Twenty years of research, do animals use wildlife crossings?

Supplementary abstracts

Robert van Meeteren and Gerard Smit (ed.)

Bureau Waardenburg bv
Ecology & landscape

Twenty years of research, do animals use wildlife crossings?

Supplementary abstracts

Robert van Meeteren and Gerard Smit (ed.)

Report number: 15-205

Date of publication: October 27th, 2015

Photographs cover: Jeroen Brandjes, Dimitri Emond, Gerard Smit

Van Meeteren, R. & G.F.J. Smit, 2015. Twenty years of research, do animals use wildlife crossings?. Bureau Waardenburg Report nr. 15-205 Bureau Waardenburg, Culemborg.

Keywords: fauna, infrastructure, ecoducts, wildlife tunnels, wildlife crossings.

Bureau Waardenburg bv
Consultants for environment & ecology

P.O. Box 365 4100 AJ Culemborg, The Netherlands
Tel. +31 345 51 27 10 Fax +31 345 51 98 49
info@buwa.nl www.buwa.nl

Preface

During the last decennia several hundreds of wildlife crossings have been realised in the Netherlands by national, regional and local governments. These crossings cover a wide variety of measures facilitating the movements of animals over and under highways, regional and local roads, railways and waterways.

Since 1994, we have carried out studies on the actual use of such defragmentation measures by animals. This includes underpasses as ledges and banks at waterways, fauna tunnels, stump walls and overpasses as ecoducts, green ways and a marten bridge.

In this supplement you will find the abstracts of more than 50 project reports written and eight papers in the last twenty years on fauna and infrastructure. These projects were carried out for local governments, provinces, the national government as well as builders and contractors.

This supplement provides a solid overview of twenty years of experience with wildlife crossings and we are pleased to be able to share this with you.

A.J.M. Meijer
Director

G.F.J. Smit
Team manager

The projects have been carried out by: Jeroen Brandjes, Paul Boddeke, Martijn Boonman, Rombout van Eekelen, Dimitri Emond, Gerlof Hoefsloot, Robert van Meeteren, Fabrice Ottburg, Jan Reitsma, Herman Sips, Gerard Smit, Dirk van Straalen, Pieter Veen, Martijn Veen, Fleur van Vliet, Dennis Wansink.

Content

1 Introduction

Our first project was carried out in 1994 for the Ministry of Transport and Infrastructure. The question to be answered was: are animals using three modified underpasses to cross the highway A7 in a small forest in the northern part of the Netherlands?

In the two decades that followed we conducted multiple studies to assess the use of wildlife crossings by fauna, adding up to a total of more that 450 wildlife crossings. Based on our practical field experience we have advised on measures to improve the function of existing over- and underpasses for fauna and give recommendations as to the locations and types of crossing that can be best applied to facilitate animal movements.

In the past twenty years the methods we used in our field studies developed. Early studies were carried out with track beds made of sand substrate. Starting in 1997 we used track boards and track tubes with a combination of ink and paper to register animal tracks. We also performed pilot studies with electronic counting devices and used automated video recordings bases on security equipment. At present at most locations we use track beds or track boards in combination with wildlife cameras.

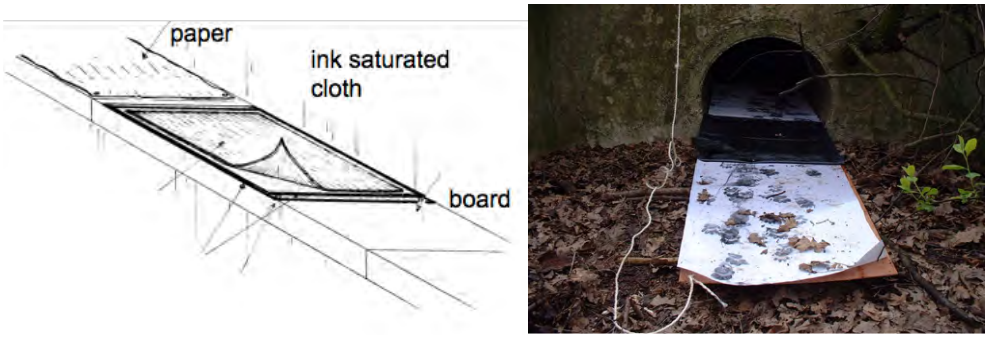

Figure 1.1 Track board with 'ink and paper' (right paper with badger prints).

Track studies were often carried out in autumn for a period of six to eight weeks. In the Netherlands in autumn most mammal species - target species - are active and occur at higher densities compared with spring and summer period. Some studies cover the spring as well as autumn period.

We compiled a meta-database with the results of 45 field studies. This database covers the registration of animals at a total of 450 wildlife crossings. A report with an analysis of these results is in progress. This supplement will be included in the final report.

Figure 1.2 Tracks of amphibians can be determined at species group level (left frog and right salamander).

Figure 1.3 Sand bed in extended bank track surveys.

2 Field studies

1. **Fauna crossings of highway A7 in the forest Robbenoordbos**

   Reference: *Sips H.J.J., 1994. Bestaande faunapassages van de rijksweg A7 in het Robbenoordbos. Report 94-48, Bureau Waardenburg, Culemborg.*

   Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*)

   Study subject: Three non-wildlife engineered banks under viaducts of highway A7 in a forest.

   Abstract: In the context of our National Nature Network ('EHS'), the corridor between the lakes Amstelmeer and IJsselmeer is important for wildlife dispersal in the province of North-Holland. The forest 'Het Robbenoordbos' and channels in the area form the corridor. The banks of the channels serve as important landscape elements that provide cover for dispersion of wildlife. Within Het Robbenoordbos the highway A7 is a barrier for dispersal of wildlife. Rijkswaterstaat Noord-Holland aimed to optimise the existing underpasses under the highway for animal movements. For an effective implementation, an initial survey of three (non adapted) passages was carried out with sand beds to detect animal footprints and live traps to examine the current use of wildlife using underpasses of the A7.
   In total, tracks of seven mammal species and one bird species were found; most frequent tracks were of mice and rat spec. Live traps resulted in confirming the occurrence of two mice species, mainly found at the eastern border of the passages. In conclusion, the three viaducts with continuous banks as underpasses are used by a limited number of species. Improvements have to be made to facilitate dispersion of more species.

2. **Survey of the use by fauna of the non-adapted viaduct "Mauritskamp" over highway A28**

   Reference: *Brandjes G.J. & G.F.J. Smit, 1996. Oriënterend onderzoek naar het gebruik door fauna van het viaduct "Mauritskamp" over de A28. Report 96-63, Bureau Waardenburg, Culemborg.*

   Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*)

   Study subject: A non-wildlife engineered overpass of highway A28, forest and heath vegetation.

   Abstract: At the 'Utrechtse Heuvelrug', a large forest, the highway A28 is one of the most important barriers against wildlife dispersal. Some viaducts over the highway provide potential for crossings for wildlife. *Rijkswaterstaat Directie Utrecht* wanted to

adapt viaduct 'Mauritskamp' (with limited traffic) to facilitate wildlife crossings. In this study we assessed use by fauna for the non-adapted (zero) situation.
A limited number of species made use of the non-adapted viaduct. While in adjacent habitats several target species such as fox, roe deer, rabbit and sand lizard were present, no tracks of these species were detected at the viaduct. There was no indication that they actually used the viaduct to cross the highway.
Measures were proposed to adapt the viaduct for optimizing animal movements. Adapting the (not functional) pedestrian paths on both sides was proposed, by providing sandy substrate with a stump wall and vegetation resembling the natural habitat in the direct surroundings. These measures have since been applied.

3. Use by animals of fauna crossings near waterways, a pilot survey

Reference: *Brandjes G.J. & G. Veenbaas, 1998. Het gebruik van faunapassages langs watergangen onder rijkswegen in Nederland: Een oriënterend onderzoek. Report W-DWW-98-29, Rijkswaterstaat, Delft.*

Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*)

Study subject: Twenty underpasses adapted for animals movements at the waterway crossings of highways, culverts with ledges and extended banks under viaducts.

Abstract: Because of the fragmentation in the Netherlands due to infrastructural development, Rijkswaterstaat have tried to counteract this effect by the introduction of wildlife crossings. In 1997, a field survey was conducted at 20 locations in the Netherlands of waterway crossings that have been adapted to facilitate animal movements. All crossings functioned well and showed that a large variety of mammal species (10+), amphibians (newt and toads) and waterbirds made use of the crossings. Underpasses with wider dimensions were used considerably more frequently than narrower passages. In conclusion, the wider and shorter the crossing, the more species and number of tracks (track frequency) are found. In addition, ledges under culverts are less preferred by wildlife than extended banks, the latter in general contains a more natural substrate.

4. Animals use fauna passageways under highway A6 in Flevoland

Reference: *Brandjes G.J. & G.F.J. Smit, 1998. Dieren gebruiken faunapassages onder de A6 in Flevoland, onderzoek 1998. Studie naar het gebruik van faunavoorzieningen en een oriënterend muizenonderzoek. Report 99-07, Bureau Waardenburg, Culemborg.*

Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*)

Study subject: A bicycle tunnel and small wildlife tunnel under highway A6, an additional mice survey to analyse the effect of different mowing regimes.

Abstract: Rijkswaterstaat IJsselmeergebied intended to increase the number of wildlife crossings at intersections of highways and the National Nature Network (EHS) in the province Flevoland. A study was carried out to assess the use by animals of two new crossings under highway A6. In addition, the effect on mice density in the highway verges of different mowing regimes was studied. High mice density might be a cause for the high number of road kills of barn owls found at some transects of the A6.

In the winter of 1998/1999 two passages under the A6 highway (a bicycle tunnel and small wildlife tunnel) were surveyed using sand/ink beds. The mice survey was carried out with track tubes placed in 10 m x 10 m quadrants in vegetation with annual and biannual mowing regime.

A limited number of animals were found to make use of the crossings, with a total of five mammal (most frequently mice) and two bird species. For the mice survey, track tubes were effective in assessing local differences in mice densities for the two mowing regimes. However, this initial study does not give conclusive results on the effect of mowing regime on the availability of mice as prey. It was advised to monitor changes in vegetation and mice density for a period of several years.

Figure 2.1 Fauna crossing next to waterway.

5. Use by animals of fauna crossings next to waterways, experimental study: non-adapted situation

Reference: *Brandjes G.J. 1999. Het gebruik van faunapassages langs watergangen onder rijkswegen: Experimenteel onderzoek-uitgangssituatie. Report 99-05, Bureau Waardenburg, Culemborg.*

Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*)

Study subject: Experimental study of 46 waterway underpasses at highways, 22 culverts with ledges and 24 extended banks.

