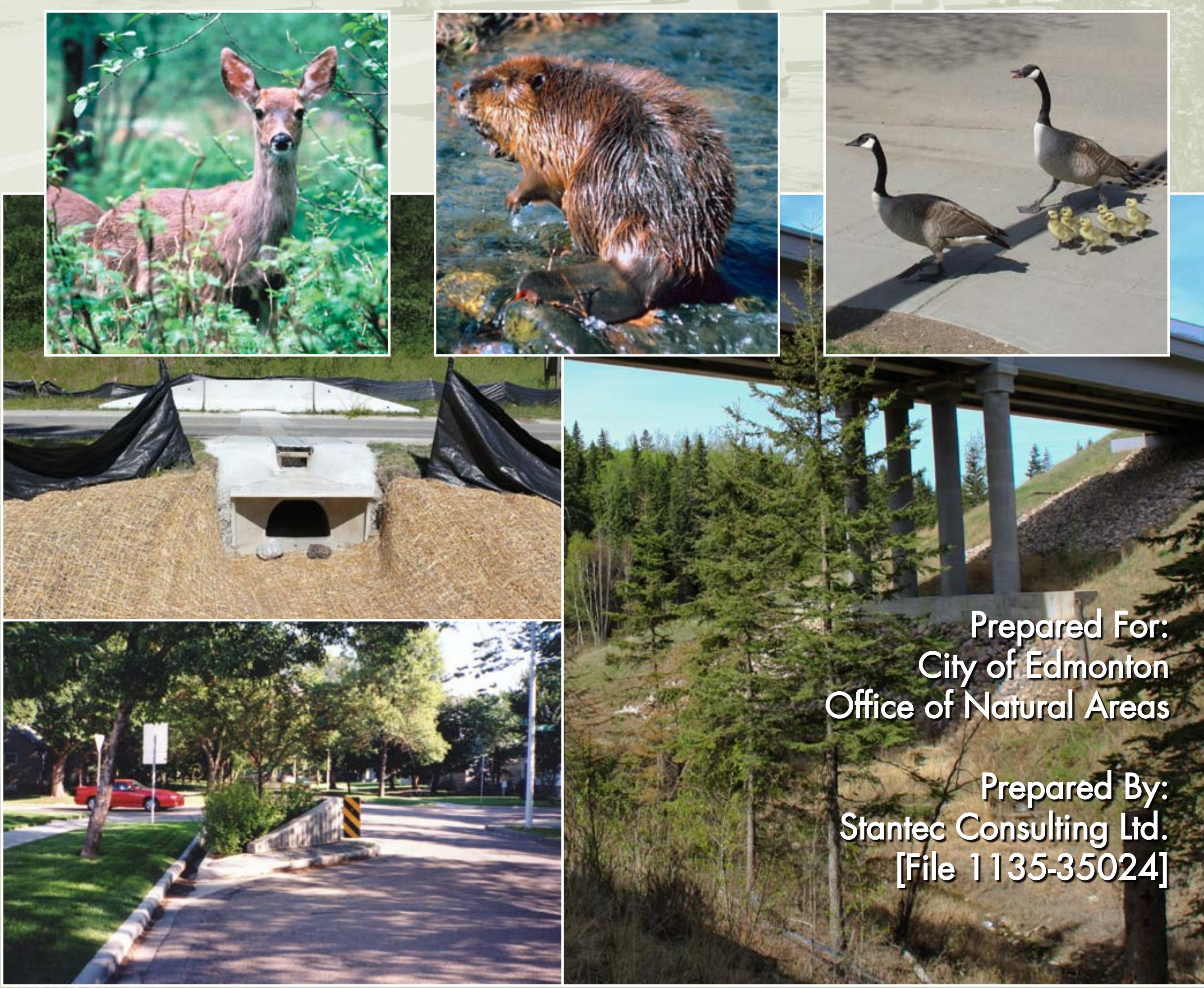
# WILDLIFE PASSAGE ENGINEERING DESIGN GUIDELINES

June, 2010

THE CITY OF Edmonton



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City of Edmonton
Office of Natural Areas

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# Acknowledgements

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# Table of Contents

# 1.0 INTRODUCTION

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## 1.1 GUIDELINES PURPOSE & OBJECTIVES

The City of Edmonton Wildlife Passage Engineering Design Guidelines were designed to provide transportation designers and decision makers with recommendations that will incorporate the needs of wildlife into transportation projects.  The desired outcome from these guidelines is two-fold:

1) to maintain habitat connectivity and reduce genetic isolation among Edmonton's wildlife populations so that these communities continue to fulfill their ecological, social and economic functions; and

2) to aid in the reduction of human wildlife conflict, improving awareness, safety and reducing collisions.

Achieving these goals will include restoring connections where they have been removed and ensuring that existing connections remain as the City of Edmonton expands.  The guidelines are intended to be a practical approach to the problem of anthropogenic habitat fragmentation/human wildlife conflict and recognize that not every location will benefit from expensive crossing structures.  The areas considered for large scale mitigation (i.e. a large wildlife underpass) will include known, significant, natural areas with future value.  Wildlife in areas with lower environmental value can benefit from minor improvements such as traffic calmed areas, signage, and altered lighting or curb structure.

Wildlife-vehicle collisions are a growing concern as more habitat is converted to human uses. As shown in Figure 1.1 below, there was a significant increase in the number of wildlife-vehicle collisions between 1996 and 2000 leading to almost a 30% increase (L-P Tardif & Associates Inc. 2003).  A greater number of wildlife-vehicle collisions means additional human injuries and in some cases mortality. Wildlife-vehicle collisions also increase the value of insurance claims.

Transportation planners routinely incorporate the elements of human infrastructure into their designs including sewer systems, water supply and utilities. By incorporating ecological infrastructure (core habitat and ecological connections), we can ensure that present day ecological function will remain in the future and improve safety on our roadways.

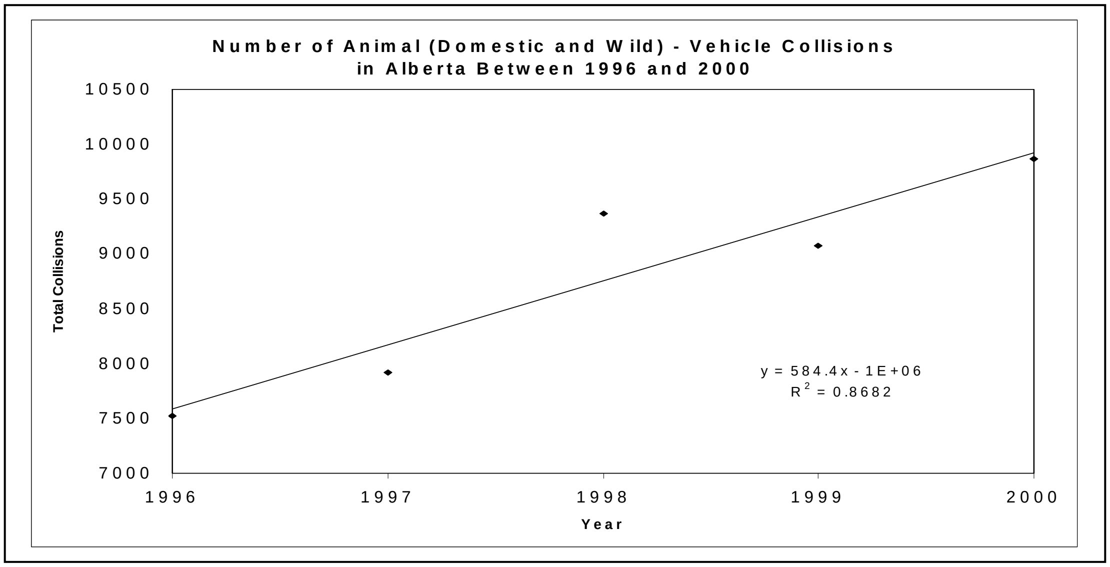



Figure 1.1: Statistics collected on wildlife-vehicle collisions in Alberta. Source: L-P Tardif & Associates Inc. 2003

## 1.2 HOW TO USE THE GUIDELINES

These guidelines were written with the assumption that a Wildlife Passage Project would be completed as a partnership between ecologists and transportation engineers. Background ecological information has been provided to assist the transportation engineer with the decision process; however, if the engineer is uncertain about the information at any point it may be beneficial to consult an ecologist. These guidelines are not intended to be overly prescriptive and should allow enough flexibility to achieve a unique design for each location that suits both wildlife and humans in that area.

When using the guidelines it is important to note that some of the mitigation options provided were initially designed and tested in rural areas. Urban wildlife is also more adapted to disturbance than rural wildlife and may be more likely to smaller structures and/or cross busier roads than rural wildlife. These two key points should be considered when selecting appropriate mitigation.

### 1.2.1 Guidelines Organization

The guidelines are organized so that they may be used at a variety of stages in the life cycle of a transportation project including planning, design, operation and maintenance. The document is designed so that an individual may enter the document at any one of these stages without having to complete previous sections. For example, if the planning for a project was completed two years ago, the transportation engineer may skip Section 3 and proceed directly to Section 4.

The information in this document is organized into two main parts: the report (sections 1 through 8) and supplemental information (Appendices A through E). Two Decision Trees have also been provided at the End of Section 1 and a checklist has been provided in Appendix D to help the user navigate the guidelines.

The Mitigation Toolbox (Section 4.5) is an abbreviated version of Appendix A. It was written to provide the user with a brief summary of the available options. The user is to turn to Appendix A for the specific design requirement associated with each mitigation option. When the user becomes familiar with designing to accommodate wildlife, they may not need to turn to Appendix A and may use Section 4.5 as a refresher.

1.2.1.1 Main Report

The main portion of the report is organized into 8 sections. The primary topic discussed in each section is described below:

- Section 1 – How to use the document and the Decision Trees
- Section 2 – Background information about corridors, crossings and why they are important
- Section 3 – Information relevant to the planning stages
- Section 4 – Information about project design
- Section 5 – Information regarding construction
- Section 6 – information regarding operations and maintenance
- Section 7 – Glossary of useful terms
- Section 8 – Reference section

1.2.1.2 Supplemental Information

The supplemental information is organized into five appendices. The main information available in these sections is described below:

- Appendix A – detailed design information for wildlife mitigation. This section is affiliated with Section 4
- Appendix B – supplemental information about species diet, habitat and home range. It also provides a list of other ecological studies that may be useful
- Appendix C – summary of some applicable legislation
- Appendix D – checklist/worksheet that may be used to help guide the individual through the process
- Appendix E – copies of relevant maps and policies

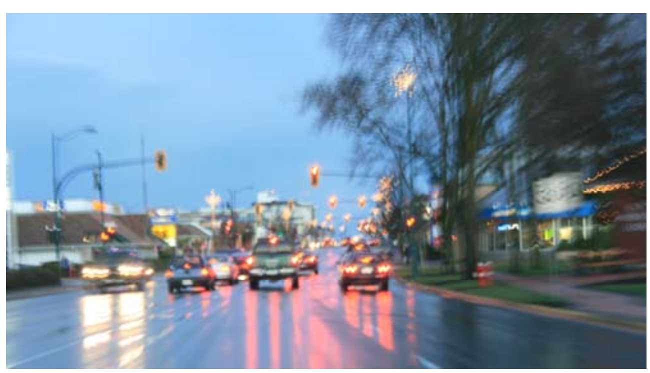
#### 1.2.1.3 Decision Trees

The decision trees included with this document are designed to provide an overview of the basic steps recommended at key stages in the life cycle of a wildlife crossing project. The Decision Tree 1 provides a general overview of the decision making process with an emphasis on the planning stages. The Decision Tree 2 focuses specifically on the design portion of the guidelines and will assist with picking appropriate mitigation options for the project area.

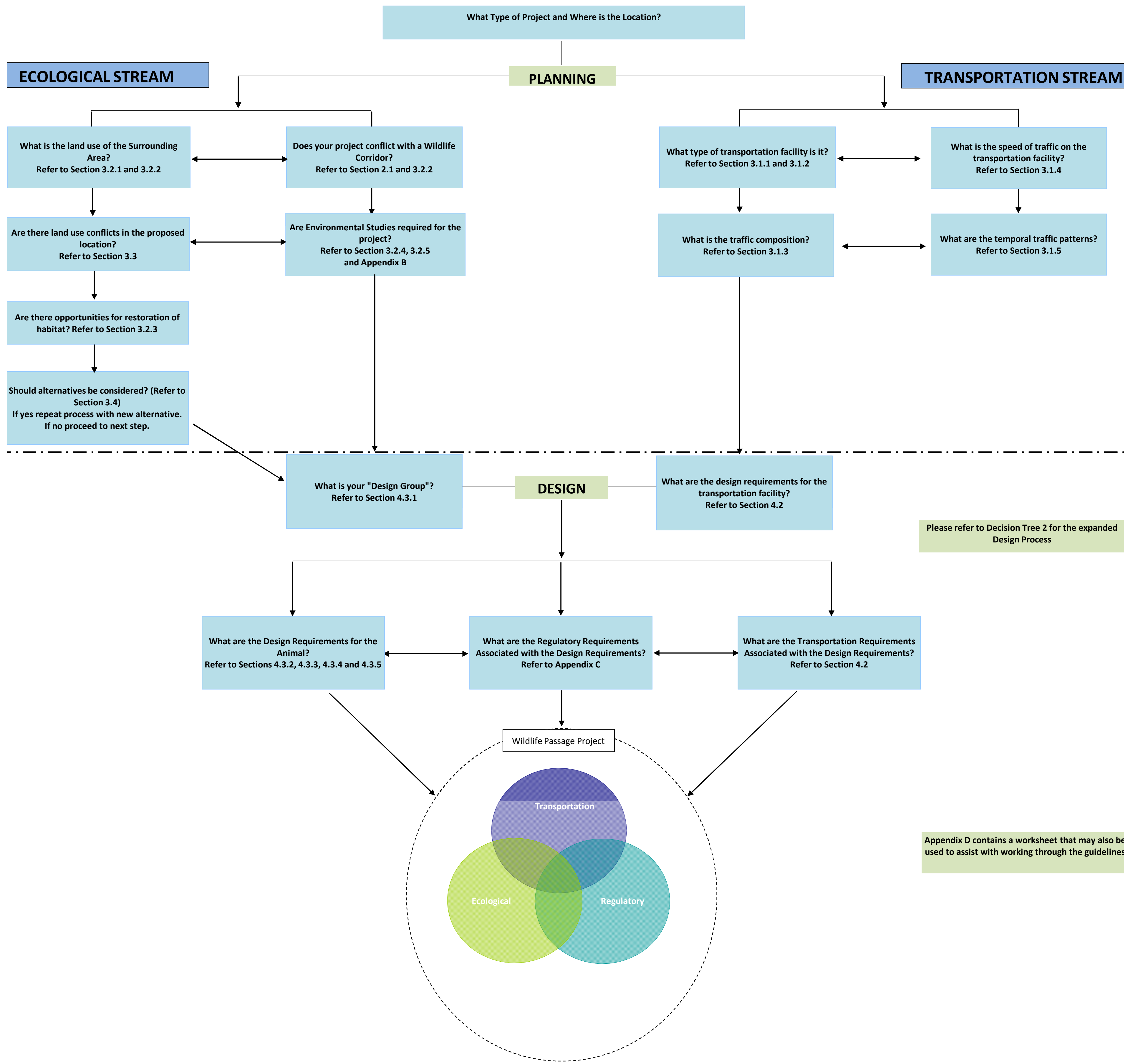
In addition to the decision trees, checklists are provided in Appendix D. The checklists offer more detail than the decision trees and are a useful tool for project management as they provide a location to store important project details.

Both the checklists and decision trees are supplemental to the textual information and should not be used as stand-alone documents. Depending on personal preference, the checklists and decision trees may be used together, separately or not at all.

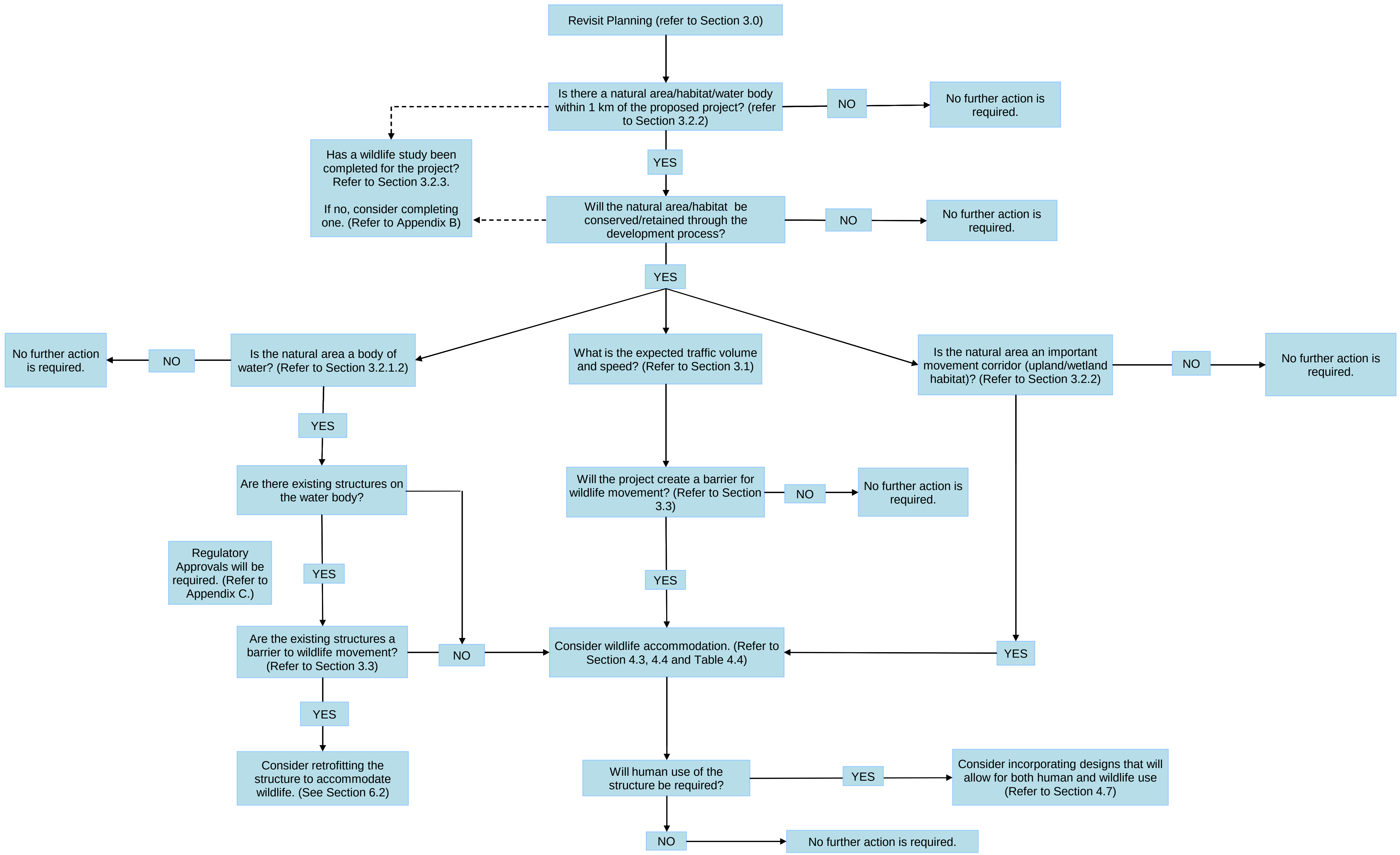
Once familiar with the material presented in these guidelines, the decision trees and checklists may act as shortcuts and enable the transportation designer to move through the information in a more efficient manner.



# Decision Tree 1: Wildlife Passage Engineering Design Guidelines Process Overview



# Decision Tree 2: Wildlife Passage Engineering Design Guidelines Detailed Design

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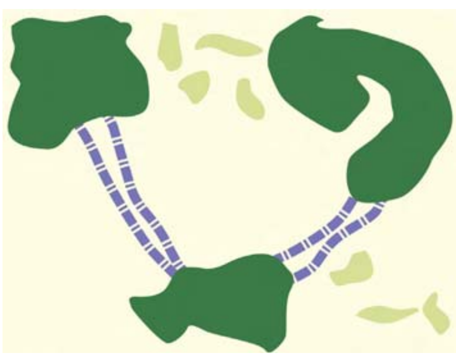
# 2.0 BACKGROUND

# 2.0 Background

## 2.1 WHAT IS A WILDLIFE CORRIDOR?

A wildlife corridor is a linear landscape feature composed of native vegetation that connects two or more areas of functional habitat and facilitates wildlife movement between the habitat patches (Beier and Loe 1992, Collinge 1996, Rosenberg *et al.* 1995, Hess and Fischer 2001, Beier et al. 2008). Corridors generally connect areas of former contiguous habitat rather than areas that were historically isolated (Beier and Loe 1992). A series of stepping stone habitats can also provide connectivity and function as a corridor (Government of New South Wales 2004).



An Illustration depicting some key components of a developed landscape: core habitat areas (dark green), corridors (blue) and stepping stones (light green). (Drawing Credit: City of Edmonton 2008)

Corridors are an ideal solution to provide ecological connectivity when:

- human disturbance has rendered most of the landscape uninhabitable to native species;
- the species of interest are habitat specialists that require a specific diet or can survive in a narrow range of environmental conditions;
- the species of interest requires resources while traveling to another part of its home range;
- the desired outcome is population and community stability and connectivity rather than facilitating random movement;
- continuous habitat is required for ecosystem processes (Bennett 1991).

Corridors exist at different scales across the landscape. They may be broad and provide linkage between large tracts of habitat (i.e. mountain ranges), regional and provide linkage between topographical features (i.e. ridges and valleys), or localized and provide linkage between small scale landscape features (i.e. wetlands and upland) (Government of New South Wales 2004). There are five general corridor types:

1. Natural Habitat Corridors –intact natural areas of native cover and/or topographic relief formed by natural processes. They may include streams, riparian zones, tracts of forested land or native prairie;
2. Remnant Habitat Corridors – areas of natural vegetation with disturbed surroundings;
3. Regenerated Habitat Corridors – areas that were once disturbed and have been re-vegetated by rootstocks, stored or dispersed seed;

4. Planted Habitat Corridors – vegetation established by humans. These include windbreaks, hedgerows, and shelterbelts; and

5. Disturbance Habitat Corridors – linear disturbances resulting from roads, railways or seismic lines. These may or may not benefit wildlife (Forman and Godron 1986).

All corridors, regardless of size, allow for genetic exchange between otherwise isolated populations, movement between habitat areas required for different parts of a species life cycle, access to different parts of the species home range, recolonization of acceptable habitat where populations are locally extinct and relocation if habitat becomes unsuitable due to natural disaster or environmental change (Beier and Loe 1992, Merrow 2007, Seiler 2001, Andrews 1993). Corridors will also allow for mobility in an urban context where much of the remaining habitat is fragmented.

In addition to assisting species transportation between fragments, a corridor may also function as habitat for small, less mobile species (Rosenberg *et al.* 1995, Hess and Fischer 2001). Use of a corridor will depend on the characteristics of the species of interest including home range size, animal size, foraging pattern, mobility, and the adjacent habitat characteristics (Collinge 1996, Clevenger and Waltho 2004). For example, amphibians will primarily use areas connecting wetlands or areas connecting wetland to upland while large terrestrial animals will often be found in larger habitat patches and ravines. The species tolerance to disturbance will also dictate whether they will be willing to use a corridor in an urban setting.

### 2.1.1 Comparing Corridors and Crossing Structures

Crossing structures essentially aim to increase the permeability of transportation infrastructure for wildlife (Bekker and Iuell 2004, Clevenger and Waltho 2004). Crossings vary in construction and design but all serve as small, localized constrictions along a corridor (Clevenger and Waltho 2004, Beier and Loe 1992). Crossing structures are infrastructure incorporated at crossings to mitigate against barriers to movement. For the purpose of these guidelines, the primary barrier considered is roadways. Crossing structures may be

The North Saskatchewan River Valley: The largest wildlife corridor in the City of Edmonton. (Photo Credit City of Edmonton, used with permission)

incorporated into new design projects or existing structures may be retrofitted to suit the needs of target species in the area (Bekker and Iuell 2004). The most effective crossing structures are designed with several species in mind and are linked to larger landscape features (Bekker and Iuell 2004, Clevenger and Waltho 2004). Crossing structures will be

ineffective, regardless of design, if the adjacent habitat has high human disturbance and low habitat quality (Clevenger and Waltho 2004, Jackson and Griffin 2000, Haas 2001, Ng et al. 2004).

### 2.1.2 Why Are Corridors and Crossing Structures Important?


Conceptual drawing for the proposed wildlife crossing located in the Aurum Energy Park, northeast Edmonton. (Stantec Consulting Ltd. 2009)

Human development divides contiguous landscape into increasingly smaller fragments reducing and segregating high quality habitat.  Associated with fragmentation is an increase in habitat edge and shift in vegetative community structure favoring invasive and shade intolerant species, altered microclimate, and increase in generalist species (Laurance and Yensen 1991, Collinge 1996).  This effectively reduces habitat for disturbance sensitive species and segregates populations (Laurance and Yensen 1991, Collinge 1996).

Transportation infrastructure is ubiquitous in modern society and is a significant source of fragmentation.  The traffic noise, artificial lighting, vehicle motion, and physical structure of the road can pose a barrier for wildlife immigrating between isolated populations, undergoing seasonal migration, or traveling though their home range (Trocme 2006, Ruediger and DiGiorgio 2006, Bekker and Iuell 2004, Jackson 1996, Seiler 2001). Disruptions to movement and dispersal reduce effective habitat size, result in genetic isolation and inbreeding, and can ultimately lead to extinction (Seiler 2001, Vaughan 2002). Connecting these fragments with corridors is thought to minimize the effects of habitat fragmentation (Collinge 1996, Beier 1993). In the case of national parks, only the Kootenay-Banff-Jasper-Yoho, which has high connectivity, managed to maintain all the mammalian species while other parks experienced a 45% loss of mammalian diversity (Bannerman 1997).

Population survivorship can be significantly improved with even low levels of immigration, and the presence of corridors can increase critical habitat area by 200-600 $km^2$ when compared to areas without corridors (Beier 1993). Connecting remaining habitat fragments is essential for the future survival of many species.

In addition to conservation of species, wildlife crossings provide socio-economic benefits. Driver safety is enhanced when wildlife is provided with safe crossing points as the need for wildlife to risk crossing between vehicles is eliminated when a better alternative is provided. Removing wildlife from roadways also reduces the number of collisions, human fatalities, injuries and damage to property.

# 3.0 PLANNING GUIDELINES

# 3.0 Planning Guidelines

## 3.1 IDENTIFYING TRANSPORTATION NETWORK COMPONENTS

This section will help the user define the goals of the transportation facility and any specific design requirements associated with the specific goals. Road types, speeds, widths and other traffic patterns are important considerations that need to be identified to determine the overall impacts of the project. These parameters will influence the ecological goals and potential mitigation required (if any).

### 3.1.1 Classification

The basic classification of transportation infrastructure will provide the transportation engineer/designer with information regarding the requirements of the facility. The classification will control elements of the design and provide an indication of importance to the transportation system.

Pursuant to Edmonton's Transportation System Bylaw 13423 (2005), there are three roadway classifications and one fixed rail transit classification as listed below (a copy of this Bylaw and maps of the Edmonton Transportation System have been provided in Appendix E for reference):

***Arterial Roads*** – For arterial roads, traffic movement is the primary consideration and land access is a secondary function. Urban arterials normally carry high traffic volumes and can range from two to six lane facilities with a high degree of access control (TAC 1999). The carriageway width for five lane undivided/divided arterials and major six lane arterials are typically 21.3 m and 28.7 m wide respectively. The traffic volume using a collector road is generally greater than 5,000 vehicles per day.

***Collector Roads*** – For collector roads, traffic movement and land access are of equal importance (TAC 1999). Buses normally travel on collector roadways within Edmonton. The carriageway width for residential collector roads and major collector roads (bus routes) are typically 11.5 m and 14.5 m wide respectively. The traffic volume using a collector road is generally between 1,000 to 5,000 vehicles per day.

***Local Roads*** - The main function of local roads is to allow vehicles to access properties (TAC 1999). The carriageway width for a local residential road is typically 9.0 m wide. The traffic volume using a local road is generally less than 1,000 vehicles per day.

***Light Rail Transit (LRT)*** – Light rail transit is a high quality fixed route rail transit that is owned and operated by the City of Edmonton.

Other transportation facilities in Edmonton include:

*Heavy Rail* – Currently the only heavy rail operators in Edmonton are Canadian National Railways and Canadian Pacific Railways. The heavy rail industry is federally regulated and the railways are owned by the private companies. Any projects interacting with heavy rail facilities or intending to use rail right-of-way will have to coordinate with the appropriate rail company.

*Multi-use trails and active mode corridors* – Of a variety of levels of importance, they may serve recreational uses or function as a transportation facility. Of note, the trails and paths may form part of the Multi-Use Corridor Network or be part of the Cycle Edmonton Network.

There are highways that fall under provincial jurisdiction, where any projects would need to be coordinated with Alberta Transportation. Currently, Alberta Transportation governed highways within city limits include:

- Anthony Henday Drive and any crossing roadways within the Transportation Utility Corridor;
- Yellowhead Trail from Anthony Henday Drive to the western city limits;
- Manning Drive from Anthony Henday Drive to the eastern city limits;
- Highway 28A from Manning Drive to the northern city limits; and
- Calgary Trail/Gateway Boulevard from Anthony Henday Drive to the southern city limits.

Current information regarding the ownership/responsibility and classification of roadways in Edmonton can also be found in the Transportation System Bylaw (13423) (City of Edmonton 2005).

The Transportation Planning Branch at the City of Edmonton is responsible for producing the Transportation System Bylaw. Contact information is as follows:

- Transportation Planning 13th Floor, Century Place, 9803 – 102A Avenue, Edmonton, Alberta, Canada, T5J 3A3, Phone: (780) 496-1795, Fax: (780) 496-4287, Email:transplanning@edmonton.ca

### 3.1.2 Network Function

Road networks within the City's overall transportation system are identified in the Draft Transportation Master Plan (TMP) dated October 2008 (City of Edmonton 2008b). These road networks include:

Ensure that the most up-to-date sources of information are used.

*Anthony Henday Drive* – Anthony Henday Drive falls under provincial jurisdiction and is planned to be a high standard, free flow facility that will be ultimately grade separated.

*Inner Ring Road* – The inner ring road is planned to be a 70 km/h, six lane facility which caters to cross city traffic. The current plan refers to reducing direct access in an effort to improve the level of service (increase free flow) on the facility.

*Highway Connectors* – The highway connectors are roadways that connect the Inner Ring Road and Anthony Henday Drive to provincial highways. The roadway standards are planned to be similar to the Inner Ring Road, with a 70 km/h posted speed and limited access opportunities.

The Draft TMP (City of Edmonton 2008)Concept for 2040 displays each roadway network. A copy of this map is included in Appendix E. An updated TMP is currently being prepared for council consideration for June 23, 2009. The Transportation Planning Branch is responsible for producing the TMP, and can be contacted for up-to-date information at the information listed above.

*Transit* – Edmonton Transit System (ETS), St. Albert Transit, and Strathcona County Transit currently operate transit service within the City of Edmonton. There is a

wide range in the number of buses and riders using any portion of the transit network. Transit vehicles generally operate on collector and arterial roadways. Information on the transit systems' routes and frequencies are available on each authority's websites. Contact information for each of the three transit authorities operating in Edmonton are as follows:

- Edmonton Transit System, Attention: Customer Concerns, P.O. Box 2610, Stn. Main, Edmonton, Alberta, T5J 3R5, Phone: (780) 496-5311, Email: etransit@edmonton.ca, website: www.takeets.com)

- St. Albert Transit, 235 Carnegie Drive, St. Albert, Alberta, T8N 5A7, Phone: (780) 418-6060, Fax: (780) 459-4050, Email: transit@st-albert.net, Website: www.ridestat.ca

- Strathcona County Transit, 2001 Sherwood Drive, Sherwood Park Alberta, T8A 3W7, Canada, Phone: (780) 464-7433, Email: transit@strathcona.ab.ca, website: http://www.strathcona.ab.ca/Strathcona/Departments/Transit/default.htm

*Truck Routes* – Trucks must travel on designated truck routes to as close as possible to their destination before leaving the truck route. Truck routes will have a higher percentage of large vehicles travelling that require more area to turn and more space to stop. Truck routes also facilitate commercial goods movements, which are important to the regional economy.

The Transportation Operations Branch is responsible for producing the Truck Route Map. Contact information is as follows:

- Transportation Operations 9803 - 102A Avenue, Edmonton, AB, T5J 3A3, Phone: (780) 496-3095, Fax: (780) 496-1757, email: transportationoperations@edmonton.ca, Website: http://www.edmonton.ca/transportation/truck-route-map.aspx

*Trails and Paths* – Trails and paths provide for human powered transport for both transportation and recreational purposes. Users are highly maneuverable, operate at a wide variety of speeds, and generally generate less noise compared to automobiles. The potential for the presence of domestic animals is a possibility on most trails and paths.

The Transportation Planning Branch at the City of Edmonton is responsible for producing the Cycle Edmonton Map. Contact information is as follows:

- Transportation Planning(13th Floor, Century Place, 9803 – 102A Avenue, Edmonton, Alberta, Canada, T5J 3A3, Phone: (780) 496-1795, Fax: (780) 496-4287 Email: transplanning@edmonton.ca, website: http://www.edmonton.ca/transportation/cycling_walking/bike-map.aspx

### 3.1.3 Traffic Composition / Users

The traffic composition and transportation facility type are linked. Multi-use trails generally facilitate the transportation and recreation of a broad range of active human users and pets.  Roadways will facilitate the transportation of a broad range of users, such as heavy trucks, buses, passenger vehicles, and bicycles. The prevalence of any type of user will depend on nearby land-uses, and network function. Traffic counts which include the classification of

users are regularly conducted on some facilities by the Transportation Planning Branch of the City of Edmonton.

The Transportation Planning Branch at the City of Edmonton is responsible for collecting transportation statistics. Contact information is as follows:

- Transportation Planning 13th Floor, Century Place, 9803 – 102A Avenue, Edmonton, Alberta, Canada, T5J 3A3, Phone: (780) 496-1795,
  Fax: (780) 496-4287
  Email: transplanning@edmonton.ca, website: http://www.edmonton.ca/ transportation/ general-transportation-statistics.aspx

#### 3.1.4 User Speeds

The speed at which the users travel will have an effect on the ability of the vehicle to perceive, react and stop in time to avoid conflicts. The posted speeds of roadways in Edmonton can be found in the Speed Bylaw #6894 (City of Edmonton 2007b), or by site check. In the case of planned roadways, most collector and local roadways, the posted speed limit will be 50km/h. For planned arterial roadways, it is likely necessary to communicate with the Transportation Planning Branch to ascertain the appropriate planned speed limit.

The Transportation Operations Branch is responsible for producing the Speed Bylaw. Contact information is as follows:

- Transportation Operations (9803 - 102A Avenue, Edmonton, Alberta, Canada, T5J 3A3, Phone: (780) 496-3095,
  Fax: (780) 496-1757,
  email: transportationoperations@edmonton.ca
  Website: http://www.edmonton.ca/city_government/city_organization/transportation-operations-bran.aspx

There may be instances where the posted speed is not the prevailing speed of the users. In this case a speed study may be appropriate. The City of Edmonton may have information on actual speeds but data collection may be necessary. Usually the $85^{th}$ percentile speed is used as a standard comparison.

#### 3.1.5 Temporal Volume Patterns

Traffic volumes vary with time. The highest use periods for most facilities are the morning and afternoon peak periods Monday to Friday. The peaks will vary depending on function of the roadway and land uses served by the roadway.

Information is usually recorded for overall daily traffic volumes and AM and PM peaks. Other timeframes may be available or have to be collected. Daily and seasonal variations for the overall city can be found on the traffic statistics website on the Traffic Flow Map, which is produced annually. A copy of this map has been included in Appendix E.

Projected traffic volume information can come from Transportation Impact Assessments and from the regional model for major arterials and collectors. This information may be available from the Transportation Planning Branch. In the absence of other information, rules of thumb can be used - arterial roadways will generally have more than 10,000 VPD (vehicles per day), collectors around 5000 VPD, and local roadways around 1000 VPD.

The Transportation Planning Branch at the City of Edmonton is responsible for collecting transportation statistics and

producing projected volumes for transportation facilities. Contact information is as follows:

- Transportation Planning (13th Floor, Century Place, 9803 – 102A Avenue, Edmonton, Alberta, Canada, T5J 3A3, Phone: (780) 496-1795, Fax: (780) 496-4287 Email: transplanning@edmonton.ca, website: http://www.edmonton.ca/transportation/g eneral-transportation-statistics.aspx

## 3.2 IDENTIFYING ECOLOGICAL NETWORK COMPONENTS

This section will help the user define the ecological goals of the project such as whether or not mitigation is required, or desired, for the project area. Landscape characteristics, species present and adjacent land use are all important considerations used to define the ecological scope of the project. When combined with the transportation goals, the outcome will be a road that is functional and safe for both drivers and wildlife.

### 3.2.1 Identify Land Use

The land use of both the project area and the adjacent lands will play a large role in determining the type and extent of mitigation required. For example, if the area surrounding the project is slated for high density residential/commercial development, then facilitating wildlife movement through this area is likely not feasible or desired.

Common sense must be used when deciding what type of mitigation is appropriate. You must also consider wildlife movement after a crossing is installed. If crossing placement will encourage wildlife to enter undesirable areas (i.e. moose downtown), then the structure should be reconsidered.

#### 3.2.1.1 Current Land Use

Common land uses in the Edmonton Area include the following:

- Residential
- Commercial
- Agricultural
- Industrial
- Institutional
- Natural Area
- Water Bodies/Drainage channels
- Rights-of-way

It is important to note that some areas may have multiple land uses. For example a road right-of-way may provide transportation, utility and drainage functions or a drainage channel may also be considered a natural area. All land uses attached to the project area should be considered.

##### 3.2.1.1.1 Definition of a Water Body

A water body for the purpose of these guidelines is any river, stream, lake, slough, wetland, depressional area, bog, or fen and includes both the bed and shore of these features. These features do not need to be inundated with water throughout the year to be considered a water body; a water body may have water flow/presence that is only intermittent or present during flood events. These areas will require special consideration as movement of both water and wildlife will need to be incorporated into the design. Additional species will be present in these locations as the water

source will increase the diversity of habitat available.

If the project will impact a water body in any way it is best to contact regulatory agencies early in the process as most of these projects will require regulatory approvals. Please refer to Appendix C or the checklist in Appendix D for additional information on applicable legislation.

#### 3.2.1.2 Future Land Use

It is important to not only consider current land use, but to also consider future development. For example, if a site contains two natural areas that are currently connected and in five or ten years the surrounding area will become an industrial park, it may not be economical to install a premium crossing to connect the two natural areas. Instead, perhaps a smaller structure, that would facilitate movement of small organisms, would be appropriate as once the industrial development is underway most of the Large Terrestrial species will no longer use the area.

A development concept may also plan on removing a natural area in the future, thus leaving the two sites unconnected. In this situation it also may not be advisable to construct large crossing structures between the two existing natural areas as removal of one in the future will mean that the crossing structures provides connectivity to nowhere. In this situation, it would be more economical to focus on other types of mitigation or restoration of habitat connectivity to surrounding areas.

### 3.2.2 Identify Potential Wildlife Corridors/Significant Natural Areas

Some areas that require linkage are obvious, like the location of a known seasonal migration route or the North Saskatchewan River, while others are less intuitive. However, within the City of Edmonton most wildlife corridors will be easily delineated by the presence of green space or water. It can be assumed that mitigation will be required for any project occurring in the North Saskatchewan River Valley, the ravines (Blackmud Creek or Whitemud Creek), and any Significant Natural Areas identified by the Office of Natural Areas (ONA). The current inventory of natural areas at the time of publication was produced by Spencer Environmental Management Services Ltd. (2006). Seven tools commonly used to assess connectivity include:

1. Aerial photographs;
2. Land ownership maps;
3. Vegetation maps;
4. Topographic maps;
5. Wildlife habitat or range maps;
6. Road kill information (Ruediger and DiGiorgio 2006); and
7. Wildlife Linkage Assessments .

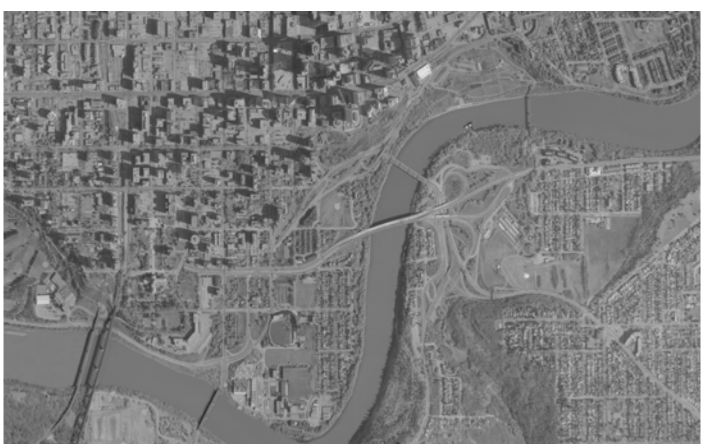
When planning a transportation project, it is best to approach it from a broad landscape perspective and integrate several of these data sources. Personal accounts, like information from hunters or local residents are incredibly useful. They may be able to tell you the locations of wildlife hotspots and identify what type of wildlife frequents the area. Radio tracking data (if available) may also be used to identify areas of high wildlife activity (Schrag 2003).

Please note that the sources for this type of information provided below is only current up to the date of document publication. Web addresses, phone numbers, and sources of information may have changed

in addition to content. The most current sources of this information must be sought at the time of project planning.

#### 3.2.2.1 Aerial Photographs

Aerial photographs provide a high resolution, landscape-wide perspective. Remnant habitat patches, residential, industrial, and commercial developments, and landscape features such as water bodies, vegetative cover and terrain are easily identified on aerial photographs. High quality habitat and habitat corridors are easily identified on aerial photographs and can be traced over long distances. It is possible to identify where roads currently bisect areas of high quality habitat and where future development will interfere with wildlife mobility. Wildlife crossings will likely be concentrated in areas with smaller average distances between roads and vegetative cover (for species that require cover) along with water bodies and drainage features (Barnum 2003). Cleared areas will attract ungulates due to the enhanced forage quality while areas with high human activity and development will likely have limited wildlife use (Gunson *et al*. 2006). These features are easily distinguished on an aerial photograph.



Aerial photograph of downtown Edmonton, the North Saskatchewan River Valley, and Mill Creek Ravine. (Source: City of Edmonton, Transportation and Streets 2007). Land uses are readily determined from this photograph: The tall buildings of downtown indicate a commercial setting; small structures in Rossdale and Bonnie Doon suggest residential; and the darker tone in the Mill Creek Ravine and North Saskatchewan River Valley are characteristic of vegetation.

Current and historical aerial photographs of the site and surrounding areas are available from Alberta Sustainable Resource Developments. Contact information is as follows:

- Air Photo Distribution 9920 - 108 Street, Main Floor, Edmonton, Alberta, Canada, T5K 2M4,
  Phone: (780) 427-3520
  Fax: (780) 422-9683
  Email: Air.Photo@gov.ab.ca
  Website: http://www.srd.alberta .ca/MapsFormsPublications/AirPhotoDistribution/Default.aspx)

#### 3.2.2.2 Land Ownership Maps

Land ownership maps identify public lands that likely include wildlife protection, and the ownership of private lands that may be key parcels for linkage. This will also identify if there are any conservation easements or additional inherent conservation requirements that must be met. If a transportation project is located near a protected area, it is likely that some sort of mitigation will be required. Land ownership maps may also identify private owners that can be targeted to help establish and maintain connections. For example, as a way to protect habitat, the Swiss government provides financial compensation to private landowners who maintain ten percent of their land as native habitat (Schrag 2003).

Land zoning maps will also identify if land is zoned for uses that are not conducive to wildlife movement. For example, if the land was currently a Greenfield but was zoned IH (Heavy Industrial) this area will likely not benefit from a wildlife crossing unless a

larger network is present. By determining land ownership, future development can be extrapolated to determine if the area is suitable for mitigation. It is also important to note that land ownership may also affect regulatory requirements for the project area.

Several resources are available to determine land use and ownership including:

- The City of Edmonton mapping website contains up to date land zoning and also posts proposed re-zoning applications. This information can be accessed at: http://maps.edmonton.ca/
- A list of protected natural areas can be found in the City of Edmonton Biodiversity Report (2008) available for download at: http://www.edmonton.ca/environmental/documents/Environment/Edmonton_Biodiversity_Report_2008.pdf
- Protected areas and ownership information is summarized in the Protection Status of Edmonton's Natural Areas figure (Spencer 2006). This map depicts protected natural areas under crown and private ownership and unprotected natural areas. This map is available for viewing at http://www.edmonton.ca/environmental/natural_areas/2006-edmonton-state-of-natural.aspx
- Land ownership information is available for purchase through the Alberta Land Titles Office:
  John E. Brownlee Building 10365-97 Street Edmonton, Alberta, Canada T5J 3W7.
  Phone: 780-427-2742
  Fax: 780-422-4290
  Hours of operation: 8:15 a.m. - 4:00 p.m. Monday to Friday
  Email: lto@gov.ab.ca) or online https://alta.registries.gov.ab.ca/spinii/logon.aspx

#### 3.2.2.3 Vegetation Maps

Vegetation maps will identify key vegetation types and assist in identifying productive habitat that may be valuable for linkage. If suitable habitat is present on both sides of a road, it is more likely that wildlife will cross (Barnum 2003). This is especially important for habitat specialists. Specialists require specific habitat or food resources that are usually sporadic (Barnum 2003). The presence of food resources will concentrate the specialists in a particular area, making it more likely that they will be affected by the road (Barnum 2003).

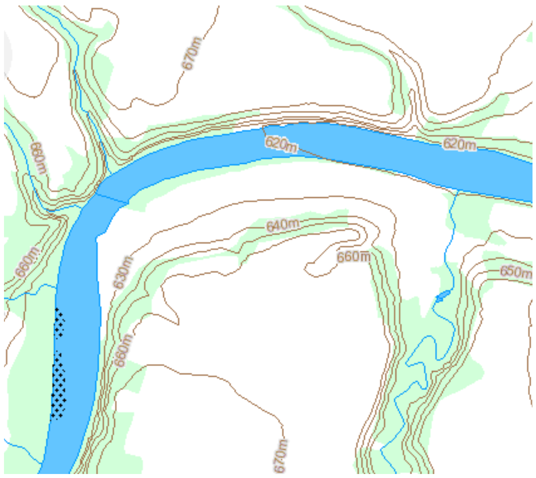
Wildlife crossing will be enhanced when linear landscape features are perpendicular to the road. Crossing is also enhanced near drainage patterns and areas where steep slopes become more moderate.

- Mapped Vegetation of the Edmonton Area (Spencer 2006) is a comprehensive vegetation map focused on the Edmonton Region. The Office of Natural Areas may be contacted to arrange for receipt of a higher resolution version of the map. This map is available online at http://www.edmonton.ca/ environmental/natural_areas/2006-edmonton-state-of-natural.aspx
- Alberta Sustainable Resource Development sells vegetation inventory datasets for different regions of the province. These are available at http://www.srd.gov.ab.ca

#### 3.2.2.4 Topographic Maps

Topographical maps identify landscape features, such as lowlands and uplands. This information may be used to distinguish different habitats that are required for an organism's life cycle. For example, amphibians must have access to wetland areas for breeding and upland areas for the

remainder of their life cycle (Merrow 2007). Wildlife also follows linear topographical features that either encourage or discourage roadway crossing depending on orientation and type as follows:




Topographic map example from the North Saskatchewan River Valley. The linear landscape features are clearly identifiable. (Source Natural Resources Canada, Atlas of Canada)

- Linear topographical features include ridgelines, sharp breaks in vegetative cover, steep slopes and drainage patterns;
- Perpendicularly oriented linear features experience enhanced wildlife crossing when compared to parallel oriented features;
- Crossing zones are more focused near drainage patterns than ridgelines; and
- Steep slopes will deter wildlife use and may act as a barrier. As a result, there may be enhanced crossing when the slope becomes moderate (Barnum 2003, Gunson *et al.* 2006).

Travel patterns of species will differ depending on behavior. Three major groups of behavior patterns exist:

1. Seasonal migration
2. Short, diurnal movement
3. Large scale foraging

Topographic maps will help identify areas in the landscape that will be prone to high wildlife use and require mitigation to maintain connectivity.

Available resources to assess topography include:

- Natural Resources Canada, Atlas of Canada, has a free topographic map site entitled Toporama – Topographic Maps. This is an online resource available at: http://atlas.nrcan.gc.ca/site/english/maps/topo/index.html
- Topographic maps are available for purchase through many retail outlets such as MapTown http://www.mapamia.com/
- Google Earth and Google Maps also display topography.

#### 3.2.2.5 Wildlife Habitat or Range Maps

The home range of the species of interest is an important consideration when looking at broad landscape connectivity. Travel patterns and distance traveled differ among species. Some organisms may undergo unidirectional movement through corridors such as terrestrial predators while foraging, others may temporarily inhabit corridors before continuing, and others are permanent residents of the corridor that undergo short movements within the linkage (Bennett 1999). Birds are highly mobile and can easily fly large distances between habitat patches and large terrestrial organisms have greater mobility than smaller ones (Bennett 1999). Carnivores have a larger home range when compared to herbivores and as a result, they require access to more land to fulfill their resource requirements (Holling 1992, Bennett 1999). Amphibians generally breed in water and hibernate on land so their home range includes both wetland and

upland habitat (Bennett 1999). All areas of an animal's home range should be considered when identifying potential corridors to ensure the resources required for survival are provided.

Wildlife habitat or range maps may provide information about wildlife sightings in the area or the possibility of wildlife presence. Suggested resources to examine wildlife range include:

- Wildlife range maps for specific species are available in many wildlife field guides. These maps are often at a very coarse detail and generally will provide wildlife range from a North American perspective.
- Fisheries habitat may be identified though Alberta Environment's Code of Practice for Watercourse Crossings. These maps are available for download through the Alberta Environment website and will identify water courses with important habitat.
- Search requests submitted to the Fisheries and Wildlife Management Information System (FWMIS) (ARSD 2009) for the project location should also include at least one section in each direction. This will provide records of wildlife sightings in the area.
- Available data on home range size is presented in Appendix B. For a more extensive list of home range size, please see Holling 1992 or Bissonette and Cramer 2008. Please note that these list several species that will not be applicable to the Edmonton Region but it may be possible to extrapolate the listed home ranges so that they apply to the species of interest. If a specific home range is required for a species (for example, if a listed species is present on the Project Area), then additional research and study may be required to determine the range of this animal.

#### 3.2.2.6 Road Kill Information

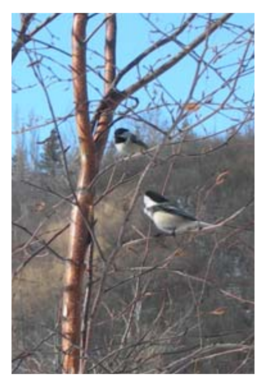
Roadkill data indicates locations where wildlife is crossing transportation infrastructure unsuccessfully. Animal-vehicle collisions are dependant on traffic volume and the amount of wildlife crossing the road so areas of high wildlife use may not be identified on low volume roads from this type of data (Barnum 2003, Gunson *et al.* 2006). Wildlife-vehicle collision data may also be inaccurate, under-representing the number of incidents or estimating the location of the incident (Barnum 2003). Collisions with small wildlife that do not damage the vehicle or near misses will likely not be reported at all. As a result, locations with high wildlife mortality may not represent the best location for habitat linkage and incorporating a corridor in these areas will enhance driver safety but may not promote linkage (NHCRP 2008).

Ensure that the most up-to-date sources of information are used. Zoning, Natural Area Inventories and legislation change over time and some of the information presented in this document may be out of date when planning your project.

For the purpose of these guidelines, road kill data is not recommended to assess potential areas for linkage due to data inaccuracy and the lack of widely available road kill data for the Edmonton area.

#### 3.2.2.7 Wildlife Linkage Assessment

In 2006, the Edmonton Office of Natural Areas published the Edmonton State of Natural Areas Report (Spencer 2006). This report integrates many of the above information sources to determine the landscape connectivity and ecological networks. This report is separated into three sections. The first section is Natural Areas Mapping which outlines the location of Edmonton's Natural areas. The second section is Landscape Linkages and



Black-Capped Chickadees. Photo Credit: Kurtis Fouquette, Stantec. Used with permission.

Connectivity Analysis which describes the functional landscape connections. The third section is Natural Areas Systems Analysis which examines existing conservation policies and analyzes the state of Edmonton's Natural Areas.

This report is an excellent resource that should be used to help identify natural areas and the location of important landscape elements that facilitate linkage. This report is available for download at: http://www.edmonton.ca/ environmental/natural_areas /2006-edmonton-state-of-natural.aspx

Copies of the City of Edmonton's Natural Areas Map and Ecological Network Map are provided in Appendix E for reference.

### 3.2.3 Identify Opportunities for Habitat Restoration

Many areas developed historically did not consider the requirements of wildlife in their design. As such, habitat may have been removed or altered or structures installed that are a barrier to wildlife movement. For example, in the south industrial area, Mill Creek was channelized historically and the water is currently transported in underground pipes. This past development removed the riparian zone in this location and poses a barrier to both terrestrial and aquatic wildlife using the Mill Creek riparian corridor. Other examples of habitat that was previously altered may include wetlands or tree stands that were removed.

When constructing new projects in existing neighborhoods there may be an opportunity to restore historical connectivity and replace lost habitat. Historical aerial photographs should be consulted to determine what habitat was present historically. If possible, the design plan should be altered in an attempt to restore historical connections. Existing infrastructure should also be examined to determine if it poses a barrier to wildlife (please refer to Section 3.3.4) and retrofits should be undertaken if required (please refer to Section 6.2).

### 3.2.4 Identify Potential Wildlife

Identifying potential wildlife in the area is a complex task that requires a variety of resources. The first step is to use aerial photographs, vegetation maps, topographical maps and wildlife habitat maps to identify potential habitat linkages (Ruediger and DiGiorgio 2006) as described in Section 3.2.2. Determining land use may help to identify the types of species that are likely to be located within the project area. A list of species organized by primary habitat preference is available in Appendix B. Please note that these lists are not extensive and are designed to be used as reference material only. They do not represent the entire range of species that may be encountered and should be used only to get a sense of the type of wildlife that are likely in the area. Specific detail on the wildlife present for a project should be collected or obtained through ecological reports.

A search should be conducted through Albert Sustainable Resource Development (ASRD) Fisheries Management Information System (FMIS) and Fisheries and Wildlife Information Management System (FWIMS) to determine the recorded wildlife in the project area. This information may be requested via email or alternatively it is available as an online mapping tool that identifies wildlife up to a 9 km radius (http://xnet.env. gov.ab.ca/imf/imf.jsp?site=fw_mis_pub). This database will not identify all of the

biodiversity present in the project location but may identify some key species or species with special needs.

If the project involves a stream or river, the Alberta Environment Code of Practice for Watercourse Crossings maps should also be consulted. This will determine the presence of important fish habitat, construction restrictions, and regulatory requirements affiliated with the project area.

#### 3.2.4.1 Identify Potential Species with Status

A second step in identifying potential wildlife is to determine if any endangered, threatened or at risk species (species with status) may be present in the area of the transportation project (Arizona Game and Fish Department 2006). Resources that should be referenced for the Edmonton area include:

- A search conducted through Alberta Conservation Information Management Centre (ACIMS)(http://tpr.alberta.ca/parks /heritageinfocentre/default.aspx) for any tracked species at the project location and for at least one section of land in each direction.
- A search through ASRD FWMIS and FMIS databases for the project location and at least one section of land in each direction. As identified above, information may be requested via email or through the online mapping tool.
- The "Observations of Special Status Species in the Edmonton Area Over the Last 50 Years" map from the 2006 Edmonton State of Natural Areas Report (Spencer 2006) is available for download at http://www.edmonton.ca/environmental/natural_areas/2006-edmonton-state-of-natural.aspx and identifies areas within the Edmonton area with rare wildlife sighting.
- Both ASRD and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) may also be used to identify the conservation status of wildlife identified in the desktop evaluation. COSEWIC is a national resource that allows for provincial searches by category and will identify the present conservation status and any changes. This information may be accessed at http://www.cosewic.gc.ca/eng/sct5/index_e.cfm. ASRD routinely publishes a Status of Alberta Wild Species report. The most recent version of this report is from 2005. The online resources associated with this report include a search feature that will identify conservation status of wildlife by category (http://www.srd.gov.ab.ca/fishwildlife/speciesatrisk/statusofalbertawildspecies/search.aspx) These tools will assist in determining if any of the species identified have special status.

If species with status are identified in these searches, research should be done to determine the species' habitat requirements, range, migration patterns, and seasonality, as well as requirements with regards to temperature, light, moisture, size, and noise. These factors will be helpful in determining if the species is likely still present in the area, and thus if the project requires relocation or mitigation.

**Please note:** Although these searches and references are useful tools, they are not a substitute for performing appropriate scientific studies and surveys specific to the project area.

For potential wildlife assessments please see Appendix B.

### 3.2.5 Is Further Information Required?

If there is not enough information available to determine the species present and the

ecological importance and connectivity of the project area then additional information may be required. A list of potential environmental studies is available in Appendix B.

## 3.3 IDENTIFY CONFLICTS WITH WILDLIFE

### 3.3.1 Current/Future Land Use Conflicts

During the planning stages of your project, it is important to identify the surrounding and/or conflicting regional and local land uses. For example, when planning it may not be an ideal situation to design for the movement of moose into the downtown core. Additionally, it may not be suitable to plan for the movement of moose in an area that is primarily surrounded by industrial land uses, since the likelihood of wildlife using the feature will likely be low unless there is a larger ecological network present. It is important to consider future land use in addition to current land use. If a piece of land currently contains a tree stand but is zoned for future industrial development, it may not be worth investing in permanent crossing mitigation. The general examples noted above illustrate the effectiveness of examining the surrounding land uses to help avoid conflicts when designing for the movement of wildlife.

### 3.3.2 Conflicts with Habitat

Generally, there may be conflicts between local wildlife and the transportation projects if:

- A Natural Areas is located within 250 m of the project site. The Office of Natural Areas maintains current lists of Natural Areas within the City of Edmonton. Natural Areas may include features such as tree stands, wetlands, rivers, lakes or streams. If a project bisects or is located near to a natural area, it is possible that wildlife using the natural area will come into conflict with the road;
- Upland and wetland habitat is bisected. If the project site contains treed area in proximity to wetland area, then considerations for wildlife movement will be required;
- Wetland and wetland habitat is bisected. If wetlands are located on either side of the proposed road, there will likely be impacts to the historical hydrology and wildlife movement
- The project involves the North Saskatchewan River Valley and/or its tributaries. The location of the North Saskatchewan River Valley and it's tributaries may be identified from the North Saskatchewan River Valley Area Redevelopment Plan Bylaw 7188 (City of Edmonton 1985);
- The project bisects linear landscape features. Examples of linear features would include hedgerows or riparian corridors; and
- The project has high traffic volume and/or speed or large vehicles (i.e. semi-trailers). Different species will be affected by traffic volume and/or speed in different ways depending on their mobility. For example, faster moving species like jackrabbits will not find collector roads to be a large barrier while amphibians will be effectively unable to cross a collector road. Refer to Section 3.3.3 for additional details.

### 3.3.3 Conflicts with Road Characteristics

Traffic volume and speed play an important role in determining whether a road will impact wildlife movement. Because vehicle traffic behaves as a filter to movement rather than an absolute barrier, the number of species both attempting and successfully crossing the road will be reduced at greater traffic volumes and speeds (Alexander *et al*. 2005). As displayed in Figure 3.1, the majority of wildlife-vehicle collisions occur on roads with intermediate traffic volume while high volume roads have essentially no incidents (Seiler 2003, Seiler and Helldin 2006). This suggests that roads with more than 10,000 vehicles per day are essentially a total barrier to wildlife movement.

The permeability of the road will differ depending on both the species characteristics and the road characteristics (Seiler and Helldin 2006, Seiler 2003, Alexander *et al.* 2005, Hels and Buchwald 2001). Faster moving species, like rabbits or deer, will experience less difficulty crossing roads than slower moving species like frogs or ducks. Ungulates typically have a higher threshold to traffic volume when compared to carnivores (Alexander *et al.* 2005). Ungulates are less inhibited by traffic noise and speed and may forage and attempt to cross busier roads than carnivores.

The expected impacts of Local, Arterial, and Collector roads are summarized below. Rail has been grouped into Arterial roadways because of the high speeds. Please note that these are generalizations and site specific features should be considered.

1. *Trails*

   All Ecological Design Groups (EDGs) should be able to successfully cross a trail although human activity may be a deterrent to species that are not disturbance adapted.

2. *Local Road (<1000 VPD)*

   Local roads will likely be a barrier to Amphibian and Small Terrestrial EDGs due to their limited velocity and poor visibility (Hels and Buchwald 2001, Jacobson *et al* 2007). Faster members of these EDGs may be successful on lower volume local roads. Mitigation is recommended if these EDGs are present.

   Local roads will likely not be a barrier to Large and Medium Terrestrial EDGs, especially rabbits, deer and coyotes, as these species have increased mobility. Mitigation will likely not be required for these EDGs unless species with status were identified.

   Most birds and bats will not be affected by a local road unless they have a high aversion to noise or are core forest species; these birds will likely not be found near the road. Care should be taken to ensure that the road does not encourage aerial wildlife to fly near vehicle height in order to reduce the chance of collisions. Some options include diversion poles and fences. These options are discussed in detail in Appendix A, Sections 1.3.6 and 1.8.

   Aquatics will not be affected by the traffic characteristics; successful passage will occur if the culvert or bridge is well designed.

