BIODIVERSITY DESIGN GUIDELINES

ROAD ECOLOGY

3

Context

Roads can affect wildlife in different ways. On a landscape scale, roads can result in significant habitat loss and fragmentation and create barriers to movement. Reducing the amount of available habitat and isolating populations can lead to biodiversity loss over time as animals are unable to meet their life requisites for food, shelter, and breeding. Animals forced to cross roads in order to move between habitats face an additional risk of mortality due to vehicle collisions. This risk increases when animals become attracted to roads for other reasons, such as opportunities to forage and hunt, or ease of movement during periods of inclement weather (e.g., snow). Wildlife-vehicle collisions are also a significant safety and cost concern for motorists; the Insurance Corporation of British Columbia (ICBC) and the BC Wildlife Collision Prevention Program estimates that between 300 and 650 people are injured each year due to wildlife incidents, which can result in tens of millions of dollars in insurance claims. Therefore, facilitating safe wildlife crossings in urban and rural areas is a benefit for both people and wildlife.

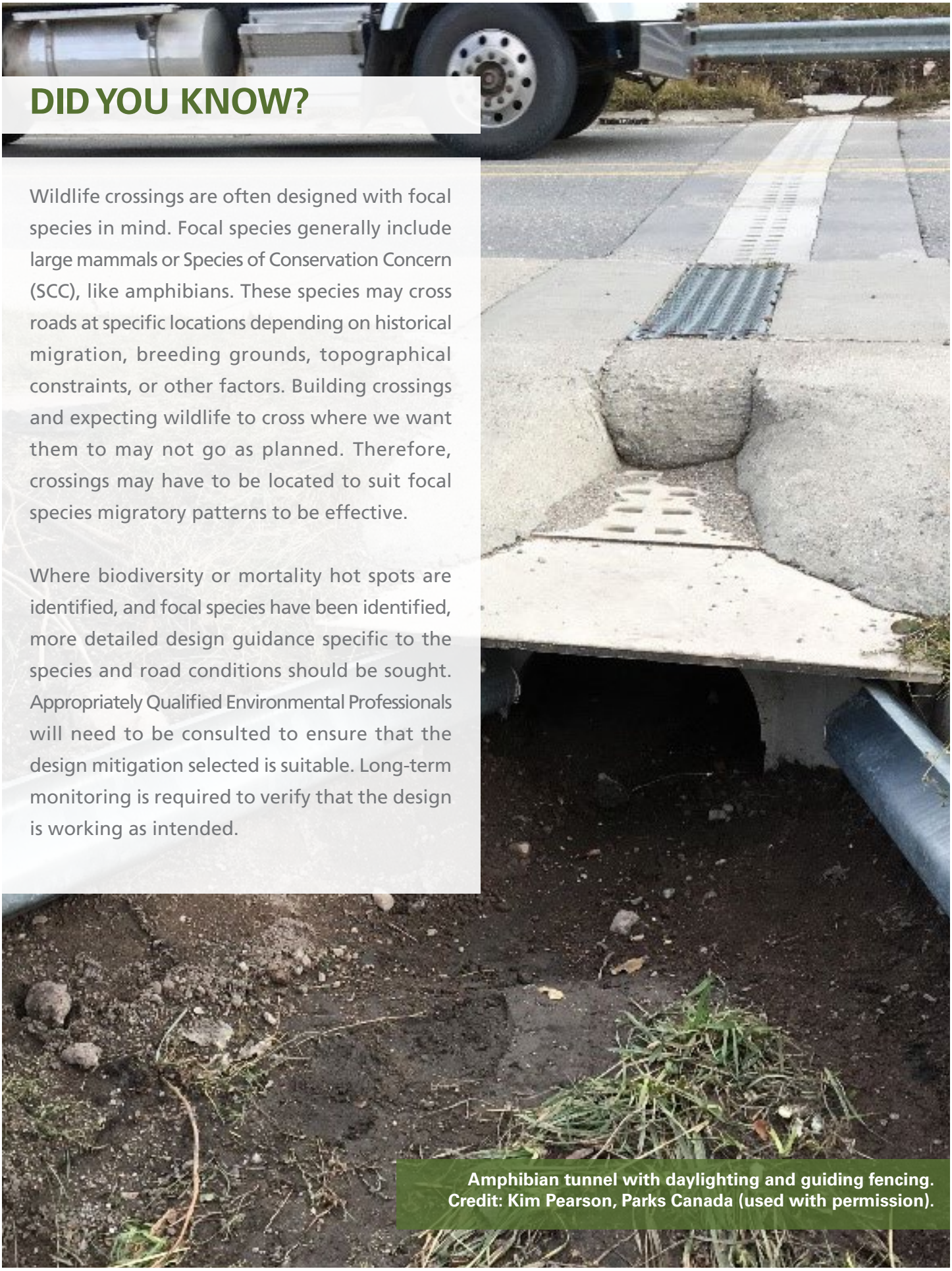
This module describes some strategies to facilitate safe wildlife crossings within the City of Surrey. A one-size-fits-all approach to road crossings is not practical due to the diversity of wildlife and variability of land uses within the City. Conversely, it is also impractical to design mitigation strategies that focus on each individual species and road crossing scenario. The strategies provided are intended to mitigate some of the impacts to wildlife populations by providing general guidance to improve permeability and habitat connectivity across roads and by reducing wildlife-vehicle collisions. Designers and managers are also provided with different tools that can be adapted to specific scenarios based on a more in-depth evaluation of the values, constraints, and opportunities that should be considered when designing safe wildlife crossings.

Mule Deer Buck
Photo credit: Jon Nelson

DID YOU KNOW?

Wildlife crossings are often designed with focal species in mind. Focal species generally include large mammals or Species of Conservation Concern (SCC), like amphibians. These species may cross roads at specific locations depending on historical migration, breeding grounds, topographical constraints, or other factors. Building crossings and expecting wildlife to cross where we want them to may not go as planned. Therefore, crossings may have to be located to suit focal species migratory patterns to be effective.

Where biodiversity or mortality hot spots are identified, and focal species have been identified, more detailed design guidance specific to the species and road conditions should be sought. Appropriately Qualified Environmental Professionals will need to be consulted to ensure that the design mitigation selected is suitable. Long-term monitoring is required to verify that the design is working as intended.



Amphibian tunnel with daylighting and guiding fencing. Credit: Kim Pearson, Parks Canada (used with permission).

Relevant Surrey Documents:

- ☑ Biodiversity Conservation Strategy (2014)
- ☑ Official Community Plan (2013)
- ☑ Neighbourhood Concept Plans (various years)
- ☑ Engineering Design Criteria Manual (2020)
- ☑ Park Design Guidelines (2020)
- ☑ Parks Standard Construction Documents (2017)
- ☑ Arterial Median Landscape Guidelines (2018)
- ☑ Supplementary Master Municipal Construction Documents (2020)
- ☑ Light Rail Wildlife Crossings Design Guidelines (2018)
- ☑ Greenways Plan (2012)

ICON LEGEND:

Large Mammals | *Med - Small Mammals* | *Bats* | *Insects* | *Pollinators* | *Invertebrates* | *Fish* | *Herptiles* | *Birds* | *Carnivores*

Cost Legend:

Relative Cost: $ (low), $$ (medium), and $$$ (high).

Module linkages:

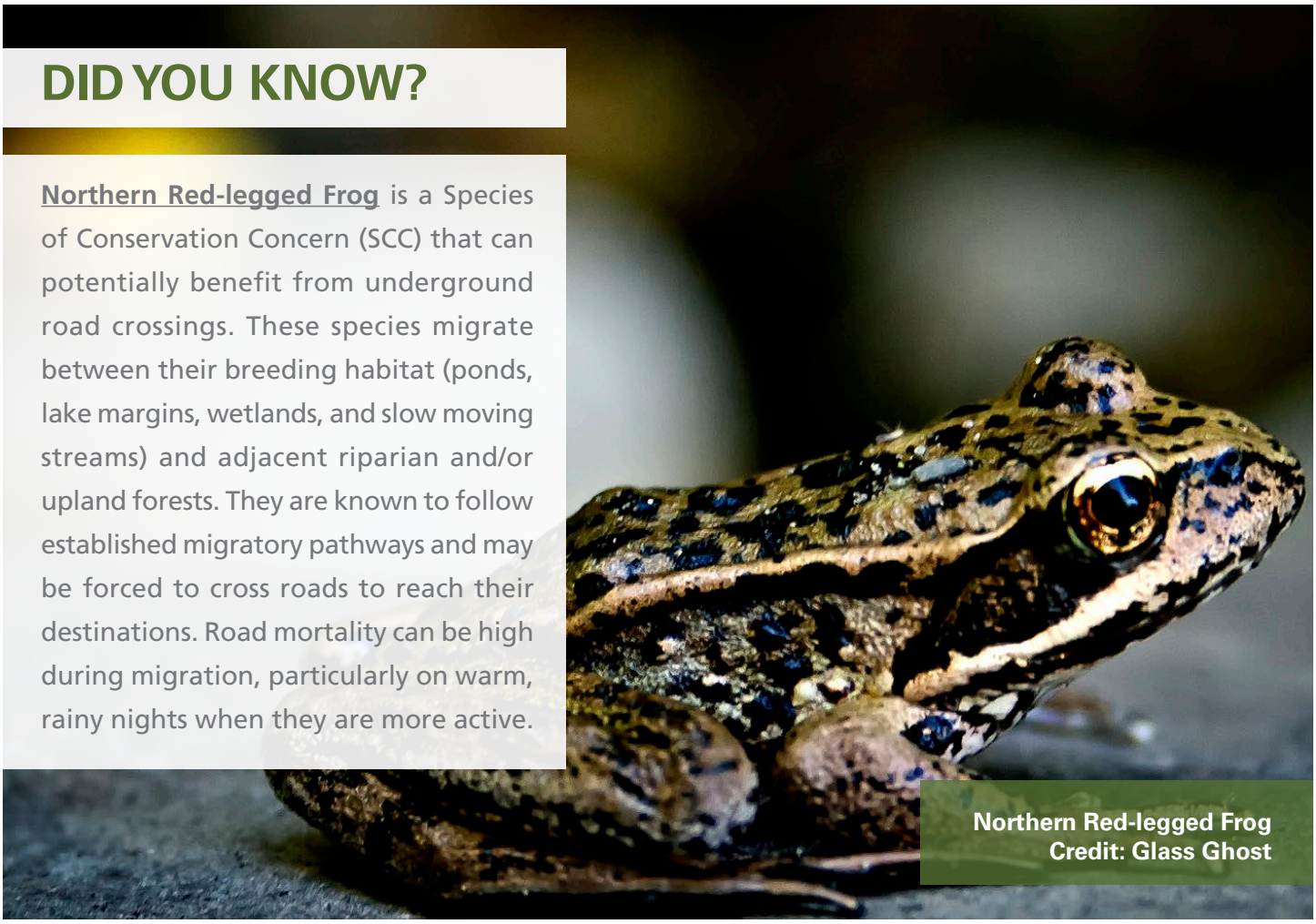
Key Considerations:

