2022-07-07

Public

Kiley Marchuk
Planning & Development Services
Strathcona County
2001 Sherwood Drive
Sherwood Park, AB T8A 3W7

Dear Ms. Marchuk,

Please find enclosed the unsigned final submission of the Astotin Creek Resiliency Study: State of the Watershed. As per discussions between Strathcona County and WSP, in addition to the previously provided signed and sealed report, we are also providing this document as an unsigned final version to enable the County to reduce the file size to meet requirements for sharing this report on the County's website.

As this file is not a locked document, WSP cannot guarantee that this report has not been modified and as such should not be relied upon for engineering purposes. When referencing this report for any purpose related to future planning or design, only the full signed and sealed document should be used. When sharing these reports on the County's website, WSP requests that a statement, or this cover letter, is included directing users to contact the County for the full final report as required.

Yours sincerely,

Joshua Maxwell, M.Sc., P.Eng. PMP.
Team Lead, Water Resources,
Municipal Engineering

Encl. Astotin Creek Resiliency Study: State of the Watershed

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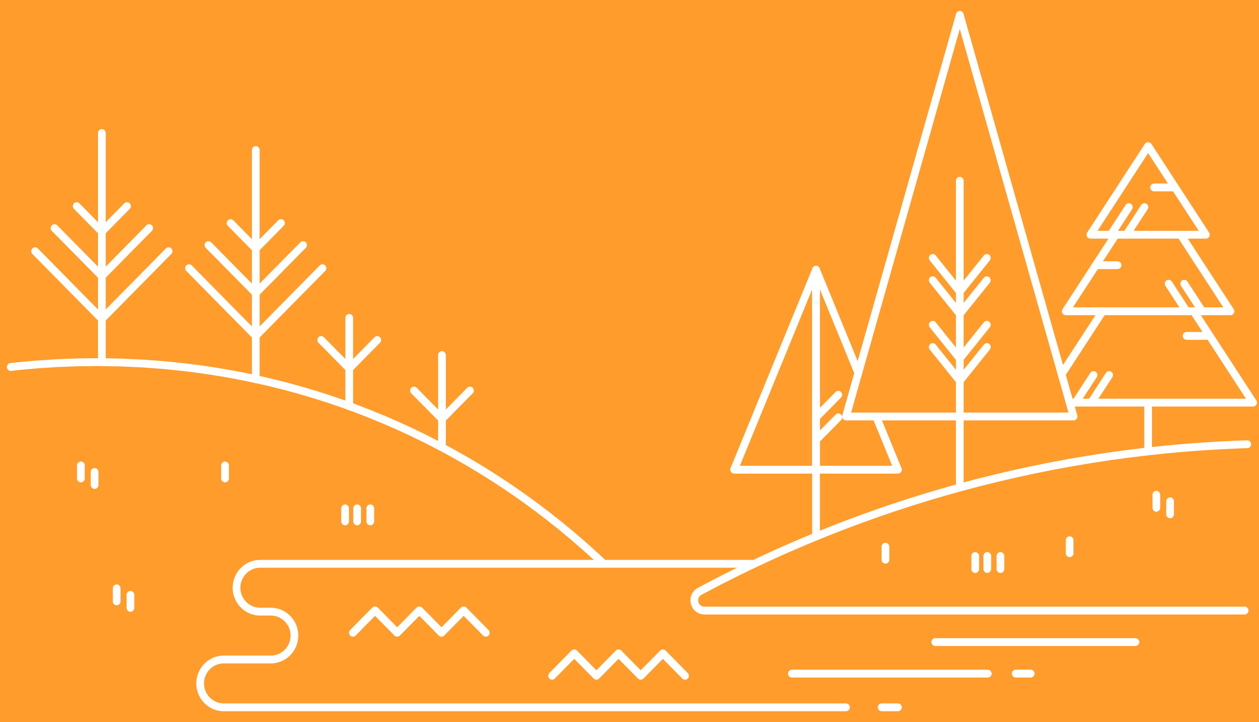
ASTOTIN CREEK

RESILIENCY STUDY

State of the Watershed

June 2022



STRATHCONA COUNTY

wsp

Territorial Acknowledgment

Strathcona County honours the past, present and future First Peoples of this land. We acknowledge that this land has embraced and nourished the Cree, Métis, Blackfoot, amongst many others, for generations. We recognize Strathcona County is within Treaty Six Territory and the homeland of the Métis Nation of Alberta, Region Two and Four.

Strathcona County has an inherent responsibility to foster healthier relationships with Indigenous Partners. We will strive to respond to the Calls to Action as outlined by the Truth and Reconciliation Commission.

Strathcona County is close in proximity to Enoch Cree Nation (maskêkosihk), Ermineskin Cree Nation (neyaskweyahk), Louis Bull Tribe (kisipatinahk), Michel First Nation, Montana First Nation (akamihk), Papaschase First Nation, Samson Cree Nation (nipisikopahk), and Saddle Lake Cree Nation (onihcikiskwapiwinihk).

Furthermore, the geographic boundaries of Strathcona County includes parts of Regions Two and Four of the Métis Nation of Alberta, and are near the Elizabeth Métis Settlement, Fishing Lake Métis Settlement, Buffalo Lake Métis Settlement, and Kikino Métis Settlement.

We recognize the importance of allying with First Peoples and taking steps to foster a healthier relationship. As such, we will demonstate ***manacitôwin****, the Cree word meaning respect for each other.*

Signatures

Soils, Vegetation, Wildlife, Fish and Aquatic Habitat

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Disclaimer

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Intended use of this report

The information included in this report is intended to provide a general understanding of the watershed and should not be used for any other purposes such as local designs.

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INTRODUCTION

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Strathcona County has **prioritized sustaining and protecting healthy ecosystems and healthy citizens** as key community goals, based on sound, evidence-based approaches. From an environmental perspective, the County has further recognized that environmental management is a shared responsibility, and can involve action at the local, regional, and global level.

These principles have informed analysis and management planning to address flood and drought resiliency in the Astotin Creek Watershed through the Astotin Creek Resiliency Study.

Starting with this comprehensive biophysical and hydrological assessment (the State of the Watershed report), and adding community engagement and stormwater drainage planning, **a Resiliency Action Plan will provide informed direction** for environmental, engineering and engagement approaches to build

The Astotin Creek watershed lies in the north part of Strathcona County, in an area supporting agricultural, industrial, and rural residential land use, as well as providing important ecological goods and services (EGS). The watershed, and the terrestrial and aquatic habitat within it, forms an important link between the North Saskatchewan River Valley and Elk Island National Park. It also lies within the northern end of the Beaver Hills Biosphere, and forms part of a regionally significant natural area **(Figure 1-1).** The watershed supports important, regional ecological functions including ecological connectivity, water quality and availability, and local watershed management can influence local and downstream conditions. Yet water management has become an important concern in this area, after several recent flood events. These events, and associated effects on property, water quality and quantity, biodiversity, and road infrastructure, have prompted Strathcona County to conduct the Astotin Creek Resiliency Study, which will ultimately provide a Resiliency Action Plan with recommendations for future watershed management. As a first step, this State of the Watershed report aims to build an understanding of the historical and current conditions along the creek, to inform management strategies in the separate Drainage Master Plan and Resiliency Action Plan.

The current condition of land, water and biodiversity within the watershed will provide important context for the Resiliency Action Plan. The watershed has experienced past agricultural and industrial development, clearing riparian habitat along the creek in some areas, and removing wetlands that could moderate run-off conditions. Beaver activity along the creek also influences water flow and storage, a boon in times of drought, but problematic in wetter years. The interaction of these influences on water flow and volume can increase risk of flooding in some parts of the watershed and prompt need for adaptive management. The creek has flooded three times in the past decade alone, affecting agricultural lands, roads and private residences, and County response with emergency mitigation measures such as road closures, pumping and monitoring flood conditions to protect roads, private homes, and property. The experiences and concerns of residents and other regional stakeholders are also important to developing a community-based Resiliency Action Plan. Cooperation of County, resident and regional stakeholders will be critical to the success of this plan.

This report describes the current state of the Astotin Creek watershed, from an ecological and land management perspective. The Introduction sections below outline the overall approach used in this study to develop a science-based, sustainable, and prioritized strategy for watershed management. This section ends with a summary of the scope of this current report, a description of the biophysical, management and community context of the watershed. The subsequent chapters describe the current management context, including the overall character of the watershed, and applicable water and environmental management policies. Next, results of desktop and field assessments of the terrestrial and aquatic aspects of the watershed are summarized. Future predicted climate and its effect on flood and drought frequency follow and set the context for future management options for a resilient watershed system, discussed in the summary and conclusions chapter.

1.1 STUDY APPROACHES AND OBJECTIVES

Watershed resiliency in this study refers to the ability of the creek to withstand and recover from drought and flood without the creek losing its ability to function or suffering damage that it cannot recover from naturally without human intervention. Resiliency planning requires an interdisciplinary and cooperative approach that assesses the watershed from an ecological and hydrological perspective and helps build a shared understanding of those values and current condition. To be effective, resiliency requires the support of all affected stakeholders, and a good understanding of the opportunities, and constraints for management.

Specific goals of the Astotin Creek Resiliency Study were to:

- Advance flood, drought, and water quality resiliency in priority areas within the Astotin Creek watershed to enhance the community and improve the environment.
- Restore and enhance ecological connectivity and function, and water quality in critical areas of the Astotin Creek watershed.

- Increase knowledge, awareness and participation by industrial landowners, private landowners, agricultural producers, and our citizens in activities that restore and sustain the function of the Astotin Creek watershed; and
- Enhance community capacity to restore and maintain critical features of the Astotin Creek watershed for future generations.

Our approach to the Astotin Creek Resiliency Study was based on environmental, engagement and engineering assessments that helped describe the current state of the watershed through the following means:

- Description of the **current ecological condition** of the watershed, including biodiversity and habitat condition of terrestrial and aquatic ecosystems in the watershed.
- Description of the **historical and current hydrological conditions of the creek**, including creek flood risk, past trends and anticipated future conditions in light of **climate change predictions.**
- Description of **current stormwater management guidelines and infrastructure** now in place to manage current and potential future levels of development.
- A concurrent **engagement program** to build awareness and solicit additional management options and support for preferred and prioritized activities from the public and other stakeholders.

The characterization of the Astotin Creek watershed provided in this report was completed over the summer and fall of 2021. These ecological and engineering assessments, plus an overview of current policy tools and other resources available to the County and its residents will help to identify options for future ecological restoration, engineering, or land management solutions. A Drainage Master Plan and a Community Engagement Summary report are published as separate reports within the overall Resiliency Study, and together, informed the development of the Astotin Resiliency Action Plan, a report to be finalized in early 2022.

As part of the public engagement program, the biophysical characterization data has also been provided online, in the Astotin Data Atlas available on the County's website.

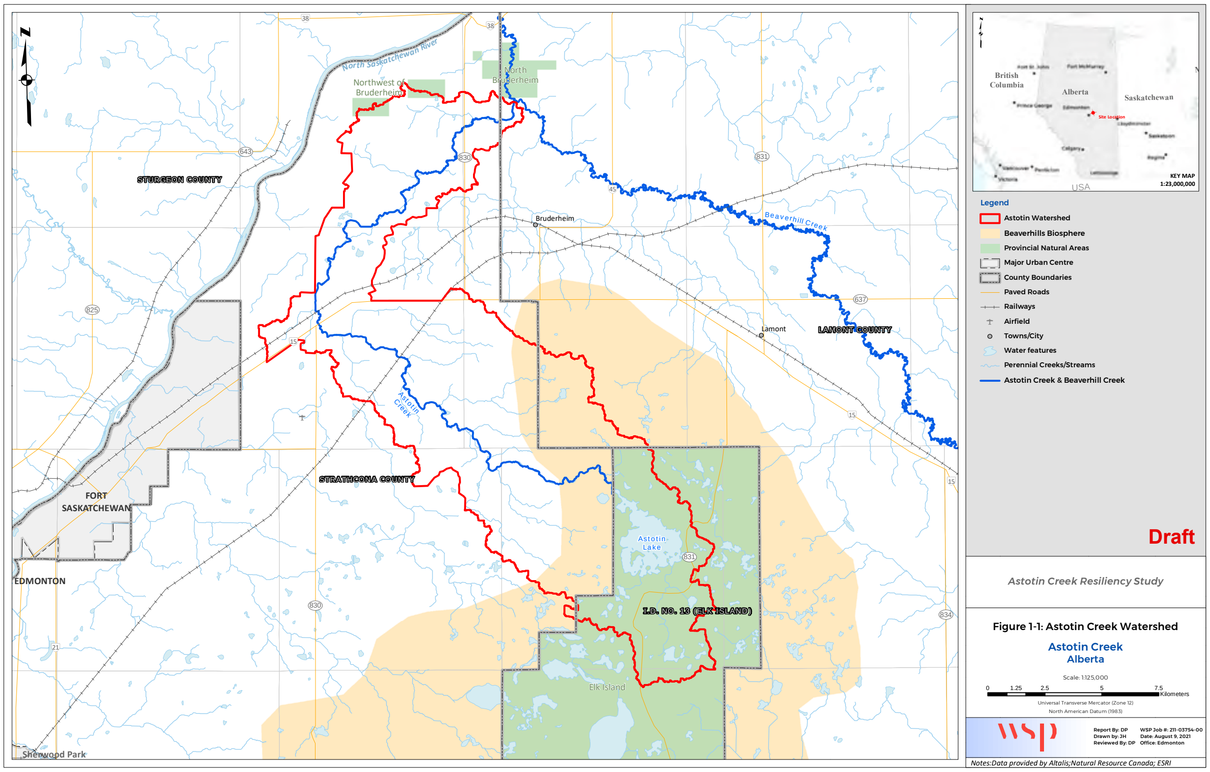


Figure 1-1: Astotin Creek Watershed

1.2 PUBLIC AND INDIGENOUS ENGAGEMENT PROGRAM

Strathcona County is committed to meaningful engagement with its residents, businesses, and neighbours. Accordingly, for this project, both public and Indigenous engagement were used to gain insights on the experiences, concerns, and management ideas for the watershed. COVID restrictions have limited opportunities for in-person events, but outreach was possible through various existing engagement tools established by County's Communications Team, including its SCOOP survey and eNewsletters to subscribing residents. Engagement was conducted in two phases. In the first phase, mail-outs with contact information and website links were sent to residents and the County hosted a virtual Open House to provide early results of the environmental and engineering assessments. The second engagement phase provided an opportunity for input into the next steps of the Astotin Creek Resiliency Study and included mailouts, additional web content, and a second virtual Open House. The County also engaged with Indigenous groups throughout the project. More information about the engagement program can be found in the Phase I Engagement Summary Report and the Phase II Engagement Summary Report.

1.3 ASTOTIN CREEK RESILIENCY STUDY SCOPE

As noted above, the Astotin Creek Resiliency Study scope includes four separate reports, each addressing specific environmental, engineering and engagement aspects:

- The State of the Watershed
- Drainage Master Plan
- What We Heard and What We Did Engagement Summary
- Resiliency Action Plan

The Resiliency Action Plan will build on the findings from the first three studies, combining environmental, engineering and engagement information to develop recommendations for sustaining the ecological benefits and human land use of this area. The Action Plan will start with risk identification, to develop consensus around necessary actions and guiding principles, then finally provide costing, and priority activities to be implemented by the County and residents in the watershed.

1.4 SCOPE OF THIS REPORT

This report, the 'State of the Watershed' study, assessed the current capacity of the Astotin Creek watershed to provide the ecological goods and services (EGS) that sustain current land use in the area. An EGS perspective can be helpful to resiliency planning, by describing the condition of 'natural capital' such as clean air and water, recreational opportunities, and flood and drought protection that is valued, but not always broadly recognized by area residents. By assessing the relative health of aquatic and terrestrial ecosystems, we can help identify risks, or 'tipping points' that will ultimately affect ecological resiliency of an area and the quality of life now enjoyed by its residents. The International Union for Conservation of Nature (IUCN, 2019) has acknowledged the link between human well-being and ecological health and recommends nature (ecosystem)-based solutions to address community needs and challenges. An EGS focus can help identify resiliency solutions that sustain communities and the environment (Figure 1-2).

The Resiliency Action Plan will build on the ecological and engineering assessments in this report to recommend nature-based and/or engineering solutions, where appropriate, for sustainable stormwater management, agricultural and industrial land use, and ecological function of the Astotin Creek Watershed.

Figure 1-2: Ecological Resiliency and Benefits through Nature-based Solutions (UCN, 2019)

EXISTING MANAGEMENT CONTEXT

2

The Astotin Creek watershed includes a **mix of developed and natural environments**, including federal and provincial protected areas. With such a diverse context, management priorities, and the policy tools required to ensure those priorities are met, must address site-specific conditions. As outlined in the sections below, these conditions are quite distinct across the watershed, and municipal planning tools have been specifically designed for them, and the broader community goals of the County.

2.1 EXISTING ENVIRONMENT

The Astotin Creek watershed lies in two ecological Natural Regions, which influences its environmental character. Past and current land use has modified these lands to form three distinct areas in terms of dominant land cover (Figure 2-1). As described below, the three areas were identified as the Upper, Middle and Lower Assessment Reaches in this study (Section 2.4, Figure 2-2). Terrain is another influence on these lands, as is ecological connectivity.

In general, the topography in much of Strathcona County is morainal, a landscape of small hills and depressions that supports abundant wetlands and forested uplands. These lands, the Cooking Lake (Beaver Hills) moraine, extend from the southeastern corner of the County through Elk Island National Park and into the Upper Astotin Creek Assessment Reach, and form part of the Beaver Hills Biosphere. The moraine is an isolated island of Alberta's Boreal Forest Natural Region and provides diverse terrestrial and aquatic habitats that can support high biodiversity. The habitat potential and species observations from this area were an early focus of conservation efforts of the County and other levels of government, as explained further in Sections 2.1.1 and 2.2.1 below and Section 6.3.2.

The northern and northwestern parts of the County, including the Middle and Lower Astotin Assessment Reaches, lie within flatter plains more suitable for development. These flatter plains are part of the Aspen Parkland Natural Region that surrounds the Beaver Hills Moraine. Cleared for agricultural and other land use during early settlement, they now have small to large patches of native woodland and grassland habitat where development was not practical.

Astotin Creek's headwaters start in Elk Island National Park, at Astotin Lake and pass immediately into rural residential lands of the Upper Assessment Reach, adjacent the park border. Moving downstream, the creek and its tributary streams pass through agricultural and industrial lands before finally reaching the confluence with the North Saskatchewan River via Beaverhill Creek, in Lamont County. The park and the three watershed assessment reaches within the Astotin Creek watershed differ considerably in their level of development and management, which as summarized below, can influence their ecological and hydrological condition and management concerns.