Abstract: Rijkswaterstaat conducted an initial study of the efficiency of wildlife crossings along waterways. Results from this study show that animals often used these crossing types. The track frequency of animals depends on the dimensions and characteristics of the individual crossing. To determine the preferred conditions for optimizing animal movements a total of 46 crossings (22 ledges and 24 extended banks) were selected. This report presents the results of a survey (sand/ink and paper) for the initial situation. In a follow up study the crossings will be adapted and the effect of the adaptation for animal use will be studied.
Animals, especially in areas where many target species are found, frequently used all crossings. At culverts with ledges the tracks of 17 species were identified (among others stone marten and squirrel). At extended banks the tracks of 25 species were identified (including roe deer and hare). Although more species were found at the extended banks, the track frequency was on average similar for ledges (2.3 tracks/day) and extended banks (2.1 tracks/day).
All crossings with ledges were found to be suitable for the next phase of the experimental research, (see Brandjes *et al* 2001). Due to disturbance by people not all locations with extended banks could be selected.

6. Animals killed by trains: study for defragmentation by rail infrastructure: questionnaires and pilot for observation probability of killed animals.

References: *Brandjes G.J. & G.F.J. Smit 1999. Aangereden dieren langs spoorwegen: Ontsnipperingsonderzoek Rail-infrastructuur Modulte Sterfte – Fase 1 'Enquête en Praktijkonderzoek trefkans. Report 99-74, Bureau Waardenburg, Culemborg.*

Client: Nederlandse Spoorwegen (*Dutch railways*)

Study subject: Explorative survey of the occurrence of animal railway kills, questionnaire for railway personnel, pilot for observation probability of animals killed by trains.

Abstract: To date (1999), information about the number of animals killed by trains in the Netherlands is rare and anecdotal. Phase one of a survey for Dutch Railways aimed to present an overview of available information by train drivers and in the literature. Based on this information a selection of possible transects for field studies was given.
Railway personnel reported that they most often observe collisions with medium-sized animals such as ducks, rabbits and cats, in numbers of several animals per kilometre railway per year. The highest numbers of observations were in open landscapes (polders), where detection by machinists is easier than in closed forest areas. Examples of high-risk areas in terms of high numbers of collisions with animals were Woerden-Alphen and Almere-Lelystad. The field study for the speed of the disappearance of cadavers of medium-sized animals showed that the highest disappearance occurred in the first 1.5 weeks (25% disappear). When searching for animals killed by train a minimum frequency of one count a week will be necessary.

Figure 2.2 Ledge with camera (middle) triggered by two infrared detectors situated at both ends of the ledge.

7. Field test of an automated system for video recording of animal crossings

Reference: *Sips H.J.J. & G.F.J. Smit 2000. Wildwisselwachter T1: Veldtest van een automatisch video-registratiesysteem bij een loopplank, ecoduct en een doorgetrokken oever. Report 00-088, Bureau Waardenburg, Culemborg.*

Client: Rijkswaterstaat (Ministry of Infrastructure and the Environment)

Study subject: Video recording at an ecoduct and two highway underpasses, a culvert with ledge and an extended bank.

Abstract: We carried out an experimental set-up with a video registration system to monitor the use of fauna crossings. The objective for video recording was to record animal behaviour and provide additional information to the standard methods of registering tracks for species that make use of crossings.
The results revealed that a video recording system (based on security equipment) can serve as a tool for monitoring crossings. For larger crossings however, such as ecoducts, the system should be adapted. The recordings did not indicate that the recorder or use of infrared light disturbs animals. Detection efficiency proved to be high (78%) and around 20% of the recordings were as false alarms. Although the device performed well, batteries have to be changed regularly and usage is limited to people with sufficient knowledge. Therefore, if used, careful implementation by skilled personnel is advised.

8. The use of viaducts and tunnels (non-adapted for fauna) by animals at the highway A1 at Veluwe.

Reference: *Van Eekelen R. & G.F.J. Smit 2000. Het gebruik door dieren van kunstwerken in de A1 op de Veluwe: Studie van viaducten, tunnels en het ecoduct bij Kootwijk. Report 00-085, Bureau Waardenburg, Culemborg.*

Client: Rijkswaterstaat *(Ministry of Infrastructure and the Environment*)

Study subject: Seven over- and underpasses not adapted for animals (viaducts, tunnels and an ecoduct) at highway A1 at a forest.

Abstract: The Veluwe is the largest forest area in the Netherlands. It is intersected by highway A1 (among others). The highway is a large barrier for the movements of animals. Along the A1 are several under- and over-passes for local traffic such as viaducts and tunnels. Those passes could have potential to facilitate animals in crossing the highway. A survey of the use of six under- and overpasses by animals was carried out. In addition, the ecoduct in the study area was included in the field study.
The findings from this study show that animals made use of the available (but not adapted for animal use) structures; tracks of 18 species were identified: 14 mammal species, three amphibians and one reptile species. Underpasses were used more frequently than overpasses, which were only used by a limited number of species. This large difference was probably caused by the hard substrate (concrete) and the lack of coverage (vegetation) of the overpasses. Underpasses provided cover by their nature and strips with sediment (earth, sand, debris) accumulate along the walls.

Figure 2.3 Green overpass (A28 - Utrecht - Amersfoort).

9. Animals use six adapted over- and underpasses at three highways.

Reference: *Ottburg F.G.W.A. & G.F.J. Smit 2000. Het gebruik door dieren van faunapassages van Directie Utrecht: Studie van locaties op de A27, A28 en A12; vier stobbenwallen, één groenstrook en één float land. Report 00-086, Bureau Waardenburg, Culemborg.*

Client: Rijkswaterstaat *(Ministry of Infrastructure and the Environment*)

Study subject: Six over- and underpasses at highways, four stump walls, one greenway and one floating land

Abstract: Different highways dissect the Utrechtse Heuvelrug, the second largest forest in the Netherlands. Highways including the A27, A28 and A12 are large barriers for the movements of animals. Different crossing types have been constructed to mitigate this fragmentation by the highways. We studied six of these crossings with the use of sand beds.
Tracks of about 16 terrestrial species were registered: 13 mammal and three amphibian species. The highest number of species was registered for an extended bank under a viaduct of the A28. The bank has a stump wall, which provides shelter for terrestrial species. The floating land at the viaduct Kromme Rijn (A12), which serves as a stepping-stone, did not reveal any animal activity.

Figure 2.4 Stump wall under highway (A27, Groenendaal).

Figure 2.5 Green strip over highway (A27, Nieuwe wetering).

10. Use by animals of fauna crossings next to waterways, experimental study: adapted situation.

Reference: *Brandjes G.J., G. Veenbaas, I. Tulp & M.J.M. Poot, 2001. Het gebruik van faunapassages langs watergangen onder rijkswegen: Resultaten van een experimenteel onderzoek. Report W-DWW-2001-026, Rijkswaterstaat, Delft.*

Client: Rijkswaterstaat *(Ministry of Infrastructure and the Environment*)

Study subject: Experimental study of 46 adapted waterway underpasses at highways, 22 culverts with ledges and 24 extended banks.

Abstract: This study is the follow up of the initial research for Rijkswaterstaat by Brandjes (1999). Its objective was to assess the passage characteristics that influence the use of wildlife underpasses along waterways under highways. All crossings were optimized for animals by providing cover (branches, tree stumps) at broadened ledges.
A total of 46 passages were studied. Overall, a large number of species used the crossings, 18 species were recorded for ledges in culverts and 30 species for extended banks under viaducts. At the larger modified banks more weasel passages were recorded. The common assumption is the wider the passageway, that more animal passages are recorded. Human activity is negatively correlated with crossing usage by different species. Lastly, available habitat is a major determinant of the number and frequencies of species that use a passageway.

11. The use by animals of six non-adapted highway overpasses in Noord-Brabant.

Reference: *Van Eekelen R. & G.F.J. Smit, 2001. Het gebruik door dieren van zes viaducten in Noord-Brabant: Uitgangssituatie. Report 01-093, Bureau Waardenburg, Culemborg.*

Client: Provincie Noord-Brabant (*Province of Noord-Brabant*)

Study subject: Six non-adapted highway overpasses, viaducts, in North-Brabant

Abstract: A field survey was carried out at six overpasses with the potential for facilitating animal movements over three highways (A50, A58 and A67) in the province of North-Brabant. The survey was carried out using standard methods for track registration (sand beds and track tubes over six weeks).
The results revealed that 12 species used the crossings: nine mammal, two amphibian and one reptile species. The number of species was found to be relative large for non-adapted situations, the passing frequency was very low. This low frequency is in line with frequencies found at other overpasses in the Netherlands. The numbers of species were considerably higher for most locations. This is probably caused by the presence of forest/heathland near most surveyed locations in North-Brabant, which is

often lacking at other overpasses throughout the Netherlands. Low numbers of species were found on overpasses with little vegetation or close to urban areas.

12. Applying automated video recordings at different types of fauna crossings.

Reference: *Smit G.F.J. & H.J.J. Sips, 2001. Automatische videoregistratie bij diverse typen faunapassages (2001). Report 01-112, Bureau Waardenburg, Culemborg.*

Client: Rijkswaterstaat *(Ministry of Infrastructure and the Environment*)
Study subject: Video recordings at six highway crossings.

Abstract: Rijkswaterstaat, Dienst Weg- en Waterbouwkunde commissioned Bureau Waardenburg and Atelier Sips to develop an automated wildlife detection system: the *Wildwisselwachter-1*. In 2000, this system was developed and afterwards tested at three locations. For this survey, the system was placed at six additional locations to gain more experience and optimise the system. The locations comprised of four different types of crossings at five highways.
The results indicated that the recording system functioned well: a total of 11 mammal species were recorded ranging from small animals (mice) to large animals (roe deer and wild boar at Kootwijk). Besides native animals, one exotic species (American mink) was recorded. Recordings revealed that animal activity was highest during dusk and dawn. Moreover, additional information could be gathered such as animal behaviour and the possibility of individual recognition. Despite of the positive outcomes the system had some drawbacks: batteries needed regular replacement due to the many false triggers that observed during recording. Nevertheless, even with these drawbacks the application of automatic video recordings serves as a viable tool for evaluating wildlife passages.

13. The application of automated video recordings at fauna crossings.

Reference: *Sips, H.J.J., G.F.J. Smit & G. Veenbaas, 2002. De toepasbaarheid van automatische videoregistratie bij faunapassages. Report DWW-2002-108, Rijkswaterstaat, Delft.*

Client: Rijkswaterstaat *(Ministry of Infrastructure and the Environment*)

Study subject: Compilation of earlier field studies 2000-2002 with automated video recordings and technical details.

Abstract: In the period 2000 to 2002 an automated wildlife detection system was tested: the *Wildwisselwachter-1*. Field tests involved different crossing types including ledges, an extended bank, wildlife tunnel and ecoduct. Automated video recording proved to be suitable for studying the behaviour of animals at wildlife crossings. At most crossings passages were well detected by the infrared system. At large

crossings such as ecoducts the range of the camera limited the detected area. In the field studies a total of 16 different mammal species were recorded.

Figure 2.6 Badger prints in small wild life tunnel (A73).