There are three general strategies to reduce wildlife-road collisions: Change driver behaviour; modify/control wildlife access; and, provide infrastructure to facilitate safe crossing. Effective wildlife-friendly road crossings should integrate all three. Additional considerations include:

- ☑ Coordinate across departments to ensure effective planning and implementation of wildlife crossing strategies in roads, rights-of-way, multi-use pathways and adjacent areas.
- ☑ Designing wildlife friendly crossings for multiple species can be challenging due to the differences in behaviour, habitat requirements, home range sizes, and movement patterns.
- ☑ Wildlife crossings should consider adjacent land use and identified corridors such as those in the City's Green Infrastructure Network.
- ☑ Effective wildlife-crossings allow for safe movement across (i.e., at grade), under, and/or over roads.
- ☑ Identifying the proper type and location of crossing structures is critical to ensure effective mitigation for wildlife.
- ☑ Design and construction can be costly for large structures. Integrating existing topography and landscape features with crossing structures can reduce costs.
- ☑ Traffic volume and road type can affect the risk of wildlife-vehicle collisions. Generally, high volume roads have higher mortality, but can deter crossing for some species. Whereas, roads with low traffic volumes may encourage crossings for some species, increasing the risk of collision.
- ☑ Maintaining cover and permeability (i.e., accessibility) are key factors to reduce risk of predation and permit escape and safe movement away from roadways.
- ☑ Standard size bridges and culverts often provide insufficient room to accommodate wildlife movement, particularly for terrestrial species and large mammals, and especially during high flow events.
- ☑ Wildlife crossings cannot compromise criteria for road safety and drainage. Sightlines must be considered for road crossings, specifically factors such as grade-elevation changes, curvature of the road, and placement of vegetation that may obscure driver vision.
- ☑ Wildlife crossings should be designed to permit monitoring and maintenance to verify crossing effectiveness.
- ☑ Traditional wildlife road crossing signage is often ignored by motorists; Use sparingly or in combination with other mitigation strategies. For example, warning signs activated by wildlife movement in high-risk areas.

DID YOU KNOW?

Northern Red-legged Frog is a Species of Conservation Concern (SCC) that can potentially benefit from underground road crossings. These species migrate between their breeding habitat (ponds, lake margins, wetlands, and slow moving streams) and adjacent riparian and/or upland forests. They are known to follow established migratory pathways and may be forced to cross roads to reach their destinations. Road mortality can be high during migration, particularly on warm, rainy nights when they are more active.



Northern Red-legged Frog
Credit: Glass Ghost

- ☑ Directional lighting can increase visibility for drivers and improve reaction time to crossing wildlife, particularly at night when many species are more active.
- ☑ Speed reduction strategies such as the use of speed bumps are better suited for local roads but not higher volume roads.
- ☑ Presence of wildlife crossing infrastructure may encourage human use and result in unwanted activity and disturbance. Consider strategies to deter human access, particularly within proximity to sensitive habitat.

3.1 AT GRADE CROSSINGS

3.1.1 FENCING

Wildlife exclusion structures include fences and walls designed to keep wildlife from accessing and crossing in certain areas, particularly those areas with low visibility. Fences can be used in concert with one-way gates (to allow exit but not entrance onto the roadway) and to guide wildlife to appropriate crossing locations. Fences can be designed for a diversity of species and are one of the most common mitigation strategies to prevent road mortality, particularly for small mammals, amphibians, and reptiles.[2]

Design Guidelines:

- ☑ Design for the target species and consider fencing location, type, materials, mesh size, spacing, and dimensions.
- ☑ Locate fences in priority hotspots where wildlife has been consistently crossing year after year.
- ☑ Extend barrier the entire length of the treatment area and beyond (i.e., include an additional buffer zone). Tie the barrier ends into another feature (e.g., concrete abutment, steep slope) or design curved ends to deter wildlife from going around the end of the fence. Ending a fence in an urban area can also deter wildlife use.
- ☑ Install barriers on both sides of the road unless there are pre-existing barriers to wildlife movement. Start and end fence on both sides of road at same point, where possible.
- ☑ Integrate a safe crossing location into the fence to allow wildlife movement but ensure there are no other unnecessary gaps. Locate fences and guide-walls appropriately to maximize use of crossing structures.
- ☑ Include vegetation in the design to reduce sun exposure and provide shade and cover, particularly if fencing is designed for amphibians and/or reptiles.

Focal Guilds and Species: 

Cost: $-$$

Where to Implement: Can be deployed in suitable habitats in conjunction with wildlife crossing structures.

What to watch for:

- ☑ Additional measures to prevent animals from tunnelling or crawling under fencing or climbing over top may be required. Fences are often buried in the ground and climbing deterrents may be added for amphibians and small mammals.
- ☑ Fences with different mesh sizes can be combined to include a high large-mesh fence and low fine-mesh fence that is angled to prevent climbing.

Fabric fence to guide amphibians
Credit: Barb Beasley

- ☑ Slope erosion and wash-outs can potentially cause gaps in the fence. Fences can be subject to failure and collapse if not installed with proper materials or erected and braced properly and in the right location.
- ☑ Prey species may become vulnerable to predators that learn to hunt along fence lines.
- ☑ Conduct regular monitoring to ensure fences are functioning properly, wildlife are not trapped, and that gates and wildlife funnels at key points of the fencing are maintained and functioning properly.
- ☑ Some vegetation maintenance may be required to ensure wildlife is not able to breach or climb over fencing.

Co-benefits:

- ☑ Reduce wildlife-mortality.
- ☑ Improve road safety.
- ☑ Lower insurance costs.

FURTHER READING:

Animex Wildlife Fencing and Mitigation Solutions. [3]
The Evolution of Wildlife Exclusion Systems on Highways in British Columbia. [4]
Road Passages and Barriers for Small Terrestrial Wildlife.[5]
Wildlife Passage Engineering Design Guidelines.
Guidelines for Amphibian and Reptile Conservation During Road Building & Management Activities in British Columbia.[6]
CVC Fish and Wildlife Crossing Guidelines.[7] **Construction Guidelines for Wildlife Fencing and Associated Escape and Lateral Access Control Measures.**[8]
Wildlife Crossings Guidance Manual.[9]

3.1.2 ONE-WAY GATES

Animals can get trapped if they manage to breach a fence or walk around the fence ends. One-way gates are used in conjunction with wildlife fencing to allow animals trapped on the roadway an escape path to adjacent habitat areas. One-way gates are typically designed for large mammals, particularly ungulates (e.g., deer). Studies have shown one-way gates to be moderately effective in reducing vehicle mortality.[10]

Design Guidelines:

- ☑ Ensure gate tynes are wildlife-safe. Disk and ball tyne designs can reduce the risk of snaring and impalement.
- ☑ Integrate with suitably high fencing system (2.4m), ungulate guards, and crossing structures to improve effectiveness.

Focal Guilds and Species:

Cost: $

Where to Implement: Can be deployed in diversity of land cover/land use areas where habitat conditions are suitable.

What to Watch For:

- ☑ One-way gate designs should ensure that wildlife does not get stuck or impaled in the gate. Pair with species-appropriate fencing.
- ☑ Regular monitoring ensures gates are functioning properly, wildlife are not trapped, and fences along gates are maintained. Reduce vegetation around gates to maintain clear access.
- ☑ Earthen escape ramps and jump-outs have also proven to be effective strategies to allow large mammals an escape path from roadways. These strategies also provide a more natural look. The British Columbia Ministry of Transportation has raised some safety concerns regarding use of these structures by mountain bikers, ATV riders, and hikers.[4]

3.1.3 WILDLIFE *"CROSSWALKS"*

Wildlife crosswalks are structures designed to be level with the road and use fencing to direct animals to an appropriate, painted crossing point where drivers can anticipate their presence. Wildlife crosswalks are a more cost-effective alternative to overpasses or underpasses. The effectiveness of this strategy has not been substantially evaluated.[11]

Design Guidelines:

- ☑ Use fencing and natural features (e.g., boulders) to guide wildlife to crossing location and deter entrance into fenced right-of-way. Install one-way gates where appropriate.
- ☑ Paint white lines and/or apply raised rib line along the crosswalk to enhance visibility for motorists.
- ☑ Remove vegetation along the path to discourage foraging.

Deer gate
Credit: Folk Photographer

☑ Install warning and/or wildlife-activated signs.

Focal Guilds and Species:

Cost: $$

Where to Implement: Low volume roads in Urban Matrix. Crosswalks are less effective on busy roads.

FURTHER READING:

The Evolution of Wildlife Exclusion Systems on Highways in British Columbia.[4]
Construction Guidelines for Wildlife Fencing and Associated Escape and Lateral Access Control Measures.[8]
Wildlife Passage Engineering Design Guidelines
Construction Guidelines for Wildlife Fencing and Associated Escape and Lateral Access Control Measures.[5]

Table 1. Fencing Dimensions, Materials and Considerations for various species groups. Adapted from (Huijser et al. 2015).