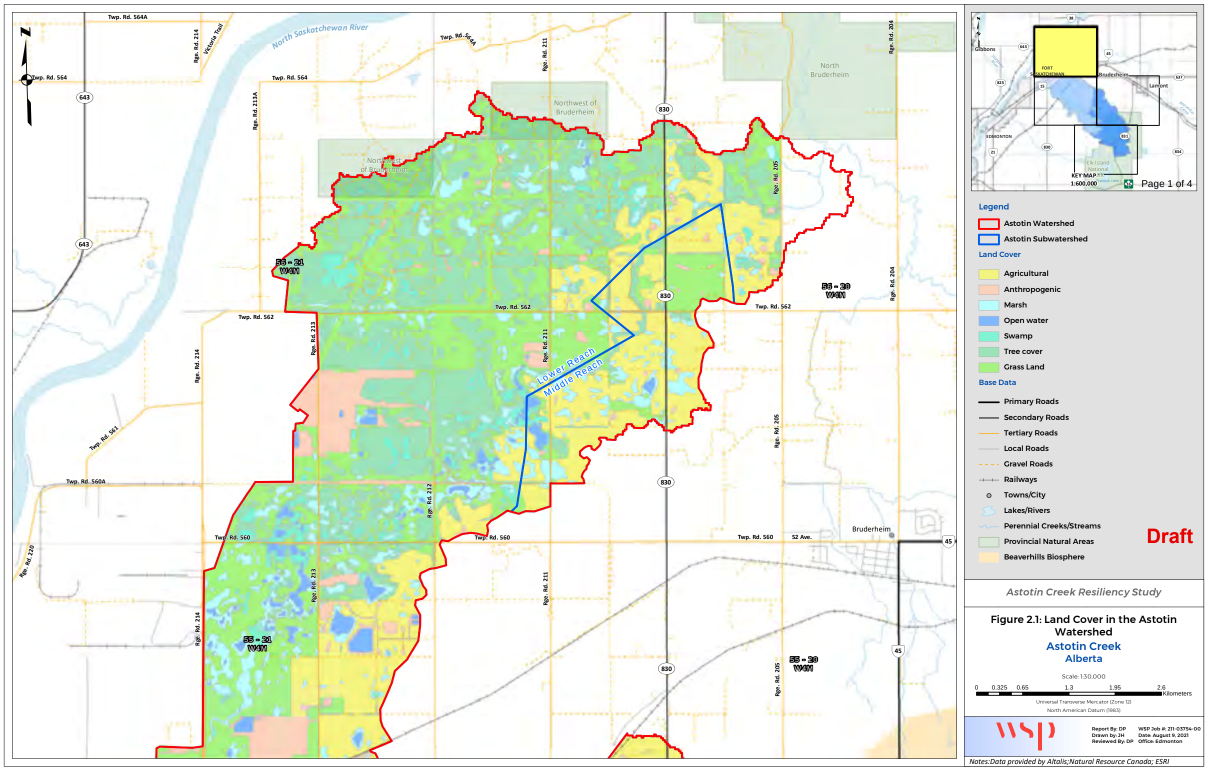
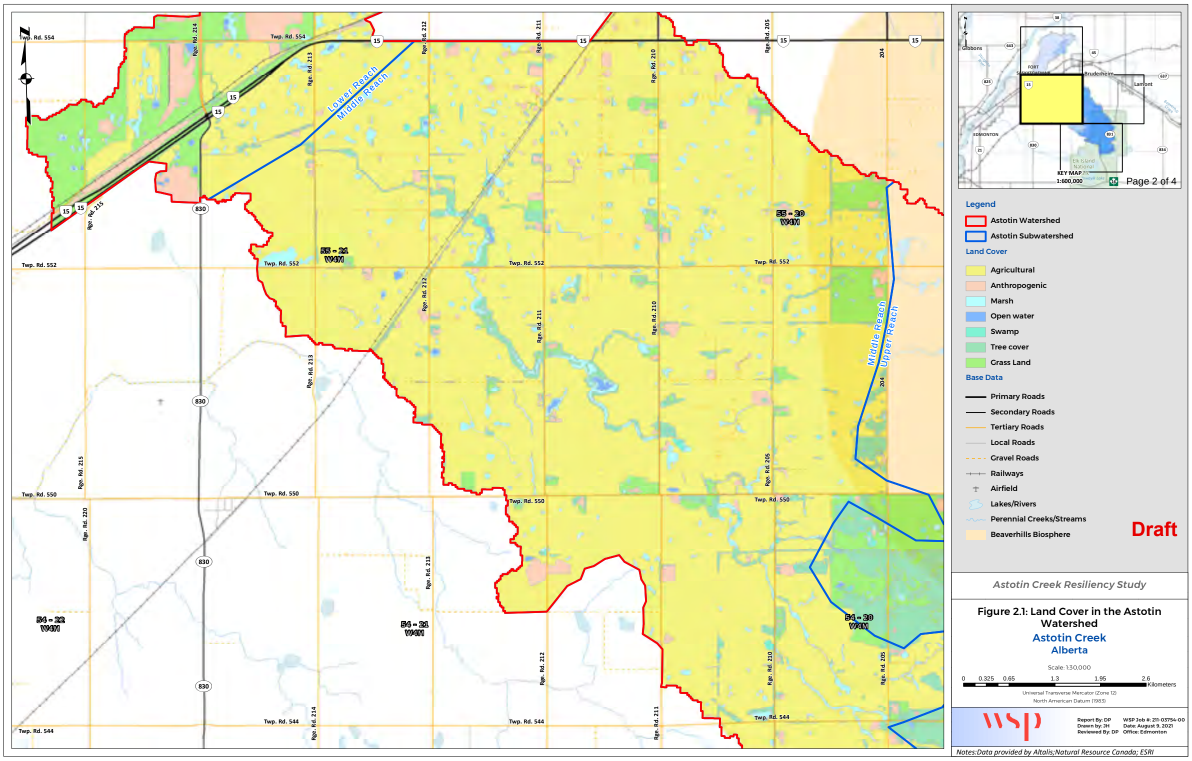


Figure 2-1: Land Cover in the Astotin Creek Watershed



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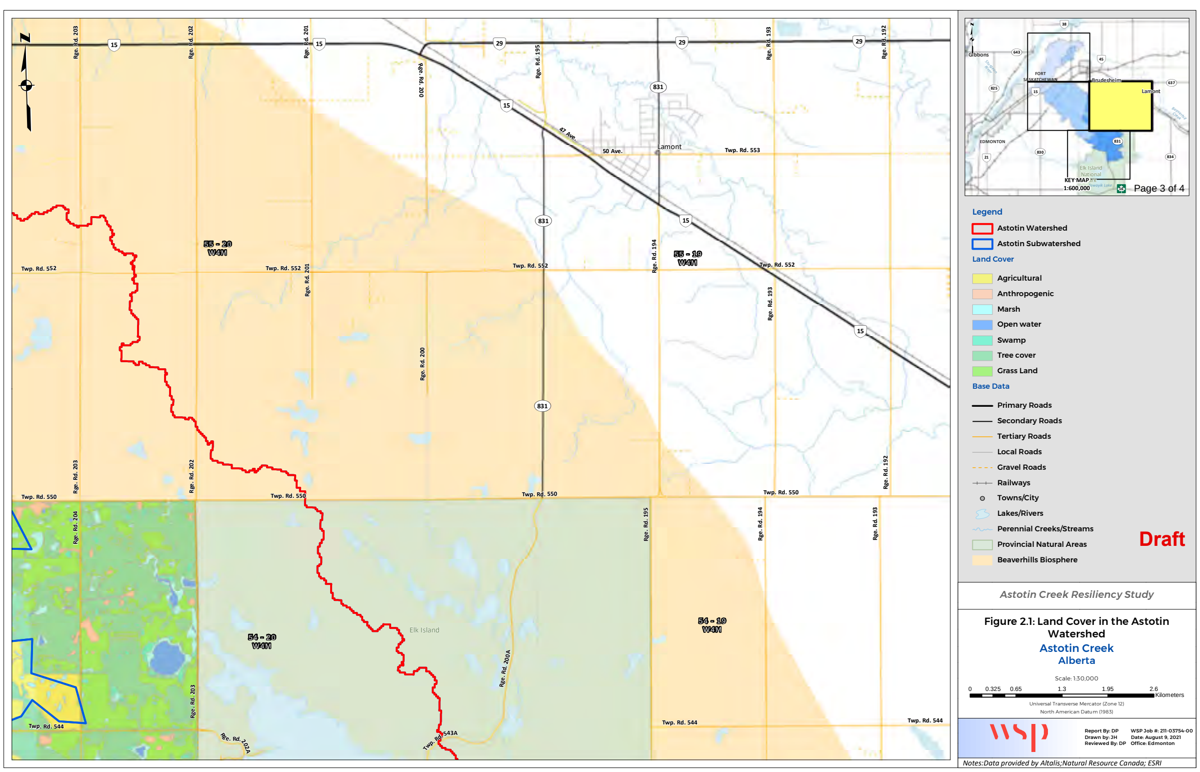

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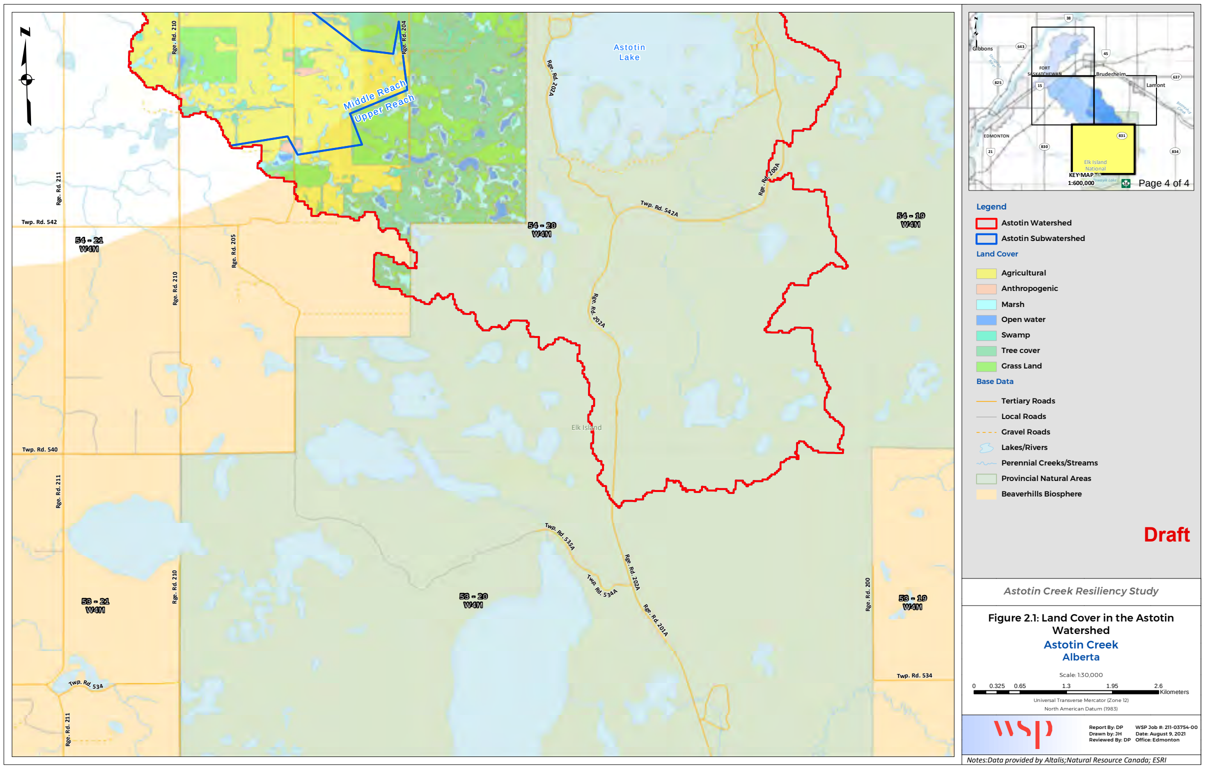

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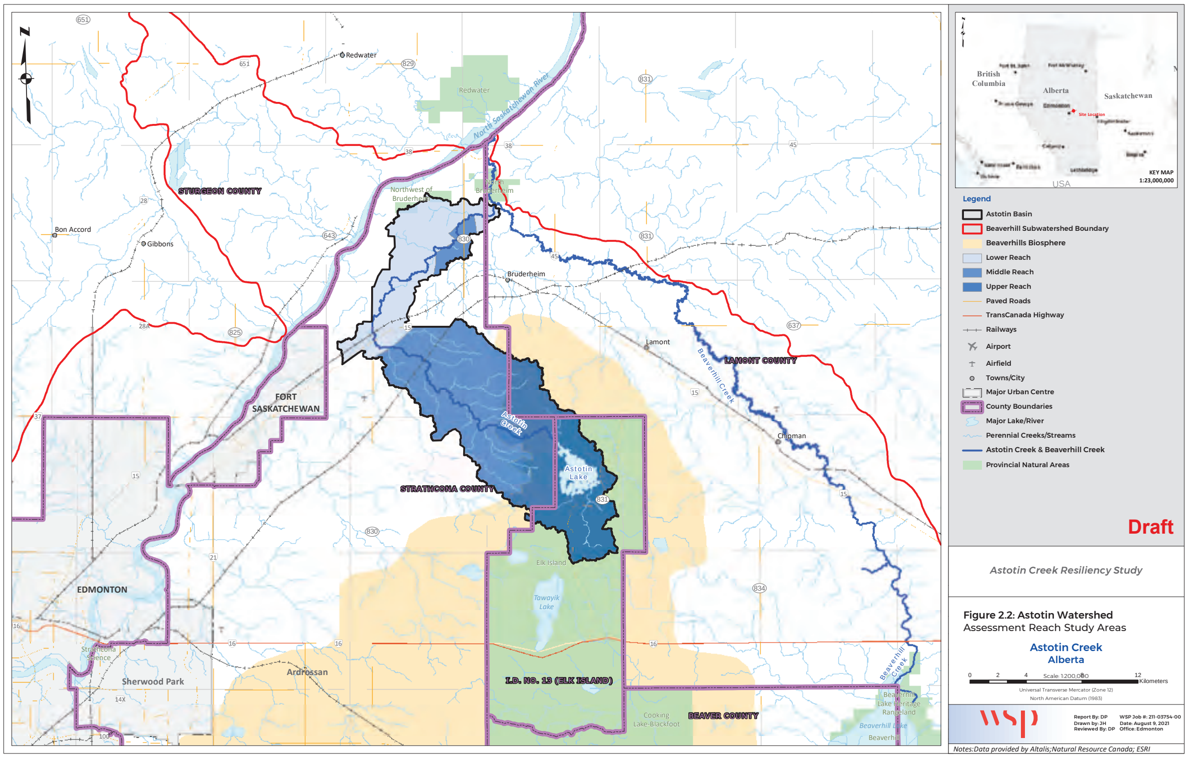

Figure 2-2: Astotin Creek Watershed Assessment Reach Study Areas

2.1.1 ELK ISLAND NATIONAL PARK AND BEAVER HILLS BIOSPHERE

The Astotin headwaters lie within Elk Island National Park, a large federal protected area with abundant natural habitat, biodiversity. It is part of the Beaver Hills Biosphere, which extends south through the Cooking Lake Blackfoot Provincial Recreational Area, Ministik Bird Sanctuary and Miquelon Lakes Provincial Park. Both areas play a role in conserving regionally important natural values of this area, a disjunct area of boreal habitat, but through different mandates.

Elk Island National Park was created in 1906 as an elk preserve, one of Canada's first wildlife refuges (Beaver Hills Initiative, 2015). As part of Canada's national park system, it has continued to play a significant role in conserving the ecological integrity of its boreal habitat and species at risk, most notably in the recovery of plains and wood bison and trumpeter swan populations. The Beaver Hills Biosphere was created in recognition of its abundant forests, wetland, and lake habitats, which support high boreal biodiversity within and outside protected areas. As a UNESCO Biosphere Reserve, it aims to demonstrate how sustainable development can be achieved in a conserved and lived-in landscape through regional cooperation on land management, education, and research. Elk Island National Park and the Beaver Hills Biosphere both play an important role in sustaining the ecological function and benefit of the Upper Astotin Watershed, and through the creek's hydrogeological and habitat connections, its downstream reaches as well.

Many of the species found in the Biosphere rely on protected areas like Elk Island National Park to provide key life requirements. Other species, like trumpeter swans and bison have benefited from park management to recover from near extinction population levels. Boreal species like moose and fisher have been found throughout the Beaver Hills Biosphere, on both protected and private land, and illustrate well the ecological benefits achievable through regional land management within a Biosphere. Beavers are abundant in Elk Island National Park and through the rest of the Beaver Hills Moraine, due to the extensive wetland habitat available across this area. In keeping with the conservation mandate of Elk Island National Park, park managers control beaver impoundments in Astotin Creek using non-lethal management (e.g., beaver deceivers and pond-levelers), which limits flooding while maintaining flow and beaver populations. Juvenile beavers may move out from the park into the surrounding streams and wetlands, including along Astotin Creek. These dispersing individuals can create conflicts with private landowners downstream of the park, but also provide other ecological benefits, including sustained water during drought. The Beaver Hills Biosphere has investigated alternative means of managing such conflicts through on-going research within the moraine context, a relevant example of the benefits of the Biosphere to the Astotin Creek and similar watersheds. Beaver impacts and benefits are particularly relevant to control of flooding impacts and discussed in more detail in Section 2.1.5.

2.1.2 RURAL RESIDENTIAL LANDS

The Upper Assessment Reach within Strathcona County crosses forested lands with rural residential and some agricultural land use (e.g., grazing). Development has been low-density, and upland habitats have experienced little disturbance or clearing. Naturally vegetated areas include aspen-dominated forest and wetlands in the uplands, and the creek typically has a wide vegetated buffer. These areas have been identified in past County studies and policies as environmentally sensitive areas (see Section 2.3). Like in Elk Island National Park, beaver activity is also high through this area, and old and new dams can be found along this section of the creek. Beaver dams here are managed by the County on request of landowners, or where roads are impacted, mainly using lethal means, including

2.1.3 AGRICULTURAL LANDS

The Middle Assessment Reach has been extensively cleared for agricultural crop and pasture use. Native habitat has been retained where development was not practical, or where landowners have chosen not to clear the land. Small patches of forest remain in some upland locations and along the creek, where it provides vegetated buffers of variable width along the creek edge. Wetlands have been influenced by agricultural practices (e.g., seasonal cultivation) or diversion, although there are some larger wetlands, including a large reservoir (the Josephburg Reservoir), created by a weir on Astotin Creek. Such areas have been identified as environmentally sensitive areas, particularly creek riparian zones for their potential to support wildlife movements across the landscape (Geowest Environmental Consultants, 1997; Spencer Environmental Management Ltd [Spencer], 2005). Other impoundments include a smaller ponded area created by a weir at the CN rail line. Beaver is also found along this section of the creek but are limited to areas with adequate woody vegetation for food and dam construction. As in the Upper Assessment Reach, the County manages beaver flooding concerns affecting road infrastructure, or on request of landowners.

2.1.4 INDUSTRIAL HEARTLAND

The Lower Assessment Reach is also largely naturally vegetated, with extensive forests and wetlands that extend beyond the watershed and into Lamont County to connect with the North Saskatchewan River valley. These areas have been identified as environmentally sensitive areas in County policies for their potential to support abundant wildlife and a regionally important ecological connection with the river valley. Two provincial Natural Areas also lie within this part of the watershed, North Bruderheim Provincial Recreation Area and North of Bruderheim Natural Area (Figure 2-2). The Lower Assessment Reach also lies within the Industrial Heartland, an area designated by the County for large petrochemical industrial developments. Several existing facilities, such as Shell's Scotford plant and other petrochemical sites have been long established within this area, as well as supporting railway and road networks. Culverts have been actively managed to control flow by industrial landowners, and the County. Beavers are also found throughout this area, likely attracted by the extensive wetland habitat, the persistent water flow in the creek and availability of forested riparian habitat. As elsewhere in the County areas of the Astotin Creek watershed, beaver management has been used to address site-specific flooding, at the request of landowners, including industry.

2.1.5 BEAVER CONFLICT AND MANAGEMENT

Beavers are a common management concern in many municipalities, due to the flooding caused by their dams and the cutting of riparian shrubs and trees. An 'ecological engineer', beaver can modify environments to create the ponded habitat they require, which can also put them in to conflict with adjacent landowners (Auster, et al., 2021; Yarmey and Hood, 2021). Flooding caused by their dams can affect adjacent property and land use and the persistent cutting of trees and shrubs can remove vegetation with aesthetic or recreational value, or cause property damage from felled trees. Beavers are not just a nuisance though;

they can also provide important benefits. Research from studies throughout the boreal regions in North America and Europe have identified various ecological EGS from beaver activity, including a large body of research conducted in the Beaver Hills Moraine. A balanced understanding of the impacts and benefits of beaver activity is increasingly used in municipal beaver management (Hood et al., 2018), in part because beavers are difficult to remove entirely from an area. Recognition of the benefits as well as the impacts can help promote strategies for co-existence.

Beavers are a central-place forager - they collect food from a certain distance around the waterbody where they establish their lodge (central place). They use water as a secure refuge from their terrestrial predators, often excavating the pond bottom to increase depth and allow winter access from their lodges to a stored food cache of twigs and branches (Hood and Larson, 2015). In on-stream systems, they sometimes build a series of dams, which allows them to expand their terrestrial foraging area while still offering escape to water. In wetland areas, they will also dig channels to facilitate access to adjacent upland habitat (Hood and Larson, 2015). Those channels, in turn, funnel water toward the pond, and with pond deepening (and reduced evaporative loss), contribute to enhanced water retention during drought periods. During the 2002 drought, for example, beaver ponds in Elk Island National Park had nine times more surface water extent during a 1:100-year drought (measured by open water area) than ponds without beaver (Hood and Bayley, 2008). In the southern part of the Beaver Hills Moraine, pond volume to surface area was found to be increased by 50% due to digging of channels by beavers, and these channels extended 200-300 m long (Hood and Larson, 2015). Ponds and channels can provide other ecological benefits by providing habitat for a variety of other aquatic and semi-aquatic species, including aquatic invertebrates, amphibians, waterfowl, and semi-aquatic mammals such as water voles, mink, river otter and muskrat (Anderson et al., 2015; Naiman et al., 1984), even in agricultural areas (Nelner and Hood, 2011).

