Riparian Area Assessment for the Buffalo, Kneehills, Little Red Deer & Threehills Subwatersheds

FINAL REPORT

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Prepared for:

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Front Cover Photo: Kneehills Creek
Credit: Red Deer River Watershed Alliance

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Acknowledgements

Fiera Biological would like to thank the Red Deer River Watershed Alliance for their leadership and guidance throughout this project.

We would also 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 (WRRP), which aims to restore or enhance previously degraded priority areas within Alberta's watersheds, including riparian areas. Additionally, the Government of Alberta provided spatial data that was essential for the successful completion of this project.

The RDRWA also wishes to thank Mountain View County, Red Deer County, Lacombe County, Kneehill County, and the Municipal District of Bighorn for participating in this project.

Executive Summary

Riparian lands have substantial ecological, economic, and social value, and as such, the effective management of these habitats is a critical component to the maintenance of watershed health. In an effort to better manage riparian habitats within the Red Deer River watershed, the Red Deer River Watershed Alliance (RDRWA) retained Fiera Biological Consulting to assess riparian habitat along approximately 5,285 km of shoreline within the Buffalo, Kneehills, Little Red Deer, and Threehills subwatersheds. These four subwatersheds cover an area of ~11,754 km^2 and are located in central Alberta, roughly between Ponoka and Airdrie.

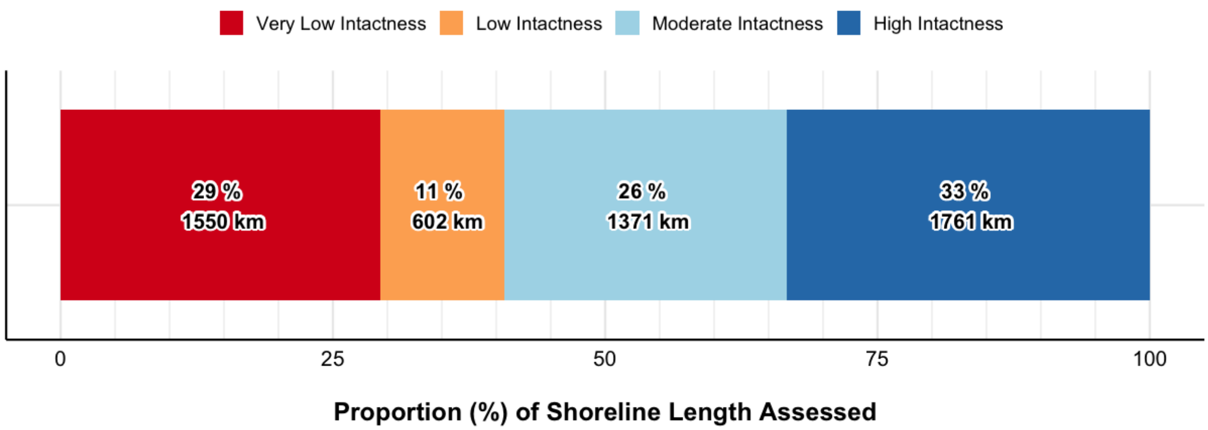
Riparian management areas (RMAs) located along shorelines of interest were evaluated using a desktop-based approach that utilizes a current land cover layer. An RMA is defined as an area adjacent the shoreline that typically includes the near-shore emergent vegetation zone, the riparian zone, and a riparian protective (buffer) zone. For the purpose of this study, RMAs had a fixed width of 50 m and a variable length that was determined based upon major breaks in the cover of natural vegetation.

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. Intact riparian zones play a vital role in the exchange of inorganic and organic material between the terrestrial and aquatic ecosystems via the interception of sediments and nutrients that runoff from adjacent upland habitats, and through the supply of leaf litter and woody debris. Intact riparian vegetation also regulates water temperature and the instream light environment, thereby ensuring suitable habitat for a range of aquatic species. Further, riparian habitats stabilize the banks of waterbodies and help to modulate water velocities and high water events, thereby improving water quality and protecting surrounding lands from flooding. Given the significant role that an intact riparian zone has on providing ecosystem services and supporting healthy and functional aquatic ecosystems, there is a need to effectively manage riparian areas. Thus, understanding the distribution of intact riparian habitat across the landscape and identifying areas where riparian intactness has been degraded is essential to improving conservation and management outcomes.

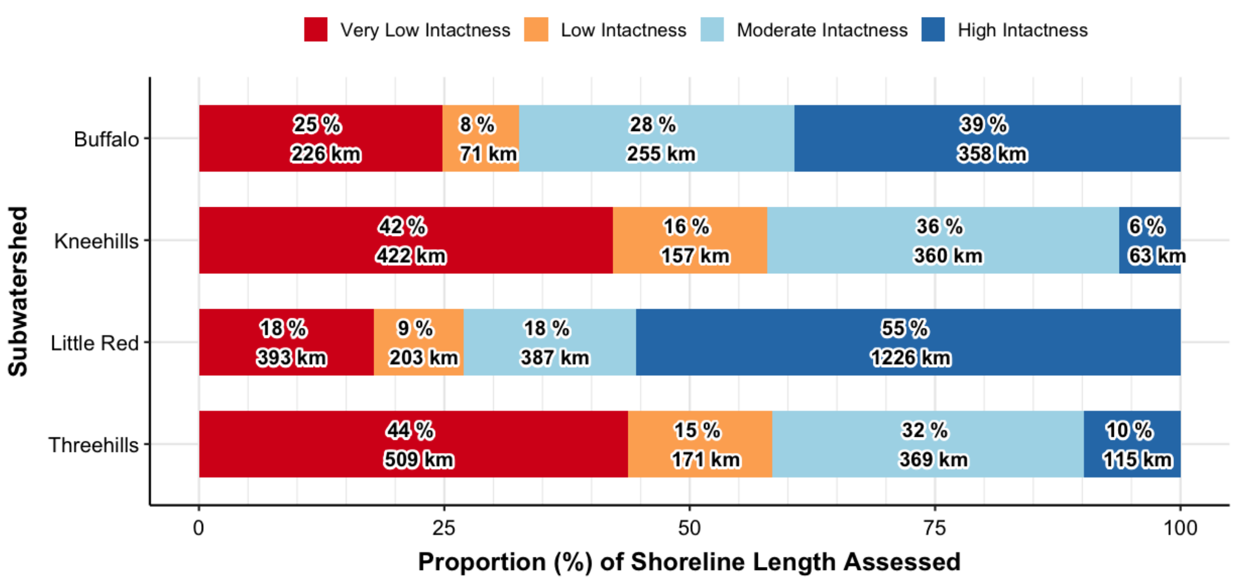
As part of this study, approximately 4,373 km of shoreline was newly assessed, including the left and right banks of 85 watercourses and the shoreline of 47 lakes and reservoirs. For the purposes of reporting at the subwatershed level and for summarizing results for Red Deer County, an additional 912 km of shoreline (24 watercourses and 25 lakes and reservoirs) was included from studies that have been previously completed in the study area using the same assessment method. Combined, this report summarizes results for a total of 5,285 km of shoreline, including the left and right banks of 109 watercourses and 72 lakes and reservoirs. Overall, roughly a third (33%, or 1,761 km) of the shoreline was classified as High Intactness, with an additional 26% (1,371 km) of the shoreline classified as Moderate Intactness. The remaining shoreline was classified as either Low (11%, 602 km) or Very Low (29%, 1,550 km) Intactness.

When intactness was compared by subwatershed, both the Little Red Deer and Buffalo had more than 65% of their shorelines rated as either High or Moderate Intactness, with the greatest proportion of shoreline rated as Very Low Intactness being located within the Threehills (44%) and Kneehills (42%) subwatersheds.

RIPARIAN INTACTNESS FOR ALL WATERBODIES ASSESSED IN THIS STUDY

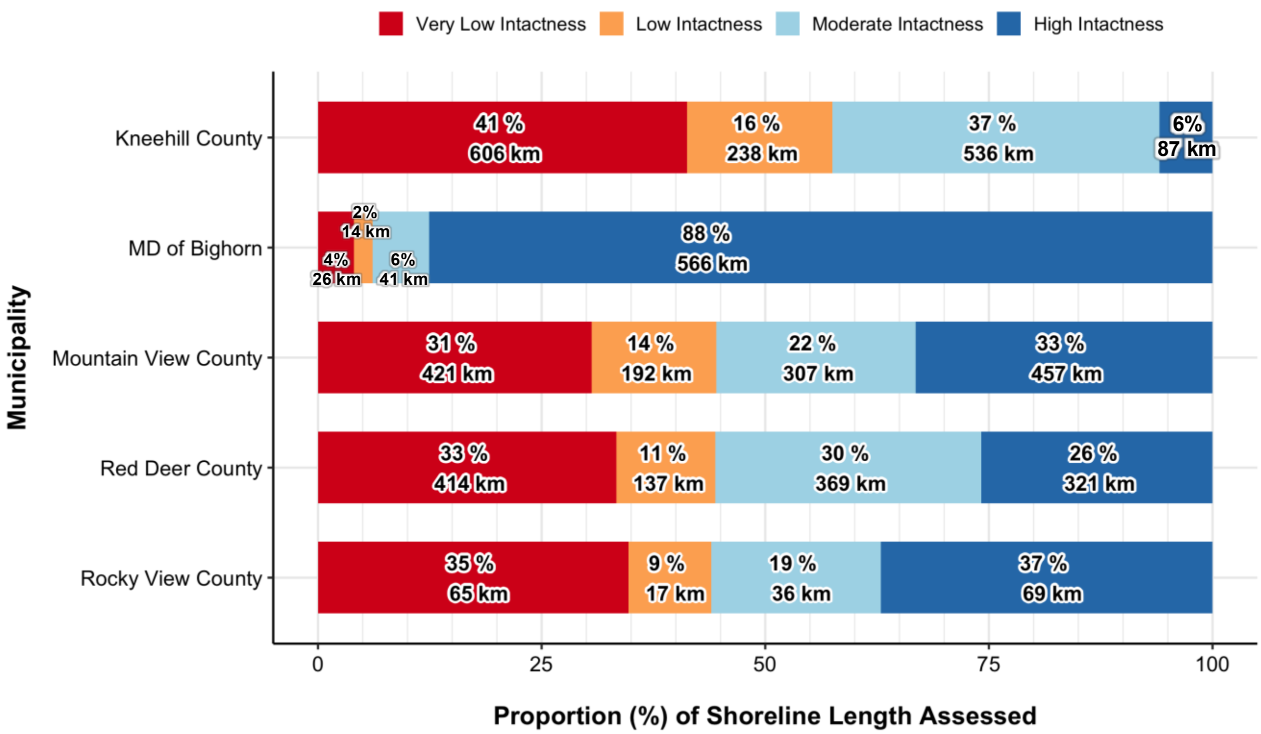


RIPARIAN INTACTNESS SUMMARIZED BY SUBWATERSHED

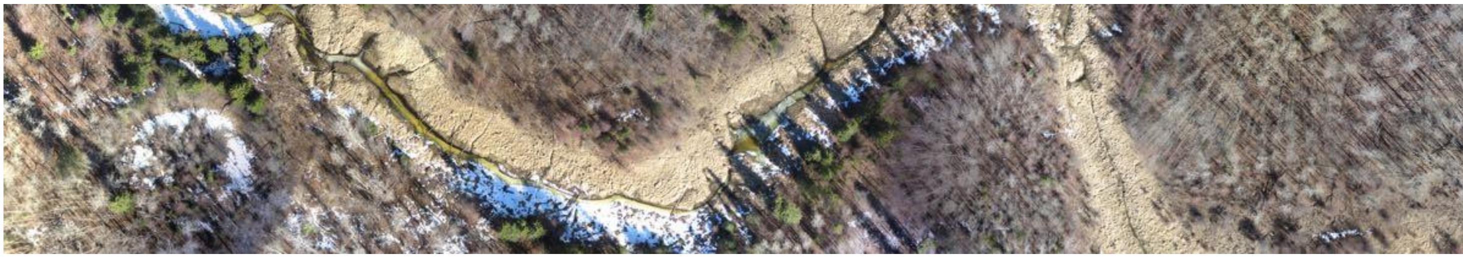


When intactness was evaluated for a selected number of municipalities that intersected the study area, the Municipal District (MD) of Bighorn County had the greatest proportion (88%, or 566 km) of its shoreline classified as High Intactness, whereas Kneehill County, Mountain View County, Red Deer County, and Rocky View County all had less than 40% of their shoreline classified as High Intactness. Kneehill County had the greatest proportion and length of shoreline rated as Low (16%, 238 km) and Very Low Intactness (41%, 606 km).

RIPARIAN INTACTNESS SUMMARIZED BY MUNICIPALITY



This project has generated scientific information that can be used to inform riparian management and stewardship within the Red Deer River watershed. Notably, the information generated from this satellite-based assessment is not intended to replace more detailed, site-specific field assessments of riparian health or condition. Rather, the data contributes to a foundation of scientific evidence about riparian habitats in the Red Deer River watershed, and can be used to target areas where additional field-based assessment or restoration and conservation activities could be focused to improve water quality, biodiversity, and drought and flood resilience.



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
HUC: Hydrologic Unit Code
RDRWA: Red Deer River Watershed Alliance
RMA: Riparian Management Area

Glossary

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

Hydrologic Unit Code (HUC): The Hydrologic Unit Code (HUC) 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 (USGS), 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 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 over 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 Red Deer 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, via the interception of sediments and nutrients that runoff from adjacent upland habitats and through the supply of leaf litter and woody debris. Furthermore, intact riparian vegetation can modulate the transfer of solar energy to the aquatic ecosystem, regulating water temperatures and the instream light environment, ensuring suitable habitat for a range of aquatic species (Ibid). 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 (Orewole et al. 2015; Olokeogun et al. 2020). Riparian vegetation also slows floodwater and increases 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 in 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 and/or inventories of riparian areas. In this type of assessment, such as the Alberta Riparian Habitat Management Society (ARHMS, also known as “Cows & Fish”) Riparian Health Assessment, detailed and local-scale traits of riparian areas are evaluated by trained practitioners, and a comprehensive and thorough assessment of riparian condition is made. Metrics 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 landowner or other interested stakeholders an idea of where to focus management activities. To date, the vast majority of the field-based riparian assessments completed by Cows and Fish have been in central and southern Alberta, and while the site-specific detail offered by this approach cannot be matched, these assessments are limited in their ability to provide information for planning and management at municipal, regional, or larger scales.

Although existing ground-based assessment methods are useful for gathering information about the general condition of riparian habitat at small spatial extents, the site-specific delineation employed for these assessments cannot be scaled up to provide information about riparian condition across larger geographic areas. Further, the results of these assessments are typically not available publicly due to confidentiality agreements with landowners.

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). Notably, several waterbodies have been assessed using aerial videography in the Red Deer River watershed, including Red Deer, Medicine, Blindman and Little Red Deer Rivers, and Sylvan, Gull, and Buffalo Lakes (O2 Planning + Design 2013; Fiera Biological 2018d).

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 (Figure 1 and 2). To date, this method has been used to assess over 45,000 km of shoreline across north and central Alberta (Fiera Biological 2018a-e, 2019, 2020a-b, 2021a-f), including 1,782 km of shoreline in the Medicine-Blindman Rivers HUC 6 watershed (Fiera Biological 2020a).

Figure 1. Riparian intactness is a measure of how “natural” a shoreline is. Highly intact shorelines (left) are dominated by natural vegetation and other natural cover types, while shorelines classified as very low intactness (right) are dominated by human-build structures, roads, and manicured or disturbed vegetation.

Figure 2. Using a “bird’s eye view”, the satellite-based GIS riparian assessment method measures the type and amount of natural versus human-created land cover types present within 50 m of the shoreline. Shorelines classified as high intactness are almost entirely covered by natural cover. Shorelines that are considered to have very low intactness are dominated by human structures and modified or disturbed vegetation.

1.3. Study Objectives

The overall goal of this project is to contribute to the improvement of watershed health and flood and drought resilience in the Red Deer River watershed. In order to achieve this goal, this study had the following primary objectives:

1) Create a recent land cover layer within 50 m of selected shorelines and use this layer to assess the intactness of riparian areas along major waterbodies in the Buffalo, Kneehills, Little Red Deer, and Threehills subwatersheds.
2) Combine intactness results derived from this current study with results from previously completed assessments in the Buffalo subwatershed and portions of the Medicine-Blindman Rivers HUC 6 watershed (Fiera Biological 2018d, 2019, 2020a, and 2021d), and summarize the results at various scales (e.g., subwatershed, municipality, watercourse).
3) Provide guidance on how the results from the intactness assessment can be used to target conservation and restoration efforts for riparian areas.

The results of this study provide stakeholders with an overview of the status of riparian management areas within the Buffalo, Kneehillls, Little Red Deer, and Threehillls subwatersheds. This in turn allows organizations throughout each of the subwatersheds to focus restoration, management efforts, and/or resources in areas of greatest need. Further, this approach 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 generally characterizing the current condition of riparian management areas within the Red Deer River 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 6m resolution satellite image. Furthermore, because overhead satellite imagery is used to create the land cover layer used to assess intactness, this assessment is not able to evaluate impacts associated with structures or activities that are obscured by an extensive tree canopy (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 within 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 subwatershed, 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. Especially in areas of more open or natural grazing practices, the level of impact on riparian vegetation by grazing cattle can be difficult to conclusively determine using satellite imagery. Thus,

there may be some disagreement between intactness results obtained using a satellite-based versus a ground-based method.

- 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 (i.e., if the riparian management area was within a municipality or touched the boundary of a municipality, then it was used to tabulate summaries 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 study area encompasses over 11,750 km^2 within the Red Deer River watershed, with the primary focus being on watercourses and water bodies located within the Buffalo (2,561 km^2), Kneehills (2,492 km^2), Little Red Deer (3,697 km^2), and Threehills (3,005 km^2) subwatersheds (Map 1). Located upstream of the City of Red Deer, the Little Red Deer subwatershed is considered to be part of the Lower Headwaters Zone of the Red Deer River watershed, while the Buffalo, Kneehills, and Threehillls subwatersheds are all considered part of the Central Agricultural Zone (RDRWA 2016). These four subwatersheds cover five Natural Regions, including the Rocky Mountain, Foothills, Boreal, Parkland, and Grassland Natural Regions (Map 2).

Human activity is prevalent across the four subwatersheds, with 65% of the lands classified into anthropogenic cover types (Figure 3). Agriculture (cropland and pasture) make up the largest proportion of lands modified by human activity (62%), with Built Up areas making up the remaining 3%. Approximately 35% of the study area consists of natural land cover types, such as forests (19%), natural grasslands (9%), wetlands (4%), open water (2%), and natural bare ground (1%).

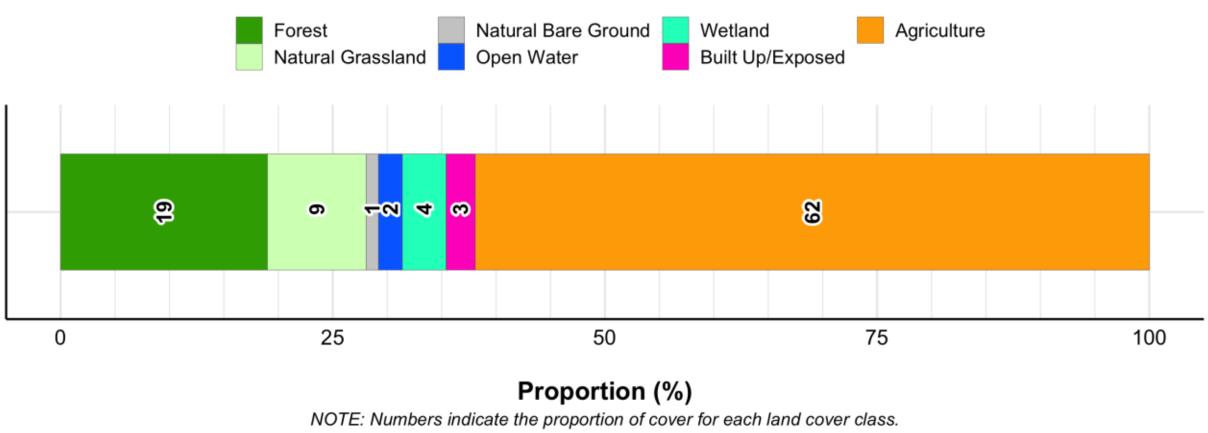


Figure 3. Total proportional cover by land cover class for all four subwatersheds included in this study. Land cover totals area based on the 2020 Agriculture and Agri-Food Canada land cover.

Land cover varies substantially by subwatershed (Figure 5; Map 3). The Little Red Deer has the greatest proportion of natural cover types (54%), while the Kneehills has the lowest proportion of natural cover types (16%). Across the study area, natural cover is most prominent in the western portion of the Little Red Deer and the eastern portion of the Buffalo subwatersheds (Map 3). Natural and woody cover is also present around larger watercourses and waterbodies throughout each of the four subwatersheds. Agricultural cover is widespread in both the Kneehills (81%) and Threehills (71%) subwatersheds (Figure 5; Map 3).

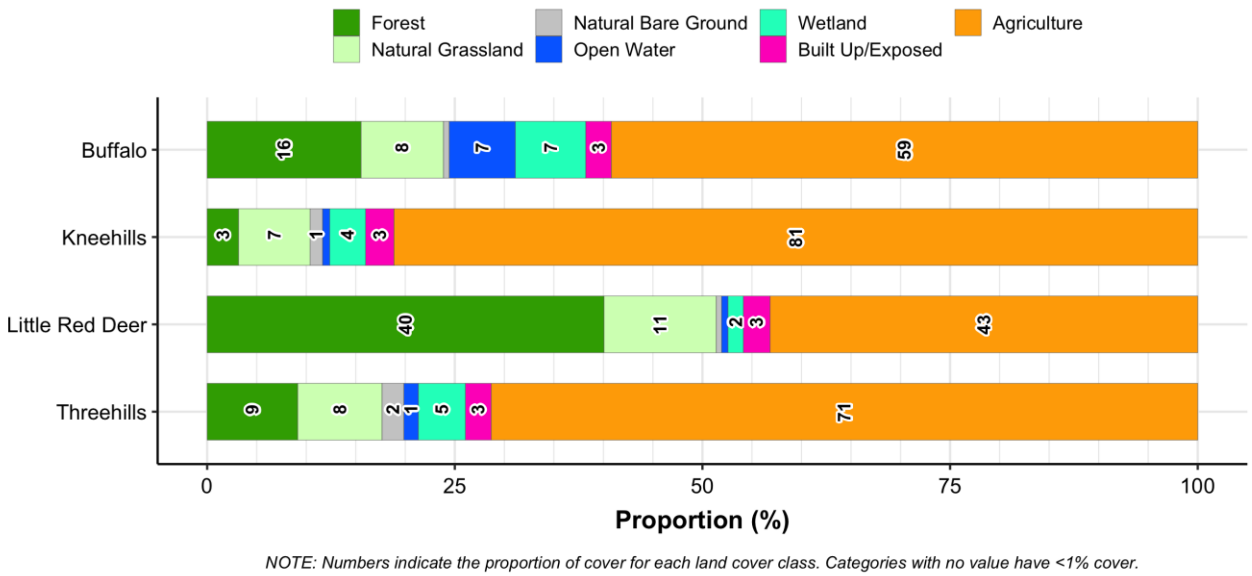
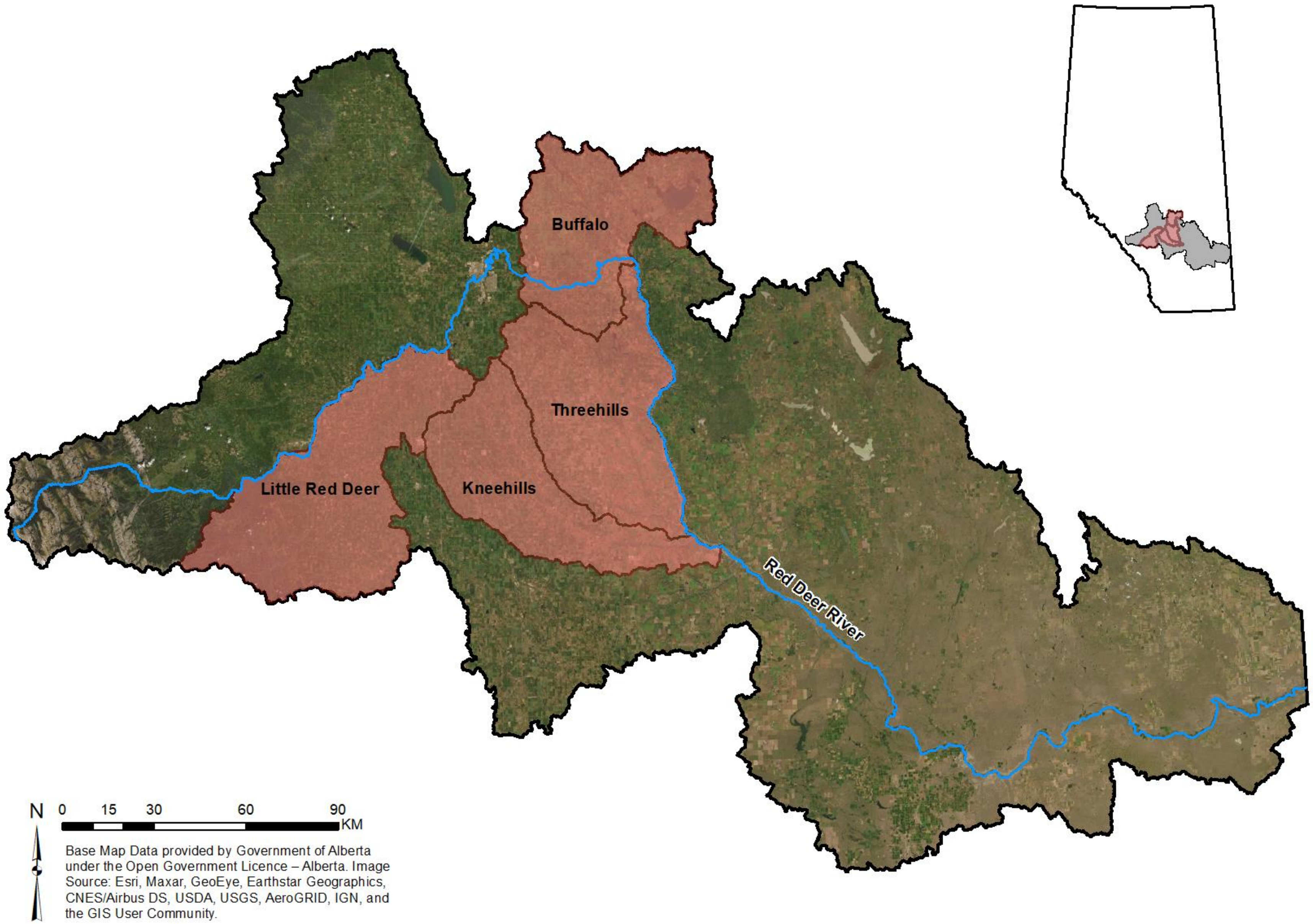


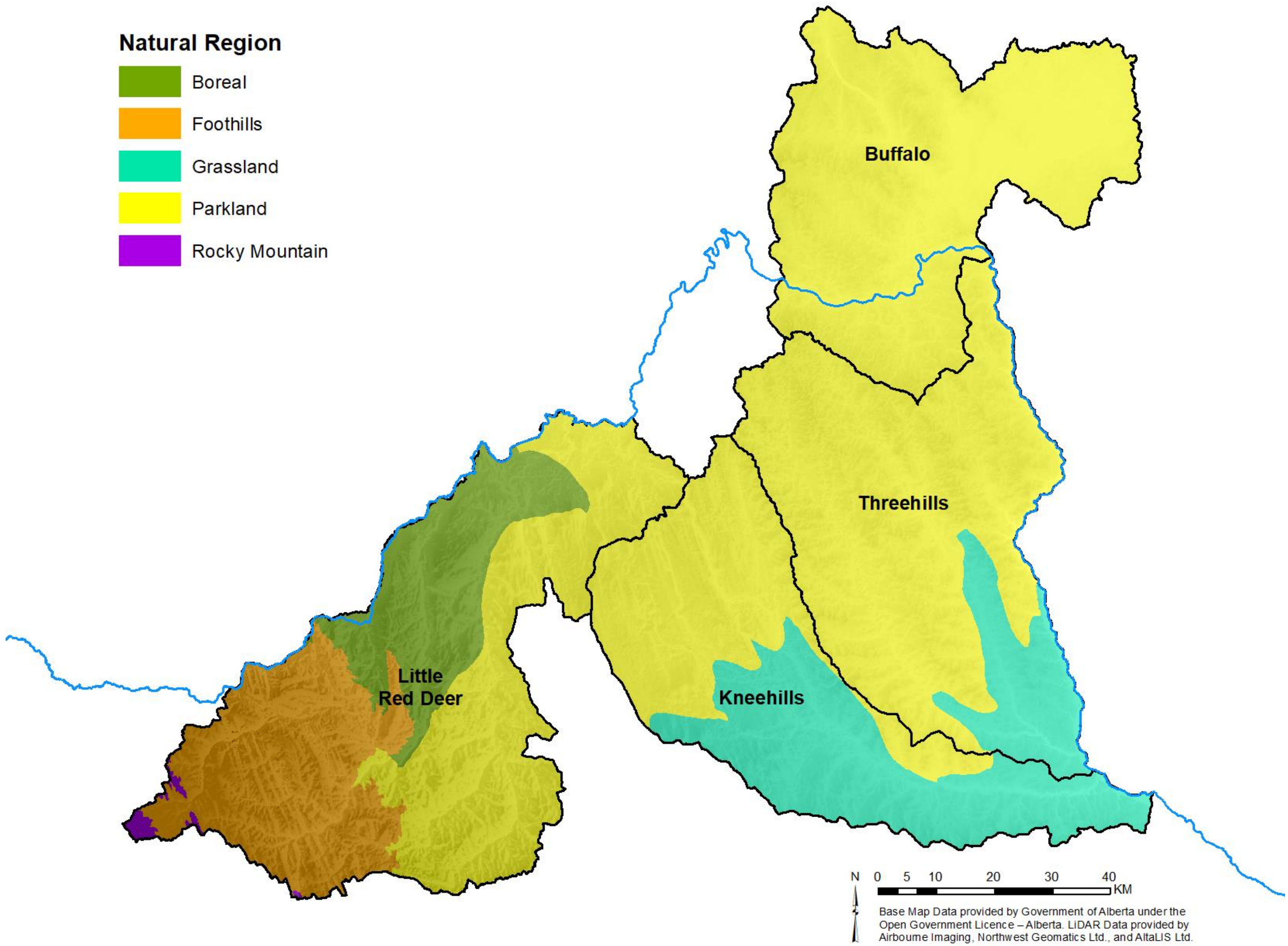
Figure 4. Total proportional cover by land cover class for each subwatershed included in this study. Land cover totals area based on the 2020 Agriculture and Agri-Food Canada land cover.

As part of this study, approximately 4,373 km of shoreline was assessed, including the left and right banks of 85 watercourses and 47 lakes and reservoirs (Map 4). For the purposes of reporting at the subwatershed level and for summarizing results for Red Deer County, intactness results for an additional 912 km of shoreline (24 watercourses and 25 lakes and reservoirs) was included from previously completed satellite-based riparian assessments (Fiera Biological 2018d; Fiera Biological 2018e; Fiera Biological 2021d). When combined, a total of 5,285 km of shoreline has been assessed within the study area, including the left and right banks of 109 watercourses and 72 lakes and reservoirs (Map 4). The mainstem of the Red Deer River was not mapped because the satellite-based assessment method was not developed to be applied to very large rivers. A summary of results is provided for each subwatershed in Sections 5 through 8.

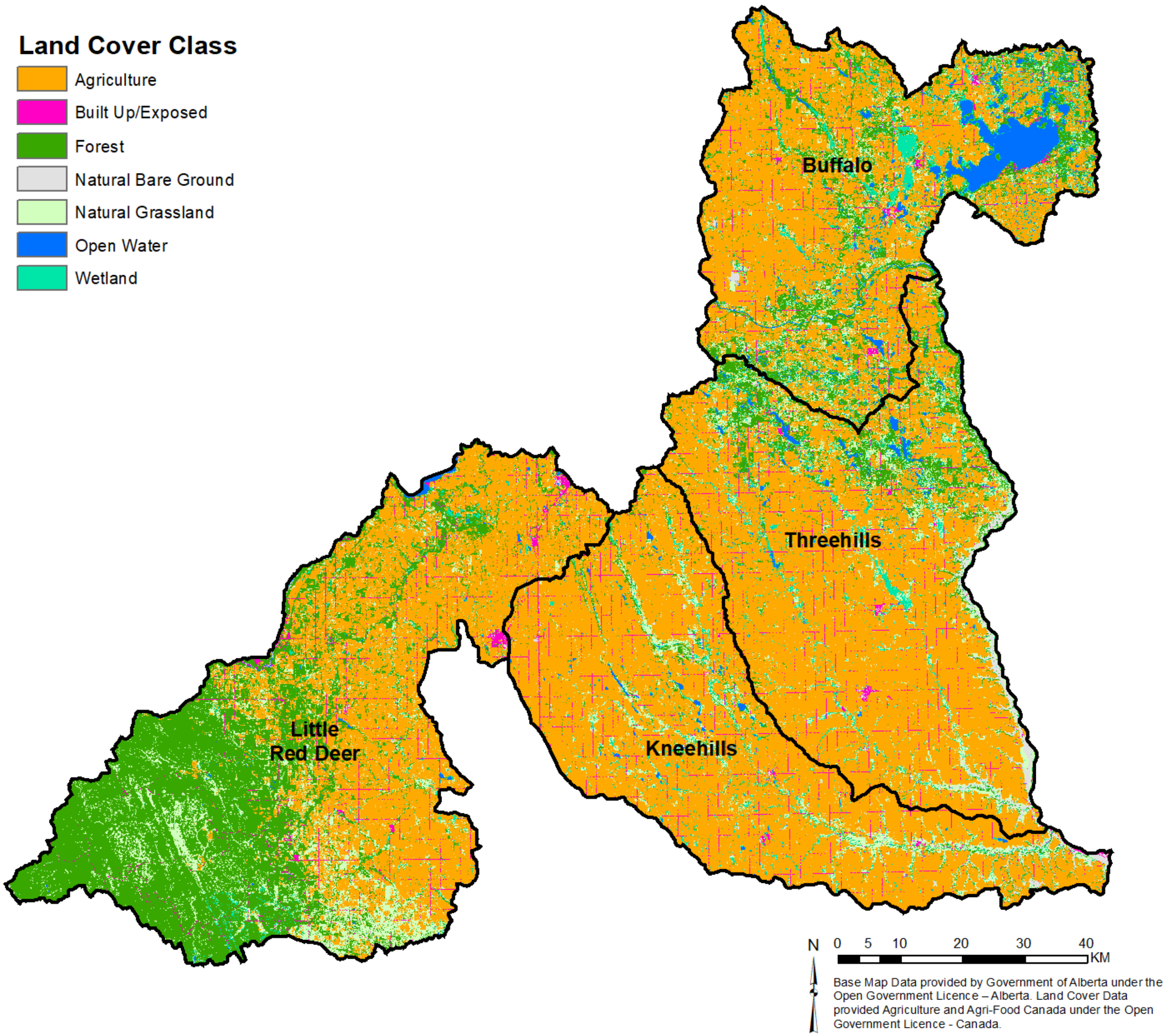
As part of this report, and as per the request of the RDRWA, municipal summaries were created for five rural counties that intersect portions of the four subwatersheds (see Sections 9.2 to 9.6 for summary of results). These five rural counties include: Kneehill County, the Municipal District (MD) of Bighorn, Mountain View County, Red Deer County, and Rocky View County (Map 4 and Map 5). The results that are summarized for the MD of Bighorn, Mountain View County, Kneehill County, and Rocky View County include shorelines that were assessed as part of this current study (Map 4). Red Deer County overlaps with areas that were assessed as part of this study, as well as areas that have been previously assessed using the same satellite-based method (Fiera Biological 2018d, 2018e, and 2020a). In order to create a comprehensive summary that includes all waterbodies that have been assessed to date, the Red Deer County summary presented in Section 9.5 incorporates newly assessed and previously assessed waterbodies (Map 4). This was done at the request of the RDRWA.



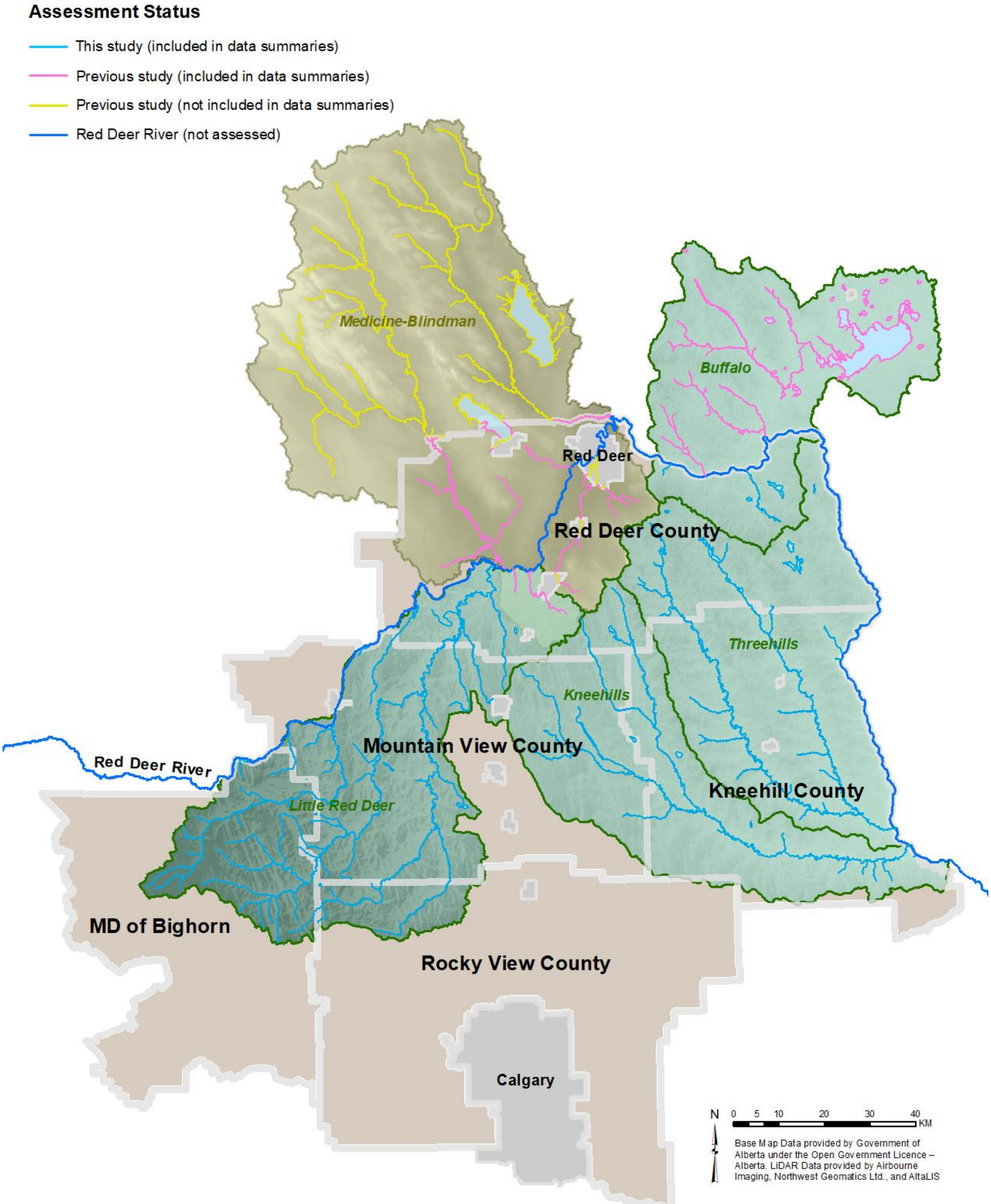
Map 1. Location of the four subwatersheds that were included in this study within the Red Deer River HUC2 watershed.



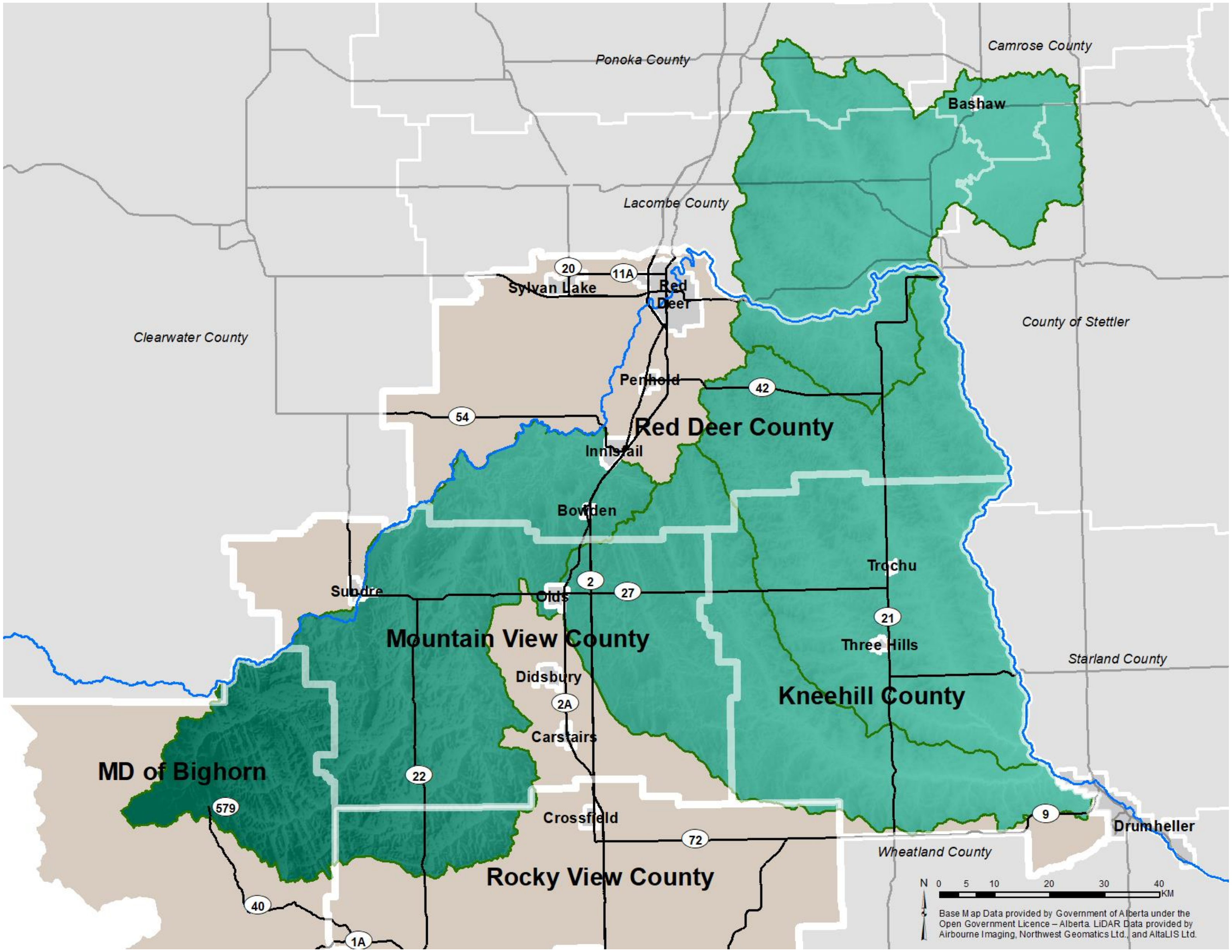
Map 2. The four subwatersheds included in this study encompass five different Natural Regions.



Map 3. Land cover across the four subwatersheds, based on the 2020 Agriculture and Agri-Food Canada land cover.



Map 4. Waterbodies assessed as part of this project (blue), waterbodies assessed as part of previous riparian assessment projects and are included in the data summaries provided in this report (pink), and waterbodies assessed as part of previous riparian assessment projects and are not included in the data summaries provided in this report (yellow).



Map 5. Municipalities, cities, towns, and major highways that are located in the study area and overlap the four subwatersheds that were included in this study (in green). As per the scope provided by the RDRWA, the municipalities (in brown) that were considered for data summaries in this report included Kneehill County, the MD of Bighorn, Mountain View County, Red Deer County, and Rocky View County. Note that riparian assessment results for other intersecting municipalities (Lacombe, Ponoka, Clearwater, and Camore Counties) have been created as part of previous projects (see Fiera Biological 2021d).

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), 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 6 and SPOT 7 satellite imagery from 2019 and 2020, which was obtained by the RDRWA through an agreement with the Government of Alberta.

To create a 6 m classification for the buffer areas of the waterbodies of interest, seven separate SPOT 6/7 image scenes were classified. Because of differences in the acquisition date and image quality, each scene was classified individually, but using the same classification methodology. For each satellite image, the four SPOT 6/7 bands were combined with a set of ancillary raster data products that were specifically generated for use in the classification (Table 1). The SPOT 6/7 imagery was used to generate layers for the first four principal components 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 and 1 m LiDAR products was used to derive terrain layers including Probability of Depression, Cost Distance to Water, and Deviation from Mean Elevation. As well, historic image analysis was performed in Google Earth Engine to generate mean summer temperature maps from Landsat 8 imagery and mean and standard deviation maps of NDVI from Sentinel 2 imagery (Table 1). Land cover classes were chosen and organized hierarchically into nested levels to facilitate training data selection and modelling (Table 2). Training data were manually selected for each SPOT 6/7 scene for the following classes: Coniferous; Deciduous; Shrub; Lowland Graminoid; Lowland Woody; Open Water; Agriculture Pasture; Cropland; Human Built; Natural Bare Ground. A random forest classification was performed on each SPOT 6/7 band stack, which included the four SPOT 6/7 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 natural, non-woody low cover vegetation, the Disturbed Vegetation class was added to account for non-agricultural human impacted low vegetation cover and areas with managed or manicured vegetation, and the Agricultural Depression class was added to account for altered wetland basins in agricultural fields. The Alberta Base features Roads layer was used to add in a Roads class. The seven classifications were then mosaicked together and clipped to within 50 m of the shoreline of assessed waterbodies. Quality control and editing for the buffer area was then completed, the final 14-class “Level 2” land cover classification was used to assess riparian intactness (Table 2).

Table 1. Description of the spatial data obtained or derived for use in the assessment of riparian management area Intactness.

Data Layer	Year	Source	Usage
SPOT 6/7 Satellite Imagery	2019/2020	Government of Alberta	Derivation of land cover classification
15 m LiDAR DEM	n/d	Government of Alberta	Derivation of data products for classification
Principal Component Layers 1-4	2019/2020	Fiera Biological. Layers were created using SPOT 6 satellite data provided by the Government of Alberta	Derivation of land cover classification
Normalized Difference Vegetation Index (NDVI)	2019/2020	Fiera Biological. Layer was created using SPOT 6/7 satellite data provided by the Government of Alberta	Derivation of land cover classification
Blue Normalized Difference Vegetation Index (BNDVI)	2019/2020	Fiera Biological. Layer was created using SPOT 6/7 satellite data provided by the Government of Alberta	Derivation of land cover classification
Green Ratio Vegetation Index (GRVI)	2019/2020	Fiera Biological. Layer was created using SPOT 6/7 satellite data provided by the Government of Alberta	Derivation of land cover classification
Iron Oxide Index (IOI)	2019/2020	Fiera Biological. Layer was created using SPOT 6/7 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
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
Deviation from Mean Elevation	n/d	Fiera Biological. Layer was created using LiDAR DEM data provided by the Government of Alberta	Derivation of land cover classification
Roads	2014	Alberta Base Features	Derivation of land cover classification
Mean Summer Temperature	2013-2018	Fiera Biological. Layers created using Landsat 8 imagery	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
ABMI Human Footprint	2018	Alberta Biodiversity Monitoring Institute	Semi-automated clean-up of classification
6 m Land Cover	2019/2020	Fiera Biological. Layer was created using SPOT 6/7 satellite data provided by the Government of Alberta and derived layers	Derivation of RMAs and quantification of intactness metrics

Table 2. Land cover classes that were used to derive the land cover classification for the four watersheds.

Level 1	Level 2	Description
Forest	Coniferous	Coniferous trees (needle-leaf) cover greater than 75% of treed area.
	Deciduous	Broadleaf trees covering greater than 75% of treed area.
	Shrub	Shrubs (<2 m tall) covering greater than 75% of area.
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 Graminoid	Low lying areas dominated by emergent or graminoid vegetation and depressional areas adjacent to streams/creeks and lakes, or areas dominated by graminoid vegetation where surface water flow is apparent.
	Lowland Woody	Depressional areas dominated by deciduous tree or shrub cover. Surface water flow may be apparent.
Agricultural Depression	Agricultural Depression	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. A total of 270 samples were used to assess accuracy, with a minimum number of 10 samples validated for each class. The Agricultural Depression class was not included in the accuracy assessment because it covers less than 1% of the buffer land cover area, and collecting enough samples to validate this class was not feasible.

Overall accuracy at Level 1 for the classification was 91% with a Kappa statistic of 0.88 (Table 3). Class accuracies were high for all classes, with minor confusion between the Agriculture and Natural Grassland classes in areas where the impact by cattle grazing is difficult to interpret. Some confusion also occurred between the Wetland (lowland graminoid) and Natural Grassland categories, and the Forest and Wetland (lowland woody) categories, which is expected given the difficulty discerning between these classes without confirmation from a field visit. Users of this buffer land cover classification should note that many riparian areas next to streams and rivers have been classified as the Wetland cover class (e.g., lowland graminoid, lowland woody) throughout many parts of the study area.

While the land cover and riparian assessment results for the four subwatersheds 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. When compared to the aerial videography method, overall agreement between the GIS and videography scores was over 75% (Fiera Biological 2018a), and when compared to data collected in the field, the overall agreement between the GIS and field scores was 77% (Fiera Biological 2019). Disagreement between the GIS and field or videography scoring was often related to variability in the interpretation of somewhat “subjective” land cover classes, such as when deciding between natural grassland and pasture or disturbed vegetation.

Table 3. Accuracy assessment results for the Level 1 land cover classes.

