportation and Active Transit.

The first project was completed to provide municipal flood line mapping of the Gaspereau River primary watershed in Kings County, Nova Scotia. The second project was completed to provide engineering services to aid in the design of two new bridges and planning the future of another structure which crosses the Cornwallis River in the Town of Berwick, Kings County.

Both reports provide water levels (WLs) for existing and future climate change conditions. The Dillon's report provides WLs for the 1-in-20-year and 1-in-100-year events while the WSP report includes WLs for a range of return periods, from the 1-in-2-year to the 1-in-100-year event which align with the scenarios used in this study. A comparison of the 1-in-100-year WLs from both reports showed that the WSP values are slightly higher than those in the Dillon report. Therefore, using the WSP WLs is considered a more conservative approach for this study. Table 2-3 provides the water levels entered in the PCSWMM model, based on the WSP report and Figure 2-5 illustrates the location of each outfall in the PCSWMM model.

Table 2-3: Water Levels Used for Boundary Condition in the PCSWMM Model

PCSWMM Outfall Name	WSP XS Name	5-Year Ex- 2021	5-Year CC- 2096	100-Year Ex- 2021	100-Year CC- 2096
OF1	N/A	N/A	N/A	N/A	N/A
OF2	15658	26.16	26.27	26.72	26.81
OF3	12803	25.63	25.73	26.06	26.17
OF4	11270	25.36	25.42	25.59	25.68
OF5	N/A	N/A	N/A	N/A	N/A
OF9	14962	26.06	26.19	26.66	26.75
OF10	10029	24.81	24.88	25.22	25.29
OF20	N/A	N/A	N/A	N/A	N/A
J50	N/A	N/A	N/A	N/A	N/A
J330	N/A	N/A	N/A	N/A	N/A

Outfalls that were not associated with a cross-section in the WSP report were assessed in the model and found to have a significant distance or elevation drop to the downstream receiver and as such modelled as outfalls with a normal flow boundary condition. The long distance and significant elevation drop between the urban area of interest and the normal condition outfalls, means that there is minimal to no risk of backwater effects being neglected in the model.

The upstream watershed for the Cornwallis River is significantly larger and is predominately vegetated land cover compared to the smaller and urbanized drainage areas within the Town. The two systems will therefore have very different times to peak. There is no dynamic modelling of the Cornwallis River to define the time to peak in the system but due to the differences, the probability of the Cornwallis River being at its 1:100-year water level while the Town of Berwick experiences 1:100-year precipitation is low, and simulating both

conditions in the same model would be extreme. Using the static elevations of the Cornwallis River that are available, the worst-case flood line is derived from a simulation with the 1:100-year runoff combined with the 1:5-year boundary condition in the Cornwallis River and the 1:5-year runoff combined with the 1:100-year boundary condition in the Cornwallis River. The combined flood line approach ensures that the resulting flood line reflects realistic and representative flood scenarios, balancing the influence of both local runoff and riverine conditions without overstating the severity of a joint condition.

2.4 Model Validation

Like any other modelling process, the Town of Berwick's Stormwater drainage model requires validation with data that accurately represents the factors contributing to the flood event experienced in the Town. The model was validated using the 1:100-year design storm for existing climate conditions and comparison of the model results against standard runoff coefficients. The resulting runoff coefficients from the model, simulated from the input watershed characteristics (Section 2.3.1), should be consistent with expected representative runoff coefficients. As illustrated in Figure 2-5 and Figure 2-6, rural areas (highly vegetated sub catchments) have runoff coefficients less than 0.4. Medium intensity residential areas have a runoff coefficient between 0.4 and 0.6, and more densely populated areas have runoff coefficients between 0.6 and 0.8 or even higher.

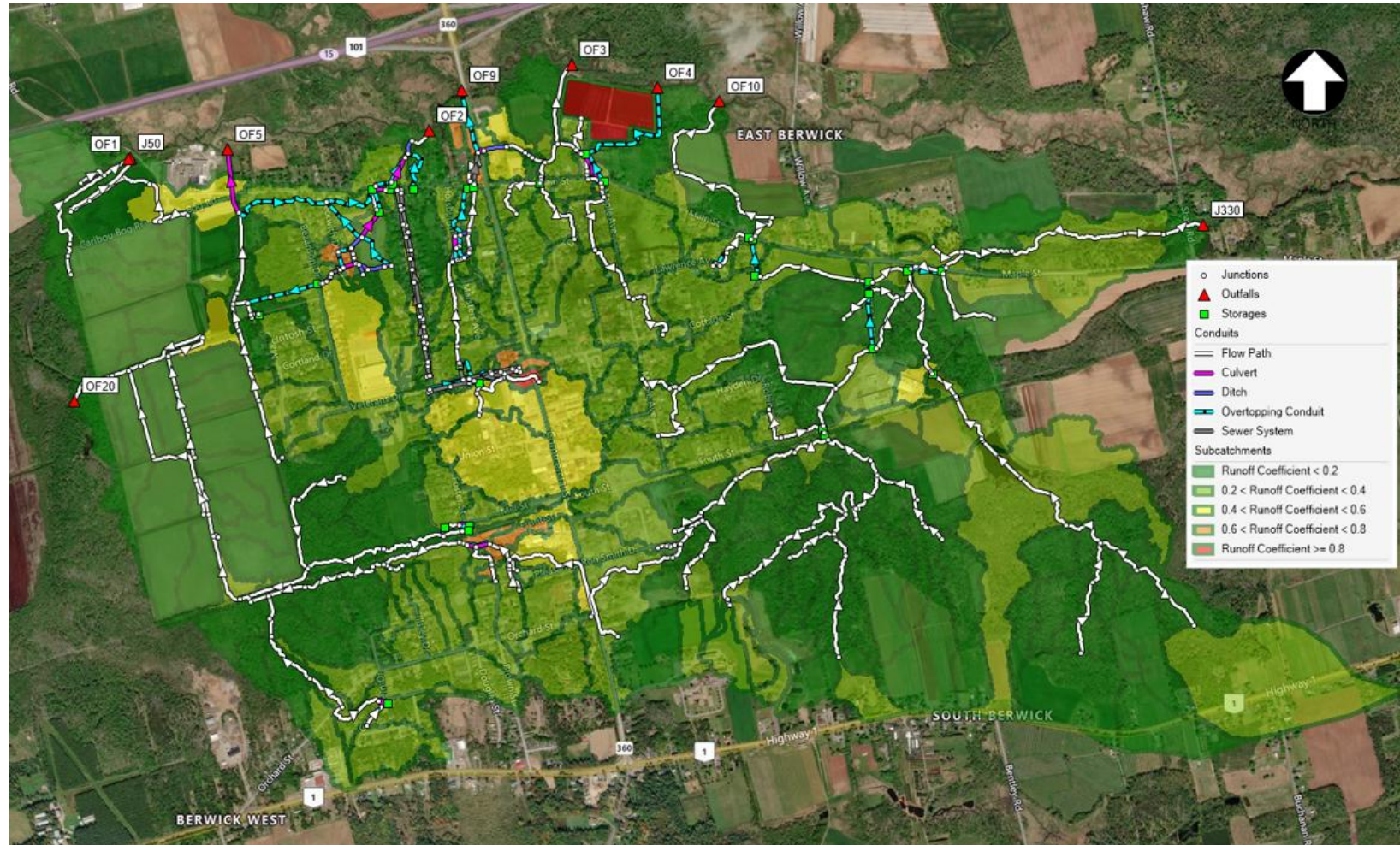


Figure 2-5: Berwick Stormwater Model Sub Catchments, Color-Coded Based on Runoff Coefficient



Locations within the Town that have experienced flooding – in the past and recently during a large event on July 11, 2024 – were identified during discussions with the Town and are listed in Table 2-4. These reported flooding locations and other locations discussed during the site visit were used to validate the model outputs and assess simulation accuracy for the 1:100-year design storm under existing climate condition scenario as well as the July 11, 2024, event.

Table 2-4: Validation Locations Summary

Area of Historical Flooding	Area Flooded in 1:100-year Climate Change Model ?	Area Flooded in July 11, 2024 Event Model?	Comment
Public works yard	Yes	Yes	
Easement between Beckwith and Galla that has some flooding	Yes	No	
Main and Commercial intersection to the Fire Department	Yes- Southeast part of Main and Commercial intersection	Yes- Southeast part of Main and Commercial intersection	
Foster and Main	Yes	Yes	
Ball field and playground in Centennial Park (large structure with weir downstream)	Yes	Yes	
Commercial and Union (regular, recurring, localized flooding. Does drain when rain stops but could freeze. Soils are sandy)	No	No	The level of detail in the model did not identify any low points at this location for runoff to pond. This is likely due to localized drainage issues or the minor system operating beyond design capacity.
Commercial and South (regular, recurring, localized flooding. Does drain when rain stops but could freeze. Soils are sandy)	No	No	The level of detail in the model did not identify any low points at this location for runoff to pond. This is likely due to localized drainage issues or the minor system operating beyond design capacity.

Area of Historical Flooding	Area Flooded in 1:100-year Climate Change Model ?	Area Flooded in July 11, 2024 Event Model?	Comment
Pond behind 122 Maple Avenue. Continues down Hayden	Yes	Yes	
Flooding close to the potential development lands at 226 Main Street, north of Main Street	Yes	Yes	The potential development is in an area that floods due to the river floodplain consistent with the model
Bridge at Willow Avenue. Culverts north of this area, which have collapsed and been filled with gravel, has increased risk.	N/A	N/A	The bridge has not been included in the model, as it falls outside of the scope of this study.
Southern most arrays in solar garden are at risk of water exposure during spring when Cornwallis floods due to ice buildup downstream	N/A	N/A	Out of scope of this study
Wheatons and Fire Hall have not flooded, but areas around them have. Could be used for calibration. Fire hall parking lot does not flood, but Legion parking lot does.	Yes	Yes	The topography shows that the raised land on the Wheatons and Fire Hall are not subject to flooding but the low lying lands north of Main Street are subject to river flooding.

2.4.1 Rainfall Data for the Validation Event

Rainfall data is often one of the largest uncertainties in the calibration process. The rainfall intensity and total rainfall volume can vary significantly within the watershed. As the watershed size becomes larger, using a single point to estimate the rainfall across the entire watershed becomes less representative. Another uncertainty with using an isolated rainfall gauge is that the peak flow can be significantly affected by how the storm travels over the watershed.

Historical annual maximum rainfall records for Kentville CDA CS station indicates a large event in 1971 with 124.2mm rainfall with 24-hour event duration. Since high resolution data for this event is not available online, CBCL looked for more recent events and found that another large event had occurred in 2019 with 107.2mm rainfall in 24 hours. However, since the Town specifically mentioned the flooding locations in July 2024 during the kick of meeting, it was necessary to validate the model based on the data obtained for this event. Hourly rainfall for this event was obtained from ECCC website for Kentville climate station. A comparison between July 2024 event and a range of design storms with different return periods for Kentville IDF station is provided in the following section.

2.4.2 Comparison of rainfall event with ECCC statistics

The July 2024 rainfall event was compared with standardized statistical analyses carried out by ECCC in the Intensity-Duration-Frequency (IDF) curves and is presented below in Figure 2-7.

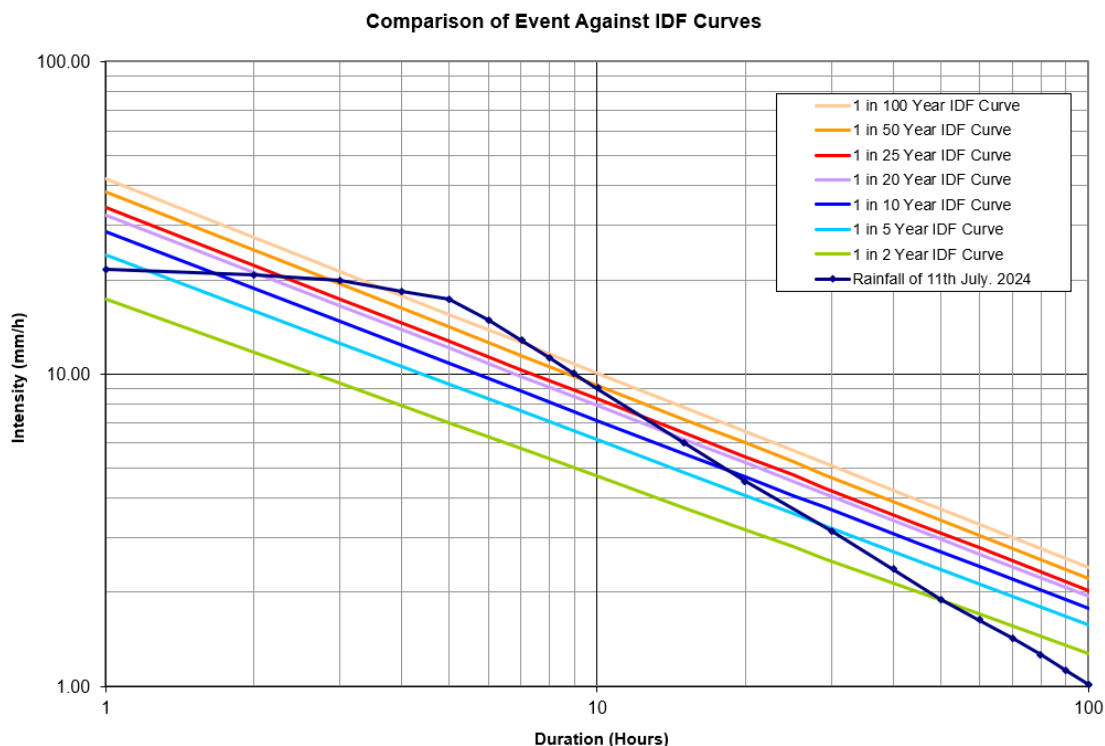


Figure 2-7: Comparison of July 11, 2024, Event with Kentville CDA CS IDF Curves

As shown in the graph, the event exceeded the 1: 100-year event for short durations (4 to 7 hours) and had a magnitude between 1: 5-year to 1: 10-year for 24-hour durations. Figure A-1 in Appendix A compares the flood extents generated by this event with those produced by the 1: 5-year and 1: 100-year storm events under existing climate conditions.

2.5 Uncertainty

As with any hydrologic-hydraulic model there is uncertainty in both physical data as well as model parameter selection and setup including:

- ▶ Topographic detail within the channel and floodplain (LiDAR definition and topographical surveying).
- ▶ Measurements of hydrologic parameter inputs (soil infiltration, surface roughness, effective impervious area) which are naturally uncertain.
- ▶ Hydraulic loss parameters (channel roughness, energy losses at structures), which also carry a high degree of uncertainty, and can quickly change if debris or ice is present.
- ▶ Computational uncertainty (computational/iteration schemes used to resolve finite difference hydrodynamic equations).
- ▶ Validation data uncertainty (amount and location of precipitation, water level data, and groundwater contribution).
- ▶ Natural seasonal changes (most hydrological parameters change throughout the year).
- ▶ Climate change uncertainty.

Each of the above sources of uncertainty will compound the overall uncertainty of the model results. The exact uncertainty cannot be determined due to the wide variation of each of these sources, but it is generally accepted that a validated model still carries a $\pm 30\%$ range of uncertainty.

3 Modelling Results

As explained in Section 2.3.5 of this report, combining a 1:100-year riverine flood with a 1:100-year Cornwallis River water level would result in a very conservative (or overly extreme) estimate of flood extents and does not necessarily reflect realistic flood risk. Therefore, CBCL adopted a more realistic approach by combining the two scenarios including (1) a 1:100-year rainfall event with 1:5-year Cornwallis River water levels, and (2) a 1:5-year rainfall with 1:100-year Cornwallis River water levels, for both existing and future climate conditions. The maximum water levels from both scenarios were then extracted to delineate the flood extents for this project. To facilitate the interpretation of the model results, flooded locations are discussed in detail, considering the properties, roads, or other infrastructures that are at risk of flooding.

Flooding at rural areas, farmlands, or barren lands where there are no structures or infrastructure, are not discussed in this report. However, they are included in the generated flood maps. If development is proposed to occur in these areas, care and connection should be executed in the design of the stormwater management systems to service these developments and how they will be connected to existing stormwater systems.

3.1 Spartan Avenue, Gravenstein Drive, and Orchard Street

The model results indicate some localized flooding issues at the intersection of Gravenstein Drive and Spartan Avenue. No dwellings appear impacted in the existing climate, however under climate change there is a greater extent of flood risk, including potential impacts to dwellings near the intersection of Spartan Avenue and Gravenstein Drive (Figure 3-1). Road overtopping is also observed under future climate change conditions, as indicated by the spill points shown in the figure below. These spill points represent locations where water overtops the local terrain and is redirected into neighboring drainage areas.

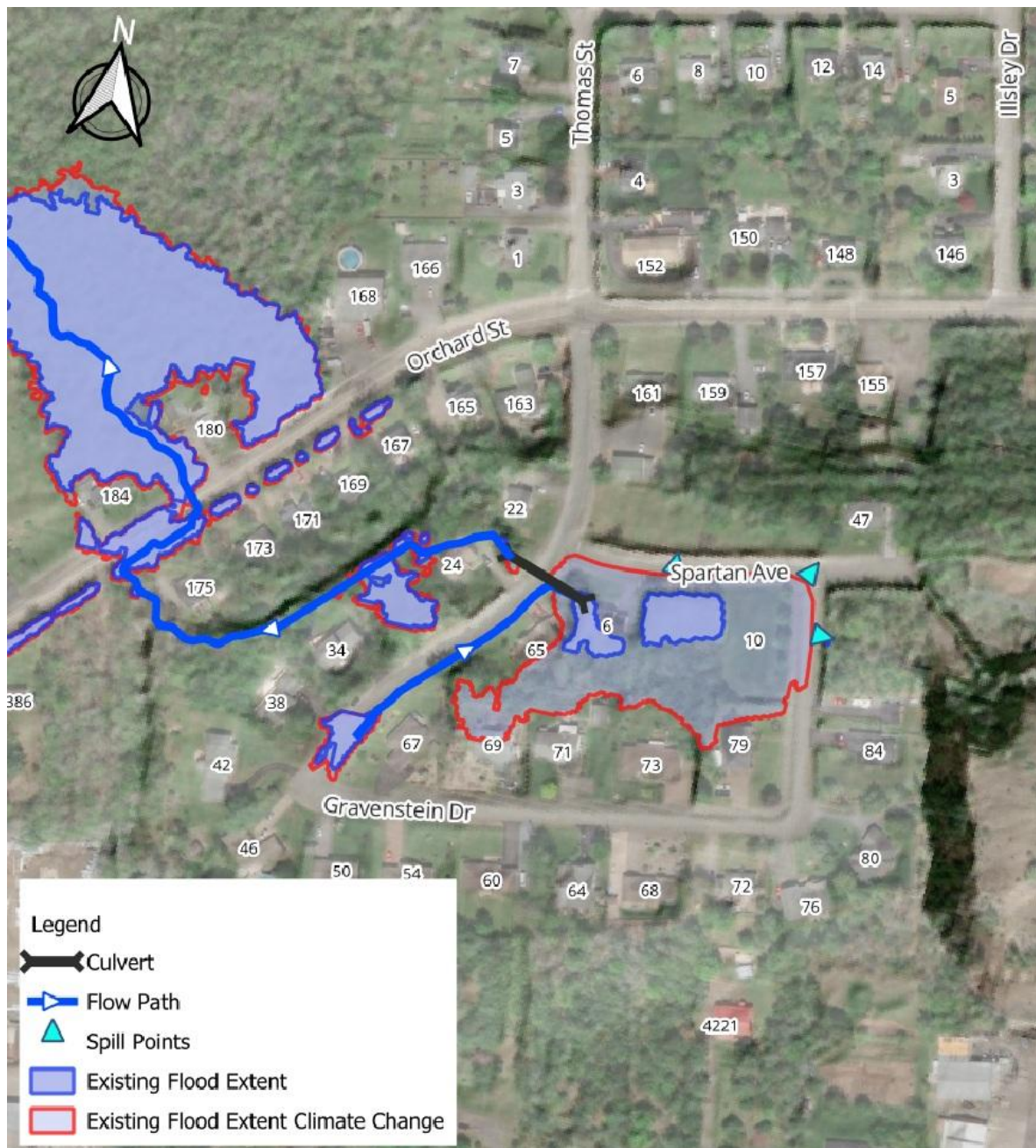


Figure 3-1: Flood Extents around Spartan Avenue, Gravenstein Drive, and Orchard Street

3.2 Pleasant Street and Brown Street

As shown on Figure 3-2, overland flow at Brown Street and Lions Gate intersection shows no risk in the model to the surrounding dwellings but can affect pedestrian access path under both existing and climate change scenarios.

Flooding is observed at the intersection of Browns Street and Front Street which is mainly due to overtopping of the culverts under large events. No dwellings around the culverts appear at risk with the exception of 170 Brown street. However, 170 Brown Street is a recently constructed dwelling, and the DEM used in this study does not capture the updated grading around this property. It is assumed that appropriate site grading and stormwater management measures are in place for this area. Overall, ponding depths are low at this area, although roads will be covered, they should still be passable by emergency vehicles.

Additionally, two culverts modelled on Foster Street exhibit some water backup; however, the flood extents in this area do not indicate overtopping of the roadway (Figure 3-2). Both culverts are modelled with a diameter of 300mm. The size and material of the southern culvert was confirmed during the field survey however its outlet was not visible. The size of the northern culvert was assumed as it could not be verified during the field survey. If the assumed culvert information is found to differ from that used in the model, the results will need to be re-evaluated.

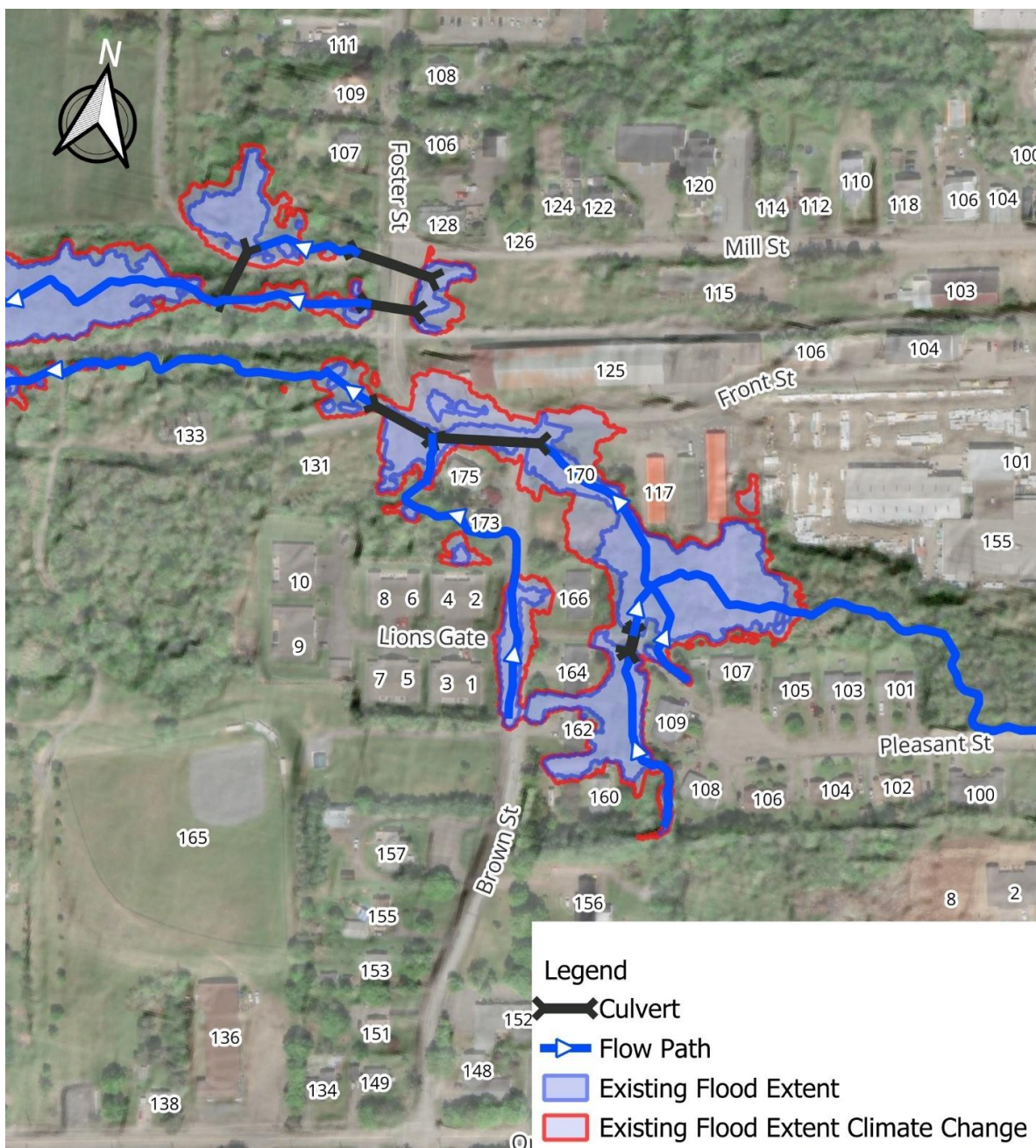


Figure 3-2: Flood Extents for Pleasant Street, and Brown Street

3.3 Bezanson Drive

The culvert beneath Bezanson Drive provides drainage for the open fields on the west side of Bezanson Drive and conveys flows east under normal operating conditions. However, as water levels rise during higher flow events, the hydraulic grade line increases and may result in the ponding in the fields overtopping into the drainage system to the west. The

model indicates that there is the potential for this to occur under the climate change event and for there to be reverse flow conditions through the Bezanson Drive culvert. The potential for the bidirectional behavior is dependent on upstream and downstream water surface elevations and can be represented in the model. As shown in Figure 3-3, model results indicate some ponding upstream and downstream of the culvert under Bezanson Drive, although it is contained to the vegetated areas and no dwellings are impacted under existing climate conditions. CBCL recommends regular culvert maintenance (i.e., clearing of vegetation and removal of sediment buildup) to reduce the risk of flooding in surrounding areas. Under climate change there will be an increase in flood risk to private dwellings at the rear of Bezanson Drive and Beckwith Drive.

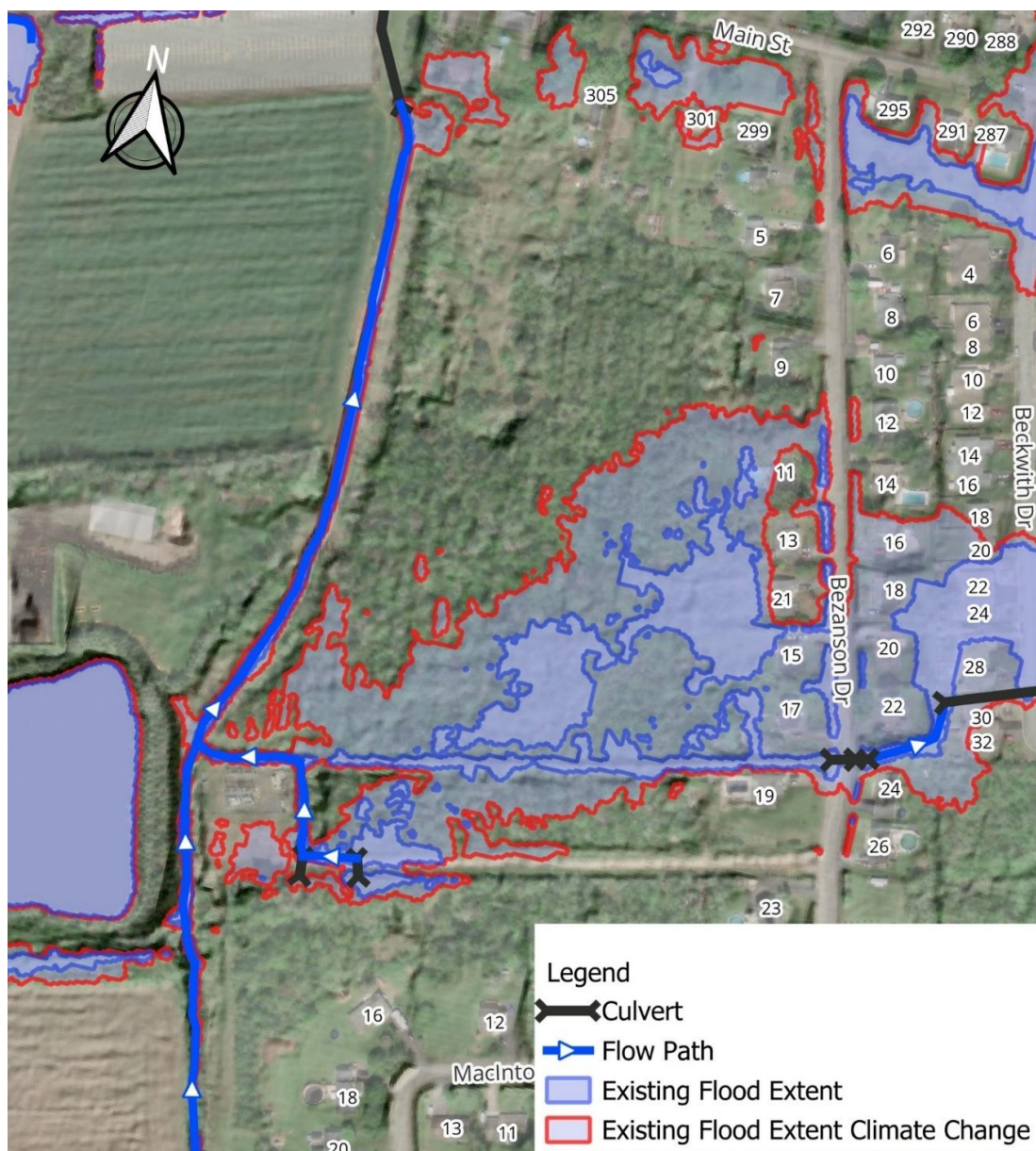


Figure 3-3: Flood Extents around Bezanson Drive

3.4 Foster Street

The model results indicate significant flooding around the new development east of Beckwith Drive (Figure 3-4), however, the flood lines were mapped using topographic information that is not representative of the latest grading for the new development. To prevent flooding in the new development appropriate stormwater management strategies will need to be implemented.

