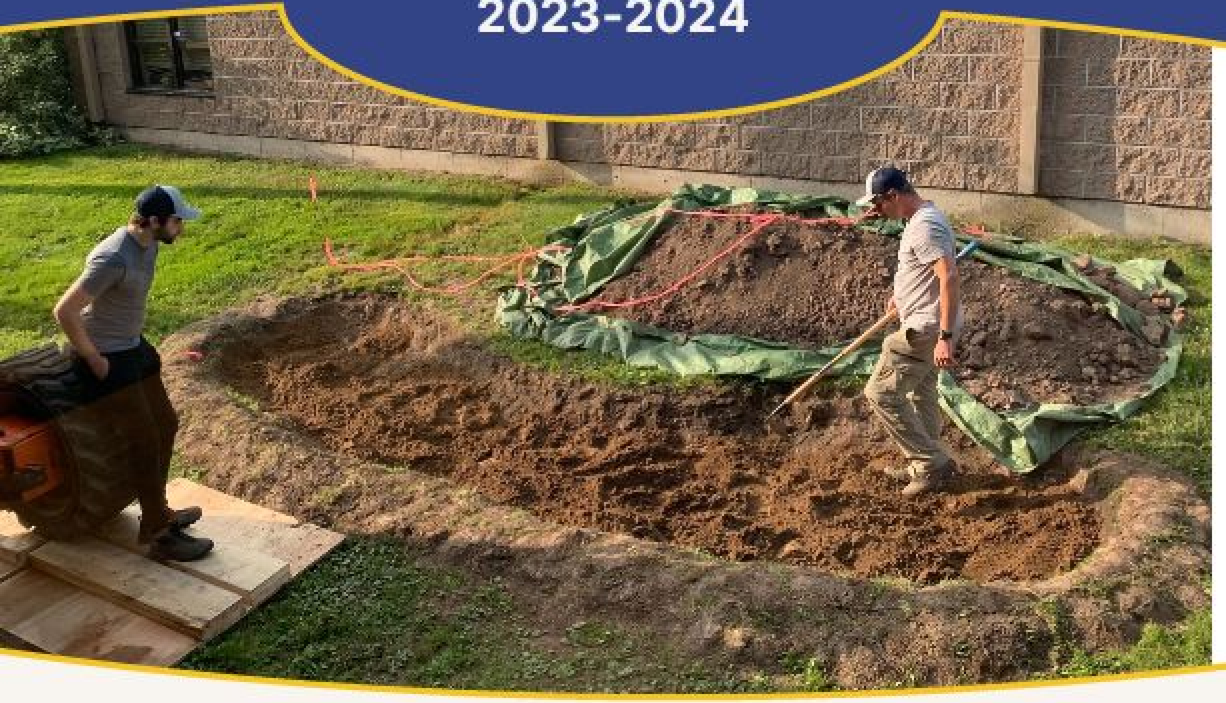
# WATER GUARDIAN

## Stronger together in Climate Resiliency and Stormwater Management

REPORT

2023-2024



ALLIANCE DU BASSIN VERSANT
PETITCODIAC
WATERSHED ALLIANCE

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# DISCLAIMER

The Petitcodiac Watershed Alliance (PWA) is a non-profit environmental charity that works to improve and maintain the ecological systems within the Petitcodiac River Watershed. We use local science to educate community members within the watershed about the ecology within the Petitcodiac River's watershed boundary, and the importance of protecting this unique river system.

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# EXECUTIVE SUMMARY

New Brunswick is projected to experience the worst impacts of climate change through increased flooding, extreme storm events, and increase in rainfall runoff and spring melt runoff. The province encounters water pollution from non-point sources due to runoff from agricultural, forestry, and residential, and urban activities (DELG, 2019). Climate change destabilizes water quality and quantity in the area and requires a multifaceted approach to successful adaptation. Therefore, community involvement from the public, other non-profit organizations, businesses, and local governments is imperative to increasing the resiliency of the community.

Green infrastructure can be defined as a natural or nature-based area that provides ecological services of water management. With a focus on green infrastructure, the PWA have worked to expand the Water Guardian project with the installation of rain gardens and seek to expand this further to better manage stormwater and climate change impacts in the watershed particularly in urban areas. Rain gardens are a nature-based solution to climate change impacts by providing flood mitigation and stormwater management with the use of native water-loving plants that absorb and purify rainfall runoff from nearby impermeable surfaces like pavement and rooftops.

During another year, the PWA staff, partners, and volunteers successfully and safely planted two new green infrastructures within the Petitcodiac watershed in the form of rain gardens. In addition, two more rain gardens are under construction, and another will be finished in 2024. These rain gardens were created in areas that will benefit from stormwater management, flood mitigation, and increased habitat for species such as pollinators in urban environments, and a biodiverse selection of native water-loving plant species that will remediate urban soil through nutrient cycling. Through working carefully with municipal partners, other non-profits organizations, and communities across the Petitcodiac watershed, the PWA grew climate change resiliency through the construction of rain gardens, working to build municipal capacity and public support for equitable, abundant, and thriving green infrastructures as well as educating general community and students with local workshops on project topics. The Water Guardian project succeeded in encouraging green infrastructure to lead climate change resiliency in Petitcodiac watershed communities.

# ACKNOWLEDGEMENTS

This work was made possible thanks to the generous support from **Environmental Trust Fund** (ETF), **Environmental and Climate Change Canada (ECCC)**, and **Canada Summer Jobs** (CSJ). It is thanks to these funds that the PWA can help make a positive impact on watershed habitats through water quality monitoring and natural resources conservation for the concerned communities. Thank you to the City of Moncton, the City of Dieppe, the Ashford Group, and the Gunningsville School for their on-going support.

I also want to thank all the support from the board of directors and everyone at the PWA; thanks to Kelsey Wilson, Cristina da Silva Gonçalves, Shane Boyd, Antony Thériault, Danis Comeau, Claire Johnson, and the former staff Kelcey McClean for their incredible work and dedication to our environmental projects.

# RÉSUMÉ GÉNÉRAL


L’Alliance du Bassin Versant Petitcodiac (ABVP) a réussi à étendre l'impact de l'infrastructure verte et de la sensibilisation de la communauté sur la résilience aux changements climatiques pendant la durée de ce projet (2023-2024).