The water held in beaver ponds can also influence adjacent soils through shallow groundwater infiltration. A study in the Western United States found that the higher soil moisture around beaver ponds prevented wildfire advances into the riparian zone (Fairfax and Whittle, 2020). Riparian zones with beaver experienced three times less fire than those without beaver. In areas facing higher frequencies of drought due to climate change, beaver may offer some protection.

Although foraging activity and flooding can alter the structure of the riparian vegetation buffer, this disturbance can increase biodiversity by creating new or enhancing existing habitat features. Organic matter and nutrients are added to beaver ponds from felled trees and shrubs, woody cached material, and vegetation submerged by flooding, thus increasing aquatic productivity, from aquatic vegetation to invertebrate populations (Vehkaoja, 2016). Similarly, snags used by woodpeckers and other cavity nesters increase due to tree mortality in beaver-flooded areas (Vehkaoja, 2016). Community composition and structure are continually altered by beaver foraging, but regrowth of shrubs and young tress can also support moose and deer, which also rely on woody species for winter food (Hood and Bayley, 2009). Beaver activity has been proposed as a restoration technique in some areas, due to their effects on ecological productivity (Vehkaoja, 2016). Beaver impoundments can also attenuate flood levels, by holding back water during flood events, as well as hold mercury and other trace elements in forms inaccessible to wildlife and plants (Ecke et al., 2017; Westbrook et al., 2020).

Regardless, flooding impacts caused by damming of culverts by beavers and other road infrastructure can create on-going maintenance issues, as well as property damage (Hood et al., 2018). Beaver management can become a polarizing issue in rural areas, dependant on the positive or negative perceptions of residents of beaver activities (Yarmey and Hood, 2021). Under the provincial Wildlife Act, beaver can be removed by a licensed trapper where they create a nuisance for landowners or land managers (e.g., at County culverts and bridges). The County has established a policy for removing beaver, and other vertebrate species considered as nuisance species, through humane means, and will respond to landowner concerns to assist in wildlife control on request. The County also uses trapping and dam breaching to remove beaver and dams to protect its own infrastructure.

Such management activities tend to provide short-term relief though, as beaver soon recolonize these areas and re-establish dams and pond habitat. The costs of ongoing traditional maintenance and repair to blocked culverts and bridges can result in considerable annual cost, although costs are not always tracked by municipalities (Hood et al., 2018). Total annual costs for traditional maintenance of beaver impacted infrastructure provided by 48 Alberta municipalities and four provincial park districts that do track costs was over $3M in 2018 (Hood, et al. 2018). Costs ranged considerably, depending on beaver density and available habitat, which influences frequency of maintenance, but also the resources used for maintenance (staff, equipment). Alternative management techniques, such as ‘beaver deceivers’, ‘pond levellers’ and exclusion fencing are increasingly promoted by organizations, such as Cows and Fish and the Miistakis Institute, to maintain beaver and their various benefits, while minimizing flooding and property damage effects. Hood et al. (2018) found installation of 12 pond levellers at the Cooking Lake-Blackfoot Provincial Recreation Area had a present net value benefit of $81,519 over three years of operation, and $179,440 over 7 years of implementation, due to near elimination of maintenance and flood repair.

2.2 HISTORICAL AND INDIGENOUS CULTURAL RESOURCES

The Astotin Creek watershed and surrounding region has seen a dramatic shift in land use over the past two centuries. This shift has brought about competing interests in the land, from Indigenous land users to a growing settler population, and later, to industrial and agricultural development pressures. Balancing the needs of the people of Strathcona County, the environment, and industry continues to be a challenge today.

2.2.1 HISTORICAL DEVELOPMENT SUMMARY

The Astotin Creek Watershed was traditionally occupied by multiple Indigenous groups who accessed the area for hunting, trapping, and gathering of nomadic tribes. In the mid to late 18th century, the development of forts and permanent camps in the Edmonton area began (MacDonald, 2009). This settlement was driven by European fur traders and the Hudson's Bay Company (HBC), which had been granted control over the entire drainage system of the Hudson Bay by the British Crown. The Indigenous people of the region were major trading partners of the HBC, and the growth of the fur trade also led to several First Nation and Métis groups establishing permanent camps in the region, leading to a shift away from their previously nomadic lifestyles (MacDonald, 2009).

These small forts and camps were only the beginning of significant changes to land use in the region. Increased pressure on ecological resources, particularly fur-bearing mammals, contributed to the decline of the fur trade in the mid-19th century. The HBC eventually transferred many of its lands to the Dominion of Canada in 1869 (MacDonald, 2009). The decline of the fur trade and the surveying and sale of land parcels to incoming settlers, led to increased tensions between Indigenous groups and settlers. The Dominion of Canada began establishing numbered treaties in what is now Alberta, with the goal of transferring title of land from First Nations to the Crown (Beaver Hills Initiative, 2015). The Astotin Creek watershed now lies within Treaty 6 territory, which extends across central Alberta into Saskatchewan. First Nations people residing in the area were given reserve land to the south, near Battle River, and to the west, in what is now Edmonton. While some Métis settlements remained in the area, Indigenous people were largely pushed out of the region by European settlement in the coming years (Beaver Hills Initiative, 2015).

With a commitment from the Dominion of Canada towards permanent, organized European settlement in the region, land use transitioned primarily to agriculture by the end of the 19th century (Beaver Hills Initiative, 2015). The increase in settlement and agriculture drove growth of the forestry industry in the region, supplying wood for the newcomers' homesteads (Beaver Hills Initiative, 2015). With the completion of the railway in the early 20th century, more settlers arrived and small industries, including coal mining, began operating (Beaver Hills Initiative, 2015). Coordinated wildlife conservation initiatives, such as the development of Elk Island National Park in 1906, followed in response to the ecological risks associated with rapid settlement (Beaver Hills Initiative, 2015).

2.2.2 INDIGENOUS LAND USE AND CULTURAL CONNECTIONS

First Nations peoples have hunted, trapped, fished, conducted ceremony, and lived in the Astotin Creek watershed and surrounding area for thousands of years. The area's rich resources, including waterbodies, forests, open prairies, and hills provided food, shelter, and materials for ceremony (Matters and Hood, 2016). The animals and plants that still make the ecosystem what it is today, such as elk, deer, moose, beaver, waterfowl, berries, and wild vegetables, provided food for the many groups that passed through the region. The name of the moraine lands along the southern border of the watershed, amiskwaciy (Cree), or Beaver Hills, recognized the abundance of this fur bearing mammal and its importance for Indigenous livelihood. The water systems in the watershed provided fresh drinking water, and the forests provided wood for shelter, fire, and poles used for ceremony (Matters and Hood, 2016). While the landscape has changed, as has access to the land for hunting, gathering, and cultural use, Indigenous people still hold strong ties to the land today (Matters and Hood, 2016).

Indigenous perspectives on the region and land are often missing from the written records (Matters and Hood, 2016). Prior to European settlement, the Nehiyaw (Cree) and Niitsitapi (Blackfoot) people primarily occupied the region, moving in nomadic camps. Over time, the Nakoda Sioux, Saulteaux, and Dane-zaa all visited the area during certain periods or times of the year. During the early arrival of European traders and settlers, First Nations (primarily Cree) and, eventually, Métis people were highly involved in the fur trade and some groups established permanent camps and settlements in the Beaver Hills (MacDonald, 2009). Following the declining fur trade, the increase in European settlement and the establishment of Indian Reserves in the late 19th century, the Indigenous peoples were pushed from the area. Some Métis groups remained until the early-20th century but had largely dispersed by the mid-20th century due to increased agricultural pressures (Matters and Hood, 2016).

Despite being forced from their lands due to encroaching settlement, Indigenous interest in and connection to the land persist today and efforts are being made to explore and expand upon that connection. The cultural links of First Nations people to the moraine extend over thousands of years. And while Métis people moved to the area much later, they still hold strong ties to their traditional ways of life that were supported by the region's resources and fur trade (Matters and Hood, 2016). While the Astotin Creek watershed does not have much public land accessible for hunting, trapping, or harvesting today, the Beaver Hills area to the south is still used for winter hunting (Matters and Hood, 2016).

The inclusion of Indigenous knowledge and perspectives in developing the Astotin Resiliency Action Plan will help to enhance the narrative about the Astotin Creek watershed and surrounding area and can help to better understand land use and conservation opportunities in the region. While many people who now live in the Astotin Creek watershed have a strong understanding of the complexities of the landscape and a strong connection to it, Indigenous land users and knowledge holders have a unique, long-term perspective on the region, and a deep connection to the land and water, developed over many generations. The meaningful inclusion of their voices will contribute to the long-term resiliency of the creek.

2.3 CURRENT POLICY CONTEXT

2.3.1 ENVIRONMENTAL PLANS, PROGRAMS AND POLICIES

Strathcona County has long acknowledged the importance of a healthy environment to the quality of life enjoyed by its residents. Strathcona County's Municipal Development Plan (MDP) and the recently adopted Environmental Framework (2021) recognize the value of its natural beauty and quality of life, and the importance of cooperative efforts to conserve and enhance the quality of air, water, land, and natural systems found in the region. The Environmental Framework provides guidance to assess and document environmental factors and impacts in planning and decision-making. Through an ecosystem model that stresses the importance of a life-cycle view, the framework considers abiotic (air, water, land), biotic (biodiversity), energy and waste outcomes of management. It also stresses the importance of human influence: the network of County departments and other government and non-governmental organizations, and its citizens can also play a role in building policy. This approach replaces the previous 2009 Environmental Sustainability Framework, but builds on it, and other plans and policies that the previous framework generated.

Specific to the Astotin Creek watershed, the MDP has identified lands adjacent the North Saskatchewan River and west of Elk Island National Park as key wildlife and biodiversity zones. Other specific parcels have been designated as Environmentally Significant Areas based on past studies completed by the County. This includes the Prioritized Landscape Ecology Assessment (PLEA) study, which identified prioritized natural features and wildlife habitats across Strathcona County for the conservation easement program initiated in 1996 (Geowest, 1997). An updated study, the Assessment of Environmental Sensitivity and Sustainability (Spencer, 2005), based on the 2007 Beaver Hills Land Management Framework, identified Priority Environmental Management Areas (PEMAs). The PLEA and PEMA inform other environmental policies, and also supported Policy Areas updated in the 2007 and the current MDP (for more information on these two studies, see Section 6.3.2). The Heartland Industrial Area Structure Plan 24-2018 (ASP) and supporting Biophysical Assessment provided additional environmental management guidelines for the Lower Astotin Creek area.

To support statutory land use policies such as the MDP and LUB, Strathcona County has established various additional policies to help achieve these goals. Policies relevant to the Astotin Creek Resiliency Study include:

- Conservation of Biological Diversity Policy (SER-012-011)
- Conservation and Environmental Reserve Easements Directive (SER-009-031D)
- Biophysical Assessment Directive (SER-009-032D)
- Tree Conservation Directive (SER-009-042D)
- Wetland Conservation Directive (SER-009-038)
- Light Efficient Community Policy (SER-009-038)
- Legacy Lands Directive (SER-012-010D)
- Weed and Pest Control Policy (SER-001-034)
- Vertebrate Nuisance Control Policy (SER-001-009)
- Surface Water Drainage By-Law (By-law 32-2017)

Together, these policies provide mechanisms for the County to assess, conserve or mitigate environmental impact to ecologically important areas, mostly related to areas of human use. Some are applied in situations where new development is planned, while 'nuisance' policies (e.g., for weeds or vertebrate nuisance species) address management of developed and undeveloped sites. A notable exception is the Legacy Lands Directive, which provides a process for the County to acquire lands of high ecological value and protect ecological linkages through conservation easements or other means.

The Vertebrate Nuisance Control Policy allows a landowner and/or the County to control, through humane means, wildlife impacting land use (e.g., beaver, muskrat, coyote, skunks). This includes removal of beaver and breaching beaver dams, both of which could also affect ecological conditions (e.g., through release of accumulated sediments, or loss of flood attenuation potential). Similarly, the Surface Water Drainage Bylaw focuses on controlling storm run-off to protect properties and roads and other County infrastructure. While it incorporates some environmental considerations, such as stormwater treatment and prevention of release to environmentally sensitive areas, its focus is mainly on provincial regulatory requirements for flood and water quality protection.

The County's Wetland Conservation Directive, in contrast, considers how wetlands could be conserved, restored, or rehabilitated, by avoiding and minimizing wetland loss during land development, or replacing or restoring degraded wetlands in compensation for current and historical wetland loss. Through the provincial Wetland Replacement Program, Strathcona County is working in partnership with Alberta Environment and Parks to restore and replace wetlands within the County. Through that program, funds collected from the loss of wetlands during current development in the County can be applied to projects that would replace habitat in areas of the County that have experienced higher historical loss. This particular program offers an opportunity to restore wetland habitat and flood storage potential in the Astotin watershed.

2.3.2 DEVELOPMENT AND LAND USE PLANNING

Strathcona County, like most municipalities, has developed a Municipal Development Plan (MDP) (Strathcona County, 2020) and associated Land Use Bylaw (LUB) to manage land development in its jurisdiction. The MDP outlines a broad development vision across the County, with different policy areas each outlining permitted types and densities of development. The MDP identifies three policy areas within the Astotin Creek watershed, each roughly matching the three Assessment Reaches described above.

- The Upper Assessment Reach lies within the **Beaver Hills Policy Area**, created to conserve natural areas adjacent Elk Island National Park as a buffer the park from more intensive land use. Agricultural land use and low-density development can occur, including rural residential areas.
- The Middle Assessment Reach lies within the **Agriculture Large Holdings Policy Area**, created to help maintain the long-standing, larger scale farming operations in this area, and limit potential subdivision. Land use is intended to remain focused on agriculture.
- The Lower Assessment Reach lies within the **Heartland Policy Area** and extends from just south of Highway 14 to the North Saskatchewan River. It was created to focus petrochemical industry development in an area with access to road, rail, and pipeline infrastructure. Although some agricultural land remains in the area, permitted future development includes commercial land use and new industrial projects, and various land parcels are currently held by industrial companies.

Strathcona County's Land Use Bylaw provides more specific guidance for future development. Land use districts mapped within the rural areas of the County designate specific land use zones, and the bylaw outlines permitted density, setbacks, access and building specifications. Together the MDP and LUB give the broader vision for future development, and tools that can help manage other high-level goals relevant to watershed resiliency, such as stormwater management, ecological conservation and wetland conservation, restoration, and replacement.

2.3.3 EXISTING STORMWATER PLANS, PROGRAMS AND POLICIES

Municipal and provincial regulations, guidelines and standards govern stormwater management requirements for developments. The documents described next are relevant to development within the watershed.

2.3.3.1 Municipal Plans, Standards and Guidelines

The Strathcona County Municipal Development Plan – Bylaw 20-2017 (Strathcona County, 2020) is the County's high-level long-term planning and policy document. The County's MDP outlines that watersheds experiencing active development, such as the Heartland Policy Area, require master drainage plans and master utility plans. The MDP further encourages (1) a regional approach to water demand management, (2) improving water quality within stormwater management facilities, (3) opportunities for non-potable water irrigation and (4) implementing stormwater best management practices and low impact development. The Strathcona County Best Management Practices for Stormwater Management Facilities (Strathcona County, 2021a) outlines guidelines and best management practices (BMPs) to protect the overall North Saskatchewan watershed (NSRW). The Astotin Creek watershed is technically a sub-watershed of the NSRW. The County sets out quality and quantity requirements for stormwater such that there is as little impact as possible to receiving streams and natural systems. The County has adopted five types of BMPs: source control, lot level, conveyance, pre-treatment, and treatment BMPs such as dry ponds, wet ponds, constructed wetlands, and naturalized wetlands.

The Strathcona County Design and Construction Standards (Strathcona County, 2021b) provide information for the design of municipal systems. The County's standards require a stormwater management plan for developments in the Rural Service Area, which includes the Astotin Creek watershed. Stormwater management plans in the County should address the following items:

- elimination or mitigation of property damage and flooding.
- maintenance of pre-development runoff release rates or as required to protect the receiving watercourse(s).
- erosion and sedimentation control in creeks, drainage courses and ditches; and,
- the protection of significant wetlands.

2.3.3.2 Alberta's Industrial Heartland (AIH) Plans

Two documents exist to guide industrial developments in the AIH. The County's stormwater management plan for its portion of the AIH, including lands within the Astotin Creek watershed, was developed in 2016 (Stantec Consulting Ltd., 2016). The stormwater management plan recommends a typical urban drainage system with 16 onsite detention facilities. The design of the minor and major drainage systems will use the 1:5 and the 1:100-year return periods, respectively. Subsequently, the County developed an Area Structure Plan (ASP) for the AIH (Strathcona County, 2018). The Heartland Industrial ASP identified general infrastructure needs and services requirements and natural and environmentally significant areas. Individual developments must manage stormwater in the AIH, which will continue to drain to Astotin Creek. Further, the Heartland Industrial ASP states that stormwater management plans are to be developed for each catchment of the Astotin Creek watershed (16 in total) to ensure effective and coordinated stormwater management for the 1:100-year rainfall event.

2.3.3.3 Provincial Guidelines and Regulations

Additional provincial guidelines and regulations relevant to stormwater include the following (non-exhaustive) list:

- Water Act
- Environmental Protection and Enhancement Act
- Wastewater and Storm Drainage Regulation (Alberta Regulation 119/1993)
- Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems
- Stormwater Management Guidelines for the Province of Alberta (Alberta Environmental Protection, 1999)

A complete list of applicable policy documents is provided in Strathcona County (2021a) and Strathcona County (2021b).

2.4 Biodiversity Study Areas

The three distinct watershed assessment reaches (Upper, Middle, Lower Assessment Reaches, Figure 2-2) of the Astotin Creek watershed were identified based on current land cover and land use, which in turn would support different biodiversity. The biodiversity survey was designed to characterize the soils, vegetation, and wildlife of the different habitats in and adjacent to the Astotin Creek. Aquatic habitat conditions were also surveyed in areas where land access was allowed, to assess potential to support fish and other aquatic species along the creek. These surveys also helped assess the effects of past land management along the creek on vegetation and wildlife and illustrate current condition of those habitats across the watershed. Ultimately, the survey will help inform conservation, restoration, and management recommendations for the Resiliency Action Plan. Table 2-1 describes variables influencing biodiversity within these assessment reaches.

Table 2 -1 Variables Influencing Biodiversity within the Assessment Reaches of Astotin Creek watershed

Assessment Reach	Land Cover – Landscape Level	Riparian Land Cover Influences
Upper Reach	**Natural/Intact:** limited disturbance, large & connected natural habitats (riparian, uplands)	• Forest • Shrub • Meadow/pasture • Anthropogenic development (rural residential)
Middle Reach	**Cleared:** remnant native vegetation (riparian and upland), low connectivity along creek and very low across uplands	• Agriculture • Remnant riparian • Meadow/pasture • Anthropogenic development (farm residence)
Lower Reach	**Semi-cleared:** larger natural patches mixed with cleared/ industrial developed lands, moderate connectivity along creek and with adjacent uplands	• Forest • Shrub • Meadow/pasture • Anthropogenic development (agricultural and industrial)

SOILS

3

The soil characteristics of each part of the Astotin Creek watershed have supported development of both its natural and human landscape. Soils in the Astotin Creek watershed were deposited during the last glacial retreat across these plains, but with quite different results. The Upper Assessment Reach lies within the Beaver Hills Moraine, a hummocky landscape with forested uplands and abundant wetlands that has had limited development. The Middle and Lower Assessment Reaches lie in undulating plains formed from clay and sandy sediment glacial deposits suitable for a variety of types of development. Those differences can also inform future management of the watershed, regarding erosion risk, restoration, and land development.

3.1 Methods

Soil information was drawn from three main sources:

- Canada Land Inventory (CLI) Agricultural Soil Capability Mapping,
- AGRASID, and
- the Assessment of Environmental Sensitivity and Sustainability (Spencer, 2005)

The CLI and AGRASID resources have long been used by rural municipalities to identify areas of high value for agricultural land use. The AGRASID has also been used to identify areas of sensitive soil (e.g., sandy or coarse soils). These two resources were also used to map out areas of environmental sensitivity in the Assessment of Environmental Sensitivity and Sustainability (Spencer, 2005), which provided a useful summary for this current assessment.

