Nose Creek Watershed Riparian Area Assessment

FINAL REPORT

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Nose Creek Watershed Partnership

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Acknowledgements

The Nose Creek Watershed Partnership (NCWP) would like to acknowledge the financial assistance of the Government of Alberta, without which this project would not have been possible. The Government of Alberta contributed to the delivery of this project through the Watershed Resiliency and Restoration Program, which aims to restore or enhance previously degraded natural habitats, including riparian habitat, within priority watersheds across Alberta. Additionally, the Government of Alberta provided spatial data that was essential for the successful completion of this project. Additionally, the NCWP would like to acknowledge the support of all Partners and organizations for their ongoing effort to maintain functioning riparian areas in the watershed.

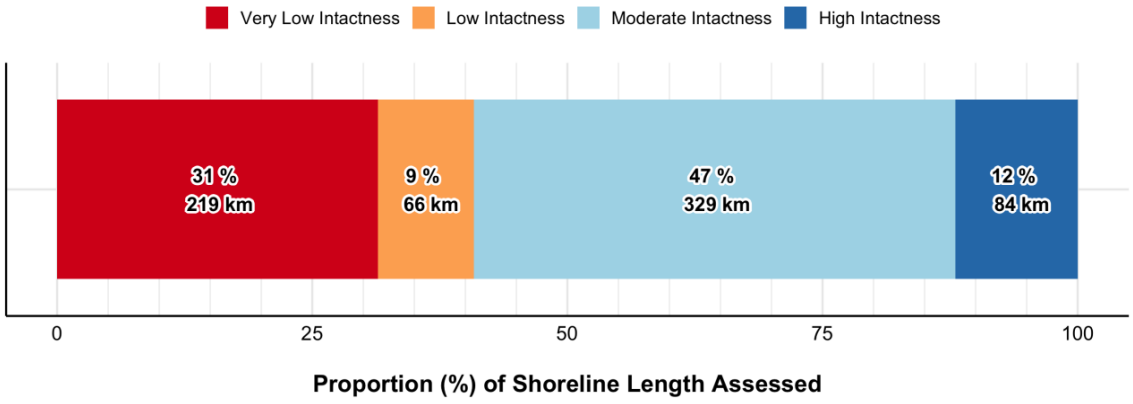
Executive Summary

Riparian habitats are critical components of healthy and functional aquatic ecosystems, and provide a wide range of ecological, economic, and social values to human communities. Intact riparian habitats stabilize the banks of waterbodies and help modulate water velocities and high water events, thereby improving water quality and protecting surrounding lands from flooding. Intact riparian areas also play a vital role in the exchange of inorganic and organic material between terrestrial and aquatic ecosystems, and regulate water temperature and the instream light environment, thereby ensuring suitable habitat for a wide range of aquatic species. Given the important ecosystem functions and services that are supported by riparian habitats, there is a critical need to manage these habitats more effectively. In particular, identifying areas where riparian habitat has been degraded is essential to improving conservation and management outcomes.

In an effort to better understand riparian condition at a watershed scale, the Nose Creek Watershed Partnership (NCWP) retained Fiera Biological Consulting to assess riparian habitat within the Nose Creek watershed. Located in the western portion of the Bow River basin, Nose Creek is a HUC 8 watershed that covers an area of approximately 990 km^2. Human development is prominent in the watershed, with anthropogenic land cover types (e.g., agriculture and urban development) accounting for approximately 80% of the watershed.

Riparian vegetation intactness was assessed along the shorelines of interest using a desktop-based assessment tool that utilizes a current land cover layer derived from satellite imagery. Intactness was assessed within riparian management areas (RMAs) that had a variable length, as determined by major breaks in the proportion of vegetation cover along the shoreline, and a fixed 50 m buffer that extended perpendicular to the shoreline. Within each RMA, intactness was assessed using a number of GIS metrics that determined the type and extent of vegetation and human disturbance. Intactness was used as the measure of riparian condition because the relationship between an intact riparian zone and the health or function of the aquatic environment is well established.

The riparian assessment included 24 creeks and streams, as well as 12 lakes and reservoirs, totalling approximately 697 km of shoreline. The majority of the shoreline assessed within the Nose Creek watershed was classified as Moderate Intactness (47%, or 329 km), while 40% (285 km) of the shorelines assessed were classified as either Very Low or Low Intactness. Only 12% (84 km) of the shorelines assessed in this watershed were classified as High Intactness.



Intactness was evaluated for five jurisdictions within the watershed: Airdrie, Calgary, Crossfield, Mountain View County, and Rocky View County. The greatest length of shoreline assessed in this study was associated with Rocky View County (472 km, or 68% of the total), with Mountain View County having the least amount of shoreline assessed (1 km). For jurisdictions that had more than 10 km of shoreline assessed, Crossfield and Airdrie had the highest proportion of shoreline classified as either Low or Very Low Intactness, with Rocky View County having the highest proportion of shoreline classified as either Moderate or High Intactness.

Spatial Extent	Total Length Assessed (km)	Proportion (%) of Shoreline within Intactness Category					
		Very Low	Low	Moderate	High	Very Low + Low	Moderate + High
Nose Creek HUC 8 Watershed	696.7	31.4	9.4	47.1	12.0	41	59
Airdrie	81.7	41.0	8.6	46.3	4.1	50	50
Calgary	130.6	35.6	13.4	46.8	4.2	49	51
Crossfield	11.8	46.6	5.8	46.3	1.3	52	48
Mountain View County	1.0	4.0	0.0	47.5	48.5	4	96
Rocky View County	471.7	28.3	8.6	47.4	15.7	37	63

This project has generated scientific information that can be used along with other information as the basis for managing and conserving riparian areas within the Nose Creek watershed. Specifically, the results from this study can be used to measure progress towards achieving the riparian management goals and targets that have been set out by the NCWP and its stakeholders.

List of Terms

Abbreviations

AAFC: Agriculture and Agri-food Canada
ABMI: Alberta Biodiversity Monitoring Institute
AGS: Alberta Geological Survey
ARHMS: Alberta Riparian Habitat Management Society (Cows & Fish)
BMP: Best Management Practice
DEM: Digital Elevation Model
ECCC: Environment and Climate Change Canada
HUC: Hydrologic Unit Code
IWMP: Integrated Watershed Management Plan
NCWP: Nose Creek Watershed Association
RMA: Riparian Management Area

Glossary

Aerial Videography: Video captured from a low-flying aerial platform, such as helicopter or ultralight aircraft.

Hydrologic Unit Code (HUC): The Hydrologic Unit Code Watersheds of Alberta represent a collection of nested hierarchically structured drainage basin feature classes that have been created using the Hydrologic Unit Code system of classification developed by the United States Geological Survey, with accommodation to reflect the pre-existing Canadian classification system. The HUC Watersheds of Alberta consist of successively smaller hydrologic units that nest within larger hydrologic units, resulting in a hierarchal grouping of alphanumerically-coded watershed feature classes. The hydrological unit codes include HUC 2, HUC 4, HUC 6, HUC 8, and HUC 10 with HUC 2 being the coarsest level of classification and HUC 10 being the finest level of classification.

Indicator: A measurable or descriptive characteristic that can be used to observe, evaluate, or describe trends in ecological systems through time.

Intactness: In reference to the condition of natural habitat, intactness refers to the extent to which habitat has been altered or impaired by human activity, with areas where there is no human development being classified as high intactness.

Left Bank: The bank of a river, stream, or creek that is on the left when facing downstream.

Metric: A qualitative or quantitative aspect of an *indicator*; a variable which can be measured (quantified) or described (qualitatively) and demonstrates either a trend in an indicator or whether or not a specific threshold was met.

Resilience: The capacity of an ecosystem to resist, absorb, and recover from the effects of natural and human-caused disturbance to preserve ecological and hydrological services and functions.

Right Bank: The bank of a river, stream, or creek that is on the right when facing downstream.

Riparian Area, Riparian Habitat, Riparian Land, or Riparian Zone: Riparian lands are transitional areas between upland and aquatic ecosystems. They have variable width and extent both above and below ground. These lands are influenced by and/or exert an influence on associated waterbodies, which includes alluvial aquifers and floodplains, when present. Riparian lands usually have soil, biological, and other physical characteristics that reflect the influence of water and/or hydrological processes (Clare and Sass 2012).

Riparian Management Area: As per Teichreb and Walker (2008), and for the purpose of this report, a riparian management area is defined as an area along the shoreline of a waterbody that includes near-shore emergent vegetation zone, the riparian zone, and a riparian protective (buffer) zone.

Strahler Order: A method of classifying and assigning a numeric order to streams in a network based on the number of tributaries. First order streams are dominated by overland flow and have no upstream concentrated flow; whereas higher order streams have a greater number of upstream tributaries. Stream order increases when stream of the same order intersect.

Waterbody: Any location where water flows or is present, whether or not the flow or the presence of water is continuous, intermittent or occurs only during a flood. This includes, but is not limited to lakes, wetlands, aquifers, streams, creeks, and rivers.

Watercourse: A natural or artificial channel through which water flows, such as in creeks, streams, or rivers.

Watershed: An area that, on the basis of topography, contributes all water to a common outlet or drainage point. Watersheds can be defined and delineated at multiple scales, from very large (e.g., thousands of square kilometers, such as the Bow River River watershed) to very small local watersheds (e.g., square metres, such as a small prairie wetland).

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1.0 Introduction

1.1. Background

Riparian areas are highly complex and dynamic “transitional habitats” that are found along the edge of waterbodies, including rivers, streams, lakes, wetlands, and springs. Riparian areas show steep hydrological and environmental gradients from the water’s edge to the adjacent uplands, and are critical for facilitating the transfer of energy and materials between terrestrial and aquatic ecosystems (NRC 2002). Hydrology (both groundwater and surface water) is the driving force behind the physical, chemical, and biological processes that characterize riparian habitats, and because riparian lands are under the influence of both terrestrial and aquatic processes (e.g. nutrient and sediment transfer), these areas tend to be more biologically productive and have higher levels of biodiversity than other habitats of comparable size (Ibid).

From the perspective of human communities, riparian areas provide a multitude of beneficial ecosystem functions and services, and the relationship between an intact riparian zone and the integrity of the aquatic environment is well established (Pusey and Arthington 2003). For example, intact riparian zones play a vital role in the exchange of inorganic and organic material between the terrestrial and aquatic ecosystems by intercepting sediments and nutrients that runoff from adjacent lands, as well as through the supply of leaf litter and woody debris. Intact riparian vegetation also modulates the transfer of solar energy to the aquatic ecosystem, which regulates water temperatures and the instream light environment, thereby creating suitable habitat for a range of aquatic species (Pusey and Arthington 2003). Riparian habitats also improve water quality and reduce flooding by stabilizing the banks of waterbodies and modulating water velocities, (Orewole et al. 2015; Olokeogun et al. 2020), while also slowing floodwater and increasing floodplain residence times, which increases recharge to groundwater aquifers (Swanson et al. 2017). In turn, this allows water to seep back into streams during low water or drought periods (Blackport et al. 1995), thereby stabilizing base water flows (Caissie 1991; Blackport et al. 1995).

Despite the importance of these habitats, the loss and impairment of riparian lands across Alberta over the last century has been significant (Clare and Sass 2012), and as a result, recent watershed management efforts throughout the province have been focused on identifying priority areas for riparian restoration and habitat management. In order to efficiently target habitat restoration efforts and resources across large spatial extents, however, there first needs to be reliable information about the location, condition, and function of riparian habitats.

1.2. Methods for Assessing Riparian Areas

1.2.1. Field Assessment

The finest scale and most detailed evaluations of riparian condition come from “boots-on-the-ground” site-specific field assessments (survey) and/or inventories of riparian areas, such as the Alberta Riparian Habitat Management Society (ARHMS, also known as “Cows & Fish”) Riparian Health Inventory (RHI) and Riparian Health Assessment (Survey) (ARHMS 2020). In RHI method, detailed and local-scale traits of riparian areas are evaluated by trained practitioners, and a comprehensive and thorough evaluation of riparian condition is made. The resulting riparian health score is derived from the inventory details following field data collection. In the Riparian Health Assessment (Survey) method, local-scale traits of riparian areas are also evaluated by trained practitioners, but with less detail, and the resulting health score is determined in the field. The metrics of both methods evaluate a wide range of riparian attributes including: vegetation type, structure, and composition; bank characteristics; soil attributes; and land use and disturbance. The final compiled score provides a snapshot of whether a riparian area is “Healthy”, “Healthy, but with problems”, or “Unhealthy”, and gives a land-owner or other interested stakeholders an idea of where to focus management activities.

To-date, there have been a number of ground-based riparian assessments completed by Cow and Fish within the Nose Creek watershed. The first was a baseline riparian health inventory that was completed in 2000, which included 36 sites that encompassed approximately 17 km of shoreline along Nose Creek and 11 km along West Nose Creek (Cows and Fish 2001). This was followed in 2009 by an assessment of four of the original sites from the 2000 baseline inventory, as well as four new sites, which combined encompassed 3.8 km along Nose Creek and 1.4 km along West Nose Creek (Cows and Fish 2010). Overall, the results from both of these studies suggested that the majority of riparian areas assessed were either unhealthy, or were healthy with problems. In addition to these studies, there have been a number of sites that have been assessed along Nose Creek and West Nose Creek within Calgary. This includes benchmark photographic monitoring (PESL 2007) and Riparian Health Inventory assessments. The RHI assessments, which have been completed for The City of Calgary, include seven sites along Nose Creek and six site along West Nose Creek (Personal Communication, The City of Calgary. These sites have been assessed twice between 2007 and 2022,with a site revisit frequency of approximately 5-years (Halawell and Hull 2008; Hull 2009; Personal Communication, The City of Calgary). Generally, sites along Nose Creek have been characterized as “Unhealthy”, while sites along West Nose Creek are generally in the “Healthy with Problems” category.

Although existing ground-based assessment methods offer exceptional site-specific details about riparian condition, the small-scale delineation employed for these assessments cannot be scaled up to provide information about riparian condition across larger geographic areas. Additionally, the results of these assessments are typically not available publicly due to confidentiality agreements with landowners. Consequently, ground-based surveys are limited in their ability to provide information for planning and management at municipal, regional, or larger scales.

1.2.2. Aerial Videography

As an alternative to the highly detailed information required and the substantial time and cost investment associated with field assessments, alternative approaches that utilize recorded video have been applied to assess riparian areas over larger spatial extents. Aerial videography is a tool for assessing riparian habitat where a trained analyst uses spatially referenced continuous video to evaluate a hydrologic system. Instead of walking around and observing the site, the observation takes place through video images acquired from an oblique angle at altitudes of 60 m or less. Riparian condition is assessed within a “riparian management area” (RMA) polygon, and like the field-based Alberta Riparian Habitat Management Society Riparian Health Assessment, the evaluator answers a series of questions about the functional attributes of the riparian lands to derive a score that is then classified according to three health categories that are akin to the field-based approach.

Videography has been applied by various organizations across Alberta using a variety of airborne video platforms (e.g., Mills and Scrimgeour 2004, AENV 2010, NSWA 2015). The benefit of videography is that the

entire riparian area of a lake or river can be assessed at one time, while providing a permanent geo-referenced video record of the current status of shoreline. It provides a relatively rapid method to produce a "coarse filter" assessment of riparian health. This approach is not intended to replace field-based assessments, but rather, complement them by allowing larger areas to be evaluated in an approximate fashion, to be followed by more detailed checks on the ground. The goal of the videography assessments is to provide information over larger areas at a lower cost, such that the management of riparian areas at larger scales (i.e. entire lake or river system) can be directed by standardized measurements. In many cases, videography can be very cost-effective per kilometer of shoreline observed. At a certain scale, however, the size of the study area and the width of the stream or river make assessments by videography cost prohibitive. Compared to ground-based methods, aerial videography offers a broader scale and relatively coarse assessment of riparian condition; however, at larger scales, such as for entire watersheds, this method becomes limited in practicality and efficiency (i.e., time and cost).

1.2.3. Satellite Remote Sensing & GIS Assessment

In response to a growing need for an assessment method that could evaluate riparian condition at large spatial extents (i.e., entire watersheds), Fiera Biological developed a Geographic Information System (GIS) method to assess thousands of kilometers of shoreline in a reliable and cost-effective way. This method was developed using metrics comparable to existing ground-based and aerial videography methods, and the results have been validated using both aerial videography (Fiera Biological 2018a) and field data (Fiera Biological 2019).

The assessment method uses automated and semi-automated GIS techniques to quantify the intactness of riparian management areas using freely available or low cost spatial data. This method combines imagery from satellites with information about the terrain (e.g., relative differences in elevation, location of depressions, etc.,) to create a land cover dataset that is then used to measure and quantify the amount of natural and human cover types present along the shorelines of a water body. The shoreline is then classified into condition categories along a gradient of how "intact" the vegetation is, with areas that are dominated by natural vegetation being considered highly intact, and areas dominated by human-created land cover types (e.g., roads, houses, agricultural crops) being considered to have very low intactness. To date, this method has been used to assess over 42,000 km of shoreline across central Alberta (Fiera Biological 2018a-e, 2019, 2020a-b, 2021a-g, 2022a-c), including 659 km in the Bow River watershed (Fiera Biological 2021g and 2002c).

1.3. Study Objectives

The Nose Creek Watershed Water Management Plan provides guidance for the management of land and water resources in the Nose Creek watershed, and specifically identifies riparian health and function as a management issue (PESL 2018). The goal of the management plan is to *protect riparian areas and manage streamflows in the Nose Creek watershed to mitigate the impacts of flood and drought, and improve water quality for water users and aquatic life* (PESL 2018, pg. 6). Consistent with this goal, the objective of this project is to identify riparian areas that can be restored and/or conserved, such that they can contribute to the maintenance of a functioning riparian system. Specifically, this project contributes to the goal of protecting riparian areas by:

1) Creating a recent land cover and using this layer to assess the intactness of riparian areas along selected waterbodies.
2) Providing guidance on how the results of the intactness assessment can be used to prioritize conservation and restoration efforts in the watershed.

The results of this study provide stakeholders with a snapshot of the status of riparian management areas in the watershed. This in turn allows for the targeting of resources and management effort towards areas with the greatest need, or where those resources or efforts are likely to have the greatest overall positive impact. Further, this approach to evaluating riparian areas has been adapted and applied in other watersheds throughout the province, thereby allowing for a standardization of the methods used to conduct large-scale riparian assessments in Alberta.

1.4. Purpose and Intended Use

This assessment synthesizes data from a variety of sources, with the goal of improving the understanding of the current condition of riparian areas in the Nose Creek watershed. Readers are asked to consider the following points regarding the scope of this assessment as they review the methods and interpret the results of this study:

- Assessments characterize the relative intactness of riparian areas using a collection of indicators and associated metrics that are measurable in a GIS environment at a pixel resolution of 6 m. These assessments do not provide a statement on the absolute condition of riparian areas, and do not reflect the influence of factors that were not or cannot be included or considered for analysis. For example, this analysis cannot assess the occurrence or abundance of weeds within a riparian area, given that this type of cover cannot be resolved in a 6 m resolution satellite image. Furthermore, because overhead satellite imagery is used to create the land cover layer that is used to evaluate intactness, any impacts associated with structures or activities that are obscured by an extensive tree canopy cannot be evaluated (e.g., small structures, stormwater outfalls, etc.).
- In completing these assessments in a number of watersheds throughout Alberta, we have found that higher riparian intactness scores are more frequently associated with higher-order Strahler streams and rivers, whereas lower-order streams (many of which are unnamed) tend to have a much greater proportion of their shorelines assessed as Low or Very Low condition, particularly in agricultural landscapes. Thus, the overall intactness values for a watershed may be strongly influenced by the order of streams included in the assessment, as well as the dominant land use in the watershed.

