Cohort 2 National Project Final Technical Report

Town of Florenceville-Bristol, New Brunswick

February 2020

Municipal Natural Assets Initiative

Making Nature Count

INVEST IN NATURE

The Municipal Natural Assets Initiative (MNAI) is changing the way municipalities deliver everyday services, increasing the quality and resilience of infrastructure at lower costs and reduced risk. The MNAI team provides scientific, economic and municipal expertise to support and guide local governments in identifying, valuing and accounting for natural assets in their financial planning and asset management programs and developing leading-edge, sustainable and climate resilient infrastructure.

Acknowledgements

Technical report prepared by: MNAI Technical Team: Michelle Molnar, Jeff Wilson, Josh Thiessen, Amy Taylor; WWF-Canada: Simon J. Mitchell

Reviewers: MNAI: Roy Brooke; WWF-Canada: Simon J. Mitchell; WVRSC: Barb Sharp; Town of Florenceville-Bristol: Sarah Pacey, CAO

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Convening organizations: Smart Prosperity Institute, David Suzuki Foundation, Town of Gibsons, BC, and Roy Brooke and Associates were the original convening partners for the Municipal Natural Assets Initiative and the Cohort 2 project leading to this report was initiated by them.

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Summary

The Municipal Natural Asset Initiative (MNAI) project was initiated by the Western Valley Regional Service Commission (WVRSC) and World Wildlife Fund Canada (WWF Canada) for Florenceville-Bristol to increase their understanding of how proper management of natural assets within the community can reduce soil erosion and thereby reduce soil loss and improve water quality. To that end, the project examined flood and stormwater flows under alternative land cover scenarios to assess the contribution of natural assets to erosion control.

The project area is located along the St. John River in the community of Florenceville-Bristol within the WVRSC. According to the 2016 census, Florenceville-Bristol is a community of 1,604 people with 723 private dwellings predominately located along the banks of the St. John River. The specific project areas are 2 catchments on the south side of the St. John River that cover 182 hectares. The catchment areas play an important role in water retention preventing flooding and downstream erosion.

The Florenceville-Bristol project examined the impact of changes in surface conditions in the upper watershed on peak flow levels taking into account changing climate conditions. Two scenarios were examined. Scenario 1 examined peak flow rates under existing conditions at 3 storm return periods: 1 in 5 year storm, 1 in 100 year storm, and 1 in 100 year storm + 20%. Scenario 2 examined peak flow rates assuming a change in land cover in the upper watershed from forest to agriculture under the same 3 storm return periods as in Scenario 1. The scenarios were modelled by Crandall Engineering Ltd., which provided a report detailing their approach and findings.

Modelling results demonstrate the contribution of the natural assets to managing peak flow rates under the 2 scenarios. Considering a 1 in 5 year storm, the increase in peak flow from scenario 1 (current land cover) to scenario 2 (shift in land cover from forest to agriculture), was estimated to be 94%. This increase is 65% for a 1 in 100 year storm and 59% for a 1 in 100 year storm + 20%. The modelling results thus demonstrate a significant increase in the peak flows if the surface condition of the upper watershed is changed from forest to agriculture. The impact is most significant for smaller rain events (1:5-year).

The replacement cost method was used to estimate the value of forest lands within the project area. The replacement cost approach assumes that a natural asset's value is at least equal to the cost of replacing them with engineered alternative(s) capable of providing the same level of service. Overall, to replace the peak flow attenuation services provided by forest cover in the project area would cost $3.5 million. If climate change increases the intensity of rainfall for a 1:100 year event by 20%, the value of peak flow attenuation services increases by $600,000 to $4.1 million. This cost does not include the value of co-benefits (e.g. access to green and recreational space for residents, wildlife habitat, hydraulic detention, and water quality functions) derived from the natural assets within the study area.

To ensure the long term stormwater services provided by the forested area within the project site, consideration should be given to the development of a natural asset management plan. The goal of such a plan is to ensure management decisions protect and enhance natural values and that human use within the area does not cause unacceptable impacts to their condition and level of service. Consideration can also be given to the development of a natural asset policy, documentation of the life cycle cost of natural asset management, and bylaws that prioritize standards and requirements for the provision of stormwater management via natural assets over built assets.

1 Introduction

The term "municipal natural assets" refers to the stock of natural resources or ecosystems that is relied upon, managed, or could be managed by a municipality, regional district, or other form of local government for the sustainable provision of one or more local government services (MNAI, 2017). By conceptualizing nature as an asset, we can codify, measure, and track the ways in which we depend on and impact the environment. Business and economic activity depends on natural assets to provide important inputs into production such as clean water, minerals, and timber. Natural assets are also important to human physical and social well-being. Benefits in terms of better air quality, water quality, flood protection, and climate stability are well established. Urban greenspaces, parks, wetlands, and protected areas provide important recreation spaces and buffer the effect of extreme heat in urban settings reducing the prevalence of respiratory infections and heat related illnesses. If natural assets are not managed responsibly, their value depreciates as does their ability to provide services from which humans and nature benefit. Indeed, like any asset, natural assets need to be carefully managed to ensure a sustainable supply of services.

Communities like Florenceville-Bristol recognize that it is as important to understand, measure, manage and account for natural assets as it is for engineered ones. Florenceville-Bristol has undergone a detailed inventory of traditional municipal assets and is interested in developing a better understanding of natural assets and how they can be included alongside traditional asset management. To that end, the Municipal Natural Asset Initiative (MNAI) project was initiated by the Western Valley Regional Service Commission (WVRSC) and WWF-Canada for Florenceville-Bristol to increase their understanding of how proper management of the natural assets within the community contribute to reduced soil erosion and hence reduced soil loss and improved water quality. This report summarizes the results of the Florenceville-Bristol project. It is organized as follows:

- This **Introduction** chapter describes the project objectives, the study area and provides a brief overview of the relevant natural assets.
- The **Methodology** chapter describes the modelling approach that was employed to assess the benefits derived from natural assets around Florenceville-Bristol.
- The **Assessment of Natural Assets** chapter describes the quantity and condition of natural assets in the study area including the value of the assets for erosion control.
- The **Planning for Natural Assets** chapter describes specific actions that should be considered in a natural asset plan to protect the natural assets of interest.
- The **Implementation of Natural Assets Plan** chapter describes the challenges that may limit the implementation of the natural asset plan as well as strategies for overcoming those challenges.
- The **Conclusion** chapter summarizes the approach and findings of the study and articulates next steps and key priorities for Florenceville-Bristol and WVRSC.
- **Appendices** at the end of the report contain information of relevance to the project and associated outcomes.

1.1 Objective

Based on discussions with WVRSC and Florenceville-Bristol, it was decided that the MNAI project would focus on erosion issues in the community. A number of specific areas within Florenceville-Bristol where erosion issues exist and maintenance is required were noted:

- Erosion around the boardwalk along the St. John river, largely caused by ice jams and scouring.
- Erosion correlated with areas where there is major flooding, specifically around the sewage lagoon.
- Road washouts caused by heavier rainfall events.