	Agriculture	Built Up / Exposed	Disturbed Vegetation	Forest	Natural Bare Ground	Natural Grassland	Open Water	Wetland	User Accuracy
Agriculture	77	0	0	0	0	0	0	1	99%
Built Up / Exposed	0	9	1	0	0	0	0	0	90%
Disturbed Vegetation	2	1	9	0	0	0	0	0	75%
Forest	0	0	0	43	0	1	0	5	88%
Natural Bare Ground	0	0	0	0	10	0	0	0	100%
Natural Grassland	4	0	0	0	0	28	0	4	78%
Open Water	0	0	0	0	0	0	13	0	100%
Wetland	0	0	0	3	0	2	1	56	90%
Producer Accuracy	93%	90%	90%	93%	100%	90%	93%	85%	91%

NOTE: Producer accuracy measures errors of omission (exclusion) and assesses how well real-world land cover types have been classified. User accuracy measures errors of commission (inclusion), which represents the likelihood of a classified pixel matching the land cover type of its corresponding real-world location.

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 6/7 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 derived the land cover layer for this project.

Figure 5. 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 study. 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).

RMAs are areas along the shoreline of a waterbody that include the near-shore emergent vegetation zone, the riparian zone, and a riparian protective (buffer) zone (Figure 6). An RMA has two spatial components: width and length. For this assessment, riparian intactness was evaluated within RMAs that had a static 50 m wide buffer that was applied to the left and right banks of each watercourse. For lakes, a single 50 m wide buffer was applied to the shoreline. This buffer width was selected because when GIS-derived results from various buffer widths (25 m, 50 m, 100 m) were tested and compared to videography validation data, the 50 m buffer results correlated most strongly with the validation data (Fiera Biological 2018a). 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.

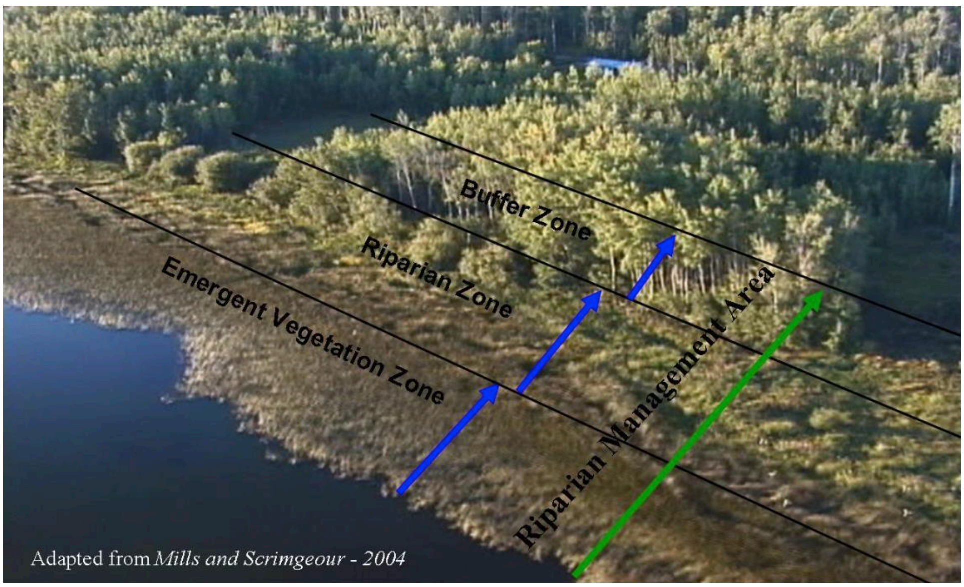


Figure 6. Schematic showing the different shoreline components included in a “riparian management area” (image taken from Teichreb and Walker 2008).

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. Assigning Unique IDs to Edited Water Boundary Data

Many of the waterbodies in the provincial hydrography data are unnamed features with no unique identification code. Additionally, some names are duplicated several times for features across the province, which can result in confusion and also makes reporting results complicated. As part of the development of the riparian assessment methodology, a naming schema for newly assessed waterbodies was developed as part of a riparian assessment project completed for the North Saskatchewan River and Battle River watersheds (Fiera Biological 2021d). This naming schema has been developed to be applied at the HUC 6-level to ensure each waterbody can be identified uniquely and summarized individually. Features within the Buffalo, Kneehills, Little Red Deer, and Threehills subwatersheds were named using the following set of rules (examples provided are meant to be illustrative and are not specific to this project):

- **Named Streams** – Streams, creeks, or rivers with an existing name in the Alberta Base Features hydrography dataset or the FWMIS Hydro Arcs dataset retained their existing name. If a name was duplicated in a HUC 6 (e.g., two different streams both named Happy Stream), they were numbered sequentially from west to east (i.e., Happy Stream 1, Happy Stream 2).
- **Named Lakes** – Lakes with an existing name in the Alberta Base Features hydrography dataset or the FWMIS Hydro Arcs dataset retained their existing name. If a named was duplicated in a HUC 6 (e.g., two different lakes both named Pleasant Lake), they were numbered sequentially from west to east (i.e., Pleasant Lake 1, Pleasant Lake 2).
- **Unnamed Lakes and Reservoirs** – Lakes or reservoirs with no name in either of the provincial hydrography datasets were assigned a unique ID by combining “UL” or “UR” with the HUC 6 numeric ID code, along with a number starting at 01 and increasing sequentially moving north to south and west to east (e.g., for unnamed lakes assessed in the Frog HUC 6, the IDs are “UL-110302-01”, “UL-110302-02”, etc.).
- **Unnamed Creeks** – Streams and creeks with no name assigned in either provincial hydrography datasets were named based on the type of waterbody they flowed into, as follows:
    - **Unnamed Creek into Named Stream** – Unnamed creeks were named based on the Named Stream they flowed into and numbered sequentially starting at the furthest point upstream (e.g., Hooray River-01, Hooray River-02, Hooray River-03). All branches upstream from where a given tributary entered a named stream were considered the same unnamed creek for the purposes of this project.
    - **Unnamed Creek into Named Lake** – Unnamed creeks were named based on the Named Lake they flowed into and numbered sequentially starting at the “12-o-clock” position (e.g., Smiling Lake-01, Smiling Lake -02, Smiling Lake -03). All branches upstream from where a given tributary entered a named lake were considered the same unnamed creek for the purposes of this project.
    - **Unnamed Creek into Unnamed Lake** – Unnamed creeks were named based on the Unnamed Lake they flowed into and numbered sequentially starting at the “12-o-clock” position starting with “US” (e.g., UL-110302-01-US01, UL-110302-01-US02, UL-110302-01-US03). All branches upstream from where a given tributary entered an unnamed lake were considered the same unnamed creek for the purposes of this project .
    - **Isolated Unnamed Creek** – Isolated unnamed creeks (i.e., does not flow downstream into any other water body) were named by combining “US” with the HUC 6 numeric ID code, along with a number starting at 01 and increasing sequentially moving north to south and west to east (e.g., for isolated unnamed creeks assessed in the Paintearth HUC 6, the IDs are “US-090201-01”, “US-090201-02”, etc.).
    - **Unnamed Creek into Unnamed Creek** – Unnamed creeks were named based on the Isolated Unnamed Creek they flowed into and numbered sequentially starting at furthest point upstream (e.g., US-090201-01-US01, US-090201-01-US02).

3.1.6. 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 (Lowland Woody and Lowland Graminoid), Forest, and Natural Grassland. To quantify Metric 2, the percent cover of Forest and Lowland 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, 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. These weights were selected because they were comparable to the weights applied in the aerial videography method, which was used as the basis for the development of the satellite-based methodology (Fiera Biological 2018a). 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.

3.2. Data Summaries

All municipal data summaries were generated using a spatial intersect rule in ArcGIS, where the results from each analysis (i.e., intactness, pressure, priority) were intersected with the municipal boundary layer. Summarizing the data in this way captures the assessed shorelines that fall within the municipal boundary; however, it should be noted that there are spatial discrepancies between the municipal boundary data and the provincial hydrography data that are freely available from AltaLIS. For example, in many instances, municipal boundaries follow the boundary of a waterbody (e.g., the boundary between two Counties follows a creek or river) and often, the boundary topology of these two features do not match. In these instances, some minor edits may have been made to correct the intersection outputs and reassign results from one municipality to another, but in most cases, municipal boundary layers were not extensively edited to correct topological errors. As a result, the municipal summaries of shoreline length for intactness and priority are approximate and should be considered estimates that reflect relative differences between municipalities.

4.0 Subwatershed Results Summary

Within each of the four subwatersheds, riparian intactness was determined for approximately 5,285 km of shoreline that was assessed as part of this study, or as part of a previously completed study that used the same assessment methodologies (Map 4). Approximately 42% of the shoreline that has been assessed is located within the Little Red Deer subwatershed (2,209 km), with 22% located in the Threehills subwatershed (1,165 km), 19% in the Kneehill subwatershed (1,002 km), and 17% located in the Buffalo subwatershed (910 km).

Overall, 33% (1,761 km) of the shoreline that has been assessed in these four subwatersheds has been classified as High Intactness, with a further 26% (1,371 km) classified as Moderate Intactness (Figure 7). Approximately 40% of the shoreline was classified as either Low (11%, 602 km) or Very Low (29%, 1,550 km) Intactness.

When riparian intactness is compared across each of the four subwatersheds, the Little Red Deer had the greatest length (1,226 km) and proportion (55%) of shoreline classified as High Intactness, followed by the Buffalo subwatershed (658 km, 39%; Figure 8 and Figure 9). Conversely, the Threehills subwatershed had the greatest length and proportion (509 km, 44%) of shoreline classified as Very Low Intactness, with the Kneehills subwatershed having a similar amount of shoreline (422 km, 42%) classified as Very Low Intactness.

More detailed intactness results for each subwatershed, including intactness summaries for each water body that was assessed, is presented in Sections 5 through 8.

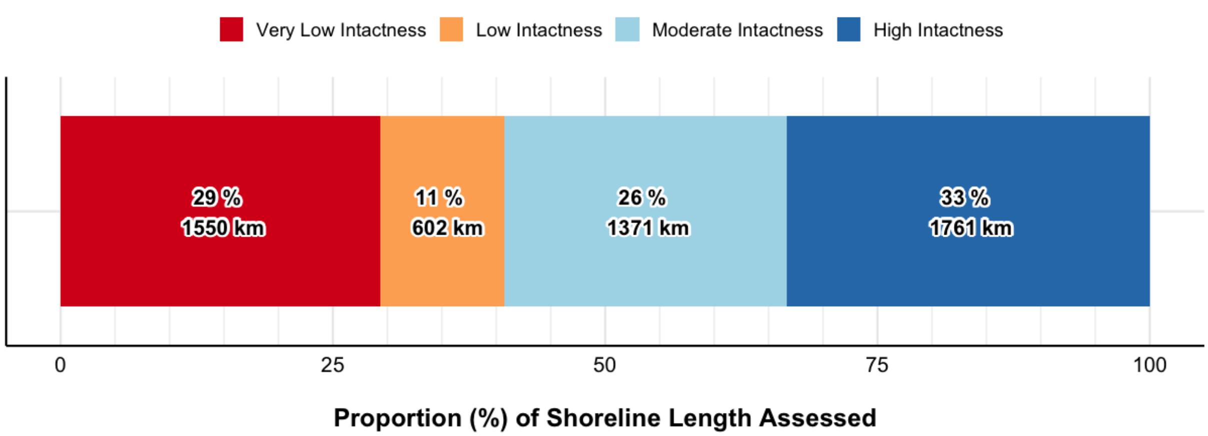


Figure 7. The total proportion and length of shoreline assigned to each riparian intactness category for waterbodies assessed in this study.

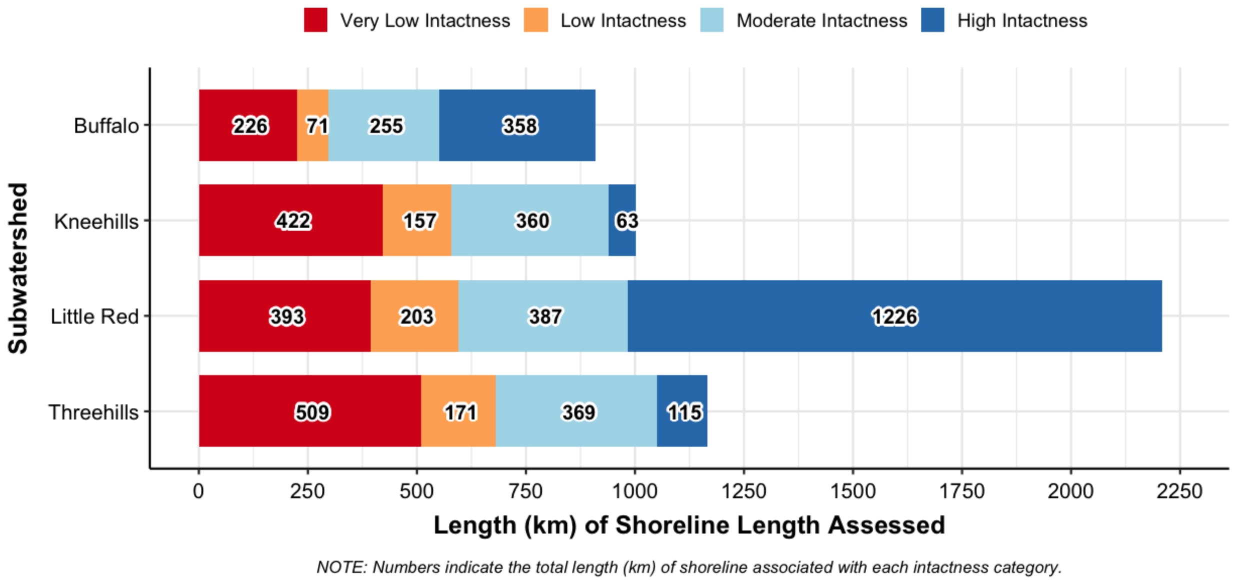


Figure 8. The total length of shoreline within the study area assigned to each riparian intactness category, summarized by subwatershed.

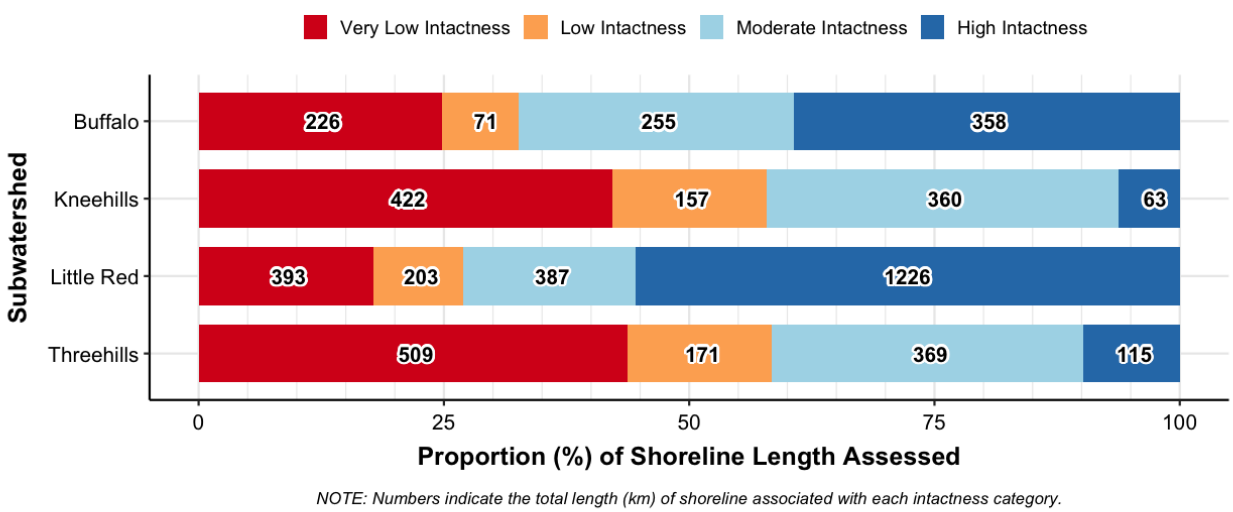


Figure 9. The total proportion of shoreline within the study area assigned to each riparian intactness category, summarized by subwatershed.

5.0 Buffalo Subwatershed Results

5.1. Shorelines of Interest

The Buffalo subwatershed covers an area of approximately 2,561 km^2 and is the most northerly of the four subwatersheds assessed in this study. In the Buffalo subwatershed, 910 km of shoreline was assessed, including 25 watercourses (Map 6) and 31 lakes and reservoirs (Map 7; Table 4). Of these, 9 waterbodies (3 watercourses and 6 lakes) were newly assessed as part of this project. The other 22 watercourses and 25 lakes were assessed as part of previous riparian assessment projects completed by Fiera Biological (2018d and 2021d).

The majority of the subwatershed is covered by anthropogenic land cover types, with agriculture accounting for the majority of the human cover (59%) (Figure 10). The remaining 38% of the subwatershed is covered by natural land cover types, with forest accounting for the majority of the natural cover (16%). Natural cover tends to be located in the south and east portions of the watershed, while the western and northwestern areas are dominated by agriculture. Compared to the other subwatesheds, the Buffalo has a very high proportion of open water cover (7%), which is attributed to the presence of several large lakes, including Buffalo Lake.

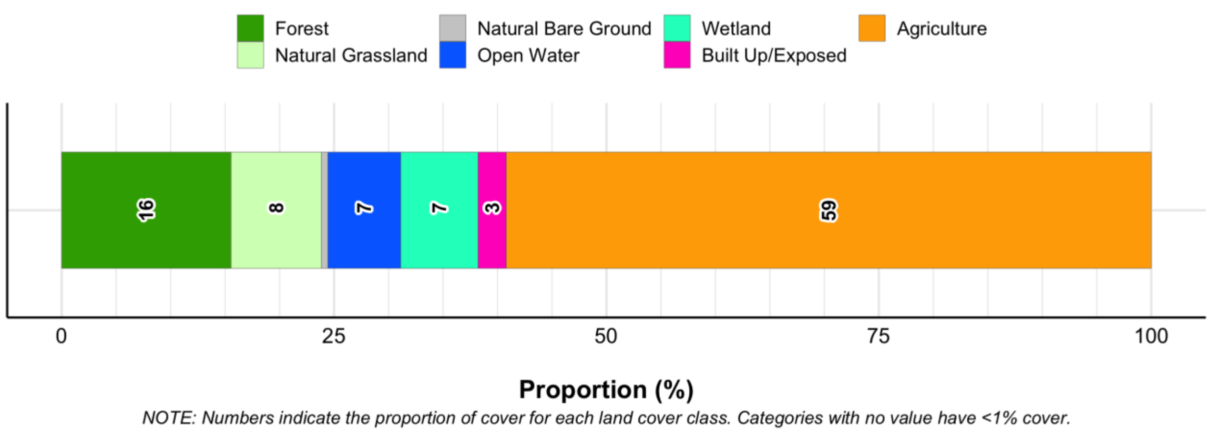
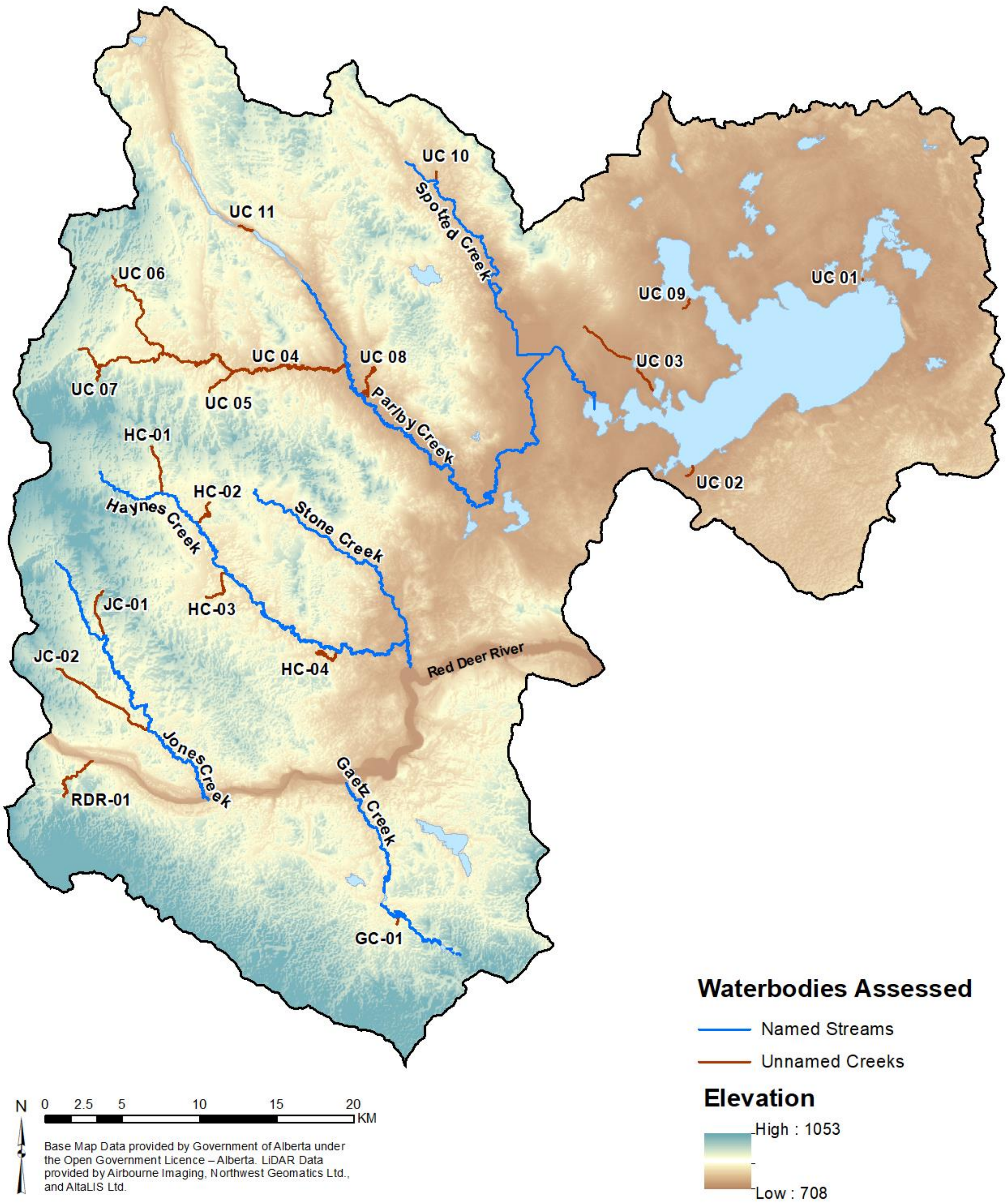


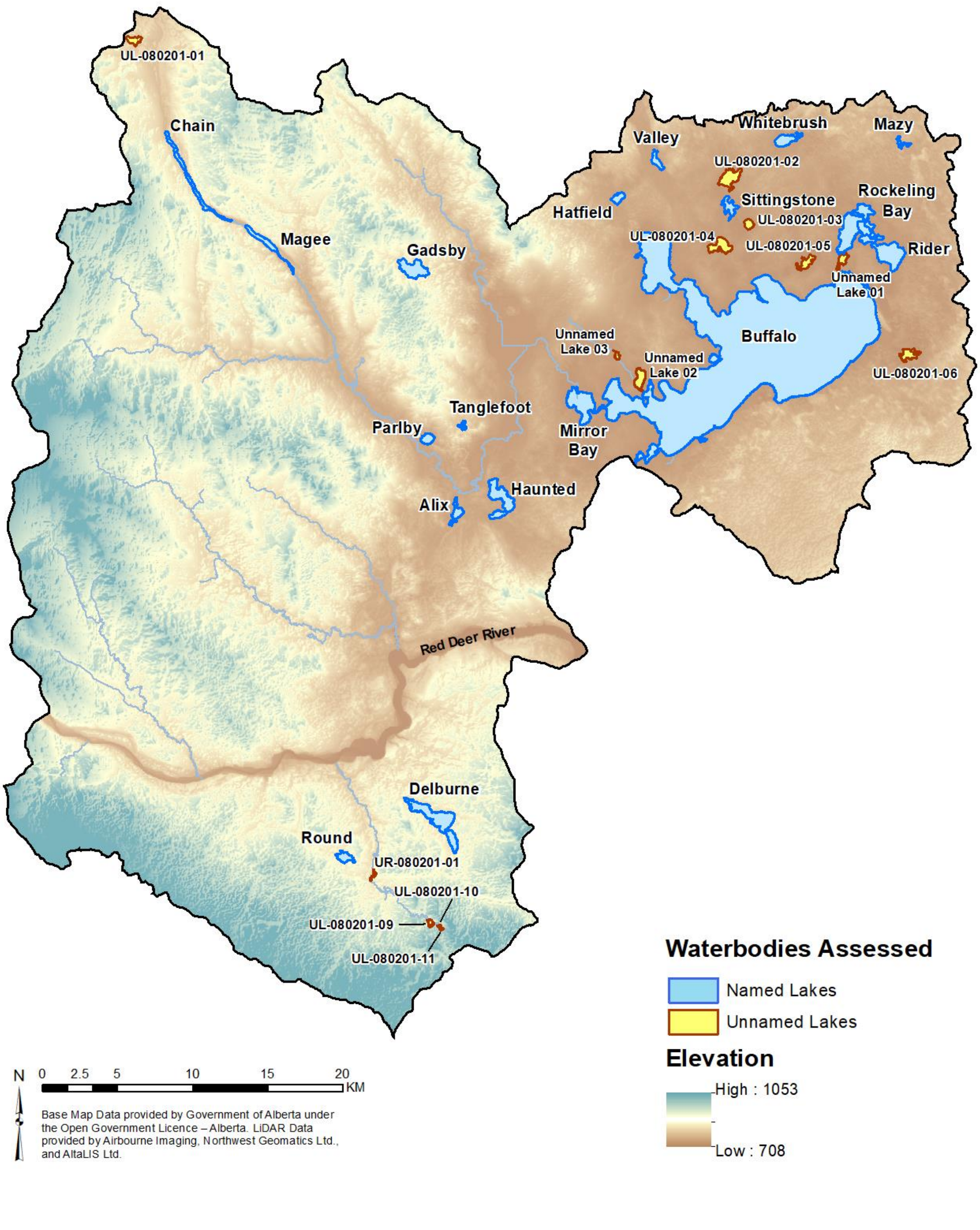
Figure 10. The proportion of the Buffalo subwatershed assigned to each land cover class. Land cover data is based on the 2020 Agriculture and Agri-Food Canada land cover.

Table 4. Waterbodies in the Buffalo subwatershed that have been assessed using the satellite-based riparian assessment method. The shoreline length listed for each stream represents the sum of the shoreline that was assessed on both the left and right banks.

Waterbody Name	Length of Shoreline Assessed (km)
Streams	
Gaetz Creek	39.6
Haynes Creek	96.3
Jones Creek	67.0
Parlby Creek	132.4
Spotted Creek	47.3
Stone Creek	38.6
Unnamed Creeks (19)	172.8
Lakes & Reservoirs	
Alix Lake	5.8
Buffalo Lake	115.1
Chain Lakes	16.6
Delburne Lakes	15.5
Gadsby Lake	7.1
Hatfield Lake	3.0
Haunted Lakes	10.4
Magee Lake	11.8
Mazy Lake	4.7
Mirror Bay	14.3
Parlby Lake	2.7
Rider Lake	12.4
Rockeling Bay	24.2
Round Lake	4.0
Sittingstone Lake	6.8
Tanglefoot Lake	2.7
Valley Lake	3.8
Whitebrush Lake	6.2
Unnamed Lakes (13)	47.8
TOTAL	**910.0**



Map 6. Location of named streams and unnamed creeks that were assessed in the Buffalo subwatershed.



Map 7. Location of named and unnamed lakes that were assessed in the Buffalo subwatershed.

5.2. Riparian Management Area Intactness

Of the 910 km of shoreline that was assessed in the Buffalo subwatershed, 39% (or 358 km) was categorized as High Intactness, with an additional 28% (255 km) assessed as Moderate Intactness (Figure 11). The remaining 33% of shoreline was categorized either Low (8%, 71 km) or Very Low Intactness (25%, 226 km). High Intactness shoreline are generally associated with lakes and areas where streams have woody cover that has not be cleared, while Very Low Intactness shoreline are generally associated with agricultural land use.

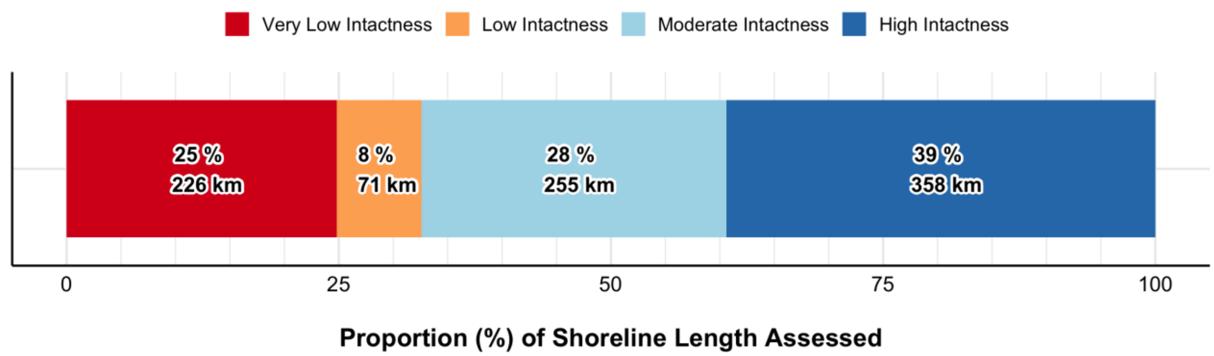


Figure 11. The total proportion and length of shoreline assigned to each riparian intactness category for all shoreline assessed in the Buffalo subwatershed.

Of the six named streams assessed in the Buffalo subwatershed, three streams, Haynes Creek, Jones Creek, and Stone Creek had more than 70% of their shorelines assessed as either Moderate or High Intactness, with Haynes Creek having the greatest proportion of shoreline assessed as High Intactness (Figure 12; Map 8). Conversely, Gaetz Creek and Parlby Creek had over 50% of shoreline assessed categorized as Low or Very Low Intactness. Gaetz Creek had the greatest proportion (64%) of Very Low and Low Intactness shorelines, while Parlby Creek had the greatest proportion (51%) and length (67 km) of shoreline assessed as Very Low. Spotted Creek had roughly equal proportions of High and Moderate Intactness shoreline (52%) and Low and Very Low Intactness shoreline (48%), although, the Very Low Intactness shoreline accounted for 42% of its total length.

Nineteen unnamed creeks were assessed for intactness within this subwatershed, and of these, nine (or 47%) had more than half of their shorelines assessed as High or Moderate Intactness (Figure 13; Map 8). In contrast, 10 of the unnamed creeks had more than 50% of their shorelines assessed as Very Low or Low Intactness, and six of these, Haynes Creek-01, Unnamed Creek 02, Unnamed Creek 03, Unnamed Creek 07, Unnamed Creek 09, and Unnamed Creek 10, had greater than 50% of their shoreline assessed as Very Low Intactness. Unnamed Creek 03 had the greatest length (9 km) of shoreline assessed as Very Low Intactness (Figure 13).

A large number of lakes were assessed as part of this study, including 18 named lakes and 13 unnamed lakes and reservoirs (Map 9). Overall, the named lakes were in relatively good condition, with 12 (or 67%) of the named lakes having 75% or more of their shorelines assessed as High or Moderate Intactness (Figure 14). The exceptions to this were Mirror Bay and Alix, Delburne, Parlby, Round, and Valley Lakes, which all had more than 25% of their shoreline assessed as Very Low or Low Intactness. Valley Lake had the greatest proportion (48%) of shoreline assessed as Very Low Intactness, while Buffalo Lake had the greatest length (15 km) of shoreline assessed as Very Low Intactness (Figure 14).

Unnamed lakes were also in relatively good condition, with just over half of the lakes having greater than 75% of their shoreline assessed as High or Moderate Intactness (Figure 15; Map 13). Of these, three had 100% of their shoreline assessed as High Intactness. Six of the unnamed lakes had more than 25% of their shoreline assessed as either Very Low or Low Intactness, with one lake, UL-080201-10, having more than half of its shoreline assessed as Very Low Intactness (Figure 15).

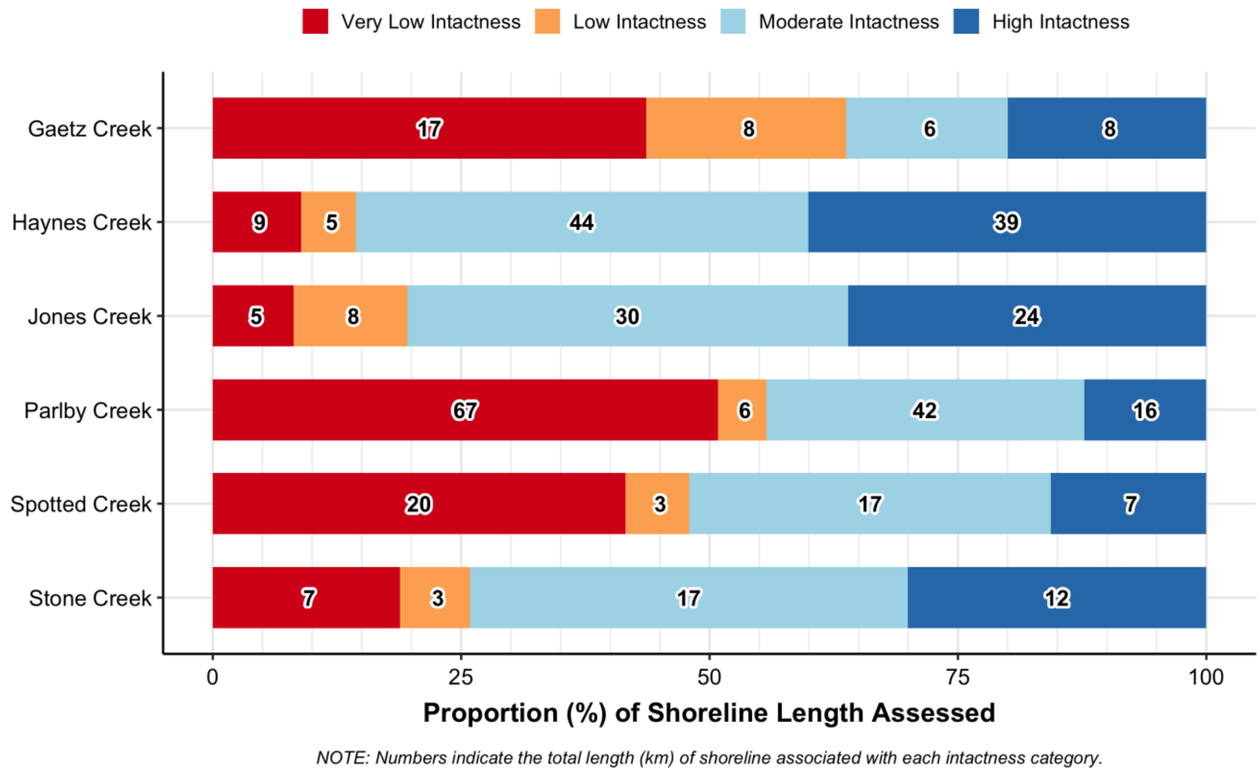


Figure 12. The total proportion of shoreline assigned to each riparian intactness category for named streams assessed in the Buffalo subwatershed.

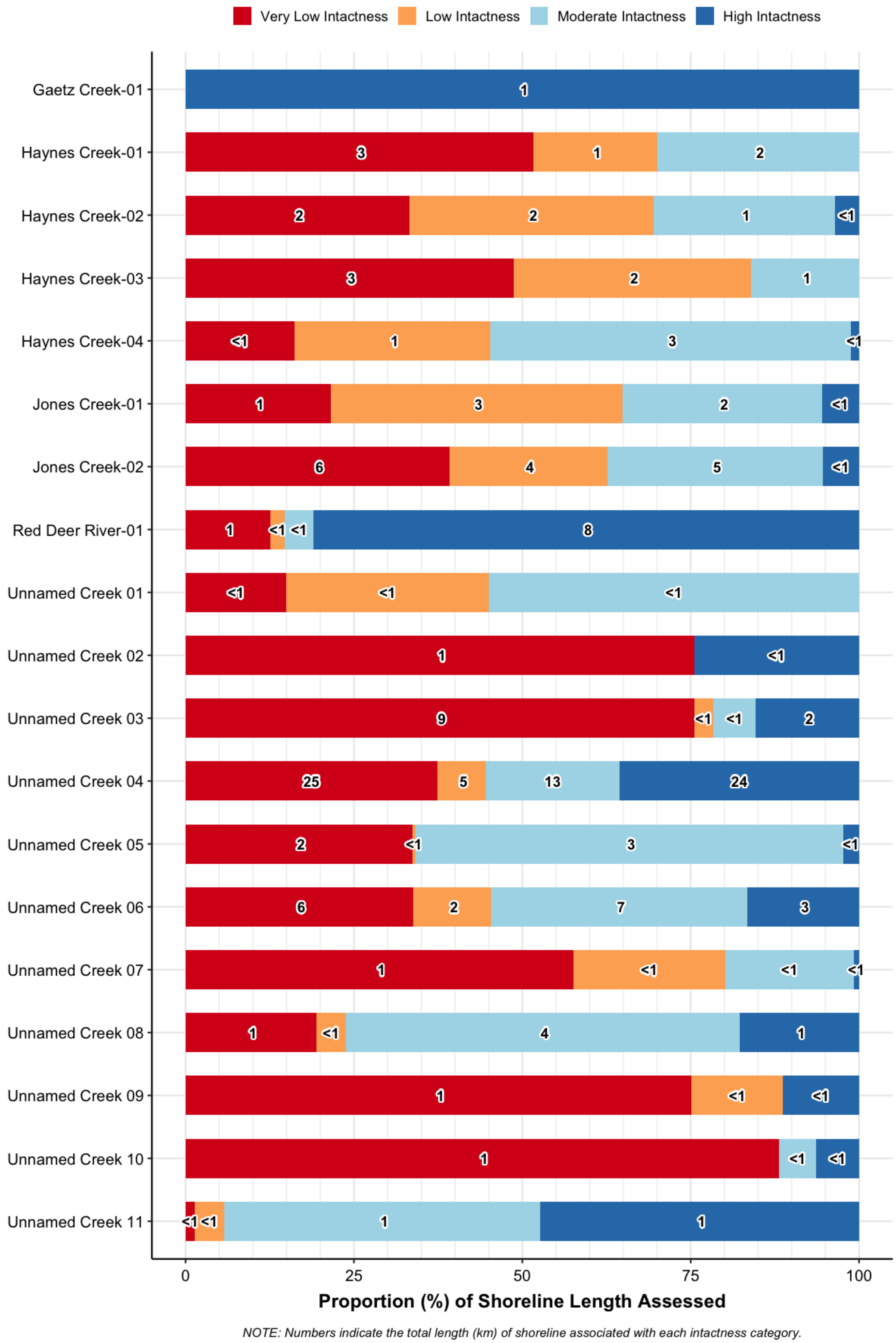


Figure 13. The total proportion of shoreline assigned to each riparian intactness category for unnamed creeks assessed in the Buffalo subwatershed.

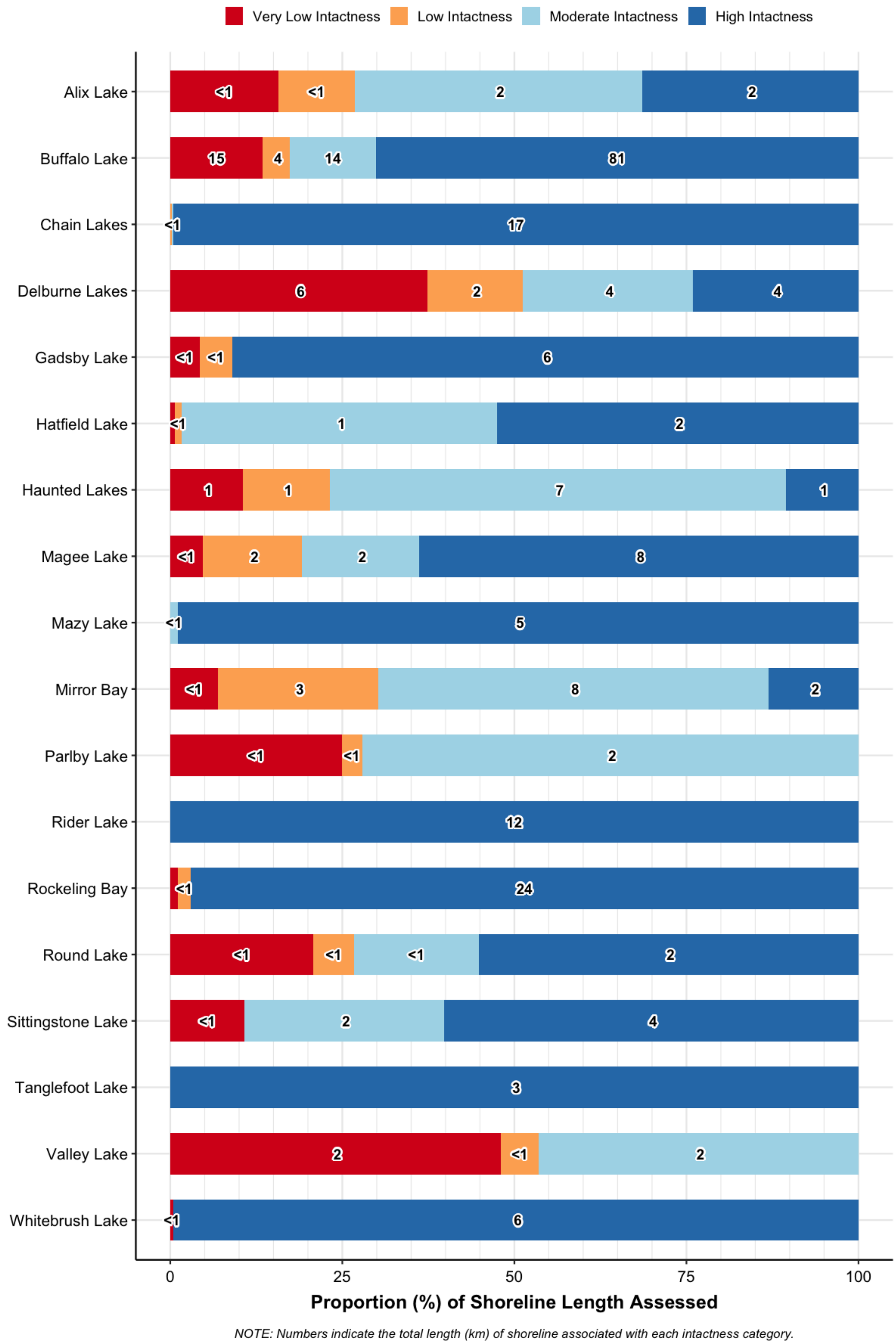


Figure 14. The total proportion of shoreline assigned to each riparian intactness category for named lakes assessed in the Buffalo subwatershed.

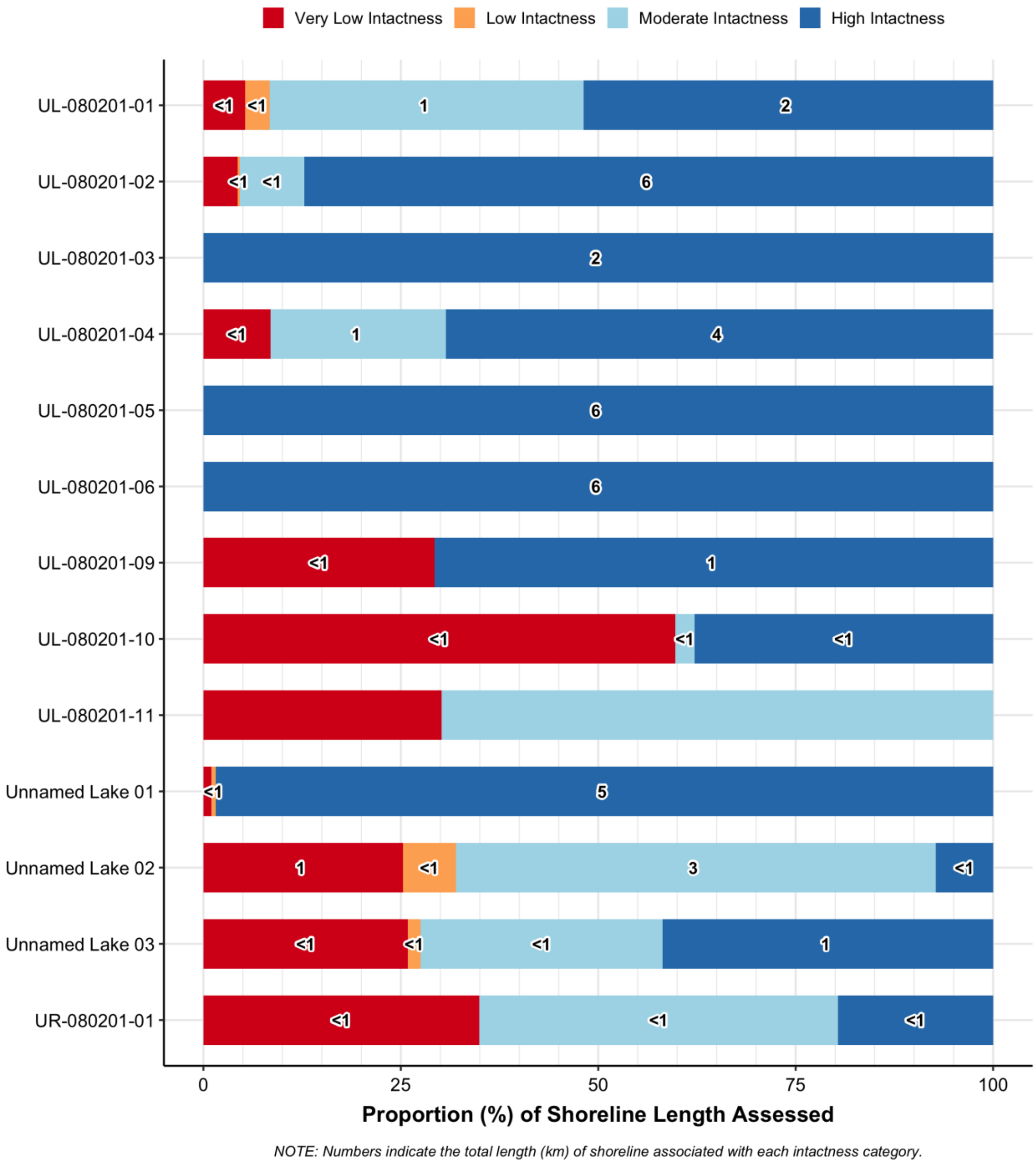
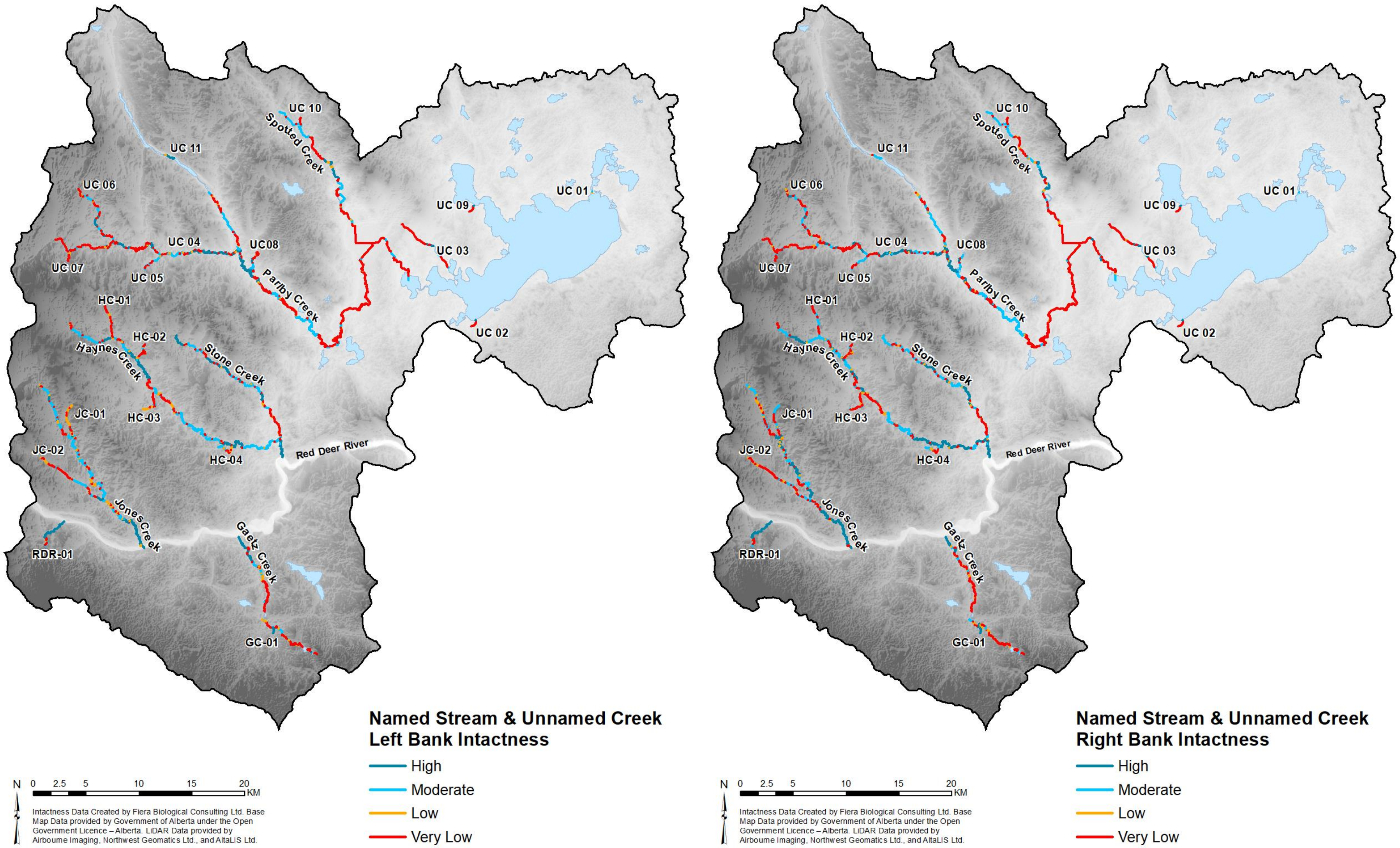
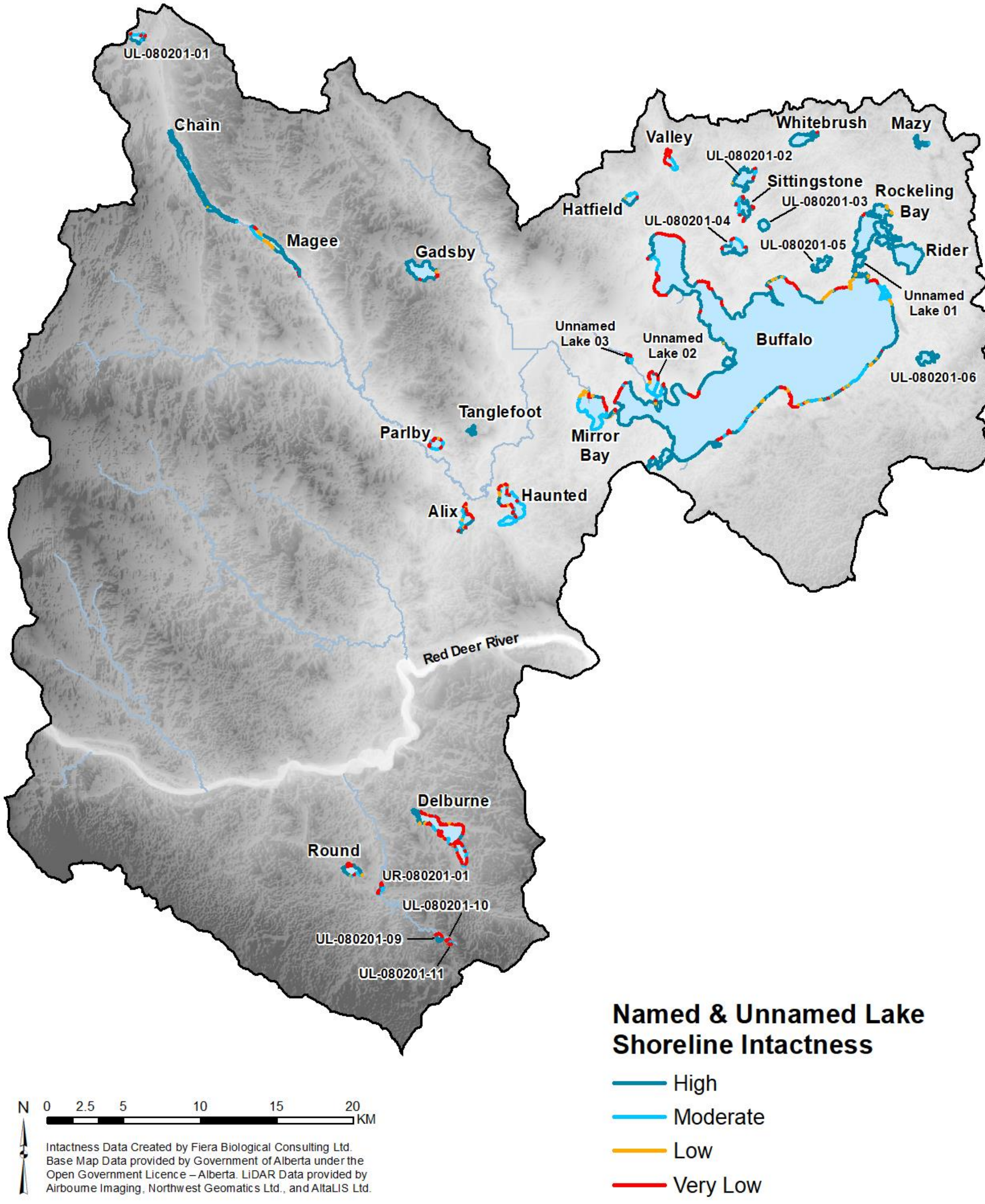


Figure 15. The total proportion of shoreline assigned to each riparian intactness category for unnamed lakes assessed in the Buffalo subwatershed.