SPECIES GROUP	FENCING DIMENSIONS	MATERIAL TYPE	COMMENTS
Ungulates & Large mammals	2.4m high Mesh size: 15 – 18cm Or electric (as low as 1.8m high)	Woven galvanized wire mesh (12.5 gauge) Post material: treated wood Post dimensions: 13cm diameter spaced 4.2 – 5.4m apart for line posts and 16cm corner posts. Posts typically 3-4 ft deep in ground.	Electric fencing may be used and fence height decreased to 1.2 – 1.5m. Fence height may be increased for large carnivores (bears). Fence flush to ground. May be combined with smaller (8cm) mesh size at bot-tom for multi-species considerations. No dig barrier or overhang required.
Medium Sized Mammals (e.g. bobcat)	0.9 – 1.8 m high Mesh size: 8 cm or chain-link.	Woven wire mesh (12.5 gauge) with electrical wires along bottom and top	Can be modified to include floppy overhang to exclude feral cats (e.g., 1.15m high with 60 cm curved 'flop-py' overhang (effective for feral cats). Dig barrier required.
Amphibians	0 .4 – 0.6m high, and buried 0.1m into ground	Recommend smooth plastic sheets (high-density poly-ethylene (HDPE) Wood or metal posts	Can be attached to fence for medium or large sized mammals. Dig barriers needed for species that dig. Overhang/climb barrier suggested.
Snakes	0.6 – 1.1m	Smooth plastic sheets (HDPE) or barrier wall (concrete). Wood or metal posts.	Dig barrier (0.1m in ground) Overhang barrier required.
Turtles	0.30 – 0.60m high, and buried 5 – 20cm into ground	Woven vinyl erosion control fencing with wooden stakes or mesh wire (e.g., 1X1cm or 1.3 x 1.3cm or 2.4 x 5.0cm	Sometimes can contain aluminum flashing atop.
Multi-species design			Fine-mesh for small mammals at first section of ground can be combined with larger-mesh for larger mammals in upper sections. Or alternatively amphibian fencing can be attached at lower portions. A buried apron angled away from the road can be attached to prevent digging. High tensile wire on top of a wildlife fence may reduce damage from falling trees and reduce maintenance.

3.1.4 WILDLIFE CURBS

Wildlife curbs prevent animals from being trapped while crossing roadways, reducing the risk of traffic mortality, predation, or overheating. There are different designs depending on the objective and species. Inset curbs prevent amphibians from falling into storm drains (as they naturally follow the curb wall and bypass storm grating). Gently sloping or angled curbs prevent small wildlife from being trapped by vertical curbs too steep to climb over.

Design Guidelines:

- ☑ Include gentle slope, drop-down or ramp in curb design (incline to be no more than 45 degree).
- ☑ Install gaps or curb cuts if a continuous slope treatment is not possible.
- ☑ Roughen curbs to provide easy to climb surfaces for species like salamanders.
- ☑ Where flood risks and maintenance schedules can accommodate them, install screens over storm sewer grates to avoid entrapment of amphibians
- ☑ Minimize width of grate slits to no wider than 16 mm.
- ☑ Consider re-aligning grates away from curb (where possible) or including more grates to reduce the amount of surface runoff at crossings.
- ☑ Integrate gaps in Jersey barriers to allow small wildlife to escape roadway.

Focal Guilds and Species: 

Cost: $$

Where to Implement: Urban Matrix. GIN corridor crossings and areas associated with high amphibian use (e.g. streams and wetlands).

What to Watch For:

- ☑ May require regular cleaning and maintenance to prevent flooding from leaves and debris blocking screens and narrow grates.
- ☑ Potential misuse of curbs by motorists should be considered.

3.1.5 DIVERSIONARY METHODS – POLES, FENCES, BERMS, VEGETATION

Diversionary methods include artificial and natural methods to reduce vehicle collisions by creating a perceived barrier and encouraging birds, bats, and perhaps even flying insects to change their flight path above traffic while crossing. Birds and bats that forage along roadways and birds that use bridges as habitat are considered most at risk of collisions causing injury or mortality.[5]

Design Guidelines:

- ☑ Diversion poles are usually used on bridges. Consider height, width, and spacing of poles when installing. Install poles a minimum of 3m high. Bridges with larger

Wildlife Curb
Credit: Parks Canada

vehicles may require taller poles. Space poles close enough together to deter through-flight; spacing will depend on target species (consult a QEP).

- ☑ Keep height of diversion fences a minimum of 1.8m and taller (above height of traffic) if possible.
- ☑ Install berms that are taller than the height of traffic (minimum 3m).
- ☑ Add reflective markers to barriers.
- ☑ Keep roadside plantings dense and higher than height of traffic. Plant trees at both sides of bridges. Planting taller vegetation in medians can encourage birds to cross at desired locations.

Focal Guilds and Species:

Cost: $-$$

Where to Implement: Anywhere habitat conditions permit, especially around bridges, known forage spots along roadways, migration routes, and GIN corridors.

What to Watch For:

- ☑ Planting trees close to roadside may not be practical or safe. For roadside tree planting, it may be necessary to irrigate vegetation during the first few years.
- ☑ Diversion fences are less effective than berms for reducing vehicle-bat collisions due to the flight patterns of bats.
- ☑ Consider potential restrictions for maintenance access to adjacent (roadside) areas that may be created by diversionary devices.

Co-benefits:

- ☑ Berms can reduce noise and road sightlines.
- ☑ Vegetation can help reduce greenhouse gases/air pollution and capture/filter rain and stormwater.

FURTHER READING:

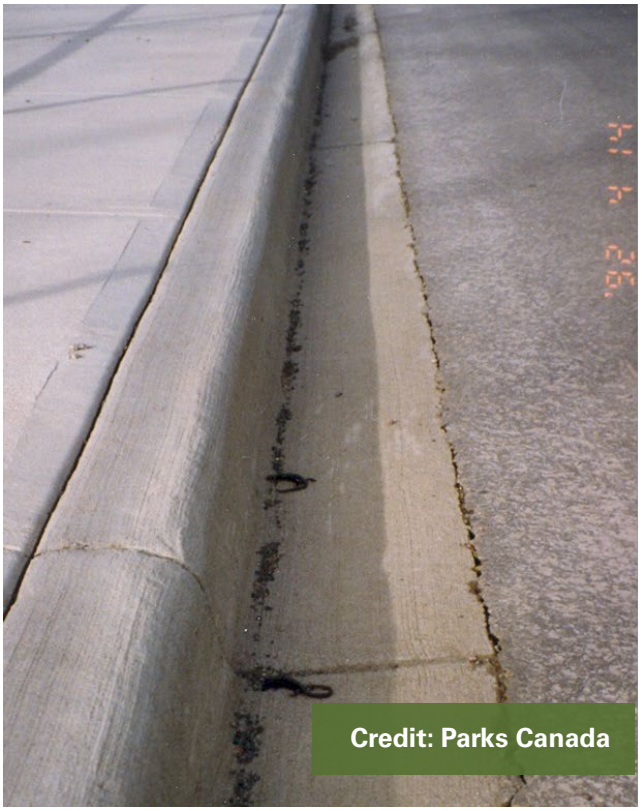
Wildlife Passage Engineering Design Guidelines.[5]
CVC Fish and Wildlife Crossing Guidelines.[7]
Guidelines for Amphibian and Reptile Conservation During Road Building & Management Activities in British Columbia.[6]

CASE STUDY

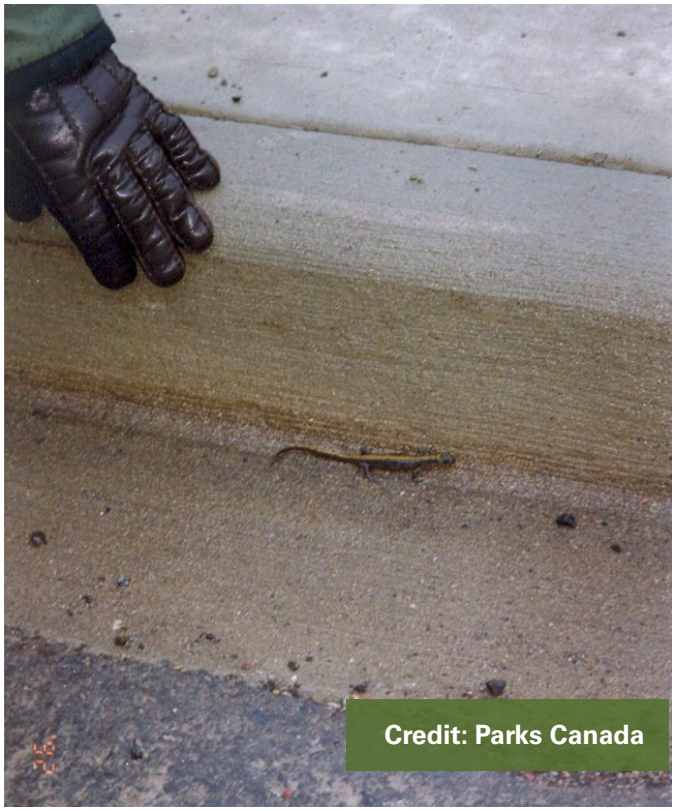
Wildlife Curbs

Waterton Lakes National Park, AB

Vertical curbs constructed as part of a road improvement project in Waterton Lakes National Park were discovered to be trapping thousands of Long-toed Salamanders as they moved across the road as part of their annual migration. Unable to escape the roadway, the salamanders were more susceptible to road mortality from passing vehicles and predation due to lack of cover. The vertical curbs were replaced with gently-sloped cement curbs that were 'roughened' to provide toe-holds for climbing salamanders. Additional drains were also installed on the roadway to reduce water volume and the number of salamanders being washed down the road.