- Intactness ratings are intended to support a screening-level assessment of management and/or conservation priorities across broad geographic areas (e.g., HUC 8 watershed, municipality, stream reach). *The tool assessments are not meant to replace more detailed, site-specific field assessments of riparian health or condition*. Instead, intactness ratings should be used to highlight smaller, more localized areas where field assessments and further validation may be required.
- The provincial hydrography data for streams, creeks, rivers, and lakes was used to delineate the shoreline of the waterbodies included in this assessment. Because waterbodies are dynamic and their boundaries change seasonally and annually, the boundaries for the waterbodies included in this study had to be manually adjusted to ensure that the boundary was reflective of the current location of the shoreline, as well as consistent with the imagery that was used to complete the riparian assessment. Notably, the location of the boundaries used in this assessment may not be representative of the location of these same waterbodies in the future. Further, the spatial boundaries of waterbodies within the watershed that were not assessed as part of this study have not been updated.
- The jurisdictional summaries in this report were based on the boundaries available in the Alberta Base Features dataset and were generated using a spatial intersect rule in the GIS, meaning that if the riparian management area was within a municipality or touched the boundary of a municipality, then it was included in the results summary for that municipality. It should be noted that where a watercourse defines the boundary between two jurisdictions, there is often a substantial spatial offset between the base feature jurisdictional boundary and the water boundary that is digitized as part of this riparian assessment. This is particularly an issue for municipal boundaries, and it is often unclear which municipality is responsible for the management of the left or right bank of a waterbody that defines the boundary of more than one municipality. Editing municipal boundaries to conform with the water boundaries applied in this project was beyond the scope of work, and as such, there may be instances where the spatial intersect rule applied to generate the summaries does not precisely reflect the riparian areas associated with a jurisdiction. Consequently, the jurisdictional summaries provide a *general estimate* of the amount of shoreline that was assessed in the study, as well as the condition of the associated riparian management areas identified for each jurisdiction.

2.0 Study Area

The Nose Creek watershed is located in southwestern Alberta, within the Bow River basin (Map 1). The watershed covers an area of approximately 990 km^2 and intersects the Foothills Fescue, Central Parkland, and Foothills Parkland Natural Subregions (Map 2). The watershed boundary that was used to define the study area for this assessment was provided by the NCWP, and while it is similar to the Nose Creek HUC 8 watershed boundary defined by the Government of Alberta, there are slight differences between the two boundaries.

The Nose Creek watershed is highly developed and urbanized, with agriculture, agricultural depressions (typically cultivated wetlands), disturbed vegetation, and built-up land cover types accounting for approximately 80% of the watershed area (Figure 1; Map 3). Natural cover accounts for the remaining 20% of the watershed, with grassland, trees, and shrubs making up the greatest proportion of natural cover types (Figure 1). Natural cover is generally concentrated in the west central portion of the watershed, while also being associated with several watercourses and major urban parks (Map 3). The southern portion of the watershed intersects the major urban municipality of Calgary, with the City of Airdrie and the Town of Crossfield also being located in the watershed (Map 4). The majority of the lands located outside of these major towns and cities fall within Rocky View County, with a very small portion of the watershed area falling within Mountain View County.

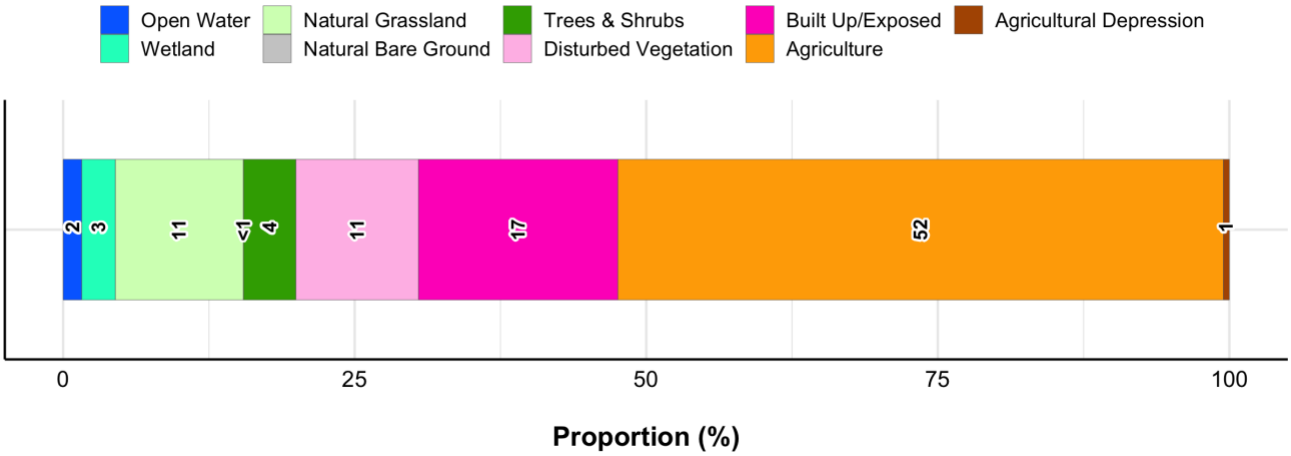


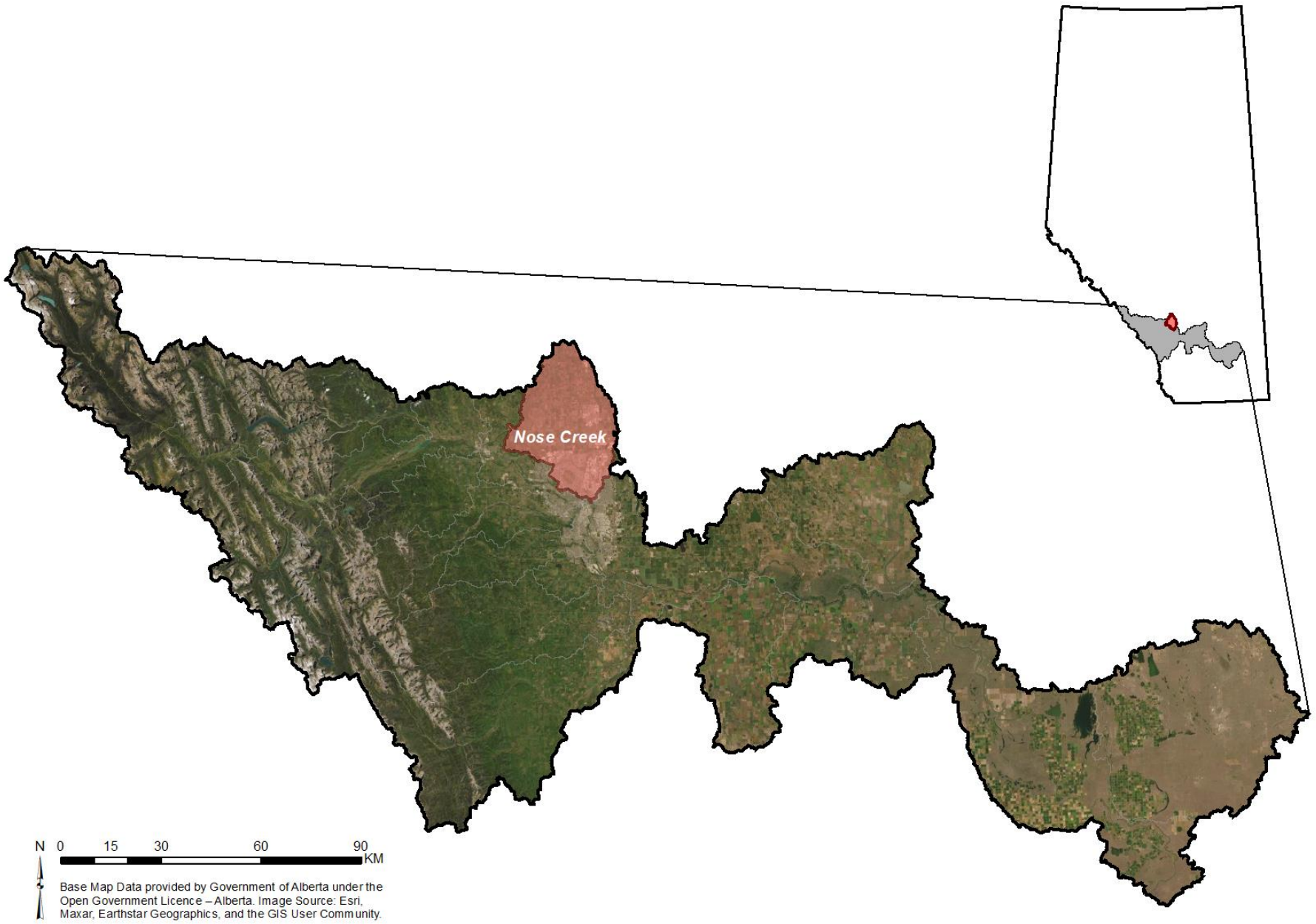
Figure 1. Proportion of the watershed covered by major (Level 1) land cover class. See Table 3 for a description of each land cover class.

Just under 700 km of shoreline was assessed as part of this study, and included the left and right banks of six major creeks, as well as 18 streams that do not have names in the provincial government stream data; however, some of these watercourses may have local names that were not used in this study (Table 1; Map 5). This assessment also included a number of named lakes and unnamed lakes and reservoirs that intersect the watercourses that were assessed (Table 1; Map 6).

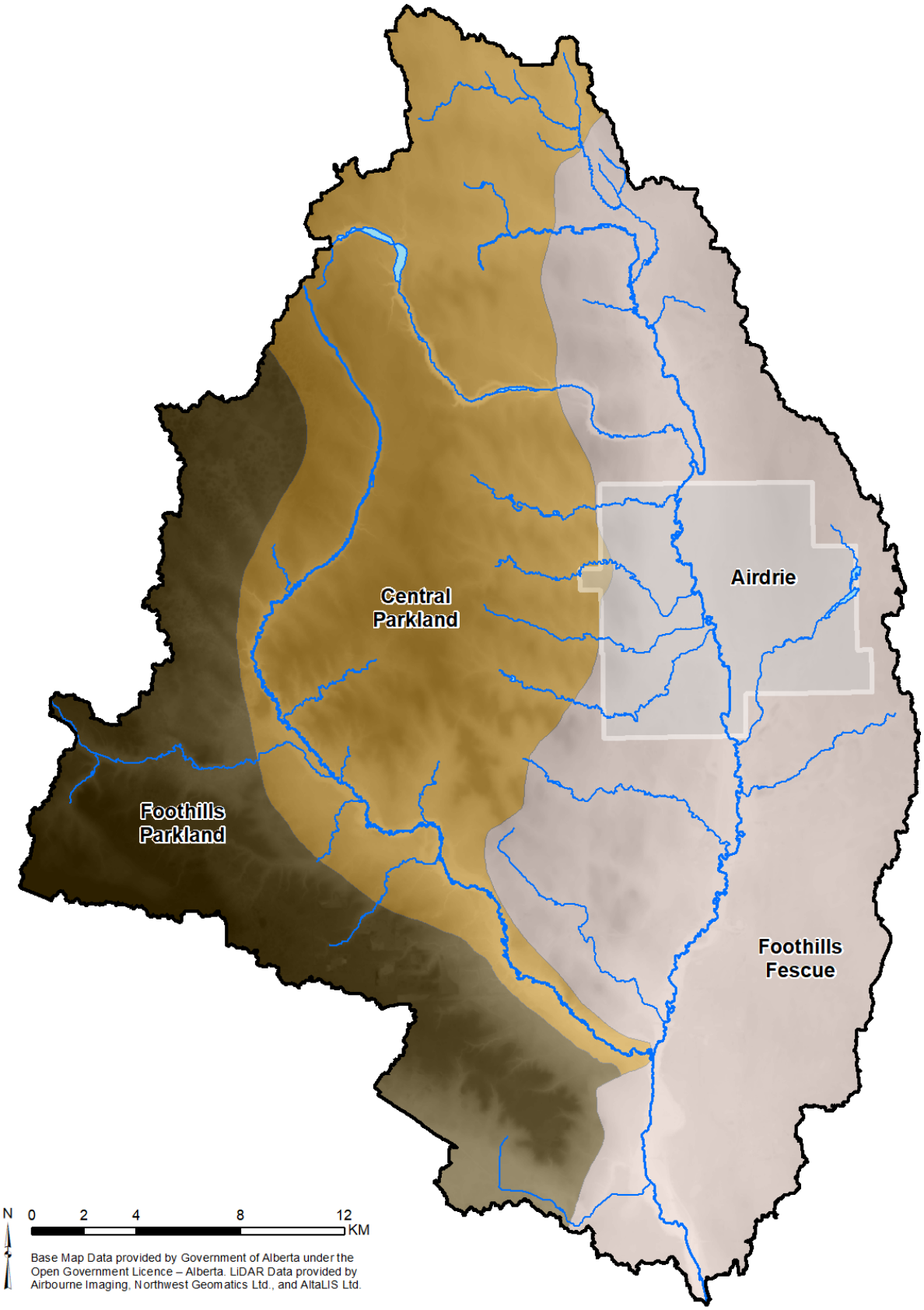
Notably, there are several watercourses in the watershed that have been highly modified by urban development. This includes portions of Confederation Creek and Beddington Creek within the City of Calgary, both of which have been re-routed into underground stormwater pipes for a portion of their length. This includes approximately 14 km (~75%) of shoreline associated with Confederation Creek and 7 km (~28%) associated with Beddington Creek. Additionally, there is approximately 19 km of shoreline associated with four different tributaries to Nose Creek within the City of Airdrie that have been integrated into the City's stormwater infrastructure and are no longer considered "natural". All of these modified shorelines have been excluded from this assessment.

Table 1. Watercourses in the Nose Creek watershed that were assessed as part of this project. The shoreline length listed for each watercourse represents the total length of the shoreline that was assessed on both the left and right banks.

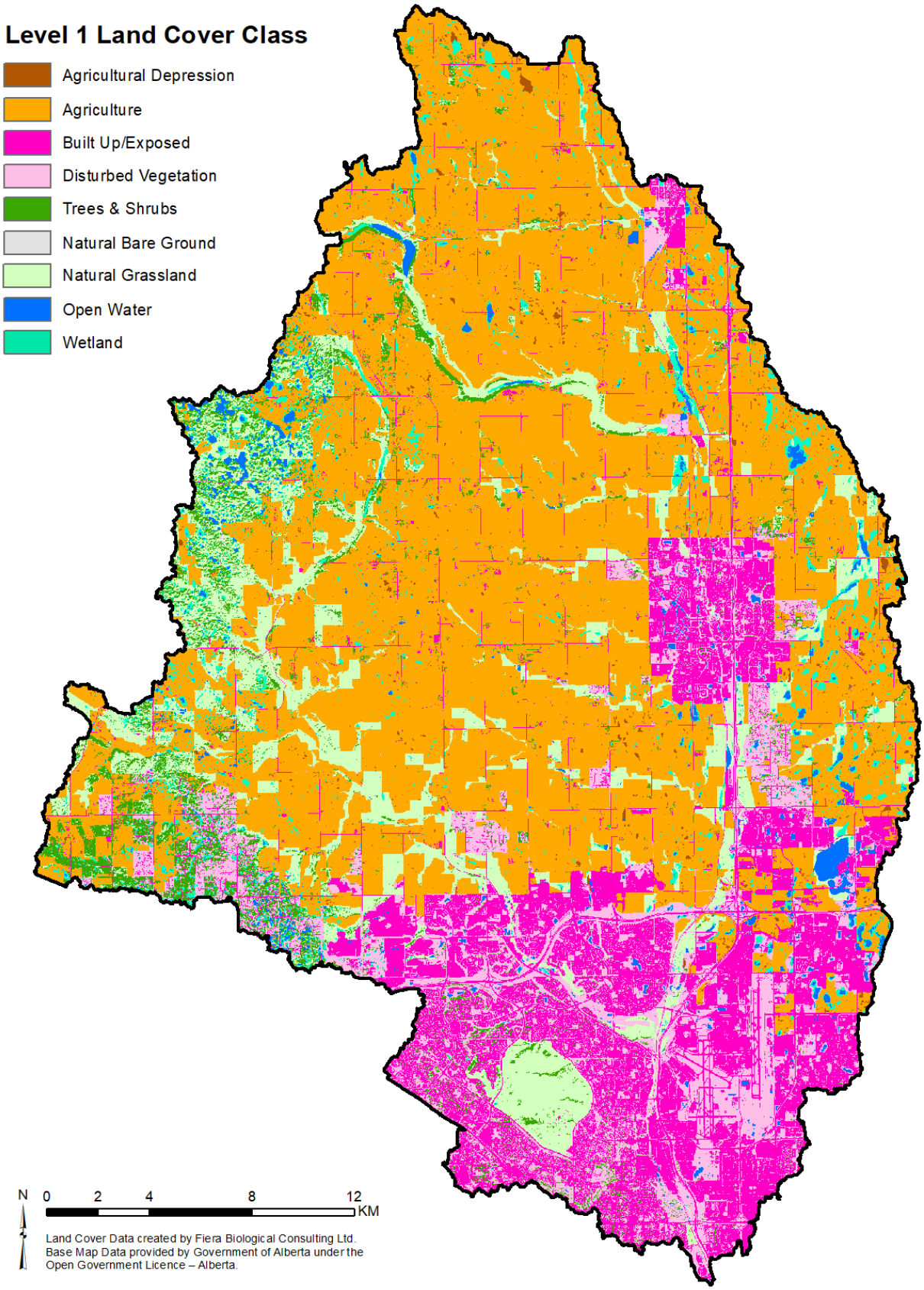
Waterbody Name	Length of Shoreline Assessed (km)
Creeks	
Beddington Creek	18.5
Bigspring Creek	39.5
Confederation Creek	4.9
Nose Creek	353.6
West Nose Creek	185.6
Writing Creek	44.8
Unnamed Streams (18)	23.2
Lake/Reservoir	
Dewitt's Pond	1.1
Near Lakes A	5.2
Near Lakes B	3.5
Unnamed Lakes	15.7
Unnamed Reservoirs	1.1
TOTAL	**696.7**



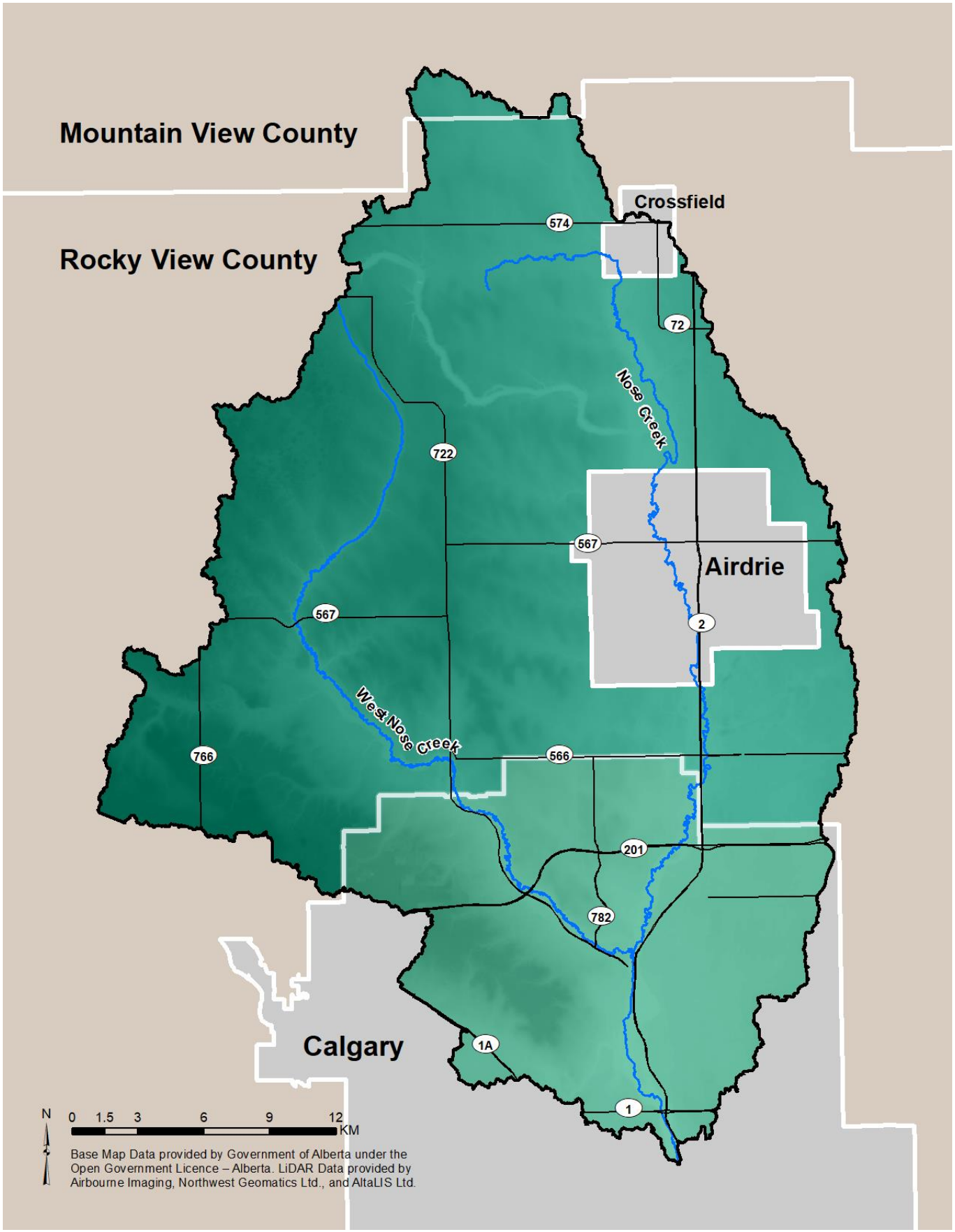
Map 1. The Nose Creek HUC 8 watershed located in the Bow River watershed.