The primary goal of the MNAI project was to understand the role natural assets play in controlling erosion and the associated implications for the maintenance of culverts and roadside ditches. The project thus examined flood and stormwater flows under alternative land cover scenarios to assess the contribution of natural assets to erosion control.

1.2 Project Area

The project area is located along the St. John River through the community of Florenceville-Bristol within the WVRSC. According to the 2016 census, Florenceville-Bristol is a community of 1,604 people with 723 private dwellings predominately located along the banks of the St. John River. The specific area of concern are the 2 catchment areas (labelled A and B in Figure 1) on the south side of the St. John River. The total catchment area (sum of catchments A and B) is 182 hectares. The catchment areas play an important role in water retention preventing flooding and downstream erosion. The subdivision, including Tapley Road and Sentier New Brunswick Trail as well as dwellings along route 105 below the catchment area are vulnerable to flooding.

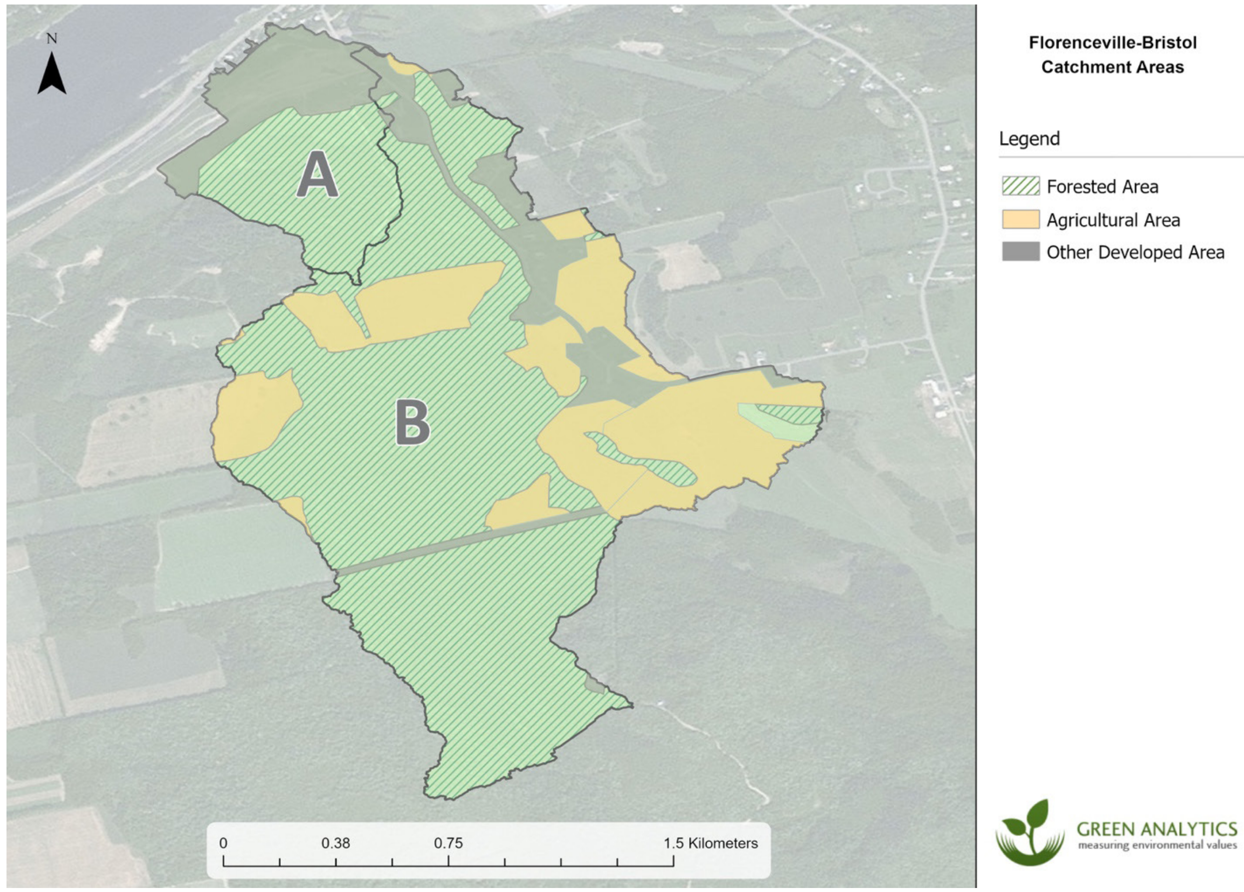

Figure 1. Florenceville-Bristol catchment areas. Source: Green Analytics

The project area consists of forest land (63.6%), agriculture land (22.6%), and developed land (13.8%) (Table 1). The Bristol Heights subdivision is located within catchment A and consists of 44 hectares of residential lots which are serviced by 1.5 kilometers of road. A portion of land adjacent to the current subdivision wwn tower are also located within the project area.

TABLE 1 – LAND COVER IN THE PROJECT AREA

Land Cover Type	Catchment A (ha)	Catchment B (ha)	Total Area (ha)
Forest	17.2	98.5	115.7
Agriculture		41.1	41.1
Developed	10.7	14.4	25.1
Total	**27.9**	**154.0**	**181.8**

1.3 Natural Asset Focus

MNAI defines natural assets as ecosystem features that are nature-based and provide services that would otherwise require the equivalent of engineered infrastructure (MNAI, 2017). For local governments, natural assets can include forests that convey stormwater and recharge aquifers, wetlands that reduce flooding risk, and coastal areas that protect against storm surges and sea level rise, among others. By identifying natural assets at the community level and prioritizing them in municipal asset management portfolios, local governments can secure important budget savings while also delivering vital municipal services. Budget savings can be realised through reduced or eliminated capital costs, lower operating costs, and lower renewal costs. Local governments will also be better prepared to deal with the effects of climate change (MNAI, 2017).

The natural assets of interest to the Florenceville-Bristol project are those that provide significant erosion control benefits, namely the forested land in the upper areas of catchments A and B that protect the settled areas along the river. These areas were identified by examining areas of regular flood and stormwater flows. They consist of multiple land parcels with multiple owners, including the town of Florenceville-Bristol. While the upper areas of the catchments have likely been forested for some time (given the topography of the area) there has been active forest harvesting on several parcels within the catchments. This is likely to continue. Private forest owners in the region have access to a number of programs operated by the Carleton-Victoria Wood Producers Association and Forest Products Marketing Board, including woodlot silviculture, road location, block layout and product marketing.

2 Approach

This section of the document describes the approach employed to complete the Florenceville-Bristol project. An overview of the MNAI approach is provided along with a more detailed description of the modelling work that was completed.

2.1 MNAI Approach

MNAI's natural asset methodology is rooted in modern, structured asset management processes. The methodology follows the standard asset management assess, plan and implement steps, highlighting novel considerations required for local natural assets and associated services.

MNAI has a range of tools, including templates and guidelines, that are configured for use according to local government needs. The methodology and tools are delivered through ongoing support from the MNAI technical team over the project life. The levels and details of this support are described in a Memorandum of Understanding that MNAI signs with local government partners.