Credit: Parks Canada



Credit: Parks Canada

3.2 TRAFFIC MANAGEMENT

3.2.1 SPEED BUMPS

Speed bumps are a traffic calming measures that can be used to improve wildlife visibility and to assist in wildlife passage. Speed bumps are often used in combination with other measures including signage and animal-vehicle detection systems.

Guilds and Focal Species: Most wildlife species.
Cost: $-$$

Where to Implement: Local roads with low speed limits, poor visibility due to road curvature or vegetation, or wildlife corridors (GIN).

What to Watch For:

- ☑ Specific criteria for installation must be considered to ensure no undue impacts to emergency services, transit, and other vehicles.

3.2.2 SIGNAGE

Signs can be used to alert motorists of the potential presence of animals crossing, particularly in high risk collision areas. Different types of wildlife warning signs can be employed, including standard, seasonal, and enhanced designs that incorporate lights, are interactive, or use motion sensors that are wildlife-activated. Signage is often implemented with other mitigation measures. Signage can also be multi-functional and designed to act as public art installations.

Design Guidelines:

- ☑ See Module 8: Signage for design guidelines for different types of signs .

Focal Guilds and Species: 
Cost: $-$$

Where to Implement: Known wildlife crossings, wildlife mortality hotspots, wildlife corridors within the Green Infrastructure Network.

What to Watch For:

- ☑ Standard warning signs are seen as low cost mitigation approaches, but are generally considered ineffective. This is particularly true in urban areas where drivers often travel the same routes and become habituated to conditions, resulting in signs being ignored altogether.
- ☑ Signs are more effective for large wildlife.
- ☑ Animal detection systems can be moved to coincide with seasonal wildlife movement patterns.
- ☑ Maintenance is required to ensure signage is visible during appropriate times.
- ☑ May require lighting and additional measures for human safety.

Speed bump on local road
Credit: Payton Chung

Wildlife crossing sign
Credit: City of Surrey

- ☑ Wildlife still has to cross the road and there is some risk of mortality due to vehicle collisions.
- ☑ Signage style should be considered for effectiveness against human complacency.
- ☑ Signage style should be considered for effectiveness against human complacency.

FURTHER READING:

Wildlife Passage Engineering Design Guidelines.[5]

3.2.3 MEDIANS

Planted medians are typically constructed for aesthetic values and road safety, and can help wildlife navigate and cross habitats fragmented by roads. Conversely, removal of existing medians may be a consideration where narrowing road widths will reduce vehicle speed and subsequent risk of wildlife-vehicle collisions.

Design Guidelines:

☑ See Module 6: Maintained Landscapes for design guidelines for medians.

What to Know:

☑ Medians are more likely to be used by generalist species, including birds, that are more common in the urban matrix.

☑ Maintaining road user sightlines is essential near intersections, walkways, crosswalks, driveways, and other priority locations. Median plantings may be limited in height, width, or length, and/or may require frequent maintenance (e.g., trimming).

☑ Medians can attract wildlife, inducing them to cross roads and potentially entrap them. Avoiding planting palettes that include forage opportunities for herbivores (e.g. deer), and fruiting species that attract birds, can decrease the potential for wildlife-vehicle collisions.

☑ Removal or narrowing of medians should be reviewed on a case-by-case basis and integrated with other roadwork projects to reduce costs.

3.2.2 SPEED LIMIT REDUCTION

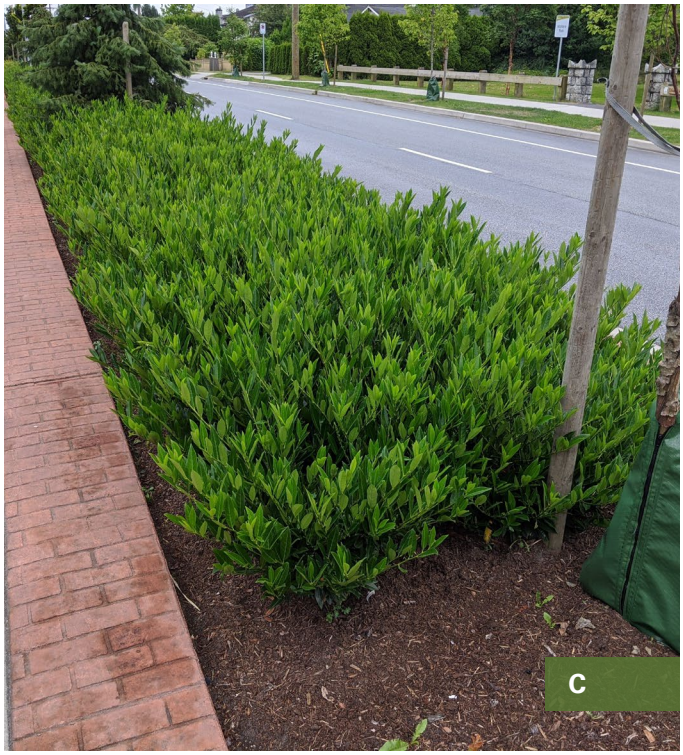
Speed limit reductions have been shown to reduce wildlife-vehicle collisions by allowing drivers more time to react to wildlife crossing a road. Reduced speeds can also encourage wildlife movement, reduce the risk of collision and mortality, and improve overall landscape permeability (i.e., compatibility of developed, semi-developed, and natural landscapes with wildlife needs). Small reductions in speed can make a big difference. For example, bird collisions are rare when traffic moves below 40 km/hr but increase above 55 km/hr.[13] Research has shown deer collisions were 7 times higher for roads with speed limits of 60 to 70km/hr compared to roads with speed limits below 50km/hr.[14]

Where to Implement: Areas where a road is close to water, forest, and open habitat. Known wildlife crossings, particularly for slower, more visible species.

What to Know:

☑ Seasonal or more specific daytime speed reductions may be considered based on wildlife activity (e.g., migration, breeding season, or other ecologically sensitive periods).

☑ Speed limit reductions should be planned in accordance with the Motor Vehicle Act and be considered in conjunction with signage, driver education, traffic calming, and enforcement mechanisms.



A - Boulevard bump out - Credit: City of Surrey
B - Reduced speed sign - Credit: Taber Andrew Bain
C - Planted median, Surrey - Credit: City of Surrey

3.3 BELOW GRADE CROSSINGS

3.3.1 UNDERPASS – TERRESTRIAL, SMALL TO MEDIUM SIZED MAMMALS

These wildlife underpass structures are designed primarily for small and medium-sized mammals, and they can they can also be adapted for use by amphibians and reptiles.[15]

Design Guidelines:

- ☑ Consult an appropriately Qualified Environmental Professional to determine crossing dimensions based on the needs of target species or other connectivity objectives.
- ☑ Recommended dimensions for small to medium-sized mammals are 0.3 – 1.2m wide and 0.3 – 1.2m high.
- ☑ Recommended dimensions for amphibians and reptiles are 0.3 – 1m diameter.
- ☑ Where shorter tunnel length is preferred over one long underpass. Combine two structures with a daylit central median in between.
- ☑ Include natural vegetation and berms near the openings to help funnel wildlife towards structures. Amphibians are unable to learn where crossings are and must be directed towards them.
- ☑ Include natural substrate to maintain moisture and humidity. This is especially important for amphibians.
- ☑ Include cover objects and micro-habitat features and ensure substrate does not impede movement. Avoid use of rip-rap.
- ☑ Provide light and maintain similar temperature inside structure to those of surroundings. This can be achieved by incorporating slots or grates to create openings or using two shorter structures instead of one long one.
- ☑ Use wildlife fencing to funnel wildlife to underpasses.
- ☑ See Aquatic Underpass section for further design guidance if underpass conveys water or drainage.

Focal Guilds and Species: 

Cost: $-$$

Where to implement: Known wildlife travel corridors; GIN road crossings; Road sections that are raised, on level ground, or cross riparian habitats and drainages.

What to Know:

- ☑ Monitor to ensure human use has not created conditions unsuitable for wildlife use.
- ☑ Conduct routine monitoring and maintenance to ensure that there are no obstructions (including overgrown weeds and invasive plants) that might impede wildlife use.
- ☑ Fencing will need to be checked on a regular basis to assess for proper function.

DID YOU KNOW?

The concept of openness is frequently used to plan and design wildlife underpasses. Openness is a measure used to define the relative visibility provided to wildlife within a structure, and is calculated by multiplying the height and width of a structure's opening and then dividing by its length (HxW)/L. Structures with a relatively high openness ratio are thought to more likely be used by larger species due to the increased visibility and light available. However, there are questions regarding the validity of openness ratios due to the measure's high correlation to underpass length, in addition to not considering other factors (e.g., habitat quality, target species) that may affect performance.[15] Openness is not used as a measure in this module; however, minimum entrance dimensions (height and width) are provided. These measures should be considered in conjunction with road specifications and other factors to determine if any upward adjustments to these dimensions are necessary.

Small mammal underpass
Credit: Barb Beasley

Co-benefits:

- ☑ Reduce wildlife-mortality.
- ☑ Improve road safety.
- ☑ Lower insurance costs.
- ☑ Improve aesthetics (underpass is hidden from view).
- ☑ Convey water.

3.3.2 UNDERPASS – TERRESTRIAL, LARGE MAMMALS

Wildlife underpass structures are designed specifically for large mammals, and can also be used by small and medium-sized mammals.

Design Guidelines:

- ☑ Size dimensions based on the crossing needs of target species or connectivity objectives. Consult an appropriately Qualified Environmental Professional.
- ☑ Avoid creating narrow, dark spaces that will deter use. Optimal dimensions for terrestrial underpasses are > 10m wide and > 4m high. Minimum dimensions are 7m wide and 4m high.
- ☑ Ensure clear sightlines to vegetation on other side of structure.
- ☑ Employ sloped sides rather than steep vertical sides to increase openness.
- ☑ Include natural, well-drained substrate (e.g., soil, mulch). Avoid use of riprap. Keep substrate continuous with surroundings.
- ☑ Incorporate cover objects and micro-habitat features.
- ☑ Keep entrances natural and incorporate native vegetation. Vegetation should be kept low to increase visibility and reduce cover opportunities for predators.
- ☑ See Aquatic Underpass section 3.3.6 for further design guidance if underpass conveys water or drainage.