On prévoit que le Nouveau-Brunswick subira les pires effets des changements climatiques en raison de l'augmentation des inondations, des tempêtes extrêmes et de l'augmentation du ruissellement des pluies et de la fonte des neiges. La province est confrontée à la pollution de l'eau par des sources non ponctuelles en raison du ruissellement des activités agricoles, forestières, résidentielles et urbaines (MEGL, 2019). Les changements climatiques déstabilisent la quantité d'eau dans la région et nécessite une approche à multiples facettes pour une adaptation réussie. L'implication communautaire du grand public, d'autres organismes à but non lucratif et des administrations locales est impérative pour augmenter la résilience de la communauté dans son ensemble.

L'infrastructure verte peut être définie comme une zone naturelle ou basée sur la nature qui fournit des services écologiques de gestion de l'eau. En mettant l'accent sur l'infrastructure verte, l’ABVP a travaillé à l'expansion du projet Water Guardian ‘’Gardien des eaux’’ avec l'installation de jardins de pluviaux et cherche à approfondir ce projet afin de mieux gérer les eaux pluviales et les impacts aux changements climatiques dans le bassin versant, en particulier dans les zones urbaines. Les jardins pluviaux sont une solution naturelle aux impacts des changements climatiques. Ils permettent d'atténuer les inondations et de gérer les eaux pluviales grâce à l'utilisation de plantes indigènes aimant l'eau qui absorbent et purifient le ruissellement des eaux de pluie provenant des surfaces imperméables voisines, telles que les trottoirs et les toits.

Au cours d’une autre année, le personnel, les partenaires et les bénévoles de l’ABVP ont planté avec succès et en toute sécurité 2 nouvelles infrastructures vertes dans le bassin versant de Petitcodiac sous la forme de jardins pluviaux. De plus, 2 autres jardins pluviaux sont en construction et seront terminés en 2024. Ces jardins pluviaux ont été créés dans des zones qui bénéficieront de la gestion des eaux pluviales, de l’atténuation des inondations et de l’augmentation de l’habitat pour des espèces telles que les pollinisateurs dans les environnements urbains et une sélection biodiversifiée d’espèces végétales indigènes aimant l’eau qui assainiront les sols urbains grâce au cycle des nutriments. En travaillant étroitement avec des partenaires municipaux, d'autres organismes à but non lucratif et des communautés du bassin versant de la Petitcodiac, l’ABVP a accru sa résilience aux changements climatiques grâce à la construction de jardins pluviaux, en travaillant à renforcer la capacité municipale et le soutien du public en faveur d'infrastructures vertes, équitables, abondantes et prospères. L’ABVP continu d'éduquer la communauté en général et les étudiants avec des ateliers locaux sur les sujets du projet. Le projet, Water Guardian ‘’Gardien des eaux’’ a réussi à encourager que les infrastructures vertes deviennent un moteur de résilience aux changements climatiques dans les communautés du bassin versant de Petitcodiac.

# REMERCIEMENTS

Ce travail a été rendu possible grâce au généreux soutien du Fonds en fiducie pour l'environnement (FFE), d'Environnement et Changement climatique Canada (ECCC) et d'Emplois d'été Canada (CSJ). C'est grâce à ces fonds que la PWA peut contribuer à avoir un impact positif sur les habitats des bassins versants grâce à la surveillance de la qualité de l'eau et à la conservation des ressources naturelles pour les communautés concernées. Merci à la Ville de Moncton, à la Ville de Dieppe, au Groupe Ashford et à l'école de Gunningsville pour leur soutien continu.

Je tiens également à remercier tout le soutien du conseil d'administration et de tout le monde à la PWA. Merci à Kelsey Wilson, Cristina da Silva Goncalves, Shane Boyd, Antony Thériault, Danis Comeau et Claire Johnson pour leur travail incroyable et leur dévouement à nos projets environnementaux.

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# 1 INTRODUCTION

## 1.1 Context

The Petitcodiac Watershed Alliance (PWA) has been developing the Water Guardian project since 2014 to benefit the ecosystems and communities within the Petitcodiac River watershed by taking actions to restore and protect our water quality. The project is informed by the long-term water quality monitoring program that the PWA have accumulated data within established sites on streams and rivers within the watershed since 1997, in which stormwater runoff has been identified as one of the worst water quality impacts across the watershed. The aim of the project is to limit and significantly reduce the pollutants entering the Petitcodiac Watershed freshwater system, along with implementing solutions that offset the harmful impacts of urbanization. From rain barrels to rain gardens, the Water Guardian project has taken action to mitigate climate change impacts on the many communities of the Petitcodiac watershed. Since 2014, the PWA has conducted surveys to determine the barriers to adopting sustainable behavior, limiting residential runoff, and use the information to remove barriers within our communities. From those results and with the funding from multiple donors the PWA has provided over 450 free rain barrels to collect and store rainwater at residences, and over 500 in-home water conservation tools such as “toilet tank banks” and water saving shower heads. Over time the project has expanded to green infrastructure education, installation, and conservation. This project seeks to reduce floods & flood damage, reduce surface runoff flowing into the Petitcodiac River, create habitat for species with a focus on pollinators and species-at-risk, and increase local knowledge of green infrastructures such as rain gardens to address climate change impacts.

Impacts to water quality vary per tributary or area of the watershed under consideration, but the entirety of the watershed is vulnerable to climate change impacts. The Water Guardian project seeks to help communities of the Petitcodiac Watershed adapt to climate change vulnerabilities of New Brunswick, and the growing impacts of stormwater runoff, pollution pathways, and flooding. Urban areas are sensitive to climate change impacts by the lack of natural buffers to protect communities with higher population density than rural areas. The climate change impacts specific to the Petitcodiac Watershed communities are not limited to but can be observed in the increase of stormwater runoff, flooding, and a trend of increasing air temperatures due to the urban heat island effect. The Water Guardian project activities in 2023 focused on the most population dense area of the Petitcodiac Watershed, which is the tri-community area of the City of Moncton, the City of Dieppe, and the Town of Riverview, also referred to as the Greater Moncton Area.