Further downstream, overtopping of Main Street at Foster Street is shown which will increase under climate change conditions. This suggests that the existing culvert is undersized and should be upsized to reduce the risk of flooding at this location. The model indicates that Main Street will be inundated by floodwaters in the 1:100-year event under existing climate conditions.

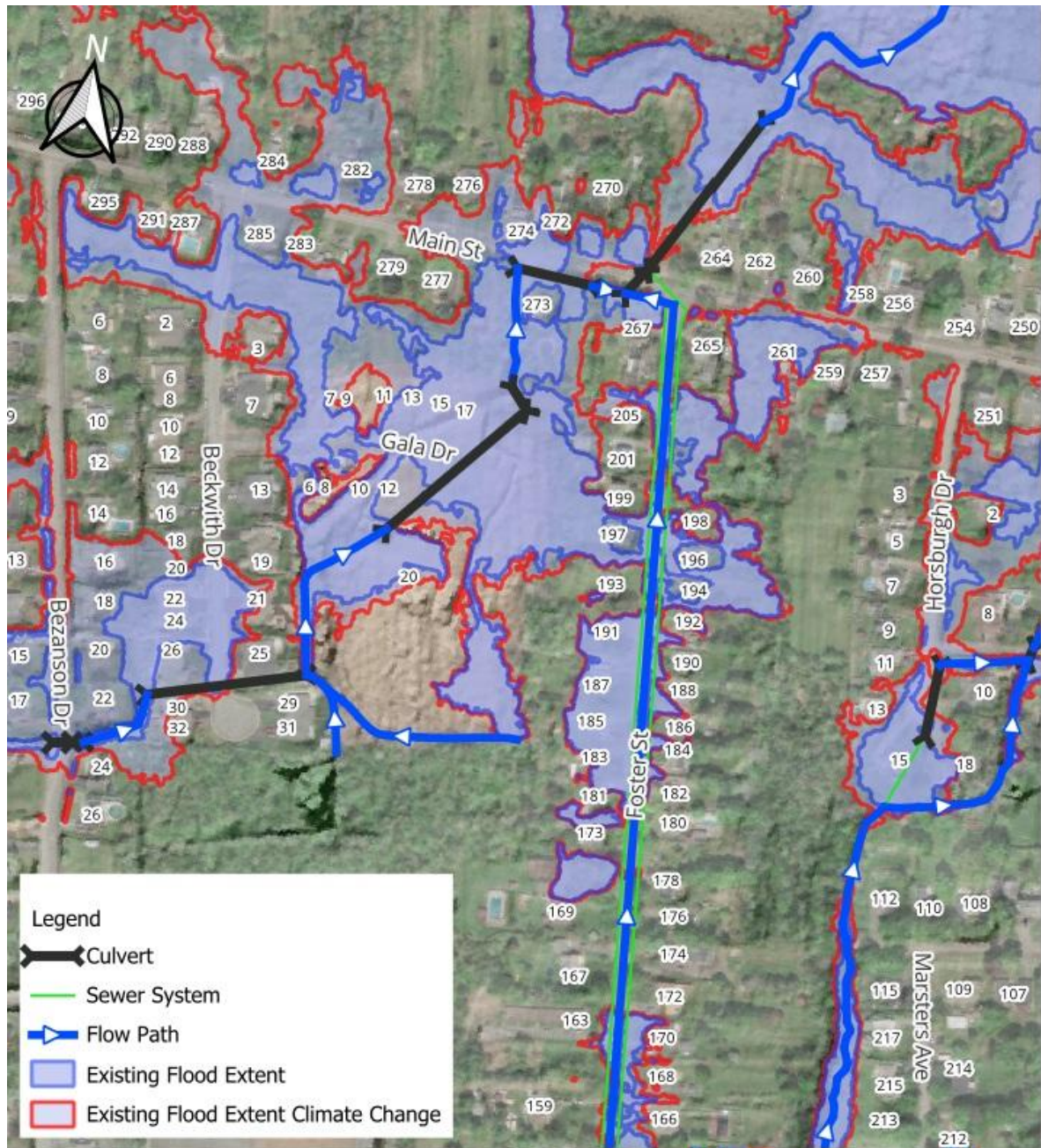


Figure 3-4: Flood Extents around Foster Street

3.5 Cottage Street at Centennial Park

Part of the minor system previously modelled was incorporated into the major system modeling at Cottage Street to provide additional representation of the flows in this area. Figure 3-5 indicates flooding in the Centennial Park (Rainforth Park) open space recreational area just south of Cottage Street, as well as cottage street overtopping. Flood risk will increase under climate change scenario, affecting a larger extent of the park.

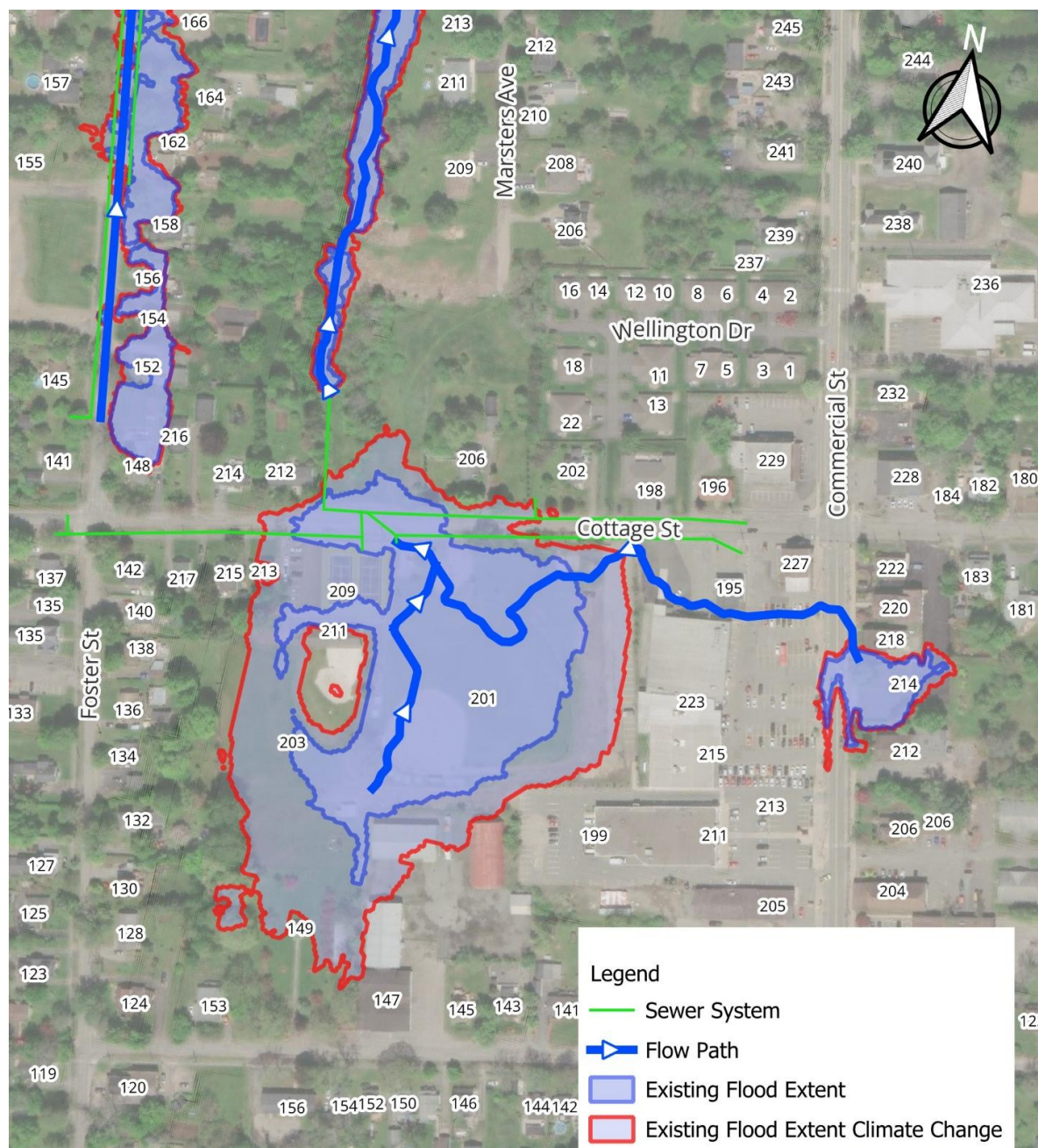


Figure 3-5: Flood Extents for Cottage Street at Centennial Park

3.6 Horsburgh Drive

Model results show flood risk for dwellings at the south end of the Horsburgh Drive cul-de-sac (Figure 3-6). There is a ditch which runs to the south and east of 18 and 10 Horsburgh Drive and connects to the culvert under the driveway of 8 Horsburgh Drive. The ditch was surveyed, including the top and bottom of the slope, up to the point where it transitions into the narrower, rock-lined section. A few additional survey points were also collected along the rock-lined portion. During the survey, it was observed that the transition area was accumulating a significant amount of fallen leaves, creating a partial blockage and restricting water flow.

The ditch system has been included in the model along with the surveyed culvert system conveying the flows along the boundary between 15 and 18 Horsburgh Drive. The surveyed culvert system connects into a sewer under Horsburgh Drive at a catch basin and discharges into a ditch running along the driveway of 8 Horsburgh Drive to the culvert under the driveway.

Flooding is observed upstream of the modelled culvert (600mm diameter, HDPE) under the driveway of 8 Horsburgh Drive, indicating that the culvert is undersized to convey the 1:100-year storm under existing and future climate conditions. Flood risk is also a result of the lack of capacity upstream at the drainage path behind 18 Horsburgh Drive which places the dwelling at risk of flooding.



Further downstream, model results indicate that there is ponding upstream of the two modelled culverts under Main Street at the intersection with Commercial Street. No overtopping of the road occurs under existing climate condition, but there is ponding across the private lots which extends up to Horsburgh Drive, as well as road overtopping in the climate change event.

3.7 Main Street at Commercial Street

As shown on Figure 3-7, based on model results there is some flooding southeast of Main Street and Commercial Street intersection which is mainly limited to backyards and vegetated areas except for 235 and 237 Main Street where flood lines are extended to the buildings.

North of Main Street, there is some ponding which extends onto the lower additional parking area of the commercial building at 292 Commercial Street. The ponding touches the edge of the parking lot of the Royal Canadian Legion Branch but does not appear to extend into the parking area. The ponding is due to the water levels of the Cornwallis River rather than inadequate conveyance capacity.

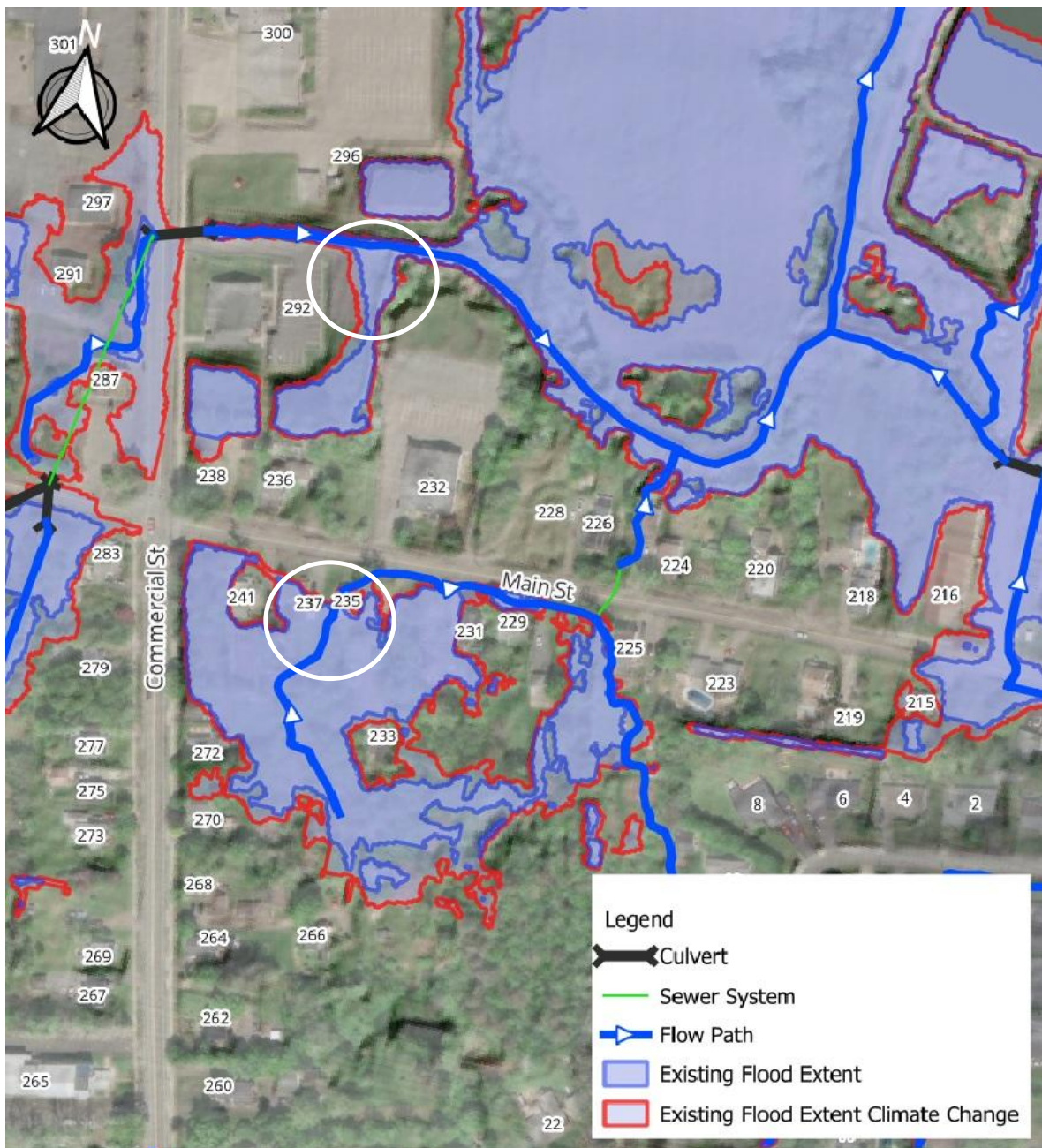


Figure 3-7: Flood Extents around Main Street and Commercial Street

3.8 Main Street at Maple Avenue

The model indicates that there is ponding on the southeast corner of the intersection of Maple Avenue and Main Street (Figure 3-8) due to restrictions in the capacity of the inlet to the culvert conveying flow under Main Street to the open channel along the access road to the lagoons at the Berwick Electric Commission building. The channel crosses under the access road and discharges to the Cornwallis River.

The ponding in the southeast corner overtops Maple Avenue and there may be around 340mm depth of ponding on Maple Avenue in the 1:100-year event under existing climate scenario. Although there is impact from the downstream Cornwallis River the ponding is predominantly due to upstream runoff. West of the intersection with Maple Avenue on Main Street there is overtopping of Main Street of around 300mm depth at the low point in the 1:100-year event under existing climate conditions. Under the climate change scenario, model results indicate road overtopping east of the intersection.

North of Main Street there is ponding across the public works yard for the Berwick Electric Commission building, the access road to the lagoon wastewater treatment facility and the open space area. Flooding in the area north of Main Street is due to the high-water levels in the Cornwallis River.

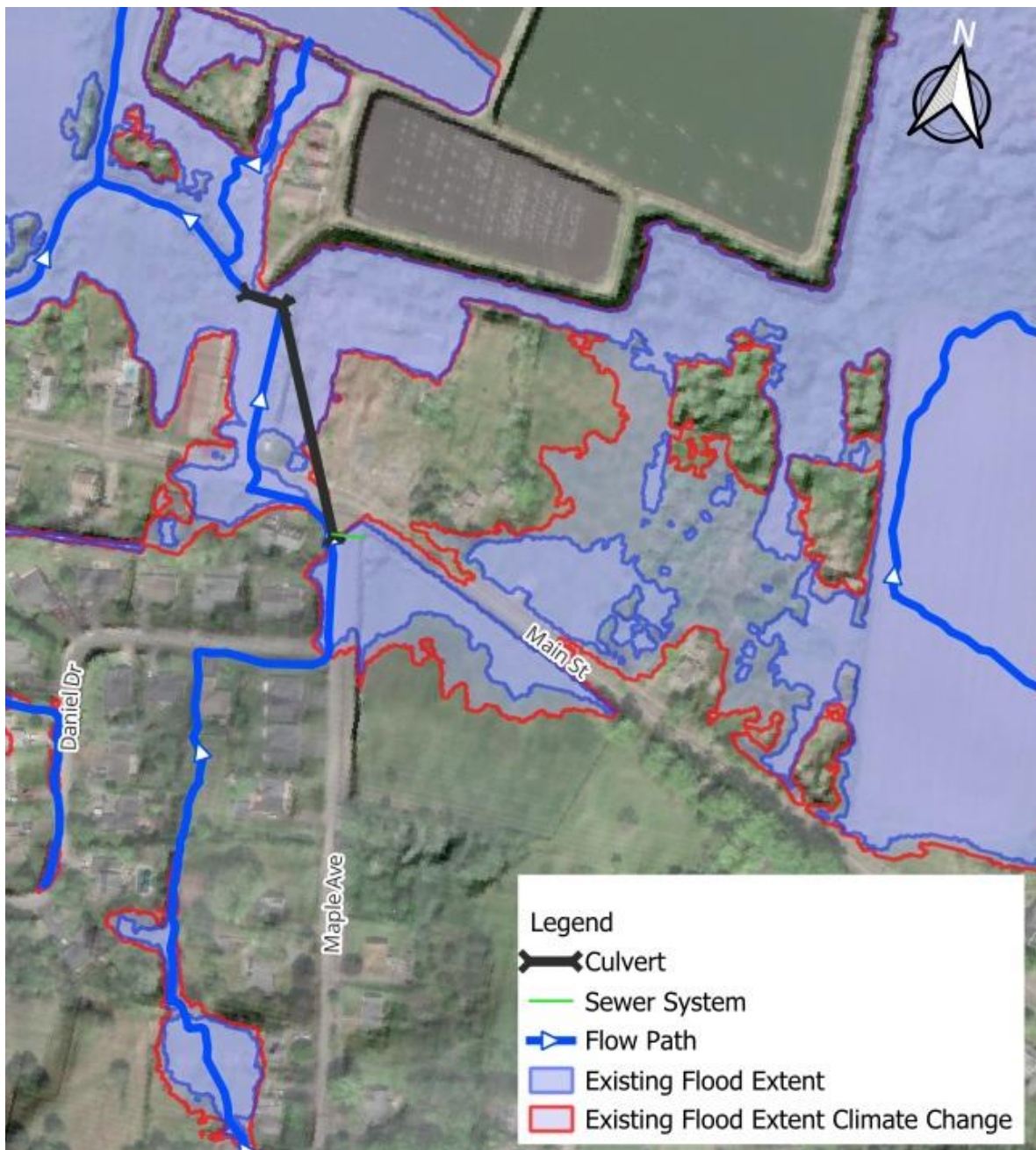


Figure 3-8: Flood Extents around Main Street and Maple Avenue

3.9 Main Street at Cottage Street / Lawrence Avenue

Overland flow and ponding around low lying areas at Cottage Street and Main Street has been observed in the model results (Figure 3-9). The low-capacity culvert on Lawrence Avenue results in overland sheet flow down the hill, impacting 134 Lawrence Avenue at risk of flooding under a 1:100-year event.



Figure 3-9: Flood Extents around Main Street at Cottage Street

3.10 Hayden Drive

As depicted on Figure 3-10, model results show some ponding at the intersection of Maple Avenue and Hayden Drive due to the low point on the east side of Maple Avenue and the flow overtopping Maple Avenue to drain down Hayden Avenue. The risk to the dwellings is relatively low and flow depths across the road are around 180mm under existing climate condition. However, this could limit emergency access particularly under future climate condition.

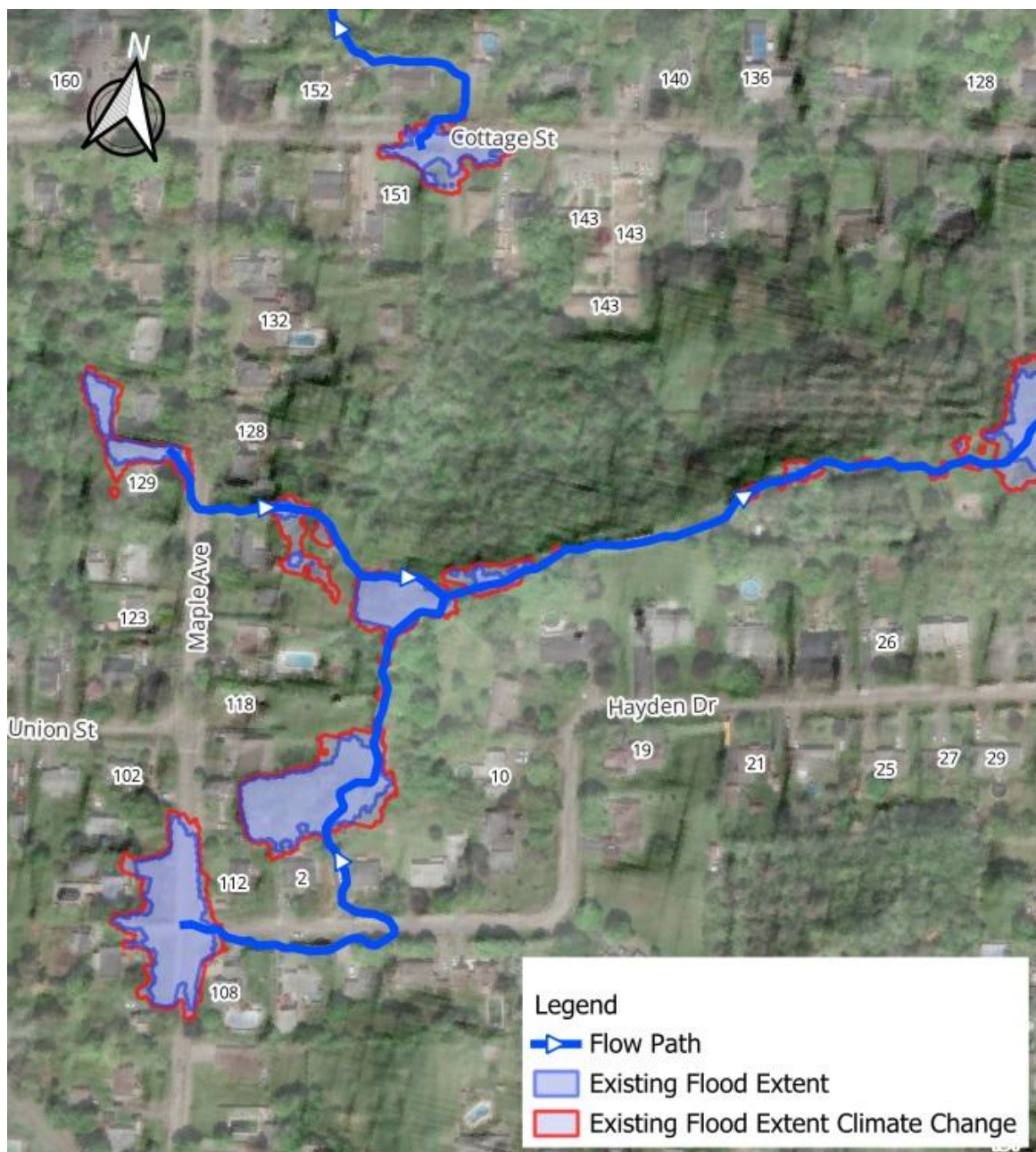


Figure 3-10: Flood Extents around Maple Avenue and Hayden Drive

3.11 Morris Brook at Main Street

Model results indicate flooding upstream of Maple Street and inundation of the existing stormwater management facility adjacent to 107 Main Street (Figure 3-11). The stormwater management pond was identified based on aerial imagery, and a storage curve was developed for the pond using the available DEM and the Storage Creator tool in PCSWMM. The modelling indicates that the pond lacks sufficient capacity to retain the runoff generated during a 1:100-year storm event, however, the main restriction in the model is the capacity of the downstream rectangular box culvert under Maple Street. Based on the model results, Maple Street could experience flooding under a 1:100-year event but there is extensive backwater from the box culvert under Maple Street which would back up into the storage pond. Climate change scenario shows significant road overtopping in this area.

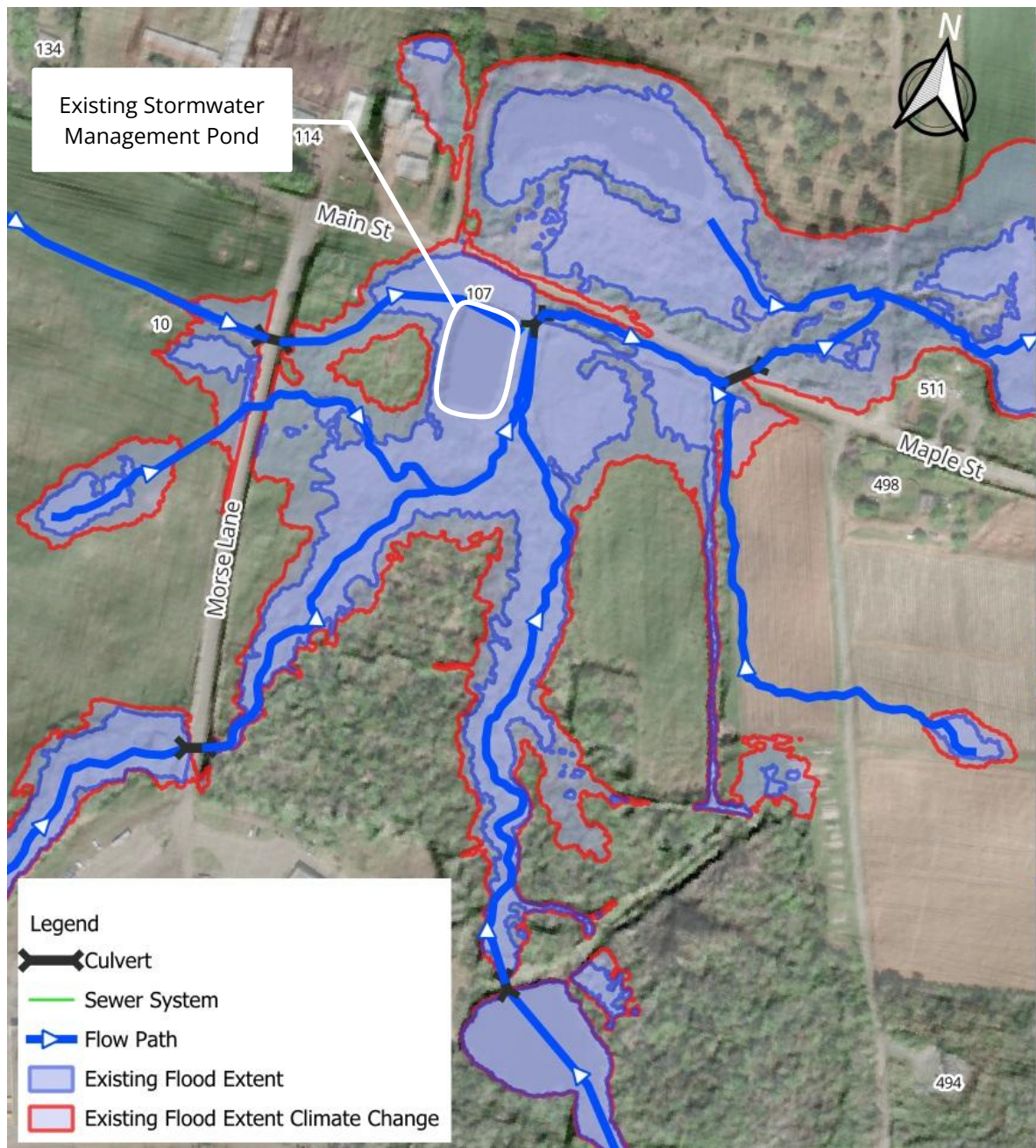


Figure 3-11: Flood Extents for Morris Brook at Main Street

4 Mitigation Options

This section will discuss the various mitigation options that CBCL modelled and conceptually designed as part of this project.

4.1 Mitigation Suitability

To maximize the impact of recommended upgrades, CBCL assessed the suitability and priority for each flooded area of interest with the following criteria:

- ▶ **Cause of flooding:** Only flooding caused by deficient municipal infrastructure is within the mitigation scope.
- ▶ **Dwelling impacts:** To maximize the positive effects of mitigation efforts, flood impacts to residential dwellings were prioritized over vegetated/vacant areas.
- ▶ **Road overtopping:** Preventing excessive overtopping flow helps maintain access for emergency vehicles and is a priority especially along busier roads and where overtopping would be to the extent as to reduce access for emergency vehicles.

Each area of interest was assessed against these criteria as presented below in Table 4-1.

Table 4-1: Mitigation Suitability Summary for Each Area of Interest

Area	Cause of Flooding	Dwelling Impacts?	Road Overtopped?	Comments	Mitigation Suitability
Spartan Ave., Gravenstein Dr., & Orchard St.	Municipal infrastructure (undersized culvert)	☒	☒	Impacts of upsized culverts to be modelled.	High
Pleasant St. & Brown St.	Municipal infrastructure (undersized culvert)	☐	☐	Dwellings are not impacted, nor does the road overtop. Upgrades are not a priority.	Low

Area	Cause of Flooding	Dwelling Impacts?	Road Overtopped?	Comments	Mitigation Suitability
Bezanson Dr.	Municipal infrastructure (undersized culvert) and tailwater conditions	☐	☒	Impacts of culvert upgrades and flow diversion to be modelled.	Medium
Foster St.	Municipal infrastructure (undersized culvert)	☒	☒	Impacts of upsized culverts to be modelled.	High
Cottage St. at Centennial Park	Municipal infrastructure (undersized culvert and ditch)	☐	☒	Surface storage of stormwater within centennial park to be modelled.	Medium
Horsburgh Dr.	Municipal infrastructure (undersized culverts, storm pipes, and ditches)	☒	☒	Culvert and channel upgrades to be modelled.	High
Main St. at Commercial St.	Tailwater conditions	☒	☒	Flooding is due to tailwater conditions and is thus infeasible to mitigate.	None
Main St. at Maple Ave.	Municipal infrastructure (undersized culvert) and tailwater conditions	☐	☒	Dwellings are not impacted, and tailwater conditions could somewhat limit the effect of culvert upsizing.	Low
Main St. at Cottage St./Lawrence Ave.	Municipal infrastructure (undersized culvert)	☒	☐	Culvert upgrades to be modelled.	Medium
Hayden Dr.	Poor gravity drainage	☐	☒	Flooding is not due to municipal infrastructure and does not affect dwellings. It is therefore not a priority.	None

Area	Cause of Flooding	Dwelling Impacts?	Road Overtopped?	Comments	Mitigation Suitability
Morris Brook at Main St.	Municipal infrastructure (undersized culvert) and tailwater conditions	☐	☒	The flooding occurs in an open field and is therefore not a priority.	Low

This assessment informed the direction and focus of CBCL's mitigation strategies. The following sections describe where infrastructure upgrade opportunities were identified for the medium and high suitability areas, and the associated design concepts and their impacts on flooding.