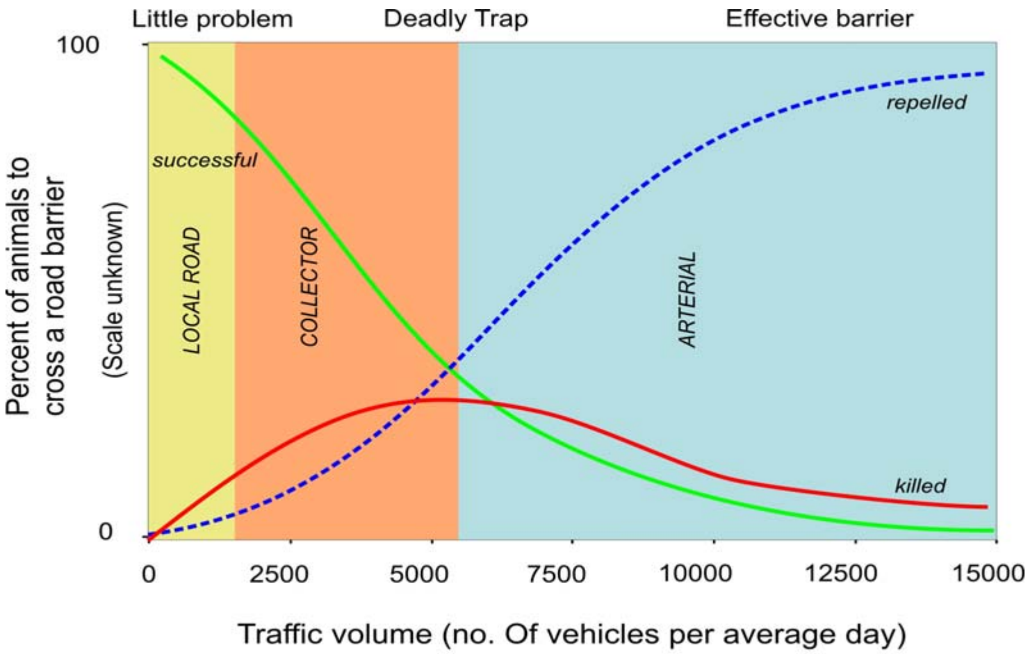




**Figure 3.1:** A representation of the permeability of roads in relation to traffic volume. At lower traffic volumes the road does not pose a threat to connectivity. When traffic volume reaches 10,000 vehicles per day few wildlife even attempt to cross the road. (This data is primarily based on large terrestrials and is adapted from Seiler2003

3. *Collector Road (1000 – 5000 VPD)*

Collector roads will likely pose a barrier to movement by small and medium terrestrial wildlife along with amphibians. Some faster moving species, like rabbits may not be significantly affected depending on the vehicle speed. Mitigation is recommended if these EDGs are present. If barriers are to be installed (jersey barrier, noise barrier) gaps should be included in the design to prevent wildlife from becoming trapped on the road.

Large terrestrial wildlife will be able to successfully cross the road in most cases although the noise and speed of vehicles may be a barrier. Wildlife experience difficulty assessing the distance of a fast moving vehicle and at fast speeds there is limited driver reaction time (Seiler and Helldin 2006). Options to increase driver awareness of wildlife presence may be beneficial in these situations.

Most birds and bats will not be affected by a collector road unless they have a high aversion to noise or are core forest species; these birds will likely not be found near the road. Care should be taken to ensure that the road does not encourage aerial wildlife to fly near vehicle height in order to reduce the chance of collisions.

Aquatics will not be affected by the traffic characteristics; successful

passage will occur if the culvert or bridge is well designed.

4. *Arterial Road (>5000 VPD)*

Arterial Roads will likely be a barrier to terrestrial wildlife because the high volume, speed, and width associated with arterials will deter most organisms from attempting to cross the road. Wildlife that attempts to cross the road will likely not be successful. Mitigation is recommended if these EDGs are present. If barriers are to be installed (jersey barrier, noise barrier) gaps should be included in the design to prevent wildlife from becoming trapped on the road.

Some birds may not experience difficulty flying over busy roads (St. Clair 2003). Care should be taken to ensure that the road does not encourage aerial wildlife to fly near vehicle height in order to reduce the chance of collisions. Mitigation is recommended if the roadway is near breeding habitat (Hirvonen 2001, James 2006).

Aquatics will not be affected by the traffic characteristics; successful passage will occur if the culvert or bridge is well designed.

### 3.3.4 Conflicts with Existing Infrastructure

Many existing structures were not designed for wildlife and were installed with human function/traffic flow as the major goal. For example, culverts were installed to convey water underneath the road, or jersey barriers put in place to minimize vehicle crossover in the event of an accident. We now realize that these structures are a problem for wildlife and ecosystem function. Perched culverts (see Figure 3.2) will not allow for fish and other aquatic passage and traditional jersey barriers may trap wildlife on the road (creating safety concerns as well).

Situations that are not effective for facilitating wildlife passage include:

- perched culverts;
- structures with insufficient water depth for aquatic passage (i.e. aquatic species in the area cannot physically travel upstream or downstream due to reduced flows or alteration of the streambed);

**Figure 3.2:** A perched culvert poses a barrier to aquatic wildlife. This culvert should be replaced. (Photo Credit: Stantec. Used with permission)

Most historical road design only considered human function. These structures are now recognized as a barrier to wildlife and should be adapted to meet the ecological needs.

- structures with excessive water velocities (i.e. velocity that is greater than the water velocity of the stream pre and post culvert);
- bridges or culverts without dry land on the sides (see Figure 3.3);
- structures that incorporate both pedestrian and wildlife into the same structure;
- riparian zones that have been infilled to install a roadway; and

**Figure 3.3:** This Bridge does not incorporate the bank of the stream and will not facilitate terrestrial wildlife movement. Any terrestrial animals in the area will be forced to travel over the road. (Photo Credit: Stantec. Used with permission Stantec)

- Physical barriers (traditional jersey barriers, walls, water bearing culverts clogged with wood or other debris)

If the project area includes infrastructure that is a barrier to wildlife, the structure should be replaced or retrofitted. For more information on retrofitting see Section 6.2.

### 3.3.5 Where to Expect Conflict in Edmonton

Areas within the Edmonton region where conflicts are likely to occur and mitigation will be required include:

- North Saskatchewan River Valley;
- Tributaries to the North Saskatchewan River Valley;
- Transportation projects that intersect with other streams or lakes;
- Transportation projects that intersect upland and wetland habitat;
- Transportation projects that bisect natural areas, tree stands, wildlife corridors; and
- Areas with threatened or endangered species.

North Saskatchewan River Valley in the Fall – an area to anticipate opportunities to improve connectivity. (Photo Credit: Meghan Chisholm, Stantec. Used with permission)

Areas within the Edmonton region where conflicts may occur but mitigation will likely not be required include:

- Local roads with a predominance of large species or fast moving species (like deer and jackrabbits);
- Areas where connection would lead wildlife to undesirable locations (ie. an industrial park); and

- Areas where the surrounding property is zoned for re-development in the near future. This will be site specific as some locations zoned for development may still facilitate movement and provide habitat for certain wildlife.

### 3.4 CAN CONFLICTS BE AVOIDED?

Can you realign a road so that it goes around the tree stand? Can you move where connectors join to reduce traffic volume in ecologically sensitive areas? Can you build a bridge rather than a culvert so that native habitat is spanned rather than infilled? Can additional stream bank be incorporated beneath the bridge?

Avoiding a conflict is the preferred solution as it will maintain ecosystem function and reduce wildlife disturbance. Obviously, there are situations where the conflict can not be avoided. When this situation occurs, you will mitigate for the disturbance.

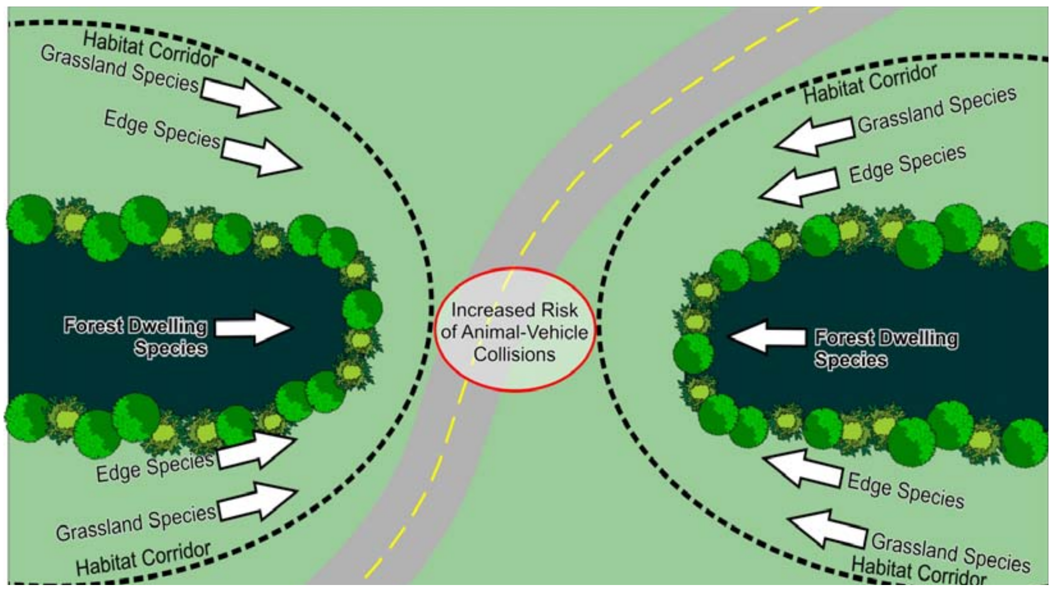



**Figure 3.4:** An illustration of the interactions between wildlife corridors and transportation infrastructure. Whenever a road intersects a wildlife corridor there will be conflicts between the vehicles and wildlife. This may lead to death or injury to both wildlife and humans. Adapted from Donaldson 2006b. (Illustration Credit: Sara King, Stantec)

# 4.0 DESIGN GUIDELINES

# 4.0 Design Guidelines

## 4.1 RE-VISIT PLANNING

### 4.1.1 Has Anything Changed Since Initial Planning?

It is good practice to review the planning stage before proceeding to design. Has anything changed? Is the proposed land use the same? Has the road design been altered? Has budget allocation been adjusted? etc. Have the changes, if any, resulted in additional or different conflicts with wildlife movement? Addressing these types of questions will ensure valuable resources (time and money) are not wasted on multiple design revisions. Transportation Detailed design

## 4.2 TRANSPORTATION DETAILED DESIGN

Design requirements for transportation facilities are set out in the City Design & Construction Standards. Volume 2 – Roadways of the City Design & Construction Standards includes the most relevant information regarding transportation facility design, and includes the design requirements for multi-use trails and sidewalks.

When designing a transportation facility, minimizing the human factors that contribute to accidents will enhance safety of both drivers and wildlife near wildlife corridors. Two factors that will contribute to safer travel is expectancy and increased reaction time.

### 4.2.1 Road Design Considerations

The design of a roadway can help to reduce the effects of transportation infrastructure on wildlife. Some simple principles that should be considered in the road design include:

1. Consider the slope of the roadside: Steep slopes along the roadside will prevent drivers from seeing wildlife along the side of the roadway and will decrease the amount time a driver has to react. Most roads have 3:1 slopes. At a maximum, slopes of 1:1 may be used (Huijser *et al.* 2008). If slopes steeper than a 1:1 are required, a flat area should be incorporated near the road edge (Huijser *et al.* 2008).

2. Consider potential/known areas of higher wildlife activity: There will likely be enhanced wildlife activity near streams, lakes, linear landscape features (hedgerows, ridges), or migration routes (please refer to Section 3.2.2 for additional information on identifying wildlife corridors). Ideally the road should be re-aligned to avoid disturbing an area of high wildlife use; however this is not always possible. Care should be taken to ensure wildlife and driver safety. Some options include:

   a. Minimize curves;

   b. Avoid steep slopes; and

   c. Consider mitigation (Huijser *et al.* 2008).

3. Consider the impacts of drainage ditches: Many roadside ditches collect water and salt (Huijser *et al.* 2008). This may attract wildlife to the roadside. The design of the road should not create pooled water especially near busy roads.

4. Consider the implications of the roadway design for emergency response access and maintenance access. Various City departments will likely be required to maintain the vegetation in the area so appropriate slope and access points should be provided for these departments.

## 4.3 ECOLOGICAL DETAILED DESIGN

This section is intended to provide the reader with specific information on how to design roadway features that will also meet the needs of wildlife. The preferences of the major species groupings are identified near the beginning of this section and should be kept in mind while working through the rest of the document.

### 4.3.1 Identify Ecological Design Group

#### 4.3.1.1 What is an Ecological Design Group?

The vast biodiversity in nature provides a challenge when attempting to maintain connectivity and reduce genetic isolation. Each species within an area will have slightly different habitat requirements and behaviour making it difficult to design a corridor that will satisfy the requirements of all species. In addition, there is insufficient data for many species which provides a challenge when attempting to understand their life history strategy and to design a corridor that will satisfy the requirements.

For the purpose of these guidelines, the diversity of species has been grouped into the following categories: Large Terrestrial, Medium Terrestrial, Small Terrestrial, Amphibians, Aquatic Species, Aerial Mammals, Scavenger Birds, Birds of Prey, Water Birds, Ground Dwelling Birds, and Other Birds. This classification system was chosen because it encompasses several species characteristics that should be considered during connectivity planning and design. These groupings attempt to link animals based on the type and frequency of mitigation that will be effective. This grouping also incorporates the specific problems encountered by individual wildlife. For example, scavenger birds have a high risk of mortality along roadsides because they forage on road kill (Jacobson 2005).

Ecological Design Groups (EDGs) are used throughout this document as a way to group species with similar requirements and provide ease of navigation.

The physical size of the species dictates how large a crossing must be to physically accommodate the animal. However, factors other than size may also dictate crossing structure preferences. For example, some larger terrestrial species, like deer, prefer large open crossing structures with good visibility to the

other side while smaller terrestrial species, like mice, prefer smaller crossing structures with ample overhead cover (Ruediger and DiGiorgio 2006, McDonald and St. Clair 2004). This preference is likely related to predatory response.

Size also appears to predict the dispersal distance. Larger animals generally have larger home ranges when compared to smaller organisms (Ottaviani et al. 2006, Bennett 1999, Hendriks 2007, Dahle et al 2006). Smaller organisms do not require as many resources for survival and reproduction as larger organisms and therefore require less land mass for foraging. Larger organisms are also physically able to travel further distances than smaller organisms. This relationship is not perfect and may be locally altered due to population density, habitat quality, and spatial arrangement of habitat patches (Hendriks 2007, Dahle et al 2006, Ottaviani et al. 2006). As a result, roads may pose more of a barrier to small organisms because they represent a large distance, relative to size, and have no overhead cover.

Home range size is important when looking at the broad landscape connectivity and should be an integral part of the planning process. Wildlife movement falls into roughly four categories.

1. Short foraging behaviour within a small area;

2. Diurnal movement (ex. Moose moving from the forest to the lake then back to the forest on a daily time scale);

3. Large scale foraging behaviour (ex. wolf moving throughout a large area to find food over several days); and

4. Migration – can be over long distances or short distances. This movement is predictable.

The type of movement most common to the target species will help to determine placement of mitigation. For example, species that undergo frequent, short movements will need mitigation placed closer together than a species that undergoes large scale landscape movement. For the design process, specific species requirements (ex. is the culvert physically large enough to accommodate the species?) and local landscape features are more important when trying to successfully maintain genetic flow across roadways.

Aerial, aquatic, and amphibian species were divided into separate categories due to differences in mobility and life history. Aerial species are highly mobile if the correct conditions exist. For example, some species of birds will not fly in open spaces with gaps larger than 45 m (Tremblay and St. Clair 2009). Aquatic species movement is restricted to water bodies and as such, their ability to disperse throughout the landscape is limited. Amphibians are segregated from the other groupings because many of

them require access to both wetland and upland habitats and have limited mobility when compared to larger terrestrial mammals. They also have specific moisture requirements that must be included in the crossing design (Jackson 1996, Cramer and Bissonette 2006, Jackson and Griffin 2000).

#### 4.3.1.2 Choosing Potentially Affected Species to Work With

When planning a transportation project it is important to identify species within the study area that will be affected by the development. In this report, the needs of various potentially affected species have been lumped together into design groups for the sake of simplifying mitigation options. It should be noted that several potentially affected species and ecological design groups will likely be selected for any given project.

The first step in determining the potentially affected species is to determine which species of wildlife are present in the area. This information may be obtained from background information (see Section 3.2.2 and 3.2.3) and specific studies. Determining the types of studies required is discussed further in Appendix B.

Upon completion of wildlife studies, **all** species identified as utilizing the area should be considered for selection as potentially affected species. Special attention should be paid to:

- Species that require dispersal for survival (Beier et al. 2006);
- Species that are integral to ecological processes (eg. predation, pollination) (Beier *et al.* 2006);
- Species that are dominant but could become less important if connectivity is lost (Beier *et al.* 2006);
- Species that need connectivity to prevent genetic divergence (Beier *et al.* 2006);
- Species that disperse over short distances or have their movement restricted by habitat availability (Beier *et al.* 2006);
- Species that prefer not to cross barriers, or cannot cross barriers (Beier *et al.* 2006);
- Species experiencing high vehicle associated mortality in or near the study area; and
- Rare, endangered, or vulnerable species.

All wildlife that utilize the area and that have one or more of these characteristics should be a potentially affected species for the project.

The selection of potentially affected species should be performed by an ecologist familiar with the local wildlife and their habitat, breeding, and connectivity needs.

Some suggestions on how to identify the types of species present in the project area include:

Several potentially affected species and EDGs will likely be selected for a given project.

Local ecologists should be consulted to identify potentially affected species within the project area and determine the resources required by the affected species.

1. Desktop Evaluation (Refer to Section 3.2);

2. Field Assessment - A site visit may be useful at this stage to accurately define the current land use characteristics, topography, and the wildlife located in the project area; and

3. Other Studies (see Appendix B for a list of studies).

#### 4.3.1.3 How To Establish Your Ecological Design Group

Once the potentially affected species for the project have been established, the design groups that they belong within should be determined. This is done using Table 4.1, with more detailed species requirements and classifications provided in Appendix B.

Large, Medium, and Small Terrestrial Groupings are distinguished based on height: 1 m; 0.1-1m; and less than 0.1 m respectively.

Sizes between Large, Medium, and Small Terrestrial design groups were determined as follows: Average adult height greater than 1 m is Large; from 0.1-1 m is Medium; and less than 0.1 m is Small. Divisions between birds of prey and other groups are determined by whether or not species belonged to families generally considered to be birds of prey, including falcons, hawks, eagles, and owls. Scavenger birds are those that forage through scavenging, and water birds are those that forage while in water or by wading in water or near shorelines, and does not include birds that forage for aquatic or water-related prey from the air (such as osprey or kingfishers). Ground dwelling birds are those that live and forage primarily on the ground.

In some cases a single species of wildlife may fall into more than one design group; in these cases **both** design groups will require appropriate mitigation. For example, amphibians in their tadpole stage fall under the "Aquatic" design group, while in their adult stage fall into the "Amphibian" design group. Thus, if a given project is affecting both aquatic and upland amphibian habitats, an amphibian will require mitigation for both "Aquatic" and "Amphibian" design groups.

A single species may fall into more than one Ecological Design Group.

**Table 4.1 - Species and Design Groups Summary**

| Design Group* | | Example | General Habitat Information |
|---|---|---|---|
|  | **Large Terrestrial** | 1. Moose **<br>2. Deer | Need forested area for cover, and ungulates require considerations for grazing needs. Primary ungulate activity occurs at dawn or dusk. Ungulate activity near roads peaks during the fall and spring. Ungulates are more aggressive and less cautious during the fall rut. |
|  | **Medium Terrestrial** | 1. Porcupine<br>2. Coyote<br>3. Rabbit | Mixture of habitat requirements: Porcupines require forested habitat; badgers require open habitat; and coyotes or hares may live in either. |

| Design Group* | Example | General Habitat Information |
|---|---|---|
| **Small Terrestrial** | 1. Mouse<br>2. Red Squirrel<br>3. Weasel | Mixture of habitat requirements: Red squirrels require forested habitat, while ground squirrels require open habitat. Weasels and some mice may inhabit either. |
| **Amphibians** | 1. Canadian toad<br>2. Tiger salamander | Requires moist substrates, and semi- permanent to temporary water for tadpole stage depending on species. Also need access between lowland habitats and between lowland and upland habitat for feeding and dispersal. |
| **Aquatic** | 1. Lake Sturgeon<br>2. Northern Pike<br>3. Longnose Sucker<br>4. Mollusks | Need aquatic habitats with flow velocities low enough to allow for upstream movement and dispersal. Substrate in habitat must allow for cover and resting locations, and appropriate substrate may be needed for breeding. Access to overwintering habitats for most fish is essential. For mollusks, substrates must be conducive for attachment. |
| **Aerial Mammals** | 1. Little Brown Bat<br>2. Northern Long-eared Bat | Require feeding and nesting locations with access in between. Nesting site needs vary by species. Nesting sites must remain undisturbed during winter hibernation. |
| **Scavenger Birds** | 1. Raven<br>2. Crow<br>3. Magpie | Need sufficient habitat for nesting and safe foraging. Most populations are not at risk; however their overpopulation may put other species at risk. |
| **Birds Of Prey** | 1. Red Tailed Hawk<br>2. Great Horned Owl | Requirements vary; many species require relatively undisturbed nesting sites, while others may nest near human habitation. Require safe foraging habitat, and safe migration routes and destinations. |
| **Water Birds** | 1. Seasonal Ponds<br>a. Mallard<br>b. Shorebirds<br>2. Permanent Water<br>a. Golden Eye<br>b. Buffleheads | Require open water and/or appropriate shoreline for feeding and nesting, varying by species. Most are ground-nesting and thus require safe, undisturbed sites for nesting. Nesting habitat requirements varies by species. Require safe migration routes and destinations. |
| **Ground Dwelling Birds** | 1. Gray Partridge<br>2. Sharp-tailed Grouse | Require safe open habitats for foraging and nesting. Nesting requires safe open grassy or shrubby areas. Require safe migration routes and destinations. Ground nesting birds should be included in this category during nesting season. |

*Please be advised that these groupings are very general and that variations in requirements for each species within the design groups may exist. Also note that these groupings do not take into consideration feeding habitat, breeding habitat, or seasonality.

** Moose may be more common on the outskirts of the City while deer are more common in the river valley.

| Design Group* | Example | General Habitat Information |
|---|---|---|
| **Other Birds** | 1. Downy woodpecker (Core Forested)<br>2. Black Capped Chickadee (Edge/Woodland)<br>3. Grasshopper Sparrow (Grassland)<br>4. Red-winged Blackbird (Wetland) | Requirements vary significantly by species. Most species require at least some forested habitat for nesting and perching, although some are ground nesting or nest in wetland vegetation or shrubs. Most are migratory and require safe migration routes and destinations. |

#### 4.3.2 Identify Needs of Ecological Design Group

Each Ecological Design Group (EDG) has specific requirements for effective crossings. In most situations, there will be more than one ecological design group present. The requirements for an individual EDG may or may not meet the needs of the other groups present. However, minor alterations can be made to a structure to facilitate a wider range of movement (refer to Section 4.6).

In general, passages should be designed so that wildlife can see through or over the structure to suitable habitat on the other side (Ruediger and DiGiorgio 2006). Substrate will also influence crossing use. Structures surfaced with natural substrates are preferred over manufactured surfaces like concrete, corrugated metal, asphalt, or gravel; animals are less hesitant to use natural looking structures (Mastro *et al.* 2008, Ruediger and DiGiorgio 2006). Another important component is to educate the public regarding the need for crossing mitigation and appropriate behaviour and use of wildlife crossings.

General design requirements for each EDG are summarized in Sections 4.3.2.1 through 4.3.2.11 below, and are further summarized and detailed in Table 4.1. Supplemental information by species is available in Appendix B.

##### 4.3.2.1 Large Terrestrial

Large terrestrial activity varies seasonally and temporally as shown by collision data. Interactions with vehicles peak 1 to 2 hours after sunset corresponding to peak forage activity and in October-November corresponding with mating season (Jalkotzy *et al.* 1997, L-P Tardif & Associates 2003). Ungulates also use

A moose foraging along the margins of a wetland. Photo Credit: Meghan Chisholm, Stantec. Used with permission.

riparian zones as travel corridors and are more abundant in areas with high forage value (Leblanc *et al.* 2006).

Just like people, large terrestrial wildlife avoid narrow and dark spaces. To encourage crossing use, underpasses with high openness ratios and large sizes are preferred (Ruediger and DiGiorgio 2006, Clevenger and Waltho 1999, Bissonette 2006). Moose will require larger structures than other ungulates (Ruediger and DiGiorgio 2006).

In addition to large, open structures, Large Terrestrial preferences include:

- A clear line of sight through the structure; road cuts, drop offs, and cliffs will dissuade the animal from using the crossing (Ruediger and DiGiorgio 2006);

- Structures should be as flat as the terrain permits. Steep grades will reduce the openness and therefore reduce use of the structure;

- Side walls in underpasses should be gently sloped. Ungulates also prefer crossings that do not have straight vertical sides, as these provide lower openness and possibly perceived ledges where predators could hide;

- Dry ground on either side of the crossing. Although ungulates can walk through water, they prefer to walk on dry ledges along the sides of crossings (NHCRP 2008);

- Natural substrate consisting of soil or vegetated soil. Riprap should not be used as ungulates have difficulty walking over it (Ruediger and DiGiorgio 2006). If it must be used it should be buried and vegetated;

- Natural approaches to crossing structures. Bright objects, excess fill, construction material, and/or equipment should not be located near the entrance (Ruediger and DiGiorgio 2006);

- Vegetation near the entrance. This will assist in making the structure appear natural; however, densely vegetated entrances may inhibit use by some prey species due to the perceived ambush cover for predators (Jackson and Griffin 2000). Lower stature vegetation may be a better option and vegetation should not alter line of sight to the other side; and

- Natural light. A high openness ratio will incorporate natural light. If the road has multiple lanes it may be difficult to design a structure with ample openness and natural light. In this case, incorporating the median of a divided roadway and installing two crossing structures, rather than one that spans the entire road, will serve as better mitigation (Cramer and Bissonette 2006, Ruediger 2001). Sky lights may also be used to increase natural light and as a last resort, artificial light may be incorporated throughout the structure.

#### 4.3.2.2 Medium Terrestrial

Medium terrestrial wildlife in the Edmonton area are composed of a variety of species with differing life characteristics. Most species prefer

well-vegetated crossings. Medium Terrestrial wildlife will use smaller structures and do not require the high openness ratios of Large Terrestrials.

In addition, Medium Terrestrial preferences include:

- Incorporation of a waterway for otters, beavers, and muskrats. Otters require that stream gradients and currents remain unaltered (Jalkotzy et al. 1997);
- Dry ground on either side of the crossing if water is conveyed. Most other medium terrestrial species require banks to be included in the passage that remain dry and incorporate minimal rocks (NHCRP 2008);
- Natural approach to the crossing. Native vegetation should be included near the opening and may be used to help funnel wildlife towards the structure. As with Large Terrestrials the crossing should not be brightly coloured and there should be no equipment, fill or leftover construction material near the entrance (Ruediger and DiGiorgio 2006); and

A beaver enjoying an afternoon snack. (Photo Credit: Stantec. Used with permission.)

- Structures aligned with natural drainage (Jalkotzy *et al.* 1997). Medium carnivores generally prefer structures aligned with drainage patterns rather than simply well designed structures.

#### 4.3.2.3 Small Terrestrial

Small Terrestrial species prefer smaller crossing structures with lower openness as their primary concern is protection from predators. Often, small raised berms composed of natural substrate are used to funnel and guide small terrestrial wildlife across or through larger passages.

Red Squirrel. Photo Credit: Meghan Chisholm, Stantec. Used with permission.

In addition, Small Terrestrial preferences include:

- Dry ground on either side of the crossing if water is conveyed. Most small terrestrial species require banks to be included in the passage

that remain dry (NHCRP 2008). Alternatively, a floating ledge along the side of a wet culvert will also be used by Small Terrestrials;

- Overhead cover to provide protection from predators in larger structures designed for multiple species. This can include shrubs and other vegetation, rocks, logs, and stumps (Arizona Game and Fish Department 2006);

- Natural substrate and natural crossing approach; and

- Limited mowing as many Small Terrestrials use grassy roadsides as habitat (NHCRP 2008).

#### 4.3.2.4 Amphibians

Amphibians and reptiles have small home range sizes relative to other vertebrates and many return to natal breeding areas (BC Ministry of Water, Land and Air Protection 2004). The majority of amphibians, however, are

Photo Credit: Gil Barber, Stantec. Used with permission

believed to remain within a couple hundred metres of breeding sites and juvenile dispersal is thought to be less than 1 km (BC Ministry of Water, Land and Air Protection 2004). Amphibian movement will often occur between wetland and wetland/riparian habitat and between wetland and upland habitat to complete their life cycle. This migration between wetland and upland

Garter Snake. (Photo Credit: Kurtis Fouquette, Stantec. Used with permission)

habitat occurs in the spring and often consists of large numbers of amphibians. Some amphibians will also regularly travel between upland and wetland habitat for forage.

It is important to note that many crossings designed for terrestrial wildlife follow drainage patterns and as such will not be as effective for amphibians because most of their movement is not affiliated with streams (Jackson 1996, Arizona Game and Fish Department 2006).

In addition to connecting upland and wetland habitat, Amphibian preferences include:

- A moist environment. Amphibians require that their skin stay moist in order to survive. Amphibians are

also sensitive to light and temperature (Merrow 2007);

- Structures with low thermal conductivity. PVC pipes are preferred over steel because steel is an effective conductor of cold during spring migration (BC Ministry of Water, Land and Air Protection 2004, CARCNET 2008). Amphibians will not a structure if it is too cold;

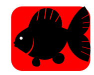
- Natural substrate. This will assist in maintaining appropriate moisture and humidity. In addition, amphibians experience difficulty walking over riprap (Ruediger and DiGiorgio 2006);

- Microclimate inside the crossing that is similar to the surroundings (BC. Ministry of Water, Land and Air Protection 2004, CARCNET 2008). Larger structures are better at maintaining microclimate although smaller structures with slotted tops are also effective (BC. Ministry of Water, Land and Air Protection 2004, CARCNET 2008);

- Structures that are placed within metres of natural migration routes. Amphibians cannot “learn” where crossing structures are so placement is important (NCHRP 2008, BC Ministry of Water, Land and Air Protection 2004, Jackson and Griffin 2000);

- Sloped and roughened curbs along roadsides. Traditional curbs are a barrier to many amphibians, especially salamanders, due to their limited mobility (Parks Canada 2008, Elmiger and Trocme 2007). Grates or screens may be required over storm sewers in areas with high amphibian use to prevent entrapment in stormwater systems; and

- Downed logs and other decaying woody material to provide shelter and feeding sites. Rock outcrops with southern exposure will also encourage use by snakes and other reptiles (BC Ministry of Water, Land and Air Protection 2004).

#### 4.3.2.5 Aquatic 

Aquatic wildlife are especially vulnerable to poorly designed crossings. Problems associated with many typical crossings include increased water velocity (due to a change in slope, direction of flow, and/or substrate) or hanging culverts creating a barrier to upstream movement, and vegetation removal causing an increase in water temperature. For these reasons, bridges or open bottom culverts that do not alter the streambed are the preferred passage type. However, if properly designed and installed, closed bottom or box culverts may also provide suitable connectivity for aquatic wildlife.

A small fish. (Photo Credit: Kurtis Fouquette, Stantec. Used with permission.)

In order to minimize the change in water temperatures and the resulting alteration of the aquatic community associated with vegetation removal, removal in the vicinity of crossings incorporating water bodies should be minimized, and replanted as soon as possible after the completion of the project.

#### 4.3.2.6 Aerial Mammals

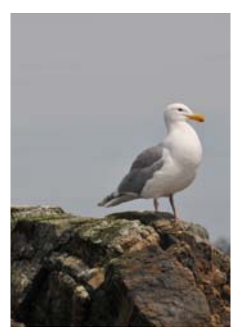
Bats are highly mobile and primarily active at night. They require both night and day roosts; night roosts are used to digest food between feedings and day roosts are to protect bats from predators and weather (Keely and Tuttle 1999). Night roosts are generally in open areas, such as between bridge support beams, that are protected from wind while day roosts are in dark, tight areas like expansion joints or crevices (Keely and Tuttle 1999).

Bats are often overlooked when designing crossings and corridors. They are important to consider as they provide important ecosystem functions, like consuming insects, and many species are at risk or threatened. Several simple strategies exist that may be used to create more bat-friendly roadways. These include:

- Retrofitting existing bridges and culverts to provide day and night roosts (see Section 6.2.7);
- Creating and maintaining linear features such as hedgerows or windbreaks parallel to the roadway to lure bats away from roadways. Create linear features perpendicular to the road in areas where bat crossing is desired;
- Maintaining a relatively wide strip of poorer habitat such as grass immediately adjacent to the roadway;
- Providing unlit safe crossing points such as bridges or large culverts where bats are known to cross, with vegetation planted in a way that directs them towards the crossing (Wray et al. 2005). If lighting must be used it should minimize spill light. (Refer to Appendix A, Section 1.3);
- Building up earthworks on either side of the road can help to "lift" the bats over the road safely and maintain habitat connectivity (Wray *et al.* 2005). (Refer to Appendix A, Section 1.9); and
- Installing taller streetlights. Most bats forage on insects and large numbers of insects generally congregate near light sources. Installing high level streetlights will force both the insects and the bats to fly higher and avoid collisions with vehicles (FWHA 2003).

#### 4.3.2.7 Scavenger Birds

One of the primary concerns regarding scavenger birds is their foraging behaviour along roadways, searching for roadkill (Jacobson 2005). In searching for and consuming roadside carrion, these birds are themselves put at risk for becoming the casualty of a wildlife-vehicle collision. Mitigation for scavenger birds involves frequent

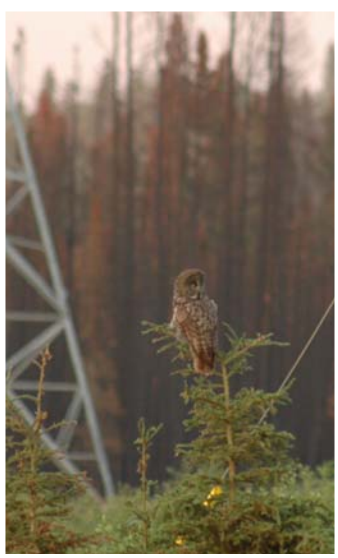


Scavenger Bird. (Photo Credit: Marc Obert, Stantec. Used with permission.)

monitoring and prompt clean-up of roadkill. This will reduce roadway foraging and decrease the chance of collisions with scavenger birds. Not removing roadkill promptly also leads to higher scavenger bird populations, which may in turn affect the populations of other nesting birds in the area, as scavengers often prey on nesting young.

#### 4.3.2.8 Birds of Prey

Many birds of prey frequently use roadways for hunting grounds (Jacobson 2005), due to the easy visibility of small and medium-sized wildlife as they travel along roadways and their edges and medians. Owls in particular are susceptible to wildlife-vehicle collisions because they forage near the heights of windshields and often do so in the dark, when driver visibility is decreased (Jacobson 2005).

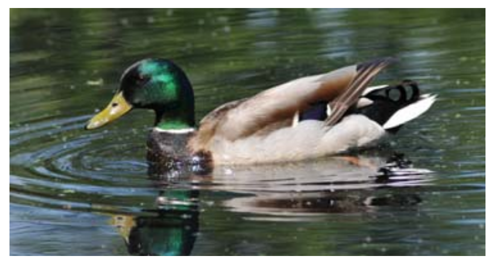


Bird of Prey - Great Grey Owl. (Photo Credit: Marc Obert, Stantec. Used with permission.)

As well, some birds of prey may act as scavengers of roadkill when it is available, or nest on bridges, also putting them at a higher risk. Mitigation for birds of prey may include the installation of diversionary methods, reduced speed limits (especially at night if owls are the primary birds affected), as well as those mentioned in Section 4.3.2.7.

#### 4.3.2.9 Water Birds

Water birds may be particularly vulnerable to wildlife-vehicle collision when roadways are placed near or over



Water Bird - Mallard. (Photo Credit: Marc Obert, Stantec. Used with permission.)

waterways. Many water birds require a significant distance to become airborne and gain altitude, and thus often fly at low altitudes when near the shore or when at the height of bridges of other crossing structures. Avoidance of oncoming vehicles can be particularly difficult for these species, and particularly so when bridges are approximately perpendicular to the wind direction (Jacobson 2005). Diversionary methods are considered the most effective mitigation measure.

Some water birds, such as mallards and killdeer, are also ground-nesting birds. Issues faced by these species are discussed under Section 4.3.2.10.

#### 4.3.2.10 Ground-Dwelling Birds

Ground-dwelling and ground-nesting birds face dangers with regards to roadways by wildlife-vehicle collisions as well as through roadside vegetation management practices (Jacobson 2005). Wildlife-vehicle collisions are particularly prevalent among ground-dwelling birds and the young of ground-nesting birds. Mitigation for this may include the installation of diversionary measures, reduced speed limits, or crossing structures such as bridges. Vegetation management along roadways often involves mowing and/or chemical application, which may cause significant mortality among the eggs and young of birds nesting within or near roadway rights-of-way. Effective mitigation strategies for these species include delaying mowing until ground-nesting birds are fully fledged, or forgoing mowing altogether.

#### 4.3.2.11 Other Birds

Various birds not mentioned in the previous design groups may also have specific mitigation measures that best ensure their survival. Some of these include:

- Maintaining shoreline habitat, or performing other mitigation measures designed to aid tired birds that make landfall after spending a significant time airborne during migration (Jacobson 2005);

- Avoiding the planting of fruit trees on roadway medians to avoid wildlife-vehicle collisions with fruit-eating birds such as robins and other thrushes, waxwings, and grackles (Jacobson 2005);

- Incorporating tall vegetation flanking bridges or in areas where bird passage over the road is desired. Vegetation will help birds cross the road by "lifting" them up and over the vehicles. Planting vegetation in the medians of wide roads will also reduce the size of the gap in habitat and encourage birds to cross;

- Avoiding the construction of dykes or other land passages across wetlands and open waterways to avoid providing increased predator access (particularly to island nesting sites) and to prevent habitat fragmentation (Jacobson 2005);

- Decreasing use of, or finding alternatives to, salt and sand as de-icing agents due to the high mortality among pine siskins and other winter finches that ingest the toxic salt and sand (Jacobson 2005). These animals often die either as a direct result of ingestion or as a result of wildlife-vehicle collisions, particularly while in the lethargic state resulting from ingestion. Other mitigation strategies may include using velocity spreaders, temperature sensors in roadways to minimize application, or signage instructing drivers to honk their horns and slow down to give congregated birds sufficient time to escape;

- Minimizing the clearing of road rights-of-way where brood parasitism by brown-headed cowbirds (*Molothrus ater*) is a

concern, or where the spread of other noxious plants or animals may be facilitated by clearing (Jacobson 2005);

- Following the recommendations of the Avian Power Line Interactions Committee (APLIC 2006), such as installing facilities underground whenever possible, to avoid bird mortality as a result of hitting power lines;

- Performing bridge maintenance activities in ways that do not conflict with bridge-nesting species such as peregrine falcons (*Falco peregrinus*) and cliff swallows (*Hirundo pyrrhonota*) (Jacobson 2005); and

- Creating roadways in ways that reduce habitat fragmentation for birds and large predators (large predators reduce the populations of medium-sized predators that feed more largely on birds) (Jacobson 2005).

#### 4.3.3 Identify Size of Mitigation

Different Ecological Design Groups (EDGs) will require different levels of openness and size of mitigation for optimal use. The road design will greatly influence the need to adjust the different variables such as length, width, and height. For example, an arterial road will require a longer culvert than a local road because its design dictates a wider road. Longer culverts generally decrease openness, so the cross sectional area must become larger to maintain the required openness. Below is a formula to determine openness if other dimensions of the road are known.

Table 4.2, below, summarizes preferred openness ratios and dimensions for crossing structures. It is important to note that several of these dimensions come from a literature review of sources that are primarily rural based; as urban wildlife is more adapted to disturbance, they may be more "willing" to use slightly smaller structures.

$$\text{Openness} = \frac{\text{Height} \times \text{Width}}{\text{Length}}$$

**Table 4.2 – Summary of Preferred Dimensions for Crossing Structures**

| Design Group | Optimal Fence Height (m) | Recommended Fence Type | Optimal Passage Dimensions (Height x Width) (m) | Optimal Passage Openness (m) | Optimal Frequency (m) | Comments |
|---|---|---|---|---|---|---|
| Large Terrestrial | 2-4 | Chain link or woven wire | 2.4 x 6 or 3.1 x 3.1 | 1.5 | Will depend on species | Moose will require larger structures than deer |
| Medium Terrestrial | 1-1.8 | Chain link | 1.5 x 1.5 | 0.4 | 150-300 | |
| Small Terrestrial | 1-1.8 | Fine mesh that organism cannot crawl though | 0.3 x 0.3 | ≤0.4 | 50 - 100 | Voles require smaller "vole tubes" |
| Amphibian | 0.3 (salamander) 0.6-0.9 (frog). Should have a 15 cm wide lip at the top. | Small concrete wall is best or drift fence constructed out of polythene like a silt fence | 0.2- 0.6 diameter with slotted top 1.2 - 2.0 diameter without slots. | 0.16 | 50 | Must remain moist. Alignment should be with migration routes not necessarily drainage patterns |
| Aerial Mammals | N/A | N/A | 1.5-3.0 m tall and at least 3 m above the ground | | | Use culverts to roost |

Sources: BC Ministry of Water, Land and Air 2004, Clevenger and Waltho 1999, Bank *et al*. 2002, Arizona Game and Fish Department 2006 Ruediger and DiGiorgio 2006. Jackson 2003, Huijser *et al.* 2008.

Incorporating a gap in the median and installing two crossing structures is an option that will increase the amount of natural light and openness of the structure. As a result, a smaller structure may be used, thus reducing costs.

### 4.3.4 Identify Placement of Mitigation

Passages should be placed where they are easily seen by wildlife and should be in the same line of sight as the approach (Bissonette 2006). Passages should be located out of the line of sight of areas frequented by humans (particularly pedestrians), or barriers should be erected to block the line of sight from these areas (NCHRP 2008). Placement should coincide with natural movement especially for smaller wildlife like amphibians.

### 4.3.5 Identify Frequency of Mitigation

Travel distance for specific EDGs is an important consideration when determining frequency of mitigation. Large passage structures suitable for more mobile species may not have to be spaced as closely as passageways designed for small mammals, amphibians and reptiles. A mixture of widely spaced large structures and more frequent small structures positioned to facilitate animal passage within designated "connectivity zones" would likely represent a more cost effective strategy for mitigation than a series of large multi-species structures. (Jackson and Griffin 2000).

The "appropriate" number and spacing of mitigation will largely depend on the species present. Larger wildlife can learn to use crossing structures while smaller organisms strictly driven by instinct will experience greater difficulty. Amphibians are an example of wildlife that may have difficulty "finding" new crossing structures. They undergo seasonal migrations between upland and lowland sites; a behaviour

Allometric scaling and optimal placement will be useful in making decisions for individual projects but should not be considered the sole deciding factor.

Additional research may be required to determine the behaviour and distribution of species within the project area.

A summary of home range distances, MedDD and LHRD is available in Appendix B.

driven primarily by instinct. For this reason, it is important to place crossing structures in locations close to natural migration patterns. It is suggested that amphibians should be able to find a structure within meters of their migration pathway (NCHRP 2008). Banff National Park constructed mitigation structures every 1.9 km with overpasses every 9 km while other studies recommend placing crossings 150 – 300 m apart using a variety of sizes to achieve a high rate of passage for a variety of species (Schrag 2003, Donaldson 2006b). Monitoring studies suggest that incorporating several small crossing structures is more effective than a few larger structures (Bank *et al.* 2002).

Mathematical equations, such as allometric scaling, may also help to identify crossing structure frequency. While not without problems, this approach may be more accurate. Allometric scaling incorporates home range size and dispersal distance to determine the crossing structure frequency that provides roadway permeability (Bissonette and Cramer 2008). Animals of similar size have comparable home range and ecological neighbourhood size so the assumption is that animals of a similar size will use similarly spaced crossings (Bissonette and Cramer 2008). The Linear Home Range Distance (LHRD) approach, calculated by taking the square root of the home range (√HR), and the Median Dispersal Distance (MedDD), calculated by multiplying the square root of the home range by seven (7*√HR), are two possible approaches to determine mitigation spacing (Bissonette and Cramer 2008).

Consultation with an ecologist is recommended for work related to home range, especially if rare species are present.

The LHRD method represents shorter, daily movement and places mitigation close together, while the MedDD method represents less frequent dispersal events and places mitigation further apart (Bissonette and Cramer 2008, Bissonette and Adair 2007). Because most community wide dispersal consists of short, daily movements, the LHRD method provides the highest permeability when appropriately designed and placed crossings are used (Bissonette and Cramer 2008, Bissonette and Adair 2007).

The MedDD method may place mitigation too far apart to allow for frequent movement across the road (Bissonette and Cramer 2008, Bissonette and Adair 2007). Connectivity, not permeability, is achieved using the MedDD approach (Bissonette and Adair 2007).

**Linear Home Range Distance** (LHRD) = √HR

**Median Dispersal Distance** (MedDD) = 7 *x* √HR

Another alternative is to use MedDD as the upper bound and LHRD as the lower bound and place the mitigation in the middle (Bissonette and Cramer 2008). Although allometric scaling is useful, it is not without problems. Home range assumes that the animal uses all parts of its range which is often not the case (Bissonette and Adair 2007). Home range size also varies depending on the individual and resource availability (Bissonette and Adair 2007). Local information about migration pathways, areas of local movement and hotspots of vehicle collisions must also be incorporated when determining where to place mitigation (Bissonette and Cramer 2008).

A summary table of home range distances, MedDD and LHRD is available in Appendix B (Section 10.3) for species with available data. If additional species are present, it may be possible to extrapolate this data, or additional studies may be completed. If rare species are present additional work will be required.

It must be stressed that while the information above about allometric scaling and optimal placement derived from other literature will be useful in making decisions for individual projects, it should not be considered the sole deciding factor. Additional research should be undertaken in the study area to identify the targeted species' behaviour and distribution as this will vary depending on the available resources, human disturbance, and other environmental conditions (Donaldson 2006b).

### 4.3.6 Costs and Benefits Associated with Crossings

#### 4.3.6.1 Large Terrestrial

In Edmonton, deer-vehicle collisions reported in 2002, 2003, and 2004 totalled 115, 101, and 117 respectively (Ng et al 2008), averaging 111 per year. These accidents do not come without a cost to wildlife, vehicles, and human life and injury. The installation of wildlife passages, and particularly passages designed for deer and other large mammals, has been shown to have a positive net economic gain in some situations (Bissonette et al. 2008).

While no data on the cost of wildlife-vehicle collisions was found for Canada, Bissonette et al. (2008) performed an analysis for deer-vehicle collisions in Utah. This analysis showed, by taking into account costs from human fatalities, vehicular damage, loss of deer, and human injury, that the average cost per collision was $3,470 USD in 2001, which adjusted by the U.S. Consumer Price Index for 2009, equals approximately $4,140 USD, or $5,200 CAD (based on the exchange rate on February 20, 2009, at 0.796 USD). At this rate, the average annual cost of deer-vehicle collisions in Edmonton would be approximately $577,200. This cost does not include costs associated with carcass removal and disposal, or the ecological costs associated with the loss of wildlife. No information has been found that calculates similar costs for collisions with other large wildlife found in the Edmonton area (e.g. moose, black bears), but due to the typically large size of these animals, one would expect the costs to be somewhat higher, due to the increased severity of

collisions and the higher value of the wildlife.

In order to determine if a crossing structure will be cost-effective, the price of the structure must be weighed against several variables, including the frequency of collisions in a given location, the cost of the structure and associated fencing, the expected lifetime of the structure, the maintenance costs of the roadways with versus without the structure, and the estimated effectiveness of the structure in preventing collisions. Bissonette (2007) contains detailed calculations on determining these numbers, which goes beyond the scope of this report. Nonetheless, simple calculations can show that in a location with an average collision rate of 15 accidents per year, a crossing structure of an estimated lifetime of 70 years, with an effectiveness of preventing 80% of the collisions, would be cost-effective if the installation and maintenance costs are $4,368,000 ($5200*15*70*0.8 =$4,368,00) or less over the same period. Please note that this calculation does not adjust for inflation for the costs of collisions or the costs of maintenance. Nonetheless, this sample calculation shows that it can be very cost-effective to construct and maintain wildlife passages.

A crossing structure in locations with 15 wildlife-vehicle collisions per year is cost effective assuming installation costs and maintenance costs are $4, 368,00.00 or less over a 70 year period.

### 4.3.6.2 Other Wildlife Crossings

Performing a cost-benefit analysis for wildlife crossings designed for animals other than large mammals is much more difficult, as the average direct cost to people is not available, and would likely not be as high due to the smaller amount of damage done to vehicles and those driving them. In these cases, the ecological costs of the loss of wildlife must be considered, particularly in the case of endangered, at-risk, or vulnerable species. There are also many tangible services that smaller wildlife provide, such as pest control (e.g. amphibians and bats controlling insect pests, and coyotes, weasels, and raptors controlling rodents), contributing to eco-tourism, providing food sources for people (e.g. ducks) and larger wildlife, and providing aesthetic and recreational value (e.g. birdwatching).

### 4.3.6.3 Construction Costs

Costs for passage construction are generally not provided in the literature as the costs are site specific. Estimated costs are provide below in Table 4.3. Please note that these costs do not take into account inflation and that many of the prices are United States currency (USD).

**Table 4.3 – Summary of Estimated Costs for Various Types of Wildlife Crossings Based On Other Wildlife Crossing Projects**

| Structure | Estimated Cost | Comments |
|---|---|---|
| Signage | Traditional: $95/sign<br>Non-Traditional: $2000/sign<br>Seasonal Signs: $200/sign<br>Animal Detection Signs: $65,000-$154,000 per 1.6 km | • Signs do not restrict wildlife movement<br>• Traditional signs may not be as effective<br>• Animal detection systems can be moved if wildlife patterns change |
| Reflectors | $10,000/km to install and | • Difficult to keep reflectors clean all the time |

| Structure | Estimated Cost | Comments |
|---|---|---|
| | maintenance of $500-$100/km annually | • Effectiveness in urban areas limited |
| Fencing | Varies: $35-$90 CAD/m depending on the type of post and if mesh is used along the bottom (Huijser *et al.* 2007, Schrag 2003) | • Benefits of fencing outweighed the costs in 12 out of 16 cases (Huijser et al. 2007). |
| Escape Routes | One Way Gates: $8,000<br>Jump Out: $6,425 to $13,241 USD (Huijser et al. 2008) | • Escape routes should be used if fencing is used. |
| Public Education | Varies: $6,500 – $16,335 for printed material and labour | |
| Traffic Calming | Inexpensive unless done as reconstruction project | • Slowing traffic increases reaction time<br>• Will lead to congestion on busy roads<br>• May be issues with snow removal |
| Reduced Speed Limits | Sign replacement $100/sign; additional cost for enforcement | • More reaction time<br>• Reduction in speed without changes in road configuration can effect traffic patterns |
| Wildlife Crosswalk | $28,000 USD per structure (4 lane road) and $15,000 per structure (2 lane road) (Lehnert and Bissonette 1997) | |
| Reduce/remove Roadkill | $100 (deer) to $350 (moose) | • Reduce secondary roadkill |
| Diversionary Methods | Diversion Poles: $48.60 USD per pole installation (Bard *et al.* 2002) | • Cost from reduction of bird deaths six times greater than cost of installation (Shwiff et al 2003) |
| Culverts | $50,000 USD (Schrag 2003)<br>Elliptical Culvert: $5,400/m; $225,000 total cost | |
| Box Culvert | $350,000 USD (Schrag 2003)<br>$2,800/m; $180,000 total cost | |
| Amphibian Tunnel | $2,000.00 USD | |
| Bridge | Long Tunnel: $24,000,000 for a 200 m section<br>Landscape Bridge: $12,500,000 for 200 m section<br>Open Span Bride: $55,000/m | • Long tunnels/landscape bridges built in areas with sensitive landscape (i.e floodplain) |
| Overpass | $1-1.5 Million USD (Schrag 2003). | • Although expensive, an overpass will provide connectivity for the widest range of species and preserves natural light and moisture regimes<br>• Should be used in highly sensitive areas |
| NOTES | All costs from Huijser *et al.* 2007 unless otherwise specified<br>Costs do not take into account inflation | |

## 4.4 IDENTIFY MITIGATION

Mitigation, for the purpose of this document, is intended to be site specific and practical. Various different mitigation options have been provided in Section 4.5 and range from simple, low cost alternatives to complex, higher cost designs. Some of these options have primarily been used in rural settings but have been tweaked to suit an urban environment. Other options, such as wildlife overpasses, have been included primarily to provide a comprehensive overview of all the alternatives as there will likely be few locations in Edmonton that would require this type of structure.

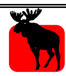
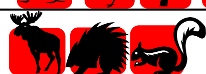
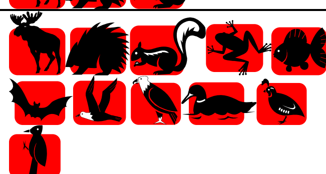
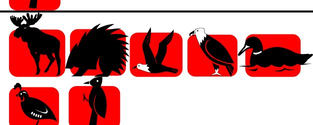
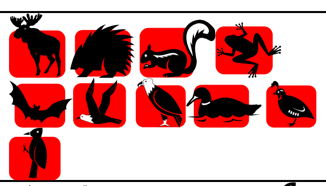
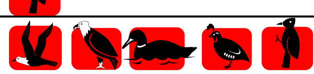
## 4.5 MITIGATION TOOLBOX

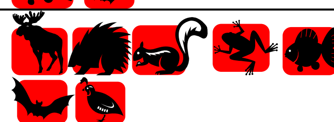
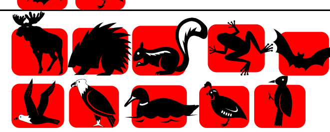
If the conflict between wildlife and human development cannot be avoided, then mitigation must be considered. There are a finite number of options to choose from to help improve road permeability and wildlife connectivity. Many of these options are not "stand alone" solutions and should be used in concert to achieve maximum connectivity and driver safety. For example, the combination of underpasses or overpasses in conjunction with fencing is the most effective strategy for providing landscape connectivity while reducing wildlife-vehicle collisions (Gagnon et al. 2007). In an area where there are numerous bird casualties, optimal landscape permeability (and minimal damage to humans and their property) could be achieved through planting trees in the median, removing any fruiting shrubs/trees from the specific location and introducing a public education campaign to advise drivers to slow down in the area so the birds have enough time to move. There is no correct answer and the suite of mitigation options chosen will be site specific. As a general rule of thumb, areas with high conservation value will require more extensive (and costly) mitigation.

When choosing a mitigation strategy it is important to note that, many of the larger scale mitigations (eg. a box culvert) can be beneficial to a wide range of design groups with some minor alterations. In most situations, the design of the crossing structure can be determined by the largest EDG and subsequent smaller EDGs may be incorporated into the structure using the suggestions in Section 4.6. It is important to note that smaller EDGs will require more frequent mitigation and may not be entirely covered by a single structure designed for a large design group. In addition, smaller organisms driven by instinct (i.e. an amphibian undergoing seasonal migration) cannot "learn" how to use crossing structures so placement will be critical. For more information on crossing placement please refer to Section 4.3.4 and 4.3.5.

**Please Note:** Limiting human access to wildlife crossing structures is critical and will influence mitigation success (Schrag 2003).

**Table 4.4 - Mitigation Summary Table**

| *Option* | *Mitigation* | *Ecological Requirements* | *Transportation Requirements* |
|---|---|---|---|
| *1* | ***Signage and/or Reflectors*** |  | ***Lower volume roads. If it is going to be used on roads with higher volume or speed, it should be combined with other mitigation.*** |
| *2* | ***Fencing**** |  | ***Can be used on any road but may not be cost effective for minor roads.*** |
| *3* | ***Altered Lighting**** |  | ***ALL*** |
| *4* | ***Altered Sight Lines*** |  | ***Multi-use trails. May also be used if sight of human activity deters use of a crossing*** |
| *5* | ***Public Education*** |  | ***ALL*** |
| *6* | ***Traffic Calmed Areas*** |  | ***Suitable for roads with average speed below 50km/hr or in an area with high bird breeding densities.*** |
| *7* | ***Reduced Speed Limits*** |  | ***Useful in areas of high wildlife-vehicle collisions*** |
| *8* | ***Wildlife "Crosswalk"*** |  | ***Roads with low traffic volume. Should be used in conjunction with signs.*** |
| *9* | ***Diversionary Methods*** |  ***Other birds using bridges as habitat*** | ***Effective for bridges and any road with wildlife foraging along the right-of-way*** |
| *10* | ***Reduce/Remove Road kill*** |  | ***Suitable for all roads*** |
| *11* | ***Vegetation Management*** |  | ***Suitable for all roads*** |
| *12* | ***Noise Barriers*** |  | ***Roadway that is near valuable nesting habitat for birds (eg. near a wetland). Note: this will behave as a barrier to terrestrial wildlife.*** |
| *13* | ***Curb Improvements*** |  | ***Useful in all areas where small wildlife may be trapped on the road.*** |

| | | | |
|---|---|---|---|
| *14* | *Closed Bottom Culvert†* |  | *Suitable for roads crossing minor drainage channels. May also be used in areas without drainage to assist small and medium terrestrials. In areas with drainage, ledges on the sides may be used to accommodate some terrestrial species.* |
| *15* | *Amphibian Tunnel* |  | *Any road running bisecting wetland-upland habitat or wetland-wetland habitat* |
| *16* | *Open Bottom Culvert*** |  | *Suitable for roads crossing minor drainage channels. May also be used in areas without drainage to assist small and medium terrestrials.* |
| *17* | *Box Culvert*** |  | *Suitable for roads crossing larger drainage channels. May also be used in areas without drainage to assist small and medium terrestrials* |
| *18* | *Bridges*** |  | *Requires grade separation* |
| *19* | *Tunnel/Overpass* |  | *Effective in sensitive natural areas, areas without grade separation, areas where the terrain on either side of the road is higher than the road.* |

* Should be complementary to other mitigation and not used as a stand alone treatment
** Improvements are required for more than one Ecological Design Group to benefit from this crossing
† Should only be used in areas that do not have critical fish habitat or species at risk. Stream widths must be less than 2.5 m and gradients less than 6%.

### 4.5.1 Signage and/or Reflectors

Signs are generally used to notify drivers that they may encounter wildlife on or near the road and are most effective for large wildlife. In situations with high traffic volumes or speeds, signs alone will not be enough to maintain connectivity. As traffic volume increases, there is a barrier effect where wildlife will not attempt a road crossing (NCHRP 2008). In these cases, if signs are chosen they should be used in conjunction with other mitigation such as below-grade or above-grade crossings.

Figure 4.1: An example of a traditional permanent sign. Microsoft Office 2002

The types of signs commonly used are listed below:

- Traditional permanent signs (Please refer to Appendix A, Section 1.1.1 for additional information);
- Temporary seasonal signs (Please refer to Appendix A, Section 1.1.2 for additional information);

- Interactive signs (Please refer to Appendix A, Section 1.1.3 for additional information); and
- Animal activated signs(Please refer to Appendix A, Section 1.1.4 for additional information).

Reflectors are thought to delay crossing until vehicles have passed (Putman 1997). The effectiveness of reflectors is questionable and only recommended for rural areas with light vehicular traffic (Mastro *et al.* 2008, Rea 2003, Pafko and Kovach 1996, Bank *et al.* 2002). As such, reflectors are not recommended to assist with wildlife movement or driver safety in the urban and suburban regions of Edmonton. Please refer to Appendix A, Section 1.1.5 for additional information.

#### 4.5.2 Fencing

Fencing restricts access to the roadway and funnels wildlife to appropriate crossing points. Fencing should be used in conjunction with other mitigation options as fencing alone will only serve to further fragment populations. The fence should be installed so that large wildlife cannot push the fence away from the pole and routine maintenance is required to ensure that the fence performs as desired (Bank *et al.* 2002). If holes or gaps are present in the fence, wildlife will be able to access the road. Fencing design will differ depending on the EDG present as indicated below:

- Large Terrestrial – Fences should be 2.0 to 3.0 m tall and chain link is recommended (Arizona Game and Fish Department 2006). If fencing is extensive escape routes such as jump-outs or one way gates will be required to ensure wildlife is not trapped on the road. Please refer to Appendix A, Section 1.2.1 and 1.2.5 for additional information;
- Medium Terrestrial – Fences should be 1 to 1.8 m tall and chain link is recommended (Arizona Game and Fish Department 2006). Escape routes may be required if fencing is extensive. Please refer to Appendix A, Section 1.2.2 and 1.2.5 for additional information;
- Small Terrestrial – Fences should be 1 to 1.8 m tall and composed of a fine mesh either 2 cm by 2 cm or 4 cm by 4 cm (Bank *et al*. 2002, Arizona Game and Fish Department 2006). The mesh should be buried 20 to 40 cm to prevent digging underneath (Bank *et al.* 2002, Schrag 2003, Arizona Game and Fish Department 2006, Ruediger and DiGiorgio 2006). Please refer to Appendix A, Section 1.2.3 and 1.2.5 for additional information; and
- Amphibian – Fences may consist of drift fences or small walls with low penetrability (i.e. concrete, steel) (NCHRP 2008, Arizona Game and Fish Department 2006). A 0.3 m tall fence will be effective for salamanders while 0.6 to 0.9 m fences are required for frogs (Woltz *et al.* 2008, Jackson 2003). A lip or an overhang approximately 15 cm wide should be included at the top to prevent climbing or

jumping over. Please refer to Appendix A, Section 1.2.4 for additional information.

#### 4.5.3 Altered Lighting

Increasing the amount of light along a roadside does not decrease wildlife-vehicle collisions and in fact decreases habitat quality and negatively impacts migratory birds (Bank *et al*. 2002, Mastro *et al*. 2008, Longcore and Rich 2004, FHWA 2003). Some options to reduce the effects of light pollution include:

- Reduce the number or intensity of streetlights (Please refer to Appendix A, Section 1.3.1 for additional information);
- Omit lighting in ecologically sensitive areas (Please refer to Appendix A, Section 1.3.2 for additional information);
- Use highly reflective materials on signs rather than lighting them up (Please refer to Appendix A, Section 1.3.3 for additional information);
- Choose lights that minimize spill light, upward light, and glare (Please refer to Appendix A, Section 1.3.4 for additional information);
- Reduce light pollution during migratory season (Please refer to Appendix A, Section 1.3.5 for additional information); and
- Install streetlights at heights that will place any birds or bats foraging near the light far above traffic height. (Please refer to Appendix A, Section 1.3.6 for additional information).