Focal Guilds and Species: Most wildlife species.
Cost: $$$

Where to Implement: Known wildlife travel corridors; High mortality hot spots and major GIN corridor road crossings.

What to know:

- ☑ Avoid creating conditions that encourage human use and disturbance to wildlife.
- ☑ Conduct routine monitoring and maintenance to ensure that there are no obstructions (including overgrown weeds and invasive plants) that might impede wildlife use.
- ☑ Fencing will need to be checked on a regular basis to assess for maintenance and upgrades.

3.3.3 UNDERPASS – TERRESTRIAL, MULTI-USE

Multi-use underpasses are similar to large mammal underpasses but are smaller and designed for both wildlife and people. Recreational or agricultural use may be acceptable provided disturbance is minimal. Multi-use underpasses are not appropriate for all wildlife species, but are a good choice for urban areas where generalist species are common.

Design Guidelines:

- ☑ Avoid creating narrow, dark spaces that will deter use. Locate in areas where passage is wide but not long.
- ☑ Size dimensions based on the crossing

needs of target species or connectivity objectives. Consult an appropriately Qualified Environmental Professional.

- ☑ Recommended dimensions for terrestrial underpasses are > 7m wide and > 3.5m high. Minimum dimensions are 5m wide and 2.5m high.
- ☑ Create moist micro-climatic conditions and prefer natural, well-drained substrates (e.g., soil, mulch). Keep substrate continuous with surroundings.
- ☑ Incorporate cover objects and micro-habitat features.
- ☑ Encourage open designs that will allow natural light and growth of native vegetation.
- ☑ Confine human use to one side of structure if there is sufficient width (> 12m). Use vegetation to shield human use.
- ☑ See Aquatic Underpass section 3.3.6 for further design guidance if underpass conveys water or drainage.

Guilds and Focal Species: 

Cost: $$-$$$

What to Know:

- ☑ The need for more space and lighting to accommodate people and address safety concerns means wildlife use will primarily be limited to generalist species that are common in and/or adapted to human-dominated environments.
- ☑ Discourage human use (by using design interventions, signage, or other strategies) to mitigate disturbance effects on wildlife.
- ☑ Amphibians are not likely to use this type of passage unless located in migratory route during dispersal.
- ☑ Monitor to ensure human use has not created conditions unsuitable for wildlife use.
- ☑ Conduct routine monitoring and maintenance to ensure that there are no obstructions (including overgrown weeds and invasive plants) that might impede wildlife use.
- ☑ Fencing will need to be checked on a regular basis to assess for proper function.

Co-benefits:

- ☑ Provides opportunities for recreation and mobility.
- ☑ Improves aesthetics (hidden from view).
- ☑ Convey water.

FURTHER READING:

Road Passages and Barrier for Small Terrestrial Wildlife[2]
Guidelines for Amphibian and Reptile Conservation During Road Building & Management Activities in British Columbia.[6]
Wildlife Crossing Structure Handbook - Design and Evaluation in North America. [15]
Wildlife Passage Engineering Design Guidelines.[5]
Wildlife Crossing Structure Handbook - Design and Evaluation in North America.[15]

3.3.4 CULVERT – AQUATIC, AMPHIBIANS TUNNEL

Structures designed specifically for passage by herptiles, although other small and medium-sized wildlife may use them. Many different amphibian and reptile designs have been used to meet the specific requirements of each species.

Design Guidelines:

- ☑ Locate tunnels in known herptile migration routes.
- ☑ Size tunnel width accordingly. Width will increase with tunnel length; however, the minimum width should be at least 0.5m and preferably at least 1m. Tunnels should be as short as possible.
- ☑ Create moist micro-climatic conditions and prefer natural, well-drained substrates (e.g., soil, mulch). Keep substrate continuous with surroundings.
- ☑ Avoid riprap and large rocks which can be a barrier to movement.
- ☑ Maintain tunnel entrances at grade (avoid stepping up or down).
- ☑ Ambient light, temperature and moisture conditions need to be maintained (e.g. with slots/grates).
- ☑ Use polymer concrete material for increased durability and longevity.
- ☑ Install fencing to funnel wildlife to entrance.
- ☑ Place structures no more than 50 – 100m apart for amphibians depending on migration radius and 150m apart for reptiles.
- ☑ Mow grass within 0.5m of the guiding wall/ fence on the side that amphibians will travel. This is particularly important during migratory periods (e.g., adults moving back and forth for breeding; juvenile outmigration from breeding sites).

Focal Guilds and Species: 

Cost: $-$$

Where to Implement: Known migration routes to/from breeding areas (e.g., ponds, lakes, streams, other aquatic habitats).

What to know

- ☑ Amphibians may have difficulty finding new crossing structures.
- ☑ Structures can be difficult to maintain if they are long and daylighting is needed. Some daylighting will be required if crossing length exceeds two traffic lanes.
- ☑ Monitor to ensure human use has not created conditions unsuitable for wildlife use.
- ☑ Conduct routine monitoring and maintenance to ensure that there are no obstructions (including overgrown weeds and invasive plants) that might impede wildlife use.
- ☑ Fencing will need to be checked on a regular basis to assess for maintenance and upgrades.

CASE STUDY

Frog Tunnels,

Pacific Rim National Park, Tofino, BC

Frog tunnels constructed in Pacific Rim National Park near Tofino, BC, have proven effective to reduce Red-legged Frog mortality. Tunnel locations were selected based on data showing where migration and mortality was occurring. Directional fencing and lock-block walls were integrated in their design to keep frogs off the road and direct them to the tunnels where they could cross safely. Soil and logs placed in the tunnel provided natural substrate and cover to encourage safe movement and enhance connectivity. Tunnel dimensions permitted a hopping clearance of 30cm, but also proved adequate for other non-target species such as salamander and mink.

Credit: Barb Beasley

3.3.5 CULVERT – AQUATIC, SMALL TO MEDIUM MAMMALS, AMPHIBIANS

Crossing structures designed for use by small and medium-sized wildlife associated with riparian habitats or irrigation canals.

Design Guidelines:

- ☑ Size dimensions based on road width, structure type, and requirements of target species. Consult an appropriately Qualified Environmental Professional.
- ☑ Install dry platforms above the high water mark that is connected to adjacent habitat. Minimum platform width is 0.5m. Prefer installing walkways on both sides of watercourse; however, one is acceptable if space is limited.
- ☑ Maintaining suitable habitat (i.e., vegetation and cover) leading to the entrance can provide protection for smaller animals from predation.
- ☑ Consider position and slope of walkways under high-water conditions to allow passage. Access ramps should be less than 30 degrees slope.

Focal Guilds and Species: 

Cost: $-$$

Where to Implement: Riparian and wetland habitats; irrigation canals.

What to know:

- ☑ Culverts designed to meet drainage and hydraulic requirements generally do not consider wildlife movement, particularly terrestrial wildlife species that avoid water.
- ☑ Monitor to ensure human use has not created conditions unsuitable for wildlife use.
- ☑ Conduct routine monitoring and maintenance to ensure that there are no obstructions (including overgrown weeds and invasive plants) that might impede wildlife use.
- ☑ Fencing will need to be checked on a regular basis to assess for maintenance and upgrades.

Co-benefits:

- ☑ Improve aesthetics (underpass is hidden from view).
- ☑ Convey water (drainage).

FURTHER READING:

Road Passages and Barriers for Small Terrestrial Wildlife.[2]
Wildlife Crossing Structure Handbook - Design and Evaluation in North America. [15]
Guidelines for Amphibian and Reptile Conservation During Road Building & Management Activities in British Columbia.[6]
Wildlife Passage Engineering Design Guidelines.[5]

CASE STUDY

Wildlife Crossing, Redwood NCP

Surrey, BC

Central to the Redwood Neighbourhood Community Plan area is a critical corridor connecting Redwood Park in the south with the protected biodiversity hub and ALR lands in the north. The corridor will be a minimum of 50m wide with limited public access. There will be a special design cross section including a wildlife underpass where this corridor crosses an arterial road (24th Avenue). The underpass will be a specialized culvert 1m high by 3m wide designed to support small animal crossing.

Credit: City of Surrey

3.3.6 UNDERPASS – AQUATIC

Clear span bridges that include a raised bench designed to allow passage of moving water and wildlife. Structures can accommodate a large diversity of species, including large mammal species.

Design Guidelines:

- ☑ Consider channel width and floodplain when sizing dimensions for underpasses.
- ☑ Locate pathway above the high-water mark. Bench should be at a height that will not be inundated by water during high flow periods and at a slope that is traversable by wildlife. The recommended path width is > 3m for underpasses, with recommended height > 4m. Minimum width and height are 2m and 3m respectively.
- ☑ Additional cover and a passage bench above high water can encourage use by small mammals.
- ☑ Use substrates with smoother surfaces where possible. Angular, jagged riprap can trap amphibians and reduce mobility.
- ☑ Maintain continuous substrate with adjacent habitat.

Focal Guilds and Species:

Cost: $$$

Where to Implement: Riparian; Streams; Wetlands.

What to Know:

- ☑ Bridges designed to meet drainage and hydraulic requirements generally do not consider wildlife movement, particularly terrestrial wildlife species that avoid water.
- ☑ Large mammal use depends on how structure is adapted for their specific crossing needs.
- ☑ Amphibians not likely to use structure unless located in migratory route for breeding or dispersal.
- ☑ Monitor to ensure human use has not created conditions unsuitable for wildlife use.
- ☑ Conduct routine monitoring and maintenance to ensure that there are no obstructions (including overgrown weeds and invasive plants) that might impede wildlife use.
- ☑ Fencing will need to be checked on a regular basis to assess for maintenance and upgrades.

