

# Cibuk wind farm

## Additional bird survey report (Nov 2011 to July 2012)

Continental Wind Partners

August 2012

Atkins

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The report details the results of bird surveys conducted at the Cibuk wind farm from November 2011 to July 2012. The surveys were carried out by Continental Wind Partners and Atkins. The results show that the wind farm is not a significant barrier to bird migration and that the majority of birds observed were common species. The report also includes recommendations for future surveys and mitigation measures.

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# Executive summary

Continental Wind Partners (CWP) intends to develop a 160+ MW wind farm project in Serbia. The proposed site is located about 50 km to the north east of Belgrade (in Vojvodina province) and covers an area of approximately 3,716 Hectares.

Baseline data was collected between September 2009 and February 2011 by two teams of local bird specialists, managed by Ecoda Ltd, Germany. However, an EIA scoping report for the CWP Dolovo wind farm in Serbia was produced by Atkins in June 2011. This scoping report identified some disparities between the survey methodologies of the two teams; bird flight data, although thorough, was not suitable for undertaking collision risk analysis (an increasingly used technique which identifies bird species most at risk of collision with wind turbines). In addition, the breeding bird data was not suitable for territory analysis.

In order to enable Collision Risk Analysis to be performed and to bring the data collected in line with the current UK guidance on carrying out an ornithological Impact Assessment for a proposed wind farm, additional survey data was collected between November 2011 and July 2012.

An assessment of the additional data collected between November 2011 and July 2012 suggests that the findings are consistent with the original baseline data collected between September 2009 and February 2011 and the interpretation of that data:

- A total of 93 species were recorded during the additional bird surveys between November 2011 and June 2012. This species list is similar to the 117 species recorded between September 2009 and February 2011, with the lower number believed to be reflective of the reduced survey effort.
- The additional vantage point survey data collected between November 2011 and July 2012 supports the findings of the original baseline data (collected between September 2009 and February 2011), identifying the same ten target species with the greatest number of flights: common buzzard, Eurasian kestrel, Eurasian hobby, western marsh harrier, hen harrier, northern goshawk, Eurasian sparrowhawk, greylag goose, greater white-fronted goose and European bee-eater.
- Collision risk analysis of the additional vantage point survey data confirmed that the proposed wind farm is not expected to have a significant impact on any of the target species.
- The breeding bird surveys carried out between March 2012 and July 2012 has identified nine species that bred within the survey squares and a further six species that possibly had breeding territories within or near the breeding squares. Nine of these species were identified as breeding species within the wind farm site in the Environmental and Social Impact Assessment (Atkins, 2012). The Environmental and Social Impact Assessment identified a further eight species believed to breed within the wind farm site, of which seven were recorded during the 2012 breeding surveys, but are not thought to actually breed within the breeding bird squares.
- The breeding bird surveys carried out between March 2012 and July 2012 identified three confirmed common quail territories and a further possible five common quail territories within the breeding bird survey squares. When multiplied by 6.19 to represent the total area of the wind farm site (3,716 Hectares), this equates to approximately 19-50 territories. This gives a mean of 34.5 territories and supports the estimation of 30 common quail territories in the Environmental and Social Impact Assessment (Atkins, 2012).

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### Atkins

Atkins is a leading global provider of environmental and social impact assessment services. The company has extensive experience in the wind energy sector and has worked on numerous projects across the world. Atkins was commissioned to conduct a collision risk analysis and breeding bird survey for the CWP Dolovo wind farm project in Serbia. The findings of the survey are consistent with the original baseline data and support the estimation of 30 common quail territories in the Environmental and Social Impact Assessment (Atkins, 2012).



- *Windfarms and Birds: Calculating a Theoretical Collision Risk Assuming no Avoiding Action* (Scottish Natural Heritage, 2000)<sup>6</sup>; and,
- *Bird Monitoring Methods*<sup>7</sup>.

## 2.1. Field survey

Surveys were carried out by two local expert bird surveyors (Goran Sekulic, Institute for Nature Conservation of Serbia and Stefan Skoric, University of Belgrade), under the management and assistance of an Atkins ornithologist (Paul Watts). The following survey protocol was designed to bring the baseline data collected in line with the current UK guidance on carrying out an ornithological Ecological Impact Assessment for a proposed wind farm:

- 36 hours of Vantage Point (VP) survey work at six Vantage Point locations (total of 216 hours) during the 2011-2012 winter season (November 2011 to early March 2012);
- 36 hours of Vantage Point survey work at six Vantage Point locations (total of 216 hours) during the 2012 breeding bird season (mid-March 2012 to July 2012);
- Nine breeding bird surveys during the 2012 breeding season (mid-March 2012 to July 2012).

This approach ensured that the survey work covers a full winter and breeding season, in accordance with Natural England and Scottish Natural Heritage guidance. The proposed wind farm site is not considered to be significant for migrating birds during spring and autumn (Ecoda, 2011<sup>8</sup>) and therefore did not require additional survey effort during these periods.

### Vantage point (VP) surveys

For the original baseline data collected between September 2009 and February 2011, 5 VP locations were used by Team 1, and 6 VP locations were used by Team 2 (Ecoda, 2011).

The 6 VP locations used by Team 2 were considered to give sufficient coverage of the wind farm site to gain an understanding of the use of the airspace by flying birds. These VPs were used for the additional surveys in 2011-2012, with the exception of VP5, which was originally located on the edge of Deliblato Sands (1.3km from the wind farm site) and has been relocated to the edge of the wind farm site to allow better coverage of the wind farm area. All VPs are all located at the outer edge of the wind farm site (allowing coverage of the wind farm site, whilst avoiding disturbance of birds within the wind farm site), with the exception of VP3 which is located at the edge of the Deliblato Sands Important Bird Area, approximately 1km to the east of the proposed wind farm site. See Figure 1, page 10, for a map of the VP locations.

### Winter VP surveys

Thirty-six hours of survey were conducted at each VP during the winter season (November 2011 to early March 2012), following Natural England guidance (Natural England, 2010) and Scottish Natural Heritage survey guidance (Scottish Natural Heritage, 2005).

<sup>5</sup> Scottish Natural Heritage (2006) *Assessing Significance of Impacts from Onshore Windfarms on Birds Outwith Designated Areas*. Scottish Natural Heritage.

<sup>6</sup> Scottish Natural Heritage (2000) *Windfarms and Birds: Calculating a Theoretical Collision Risk Assuming no Avoiding Action*. Scottish Natural Heritage.

<sup>7</sup> Gilbert, G., Gibbon, D. and Evans, J. (1998) *Bird monitoring methods: a manual of survey techniques for key UK species*. Sandy: Royal Society for the Protection of Birds.

<sup>8</sup> Ecoda (2011) *Expert opinion on the expected impact on birds* Ecoda Consulting

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Atkins is a leading international environmental and sustainability consultancy. We provide a wide range of services to our clients, including environmental impact assessment, strategic environmental assessment, and environmental management systems. Our expertise is in the areas of energy, infrastructure, and natural resources. We have a proven track record of delivering high-quality, cost-effective solutions to our clients. Our team consists of highly qualified professionals with extensive experience in the field. We are committed to providing our clients with the highest level of service and expertise. Our services are designed to help our clients meet their environmental and sustainability goals. We are a global organization with offices in many countries. We are proud to be a part of the Atkins group, which is a leading provider of professional services worldwide. We are committed to excellence in everything we do. We are a team of professionals who are passionate about their work and dedicated to providing the best possible service to our clients. We are a company that values innovation and creativity. We are a company that is always looking for new ways to improve our services and our clients' experience. We are a company that is committed to the environment and to sustainable development. We are a company that is proud to be a part of the Atkins group. We are a team of professionals who are committed to providing the highest quality of service to our clients. We are a company that is always looking for new ways to improve our services and our clients' experience. We are a company that is committed to the environment and to sustainable development. We are a company that is proud to be a part of the Atkins group.



|                       |    |    |   |        |    |
|-----------------------|----|----|---|--------|----|
| Western marsh harrier | II | II | I |        |    |
| Hen harrier           | II | II | I | SPEC 3 |    |
| Montagu's harrier     | II | II | I |        |    |
| Northern goshawk      | II | II |   |        |    |
| Eurasian sparrowhawk  | II | II |   |        |    |
| Common buzzard        | II | II |   |        |    |
| Rough-legged buzzard  | II | II |   |        |    |
| Booted eagle          | II | II | I | SPEC 3 |    |
| Common kestrel        | II | II | I | SPEC 3 |    |
| Red-footed falcon     | II | II | I | SPEC 3 | NT |
| Merlin                | II | II | I | SPEC 3 |    |
| Eurasian hobby        | II | II | I |        |    |
| Saker falcon          | II | II | I | SPEC 1 | VU |
| Peregrine falcon      | II | II | I |        |    |
| Common crane          | II | II | I | SPEC 2 |    |
| Long-eared owl        | II |    |   |        |    |
| Eurasian scops owl    | II |    |   | SPEC 2 |    |
| Little owl            | II |    |   | SPEC 3 |    |
| Barn owl              | II |    |   | SPEC 3 |    |
| Tawny owl             | II |    |   |        |    |
| European bee-eater    | II | II |   | SPEC 3 |    |
| European roller       | II | II | I | SPEC 2 | NT |

**Explanations for Table 1**

| Column heading         | Convention description   | Protected status   |
|------------------------|--|--|
| <b>Bern</b>            | Convention on the Conservation of European Wildlife and Natural Habitats | II: strictly protected fauna species.  |
|                        |  | III: protected fauna species.  |
| <b>Bonn</b>            | Bonn Convention on the Conservation of Migratory Species of Wild Animals | I: Endangered migratory species.   |
|                        |  | II: Migratory species conserved by agreements.   |
| <b>Birds Directive</b> | 2009/147/EC of the European Parliament and of the Council of 30          | I: The species mentioned in Annex I shall be the subject of special conservation measures concerning their habitat in order to ensure their survival and reproduction in their area of distribution. |
|                        |  | IIa: The species referred to in Annex II, Part A may be hunted in the geographical sea   |

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 2009/147/EC of the European Parliament and of the Council of 30  
 I: The species mentioned in Annex I shall be the subject of special conservation measures concerning their habitat in order to ensure their survival and reproduction in their area of distribution.  
 IIa: The species referred to in Annex II, Part A may be hunted in the geographical sea



Assessment estimated that approximately 30 pairs of common quail breed within the wind farm site and provided mitigation habitat creation options based on this.

Further breeding bird surveys were carried out in line with UK guidance (NE, 2010), allowing breeding territory distributions to be established for all birds, including common quails.

Nine surveys were carried out, twice monthly between mid-March 2012 and July 2012.

The wind farm site consists entirely of intensive arable land, with a network of tracks and roads lined sparsely with hedges and patches of relic steppe grassland (for a detailed description see Phase 1 section of the Environmental and Social Impact Assessment (Atkins, 2012)). As the habitat is homogenous across the site, it is considered that a detailed assessment of a representative proportion of the site, would allow an accurate extrapolated estimation of the breeding populations within the wind farm site as a whole.

Six squares, each 1km<sup>2</sup>, were selected. These squares were chosen as they were spread across the wind farm site and contained sufficient tracks to allow survey access within 200m of every point within the survey area; this access was considered sufficient to allow all vocal birds within the survey area to be recorded due to the open habitats present. The survey squares are shown in Figure 1.

Each survey visit consisted of two surveyors, each covering 3 x 1km<sup>2</sup> squares (therefore covering 6 x 1km<sup>2</sup> squares between them).

Surveys started shortly after sunrise, when birds are the most active and the starting point and direction of the survey route was varied each time to ensure that there was no tendency for any part of the survey area to be visited earlier or later in the day. Surveys were undertaken in fair weather conditions (i.e. not in heavy rain, poor visibility or wind greater than Beaufort 4<sup>9</sup>).

Blank maps of the survey route and boundary were used by the surveyor for each survey. All birds observed and any behavioural activity (such as singing, carrying food) was recorded on a map for each survey. The map also included details of date, start and finish time, sunrise time and weather. See Appendix A for a list of survey dates, start times and weather.

<sup>9</sup> Beaufort scale is an empirical measure for describing wind speed, ranging from 0 (calm) to 12 (hurricane). Beaufort 4 = moderate breeze (11-16 knots)

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The wind farm site consists entirely of intensive arable land, with a network of tracks and roads lined sparsely with hedges and patches of relic steppe grassland (for a detailed description see Phase 1 section of the Environmental and Social Impact Assessment (Atkins, 2012)). As the habitat is homogenous across the site, it is considered that a detailed assessment of a representative proportion of the site, would allow an accurate extrapolated estimation of the breeding populations within the wind farm site as a whole.











### 3.2. Breeding bird surveys

A total of 47 species were recorded during the breeding bird surveys carried out between March and July 2012, of which 31 species are thought to breed within or near the wind farm site (see Appendix D for a full list of species and their breeding status).

A review of the breeding bird surveys has identified nine species that were confirmed to have breeding territories within the survey squares: common quail, corn bunting, crested lark, Eurasian skylark, European bee-eater, European stonechat, red-backed shrike, tawny pipit and yellow wagtail. See Appendix E for territory maps for each of the six breeding bird squares.

Seven of these species were identified in the Environmental and Social Impact Assessment (Atkins, 2012) as breeding within the wind farm survey area. European bee-eater and tawny pipit were not identified as breeding within the wind farm survey area in the Environmental and Social Impact Assessment, but have been confirmed as breeding during the additional bird surveys (a pair of European bee-eaters were observed at a nest hole and tawny pipits were observed singing and seen carrying food).

The 2012 breeding bird surveys also recorded a further 6 species considered to have possible breeding territories within or near the breeding bird squares: blackcap, chaffinch, common whitethroat, Eurasian kestrel, Eurasian tree sparrow and house sparrow. Of these, Eurasian kestrel was confirmed as breeding in the Environmental and Social Impact Assessment, and Eurasian tree sparrow and house sparrow were thought to probably breed within the wind farm survey area.

The Environmental and Social Impact Assessment identified a further eight species as breeding within the wind farm survey area: common buzzard, common cuckoo, common pheasant, European magpie, grey partridge, hooded crow, turtle dove and whinchat.

All of these species, with the exception of grey partridge, were recorded during the breeding bird surveys carried out between March 2012 and June 2012. These species are all believed to breed within the wind farm site or immediate surrounds but are not considered to actually breed within the breeding bird squares.

Table 4 gives a list of bird species identified as breeding within the wind farm survey area in the Environmental and Social Impact Assessment or recorded as confirmed or possible breeding during the 2012 breeding bird surveys.

**Table 4. Breeding status of birds within the proposed wind farm site**

| Species            | Breeding status in Environmental and Social Impact Assessment (Atkins, 2012) | Breeding status in 2012 breeding bird surveys                                  |
|--------------------|--|--|
| Blackcap           | Not recorded as breeding within wind farm survey area                        | Probably breeds within or near survey squares                                  |
| Common buzzard     | Breeds within wind farm survey area  | Breeds within or on outskirts of wind farm site, but not within survey squares |
| Common cuckoo      | Breeds within wind farm survey area  | Breeds within wind farm site, but not within survey squares                    |
| Common pheasant    | Breeds within wind farm survey area  | Breeds within or on outskirts of wind farm site, but not within survey squares |
| Common quail       | Breeds within wind farm survey area  | Breeds within survey squares   |
| Common whitethroat | Not recorded as breeding within wind farm survey                             | Probably breeds within or near survey squares                                  |

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Atkins (2012) identified the following species as breeding within the wind farm survey area:

- Common quail
- European bee-eater
- European stonechat
- Red-backed shrike
- Tawny pipit
- Yellow wagtail
- Blackcap
- Chaffinch
- Common whitethroat
- Eurasian kestrel
- Eurasian tree sparrow
- House sparrow
- Common buzzard
- Common cuckoo
- Common pheasant
- Hooded crow
- Turtle dove
- Whinchat







## 4. Discussion

### 4.1. Collision risk

Six target species are predicted to have a single collision fatality every 20 years or longer:

- Eurasian sparrowhawk (one fatality every 38 years);
- Black kite (one fatality every 36 years);
- Northern goshawk (one fatality every 36 years);
- Hen harrier (one fatality every 51 years);
- Saker falcon (one fatality every 74 years);
- Black stork (one fatality every 58 years)

It is considered that these species can be immediately excluded from any potential significant collision impacts as a result the proposed wind farm. This is because the rate of collision fatality is so low that it would not have an impact on the population size of these birds at a local, regional or country scale, when considered against environmental factors such as habitat change and climate change.

For the remaining seven species (including greylag geese and greater white-fronted geese combined in a single group) that cannot be immediately excluded, population estimates have been collated from Ecoda (2011). In addition, background adult mortality rates (juvenile mortality rates are higher, so using adult mortality only is considered to provide a precautionary underestimate) have been established from Robinson (2005)<sup>11</sup>. The background mortality rates are based on UK populations, but these are considered to give a fair indication of population background mortality rates throughout Europe.

Background mortality rates were not available for white stork and European bee-eater, so a precautionary level of 10% annual mortality has been used.

- An estimate of 10% annual mortality for white stork is believed to be a cautious estimate. This has been based the lowest annual mortality rate of any closely related species: common crane has an annual mortality rate of 10%, grey heron has an annual mortality rate of 28% and little egret has an annual mortality rate of 29%.
- An estimate of 10% annual mortality for European bee-eater is believed to be a cautious estimate for a passerine species. The closely related common kingfisher has an annual mortality rate of 72%.

Based on the estimated population size and the background mortality rates, it has been possible to estimate an annual mortality figure for each target species population. Table 6 assesses whether the predicted number of collisions per year as a result of the proposed wind farm will have a significant impact on the annual mortality of each target species population at a level of 5% significance.

The predicted collision rates are considered to be non-significant on the bird populations for all target species

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<sup>11</sup> Robinson, R. (2005) BirdFacts: profiles of birds occurring in Britain and Ireland (BTO Research Report 407). BTO, Thetford.

**Table 6. Significance of annual mortality estimates of target species recorded at collision risk height during the additional vantage point surveys (November 2011 – July 2012)**

| Species  | Estimated population size   | Background adult mortality rate (taken from Robinson, 2005)               | Annual regional mortality number | Predicted number of collisions per year | Significance (5% of background mortality = significant) |
|--|---|---|----------------------------------|---|---|
| Common buzzard   | 1600-2000 in Vjvodina region  | 10%   | 160-200                          | 0.90                                    | Not significant at a regional level                     |
| Eurasian kestrel   | 2,600-3,400 Vjvodina region   | 31%   | 806-1054                         | 0.43                                    | Not significant at a regional level                     |
| Grey goose species (greater white-fronted goose and greylag goose) | 10,000 – 15,000 greater white-fronted geese winter in Serbia and Montenegro | 28%   | 2800-4200                        | 56                                      | Not significant at a national level                     |
|  | >240,000 greylag geese breed in Europe                                      | 17%   | >40800                           |   | Not significant at a European level                     |
| White stork  | 2,000-2,200 in Vjvodina region  | Not known, estimated to be 10% (precautionary rate based on common crane) | 200-220                          | 0.56                                    | Not significant at a regional level                     |
| Common crane   | 148,000-220,000 breeding population in Europe                               | 10%   | 14,800-22,000                    | 1.9                                     | Not significant at a European level                     |
| Great cormorant  | 2,000-2,400 in Vjvodina region  | 12%   | 240-288                          | 0.31                                    | Not significant at a regional level                     |
| European bee-eater   | 2,000-4,000 in Vjvodina region  | Not known, precautionary estimate of 10% used                             | 200-400                          | 0.43                                    | Not significant at a regional level                     |

However, due to the limited availability of data on Serbia's birds, target species population sizes were not available at a regional level for greater white-fronted goose, greylag goose and common crane. For these target species, only European population estimates were available, and therefore Table 6 is only able to conclude that greater white-fronted goose, greylag goose and common crane will not be significantly affected by the proposed wind farm at a European population level.

These three target species have been discussed in greater detail below.

#### **Grey geese (greylag goose and greater white-fronted goose)**

It was only possible to establish estimates of greylag geese at a European level (>240,000) and greater white-fronted geese at a national level (10,000-15,000).

An annual mortality of 56 grey geese would not be significant (at 5% significance) with a background mortality of 17%, if regional wintering populations reached 6,590. During the winter surveys, it was noted that grey geese were not abundant throughout the region and were not restricted to the proposed wind farm site. With flocks of up to 1000 geese recorded during the vantage point surveys, it is considered likely that the regional population exceeds 6,590.

As described in the Environmental and Social Impact Assessment (Atkins, 2012), greylag geese and greater white-fronted geese are expected to be displaced from the wind farm to alternative foraging grounds, rather than being at risk of collision.

It is considered that the combination of (i) numbers of grey geese overwintering in the region likely to exceed 6,590 (due to the large numbers observed throughout the region), and (ii) the expectation that the estimated collision rate of 56 birds a year is an overestimate (due to predicted displacement rather than collision as described in Atkins, 2012), means that the proposed wind farm will have a non significant impact on the regional greylag goose and greater white-fronted goose populations.

### **Common crane**

It was only possible to establish estimates of common cranes at a European level (148,000-220,000).

An annual mortality of 1.9 common cranes would not be significant (at 5% significance) with a background mortality of 10%, if regional passage populations reached 380.

Common cranes were only recorded passing through the site on 4 occasions (with flocks of up to 60 birds recorded). Birdlife International (France) describes the European common crane migration<sup>12</sup>, with up to 45,000 common cranes passing south through Hungary (typically at heights of 200-1000m) on their way to winter in Spain. It is therefore considered that this major common crane passage is likely to occur across the wider regional area, with numbers passing through the Vojvodina region far exceeding 380 birds.

Therefore it is considered that the predicted collision mortality of 1.9 birds per year will have a non significant impact on the regional common crane populations.

## **4.2. Breeding birds**

The Environmental and Social Impact Assessment (Atkins, 2012) estimated that approximately 30 pairs of common quail breed within the wind farm site. It was estimated that approximately 20% of the wind farm common quail population will be displaced by the operational turbines, equating to 6 common quail territories.