Map 8. Intactness for the left and right banks of named streams and unnamed creeks that were assessed in the Buffalo subwatershed.



Map 9. Intactness for the shoreline of named and unnamed lakes that were assessed in the Buffalo subwatershed.

6.0 Kneehills Subwatershed Results

6.1. Shorelines of Interest

The Kneehills subwatershed is approximately 2,492 km^2 in size, and falls within both the Parkland and Grassland Natural Regions (Map 2). Within this watershed, just over 1,000 km of shoreline was assessed as part of this study, including 16 watercourses and 12 lakes and reservoirs (Table 5; Map 10). No previous satellite-based assessments have been completed in this subwatershed to-date. Notably, the majority of the shoreline assessed within this subwatershed was associated with Kneehills Creek (Table 5).

The vast majority of this subwatershed (84%) is covered by anthropogenic land cover types, with agriculture accounting for almost all of the human cover (81%) (Figure 16). The remaining 16% of the subwatershed is covered by natural cover types, with natural grassland predominating as the main natural cover type (7%). Agriculture occurs across the entire watershed, with natural areas tending to be associated with Kneehills Creek, and in isolated pockets scattered elsewhere throughout the subwatershed.

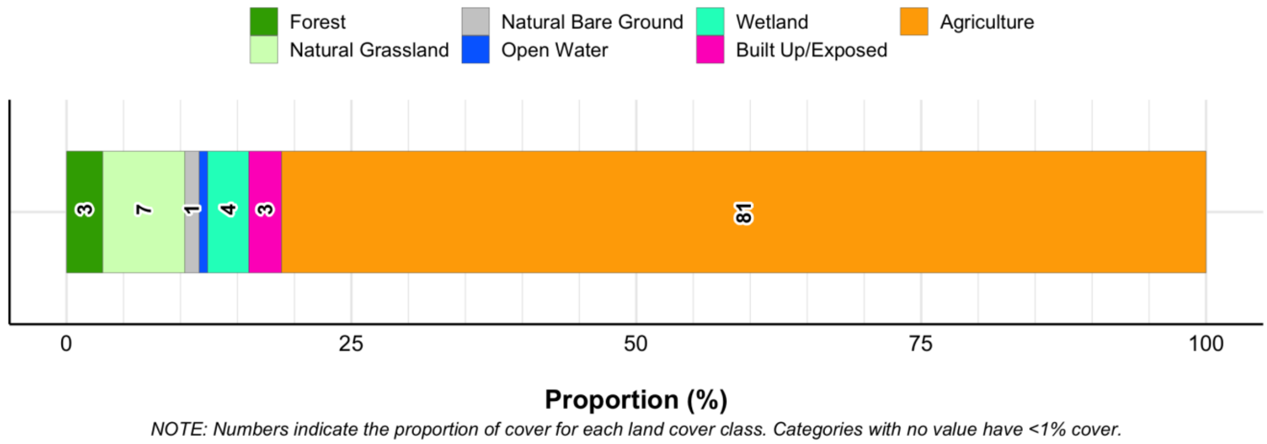
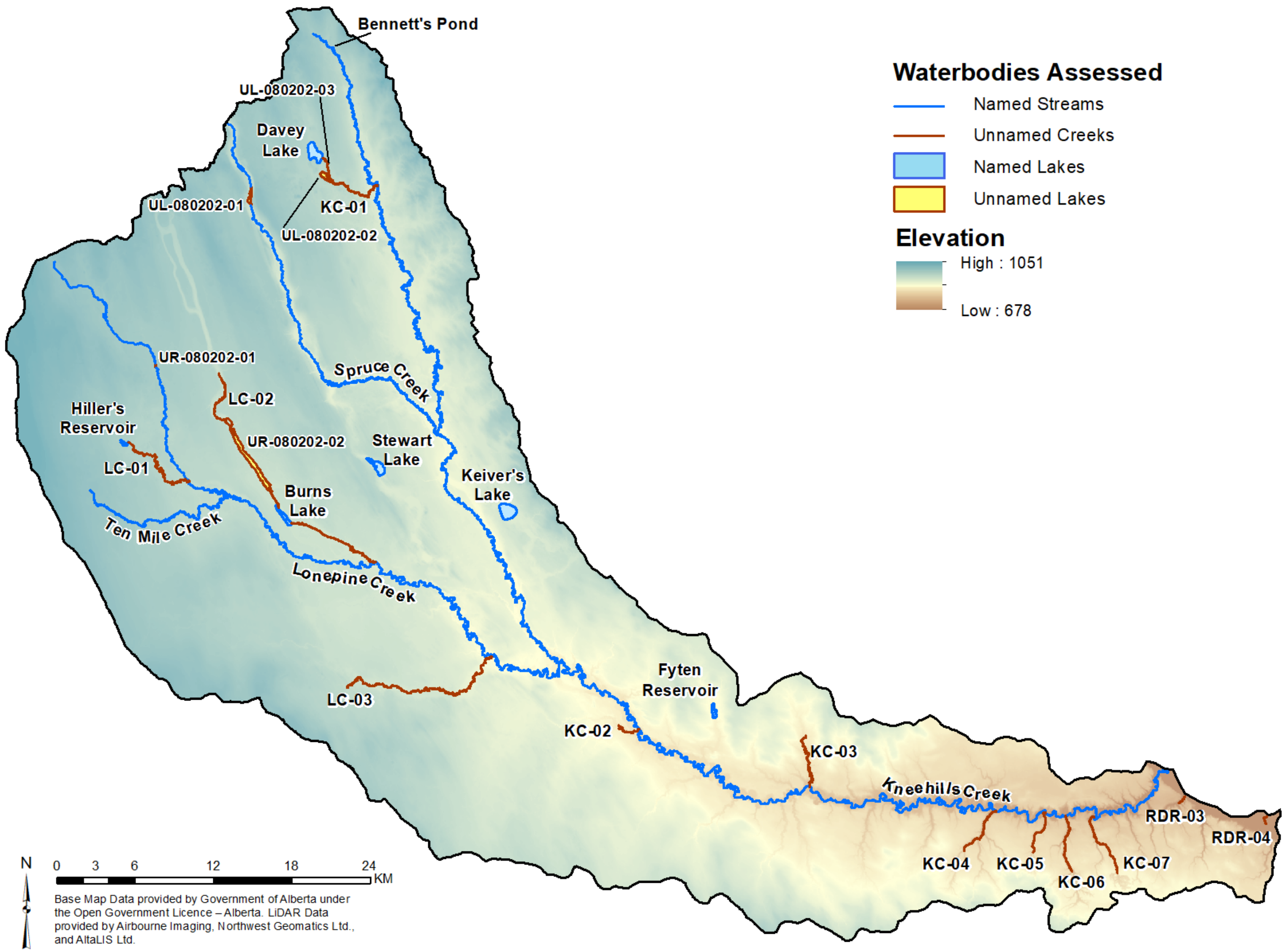


Figure 16. The proportion of the Kneehills subwatershed assigned to each land cover class. Land cover data is based on the 2020 Agriculture and Agri-Food Canada land cover.

Table 5. Waterbodies in the Kneehills subwatershed that were assessed as part of this project. The shoreline length listed for each stream represents the shoreline that was assessed on both the left and right banks.

Waterbody Name	Length of Shoreline Assessed (km)
Streams	
Kneehills Creek	429.0
Lonepine Creek	196.9
Spruce Creek	100.0
Ten Mile Creek	41.9
Unnamed Creeks (12)	189.9
Lakes & Reservoirs	
Bennett's Pond	0.7
Burns Lake	4.2
Davey Lake	4.7
Fyten Reservoir	3.2
Hiller's Reservoir	2.3
Keiver's Lake	4.1
Stewart Lake	4.7
Unnamed Lakes (5)	20.3
TOTAL	**1,001.9**



Map 10. Location of waterbodies that were assessed in the Kneehills subwatershed.

6.2. Riparian Management Area Intactness

Within the Kneehills subwatershed, a total of 1,002 km of shoreline was assessed, with only 6% (63 km) categorized as High Intactness, and 36% (360 km) assessed as Moderate Intactness (Figure 17). The remaining 58% of shoreline was categorized Low (16%, 157 km) or Very Low Intactness (42%, 422 km). Much of the shoreline categorized as High Intactness is located in the eastern portion of the subwatershed, where the lower reaches of Kneehills Creek drain into the Red Deer River (Map 11 and Map 12).

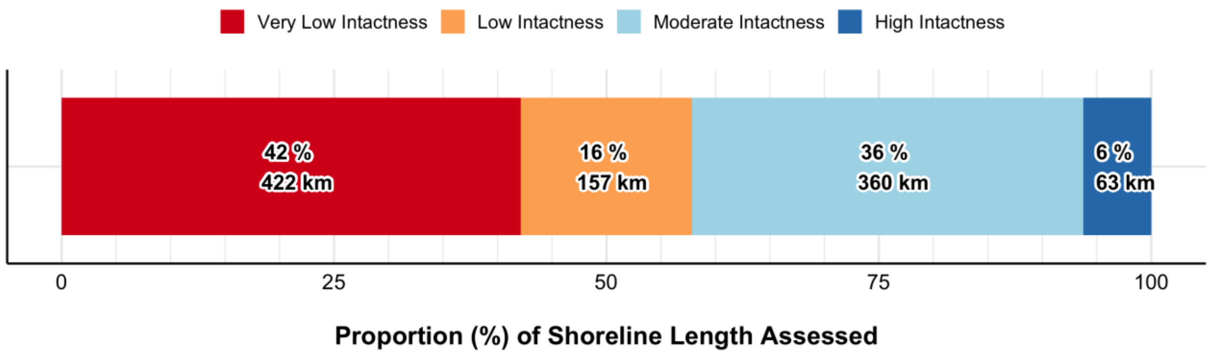


Figure 17. The total proportion and length of shoreline assigned to each riparian intactness category for all shoreline assessed in the Kneehills subwatershed.

All of the four named streams assessed in the Kneehills subwatershed had more than half of their shorelines assessed as either Low or Very Low Intactness, with Spruce Creek and Ten Mile Creek having more than 80% of their shorelines assessed as Low or Very Low Intactness (Figure 18). Spruce Creek had the greatest proportion (65%) of shoreline assessed as Very Low Intactness, while Lonepine Creek had then greatest length (105 km) of shoreline assessed as Very Low Intactness. All four streams had 5% or less of their shoreline assessed as High Intactness, although Kneehills Creek had 43% of its shoreline assessed as Moderate Intactness (Figure 18; Map 11 and Map 12).

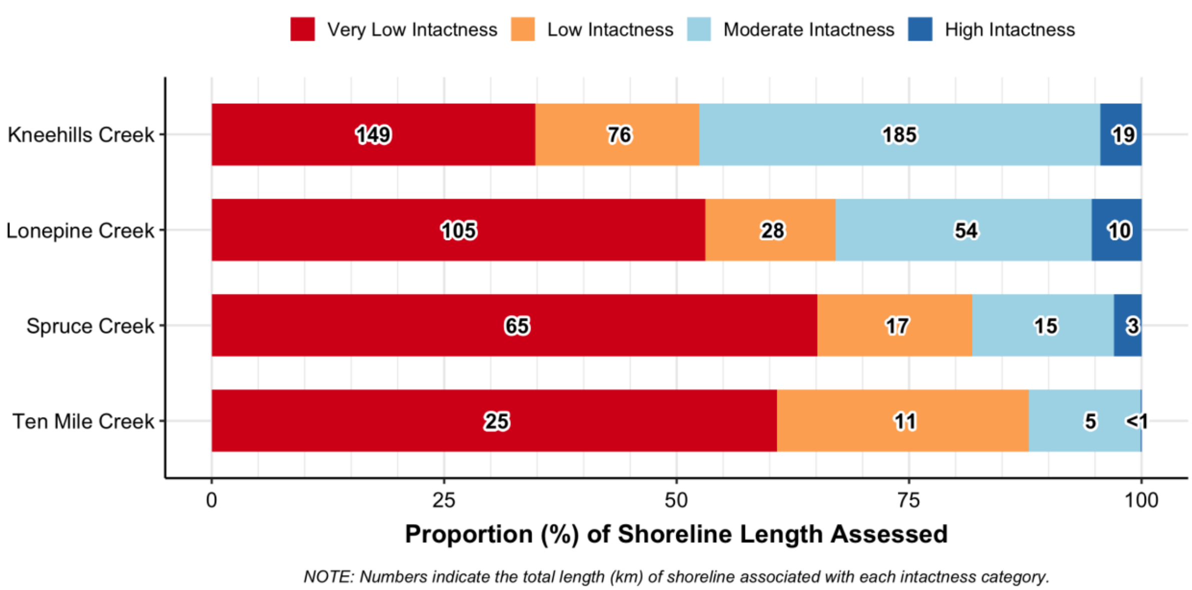


Figure 18. The total proportion of shoreline assigned to each riparian intactness category for named streams assessed in the Kneehills subwatershed.

Twelve unnamed creeks were assessed for intactness within this subwatershed, and of these, 8 (or 67%) had more than half of their shorelines assessed as High or Moderate Intactness (Figure 19; Map 11 and Map 12). Five of these, Kneehills Creek-05, -06, -07, and -08, and Red Deer River-03 had more than 85% of their shorelines assessed as High or Moderate Intactness. In contrast, four of the unnamed creeks had more than half of their shorelines assessed as Very Low or Low Intactness, with Kneehills Creek-02 having the greatest proportion (72%) of shoreline assessed as Very Low Intactness, and Lonepine Creek-03 having the greatest length (20 km) of shoreline assessed as Very Low Intactness (Figure 19).

Seven named lakes and five unnamed lakes and reservoirs were assessed in this subwatershed (Map 11). Named lakes varied in condition, with four of the lakes having more than half of their shorelines assessed as Low or Very Low Intactness (Figure 20). Of these, Burns Lake, Fyten Reservoir, and Hiller’s Reservoir had roughly 60% of their shoreline assessed as Very Low Intactness. Bennett’s Pond, Keiver’s Lake, and Steward Lake all had more than 80% of their shoreline assessed as High or Moderate Intactness, with Keiver’s Lake having the greatest proportion (88%) and length (4 km) of High Intactness shoreline.

Unnamed lakes and reservoirs were in relatively poor condition, with all of the unnamed lakes having more than half of their shoreline assessed as Very Low or Low Intactness (Figure 21). Of these, UL-080202-01 and UR-080202-01 had all of their shoreline assessed as Very Low or Low Intactness. UR-080202-02 had the greatest proportion and length of High Intactness (19%, 2 km) and Moderate Intactness (30%, 4 km) shoreline (Figure 21).

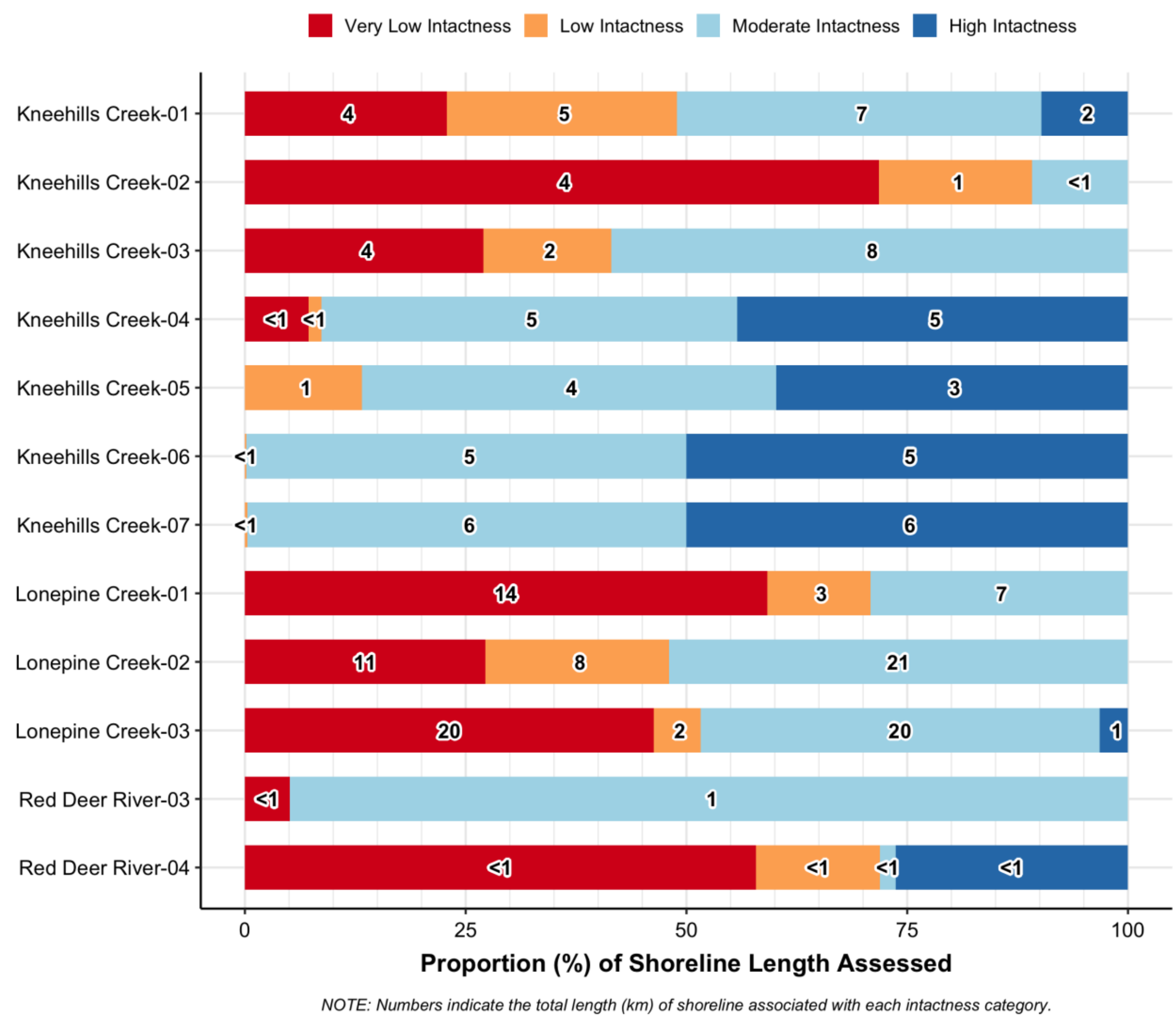


Figure 19. The total proportion of shoreline assigned to each riparian intactness category for unnamed creeks assessed in the Kneehills subwatershed.

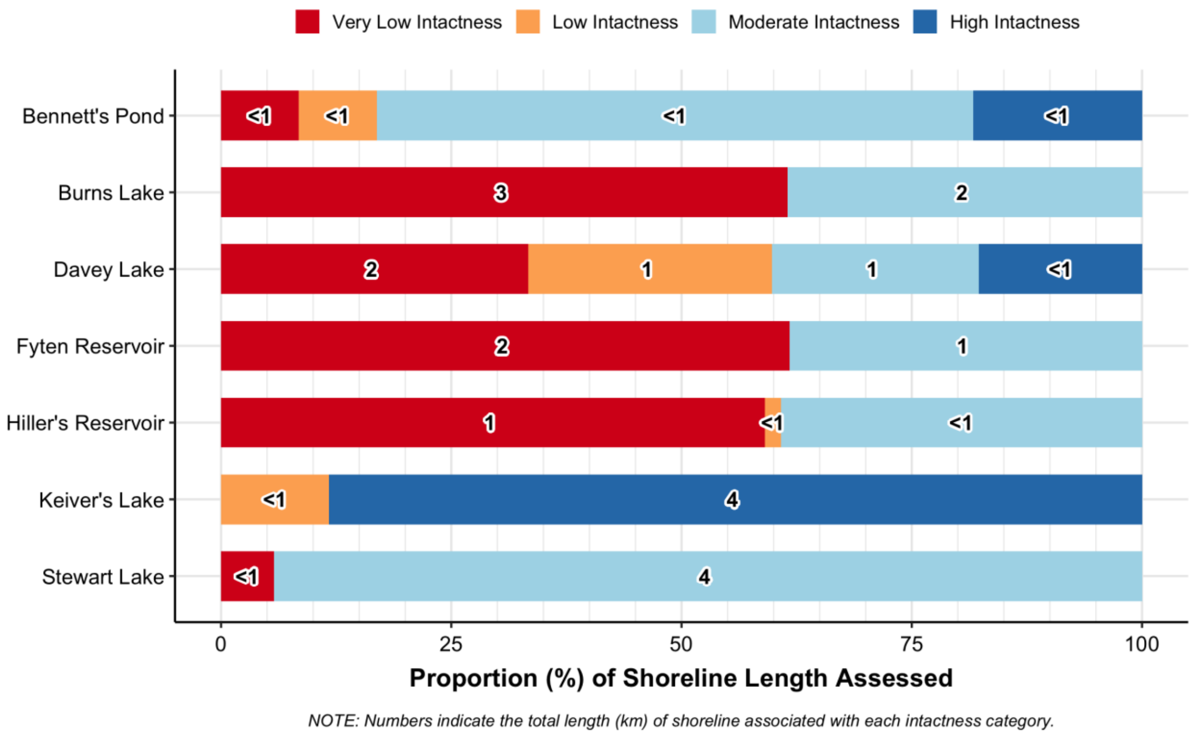


Figure 20. The total proportion of shoreline assigned to each riparian intactness category for named lakes assessed in the Kneehills subwatershed.

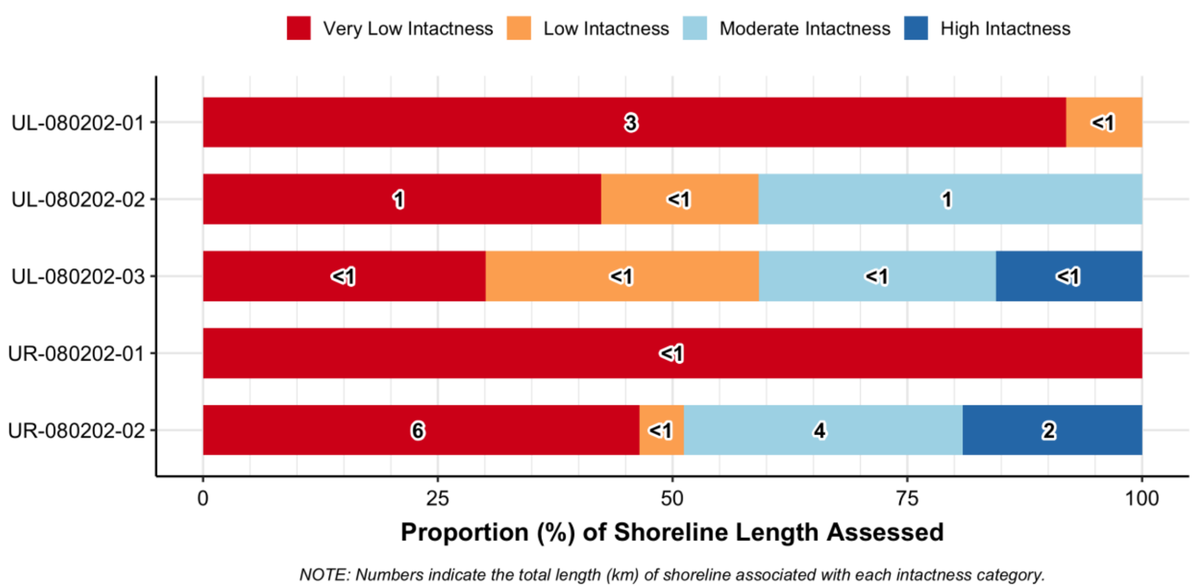
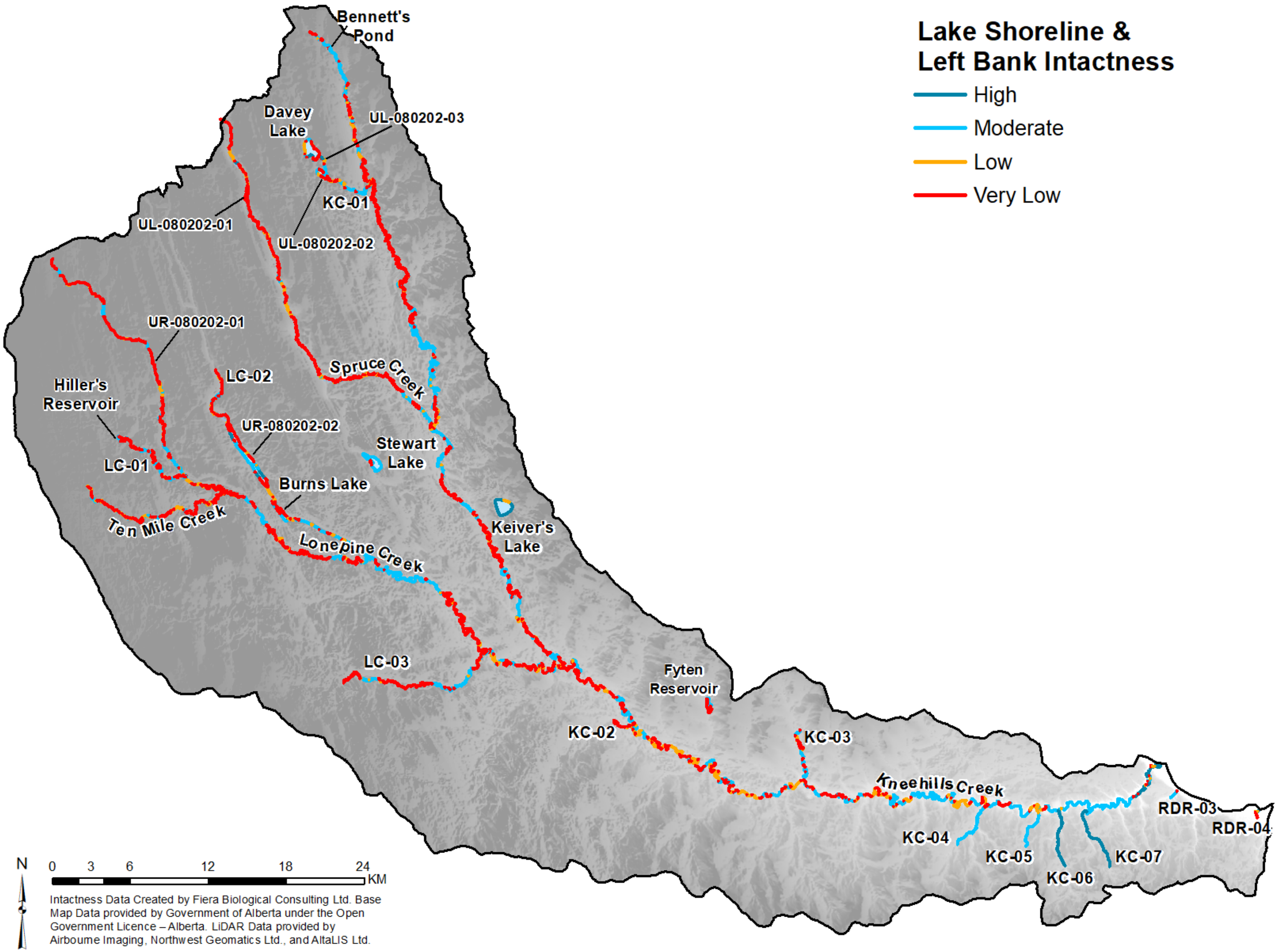
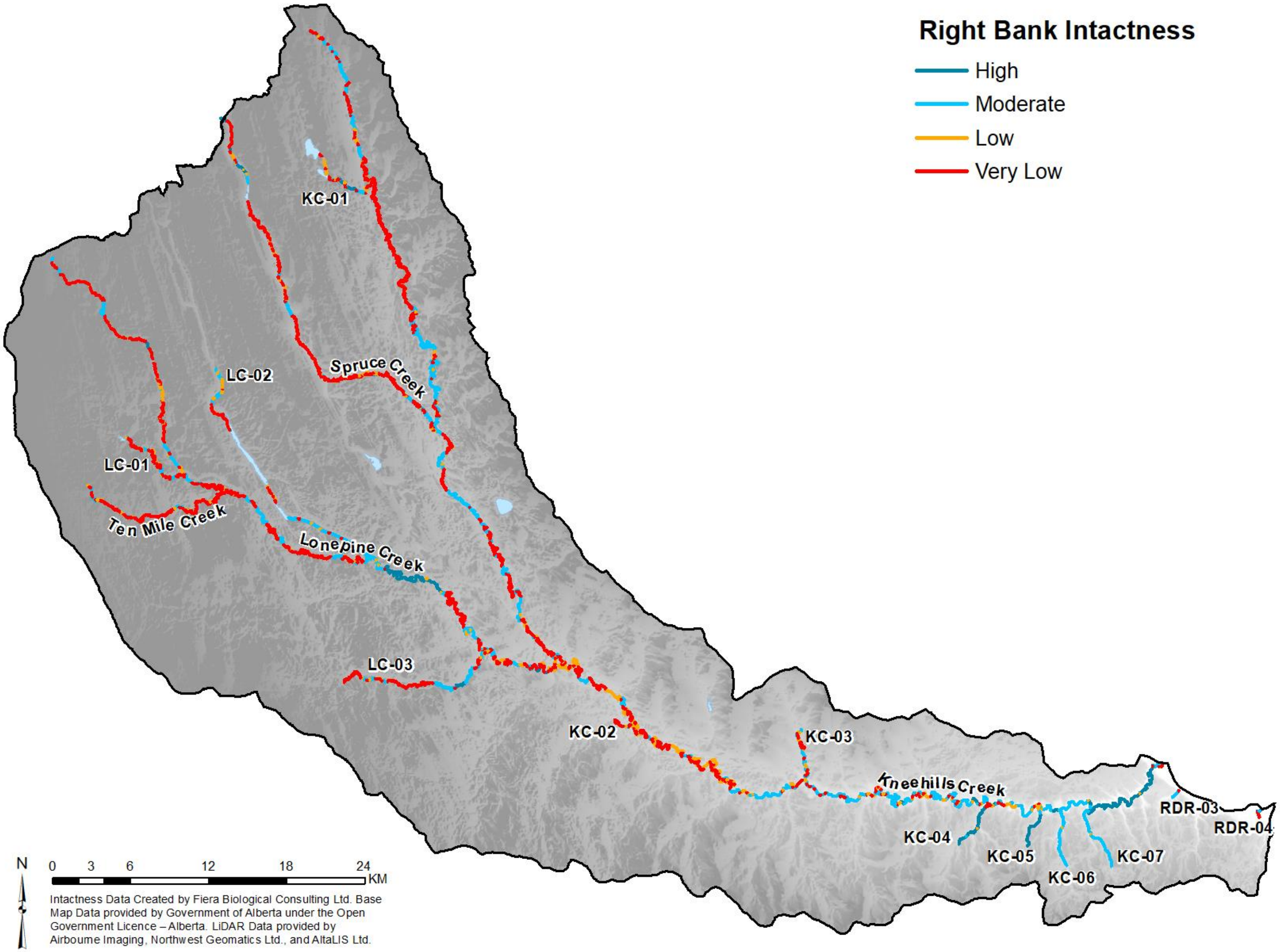


Figure 21. The total proportion of shoreline assigned to each riparian intactness category for unnamed lakes assessed in the Kneehills subwatershed.



Map 11. Intactness for the left banks of watercourses and lake shorelines that were assessed in the Kneehills subwatershed.



Map 12. Intactness for the right banks of watercourses that were assessed in the Kneehills subwatershed.

7.0 Little Red Deer Subwatershed Results

7.1. Shorelines of Interest

At almost 3,700 km^2, the Little Red Deer subwatershed is the largest and most westerly of the four watersheds assessed in this study. Located within the Lower Headwaters Zone of the Red Deer River watershed, this subwatershed drains to the Red Deer River, which flows downstream to the City of Red Deer. Given its location in the lower headwaters region, this subwatershed is important to both flood and drought resiliency of the larger river watershed. Just over 2,200 km of shoreline was assessed in the Little Red Deer subwatershed as part of this study, including 48 watercourses and 17 lakes and reservoirs (Table 6; Map 13 and Map 14). All but two of the waterbodies in this subwatershed were newly assessed as part of this project; two unnamed creeks, located in the northern-most part of the watershed, were previously assessed as part of the riparian assessment of the Medicine-Blindman Rivers HUC6 watershed that was conducted for the RDRWA in 2018 (Fiera Biological 2018e).

The majority of the Little Red Deer subwatershed is covered by natural land cover types (54%), with forest accounting for most of the natural cover (40%) and natural grassland making up an additional 11% (Figure 22). The remaining 46% of the subwatershed is covered by anthropogenic land cover types, with agriculture accounting for the majority of the human cover (43%). Natural cover is concentrated in the southwest portion of the watershed, and the land cover transitions to predominantly agriculture moving to the east and northeast.

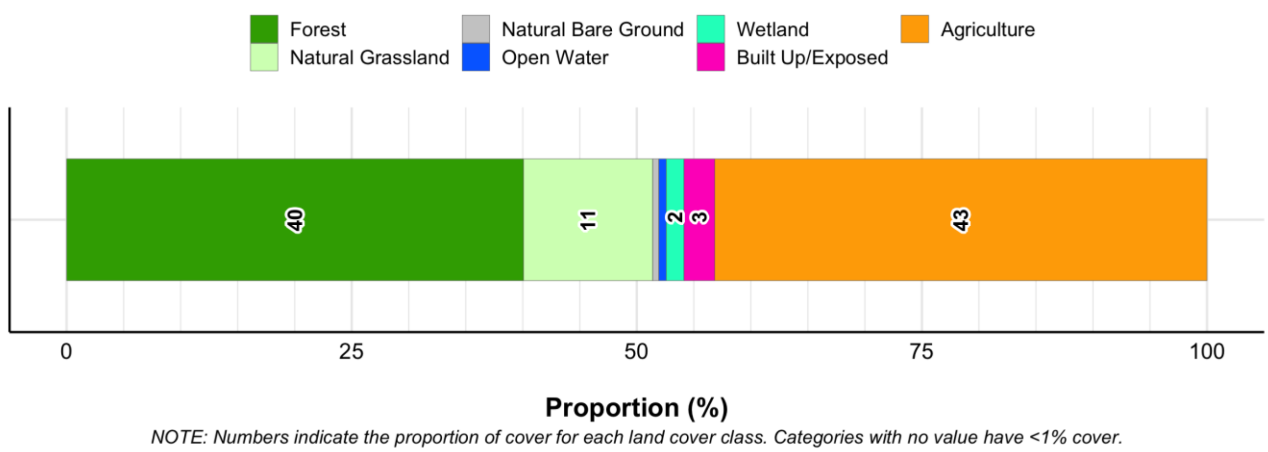


Figure 22. The proportion of the Little Red Deer subwatershed assigned to each land cover class. Land cover data is based on the 2020 Agriculture and Agri-Food Canada land cover.

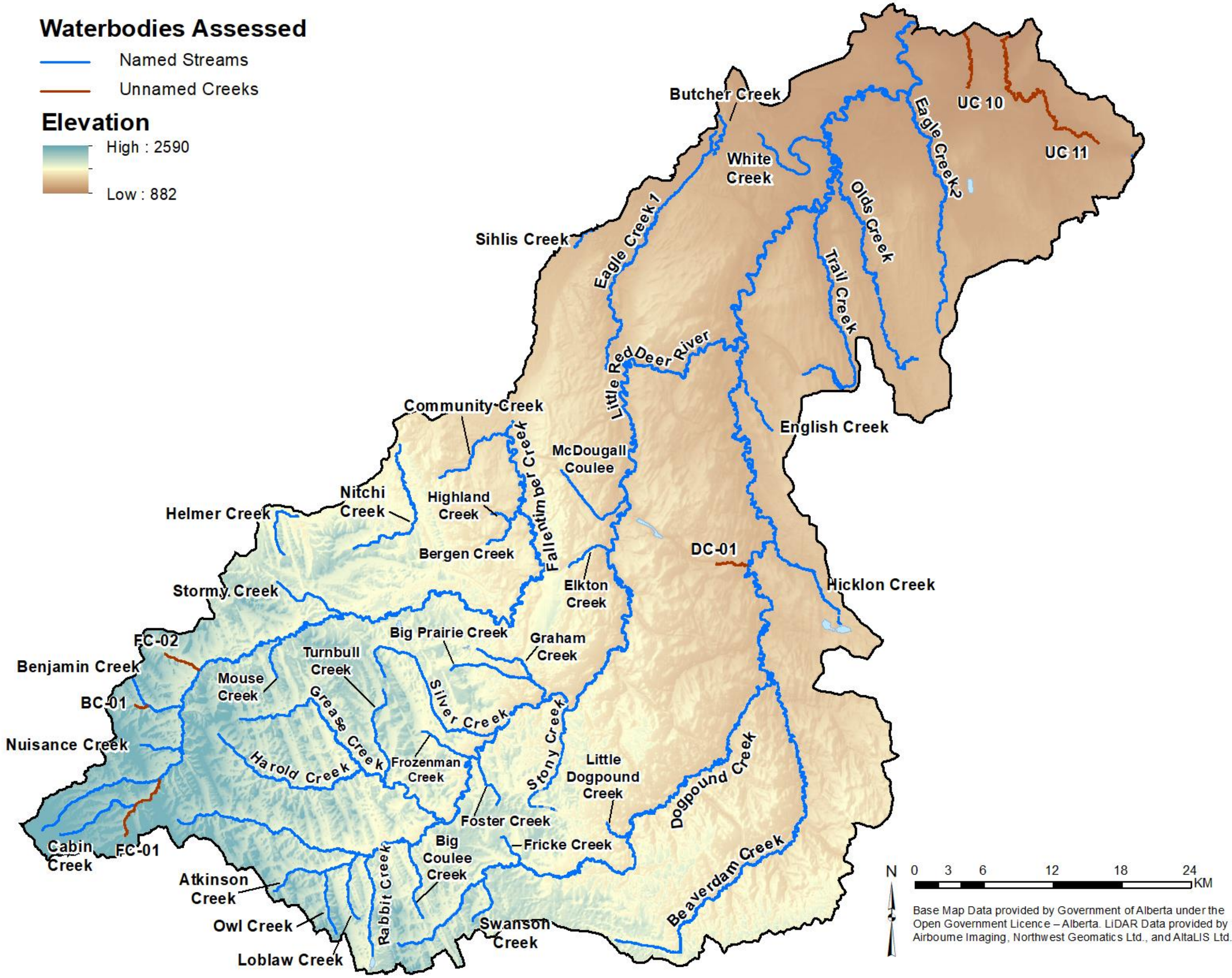
Table 6. Waterbodies in the Little Red Deer subwatershed that were assessed as part of this project. The shoreline length listed for each stream represents the shoreline that was assessed on both the left and right banks.

Waterbody Name	Length of Shoreline Assessed (km)
Streams	
Atkinson Creek	21.3
Beaverdam Creek	137
Benjamin Creek	14.7
Bergen Creek	8.9
Big Coulee Creek	16.8
Big Prairie Creek	26.1
Butcher Creek	10.5
Cabin Creek	19.3
Community Creek	20.2
Dogpound Creek	324.6
Eagle Creek 1	84
Eagle Creek 2	73.9
Elkton Creek	10.2
English Creek	13.5
Fallentimber Creek	223
Foster Creek	10.1
Fricke Creek	7.3
Frozenman Creek	11.7
Graham Creek	14.8
Grease Creek	72.9
Harold Creek	47.1
Helmer Creek	13.3
Hicklon Creek	31.7
Highland Creek	9.1
Little Dogpound Creek	6.9
Little Red Deer River	425.6
Loblaw Creek	11.4
McDougall Coulee	18.2
Mouse Creek	9.3
Nitchi Creek	39.6
Nuisance Creek	8.2
Olds Creek	71.9
Owl Creek	12.2
Rabbit Creek	20.5
Sihlis Creek	8.2
Silver Creek	41.2
Stony Creek	26.5
Stormy Creek	17.4
Swanson Creek	9.9
Trail Creek	61
Turnbull Creek	22.2
White Creek	29.3
Unnamed Creeks (6)	114.2

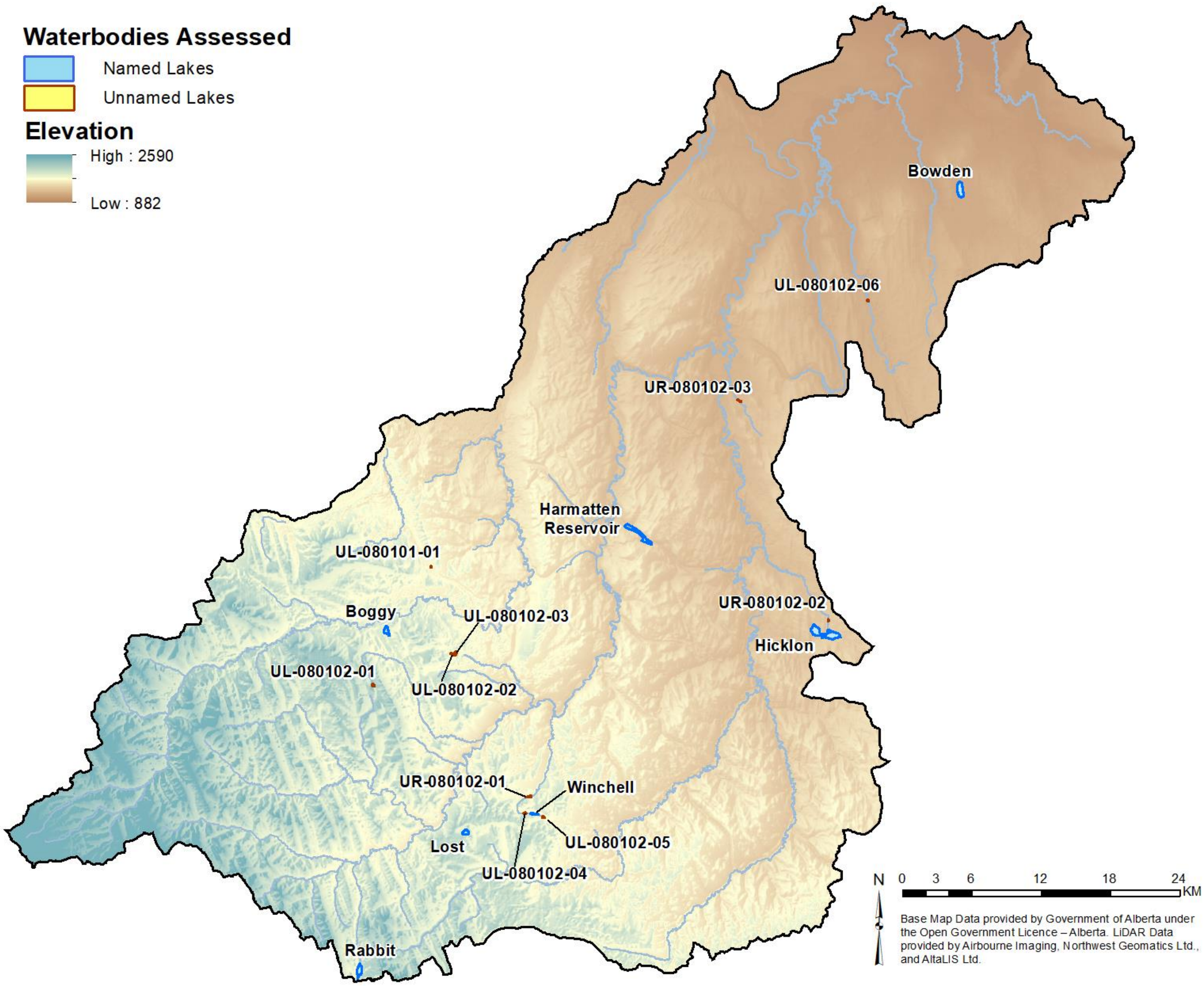
Continued …

Table 6 *continued*. Waterbodies in the Little Red Deer subwatershed that were assessed as part of this project. The shoreline length listed for each stream represents the shoreline that was assessed on both the left and right banks.

Waterbody Name	Length of Shoreline Assessed (km)
Lakes & Reservoirs	
Boggy Lake	2.2
Bowden Lake	3.2
Harmatten Reservoir	6.4
Hicklon Lake	7.8
Lost Lake	1.5
Rabbit Lake	3.0
Winchell Lake	1.4
Unnamed Lakes (10)	7.9
TOTAL	**2,208.5**



Map 13. Location of named streams and unnamed creeks that were assessed in the Little Red Deer subwatershed.



Map 14. Location of named and unnamed lakes that were assessed in the Little Red Deer subwatershed.

7.2. Riparian Management Area Intactness

Just over half (55%, 1,226 km) of the shoreline in the Little Red Deer subwatershed was categorized as High Intactness, with an additional 18% (387 km) assessed as Moderate Intactness (Figure 23). The remaining 27% of shoreline was categorized as either Low (9%, 203 km) or Very Low Intactness (18%, 393 km). High Intactness shoreline tended to be associated with the western half of the subwatershed, while shorelines classified as Very Low Intactness were primarily associated with the eastern half of the subwatershed where agriculture is the dominant land use (Map 15-Map 17).