#### 4.5.4 Altered Sight Lines

Human activity in wildlife habitat or corridors may result in habitat avoidance and essentially increase fragmentation effects (Jackson and Griffin 2000, Clevenger and Waltho 1999, Jalkotzy et al 1997, Phillips *et al.* 2001). Limiting the visibility of humans will increase habitat use (Philips *et al.* 2001). Please note that it is primarily peripheral vision of human activity that this category attempts to reduce; most wildlife requires clear sight lines through the structure for successful crossing. Possibilities to limit sight include:

- Natural Structures that will block sight of human trails, roads, or other activity (i.e. boulders, vegetation) (please refer to Appendix A, Section 1.4.1 for additional information);
- Noise barriers or opaque fence (please refer to Appendix A, Section 1.4.2 for additional information);
- Undulatory path structure (please refer to Appendix A, Section 1.4.3 for additional information); and
- Jogs in path structure (please refer to Appendix A, Section 1.4.5 for additional information).

#### 4.5.5 Public Education

Providing the public with information about the conflicts between wildlife and roads may decrease the number of collisions and increase the

effectiveness of crossing structures. Education can take many forms including web or print articles, brochures, and public information sessions. Some useful topics include:

- Information about how to react if wildlife is on the road (please refer to Appendix A, Section 1.5.1 for additional information);
- Information about when you are most likely to encounter wildlife (please refer to Appendix A, Section 1.5.2 for additional information);
- Information about the purpose of crossing structures (please refer to Appendix A, Section 1.5.3 for additional information); and
- Information about the effects of littering on wildlife. For example, litter along roadsides attracts scavenger birds and makes them more susceptible to collisions. Feeding wildlife also decrease their fear of humans as the wildlife will view humans as a food source. As a result, wildlife may interact with humans more frequently in an attempt to obtain food.

#### 4.5.6 Traffic Calmed Areas

Incorporating design elements that force reduced speeds and/or limit access to certain areas will improve connectivity while at the same time reducing traffic noise (Van Langevelde *et al.* 2007). Common traffic calming measures include:

- Speed humps (please refer to Appendix A, Section 1.6.1 for additional information);
- Sidewalk extensions (please refer to Appendix A, Section 1.6.2 for additional information);
- Raised medians (please refer to Appendix A, Section 1.6.3 for additional information);
- Traffic Circles (please refer to Appendix A, Section 1.6.4 for additional information); and
- Rumble strips (Huijser et al. 2007) (please refer to Appendix A, Section 1.6.5 for additional information).

#### 4.5.7 Reduced Speed Limits

The number of wildlife-vehicle collisions within the City of Edmonton and other jurisdictions was found to increase in areas with high traffic speed (Schrag 2003, Ng *et al.* 2008, Huijser et al. 2007). Both birds and mammals experience a greater probability of being hit by a vehicle at speeds greater than 50 km/hr with the majority of wildlife death occurring at speeds greater than 72 km/hr (Schrag 2003, Ng *et al.* 2008, Huijser et al. 2007). A 5km/hr reduction in speed reduces the number of casualties by 32% (Huijser *et al.* 2007). In Edmonton, collisions were highest in November (Ng *et al.* 2008), leading to the suggestion that seasonally reduced traffic speeds may benefit wildlife.

Ways to reduce vehicle speed on roadways include:

- Photo radar (please refer to Appendix A, Section 1.7.1 for additional information);
- Incorporating traffic calming measures (please refer to Appendix A, Section 1.7.2 for additional information);
- Planting trees or other vegetation near the road (please refer to Appendix A, Section 1.7.3 for additional information);
- Post seasonal or temporary signs with reduced speed limits (please refer to Appendix A, Section 1.7.4 for additional information); and
- Change posted speed limit (please refer to Appendix A, Section 1.7.5 for additional information).

Reducing speed limits is a low cost alternative that appears to increase driver reaction time and reduce the number of wildlife-vehicle collisions. An additional benefit to this mitigation is that wildlife movement is not restricted. Please note that this alternative may not be a reasonable solution on high volume, high speed roads.

#### 4.5.8 Wildlife "Crosswalks"

Wildlife crosswalks are unique in that they take something most drivers are familiar with, a pedestrian crosswalk and turn it into a feature that will direct wildlife across the road in an area where drivers can anticipate their presence. The basic elements of a wildlife crosswalk include right-of-way fencing that funnels wildlife to the crossing point with riprap and boulders along the sides guiding the animal towards the road (Lehnert and Bissonette 1997). The road surface is painted with cattle guard lines to serve as visual guides (Lehnert and Bissonette 1997). Interactive signs are often incorporated to signal to drivers that there is wildlife on the right of way much like pedestrian crossing lights (Mastro *et al.* 2008)(Please refer to Appendix A, Section 1.8 for additional information).

#### 4.5.9 Diversionary Methods

Collisions between flying species and vehicles often occur either from foraging behaviour or difficulty clearing obstacles during flight. Both bats and birds of prey often forage for prey near roadsides at the height of oncoming vehicles (Erritzoe *et al.* 2003, Jacobson 2005). Water birds or birds using bridges as habitat often do not fly higher than the bridge deck placing them at the same height as vehicles (Jacobson 2005, FHWA 2003). Diversionary methods aim to create a perceived barrier that forces a higher flight path thus removing the potential for collision.

Options to divert flight include:

- Diversion Poles (please refer to Appendix A, Section 1.9.1 for additional information);
- Diversion Fence (please refer to Appendix A, Section 1.9.2 for additional information);
- Berms (please refer to Appendix A, Section 1.9.3 for additional information); and

- Vegetation (please refer to Appendix A, Section 1.9.4 for additional information).

#### 4.5.10 Reduce and/or Remove Roadkill

Scavengers feeding on road kill are at greater risk to become secondary road kill (Huijser *et al.* 2007, Jacobson 2005). Removing road kill on a regular basis will reduce the number of scavengers on the roadside and direct them towards more appropriate and less dangerous food sources (Please refer to Appendix A, Section 1.10 for additional information).

#### 4.5.11 Vegetation Management

Roadsides are often used for foraging by large terrestrial species and as habitat for many smaller terrestrial species and ground dwelling birds (FWHA 2003, White 2007, Joyce and Mahoney 2001, Mastro *et al.* 2008). By altering the types of vegetation planted and the maintenance regimes, one can effectively increase the amount of habitat while decreasing the risk of collisions with large terrestrial mammals (Rea 2003, White 2007, FWHA 2003, Mastro *et al.* 2008, Bank *et al.* 2002, Ng et al 2008).

Options for vegetation management include:

- Incorporate “no-mow” zones on road rights-of-way (please refer to Appendix A, Section 1.11.1 for additional information);
- Decrease forage value of roadside vegetation (please refer to Appendix A, Section 1.11.2 for additional information);
- Reduce palatability of roadside vegetation (please refer to Appendix A, Section 1.11.3 for additional information); and
- Plant vegetation to guide wildlife to appropriate crossing points. This could be in the form of linear vegetation guiding wildlife towards an undercrossing or tall plantings to direct birds and bats up and over the road (please refer to Appendix A, Section 1.11.4 for additional information).

#### 4.5.12 Noise Barriers

Noise barriers are commonly used in urban settings to reduce noise disturbance in residential areas. This same principle may be applied to wildlife. Birds are especially sensitive to traffic noise because they rely on song to define territories and find mates (Glista *et al*. 2008). Noise pollution may also disturb nesting birds (Bank *et al.* 2002). Noise barriers may also benefit other Ecological Design Groups although caution is required when using them as they may be a barrier to wildlife passage if additional mitigation is not used in conjunction (Bank *et al.* 2002).

Common noise barrier designs include:

- Soil Berms (please refer to Appendix A, Section 1.12.2 for additional information);
- Solid Walls (concrete, brick) (please refer to Appendix A,

Section 1.12.3 for additional information); and

- Transparent Walls (please refer to Appendix A, Section 1.12.4 for additional information).

#### 4.5.13 Curb Improvements

Traditional curb structures may pose a barrier to amphibian or small mammal movement. The size and structure of most curbs makes it difficult for amphibians to climb over them. Amphibians and small mammals become trapped on the roadway and the probability of mortality increases.

In areas with high amphibian use, the following options should be considered:

- Curbs with ramps, breaks or gentle slope (no more than 45$^o$) (please refer to Appendix A, Section 1.13.1 for additional information);

- Breaks or "scuppers" in jersey barriers (please refer to Appendix A, Section 1.13.2 for additional information); and

- Installation of screens over large storm drains to prevent entrapment (please refer to Appendix A, Section 1.13.3 for additional information).

#### 4.5.14 Culverts

Closed bottom culverts are an inexpensive, effective method of providing connectivity for smaller organisms. Culverts may be used along existing drainage patterns to incorporate both aquatic and terrestrial wildlife or installed in dry locations focusing on terrestrial connectivity. If installed in a drainage course, care should be taken to ensure that the culvert incorporates the natural stream bed and at least 1.2 times the ordinary high water mark and flood plain (if applicable) to avoid channel constriction and increased water velocity (BC Ministry of Forests 2002). This will also provide a dry passage area that will facilitate terrestrial passage (Foresman 2004, Schrag 2003). To ensure maximum use, the culvert should appear natural and any exposed metal or concrete on the bottom should be covered with natural substrate (Ruediger and DiGiorgio 2006, Bank *et al.* 2002). The type of substrate required will depend on the location. If the culvert is water bearing the substrate should be similar to the substrate located up and downstream of the culvert. If the culvert is dry then soil or small rocks would be appropriate. Regulatory agencies, such as Fisheries and Oceans Canada, should be contacted for additional information on substrate choices. An ecologist should also be contacted to identify substrate material that is appropriate for the project location. Input from engineers regarding substrate should also be obtained to minimize the potential for erosion and sedimentation.

For optimal performance, fencing should be used in conjunction with the culvert. If given the choice, most wildlife would prefer to use the open sky route (over the road) rather than the darker culvert route. Incorporating fencing will remove this option and enhance both driver and wildlife safety.

Each Ecological Design Group will have different requirements for culvert design.

Culverts bottoms should be covered with natural substrate. Exposed metal, concrete, or plastic deters some wildlife.

Discussions with regulatory agencies and/or ecologists should be conducted to determine appropriate substrate for the location

Please refer to Appendix A, Section 1.14.1 for additional information.

Culverts fall into the general classes listed below:

- Closed Bottom Culvert –These structures are generally not recommended for large terrestrial species and should not be used in areas with critical fish habitat or aquatic species at risk (BC Ministry of Forests 2002). Culvert design will differ depending on the EDG's present. Please refer to Appendix A, Section 1.14.2 for additional information.

- Open Bottom Culvert – These structures are preferred over closed bottom culverts as they maintain the existing soil surface and associated ecological function. Culvert design will differ depending on the EDGs present. Please refer to Appendix A, Section 1.14.3 for additional information.

- Box Culvert – Box culverts are preferred over other culvert designs because they have a larger interior space (Ruediger and DiGiorgio 2006). This type of structure is common in areas with flash floods but can be used in other areas to benefit a wide number of species (Ruediger and DiGiorgio 2006). Culvert design will differ depending on the EDG's present. Please refer to Appendix A, Section 1.14.4 for additional information.

- Amphibian Tunnel – Many amphibians require connection between upland and wetland habitat to complete their life cycle (Schrag 2003, Bank *et al.* 2002). Care must be taken to ensure that the crossing is placed in line with their natural migratory pathways and that appropriate moisture and temperature is maintained within the structure (Jackson 2003, BC Ministry of Water, Land, and Air Protection 2004). Tunnels should be a minimum of 0.2 m in diameter if a slotted grate will be incorporated on the top or 1.2 m in diameter without a slotted top (Jackson 2003, BC Ministry of Water, Land, and Air Protection 2004). Please refer to Appendix A, Section 1.14.5 for additional information.

Each EDG has different preferences when it comes to crossing design. In most situations, these elements can be incorporated into a single structure. For more information on how to facilitate passage of several EDGs please refer to Section 4.6.

Figure 4.3: Wildlife crossing at Wedgewood Ravine and Anthony Henday. Note the high openness, gently sloped sidewalls, and incorporation of natural substrate and vegetation. (Photo Credit: Meghan Chisholm, Stantec Consulting Ltd. Used with permission.)

#### 4.5.15 Bridges

Bridges are preferred to culverts for providing connectivity. These structures can be long, spanning both riparian and upland habitat, and minimize alteration of the original habitat while providing a sense of openness required by many species of large terrestrial wildlife (Bank *et al.* 2002 Jackson and Griffin 2000). Bridges are often used in areas with grade separation including valleys, gorges, and over water bodies. If crossing water, bridges should ideally incorporate 10 metres of bank vegetation on either side of the water body and should encompass the entire floodplain (Donaldson 2006b). Sharp, vertical side walls and riprap should be avoided and the substrate should be natural (Jackson and Griffin 2000, Arizona Game and Fish Department 2006).

Bridges generally fall into one of two categories listed below:

- Expanded Bridges; and
- Viaducts.

Please refer to Appendix A, Section 1.15 for additional information on bridge design.

Each EDG has different preferences when it comes to crossing design. For bridges several of these elements should be incorporated to provide optimal connectivity. For more information on how to facilitate passage of several EDGs please refer to Section 4.6.

#### 4.5.16 Overpasses

Overpasses, if designed correctly, provide the best connection for the largest number of species as they are less confining, quieter, maintain ambient temperature and moisture, and have natural light (Jackson and Griffin 2000). Overpasses should be 50 to 60 m wide and incorporate natural features like vegetation, rocks, and stumps (Schrag 2003, Jackson and Griffin 2000, Bank *et al.* 2002). Hourglass shaped features that narrow to 8 to 35 m in the center are thought to reduce construction costs while still maintaining connectivity (Schrag 2003, Jackson and Griffin 2000). In areas with high traffic volume, noise barriers are sometimes used to serve as a noise and visual barrier against the traffic (Bank *et al*. 2002).

They are often ideal for areas with high ecological importance, high vehicle traffic and low topographic relief (such as along the Banff Parkway). Although these structures are perceived as one of the best mitigation options, installation of this type of structure will be unlikely within Edmonton. Please refer to Appendix A, Section 1.16 for additional information on overpass design.

If this structure has been identified as the appropriate mitigation for your project, please note that each EDG has different preferences when it comes to crossing design. For overpasses several of these elements should be incorporated to provide optimal connectivity. For more information on how to facilitate

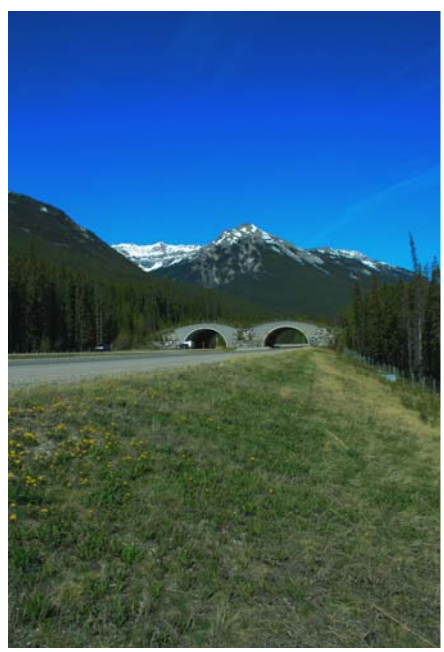
passage of several EDG's please refer to Section 4.6.

### 4.6 DESIGNING CROSSINGS FOR MULTIPLE SPECIES

In most situations, you will not be designing for one Ecological Design Group; there will likely be several groups of species each with specific needs. In this case, the best strategy may be to design a crossing structure for the largest species and incorporate several small design elements to accommodate other EDGs. If the disturbed area is large, it may be better to incorporate several crossing structures throughout.

Basic suggestions on ways to incorporate several EDGs into a crossing structure include:

- Incorporate rocks, stumps and other low lying vegetative cover to increase use of the structure by small terrestrial species;
- Incorporate dry passage into water bearing structures to promote terrestrial passage. You may retrofit existing wet culverts by installing ledges or use below-grade crossing structures that encompass land adjacent to the water body;
- Incorporate lighting with minimal spill light or omit lighting to promote bat use. This will also benefit amphibians and many birds;
- Include sheltered crevices or bat roosting areas in bridges or box culverts (see Section 6.2.7 and Appendix A, Section 1.14.1.6 for additional information). Box culverts with a dome in the center will also provide roosting habitat for bats;
- Plant vegetation close to the road in certain locations where you want wildlife to cross. Both birds and bats will follow linear vegetation and prefer to cross roads in areas with the smallest gap. This will also encourage terrestrial species that like cover to use this area as a crossing;
- Ensure moist substrate is present to encourage amphibians; and
- Incorporate small berms or tubes (like a vole pipe) in larger structures designed for Large Terrestrials. This will provide a sense of security for smaller wildlife and will direct them through the crossing.



Wildlife overpass in Banff National Park. (Photo credit: Meghan Chisholm, Stantec Consulting Ltd. Used with permission.)

When designing a structure for several species, the needs of the EDGs present should be assessed to determine if there are any specific requirements (i.e. amphibians require moist substrate). For more information on preferences and requirements of each EDG please refer to Section 4.3.2 and Appendix B.

### 4.7 DESIGNING CROSSINGS FOR HUMANS AND WILDLIFE

Ideally, all corridors and crossings designed for wildlife should have limited human access as this will maximize wildlife use. However, in an urban environment like the City of Edmonton, where natural land is limited, human use is inevitable for recreational or transportation purposes. Wildlife and humans can use the same green spaces for movement especially considering that wildlife and human peak activity often occurs at different times of the day. For example, deer are primarily active at dawn and dusk while people are primarily active during the middle of the day.

Several suggestions on making a corridor or crossing useable for both people and wildlife are listed below:

- Domestic animal and livestock access should be limited;
- The human use trail (bike path, walking trail) should be located on one side of the corridor/crossing and **NOT** in the center (Huijser *et al.* 2008) (see Figure 4.4);
- Vegetation, rocks, or other materials may be used to create visual barriers between the human part of the corridor and the wildlife part ;
- Vegetation, stumps, rocks, or branches should be incorporated to provide overhead cover;
- The human section and the wildlife section may be physically separated (vertically or horizontally). For example, there could be two parallel overpasses, one for humans and one specifically for wildlife (see Figures 4.5); and
- shared use underpasses are only recommended when the passage is wide but not too long (O'Brien 2006).

Appendix A, Section 1.4 on altered sight lines should also be consulted for suggestions on how to limit the sight of humans.

**Figure 4.4:** 23 Avenue - Whitemud Creek crossing. Note that the trail/access road located on the right side of the crossing for human use. (Photo credit: Meghan Chisholm, Stantec. Used with permission).

If the target species are adapted to humans then little will be required to make the corridor usable by humans and wildlife; however, if the species is highly human intolerant it would be advisable to install a separate structure for the wildlife. For example, jackrabbits are quite happy sharing a greenway with pedestrians and cyclists while a moose might be a bit more wary of an area with human activity.

In areas where a human/wildlife use trail joins up with roads, measures may be required to limit wildlife access to the road while still allowing human access. This may include fencing (refer to Appendix A, Section 1.2), wildlife crosswalks (refer to Appendix A, Section 1.8), or signs (refer to Appendix A, Section 1.1). If fencing is used, swing gates and/or Texas gates should be used to allow human access to the roadway while limiting wildlife access. Alternatively, a below-grade crossing structure could be installed if it is desirable to allow for wildlife movement to the other side of the road.

**Figure 4.5:** Anthony Henday - Whitemud Creek crossing. Note that the pedestrian walkway is vertically segregated from the creek. (Photo credit: City of Edmonton. Used with permission).

# 5.0 CONSTRUCTION GUIDELINES

# 5.0 Construction Guidelines

## 5.1 BENEFICIAL MANAGEMENT PRACTICES (BMPS)

If your transportation project will have an impact on wildlife in the area, there are several simple practices that can lessen these impacts during construction. In addition to these practices, Federal, Provincial and Municipal regulatory agencies should be contacted to determine any required practices or regulatory approvals that may be required for your project. Additional information on applicable regulations is provided in Appendix C and a useful regulatory checklist is available in Appendix D.

Any natural or sensitive areas to be retained onsite should be well-marked prior to construction using highly visible material.

### 5.1.1 Implement Erosion and Sediment Control Measures

Appropriate measures should be taken to avoid excess erosion or sedimentation. These are common practices that should be used for every project. Settling ponds, silt fences, or matting are examples of erosion and sediment control measures.

Suggestions to decrease erosion and sedimentation include the following:

- minimize bare ground;
- use appropriate barriers;
- dewater prior to excavation; and
- prevent excavated material from entering neighbouring land (River and Stream Continuity Partnership 2006).

Please refer to the City of Edmonton Erosion and Sediment Control Guidelines for complete details on appropriate erosion and sediment control measures.

### 5.1.2 Manage Topsoil and Subsoils

Topsoil and subsequent subsoils should be stripped and stockpiled separately, taking care to avoid admixing. Once construction is complete, the subsoil and topsoil should be replaced in the appropriate sequence (i.e. subsoils on the bottom, topsoil on the top).

### 5.1.3 Minimize the Impacts of Dewatering

Dewatering may be required for a transportation project. If dewatering is required, approvals must be obtained from the appropriate regulatory agencies.

Several suggestions to minimize the impact of dewatering include:

- minimize extent and duration;
- use a bypass channel to maintain stream continuity (a requirement in fish bearing waterbodies);
- gradually dewater the stream to prevent abrupt changes;
- salvage any stranded aquatic organisms; and

- collect construction drainage and treat to remove sediment (River and Stream Continuity Partnership 2006).

#### 5.1.4 Minimize Tree Removal

In many situations the road right-of-way exceeds the amount of land required for the road. By only clearing the land required to construct the road, valuable habitat will be preserved. This should be considered as part of the overall vegetation management strategy for the type of road, expected traffic, speed and wildlife species.

#### 5.1.5 Conduct a Pre-Construction Salvage

Before clearing the land for construction, a limited number of species can be salvaged for relocation or restoration after the project (White 2007). Vegetation, aquatic organisms or amphibians are good candidates for these activities. Advice from a qualified professional and/or Alberta Fish and Wildlife should be obtained prior to implementing these strategies.

#### 5.1.6 Minimize Impact of Construction Equipment Storage

Keep the size of the construction staging area to a minimum and avoid disturbing new areas for equipment storage. If possible, keep equipment in a previously disturbed site.

Equipment should be repaired prior to starting the project to avoid leaks. Fisheries and Oceans Canada regulations state that refueling sites and hazardous material storage areas should not be located within 100 m of water bodies or other sensitive areas (Fisheries and Oceans Canada 2008, River and Stream Continuity Partnership 2006).

#### 5.1.7 Avoid Construction during Ecologically Sensitive Periods

Construction should not occur during important breeding, spawning or nesting seasons. Spawning season will depend on the water body – refer to the Alberta Environment Codes of Practice Maps for Water Course Crossings to identify restricted activity periods. These restricted activity periods identify the time period when fish migration, spawning, egg incubation, fry emergence or early fry development are likely to occur in a water body.

For stream construction, the most favourable time is during periods of low flow, generally July 1 to October 1 (River and Stream Continuity Partnership 2006) although this may interfere with ecological processes.

Migratory bird season will depend on the species. Generally, construction should be limited between April 15 to August 31 to avoid disturbing the birds; however, some species of owls may begin nesting as early as February. Nesting period will also depend on the weather as a warmer spring may instigate earlier breeding. The nests of migratory birds should not be disturbed ; if nesting birds are present, construction must be postponed.

#### 5.1.8 Avoid Site Pollution

Construction activities may introduce hazardous or unwanted materials to the site. Suggested measures to avoid contamination of the surrounding environment might include:

- Washing equipment prior to using it on site may help limit the spread of invasive species, disease, or introducing

other foreign contaminants from previous construction projects;

- Ensure all erosion protection materials are clean and free of excessive soil, sediment or other material;
- Bring absorbent materials and/or a spill kit to quickly deal with hydrocarbon or other chemical spills;
- If concrete mixers are to be washed near the site, ensure that concrete wash water does not enter sensitive areas;
- Locate stockpiled material away from sensitive areas (streams, wetlands, trees) and use appropriate erosion and sediment controls (River and Stream Continuity Partnership 2006); and
- Do not perform any maintenance or refueling of equipment within 100 m of a water body or sensitive area.

#### 5.1.9 Use Appropriate Waste Management

Place all refuse in closed containers and remove it from the site to an appropriate disposal facility. A large amount of waste on a site may encourage scavengers, elevating the risk of a collision. Do not dispose of any material in a water body other than material specified for placement within that water body.

#### 5.1.10 Avoid Excess Noise

Pile driving associated with constructing bridge foundations generates noise, which has adverse effects on fish, birds, and other wildlife using the area (White 2007). Experimentation with cofferdams and sound attenuation devices like bubble curtains have been used to reduce the impacts of pile driving (White 2007, Teachout 2006). The U.S. Fish and Wildlife Service also incorporated hazing to discourage diving seabirds from using the area while pile driving occurred (Teachout 2006). Noisy activities should be performed outside of breeding season and if possible, wildlife that will experience detrimental effects from the noise should be excluded from the site for the duration.

#### 5.1.11 Educate Workers

Workers should be educated on BMPs and understand the consequences of not following them. Information should be provided to workers regarding the presence of species with status in the area and any specific needs. Educating workers as to why certain practices are required may also increase their effectiveness as workers may be more likely to follow BMPs.

# 6.0 MAINTENANCE/OPERATIONS GUIDELINES

# 6.0 Maintenance / Operations Guidelines

Prior to beginning maintenance or retrofit activities Sections 3 and 4 (Planning and Design) should be re-examined. This will assist in identifying wildlife in the area and land uses and/or structures that pose a barrier to wildlife movement. The design considerations identified in Section 4 for each EDG must be incorporated into any retrofits. Areas that contain species with status (endangered, threatened, at risk etc.) may require additional measures as identified by regulatory agencies.

## 6.1 BENEFICIAL MANAGEMENT PRACTICES

If maintenance of the transportation infrastructure will impact wildlife in the area, there are several simple practices that can reduce the effects of maintenance activities. In addition to these practices, Federal, Provincial and Municipal regulatory agencies should be contacted to determine any required practices.

### 6.1.1 Implement Appropriate Erosion and Sediment Controls

Appropriate measures should be taken to avoid excess erosion or sedimentation. These are common practices that should be used for every project. Settling ponds, silt fences, or matting are examples of erosion and sediment control measures. Please refer to the City of Edmonton Erosion and Sediment Control Guidelines for complete details on appropriate erosion and sediment control measures.

### 6.1.2 Avoid Disturbance to Surrounding Lands

Existing trails, roads, or cut lines should be used as access points to minimize disturbance of existing habitat. If the project is located near a water body, proper erosion and sediment controls must be in place, in accordance with the stipulations laid out in the regulatory approval, and care should be taken to avoid making ruts in the shoreline or otherwise disturbing the water body.

If disturbance occurs to the surrounding lands, the area should be re-vegetated with native species and restored. If there is not enough growing season remaining, the site should be stabilized and vegetated the following year.

### 6.1.3 Maintain Wildlife Exclusion Fencing

For fencing to be effective, it should be inspected and maintained annually. All gaps, holes etc. should be repaired promptly and vegetation restored where necessary. If holes have developed under the fence, a one meter page wire apron should be attached and buried to prevent wildlife from digging under the fence again (Clevenger 1996).

### 6.1.4 Minimize Maintenance of Roadside Vegetation

Highly managed roadside vegetation may decrease habitat for many small and medium sized terrestrial mammals, amphibians, insects and birds (White 2007). Reducing vegetation maintenance will not

only assist ecological function, but will also reduce costs.

Suggested practices include:

- Mowing rights-of-way infrequently or preserving no-mow strips. See Appendix A, Section 1.9.4 and 1.11 on vegetation maintenance for recommendations;

- Minimize disturbance to riparian vegetation. This vegetation stabilizes shorelines and stream banks, reduces water temperature and provides shelter and habitat for many aquatic organisms (Fisheries and Oceans Canada 2008);

- Combined maintenance activities (mowing, brushing, slashing etc) should not affect more than one third of total woody vegetation (trees, shrubs) in the right-of-way within 30 m of the high water mark within a given year (Fisheries and Oceans Canada 2008); and

- Do not disturb the vegetation surrounding any wetlands, sloughs or depressional areas. If disturbance is necessary, approval under the Water Act is required.

#### 6.1.5 Minimize Site Pollution

Construction activities may introduce hazardous or unwanted materials to the site during maintenance activities. Suggested measures to avoid contamination of the surrounding environment might include:

- Wash equipment prior to using it on site to help limit the spread of invasive species, disease, or introducing other foreign contaminants from previous construction projects;

- Ensure all erosion protection materials are clean and free of excessive amounts of soil, sediment or other material;

- Bring absorbent materials and/or a spill kit to quickly deal with hydrocarbon or other chemical spills;

- Do not perform any maintenance or refueling of equipment within 100 m of a water body or sensitive area;

- Store, mix and transfer paints and solvents on land and not on bridges (Fisheries and Oceans Canada 2008);

- Use secondary containment for storage of any chemical, paints, or fuels;

- Stabilize or cover any stockpiled materials removed from the site to prevent them from entering water bodies or other sensitive areas; and

- Conduct a hazard assessment and ensure all workers are aware of the spill response plan.

#### 6.1.6 Maintain Bridges

Bridge maintenance may have adverse effects on the surrounding environment by releasing salt, sand, pesticides, and other chemicals into water bodies or by disturbing wildlife. Suggested practices to minimize these impacts include:

- Avoid disturbing nesting birds. For many birds, such as Peregrine Falcons or swallows, bridges represent nesting habitat. Because maintenance often occurs in warmer months, bridge maintenance can possibly interfere with nesting birds. Special precautions must be taken to avoid this as the *Migratory Birds Convention Act* prohibits disturbance of nesting birds. The

Montana Department of Transportation removed swallow nests prior to the breeding season and applied a sticky repellent that was removed once the maintenance was complete (Jacobson 2005). Alternatively, maintenance should be completed in a month that does not conflict with breeding;

- Seal drains and open joints before commencing deck sweeping or washing to prevent material from entering the watercourse. Clean and remove debris from drains and dispose of material appropriately. (Fisheries and Oceans Canada 2008);
- Sweep decks, curbs, sidewalks, medians and drainage devices to remove material prior to washing the bridge deck. If required, use erosion and sediment control measures to prevent sand and silt from entering the watercourse in accordance with the preventative measures laid out in the regulatory approval. (Fisheries and Oceans Canada 2008);
- When removing paint or other coatings, do not allow any paint, paint flakes, primers, abrasives, rust, solvents, degreasers or other materials to enter the water; use barges or shrouding to trap any particles. Contain any waste from these processes and dispose of them at an appropriate facility (Fisheries and Oceans Canada 2008). Follow the requirements laid out in the regulatory approval;
- Blockages (logs, stumps, garbage, branches) should not be removed during restricted activity periods (see Alberta Water Act – Code of Practice for fisheries timing windows). Blockages in water bearing streams should be removed slowly to prevent flooding, excessive stream scouring, and excessive erosion or sedimentation. Debris should be removed by hand or with machinery operating on shore or on a floating barge (Fisheries and Oceans Canada 2008);
- Avoid repairing structures with rocks that are acid generating, fractured, or break down when exposed to the elements (Fisheries and Oceans Canada 2008); and
- If water is present beneath the bridge, an inspection may be required after storm events of seasons of high flow to ensure that debris and sediment are not acting as a barrier (BC Ministry of Forests 2002).

### 6.1.7 Maintain Culverts

Culverts may be used to enhance connectivity in an area; however, inappropriate maintenance may create barriers. The following practices should be considered:

- If the culvert is water bearing, an inspection should be carried out after any storm event of seasons or high flow to ensure that debris and sediment are not acting as a barrier (BC Ministry of Forests 2002). Clearing debris and maintaining vegetation is also important for dry culverts to ensure that sight lines through the structure are not blocked (Donaldson 2006b).
- Blockages in water bearing streams should be removed slowly to prevent flooding, excessive stream scouring, and excessive erosion or sedimentation (Fisheries and Oceans Canada 2008).

- Blockages should not be removed during restricted activity periods (see Alberta Water Act – Code of Practice for fisheries timing windows).

- Removal of riparian vegetation should be kept to a minimum (Fisheries and Oceans Canada 2008).

- Machinery should be operated on land and disturbance to the banks should be minimized (Fisheries and Oceans Canada 2008).

- Closed bottom culverts should be embedded to retain stream substrate. If substrate is not being retained, the design should be re-evaluated. Weirs may help with substrate retention or large rocks may be added (BC Ministry of Forestry 2002). Baffles and weirs are prone to becoming clogged with debris and will require inspections to ensure they are functioning properly (BC Ministry of Forestry 2002).

#### 6.1.8 Implement a Monitoring Program

As part of maintenance, monitoring of the crossing for effectiveness is recommended. This will allow for shifts in structure design to better accommodate wildlife in the area. It may also provide suggestions to help improve the design and placement of future structures and will determine the strengths and weaknesses in design (Clevenger and Waltho 2004). A monitoring program should not only identify signs of structure use, but should also look for signs of hesitancy to use a structure. Tracks making a semi-circle around the crossing within a 100 m radius will indicate wildlife that is hesitant to use the structure. If these signs are noted, alterations should be made to the structure to encourage use. These changes will depend on the Ecological Design Group (EDG) and could include removing dense vegetation around the entrances to increase openness, installing low lying cover and reducing or eliminating human access.

Monitoring techniques may include snow tracking, sand beds, ink beds (for smaller wildlife), radio telemetry equipment and infrared cameras (Clevenger and Waltho 2004, Clevenger 1996, Bank *et al.* 2002).

### 6.2 RETROFITTING EXISTING STRUCTURES

Existing infrastructure may behave as a barrier to movement of a variety of organisms. For example, many culverts were designed only to transport water, and the resulting shallow water depth, high water velocity, and/or outfall drop makes it difficult for fish and other aquatic organisms to successfully move upstream and interact with other populations (Schrag 2003, BC Ministry of Forests 2002). This is especially the case for aquatic crustaceans and mollusks (Vaughan 2002, Ruediger 2001).

Retrofits can be a simple, cost effective way to improve existing structures and make them more conducive for wildlife passage. Some structures may require replacement while small additions will be all that is needed for others. For existing bridges and culverts, upgrades may include enlarging, adding an area of dry ground if the culvert is seasonally filled with water, covering the corrugated steel or concrete with natural substrate, planting vegetation around the entrance for cover, and installing fencing to funnel wildlife towards the crossing (Donaldson 2006b). Other retrofits may reduce the likeliness of vehicle collisions or increase the amount of habitat that is available.

The following section identifies common barriers to wildlife from existing structures and provides suggestions for improvement.

### 6.2.1 Inappropriately Sized Culverts and Bridges

Structure sizing must take into consideration both the hydrologic requirements (if water is present) and the wildlife requirements. Many existing structures were only designed with hydrologic processes in mind and may not facilitate wildlife while others constrict water flow and increase velocity. Undersized culverts may also accumulate debris like branches and become blocked. This will also make the structure impassable for both aquatic and terrestrial life. To avoid these effects the structure should be large enough to accommodate natural stream flow (BC Ministry of Forests 2002, Vaughan 2002).

Existing structures may be physically too small for use by target species. Many small and medium sized animals use smaller structures; however, Large Terrestrial wildlife generally prefer structures with a high openness ratio. Section 4.3.3 and Appendix A, 1.14.1 should be consulted to determine the appropriate structure size for the species of interest. When a water body is present, the replacement structure should ideally incorporate 10 m of bank vegetation on either side for bridges and should span 1.2 times the ordinary high water mark for culverts (O'Brien 2006, River and Stream Continuity Partnership 2006, Donaldson 2006b).

If the stream is fish bearing, care must be taken when upgrading the structure. Increasing the size may decrease the water depth conveyed though the structure to the point where fish passage is blocked during periods of low flow. There are several options to incorporate low flow channels such as building up material on either side so low flow water is forced into the center. If the structure has multiple cells then a concrete sill that is slightly higher than low flow levels can be used to divert all low stream flow into one culvert cell (FHWA 2003). This is an effective solution as it will maintain only one channel during low flow but facilitate a higher volume of water during periods of high flow.

Upgrading existing culverts requires planning. Streams will adapt to constricted flow and increasing the culvert size may destabilize the stream and increase the volume of water downstream (River and Stream Continuity Partnership 2006). This can lead to downstream flooding, enhanced erosion and sedimentation, and alteration to upstream and downstream habitat (River and Stream Continuity Partnership 2006). Additional analysis may be required to determine the impacts of increasing the size of an existing water bearing structure. In addition to culvert replacement, stream restoration may be required to restore continuity and facilitate passage of aquatic organisms.

**Summary of Recommendations**

- If a water body is present, culverts should span 1.2 times the ordinary high water mark at a minimum and bridges should incorporate 10 m of bank vegetation on either side (O'Brien 2006, River and Stream Continuity Partnership 2006, Donaldson 2006b). The structure should incorporate some of the riparian habitat to ensure dry passage year round;

- Size the replacement structure according to species preferences (refer to Section 4.3);
- If the structure is being enlarged, ensure that there is ample water depth for fish and other aquatic organism passage during periods of low flow (i.e. install a low flow channel); and
- If enlarging a structure, additional hydrologic analysis may be required to determine the impacts on erosion and sedimentation, upstream and downstream habitat, stream stability and downstream flooding.

#### 6.2.2 Lack of Dry Passage

Often existing bridges and culverts only span the water body but do not have enough dry land on either side for terrestrial wildlife to use. As many species refuse, or prefer not to walk through water, the structure becomes a barrier to movement (Jackson and Griffin 2000, Ruediger 2001, Jacobson *et al.* 2007). Structures that were initially installed to transport water beneath a road can easily be modified to accommodate wildlife movement

The first option to provide dry passage is to replace the existing structure with a larger one. Bridge extensions or culvert enlargements could be considered to provide additional room for movement (Donaldson 2006b). This is the ideal for situations when bridges or culverts are permanently inundated with water. Refer to Section 6.2.1 for additional information on enlarging structures.

Another option for replacement is to include multiple culvert cells (Meaney *et al.* 2007). One cell will serve as a low flow channel, while the others cells will remain dry, except during storm events. Please refer to Section 6.2.1 for suggestions to maintain connectivity for aquatic organisms when using multiple culvert cells.

Replacing the structure may not be an option for your project. In this case, installing or retrofitting a dry ledge along the sides can effectively facilitate passage of many terrestrial animals depending on the culvert and ledge size (Meaney *et al.* 2007, Foresman 2004, Schrag 2003). Typical designs include approximately 15-60 cm wide ledges installed along the side of the culvert, placed well above normal water flows, with ramps leading up to them at both ends of the culvert (Meaney *et al.* 2007, Foresman 2004). Small mounds of earth and mulch, approximately 6 m wide, have also been installed beneath a bridge in Virginia crossing high quality wetland habitat with positive results (Donaldson 2006b). The mounds were placed at the far ends of the bridge to avoid impacts to the wetland and monitoring cameras have observed hundreds of wildlife using the structures (Donaldson 2006b). Combined with fencing, this type of retrofit is cost effective, and facilitates wildlife movement while keeping wildlife off the roads.

Ledge materials may include stacked rocks, metal sheets, wooden boards, and concrete (FHWA 2003, Meaney *et al.* 2007). Metal grating with 2.5 cm diamond shaped openings is not recommended as this size of opening is too large for small mammals (Meaney *et al.* 2007). The suggested material is #13 flat galvanized expanded metal mesh (Foresman 2004, Meaney *et al.* 2007). This material has an opening of approximately 1.9 cm.

**Summary of Recommendations**

- Replace the existing structure with a larger one that incorporates dry passage. (See Section 6.2.1 for details.);
- Install multiple culvert cells. One cell will remain wet as a low flow channel while the others will provide dry passage except during storm events. (See Section 6.2.1 for details on maintaining aquatic connectivity with multiple culvert cells.); and
- Install a dry ledge along the sides. This may take the form of metal, wood or concrete ledges attached to the side or soil or rock berms. Ledges should be 15-60 cm wide and the suggested material is #13 flat galvanized expanded mesh.

### 6.2.3 Excessive Water Velocity

Enhanced water velocity though a culvert or bridge is often the result of undersized structures (Section 6.2.1) or absence of natural substrate (Section 6.2.4). This can be a serious problem as high water velocity will prevent fish and other aquatic organisms from traveling upstream. It may also scour the stream bed and lead to perched culverts or excess erosion and sedimentation. Velocity inside the culvert should be within 20% of natural stream flow (Alberta Transportation 2004a). If there are increases in velocity due to a structure, rock protection may be required at the inlet and outlet to transition the natural channel (Alberta Transportation 2004a).

If stream constriction is the reason for the velocity, an enlarged structure should be considered (see Section 6.2.1). Hydrologic studies should be conducted to determine the effects of enlarging the structure, especially if it has been in place for a long time.

Unnatural bottoms (i.e. concrete, plastic, corrugated steel) tend to increase the velocity within a structure due to the low coefficient of friction. Plastic pipes should be avoided for water bearing structures as the low friction will not facilitate aquatic passage (River and Stream Continuity Partnership 2006). Metal or concrete bridge sized culverts should be buried at least 25% of the diameter of the culvert, up to 1 m and covered with natural substrate (River and Stream Continuity Partnership 2006, Alberta Transportation 2004b). Closed bottom culverts should be buried at least 40% of the diameter (BC Ministry of Forests 2002). Please see Section 6.2.4 for additional information on incorporating natural substrates and Section 6.2.5 for information on avoiding perched culverts.

**Summary of Recommendations**

- Replace the existing structure with a larger one (see Section 6.2.1);
- Avoid unnatural bottoms (plastic, steel, concrete); and
- Bury any closed bottom structures so that natural substrate is incorporated (See Section 6.2.4).

### 6.2.4 Absence of Natural Substrate

Unnatural bottoms can make the structure impassable for aquatic life and terrestrial organisms may preferentially select against using the structure. If possible, all closed bottom structures should be embedded to provide natural substrate and increase bed friction. If the site conditions limit the extent that the culvert may be embedded and the culvert is water bearing, then an open bottom culvert or a bridge should be considered instead.

Material placed inside the structure should be of similar size, shape and composition as the material in the adjacent stream channel. All material should be clean and a heterogeneous mixture of particle sizes should be used with enough fine particles to seal the streambed (BC Ministry of Forests 2002). Some of the larger material may be problematic as it can alter stream flow and flush out fine particles. For this reason, the structure should be large enough to allow for adjusting large material by hand (BC Ministry of Forests 2002). A low flow channel must be incorporated in the structure to provide year round passage for aquatic organisms. It is a good idea to wash the simulated streambed and collect any sediment prior to allowing natural flow through the structure. Regulatory agencies and ecologists should be contacted for additional information pertaining to the type of substrate required for the project.

If the culvert is not water bearing, an alternative to embedding a culvert would be to place natural materials, including a mix of fine and coarse soils along with woody material within the culvert to cover the unnatural bottom. This will increase the use of the culvert by terrestrial wildlife (see Figure 6.1).

**Summary of Recommendations**

- Metal or concrete bridge sized culverts should be buried at least 25% of the diameter of the culvert, up to 1 m and covered with natural substrate (River and Stream Continuity Partnership 2006, Alberta Transportation 2004b). Closed bottom culverts should be buried at least 40% of the diameter (BC Ministry of Forests 2002). Natural substrate should be incorporated that simulates the adjacent streambed including a mix of coarse and fine material. A low flow channel must be incorporated for aquatic passage; and
- If the structure is not water bearing then the culvert may not need to be embedded to the same depth. However, natural substrate should be placed along the bottom including coarse and fine material along with some woody cover for terrestrial passage.

**Figure 6.1:** Natural substrate on the bottom of a dry culvert. This will be more conducive to wildlife use than a culvert with a steel or concrete bottom. (Photo credit: Meghan Chisholm, Stantec. Used with permission.)

### 6.2.5 Perched Culverts

Perched culverts are often the result of increased water velocities and structures that are not embedded. Both these factors combined lead to scour and erosion placing the culvert outlet above the elevation of the stream and creating a barrier for aquatic organisms.

To minimize the likeliness of developing a perched culvert, metal or concrete bridge sized culverts should be buried at least 25% of the diameter of the culvert, up to 1 m and covered with natural substrate (River

and Stream Continuity Partnership 2006, Alberta Transportation 2004b). Closed bottom culverts should be buried at least 40% of the diameter (BC Ministry of Forests 2002). Site specific factors such as, a stream that is prone to aggradation or bedrock near the surface, may not allow for the recommended burial depth. In these cases it may be best to install an open bottom structure like a bridge or an arch culvert. Burial depth may need to be increased if fish passage is a concern or if the cost of excavation does not increase with increased depth of excavation (Alberta Transportation 2004b).

Burial of the pipe will also incorporate natural substrate.

### 6.2.6 Physical Barriers

Jersey barriers, retaining walls and noise barriers are common structures that also impact wildlife movement. They are impenetrable barriers for most small and medium wildlife and often trap wildlife on roadways. Minor alterations can make these structures more permeable as discussed below:

**Figure 6.2:** A large scupper in a series of jersey barriers will provide an exit point for small and medium sized wildlife trapped on the roadway. (Photo credit: Meghan Chisholm, Stantec. Used with permission.)

- Installing scuppers along the bottom of jersey barriers can allow smaller terrestrial wildlife to easily pass beneath (see Figure 6.2);
- Design gaps in jersey barriers by either omitted sections or offsetting segments of continuous barriers (refer to Appendix A, Section 1.13.2 for additional information); and
- Existing curbs may be a physical barrier to amphibians and other small mammals (Elmiger and Trocme 2007, Parks Canada 2008). Ideally the curb should be slanted at an angle less than $45^{\circ}$ (Elmiger and Trocme 2007). This may be accomplished on existing curbs by pouring concrete into the corner between the road surface and the curb (Elmiger and Trocme 2007). If the entire length of the curb cannot be sloped, it is possible to slope only portions of the curb to act as ramps. Another temporary, albeit less effective, option is to allow vegetation to grow over the curb providing temporary shelter and possible areas to climb on (Elmiger and Trocme 2007). Please refer to Appendix A, Section 1.13 for additional information.

### 6.2.7 Increase Bat Habitat

Bridges can be effective habitat for bats and provide roosting areas that will protect them from weather and predators and will allow for digestion of food. Optimal temperatures within the bat boxes range between 26 to 38 degrees Celsius (Bat Conservation International 2010). In Edmonton, structures will likely need to be a dark color to achieve this temperature and should face east, southeast or south (Bat Conservation International 2010). Maintenance of bat boxes is important to keep out water and unwanted pests (i.e. wasps). Screws are recommended over nails

to improve structure longevity and joins should be caulked to keep out water (Bat Conservation International 2010).

Several designs are discussed in the Bat Conservation International Inc. *Bats in American Bridges Manual* (Keeley and Tuttle 1999). These designs are summarized below:

1. Texas Bat-Abode → for crevice-dwelling species

    - This is designed to go between bridge beams. External panels cut to fit between the bridge beams are located on either side. In between the external panels are 2.5 by 5.1 cm wooden spacers sandwiched between 1.2 to 1.9 cm wide plywood partitions. This should provide crevices 1.9 cm wide by at least 31 cm deep (Keeley and Tuttle 1999). The number of partitions is arbitrary and limited by materials and the ability of the bridge to support the extra weight.

    - Smooth surfaces need to be textured at least every 0.3 cm (Keeley and Tuttle 1999). Some options to increase irregularities include:

        - Coat panels with paint and sprinkle with rough grit;
        - Attach plastic mesh with silicone caulk;
        - Mechanically roughen the wood using a blade; and
        - Sandblast wood using a rough grit.

2. Big-Eared Bat-Abode → for species that prefer open roost areas

    - This is designed to go between bridge beams. This design requires two external panels, cut to fit between the bridge beams, with 2.5 by 5.1 cm spacers that are around 61 cm long used as braces. These spacers will secure the external panels and maintain a cavity between the external panels. Plastic mesh lining is used throughout the inside of the box and should be attached with rust resistant staples. The other methods of roughening surfaces, listed above, may also be used.

3. Oregon Wedge → primarily for day roosting habitat

    - This design has a 1.2 – 2 cm plywood panel that is at least 46 cm high by 61 cm wide on the outside with three 2.5 by 5 cm wooden strips placed along the top and sides of the plywood panel leaving the bottom open (Keeley and Tuttle 1999). If larger plywood panels are used, a vertical wooden strip should be placed every 61 cm to support the plywood (Keeley and Tuttle 1999).

    - These structures may be attached to vertical concrete sides of bridges or culverts with bolts or fast drying epoxy.

- These structures should not be used in locations that flood and should be placed at least 3 m above the ground.

#### 6.2.8 Reduce Roadway Impacts on Birds

Diversionary methods and noise barriers are relatively inexpensive methods of reducing the impacts of roads on birds. Diversionary methods help to alter the flight path of birds and reduce the chance of a vehicle collision, while noise barriers will reduce noise pollution, nest abandonment, and habitat avoidance when roads are adjacent to bird habitat. Please refer to Appendix A, Section 1.9 for diversion pole design considerations and Appendix A, Section 1.12 for noise barrier design considerations.

#### 6.2.9 Road Expansions

Road expansions increase the size of the gap between habitat patches and can reduce the connectivity between adjacent areas. If the size of the road is increasing, some simple solutions to help reduce the barrier are:

- Plant trees in the median to reduce the gap. Please refer to Appendix A, Section 1.9.4; and

- Install an undercrossing. It is best to leave the median open and essential to install two crossings (one under each lane of traffic). Keeping the middle open will allow for natural light penetration. A wider gap between lanes is preferred as narrow gaps may amplify traffic noise and inhibit wildlife (O'Brien 2006). Fencing will be important in the median to ensure that wildlife travels all the way through rather than wandering down the median. Appendix A, Sections 1.14 and 1.15 contain additional information about undercrossing design. Section 4.3.2 should also be considered to identify species specific requirements.

# 7.0 GLOSSARY

# 7.0 Abbreviations and Glossary

## 7.1 ABBREVIATIONS

AENV – Alberta Environment

ANHIC – Alberta Natural Heritage Information Centre

ASRD – Alberta Sustainable Resource Development

EDG – Ecological Design Group

FWMIS – Fisheries and Wildlife Management Information System

NSR – North Saskatchewan River

ONA – Office of Natural Areas

ROW – Right-of-Way

TMP – Transportation Master Plan

VPD – Vehicles Per Day

WVC – Wildlife Vehicle Collision

## 7.2 GLOSSARY

**Aerial Mammals:** Mammals that typically forage through flying. In the Edmonton area, this is restricted to bats.

**Allometric Scaling:** Mathematical calculation that uses animal size and movement characteristics to recommend crossing placement. Two methods are commonly used: Linear Home Range Distance (LHRD) and Median Dispersal Distance (MedDD). LHRD represents the shorter daily movement and placed mitigation closer together while MedDD represents less frequent dispersal and places mitigation further apart. LHRD provides the highest permeability (See Linear Home Range Distance and Median Dispersal Distance).

**Altered Lighting:** Changing of the lighting of an area in order to achieve a given goal, such as reducing light pollution, decreasing the impact of lighting on wildlife behaviour, and decreasing wildlife-vehicle collisions.

**Altered Mowing Regimes:** Changing of the frequency of the mowing of an area in order to achieve a given goal. In this report, it generally refers to decreasing mowing frequency in order to create wildlife habitat and/or reduce forage palatability.

**Altered Sight Lines:** Changing of a site so that visibility is reduced, generally through the creation or addition of features such as walls or treed areas. Common examples include altering sight lines down linear disturbances to decrease the ability of predators to spot prey, or erecting walls to decrease the visibility of areas frequented by humans.

**Amphibian:** Vertebrates of the Class Amphibia. In the Edmonton area, this includes frogs and salamanders. For the purpose of these guidelines reptiles, such as snakes, are included in this category.

**Amphibian Tunnel:** Small culvert designed for primarily amphibian use,

generally through maintaining a moist habitat and suitable substrate and lighting.

**Aquatic (Wildlife):** Wildlife that live under water. This includes permanently aquatic wildlife such as fish, and many crustaceans and mollusks, as well as wildlife in an aquatic life-cycle stage, such as the tadpole stage of amphibians, and the larval stages of many flying insects.

**Arch Culvert:** An open bottom structure with an arched design. See Open Bottom Culvert.

**Barrier:** Natural or man-made feature that restricts wildlife movement between habitats or between different portions of a habitat.

**Bird of Prey:** Bird that typically hunts and kills vertebrate or other large prey. In the Edmonton area, this includes birds such as hawks, falcons, eagles, and owls.

**Box Culvert:** Culvert having four sides in the shape of a rectangle or square, including a fabricated bottom. Commonly built to deal with flash floods, they generally have larger interior space than round culverts.

**Bridge:** Structure crossing over a habitat or barrier, usually more than 6 m long, which forms part of a roadway.

**Causeway:** Viaduct constructed over a wetland.

**Closed Bottom Culvert:** Culvert composed of continuous round pipe, and generally constructed from metal, cement or plastic. The bottom portion may or may not be buried, and may have drainage slots on the top.

**Contiguous Landscape:** An area where the natural features are intact and joined together and there is limited human or road development. The opposite would be a fragmented landscape where several roads and housing development break up a natural feature.

**Connectivity:** The degree to which organisms are able to travel between habitat patches, most affected by the distance between habitat patches, and the presence of barriers or filters to movement between them.

**Corridor (Wildlife):** Habitat composed of contiguous native vegetation utilized by wildlife primarily for movement, connecting two or more functional habitat patches. For more information see Section 2.1.

**Corridor (Transportation):** A linear parcel of land allocated to transportation facilities such as trains, cars, or bicycles.

**Crossing:** Location along a barrier to wildlife movement (most commonly roadways) where movement occurs. This movement may or may not be facilitated by a crossing structure.

**Crossing Structure**: Infrastructure placed at a crossing site to mitigate barriers to movement.

**Culvert:** Conduit or passageway under a road or other obstruction, which may or may not convey water.

**Deer-Vehicle Collision:** A type of wildlife-vehicle collision in which deer

are the wildlife involved. This is the most commonly reported type of wildlife-vehicle collision in North America, due to the commonness and large size of deer. It generally results in significant vehicle damage and the animal's immediate or eventual death, and often causes human injury and occasionally human death.

**Deer Reflector:** Reflective objects placed along roadsides to warn wildlife of oncoming traffic. The reflector emits a red light that mimics a predator's eyes and is thought to prevent deer from crossing the road until the vehicle has passed.

**Dispersal:** A process of species spreading out geographically

**Diurnal Movement:** activities, such as foraging, is pursued during the day

**Diversion Poles:** Poles erected along a roadway in order to divert the flight patterns of flying wildlife away from vehicle traffic.

**Drift Fence:** Fine mesh fencing made of plastic or metal used to direct amphibians towards a crossing point. Silt fence would be an example.

**Driver:** Human riding on, or driving in, a vehicle along a roadway. This includes primarily motor vehicles, but also includes other vehicles such as bicycles.

**Ecological Design Group:** Group consisting of wildlife species that have similar crossing structure requirements.

**Expanded Bridge:** Bridge built over drainage courses that include both the drainage course and adjacent upland, providing connectivity for both aquatic and terrestrial wildlife. Because their movements often follow waterways, many large wildlife species may use these structures.

**Foraging:** the act of searching for food throughout the landscape. Foraging may occur over large distances or short distances depending on the species in question

**Generalist:** Animals that are opportunistic and can survive in a wide range of habitat conditions and may consist of a varied diet. These are generally disturbance adapted. A raccoon would be considered a generalist as it can live in many different habitats and will eat almost whatever it finds.

**Ground-Dwelling Birds:** Birds that spend the majority of their foraging time on the ground. In the Edmonton area, this includes birds such as grouse and partridges.

**Habitat:** The area used by a species for its basic requirements of life, including water, food, reproduction, shelter, migration, and escape from predators.

**Habitat Fragmentation:** The dividing of habitat patches into smaller habitat patches by disturbance. In the Edmonton area, this has typically occurred as a result of agricultural, industrial, commercial, residential, and transportation development.

**Human:** Any human person, regardless of age, size, race, gender, or employment.

**Large Scale Foraging:** Foraging (searching for food) that occurs over large distances. For example, a wolf will

travel several kilometres for food while a mouse may only travel meters.

**Large Terrestrial (Wildlife):** Terrestrial wildlife with a height of more than 100 cm. In the Edmonton Area, this includes species such as deer and moose.

**Life Cycle:** The stages of an organisms life from birth to death. Often includes physical changes and different habitat and diet. For example, a frog begins as a tadpole living in the water and then moves to land for its adult life, returning to the water to breed.

**Linear Home Range Distance (LHRD):** An allometric scaling method that may be used to identify the required frequency of crossing mitigation. This is calculated by taking the square root of the home range. (See Alometric Scaling)

**Medium Terrestrial (Wildlife):** Terrestrial wildlife intermediate in size between large terrestrial and small terrestrial, i.e. of a height of 10-100 cm. In the Edmonton area, this includes species such as coyote, porcupine, rabbit, and beaver.

**Mitigation:** Actions taken to offset the ecological impacts of a project. This may be in the form of habitat retention and/or protection on or off-site, the construction of crossing structures or new habitats, compensation payments, or other measures.

**Natural Area:** A large habitat patch consisting of native vegetation. For the purpose of these guidelines this term refers to the natural areas identified in the 1993 Geowest survey conducted for the City of Edmonton.

**Noise Barrier:** Structure designed to reduce the travel of noise from one area to another, typically involving noise from traffic, construction or other human activities. Noise barriers are most commonly walls or earthen berms.

**North Saskatchewan River:** The main wildlife corridor that runs through the City of Edmonton. For the purpose of these guidelines tributaries and ravines (such as Whitemud Creek and Blackmud Creek) are considered to be part of the North Saskatchewan River Valley. The North Saskatchewan River Valley Area Redevelopment Plan Bylaw 7188 may be consulted to provide a general overview of those lands considered to be within the River Valley.

**Open Bottom Culvert:** Arch culvert with a natural bottom, generally constructed of steel, plastic, or other material. These may be used over streams or on upland sites, to facilitate drainage and/or wildlife passage.

**Open Span Bridge:** Bridge with either no intermediate structural support (single span bridge) or one or more intermediate support column (multiple span bridge), often constructed over natural drainage courses. Open span bridges are high enough to facilitate crossing of most large mammals.

**Openness (Openness Ratio):** Characteristic of a structure calculated by its (Height x Width)/Length. This relates to the ability of wildlife to see through the structure and not feel confined when traveling though.

**Other Birds:** Birds not falling into the categories of scavenger birds, birds of prey, water birds, or ground-dwelling

birds, composed of a large variety of species.

**Overcrossing/Overpass:** A crossing structure, usually vegetated, that allows wildlife to cross overtop of a barrier. These structures are useful for many species, and in particular those that do not use underpasses. May also be called an ecoduct, wildlife bridge, or green bridge.

**Oversized Culvert:** Culvert built over drainage courses that include both the drainage course and adjacent upland, providing connectivity for both aquatic and terrestrial wildlife.

**Perched Culvert:** Closed-bottom culvert, or possibly box culvert, in which the culvert is located above the water or other substrate at one or both ends. This most commonly occurs as a result of the eroding away of the downstream end of an improperly installed culvert containing running water, but may also be the result of improper design or installation.

**Riparian: T**he land along the banks or rivers, streams, lakes.

**Roadway:** Any passageway designed for motor vehicle traffic, including paved and gravel roads.

**Road Kill:** Wildlife killed as the result of wildlife-vehicle collisions.

**Scavenger Bird:** Bird that forages along roadsides and may eat from scavenged carcasses. In the Edmonton Area, this includes birds such as crows, ravens, and magpies, and may also include some birds of prey.

**Scupper:** An opening in an open air structure for the purpose of draining water. For the purpose of these guidelines a scupper is an opening in the bottom of a permanent barrier (ex. jersey barrier) that allows for passage beneath the structure.

**Secondary Road Kill:** Wildlife that is killed while foraging on existing road kill.

**Signage:** Signs used to warn drivers when entering areas where wildlife-vehicle collisions are more likely to occur.

**Small Terrestrial (Wildlife):** Terrestrial or arboreal wildlife less than 10 cm tall. In the Edmonton Area, this includes wildlife such as snakes, mice, voles, shrews, squirrels, weasels, and many invertebrates.

**Specialist:** Animals that are limited to a narrow range of habitat conditions or require a specific diet. A koala would be an example of a specialist as it only eats eucalyptus leaves.

**Stepping Stone:** small, non-linear patches of native vegetation that facilitate movement between larger patches of core habitat.

**Stream Gradient**: The slope of a stream expressed as a drop in elevation over distance.

**Substrate**: The base material. In the context of these guidelines, this refers to the material resting on the bottom of a crossing structure. This could be composed of soil, rocks, sand, silt, clay or any combination of these.

**Traffic Calming:** Area where the speed and/or volume of vehicle traffic is reduced, through the use of barriers, altered roadway width or direction, or through limiting traffic access.

**Tunnel:** Structure in which a roadway is tunneled through a substantial amount of soil or rock, so that the materials above remain undisturbed. May also be used to describe long culverts, and in particular those used for amphibian passage (see **Amphibian Tunnel**).

**Underpass:** Any crossing structure in which wildlife travel under a roadway or other barrier. This includes both bridges and culverts.

**Upland:** The land along a stream or water body that is at a higher elevation than the riparian vegetation.

**Vegetation Management:** The changing or management of the vegetation in an area in order to achieve a given goal.

**Viaduct:** Long, multiple span bridges, usually built over valleys or gorges that cross streams along with habitat adjacent to the drainage course. These provide a sense of openness required for many larger species.

**Vole Tube:** Small pipe, often made out of rain gutter downspout material, made to facilitate the passage of voles through an underpass.

**Water Birds:** Swimming, diving, or wading birds utilizing open water or shorelines as their primary habitat. In the Edmonton area, this includes birds such as ducks, geese, swans, pelicans, cormorants and shorebirds.

**Wet Culvert:** A culvert that is permanently inundated with water. This type of culvert poses a barrier to terrestrial wildlife movement.

**Wetland:** Depressional areas that have seasonal, temporary, or permanent water and/or contain water-loving vegetation (cattails, sedges, reeds). Other commonly used terms used to describe wetlands include depressional area, slough, low lying area among others.

**Wildlife:** Living, non-domesticated animals existing unrestrained. Generally refers to vertebrates, but may also include invertebrate animals.

**Wildlife Crosswalk:** Structure along a roadway created to provide a safe crossing area for wildlife upon the roadway. Reduced speed limits, traffic calming, and/or signage are used to make drivers aware of the area and drive appropriately.