During the 2012 breeding bird surveys, common quails were recorded in 4 squares, with three breeding territories confirmed and a further five possible common quail territories (where birds were recorded on single occasions).

When multiplied by 6.19 to represent the total area of the wind farm site, an extrapolation of the confirmed and possible common quail territories within the squares produced an estimate of 19-50 territories within the wider wind farm site. This gives a mean of 34.5 territories and supports the 30 common quail territories estimated in the Environmental and Social Impact Assessment (Atkins, 2012).

It is considered that the 2012 breeding bird survey data supports the findings of the Environmental and Social Impact Assessment (Atkins, 2012), estimating a similar number of common quail breeding territories, and therefore supporting the proposed mitigating habitat creation of 4.5 ha of fallow strips and flower-rich field margins over 250 m from any wind turbines.

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<sup>12</sup> Ligue pour Protection des Oiseaux *The common crane* ([http://champagne-ardenne.lpo.fr/English/e\\_grue\\_cendree.htm](http://champagne-ardenne.lpo.fr/English/e_grue_cendree.htm); accessed 17<sup>th</sup> August 2012)

## 5. Summary

The additional data collected between November 2011 and July 2012 has enabled collision risk analysis and breeding bird territory analysis to be carried out. The findings support the interpretation of the original baseline data collected between September 2009 and February 2011:

- A total of 93 species were recorded during the additional bird surveys between November 2011 and June 2012. This species list is similar to the 117 species recorded between September 2009 and February 2011, with the lower number believed to be reflective of the reduced survey effort.
- The additional vantage point survey data collected between November 2011 and July 2012 supports the findings of the original baseline data (collected between September 2009 and February 2011), identifying the same ten target species with the greatest number of flights: common buzzard, Eurasian kestrel, Eurasian hobby, western marsh harrier, hen harrier, northern goshawk, Eurasian sparrowhawk, greylag goose, greater white-fronted goose and European bee-eater.
- Collision risk analysis of the additional vantage point survey data confirmed that the proposed wind farm is not expected to have a significant impact on any of the target species.
- The breeding bird surveys carried out between March 2012 and July 2012 has identified nine species that bred within the survey squares and a further six species that possibly had breeding territories within or near the breeding squares. Nine of these species were identified as breeding species within the wind farm site in the Environmental and Social Impact Assessment (Atkins, 2012). The Environmental and Social Impact Assessment identified a further eight species believed to breed within the wind farm site, of which seven were recorded during the 2012 breeding surveys, but are not thought to actually breed within the breeding bird squares.
- The breeding bird surveys carried out between March 2012 and July 2012 identified three confirmed common quail territories and a further possible five common quail territories within the breeding bird survey squares. When multiplied by 6.19 to represent the total area of the wind farm site, this equates to approximately 19-50 territories. This gives a mean of 34.5 territories and supports the 30 common quail territories estimated in the Environmental and Social Impact Assessment (Atkins, 2012).

## Appendix A. Survey details

| Survey type   | Location | Survey No. | Date       | Start Time | Weather  |
|---------------|----------|------------|------------|------------|--|
| Vantage Point | VP1      | 1          | 22/01/2012 | 08:00      | 3°C, overcast (100%), light W wind, light rain/snow stopped after 1 hour, good visibility. |
| Vantage Point | VP1      | 2          | 22/01/2012 | 12:55      | 6°C, 20% cloud cover, light NW wind, dry, good visibility.                                 |
| Vantage Point | VP1      | 3          | 23/01/2012 | 08:00      | 5°C, 10% cloud cover, dry, clear visibility.   |
| Vantage Point | VP1      | 4          | 23/01/2012 | 10:15      | 5°C, 20% cloud cover, dry, clear visibility.   |
| Vantage Point | VP2      | 1          | 15/01/2012 | 11:48      | 1°C, 90% cloud, NW strong wind, dry, good visibility.                                      |
| Vantage Point | VP2      | 2          | 21/01/2012 | 08:36      | 0°C, clear sky, dry, clear visibility.   |
| Vantage Point | VP2      | 3          | 22/01/2012 | 10:25      | 4°C, 40% cloud cover, dry, clear visibility.   |
| Vantage Point | VP2      | 4          | 23/01/2012 | 12:50      | 7°C, 5% cloud cover, dry, clear visibility.  |
| Vantage Point | VP3      | 1          | 21/01/2012 | 11:00      | 50% cloud cover, NW wind, dry, clear visibility.   |
| Vantage Point | VP3      | 2          | 21/01/2012 | 13:15      | 0°C, 30% visibility, NW wind, dry, clear visibility.                                       |
| Vantage Point | VP3      | 3          | 22/01/2012 | 08:16      | 5°C, 80% cloud cover, dry, clear visibility.   |
| Vantage Point | VP3      | 4          | 29/01/2012 | 07:49      | 5°C, 20% cloud cover, dry, clear visibility.   |
| Vantage Point | VP4      | 1          | 15/01/2012 | 09:35      | -1°C, 20% cloud cover, strong NW wind, dry, clear visibility.                              |
| Vantage Point | VP4      | 2          | 21/01/2012 | 11:25      | 4°C, 70% cloud cover, strong NW wind, dry, clear visibility.                               |
| Vantage Point | VP4      | 3          | 21/01/2012 | 13:40      | 4°C, 50% cloud cover, strong NW wind, dry, clear visibility.                               |
| Vantage Point | VP4      | 4          | 23/01/2012 | 07:30      | 2-3°C, 7 okta cloud cover, still, dry, clear visibility.                                   |
| Vantage Point | VP5      | 1          | 21/01/2012 | 08:05      | 0°C, 20% cloud cover, NW wind, dry, clear visibility.                                      |
| Vantage Point | VP5      | 2          | 22/01/2012 | 11:00      | 5°C, 80% cloud cover, dry, clear visibility.   |
| Vantage Point | VP5      | 3          | 22/01/2012 | 13:10      | 5°C, 5% cloud cover, dry, clear visibility.  |
| Vantage Point | VP5      | 4          | 29/01/2012 | 10:15      | 0°C, 10% cloud cover, dry, clear visibility.   |
| Vantage Point | VP6      | 1          | 15/01/2012 | 07:14      | -3°C, 80% cloud cover, later 50%, strong NW wind, dry, clear visibility.                   |
| Vantage Point | VP6      | 2          | 23/01/2012 | 09:55      | 5-6°C, 5 okta cloud cover, still, dry, clear visibility.                                   |
| Vantage Point | VP6      | 3          | 23/01/2012 | 12:10      | 5°C, 1 okta cloud cover, NW wind, dry, clear visibility.                                   |
| Vantage Point | VP6      | 4          | 29/01/2012 | 12:33      | -3°C, 20% cloud cover, dry, clear visibility.  |
| Vantage Point | VP1      | 1          | 28/02/2012 | 06:55      | 2-3°C, overcast (100%), NE strong wind, dry, good visibility.                              |
| Vantage Point | VP1      | 2          | 28/02/2012 | 09:10      | 4-5°C, 60% cloud cover, 30% in the second hour, NE strong wind, dry, good visibility.      |
| Vantage Point | VP1      | 3          | 29/02/2012 | 10:00      | 5-6°C, clear, NW light wind, dry, good visibility.   |
| Vantage Point | VP1      | 4          | 29/02/2012 | 12:15      | 7-8°C, clear, NW light wind, dry, good visibility.   |
| Vantage Point | VP2      | 1          | 25/02/2012 | 10:00      | 5-6°C, 70% cloud cover, 20% in second hour, NW moderate wind, dry, good visibility.        |
| Vantage Point | VP2      | 2          | 25/02/2012 | 12:15      | 7-8°C, clear, NW light wind, dry, good visibility.   |
| Vantage Point | VP2      | 3          | 26/02/2012 | 08:05      | -1°C, over cast (100%), NW light wind, dry, good visibility (2km).                         |
| Vantage Point | VP2      | 4          | 26/02/2012 | 10:20      | 3-4°C, overcast (100%), mist, NW light wind, dry, good visibility (2km).                   |
| Vantage Point | VP3      | 1          | 23/02/2012 | 08:20      | -3°C, cloud cover 2 okta, moderate NW wind, clear visibility.                              |
| Vantage Point | VP3      | 2          | 27/02/2012 | 10:05      | 0°C, cloud cover 0 okta, clear visibility.   |
| Vantage Point | VP3      | 3          | 28/02/2012 | 12:48      | 5°C, cloud cover 1 okta, clear visibility.   |
| Vantage Point | VP3      | 4          | 29/02/2012 | 08:38      | 0°C, cloud cover 5 okta, clear visibility.   |
| Vantage Point | VP4      | 1          | 25/02/2012 | 07:05      | 5°C, 70% cloud cover, NW moderate wind, dry, good visibility.                              |
| Vantage Point | VP4      | 2          | 26/02/2012 | 12:55      | 3°C, 90% cloud cover, calm, light NW wind, dry, good visibility.                           |
| Vantage Point | VP4      | 3          | 28/02/2012 | 12:15      | 7°C, clear, moderate N wind, dry, good visibility.   |

Cibuk wind farm – additional vantage point survey

|               |     |   |            |       |  |
|---------------|-----|---|------------|-------|--|
| Vantage Point | VP4 | 4 | 29/02/2012 | 07:05 | -1°C, clear with mist, calm with light W wind later, dry, good visibility (2km). |
| Vantage Point | VP5 | 1 | 23/02/2012 | 10:45 | 0°C, cloud cover 3 okta, moderate NW wind, clear visibility.                     |
| Vantage Point | VP5 | 2 | 27/02/2012 | 12:32 | 3°C, clear, clear visibility.  |
| Vantage Point | VP5 | 3 | 28/02/2012 | 08:10 | 2°C, cloud cover 3 okta, clear visibility.                                       |
| Vantage Point | VP5 | 4 | 29/02/2012 | 13:17 | °C, cloud cover okta, clear visibility.  |
| Vantage Point | VP6 | 1 | 23/02/2012 | 13:04 | 0°C, clear, moderate NW wind, clear visibility.                                  |
| Vantage Point | VP6 | 2 | 27/02/2012 | 07:38 | -2°C, clear, clear visibility.   |
| Vantage Point | VP6 | 3 | 28/02/2012 | 10:23 | 5°C, cloud cover 4 okta, clear visibility.                                       |
| Vantage Point | VP6 | 4 | 29/02/2012 | 11:00 | 0°C, cloud cover 5 okta, clear visibility.                                       |
| Vantage Point | VP1 | 1 | 18/03/2012 | 09:00 | 15°C, clear, dry, clear visibility   |
| Vantage Point | VP1 | 2 | 18/03/2012 | 11:15 | 20°C, clear, dry, strong wind, clear visibility                                  |
| Vantage Point | VP1 | 3 | 24/03/2012 | 07:15 | 11°C, clear, dry, still, clear visibility  |
| Vantage Point | VP1 | 4 | 25/03/2012 | 11:55 | 20°C, cloud cover 1 okta, moderate breeze, clear visibility, dry                 |
| Vantage Point | VP2 | 1 | 13/03/2012 | 08:46 | 15°C, clear, dry, clear visibility   |
| Vantage Point | VP2 | 2 | 18/03/2012 | 11:02 | 20°C, clear, dry, moderate breeze, clear visibility                              |
| Vantage Point | VP2 | 3 | 24/03/2012 | 09:30 | 20°C, clear, dry, moderate breeze, clear visibility                              |
| Vantage Point | VP2 | 4 | 24/03/2012 | 11:45 | 20°C, cloud cover 1 okta, moderate breeze, clear visibility, dry                 |
| Vantage Point | VP3 | 1 | 18/03/2012 | 13:55 | 20°C, clear, moderate breeze, clear visibility, dry                              |
| Vantage Point | VP3 | 2 | 19/03/2012 | 08:49 | 5°C, cloud cover 2 okta, gentle breeze, clear visibility, dry                    |
| Vantage Point | VP3 | 3 | 27/03/2012 | 07:25 | 8°C, cloud cover okta 1, still, clear visibility, dry                            |
| Vantage Point | VP3 | 4 | 30/03/2012 | 10:07 | 10°C, cloud cover okta 8, moderate breeze, clear visibility, dry                 |
| Vantage Point | VP4 | 1 | 18/03/2012 | 13:45 | 20°C, clear, gentle breeze, clear visibility, dry                                |
| Vantage Point | VP4 | 2 | 19/03/2012 | 08:13 | 15°C, cloud cover okta 3, dry, clear visibility                                  |
| Vantage Point | VP4 | 3 | 27/03/2012 | 12:10 | 20°C, cloud cover okta 3, dry, still, clear visibility                           |
| Vantage Point | VP4 | 4 | 30/03/2012 | 12:18 | 10°C, cloud cover okta 8, moderate breeze, clear visibility, dry                 |
| Vantage Point | VP5 | 1 | 19/03/2012 | 11:39 | 20°C, cloud cover okta 2, moderate breeze, clear visibility, dry                 |
| Vantage Point | VP5 | 2 | 19/03/2012 | 13:54 | 20°C, cloud cover okta 2, moderate breeze, clear visibility, dry                 |
| Vantage Point | VP5 | 3 | 27/03/2012 | 09:43 | 12°C, cloud cover okta 1, still, clear visibility, dry                           |
| Vantage Point | VP5 | 4 | 30/03/2012 | 07:43 | 7°C, cloud cover okta 7, moderate breeze, clear visibility, dry                  |
| Vantage Point | VP6 | 1 | 19/03/2012 | 11:29 | 5°C, cloud cover 1 okta, gentle breeze, clear visibility, dry                    |
| Vantage Point | VP6 | 2 | 19/03/2012 | 13:44 | 5°C, cloud cover 3 okta, gentle breeze, clear visibility, dry                    |
| Vantage Point | VP6 | 3 | 25/03/2012 | 07:10 | 10°C, clear, still, clear visibility, dry  |
| Vantage Point | VP6 | 4 | 25/03/2012 | 09:25 | 15°C, clear, dry, clear visibility, dry  |
| Vantage Point | VP1 | 1 | 16/04/2012 | 15:40 | 20°C, clear, moderate breeze, clear visibility, dry                              |
| Vantage Point | VP1 | 2 | 21/04/2012 | 07:10 | 10°C, cloud cover okta 7, moderate breeze, clear visibility, dry                 |
| Vantage Point | VP1 | 3 | 21/04/2012 | 09:25 | 13°C, cloud cover okta 5, moderate breeze, clear visibility, dry                 |
| Vantage Point | VP1 | 4 | 30/04/2012 | 13:20 | 30°C, clear, moderate breeze, clear visibility, dry                              |
| Vantage Point | VP2 | 1 | 16/04/2012 | 13:20 | 20°C, clear, moderate breeze, clear visibility, dry                              |
| Vantage Point | VP2 | 2 | 22/04/2012 | 08:27 | 12°C, cloud cover okta 7, moderate breeze, clear visibility, dry                 |
| Vantage Point | VP2 | 3 | 22/04/2012 | 10:42 | 15°C, cloud cover okta 7, moderate breeze, clear visibility, dry                 |
| Vantage Point | VP2 | 4 | 30/04/2012 | 15:45 | 30°C, clear, moderate breeze, clear visibility, dry                              |
| Vantage Point | VP3 | 1 | 06/04/2012 | 09:32 | 13°C, cloud cover okta 2, moderate breeze, clear visibility, dry                 |
| Vantage Point | VP3 | 2 | 09/04/2012 | 06:50 | 7°C, cloud cover okta 7, still, clear visibility, dry                            |
| Vantage Point | VP3 | 3 | 17/04/2012 | 11:48 | 15°C, cloud cover okta 4, moderate breeze, clear visibility, dry                 |
| Vantage Point | VP3 | 4 | 25/04/2012 | 06:48 | 7°C, cloud cover okta 5, still, clear visibility, dry                            |
| Vantage Point | VP4 | 1 | 16/04/2012 | 11:05 | 17°C, clear, moderate breeze, clear visibility, dry                              |
| Vantage Point | VP4 | 2 | 21/04/2012 | 12:10 | 15°C, cloud cover okta 5, moderate breeze, clear visibility, dry                 |

Cibuk wind farm – additional vantage point survey

|               |     |   |            |       |   |
|---------------|-----|---|------------|-------|---|
| Vantage Point | VP4 | 3 | 22/04/2012 | 06:10 | 7°C, cloud cover okta 4, moderate breeze, clear visibility, dry         |
| Vantage Point | VP4 | 4 | 30/04/2012 | 18:00 | 27°C, clear, moderate breeze, clear visibility, dry                     |
| Vantage Point | VP5 | 1 | 06/04/2012 | 07:10 | 10°C, cloud cover okta 3, moderate breeze, dry, clear visibility        |
| Vantage Point | VP5 | 2 | 09/04/2012 | 11:15 | 10°C, cloud cover okta 6, still, dry, clear visibility                  |
| Vantage Point | VP5 | 3 | 17/04/2012 | 09:20 | 10°C, cloud cover okta 4, moderate breeze, dry, clear visibility        |
| Vantage Point | VP5 | 4 | 25/04/2012 | 11:23 | 13°C, cloud cover okta 5, still, dry, clear visibility                  |
| Vantage Point | VP6 | 1 | 06/04/2012 | 11:55 | 15°C, cloud cover okta 2, moderate breeze, dry, clear visibility        |
| Vantage Point | VP6 | 2 | 09/04/2012 | 09:07 | 10°C, cloud cover okta 8, still, dry, clear visibility                  |
| Vantage Point | VP6 | 3 | 17/04/2012 | 07:05 | 10°C, cloud cover okta 2, moderate breeze, dry, clear visibility        |
| Vantage Point | VP6 | 4 | 25/04/2012 | 09:10 | 10°C, cloud cover okta 5, still, dry, clear visibility                  |
| Vantage Point | VP1 | 1 | 12/05/2012 | 06:05 | 13°C, clear, still, dry, clear visibility                               |
| Vantage Point | VP1 | 2 | 15/05/2012 | 08:20 | 24°C, clear, gentle breeze, dry, clear visibility                       |
| Vantage Point | VP1 | 3 | 19/05/2012 | 10:55 | 20°C, cloud cover okta 1, moderate breeze, dry, clear visibility        |
| Vantage Point | VP1 | 4 | 19/05/2012 | 13:10 | 20°C, cloud cover okta 1, moderate breeze, dry, clear visibility        |
| Vantage Point | VP2 | 1 | 12/05/2012 | 10:35 | 29°C, clear, light breeze, dry, clear visibility                        |
| Vantage Point | VP2 | 2 | 19/05/2012 | 08:30 | 15°C, clear, light breeze, dry, clear visibility                        |
| Vantage Point | VP2 | 3 | 21/05/2012 | 12:10 | 20°C, cloud cover okta 8, strong wind, dry, clear visibility            |
| Vantage Point | VP2 | 4 | 29/05/2012 | 07:49 | 15°C, cloud cover okta 8, moderate breeze, dry, clear visibility        |
| Vantage Point | VP3 | 1 | 19/05/2012 | 11:27 | 20°C, cloud cover okta 1, moderate breeze, dry, clear visibility        |
| Vantage Point | VP3 | 2 | 19/05/2012 | 13:43 | 22°C, cloud cover okta 1, gentle breeze, dry, clear visibility          |
| Vantage Point | VP3 | 3 | 28/05/2012 | 07:10 | 15°C, cloud cover okta 3, dry, clear visibility                         |
| Vantage Point | VP3 | 4 | 30/05/2012 | 09:30 | 20°C, cloud cover okta 3, light breeze, dry, clear visibility           |
| Vantage Point | VP4 | 1 | 19/05/2012 | 11:30 | 20°C, cloud cover okta 3, dry, still, clear visibility                  |
| Vantage Point | VP4 | 2 | 19/05/2012 | 13:30 | 20°C, cloud cover okta 2, still, dry, clear visibility                  |
| Vantage Point | VP4 | 3 | 21/05/2012 | 12:05 | 20°C, cloud cover okta 7, strong wind, dry, clear visibility            |
| Vantage Point | VP4 | 4 | 29/05/2012 | 10:00 | 15°C, cloud cover okta 8, moderate breeze, light rain, clear visibility |
| Vantage Point | VP5 | 1 | 19/05/2012 | 08:46 | 15°C, clear, still, dry, clear visibility                               |
| Vantage Point | VP5 | 2 | 20/05/2012 | 09:36 | 20°C, cloud cover okta 1, moderate breeze, dry, clear visibility        |
| Vantage Point | VP5 | 3 | 20/05/2012 | 11:51 | 20°C, cloud cover okta 3, dry, gentle breeze, clear visibility          |
| Vantage Point | VP5 | 4 | 28/05/2012 | 09:25 | 15°C, cloud cover okta 1, still, dry, clear visibility                  |
| Vantage Point | VP6 | 1 | 19/05/2012 | 08:39 | 17°C, clear, still, dry, clear visibility                               |
| Vantage Point | VP6 | 2 | 20/05/2012 | 09:45 | 20°C, clear, still, dry, clear visibility                               |
| Vantage Point | VP6 | 3 | 20/05/2012 | 12:00 | 29°C, cloud okta 3, light breeze, dry, clear visibility                 |
| Vantage Point | VP6 | 4 | 28/05/2012 | 11:39 | 15°C, cloud okta 1, still dry, clear visibility                         |
| Vantage Point | VP1 | 1 | 09/06/2012 | 18:10 | 22°C, cloud cover okta 3, moderate breeze, dry, clear visibility        |
| Vantage Point | VP1 | 2 | 24/06/2012 | 06:30 | 24°C, clear, gentle breeze, dry, clear visibility                       |
| Vantage Point | VP1 | 3 | 29/06/2012 | 14:15 | 33°C, clear, still, dry, clear visibility                               |
| Vantage Point | VP1 | 4 | 29/06/2012 | 16:30 | 32°C, clear, still, dry, clear visibility                               |
| Vantage Point | VP2 | 1 | 09/06/2012 | 15:55 | 24°C, cloud cover okta 5, moderate breeze, dry, clear visibility        |
| Vantage Point | VP2 | 2 | 23/06/2012 | 09:45 | 29°C, clear, light breeze, dry, clear visibility                        |
| Vantage Point | VP2 | 3 | 23/06/2012 | 12:00 | 31°C, clear, light breeze, dry, clear visibility                        |
| Vantage Point | VP2 | 4 | 29/06/2012 | 07:25 | 22°C, clear, light breeze, dry, clear visibility                        |
| Vantage Point | VP3 | 1 | 12/06/2012 | 07:10 | 22°C, cloud cover okta 2, moderate breeze, dry, clear visibility        |
| Vantage Point | VP3 | 2 | 15/06/2012 | 11:13 | 30°C, clear, still, dry, clear visibility                               |
| Vantage Point | VP3 | 3 | 20/06/2012 | 09:21 | 24°C, cloud cover okta 1, still, dry, clear visibility                  |
| Vantage Point | VP3 | 4 | 22/06/2012 | 11:04 | 30°C, cloud cover okta 1, still, dry, clear visibility                  |
| Vantage Point | VP4 | 1 | 09/06/2012 | 13:40 | 25°C, cloud cover okta 3, strong wind, dry, clear visibility            |
| Vantage Point | VP4 | 2 | 23/06/2012 | 07:30 | 24°C, clear, gentle breeze, dry, clear visibility                       |