14. Animals use 45 small fauna tunnels under highways.

Reference: *Brandjes G.J., R. Van Eekelen, K. Krijgsveld & G.F.J. Smit, 2002. Het gebruik van faunabuizen onder rijkswegen. Report DWW-2002-123. Rijkswaterstaat Delft.*

Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*)

Study subject: Forty-five small fauna tunnels under highways (length 50-80 m, width 0.3-0.8 m)

Abstract: Studies of small wildlife tunnels, so-called badger tunnels, increased the knowledge of the use of these tunnels by badgers. Information on their use by other species and the factors determining this usage remained unclear. In 2001 and 2002, a field survey was carried out for 45 wildlife (badger) tunnels. The objective was to learn which characteristics are important for the function of these tunnels for animal movements. The locations were selected based on a literature study and previous research. Tunnels intensively used by badgers were not selected since the use by badgers was considered to have a negative influence on use by other species. For all

tunnels, animal tracks were recorded using ink and paper track boards. In the direct surrounding of each tunnel a covered reference track board was placed.
A total of 14 target species (mammals and amphibians) was recorded for all of the tunnels surveyed. Small species such as amphibians and mice were recorded at tunnels and reference boards. Salamanders were only recorded at reference boards and not in tunnels. Species with small home ranges are not expected to search for the tunnels to cross highways. Larger mammal species (marten, polecat, fox) will use the tunnels more intentionally. Different crossing characteristics, such as tunnel length and tunnel diameter, influence how frequently a passage is used. Amphibians and mustelids more frequently used tunnels smaller than 40 meters. Amphibians used humid tunnels more frequently than tunnels with dry conditions. Tunnels did not show differences in temperature. The variety in tunnel length and diameter did not influence microclimate conditions. The variety in landscape elements - as guiding structures – had no effect on observed species and track frequencies.

Figure 2.7 Extended bank for wild life (N11 Alphen ad Rijn).

15. The use by animals of ten crossings under highway N11.

Reference: *Van Eekelen R., 2002. Het gebruik door dieren van faunapassages bij de Elfenbaan: N11, Traject Alphen a/d Rijn-Zoeterwoude-Rijndijk (2002). Report 02-094, Bureau Waardenburg, Culemborg.*

Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*)

Study subject: Nine wildlife tunnels and one culvert under the N11 in open landscape.

Abstract: Ten crossings under the N11 were studied as corridors for animals. These included crossings between continuous embankments, one unused bicycle tunnel and one culvert with ledges. We made use of track surveys by sand beds.
In total, 15 mammal species were registered for the various crossings, (weasel and hare among others) and different amphibians (salamander, toad). Both indigenous mammals and exotic mammals, such as the muskrat (*Ondatra zibethicus*), seemed to make use of the passages. The track frequency found seemed to strongly depend on the type of crossing. In general, the larger and more humid the crossing, the more species were registered and higher the frequency of tracks.

16. The use by animals of crossings under highways in the province of Zuid-Holland.

Reference: *Van Eekelen, R., G.F.J. Smit, 2002. Het gebruik door dieren van faunapassages in Zuid-Holland. A4, A13 en A16 (2002). Report 02-131, Bureau Waardenburg, Culemborg.*

Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*)

Study subject: Ten different wildlife crossings at highways A4, A13 and A16.

Abstract: In recent years, 32 wildlife crossings have been constructed at state highways in the province of South-Holland to facilitate the movements of wildlife. The functionality has been earlier evaluated at 17 of the passages. In this study, ten of the remaining passages were selected and surveyed. This included four different crossing types which we surveyed with sand/ink beds during a period of eight weeks in the autumn of 2002.
Nine mammals and three amphibian species were registered, mostly tracks of mice and brown rats. The track frequency varied greatly per passage, which is most plausibly related to the size dimensions of passages and the location of passages within a habitat. Sand beds became disturbed by either human presence or wind, which could have resulted in the loss of small animal tracks. However, a statistical correction was carried out for severe disturbance to justify animal usage between the wildlife crossings.

Figure 2.8 Set up for video recording at a badger tunnel (A50 Oosterhuizen).

17. Videoregistration at a badgertunnel under highway A50 at Veluwe.

Reference: *Sips H.J.J., G.J. Brandjes & Smit G.F.J. 2003. Automatische videoregistratie fauna in dassentunnel A50 Oosterhuizen. Report 03-012, Bureau Waardenburg, Culemborg.*

Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*)

Study subject: One Badger tunnel, long term video registration

Abstract: In the years leading up to this study, Rijkswaterstaat conducted several surveys on the use of wildlife crossings. These surveys were mainly carried out with the aid of tracking methods such as sand beds/paper and ink boards, which have been criticised due to shortcomings in animal observation. To counteract these problems, a new method with video recording named 'Faunamonitor-T1' was developed and tested (Sips & Smit, 2000). To gain more experience and optimise the use of this system, a new survey was conducted at a badger tunnel (A50) in winter 2001 to spring 2002. The camera proved to function well with a total of ten mammals observed by the system throughout three testing periods. Especially polecat and house cat showed to pass the crossing purposefully, while rabbit and mice just wandered around at the entrance of the tunnel. Some species showed disturbance by

the video system; however, it is assumed that this effect will be levelled out with longer sampling periods.

18. The use by animals of 22 fauna crossings within the urban area of Utrecht.

Reference: *Brandjes G.J. 2006. Monitoring gebruik faunapassages Gemeente Utrecht 2004-2005: Onderzoek op 22 locaties in het stedelijk gebied van Utrecht. Report 06-009, Bureau Waardenburg, Culemborg*.

Client: Gemeente Utrecht (*Municipality of Utrecht*)

Study subject: Twenty-two locations with different crossing structures in urban area.

Abstract: Within the urban area of Utrecht an increasing number of wildlife crossings have been constructed under roads, railways and along channels to mitigate fragmentation effect for wildlife dispersal. In 2004 and 2005, we conducted a field survey to assess the function of 22 crossings for urban wildlife in Utrecht.
Results revealed a low to reasonable number of species use the crossings, depending on the location. In total, tracks of nine mammal species were registered, with the majority of these house cats and mice. The low number of target species seemed to be related to the relative long length of some crossings (>75 metres) and the bad connection with suitable habitat next to different crossings. Due to the urban environment, humans and dogs use many of the crossings, which is a source of disturbance for other animals that use the crossings.

Figure 2.9 Tunnel for badgers (A326).

19. Use by animals of 13 fauna crossings of highways A12, A27 en A28.

Reference: *Brandjes G.J. & F. Van Vliet 2006. Monitoring gebruik faunapassages Rijkswaterstaat Utrecht: Onderzoek op 13 locaties langs rijkswegen A12, A27 en A28. Report 05-259, Bureau Waardenburg, Culemborg.*

Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*)

Study subject: Over- and underpasses at 13 locations at three highways

Abstract: Since the early 1990s, Rijkswaterstaat have realised a large number of wildlife crossings in the province of Utrecht. New crossings are planned for the coming years. Knowledge on how the existing crossings function is still incomplete. For this survey, 13 different locations along the A12, A27 and A28 were studied using track surveys in autumn 2005 to spring 2006.
In total, tracks of 18 animal species were registered: 14 mammal species, three amphibians and viviparous lizard. Mammals made use of all crossings (100%), while amphibians were only found at 70% of the crossing locations and the lizard at one location. At some locations fences and a lack of vegetation limited crossing frequency.

Figure 2.10 Stump wall under viaduct Monnikenberg (A27).

20. Use of a pine marten bridge over highway A12 and ecoduct Leusderheide over A28.

Reference: *Brandjes G.J., F. Van Vliet, H.J.J. Sips & R.Van Beurden 2006. Onderzoek boommarterbrug (A12) en Ecoduct Leusderheide (A28). Report 06-145, Bureau Waardenburg, Culemborg.*

Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*)

Study subject: Pine marten bridge and ecoduct

Abstract: Since the beginning of the 1990s the Rijkswaterstaat Utrecht constructed 34 wildlife crossings to mitigate fragmentation by infrastructure. Knowledge about the practical use of these crossings by animals is limited. We studied a tree bridge for pine marten (A12) and the ecoduct Leusderheide (A28) using track survey, video recording and bat detectors.
Results did not reveal that pine marten used the tree bridge. Camera recordings showed the use by bat species. At the ecoduct, tracks and recordings of ten mammal, amphibians, reptiles, birds and bat species were found. More species were expected to use the ecoduct in future years once the vegetation develops. It was advised to stimulate a heterogeneous habitat to accommodate a variety of species.

21. Use by animals of 19 crossings at highway A2, A12, A27 and A28.

Reference: *Van Vliet F. & G.J. Brandjes 2006. Monitoring gebruik faunapassages Rijkswaterstaat Utrecht: Onderzoek op 19 locaties langs rijkswegen A2, A12, A27 en A28. Report 06-090, Bureau Waardenburg, Culemborg*

Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*)

Study subject: Monitoring wildlife use of 19 different passages under highways

Abstract: Since the beginning of the 1990s, Rijkswaterstaat Utrecht decided to develop several wildlife crossings to mitigate the negative effect of infrastructural development on wildlife dispersal. This study was the last of three planned studies that were commissioned by Rijkswaterstaat Utrecht to assess the functioning of established crossings for wildlife. A total of 19 crossings were surveyed at four state highways (track surveys, bat detector at one location) in the spring and autumn of 2006.
The findings showed that the crossings served their purpose well and tracks of many target- and non-target species were observed with even bats being recorded at one location. Locations were used by a total of 12 mammal species and amphibians visited 89% of the crossings. Surprisingly, no tracks of target species, including roe deer, squirrel and weasel, were found, which is probably caused by unsuitable dimensions (roe deer), limited openness and limited dispersion.

Figure 2.11 Tunnel for fauna, Fort Vechten (A12).

22. Use by animals of 47 underpasses of regional roads in Noord-Brabant.

Reference: *Smit G.F.J. 2007. Monitoring Faunapassages Noord-Brabant pilot 2006: Monitoring van het gebruik van 47 faunapassages onder provinciale wegen. Report 06-260, Bureau Waardenburg, Culemborg*

Client: Provincie North-Brabant (*Province of Noord-Brabant*)

Study subject: Surveying wildlife use of 47 wildlife structures in North-Brabant

Abstract: Prioir to this study, the province of North-Brabant recently realised a large number of wildlife crossings with several others planned for construction. To evaluate a large number of these crossings, Bureau Waardenburg conducted a field survey of 47 of these wildlife facilities in the spring and autumn of 2006. The animal track methods used indicated that the variety of different passages are used well by several animal species. In summary, 23 species were found, with 15 mammals (with the less observed mole), at least three amphibians, one reptile and several (water) birds. Most of the crossings are used well due to the spacious dimensions, relative short length and suitable location in the landscape that positively contribute to their usage. The limited use of some crossings appeared to be caused by the lack of suitable habitats close to the crossings.

Figure 2.12 Badger tunnel (N324).

Figure 2.13 Ridge under bridge (N345).