Climate change-induced weather events and natural disasters are understood to impact mental health through sleep disorders, stress, anxiety, depression, and the development of posttraumatic stress disorder and suicidal ideation. Research on specific mental and emotional consequences caused by the slow and gradual impacts of climate change is a relatively new field (Usher, Durkin, & Bhullar, 2019). Eco-anxiety affects people aware of the impacts of climate change who go on to develop anxiety about their future and the future of the planet (Pihkala, 2018). Eco-anxiety can be addressed effectively by raising public awareness of climate mitigation strategies such as water resiliency and clean energy, and through environmentally friendly behaviours such as reducing waste, increasing reuse and recycling (Usher, Durkin, & Bhullar, 2019). Eco-anxiety in watershed communities can be effectively eased through the involvement and education of climate change mitigation strategies with the opportunity of community stewardship.

The PWA has produced and distributed educational materials about green infrastructure, climate change adaptation and resilience, and the use of natural infrastructure as a sustainable environmental management practice. Through outreach, the PWA continues to promote water protection behaviors that will contribute to the improvement of water quality within the watershed by reducing stormwater and wastewater levels through education to community members.

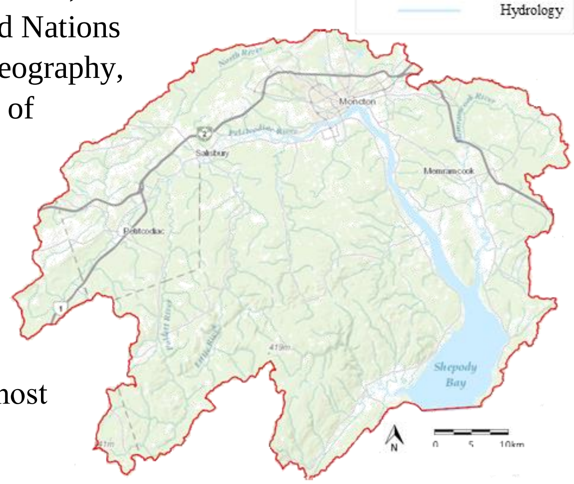
### *1.1.1 Project Area: The Petitcodiac Watershed*

The efforts of this project during 2023-2024 was to limit and significantly reduce the pollutants and urbanization impacts entering the Petitcodiac watershed freshwater system and were conducted in the Petitcodiac River watershed limits shown in Figure 1.

The Petitcodiac Watershed's boundaries are comprised of the Petitcodiac, Memramcook, and Shepody River watersheds. This watershed is in southeastern New Brunswick and has a drainage area of approximately 3,000 km$^2$, making it the third largest watershed in the province. The Petitcodiac River, along with its 10 major tributaries, runs through both rural and urban environments and drains into the Shepody Bay, at the northernmost top of the inner Bay of Fundy. Within these bounds is land spanning multiple municipal jurisdictions, while supporting the most densely populated and fastest-region of the province (approximately 160,000 people). Some of the communities along this river include: The Village of Petitcodiac, the Village of Salisbury, the Greater Moncton Area, and the Village of Hillsborough. The Memramcook River has four major tributaries that flow through rural communities Memramcook and Dorchester and joins with the Petitcodiac River. South of the Petitcodiac watershed, the Shepody River watershed drains into the Shepody Bay with its river flowing through Riverside Albert. A variety of land-uses occur throughout the river's watershed ranging from agricultural, forestry and quarrying activities to residential and commercial developments, leading to a variety of different impacts and potential associated pollution pathways. As anthropogenic expansion increases, instances of waste infiltrating aquatic habitats increase.

*Figure 1: A map of the Petitcodiac Watershed boundaries*


The watershed is part of the Fundy Biosphere Reserve (UNESCO World Heritage site), which includes an area of 442,250 hectares in the upper Bay of Fundy coast, stretching from St. Martins to the Tantramar Marsh near Sackville, and inland to the City of Moncton (Figure 2). This designation from the United Nations recognizes the uniqueness of the upper Bay of Fundy in its geography, culture, and history, in addition, emphasizing the importance of conservation and sustainability within this region (Fundy Biosphere Reserve, 2012). The Bay of Fundy tides reach upwards of 9 m in height on the Petitcodiac River, and some 14 m in the Shepody Bay area (Hopewell Rocks), uncovering kilometers of mudflats at low tide, and nourishing some of the world's greatest estuaries. Estuaries rank with tropical rainforests and coral reefs as the world's most



productive ecosystems, more productive than both the rivers and the ocean that influence them from either side (McLeod & Helidoniotis, 2005).