Cibuk wind farm – additional vantage point survey

|                      |                 |   |            |       |  |
|----------------------|-----------------|---|------------|-------|--|
| Vantage Point        | VP4             | 3 | 24/06/2012 | 09:00 | 28°C, clear, moderate breeze, dry, clear visibility              |
| Vantage Point        | VP4             | 4 | 24/06/2012 | 11:15 | 34°C, clear, light breeze, dry, clear visibility                 |
| Vantage Point        | VP5             | 1 | 12/06/2012 | 09:27 | 27°C, clear, moderate breeze, clear visibility                   |
| Vantage Point        | VP5             | 2 | 15/06/2012 | 06:47 | 25°C, cloud cover okta 3, still, dry, clear visibility           |
| Vantage Point        | VP5             | 3 | 20/06/2012 | 11:43 | 30°C, cloud cover okta 2, still, dry, clear visibility           |
| Vantage Point        | VP5             | 4 | 22/06/2012 | 08:45 | 25°C, cloud cover okta 1, still, dry, clear visibility           |
| Vantage Point        | VP6             | 1 | 12/06/2012 | 11:35 | 30°C, clear, moderate breeze, dry, clear visibility              |
| Vantage Point        | VP6             | 2 | 15/06/2012 | 08:55 | 25°C, cloud cover okta 1, still, dry, clear visibility           |
| Vantage Point        | VP6             | 3 | 20/06/2012 | 07:03 | 20°C, cloud cover okta 4, still, dry, clear visibility           |
| Vantage Point        | VP6             | 4 | 22/06/2012 | 06:37 | 23°C, clear, still, dry, clear visibility                        |
| Vantage Point        | VP1             | 1 | 07/07/2012 | 07:30 | 25°C, cloud cover okta 1, gentle breeze, dry, clear visibility   |
| Vantage Point        | VP1             | 2 | 07/07/2012 | 09:45 | 30°C, clear, gentle breeze, dry, clear visibility                |
| Vantage Point        | VP1             | 3 | 08/07/2012 | 10:32 | 30°C, clear, gentle breeze, dry, clear visibility                |
| Vantage Point        | VP1             | 4 | 14/07/2012 | 06:40 | 22°C, clear, still, dry, clear visibility                        |
| Vantage Point        | VP2             | 1 | 07/07/2012 | 07:50 | 25°C, clear, moderate breeze, dry, clear visibility              |
| Vantage Point        | VP2             | 2 | 07/07/2012 | 10:05 | 27°C, clear, light breeze, clear visibility                      |
| Vantage Point        | VP2             | 3 | 14/07/2012 | 09:05 | 26°C, clear, still, dry, clear visibility                        |
| Vantage Point        | VP2             | 4 | 27/07/2012 | 18:20 | 26°C, cloud cover okta 4, still, dry, clear visibility           |
| Vantage Point        | VP3             | 1 | 06/07/2012 | 09:20 | 30°C, cloud cover okta 1, gentle breeze, dry, clear visibility   |
| Vantage Point        | VP3             | 2 | 06/07/2012 | 11:35 | 30°C, cloud cover okta 1, gentle breeze, dry, clear visibility   |
| Vantage Point        | VP3             | 3 | 07/07/2012 | 07:32 | 30°C, cloud cover okta 2, still, dry, clear visibility           |
| Vantage Point        | VP3             | 4 | 07/07/2012 | 12:35 | 35°C, clear, gentle breeze, dry, clear visibility                |
| Vantage Point        | VP4             | 1 | 07/07/2012 | 12:40 | 32°C, clear, light breeze, dry, clear visibility                 |
| Vantage Point        | VP4             | 2 | 08/07/2012 | 10:40 | 30°C, clear, still, dry, clear visibility                        |
| Vantage Point        | VP4             | 3 | 10/07/2012 | 11:21 | 32°C, cloud cover okta 4, still, dry, clear visibility           |
| Vantage Point        | VP4             | 4 | 16/07/2012 | 06:43 | 25°C, cloud cover okta 2, still, dry, clear visibility           |
| Vantage Point        | VP5             | 1 | 06/07/2012 | 09:25 | 32°C, cloud cover okta 1, gentle breeze, dry, clear visibility   |
| Vantage Point        | VP5             | 2 | 06/07/2012 | 11:25 | 35°C, clear, still, dry, clear visibility                        |
| Vantage Point        | VP5             | 3 | 16/07/2012 | 08:43 | 25°C, cloud cover okta 2, still, dry, clear visibility           |
| Vantage Point        | VP5             | 4 | 16/07/2012 | 11:08 | 30°C, cloud cover okta 3, still, dry, clear visibility           |
| Vantage Point        | VP6             | 1 | 07/07/2012 | 09:48 | 35°C, cloud cover okta 1, still, dry, clear visibility           |
| Vantage Point        | VP6             | 2 | 07/07/2012 | 11:48 | 35°C, cloud cover okta 1, still, dry, clear visibility           |
| Vantage Point        | VP6             | 3 | 27/07/2012 | 13:45 | 27°C, cloud cover okta 5, light breeze, dry, clear visibility    |
| Vantage Point        | VP6             | 4 | 27/07/2012 | 16:00 | 28°C, cloud cover okta 5, moderate breeze, dry, clear visibility |
| Breeding bird survey | Survey square 1 | 1 | 29/03/2012 | 10:35 | sunny, still, dry  |
| Breeding bird survey | Survey square 1 | 2 | 11/04/2012 | 06:10 | sunny, strong wind, dry  |
| Breeding bird survey | Survey square 1 | 3 | 28/04/2012 | 07:35 | 15°C, sunny, still, dry  |
| Breeding bird survey | Survey square 1 | 4 | 18/05/2012 | 05:30 | 10°C, cloud cover okta 3, moderate breeze, dry                   |
| Breeding bird survey | Survey square 1 | 5 | 25/05/2012 | 08:15 | 20°C, sunny, light breeze, dry                                   |
| Breeding bird survey | Survey square 1 | 6 | 16/06/2012 | 08:20 | 20°C, sunny, still, dry  |
| Breeding bird survey | Survey square 1 | 7 | 27/06/2012 | 05:45 | 20°C, sunny, still, dry  |
| Breeding bird survey | Survey square 1 | 8 | 14/07/2012 | 05:20 | sunny, still, dry  |
| Breeding bird survey | Survey square 1 | 9 | 15/07/2012 | 09:45 | sunny, still, dry  |

Cibuk wind farm – additional vantage point  
survey

|                      |                 |   |            |       |  |
|----------------------|-----------------|---|------------|-------|--|
| Breeding bird survey | Survey square 2 | 1 | 29/03/2012 | 09:10 | sunny, still, dry                              |
| Breeding bird survey | Survey square 2 | 2 | 11/04/2012 | 07:30 | sunny, strong breeze, dry                      |
| Breeding bird survey | Survey square 2 | 3 | 28/04/2012 | 06:15 | sunny, still, dry                              |
| Breeding bird survey | Survey square 2 | 4 | 18/05/2012 | 06:45 | 10°C, cloud cover okta 2, moderate breeze, dry |
| Breeding bird survey | Survey square 2 | 5 | 25/05/2012 | 06:50 | 20°C, sunny, light breeze, dry                 |
| Breeding bird survey | Survey square 2 | 6 | 16/06/2012 | 06:10 | 20°C, sunny, still, dry                        |
| Breeding bird survey | Survey square 2 | 7 | 27/06/2012 | 07:15 | 20°C, sunny, still, dry                        |
| Breeding bird survey | Survey square 2 | 8 | 08/07/2012 | 09:05 | sunny, still, dry                              |
| Breeding bird survey | Survey square 2 | 9 | 15/07/2012 | 06:20 | sunny, still, dry                              |
| Breeding bird survey | Survey square 3 | 1 | 29/03/2012 | 07:35 | sunny, still, dry                              |
| Breeding bird survey | Survey square 3 | 2 | 11/04/2012 | 08:50 | sunny, strong breeze, dry                      |
| Breeding bird survey | Survey square 3 | 3 | 28/04/2012 | 08:55 | 20°C, sunny, still, dry                        |
| Breeding bird survey | Survey square 3 | 4 | 18/05/2012 | 07:40 | 10°C, cloud cover okta 2, still, dry           |
| Breeding bird survey | Survey square 3 | 5 | 20/05/2012 | 07:45 | sunny, still, dry                              |
| Breeding bird survey | Survey square 3 | 6 | 16/06/2012 | 07:30 | 20°C, sunny, still, dry                        |
| Breeding bird survey | Survey square 3 | 7 | 27/06/2012 | 08:30 | 25°C, sunny, still, dry                        |
| Breeding bird survey | Survey square 3 | 8 | 08/07/2012 | 07:30 | sunny, still, dry                              |
| Breeding bird survey | Survey square 3 | 9 | 15/07/2012 | 08:15 | sunny, still, dry                              |
| Breeding bird survey | Survey square 4 | 1 | 28/03/2012 | 09:55 | sunny, still, dry                              |
| Breeding bird survey | Survey square 4 | 2 | 04/04/2012 | 07:00 | cloud cover okta 3, moderate breeze, dry       |
| Breeding bird survey | Survey square 4 | 3 | 24/04/2012 | 09:45 | cloud cover okta 5, still dry                  |
| Breeding bird survey | Survey square 4 | 4 | 25/05/2012 | 07:10 | 15°C, cloud cover okta 1, still, dry           |
| Breeding bird survey | Survey square 4 | 5 | 30/05/2012 | 09:10 | 20°C, cloud cover okta 1, still, dry           |
| Breeding bird survey | Survey square 4 | 6 | 13/06/2012 | 09:12 | sunny, still, dry                              |
| Breeding bird survey | Survey square 4 | 7 | 23/06/2012 | 06:38 | sunny, still, dry                              |
| Breeding bird survey | Survey square 4 | 8 | 06/07/2012 | 07:13 | sunny, still, dry                              |
| Breeding bird survey | Survey square 4 | 9 | 18/07/2012 | 08:55 | cloud cover okta 2, still, dry                 |
| Breeding bird survey | Survey square 5 | 1 | 28/03/2012 | 08:35 | sunny, still, dry                              |
| Breeding bird survey | Survey square 5 | 2 | 04/04/2012 | 08:25 | cloud cover okta 3, moderate breeze, dry       |
| Breeding bird survey | Survey square 5 | 3 | 24/04/2012 | 07:15 | cloud cover okta 7, still, dry                 |
| Breeding bird survey | Survey square 5 | 4 | 21/05/2012 | 09:55 | cloud cover okta 8, strong breeze, dry         |

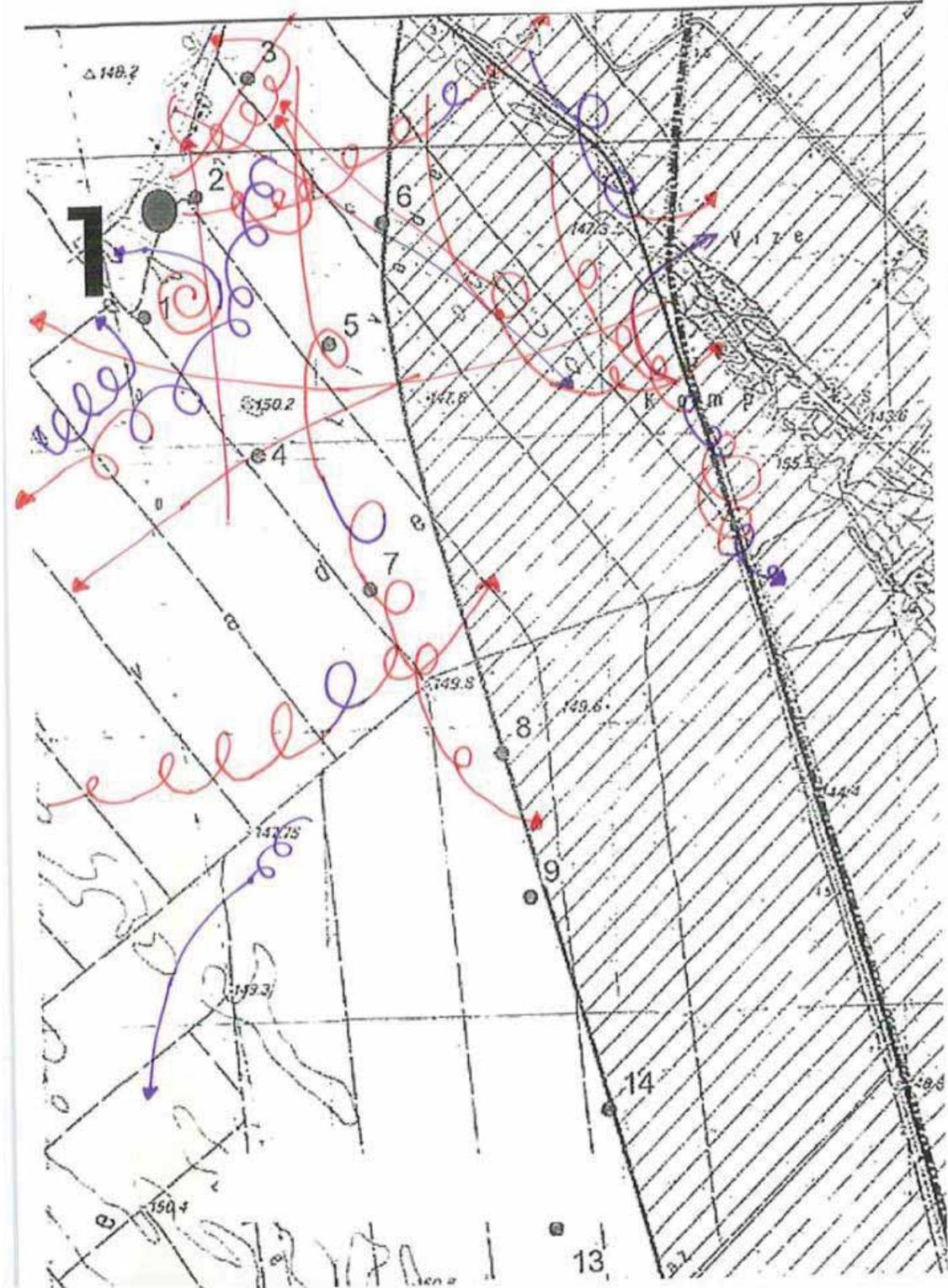
Cibuk wind farm – additional vantage point  
survey

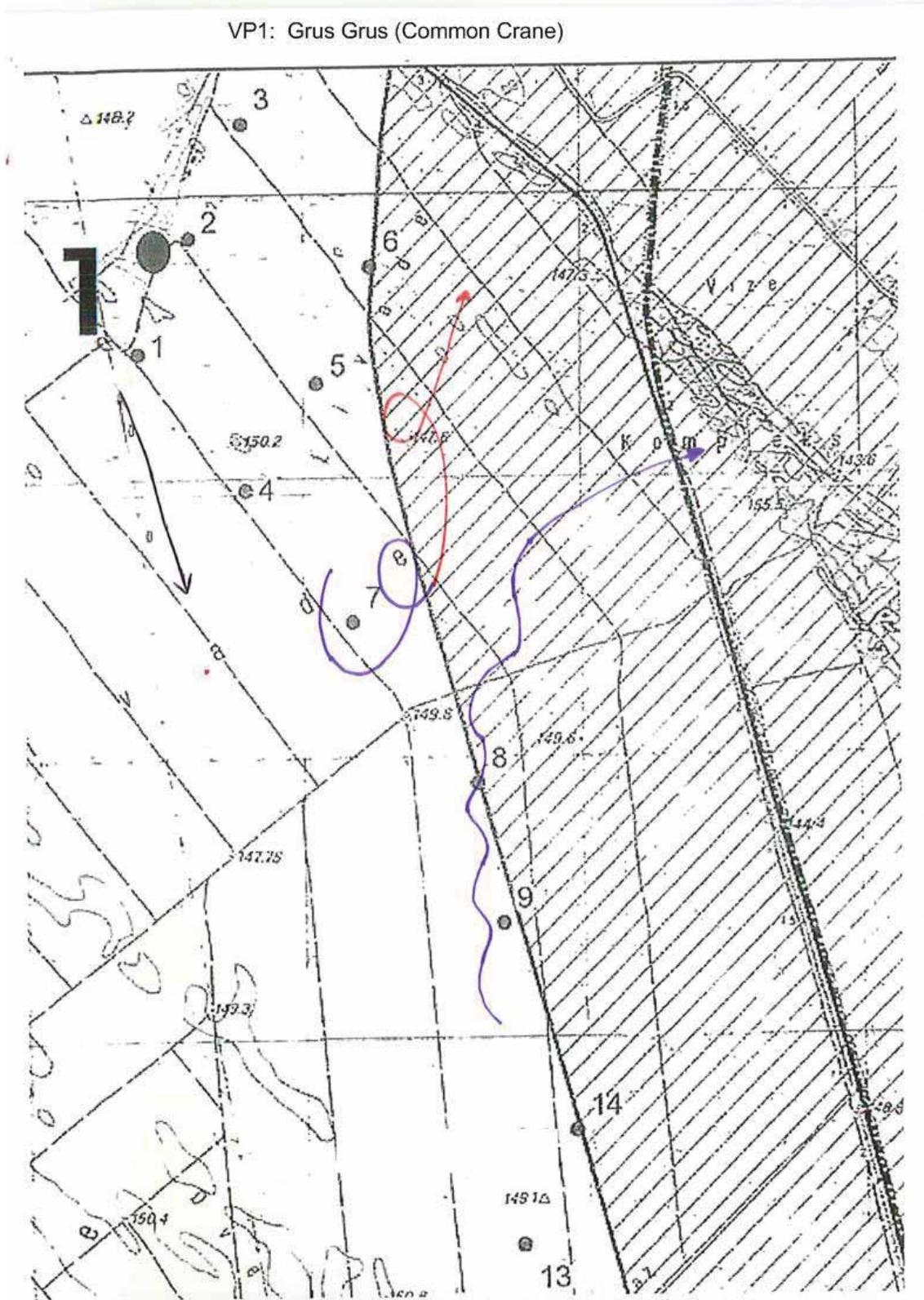
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|                      |                 |   |            |       |  |
|----------------------|-----------------|---|------------|-------|--|
| Breeding bird survey | Survey square 5 | 5 | 30/05/2012 | 06:47 | cloud cover okta 2, moderate breeze, dry |
| Breeding bird survey | Survey square 5 | 6 | 13/06/2012 | 11:25 | sunny, still, dry                        |
| Breeding bird survey | Survey square 5 | 7 | 23/06/2012 | 09:05 | sunny, still, dry                        |
| Breeding bird survey | Survey square 5 | 8 | 10/07/2012 | 07:10 | cloud cover okta 3, still, dry           |
| Breeding bird survey | Survey square 5 | 9 | 18/07/2012 | 11:02 | cloud cover okta 2, still, dry           |
| Breeding bird survey | Survey square 6 | 1 | 28/03/2012 | 07:15 | sunny, still, dry                        |
| Breeding bird survey | Survey square 6 | 2 | 04/04/2012 | 09:40 | cloud cover okta 3, moderate breeze, dry |
| Breeding bird survey | Survey square 6 | 3 | 24/04/2012 | 08:30 | cloud cover okta 7, still, dry           |
| Breeding bird survey | Survey square 6 | 4 | 21/05/2012 | 07:05 | cloud cover okta 8, strong breeze, dry   |
| Breeding bird survey | Survey square 6 | 5 | 30/05/2012 | 11:30 | sunny, moderate breeze, dry              |
| Breeding bird survey | Survey square 6 | 6 | 13/06/2012 | 06:50 | sunny, gentle breeze, dry                |
| Breeding bird survey | Survey square 6 | 7 | 23/06/2012 | 01:12 | sunny, still, dry                        |
| Breeding bird survey | Survey square 6 | 8 | 10/07/2012 | 09:03 | sunny, still, dry                        |
| Breeding bird survey | Survey square 6 | 9 | 18/07/2012 | 06:43 | sunny, still, dry                        |