4.2 Mitigation Design Concepts

Several mitigation scenarios were developed and their effectiveness in reducing flood risk within the study area was assessed for the medium and high suitability areas identified in the previous section. Each scenario represents a different combination of storage and conveyance upgrades, and flow diversions. The effectiveness of the upgrades was first assessed in the stormwater model; then, if they were effective, their implementation feasibility was investigated by implementing them into the existing terrain in Civil3D. The scenarios are described in the following subsections.

All scenarios were modelled using the 1:100-year inland rainfall combined with the 1:5-year Cornwallis River water levels, under existing and future climate change conditions to allow direct comparison of their relative performance. This is referred to as the "design event" throughout the following sections.

The scenarios have been developed to the conceptual design stage, but preliminary and detailed design will be required prior to the implementation of any of the mitigation options.

4.2.1 Scenario 1 – Baseline Mitigation

This scenario represents the baseline mitigation configuration and includes storage and conveyance improvements. This mitigation scenario includes:

- ▶ A stormwater detention area located in Centennial Park to reduce peak flows to the existing downstream ditch along Horsburgh Drive.
- ▶ Upgrades to the Main Street at Foster Street culverts and outlet pipe, as well as the driveway culvert at 273 Main Street and regrading its downstream drainage ditch

between the culvert and Foster Street to increase conveyance capacity and reduce flooding in this area.

Note that all infrastructure upgrades discussed in later mitigation scenarios are in addition to those presented in the baseline scenario.

4.2.1.1 Centennial Park Detention Area

Centennial Park was identified as a good location for stormwater detention due to it being on property owned by the Town; being comprised mainly of grassed, open space, reducing potential reinstatement costs; and being upstream of one of the identified areas of flooding (Horsburgh Drive). The proposed detention area located within Centennial Park involves lowering the ground elevation in the area relative to the surrounding grade by 1.0 to 1.5m to provide stormwater storage during large storm events. This is anticipated to reduce the flood extents in the downstream ditch north of Cottage Street in the Horsburgh Drive area by reducing peak flows to the ditch.

In the stormwater model, the detention area was implemented with an active storage volume of 8,550m³ and an outlet pipe size of 750mm with a 590mm orifice for peak flow control. The detention area's outlet pipe connects to the existing control structure on the north side of Cottage Street. The existing weir in this structure is proposed to be removed. The reduction in flood extents with the detention area implemented compared to the existing conditions, under current climate and climate change conditions, are shown below in Figure 4-1. Note that the areas shown in this figure are north of the detention area itself, as its impacts are primarily downstream.

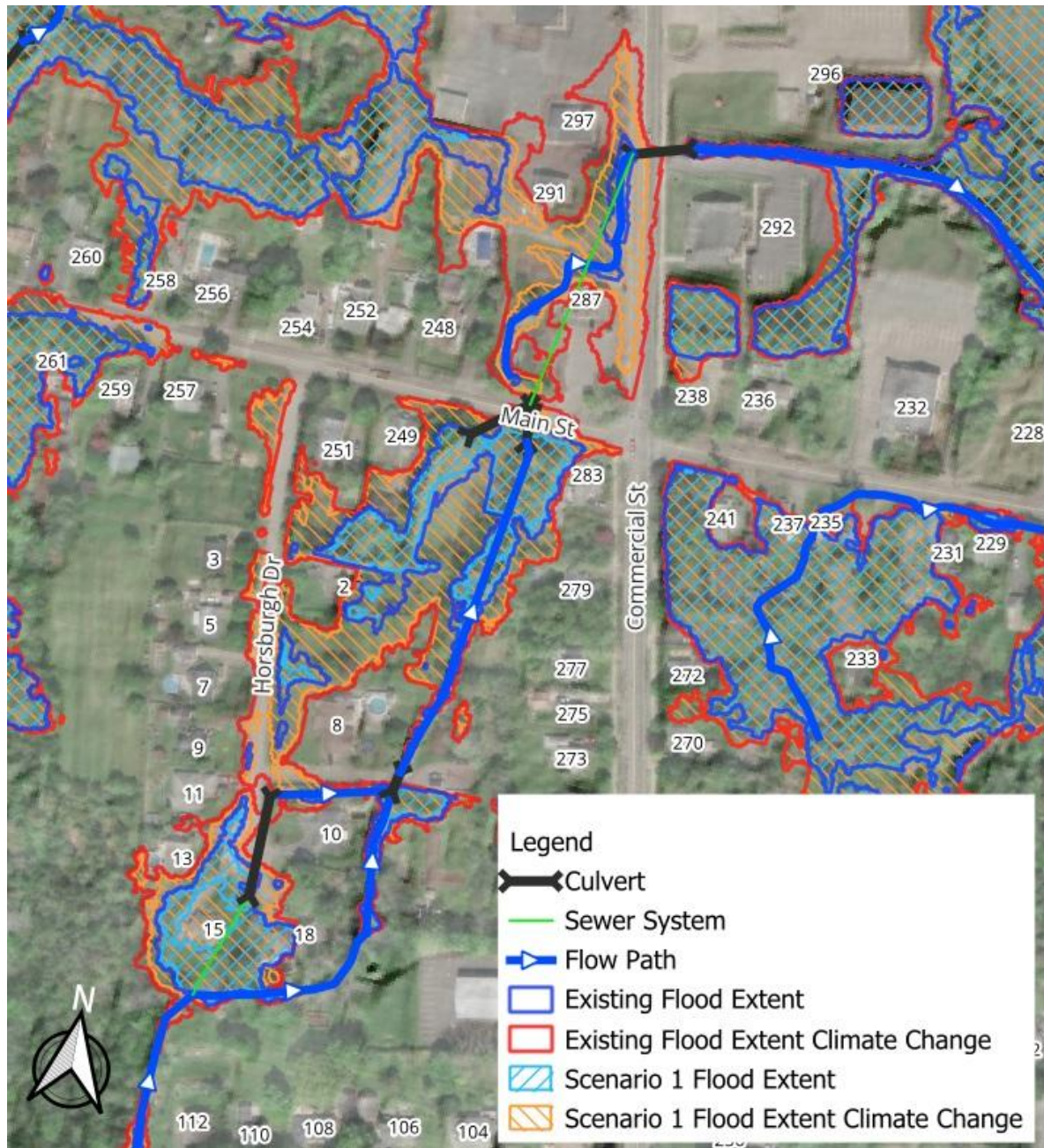


Figure 4-1: Flood Extents for Scenario 1 compared to Existing Flood Extents for Horsburgh Drive

The modelling results above show reduction in flood extents primarily along the northernmost portions of the outlet ditch, and further north beyond the ditch's outlet along commercial street. Under both climate conditions, the detention area resulted in some reductions in flood risk in the residential area between Commercial Street and Horsburgh Drive near the north end of the ditch. Further upstream, at the south end of

Horsburgh Drive, the impact is not as great. In this area, the ditch is relatively flat and thus has a lower capacity; further mitigation is required to reduce flooding here. Modelling also indicates that the detention area fully drains in approximately 20.5 hours.

The modelling results indicated the detention area could reduce flooding impacts. Therefore, its constructability was investigated by implementing it into the existing terrain in Civil3D. The park's current use and accessibility was considered as the intent is for the park to continue to function as a park. To accommodate this, the inner side slopes were set at 8:1, and the bottom slopes northward to prevent extended pooling that would otherwise occur in a typical flat-bottom detention area. A low-flow channel would also be graded into the bottom of the detention area to provide adequate drainage for small storm event. A sketch of a potential layout for the Centennial Park detention area is shown below in Figure 4-2.



Figure 4-2: Centennial Park Detention Area Details

4.2.1.2 Main Street at Foster Street Culvert Upgrades

Under existing conditions, the triple-barrel 600mm concrete culverts that convey stormwater from the south to north side of Main Street do not have sufficient capacity for larger storms, resulting in flooding upstream of the culverts, on the south side of Main Street. These culverts connect to a 950mm diameter outlet pipe that discharges to Rand Brook and ultimately to Cornwallis River.

Upgrading the culverts and the outlet pipe is intended to increase the conveyance capacity of this system towards Rand Brook, ultimately reducing the flood extents south of Main Street adjacent to Foster Street. Due to the small elevation differences between the culvert inlets and the outfall, there was a practical limit on the possible size increase. We modeled replacing the 3 x 600mm diameter culverts and 950mm diameter outlet pipe with 2 x 1050mm pipes from the south side of Main Street to the outlet into the Brook. The existing 600mm circular driveway culvert at 273 Main street was also replaced with a 1800mm width x 900mm height box culvert (5m length). Its downstream ditch was regraded and resized to a 2m bottom width, 1.5m depth and 3H:1V side slopes in the model. The changes in flood extents due to these upgrades are shown below in Figure 4-3.

As noted in Section 3.4, the flood lines were generated using topographic data that does not reflect the most recent grading associated with the new development around Gala Drive (dotted area in Figure 4-3). Therefore, the mapped flood extents in this area should not be considered representative of current site conditions.

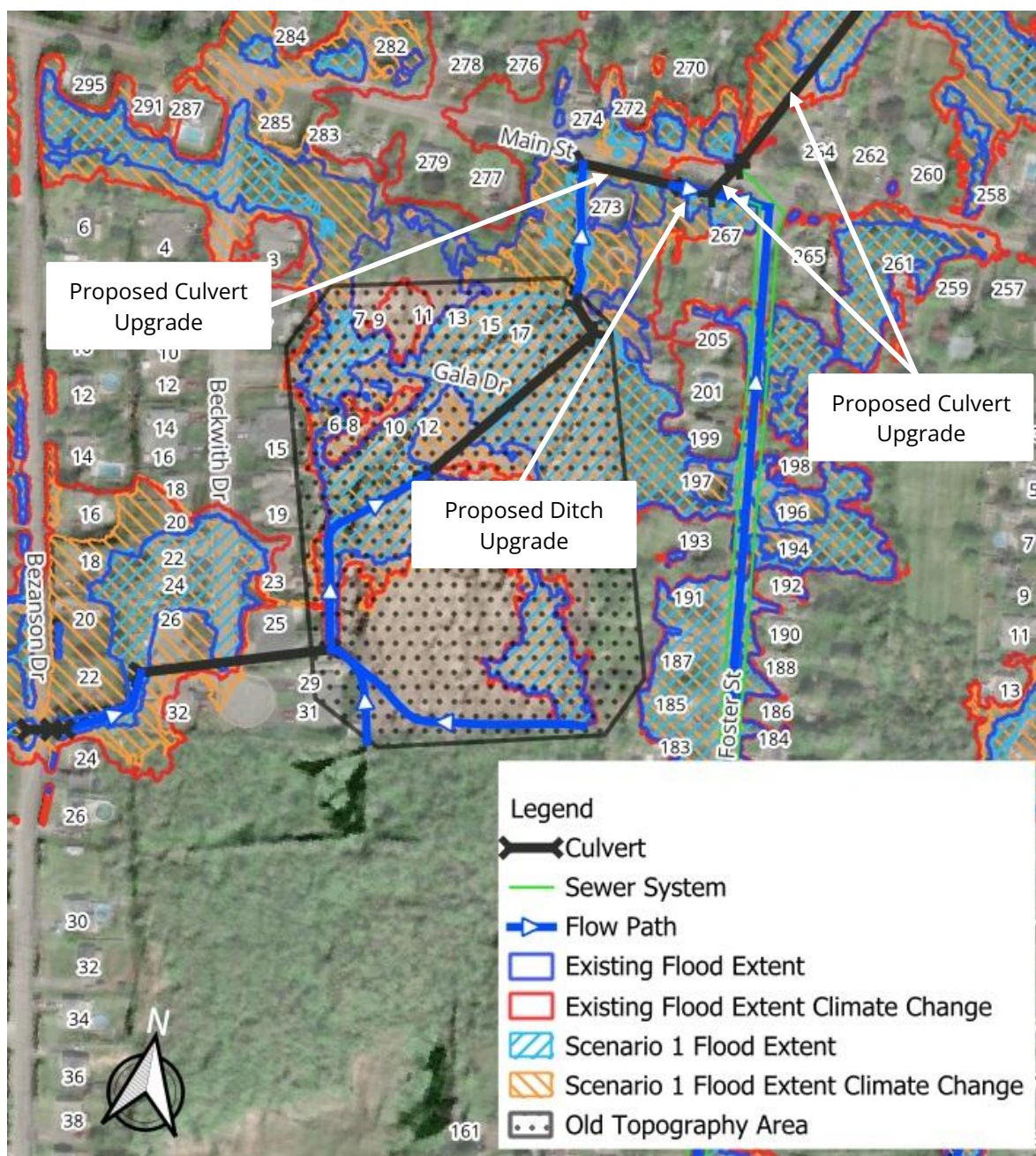


Figure 4-3: Flood Extents for Scenario 1 Compared to Existing Flood Extents Around Main Street and Foster Street

The Main Street at Foster Street culvert upgrades have a relatively small additional impact on flood extents when added to the Centennial Park Pond, however this is to be expected given that the upgrades are at a smaller scale. Reduction in the flood extents are predicated both on the north and south sides of Main Street, in areas immediately adjacent to the conveyance system, owing to the increased conveyance capacity. The culvert upgrades are modelled to increase the maximum flow rate through the culverts by 50%

under both current climate and climate change conditions, compared to the existing infrastructure.

Challenges with ground cover over the pipes were encountered when implementing these upgrades into the Civil3D model. The existing inverts of the existing triple-barrel concrete culverts are too high to accommodate larger pipes; minor regrading of the ditch on the south side of Main Street would be required to maintain adequate ground cover. The proposed bottom of ditch elevation is equal to the inlet pipes' inverts of 26.2m, approximately 0.7m lower than the existing ditch. In addition to accommodating the larger pipes, this will also allow more static head to build up in high-flow conditions before spill occurs, further increasing conveyance capacity.

The existing 900mm HDPE outlet pipe also has minimal ground cover under existing conditions. To install the larger pipes, an invert drop would be required. To accommodate the larger-diameter pipes with lowered inverts, a new precast structure with a deeper sump will be required to be evaluated during detailed design. The existing outlet location and elevation is proposed to be maintained. Refer to Figure 4-4 for a sketch detailing the Main Street at Foster Street culvert upgrades. Note that although there is existing storm infrastructure along the existing outlet pipe, the Town has no utility/infrastructure easement. The acquisition of easements is discussed later in Section 5.2.1.



Figure 4-4: Sketch of Main Street at Foster Street Culvert Upgrades

4.2.1.3 Additional Channel Improvements

Scenario 1 (the baseline scenario) was further refined by incorporating channel improvements for a major flow path. The ditch south of the Horsburgh Drive cul-de-sac, and the major flow path downstream of the ditch were formalized into a trapezoidal channel with a 2m bottom width, 2m depth, and completed with side slopes at 3:1 while still following the original flow path. Modelling results indicate that these channel upgrades did not decrease overland spill across the properties along Horsburgh Drive. Figure 4-5 compares the modelled flood extents for scenario 1 with and without channel improvements.

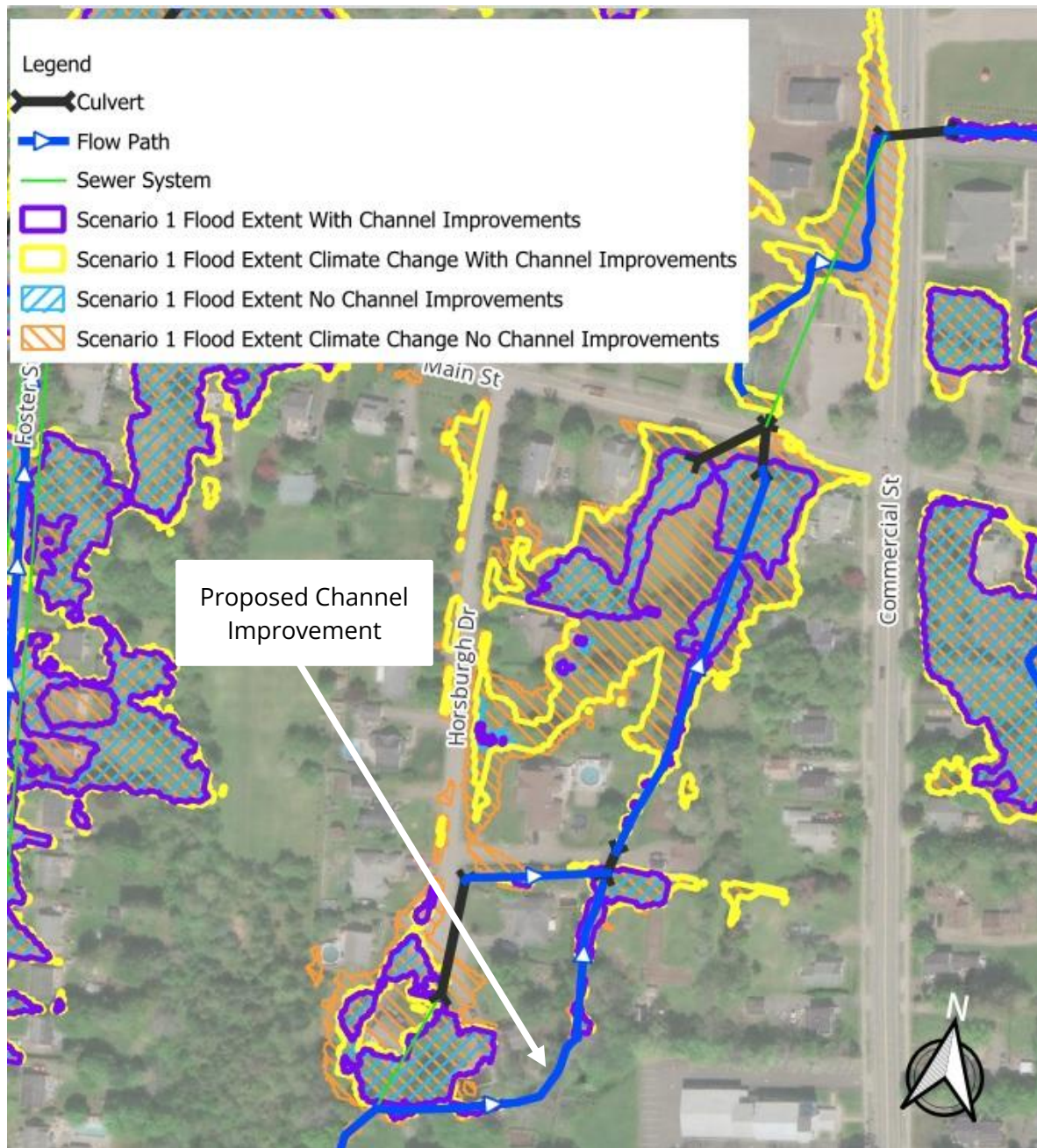


Figure 4-5: Flood Extent Comparison for Scenarios 1 With and Without Channel Improvements, Around Horsburgh Drive

As shown above, along the east side of Horsburgh Drive, proposed channel improvements resulted in negligible reduction in flood extents compared to scenario 1 without the additional channel improvement.

In addition to not providing much improvement in flood extents, constructability challenges were encountered while attempting to integrate this design concept into the existing terrain. The existing ditch is constrained on both banks by residential dwellings, pools, and gardens, greatly limiting its maximum channel width. The driveway culvert going under the driveway at 8 Horsburgh Drive also severely bottlenecks flow through the ditch and would require significant upsizing to adequately convey flow without overtopping the driveway. Although it is infeasible to construct, the model results indicate that channel upgrades could still lead to some minor reduction in flood extents.

4.2.2 Scenario 2 – Maximum Storage & Flow Diversion

This hypothetical scenario evaluates the impact of maximizing upstream storage on the Horsburgh Drive area, combined with diverting flow away from the Main Street at Foster Street area. This was done by oversizing the Centennial Park detention area beyond what is possible given the space constraints (approximately 2.5 times the storage of the baseline mitigation scenario, for a total of 21,500m³) and downsizing the outlet structure to utilize the full benefit of the larger storage volume.

The concept of diverting flows away from Foster Street to reduce the flood extents around Main Street at Foster Street was also investigated. This was done by changing the outlet location of sub-catchments west of Bezanson Drive such that they drained to the western flow path, instead of flowing through the culvert under Bezanson Drive and towards Foster Street.

This mitigation scenario did decrease flooding across Horsburgh Drive with the increased storage volume, as shown in Figure 4-6.

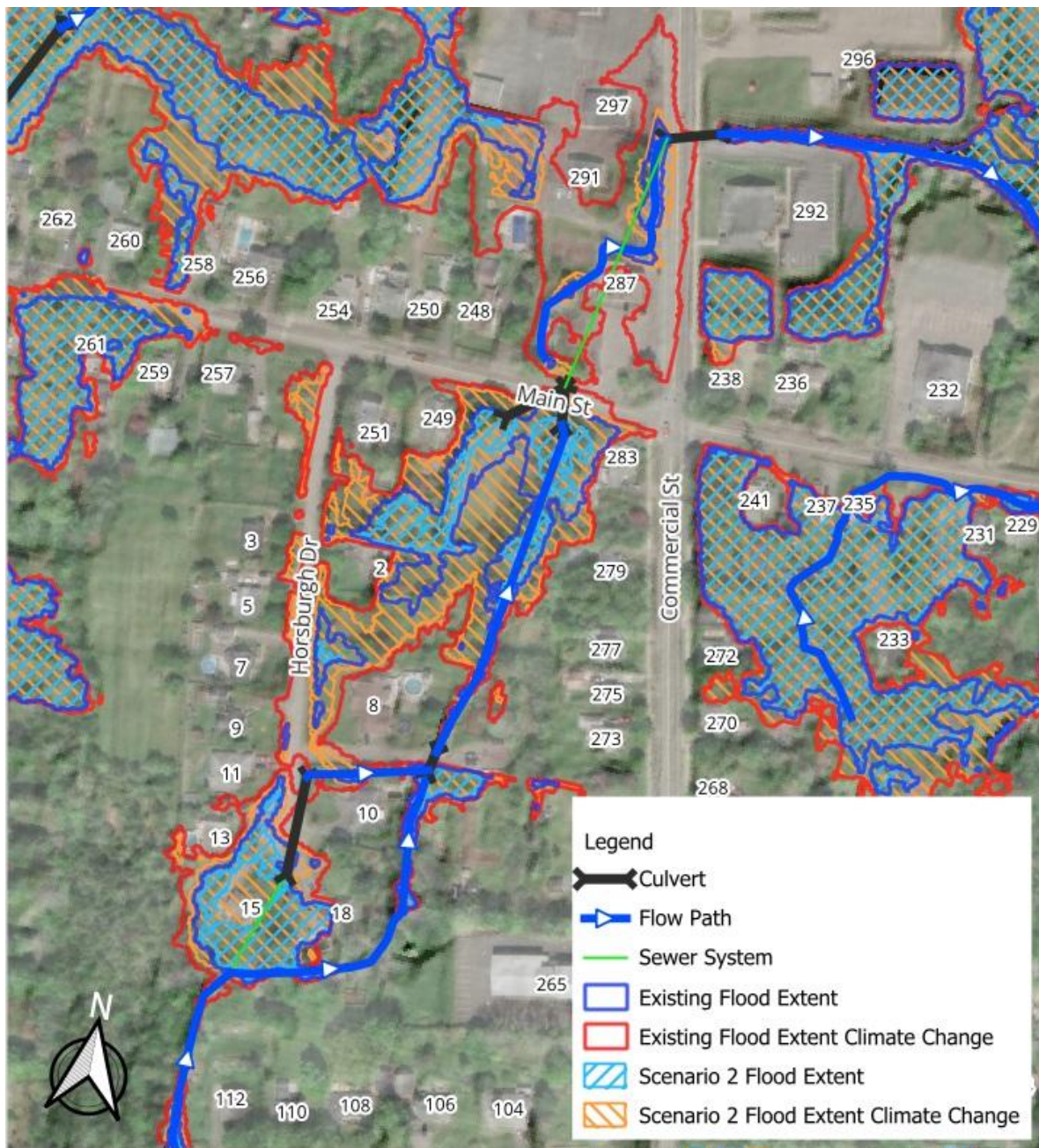


Figure 4-6: Flood Extents for Scenario 2 compared to Existing Flood Extents, Around Horsburgh Drive Based on Increased Storage Volume

As shown on the previous page, the flood extents around Horsburgh Drive were decreased due to the increased storage volume, indicating that pursuing additional storage volume would have positive effects. It is worth mentioning that a small section of Horsburgh Drive is still at risk of overtopping under the future climate change conditions.

Although the scenario itself is not possible, this success informed the direction of other mitigation scenarios by indicating the scale of stormwater storage that would be required to alleviate flooding.

The flow diversion concept resulted in larger flood extents at west of Bezanson Drive and did not show any improvements east of Bezanson Drive, compared to the existing conditions flood extents (refer to Figure 4-7). As such, the concept of diverting flow away from the Main Street at Foster Street culverts was not developed further.

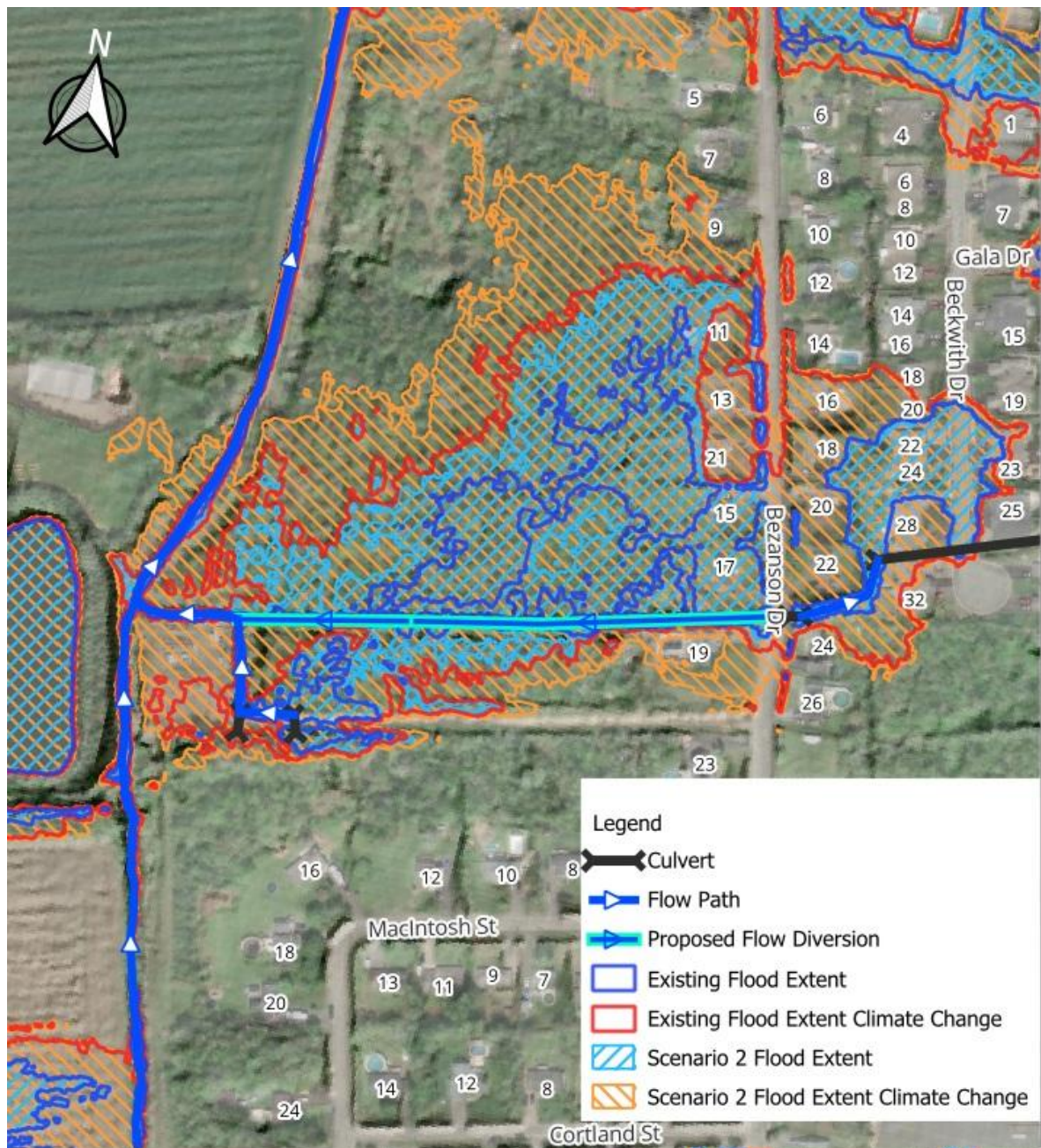


Figure 4-7: Flood Extents for Scenario 2 Compared to Existing Flood Extents, Around Bezanson Drive, With Flow Diversion

4.2.3 Scenario 3 – Rock Check Dams and Channel Storage

Scenario 3 is hypothetical, evaluating the maximum effectiveness of distributed storage in the channel north of Cottage Street and south of Horsburgh Drive when combined with the Centennial Park detention area. The channel was oversized beyond what is possible with the space constraints, with a 20m bottom width, 1m depth, and completed with side slopes at a 3:1 grade. Four rock check dams were added within the channel to provide distributed storage, with each consisting of a 0.15m bottom orifice and a rectangular weir with a 0.5m offset, 0.5m height, and 1m length. The modelling schematic for Scenario 3 is illustrated in Figure 4-8.

