ARUP

Public Water Management Company Srbijavode

European Bank for Reconstruction and Development

Environmental and Social Impact Assessment, Climate Change Assessment and Technical Assessment for Pambukovica Dam in Serbia

Biodiversity Impact Assessment

Appendix 1 - Bat Activity Surveys Technical Report

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1. Introduction

1.1 Purpose and scope of this report

The consultancy services of Arup DOO BEOGRAD (VRAČAR) (Arup) were acquired to carry out baseline bat activity surveys in 2023 and 2024 at the proposed Pambukovica Dam development site, for the purpose of informing the environmental and social impact assessment (ESIA) and environmental impact Assessment (EIA) of the development site.

The purpose of this report is to present the methodology, results and limitations of a series of baseline bat activity surveys undertaken throughout the site by Arup and a subcontractor in late July/early August 2023 and between August and October 2024.

The results from this report will highlight areas across the site that hold significance associated with bats and their ecology. These results will be used to inform the impact assessment of the proposed scheme outlining appropriate mitigation and compensation measures as required, with reference to the 'Mitigation Hierarchy'[1]. This report has been produced in accordance with Serbian and international environmental legislation specific to bats.

1.2 Ecological context of the site location

The site is situated between Pambukovica and Gola glava in the munipality of Ub, Serbia. Areas designated for the construction of the proposed dam reservoir and irrigation system are situated within a complex and multifaceted landscape that comprises rural, agricultural and natural elements. The majority of the terrain is dedicated to arable land, where intensive annual crop agriculture prevails, catering to the region's agricultural needs. Scattered throughout the area are patches of natural forests. Additionally, there are narrower sections where natural vegetation has been modified to accommodate agricultural practices. The River Ub meanders across the site, with a varying degree of modification and natural features. Along its course, road crossings facilitate human movement and connectivity. Some of its tributaries are known to be ephemeral, active only during seasonal rains or sudden flash floods.

In this diverse landscape, an array of species groups has been documented through field surveys, demonstrating the ecological richness of the area. In terrestrial habitats, a wide range of invertebrate species and mammals have been recorded. Among the notable findings are several species of amphibians, which thrive in the seasonal water bodies formed by the river's tributaries during periods of rainfall. Avian diversity is particularly prominent, with the region serving as a habitat for numerous resident and migratory bird species. The riverine ecosystem supports a variety of fish species and freshwater molluscs, contributing to the overall aquatic biodiversity. However, it's important to note that alongside these native species, certain invasive species have established within the area which will need further consideration and mitigation efforts.

No Legally Protected or Internationally Recognized Areas of Biodiversity Value areas (as defined by EBRD[2]) are located within the vicinity of the proposed project area. The closest legally protected areas to the project site are the Obedska Bara (Swamp) Nature Reserve / Candidate Emerald Site (CES), located 19 km away, and the Klisura Reke Gradac (Gradac River Gorge) CES, located 18 km away. Further information is provided within the desk study results in Section 3.1.

[1] The overarching aims of ecological work used to inform the planning process are to minimise harm and to maximise benefits for biodiversity resulting from development. The generally accepted way of doing this, now embedded within the planning system, is to follow the "mitigation hierarchy". This seeks as a preference to avoid impacts then to mitigate unavoidable impacts, and, as a last resort, to compensate for unavoidable residual impacts that remain after avoidance and mitigation measures (BS42020:2013 Biodiversity Code of Practice for Planning and Development. (BSI Standards Limited 2013).

[2] EBRD (2020) Guidance Note 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources (v. September 10, 2020).

1.3 Definition of the Biodiversity Study Area

The Biodiversity Study Area (Drawing 1) was defined as the dam footprint (including the estimated construction area) and the area of the reservoir when full, plus a 100m buffer. In addition, a survey buffer was applied to the following key construction areas:

- 100m for the E21 highway watercourse crossing of the River Ub that will need to be raised above the reservoir level as part of the project,
- 50 m for Seven sediment trap dams that have been planned to be constructed in the upstream catchment to mitigate arrival of sediment into the reservoir,
- 100 m for the irrigation area.

In addition to the Biodiversity Study Area, information on habitats within the downstream Irrigation Area (Figure 1) was also collected to inform further assessment. The Irrigation Area consists of the land area downstream of the reservoir, where a network of pipes and/or water channels would be constructed to transfer water stored in the reservoir to the wider catchment for irrigation during operation.

1.4 Survey objectives

The key objectives for the baseline bat activity surveys were:

- to devise the survey methodologies, in compliance with all applicable national and international requirements, generally accepted European and international guidance and current best practice;
- to undertake a programme of activity surveys at the proposed project area to establish the ecological baseline with regard to bats;
- to report on the survey findings, with a view to inform the assessment of impacts of the proposed project area on bats.

1.5 Legislation and policy context

A framework of international and national legislation, requirements, standards and guidance exists to protect and conserve bat populations throughout Serbia.

1.5.1 International legislation

Bats are protected under several international conventions, notably the Bern Convention on the Conservation of European Wildlife and Natural Habitats, and the Convention on the Conservation of Migratory Species of Wild Animals (CMS or Bonn Convention), both of which Serbia has ratified and implemented. The Bern Convention categorises species into two appendices: Appendix II for Strictly Protected Fauna Species, which includes all European bat species except the common pipistrelle (*Pipistrellus pipistrellus*) listed in Appendix III for Protected Fauna Species. The CMS lists all bat species in Appendix II, indicating they have an unfavourable conservation status and require international agreements for their protection. One such agreement is the Agreement on the Conservation of Populations of European Bats, also known as EUROBATS[3], which Serbia has also ratified.

In the European Union (EU), bat protection is governed by the Habitats Directive[4], which lists all European bat species in Annex IV as species needing strict protection, and 13 species found in Serbia in Annex II, requiring the designation of Special Areas of Conservation (SACs). These SACs, along with Special

[3] The Agreement on the Conservation of Populations of European Bats (EUROBATS), "UNEP/EUROBATS – Agreement on the Conservation of Populations of European Bats," [Online]. Available at: https://www.eurobats.org/. [Accessed January 2025].

[4] Joint Nature Conservation Committee (JNCC), "Council Directive 92/43/EEC (The Habitats Directive) Annex II Species List," [Online]. Available at: https://sac.jncc.gov.uk/species/. [Accessed January 2025].

Protected Areas (SPAs), form the Natura 2000 ecological network under the Habitats Directive, which also serves as an EU implementation mechanism for the Bern Convention and CMS.

The EU mandates Environmental Impact Assessments (EIA) for all developments likely to significantly affect the environment, regulated by the Directive on the assessment of the effects of certain public and private developments on the environment. As an EU candidate country, Serbia must fully transpose and implement EU legislation by the time of accession. However, Serbian legislation in relevant areas is already largely harmonised and implemented.

1.5.2 Serbian legislation and regulatory requirements

The primary legislation for nature protection in Serbia is the Law on Nature Protection[5,6], which has been amended and corrected to fully align with relevant EU legislation. This law governs the protection of wild species and natural habitats, the designation of protected areas, and the establishment of the Ecological Network of Serbia. Strictly Protected and Protected wild species are listed under the subsidiary bylaw, the Code of Regulations on the Declaration and Protection of Strictly Protected and Protected Wild Species of Plants, Animals, and Fungi[7]. All bat species in Serbia are classified as Strictly Protected, except for the Alpine long-eared bat (*Plecotus macrobullaris*) and the European free-tailed bat (*Tadarida teniotis*), which were only recently recorded in Serbia.

Conservation Priority habitat types are detailed in another bylaw: the Code of Regulations on the Criteria for Designation of Habitat Types, Sensitive, Endangered, Rare, and Conservation Priority Habitat Types, and on Protection Measures for Their Preservation[4].

Protected areas are designated and regulated by specific subsidiary bylaws. Once the Ministry announces on its website that a protection procedure has begun for an area, that area is considered protected. The Ecological Network of Serbia, which became part of the European Natura 2000 network (SPAs and SACs) upon Serbia's EU accession, is established and regulated by the subsidiary regulation on The Ecological Network[8]. The designation of Ecological Network sites is ongoing, with new areas continuously added. The Institute for Nature Protection of Serbia prepares and updates electronic records and maps of the Ecological Network.

Legislation requires that Nature Protection Conditions be obtained from the competent authority: the Institute for Nature Conservation of Vojvodina Province (IfNC), for all activities affecting the natural environment. For proposed developments that might disrupt wildlife migration routes, fragment habitats, or disturb their life cycles, legislation mandates that negative impacts be mitigated during construction and operation.

Ecological Impact Assessments (EIAs) in Serbia are regulated by the primary Law on EIA and subsidiary bylaws. The Provincial Secretariat for Urban Planning and Environment Protection of the Vojvodina Province is the competent authority for EIAs. National legislation on EIA was reviewed in 2011 to ensure all impacts on Serbian bat populations are considered in development proposals[9].

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[5] Official Gazette Of The Republic Of Serbia (36/2009a): Law On Nature Protection. Official Gazette Of The Republic Of Serbia, 36/2009, Belgrade.

[6] Official Gazette Of The Republic Of Serbia (88/2010a). Law On The Spatial Plan Of The Republic Of Serbia Dated 2010 To 2020. Official Gazette Of The Republic Of Serbia, 88/2010, Belgrade.

[7] Official Gazette Of The Republic Of Serbia (5/2010): Rulebook On The Proclamation And Protection Of Strictly Protected Wild Species Of Plants, Animals And Fungi. Official Gazette Of The Republic Of Serbia, 5/2010, Belgrade.

[8] Official Gazette Of The Republic Of Serbia (102/2010): Regulation On The Ecological Network. Official Gazette Of The Republic Of Serbia, 102/2010, Belgrade.

[9] Paunovic, M., Karapandža, B., Ivanović, S. Wildlife Conservation Society (MUSTELA) (2011), "BATS AND ENVIRONMENTAL IMPACT ASSESSMENT Methodological guidelines for environmental impact assessment and strategic environmental impact assessment", [Online]. Available at: https://www.researchgate.net/publication/266555086_BATS_AND_ENVIRONMENTAL_IMPACT_ASSESSMENT_Methodological_guidelines_for_environmental_impact_assessment_and_strategic_environmental_impact_assessment [Accessed January 2025].

1.5.3 International requirements, standards and guidance

All developments financed by the EBRD must comply with their Environmental and Social Policy (ESP) and a comprehensive set of specific Performance Requirements (PRs) outlined within it. The latest ESP has been effective since January 1, 2020[10]. For Pambukovica Dam Studies, the most relevant is PR 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources, which includes additional guidance[11] and two best practice documents[12,13]. These documents strongly reference the IFC Performance Standard 6[14] (PS6) and its guidance[15]. PR 6 states that in planning and conducting biodiversity-related baseline and impact assessments, clients should refer to relevant good practice guidance.

The IFC, along with other International Financial Institutions (IFIs), requires that all clients and their developments adhere to the IFC's Sustainability Framework and its specific Performance Standards (PSs) on Environmental and Social Sustainability, as well as the World Bank Group's Environmental, Health, and Safety (EHS) Guidelines. Relevant to Pambukovica Dam Studies is PS 6[14], supported by comprehensive implementation guidance. The latest sector-specific World Bank Group's EHS Guidelines, effective since August 2015, mandate that "where robust in-country guidelines are not yet developed for bat and bird related issues, international guidelines should be used" These include NatureScot's guidelines for birds and the latest EUROBATS and Bat Conservation Trust (BCT) guidelines for bats.

The latest EUROBATS[3] and the second edition of the BCT survey guidelines[16] are considered referential by IFIs and are widely accepted as best practice with regards to bats. Although the two sets of guidelines differ in survey methodologies, consistent implementation of both guidelines ensures robust impact assessments. This report and subsequent reports followed EUROBATS guidelines and the latest BCT guidelines[17].

Readers should refer to the original legislation for definitive interpretation and consider any amendments or accompanying guidance notes or PRs.

1.6 Bat species ecology

All bat species in Serbia are nocturnal, emerging from their roosts at dusk. Bats have been found to roost in a number of places, including trees, barns, buildings (within lofts, roof structures, basements, cladding and cavity walls), bridges and underground sites (e.g., mines and tunnels). Their preferred roosting location depends on a number of factors, such as species, gender, breeding status and time of year. Bats utilise an array of habitats as foraging areas, including riparian habitats, woodland and grassland, feeding on a variety

[10] European Bank for Reconstruction and Development (EBRD) (2019), "Environmental and Social Policy", [Online]. Available at: https://www.ebrd.com/documents/comms-and-bis/environmental-and-social-policy.pdf [Accessed January 2025].

[11] European Bank for Reconstruction and Development (EBRD) (2016), "Guidance Note - EBRD Performance Requirement 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources", [Online]. Available at: http://www.ebrd.com/documents/environment/pdf-guidance-note-ebrd-performance-requirement-6.pdf [Accessed January 2025].

[12] Gullison, R. E., Hardner, J., Anstee, S., Meyer, M. (2015), "Good Practices for the Collection of Biodiversity Baseline Data. Multilateral Financing Institutions Biodiversity Working Group & Cross-Sector Biodiversity Initiative", [Online]. Available at: http://www.ebrd.com/documents/environment/biodiversity-baseline.pdf [Accessed January 2025].

[13] Hardner, J., Gullison, R. E., Anstee, S., Meyer, M. (2015), "Good Practices for Biodiversity Inclusive Impact Assessment and Management Planning. Multilateral Financing Institutions Biodiversity Working Group & Cross-Sector Biodiversity Initiative", [Online]. Available at: http://www.ebrd.com/documents/environment/biodiversity-impact-management.pdf [Accessed January 2025].

[14] The International Finance Corporation (IFC) (2012), "Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources", [Online]. Available at: http://www.ifc.org/wps/wcm/connect/bff0a28049a790d6b835faa8c6a8312a/PS6_English_2012.pdf?MOD=AJPERES [Accessed January 2025].

[15] The International Finance Corporation (IFC) (2019), "Guidance Note 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources", [Online]. Available at: https://www.ifc.org/wps/wcm/connect/5e0f3c0c-0aa4-4290-a0f8-4490b61de245/GN6_English_June-27-2019.pdf?MOD=AJPERES&CVID=mRQjZva [Accessed January 2025].

[16] Hundt, L, Ed. Bat Conservation Trust (BCT) (2012), "Bat Surveys: Good Practice Guideline, 2nd edition" [Report] [Accessed January 2025].

[17] Collins, J. The Bat Conservation Trust (BCT) (2023), "Bat Surveys: Bat Surveys for Professional Ecologists: Good Practice Guidelines (4th edition.)" [Report] [Accessed January 2025].

of insect species. Foraging areas and insect prey differ between each species of bat, with different species adapted for hunting in a variety of ways. Many bat species are also known to use multiple different habitat types to forage, highlighting the importance of landscape scale assessment to ensure the persistence of a mosaic of habitats across important foraging areas.

In order to move between their roosts and foraging grounds, bats commonly use linear features as commuting corridors. Hedgerow and treelines, in addition to small patches of woodland, rivers and streams, provide protection and cover from predators and enable bats to emerge and disperse earlier. Where these features are comprised of diverse plant assemblages, suitable to support insect populations, they may be used for opportunistic foraging, with bats feeding on the way to their main foraging areas. Relevant background information on species-specific ecology should be used to inform future surveys and assessments, including their distribution, range, suitable habitats, life cycle and threats. For example, the Core Sustenance Zone (CSZ)[18] of a species refers to the area surrounding a communal bat roost within which habitat availability and quality will have a significant influence on the resilience and conservation status of the colony using the roost. This will influence the area in which surveys should be conducted, and the scale at which impacts and associated mitigation/compensation will be considered for the proposed scheme.