## **Appendix B. Vantage point bird flight maps**

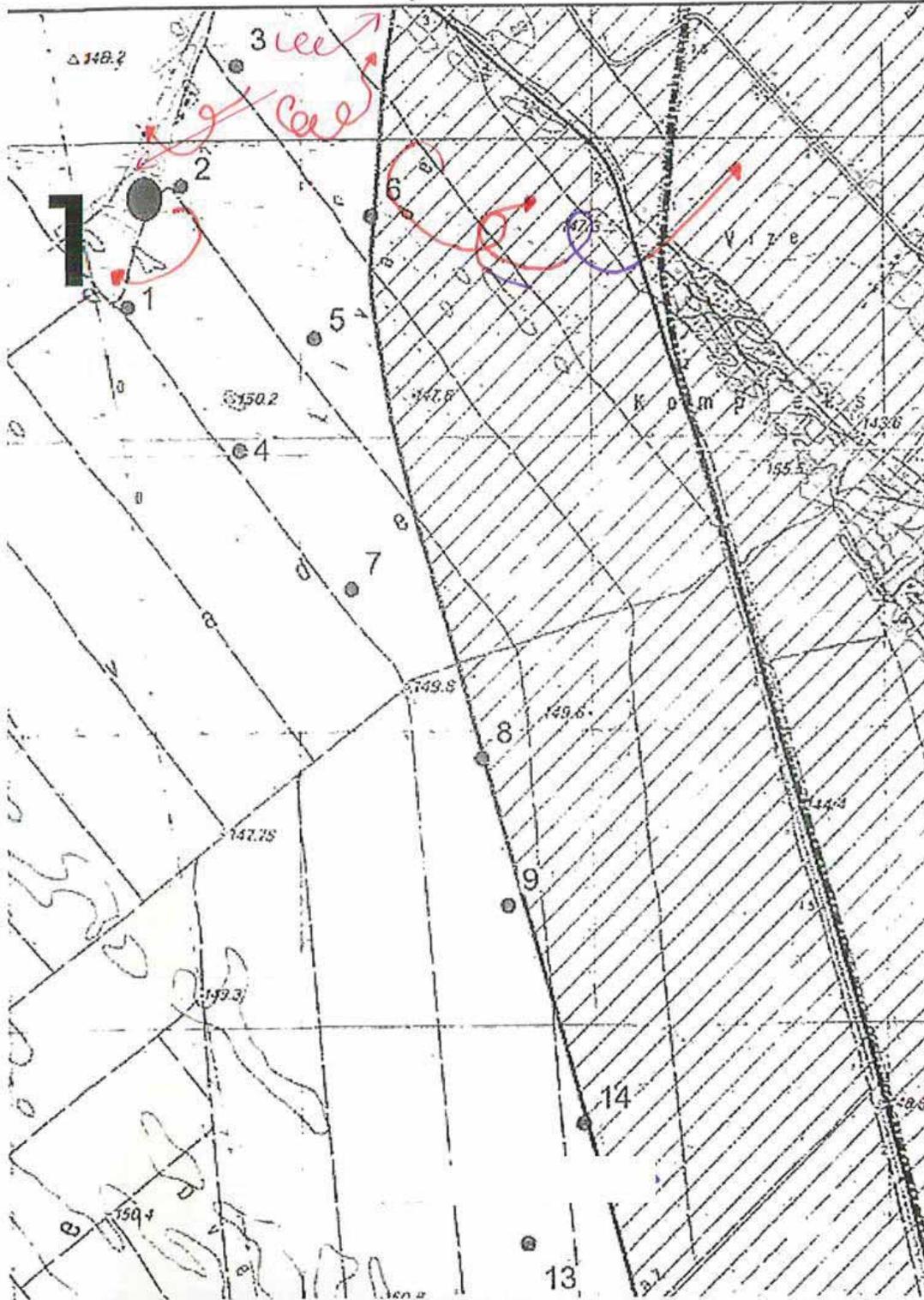
VP1: Buteo Buteo (Common Buzzard)



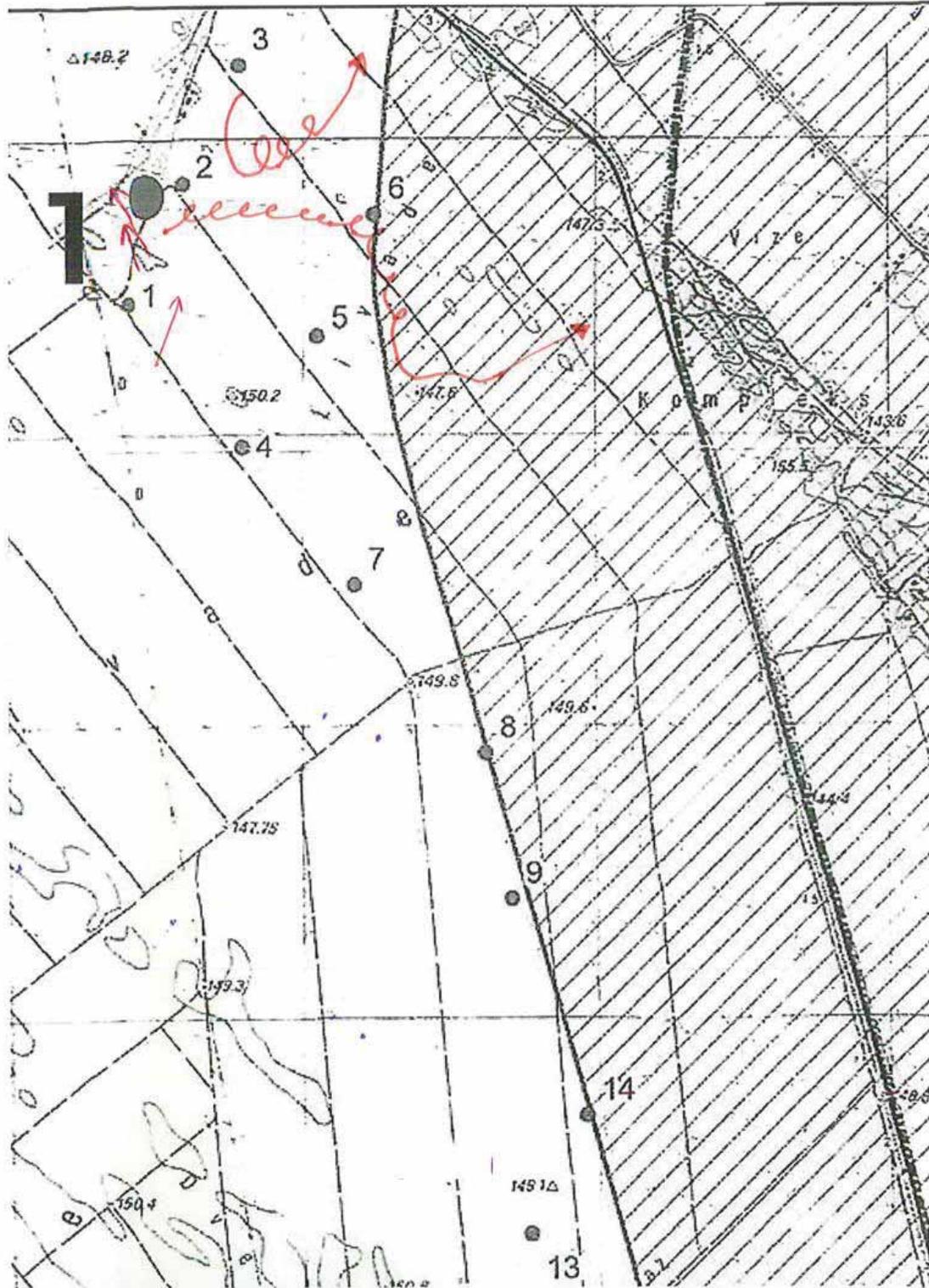




VP1: Falco Tinnunculus (Eurasian Kestrel)

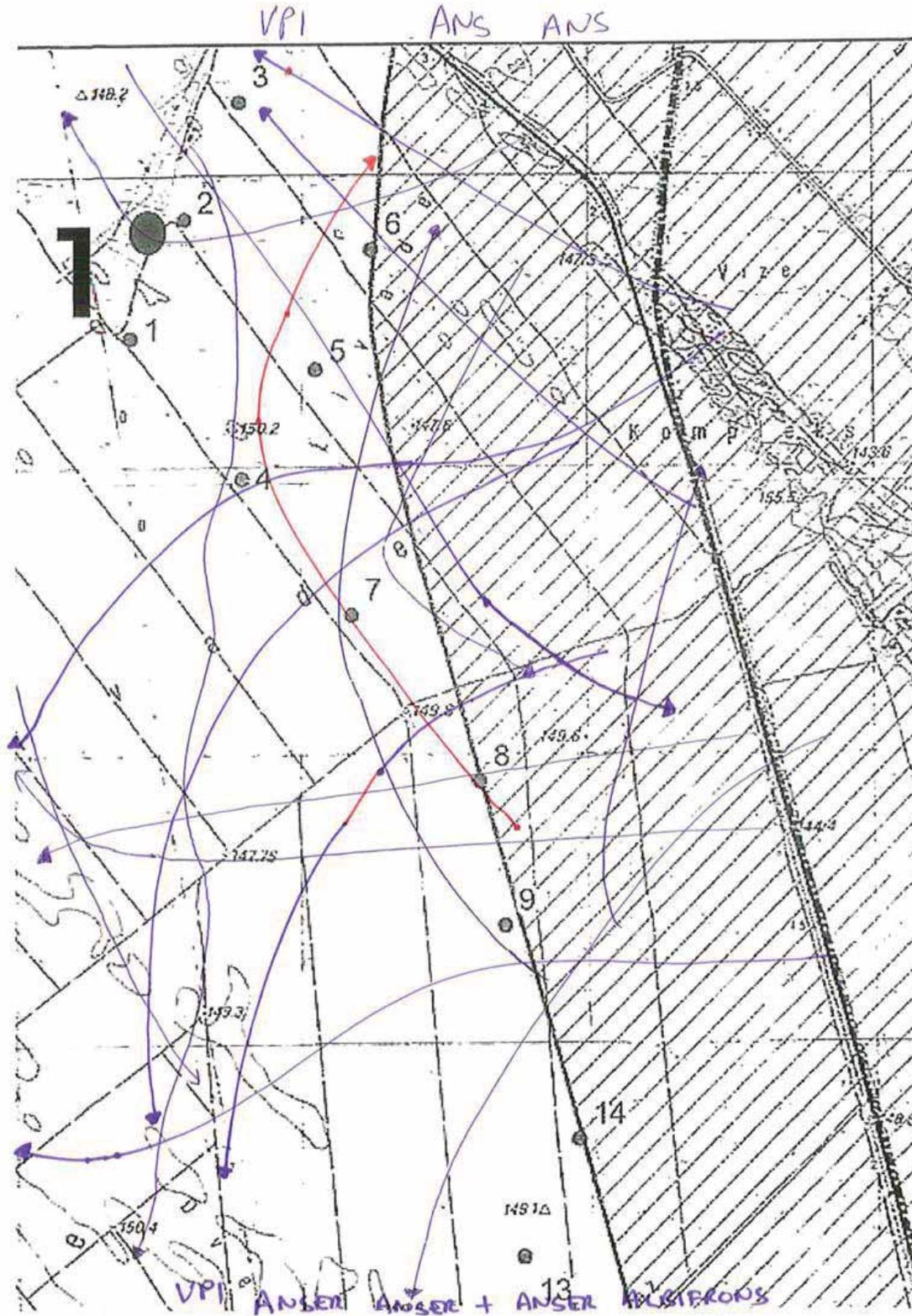


VP1: *Accipiter gentilus* (Northern Goshawk)

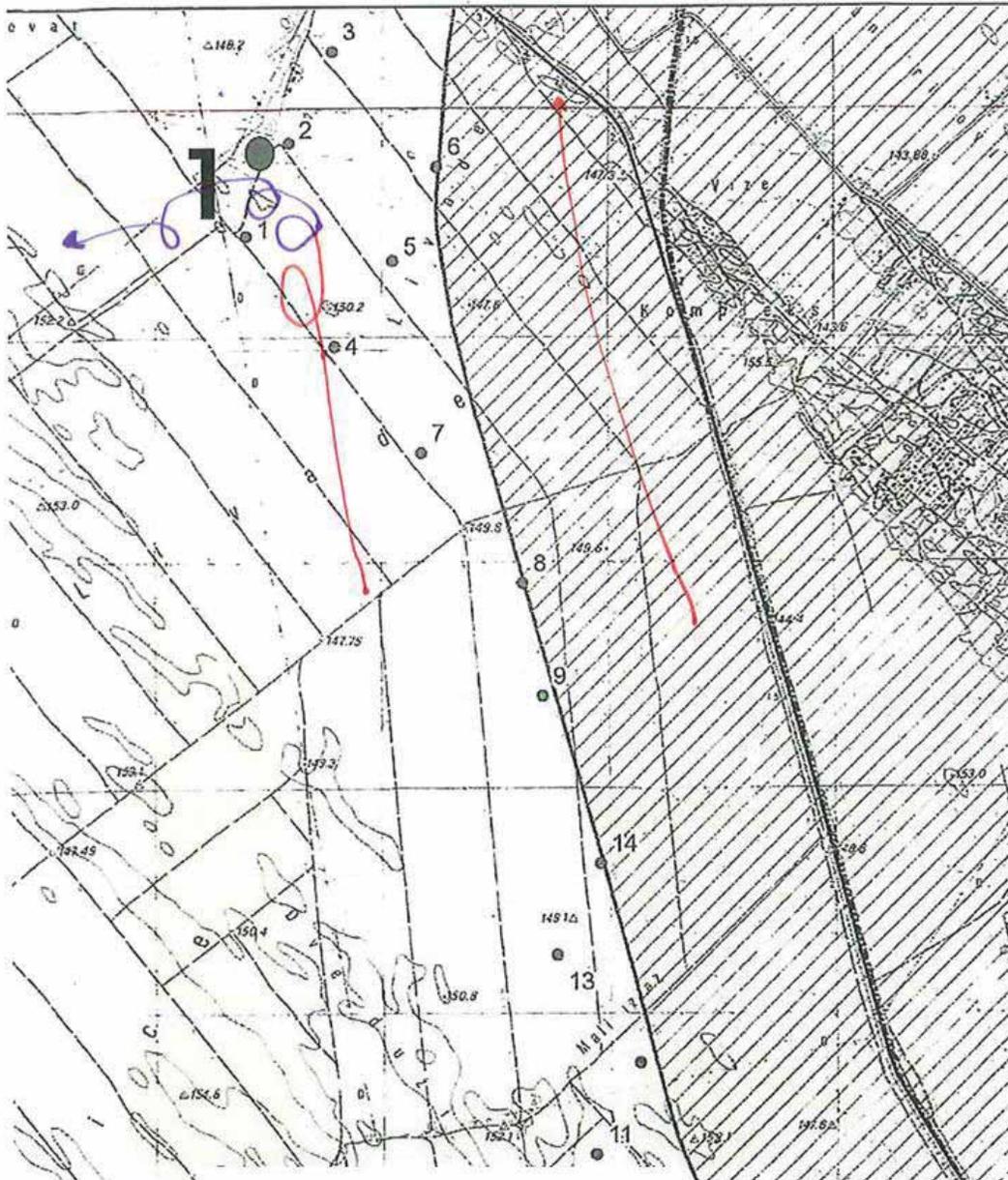




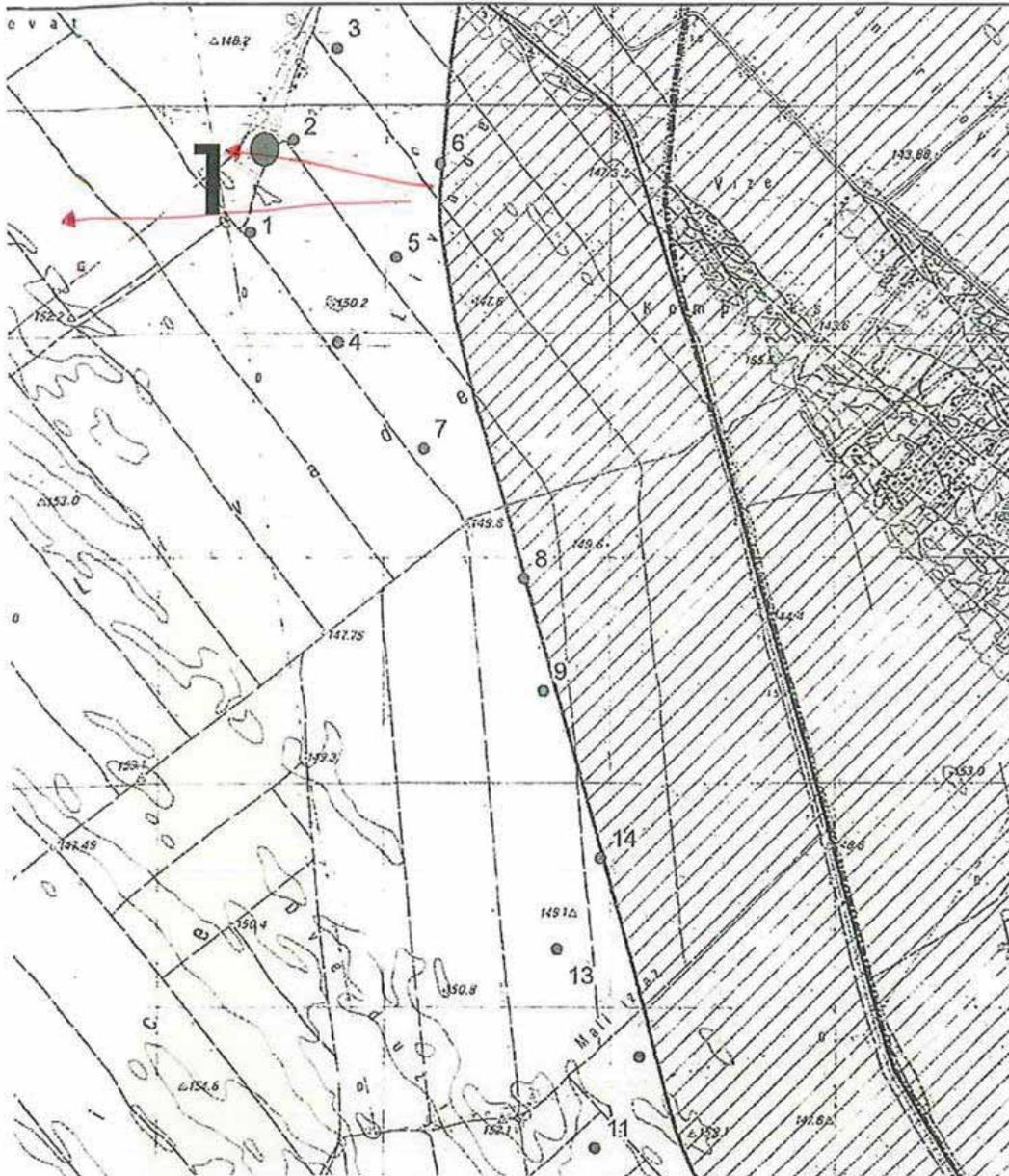




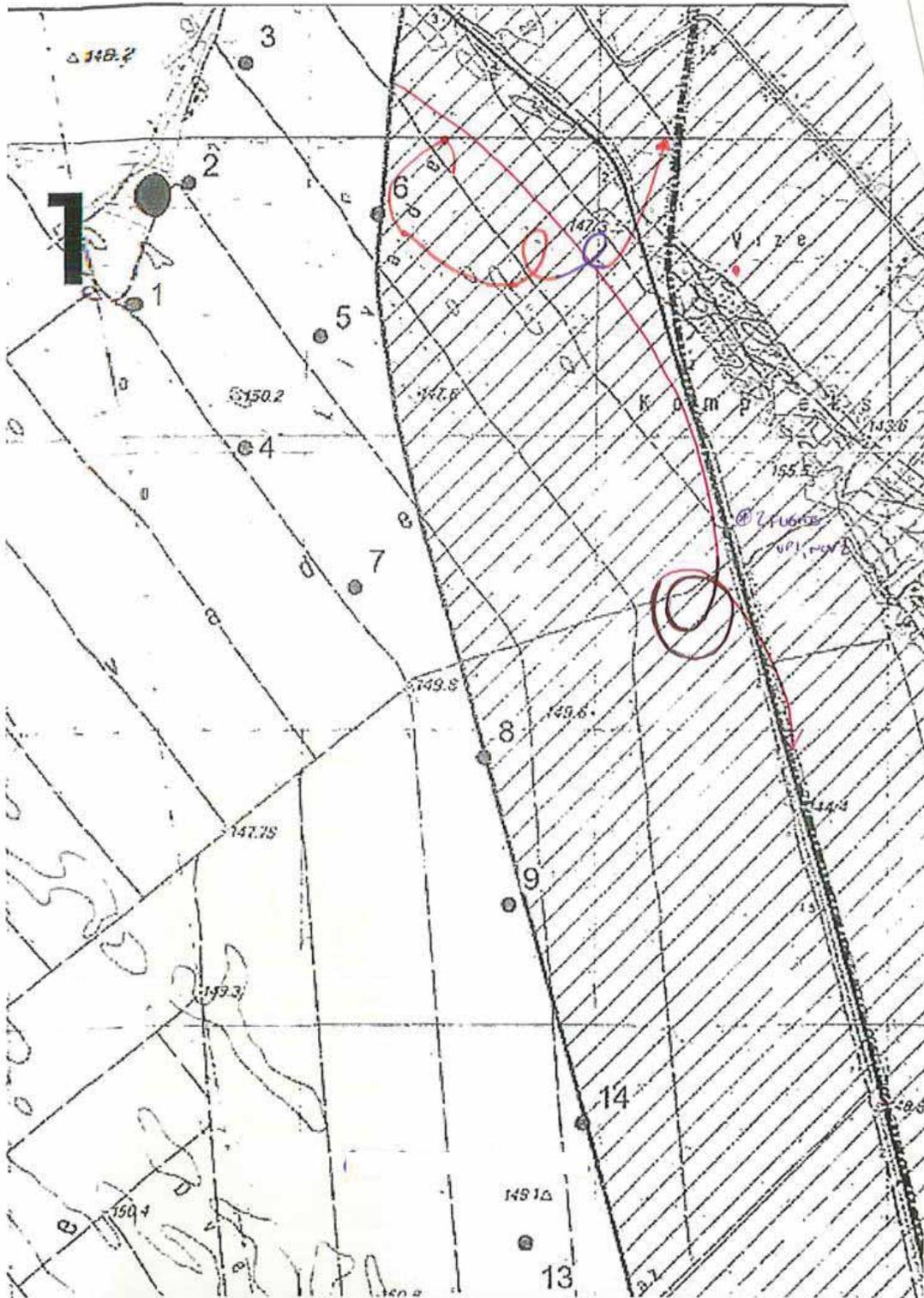
VP1: Circus cyaneus (Hen Harrier)



VP1: Falco columbarius (Merlin)



VP1: Accipiter gentilis (Northern Goshawk)