This impractically upsized channel with distributed storage reduced peak flow during the design storm by approximately 50% and the overland flow volume by approximately 66%, demonstrating that only infeasible amounts of distributed storage could be able to achieve meaningful flood extent reduction.

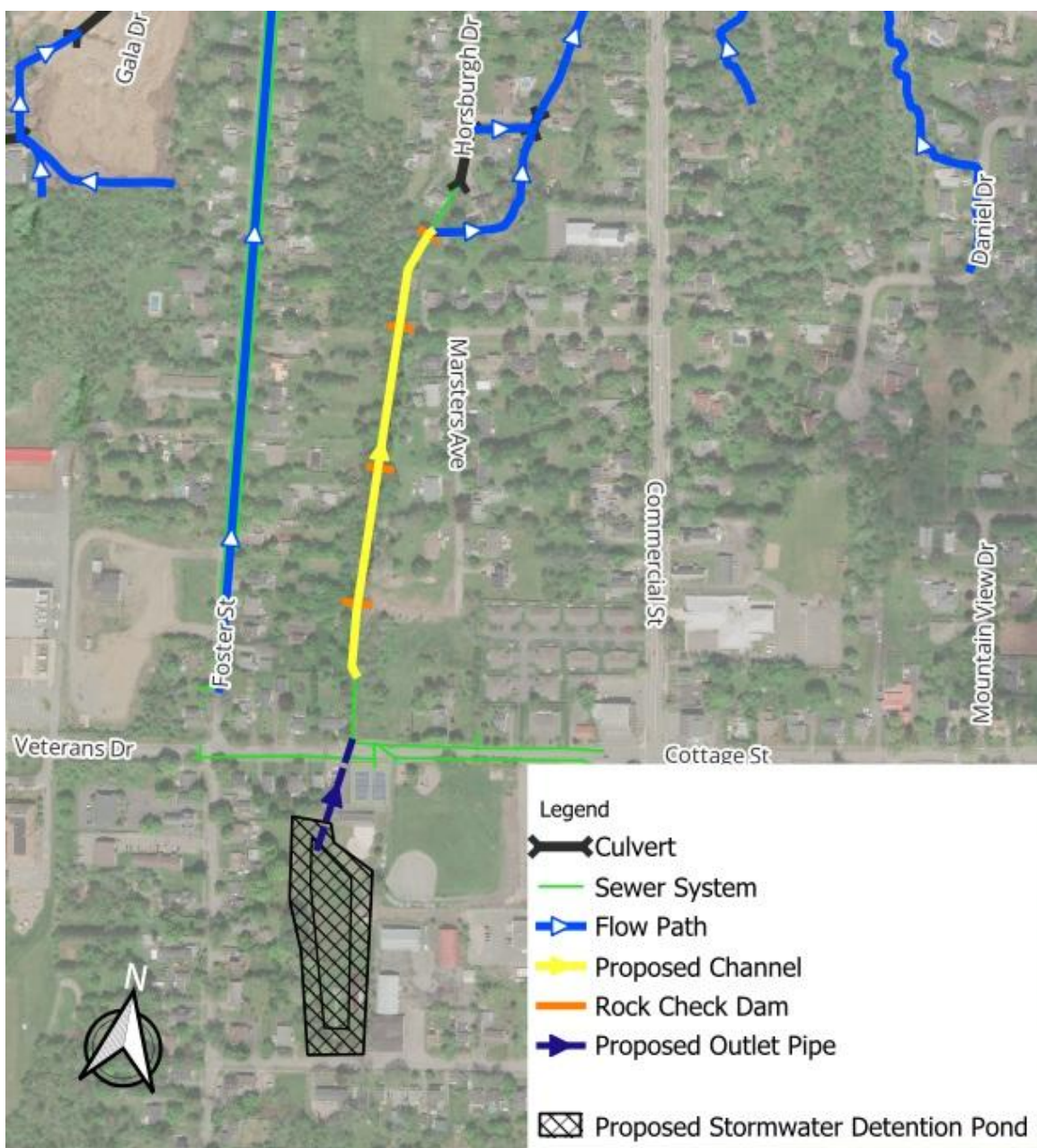


Figure 4-8: Schematic Representation of the Model Used in Scenario 3

4.2.4 Scenario 4 – Horsburgh Drive Conveyance Upgrade

Scenario 4 is an expansion on the baseline scenario and evaluates localized infrastructure upgrades along Horsburgh Drive. The existing 375mm pipe and 300mm culvert along Horsburgh Drive were replaced with 900mm diameter pipes to capture upstream flows and divert the watercourse beneath Horsburgh Drive. The existing 900mm sewer pipe that conveys flow from north of Main Street to the culvert beneath Commercial Street was also

replaced with a 1200mm pipe in the model. A schematic representation of the model is shown in Figure 4-9. This option did not lead to significant improvements in conveyance or flooding conditions, would pose significant constructability challenges, and would have high capital costs; therefore, it was not pursued further.

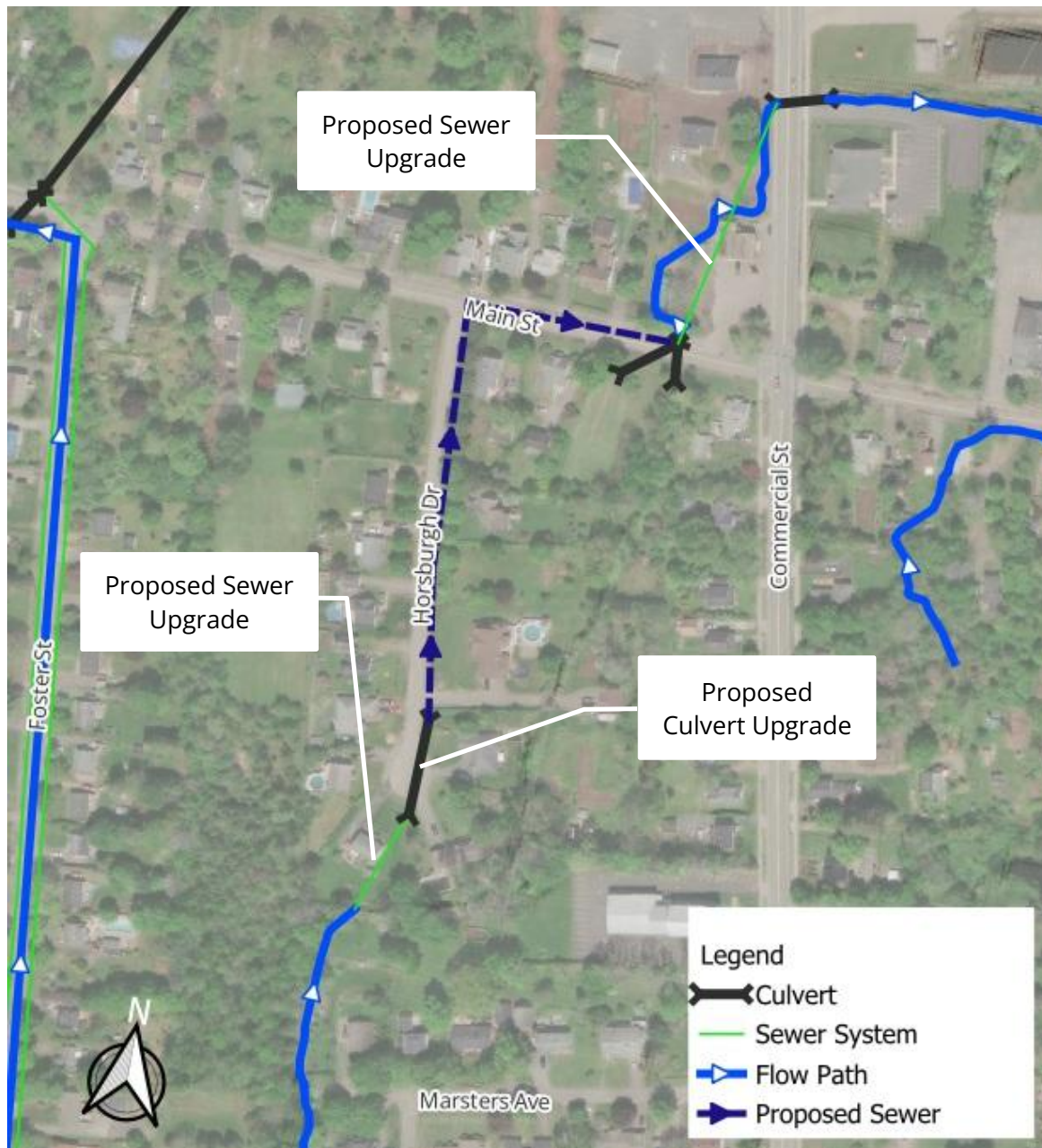


Figure 4-9: Schematic Representation of the Model Used in Scenario 4

4.2.5 Scenario 5 – Channel Diversion to Main Street

Scenario 5 is an expansion of the baseline mitigation scenario, wherein some outflow from the Centennial Park detention area and runoff from Horsburgh Drive is redirected away from the existing channel east of the road and into a new proposed channel. This was done to address the limitations inherent to the baseline mitigation scenario, which were the storage volume in the detention area being limited by space constraints, and the conveyance capacity of the existing ditch. The limited storage volume necessitates a certain outflow rate, and the capacity of the existing ditch is not sufficient to convey it, and the ditch could not be expanded due to space constraints on either bank following the 90-degree bend at the south end of Horsburgh Drive.

The proposed channel is located to avoid the same space constraints as the existing ditch, allowing it to be wider and have sufficient conveyance capacity. It has a 2m bottom width, 1m depth, and is completed with 3:1 side slopes. The proposed channel alignment runs through the backyard of 259 Main Street – an easement would be required for this channel – north along the western property lines of the residential dwellings until 3 Horsburgh Drive.

The proposed channel terminates before it reaches Main Street. Here, it then drains into a ditch-inlet or birdcage catch basin with a 1200mm pipe. The catch basin layout allows additional head to build up in the outlet pipe, increasing flow relative to a system with an at-grade headwall inlet. The 1200mm pipe crosses underneath Main Street before connecting to a 1800mm diameter manhole whereafter the second run of pipe then discharges straight to a proposed outfall in the Cornwallis River.

The resulting modelled flood extents for scenario 5, compared to existing conditions, are shown below in Figure 4-10.

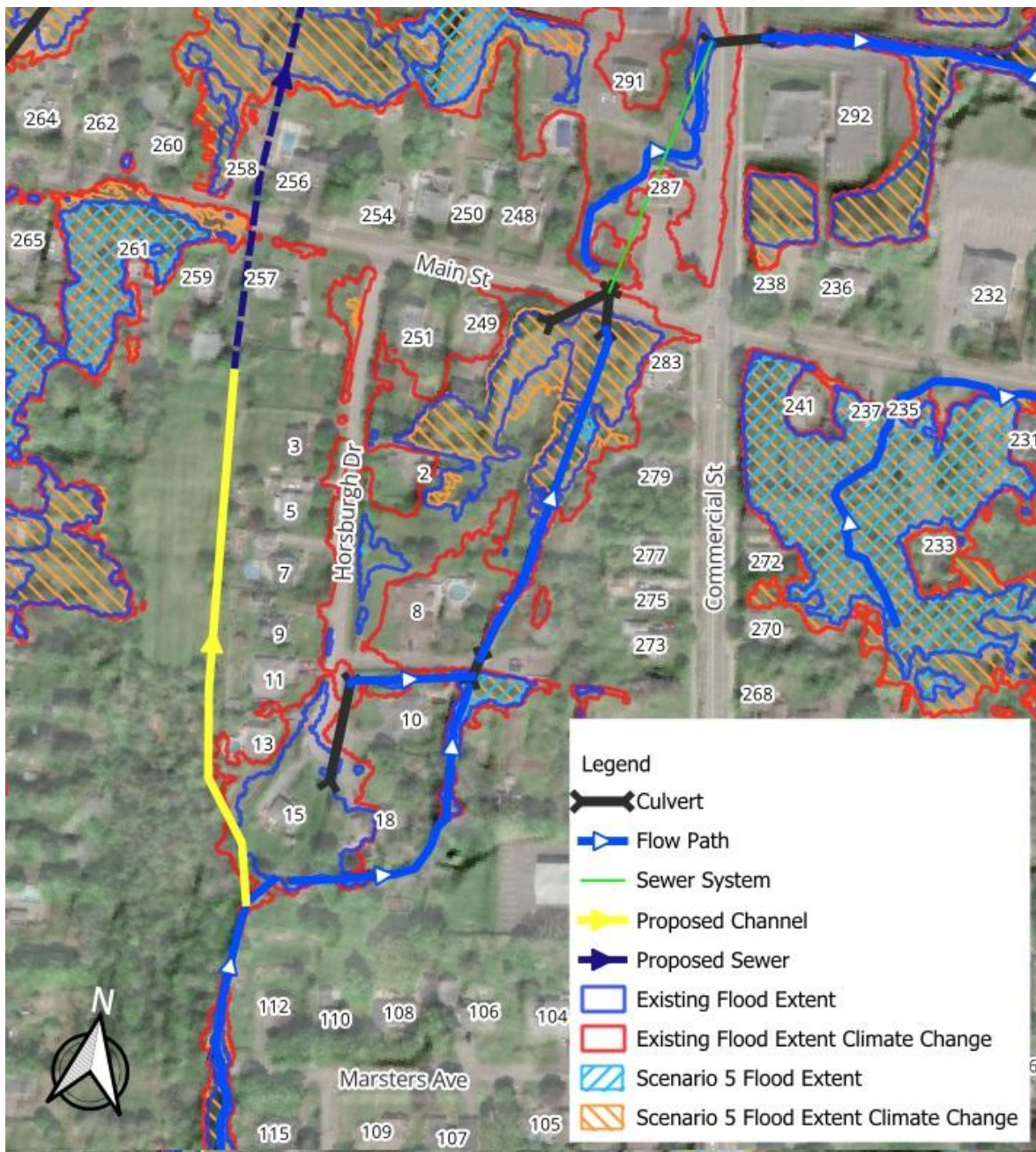


Figure 4-10: Flood Extents for Scenario 5 compared to Existing Flood Extents for Horsburgh Drive

As shown by the flood extents mapping, the proposed channel diversion eliminates flooding on the south end of Horsburgh Drive and drastically reduces the flood extents on the north end of the channel and areas further downstream. However, the driveway culvert located at 8 Horsburgh Drive still acts as a bottleneck for the existing ditch, indicated by the minimal reduction in flood extents immediately upstream of it.

These upgrades were able to be implemented into the existing terrain. Considerations to ground cover were crucial for the pipe crossing underneath Main Street. The first run of pipe requires a steeper slope in order to have sufficient ground cover. Following its crossing, it connects to a proposed manhole and outlets through a second run of pipe at a shallower grade, allowing it to tie into the proposed outfall at existing grade. A sketch of the mitigation design is shown below in Figure 4-11.



Figure 4-11: Sketch of the Channel Diversion

4.2.6 Scenario 6 – Channel Diversion with Detention

Scenario 6 has a similar proposed channel diversion and existing channel formalization to that presented in scenario 5. Like scenario 5, some flow is redirected away from the existing ditch east of Horsburgh Drive. Instead of discharging from the channel directly into an outlet pipe however, the channel ends further upstream just beyond the backyard of 9 Horsburgh Drive and discharges into a secondary stormwater detention area located in the

backyard of 259 Main Street. A storage area was added to the model to represent this, with approximately 1,500m³ of storage. Stored water drains out of the detention area through a birdcage catch basin with a 1200mm outlet pipe to a proposed outfall adjacent to the Cornwallis River. The flood extents under scenario 6 are shown and compared to the existing flood extents below in Figure 4-12.

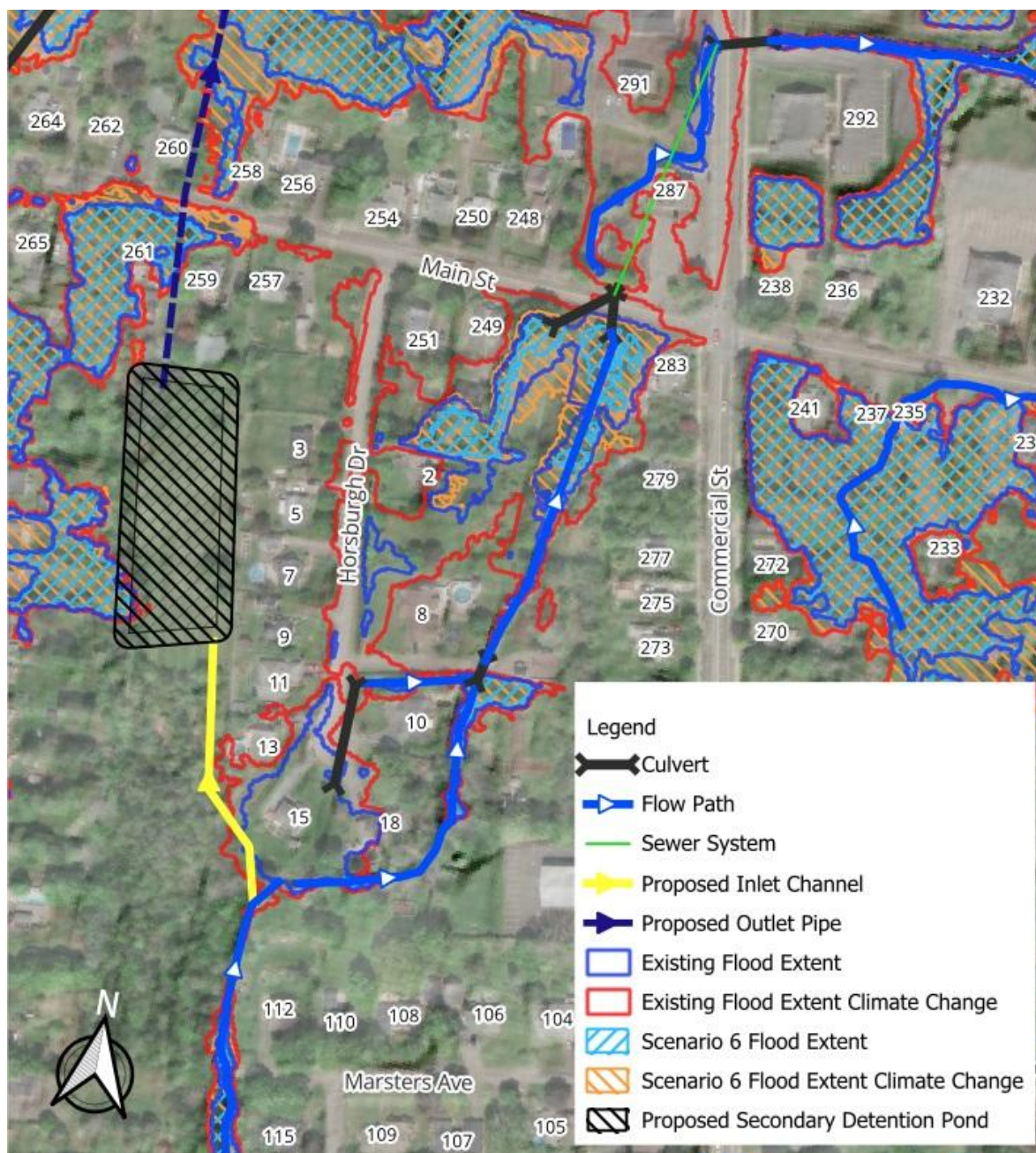


Figure 4-12: Flood Extents About Horsburgh Drive for Existing and Scenario 6 Conditions

As shown above, modelling indicates that this secondary detention area would achieve flood extent reduction similar to that achieved under scenario 5, most notably on the south and east sides of Horsburgh Drive, the west side of Commercial Street north of Main Street, and the north side of Main Street west of Commercial Street.

Due to the good flood extent reduction, implementation of this mitigation strategy was investigated. Figure 4-13 shows a sketch of the proposed channel, stormwater detention area, and outlet system configuration.



Figure 4-13: Proposed Grading Extents of Secondary Detention Area

Also similar to scenario 5, ground cover for the outlet pipe under Main Street would be limited and require special consideration. The two options for addressing this are the same as scenario 5; either install the first pipe run with a higher slope to give it sufficient cover under the existing road profile or raise Main Street around this area.

Like the Centennial Park detention area, a small low-flow channel would also be included to ensure that the green space remains dry and usable shortly following the frequent minor events.

4.2.7 Public Works Building

Works independent of the mitigation options presented above would be required to protect the Public Works building from flooding. As previously discussed, the flooding of the Town's Public Works building is due to the high-water levels (HWLs) in the Cornwallis River and not due to deficient stormwater infrastructure. Therefore, there are only two approaches to protecting the building from future damages: either protect against the HWL or relocate the building to a new property outside of the floodplain.

Protection against the HWL could be achieved either by installing a berm around the property or raising the building and the surrounding ground. The HWL during the design event (1:100-year climate change storm with 1:5-year Cornwallis River water levels) as identified in the 2021 Berwick Hydraulic Study by others is 26.2m. To achieve 300mm of freeboard during this event, either the building and surrounding areas must be raised to, or a berm must be constructed to, an elevation of 26.5m.

4.2.7.1 Berming

For stormwater to be effectively managed with berming, the runoff from within the bermed area must be considered in the design. If a berm is constructed around the site, the protected areas will become the local low point relative to the surrounding inundated areas, preventing gravity drainage. Therefore, the resulting runoff must either be stored or pumped out of the bermed area.

According to modelling, approximately 700m³ of runoff would be generated within the bermed area during the design storm. Given the space and elevation constraints present in the public works site, the maximum storage that can be achieved either with underground or surface storage solutions with gravity drainage is not sufficient. Underground storage would be installed beneath the parking area, and surface storage would be achieved by depressing the parking area.

The required storage volume can be reduced with the implementation of a stormwater pumping system. A higher pumping rate reduces the required storage, although a higher-capacity pump will have higher capital costs both with the pump itself and the required appurtenances. A 10L/s pump would reduce the required storage to approximately 220m³. This could be achieved either with surface or underground storage. A sketch depicting this design solution is shown below in Figure 4-14. Note that this figure shows the bottom of the surface storage area as having a uniform elevation; under detailed design, it would have to be graded to drain towards catch basins located in local low points.

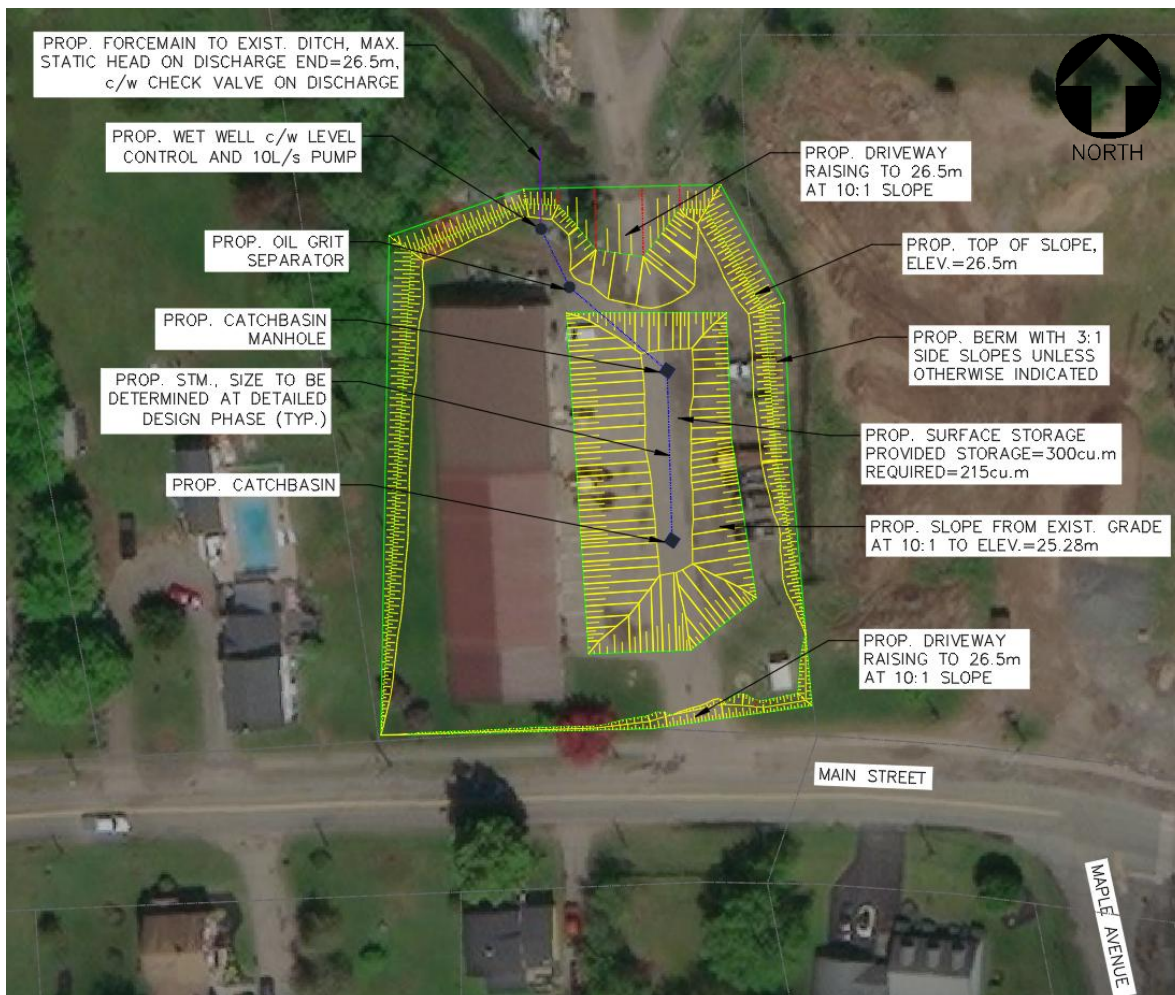


Figure 4-14: Sketch of Bermed Public Works Site with Surface Storage and Pumping

An alternative to surface storage in the parking lot would be underground storage, which becomes feasible due to the lowered storage requirements with pumping. This would prevent the parking area from becoming inundated and increase safety and allow access to the building during intense storm events but would also carry increased capital costs due to increased excavation and the use of specialized stormwater management products. The underground storage system would require similar excavation extents to that of the surface storage, but deeper to achieve the required ground cover. A sketch showing a possible layout for this design solution is shown below in Figure 4-15.

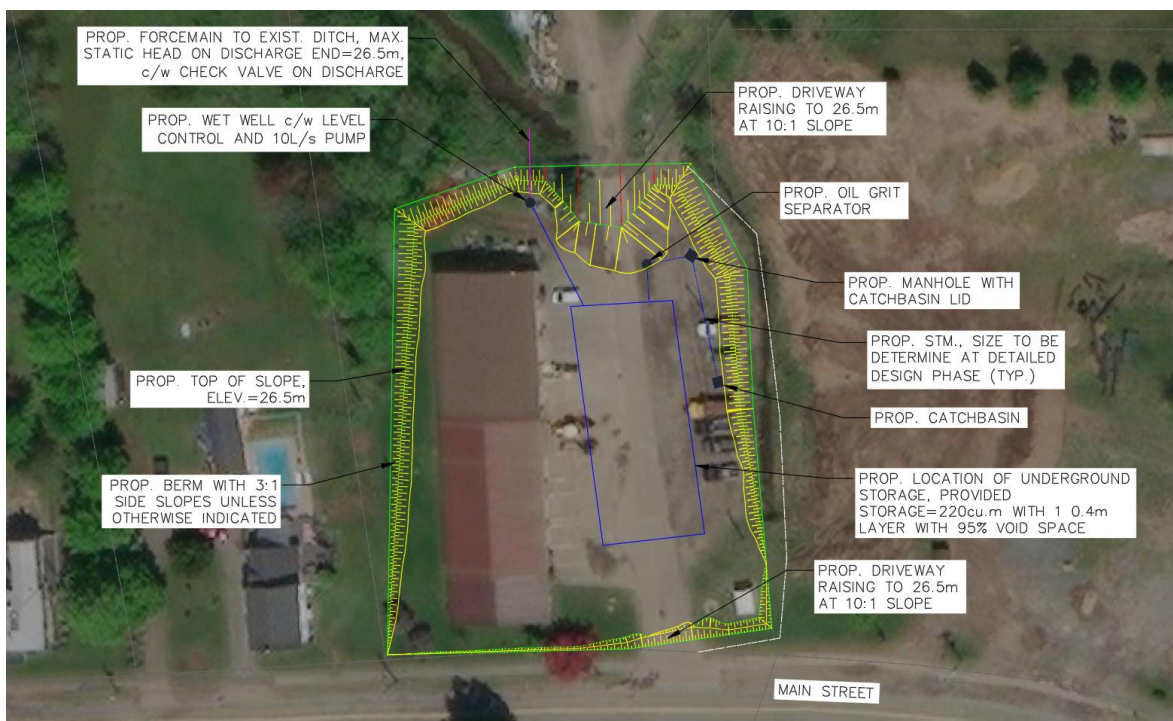


Figure 4-15: Sketch of Bermed Public Works Site with Underground Storage and Pumping

Sediment control must be considered as much of the site is comprised of gravel parking areas. Both sketches include an oil-grit-separator (OGS) to remove sediment and any oils from the stormwater before discharging it through the pump to the receiving channel. Under existing conditions no sediment control is being used at the public works site; this would improve the quality of discharged stormwater and help decrease maintenance requirements for the pumps.

4.2.7.2 Site Raising

Building-raising has been successfully implemented in the Town before as seen with the Volunteer Fire Department building, which was previously located within the floodplain. the ground elevation of the Public Works building and surrounding areas must be raised to 26.5m. The existing grade ranges in elevation from approximately 25.5 to 26.7m.

The concept design uses a 3:1 side slope to tie into the existing ground at non-driveway locations while using 10:1 slopes to tie into the existing roadways (i.e., Main Street and the access road leading to the wastewater treatment plant). The anticipated extents of grading are shown in Figure 4-16.



