NCHRP 25-25, Task 113

ROAD PASSAGES AND BARRIERS FOR SMALL TERRESTRIAL WILDLIFE SPECIES

SUMMARY CONSIDERATIONS FOR NON-DESIGNATED DRAINAGE CULVERTS

Prepared for:

AASHTO Committee on Environment and Sustainability

Prepared by:

Kari E. Gunson[1] & Marcel P. Huijser[2]

[1]Eco-Kare International
644 Bethune Street, Peterborough, Ontario, K9H 4A3, Canada
[2]Western Transportation Institute – Montana State University
PO Box 174250, Bozeman, MT 59717-4250, USA

In Association with
Louis Berger US, Inc.
A WSP Company
412 Mt. Kemble Avenue,
Morristown, NJ 07962

September 2019

ACKNOWLEDGMENTS

This study was conducted for the American Association of State Highway and Transportation Officials (AASHTO) Committee on Environment and Sustainability, with funding provided through the National Cooperative Highway Research Program (NCHRP) Project 25-25, Task 113, *Road Passages and Barriers for Small Terrestrial Wildlife: Summary and Repository of Design Examples*. NCHRP is supported by annual voluntary contributions from the state departments of transportation (DOTs). Project 25-25 is intended to fund quick response studies on behalf of the Committee on Environment and Sustainability. The report was prepared by Marcel P. Huijser of the Western Transportation Institute - Montana State University and Kari E. Gunson of Eco-Kare International under contract to Louis Berger U.S. Inc., A WSP company (contract manager Edward Samanns). The work was guided by a technical working group that included:

- Kris Gade, Arizona DOT (Chair)
- Bridget Donaldson, Virginia DOT
- Jill Garton, Iowa DOT
- Chris Maguire, Oregon DOT
- Matthew Perlik, Ohio DOT
- Jeff Peterson, Colorado DOT
- Paul Wagner, Washington State DOT
- Dan Buford, FHWA (liaison)
- Melissa Savage, AASHTO (liaison)

The project was managed by Ann Hartell, NCHRP senior program officer.

DISCLAIMER

SUMMARY CONSIDERATIONS FOR NON-DESIGNATED DRAINAGE CULVERTS

This document summarizes considerations for small animal use of existing non-designated passages, primarily drainage culverts that were installed to convey water. This summary is based on the literature review, survey report, and knowledge and experience of the authors. The literature review and survey report are available as separate documents produced for this project (NCHRP 25-25, Task 113).

A. GENERAL CONSIDERATIONS

General considerations include the design and operation and maintenance issues associated with existing structures that were implemented for purposes other than small animal passage, primarily to convey water under a road. The location of the structure, structure type, structure dimensions, and habitat near or adjacent to the structure were at least partially designed for water passage and are only later considered for passage by amphibians, reptiles, or mammal species smaller than a coyote (*Canis latrans*).

The structures need to be evaluated to assess whether they are in the correct location and are designed adequately to meet the passage criteria of the target species. Several passage assessments have been developed for small animal passage (Kintsch & Cramer 2011). In some cases, a drainage culvert will not require any modifications other than supplementary exclusion fencing (Case Study 2). It is important to assess these types of existing structures to evaluate the modifications required. In some cases when culvert replacements are completed, recommendations such as upsizing culverts can be implemented (see *Evaluation* below).

Characteristics

Location: Drainage structures are constructed in lower wet areas, often along streams or adjacent to wetlands, and are only functional for small animals that occur in or can move through this type of habitat. In turn, smaller animals that move in relatively dry upland habitat will require designated structures installed in higher ground that remain dry when drainage structures are filled with water (Case Study 3). In some cases, structures in ephemeral or intermittent drainages that remain dry for part or most of the year can provide dry animal passages (Case Study 3).

Structure Type: This summary addresses smaller structures (less than or equal to 3 meters [m] diameter, height, and width). These structures vary in shape from round, elliptical, arched, or box and are made of various materials such as metals, e.g. corrugated steel pipe, plastics (high density polyethylene [HDPE]) and polyvinyl chloride (PVC), or cement. In most cases, these structures will have a bottom; however, in some cases, arched culverts may be installed on footings to maintain the natural substrate conditions.

Hydrology: Drainage culverts are existing structures in roads that have been installed for the passage of water. Water flow is intermittent or permanent, depth varies, and the structure is partially to fully submerged during certain periods of the year. Therefore, it is essential to evaluate if these conditions are suitable for the target small animal species.