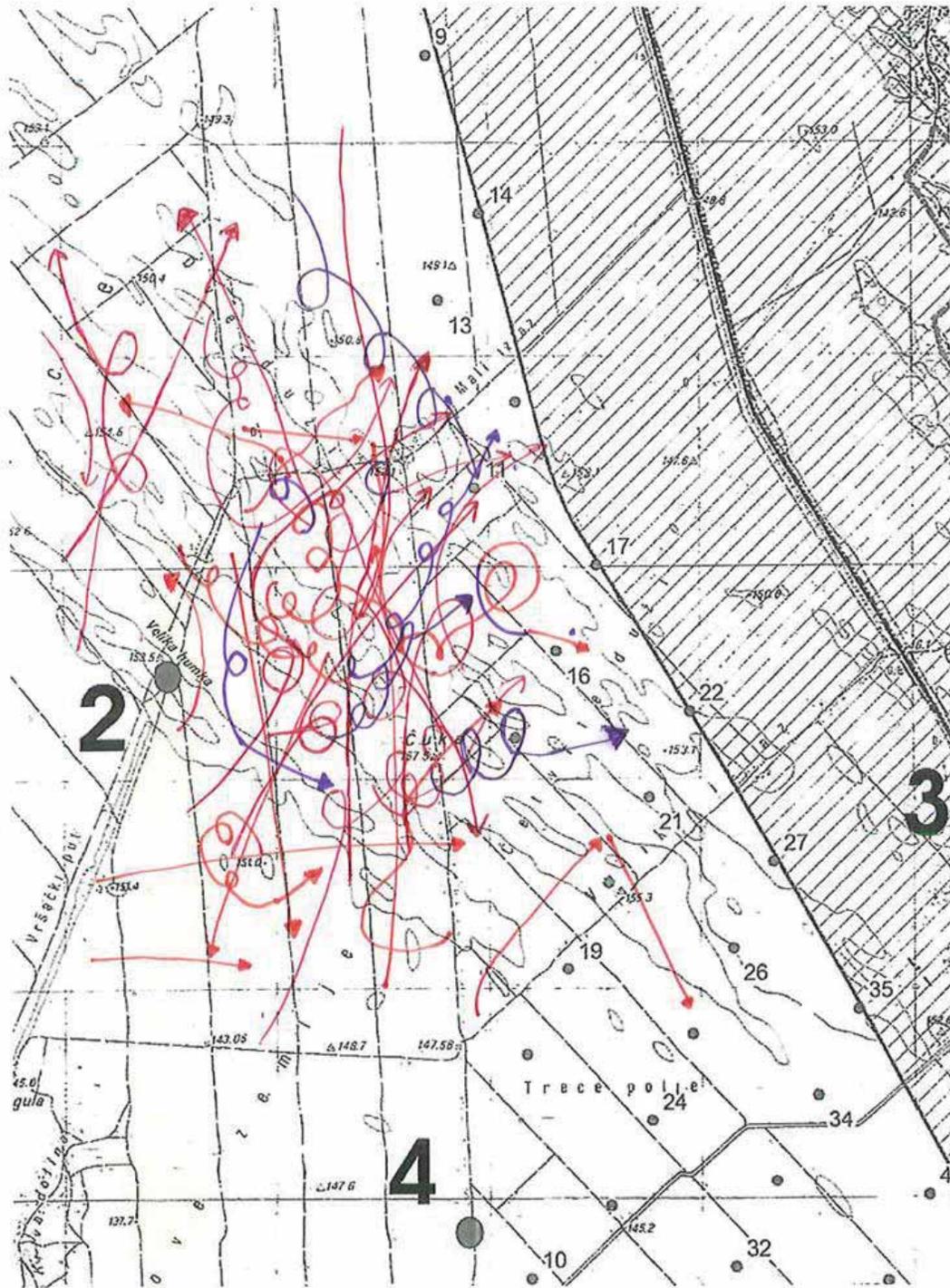


VP1: Falco cherrug (Saker Falcon)

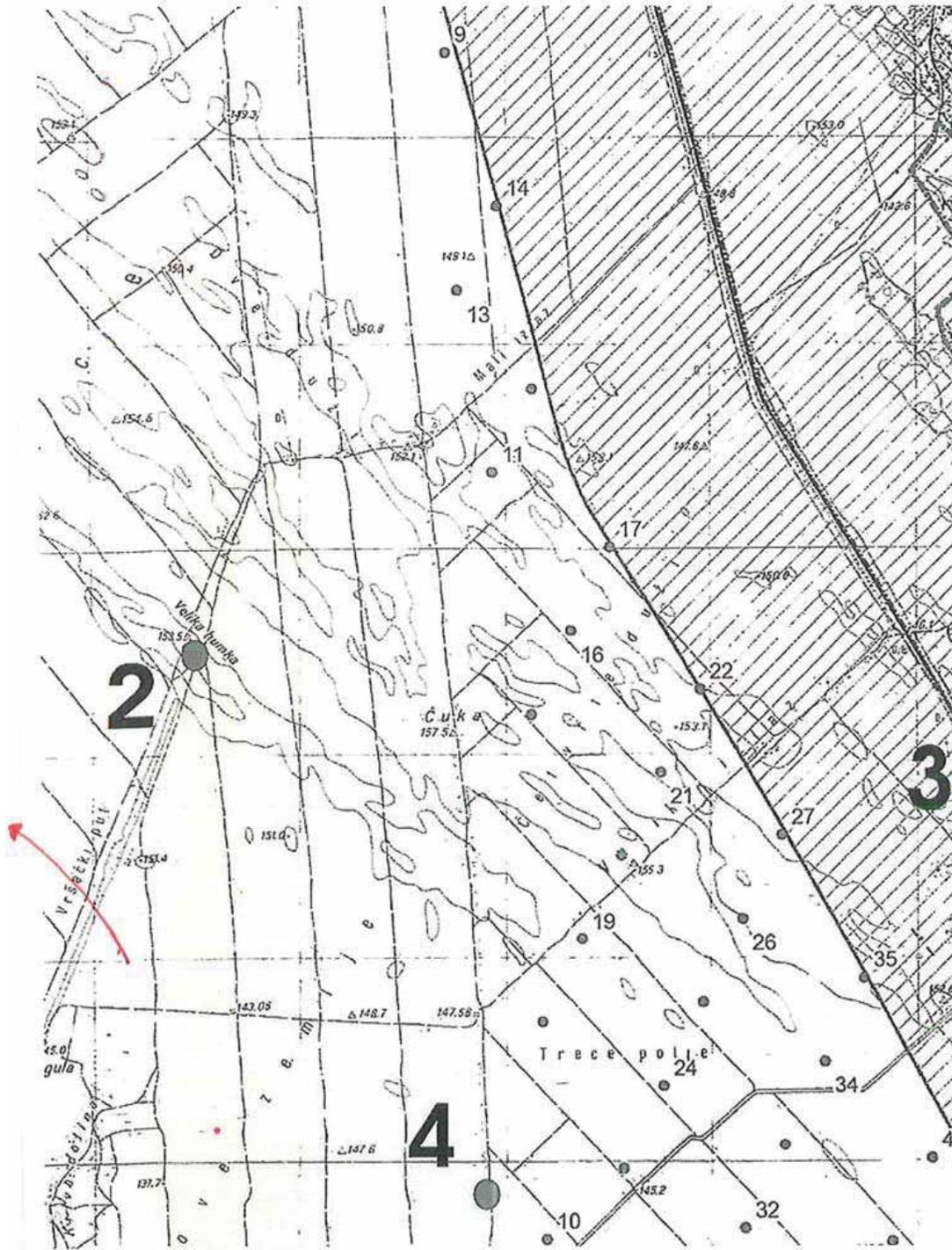




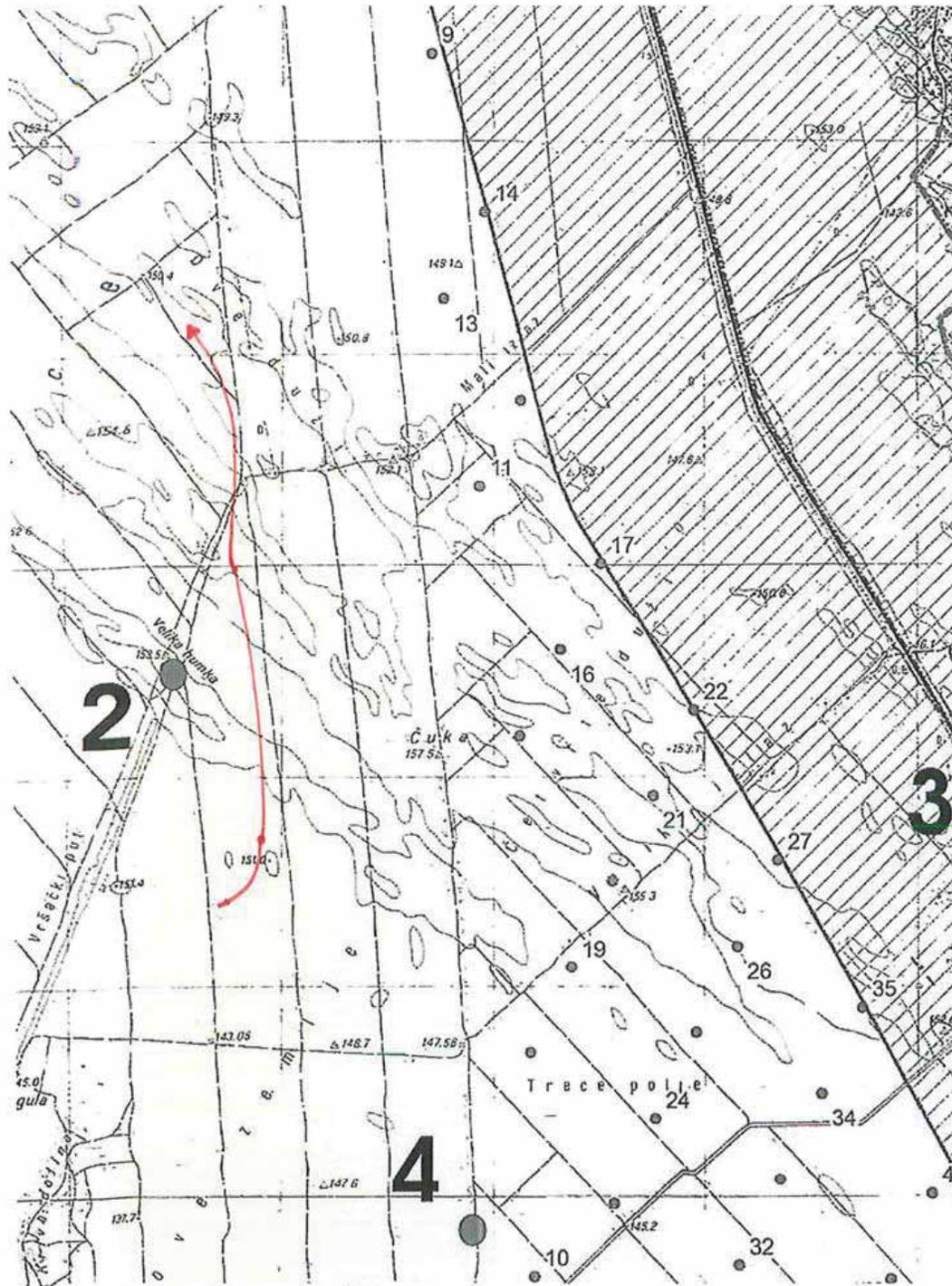
VP2: *Buteo buteo* (Common Buzzard)



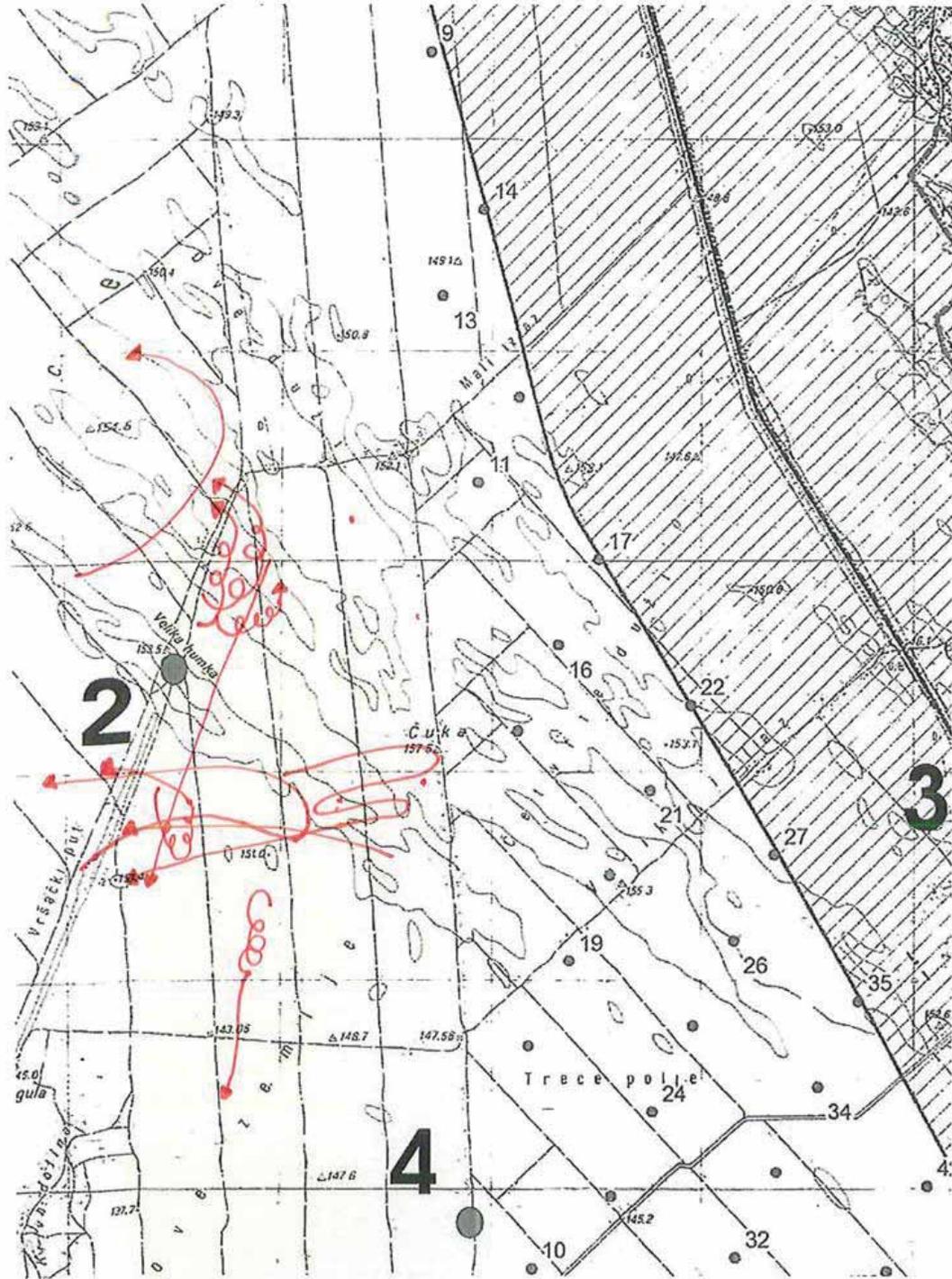
VP2: Grus Grus (Common Crane)



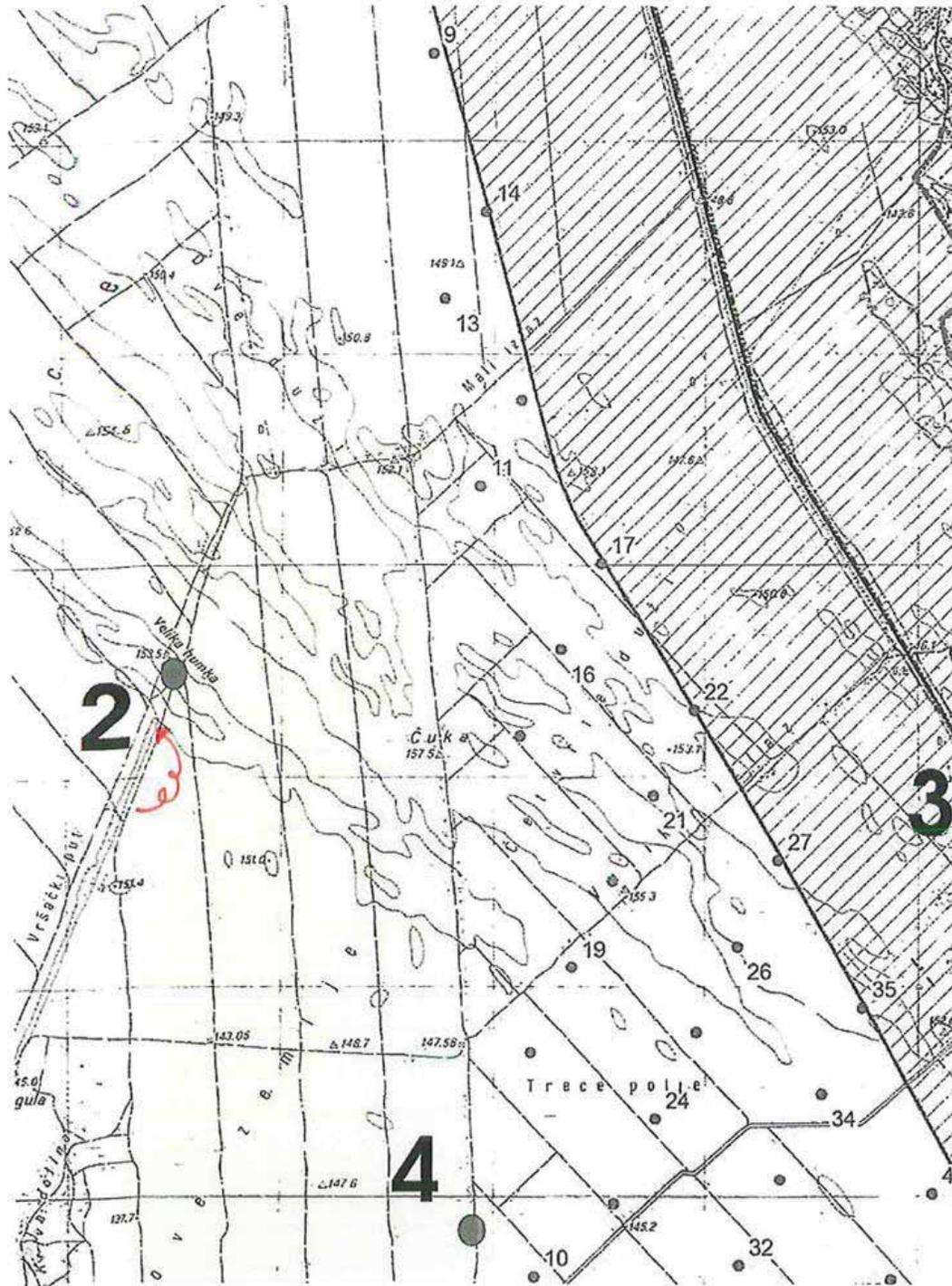
VP2: Falco Subbuteo (Eurasian Hobby)



VP2: *Falco tinnunculus* (Eurasian Kestrel)

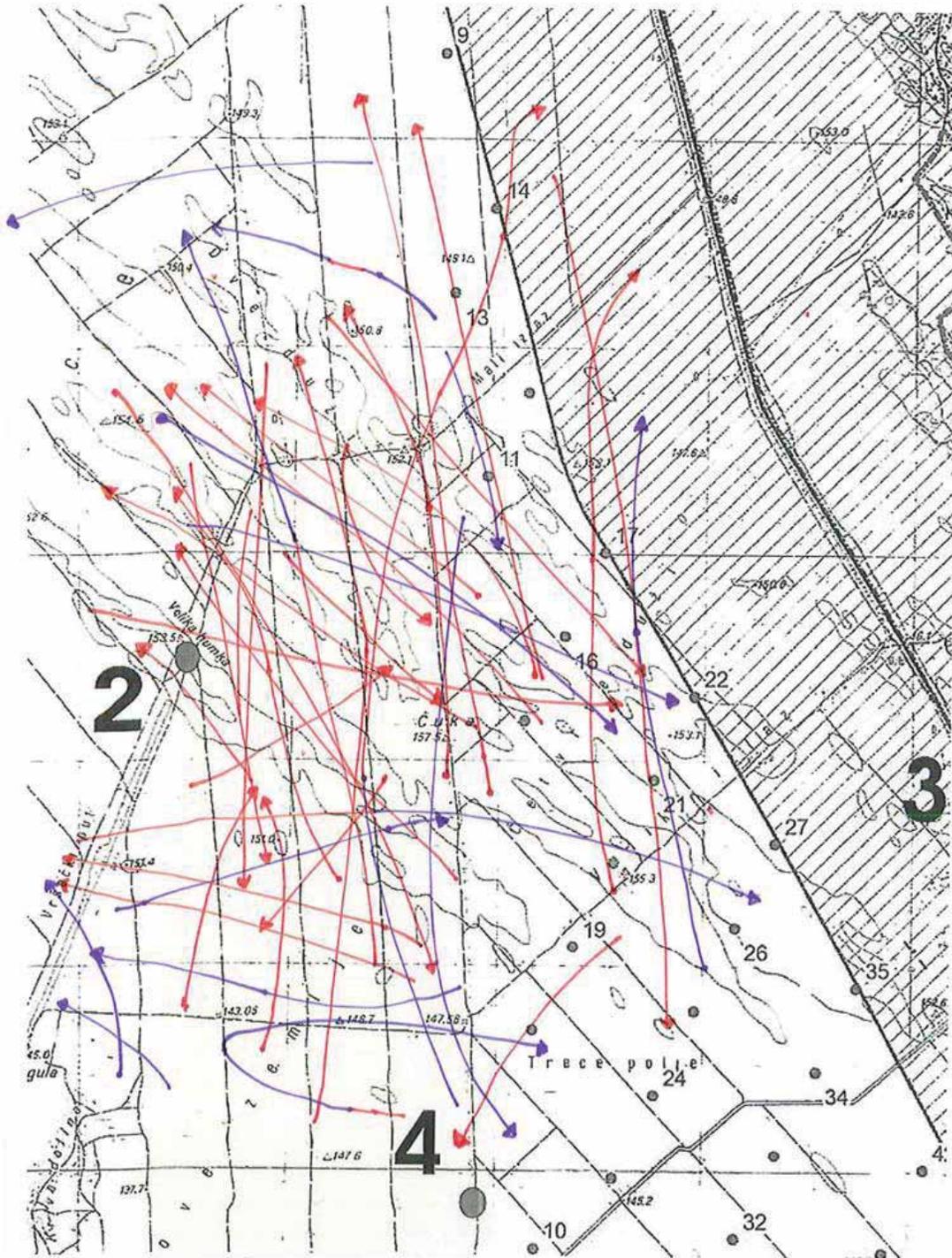


VP2: Accipiter nisus (Eurasian Sparrowhawk)