Figure 4-16: Extents of Proposed Grading to Raise Public Works Area

Based on these grading limits and the existing topography, approximately 1,600m³ of fill would be required to complete this work. Note that this does not account for the additional fill required to achieve positive drainage away from the public works area, and it instead assumes a uniform elevation of 26.5m for the entire raised area.

4.2.8 Lifecycle Renewal Opportunities

In addition to the large capital projects presented above, culvert upsizing as part of lifecycle renewal programs provides opportunities to reduce flood risk as future climate changes intensifies rainfall patterns. Beyond general lifecycle renewal, there are three specific locations identified where culvert upgrades during lifecycle renewals were investigated, due to existing flood impacts on dwellings and road access.

4.2.8.1 Gravenstein Drive at Spartan Avenue

Upsizing the existing 300mm culvert located at Gravenstein Drive at Spartan Avenue reduces the upstream ponding. The existing culvert was upgraded to a triple-barrel 600mm culvert in the model. Figure 4-17 shows the resulting reductions in flood risk extents. Note that site constraints may affect sizing, and the preliminary design should address conveyance downstream through the private property and across Orchard Street as part of

the upgrade package, as the increased flow through the culvert may have negative downstream impacts.

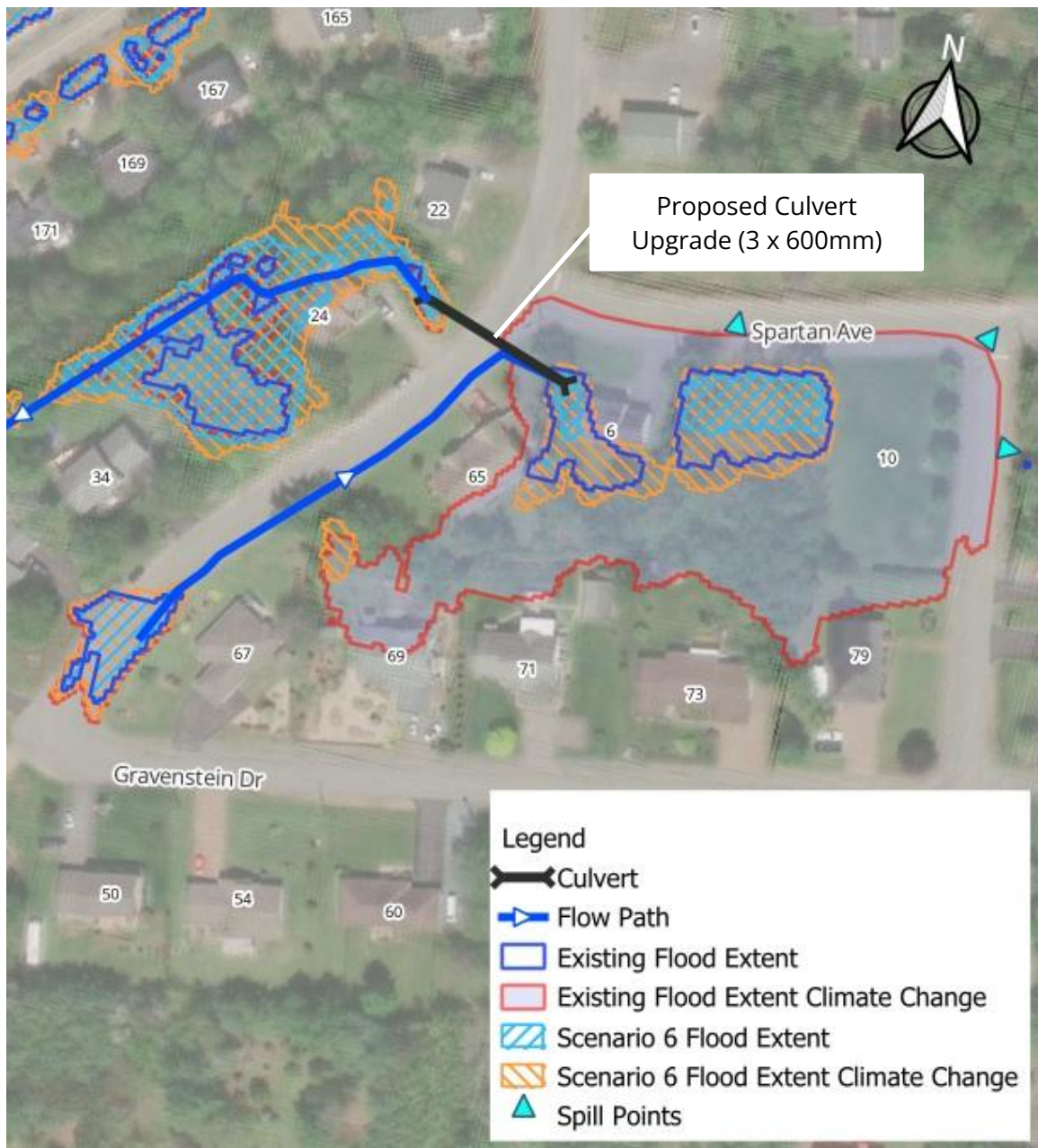


Figure 4-17: Gravenstein Drive at Spartan Avenue Culvert Upgrade Flood Extent Mapping

Flood extent mapping indicates that upsizing the Gravenstein Drive at Spartan Avenue culvert will reduce the flooding extents within the block bounded by these two streets. The greatest impacts are seen between the two climate change events, where most of the block goes from being fully inundated to having most of the flooding contained to just one

property. Under existing climate conditions, the flooding experienced by 6 Spartan Avenue and 65 Gravenstein Drive is also reduced by the upgrade.

4.2.8.2 Brown Street at Front Street

The culvert and storm minor system around Brown Street at Front Street provides drainage for lands around Pleasant Street and Lions Gate, and upgrades to reduce the flood risk in these areas were investigated in the model. The two culverts between 164 and 166 Brown Street, originally 250mm and 300mm in diameter were replaced with two 600mm culverts in the model. Further downstream, the existing triple-barrel 250mm diameter culvert beneath Brown Street and its immediate downstream 250mm culvert were replaced with triple-barrel 600mm diameter culvert system in the model to determine potential reductions in flood risk. Preliminary design should take into account site constraints and ensure proper conveyance channels upstream and downstream to a sufficient outlet. Figure 4-18 below shows the flood extent reduction associated with these upgrades.

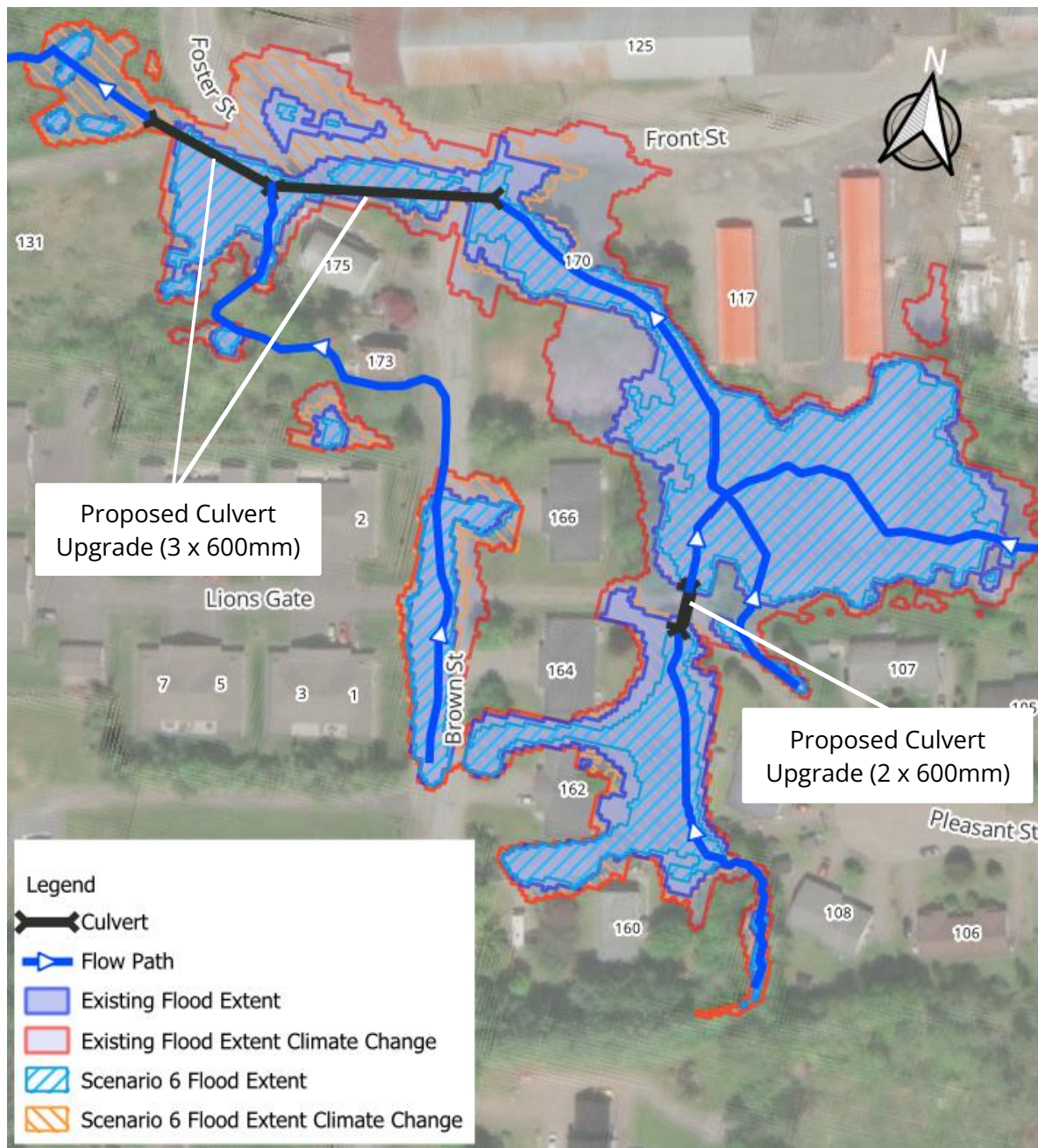


Figure 4-18: Brown Street at Front Street Culvert Upgrades Flood Extents

Model results indicate that these culvert upgrades improves conveyance in all events, although due to the local topography there is a greater impact on flood extents when the events previously overtopped the top of bank of the depressed channel area, which provides some relief to flooded residential properties. Assessments should be undertaken during culvert upgrades to ensure there is no conveyance restrictions in the downstream channel.

4.2.8.3 Lawrence Avenue and Main Street at Cottage Street

Culvert upgrades around Main Street at Cottage Street, and the terminus of Lawrence Avenue were implemented into the PCSWMM model to quantify their potential impact. At 134 Lawrence Avenue, the property's 250mm driveway culvert upsized to 600mm. Further downstream, the 375mm driveway culvert at 157 Main Street was replaced with a double-barrel 600mm culvert while the 450mm culvert crossing under Main Street was replaced with a triple-barrel 900mm culvert. Modelled flood extents before and after the upgrades are shown in Figure 4-19.

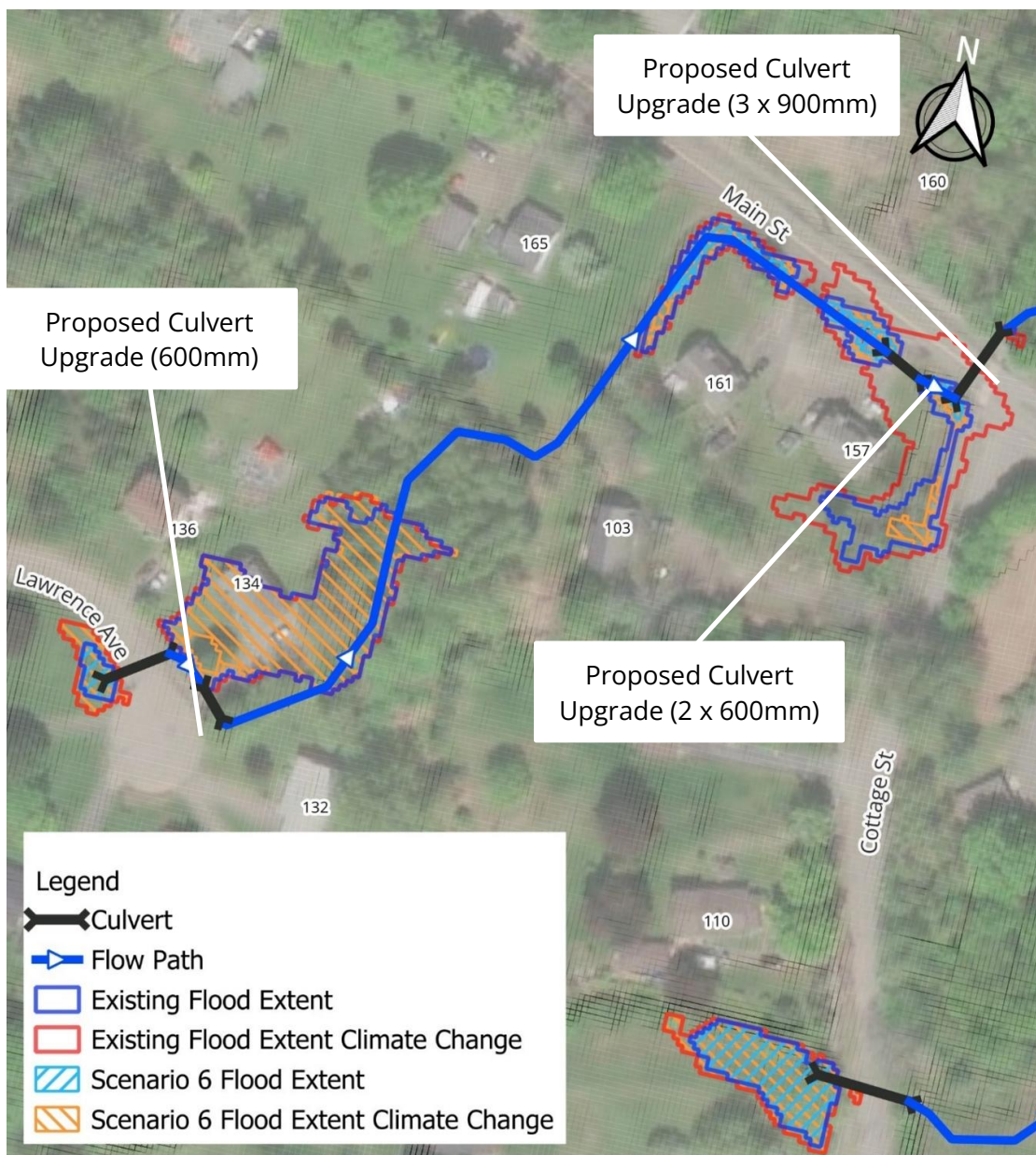


Figure 4-19: Main Street and Lawrence Avenue Culvert Upgrades Flood Extents

Modelling results indicate that upsizing the culverts in the Main Street and Lawrence Avenue area will mostly provide flood extent reduction around the intersection of Main Street and Cottage Street for both existing climate and climate change conditions. Flooding about 134 Lawrence Avenue is eliminated under existing climate conditions, however under climate change conditions the channel is overtopped. Once flow leaves the channel, the depth of overland flow is relatively uniform. Preventing this would require impractically large culverts; channel capacity upgrades should be investigated to accommodate the increased flow through the 600mm culvert.

5 Recommendations

5.1 Infrastructure Upgrades

5.1.1 Baseline Mitigation

Modelling results indicate that the baseline mitigation scenario would result in lower flood elevations during the design event. This scenario is comprised of two components: the lowering of Centennial Park to allow it to act as a stormwater detention area and upsizing the triple-barrel 600mm concrete culverts under Main at Foster Street as well as the existing outlet pipe downstream of them, and the upstream 600mm HDPE driveway culvert.

The Centennial Park detention area will reduce peak flows into the existing ditch north of the park along Horsburgh Drive and thereby decrease overflows from the channel into private properties during the design event. The culvert upgrades will increase the conveyance capacity to this important outfall location and decrease the amount of water overtopping Main Street from south to north.

5.1.2 Additional Mitigation

The infrastructure upgrades associated with the baseline scenario will provide some resilience to increasingly severe storm events. This can be further increased with the implementation of either mitigation scenarios 5 or 6. These options both involve formalization of the ditch downstream of Centennial Park, as well as flow diversion away from the ditch east of Horsburgh Drive, which is heavily constrained due to the existing structures adjacent to the ditch. Modelling indicates that mitigation scenario 5 significantly reduces spilling of stormwater onto the private properties on the east side of Horsburgh Drive but introduces a flood risk to those located at 3 and 5 Horsburgh Drive (previously shown in Figure 4-10), whereas mitigation scenario 6 has the same benefit but does not introduce the same flood risk. It is anticipated that scenario 5 will, however, have lower property acquisition costs.

5.1.3 Public Works Site

Finally, the flooding of the public works building is caused solely by water levels in the Cornwallis River rather than inadequate conveyance. Therefore, the two approaches to this

issue would be either to acquire a new property outside the floodplain for a new public works building, or to protect against the HWLs. The latter could be achieved either by installing a berm around the public works site, along with on-site stormwater management to prevent flooding within the bermed area, or by raising the entire public works site along with the demolition and reconstruction of the existing public works building. CBCL recommends proceeding with a phased approach, where the berm is implemented first as a temporary solution until the public works building requires replacement, and therefore is not demolished prematurely. Note that both options, installing a berm or raising the site, of the public works site will result in a loss of floodplain land; proper permitting will have to be attained with Nova Scotia Environment and Climate Change.

5.1.4 Lifecycle Renewal

Modelling results indicated that the lifecycle renewal opportunities described in Section 4.2.8 had varying impacts. The upgrades around Gravenstein Drive at Spartan Avenue were effective in reducing flooding on the bounded block but should be combined with confirmation of downstream channel conveyance capacity. Around Brown Street at Front Street, road overtopping was reduced by the upsized culverts, but dwelling impacts are not able to be feasibly resolved without significant infrastructure expansion. The Lawrence Avenue and Main Street at Cottage Street upgrades were shown to generally be effective in reducing flooding in both areas. Generally, lifecycle renewal should provide opportunity to ensure minimum culvert sizing of 500mm diameter for driveway culverts and designed roadway crossing culverts with a criterion of a headwater-to-depth ratio of 1 (i.e., the maximum ponding depth at the inlet of the culvert should not exceed the diameter of the culvert).

5.2 General Recommendations

5.2.1 Easements

CBCL recommends the establishment of several easements to support both the installation of recommended stormwater infrastructure and providing access to existing infrastructure for easier maintenance. The locations of the suggested easements were guided by two major considerations: first, to ensure future connectivity of infrastructure that passes through private property where it is necessary for upstream servicing as required by the Town; and secondly, to minimize impact on private residential properties. Generally, minimizing easement impact was achieved by locating them along property lines and following existing overland flow paths, which would give landowners flexibility to develop their lot while still being required to maintain the watercourse route through the parcel.

A map of the recommended easements is shown below in Figure 5-1. The easements are approximately 6m wide for maintenance access; watercourses may extend beyond an easement during high flow events depending on the topography. Note that either

additional easements, or property acquisitions, would have to be established to support mitigation options 5 and 6. The Town should seek legal counsel and a land surveyor for the preparation of easements or acquisition of private property.



Figure 5-1: Recommended Easements

Note that the four proposed easements shown in red would only be required if either mitigation scenario 5 or 6 was to be implemented; they are for the proposed infrastructure associated with these scenarios. Furthermore, in order to implement the secondary detention area described in scenario 6, the Town would have to acquire the rear yard portion of the residential property located at 259 Main Street.

5.2.2 Maintenance

During site visits and surveying, CBCL personnel identified several flow paths that were impeded by excessive sediment deposits, accumulation of dead vegetation, and/or vegetation growth. Figure 5-2 shows a portion of the ditch along Horsburgh Drive blocked by leaves and sticks. Another significant blockage is shown in Figure 5-3, in the culvert under Commercial Street. Here, both sediment and organic matter buildup appeared to be significantly reducing the conveyance capacity of the culvert.



Figure 5-2: Example of Ditch Blockage in Horsburgh Drive Ditch



Figure 5-3: Example of Blocked Infrastructure on Commercial Street due to Sediment and Organic Matter Buildup

Although blockages may appear to be localized, the reduction in conveyance capacity causes an increase in water level in all areas upstream of the blockage. CBCL recommends that the Town take proactive, scheduled maintenance measures to ensure that ditches, channels, and culverts remain unblocked and free flowing. This will ensure that the stormwater infrastructure that is in place is working to its maximum potential and is not causing additional upstream issues.

Another example of this was observed during the validation of the model. According to information received from the Town, the area adjacent to the new development at 226 Main Street (now cancelled) experiences flooding during large storm events. This was not captured in the model; analysis of the local topography suggested that a culvert would be located in this area to allow it to drain. This culvert could not be found during site visits, indicating that flooding in the area is likely due to inadequate maintenance.

5.2.3 Regulation & Design Specifications

The Town presently relies upon broad stormwater management objectives, as well as reference to provincial guidelines, to guide development as outlined in the Town of Berwick Municipal Services Specifications Manual. While this establishes broad intent, updating the specifications to include simple municipality-specific design criteria regarding stormwater quantity and quality control would be beneficial.

Firstly, specific design requirements help translate the broad goals into measurable and enforceable criteria that can be objectively evaluated, both by the Design and Town Engineers. This would lead to consistent interpretation by all parties and reduces the chance for conflicting views regarding design requirements and acceptability. That being considered, CBCL recommends the following requirements be implemented into the Town's current storm drainage system specifications, at a minimum:

- ▶ Quantity control:
 - Flow control such that post-development peak flows do not exceed those under pre-development conditions for the 1- to 100-year design storms.
 - Volume control such that on-site retention or infiltration captures the first 15mm of runoff.
 - Overland flow routes must be identified to safely convey the 1:100-year design storm.
- ▶ Quality control:
 - 80% total suspended solids removal using approved best-management practices, such as stormwater management ponds or low-impact developments (LIDs).
 - Require use of pre-treatment (e.g., oil-grit separators) for commercial and industrial land uses and other high-traffic areas.
- ▶ Operation and maintenance plan submission for stormwater management facilities.

These measures may induce higher costs for developers intending to build in the Town. however, like preventative maintenance for existing infrastructure, higher standards for new infrastructure may will provide long-term benefits with inherent resiliency to growth and climate change and will reduce the need for reactive retrofits and upgrades to existing infrastructure.

Should the Town decide to pursue this route, under a separate project CBCL could act as the Town's engineer to help with municipality-specific stormwater management design guidelines that fit the needs of the community.

5.2.4 Development Restrictions

The Province undertook Municipal Flood Line Mapping of the Cornwallis River in 2023 which delineated the Floodway and Floodway Fringe for the river corridor through the Town of Berwick. The Floodway and Flood Fringe are defined as the 1:20- and 1:100-year river-induced flood extents, respectively.

This Stormwater Management Plan has also allowed delineation of areas of "Flood Risk" throughout the Town due to rainfall-induced overland flow. The Flood Risk areas are not defined by provincial legislation but inform development direction within the Town. The delineations under current climate and climate change conditions are shown below in Figure 5-4 and Figure 5-5, respectively. Full-size plots of both drawings are available in Appendix B.

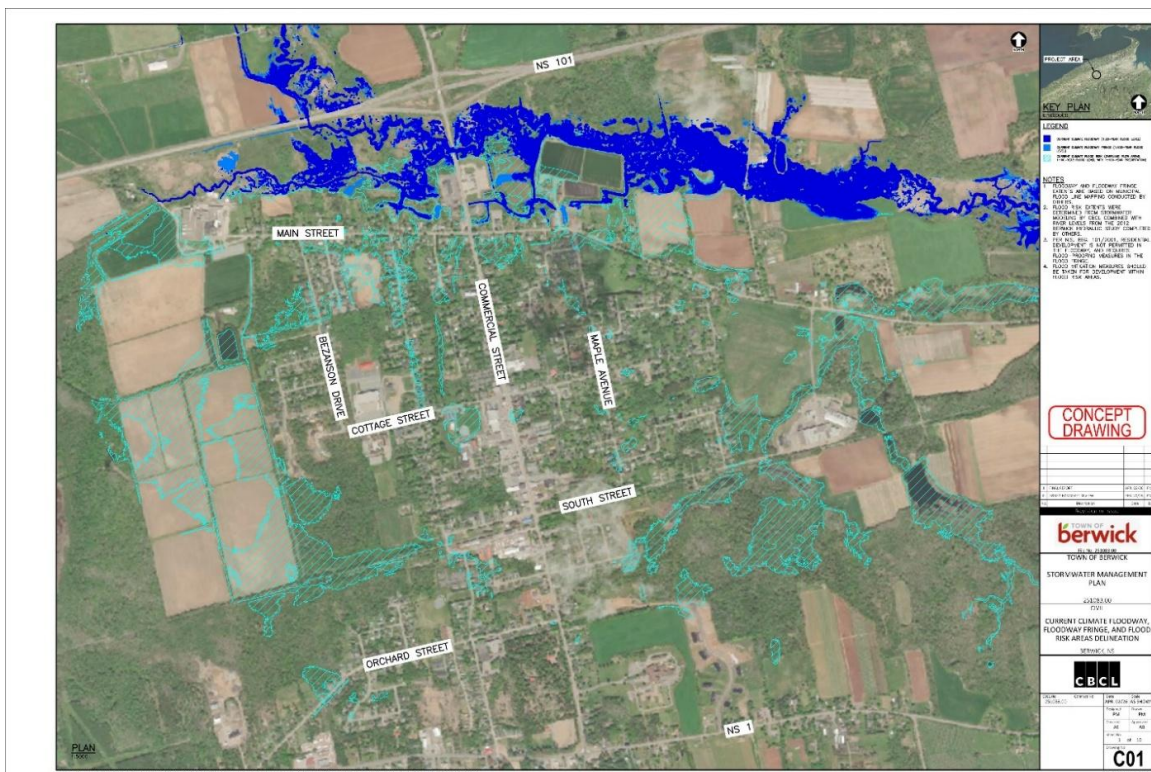


Figure 5-4: Floodway, Floodway Fringe, and Flood Risk Area Mapping, Current Climate

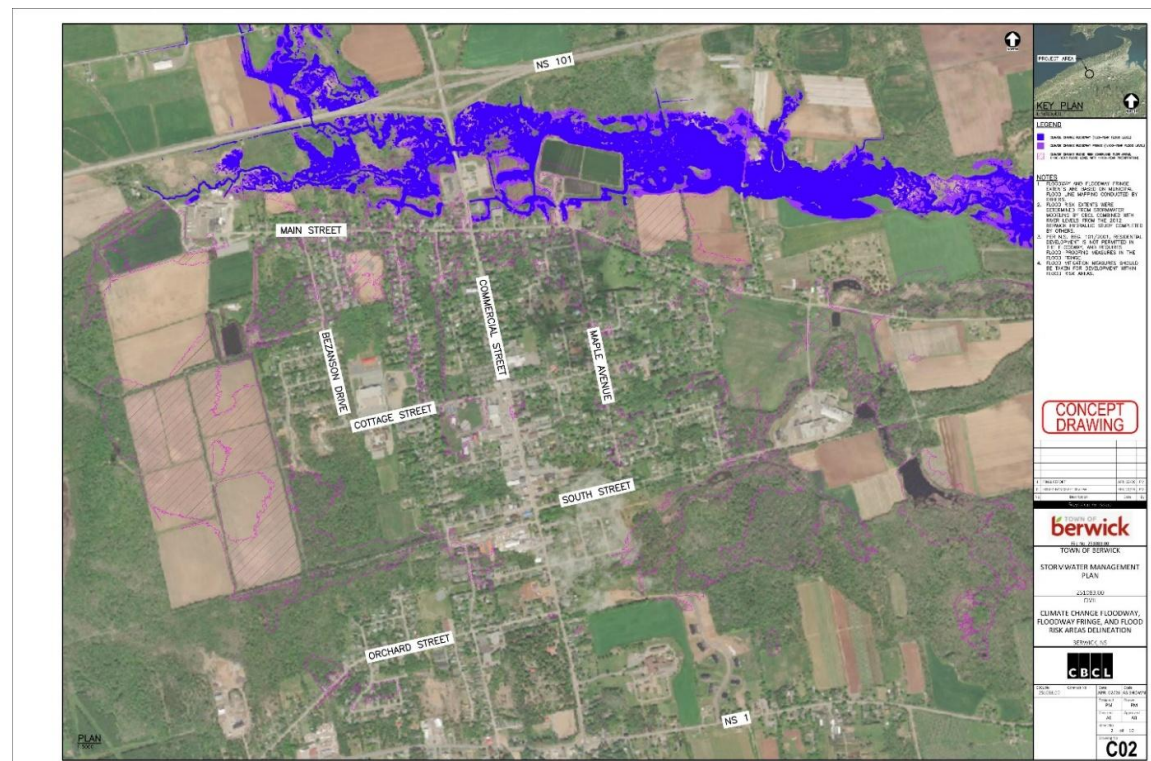


Figure 5-5: Floodway, Floodway Fringe, and Flood Risk Area Mapping, Climate Change

Under the Nova Scotia Statement of Provincial Interest Regarding Flood Risk Areas, the only development that can take place within the Floodway is restricted to uses such as roads, open space uses, utility and service corridors, parking lots and temporary uses. The placement of fill, which would remove storage capacity from the Floodway, is prohibited.

Flood-proofed development can be undertaken within the Floodway Fringe, with exceptions. Residential institutions such as hospitals, senior citizen homes, homes for special care and similar facilities where flooding could pose a significant threat to the safety of residents if evacuation became necessary cannot be within the Floodway Fringe. Any storage of hazardous materials is also prohibited in the Floodway Fringe and placement of fill is limited to that required for flood proofing or flood risk management.

The flood risk areas are those areas where overland flow in the 1:100-year event could pose a flood risk and while development should not be restricted as a result of the mapped flood risk, the risk should be mitigated as part of the development. The flood risk areas can also be used by the Town of Berwick to integrate capacity improvements as part of lifecycle renewals in those areas.