Evaluation: Existing drainage culverts were selected for small animal passage and evaluated for potential amphibian, reptile, and small mammal passage 16, 30, and 35 times, respectively, at various box and round drainage culverts (Literature Review Report). In the 26 studies that monitored passage use, 20 (77%) documented passage by small animals. The following are a list of general considerations to evaluate whether existing drainage structures are suitable for small animal use:

- Location, i.e., existing suitable habitat for target species
- Number and spacing of existing structures within habitat bisected by road
- Size of structure, i.e., width, height (or diameter) and length
- Micro-habitat conditions, i.e., water flow, depth and permanency, temperature adjacent to and inside structure

Existing structures may be modified to encourage use by small animals. Rails and shelving were helpful to allow dry passage by terrestrial mammals (Goldingay et al. 2018, see Case Study 3). Also, several studies found that the use of crossing structures by small animals was negatively correlated with length (Smith 2003; Ascensão & Mira 2007; Chambers & Bencini 2015). Other options to facilitate use by small animals include creation of habitat such as vegetation and natural substrate at crossing approaches, in medians, and inside structure (if possible due to small size) to enhance use. For amphibians, dry refugia such as smooth and flat boulders can be beneficial.

The primary modification to enhance species use in the reviewed studies was the addition of both temporary or permanent exclusion barriers and/or funneling guide-walls to direct small animals to existing structures. Therefore, the adjacent terrain and road features must also be evaluated to assess feasibility for this type of installation (see Barrier Considerations Report).

Maintenance: Maintenance of non-designated crossing structures is focused on maintaining adequate permeability of water flows and animal passage. Specific maintenance includes ensuring scouring or erosion does not create a "perched entrance" or other barriers that prevent the target animal access to a structure, preventing beaver damming inside the culvert, and removing debris. Vegetation such as cattails (*Typha sp.*) and common reed (*Phragmites sp.*) may need to cleared routinely.

Species-specific Considerations

Aquatic Small Animals (e.g., Freshwater Turtles, Aquatic Amphibians, Snakes, and Mammals): Existing drainage culverts with intermittent or permanent water are potentially suitable structures for animals that live in aquatic habitat (e.g., wetlands, ponds or along streams). When water flow is adequate, these animals can swim or, in cases of shallow water, walk through the culverts. These structures are more suitable when they are not fully submerged because they allow some light into the tunnel, which is especially important for turtles (Caverhill et al. 2011; Heaven et al. 2019).

In several studies, substantial water flow impeded upstream passage by spotted salamanders ((Jackson & Tyning 1989; Patrick et al. 2010) and long-toed salamanders (Atkinson-Adams 2015). Possible modifications to allow both upstream and downstream movements include modifying hydraulic flow with the use of boulders and baffles to reduce water velocity at entrances and inside the culverts. Stepping stones can also be added to the stream floor to allow rest stops during passage.

In some cases, screens can be added to culvert entrances to deter debris from plugging culverts or to inhibit other wildlife such as beavers from damming inside the structures (Figure 1). These screens may trap other wildlife and block animals from entering the culverts. More research is needed to find solutions that allow wildlife passage for target animals and discourage debris accumulation and damming by beavers. One potential solution includes modifying the screen (i.e., changing the mesh size to allow permeability of the target species while still excluding debris and beavers). Other solutions include using flow devices, diversionary dams, and fence barriers strategically placed to deter beavers from damming culverts and entrances. Wildlife passage must be considered in these solutions, and include integration of a gap, gate, or door in the diversionary barrier (Danby & Gunson in prep).

Figure 1: *A metal grate on a drainage culvert to deter beaver access and associated beaver dams inside drainage culvert; these screens impede movement by turtles and other animals through drainage culvert. Photo Credit: Ausable Bayfield Conservation Authority.*

Snakes: Habitat requirements vary considerably among snake species; therefore, drainage culvert adequacy will vary. Some evidence suggests that temperature may influence when snakes and turtles will cross through culverts and that these animals tend to cross in the afternoon when diurnal temperatures peak (Colley et al. 2017; Eco-Kare International 2019). Aquatic or semi-aquatic snakes are more prone to use existing drainage culverts with some water; however, water temperatures may be more of a limiting factor for snakes than turtles. Research has shown that snakes turn around more often at culvert entrances filled with water than turtles do (Gunson 2019). Drainage culverts that dry out in unison with peak terrestrial snake movements are ideal for connectivity across roads.

Snakes tend to bask in warm places and often seek cover. Potential modifications to drainage structures include installation of skylights in tunnels, especially at the entrances. When structures are dry, inclusion of root wads' cover boards, sandy soils, wood chips, and other vegetation debris both inside culverts and near culvert entrances improve microhabitat conditions during crossing and facilitate snakes entering the culverts.