Map 2. The Nose Creek watershed in Alberta includes areas that fall within the Foothills Parkland, Central Parkland, and Foothills Fescue Natural Subregions.

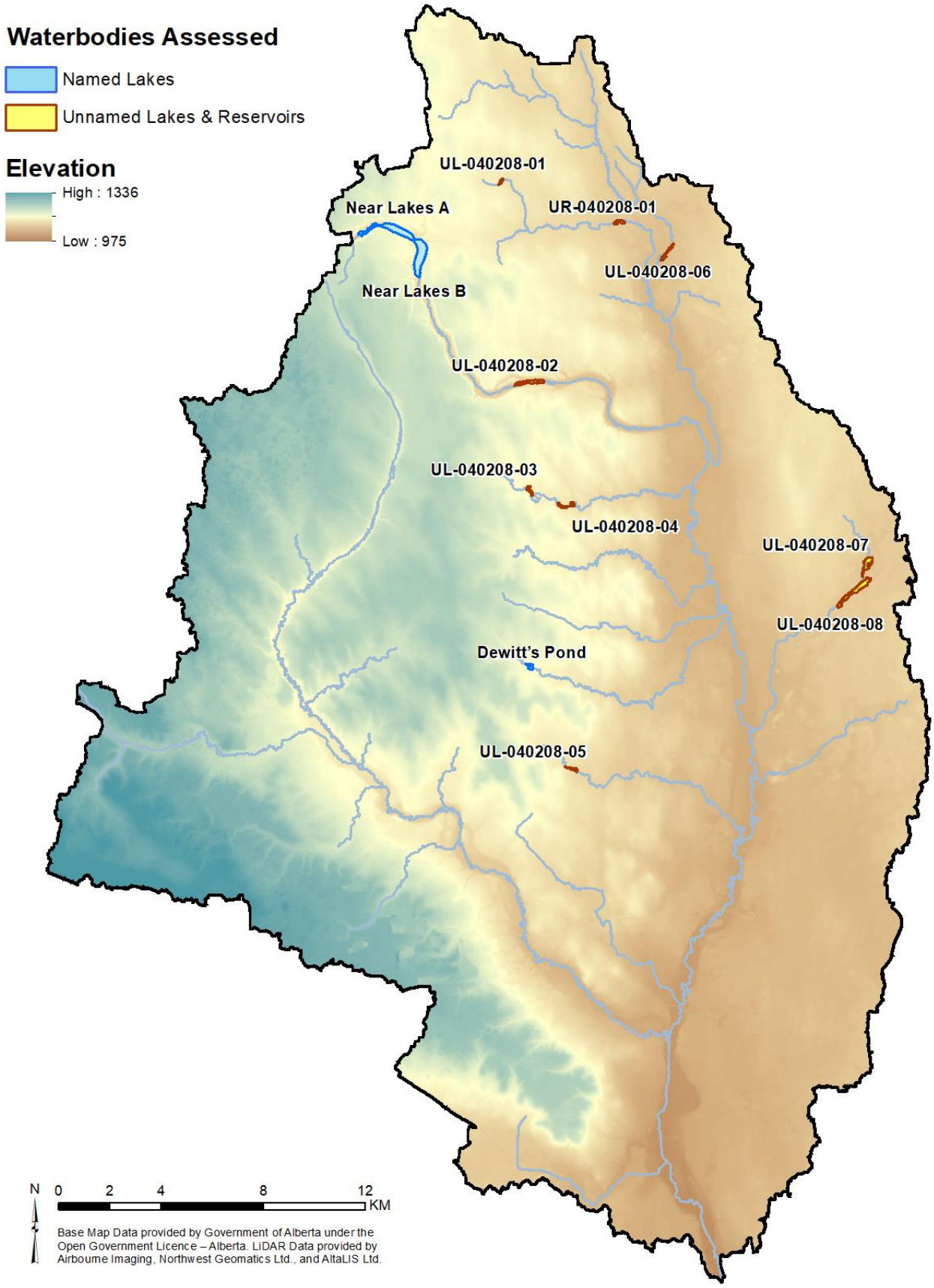


Map 3. Land cover in the Nose Creek watershed, created using SPOT 7 imagery from 2020.



Map 4. Major highways and major jurisdictions located within the watershed.

Map 5. Location of the named streams and unnamed creeks that were assessed in this study.



Map 6. Location of the named lakes and unnamed lakes and reservoirs that were assessed in this study.

3.0 Methods

3.1. Assessing Riparian Intactness

3.1.1. Land Cover Classification

To quantify riparian intactness in a GIS environment, several data sets are required, including a current land cover layer. While a freely available and current land cover layer is available from Agriculture and Agri-Food Canada (AAFC) for this watershed, the resolution of this data (30 m pixel size) is too coarse to accurately assess vegetation within riparian management areas. Consequently, a 6 m pixel resolution land cover layer was created using SPOT 7 satellite imagery from 2020, which was obtained by the NCWP free of charge from the Government of Alberta and created as part of a larger land cover classification project currently being created for the Bow River Basin.

The 6m land cover classification was created for the entire watershed and consisted of a single SPOT 7 scene. The satellite image was combined with a set of ancillary raster data products that were specifically generated for use in the classification (Table 2). The SPOT 7 imagery was used to generate layers for the first four principal component layers of the four band image, Normalized Difference Vegetation Index (NDVI), Blue Normalized Difference Vegetation Index (BNDVI), Green Ratio Vegetation Index (GRVI), and Iron Oxide Index (IOI), and a 5 m LiDAR DEM created from 15 m, 7.5 m, and 1 m LiDAR products was used to derive terrain layers including Probability of Depression and Cost Distance to Water. As well, historic image analysis was performed in Google Earth Engine to generate mean and standard deviation maps of NDVI and mean and standard deviation maps of NDWI from Sentinel 2 imagery (Table 2). Land cover classes were chosen and organized hierarchically into nested levels to facilitate training data selection and modelling (Table 3). Training data was manually selected for the SPOT 7 scene for the following classes: Coniferous; Cropland; Pasture; Deciduous; Open Water; Human Built; Lowland Mineral Graminoid, and Lowland Mineral Woody. A random forest classification was performed on the SPOT 7 band stack, which included the four SPOT 7 bands and additional ancillary layers. Random forest is a classification algorithm that is based on a set of decision trees derived by repeatedly selecting random subsets of training data and applying them to the layers in the band stack to create predictive models. By creating multiple models of decision trees, the best model and combination of information from the information in the band stack is determined and better prediction performance is obtained (Ho 1995). For this classification, 70% of the training data was used to train the classifier and the remaining 30% of the data was held back to validate the preliminary results.

Following the first stage of the classification, decision rules and manual editing were used to fix general classification errors. During this stage, the Natural Grassland class was added to the classification to account for areas of low and non-woody natural vegetation, Natural Bare Ground was added to account for undisturbed and unvegetated areas, Lowland Mineral - Saline was added to account for saline soils

and water within saline wetlands, a Shrub class was added to identify areas dominated by tall shrubs, a Disturbed Vegetation class was added to account for non-agricultural human impacted low vegetation cover and areas with managed or manicured vegetation, and a Lowland Graminoid Disturbed class was added to account for disturbed wetlands in agricultural fields. Finally, the Alberta Base features Roads layer was used to add in a Roads class to complete the 15-class “Level 2” land cover classification (Table 3).

Table 2. Description of the spatial data obtained or derived for use in the assessment of riparian management area Intactness.

Data Layer	Year	Source	Usage
SPOT 7	2020	Government of Alberta	Derivation of land cover classification
5 m LiDAR DEM	n/d	Government of Alberta (derivative of 15 m LiDAR data)	Derivation of data products for classification
Principal Component Layers 1-4	2020	Fiera Biological. Layers were created using SPOT 7 satellite data provided by the Government of Alberta	Derivation of land cover classification
Normalized Difference Vegetation Index (NDVI)	2020	Fiera Biological. Layer was created using SPOT 7 satellite data provided by the Government of Alberta	Derivation of land cover classification
Blue Normalized Difference Vegetation Index (BNDVI)	2020	Fiera Biological. Layer was created using SPOT 7 satellite data provided by the Government of Alberta	Derivation of land cover classification
Green Ratio Vegetation Index (GRVI)	2020	Fiera Biological. Layer was created using SPOT 7 satellite data provided by the Government of Alberta	Derivation of land cover classification
Iron Oxide Index (IOI)	2020	Fiera Biological. Layer was created using SPOT 7 satellite data provided by the Government of Alberta	Derivation of land cover classification
Probability of Depression	n/d	Fiera Biological. Layer was created using LiDAR DEM data provided by the Government of Alberta	Derivation of land cover classification
Cost Distance to Water	n/d	Fiera Biological. Layer was created using LiDAR DEM data provided by the Government of Alberta	Derivation of land cover classification
Roads	2019	Alberta Base Features	Derivation of land cover classification
Mean and Standard Deviation of NDVI	2013-2018	Fiera Biological. Layers created using Sentinel 2 imagery	Derivation of land cover classification
Mean and Standard Deviation of NDWI	2013-2018	Fiera Biological. Layers created using Sentinel 2 imagery	Derivation of land cover classification
ABMI Human Footprint	2018	Alberta Biodiversity Monitoring Institute	Semi-automated clean-up of classification
6 m Land Cover	2020	Fiera Biological. Layer was created using SPOT 7 satellite data provided by the Government of Alberta and derived layers	Derivation of RMAs and quantification of intactness metrics

Table 3. Land cover classes that were used to derive the land cover classification for the Nose Creek watershed.

Level 1	Level 2	Description
Trees & Shrubs	Coniferous	Areas with >75% cover by coniferous (needle-leaf) trees.
	Deciduous	Areas with >75% cover by broadleaf trees.
	Shrub	Areas with >75% cover by tall shrubs (<2 m height). Includes shrubs in riparian areas.
Natural Grassland	Natural Grassland	Naturally grassy areas with <1/3 shrub cover and <10% tree cover.
Open Water	Open Water	Any open water (lakes, permanent wetlands, standing water) and flowing water. Includes artificial waterbodies (e.g., dugouts and reservoirs).
Wetland	Lowland Mineral - Graminoid	Depressional or low lying areas dominated by mineral soils that have >25% cover by emergent or graminoid vegetation.
	Lowland Mineral - Woody	Depressional or low lying areas dominated by mineral soils that have >25% cover by coniferous/deciduous trees or shrubs.
	Lowland Mineral - Saline	Depressional or low lying areas dominated by exposed saline soil or saline water.
Agricultural Depression	Lowland Graminoid Disturbed	Human impacted/altered wetland basins in agricultural areas lacking intact emergent vegetation. In croplands these basins are typically cultivated and/or drained, and in pasture these low lying areas may be drained and/or utilized for agricultural purposes such as providing water for cattle.
Natural Bare Ground	Natural Bare Ground	Naturally occurring bare soil, sand, sediment, banks, and beaches.
Agriculture	Pasture	Agricultural areas used primarily as pasture or hayland.
	Cropland	Agricultural areas used primarily as cereal crop. Tilled most years.
Disturbed Vegetation	Disturbed Vegetation	Non-agricultural human-impacted or managed non-woody vegetation.
Built Up/Exposed	Human Built	Human built features and human-caused exposed/bare areas.
	Roads	Paved and unpaved roads.

3.1.2. Land Cover Classification Accuracy Assessment

Accuracy of the land cover was assessed using traditional remote sensing techniques, which provide a measure of accuracy for each land cover class, as well as an overall accuracy for all classes combined. Accuracy of the land cover layer was assessed at Level 1 using a stratified validation dataset that was a combination of held back training data points (samples collected at the same time as training data was selected, but were not used to train the random forest model) and randomly selected points that were collected by a trained photo interpreter. The Natural Bare Ground class was not included in the accuracy assessment because it accounted for less than 0.1% of the land cover, and acquiring enough independent samples for the accuracy assessment was not feasible. A total of 296 samples were used to assess accuracy, with a minimum number of 10 samples for each validated class.

Overall accuracy at Level 1 for the classification was 96% with a Kappa statistic of 0.95 (Table 4). Class accuracies were high for all classes. A qualitative review of the land cover classification was also performed, and users of this land cover classification should note that many riparian areas next to streams and rivers are classified as natural grassland or shrub; however in some instances, these areas may have been classified as wetland/lowland classes.

While the land cover and riparian assessment results for the Nose Creek watershed were not validated using field data, previous riparian assessments completed using this GIS method have been validated using aerial videography data (Fiera Biological 2018a), as well as high resolution imagery and data collected in the field (Fiera Biological 2019). In each case, the riparian assessment results were considered to be very robust when compared against the validation data.

Table 4. Accuracy assessment results for the Level 1 land cover classes.

	Agricultural Depression	Agriculture	Built Up	Disturbed Vegetation	Forest	Natural Grassland	Open Water	Wetland	User's Accuracy
Agricultural Depression	10	0	0	0	0	0	0	0	**100%**
Agriculture	0	125	0	1	0	1	0	0	**98%**
Built Up/Exposed	0	0	42	0	0	0	0	0	**100%**
Disturbed Vegetation	0	1	0	25	0	0	0	0	**96%**
Forest	0	1	0	0	29	1	0	2	**88%**
Natural Grassland	0	2	0	0	0	25	0	0	**93%**
Open Water	0	0	0	0	0	0	10	0	**100%**
Wetland	0	1	0	0	1	0	0	19	**90%**
Producer's Accuracy	**100%**	**96%**	**100%**	**96%**	**97%**	**93%**	**100%**	**90%**	**95%**

NOTE: Producer's accuracy measures errors of omission, which is a measure of how well real-world land cover types can be classified. User's accuracy measures errors of commission, which represents the likelihood of a classified pixel matching the land cover type of its corresponding real-world location. For example, for the Agriculture class, all of the mapped areas classified as agriculture were agriculture when compared to "real life", which gives a Producer's Accuracy of 100%; however, when validation points were assessed to see if they matched the associated mapped class (e.g., Built Up, Disturbed Vegetation, etc.), some of these "real life" points were mapped as agriculture.

3.1.3. Editing Water Boundary Data

The provincial hydrography data for the waterbodies of interest were used to delineate the shorelines included in this assessment. Due to the dynamic nature of waterbodies and the vintage of the provincial dataset, the location of the hydrography feature does not always correspond well with shorelines in current satellite imagery. In order to ensure the generation of RMAs and quantification of the intactness metrics were accurate, the hydrography data was manually edited, where necessary, to ensure that the boundaries corresponded with the SPOT 7 imagery and the land cover classification. For streams, the edited water boundary represents the approximate centreline of the watercourse. Where the width of a stream or creek was greater than 20 m for a distance of more than 50 m in the SPOT imagery, or the stream passed through an area of open water greater than 1.0 ha, the stream was split and edited to have a unique left and right bank. Lake and open water shorelines were edited to approximate the location of the boundary between the upland and riparian zone. The edited water boundaries for assessed features have an approximate mean accuracy of +/- 5 m relative to their location in the SPOT imagery that was used to derive the land cover layer for this project.

Figure 2. Example of the spatial inaccuracies associated with stream boundaries, where the location of the stream centre line does not match the actual location of the stream and exceeds the 5 m accuracy tolerance in the SPOT imagery. In this example, the yellow lines represent the location of the streamline from the provincial data and the blue line represents the manually edited location of the new stream centre line.

3.1.4. Delineating Riparian Management Area Width and Length

In order to allow for comparisons between watersheds, the GIS methods that were developed to assess riparian areas in the Modeste watershed (Fiera Biological 2018a) were applied in this watershed. As per the GIS method, which was developed to closely match previously developed aerial videography methods (Teichreb and Walker 2008), riparian intactness was assessed within a "riparian management area" (RMA).

An RMA has two spatial components: width and length. For this assessment, riparian intactness was evaluated in RMAs with a static 50 m wide buffer that was applied to the left and right banks of each watercourse. When assessing riparian condition using aerial videography, RMA length is determined by a change in the score of any single metric, and is thus variable. In order to replicate this approach, we chose to delineate the upstream and downstream extents of each RMA based upon major changes in the proportion of natural cover along the shoreline.

In order to determine the longitudinal extent of each RMA, the proportion of all natural cover types along the shoreline was evaluated, with the start and end points of each RMA corresponding with locations where there were major changes in the proportion of natural cover. To calculate the proportion of natural cover, all natural cover classes in the land cover (i.e., Wetland, Open Water, Natural Grassland, Natural Bare Ground, Forest) were selected and exported as a single layer. The stream layer was then divided into 10-meter segments on the left and right banks and the proportion of natural cover within a 25 m moving window was calculated for each segment. A threshold was used to identify locations along the shoreline within the moving window where there was greater than or less than 55% natural cover. All adjoining homogeneous segments of less than or more than 55% natural cover were then merged to became a single RMA. This threshold value was selected based upon an iterative threshold testing procedure to determine the percent of natural vegetative cover that best approximated the videography RMA boundaries (Fiera Biological 2018a). To reduce error associated with misclassification in the 6 m land cover, very small RMAs (≤10 m) were merged and dissolved with neighbouring segments.

3.1.5. Indicator Quantification and Riparian Intactness Scoring

Intactness with each riparian management area was quantified using the following metrics:

Metric 1: Percent cover of natural vegetation;

Metric 2: Percent cover of woody species;

Metric 3: Percent cover of all human impact and development (human footprint).

To quantify Metric 1, all natural cover classes were selected from the land cover layer and the proportion of the RMA covered by those cover classes was calculated. The natural classes used to quantify this metric included: Wetland (Mineral-Woody, Mineral-Graminoid, Peat-Woody, Peat-Graminoid), Forest (Coniferous, Deciduous, Shrub), and Natural Grassland. To quantify Metric 2, the percent cover of Forest (Coniferous, Deciduous, Shrub) and Treed Wetland (Mineral-Woody, Peat-Woody) land cover classes was quantified for each RMA. For Metric 3, the percent cover of the following land cover classes were used to calculate human footprint within each RMA: Cropland, Pasture, Agricultural Depression (Mineral – Disturbed Graminoid), Disturbed Vegetation, and Built Up/Exposed.

Once each metric was quantified, the values were range-standardized and were aggregated using a weighting comparable to the aerial videography methods. The metrics were weighted as follows: Metric 1: 0.15; Metric 2: 0.25; Metric 3: 0.60. The weighted scores were aggregated to derive a final RMA score that ranged between 0 and 100, and these scores were converted into intactness categories using the following categorical breaks:

- High Intactness (≥75-100): Vegetation within the RMA is present with little or no human footprint.
- Moderate Intactness (≥50-75): Vegetation within the RMA is present with some human footprint.
- Low Intactness (≥25-50): Vegetation cover within the RMA is limited and human footprint is prevalent.
- Very Low Intactness (0-25): Vegetation cover within the RMA is mostly cleared and human footprint is the most dominant land cover.

4.0 Results

4.1. Watershed Overview

Riparian intactness was calculated for approximately 697 km of shoreline in the Nose Creek watershed.

Overall, 12% (84 km) of the shoreline that was assessed was classified as High Intactness, with a further 47% (329 km) classified as Moderate Intactness (Figure 3; Map 7, Map 8, and Map 9). The remaining shoreline was classified as either Low (9%, 66 km) or Very Low (31%, 219) Intactness.