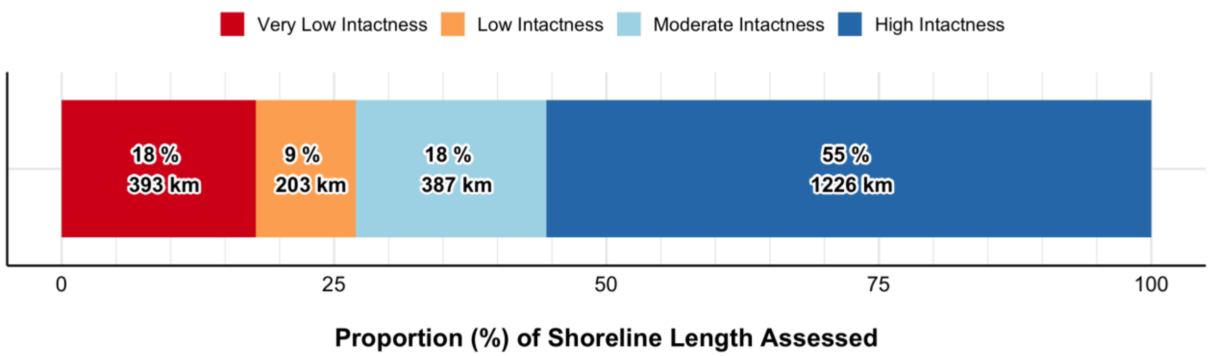


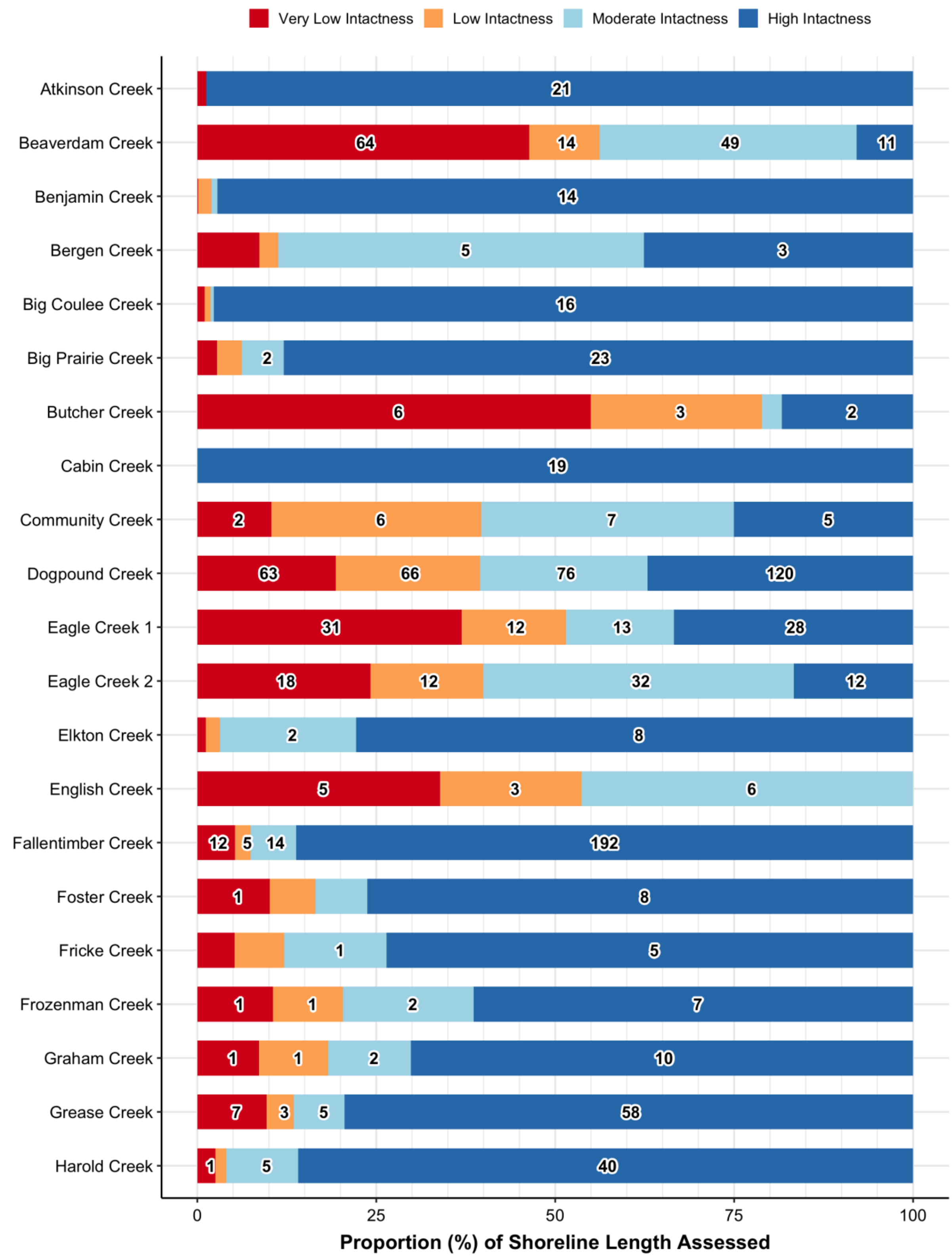
Figure 23. The total proportion and length of shoreline assigned to each riparian intactness category for all shoreline assessed in the Little Red Deer subwatershed.

A total of 42 named streams were assessed in the Little Red Deer subwatershed (Map 15 and Map 16), with 29 (or 69%) of these waterbodies having more than 75% of their shorelines assessed as either Moderate or High Intactness (Figure 24). Seven of the named streams, including Atkinson Creek, Benjamin Creek, Big Coulee Creek, Cabin Creek, Loblaw Creek, Mouse Creek, and Stormy Creek were highly intact, with 95% or more of their shorelines classified as High Intactness. Conversely, seven of the named streams, including Beaverdam Creek, Butcher Creek, Eagle Creek 1, English Creek, Hicklon Creek, Olds Creek, and Trail Creek had over 50% of shoreline assessed as Low or Very Low Intactness. Hicklon Creek had the greatest proportion (54%) of Very Low Intactness shoreline and Beaverdam Creek had the greatest length (64 km) of Very Low Intactness shoreline.

Unnamed creeks assessed within this subwatershed were in relatively good condition (Map 15 and Map 16). All six unnamed creeks had greater than 50% of their shoreline assessed as High or Moderate Intactness, and of these, four had more than half of their shorelines assessed as High Intactness (Figure 25). Fallentimber Creek-01 had the greatest proportion (98%) of High Intactness shoreline. In contrast, three of the unnamed creeks had 25% or more of their shorelines assessed as Very Low or Low Intactness. Unnamed Creek-10 had the greatest proportion (28%) of Very Low Intactness, while Unnamed Creek had the greatest length (15 km) of shoreline assessed as Very Low Intactness.

Named lakes assessed within this subwatershed were also in relatively good condition (Map 17). Four of the seven lakes assessed, Boggy Lake, Lost Lake, Rabbit Lake, and Winchell Lake, had 100% of their shoreline assessed as High Intactness, and Bowden Lake had 71% of its shoreline assessed Moderate Intactness (Figure 26Figure 14). Conversely, Harmatten Reservoir and Hicklon Lake had greater than 50% of their shorelines assessed as Very Low or Low Intactness. Of these, Harmatten Reservoir had the greatest proportion (57%) of shoreline assessed as Very Low Intactness, although Hicklon had the greatest proportion (86%) of shoreline assessed as Very Low and Low Intactness (Figure 26).

Unnamed lakes and reservoirs varied in condition, with five of the ten waterbodies having greater than 75% of their shoreline assessed as High or Moderate Intactness (Figure 27). Of these, three had 100% of their shoreline assessed as High Intactness. The other five waterbodies all had more than 25% of their shoreline assessed as either Very Low or Low Intactness, with two waterbodies, UL-080202-06 and UR-080102-02, having 100% of their shoreline assessed as Very Low or Low Intactness (Map 17).



NOTE: Numbers indicate the total length (km) of shoreline associated with each intactness category.
Categories with no label contain <1 km of shoreline.

Figure 24. The total proportion of shoreline assigned to each riparian intactness category for named streams assessed in the Little Red Deer subwatershed.

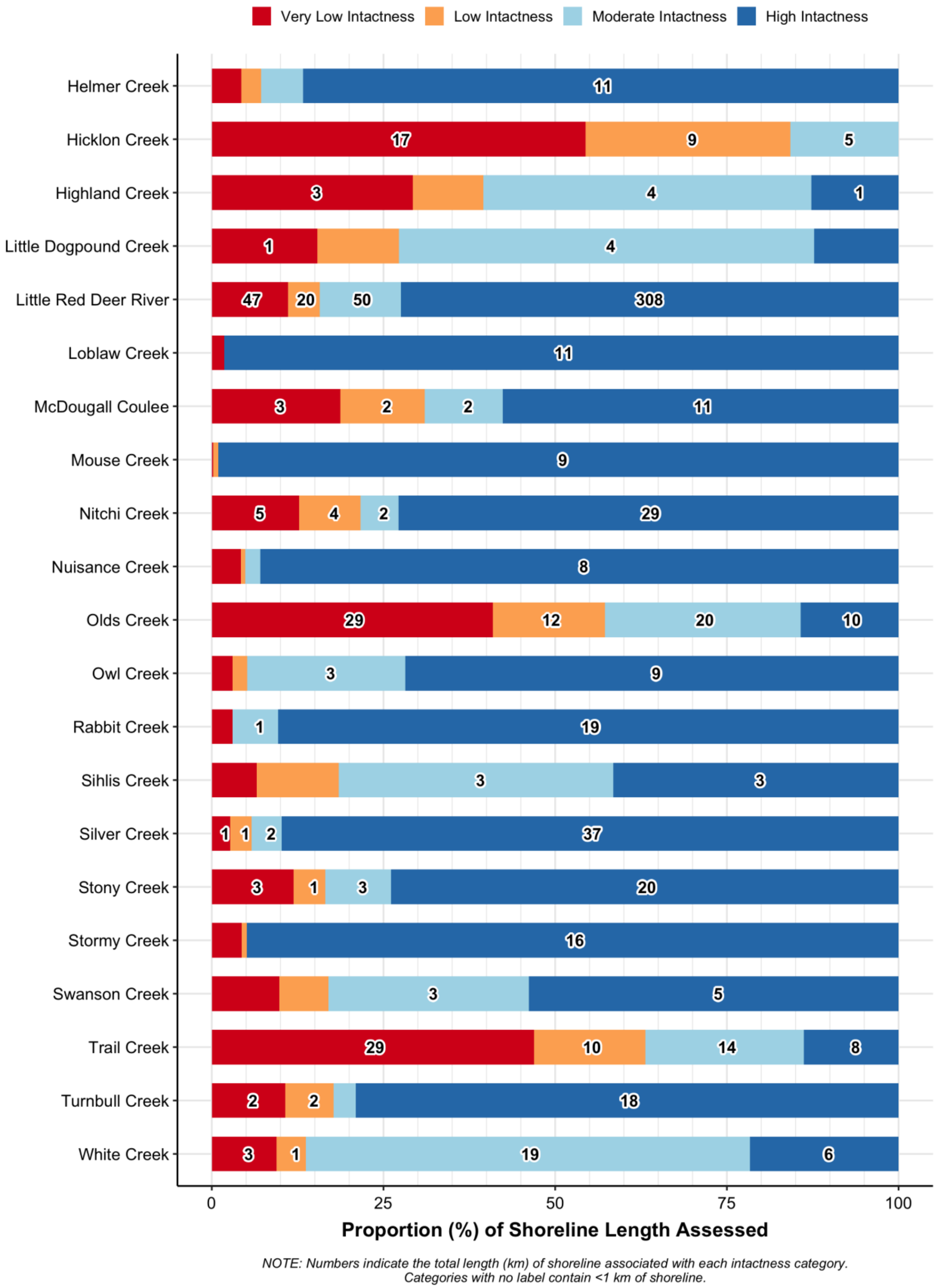
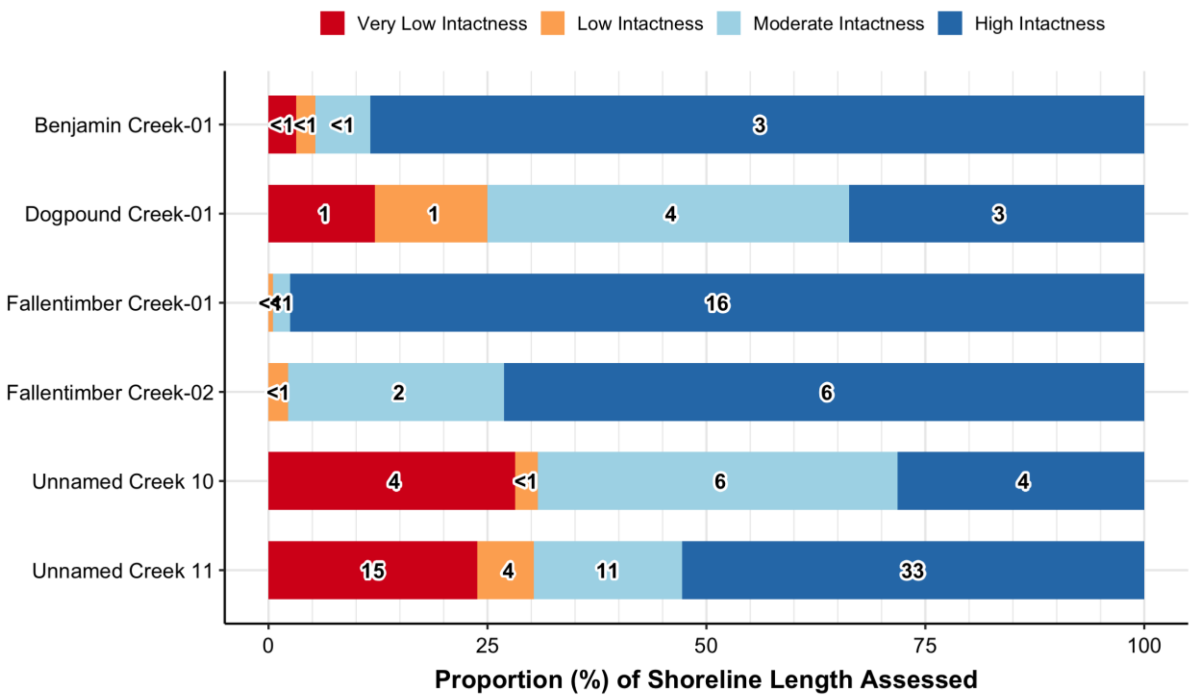
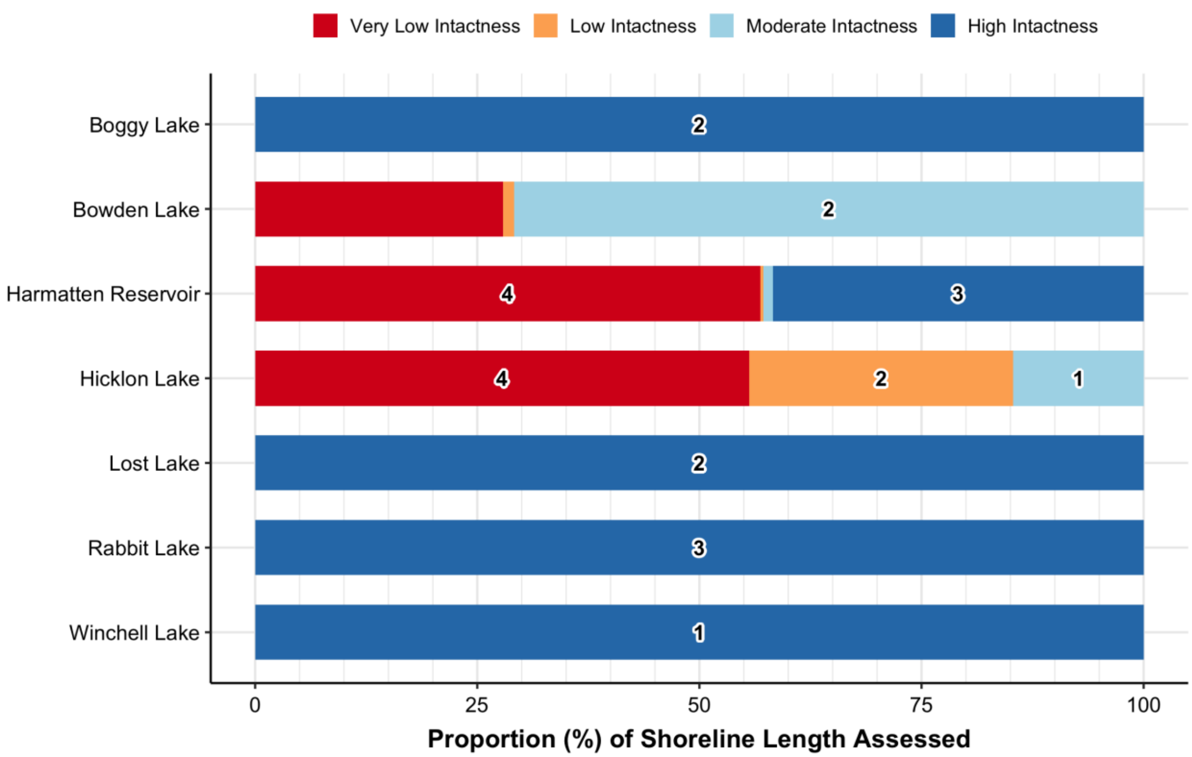


Figure 24 continued. The total proportion of shoreline assigned to each riparian intactness category for named streams assessed in the Little Red Deer subwatershed.



NOTE: Numbers indicate the total length (km) of shoreline associated with each intactness category.

Figure 25. The total proportion of shoreline assigned to each riparian intactness category for unnamed creeks assessed in the Little Red Deer subwatershed.



NOTE: Numbers indicate the total length (km) of shoreline associated with each intactness category.
Categories with no label contain <1 km of shoreline.

Figure 26. The total proportion of shoreline assigned to each riparian intactness category for named lakes assessed in the Little Red Deer subwatershed.

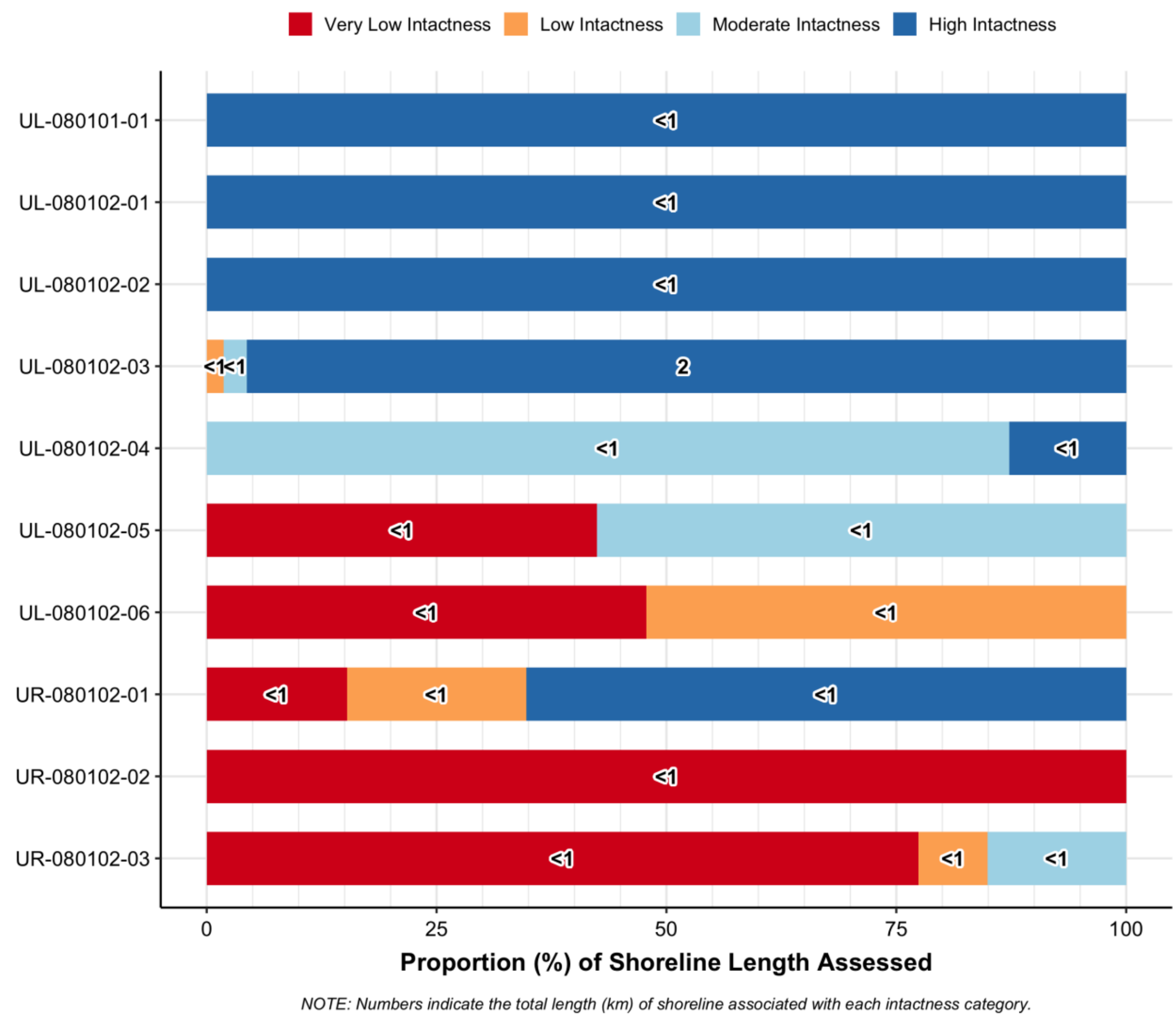
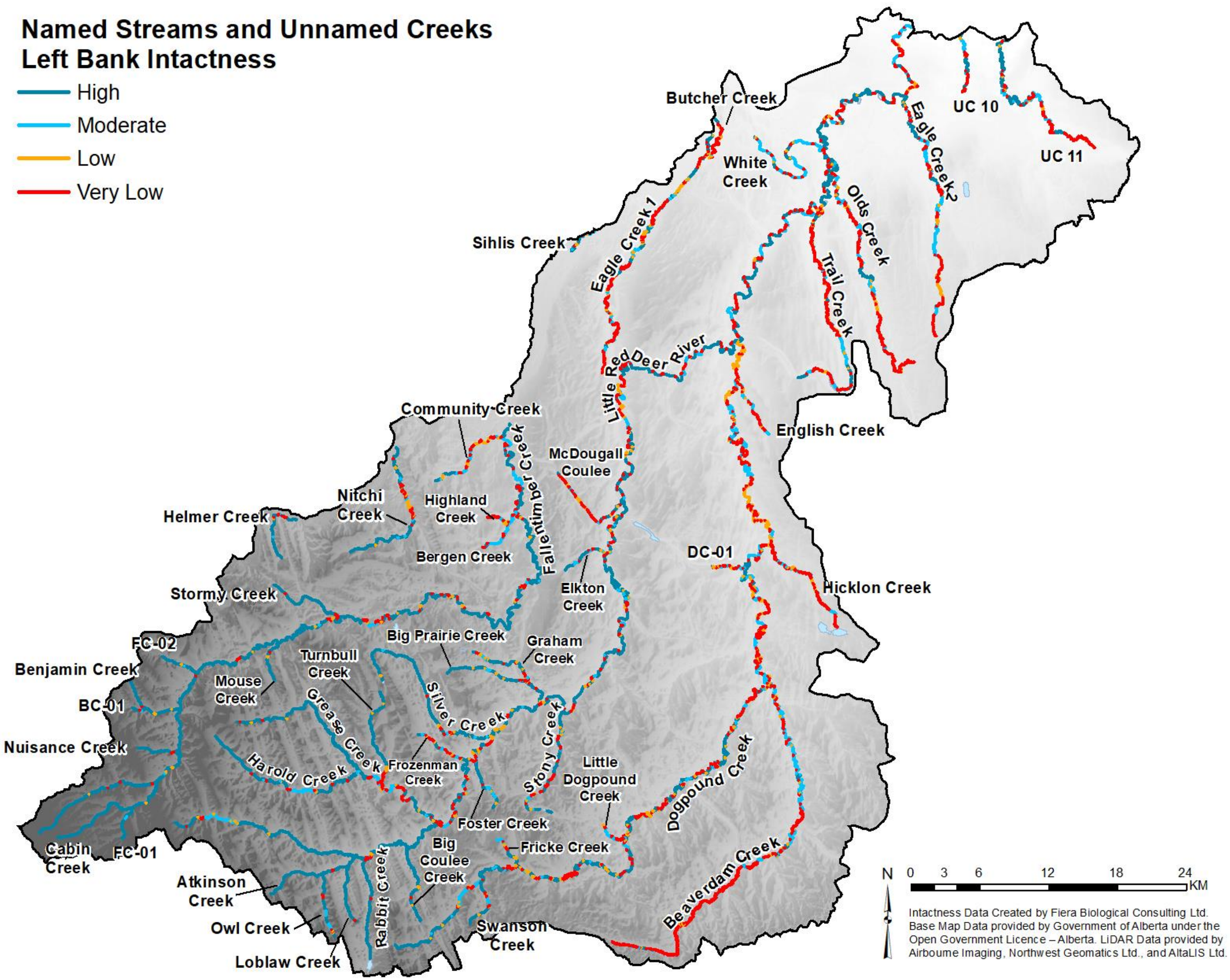
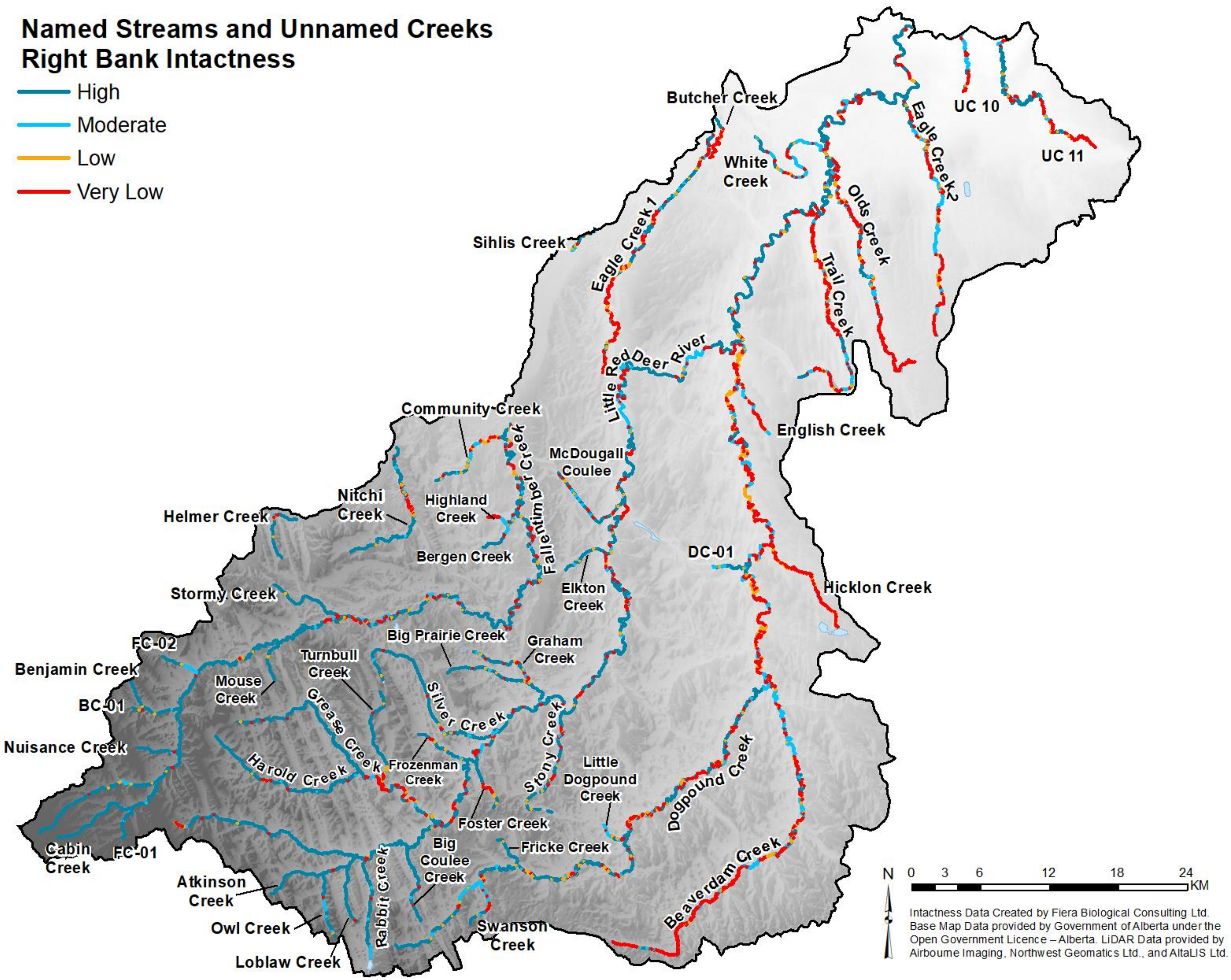


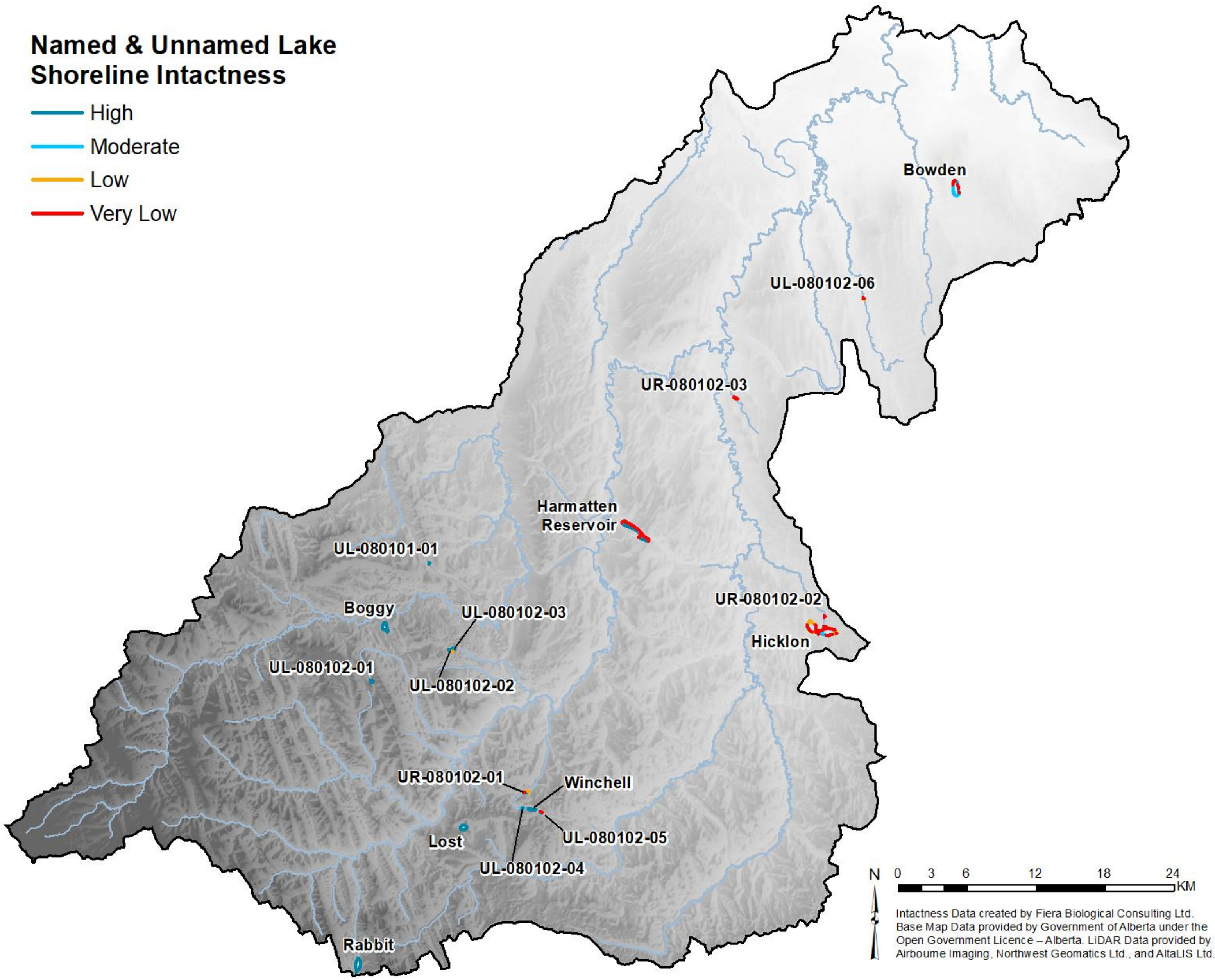
Figure 27. The total proportion of shoreline assigned to each riparian intactness category for unnamed lakes assessed in the Little Red Deer subwatershed.



Map 15. Intactness for the left banks of named streams and unnamed creeks that were assessed in the Little Red Deer subwatershed.



Map 16. Intactness for the right banks of named streams and unnamed creeks that were assessed in the Little Red Deer subwatershed.



Map 17. Intactness for the shoreline of named and unnamed lakes that were assessed in the Little Red Deer subwatershed.

8.0 Threehills Subwatershed Results

8.1. Shorelines of Interest

The Threehills subwatershed, which is approximately 3,004 km^2 in size, occurs primarily within the Parkland Natural Region, but transitions to the Grassland Natural Region at its southern extent. A large majority (74%) of this subwatershed is covered by anthropogenic land cover types, with agriculture accounting for most of the human cover (71%) (Figure 28). The remaining 26% of the subwatershed is covered by natural cover types, with forest (9%) and natural grassland (8%) being present in roughly equal amounts. Natural cover is concentrated within the northern portion of the watershed, as well as along the southern banks of Threehills and Ghostpine Creeks. Agriculture predominates elsewhere throughout the watershed.

In the Threehills subwatershed, 1,165 km of shoreline was assessed, including 20 watercourses and 12 lakes and reservoirs (Table 7; Map 18). All of these waterbodies were assessed as part of this project, as no previous satellite-based riparian assessments have been completed in this subwatershed to-date.

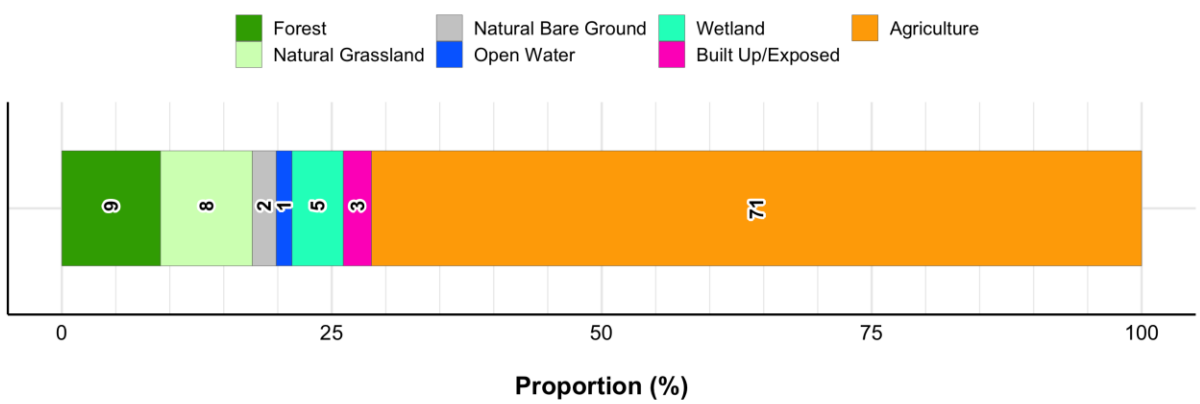
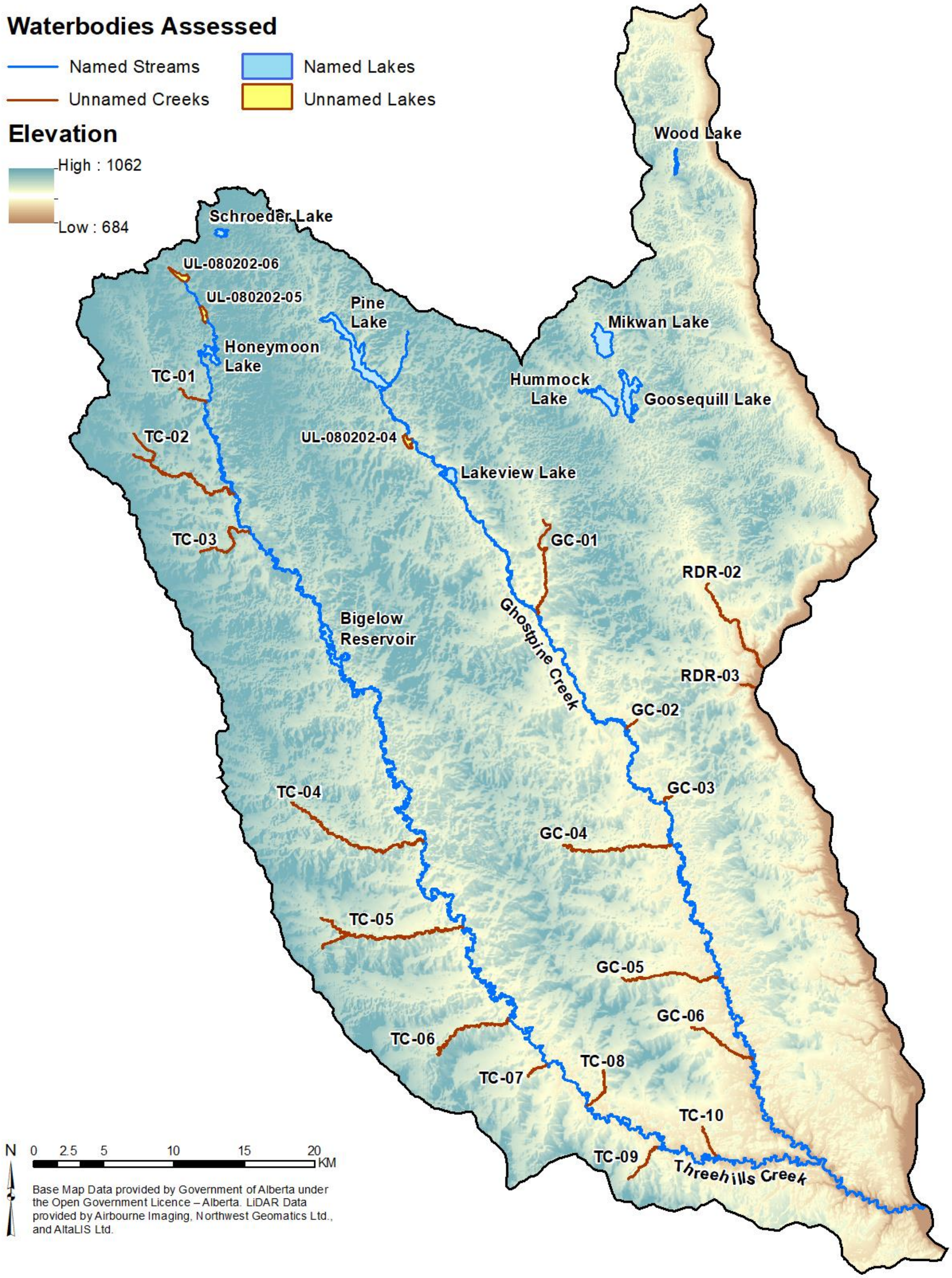


Figure 28. The proportion of the Threehills subwatershed assigned to each land cover class. Land cover data is based on the 2020 Agriculture and Agri-Food Canada land cover.

Table 7. Waterbodies in the Threehills subwatershed that were assessed as part of this project. The shoreline length listed for each stream represents the shoreline that was assessed on both the left and right banks.

Waterbody Name	Length of Shoreline Assessed (km)
Streams	
Ghostpine Creek	309.7
Threehills Creek	449.3
Unnamed Creeks (18)	312.1
Lakes & Reservoirs	
Bigelow Reservoir	13.3
Goosequill Lake	14.1
Honeymoon Lake	6.4
Hummock Lake	9.9
Lakeview Lake	4.3
Mikwan Lake	7.1
Pine Lake	20.4
Schroeder Lake	3.8
Wood Lake	4.3
Unnamed Lakes (3)	10.3
TOTAL	**1,165.0**



Map 18. Location of waterbodies that were assessed in the Threehills subwatershed.

8.2. Riparian Management Area Intactness

A total of 1,164 km of shoreline was assessed within the Threehills subwatershed, with only 10% (115 km) categorized as High Intactness, and an additional 32% (369 km) assessed as Moderate Intactness (Figure 29). The remaining 59% of shoreline was categorized Low (15%, 171 km) or Very Low Intactness (44%, 509 km). High Intactness shoreline is generally associated with the southern-most lower reaches of Threehills Creek, where it drains into the Red Deer River, and with lakes (Map 19 and Map 20). Shorelines rated as Very Low Intactness are generally associated with areas dominated by agricultural land use.

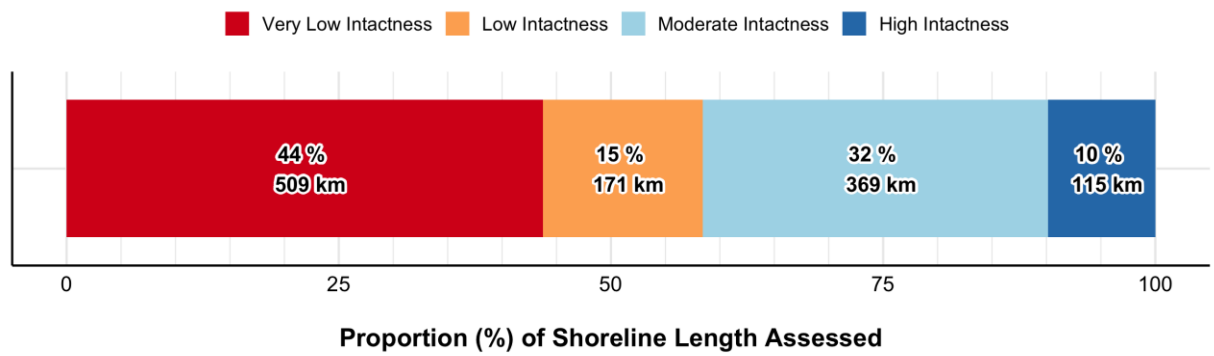


Figure 29. The total proportion and length of shoreline assigned to each riparian intactness category for all shoreline assessed in the Threehills subwatershed.

Two named streams were assessed in the Threehills subwatershed: Ghostpine Creek and Threehills Creek (Map 19 and Map 20). Both of these creeks had more than half of their shorelines assessed as Low or Very Low Intactness, with Threehills Creek having the greatest proportion (55%) and length (249 km) of shoreline assessed as Very Low Intactness (Figure 30). Ghostpine Creek had 48% of its shoreline assessed as High or Moderate Intactness, although only 3% (11 km) was categorized as High Intactness.

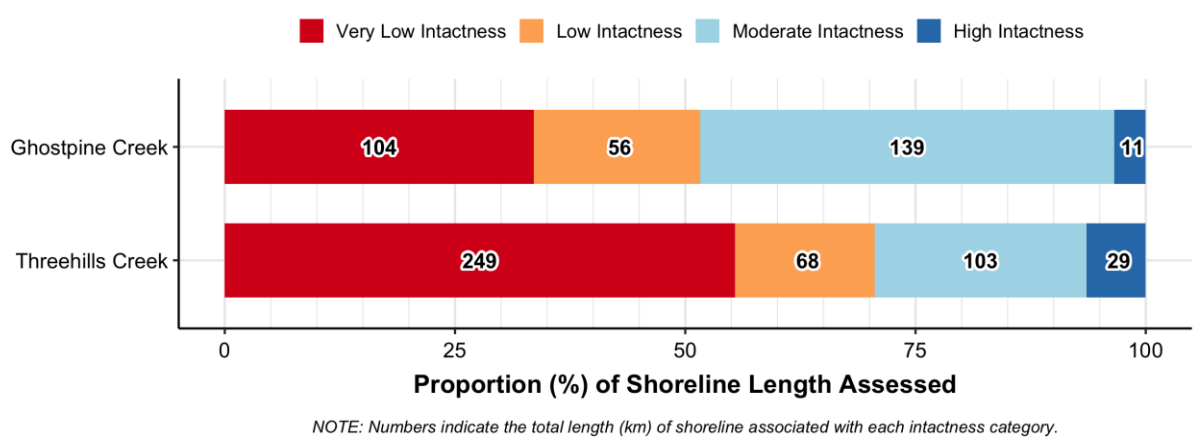


Figure 30. The total proportion of shoreline assigned to each riparian intactness category for named streams assessed in the Threehills subwatershed.

Eighteen unnamed creeks were assessed for intactness within this subwatershed (Map 19 and Map 20). Ten (or 47%) of the unnamed creeks had over half of their shorelines assessed as High or Moderate Intactness; however, with the exception of Red Deer River-03, the majority of these watercourses had a higher proportion of shoreline classified as Moderate than High Intactness (Figure 31). In contrast, eight of the unnamed creeks had more than half of their shorelines assessed as Very Low Intactness, with seven of these creeks having more than 75% of their shorelines classified as either Low or Very Low Intactness. Threehills Creek-03 had the greatest proportion (94%) of shoreline assessed as Very Low Intactness, while Threehills Creek-05 had the greatest length (33 km) of shoreline assessed as Very Low Intactness.

Of the named lakes and reservoirs assessed in this subwatershed, seven (78%) had more than half of their shoreline assessed as High or Moderate Intactness (Figure 32; Map 20). Of these, Goosequill Lake, Mikwan Lake, and Wood Lake all had greater than 95% of their shorelines assessed as High Intactness, with Goosequill Lake having the greatest proportion (~100%) and length (14 km) of High Intactness shoreline. In contrast, Bigelow Reservoir and Lakeview Lake had more than half of their shorelines assessed as Very Low or Low Intactness. Bigelow Reservoir had the greatest proportion (67%) and length (9km) of shoreline assessed as Very Low Intactness (Figure 32).

Unnamed lakes were in relatively good condition, with all three having greater than 65% of their shoreline assessed as High or Moderate Intactness. UL-080202-06 had the greatest proportion (75%) and length (3 km) of shoreline assessed as High Intactness (Figure 33). All three unnamed lakes had roughly the same proportion(~20%) of shoreline assessed as Very Low Intactness.

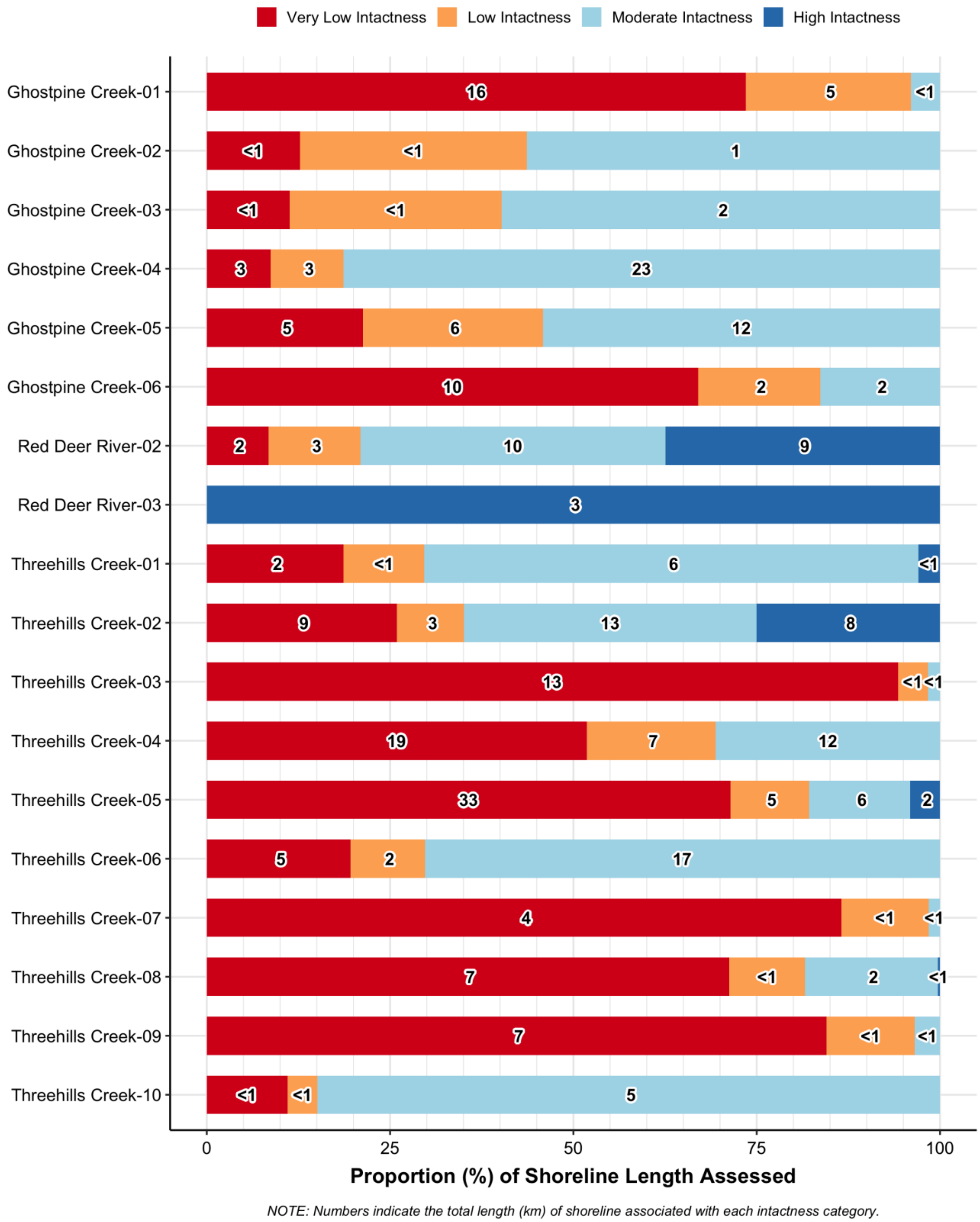


Figure 31. The total proportion of shoreline assigned to each riparian intactness category for unnamed creeks assessed in the Threehills subwatershed.

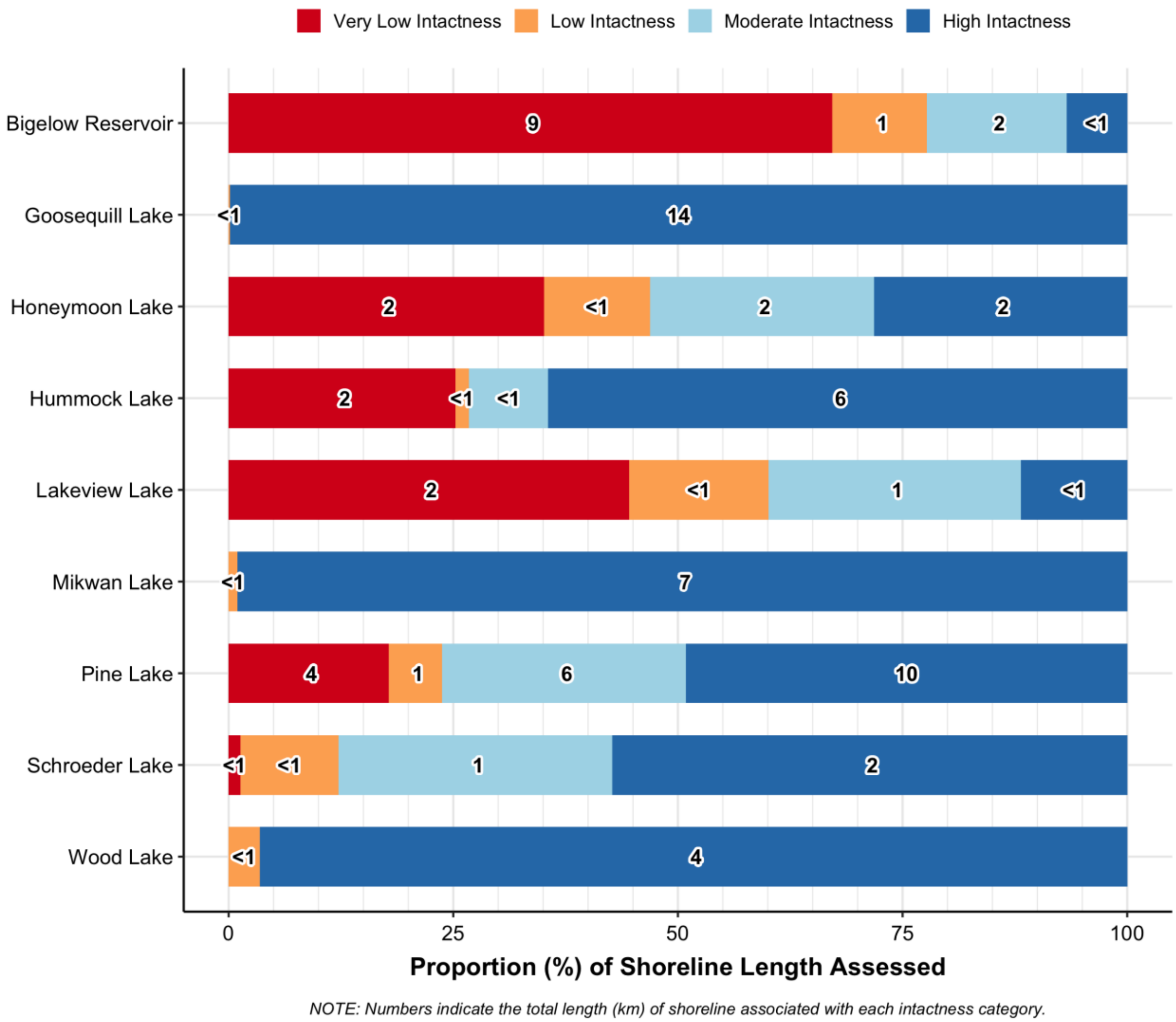


Figure 32. The total proportion of shoreline assigned to each riparian intactness category for named lakes assessed in the Threehills subwatershed.