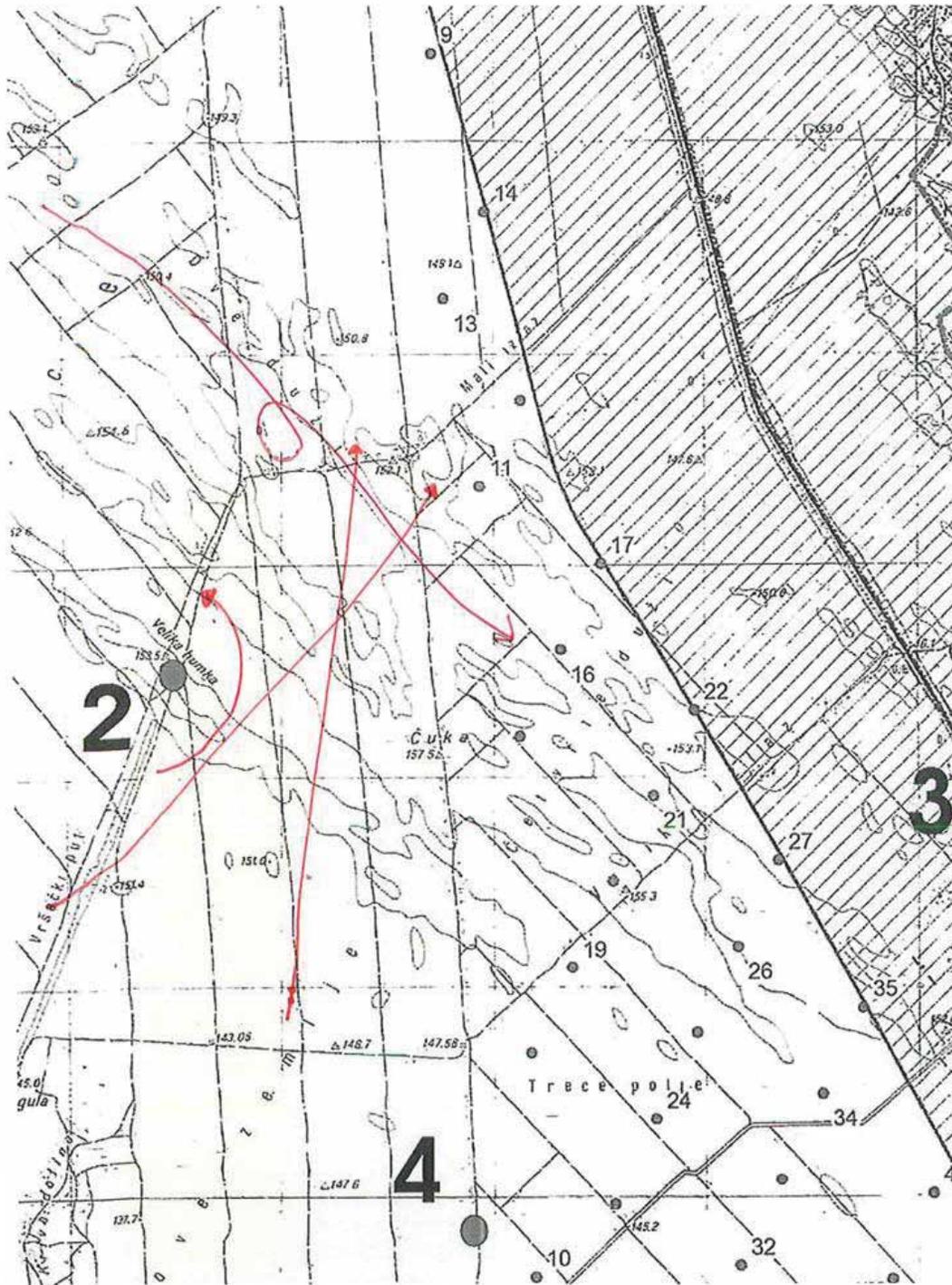
VP2: Anser Anser & Anser Albifrons (Grey geese (greylag goose and greater white-fronted goose))



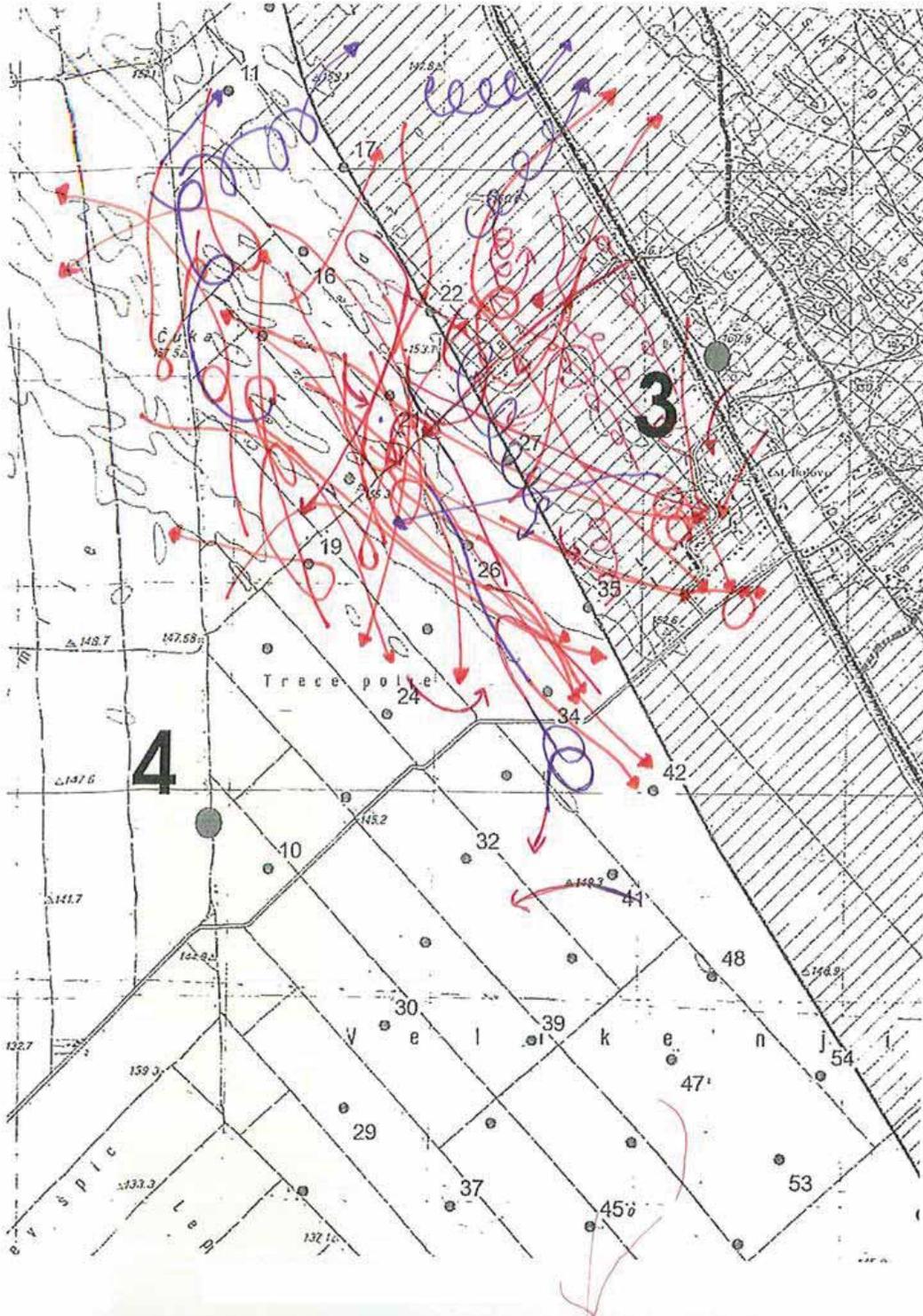




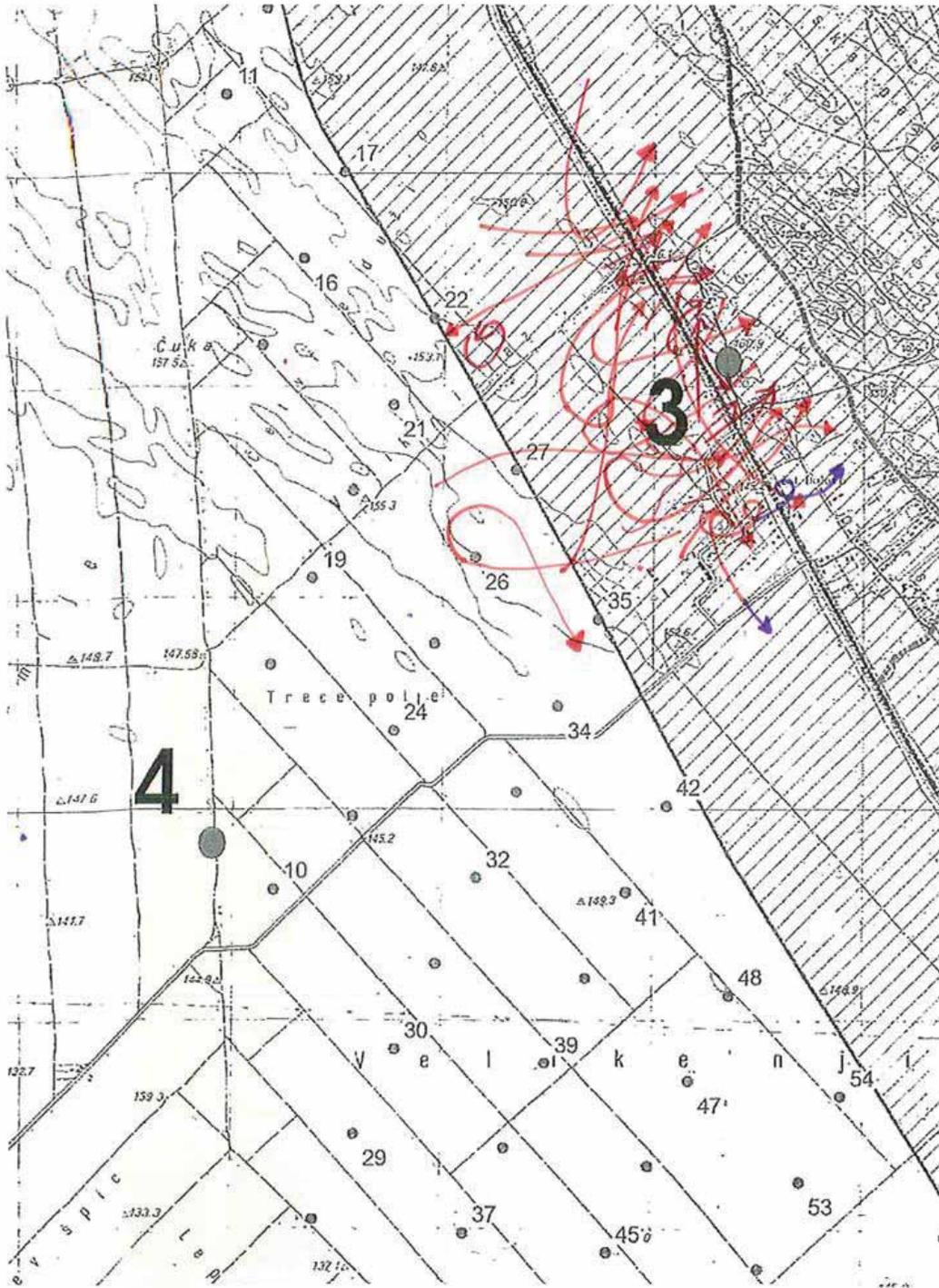
VP2: Circus Aeruginosus (Western Marsh Harrier)



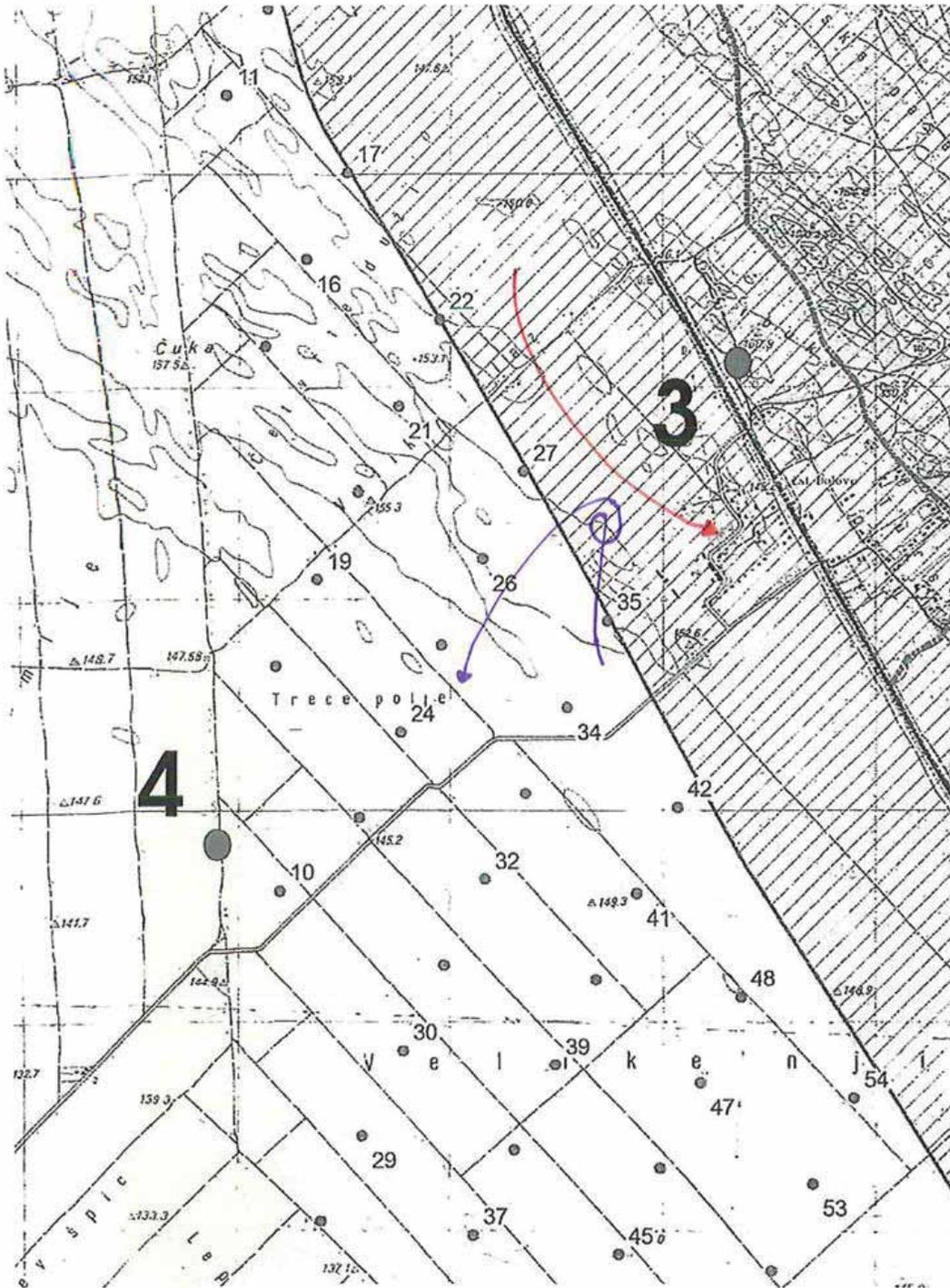
VP3: Buteo Buteo (Common Buzzard)



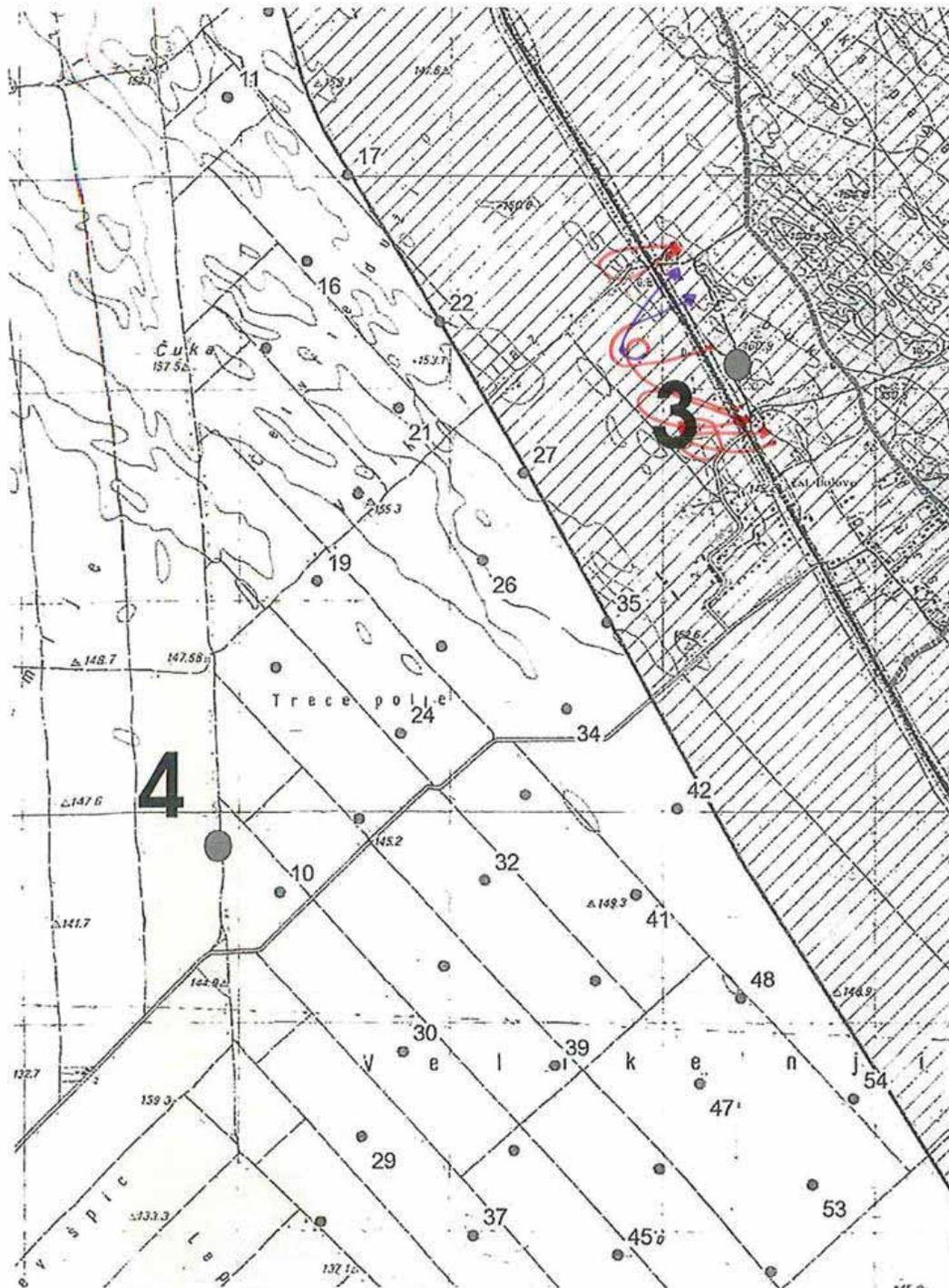
VP3: Falco Tinnunculus (Eurasian Kestrel)



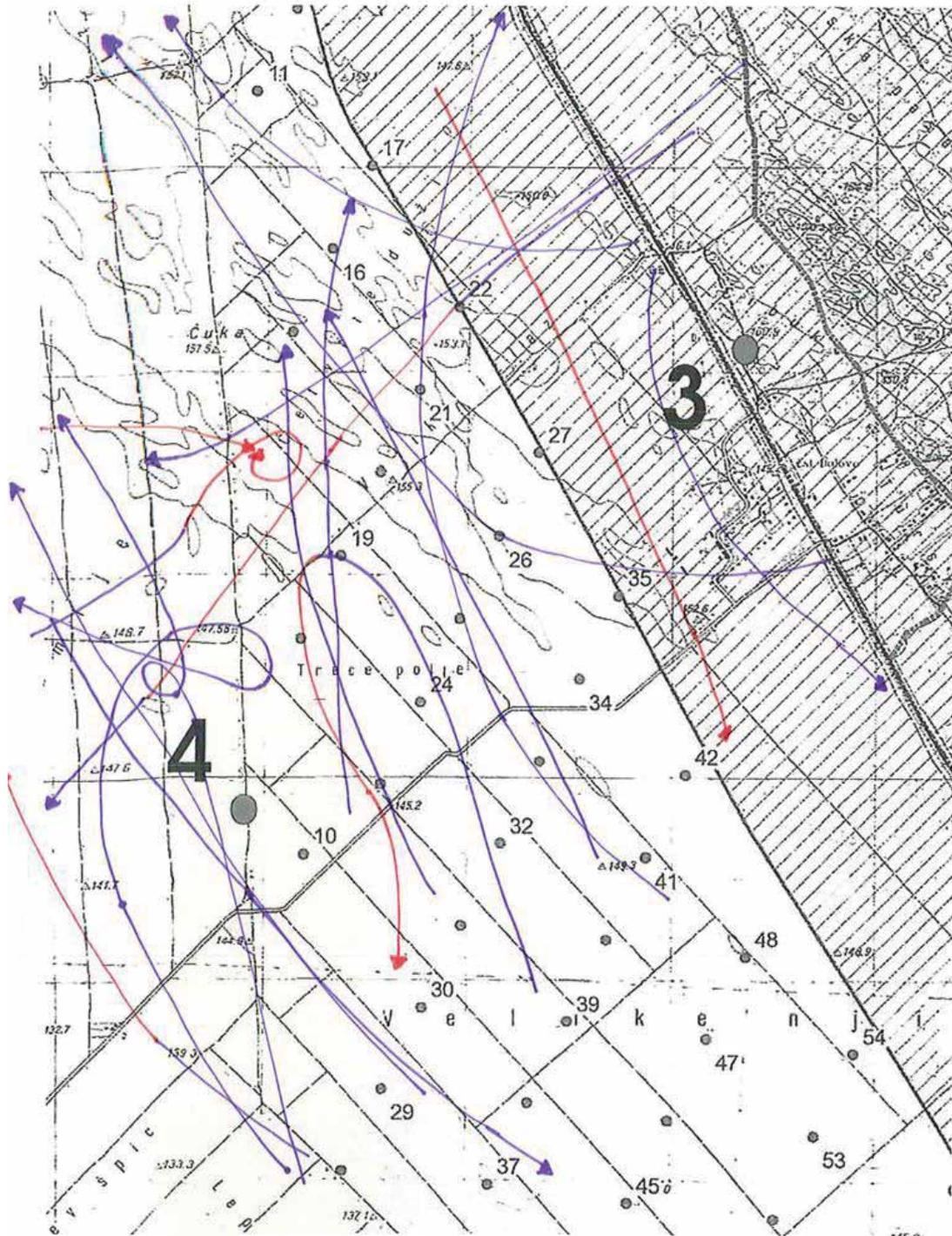
VP3: Accipiter Nisus (Eurasian Sparrowhawk)