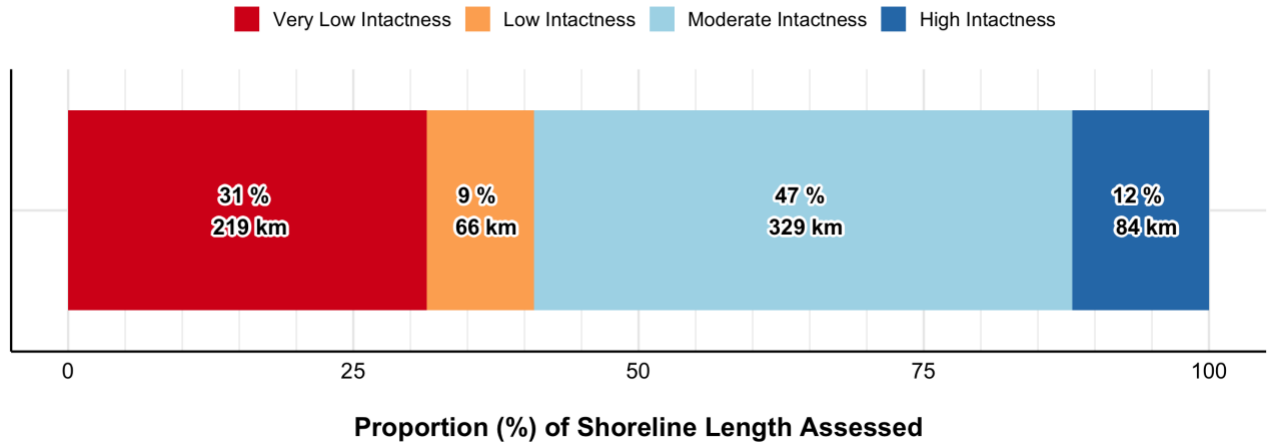
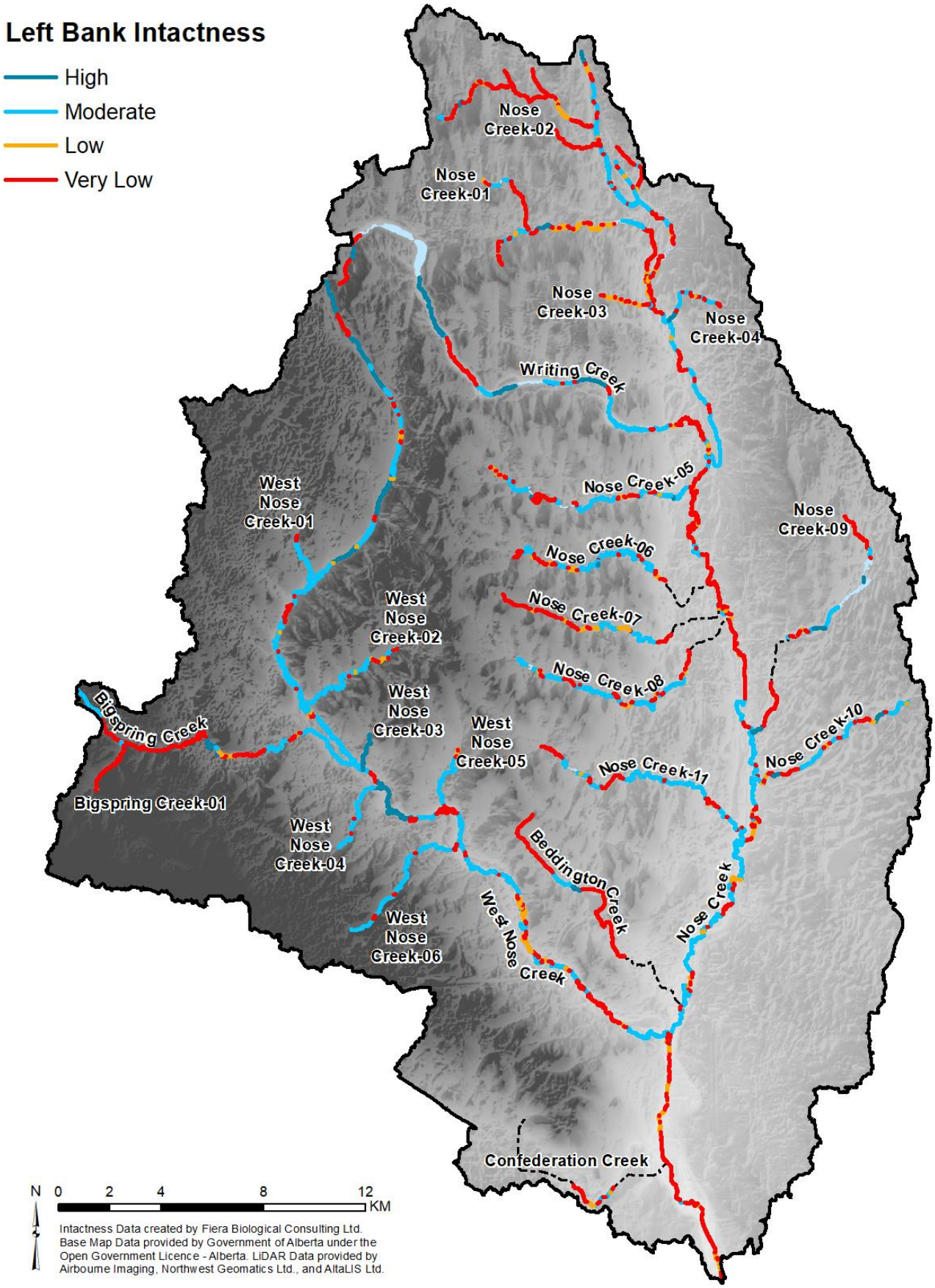
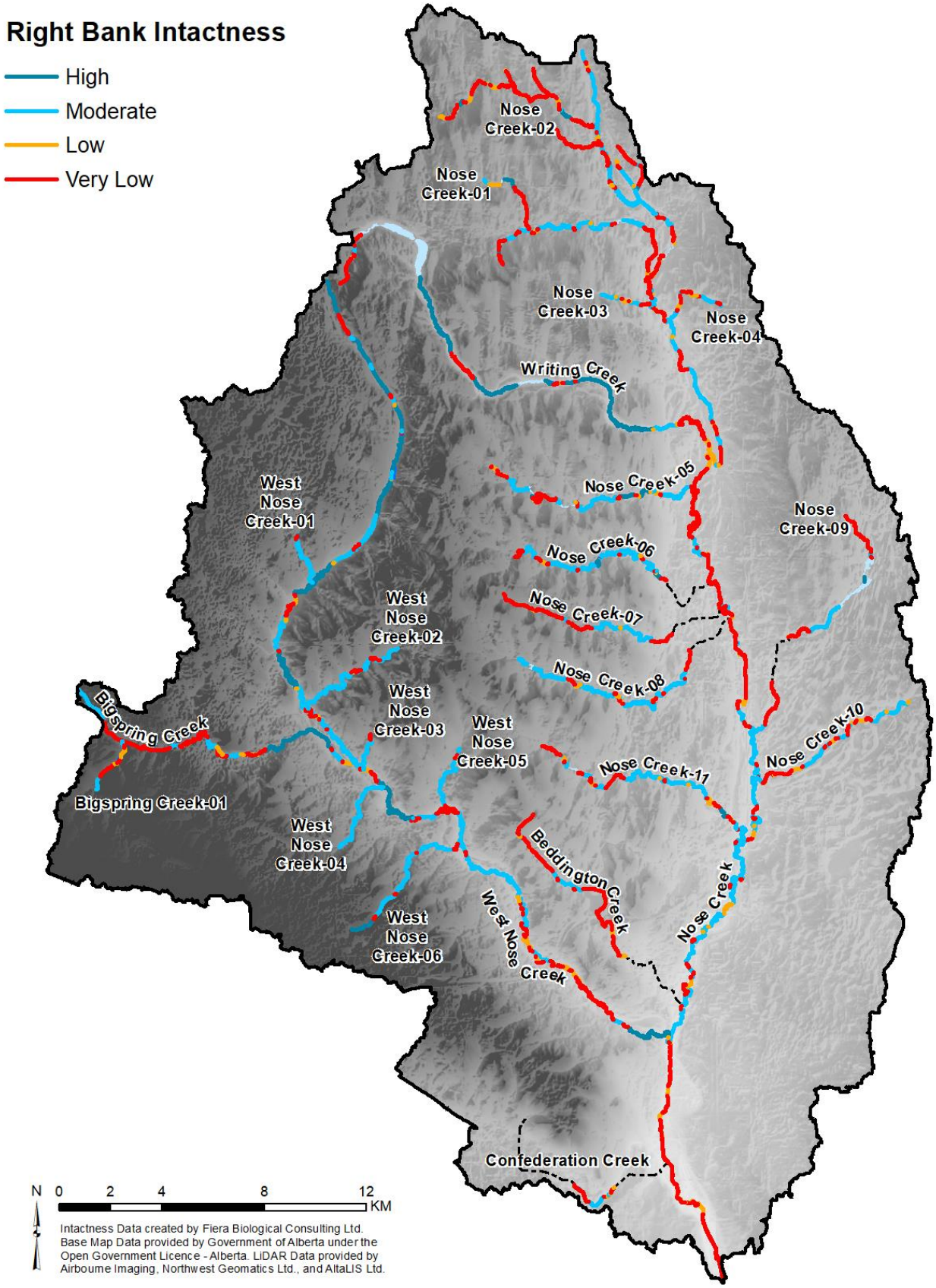


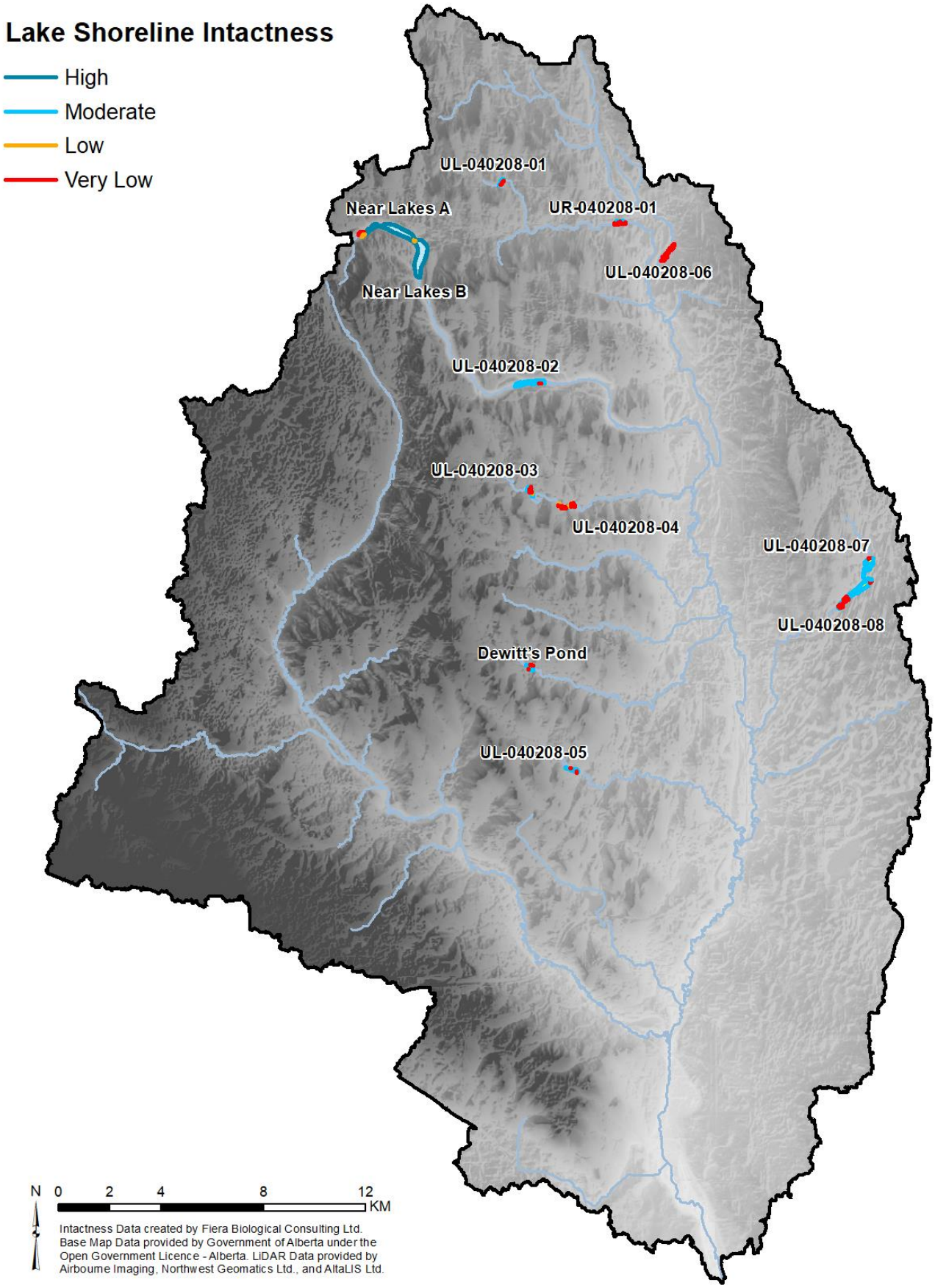
Figure 3. The total proportion of shoreline in the Nose Creek watershed assigned to each riparian intactness category.



Map 7. Intactness for the left bank of named streams and unnamed creeks that were included in this study.



Map 8. Intactness for the right bank of named streams and unnamed creeks that were included in this study.



Map 9. Intactness for the shorelines of lakes and reservoirs that were included in this study.

Five out of the six named waterbodies in the watershed had more than 25% of their shorelines assessed as Very Low Intactness (Figure 6). The portion of Beddington Creek that was assessed in this study had the greatest proportion of its shoreline assessed as Very Low intactness (76%), while Nose Creek had the greatest length (61 km) of shoreline assessed as Very Low Intactness. When the two lowest intactness categories are considered together, Beddington, Bigspring, Confederation, and Nose Creeks all had 50% or more of their shorelines classified as either Very Low or Low Intactness. Conversely, West Nose Creek and Writing Creek had more than 50% of their shorelines assessed as either Moderate or High Intactness (Figure 6).

Of the 18 Unnamed Creeks that were assessed, six had 50% or more of their shoreline classified as Low or Very Low Intactness (Figure 7). Only one unnamed creek (West Nose Creek-03) had 50% or more of its shoreline assessed as High Intactness. When High and Moderate Intactness categories are considered together, 12 of the 18 unnamed creeks had more than 50% of their shorelines classified in one of these two categories.

All three of the named lakes assessed in the watershed had more than 75% of their shorelines assessed as either High or Moderate Intactness, with Near Lakes (A and B) having the majority of their shorelines assessed as High Intactness (Figure 6). There was a relatively small amount of shoreline (less than 20 km) associated with the unnamed lakes and reservoirs, and three of the nine unnamed lakes/reservoirs had more than 50% of their shoreline assessed as either Very Low or Low Intactness (Figure 7). The remaining six unnamed lakes/reservoirs had the majority of their shorelines assessed as Moderate Intactness.

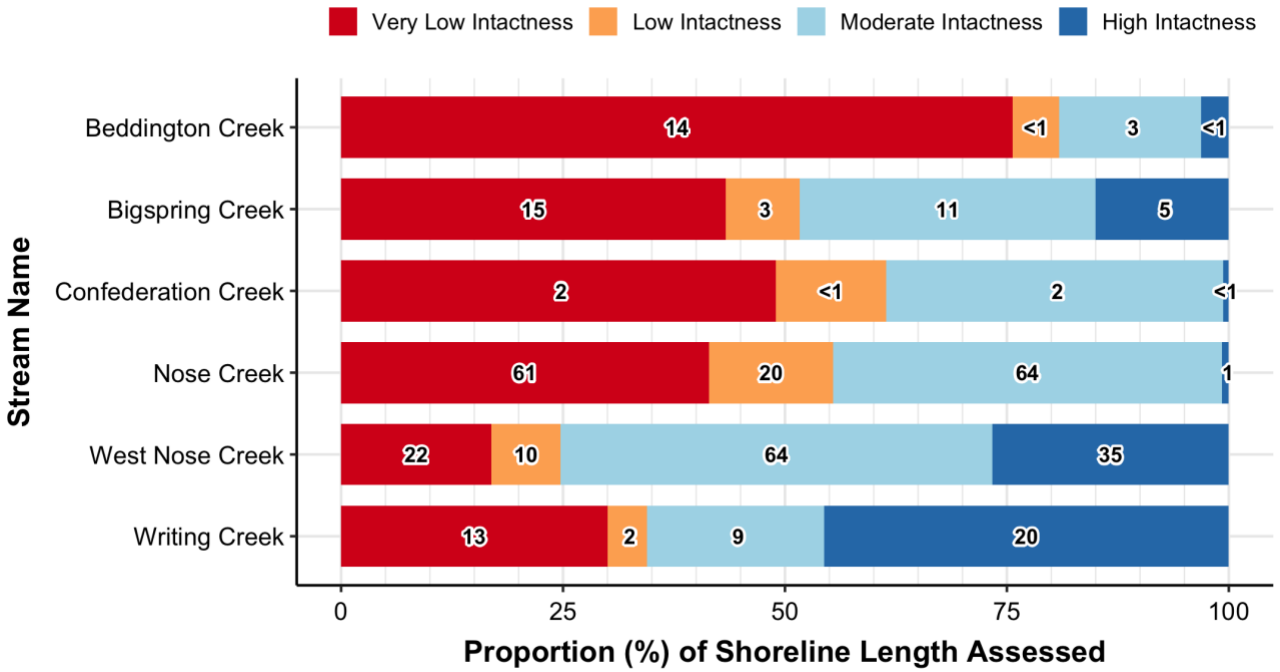


Figure 4. The total proportion of shoreline assigned to each riparian intactness category for named streams in the Nose Creek watershed.

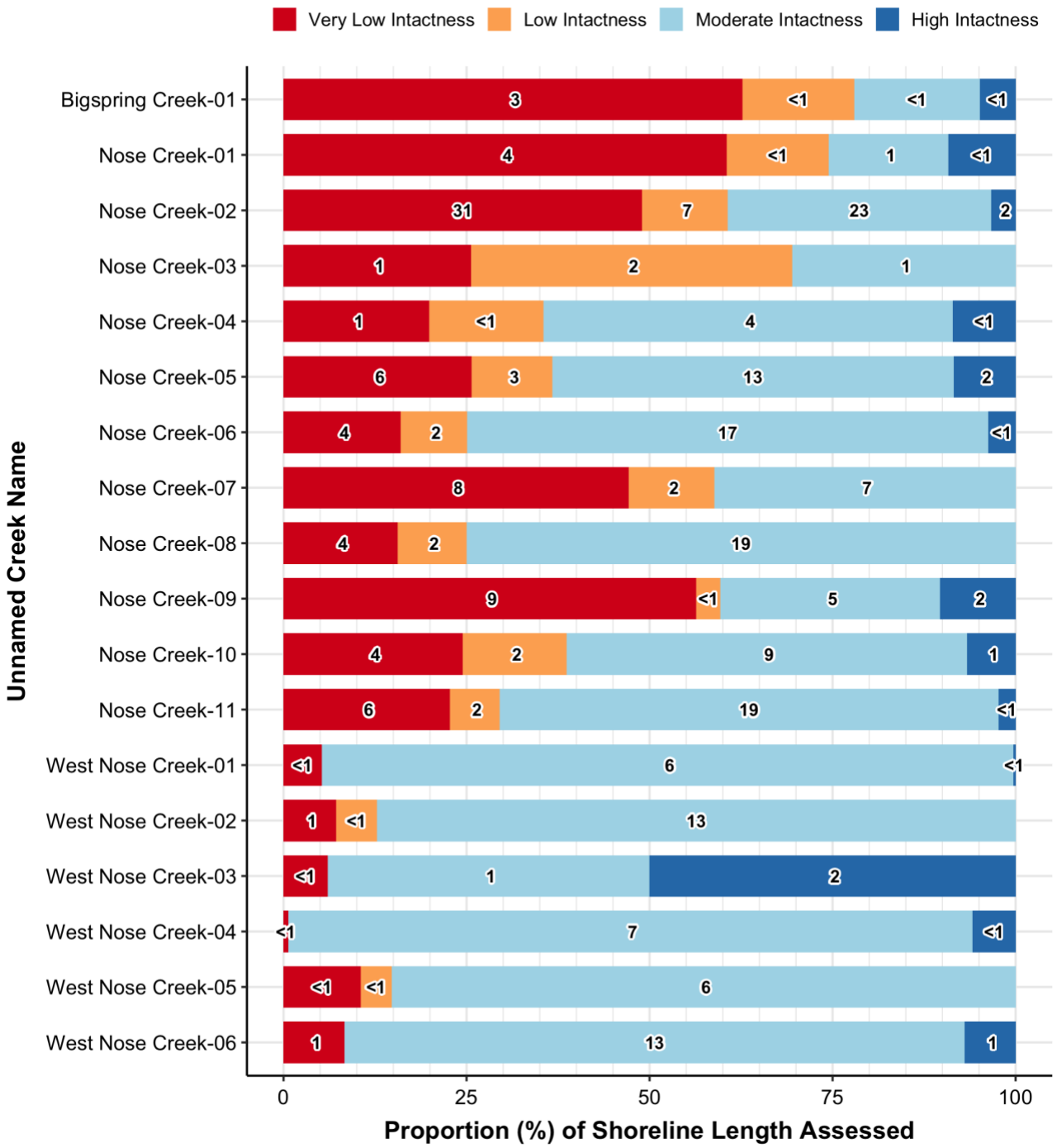


Figure 5. The total proportion of shoreline assigned to each riparian intactness category for Unnamed Creeks in the Nose Creek watershed.