**Wildlife-Vehicle Collision:** A collision between any species of wildlife and a vehicle, most commonly referring to collisions with vertebrates. This includes deer-vehicle collisions.

# 8.0 REFERENCES

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# APPENDIX A - MITIGATION TOOLBOX

# Appendix A - Mitigation Toolbox

## 1.1 SIGNAGE AND/OR REFLECTORS

Signs are generally only effective for large wildlife. Some locations have installed warning signs for smaller organisms, however, studies investigating vehicle-amphibian collisions identified that a small portion of drivers intentionally hit the amphibians (NCHRP 2008). This suggests that underpasses would be more effective than warning signs for enhancing road permeability for small organisms. Signs combined with speed limits and flashing lights have a positive impact on the reduction of wildlife-vehicle collisions (Schrag 2003). However, they are not as effective at maintaining areas with high traffic volume or speeds. In these cases, signs should be used in conjunction with other mitigation options like below or above grade crossing structures.

### 1.1.1 Traditional Permanent Signs

Traditional yellow, diamond shaped signs with a black silhouette of an animal are generally regarded as ineffective (Mastro *et al.* 2008). Due to the ubiquity of these signs, drivers often ignore them and driver awareness is not enhanced (Mastro *et al.* 2008, Ruediger and DiGiorgio 2006). See Figure A.1 and A.2 for examples of traditional permanent signs.


**Figure A.1:** Examples of static sign alerting drivers to the presence of wildlife on the road. (Photo Credit: Meghan Chisholm, Stantec. Used with permission.)



**Figure A.2:** Additional examples of static signs alerting drivers to the presence of wildlife. These signs are less traditional as they use charismatic species to capture the drivers attention This type of sign is likely more effective than the silhouette featured on the left as people are not used to seeing them . (Photo credit: Meghan Chisholm, Stantec. Used with permission.)

### 1.1.2 Temporary Seasonal Signs

This type of signage warns drivers about specific events or hazards that only occur during certain times of the year. For example temporary signs could be placed along the roadway during seasonal migrations. A decrease in both vehicle speed and wildlife collisions was noted with temporary seasonal signs when compared to permanent signs (Mastro *et al.* 2008, Huijser *et al.* 2007). The benefit of temporary signs is that drivers are not accustomed to them. See Figure A.3 for an example of a temporary seasonal sign.

### 1.1.3 Interactive Signs

Interactive signs are permanent or temporary structures that display a message to motorists regarding highway conditions (Mastro *et al.* 2008). Drivers often slow down to read the message. This type of sign decreases vehicle speed to a greater extent than a sign with no message (Mastro *et al.* 2008). See Figure A.3 for examples of interactive signs.

### 1.1.4 Animal Activated Signs

Animal activated signs have a high potential for lower volume roads with large wildlife (Ruediger and DiGiorgio 2006). Several detection systems exist:

- Active detection (i.e. microwave): This system constantly emits a signal and the reflectance is measured;
- Passive detection (e.g. video or infrared): This system detects wildlife by receiving a signal. This system requires corrections so warm moving vehicles do not activate it;
- Break the beam systems: This system has a sensor and a transmitter that sends infrared, laser, or microwave


**Figure A.3:** Examples of interactive signs. The left photograph contains a temporary interactive sign that may be used seasonally while the one on the right is of a permanent interactive sign. (Photo credit: Meghan Chisholm, Stantec. Used with permission.)

radio signals. When the signal is broken by a large animal the sign is activated;

- Radio-Collar: This system detects radio-collared animals that enter the road right-of-way. This technology is limited as it depends on animals being tagged; and

- Seismic Sensors: This system detects soil vibrations as the animal walks towards the road right-of-way (Huijser *et al.* 2007).

Switzerland uses the passive detection method. Heat sensors determine the presence of wildlife near the road, which lights up a sign indicating to drivers that wildlife is on the road (Bank *et al.* 2002). Swiss signs also include a reduced speed limit that lights up when activated (Bank *et al.* 2002). The benefit of this type of system is its mobility; unlike a crossing structure, wildlife detection systems can be moved to respond to changes in the surrounding landscape. Case studies from Switzerland have found that signs triggered with wildlife proximity have been the most effective at altering human behaviour (Schrag 2003, Huijser *et al.* 2007). While positive results have come from Switzerland, this technology is not cheap. Prices range from $65,000 to $154,000 USD per 1.6 km (Huijser *et al.* 2007). Other jurisdictions experimenting with these systems have also found that certain sensor technology is not always reliable (Huijser *et al.* 2007).

Animal activated signs are often the most effective for reducing the number of wildlife-vehicle collisions while traditional permanent signs are the least effective (Schrag 2003, Huijser *et al.* 2007, Mastro *et al.* 2008, Ruediger and DiGiorgio 2006).

#### 1.1.5 Reflectors

Reflectors emit a red color when struck by headlights that is thought to mimic a predator's eyes, thus delaying road crossing until it is safe (Putman 1997, Pafko and Kovach 1996). Scientific literature regarding the effectiveness of reflectors provides inconclusive results (Mastro *et al.* 2008, Rea 2003). The European COST 341 report states that these devices are not effective while the Minnesota Department of Transportation found that reflectors decreased wildlife-vehicle collisions by 80% although they were not as effective in suburban areas (Bank *et al.* 2002, Pafko and Kovach 1996).

Reflectors may be useful in areas of intermittent traffic where delaying crossing until vehicles have passed may be enough to maintain habitat connectivity (Putman 1997). If these are used for mitigation, they should be used in rural areas where vehicle traffic is light (Pafko and Kovach 1996). Reflectors are not likely to assist with wildlife movement or driver safety in the Edmonton area.

### 1.2 FENCING

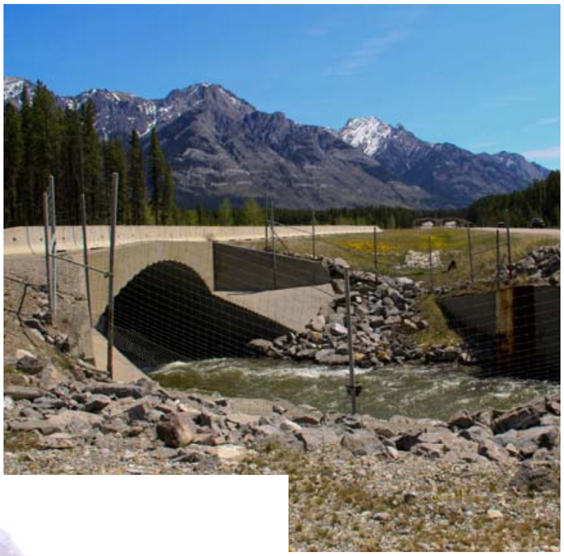
Fencing may be used to prevent wildlife entry onto roadways and funnel wildlife towards appropriate crossing points. To remain effective fencing must be properly maintained as any holes or gaps in the fence will serve as a preferred pathway and will allow wildlife to enter the road (Mastro *et al* 2008). Fencing should also be present on both sides of the right-of-way. Although fencing is effective at decreasing roadkill (Schrag 2003), it is important that it not be used as stand alone mitigation. If no crossing points are provided for wildlife, fencing will serve only to further fragment populations.

Because wildlife tends to follow fence lines, fence ends can concentrate the number of wildlife-vehicle collisions. The best location for fence ends is areas with unsuitable habitat or safe crossing opportunities. These may include steep rugged terrain, areas with high human disturbance, habitats that restricts movement (i.e. a lake for terrestrial species or open area for core forest species) or a crossing structure (Huijser *et al.*2008). Concrete barriers or boulder fields may also prevent wildlife from entering the right-of-way at fence ends (Huijser *et al.* 2008) (see Figure A.4). Fence ends should end directly opposite of each other rather than offset (Huijser *et al* 2008).

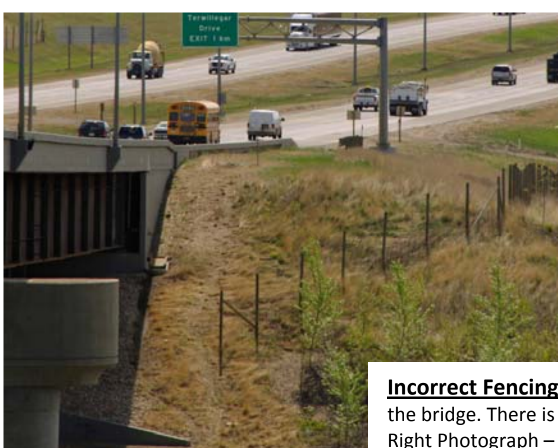
If fencing is used near crossing structures, it must funnel wildlife towards the structure and not leave any gaps between the end of the fence and the structure. Wildlife will preferentially select the open air route (over the road) rather than the dark tunnel route (under the road) (Tonjes 2006, Ruediger and DiGiorgio 2006).

Fence height and material will vary depending on the Ecological Design Group that is present.  Common fence materials include woven metal wire, chain link and plastic mesh. Electrified fences are also an option. Higher gauge and galvanized wire is recommended for woven wire fences as it is more durable and will last longer (Huijser *et al.* 2008). All metal components should be either stainless steel or heavily galvanized and any wood used must be pressure treated. Fence posts may be wood or metal depending on the substrate; metal posts are often chosen in areas with rocky soil and are more expensive than wooden posts (Huijser *et al.* 2007). Pressure treated wood posts should be at least 13 cm in diameter for line posts and 16 to 18 cm in diameter for the braces and corner posts (Huijser *et al.* 2008). This type of fence has a life span of 20 to 30 years although larger diameter posts will be more durable and likely last longer (Huijser *et al.* 2008). A protective top cable with high tension can be used on top of the fence to help reduce the number of repairs when trees fall on the fence (Huijser *et al.* 2007).

**Figure A.4:** Fence ends surrounded by a field of boulders. This will prevent a concentration of wildlife at the end of the fence. (Photo credit: Meghan Chisholm, Stantec. Used with permission.)



**Correct Fencing Placement (clockwise from top left):** Fencing must be included in the median if an open median design is used. Fencing joins up tightly with this the sides of this arch culvert. The fence funnels wildlife to this box culvert but does not allow access to the right-of way. The fence line joins tightly with the side of this open span bridge. If a person can fit through a gap between the structure and the fence then so can wildlife. (Photo credit: Meghan Chisholm, Stantec. Used with permission.)



**Incorrect Fencing Placement:** Left Photograph – This fence line does not join with the bridge. There is nothing preventing wildlife from accessing the right-of-way. Right Photograph – this large gap between the bottom of the fence and the substrate will allow small and medium sized terrestrials to enter the right-of-way. (Photo credit: Meghan Chisholm, Stantec. Used with permission.)

### 1.2.1 Large Terrestrial

Fence heights of 2.0 to 3.0 m are effective for preventing large ungulates from entering the roadway (Bank *et al.* 2002, Mastro *et al* 2008, Sielecki 2005, Arizona Game and Fish Department 2006). The fence should be installed so that large wildlife cannot push the fence away from the pole (Bank *et al.* 2002) (see Figure A.5). If fencing is used near a bridge, there should be no gaps between the fence and the bridge to ensure that wildlife is funnelled beneath the bridge (Arizona Game and Fish Department 2006, Ruediger and DiGiorgio 2006).

If fencing is extensive, escape routes should be present in the event that the animal gets trapped on the roadway. These may include one way gates, jump-outs (soil ramp), or double swing gates that will also allow human access to the highway (see Appendix A, Section 1.2.5) (Schrag 2003, Bank *et al.* 2002, Arizona Game and Fish Department 2006).

### 1.2.2 Medium Terrestrial

Fences should be 1 to 1.8 m high depending on the species present, and chain link fencing is suggested (Arizona Game and Fish Department 2006). This mesh fence should be buried 20 to 40 cm below the soil surface to prevent animals from digging beneath the fence (Bank *et al.* 2002, Schrag 2003, Arizona Game and Fish Department 2006, Ruediger and DiGiorgio 2006) (see Figure A.6). If fencing is extensive, escape routes should be present in the event that the animal gets trapped on the highway. These may include one way gates, or debris piled by the fence for climbing (see Appendix A Section 1.2.5) (Schrag 2003, Bank *et al.* 2002, Arizona Game and Fish Department 2006).

### 1.2.3 Small Terrestrial

To prevent small organisms from entering the roadway, a fine mesh wire, either 2 cm by 2 cm or 4 cm by 4 cm, is often placed at the bottom of the fence, about a third of the way up (Bank *et al.* 2002). This mesh fence should be buried 20 to 40 cm below the soil surface to prevent animals from

**Figure A.5:** Fencing for large terrestrial wildlife. Note how the fence posts are on the right-of-way side to prevent wildlife from pushing the fence off the post. (Photo credit: Meghan Chisholm, Stantec. Used with permission.)

**Figure A.6:** Buried fence with smaller openings to limit roadway access by small and medium sized wildlife. This will also prevent digging wildlife from entering the right-of-way . (Photo credit: Meghan Chisholm, Stantec. Used with permission.)

Fencing must funnel wildlife towards an appropriate crossing point .

There should be no gaps between the fence and a crossing structure as animals will always choose the open sky route rather thann the dark underpass route

digging beneath the fence (Bank *et al.* 2002, Schrag 2003, Arizona Game and Fish Department 2006, Ruediger and DiGiorgio 2006) (see Figure A.6). Fencing should be 1 to 1.8 m tall, and there should be no gaps between the fence and the crossing structure (Arizona Game and Fish Department 2006). If fencing is extensive escape routes may be required to allow wildlife trapped on the right-of-way to re-enter adjacent habitat. Please refer to Appendix A, Section 1.2.5 for additional information on escape routes.

**Figure A.8:** One of the Waterton Lakes National Park Salamander Crossings. Note how silt fencing is used to help direct the amphibians towards the structure. However, the fencing in this photograph is likely ineffective as there is a large gap between the fence and the structure. Salamanders will be able to access the road at this point. (Photo Credit: Gil Barber, Stantec. Used with Permission.)

**Figure A.7:** Silt fence used along the bottom of a deer fence near a wetland to prevent amphibians from accessing the right-of-way. (Photo credit: Meghan Chisholm, Stantec. Used with permission.)

### 1.2.4 Amphibian

Drift fences, such as silt fence, or small walls should be used to funnel amphibians towards their crossing structure (NCHRP 2008). Jackson (2003) recommends short wing walls angling out from the passage at a 45 degree angle, with vertical retaining walls angling out from these at a broad angle, for 30 to 60 m. Fences are most effective if they do not alter amphibian movement by more than 60 degrees (Huijser *et al.* 2008).

Walls should be composed of impenetrable materials such as concrete, metal, vinyl, or a very fine mesh (Arizona Game and Fish Department 2006). Silt fences have also been used successfully (see Figure A.7 and A.8). Mesh wire fences should be avoided as amphibians can climb the mesh (Huijser *et al.* 2008). A 15 cm lip should be included at the top of the fence to prevent animals from climbing over (FWHA 2003, BC Ministry of Water, Land, and Air Protection 2004).

The height of the fencing will depend on the types of amphibians using the crossing; a 0.3 m high wall is effective for salamanders (Merrow 2007, Jackson 1996), but walls of 0.6-0.9 cm are required for frogs (Woltz *et al.* 2008, Jackson 2003). Walls should ideally be flush with the ground surface on the side closest to the road (Jackson 2003).

Vegetation along the fencing should be removed, as some snakes and frogs may use the vegetation to climb over fencing (Arizona Game and Fish Department 2006).

### 1.2.5 Escape Routes

If fencing is extensive, escape routes may be required in the event that the animal

gets trapped on the highway. These may include one way gates, jump-outs (soil ramp), or double swing gates that will also allow human access to the highway (Schrag 2003, Bank *et al.* 2002, Putman 1997, Arizona Game and Fish Department 2006, Ruediger and DiGiorgio 2006).

Jump-outs consist of a vegetated soil ramp, located on the road right of way, with a 1.5 m high wall on the opposite side (Mastro *et al*. 2008) (See Figure A.9). Ungulates walk up the ramp and jump down 1.5 m and are no longer trapped on the road (Mastro *et al.* 2008). Ungulates use escape ramps more often than one way gates although these are not often used due to safety concerns relating to human activities such as mountain biking (Mastro *et al.* 2008, Sielecki 2005).

The wall should have a steep face and be reinforced with a rigid material such as concrete blocks. The landing spot should have loose soil or soft material to prevent injury and jump outs should be set back from the fence and surrounded by protective vegetation (Huijser *et al.* 2008). Vegetation cover will remove vehicles from site and give the animal time to calm down and decide if it wants to jump off or not (Huijser *et al.* 2008).

One-way gates should use a tyne with a disk or a ball greater than 4 cm in diameter on the end (for design details, see Sielecki 2005). This design does not impale or ensnare animals that try to move backwards through the gate (Sielecki 2005). The tynes should face away from the road and direct movement off the road (see Figure A.10).

Figure A.9: A Jump-Out designed for Large Terrestrials. Note that the wildlife exclusion fence joins closely with the structure and that the ramp is set back from the road and is vegetated. (Photo Credit: Trisha White, TransWild Alliance. Used with permission.)

**Figure A.10**: Escape routes. (Counterclockwise from top right) A spring loaded spring gate to allow human access to the highway; a one-way gate that has been fenced over so it cannot be used. The photo is taken from inside the fence. The direction of the tynes allows movement off the road ROW but not back onto the ROW. A close up of the tynes on the one way gate. This style of tyne should not be used as they are a ensnarement hazard. (Photo credit: Meghan Chisholm, Stantec. Used with permission.)

For Small and Medium Terrestrial species small hinged doors placed at ground level will let them escape the road right-of-way (Huijser *et al.* 2008). The hinges on these structures will eventually wear out and need replacement. There is also the risk that they may become permanently stuck open (Huijser *et al.* 2008). An alternative to gates is to pile stumps, tree branches or other natural materials on the right-of-way side of the fence so that small and medium sized animals may climb out of the right-of-way (Huijser *et al.* 2008).

## 1.3 ALTERED LIGHTING

One might think that heightened light levels along roadways would increase the ability of drivers to observe and avoid wildlife; however, trials have indicated that increasing the amount of light does not reduce wildlife-vehicle encounters (Bank *et al*. 2002, Mastro *et al*. 2008). Heightened light levels release an excess of artificial light into the natural environment, otherwise known as light pollution. Light pollution has numerous ecological effects.

Enhanced light levels may decrease habitat value and negatively impact nesting birds (Bank *et al.* 2002). Associated with light pollution is premature nesting and alteration of normal migratory routes as birds are attracted to bright lights (Longcore and Rich 2004). Attraction to light sources also impairs amphibian movement between breeding areas and alters predator-prey interaction, often making it easier for the predator (Longcore and Rich 2004). Small alterations to lighting design may greatly benefit wildlife.

#### 1.3.1 Reduce the Number or Intensity of Streetlights

A simple solution to reduce light pollution is to reduce the number of lights used in an area. This could mean omitting every second light or only lighting areas that require high driver visibility like intersections. Decorative lighting should be avoided and lights for advertising should focus downward (City of Toronto 2007).

Another easy solution is to install light bulbs with lower wattage. This will reduce the amount of light produced and the glare experienced by drivers. The City of Calgary recently began retrofitting existing lights with flat lens fixtures and decreased wattage by 100 w (City of Calgary 2008). In addition to reduced light pollution, the calculated savings from this project will be $1.7 Million per year in energy costs (City of Calgary 2008).

Reducing the number and intensity of streetlights not only benefits wildlife, it also makes sense economically.

#### 1.3.2 Omit Lighting in Ecologically Sensitive Areas

Ecologically sensitive areas such as wetlands, fish spawning areas, bird migration routes or locations of frequent bat activity may be especially sensitive to light pollution. If the project area includes sensitive habitat or species with status that are affected by light pollution, it is advisable to reduce the number and intensity of streetlights at a minimum. If possible, it is recommended that lighting be omitted.

#### 1.3.3 Use Highly Reflective Materials

Another alternative to help minimize lighting requirements is to install highly reflective material on signs, road striping and other important features (retro-reflectivity)(Jacobson 2005). This will reduce or eliminate the need for illumination from overhead lighting. This principle has been used with success on the Ravenel Bridge in South Carolina in an attempt to limit the impacts of bridge lighting on migratory birds (FHWA 2003).

Reflective materials deteriorate with the elements and will need periodic replacement to remain effective.

#### 1.3.4 Choose Lights That Minimize Spill and Glare

Many traditional lights are not efficient. A large portion of the light produced is wasted because it is directed upward or is spilled out beyond the areas that require the light. Lights for decoration and/or advertising should be directed downward rather than upward (City of Toronto 2007). Flat lens fixtures should be selected as they have less glare than traditional lights and will help to reduce light pollution (City of Toronto 2007, Jacobson 2005). Figure A.11 depicts several preferred and discouraged lighting options.

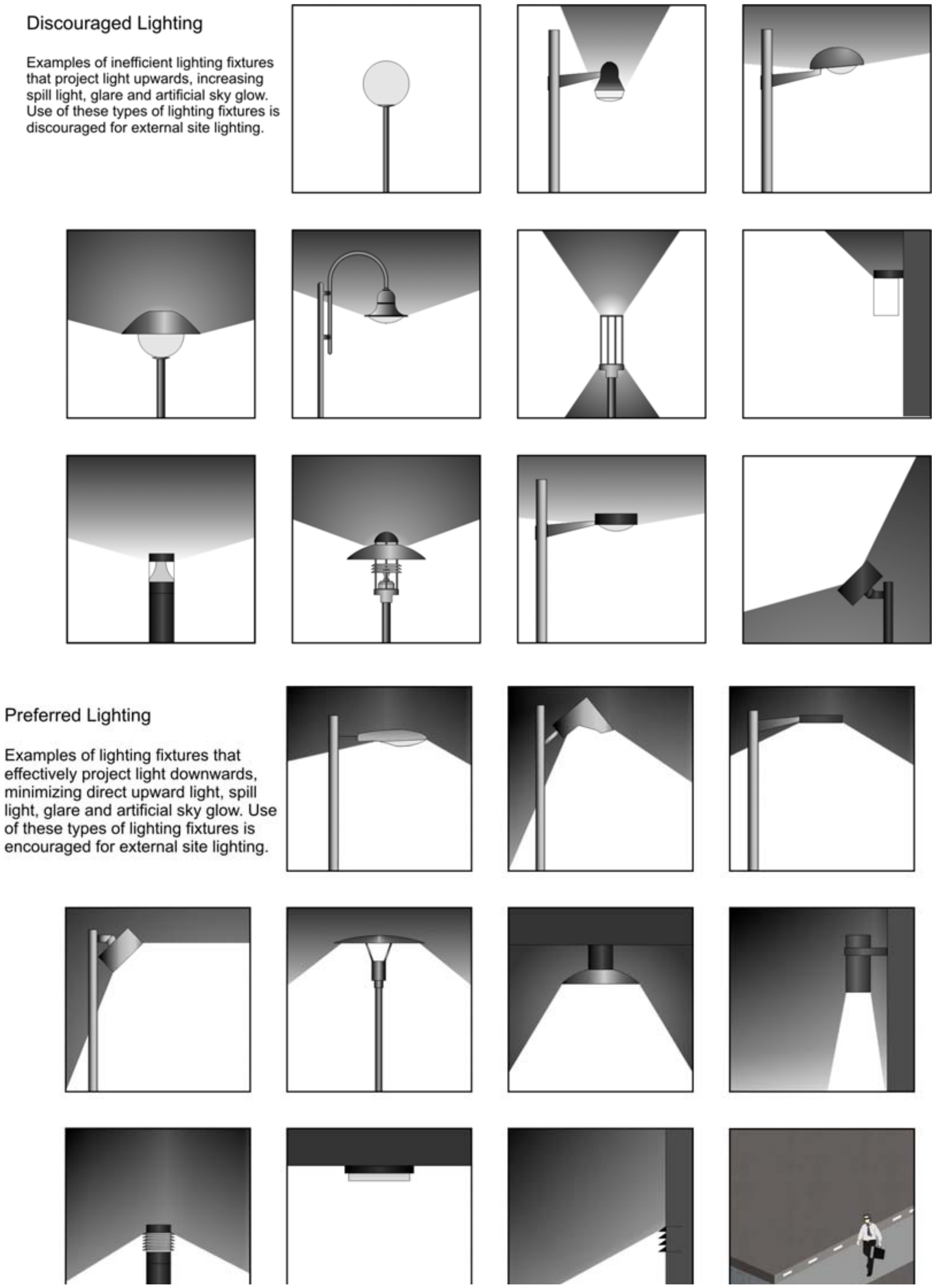



**Figure A.11**: Prefered and discouraged lighting styles. The preferred lighting directs light downward and reduces the spill light. This is more efficient and will reduce the amount of light pollution, thus benefiting birds, amphibians and other wildlife. Adapted from the City of Toronto 2007 (Illustration credit: Lara Grebaz, Stantec)

### 1.3.5 Reduce Light Pollution during Migratory Season

Migratory season generally occurs during the spring (April/May) and fall (August/September). Not all birds migrate for the duration of this time period. Migratory dates are species specific and further information may be required to determine the exact migration window for the species of interest. Decorative bridge lighting is also turned off during migratory season (FHWA 2003). Reducing the amount of light pollution will assist nocturnal species and birds relying on starlight for navigation and will not disadvantage prey species.

### 1.3.6 Install Streetlights at Greater Heights

Flying insects often congregate around streetlights at night. This represents a steady food source for many bats and some bird species. As the bats hunt for insects they often fly near vehicle height and are at greater risk for a collision (FHWA 2003). Increasing the height of streetlights in areas with high bat activity will make the bats fly higher to forage therefore decreasing the possibility of a collision (FWHA 2003).This has been used with success in Indiana where workers installed “high mast” lighting along the I-64 (FWHA 2003).

## 1.4 ALTERED SIGHT LINES

Human activity in or near wildlife corridors has a negative impact on wildlife in the area. Wildlife avoid areas with high human use which can further reduce available habitat (Jackson and Griffin 2000, Clevenger and Waltho 1999, Jalkotzy et al 1997, Phillips *et al.* 2001). The sight of vehicles and bicyclists was shown to deter use of an undercrossing by large ungulates (Phillips *et al.* 2001). Incorporating a temporary screen blocking humans from sight increased ungulate use of the crossing structure by sixty-five percent (Phillips *et al.* 2001).

There are several options that may be used to limit visibility of human activity. Most of these options do not have set design standards. The size, types of material, and placement will be site specific and depend on the species present and the physical characteristics of the project area. Flexibility and creativity is warranted when incorporating these principles.

### 1.4.1 Natural Barriers

Visual barriers made of natural materials will maintain the natural look of the area and further encourage wildlife use. Options under this category may include vegetation, soil or boulders. These structures should be large enough to block sight of humans for the targeted Ecological Design Group (EDG) and reduce noise levels (see Figure A.12).

An example of use might be if there is a large culvert running beneath a bicycle trail, planting some dense shrubs or trees along the side of the trail will reduce the visibility of the bicycle activity.

### 1.4.2 Noise Barriers or Opaque Fences

Noise barriers and opaque fences are similar to natural barriers (Appendix A, Section 1.4.1). Their purpose is to block sight of human behaviour. Noise barriers are also often used near busy roads to reduce noise pollution in residential neighbourhoods. This principle may be applied to areas with wildlife to reduce the disturbance from both human noise and sight. Noise barriers may be installed in ecologically sensitive areas. Additional information on noise barrier design is available in Appendix A, Section 1.12.

**Figure A. 12:** Soil Berm. This barrier surrounds a box culvert in Banff, Alberta. This will serve to both reduce traffic noise and remove the vehicles from sight for wildlife using the crossing. (Photo credit: Meghan Chisholm, Stantec. Used with permission.)

Opaque fences may be constructed of wood, metal, or chain link with plastic woven into the links. The height will depend on the EDGs in the project area. Fences are generally not designed to reduce noise but will effectively block wildlife vision. Fences will be beneficial in areas with lower noise levels like a multi-use trail or local road. Incorporating a gap between the bottom of the fence and the soil will also allow for passage of small organisms beneath the fence.

It is important to note that noise barriers and fences are physical barriers and may further fragment habitat. Additional mitigation, such as a crossing structure, should be used in conjunction to ensure adequate connections.

### 1.4.3 Undulatory Path Structure

An undulatory path structure will incorporate a wavelike, rolling motion. The purpose of this is to create areas where wildlife can freely cross and forage alongside the path without seeing the humans that are also using the path. This option is best suited for trails as incorporating a hilly design onto a roadway may be a threat to human safety as it reduces visibility.

### 1.4.4 Jogs in Path Structure

The principles behind a zigzagging path structure are the same as an undulatory path structure. The difference is that the plane of motion is horizontal rather than vertical. This design works best if there is vegetation along the sides of the path as this will help limit sight lines and create “blind spots” where wildlife can exist without always being disturbed by the sight of humans.

Again, like undulatory paths, jogs in paths are best suited for trails as they will reduce visibility on roadways and may be a threat to human safety.

## 1.5 PUBLIC EDUCATION

Public awareness is an important component of any project. The amount of "buy-in" may dictate whether a project goes through and how effective the mitigation will be. Campaigns should provide specific information as this is more effective than providing general information (Mastro *et al.* 2008). Education can take many forms including information sessions, brochures, signs, and web or print articles. There are no set standards on what should be included in this information. The information required by the public will be site specific. Useful topics are discussed below in detail.

### 1.5.1 How to React to Wildlife on Roads

Many drivers, especially those from urban centers, rarely encounter wildlife in their daily driving. Drivers often experience difficulty in reacting to wildlife on or near roads because they are unsure of how to behave. As a result, they often respond erratically and endanger both the wildlife and themselves.

An example of a campaign is the one in Glacier and Mount Revelstoke National Parks. Motorists are given brochures informing them that birds often ingest highway salt which makes them lethargic and unable to respond to approaching vehicles in a timely fashion (Jacobson 2005). The brochure requests motorists to honk their horns at congregated birds to give them ample time to get away (Jacobson 2005). Education and awareness campaigns, such as this, that inform drivers on avoiding and responding to wildlife on the road may help to reduce the probability of a fatal collision (Huijser et al. 2007).

### 1.5.2 Seasonality of Wildlife Encounters

Wildlife activity around roads is seasonal. Many smaller organisms such as amphibians undergo seasonal migration from their hibernation sites to their breeding grounds while larger organisms such as deer are more prone to collisions during their breeding season in the fall. Public awareness campaigns informing people when to expect migration or breeding may make them more aware of the potential for wildlife interaction. For example, the Alberta Motor Association (AMA) annually posts articles informing drivers about what to expect during the fall rut in the National Parks and warns drivers to be cautious.

### 1.5.3 Purpose of Crossing Structures

Wildlife are most likely to use structures with limited human activity (Clevenger and Waltho 1999, 2000). Unfortunately, many people do not understand why crossings have been installed and may use them for recreational activities such as riding quads or walking. Informing the public about wildlife crossing structures and why they were installed may increase effectiveness as recreational use will likely be limited. This may also instil some public pride and individuals may seek to protect structures located within their neighbourhood from inappropriate use. See Figure A.13 for an example of the type of sign that could be placed near a wildlife crossing.

## 1.6 TRAFFIC CALMED AREAS

Incorporating design elements that force reduced speeds and/or limit access to certain areas will improve connectivity while at the same time reducing traffic noise (Van Langevelde *et al.* 2007). By reducing traffic volume and speed, driver


**Figure A.13**: Public Education Sign. This sign informs people about wildlife corridors to prevent access to the area. (Photo credit: Meghan Chisholm, Stantec. Used with permission.)

stopping distance is increased and the risk of collision events decreases (Huijser et al. 2007). Traffic calming measures will also decrease the noise levels in an area. The reduction of volume, speed, and noise will increase the use of habitat adjacent to the road and increase the amount of wildlife successfully crossing the road. Additional information about the effects of reducing traffic speed can be found in Appendix A, Section 1.7.

Traditional calming measures used in residential neighbourhoods include speed bumps, sidewalk extensions, raised medians, rumble strips, and traffic circles (Huijser et al. 2007). It is important to note that these structures should not be used on high speed roadways as they are potentially dangerous (Huijser et al. 2007).

Traffic calming measures may be used in conjunction with other mitigation to increase effectiveness. For example, a vegetated raised median will slow down traffic and will also decrease the gap width of the road making it more permeable for birds and bats. Constricting the road over areas with wildlife underpasses will reduce noise levels (because of the slower speed) and may also decrease the length of the structure.

### 1.6.1 Speed Humps

Speed humps are rounded raised areas placed on the road surface. They are usually three to five meters long, seven to ten centimetres high and cover the entire width of the road making them different from the shorter speed bumps observed in parking lots (Fehr & Peers Transportation Consultants 2008). Speed humps decrease traffic speed and the number of accidents by an average of 22% and 26% respectively (Fehr & Peers Transportation Consultants 2008). This is the largest decrease in speed among all the types of traffic calming measures.

In addition to effectively reducing speed, speed humps are relatively inexpensive measures with price tags around $2,000 to $3,000 USD (Fehr & Peers Transportation Consultants 2008).

### 1.6.2 Sidewalk Extensions (Bump-Outs)

Sidewalk extensions narrow the width of the street. These may occur across two lanes, where the side walk simultaneously extends narrowing both lanes of traffic, or they may completely block one lane and only allow for travel in one direction (See Figure A.14)(Fehr & Peers Transportation Consultants 2008). Sidewalk extensions are effective in areas with speed problems (Fehr & Peers Transportation Consultants 2008).

Sidewalk extensions reduce speed by an average of 7% and cost between $7,000 and $10,000 USD (Fehr & Peers Transportation Consultants 2008). In addition to reducing speed, if sidewalk extensions are vegetated with trees, this will reduce the gap created by the road and may assist wildlife, such as birds, with road crossings.

### 1.6.3 Raised Medians

A raised median consists of an island along the center of the street (see Figure A.15). This feature narrows the travel lanes and forces drivers to slow down (Fehr & Peers Transportation Consultants 2008). Often these structures are used near pedestrian crosswalks or at the entrances to neighbourhoods (Fehr & Peers Transportation Consultants 2008). Speed reduction from raised medians is limited with an average decrease in speed of 7% although they are effective at reducing traffic volume (Fehr & Peers Transportation Consultants 2008). These structures cost between $8,000 and $15,000 USD.

If medians are vegetated with trees and shrubs, this will reduce the habitat gap created by the road and will assist wildlife, such as birds, with crossings the road. See Appendix A, Section 1.9.4 for additional information.

### 1.6.4 Traffic Circles

Traffic circles are placed at intersections and divert traffic in a circular motion, rather than straight though. Smaller traffic circles should be used in areas with small vehicle use where speed and volume reduction is the primary concern. Traffic circles should not be used in areas with high truck use because trucks generally have a difficult time turning around traffic circles (Fehr & Peers Transportation Consultants 2008). Traffic circles decrease speed by an average

**Figure A.14**: Sidewalk extension. These will reduce the perceived with of the road and slow down traffic. In addition to a speed reduction, if extensions are vegetated this may make it easier for wildlife to cross the gap created by the road. (Photo credit: SMKC, Stantec. Used with permission.)

of 11% and costs vary with materials and size (Fehr & Peers Transportation Consultants 2008). The central portion of traffic circles can be landscaped. This may create additional habitat for disturbance adapted birds, insects, and small mammals.

Compared to speeds of 50 km/hr, deer-vehicle collisions are 17 times more likely at speeds above 80 km/hr (Ng *et al.* 2008).

### 1.6.5 Rumble Strips

Rumble strips texture pavement creating an uneven surface for travel. They are effective in areas with high pedestrian use where noise is not a concern (Fehr & Peers

**Figure A.15**: Raised Median. These can help minimize the barrier created by roads for wildlife and pedestrians (Photo credit: SMKC, Stantec. Used with permission.)

Transportation Consultants 2008). Rumble strips may also be used to make drivers aware of upcoming road features like stop signs or crosswalks.

### 1.7 REDUCED SPEED LIMITS

Vehicle speed appears to have a greater impact on wildlife than traffic volume (Massachusetts Highway Department 2006). Reducing the speed limit on a roadway can enhance permeability and reduce vehicle associated wildlife mortality. For example, mortality of rabbits and songbirds increased at speeds greater than 65 kilometres per hour (Massachusetts Highway Department 2006). A similar result was noted in the Yellowstone National Park, where 85% of all wildlife deaths occurred in areas with speeds above 72 km/hr, and the number of deaths experienced a significant increase in areas with speed limits of 88 km/h (Schrag 2003). A 5 km/hr reduction in speed, from 80 km/hr to 75 km/hr, reduced casualties by 32% (Huijser et al. 2007).

Most literature examines the relationships between speed limits and large terrestrial mammals. However, reducing speed limits may also assist avian mobility. Collisions were rare for birds where speed limits were below 40 km/hr, but started where speed limits were 56 km/hr (Erritzoe et al 2003). High speeds also increase air turbulence which may throw small birds. A reduction in vehicle speed also reduces noise associated with traffic, which can be a disturbance to wildlife (Van Langevelde et al. 2007). This may be particularly effective near wetlands hosting breeding birds.

Within the City of Edmonton, it was found that deer-vehicle collisions were 17 times more frequent where speed limits were above 80 km/hr, and seven times more frequent where speed limits were between 60-70 km/hr, when compared to areas where speed limits were below 50 km/hr (Ng *et al* 2008). It was also noted that such collisions were highest in November, leading to a suggestion that seasonally reduced traffic speeds would be beneficial within the City.

Areas where collisions most commonly occur and thus should be considered for reduced speeds include areas near water, areas near elevated roadways (Hubbard *et al.* 2000), areas where forest cover is closer to the road (Finder *et al.* 1999), areas of lower road density, at interchanges and areas with high amounts of non-forest green space (Ng *et al.* 2008).

Reducing speed limits is a low cost alternative that appears to increase driver reaction time and reduce the number of wildlife-vehicle collisions. An additional benefit to this mitigation is that wildlife movement is not restricted. Please note that this alternative may not be a reasonable solution on high volume, high speed roads.

#### 1.7.1 Photo Radar

Drivers instinctively slow down when they see photo radar to avoid the dreaded speeding ticket. This principle may be applied to areas with high wildlife use in an attempt to reduce vehicle speed and therefore increase the roadway permeability (Ng *et al.* 2008). Photo radar may be useful seasonally during ecologically sensitive periods such as ungulate breeding in the fall when they are not as cautious around roads. This may not be something that a roadway designer can implement. Instead, this may be a suggestion made to the municipality that will be maintaining the road.

### 1.7.2 Traffic Calming

Traffic calming measures to reduce speed are often visual barriers that make drivers unsure and as a result they slow down. These methods may include painted lines on the road that make the road appear narrower, areas where the curb bulges outward and physically narrows the road, or traffic circles. Further information about implementing traffic calming measures is available in Appendix A, Section 1.6.

### 1.7.3 Vegetation Near The Road

Planting vegetation near the road creates the sense that the road is narrow. Drivers tend to drive faster when the roadsides are clear and visibility is wide and slower when visibility is narrowed (Forman and McDonald 2007). Slower speeds also increase reaction time and drivers will be able to react much more quickly to wildlife on the road. In addition to reducing driver speed, vegetation on roadsides will also create additional habitat for small organisms like insects and mice, and will filter pollutants washed off the road surface (Forman and McDonald 2007).

### 1.7.4 Seasonal or Temporary Speed Limits

As previously discussed, wildlife behaviour on roads varies seasonally. Many migrations occur during the spring, ungulate breeding often occurs during the fall, and several species of birds and mammals are attracted to the salt used on roads during the winter. Seasonal behaviour may increase the amount of wildlife on or near the roads or decrease wildlife reaction time. For example, winter finches are attracted to highway salt but become lethargic after ingesting it and have difficulty fleeing approaching vehicles and deer are preoccupied and less cautious during fall mating season (Jacobson 2005). Wildlife-vehicle collisions may increase during these periods. Reducing the speed limit will help increase driver reaction time and reduce the chance of a wildlife-vehicle collision.

Speed limits may be posted seasonally using mobile signs that are brought out during the season of concern or by covering up a portion of an existing roadside when not required.

Designing a road with reduced speed limits in ecologically sensitive areas is recommended to both enhance wildlife use and driver safety.

### 1.7.5 Change Posted Speed Limit

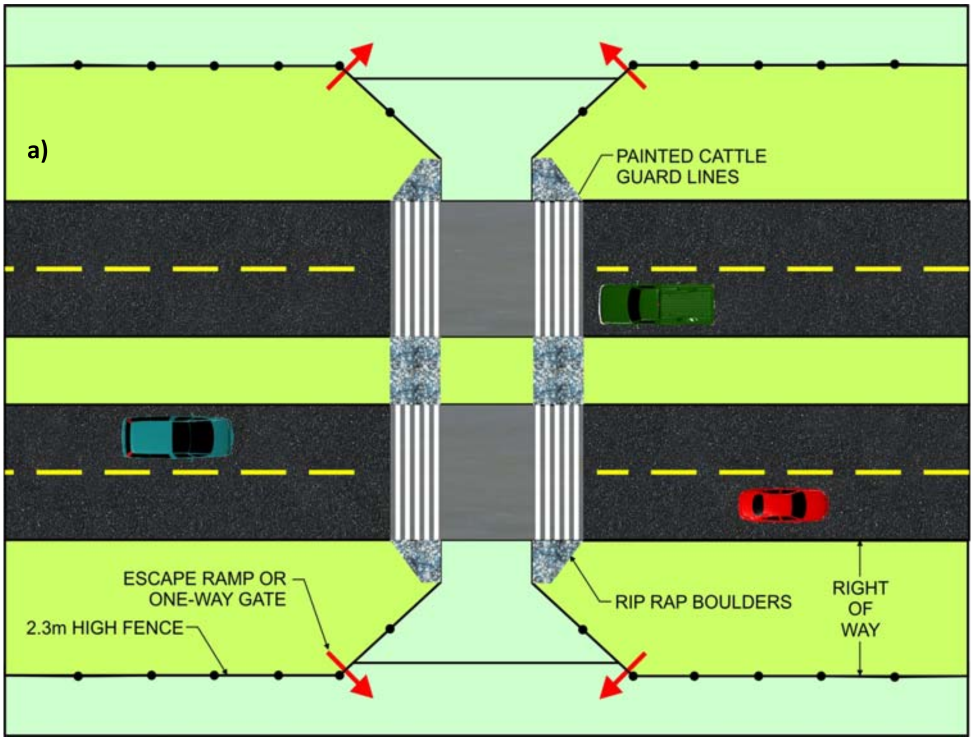
Changing the posted speed limit for existing roads may be a difficult undertaking. However, if the road is located in a sensitive ecological area or if there is a lot of wildlife mortality this may be a worthwhile venture. If the road is still in the design stage it may be easier to change the expected speed limit. In this case, the design will have to be re-considered to accommodate the reduction in speed. Speed reductions do not have to be drastic to be effective. Reducing the speed from 80 km/hr to 75 km/hr was shown to reduce casualties by 32% (Huijser et al. 2007). It can be inferred that a greater reduction in speed would likely lead to a greater reduction in the number of wildlife casualties. Reducing the speed limit in ecologically sensitive areas (wetlands, large tree stands) is recommended as it will enhance roadway permeability, reduce noise levels, and increase the safety of both drivers and wildlife.

Canada Geese and goslings crossing Jasper Avenue in a pedestrian crosswalk guided by Stantec personnel (Photo credit Heena Chavda, Stantec. Used with permission.)

## 1.8 WILDLIFE "CROSSWALKS"

### 1.8.1 Basic Design

Wildlife "crosswalks" aim to direct animals to an appropriate crossing point where motorists can anticipate their presence. This system relies on fencing that is at least 2.3 m high around the right-of-way to exclude wildlife (Lehnert and Bissonette 1997). At the selected crossing points the fence height is reduced to 1.0 m, a height that large ungulates can jump over but will exclude smaller wildlife (Lehnert and Bissonette 1997). Fencing 2.3 m high is used to funnel the wildlife within 9.1 m of the roadway where cobble stones (20 to 30 cm diameter) are placed on either side of the path (Lehnert and Bissonette 1997). Because ungulates prefer not to walk over rip rap and boulders, the ungulates will remain on the path and not wander onto the right-of-of way (Ruediger 2001, Mastro *et al.* 2008, Lehnert and Bissonette 1997). The road surface is painted with cattle guard lines to serve as visual crosswalk boundaries for oncoming motorists and to help guide wildlife to the opposite side of the road (Lehnert and Bissonette 1997). The same set up of cobblestones and fencing is present on the opposite side of the road to direct deer to the adjacent habitat (Lehnert and Bissonette 1997). Vegetation is not present along the cobblestone path to discourage foraging and congregation near the roadway, and one-way gates or earthen escape ramps are incorporated near the crosswalks to provide an escape route for any deer trapped on the right-of-way (Lehnert and Bissonette 1997). In addition, warning signs are used to alert motorists of the crosswalk (Lehnert and Bissonette 1997). See Figure A.16 for an illustration of a wildlife crosswalk.



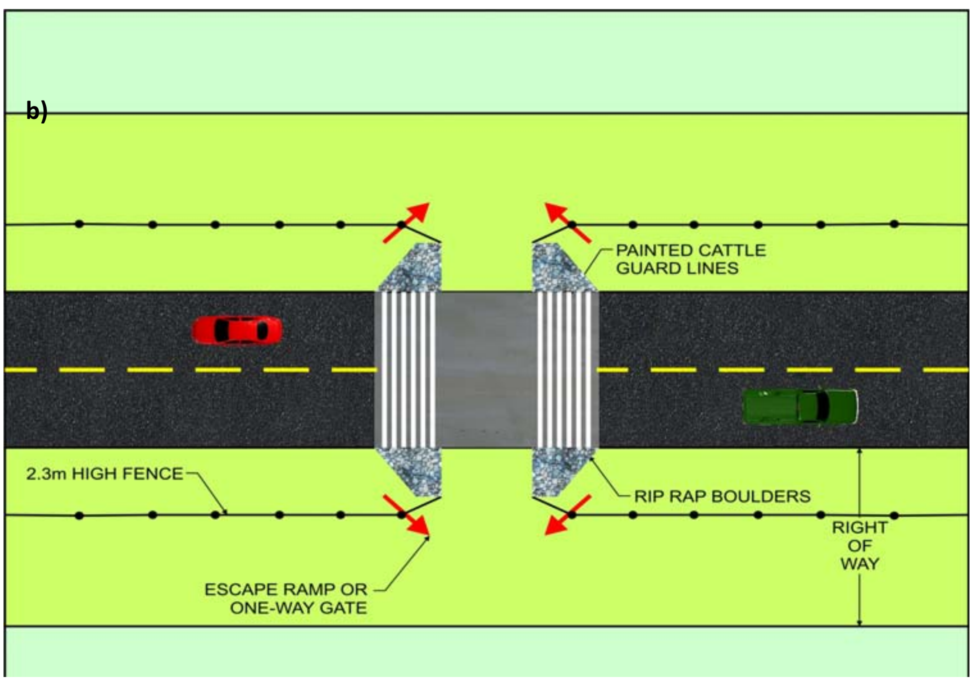




**Figure A.16**: a) Wildlife crosswalk design for a four lane road. The fence is placed at the outer edge of the right-of-way. b) The alternative wildlife crosswalk design that places the fence in the center of the right-of-way. Adapted from Lehnert and Bissonette 1997. (Illustration credit, Nathan MacDonald, Stantec.)

An alternative design suggested by Lehnert and Bissonette (1997) is to place right-of-way fencing parallel to the cobblestones, so the fence is closer to the road (see Figure A.16 b). They suggest that this may reduce the number of ungulates walking across the road surface (around the cobblestones) to forage on the right-of-way. Substituting the remaining vegetation on the highway side of the fence with non-palatable species may also encourage deer to remain off the road.

### 1.8.2 Effectiveness and Use

Although these structures are not widespread, and have not undergone a large number of scientific trials, they do show promise in providing a safe crossing point for larger terrestrial wildlife. Implementation of wildlife crosswalks reduced ungulate-vehicle collisions and deer use of the road right-of-way in one trial (Lehnert and Bissonette 1997). When deciding if crosswalks are appropriate mitigation, the type of road, amount of traffic, and seasonal use of the crosswalk must be considered. These structures are not as effective on busy roads but show promise on low volume roads, especially when combined with wildlife activated signs, which better alert motorists of wildlife presence (Mastro *et al.* 2008). In addition, cobblestones are not effective deterrents when covered by deep snow (Lehnert and Bissonette 1997).

Cost for installation was estimated at $28,000 per structure for a four lane road, and $15,000 per structure for a two lane road (Lehnert and Bissonette 1997).

## 1.9 DIVERSIONARY METHODS

Diversionary methods all attempt to alter the behaviour of wildlife in order to reduce the chance of collisions and increase the permeability of the roadway. Several of these options will have multiple effects. For example, soil berms will not only direct the flight path of aerial species above vehicle traffic, they may also reduce noise levels in adjacent habitat and will block sight of the road. The type of diversionary method chosen will be site specific and depend on road design and species present.

### 1.9.1 Diversion Poles

Bridges over water bodies can behave as both a barrier and a threat to avian populations. Birds are twice as likely to fly over bridges than under even if the route under the bridge is more direct (Tremblay and St. Clair 2009). When birds fly over bridges they often only fly as high as the guardrails putting them at perfect height to be struck by vehicles (FHWA 2003) When wind direction is perpendicular to the bridge, downdrafts often form forcing birds downward and increasing the risk of collision (Jacobson 2005). Water birds (i.e. ducks) and birds using bridges as habitat (i.e. swallows) are at a greater risk near bridges because they routinely use the surrounding area.

Two designs have been used with success. The Florida Department of Transportation (DOT) installed aluminium poles along the edge of a bridge as shown in Figure A.17. The poles are 3 m tall and 5.1 cm in diameter and attached vertically to the bridge (Shwiff *et al.* 2003). To prevent birds from flying between, the poles are fastened to the bridge and spaced 3.7 m apart (Jacobson 2005, Shwiff *et al.* 2003). The cost of installation for the 122 poles was $5,900 USD (Shwiff *et al.* 2003, Bard *et al.* 2002). A similar method was employed by the Texas Department of Transportation although they installed a 1.8 m tall chain link fence along both sides of the bridge. Both methods create a perceived barrier that forces the birds to fly higher and successfully cross the road (Jacobson 2005, FHWA 2003). Diversion poles are successful and cost effective ways to reduce the number of birds killed by vehicles and

**Figure A.17**: Diversion poles used on the Sebastian Inlet State Park in Florida. Photo Credit: Alice M. Bard, Florida Park Service. Used with permission.

therefore increase their ability to move across the road. For a cost of less than $50 per pole, the Florida DOT reduced seabird deaths by 74% (personal communication, Alice Bard, Florida Department of Environmental Protection).

The height of the diversionary methods may differ depending on the types of vehicles using the facility. For example, bridges with primarily large semi-trailers may require taller diversions than areas with predominantly residential car use. If additional information is required regarding diversion pole specifications Alice Bard with the Florida Department of Transportation may be a useful resource. Her contact information is as follows: (P): 1-407-884-2000; (E): Alice.Bard@dep.state.fl.us.

### 1.9.2 Diversion Fence

Roads offer a variety of food sources including garbage, roadkill and insects, which attract a variety of wildlife. Many birds of prey, such as owls, forage along roadsides due to the good visibility and abundance of prey (Erritzoe *et al.* 2003, Jacobson 2005). Because their foraging height is close to vehicle height, they are often the victims of traffic induced mortality (Jacobson 2005). Placing a low fence or closely spaced diversion poles with reflective markers along roadway verges or medians will force the birds to fly higher and therefore remove them from vehicle striking height.

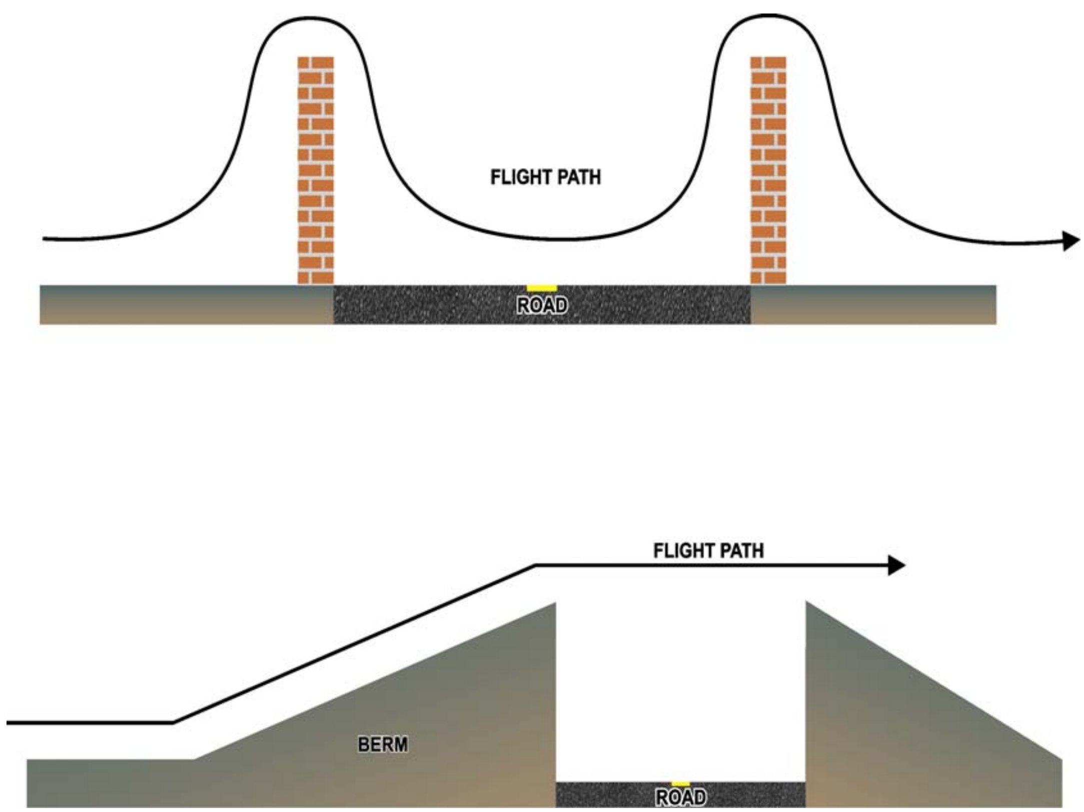



**Figure A.18**. Flight path of birds and bats over fences and berms. Adapted from Wray *et al.* 2005. (Illustration Credit Sarah King, Stantec).

### 1.9.3 Berms

Incorporating berms in areas with high aerial wildlife activity can help increase the permeability of roadways for bats and birds. Berms are generally composed of built up soil and are often seen near residential areas to reduce roadway noise. Like the previous diversionary methods, berms direct flight paths upward and away from vehicles therefore reducing the probability of collisions. Berms are more effective than using fencing to keep bats off the road. As shown in Figure A.18, any bats will fly over the fence, twist and return to their original altitude, then regain altitude to fly over the fence on the opposite side of the road (Wray *et al.* 2005). This does not reduce the risk of vehicle collisions. The gentle slope of berms will slowly force the bat to rise in altitude and appears to extend this higher flight path across the road (Wray *et al.* 2005). This principle can likely be applied to birds.

The height of the berm will differ depending on the types of vehicles using the road. Berms should be taller than the height of the largest vehicles using the road. Heights of 3 m or more are recommended as they reduce the probability of collision by 75% when compared to sections without embankments (Pons 2000).

Berms may also benefit other wildlife in the surrounding area by reducing noise and removing the road from sight. Berms will also not behave as an impenetrable barrier, like fences or other types of noise barriers, and wildlife will be able to move to the opposite side of the road assuming that traffic volume is not a barrier.

### 1.9.4 Vegetation

Vegetation may be used as a natural way to direct the flight of birds and bats upward and above traffic and limit the barrier effect of roadways. Trees and shrubs planted close to the roadside and in the median (if present) will have a similar effect to berms (see Appendix A, Section 1.9.3) in that trees will help to extend the higher flight path of the bird or bat so that it may successfully cross the road (Tremblay 2006) (see Figure A.19). Bird movement is greatest when the habitat gaps are below 45 m (Tremblay and St. Clair 2009). Planting vegetation along the road and median will help to reduce the size of the habitat gap created by the road and may act as stepping stones (Tremblay and St. Clair 2009). These plantings must be dense and taller than the highest vehicles using the road.

Terrestrial wildlife will likely also use these locations for crossing as there will be additional overhead cover. A high density of

In urban areas, roadsides may represent some of the little remaining habitat for small and medium sized animals.

The habitat value of a roadside should be considered when designing and maintaining roadways.

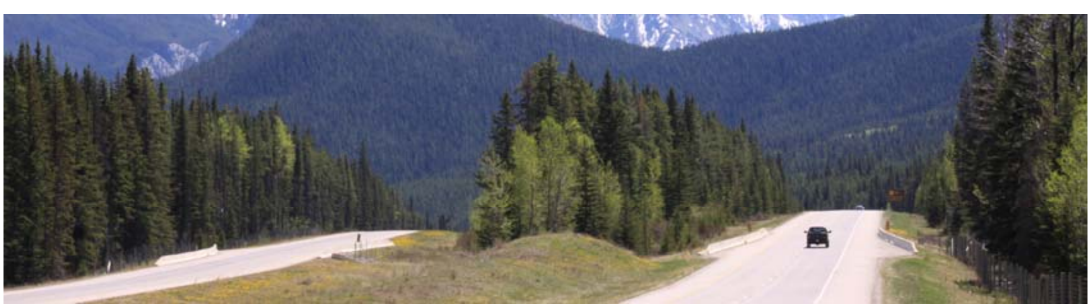


**Figure A.19**: Vegetation planted in median of the highway will increase permeability for birds and other wildlife by acting as a stepping stone. (Photo credit: Meghan Chisholm, Stantec. Used with permission.)

tree plantings in the median may not be required as birds were observed using even single trees to travel across roads (Tremblay and St. Clair 2009). Planting trees close to the edge of the roadside and in the median is not practical or safe in all situations. This approach should only be used in areas where bird crossing is desired. For example planting tall trees along the road between a tree stand and a heavy industrial area may not be preferred as there is limited functional habitat for them in the industrial area.

As discussed in Appendix A, Section 1.9.1, birds prefer to fly over bridges rather than under them. It is recommended that trees also be planted on either side of the bridge whenever possible to facilitate bird movement through the riparian corridor (Tremblay and St. Clair 2009).

Native plant species should be selected for use as a high proportion of exotic and invasive plants will reduce species richness, create barriers and therefore enhance habitat fragmentation for some of the smaller wildlife such as reptiles (Jellinek *et al.* 2004).

### 1.10 REDUCE AND/OR REMOVE ROADKILL

Roadkill represents a food source for many opportunistic scavengers. Carcasses on road surfaces attract scavengers, including mammals and birds, and places them at risk from vehicular collisions. Bird counts along the Trans Canada Highway indicated that non-scavenging birds were the most abundant; however, scavenging birds dominated the roadkill counts (Longmore *et al.* 2009). Scavenging birds are a high risk group and experience increased vehicle mortality, especially on roads with fast traffic (Longmore *et al.* 2009). It is suggested that this occurs because vehicles travel faster than traditional land predators. The birds cannot conceptualize the amount of time required to escape and they end up being vehicle casualties (Longmore *et al.* 2009

To reduce secondary road kill events as a result of roadside scavenging, roadkill removal and appropriate disposal should be part of the maintenance plan for the road (Huijser et al. 2007). An interesting alternative for disposal of roadkilled wildlife is to compost the remains rather than bury them in a landfill or other disposal site (FHWA 2003). The New York State Department of Transportation has a successful program in place that effectively disposes the remains in a fast, inexpensive and odour free way. The end products may also be used to help enhance the soils surrounding the road.

If the amount of roadkill increases, then other mitigation should be considered to reduce roadkill. This may be accomplished by decreasing speed (see Appendix A, Section 1.6 and Section 1.7) or installing crossing structures and/or fences (refer to Appendix A, Section 1.2, and Section 1.15.)

### 1.11 VEGETATION MANAGEMENT

Roadsides contain a wide diversity of plant and animal species. In highly developed areas where much of the native vegetation has been destroyed, roadsides can represent some of the little remaining habitat left (Huijser and Clevenger 2006). Shrubs and trees are valuable nesting sites for many birds and also represent a source of food and shelter for terrestrial mammals.

Managing roadside vegetation appropriately aims to both improve the resources available for many small

terrestrial species and limit the use of roadsides by larger terrestrial species.

### 1.11.1 No-Mow Zones

Clearing roadside vegetation may have a significant impact on wildlife collisions and passage use. The effect of clearing vegetation on driver safety is mixed. Some research suggests that a 20 m cleared strip of vegetation on either side of the road reduces wildlife-vehicle collisions while other research indicates that wildlife collisions were most likely to occur when open habitat was present along the roadside (Mastro *et al.* 2008, Gunson *et al.* 2006). Cleared vegetation is supposed to increase driver visibility; however, as most wildlife-vehicle collisions occur at night, this effort may be futile.

Highly managed roadsides often contain only a few species of grass that out compete native vegetation (Huijser and Clevenger 2006). Mowing in combination with hay removal also removes nutrients from the soil making it difficult for most plants to grow (Huijser and Clevenger 2006). Decreasing the frequency of mowing will increase the plant diversity and therefore the number of resources available for insects and small and medium sized wildlife. An added benefit to this option is the reduction in maintenance costs. Significant savings are available if roadsides that are not manicured are accepted.

Common wildlife-friendly mowing practices include:

- Dividing the right-of-way into zones with different maintenance levels;
- Implementing rotational mowing schedules; and
- Refraining from mowing until an appropriate time of year.

For example, the Arkansas Highway and Transportation Department's mowing schedule includes several zones: a high maintenance zone near the road and transition zones towards the edge of the right-of-way (FHWA 2003). The 7 to 23 meter wide strips that are infrequently mowed create habitat for ground dwelling and nesting birds and small mammals (like mice) that use roadside verges as habitat (FHWA 2003).

Nebraska instituted a rotational mowing schedule where no more than one third of a district will be mowed in any one year (White 2007). Considering that 25% of pheasants in Nebraska were hatched in roadsides, this altered maintenance schedule will help to reduce the amount of chick mortality (White 2007).

Finally, the South Dakota Department of Transportation limits roadside mowing until the end of nesting season to prevent mortality, nest abandonment, and habitat destruction of birds using the right-of-way (FWHA 2003).

Proper management of roadside vegetation can be an easy, cost effective solution that will prevent interactions between foraging wildlife and vehicles while creating habitat for small mammals, insects, and birds.