It should be noted that the flood risk areas are delineated between Main Street and the Cornwallis River based on the more conservative flood levels resulting from the bridge study in 2021 rather than the Municipal Flood Line Mapping.

6 Costing

CBCL prepared a high-level cost estimate for each mitigation strategy to enable comparison between each strategy, not to set actual construction project budgets – this would require detailed design to confirm the exact sizing of proposed infrastructure and its routing, construction methods, property impacts, and other issues. The estimates presented below are considered Class D Cost (Planning) Estimates for a moderately complex project. If the mitigation options are developed and refined further, the cost estimate will also become more accurate.

The mitigation costs presented below were developed based on measured units with estimated unit rates combined with allowances. Quantities were calculated by implementing the mitigation options into Civil3D, enabling pipe lengths, earthworks volumes, and reinstatement areas to be determined. The estimates contain contingencies for design development, construction, and engineering, described below:

- ▶ Engineering contingency estimates design services that may be required in the design and construction phase of the project, possibly including engineering services, geotechnical investigation, surveying, and approvals; a value of 12% was used for the estimates.
- ▶ Design development allowance accounts for items that have not been investigated or known to be part of the project at this stage; a value of 35% was used for the estimates.
- ▶ Construction contingency accounts for unforeseen items that may come up during construction due to inevitable uncertainty during the design phase; a value of 10% was used for the estimates.

Note that items such as land purchases, legal services, staff time, and complex environmental assessment are not included in the estimates. A summary of the overall costing for each mitigation option is presented below. A complete item-by-item breakdown of each option's cost is available in Appendix C. A condensed, categorized cost estimate is also provided in Table 6-1. Since both portions of the baseline mitigation strategy can be completed independently, a separate cost has been provided for each of them. The costs for scenarios 5 and 6 are also presented separately as these options are mutually exclusive.

For phase 2 of the public works mitigation, the demolition of the existing building and the construction of the new one is included under removals and proposed infrastructure, respectively. Note that the required property acquisition costs for both channel upgrade and diversion options are not included in these estimates.

Table 6-1: Major Projects Costing Summary

Item	Scenario 1 (Baseline Mitigation)		Channel Upgrades & Diversion		Public Works Mitigation		
	Centennial Park Detention	Main at Foster St Culvert Upgrades	Scenario 5 (No Additional Detention)	Scenario 6 (Additional Detention)	Ph. 1 Option A	Ph. 1 Option B	Ph. 2
Removals	\$ 0	\$ 19,711	\$ 0	\$ 0	\$ 0	\$ 0	\$ 392,951
Earthworks	\$ 247,135	\$ 7,475	\$ 338,600	\$ 443,146	\$ 52,992	\$ 54,556	\$ 73,600
Proposed Infrastructure	\$ 150,953	\$ 495,628	\$ 407,000	\$ 387,700	\$ 299,000	\$ 703,800	\$ 3,210,951
Roadworks & Reinstatements	\$ 379,478	\$ 21,656	\$ 97,929	\$ 258,518	\$ 157,516	\$ 133,630	\$ 163,132
Provisional	\$ 0	\$ 0	\$ 0	\$ 0	\$ 15,000	\$ 50,000	\$ 0
<i>Design Development Allowance (35%)</i>	<i>\$ 272,148</i>	<i>\$ 190,565</i>	<i>\$ 295,235</i>	<i>\$ 381,277</i>	<i>\$ 183,578</i>	<i>\$ 329,695</i>	<i>\$ 1,344,222</i>
<i>Construction Contingency (10%)</i>	<i>\$ 105,000</i>	<i>\$ 73,600</i>	<i>\$ 113,900</i>	<i>\$ 147,100</i>	<i>\$ 70,900</i>	<i>\$ 127,200</i>	<i>\$ 518,500</i>
<i>Engineering & Design Fees (12%)</i>	<i>\$ 138,600</i>	<i>\$ 97,160</i>	<i>\$ 150,350</i>	<i>\$ 194,180</i>	<i>\$ 93,590</i>	<i>\$ 167,910</i>	<i>\$ 684,420</i>
TOTAL	\$ 1,293,600	\$ 906,800	\$ 1,403,300	\$ 1,812,300	\$ 873,500	\$ 1,567,200	\$ 6,388,000

All phases of the public works mitigation also include borrowed fill. Should any of the phases be completed concurrently with the Centennial Park detention area works, excavated cut from the park could be used as fill for the berms or site raising as a cost-saving measure.

Class D cost estimates were also prepared for each of the culvert upgrades discussed in Section 4.2.8. Considering their low complexity, the cost for each of these is presented in Table 6-2 as a lump sum, including removal and disposal of existing infrastructure, supply and installation of new infrastructure, and reinstatement. The design development allowance, construction contingency, and engineering and design services are also lower relative to the capital projects to reflect this. Refer to Section 4.2.8 for figures depicting the locations of each of the upgrades.

Table 6-2: Lifecycle Renewal Projects Costing Summary

Location	Existing Infrastructure	Proposed Upgrade	Cost
Gravenstein Drive at Spartan Avenue	300mm culvert	Triple-barrel 600mm culvert	\$ 107,000
Brown Street at Front Street	Double-barrel 250 and 300mm culverts; 250mm culverts	Double-barrel 600mm culvert; triple-barrel 600mm culverts	\$ 275,000
Main Street and Lawrence Avenue	250mm culvert; 375mm culvert; 450mm culvert	600mm culvert; double-barrel 600mm culvert; triple-barrel 900mm culvert	\$ 93,000
			\$
<i>Design Development Allowance (30%)</i>			\$ 142,500
<i>Construction Contingency (5%)</i>			\$ 30,900
<i>Engineering and Design Services (8%)</i>			\$ 51,920
TOTAL			\$ 700,900

7 Overall Stormwater Management Plan

To tie-together all aspects of the project, including the flood extents under existing and proposed conditions, existing and proposed infrastructure, proposed easements, and overall costing, Figure 7-1 and Figure 7-2 show these aspects combined, under the existing climate conditions. These are screenshots of full-size layout drawings; please refer to Appendix B for full-size versions and versions showing the flood extents of other design storms under existing climate and climate change conditions.

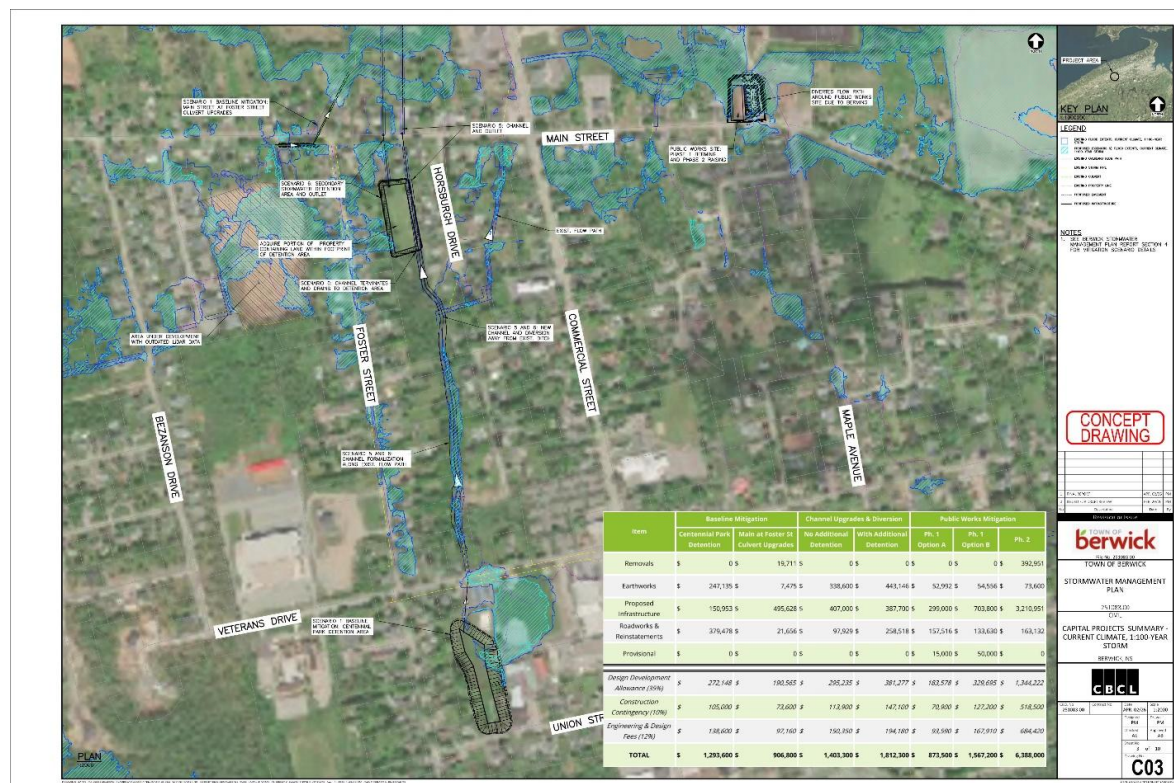


Figure 7-1: Major Projects Overview, Current Climate, 1:100-Year Storm



Figure 7-2: Lifecycle Renewal Projects Overview, Current Climate, 1:100-Year Storm

8 Closing

This study identifies pieces of stormwater infrastructure within the Town that lack capacity to convey stormwater generated during a 1: 5-year rainfall event with 1:100-year Cornwallis River water levels as well as 1:100-year rainfall event with 1:5-year Cornwallis River water levels, under both existing climate and climate change conditions. Modelling shows that the Town's major stormwater system is vulnerable to increased precipitation caused by climate change, highlighting the need for infrastructure upgrades in key areas, improvements to ongoing maintenance practices for critical pieces of infrastructure, and implementation of robust and comprehensive stormwater management design guidelines.

It is important to note that the findings of this study are preliminary and based on several assumptions and uncertainties. More representative model results would require additional precise input data, including culverts, ditches, and ponds' locations, sizes, materials, inlet and outlet invert elevations, which were not available for some locations in this study. Addressing these data gaps is necessary for developing more reliable and more detailed recommendations for stormwater management in Town of Berwick.



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9 References

- Cannon, A.J., Sobie, S.R., and Murdock, T.Q. (2015). Precipitation by Quantile Mapping: How Well Do Methods Preserve Changes in Quantiles and Extremes? *Journal of Climate*, 28:17, 6938-6959.
- Cannon, A.J., Jeong, D.II, Zhang, X., & Zwiers, F.W. (2020). Climate-Resilient Buildings and Core Public Infrastructure: an assessment of the impact of climate change on climatic design data in Canada. <https://climate-scenarios.canada.ca/?page=buildings-report-overview>.
- CSA. (2019). Technical Guide Development, interpretation, and use of intensity-duration-frequency (IDF) information: Guideline for Canadian water resource practitioners. CSA PLUS 4013:19.
- Westra, S., Alexander, L.V., and Zwiers, F.W. (2014). "Global Increasing Trends in Annual Maximum Daily Precipitation," *Journal of Climate* 26:11, 3904–3918.
- Dillon Consulting Limited, (2023). Gaspereau Primary Watershed Flood Line Mapping (Final Report). Prepared for the Town of Kentville.
- WSP Canada Inc. (2021). PS21-18 Berwick Hydraulic Study. Prepared for the Department of Nova Scotia Transportation and Active Transit.

APPENDIX A

Additional Figures

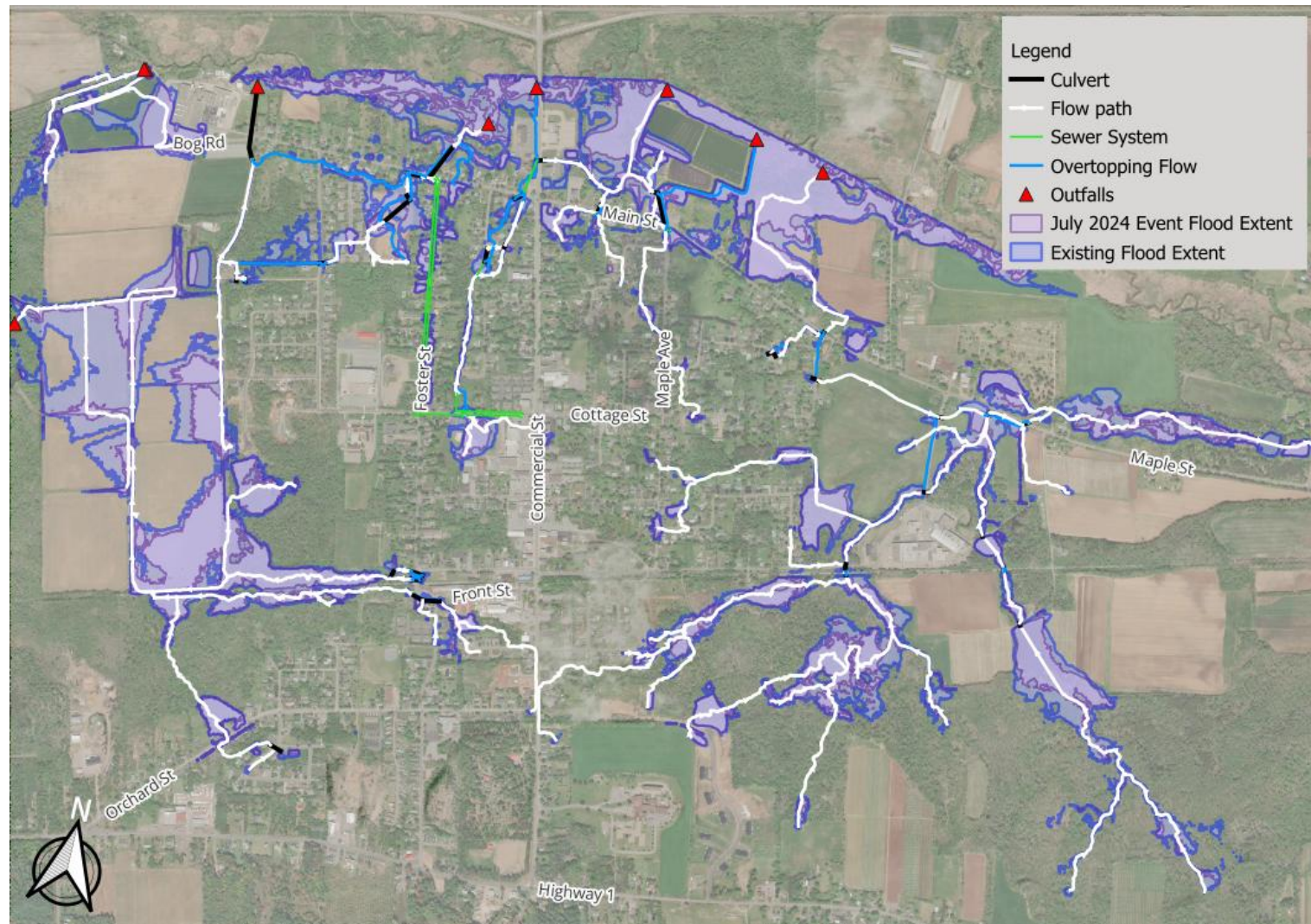


Figure A-1: Comparison Between the Flood Extents Generated from the July 2024 Event vs. the 1:100-year Storm Event under Existing Climate Conditions

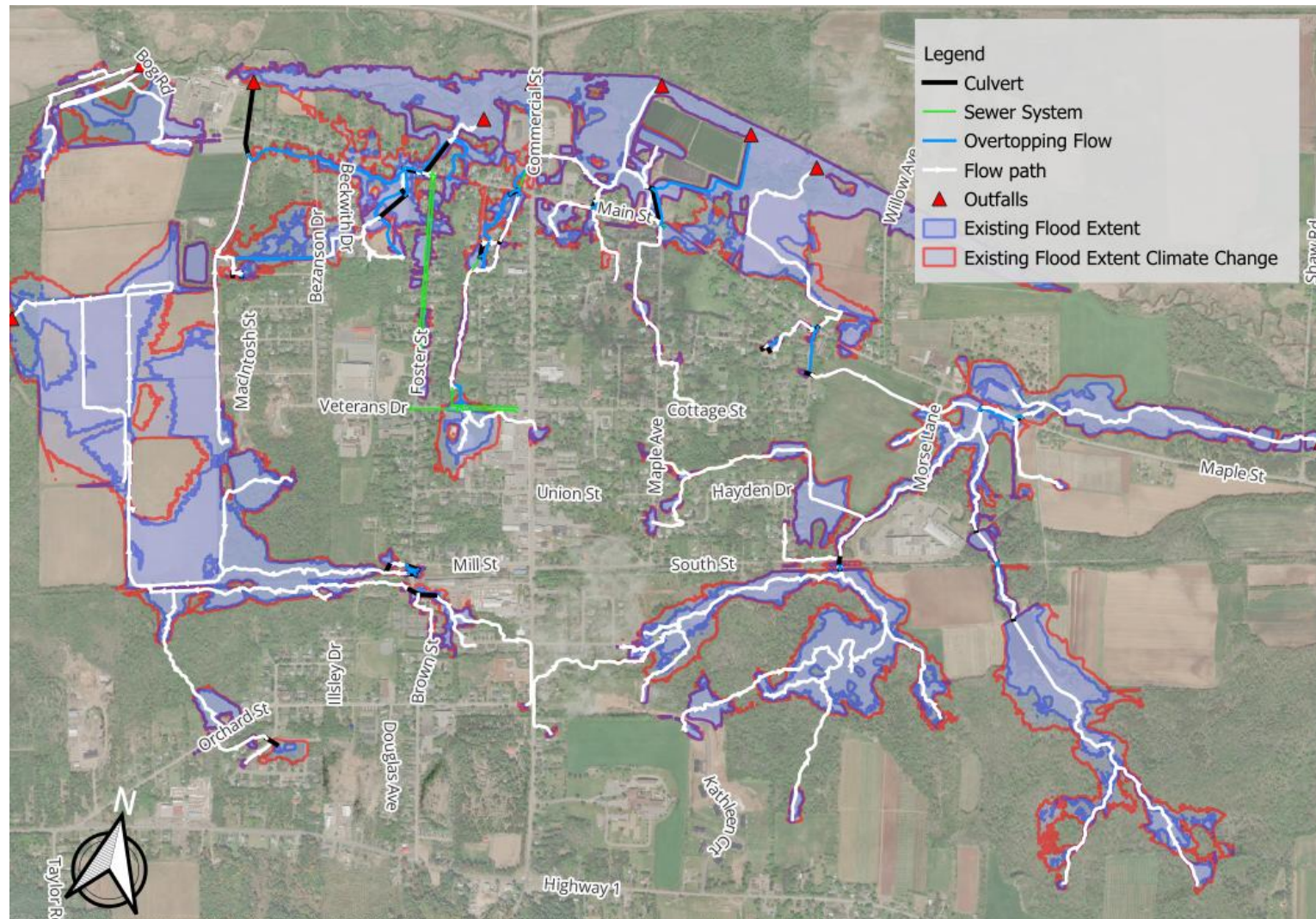
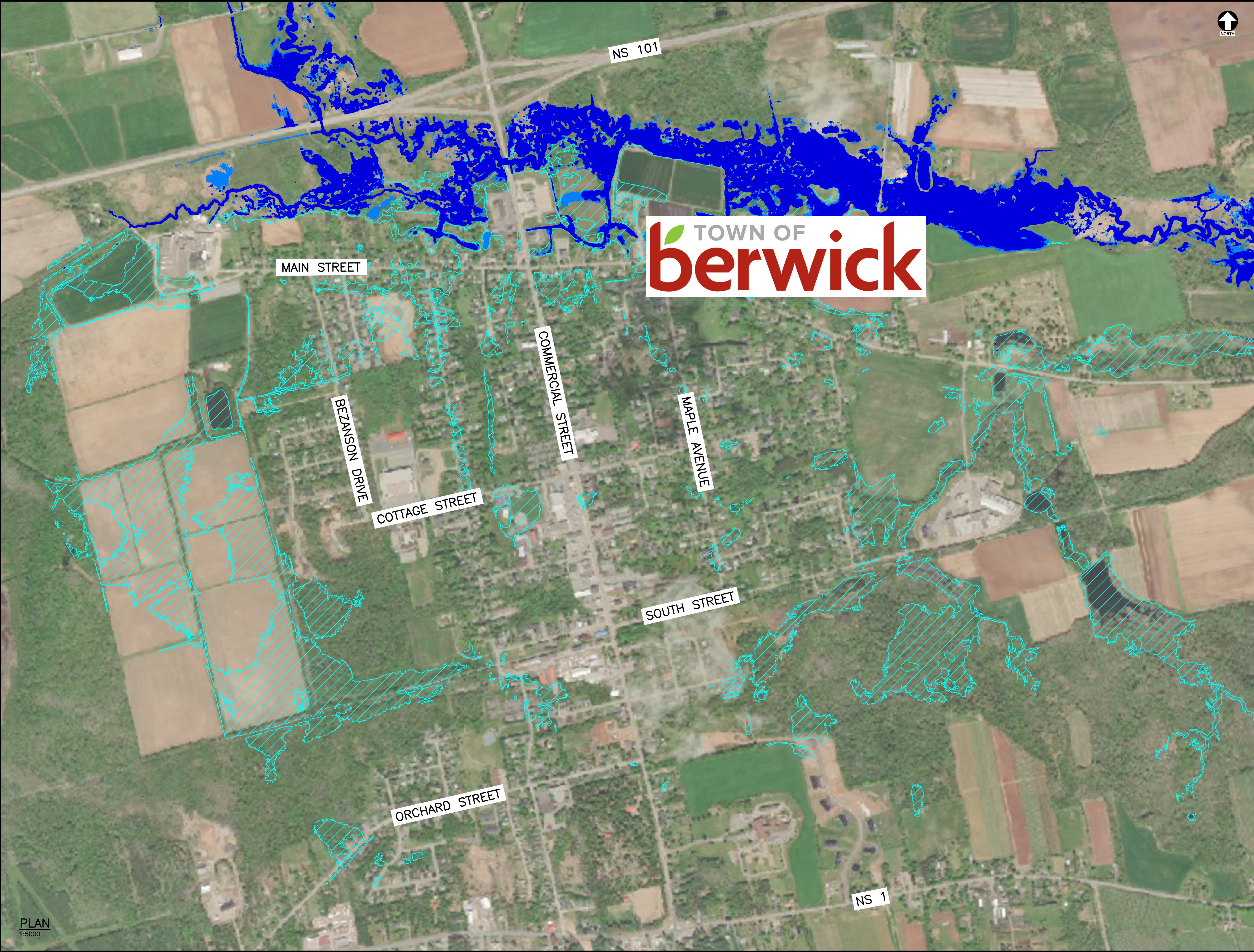


Figure A-2: Comparison Between the Flood Extents Generated from 1: 100- year- Design Storm, Combined with Cornwallis River Water Levels under Existing Climate Conditions vs. Future Climate Change Conditions

APPENDIX B

Full-Size Drawings





NORTH



PROJECT AREA

KEY PLAN

1:1000000



NORTH

LEGEND

-  CURRENT CLIMATE FLOODWAY (1:20-YEAR FLOOD LEVEL)
-  CURRENT CLIMATE FLOODWAY FRINGE (1:100-YEAR FLOOD LEVEL)
-  CURRENT CLIMATE FLOOD RISK (OVERLAND FLOW AREAS, 1:100-YEAR FLOOD LEVEL WITH 1:100-YEAR PRECIPITATION)

NOTES

- FLOODWAY AND FLOODWAY FRINGE EXTENTS ARE BASED ON MUNICIPAL FLOOD LINE MAPPING CONDUCTED BY OTHERS.
- FLOOD RISK EXTENTS WERE DETERMINED FROM STORMWATER MODELING BY CBCL COMBINED WITH RIVER LEVELS FROM THE 2012 BERWICK HYDRAULIC STUDY COMPLETED BY OTHERS.
- PER N.S. REG. 101/2001, RESIDENTIAL DEVELOPMENT IS NOT PERMITTED IN THE FLOODWAY, AND REQUIRES FLOOD-PROOFING MEASURES IN THE FLOOD FRINGE.
- FLOOD MITIGATION MEASURES SHOULD BE TAKEN FOR DEVELOPMENT WITHIN FLOOD RISK AREAS.

CONCEPT
DRAWING

No.	Description	Date	By
1	FINAL REPORT	APR. 02/26	PM
0	ISSUED FOR DRAFT REVIEW	FEB. 20/26	PM

Revision or Issue



File No. 251083.00

TOWN OF BERWICK

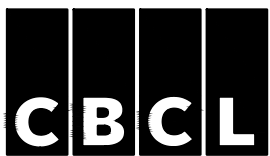
STORMWATER MANAGEMENT PLAN

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CURRENT CLIMATE FLOODWAY, FLOODWAY FRINGE, AND FLOOD RISK AREAS DELINEATION

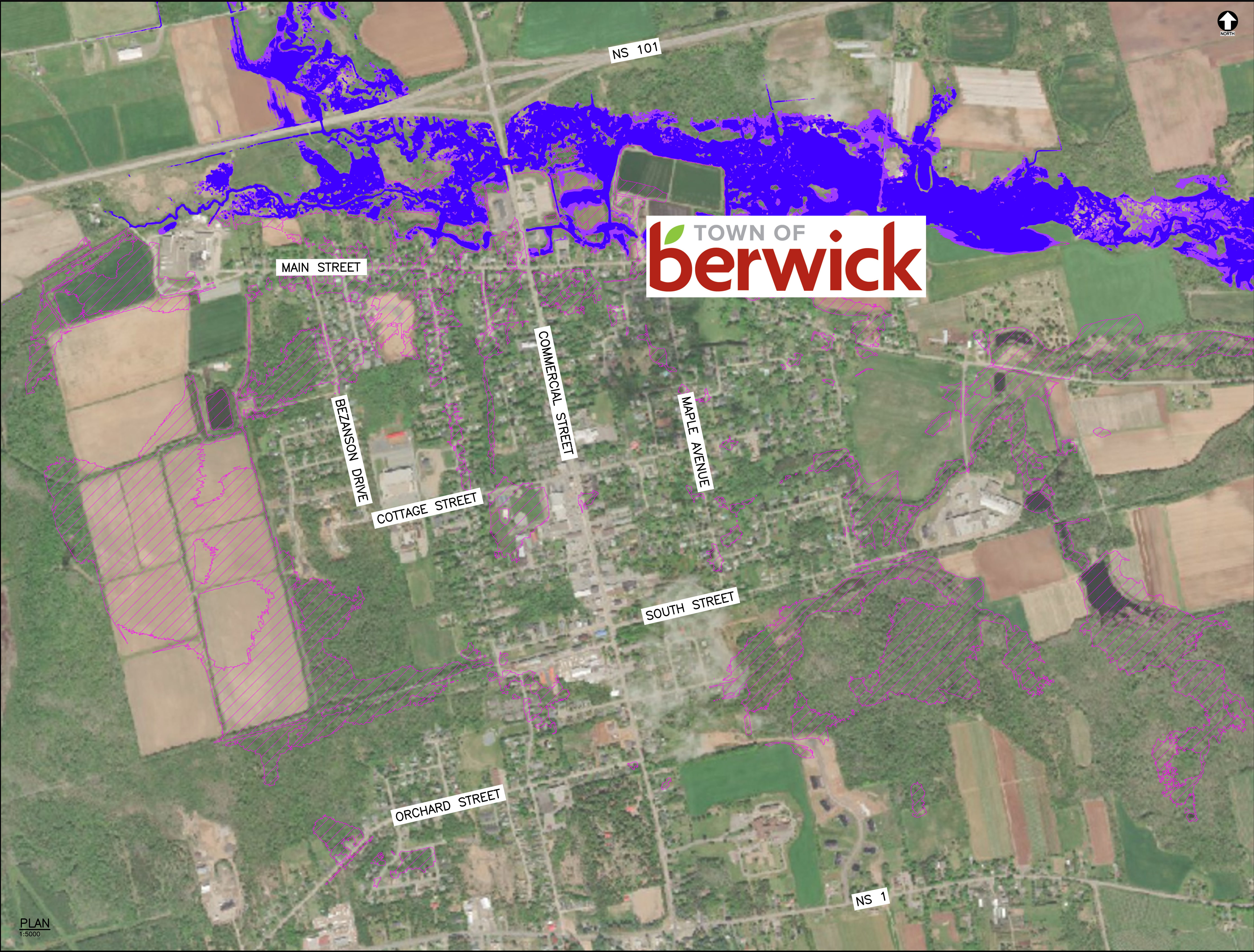
BERWICK, NS



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251083.00		APR. 02/26	AS SHOWN
		Designed PM	Drawn PM
		Checked AE	Approved AB
		Sheet No 1 of 10	
		Drawing No	

C01

PLAN
1:5000



- LEGEND**
- CLIMATE CHANGE FLOODWAY (1:20-YEAR FLOOD LEVEL)
 - CLIMATE CHANGE FLOODWAY FRINGE (1:100-YEAR FLOOD LEVEL)
 - CLIMATE CHANGE FLOOD RISK (OVERLAND FLOW AREAS, 1:100-YEAR FLOOD LEVEL WITH 1:100-YEAR PRECIPITATION)

- NOTES**
- FLOODWAY AND FLOODWAY FRINGE EXTENTS ARE BASED ON MUNICIPAL FLOOD LINE MAPPING CONDUCTED BY OTHERS.
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 - PER N.S. REG. 101/2001, RESIDENTIAL DEVELOPMENT IS NOT PERMITTED IN THE FLOODWAY, AND REQUIRES FLOOD-PROOFING MEASURES IN THE FLOOD FRINGE.
 - FLOOD MITIGATION MEASURES SHOULD BE TAKEN FOR DEVELOPMENT WITHIN FLOOD RISK AREAS.