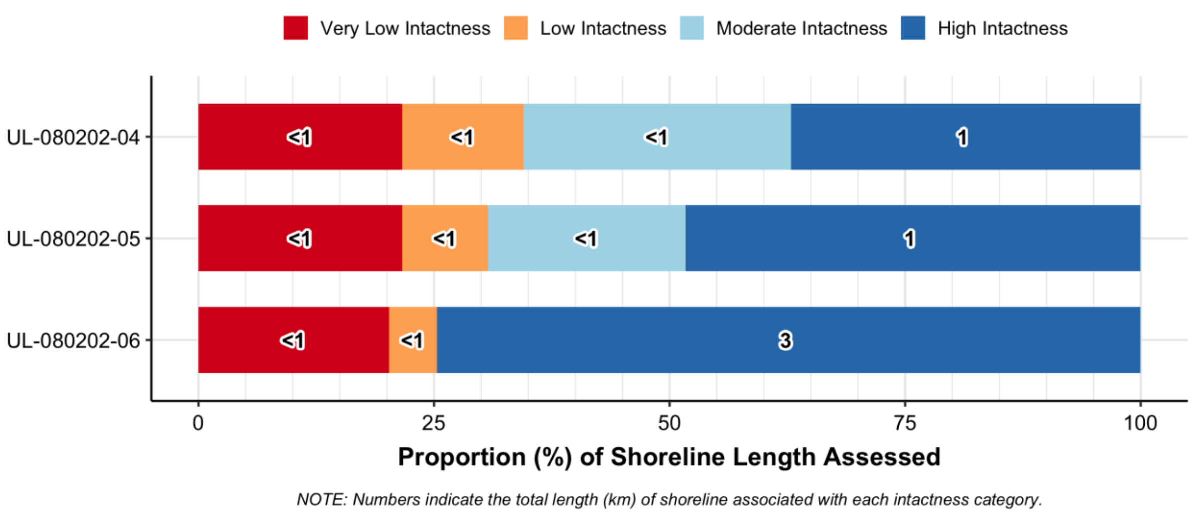
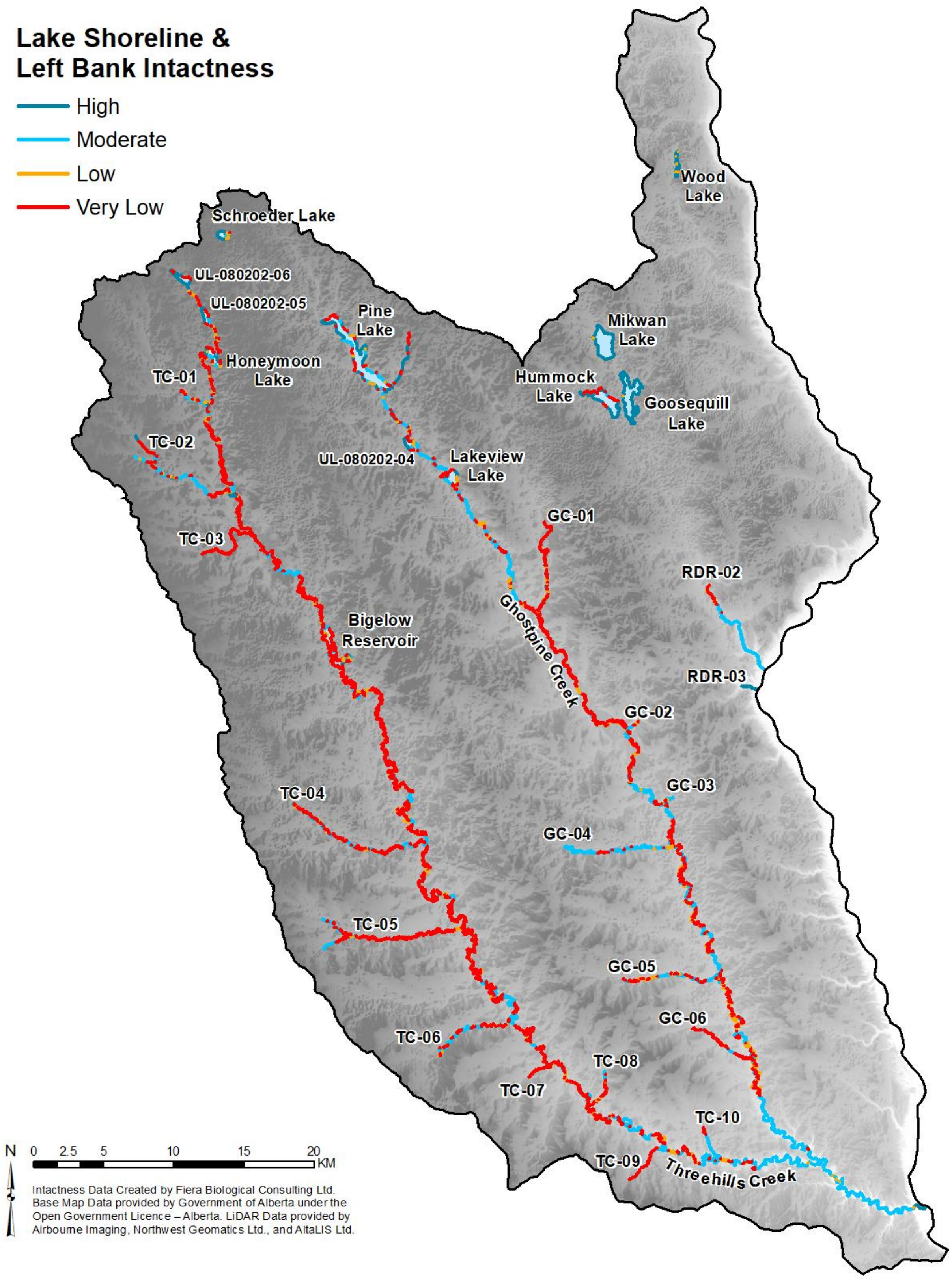
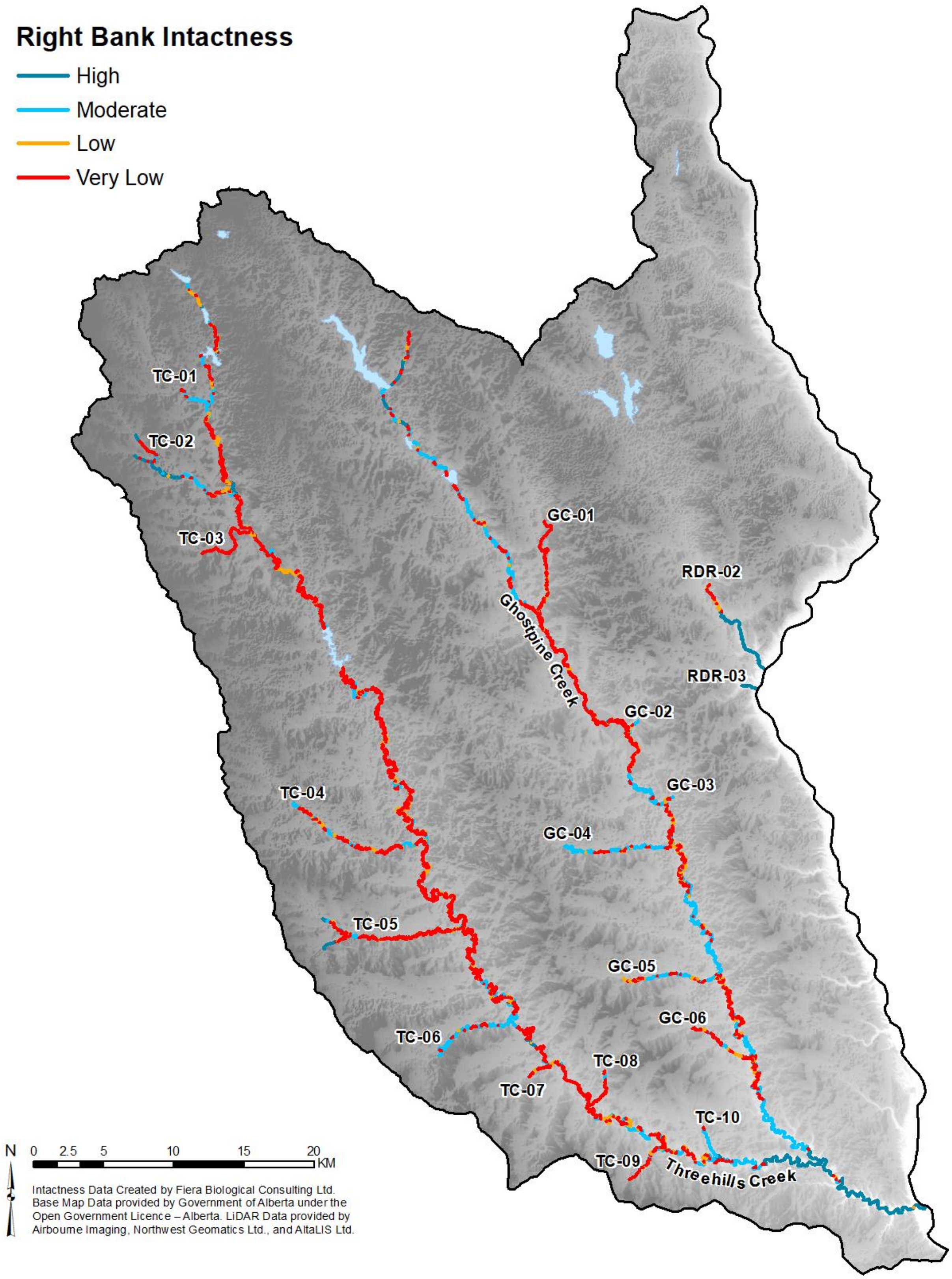


Figure 33. The total proportion of shoreline assigned to each riparian intactness category for unnamed lakes assessed in the Threehills subwatershed.



Map 19. Intactness for the left banks of watercourses and lake shorelines that were assessed in the Threehills subwatershed.



Map 20. Intactness for the right banks of watercourses that were assessed in the Threehills subwatershed.

9.0 Municipal Results

9.1. Comparison of Intactness

In order to provide riparian assessment information that is relevant from a municipal planning and policy perspective, this section summarizes riparian intactness within five rural municipalities that intersect the subwatersheds included in this study. Specifically, results are summarized for the rural municipalities of Kneehill County, the MD of Bighorn, Mountain View County, Red Deer County, and Rocky View County (Figure 34).

Notably, Red Deer County overlaps with the Blindman-Medicine River HUC6 watershed (Map 4), where previous satellite-based riparian assessments have been completed (Fiera Biological 2018d, 2018e, 2020a). At the request of the RDRWA, all previously assessed shorelines that intersect Red Deer County were included in the municipal summaries along with all newly assessed shorelines, in order to provide a complete and comprehensive summary of all shorelines that have been assessed to date in the County. Other municipalities that intersect these subwatersheds (e.g., Lacombe, Ponoka, Clearwater, and Camrose Counties) were not included in this report because riparian assessment results for these jurisdictions have already been compiled as part of a previous study (Fiera Biological 2021d). Notably, riparian assessment results for all municipalities that intersect the Red Deer River watershed can be accessed via an interactive web portal (www.riparianresourcesab.info).

When the proportion of shoreline length assigned to each intactness category was evaluated, all municipalities, with the exception of Kneehill County had over half of their shorelines classified as Moderate or High Intactness (Figure 35). The MD of Bighorn had the highest proportion (88%) and length (566 km) of shoreline classified as High Intactness. Conversely, Kneehill County had the highest proportion (41%) and length (606 km) of shoreline classified as Very Low Intactness. Mountain View County and Red Deer County also had more than 30% and over 400 km of shoreline assessed as Very Low Intactness.

A more detailed breakdown of results by municipality is provided in sections 5.2 through 5.6.

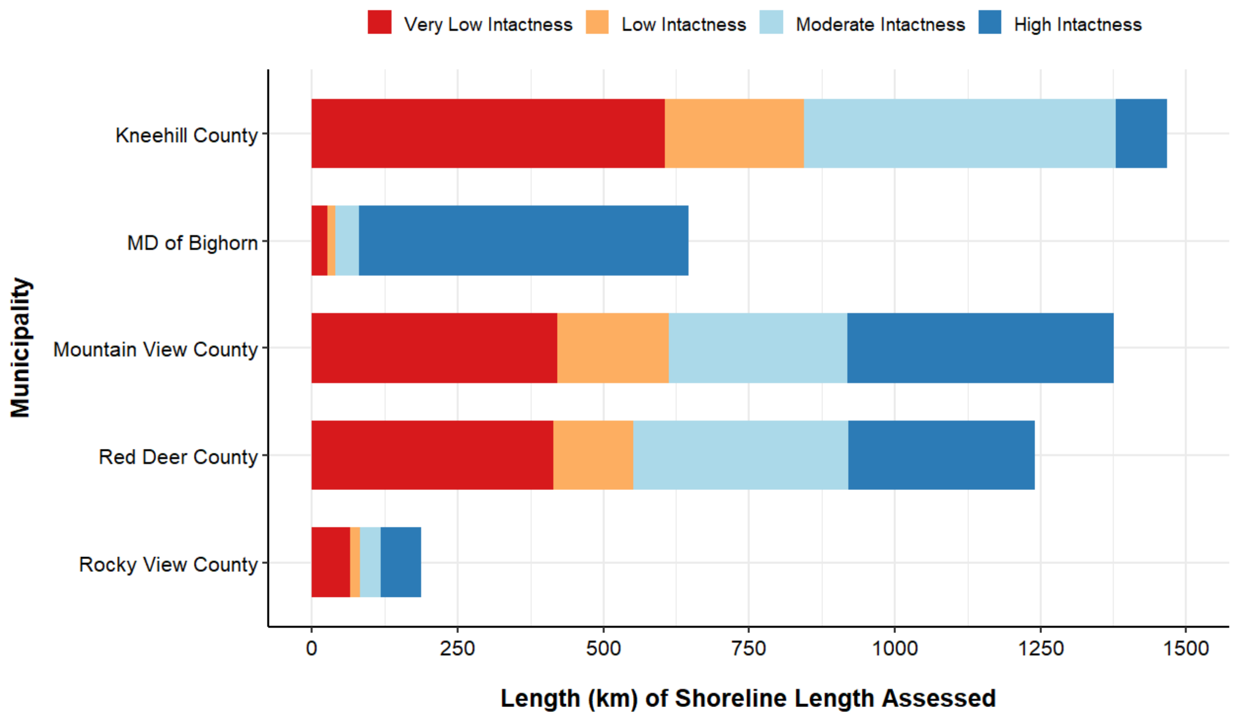


Figure 34. The total length of shoreline assigned to each riparian intactness category, summarized by municipality.

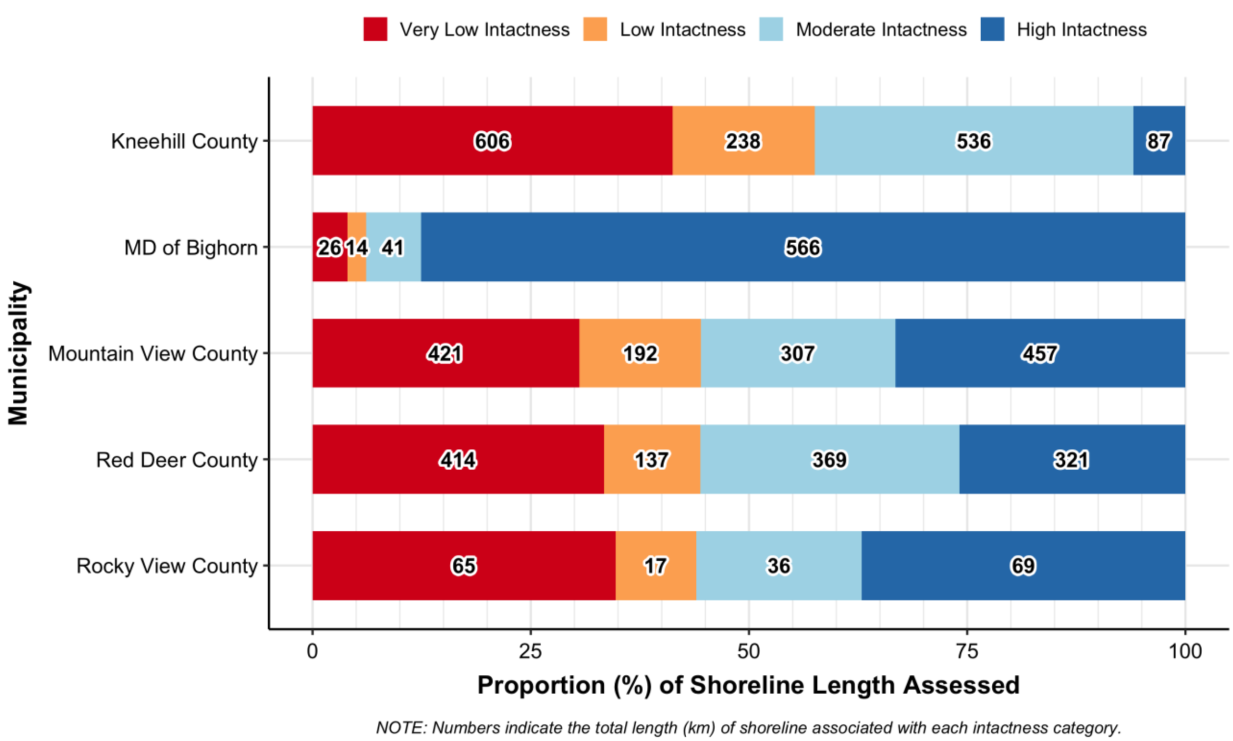


Figure 35. The proportion of shoreline length assigned to each riparian intactness category, summarized by municipality. Numbers indicate the approximate length (km) of shoreline associated with each intactness category.

9.2. Kneehill County

Kneehill County overlaps both the Kneehills and Threehills subwatersheds, with 94% of the county being covered by these two subwatersheds (Map 4). Agriculture is the predominant land cover in this county (80%), with natural cover accounting for approximately 17% of the land cover (Figure 36). Natural grassland (7%) and wetland (4%) make up the greatest proportion of natural cover, with this cover tending to be associated with the southern portions of Kneehills, Threehills, and Ghostpine Creek.

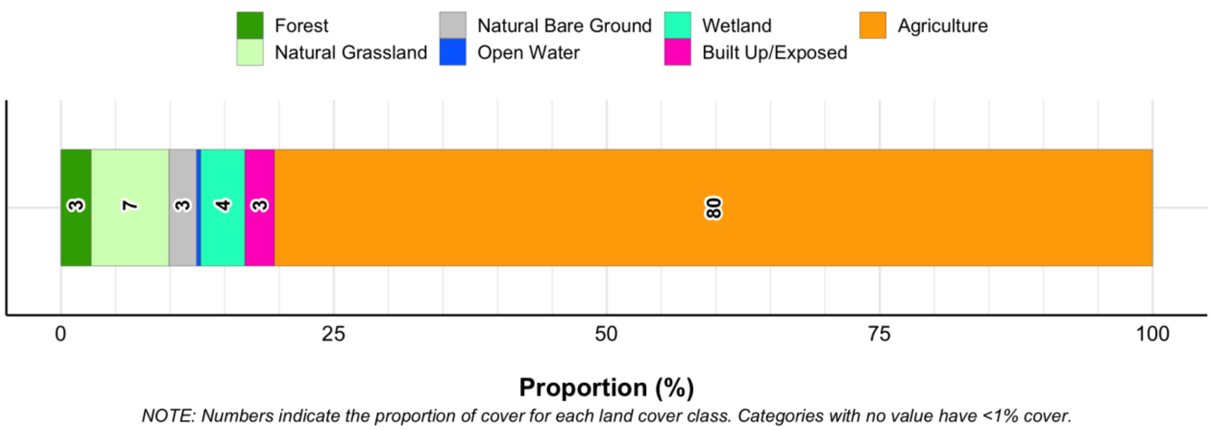


Figure 36. The proportion of Kneehill County assigned to each land cover class. Land cover data is based on the 2020 Agriculture and Agri-Food Canada land cover.

A total of 1,467 km of shoreline was assessed within Kneehill County, with only 6% (87 km) categorized as High Intactness and an additional 37% (546 km) assessed as Moderate Intactness (Figure 37). The remaining 57% of shoreline was categorized as Low Intactness (16%, 238 km) or Very Low Intactness (41%, 606 km). These results included both the left and right shorelines of watercourses.

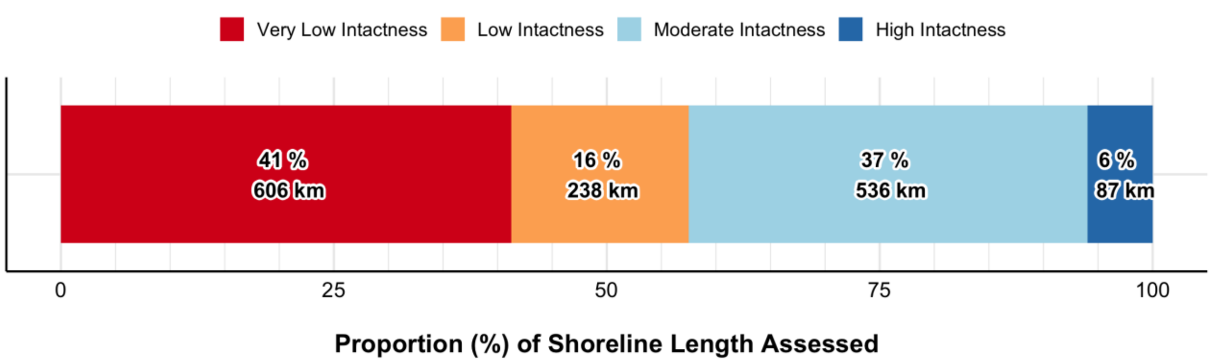


Figure 37. Overall intactness for waterbodies assessed within Kneehill County.

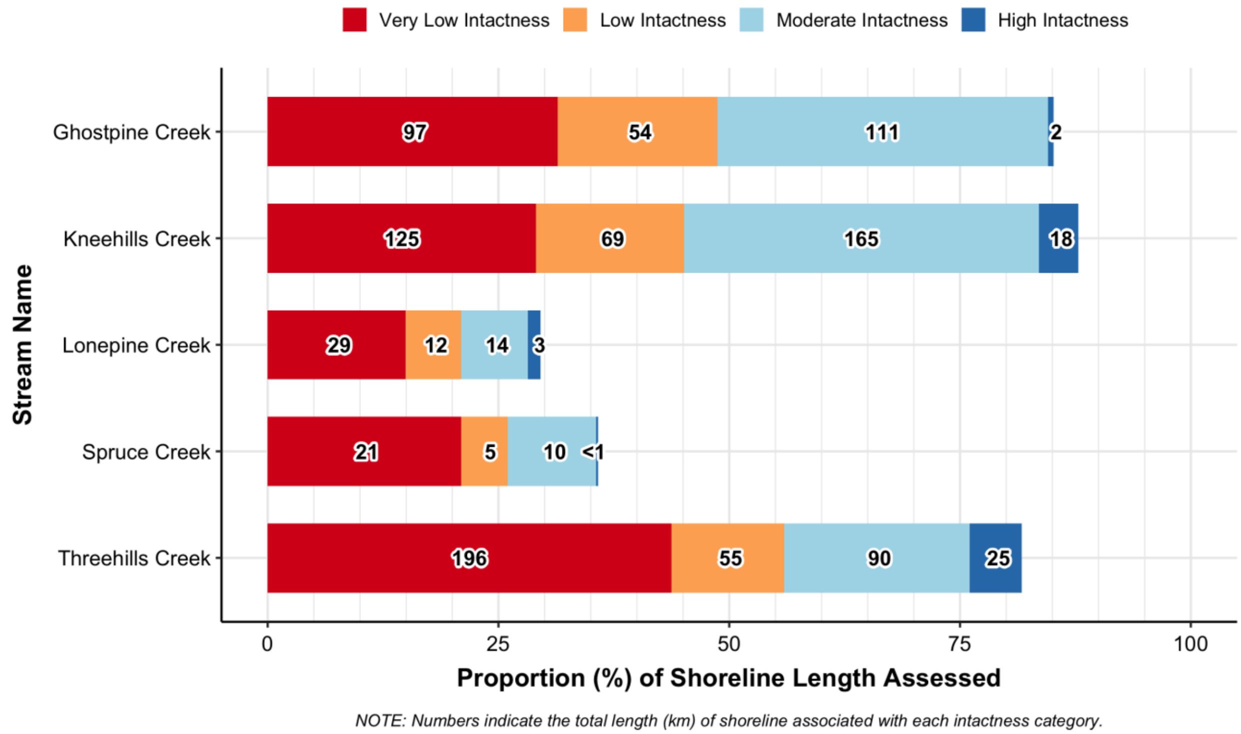


Figure 38. The proportion of shoreline length assigned to each riparian intactness category for named watercourses within Kneehill County.

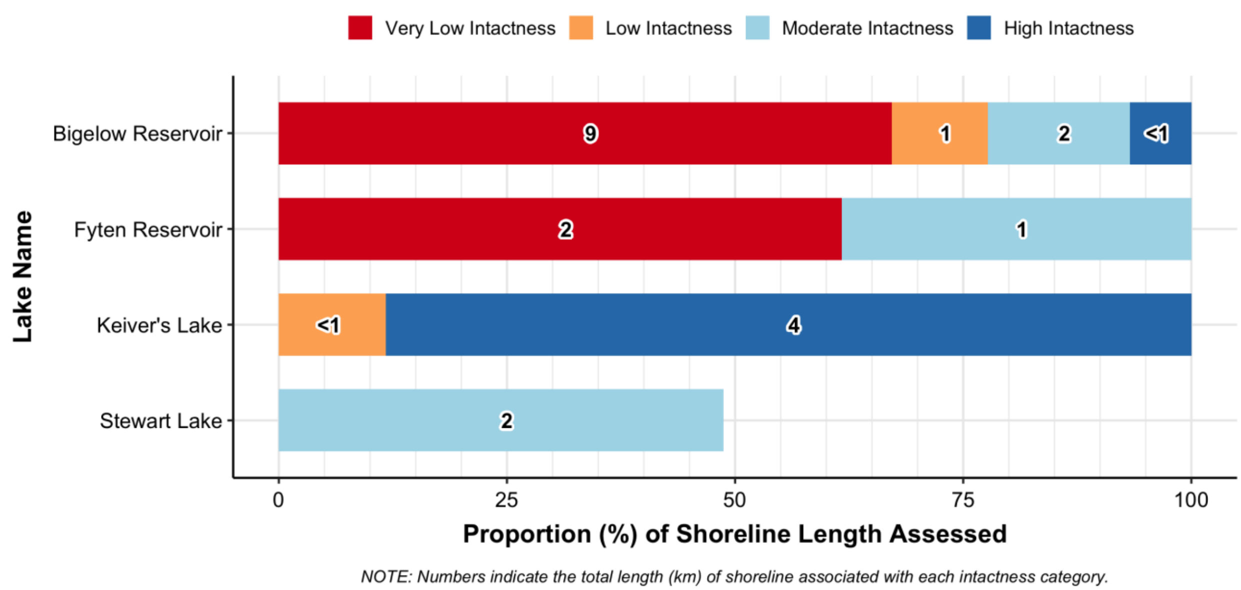


Figure 39. The proportion of shoreline length assigned to each riparian intactness category for named lakes within Kneehill County.

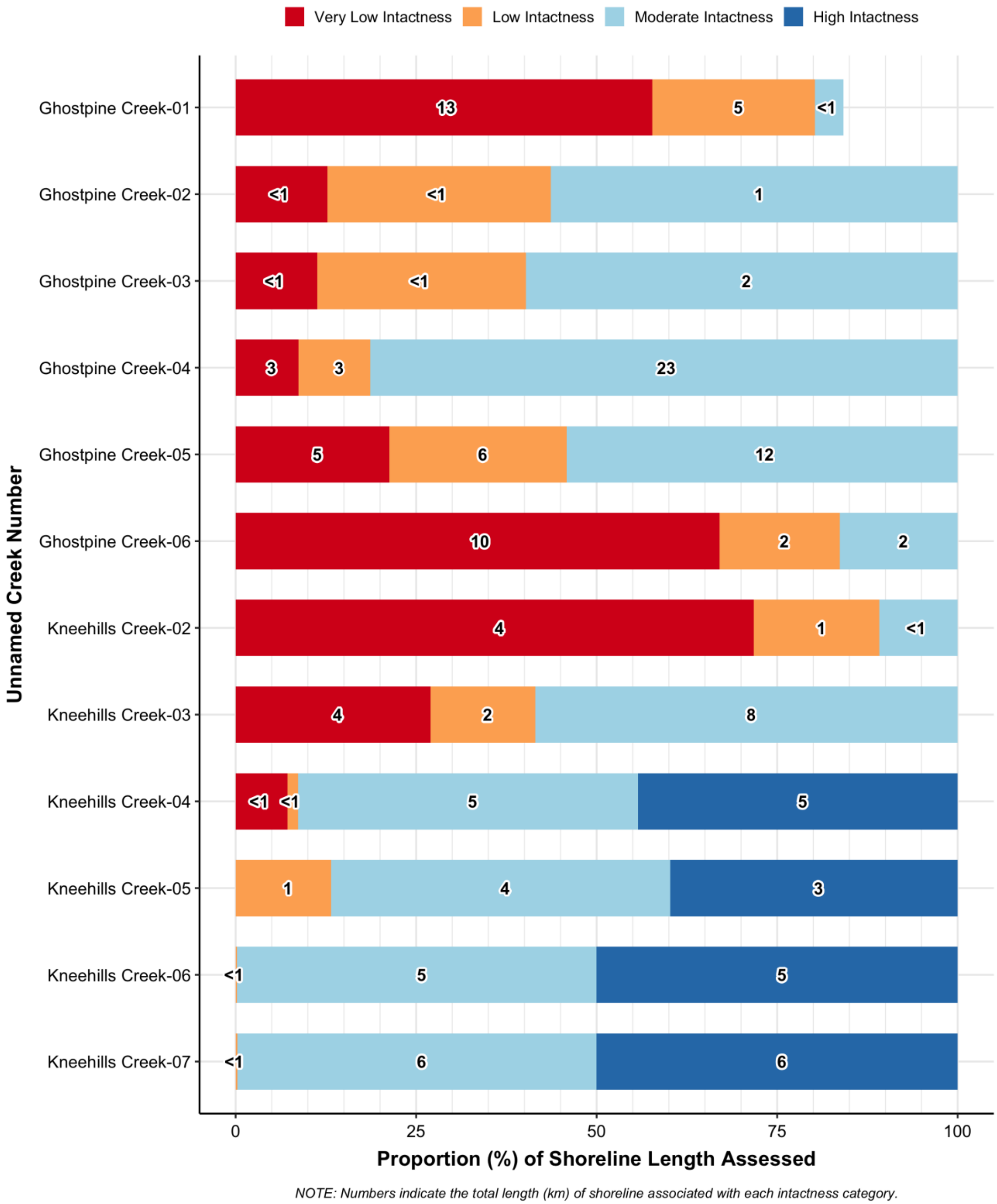


Figure 40. The proportion of shoreline length assigned to each riparian intactness category for unnamed watercourses within Kneehill County.

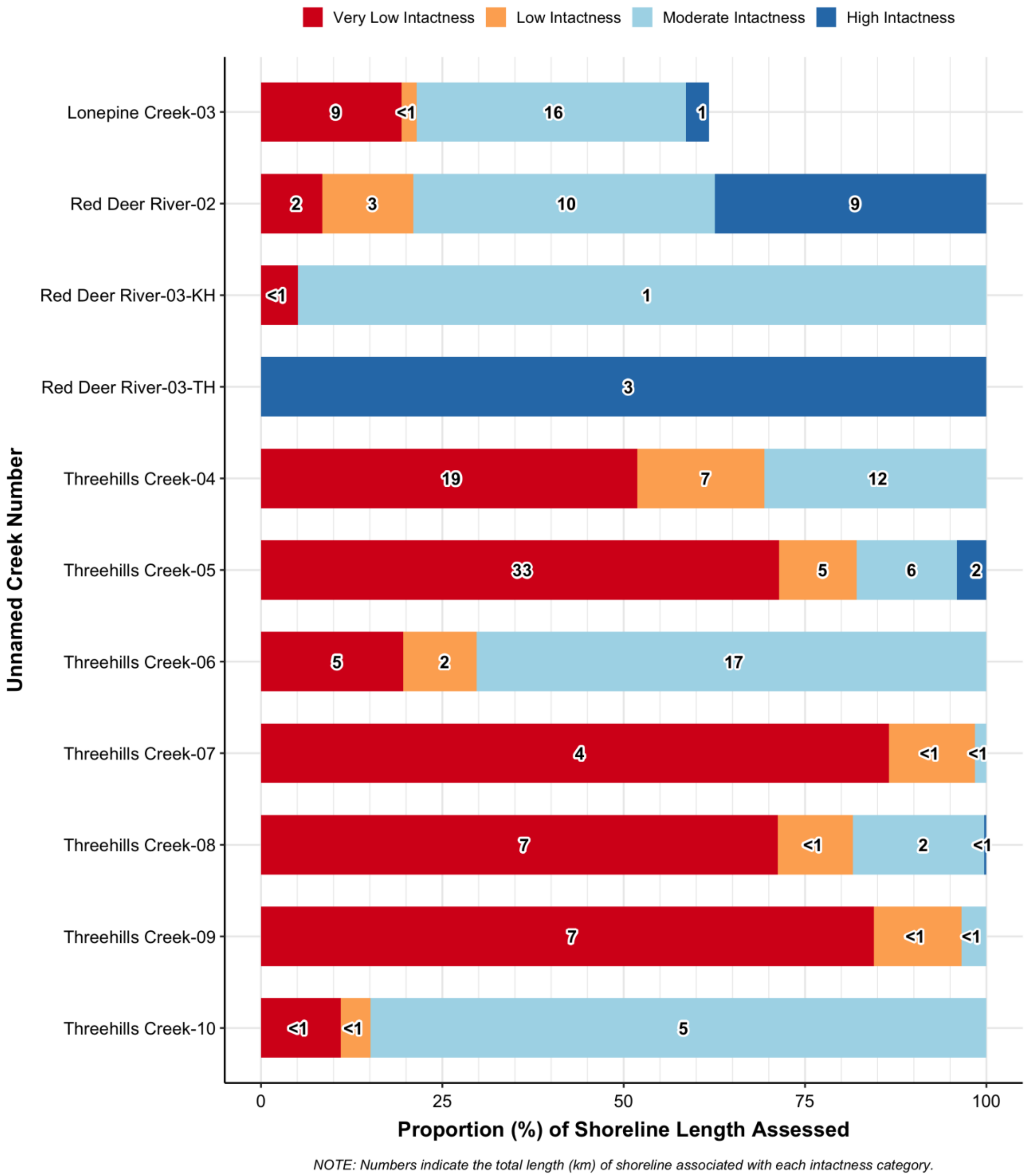
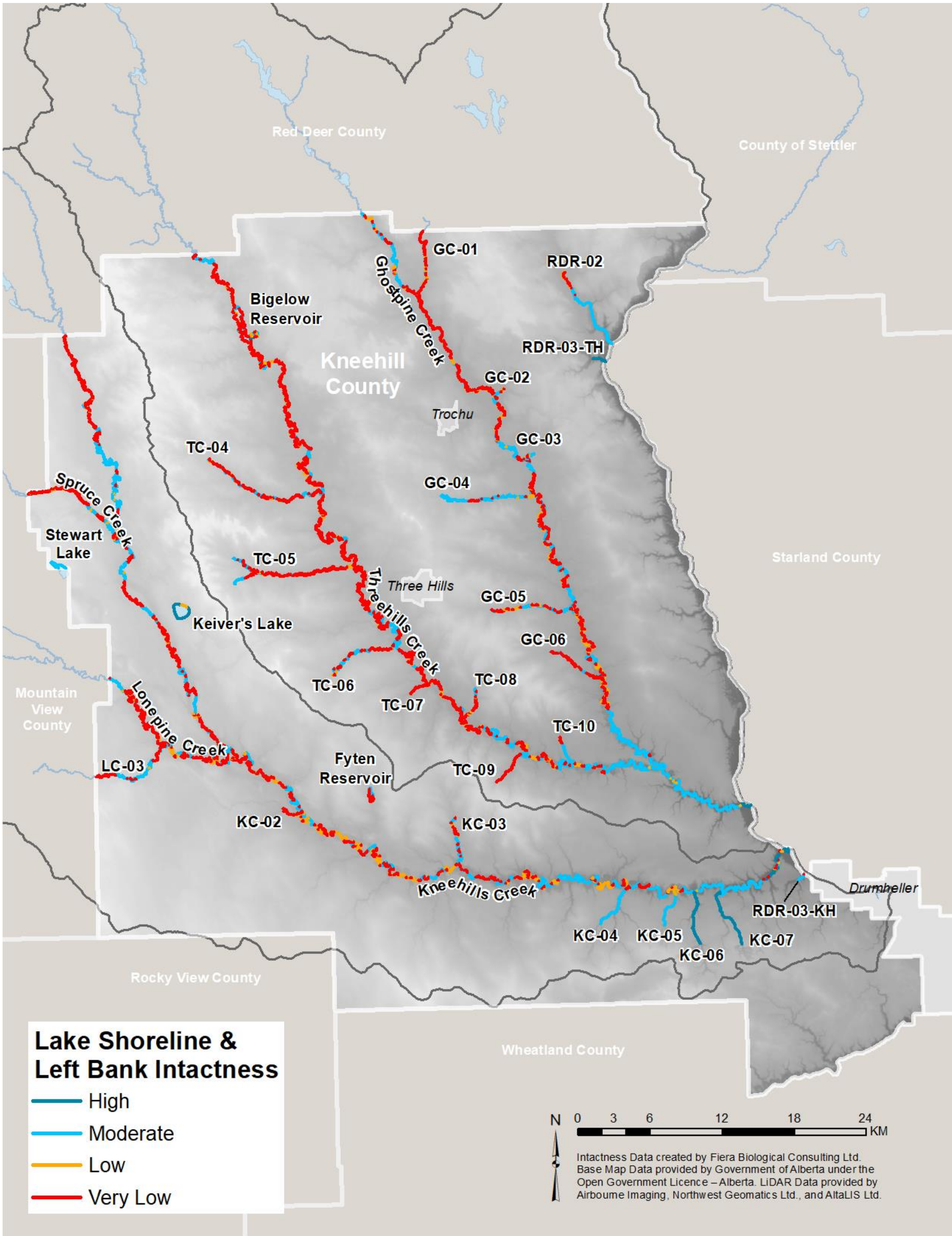
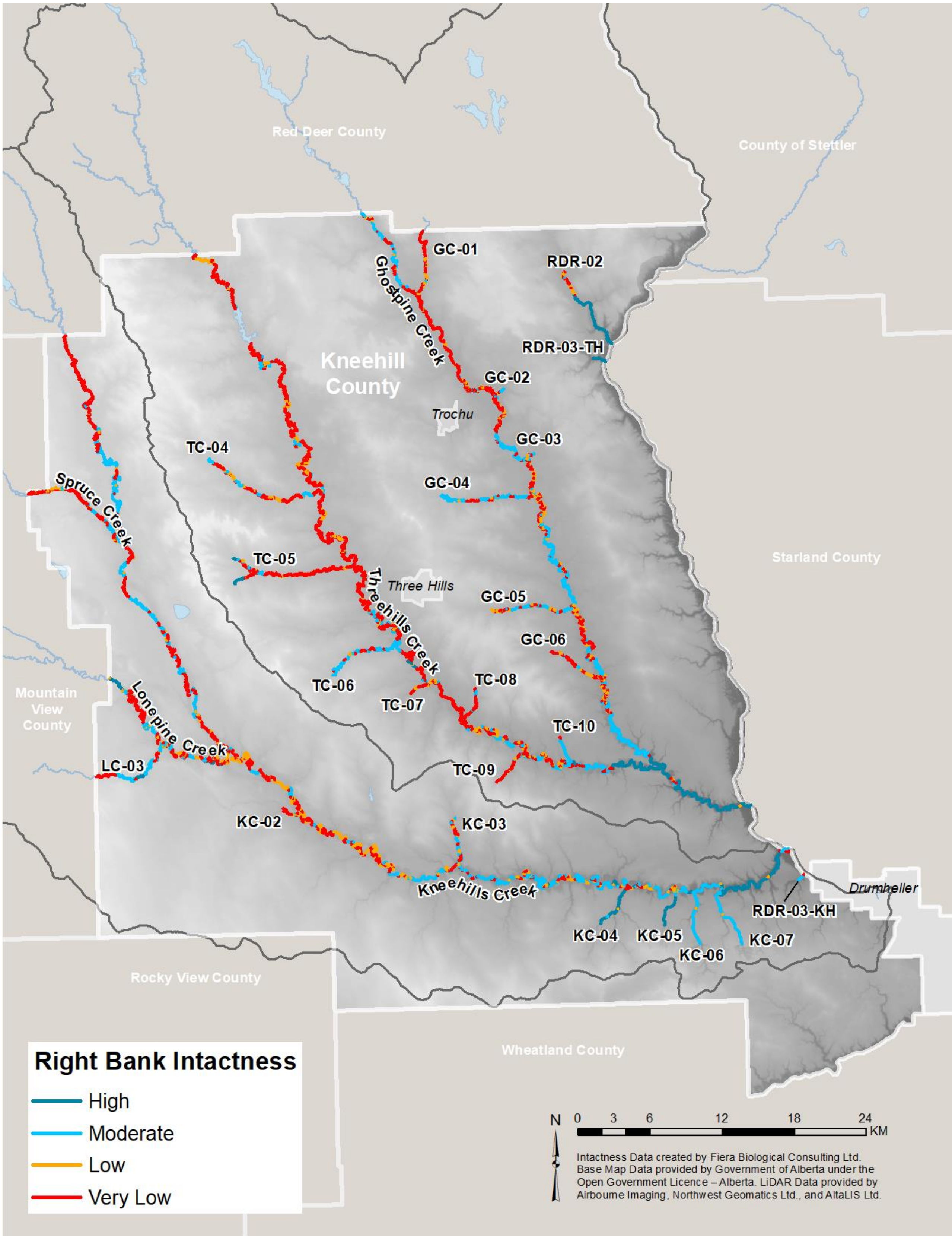


Figure 40 *continued*. The proportion of shoreline length assigned to each riparian intactness category for unnamed watercourses within Kneehill County.



Map 21. Intactness for the left banks of watercourses and lake shorelines that were assessed in Kneehill County.



Map 22. Intactness for the right banks of watercourses that were assessed in Kneehill County.

9.3. MD of Bighorn

Approximately 30% of the Municipal District (MD) of Bighorn overlaps with the Little Red Deer subwatershed (Map 4). The vast majority of the land cover in this county is natural (98%), with anthropogenic cover accounting for only 2% of the cover (Figure 41). Forest makes up the majority of the land cover (72%), with a high proportion of natural bare ground (14%) and natural grassland (10%) in the mountainous areas of the county. The small proportion of anthropogenic cover is predominately associated with built up areas.

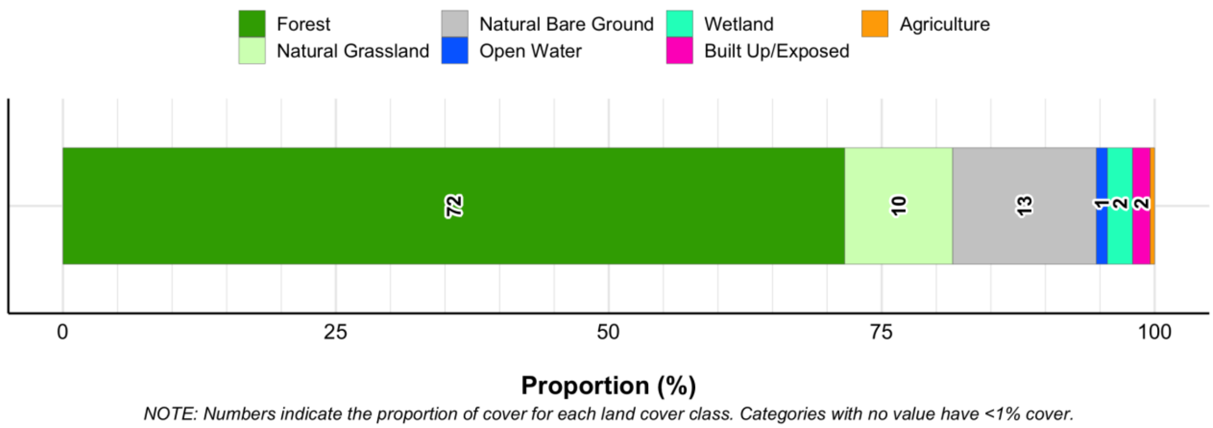


Figure 41. The proportion of the MD of Bighorn assigned to each land cover class. Land cover data is based on the 2020 Agriculture and Agri-Food Canada land cover.

A total of 647 km of shoreline was assessed within the MD of Bighorn with the majority (88%, 566 km) categorized as High Intactness (Figure 42). A very small portion of the shorelines were assessed as being Very Low or Low Intactness (6%, 40km). These results included both the left and right shorelines of watercourses.

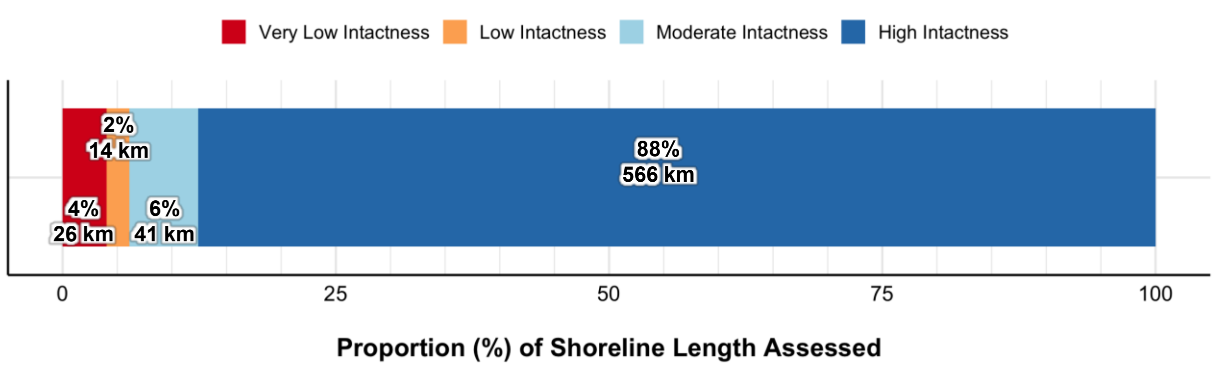


Figure 42. Overall intactness for waterbodies assessed within the MD of Bighorn.

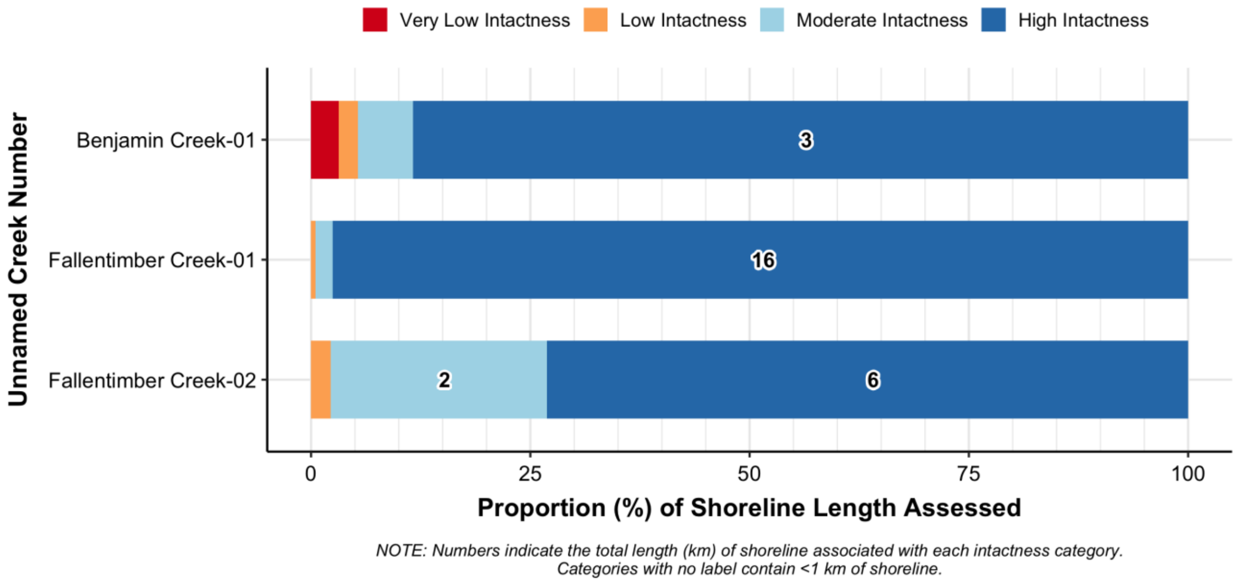


Figure 43. The proportion of shoreline length assigned to each riparian intactness category for unnamed watercourses within the MD of Bighorn.