3.2 Existing Conditions

The agricultural capability of soils within the Astotin Creek watershed are generally reflected in existing land use patterns in the Upper, Middle and Lower Assessment Reaches. CLI mapping shows higher capability (Class 1) soils are the dominant soil type in the Middle Assessment Reach (Spencer, 2005; Figure 3-1), an area largely cleared for cereal crop use. The Upper Assessment Reach has lower capability soils (Class 4 and 5), particularly adjacent to Elk Island National Park, which have significant limitations for cereal crop development. An area of Class 2 soils, with slight limitations lies between the Upper and Middle Assessment Reaches and is under crop production. The Lower Assessment Reach also has a mixture of soil capabilities: with predominantly Class 2 soils on the western side of this part of the watershed, and a mixture of Class 1, 2, 4 and 5 soils on the eastern side. Not surprisingly, these soil classifications generally correspond to land cover, with more naturally vegetated areas in areas of lower agricultural capability.

Soils in the Middle and Lower Astotin Assessment Reaches are generally characteristic of the Aspen Parkland Natural Subregion, with Black and Dark Brown Chernozems (soils that develop under grasslands) and Dark Gray Chernozems and Luvisols (developed under forested sites) (Natural Regions Committee [NRC], 2006). These are the soils showing high agricultural capability in the CLI mapping for the area: on generally level terrain, with good soil texture and fertile soil composition. The Upper Assessment Reach, within the Beaver Hills Moraine, and the Dry Mixedwood Boreal Natural Subregion, generally has Gray and Dark Gray Luvisols on uplands and Gleysols and Organic soils in wetlands. Terrain is hummocky, and less conducive to cereal crop agriculture.

More specifically, AGRASID (Alberta Agriculture and Forestry, 2020) shows the Upper Assessment Reach soils include a mixture of poorly drained soils, mainly of medium texture (clay, clay-loam), developed on hummock terrain of varied relief (Figure 3-2). Immediately adjacent to Elk Island National Park and extending west through this part of the watershed, the CAOA19/H1m soil unit has Orthic Gray Luvisols with some Chernozemic soils, clay to clay-loam texture, and medium relief. The RMUC2/H1l unit has low relief terrain and a mixture of Orthic Dark Gray Chernozems with loam silty-loam soils developed over aeolian (sandy) and lacustrine sediments, and Dark Gray Luvisols on medium textured, loam, clay-loam soils developed over till. The COUC2/H1m soils are Orthic Gray Luvisols Dark Gray Luvisols of loam, clay-loam texture developed over till, on landforms of medium relief. A small pocket of ELGB1/H1m soils is unique in supporting moderately coarse textured (sandy loam, and sand, loam and to sandy loam) soils, over aeolian or lacustrine deposits (Dark Gray Luvisols). A former sand pit was developed at this site and is now partly conserved as a County natural area.

The agricultural soils of Middle Assessment Reach are dominated by AGS2/U1h soils, Eluviated Black Chernozems on poorly drained, medium textured (loam clay-loam) soils, developed on glacial till (Figure 3-2). Small pockets of poorly drained, NVR1/U1j soils, Gleyed Black Chernozem on fine textured soils (clay silty clay) and Eluviated Black Chernozems on medium textured (loam, clay loam), AGS2/H1j soils also lie in this area. Terrain is undulating, with low relief and thus amenable for cereal agriculture.

The soils of the Lower Assessment Reach are quite varied, with a mixture of terrain and soils of higher agricultural suitability and unique terrain associated with sandy soils (Figure 3-2). Developed over wind and water influenced deposits, soil units extend in bands paralleling the river valley, each with distinctive terrain, drainage, and texture characteristics. The western side of the Assessment Reach is dominated by Eluviated Chernozem soils on undulating terrain of low relief (Alberta Agriculture and Forestry, 2020). This MMO2/U1j soil unit has fine-textured (clay, silty -clay) soils, while the AGS1/U1h unit has medium textured loam, clay-loam soils. A band of NVR1/L1, Gleyed Black Chernozems and fine textured (clay, silty-clay) soils form a level plain, running southwest to northeast through the middle of the Heartland area. To the northeast, AGS2/U1h soils extend north of Highway 15 into the Lower Assessment Reach from the Middle Assessment Reach. Between Highway 15 and the river, through the east end of the Lower Assessment Reach, there are bands of different soil units: Eluviated Black Chernozems on poorly drained, medium textured sediments (loam, silt-loam, POK2/U1h) on undulating terrain with high relief; poorly drained Orthic Black Chernozems on coarse sand to loamy-sand soils (MDR2/H1l); and very coarse, sand to loam sand soils (MDR2/U1h) with high to low relief. The PRZO1/D2j unit, at the north part of this part of the Assessment Reach is a very coarse textured, sand to loam sandy Eluviated Eutric Brunisol, with pockets of organic soils (ZOR) and low-relief, parabolic dune landforms. The North of Bruderheim and North Bruderheim Natural Areas have conserved some of this unique landscape.

Soil texture provides a good indication of erosion risk. Coarse to fine sandy and fine silty soils are highly erodible to wind and water erosion, while medium textured clays are less so. Spencer Environmental Management Services Ltd. (2005) mapped soil texture across the County, by extracting texture data from the AGRASID database (Figure 3-3). This mapping shows medium texture soils across much of the Astotin Creek watershed, with area of fine textured soils adjacent to Elk Island National Park, and across most of the Industrial Heartland area within the Astotin watershed. Coarse textured (sandy) soils extend east from Fort Saskatchewan to the County boundary, and along the northern edge of the Astotin Creek watershed. There is potential for small pockets of sandy soils to occur through this area, as well as localized deposits along the creek and its tributaries.

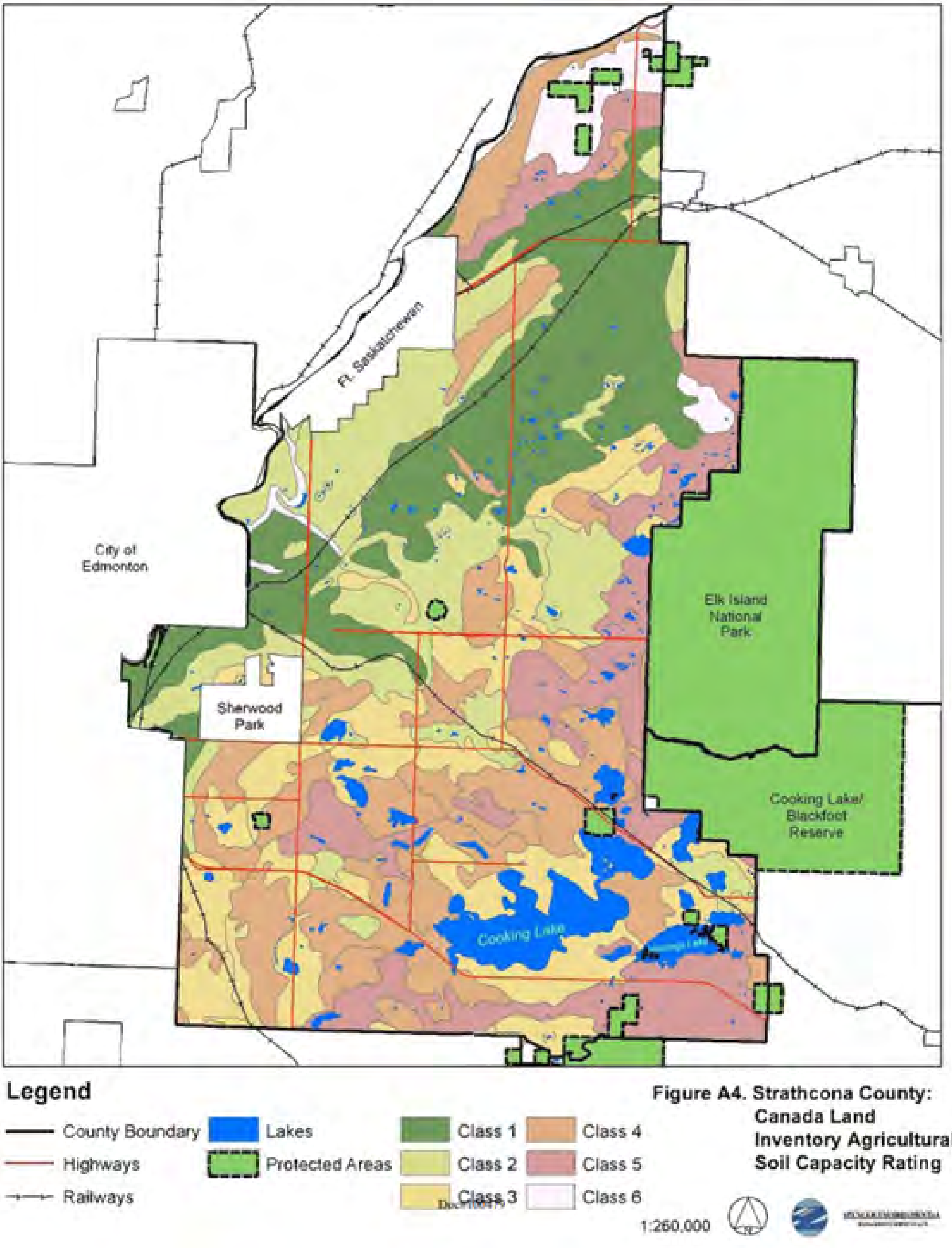

Figure 3 -1 Canada Land Inventory Agricultural Soil Capability Rating (Spencer, 2005)