**CONCEPT
DRAWING**

1	FINAL REPORT	APR. 02/26	PM
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Revision or Issue



File No. 251083.00

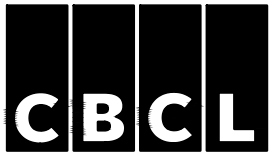
TOWN OF BERWICK

STORMWATER MANAGEMENT
PLAN

251083.00
CIVIL

CLIMATE CHANGE FLOODWAY,
FLOODWAY FRINGE, AND FLOOD
RISK AREAS DELINEATION

BERWICK, NS



CBCL No. 251083.00	Contract No.	Date APR. 02/26	Scale AS SHOWN
		Designed PM	Drawn PM
		Checked AE	Approved AB
		Sheet No 2 of 10	Drawing No C02



LEGEND

	EXISTING FLOOD EXTENTS, CURRENT CLIMATE, 1:100-YEAR STORM
	PROPOSED (SCENARIO 6) FLOOD EXTENTS, CURRENT CLIMATE, 1:100-YEAR STORM
	EXISTING OVERLAND FLOW PATH
	EXISTING STORM PIPE
	EXISTING CULVERT
	EXISTING PROPERTY LINE
	PROPOSED EASEMENT
	PROPOSED INFRASTRUCTURE

NOTES

1. SEE BERWICK STORMWATER MANAGEMENT PLAN REPORT SECTION 4 FOR MITIGATION SCENARIO DETAILS

CONCEPT
DRAWING

1	FINAL REPORT	APR. 02/26	PM
0	ISSUED FOR DRAFT REVIEW	FEB. 20/26	PM
No.	Description	Date	By

Revision or Issue

File No. 251083.00
TOWN OF BERWICK

STORMWATER MANAGEMENT
PLAN

251083.00
CIVIL

CAPITAL PROJECTS SUMMARY -
CURRENT CLIMATE, 1:100-YEAR
STORM

BERWICK, NS

CBCL No. 251083.00	Contract No.	Date APR. 02/26	Scale 1:2000
		Designed PM	Drawn PM
		Checked AE	Approved AB
		Sheet No 3	of 10
		Drawing No C03	



PLAN
1:2000



- LEGEND**
- EXISTING FLOOD EXTENTS, CLIMATE CHANGE, 1:100-YEAR STORM
 - PROPOSED (SCENARIO 6) FLOOD EXTENTS, CLIMATE CHANGE, 1:100-YEAR STORM
 - EXISTING OVERLAND FLOW PATH
 - EXISTING STORM PIPE
 - EXISTING CULVERT
 - EXISTING PROPERTY LINE
 - PROPOSED EASEMENT
 - PROPOSED INFRASTRUCTURE

NOTES
1. SEE BERWICK STORMWATER MANAGEMENT PLAN REPORT SECTION 4 FOR MITIGATION SCENARIO DETAILS

**CONCEPT
DRAWING**

1	FINAL REPORT	APR. 02/26	PM
0	ISSUED FOR DRAFT REVIEW	FEB. 20/26	PM
No.	Description	Date	By

Revision or Issue

File No. 251083.00
TOWN OF BERWICK

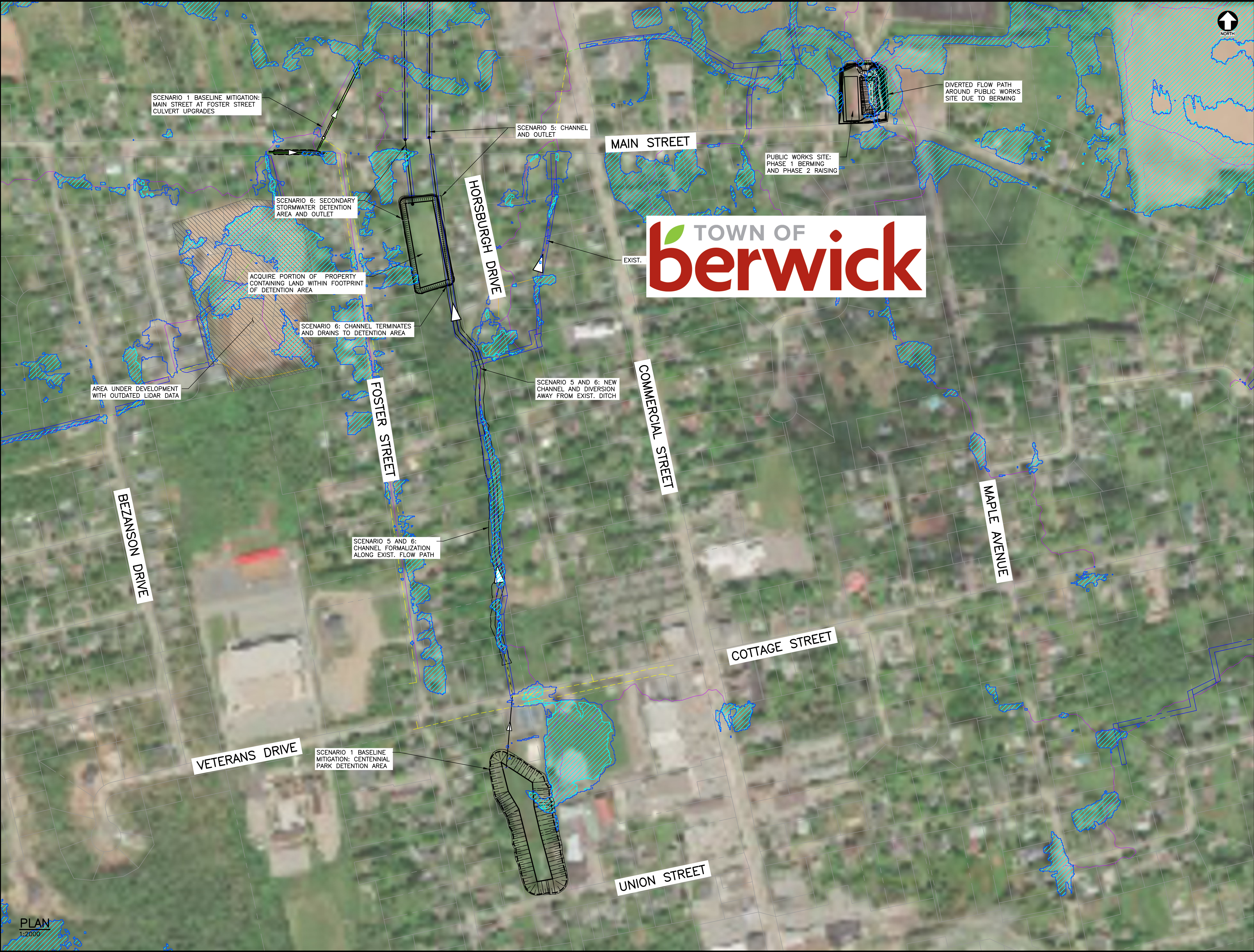
**STORMWATER MANAGEMENT
PLAN**

251083.00
CIVIL

**CAPITAL PROJECTS SUMMARY -
CLIMATE CHANGE, 1:100-YEAR
STORM**

BERWICK, NS

CBCL No. 251083.00	Contract No.	Date APR. 02/26	Scale 1:2000
Designed PM		Drawn PM	
Checked AE		Approved AB	
Sheet No 4		of 10	
Drawing No C04			



LEGEND

	EXISTING FLOOD EXTENTS, CURRENT CLIMATE, 1:10-YEAR STORM
	PROPOSED (SCENARIO 6) FLOOD EXTENTS, CURRENT CLIMATE, 1:10-YEAR STORM
	EXISTING OVERLAND FLOW PATH
	EXISTING STORM PIPE
	EXISTING CULVERT
	EXISTING PROPERTY LINE
	PROPOSED EASEMENT
	PROPOSED INFRASTRUCTURE

NOTES

1. SEE BERWICK STORMWATER MANAGEMENT PLAN REPORT SECTION 4 FOR MITIGATION SCENARIO DETAILS

CONCEPT
DRAWING

1	FINAL REPORT	APR. 02/26	PM
0	ISSUED FOR DRAFT REVIEW	FEB. 20/26	PM
No.	Description	Date	By

Revision or Issue

File No. 251083.00
TOWN OF BERWICK

STORMWATER MANAGEMENT
PLAN

251083.00
CIVIL

CAPITAL PROJECTS SUMMARY -
CURRENT CLIMATE, 1:10-YEAR
STORM

BERWICK, NS

CBCL No. 251083.00	Contract No.	Date APR. 02/26	Scale 1:2000
		Designed PM	Drawn PM
		Checked AE	Approved AB
		Sheet No 5	of 10
		Drawing No	C05



PLAN
1:2000



- LEGEND**
- EXISTING FLOOD EXTENTS, CLIMATE CHANGE, 1:10-YEAR STORM
 - PROPOSED (SCENARIO 6) FLOOD EXTENTS, CLIMATE CHANGE, 1:10-YEAR STORM
 - EXISTING OVERLAND FLOW PATH
 - EXISTING STORM PIPE
 - EXISTING CULVERT
 - EXISTING PROPERTY LINE
 - PROPOSED EASEMENT
 - PROPOSED INFRASTRUCTURE

NOTES
1. SEE BERWICK STORMWATER MANAGEMENT PLAN REPORT SECTION 4 FOR MITIGATION SCENARIO DETAILS

**CONCEPT
DRAWING**

1	FINAL REPORT	APR. 02/26	PM
0	ISSUED FOR DRAFT REVIEW	FEB. 20/26	PM
No.	Description	Date	By

Revision or Issue



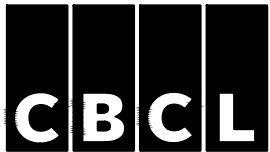
File No. 251083.00
TOWN OF BERWICK

STORMWATER MANAGEMENT
PLAN

251083.00
CIVIL

CAPITAL PROJECTS SUMMARY
- CLIMATE CHANGE,
1:10-YEAR STORM

BERWICK, NS



CBCL No. 251083.00	Contract No.	Date APR. 02/26	Scale 1:2000
		Designed PM	Drawn PM
		Checked AE	Approved AB
		Sheet No 6 of 10	Drawing No C06



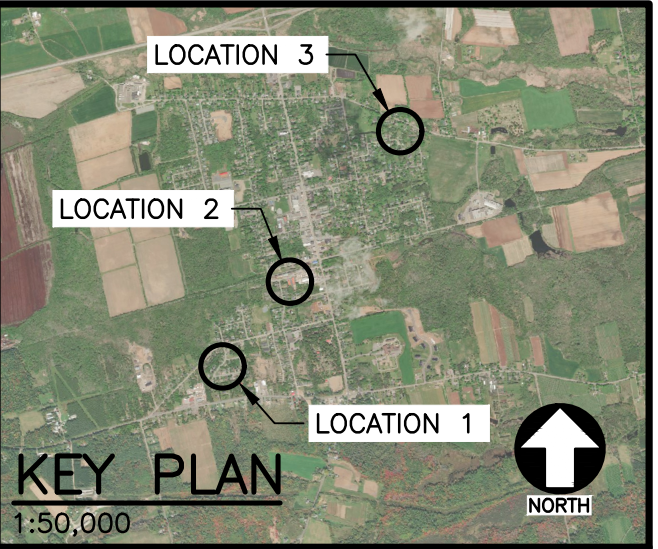
LOCATION 1: GRAVENSTEIN DRIVE AT SPARTAN AVENUE
1:1,000



LOCATION 3: LAWRENCE AVENUE, MAIN STREET AT COTTAGE STREET
1:500



LOCATION 2: BROWN STREET AT FRONT STREET
1:1,000



LEGEND	
	EXISTING FLOOD EXTENTS, CURRENT CLIMATE, 1:100-YEAR STORM
	PROPOSED (SCENARIO 6) FLOOD EXTENTS, CURRENT CLIMATE, 1:100-YEAR STORM
	EXISTING OVERLAND FLOW PATH
	EXISTING STORM PIPE
	EXISTING CULVERT
	EXISTING PROPERTY LINE
	PROPOSED EASEMENT

CONCEPT
DRAWING

1	FINAL REPORT	APR. 02/26	PM
0	ISSUED FOR DRAFT REVIEW	FEB. 20/26	PM
No.	Description	Date	By

Revision or Issue



File No. 251083.00
TOWN OF BERWICK

STORMWATER MANAGEMENT
PLAN

251083.00
CIVIL

LIFECYCLE RENEWAL PROJECTS
SUMMARY - CURRENT CLIMATE,
1:100-YEAR STORM

BERWICK, NS



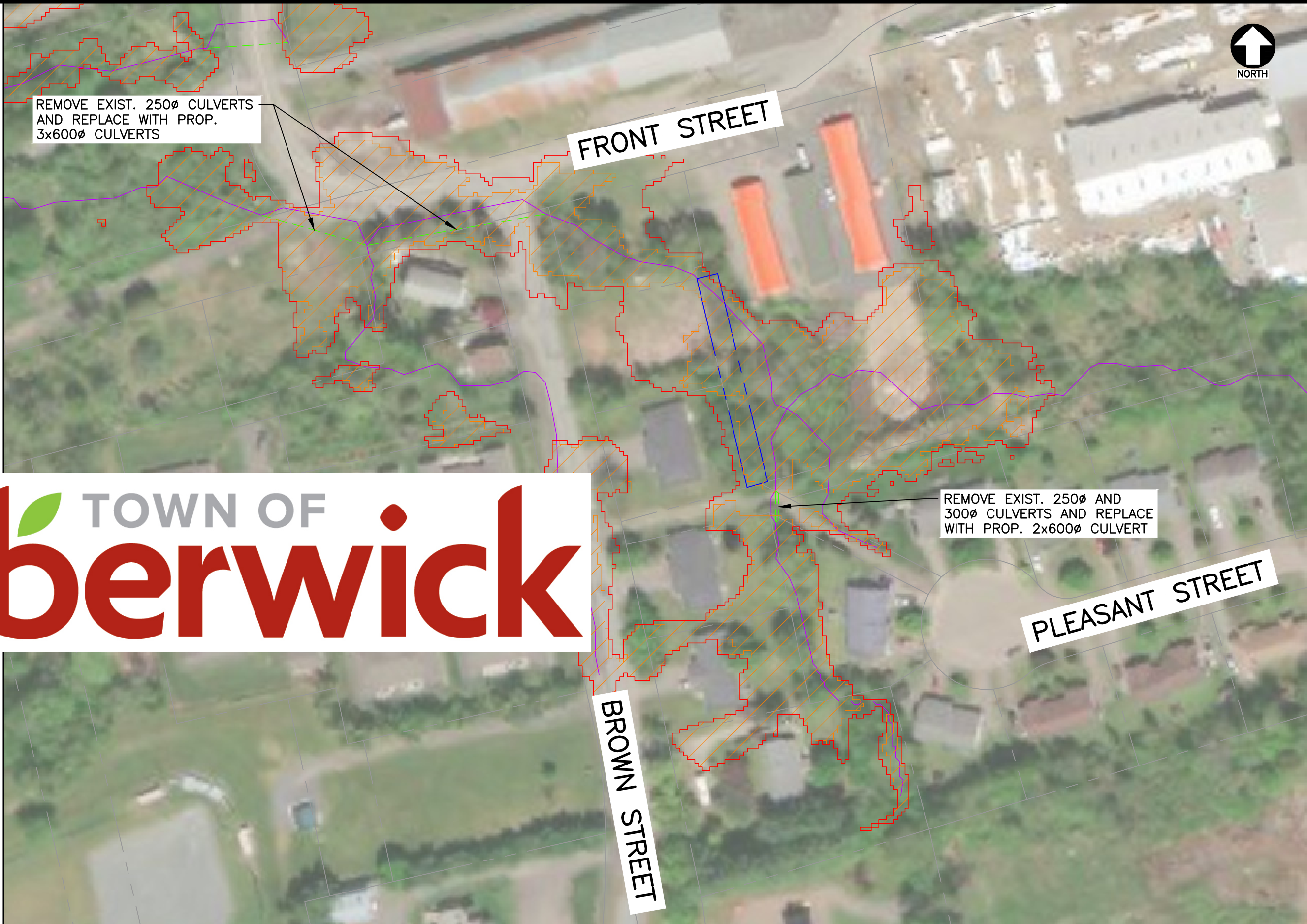
CBCL No. 251083.00	Contract No.	Date APR. 02/26	Scale AS NOTED
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		Checked AE	Approved AB
		Sheet No. 7	of 10
		Drawing No.	C07



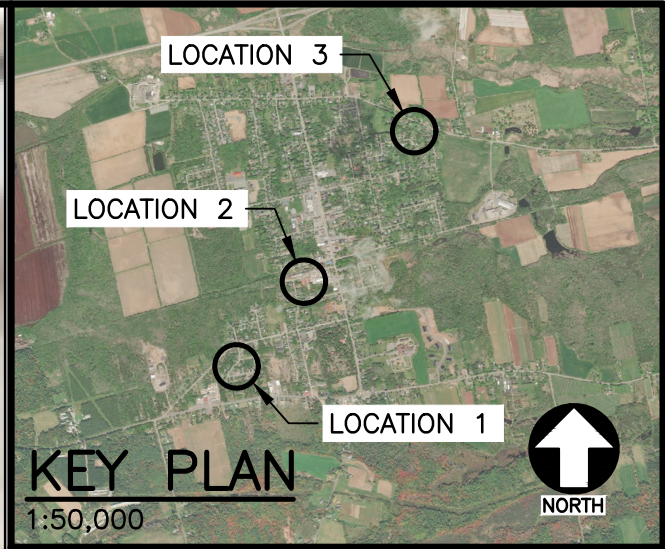
LOCATION 1: GRAVENSTEIN DRIVE AT SPARTAN AVENUE
1:1,000



LOCATION 3: LAWRENCE AVENUE, MAIN STREET AT COTTAGE STREET
1:500



LOCATION 2: BROWN STREET AT FRONT STREET
1:1,000



LEGEND			
[Red outline]	EXISTING FLOOD EXTENTS, CLIMATE CHANGE, 1:100-YEAR STORM		
[Orange hatched]	PROPOSED (SCENARIO 6) FLOOD EXTENTS, CLIMATE CHANGE, 1:100-YEAR STORM		
[Purple line]	EXISTING OVERLAND FLOW PATH		
[Yellow dashed line]	EXISTING STORM PIPE		
[Green dashed line]	EXISTING CULVERT		
[Blue dashed line]	EXISTING PROPERTY LINE		
[Red dashed line]	PROPOSED EASEMENT		

CONCEPT
DRAWING

1	FINAL REPORT	APR. 02/26	PM
0	ISSUED FOR DRAFT REVIEW	FEB. 20/26	PM
No.	Description	Date	By

Revision or Issue



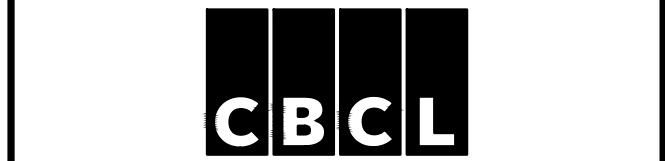
File No. 251083.00
TOWN OF BERWICK

STORMWATER MANAGEMENT
PLAN

251083.00
CIVIL

LIFECYCLE RENEWAL PROJECTS
SUMMARY - CLIMATE CHANGE,
1:100-YEAR STORM

BERWICK, NS



CBCL No. 251083.00	Contract No.	Date APR. 02/26	Scale AS NOTED
		Designed PM	Drawn PM
		Checked AE	Approved AB
		Sheet No. 8	of 10
		Drawing No.	C08



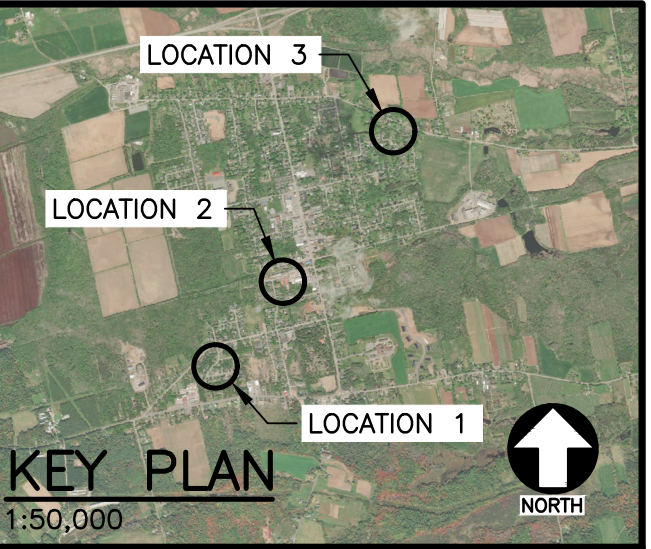
LOCATION 1: GRAVENSTEIN DRIVE AT SPARTAN AVENUE
1:1,000



LOCATION 3: LAWRENCE AVENUE, MAIN STREET AT COTTAGE STREET
1:500



LOCATION 2: BROWN STREET AT FRONT STREET
1:1,000



- LEGEND**
- EXISTING FLOOD EXTENTS, CURRENT CLIMATE, 1:10-YEAR STORM
 - PROPOSED (SCENARIO 6) FLOOD EXTENTS, CURRENT CLIMATE, 1:10-YEAR STORM
 - EXISTING OVERLAND FLOW PATH
 - EXISTING STORM PIPE
 - EXISTING CULVERT
 - EXISTING PROPERTY LINE
 - PROPOSED EASEMENT

**CONCEPT
DRAWING**

1	FINAL REPORT	APR. 02/26	PM
0	ISSUED FOR DRAFT REVIEW	FEB. 20/26	PM
No.	Description	Date	By

Revision or Issue



File No. 251083.00
TOWN OF BERWICK

STORMWATER MANAGEMENT
PLAN

251083.00
CIVIL

LIFECYCLE RENEWAL PROJECTS
SUMMARY - CURRENT CLIMATE,
1:10-YEAR STORM

BERWICK, NS



CBCL No. 251083.00	Contract No.	Date APR. 02/26	Scale AS NOTED
	Designed PM	Drawn PM	
	Checked AE	Approved AB	
	Sheet No. 9	of 10	
	Drawing No. C09		



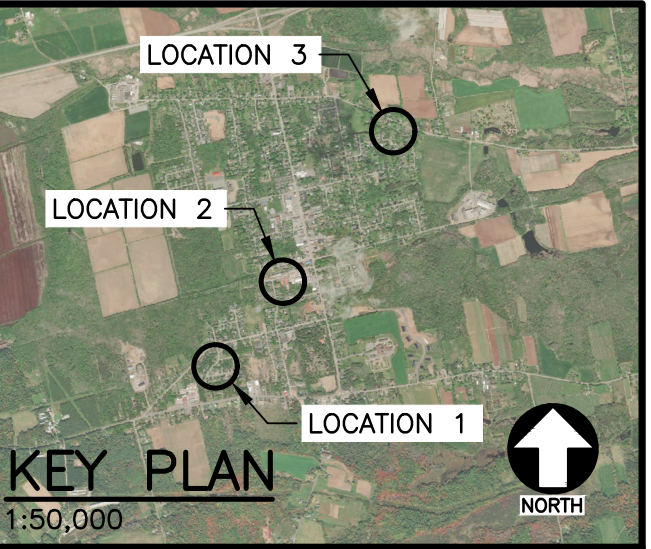
LOCATION 1: GRAVENSTEIN DRIVE AT SPARTAN AVENUE
1:1,000



LOCATION 3: LAWRENCE AVENUE, MAIN STREET AT COTTAGE STREET
1:500



LOCATION 2: BROWN STREET AT FRONT STREET
1:1,000



LEGEND			
	EXISTING FLOOD EXTENTS, CLIMATE CHANGE, 1:10-YEAR STORM		
	PROPOSED (SCENARIO 6) FLOOD EXTENTS, CLIMATE CHANGE, 1:10-YEAR STORM		
	EXISTING OVERLAND FLOW PATH		
	EXISTING STORM PIPE		
	EXISTING CULVERT		
	EXISTING PROPERTY LINE		
	PROPOSED EASEMENT		

CONCEPT
DRAWING

1	FINAL REPORT	APR. 02/26	PM
0	ISSUED FOR DRAFT REVIEW	FEB. 20/26	PM
No.	Description	Date	By

Revision or Issue

File No. 251083.00			
TOWN OF BERWICK			
STORMWATER MANAGEMENT PLAN			
251083.00			
CIVIL			
LIFECYCLE RENEWAL PROJECTS SUMMARY - CLIMATE CHANGE, 1:100-YEAR STORM			
BERWICK, NS			
CBCL No.	Contract No.	Date.	Scale
251083.00		APR. 02/26	AS NOTED
		Designed PM	Drawn PM
		Checked AE	Approved AB
		Sheet No. 10	of 10
		Drawing No.	C10

APPENDIX C

Class D Opinion of Probable Cost



OPINION of PROBABLE CONSTRUCTION COSTS
PROJECT NAME: Berwick Stormwater Management Plan
Berwick, NS

DATE:	24-03-2026
CBCL No:	251083.00
Prepared by:	PG
Reviewed by:	AT
Budget Class:	Class D

SUMMARY

SCHEDULE OF QUANTITIES AND UNIT PRICES

Item	Description	Unit	Est. Qty.	Unit Price	Subtotal Price
1. Phase 1 a) Public Works Site - Surface Storage					
EARTHWORKS					
1.101	Imported Borrow	m3	974	\$ 46	\$ 44,781
1.102	Mass Excavation - Common Reuse on Site	m3	255	\$ 32	\$ 8,211
STORM SYSTEM					
1.103	Storm Sewer - 250mm PVC DR35	m	50	\$ 690	\$ 34,500
1.104	Storm Sewer - 200mm Forcemain	ea	10	\$ 1,150	\$ 11,500
1.105	Catch Basin	ea	1	\$ 6,900	\$ 6,900
1.106	Storm Manhole	ea	1	\$ 12,650	\$ 12,650
1.107	Oil Grit Separator	ea	1	\$ 23,000	\$ 23,000
1.108	Wet Well	ea	1	\$ 207,000	\$ 207,000
1.109	200mm Tideflex Check Valve	ea	1	\$ 3,450	\$ 3,450
ROADWORK & REINSTATEMENT					
1.110	Asphalt	m2	752	\$ 69	\$ 51,888
1.111	Type I Gravel - 150mm Thick	m2	752	\$ 23	\$ 17,296
1.112	Type II Gravel - 250mm Thick	m2	752	\$ 29	\$ 21,620
1.113	Gravel Parking Area	m2	810	\$ 53	\$ 42,849
1.114	Topsoil and Sod - 150mm Thick	m2	430	\$ 29	\$ 12,363
1.115	Environmental Protection	LS	1	\$ 11,500	\$ 11,500
PROVISIONAL					
1.116	Removals of storm management infrastructure	LS	1	\$ 15,000	\$ 15,000
DESIGN DEVELOPMENT ALLOWANCE - Note 1				30%	\$ 157,352
ESTIMATE BEFORE CONSTRUCTION CONTINGENCY					\$ 682,000
CONSTRUCTION CONTINGENCY - Note 2				5%	\$ 34,100
ESTIMATE CONSTRUCTION CONTRACT PRICE with CONTINGENCY (excl. HST)					\$ 716,100
Engineering and Design Services				8%	\$ 57,290
TOTAL ESTIMATE CONSTRUCTION & ENGINEERING PRICE (Excluding HST)					\$ 773,400
THIS OPINION OF PROBABLE COSTS IS PRESENTED ON THE BASIS OF EXPERIENCE, QUALIFICATIONS, AND BEST JUDGEMENT. IT HAS BEEN PREPARED IN ACCORDANCE WITH ACCEPTABLE PRINCIPLES AND PRACTICES. SUDDEN MARKET TREND CHANGES, NON-COMPETITIVE BIDDING SITUATIONS, UNFORESEEN LABOUR AND MATERIAL ADJUSTMENTS, UNFORESEEN SITE CONDITIONS, AND THE LIKE ARE BEYOND THE CONTROL OF CBCL LIMITED. IT IS NOT A PREDICTION OF LOW PRICE. AS SUCH WE CANNOT WARRANT OR GUARANTEE THAT ACTUAL COSTS WILL NOT VARY FROM THE OPINION PROVIDED. IT IS BASED ON THE DATE OF THIS BUDGET.					
Note 1	This Allowance is to account for uncertainty in construction cost due to undefined design scope.				
Note 2	The Construction Contingency is to factor in potential post tender Change Orders.				



OPINION of PROBABLE CONSTRUCTION COSTS
PROJECT NAME: Berwick Stormwater Management Plan
Berwick, NS

DATE:	24-03-2026
CBCL No:	251083.00
Prepared by:	PG
Reviewed by:	AT
Budget Class:	Class D

SUMMARY

SCHEDULE OF QUANTITIES AND UNIT PRICES

Item	Description	Unit	Est. Qty.	Unit Price	Subtotal Price
1. Phase 1 b) Public Works Site - Underground Storage Alternate					
EARTHWORKS					
1.101	Imported Borrow	m3	885	\$ 46	\$ 40,710
1.102	Mass Excavation - Common	m3	430	\$ 32	\$ 13,846
STORM SYSTEM					
1.103	Storm Sewer - 250mm PVC DR35	m	25	\$ 690	\$ 17,250
1.104	Storm Sewer - 200mm Forcemain	m	10	\$ 1,150	\$ 11,500
1.105	Catch Basin	m	1	\$ 6,900	\$ 6,900
1.106	Oil Grit Separator	ea	1	\$ 23,000	\$ 23,000
1.107	Underground Stormwater Detention System	LS	1	\$ 434,700	\$ 434,700
1.108	Wet Well	Ea	1	\$ 207,000	\$ 207,000
1.109	200mm Tideflex Check Valve	Ea	1	\$ 3,450	\$ 3,450
ROADWORK & REINSTATEMENT					
1.110	Asphalt	m2	690	\$ 69	\$ 47,610
1.111	Type I Gravel - 150mm Thick	m2	690	\$ 23	\$ 15,870
1.112	Type II Gravel - 250mm Thick	m2	690	\$ 29	\$ 19,838
1.113	Gravel Parking Area	m2	500	\$ 53	\$ 26,450
1.114	Topsoil and Sod - 150mm Thick	m2	430	\$ 29	\$ 12,363
1.115	Environmental Protection	LS	1	\$ 11,500	\$ 11,500
PROVISIONAL					
1.116	Removals of storm management infrastructure	LS	1	\$ 50,000	\$ 50,000
DESIGN DEVELOPMENT ALLOWANCE - Note 1				30%	\$ 282,596
ESTIMATE BEFORE CONSTRUCTION CONTINGENCY					\$ 1,225,000
CONSTRUCTION CONTINGENCY - Note 2				5%	\$ 61,250
ESTIMATE CONSTRUCTION CONTRACT PRICE with CONTINGENCY (excl. HST)					\$ 1,286,300
Engineering and Design Services				8%	\$ 102,910
TOTAL ESTIMATE CONSTRUCTION & ENGINEERING PRICE (Excluding HST)					\$ 1,389,300
THIS OPINION OF PROBABLE COSTS IS PRESENTED ON THE BASIS OF EXPERIENCE, QUALIFICATIONS, AND BEST JUDGEMENT. IT HAS BEEN PREPARED IN ACCORDANCE WITH ACCEPTABLE PRINCIPLES AND PRACTICES. SUDDEN MARKET TREND CHANGES, NON-COMPETITIVE BIDDING SITUATIONS, UNFORESEEN LABOUR AND MATERIAL ADJUSTMENTS, UNFORESEEN SITE CONDITIONS, AND THE LIKE ARE BEYOND THE CONTROL OF CBCL LIMITED. IT IS NOT A PREDICTION OF LOW PRICE. AS SUCH WE CANNOT WARRANT OR GUARANTEE THAT ACTUAL COSTS WILL NOT VARY FROM THE OPINION PROVIDED. IT IS BASED ON THE DATE OF THIS BUDGET.					
Note 1	This Allowance is to account for uncertainty in construction cost due to undefined design scope.				
Note 2	The Construction Contingency is to factor in potential post tender Change Orders.				