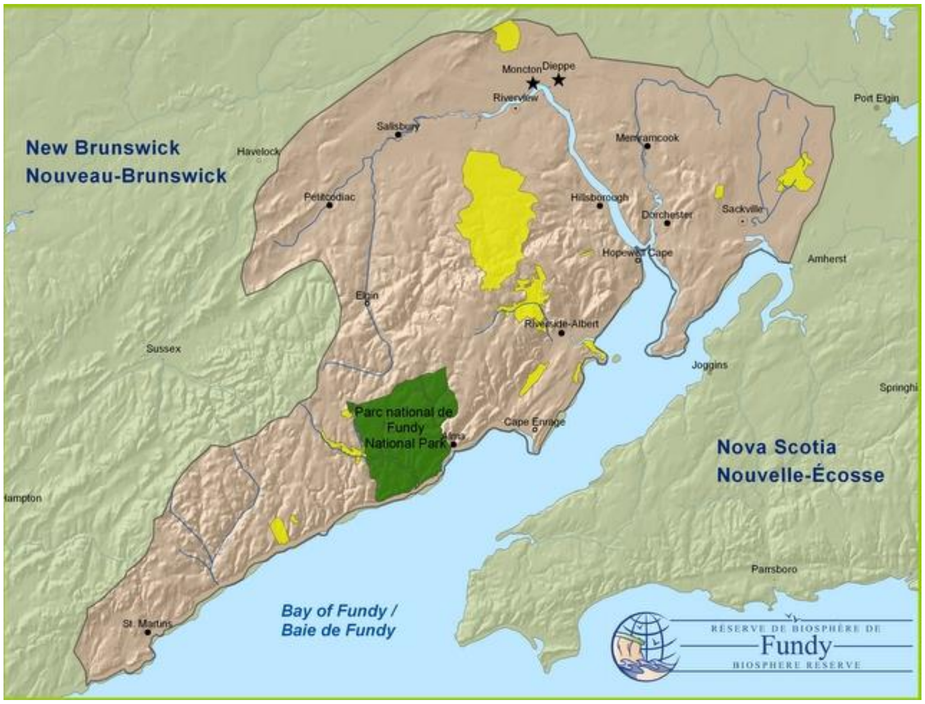



*Figure 2: A map of the Fundy Biosphere Reserve*

## *1.1.2 Green Infrastructure and community education on water destiny*

Green infrastructure has become the focus of the Water Guardian project efforts. Green infrastructure can either be described as natural or nature-based infrastructure. Natural infrastructure is an area that provides ecological services, and nature-based infrastructure is an area that is built through human efforts that mimic a naturally found area. They can be planned and managed semi-natural systems that employ elements of natural services lacking in traditional gray infrastructure (Hawkins & Prickett, 2014). Green infrastructure can already be found in cityscapes including public parks, recreation areas, gardens, and street trees, as well as emerging urban greening technologies like rain gardens, green roofs, and green walls (Norton, et al., 2013). These green technologies also include large impact projects such as planting trees that can remediate contaminated soil (phytoremediation) or constructing wetlands that treat industrial wastewater (Hawkins & Prickett, 2014). Green infrastructure reinforces the climate resiliency of any area, but urban areas are in the greatest need. These infrastructures can provide urban areas with the ecological services necessary to mitigate climate change-fueled impacts of stormwater runoff, flooding, and the urban heat island effect.

*Figure 3: Wild roses growing in a riparian zone along Little River in the Village of Salisbury*

The urban heat island effect describes urban areas with higher temperatures during the day and night than nearby rural landscapes (Norton, et al., 2013). Though research is not available on the urban heat island effect within urban and rural New Brunswick, there is evidence of higher temperatures recorded in the recent past within City of Moncton compared to the Village of Alma within Petitcodiac Watershed boundaries (see Appendix 7.1 for more details). Cities can exhibit their own microclimate and are typically warmer than surrounding rural areas, because they tend to contain less vegetation and bodies of water than rural areas. Existing green spaces including forests and wetlands are under threat by increasing population densities. The need to protect and re-introduce green and blue spaces arises to adapt cityscapes to enhance climate resiliency (Gunawardena, M.J.Wells, & T.Kershaw, 2017).

*Figure 4: Pollinator species at the Centennial rain garden (left) and the Redwater Park rain garden (right)*

Bad land management practices can accelerate climate change impacts. Deforestation by urban development and cities expanding into natural wetlands can decrease the capacity of a region to absorb carbon emissions, deflect solar radiation, and prevent major flooding. Nature-based infrastructure can be integrated into an urban area to regain these lost benefits that help protect communities from the urban heat island effect, Green House Gas (GHG) emissions like carbon dioxide, and extreme rainfall/ snowmelt events. Urban expansion is also understood to impact food security through the loss of cropland; however, these impacts can be reduced by green infrastructure. Through providing unique locations for growing food (e.g green roofs, rain gardens, green wall), urban green infrastructure can be beneficial to food security as well as increase climate resiliency (IPCC, 2019).

#### *1.1.2.1 Rain gardens*

Rain gardens are a landscaped, shallow depression (usually 4-8 inches deep) made up of water-loving native plants, grasses, and soils. Rain gardens are an inexpensive method to reduce stormwater runoff in an area lower in elevation to nearby impervious surfaces. They are designed to capture, store, and release filtered rainwater back into streams and lakes at a slower rate. Rainwater runoff flows from surfaces that prevent the water reaching the soil, such as the impermeable surfaces of roofs, driveways, and other hard surface areas. Rain gardens allow rainwater runoff to absorb naturally into the ground. The gardens are planted with native grasses, plants, and flowers that absorb 30-40% more rainwater than the average grass-covered lawn and will grow deep roots that break up the soil and improve its permeability (EOS Eco-Energy, 2018). Rain gardens collect rainwater from roofs, driveways and other hard surface areas and let it absorb naturally into the ground**.**

Traditional gray infrastructures (e.g. piped drainage, water treatment systems) are built to draw stormwater runoff away from urban structures, while green infrastructure is built to have the capacity to reduce and treat stormwater at the source: rainfall (EPA, 2019). Rainfall runs off roofs, streets, and parking lots to gutters, drains, and storm sewers carrying plastic, bacteria, heavy metals, and other pollutants all discharged into our freshwater river system. Heavy rainfall or extreme rainfall events can also cause erosion and flooding that cause damage to habitats and properties. Rain gardens are made of native vegetation and sandy soil that restores natural processes of water management. The green spaces provide habitat, flood protection, clean air, and cleaner water to urban areas. Rain gardens are an asset in stormwater management as they mimic the natural systems found in wetland habitats and soak up a considerable amount of rainfall and stormwater runoff. Particulates and pollutants in runoff water are filtered by rain garden plant species and will infiltrate the soil to replenish groundwater reserves.

Native species are used in the rain gardens to prevent the spread of invasive or alien species that may impact surrounding ecosystems and/or species at risk. Using native species is paramount to building and encouraging sustainable gardens and can also protect the existing green infrastructure of the region. Glossy Buckthorn is a water-loving plant species and would fare well in rain gardens, but this European shrub has impacted biodiversity in New Brunswick wetlands (Mazerolle, 2018 ). Decisions of which plant species to use can make a greater impact than that of a few years. Native species will also tend to need less maintenance and care, as they are well adapted to the climate experienced in this region. Most of the rain garden native species that are used can be found in wetland habitats across eastern Canada. Flower species were carefully selected with different bloom times to attract pollinator species. However, in some places and seasons, the finding of native species in local nurseries may be a challenge due to the high demand and/or low production. Therefore, more appeal and incentive from the community and government to local nurseries for growing and commercialization of native plants need to be implemented. Unfortunately, two of the plants we planted in our rain gardens were non-native from our region (i.e., Yellow Flag Iris and Purple Coneflower) and we are working to modify this scenario for the next years. The plant species including flowers, and grasses that were planted in the rain gardens during the 2023 field season can be found in the Table 1.

| Plant Common Name | Nom français | Latin Name | Rain Garden |
|---|---|---|---|
| Joe Pye Weed* | Eupatoire maculée | *Eutrochium maculatum* | PWA, GUN |
| White Turtlehead* | Galane glabre | *Chelone glabra* | GUN |
| Yellow Flag Iris | Iris jaune des marais | *Iris pseudacorus* | PWA |
| Native Rush* | Narcissus jonquilla | *Juncus effusus* | PWA, GUN |
| Purple Coneflower | L'échinacée pourple | *Echinacea purpurea* | PWA |
| Red Osier Dogwood* | Cornouiller stolonifère | *Cornus stolonifera* | PWA, GUN |