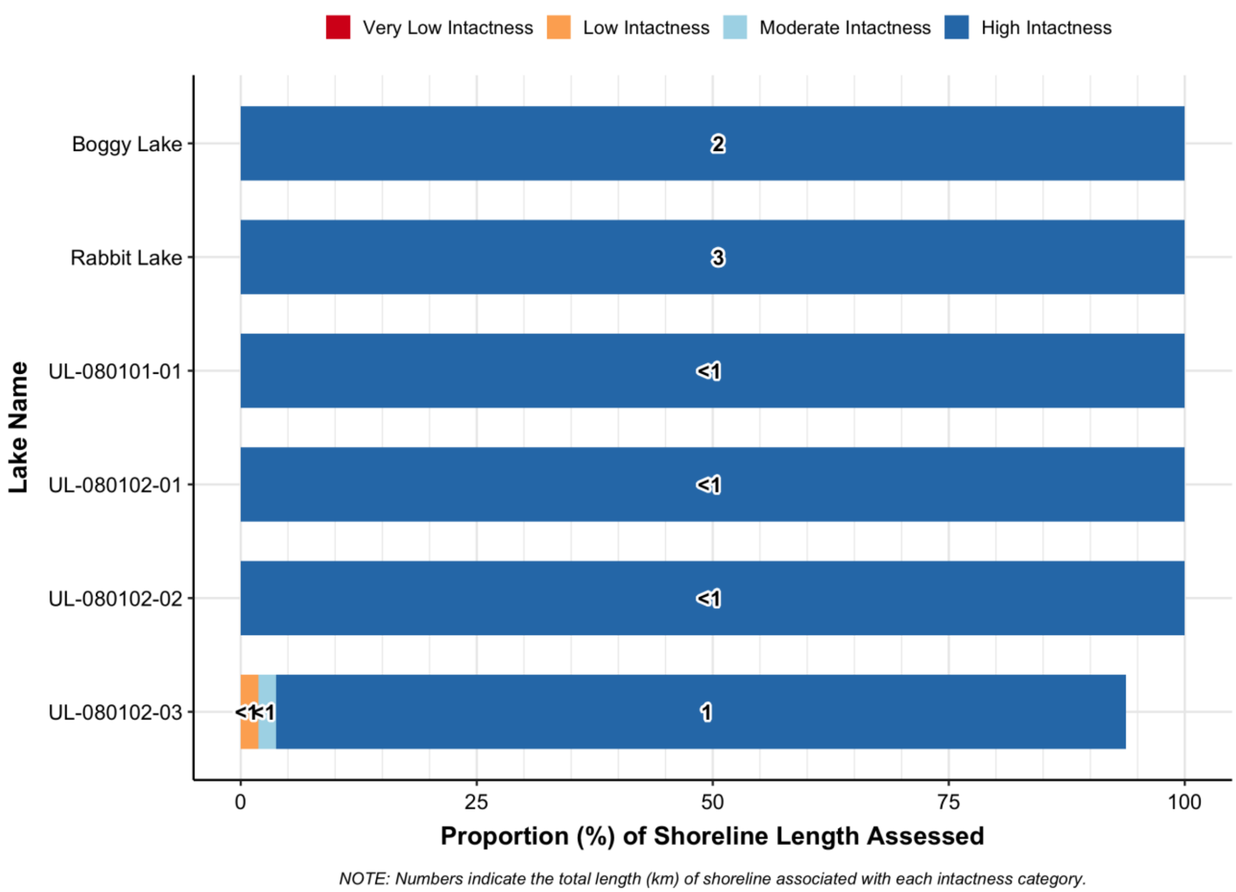


Figure 44. The proportion of shoreline length assigned to each riparian intactness category for named and unnamed lakes within the MD of Bighorn.

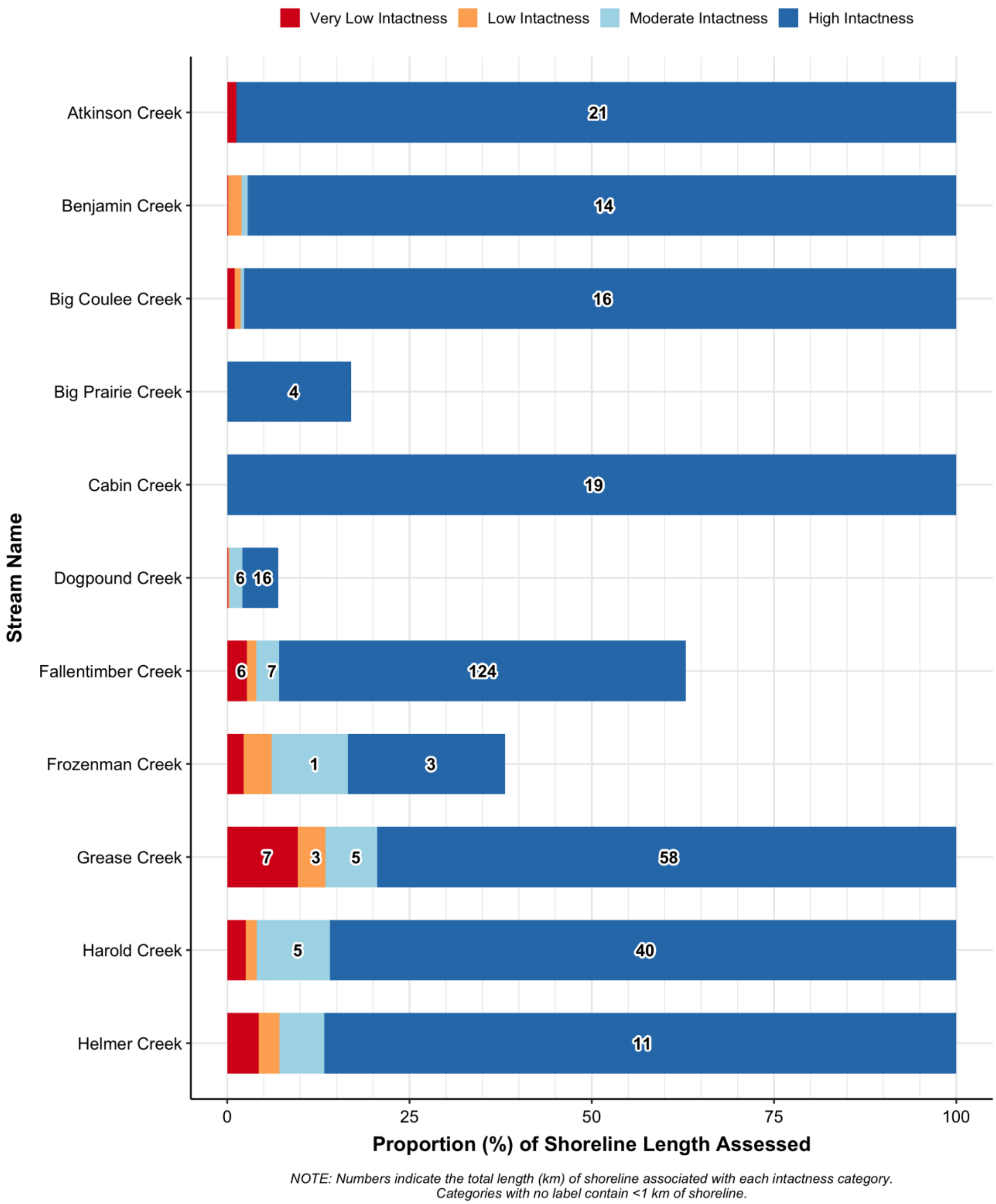
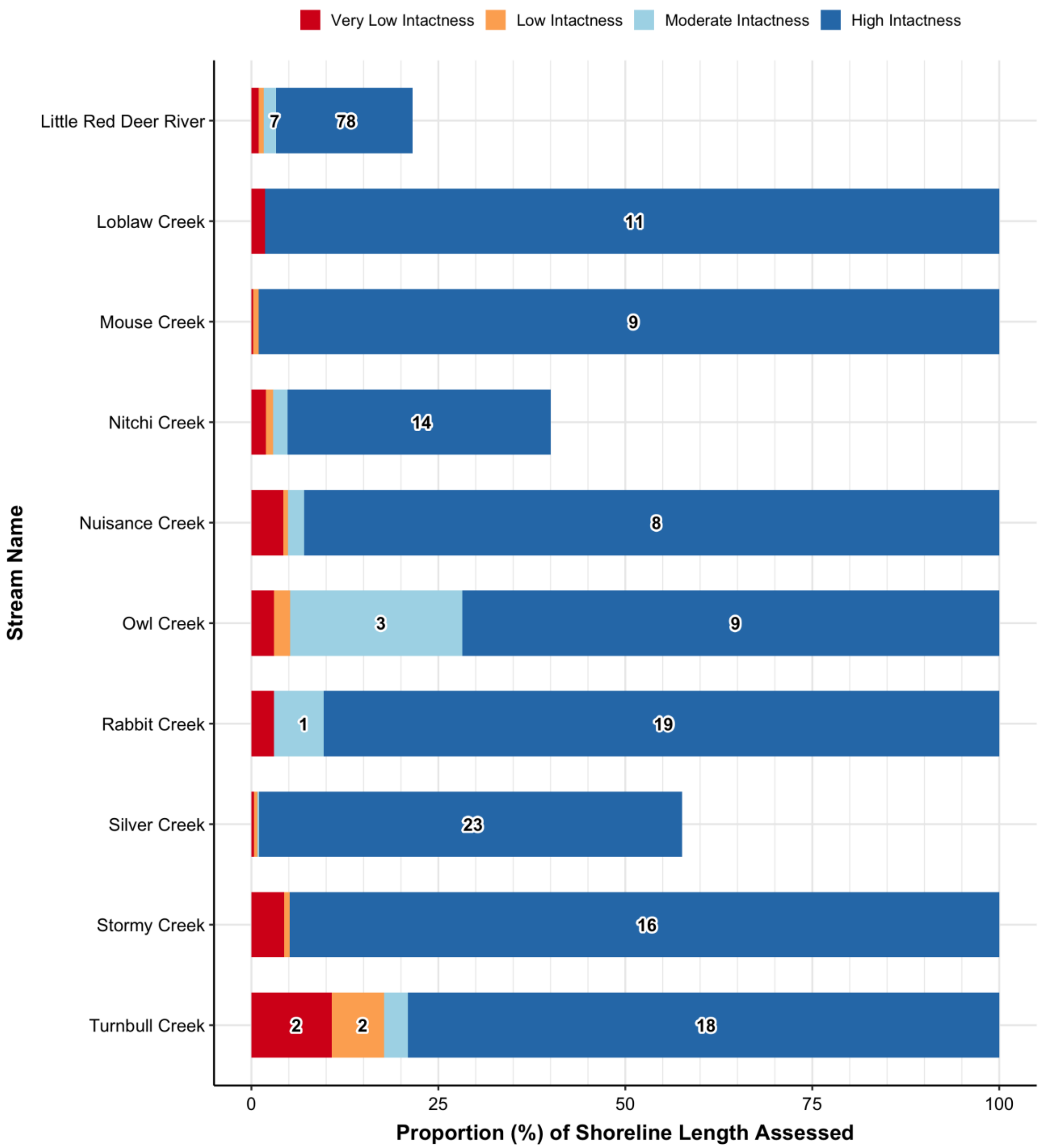
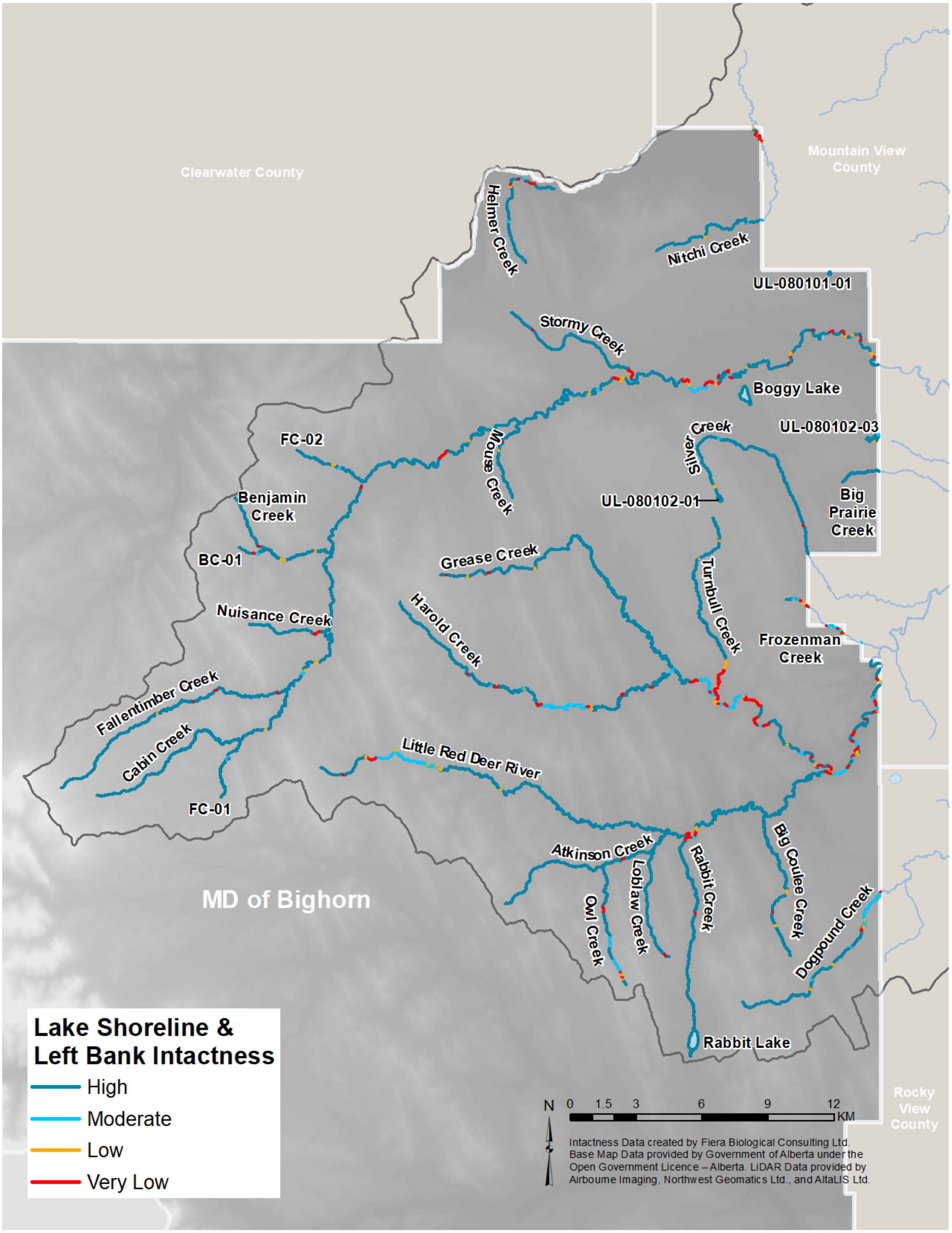


Figure 45. The proportion of shoreline length assigned to each riparian intactness category for named watercourses within the MD of Bighorn.

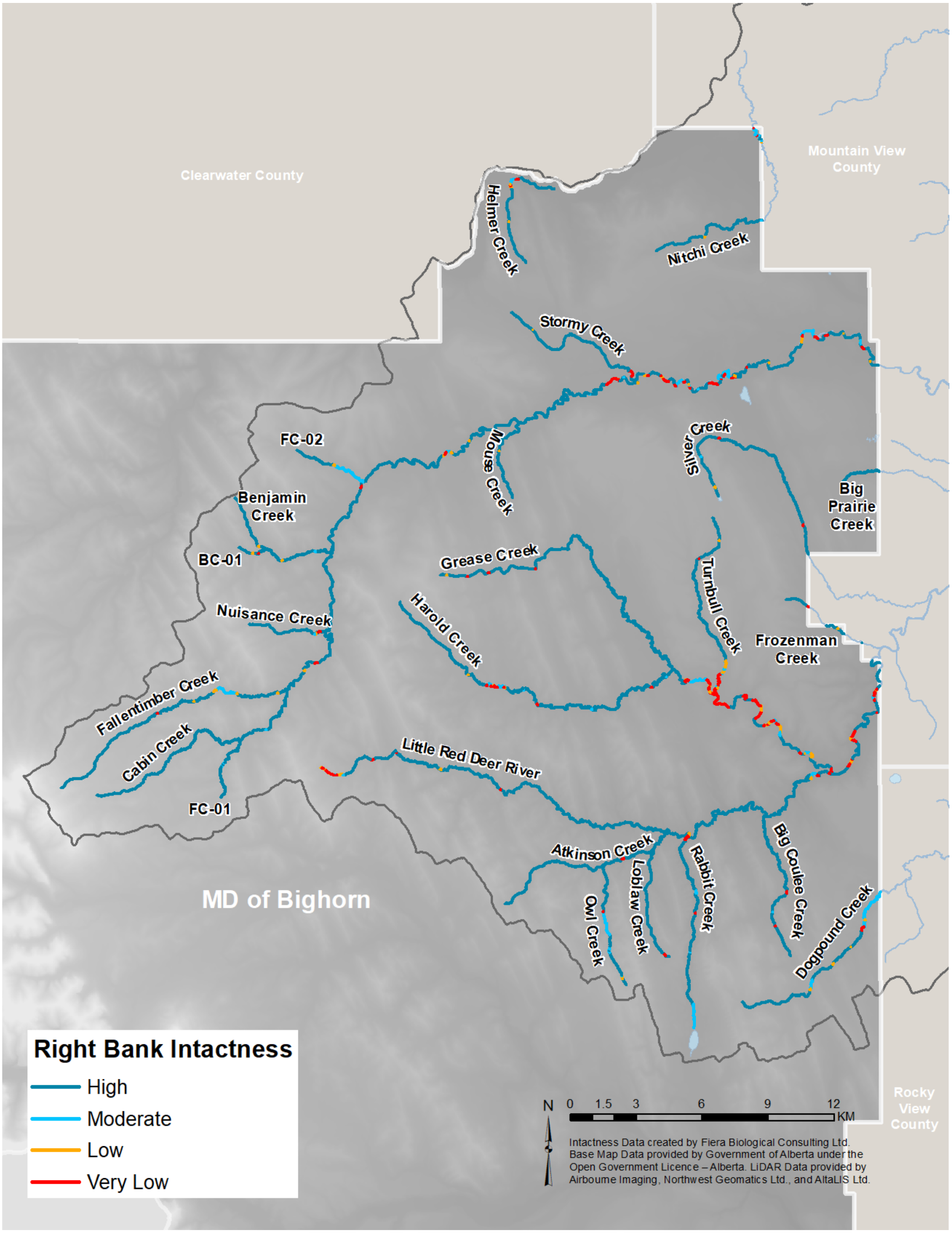


NOTE: Numbers indicate the total length (km) of shoreline associated with each intactness category. Categories with no label contain <1 km of shoreline.

Figure 45 *continued*. The proportion of shoreline length assigned to each riparian intactness category for named watercourses within the MD of Bighorn.



Map 23. Intactness for the left banks of watercourses and lake shorelines that were assessed in the MD of Bighorn.



Map 24. Intactness for the right banks of watercourses that were assessed in the MD of Bighorn.

9.4. Mountain View County

Mountain View County overlaps both the Little Red Deer and Kneehills subwatersheds, with 71% of the county being covered by these two subwatersheds (Map 4). The majority of the land cover in this county is agriculture (66%), with natural cover accounting for 31% of the cover (Figure 35). Forest and natural grassland make up 19% and 9% of the land cover, respectively, with this cover tending to be associated with the western portions of the county. Agriculture is the predominate land cover in the central and eastern portions of the county.

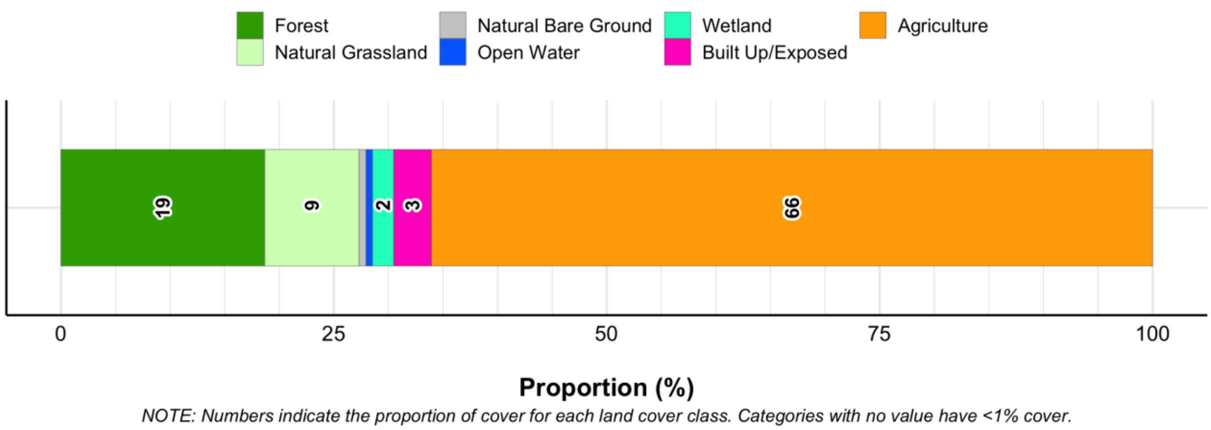


Figure 46. The proportion of Mountain View County assigned to each land cover class. Land cover data is based on the 2020 Agriculture and Agri-Food Canada land cover.

A total of 1,377 km of shoreline was assessed within Mountain View County with 33% (457 km) categorized as High Intactness and an additional 22% (307 km) assessed as Moderate Intactness (Figure 47). The remaining 45% of shoreline was categorized as Low Intactness (14%, 192 km) or Very Low Intactness (31%, 421 km). These results included both the left and right shorelines of watercourses.

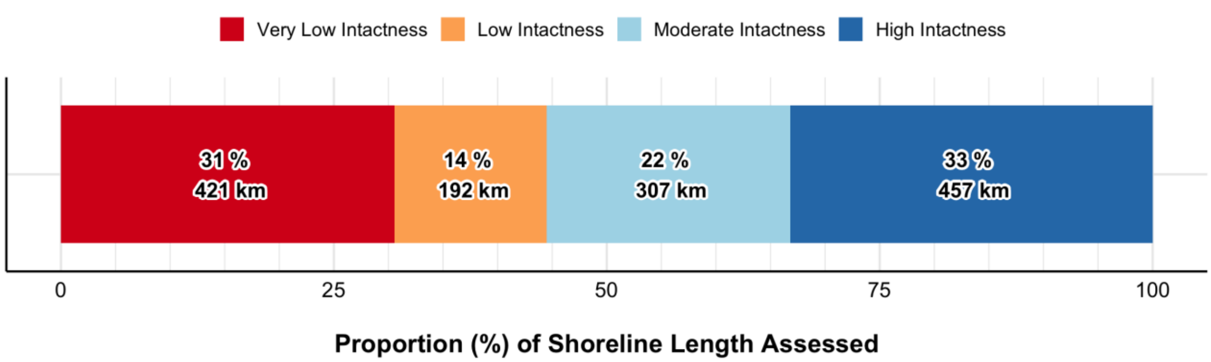


Figure 47. Overall intactness for waterbodies assessed within Mountain View County.

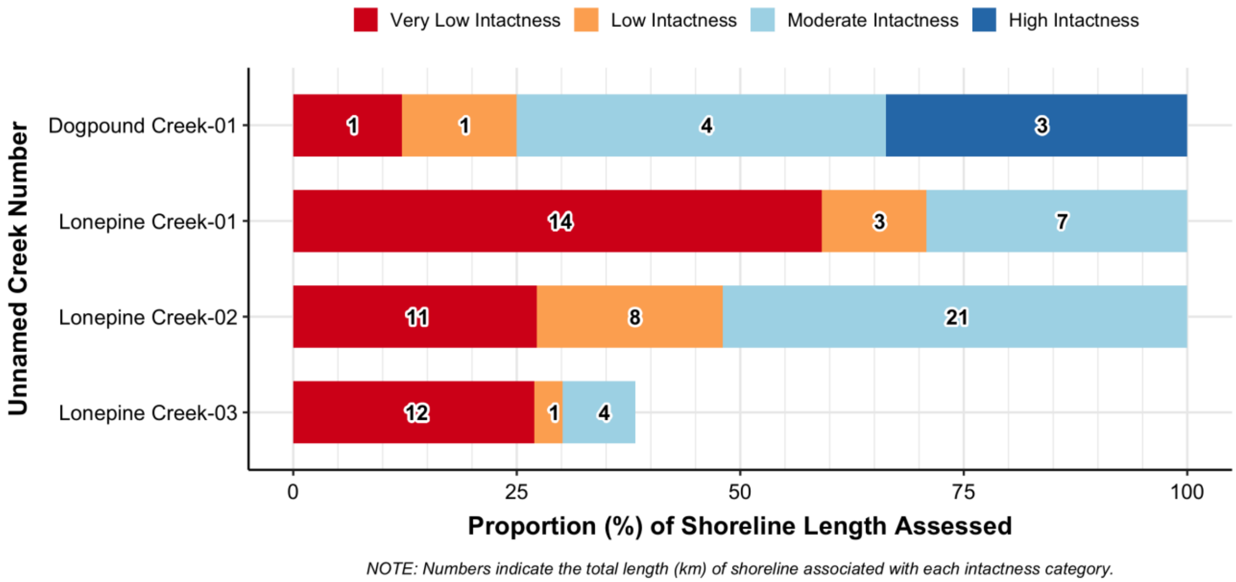


Figure 48. The proportion of shoreline length assigned to each riparian intactness category for unnamed watercourses within Mountain View County.

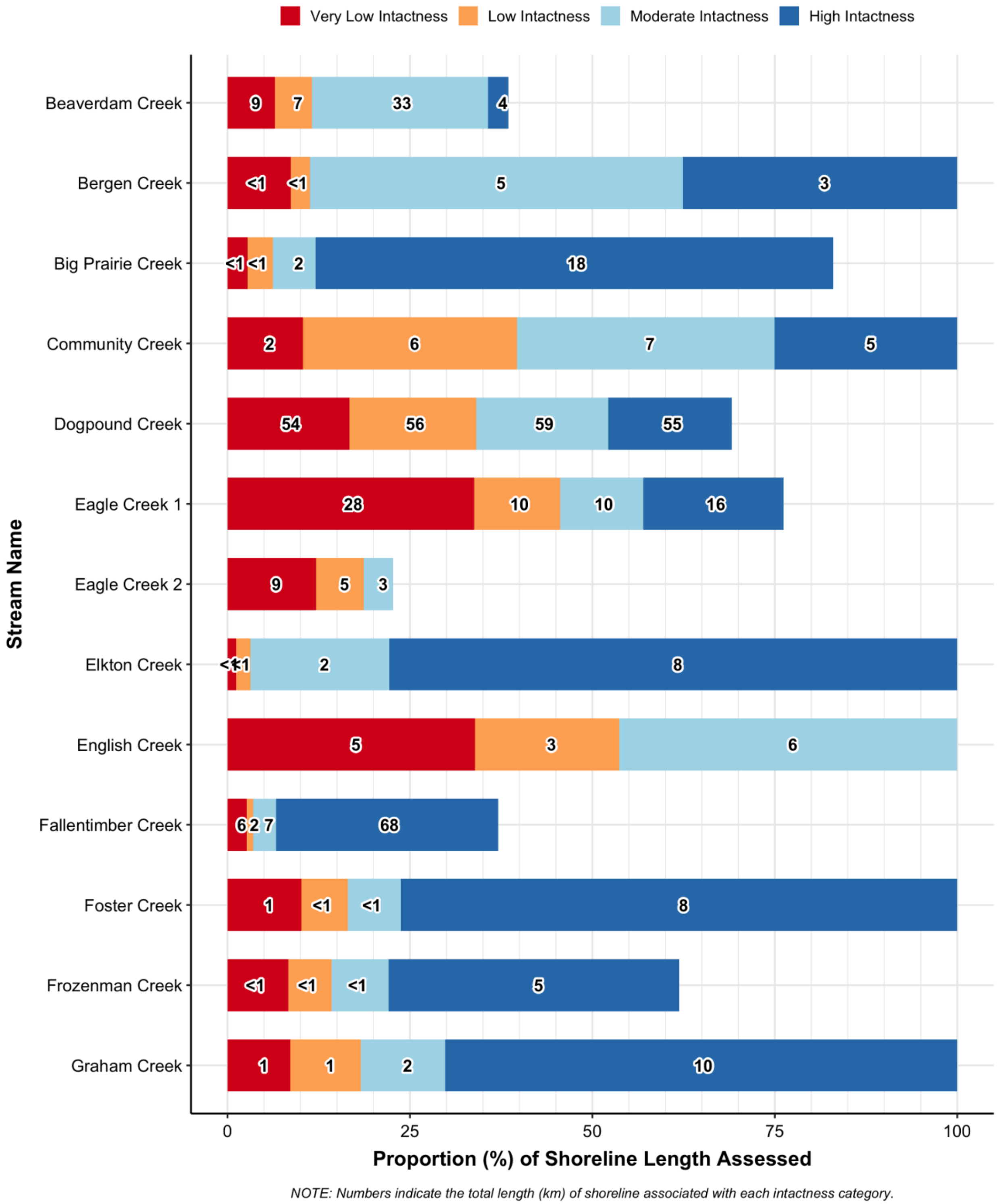


Figure 49. The proportion of shoreline length assigned to each riparian intactness category for named watercourses within Mountain View County.

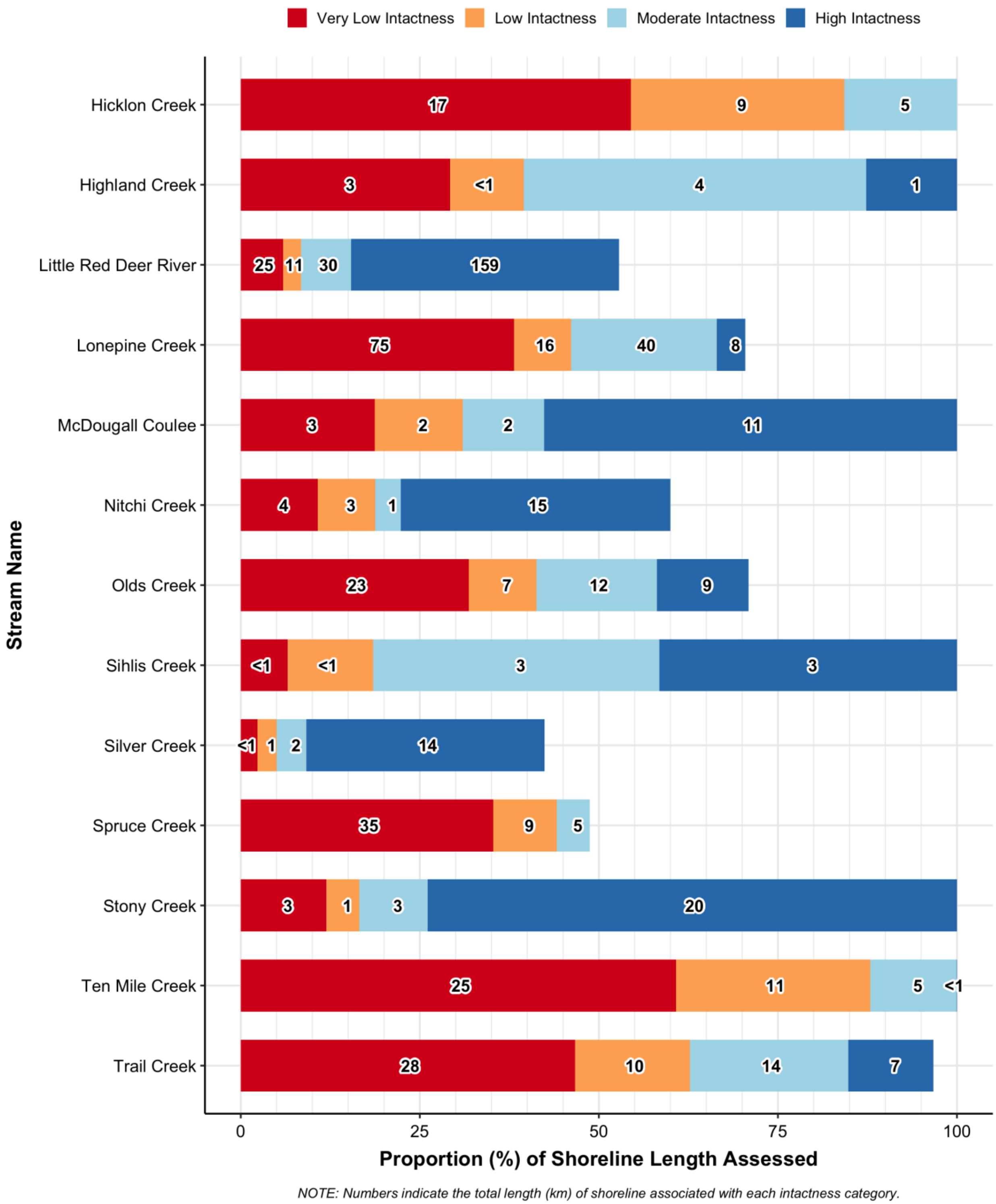


Figure 49 *continued*. The proportion of shoreline length assigned to each riparian intactness category for named watercourses within Mountain View County.

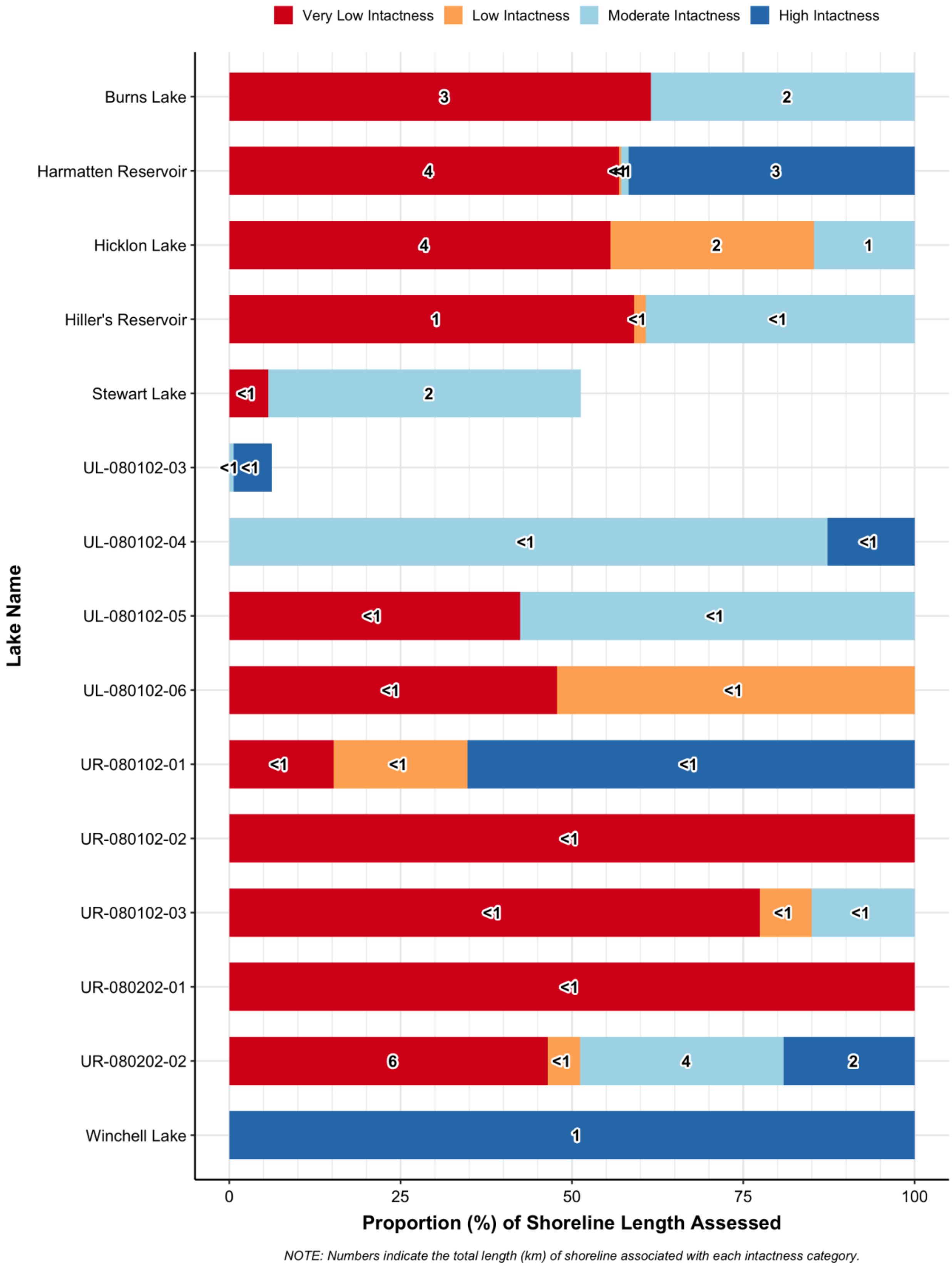
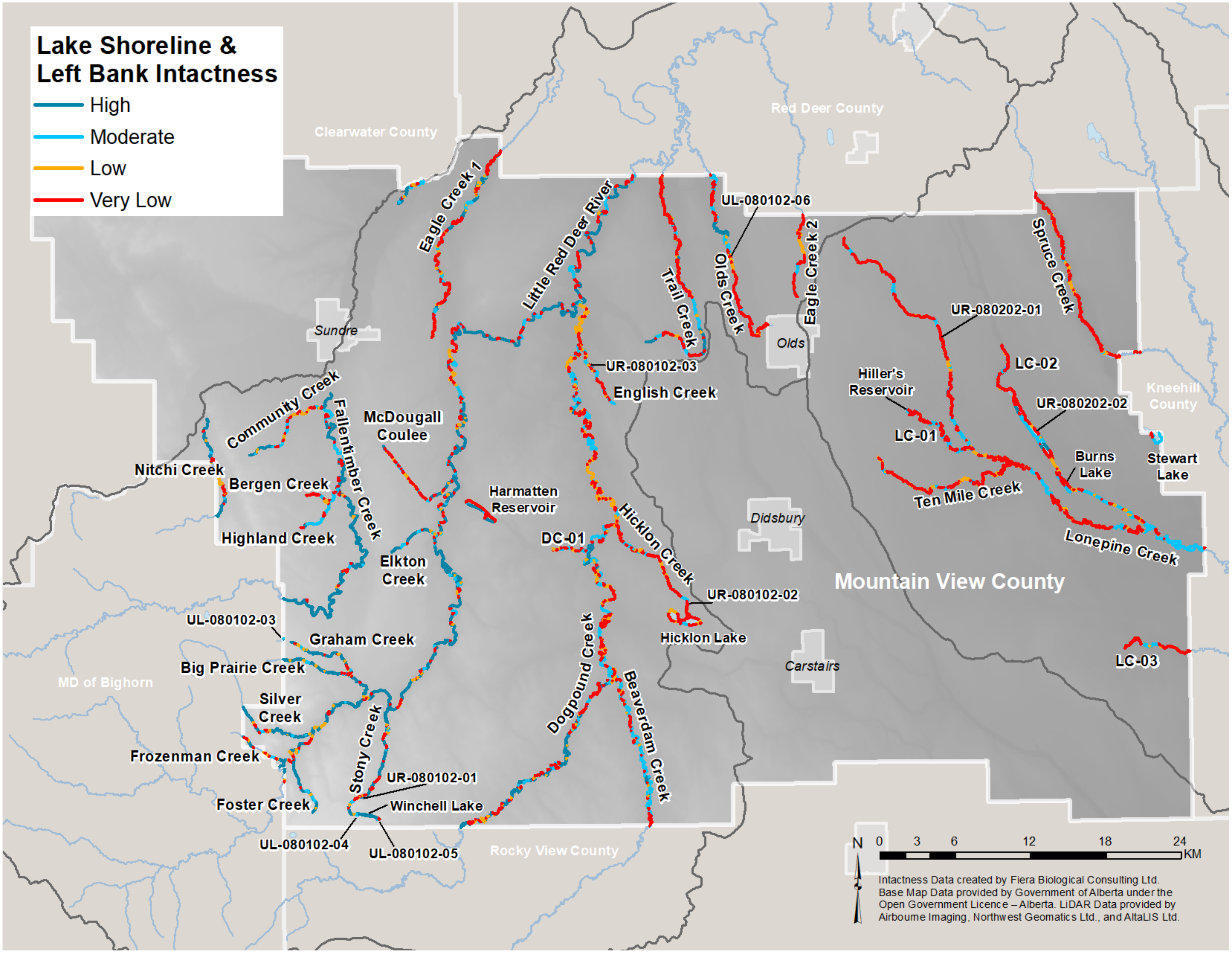
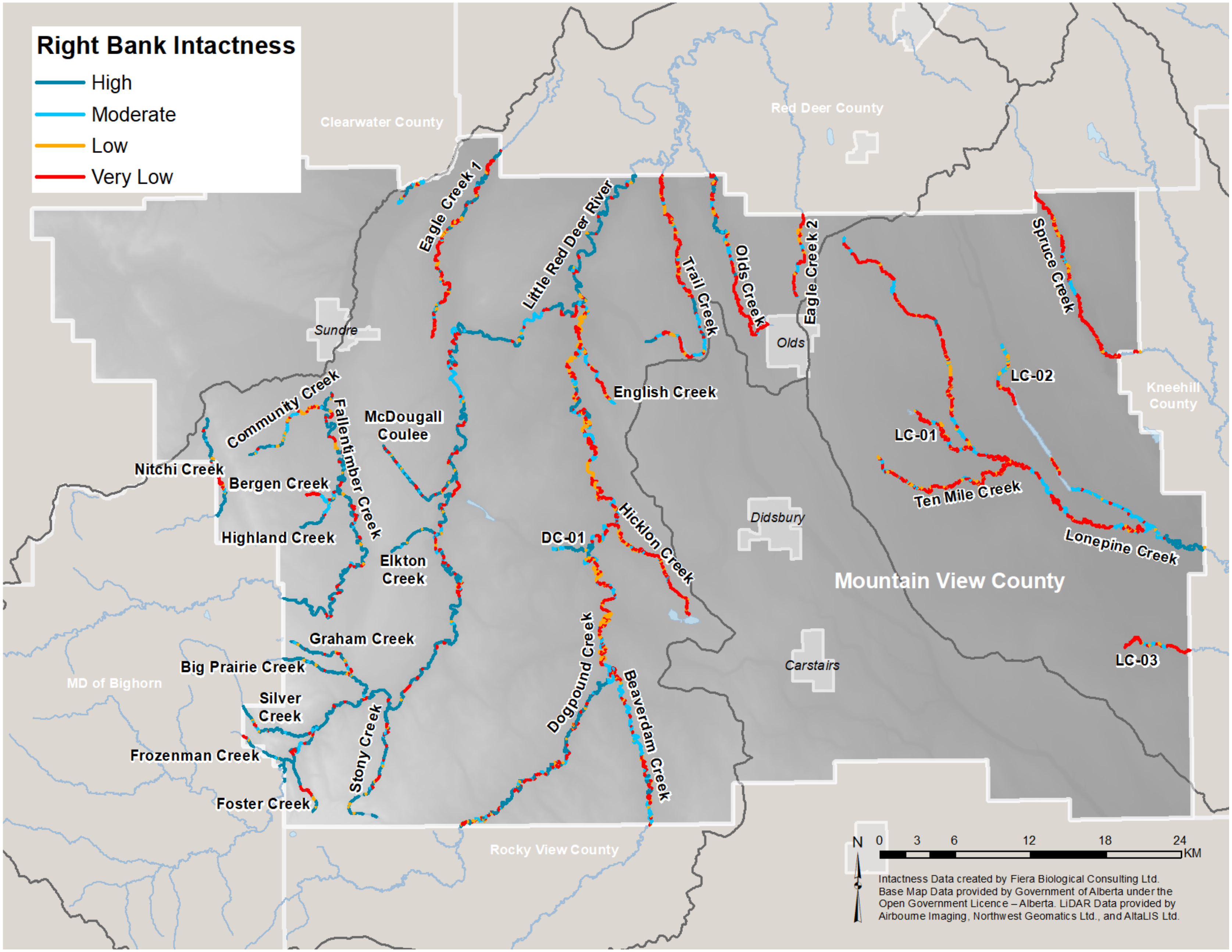


Figure 50. The proportion of shoreline length assigned to each riparian intactness category for named and unnamed lakes and reservoirs within Mountain View County.



Map 25. Intactness for the left banks of watercourses and lake shorelines that were assessed in Mountain View County.



Map 26. Intactness for the right banks of watercourses that were assessed in Mountain View County.

9.5. Red Deer County

Approximately 55% of Red Deer County overlaps with the Buffalo, Kneehills, Little Red Deer, and Threehills subwatersheds (Map 4). In addition, ~40% of the county overlaps with the Medicine-Blindman Rivers HUC6 watershed, where a number of satellite-based riparian assessments have been previously completed (Fiera Biological 2018d, 2018e, 2020a). To date, only a small proportion (~5%) of the county has not been assessed using the satellite-based riparian assessment method. At the request of the RDRWA, the intactness summaries presented in this section were generated using data from this current and all previous studies, in order to provide a comprehensive summary for this county.

The majority of the land cover in Red Deer County is anthropogenic, with agriculture accounting for roughly 66% and built up areas covering 5% of the county (Figure 51). Natural cover makes up the remaining 30% of the land cover, with the majority of natural cover being forest (15%), natural grassland (7%), and wetlands (4%).

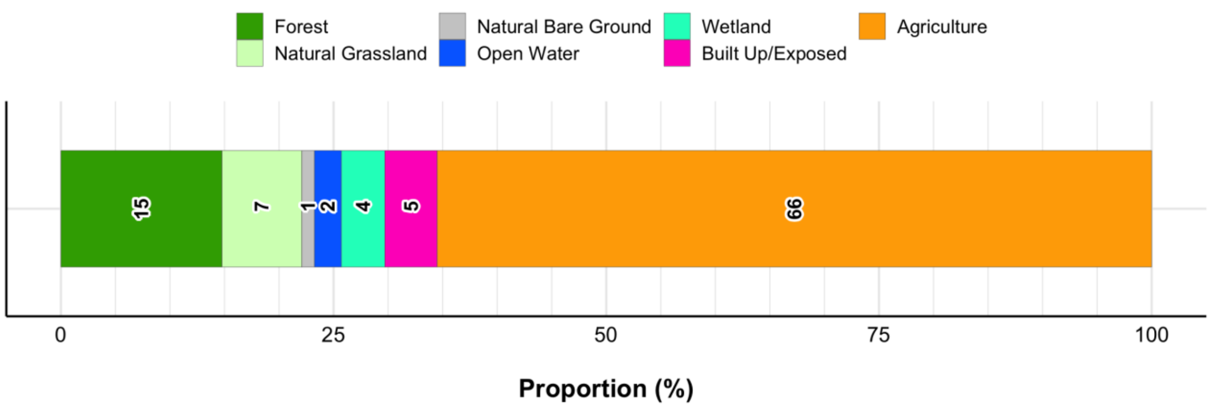


Figure 51. The proportion of Red Deer County assigned to each land cover class. Land cover data is based on the 2020 Agriculture and Agri-Food Canada land cover.

A total of 1,241 km of shoreline has been assessed within Red Deer County, with 26% (321 km) categorized as High Intactness, and an additional 30% (369 km) assessed as Moderate Intactness (Figure 37). The remaining 57% of shoreline has been categorized as Low Intactness (11%, 137 km) or Very Low Intactness (33%, 414 km). These results included both the left and right shorelines of watercourses.

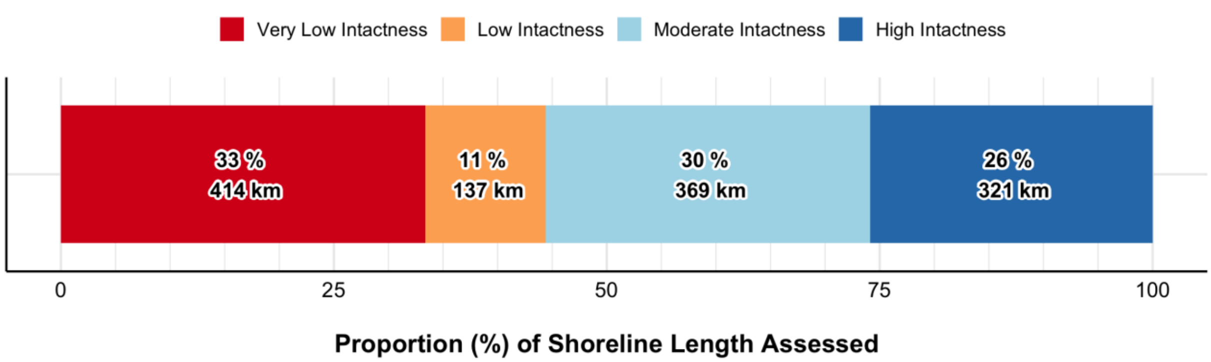


Figure 52. Overall intactness for waterbodies assessed within Red Deer County.