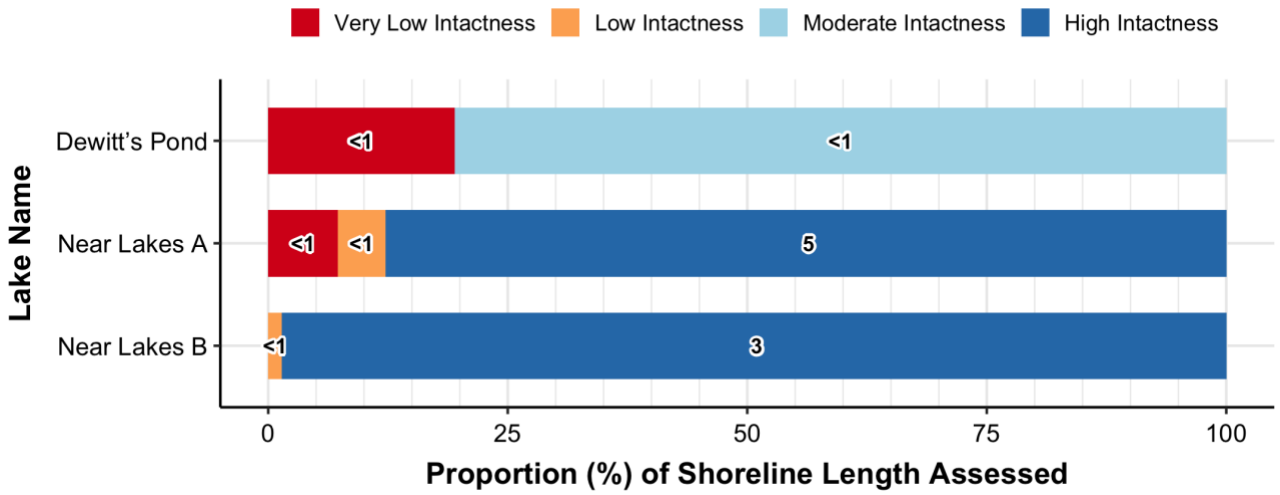


Figure 6. The total proportion of shoreline assigned to each riparian intactness category for Named Lakes in the Nose Creek watershed.

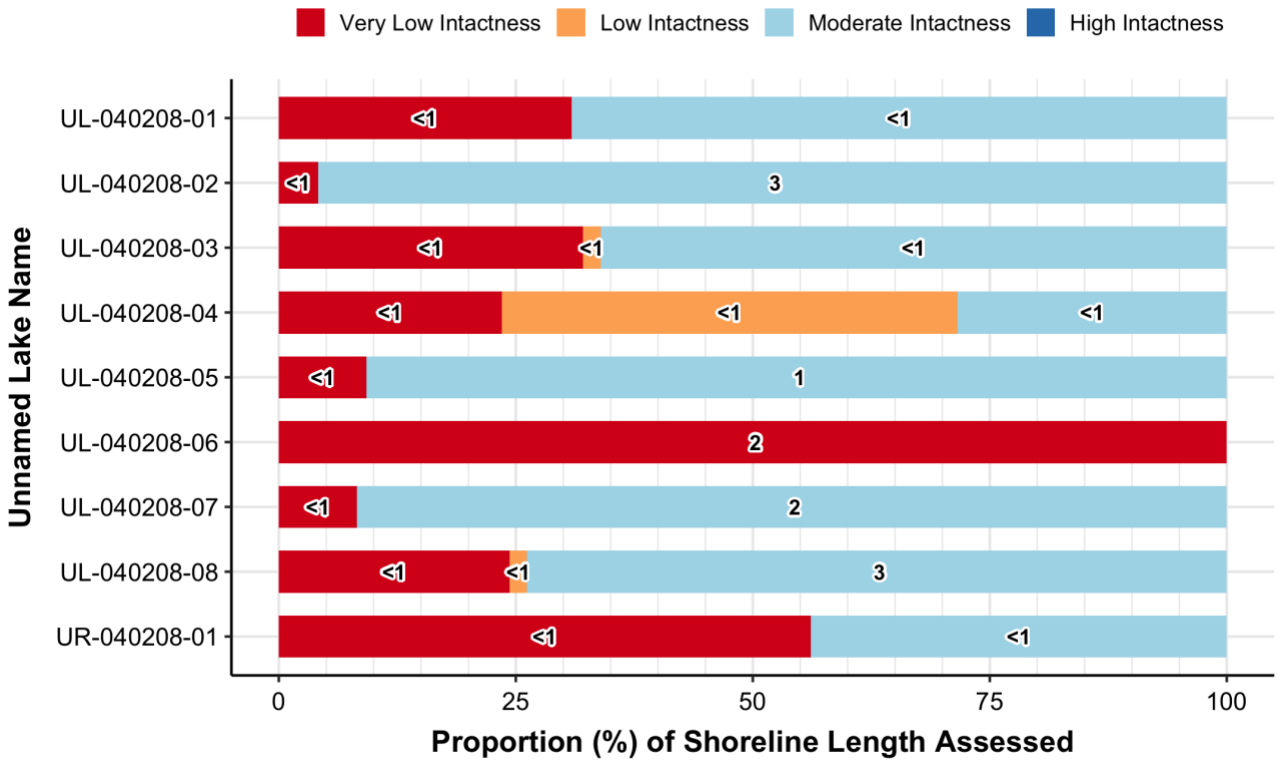


Figure 7. The total proportion of shoreline assigned to each riparian intactness category for Unnamed Lakes in the Nose Creek watershed.

4.2. Jurisdictional Overview

Five jurisdictions intersect the Nose Creek watershed: Airdrie, Calgary, Crossfield, Mountain View County, and Rocky View County (Map 10, Map 11, and Map 12). The greatest length of shoreline assessed in this study was associated with Rocky View County (~472 km), with a substantial amount of shoreline also being associated with Calgary (~132 km) and Airdrie (~82 km) (Figure 8). For Crossfield and Mountain View County, the length of shoreline associated with these jurisdictions was substantially less, with approximately 12 km being assessed within Crossfield, and only 1 km of shoreline falling within Mountain View County. Airdrie, Calgary, and Crossfield all had the highest proportion of shoreline evaluated as either Very Low or Low Intactness, while Rocky View County had the greatest length of shoreline assessed as Very Low Intactness (Figure 9).

A summary of results by jurisdiction is provided in Sections 4.2.1 through 4.2.5. An additional summary of intactness by waterbody and jurisdiction can be found in Appendix A.

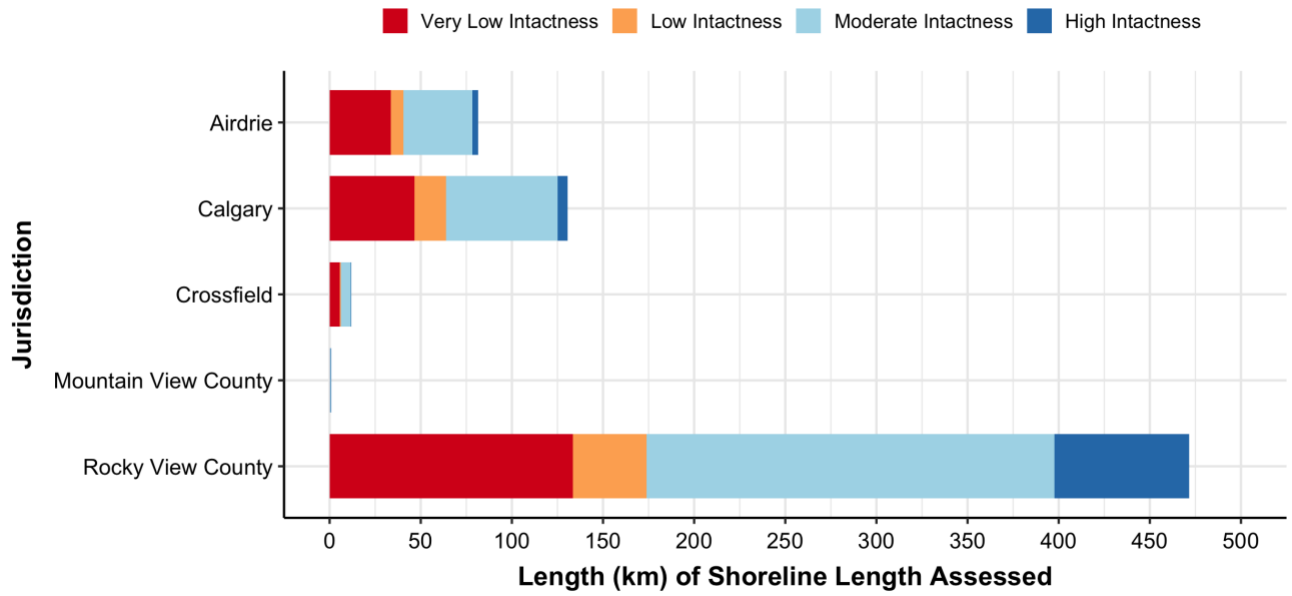


Figure 8. The total length of shoreline assigned to each riparian intactness category, summarized by jurisdiction.

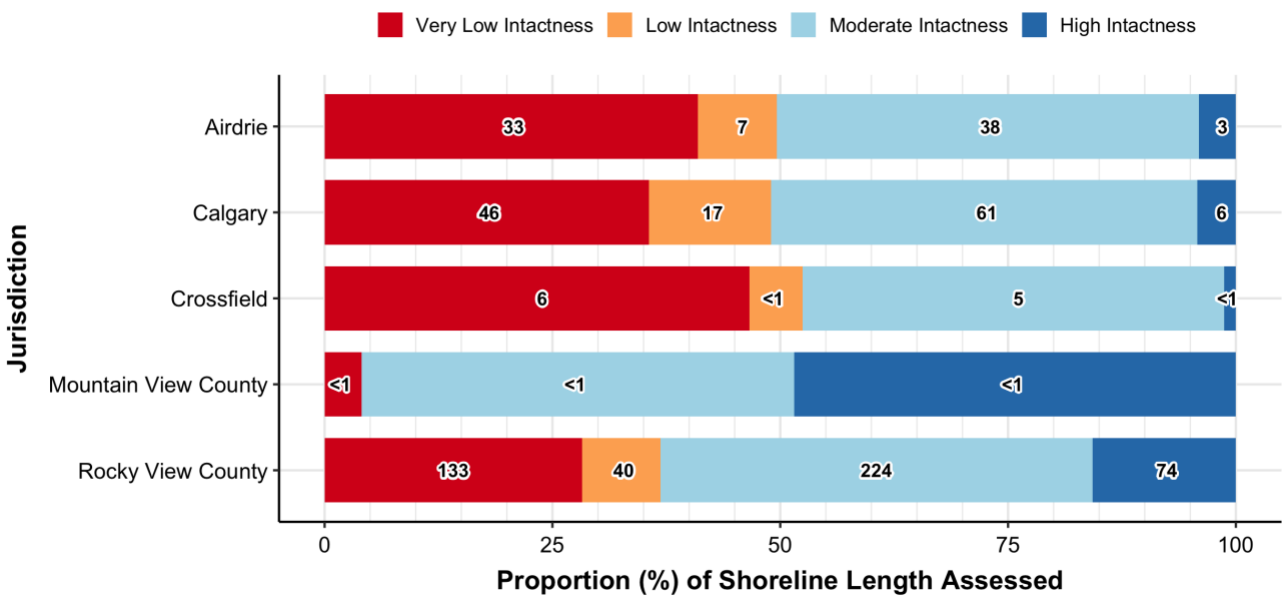
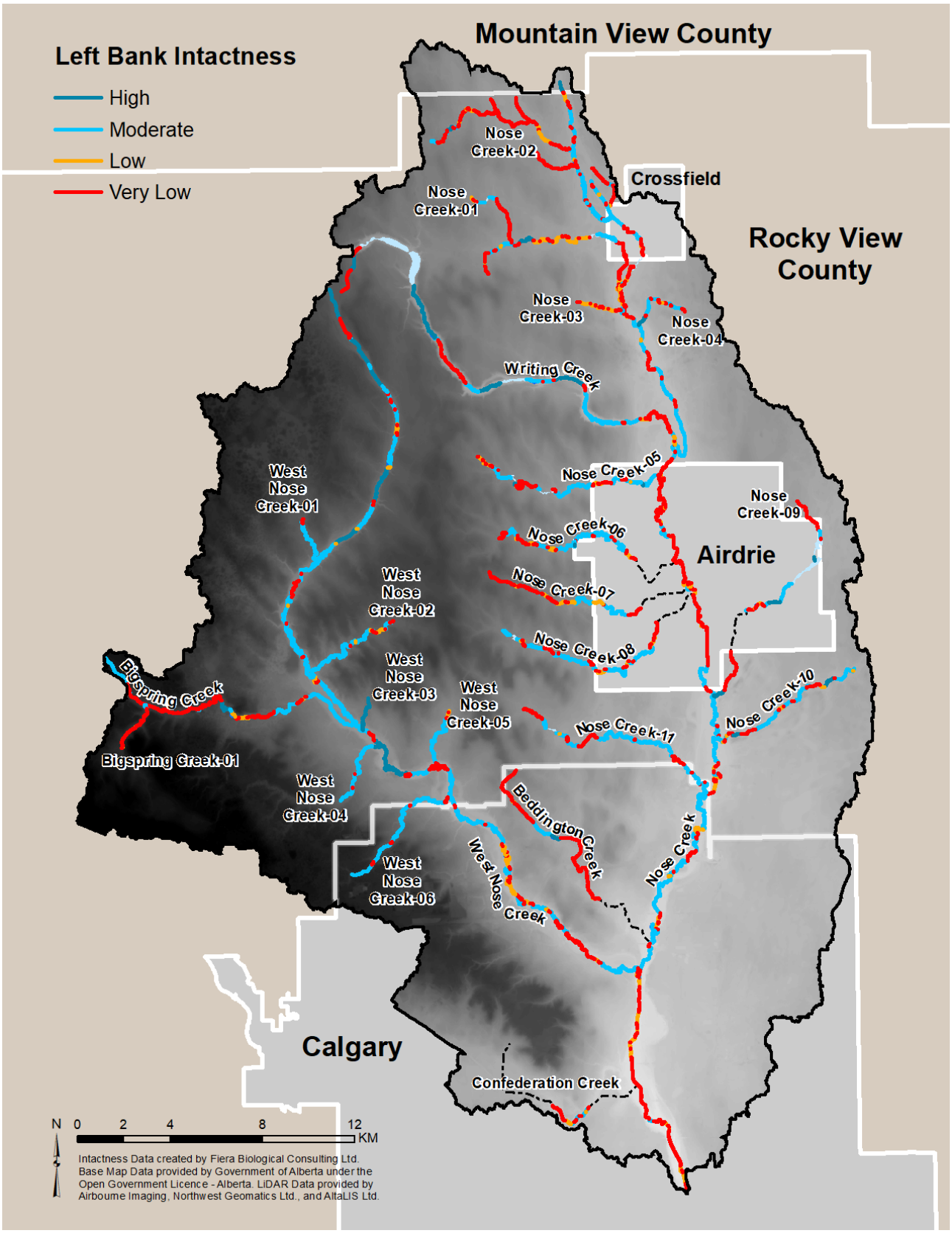
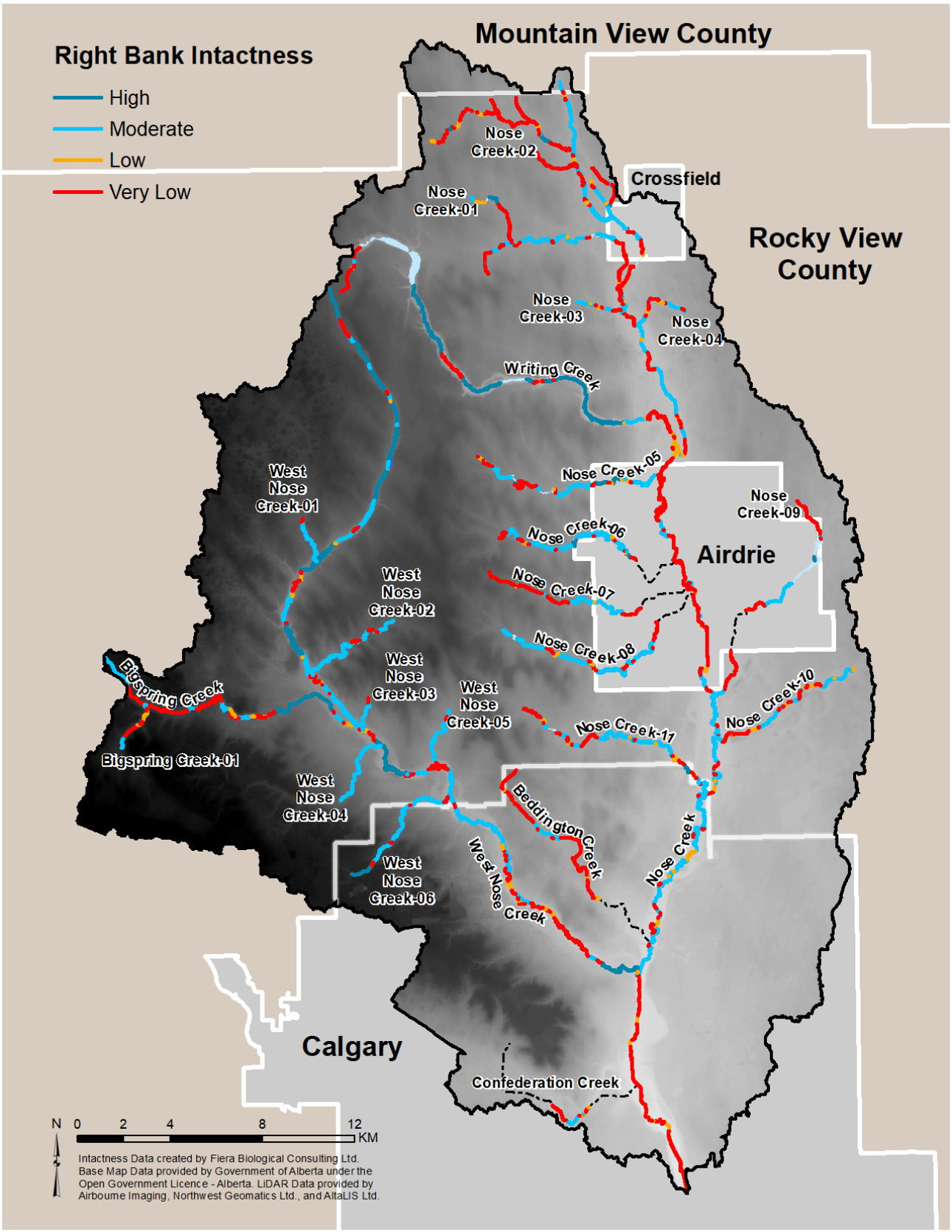