***Table 1: List of plant species used in rain gardens during 2023 listed by common name, French name, Latin name, and corresponding rain garden in which they were planted including Petitcodiac Watershed Alliance office (PWA), and Gunningsville School (GUN). Asterisk (*) highlights native species.***

#### *1.1.2.2 Watershed map for students' education*

Within the urban areas of the lower sub watershed, there are many neighborhoods that have combined sewage overflows into local streams due to aged infrastructure that the City of Moncton will need to budget to replace. While extreme weather events often overload our current sewer infrastructure with rainfall and outflow into the local streams or the Petitcodiac River directly, more education on which areas impact which streams help our community see the need to mitigate these water quality impacts, which can be done through water conservation practices. The PWA used the City of Moncton sewershed map to create a map for students and teachers to educate youth about these impacts. These resources were shared with teachers in the area either directly or through an established outreach partnership with PWA staff to visit and present them. This activity will help support the cognitive and action-oriented dimensions of climate education from the provincial Climate Education Framework. These resources were shared with teachers in the area either directly or through an established outreach partnership with PWA staff to visit and present them.

## 1.2 Environmental Concerns

The New Brunswick government is expecting climate change impacts related to temperature and precipitation. The climate models of the Fifth Assessment Report by the International Panel on Climate Change predict mean global temperatures will rise from 1 to 6°C by the year 2100 (IPCC, 2014). Any increase in mean global temperatures risks longer and more intense storm surges. The frequency of winter thaws and intensity of precipitation events have increased in New Brunswick, with snowpack in southern New Brunswick shown a decrease by 50% due to temperature fluctuations (DELG). There are also expected increases in the Bay of Fundy tidal range (R.J. Daigle Enviro, 2017). The climate projections for the province following four GHG emission scenarios show a substantial increase in mean temperature over all seasons over time horizons studies over the next six decades at least, with an increase expected for very hot days (maximum temperature higher than 30 °C) for continental cities such as Moncton of +10 to +35 hot days annually by 2080 and expected growing season length extended by +29 to +61 days (Roy & Huard, 2016). All these possible impacts culminate into a future of climate uncertainty that needs to be matched with adaptation at the local level to increase climate resiliency.

New Brunswick faces serious infrastructural damage each year due to flooding. There is strong evidence of observed climate change impacts globally in changing precipitation and snow melt that are altering hydrological systems and affecting water resources in terms of quantity and quality (IPCC, 2014). Communities of Atlantic Canada face coastal and inland flooding risks due to climate change, and coastal drivers of risks differ in the relative severity of their impacts throughout Atlantic Canada (Dietz & Arnold, 2021). A disruption of the quantity and quality of water can greatly impact terrestrial and aquatic ecosystems, and in turn impact the health of urban and rural communities.

An increase in precipitation increases the amount of stormwater runoff. Stormwater runoff is generally contaminated with many substances that can adversely affect the water quality in freshwater streams including hydrocarbons, vehicle fluids, fecal matter, sediment, microplastics, and increases in temperature. The PWA's Water Quality Reports since 2012 have all identified stormwater management as the largest issue to urban water quality within the Petitcodiac Watershed. Due to climate change impacts, we could see an increase in stormwater runoff and pollutants severely contaminating the watershed and its aquatic systems.

Geographical ranges of activities for many terrestrial, freshwater, and marine species have shifted including migratory patterns, abundances, and species interactions due to climate change impacts. In New Brunswick, warming temperatures threaten cold-water species such as the Brook Trout (*Salvelinus fontinalis*) and Atlantic Salmon (*Salmo salar*). Cold water fish species can only survive and thrive within a limited temperature range: Brook Trout require cooler temperatures (ideally 13–18 °C), but are able to survive in water temperatures of up to 22 °C. However, at this temperature, these cold-water fish must be able to find thermal refuges or regions within a river where water temperatures are cooler, or they will die (Bain & Stevenson, 1999). Prolonged exposure to temperatures greater than

24°C is lethal for trout and salmon species (MacMillan, Cassie, LeBlanc, & Crandlemere, 2005), and can put fish at a competitive disadvantage in the wild due to physiological stress (DFO, 2012).

# 2 METHODS

## 2.1 Green Infrastructure

Green infrastructure uses plant and soil systems, permeable materials, and rain harvesting to reduce water draining to sewer systems and surface waters (EPA, 2019). Infiltration of water through a soil system and evapotranspiration of stormwater runoff through vegetation effectively reduces flow to the wastewater treatment facility and directly to the Petitcodiac River surface waters. All green infrastructure has the potential to convert stormwater runoff and solar energy into physical growth. Plants that are water-loving used in rain gardens will have the capacity to absorb the most water, therefore benefitting areas prone to impacts of flooding and stormwater runoff. Nature-based solutions can be designed for a specific need, such as water purification or carbon sequestration, while providing enhanced habitat for wildlife and pollinator species (Hawkins & Prickett, 2014). Plants that thrive in direct sunlight have the capacity to absorb the most solar and use this for photosynthesis, to synthesize solar energy, water, carbon dioxide, and minerals into organic resources that the plant uses, and generate oxygen as a by-product.