1.7 Status of bats at national level

The national report on the implementation of the agreement on the conservation of bats in Europe for Serbia, updated in 2010[19] states that there are 29 bat species resident to Serbia. However, a study published in 2020[20] reports that Serbia is home to 31 resident bat species, including five species of Horseshoe Bats (*Rhinolophidae*), 24 species of Vesper Bats (*Vespertilionidae*), and one species each from the families of Long-winged Bats (*Miniopteridae*) and Free-tailed Bats (*Molossidae*).

This study also provided a detailed insight into the recent spatial distribution of bat species throughout Serbia. In the Vojvodina region, 23 species were documented across 102 sites, accounting for 16.9% of the total records. Whereas the Central Serbia region hosted all 31 species, recorded at 494 sites, representing 81.5% of the total records. In contrast, only 14 species were identified in Kosovo and Metohija regions, distributed across 10 sites, comprising just 1.6% of the total records. Additionally, researchers evaluated the potential presence of 14 other species within these regions.

When analysed by altitudinal zones, the study revealed distinct patterns. The Pannonian zone recorded 23 species across 186 sites, accounting for 30.7% of the total records. The Peripannonian zone documented 27 species at 181 sites, making up 29.9% of the total records. Meanwhile, the Mountainous-Valley zone emerged as the most biodiverse, with all 31 species observed at 239 sites, contributing 39.4% of the total records. Out of the 606 surveyed locations throughout Serbia, 421 were identified as roosting sites, making up 69.9% of the total. The remaining sites included 125 foraging or commuting areas, comprising 20.5%. Among the most significant sites, 273 were hibernation roosts, 126 were maternity roosts, and 34 were mating roosts, highlighting their ecological importance to Serbia.

Table 1 below provides a summary of the status, distribution, and ecology of Serbian bat species as stated in the most recent species update[20], focusing on those recorded during the bat activity surveys.

[18] Bat Conservation Trust (BCT), "Bat Species Core Sustenance Zones and Habitats for Biodiversity Net Gain," [Online]. Available: https://www.bats.org.uk/resources/guidance-for-professionals/bat-species-core-sustenance-zones-and-habitats-for-biodiversity-net-gain. [Accessed January 2025].

[19] Ministry of Environment and Spatial Planning, Republic of Serbia, "National report on the implementation of the agreement on the conservation of bats in Europe – Serbia 2010," [Online]. Ava: https://www.eurobats.org/sites/default/files/documents/pdf/National_Reports/nat_rep_Serb_2010.pdf

[20] Paunovic, M., Karapandža, B., Budinski, I. and Stamenković, S. (2020), "Bats (Mammalia, Chiroptera) of Serbia," [Online]. Available: https://www.researchgate.net/publication/349279402_Bats_Mammalia_Chiroptera_of_Serbia_Fauna_slepih_miseva_Mammalia_Chiroptera_Srbije. [Accessed January 2025].

Table 1: Summary of species and their associated status, distribution and ecology

Species name (scientific name)	Description
Western barbastelle bat (*Barbastellus barbastellus*)	The western barbastelle bat is considered a relatively rare species that is never abundant. In Serbia, it has been recorded at seven sites to date. Observations typically involve single individuals, although groups of 2–5 have occasionally been found hibernating in caves or captured with mist nets near cave entrances during other seasons. One notable record is of a single gravid female from Obedska Bara pond . Known roosts are found at altitudes ranging from 70 to 1,000 meters, with the species showing a preference for cooler habitats, particularly in well-preserved riparian or mountain beech forests.
Common serotine (*Eptesicus serotinus*)	This species is widespread and common, but most records consist of single individuals observed at 48 sites across the country. However, information about its bionomics remains limited, with only one breeding roost documented so far within a tree hollow in Central Serbia .
Savi's pipistrelle (*Hypsugo savii*)	Although considered a common and widespread species in limestone areas of Serbia, including all altitudes and parts of Belgrade, it has been recorded at only 19 sites, two of which were previously reported. Summer roosts have been observed in rock crevices and modern apartment buildings in Belgrade, while winter roosts have been found in rock crevices and at cave entrances.
Schreiber's bent-wing bat (*Miniopterus schreibersii*)	This is one of the most common and widespread cave-dwelling bat species in Serbia, known for forming very large colonies. To date, 51 roosts have been identified. It often shares roosting sites within caves, old mines, and fortresses with greater mouse-eared bats (Myotis myotis), lesser mouse-eared bats (Myotis blythii) and long-fingered bats (Myotis capaccinii), frequently forming mixed colonies with these species. Medium-distance seasonal migrations between winter and summer roosts have also been observed.
Alcathoe bat (*Myotis alcathoe*)	Recent research, including genetic analyses, has confirmed the presence of this species in Serbia. It has been recorded at four sites so far. While it could be common and widespread, it is likely less abundant than whiskered bat (Myotis mystacinus). Targeted field studies, as well as investigations into its bionomy, morphology, and genetics, are currently ongoing.
Bechstein's bat (*Myotis bechsteinii*)	The Bechstein's bat is widespread but confined to specific, well-preserved forest habitats, with records from 18 sites. Most observations involve single specimens, either mist-netted at cave entrances or found hibernating within them. Individual bats have also been recorded hibernating in artificial underground structures, such as the Petrovaradin Fortress in Novi Sad. A few specimens have been mist-netted and ringed near forested streams and in riparian forests. Additionally, a gravid female was observed in early July in Eastern Serbia.
Brandt's bat (*Myotis brandtii*)	The status of this species, recently recorded in Serbia for the first time, remains unknown. Single specimens have been observed at five sites, three in eastern Serbia and two in western Serbia.
Long-fingered bat	This is a common cave-dwelling species recorded at 36 sites, predominantly in limestone areas at lower altitudes across the country. It forms colonies in caves, either alone or alongside other species, most commonly Schreiber's bent-wing bats, greater mouse-eared bats, and lesser mouse-eared bats, as well as other cave-dwelling bats. It primarily hibernates in large caves, often those with underground streams. In Serbia, colonies can consist of up to 4,000 individuals during hibernation and 200–1,000 individuals in nursery sites.
Daubenton's bat (*Myotis daubentonii*)	This widely distributed species is found throughout the country in suitable habitats, most commonly near wetlands and water bodies. High abundance has been observed at several wetlands in Eastern Serbia and the Province of Vojvodina, with records from 33 sites. During winter, only a small number of individuals have been found hibernating in caves, suggesting that this species primarily hibernates in hollow trees. While no summer roosts have been documented, it is assumed that hollow trees serve as summer roosting sites as well.
Geoffroy's bat (*Myotis emarginatus*)	This is a relatively common and widespread species, though typically not very abundant. It has been recorded at 30 sites. Summer roosts are found in buildings and caves, with nursery colonies of 200–500 individuals often mixed with greater horseshoe bats (Rhinolophus ferrumequinum), and occasionally with Schreiber's bent-wing bats and Mediterranean horseshoe bats (Rhinolophus Euryale). In winter, single specimens are usually found hibernating in caves.
Whiskered bat	This species is relatively frequent and widely distributed in Serbia. Based on current knowledge and recent genetic analyses of specimens from Serbia, all individuals previously identified as steppe whiskered bat (Myotis aurascens) actually belong to this species, most likely a Balkan subspecies.

Species name (scientific name)	Description
	Whiskered bat appears to be less common and abundant than the subspecies, at least in areas south of the Sava and Danube rivers, where the two forms typically coexist. To date, 25 sites have been confirmed, all in woodlands where the species seems to forage near forest edges. It has been regularly mist-netted during all seasons, particularly along the banks of temporary or permanent small water bodies, and has also been captured at cave entrances.
Natterer's bat (*Myotis nattereri*)	The status of this species is not well understood, as it has been rarely encountered in Serbia. It has been recorded at 13 sites, with only 4 of those being small nurseries. The remaining records consist of single specimens or small groups.
Leisler's bat (*Nyctalus leisleri*)	Little is known about the status of this species, as it has been found quite rarely. So far, it has been recorded at 9 sites, with 2 of those being previously reported. However, it may be present throughout the country in suitable habitats and could be quite numerous during migration. Most recorded specimens have been mist-netted in foraging areas during transitional periods and the summer.
Common noctule (*Nyctalus noctula*)	This species is widely distributed, common, and abundant, with records from 106 sites. Hibernating colonies, ranging from a few to several thousand individuals, have been found in cracks and cavities in buildings and bridges, hollow trees, and fissures in rocks at cave entrances. It has been recorded throughout the year, though there is no confirmed data on breeding, aside from a doubtful single report from western Serbia.
Kuhl's pipistrelle (*Pipistrellus kuhlii*)	Although this species was first recorded in Belgrade in 1994, there have been numerous recent sightings in cities and other human settlements across Serbia. It is known from 46 sites, and all stages of its life cycle have been observed. In recent years, special attention has been given to studies on the replacement of common pipistrelle (Pipistrellus pipistrellus), which was previously predominant in urban habitats, by this species.
Nathusius' pipistrelle (*Pipistrellus nathusii*)	In recent years, this species has often been recorded during the summer and transitional periods, primarily at foraging sites. Several specimens have been ringed, and the species has been documented at 23 sites.
Common pipistrelle	Although it is a common and widespread species, no studies on its biology and ecology have been conducted. It is known from 56 sites, including both summer and winter roosts in buildings and caves. Interestingly, in human settlements, particularly in large cities, this species has been significantly replaced by Kuhl’s pipistrelle since the 1990s. Ongoing research is focused on understanding the relationship between these two species and their respective ecologies.
Soprano pipistrelle (*Pipistrellus pygmaeus*)	The taxonomic status of this species was recently confirmed by a decision from the International Commission for Zoological Nomenclature in 2003. So far, 18 sites, primarily foraging areas, have been recorded in the Srem region and near Belgrade, mostly through the use of bat detectors. A revision of the identification of specimens in museum collections is currently underway, as common pipistrelle and soprano pipistrelle were not distinguished until recently.
Brown long-eared bat (*Plecotus auritus*)	The brown long-eared bat is widespread across the country, found at both low and high altitudes, although it is never abundant. To date, it has been recorded at 20 sites, primarily in a variety of roost types (underground, overground, artificial, natural) and also at foraging sites.
Grey long-eared bat (*Plecotus austriacus*)	The grey long-eared bat is one of the most common and widespread species in the country, though most records consist of single specimens. To date, 46 sites have been recorded. It regularly hibernates in underground sites.
Mediterranean horseshoe bat (*Rhinolophus Euryale*)	This species is a common cave dweller found in hilly and mountainous limestone areas. It is the most common and abundant of the three "medium-sized" horseshoe bat species, with records from 60 sites. It forms mixed summer and nursery colonies of 100–400 individuals alongside other cave-dwelling species. It hibernates in caves, with the largest known colonies consisting of 1,000–2,000 individuals, often together with Blasius’s horseshoe bats (Rhinolophus blasii) and Mehely’s horseshoe bats (Rhinolophus mehelyi), or with Geoffroy's bats at lower altitudes. Short-distance seasonal migrations between winter and summer roosts have been observed.
Greater horseshoe bat (*Rhinolophus ferrumequinum*)	This is a widely distributed and common species, recorded at 159 sites, mostly in natural underground habitats, with fewer records in artificial structures such as buildings and old mines. Nursery colonies have been observed in small caves, at cave entrances, and (outside limestone areas) in attics, typically consisting of 100–350 individuals, sometimes mixed with Geoffroy’s bats.

Species name (scientific name)	Description
	In winter, it is found in underground roosts, often as single individuals or small groups of 10–15, though hibernating colonies of 200–500 individuals have also been recorded. The largest known winter colony contained up to 1,200 individuals. Short- and medium-distance seasonal migrations between winter and summer roosts have been observed.
Lesser horseshoe bat (*Rhinolophus hipposideros*)	This is a widespread species, common but never abundant, with records from 111 sites, none of which are in lowlands or river valleys. Breeding colonies, mostly observed in buildings (lofts or other uninhabited premises), typically range from 5–6 to around 30 individuals. During the winter period, it is found exclusively in underground roosts, where it is usually recorded as single individuals or up to about 30 individuals in one roost.
European free-tailed bat (*Tadarida teniotis*)	The presence of this species has recently been confirmed in Montenegro, Bosnia and Herzegovina, Macedonia, and Bulgaria. It is expected to be found in the thermophilous limestone areas of Eastern, Western, and Southern Serbia, particularly in specific sites within canyons and gorges.
Parti-coloured bat (*Vespertilio murinus*)	There are 22 records of this species, mostly from buildings, with the majority coming from Belgrade and its surroundings. Single specimens have also been recorded throughout Serbia. There is no evidence of breeding or wintering in Serbia so far, as most records are from transitional periods.

2. Methodology

2.1 Desk study

2.1.1 Protected areas

A desk study search of Legally Protected or Internationally Recognised Areas of Biodiversity Value areas in proximity to Biodiversity Study Area was undertaken. This included but was not limited to Emerald sites (including candidate sites), Ramsar sites, Key Biodiversity Areas and National Parks.

2.1.2 IUCN screening and literature review

A desk study search was conducted using the IUCN website[21] to identify CR, EN, VU species within a 20km buffer of Biodiversity Study Area.

In addition to the IUCN Screening, a thorough review of scientific articles related to the biodiversity of the broader region was undertaken. The closest reference area for this review was the artificial fishpond Dokmir, located 5km from the Pambukovica Dam.

The information collected during the literature review, together with the expert opinion from Arup, allowed to create lists of species and habitats potentially present within the local study area. The local study area includes the project components, associated facilities and temporary facilities, as well as the expected Area of Influence of the project.

2.2 Bat activity field surveys

2.2.1 Overview

Field surveys in the form of transect surveys and static detector surveys were undertaken in late July/early August 2023 (one survey visit) and between August and October 2024 inclusive, to establish key commuting and foraging habitat for the bat assemblage within the study area. Activity transect and automated detector surveys were led by a combination of suitably experienced bat ecologists. All surveys were undertaken with reference to:

- EUROBATS[3];
- Bat Surveys for Professional Ecologists: Good Practice Guidelines (4th edition[17]); and

The objectives of these surveys were to establish the ecological baseline of the proposed development with regards to bats, and thus to provide information to be used to assess the impacts of the proposed development on bats, and develop appropriate mitigation measures. Arup devised all aspects of these methodologies in accordance with current GIIP and IFIs requirements (as elaborated above in Section 1.5).

2.3 Activity transect surveys

2.3.1 Data collection

The aim of these surveys is to identify and assess the presence, activity levels, and habitat use of bat species across the biodiversity study area

Three pre-determined transects (Table 2) were defined to provide thorough coverage and representation of the Biodiversity Study Area, both spatially and ecologically, with reference to relevant guidance. Transect routes were devised from satellite imagery and aerial photographs and encompassed features that are suitable for “Priority” bats e.g. woodland edges, watercourses, lines of trees, and scrub habitat to allow for a

[21] The ICUN Red List of Threatened Species (2024). Available [ONLINE] at: https://www.iucnredlist.org. [Accessed January 2025].

comparison of bat activity across the site. The approximate distance of each transect was between 2.4 and 5 km, and each transect route was supplemented with three stopping locations where higher levels of bat activity or disturbance are expected, such as areas of favourable habitat and key construction sites (i.e., the proposed dam location and the proposed elevation of the existing road). The location and layout of each transect route, including supplementary stopping locations is provided in Drawing 2.