Asset management strategies require a multi-disciplinary, team-based approach. The MNAI process therefore begins with an initial engagement session with community representatives from across a range of disciplines. This includes, for example, representatives from Parks, Public Works, GIS, Engineering, Planning, Water and Wastewater, and Finance. During the initial engagement session, plans and priorities of the community are discussed, and key natural assets within the jurisdictional boundaries of the community are identified along with the important services they provide. Site visits to the natural assets may be undertaken and key geospatial features observed and documented. The objectives of this initial engagement session are to identify:

- the natural asset/s that will be the focus of the natural asset assessment,
- the geographic boundary/ies of the focus assets,
- the skillsets and expertise of relevance to the natural asset assessment,
- community personnel that will engage in the assessment process, and
- data needs of the assessment and the sources for the relevant data.

The initial community engagement session for the Florenceville-Bristol project took place on May 24, 2018. Appendix A contains the agenda for the session along with a list of participants. At the completion of the session, the focus on the role of natural assets in providing erosion control benefits was established.

Following the initial community engagement session, the MNAI team works with the target community to complete a natural asset assessment. The assessment generally involves the following steps:

1. Define the scope of the natural assets.
2. Inventory the natural assets by collecting and organizing existing information about the natural assets.
3. Conduct a condition assessment of the natural assets.
4. Conduct a risk assessment of the natural assets.
5. Quantify existing service levels from the natural assets.
6. Develop scenarios to explore alternative management plans and future implications to existing service levels from the natural assets.
7. Quantify service levels under alternative scenarios.
8. Develop operation and management plans based on existing conditions, risks, and desired service level trajectories.

The steps above were completed for Florenceville-Bristol with a focus on the subset of natural assets that provide erosion control services. The scope of the project was determined by weighing the project objectives against data availability and proposed modelling and economic approaches. The asset inventory was informed by land cover data obtained from the community and provincial data sets. The condition and risk assessment were conducted in consultation with community representatives. The same approach was taken to defining the alternative management scenarios and future implications to existing service levels. The modelling approach employed to quantify the service levels under the alternative scenarios (Step 7 above) is described below.

2.2 Modelling Approach for Scenario Analysis

The Florenceville-Bristol project examined the impact of changes in surface conditions in the upper watershed on peak flow levels taking into account changing climate conditions. Two scenarios were examined:

- **Scenario 1** examined peak flow rates under existing conditions at 3 storm return periods: 1 in 5 year storm, 1 in 100 year storm, and 1 in 100 year storm + 20%. The higher storm return periods reflect predicted increased intensity of storm events due to climate change.
- **Scenario 2** examined peak flow rates assuming a change in land cover in the upper watershed from forest to agriculture land under the same 3 storm return periods as were explored for Scenario 1.

The scenarios were modelled by Crandall Engineering Ltd., which provided a report detailing their approach and findings. These are summarized in the current document. Figure 2 shows the project area, which consists of 2 catchment areas (specifically catchment area A and catchment area B) and associated sub-catchment areas. These catchment areas were the focus of the peak flow assessment. The figure notes the area (in hectares) for each sub-catchment. For the purposes of Scenario 2, sub-catchments A1, A2 and B1 were assumed to be converted from forested to agricultural lands.

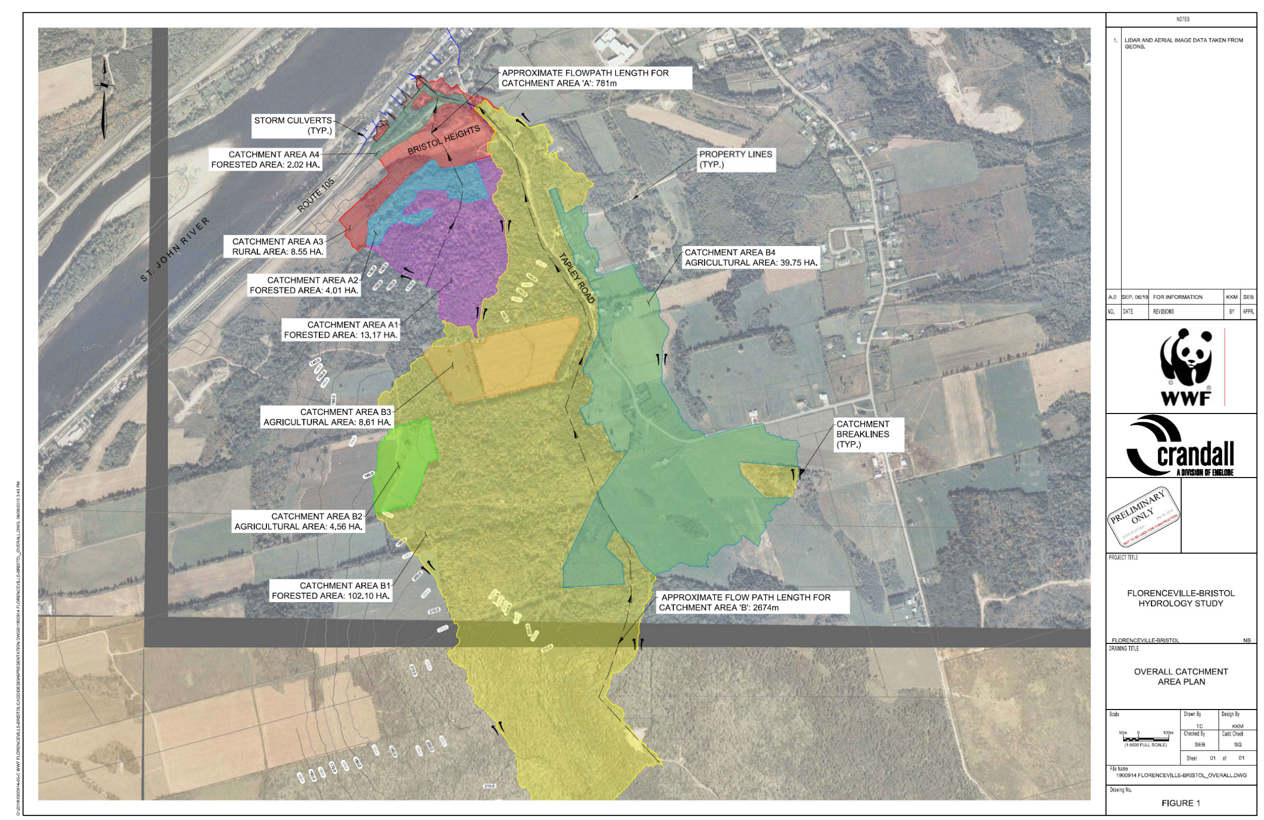

Figure 2. Project area with catchment and sub-catchment areas delineated. Source: WWF-Canada & Crandall Engineering Ltd.