Terrestrial Small Mammals and Tortoises: Drainage culverts that are dry or have little water may provide suitable conditions for passage by terrestrial small animals such as desert tortoises and mammals. Some research shows tortoises used various round and box drainage culverts that were dry and ranged from 33–66 m in length when fencing was present (Boarman & Sazaki 1996). When drainage culverts are permanently flooded but not fully submerged, adequately sized ledges and rails may be used to facilitate drier passage for these animals (see Case Study II). Cinder blocks and PVC pipe may also be used as cover objects for small mammals (Tracey et al. 2014; Figure 2).

Figure 2: *Cinder blocks laid on top of black PVC pipe in a dry culvert built for larger animals. Photo Credit: (For a U.S. Geological Survey project) Jeff Tracey, Western Ecological Research Center, U.S. Geological Survey.*

REFERENCES

Ascensão F., and A. Mira. 2007. Factors affecting culvert use by vertebrates along two stretches of road in southern Portugal. Ecological Research **22**:57–66.

Atkinson-Adams M.R. 2015. Movement and habitat use of the Long-Toed Salamander (Ambystoma macrodactylum) in Waterton Lakes National Park, Alberta. MSc. in Ecology from the University of Alberta. 175 pages.

Boarman W.I. and M. Sazaki. 1996. Highway mortality in Desert Tortoises and small vertebrates: success of barrier fences and culverts. Proceedings of the Florida Department of Transportation/Federal Highway Administration Transportation.

Caverhill B., B. Johnson, J. Phillips, E. Nadeau, M. Kula, and R. Holmes. 2011. Blanding's Turtle (Emydoidea blandingii) and Snapping Turtle (Chelydra serpentina) habitat use and movements in the Oakland Swamp wetland complex, Ontario, Canada, and their response to the Provincial Highway 24 exclusion fence and aquatic culvert ecopassage from 2010-2011. Report prepared by the Toronto Zoo, Adopt-A-Pond program, Toronto, ON.

Chambers B. and R. Bencini. 2015. Factors affecting the use of fauna underpasses by bandicoots and bobtail lizards. Animal Conservation **18**:424–432.

Colley M., S.C. Lougheed, K. Otterbein, and J. Litzgus. 2017. Mitigation reduces road mortality of a threatened rattlesnake. Wildlife Research.

Danby R. and K. Gunson. in prep. Beaver exclusion-turtle passage concept designs: Literature review and field testing. Report in progress for the Ontario Ministry of Transportation.

Eco-Kare International. 2019. Effectiveness monitoring of wildlife crossing structures and exclusion fencing on Highway 69: Parry Sound District: 2016-2018. Draft report submitted to the Ministry of Transportation.

Goldingay R.L., B.D. Taylor, and J.L. Parkyn JL. 2018. Movement of small mammals through a road-underpass is facilitated by a wildlife railing. Australian Mammalogy.

Gunson K. 2019. Comparaison du passage de tortues et de serpents dans des ponceaux de drainage le long de deux autoroutes en Amérique du Nord. Le Naturaliste canadien **143**:81–84.

Heaven P.C., J.D. Litzgus, and M.T. Tinker. 2019. A unique barrier wall and underpass to reduce road mortality of three freshwater turtle species. Copeia **107**:92–99.

Jackson S.D., and T.F. Tyning. 1989. Effectiveness of drift fences and tunnels for moving spotted salamanders Ambystoma maculatum under roads. Pages 93–99 in T. E. S. Langton, editor. Amphibians and Roads: Proceedings of the Toad Tunnel Conference, Rendsburg, West Germany. ACO Polymer Products, Shefford, England. Available from http://works.bepress.com/cgi/viewcontent.cgi?article=1017&context=scott_jackson (accessed April 10, 2014).

Kintsch J., and P.C. Cramer. 2011. Permeability of existing structures for terrestrial wildlife: A passage assessment system. Page 187. Report # WA-RD 777.1. Final report for the Washington State Department of Transportation, Olympia, WA.

Patrick D.A., C. M. Schalk, J.P. Gibbs, and H.W. Woltz. 2010. Effective culvert placement and design to facilitate passage of amphibians across roads. Journal of Herpetology **44**:618–626.

Smith D.J. 2003. Monitoring wildlife use and determining standards for culvert design. Page 87. Report # BC354-34. Florida Department of Transportation, Tallahassee, Florida.

Tracey J.A., C. S. Brehme, C. Rochester, D., and R.N. Fisher. 2014. A field study of small vertebrate use of wildlife underpasses in San Diego County. U.S. Geological DRAFT Data Summary prepared for California Department of Fish and Wildlife. 74 pp.