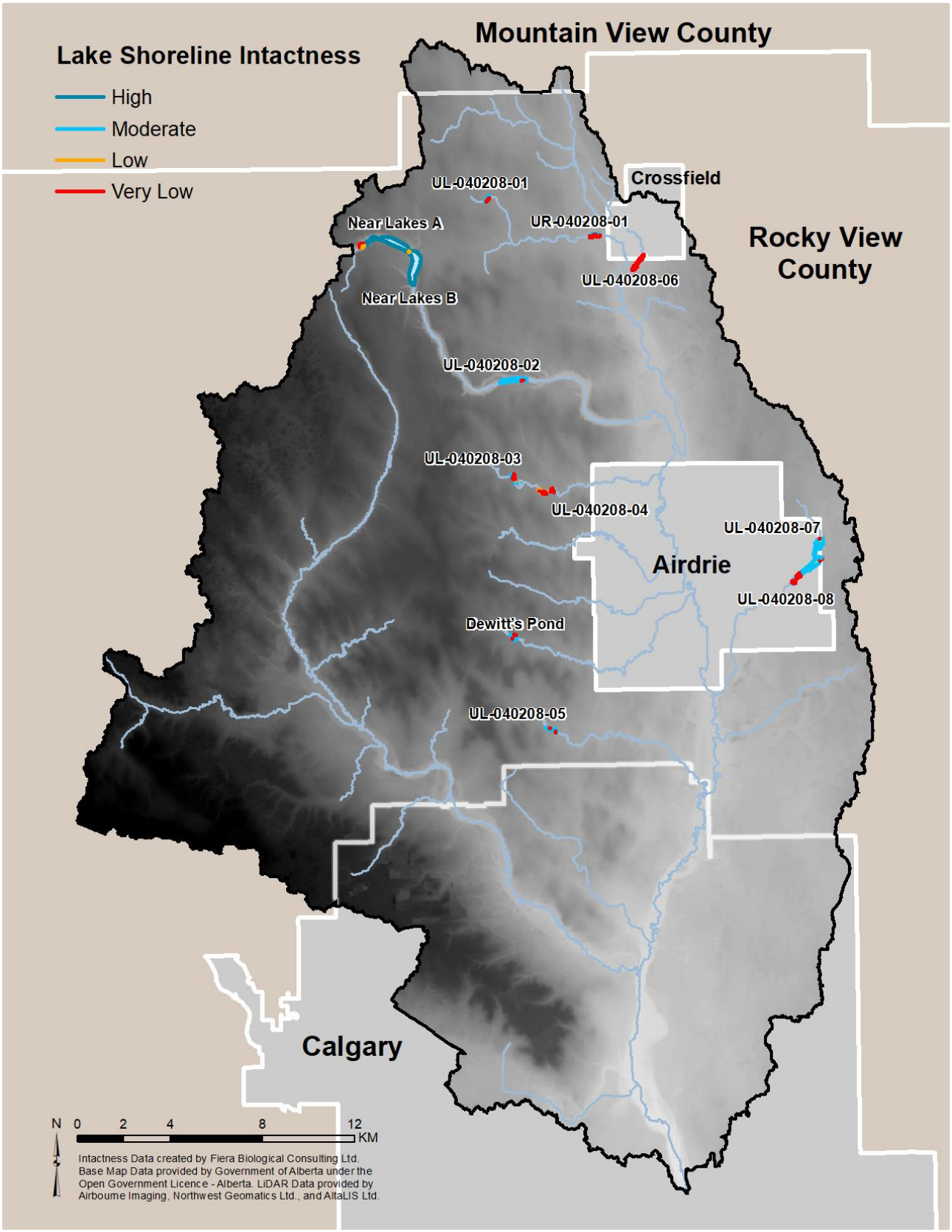
Figure 9. The proportion of shoreline length assigned to each riparian intactness category, summarized by jurisdiction.



Map 10. Intactness the left bank of watercourses included in this study, by jurisdiction.



Map 11. Intactness for the right bank of watercourses included in this study, by jurisdiction.



Map 12. Intactness for unnamed lakes and reservoirs included in this study, by jurisdiction.

4.2.1. Airdrie

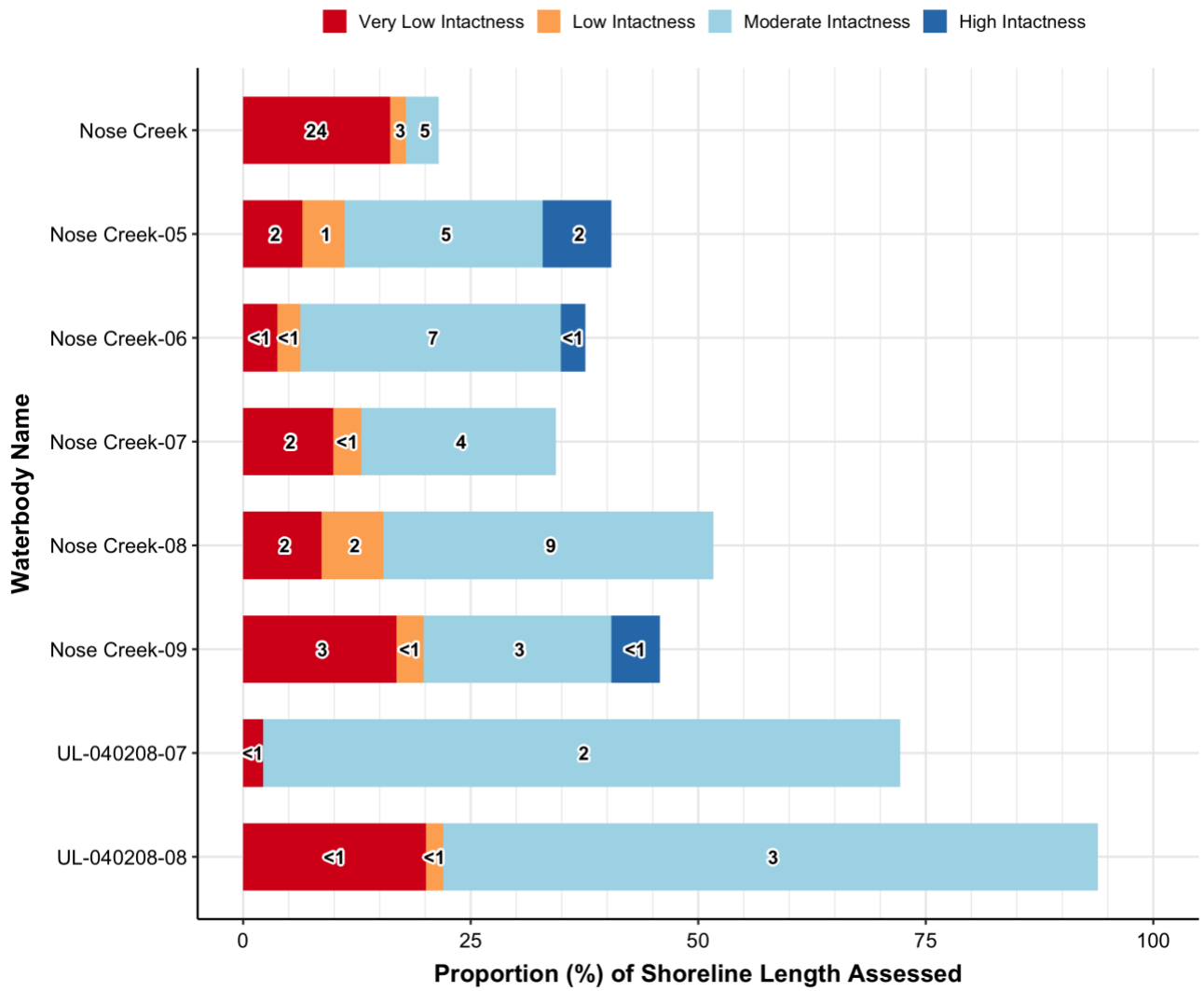


Figure 10. The proportion of shoreline length assigned to each riparian intactness category for waterbodies located within the City of Airdrie.

4.2.2. Calgary

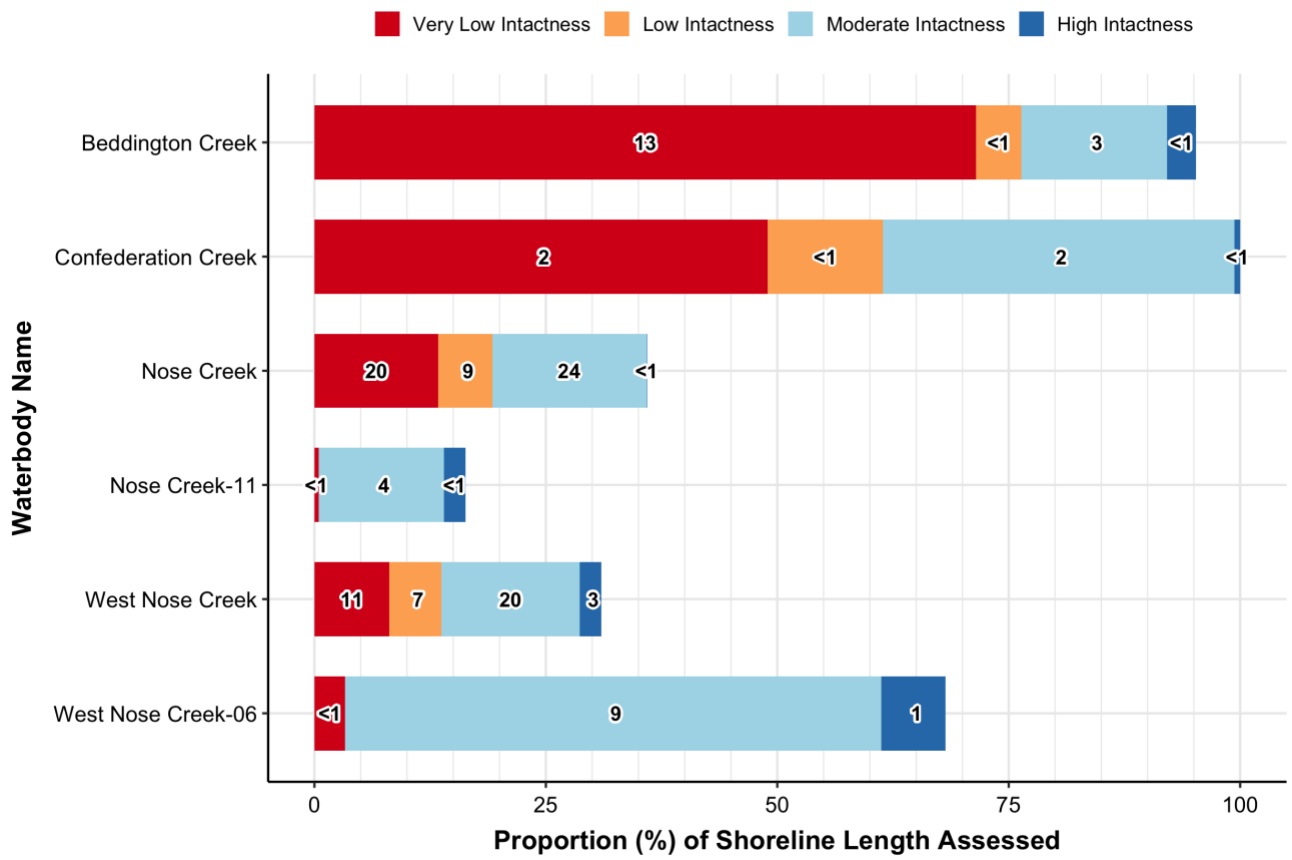


Figure 11. The proportion of shoreline length assigned to each riparian intactness category for waterbodies located within the City of Calgary.

4.2.3. Crossfield

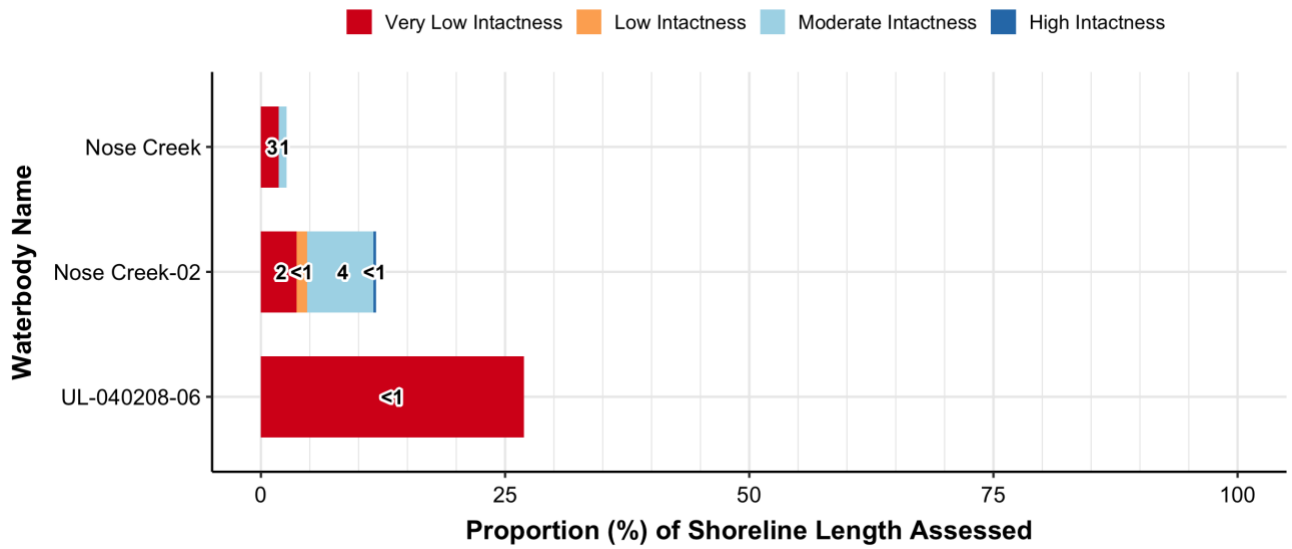


Figure 12. The proportion of shoreline length assigned to each riparian intactness category for waterbodies located within the Town of Crossfield.

4.2.4. Mountain View County

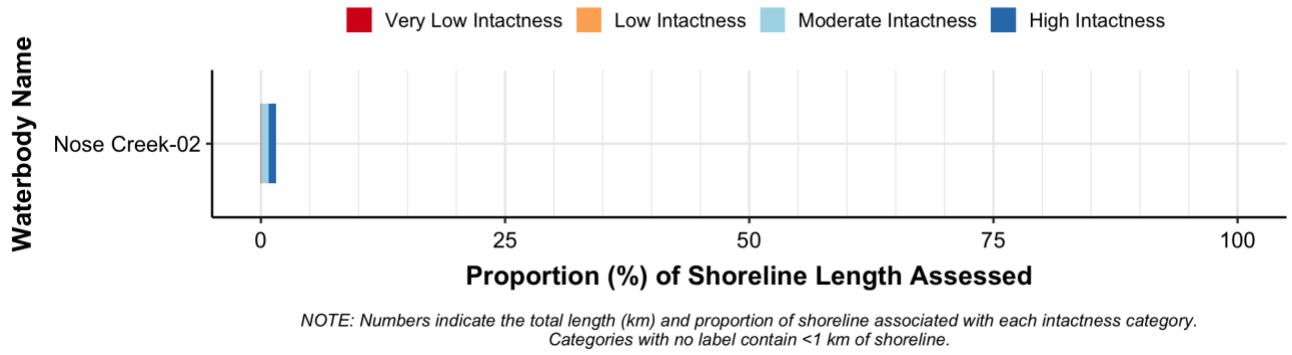


Figure 13. The proportion of shoreline length assigned to each riparian intactness category for waterbodies located within Mountain View County.

4.2.5. Rocky View County

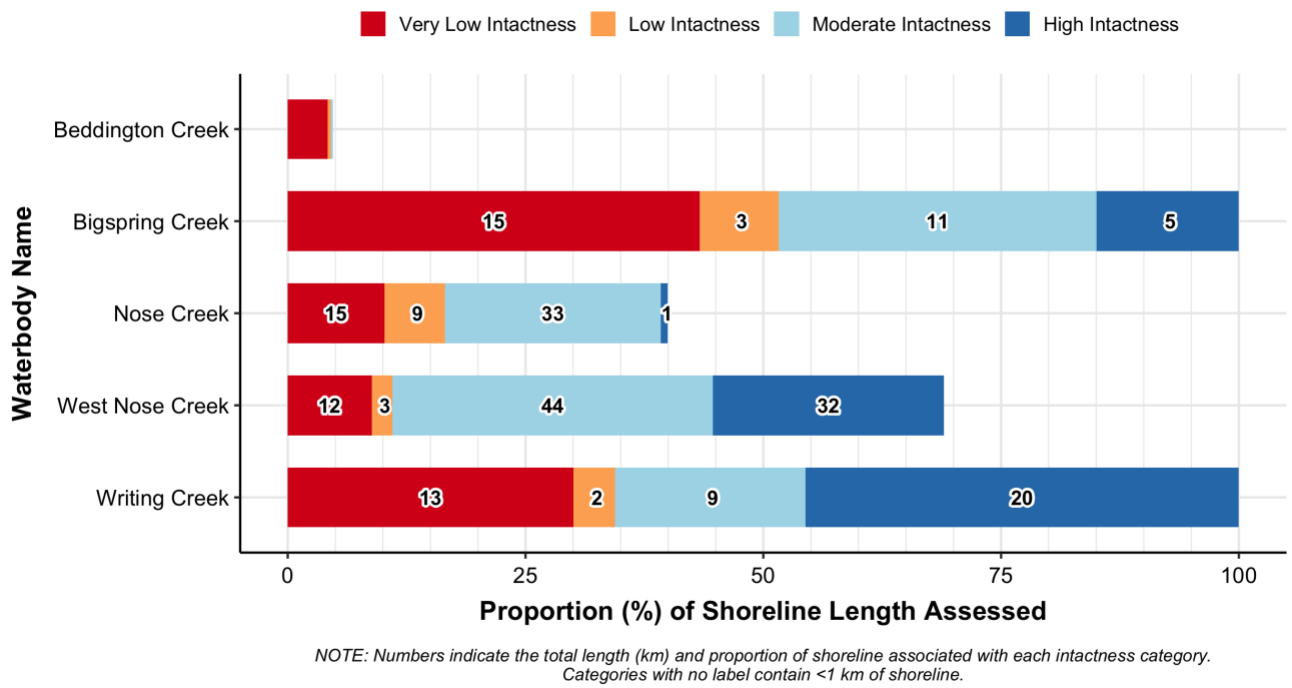


Figure 14. The proportion of shoreline length assigned to each riparian intactness category for named creeks located within Rocky View County.

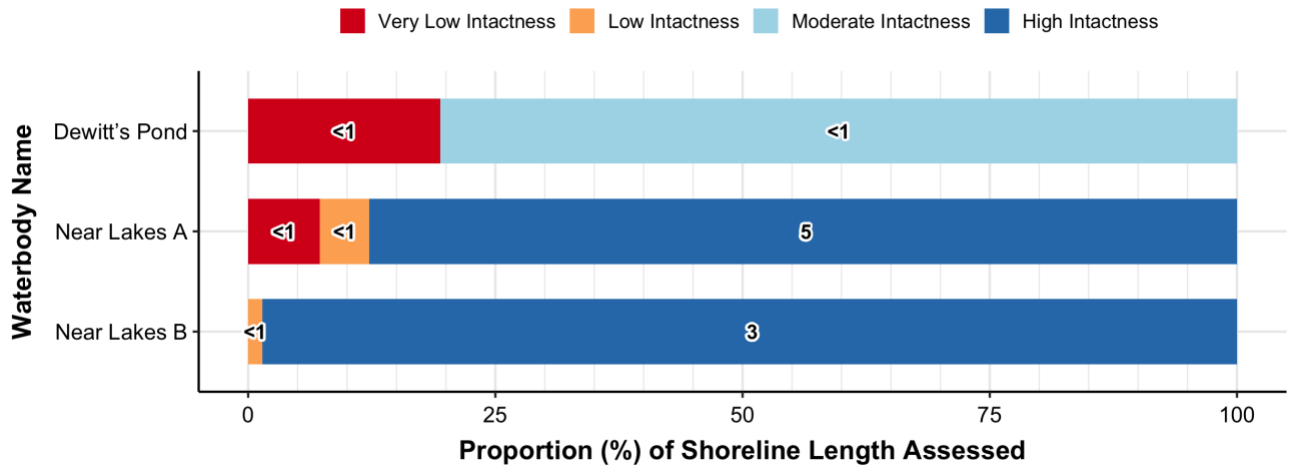


Figure 15. The proportion of shoreline length assigned to each riparian intactness category for named lakes located within Rocky View County.