To assess the peak flow rates under the 2 scenarios for the 2 catchment areas, Crandall Engineering Ltd. used the USSCS TR-20 Method, a storm event surface water hydrologic approach that is applied at a watershed scale. The approach enables the hydrologic evaluation of flood events. It is suitable for analyzing current watershed conditions (as in Scenario 1) as well as the impact of potential changes within a watershed (as in Scenario 2). Multiple storms (or rainfall frequencies) can be analyzed within one model run (i.e. 1 in 5, 1 in 100 and 1 in 100 + 20% events).[1]

Three inputs were required to complete the modelling:

- Rainfall Hyetograph [based on Intensity-Duration-Frequency (IDF) curves] - Rainfall intensity was determined from IDF curves obtained from Environment Canada. Specifically, the IDF curve from St. Leonard 'A' (2014) was used for this exercise. The Beechwood Station IDF curve was considered, however, due to a lack of recent data, it was not selected.
- Curve Number (CN) - To determine the CN for each of the project areas, the soils within the catchment areas were categorized into one of the 4 hydrologic soil groups (HSG) representing surface infiltration rate and subsurface permeability. Using the Woodstock-Florenceville soil survey report,[2] the predominant soil types in the area were identified as Caribou (Ca) and Carleton (Cr) Till, which are classified as either B or C using the USSCS HSG classification methodology. For this exercise, the HSG classification 'C' was conservatively selected for the catchment areas.
- Time of Concentration - Time of concentration for the project area was calculated based on the City of Moncton Design Criteria Manual.[3] The relevant catchment areas consist of overland sheet flow and shallow concentrated flow. Sheet flow occurs in the first section of the flow path where the maximum length is based on the surface condition and the slope. Shallow concentrated flow occurs for the remainder of the flow segment. The impact of driveway culverts or cross-culvert restrictions/storage were not considered for this exercise due to the lack of available information. Appendix B describes the equations required to calculate the time of concentration for the project area.

The inputs above were entered into the hydrological model to determine peak flows based on the time of concentrations for the project area, specifically for the cross culvert on Route 105 for each of the scenarios.

1 The USSCS TR-20 Method was modelled using HydroCad (Version 10.0) software.

2 Fahmy, S.H., Rees, H.W., and Solely, T.J., 2001.

3 City of Moncton, 2013.

3 Natural Asset Assessment

This section of the report presents the results of the assessment of natural assets within the project area. As is noted, the natural asset assessment process begins with the completion of an asset inventory. For this community, the natural assets of focus are the forest lands within catchment A and catchment B.

3.1 Asset Inventory

Once catchment boundaries were defined, forest and land cover data was overlaid to define the relevant natural assets. With forest being the primary natural asset of interest, the inventory was developed based on the best available forest data.[4] Table 2 summarizes the natural asset inventory organized by forest types within each of the catchment areas and Figure 3 depicts the spatial distribution of these forest types.

TABLE 2 – NATURAL ASSET INVENTORY FOR THE PROJECT AREA

Forest Cover Type	Catchment A (ha)	Catchment B (ha)	Total Area (ha)
Balsam Fir		11.6	11.6
Beech		7.6	7.6
Birch	2.0	9.5	11.6
Eastern hemlock		3.7	3.7
Poplar		15.0	15.0
Red Maple	0.3	10.9	11.1
Red Spruce		4.6	4.6
Sugar Maple		19.3	19.3
White Spruce	10.9	12.8	23.6
Unknown	4.0	3.5	7.5
Total Forest Cover	**17.2**	**98.5**	**115.7**

4 Spatial data was accessed from GeoNB open data website: http://www.snb.ca/geonb1/e/DC/forest.asp

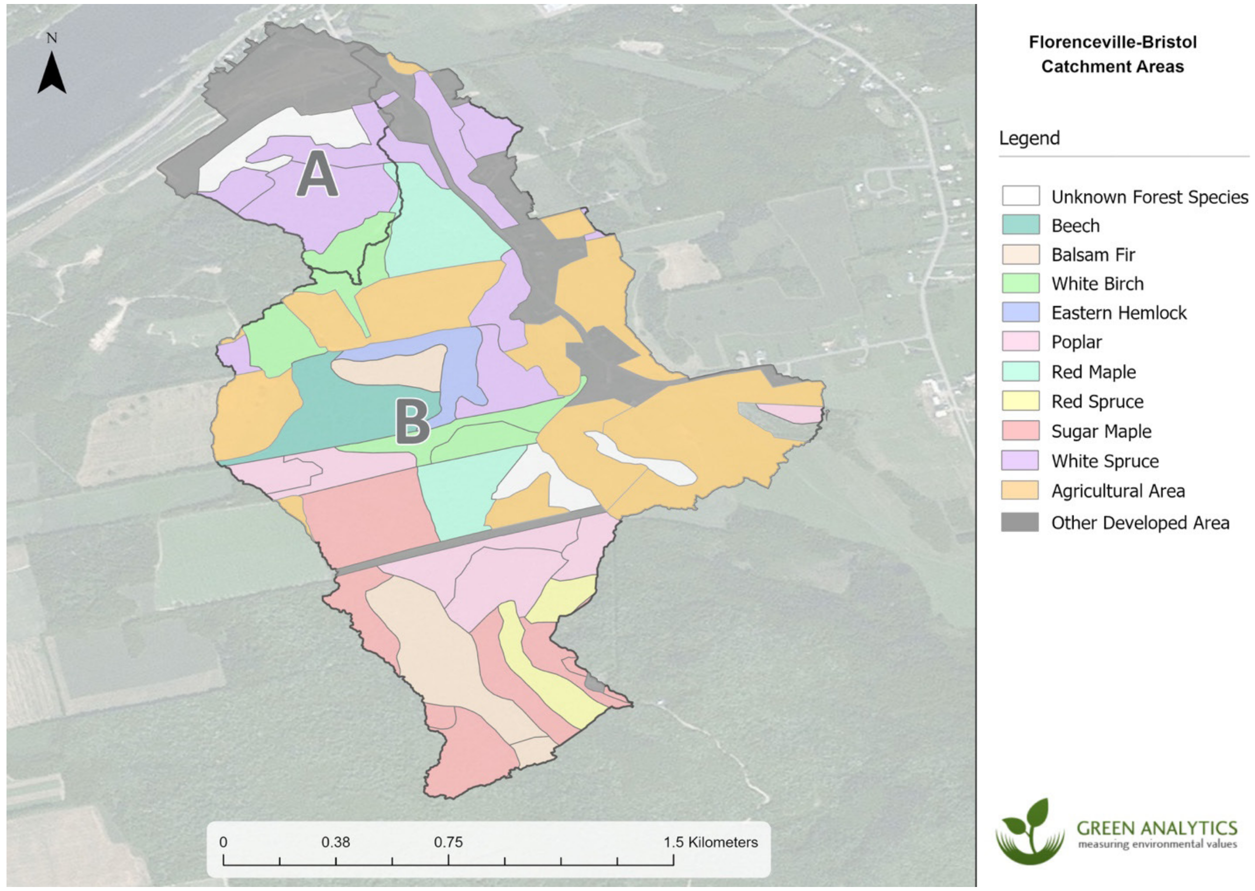

Figure 3. Forest asset details by catchment area. Source: Green Analytics.

3.2 Condition Assessment

The condition of natural assets influences the provision of ecosystem services and the resiliency of such assets to threats. A condition assessment examines how well assets are functioning in relation to their ability to provide services. A baseline condition assessment can be used as a basis for modelling changes in the level of ecosystem service provision that may result from interventions or impacts that affect asset conditions.