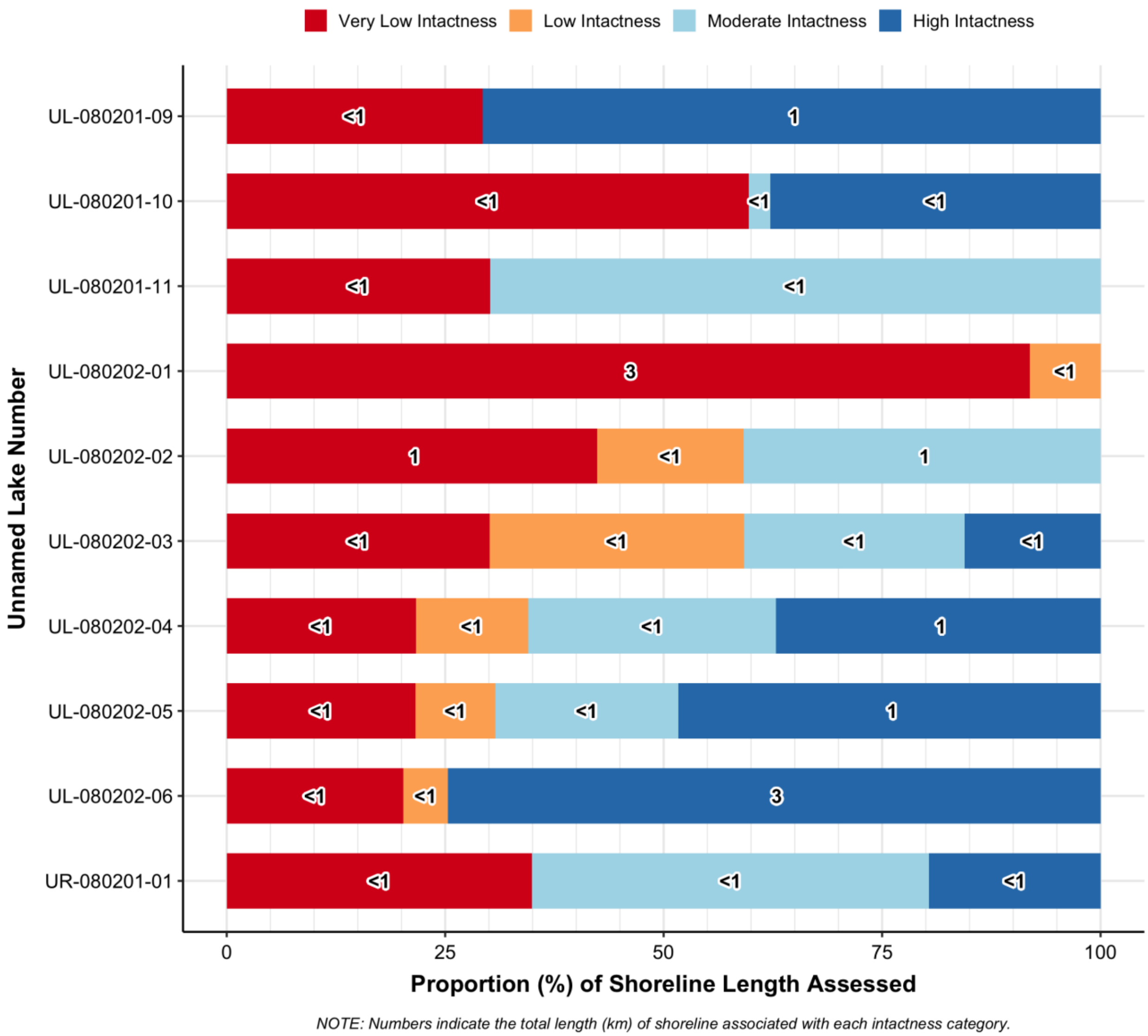


Figure 53. The proportion of shoreline length assigned to each riparian intactness category for unnamed lakes and reservoirs within Red Deer County.

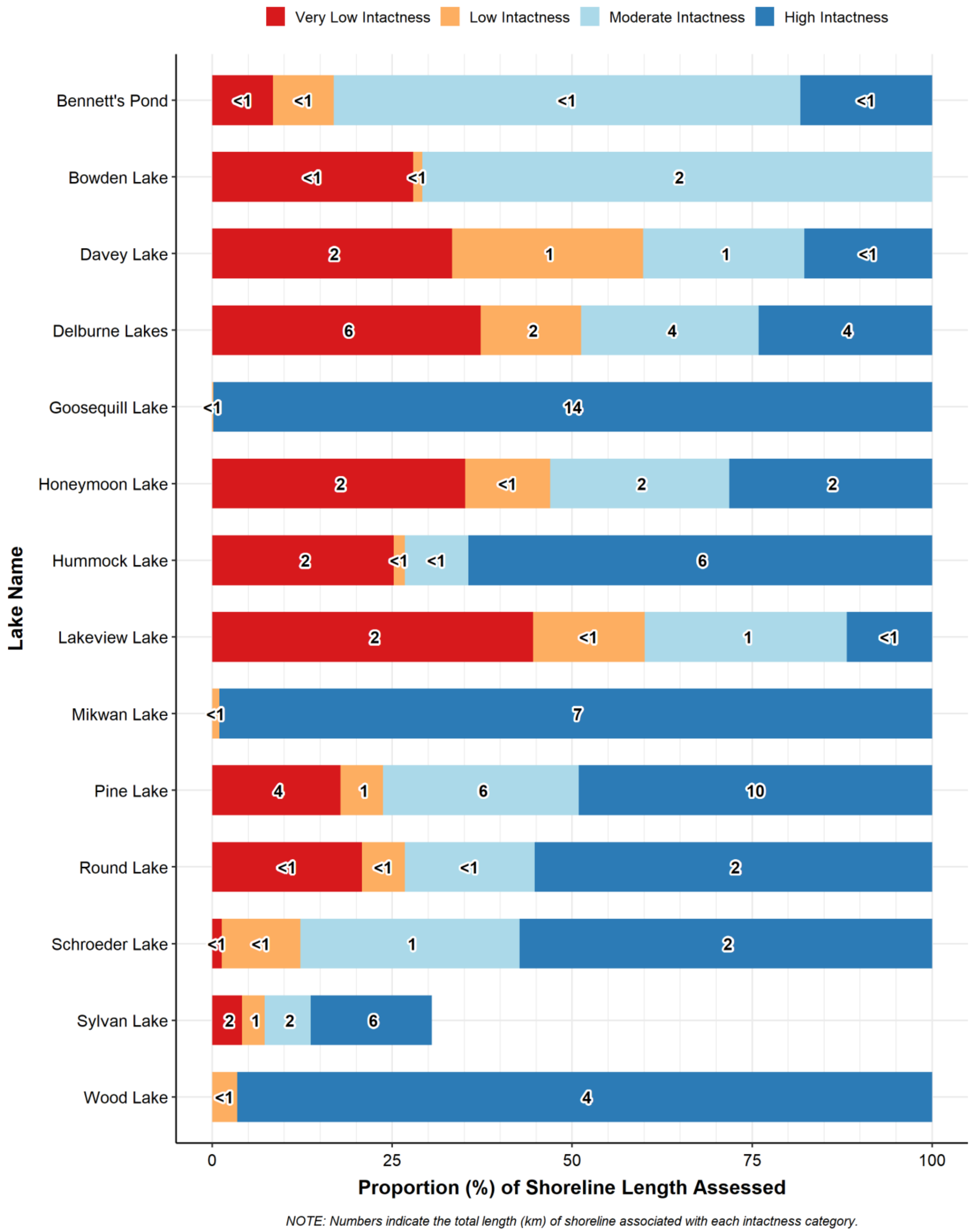


Figure 54. The proportion of shoreline length assigned to each riparian intactness category for unnamed lakes and reservoirs within Red Deer County.

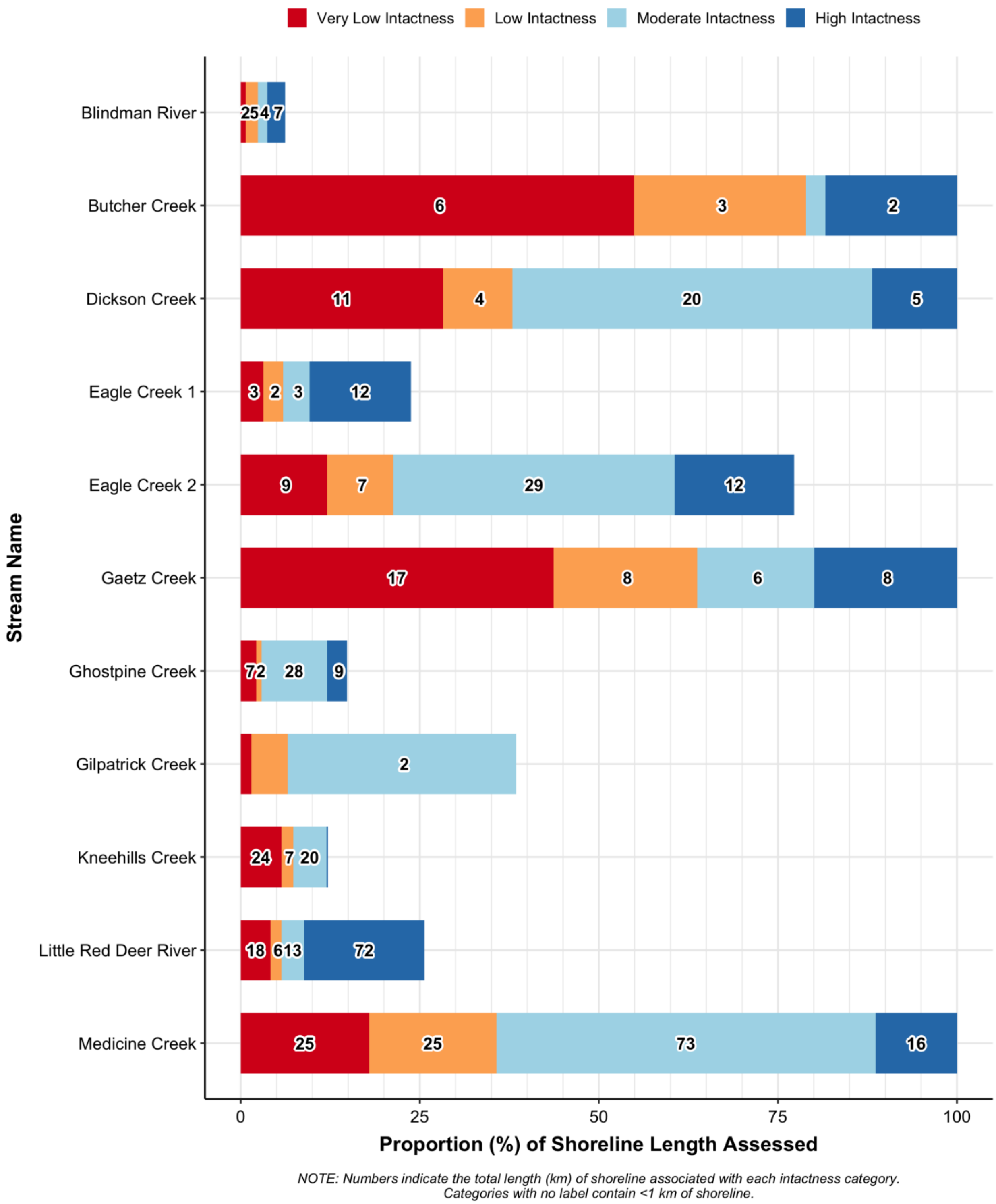


Figure 55. The proportion of shoreline length assigned to each riparian intactness category for named watercourses within Red Deer County.

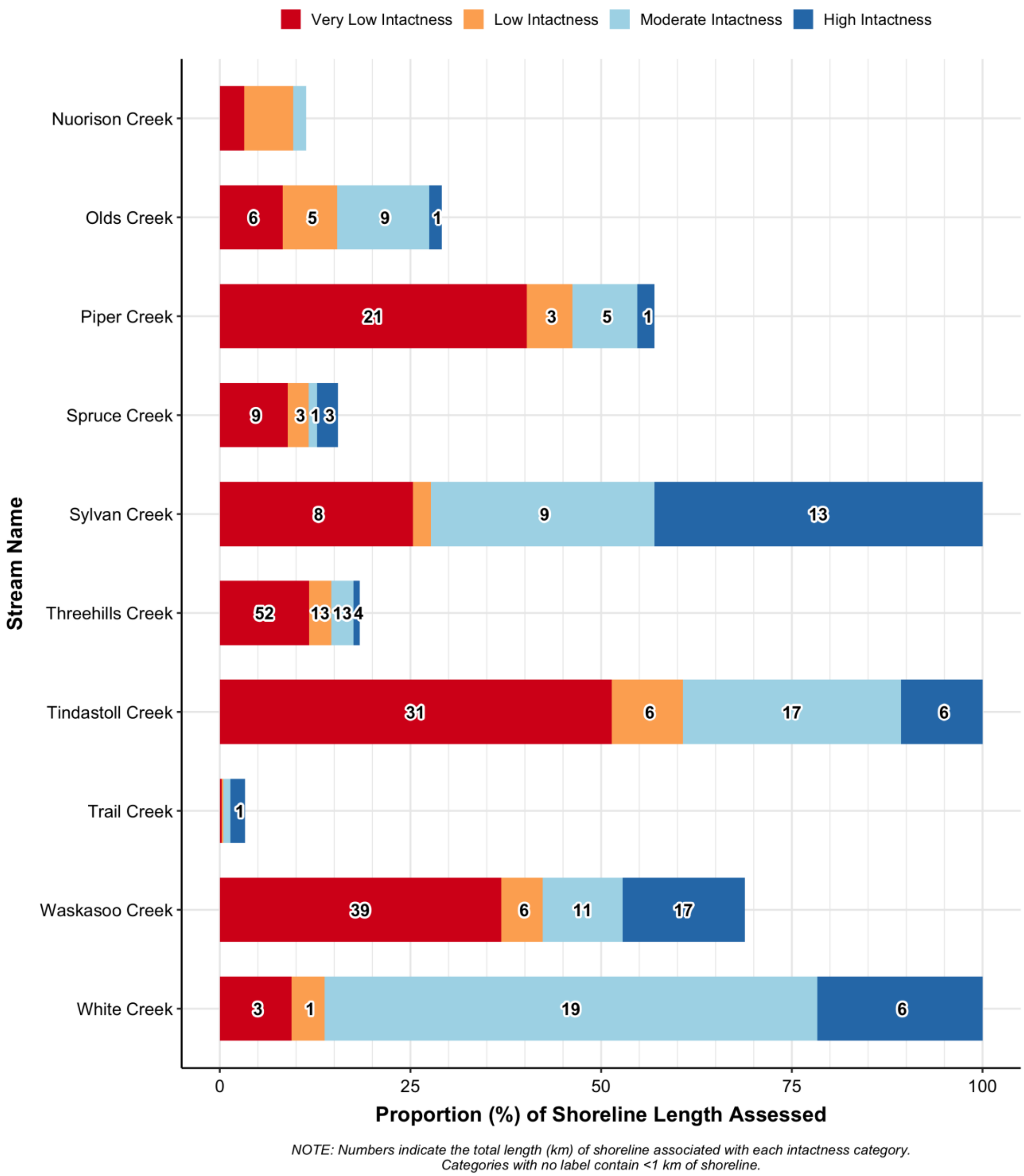


Figure 55 *continued*. The proportion of shoreline length assigned to each riparian intactness category for named watercourses within Red Deer County.

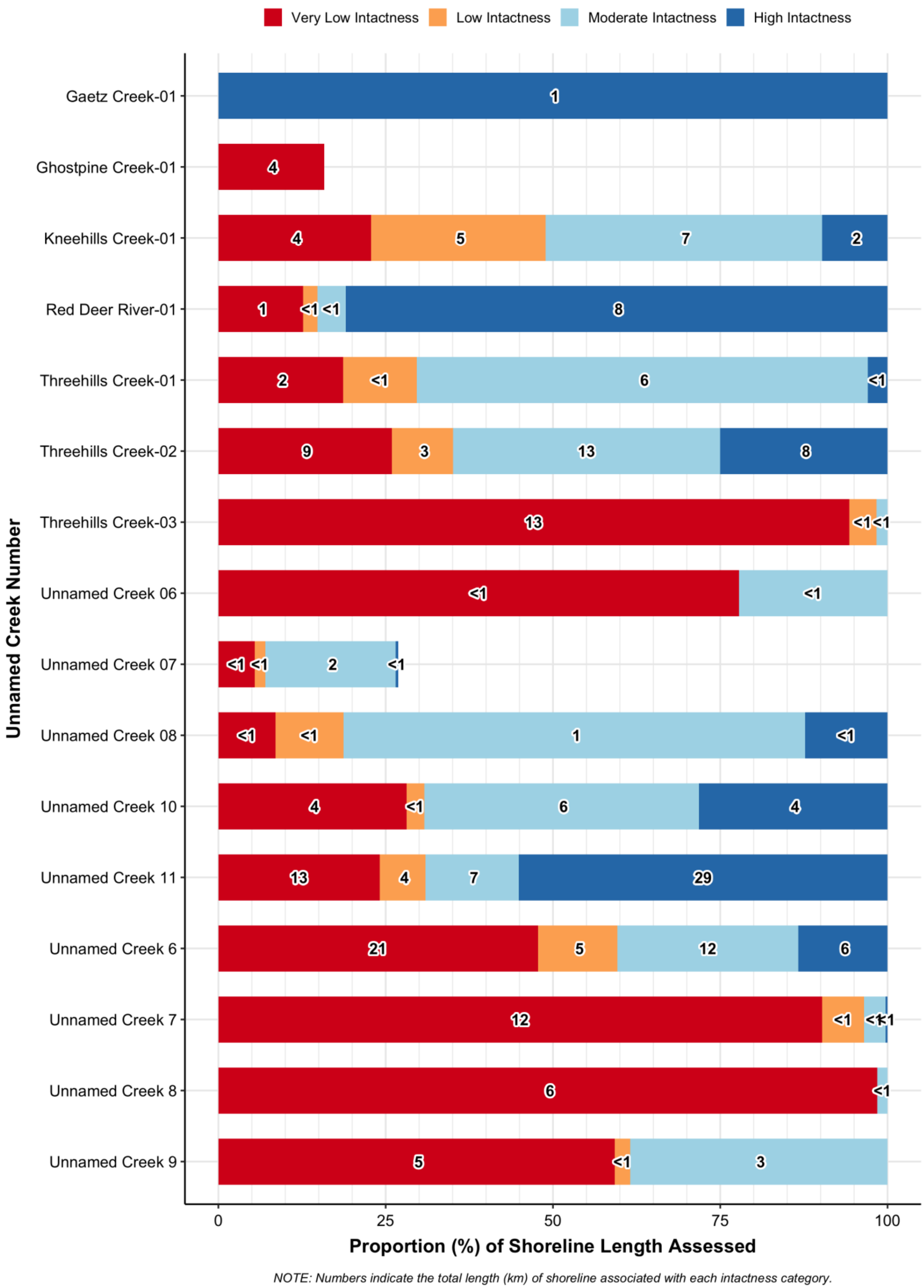
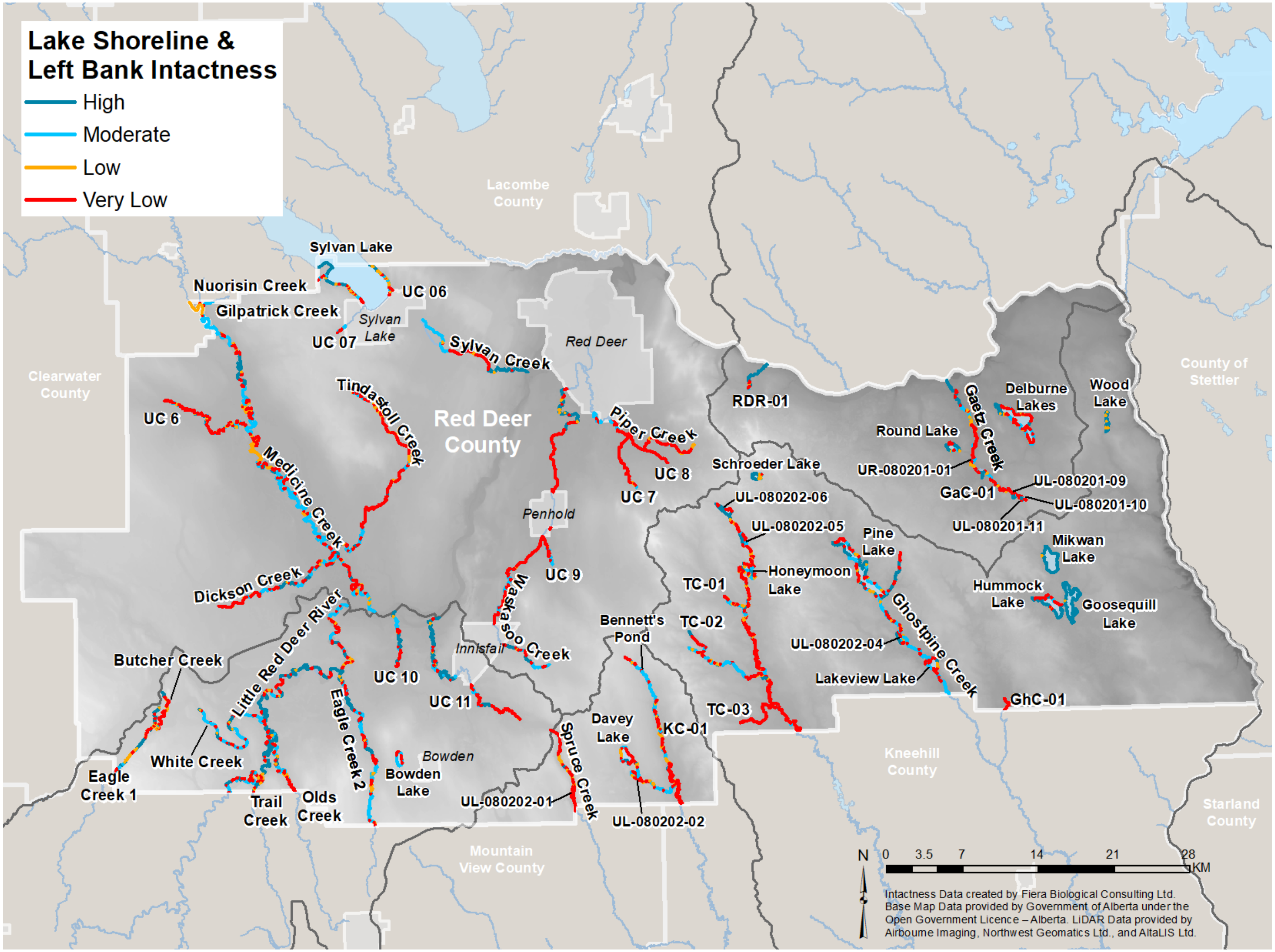
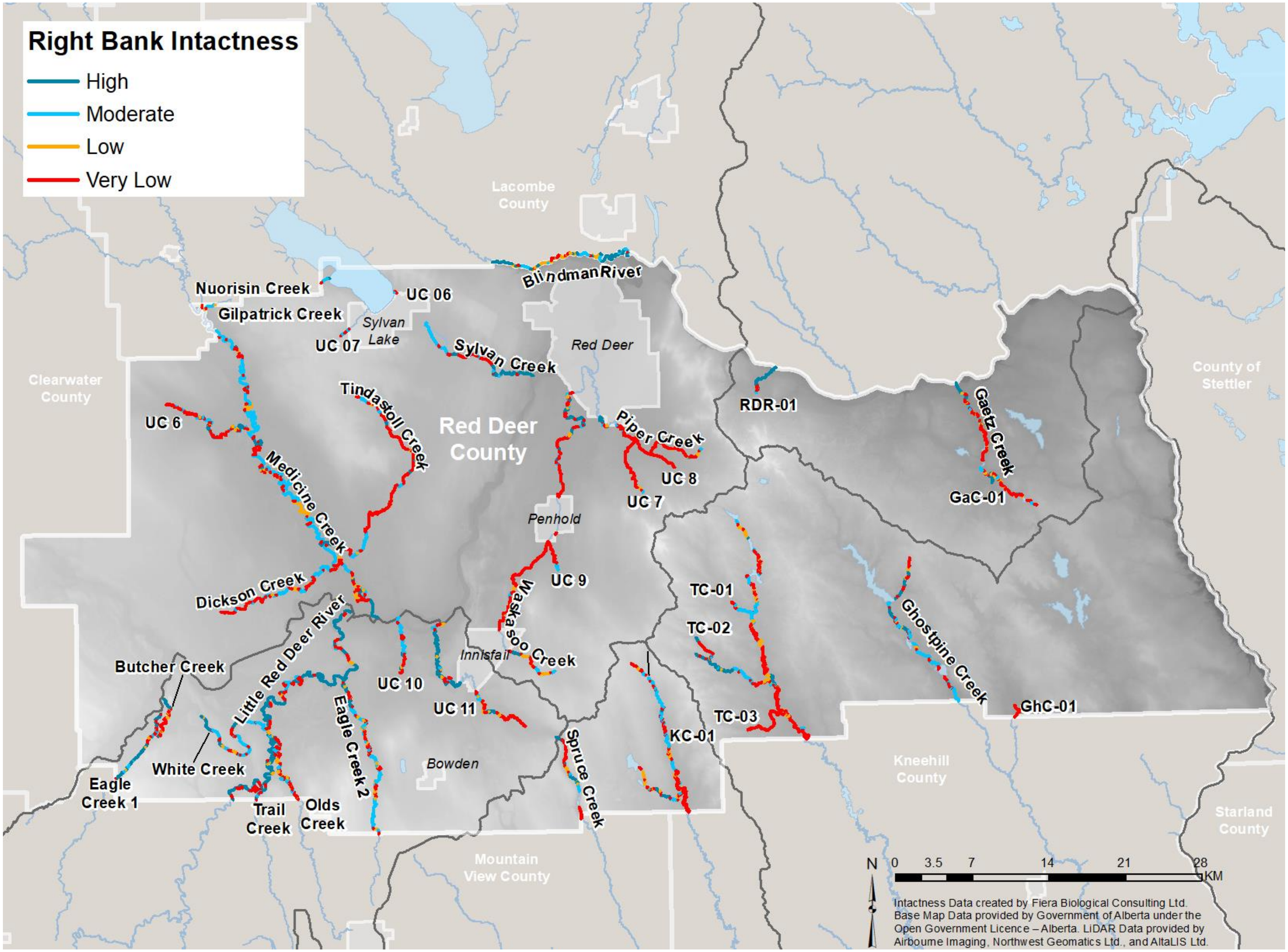


Figure 56. The proportion of shoreline length assigned to each riparian intactness category for unnamed watercourses within Red Deer County.



Map 27. Intactness for the left banks of watercourses and lake shorelines that have been assessed in Red Deer County.



Map 28. Intactness for the right banks of watercourses that that have been assessed in Red Deer County.

9.6. Rocky View County

Approximately 8% of Rocky View County overlaps with either the Little Red Deer or the Kneehills subwatersheds (Map 4), with the majority of this county having never been included in a satellite-based riparian assessment.

Just over half of the land cover in this county is anthropogenic, with agriculture making up 51% and built-up areas making up 6% of that cover (Figure 57). Natural cover types make up the remaining portion of the county, with natural grassland making up the largest proportion of the natural cover (23%). Forest (13%) and wetlands (5%) make up a the majority of the remaining natural cover.

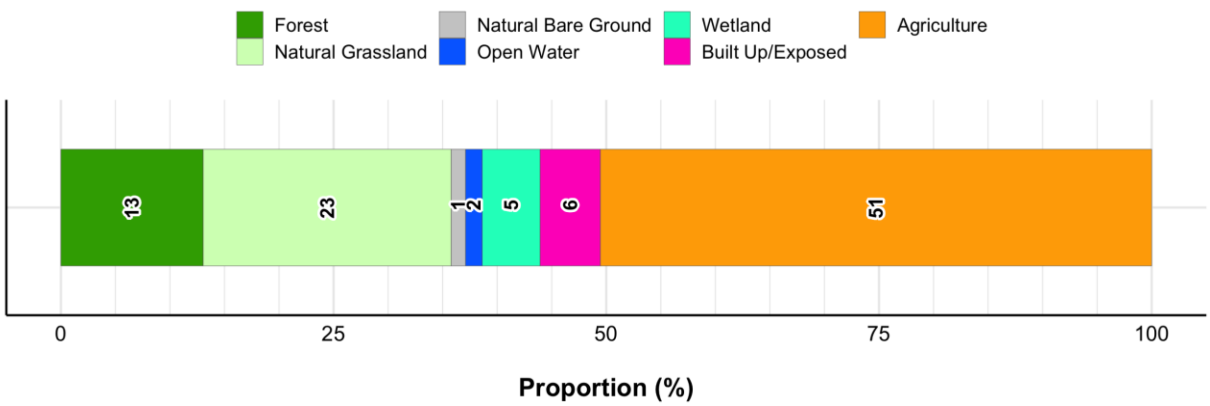


Figure 57. The proportion of Rocky View County assigned to each land cover class. Land cover data is based on the 2020 Agriculture and Agri-Food Canada land cover.

A total of 189 km of shoreline was assessed within Rocky View County, with 37% (69 km) categorized as High Intactness and an additional 19% (36 km) assessed as Moderate Intactness (Figure 58). The remaining 44% of shoreline was categorized as Low Intactness (9%, 17 km) or Very Low Intactness (35%, 65 km). These results included both the left and right shorelines of watercourses.

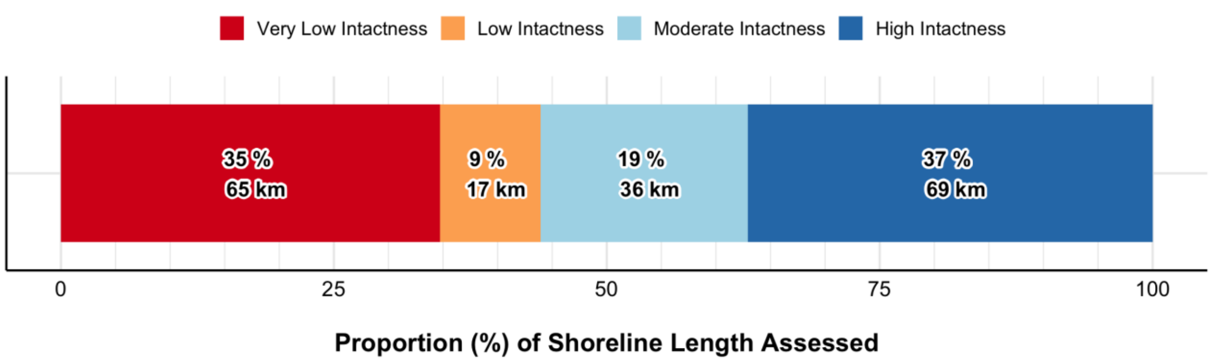


Figure 58. Overall intactness for waterbodies assessed within Rocky View County.

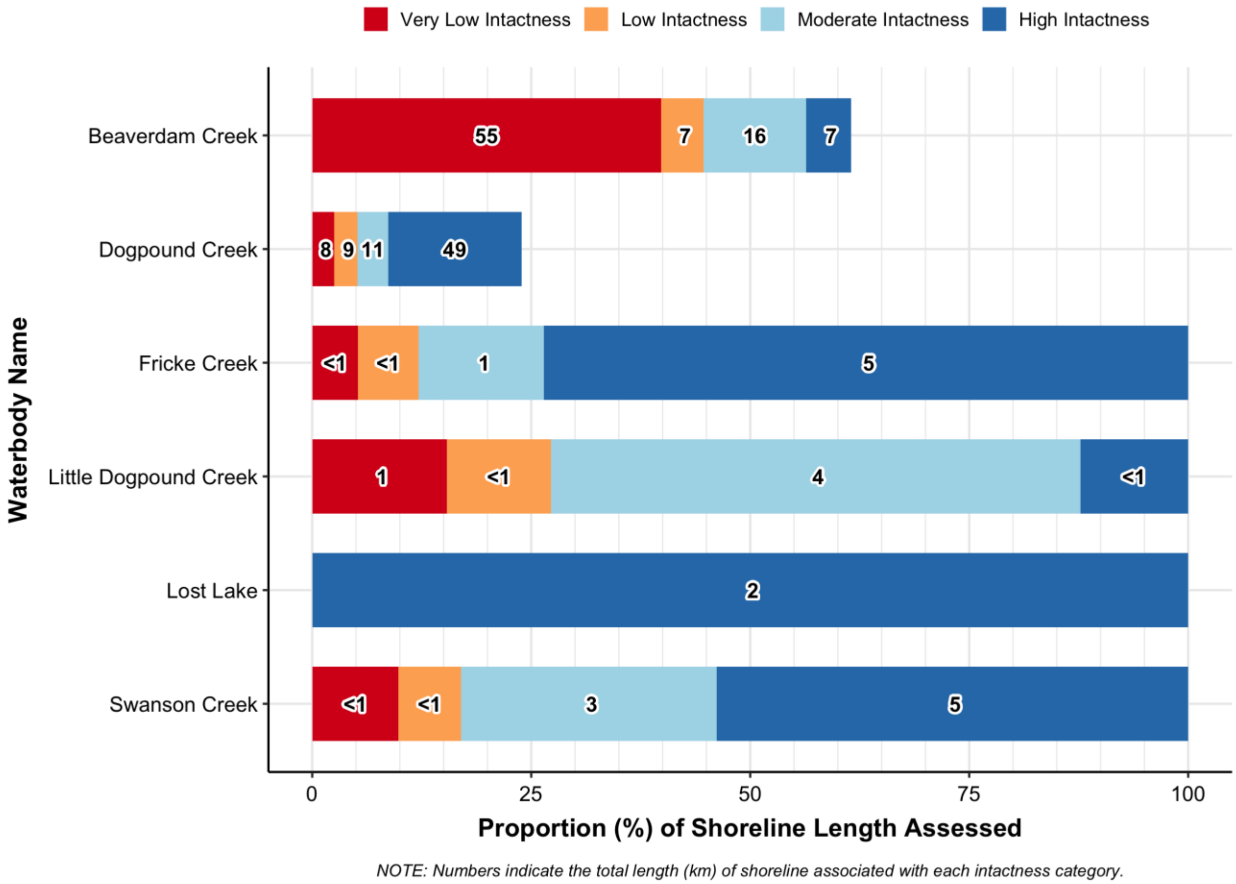
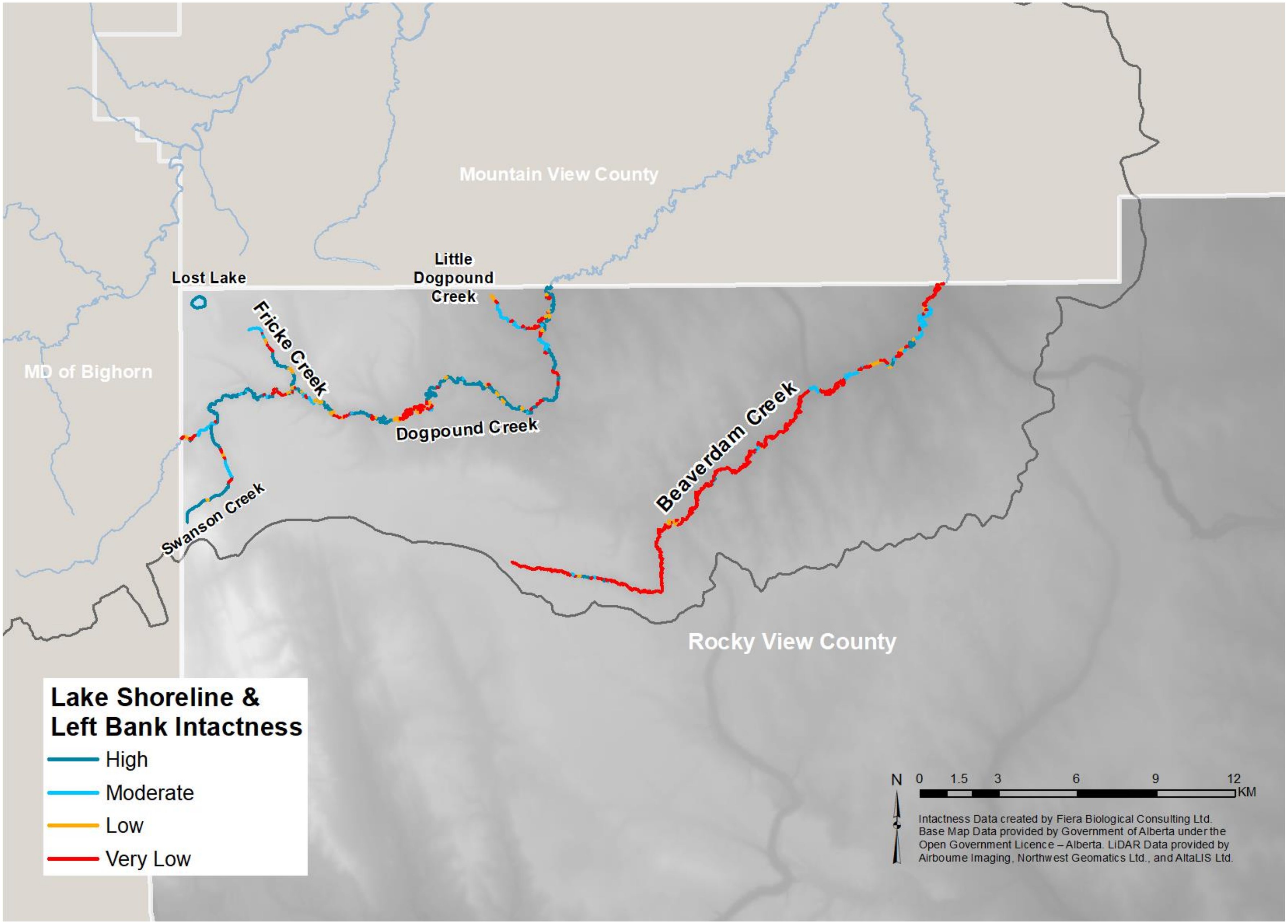
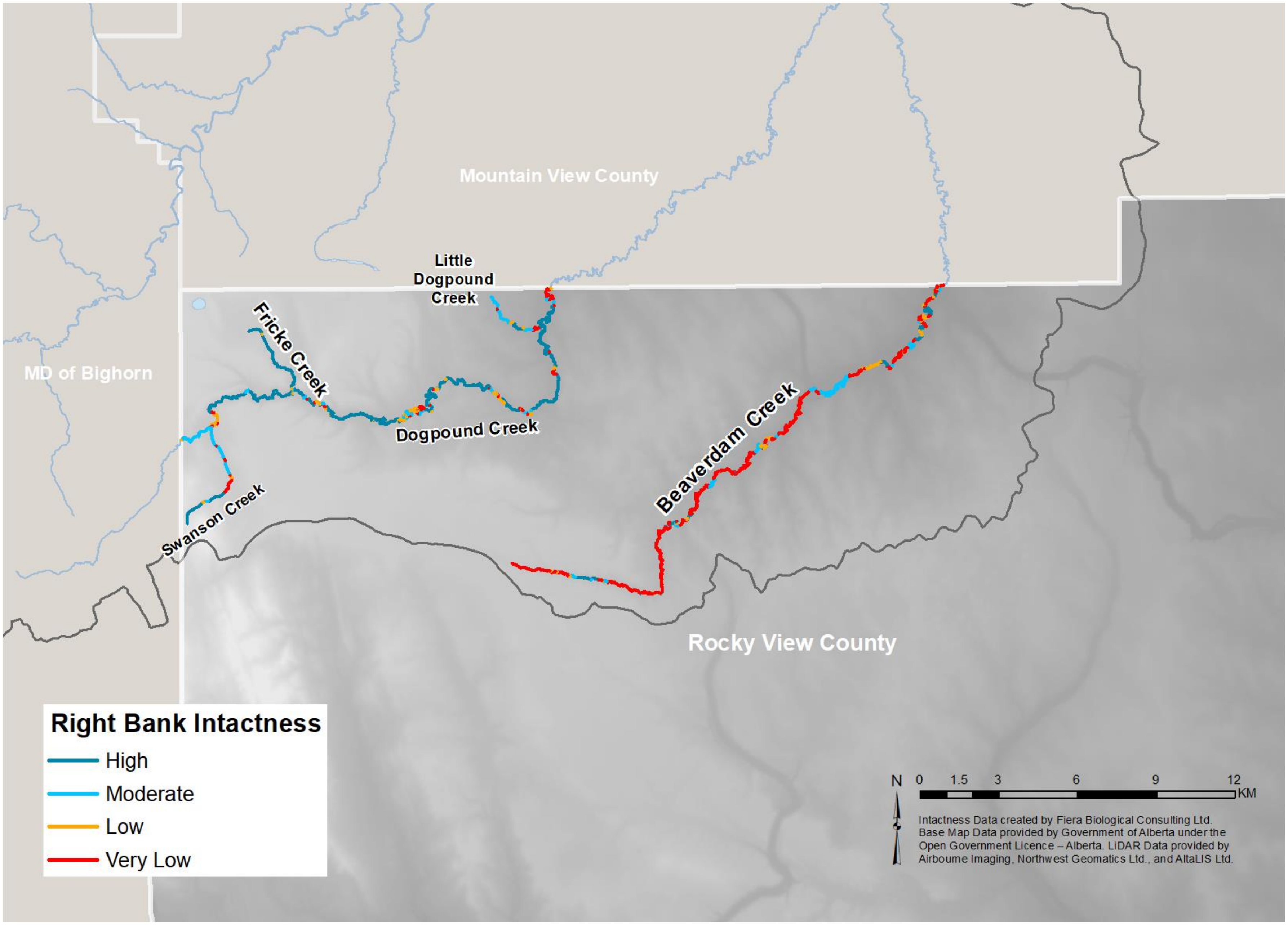


Figure 59. The proportion of shoreline length assigned to each riparian intactness category for assessed watercourses and lakes within Rocky View County.



Map 29. Intactness for the left banks of watercourses and lake shorelines that were assessed in Rocky View County.



Map 30. Intactness for the right banks of watercourses that were assessed in Rocky View County.

10.0 Riparian Land Management

Riparian intactness assessments are a screening-tool that can help to support a dialogue about riparian management and stewardship options. These assessments fill an essential data gap in watershed management by providing information about the intactness of riparian areas that can be used by a wide range of stakeholders, from Watershed Planning and Advisory Councils (WPACs) and stewardship groups, to municipalities and local landowners:

- **WPACs and local stewardship groups***:* Riparian intactness data can be used by a wide range of watershed groups to inform integrated watershed management planning, identify priority areas for potential restoration and/or conservation, and to understand the potential for riparian areas to contribute to key watershed outcomes (e.g., flood and drought resiliency, water quality). In particular, the data can be used to understand existing (baseline) conditions, which then allows for the identification of restoration or management targets, and the measurement of progress towards those targets. An example of how intactness data can be used by watershed groups to create a Riparian Habitat Management Framework is provided in Section 10.1.

- **Municipalities***:* Municipalities may use intactness data to set conservation or restoration targets, as well as to prioritize or guide programming decisions related to planning, conservation, restoration, and education. Section 11.0 outlines some of the existing tools for riparian management that may support this type of work. Areas with High or Moderate Intactness may be suitable for discussions regarding conservation options, whereas areas with Low or Very Low Intactness may be suitable areas to target for restoration and/or outreach.

- **Landowners***:* Local landowners may use intactness information to understand conditions on their land, which may lead them to explore the various riparian habitat management opportunities that may be available to them. For example, based on the intactness results, landowners may choose to request a site-specific assessment from an organization such as Cows and Fish. These site-specific assessments provide detailed information about the condition of riparian areas, and also provide information to landowners about best management practices and other management options for maintaining or improving the condition of riparian habitat on their land.

10.1. Creating a Riparian Habitat Management Framework

Data is foundational to conservation planning because it allows for the development of an evidence-based adaptive management framework. In order to maintain or improve riparian habitat condition, a baseline of current condition is required. This baseline then becomes the benchmark against which achievable outcomes and measurable targets can be developed, and relevant collective action by key stakeholders can be identified. These actions can then be monitored on a regular basis to provide an evaluation of outcomes that feed into an adaptive and reflexive approach to riparian land management through time.

Central to the goal of improving riparian habitat outcomes is the development of a framework with specific objectives for riparian management and conservation. Objectives may address different types of goals, such as environmental (e.g., targets for amount of intact riparian area), social (e.g., increase in awareness), and/or programmatic (e.g., development of municipal policy or application of BMPs). Each defined objective should have associated measures, targets, and actions that are developed to ensure that the associated objective is achievable, and success towards achieving each objective can be measured. A definition for each of the key building blocks for the development of a riparian management framework is provided below:

Objective:	High-level statements of desired future conditions (outcomes).
Measure:	Specific metrics that can be quantified to assess the progress towards, and the degree to which, desired future conditions have been achieved.
Target:	Values of measurable items (metrics) that indicate the attainment of a desired condition. In the current context these may be expressed as a single value or as a range to acknowledge the inherent variability of ecosystems.
Action:	Management actions, plans, or policies for achieving stated objectives.

While the development of a riparian management framework and associated objectives should be undertaken collectively by stakeholders, we provide a number of key recommendations below that may be considered in the development of a riparian management plan.

10.1.1. Key Recommendations

The development of management objectives needs to consider ecological, social, and economic factors, and should acknowledge that maintaining functional and resilient ecological and hydrological systems is fundamental to maintaining healthy and vibrant human communities. Below we outline what we consider to be important riparian management objectives for the Buffalo, Kneehills, Little Red Deer, and Threehills subwatersheds, and offer considerations and suggestions for the selection of measures and targets for each objective. We also offer a list of high-level actions for each objective. Further discussion about potential actions that can be undertaken to improve riparian habitat management is provided in Section 11.0. Note that this list of management objectives is not exhaustive, and there may be other important riparian habitat management objectives defined by stakeholders.

Objective 1:

- Maintain or improve watershed resilience by conserving high quality riparian habitat.

Measure:

- Proportion (%) of shoreline assessed as Moderate and/or High Intactness.

This objective can include a measure of conservation at multiple and nested spatial extents. For example, a target for conservation of high quality riparian habitat can be developed for the Red Deer River watershed as a whole, and/or can also include measures and targets for riparian habitat conservation at the scale of the individual subwatershed, municipality, and/or individual water body. Measures for riparian habitat conservation may also be specific to the type (order) and the location (e.g., headwaters) of the stream. For example, riparian vegetation provides proportionately greater benefits to instream habitat along the headwaters of streams specifically as it relates to the regulation of temperature, flow, and sediment regimes (Wipfli and Musslewhite 2004; Anonymous 2007). Because of this, there may be a desire to preferentially target riparian habitat along headwater streams for conservation. Alternatively, retention of riparian habitats along higher order streams could be prioritized in areas where habitat connectivity and biodiversity conservation is a priority.

Targets:

There is no universally accepted scientific target for the total amount of riparian habitat that should be maintained within a watershed; however, there is scientific consensus that the higher the quality and the greater the amount of riparian habitat that is maintained on the landscape, the better the outcomes for biodiversity, water quality, and water quantity. Further, there is no universal consensus on the width of vegetation along streams that should be maintained; however, there is general scientific agreement that factors such as the size (order) of the stream, the steepness of the banks, and the specific management concerns of the local system (e.g., soils, type of adjacent land use and land cover) should all be factors considered when determining the amount (width) of vegetation retained adjacent to a stream. For example, Environment and Climate Change Canada suggests as a riparian management guideline that 75% of a stream's length should be naturally vegetated, and that both sides of a stream should have a minimum 30-meter-wide naturally vegetated zone, while also acknowledging that wider buffers may be appropriate in some circumstances (Government of Alberta 2012; Environment Canada 2014).

Results from this study provide an important baseline that can be used to inform the selection of targets for this objective, as well as to measure improvement and progress towards achieving targets (Table 8). The target for this conservation objective could include specifying an individual target for the desired amount of Moderate and High Intactness at the subwatershed scale (e.g., ≥30% Moderate and ≥50% High). In addition, or as an alternative, overall targets for this objective can be set for each municipality. In this case, the Threehills and Kneehills subwatersheds, as well as Kneehill County could be spatially targeted for restoration activities, given that these areas have a lower proportion of Moderate/High Intactness shorelines than other locations within the study area.

Table 8. Proportion of riparian areas that have been classified into each of the riparian intactness categories (Very Low, Low, Moderate, High), summarized by various spatial extents (subwatershed, Municipality). Grey columns are the sum total of the Very Low + Low and the Moderate + High categories.

		Proportion (%) of Shoreline within Intactness Category					
Spatial Extent	**Length Assessed (km)**	**Very Low**	**Low**	**Total of Very Low + Low**	**Moderate**	**High**	**Total of Moderate + High**
Buffalo Subwatershed	910.0	25	8	33	28	39	67
Kneehills Subwatershed	1,001.9	42	16	58	36	6	42
Little Red Deer Subwatershed	2,208.5	18	9	27	18	55	73
Threehills Subwatershed	1,165.0	44	15	59	32	10	42
Kneehill County	1467.1	41	16	57	37	6	43
MD of Bighorn	645.8	4	2	6	6	88	94
Mountain View County	1376.5	31	14	45	22	33	55
Red Deer County	1317.2	33	11	44	30	26	56
Rocky View County	187.4	35	9	44	19	37	56

Once subwatershed or municipal targets have been set, finer scale spatial targets can be set for individual lakes or streams. For example, riparian habitat along creeks in the headwaters of the Red Deer River and/or each subwatershed could be prioritized for conservation, or as an alternative, riparian areas along creeks with important ecological values, such as threatened or sensitive fish populations, could be prioritized for conservation.

Actions:

There are a number of actions that could be taken to achieve conservation objectives, including (but not limited to):

- Incentivize voluntary conservation of riparian habitat on private land through payment for ecosystem services, changes to tax regimes, or other BMP programs.
- Develop education and outreach programs to encourage stewardship and conservation of riparian habitats on private land.
- Secure high conservation priority riparian habitats through purchase or through other land securement mechanisms available to conservation groups, land trusts, or municipalities.
- Develop provincial and/or municipal development setback and riparian land management policies.
- Create a municipal habitat conservation and restoration fund to allow for the securement of high priority riparian conservation areas.

Objective 2:

- Reduce flood risk by restoring riparian habitats that have been impacted or impaired.

Measure:

- Proportion (%) of shoreline assessed as Very Low and/or Low Intactness.

Similar to Objective 1, this measure can include multiple and nested spatial extents, and can also include finer scale spatial targeting of particular regions or high-priority waterbodies.

Targets:

Riparian habitats stabilize the banks of waterbodies and help modulate water velocities and high water events, thereby protecting surrounding lands from flooding (Orewole et al. 2015; Olokeogun et al. 2020). Thus, limiting the amount and extent of riparian habitat that has been severely impacted and restoring these areas should be an important goal for riparian habitat management, particularly in areas that are prone to flooding.

For this objective, a target such as having <25% of each waterbody's shoreline classified as Very Low or Low Intactness could be applied in each subwatershed (Environment Canada 2014); however, given that over half of the waterbodies assessed in this study do not currently meet this target, focusing initial restoration efforts on waterbodies that are in the worst condition may be appropriate. For example, waterbodies with >50% of their shoreline classified as Very Low Intactness could be targeted, and in this case, the focus would be on 37 of the waterbodies assessed in this study (Table 9). Notably, this list could be be expanded to include a number of other waterbodies as targets are adjusted to meet the needs of stakeholders in each of the subwatersheds.

Actions:

There are a number of actions that could be taken to achieve the targets specified under Objective 2, including (but not limited to):

- Incentivize riparian habitat restoration on private land through payment for ecosystem services, changes to tax regimes, or other BMP programs.
- Develop education and outreach programs to encourage private land restoration, particularly for landowners located upstream of flood prone areas.
- Partner with conservation organizations to promote and encourage restoration on private lands.
- Create a municipal habitat conservation and restoration fund to pay for riparian habitat restoration on public lands, with a specific focus on restoring areas identified as Very Low or Low Intactness.