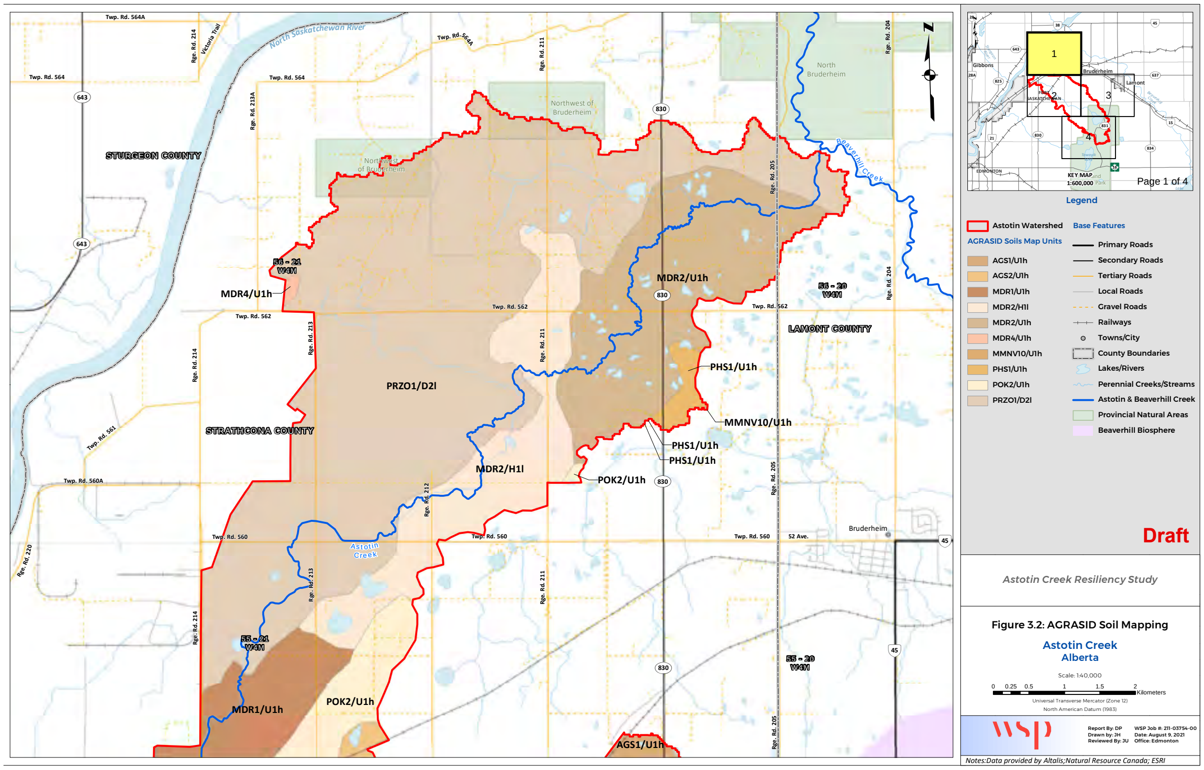

Figure 3 -2 AGRASID Soil Mapping

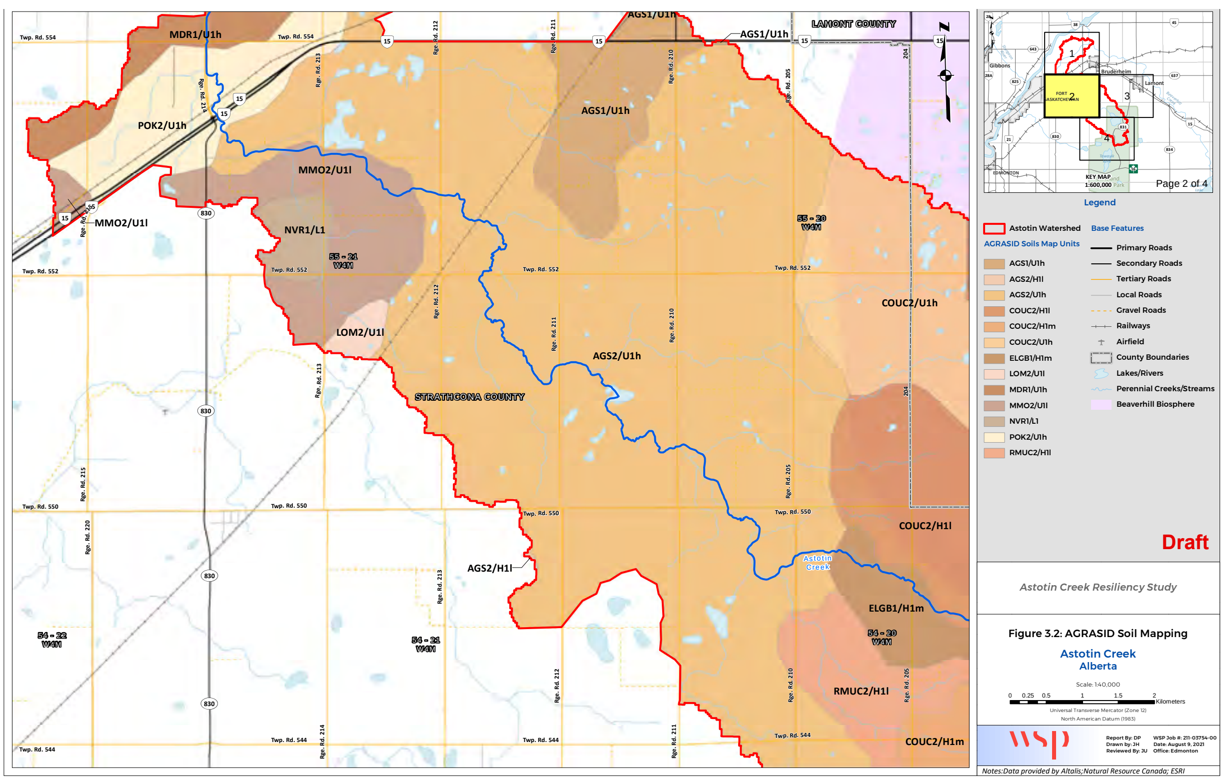

Figure 3 -2 AGRASID Soil Mapping

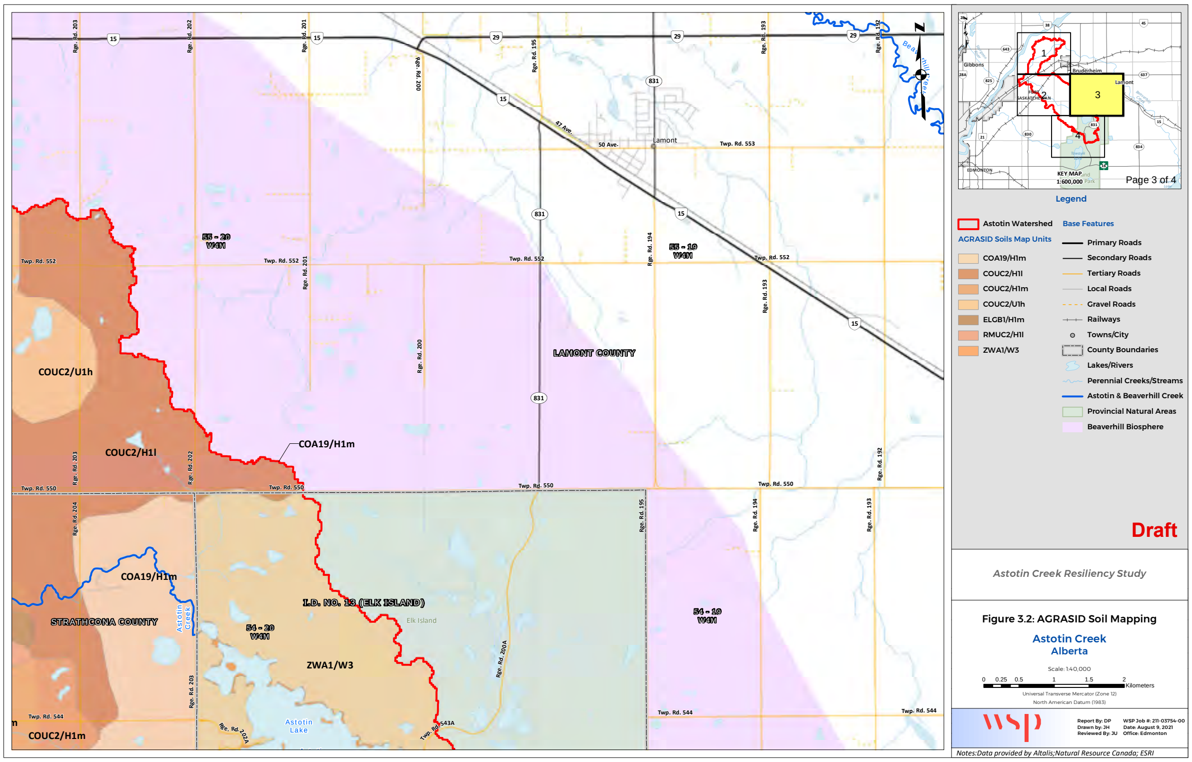

Figure 3 -2 AGRASID Soil Mapping

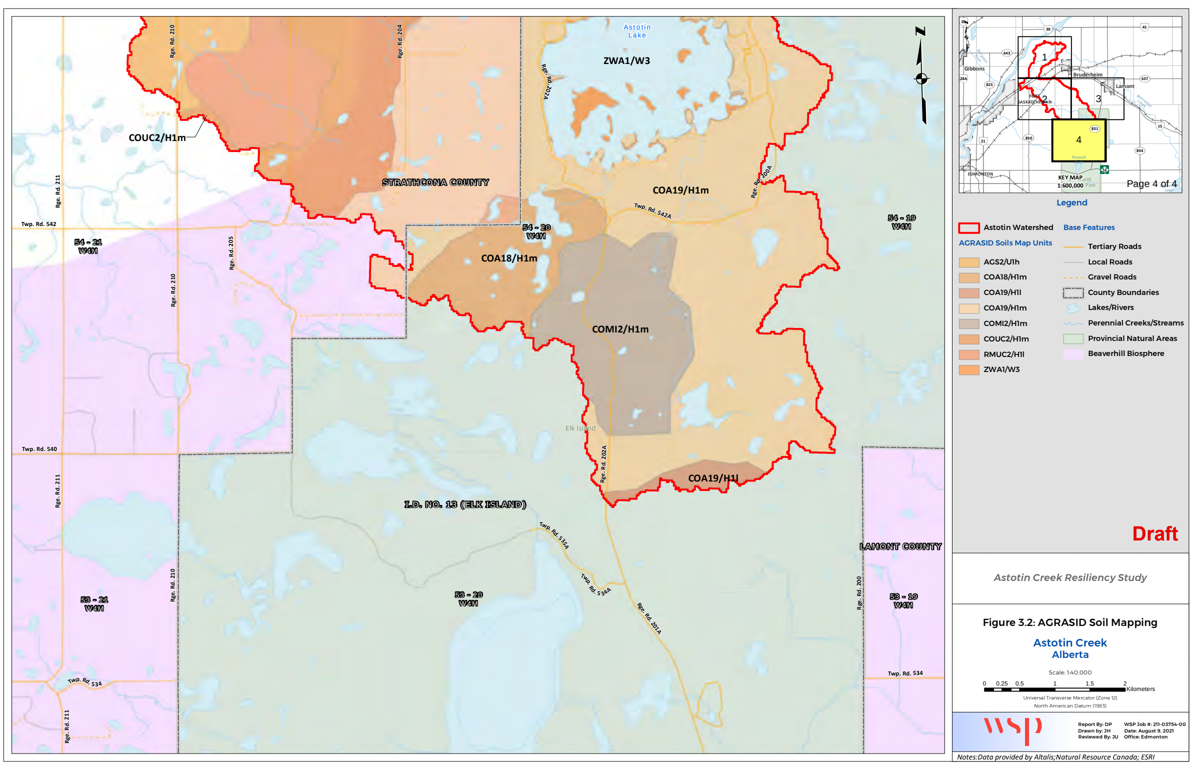

Figure 3 -2 AGRASID Soil Mapping

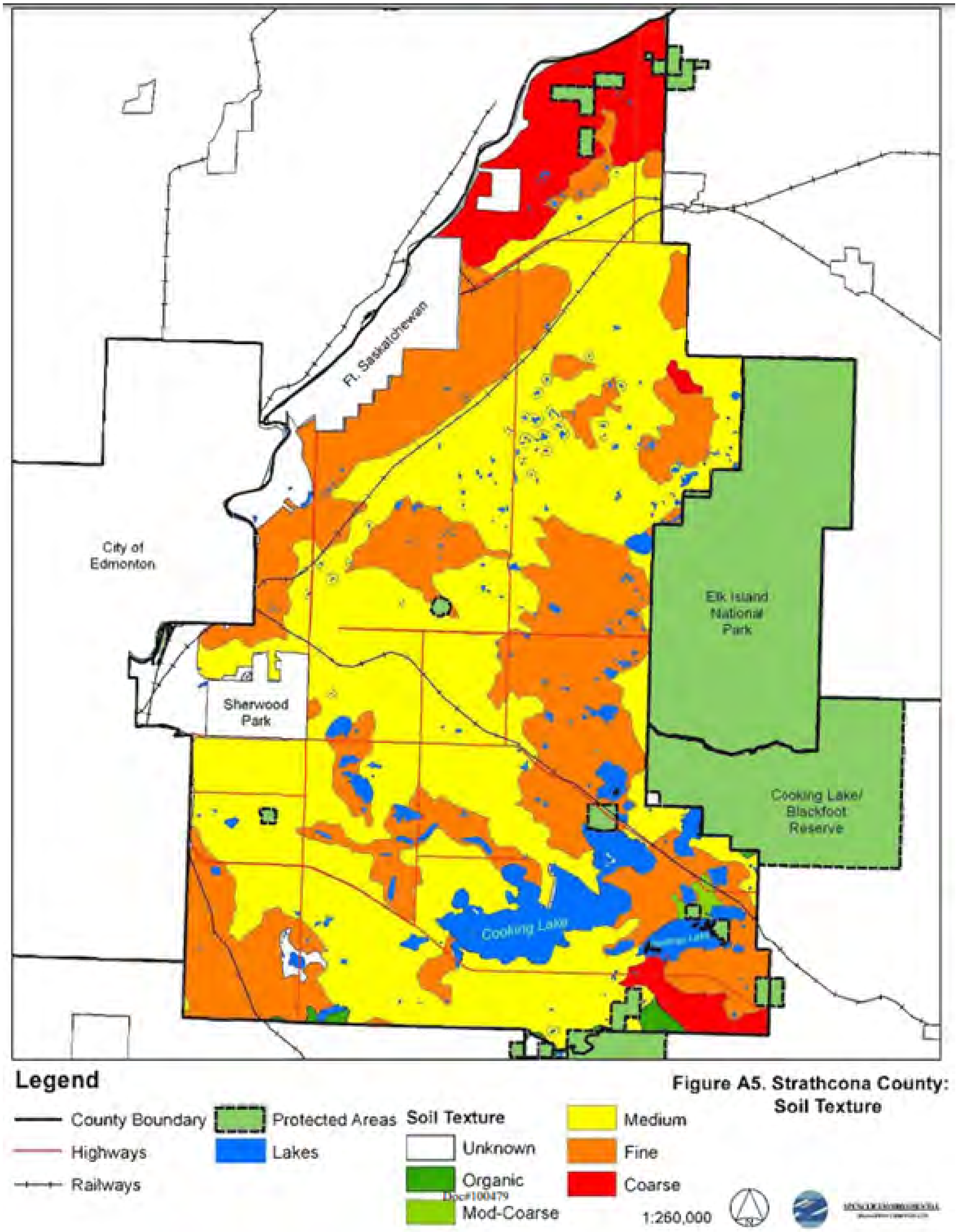

Figure 3 -3 Soil textures across Strathcona County (Spencer, 2005)

3.3 Summary

Soil characteristics provide insight to areas of higher erosion risk, which in turn can contribute to potential for sediment release to aquatic habitats. Soil characteristics also indicate where ecological restoration may be challenging (e.g., sandy soils). Key considerations relative to soils along the three assessment reaches include the following:

- **Vegetated buffers that have been impacted by past agricultural cropping pose an erosion risk**. Vegetation can anchor soils adjacent to stream, preventing erosion of banks during flood and severe storm events. Vegetation buffers can also filter out sediments that may be carried in overland surface flows toward on-stream stormwater treatment facilities, or the creek itself. Such measures are particularly important in sandy areas, which are more susceptible to erosion.

- **Existing soil characteristics in the creek and along riparian edge are continually affected by water flow, and such change is natural**. Sandy soils will be carried by water and accumulate in localized sand bars along creek flood zones. Erosion along creek bends and turns is also natural, but is worsened where riparian vegetation (including trees, shrubs, and grasses) has been removed.

- **Sandy and silty soils present in the upland areas of the watershed are more sensitive to wind and water erosion, but also influence water infiltration and shallow groundwater flow to the creek and its tributaries**. Sandy areas that occur in pockets across the watershed will have faster water infiltration rates than areas of fine to medium texture. Such areas will also be less resistant to drought. Soil textures adjacent creeks and wetlands will also influence available soil moisture due to shallow groundwater flow.

SURFACE WATER AND GROUNDWATER

4

The Astotin Creek watershed lies in an area with varied terrain, which has directed surface run-off in Astotin Creek and its tributary streams, as well as wetlands and larger waterbodies, including Astotin Lake, at the creek headwaters in Elk Island National Park. This hydrological network carries most surface flows from across the watershed to the North Saskatchewan River - a relatively short direct distance but a much longer, and convoluted path along the creek. The section of Astotin Creek within the County's boundaries is about 50 km long, not including its tributaries. Groundwater connections in this area are also interesting, with extensive recharge zones. Water management in this area thus must consider both surface flows, and connections to underlying aquifers.

4.1 Hydrology

The recent flooding events experienced within the Astotin Creek watershed were generated by meteorological events that overwhelmed the Astotin Creek flow capacity. A good understanding of the local hydrology is therefore required to understand the flood dynamic of the region. Regional climate and streamflow data were reviewed to understand the driving mechanism behind the recent flood events.

This section summarizes the general hydrologic characteristics of the Astotin Creek watershed. This summary includes a description of the data collected and reviewed, a description of the Astotin Creek hydrological characteristics and a review of the Astotin Creek flooding history. A more detailed description of the hydrology of the watershed is included in the separate Astotin Creek Resiliency Study, Drainage Master Plan.

4.1.1 AVAILABLE DATA

4.1.1.1 Geospatial Data

The following geospatial data was used to delineate the Astotin Creek watershed and determine its drainage characteristics:

- National Hydraulic Network (NHN),
- 25 m National Topographic System Digital Elevation Model (DEM), and
- LiDAR data gathered by Airborne Imaging in 2018 (0.5 m resolution).

Geospatial data must be supplemented with field data to refine our understanding of the Astotin Creek conveyance characteristics. WSP conducted a site visit in June 2021, during which the following data was collected:

- Bathymetric and topographic data
- Water levels
- Main culvert and bridge dimensions along Astotin Creek
- The location and elevation of beaver dams
- The current condition of the culverts and bridges, vegetation in the floodplain, and debris in the creek
- Flow measurements

4.1.1.2 Climate Data

The closest climate station to Astotin Creek that provides precipitation, snowpack, and temperature data is the Elk Island National Park (Elk Island) Station. The Elk Island station is located at the head of the Astotin Creek watershed, at an elevation of about 716 m and the only station located within the Astotin Creek watershed. The meteorological data recorded at this station was analyzed to derive the climate trend and behavior of Astotin Creek. Table 4-1 summarizes the characteristics of Elk Island station climate dataset.

Table 4 -1 Elk Island National Park Station Characteristics

Name	Climate ID	Elevation (m)	Distance to the project site (km)	Available years	Number of years
Elk Island National Park	3012275	716.2	30	1982-2020	39

4.1.1.3 Streamflow Data

Streamflow data are collected, analyzed, and published by Water Survey Canada (WSC) at specific locations across Canada and Alberta. However, there are no active or discontinued hydrometric stations measuring streamflow data on Astotin Creek. Its flow data must therefore be derived from other stations located on neighbouring streams.

Thirteen gauged streams located near the project site were identified in the region. Table 4-2 summarizes the characteristics of the stream catchments at these stations. Among these stations, three were discontinued, meaning that WSC suspended acquisition of streamflow data at these stations. Only six stations offered more than 20 years of flow measurements, two of which, Pointe-Aux-Pins Creek near Ardrossan station and Waskatenau Creek near Waskatenau station, are located closer to the project area. Waskatenau Creek station is on the north side of the North Saskatchewan River about 35 km northeast of the Astotin Creek outlet to the river. The Pointe-Aux-Pins Creek station is located about 20 km southwest of the Astotin Creek watershed and has similar characteristics to the Astotin Creek watershed, such as size, land use, and topography. Therefore, the Pointe-Aux Pins station was considered most representative of Astotin Creek drainage and was used as a proxy to derive the main hydrological characteristics of Astotin Creek.

4.1.2 WATERSHED AND STREAM DESCRIPTION

Astotin Creek flows northwest from Elk Island National Park towards Highway 15, after which the creek turns northeast and eventually discharges into Beaverhill Creek, about 5 km upstream of its junction with the North Saskatchewan River. The Astotin Creek watershed at the junction with Beaverhill Creek was delineated using the 25 m DEM, which led to a total drainage area of 184 km2. Figure 4-1 shows the delineated Astotin Creek watershed as well as the Pointe-aux-Pins Creek watershed, which was used as a proxy to derive drainage characteristics of Astotin Creek. Table 4-3 summarizes the key drainage characteristics of both watersheds, showing that both catchments have similar size, topography, and slope.

Table 4 -2 Available Nearby Hydrometric Stations

Station	ID	Drainage Area (km2)		Record (yr)			Distance from Astotin Creek's outlet (km)	Historical peak flow (m3/s)	Year of peak flow	Unit discharge (m3/s/km2)	Notes
		Gross	Effective	From	To	Length of record					
Atim Creek at Century Road	05ea012	288	80.4	2007	2021	14	75	7.16	2012	0.0249	Active
Atim Creek near Spruce Grove	05EA009	315	91.7	1978	1996	18	70	9.98	1996	0.0317	Disc.
Beaverhill Creek near the Mouth	05EB015	2930		1974	1986	12	<5	78.7	1983	0.0269	Disc.
Blackmud Creek near Ellerslie	05DF003	673	374	1935	2021	86	65	19.4	1983	0.0288	Active
Carrot Creek near the Mouth	05EA011	97.1	39.2	2007	2021	14	55	5.32	2011	0.0548	Active
Kilini Creek at TWP Road No 543	05EA013	168	137	2013	2021	8	80	3.08	2013*	0.0183	Active
Pointe-Aux-Pins Creek near Ardrossan	05EB902	106	63.2	1979	2021	42	35	16.2	1983	0.1528	Active
Strawberry Creek near the Mouth	05DF004	592	589	1966	2021	55	95	309	1990	.0522	Active
Wabamun Creek near Duffield	05DE003	513	464	1927	1995	68	105	309	1990	0.6023	Disc.
Waskatenau Creek near Waskatenau	05EC002	313	207	1966	2021	55	30	45.3	1971	0.1447	Active
Weed Creek at Thorsby	05DF008	200	200	2005	2021	16	100	75.7	2007	0.3785	Active
West Whitemud Creek near Ireton	05DF007	65.4	53.2	1976	2021	45	85	7.1	2007	0.1086	Active
Whitemud Creek near Ellerslie	05DF006	330	301	1969	2021	52	65	114	1974	0.3455	Active

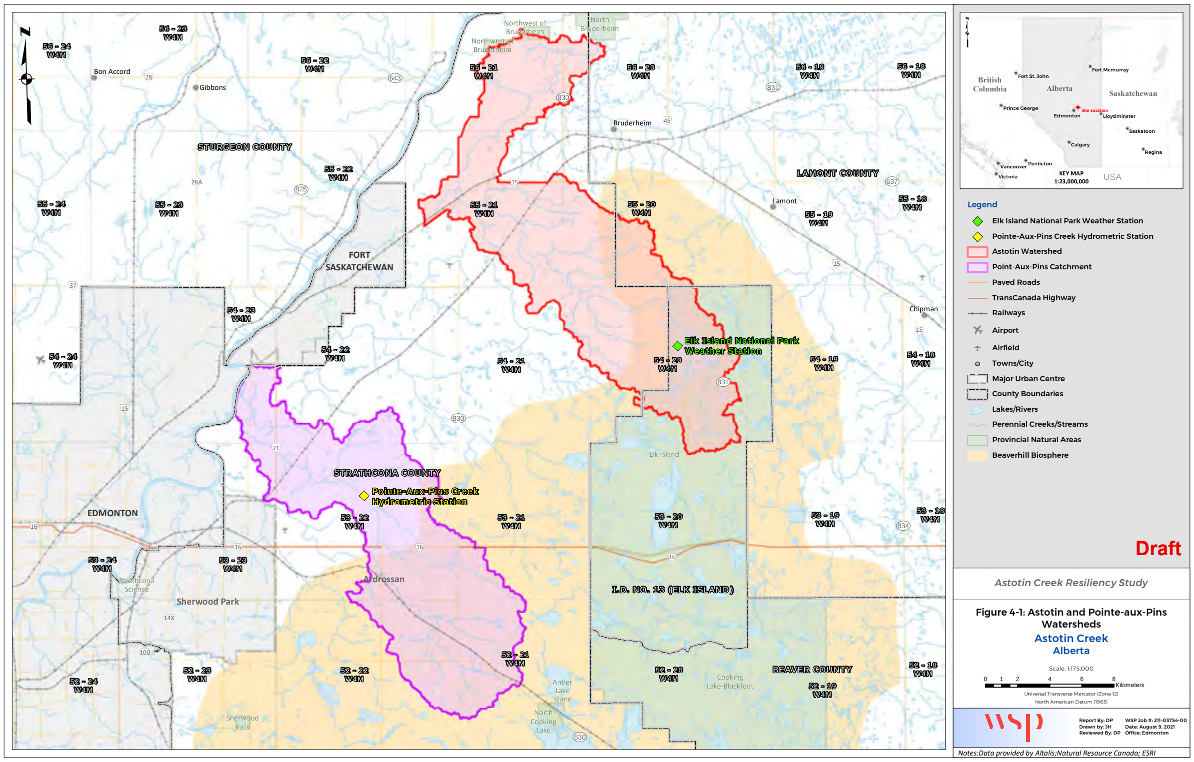

Figure 4 -1 Astotin and Pointe-aux-Pins Watershed Boundaries

Table 4 -3 Catchment Physical Characteristics

Characteristics	Astotin Creek	Pointe-aux-Pins Creek
Area (km2)	**184.3**	155.2
Longest flow path (km)	**48.5**	37.7
Average slope (%)	**2.8**	3.6
Minimum elevation (m)	611.7	599.3
Average elevation (m)	675.7	701.0
Maximum elevation (m)	742.6	770.5

To confirm the suitability of using Pointe-Aux-Pins Creek flow as a proxy for flood analysis of Astotin Creek, land use of both watersheds were also compared, as shown in Table 4-4. The land use data was downloaded from the 2015 Canada Land Cover database, which covered both watersheds. A total of 60% of the Astotin catchment and 65% of the Pointe-Aux-Pins catchment were croplands. The next dominant land use in both catchments was temperate or sub-polar broadleaf deciduous forest, covering about 16% of the catchments, followed by urban and built-up land use. Urban and built-up land use covers 4.8 % of the Astotin catchment, which was slightly lower than the 7.2 % in the Point-Aux-Pins catchment. Waterbodies covered 5.1 % of the Astotin catchment and 2.8 % of the Point-Aux-Pins catchment. Other land uses were minor, and each covered less than 1 % of each catchment. Similar comparisons applied using the Alberta Biodiversity Monitoring Institute (ABMI, 2010) land cover data, which is finer resolution mapping, although a bit older than the Canadian inventory data.

These data show that the catchments seem comparable and would be expected to have similar runoff characteristics (e.g., similar generated flow per unit of area for the same precipitation).

Table 4 -4 Catchment Land Use (Canada Land Cover Inventory (2015), ABMI Land Cover (2010))

Type of Land Use	% of the total area	
	Astotin Creek	Pointe-aux-Pins Creek
Canada Land Inventory (2015)		
Temperate or sub-polar needleleaf forest	**0.9%**	0.4%
Temperate or sub-polar broadleaf deciduous forest	**16.4%**	16.3%
Mixed forest	0.8%	0.6%
Temperate or sub-polar shrubland	11.7%	7.5%
Wetland and lakes (waterbodies)	5.1%	2.8%
Cropland	60.1%	65.0%
Barren land	0.1%	0.2%
Urban and built-up	4.8%	7.2%
ABMI Land Cover (2010)		
Water	5.3%	2%
Exposed Land	0%	0.3%
Developed	9.3%	16%
Shrubland	8%	0.3%
Grassland	4.7%	14%
Agriculture	50%	49%
Coniferous forest	0.6%	0.2%
Broadleaf forest	21%	18%
Mixed forest	0.5%	0.1%

4.1.2.1 Channel and Floodplain Characteristics

Figure 4-2 shows the longitudinal profile of Astotin Creek starting downstream of Astotin Lake and ending upstream of the Beaverhill Creek junction. According to this profile, the creek is steeper for the first 24 km, relative to the rest of the creek, with an average slope of 0.36% upstream of Highway 15. This is followed by a milder, 14 km long section at a 0.05% slope. The remainder of Astotin Creek has a slope of 0.11% before reaching Beaverhill Creek.

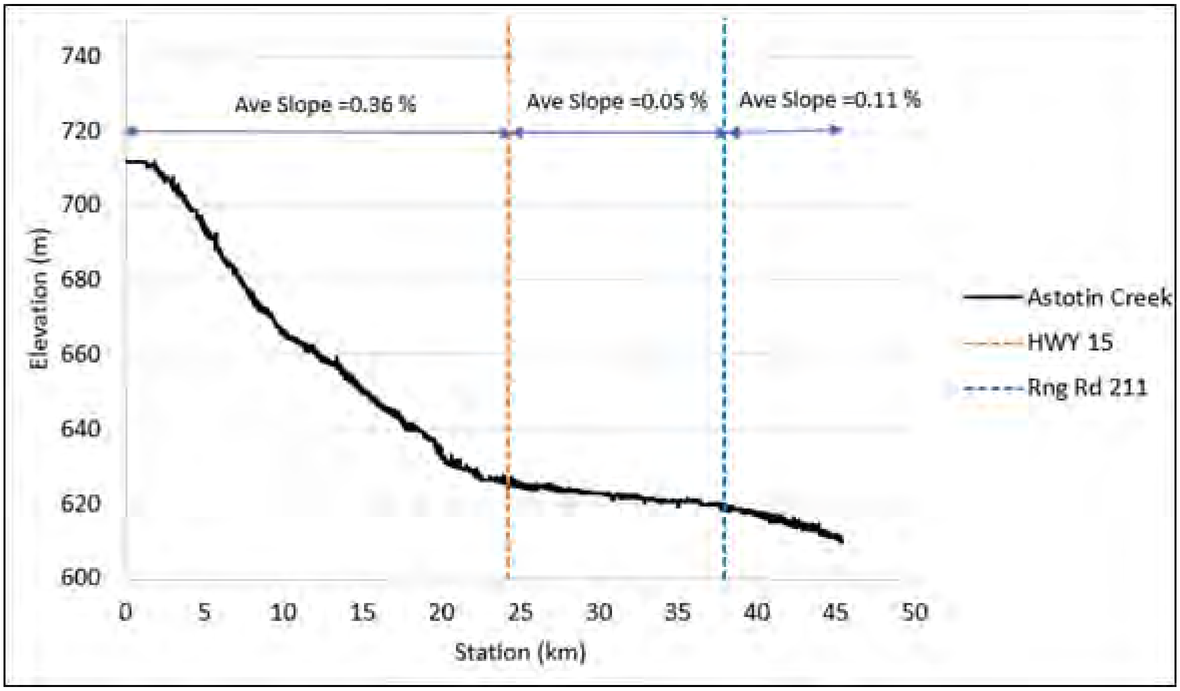

Figure 4 -2 Astotin Creek Longitudinal Profile

Field survey found the creek was channelized between stations 10 km and 11.6 km with an approximate bottom width of 1-3 m and bankfull width of up to 8 m. The creek was also channelized between stations 24 km and 26.4 km, with an approximate average bottom width of 1-4 m and bankfull width of up to 10 m. The side slopes varied from almost 1:2.5 to almost flat along the creek at these locations. Figure 4-3 shows an example of a channelized section of Astotin Creek.