### 1.11.2 Decrease Forage Value

Frequent roadside maintenance practices preserve vegetation in an early successional state (Rea 2003). This increases the palatability of roadside vegetation which in turn increases the amount of wildlife foraging along right-of-ways and the number of collisions with large mammals (Rea 2003, Mastro *et al.* 2008). Because

large ungulates browse based on quality, they represent a special concern (Rea 2003). Their large size and preference for palatable vegetation increases the probability for dangerous collisions. By decreasing the roadside forage value, wildlife will be encouraged to use other parts of their habitat to find high quality food sources, thus decreasing the risk of wildlife-vehicle encounters

A decrease in roadside forage value may be accomplished by decreasing mowing frequency or planting less palatable species (see Appendix A, Section 1.9.3). Cutting vegetation early in the growing season, rather than the middle, reduces the nutritional quality of the plant (Rea 2003). Care must be taken if vegetation is to be cut early in the season as some birds may be nesting.

Forage value may also be decreased by reducing the frequency of mowing as older vegetation is less palatable (Ng *et al* 2008). Please refer to Appendix A, Section 1.9.1 for additional information on mowing regimes.

#### 1.11.3 Reduce Palatability

Planting non-palatable vegetation will also discourage use of the right-of-way. Planting non-palatable species decreases the roadside forage value resulting in a reduction in wildlife-vehicle collisions (Bank *et al.* 2002, Mastro *et al.* 2008, Ng et al 2008). Large herbivores are not the only wildlife that may benefit from appropriately selected vegetation. Birds are attracted to fruiting plants which results in heightened collisions (Jacobson 2005). Careful selection of roadside vegetation for landscaping purposes is important to ensure that wildlife mortality is not inadvertently enhanced.

#### 1.11.4 Guiding Wildlife with Vegetation

Most wildlife will follow linear landscape features such as hedgerows or riparian corridors (Barnum 2003). Bats and birds are known to travel along planted hedgerows and are often placed in danger when a road bisects a linear vegetation feature (Wray *et al*. 2005). Vegetation can be used as a linear guide to funnel wildlife towards an appropriate crossing point. This may also be used to reduce the uncertainty of where wildlife will cross and limit it to areas with vegetation close to the road. Appendix A, Section 1.9.4 should be consulted for additional information on using vegetation to divert flight paths of aerial species.

Vegetation may also be used to direct wildlife towards crossing structures. This principle has been applied to both terrestrial species and bats with success (Wray *et al.* 2005, Schrag 2003). If vegetation will be used to direct bats towards crossing structures, tall plantings should not occur on the top of the undercrossing as this may encourage the bats to fly up and over the road rather than through the undercrossing (Wray *et al.* 2005).

European countries have had success planting less desirable plant material near roadways and plants with higher foraging value near crossing structures to encourage use (Bank *et al*. 2002). An additional benefit of vegetation is that it will increase the natural appearance of the crossing structure. The presence of natural vegetation around passage entrances also increases structure effectiveness for small and medium terrestrial mammals along with amphibians (Arizona Game and Fish Department 2006, Ruediger and DiGiorgio

2006, Wildlife Crossing Toolkit 2005a, Jackson and Griffin 2000).

The types of vegetation used and the size will differ depending on the EDG. For example, a mouse will require smaller shrubs to direct them while a deer will require larger plantings. Different species will also preferentially forage on different types of plant material. Species diets will have to be considered when choosing plants for low forage quality.

## 1.12 NOISE BARRIERS

Vehicle noise is a pervasive and unwanted disturbance in our daily life. This excessive noise is often referred to as noise pollution. To limit the disturbance of traffic noise, noise barriers are often built between highways or busy roads and residential developments. Noise barriers are solid structures composed of a variety of materials including concrete, wood, and soil. They do not eliminate noise but generally reduce noise by 5-10 decibels, effectively cutting traffic noise in half (FHWA 2001).

Wildlife also experiences the effects of noise pollution often avoiding a portion of the land adjacent to the road (Jalkotzy *et al*. 1997). The extent of the effects of noise pollution on wildlife differs between species as some species are disturbance tolerant while others are distubance intolerant. Noise barriers may also be used in ecologically sensitive areas to reduce noise pollution. They are often used in areas with nesting birds, like wetlands, as noise may result in nest abandonment (Bank *et al.* 2002). Soil berms have been used in Banff National Park around underpasses to help alleviate roadway noise (Schrag 2003).

### 1.12.1 General Design

Noise barriers absorb or reflect sound back across the highway. To be effective, the noise barrier must be tall enough to block the sight of the road in the area that is to be protected (FWHA 2001). Designing the noise barrier to block the sight line of the road will decrease the noise adjacent to the road by 5 db (FWHA 2001). Each additional meter of height will further reduce noise by 1.5 db (FWHA 2001). The size of the vehicles using the areas will influence the required height of the noise barrier. For example, areas with larger vehicles, like trucks, will require taller noise barriers.

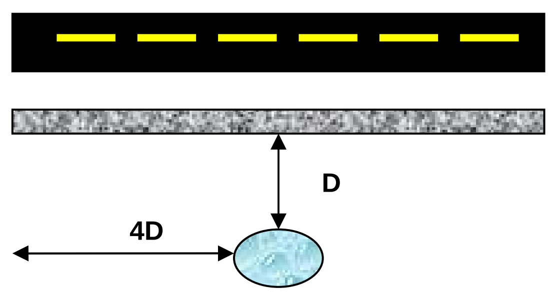



**Figure A.20**: Optimal noise barrier length in relation to distance from the noise barrier.( Adapted from FWHA 2001)

Openings in the barrier will render the noise barrier ineffective as noise will travel around the ends (FWHA 2001). The length of the noise barrier should extend beyond the area that is being protected to avoid diffracted noise around the ends. For optimal noise reduction, the barrier should be at least eight times as long as the distance from the sensitive area to the noise barrier (see Figure A.20).

These structures should be used with caution as they are solid and may enhance

fragmentation if additional mitigation is not used (Bank *et al.* 2002). Culverts or some type of underpass system should be used in ecologically sensitive areas to promote connectivity (Elmiger and Trocme 2007).

### 1.12.2 Soil Berms

Soil berms appear more natural than other types of noise barriers and they reduce noise by an extra 3 db when compared to vertical walls (FWHA 2001). Soil berms are preferred over other types of noise barriers because they are not an absolute barrier to wildlife. If desired, wildlife will be able to travel over the soil berms and access habitat on the other side of the transportation project. Please note that this may not be desirable in all situations (i.e. you may not want to encourage wildlife to cross the soil berm into an industrial area).

Earth berms require a lot of land to construct and may not be feasible in locations where the land adjacent to the road should not be highly disturbed. For example, if the transportation project bisects a wetland, it would not be advisable to disturb additional wetland habitat to construct soil berms.

Please refer to Appendix A, Section 1.10.1 for general noise barrier design.

### 1.12.3 Solid Walls

Solid walls may be constructed from metal, wood, concrete, or masonry. The material chosen should be ridged and dense (at least 20 kg/$m^2$) (FWHA 2001). Walls require less horizontal space when compared to berms, but are often limited to 8 m of height (FWHA 2001). Landscaping around the noise barrier is suggested as it will make the structure appear more natural with higher aesthetic value.

Please refer to Appendix A, Section 1.10.1 for general noise barrier design.

### 1.12.4 Transparent Walls

Transparent walls, or partially transparent walls, are often used in situations to preserve scenic vistas. This type of structure is dangerous for birds as they cannot see the transparent barrier and will often fly into the wall becoming injured or killed (City of Toronto 2007, Elmiger and Trocme 2007).

To reduce the danger to birds while still reducing noise, the transparent portion should be patterned. Adhesive stripes 1 to2 cm wide spaced 5 to10 cm apart have been shown to reduce the number of birds colliding with transparent structures (Elmiger and Trocme 2007). There should be no trees or shrubs in the immediate vicinity of the transparent portion as this will further attract birds to the area (Elmiger and Trocme 2007). Another emerging alternative is to use ultra-violet reflecting glass (Elmiger and Trocme 2007). While both these options will be useful, the best solution is to choose opaque materials that require less maintenance, have better acoustic properties and will not injure birds in the area.

Please refer to Appendix A, Section 1.10.1 for general noise barrier design.

## 1.13 CURB IMPROVEMENTS

Structures on the side of roads are often difficult for smaller wildlife to traverse. Simple solutions can be implanted to reduce the number of organisms trapped on roads and increase the connectivity between surrounding habitat. While curb improvements can help prevent amphibians and small mammals from being trapped on the road, if the transportation

infrastructure intersects a known migration point or area of high use, a below grade crossing structure is recommended.

### 1.13.1 Curbs with Ramps, Breaks, or Gentle Slope

The majority of drainage in an urban are is through curbs sewers and an underground drainage system rather than culverts. Traditional curbs can be a barrier to movement of some amphibians and small terrestrial mammals. They have difficulty climbing over curbs and may follow them rather than climbing over (Elmiger and Trocme 2007, Parks Canada 2008). These effects were observed in Waterton Lakes National Park with salamanders and in Switzerland with frogs (Elmiger and Trocme 2007, Parks Canada 2008). Animals trapped on the roadway are at a higher risk to vehicle mortality, predators, and drying out or overheating. They may also find themselves a great distance from where they started and may not be able to find the resources required for survival.

**Figure A.21:** Gently sloped curbs in Waterton National Park. (Photo Credit Gil Barber, Stantec. Used with permission)
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To ensure that curbs are not a barrier they should be roughened so that amphibians can get a toehold and climb over (Parks Canada 2008). Curbs should also be gently sloped with angles no more than 45$^{o}$ (Elmiger and Trocme 2007) (See Figure A.21). If it is not possible to slope the entire curb, regularly spaced sloped portions are acceptable. Additional options include breaks or gaps in the curb, and wooden ramps or small piles of rocks along the curb (Bank *et al.* 2002, Elmiger and Trocme 2007). Allowing vegetation to grow over the curb may also provide places for animals to hide or escape (Elmiger and Trocme 2007). Please note that this is not as effective as ramps or other escape mechanisms (Elmiger and Trocme 2007).

### 1.13.2 Breaks or "Scuppers" in Jersey Barriers

Jersey barriers are another common structure usually observed on busy roads to prevent vehicles from entering into oncoming traffic. While these structures do promote human safety, they often trap small wildlife on the road putting them at risk from vehicles, predators, or the elements.

The two main options to increase jersey barrier permeability are to place regularly spaced gaps between the barriers or to install drains, or scuppers on the bottom (See Figure A.22). The size of the scupper will differ depending on the wildlife in the area. Most scuppers extend approximately a third to halfway up the height of the barrier. Removing a section of the jersey barrier in areas of known wildlife use can decrease the amount of wildlife trapped on the road (Huijser *et al.* 2008 Bank *et al.* 2002). If safety requirements do not allow for omitted sections, then the barriers may be offset, with a 1 m gap between each section (FWHA 2003) (see Figure A.22). This will allow for wildlife movement but still function as a continuous barrier to prevent traffic from crossing into oncoming traffic

**Figure A.22**: Creating gaps in jersey barriers. Upper left: A scupper on the Trans Canada Highway (Photo Credit Meghan Chisholm, Stantec).

Lower Right: offsetting overlapping sections of jersey barriers to allow for permeability ( Photo Credit Bruce April and California Department of Transportation). Photos used with permission.

(FWHA 2003). Please note that incorporating gaps in jersey barriers is not the best solution for encouraging wildlife movement across the road (personal communication. Bruce April, California Department of Transportation). These should primarily be used to prevent wildlife from becoming trapped on a road and should not be considered as a sole mitigation measure in areas with high ecological importance.

For guardrails, box beam guardrails are recommended over W-beam guardrails; small and medium sized wildlife can easily pass under while larger wildlife will be more visible to drivers (Huijser *et al.* 2008)

### 1.13.3 Screens on Storm Drains

Many small animals trapped on the road by curbs or other roadside barriers follow the road searching for an exit (Elmiger and Trocme 2007). Some end up falling through stormsewer drains and end up in the sewer or waste treatment plants (Elmiger and Trocme 2007). Amphibians trapped on the road are especially at risk because they are likely searching for moist shelter (Elmiger and Trocme 2007). Incorporating screens or reducing the size of drain slits will help prevent entrapment (Bank *et al.* 2002, Elmiger and Trocme 2007). If slits are to be used, they should be no wider than 16 mm (Elmiger and Trocme 2007).

An alternative to screens is to re-align the location of drainage collection points. By placing drains in the center of a road, rather than along the curb, amphibians following curbs will be less likely to fall into the storm sewer (Elmiger and Trocme 2007). Please note this design consideration will likely

only be practical in new developments. For existing drains, screens or covers with smaller slits are recommended.

In Waterton National Park, Parks Canada increased the number of storm drains in order to decrease the amount of surface runoff along the road (Parks Canada 2008). This simple solution reduced the number of salamanders being washed into the stormsewer during their spring migration (Parks Canada 2008).

### 1.14 CULVERTS

Culverts are below grade crossing structures that can be used to help wildlife safely cross the road. Culverts have traditionally been used only to convey water beneath roads. It has been shown that many types of wildlife will use culverts to access habitat on the opposite side of the road. The size of the culvert will depend on the target species and the roadway length. Larger species require larger culverts (Jackson and Griffin 2000, Arizona Game and Fish Department 2006, Ruediger and DiGiorigio 2006). In addition, wider roads will require larger culverts to maintain the optimum openness ratio for the target species (refer to Section 4.3.12 for a summary of structure size). For optimal effectiveness, culverts should be used in conjunction with fencing to force wildlife to use the below grade crossing rather than the road surface. Please refer to Appendix A, Section 1.2 for information on fencing design.

#### 1.14.1 General Design

There are several design considerations that should be incorporated into every below-grade crossing regardless of the Ecological Design Group (EDG). These considerations are summarized below:

- If a water body is present, culverts should span 1.2 times the ordinary high water mark (see Figure A.22) (River and Stream Continuity Partnership 2006, Donaldson 2006b). This will incorporate dry passage into the structure and allow for use by terrestrial wildlife;

- Culverts should be wide enough to allow the natural stream velocity to be maintained (BC Ministry of Forests 2002, Vaughan 2002). Stream velocity inside the culvert should be within 20% of the adjacent stream velocity (Alberta Transportation 2004a, Bates *et al.* 2003);

- The substrate should be natural and include soil, rocks, and vegetation. Concrete, asphalt, gravel, and corrugated steel bottoms should be avoided (Ruediger 2001, Ruediger and DiGiorgio 2006, Cramer and Bissonette 2007). Natural bottoms will encourage wildlife use and will also help to limit the development of perched culverts for water bearing structures (Alberta Transportation 2004b);

- Many species are discouraged by steep slopes in crossing approach. Slopes of 16%, or less, are acceptable in flat areas while slopes of 25%, or less, are appropriate for hilly areas (O'Brien 2006);

- Metal or concrete bridge sized culverts should be buried at least 25% of the diameter of the culvert, up to 1 m and covered with natural substrate (River and Stream Continuity Partnership 2006, Alberta Transportation 2004b). Closed bottom culverts should be buried at least 40% of the diameter (BC Ministry of Forests 2002). See Figure A.23.;

- The substrate on the bottom of a water bearing structure should closely resemble that of the streambed upstream and downstream. It should also incorporate a mix of coarse and fine material (BC Ministry of Forests 2002). Large materials should be carefully placed so they do not flush out fine materials (BC Ministry of Forests 2002). See Figure A.23.;
- The design of a water bearing structure should incorporate a low flow channel. This may be accomplished by building up material on either side so low flow water is forced into the center. Alternatively, if the structure has multiple cells, a concrete sill that is slightly higher than low flow levels can be used to divert all low stream flow into one of the culvert cells (FHWA 2003);

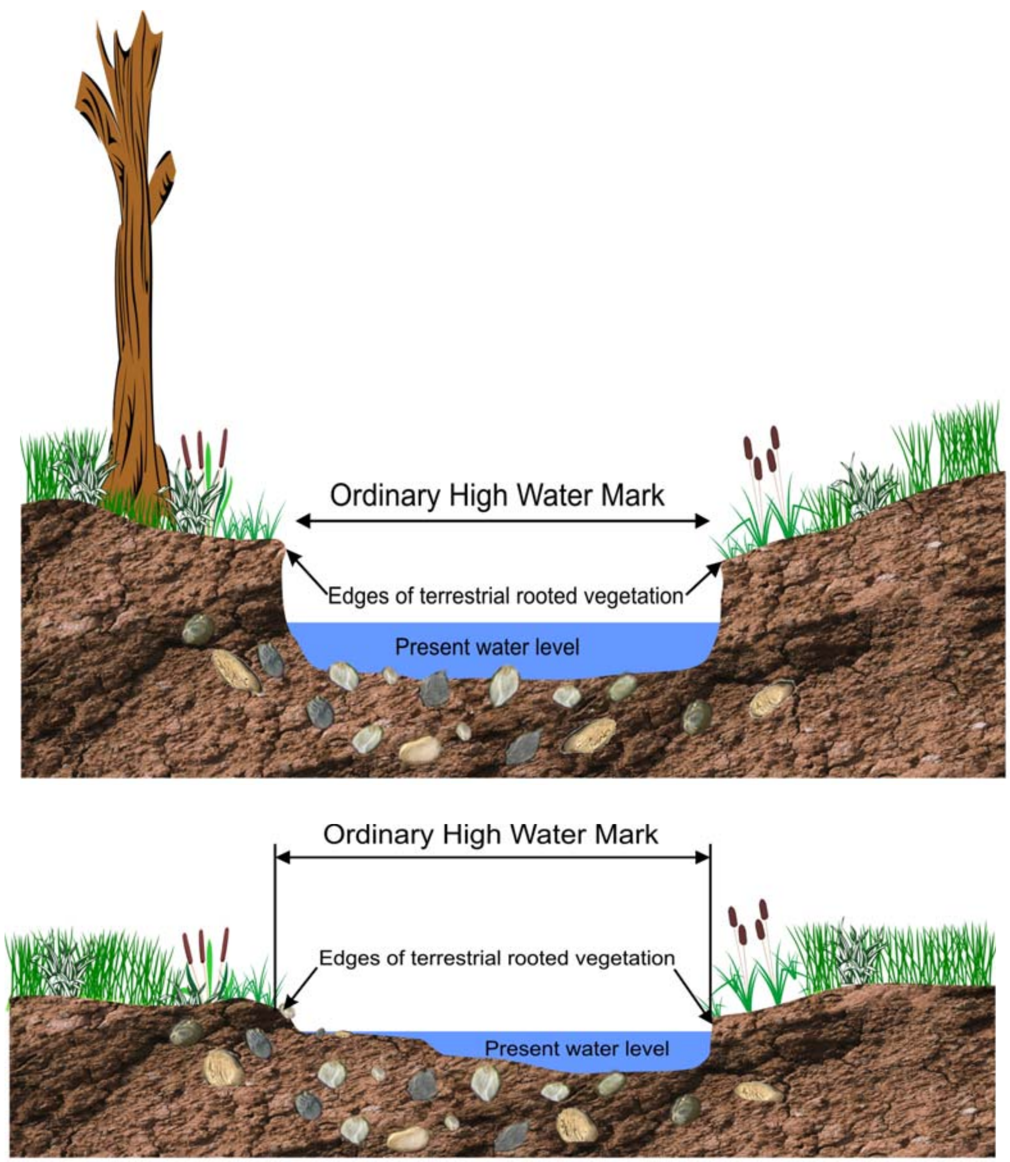



**Figure A.22**: Ordinary high water mark for streams and rivers. (Illustration Credit, Sarah King, Stantec)

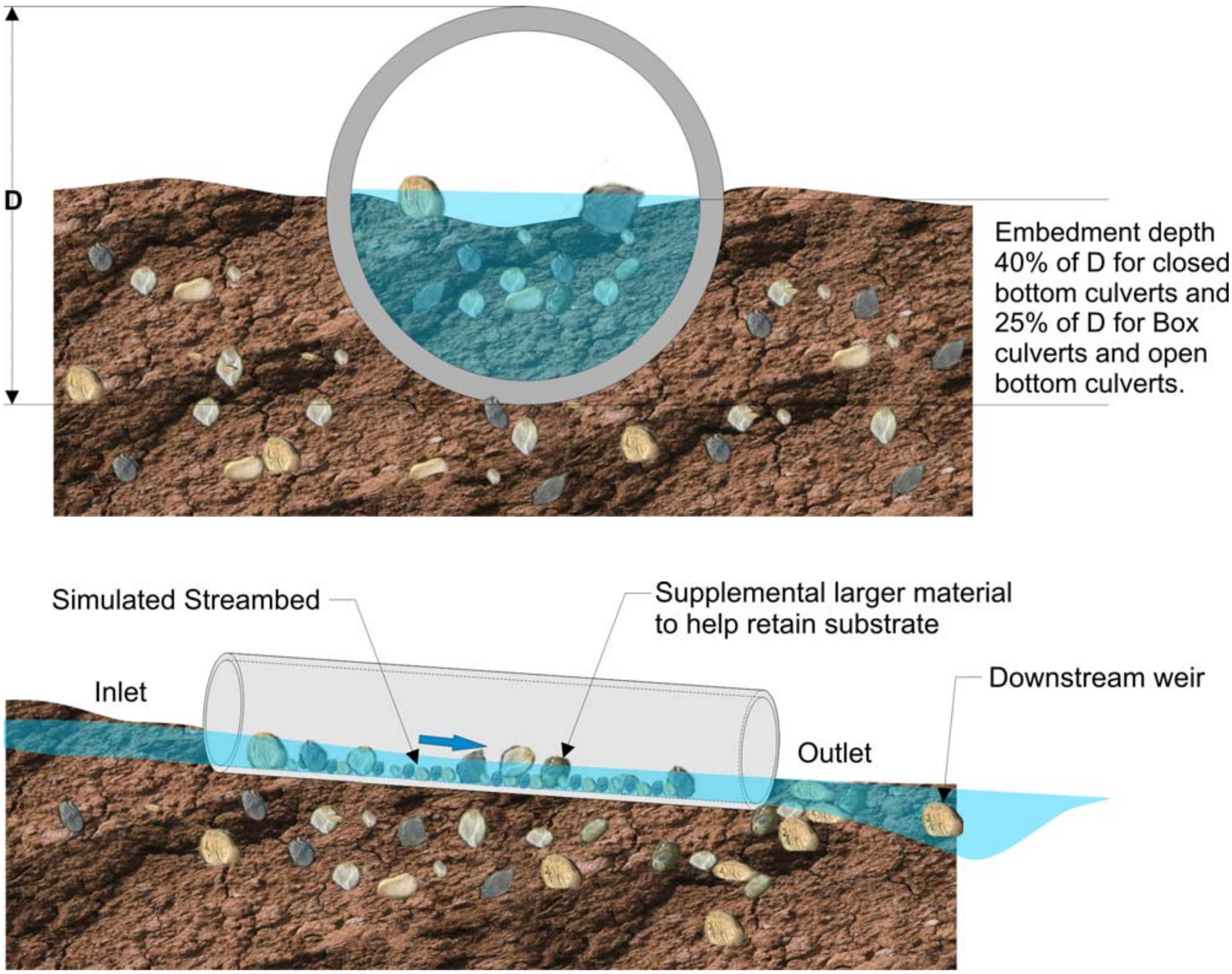



**Figure A.23**: Cross sections for culverts. Culverts should be embedded to provide natural substrate and prevent perching. The bottom should simulate the adjacent streambed. Adapted from BC Ministry of Forests 2002. (Illustration credit: Sara King, Stantec.)

- If the culvert is water bearing, the angle of the culvert should match that of the natural streambed (BC Ministry of Forests 2002). Ideally, the culvert should be placed at a low point along the streambed profile (BC Ministry of Forests 2002); and

- The approach to the structure should appear natural. Bright colours should not be used and excess construction materials, such as piles of soil, should not be left near the entrance. Storage of equipment near the entrance will also decrease the chances of wildlife use.

### 1.14.1.1 Large Terrestrial

Optimal structures for Large Terrestrial species are large with high openness ratios (Donaldson 2006b, NCHRP 2008, Mastro *et al.* 2008, Arizona Game and Fish Department 2006). Please refer to section 4.3.3 for additional information on calculating openness. Large open structures

are especially important for prey species like deer or moose who avoid dark passages (NCHRP 2008). Additional design considerations for Large Terrestrial wildlife are summarized below:

- Minimum size should be 2.4 m high by 6.1 m wide or 3.1 m high by 3.1 m wide with openness ratios of 1.5 (Donaldson 2006b, NCHRP 2008, Mastro *et al.* 2008, Arizona Game and Fish Department 2006). This large size will allow for natural light penetration and will make the structure seem open. It may also allow for natural processes like decomposition and vegetation growth;

- Short structures are preferred over long ones (Schrag 2003). If the road has multiple lanes, you should consider installing two structures that open in the median rather than one long structure;

- If the design of the transportation project dictates that the crossing structure must be low, then the structure will have to be very wide to compensate (Donaldson 2006a);

- Deer are more willing to use some of the smaller below grade crossings while moose and elk are less willing to use below grade crossings. If moose or elk are the target species, the structure must be large; ideally a bridge or wildlife overpass should be selected instead (Bissonette 2006, NCHRP 2008);

- Large Terrestrials prefer structures with clear sight lines to the opposite end (Mastro *et al.* 2008, Jackson and Griffin 2000). If the animal can see good habitat on the opposite side it will be more likely to use the structure. For example, if the design of the below-grade crossing makes it appear like there is a cliff on the other side, most animals will not risk entering the crossing;

- Natural, woody vegetation should also be present surrounding the openings (Mastro *et al.* 2008, Ruediger and DiGiorgio 2006). This vegetation should not block the sight lines through the structure; prey species may avoid structures with densely vegetated entrances as the vegetation may provide perceived ambush cover for predators (Jackson and Griffin 2000);

- A minimum dry walkway width of 2 m is recommended for water bearing structures. The preferred walkway width is 3 m (Huijser *et al.* 2008); and

- The species of interest will influence design and placement. Carnivore use of crossing structures is most influenced by noise and human disturbance (i.e. they will be more likely to use something further away from busy, noisy development) while ungulate use of crossing structures is most influenced by landscape features and design of the structure (i.e. openness, distance to drainage) (Clevenger and Waltho 2000).

Because Large Terrestrials prefer large, open structures closed bottom culverts should be avoided. Open bottom culverts are acceptable; however, box culverts will likely be the most effective.

#### 1.14.1.2 Medium Terrestrial

Medium Terrestrial species will use smaller structures than Large Terrestrials. Large culverts with minimum diameters of 1 to 1.5 m or dimensions of 2.4 m x 2.4 m are acceptable (Ruediger and DiGiorgio 2006, NCHRP 2008). Structures should have an openness ratio of at least 0.4 (NCHRP 2008).

This size of structure will provide ample openness yet will incorporate some overhead cover. Additional design considerations for Medium Terrestrial wildlife are summarized below:

- Predatory species will be more willing to use smaller structures (Ruediger and DiGiorgio 206) than prey species;
- Carnivore (coyotes, martens, weasels) use of crossing structures is highly correlated to proximity to drainage (Schrag 2003);
- Weasels prefer culverts with high clearance and low openness ratios while martens prefer culverts with low clearance and high openness ratios (Clevenger *et al.* 2001). Hares were less likely to use structures with poor through-culvert visibility (Clevenger *et al.* 2001);
- Overhead cover, such as low bushes, logs or stumps should be incorporated to provide protection for smaller prey species (Bank *et al.* 2002); and
- A minimum dry walkway width of 0.5-0.7 m is recommended for water bearing structures. The preferred walkway width is 1 m (Huijser *et al.* 2008).

#### 1.14.1.3 Small Terrestrial

Small Terrestrial species prefer small, confined structures (McDonald and St. Clair 2004). Optimal structures have diameters of 0.3 m to 1.0 m and openness ratios of 0.4 (Arizona Game and Fish Department 2006, Ruediger 2001). Additional design considerations for Small Terrestrial wildlife are summarized below:

- Small ledges on the sides of "wet" culverts (i.e. those which have the bottom entirely covered in water) will facilitate the passage of many smaller terrestrial species (Meaney *et al.* 2007, Foresman 2004, Schrag 2003). Typical designs include approximately 15 to 60 cm wide ledges installed along the side of the culvert, placed well above normal water flows, with ramps leading up to them at both ends of the culvert (Meaney *et al.* 2007, Foresman 2004). Care should be taken to ensure that there is a seamless transition between the ledge and the surrounding landscape (i.e. ledges should not end abruptly and there should be no obstacles) (Tonjes 2006). If there are obstacles, then the smaller wildlife will not be able to use the crossing. Ramps or gentle slopes should be incorporated to maximize use of the structure;
- Vole tubes should be used in areas with vole activity (Foresman 2004). Vole tubes are pipes, often made out of rain gutter downspout material, made to facilitate the passage of voles, which often avoid other passage types. These provide a sense of protection, because of the small size, and reduce the threat of predators;
- Small drainage culvers are very successful in permitting movement between habitat patches (McDonald and St. Clair 2004);
- The frequency of structure placement is important for small mammals due to their limited mobility. Crossing structures placed at least 60m apart will be more effective in providing roadway permeability and habitat connectivity (McDonald and St. Clair 2004);

- Site selection is important for Small Terrestrial crossings. For example, in Switzerland pipe culverts for small mammals are placed near hedgerows to provide additional habitat (Schrag 2003); and

- Natural ground cover such as rocks, stumps, or vegetation should be used in the entrance and throughout the crossing to provide overhead cover and protection from predators (Arizona Game and Fish Department 2006, Ruediger 2001, Jackson and Griffin 2000, McDonald and St. Clair 2004).

#### 1.14.1.4 Amphibian

Amphibians generally prefer smaller, confined structures (Arizona Game and Fish Department 2006). Optimal structures have a minimum diameter of 0.2 – 0.6 m if a slotted top is used and 1.2 – 2.0 m if a slotted top is not used (Merrow 2007). Additional design considerations for Amphibians are summarized below:

- Amphibians are primarily instinct driven and will have a difficult time "learning" where crossing structures are located and how to use them. For this reason, fencing must be used to direct amphibians towards the structure and structures should be placed no more than 50 m apart (Jackson 2003);

- Structures must be placed in line with natural amphibian migration (BC Ministry of Water, Land and Air 2004). Most amphibian migration is not aligned with drainage patterns and instead occurs between upland and wetland habitat (BC Ministry of Water, Land and Air 2004, Jackson 1996, Arizona Game and Fish Department 2006). Because other EDGs travel along riparian corridors, crossings designed for them will likely not be useful for amphibians in most situations;

- Amphibians prefer moist conditions and display less hesitation when entering structures with sufficient light (Jackson 1996, Cramer and Bissonette 2006, 2007);

- Amphibians are sensitive to microclimate change (BC Ministry of Water, Land and Air 2004). Microclimate within the structure should be similar to the microclimate outside of the structure. This can be accomplished by using slotted tops or a larger sized structure to allow for light, air circulation, and moisture (Jackson 2003, Merrow 2007, Huijser *et al.* 2008). Animals are more hesitant to use structures with large changes in temperature, moisture, light, and humidity (BC Ministry of water, Land and Air 2004);

- Steel pipes are not recommended due to their high conductivity of cold temperatures especially during spring migration (BC Ministry of Water, Land and Air 2004, CARCNET 2008); and

- The length of the structure should be kept to a minimum (BC Ministry of Water, Land and Air 2004).

#### 1.14.1.5 Aquatic

The most important consideration for aquatic organisms is to ensure that the crossing does not dramatically alter the stream characteristic (velocity, water depth, etc). The size of the structure must be large enough to incorporate the entire stream without constricting it during periods of high flow. Additional design considerations for Aquatic wildlife are summarized below:

- Streambed materials are also important for aquatic organism passage, and should be made to simulate the natural streambed. Rocks and other natural materials should be placed to create eddies and invertebrate habitat. Large material should be placed by hand to ensure that the placement does not enhance roughness and wash away all the fine particles (BC Ministry of Forests 2002);

- Vegetation, and particularly vegetation that causes shading, should be maintained as much as is possible around the culvert during installation, as decreasing shading increases water temperatures, causing lower oxygen levels, a change in invertebrate communities, and increased algal growth (King et al. 2000); and

- Low flow channels must be incorporated so that aquatic passage may occur at all times.

**1.14.1.6 Aerial Mammal**

Bats may use below grade crossing structures for roosting habitat or to safely access other parts of their foraging habitat. Large structures 1.8 to 2.2 m in diameter, aligned with natural flight paths are suggested (Wray *et al.* 2005). Additional design considerations for Aerial Mammals s are summarized below:

- Bats require areas for day roosting and night roosting. Day roosting areas are used to provide protection from predators and to buffer weather changes while night roosting areas are where bats go to digest food between nighttime feeding (Keeley and Tuttle 1999);

- Day roosts are often in bridges and culverts. For bridges, bats prefer vertical crevices 3 cm wide, 30 cm or more deep, and 3 m above the ground (Keeley and Tuttle 1999). For culverts, bats prefer concrete box coverts 1.5 to 3 m tall and 100 m long. The roosting area should be rainwater sealed, not susceptible to flooding, contain dark areas with roughened walls, ceilings and crevices, and not be situated under a busy road (Keeley and Tuttle 1999);

- Night roosts are often located beneath bridges because of the warmth radiated by the sun warmed structure. Bats will often avoid small culverts unless they are 1.5 m tall (Keeley and Tuttle 1999);

- Bats prefer roosting habitat that is composed of concrete (Keeley and Tuttle 1999);

- Structures may be retrofitted to provide roosting habitat. Please refer to Section 6.2.8 for additional information;

- Structures should be aligned with areas where bats are likely to cross. For example, many bats follow linear structures like hedgerows (Wray *et al* 2005). If the transportation project will interfere with an existing hedgerow, then a below-grade crossing could be installed in line with the former hedgerow to allow for safe passage; and

- Bays formed around the culvert to make a funnel shape will increase use (Wray *et al.* 2005). Plantings around the below-grade crossing will also visually direct the bats to the structure. Care should be taken to ensure plantings do not extend above the crossing as this may encourage bats to fly up and over the road rather than though the structure (Wray *et al.* 2005).

A bat being held during a survey. (Photo Credit Marc Obert, Stantec Consulting Ltd. Used with permission.)

#### 1.14.2 Closed Bottom Culverts

Closed bottom culverts are some of the most recognizable structures. They are relatively inexpensive and are very effective for most small and medium sized mammals (Clevenger and Waltho 1999). The size of the culvert will depend on the EDG (refer to Section 4.3 and Appendix A, Sections 1.14.1.1 through 1.14.1.6) and it is important to incorporate all of the general design considerations listed above in Appendix A, Section 1.14.1. Additional design considerations pertaining specifically to closed bottom structures are listed below:

- Closed bottom structures should be used in small streams with channel widths less than 2.5 m (BC Ministry of Forests 2002);

- They should not be used in critical habitat containing high value spawning or rearing habitat (deep pools, undercut banks, stable debris, abundance of suitably sized spawning gravel), recreational or commercial fishery, or species at risk (red and blue-listed or COSEWIC listed) (BC Ministry of Forests 2002);

- Perched culverts are often a concern for closed bottom structures. Perched culverts are a complete barrier for fish and other aquatic organisms and must be avoided (Vaughan 2002). Perched culverts occur from either design and installation or erosion that has removed the substrate from underneath the outfall. To prevent perched culverts, at least 40% of the culvert’s diameter should be embedded (BC Ministry of Forests 2002). If the location does not allow the pipe to be buried to this depth, an alternative structure should be considered (bridge or open bottom culvert) (BC Ministry of Forests 2002; and

- Closed-bottomed culverts should not be used in stream meanders due to erosion and sedimentation problems (B.C. Ministry of Forests 2002).

An example of a closed bottom culvert is included in Figure A.24.

### 1.14.3 Open Bottom Culverts

Open bottom culverts are better than closed bottom structures as they incorporate the natural substrate and are often much larger. The size of the culvert will depend on the EDG (refer to Section 4.3 and Appendix A, Sections 1.14.1.1 through 1.14.1.6) and it is important to incorporate all of the general design considerations listed above in Appendix A, Section 1.14.1. An additional design considerations pertaining specifically to open bottom structures is that open bottom culverts should be embedded to at least 25% of the vertical rise of the arch up to 1 m and covered with natural substrate (River and Stream Continuity Partnership 2006, Alberta Transportation 2004b)

An example of an open bottom culvert is available in Figure A.25.

**Figure A.24**: Closed Bottom Culvert. Note the branches near the entrance that will provide cover for small wildlife.. (Photo Credit: Meghan Chisholm, Stantec. Used with permission).

**Figure A.25**: Open Bottom Culvert. Located in Fort Saskatchewan, note the natural substrate and presence of dry passage. (Photo Credit: Meghan Chisholm, Stantec. Used with permission.)

### 1.14.4 Box Culverts

Box culverts are preferred over other types of culverts because their rectangular shape makes the structure feel larger and more open (See Figure A.26). The size of the culvert will depend on the EDG (refer to Section 4.3 and Appendix A, Sections 1.14.1.1 through 1.14.1.6) and it is important to incorporate all of the general design considerations listed above in Appendix A, Section 1.14.1. Additional design considerations pertaining specifically to box culverts are listed below:

- Box culverts should be embedded to at least 25% of the vertical rise up to 1 m and covered with natural substrate River and Stream Continuity Partnership 2006, Alberta Transportation 2004b); and
- Box culverts may be designed to incorporate roosting habitat for bats (figures A.27 throughA.29). This is accomplished by incorporating a raised dome in the center of the culvert. Culverts should be at least 1.5 m high with an additional 0.6 m of height in the center. The raised area can be between 0.6 to 15 m wide (See Figure A.27 and A.28). The walls and ceilings should be roughened to provide footholds. Incorporating this raised area will trap warm air, reduce light, and reduce exposure to the elements (wind, rain) (Keeley and Tuttle 1999).

**Figure A.26**: Single Cell Box Culvert along the Trans Canada Highway. (Photo Credit: Meghan Chisholm, Stantec. Used with permission).

**FigureA.27**: The interior of a box culvert modified to include bat roosting. Photo Credit: Melisa Montemayor, Texas Department of Transportation. Used with permission

**FigureA.28**: The exterior of the box culvert modified for bat roosting while under construction. Photo Credit: Melisa Montemayor, Texas Department of Transportation. Used with Permission

**Figure A.29:** A multi-cell box culvert in Texas modified to include roosting habitat for bats. (Photo Credit: Mark Alvarado, Texas Department of Transportation. Used with permission.)

### 1.14.5 Amphibian Tunnels

Amphibian tunnels are similar to other culvert types although there are some alterations in the design. Box culverts are preferred over other types of culverts because their rectangular shape makes the structure feel larger and more open. Most amphibian tunnels are metal or concrete with diameters of 0.4 to 2.0 m although larger crossing structures may be adapted to incorporate amphibians (Bank *et al.*

2002). Refer to Section 4.3 and Appendix A, Section 1.14.1.6 for additional design considerations. Please also incorporate all of the applicable general design considerations listed above in Appendix A, Section 1.14.1. Additional design considerations pertaining specifically to box culverts are listed below:

- Soil and air humidity inside the structure must be similar to the surroundings (Huijser *et al.* 2008). Slotted tops are one way of accomplishing this (See Figures A.30 through A.32);

- Rectangular structures are preferred over round ones due to the increased openness (Huijser *et al.* 2008). The square shape is also more difficult for amphibians to climb and fences connect better to square shapes than round ones (Huijser *et al.* 2008);

- The design of the structure should prevent standing water (Huijser *et al.* 2008, Merrow 2007). The bottom should be sloped to one side so that any water that accumulates will stay on one side while leaving a dry area on the other side (Merrow 2007);

- Structures should be kept as short as possible (Jackson 1996). The length of structure can be shortened by constructing headwalls and wing walls just outside road shoulder (Merrow 2007) (See Figure A.32);

**Figure A.31**: The inside of an amphibian tunnel in Waterton Lakes National Park. Note how the grated top allows for light penetration throughout the tunnel. This tunnel design would improve if natural substrate was incorporated. (Photo Credit Gil Barber, Stantec Consulting Ltd. Used with Permission.)

**Figure A.30:** Top view of a salamander tunnel in Waterton Lakes National Park. Note the grate to allow for light and moisture penetration. Silt fences are also used on both sides of the road to restrict access to the road. (Photo Credit Gil Barber, Stantec Consulting Ltd. Used with permission.)

- One way pipes may also be used to facilitate amphibian access to upland and wetland habitat. These incorporate one-way entrances to the tunnels with a vertical chute that prevents animals from climbing back out (BC Ministry of water, Land and Air Protection 2004). One pipe allows access to the wetland habitat while a pipe going the opposite way provides a pathway to the upland habitat while reducing mortality (Schrag 2003, Bank *et al.* 2002). It appears that these one-way tunnels may be more effective that other amphibian tunnels that allow movement in both directions (Bank *et al.* 2002);

- Fences should be used in conjunction to ensure amphibians are directed towards the structure (refer to Appendix A, Section 1.2.4) (NCHRP 2008). Wing walls angling out at 45 degrees should be located on either side of the structure with retaining walls or other types of fencing located on either side of the wing walls (Jackson

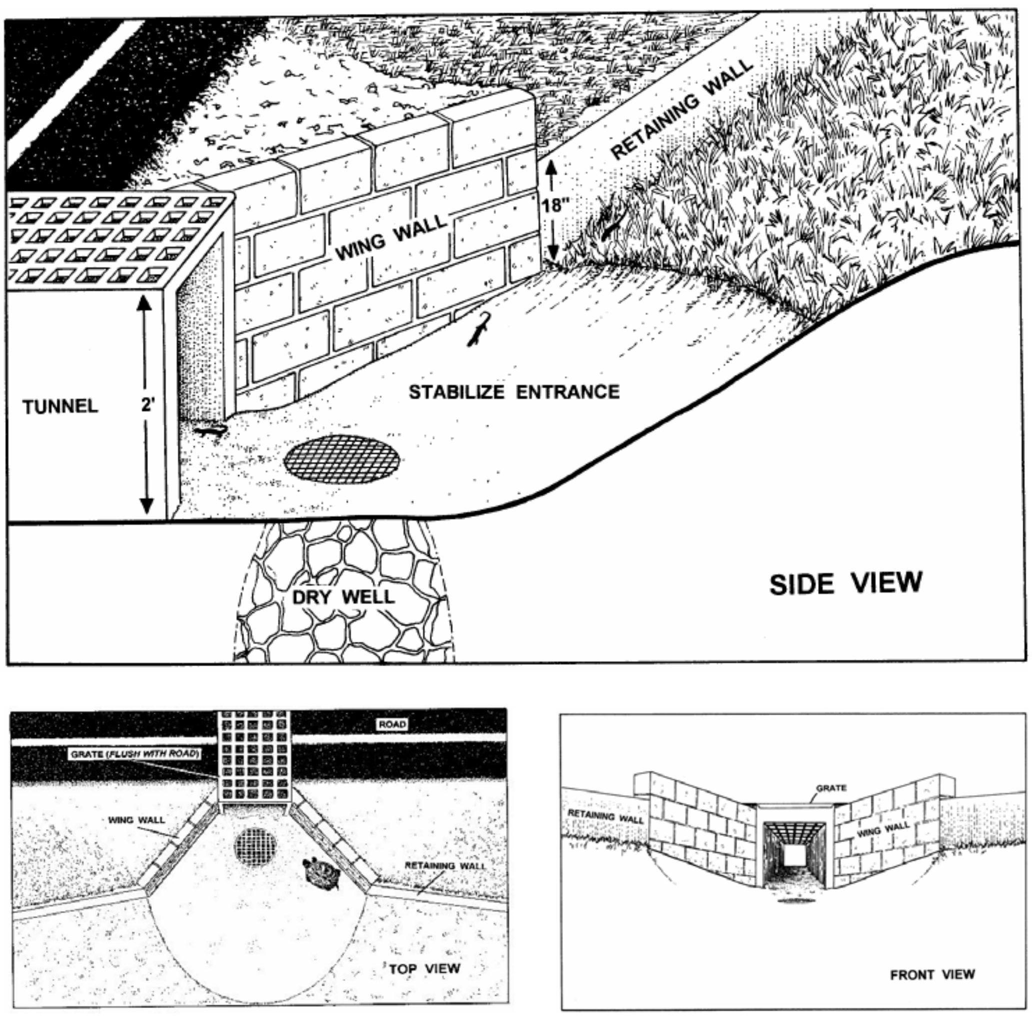



**Figure A.32:** Schematic drawings of an amphibian tunnel. (From Jackson 2003. Illustrations by Tamara Sayre. Used with permission.)

2003). The fences/retaining wall should be at least 45 cm tall and extend for 30 to 60 m (Jackson 2003);

- Moist substrate is required to ensure that the amphibian's skin does not dry out and natural light should be incorporated to assure the amphibian that the tunnel leads to suitable habitat (NCHRP 2008). Sandy soil like sandy loam are recommended to cover the bottom (Jackson 2003); and

- Structures with slotted tops may allow for salts and sands to enter the tunnel during winter months and there may be safety/maintenance concerns associated with snow plowing (Jackson 2003, Merrow 2007). In these cases it may be advisable to install a larger structure (1.2 m x 1.2 m rather 0.6 m x 0.6 m) without a slotted top (Jackson 2003, Merrow 2007). Another option could be to have removable metal grates that are replaced with solid metal covers during the winter months. This may also help to reduce maintenance costs associated with cleaning out the sand and silt built up during the winter.

### 1.15 BRIDGES

Bridges are another type of below-grade crossing. They are preferred to culverts because they often span a larger area and incorporate several habitat types. Depending on the size of the bridge, water, riparian, and upland habitat may be included under one structure.

The two most common types of bridges fall into the categories of Expanded Bridges and Viaducts. Expanded bridges occur when roads cross rivers or streams and the bridge extends to provide upland travel adjacent to the waterway (Jackson and Griffin 2000). Viaducts are elevated roadways that span valleys and gorges. They are different from expanded bridges because they are higher and cross not only the stream but the adjacent upland habitat as well (Jackson and Griffin 2000). These structures are often higher and allow for natural vegetation growth and high openness ratios. Viaducts also minimize alteration of the original habitat (Bank *et al.* 2002). Because higher bridges with wider passage areas are more successful than lower bridges, viaducts are recommended for areas of high ecological importance (Jackson and Griffin 2000).

Please refer to General Design Considerations (Appendix A, Section 1.14.1) and Ecological Design Group considerations for below-grade crossings (Appendix A, Sections 1.14.1.1 through 1.14.1.6) as these principles also apply to bridges. Additional design considerations pertaining specifically to bridges are listed below:

- Bridges should ideally incorporate 10 m of bank vegetation on either side of the water body (O'Brien 2006, Donaldson 2006b). This will allow for dry passage beneath the structure and prevent terrestrial species from having to cross over the road (Mastro *et al.* 2008);

- Minimum widths of 15 m and minimum heights of 3 to 4 m are ideal (O'Brien 2006);

- Rip rap should be avoided for bank armoring as it is difficult for ungulates to walk over (Arizona Game and Fish Department 2006). If it must be used it should be buried, covered with topsoil and seeded with natural vegetation (Arizona Game and Fish Department 2006);

- The stream bank should be kept natural as ungulates avoid structures with sharp vertical walls (Jackson and Griffin 2000). Sharp vertical side walls create a perceived ledge for predator ambush;
- Due to the large size of bridges, stumps, rocks, or shrubs should be incorporated throughout to provide cover for small wildlife (Schrag 2003, Bank *et al.* 2002);
- As with culverts, the approach to bridges should be natural. Brightly coloured objects should not be used, leftover construction material, such as soil piles, should be removed and equipment should not be stored near the entrance;
- If the bridge is twinned, use a large gap between the lanes. A narrow gap will disturb animals due to sudden bursts of traffic noise (O'Brien 2006);
- Incorporating vertical crevices 0.25 to 3 cm wide and 30 cm deep, located at least 3 m above the ground will encourage bats to roost (Keeley and Tuttle 1999). Expansion joints or other crevices with widths between 1.9 to 2.5 cm will allow for bat roosting habitat as well (Keeley and Tuttle 1999); and
- Existing bridges may also be retrofitted to accommodate day roosting habitat for bats. Please refer to Section 6.2.7 for additional information.

**Figure A.33:** An expanded bridge in Banff, Alberta that allows for wildlife passage. (Photo Credit Trisha White, TransWild Alliance. Used with Permission)

**Figure A.34:** A viaduct in Calgary, Alberta. Note the incorporation of natural vegetation and the high openness. (Photo Credit SMKC, Stantec. Used with Permission)

**Figure A.35:** Ellerslie Road – Blackmud Creek Crossing located in Edmonton, Alberta.

Top photograph: looking south at the crossing the right hand side (west side) of the photograph has a gabion wall along the water. Eventually, this side of the bridge will have a pedestrian trail and will likely have limited wildlife use (Photo Credit: Kurtis Fouquette, Stantec).

Bottom Photograph: looking north at the crossing. The right hand side (east side) of the photograph will be more conducive to wildlife as the bank is gently sloping, the ledge is wider and there is more space between the ground and bridge so the passage will feel more open.

Photographs used with permission.

## 1.16 OVERPASSES

Overpasses, especially ones greater than 50 to 60 m wide, are very effective, especially for large mammals (Schrag 2003, Jackson and Griffin 2000). Overpasses facilitate movement of more species and are less confining, quieter, maintain ambient temperature and moisture, and have natural light (Jackson and Griffin 2000). Overpasses should be at least 60 m wide, especially for large mammals: wildlife behaviour changes when lower widths are used (Bank *et al* 2002). However, most European overpasses are hourglass shaped with a narrow point of 8 to 35 m (Schrag

2003, Jackson and Griffin 2000). This is thought to reduce construction costs while still maintaining connectivity (Schrag 2003). Longer overpasses will require greater widths. It is recommended that the width not be less than 80% of the length (O'Brien 2006).

When designing an overpass, arched designs should be avoided. Wildlife appear to be more hesitant to use arched structures because they cannot see across to the other side (Schrag 2003). A gradual approach should be used, ideally a 5:1 slope, to allow animals to see across to the opposite side (Huijser *et al.* 2008). Placing structures at a low point in topography will also increase visibility and may encourage wildlife to use it (Schrag 2003).

Native vegetation should be used to create a natural-looking environment on overpasses. In Switzerland, hedges, ponds, bushes, rocks, and stumps are used to eliminate noise and light infiltration on overpasses (Schrag 2003, Jackson and Griffin 2000). Overhead cover will be important for smaller animals as they require cover to hide from predators. For amphibians, pumps may be used to transfer water to the center and create a wet zone that will allow for amphibian crossing (Huijser *et al.* 2008). To facilitate vegetation growth, the soil depth on the overpass should be 0.5-2m deep (Jackson and Griffin 2000). Grasses, trees, and shrubs should be planted although species that grow tall and have extensive root systems should be avoided (Huijser *et al.* 2008). Ideally, native plantings should be incorporated.

Some sort of fencing should be present on both sides of the overpass to prevent wildlife from jumping off. Large vertical wooden fences are used on some busier locations to serve as a noise and visual barrier (Bank *et al.* 2002). Most overpasses have berms or screens that are taller than 2.5 m (Huijser *et al*. 2008) (see Figure A.36). If using soil berms, please note that lighter material may be used for the core to reduce the weight on the structure (Huijser *et al.* 2008).

On narrower overpasses, tall fences may decrease the openness of the crossing and act as a deterrent for some species (Bank *et al.* 2008, Huijser *et al.* 2008). To reduce this effect the barrier may be oriented outwards (Huijser *et al.* 2008).

**Figure A.36:** Wildlife overpasses.

Top right photograph: Wildlife overpass in Banff, Alberta. Note the fencing along the top, the presence of trees and the boulder field on the sides to prevent wildlife from accessing the highway. (Photo Credit, Meghan Chisholm, Stantec).

A soil berm along the edge of an overpass in Banff, Alberta. This will help to reduce traffic noise for wildlife using the structure. (Photo Credit: Trisha White, TransWild Alliance).

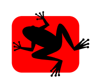
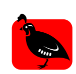
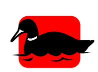
Photographs used with permission.

# APPENDIX B – WILDLIFE REFERENCE

# Appendix B - Wildlife Reference

This section is designed to be used as additional reference material to identify species specific information about habitat, diet, and home range. Please note that this is not an extensive list and the focus is on the most common species in the Edmonton area. As such, it may not contain information about all of the species located around your project area.

Ecological Design Groups are also identified in these tables. Please see below for an explanation of abbreviations and symbology:

| Ecological Design Group | Abbreviation | Symbology |
|---|---|---|
| Large Terrestrial | LT |  |
| Medium Terrestrial | MT |  |
| Small Terrestrial | ST |  |
| Aerial Mammal | AM |  |
| Aquatic | AQ |  |
| Amphibian | AMP |  |
| Birds of Prey | BOP |  |
| Scavenger Bird | SB |  |
| Ground Dwelling Bird | GDB |  |
| Water Birds | WB |  |
| Other Birds | OB |  |

The information for this section comes from a variety of resources. These resources are listed below in the event that more information is required.

Alberta Sustainable Resource Development (ASRD). 2005. Status of Alberta Wild Species 2005. Online Resource. URL: http://www.srd.gov.ab.ca/fishwildlife/speciesatrisk/ statusofalbertawildspecies/search.aspx

Alsop, F.J. 2005. Birds of Canada Field Guide. Dorling Kindersley Limited. Toronto, Ontario.

Bowers, N., R. Bowers, K. Kaufman. 2004. Mammals of North America. Houghton Mifflin Company. New York, NY.

Federation of Alberta Naturalists. 1992.The atlas of breeding birds of Alberta .Eds. G.P. Semenchuck. Federation of Alberta Naturalists, Edmonton, Alberta.

Russell, A.P. and A.M. Bauer. 2000. The Amphibians and Reptiles of Alberta: A Field Guide and Primer of Boreal Herpetology Second Edition. University of Calgary Press. Calgary, AB.

Nature Serve Explorer. 2009. Online Encyclopedia of Life. Online Resource. ULR: http://www.natureserve.org/explorer/

University of Michigan Museum of Zoology. 2008. Animal Diversity Web. Online Resource. ULR: http://animaldiversity.ummz.umich.edu/site/index.html

**Other books that may be useful**

Burt, W.H. 1980. Peterson Field Guide Series. A Field Guide to the Mammals: North America North of Mexico. Houghton Mifflin Company. New York, NY.