Table 2: Activity transect survey locations

Date of transect survey	Site reference	Location		Transect length
		Latitude	Longitude	
29/07/2023	Transect 1	N 44.402331°	E 19.885573°	3.1km
		N 44.402254°	E 19.885353°	
30/07/2023	Transect 2	N 44.405318°	E 19.902636°	5.4km
		N 44.406764°	E 19.894819°	
07/08/2023	Transect 3	N 44.432188°	E 19.909232°	2.4km
		N 44.428852°	E 19.907902°	

Every survey commenced at sunset, with the duration of each transect extending until dawn the following day. The transect routes were walked at a steady constant pace, stopping at the pre-identified stopping locations. Each transect was conducted by two experienced surveyors with one member focused on observing the surrounding bat activity, while the other member documented a time stamped narrative for each observation. The time stamped narrative comprised information on the following aspects (where natural light levels were not a major constraint:

- Bat species;
- Number of bats;
- Flight direction;
- Apparent behaviour, e.g. feeding buzzes or social calling; and
- How bats responded to permanent or temporary features on site, e.g. waterbodies, tree lines, watercourses, sheltered areas and artificial lighting.

The pre-determined transects were walked once through the survey period. Throughout the duration of the transect surveys, bat calls were recorded using Petersson 240x and Echo Meter Touch 2 Pro bat detectors, allowing for data to be captured in time expansion, full spectrum and frequency division formats. The location corresponding to each bat pass was also noted by the surveyor at the time of recording and automatically captured via a GPS device, for subsequent data analysis.

Surveys were conducted on three occasions, with at least a month between each survey to allow for monthly variation in bat activity. Surveys were undertaken in optimal conditions with no rain or windy conditions. Survey dates and weather conditions are provided in Appendix A.

2.3.2 Transect data acoustic analysis

The detectors record bat calls, and produce a .wav file containing a sequence of calls. Each file is considered as a time a bat passed the recorder. For this report results of activity are shown in terms of bat passes.

Subsequent analysis of bat calls recorded of the duration of activity transect surveys was undertaken using Wildlife Acoustics Kaleidoscope Pro software, including the use of Automatic identification (ID), supported by further verification by experienced ecologists. The auto ID feature in Kaleidoscope Pro for bat echolocation calls was deemed to not be reliable for *Myotis* species. Therefore, each call was additionally verified manually to ensure the accuracy of species identification and to validate the obtained data. For

Myotis species, the following parameters were used for differentiation: peak frequency, audibility of calls below/above the proposed frequency, velocity of repetition rate, and intensity of recorded clicks.

2.4 Automated detector surveys

2.4.1 Data collection

Automated detector surveys were undertaken at seven locations (SMM-01 to SMM-07) across the Biodiversity Study Area between August and October 2024 inclusive. The specification of automated detectors used were Wildlife Acoustics SongMeter Mini Bat full spectrum bat detectors (referred to as 'static detectors or SMM-xx'). Static detectors were set up to begin recording bat calls 30 minutes before sunset, continuing until 30 mins after sunrise, collecting data on at least five consecutive nights per deployment month in appropriate (or best available) weather conditions. Selected survey period, including deployment dates, are provided in Appendix B.

Each static detector location, as shown in Drawing 3, was chosen based on the presence of suitable habitats and features that could be directly or indirectly impacted by the proposed development. The selection process also relied on professional judgment to identify habitats likely to be important for bats, both as flight corridors and/or for foraging. These habitats included hedgerows, woodlands, grasslands, scrub, and arable areas. Descriptions of the habitats and features at each static deployment location are provided in Table 3 below.

Table 3: Descriptions for automated static detector locations

Static Detector ID	Location		Feature and connected habitats/features in the wider landscape
	Latitude	Longitude	
SMM-01 (Photograph 1& Photograph 2)	19°54'30.71"E	44°25'40.76"N	Detector positioned on a tree leaning over a shallow section of the river with a rocky bed. Both sides of the riverbank are densely vegetated, creating a natural corridor. The detector faced southeast along the river, directly above the water. Signs of human presence were evident, with cornfields located in close proximity to the site.
SMM-02 (Photograph 3 & Photograph 4)	19°54'07"E	44°25'30"N	Detector location was deep within an open, sparse forest, positioned on a steep slope. The river lies approximately 200 meters away in a straight line. The trees in the area are slender and overgrown with ivy, creating a lightly vegetated understory. The detector's microphone faced southeast into the woodland. Above the forest, there are sunflower fields surrounded by invasive ragweed (Ambrosia spp.).
SMM-03 (Photograph 5 & Photograph 6)	19°54'13.97"E	44°25'24.96"N	Detector location was situated at a river pool, a widened section of the river, with the detector mounted on a tree beside the water. The ground level was rich in scrub vegetation, including climbers and scattered trees such as willow (*Salix sp.*) and alder (*Alnus sp.*). Nearby, there is a cornfield, adding to the habitat diversity. The water here is deeper compared to other locations, creating a distinct aquatic environment. The microphone was oriented south along the river corridor.
SMM-04 (Photograph 7 & Photograph 8)	19°54'06"E	44°25'04"N	Detector was positioned right next to the river, where the riverbed was partially exposed in places, resembling small pools rather than a continuous water flow. Alder trees were present in the area, and the detector was mounted on one of these trees. The microphone faced south-east along the river corridor. In close proximity to the site was a cornfield, with a tractor-access path leading directly to the river, cornfield, located just 5 meters away from water.
SMM-05 (Photograph 9 & Photograph 10)	19°54'16.38"E	44°24'45.43"N	Detector was situated deep within the forest, with the detector placed on a small elevation. This site featured a natural corridor formed by raised terrain on both sides. The forest was open and easily navigable, with a sparse herbaceous layer. The microphone was oriented south-east, aligned along the natural corridor within the woodland. The location was approximately 300 meters away from the nearest water source in a straight line.

Static Detector ID	Location		Feature and connected habitats/features in the wider landscape
	Latitude	Longitude	
SMM-06 (Photograph 11 & Photograph 12)	19°53'34.87"E	44°24'24.95"N	Detector was positioned beneath a road bridge, behind a concrete pillar supporting the structure. The surrounding vegetation consisted of scrub and black locust (*Robinia pseudoacacia*). Beneath the bridge, the water formed shallow pools, which were almost entirely dry during certain periods. The detector was placed on a slope just behind the concrete pillar, approximately 3-4 meters from the water.
SMM-07 (Photograph 13 & Photograph 14)	19°53'42.18"E	44°24'12.13"N	Detector location was situated on the riverbed, with the detector mounted on a branch positioned horizontally above it. Both sides of the riverbed were densely covered with herbaceous vegetation. During the survey months, the water was scarce, and the riverbed was largely dry. This section of the riverbed formed an effective corridor for bats, with the microphone facing south-west along the river corridor.

Each static detector was deployed on a monthly basis between August and October 2024 inclusive. Before each deployment, weather data, including temperature, wind speed, and precipitation, were reviewed using online sources to confirm that conditions were optimal for the entire deployment period. To gain a detailed understanding of the daily dynamics of bat activity, and to facilitate the development of a more targeted mitigation program if required, registered bat calls were recorded upon activation and assigned a timestamp. For consistency, the same model of static bat detector was used throughout the survey duration, with the same parameter settings and microphone type, as recommended in best practice guidance[17]. Detectors were deployed by experienced ecologists, positioning the omnidirectional microphones at appropriate heights and directions to maximise the recorded activity and to avoid obstruction of sound by dense foliage or other potential sound barriers where possible.

2.4.2 Static data acoustic analysis

The detectors recorded bat calls and produced .wav file containing a sequence of calls within a short time duration (15 seconds max was set as parameter). Each file can be considered a time a bat passed the recorder, i.e. a “bat pass”. For the purpose of this report, the number of files recorded by the detectors each night was considered as a proxy value for the number of “bat passes”.

Following the completion of the automated detector surveys the files recorded were uploaded to the British Trust of Ornithology’s (BTO) Acoustic Pipeline[22] for processing and auto identification of bat species. The BTO Acoustic Pipeline utilises machine learning algorithms to analyse and categorise acoustic pulses within uploaded recordings. The Pipeline can assign up to four potential identities to a single recording based on probability distributions derived from detected pulses. These probabilities help determine species identities, along with an estimated likelihood of accurate classification. This estimation specifically refers to the false positive rate, the probability that an assigned identification is incorrect. The Pipeline adjusts this probability so that a higher probability corresponds to a lower false positive rate, for example, if a species is identified with a probability of 0.9, there is a 10% chance that the classification is incorrect.

As recommended by recent BTO research[23] files that were assigned a probability of less than 0.5 (50%) following processing were immediately discarded. Furthermore, the BTO Acoustic Pipeline states that a number of bat species can be difficult for an experienced analyst to assign species in areas where their ranges overlap. These European species included the following:

1. Whiskered (*Myotis mystacinus*), alcathoe (*Myotis alcathoe*) and Brandt's bats (*Myotis brandtii*)

[22] British Trust of Ornithology Acoustic Pipeline [Online], Available at: https://bto.org/pipeline.

[23] Barré *et al*., 2019, Accounting for automated identification errors in acoustic surveys. Methods in Ecology and Evolution, British Ecological Society [Online], Available at: https://batability.co.uk/wp-content/uploads/2021/04/Barre-et-al.-2019-Accounting-for-automated-identification-errors-in-acoustic-surveys.pdf.

2. Leisler's (*Nyctalus leisleri*) and parti-coloured bats (*Vespertilio murinus*)
3. Nathusius' pipistrelle (*Pipistrellus nathusii*) and Kuhl's pipistrelle (*Pipistrellus kuhlii*)

This approach is required to lower the probability of misidentification of European bat species recorded throughout the survey period. Without conclusive evidence in the form of diagnostic social and/or feeding buzzes or bats in the hand, the grouping of these cryptic species should be withheld. However, this grouping is not expected to significantly impact the results of this assessment.

All calls that were assigned a species, except those identified as less than 0.5 or labelled as noise, were subject to a two-step verification process using Wildlife Acoustic's Kaleidoscope Pro Software. This verification process followed the specific methods outlined in Appendix C. These methods set tailored species-specific thresholds to assist both technician and auditor verify and review recordings accurately.

During the first stage of verification, an experienced ecologist with over 5 years of acoustic analysis experience (technician) manually reviewed at least 10% of files identified to a species and/or species group. After the initial verification stage, a second experienced ecologist (auditor) reviewed the manual verification conducted by the first ecologist (technician). As part of this second verification stage, the auditor reassessed the technician's manual verification before the twice-verified results were finalised and included in this report in the form of proportional results. Proportions were established for each location throughout the survey period. It is important to note that this is used to quantify bat activity, not bat abundance, which cannot be inferred from these acoustic recordings.

2.5 Limitations and assumptions

Ecological surveys are limited by factors which affect the presence of plants and animals such as the time of year, migration patterns and behaviour. Therefore, the absence of evidence of any particular species should not be taken as conclusive proof that the species is not present or that it will not be present in the future. However, professional judgement allows for the likely presence of these species to be predicted with sufficient certainty to not significantly limit the validity of these findings. Any latitude and longitude coordinates provided within this report are approximate (obtained through handheld GPS devices) and should be used as a guide only to provide further context to the surrounding habitat. The survey schedule was adjusted to accommodate adverse weather conditions, including the major flooding in Central Serbia which occurred which occurred at the end of May 2023 and gradually subsided into early June 2023.

A limitation associated with analysis of the automated static detectors, is related to the confidence thresholds set for each species. Calls above the confidence thresholds as stated in the protocol in Appendix C were accepted without manually checking. The benefit of using Automatic-Identification (Auto-ID) software ensures consistent application of rules for species identification, unlike human observers who vary in experience and capability. This variability makes it challenging to maintain consistency across different observers and even within the same observer over time. Additionally, human errors can become reinforced over time, a phenomenon known as 'concept drift,' which Auto-ID software avoids entirely[24]. However, as the methodology was the same for each static location the results should still provide a reliable assessment on activity across the site, also all species included within the results have been subject to a rigorous two stage QA process and therefore the results provide a reliable assessment of species/species groups present on site.

Additionally, activity levels should not be compared at face value between species, as some species are more detectable than others. For instance, the data recorded using bat detector recordings are biased towards bats that use louder echolocation calls. Therefore, quiet species such as long-eared bats (*Plecotus sp.*) and bats with directional calls such as horseshoe bats (*Rhinolophus sp.*) may be under recorded due to the limited recording range of the equipment. This is an unavoidable limitation for all surveys using bat detectors, the implications of which have been considered when analysing the results. Bat calls of *Myotis* and *Plecotus*

[24] Recommendations for using automatic bat identification software with full spectrum recordings [Online]. Available: https://cdn.bats.org.uk/uploads/pdf/AutomaticID_Recommendations_Version_date_210416.pdf?v=1541765866. [Accessed January 2025].

genus were not identified to species level. Bats in this genus cannot reliably be separated on calls alone due to the overlap in call characteristics between the species. However, recommended mitigation measures would still be of relevance to grouped species and therefore are not considered to be a significant constraint.

3. Results and interpretation

3.1 Desk study

3.1.1 Protected areas

There are no Legally Protected or Internationally Recognized Areas of Biodiversity Value areas (as defined by EBRD) in the vicinity of the proposed project area. The closest legally protected areas to the project site are the Obedska Bara (Swamp) Nature Reserve and Candidate Emerald Site (CES), located 19 km away, and the Klisura Reke Gradac (Gradac River Gorge) CES, located 18 km away. These protected sites were not specifically designated for bat populations; however, the descriptions of their habitats below suggest that they could support any bat populations residing within the study area, as such these are enclosed for completeness. Full descriptions of the habitat located within these protected areas is provided in Table 4 and illustrated in Drawing 1.

Table 4: Closest protected areas to the project site.

Site name	Description	Distance and Orientation
Obedska Bara CES (RS0000003) and IBA	Obedska bara is positioned in the alluvial plane of the Sava river (46-95 river km) in southern Srem, Vojvodina Province. It is largest alluvial area in whole Serbia (around 12000 ha) and it represents an authentic mosaic of forest, meadows, swamp and pond habitats. More than 30 aquatic, forest and meadow plant communities have been described. Along the borders of IBA more than 20 settlements are situated and two inside of IBA (Kupinovo and Obrež) which belongs to six municipalities (Surčin, Obrenovac, Vladimirci, Šabac, Ruma and Pećinci). This site qualifies as a Key Biodiversity Area of international significance because it meets one or more previously established criteria and thresholds for identifying sites of biodiversity importance (including Important Bird and Biodiversity Areas, Alliance for Zero Extinction sites, and Key Biodiversity Areas). The site was identified as important in 2019 due to regularly supporting significant populations of the bird species, meeting ('triggering') IBA criteria.	19km North
Klisura Reke Gradac CES (RS0000054) and Valjevske mountains IBA	The Gradac river gorge, with its source tributaries has the special characteristics and the degree of preservation. It lies south of Valjevo and influent in the Kolubara river, of which it is a right tributary. The river gorge is the habitat of a number of rare plant and animal species. In the river brook trout, chub, barbel can be found. The biggest attraction of Gradac river are undoubtedly the otters. The gorge of the river has more than 70 karst caves. The Degurić cave is, according to the latest research, the longest and in the region of the Valjevo karst. In the caves, traces of palaeolithic, and middle ages ancient times have been discovered. The gorge is part of a larger IBA, located in the far west of the country near the Drina River and the state border with Bosnia and Herzegovina. It spans over 60 km between the cities of Valjevo and Bajina Bašta, encompassing a diverse mountainous region. Key features of the area include mountains such as Maljen, Povlen, Medvednik, Jablanik, Bobija, and Sokolina, as well as gorges carved by rivers like Trešnjica, Gradac, and others. The IBA is predominantly covered by deciduous forests, interspersed with numerous streams, meadows, and pastures, creating a rich and varied landscape.	18km South-west

3.2 IUCN screening and literature review

A preliminary IUCN screening indicated the potential presence of 33 ‘threatened species’ as defined by EBRD criteria (EBRD GN6), i.e. species defined as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU) according to IUCN within a 20 km buffer of the Biodiversity Study Area (A.1). Within these records were two bat species, Schreiber's bent-winged bat and long-fingered bat. Both these bat species are classified as vulnerable according to the IUCN, listed as Annex II of the Habitats and Species Directive, and are strictly protected under Serbian legislation through the Decree on the Proclamation and Protection of Strictly Protected and Protected Wild Species of Plants, Animals, and Fungi.