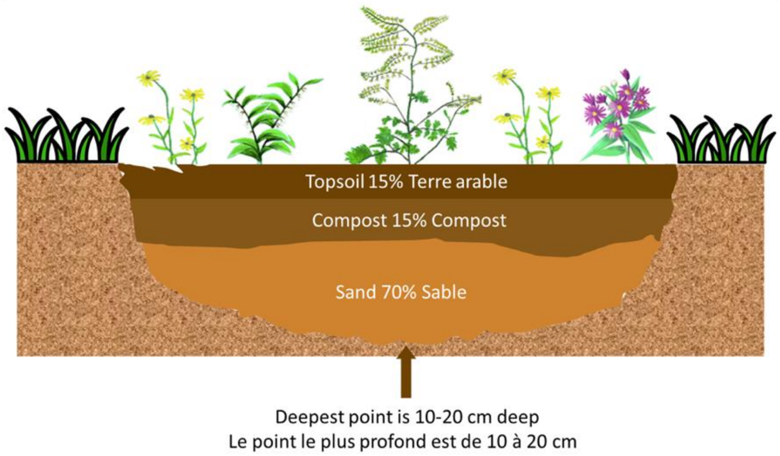
### *2.1.1 Rain gardens*

Each rain garden location was scouted and assessed for permeability of rain, amount of shade, and presence of any near-by invasive plant species. Rain gardens should be planted at least 3m (10ft) from building foundations and other structures like sidewalks and driveways. The size and location of the rain garden was determined with the partner group/organization and confirmed by the landowner, with proximity to existing structures and expected root growth taken into consideration. Also, the sizes of the rain gardens were determined according to the contributing drainage area of the nearby rooftop or lot. A survey of each proposed area was completed by NB Power and Enbridge to identify potential hazards of underground electrical wires or natural gas lines. A locate was obtained by Enbridge upon completion of surveys, that are required by the province of New Brunswick before digging in any area.

Materials were organized by PWA staff and discussed with partners. We favored native plant species in our selection, catering to each individual location, including flowering species of various seasons for pollinators and at least one edible plant species. Cornhill Nursery supplied the plant species for all rain gardens. A recommended rain garden-specific mixture of soil of 70% sand, 15% topsoil, and 15% compost (EOS Eco-Energy, 2018) was purchased from local landscaping company Audubon Organics. Mulch was purchased from Audubon Organics. We re-used local topsoil from the rain garden spots as much as we can (Figure 5).

The EPA national stormwater calculator estimates clay-loam soil in areas moderately steep absorb 4mm of rainfall per hour (Rossman & Bernagros, 2019), which describes the area that most rain gardens are installed within the watershed boundaries, with a few exceptions.

***Figure 5: Rain garden cross-section designed by PWA project technician Nattayada Thongboonmee displaying the recommended soil mixture and depth for a rain garden***




Volunteers were recruited for each site, and a brief presentation of rain garden benefits, purpose, and process was given to participants to give them an educative experience.

Rain gardens were dug at least 8 - 12 inches deep, with the deepest point at the center of the garden to encourage water to infiltrate into the sandy soil. Native plant species were planted in a recommended soil mixture, then topped with 6cm of mulch (Figure 6). Gardens were maintained by partner groups or PWA staff for the first few weeks to ensure sufficient watering for the water-loving species planted.

*Figure 6: PWA staff and kids planting several native species in the Gunninsgsville school rain garden*

# 3 RESULTS AND DISCUSSION

## 3.1 Impact of Green Infrastructure

### 3.1.1 Rain gardens

During the 2023 field season the PWA team successfully installed two rain gardens within the boundaries of the Petitcodiac Watershed with the help of dedicated partners, volunteers, and staff. During the Water Guardian project period of 2023-2024 there were 34 volunteers that participated in rain garden planting activities. In addition, there are two more rain gardens under construction and one 250sqm rain garden that will be constructed in 2024. Unfortunately, we could not finish all the proposed rain gardens because of the excess of rain and heat which flooded one of the rain garden sites during the construction. Staff transition and delays in receiving responses from landowners for final approval of rain gardens also led to delays in implementation.

#### 3.1.1.1 The PWA rain garden

The PWA rain garden was designed and built beside the PWA office at the Highfield street in the Moncton Downtown, one of the regions most impacted with the highest temperature and absence of green infrastructures. The site was chosen by the PWA in collaboration with Ashford Group to ensure stormwater from rooftops would be partially captured by the garden. We also expect a gradual increase in the biodiversity of species (mainly pollinators) visiting the area over the years. The rain garden is 65 sqft and it originally contained 23 individuals and 4 species of plants (Table 1, Figure 7).

***Figure 7: PWA staff and volunteers putting topsoil on the rain garden (left), completed rain garden on the Downtown Moncton (right)***

#### *3.1.1.2 The Gunningsville school rain garden*

The rain garden installed at the Gunningsville school on Karolle Rd, Riverview Town, borders a sloped yard and receives water from the uphill area. The area was constantly flooded in the past due to unfavorable topography. It is 172 sqft and it originally contained 36 individuals and 4 species of plants (Table 1, Figure 8). All digging and bioretention soil incorporation were done by volunteers and the PWA staff. Water-loving native plants were transplanted by the students in a recreational activity where they were informed by the ecological importance of the rain garden and asked a bunch of interesting questions, such as what kind of animals this garden will attract?

*Figure 8: Gunningsville school rain garden built with the help of volunteers (corner left). Kids helped in transplanting plants to the rain garden (corner right and bottom)*

### *3.1.1.3 The Hal Betts rain gardens*

The Hal Betts rain gardens were designed next to the field bets and parking at Assomption Blvd, Moncton. They receive a great amount of water due to unfavorable topography, similarly the Gunningsville school rain garden. The two rain gardens of this area were designed and built by volunteers and PWA staff. We moved a large amount of topsoil that was not used in PWA rain garden, making it more ecologically sustainable. Unfortunately, bad weather, logistics delays, and staff transition prevented us from finishing the last steps, i.e., transplant plants and incorporate mulch (Figure 9). The rain gardens are 65sqft each one and we are planning to plant a total of 37 individuals and 4 species during the spring/2024.

***Figure 9: Hal Betts rain garden adjacent to the parking lot under construction. We are planning to finish this rain garden in the next spring/2024.***

## 3.2 Impact of Community Involvement

### *3.2.1 Outreach*

The PWA is committed to environmental outreach to the communities of the Petitcodiac Watershed. Outreach is carried out to spread information and research to the community through virtual and in-person presentations, workshops, and meetings at events, festivals, and schools to increase climate resiliency within the watershed communities through education.

***Figure 50: PWA staff member leading a class of students in wetland activities***

Staff members coordinated with several local schools to offer educational resources to Science and Environmental classes such as a general pre-recorded presentation and in-person presentations on topics such as: the Petitcodiac watershed, ecological features of the watershed, a summary of PWA project activities, recent research by the PWA, aquatic pollution, and climate change. Workshops on environmental subjects such as watershed habitats, best land management practices, and aquatic pollution were also offered to middle school and high school students and teachers live. We also focused on virtual events and workshops and used our social platforms such as Facebook, Instagram, and PWA website to share educational resources and achievements of project activities (Figure 11).