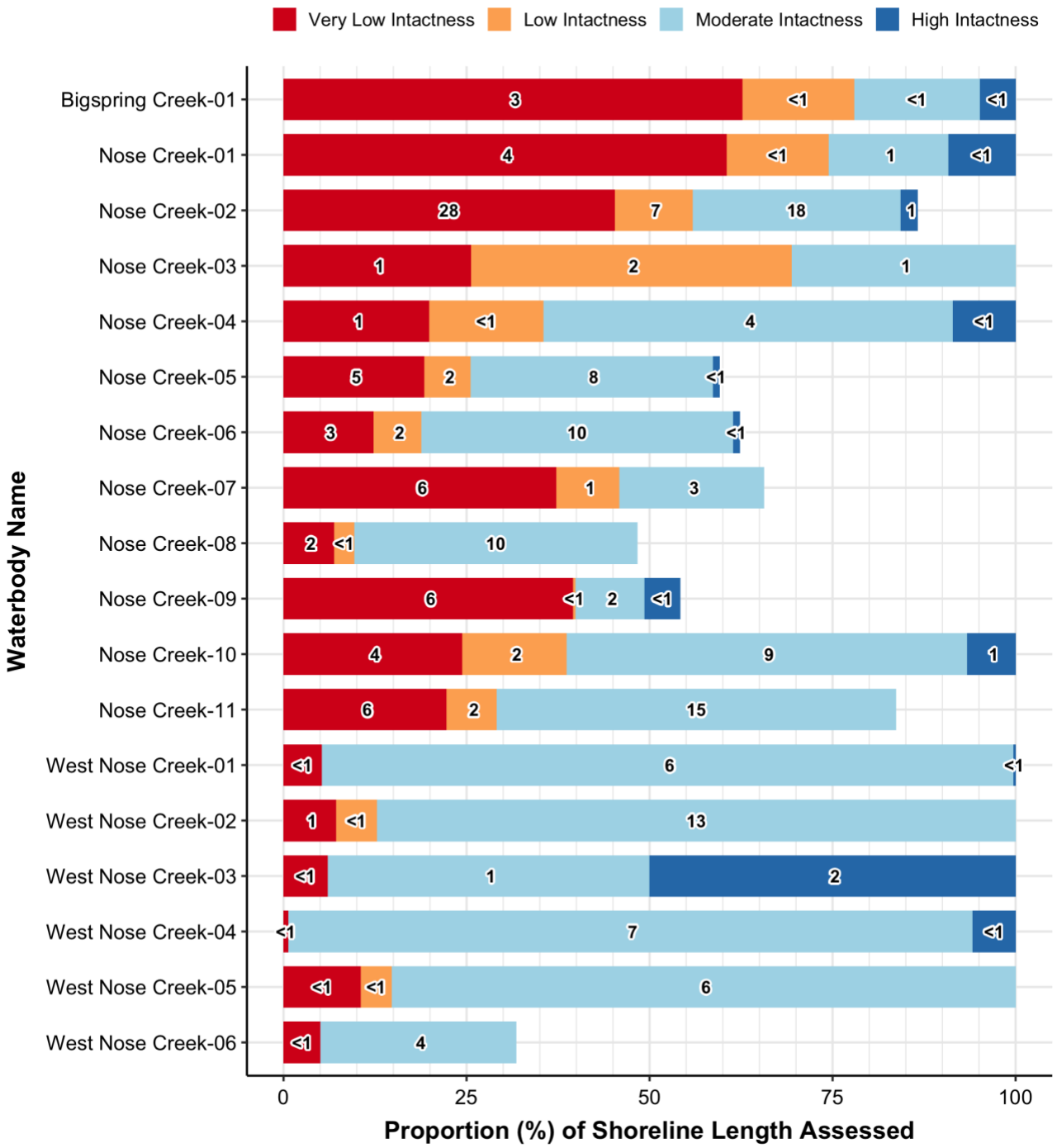


Figure 16. The proportion of shoreline length assigned to each riparian intactness category for unnamed creeks located within Rocky View County.

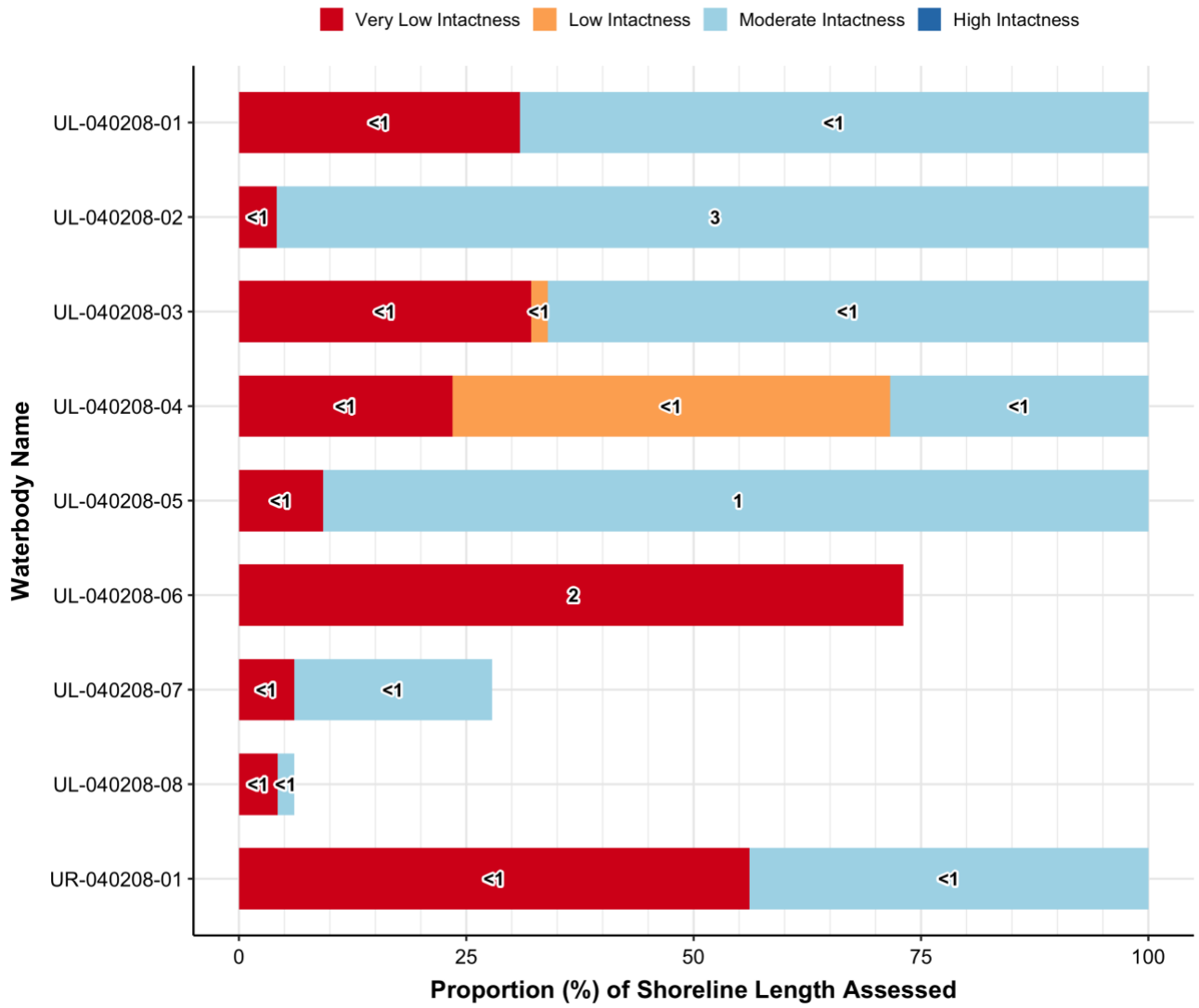


Figure 17. The proportion of shoreline length assigned to each riparian intactness category for unnamed lakes and reservoirs located within Rocky View County.

5.0 Managing Riparian Areas

Foundational to any conservation planning exercise is the collection and generation of scientific information that can be used as the basis for the development and implementation of an evidence-based adaptive management framework. There are a number of watershed management planning processes that have been completed or are on-going in the Watershed. For example, the Nose Creek Watershed Water Management Plan (NCWWMP) was recently updated, and this plan describes baseline conditions and specifies health targets and thresholds for riparian areas in the watershed (PESL 2018). Notably, the riparian health targets and thresholds specified in the NCWWMP refer directly to ground-based riparian health assessments as the method for assessing and measuring riparian condition, and further specifies as a target that all riparian areas in the watershed score within the “Healthy” range.

As discussed in Section 1.2, field-based Riparian Health Assessments and GIS-based intactness assessments measure different attributes of a riparian area, and thus, are not directly comparable. Consequently, the targets and thresholds specified in the Nose Creek WMP cannot be directly translated and compared to intactness results from this study. However, riparian health and intactness are correlated, and because of this, the intactness results can be used to generally understand the status of riparian areas in the watershed. As a result, the intactness results can be used by the NCWP and its stakeholders to develop achievable outcomes and measurable targets for riparian habitats.

At present, 59% of the shorelines assessed in this study were classified as either Moderate or High Intactness, with only 12% of shorelines being classified as High Intactness. These results suggest that additional efforts and resources need to be directed towards riparian conservation and restoration if the WMP targets for riparian health are going to be achieved. Importantly, the results from this study can be used by the NCWP and its stakeholders to advance their riparian management goals towards their targets. For example, intactness results can be used to identify waterbodies that are likely to be underperforming relative to riparian health targets, and further, specific spatial locations along those shorelines can be identified using the spatial data from this study. Notably, the intactness results indicate that only two waterbodies assessed in this study (Near Lakes A and B) have more than 75% of their shoreline classified as High Intactness (Table 5). Further, less than half of the waterbodies assessed have 75% or more of their shorelines assessed as either Moderate or High Intactness.

Table 5. Proportion of shoreline length that has been classified in each of the riparian intactness categories, summarised for individual waterbodies. More information on these waterbodies, including the proportion of the shoreline that is associated with each municipality located in the watershed, can be found in Appendix A.

Waterbody	Length Assessed (km)	Proportion (%) of Shoreline within Intactness Category					
		Very Low	Low	Very Low + Low	Moderate	High	Moderate + High
Beddington Creek	18.5	76	5	81	16	3	19
Bigspring Creek	34.2	43	8	52	33	15	48
Bigspring Creek-01	5.3	63	15	78	17	5	22
Confederation Creek	4.9	49	12	61	38	1	39
Dewitt's Pond	1.1	19	0	19	81	0	81
Near Lakes A	5.2	7	5	12	0	88	88
Near Lakes B	3.5	0	1	1	0	99	99
Nose Creek	146.2	41	14	55	44	1	45
Nose Creek-01	6.7	61	14	74	16	9	26
Nose Creek-02	62.9	49	12	61	36	3	39
Nose Creek-03	4.7	26	44	69	31	0	31
Nose Creek-04	6.3	20	16	36	56	9	64
Nose Creek-05	24.3	26	11	37	55	8	63
Nose Creek-06	23.3	16	9	25	71	4	75
Nose Creek-07	17.2	47	12	59	41	0	41
Nose Creek-08	25.4	16	9	25	75	0	75
Nose Creek-09	16.1	56	3	60	30	10	40
Nose Creek-10	16.4	24	14	39	55	7	61
Nose Creek-11	27.3	23	7	30	68	2	70
UL-040208-01	0.7	31	0	31	69	0	69
UL-040208-02	2.6	4	0	4	96	0	96
UL-040208-03	1.1	32	2	34	66	0	66
UL-040208-04	1.8	23	48	72	28	0	28
UL-040208-05	1.2	9	0	9	91	0	91
UL-040208-06	2.2	100	0	100	0	0	0
UL-040208-07	2.3	8	0	8	92	0	92
UL-040208-08	3.8	24	2	26	74	0	74
UR-040208-01	1.1	56	0	56	44	0	44
West Nose Creek	132.0	17	8	25	49	27	75
West Nose Creek-01	5.9	5	0	5	94	0	95
West Nose Creek-02	14.6	7	6	13	87	0	87
West Nose Creek-03	3.3	6	0	6	44	50	94
West Nose Creek-04	8.0	1	0	1	94	6	99
West Nose Creek-05	6.9	11	4	15	85	0	85
West Nose Creek-06	14.8	8	0	8	85	7	92
Writing Creek	44.8	30	4	34	20	46	66

6.0 Existing Tools for Riparian Habitat Management

Riparian land management in Alberta falls under the jurisdiction of the federal, provincial, and municipal governments. While Alberta does not have legislation or policy that explicitly manages riparian lands, there are a number of laws, regulations, standards, policies, and voluntary programs that can be used to direct the management of riparian lands, or land that directly adjoins riparian lands. The following sections highlights the key legislation, policies, and programs that are currently in place for riparian land management in the province of Alberta. Note that this is not intended to be an exhaustive list; rather, it is intended to highlight legislation, policy, and programs that are considered to be the most relevant and commonly employed to achieve riparian land conservation in the province.

6.1. Guidelines, Policies, and Legislation

Federal jurisdiction over riparian areas in Alberta is somewhat limited in scope. Exceptions to this include the authority to manage natural habitats and associated wildlife on federal land (e.g., First Nation Reserves, National Parks), as well as the authority to regulate migratory birds, fish and fish habitat, navigable waters, and species at risk. A summary of relevant federal laws and regulations that may apply to riparian management in the watershed are listed in Table 6.

At the provincial level, there a number of statutory laws, regulations, and standards that directly or indirectly relate to the management of riparian habitat on both private and public land. The responsibility for managing riparian land falls to a number of provincial ministries and departments, and the mechanisms through which riparian lands are managed varies with respect to whether these habitats are located on private land (White Zone) or public land (Green Zone). In addition, the nature of the disposition and the activities associated with the land use(s) (e.g., forestry, oil and gas, agriculture, or urban development) influences how riparian lands are managed on both private and public land.

In instances of overlapping land use or activities (e.g., forest harvest operating together with oil and gas exploration), the manner in which riparian lands are managed is directed by the laws, regulations, and standards that are specific to that particular land use or activity. In these situations, coordination between the various government ministries responsible for enacting those laws, regulations, or standards is an important aspect of successful riparian management outcomes. Regardless of where the riparian land is located, or what the land use and associated activities may be, the provincial government has jurisdiction over the management of all water in the province under the *Water Act*, as well as all lands that are defined as “public” (regulated under the *Public Lands Act*), which includes the bed and shore of all permanent waterbodies, regardless of whether these waterbodies are located on private land.

In addition to provincial laws and regulations, the Government of Alberta has a wide range of policies, standards, or guidelines that provide direction for the management of natural areas, wildlife, and wildlife habitat. The majority of these policies are voluntary and require the application of best management practices to achieve the desired management goals. One exception to this is the provincial wetland policy. Wetlands are regulated as waterbodies under the *Water Act*, and as such, an approval is required to undertake any works that may impact a wetland. Thus, the principles and goals of the wetland policy and the associated wetland compensation guide are enforced through the *Water Act* application process.

A list and description of provincial laws, regulations, and policies that may apply to the management of riparian areas in the watershed is provided in Table 7.

Table 6. List and description of Federal laws and regulations that may apply to the management of riparian areas in the Nose Creek watershed.

Federal Law or Regulation	Application to the Management of Riparian Areas
Migratory Bird Convention Act	This legislation is based on international treaty signed by Canada and the United States of America that aims to protect migratory birds from indiscriminate harvesting and destruction on all lands within Canada. Under this Act, efforts should be made to provide for and protect habitat necessary for the conservation of migratory birds, and to conserve habitats that are essential to migratory bird populations, such as nesting, wintering grounds, and migratory corridors.
Fisheries Act	Includes provisions for the protection of fish and fish habitat, and requires an authorization for activities that cause serious harm to fish.
Species At Risk Act	The Federal government has jurisdiction over all SARA-listed species on federally owned lands, including national parks, Department of National Defence lands, and First Nations Reserve lands. Management of SARA-listed species on provincial crown land, or on lands held by private citizens of Alberta, falls under the jurisdiction of the provincial government. In these cases, the provincial government is obligated to protect listed species to the same standards set forth by the Federal government. In cases where provincial governments do not meet these standards, the Federal Minister may issue an order in council to protect federally listed species that occur on provincial or private lands.

Table 7. List and description of Provincial laws, regulations, and policies that may apply to the management of riparian areas in the Nose Creek watershed.

Legislation, Regulation, or Policies	Application to the Management of Riparian Areas
Agricultural Operation Practices Act	Regulates and enforces confined livestock feeding operations planning for siting, manure handling/storage, and environment standards.
Alberta Land Stewardship Act	Creates authority of regional plans and enables the development of conservation and stewardship tools that can be used to acquire and manage natural areas. These tools include conservation easements, conservation directives, conservation offsets, and transfer of development credits.
Alberta Wetland Policy & Wetland Mitigation Directive	Pursuant to the *Water Act*, the provincial wetland policy prohibits the unauthorized drainage or disturbance of wetlands. The stated goal of the policy is to "conserve, restore, protect, and manage Alberta's wetlands to sustain the benefits they provide to the environment, society, and economy". If wetland loss or impacts are authorized by the province under the *Water Act*, the permittee is responsible for the replacement of lost wetland habitat at the ratio stipulated by the province. While this policy does not explicitly manage riparian land, there is opportunity within the stated goals and intent of this policy to extend the policy to include riparian lands.
Environmental Protection and Enhancement Act (EPEA)	This legislation aims to protect air, land and water by regulating the process for environmental assessments, approvals, and registrations. In particular, stormwater drainage that is directed to any surface waterbody requires an EPEA approval. Further, the Environmental Code of Practice for Pesticides provides a standard for operating practices that restrict the deposition of pesticides into or onto any open waterbody.
Municipal Government Act (MGA)	Updated in June 2018, the modernized MGA provides municipalities with the authority to adopt statutory plans and bylaws that direct land use and development at subdivision. The MGA also grants limited rights to designate reserves at subdivision that can be used to conserve natural areas, and gives municipalities authority to regulate water on municipal lands, manage private land to control non-point source pollution, and adopt land use practices that are compatible with the protection of the aquatic environment, including development setbacks on waterbodies.
Municipal Land Use Policies	Pursuant to Section 622 of the MGA, these Policies were established by Municipal Affairs to supplement planning provisions in the MGA and the Subdivision and Development Regulation, and to create a conformity of standard with respect to planning in Alberta. Section 5 of the Land Use Policies encourages municipalities to identify significant waterbodies and watercourses in their jurisdiction, and to minimize habitat loss and other negative impacts of development through appropriate land use planning and practices. Section 6 encourages municipalities to incorporate measures into planning and land use practice that minimizes negative impacts on water resources, including surface and groundwater quality & quantity, water flow, soil erosion, sensitive fisheries habitat, and other aquatic resources. Municipalities within the watershed that have specific guidance for managing riparian areas include Calgary, Airdrie, and Rocky View County.

Continued …

Table 7 *continued …* List and description of Provincial laws, regulations, and policies that may apply to the management of riparian areas in the Nose Creek watershed.

Legislation, Regulation, or Policies	Application to the Management of Natural Areas
Public Lands Act	Regulates and enforces activities that affect the Crown-owned bed and shore of waterbodies, as well as Crown-owned riparian and upland habitats (e.g., forest and grazing leases).
Stepping Back from the Water: A Beneficial Management Practices Guide for New Developments Near Waterbodies	This document provides discretionary guidance to local authorities to assist with "decision making and watershed management relative to structural development near waterbodies", and includes recommendations for development setbacks (buffers) on waterbodies to protect aquatic and riparian habitats.
Soil Conservation Act & Regulations	Regulates activities that may cause erosion and sedimentation of a waterbody.
Surveys Act	Definitions for the "legal bank" of a waterbody, upon which the Crown-owned "bed and shore" is defined. The legal boundary between the bed and shore and the adjacent lands is the naturally occurring high water mark, and may not extend to include the full extent of riparian lands adjacent to a waterbody.
Water Act	The stated purpose of this Act is to support and promote water conservation and management. Under the Act, any activity that causes or has the potential to cause an effect on the aquatic environment requires an approval. Regulations and Codes of Practice under this Act apply to water and water use management, the aquatic environment, fish habitat protection practices, in-stream construction practices, and storm water management.
Weed Control Act	Noxious and prohibited noxious weeds listed under Schedule 1 must be controlled (noxious weed) or destroyed (prohibited noxious weed) by the owner of the land on which the listed weed occurs.
Wildlife Act & Species at Risk Program	Regulates and enforces protection of wildlife species and their habitats, which may include riparian dependent species.