23. Use by animals of fauna crossings and corridors at the landscape park Susteren.

Reference: *Brandjes G.F., F. Van Vliet & G. Hoefsloot 2006. Onderzoek flora en fauna Landschapspark Susteren: Monitoring faunapassages en inventarisatie ecologische zones bij de N297. Report 06-271, Bureau Waardenburg, Culemborg.*

Client: Provincie Limburg (*Province of Limburg*)

Study subject: Six over- and underpasses and a survey of an ecological corridor

Abstract: In 2004, the province of Limburg started with the construction of the N297. To facilitate the distribution of wildlife in that region, six locations with wildlife crossings were been developed. To evaluate the performance of these locations and the corridor with different habitats, we carried out a survey of the crossings and ecological corridors. The wildlife crossings (including an 'ecombiduct') were surveyed with standard track survey methods and the ecological corridors with a multi-taxa terrestrial assessment.
For the crossings we found tracks of 18 different species: 14 mammals (including roe deer), three amphibians and one reptile (probably viviparous lizard). The extended banks with stump walls and the ecombiduct were used by a large number of species, which was expected to increase in the following years with the development of the vegetation. In the ecological corridors, a variety of species were found; 72 plants, 28 breeding birds, five mammal, two amphibians, one reptile and several insect species. In conclusion, the combination of wildlife crossings and ecological corridors showed to be of substantial value for animal species.

Figure 2.14 Ecombiduct (N297 Susteren).

24. Via Limburg: pilot for 20 crossings at regional roads and highways.

Reference: *Van Vliet F. & G.J. Brandjes 2007. Monitoring faunapassages in het kader van Via Limburg: Pilot studie naar het gebruik van faunavoorzieningen door dieren onder de N271, N273, N293, A73-Noord en A79. Report 07-207, Bureau Waardenburg, Culemborg.*

Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*) & Provincie Limburg (*Province of Limburg*)

Study subject: Twenty over- and underpasses

Abstract: Rijkswaterstaat Directie Limburg and the Province of Limburg planned to construct four new regional roads in central Limburg. The Flora and Fauna Act required that the construction of these roads included mitigation measures to facilitate fauna movements. We carried out a pilot study in central Limburg at 20 existing crossings to assess the function of these crossings for wildlife in the region.
Results varied strongly between crossings. In total, tracks of 11 mammal species and several amphibians were observed. The number of species detected was considerably lower when crossings were narrow or extensive in length. The most frequently used crossings had suitable habitats within the direct surroundings.

Figure 2.15 Badger prints in small wild life tunnel (A73).

25. Animals use ecoduct De Borkeld over highway A1.

Reference: *Brandjes G.J., Van der Velde E. & D. Emond 2007. Resultaten ecoduct De Borkeld rijksweg A1, 2006-2007. Report 07-136, Bureau Waardenburg, Culemborg.*

Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*)

Study subject: Ecoduct De Borkeld, highway A1.

Abstract: In 2003, ecoduct the Borkeld (A1) was constructed to facilitate the crossing of wildlife in this eastern region of the Netherlands. We conducted a survey, commissioned by Rijkswaterstaat Oost-Nederland, to evaluate how well this ecoduct functions. This study was executed in 2006-2007 using camera traps and sand beds at different locations (middle and sides of the ecoduct) and bat detectors. Track surveys were carried out in both years; camera traps and bat detectors were used in 2007.
The outcomes from this survey showed that the ecoduct functioned well after its construction in 2003. A total of ten terrestrial mammal species, two amphibians and one reptile (viviparous lizard) were registered. Among the mammals, wild boar was one of the observed species. In addition, various birds and bat species made use of the ecoduct. The stump wall was a valuable habitat for viviparous lizard, small mammals and various bird species.

26. Do animals use ten crossings at a highway in Zeeuws-Vlaanderen.

Reference: *Emond D. & F. Van Vliet 2008. Evaluatie tien faunapasssages Zeeuws-Vlaanderen. Report 08-200, Bureau Waardenburg, Culemborg.*

Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*) & Provincie Zeeland (*Province of Zeeland*)
Study subject: Ten underpassages in Zeeuws-Vlaanderen, an additional mammal survey.

Abstract: Within the context of the defragmentation of 'robust corridors' and the National Ecological Network (EHS), Rijkswaterstaat Zeeland and the province of Zeeland constructed several wildlife corridors. In 2008, we carried out a standard track survey for ten crossings. For three crossing locations we undertook a local mammal survey with live traps.
Tracks of seven mammal species were found. No tracks of other animal groups such as amphibians and reptiles were found, although common toad and common frog were observed next to two locations. With the live traps, five species of mice were registered. This was in line with the track survey, which indicated a high frequency of mice. In conclusion, most crossings were used by several mammal species. The lack of amphibian tracks was probably caused by the limited activity during the sampling

period. It was expected that improvements (stump wall, fences) would result in more species visiting the crossings.

27. Underpasses of highways and railways as corridors for bats.

Reference: *Boonman M. 2010. Het gebruik van duikers onder wegen en spoorlijnen door vleermuizen. Report 10-214, Bureau Waardenurg, Culemborg.*
Reference: *Boonman M. 2011. Factors determining the use of culverts underneath highways and railway tracks by bats in lowland areas. Lutra 2011 54 (1): 3-16.*

Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*)

Study subject: Dimensions of 54 culverts used by bats.

Abstract: In urbanising environments, the construction of suitable underpasses for bats under highways and railway tracks is becoming increasingly important to avoid habitat fragmentation. Culverts provide valuable and low cost underpasses as they are already an intrinsic part of highway design and many bat species associated with water are likely to follow the streams or canals that flow through them. Bat detectors were employed to study the use of 54 culverts by bats in the Netherlands. The aim of the study was to define the factors that determine bats' use of culverts. Bats were observed in the vast majority of the culverts that were studied, thereby underlining the importance of culverts in habitat defragmentation. Species adapted to hunting in open habitats, such as the noctule (*Nyctalus noctula*) and the serotine (*Eptesicus serotinus*), were often recorded in front of the entrance but rarely inside culverts. For the three species that were regularly recorded inside culverts, Daubenton's bat (*Myotis daubentonii*), pond bat (*Myotis dasycneme*) and common pipistrelle (*Pipistrellus pipistrellus*), cross sectional area was the most important factor that determined culvert use. Height was the most important component of cross sectional area for bats. Length proved to be a non-significant factor, suggesting that bat underpasses are not affected by the widening of the above-lying infrastructure. Additional guidance by treelines along the banks did not increase the use of culverts by the three species. The implication of the different preferences for cross sectional area on the design of infrastructure is discussed.

28. The use by animals of 24 fauna crossings within the urban area of Utrecht.

Reference: *Emond D. & G.J. Brandjes 2010. Monitoring gebruik faunapassages Gemeente Utrecht 2009-2010: Onderzoek op 24 locaties in het stedelijk gebied. Report 10-251, Bureau Waardenurg, Culemborg.*

Client: Gemeente Utrecht (*Municipality of Utrecht*)

Study subject: Twenty-four locations with different crossing structures in urban area.

Abstract: Within the urban area of Utrecht an increasing number of wildlife crossings have been constructed under roads, railways and along channels to mitigate fragmentation effect for wildlife dispersal. In 2000 to 2010, we conducted a field survey to assess the function of 24 crossings for urban wildlife in Utrecht.
Results indicated that a limited number of animals used the crossings, with a total of nine mammal and three amphibian species. At most locations, tracks of a few species were found, with most commonly mice, house cat and brown rat. The results were lower than expected, which could be related to crossing length (>75 metres), lack of connection and disturbance by humans. However, results might be biased, because of wind disturbance to some of the sand beds and therefore some animal tracks may have been missed at these locations.

Figure 2.16 Small wild life tunnel (A2 Boxtel).

29. Study of 39 fauna crossings at regional roads in the province of Gelderland.

Reference: *Arcadis & Bureau Waardenburg 2010. Monitoring en inspectie faunavoorzieningen Gelderland 2010. Onderzoek naar het functioneren van 39 faunavoorzieningen in de provincie Gelderland. Arcadis, Apeldoorn.*

Client: Provincie Gelderland (*Province of Gelderland*)

Study subject: Thirty-nine small wildlife crossings including two reptile crossings, one amphibian and one large wildlife tunnel in Gelderland.

Abstract: The province of Gelderland manages an increasing number of wildlife crossings. In 2007, a number of these passages were monitored by Arcadis and Ecogroen. New crossings have been established since this monitoring. Arcadis (technical analysis) and Bureau Waardenburg (implementation and reporting) conducted a comprehensive survey of these crossings. The fieldwork encompassed 39 passages (35 badger, two reptile, one amphibian and one large wildlife tunnel) across the province.
Results indicated a total of 12 mammal (including mustelids) two amphibian and one snake species. The track frequency for most species was low and they were registered at a few crossings. The findings were substantially lower than results for comparable crossings at other locations. Arguments for this low species presence are: inundation of some tunnels and excessive growth of bushes at crossing entrances. In order to improve use, these factors should be addressed by taking appropriate managing measures (removal of bushes, dig out entrances, close frequently inundated facilities).

Figure 2.17 Fauna tunnel (N304).

30. Study of 43 fauna crossings at regional roads in the province of Gelderland.

Reference: *Arcadis & Bureau Waardenburg 2011. Monitoring en inspectie faunavoorzieningen Gelderland 2011. Onderzoek naar het functioneren van 43 faunavoorzieningen in de provincie Gelderland. Arcadis, Apeldoorn.*

Client: Provincie Gelderland (*Province of Gelderland*)

Study subject: Forty-three small wildlife crossings in Gelderland.

Abstract: The province of Gelderland manages an increasing number of wildlife crossings. Arcadis (technical analysis) and Bureau Waardenburg (implementation and reporting) conducted an overall survey for 43 crossings. Some of these crossings were studied in 2007.
Results indicated an increasing use by mustelids since 2007.

Figure 2.18 Herpetoduct (N310).

31. Monitoring animal use of ecological corridor De Doorbraak at highway A35.

Reference: *Emond D., G.J. Brandjes, R. Van Beurden & H. De Jong 2011. Monitoring ecopassage De Doorbraak, rijksweg A35. Report 11-184, Bureau Waardenurg, Culemborg.*

Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*)

Study subject: Wildlife underpass 'De Doorbraak' with wet and dry habitat connecting a new established creek

Abstract: In 2004, the construction started of a new creek 'De Doorbraak'. Besides common functions such as preventing drought and flooding, it is expected to facilitate wildlife as an ecological corridor. The creek crosses infrastructure such as the highway A35. At this location, a fauna crossing has been constructed as an extension of the creek and consists of wet and dry habitats. We carried out a study of the fauna crossing with camera traps, track surveys, Anabat and live traps.
Our results indicate that the crossing serves it purpose well. Both the wet and dry habitats have proven to support the crossing of several species. In dry habitats ten mammal (excluding dogs and horses), three amphibian and several bird species were observed. At the ledge, as a corridor for wet habitats, seven mammal species, amphibians, waterbirds and bat species were observed. The stump wall and rock walls provided the animals guidance and cover. Species such as roe deer were not registered, despite being present in adjacent habitat. This lack of some species could have been due to the lack of cover in the corridor and the disturbance by horses and humans that visited the corridor during the sampling period.