To develop a baseline condition assessment, community representatives examined the natural areas. Based on the field assessment, each area was given a condition rating based on expert field staff judgement. Opportunities for improvement were also noted. The results of this assessment are summarized in Table 3. Condition ratings were defined as follows:

- Very good - Well maintained, good condition, no signs of deterioration in ecological conditions.
- Good - Ecological conditions appear to be sufficient, some minor localized (or isolated) impacts noticeable, which may be a warning sign of possible decline.
- Fair - Clear signs of deterioration in ecological function and service influencing factors.
- Poor - Condition is below standard with large portion/s of the system exhibiting significant deterioration in ecological function.
- Very poor - Widespread signs of advanced deterioration, unlikely the natural asset is providing any functional service.

TABLE 3 – NATURAL ASSET CONDITION ASSESSMENT FOR THE PROJECT AREA

Asset Zone	Catchment	Description	Physical Condition	Potential for improvement (Y/N)	Potential improvement opportunities
Upper Natural Area	A	Red Maple	Good	Y	Note 1
Upper Natural Area	A	Sparse White Birch	Poor	Y	Note 2
Upper Natural Area	A	White Birch	Good	Y	Note 1
Upper Natural Area	A	White Spruce	Good	Y	Note 1
Lower Developed Area	A	Developed	Fair	Y	Note 3
Lower Developed Area	A	Road	NA	N	
Lower Developed Area	A	Transmission Route	Fair / Poor	N	
Lower Developed Area	A	Unclassified Forest	Fair / Poor	Uncertain	Note 4
Upper Natural Area	B	Unclassified Forest	Fair	Y	Note 1
Upper Natural Area	B	White Birch	Good	Y	Note 1
Upper Natural Area	B	Poplar	Good	Y	Note 1
Upper Natural Area	B	Red Maple	Good	Y	Note 1
Upper Natural Area	B	White Spruce	Good	Y	Note 1
Upper Natural Area	B	Beech	Good	Y	Note 1
Upper Natural Area	B	Eastern hemlock	Good	Y	Note 1
Upper Natural Area	B	Balsam fir	Good	Y	Note 1
Upper Natural Area	B	Red spruce	Good	Y	Note 1
Upper Natural Area	B	Sugar maple	Good	Y	Note 1

Potential Improvement opportunity notes:

1. All Upper Natural Areas could benefit from the promotion of more tolerant / resilient trees, namely the longer-lived species: sugar maple, yellow birch, white pine, etc. The upper portion is sporadically harvested and is generally in good condition.
2. This appears to be an old field site that hasn't regenerated well. Promoting the growth of more tolerant species (through planting, maybe some thinning) would be advantageous.
3. Increased canopy cover on properties would be beneficial. As would better management of stormwater through permeable pavers, rain barrels, better diversion ditches / swales for surface runoff.
4. This 'forest' is mainly young white birch, poplar, willow and shrub species. It is predominantly located along a screened / armor stone bank. Limited opportunity for improvement. Views to the river from the houses above could impact restoration options.

3.3 Stormwater Control Benefits

To quantify the level of service provision, a modelling analysis was completed to examine peak flow with and without forest cover in catchment A and catchment B, as summarized in section 4.2.

Appendix C presents detailed results for the time of concentration and CN values used to estimate peak flow rates for Scenarios 1 and 2. Peak flow values for each of the scenarios are presented in Table 4. These values were calculated using hydrological modelling and are based on the time of concentration and CN values contained in Appendix B and the IDF curve from St. Leonard N.B. Table 4 also compares the percent increase in peak flow when the upper watershed surface condition is changed from forested to agriculture.

TABLE 4 – INCREASE (%) IN PEAK FLOW RATES BETWEEN SCENARIOS BY STORM			
Storm	Peak Flow (m³/s)		% Increase
	Scenario 1	Scenario 2	
1:5 Year	1.85	3.59	94
1:100 Year	5.23	8.64	65
1:100 Year + 20%	7.49	11.88	59

The modelling results demonstrate a significant increase in the peak flows if the surface condition of the upper watershed is changed from forest to agriculture. The impact is most significant for smaller rain events (1:5-year) due to the ground becoming saturated during large rainfall events (the saturation of the land reduces the influence of infiltration rates on the overall runoff). In other words, the loss of forest assets would double peak flows during a 1:5 year precipitation event and increase such flows by two-thirds in a 1:100 year event.

3.4 Value of Stormwater Control Benefits

The replacement cost method was used to estimate the value of forest lands within the project area. The replacement cost approach assumes that a natural asset's value is *at least* equal to the cost of replacing them with engineered alternative(s) capable of providing the same level of service. This is because natural assets can have a range of co-benefits and associated values, as discussed in the next section, that are not captured by the replacement cost method. The cost of replacing the forest area with stormwater management ponds to provide an equivalent detention function for stormwater was based on the required storage volume and an assumed cost of $175 per cubic meter.[5] This unit volume cost is reflective of the design and construction for a stormwater detention pond with landscaping and environmental components and excludes land purchases. Table 5 summarizes the replacement costs.

TABLE 5 – SUMMARY OF REPLACEMENT COST		
Storm	Storage Volume Required to Offset Change in Peak Flows (m³)	Replacement Cost ($ millions)
1:100 Year	19,991	3.50
1:100 Year + 20%	23,296	4.08
Difference	3,305	0.58

Overall, to replace the peak flow attenuation services provided by forest cover in catchment A and catchment B would cost $3.5 million. While climate change wasn't explicitly modelled, the potential implications from climate change (i.e. a 1:100 year event becomes more intense) are explored with the 1:100 year + 20% storm scenario. The results suggest that if climate change increases the intensity of rainfall for a 1 in 100 year storm event by 20%, the value of peak flow attenuation services increases by $600,000 to $4.1 million.

5 The value $175 per cubic metre is based on values estimated for Gibsons BC. For more details see:
Sahl, J., Hamel, P., Molnar, M., Thompson, M., Zawadzki, A. and Plummer, B. (2016). Economic Valuation of the stormwater management services provided by the Whitetower Park ponds, Gibsons, BC. This appears to be a conservative estimate based on other literature. For instance, in the US the EPA estimates an average value of $6.80 per cubic foot (or $240 per cubic metre): https://www3.epa.gov/region1/npdes/stormwater/ma/green-infrastructure-stormwater-bmp-cost-estimation.pdf

3.5 Natural Asset Co-Benefit

This project focuses on the stormwater management benefits of the natural land cover in catchments A and B in Florenceville-Bristol. In the process of incorporating these services into an asset management plan, care must be taken to also recognize the co-benefits of the natural assets of interest in decision-making. Economic and policy decisions that focus narrowly on the trade-offs between conventional infrastructure and natural infrastructure may overlook the broader range of benefits to the detriment of the community. The values presented above only account for costs to provide equivalent flood management services. They do not include the value of features such as access to green and recreational space for residents, wildlife habitat, hydraulic detention, and water quality functions. Consideration of the value of these co-benefits would increase the total value of the natural assets. Although the scale of these benefits are commensurate with the size of the project site, scaling up the practice of natural asset management across the Town could result in a higher range of co-benefits.