While the provincial government holds the authority to regulate water and public land throughout the province, municipalities are given the authority to manage lands within their jurisdiction under the *Municipal Government Act* (MGA), which was modernized and revised in July 2018. Under Part 1, Section 3, the Act outlines the following purposes of a municipality:

1) To provide good governance and foster the well-being of the environment;
2) To provide services that are in the opinion of council to be necessary or desirable;
3) To develop and maintain safe and viable communities; and
4) To work collaboratively with neighbouring municipalities to plan, deliver, and fund intermunicipal services.

A primary power given to municipalities is land use planning and development, which allows municipalities to set the conditions under which lands are subdivided and developed. Further, each municipality must develop statutory planning documents that provide a framework and vision for development and land use within their jurisdictions. Statutory planning documents that are required include:

- Municipal Development Plans
- Intermunicipal Development Plans
- Area Structure Plans
- Area Redevelopment Plans

Within these planning documents, municipalities can provide specific direction for development requirements that may influence the conservation of riparian habitat. In addition to statutory planning documents, municipalities can influence the management of riparian areas by enacting Land Use Bylaws that set forth requirements for development setbacks on environmentally sensitive lands. For example, municipalities can provide specific direction for development requirements in or near riparian habitat, or set forth minimum development setback widths on Environmental Reserve (ER), environmentally sensitive land, or waterbodies and watercourses.

The MGA also gives municipalities the power to enact land use bylaws, as well as the authority to designate land as Environmental Reserve at the time of subdivision. Environmental Reserves are defined in Section 664 as waterbodies or watercourses, lands that are unstable or subject to flooding, and lands "not less than 6 metres in width abutting the bed and shore" of a waterbody or watercourse. While the Act allows municipalities to take a 6 metre (or more) setback on Environmental Reserve lands, the conditions under which this taking is permitted is limited to cases where the setback is required to prevent pollution, provide public access to the bed and shore of the waterbody or watercourse, prevent development of land that presents a significant risk to persons or property if developed, or to preserve natural features that in the opinion of the subdivision authority should be preserved. In addition to the limited opportunities that are available for conserving riparian land as Environmental Reserve, Section 640(4)(l) of the Act allows municipalities to establish development setbacks on lands subject to flooding, low lying or marshy areas, or within a specified distance to the bed and shore of any waterbody.

6.2. Acquisition of Riparian Lands

It is important to note that while there is a wide range of different federal, provincial, and municipal laws and policies that regulate activities within or near riparian areas, these regulations by themselves to do not necessarily result in the conservation of riparian habitat. In many cases, existing laws regulate *activities* that may impact riparian habitats (e.g., the provincial *Water Act*), but do not regulate the habitats themselves. As a result, many of the existing laws result in approvals that allow for the removal or alteration of riparian areas under certain conditions outlined within the approval. In some cases, these regulations require compensation or replacement of impacted habitats (e.g., the Provincial wetland policy and the federal *Fisheries Act*), but typically, existing laws and policies do not prevent land development, and there is very little provision for riparian habitat conservation in existing laws and policies, particularly as it relates to federal and provincial regulation.

At the municipal level, most municipalities have environmental and land use legislation, policies, and guidelines that provide direction for how to target riparian habitats and other natural areas for conservation, as well as guidance for how to integrate these habitats into a neighbourhood post-development. However, there are only a small number of tools or mechanisms available that enable the *acquisition* of lands by the municipality (or a third party) for the purpose of conservation. In some cases, these tools are only available to municipalities at particular times during the development process (e.g., at subdivision). In other instances, there may be restrictions on the amount of land that municipalities can set aside for conservation, as natural area conservation must be considered alongside other land use demands, such as school and park sites. In many cases, municipalities may have undertaken an ecological inventory to identify high priority areas for conservation, and have the appropriate legislation or

policies in place to manage these areas, but may lack the appropriate tools (or associated resources) to acquire high priority conservation areas.

One of the most effective conservation mechanisms for aquatic habitats within municipalities is the *Public Lands Act*. Pursuant to this legislation, the Province of Alberta owns the bed and shore of all permanent and naturally occurring waterbodies, including lakes, rivers, streams, and wetlands. Under this Act, all permanent and naturally occurring waterbodies are Crown land, and development must avoid these features. If development can not be avoided, the Crown determines whether temporary construction or permanent occupation will be authorized, and in many cases, authorized activities that result in the loss of Crown land is subject to compensation. In the case of riparian habitats along streams and rivers and permanent wetlands, the determination of whether riparian areas are considered to be part of the Crown claimed waterbody is contingent on the existence of a legal survey, and the location of the water boundary that is determined by the surveyor, as per the Surveyors Act. In this regard there are known inconsistencies with respect to how surveyors determine the location of the water boundary, and this may or may not include riparian habitat.

The second provincial legislation that enables municipalities to develop and implement land conservation and stewardship tools is the *Alberta Land Stewardship Act* (ALSA). Under ALSA, the following tools may be utilized to conserve riparian areas in municipalities:

Conservation Easement:

A conservation easement is a voluntary contractual agreement between a private landowner and a qualified organization, such as a municipality, Land Trust organization, or conservation group. There are only three allowable purposes for a conservation easement under the *Alberta Land Stewardship Act*, and these include the protection, conservation and enhancement of 1) the environment, 2) natural scenic or aesthetic values, or 3) agricultural land or land for agricultural purposes. Under a conservation easement, the landowner retains title to the land, but certain land use rights are extinguished in the interest of conserving and protecting the land. The land use restrictions that apply to the property are negotiated and agreed to at the outset (for example, a restriction on subdivision), and the conservation easement (and the land use restrictions) are registered on title and are transferred to a new land owner if the land is sold. Conservation easements can be negotiated by a private land owner at any time, but the easement must be held by a qualified organization.

Conservation Directive:

A conservation directive allows the Alberta Government to identify private lands within a regional plan for the purpose of protection, conservation, or enhancement of environmental, natural scenic, or aesthetic values. Ownership of the lands is retained by the land owner, and the directive describes the precise nature and intended purpose for the protection, conservation, or enhancement of the lands. A conservation directive must be initiated by the provincial government, and to date, this tool remains largely untested (Environmental Law Centre 2015).

Conservation Offset:

A conservation offset is a tool that allows industry to offset the adverse environmental effects of their activities and development by supporting conservation activities and/or efforts on other lands. In order for conservation offsets to be effective, there must first be guidelines and rules for where offsets can be applied, and provisions for accountability, including monitoring and compliance. While conservation offsets are available as a tool for the conservation of natural areas in the Nose Creek watershed, work would first have to be done to create a proper framework to create eligibility rules, pricing and bidding rules for selling and buying offsets, and rules for combining buyers and sellers.

Transfer of Development Credits (TDCs):

Transfer of development credits is a tool that creates and incentive to redirect development away from specific landscapes in order to conserve areas for agricultural or environmental purposes. This tool allows land development and conservation to occur at the same time, while also allowing owners of the developed and undeveloped lands to share in the financial benefits of the development activity. A TDC program can be used to designate lands as a conservation area for one or more of the following purposes:

- The protection, conservation and enhancement of the environment;
- The protection, conservation and enhancement of natural scenic or aesthetic values;
- The protection, conservation and enhancement of agricultural land or land for agricultural purposes;
- Providing for all or any of the following uses of the land that are consistent with the following purposes: recreational use, open space use, environmental education use, or use for research and scientific studies of natural ecosystems; and
- Designation as a Provincial Historic Resource or a Municipal Historic Resource under the *Historical Resources Act*.

Before TDCs can be used by municipalities as a conservation tool, they must be established through a regional plan, or they must be approved by the Provincial Government.

Outside of the conservation tools that have been created through the *Alberta Land Stewardship Act*, there are other mechanisms through which municipalities may acquire lands for conservation, most of which rely on voluntary conservation action taken by private land owners. These tools may be utilized at any time during the municipal planning and development process, and include:

Land Purchase:

Municipalities can purchase land from a private land owner at any time for the purpose of conservation. For example, the City of Edmonton established a Natural Areas Reserve Fund in 1999, with the purpose of using these funds to purchase and protect natural areas. While land purchase for conservation is an option that is available, many municipalities do not have the financial resources available to purchase lands within their municipal boundaries, as the market value for these lands can be very high.

Land Swap:

In some cases, a land developer may be willing to “swap” or exchange natural areas for other developable lands that are owned by the municipality. In this case, the municipality and the developer would enter into an agreement to exchange the lands, such that the natural areas can be conserved.

Land Donation:

Land donation involves the transfer of ownership from a private land owner to the municipality, or to a conservation organization or land trust, who would hold the land for conservation in perpetuity. Lands that are donated to a conservation organization or land trust are eligible for the federal government’s Ecological Gifts program which provides donors with significant tax benefits.

The final set of conservation tools are directly available to municipalities, and are the most common and frequently used tools for acquiring riparian areas as part of land development and planning. However,

these tools are enabled through the *Municipal Government Act*, which only gives municipalities the authority to use these tools at the time of subdivision. Thus, municipalities can only utilize these tools through formal land development and planning processes.

Environmental Reserve (ER):

Environmental Reserves are defined in the Act as waterbodies, watercourses, lands that are unstable or subject to flooding, and lands "not less than 6 metres in width abutting the bed and shore" of a waterbody or watercourse. While the Act allows municipalities to take a *minimum* of a 6 metre setback on Environmental Reserve lands (with no stated maximum), the conditions under which this taking is permitted is limited to cases where the setback is required to prevent pollution or provide public access to the bed and shore of the waterbody or watercourse. In addition, Section 640(4)(l) of the Act allows municipalities to establish development setbacks on lands subject to flooding, low lying or marshy areas, or within a specified distance to the bed and shore of any waterbody.

Environmental Reserve Easement:

In instances where the municipality and the landowner agree, Environmental Reserve lands may be designated as an Environmental Reserve Easement. An ER Easement serves the same purpose as ER, but differs in that the title of the reserve lands remains with the land owner; however, ER easements are registered on title by caveat in favour of the municipality.

Conservation Reserve:

Under Section 664.2(1), municipalities may designate an area as a Conservation Reserve if the area contains significant environmental features that are not required to be provided as Environmental Reserve. Under the Act, the purpose of taking the Conservation Reserve is to protect and conserve the significant environmental features in a manner that is consistent with other statutory planning documents. In designating a Conservation Reserve, the municipality must compensate the landowner in an amount that is equal to the market value at the time of the subdivision approval application.

6.3. Public Engagement

Public engagement is a critical component to the successful conservation and management of riparian areas. Without the support of the public, successful implementation of restoration and management programs are not possible. Further, many of the acquisition tools outlined above rely on voluntary participation by the public (e.g., land donations and conservation easement). Thus, ensuring that the public are aware of the various voluntary programs that exist for riparian habitat conservation, as well as formulating active partnerships that can capitalize on the public's willingness to participate in such programs, is critical to the conservation and restoration of riparian habitats. Public engagement can take several forms, including the following:

Education, Extension and Outreach:

Increasing public awareness and appreciation for natural areas is a critical component to effective conservation and management. Thus, creating educational opportunities and programs, as well as supporting local conservation and stewardship groups is critical to achieving desired riparian conservation and restoration objectives in the Nose Creek watershed.

Partnerships:

Engaging in strategic partnerships to promote voluntary land conservation and management activities on private lands is essential. Central to this is developing partnerships with landowners, land trusts, and conservation organizations, developing strong inter-municipal policies, and partnerships with the provincial government to promote and enhance collaboration and improve conservation outcomes.

All of the tools outlined in this section are currently available to stakeholders in the Nose Creek watershed for the purpose of conserving and managing riparian habitats; however, in order to focus management action in the watershed, it is essential that the NCWP and its partners first define objectives and targets for the conservation, restoration, and management of riparian habitats. Once these objectives and targets have been outlined, specific action and the relevant tools associated with those actions can be identified. In some cases, there may be existing tools in place to achieve the desired management outcomes. In other cases, there may be gaps in the available tools, and new policies, partnerships, or programs may need to be developed in order to achieve the desired management objectives.

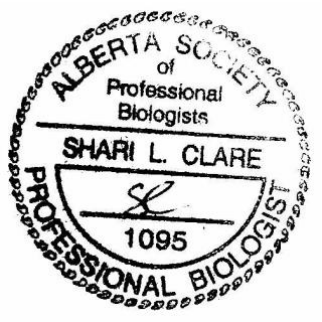
7.0 Conclusion

The overall goal of this project was to quantify and characterize the intactness of riparian management areas along a number of selected waterbodies in the Nose Creek watershed. In total, just under 670 km of shoreline was assessed, with 59% of the shoreline assessed as either High (12%) or Moderate (47%) Intactness, with the remaining 41% of the shoreline classified as Very Low (31%) or Low (9%) Intactness.

The intactness ratings provided in this report are intended to support a screening-level assessment of riparian areas in the Nose Creek Watershed, and are not meant to replace more detailed, site-specific field assessments of riparian health or condition. Instead, this information should be used to generally characterize riparian areas, and to highlight smaller, more localized areas where field assessment or further validation may be required. Ultimately, the results of this work provide the NCWP, local municipalities, stewardship groups, and other partners with an overview of the status of riparian areas, and serves as a foundation of scientific evidence that can be used to support stewardship and management efforts throughout the region.

7.1. Closure

This report was written by:



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Personal Communication:

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Appendix A: Intactness Summary Table

Table A-1. Length (km) and proportion (%) of shoreline classified into each Intactness category, summarized by waterbody and municipality.

Waterbody Name & Intersecting Jurisdiction(s)	Intactness								TOTAL	
	Very Low		Low		Moderate		High			
	km*	%	km*	%	km*	%	km*	%	km*	%
Beddington Creek										
Calgary	13.2	71	0.9	5	2.9	16	0.6	3	17.6	95
Rocky View County	0.8	4	0.1	0	0.0	0	0.0	0	0.9	5
Bigspring Creek										
Rocky View County	14.8	43	2.9	8	11.4	33	5.1	15	34.2	100
Bigspring Creek-01										
Rocky View County	3.3	63	0.8	15	0.9	17	0.3	5	5.3	100
Confederation Creek										
Calgary	2.4	49	0.6	12	1.9	38	0.0	1	4.9	100
Dewitt's Pond										
Rocky View County	0.2	19	0.0	0	0.9	81	0.0	0	1.1	100
Near Lakes A										
Rocky View County	0.4	7	0.3	5	0.0	0	4.6	88	5.2	100
Near Lakes B										
Rocky View County	0.0	0	0.1	1	0.0	0	3.5	99	3.5	100
Nose Creek										
Airdrie	23.6	16	2.5	2	5.3	4	0.0	0	31.5	22
Calgary	19.6	13	8.5	6	24.3	17	0.1	0	52.6	36
Crossfield	2.6	2	0.0	0	1.2	1	0.0	0	3.8	3
Rocky View County	14.8	10	9.4	6	33.1	23	1.0	1	58.4	40
Nose Creek-01										
Rocky View County	4.1	61	0.9	14	1.1	16	0.6	9	6.7	100
Nose Creek-02										
Crossfield	2.3	4	0.7	1	4.3	7	0.2	0	7.4	12
Mountain View County	0.0	0	0.0	0	0.5	1	0.5	1	1.0	2
Rocky View County	28.5	45	6.7	11	17.9	28	1.5	2	54.5	87
Nose Creek-03										
Rocky View County	1.2	26	2.0	44	1.4	31	0.0	0	4.6	100
Nose Creek-04										
Rocky View County	1.3	20	1.0	16	3.5	56	0.5	9	6.3	100
Nose Creek-05										
Airdrie	1.6	7	1.1	5	5.3	22	1.8	8	9.8	40
Rocky View County	4.7	19	1.5	6	8.0	33	0.2	1	14.5	60
Nose Creek-06										
Airdrie	0.9	4	0.6	3	6.7	29	0.6	3	8.8	38
Rocky View County	2.9	12	1.5	7	9.9	43	0.2	1	14.5	62
Nose Creek-07										
Airdrie	1.7	10	0.5	3	3.7	21	0.0	0	5.9	34
Rocky View County	**6.4**	**37**	**1.5**	**9**	**3.4**	**20**	**0.0**	**0**	11.3	66
Nose Creek-08										
Airdrie	**2.2**	**9**	**1.7**	**7**	**9.2**	**36**	**0.0**	**0**	13.1	52
Rocky View County	1.8	7	0.7	3	9.8	39	0.0	0	12.3	48
Nose Creek-09										
Airdrie	2.7	17	0.5	3	3.3	21	0.9	5	7.4	46
Rocky View County	**6.4**	**40**	**0.1**	**0**	**1.5**	**9**	**0.8**	**5**	8.7	54

Continued …

Table A-1 *ontinued*. Length (km) and proportion (%) of shoreline classified into each Intactness category, summarized by waterbody and municipality.

Waterbody Name & Intersecting Jurisdiction(s)	Intactness								TOTAL	
	Very Low		Low		Moderate		High			
	km*	%	km*	%	km*	%	km*	%	km*	%
Nose Creek-10										
Rocky View County	4.0	24	2.3	14	9.0	55	1.1	7	16.4	100
Nose Creek-11										
Calgary	0.1	0	0.0	0	3.7	14	0.6	2	4.5	16
Rocky View County	6.1	22	1.9	7	14.9	55	0.0	0	22.9	84
UL-040208-01										
Rocky View County	0.2	31	0.0	0	0.5	69	0.0	0	0.7	100
UL-040208-02										
Rocky View County	0.1	4	0.0	0	2.5	96	0.0	0	2.6	100
UL-040208-03										
Rocky View County	0.4	32	0.0	2	0.7	66	0.0	0	1.1	100
UL-040208-04										
Rocky View County	0.4	23	0.9	48	0.5	28	0.0	0	1.8	100
UL-040208-05										
Rocky View County	0.1	9	0.0	0	1.1	91	0.0	0	1.2	100
UL-040208-06										
Crossfield	0.6	27	0.0	0	0.0	0	0.0	0	0.6	27
Rocky View County	1.6	73	0.0	0	0.0	0	0.0	0	1.6	73
UL-040208-07										
Airdrie	0.1	2	0.0	0	1.6	70	0.0	0	1.7	72
Rocky View County	0.1	6	0.0	0	0.5	22	0.0	0	0.6	28
UL-040208-08										
Airdrie	0.8	20	0.1	2	2.7	72	0.0	0	3.6	94
Rocky View County	0.2	4	0.0	0	0.1	2	0.0	0	0.2	6
UR-040208-01										
Rocky View County	0.6	56	0.0	0	0.5	44	0.0	0	1.1	100
West Nose Creek										
Calgary	10.7	8	7.4	6	19.7	15	3.1	2	40.9	31
Rocky View County	11.6	9	2.9	2	44.5	34	32.1	24	91.1	69
West Nose Creek-01										
Rocky View County	0.3	5	0.0	0	5.6	94	0.0	0	5.9	100
West Nose Creek-02										
Rocky View County	1.0	7	0.8	6	12.7	87	0.0	0	14.6	100
West Nose Creek-03										
Rocky View County	0.2	6	0.0	0	1.5	44	1.7	50	3.3	100
West Nose Creek-04										
Rocky View County	0.1	1	0.0	0	7.5	94	0.5	6	8.0	100
West Nose Creek-05										
Rocky View County	0.7	11	0.3	4	5.9	85	0.0	0	6.9	100
West Nose Creek-06										
Calgary	0.5	3	0.0	0	8.6	58	1.0	7	10.1	68
Rocky View County	0.8	5	0.0	0	4.0	27	0.0	0	4.7	32
Writing Creek										
Rocky View County	13.5	30	2.0	4	9.0	20	20.4	46	44.8	100

*NOTE: All jurisdictional data summaries were generated by using a spatial intersect rule in ArcGIS. Summarizing the data in this way captures the assessed shorelines that fall within the jurisdiction's boundary; however, it should be noted that there are spatial discrepancies between the jurisdictional boundary data and the provincial hydrography data that are freely available from AltaLIS. As a result, the jurisdictional summaries of shoreline length for intactness and priority are approximate and should be considered estimates that reflect relative differences between jurisdictions.