32. Monitoring animal use of ecological corridor Oude Haagseweg in Amsterdam.

Reference: *Brandjes G.J., D. Emond 2011. Monitoring faunapassage Oude Haagseweg te Amsterdam. Report 11-028, Bureau Waardenurg, Culemborg.*

Client: Gemeente Amsterdam (*Municipality of Amsterdam*)

Study subject: Examination of the effectiveness of a wildlife tunnel under the road 'Oude Haagseweg'

Abstract: The municipality of Amsterdam planned to replace the concrete pavement of the road 'Oude Haagseweg'. However, a wildlife crossing was located at the crossing of the 'Christoffel Plantijnpad', which needed to be incorporated in the planning of the road construction. To plan road construction carefully, it was necessary to know how well the crossing functioned in relation to the local wildlife. We performed a survey of the crossing in the spring and autumn of 2011, with three ink beds divided over the three compartments of the crossing.
Results showed tracks of a total of seven species (four mammals and three amphibians), with the most frequently recorded bring mice and brown rat. Detection in all three compartments showed that the passage performed well, and is even suitable for mustelid species such as stoat (indicate by complete passage by stoats). No evidence was found for large spring migration of amphibians such as common toad, which could be due to the absence of guiding structures towards the passage. The effect of the crossing was limited in comparison with the extended green area in the surrounding area. Therefore, we advised the construction of two additional crossings.

33. Meta-analysis of 139 small wildlife tunnels to determine which factors have an influence of tunnel use by badgers.

Reference: *Emond D., W. Lengkeek & G.J. Brandjes 2011. Succesfactoren dassentunnels: Studie naar de technische randvoorwaarden die het gebruik van dassentunnels beïnvloeden. Report 11-090, Bureau Waardenurg, Culemborg.*

Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*)

Study subject: Meta-analysis of 139 small wildlife tunnels.

Abstract: From the national Defragmentation Long-term Programme, MJPO, and regional initiatives of defragmentation, several hundreds of small wildlife tunnels have been established under railways the last few years. This study provides an overview of the data derived from 15 years of monitoring crossings by our company. We analysed which technical factors influenced the use of wildlife tunnels by badgers. A total of 139 crossings were analysed, statistical analyses (Principal Component Analysis and GLM) were carried out for crossing characteristics (size dimensions, material, shape, maintenance conditions) and landscape factors (landscape type, distance to nearest badger sett, badger density).
Results showed that none of the crossing characteristics had a major influence on the use by badgers. This is in line with the badgers' ecology, the animal can be considered smart and resourceful. Some factors (moisture) were not present everywhere although can have an influence under severe conditions. Looking at the landscape, results show the landscape type and badger density are major for badger use of crossings.

34. Monitoring Ecoduct De Munt, Wuustwezel Belgium T1.

Reference: *Brandjes G.J., D. Emond, K.D. van Straalen, & B. Achterkamp 2013. Monitoring ecoduct De Munt, Wuustwezel (België). Tussenrapportage meetjaar 2012 (T1). Report 13-028, Bureau Waardenurg, Culemborg.*

Client: Vlaamse overheid – Departement Leefmilieu, Natuur en Energie (*Belgium government)*

Study subject: Ecoduct De Munt (E19) one year after construction.

Abstract: Ecoduct De Munt was constructed in 2011 and crosses the E19 and the high-speed railway between Antwerp and Breda. We carried out a before-after study to collect information of species that use the ecoduct, the vegetation development, road kills, additional use by walkers and pets. For this study we used camera traps, track survey, cover boards, live traps, Anabat, pit falls, malaise falls and PQs.
At T1, a total of 23 mammal and two amphibian species were detected at the ecoduct. Three amphibian species were detected at the site of the construction. The stump wall

had a higher density of species compared to the side of the ecoduct without the stump wall. The invertebrate fauna included (butterflies, ten dragonflies, two grasshoppers a few carabid beetles and spiders). More hoverfly species were detected at the ecoduct compared with a reference. Road kills (hedgehog and hare) were only occasionally found. The frequency of human visits was unexpectedly high.

35. Fauna crossing Krakelingweg Zeist.

Reference: *Brandjes, G.J. & D. Emond, 2014. Faunapassages Krakelingweg, Zeist. Onderzoek naar het gebruik van een drietal kleine faunatunnels in 2013. Rapport 13-263. Bureau Waardenburg, Culemborg.*

Client: Gemeente Zeist (*Municipality Zeist*)

Study subject: Three wildlife tunnels under a local road.

Abstract: The newly constructed Krakelingweg included three small wildlife tunnels to mitigate the barrier for fauna. Target species were slowworm, amphibians and small mammals. We studied tunnel usage by fauna with the aid of camera traps, track boards and cover boards.
Results indicated frequent use of the tunnels by frogs, wood mice and domestic cats. Passages of slowworms were not detected. Fox and mustelids were occasionally detected. It was expected that the frequency of passages would increase in the coming years. It is questionable if slowworm will use the tunnels in future since they were present in very low densities.

36. Monitoring the use by fauna of Ecoduct Nijverdal.

Reference: *Emond D. & G.J Brandjes 2014. Resultaten monitoring ecoduct Nijverdal 2013. Report 14-045a, Bureau Waardenurg, Culemborg*

Client: H2Eco (contractor)

Study subject: Wildlife overpasses, the ecoduct at Nijverdal.

Abstract: A collaborative project between ProRail, Rijkswaterstaat and the province of Gelderland resulted in the construction of nine ecoducts for the Veluwe, Sallandse Heuvelrug and Utrechtse Heuvelrug. As part of the project, monitoring was planned two years after the establishment of these wildlife crossings. We carried out a survey in the spring and autumn of 2013 using camera traps and cover boards (reptiles).
A total of 11 ground-dwelling species were detected: eight mammals, two amphibians and one reptile species. Birds used the ecoduct for foraging and breeding. The number of species was limited in relation to the habitat surrounding the ecoduct. This was due to the lack of vegetation cover following the recent construction. The quick

response of species indicates the potential of the ecoduct. The number of species and frequency of visits is expected to increase when vegetation develops in the coming years.

37. Monitoring the use by fauna of Ecoduct Hulshorst.

Reference: *Emond D. & G.J Brandjes 2014. Resultaten monitoring ecoduct Hulshorst 2013. Report 14-045b, Bureau Waardenurg, Culemborg*

Client: H2Eco (contractor)

Study subject: Wildlife overpasses, the ecoduct at Hulshorst.

Abstract: A collaborative project between ProRail, Rijkswaterstaat and the province of Gelderland resulted in the construction of nine ecoducts for the Veluwe, Sallandse Heuvelrug and Utrechtse Heuvelrug. As part of the project, monitoring was planned two years after establishment of these wildlife crossings. We carried out a survey in the spring and autumn of 2013 using camera traps and cover boards (reptiles).
Results showed a surprisingly number of species made use of the ecoduct 1.5 years after construction. A total of 12 ground-dwelling species were detected: ten mammal (including red deer), one amphibian and one reptile species. We observed 46 species of birds using the ecoduct for foraging and breeding. The guidance towards the ecoduct was good, due to fencing and establishment of vegetation. A limited number of animals were found as victims of road traffic accidents. It can be concluded that the ecoduct functioned well and that the number of species can be expected to increase when the vegetation matures.

38. Monitoring the use by fauna of Ecoduct Petrea.

Reference: *Emond D. & G.J Brandjes 2014. Resultaten monitoring ecoduct Petrea 2013. Report 14-045c, Bureau Waardenurg, Culemborg*

Client: H2Eco (contractor)

Study subject: wildlife overpasses, the ecoduct at Petrea.

Abstract: A collaborative project between ProRail, Rijkswaterstaat and the province of Gelderland resulted in the construction of nine ecoducts for the Veluwe, Sallandse Heuvelrug and Utrechtse Heuvelrug. As part of the project, monitoring was planned two years after establishment of these wildlife crossings. We carried out a survey in the spring and autumn of 2013 using camera traps and cover boards (reptiles), Anabat recordings and field observations.
Results indicated a moderate number of species used the ecoduct including, eight mammal (most frequently wild boar, roe deer and red deer), three reptile (e.g.

viviparous lizard), four amphibian and three bat species. We observed 45 bird species and a multitude of insect species using the ecoduct as foraging and breeding area. Less common and rare species of dragonfly and grasshoppers were found, mainly due to the presence of a wetland west of the passage. The stump wall was habitat for four bird species, small mammals and several insect species. The fencing was deemed good and no road kills were found during the sampling period.

Figure 2.19 Ecoduct Hoog Buurlo

39. Monitoring the use by fauna of Ecoduct Hoog Buurlo.

Reference: *Emond D. & G.J Brandjes 2014. Resultaten monitoring ecoduct Hoog Buurlo 2013. Report 14-045d, Bureau Waardenurg, Culemborg*

Client: H2Eco (contractor)

Study subject: Wildlife overpasses, the ecoduct at Hoog Buurlo.

Abstract: A collaborative project between ProRail, Rijkswaterstaat and the province of Gelderland resulted in the construction of nine ecoducts for the Veluwe, Sallandse Heuvelrug and Utrechtse Heuvelrug. As part of the project, monitoring was planned two years after establishment of these wildlife crossings. We carried out a survey in the spring and autumn of 2013 using camera traps and cover boards (reptiles), Anabat recordings and field observations.
We observed a total of 11 ground-dwelling mammal (large numbers of red deer and wild boar), four bat, four reptile (frequently slowworm), four amphibian and several

insect species. Up to 40 bird species were detected, more than half were breeding in the study area and four on the stump wall. The highest number of species for all four ecoducts surveyed in 2013 was recorded at Hoog Buurlo. With the exception of a hare that was on the wrong side of the fence, no road kills were observed. Hoog Buurlo was used by animals surprisingly quickly with its good quality of fencing and ponds.

Figure 2.20 Ecoduct JP Thijsse.

40. Monitoring the use by fauna of Ecoduct J.P. Thijsse.

Reference: *Emond D. & G.J Brandjes 2014. Resultaten monitoring ecoduct J.P. Thijsse 2014. Report 14-045e, Bureau Waardenurg, Culemborg*

Client: H2Eco (contractor)

Study subject: Wildlife overpasses, the ecoduct at J.P. Thijsse.

Abstract: A collaborative project between ProRail, Rijkswaterstaat and the province of Gelderland resulted in the construction of nine ecoducts for the Veluwe, Sallandse Heuvelrug and Utrechtse Heuvelrug. As part of the project, monitoring was planned two years after establishment of these wildlife crossings. We carried out a survey in the spring and autumn of 2014 using camera traps and cover boards (reptiles), Anabat and field observations.
We detected a surprisingly high number of species: 14 mammal species (including cat), two reptiles, three amphibian species and a multitude of insect species. Five bat and one bird species used the ecoduct as a flying route. We observed 42 bird species

in the area. Mammals such as red deer, badger, fox and hare frequently crossed the ecoduct, and sand lizards were also observed using the ecoduct. Fencing is appropriate for most species but does not prevent pine and stone martens accessing the highway.

41. Monitoring the use by fauna of Ecoduct Oud Reemst.

Reference: *Emond D. & G.J Brandjes 2014. Resultaten monitoring ecoduct Oud Reemst 2014. Report 14-045f, Bureau Waardenurg, Culemborg*

Client: H2Eco (contractor)

Study subject: Wildlife overpasses, the ecoduct at Oud Reemst.