3.3 Activity transect surveys

The activity transect surveys confirmed the presence of 13 bat species as presented in Table 5. Full results of each transect survey, including behaviour observed and when the first bat was detected in relation to sunset is provided in Appendix D. Spatial results for each transect route, including flight direction, are illustrated below.

Table 5: Activity transect survey results and their protection status

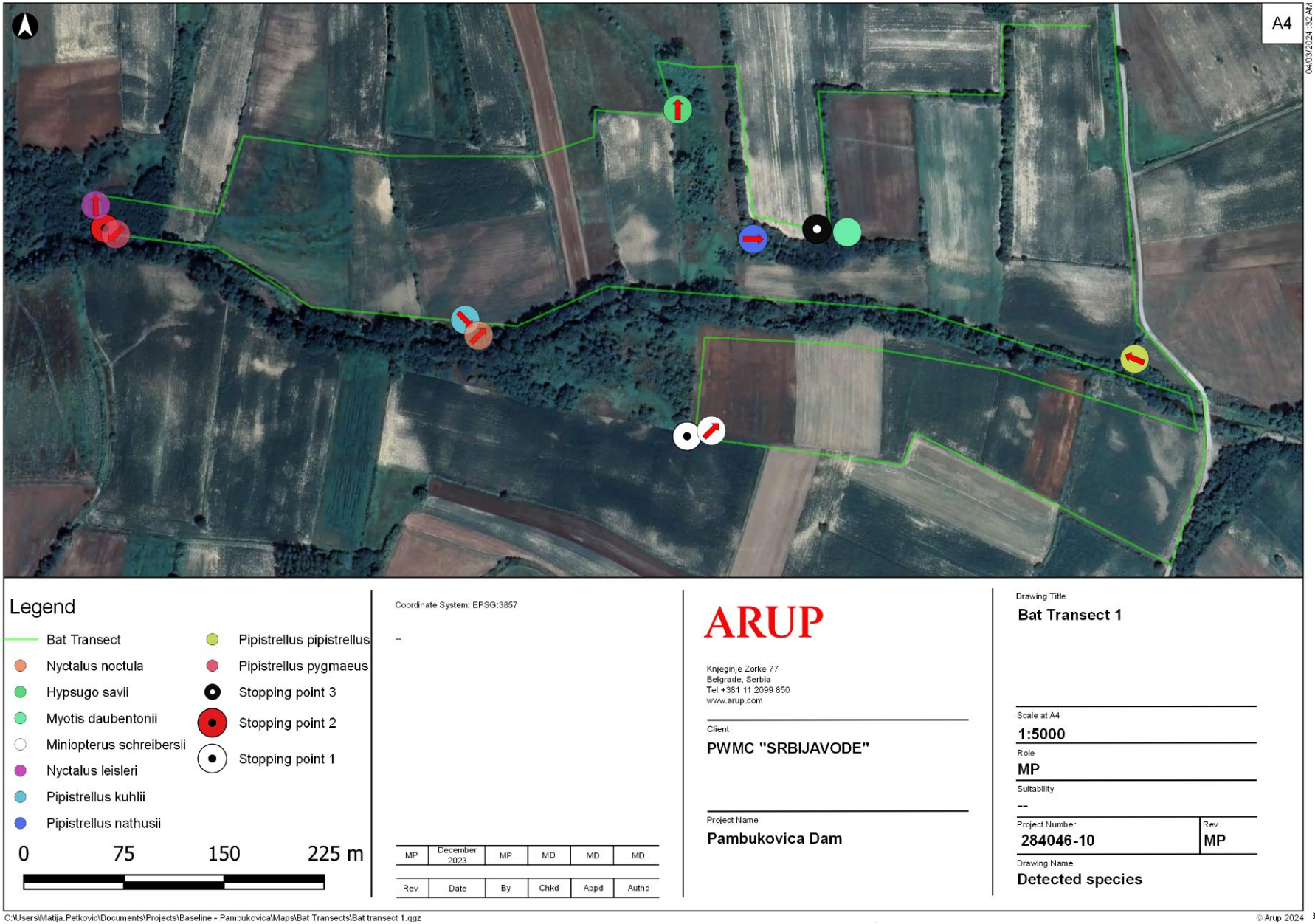
No.	Scientific name	Common name	IUCN Global	IUCN Europe	Habitats and species directive / Bern Convention	Serbian legislation
1.	*Pipistrellus kuhlii*	Kuhl's pipistrelle	LC	LC	IV	SP
2.	*Pipistrellus nathusii*	Nathusius' pipistrelle	LC	LC	IV	SP
3.	*Pipistrellus pygmaeus*	Soprano pipistrelle	LC	LC	IV	SP
4.	*Pipistrellus pipistrellus*	Common pipistrelle	DD	LC	IV	SP
5.	*Nyctalus leisleri*	Leisler's bat	LC	LC	IV	SP
6.	*Nyctalus noctula*	Common noctule	LC	LC	IV	SP
7.	*Miniopterus schreibersii*	Schreiber's bent-wing bat	VU	??	II	SP
8.	*Hypsugo savii*	Savi's pipistrelle	LC	LC	IV	SP
9.	*Barbastella barbastellus*	Barbastelle	NT	VU	II, BC	SP
10.	*Myotis daubentonii*	Daubenton's bat	LC	??	IV	SP
11.	*Myotis alcathoe*	Alcathoe bat	DD	DD	IV	SP
12.	*Myotis bechsteinii*	Bechstein's bat	NT	VU	II, BC	SP
13.	*Plecotus austriacus*	Grey long-eared bat	NT	NT	IV	SP

- Decree on proclamation and protection of strictly Protected and Protected wild species of plants, animals and fungi ("Official Gazette of the Republic of Serbia", No. 5/2010, 47/2011, 32/2016 and 98/2016) - **SP – strictly protected** (wild species of plants, animals and fungi are wild species that have disappeared from the territory of the Republic of Serbia or its parts, returned to reintroduction programs, extremely endangered, endangered, relict, locally endemic, stenoendemic, internationally significant and protected wild species, of special importance for conservation of biological diversity of the Republic of Serbia; **P – protected species** (wild species of plants, animals and fungi in order to preserve biological diversity, natural gene pool, i.e. species that have special significance from ecological, ecosystem, biogeographical, scientific, health, economic and other aspects for the Republic of Serbia).
- BC - Convention on the conservation of European wildlife and natural habitats, revised **annex I of resolution 6** (1998) of the standing committee to the Bern convention.
- IUCN Global or European - IUCN **Vulnerable (VU)**, **Least Concern (LC)**, **Near Threatened (NT)**, **Data Deficient (DD).**
- EU Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora **Annex I-IV**

The Western barbastelle, classified as Vulnerable (VU) on the IUCN European Red List, was recorded over the course of the activity transect surveys. This bat species is strictly protected in Serbia and has a broad distribution across most of Europe. It is native to the Palearctic biogeographic region and can also be found in the southern half of Britain, Mediterranean islands, Morocco, and the Canary Islands.

Western barbastelles typically roost in hollow trees, behind loose bark, and in the outer zones of caves, mines, and cellars. They emerge from their daytime roosts before sunset and are known for their considerable wandering behaviour. While they often fly close to the ground, they may forage at higher altitudes during favourable weather conditions, predominantly along habitat edges. From November to March, Western barbastelles enter hibernation, often gathering in large clusters. Their winter habitats generally include fissures within caves, mines, and other underground structures characterised by low ambient temperatures and dry air[25]. Occasionally, they share hibernation clusters with *Plecotus auritus*. Hibernating individuals emerge approximately every two weeks. Over the course of the transect surveys barbastelle were recorded on Transect 2 and Transect 3 adjacent to the River Ub.

[25] Jens Rydell, Wiesław Bogdanowicz, 'Barbastella barbastellus, Mammalian Species, Issue 557, 9 May 1997, Pages 1–8', [Online]. Available at: https://doi.org/10.2307/3504499. [Accessed January 2025].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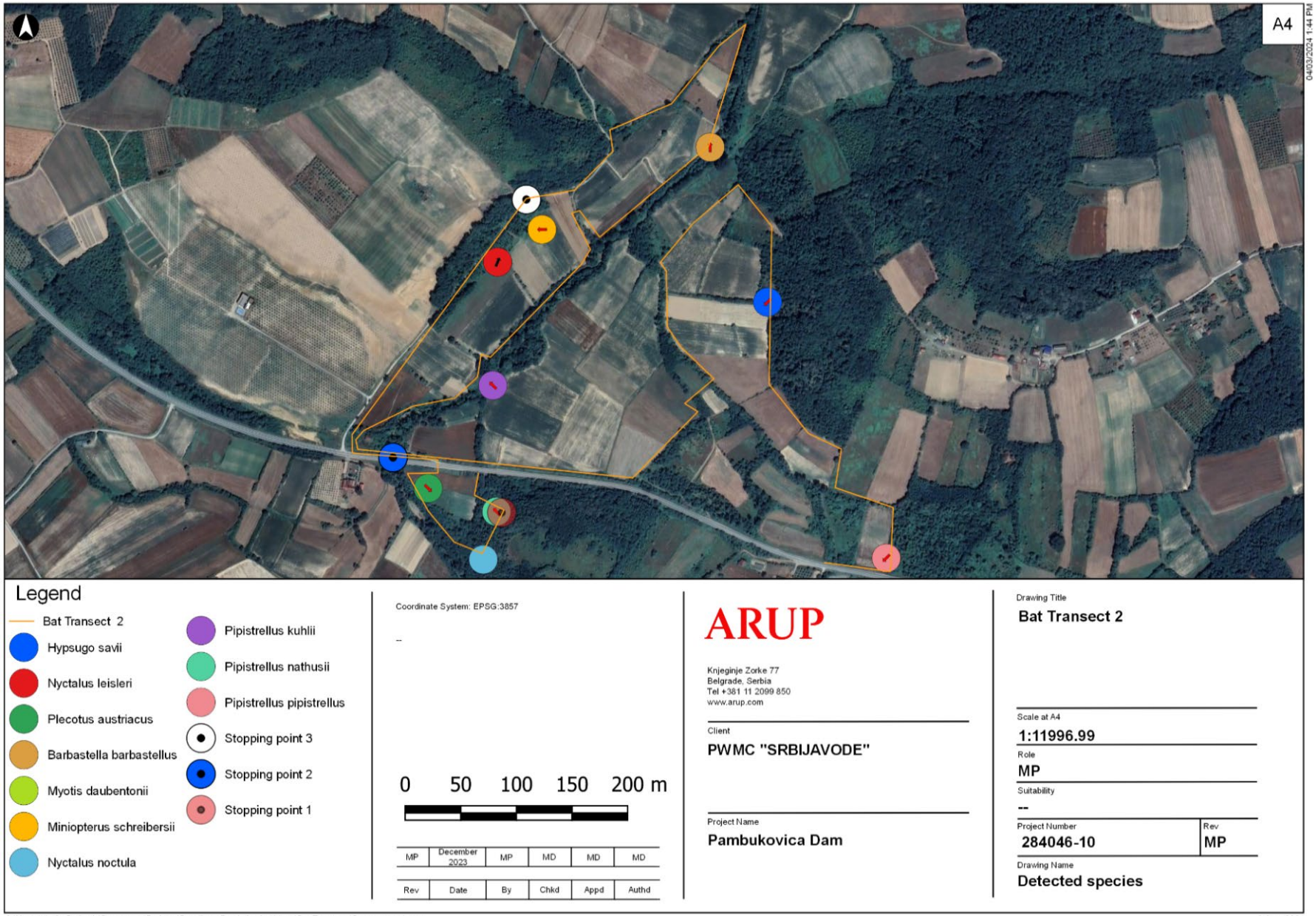
© Arup 2024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Nyctalus leisleri
Plecotus austriacus
Barbastella barbastellus
Myotis daubentonii
Miniopterus schreibersii
Nyctalus noctula
Pipistrellus kuhlii
Pipistrellus nathusii
Pipistrellus pipistrellus
Stopping point 3
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ARUP
Knjeginje Zorke 77
Belgrade, Serbia
Tel +381 11 2099 850
www.arup.com
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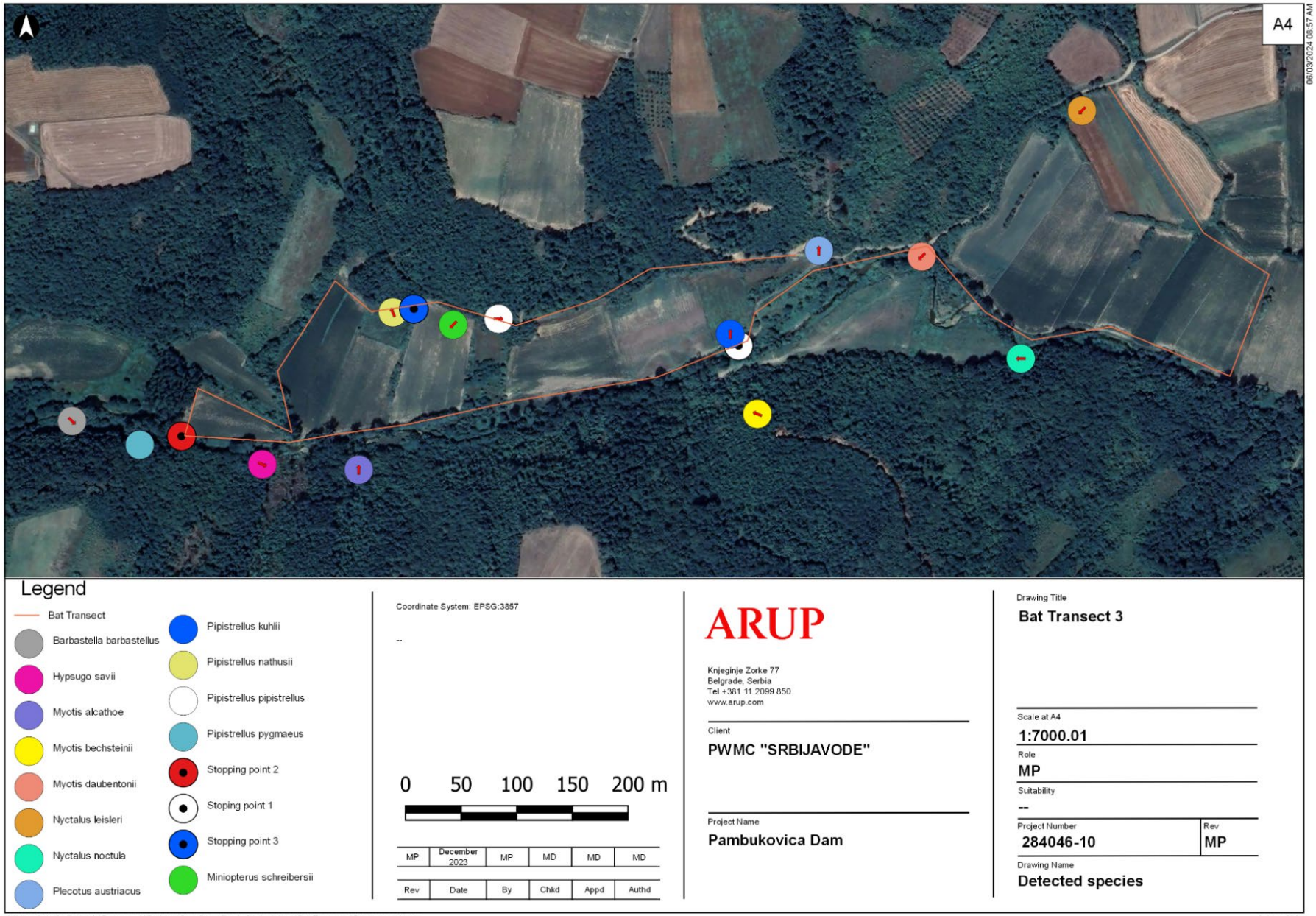
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Bat Transect
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Myotis bechsteinii
Myotis daubentonii
Nyctalus leisleri
Nyctalus noctula
Plecotus austriacus
Pipistrellus kuhlii
Pipistrellus nathusii
Pipistrellus pipistrellus
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Detected species
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3.4 Automated detector surveys

Full results of automated static detectors are presented in Appendix E and discussed within the following section. The automated bat static detectors identified a total of 24 species, including those belonging to cryptic species groups. This included seven Annex II species: western barbastelle, common bent-wing bat, long-fingered bat, Geoffroy's bat, Mediterranean horseshoe bat, greater horseshoe bat and lesser horseshoe bat (*Rhinolophus hipposideros*). Additionally, 17 other species were recorded: common serotine, Savi's pipistrelle, Alcathoe bat, Brandt's bat, Daubenton's bat, whiskered bat, Natterer's bat, Leisler's bat, common noctule, Kuhl's pipistrelle, Nathusius' pipistrelle, common pipistrelle, soprano pipistrelle, brown long-eared bat, grey long-eared bat, European free-tailed bat and parti-coloured bat.