Co-benefits:

- ☑ Improve aesthetics (hidden from view).
- ☑ Convey water.

FURTHER READING:

Wildlife Crossing Structure Handbook - Design and Evaluation in North America.[15]
Wildlife Passage Engineering Design Guidelines.[5]
CVC Fish and Wildlife Crossing Guidelines.[7]

3.4 ABOVE GRADE CROSSINGS

3.4.1 CANOPY CROSSING

Canopy crossings refer to practices designed for semi-arboreal and arboreal species that commonly use canopy cover for travel. Natural crossings use large trees with branches that arch over a road and allow wildlife to move between fragmented habitats while reducing risk of road mortality. Installation of ropes or cables may be considered where the tree canopy has not fully developed.

Design Guidelines:

- ☑ Plan for larger trees with spreading canopies that will create connectivity over roadways.
- ☑ Preserve large trees where possible when creating linear corridors, as young and newly planted trees take some time to mature.
- ☑ Install ropes or cables across small roads where canopy does not extend far enough to permit crossing. Ropes can be connected to trees or permanent fixtures (e.g., posts).

Focal Guilds and Species: 

Cost: $-$$

Where to Implement: Forested areas close to road.

What to know:

- ☑ Protect boulevard trees in important crossing locations. Select crossing locations that are not subject to future road infrastructure improvements that may affect trees. Ensure trees are not encumbered by underground utilities or other infrastructure that may require ongoing maintenance or access.
- ☑ Pruning may be required to guide branch growth and manage potential tree hazards.
- ☑ Regular inspection and maintenance are needed to avoid deterioration and wear of materials used for the canopy crossing and replacement of components in poor condition.
- ☑ Regular street tree maintenance and hazard tree monitoring may be required.

Co-benefits:

- ☑ Improve visual aesthetics by integrating with public art.
- ☑ Provide shade and cooler temperatures.
- ☑ Reduce urban heat island effect.

FURTHER READING:

Wildlife Crossing Structure Handbook - Design and Evaluation in North America.[15]

3.4.2 LANDSCAPE BRIDGE/ WILDLIFE OVERPASS

Crossing structures designed exclusively for the passage of wildlife over roads to minimize road mortality and connect fragmented habitat. Landscape bridges support the greatest diversity of wildlife and should be situated in areas where there are major wildlife corridors.

Design Guidelines:

- ☑ Design overpass with a minimum width of 40m (50m recommended).
- ☑ Ensure sufficient space to accommodate bridge approaches.
- ☑ Mimic adjacent habitat including substrate and vegetation. Ensure suitable soil depth to support larger vegetation. Plant trees and shrubs to provide cover.
- ☑ Provide a mix of open and shrub/tree habitat.
- ☑ Establish light and noise barriers (e.g., berms, walls, dense vegetation) on either side of crossing structure.
- ☑ Install wildlife fencing to direct wildlife to crossing structure.
- ☑ Introduce cover and micro-habitat features for smaller wildlife species.

Focal Guilds and Species: 

Cost: $$$

Where to Implement: Anywhere with sufficient space on both sides of the road to construct. Best suited in areas bordered by elevated terrain (to reduce slope), major wildlife corridors, road collision hot spots, and highways and major arterial roads.

What to Know

- ☑ Wildlife and humans may use the same crossings for movement with some design adaptations; however, species less tolerant to human disturbance may avoid structures or prefer to cross at night when there is less activity.
- ☑ Monitor and maintain walls and fences.
- ☑ Plants may need to be maintained (e.g., irrigated) for first few years while they establish and during dry summers.
- ☑ Control human use to minimize wildlife disturbance.

FURTHER READING:

Wildlife Crossing Structure Handbook - Design and Evaluation in North America.[15]
Wildlife Passage Engineering Design Guidelines.[5]

Additional information, including design guidance, on wildlife-crossings can be found here:
BC Ministry of Transportation and Infrastructure (MOTI) – Wildlife Monitoring Program. [16]
Roads and Wildlife Portal (Canada).[17]
Wildlife and Roads (North America).[18]

A - Tree Canopy Crossing - Credit: Payton Chung
B - Wildlife Overpass, Banff National Park - Credit: Brian Sterling

3.5 ROAD CROSSING PALETTES

This section includes general multi-species design templates (i.e., palettes) for biodiversity-friendly road crossings within the City of Surrey. These palettes are based on existing best practices and guidelines and refer to relevant road types that intersect the City's Green Infrastructure Network (GIN). Road types include local, collector, and arterial roads. Provincial and Regional roads are not included as these roadways involve additional jurisdictions.

Road palettes include at grade, above grade, and below grade crossing designs, often in combination. The palettes do not cover all crossing scenarios and are not specific to any one species of wildlife; however, palettes can be modified and/or adapted to other conditions and focal species where required. An appropriately Qualified Environmental Professional should be consulted during the planning and design stage for all wildlife-crossings to verify biodiversity management objectives and ensure design specifications adhere to best practices.

ARTERIAL ROADS

Arterial roads are the main roads through the city. They are used by public transit and are important routes for emergency services. Arterial roads are planned to have four travel lanes, a landscaped median, grass boulevard with trees, sidewalks and street lighting. Some arterial roads are planned to be non-standard and have more or fewer lanes and different transit options.

Examples: Utility/GIN crossing at 140th Street north of 92nd Avenue; GIN/watercourse crossing at 96th Avenue west of 139th Street.

Collector Roads

Collector roads allow for traffic within larger neighbourhoods and town centres that are all potential transit routes. Collector roads are all planned to have two travel lanes (one in each direction), bike lanes, grass boulevards with street trees, sidewalks and streetlights, and parking on at least one side of the road.

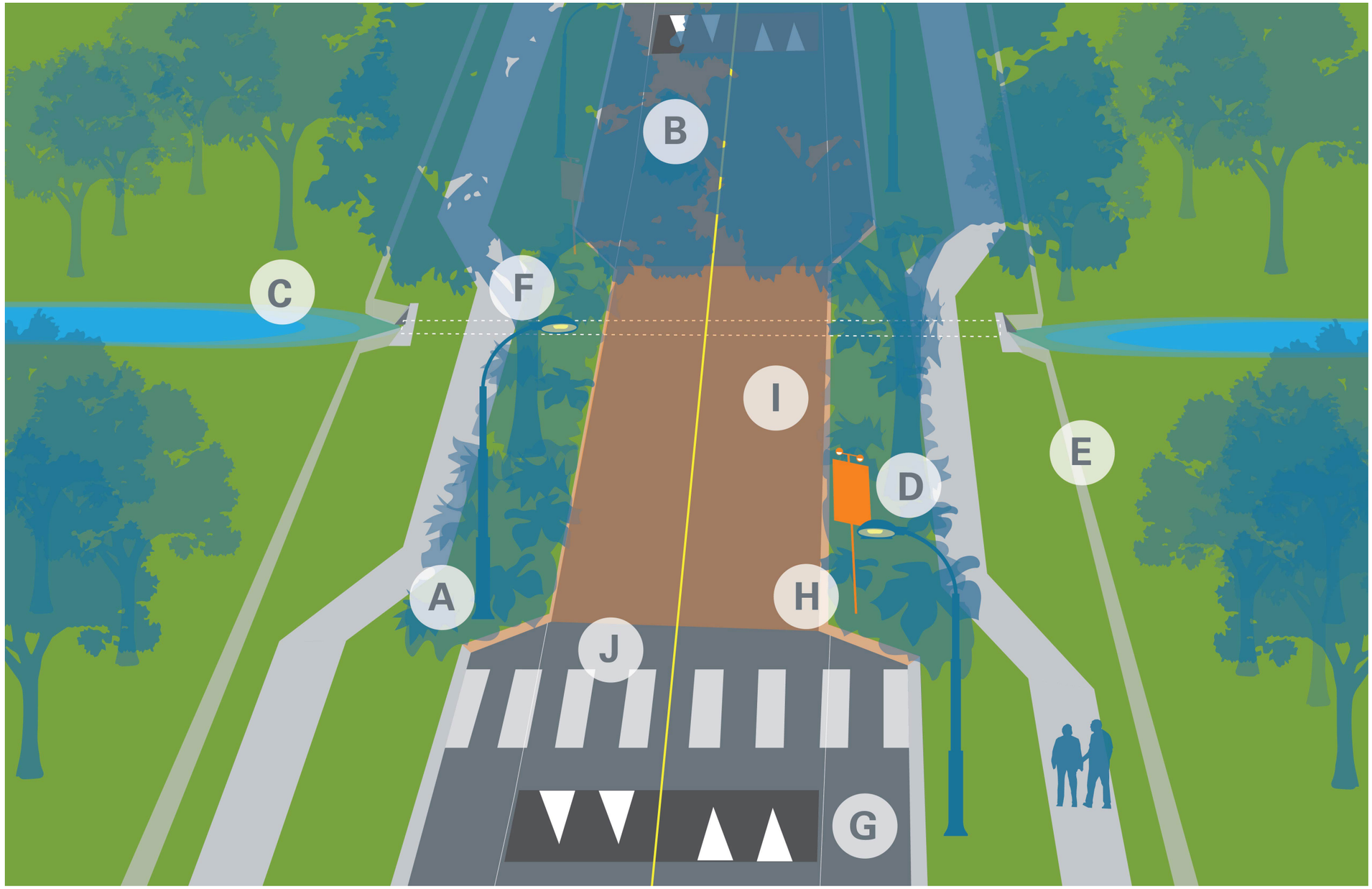
Examples: Utility/GIN crossing at 134th Street south of 92nd Avenue.