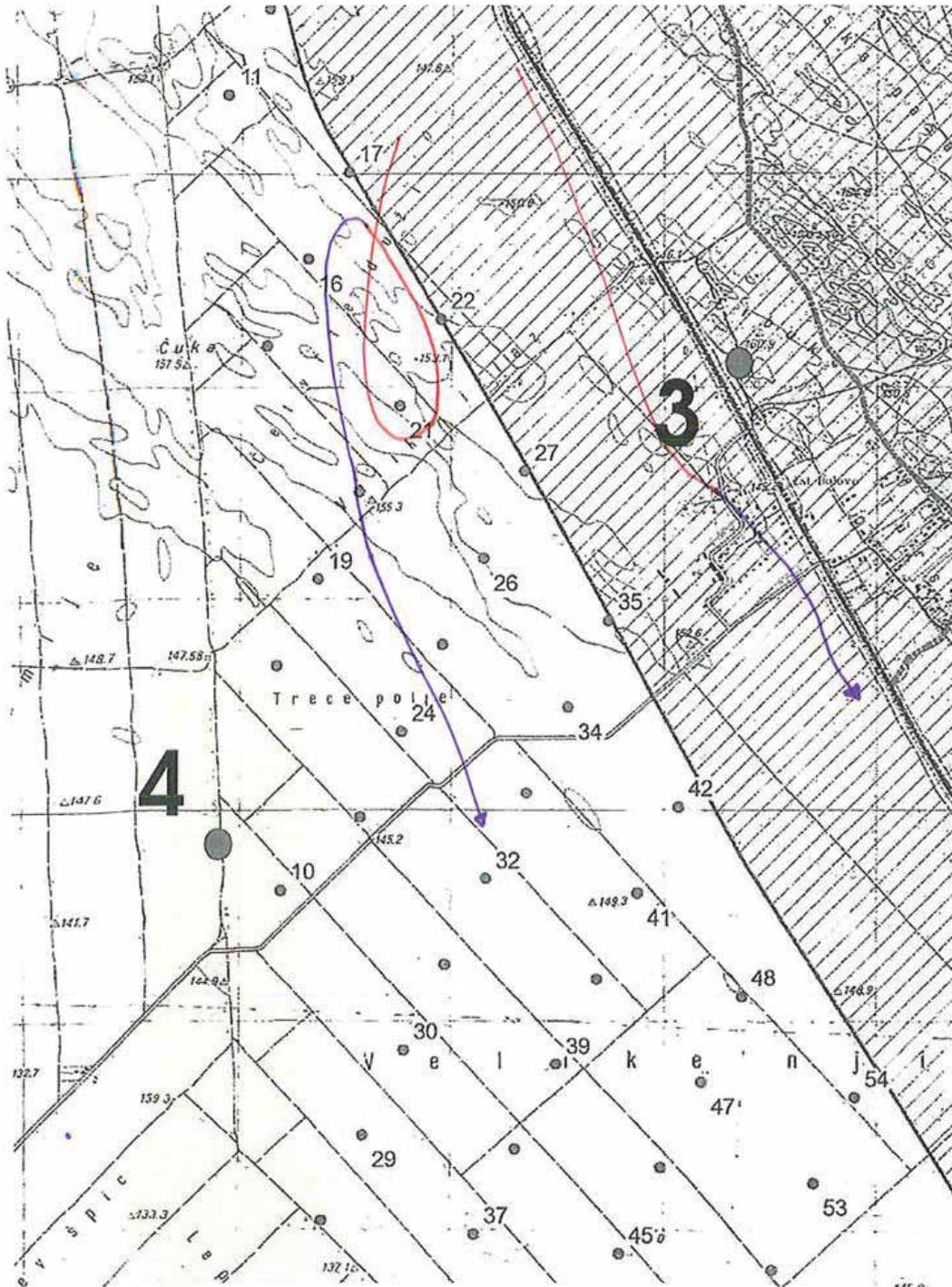
VP3: Merops Apiaster (European Bee-Eater)



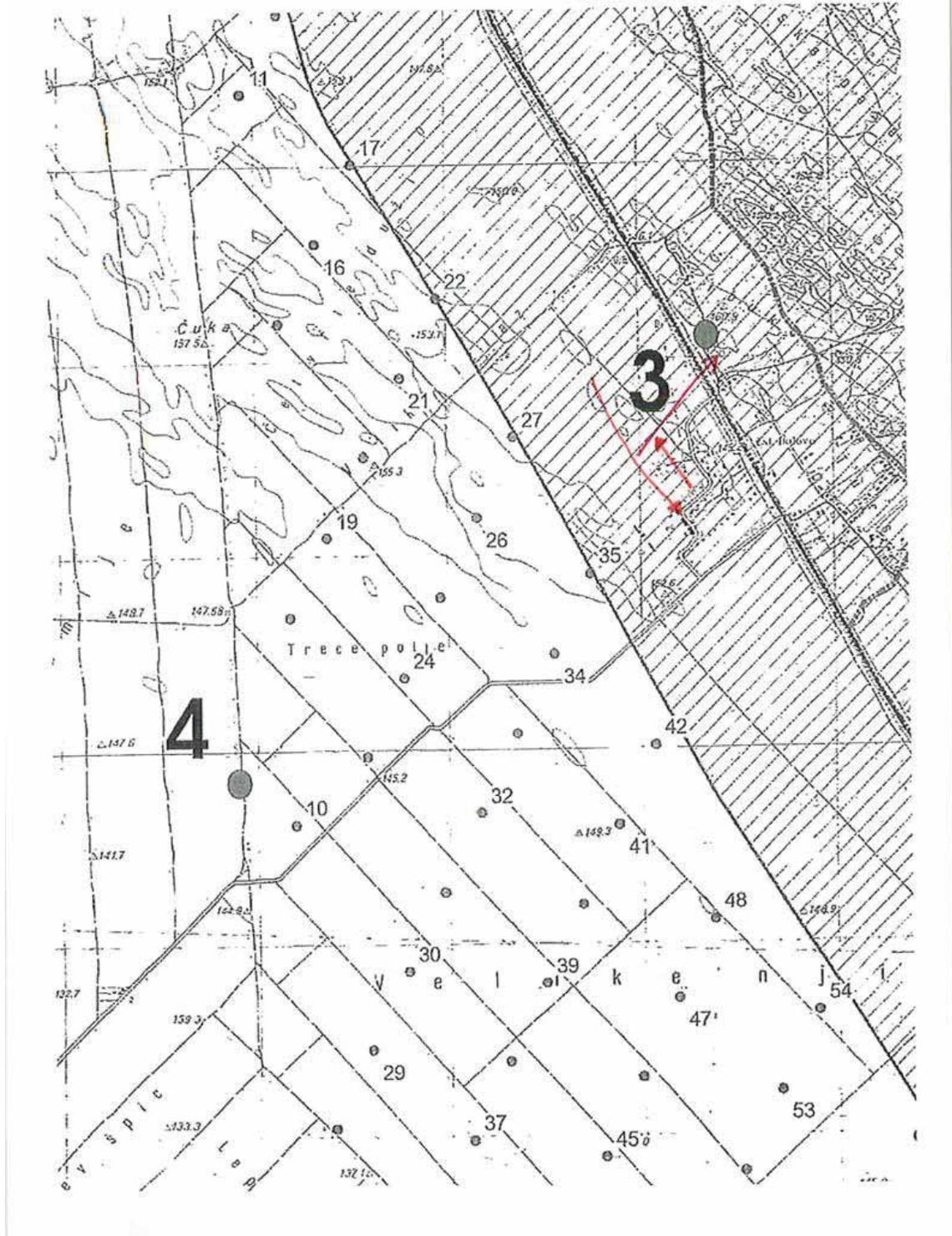
VP3: Anser Anser & Anser Albifron (Grey Geese (greylag goose and greater white-fronted goose))



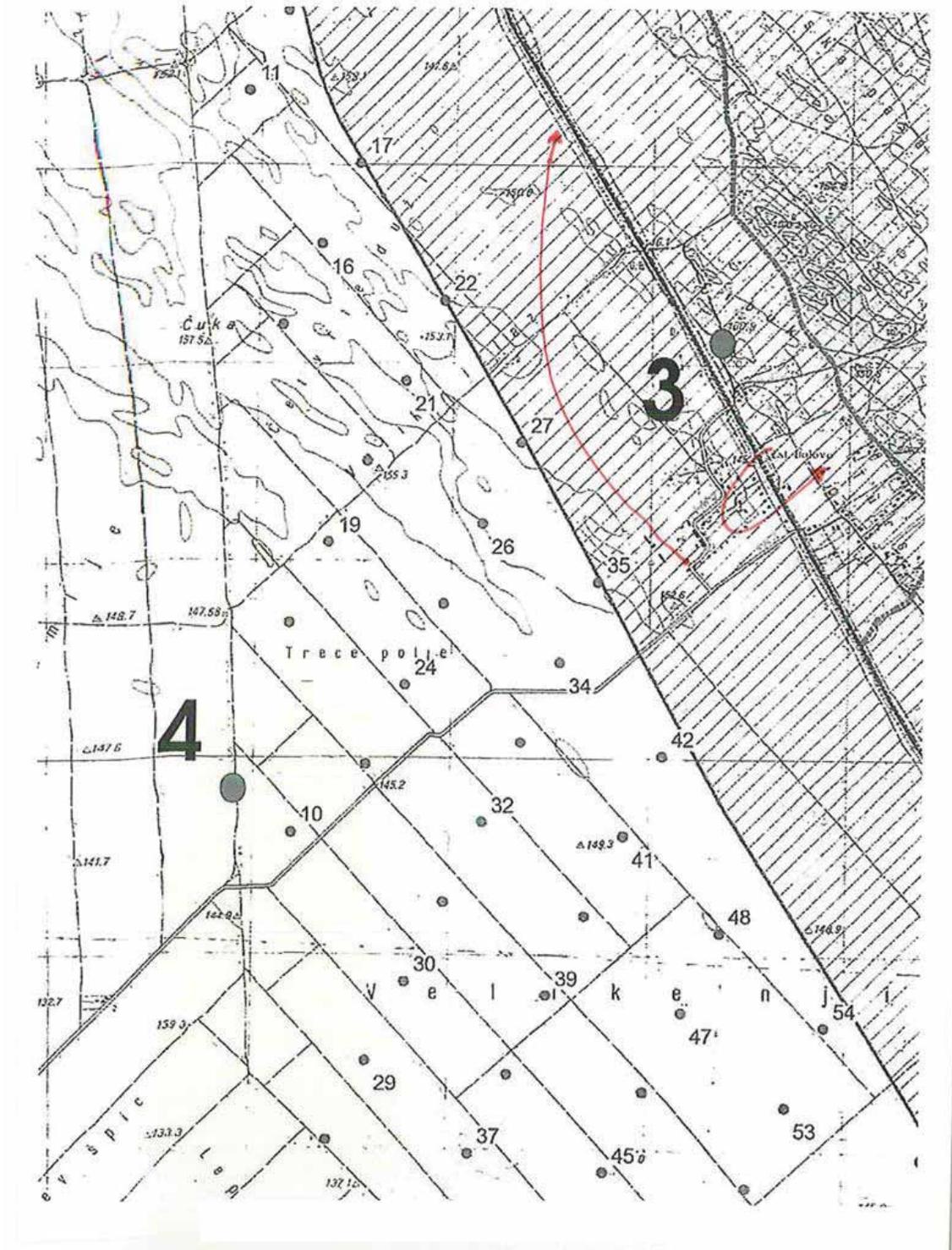
VP3: Circus Cyaneus (Hen Harrier)



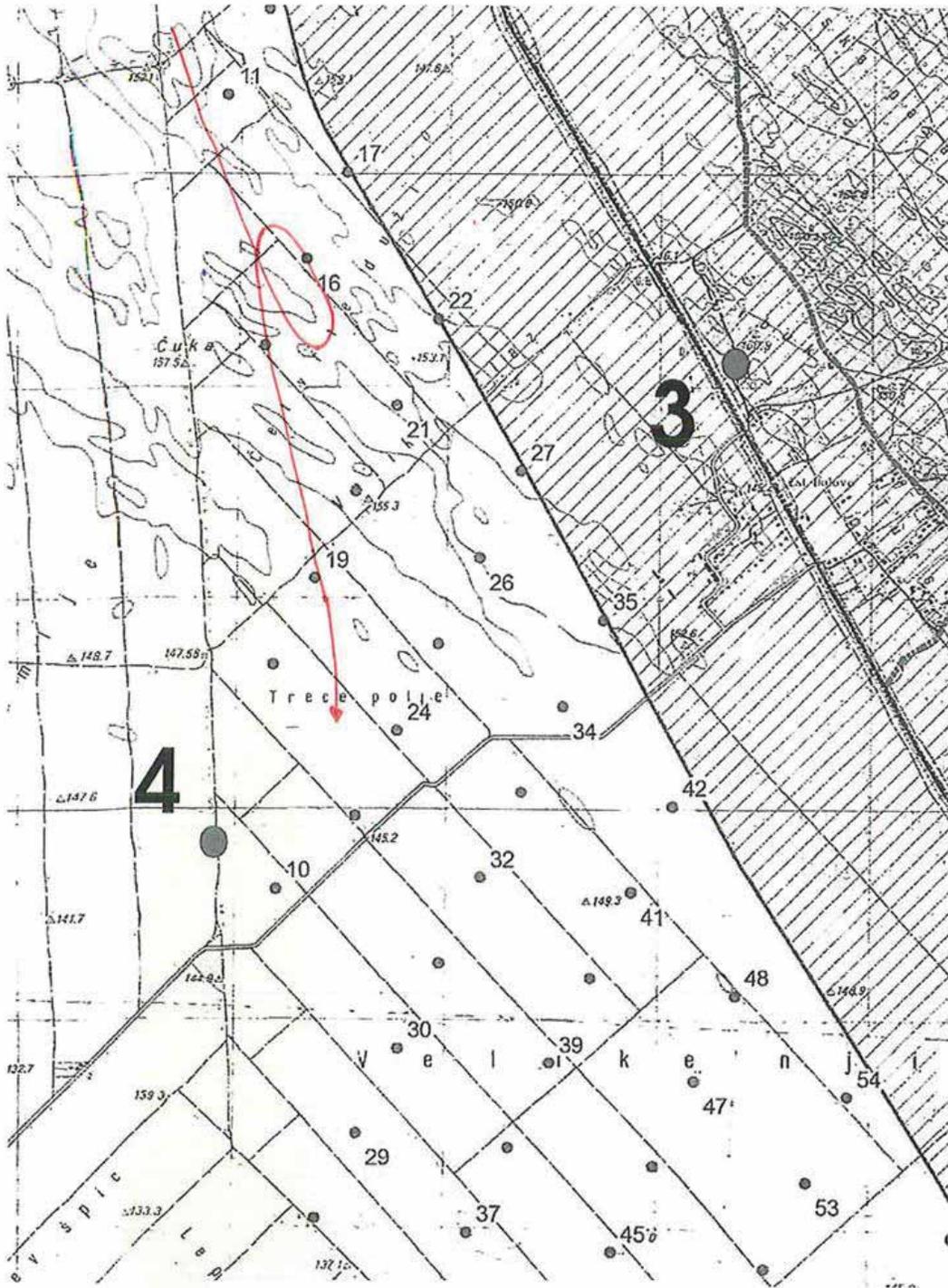
VP3: Falco Columarius (Merlin)



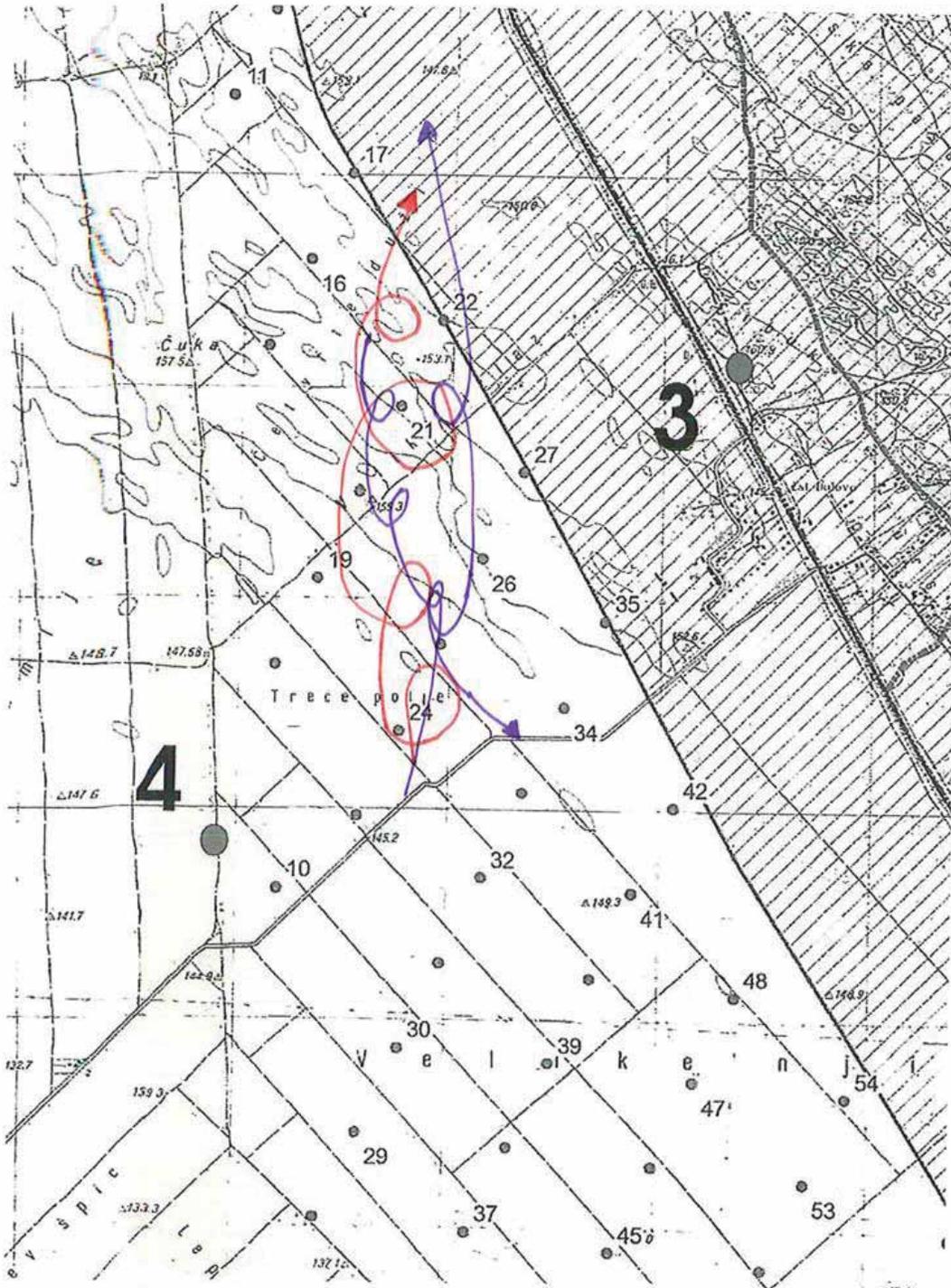
VP3: Accipiter Gentilus (Northern Goshawk)



VP3: Circus Aeruginosus (Western Marsh Harrier)