This section reviews the co-benefits of significance to the Town of Florenceville-Bristol (Table 6). Each co-benefit of interest includes a discussion of its significance, whose well-being is improved by the existence/flow of the co-benefit (the beneficiaries) and possible assessment methods.

TABLE 6 – CO-BENEFITS OF NATURAL LAND COVER IN FLORENCEVILLE-BRISTOL			
Co-benefit	Beneficiaries	Significance	Possible assessment method (and data needs)
Improvements to freshwater health	Population of Florenceville-Bristol Downstream communities Freshwater species Industry (McCain) Recreational users	At the local scale, natural riparian vegetation and the surrounding terrestrial landscape play an important role in protecting the integrity of freshwaters (Richardson et al., 2010a; Richardson et al, 2010b). Riparian areas provide shade and thermal moderation, bank integrity, organic matter inputs, nutrient storage and sequestration, supplies of terrestrial invertebrates and important species habitat (Naiman and Decamps, 1997; Richardson, 2008). Terrestrial habitat provides leaf litter and organic matter as an energy source and terrestrial invertebrates as a diet source for fish species (Wallace et al., 1999; Wipfli, 1997; Carpenter et al., 2005).	Updates to: WWF-Canada Saint-John – St. Croix Watershed Report The Saint John River: A State of Environment Report (by Kidd et. al.)

Climate change resiliency / adaptation	Population of Florenceville-Bristol Other communities – to the extent learnings are shared	The average annual temperature in New Brunswick has risen by 1.5°C over the past century, with 1.1°C of this increase occurring in the past 30 years (Diamond & Dietz, 2017). The province is already seeing more floods and dry spells and more frequent extreme weather events. Looking ahead to 2080, temperatures could increase from 2.5 to 6.5°C (ibid). Experts are warning that the world will be faced with severe climate impacts even if stringent mitigation action is implemented. As such, many are turning renewed attention to building local adaptive capacity to improve climate resiliency[6]. One approach involves working with ecosystems, rather than relying solely on conventional engineered solutions, to address a range of environmental, social and economic challenges in a sustainable way (Bauduceau et al., 2015). A growing body of research is demonstrating the resiliency of nature and its ability to buffer communities from many of the effects of climate change (e.g. Gómez-Baggethun, & Barton, 2013, FCM 2004, Cirillo and Podolsky 2012, Arkema et al., 2017). Approaches such as municipal natural asset management can contribute to local resiliency.	WWF-Canada and the communities they are working with are developing an approach to identify resilience indicators that employ social-ecological systems thinking and builds on (1) global knowledge of assessing and measuring urban resilience to climate change; (2) information on community climate change vulnerability; (3) local insights on qualities and actions taken that made the community resilient to past climate-related hazards; and (4) local insights on capabilities, assets and relationships that the community needs to have to successfully adapt to long-term changes.
Biodiversity	Population of Florenceville-Bristol Visitors to Town	Loss of biodiversity may have reverberating consequences on ecosystems because of the complex interrelations among species. Biodiversity is important to the survival and welfare of human populations because it has impacts on our economies, cultures, health and the provision of ecosystem services. The Canadian Biodiversity ecosystem status and trends report (2010) lists the trends influencing lakes and river as: Seasonal changes in magnitude of stream flows; Increases in river and lake temperatures; Decreases in lake levels; and Habitat loss and fragmentation	Updates to BiotaNB, a biodiversity project organized out of the New Brunswick Museum. The project will help lay the groundwork for a New Brunswick biodiversity baseline that is still largely lacking. School bioblitz events or bird counts to track and develop biodiversity indicators.

6 Climate resilience is defined by the IPCC (2014) as "the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation."

4 Planning for Natural Assets

The effectiveness of a natural capital asset within a stormwater management plan needs to be measured periodically to ensure that the natural asset's performance is functioning as expected and unimpeded over time. A management plan is one mechanism that can be used to establish strategies and tasks for conservation, land use, and forest operations. The goal of such a plan is to ensure management decisions protect and enhance natural values and that human use within the area does not cause unacceptable impacts to their condition and level of service (taking into consideration landowner goals such as timber production).

The modelling work completed for this project helps build a case for appropriate management of watersheds A and B to ensure they continue to provide stormwater management services and avoid further issues of erosion caused by stormwater flows. Improvements in these watersheds (e.g. increased natural cover) could help mitigate erosion within the Bristol Heights development thereby easing pressure on ditches and culverts along the roadway that transfer water to the Saint John river.

5 Implementation of Natural Asset Plan

The natural asset inventory and valuation completed through this project provides a basis for taking concrete, evidence-based, actions to protect and manage the assets that support erosion control for the community. Results also provide an initial, coarse, understanding of the implications of climate change on erosion levels.

Although the MNAI project with WWF-Canada, WVRSC and the Town of Florenceville-Bristol has concluded, work remains to translate the results of this project into core management and financial processes. Recommended next steps from the MNAI project team follow.

Consider developing a natural asset policy

A natural asset management policy formalizes commitments to integrate nature into asset management at the strategic level in local governments. An asset management policy sets out *what* the local government will do in terms of asset management and is generally council-endorsed. It describes principles that the local government will follow when implementing asset management practices to meet its strategic objectives; who will be responsible for ensuring the policy will be implemented; and the scope of assets and services covered by the policy.

An example of principles included in a good practice asset management policy from the Federation of Canadian Municipalities Leadership in Asset Management Program include:

1. **Service delivery to customers,** which centres decision-making on delivering defined levels of service that reflect customer expectations while balancing risk and affordability.
2. **Long-term sustainability and resilience,** which requires that services and infrastructure assets be socio-culturally, environmentally and economically sustainable over the long-term. This involves long-term planning that manages risks, incorporates triple bottom line (socio-cultural, environmental, economic) considerations, climate change awareness, and resilience.
3. **Holistic and integrated approach,** where decisions are made collaboratively across departments and disciplines.
4. **Fiscal responsibility,** which requires robust asset management decision-making processes to make the best use of available funds to deliver services to communities.
5. **Innovation and continual improvement,** which recognizes that asset management is an ongoing process and that a culture of continual improvement will enable the local government to deliver services to the community and stakeholders more effectively and efficiently.

Natural assets can be included in the scope of an asset management policy. Consideration of natural asset ownership is critical at this stage. In some cases, management and monitoring of the assets is possible without ownership (such as the management of Gibsons' aquifer). In other cases, negotiation with senior government is required to identify roles and responsibilities (such as with watershed management). In situations where regulations are required to protect an asset, the presence of conflicting needs may make management for local services difficult or impossible (for example in the case of a provincial forest that provides local stormwater conveyance but also has an active harvesting licence). In these latter cases, local governments may wish to build a business case for further discussions with senior government officials.

A good practice asset management policy usually starts with the policy's intent, describes how the policy will support the achievement of the local government's strategic objectives, and lists the strategic documents that it is aligned with, like an official community plan or a municipal strategic plan. Strategic documents related to conservation, protection or management of natural assets such as climate adaptation strategies, urban forest management plans, and/or source water protection plans can be included.