Local Roads

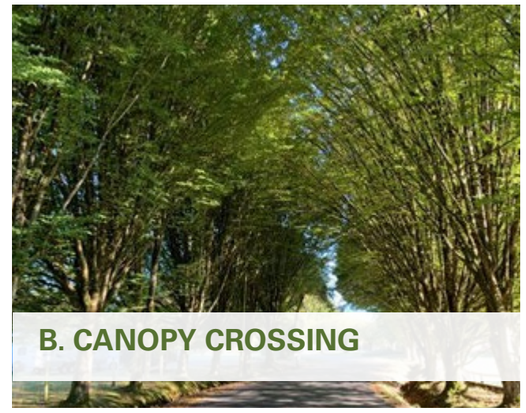
Local roads are mostly for local traffic and to connect communities. Most local roads have two-way travel, grass boulevards with street trees, sidewalks and streetlights, parking on at least one side of the road. Some local roads have two travel lanes, whereas others are "queuing streets". A queuing street has one travel lane with on-street parking and so drivers have to pull over to let oncoming cars to pass. These streets lower the speed of traffic and minimize the pavement width, so there isn't as big an impact on the environment or as much demand on the drainage system.

Examples: GIN/watercourse crossing at 62nd Avenue west of 140th Street

Design Strategy	Local Road	Collector Road	Arterial Road
Fencing	x	x	x
One-way Gates		x	x
Wildlife Crosswalks	x	x	
Wildlife Curbs	x	x	
Diversionary Methods (Poles, Fences, Berms, Vegetation)	x	x	x
Speed Bumps	x	x	
Signage	x	x	x
Medians			x
Speed Limit Reduction	x	x	x
Underpass – Terrestrial (Small –Med Mammal)	x	x	
Underpass – Terrestrial (Large Mammal)		x	x
Underpass – Terrestrial (Multi-Use)		x	x
Culvert – Aquatic, Amphibians Tunnel	x	x	
Culvert – Aquatic, Small – Medium Mammals, Amphibians	x	x	
Underpass - Aquatic	x	x	x
Canopy Crossing	x	x	
Landscape Bridge/Wildlife Overpass			x
Other Features			
Curb Bump Outs/ Remove Parking Lane	x	x	x
Planting			
Lighting	x	x	x
LID (e.g., bioswale, rain garden)	x	x	x
Coloured Pavement	x	x	x



A. PLANTED BUMP-OUT

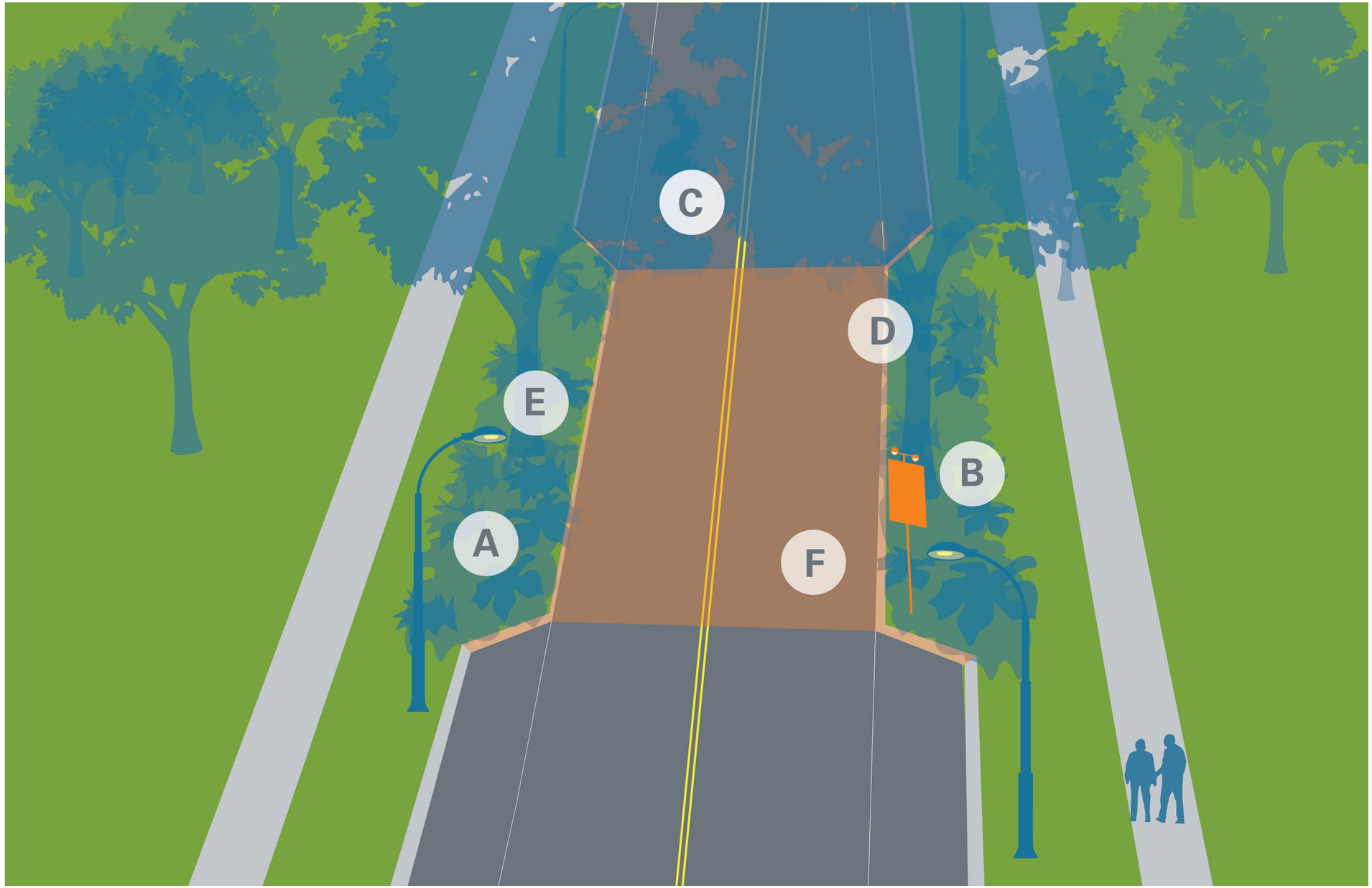


B. CANOPY CROSSING

C. MODIFIED CULVERT

Fig. 1: LOCAL ROAD - STREAM CROSSING

D. BRANDED SIGNAGE
E. WILDLIFE FENCE
F. WILDLIFE FRIENDLY LIGHTING
G. SPEED BUMP
H. WILDLIFE CURBS
I. BRANDED/COLOURED PAVEMENT
J. PEDESTRIAN CROSSWALK



A. PLANTED BUMP-OUT

B. BRANDED SIGNAGE

D. WILDLIFE CURBS

Fig. 2: COLLECTOR ROAD - TERRESTRIAL CROSSING

C. CANOPY CROSSING
D. WILDLIFE CURBS
E. WILDLIFE FRIENDLY LIGHTING
F. BRANDED/COLOURED PAVEMENT

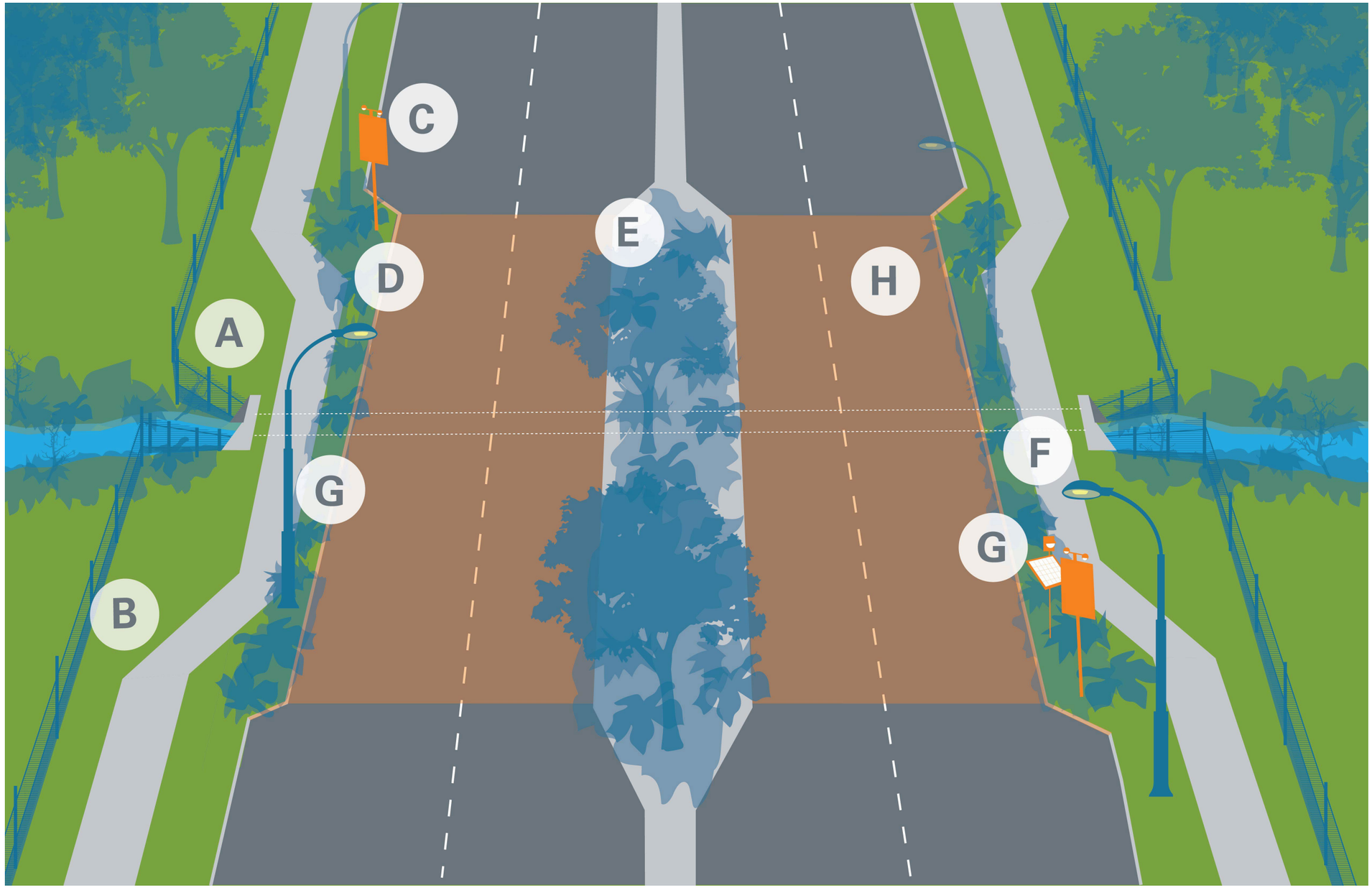
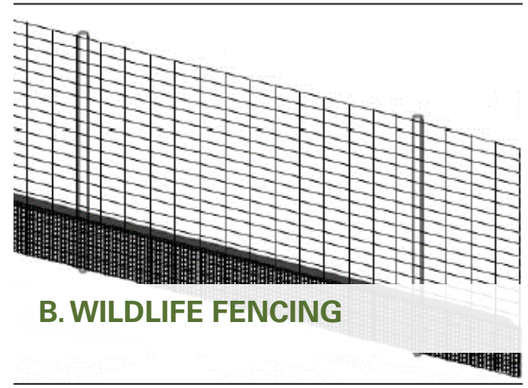