A spatial summary of bat activity is provided in Table 6, listing species recorded across all automated detector locations for the 2024 survey period (August to October inclusive).

Table 6: Spatial summary of bat activity throughout the survey period

No.	Scientific name	Common name	Total Bat passes per location							
			Location 1	Location 2	Location 3	Location 4	Location 5	Location 6	Location 7	Grand total
1.	*Barbastella barbastellus*	Barbastelle	78	3	35	36	3	76	26	**257**
2.	*Eptesicus serotinus*	Common Serotine	10	1	0	2	1	31	1	**46**
3.	*Hypsugo savii*	Savi's Pipistrelle	3	1	1	3	22	2	4	**36**
4.	*Miniopterus schreibersii*	Schreiber's bent-wing bat	137	2	57	9	0	230	18	**453**
5.	*Myotis alcathoe*	Alcathoe Bat	0	0	0	1	0	0	1	**2**
6.	*Myotis capaccinii*	Long-fingered Bat	1	0	12	2	0	31	4	**50**
7.	*Myotis daubentonii*	Daubenton's Bat	163	1	658	39	0	603	57	**1521**
8.	*Myotis emarginatus*	Geoffroy's Bat	26	0	23	24	5	66	12	**156**
9.	*Myotis nattereri*	Natterer's Bat	87	21	20	11	9	17	16	**181**
10.	*Nyctalus noctula*	Noctule	16	39	30	33	57	91	19	**285**
11.	*Pipistrellus pipistrellus*	Common pipistrelle	406	5	337	866	0	2145	138	**3897**
12.	*Pipistrellus pygmaeus*	Soprano pipistrelle	122	7	100	26	0	406	95	**756**
13.	*Plecotus auritus*	Brown Long-eared Bat	7	0	4	0	0	12	1	**24**
14.	*Plecotus austriacus*	Grey Long-eared Bat	4	0	9	4	2	9	58	**86**
15.	*Rhinolophus euryale*	Mediterranean Horseshoe Bat	0	0	0	0	0	0	1	**1**
16.	*Rhinolophus hipposideros*	Lesser horseshoe bat	1	0	25	3	0	2	31	**62**
17.	*Rhinolophus ferrumequinum*	Greater horseshoe bat	230	0	119	52	0	77	54	**532**
18.	*Tadarida teniotis*	European Free-tailed Bat	93	112	12	81	5	218	35	**556**
19.	*Myotis mystacinus and M. brandtii*	Whiskered and Brandt's Bat	57	0	33	16	2	252	12	**372**
20.	*Nyctalus leisleri and Vespertilio murinus*	Leisler's and Parti-coloured Bat	49	25	9	31	2	50	54	**220**
21.	*Pipistrellus nathusii and P. kuhlii.*	Nathusius' and Kuhl's Pipistrelle	3105	326	2253	1533	13	5879	500	**13609**
		Totals	**4595**	**543**	**3737**	**2772**	**121**	**10197**	**1137**	**23102**

* Light red highlight indicates the location where the highest bat activity for each species was experienced throughout the survey period.

3.4.1 Activity by location

Overall bat activity (relative to bat passes) was highest at locations 1, 3, 4 and 6, compared to locations 2, 5 and 7 where activity levels were comparatively lower. Locations with the highest bat activity levels were installed along or immediately adjacent to the corridor of the River Ub. Whereas locations 2, 5 and 7 are sited within woodland habitat located 50-300m away from the alignment of the River Ub. The proportion of recorded bat activity throughout the survey period is illustrated below in Figure 1.

Location 1

Location 1 exhibited significant bat activity, particularly in species such as Nathusius' and Kuhl's pipistrelle, which recorded an exceptionally high count throughout the survey period, with the majority of passes being recorded in August alone. This highlights a strong presence of Nathusius' and Kuhl's pipistrelle during late summer. Common pipistrelle was another dominant species throughout the survey period, aligning with a peak of activity in August. Comparatively, a steep decline of passes followed through to October. The greater horseshoe bat, Daubenton's bat, and Schreiber's bent-wing bat also had notable numbers, suggesting the possible availability of underground roosts such as caves or tunnels nearby. Whereas, a single Mediterranean Horseshoe Bat, was detected in September, suggests that some roosting or foraging conditions are present but may be on the fringe of this species preferred habitat or geographic range. More notably, barbastelle, noctule, and greater horseshoe bats were most frequently recorded at Location 1 compared to other locations. Location 1 recorded the high species diversity with 19 species being recorded, highlighting the importance of the habitat in the immediate vicinity of Location 1 for these species in particular.

Location 2

Activity at Location 2 was comparatively low, exhibiting one of the lowest species diversities of 12 species and accounting for only 2% of the total data collected during the survey period. Despite this Nathusius' and Kuhl's pipistrelle were the most numerous. Natterer's, Leisler's, noctule and parti-coloured bat exhibited a moderate presence. Notably, no species from the Plecotus or Rhinolophus families were recorded at Location 2. Similar to other locations, bat activity peaked in August and declined through to October, with the majority of species records collected in August. In contrast, passes from barbastelle, Savi's pipistrelle and Schreiber's bent-wing bat were only recorded later in the survey period in October, suggesting the possibility of increased activity (possibly mating activity), before the onset of colder months. Additionally, the presence of European free-tailed bats, suggests that open-air foraging opportunities are available near to location 1, allowing this fast-flying species to thrive.

Location 3

Location 3 exhibited relatively high levels of bat activity, in particular Nathusius' and Kuhl's pipistrelle, Daubenton's bat and Common pipistrelle. Greater horseshoe bat and soprano pipistrelle were present in moderate numbers, indicating that the habitat in this area offers suitable roosting and foraging conditions for these species. Interestingly, Schreiber's bent-wing bat recorded a notable presence. Furthermore, the high species diversity record at location 3 of 19 species highlights this location's ecological importance for various different bat species, which have varying roosting niches.

Location 4

Location 4 exhibited a strong presence of pipistrelle species, with common pipistrelles and Nathusius' and Kuhl's pipistrelles recorded in high numbers. The high numbers of Pipistrellus species reinforce the area's suitability for foraging, particularly for these adaptable species that thrive in cluttered environments. The dominance of these species throughout the survey period suggests an abundance of suitable prey and foraging conditions within the vicinity of location 4. Noctule and Natterer's bat were also recorded, reflecting the importance of available habitat to support species with different flight and foraging strategies. Whiskered, alcathoe, and Brandt's bats contribute to the high species diversity at location 4, suggesting a variety of microhabitats available. Compared to other locations, location 4 shares a similar species diversity pattern with location 3, reinforcing the idea that this area provides a balance of roosting and foraging habitats for a range of bat species. The combination of high pipistrelle numbers and a diverse array of other species highlights the ecological value of this location for bats with varying roosting niches and potential to roost within the broadleaved woodland parcels adjacent to Location 4.

Location 5

Unlike other locations, location 5 recorded significantly lower bat activity, accounting for 1% of the total data collected throughout the survey period. Nathusius' and Kuhl's pipistrelle were among the least detected species, indicating that this location might not be of importance for this species. Natterer's bat was the most frequently recorded species at location 5, with a high number of these passes being recorded in August. This peak in activity suggests that seasonal factors, such as insect abundance, may influence Natterer's bat presence at this location. Notably, location 5 had the highest recorded numbers of Savi's pipistrelle, compared to other locations, suggesting that this species may favour specific conditions present at this location, such as microclimate factors or prey availability.

Other species, including barbastelle, Geoffroy's bat, noctule, European free-tailed bat, and grey long-eared bat, were recorded in notably low numbers. The absence or extremely low detection of several species, such as, Daubenton's bat, and *Rhinolophus* species suggests that location 5 lacks the necessary ecological conditions or management to support a diverse bat community. The relatively low numbers for many bat species indicate that the immature woodland where location 5 is might not provide the aging tree conditions required to promote for roosting or foraging. Possible limiting factors include habitat structure, such as lack of suitable roosting sites (e.g., tree cavities or old buildings), and prey availability, which may be insufficient to sustain higher bat activity levels. Additionally, other influences or competition with other more suitable habitats nearby (the adjacent River Ub corridor) could further explain the reduced bat activity at this location.

Location 6

Location 6 has emerged as a major hub for bat activity, with an extraordinary count of Nathusius' and Kuhl's pipistrelles, aligning with peak activity in August. Common pipistrelle also exhibited a strong presence, further highlighting the significance of this location for *pipistrellus* species. Notably, location 6 is situated at the underpass of a main road directly adjacent to the alignment of the River Ub. The exceptionally high bat activity at this location strongly suggests that bats are utilising the underpass as a significant flyway or commuting route. This underpass provides a safe and sheltered passageway from the main road above, facilitating the movement of bats across the landscape and ensuring connectivity between their roosting and foraging habitats. The recording of increased Daubenton's bat passes further emphasises the importance of the River Ub for foraging.

Additionally, the presence of Schreiber's bent-wing bat and European free-tailed bats indicate that location 6 supports a diverse mix of cave-roosting and high-altitude foraging species, suggesting the possible availability of underground roosts such as caves or tunnels nearby. Smaller but consistent numbers of greater horseshoe bats, Natterer's bats, and Geoffroy's bats reflect a diverse and balanced bat community utilising the site. Despite this, location 6 recorded the highest quantity of Geoffroy's bat. The presence of barbastelle and whiskered, alcathoe, and Brandt's bat passes adds further depth to the species richness, demonstrating that the site accommodates a variety of foraging and roosting behaviours. Lower but notable numbers of species such as the noctule, common serotine, and long-fingered bat suggest that while these species use the area, they may rely on alternative habitats nearby for primary roosting or foraging.

Meanwhile, the minimal recordings of Savi's pipistrelle and lesser horseshoe bat possibly indicate marginal use of this site by these species. Overall, the diversity of bat species recorded at Location 6 suggest that it plays a critical role in activities, such as commuting, roosting, and foraging. The presence of both high-flying and water-dependent species, along with those favouring caves and woodland, highlights the ecological importance of this location as a key habitat within the broader bat conservation landscape. Most importantly the underpass clearly serves as a crucial connectivity feature, emphasising its importance as a safe passageway for bats and reinforcing the need to preserve and protect such structures within the wider landscape.

Location 7

Location 7 was not as abundant for bats as Location 6. However, Nathusius' and Kuhl's pipistrelle, common pipistrelle, and soprano pipistrelle were recorded the most, reinforcing this locations suitability for *pipistrellus* species, likely due to the availability of foraging and roosting habitats. The presence of Daubenton's bat and Natterer's bat suggests moderate suitability for both aerial and water-dependent feeders.

Additionally, the presence of Geoffroy's bat, which is known to prefer cluttered habitats such as woodlands and riparian habitat, further supports the idea that this location offers a mixture of available foraging habitats. The detection of the greater horseshoe bat and lesser horseshoe bat highlights a combination of roosting habitats, potentially including caves, abandoned structures, and dense woodland, essential for their survival. The presence of Schreiber's bent-wing bat shows the significance of this location for migratory and cave-dwelling species. Similarly, the presence of Leisler's and parti-coloured bat and noctule bats reinforces the suitability of this area for high-flying, open-air foragers that rely on mature woodlands and open landscapes. The detection of barbastelle is noteworthy, as this species favours woodlands with aging growth, a mix of open spaces and dense canopies, suggesting that Location 7 provides suitable conditions for this species.

Species detected in lower numbers, such as Savi's pipistrelle, Long-fingered bat and common serotine indicate that while their preferred foraging conditions may not be widespread at this location, they are still present in small numbers, possibly using the site intermittently. Overall, the high diversity of 21 bat species being recorded at Location 7 indicates the importance of the River Ub corridor, adjacent woodland habitat, opportunities for open-air foraging and suitable roosting resource, making this location and the surrounding habitat important for bat ecology.


August
September
October
Static 1
Static 2
Static 3
Static 4
Static 5
Static 6
Static 7
Whiskered Bat
Soprano Pipistrelle
Serotine
Schreibers' Bat
Savi's Pipistrelle
Parti-coloured Bat
Noctule
Natterer's Bat
Nathusius' Pipistrelle
Mediterranean Horseshoe Bat
Long-fingered Bat
Lesser Horseshoe Bat
Leisler's Bat
Kuhl's Pipistrelle
Grey Long-eared Bat
Greater Horseshoe Bat
Geoffroy's Bat
European Free-tailed Bat
Daubenton's Bat
Common Pipistrelle
Brown Long-eared Bat
Brown long-eared bat
Brandt's Bat
Barbastelle
Alcathoe Bat
0
25
50
75
100
Proportion of total calls (%)

Figure 1: Proportion of bat activity throughout the survey period at each static location

3.4.2 Activity by species/ species group

Across all seven locations, bat activity showed a general decline from August to October, with some species exhibiting notable variations likely influenced by seasonal behaviours such as mating, moving towards hibernation sites, migration and foraging patterns based on prey availability. In August, high numbers of Nathusius' and Kuhl's pipistrelle were recorded, particularly at Locations 1, 3, and 6, where counts exceeded 1,000 individuals. Nathusius' pipistrelle, which are known for their long-distance migratory behaviour, experienced a sharp decline over the following months, suggesting a possible movement towards wintering sites. Similarly, common pipistrelle, which were abundant throughout August saw major reductions in September and October, reinforcing the possibility of juvenile bats dispersing or the start of mating.