***Figure 11. 2023 EcoFest hosted at the Magnetic Hill Zoo. PWA staff brought outreach materials of all projects for events.***

Over the project period from 2023-2024 the PWA were fortunate to have the help of 34 rain garden volunteers. We presented four skill-building workshops at the rain garden sites before the building. In addition, we have created bilingual resources, such as rain garden signage installed in the rain garden places, and brochures informing how to build a rain garden. In regarding to local partners organizations, we had seven consultation meetings, including the Ashford Group, City of Moncton, City of Dieppe, and schools. The PWA is currently working with the City of Dieppe to establish equitable, abundant, and thriving green infrastructure in city limits as well under the Living Cities project in partnership with the Garden Cities Project, Green Communities Canada, and other pan-Canadian partners and stakeholders.

The PWA seeks to increase local awareness about stormwater runoff. A sewershed map resource has been started, with GIS data received from City of Moncton and maps created. A collection of educational resources from other jurisdictions on wastewater management has been gathered to help direct the creation of this resource to educate youth in schools on local urban stormwater impacts. The sewershed lesson plan aims to equip school teachers with comprehensive tools to educate students

about the importance of Watersheds and Sewersheds before the end of the 2024 school year. It delves into defining Watersheds and Sewersheds, explaining their significance in environmental conservation and public health. Through a focus on the Petitcodiac Watershed and Sewershed as a case study, students gain insight into local contexts and challenges. The lesson plan highlights ongoing efforts and improvements in stormwater management, fostering a deeper understanding of sustainability practices. Key vocabulary is integrated throughout, empowering students with the language necessary to engage meaningfully with the subject matter.
The New-Brunswick Anglophone and Francophone district has been contacted with this info and shared some valuable outreach resources in respect to their Climate education framework. At least one teacher has been shown this material and is interested in utilizing the Watershed and Sewershed lesson plan before the end of the 2024 school year.

# 4 CONCLUSION

The PWA succeeded in expanding the impact of green infrastructure and community outreach on climate change resiliency. PWA staff, partners, and volunteers safely planted two new green infrastructures within the Petitcodiac watershed in the form of rain gardens and three more are about to finish in 2024. These rain gardens were created in areas that will benefit from stormwater management, flood mitigation, and increased habitat for species such as pollinators in urban environments, and a biodiverse selection of native water-loving plant species that will remediate urban soil through nutrient cycling. The four rain gardens are located at Downtown and Hal Betts in the City of Moncton, and at the Gunningsville school in Riverview town. The fifth and biggest rain garden will be built in Dieppe. Thanks to the help of 31 volunteers and many incredible partner organizations, the gardens were planted with rain garden-specific soil and most native flowering species.

Through working carefully with municipal partners and communities across the Petitcodiac watershed, the PWA grew climate change resiliency and completed outreach to the watershed communities through attending community events and festivals, school presentations, clean-ups, and virtual workshops. The PWA increased local awareness about stormwater runoff, green infrastructure, and nature-based solutions to increase climate resiliency within watershed communities.

In conclusion, the advocates for green infrastructure within the community, partner organizations, and the municipal staff in watershed communities were paramount to the success of the Water Guardian project for the 2023-2024 period. Through consolidated efforts within this project, nature-based solutions to stormwater runoff and flooding were implemented, rain harvesting techniques were adopted, and community awareness of best water management practices was increased through educative experiences. During this period the project successfully facilitated activities that will directly improve the water quality of the watershed through targeting vulnerabilities of stormwater runoff and flooding, and climate change mitigation strategies were followed.

# 5 RECOMMENDATIONS

While the success of many green infrastructure installations expands every year, with the growth of the plants and roots stabilizing the environment they were planted to hold together, it is easy to disregard the need for further green expansion. As urbanization expands urban cities further into the natural surroundings, there will be a greater need to integrate natural environments into the future of our cities. Integrating natural environments can be done by the individual, the community, landowners, municipal planners, businesses, and non-profit organizations. By weaving natural systems into the structures, we create, we grow the climate resiliency of the places we live in. If we can achieve symmetry between nature and development, we secure a healthier environment for ourselves, wildlife, and the freshwater systems we rely heavily upon.

## 5.1 Green Infrastructure

Wetlands provide ecological services such as carbon sequestration, water purification, groundwater replenishment, shoreline stabilization, storm protection, and flood control. They are also critical habitat for many species-at-risks and are reservoirs of biodiversity. In New Brunswick we are fortunate to have a diversity of different wetlands, all providing valuable ecological services to society and wildlife. Protections for wetlands should increase to conserve these ecological services. Wetland restoration is another way to provide support to existing wetlands that may be drained or damaged.

*Figure 12: PWA staff member assessing a wetland in Memramcook*

Urban trees and forests are hugely beneficial to the cities we live in and provide sanctuaries for wildlife in an expanding urban area. The benefits of urban trees include purification of air quality by having the capacity to filter air pollutants and air particulates, decreasing air temperature 2°C to 8°C in an area, water management, and providing psychological benefits to communities (UN, 2016). Municipal parks and trees help mitigate the impacts of climate change for communities of the Petitcodiac Watershed. The importance of investing in stormwater management is synonymous with investing in parks and urban forests (Kazmierczak & Carter, 2010). They also act as habitat corridors for wildlife, providing connectivity in urban areas that can fragment sources of food and shelter for wildlife. Acknowledging the importance of urban forests and integrating habitat corridors within urban areas are important in achieving climate change resiliency.

*Figure 12: Hemlock stands in an urban forest in the Vision Lands area of the City of Moncton*

## 5.2 Nature-Based Solutions

Incentivizing and strategizing green infrastructure projects is a key part of any climate change adaptation strategy. The City of Moncton, the City of Dieppe, and the Town of Riverview have implemented many nature-based infrastructure projects into their urban planning and development strategies including the naturalized retention ponds, bioswales, and rain gardens. The continuation of these activities as well as sharing knowledge and experience with nature-based infrastructure is key to expanding efforts to other municipalities and communities.

Implementing nature-based solutions can also be most effective at varying levels of production. While municipalities have the capacity and resources to create naturalized retention ponds while homeowners may not, different scales of projects can be adopted. Encouraging homeowners to naturalize ditches, install rain gardens, build green roofs, and consider smaller scale nature-based solutions to pooling and stormwater runoff on any property can also make a large impact on water management in the watershed. Organizations and businesses can also get involved and adopt nature-based infrastructure.