Beletsky, L. 2006. Birds Songs: 250 North American Birds in Song. Chronicle Books. San Francisco, CA

## 1.1 WILDLIFE IN EDMONTON

| EDG | Scientific Name | Common Name | Diet | Additional Information |
|---|---|---|---|---|
| **Amphibians** | | | | |
| | *Ambystoma tigrinum* | Tiger Salamander | Insects, mites, earthworms, mollusks, small vertebrates | Active early spring to early fall. Lakes, ponds, dugouts but tolerant of dry conditions. Mating occurs after early spring migration to breeding sites in permanent/semi permanent standing water. Distribution occurs in short-grass prairie, aspen parklands, boreal forest. |
| | *Bufo boreas* | Western Toad | Worms, slugs, insects arthropods | Found around ponds, streams rivers lakes. Active April - September. Largely terrestrial species that dig hibernacula. Prefers damp conditions. Congregates at bodies of water (pools or small ponds) to breed. Prefers sandy bottoms for laying eggs. Will breed in permanent or temporary water. Occurs in boreal, sub alpine, alpine, aspen parkland, short grass prairie. Pesticides, pollution and drought threaten this species. |
| | *Bufo hemiophrys* | Canadian Toad | Arthropods, insects | Active April to September. Diurnal species that burrows at night. Breeds in shallows of lakes, ponds, ditches, marshes, other temporary bodies of water. Primarily found in aspen parkland, and boreal with some records in short grass prairie. Habitat is threatened by drought, conversion, |

| EDG | Scientific Name | Common Name | Diet | Additional Information |
|---|---|---|---|---|
| | | | | agricultural chemicals and oil and gas activities. |
| | *Pseudacris maculata* | Boreal Chorus Frog | Insects, snails, millipede, small invertebrates | Found in grassy pools, lakes, marshes, and almost any body of water. Occurs on farms, in cities anywhere with suitable habitat except where pesticides are heavily used. Breeding in April to June. Breeds in any body of water (shallow to deep) and lays eggs in clumps attached to vegetation. |
| | *Rana pipiens* | Northern Leopard Frog | Insects, spiders, small invertebrates | Found in springs, streams, marshes, and other permanent water with abundant aquatic vegetation. Streams are used for dispersal. Hibernates in mud at bottom of standing water or under rocks in streams. Generally found und in areas where vegetation provides good ground cover. Designated as "Threatened" under the Wildlife Act. |
| | *Rana sylvatica* | Wood Frog | Mollusks, worms, insects, arthropods | Diurnal species that is found in wooded areas or areas associated with open ponds. Hibernates on land beneath litter and humus. Has a physiochemical mechanism to prevent cold and dryness. Forages far away from water. Largely terrestrial in non breeding season. |
| | *Thamnophis radix* | Plains Garter Snake | Frogs, fish, small mammals | Favours ponds, streams, and wetlands to hunt for prey. Threatened by increased development surrounding oil and gas activity. |
| | *Thamnophis sirtalis* | Red Sided Garter Snake | Fish, amphibians, reptiles, birds, small mammals, worms, arthropods | Broad habitat tolerance. Lives in vicinity of ponds, marshes, dugouts, ditches, streams. Found in forested, urban areas, and farms. Threatened by increased development surrounding oil and gas activity. |
| **Aquatic** | | | | |
| | *Acipenser fulvescens* | Lake Sturgeon | Insects, aquatic plants, invertebrates | Habitat degradation and over fishing has lead to population declines. Designated as "threatened" under the Wildlife Act. |
| | *Catostomus catostomus* | Longnose Sucker | Algae, aquatic plants, small invertebrates[1] | Bottom feeder, spends majority of time in shallow water. Requires pebbles and gravel beds to lay its eggs. |
| | *Catostomus commersonii* | White Sucker | Algae, aquatic plants, small invertebrates | Bottom feeder, spends majority of time in shallow water. Requires pebbles and gravel beds to lay its eggs. |
| | *Esox lucius* | Northern Pike | Fish, insects, frogs, | Top food chain species whose habitat is calm, deep water including ponds and creek mouths. Spawning occurs in flooded vegetation. |

[1] http://www.michigan.gov/dnr/0,1607,7-153-10364_18958-45693--,00.html

| EDG | Scientific Name | Common Name | Diet | Additional Information |
|---|---|---|---|---|
|  | *Hiodon alosoides* | Goldeye | Insects, crustaceans, fish, frogs, shrews[2] | Prefers slower moving waters of streams and lakes[3]. Is mainly nocturnal and undertakes seasonal migration in some areas (upstream in spring and downstream in fall). Spawns in shallow firm bottom sites in river pools or backwaters[4]. |
|  | *Lota lota* | Burbot | Aquatic insects, mollusks, invertebrates, fish | Common in cold, deep water, prefers benthic habitat. May migrate large distances between spawning and non-spawning habitat[5] Primarily spawns in lakes but may move into rivers. River spawning occurs in areas of low velocity. |
|  | *Prosopium williamsoni* | Mountain Whitefish | Aquatic and terrestrial insects, fish. | Benthic species prefers clear streams with large pools. Stream populations spawn in riffles over gravel and small rubble. Most feeding occurs at dusk or after dark[6]. |
|  | *Stizostedion canadense* | Sauger | Insects, fish, zooplankton, invertebrates | Found in slow moving rivers and may be vulnerable to habitat degradation in these systems. Little is known about this species. Spawns on sandy and rocky shores in lakes and in deep rocky runs in rivers. Most active in evening and early morning. |
|  | *Stizostedion vitreum* | Walleye | Insects, fish, frogs, snails, small mammals, invertebrates | Live in both rivers and lakes and migrate long distances to reach spawning grounds in the spring. Prefers lakes, pools, and backwaters, and moderately deep water. Avoids bright light and is often found in aquatic vegetation, in holes of tree roots. Is mostly nocturnal. |
| **Terrestrial Mammals** | | | | |
|  | *Alces alces* | Moose | Willow and aspen leaves, aquatic plants, twigs, woody stems | Breeds in the fall spending summer months in areas with water, shade, or mud. Can be found in riparian, wetland, and forest habitat. Active throughout the day but most active at dawn and dusk. Home range up to 4000 ha. |
|  | *Cervus elaphus* | Elk | Grazer: Grass, weeds, shrubs, trees | Mating occurs during the fall (September-October). Found in a variety of forested habitats and alpine pastures, marshy meadows, river flats and aspen parklands. Active from dusk to dawn diurnal feeding is more common in summer than winter.[7] |
|  | *Odocoileus hemionus* | Mule Deer | Eats new growth of grasses, bushes, trees, acorns | Breeding occurs late fall (November-Decemberz). Home range is at least 30 -240 ha correlated to food, water and cover availability. Adapts to a variety of habitat with both cover and open area for feeding. Prefers drier habitat like deserts and grasslands. Most activity occurs at dawn and dusk. |

[2] http://en.wikipedia.org/wiki/Goldeye
[3] http://en.wikipedia.org/wiki/Goldeye
[4] http://www.natureserve.org/explorer/servlet/NatureServe?searchName=Hiodon%20alosoides
[5] http://www.natureserve.org/explorer/
[6] http://www.natureserve.org/explorer/
[7] http://animaldiversity.ummz.umich.edu/site/index.html

| EDG | Scientific Name | Common Name | Diet | Additional Information |
|---|---|---|---|---|
| | *Odocoileus virginianus* | White Tailed Deer | Variety of plants including leaves, twigs, grass, berries, acorns, fungi, human gardens | Breeding occurs in late October –November. Home range is not very large, approximately16-120 ha. Adapts to a variety of habitat. Prefers open forests bordering on old fields of natural meadows. Likes moister habitat (riparian, wetland). Active day and night but most active at dawn and dusk. |
| | *Canis latrans* | Coyote | Opportunistic feeder. Hunts and scavenges | Mates in late winter and digs dens into the ground. Adults travel an average of 20 km a day and home range may be larger in the winter than summer. Adaptable to many habitats including those with human disturbance. Is mainly crepuscular and nocturnal. Are a keystone predator that keeps many populations of small mammals under control. |
| | *Castor canadensis* | Beaver | Eats bark of willow, aspen, other trees | Breeding occurs in February-March. Young disperse from their family group in late summer. Beavers are keystone species that have a large impact on aquatic and riparian ecosystems. Beavers usually are found within 0.8 km of their den and avoid fast moving streams with strong wave action. Commonly associated with deciduous tree and shrub communities. Primarily crepuscular and nocturnal but may also be diurnal. |
| | *Erethizon dorsatum* | Porcupine | Feeds on inner bark and twigs of trees in winter; in summer eats sedges, grasses acorns, other plant. Fond of salt | Breeds in the fall and have a summer range of 50-100 ha. Prefers forest (conifers, mixed wood), fallen logs, standing tree snags. Is also found in riparian zones, grasslands, and shrubs. Activity is primarily nocturnal or circadian but is frequently seen during the day. |
| | *Lepus americanus* | Snowshoe Hare | Feeds on grass, leaves, berries, bark conifer buds in winter | Breeding season occurs in the spring and summer. Home range is 5-20 ha. Prefers forested habitat. Common in alder swamps, aspen groves, hardwood forests. Primarily crepuscular and nocturnal species. |
| | *Lepus townsendii* | White Tailed Jackrabbit | Feeds on grass, weeds, shrubs, cultivated crops | Breeding occurs in spring. Common in grassland and shrubland and is adapted to disturbance. Primarily crepuscular and is active throughout the year. Home range is thought to be small. |
| | *Martens spp* | Marten | Small animals, berries, seeds, insects, carrion | Breeding season occurs during the summer and are common in mature, dense coniferous forest. Also found in riparian areas. Home range may be larger when food is scarce. Are primarily nocturnal in winter and diurnal in summer. |
| | *Mephitis mephitis* | Skunk | Carrion feeder (Seen along roadsides). Also feeds on insects, mice, frogs, crayfish, eggs, fruit | Found in forested and herbaceous wetland, riparian, semi open country with meadow. Burrows in soil, fallen logs, standing snags and hollow trees and is adapted to disturbance. Activity is mainly crepuscular and nocturnal although sometimes active in daytime. May be dormant during extended periods of cold weather. |

| EDG | Scientific Name | Common Name | Diet | Additional Information |
|---|---|---|---|---|
|  | *Mustela spp.* | Weasel | Rodents, small rabbits, birds, eggs, insects | Breeds during summer months. Female home range is smaller than male. Favours areas near water and burrows in soil, fallen logs, standing tree snags. Long-Tailed weasel is listed as a species at risk due to habitat loss, pesticide use, and wetland drainage. Tolerant of close proximity to humans. Primarily nocturnal or crepuscular but can be seen during daytime. Known to control rodent populations. |
|  | *Ondatra zibethicus* | Muskrat | Cattails, bulrushes, sedge, aquatic plants, frogs, fish, invertebrates | Does not forage far from home site unless habitat is marginal. Favours freshwater or brackish marshes, lakes, ponds, swamps or other bodies of slow moving water. Most abundant in areas with cattail. Activity is mainly nocturnal but frequently seen in daylight. |
|  | *Vulpes vulpes* | Red Fox | Hunts and scavenges for birds, small mammals, reptiles, fruit, insects, carrion | Breeds in winter. Summer home range is less extensive than winter home range. Prefers mix of open fields and wooded or brushy country. Mainly crepuscular and nocturnal. |
|  | *Myodes gapperi* | Southern Red-Backed Vole | Leaves and shoots, fruit, berries, nuts, seeds, bark, roots, lichen, fungi, insects | Prefers ground with cluttered logs and stumps. Also prefers coniferous forests although deciduous or mixed wood forests are also acceptable. Nests are constructed under the roots of stumps, logs, or brush piles but may also be in holes or branches of trees. Often travel through underground passages to forage and are agile jumpers and climbers. Home range is around 0.14 ha in the winter to 1.4 ha in the summer. Sometimes store food for winter although continue to forage under the snow. Mainly nocturnal and is active year round. |
|  | *Glaucomys sabrinus* | Northern Flying Squirrel | Fungi, lichen, plants, insects, nuts, buds, seeds, fruit | Breeding season in early spring. Lives in family groups and are highly social. Home range estimated between 3-13 ha. Prefers coniferous forest and is less common in mixed wood or deciduous forest. Optimal conditions are cool, moist mature forest with abundant standing and downed snags. Activity is primarily nocturnal and is active through the year. |
|  | *Microtus pennsylvanicus* | Meadow Vole | Plant matter, grasses, roots, seeds | Breeds throughout the year with peak activity in spring. Found in forested areas, wetlands, and riparian. Burrows in soil or fallen logs and debris. Activity is circadian but tends to be more nocturnal in summer and diurnal in winter. |
|  | *Mus musculus* | House Mouse | Fruit, invertebrates, carrion, nuts, flowers, plant | Generally live in close association with humans and are listed as exotic/alien by ASRD (2005). Breeds throughout the year in mild conditions and seasonally in nature. Activity is circadian although primarily nocturnal. |
|  | *Peromyscus maniculatus* | Deer Mouse | Seeds, berries, insects, mushrooms roots | Home range is less than 1 ha. Burrows in soil, fallen logs, and debris. Uses a variety of upland and riparian habitat. Primarily nocturnal and is active through the year. |
|  | *Sorex hoyi* | Pygmny Shrew | Invertebrates | Prefers dense understory. Moist habitat preferred over dry. Requires soil and/or fallen logs and debris for burrowing. Peak activity is at night. |

| EDG | Scientific Name | Common Name | Diet | Additional Information |
|---|---|---|---|---|
| | *Sorex monticolus* | Montane Shrew/Dusky Shrew | Insects and invertebrates | Prefers moist habitat with dense low cover. Dense ground cover is required for predator avoidance. Requires soil and/or fallen debris. Circadian and active throughout the year. |
| | *Sorex palustris* | Water Shrew | Aquatic insects and other invertebrates | Present in shallow water with thick overhanging riparian growth. Rarely found far from water. Nests in sites near water such as underground burrows, rafted logs or other areas providing shelter. Two main periods of activity are four hours after sunset and just before sunrise. |
| | *Tamias minimus* | Least Chipmunk | Acorns conifer seeds, buds, berries, flowers, fungi, insects | Prefers open coniferous forest but commonly found near rock cliffs, river bluffs, and jack pine stands. Most active between April and October and hibernates during the winter although may be active on warm winter days. |
| | *Tamiasciurus hudsonicus* | Red Squirrel | Nuts, seeds, insects, eggs, mushrooms, tree sap | Favours conifers (pine, spruce, fir, hemlock) but also in mixed forest. Most active 2 hours after sunrise and before sunset. Crepuscular and Diurnal. |
| | *Thomomys talpoides* | Gopher | Roots, stems, bulbs, tubers and leaves, domestic crop | Prefers areas with well developed soil (for digging) and low growing plants for food. Active throughout the year. Does not hibernate but often inactive in winter and midsummer. Most burrowing activity occurs in spring and fall. Circadian but peaks of activity at dawn and dusk. |
| | *Zapus hudsonius* | Meadow Jumping Mouse | Invertebrates, seeds, leaves, buds, fruits, and fungi | Mainly nocturnal and hibernates during winter (September to April). Found in moist habitat with thick vegetation (i.e shrubby parts of marshes, meadows, and riparian areas). |
| | *Zapus princeps* | Western Jumping Mouse | Feeds on insects and invertebrates in spring. Grass seeds and small fruits by summer. | Hibernates during winter. Found moist areas with dense grass/shrub cover (marshes, along banks of streams and ponds). |
| **Aerial Mammals** | | | | |
| | *Eptesicus fuscus* | Big Brown Bat | Insects | Forages in wooded areas, farmland, cities. Rests under loose tree bark, in tree hollows, rock crevasses, buildings, caves. |
| | *Lasionycteris noctivagans* | Silver Haired Bat | Insects | Roosts in old growth coniferous/mixed wood forests. Forages over water and in clearings. |
| | *Lasiurus cinereus* | Hoary Bat | Insects | Roosts in trees. |
| | *Myotis lucifugs* | Little Brown Bat | Insects | Common in residential areas. Daytime roosts are often in buildings. Forages over water. |

**Birds**

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| *Buteo jamaicensis* | Red-Tailed Hawk | Small to medium mammals, reptiles, amphibians, insects, fish | Carries prey to perch, partially eats large prey on ground. |
| *Buteo swainsoni* | Swainson's Hawk | Grasshoppers and crickets, squirrels, mice, lizards, frogs, toads, rabbits | Hunts for prey. Common in grasslands and agricultural grain fields. |
| *Falco columbarius* | Merlin | Birds, mammals, large insects | Flies close to ground to catch prey. May frequent cities in winter. |
| *Agelaius phoeniceus* | Red Winged Blackbird | Seeds, grain, berries, fruit, insects, mollusks | Common in fields, riparian thickets and scrub, freshwater marshes. |
| *Bombycilla cedrorum* | Cedar Waxwing | Fruit, plants, insect, sap | Hunts insects along streams. Common in woodland, forest edges. Less common in farmlands, towns, suburbs. |
| *Bombycilla garrulus* | Bohemian Waxwing | Insects, fruits, berries, sap | Common in mixed coniferous and open coniferous woodlands. |
| *Carduelis flammea* | Common Redpoll | Weed and grass seeds, insects | Common in scrubby areas. |
| *Carduelis pinus* | Pine Siskin | Seeds, | Abundant in coniferous and mixed forest, woodlands, parks, weedy fields, and near human habitations. |
| *Carduelis tristis* | American Goldfinch | Seeds | Avoids mature forests and is usually in overgrown or cultivated fields, pastures, roadsides, shorelines. Thistles, dandelions and sunflowers are favored habitat for food and nesting material. |
| *Carpodacus purpureus* | Purple Finch | Seeds, insects, some fruit | Common in open coniferous and mixed wood forest, forest edges, and suburbs. |
| *Catharus guttatus* | Hermit Thrush | Insects, small invertebrates, berries, fruit | Neotropical migrant. Breeds in heavily wooded forests with a mix of conifers and deciduous. |
| *Catharus ustulatus* | Swainson's Thrush | Insects, snails, earthworms | Prefers conifers and mixed forest for nesting. Vulnerable to logging-induced habitat loss. |
| *Colaptes auratus* | Northern Flicker | Insects, berries | Breeds in mixed deciduous and coniferous forests. Prefer moderately open areas and are often found at forest edges, wetlands, shelterbelts. |
| *Columba livia* | Rock Pigeon | In the wild eat grass, weeds, seeds, grains, clover, berries. In the city eats bread crumbs and garbage | Common in urban settings. |
| *Dendroica coronata* | Yellow Rumped Warbler | Insects, tree sap | Abundant in coniferous forest and mixed forest. |

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| *Dendroica petechia* | Yellow Warbler | Insects, some fruit | Common in riparian thickets, second growth woodlands, gardens, orchards, wetlands. |
| *Empidonax minimus* | Least Flycatcher | Insects, berries, seeds | Neotropical migrant. Declining population. |
| *Euphagus cyanocephalus* | Brewer's Blackbird | Insects, fruit, seeds, grains | Common in shrub, riparian woodlands, farms, and around human habitation. |
| *Geothlypis trichas* | Common Yellowthroat | Insects, spiders | Common in marshes, brushy fields, hedgerows, woodland edges. Vulnerable to habitat loss by wetland drainage. |
| *Junco hyemalis* | Dark Eyed Juno | Seeds, grains, insects, berries | Common in coniferous forests, mixed forests, and bogs. |
| *Larus pipixcan* | Franklin's Gull | Insects, fish, leeches, earthworms, crustaceans | Often in large, reedy lakes and marshes. Forages over water, grassy meadows. |
| *Melopiza melodia* | Song Sparrow | Insects, grain, seeds, berries | Abundant in brushy areas, thickets, riparian scrub, weedy fields, urban lawns. |
| *Molothrus ater* | Brown Headed Cowbird | Insects, grains, seeds, fruits | Common in woodlands, forest edge, agricultural areas, and around human habitation. |
| *Passer domesticus* | House Sparrow | Insects, seeds, grain, fruit | Abundant in urban areas, cultivated areas, and around human habitation. |
| *Passerculus sandwichensis* | Savannah Sparrow | Seeds and insects | Abundant in open grassy landscapes. |
| *Picoides pubescens* | Downy Woodpecker | Insects, seeds, nuts, berries, snails, spiders | Drill in dead limbs or tree trunks. |
| *Picoides villosus* | Hairy Woodpecker | Wood boring insects, larvae, insects, nuts, seeds | Roosts in tree cavities. |
| *Piranga ludoviciana* | Western Tanager | Fruit and insects | Common in coniferous forests. |
| *Poecil atricapilla* | Black Capped Chickadee | Insects, seeds, fruit | Common in deciduous or mixed woodlands. Often in riparian growth. |
| *Regulus calendula* | Ruby Crowned Kinglet | Insects, fruits, seeds, tree sap | Vulnerable to habitat loss from logging. Common in coniferous and mixed forests. |
| *Sayornis phoebe* | Eastern Phoebe | Insects, fish, berries, | Parasitized by cowbirds builds nests in buildings, dams, bridges and culverts. |
| *Setophaga ruticilla* | American Redstart | Insects, spiders, berries, fruit | Common in wet deciduous woodland edges, riparian woodlands. |
| *Sitta canadensis* | Red Breasted Nuthatch | Conifer seeds, nuts, insects | Found in coniferous and mixed wood forests. |

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| | *Sitta carolinensis* | White Breasted Nuthatch | Nuts, seeds, spiders, insects | Roosts in tree cavities in winter and tree bark in summer. |
| | *Sphyrapicus varius* | Yellow Bellied Sapsucker | Insects fruit, berries, tree buds | Drills holes in trees for food. |
| | *Spizella arborea* | American Tree Sparrow | Seeds, insects, berries, catkins of willow | Common in weedy fields, open areas with brush and scattered trees, groves of small conifers, and marshes. |
| | *Spizella pallida* | Clay Coloured Sparrow | Seeds and insects | CommIn brushy weedy fields, riparian thickets, forest edges. |
| | *Spizella passerina* | Chipping Sparrow | Seeds, insects | Common in open mixed coniferous-deciduous forest, forest edges, gardens, lawns, and short grassed fields |
| | *Sturnus vulgaris* | European starling | Insects, fruits, grains | Introduced to North America in 1890. Feeds in open areas. |
| | *Tachycineta bicolor* | Tree Swallow | Insects, small crustaceans, berries. | common in open fields, marshes, towns. Very adaptable . Also inhabits country and woodland edges near water. |
| | *Troglodytes aedon* | House Wren | Insects, spiders, snails | Common in open woodlands, farmlands, suburbs, gardens, parks, shrubs. |
| | *Turdus migratorius* | American Robin | Earthworms, insects, berries | Adapted to human disturbance especially agricultural areas and combination of lawns and deciduous trees. Abundant in forest, woodland, gardens, parks. |
| | *Vermivora celata* | Orange Crowned Warbler | Insects, some fruit | Forages for food in branches and foliage of low trees, shrubs, and grasses. |
| | *Vermivora peregrina* | Tennessee Warbler | Insects, fruit, seeds | Common in coniferous and mixed woodlands. |
| | *Vireo gilvus* | Warbling Vireo | Insects, berries | Parasitized by cowbirds, declines in areas where deciduous trees are sprayed with pesticides. |
| | *Zonotrichia albicollis* | White Throated Sparrow | Weed seeds, fruit, tree buds, insects | Common in conifer and mixed forests, clearings, and forest edges. |
| | *Zonotrichia leucophrys* | White Crowned Sparrow | Seeds, insects, plants | Common in woodlands, thickets, wet meadows. |
| | *Corvus brachyrhynchos* | American Crow | Insects, small invertebrates, small amphibians, small mammals, eggs, waste corn and other grains, fruits, field crop, garbage, carrion | Disturbance adapted. Needs open areas for foraging and wooded areas to nest. Is an edge-adapted species. |
| | *Corvus corax* | Common Raven | Small invertebrates, carrion, refuse | Non migratory, found in all types of habitat as long as forested area is available for nesting.. |
| | *Cyanocitta cristata* | Blue Jay | Insects, carrion, eggs, snails, fish, frogs, reptiles, small mammals | Former forest dweller, haS adapted to cities, parks, gardens, forest fragmentation. Widespread in woodlands and residential areas with large shade trees. |

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| *Larus californicus* | California Gull | Agricultural pests (grasshoppers, rodents), fish, eggs, worms, spiders, refuse, carrion | Active forager, breeds near freshwater and alkaline lakes, marshes and rivers. Found around ploughed fields and dumps. |
| *Larus delawarensis* | Ring-Billed Gull | Earthworms, insects, insect larvae, fish, grain, rodents, refuse | forages in dumps, parking lots, near human populations. Also forages in water bodies. Adaptable to human disturbance. |
| *Pica hudsonia* | Black-Billed Magpie | Insects, larvae, carrion, | often found in open country with brushy thickets and scattered trees, especially riparian groves. |
| *Actitis macularia* | Spotted Sandpiper | Invertebrates, insects, larvae, fish | Nest in pebbles, grass, bare soil. |
| *Anas americana* | American Wigeon | Vegetation | Grazes on shore and in fields, feeds in shallow water. |
| *Anas platyrhynchos* | Mallard | Plants also insects, mollusks, crustaceans | Dabbles for plant food. Also forages on shore in fields and woodlots. Leaps directly into flight from water. |
| *Aythya affinis* | Lesser Scaup | Plant and animals material | Dependant on permanent and semi-permanent wetlands with pondweed and red beds and cattails. Nests in vegetation 20 to 60 cm high often in sedge meadow. |
| *Branta canadensis* | Canada Goose | Feed on aquatic and terrestrial plants | Dabblers and grazers. |
| *Bucephala clangula* | Common Goldenye | Mollusks, crustaceans, insects, aquatic plants | Dives for food. Nests in tree snags, deciduous, conifers, man made boxes. |
| *Charadrius vociferus* | Kildeer | Insects | Obtains food from riverbank, golf courses, fields, lawns. Habitat is open grassy uplands, lakeshore clearings, river banks. After nesting will be found near margins of ponds and lakes and other muddy moist places. |
| *Fulica americana* | American Coot | Fronds, leaves, seeds, roots of aquatic plants, insects, amphibians, mollusks, small fish | Feeds in shallows by immersing head or by picking food off the water surface. Gains flight from the water. |
| *Limosa fedoa* | Marbled Godwit | Crustaceans, mollusks, worms, insects, vegetation | Probes in mudflats for food. Nests in grassy meadows near water. |
| *Mergus merganser* | Common Merganser | Small fish, mollusks, crustaceans, aquatic insects, some plants | Dives for food. Takes off from water often flies low following stream courses. Nests in trees, buildings. |
| *Podiceps grisegena* | Red necked Grebe | Crustaceans and small fish. Gathers by diving | Found in open water, shorelines with emergent and submergent vegetation. Needs about 50 to 60 m of open water for takeoff. Nests built on floating mass of decayed and fresh aquatic vegetation in shallow |

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| | | | | water, anchored to reeds. |
| | *Porzana carolina* | Sora | Plants insects, spiders, small crustaceans, snails | Prefers moist, wetland habitat. Needs partial margin of sedges, rushes or cattails. Flooded willow swamps are less favored but may be used for breeding. Nests are anchored in cattail or rushes and placed 15 to 30 cm above water. |
| | *Recurvirostra americana* | American Avocet | Insects, shrimp, crustaceans. | Prefers shallow muddy borders of saline or alkaline lakes or wetlands. Also found in sparsely vegetated marshes. Pools in drawdown are important for feeding and open mudflats or sandy islands with sparse vegetation are used for nesting. |
| | *Perdix Perdix* | Gray Partridge | Leaves, grass, clover, insects, weed seeds | Found in Parkland and Grassland. Mostly in open grassland and agricultural lands with adjacent woody cover. |
| | *Tympanuchus phasianellus* | Sharp Tailed Grouse | Insects, seeds, leaves, flowers, fruit | Has generalized habitat requirements. Found in open prairie, shrubby sandhills and margins of water courses. In the Boreal, it uses openings made by fire, bogs, and man. Vulnerable to wetland loss; sensitive to human disturbance. |
| | *Bonasa umbellus* | Ruffed Grouse | Seeds, fruits, berries, leaves and insects | Aspen dominated and mixed wood forests. Small openings in deciduous forest are important for brood use and heavy understory is required for drumming sites. |

Yellow colour indicates provincial listing as “Sensitive”

Orange colour indicates provincial listing as “May Be At Risk”

Red colour indicates provincial listing as “At Risk”

### 1.2 HABITAT-SPECIES CHARTS

The following tables provide reference information regarding they typical species found in specific habitats. This information is designed to be used as a basic reference to give the transportation engineer a general idea of what species will likely be found in their project area. Consultation with an ecologist is recommended to determine the types of wildlife that are actually located in the area.

#### 1.2.1 Riparian

| | EDG | Scientific Name | Common Name |
|---|---|---|---|
| **Amphibians** | | | |
| | AMP | *Ambystoma tigrinum* | Tiger Salamander |
| | AMP | *Bufo boreas* | Western Toad |
| | AMP | *Bufo hemiophrys* | Canadian Toad |
| | AMP | *Pseudacris maculata* | Boreal Chorus Frog |
| | AMP | *Rana pipiens* | Northern Leopard Frog |
| | AMP | *Rana sylvatica* | Wood Frog |
| | AMP | *Thamnophis radix* | Plains Garter Snake |
| | AMP | *Thamnophis sirtalis* | Red Sided Garter Snake |
| | AMP | *Ambystoma tigrinum* | Tiger Salamander |
| **Terrestrial Mammals** | | | |
| | LT | *Alces alces* | Moose |
| | LT | *Cervus elaphus* | Elk |
| | LT | *Odocoileus hemionus* | Mule Deer |
| | MT | *Castor canadensis* | Beaver |
| | MT | *Mustela spp.* | Weasel |
| | MT | *Ondatra zibethicus* | Muskrat |
| | ST | *Sorex hoyi* | Pygmny Shrew |
| | ST | *Sorex monticolus* | Montane Shrew/Dusky Shrew |
| | ST | *Sorex palustris* | Water Shrew |
| | ST | *Zapus princes* | Western Jumping Mouse |
| **Birds** | | | |
| | OB | *Agelaius phoeniceus* | Red Winged Blackbird |
| | OB | *Bombycilla cedrorum* | Cedar Waxwing |
| | OB | *Dendroica petechia* | Yellow Warbler |
| | OB | *Empidonax minimus* | Least Flycatcher |
| | OB | *Euphagus cyanocephalus* | Brewer's Blackbird |
| | OB | *Melopiza melodia* | Song Sparrow |
| | OB | *Sturnus vulgaris* | European Starling |
| | SB | *Corvus brachyrhynchos* | American Crow |
| | SB | *Corvus corax* | Common Raven |
| | SB | *Pica hudsonia* | Black-Billed Magpie |
| | WB | *Actitis macularia* | Spotted Sandpiper |
| | WB | *Limosa fedoa* | Marbled Godwit |
| | WB | *Porzana carolina* | Sora |
| | WB | *Recurvirostra americana* | American Avocet |

### 1.2.2 Treed Areas

| | EDG | Scientific Name | Common Name |
|---|---|---|---|
| **Amphibians** | | | |
| | AMP | *Rana sylvatica* | Wood Frog |
| | AMP | *Thamnophis sirtalis* | Red Sided Garter Snake |
| **Terrestrial Mammals** | | | |
| | LT | *Alces alces* | Moose |
| | LT | *Cervus elaphus* | Elk |
| | LT | *Odocoileus hemionus* | Mule Deer |
| | LT | *Odocoileus virginianus* | White Tailed Deer |
| | MT | *Canis lantrans* | Coyote |
| | MT | *Erethizon dorsatum* | Porcupine |
| | MT | *Lepus americanus* | Snowshoe Hare |
| | MT | *Lepus townsendii* | White Tailed Jackrabbit |
| | MT | *Martens spp* | Marten |
| | MT | *Mephitis mephitis* | Skunk |
| | MT | *Mustela spp.* | Weasel |
| | MT | *Vulpes vulpes* | Red Fox |
| | ST | *Clethrionomys gapperi* | Vole |
| | ST | *Glaucomys sabrinus* | Northern Flying Squirrel |
| | ST | *Microtus pennsylvanicus* | Vole |
| | ST | *Mus musculus* | House Mouse |
| | ST | *Peromyscus maniculatus* | Deer Mouse |
| | ST | *Sorex hoyi* | Pygmny Shrew |
| | ST | *Tamias minimus* | Least Chipmunk |
| | ST | *Tamiasciurus hudsonicus* | Red Squirrel |
| **Aerial Mammals** | | | |
| | AM | *Eptesicus fuscus* | Big Brown Bat |
| | AM | *Lasionycteris noctivagans* | Silver Haired Bat |
| | AM | *Lasiurus cinereus* | Hoary Bat |
| | AM | *Myotis lucifugs* | Little Brown Bat |
| **Birds** | | | |
| | BOP | *Buteo jamaicensis* | Red-Tailed Hawk |
| | BOP | *Falco columbarius* | Merlin |
| | OB | *Bombycilla cedrorum* | Cedar Waxwing |
| | OB | *Bombycilla garrulus* | Bohemian Waxwing |
| | OB | *Carduelis flammea* | Common Redpoll |
| | OB | *Carduelis pinus* | Pine Siskin |
| | OB | *Carduelis tristis* | American Goldfinch |
| | OB | *Carpodacus purpureus* | Purple Finch |
| | OB | *Catharus guttatus* | Hermit Thush |
| | OB | *Catharus ustulatus* | Swainson's Thrush |
| | OB | *Colaptes auratus* | Northern Flicker |
| | OB | *Columba livia* | Rock Pigeon |
| | OB | *Dendroica coronata* | Yellow Rumped Warbler |
| | OB | *Dendroica petechia* | Yellow Warbler |
| | OB | *Empidonax minimus* | Least Flycatcher |
| | OB | *Euphagus cyanocephalus* | Brewer's Blackbird |
| | OB | *Geothlypis trichas* | Common Yellowthroat |
| | OB | *Junco hyemalis* | Dark Eyed Juno |
| | OB | *Passer domesticus* | House Sparrow |
| | OB | *Picoides pubescens* | Downy Woodpecker |

| EDG | Scientific Name | Common Name |
|---|---|---|
| OB | *Picoides villosus* | Hairy Woodpecker |
| OB | *Piranga ludoviciana* | Western Tanager |
| OB | *Poecil atricapilla* | Black Capped Chickadee |
| OB | *Regulus calendula* | Ruby Crowned Kinglet |
| OB | *Sayornis phoebe* | Eastern Phoebe |
| OB | *Setophaga ruticilla* | American Redstart |
| OB | *Sitta canadensis* | Red Breasted Nuthatch |
| OB | *Sitta carolinensis* | White Breasted Nuthatch |
| OB | *Sphyrapicus varius* | Yellow Bellied Sapsucker |
| OB | *Spizella arborea* | American Tree Sparrow |
| OB | *Spizella pallida* | Clay Coloured Sparrow |
| OB | *Spizella passerina* | Chipping Sparrow |
| OB | *Tachycineta bicolor* | Tree Swallow |
| OB | *Troglodytes aedon* | House Wren |
| OB | *Turdus migratorius* | American Robin |
| OB | *Vermivora celata* | Orange Crowned Warbler |
| OB | *Vermivora peregrina* | Tennessee Warbler |
| OB | *Vireo gilvus* | Warbling Vireo |
| OB | *Zonotrichia albicollis* | White Throated Sparrow |
| OB | *Zonotrichia leucophrys* | White Crowned Sparrow |
| SB | *Corvus brachyrhynchos* | American Crow |
| SB | *Corvus corax* | Common Raven |
| SB | *Cyanocitta cristata* | Blue Jay |
| SB | *Pica hudsonia* | Black-Billed Magpie |

### 1.2.3 Permanent Water

| | EDG | Scientific Name | Common Name |
|---|---|---|---|
| **Amphibians** | | | |
| | AMP | *Ambystoma tigrinum* | Tiger Salamander |
| | AMP | *Rana sylvatica* | Wood Frog |
| **Aquatic** | | | |
| | AQ | *Acipenser fulvescens* | Lake Sturgeon |
| | AQ | *Catostomus catostomus* | Longnose Sucker |
| | AQ | *Colostomies commersoni* | White Sucker |
| | AQ | *Esox lucius* | Northern Pike |
| | AQ | *Hiodon alosoides* | Goldeye |
| | AQ | *Lota lota* | Burbot |
| | AQ | *Prosopium williamsoni* | Mountain Whitefish |
| | AQ | *Stizostedion canadense* | Sauger |
| | AQ | *Stizostedion vitreum* | Walleye |
| **Terrestrial Mammals** | | | |
| | MT | *Castor canadensis* | Beaver |
| | MT | *Ondatra zibethicus* | Muskrat |
| | ST | *Sorex palustris* | Water Shrew |
| **Birds** | | | |
| | OB | *Larus pipixcan* | Franklin's Gull |
| | OB | *Sayornis phoebe* | Eastern Phoebe |
| | SB | *Larus californicus* | California Gull |
| | SB | *Larus delawarensis* | Ring-Billed Gull |

| EDG | Scientific Name | Common Name |
|---|---|---|
| SB | *Pica hudsonia* | Black-billed Magpie |
| WB | *Actitis macularia* | Spotted sandpiper |
| WB | *Anas americana* | American Wigeon |
| WB | *Anas platyrhynchos* | Mallard |
| WB | *Aythya affinis* | Lesser Scaup |
| WB | *Branta canadensis* | Canada Goose |
| WB | *Bucephala clangula* | Common Goldenye |
| WB | *Charadrius vociferus* | Kildeer |
| WB | *Fulica americana* | American Coot |
| WB | *Mergus merganser* | Common Merganser |
| WB | *Podiceps grisegena* | Red necked Grebe |
| WB | *Recurvirostra americana* | American Avocet |

### 1.2.4 Grassland

| | EDG | Scientific Name | Common Name |
|---|---|---|---|
| **Terrestrial Mammals** | | | |
| | LT | *Odocoileus virginianus* | White Tailed Deer |
| | MT | *Lepus americanus* | Snowshoe Hare |
| | MT | *Lepus townsendii* | White Tailed Jackrabbit |
| | MT | *Vulpes vulpes* | Red Fox |
| | ST | *Microtus pennsylvanicus* | Vole |
| | ST | *Mus musculus* | House Mouse |
| | ST | *Thomomys talpoides* | Gopher |
| | ST | *Zapus hudsonius* | Meadow Jumping Mouse |
| **Birds** | | | |
| | BOP | *Buteo swainsoni* | Swainson's Hawk |
| | BOP | *Falco columbarius* | Merlin |
| | OB | *Carduelis flammea* | Common Redpoll |
| | OB | *Carduelis tristis* | American Goldfinch |
| | OB | *Columba livia* | Rock Pigeon |
| | OB | *Larus pipixcan* | Franklin's Gul |
| | OB | *Melopiza melodia* | Song Sparrow |
| | OB | *Molothrus ater* | Brown Headed Cowbird |
| | OB | *Passer domesticus* | House Sparrow |
| | OB | *Passerculus sandwichensis* | Savannah Sparrow |
| | OB | *Sayornis phoebe* | Eastern Phoebe |
| | OB | *Spizella arborea* | American Tree Sparrow |
| | OB | *Spizella pallida* | Clay Coloured Sparrow |
| | OB | *Sturnus vulgaris* | European Starling |
| | OB | *Tachycineta bicolor* | Tree Swallow |
| | OB | *Troglodytes aedon* | House Wren |
| | OB | *Turdus migratorius* | American Robin |
| | OB | *Zonotrichia leucophrys* | White Crowned Sparrow |
| | SB | *Corvus brachyrhynchos* | American Crow |
| | SB | *Corvus corax* | Common Raven |
| | SB | *Larus californicus* | California Gull |
| | SB | *Larus delawarensis* | Ring-Billed Gull |
| | SB | *Pica hudsonia* | Black-Billed Magpie |

### 1.2.5 Wetland

| | EDG | Scientific Name | Common Name |
|---|---|---|---|
| **Amphibians** | | | |
| | AMP | *Bufo boreas* | Western Toad |
| | AMP | *Bufo hemiophrys* | Canadian Toad |
| | AMP | *Pseudacris maculata* | Boreal Chorus Frog |
| **Terrestrial Mammals** | | | |
| | MT | *Castor canadensis* | Beaver |
| | MT | *Ondatra zibethicus* | Muskrat |
| | ST | *Sorex hoyi* | Pygmny Shrew |
| | ST | *Sorex palustris* | Water Shrew |
| **Birds** | | | |
| | OB | *Agelaius phoeniceus* | Red winged blackbird |
| | OB | *Geothlypis trichas* | Common yellowthroat |
| | OB | *Setophaga ruticilla* | American redstart |
| | SB | *Pica hudsonia* | Black-billed Magpie |
| | WB | *Actitis macularia* | Spotted sandpiper |
| | WB | *Anas americana* | American Wigeon |
| | WB | *Anas platyrhynchos* | Mallard |
| | WB | *Aythya affinis* | Lesser Scaup |
| | WB | *Branta canadensis* | Canada Goose |
| | WB | *Bucephala clangula* | Common Goldenye |
| | WB | *Charadrius vociferus* | Kildeer |
| | WB | *Fulica americana* | American Coot |
| | WB | *Limosa fedoa* | Marbled godwit |
| | WB | *Porzana carolina* | Sora |
| | WB | *Recurvirostra americana* | American Avocet |

## 1.3 HOME RANGE AND DISPERSAL DISTANCE CHART

The information presented in the chart below is to be used as a reference for Section 4.3.5. This table contains home ranges for several common species. If rare species or species not on this table are present, additional research is recommended to help determine the home range of the species.

| EDG | Scientific Name | Common Name | HR (ha) | HR ($km^2$) | √HR (km) | 7*√HR (km) |
|---|---|---|---|---|---|---|
| **Terrestrial Mammals** | | | | | | |
| LT | *Alces alces* | Moose | 1215.00 | 12.15 | 3.49 | 24.40 |
| LT | *Cervus elaphus* | Elk | 1292.54 | 12.93 | 3.60 | 25.17 |
| LT | *Odocoileus hemionus* | Mule Deer | 285.27 | 2.85 | 1.69 | 11.82 |
| LT | *Odocoileus virginianus* | White Tailed Deer | 196.06 | 1.96 | 1.40 | 9.80 |
| MT | *Canis lantrans* | Coyote | 7597.57 | 75.98 | 8.72 | 61.01 |
| MT | *Erethizon dorsatum* | Porcupine | 11.29 | 0.11 | 0.34 | 2.35 |
| MT | *Lepus americanus* | Snowshoe Hare | 5.93 | 0.06 | 0.24 | 1.70 |
| MT | *Lepus townsendii* | White Tailed Jackrabbit | 145.55 | 1.46 | 1.21 | 8.45 |
| MT | *Martens spp* | Marten | 209.31 | 2.09 | 1.45 | 10.13 |
| MT | *Mephitis mephitis* | Skunk | 294.67 | 2.95 | 1.72 | 12.02 |
| MT | *Mustela spp.* | Weasel | 111.29 | 1.11 | 1.05 | 7.38 |
| MT | *Vulpes vulpes* | Red Fox | 387.34 | 3.87 | 1.97 | 13.78 |

| EDG | Scientific Name | Common Name | HR (ha) | HR ($km^2$) | √HR (km) | 7*√HR (km) |
|---|---|---|---|---|---|---|
| ST | *Clethrionomys gapperi* | Vole | 0.25 | 0.00 | 0.05 | 0.35 |
| ST | *Glaucomys sabrinus* | Northern Flying Squirrel | 4.14 | 0.04 | 0.20 | 1.42 |
| ST | *Microtus pennsylvanicus* | Vole | 0.12 | 0.00 | 0.03 | 0.24 |
| ST | *Peromyscus maniculatus* | Deer Mouse | 0.81 | 0.01 | 0.09 | 0.63 |
| ST | *Sorex monticolus* | Montane Shrew/Dusky Shrew | 0.11 | 0.00 | 0.03 | 0.23 |
| ST | *Tamias minimus* | Least Chipmunk | 6.73 | 0.07 | 0.26 | 1.82 |
| ST | *Tamiasciurus hudsonicus* | Red Squirrel | 1.10 | 0.01 | 0.10 | 0.73 |
| ST | *Thomomys talpoides* | Gopher | 0.02 | 0.00 | 0.01 | 0.10 |
| **Birds** | | | | | | |
| BOP | *Buteo jamaicensis* | Red-Tailed Hawk | 424.92 | 4.25 | 2.06 | 14.43 |
| BOP | *Buteo swainsoni* | Swainson's Hawk | 246.46 | 2.46 | 1.57 | 10.99 |
| OB | *Dendroica petechia* | Yellow Warbler | 0.17 | 0.00 | 0.04 | 0.29 |
| OB | *Empidonax minimus* | Least Flycatcher | 0.18 | 0.00 | 0.04 | 0.30 |
| OB | *Melopiza melodia* | Song Sparrow | 0.16 | 0.00 | 0.04 | 0.28 |
| OB | *Spizella passerina* | Chipping Sparrow | 3.08 | 0.03 | 0.18 | 1.23 |

Data sources: Bissonette and Adair 2007; Holling 1992

### 1.4 ADDITIONAL STUDIES

Additional studies may be required if sufficient ecological information is not available for the project area. The types of studies that should be done for a given project should be determined by looking at the potentially affected species. The primary purpose of the studies should be to:

- Determine if the potentially affected species is actually using the habitat;
- Determine which habitats the potentially affected species are using; and
- Determine which habitat patches require connectivity for continued species persistence.

Lists of potential studies that could be performed are included below and organized by habitat type. This list was created to provide transportation engineers with some background on the types of environmental studies that are available and will provide a starting point for requesting environmental services from qualified professionals.

### 1.4.1 Surveys for Wetland and Riparian Habitats

- Amphibian survey
- Small, medium, and large terrestrial wildlife survey
- Bird survey
- Fish survey if wetland is, or is permanently or seasonally connected to, a permanent water body
- Bat survey if area is near potential roosting habitats such as tree stands or old buildings

### 1.4.2 Surveys for Forested Habitats

- Small, medium, and large terrestrial wildlife survey
- Bird survey
- Bat survey if area is near wetland or riparian habitats

### 1.4.3 Surveys for Grassland and Cropland Habitats

- Small, medium, and large terrestrial wildlife survey
- Bird survey

### 1.4.4 Surveys for Highly Developed Habitats

- Amphibian survey if area is near wet habitats
- Small and medium terrestrial wildlife survey
- Bird survey (especially if tree or wetland disturbance will occur)
- Bat survey if area is near wetland or riparian habitats

# APPENDIX C REGULATORY CONTEXT

# Appendix C - Regulatory Context

This section is intended to provide the user with an overview of legislation that potentially may be applicable to the transportation project. Please note, this list is not extensive and additional legislation may apply to the project. Several regulatory approvals will likely be required for the project.

It is recommended that regulatory bodies are consulted early in the project life to determine requirements. These regulatory requirements may limit the types and design of mitigation measures and it is good to be aware of these restrictions early in the process.

## 1.1 REGULATORY CONTEXT

Various federal, provincial and municipal acts and bylaws likely apply to the project; this document was not written pursuant to any one piece of legislation. A list of applicable legislation, although not exhaustive, and how it relates to this project has been provided in the following sections.

### 1.1.1 Federal Legislation

### 1.1.2 Migratory Birds Convention Act

The *Migratory Birds Convention Act, 1994* (MBCA) and the *Migratory Birds Regulations* (MBR) are directed at the protection and preservation of migratory birds and migratory bird habitat. The MBCA and MBR apply to various:

- migratory game birds, including ducks, geese, swan, cranes, shorebirds and pigeons;
- migratory insectivorous birds, including chickadees, cuckoos, hummingbirds, robins, swallows and woodpeckers; and
- other migratory non-game birds, including gulls, herons, loons, and puffins.

This legislation creates a number of prohibitions designed to protect and preserve migratory birds. These include, but are not limited to:

- prohibition against disturbing, destroying, or taking a nest, egg, or nest shelter of a migratory bird; and
- prohibition against depositing or permitting to be deposited oil, oil wastes or any other substances harmful to migratory birds in any waters or any area frequented by migratory birds.

The Minister can issue permits for certain activities related to migratory birds. However, there are no permits for disturbing, destroying, or taking a nest, egg, or nest shelter of a migratory bird, nor for depositing or permitting to be deposited oil, oil wastes or any other substances harmful to migratory birds in any waters or any area frequented by migratory birds. These activities are strictly prohibited by the legislation. If municipal development activities result in the destruction or disturbance of migratory birds, nests or eggs, Environment Canada can take enforcement action.

Typically, if construction activities necessitate the cutting, transplanting or disturbance of trees or other nesting areas

of migratory birds, Environment Canada will stipulate the times of the year that the construction can be undertaken (which coincides with times that the birds are not nesting and raising their young). These timeframes can vary depending on the particular migratory bird species, but will typically range between March/April through to September/October.

This *Act* will become important during tree removal activities necessary for the development of the area (Environment Canada 2008).

#### 1.1.2.1 Fisheries Act

The *Fisheries Act* is directed at the proper management and control of Canada's fisheries, conservation of fish and protection of fish habitat, and prevention of pollution. Under this Act, any activity that has the potential to harm or disrupt or destroy fish habitat requires authorization from the Minister (Fisheries and Oceans Canada 2008).

#### 1.1.2.2 Navigable Waters Protection Act

The primary objective of the *Navigable Waters Protection Act* is to protect Canada's waterbodies by prohibiting any activity that may hamper their navigability. This may include such river work activities as:

- Any bridge, boom, dam, causeway, wharf, dock, boathouse, intake, outfall, etc.;
- Dredging; dumping of fill, retaining wall, groyne, breakwater;
- Submarine or overhead cables, tunnel, pipeline;
- Aquaculture facilities; and
- Any other device, structure, or thing whether similar in character to the above or not.

The Minister of Transport is responsible for determining the navigability of a waterbody and will determine regulatory requirements based on this overall assessment. The legislation is generally inclusive of any navigable waterbody beginning at their high water mark (Transport Canada 2005)

#### 1.1.2.3 Species at Risk Act (SARA)

The *Species at Risk Act* provides protection for Canadian indigenous species, subspecies, and distinct populations to prevent them from becoming extirpated or extinct, and provides for the recovery of endangered and threatened wildlife species and their habitats (Environment Canada 2005)

### 1.1.3 Provincial Legislation

#### 1.1.3.1 Water Act

The *Water Act* came into force on January 1, 1999 and focuses on protecting and managing Alberta's water resource. The Water Act identifies the following as surface water bodies:

- Any permanent or intermittent surface water body supporting an aquatic and terrestrial environment, including soil types, plant and animal species. (e.g. slough/marsh wetlands, alkali sloughs, prairie potholes, shallow open water, ephemeral wetlands, bogs, fens, lakes, peat lands, oxbows, swamps, muskeg, water courses);
- A water body created solely as a compensatory wetland as a meditative measure due to the loss or destruction

of a previous natural surface water body; and

- A wetland control project.

(Alberta Environment 2008)

The *Water* Act provides Alberta Environment authority over all the water in the province. Under the *Water Act* the following activities related to water bodies require an approval:

- Partial or complete infilling of a water body for recreational, agricultural, and industrial uses, road construction, residential development, or any other purpose;
- Any activity impacting, or has the potential to impact (cumulative effects), the aquatic environment and involving the disturbance, alteration, or modification of a water body which includes field ditching;
- Erosion protection (e.g. rip-rap, rock armouring, gabion baskets, etc);
- Removal or destruction of vegetation, aquatic plants and trees within the confines of bed and shores of a water body;
- Draining of a water body; or,
- Re-alignment of a water body.

In addition, the Act also addresses the following:

- Protects existing licenses that are in good standing, by bringing them forward into and making them subject to the new *Act;*
- Protects existing traditional agricultural uses of water through a streamlined, voluntary registration process that "grandfathers" the relative priority of the right according to the date when the water was first used;
- Recognizes the importance of protecting Alberta's rivers, streams, lakes and wetlands, by requiring that a strategy for protecting the aquatic environment be developed as part of the provincial water management planning framework;
- Prohibits the export of Alberta's water to the United States; and
- Prohibits any inter-basin transfers of water between Alberta's major river basins.

The *Act* prescribes that all water is the property of the Crown. An approval is required to conduct an activity in a water body (s.36). An activity is defined broadly to include placing/constructing works within a water body, removing or disturbing ground and/or vegetation that results in altering the flow, level, direction and/or location of a water body. A license is required to divert or transfer water from a water body (s.49 (Alberta Environment 2008).

#### 1.1.3.2 Public Lands Act

In 1930, Canada transferred control for the natural resources in Alberta to the province. Alberta passed the *Provincial Lands Act* on March 28, 1931, for the administration of lands, minerals, forests, fisheries and to control the drilling of gas wells. In 1949, this legislation was amended to become the *Public Lands Act*. It currently regulates various public land uses (i.e. forestry, grazing, land dispositions), sale and purchase of land, and declaration of water bodies as being owned by the Crown.

Any construction activity that falls within Crown owned land requires approvals and authorization by Alberta Sustainable Resource Development (Alberta Sustainable Resource Development 2008).

#### 1.1.3.3 Provincial Parks Act

The *Provincial Parks Act* allows for the establishment of provincial parks within the Province of Alberta and gives authority to the Ministry of Tourism, Parks, Recreation and Culture to manage these parks.

If proposed development impacts a Provincial Park, the work will need to be coordinated through the Ministry of Tourism, Parks, Recreation and Culture (Alberta Ministry of Tourism, Parks, Recreation, and Culture 2008).

#### 1.1.3.4 Alberta Wildlife Act

Section 38 of the *Wildlife Act* states that without authorization, a person shall not willfully “molest, disturb or destroy a house, nest or den of prescribed wildlife or a beaver dam in prescribed areas or at prescribed times.” “Prescribed wildlife” is defined as;

- wildlife animals that are endangered animals, throughout Alberta and throughout the year;
- migratory birds as defined in the Migratory Birds Convention Act (Canada) throughout Alberta and throughout the year;
- snakes and bats, throughout Alberta and from September 1 to April 30;
- houses and dens of beaver on any land that is not privately owned, houses;
- nests and dens of all wildlife in a wildlife or game bird sanctuary; and
- hibernacula of prairie rattlesnake throughout Alberta and throughout the year.

(Alberta Sustainable Resource Development 2008)

#### 1.1.3.5 Environmental Protection and Enhancement Act

The *Wastewater and Storm Drainage Regulatio*n, under *The Environmental Protection and Enhancement Act* (EPEA) (1992), gives Alberta Environment the responsibility of regulating storm drainage and wastewater systems including the establishment of standards for such facilities and their operation.  This includes naturalized wetlands, other stormwater management facilities, outfalls and related piping (Alberta Environment 2008).

#### 1.1.3.6 Historical Resources Act

The need to preserve and study historic resources has long been recognized and was officially reflected in the passage of the *Alberta Heritage Act* in 1973 (now the *Alberta Historical Resources Act*). Most of Alberta's historic resources fall into one of three categories: buildings and other structures; archaeological sites; and palaeontological sites.

The *Historical Resources Act* provides the framework for Historic Resources Impact Assessments (HRIAs) and mitigative studies.  If a project or activitiy could result in the alteration, damage or destruction of an historic resource, the proponent may be required to:

- conduct an HRIA on lands that may be affected by the activity;

- submit to Alberta Culture and Community Spirit a report discussing the results of the HRIA;
- avoid any historic resources endangered by activity; or
- mitigate potential impacts by undertaking comprehensive studies.

(Alberta Ministry of Tourism, Parks, Recreation, and Culture 2008)

#### 1.1.4 Municipal Legislation and Policies

##### 1.1.4.1 North Saskatchewan River Valley Area Redevelopment Plan (Bylaw 7188)

Edmonton's Bylaw #7188 was put in place to ensure the preservation of the natural character and environment of the North Saskatchewan River Valley (NSRV) and Ravine System. This bylaw defines what areas are included in the River Valley and Ravine System and stipulates that an environmental review process must take place for every development within this area (City of Edmonton 2008).

##### 1.1.4.2 Natural Area Systems Policy (Policy C531)

Edmonton's Policy C531 gives the City direction to conserve natural areas located within the City's table lands. The policy stipulates that natural site assessments (NSAs) should be completed on natural areas identified in the Inventory of Environmentally Sensitive and Significant Natural Areas report (Geowest 1993). Upon the decision to conserve a site, the policy also requires that a management plan be completed for the natural area (City of Edmonton 2008).

### 1.2 ENVIRONMENTAL STUDIES

All levels of government require specific environmental studies that do one of two things: identify the current and historical biological conditions present on site; or identify the potential impacts and possible mitigations associated with current site conditions. The list below outlines (but is not limited to) a variety of regulatory requirements that may or may not affect a project, according to the respective governing agent.

#### 1.2.1 Federal

##### 1.2.1.1 The Department of Fisheries and Oceans Canada

Before you start your project, contact your local Department of Fisheries and Oceans Canada office in your area to discuss in general terms the construction of the work you are proposing to build.

In order to identify if any waterbodies in or around the subject site are fish bearing, a Fish Habitat Assessment may be required. The field assessment is conducted by a qualified aquatic specialist and generally includes the inventory of the following variables within the waterbody in question:

- channel characteristics (pattern, average channel width and wetted width, average);
- habitat-type quality (pool, run and flat);
- bed material (% substrate size distribution and compaction);
- bank characteristics (height, slope, % unstable, and texture);
- vegetation (instream and riparian); and

- stage of stream.

#### 1.2.1.2 Navigable Waters Protection Act (NWPA)

Before you start your project, contact the nearest Navigable Waters Protection Program (NWPP) Office to discuss the proposed construction. For the Edmonton area, the current contact information is as follows:

Transport Canada, Prairie and Northern Region
Canada Place, 1100-9700 Jasper Avenue
Edmonton AB, T5J 4E6
Phone: 780-495-8215
Fax: 780-495-8607

Navigable Waters Protection Officers will assist with determining the application requirements.

Finalized the project design should be submitted to the NWPP Office and should include details about the applicant, the nature of the work, other permits obtained, property ownership and drawings and plans of the proposed work. It is extremely important that plans be drawn accurately. Details of work may also include:

- Proposed construction schedule;
- Status of work (existing, proposed, or both);
- Name of waterway where the work is or will be located including width and depth;
- Legal description (section, lot number, concession, county/township, city/town, province/territory, etc.);
- Environmental assessment documents, if available;
- Identification of upland property owners; and
- Method of construction, i.e., equipment to be used, temporary construction that may impact on navigation.

### 1.2.2 Provincial

#### 1.2.2.1 Environmental Protection and Enhancement Act (EPEA)

Before you start your project, contact the Alberta Environment Approvals Centre to discuss in general terms the construction of the work you are proposing to build.

An Alberta Environment Officer will assist you in determining what information and documentation is required for preparing and submitting an application under the EPEA. Details of work may include:

- Proposed construction schedule;
- Finalized engineering drawings;
- Status of work (existing, proposed, or both);
- Legal description (section, lot number, concession, county/township, city/town, province/territory, etc.);
- Environmental assessment documents, if available;
- Identification of upland property owners; and
- Method of construction, i.e., equipment to be used, temporary construction that may impact on navigation.

#### 1.2.2.2 The Water Act

The province is the owner of all water in Alberta and the department is responsible for managing this very important resource. Alberta's *Water Act* requires that an approval and/or license be obtained before undertaking a construction activity in a water body or before diverting and using water from a water body. Some activities and/or diversions of water are exempt from requiring an approval or license.

For the purposes of this guide, the following criteria shall be used to identify a surface water body:

- Any permanent or intermittent surface water body supporting an aquatic and terrestrial environment (including soil types, plant and animal species) (e.g. slough/marsh wetlands, alkali sloughs, prairie potholes, shallow open water, ephemeral wetlands, bogs, fens, lakes, peatlands, oxbows, swamps, muskeg, water courses);
- A water body created solely as a compensatory wetland as a mitigative measure due to the loss or destruction of a previous natural surface water body; and
- A wetland control project.

The following are not considered water bodies for the purpose of this guide (*Water Act* approvals may still be required):

- roadside ditches;
- artificial waterbodies (reservoirs, dugouts, borrow pits, storm water detention/retention ponds, etc.) that are not constructed as wetland control projects or as a mitigation measure for the loss of natural water bodies; and,
- temporary flooding of land during snowmelt, spring runoff or heavy rainstorms.

The services of a Qualified Aquatic Environment Specialist should be retained to undertake pre-development and post-development aquatic environment assessments when the department determines a need to develop mitigation options. The following assessments are often required for projects that may have adverse effects on Alberta's waterbodies and are the responsibility of the proponent:

- Wetland Assessment (Wetland Compensation);
- Hydrological Analysis;
- Erosion and Sedimentation Control Plan; and
- Topographical Survey.

(Alberta Environment 2008)

#### 1.2.2.3 Public Lands Act

The province is the owner of the bed and shore on all permanent waterbodies in Alberta. Alberta's *Public Lands Act* requires that an approval and/or license be obtained before undertaking a construction activity in a water body or before diverting and using water from a water body. Some activities and/or diversions of water are exempt from requiring an approval or license. The following assessments are often required for projects that may have effects on Alberta's waterbodies and are the responsibility of the proponent:

- Wetland Assessment (Wetland Compensation); and

- Application Form for Shore Line / Water Body Modification

(Alberta Sustainable Resources Development 2008)

#### 1.2.2.4 Historical Resources Act

Before you start your project, contact the Alberta Culture and Community Spirit Branch to discuss in general terms the construction of the work you are proposing to build.

An Officer will assist you in determining what information and documentation is required for preparing and submitting an application under the *Historical Resources Act*. Details of work may include:

- Proposed construction schedule;
- Status of work (existing, proposed, or both);
- Legal description (section, lot number, concession, county/township, city/town, province/territory, etc.);
- Identification of upland property owners; and
- Method of construction, i.e., equipment to be used, temporary construction that may impact on navigation.

If any lands located within the project are identified as containing or having the potential to contain significant archeological sites, then a Historical Resource Assessment may be required. A Historic Resources Impact Assessment (HRIA) is an evaluation of the effect of a proposed operation or activity on historic resources. HRIA's must be done prior to construction or excavating projects where there is the potential for damage to archaeological remains, above or below the ground. An HRIA is carried out by a professional archaeologist. (Alberta Ministry of Tourism, Parks, Recreation, and Culture 2008)

### 1.2.3 Municipal

#### 1.2.3.1 North Saskatchewan River Valley Area Redevelopment Plan (Bylaw 7188)

Edmonton's Bylaw #7188 was put in place to ensure the preservation of the natural character and environment of the North Saskatchewan River Valley (NSRV) and Ravine System. Environmental studies pursuant to Bylaw 7188 may include (but is not limited) the following reports:

- Municipal Environmental Impact Assessment;
- Municipal Environmental Screening Report;
- Stage I and II Natural Site Assessments;
- Phase I, II, and III Environmental Site Assessments;
- Wetland Assessment; and
- Ecological Network Report.

#### 1.2.3.2 Natural Area Systems Policy (Policy C531)

Edmonton’s Policy C467 gives the City direction to conserve natural areas located within the City’s table lands and to integrate them into new developments whenever possible. The policy stipulates that natural site assessments (NSAs) should be completed on natural areas identified in the Inventory of Environmentally Sensitive and Significant Natural Areas report

(Geowest 1993). Environmental studies pursuant to Policy C467 may include (but is not limited) the following reports:

- Stage I and II Natural Site Assessments;
- Natural Area Management Plans; and
- Environmental Review Requirements.

(City of Edmonton 2008)

# APPENDIX D – USER CHECKLISTS

# Appendix D – User Checklists

The checklist presented in this section is designed as an additional tool to highlight the important questions that must be answered when designing a wildlife passage and to provide a place to organize the information obtained during the process. Use of this checklist is not a requirement and it may or may not be helpful to certain individuals.

The checklist follows the general flow of both the document and Decision Tree 1 and Decision Tree 2. If additional information is required for a specific question section references have been provided. If "unknown" is checked for any of the questions additional study may be required.

Transportation engineers may have difficulty answering some questions with certainty. As a result, it is strongly advised that the process of designing a wildlife passage be a joint effort between both ecologists and engineers.

## 1.1 PLANNING CHECKLIST

Project: ______________________________

Date: ______________________________

Location: ______________________________

______________________________

**1. IMPORTANT CONSIDERATIONS**

| | | | |
|---|---|---|---|
| Will the activity have a substantial adverse effect by habitat modifications on any species sensitive species or sensitive natural areas identified in local or regional policies or regulations? | ☐ Yes | ☐ No | ☐ Unknown |
| Will the activity have an adverse effect on locally or provincially significant wetlands through removal, filling, hydrological interruption, or others activities? | ☐ Yes | ☐ No | ☐ Unknown |
| Will the activity interfere with the movement of any resident or migratory fish or wildlife species or previously existing wildlife corridors? | ☐ Yes | ☐ No | ☐ Unknown |

*Please note: Checking 'Yes' or 'Unknown' to one or more of the questions stated above, may result in the requirement for further biological studies and/or correspondence with various governing agents to determine regulatory requirements

### 2. IDENTIFY PROPOSED LAND USE

Check any of the land uses that will apply to both the project area and adjacent area. Assess both current and future land uses. Please refer to Section 3.2.1 for additional information

| | | | |
|---|---|---|---|
| Residential | ☐ | Industrial | ☐ |
| Commercial | ☐ | Institutional | ☐ |
| Agricultural | ☐ | Conserved | ☐ |

### 2. IDENTIFY ECOLOGICAL COMPONENTS OF PROJECT AREA

Indicate whether any of the following ecological components are located on the project area and will be affected by the proposed activity. Refer to Section 3.2.2 for assistance

| | | |
|---|---|---|
| North Saskatchewan River (NSR) | ☐ Yes | ☐ No |
| Water courses (excluding the NSR) | ☐ Yes | ☐ No |
| Natural Areas (Geowest 1993, Spencer 2006) | ☐ Yes | ☐ No |
| Wildlife corridors (refer to question 4) | ☐ Yes | ☐ No |
| Wetlands | ☐ Yes | ☐ No |
| Lakes | ☐ Yes | ☐ No |
| Woodland | ☐ Yes | ☐ No |

### 3. IDENTIFY ECOLOGICAL COMPONENTS OF ADJACENT AREA

Indicate whether any of the following ecological components are located on the adjacent land will be affected by the proposed activity. Refer to Section 3.2.2 for assistance

| | | |
|---|---|---|
| North Saskatchewan River (NSR) | ☐ Yes | ☐ No |
| Water courses (excluding the NSR) | ☐ Yes | ☐ No |
| Natural Areas (Geowest 1993, Spencer 2006) | ☐ Yes | ☐ No |
| Wildlife corridors (refer to question 4) | ☐ Yes | ☐ No |
| Wetlands | ☐ Yes | ☐ No |
| Lakes | ☐ Yes | ☐ No |
| Woodland | ☐ Yes | ☐ No |

**4. IDENTIFY WILDLIFE CORRIDORS**

If you are unsure whether a wildlife corridor is located on the project area, please review the checklist below. A corridor may be present if your project area contains one of the following:

| | | |
|---|---|---|
| Linear landscape features (Ridges, valleys, rivers, sharp breaks in vegetative cover) | ☐ Yes | ☐ No |
| Identified Natural Areas (within 1 km of the project) | ☐ Yes | ☐ No |
| Water bodies (wetlands, lakes, rivers, streams) | ☐ Yes | ☐ No |
| Known migratory pathways | ☐ Yes | ☐ No |
| Hedgerows, shelterbelts, windbreaks | ☐ Yes | ☐ No |
| Greenways | ☐ Yes | ☐ No |

Please note that some corridors are more important ecologically than others and will have greater wildlife use. for example, a natural riparian corridor will likely have a greater diversity and frequency of wildlife use than a greenway. Please refer to Section 3.2.2 for additional resources that may be used to identify wildlife corridors.

**5. IDENTIFY HABITAT IN THE PROJECT AREA**

Please indicate the types of habitat located on the project area

| | | | |
|---|---|---|---|
| Riparian | ☐ Yes | ☐ No | ☐ Unknown |
| Permanent Water Body (Stream/Lake) | ☐ Yes | ☐ No | ☐ Unknown |
| Wetland/Slough/Marsh | ☐ Yes | ☐ No | ☐ Unknown |
| Trees or Forested Land | ☐ Yes | ☐ No | ☐ Unknown |
| Grassland/Pasture Land/ Hay Field | ☐ Yes | ☐ No | ☐ Unknown |

Please note: Each habitat type identified above has a corresponding species list found in Appendix B.
If "unknown" is checked future studies will be required

**6. IDENTIFY POTENTIAL LOCATIONS FOR HABITAT RESTORATION**

Please identify any possibilities for restoration of habitat and connectivity. This could include restoring portions of a cattle-damaged creek or re-planting trees. Refer to Section 3.2.3.

**7. IDENTIFY CONFLICTS WITH CURRENT/FUTURE LAND USE**

Please identify any foreseen conflicts between the land use and wildlife movement (Use Questions 1 through 5). This may mean that no action is required. Please refer to Section 3.3.1. An example of a land use conflict could be an area slated for industrial development that is located adjacent to a natural feature. In this situation, you may not want to promote wildlife movement into the industrial park.