Some species displayed fluctuating patterns, such as the barbastelle and Schreiber's bent-wing bat, with peak counts in September before declining again. This could be attributed to their roosting behaviour, as these bats often switch between summer and winter roosts during transitional months. Noctule bat, a species that is partially migratory, showed sporadic increases, particularly at Locations 1 and 3 in September, possibly reflecting movement between feeding and mating sites. Additionally, at location 7 grey long-eared bat exhibited a unique late-season peak in September, which may be linked to increased foraging activity before the onset of colder months.

Another key observation is the decline in Daubenton's bat numbers, particularly at Locations 1, 3, and 6. This species is heavily dependent on waterbodies for foraging and therefore individuals might have relocated throughout later months. However, Schreiber's bat, a cave-dwelling species, maintained moderate activity levels into October, possibly due to its preference for sheltered roosts that provide more stable conditions.

Overall, the data collected during the survey period (acknowledging the lack of data collected for spring and early summer) suggests a seasonal trend where bat activity is highest in late summer, decreasing steadily as autumn progresses due to shifts in foraging, mating and roosting behaviour. The variations in species-specific trends highlight the complexity of bat ecology, influenced by habitat preferences, food availability, and climatic conditions.

3.4.3 Nightly bat activity

The nightly bat activity in relation to sunset at each location is illustrated in Figure 2 below. The results show that generally the earliest calls in relation to sunset were recorded at locations 1, 3, 4 and 6, with earliest records after sunset coming from location 1 and 6.

European free-tailed bat, parti-coloured bat and noctule were among the most common species recorded before sunset each night throughout the survey period, particularly at location 1, 4 and 6. Meanwhile, location 2, 3, 5 and 7 recorded the majority of bat activity after sunset. The locations where bats were recorded earlier predominantly corresponded with the static detectors deployed along the alignment of the River Ub, indicating that roosts could be present within the surrounding landscape.

[SOUND ANALYSIS PENDING REGARDING TO EUROPEAN FREE-TAILED BAT AFTER DISCOVERING DISCREPENCIES AT THE VERIFICATION STAGE]

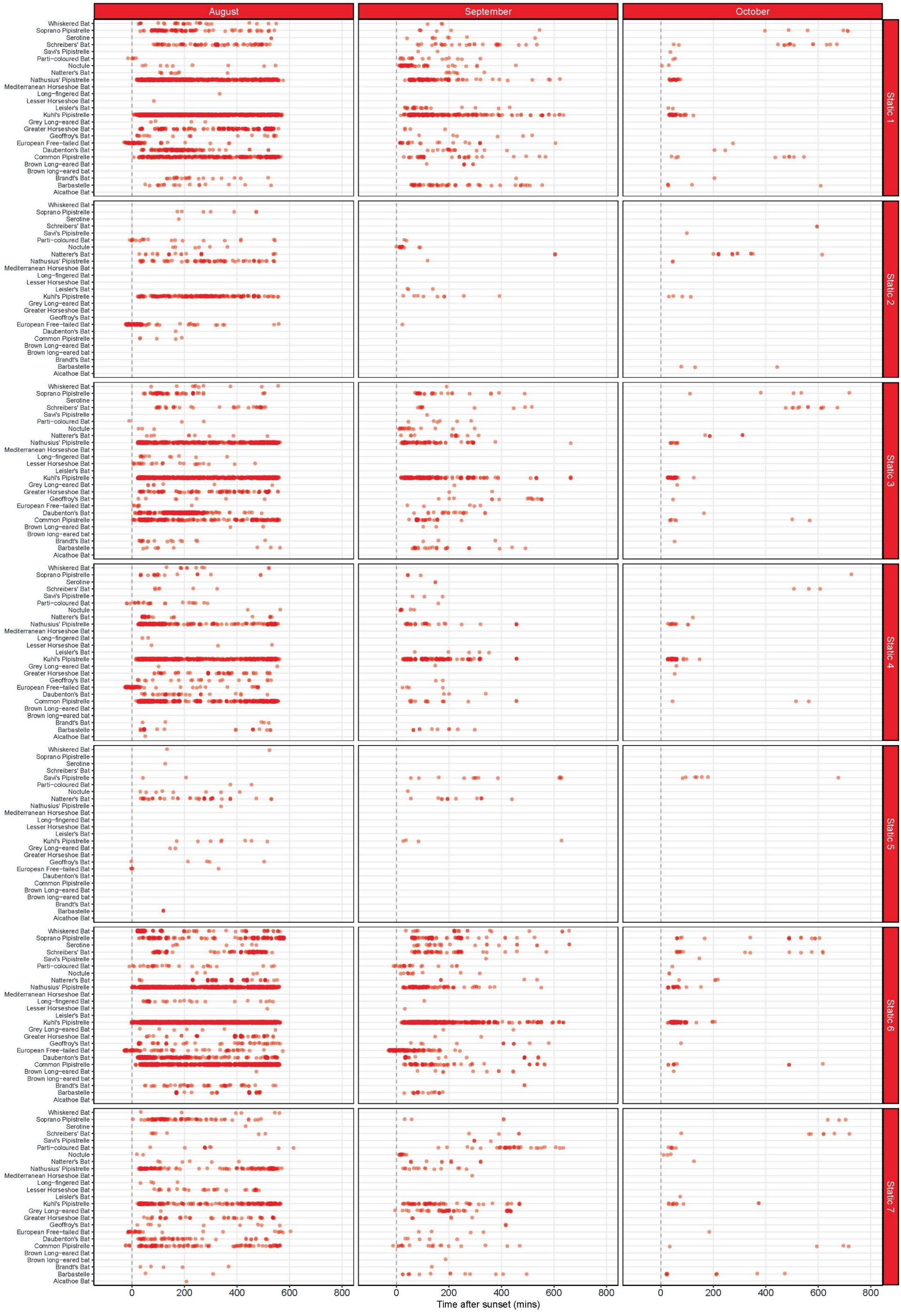


Figure 2: Bat activity throughout a nightly period at each static location

4. Conclusion

All bat species found in Serbia are under strict legal protection and according to the EU Habitats Directive they are all listed in Annex IV, and are strictly protected under Serbian legislation through the Decree on the Proclamation and Protection of Strictly Protected and Protected Wild Species of Plants, Animals, and Fungi. 13 of these species listed are also listed in Annex II. This Directive serves as a cornerstone for the establishment and management of Natura 2000, a network of protected areas across EU Member States.

The activity transect surveys confirmed the presence of 13 bat species throughout the site. The species recorded included three Annex II; western barbastelle bat, Schreiber's bent-wing bat and Bechstein's bat. In addition to 10 other species; Savi's pipistrelle, alcathoe bat, Daubenton's bat, Leisler's bat, common noctule, Kuhl's pipistrelle, Nathusius' pipistrelle, common pipistrelle, soprano pipistrelle and grey long-eared bat.

The results of the automated detector surveys reinforce the findings from the activity transect surveys, showing that bat activity was highest at locations near the River Ub (Locations 1, 3, 4, and 6) and lower at woodland sites further from the river (Locations 2, 5, and 7). Location 6 recorded the highest bat activity, particularly among pipistrelle species, likely due to the presence of an underpass facilitating safe movement/commuting through. Location 1 exhibited the greatest species diversity, emphasising its ecological importance, while Location 5 had the lowest bat activity, suggesting less favourable habitat conditions in this area. These findings underscore the critical role of riparian corridors and man-made structural features in supporting diverse and abundant bat populations.

Additionally, the automated detector surveys identified five additional Annex II species; long-fingered bat, Geoffroy's bat, Mediterranean horseshoe bat, greater horseshoe bat, and lesser horseshoe bat, complementing the species recorded in the activity transect surveys. Seven other species were also detected, including the common serotine, Brandt's bat, whiskered bat, Natterer's bat, brown long-eared bat, European free-tailed bat, and parti-coloured bat. The bat species recorded over the course of the surveys are listed below in Table 7 with their corresponding global, European and national conservation status's.

Table 7: Bat species recorded, including their corresponding global, European and national conservation status's.

	Scientific name	Common name	IUCN global status [26]	IUCN European status [26]	Habitats Directive Annex IV [27]	Habitats Directive Annex II [27]	Bonn Convention (Appendix II)	Bern Convention (Annex I of Resolution 6)	Bern Convention (Appendix II)	Serbian Legislation [28]	Serbian national status [29]
1.	*Barbastella barbastellus*	Western barbastelle bat	NT	VU	✓	✓	✓	✓	✓	SP	VU
2.	*Eptesicus serotinus*	Common serotine	LC	LC	✓	×	✓	×	✓	SP	LC
3.	*Hypsugo savii*	Savi's pipistrelle	LC	LC	✓	×	✓	×	✓	SP	LC
4.	*Miniopterus schreibersii*	Schreiber's bent-wing bat	NT	NT	✓	✓	✓	✓	✓	SP	LC

[26] The ICUN Red List of Threatened Species (2024) - IUCN Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD). Available [ONLINE] at: https://www.iucnredlist.org. [Accessed March 2025].

[27] Joint Nature Conservation Committee (JNCC), "Council Directive 92/43/EEC (The Habitats Directive) Annex II and Annex IV Species List," [Online]. Available at: https://sac.jncc.gov.uk/species/. [Accessed March 2025].

[28] Decree on proclamation and protection of strictly Protected and Protected wild species of plants, animals and fungi ("Official Gazette of the Republic of Serbia", No. 5/2010, 47/2011, 32/2016 and 98/2016)

[29] Ministry of Environment and Spatial Planning, Republic of Serbia, "National report on the implementation of the agreement on the conservation of bats in Europe – Serbia 2010," [Online]. Ava: https://www.eurobats.org/sites/default/files/documents/pdf/National_Reports/nat_rep_Serb_2010.pdf [Accessed March 2025].

	Scientific name	Common name	IUCN global status [26]	IUCN European status [26]	Habitats Directive Annex IV [27]	Habitats Directive Annex II [27]	Bonn Convention (Appendix II)	Bern Convention (Annex I of Resolution 6)	Bern Convention (Appendix II)	Serbian Legislation [28]	Serbian national status [29]
5.	*Myotis alcathoe*	Alcathoe bat	DD	DD	✓	×	✓	×	✓		DD
6.	*Myotis bechsteinii*	Bechstein's bat	NT	VU	✓	✓	✓	✓	✓	SP	NT
7.	*Myotis brandtii*	Brandt's bat	LC	LC	✓	×	✓	×	✓	SP	DD
8.	*Myotis capaccinii*	Long-fingered bat	VU	VU	✓	✓	✓	✓	✓	SP	LC
9.	*Myotis daubentonii*	Daubenton's bat	LC	LC	✓	×	✓	×	✓	SP	LC
10.	*Myotis emarginatus*	Geoffroy's bat	LC	LC	✓	✓	✓	✓	✓	SP	NT
11.	*Myotis mystacinus*	Whiskered bat	LC	LC	✓	×	✓	×	✓	SP	LC
12.	*Myotis nattereri*	Natterer's bat	LC	LC	✓	×	✓	×	✓	SP	NT
13.	*Nyctalus leisleri*	Leisler's bat	LC	LC	✓	×	✓	×	✓	SP	LC
14.	*Nyctalus noctula*	Common noctule	LC	LC	✓	×	✓	×	✓	SP	LC
15.	*Pipistrellus kuhlii*	Kuhl's pipistrelle	LC	LC	✓	×	✓	×	✓	SP	LC
16.	*Pipistrellus nathusii*	Nathusius' pipistrelle	LC	LC	✓	×	✓	×	✓	SP	LC
17.	*Pipistrellus pipistrellus*	Common pipistrelle	LC	LC	✓	×	✓	×	✓	SP	LC
18.	*Pipistrellus pygmaeus*	Soprano pipistrelle	LC	LC	✓	×	✓	×	✓	SP	DD
19.	*Plecotus auritus*	Brown long-eared bat	LC	LC	✓	×	✓	×	✓	SP	NT
20.	*Plecotus austriacus*	Grey long-eared bat	LC	LC	✓	×	✓	×	✓	SP	LC
21.	*Rhinolophus euryale*	Mediterranean horseshoe	NT	VU	✓	✓	✓	✓	✓	SP	NT
22.	*Rhinolophus ferrumequinum*	Greater horseshoe bat	LC	LC	✓	✓	✓	✓	✓	SP	LC
23.	*Rhinolophus hipposideros*	Lesser horseshoe bat	LC	LC	✓	✓	✓	✓	✓	SP	NT
24.	*Tadarida teniotis*	European free-tailed bat	LC	LC	✓	×	✓	×	✓	SP	DD
25.	*Vespertilio murinus*	Parti-coloured bat	LC	LC	✓	×	✓	×	✓	SP	LC

A comprehensive impact assessment, including mitigation and enhancement measures, will be included in the Environmental and Social Impact Assessment (ESIA) for the proposed development.

4.1 Report Validity

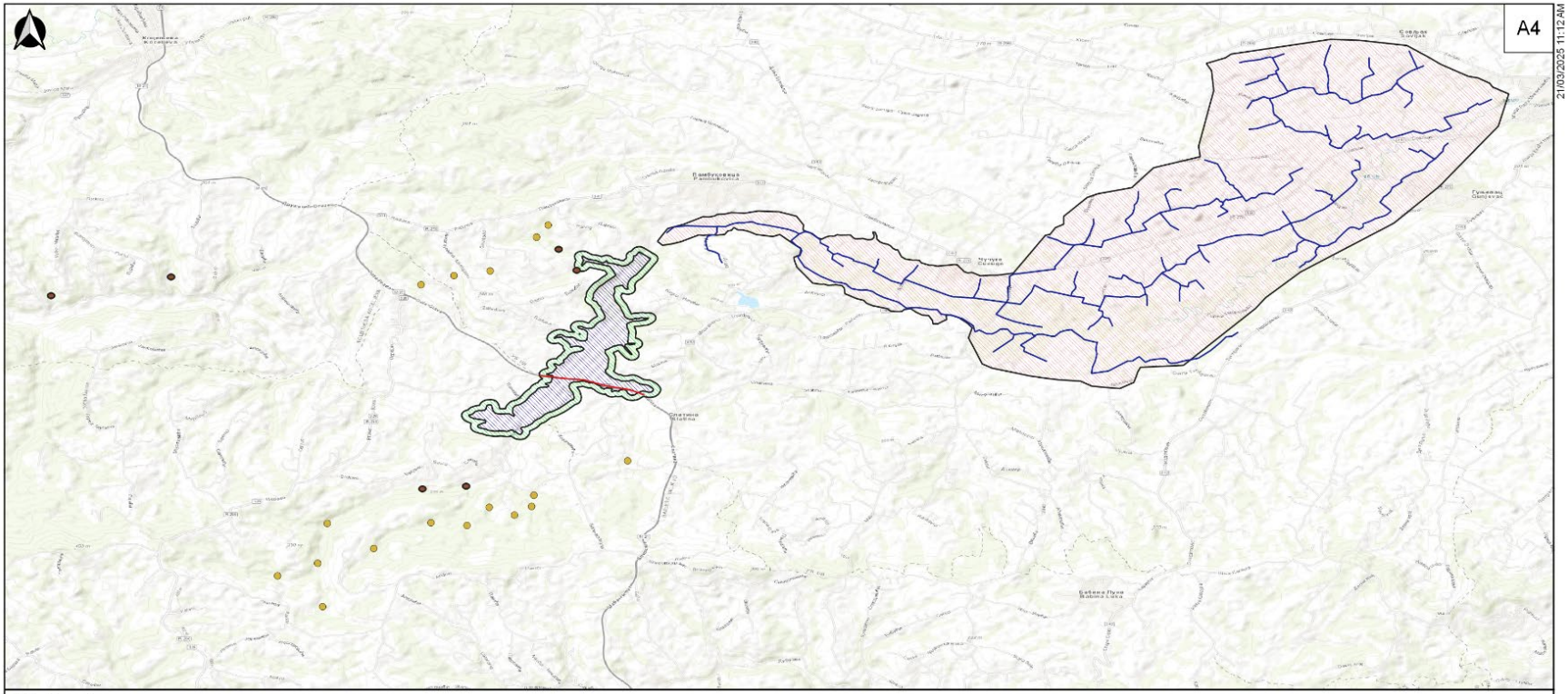
This report is the result of survey work undertaken between July 2023 and October 2024. This report refers, within the limitations stated, to the condition or proposed works of the site at the time of the surveys. Changes in legislation, guidance, best practice, etc. may necessitate a re-assessment/survey. No warranty is given as to the possibility of future changes in the condition of the Site.