Abstract: A collaborative project between ProRail, Rijkswaterstaat and the province of Gelderland resulted in the construction of nine ecoducts for the Veluwe, Sallandse Heuvelrug and Utrechtse Heuvelrug. As part of the project, monitoring was planned two years after establishment of these wildlife crossings. We carried out a survey in the early spring and autumn of 2014 using camera traps and cover boards (reptiles) and field observations.
We detected a total of ten mammal species (including Sayaguesa cattle and mouflon), three reptiles (including common European viper), three amphibian species and several insect species. Most frequently observed were roe deer, hare, rabbit, common toad, natterjack toad and smooth newt. We observed 34 bird species, but found no indication that the ecoduct was of functional use. No road kills were found, indicating that the fencing is sufficient.

Figure 2.21 Ecoduct Huis ter Heide.

42. Monitoring the use by fauna of Ecoduct Huis ter Heide.

Reference: *Emond D. & G.J Brandjes 2014. Resultaten monitoring ecoduct Huis ter Heide 2014. Report 14-045g, Bureau Waardenurg, Culemborg*

Client: H2Eco (contractor)

Study subject: Wildlife overpasses, the ecoduct at Huis ter Heide.

Abstract: A collaborative project between ProRail, Rijkswaterstaat and the province of Gelderland resulted in the construction of nine ecoducts for the Veluwe, Sallandse Heuvelrug and Utrechtse Heuvelrug. As part of the project, monitoring was planned two years after establishment of these wildlife crossings. We carried out a survey in the early spring and autumn of 2014 using camera traps and cover boards (reptiles) and field observations.
We detected a total of nine mammal species (including cat), two reptiles, one amphibian species and several insect species. We observed 28 bird species in the surrounding area. Not all recorded species were confirmed as using the ecoduct. Slowworm was found incidentally around the border area. Results indicated that target species (more frequently roe deer) accepted the ecoduct soon after its construction. Fencing was successful in minimising road kills. We found humans (and associated pets) often illegally used the overpass, which might have negative influence on its success. It was recommended to erect fencing to reduce accessibility for humans.

43. Monitoring the use by fauna of Ecoduct Zwaluwenberg.

Reference: *Emond D. & G.J Brandjes 2014. Resultaten monitoring ecoduct Zwaluwenberg 2014. Report 14-045h, Bureau Waardenurg, Culemborg*

Client: H2Eco (contractor)

Study subject: Wildlife overpasses, the ecoduct at Nijverdal.

Abstract: A collaborative project between ProRail, Rijkswaterstaat and the province of Gelderland resulted in the construction of nine ecoducts for the Veluwe, Sallandse Heuvelrug and Utrechtse Heuvelrug. As part of the project, monitoring was planned two years after establishment of these wildlife crossings. We carried out a survey in the early spring and autumn of 2014 using camera traps and cover boards (reptiles) and field observations.
We detected six mammal species, one reptile, three amphibian species and several insect species. Mammals were observed infrequently. It was expected that the ecoduct would become more suitable when construction of the ecoduct over the N417 was completed. Both ecoducts are important elements in the local ecological corridor. Fencing is sufficient with no or limited road kills found.

44. Monitoring the use by fauna of Ecoduct Middachten.

Reference: *Emond D. & G.J Brandjes 2014. Resultaten monitoring ecoduct Middachten 2014. Report 14-045i, Bureau Waardenurg, Culemborg*

Client: H2Eco (contractor)

Study subject: Wildlife overpasses, the ecoduct at Middachten.

Abstract: A collaborative project between ProRail, Rijkswaterstaat and the province of Gelderland resulted in the construction of nine ecoducts for the Veluwe, Sallandse Heuvelrug and Utrechtse Heuvelrug. As part of the project, monitoring was planned two years after establishment of these wildlife crossings. We carried out a survey in the early spring and autumn of 2014 using camera traps and cover boards (reptiles), Anabat and field observations.
We detected a total of 13 mammal species (including cat), two amphibians and several insect species. Roe deer was a frequent visitor of the ecoduct. No reptile or bat species were detected, probably due to unsuitable habitat. We observed 37 bird species in the area, although there was no indication the ecoduct was of functional use. No road kills were found, indicating that the fencing is sufficient. It was recommended to provide a pond next to the ecoduct to improve the adjacent habitat.

45. Monitoring Ecoduct De Munt, Wuustwezel Belgium T3.

Reference: *Brandjes G.J., D. Emond, K.D. van Straalen, & B. Achterkamp 2015. Monitoring ecoduct De Munt, Wuustwezel (Belgie). Tussenrapportage meetjaar 2014 (T3). Report 15-027, Bureau Waardenurg, Culemborg.*

Client: Vlaamse overheid – Departement Leefmilieu, Natuur en Energie (*Belgium government)*

Study subject: Ecoduct De Munt (E19) three years after construction.

Abstract: Ecoduct De Munt was constructed in 2011 and crosses the E19 and the high-speed railway between Antwerp and Breda. We carried out a before-after study to collect information of species that used the ecoduct, the vegetation development, road kills, as well as additional use by walkers and pets. For this study we used camera traps, track survey, cover boards, live traps, Anabat, pit falls, malaise falls and PQs.
At T3, a total of 21 mammal species and two amphibians were detected at the ecoduct. Five amphibian species were detected at the base of the construction. The stump wall had a higher density of species compared to the side of the ecoduct without a stump wall. The invertebrate fauna included (14 butterflies, eight dragonflies, five grasshoppers, carabid beetles and spiders). The number of hoverfly species was

comparable with the reference situation. Road kills (hedgehog and hare) were found only occasionally. The frequency of human visits strongly decreased after 2012.

46. Monitoring Ecoduct De Munt, Wuustwezel Belgium T0-T3.

Reference: *Emond D., G.J. Brandjes & B. Achterkamp 2015. Monitoring ecoduct De Munt, Wuustwezel (Belgie). Eindrapport T0-T3. Report 15-124, Bureau Waardenurg, Culemborg.*

Client: Vlaamse overheid – Departement Leefmilieu, Natuur en Energie (*Belgium government)*

Study subject: Ecoduct De Munt (E19) before (T0: 2008-2009) and after construction, 1 year (T1: 2012) and 3 years (T3: 2014).

Abstract: Ecoduct De Munt was constructed in 2011 and crosses the E19 and the high-speed railway between Antwerp and Breda. We carried out a before-after study to collect information of species that use the ecoduct, the vegetation development, road kills, additional use by walkers and pets. For this study we used camera traps, track survey, cover boards, live traps, Anabat, pit falls, malaise falls and PQs.
At T3, a total of 27 mammal species is detected at and around the ecoduct. Three of these species (wild boar, raccoon and field vole) were only detected in the vicinity of the ecoduct. Three years after construction the majority of mammal species in the region used the ecoduct. This included all five bat species recorded in the area, although no structural daily migration occurred. At T1, four amphibian species were detected and at T3 these species were found to be reproducing in the pond next to the ecoduct. The invertebrate fauna was rich (49 carabid beetles, 36 spiders, 30 hoverflies, 20 butterflies, 14 dragonflies and nine grasshoppers). For the period T0-T3 a total of 95 bird species were observed, some breed at the ecoduct or in the immediate surrounding. Road kills (hedgehog and hare) were found only occasionally. The frequency of human visits strongly decreased after 2012.

3 Desk studies

47. Overview current state of knowledge about the use of fauna crossings over and under highways and study proposal

Reference: *Smit G.F.J. 1996. Het gebruik van faunapassages bij rijkswegen: Overzicht en onderzoeksplan. Report W-DWW-96-116, Rijkswaterstaat, Delft.*

Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*)

Study subject: Construction of a research proposal that serves as a guideline to conduct a evaluation of wildlife crossings.

Abstract: In the Netherlands, a growing number of wildlife crossings have been constructed over and under motorways, railways and waterways during the past few decades. These crossings take a wide range of different forms, such as badger tunnels, amphibian tunnels, structures near waterways and ecoducts. Rijkswaterstaat needed to increase their knowledge about the efficiency of these structures. Former studies in the Netherlands focused on ecoducts and badger and amphibians tunnels. Although the adaptation of crossings at waterways under highways is regular practice in the Netherlands, no information was available on their use by fauna. In this study, a research proposal was set up with the aim of guiding researchers on how to evaluate crossings near waterways as efficiently as possible. The research proposal consists of two phases. In the first phase existing wildlife crossings near waterways are studied. The second phase proposes a systematic survey to assess the parameters (width, available cover, substrate, etc.) that facilitate the use of these crossings by animals.
Most wildlife crossing studies use methods for track registration (sand bed/paper and ink board), which provides useful information, but are labour intensive. A study into the application of electronic counting devices was advised.

48. Overview of study methods for assessing the use of fauna crossings

Reference: *Brandjes G.J. & G.F.J. Smit, 1996. Overzicht onderzoeksmethoden gebruik faunapassages. Report W-DWW-96-117, Rijkswaterstaat, Delft.*

Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*)

Study subject: Literature study of applied study methods to evaluate wildlife crossings.

Abstract: In the Netherlands a growing number of wildlife crossings have been constructed over and under motorway, railway and waterways during the last few decades. Rijkswaterstaat needed more knowledge about the use of these crossings by wildlife.

This literature study provides an overview of the methods used to perform surveys considering wildlife crossings and the state of knowledge at the time. The methods were divided into two groups. The first group, (landscape inventories, live traps and observations) focuses more on the presence of fauna in the immediate surroundings of crossings. The second group (track methods, hair surveys, electronic counters, and camera traps) describes the methods that can be used to observe the actual use of the crossing by animals. Each of the methods has its own characteristics such as focus species, applicability (explorative, qualitative, quantitative), sampling duration and sampling requirements. The method can be applied for the potential species in the surrounding area of a crossing, the number of species passing the crossing (qualitative) and frequency of use of the crossing (quantitative). Sampling duration is the time mentioned in studies for observation and sampling requirements specifies material or other conditions necessary.

49. Assessment of cost-benefit of fauna crossings in the Netherlands.

Reference: *Van Iwaarden J.M. 2003. Integrale beoordeling van faunavoorzieningen langs wegen in Nederland. Internship report, Bureau Waardenburg, Culemborg.*

Client: Saxion Hogeschool (*Saxion, University of Applied Sciences*)

Study subject: Integrated assessment of different wildlife crossings via a cost (crossing project investments)-benefits (environmental effectiveness) analysis

Abstract: The Netherlands is densely populated. Due to constant development, and especially infrastructural changes, fragmentation has become a serious problem. Roads have intersected habitats of flora and fauna, which has led to habitat loss, disturbance and isolation of animal populations. Applying wildlife crossings that facilitate safe animal movement and dispersion that support population renewal mitigates fragmentation. Research was carried out on the applicability of such measures. An overall assessment that compares environmental efficiency in relation to the expenses for construction and maintenance was missing. This thesis was carried out as an integrated assessment of the environmental efficiency and expense of the different types of wildlife crossing. First, the results of available field studies were compared across different crossing types, taking into account target species and (number of) locations where the measures are applied. Secondly, a database was compiled with crossing frequency and expenses for comparison of both variables. Thirdly, these results were compared with cost estimates from Bureau Waardenburg and Rijkswaterstaat Utrecht. It was clear that ecoducts have the highest environmental efficiency, although are most expensive of all crossing types. Large wildlife tunnels are four times cheaper and similar to ecoducts in their environmental efficiency. Badger tunnels are cheaper still, but perform only moderately. At underpasses with waterways, extended banks and culverts with ledges perform reasonably well, where wooden ledges are the cheapest option. Stump walls are inexpensive, however their functionality is limited.