Several anthropogenic features were observed along Astotin Creek, such as bridges and culverts. Where possible, the main features of these crossings were surveyed, as summarised in Table 4-5. The location of each of these crossings is shown on Figure 1 of Appendix A.

There were many beaver dams along the creek, especially along the natural, unchanneled section of the creek, as shown on Photographs 1 to 3 of Appendix A. Besides beaver dams, several piles of woody debris from natural washouts were observed along the creek, which could potentially reduce the creek's conveyance capacity and block culverts and narrow bridges, as shown on Photograph 4 and 5 of Appendix A. Other anthropogenic features reducing the creek's discharge capacity were identified within the study area, such as fences crossing the creek (Photograph 6 of Appendix A).

Figure 4 -3 Channelized Section of Astotin Creek

Table 4 -5 Surveyed Crossings along Astotin Creek

Structure ID	Location	Type	Number of culverts/ bridge spans	Diameter (mm)/ approximate span – height (m)
1	**RR 203**	Culvert	2	800, 800
2	**54511 RR 204**	Culvert	1	1120
3	54511 RR 204	Culvert	1	1060
4	RR 204	Culvert	1	1200
5	RR 205	Culvert	1	1200
6	RR 210	Bridge	1	9.4-2.2
7	TWP 550	Bridge	1	5.4-2.4
8	RR 210	Bridge	1	5.5-2.1
9	RR 211	Bridge	1	7.5-2.6
10	TWP 552	Bridge	1	5.5-2.1
11	Railroad	Unknown	Unknown	Unknown
12	RR 212	Culvert	1	3180
13	RR 213	Bridge	1	7.4-2.1
14	TWP 553	Bridge	1	7.5-1.8
15	HWY 15	Culvert	1	5000
16	HWY 15	Bridge	2	5.6-2.8
17	Railroad	Bridge	5	18.6-4.1
18	TWP 554	Bridge	1	7.4-2.5
19	TWP 560	Culvert	1	2670
20	RR 213	Bridge	1	8-1.7

Structure ID	Location	Type	Number of culverts/ bridge spans	Diameter (mm)/ approximate span – height (m)
21	**Local Road on TWP 560**	Culvert	3	1100, 1200, 1200
22	**RR 212**	Culvert	3	920, 1200, 780
23	Railroad	Culvert	2	1000, 1000
24	RR 211	Bridge	1	9.4-1.8
25	TWP 562	Bridge	1	5.5-2.4
26	RR 210	Bridge	3	25.5-3.6
27	RR 205	Bridge	3	22.5-5

4.1.3 FLOODING HISTORY

The lack of streamflow data on Astotin Creek limited the analysis of flooding history on the creek itself and potential timing, and climatic explanations of flood events. The Pointe-aux-Pins streamflow data provided good local data though, which could be extrapolated to the adjacent watershed. Other regional studies from the greater Edmonton region provided context for the flood events reported on Astotin Creek in the past.

4.1.3.1 Pointe-aux-Pins Flood Analysis

The analysis of the Pointe-aux-Pins streamflow data suggests that the Astotin Creek flood regime is driven by a mix of snowmelt and rainfall events. The historical peak flow timing at Pointe-aux-Pins Creek station was analyzed, and the main cause of flooding was determined for each year of streamflow record. This analysis revealed that the peak flow timing generally occurred in March-May due to snowmelt or in July-August due to rainfall events. Figure 4-4 plots the yearly peak flow recorded at the Pointe-aux-Pins Creek station since 1979 and whether it occurred in summer or spring. Out of the 40 years of records, 15 peak flows can be attributed to rainfall events and 25 to snowmelt or rain-on-snow events. The three largest recorded floods (1983, 1997, and 2011), all correspond to rainfall events.

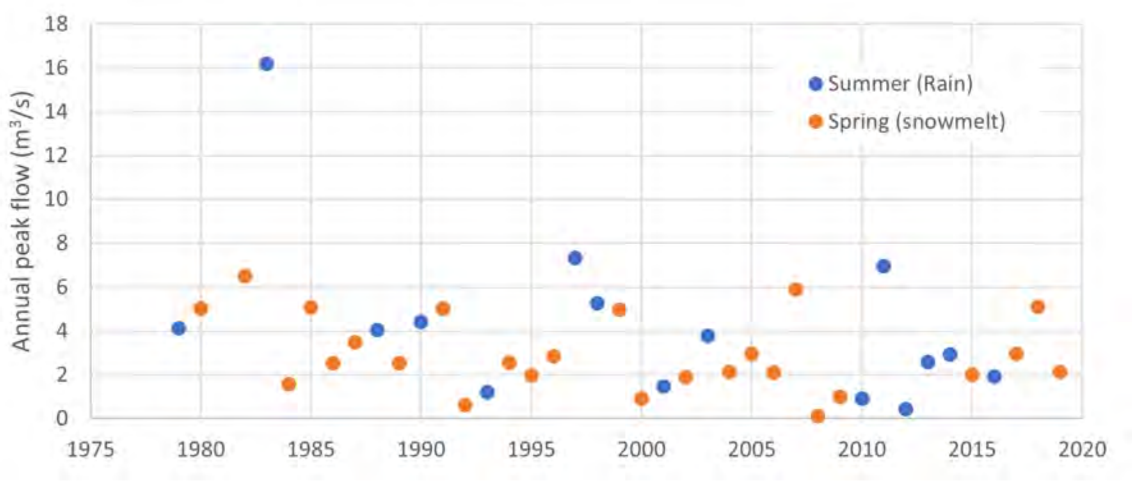

Figure 4 -4 Historical Peak Flows Recorded at the Pointe-aux-Pins Creek near Ardrossan Station (ID:05EB902)

Further analysis of the streamflow data indicated that the maximum flood on record was 16 m^3/s and occurred on June 25, 1983, due to a rainy 10-day period generating 217 mm of rain in Elk Island National Park. This period also corresponds to the largest 5-day precipitation event on record in the Elk Island National Park, as shown in Figure 4-5.

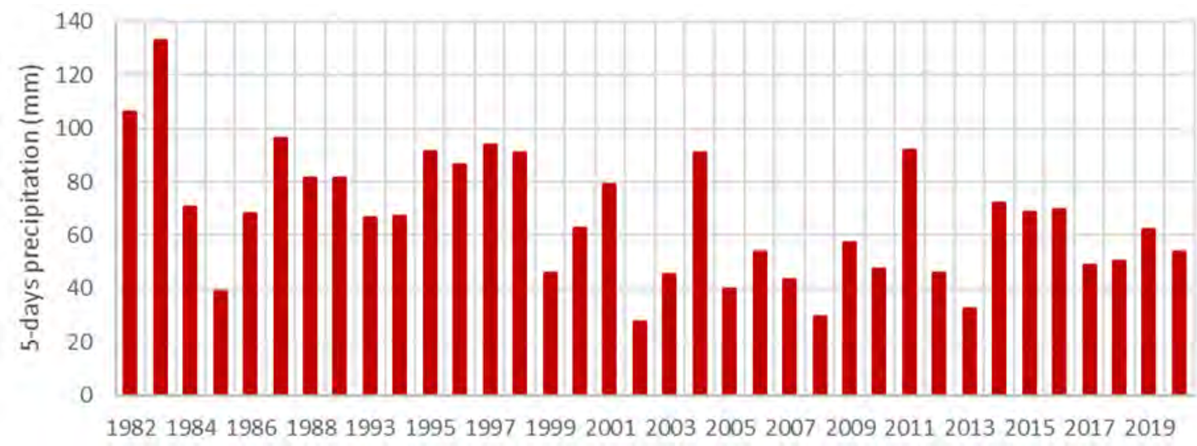

Figure 4 -5 Five-day precipitation record at the Elk Island National Park meteorological station

4.1.3.2 Regional Flood Comparisons

The impact of the 1983 flood on Astotin Creek is poorly documented, and no testimony of flood damages could be collected. However, the Nisku Flood Hazard Study, completed by Northwest Hydraulic Consultants [NHC] in 2014, mentions that the 1983 event corresponds to the second largest flood on record for the Blackmud Creek, located about 50 km southwest of Astotin Creek. According to this study, the 1983 event resulted in the creek overflowing its banks between Airport Road and Highway 625 (NHC, 2014). However, the 1983 flood appeared to have been less severe on Blackmud Creek than on Pointe-aux-Pin Creek based on their respective recorded peak discharge.

The historic flood of 1974 is also reported to have caused extended flooding damage in the Edmonton region. However, the Pointe-aux-Pins Creek station was not yet active in 1974 and the severity of this flood event in the Astotin Creek area is also uncertain. A 1998 flood hazard study conducted in Lamont County indicates that the 1974 spring flood was not reported to have been notably severe in the Lamont area (Stanley Associates Engineering Ltd., 1998). Lamont Creek is located about 5 km to the east of the Elk Island National Park and is expected to experience similar meteorological events as Astotin Creek, given their proximity.

4.1.3.3 Astotin Creek Flood Analysis

The most recent flood events along Astotin Creek occurred in 2018 and 2020. Based on the measured discharge at Pointe-aux-Pins Creek station, the 2018 flood peaked on April 22 and reached a flow of

5.1 m^3/s, mainly due to rapid snowmelt with minimal precipitation recorded at the Elk Island station. As shown in Figure 4-6, most of the flooding was observed upstream of Highway 15, where properties and farmlands were inundated. The 2020 spring flood, which occurred around May 6, 2020, led to road closures due to overland flooding at several locations along Astotin Creek. There is no available streamflow record at Pointe-aux-Pins Creek for that period, but the extent of flooding is reported to have been less severe than the 2018 flood event.

The response to the April 2018 flood event required deployment of both County Transportation and Agricultural Services (TAS) equipment and resources to protect landowner and County property. By Tuesday April 24, 2018, the County had received reports of more than 515 culvert issues, with nearly 427 resolved as of Tuesday morning (Proulx, 2018). Response efforts included:

- 2,500 sandbags laid out by Strathcona County
- 650 tons of sand used for home protection
- 450 feet of rapid deploy water worms, plus 26 active pumps
- 36 daytime TAS staff working on solutions and mitigation, and 18 nighttime workers

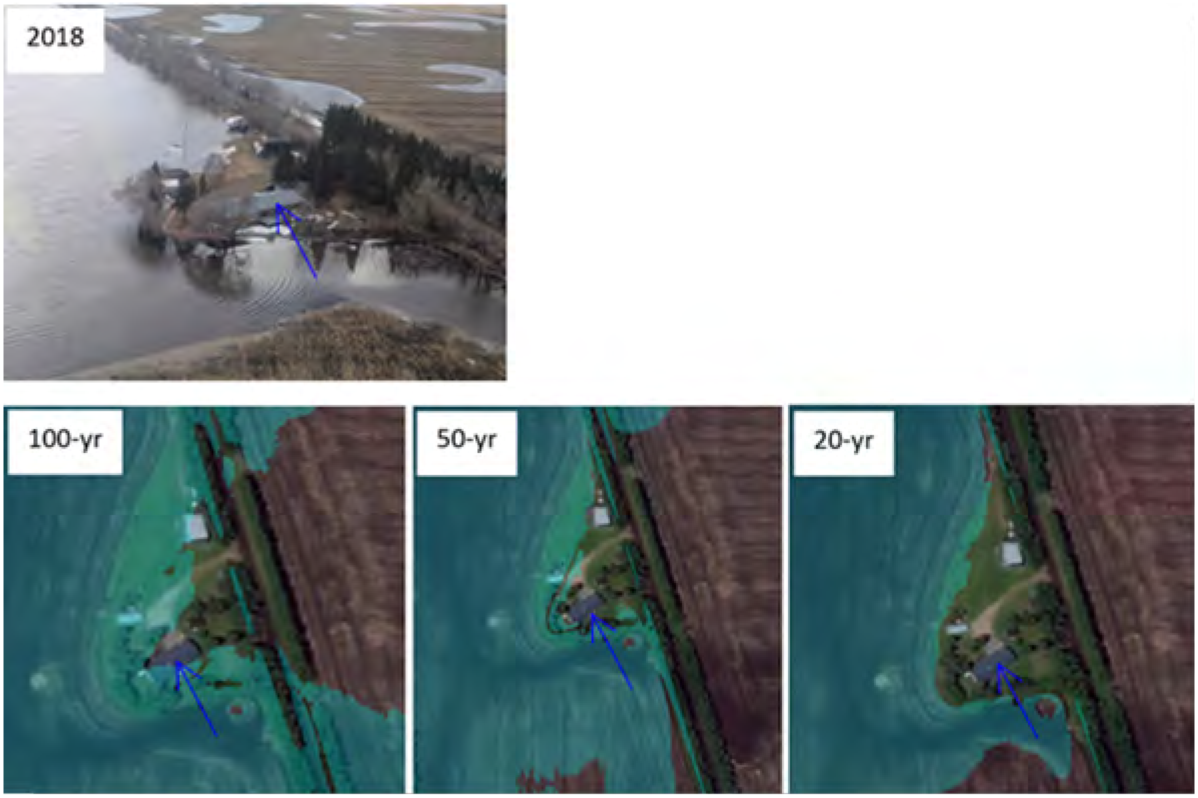

Figure 4 -6 Aerial view of the 2018 flood at SE21-55-21-4, relative to modelled floods from Astotin Creek

4.2 GROUNDWATER

Groundwater elevations were mapped by Hydrogeological Consultants Ltd. [HCL] (2001) across Strathcona County. Spencer Environmental Management Services Ltd. (2005) identified recharge and discharge zones from the GIS dataset used to develop this study, to help map areas of potential contamination risk to groundwater resources. For the Astotin Creek watershed area, this mapping can also identify areas where near surface groundwater flows may occur. As shown in Figure 4-7, much of the northern part of the County lies in groundwater recharge areas, which may support flow in the creek or in wetlands within the watershed. Groundwater flows will influence water availability, particularly where interaction with surface waters is possible, such as at recharge zones.

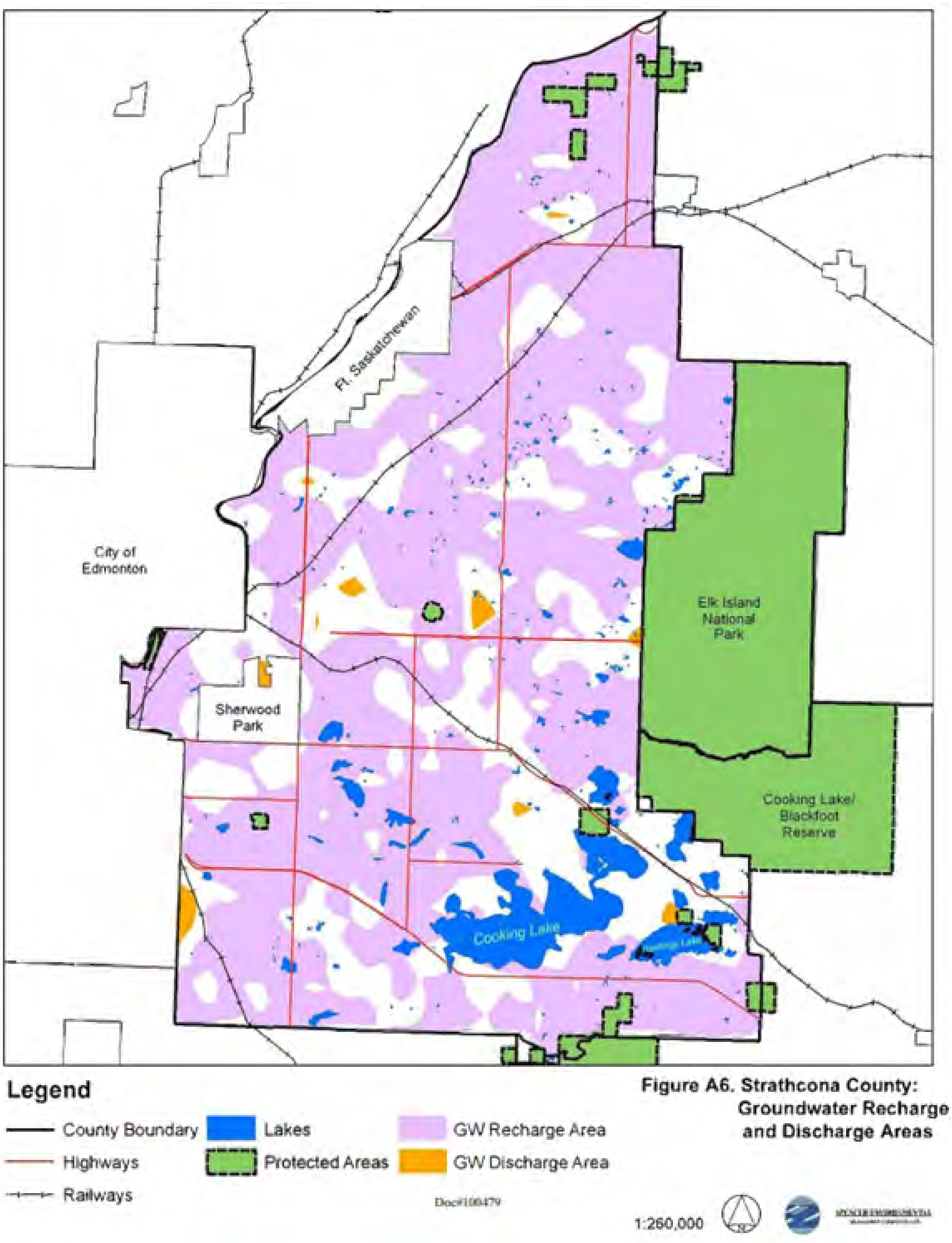

Figure 4 -7 Groundwater Recharge and Discharge Areas (Spencer, 2005)

4.3 STORMWATER MANAGEMENT

The Astotin Creek watershed is located approximately 40 kilometres northeast of Edmonton, Alberta. The watershed boundary encompasses 184.3 km2 (or 18,430 ha) of land within Strathcona County, Lamont County, and Improvement District No. 13 (Elk Island National Park), as shown in Figure 4-1. Astotin Creek is the principal watercourse draining the watershed. The creek originates in Astotin Lake, within Elk Island National Park, and flows in a northerly direction toward the North Saskatchewan River. Astotin Creek is approximately 50 kilometres long and meanders in an arc fashion to the north, joining Beaverhill Creek east of Range Road 205, about 2.5 kilometres north of Township Road 562. From the confluence of the creeks, water flows north for about 5 kilometres to its discharge outlet to the North Saskatchewan River. Tributaries and smaller drainageways convey runoff from across the watershed toward Astotin Creek, as shown in Figure 4-1.

Drainage patterns throughout much of the watershed generally appear to follow pre-development or natural patterns, except where modified due to the development of the transportation network. Alterations to the natural drainage patterns consist mainly of the placement of hydraulic structures across roadways (i.e., bridges or culverts) as well as straightening or realignment of portions of the creek itself and other drainage ways along roads.

The land uses within the lower parts of the watershed are primarily agricultural and industrial and are part of the County's Rural Service Area. The industrial area is only partially cleared while much of the agricultural area appears fully cleared. The watershed also includes the Heartland Policy Area. This policy area established industrial land use zones and forms the County's portion of the Alberta's Industrial Heartland (AIH). The AIH is zoned to include heavy industrial, transitional, and agri-industrial land uses.