While research will be conducted annually on existing PWA rain garden projects, the need for nature-based solutions grows each year as flooding and stormwater runoff increases. Nature-based solutions are proven to be an effective and inexpensive option to achieving climate resiliency and can be adopted at any scale of operation. The Petitcodiac Watershed would benefit greatly from further expansion of nature-based solutions to impacts of urbanization, stormwater pollution, and flooding.

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# 7 APPENDICES

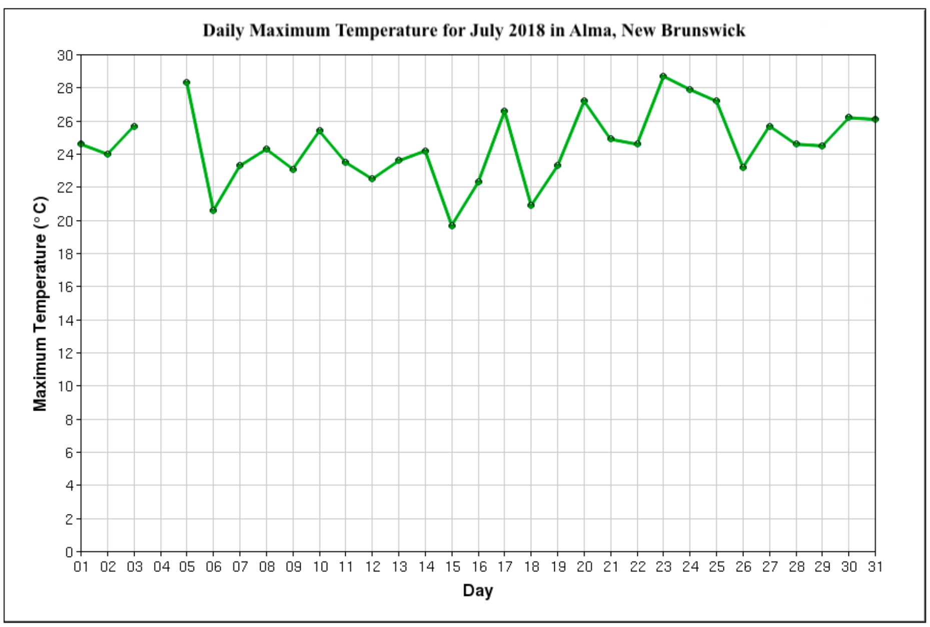
## 7.1 Appendix 1: Climate Within the Watershed

New Brunswick falls within the temperate broad-leaved forest category but is situated far enough north to have several boreal elements, including the prominence of balsam fir, jack pine, tamarack, and spruce species. Since the immediately post-glacial period, the Appalachian Mountains have remained above sea level and thus have served as an effective north–south migration corridor. This has resulted in a blending of northern and southern floral and faunal elements in the Atlantic region. The unique mixture of forested and non-forested ecosystems in the Maritimes has been recognized by Canadian and North American classification frameworks as a definable forest region called the Acadian Forest or, more recently, the Atlantic Maritime Ecozone. In New Brunswick, the climatic gradients characteristically are determined by a combination of elevation above sea level and proximity to the ocean (NB Ecosystem Classification Working Group, 2007).

The Petitcodiac River Watershed is typically a temperate continental climate, where the ocean modifies continental air masses. The extent of the continental effect depends to a large degree on wind direction, with the onshore winds causing the most moderation. By temperate we understand that the annual thermal average is not very characteristic (between - 10º and +20 ºC), but where the temperature and not the precipitation impose the seasonal rate. Winters are cool to cold, where the lowest monthly average can be near - 40ºC; summers are warm to hot. As a result, trees lose their leaves during winter (NB Ecosystem Classification Working Group, 2007).

Temperature variances are experienced between rural and urban regions within the Petitcodiac Watershed. Though research on the urban heat island effect in New Brunswick is not currently available, there are examples in the recent past where the City of Moncton has experienced temperatures higher than rural areas in the Petitcodiac Watershed. Historical climate data from Environment and Climate Change Canada shows the variance in maximum temperature of July 2018 >2°C higher in the City of Moncton than the Village of Alma during the day and night.

*Figure A 1: Line graph of daily maximum temperature for July 2018 taken in Alma, New Brunswick*




## 7.2 Appendix 2: Glossary Terms

***Aboiteau.*** A dyke constructed to stop high tides from inundating marshland; A wooden sluice is then built into the dyke, with a hinged door (clapper valve) that swings open at low tide to allow fresh water to drain from the farmland but swings shut at high tide to prevent salt water from inundating the fields.

Aboiteau farming is intimately linked with the story of French Acadian colonization of the shores of the Bay of Fundy in the 17th and 18th centuries.

***Eco-anxiety.*** Feelings of worry, helplessness, and unease caused by living through slow, gradual impacts of climate change. A chronic fear of environmental catastrophe. It cannot be diagnosed as a medical condition but can exacerbate pre-existing mental health problems.

***Green infrastructure.*** Natural or nature-based plant systems/ green technologies that provide economic, environmental, and social benefits. These natural systems that provides valuable ecological services can be protected, such as a wetland, riparian zone, waterway, or urban forest. Nature-based systems include that of a rain garden, bioswale, green roof, or green walls.

***Impermeable surfaces***. Any solid surface (or surface of a structure) that does not allow water to drain through and permeate through the soil into groundwater reserves, forcing the water to run off the surface. Impermeable surfaces are created by asphalt, brick, stone, and concrete. Examples of structures with impermeable surfaces include pavement, parking lots, and rooftops. In urban development, natural soil can also be compacted in a construction area that impacts its impermeability.

***Stormwater runoff.*** Water from precipitation events and snow melt that does not infiltrate into soil but drains freely off surfaces of land and infrastructure. Stormwater runoff will flow into anthropogenic pollutants (e.g. fertilizer, pesticides, hazardous materials, plastic) and carry them to near-by rivers, tributaries, or other water bodies.

***Urbanization.*** The process of making an area increasing urban. The expansion and development of cities and urban territory that impedes on natural systems, whether expanding outwards or upwards. Can also be defined as the movement of populations from rural areas to urban areas.