___

___

___

___

| | | |
|---|---|---|
| Is there reason to believe that providing mobility through this area will be beneficial and sustainable? | ☐ Yes | ☐ No |

Wildlife mitigation will likely be required if yes is checked

**8. IDENTIFY CONFLICTS WITH HABITAT**

| Wildlife-vehicle conflicts may occur if the project area involves the items listed below | | | |
|---|---|---|---|
| Natural Area within 1 km | ☐ Yes | ☐ No | ☐ Unknown |
| Upland-Wetland Habitat is Bisected | ☐ Yes | ☐ No | ☐ Unknown |
| Wetland-Wetland Habitat is Bisected | ☐ Yes | ☐ No | ☐ Unknown |
| North Saskatchewan River Valley and any of its Tributaries | ☐ Yes | ☐ No | ☐ Unknown |
| The project has high traffic or speed | ☐ Yes | ☐ No | ☐ Unknown |
| The project area contains species with status (Section 3.2.4.1) | ☐ Yes | ☐ No | ☐ Unknown |

Wildlife mitigation will likely be required if yes is checked; additional studies may be required if unknown is checked

**9. IDENTIFY PHYSICAL BARRIERS**

| Please identify the presence of any potential barriers to wildlife movement | | |
|---|---|---|
| High traffic volume and/or speed (see Section 3.3) (i.e. arterial roads for fast moving wildlife, local roads for slow moving wildlife) | ☐ Yes | ☐ No |
| Perched culverts (see Section 3.3.4) | ☐ Yes | ☐ No |
| Insufficient water depth for aquatic passage (i.e. water is not deep enough for organism to physically pass) | ☐ Yes | ☐ No |
| Water velocity in excess of upstream and downstream velocity | ☐ Yes | ☐ No |
| Culverts without dry passage area | ☐ Yes | ☐ No |

| | | |
|---|---|---|
| Undersized Culverts (not physically large enough to accommodate EDG or becomes blocked with debris like branches) | ☐ Yes | ☐ No |
| Retaining walls | ☐ Yes | ☐ No |
| Traditional jersey barriers and/or noise barriers | ☐ Yes | ☐ No |
| Other | | |

Please note: These barriers will affect different EDGs in different ways. Some barriers may not be applicable to your project (e.g. Jersey barriers may not be a barrier if only Large Terrestrial species are present)

**10. WILDLIFE AND TRANSPORTATION CONFLICTS**

| | | |
|---|---|---|
| **a)** Please indicate whether a conflict will exist between the project and wildlife in the area? (Refer to Section 3.3.5) | | |
| | ☐ Yes | ☐ No |

| | | |
|---|---|---|
| **b)** Can this conflict be avoided? (Refer to Section 3.4) | | |
| | ☐ Yes | ☐ No |

Wildlife mitigation will be required if "no" is checked for 9 b)

**11. PROPOSED SOLUTIONS**

| | | |
|---|---|---|
| Please indicate what types of solutions will be used to mitigate for the disturbance to wildlife in the project area (before, after, and during). | | |
| Retention of existing habitat | ☐ Yes | ☐ No |
| Restoration or enhancement of existing habitat (Section 3.2.3) | ☐ Yes | ☐ No |
| Habitat protection during construction | ☐ Yes | ☐ No |
| Wildlife corridors | ☐ Yes | ☐ No |
| Wildlife Crossings<br>**(Please proceed to Section 4.0 and Checklist 12.2)** | ☐ Yes | ☐ No |
| Management Plan | ☐ Yes | ☐ No |
| Monitoring | ☐ Yes | ☐ No |

Wildlife mitigation will likely be required if yes is checked

## 1.2 DESIGN CHECKLIST

Project: ______________________________

Date: ______________________________

Location: ______________________________

### 1. ECOLOGICAL DESIGN GROUP

| Please identify the Ecological Design Group(s) located in the project area (Refer to Section 4.3.1) | | | |
|---|---|---|---|
| Large Terrestrial | ☐ Yes | ☐ No | ☐ Unknown |
| Medium Terrestrial | ☐ Yes | ☐ No | ☐ Unknown |
| Small Terrestrial | ☐ Yes | ☐ No | ☐ Unknown |
| Amphibian | ☐ Yes | ☐ No | ☐ Unknown |
| Aquatic | ☐ Yes | ☐ No | ☐ Unknown |
| Aerial Mammal | ☐ Yes | ☐ No | ☐ Unknown |
| Scavenger Birds | ☐ Yes | ☐ No | ☐ Unknown |
| Birds of Prey | ☐ Yes | ☐ No | ☐ Unknown |
| Water Birds | ☐ Yes | ☐ No | ☐ Unknown |
| Ground Dwelling Birds | ☐ Yes | ☐ No | ☐ Unknown |
| Other Birds | ☐ Yes | ☐ No | ☐ Unknown |
| Unknown | ☐ Yes | ☐ No | ☐ Unknown |

If unknown is checked, please refer to Appendix B for additional studies. Consult an ecologist for assistance.

### 2. RARE AND PROTECTED SPECIES

Please identify any rare or protected species (Red and Blue Listed or COWSEWIC Listed) (please see Section 3.2.3.1 for further information on identifying species with status.)

______________________________

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If any rare or protected species have been identified additional studies will be required to determine specific crossing requirements. Regulatory agencies must be contacted if rare or protected species are identified.

**3. WILDLIFE PREFERENCES**

Please identify any specific needs that are required by the Ecological Design Group(s). (Refer to Section 4.3.2 and Appendix B)

If any rare or protected species have been identified additional studies will be required to determine specific crossing requirements. Regulatory agencies must be contacted if rare or protected species are identified.

Please indicate which mitigation possibilities meet the ecological, transportation, and regulatory requirements for your project (refer to Section 4.4 and 4.5)

**4. IDENTIFY APPROPRIATE MITIGATION**

**a)** Please indicate which mitigation possibilities meet the ecological, transportation, and regulatory requirements for your project (refer to Section 4.4 and 4.5). This table corresponds to Table 4.4 and is designed to help determine what mitigation options meet the three requirements. If an option does not meet all three then it should not be considered. More than one mitigation option may meet all three requirements. In this case, the best option should be chosen or a combination of several should be considered.

| | **Requirements** | | |
|---|---|---|---|
| | **Ecological** | **Transportation** | **Regulatory** |
| **Signage and/or Reflectors** | ☐ | ☐ | ☐ |
| **Fencing** | ☐ | ☐ | ☐ |
| **Altered Lighting** | ☐ | ☐ | ☐ |
| **Altered Sight Lines** | ☐ | ☐ | ☐ |
| **Public Education** | ☐ | ☐ | ☐ |
| **Traffic Calmed Areas** | ☐ | ☐ | ☐ |
| **Reduced Speed Limits** | ☐ | ☐ | ☐ |
| **Wildlife "Crosswalk"** | ☐ | ☐ | ☐ |
| **Diversionary Methods** | ☐ | ☐ | ☐ |
| **Reduce/Remove Roadkill** | ☐ | ☐ | ☐ |
| **Vegetation Management** | ☐ | ☐ | ☐ |
| **Noise Barriers** | ☐ | ☐ | ☐ |
| **Curb Improvements** | ☐ | ☐ | ☐ |
| **Closed Bottom Culvert** | ☐ | ☐ | ☐ |
| **Amphibian Tunnel** | ☐ | ☐ | ☐ |

| | | | |
|---|---|---|---|
| **Open Bottom Culvert** | ☐ | ☐ | ☐ |
| **Box Culvert** | ☐ | ☐ | ☐ |
| **Bridges**** | ☐ | ☐ | ☐ |
| **Tunnel/Overpass** | ☐ | ☐ | ☐ |

**b)** Please identify the crossing mitigation(s) that will BEST meet all the requirements

______________________________

______________________________

______________________________

**5. MITIGATION SIZE**

If culvert or bridge-like structures are selected, please calculate the size of mitigation required. This will vary depending on the Ecological Design Group and the size of the road. Use the openness calculation to help assess mitigation size (Refer to Section 4.3.3)

| Openness = Height x Width / Length | Openness Ratio (m) | | | | |
|---|---|---|---|---|---|
| | Large Terrestrial | Medium Terrestrial | Small Terrestrial | Amphibian | Aquatic |
| | 1.5 | 0.4 | ≤0.4 | 0.16 | Encompasses entire channel width |

EDG Preferred Openness ______________________________

Structure Length ______________________________

Structure Width ______________________________

Structure Height ______________________________

**6. MITIGATION FREQUENCY**

If the project area encompasses a large portion of the EDGs home range, several structures may be required to reduce vehicle-wildlife collisions and provide habitat connectivity. Please refer to Section 4.3.5 for assistance in determining if multiple structures are required and how close they must be placed.

______________________________

______________________________

______________________________

**7. COST-BENEFIT ANALYSIS**

A cost-benefit analysis may be completed to determine the relative need for a structure. Please note that a cost-benefit analysis may not adequately reflect the value of important habitat and rare species. Please refer to Section 4.3.6 for additional information

## 1.3 REGULATORY CHECKLIST

This checklist provides a summary of common legislation that may be applicable to the project. Additional legislation may apply depending on the area. Please refer to Appendix C for additional information on regulatory requirements.

# Regulatory Checklist

This table indicates if an approval or ecological study, survey, or report may be required with the various governing agents outlined below, for lands that include one or more portions of the described lands. Please note that this checklist is specific to the City of Edmonton and may or may not apply to other jurisdictions. Municipal planning and development requirements such as Structure Plans, Environmental Assessents, Natural Site Assessments, and Natural Areas Management Plans have also not been included in this table. A provincial or federal Environmental impact Assessment may be required if work involves other municipalities in addition to the City of Edmonton.

| Regulation | **Municipal Environmental Review or Environmental Impact Assessment (Bylaw 7188)** | **Historical Resources Act Approval** | **Water Act Approval** | **Navigable Waters Act Approval** | **EPEA Approval** | **Fisheries Act Approval** | **Public Lands Act Licence of Occupation Or Temporary Field Authorization** | Public Lands Act Water Body Claim Inquiry | Ecological Network Report | Migratory Birds Convention Act Survey and Report* |
|---|---|---|---|---|---|---|---|---|---|---|
| Jurisdiction | City of Edmonton Planning & Development | Alberta Community Development St. Steven's College | Alberta Environment Northern Region Compliance & Approvals | Pacific Region Navigable Waters Protection Division | Alberta Environment Northern Region Compliance & Approvals | Dept. Fisheries & Oceans Habitat Management | Alberta Sustainable Resource Development Public Lands Division Land Administration Branch | Alberta Sustainable Resource Development Public Lands Division Land Administration Branch | City of Edmonton Planning & Development | Environment Canada |
| North Saskatchewan River valley and ravine system, or a tributary thereof (NSR) | X | X | X | X | X | X | X | | X | X |
| Any non-NSR permanent or temporary waterway | | X | X | X | X | X | X | | X | X |
| Any wetland | | X | X | X | X | X | | X | X | X |
| Any naturally vegetated area | | X | | | X | | | | X | X |
| Area in which none of the above apply | | X | | | X | | | | X | X |

* If work to be performed within migratory bird nesting season. Report/approval not required to be submitted to regulatory authorities.

# APPENDIX E – MAPS

# Appendix E – MAPS

## 1.1 ECOLOGICAL MAPS AND POLICIES

Included in this section are several maps and documents relating to Edmonton's ecological network. Please note that these are only current up to the date of publication. Please ensure that the most recent documents are used for the project.

### 1.1.1 Natural Area Systems Policy C-531

This policy was put in place to assist with conserving, protecting and restoring biodiversity in the Edmonton area. This policy provides some background as to why these guidelines were put in place.

### 1.1.2 City of Edmonton Natural Areas Map 2007

This figure outlines the significant natural areas and environmentally sensitive areas within the Edmonton region. This map should not be used as the final determinant in whether a crossing will be required. The criteria for natural area identification used a minimum size of 1 hectare. Many wetlands are smaller than this but would still benefit from wildlife mitigation. While this map is a useful reference, site specific identification of natural areas must be completed.

This map will be updated on a regular basis.  Please contact the Office of Natural Areas for the most recent version.

### 1.1.3 Edmonton's Ecological Network

This figure depicts the connectivity of the Edmonton area. It may assist in identifying important corridors and linkages. The map should not be used to ultimately determine whether corridors are present on the project area. Site specific assessments must be completed in addition to consultation of this map.

## 1.2 TRANSPORTATION MAPS AND POLICIES

### 1.2.1 City of Edmonton Bylaw 13423

Bylaw 13423 identifies the current road classifications within the City of Edmonton.

### 1.2.2 The City of Edmonton Transportation System Bylaw

This figure outlines the major road classifications within the City of Edmonton.

### 1.2.3 Figure 7.1 – Transportation Master Plan Concept 2040

This figure outlines the proposed future transportation system. This may be used to assist in identifying future land use and/or traffic patterns in the project area.

### 1.2.4 2007 Traffic Flow Map

This figure outlines the traffic volumes and temporal patterns of roadway use within the City of Edmonton. This may be used to identify if the road will be a barrier to the Ecological Design Groups located on the project area.

# CITY POLICY

**POLICY NUMBER:** C531

**REFERENCE:**

Council 1995 07 25

**ADOPTED BY:**

City Council
17 July 2007

**SUPERSEDES:**

Policy C467

**PREPARED BY:** Office of Natural Areas

**DATE:** 5 June 2007

**TITLE:** **Natural Area Systems**

**Policy Statement:**

Since Edmonton was settled more than 100 years ago, the natural environment has supported us and shaped our collective identity. Edmontonians are proud of the city's natural heritage. To safeguard our natural capital and the associated ecological services, the City of Edmonton is committed to conserving, protecting, and restoring our natural uplands, wetlands, water bodies, and riparian areas, as an integrated and connected system of natural areas throughout the city. Natural area systems provide essential habitat for plants and animals, support biodiversity, and maintain a high quality of life for current and future citizens by supplying critical ecological services, as well as opportunities for education, research, appreciative forms of recreation, and aesthetic and spiritual inspiration.

The City of Edmonton will balance ecological and environmental considerations with economic and social considerations in its decision making and demonstrate that it has done so.

The City of Edmonton recognizes that it can accomplish the work that is required to achieve conservation more efficiently and effectively by supporting and developing partnerships to achieve effective conservation results. Therefore, the City will lead by example – engaging the public in natural area issues, and encouraging businesses, residents, and the community to secure new natural area systems and steward what we have effectively.

**The purpose of this policy is to:**

- Enhance and sustain the quality of life for Edmontonians.
- Conserve, protect, and restore biodiversity throughout Edmonton recognizing the urban context that we work within;
- Ensure consistent, uniform and equitable conservation practices that are based on the best available science;
- Direct Administration to:
  - plan our city so that our ecological systems will function effectively at neighbourhood, city and regional scales,
  - conserve natural area systems in discharging their duties, and
  - require ecological information to support planning and development applications;
- Conserve, protect, and restore natural area systems through the physical planning and development process; according to the provisions of municipal, provincial and federal policy and legislation;
- Encourage voluntary conservation and corporate and private sponsorship of natural sites;
- Promote the awareness and participation of landowners, the general public and non-government organizations in conserving, preserving, and restoring natural sites; and
- Incorporate the local ecological knowledge of Edmonton's citizens and organizations into our decisions.

# CITY PROCEDURE



**Restoration:** the re-establishment of habitat in order to improve ecological processes or connectivity.

**Uplands:** The elevated, typically forested lands beyond the lowlands that border rivers or wetlands.

**Riparian:** Relating to the banks of a natural course of water.

# City of Edmonton Natural Areas in 2007


**Note:** The North Saskatchewan River Valley and several sections of the adjoining ravine system are categorized as regionally important core biodiversity areas. Although much of the river valley area was not included in the original assessment of Environmentally Sensitive and Significant Natural Areas, based on its regional importance, the entire North Saskatchewan River Valley area is considered an Environmentally Sensitive Area.

Prepared by Office of Natural Areas
Map produced: April 2009

GIS mapping data provided by Golder Associates Ltd.

# Edmonton's Ecological Network

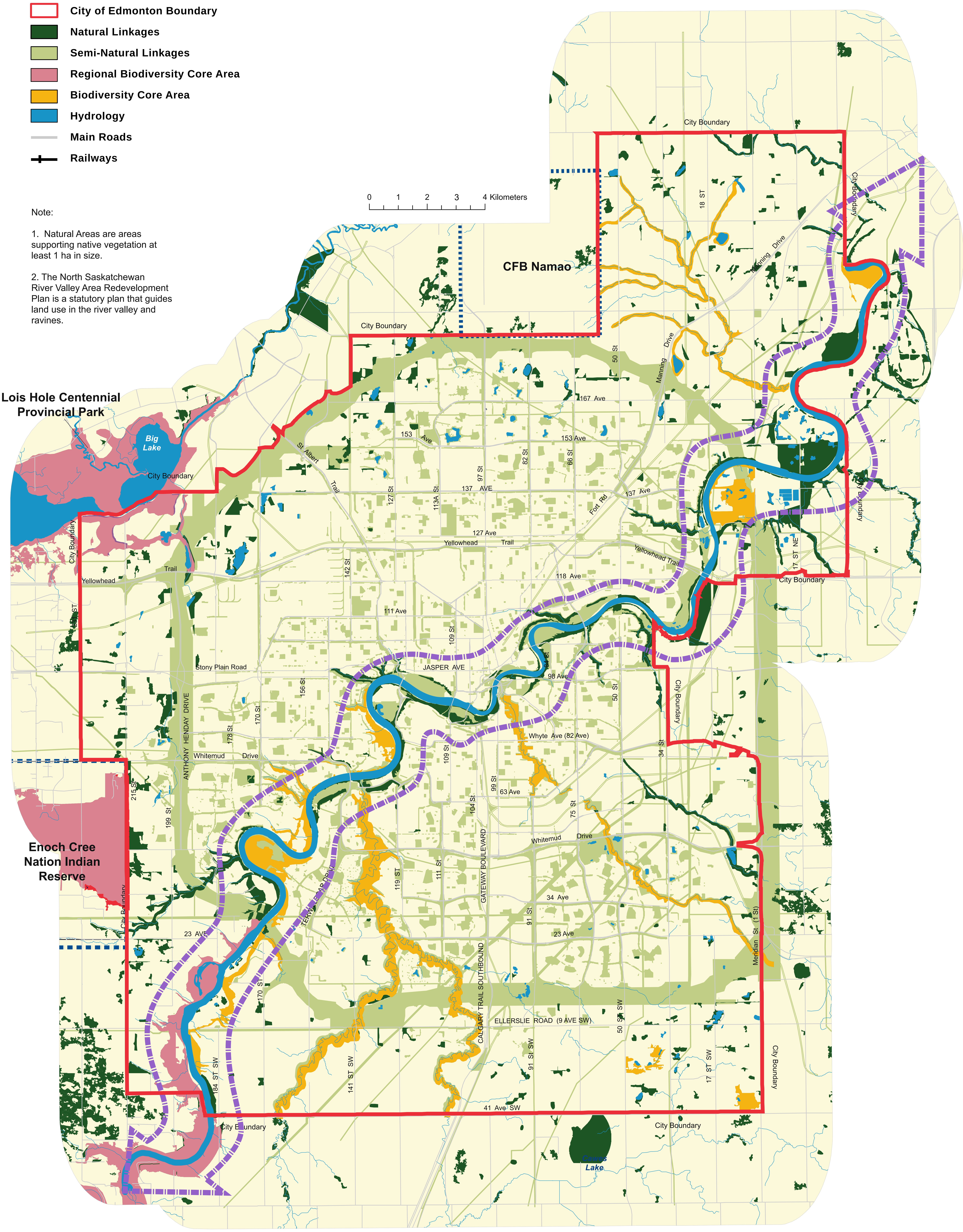
Legend

- Regional Biological Corridor
- City of Edmonton Boundary
- Natural Linkages
- Semi-Natural Linkages
- Regional Biodiversity Core Area
- Biodiversity Core Area
- Hydrology
- Main Roads
- Railways

Note:

1. Natural Areas are areas supporting native vegetation at least 1 ha in size.

2. The North Saskatchewan River Valley Area Redevelopment Plan is a statutory plan that guides land use in the river valley and ravines.



# CITY OF EDMONTON

# BYLAW 13423

# BEING A BYLAW TO ESTABLISH A TRANSPORTATION SYSTEM FOR THE CITY OF EDMONTON

**(CONSOLIDATED ON MARCH 7, 2005)**

**BYLAW NO. 13423**

Being a Bylaw to Establish a Transportation
System for The City of Edmonton

WHEREAS the City Council for The City of Edmonton has caused to be prepared a comprehensive transportation study report in accordance with section 3 of *the City Transportation Act, R.S.A. 2000, c.C-14* for the development of an integrated transportation system designed to service the needs of the entire City of Edmonton, the transportation study report consisting of the following:

**__The Transportation Study Report__**

1. Transportation Master Plan (March, 1999)

**__Other Reports__**

1. Public Involvement Program Phase 1 Report, (April, 1994)
2. Household Travel Survey, (May, 1995)
3. Economic Forecasts, Edmonton City and C.M.A. 1995 - 2020, (May 8, 1995)
4. Vehicle Emissions Project, (March 15, 1996)
5. Truck Route Study, (May, 1996)
6. Ten Year Transit Service and Fare Strategy Plan, (July, 1996)
7. Transportation Demand Management Study, (July, 1996)
8. The Cost of Transporting People in The City of Edmonton, (September, 1996)
9. Core Values Trade-Off Study, (December, 1996)
10. Possible Plan Directions, (May 26, 1997)
11. Transportation Funding Study, (December, 1997)

AND WHEREAS City Council prior to second reading of this Bylaw has caused notice of this Bylaw to be published at least once a week for 2 consecutive weeks in 1 or more newspapers having general circulation within the city, the last of such publications being at least 14 days before the date fixed for the second reading of this Bylaw.

AND WHEREAS in the consideration of this Bylaw City Council has duly heard and considered representations presented either personally or through an agent of all interested parties to this Bylaw.

AND WHEREAS City Council considers this Bylaw to be in the public interest.

NOW THEREFORE, THE CITY COUNCIL OF THE CITY OF EDMONTON duly assembled, enacts as follows:

1. This Bylaw (13423) shall be known as “The City of Edmonton Transportation System Bylaw”.

2. In accordance with the transportation study reports herein before described, City Council hereby establishes a transportation system for The City of Edmonton consisting of the following:

a) That plan attached to this Bylaw entitled “The City of Edmonton Transportation System Bylaw” and incorporated as part of this Bylaw as Appendix “A”.

b) That schedule attached to this Bylaw entitled “ Physical Description of Arterial Roadways” and incorporated as part of this Bylaw as Appendix “B”.

c) That schedule attached to this Bylaw entitled “ Physical Description of Collector Roadways” and incorporated as part of this Bylaw as Appendix “C”.

d) That schedule attached to this Bylaw entitled “ Physical Description of Light Rail Transit” and incorporated as part of this Bylaw as Appendix “D”.

e) That schedule attached to this Bylaw entitled “Principles of Light Rail Transit and Busway Development” and incorporated as part of this Bylaw as Appendix “E”.

f) That schedule attached to this By-law entitled “Physical Description of Arterial Roadways subject to Agreements With the Province of Alberta” and incorporated as part of this by-law as Appendix “F”.
(S.2, Bylaw 13939, March 7, 2005)

subject to the following conditions, namely:

a) That the financial resources necessary for the construction of the said transportation system will be available to The City of Edmonton

b) That the City of Edmonton may amend this Bylaw from time to time by the addition or deletion of transportation facilities or in any other manner, subject to the approval of the Lieutenant Governor in Council.

3. This Bylaw shall come into force on the date that it is approved by the Lieutenant Governor in Council.

4. The existing Transportation System Bylaw, Bylaw 11778 as amended and all its amendments, is hereby repealed effective the date on which Bylaw 13423 is approved by the Lieutenant Governor in Council.

(Note: Consolidation made under Section 69 of the *Municipal Government Act*, R.S.A., 2000, c. M-26 and Bylaw No. 12005, and printed under the City Manager's authority)

Bylaw No. 13423, passed by Council October 7, 2003:

Amendments:

Bylaw 13939, March 7, 2005

# APPENDIX "B"

# PHYSICAL DESCRIPTION OF ARTERIAL ROADWAYS

# THE CITY OF EDMONTON

# TRANSPORTATION SYSTEM BYLAW

# NUMBER 13423

**1. AVENUES**

| Avenue | Limits | P |
|---|---|---|
| 227 Avenue | 17 Street NE West to 50 Street NW | |
| 195 Avenue | 17 Street NE West to 18 Street NW | |
| 195 Avenue NW | Meridian Street (1 Street) West to 18 Street NW | |
| 195 Avenue NW | 18 Street NW West to City Limit | |
| 167 Avenue NW | Meridian Street(1 Street) West to 97 Street NW | |
| 167 Avenue NW | 112 Street NW West to Campbell Road NW | |
| 167 Avenue NW | 142 Street NW West to Campbell Road NW | * |
| 167 Avenue NW | Manning Drive NW West to 50 Street NW | * |
| 153 Avenue NW | Meridian Street (1 Street) West to 18 Street NW | |
| 153 Avenue NW | Fort Road NW West to Manning Drive NW | * |
| 153 Avenue NW | 18 Street NW West to Fort Road NW | |
| 153 Avenue NW | Manning Drive NW West to 139 Street NW | |
| 153 Avenue NW | 139 Street NW West to St. Albert Trail NW | * |
| 137 Avenue NE | East City Limits West to TUC | * |
| 137 Avenue NE | East City Limits West to 17 Street NE | |
| 137 Avenue NW | Victoria Trail NW West to 199 Street NW | |
| 137 Avenue NW | 170 Street NW Northwest to TUC | * |
| 128 Avenue NW | 184 Street NW Northwest to 132 Avenue NW | * |
| 127 Avenue NW | 66 Street NW West to 127 Street NW | |
| 118 Avenue NW | Yellowhead Trail NW West to 106 Street NW | |
| 118 Avenue NW | Kingsway NW West to 184 Street NW | |
| 115 Avenue NW | 80 Street NW West to Fort Road NW | |
| 112 Avenue NW | 50 Street NW West to 90 Street NW | |
| 111 Avenue NW | 101 Street NW West to TUC | |
| 108A Avenue NW | 97 Street NW Southwest to 101 Street NW | |
| 108 Avenue NW | 116 Street NW Northwest to 119 Street NW | |
| 107A Avenue NW | 92 Street NW Southwest to 101 Street NW | |
| 107 Avenue NW | 101 Street NW West to 184 Street NW | |
| 106 Avenue NW | 50 Street NW West to 84 Street NW | |
| 106 Avenue NW | 97 Street NW West to 117 Street NW | |
| 104 Avenue NW | 101 Street NW West to 121 Street NW | |
| 103A Avenue NW | Jasper Avenue NW West to 101 Street NW | |
| 103 Avenue NW | 101 Street NW West to 109 Street NW | |
| 102A Avenue NW | Jasper Avenue NW West to 101 Street NW | |
| 102 Avenue NW | 95 Street NW West to 109 Street NW | |
| 102 Avenue NW | 124 Street NW West to Stony Plain Road NW | |
| 101 Avenue NW | East City Limit West to 75 Street NW | |
| 101 Avenue NW | 95 Street NW West to 95A Street NW | |
| 100 Avenue NW | 102 Street NW West to 116 Street NW | |
| 100 Avenue NW | 149 Street NW West to TUC | |
| 98 Avenue NW | 50 Street NW West to James MacDonald Bridge NW | |
| 97 Avenue NW | James MacDonald Bridge NW West to 109 Street NW | |
| 95 Avenue NW | 170 Street NW West to 189 Street NW | |
| 95 Avenue NW | Winterburn Road (215 Street) NW West to Hillview Road (231 Street) NW | |
| 92 Avenue NW | East City Limit West to 50 Street NW | |
| 90 Avenue NW | 50 Street NW West to 85 Street NW | |
| 87 Avenue NW | 109 Street NW West to Groat Road NW | |
| 87 Avenue NW | 142 Street NW West to TUC | |
| 87 Avenue NW | Winterburn Road (215 Street) NW West to Hillview Road (231 Street) NW | * |
| 71 Avenue NW | 113 Street NW West to Belgravia Road NW | |

* Indicates Proposed Facility

| | | |
|---|---|---|
| 69 Avenue NW | 170 Street NW West to TUC | |
| 63 Avenue NW | 86 Street NW West to 104 Street NW | |
| 62 Avenue NW | Goodwin Gate NW West to Winterburn (215 Street) NW | * |
| 61 Avenue NW | 104 Street NW West to 113 Street NW | |
| 60 Avenue NW | 113 Street NW West to 115 Street NW | |
| 51 Avenue NW | 86 Street NW West to 122 Street NW | |
| 45 Avenue NW | Lessard Road NW West to TUC | |
| 45 Avenue NW | 199 Street NW West to Winterburn Road (215 Street) NW | |
| 41 Avenue SW | East City Limit West to Service Road East of Gateway Boulevard SW | |
| 41 Avenue SW | Calgary Trail West Service Road SW West to 184 Street SW | |
| 40 Avenue NW | Terwillegar Drive NW West to Riverbend Road NW | |
| 38 Avenue NW | 21 Street NW West to 34 Street NW | |
| 38 Avenue NW | 23 Avenue NW West to 21 Street NW | * |
| 34 Avenue NW | 34 Street NW West to 119 Street NW | |
| 30 Avenue SW | Calgary Trail West Service Road SW West to 127 Street SW | |
| 28 Avenue NW | 66 Street NW West to Parsons Road NW | |
| 25 Avenue SW | 66 Street SW West to 184 Street SW | * |
| 23 Avenue NW | East City Limit West to Terwillegar Drive NW | |
| 23 Avenue NW | TUC West to 17 Street NW | * |
| 23 Avenue NW | TUC to approx. 800m West of 184 Street SW | * |
| 9 Avenue SW | 207 Street SW West to Winterburn Road (215 Street) SW | |

* Indicates Proposed Facility

## 2. STREETS

| Street | Limits | P |
|---|---|---|
| 17 Street NE | 195 Avenue NE North to Manning Drive NE | |
| 17 Street NE | Highway 16 East North to 137 Avenue NE | |
| 17 Street SW | 41 Avenue SW North to TUC | |
| 17 Street NW | TUC North to Sherwood Park Freeway NW | |
| 18 Street NW | 153 Avenue NW North to North City Limit | |
| 34 Street SW | 41 Avenue SW North to TUC | |
| 34 Street NW | TUC North to Sherwood Park Freeway NW | |
| 34 Street NW | Fort Road NW North to 167 Avenue NW | |
| 34 Street NW | 167 Avenue NW North to North City Limit | |
| 50 Street SW | 41 Avenue SW North to TUC | |
| 50 Street NW | TUC North to 106 Avenue NW | |
| 50 Street NW | 112 Avenue NW North to North City Limit | |
| 50 Street NW | 153 Avenue NW North to TUC | * |
| 66 Street NW | 118 Avenue NW North to North City Limit | |
| 66 Street NW | TUC North to Whitemud Drive NW | |
| 66 Street SW | 41 Avenue SW North to TUC | |
| 66 Street SW | 41 Avenue SW Northeast to 25 Avenue SW | * |
| 66 Street NW | 178 Avenue NW Northeast to North City Limit | * |
| 75 Street NW | Whitemud Drive NW North to 101 Avenue NW | |
| 80 Street NW | 115 Avenue NW North to Fort Road NW | |
| 82 Street NW | Jasper Avenue NW North to North City Limit | |
| 83 Street NW | Argyll Road NW North to 90 Avenue NW | |
| 84 Street NW | 98 Avenue NW North to 106 Avenue NW | |
| 85 Street NW | 90 Avenue NW North to 98 Avenue NW | |
| 86 Street NW | Stadium Road NW North to Fort Road NW | |
| 91 Street SW | Parsons Road SW Northeast to TUC | |
| 91 Street NW | TUC North to 63 Avenue NW | |
| 91 Street NW | 41 Avenue SW Northeast to Parsons Road SW | * |
| 95 Street NW | 101 Avenue NW North to 118 Avenue NW | |
| 97 Street NW | Jasper Avenue NW North to TUC | |
| 99 Street NW | 34 Avenue NW North to Saskatchewan Drive NW | |
| 100 Street NW | McDougall Hill NW North to 103A Avenue NW | |
| 101 Street NW | MacDonald Drive NW North to 118 Avenue NW | |
| 102 Street NW | 100 Avenue NW North to MacDonald Drive NW | |
| 104 Street NW | Whitemud Drive NW North to Saskatchewan Drive NW | |
| 104 Street NW | River Valley Road NW North to 97 Avenue NW | |
| 105 Street NW | River Valley Road NW North to 107 Avenue NW | |
| 106 Street NW | 97 Avenue NW North to 104 Avenue NW | |
| 106 Street NW | Kingsway Avenue NW North to 119 Avenue NW | |
| 107 Street NW | 119 Avenue NW North to Yellowhead Trail NW | |
| 109 Street NW | 61 Avenue NW North to Princess Elizabeth Avenue NW | |
| 111 Street SW | 30 Avenue SW North to TUC | |
| 111 Street SW | 35 Avenue SW North to 15 Avenue SW | * |
| 111 Street NW | TUC North to 61 Avenue NW | |
| 112 Street NW | Whyte Avenue (82 Avenue) NW North to 87 Avenue NW | |
| 112 Street NW | Castle Downs Road NW North to TUC | |
| 112 Street NW | 176 Avenue NW Northeast to TUC | * |
| 113 Street NW | 61 Avenue NW North to 72 Avenue NW | |
| 113A Street NW | 127 Avenue NW North to 137 Avenue NW | |
| 114 Street NW | 72 Avenue NW North to 87 Avenue NW | |

| | | |
|---|---|---|
| 116 Street NW | 100 Avenue NW North to 108 Avenue NW | |
| 117 Street NW | 105 Avenue NW North to 108 Avenue NW | |
| 119 Street NW | TUC North to Twin Brooks Way NW | |
| 119 Street NW | Twin Brooks Way NW North to 23 Avenue NW | * |
| 119 Street NW | 23 Avenue NW North to Whitemud Drive NW | |
| 119 Street NW | 108 Avenue NW North to Kingsway NW | |
| 121 Street NW | Kingsway NW North to Yellowhead Trail NW | |
| 122 Street NW | Whitemud Drive NW North to Fox Drive NW | |
| 124 Street NW | Jasper Avenue NW North to 118 Avenue NW | |
| 127 Street SW | 41 Avenue SW North to TUC | |
| 127 Street SW | 41 Avenue SW North to 15 Avenue SW | * |
| 127 Street NW | 118 Avenue NW North to North City Limit | |
| 127 Street NW | 167 Avenue NW Northwest to North City Limit | * |
| 127 Street SW | 41 Avenue SW Northeast to 15 Avenue SW | |
| 142 Street NW | 137 Avenue NW North to North City Limit | |
| 142 Street NW | 137 Avenue NW North to TUC | * |
| 142 Street NW | 87 Avenue NW North to Yellowhead Trail NW | |
| 142 Street SW | 41 Avenue SW North to Ellerslie Road SW | |
| 142 Street NW | 137 Avenue North to TUC | |
| 142 Street NW | 167 Avenue North to TUC | * |
| 149 Street NW | Whitemud Drive NW North to 128 Avenue NW | |
| 149 Street NW | 128 Avenue NW North to 137 Avenue NW | * |
| 156 Street NW | 87 Avenue NW North to St. Albert Trail NW | |
| 159 Street NW | Whitemud Drive NW North to 87 Avenue NW | |
| 163 Street NW | 87 Avenue NW North to 107 Avenue NW | |
| 170 Street SW | 41 Avenue SW North to TUC | |
| 170 Street NW | Callingwood Road (62 Avenue) NW North to North City Limit | |
| 178 Street NW | Callingwood Road (62 Avenue) NW North to 118 Avenue NW | |
| 184 Street SW | 41 Avenue SW North to Ellerslie Road (9 Avenue) SW | * |
| 184 Street SW | 41 Avenue SW North to Ellerslie Road (9 Avenue) SW | |
| 184 Street NW | 23 Avenue NW North to TUC | |
| 184 Street NW | 100 Avenue NW North to North City Limit | |
| 184 Street NW | 128 Avenue NW North to North City Limit | * |
| 199 Street NW | Quadrant Avenue (1 Avenue) North to Guardian Road NW | |
| 199 Street NW | 35 Avenue NW North to 45 Avenue NW | * |
| 207 Street SW | 9 Avenue SW North to Quadrant Avenue (1 Avenue) | |

* Indicates Proposed Facility

## 3. NAMED ROADWAYS

| Name | Limits | P |
|---|---|---|
| Alex Taylor Road NW | Rowland Road NW Northwest to Jasper Avenue NW | |
| Allendale Road NW | 104 Street NW Southwest to 61 Avenue NW | |
| Argyll Road NW | Sherwood Park Freeway NW Southwest to 86 Street NW | |
| Belgravia Road NW | 71 Avenue NW West to Fox Drive NW | |
| Bellamy Hill NW | 97 Avenue NW North to MacDonald Drive NW | |
| Calgary Trail NW | TUC North to 150m North of 55 Avenue NW | |
| Calgary Trail West Service Rd SW | 41 Avenue SW North to 30 Avenue SW | |
| Callingwood Road (62 Avenue) NW | 170 Street NW West to TUC | |
| Callingwood Road (62 Avenue) NW | TUC West to Goodwin Gate NW | |
| Campbell Road NW | St. Albert Trail NW Northeast to North City Limit | |
| Castle Downs Road NW | 137 Avenue NW North/East to 97 Street NW | |
| Connors Road NW | 85 Street NW Northwest to Low Level Bridge NW | |
| Ellerslie Road (9 Ave) SW | East City Limit West to Gateway Boulevard SW | |
| Ellerslie Road (9 Ave) SW | Calgary Trail SW West to 184 Street SW | |
| Ellerslie Road (9 Ave) SW | 178 Street SW Southwest to 184 Street SW | * |
| Fort Road NW | 86 Street NW Northeast to 115 Avenue NW | |
| Fort Road NW | 80 Street NW Northeast to 137 Avenue NW | |
| Fox Drive NW | Belgravia Road NW West to Whitemud Drive NW | |
| Gateway Boulevard NW | TUC North to Saskatchewan Drive NW | |
| Grierson Hill NW | Low Level Bridge NW North to 95A Street NW | |
| Groat Road NW | 87 Avenue NW North to 118 Avenue NW | |
| Guardian Road NW | 199 Street NW Northwest to Whitemud Drive NW | |
| Hillview Road (231 St) NW | Whitemud Drive NW North to Yellowhead Trail NW | |
| Jasper Avenue NW | 82 Street NW West to 124 Street NW | |
| Kingsway NW | 101 Street NW Northwest to 118 Avenue NW | |
| Lessard Road NW | Callingwood Road (62 Avenue) NW West to TUC | |
| Lessard Road NW | TUC West to Winterburn Road (215 Street) NW | * |
| Lewis Estates Boulevard NW | Whitemud Drive NW North to 87 Avenue NW | |
| MacDonald Drive NW | 100 Street NW West to 102 Street NW | |
| Manning Drive NW | 137 Avenue NW Northeast to East City Limit | |
| Mayfield Road NW | 170 Street NW Northeast to 111 Avenue NW | |
| McDougall Hill NW | Low Level Bridge NW North to 100 Street NW | |
| Meadowlark Road NW | 87 Avenue NW Northeast to 156 Street NW | |
| Meridian Street (1 Street) | 153 Avenue NW North to 195 Avenue NW | |
| Meridian Street (1 Street) | Manning Drive NE North to North City Limit | |
| Meridian Street (1 Street) | Highway 16 East North to 137 Avenue NE | |
| Muskekosi Trail NW | 199 Street NW West to Hillview Road (231 Street) NW | * |
| Norwood Boulevard NW | 90 Street NW West to 101 Street NW | |
| Parsons Road NW | TUC North to 34 Avenue NW | |
| Parsons Road SW | 91 Street SW North to TUC | |
| Princess Elizabeth Avenue NW | Kingsway NW Northeast to 118 Avenue NW | |
| Quadrant Avenue (1 Avenue) | 199 Street SW West to 207 Street SW | |
| Queen Elizabeth Park Road NW | Saskatchewan Drive NW Northwest to Walterdale Hill Road NW | |
| Rabbit Hill Road NW | TUC North/ Northwest to Riverbend Road NW | |
| Rabbit Hill Road SW | 25 Avenue SW Northeast to TUC | * |
| River Valley Road NW | 105 Street NW West to Groat Road NW | |
| Riverbend Road NW | Terwillegar Drive NW North to 40 Avenue NW | |
| Roper Road NW | 50 Street NW West to 86 Street NW | |
| Roper Road NW | East City Limit West to 50 Street NW | * |
| Rossdale Road NW | Low Level Bridge Southwest to 105 Street NW | |

* Indicates Proposed Facility

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|---|---|---|
| Rowland Road NW | 84 Street NW West to 95 Street NW | |
| Saskatchewan Drive NW | University Avenue NW North to 87 Avenue NW | |
| Saskatchewan Drive NW | 99 Street NW West to 109 Street NW | |
| Sherwood Park Freeway NW | East City Limit West to 71 Street NW | |
| St. Albert Trail NW | 118 Avenue NW Northwest to the North City Limit | |
| Stadium Road NW | 86 Street NW Southwest to 92 Street NW | |
| Stony Plain Road NW | 121 Street NW West to TUC | |
| Stony Plain Road NW | TUC West to West City Limit | |
| Strathcona (Scona) Road NW | Saskatchewan Drive NW North to Connors Road NW | |
| Suder Greens Drive NW | Webber Greens Drive NW West to 207 St NW | * |
| Suder Greens Drive NW | 207 Street NW West to Breckenridge Drive NW | |
| Suder Greens Drive NW | Breckenridge Drive NW West to Hillview Road (231 St) NW | * |
| Terrace Road NW | 101 Avenue NW Southwest to 98 Avenue NW | |
| Terwillegar Drive NW | TUC North to Whitemud Drive NW | |
| Terwillegar Drive NW | 170 Street NW Northeast to TUC | * |
| University Avenue NW | 114 Street NW West to Saskatchewan Drive NW | |
| Victoria Park Road NW | 116 Street NW West to Groat Road NW | |
| Victoria Trail NW | 118 Avenue NW North to 153 Avenue NW | |
| Victoria Trail NW | 153 Avenue NW North to TUC | * |
| Walterdale Hill NW | 109 Street NW Northeast to River Valley Road NW | |
| Wayne Gretzky Drive NW | 101 Avenue NW North to Yellowhead Trail NW | |
| Webber Greens Drive NW | TUC West to Winterburn Road (215 St) NW | * |
| Whitemud Drive NW | East City Limit West to TUC | |
| Whitemud Drive NW | TUC West to West City Limit | |
| Whitemud Drive NW | Lewis Estates Boulevard NW West to Hillview Road (231 St) NW | * |
| Whyte Avenue (82 Avenue) NW | 71 Street NW West to 114 Street NW | |
| Winterburn Road (215 Street) NW | South City Limit North to Yellowhead Trail NW | |
| Winterburn Road NW | Yellowhead Trail NW North to North City Limit | * |
| Yellowhead Trail NW | East City Limit West to TUC | |

* Indicates Proposed Facility

# APPENDIX "C"

# PHYSICAL DESCRIPTION OF COLLECTOR ROADWAYS

# THE CITY OF EDMONTON

# TRANSPORTATION SYSTEM BYLAW

# NUMBER 13423

**2. AVENUES**

| Avenue | Limits |
|---|---|
| 211 Avenue NE | East City Limit West to Fort Road NE |
| 195 Avenue NE | North Saskatchewan River West to 17 Street NE |
| 180 Avenue NW | 99 Street NW West to 104 Street NW |
| 179 Avenue NW | 91 Street NW West to 95 Street NW |
| 179 Avenue NW | 107 Street NW West to 110 Street NW |
| 176 Avenue NW | 97 Street NW West to 112 Street NW |
| 173 Avenue NW | 82 Street NW West to 87 Street NW |
| 172 Avenue NW | 100 Street NW West to 109 Street NW |
| 171 Avenue NW | 109 Street NW West to 115 Street NW |
| 171 Avenue NW | 112 Street NW West to 115 Street NW |
| 168 Avenue NW | 91 Street NW West to 95 Street NW |
| 167 Avenue NE | West of North Saskatchewan River West to Meridian Street (1 Street) |
| 165 Avenue NW | 95 Street NW West to 97 Street NW |
| 165 Avenue NW | 66 Street NW West to Ozerna Road NW |
| 165 Avenue NW | 62 Street NW West to 64 Street NW |
| 164 Avenue NW | 77 Street NW West to 82 Street NW |
| 164 Avenue NW | 100 Street NW West to 109 Street NW |
| 164 Avenue NW | 84 Street NW West to 92 Street NW |
| 163 Avenue NW | 64 Street NW West to 66 Street NW |
| 162 Avenue NW | Castledowns Road NW West to 121 Street NW |
| 162 Avenue NW | 55A Street NW West to 64 Street NW |
| 162 Avenue NW | 82 Street NW West to 84 Street NW |
| 162 Avenue NW | 92 Street NW West to 97 Street NW |
| 162 Avenue NW | 50 Street NW (East) Northwest to 50 Street NW (West) |
| 162 Avenue NW | 122 Street NW West to 131 Street NW |
| 161 Avenue NW | 121 Street NW Northwest to 129 Street NW |
| 160 Avenue NW | Manning Drive NW West to Brintnell Boulevard NW |
| 160 Avenue NW | 77 Street NW West to 90 Street NW |
| 160 Avenue NW | 95 Street NW West to 100 Street NW |
| 158 Avenue NW | 127 Street NW West to 129 Street NW |
| 158 Avenue NW | 109 Street NW West to 112 Street NW |
| 158 Avenue NW | 64 Street NW West to Ozerna Road NW |
| 157 Avenue NW | Castledowns Road NW West to 121 Street NW |
| 156 Avenue NW | 59A Street NW West to 64 Street NW |
| 156 Avenue NW | 84 Street NW West to 91 Street NW |

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| 155 Avenue NW | 100 Street NW West to Beaumaris Road NW |
| 155 Avenue NW | 129 Street NW West to 138 Street NW |
| 154 Avenue NW | 73A Street NW West to 78 Street NW |
| 153 Avenue NE | 17 Street NE West to Meridian Street (1 Street ) |
| 152 Avenue NW | Castle Downs Road NW West to 121 Street NW |
| 151 Avenue NW | 18 Street NW West to Kirkness Road NW |
| 150 Avenue NW | 87 Street NW West to 94 Street NW |
| 150 Avenue NW | 129 Street NW West to 139 Street NW |
| 149A Avenue NW | 72 Street NW West to 87 Street NW |
| 149 Avenue NW | 57 Street NW West to 72 Street NW |
| 147 Avenue NW | Fraser Way NW West to 21 Street NW |
| 146 Avenue NW | 21 Street NW West to 26 Street NW |
| 145 Avenue NW | Castle Downs Road NW West to 121 Street NW |
| 144 Avenue NW | 20 Street NW West to Manning Drive NW |
| 144 Avenue NW | 50 Street NW West to 97 Street NW |
| 142 Avenue NW | Clareview Station Drive NW Northwest to Manning Drive NW |
| 142 Avenue NW | 121 Street NW West to 127 Street NW |
| 141 Avenue NW | 53 Street NW West to 54 Street NW |
| 141 Avenue NW | 74 Street NW West to 79 Street NW |
| 140 Avenue NW | 58 Street NW West to 66 Street NW |
| 140 Avenue NW | 69 Street NW West to 74 Street NW |
| 140 Avenue NW | 87 Street NW West to 94 Street NW |
| 139 Avenue NW | 23 Street NW West to 36 Street NW |
| 139 Avenue NW | 40 Street NW West to Clareview LRT Station |
| 139 Avenue NW | 54 Street NW West to 58 Street NW |
| 139 Avenue NW | Castle Downs Road NW West to 121 Street NW |
| 137 Avenue NW | 20 Street NW West to Victoria Trail NW |
| 135 Avenue NW | 24 Street NW West to Victoria Trail NW |
| 135 Avenue NW | Delwood Road NW West to 82 Street NW |
| 135 Avenue NW | 85 Street NW West to 104A Street NW |
| 135 Avenue NW | 122 Street NW West to 132A Street NW |
| 135 Avenue NW | 135 Street NW West to 140 Street NW |
| 134B Avenue NW | 134 Avenue NW Northwest to 123A Street NW |
| 134A Avenue NW | 104A Street NW West to 107 Street NW |
| 134 Avenue NW | 37 Street NW West to 43 Street NW |
| 134 Avenue NW | 47 Street NW West to 50 Street NW |
| 134 Avenue NW | Fort Road NW West to 68 Street NW |

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|---|---|
| 134 Avenue NW | 82 Street NW  West to 85 Street NW |
| 134 Avenue NW | 97 Street NW  West to 101 Street NW |
| 134 Avenue NW | 107 Street NW  West to 122 Street NW |
| 134 Avenue NW | 132A Street NW  West to 135 Street NW |
| 134 Avenue NW | St. Albert Trail NW West to 149 Street NW |
| 133 Avenue NW | Fort Road NW  West to 58 Street NW |
| 132A Avenue NW | Clareview Road NW  West to 34 Street NW |
| 132 Avenue NW | Fort Road NW  West to 140 Street NW |
| 132 Avenue NW | 159 Street NW West to 163 Street NW |
| 131 Avenue NW | 199 Street NW West to 159 Street NW |
| 131 Avenue NW | 127 Street NW  West to 128 Street NW |
| 131 Avenue NW | St. Albert Trail NW  West to 149 Street NW |
| 130 Avenue NW | Meridian Street (1 Street)  West to 10 Street NW |
| 130 Avenue NW | 72 Street NW  West to 90 Street NW |
| 130 Avenue NW | St. Albert Trail NW  West to 144 Street NW |
| 129B Avenue NW | 90 Street NW  West to 97 Street NW |
| 129 Avenue NW | 50 Street NW  West to 72 Street NW |
| 129 Avenue NW | 103 Street NW  West to 135 Street NW |
| 128 Avenue NW | 97 Street NW  West to 101 Street NW |
| 128 Avenue NW | St. Albert Trail NW  West to 163 Street NW |
| 127 Avenue NW | 45 Street NW  West to 50 Street NW |
| 126 Avenue NW | 142 Street NW  West to 143 Street NW |
| 124 Avenue NW | 142 Street NW West to 149 Street NW |
| 123 Avenue NW | 50 Street NW  West to 54 Street NW |
| 123 Avenue NW | 142 Street NW West to 149 Street NW |
| 122 Avenue NW | Fort Road NW  West to 107 Street NW |
| 122 Avenue NW | 127 Street NW  West to 129 Street NW |
| 121A Avenue NW | 142 Street NW  West to 163 Street NW |
| 121 Avenue NW | East City Limit West to 17 Street NE |
| 121 Avenue NW | 34 Street NW West to 50 Street NW |
| 121 Avenue NE | 61 Street NW West to Wayne Gretzky Drive NW |
| 120 Avenue NW | 75 Street NW  West to 82 Street NW |
| 119 Avenue NW | Abbotsfield Road NW  West to 34 Street NW |
| 119 Avenue NW | Fort Road NW  West to 82 Street NW |
| 119 Avenue NW | 122 Street NW  West to 123 Street NW |
| 118A Avenue NW | 184 Street NW  West to Transportation Utility Corridor |
| 118A Avenue NW | 199 Street NW  West to Winterburn Road NW (215 Street) |

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|---|---|
| 117 Avenue NW | 167 Street NW  West to 170 Street NW |
| 116 Avenue NW | 178 Street NW West to 181 Street NW |
| 115 Avenue NW | 79 Street NW  West to 80 Street NW |
| 115 Avenue NW | Fort Road NW  West to 97 Street NW |
| 115 Avenue NW | Groat Road NW  West to 149 Street NW |
| 114 Avenue NW | 34 Street NW  West to 50 Street NW |
| 114 Avenue NW | 124 Street NW  West to 139 Street NW |
| 114 Avenue NW | 142 Street NW West to 184 Street NW |
| 112 Avenue NW | 142 Street NW  West to 163 Street NW |
| 112 Avenue NW | Winterburn Road NW (215 Street)  West to 231 Street NW |
| 111 Avenue NW | 32 Street NW  West to 34 Street NW |
| 111 Avenue NW | 82 Street NW  West to 84 Street NW |
| 110 Avenue NW | 149 Street NW  West to 161 Street NW |
| 109B Avenue NW | 139 Street NW  West to 142 Street NW |
| 109A Avenue NW | 135 Street NW  West to 139 Street NW |
| 109 Avenue NW | 46 Street NW  West to 56 Street NW |
| 109 Avenue NW | 146 Street NW  West to 149 Street NW |
| 109 Avenue NW | 161 Street NW  West to 163 Street NW |
| 109 Avenue NW | Mayfield Road NW  West to 166 A Street NW |
| 107 Avenue NW | 32 Street NW  West to 34 Street NW |
| 107 Avenue NW | 46 Street NW  West to 48 Street NW |
| 107 Avenue NW | 184 Street NW West to 190 Street NW |
| 107 Avenue NW | 199 Street NW  West to Winterburn Road NW (215 Street) |
| 106B Avenue NW | 48 Street NW  West to 50 Street NW |
| 106 Avenue NW | 34 Street NW  West to 38 Street NW |
| 106 Avenue NW | 45 Street NW  West to 50 Street NW |
| 106 Avenue NW | 95 Street NW  West to 97 Street NW |
| 105 Avenue NW | 101 Street NW  West to 116 Street NW |
| 105 Avenue NW | 121 Street NW  West to 124 Street NW |
| 105 Avenue NW | 170 Street NW  West to 184 Street NW |
| 104 Avenue NW | 156 Street NW  West to 163 Street NW |
| 104 Avenue NW | 184 Street NW West to 188 Street NW |
| 103A Avenue NW | Fulton Road NW  West to 65 Street NW |
| 103 Avenue NW | 45 Street NW  West to 50 Street NW |
| 103 Avenue NW | 95 Street NW  West to 97 Street NW |
| 103 Avenue NW | 100 Street NW  West to 101 Street NW |
| 103 Avenue NW | Mayfield Road NW  West to 172 Street NW |

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| 102 Avenue NW | 111 Street NW  West to 124 Street NW |
| 102 Avenue NW | 172 Street NW West to 184 Street NW |
| 101A Avenue NW | 89 Street NW  West to 92 Street NW |
| 101A Avenue NW | 99 Street NW  West to 100A Street NW |
| 101 Avenue NW | 75 Street NW  West to 84 Street NW |
| 100A Avenue NW | 156 Street NW  West to 163 Street NW |
| 100 Avenue NW | 116 Street NW  West to 121 Street NW |
| 99 Avenue NW | 101 Street NW  West to 103 Street NW |
| 99 Avenue NW | 104 Street NW  West to 112 Street NW |
| 99 Avenue NW | 170 Street  NW West to 175 Street NW |
| 98A Avenue NW | 174 Street NW West to 178 Street NW |
| 98 Avenue NW | 49 Street NW  West to 50 Street NW |
| 98 Avenue NW | 103 Street NW  West to 105 Street NW |
| 98 Avenue NW | 178 Street NW  West to 182 Street NW |
| 97A Avenue NW | 182 Street NW  West to 189 Street NW |
| 97 Avenue NW | 109 Street NW  West to 111 Street NW |
| 96 Avenue NW | 105 Street NW  West to 107 Street NW |
| 96 Avenue NW | 142 Street NW  West to 145 Street NW |
| 95 Avenue NW | 75 Street NW  West to Connors Road NW |
| 95 Avenue NW | 142 Street NW  West to 170 Street NW |
| 95 Avenue NW | 176 Street NW West to 178 Street NW |
| 94B Avenue NW | 49 Street NW  West to 75 Street NW |
| 93 Avenue NW | 48 Street NW  West to 50 Street NW |
| 93 Avenue NW | 165 Street NW  West to 168 Street NW |
| 92 Avenue NW | 50 Street NW  West to Ottewell Road NW |
| 92 Avenue NW | 116 Street NW  West to 120 Street NW |
| 92 Avenue NW | 149 Street NW  West to 163 Street NW |
| 91 Avenue NW | 142 Street NW  West to 149 Street NW |
| 91 Avenue NW | 182 Street NW West to 184 Street NW |
| 90 Avenue NW | 170 Street NW  West to 178 Street NW |
| 89 Avenue NW | 182 Street NW West to 184 Street NW |
| 89 Avenue NW | 112 Street NW  West to 114 Street NW |
| 88 Avenue NW | 91 Street NW West to 92 Street NW |
| 88 Avenue NW | 163 Street NW  West to 168 Street NW |
| 86 Avenue NW | 60 Street NW  West to 75 Street NW |
| 85 Avenue NW | 56 Street NW  West to 60 Street NW |
| 84 Avenue NW | 182 Street NW  West to 189 Street NW |

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| 83 Avenue NW | 99 Street NW West to 100 Street NW |
| 83 Avenue NW | Gateway Boulevard NW West to 109 Street NW |
| 83 Avenue NW | 112 Street NW West to 114 Street NW |
| 83 Avenue NW | 159 Street NW West to 169 Street NW |
| 82 Avenue NW | 50 Street NW West to 71 Street NW |
| 81 Avenue NW | Gateway Boulevard NW West to 109 Street NW |
| 81 Avenue NW | 175 Street NW West to 182 Street NW |
| 80 Avenue NW | 18 Street NW West to 25 Street NW |
| 80 Avenue NW | Gateway Boulevard NW West to 105 Street NW |
| 80 Avenue NW | 142 Street NW West to 149 Street NW |
| 80 Avenue NW | 167 Street NW West to 169 Street NW |
| 79 Avenue NW | 104 Street NW West to 105 Street NW |
| 77 Avenue NW | 184 Street NW West to 188 Street NW |
| 76 Avenue NW | East City Limit West to 67 Street NW |
| 76 Avenue NW | Girard Road NW West to 99 Street NW |
| 76 Avenue NW | Gateway Boulevard NW West to Saskatchewan Drive NW |
| 76 Avenue NW | 149 Street NW West to 159 Street NW |
| 76 Avenue NW | 172 Street NW West to 184 Street NW |
| 73 Avenue NW | 75 Street NW West to 83 Street NW |
| 72 Avenue NW | 67 Street NW West to 71 Street NW |
| 72 Avenue NW | 109 Street NW West to 114 Street NW |
| 70 Avenue NW | 79 Street NW West to 81 Street NW |
| 69 Avenue NW | 42 Street NW West to 43A Street NW |
| 69 Avenue NW | 199 Street NW West to Glastonbury Boulevard NW |
| 68 Avenue NW | Eleniak Road NW West to 75 Street NW |
| 66 Avenue NW | 86 Street NW West to 99 Street NW |
| 65 Avenue NW | 109 Street NW West to 112 Street NW |
| 64 Avenue NW | 170 Street NW West to 178 Street NW |
| 63 Avenue NW | 122 Street NW West to 129 Street NW |
| 62 Avenue NW | 122 Street NW West to 129 Street NW |
| 61 Avenue NW | 86 Street NW West to 87A Street NW |
| 61 Avenue NW | Gateway Boulevard NW West to 104 Street NW |
| 60 Avenue NW | 97 Street NW West to 99 Street NW |
| 60 Avenue NW | 143 Street NW West to 144 Street NW |
| 58 Avenue NW | 86 Street NW West to 97 Street NW |
| 57 Avenue NW | 109 Street NW West to 114 Street NW |
| 57 Avenue NW | 172 Street NW West to 189 Street NW |

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| 56 Avenue NW | 105 Street NW West to 106 Street NW |
| 56 Avenue NW | 148 Street NW West to Riverbend Road NW |
| 55 Avenue NW | 50 Street NW West to 51 Street NW |
| 55 Avenue NW | 104 Street NW West to 105 Street NW |
| 53 Avenue NW | 141 Street NW West to Riverbend Road NW |
| 52 Avenue NW | 184 Street NW West to 190 Street NW |
| 51 Avenue NW | 54 Street NW West to Roper Road NW |
| 51 Avenue NW | 122 Street NW West to 124 Street NW |
| 50 Avenue NW | 142 Street NW West to 143 Street NW |
| 49 Avenue NW | 186 Street NW West to 191 Street NW |
| 48 Avenue NW | 122 Street NW West to Lansdowne Drive NW |
| 47 Avenue NW | 106 Street NW West to 107 Street NW |
| 44 Avenue NW | Jackson Road NW West to 50 Street NW |
| 43A Avenue NW | 24 Street NW West to 30 Street NW |
| 43 Avenue NW | 30 Street NW West to 38 Street NW |
| 43 Avenue NW | 114 Street NW West to 116 Street NW |
| 42 Avenue NW | Calgary Trail NW West to 108 Street NW |
| 42 Avenue NW | 121 Street NW West to 124 Street NW |
| 41 Avenue NW | 38 Street NW West to 44 Street NW |
| 41 Avenue NW | 66 Street NW West to Millbourne Road NW |
| 41 Avenue NW | 116 Street NW West to 117 Street NW |
| 40 Avenue NW | 50 Street NW West to 62 Street NW |
| 40 Avenue NW | 106 Street NW West to 124 Street NW |
| 39 Avenue NW | 91 Street NW West to 99 Street NW |
| 38 Avenue NW | 34 Street NW West to 44 Street NW |
| 38 Avenue NW | Mill Woods Road East NW West to Mill Woods Road NW |
| 38 Avenue NW | 105 Street NW West to 106 Street NW |
| 37A Avenue NW | 17 Street NW West to 31A Street NW |
| 37 Avenue NW | 108 Street NW West to 117 Street NW |
| 36A Avenue NW | Woodvale Road West NW West to Millbourne Road NW |
| 36A Avenue NW | 105 Street NW West to 108 Street NW |
| 36 Avenue NW | 37 Street NW West to 48 Street NW |
| 36 Avenue NW | Mill Woods Road NW West to 85 Street NW |
| 35 Avenue NW | 31A Street NW West to 34 Street NW |
| 34 Avenue NW | 30 Street West to 31A Street NW |
| 33 Avenue NW | 25 Street NW West to Silver Berry Road NW |
| 32A Avenue NW | 106 Street NW West to 109 Street NW |

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| 32 Avenue NW | Silver Berry Road NW West to 25 Street NW |
| 31 Avenue NW | 50 Street NW West to Youville Road East NW |
| 31 Avenue NW | Youville Road West NW West to Lakewood Road NW |
| 31 Avenue NW | 97 Street NW West to 99 Street NW |
| 31 Avenue NW | 112 Street NW West to 116 Street NW |
| 29A Avenue NW | 109 Street NW West to 111 Street NW |
| 29 Avenue NW | Lakewood Road NW West to Mill Woods Road NW |
| 29 Avenue NW | 105 Street NW West to 109 Street NW |
| 28A Avenue NW | Silver Berry Road NW West to 34 Street NW |
| 28 Avenue NW | 48 Street NW West to 66 Street NW |
| 28 Avenue NW | 116 Street NW West to 124 Street NW |
| 28 Avenue SW | 17 Street SW West to 34 Street SW |
| 27 Avenue NW | Saddleback Road NW West to 116 Street NW |
| 26 Avenue NW | 37 Street NW West to 48 Street NW |
| 25 Avenue NW | 105 Street NW West to 109 Street NW |
| 25 Avenue NW | 112 Street NW West to 124 Street NW |
| 23 Avenue NW | Haddow Drive NW West to Hector Road NW |
| 22 Avenue NW | 112 Street NW West to Saddleback Road NW |
| 21 Avenue NW | Parsons Road NW West to 99 Street NW |
| 21 Avenue NW | 104 Street NW West to 109 Street NW |
| 20 Avenue NW | 37 Street NW West to 48 Street NW |
| 20 Avenue NW | 104 Street NW West to 105 Street NW |
| 20 Avenue NW | 94 Street NW West to Karl Clark Road NW |
| 19A Avenue NW | 54 Street NW West to 62 Street NW |
| 19A Avenue NW | 89 Street NW West to 92 Street NW |
| 19 Avenue NW | 48 Street NW West to 54 Street NW |
| 19 Avenue NW | 62 Street NW West to Knottwood Road East NW |
| 19 Avenue NW | Parsons Road NW West to Calgary Trail NW |
| 19 Avenue NW | 105 Street NW West to 111 Street NW |
| 18 Avenue SW | 121 Street SW North/West to Rutherford Road SW |
| 18 Avenue NW | 34 Street NW West to 37 Street NW |
| 17 Avenue NW | 94 Street NW West to Karl Clark Road NW |
| 16A Avenue NW | 34 Street NW West to Mill Woods Road East NW |
| 15 Avenue SW | Rutherford Road SW West to 127 Street SW |
| 15 Avenue NW | 115A Street NW West to Twin Brooks Way NW |
| 13 Avenue NW | 48 Street NW West to 54 Street NW |
| 13 Avenue NW | Parsons Road NW West to 102 Street NW |