Stormwater from the agricultural lands runs off into smaller drainageways and tributaries, then the creek. On the other hand, stormwater from the industrial development sites is collected in privately owned and operated stormwater management facilities (SWMFs) for quantity control and quality enhancement (see Figure 1 in Appendix A). Some of the existing industrial developments retain stormwater that may not be returned to the creek. Other industrial developments release stormwater at a controlled rate into the creek only after water quality testing has been completed and approved for discharge to the creek. All SWMFs include either control structures, valves, or pump stations designed to release stormwater at a unit peak historical discharge rate of 4.0 L/s/ha. Discharge rates are examined in more detail in the Master Drainage Plan of the Astotin Creek Resiliency Study.

4.4 SUMMARY

Past flood events have been linked to either spring run-off or large summer storm events. Logjams and woody debris, fences and undersized culverts and bridges can also reduce the creek's discharge capacity. Such factors are discussed in further detail in the Drainage Master Plan.

VEGETATION

5

The three Assessment Reaches within the Astotin Creek watershed each support different dominant vegetation communities, including both native and non-native / agricultural communities. The vegetation assessment aimed to describe these communities in terms of the dominant species found in each plant community, presence of species of management concern and types of wetlands. The biodiversity of each area was also characterized using both field survey data of species observed in different habitat types, and iNaturalist citizen science information.

5.1 Methods

5.1.1 AVAILABLE DATA

Nature apps allow citizen scientists, naturalists, and biologists to map and share observations of biodiversity via a website or mobile application. Increased use by various users and checks of the observations within the apps to ensure accuracy have made these apps a valuable tool for biodiversity data collection. Two applications were utilized for this Project: iNaturalist and NatureLynx[1]. iNaturalist, a joint initiative between the California Academy of Sciences and the National Geographic Society, is an online platform that generates scientifically valuable biodiversity data globally (iNaturalist, 2021). NatureLynx, created by the Alberta Biodiversity Monitoring Institute, is a similar tool designed specifically for Alberta's ecosystems (NatureLynx, 2021).

[1] iNaturalist: https://www.inaturalist.org/projects/astotin-watershed-biodiversity-project
NatureLynx: https://naturelynx.ca/Missions/84/details

Both apps allow interested researchers to create a 'project' for specific study areas, and to extract observation data in an Excel format for ease of analysis. Observations include a date, location, photo/sound recording and a rating of the 'grade' of the observation confirming species-level identification. All observations must be wild (not captive or cultivated) organisms and depending on the participants in a location, can include vegetation, insect, wildlife, and fish species. From the iNaturalist dataset, all 'verified' and 'research-grade' observations were compiled; 'casual' observations unverified by other participants were excluded. NatureLynx did not provide any observations for the project area. Species records included spatial locations, taxonomic group (e.g., plants, mammals, birds, etc.), date of observation and verification status, which helped identify locations within the watershed.

Developing a project at this location allowed us to expand data collection beyond the scope and timeframe for 2021 field surveys. Within both applications, the "Astotin Creek Resiliency Study" was established to collect citizen science observations within a five-kilometre buffer from the Astotin Creek watershed study area, as originally identified by the County .Projects created on these two apps also offered a means of engaging local and interested participants in the biodiversity within an area, and links were featured in public and stakeholder engagement materials. Initial observations were about 2,500 when the project started (currently 3,300 at the time of this report), indicating considerable interest in the biodiversity of this area.

The study area was later revised to use the updated Astotin Creek watershed area completed for this study, to extract relevant records from the two apps. The original watershed area remains on the nature app projects, which will allow for continual data collection and regional comparison. Using the revised watershed boundary and the three Assessment Reaches, we could identify observations, and tabulate total observations and species richness observed for each Assessment Reach. The results provided another means to assess relative biodiversity across the watershed, for vegetation (and wildlife, as described in Section 6.1.1).

5.1.2 PLANT COMMUNITIES

Existing reports, maps, and databases completed within or near the Astotin Creek watershed were reviewed to better understand the environmental sensitivities within the Astotin Creek watershed including:

- Significant Natural Features and Landscapes of Strathcona County (Westworth and Knapik, 1987)
- Assessment of Environmental Sensitivity and Sustainability in Support of the Strathcona County MDP Review (Spencer, 2005)
- Prioritized Landscape Ecology Assessment of Strathcona County (Geowest, 1997)

Field surveys were conducted to confirm plant community mapping within the Astotin Creek watershed, and to describe characteristic and dominant species found in these communities. Survey sites were selected using aerial imagery of the plant communities found adjacent to Astotin Creek and used to create a stratified representative sample of communities of each Assessment Reach (Figure 5-1 and Table 5-1). Not all community types present in each Assessment Reach could be sampled due to limitations on land access, but replicate sites were identified in at least two of the three reaches. Creek sites were not identified in the Lower Assessment Reach, since much of the accessible areas of this reach had large open water wetlands (identified as wetlands).

Table 5 -1 Sampled Habitats in Each Assessment Reach

Plant Community Type	Sample Sites by Assessment Reach			Total Sites
	Upper Reach	Middle Reach	Lower Reach	
Pasture	**1**	--	1	2
Deciduous	**2**	1	2	5
Conifer	1	--	1	2
Wetland	2	--	3	5
Creek	1	1	--	2

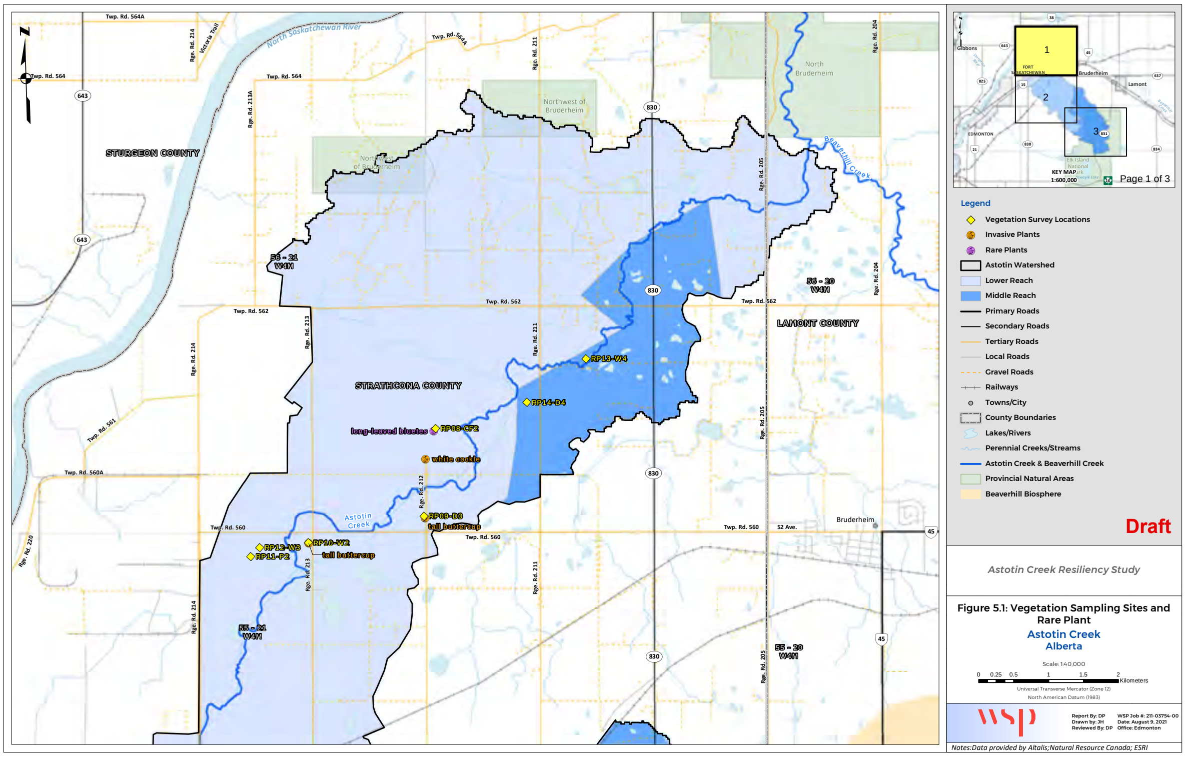

Figure 5 -1 Vegetation Sampling Sites and Rare Plants

Plant community characterization surveys were conducted on June 15 to 18, 2021 at each of the sixteen survey sites. At each plant community characterization survey location, we collected representative photographs, general structural stage information, and percent cover data from a 10 m x 10 m plot. A comprehensive species list was also compiled as part of a rare vascular plant survey (see methods below). Photographs of representative sites are provided in Appendix B, with summary tables of plant species observed in survey sites (see Table 1, Appendix B). Incidental observations of weeds and wildlife were also recorded and combined with the comprehensive vegetation survey data to determine overall vegetation species diversity in each Assessment Reach. These results were compared against observations collected in iNaturalist to help assess differences in biodiversity in each reach.

5.1.3 PLANT SPECIES OF MANAGEMENT CONCERN

To identify past records of plant species of management concern, we first checked the Alberta Conservation Information Management System (ACIMS), a database with records of plant species and communities of management concern. These observations include plant species listed under Schedule 1 of the Species at Risk Act (SARA) (Government of Canada [GOC], 2021) and the Alberta Wildlife Act (Province of Alberta, 1997), as well as those ranked under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC; GOC, 2021) and ACIMS list of All Tracked and Watched Elements (Alberta Environment and Parks [AEP], 2021a).

Results of the ACIMS check were supported by rare vascular plant surveys conducted during vegetation field surveys within each plant community site, on June 15 to 18, 2021 (Figure 5-1).

Rare plant surveys followed the Alberta Native Plant Council (ANPC) Guidelines for Rare Vascular Plant Surveys in Alberta (ANPC, 2012) and were completed by a rare plant specialist. At each of the vegetation community survey sites, a comprehensive species list was compiled until no additional species were found. Rare plants were determined according to standards in the ANPC guide (ANPC, 2012) and included any species that is currently listed on the ACIMS list of All Tracked and Watched Elements (AEP, 2021a). Rare ecological communities were identified from the ACIMS Ecological Community Tracking List (Allen, 2014).

Invasive (weedy) species were not specifically surveyed during vegetation field work, as the emphasis was instead on dominant species characterizing the plant communities found in the study area. Invasive species were noted where they were abundant enough to be considered dominant, or common at a site though.

5.1.4 WETLAND AND LAND COVER MAPPING

Although wetlands and terrestrial land cover have been identified in various past mapping exercises, most of these were at relatively coarse scale (e.g., the Alberta Merged Wetland Inventory, Alberta Biodiversity Monitoring Institute (ABMI) Land Cover 2010 mapping). These data have known limitations due in part to scale. These data can also be somewhat outdated and may not represent current conditions. Wetland mapping was updated to 1:5,000 scale mapping using automated GIS classification techniques that combined Sentinel 2 multi-spectral satellite imagery (10 m resolution), and the County's orthoimagery and LiDAR terrain data (2018 data, 0.5 m resolution) to delineate and classify wetlands and map upland land cover.

An automated land cover classification uses various types of input descriptors to identify natural features like wetlands and upland habitats, drawn from various data sources. Generally, the initial step uses watershed / topography analysis to identify drainage systems and depressions that may collect surface water using the terrain data. These depressions are then classified using the imagery sources (Sentinel 2 and orthoimagery) to identify wetland classes. Uplands can be classified from imagery data in a subsequent step once wetland delineations are confirmed. To identify relevant diagnostic features in the imagery and terrain conditions, confirmed habitat mapping ('training data') are used as initial inputs to the analysis. In this case, we used an existing wetland and upland classification layer as a 'training' dataset, the Alberta Biodiversity Monitoring Institute's (ABMI) land cover mapping (1:20,000 scale, 2010 data), which was checked against aerial imagery to identify several accurate sites for each wetland and upland cover type across the Astotin Creek watershed study area.

Wetland identification and mapping is the more challenging analysis, due to the variation in wetland types in any area (e.g., marshes, swamps, and peatlands). GIS analysis was performed using a hierarchical approach, based on analysis of satellite imagery, topographic indices generated from terrain data, and final confirmation using interpretation of aerial imagery. As a first step, probable wetland areas were identified from a pixel-based classification of the multispectral Sentinel 2 data. We selected early June 2020 Sentinel imagery, which provided data from a period of high-water level, to maximize spectral (infrared) response for soil moisture detection. Sentinel multi-spectral data was used to calculate the Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI), two key indicators of wetland vegetation and soil moisture. Classification then was performed using a Random Forest algorithm with the following input variables: Red, Green, and Blue (RGB) bands, infrared band, NDVI and NDWI. In addition to the spectral band indices, indices from the terrain LiDAR dataset were extracted and included in the classification, the Topographic Wetness Index (TWI) and the Depth to Water Index (DTW).

Next, object-based classification was performed to identify wetland classes, using a series of descriptive statistics extracted from previous analysis of satellite and topographic layers. A final verification was performed using visual interpretation of the orthoimagery to ensure accuracy of wetland classification and delineation (1:10,000 scale). In a last step of analysis for the Resiliency Action Plan, wetland mapping will be further refined using results of 'rain on grid' hydrology analysis to include wetland areas in climate change scenario analyses. The 'rain on grid' model identifies areas of water accumulation in the landscape and adds additional hydrological information to wetland mapping.

5.1.5 RIPARIAN HABITAT INTACTNESS ANALYSIS

Updated land cover mapping allowed analysis of the intactness of the riparian vegetation buffer. The riparian buffer, vegetated habitat adjacent the stream can help filter out sediments and nutrients, and wider buffers can also support wildlife movement, or even support breeding or resident (territorial) use. Clearing of these buffers for agriculture and other land uses removes vegetation, reducing their functional value. To assess the intactness of riparian habitat, we identified and mapped naturally vegetated lands adjacent Astotin Creek and its tributaries, within a 30 m and 100 m buffer zone. A 30 m buffer zone is broadly accepted as a minimum width for water quality protection (City of Edmonton, 2006; Alberta Environment and Sustainable Resource Development [ESRD], 2012), while a 100 m buffer would provide hiding cover for large and medium sized animals (e.g., deer, moose, coyote), and breeding habitat for various songbirds (see Section 6.3.1 for more information on wildlife buffer widths).

5.2 Existing Conditions

5.2.1 ECOLOGICAL SETTING

As noted previously, the Astotin Creek watershed lies within both the Central Parkland Natural Subregion and the Dry Mixedwood Natural Subregion. The Central Parkland Natural Subregion extends across much of central Alberta at elevations ranging between 500 m and 1,250 m (NRC, 2006). In the County, this Natural Subregion is characterized by level to undulating terrain with hummocky moraine landforms (Strathcona County, 2017). Surficial deposits range from hummocky ground moraines to glaciolacustrine deposits. Soils are generally Black and Dark Brown Chernozems under grasslands and Dark Gray Chernozems and Luvisols under trembling aspen (Populus tremuloides) forest stands. Much of this Natural Subregion has been cleared for use as agricultural croplands, due to highly productive and suitable soils. Remnant patches of natural vegetation consist of aspen stands, with balsam poplar (Populus balsamifera) on moist sites. Understory species can be variable depending on parent material and moisture regimes, but include saskatoon (Amelanchier alnifolia), prickly rose (Rosa acicularis), beaked hazelnut (Corylus cornuta), and various forbs and grasses (NRC, 2006). Typically, marshes in this Natural Subregion are dominated by common cattail (Typha latifolia), sedges (Carex spp.), and bulrushes (Scirpus spp.), and swamps are usually willow (Salix spp.) dominated. Both wetland communities are commonly found on wet, poorly drained Gleysolic soils across the Central Parkland Natural Subregion (NRC, 2006).

The Dry Mixedwood Natural Subregion is mostly found north of the North Saskatchewan River, extending across the north-central part of the province at elevations between 225 m and 1,225 m (NRC, 2006). The Beaver Hills Moraine though, is a disjunct 'island' of this Subregion, surrounded by Aspen Parkland. This southern extent of the Natural Subregion is characterized by hummocky uplands with surficial deposits of glacial till. Soils are generally Gray and Dark Gray Luvisols on uplands and Gleysols and Organic soils in the oft abundant depressional wetlands. Vegetation is characterized by aspen stands with understories of beaked hazelnut, prickly rose, wild sarsaparilla (Aralia nudicaulis), cream coloured vetchling (Lathyrus ochroleucus), purple peavine (Vicia americana), and marsh reed grass (Calamagrostis canadensis) (NRC, 2006). Moister sites are dominated by balsam poplar, aspen and white spruce (Picea glauca) as pure or mixedwood stands. Understories are dominated by red-osier dogwood (Cornus stolonifera), prickly rose and a diverse array of herbaceous species in deciduous and mixedwood stands or feathermosses and horsetails in coniferous stands (NRC, 2006).

5.2.2 PLANT COMMUNITIES

The Upper, Middle and Lower Assessment Reaches of the Astotin Creek watershed can be generally described with the following characteristics:

- The Upper Assessment Reach consists of large, well connected natural habitats (riparian and uplands) with some rural residential and agricultural development.
- The Middle Assessment Reach is dominated by agricultural development with limited native vegetation and low connectivity.
- The Lower Assessment Reach has some larger patches of natural habitats with moderate connectivity interspersed within cleared/industrial developed lands.

The updated land cover mapping highlights these differences in upland vegetation (Table 5-2, Figure 1 in Appendix B). Wetlands will be discussed in more detail below. The Upper Assessment Reach has a mixture of treed (931 ha) and grassland (611 ha) cover, but less agricultural and anthropogenic development (135 ha and 38 ha respectively). Agricultural and grassland areas (including a mix of pasture and native grasslands) are the dominant cover in the Middle Assessment Reach (6,083 ha and 410 ha respectively) and anthropogenic, developed areas are also more extensive (190 ha). Tree cover is relatively sparse (284 ha), and patchy (Figure 1 in Appendix B). In the Lower Assessment Reach, agricultural and grassland (again, pasture and native grasslands) and tree cover are the dominant cover types (7,042 ha, 2.468 ha and 2,186 ha, respectively). Anthropogenic (here mostly industrial) development is larger than in other assessment reaches, but still a relatively small proportion of the overall area (615 ha). These results reflect the extensive clearing in the Middle Assessment Reach, which have left isolated fragments of the natural vegetation that is the dominant land cover in the other assessment reaches.

Table 5 - 2 Area (ha) of Land Cover across the Astotin Assessment Reaches

Land Cover	Total Area (ha)			Total
	Upper Reach	Middle Reach	Lower Reach	
Agricultural	**135**	6,038	869	7,042
Anthropogenic	**38**	190	387	615
Grassland	611	410	1447	2,468
Marsh	144	313	354	811
Open water	57	21	89	167
Swamp	52	35	172	259
Tree cover	931	284	971	2,186
Total	**1,968**	**7292**	**4289**	**13,549**

A total of 162 vascular plant species were identified across the Astotin Creek watershed during the vegetation surveys, with more species diversity within the Upper and Lower Assessment Reaches than the Middle Assessment Reach (Table 5-3). The iNaturalist nature app results also had more species observations in the Upper Assessment Reach area, although this may reflect the access of citizen scientists to naturally vegetated areas, as well as patterns in species diversity (Table 5-4). Observed species also included a variety of species not typically surveyed in biophysical assessments, including insects and butterflies. The remnant naturally vegetated areas in the Middle Assessment Reach were often located along or adjacent to the creek, on private land and away from roads. The Upper and Lower Assessment Reaches generally had more diverse types of habitat than did the Middle Assessment Reach (see Figure 2-1, and Figure 1 in Appendix B), and it may be that both access and interest was higher for observers active in these areas.

Regardless, more diverse habitat will often result in higher plant species diversity over a broad area since each habitat may offer different growing conditions. When examining our survey results by habitat type, across the three assessment reaches, species diversity appeared linked to the different types of habitat sampled in each reach (Table 5-5). Species diversity can also depend on the size of intact habitat area (e.g., forest stands versus narrow hedgerows); larger areas of the same habitat will often support higher plant diversity. We found higher plant diversity within sites in the deciduous forested sites type in the Upper and Lower Assessment Reaches than in the Middle Assessment Reach, the only habitat type we were able to sample across all three reaches. These latter areas tended to have less fragmented and larger forested areas (see Figure 1 in Appendix B). The Middle Assessment Reach, due to extensive conversion of land to agricultural uses had smaller forested patches. Our vegetation survey was limited by access permissions though, in all assessment reaches, and we were not able to sample all the habitat represented in each reach.