Fig. 3: ARTERIAL ROAD - STREAM CROSSING

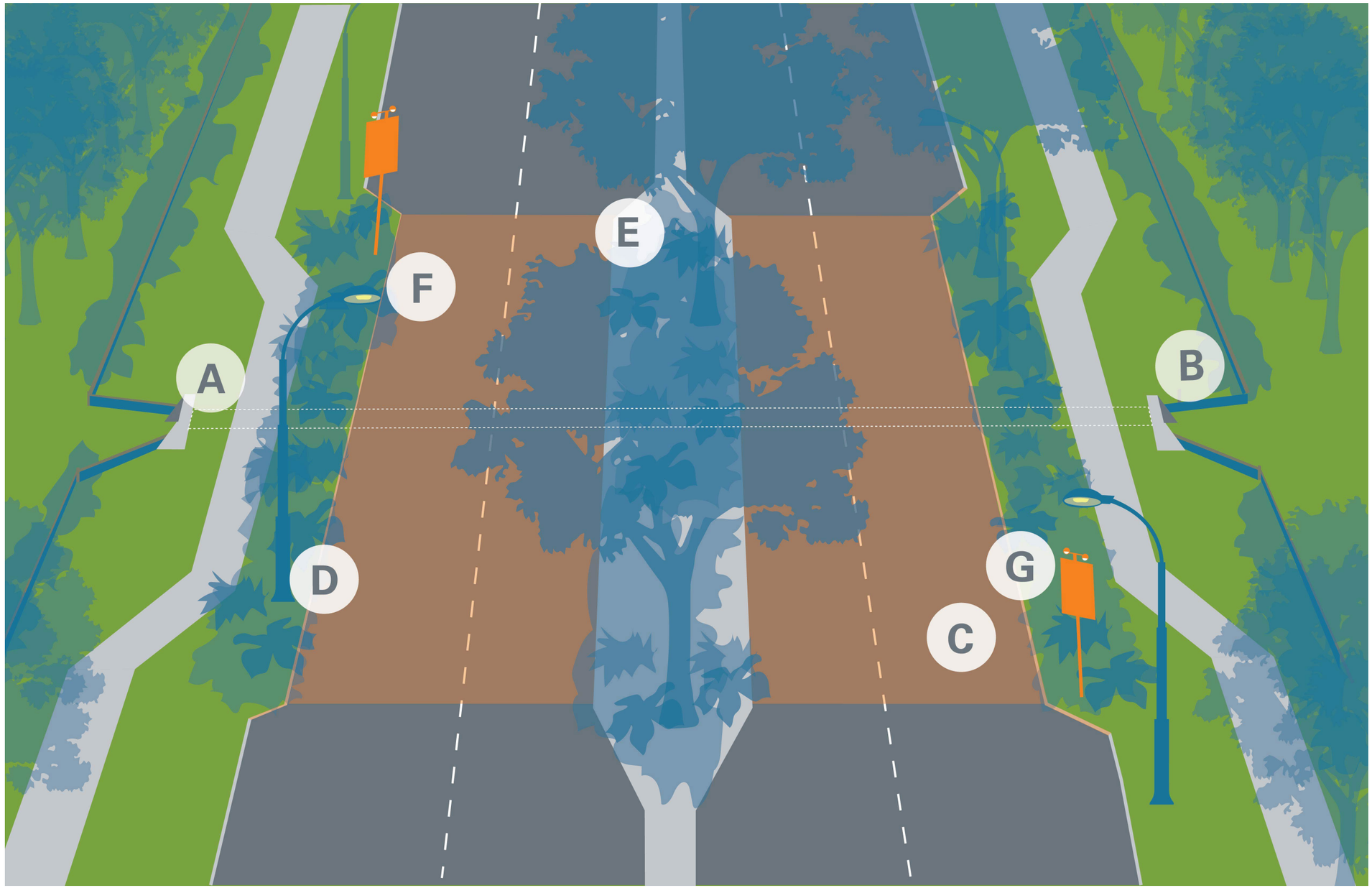
A. MULTI-SPECIES TUNNEL



B. WILDLIFE FENCING

C. WILDLIFE SIGNAGE

D. WILDLIFE CURBS
E. PLANTED MEDIAN - REFUGE
F. WILDLIFE FRIENDLY LIGHTING
G. EHANCED/BRANDED SIGNAGE
(COULD INCLUDE ANIMAL DETECTION SYSTEM)
H. BRANDED/COLOURED PAVEMENT



A. MULTI-SPECIES TUNNEL

B. WILDLIFE FENCING

G. BRANDED & ENHANCED SIGNAGE

(*LIKELY MORE GENERAL THAN SPECIES SPECIFIC EXAMPLE PROVIDED)

C. BRANDED/COLOURED PAVEMENT
D. WILDLIFE CURBS
E. PLANTED MEDIAN - REFUGE
F. WILDLIFE FRIENDLY LIGHTING

Fig. 4: ARTERIAL ROAD - TERRESTRIAL CROSSING

REFERENCES

[1] Wildlife Collision Prevention Program. "Wildlife Collision Prevention Program." Wildlifecollisions.ca, wildlifecollisions.ca/wildlife-collision-prevention-program.htm. Accessed 9 Feb. 2021.

[2] Huijser, Marcel P., and Kari E. Gunson. Road Passages and Barriers for Small Terrestrial Wildlife. American Association of State Highway and Transportation Officials (AASHTO) Committee on Environment and Sustainability, Sept. 2019.

[3] Animex Wildlife Fencing and Mitigation Solutions. "Animex Fencing | Wildlife Exclusion Fencing & Mitigation Solutions." Animex, animexfencing.com/. Accessed 9 Feb. 2021.

[4] Sielecki, Leonard E. The Evolution of Wildlife Exclusion Systems on Highways in British Columbia. BC Ministry of Transportation, 20 May 2007.

[5] Chisholm, Meghan, et al. Wildlife Passage Engineering Design Guidelines. City of Edmonton, June 2010.

[6] Wind, Elke, et al. Guidelines for Amphibian and Reptile Conservation during Road Building and Management Activities in British Columbia. Ministry of Environment and Climate Change Strategy, 30 Mar. 2020.

[7] Credit Valley Conservation. CVC Fish and Wildlife Crossing Guidelines. Credit Valley Conservation, 28 Apr. 2017.

[8] Huijser, Marcel P., et al. Construction Guidelines for Wildlife Fencing and Associated Escape and Lateral Access Control Measures. American Association of State Highway and Transportation Officials (AASHTO), Apr. 2015.

[9] Meese, Robert J., et al. Wildlife Crossings Guidance Manual. California Department of Transportation, Mar. 2009.

[10] Conservation Evidence. "Install One-Way Gates or Other Structures to Allow Wildlife to Leave Roadways - Conservation Evidence." Www.conservationevidence.com, www.conservationevidence.com/actions/2558. Accessed 10 Feb. 2021.

[11] Conservation Evidence. "Conservation Evidence: Evidence Data." Www.conservationevidence.com, www.conservationevidence.com/data/index. Accessed 10 Feb. 2021.

[12] Bond, Amy, and Darryl Jones. "Wildlife Warning Signs: Public Assessment of Components, Placement and Designs to Optimise Driver Response." Animals, vol. 3, no. 4, 17 Dec. 2013, pp. 1142–1161, 10.3390/ani3041142. Accessed 2 Oct. 2020.

[13] Erritzoe, Johannes, et al. "Bird Casualties on European Roads — a Review." Acta Ornithologica, vol. 38, no. 2, Dec. 2003, pp. 77–93, 10.3161/068.038.0204. Accessed 11 Feb. 2021.

[14] Ng, Janet W., et al. "Landscape and Traffic Factors Influencing Deer-Vehicle Collisions in an Urban Environment." Human-Wildlife Interactions, vol. 2, no. 1, 2008.

[15] Clevenger, Anthony P., and Marcel P. Huijser. Wildlife Crossing Structure Handbook - Design and Evaluation in North America. U.S. Department of Transportation, Mar. 2011.

[16] Ministry of Transportation and Infrastructure. "Wildlife Management - Province of British Columbia." Www2.Gov.bc.ca, www2.gov.bc.ca/gov/content/transportation/transportation-infrastructure/engineering-standards-guidelines/environmental-management/wildlife-management. Accessed 11 Feb. 2021.

[17] The Nature Conservancy. "Roads & Wildlife Portal | Home." Roadsandwildlife.org, roadsandwildlife.org/. Accessed 11 Feb. 2021.

[18] "Wildlife and Roads: A Resource to Help Mitigate Roads for Wildlife." Wildlifeandroads.org, wildlifeandroads.org/. Accessed 11 Feb. 2021.