50. Design regulations fauna crossings for railways

Reference: *ProRail 2012. Ontwerpvoorschrift Faunavoorzieningen. Voorzieningen voor kruisen, geleiden en keren van fauna. Report OVS00056-7 ProRail Utrecht.*

Client: ProRail (*Manager railways Netherlands*)

Study subject: defining regulations for fauna crossings.

Abstract: Overview of regulations for designing fauna crossings for railways. The regulations are generic and the overview has to be used in coherence with the Leidraad Faunavoorzieningen bij Infrastructuur (Wansink *et al.* 2013).

51. Instructions for fauna measures at infrastructure.

Reference: Wansink, D.E.H, G.J. Brandjes, G.J. Bekker, M.J. Eijkelenboom, B. van den Hengel, M.W. de Haan & H. Scholma, 2013. Leidraad Faunavoorzieningen bij Infrastructuur. Rijkswaterstaat, Dienst Water, Verkeer en Leefomgeving, Delft / ProRail, Utrecht.

Client: Rijkswaterstaat (*Ministry of Infrastructure and the Environment*), ProRail (*Manager railways Netherlands*)

Study subject: Defining instructions for fauna measures at highways, railways and canals.

Abstract: Instructions are presented for provinces, Rijkswaterstaat, ProRail, local governments, waterboards and water companies, consultants and contractors involved in defragmentation measures for infrastructure. This instruction book covers the complete process of assessing defragmentation bottlenecks, potential solutions including the relation phase, maintenance and monitoring. This information was collected from various stakeholders and experts. The supplement gives the various requirements of animals for functioning corridors and examples of various measures.
The information is linked with the Basic Specification Eco Corridors of Rijkswaterstaat and Design Regulations Fauna Crossings of ProRail (2012). Examples are included for inspiration, although good solutions ask for a tailor-made approach.

4 Papers

1. **Traffic and nature on Utrechtse Heuvelrug. A strategy to counter habitat fragmentation. Smit, G.F.J. & A.J.M. Meijer, 1995. Bijdrage in Conference newsletter. International conference on habitat fragmentation, infrastructure and the role of ecological engineering. September 18-21, 1995.**

   Abstract not available.

2. **Monitoring road mortality of fauna along motorways. Smit, G.F.J. & A.J.M. Meijer, 1995. Bijdrage in Conference newsletter. International conference on habitat fragmentation, infrastructure and the role of ecological engineering. September 18-21, 1995.**

   Abstract not available.

3. **Experience with the counting of animal road casualties. Smit, G.F.J. & A.J.M. Meijer, 1999. Lutra 42: 24-33.**

   Abstract not available.

4. **Amfibieën op loopstroken onder rijkswegen. Brandjes, J.G., G. Veenbaas & G.F.J. Smit, 2000. RAVON 7, 3 (1): 1 -5. RAVON**

   Little is known about the effectiveness of adapted underpasses of water under highways. Recent studies showed that amphibians made use of ledges to pass highways. This article summarizes the results of a recent study of 32 ledges next to water under highways.

5. **Effectiveness of fauna passageways at main roads in The Netherlands. Geesje Veenbaas, Jeroen Brandjes, Gerard Smit & Edgar van der Grift. Habitat Fragmentation due to Transport Infrastructure – IENE 2003.**

   Many different types of fauna passageways have been constructed in the Netherlands and many more will be constructed within the next twenty years. In the past decade the Road and Hydraulic Engineering Institute of the Dutch Ministry of Transport, Public Works and Water Management commissioned several investigations to assess the use and effectiveness of these fauna passageways. The results of these investigations are used to improve layout, design and maintenance of both existing and planned passageways. Furthermore, the aim is to answer the question whether these passageways are effective to guarantee population viability in the long-term. This study focuses on three species: red deer (*Cervus elaphus*), badger (*Meles meles*) and the great crested newt (*Triturus cristatus*).

Figure 4.1 Steel badger tunnel with ink method (A27Bilthoven).

6. Methods to monitor the use of fauna passageways. Geesje Veenbaas, Jeroen Brandjes & Gerard Smit. International Conference on Habitat Fragmentation due to Transportation Infrastucture and Presentation of COST action 341 products Conference map – IENE 2003.

Many different types of fauna passageways have been constructed in the Netherlands and many more will be constructed within the next twenty years. In the past decade the Road and Hydraulic Engineering Division of the Dutch Ministry of Transport, Public Works and Water Management commissioned several investigations to assess the use and effectiveness of these fauna passageways. Next to gathering knowledge about the animal species that use these mitigation measures and those that don‘t, the aim of the research was to discover the most important fators affecting the use and effectiveness of fauna passageways. The results are used to improve layout, design and maintenance of both existing and planned passageways.

Recent studies have given a fairly good picture of the use of badger tunnels (fauna pipes) by badgers. However, a question that remained was which other animal species use these passageways and what factors affect this use. To answer this question some 50 fauna pipes were investigated during two periods: eight weeks in the autumn of 2001, and eight weeks in the spring of 2002. Track boards with ink pad and paper sheets, specially developed for this study, were inserted into the fauna passageways. In addition a control a track board was placed in the proximity of each tunnel. All 50 fauna pipes were used by animals during the research period. The pipes were used by a total of 14 target species: hedgehog, red fox, badger, stone marten, polecat, stoat, weasel, brown rat, wood mouse, red squirrel, hare, rabbit, toad (species

unknown) and frog (species unknown). Non-target species that used the pipes were cat and raccoon. The use of these pipes by salamanders could not be proved, although tracks of salamanders were recorded on some of the control sheets located in the immediate vicinity of each pipe. Most species, with the exception of mice and amphibians, seemed to use the fauna pipes deliberately. Most species used the pipes to the same degree in spring and autumn. Only badgers used the pipes considerably more often in spring, whereas brown rats used the pipes considerably more often in autumn. Pipe use by badgers did not have a significant negative effect on the use of the same pipe by other animal species. This suggests that some use by badgers does not exclude the use by other species. However, when a pipe was used by cats a significant negative effect on the use by other mammals (e.g. mice) was found. Mustelids and amphibians used pipes with a length of 40 metres or less more frequently than longer pipes.

With the investigation of fauna passageway use by animals, the question about the effectiveness of these passageways to guarantee population viability remained unanswered. In order to find an answer to this question, a monitoring project was started for three species: red deer, badger and great crested newt. For red deer, ecoducts (wildlife overpasses) are supposed to facilitate genetic exchange between populations intersected by roads. Badger pipes and walking strips in culverts or beneath bridges are supposed to increase population viability of badgers and great crested newts respectively.

Figure 4.2 Eco-culvert.

7. **Amphibians crossing under motorways: solutions for migration or dispersion? Gerard Smit, Jeroen Brandjes & Geesje Veenbaas. Habitat Fragmentation due to Transport Infrastructure – IENE 2006.**

Abstract: Since 1975, the Ministry of Transport, Public Works and Water Management in the Netherlands has been building fauna passageways crossing under or over motorways and has also adapted viaducts, bridges and culverts for joint use by fauna. Most fauna passageways are realised over and under four-lane highways with intensive traffic and concern badger pipes, fauna strips under bridges and in culverts and stub walls alongside the road crossings under viaducts. All are constructed with the primary aim of providing save passage for mammalian species. Surveys have been carried out, using different methods, to evaluate the use of fauna passageways by target species. Amphibians are also known to use a significant number of fauna passageways, including badger pipes longer than 40 meters.

Detailed information of amphibian use was obtained from footprints and tracks on paper using an ink bed or on sand beds on the passageway. These methods work well to distinguish prints of the species groups 'frog', 'toad' and 'newt'. These methods are not suitable to distinguish individual amphibian species.

For the most frequently used passages the number of passages is one amphibian every three to four days, which equated to 20 or more animals during the research period. Toads use fauna passageways more frequently than frogs and newts. Newts were not recorded in fauna pipes.

The frequency of amphibian use for passages under motorways is considerably lower than expected for seasonal migration. On the other hand for 'occasional use' the requirements of a fauna passageway seem less strict, compared with passages for seasonal migration. The results indicate that different types of fauna passageways play a role in mitigating the barrier effect of motorways by facilitating potential dispersion of amphibians. For choosing the best solution for a fauna passageway the requirements for amphibians next to mammalian target species are important. Fauna passageways should be located near suitable habitat.

8. **Boonman M. 2011. Factors determining the use of culverts underneath highways and railway tracks by bats in lowland areas. Lutra 2011 54 (1): 3-16.**

Abstract: In urbanising environments the construction of suitable underpasses for bats under highways and railway tracks is becoming increasingly important to avoid habitat fragmentation. Culverts provide valuable and low cost underpasses as they are already an intrinsic part of highway design and many bat species associated with water are likely to follow the streams or canals that flow through them. Bat detectors were employed to study the use of 54 culverts by bats in the Netherlands. The aim of the study was to define the factors that determine bats' use of culverts. Bats were observed in the vast majority of the culverts that were studied, thereby underlining the importance of culverts in habitat defragmentation. Species adapted to hunting in open habitats, such as the noctule (*Nyctalus noctula*) and the serotine (*Eptesicus serotinus*), were often recorded in front of the entrance but rarely inside culverts. For the three species that were regularly recorded inside culverts, Daubenton's bat (*Myotis daubentonii*), the pond bat (*Myotis dasycneme*) and the common pipistrelle

(*Pipistrellus pipistrellus*), cross sectional area was the most important factor that determined their use of culverts. Height was the most important component of cross sectional area for bats. Length proved a non-significant factor, suggesting that bat underpasses are not affected by the widening of the above-lying infrastructure. Additional guidance by treelines along the banks did not increase the use of culverts by the three species. The implication of the different preferences for cross sectional area on the design of infrastructure is discussed.

5 Literature

Arcadis & Bureau Waardenburg 2010. Monitoring en inspectie faunavoorzieningen Gelderland 2010. Onderzoek naar het functioneren van 39 faunavoorzieningen in de provincie Gelderland. Arcadis, Apeldoorn.

Arcadis & Bureau Waardenburg 2011. Monitoring en inspectie faunavoorzieningen Gelderland 2011. Onderzoek naar het functioneren van 43 faunavoorzieningen in de provincie Gelderland. Arcadis, Apeldoorn.

Boonman M. 2010. Het gebruik van duikers onder wegen en spoorlijnen door vleermuizen. Report 10-214, Bureau Waardenurg, Culemborg.