OPINION of PROBABLE CONSTRUCTION COSTS
PROJECT NAME: Berwick Stormwater Management Plan
Berwick, NS

DATE:	24-03-2026
CBCL No:	251083.00
Prepared by:	PG
Reviewed by:	AT
Budget Class:	Class D

SUMMARY

SCHEDULE OF QUANTITIES AND UNIT PRICES

Item	Description	Unit	Est. Qty.	Unit Price	Subtotal Price
1. Phase 2) Public Works Building Site					
1.201	Demolition & Disposal - Existing Public Works Building	LS	1	\$ 392,951	\$ 392,951
1.202	Construct New Public Works Building (7,600sf)	LS	1	\$ 3,210,951	\$ 3,210,951
1.203	Imported Borrow	m ³	1,600	\$ 46	\$ 73,600
1.204	Asphalt Driveway/Parking Lot	m ²	970	\$ 99	\$ 96,156
1.205	Gravel Parking Area	m ²	770	\$ 53	\$ 40,733
1.206	Topsoil and Hydroseed	m ²	990	\$ 21	\$ 20,493
1.207	Environmental Protection	LS	1	\$ 5,750	\$ 5,750
DESIGN DEVELOPMENT ALLOWANCE - Note 1				30%	\$ 1,152,190
ESTIMATE BEFORE CONSTRUCTION CONTINGENCY					\$ 4,993,000
CONSTRUCTION CONTINGENCY - Note 2				5%	\$ 249,650
ESTIMATE CONSTRUCTION CONTRACT PRICE with CONTINGENCY (excl. HST)					\$ 5,242,700
Engineering and Design Services				8%	\$ 419,420
TOTAL ESTIMATE CONSTRUCTION & ENGINEERING PRICE (Excluding HST)					\$ 5,662,200
THIS OPINION OF PROBABLE COSTS IS PRESENTED ON THE BASIS OF EXPERIENCE, QUALIFICATIONS, AND BEST JUDGEMENT. IT HAS BEEN PREPARED IN ACCORDANCE WITH ACCEPTABLE PRINCIPLES AND PRACTICES. SUDDEN MARKET TREND CHANGES, NON-COMPETITIVE BIDDING SITUATIONS, UNFORESEEN LABOUR AND MATERIAL ADJUSTMENTS, UNFORESEEN SITE CONDITIONS, AND THE LIKE ARE BEYOND THE CONTROL OF CBCL LIMITED. IT IS NOT A PREDICTION OF LOW PRICE. AS SUCH WE CANNOT WARRANT OR GUARANTEE THAT ACTUAL COSTS WILL NOT VARY FROM THE OPINION PROVIDED. IT IS BASED ON THE DATE OF THIS BUDGET.					
Note 1	This Allowance is to account for uncertainty in construction cost due to undefined design scope.				
Note 2	The Construction Contingency is to factor in potential post tender Change Orders.				



OPINION of PROBABLE CONSTRUCTION COSTS
PROJECT NAME: Berwick Stormwater Management Plan
Berwick, NS

DATE:	24-03-2026
CBCL No:	251083.00
Prepared by:	PG
Reviewed by:	AT
Budget Class:	Class D

SUMMARY

SCHEDULE OF QUANTITIES AND UNIT PRICES

Item	Description	Unit	Est. Qty.	Unit Price	Subtotal Price
2.1 Centennial Park Detention Area					
EARTHWORKS					
2.101	Mass Excavation - Common Reuse on Site	m ³	1,300	\$ 32	\$ 41,860
2.102	Mass Excavation - Common Dispose Off Site	m ³	5,100	\$ 40	\$ 205,275
STORM SYSTEM					
2.103	Storm Sewer - 750mm Concrete 65D	m	130	\$ 1,011	\$ 131,403
2.104	Headwall - 750mm Precast	ea	1	\$ 6,900	\$ 6,900
2.105	Orifice Plate- 590mm	ea	1	\$ 3,450	\$ 3,450
2.106	Connection to Existing Manhole	ea	1	\$ 9,200	\$ 9,200
ROADWORK & REINSTATEMENT					
2.107	Asphalt	m ²	275	\$ 69	\$ 18,975
2.108	Type I Gravel - 150mm Thick	m ²	275	\$ 23	\$ 6,325
2.109	Type II Gravel - 250mm Thick	m ²	275	\$ 29	\$ 7,906
2.110	Park Furnishings Removal and Reinstatement	LS	1	\$ 30,000	\$ 30,000
2.111	Topsoil and Sod - 150mm Thick	m ²	10,561	\$ 29	\$ 303,622
2.112	Environmental Protection	LS	1	\$ 12,650	\$ 12,650
DESIGN DEVELOPMENT ALLOWANCE - Note 1				30%	\$ 233,270
ESTIMATE BEFORE CONSTRUCTION CONTINGENCY					\$ 1,011,000
CONSTRUCTION CONTINGENCY - Note 2				5%	\$ 50,550
ESTIMATE CONSTRUCTION CONTRACT PRICE with CONTINGENCY (excl. HST)					\$ 1,061,600
Engineering and Design Services				8%	\$ 84,930
TOTAL ESTIMATE CONSTRUCTION & ENGINEERING PRICE (Excluding HST)					\$ 1,146,600
THIS OPINION OF PROBABLE COSTS IS PRESENTED ON THE BASIS OF EXPERIENCE, QUALIFICATIONS, AND BEST JUDGEMENT. IT HAS BEEN PREPARED IN ACCORDANCE WITH ACCEPTABLE PRINCIPLES AND PRACTICES. SUDDEN MARKET TREND CHANGES, NON-COMPETITIVE BIDDING SITUATIONS, UNFORESEEN LABOUR AND MATERIAL ADJUSTMENTS, UNFORESEEN SITE CONDITIONS, AND THE LIKE ARE BEYOND THE CONTROL OF CBCL LIMITED. IT IS NOT A PREDICTION OF LOW PRICE. AS SUCH WE CANNOT WARRANT OR GUARANTEE THAT ACTUAL COSTS WILL NOT VARY FROM THE OPINION PROVIDED. IT IS BASED ON THE DATE OF THIS BUDGET.					
Note 1	This Allowance is to account for uncertainty in construction cost due to undefined design scope.				
Note 2	The Construction Contingency is to factor in potential post tender Change Orders.				



OPINION of PROBABLE CONSTRUCTION COSTS
PROJECT NAME: Berwick Stormwater Management Plan
Berwick, NS

DATE:	24-03-2026
CBCL No:	251083.00
Prepared by:	PG
Reviewed by:	AT
Budget Class:	Class D

SUMMARY

SCHEDULE OF QUANTITIES AND UNIT PRICES

Item	Description	Unit	Est. Qty.	Unit Price	Subtotal Price
2.2 Culvert Upsizing on Main Street at Foster Street					
REMOVAL of UNDERGROUND UTILITIES					
2.201	Removal of 600mm concrete culvert	m	54	\$ 115	\$ 6,210
2.202	Removal of Concrete control structure incl. wood Cover	m	1	\$ 2,875	\$ 2,875
2.203	Removal of 900mm HDPE outlet pipe	m	110	\$ 69	\$ 7,590
2.204	Removal of 600mm HDPE Driveway Culvert	m	44	\$ 69	\$ 3,036
EARTHWORKS					
2.204	Ditching	m	65	\$ 115	\$ 7,475
STORM SYSTEM					
2.205	Storm Sewer - 1050mm Concrete 65D	m	246	\$ 1,380	\$ 339,480
2.206	Headwall - 2 barrelled 1050mm Precast Conc	ea	1	\$ 18,400	\$ 18,400
2.207	Precast Concrete Control Structure (3.0mx3.0mx2.5m)	ea	1	\$ 68,748	\$ 68,748
2.208	Concrete Box Culvert 900x1800mm	ea	6	\$ 11,500	\$ 69,000
ROADWORK & REINSTATEMENT					
2.208	Asphalt	m ²	40	\$ 69	\$ 2,760
2.209	Type I Gravel - 150mm Thick	m ²	40	\$ 23	\$ 920
2.210	Type II Gravel - 250mm Thick	m ²	40	\$ 29	\$ 1,150
2.211	Asphalt Sidewalk	m ²	8	\$ 207	\$ 1,553
2.212	Topsoil and Sod - 150mm Thick	m ²	253	\$ 29	\$ 7,274
2.213	Environmental Protection	LS	1	\$ 8,000	\$ 8,000
DESIGN DEVELOPMENT ALLOWANCE - Note 1				30%	\$ 163,341
ESTIMATE BEFORE CONSTRUCTION CONTINGENCY					\$ 708,000
CONSTRUCTION CONTINGENCY - Note 2				5%	\$ 35,400
ESTIMATE CONSTRUCTION CONTRACT PRICE with CONTINGENCY (excl. HST)					\$ 743,400
Engineering and Design Services				8%	\$ 59,480
TOTAL ESTIMATE CONSTRUCTION & ENGINEERING PRICE (Excluding HST)					\$ 802,900
THIS OPINION OF PROBABLE COSTS IS PRESENTED ON THE BASIS OF EXPERIENCE, QUALIFICATIONS, AND BEST JUDGEMENT. IT HAS BEEN PREPARED IN ACCORDANCE WITH ACCEPTABLE PRINCIPLES AND PRACTICES. SUDDEN MARKET TREND CHANGES, NON-COMPETITIVE BIDDING SITUATIONS, UNFORESEEN LABOUR AND MATERIAL ADJUSTMENTS, UNFORESEEN SITE CONDITIONS, AND THE LIKE ARE BEYOND THE CONTROL OF CBCL LIMITED. IT IS NOT A PREDICTION OF LOW PRICE. AS SUCH WE CANNOT WARRANT OR GUARANTEE THAT ACTUAL COSTS WILL NOT VARY FROM THE OPINION PROVIDED. IT IS BASED ON THE DATE OF THIS BUDGET.					
Note 1	This Allowance is to account for uncertainty in construction cost due to undefined design scope.				
Note 2	The Construction Contingency is to factor in potential post tender Change Orders.				



OPINION of PROBABLE CONSTRUCTION COSTS
PROJECT NAME: Berwick Stormwater Management Plan
Berwick, NS

DATE:	24-03-2026
CBCL No:	251083.00
Prepared by:	PG
Reviewed by:	AT
Budget Class:	Class D

SUMMARY

SCHEDULE OF QUANTITIES AND UNIT PRICES

Item	Description	Unit	Est. Qty.	Unit Price	Subtotal Price
3.a) Channel Improvements & Diversion (No Additional Detention)					
EARTHWORKS					
3.001	Mass Excavation - Common Reuse on Site	m ³	32	\$ 32	\$ 1,030
3.002	Mass Excavation - Common Dispose Off Site	m ³	4,185	\$ 40	\$ 168,446
3.003	Rip Rap	m ³	1,518	\$ 100	\$ 151,778
3.004	Geotextile	m2	4,337	\$ 4	\$ 17,346
STORM SYSTEM					
3.005	Storm Sewer - 1500mm Concrete 65D	m	248	\$ 2,100	\$ 520,800
3.006	Precast Manhole 2400mm	ea	1	\$ 32,500	\$ 32,500
3.007	Catch Basin	ea	1	\$ 6,000	\$ 6,000
ROADWORK & REINSTATEMENT					
3.008	Site Access and Reinstatement Allowance	LS	1	\$ 55,500	\$ 55,500
3.009	Asphalt	m2	25	\$ 69	\$ 1,725
3.010	Type I Gravel - 150mm Thick	m2	25	\$ 23	\$ 575
3.011	Type II Gravel - 250mm Thick	m2	25	\$ 29	\$ 719
3.012	Asphalt Sidewalk	m2	10	\$ 207	\$ 2,070
3.013	Topsoil and Sod - 150mm Thick	m2	495	\$ 29	\$ 14,231
3.014	Environmental Protection	LS	1	\$ 26,300	\$ 26,300
DESIGN DEVELOPMENT ALLOWANCE - <i>Note 1</i>				30%	\$ 299,706
ESTIMATE BEFORE CONSTRUCTION CONTINGENCY					\$ 1,299,000
CONSTRUCTION CONTINGENCY - <i>Note 2</i>				5%	\$ 64,950
ESTIMATE CONSTRUCTION CONTRACT PRICE with CONTINGENCY (excl. HST)					\$ 1,364,000
Engineering and Design Services				8%	\$ 109,120
TOTAL ESTIMATE CONSTRUCTION & ENGINEERING PRICE (Excluding HST)					\$ 1,473,200
THIS OPINION OF PROBABLE COSTS IS PRESENTED ON THE BASIS OF EXPERIENCE, QUALIFICATIONS, AND BEST JUDGEMENT. IT HAS BEEN PREPARED IN ACCORDANCE WITH ACCEPTABLE PRINCIPLES AND PRACTICES. SUDDEN MARKET TREND CHANGES, NON-COMPETITIVE BIDDING SITUATIONS, UNFORESEEN LABOUR AND MATERIAL ADJUSTMENTS, UNFORESEEN SITE CONDITIONS, AND THE LIKE ARE BEYOND THE CONTROL OF CBCL LIMITED. IT IS NOT A PREDICTION OF LOW PRICE. AS SUCH WE CANNOT WARRANT OR GUARANTEE THAT ACTUAL COSTS WILL NOT VARY FROM THE OPINION PROVIDED. IT IS BASED ON THE DATE OF THIS BUDGET.					
Note 1	This Allowance is to account for uncertainty in construction cost due to undefined design scope.				
Note 2	The Construction Contingency is to factor in potential post tender Change Orders.				



OPINION of PROBABLE CONSTRUCTION COSTS
PROJECT NAME: Berwick Stormwater Management Plan
Berwick, NS

DATE:	24-03-2026
CBCL No:	251083.00
Prepared by:	PG
Reviewed by:	AT
Budget Class:	Class D

SUMMARY

SCHEDULE OF QUANTITIES AND UNIT PRICES

Item	Description	Unit	Est. Qty.	Unit Price	Subtotal Price
3.b) Channel Improvements & Diversion with Additional Detention Alternate					
EARTHWORKS					
4.001	Mass Excavation - Common Reuse on Site	m3	221	\$ 32	\$ 7,116
4.002	Mass Excavation - Common Dispose Off Site	m3	7,379	\$ 40	\$ 297,005
4.003	Rip Rap	m	1,248	\$ 100	\$ 124,766
4.004	Geotextile	m2	3,565	\$ 4	\$ 14,259
STORM SYSTEM					
4.005	Storm Sewer - 1200mm Concrete 65D	m	265	\$ 1,500	\$ 397,500
4.006	Precast Manhole - 2100mm	ea	1	\$ 29,000	\$ 29,000
4.007	Catch Basin	ea	1	\$ 6,000	\$ 6,000
ROADWORK & REINSTATEMENT					
4.008	Site Access and Reinstatement Allowance	LS	1	\$ 55,500	\$ 55,500
4.009	Asphalt	m2	20	\$ 69	\$ 1,380
4.010	Type I Gravel - 150mm Thick	m2	20	\$ 23	\$ 460
4.011	Type II Gravel - 250mm Thick	m2	20	\$ 29	\$ 575
4.012	Asphalt Sidewalk	m2	8	\$ 207	\$ 1,553
4.013	Topsoil and Sod - 150mm Thick	m2	5,800	\$ 29	\$ 166,750
4.014	Environmental Protection	LS	1	\$ 32,300	\$ 32,300
DESIGN DEVELOPMENT ALLOWANCE - Note 1				30%	\$ 340,249
ESTIMATE BEFORE CONSTRUCTION CONTINGENCY					\$ 1,475,000
CONSTRUCTION CONTINGENCY - Note 2				5%	\$ 73,750
ESTIMATE CONSTRUCTION CONTRACT PRICE with CONTINGENCY (excl. HST)					\$ 1,548,800
Engineering and Design Services				8%	\$ 123,910
TOTAL ESTIMATE CONSTRUCTION & ENGINEERING PRICE (Excluding HST)					\$ 1,672,800
THIS OPINION OF PROBABLE COSTS IS PRESENTED ON THE BASIS OF EXPERIENCE, QUALIFICATIONS, AND BEST JUDGEMENT. IT HAS BEEN PREPARED IN ACCORDANCE WITH ACCEPTABLE PRINCIPLES AND PRACTICES. SUDDEN MARKET TREND CHANGES, NON-COMPETITIVE BIDDING SITUATIONS, UNFORESEEN LABOUR AND MATERIAL ADJUSTMENTS, UNFORESEEN SITE CONDITIONS, AND THE LIKE ARE BEYOND THE CONTROL OF CBCL LIMITED. IT IS NOT A PREDICTION OF LOW PRICE. AS SUCH WE CANNOT WARRANT OR GUARANTEE THAT ACTUAL COSTS WILL NOT VARY FROM THE OPINION PROVIDED. IT IS BASED ON THE DATE OF THIS BUDGET.					
Note 1	This Allowance is to account for uncertainty in construction cost due to undefined design scope.				
Note 2	The Construction Contingency is to factor in potential post tender Change Orders.				



OPINION of PROBABLE CONSTRUCTION COSTS
PROJECT NAME: Berwick Stormwater Management Plan
Berwick, NS

DATE:	24-03-2026
CBCL No:	251083.00
Prepared by:	PG
Reviewed by:	AT
Budget Class:	Class D

SUMMARY

SCHEDULE OF QUANTITIES AND UNIT PRICES

Item	Description	Unit	Est. Qty.	Unit Price	Subtotal Price
4. Minor Projects					
	STORM SYSTEM				
5.001	Gravenstein Drive at Spartan Drive	LS	1	\$ 107,000	\$ 107,000
5.002	Brown Street at Front Street	LS	1	\$ 275,000	\$ 275,000
5.003	Lawrence Street and Main Street	LS	1	\$ 93,000	\$ 93,000
	DESIGN DEVELOPMENT ALLOWANCE - <i>Note 1</i>			30%	\$ 142,500
	ESTIMATE BEFORE CONSTRUCTION CONTINGENCY				\$ 618,000
	CONSTRUCTION CONTINGENCY - <i>Note 2</i>			5%	\$ 30,900
	ESTIMATE CONSTRUCTION CONTRACT PRICE with CONTINGENCY (excl. HST)				\$ 648,900
	Engineering and Design Services			8%	\$ 51,920
	TOTAL ESTIMATE CONSTRUCTION & ENGINEERING PRICE (Excluding HST)				\$ 700,900

THIS OPINION OF PROBABLE COSTS IS PRESENTED ON THE BASIS OF EXPERIENCE, QUALIFICATIONS, AND BEST JUDGEMENT. IT HAS BEEN PREPARED IN ACCORDANCE WITH ACCEPTABLE PRINCIPLES AND PRACTICES. SUDDEN MARKET TREND CHANGES, NON-COMPETITIVE BIDDING SITUATIONS, UNFORESEEN LABOUR AND MATERIAL ADJUSTMENTS, UNFORESEEN SITE CONDITIONS, AND THE LIKE ARE BEYOND THE CONTROL OF CBCL LIMITED. IT IS NOT A PREDICTION OF LOW PRICE. AS SUCH WE CANNOT WARRANT OR GUARANTEE THAT ACTUAL COSTS WILL NOT VARY FROM THE OPINION PROVIDED. IT IS BASED ON THE DATE OF THIS BUDGET.

Note 1 This Allowance is to account for uncertainty in construction cost due to undefined design scope.

Note 2 The Construction Contingency is to factor in potential post tender Change Orders.

Budget Definitions

A **Class "D" Budget** is an order of magnitude conceptual budget to screen various alternative solutions. Project documents are in the initial stages but sufficient information is available to provide an indication of probable cost and allow ranking of the various options being considered. Design development is typically in the concept stage.

A **Class "C" Budget** is based on a full description of the preferred option, construction/design experience and market conditions. This estimate should be sufficient for making correct investment decisions and obtaining preliminary project approval. Design development is typically in the order of 25% complete.

A **Class "B" Budget** is based on preliminary detailed design drawings and outline specifications or performance criteria, which includes design of all major systems and subsystems. The result of all site/installation investigations have been incorporated. This budget should provide for the establishment of realistic prediction of cost and be sufficient to obtain effective project approval. Design development is typically in the order of 65% complete.

A **Class "A" Budget** is based on complete or substantially complete working drawings and specifications prior to calling for competitive bids. This estimate should be sufficient to allow a detailed reconciliation/negotiation with bidding contractors after tender. This estimate will contain only those cash allowances called for in the tender documents and will not allow for design contingencies, but include a post award construction contingency. Design development is typically in the order of 95% to 100% .

APPENDIX D

Draft Report Comment Responses



Contract Name: Berwick SWMP
Contract No.: 251083.00



Comment Tracker

Project Manager: AE

Document No.: CT01
Date Revised: 1-Apr-26

Comment Information					Response Information			
Comment No.	Submission Revision	Date	Section/PDF Page	Town of Berwick Comment	Discipline	Assignee	CBCL Response & Action	Status (Open/Closed)
1	01	2026-03-09	Contents/4	Can you add a list of acronyms?	General	PM	A list of acronyms and abbreviations has been added.	Closed
2	01	2026-03-09	1/6	Prior to this, could we have a very brief Executive Summary, with a list of the final Recommendations.	General	PM	An excecutive summary has been added to the report.	Closed
3	01	2026-03-09	1.2/6	Global change: please change all instances of "town" with "Town"?	General	PM	Any instances of "town" have been updated.	Closed
4	01	2026-03-09	1.2/7	[Spelling]	General	PM	Error fixed.	Closed
5	01	2026-03-09	2.1/8	We do use salt, but we strive to minimize the amount. We almost always use a mix of sand and salt.	General	PM	This sentence's wording has been revised to reflect this.	Closed
6	01	2026-03-09	2.3/10	Can a map be included showing the location of each of these assumptions?	Water Resources	NM	An additional figure showing this has been added.	Closed
7	01	2026-03-09	2.3.4.2/15	How come? Are we using [the SSP3-7.0 climate change scenario] because it's more representative of a most likely pathway?	Water Resources	BP/NM	Wording has been added to the end of section 2.3.4	Closed
8	01	2026-03-09	2.4/18	How do you determine which [runoff] coefficient to use for each subcatchment? Is this decided automatically based on green hues in the map, or are these hand-picked values for each subcatchment?	Water Resources	NM	Runoff coefficients are a result of the dyanmic SWMM engine hydrologic simulation. They are a result of the watershed characteristics, including extent of imperviousness, as set out in Section 2.3.1. Some wording has been added to clarify this.	Closed
9	01	2026-03-09	2.4/19	Can the report include an additional figure that is a zoomed-in view showing the area of the map that includes the predominant orange and yellow areas?	Water Resources	NM	An additional figure showing this has been added.	Closed
10	01	2026-03-09	2.4/19	What specifically does a "No" mean? Is this saying that the model was unable to replicate flood conditions in this area? If this is the case, does this suggest that some of our assumptions are inaccurate?" Perhaps just add a comment to this entry that explains this.	Water Resources	NM	No is indicative that model results are not consistent with the experience in the field. It is difficult with the descriptions to confirm depths and impacts of what is reported however the comments column has been expanded to clarify why we think there is inconsistencies between the model and the reported flooding.	Closed
11	01	2026-03-09	2.4/20	Is this referring to the open field behind (north of) 226 Main Street? Is the comment suggesting that there is a culvert running through this field, or within the small open ditch that separates the dwelling at 226 Main Street from the field?	Water Resources	NM	This has been updated to refer to the open space development lands and the flooding due to the river water levels.	Closed
12	01	2026-03-09	2.4/21	NS PW records show this bridge is a Town Asset, and we don't have any data to refute this. I do know that Don Regan, former town employee use to do inspections on this bridge, which further supports that it's a town asset.	Water Resources	NM	Reference to ownership has been removed.	Closed
13	01	2026-03-09	2.4/21	Is this saying that Wheaton's and the Firehall Properties show some degree of flooding in the modeling?	Water Resources	NM	Wording updated to clarify from the flooding notes received from the start up meeting that the raised land the properties are on are not subject to flooding but the low lying lands north of Main Street in the area are subject to riverine flooding.	Closed
14	01	2026-03-09	3.1/24	Is this localized flooding [at Gravenstein Drive at Spartan Avenue intersection] a result of the assumed culvert size at this intersection?	Water Resources	NM	Yes, however a larger culvert than is likely present will be required to reduce ponding significantly therefore confirmation of culvert size is unlikely to result in a reduction of flood area under climate change conditions.	Closed
15	01	2026-03-09	3.2/26	Can [flooding at intersection of Browns at Front Street] be fixed simply by replacing the culverts with a larger size?	Water Resources	NM	Modelling and discussion of culvert upsizing in this area (and two others) has been added.	Closed
16	01	2026-03-09	3.3/28	Is [increased flood risk to private dwellings at the rear of Bezanson Drive and Beckwith Drive] due to the culvert size that connects Beckwith to the open ditch to the east?	Water Resources	NM	No, the flow from the open ditch to the east of Bezanson Drive flows west towards Bezanson Drive based on the topographical data. A larger culvert under Bezanson Drive may reduce flood risk to properties east of Bezanson Drive but should be completed in conjunction with increases in conveyance capacity downstream so that flood risk downstream is not increased. Wording has been added to Section	Closed
17	01	2026-03-09	3.4/30	Observations by the Public Works Team during the July 11 2024 rain event support this.	General	PM	Acknowledged.	Closed
18	01	2026-03-09	3.5/31	This was also observed to occur during the July 11 2024 rain event, by the Public Works Staff.	General	PM	Acknowledged.	Closed
19	01	2026-03-09	3.11/40	Is [the box culvert under Maple Street] a NS PW, or a ToB asset? QGIS data suggests this is a ToB asset.	Civil	PM/AE	According to NSDPW Highway Programs Asset Viewer, this portion of Main/Maple Street is owned and maintained by the municipality. Therefore, it is our assumption that the box culvert is a Town asset. The box culvert is also within Town limits.	Closed
20	01	2026-03-09	4.1/42	Can [identified upgrade opportunities] be shown as a numerical list?	Civil	PM	The upgrade opportunities for each appropriate area of interest have been included in the newly added Table 4-1.	Closed



Contract Name: Berwick SWMP
Contract No.: 251083.00

Project Manager: AE

Document No.: CT01
Date Revised: 1-Apr-26

Comment Tracker

Comment Information					Response Information			
Comment No.	Submission Revision	Date	Section/PDF Page	Town of Berwick Comment	Discipline	Assignee	CBCL Response & Action	Status (Open/Closed)
21	01	2026-03-09	4.2/42	It should be more clearly explained why the mitigation options don't consider 3.1, 3.2, 3.3, 3.7, 3.8, 3.9, 3.10 and 3.11.	Civil	PM	We have added a table to Section 4.1 summarizing the suitability of each area for mitigation. Mitigation efforts were focused on flooding that a) is caused by deficient municipal infrastructure rather than local issues such as lot grading, b) affects residential dwellings and other buildings, and c) overtops roads and poses emergency access challenges.	Closed
22	01	2026-03-09	4.2.4/57	[Spelling]	General	PM	Error fixed.	Closed
23	01	2026-03-09	5.1/68	Write these recommendations as a list, with the comments as a sub-bullet. This will make it easier to see the recommendations.	Civil	PM	We agree that dividing the recommendations makes them easier to understand. Instead of a list/bullet point format, however, we have broken them out into sub-sections.	Closed
24	01	2026-03-09	5.2.4/72	Add a sentence to clarify the difference between [Floodway and Flood Fringe].	Water Resources	PM/BP	Additional verbiage has been added to explain the difference between the Floodway and the Floodway Fringe.	Closed
25	01	2026-03-09	5.2.4/72	I don't see [full-size Figures 5-4 and 5-5] in Appendix B.	Civil	PM	Drawings C01 and C02 have been added to Appendix B.	Closed
26	01	2026-03-09	5.2.4/74	Is this statement accurate?	Water Resources	PM/BP	Yes, this statement is accurate. Note that this is not a recommendation made by CBCL; this is a provincial mandate under Nova Scotia's Statements of Provincial Interest, NS Reg 101/2001.	Closed
27	01	2026-03-09	5.2.4/74	Please explain the difference in how the Floodway and Flood Fringe are delineated. Is one the 1:10 and one the 1:25-year event?	Water Resources	NM/BP	The Floodway and Floodway Fringe are defined as the 1:20- and 1:100-year river-induced flood extents. Additional verbiage has been added to make this more clear.	Closed
28	01	2026-03-09	6/76	Provide a drescription, or a reference to this description earlier in the document.	Civil	PM	The headers for the costing table have been revised to be more clear.	Closed
29	01	2026-03-09	6/76	Is this Scenario 5? Does it include ditch improvements from Cottage to Horsburgh, or just the new proposed channel?	Civil	PM	Please see response to comment No. 29. Yes, this cost includes all the infrastructure upgrades as described in Section 4.2.5. The channel improvements from Cottage to Horsburgh were included. Additional verbiage has been added to Sections 4.2.5 and 4.2.6 to make this more clear.	Closed



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