Example:

The City of Edmonton, Alberta adopted an asset management policy in March 2018 that includes natural assets in its definition of infrastructure assets covered by the policy:

"Infrastructure Asset - The physical assets that support social, cultural and economic outcomes and deliverables (services), and also includes Natural Assets and software, but not data and information. Infrastructure assets are intended to be maintained indefinitely at a particular level of service potential by the continuing replacement and rehabilitation of their components."(City of Edmonton Asset Management Strategy).

Natural asset policy template:

The City/Town of ______ recognizes the importance of natural assets in providing vital services to the community and will include these in its inventories and asset management practices. Examples include water bodies, wetlands and wildlife corridors.

Consider documenting the lifecycle cost implications of natural asset management for the project site

Although the forested area of the project site is privately owned, the Town could complete an exercise to document the Town's lifecycle costs associated with alternative management decisions, as a starting point for discussions with the landowner regarding community risks and service delivery objectives. This exercise should consider:

- **Start-up costs and financial flexibility -** Existing natural assets often have no upfront capital costs, whereas engineered assets do. Using them effectively can therefore reduce costs.
- **Operating and maintenance costs -** Operating and maintenance costs for engineered assets are just that: necessary but committed costs that keep the asset functioning and delivering services until the end of its useful life. Operating costs for a natural asset are usually lower and can be considered an investment since natural assets do not necessarily have an end of life, and with proper stewardship, increase in value.
- **End-of-life** - Both natural assets and engineered assets require ongoing maintenance and/or rehabilitation. However, at the end of the lifecycle of an engineered asset, the local government is left with an asset that has completely depreciated and must be disposed of and replaced. By contrast, well-maintained natural assets will likely have appreciated in terms of both the service/s provided to the municipality and the benefits resulting from healthy ecosystems including habitat, biodiversity, cultural, and recreational values.

Explore the use of tools, such as subdivision bylaws, for future development

The Town could consider adapting their bylaws to reflect the role of natural assets. Given development pressures, including an undeveloped subdivision downstream of the project site, one immediate possibility is amending municipal construction design guidelines to recognize and protect natural infrastructure where it is providing a service.

In the development of neighbourhoods, bylaws to prioritize standards and requirements for the provision of stormwater management via existing natural solutions could be established. This would require a development site be assessed for any features that could be maintained as opposed to removed and replaced with engineered stormwater management alternatives. Developer cost charges and on-going maintenance costs will often be less for natural assets than for engineered alternatives.

6 Conclusion

The MNAI study was initiated by WVRSC and WWF-Canada for the Town of Florenceville-Bristol to increase their understanding of how proper management of the natural assets within the community contribute to improved stormwater management. The focus of the project are 2 forested catchment areas on the south side of the St. John River, which play an important role in water retention preventing flooding and downstream erosion.

Results demonstrate that a significant increase in peak water flows would result from changing the surface condition of the upper watershed from forest to agriculture. The value of the stormwater management services provided by the forested catchments are estimated to range from $3.5 to $4.1 million.

Modelling was completed for the catchments to assess the peak flow reduction for the 5-year storm event, 100-year storm event, and 100-year storm event + 20%. The model was run under current development conditions as well assuming changes in land cover in the upper watershed for the 3 storm return periods. The modelling results demonstrate a significant increase in the peak flows if the surface condition of the upper watershed is changed from forest to agriculture. The impact is most significant for smaller rain events (1:5-year).

The replacement cost method was used to estimate the value of natural assets in the upper watershed, specifically the forests in the project area. The cost of replacing the forest area with stormwater management ponds to provide an equivalent detention function for stormwater was based on the required storage volume and an assumed cost of $175 per cubic meter. The results demonstrate that a cost of roughly $3.5 million would be required to replace the peak flow attenuation services provided by forest cover. Furthermore, if climate change increases the intensity of rainfall of a 1:100 year event by 20%, the value of peak flow attenuation services increase by $600,000 to $4.1 million.

The values presented above exclude land purchase. Neither do they include co-benefits such as improvements to freshwater health, climate change resiliency / adaptation, and increases in biodiversity.

Currently, no operation and management plans have been developed for the forests of the project area, as they are privately owned. A number of next steps have been proposed, however, to build upon the project results, including the development of a natural asset policy, documentation of lifecycle considerations and amendments to subdivision bylaws.

7 Appendix A – MNAI Community Engagement Session

Municipal Natural Assets Initiative (MNAI) – Cohort 1 Launch Workshop

For Western Valley Regional Service Commission

May 24 2018 - 0800-1700

Location:

Draft Annotated Agenda

Meeting purpose

Launch MNAI project.

Objectives

1. Ensure common understanding of: MNAI method, process & milestones; project details; roles, responsibilities and expectations
2. Develop detailed roadmap towards Milestone 1, including understanding of roles and responsibilities

Anticipated outputs

1. Final project document (although some details may continue to evolve)
2. Roadmap towards Milestone 1* including specific dates and times for regular check-ins and product deadlines[7].
3. Description of next steps

Meeting documents (available at https://tinyurl.com/y8ynjjvu)

- Signed MOU
- Project document
- MNAI introductory presentation
- MNAI presentation on data needs and collection
- Enlarged maps of site (provided by local government)
- Workplan template (to fill out at end of meeting)
- MNAI guidance document
- MNAI Communications plan
- ***Note on Milestone 1**
- Milestone 1 needs to be reached by Week 1 of September 2018.
- The Milestone is: *Creating foundation: biophysical characteristics and condition of municipal natural assets are understood and documented, all data is gathered.*
- Milestone 1 webinar will occur in first 2 weeks of September with objective of extracting and sharing key lessons or findings from data gathering (e.g. are there particular challenges or opportunities in terms of finding good data, and lessons that can be shared.
- MNAI team will provide help desk support between launch workshop and Milestone 1 webinar to make sure Milestone is reached.

7

AGENDA			
Time	**Item**	**Lead**	**Outcome & Comments**
Part 1: Creating a common understanding			
0800-0815	Welcome and introductions	Local government	
0815-0900	Overview of MNAI process: how we got here and what to expect	Roy	Objective: ensure participants understand have shared understanding of MNAI and what to expect
0900-1030	Overview of project document: goals, objectives, outputs of project	Local government with Michelle and Jeff	Objective: ensure common understanding of project
1030-1230	Visit site	Local government	Objective: gather additional information/ context on site
1230-1330	Working Lunch	All	Discussion: did the site visit change anyone's understanding of the project? Lunch provided by local government
Part 2: Roles, responsibilities and actions			
1330-1430	Introduction to goals, objectives and activities towards Milestone 1	Michelle & Jeff	Objective: ensure common understanding of what is required for effective data gathering to meet project goals
1430-1530	Discussion on roles and responsibilities towards Milestone 1	Michelle & Jeff with support from Roy	
15h30-16h30	Conclusions, next steps	Roy, Michelle, Jeff	[This part can be shortened or used to cover additional issues raised during the day]

Participant list:

Simon J. Mitchell – Lead Specialist, Freshwater, WWF-Canada

Sarah Pacey – Chief Administrative Officer, Town of Florenceville-Bristol

Brent Brown – Public Works & Maintenance Supervisor, Town of Florenceville-Bristol