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| 12 Avenue NW | 110A Street NW  West to 116 Street NW |
| 12 Avenue NW | 37 Street NW  West to 48 Street NW |
| 12 Avenue NW | 62 Street NW  West to Knottwood Road East NW |
| 11 A Avenue NW | 54 Street NW  West to 62 Street NW |
| 11 Avenue NW | 105 Street NW  West to 109 Street NW |
| 9B Avenue NW | 116 Street NW West to 127 Street NW |
| 9 Avenue NW | 110A Street NW  West to 116 Street NW |
| 9 Avenue N. W. | 170 Street NW  West to 182 Street NW |
| 9B Avenue NW | 116 Street NW  West to 127 Street NW |
| 3 Avenue NW | 97 Street NW West to Parsons Road NW |

## 2. STREETS

| Street | Limits |
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| 17 Street NE | North Saskatchewan River NE North to 153 Avenue NE |
| 17 Street NE | 181 Avenue NE North to 195 Avenue NE |
| 18 Street NW | 76 Avenue NW North to 80 Avenue NW |
| 19 Street NW | 35 Avenue NW North to 37A Avenue NW |
| 20 Street NW | 137 Avenue NW North to 144 Avenue NW |
| 21 Street NW | 38 Avenue NW North to 43A Avenue NW |
| 21 Street NW | 146 Avenue NW North to 151 Avenue NW |
| 23 Street NW | 139 Avenue NW North to 146 Avenue NW |
| 23 Street NW | 43A Avenue NW Northeast to Loop South of Whitemud Drive NW |
| 23 Street NW | 35A Avenue NW North to 38 Avenue NW |
| 24 Street NW | 135A Avenue NW North to 139 Avenue NW |
| 25 Street NW | 32 Avenue NW North to 33 Avenue NW |
| 25 Street NW | 76 Avenue NW North to 80 Avenue NW |
| 26 Street NW | 139 Avenue NW North to 142 Avenue NW |
| 26 Street NW | 146 Avenue NW North to 151 Avenue NW |
| 30 Street NW | 38 Avenue NW North to 43A Avenue NW |
| 31A Street NW | 35 Avenue NW North to 37A Avenue NW |
| 31 Street NW | 37A Avenue NW North to 38 Avenue NW |
| 32 Street NW | 107 Avenue NW North to 111 Avenue NW |
| 34 Street NW | 106 Avenue NW North to 121 Avenue NW |
| 36 Street NW | 137 Avenue NW North to 144 Avenue NW |
| 37 Street NW | 12 Avenue NW North to 20 Avenue NW |
| 37 Street NW | 26 Avenue NW North to 36 Avenue NW |
| 37 Street NW | 132 Avenue NW North to 134 Avenue NW |
| 38 Street NW | 20 Avenue NW North to 26 Avenue NW |
| 38 Street NW | 38 Avenue NW North to Johns Road NW |
| 38 Street NW | 106 Avenue NW North to 118 Avenue NW |
| 40 Street NW | Hermitage Road NW North to 139 Avenue NW |
| 42 Street NW | 137 Avenue NW North to 139 Avenue NW |
| 42 Street NW | 69 Avenue NW North to 76 Avenue NW |
| 43A Street NW | 68 Avenue NW North to 69 Avenue NW |
| 44 Street NW | 38 Avenue NW North to Jackson Road NW |
| 45 Street NW | 103 Avenue NW North to 106 Avenue NW |
| 45 Street NW | 153 Avenue NW North to 157 Avenue NW |
| 46 Street NW | 107 Avenue NW North to 109 Avenue NW |
| 47 Street NW | 20 Avenue NW North to 26 Avenue NW |

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| 48 Street NW | 12 Avenue NW  North to 20 Avenue NW |
| 48 Street NW | 26 Avenue NW  North to 36 Avenue NW |
| 48 Street NW | 92 Avenue NW  North to 93 Avenue NW |
| 48 Street NW | 106B Avenue NW  North to 107 Avenue NW |
| 49 Street NW | 92 Avenue NW  North to 101 Avenue NW |
| 50 Street NW | 106 Avenue NW  North to 109 Avenue NW |
| 50 Street NW | 114 Avenue NW North to 112 Avenue NW |
| 53 Street NW | 112 Avenue NW  North to 118 Avenue NW |
| 53 Street NW | 141 Avenue NW  North to 144 Avenue NW |
| 53 Street NW | 162 Avenue NW Northeast to 162A Avenue NW |
| 54 Street NW | 11A Avenue NW  North to 19A Avenue NW |
| 54 Street NW | 51 Avenue NW  North to 55 Avenue NW |
| 54 Street NW | 118 Avenue NW  North to 123 Avenue NW |
| 54 Street NW | 139 Avenue NW  North to 141 Avenue NW |
| 54 Street NW | McLeod Road NW North to 157A Avenue NW |
| 55 Street NW | 38 Avenue NW  North to 40 Avenue NW |
| 55 Street NW | 144 Avenue NW  North to McLeod Road NW |
| 56 Street NW | 82 Avenue NW  North to 90 Avenue NW |
| 57 Street NW | 19A Avenue NW  North to 23 Avenue NW |
| 57 Street NW | 94B Avenue NW  North to 98 Avenue NW |
| 58 Street NW | Youville Road East NW  North to Woodvale Road NW |
| 58 Street NW | 90 Avenue NW  North to 94 B Avenue NW |
| 58 Street NW | 133 Avenue NW  North to 144 Avenue NW |
| 59A Street NW | 153 Avenue NW North to 162B Avenue NW |
| 60 Street NW | 85 Avenue NW  North to 86 Avenue NW |
| 61 Street NW | 121 Avenue NW  North to 122 Avenue NW |
| 62 Street NW | 11A Avenue NW  North to 19A Avenue NW |
| 62 Street NW | 38 Avenue NW  North to 40 Avenue NW |
| 62 Street NW | 144 Avenue NW  North to 149 Avenue NW |
| 63 Street NW | 101 Avenue NW  North to Fulton Road NW |
| 63 Street NW | 140 Avenue NW  North to 144 Avenue NW |
| 64 Street NW | 158 Avenue NW  North to 162 Avenue NW |
| 65 Street NW | 103A Avenue NW  North to 109 Avenue NW |
| 66 Street NW | 112 Avenue NW  North to 118 Avenue NW |
| 67 Street NW | 68 Avenue NW  North to 76 Avenue NW |
| 68 Street NW | 112 Avenue NW  North to 118 Avenue NW |
| 68 Street NW | 132 Avenue NW  North to 134 Avenue NW |

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| 69 Street NW | 140 Avenue NW North to 144 Avenue NW |
| 71 Street NW | Lakewood Road NW North to Millbourne Road NW |
| 71 Street NW | 72 Avenue NW North to Girard Road NW |
| 71 Street NW | 77 Avenue NW North to 82 Avenue NW |
| 71 Street NW | 98 Avenue NW North to 101 Avenue NW |
| 72 Street NW | 129 Avenue NW North to 130 Avenue NW |
| 72 Street NW | 144 Avenue NW North to 149A Avenue NW |
| 73A Street NW | 153 Avenue NW North to 154 Avenue NW |
| 74 Street NW | Delwood Road NW North to 144 Avenue NW |
| 76 Street NW | 38 Avenue NW North to 51 Avenue NW |
| 76 Street NW | 119 Avenue NW North to 120 Avenue NW |
| 76 Street NW | Ozerna Road NW North to 168A Avenue NW |
| 77 Street NW | 144 Avenue NW North to 149A Avenue NW |
| 77 Street NW | 160 Avenue NW North to Ozerna Road NW |
| 78 Street SW | 14 Avenue SW North to Ellerslie Road (9 Avenue) SW |
| 78 Street NW | 154 Avenue NW North to 160 Avenue NW |
| 79 Street NW | 76 Avenue NW North to 106 Avenue NW |
| 79 Street NW | 112 Avenue NW North to 115 Avenue NW |
| 79 Street NW | 141 Avenue NW North to 144 Avenue NW |
| 79 Street NW | Argyll Road NW North to 73 Avenue NW |
| 80 Street NW | 10 Avenue NW North to Mill Woods Road NW |
| 81 Street NW | 70 Avenue NW North to 76 Avenue NW |
| 82 Street NW | Lakewood Road NW North to Richfield Road NW |
| 83 Street NW | Davies Road NW North to Wagner Road NW |
| 84 Street NW | Jasper Avenue NW North to 111 Avenue NW |
| 84 Street NW | 156 Avenue NW North to 164 Avenue NW |
| 85 Street NW | Knottwood Road NW North to Lakewood Road NW |
| 85 Street NW | 36 Avenue NW North to Mill Woods Road NW |
| 85 Street NW | 82 Avenue NW North to 90 Avenue NW |
| 86 Street NW | 51 Avenue NW North to 66 Avenue NW |
| 87 Street NW | 135 Avenue NW North to 150 Avenue NW |
| 87 Street NW | 173 Avenue NW North to 175 Avenue NW |
| 87A Street NW | 58 Avenue NW North to 61 Avenue NW |
| 88 Street SW | 21 Avenue SW North to Summerside Drive SW |
| 88 Street NW | 153 Avenue NW North to 160 Avenue NW |
| 89 Street NW | 76 Avenue NW North to 82 Avenue NW |
| 89 Street NW | 101A Avenue NW North to Rowland Road NW |

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| 90 Street NW | 127 Avenue NW North to 135 Avenue NW |
| 91 Street NW | 82 Avenue NW North to 88 Avenue NW |
| 91 Street NW | 167 Avenue NW North to 179 Avenue NW |
| 92 Street NW | 88 Avenue NW North to Connors Road NW |
| 92 Street NW | 100 Avenue NW North to 101A Avenue NW |
| 92 Street NW | Jasper Avenue NW North to Norwood Blvd. NW |
| 92 Street NW | 162 Avenue NW North to 164 Avenue NW |
| 93 Street NW | 135 Avenue NW North to 140 Avenue NW |
| 94 Street NW | 140 Avenue NW North to 150 Avenue NW |
| 94 Street NW | 17 Avenue NW North to 23 Avenue NW |
| 95 Street NW | 162 Avenue NW North to 167 Avenue NW |
| 95 Street NW | 168 Avenue NW North to 179 Avenue NW |
| 95A Street NW | 101 Avenue NW North to Jasper Avenue NW |
| 96 Street NW | 63 Avenue NW North to 82 Avenue NW |
| 96 Street NW | Jasper Avenue NW North to Norwood Boulevard NW |
| 97 Street NW | 31 Avenue NW North to 63 Avenue NW |
| 99 Street NW | Jasper Avenue NW North to 103A Avenue NW |
| 99 Street NW | 176 Avenue NW North to 180 Avenue NW |
| 100 Street NW | 82 Avenue NW North to 83 Avenue NW |
| 100 Street NW | 155 Avenue NW North to 172 Avenue NW |
| 100A Street NW | Jasper Avenue NW North to 102 Avenue NW |
| 101 Street NW | 127 Avenue NW North to 128 Avenue NW |
| 101 Street NW | 134 Avenue NW North to 135 Avenue NW |
| 102 Street NW | 103 Avenue NW North to 104 Avenue NW |
| 102 Street NW | 135 Avenue NW North to 137 Avenue NW |
| 102 Street NW | McDonald Drive North to 102 Avenue NW |
| 103 Street NW | Bellamy Hill Road NW North to 104 Avenue NW |
| 103 Street NW | 127 Avenue NW North to 129 Avenue NW |
| 104 Street NW | 20 Avenue NW North to 21 Avenue NW |
| 104 Street NW | 51 Avenue NW North to 55 Avenue NW |
| 104 Street NW | 97 Avenue NW North to 98 Avenue NW |
| 104 Street NW | 99 Avenue NW North to 104 Avenue NW |
| 104 Street NW | 176 Avenue NW North to 180 Avenue NW |
| 105 Street NW | 11 Avenue NW North to 29 Avenue NW |
| 105 Street NW | 36A Avenue NW North to 38 Avenue NW |
| 105 Street NW | 55 Avenue NW North to 56 Avenue NW |
| 105 Street NW | 76 Avenue NW North to Saskatchewan Drive NW |

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| 105 Street NW | 118 Avenue NW North to 122 Avenue NW |
| 106 Street NW | 29 Avenue NW North to Saskatchewan Drive NW |
| 106 Street NW | 96 Avenue NW North to 97 Avenue NW |
| 107 Street NW | 47 Avenue NW North to 51 Avenue NW |
| 107 Street NW | 96 Avenue NW North to 104 Avenue NW |
| 107 Street NW | 127 Avenue NW North to 132 Avenue NW |
| 107 Street NW | 175 Avenue NW North to 179 Avenue NW |
| 108 Street NW | 36A Avenue NW North to 42 Avenue NW |
| 108 Street NW | 99 Avenue NW North to 104 Avenue NW |
| 108 Street NW | 111 Avenue NW North to Kingsway Avenue NW |
| 108 Street NW | 132 Avenue NW North to 137 Avenue NW |
| 109 Street NW | 11 Avenue NW North to 32A Avenue NW |
| 109 Street NW | 57 Avenue NW North to 62 Avenue NW |
| 109 Street NW | 158 Avenue NW North to 172 Avenue NW |
| 110A Street NW | 9 Avenue NW North to 12 Avenue NW |
| 110 Street NW | 97 Avenue NW North to Jasper Avenue NW |
| 110 Street NW | 176 Avenue NW North to 179 Avenue NW |
| 110A Street NW | 9 Avenue NW Northeast to 12 Avenue NW |
| 111 Street NW | 87 Avenue NW North to Saskatchewan Drive NW |
| 111 Street NW | 97 Avenue NW North to 104 Avenue NW |
| 112 Street NW | Saddleback Road NW North to 22 Avenue NW |
| 112 Street NW | 25 Avenue NW North to 31 Avenue NW |
| 112 Street NW | 87 Avenue NW North to 89 Avenue NW |
| 112 Street NW | 99 Avenue NW North to 104 Avenue NW |
| 112 Street NW | 158 Avenue NW North to Beaumaris Road NW |
| 113 Street NW | 9 Avenue NW North to 12 Avenue NW |
| 113 Street NW | 31 Avenue NW North to 34 Avenue NW |
| 113A Street NW | 57 Avenue NW North to 60 Avenue NW |
| 114 Street NW | 34 Avenue NW North to 43 Avenue NW |
| 114 Street NW | 51 Avenue NW North to 57 Avenue NW |
| 114 Street NW | 87 Avenue NW North to 89 Avenue NW |
| 115 Street NW | 162 Avenue NW North to 173A Avenue NW |
| 115 Street NW | Malmo Road NW North to 51 Avenue NW |
| 115A Street NW | 12 Avenue NW North to 15 Avenue NW |
| 116 Street NW | 9 Avenue NW North to 12 Avenue NW |
| 116 Street NW | Saddleback Road NW North to 31 Avenue NW |
| 116 Street NW | 41 Avenue NW North to 43 Avenue NW |

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| 116 Street NW | 87 Avenue NW North to Saskatchewan Drive NW |
| 116 Street NW | 108 Avenue NW North to Tower Road NW |
| 117 Street NW | 37 Avenue NW North to 41 Avenue NW |
| 117 Street NW | University Avenue NW North to 87 Avenue NW |
| 117 Street NW | 139 Avenue NW North to 145 Avenue NW |
| 118 Street NW | 9B Avenue NW North to Twin Brooks Way NW |
| 118 Street NW | 73 Avenue NW North to 76 Avenue NW |
| 118 Street NW | 145 Avenue NW North to 152 Avenue NW |
| 119 Street NW | 87 Avenue NW North to Windsor Road NW |
| 119 Street NW | 132 Avenue NW North to 137 Avenue NW |
| 120 Street NW | Windsor Road NW North to 92 Avenue NW |
| 119 Street SW | Rutherford Road SW North to MacEwan Road SW |
| 120 Street NW | 127 Avenue NW North to 132 Avenue NW |
| 121 Street NW | 40 Avenue NW North to 42 Avenue NW |
| 121 Street NW | 100 Avenue NW North to 105 Avenue NW |
| 121 Street NW | 139 Avenue NW North to 162 Avenue NW |
| 122 Street NW | 118 Avenue NW North to 119 Avenue NW |
| 123 Street NW | 118 Avenue NW North to 119 Avenue NW |
| 124 Street NW | 25 Avenue NW North to 28 Avenue NW |
| 124 Street NW | 40 Avenue NW North to 42 Avenue NW |
| 124 Street NW | Landsdowne Drive NW North to 51 Avenue NW |
| 124 Street NW | 118 Avenue NW North to Yellowhead Trail NW |
| 127 Street NW | Stony Plain Road NW North to 118 Avenue NW |
| 127 Street NW | 62 Avenue NW North to 63 Avenue NW |
| 128 Street NW | 129 Avenue NW North to 131 Avenue NW |
| 129 Street NW | 62 Avenue NW North to 63 Avenue NW |
| 129 Street NW | 155 Avenue NW North to 162 Avenue NW |
| 131 Street NW | 153 Avenue NW North to 155 Avenue NW |
| 132 Street NW | 129 Avenue NW North to 135 Avenue NW |
| 132A Street NW | 134 Avenue NW North to 135 Avenue NW |
| 135 Street NW | 107 Avenue NW North to 115 Avenue NW |
| 135 Street NW | 129 Avenue NW North to 137 Avenue NW |
| 136 Street NW | 102 Avenue NW North to 107 Avenue NW |
| 137 Street NW | 153 Avenue NW North to 155 Avenue NW |
| 139 Street NW | 114 Avenue NW North to Dovercourt Avenue NW |
| 139 Street NW | Cumberland Road NW North to 153 Avenue NW |
| 139 Street NW | 155 Avenue NW North to 159 Avenue NW |

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| 140 Street NW | 132 Avenue NW  North to 135 Avenue NW |
| 142 Street NW | Loop South of 46 Avenue NW  North to 53 Avenue NW |
| 142 Street NW | 80 Avenue NW  North to 87 Avenue NW |
| 142 Street NW | Yellowhead Trail NW  North to 126 Avenue NW |
| 143 Street NW | 49 Avenue NW  North to 60 Avenue NW |
| 143 Street NW | Yellowhead Trail NW  North to 126 Avenue |
| 144 Street NW | 128 Avenue NW  North to 130 Avenue NW |
| 145 Street NW | 80 Avenue NW  North to 91 Avenue NW |
| 145 Street NW | 95 Avenue NW  North to 96 Avenue NW |
| 146 Street NW | 91 Avenue NW  North to 95 Avenue NW |
| 146 Street NW | McQueen Road NW  North to 109 Avenue NW |
| 146 Street NW | 131 Avenue NW  North to 134 Avenue NW |
| 148 Street NW | 56 Avenue NW  North to Riverbend Road NW |
| 148 Street NW | 128 Avenue NW  North to 131 Avenue NW |
| 149 Street NW | Rio Terrace Drive NW  North to 76 Avenue NW |
| 151 Street NW | Rio Terrace Drive NW  North to 76 Avenue NW |
| 156 Street SW | 41 Avenue SW  North to 28 Avenue SW |
| 156 Street SW | 20 Avenue SW North to TUC |
| 156 Street NW | 76 Avenue NW  North to 87 Avenue NW |
| 156 Street NW | TUC North to Terwillegar Drive  NW |
| 158 Street NW | 100A Avenue NW  North to Stony Plain Road NW |
| 159 Street NW | 76 Avenue NW  North to Whitemud Drive NW |
| 159 Street NW | Stony Plain Road NW  North to 107 Avenue NW |
| 159 Street NW | 131 Avenue NW North to 132 Avenue NW |
| 161 Street NW | 109 Avenue NW  North to 110B Avenue NW |
| 163 Street NW | 107 Avenue NW  North to 109 Avenue NW |
| 163 Street NW | 111 Avenue NW  North to 121A Avenue NW |
| 165 Street NW | 128 Avenue NW North to 132 Avenue NW |
| 165 Street NW | 87 Avenue NW  North to 95 Avenue NW |
| 166 Street NW | 100 Avenue NW  North to Stony Plain Road NW |
| 166A Street NW | 109 Avenue NW  North to 114 Avenue NW |
| 167 Street NW | 80 Avenue NW  North to 83 Avenue NW |
| 167 Street NW | 95 Avenue NW  North to Stony Plain Road NW |
| 167 Street NW | 117 Avenue NW  North to 118 Avenue NW |
| 168 Street NW | 88 Avenue NW  North to 93 Avenue NW |
| 168 Street NW | 100 Avenue NW  North to Stony Plain Road NW |
| 169 Street NW | 80 Avenue NW  North to  87 Avenue NW |

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| 170 Street NW | 16 Avenue NW North to 23 Avenue NW |
| 172 Street NW | 57 Avenue NW North to 76 Avenue NW |
| 172 Street NW | 95 Avenue NW North to 99 Avenue NW |
| 172 Street NW | 102 Avenue NW North to 107 Avenue NW |
| 175 Street NW | 81 Avenue NW North to 87 Avenue NW |
| 175 Street NW | 99 Avenue NW North to 102 Avenue NW |
| 181 Street NW | 116 Avenue NW North to 181 Street NW |
| 182 Street NW | 81 Avenue NW North to 98 Avenue NW |
| 184 Street NW | 19 Avenue NW North to 23 Avenue NW |
| 184 Street NW | Wedgewood Boulevard NW North to 77 Avenue NW |
| 184 Street NW | 89 Avenue NW North to 81 Avenue NW |
| 186 Street NW | 106A Avenue NW North to 116 Avenue NW |
| 188 Street NW | Lessard Road NW North to 49 Avenue NW |
| 188 Street NW | Callingwood Road NW North to Ormsby Road East NW |
| 188 Street NW | Ormsby Road NW North to 77 Avenue NW |
| 189 Street NW | 57 Avenue NW North to Callingwood Road NW |
| 189 Street NW | 84 Avenue NW North to 97A Avenue NW |
| 189 Street NW | 111 Avenue NW North to 114 Avenue NW |
| 190 Street NW | 52 Avenue NW North to 57 Avenue NW |
| 199 Street SW | 25 Avenue SW North to Quadrant Avenue |
| 199 Street NW | 87 Avenue NW North to 118A Avenue NW |
| 199 Street NW | Yellowhead Trail NW North Service Road North to 137 Avenue NW |
| 215 Street NW | Yellowhead Trail North Service Road NW North to about 131 Avenue NW |
| 231 Street NW | Yellowhead Trail NW North to 128 Avenue NW |

**3. NAMED ROADWAYS**

| Name | Limits |
| --- | --- |
| Abbotsfield Road NW | 118 Avenue NW Northwest to 34 Street NW |
| Airport Road NW | Kingsway Ave NW East., Northwest to Kingsway Ave NW West |
| Alberta Grain Terminals Rd. NW | 133 Street NW Northwest to St. Albert Trail NW |
| Allard Way NW | 51 Avenue NW North to 55 Avenue NW |
| Bearspaw Drive East NW | 109 Street NW Northeast to 19 Avenue NW |
| Bearspaw Drive West NW | 109 Street NW Northwest to 19 Avenue NW |
| Beaumaris Road NW | 153 Avenue NW Northwest to Castle Downs Road NW |
| Blackburn Drive West SW | Blackburn Drive East SW West to 111 Street SW |
| Blackmud Creek Crescent SW | Blackmud Creek Drive East SW Northwest to Blackmud Creek Drive SW |
| Blackmud Creek Drive SW | 111 Street SW Northeast to Ellerslie Road (9 Avenue) SW |
| Breckenridge Drive NW | Lewis Estates Boulevard NW North to 87 Avenue NW |
| Brintnell Boulevard NW | 154 Avenue NW North to 160 Avenue NW |
| Buena Vista Road NW | Laurier Park Northwest to 142 Street NW |
| Bulyea Road NW | Rabbit Hill Road NW Northwest to Terwillegar Drive NW |
| Burton Road NW | Bulyea Road NW East West to Bulyea Road NW West |
| Cameron Avenue NW | 92 Street NW West to 95 Street NW |
| Cameron Heights Drive NW | TUC North to Caldwell Way NW |
| Carter Crest Road NW | Rabbit Hill Rd NW West Southeast to Rabbit Hill Road NW East |
| Carter Crest Way NW | Leger Road NW North to Carter Crest Road NW |
| Castle Drive NW | 104 Street NW West to 179 Avenue NW |
| Clareview Road NW | Victoria Trail NW Northeast to 135A Avenue NW |
| Clareview Station Drive NW | Clareview LRT Station Northeast to 142 Avenue NW |
| Confederation Park Road NW | 111 Street NW West to 114 Street NW |
| Cumberland Road NW | 127 Street NW Northwest to 140 Street NW |
| Danbury Boulevard | Donsdale Drive NW North to Lessard Road NW |
| Davies Road NW | 86 Street NW Northeast to Wagner Road NW |
| Dechane Road NW | 184 Street NW Northeast to 57 Avenue NW |
| Dechane Way NW | Lessard Road NW Northwest to Dechane Road NW |
| Delwood Road NW | 68 Street NW West/Southwest to 132 Avenue NW |
| Dovercourt Avenue NW | 139 Street NW Northeast to St. Albert Trail NW |
| Dunluce Road NW | 115 Street NW West/Southwest to 161 Avenue NW |
| Dunvegan Road NW | 136 Street NW North to 132 Avenue NW |
| Easton Road SW | 91 Street SW East/North to Edwards Drive SW |
| Edwards Drive SW | 5 Avenue SW West to 91 Street SW |
| E.L. Smith Road | |

| | |
|---|---|
| Emily Murphy Park Road NW | 116 Street NW West to Groat Road NW |
| Falconer Gate NW (South) | Falconer Road NW West to Riverbend Road NW |
| Falconer Road NW | Rabbit Hill Road NW Southwest to Riverbend Road NW |
| Fort Road NW | 115 Avenue NW Northeast to 82 Street NW |
| Fort Road NW | 144 Avenue NW Northeast to 167 Avenue NW |
| Fort Road NW | 167 Avenue NW Northeast to 18 Street NW |
| Fort Road | 18 Street NW Northeast to 17 Street NE |
| Fraser Way NW | 147 Avenue NW Northwest to 16 Street NW |
| Fulton Road NW | 50 Street NW Southwest to 63 Street NW |
| Girard Road NW | 71 Street NW Northeast to 76 Avenue NW |
| Glastonbury Boulevard NW | 62 Avenue NW Northwest to Gillespie Crescent NW |
| Grantham Court NW | Guardian Road NW Northwest to 76 Avenue NW |
| Grantham Drive NW | 71 Avenue NW Northeast to Guardian Road NW |
| Griesbach Road NW | 97 Street NW Northwest to 153 Avenue NW |
| Haddow Drive NW | Riverbend NW Southwest to Hunters Close NW |
| Hayter Road NW | Yellowhead Trail NW Northeast to Meridian Street (1 Street) |
| Heath Road NW | Riverbend Road NW (South) North to Riverbend Road NW (North) |
| Hemingway Road NW | 199 Street NW West to 205 Street NW |
| Hermitage Road NW | Hooke Road NW Northwest to 50 Street NW |
| Hewes Way NW | 23 Avenue NW North to 28 Avenue NW |
| Hodgson Boulevard NW | Rabbit Hill Road NW East/North to TransAlta Right-of-Way |
| Hodgson Road NW | Hodgson Boulevard NW (East) West to Hodgson Boulevard NW (West) |
| Hodgson Way NW | 23 Avenue NW North to Hodgson Road NW |
| Hooke Road NW | Hermitage Road NW East, West to Hermitage Road NW West |
| Hudson Road NW | 141 Street NW Northeast to Cumberland Road NW |
| Hyndman Crescent NW | Hermitage Road NW East, West to Hermitage Road NW West |
| Jackson Road NW | Johns Road NW West to 44 Avenue NW |
| Jamha Road NW | Jackson Road NW Northwest to 50 Street NW |
| Kaasa Road East NW | Kaufman Way NW North to 38 Avenue NW |
| Karl Clark Road NW | 97 Street NW Northwest to Parsons Road NW |
| Kaufman Way NW | 34 Street NW West to Kaasa Road East NW |
| Kirkness Road NW | 144 Avenue NW Northeast to 151 Avenue NW |
| Klarvattan Road NW | 91 Street NW Northeast to 173 Avenue NW |
| Knottwood Road East NW | 12 Avenue NW North to 72 Street NW |
| Knottwood Road North NW | 72 Street NW West to 85 Street NW |
| Knottwood Road West NW | 87 Street NW North to 85 Street NW |
| Knottwood Road South NW | 12 Avenue NW West to 87 Street NW |

| | |
|---|---|
| Lakewood Road NW | 28 Avenue NW  Northwest to Millwoods Road NW |
| Lakewood Road North NW | Millwoods Road NW  West to 33 Avenue NW |
| Lakewood Road South NW | Millwoods Road NW  West to 85 Street NW |
| Lakewood Road West NW | 85 Street NW  North to 33 Avenue NW |
| Lansdowne Drive NW | 122A Street NW  Southwest to 124 Street NW |
| Leger Boulevard NW | Rabbit Hill Road NW West to Lindsay Crescent NW |
| Leger Road NW | Leger Court NW North to Carter Crest Way NW |
| Leger Way NW | Rabbit Hill Road NW West to Lambert Court NW |
| MacEwan Road SW | Ellerslie Road (9 Avenue) SW North to Marion Place SW |
| MacEwan Road SW | 111 Street SW West to 114 Street SW |
| Malmo Road NW | 115 Street NW  Northeast to 51 Avenue NW |
| Matheson Way NW | Miller Boulevard NW West to 50 Street NW |
| McLeod Road NW | 51 Street NW  Southwest to 149 Avenue NW |
| McQueen Road NW | 142 Street NW  Southwest to 107 Avenue NW |
| Millbourne Road East NW | Millwoods Road NW  Northeast to 38 Avenue NW |
| Millbourne Road East NW | 38 Avenue NW  Northwest to 76 Street NW |
| Millbourne Road West NW | 76 Street NW  Southwest to Millwoods Road NW |
| Millwoods Road NW | 80 Street NW  North to 91 Street NW |
| Millwoods Road East NW | 16A Avenue NW  North to 38 Avenue NW |
| Millwoods Road South NW | 16A Avenue NW  West to 80 Street NW |
| Miller Boulevard NW | Manning Drive NW Northwest to 153 Avenue NW |
| Oakes Gate NW | Rabbit Hill Road NW  North to Oeming Road NW |
| Oeming Road NW | Oakes Gate NW  West to Bulyea Road NW |
| Ogilvie Boulevard NW | Trans Alta Power Line right-of-way  West to Rabbit Hill Road NW |
| Ormsby Road East NW | 188 Street NW (South) North to 188 Street NW (North) |
| Ormsby Road West NW | 188 Street NW (South) West/Northwest to 188 Street NW (North) |
| Ottewell Road NW | 90 Avenue NW  North to 98 Avenue NW |
| Ozerna Road NW | 73A Street NW Northeast to 69 Street NW |
| Potter Greens Drive NW | Lewis Estates Boulevard NW East/North to Potter Greens Road NW |
| Rabbit Hill Road NW | Riverbend Road NW  Northwest to Promontory Point NW |
| Rhatigan Road East NW | Riverbend Road NW  Northeast to 40 Avenue NW |
| Rhatigan Road West NW | Riverbend Road NW  Southwest to Riverbend Road NW |
| Richfield Road NW | 82 Street NW  Northeast to 36 Avenue NW |
| Rio Terrace Drive NW | 149 Street NW  West to 151 Street NW |
| Riverbend Road NW | 40 Avenue NW NW  North to 148 Street NW |
| Rutherford Road SW | 127 Street SW West to approximately 115 Street SW |
| Rutherford Road SW | 18 Avenue SW Northeast to 119 Street SW |

| | |
|---|---|
| Saddleback Road NW | 111 Street NW  West/Northwest to 23 Avenue NW |
| Saddleback Road NW | 23 Avenue NW  North/Northeast to 111 Street NW |
| Saskatchewan Drive NW | 76 Avenue NW  North to University Avenue NW |
| Saskatchewan Drive NW | 111 Street NW  West to 116 Street NW |
| Sherbrooke Avenue NW | 129 Street NW  West to St. Albert Trail NW |
| Silver Berry Road NW | 30 Avenue Northwest to 34 Street NW |
| Silver Berry Road NW | 30 Avenue NW North to 32 Avenue NW |
| St. Albert Trail East Service Road NW | Alberta Grain Terminals Road (127 Avenue) NW Northwest to St. Albert Trail NW |
| Summerside Drive SW | Summerside Gate SW Northeast to Ellerslie Road (9 Avenue) SW |
| Summerside Gate SW | Summerside Drive SW West to Parsons Road SW |
| Summerside Link SW | 17 Avenue SW North to Summerside Gate SW |
| Sunset Boulevard SW | 13 Avenue SW North to Ellerslie Road (9 Avenue) SW |
| Taylor Green NW | 13A Avenue NW Northwest to Towne Centre Boulevard NW |
| Tegler Gate NW | Tory Road NW North to 23 Avenue NW |
| Terwillegar Boulevard NW | 142 Street NW West to Tredger Place NW |
| Terwillegar Common NW | Terwillegar Boulevard NW Northeast to Towne Centre Boulevard NW |
| Terwillegar Link NW | Terwillegar Common NW Northwest to Tompkins Way NW |
| Terwillegar Vista NW | Tompkins Way NW Northwest to Tomlinson Common NW |
| Tomlinson Common NW | Terwillegar Vista NW Northwest to Turvey Wynd NW |
| Tomlinson Common NW | Terwillegar Vista NW Northwest to Turvey Wynd NW |
| Tomlinson Way NW | Tomlinson Common NW Northeast to Towne Centre Boulevard NW |
| Tory Gate NW | 142 Street NW West to Tory Road NW |
| Tory Road NW | Terwillegar Boulevard NW Northwest to Tegler Gate NW |
| Tower Road NW | 116 Street NW  Northeast to Kingsway Avenue NW |
| Towne Centre Boulevard NW | 23 Avenue NW  South to Tomlinson Way NW |
| Tufford Way NW | Tomlinson Common NW Northeast to Towne Centre Boulevard NW |
| Twin Brooks Way NW | 15 Avenue NW Northwest to 127 Street NW |
| University Avenue NW | 103 Street NW  Northwest to 105 Street NW |
| Wagner Road NW | 75 Street NW  Southwest to 86 Street NW |
| Wanyandi Road NW | Callingwood Road NW  Northwest to Wolf Willow Road NW |
| Wedgewood Boulevard NW | 184 Street NW  South to Welbourne Drive NW |
| Windermere Crescent NW | 170 Street NW  South, North to 170 Street NW North |
| Windermere Drive NW | 9 Avenue NW  Northeast to 170 Street NW |
| Windsor Road NW | 119 Street NW  Northwest to 120 Street NW |
| Winterburn Rd(215 St) NW | Yellowhead Trail NW  North to approximately North City Limit |
| Wolf Willow Road NW | Wolf Willow Crescent NW  West to 170 Street NW |
| Woodvale Road East NW | 58 Street NW  Northeast to 38 Avenue NW |

| | |
|---|---|
| Woodvale Road West NW | 58 Street NW  Northwest to 38 Avenue NW |
| Yellowhead Trail NW N. Service Rd | 199 Street NW  West to Winterburn Road NW (215 Street) |
| Youville Drive East NW | 28 Avenue NW  Northwest to 58 Street NW |
| Youville Drive West NW | 28 Avenue NW  Northeast to 58 Street NW |

# APPENDIX "D"

# PHYSICAL DESCRIPTION OF LIGHT RAIL TRANSIT

# THE CITY OF EDMONTON

# TRANSPORTATION SYSTEM BYLAW

# NO. 13423

| LRT LINE 201 | LIMITS |
|---|---|
| LINE 201: Northeast Section | Surface line within CNR right-of-way from Clareview Station located approximately at 139 Avenue/43 Street southwest to 105 Avenue/96 Street. |
| LINE 201: Downtown Section | Underground line; from 105 Avenue/96 Street southwest to Central Station at Jasper Avenue/101 Street, then west to Corona Station at Jasper Avenue/108 Street; then southwest to 110 Street, then south along 110 Street to Grandin Station at 110 Street/98 Avenue. |
| LINE 201: University Section | Underground Line; from Grandin Station south along 110 Street, to north bank of North Saskatchewan River; across River on Dudley B. Menzies bridge, underground from south bank of River, southwest to University Station at 89 Avenue/113 Street. |
| * LINE 201: South Extension to Southgate Station | Underground from University Station, south along the west side of 114 Street, emerging from the underground alignment to a surface alignment approximately 150m south of 87 Avenue N.W., then at-grade along the west side of 114 Street to north of Belgravia Road underground below Belgravia Road. Surface line, south of Belgravia Road, approximately 350m west of 113 Street to 61 Avenue, east along the south side of 61 Avenue to 111 Street, underground below 111 Street southbound, and south along median of 111 Street to Southgate Station at 111 Street/Whitemud Drive. |
| * LINE 201: South Extension to Heritage Station | From Southgate Station, surface line, south along median of 111Street to Heritage Station, located approximately at 111 Street/23 Avenue. |

* Indicates Proposed Facility

# APPENDIX "E"

# PRINCIPLES OF LIGHT RAIL TRANSIT AND BUSWAY DEVELOPMENT

# THE CITY OF EDMONTON

# TRANSPORTATION SYSTEM BYLAW

# NUMBER 13423

# Light Rail Transit and Busway Development

## Basic Principles

### A. Statement of Intent

The intent of this document is to articulate a set of basic principles which will guide the planning, design, construction and operation of Light Rail Transit (L.R.T.) lines, Busways and related facilities in Edmonton.

The purpose of including these principles as an appendix to the Transportation System Bylaw is to ensure that the development of L.R.T. and busways in Edmonton is undertaken within a framework which is consistent with certain themes and objectives which transcend changes in decision making personnel and process.

The inclusion of these principles in this Bylaw affords the public an opportunity to intervene and influence, through a statutory hearing process, in any proposed revisions to or deviations from the principles set out herein.

The principles are intended to be flexible enough so as to reflect and be subject to varying sets of conditions, constraints and standards over time.

It is anticipated that affected communities may ask City Council to consider site specific issues arising from the development of LRT or busways in their community.

The order in which the principles are presented does not reflect any particular ranking, priority or weighting. It is recognized and accepted that the relative importance of these principles will vary depending on situations and conditions. It is further recognized and accepted that in some instances specific applications of the principles may compete with each other, in which case decisions may require certain trade offs to be made.

## A. Statement of Principles

### 1. Principles of Public Consultation

The City is committed to ongoing consultation with parties who have an interest in issues relating to the planning and development of LRT and busways. It is recognized that the specific consultation processes which are undertaken must be sufficiently flexible to allow for the diversity of public views which may be expressed over time and over different segments of LRT or busway systems. The fundamental justification for public consultation is the premise that the public has a right to participate in decisions that may affect them.

### 2. Principle of Personal Safety

The City is committed to the development of a Light Rail Transit and Busway System which in its design, construction and operation, meets with generally accepted principles of safety and is consistent with sound and accepted engineering standards and practices. The articulation of these principles, standards and practices must take into account the safety concerns and physical, demographic and land use environments of the communities along any given section of LRT line or Busway.

### 3. Principle of Community Viability

In the design, construction and operation of the LRT or Busway system, the City of Edmonton will use its reasonable efforts to maintain or reinforce those elements which contribute to the current viability of the communities adjoining the LRT or Busway system within the bounds of practicality and feasibility. It is recognized and accepted that the elements which influence community viability may vary from community to community.

### 4. Principle of Impact Mitigation

The City is committed to the practical and feasible mitigation or reduction of negative impacts on adjoining communities which may arise from the development of the LRT or Busway system.

### 5. Principle of Fiscal Responsibilities

The City is committed to the development of the LRT or Busway system in a manner which is consistent with its fiscal capabilities and fiscal priorities as may be established from time to time by City Council, as agent for the citizens of Edmonton.

### 6. Principle of Community Stability and Appropriate Revitalization

In its decision relating to land development, land use change and possible related demographic implications, the City will ensure adherence and consistency with the spirit, objectives and policies of the Municipal Development Plan and other planning instruments as may be adopted and amended from time to time.

### 7. Principle of Growth Accommodation through Public Transit Enhancement

The City affirms its commitment to the provision of an effective public transit system as a means of accommodating the City’s growing travel demands.

# APPENDIX “F”

# PHYSICAL DESCRIPTION OF ARTERIAL ROADWAYS SUBJECT TO AGREEMENTS WITH THE PROVINCE OF ALBERTA

## THE CITY OF EDMONTON

## TRANSPORTATION SYSTEM BYLAW

## NUMBER 13423

**3. AVENUES**

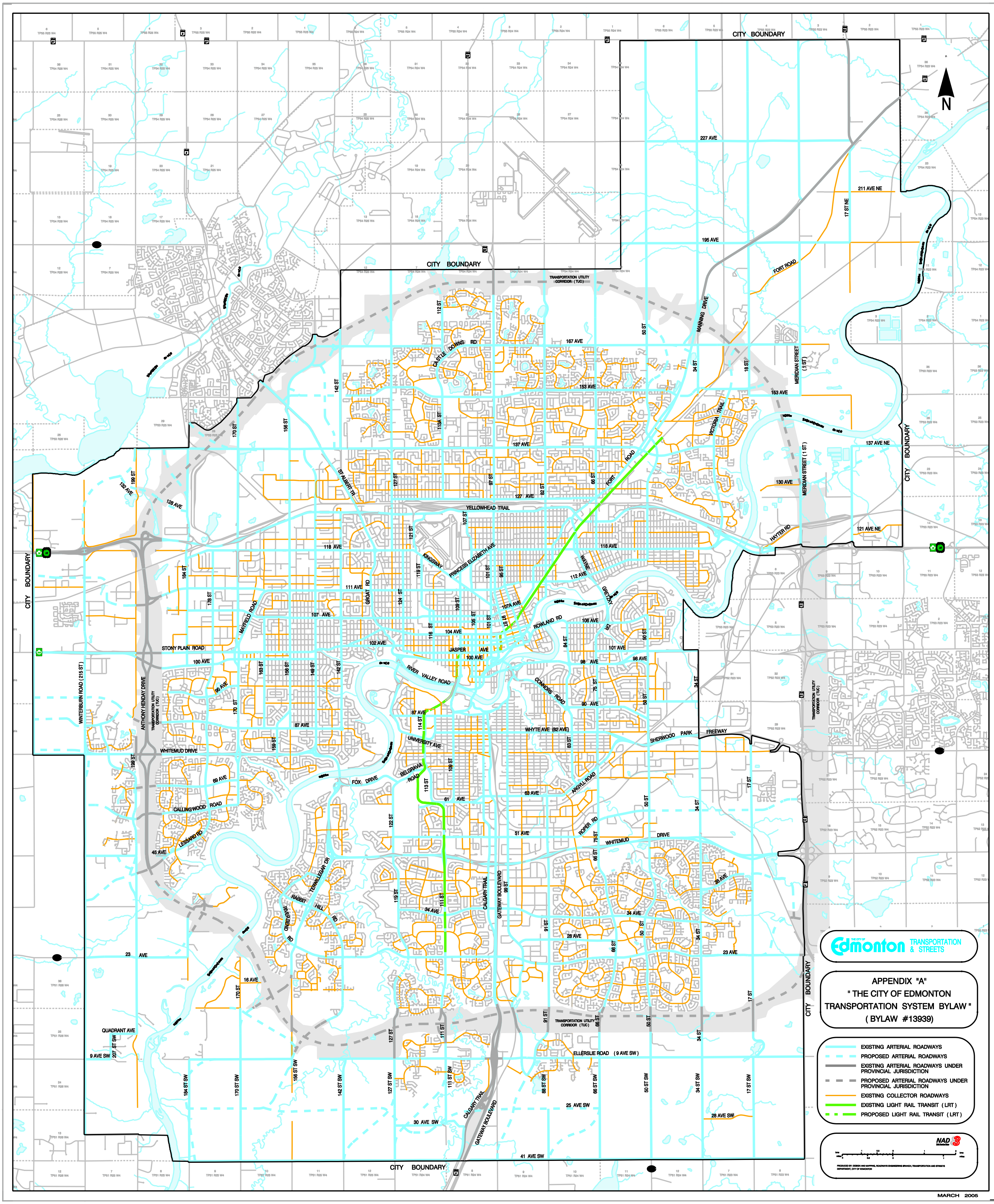
| Avenue | Limits | P |
|---|---|---|
| 111 Avenue NW | Within the Transportation and Utility Corridor | |
| 100 Avenue NW | Within the Transportation and Utility Corridor | |
| 87 Avenue NW | Within the Transportation and Utility Corridor | |
| 69 Avenue NW | Within the Transportation and Utility Corridor | * |
| 62 Avenue NW | Within the Transportation and Utility Corridor | * |
| 45 Avenue NW | Within the Transportation and Utility Corridor | |
| 34 Avenue NW | Within the Transportation and Utility Corridor | * |
| 23 Avenue NW | Within the Transportation and Utility Corridor | * |
| 25 Avenue SW | Within the Calgary Trail SW (Highway 2) Right of Way | * |
| 41 Avenue SW | Within the Calgary Trail SW (Highway 2) Right of Way | * |

**2. STREETS**

| Street | Limits | P |
|---|---|---|
| 17 Street NW | Within the Transportation and Utility Corridor | |
| 34 Street NW | Within the Transportation and Utility Corridor | |
| 50 Street NW | Within the Transportation and Utility Corridor | |
| 66 Street NW | Within the Transportation and Utility Corridor | |
| 91 Street NW | Within the Transportation and Utility Corridor | |
| 111 Street NW | Within the Transportation and Utility Corridor | |
| 127 Street NW | Within the Transportation and Utility Corridor | |

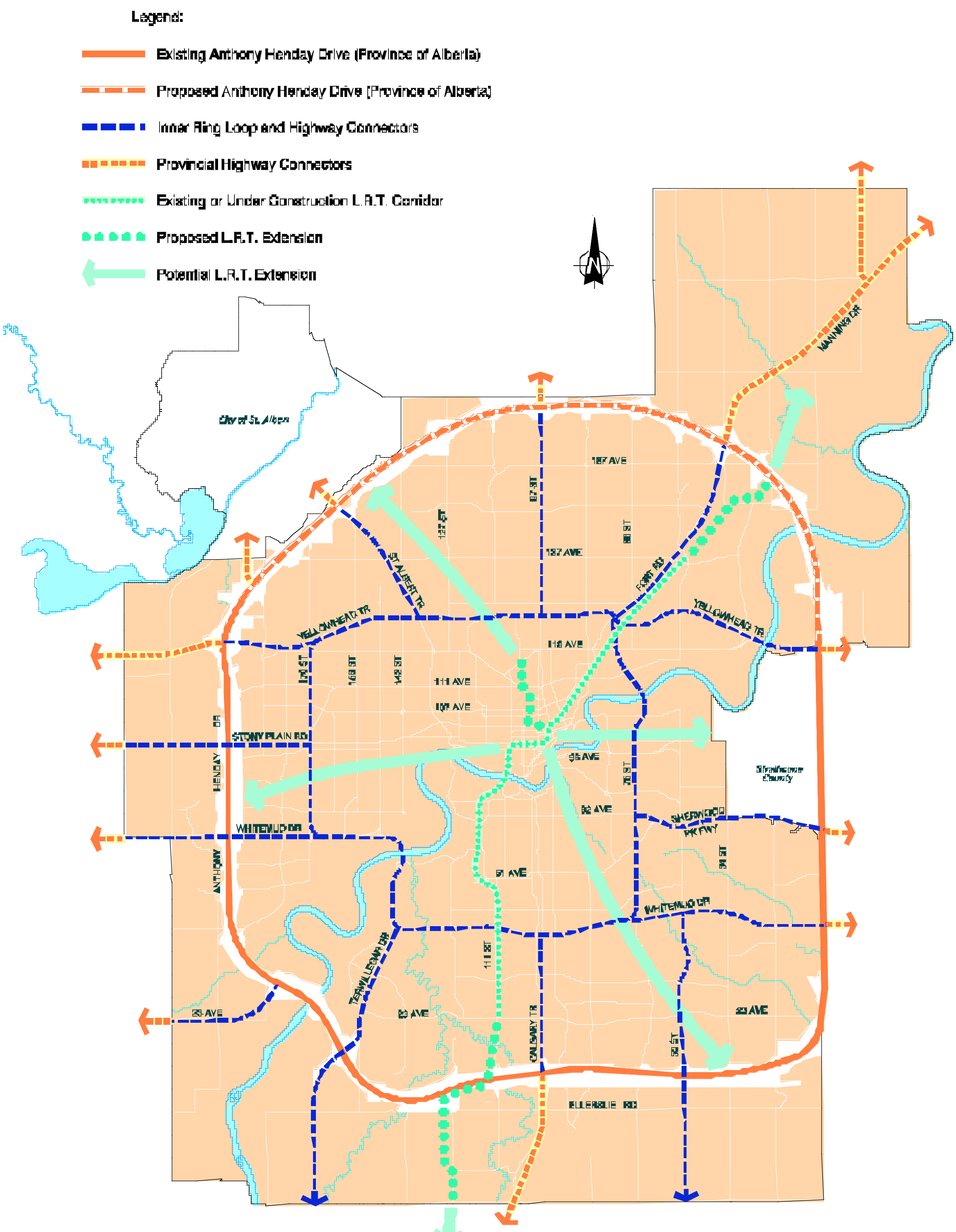
**3. NAMED ROADWAYS**

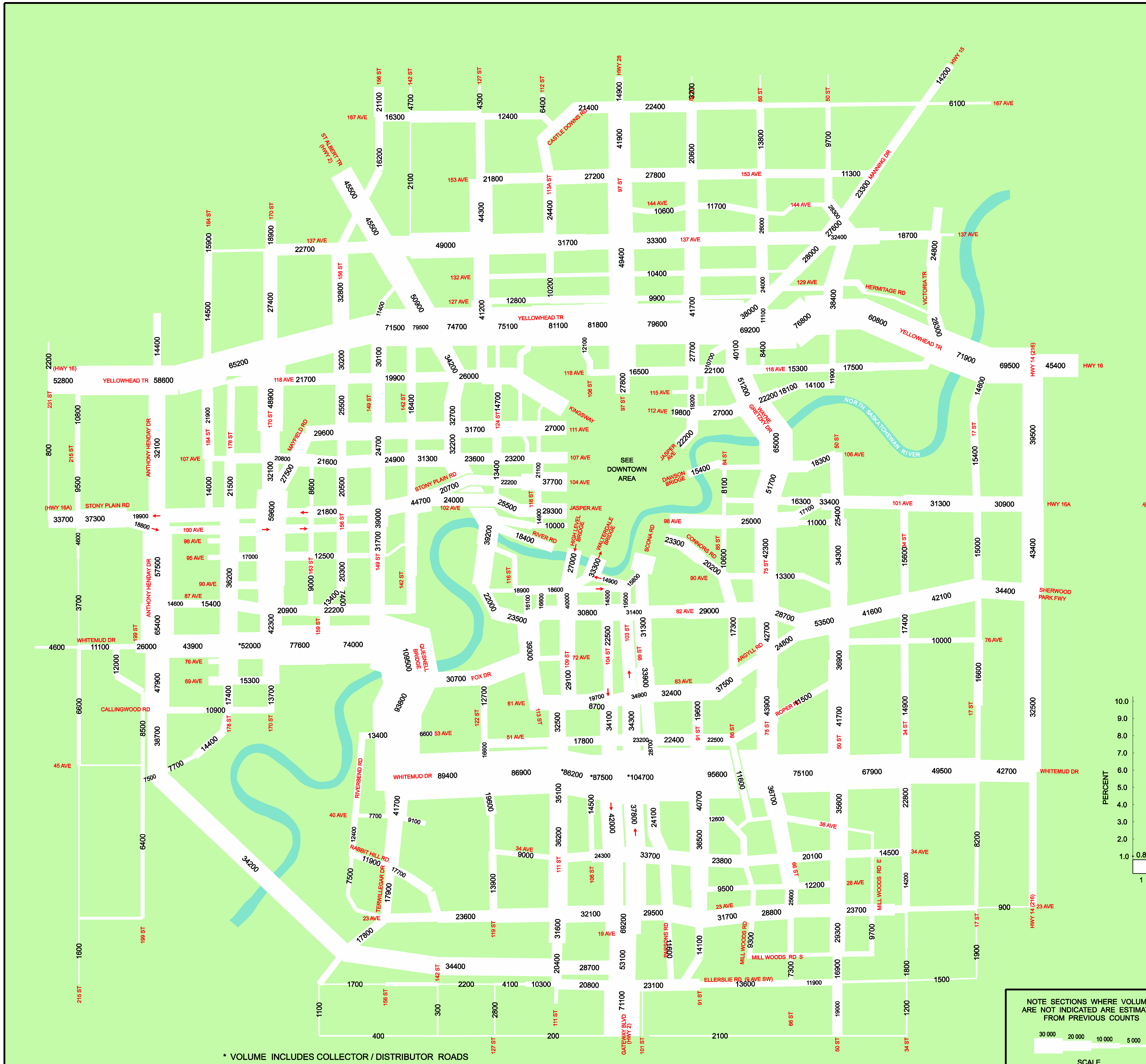
| Name | Limits | P |
|---|---|---|
| Anthony Henday Drive NW | Yellowhead Trail NW to Meridian Street (1 Street) | * |
| Anthony Henday Drive NW | Yellowhead Trail NW to 45 Avenue NW | |
| Anthony Henday Drive NW | 45 Avenue NW to Calgary Trail (Highway 2) | * |
| Anthony Henday Drive NW | Calgary Trail (Highway 2) to Highway 14 | * |
| Calgary Trail (Highway 2) SW | South City Limit to Anthony Henday Drive NW | |
| Cameron Heights Drive NW | Within the Transportation and Utility Corridor | * |
| Ellerslie Road | Within the Calgary Trail SW (Highway 2) Right of Way | |
| Yellowhead Trail NW | Anthony Henday Drive NW West to City Limit | |
| Lessard Road NW | Within the Transportation and Utility Corridor | |
| Manning Drive NW | Meridian Street (1 Street) to Transportation and Utility Corridor | |
| Manning Drive NE | East City Limit to Meridian Street (1 Street) | |
| Parsons Road NW | Within the Transportation and Utility Corridor | |
| Rabbit Hill Road NW | Within the Transportation and Utility Corridor | * |
| Stony Plain Road NW | Within the Transportation and Utility Corridor | |
| Terwillegar Drive NW | Within the Transportation and Utility Corridor | * |
| Whitemud Drive NW | Within the Transportation and Utility Corridor | |
| Yellowhead Trail NW | Anthony Henday Drive NW to West City Limit | |

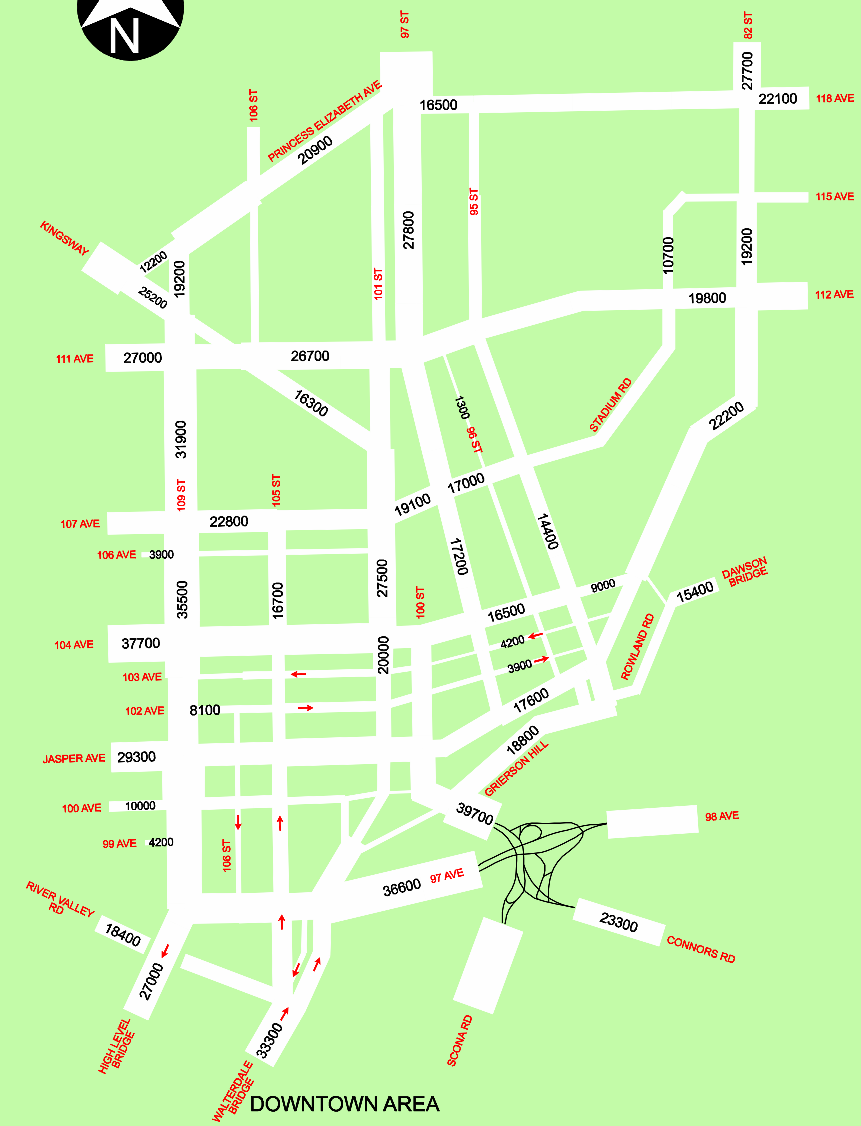


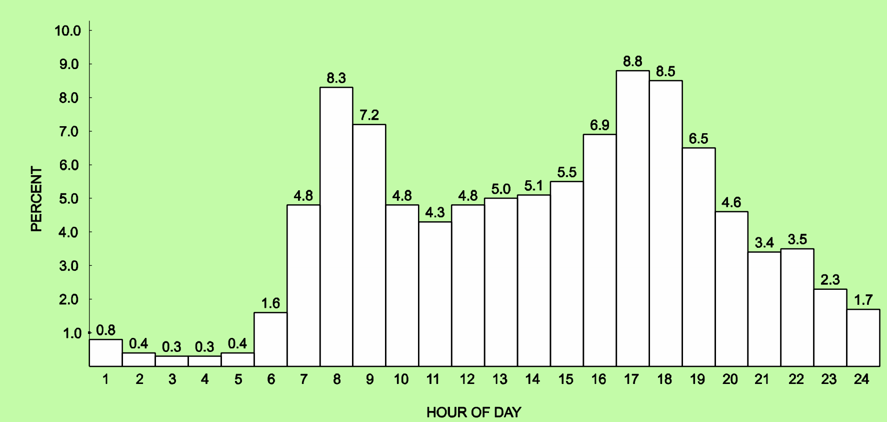
Edmonton TRANSPORTATION & STREETS
APPENDIX "A"
" THE CITY OF EDMONTON
TRANSPORTATION SYSTEM BYLAW "
( BYLAW #13939)
EXISTING ARTERIAL ROADWAYS
PROPOSED ARTERIAL ROADWAYS
EXISTING ARTERIAL ROADWAYS UNDER PROVINCIAL JURISDICTION
PROPOSED ARTERIAL ROADWAYS UNDER PROVINCIAL JURISDICTION
EXISTING COLLECTOR ROADWAYS
EXISTING LIGHT RAIL TRANSIT (LRT)
PROPOSED LIGHT RAIL TRANSIT (LRT)
NAD 83
N
CITY BOUNDARY
TRANSPORTATION UTILITY CORRIDOR (TUC)
227 AVE
211 AVE NE
195 AVE
167 AVE
153 AVE
137 AVE
137 AVE NE
130 AVE
127 AVE
121 AVE NE
118 AVE
112 AVE
111 AVE
107 AVE
107A AVE
106 AVE
104 AVE
102 AVE
101 AVE
100 AVE
98 AVE
90 AVE
87 AVE
WHYTE AVE (82 AVE)
UNIVERSITY AVE
69 AVE
63 AVE
61 AVE
51 AVE
45 AVE
38 AVE
34 AVE
28 AVE
23 AVE
16 AVE
QUADRANT AVE
9 AVE SW
ELLERSLIE ROAD (9 AVE SW)
25 AVE SW
28 AVE SW
30 AVE SW
41 AVE SW
YELLOWHEAD TRAIL
STONY PLAIN ROAD
JASPER AVE
WHITEMUD DRIVE
SHERWOOD PARK FREEWAY
FOX DRIVE
CALLINGWOOD ROAD
LESSARD RD
RABBIT HILL RD
TERWILLEGAR DR
RIVER VALLEY ROAD
BELGRAVIA ROAD
CONNORS ROAD
ROWLAND RD
ARGYLL ROAD
ROPER RD
GRETZKY RD
WAYNE
KINGSWAY
PRINCESS ELIZABETH AVE
ST ALBERT TR
CASTLE DOWNS RD
FORT ROAD
MANNING DRIVE
VICTORIA TRAIL
HAYTER RD
MERIDIAN STREET (1 ST)
MAYFIELD ROAD
GROAT RD
ANTHONY HENDAY DRIVE
WINTERBURN ROAD (215 ST)
CALGARY TRAIL
GATEWAY BOULEVARD
17 ST NE
MARCH 2005

Figure 7.1 Transportation Master Plan Concept - 2040






DISTRIBUTION OF AVERAGE ANNUAL WEEKDAY TRAFFIC BY TIME OF DAY

( BASED ON RIVER SCREENLINE )

NOTE: SECTIONS WHERE VOLUMES ARE NOT INDICATED ARE ESTIMATED FROM PREVIOUS COUNTS

30 000 20 000 10 000 5 000

SCALE

# 2007 TRAFFIC FLOW MAP

## AVERAGE ANNUAL WEEKDAY TRAFFIC

THE CITY OF Edmonton

TRANSPORTATION DEPARTMENT