The results and conclusions presented in this report are considered valid for a maximum of 18 months, after which time a suitably experienced ecologist should review the report and consider whether repeat surveys are required.

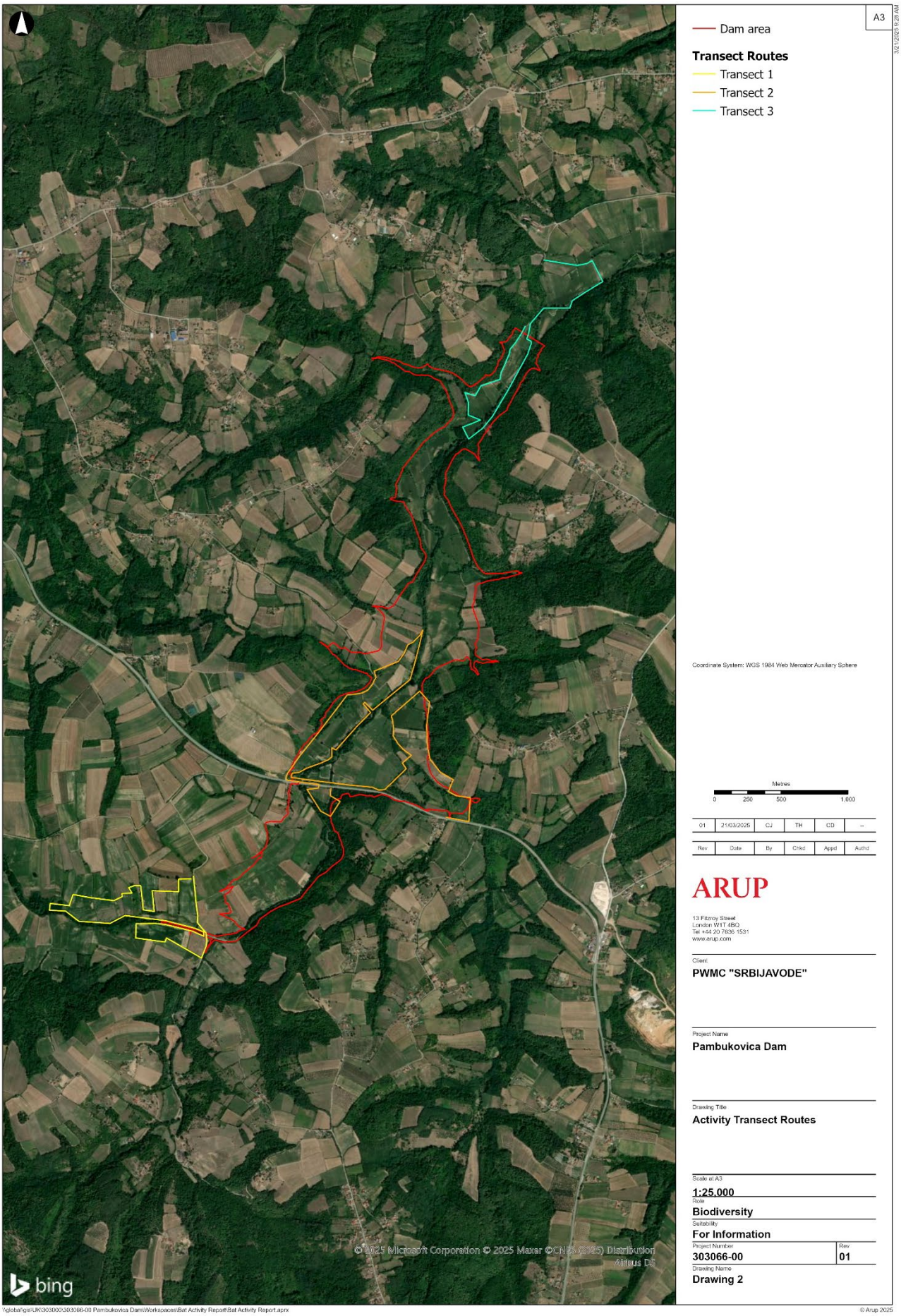
This report is produced solely for the benefit of Public Water Management Company Srbijavode and no liability is accepted for any reliance placed on it by any other party. This report is prepared for the proposed uses stated in the report and should not be used in a different context.

Drawings

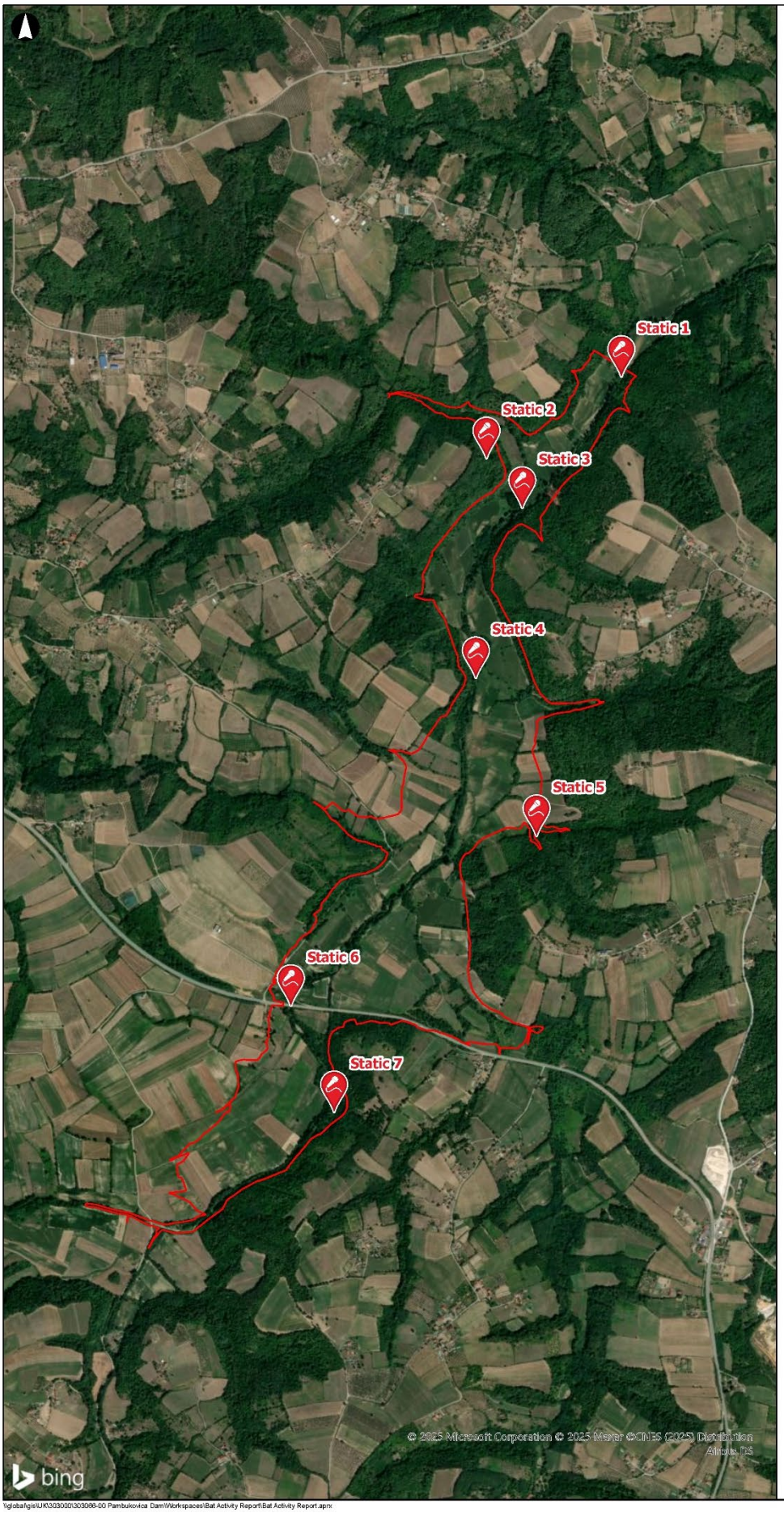
Drawing 1: Study area and project boundary


A4
21/03/2025 11:12 AM
Dam Area
Dam Area Buffer
Sediment Trap Dams
Slow Down Areas
Planned Road
Irrigation Area
Distribution network
Coordinate System: EPSG:4326
CC BY-ND 4.0
1 0 1 2 km
ARUP
Vojvode Mišića
Boulevard 17/4
BIGZ Office Building
11000 Belgrade
Client
Public Water Management Company Srbijavode
Project Name
ESIA, Climate Change Assessment and Technical Assessment for Pambukovica Dam in Serbia
PM | Februar 2025 | MP | MP | TH | MD
Rev | Date | By | Chkd | Appd | Authd
Drawing Title
Biodiveristy Study Area
Scale at A4
1:55939.44
Role
PM
Suitability
--
Project Number
303066-00
Rev
TH
Drawing Name
Biodiversity Study Map
J:\284000\284046-00 PIU Support For Srbijavode\9 Other\01 Pambukovica\04 Internal\EUK Bid Prep Docs - Pambukovica Dam Biodiversity Surveys\Maps\Habitat mapping Pambukovica Dam\Ub Habitat Map.qgz
© Arup 2025

Drawing 2: Activity transect routes



Drawing 3: Automated static detector locations



A3

Static Locations

Dam area

Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere

Metres

0 250 500 1,000

Rev	Date	By	Chkd	Appd	Authd
01	21/03/2025	CJ	TH	CD	–

ARUP

13 Fitzroy Street
London W1T 4BQ
Tel +44 20 7636 1531
www.arup.com

Client
PWMC "SRBIJAVODE"

Project Name
Pambukovica Dam

Drawing Title
Automated static detector locations

Scale at A3
1:20,000

Role
Biodiversity

Suitability
For Information

Project Number	Rev
303066-00	01

Drawing Name
Drawing 3

\\global\gis\UK\303000\303066-00 Pambukovica Dam\Workspaces\Bat Activity Report\Bat Activity Report.aprx

Drawing 4: Proximity of protected areas.


N
A4
05/02/2025 1:43 PM
Obedska bara
Bojcinska suma
Ivanovacka ada
Avala
Ponjavica
Obrenovacki zabran
Lipovicka suma- Dugi rt
Kulturni predeo Trsic - Tronosa
Pambukovica dam area
Kosmaj
Kovacevica pecina
Danilova kosa
Vrapce brdo
Prirodni prostor manastira Bogovadja
Park Bukovicke Banje
Risovaca
Petnicka pecina
Ribnica
Klisura reke Gradac
Klisura reke Tresnjice
Maljen
Rajac
Ostrovica
Inundation area
Irrigation area
Special Nature Reserve Obedska bara
Landscape of Outstanding Features Klisura reke Gradac
Natural Monument Petnicka pecina
Area of Cultural and Historical Importance Prirodni prostor manastira Bogovadja
Natural Monument Kovacevica pecina
Landscape of Outstanding Features Rajac
Natural Monument Obrenovacki zabran
Natural Monument Lipovicka suma- Dugi rt
Landscape of Outstanding Features Avala
Landscape of Outstanding Features Kosmaj
Area of Cultural and Historical Importance Vrapce brdo
Natural Monument Park Bukovicke Banje
Natural Monument Risovaca
Special Nature Reserve Klisura reke Tresnjice
Landscape of Outstanding Features Kulturni predeo Trsic - Tronosa
Landscape of Outstanding Features Maljen
Nature Park Ponjavica
Natural Monument Ostrovica
Natural Monument Bojcinska suma
Natural Monument Ribnica
Nature Reserve Danilova kosa
Natural Monument Ivanovacka ada
0
10
20 km
MP | January 2025 | SR | MD | MD | MD
Rev | Date | By | Chkd | Appd | Authd
ARUP
Bulevar vojvode Misica 17,
Belgrade,
11000, Serbia
Tel +381 11 2099 850
www.arup.com
Client
PWMC "SRBIJAVODE"
Project Name
Pambukovica Dam
Drawing Title
Protected areas and their position reagrding the Pambukovica dam
Scale at A4
1:560000
Role
SR
Suitability
--
Project Number
284046-10
Rev
MP
Drawing Name
Sara Rodic
J:\303000\303066-00 ESIA Pambukovica Dam\4 Internal\4-08 GIS\Biodiversity\Protected Areas\Protected Areas Pambukovica.qgz
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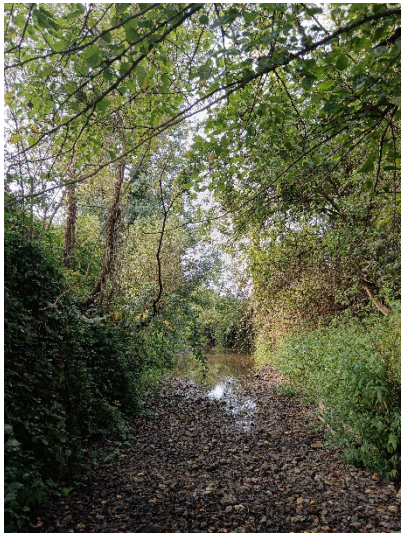
Photographs

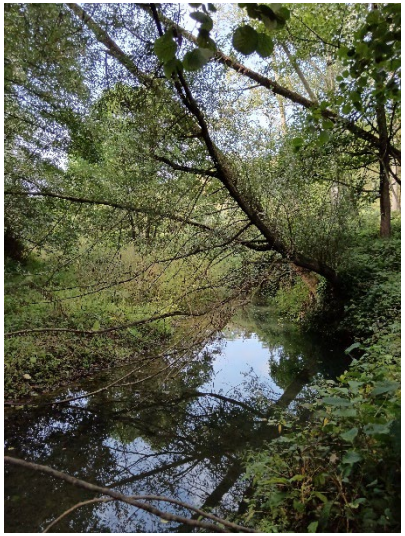


Photograph 1: SMM-01 (direction microphone was facing)

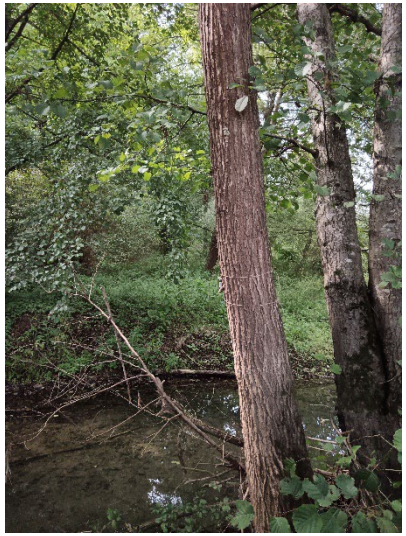
Photograph 2: SMM-01 (position)

Photograph 3: SMM-02 (direction microphone was facing)

Photograph 4: SMM-02 (position)



Photograph 5: SMM-03 (direction microphone was facing)