Kevin Booker – Agronomist, McCain Foods

Robert Capozi – Climate Change Adaptation Specialist, New Brunswick Climate Change Secretariat, DELG

Brandon Love - Specialist, New Brunswick Climate Change Secretariat, DELG

Roy Brooke – Executive Director, MNAI

Michelle Molnar – Technical Director, MNAI

Jeff Wilson – Technical Support, MNAI

Josh Thiessen – Technical Support, MNAI

Darrell Turnbull – Muddy Boots Outdoor Learning Centre

Jamie Gorman – Tobique First Nation

Brandon Searle – Opus International Consultants

Dodick Gasser – CCNB / INNOV

Anne Henderson – Solid Waste Manager, Western Valley Regional Service Commission

Barb Meed – President, Florenceville-Bristol and District Chamber of Commerce

8 Appendix B – Time of Concentration Equations

Two equations were required to calculate the time of concentration for the project area. The Kinematic Wave Equation (equation 1) was used for overland sheet flow.[8] This is an iterative equation that requires an assumption for rainfall intensity (taken from an IDF curve) to determine travel time. Rainfall intensity is dependant on a time of concentration which is equal to the travel time. The equation is solved when the overall travel time is equal to the time of concentration used to calculate rainfall intensity plus the time of concentration for the remaining flow path length.

Kinematic Wave Equation: $Tc1=Kci0.4(nL\sqrt{S})0.8$ (1)

Where:

$Tc1$ = travel time (min) for sheet flow length

n = effective Manning roughness coefficient (determined from table)

L = sheet flow length based on surface condition and slope

i = rainfall intensity (mm/hr) based on total time of concentration

S = slope (m/m) between highpoint to low point

Kc = coefficient = 6.943

The maximum sheet flow length (L) was determined using the McCuen-Spiess limitation criterion which relates the surface condition and slope to the maximum sheet flow length.

The remainder of the flow path length was assumed to be represented by shallow concentrated flow. Time of concentration was calculated based on the Shallow Concentration Flow equation (equation 2). The slope/velocity intercept 'k' varies based on surface condition. Therefore, an independent time of concentration was calculated for the flow path length travelling through a catchment area with a different surface condition.

Shallow Concentration Flow Equation: $V=k\sqrt{S}$ (2)

Where:

V = velocity (m/s)

k = slope/velocity intercept coefficient based on surface condition

S = slope (%)

The time of concentration was therefore calculated based on the following equation (equation 3).

Time of Concentration Equation: $TCx=L60V$ (3)

Where:

Tcx = travel time (min) for the flow path segment

L = flow path segment length (m)

V = velocity (m/s) determined from equation 2

8 Also known as the Morgali and Linsley Method.

The total time of concentration for the catchment was calculated by adding the total flow segment time of concentrations together from equations 1 and 3.

Total Time of Concentration Equation: $TC=TC1+TC2+TC3+TCx$ (4)

Where:

Tc = total time of concentration (min)

The table below summarizes the individual flow segments, relative catchment area, geometric characteristics and equation used to determine the time of concentration.

Table B1. Time of concentration calculation inputs

Table 1 Flow Path Segment Summary

Scenario	Flow Path Segment	Length (m)	High Point (m)	Low Point (m)	Slope (m/m)	Equation Used
1	AF1	8	175.7	175.4	0.04	1
	AF2	299	175.4	114.7	0.20	2&3
	AF3	118	114.7	98.7	0.14	
	AF4	214	98.7	78.8	0.09	
	AF5	142	78.8	57.3	0.15	
	BF1	4	296.3	296.2	0.03	1
	BF2	2450	296.2	79.5	0.09	2&3
	BF3	220	79.5	57.3	0.10	
2	AF1	17	175.7	175.4	0.02	1
	AF2	290	175.4	114.7	0.21	2&3
	AF3	118	114.7	98.7	0.14	
	AF4	214	98.7	78.8	0.09	
	AF5	142	78.8	57.3	0.15	
	BF1	7	296.3	296.2	0.01	1
	BF2	2447	296.2	79.5	0.09	2&3
	BF3	220	79.5	57.3	0.10	

9 Appendix C – Time of Concentration and CN Value Results

The table below summarizes the time of concentration results (Tc) for the shallow concentration flow segments for both scenarios (equation 2 and 3 in Appendix B). These times of concentrations are not impacted by the storm size and are therefore, re-used for each storm iteration. Flow segments are in reference to Table B1. Coefficient 'K' is based on the surface condition as per table C3.

Table C1. Time of Concentration Results – Shallow Concentration Flow

Table 2 – Time of Concentration Results – Shallow Concentration Flow

SCENARIO	CATCHMENT	FLOW SEGMENT	S (%)	K (DIMENSIONLESS)	L (M)	TC (MIN)
1	A	F2	20	0.152	299	7.3
		F3	14	0.152	118	3.5
		F4	9	0.213	214	5.5
		F5	15	0.152	142	4
					Total	**20.3**
	B	F2	9	0.152	2450	90.3
		F2	10	0.152	220	7.6
					Total	**97.9**
2	A	F2	21	0.213	290	5
		F3	14	0.213	118	2.5
		F4	9	0.213	214	5.5
		F5	15	0.152	142	4
					Total	**17**
	B	F2	9	0.213	2447	63.8
		F3	10	0.152	220	7.6
					Total	**71.4**

Table C3 displays the time of concentration results for the sheet flow portion of the flow path. These results are dependant on the type of storm, surface condition and slope. The effective Manning roughness coefficient for Scenario 1 and 2 are 0.8 (Woods – Dense Underbrush) and 0.41 (Grass) respectively.

Table 3 – Slope Velocity Intercept Coefficient

SURFACE CONDITION	SLOPE/VELOCITY INTERCEPT COEFFICIENT (K)
Forest with Heavy Ground Litter, Meadow	0.076
Woodland, Trash Fallow, Minimum Tillage Cultivation	0.152
Shirt Grass Pasture	0.213
Cultivated Straight Row	0.274
Nearly Bare and Untilled, Alluvial Fans	0.305
Grassed Water Way	0.457
Unpaved	0.491
Paved, Small Upland Gullies	0.619

Table 4 – Time of Concentration Results – Sheet Flow

				INTENSITY	ROUGHNESS COEFFICIENT	FLOW LENGTH	SLOPE	
Scenario	**Catchment**	**Storm**	**Flow Segment**	**1 (mm/hr)**	**n (dimensionless)**	**L (m)**	**S (m/m)**	**Tc (min)**
1	A	1:5 YR	F1	39.3	0.8	8	0.04	12.8
		1:100 YR		69.1				10.2
		1:100 YR + 20%		84.5				9.4
	B	1:5 YR		17		4	0.03	12.9
		1:100 YR		27.8				10.6
		1:100 YR + 20%		33.5				9.8
2	A	1:5 YR	F1	38.9	0.41	17	0.04	16.6
		1:100 YR		69.6				13.2
		1:100 YR + 20%		85.7				12.1
	B	1:5 YR		20.1		7	0.01	15.7
		1:100 YR		33.3				12.8
		1:100 YR + 20%		40.3				11.9

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