Table 9. Waterbodies assessed as part of this study with 50% or more of their shorelines classified as Very Low Intactness.

Waterbody	Subwatershed	Proportion (%) of Shoreline within Intactness Category			
		Very Low	Low	Moderate	High
UR-080202-01	Kneehills	100	0	0	0
UR-080102-02	Little Red Deer	100	0	0	0
Threehills Creek-03	Threehills	94	4	2	0
UL-080202-01	Kneehills	92	8	0	0
Unnamed Creek 10	Buffalo	88	0	6	6
Threehills Creek-07	Threehills	87	12	2	0
Threehills Creek-09	Threehills	84	12	3	0
UR-080102-03	Little Red Deer	77	8	15	0
Unnamed Creek 02	Buffalo	76	0	0	24
Unnamed Creek 03	Buffalo	76	3	6	15
Unnamed Creek 09	Buffalo	75	14	0	11
Ghostpine Creek-01	Threehills	74	23	4	0
Kneehills Creek-02	Kneehills	72	17	11	0
Threehills Creek-05	Threehills	71	11	14	4
Threehills Creek-08	Threehills	71	10	18	0
Bigelow Reservoir	Threehills	67	11	16	7
Ghostpine Creek-06	Threehills	67	17	16	0
Spruce Creek	Kneehills	65	17	15	3
Fyten Reservoir	Kneehills	62	0	38	0
Burns Lake	Kneehills	62	0	38	0
Ten Mile Creek	Kneehills	61	27	12	0
UL-080201-10	Buffalo	60	0	2	38
Lonepine Creek-01	Kneehills	59	12	29	0
Hiller's Reservoir	Kneehills	59	2	39	0
Red Deer River-04	Kneehills	58	14	2	26
Unnamed Creek 07	Buffalo	58	23	19	1
Harmatten Reservoir	Little Red Deer	57	0	1	42
Hicklon Lake	Little Red Deer	56	30	15	0
Threehills Creek	Threehills	55	15	23	6
Butcher Creek	Little Red Deer	55	24	3	18
Hicklon Creek	Little Red Deer	54	30	16	0
Lonepine Creek	Kneehills	53	14	28	5
Threehills Creek-04	Threehills	52	18	31	0
Haynes Creek-01	Buffalo	52	18	30	0
Parlby Creek	Buffalo	51	5	32	12

11.0 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.

11.1. 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 are listed in Table 10.

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 is provided in Table 11.

Table 10. List and description of Federal laws and regulations that may apply to the management of riparian areas in the Red Deer River 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 11. List and description of Provincial laws, regulations, and policies that may apply to the management of riparian areas in the Red Deer River 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. In addition, 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.

Continued …

Table 11 *continued …* List and description of Provincial laws, regulations, and policies that may apply to the management of riparian areas in the Red Deer River 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 or provide public access to the bed and shore of the waterbody or watercourse. 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.

11.2. 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 cannot 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 landowner if the land is sold. Conservation easements can be negotiated by a private landowner 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 landowner, 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 Red Deer River 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 landowners. 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 landowner 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 landowner 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 landowner; 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.

11.3. 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 Red Deer River watershed.

Partnerships:

Given the limited number of tools available to municipalities for the acquisition of riparian areas on private lands, engaging in strategic partnerships to promote voluntary land conservation and management activities is essential. Central to this is developing partnerships with 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 Red Deer River watershed for the purpose of conserving and managing riparian habitats, and a helpful first step in focusing management action is to define realistic 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.

12.0 Conclusion

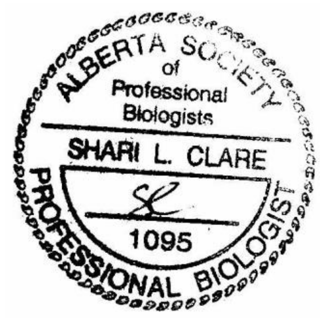
The overall goal of this project was to quantify and characterize the intactness of riparian management areas in the Buffalo, Kneehills, Little Red Deer, and Threehills subwatersheds. This study considered results from previous studies that evaluated shorelines in the Buffalo subwatershed and Red Deer County using the same satellite-based method, as well as results from newly assessed waterbodies and watercourses.

In total, approximately 5,285 km of shoreline was evaluated, with 59% of the shoreline being categorized as either High (33%, 1,761 km) or Moderate (26%, 1,371 km) Intactness. The remaining 40% of the shoreline was classified as Very Low (29%, 1,550 km) or Low (11%, 602 km) Intactness. The greatest length of shoreline classified as Very Low Intactness was located within the Threehills (509 km) and Kneehills (422 km) subwatersheds, and primarily within the jurisdiction of Kneehill County (606 km).

The intactness ratings provided in this report are intended to support a screening-level assessment of management and/or conservation priorities across the four subwatersheds included in this study, and are not meant to replace more detailed, site-specific field assessments of riparian health or condition. Instead, this information should be used to highlight smaller, more localized areas where field assessments and further validation may be required. Ultimately, the results of this work provide the RDRWA, local municipalities, stewardship groups, and other partners with an overview of the status of riparian areas within the Buffalo, Kneehills, Little Red Deer, and Threehills subwatersheds, and provides a foundation of scientific evidence that can be used to support stewardship and management efforts throughout the region.

12.1. Closure

This report was written by:



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13.0 Literature Cited

Adams, P.W. and M. Taratoot. 2001. Municipal water supplies from forest watersheds in Oregon: Fact book and catalogue. Oregon Forest Resources Institute, Portland. 100 p.

Alberta Biodiversity Monitoring Institute (ABMI). 2017. Wall-to-wall Human Footprint Inventory. Available: http://www.abmi.ca/home/data-analytics/da-top/da-product-overview/GIS-Land-Surface/HF-inventory.html.

Alberta Environment (AENV). 2010. Using Aerial Videography to Assess Riparian Areas in Southern Alberta: a Pilot Study. Alberta Environment, Calgary. 40 pp.

Alberta Environment and Sustainable Resource Development (AESRD). 2012. Guide to Reporting on Common Indicators Used in State of the Watershed Reports. Government of Alberta, Edmonton, Alberta.

Alberta Geological Survey. 2016. Relative Landslide Susceptibility Model of the Alberta Plains and Shield Regions. Available: http://ags.aer.ca/publications/MAP_605.html.

Anonymous. 2007. The technical basis of zone of sensitivity determinations under the detailed assessment procedure of the Riparian Areas Regulation. B.C. Ministry of Environment and Fisheries and Oceans Canada, Pacific Region. 55pp. Available: https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/fish-fish-habitat/riparian-areas-regulations/rar_zone_of_sensitivity__rational_2007.pdf?bcgovtm=2free

Blackport R, R. MacGregor, and J. Imhof. 1995. An approach to the management of groundwater resources to protect and enhance fish habitat. Canadian Manuscript Report of Fisheries and Aquatic Sciences, No. 2284, Ontario, Canada.

Caissie D. 1991. The importance of groundwater to fish habitat: Base flow characteristics for three Gulf Region Rivers. Canadian Data Report of Fisheries and Aquatic Sciences, No. 814, Ontario, Canada.

Clare and Sass. 2012. Riparian lands in Alberta: Current state, conservation tools, and management approaches. Report prepared for Riparian Land Conservation & Management Team, Alberta Water Council, Edmonton, Alberta. Fiera Biological Consulting Ltd. Report #1163.

Deegan, B.M., Ganf, G., and Brookes, J.D. 2010. Assessment of Riverine Ecological Condition in the Fleurieu Peninsula, South Australia: Implications for Restoration. Transactions of the Royal Society of South Australia 134: 228-242.

Donahue, W.F. 2013. Determining Appropriate Nutrient and Sediment Loading Coefficients for Modeling Effects of Changes in Landuse and Landcover in Alberta Watersheds (technical report). Water Matters Society of Alberta, Canmore, AB. http://hdl.handle.net/1880/111976

Environment Canada. 2014. How Much Habitat is Enough? Third Edition. Environment Canada, Toronto, Ontario. Pp. 130.

Environmental Law Centre. 2015. Conservation directives: Alberta's unknown and untested conservation tool. Available: http://elc.ab.ca/media/103996/ConservationDirectivesELCRecommendations.pdf. Accessed: December 30, 2016.

Fiera Biological Consulting Ltd. 2018a. Modeste Watershed Riparian Area Assessment. Report prepared for the North Saskatchewan Watershed Alliance, Edmonton, Alberta. Fiera Biological Consulting Report Number 1652. Pp. 101.

Fiera Biological Consulting Ltd. 2018b. Sturgeon Riparian Area Assessment. Report #1762. Prepared for the North Saskatchewan Watershed Alliance, Edmonton, Alberta. Pp. 113.

Fiera Biological Consulting Ltd. 2018c. Strawberry Riparian Area Assessment. Report #1773. Prepared for the North Saskatchewan Watershed Alliance, Edmonton, AB. Pp. 110.

Fiera Biological Consulting Ltd. 2018d. Riparian Assessment for North Saskatchewan Region Lakes. Report #179910. Prepared for the Alberta Environment and Parks, Policy and Planning Division, Edmonton, Alberta. Pp. 65.

Fiera Biological Consulting Ltd. 2018e. Blindman River Riparian Assessment. Report #1834. Prepared for Agroforestry & Woodlot Extension Society (AWES), Edmonton, Alberta. Pp. 39.

Fiera Biological Consulting Ltd. 2019. Riparian Assessment Validation for North Saskatchewan Region Lakes. Report #1853. Prepared for the Alberta Environment and Parks, Policy and Planning Division, Edmonton, Alberta. Pp. 45.

Fiera Biological Consulting Ltd. 2020a. Riparian Area Assessment for the Medicine-Blindman Rivers Watershed. Report #2011. Prepared for the Red Deer River Watershed Alliance, Red Deer, Alberta. Pp. 104.

Fiera Biological Consulting Ltd. 2020b. Mid-Pembina Watershed Riparian Area Assessment. Report #2012. Prepared for the Athabasca Watershed Council, Athabasca, Alberta. Pp. 80.

Fiera Biological Consulting Ltd. 2021a. West Prairie River Watershed Riparian Area Assessment. Fiera Biological Consulting Report #2014. Prepared for the Lesser Slave Watershed Council, High Prairie, Alberta. Pp. 69.

Fiera Biological Consulting Ltd. 2021b. Upper Pembina Watershed Riparian Area Assessment. Report #2012c. Prepared for the Athabasca Watershed Council, Athabasca, Alberta. Pp. 74.
Fiera Biological Consulting Ltd. 2021c. Lower Pembina Watershed Riparian Area Assessment. Report #2012b. Prepared for the Athabasca Watershed Council, Athabasca, Alberta. Pp. 77.
Fiera Biological Consulting Ltd. 2021d. Riparian Area Assessment of the North Saskatchewan and Battle River Watersheds. Report # 1987c. Prepared for the North Saskatchewan Watershed Alliance and the Battle River Watershed Alliance. Pp. 56 + Appendices.
Fiera Biological Consulting Ltd. 2021e. Jackfish-Muriel Creeks Watershed Riparian Area Assessment. Report #2044. Prepared for the Lakeland Industry & Community Association, Athabasca, Alberta. Pp. 128.
Fiera Biological Consulting Ltd. 2021f. Upper Beaver Watershed Riparian Area Assessment. Fiera Biological Consulting Report #2132. Prepared for the Lakeland Industry & Community Association, Athabasca, Alberta. Pp. 157
Flotemersch J.E., Leibowitz S.G., Hill R.A., Stoddard J.L., Thoms M.C., Tharme R.E. 2015. A Watershed Integrity Definition and Assessment Approach to Support Strategic Management of Watersheds. River Research and Applications 32: 1654–1671.
Government of Alberta. 2012. Stepping Back from the Water: A Beneficial Management Practices Guide for New Development Near Water Bodies in Alberta's Settled Region. Her Majesty the Queen in right of the Province of Alberta. Available: https://open.alberta.ca/dataset/1c70eb43-a211-4e9c-82c3-9ffd07f64932/resource/6e524f7c-0c19-4253-a0f6-62a0e2166b04/download/2012-steppingbackfromwater-guide-2012.pdf
Government of Alberta. 2018. Alberta ArcHydro Phase 2. ArcGIS Geodatabase. Available: https://open.alberta.ca/dataset/bcf911fd-741e-4c8c-9f90-9e191b1d6ed3.
Ho, T.K. 1995. Random decision forests. Proceedings of the 3rd International Conference on Document Analysis and Recognition, Montreal, QC, 14–16 August 1995. pp. 278–282.
Mills, B. and Scrimgeour, G. 2004. The Effectiveness of Aerial Videography to Characterize Lakeshore Condition. Data Report (D-2005-017) produced by Alberta Conservation Association, Alberta, Canada. 52 pp. + App.
North Saskatchewan Watershed Alliance (NSWA). 2015. Riparian Health Assessment of Wabamun Lake: An Aerial Assessment Using an Unmanned Air Vehicle (UAV). Prepared for the Wabamun Watershed Management Council, Edmonton, AB. 20pp + Appendix.
NRC (National Research Council). 2002. Riparian Areas: functions and strategies for management. National Academy Press, Washington, D.C. 428 pp.
O2 Planning + Design. 2013. Background technical report on riparian areas, wetlands, and land use. Prepared for the Red Deer River Watershed Alliance. Available: https://rdrwa.ca/wp-content/uploads/2020/09/ReportRiparianAreasWetlandsLandUse.pdf. Accessed: December 2, 2021.
Olokeogun, O. S., A. Ayanlade, and O.O. Popoola. 2020. Assessment of riparian zone dynamics and its flood-related implications in Eleyele area of Ibadan, Nigeria. Environmental Systems Research, 9(1), 1-11.
Orewole, M. O., D.B. Alaigba, and O. Oviasu. 2015. Riparian corridors encroachment and flood risk assessment in Ile-Ife: A GIS perspective. Open Transactions on Geosciences. 2(1): 17-32.
Pusey, B.J. and A.H. Arthington. 2003. Importance of the riparian zone to the conservation and management of freshwater fish: a review. Marine and Freshwater Research 54: 1-16.
RDRWA. 2016. Blueprint. An Integrated Watershed Management Plan for the Red Deer River Watershed. Available: https://rdrwa.ca/wp-content/uploads/2020/09/Blueprint_Phase1_WaterQuality_Online_Final.pdf.
Ripley, T., Scrimgeour, G., and M.S. Boyce. 2005. Bull trout (*Salvelinus confluentus*) occurrence and abundance influenced by cumulative industrial developments in a Canadian boreal forest watershed. Canadian Journal of Fisheries and Aquatic Sciences 62: 2431-2442.
Swanson, S., D. Kozlowski, R. Hall, D. Heggem, and J. Lin. 2017. Riparian proper functioning condition assessment to improve watershed management for water quality. Journal of Soil and Water Conservation. 72(2): 168–182. doi:10.2489/jswc.72.2.168.
Tchir, J.P., Hvenegaard, P.J., and Scrimgeour, G.J. 2004. Stream Crossing Inventories in the Swan and Notikewin River Basins of Northwest Alberta: Resolution at the Watershed Scale. Available: http://www.ab-conservation.com/downloads/report_series/stream-crossing-inventories-in-the-swan-and-notikewin-river-basins-of-nw-alberta-resolution-at-the-watershed-scale-2004.pdf.
Teichreb C. and Walker G, 2008. Aerial Videograhic Health and Integrity Assessment of the Riparian Management Area for Selected Reaches of the Battle River. Alberta Environment Technical Report. Available: https://www.battleriverwatershed.ca/sites/default/files/2007_Battle_River_H_and_I_Final_Report_George_24_Mar_08.pdf.
Wipfli, M.S., and Musslewhite, J. 2004. Density of red alder (Alnus rubra) in headwaters influences invertebrate and detritus subsidies to downstream fish habitats in Alaska. Hydrobiologia 520: 153-163

Appendix A: Intactness Summary Tables

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

Waterbody Name & Intersecting Municipality	Length Assessed (km)*	Intactness Category							
		Very Low		Low		Moderate		High	
		km*	%	km*	%	km*	%	km*	%
Atkinson Creek	**21.3**	**21.0**	**99**	**0.0**	**0**	**0.0**	**0**	**0.3**	**1**
MD of Bighorn	21.3	21.0	99	0.0	0	0.0	0	0.3	1
Beaverdam Creek	**137.0**	**10.8**	**8**	**13.5**	**10**	**49.2**	**36**	**63.5**	**46**
Mountain View County	52.8	3.8	3	6.9	5	33.1	24	8.9	7
Rocky View County	**84.3**	7.0	5	6.6	5	16.1	12	54.6	40
Benjamin Creek	14.7	**14.3**	**97**	**0.3**	**2**	**0.1**	**1**	**0.0**	**0**
MD of Bighorn	14.7	14.3	97	0.3	2	0.1	1	0.0	0
Benjamin Creek-01	**3.2**	**2.8**	**88**	**0.1**	**2**	**0.2**	**6**	**0.1**	**3**
MD of Bighorn	3.2	2.8	88	0.1	2	0.2	6	0.1	3
Bennett's Pond	**0.7**	**0.1**	**18**	**0.1**	**8**	**0.5**	**65**	**0.1**	**8**
Red Deer County	0.7	0.1	18	0.1	8	0.5	65	0.1	8
Bergen Creek	8.9	**3.3**	**38**	**0.2**	**3**	**4.5**	**51**	**0.8**	**9**
Mountain View County	8.9	3.3	38	0.2	3	4.5	51	0.8	9
Big Coulee Creek	16.8	**16.4**	**98**	**0.1**	**1**	**0.1**	**0**	**0.2**	**1**
MD of Bighorn	**16.8**	16.4	98	0.1	1	0.1	0	0.2	1
Big Prairie Creek	26.1	**22.9**	**88**	**0.9**	**3**	**1.5**	**6**	**0.7**	**3**
MD of Bighorn	4.4	4.4	17	0.0	0	0.0	0	0.0	0
Mountain View County	21.6	18.5	71	0.9	3	1.5	6	0.7	3
Bigelow Reservoir	**13.3**	**0.9**	**7**	**1.4**	**11**	**2.1**	**16**	**9.0**	**67**
Kneehill County	13.3	0.9	7	1.4	11	2.1	16	9.0	67
Blindman River	17.7	**7.2**	**40**	**4.7**	**27**	**3.8**	**21**	**2.0**	**11**
Red Deer County	**17.7**	7.2	40	4.7	27	3.8	21	2.0	11
Boggy Lake	2.2	**2.2**	**100**	**0.0**	**0**	**0.0**	**0**	**0.0**	**0**
MD of Bighorn	2.2	2.2	100	0.0	0	0.0	0	0.0	0
Bowden Lake	**3.2**	**0.0**	**0**	**0.0**	**1**	**2.3**	**71**	**0.9**	**28**
Red Deer County	3.2	0.0	0	0.0	1	2.3	71	0.9	28
Burns Lake	4.2	**0.0**	**0**	**0.0**	**0**	**1.6**	**38**	**2.6**	**62**
Mountain View County	**4.2**	0.0	0	0.0	0	1.6	38	2.6	62
Butcher Creek	10.5	**1.9**	**18**	**2.5**	**24**	**0.3**	**3**	**5.8**	**55**
Red Deer County	**10.5**	1.9	18	2.5	24	0.3	3	5.8	55
Cabin Creek	19.3	**19.3**	**100**	**0.0**	**0**	**0.0**	**0**	**0.0**	**0**
MD of Bighorn	19.3	19.3	100	0.0	0	0.0	0	0.0	0
Community Creek	**20.2**	**5.1**	**25**	**5.9**	**29**	**7.1**	**35**	**2.1**	**10**
Mountain View County	20.2	5.1	25	5.9	29	7.1	35	2.1	10
Davey Lake	4.7	**0.8**	**18**	**1.2**	**26**	**1.1**	**22**	**1.6**	**33**
Red Deer County	4.7	0.8	18	1.2	26	1.1	22	1.6	33
Delburne Lakes	**15.5**	**3.7**	**24**	**2.2**	**14**	**3.8**	**25**	**5.8**	**37**
Red Deer County	15.5	3.7	24	2.2	14	3.8	25	5.8	37
Dickson Creek	**40.5**	**4.8**	**12**	**3.9**	**10**	**20.3**	**50**	**11.4**	**28**
Red Deer County	40.5	4.8	12	3.9	10	20.3	50	11.4	28
Dogpound Creek	324.6	**120.4**	**37**	**65.5**	**20**	**75.9**	**23**	**62.8**	**19**
MD of Bighorn	**22.7**	15.9	5	0.4	0	5.9	2	0.5	0
Mountain View County	224.3	55.0	17	56.5	17	58.7	18	54.2	17
Rocky View County	**77.6**	49.5	15	8.7	3	11.4	4	8.1	2
Dogpound Creek-01	8.7	**2.9**	**34**	**1.1**	**13**	**3.6**	**41**	**1.1**	**12**
Mountain View County	**8.7**	2.9	34	1.1	13	3.6	41	1.1	12
Eagle Creek 1	84.0	**28.1**	**33**	**12.3**	**15**	**12.7**	**15**	**31.0**	**37**
Mountain View County	**64.0**	16.2	19	9.9	12	9.6	11	28.4	34
Red Deer County	20.0	11.9	14	2.4	3	3.1	4	2.6	3

Continued …

Waterbody Name & Intersecting Municipality	Length Assessed (km)*	Intactness Category							
		Very Low		Low		Moderate		High	
		km*	%	km*	%	km*	%	km*	%
Eagle Creek 2	**73.9**	**17.9**	**24**	**11.7**	**16**	**32.1**	**43**	**12.3**	**17**
Mountain View County	16.8	9.0	12	4.8	7	3.0	4	0.0	0
Red Deer County	57.2	8.9	12	6.8	9	29.1	39	12.3	17
Elkton Creek	**10.2**	**0.1**	**1**	**0.2**	**2**	**1.9**	**19**	**7.9**	**78**
Mountain View County	10.2	0.1	1	0.2	2	1.9	19	7.9	78
English Creek	**13.5**	**4.6**	**34**	**2.7**	**20**	**6.2**	**46**	**0.0**	**0**
Mountain View County	13.5	4.6	34	2.7	20	6.2	46	0.0	0
Fallentimber Creek	**223.0**	**11.8**	**5**	**4.9**	**2**	**14.1**	**6**	**192.2**	**86**
MD of Bighorn	140.3	6.0	3	2.9	1	7.1	3	124.4	56
Mountain View County	**82.7**	5.8	3	2.0	1	7.0	3	67.8	30
Fallentimber Creek-01	16.1	**0.0**	**0**	**0.1**	**0**	**0.3**	**2**	**15.7**	**98**
MD of Bighorn	**16.1**	0.0	0	0.1	0	0.3	2	15.7	98
Fallentimber Creek-02	8.4	**0.0**	**0**	**0.2**	**2**	**2.1**	**25**	**6.2**	**73**
MD of Bighorn	**8.4**	0.0	0	0.2	2	2.1	25	6.2	73
Foster Creek	10.1	**1.0**	**10**	**0.6**	**6**	**0.7**	**7**	**7.7**	**76**
Mountain View County	**10.1**	1.0	10	0.6	6	0.7	7	7.7	76
Fricke Creek	7.3	**0.4**	**5**	**0.5**	**7**	**1.0**	**14**	**5.3**	**74**
Rocky View County	**7.3**	0.4	5	0.5	7	1.0	14	5.3	74
Frozenman Creek	11.7	**1.2**	**11**	**1.1**	**10**	**2.1**	**18**	**7.2**	**61**
MD of Bighorn	**4.4**	0.3	2	0.5	4	1.2	10	2.5	22
Mountain View County	7.2	1.0	8	0.7	6	0.9	8	4.6	40
Fyten Reservoir	**3.2**	**2.0**	**62**	**0.0**	**0**	**1.2**	**38**	**0.0**	**0**
Kneehill County	3.2	2.0	62	0.0	0	1.2	38	0.0	0
Gaetz Creek	**39.6**	**17.3**	**44**	**8.0**	**20**	**6.5**	**16**	**7.9**	**20**
Red Deer County	39.6	17.3	44	8.0	20	6.5	16	7.9	20
Gaetz Creek-01	**1.1**	**0.0**	**0**	**0.0**	**0**	**0.0**	**0**	**1.1**	**100**
Red Deer County	1.1	0.0	0	0.0	0	0.0	0	1.1	100
Ghostpine Creek	**309.7**	**103.9**	**34**	**56.0**	**18**	**139.1**	**45**	**10.6**	**3**
Kneehill County	263.7	97.3	31	53.6	17	110.9	36	1.9	1
Red Deer County	**46.0**	6.6	2	2.4	1	28.3	9	8.8	3
Ghostpine Creek-01	22.4	**16.5**	**74**	**5.0**	**23**	**0.9**	**4**	**0.0**	**0**
Kneehill County	18.9	12.9	58	5.0	23	0.9	4	0.0	0
Red Deer County	**3.5**	3.5	16	0.0	0	0.0	0	0.0	0
Ghostpine Creek-02	2.5	**0.3**	**13**	**0.8**	**31**	**1.4**	**56**	**0.0**	**0**
Kneehill County	**2.5**	0.3	13	0.8	31	1.4	56	0.0	0
Ghostpine Creek-03	2.6	**0.3**	**11**	**0.7**	**29**	**1.5**	**60**	**0.0**	**0**
Kneehill County	2.6	0.3	11	0.7	29	1.5	60	0.0	0
Ghostpine Creek-04	**28.8**	**2.5**	**9**	**2.9**	**10**	**23.5**	**81**	**0.0**	**0**
Kneehill County	28.8	2.5	9	2.9	10	23.5	81	0.0	0
Ghostpine Creek-05	22.6	**4.8**	**21**	**5.5**	**25**	**12.2**	**54**	**0.0**	**0**
Kneehill County	**22.6**	4.8	21	5.5	25	12.2	54	0.0	0
Ghostpine Creek-06	14.4	**9.7**	**67**	**2.4**	**17**	**2.4**	**16**	**0.0**	**0**
Kneehill County	**14.4**	9.7	67	2.4	17	2.4	16	0.0	0
Gilpatrick Creek	2.4	**0.1**	**4**	**0.3**	**13**	**2.0**	**83**	**0.0**	**0**
Red Deer County	**2.4**	0.1	4	0.3	13	2.0	83	0.0	0
Goosequill Lake	14.1	**0.0**	**0**	**0.0**	**0**	**0.0**	**0**	**14.1**	**100**
Red Deer County	14.1	0.0	0	0.0	0	0.0	0	14.1	100
Graham Creek	**14.8**	**1.3**	**9**	**1.4**	**10**	**1.7**	**12**	**10.4**	**70**
Mountain View County	14.8	1.3	9	1.4	10	1.7	12	10.4	70
Grease Creek	**72.9**	**7.0**	**10**	**2.8**	**4**	**5.2**	**7**	**57.9**	**79**
MD of Bighorn	72.9	7.0	10	2.8	4	5.2	7	57.9	79

Continued …

Waterbody Name & Intersecting Municipality	Length Assessed (km)*	Intactness Category							
		Very Low		Low		Moderate		High	
		km*	%	km*	%	km*	%	km*	%
Harmatten Reservoir	6.4	3.6	57	0.0	0	0.1	1	2.7	42
Mountain View County	6.4	3.6	57	0.0	0	0.1	1	2.7	42
Harold Creek	47.1	1.2	3	0.7	1	4.7	10	40.5	86
MD of Bighorn	47.1	1.2	3	0.7	1	4.7	10	40.5	86
Helmer Creek	13.3	0.6	4	0.4	3	0.8	6	11.5	87
MD of Bighorn	13.3	0.6	4	0.4	3	0.8	6	11.5	87
Hicklon Creek	31.7	17.3	54	9.5	30	5.0	16	0.0	0
Mountain View County	31.7	17.3	54	9.5	30	5.0	16	0.0	0
Hicklon Lake	7.8	4.4	56	2.3	30	1.2	15	0.0	0
Mountain View County	7.8	4.4	56	2.3	30	1.2	15	0.0	0
Highland Creek	9.1	2.7	29	0.9	10	4.3	48	1.2	13
Mountain View County	9.1	2.7	29	0.9	10	4.3	48	1.2	13
Hiller's Reservoir	2.3	1.4	59	0.0	2	0.9	39	0.0	0
Mountain View County	2.3	1.4	59	0.0	2	0.9	39	0.0	0
Honeymoon Lake	6.4	2.2	35	0.8	12	1.6	25	1.8	28
Red Deer County	6.4	2.2	35	0.8	12	1.6	25	1.8	28
Hummock Lake	9.9	2.5	25	0.2	2	0.9	9	6.4	64
Red Deer County	9.9	2.5	25	0.2	2	0.9	9	6.4	64
Keiver's Lake	4.1	0.0	0	0.5	12	0.0	0	3.6	88
Kneehill County	4.1	0.0	0	0.5	12	0.0	0	3.6	88
Kneehills Creek	429.0	149.2	35	75.7	18	185.0	43	19.0	4
Kneehill County	376.8	124.8	29	68.8	16	164.9	38	18.4	4
Red Deer County	52.2	24.4	6	7.0	2	20.2	5	0.6	0
Kneehills Creek-01	18.0	4.1	23	4.7	26	7.4	41	1.8	10
Red Deer County	18.0	4.1	23	4.7	26	7.4	41	1.8	10
Kneehills Creek-02	5.8	4.2	72	1.0	17	0.6	11	0.0	0
Kneehill County	5.8	4.2	72	1.0	17	0.6	11	0.0	0
Kneehills Creek-03	14.1	3.8	27	2.0	14	8.2	58	0.0	0
Kneehill County	14.1	3.8	27	2.0	14	8.2	58	0.0	0
Kneehills Creek-04	11.0	0.8	7	0.2	1	5.2	47	4.9	44
Kneehill County	11.0	0.8	7	0.2	1	5.2	47	4.9	44
Kneehills Creek-05	7.9	0.0	0	1.0	13	3.7	47	3.1	40
Kneehill County	7.9	0.0	0	1.0	13	3.7	47	3.1	40
Kneehills Creek-06	10.9	0.0	0	0.0	0	5.4	50	5.4	50
Kneehill County	10.9	0.0	0	0.0	0	5.4	50	5.4	50
Kneehills Creek-07	11.6	0.0	0	0.0	0	5.8	50	5.8	50
Kneehill County	11.6	0.0	0	0.0	0	5.8	50	5.8	50
Lakeview Lake	4.3	1.9	45	0.7	16	1.2	28	0.5	12
Red Deer County	4.3	1.9	45	0.7	16	1.2	28	0.5	12
Little Dogpound Creek	6.9	1.1	15	0.8	12	4.2	60	0.9	12
Rocky View County	6.9	1.1	15	0.8	12	4.2	60	0.9	12
Little Red Deer River	425.6	47.2	11	19.6	5	50.3	12	308.5	72
MD of Bighorn	91.6	4.2	1	2.7	1	7.0	2	77.7	18
Mountain View County	224.8	25.3	6	10.5	2	29.9	7	159.1	37
Red Deer County	109.3	17.7	4	6.4	1	13.5	3	71.7	17
Loblaw Creek	11.4	0.2	2	0.0	0	0.0	0	11.2	98
MD of Bighorn	11.4	0.2	2	0.0	0	0.0	0	11.2	98
Lonepine Creek	196.9	104.5	53	27.5	14	54.3	28	10.5	5
Kneehill County	58.2	29.4	15	11.8	6	14.3	7	2.7	1
Mountain View County	138.7	75.2	38	15.7	8	40.0	20	7.8	4

Continued …

Waterbody Name & Intersecting Municipality	Length Assessed (km)*	Intactness Category							
		Very Low		Low		Moderate		High	
		km*	%	km*	%	km*	%	km*	%
Lonepine Creek-01	**23.6**	**14.0**	**59**	**2.8**	**12**	**6.9**	**29**	**0.0**	**0**
Mountain View County	23.6	14.0	59	2.8	12	6.9	29	0.0	0
Lonepine Creek-02	**39.7**	**10.8**	**27**	**8.3**	**21**	**20.6**	**52**	**0.0**	**0**
Mountain View County	39.7	10.8	27	8.3	21	20.6	52	0.0	0
Lonepine Creek-03	**44.1**	**20.4**	**46**	**2.3**	**5**	**19.9**	**45**	**1.4**	**3**
Kneehill County	27.2	8.5	19	0.9	2	16.4	37	1.4	3
Mountain View County	**16.9**	11.9	27	1.4	3	3.6	8	0.0	0
Lost Lake	1.5	**0.0**	**0**	**0.0**	**0**	**0.0**	**0**	**1.5**	**100**
Rocky View County	1.5	0.0	0	0.0	0	0.0	0	1.5	100
McDougall Coulee	**18.2**	**3.4**	**19**	**2.2**	**12**	**2.1**	**11**	**10.5**	**58**
Mountain View County	18.2	3.4	19	2.2	12	2.1	11	10.5	58
Medicine Creek	137.9	**24.7**	**18**	**24.6**	**18**	**73.0**	**53**	**15.7**	**11**
Red Deer County	**137.9**	24.7	18	24.6	18	73.0	53	15.7	11
Mikwan Lake	7.1	**0.0**	**0**	**0.1**	**1**	**0.0**	**0**	**7.1**	**99**
Red Deer County	**7.1**	0.0	0	0.1	1	0.0	0	7.1	99
Mouse Creek	9.3	**0.0**	**0**	**0.1**	**1**	**0.0**	**0**	**9.2**	**99**
MD of Bighorn	9.3	0.0	0	0.1	1	0.0	0	9.2	99
Nitchi Creek	**39.6**	**5.0**	**13**	**3.5**	**9**	**2.2**	**6**	**28.8**	**73**
MD of Bighorn	15.8	0.8	2	0.4	1	0.8	2	13.9	35
Mountain View County	23.7	4.3	11	3.2	8	1.4	4	14.9	38
Nuisance Creek	**8.2**	**0.4**	**4**	**0.1**	**1**	**0.2**	**2**	**7.6**	**93**
MD of Bighorn	8.2	0.4	4	0.1	1	0.2	2	7.6	93
Nuorison Creek	**0.7**	**0.2**	**28**	**0.4**	**57**	**0.1**	**15**	**0.0**	**0**
Red Deer County	0.7	0.2	28	0.4	57	0.1	15	0.0	0
Olds Creek	**70.9**	**28.4**	**40**	**11.7**	**17**	**20.5**	**29**	**10.2**	**14**
Mountain View County	50.2	22.6	32	6.7	9	12.0	17	9.1	13
Red Deer County	**20.6**	5.8	8	5.1	7	8.5	12	1.2	2
Owl Creek	12.2	**0.4**	**3**	**0.3**	**2**	**2.8**	**23**	**8.8**	**72**
MD of Bighorn	**12.2**	0.4	3	0.3	2	2.8	23	8.8	72
Pine Lake	20.4	**3.6**	**18**	**1.2**	**6**	**5.5**	**27**	**10.0**	**49**
Red Deer County	**20.4**	3.6	18	1.2	6	5.5	27	10.0	49
Piper Creek	53.0	**21.8**	**41**	**3.9**	**7**	**16.0**	**30**	**11.4**	**21**
Red Deer County	**53.0**	21.8	41	3.9	7	16.0	30	11.4	21
Rabbit Creek	20.5	**0.6**	**3**	**0.0**	**0**	**1.4**	**7**	**18.6**	**90**
MD of Bighorn	20.5	0.6	3	0.0	0	1.4	7	18.6	90
Rabbit Lake	**3.0**	**0.0**	**0**	**0.0**	**0**	**0.0**	**0**	**3.0**	**100**
MD of Bighorn	3.0	0.0	0	0.0	0	0.0	0	3.0	100
Red Deer River-01	**9.3**	**1.2**	**13**	**0.2**	**2**	**0.4**	**4**	**7.5**	**81**
Red Deer County	9.3	1.2	13	0.2	2	0.4	4	7.5	81
Red Deer River-02	**23.2**	**2.0**	**8**	**2.9**	**13**	**9.7**	**42**	**8.7**	**37**
Kneehill County	23.2	2.0	8	2.9	13	9.7	42	8.7	37
Red Deer River-03	**4.8**	**0.1**	**5**	**0.0**	**0**	**1.5**	**95**	**3.2**	**100**
Kneehill County	4.8	0.1	5	0.0	0	1.5	95	3.2	100
Round Lake	**4.0**	**0.8**	**21**	**0.2**	**6**	**0.7**	**18**	**2.2**	**55**
Red Deer County	4.0	0.8	21	0.2	6	0.7	18	2.2	55
Schroeder Lake	**3.8**	**0.1**	**1**	**0.4**	**11**	**1.2**	**30**	**2.2**	**57**
Red Deer County	3.8	0.1	1	0.4	11	1.2	30	2.2	57
Sihlis Creek	**8.2**	**0.5**	**7**	**1.0**	**12**	**3.3**	**40**	**3.4**	**42**
Mountain View County	8.2	0.5	7	1.0	12	3.3	40	3.4	42
Silver Creek	**41.2**	**1.1**	**3**	**1.3**	**3**	**1.8**	**4**	**37.0**	**90**
MD of Bighorn	23.7	0.2	0	0.2	0	0.1	0	23.3	57
Mountain View County	**17.5**	1.0	2	1.1	3	1.7	4	13.7	33

Continued …

Waterbody Name & Intersecting Municipality	Length Assessed (km)*	Intactness Category							
		Very Low		Low		Moderate		High	
		km*	%	km*	%	km*	%	km*	%
Spruce Creek	100.0	**65.1**	**65**	**16.7**	**17**	**15.3**	**15**	**3.0**	**3**
Kneehill County	**35.8**	21.0	21	5.1	5	9.6	10	0.2	0
Mountain View County	48.7	35.3	35	8.9	9	4.6	5	0.0	0
Red Deer County	**15.5**	8.9	9	2.8	3	1.1	1	2.8	3
Stewart Lake	4.7	**0.3**	**6**	**0.0**	**0**	**4.5**	**94**	**0.0**	**0**
Kneehill County	2.3	0.0	0	0.0	0	2.3	49	0.0	0
Mountain View County	**2.4**	0.3	6	0.0	0	2.2	46	0.0	0
Stony Creek	26.5	**3.2**	**12**	**1.2**	**5**	**2.5**	**10**	**19.6**	**74**
Mountain View County	26.5	3.2	12	1.2	5	2.5	10	19.6	74
Stormy Creek	**17.4**	**0.8**	**4**	**0.1**	**1**	**0.0**	**0**	**16.5**	**95**
MD of Bighorn	17.4	0.8	4	0.1	1	0.0	0	16.5	95
Swanson Creek	**9.9**	**1.0**	**10**	**0.7**	**7**	**2.9**	**29**	**5.3**	**54**
Rocky View County	9.9	1.0	10	0.7	7	2.9	29	5.3	54
Sylvan Creek	**31.0**	**7.9**	**25**	**0.7**	**2**	**9.1**	**29**	**13.3**	**43**
Red Deer County	31.0	7.9	25	0.7	2	9.1	29	13.3	43
Sylvan Lake	**15.1**	**4.8**	**32**	**1.5**	**10**	**2.5**	**17**	**6.2**	**41**
Red Deer County	15.1	4.8	32	1.5	10	2.5	17	6.2	41
Ten Mile Creek	**41.9**	**25.5**	**61**	**11.4**	**27**	**5.1**	**12**	**0.0**	**0**
Mountain View County	41.9	25.5	61	11.4	27	5.1	12	0.0	0
Threehills Creek	**449.3**	**249.0**	**55**	**68.1**	**15**	**103.3**	**23**	**28.9**	**6**
Kneehill County	367.0	196.5	44	54.9	12	90.3	20	25.3	6
Red Deer County	**82.3**	52.5	12	13.1	3	13.0	3	3.7	1
Threehills Creek-01	8.9	**1.7**	**19**	**1.0**	**11**	**6.0**	**67**	**0.3**	**3**
Red Deer County	**8.9**	1.7	19	1.0	11	6.0	67	0.3	3
Threehills Creek-02	33.0	**8.6**	**26**	**3.0**	**9**	**13.2**	**40**	**8.3**	**25**
Red Deer County	**33.0**	8.6	26	3.0	9	13.2	40	8.3	25
Threehills Creek-03	13.8	**13.0**	**94**	**0.6**	**4**	**0.2**	**2**	**0.0**	**0**
Red Deer County	**13.8**	13.0	94	0.6	4	0.2	2	0.0	0
Threehills Creek-04	37.6	**19.5**	**52**	**6.6**	**18**	**11.5**	**31**	**0.0**	**0**
Kneehill County	**37.6**	19.5	52	6.6	18	11.5	31	0.0	0
Threehills Creek-05	46.6	**33.3**	**71**	**5.0**	**11**	**6.4**	**14**	**1.9**	**4**
Kneehill County	**46.6**	33.3	71	5.0	11	6.4	14	1.9	4
Threehills Creek-06	24.0	**4.7**	**20**	**2.4**	**10**	**16.9**	**70**	**0.0**	**0**
Kneehill County	**24.0**	4.7	20	2.4	10	16.9	70	0.0	0
Threehills Creek-07	5.1	**4.5**	**87**	**0.6**	**12**	**0.1**	**2**	**0.0**	**0**
Kneehill County	**5.1**	4.5	87	0.6	12	0.1	2	0.0	0
Threehills Creek-08	9.3	**6.6**	**71**	**1.0**	**10**	**1.7**	**18**	**0.0**	**0**
Kneehill County	**9.3**	6.6	71	1.0	10	1.7	18	0.0	0
Threehills Creek-09	7.9	**6.7**	**84**	**1.0**	**12**	**0.3**	**3**	**0.0**	**0**
Kneehill County	**7.9**	6.7	84	1.0	12	0.3	3	0.0	0
Threehills Creek-10	6.1	**0.7**	**11**	**0.3**	**4**	**5.2**	**85**	**0.0**	**0**
Kneehill County	**6.1**	0.7	11	0.3	4	5.2	85	0.0	0
Tindastoll Creek	60.4	**31.0**	**51**	**5.6**	**9**	**17.3**	**29**	**6.5**	**11**
Red Deer County	**60.4**	31.0	51	5.6	9	17.3	29	6.5	11
Trail Creek	61.0	**28.6**	**47**	**9.9**	**16**	**14.1**	**23**	**8.4**	**14**
Mountain View County	**59.0**	28.5	47	9.8	16	13.5	22	7.3	12
Red Deer County	2.0	0.2	0	0.1	0	0.6	1	1.2	2
Turnbull Creek	**22.2**	**2.4**	**11**	**1.6**	**7**	**0.7**	**3**	**17.6**	**79**
MD of Bighorn	22.2	2.4	11	1.6	7	0.7	3	17.6	79
UL-080101-01	**0.4**	**0.0**	**0**	**0.0**	**0**	**0.0**	**0**	**0.4**	**100**
MD of Bighorn	0.4	0.0	0	0.0	0	0.0	0	0.4	100

Continued …

Waterbody Name & Intersecting Municipality	Length Assessed (km)*	Intactness Category							
		Very Low		Low		Moderate		High	
		km*	%	km*	%	km*	%	km*	%
UL-080102-01	**0.7**	**0.0**	**0**	**0.0**	**0**	**0.0**	**0**	**0.7**	**100**
MD of Bighorn	0.7	0.0	0	0.0	0	0.0	0	0.7	100
UL-080102-02	**0.8**	**0.0**	**0**	**0.0**	**0**	**0.0**	**0**	**0.8**	**100**
MD of Bighorn	0.8	0.0	0	0.0	0	0.0	0	0.8	100
UL-080102-03	1.6	**0.0**	**0**	**0.0**	**2**	**0.0**	**2**	**1.5**	**96**
MD of Bighorn	**1.5**	0.0	0	0.0	2	0.0	2	1.5	90
Mountain View County	0.1	0.0	0	0.0	0	0.0	1	0.1	6
UL-080102-04	**0.6**	**0.0**	**0**	**0.0**	**0**	**0.5**	**87**	**0.1**	**13**
Mountain View County	0.6	0.0	0	0.0	0	0.5	87	0.1	13
UL-080102-05	**0.7**	**0.3**	**42**	**0.0**	**0**	**0.4**	**58**	**0.0**	**0**
Mountain View County	0.7	0.3	42	0.0	0	0.4	58	0.0	0
UL-080102-06	**0.5**	**0.2**	**48**	**0.2**	**52**	**0.0**	**0**	**0.0**	**0**
Mountain View County	0.5	0.2	48	0.2	52	0.0	0	0.0	0
UL-080201-09	**2.0**	**0.6**	**29**	**0.0**	**0**	**0.0**	**0**	**1.4**	**71**
Red Deer County	2.0	0.6	29	0.0	0	0.0	0	1.4	71
UL-080201-10	**0.8**	**0.5**	**60**	**0.0**	**0**	**0.0**	**2**	**0.3**	**38**
Red Deer County	0.8	0.5	60	0.0	0	0.0	2	0.3	38
UL-080201-11	0.7	**0.2**	**30**	**0.0**	**0**	**0.5**	**70**	**0.0**	**0**
Red Deer County	**0.7**	0.2	30	0.0	0	0.5	70	0.0	0
UL-080202-01	3.2	**3.0**	**92**	**0.3**	**8**	**0.0**	**0**	**0.0**	**0**
Red Deer County	**3.2**	3.0	92	0.3	8	0.0	0	0.0	0
UL-080202-02	2.6	**1.1**	**42**	**0.4**	**17**	**1.1**	**41**	**0.0**	**0**
Red Deer County	2.6	1.1	42	0.4	17	1.1	41	0.0	0
UL-080202-03	1.0	**0.3**	**30**	**0.3**	**29**	**0.3**	**25**	**0.2**	**16**
Red Deer County	**1.0**	0.3	30	0.3	29	0.3	25	0.2	16
UL-080202-04	3.4	**0.7**	**22**	**0.4**	**13**	**1.0**	**28**	**1.3**	**37**
Red Deer County	**3.4**	0.7	22	0.4	13	1.0	28	1.3	37
UL-080202-05	3.0	**0.6**	**22**	**0.3**	**9**	**0.6**	**21**	**1.4**	**48**
Red Deer County	3.0	0.6	22	0.3	9	0.6	21	1.4	48
UL-080202-06	3.9	**0.8**	**20**	**0.2**	**5**	**0.0**	**0**	**2.9**	**75**
Red Deer County	**3.9**	0.8	20	0.2	5	0.0	0	2.9	75
Unnamed Creek 06	0.6	**0.5**	**78**	**0.0**	**0**	**0.1**	**22**	**0.0**	**0**
Red Deer County	0.6	0.5	78	0.0	0	0.1	22	0.0	0
Unnamed Creek 07	**8.3**	**2.4**	**29**	**1.1**	**13**	**2.6**	**32**	**2.2**	**27**
Red Deer County	8.3	2.4	29	1.1	13	2.6	32	2.2	27
Unnamed Creek 08	1.9	**0.2**	**9**	**0.2**	**10**	**1.3**	**69**	**0.2**	**12**
Red Deer County	1.9	0.2	9	0.2	10	1.3	69	0.2	12
Unnamed Creek 10	15.6	**4.4**	**28**	**0.4**	**3**	**6.4**	**41**	**4.4**	**28**
Red Deer County	15.6	4	**28**	0	2.6	6	41.0	4	28.2
Unnamed Creek 11	**62.1**	**15**	28	**4**	**6.5**	**11**	**16.9**	**33**	**52.8**
Red Deer County	62.1	15	**24**	4	6.5	11	16.9	33	52.8
Unnamed Creek 6	**43.9**	**21**	24	**5**	**11.8**	**12**	**27.1**	**6**	**13.3**
Red Deer County	43.9	21	**48**	5	11.8	12	27.1	6	13.3
Unnamed Creek 7	**13.6**	**12**	48	**1**	**6.2**	**0**	**3.2**	**0**	**0.3**
Red Deer County	13.6	12	**90**	1	6.2	0	3.2	0	0.3
Unnamed Creek 8	**5.9**	**6**	90	**0**	**0.0**	**0**	**1.5**	**0**	**0.0**
Red Deer County	5.9	6	**98**	0	0.0	0	1.5	0	0.0
Unnamed Creek 9	**7.8**	**5**	98	**0**	**2.3**	**3**	**38.5**	**0**	**0.0**
Red Deer County	7.8	5	**59**	0	2.3	3	38.5	0	0.0
UR-080102-01	**1.2**	**0**	59	**0**	**19.5**	**0**	**0.0**	**1**	**65.3**
Mountain View County	1.2	0	**15**	0	19.5	0	0.0	1	65.3

Continued …

Waterbody Name & Intersecting Municipality	Length Assessed (km)*	Intactness Category							
		Very Low		Low		Moderate		High	
		km*	%	km*	%	km*	%	km*	%
UR-080102-02	**0.5**	**0**	15	0	0.0	0	0.0	**0**	**0.0**
Mountain View County	0.5	0	**100**	0	0.0	0	0.0	0	0.0
UR-080102-03	**0.9**	**1**	100	0	7.5	0	15.1	**0**	**0.0**
Mountain View County	0.9	1	**77**	0	7.5	0	15.1	0	0.0
UR-080201-01	**2.1**	**1**	77	0	0.0	1	45.5	**0**	**19.6**
Red Deer County	2.1	1	**35**	0	0.0	1	45.5	0	19.6
UR-080202-01	**0.8**	**1**	35	0	0.0	0	0.0	**0**	**0.0**
Mountain View County	0.8	1	**100**	0	0.0	0	0.0	0	0.0
UR-080202-02	**12.7**	**6**	100	1	4.7	4	29.7	**2**	**19.1**
Mountain View County	12.7	6	**46**	1	4.7	4	29.7	2	19.1
Waskasoo Creek	**105.7**	**54**	46	8	7.9	18	17.2	**25**	**23.6**
Red Deer County	105.7	54	**151**	8	7.9	18	17.2	25	23.6
White Creek	**29.3**	**3**	151	1	4.3	19	64.6	**6**	**21.7**
Red Deer County	29.3	3	**9**	1	4.3	19	64.6	6	21.7
Winchell Lake	**1.4**	**0**	9	0	0.0	0	0.0	**1**	**100.0**
Mountain View County	1.4	0	**0**	0	0.0	0	0.0	1	100.0
Wood Lake	**4.3**	**0**	0	0	3.5	0	0.0	**4**	**96.5**
Red Deer County	4.3	0	**0**	0	3.5	0	0.0	4	96.5

*NOTE: All municipal 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 municipal boundary; however, it should be noted that there are spatial discrepancies between the municipal boundary data and the provincial hydrography data that are freely available from AltaLIS. As a result, the municipal summaries of shoreline length for intactness and priority are approximate and should be considered estimates that reflect relative differences between municipalities.