Photograph 6: SMM-03 (position)

Photograph 7: SMM-04 (direction microphone was facing)

Photograph 8: SMM-04 (position)

Photograph 9: SMM-05 (direction microphone was facing)

Photograph 10: SMM-05 (position)

Photograph 11: SMM-06 (direction microphone was facing)

Photograph 12: SMM-06 (position)

Photograph 13: SMM-07 (direction microphone was facing)

Photograph 14: SMM-07 (position)

Appendix A

Activity transect survey – weather conditions

Table 8: Activity transect survey timings and associated weather conditions

Survey No.	Date	Survey timings		Sunset time	Temperature (°C)		Rain	Cloud cover (Oktas)
		Start	End		Start	End		
1	29/07/2023	20:07	23:07	20:09	30	21	Dry	Clear sky
2	30/07/2023	19:43	22:43	20:08	28	22	Dry	Partly cloudy
3	07/08/2023	19:24	22:24	19:57	22	15	Dry	Cloudy

Appendix B

Automate detector surveys – survey deployment dates

Detector ID	Deployment month and year	Geographical location		Date deployed	Date collected	Dates with appropriate weather conditions and subsequently analysed
		Latitude	Longitude			
1	August 2024	19°54'30.71"E	44°25'40.76"N	13/08/2024	20/08/2024	13/08/2024 - 18/08/2024
	September 2024			20/09/2024	30/09/2024	20/09/2024 - 25/09/2024
	October 2024			18/10/2024	23/10/2024	18/10/2024 - 23/10/2024
2	August 2024	19°54'07"E	44°25'30"N	14/08/2024	22/08/2024	13/08/2024 - 18/08/2024
	September 2024			20/09/2024	30/09/2024	20/09/2024 - 25/09/2024
	October 2024			18/10/2024	23/10/2024	18/10/2024 - 23/10/2024
3	August 2024	19°54'13.97"E	44°25'24.96"N	13/08/2024	20/08/2024	13/08/2024 - 18/08/2024
	September 2024			20/09/2024	30/09/2024	20/09/2024 - 25/09/2024
	October 2024			18/10/2024	23/10/2024	18/10/2024 - 23/10/2024
4	August 2024	19°54'06"E	44°25'04"N	13/08/2024	22/08/2024	13/08/2024 - 18/08/2024
	September 2024			20/09/2024	30/09/2024	20/09/2024 - 25/09/2024
	October 2024			18/10/2024	23/10/2024	18/10/2024 - 23/10/2024
5	August 2024	19°54'16.38"E	44°24'45.43"N	14/08/2024	20/08/2024	13/08/2024 - 18/08/2024
	September 2024			20/09/2024	30/09/2024	20/09/2024 - 25/09/2024
	October 2024			18/10/2024	23/10/2024	18/10/2024 - 23/10/2024
6	August 2024	19°53'34.87"E	44°24'24.95"N	14/08/2024	20/08/2024	13/08/2024 - 18/08/2024
	September 2024			20/09/2024	30/09/2024	20/09/2024 - 25/09/2024
	October 2024			18/10/2024	23/10/2024	18/10/2024 - 23/10/2024
7	August 2024	19°53'42.18"E	44°24'12.13"N	14/08/2024	22/08/2024	13/08/2024 - 18/08/2024
	September 2024			20/09/2024	30/09/2024	20/09/2024 - 25/09/2024

Detector ID	Deployment month and year	Geographical location		Date deployed	Date collected	Dates with appropriate weather conditions and subsequently analysed
		Latitude	Longitude			
	October 2024			18/10/2024	23/10/2024	18/10/2024 - 23/10/2024

Appendix C

Bat acoustic analysis – species-specific thresholds for acceptance

Table 9: Species-specific acceptance thresholds for two-stage verification process

No.	Scientific name	Common name	Accept auto ID	Verify auto ID	Percentage of calls verified	Number of correct auto ID	Percentage of correct auto ID
1.	*Barbastella barbastellus*	Barbastelle	✗	✓	10%	21	64%
2.	*Eptesicus serotinus*	Common Serotine	✓	✗			
3.	*Hypsugo savii*	Savi's Pipistrelle	✓	✗			
4.	*Miniopterus schreibersii*	Schreiber's bent-wing bat	✓	✗			
5.	*Myotis alcathoe*	Alcathoe Bat	✗	✓	100%	0	0%
6.	*Myotis capaccinii*	Long-fingered Bat	✓	✗			
7.	*Myotis daubentonii*	Daubenton's Bat	✓	✗			
8.	*Myotis emarginatus*	Geoffroy's Bat	✓	✗			
9.	*Myotis nattereri*	Natterer's Bat	✓	✗			
10.	*Nyctalus noctula*	Noctule	✗	✓	10%	29	94%
11.	*Pipistrellus pipistrellus*	Common pipistrelle	✓	✗			
12.	*Pipistrellus pygmaeus*	Soprano pipistrelle	✓	✗			
13.	*Plecotus auritus*	Brown Long-eared Bat	✓	✗	94%	20	69%
14.	*Plecotus austriacus*	Grey Long-eared Bat	✓	✗	10%	6	60%
15.	*Rhinolophus euryale*	Mediterranean Horseshoe Bat	✗	✓	100%	0	0%
16.	*Rhinolophus hipposideros*	Lesser horseshoe bat	✓	✗			
17.	*Rhinolophus ferrumequinum*	Greater horseshoe bat	✓	✗			
18.	*Tadarida teniotis*	European Free-tailed Bat	✗	✓	10%		
19.	*Myotis mystacinus and M. brandtii*	Whiskered and Brandt's Bat	✓	✗			
20.	*Nyctalus leisleri and Vespertilio murinus*	Leisler's and Parti-coloured Bat	✗	✓	5%		
21.	*Pipistrellus nathusii and P. kuhlii.*	Nathusius' and Kuhl's Pipistrelle	✓	✗			

Appendix D

Activity transect survey – full results

Table 10: Activity transect survey results (Transect 1-3)

No.	Scientific name	Common name	Bat species code	Location / Number of detections	Coordinates		Flight direction	First bat detected in relation to sunset time (+hours and minutes)	Behaviour	Appearance (Yes/No) and relative speed
1.	*Pipistrellus kuhlii*	Kuhl's pipistrelle	PKU	Transect 1 – 17	44.400282°	19.879485°	SE	20min	Commuting along river	Yes, ≈ 2 m/s
				Transect 2 – 27	44.408178°	19.895144°	NW	1h 15min	Foraging along river	Yes, 2-3 m/s
				Transect 3 – 19	44.427983°	19.908075°	N	40min	Foraging over grassland	No, /
2.	*Pipistrellus nathusii*	Nathusius' pipistrelle	PNA	Transect 1 – 13	44.400825°	19.882193°	E	4h 10min	Foraging along woodland edge	Yes, 3m/s
				Transect 2 – 25	44.406145°	19.895226°	NW	1h 30min	Foraging in woodland	No, /
				Transect 3 – 15	44.425842°	19.904783°	NNW	2h 45min	Foraging along woodland edge	Yes, ≈ 2 m/s
3.	*Pipistrellus pygmaeus*	Soprano pipistrelle	PPY	Transect 1 – 1	44.400858°	19.876199°	SW	1h 17min	Commuting along river	No, /
				Transect 3 – 1	44.423264°	19.903722°	/	1h 15min	Commuting along woodland edge	No, /
4.	*Pipistrellus pipistrellus*	Common pipistrelle	PPI	Transect 1 – 7	44.400019°	19.885781°	WNW	27min	Commuting along river	Yes, 3-4 m/s
				Transect 2 – 17	44.405395°	19.904023°	SW	15min	Foraging along woodland edge	Yes, ≈ 2m/s
				Transect 3 – 4	44.426515°	19.905812°	E	48min	Foraging along woodland edge	No, /

No.	Scientific name	Common name	Bat species code	Location / Number of detections	Coordinates		Flight direction	First bat detected in relation to sunset time (+hours and minutes)	Behaviour	Appearance (Yes/No) and relative speed
5.	*Nyctalus leisleri*	Leisler's bat	NLE	Transect 1 – 2	44.401052°	19.876010°	N	43min	Foraging along river	Yes, 3-4 m/s
				Transect 2 – 7	44.410166°	19.895251°	ENE	40min	Foraging along woodland edge	No, /
				Transect 3 – 3	44.431822°	19.909178°	SW	21min	Commuting over grassland	Yes, 3 m/s
6.	*Nyctalus noctula*	Common noctule	NNO	Transect 1 – 9	44.400176°	19.879612°	NE	11min	Foraging along river	No, /
				Transect 2 – 12	44.405372°	19.894928°	/	20min	Foraging in woodland	No, /
				Transect 3 – 9	44.429789°	19.910966°	W	17min	Foraging along river	No, /
7.	*Miniopterus schreibersii*	Common bent-wing bat	MSC	Transect 1 – 5	44.399537°	19.881800°	NE	10min	Commuting over grassland	Yes, 3 m/s
				Transect 2 – 3	44.410691°	19.896253°	W	1h 51min	Commuting over grassland	No, /
				Transect 3 – 2	44.426169°	19.905453°	SW	38min	Foraging over grassland	No, /
8.	*Hypsugo savii*	Savi's pipistrelle	HAS	Transect 1 – 1	44.401697°	19.881485°	N	1h 19min	Foraging along scrubland	Yes, 2 m/s
				Transect 2 – 2	44.409521°	19.901345°	SW	46min	Foraging along woodland edge	No, /
				Transect 3 – 2	44.423967°	19.905029°	ESE	20 min	Foraging along woodland edge	No, /

No.	Scientific name	Common name	Bat species code	Location / Number of detections	Coordinates		Flight direction	First bat detected in relation to sunset time (+hours and minutes)	Behaviour	Appearance (Yes/No) and relative speed
9.	*Barbastella barbastellus*	Barbastelle	BBA	Transect 2 – 1	44.412016°	19.900048°	N	2h 5min	Commuting along river	No, /
				Transect 3 – 1	44.422962°	19.902877°	SE	5h 45min	Commuting along river	No, /
10.	*Myotis daubentonii*	Daubenton's bat	MDA	Transect 1 – 1	44.400871°	19.883078°	/	1 h	Commuting over grassland	No, /
				Transect 2 – 1	44.407935°	19.893644°	S	1h 56min	Commuting along river	No, /
				Transect 3 – 1	44.429785°	19.909094°	SW	1h 43min	Foraging along river	No, /
11.	*Myotis alcathoe*	Alcathoe bat	MAL	Transect 3 – 1	44.424584	19.905961°	N	3h 15 min	Commuting in woodland	No, /
12.	*Myotis bechsteinii*	Bechstein's bat	MBE	Transect 3 – 1	44.42764	19.909080°	WNW	5h 30 min	Commuting in woodland	Yes, 3-4 m/s
13.	*Plecotus austriacus*	Grey long-eared bat	PAU	Transect 2 – 1	44.406521°	19.893684°	SE	15 min	Commuting over grassland	Yes, 2-3 m/s
				Transect 3 – 1	44.429128°	19.908098°	N	1h 14min	Heard, not seen	No

Appendix E

Automated detector surveys – full results

Table 11 - Automated detector survey results (Location 1 to 7)

No.	Scientific name	Common name	August							September							October							Grand total
			Location 1	Location 2	Location 3	Location 4	Location 5	Location 6	Location 7	Location 1	Location 2	Location 3	Location 4	Location 5	Location 6	Location 7	Location 1	Location 2	Location 3	Location 4	Location 5	Location 6	Location 7	
1	*Myotis alcathoe*	Alcathoe Bat	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**
2	*Barbastella barbastellus*	Barbastelle	18	0	9	25	3	57	2	55	0	26	11	0	19	14	5	3	0	0	0	0	10	**257**
3	*Myotis brandtii*	Brandt's Bat	22	0	18	5	0	49	5	1	0	3	0	0	2	1	1	0	1	0	0	0	0	**108**
4	*Plecotus auritus*	Brown Long-eared Bat	0	0	2	0	0	1	0	7	0	2	0	0	10	1	0	0	0	0	0	1	0	**24**
5	*Pipistrellus pipistrellus*	Common Pipistrelle	362	5	290	848	0	2063	115	35	0	40	15	0	71	19	9	0	7	3	0	11	4	**3897**
6	*Myotis daubentonii*	Daubenton's Bat	145	1	638	36	0	551	52	16	0	19	3	0	52	5	2	0	1	0	0	0	0	**1521**
7	*Tadarida teniotis*	European Free-tailed Bat	67	111	7	77	5	82	30	25	1	5	4	0	136	4	1	0	0	0	0	0	1	**556**
8	*Myotis emarginatus*	Geoffroy's Bat	20	0	7	22	5	53	9	6	0	15	2	0	12	3	0	0	1	0	0	1	0	**156**
9	*Rhinolophus ferrumequinum*	Greater Horseshoe Bat	226	0	117	51	0	75	48	4	0	2	0	0	2	6	0	0	0	1	0	0	0	**532**
10	*Plecotus austriacus*	Grey Long-eared Bat	4	0	7	2	2	7	1	0	0	1	1	0	2	57	0	0	1	1	0	0	0	**86**
11	*Pipistrellus kuhlii*	Kuhl's Pipistrelle	1871	237	1166	938	8	3442	258	282	9	265	167	4	914	65	46	4	41	71	0	165	11	**9964**
12	*Nyctalus leisleri*	Leisler's Bat	0	0	0	0	0	0	0	24	3	0	5	0	0	0	2	0	0	0	0	0	1	**35**
13	*Rhinolophus hipposideros*	Lesser Horseshoe Bat	1	0	25	3	0	1	31	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**62**
14	*Myotis capaccinii*	Long-fingered Bat	1	0	12	2	0	30	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**50**
15	*Rhinolophus euryale*	Mediterranean Horseshoe Bat	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	**1**
16	*Pipistrellus nathusii*	Nathusius' Pipistrelle	755	73	674	315	1	1222	152	128	1	99	31	0	114	14	23	2	8	11	0	22	0	**3645**
17	*Myotis nattereri*	Natterer's Bat	9	22	9	32	44	82	6	7	3	14	0	13	5	12	0	14	7	1	0	4	1	**285**
18	*Nyctalus noctula*	Noctule	9	6	3	2	8	4	2	76	15	17	9	1	11	11	2	0	0	0	0	2	3	**181**
19	*Vespertilio murinus*	Parti-coloured Bat	5	20	3	25	2	28	11	16	2	6	1	0	21	36	2	0	0	0	0	1	6	**185**
20	*Hypsugo savii*	Savi's Pipistrelle	0	0	0	0	2	0	0	2	0	1	3	13	1	4	1	1	0	0	7	1	0	**36**
21	*Miniopterus schreibersii*	Schreibers' Bat	94	0	35	6	0	162	7	28	0	11	0	0	53	4	15	2	11	3	0	15	7	**453**
22	*Eptesicus serotinus*	Serotine	2	1	0	0	1	7	1	8	0	0	2	0	24	0	0	0	0	0	0	0	0	**46**
23	*Pipistrellus pygmaeus*	Soprano Pipistrelle	110	7	67	21	0	278	88	6	0	28	4	0	109	4	6	0	5	1	0	19	3	**756**

24	*Myotis mystacinus*	Whiskered Bat	30	0	10	11	2	180	6	3	0	1	0	0	21	0	0	0	0	0	0	0	**264**
		Totals	**3751**	**483**	**3099**	**2422**	**83**	**8374**	**829**	**729**	**34**	**555**	**258**	**31**	**1581**	**261**	**115**	**26**	**83**	**92**	**7**	**242**	**47**	**23102**