Boonman M. 2011. Factors determining the use of culverts underneath highways and railway tracks by bats in lowland areas. Lutra 2011 54 (1): 3-16.

Brandjes G.F., F. Van Vliet & G. Hoefsloot 2006. Onderzoek flora en fauna Landschapspark Susteren: Monitoring faunapassages en inventarisatie ecologische zones bij de N297. Report 06-271, Bureau Waardenburg, Culemborg.

Brandjes G.J. & F. Van Vliet 2006. Monitoring gebruik faunapassages Rijkswaterstaat Utrecht: Onderzoek op 13 locaties langs rijkswegen A12, A27 en A28. Report 05-259, Bureau Waardenburg, Culemborg.

Brandjes G.J. & G. Veenbaas, 1998. Het gebruik van faunapassages langs watergangen onder rijkswegen in Nederland: Een oriënterend onderzoek. Report W-DWW-98-29, Rijkswaterstaat, Delft.

Brandjes G.J. & G.F.J. Smit 1999. Aangereden dieren langs spoorwegen: Ontsnipperingsonderzoek Rail-infrastructuur Modulte Sterfte – Fase 1 'Enquête en Praktijkonderzoek trefkans. Report 99-74, Bureau Waardenburg, Culemborg.

Brandjes G.J. & G.F.J. Smit, 1996. Oriënterend onderzoek naar het gebruik door fauna van het viaduct "Mauritskamp" over de A28. Report 96-63, Bureau Waardenburg, Culemborg.

Brandjes G.J. & G.F.J. Smit, 1996. Overzicht onderzoeksmethoden gebruik faunapassages. Report W-DWW-96-117, Rijkswaterstaat, Delft.

Brandjes G.J. & G.F.J. Smit, 1998. Dieren gebruiken faunapassages onder de A6 in Flevoland, onderzoek 1998. Studie naar het gebruik van faunavoorzieningen en een oriënterend muizenonderzoek. Report 99-07, Bureau Waardenburg, Culemborg.

Brandjes G.J. 1999. Het gebruik van faunapassages langs watergangen onder rijkswegen: Experimenteel onderzoek-uitgangssituatie. Report 99-05, Bureau Waardenburg, Culemborg.

Brandjes G.J. 2006. Monitoring gebruik faunapassages Gemeente Utrecht 2004-2005: Onderzoek op 22 locaties in het stedelijk gebied van Utrecht. Report 06-009, Bureau Waardenburg, Culemborg.

Brandjes G.J., D. Emond 2011. Monitoring faunapassage Oude Haagseweg te Amsterdam. Report 11-028, Bureau Waardenurg, Culemborg.

Brandjes G.J., D. Emond, K.D. van Straalen, & B. Achterkamp 2013. Monitoring ecoduct De Munt, Wuustwezel (België). Tussenrapportage meetjaar 2012 (T1). Report 13-028, Bureau Waardenurg, Culemborg.

Brandjes G.J., D. Emond, K.D. van Straalen, & B. Achterkamp 2015. Monitoring ecoduct De Munt, Wuustwezel (België). Tussenrapportage meetjaar 2014 (T3). Report 15-027, Bureau Waardenurg, Culemborg.

Brandjes G.J., F. Van Vliet, H.J.J. Sips & R.Van Beurden 2006. Onderzoek boommarterbrug (A12) en Ecoduct Leusderheide (A28). Report 06-145, Bureau Waardenburg, Culemborg.

Brandjes G.J., G. Veenbaas, I. Tulp & M.J.M. Poot, 2001. Het gebruik van faunapassages langs watergangen onder rijkswegen: Resultaten van een experimenteel onderzoek. Report W-DWW-2001-026, Rijkswaterstaat, Delft.

Brandjes G.J., R. Van Eekelen, K. Krijgsveld & G.F.J. Smit, 2002. Het gebruik van faunabuizen onder rijkswegen. Report DWW-2002-123. Rijkswaterstaat Delft.

Brandjes G.J., Van der Velde E. & D. Emond 2007. Resultaten ecoduct De Borkeld rijksweg A1, 2006-2007. Report 07-136, Bureau Waardenburg, Culemborg.

Brandjes, G.J. & D. Emond, 2014. Faunapassages Krakelingweg, Zeist. Onderzoek naar het gebruik van een drietal kleine faunatunnels in 2013. Rapport 13-263. Bureau Waardenburg, Culemborg.

Emond D. & F. Van Vliet 2008. Evaluatie tien faunapasssages Zeeuws-Vlaanderen. Report 08-200, Bureau Waardenburg, Culemborg.

Emond D. & G.J Brandjes 2014. Resultaten monitoring ecoduct Hoog Buurlo 2013. Report 14-045d, Bureau Waardenurg, Culemborg

Emond D. & G.J Brandjes 2014. Resultaten monitoring ecoduct Huis ter Heide 2014. Report 14-045g, Bureau Waardenurg, Culemborg

Emond D. & G.J Brandjes 2014. Resultaten monitoring ecoduct Hulshorst 2013. Report 14-045b, Bureau Waardenurg, Culemborg

Emond D. & G.J Brandjes 2014. Resultaten monitoring ecoduct J.P. Thijsse 2014. Report 14-045e, Bureau Waardenurg, Culemborg

Emond D. & G.J Brandjes 2014. Resultaten monitoring ecoduct Middachten 2014. Report 14-045i, Bureau Waardenurg, Culemborg

Emond D. & G.J Brandjes 2014. Resultaten monitoring ecoduct Nijverdal 2013. Report 14-045a, Bureau Waardenurg, Culemborg

Emond D. & G.J Brandjes 2014. Resultaten monitoring ecoduct Oud Reemst 2014. Report 14-045f, Bureau Waardenurg, Culemborg

Emond D. & G.J Brandjes 2014. Resultaten monitoring ecoduct Petrea 2013. Report 14-045c, Bureau Waardenurg, Culemborg

Emond D. & G.J Brandjes 2014. Resultaten monitoring ecoduct Zwaluwenberg 2014. Report 14-045h, Bureau Waardenurg, Culemborg

Emond D. & G.J. Brandjes 2010. Monitoring gebruik faunapassages Gemeente Utrecht 2009-2010: Onderzoek op 24 locaties in het stedelijk gebied. Report 10-251, Bureau Waardenurg, Culemborg.

Emond D., G.J. Brandjes & B. Achterkamp 2015. Monitoring ecoduct De Munt, Wuustwezel (Belgie). Eindrapport T0-T3. Report 15-124, Bureau Waardenurg, Culemborg.

Emond D., G.J. Brandjes, R. Van Beurden & H. De Jong 2011. Monitoring ecopassage De Doorbraak, rijksweg A35. Report 11-184, Bureau Waardenurg, Culemborg.

Emond D., W. Lengkeek & G.J. Brandjes 2011. Succesfactoren dassentunnels: Studie naar de technische randvoorwaarden die het gebruik van dassentunnels beïnvloeden. Report 11-090, Bureau Waardenurg, Culemborg.

Ottburg F.G.W.A. & G.F.J. Smit 2000. Het gebruik door dieren van faunapassages van Directie Utrecht: Studie van locaties op de A27, A28 en A12; vier

stobbenwallen, één groenstrook en één float land. Report 00-086, Bureau Waardenburg, Culemborg.

ProRail 2012. Ontwerpvoorschrift Faunavoorzieningen. Voorzieningen voor kruisen, geleiden en keren van fauna. Report OVS00056-7 ProRail Utrecht.

Sips H.J.J. & G.F.J. Smit 2000. Wildwisselwachter T1: Veldtest van een automatisch video-registratiesysteem bij een loopplank, ecoduct en een doorgetrokken oever. Report 00-088, Bureau Waardenburg, Culemborg.

Sips H.J.J., 1994. Bestaande faunapassages van de rijksweg A7 in het Robbenoordbos. Report 94-48, Bureau Waardenburg, Culemborg

Sips H.J.J., G.J. Brandjes & Smit G.F.J. 2003. Automatische videoregistratie fauna in dassentunnel A50 Oosterhuizen. Report 03-012, Bureau Waardenburg, Culemborg.

Sips, H.J.J., G.F.J. Smit & G. Veenbaas, 2002. De toepasbaarheid van automatische videoregistratie bij faunapassages. Report DWW-2002-108, Rijkswaterstaat, Delft.

Smit G.F.J. & H.J.J. Sips, 2001. Automatische videoregistratie bij diverse typen faunapassages (2001). Report 01-112, Bureau Waardenburg, Culemborg.

Smit G.F.J. 1996. Het gebruik van faunapassages bij rijkswegen: Overzicht en onderzoeksplan. Report W-DWW-96-116, Rijkswaterstaat, Delft.

Smit G.F.J. 2007. Monitoring Faunapassages Noord-Brabant pilot 2006: Monitoring van het gebruik van 47 faunapassages onder provinciale wegen. Report 06-260, Bureau Waardenburg, Culemborg

Van Eekelen R. & G.F.J. Smit 2000. Het gebruik door dieren van kunstwerken in de A1 op de Veluwe: Studie van viaducten, tunnels en het ecoduct bij Kootwijk. Report 00-085, Bureau Waardenburg, Culemborg.

Van Eekelen R. & G.F.J. Smit, 2001. Het gebruik door dieren van zes viaducten in Noord-Brabant: Uitgangssituatie. Report 01-093, Bureau Waardenburg, Culemborg.

Van Eekelen R., 2002. Het gebruik door dieren van faunapassages bij de Elfenbaan: N11, Traject Alphen a/d Rijn-Zoeterwoude-Rijndijk (2002). Report 02-094, Bureau Waardenburg, Culemborg.

Van Eekelen, R., G.F.J. Smit, 2002. Het gebruik door dieren van faunapassages in Zuid-Holland. A4, A13 en A16 (2002). Report 02-131, Bureau Waardenburg, Culemborg.

Van Iwaarden J.M. 2003. Integrale beoordeling van faunavoorzieningen langs wegen in Nederland. Internship report, Bureau Waardenburg, Culemborg.

Van Vliet F. & G.J. Brandjes 2006. Monitoring gebruik faunapassages Rijkswaterstaat Utrecht: Onderzoek op 19 locaties langs rijkswegen A2, A12, A27 en A28. Report 06-090, Bureau Waardenburg, Culemborg

Van Vliet F. & G.J. Brandjes 2007. Monitoring faunapassages in het kader van Via Limburg: Pilot studie naar het gebruik van faunavoorzieningen door dieren onder de N271, N273, N293, A73-Noord en A79. Report 07-207, Bureau Waardenburg, Culemborg.

Wansink, D.E.H, G.J. Brandjes, G.J. Bekker, M.J. Eijkelenboom, B. van den Hengel, M.W. de Haan & H. Scholma, 2013. Leidraad Faunavoorzieningen bij Infrastructuur. Rijkswaterstaat, Dienst Water, Verkeer en Leefomgeving, Delft / ProRail, Utrecht.

Bureau Waardenburg bv
Research and consult for ecology and landscape
P.O.Box 365, 4100 AJ Culemborg
Tel: +31 345-512 710, Fax: +31 345-519 849
E-mail info@buwa.nl, www.buwa.nl