The dominant species for each the plant communities found in each area are further described in the sections below. These results provide further insight to effects of disturbance on plant communities in each reach.

Table 5 - 3 Total Observations and Species Richness by Assessment Reach During 2021 Vegetation Field Program

Class	Number of Species		
	Upper Reach	Middle Reach	Lower Reach
Total Observations	**216**	45	154
Species Richness	**122**	43	92

Table 5 - 4 iNaturalist Plant Species Observations by Assessment Reach

Plant Community Type	Number of Species		
	Upper Reach	Middle Reach	Lower Reach
Species Richness	**154**	11	50

Table 5 - 5 Number of Vegetation Species Identified in Each Plant Community Type by Assessment Reach

Plant Community Type	Number of Species		
	Upper Reach	Middle Reach	Lower Reach
Pasture	**22**	--	28
Deciduous	**53**	26	38
Conifer	**34**	--	25
Wetland	**48**	--	34
Creek	**34**	18	--

5.2.2.1 Upper Astotin Assessment Reach

The Upper Assessment Reach of the Astotin Creek watershed is adjacent to Elk Island National Park and in an area with terrain and soils limitations to agricultural use. A few agricultural fields and pastures are present within the Upper Reach, but generally this reach is relatively undeveloped with large tracks of deciduous forest (Figure 1 in Appendix B). Occasional conifer and mixedwood dominated stands are interspersed within the deciduous stands. Large, isolated wetlands and wetland complexes are also present within the Upper Assessment Reach. This diversity in habitat types, as well as the connectivity among them, helps to maintain vital ecological processes, such as propagation of plants through seed dispersal, limiting spread of invasive (weedy) species, and facilitating movement, breeding and other requirements of wildlife. Together, these processes help to sustain healthy and biodiverse plant communities that will be better able to recover from periodic disturbances, such as drought (i.e., they are more resilient).

Pastures have been seeded with agronomic species, though many native herb species were still present within these fields (see Table 1, Appendix B). Vegetation was dominated by smooth brome (*Bromus inermis*), Rocky Mountain fescue (*Festuca saximontana*), Kentucky bluegrass (*Poa pratensis*), plains wormwood (*Artemisia campestris*), and alfalfa (*Medicago sativa*). Patches of prickly rose (*Rosa acicularis*) and snowberry (*Symphoricarpos albus*) were interspersed throughout the pasture.

Deciduous stands were dominated by a closed canopy of aspen with understories of beaked hazelnut (*Corylus cormuta*), prickly rose, bunchberry (*Cornus canadensis*) and dewberry (*Rubus pubescens*). Deciduous stands in areas with increased disturbance from agriculture had understories dominated by marsh reed grass (*Calamagrostis canadensis*), wild strawberry (*Fragaria virginiana*), and common dandelion (*Taraxacum officinale*). Conifer stands were dominated by a close canopy of white spruce (*Picea glauca*) with an understory of red raspberry (*Rubus idaeus*), bunchberry, hemp-nettle (*Galeopsis tetrahit*), wild lily of the valley (*Maianthemum canadense*), and wild sarsaparilla (*Aralia nudicaulis*). A small stand (<0.2 ha) of jack pine (*Pinus banksiana*) was found approximately 100 m to the southwest of one survey site (RP04-CF1, Appendix B).

Wetlands were a mix of isolated marshes and swamps, mostly temporary or seasonal types with the occasional larger semi-permanent to permanent wetland. Open water marshes were common with vegetation along the boundary dominated by awned sedge (*Carex atherodes*), beaked sedge (*Carex utriculata*), common cattail (*Typha latifolia*), and turion duckweed (*Lemna turionifera*). Wetlands along the creek have been influenced by flooding associated with beaver dams. Flooding has caused the riparian willow shrub fringe to die back, replaced by a community dominated by celery-leaved buttercup (*Ranunculus sceleratus*), northern willowherb (*Epilobium ciliatum*), and, in wetted areas, turion duckweed. The riparian vegetation along Astotin Creek remains relatively undisturbed in this reach, with vegetation dominated by paper birch (*Betula papyrifera*), balsam poplar (*Populus balsamifera*), green alder (*Alnus viridis*), and tufted hairgrass (*Deschampsia cespitosa*). Within the channel, vegetation was dominated by common reed grass (*Phragmites australis*), spring water-starwort (Callitriche palustris), small bedstraw (*Gallium trifidum*), and celery-leaved buttercup.

5.2.2.2 Middle Assessment Reach

Vegetation within the Middle Assessment Reach was dominated by agricultural cropland and rangeland. Several small woodlands and wetlands were scattered throughout the reach (Figure 1 in Appendix B) but were often surrounded by agricultural lands. This loss of ecological connectivity limits the transfer of seeds that can help support biodiversity plant communities, while the extensive edge habitat adjacent agricultural and other areas of human use can facilitate the spread of weedy species. As a result, both habitat and species diversity were lower in this zone. Plant species observed in the communities in this reach are provided in Table 1, Appendix B.

Deciduous stands surveyed in the Middle Assessment Reach had a mixed aspen and poplar tree canopy with understories dominated by prickly rose, red raspberry, smooth brome, northern bedstraw (*Gallium boreale*), and star-flowered Solomon's seal (*Maianthemum stellatum*). The deciduous stands were relatively small and isolated and were heavily influenced by clearing and agricultural activities in the area.

The Astotin Creek survey site was also heavily influenced by agriculture, with cropland extending up to the riparian fringe of the creek in a large portion of the Middle Assessment Reach, which limited the native vegetation present within the riparian zone. Vegetation was dominated by smooth brome, reed canary grass (*Phalaris arundinacea*), and marsh yellow cress (*Rorippa palustris*) on the upper banks with short-awned foxtail (*Alopecurus aequalis*), spring water-starwort (*Callitriche palustris*), small bedstraw (*Gallium trifidum*), and marsh yellow cress dominating the vegetated portion of the channel.

5.2.2.3 Middle Assessment Reach

The Lower Assessment Reach is located within the northern portion of the Astotin Creek watershed where vegetation is generally characterized by jack pine mixedwood forests on sandy soils, with willow-sedge wetland complexes (Spencer, 2005). Burnt areas from past fires were noted north of Range Road 560 and Astotin Creek during the field assessment, indicating a natural disturbance not found elsewhere in the watershed. This area supported a mix of industrial land use, which has largely cleared and modified plant sites, but also large areas of retained natural lands, with agricultural lands interspersed in areas of more suitable terrain and soils. The resulting habitat and species diversity was higher than the Middle Assessment Reach and suggests more resilient natural landscape.

Pastures in this reach have been seeded with common agronomic species and were dominated by smooth brome, Rocky Mountain fescue and Kentucky bluegrass (*Poa palustris*). Several native herb species were also found in these areas (see Table 1, Appendix B).

Deciduous stands in the Lower Assessment Reach were characterized by stands of aspen and poplar with understories dominated by beaked hazelnut, bracted honeysuckle (*Lonicera involucrata*), prickly rose, red raspberry, and a variety of herbaceous forbs. One conifer stand was assessed, which was dominated by white spruce with an understory of beaked hazelnut, skunk currant (*Ribes glandulosum*), prickly rose, red raspberry, red elderberry (*Sambucus racemose*), wild sarsaparilla (*Aralia nudicalis*), and hemp-nettle.

Graminoid wetlands in this reach were dominated by awned sedge, beaked sedge, Sartwell's sedge (*Carex sartwellii*), and turion duckweed, and generally had a fringe of willow species on the pond edge (*Salix spp*.). In developed areas, wetlands were influenced by agricultural practices including cropping and livestock grazing. These wetlands were dominated by a mix of sedge species with common cattail, short-awned foxtail, yellow water crowfoot (*Ranunculus gmelinii*), celery-leaved buttercup, creeping spike-rush (*Eleocharis palustris*), wire rush and broad-leaved water-plantain (*Alisma triviale*).

5.2.3 PLANT SPECIES OF MANAGEMENT CONCERN

A review of the ACIMS dataset (AEP, 2021a) within the Astotin Creek watershed returned historical records for one rare ecological community, ten rare vascular plants and sixteen rare non-vascular plants (Table 5-6). Many of these species were classified provincially as S3 (with total population records between 20 and 100), or as SU (status unknown due to lack of information) There were also a few S1 and S2 species, with five or less records and five to 20 records, respectively. Such species are considered at high risk of extirpation. The S1 species recorded in ACIMS are non-vascular species, such as mottled-disk lichen and spotted camouflage lichen, typically found on trees and woody deadfall, and whitewash lichen, found on bark. Two S1 moss species (*Ptychostomaum cernuum* and *Torula cernua*) were also previously reported in the watershed, species found on wet soils near streams and wetlands, and on soil respectively. Suitable habitat for these species exists within the Astotin Creek watershed, but non-vascular species were not identified in the habitat survey. They may be present in any of the three assessment Reaches.

Table 5 - 6 Species of Management Concern (ACIMS summary, AEP, 2021a)

Common Name	**Scientific Name**	**Provincial Rank**	**Preferred Habitat**
Plant Communities			
cyperus-like sedge - water arum wetland	*Carex pseudocyperus - Calla palustris wetland*	S2	Seasonal to semi-permanent wetlands.
Vascular Plants			
Wilcox's Panicgrass	*Dichanthelium wilcoxianum*	S2	Dry, sandy soil in grasslands and open woods (Kershaw et al., 2001).
Clammy Hedge-Hyssop	*Gratiola neglecta*	S3	Wet, muddy sites, often in shallow water (Kershaw et al., 2001).
Long-Leaved Bluets	*Houstonia longifolia*	S3	Sandy soil in open woods and on dunes; elsewhere in grasslands (Kershaw et al., 2001).
Tall Blue Lettuce	*Lactuca biennis*	S3	Moist woods and clearings; elsewhere in swampy sites and by hot springs (Kershaw et al., 2001).
Columbia Watermeal	*Wolffia columbiana*	S2	Beaver ponds in hummocky moraines, elsewhere in moderately to extremely nutrient-rich ponds (Kershaw et al., 2001).
Western Grape Fern	*Botrychium hesperium*	S3	Wooded areas, often with other moonworts (Flora of North America Editorial Committee, eds., [FNA] 1993+).
Michigan Grapefern	*Botrychium michiganense*	SU	Average to dry sandy or calcareous soil; open woods, dunes, and roadsides (FNA, 1993+).

Common Name	Scientific Name	Provincial Rank	Preferred Habitat
Pale Moonwort	*Botrychium pallidum*	S2	Meadows, fields, and disturbed habitats (i.e. roadsides).
Dwarf Grape Fern	*Botrychium simplex*	S2	In moist meadows and along the edges of wetlands, elsewhere in dry fields and roadside ditches (Kershaw et al., 2001).
Crested Shield Fern	*Dryopteris cristata*	S3	Marshes, swamps and moist woods and thickets (Kershaw et al., 2001).
Non-Vascular Plants			
alternating dog-lichen	*Peltigera polydactyla*	S3	Grows on soil, moss, logs, rocks, and bases of trees in moist woods (Brodo et al., 2001).
brown pepper-spore lichen	*Rinodina archaea*	S2	On conifers and frequently on wood, sometimes in nutrient rich environments such as the base of tree trunks and their exposed roots adjacent to trails at elevations of 1000 to 3500 m (Brodo et al., 2001).
dragon cladonia lichen	*Cladonia squamosa*	S3	On mossy rocks, rotting wood or tree bases, primarily in temperate regions (Brodo et al., 2001).
frayed ramalina	*Ramalina roesleri*	S2	Bark, cork, plant surfaces, trunks, branches, twigs (Brodo et al., 2001).
mottled-disk lichen	*Trapeliopsis flexuosa*	S1S3	Usually on hard wood, rarely on conifer or hardwood bark or charred wood (Brodo et al., 2001).
pepper-spore lichen	*Rinodina orculata*	SU	Young bark of conifers and paper birch, rare in aspen drip zones, lower to middle elevations (Brodo et al., 2001).
shadow lichen	*Phaeophyscia cernohorskyi*	S2	On the bark of hardwoods and on rock of different kinds (Brodo et al., 2001).
spotted camouflage lichen	*Melanohalea olivacea*	S1S2	Bark, cork, plant surfaces, trunks, branches, twigs (Brodo et al., 2001).

tar-spot lichen	*Placynthiella dasaea*	S3	On bare peaty or sandy soil, or on well-rotted lignum, usually in the open or in partial shade (Brodo et al., 2001).
whitewash lichen	*Phlyctis argena*	S1?	On bark, rarely on rock elsewhere (Brodo et al., 2001).
liverwort	*Ricciocarpos natans*	SU	Floating aquatic or terrestrial liverwort. Lives on quiet eutrophic fresh water, or the mud where water recedes (FNA, 1993+).
liverwort	*Riccia fluitans*	SU	Can be found growing in tangled masses just beneath the surface of stagnant or slow-moving water, such as in a pond, lake, ditch, or canal (FNA, 1993+).
campylium moss	*Pseudocampylium radicale*	S3	Humus, litter, mineral-rich, and eutrophic wet meadows and swamps, under dense grass and sedge vegetation (FNA, 1993+).
cedar moss	*Sciuro-hypnum reflexum*	S2S3	Base of trees, hardwoods, conifers, wood and litter in boreal and hemiboreal forests (FNA, 1993+).
moss	*Ptychostomum cernuum*	S1S2	Wet soil, along streams, wetlands, calcareous habitats (FNA, 1993+).
narrow-leafed chain-teeth moss	*Tortula cernua*	S1	Soil, limestone (FNA, 1993+).

During the vegetation surveys one rare plant, long-leaved bluets (*Houstonia longifolia*) was identified at eleven locations (Figure 5-1). Observed populations in these locations ranged from 1 to over 200 individuals. This species is ranked S3, and is considered somewhat vulnerable due to other factors, such as restricted range, relatively small population size, or other factors (Alberta Parks, 2018). This species is on the ACIMS Track and Watch List as 'track all extant and selected historical EOs [Element Observations]'. A species of sandy habitats, including woodlands and dunes (Kershaw et al., 2001), this species was mainly identified within SE 31 054 20 W4M, a former sand pit area now conserved by the County under county ownership. Additional long-leaved bluets populations are also likely present within the grassland to the west and north of the surveyed area.

No other rare plants or rare ecological communities were identified during the June 2021 surveys. Two invasive (weedy) species were identified during the surveys: Canada thistle (*Cirsium arvense*) and perennial sow-thistle (*Sonchus arvensis*). These species were found in all three Assessment Reaches, although with more observations of Canada thistle (Table 1 in Appendix B). A comprehensive weed survey was not conducted for this study, and it is possible that more invasive species are present in the watershed.

Canada thistle (*Cirsium arvense*) was found in all three assessment reaches, and in a variety of plant communities. Perennial sow-thistle was also found in all assessment reaches, in different plant communities in each reach (wetland, deciduous woodland, and pasture; Table 1, Appendix B).

5.2.4 WETLAND MAPPING

Wetland mapping for the area found marsh, swamp and open-water wetland classes across the Astotin Creek watershed area (Table 5-7, Figure 1 in Appendix B). Many of these wetlands were quite small; to view land cover mapping, please see the online Astotin Data Atlas available on the County website. Marsh wetlands were the most dominant wetland class across the area (811 ha total), with more areal extent in the Middle and Lower Assessment Reaches (313 ha and 354 ha respectively). Swamps were also found across the watershed but were more extensive in the Lower Assessment Reach (172 ha). Here, the flatter gradient of the creek, and broader flood zones adjacent the creek allow for willow and other shrub swamps to develop. Some of these swamps may be coniferous swamp, or potentially peatlands. Field confirmation was not possible for this study, and differentiating swamp and peatland is based in part on depth of peat layers. Shallow open water ponds were the third most extensive wetland type in the watershed, with larger total area in the Lower Assessment Reach (89 ha) and Upper Assessment Reach (57 ha) than in the Middle Assessment Reach (21 ha). Larger shallow open water wetlands were found along the creek in the Lower Assessment Reach, again likely due to a lower gradient and broader flood zone. In the Upper and Middle Assessment Reach, open water wetlands were associated with beaver dams.

Table 5 - 7 Wetland Areas, by Assessment Reach

Wetland Type	Area (ha)			
	Upper Reach	**Middle Reach**	**Lower Reach**	**Total**
Marsh	144	313	354	811
Shallow Open water	57	21	89	167
Swamp	52	35	172	259
Total	**253**	**369**	**615**	**1237**

5.2.5 RIPARIAN INTACTNESS ANALYSIS

Examining the intactness of the 30 m and 100 m riparian vegetation buffer zones along Astotin Creek and its tributaries, the riparian buffer widths in the Upper Assessment Reach were predominantly naturally vegetated land (>95% for the 30 m and 100 m width, Table 5-8). The Lower Assessment Reach has had less disturbance within both buffer zones, with 73.8% and 72.8% natural cover in the 30 m and 100 m buffer widths respectively. The Middle Assessment Reach has experienced extensive clearing within both the 30 m and 100 m riparian buffer zones, and only 31.5% and 21.5% natural vegetation land cover remains, respectively. Past clearing has left large open gaps that would limit the ecological connections along the creek, as well as reducing water quality protection, water source and flood attenuation (Figure 1 in Appendix B). Riparian wetlands, for example, can hold back flood waters, preventing extensive flooding further downstream.

What makes good aquatic habitat?

Riparian vegetation can protect aquatic habitat. An effective and healthy riparian area can improve a variety of ecological conditions:

- Water quality
- Flood water conveyance and storage
- Bank and shoreline stabilization
- Habitat and biodiversity

Table 5 - 8 Riparian Intactness in the 30 m and 100 m Buffer, by Assessment Reach

Plant Community Type	Percentage of Riparian Plant Community in Buffer (%)					
	Upper Reach		**Middle Reach**		**Lower Reach**	
	30m	100m	30m	100m	30m	100m
Agricultural	2.4	3.0	67.0	76.7	19.7	21.5
Anthropogenic	1.0	1.5	1.5	1.8	6.5	5.7
Subtotal - Disturbed	***3.4***	***4.5***	***68.5***	***78.5***	***26.2***	***27.2***
Marsh	**15.0**	**8.7**	**10.9**	**6.4**	**15.7**	**14.2**
Shallow Open Water	**6.6**	**3.1**	**0.3**	**0.3**	**3.3**	**3.2**
Swamp	**2.2**	**2.2**	**1.6**	**0.8**	**6.5**	**6.8**
Tree (forest) cover	**50.2**	**57.9**	**13.6**	**8.0**	**22.9**	**21.0**
Grassland	**22.5**	**23.5**	**5.3**	**5.9**	**25.4**	**27.6**
Subtotal - Natural	***96.6***	***95.5***	***31.5***	***21.5***	***73.8***	***72.8***

5.2 Summary

The vegetation assessment of the three assessment reaches found differing levels of biodiversity, in terms of the types of habitats and the plant species found in them. The Middle Assessment Reach has been largely cleared for agricultural use, such that naturally vegetated areas are small and isolated from other similar habitat. Naturally vegetated areas were generally larger, more diverse in both habitat type and species diversity, and more contiguous in the Upper Assessment and Lower Assessment Reaches. Past and current rare plant populations were also more often found in these two reaches, although this may also reflect survey effort, which has focused on the Industrial Heartland and the lands adjacent Elk Island National Park. During this survey, several populations with up to 100 individuals of the long-leaved bluets (*Houstonia longifolia*), a S3 ranked rare plant species were found in a former sand pit area now protected by the County as a conservation area in SE 31 054 20 W4M. Such unique habitats often support rare plant species that are adapted to specific soil types or moisture levels, and the conservation status of this parcel highlights the value of such protection. In general, more biodiverse lands can also be more resilient: diverse plant communities supporting a variety of species, and abundant species populations can better recover from periodic disturbances, including fire, drought and flood. The larger and biodiverse areas of naturally vegetated land in the Upper and Lower Assessment Reaches can play an important role in the resiliency of the Astotin watershed.

The riparian buffer zone, which supports various ecological functions (e.g., water quality protection, ecological connectivity) was also wider and more contiguous in the Upper and Lower Assessment Reaches. The Middle Assessment Reach had long gaps in both the 30 m and 100 m buffer zone cleared for agricultural and other human use, reducing ecological connectivity and increasing risk of erosion, and release of sediments and other contaminants to the creek. Restoration of the riparian buffer in this Assessment Reach would enhance water quality and support other ecological functions, such as regional travel by wildlife, and propagation of plant species.