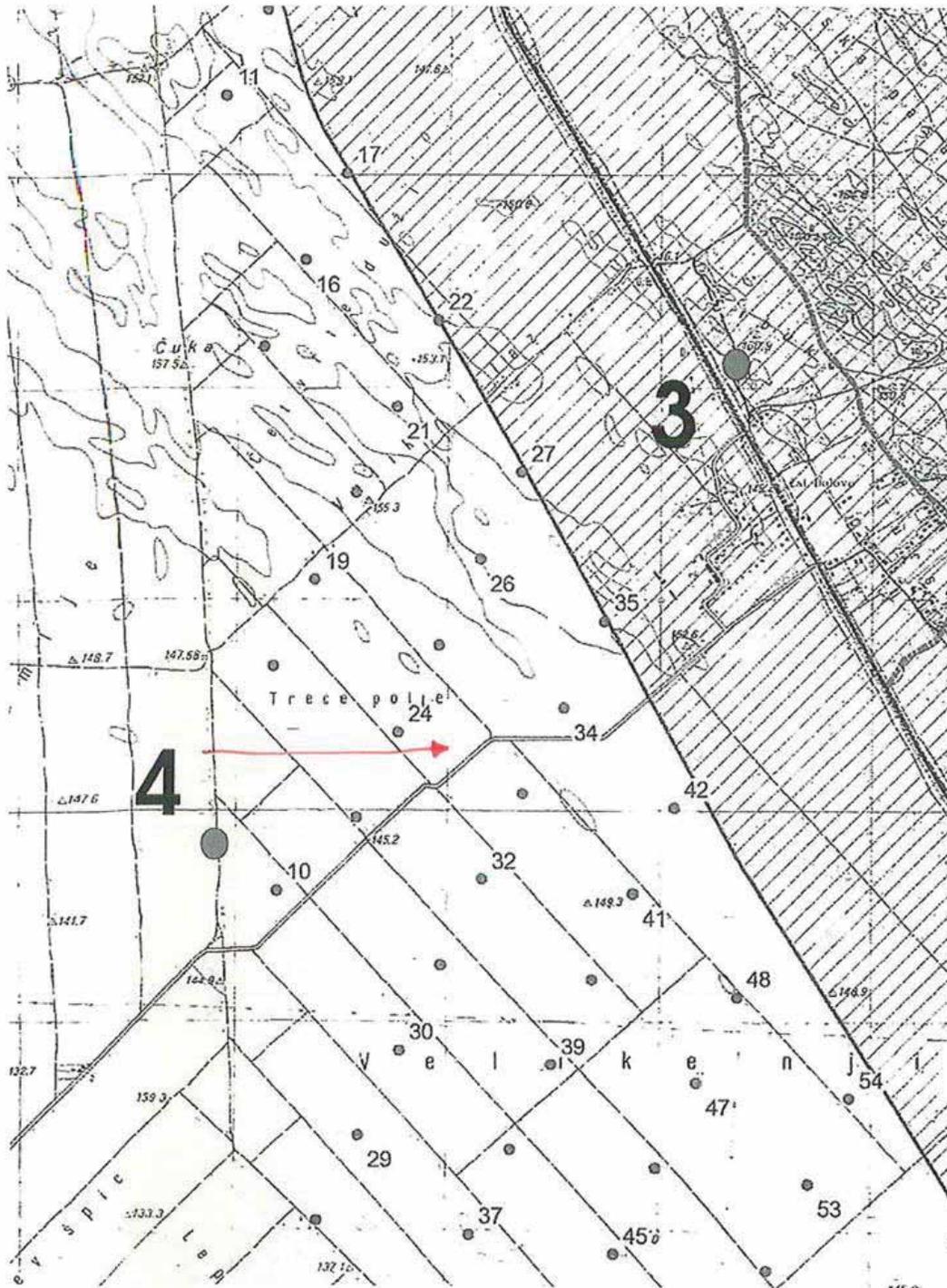


VP3: Ciconia ciconia (White Stork)

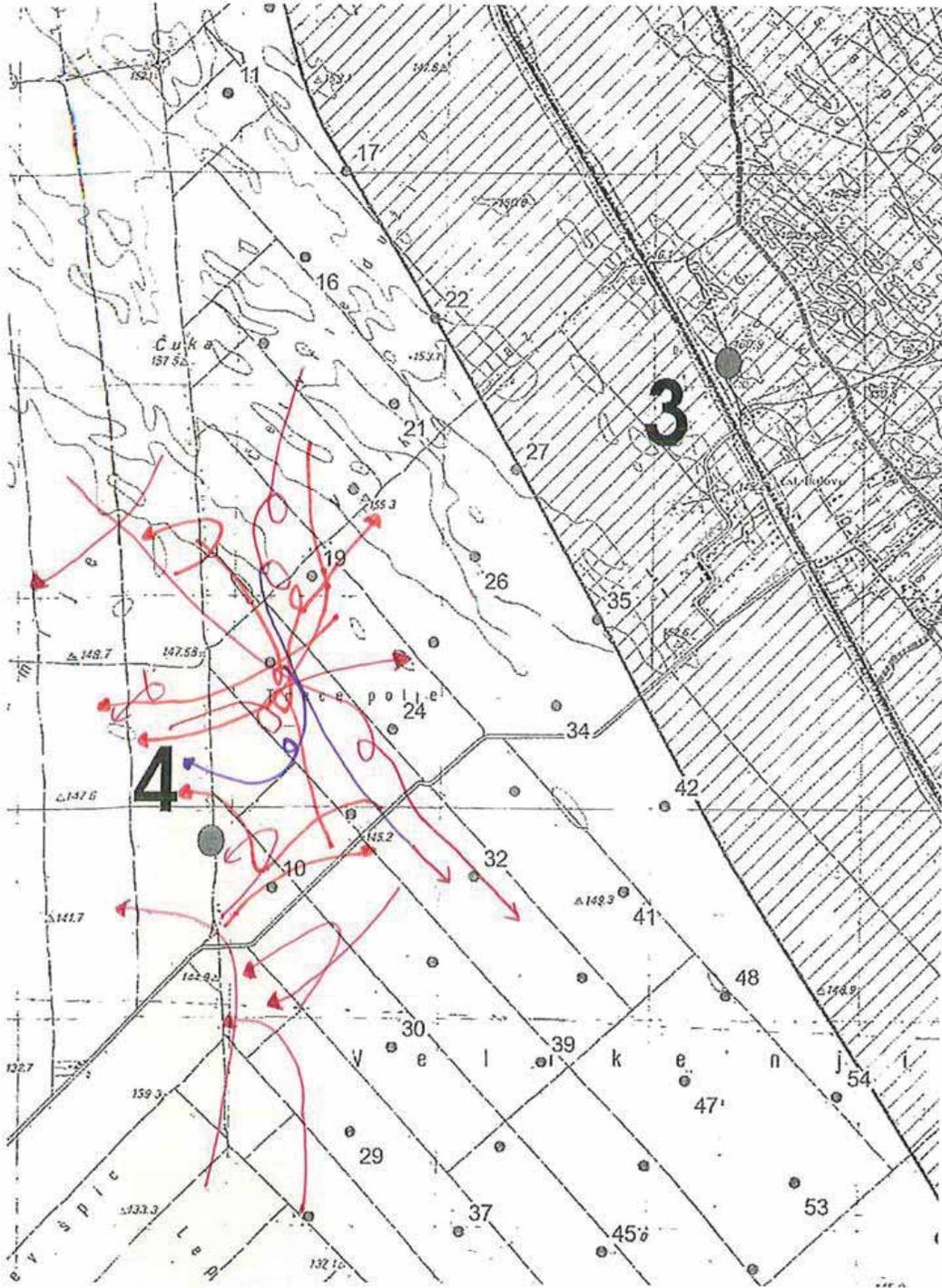




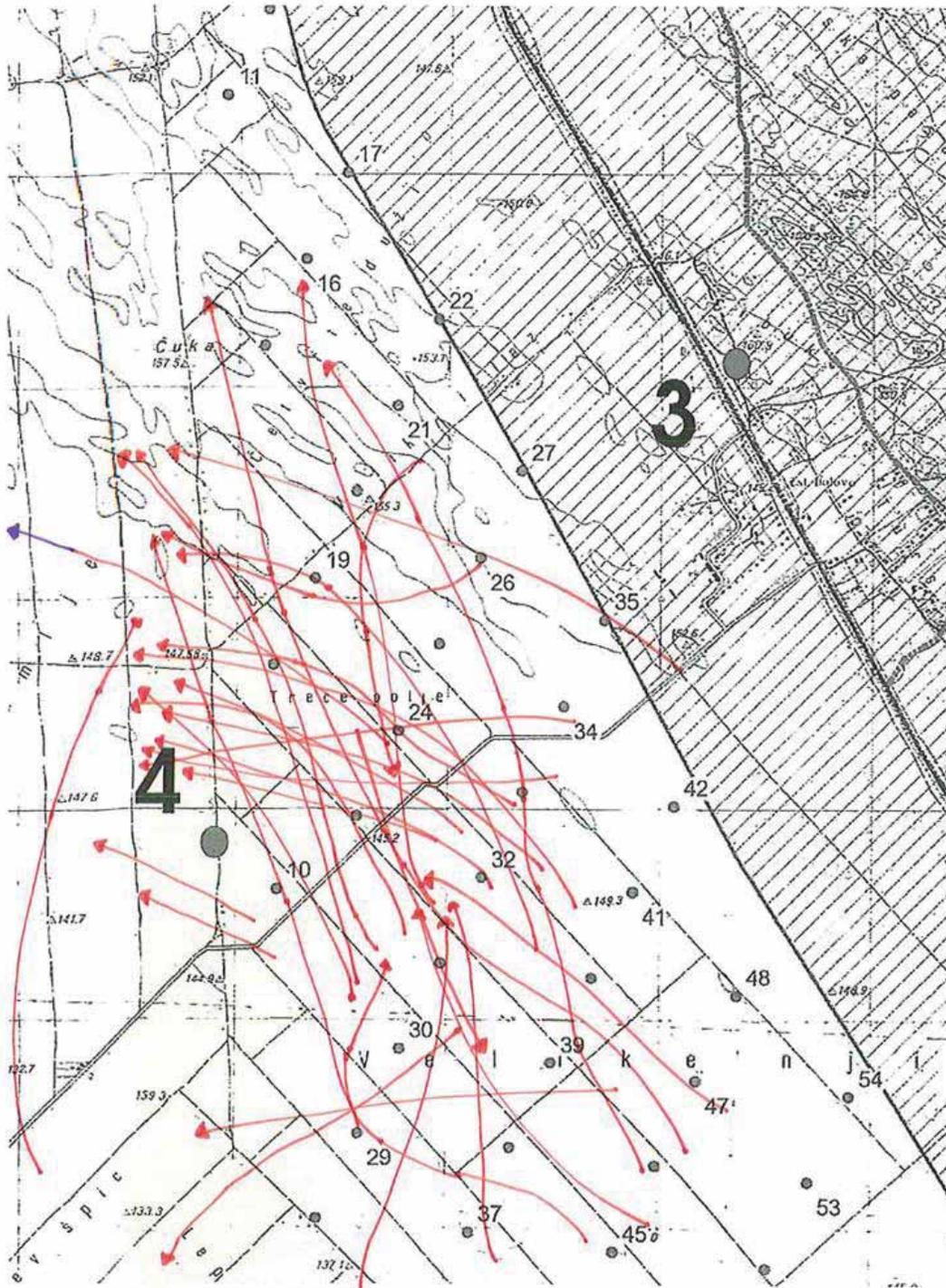
VP4: Falco Subbuteo (Eurasian Hobby)



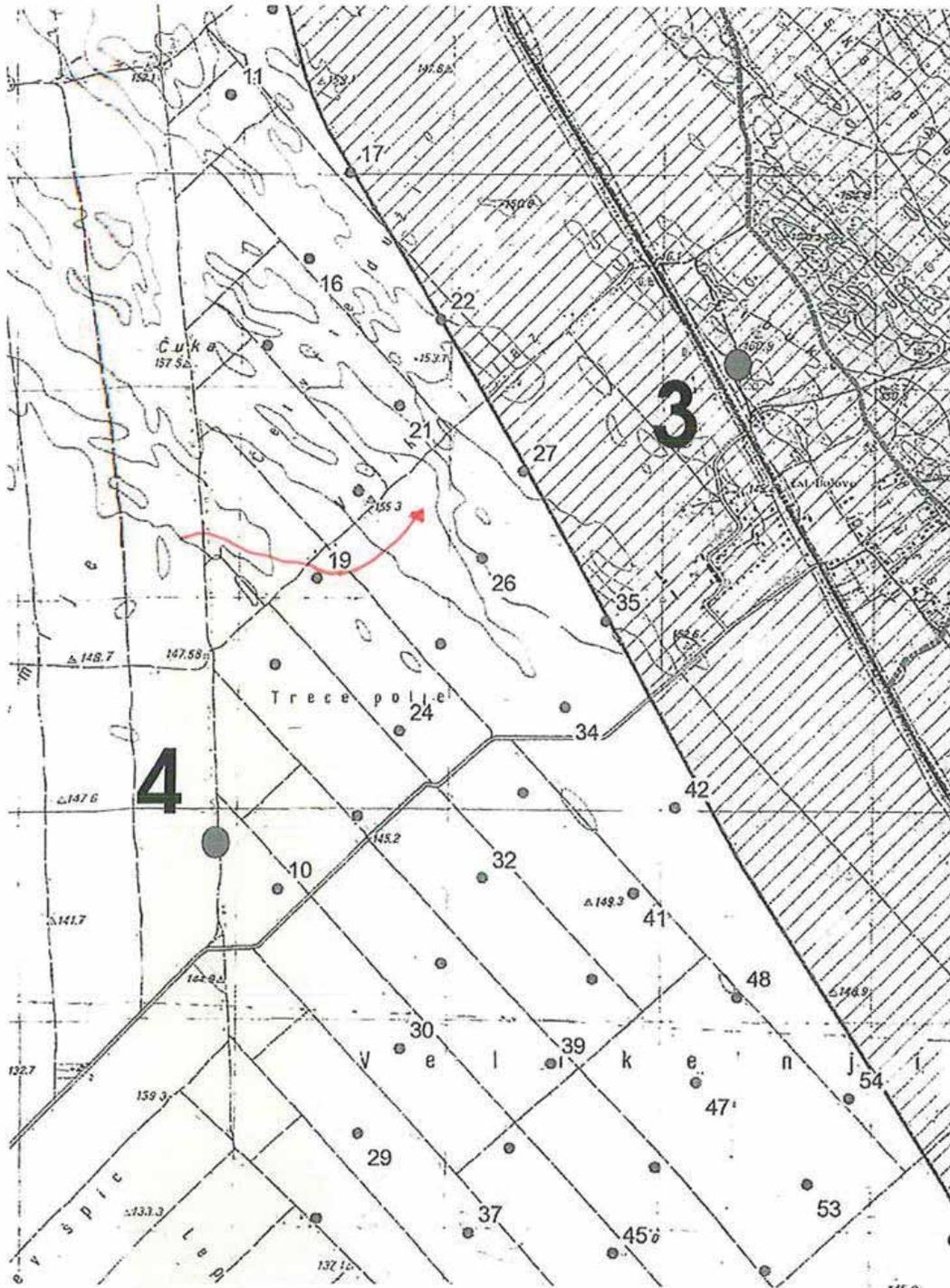
VP4: Falco tinnunculus (European Kestrel)



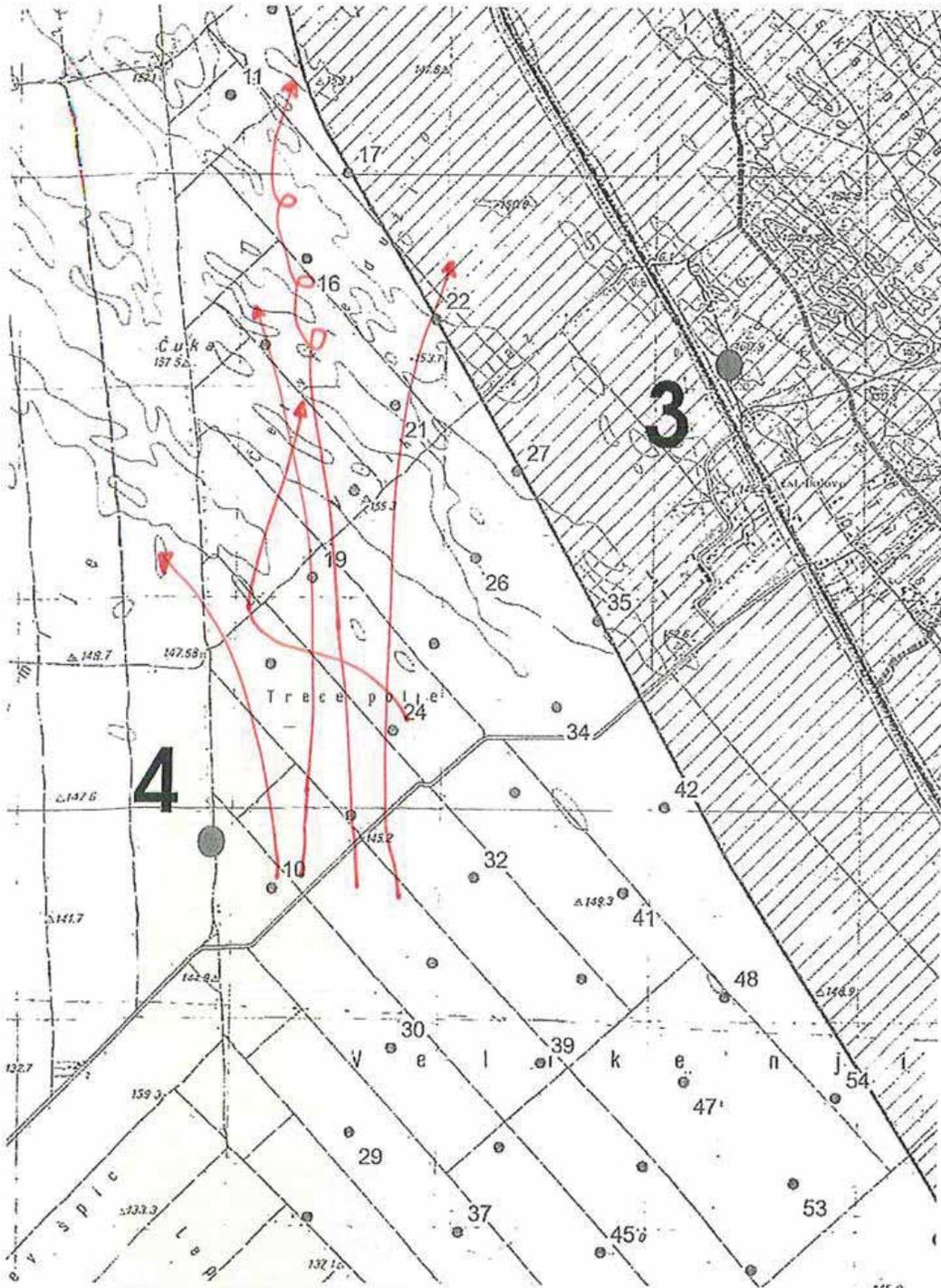
VP4: Anser Anser & Anser Albifrons (Grey Geese (greylag goose and greater white-fronted goose))



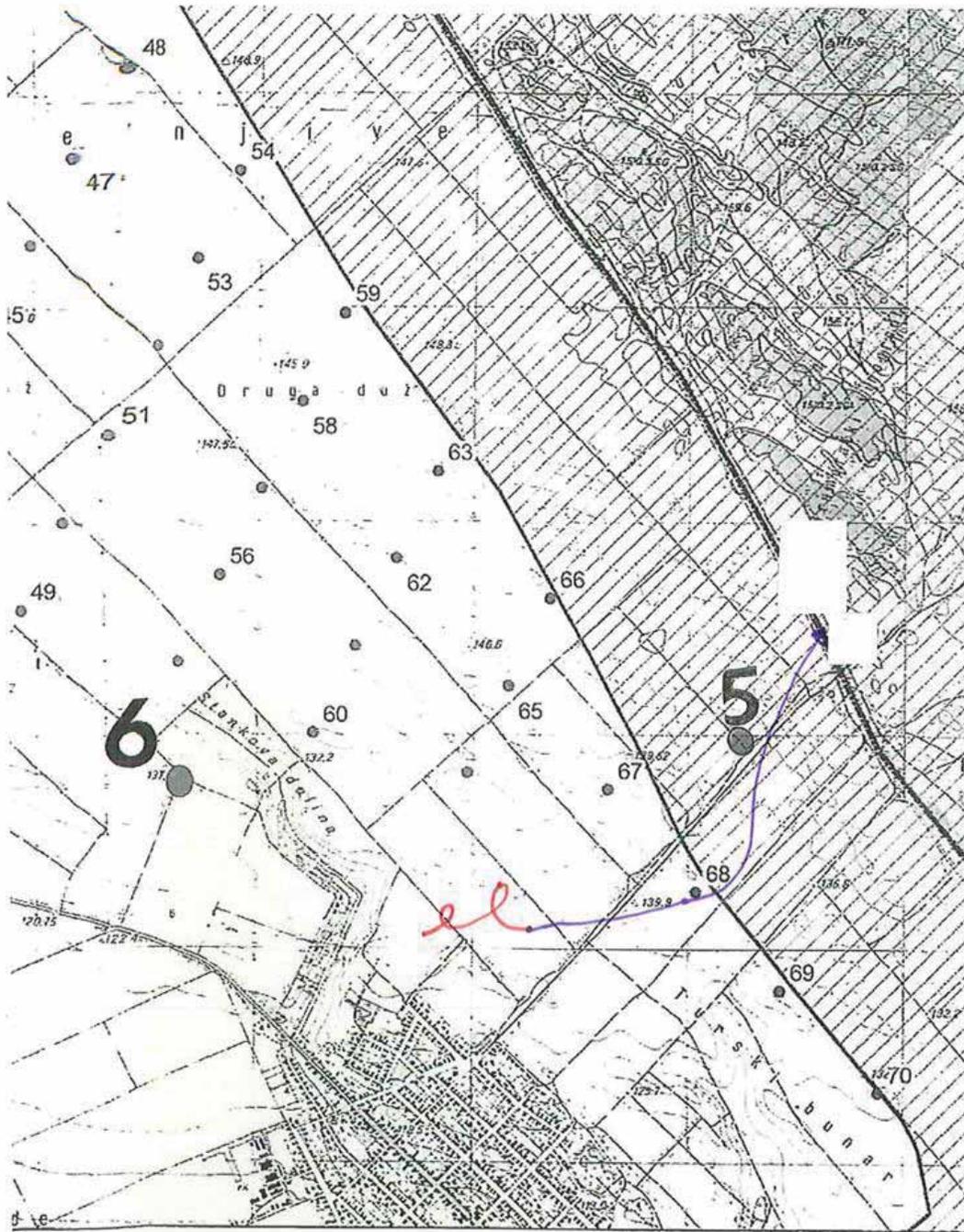
VP4: Falco cherrug (Saker Falcon)



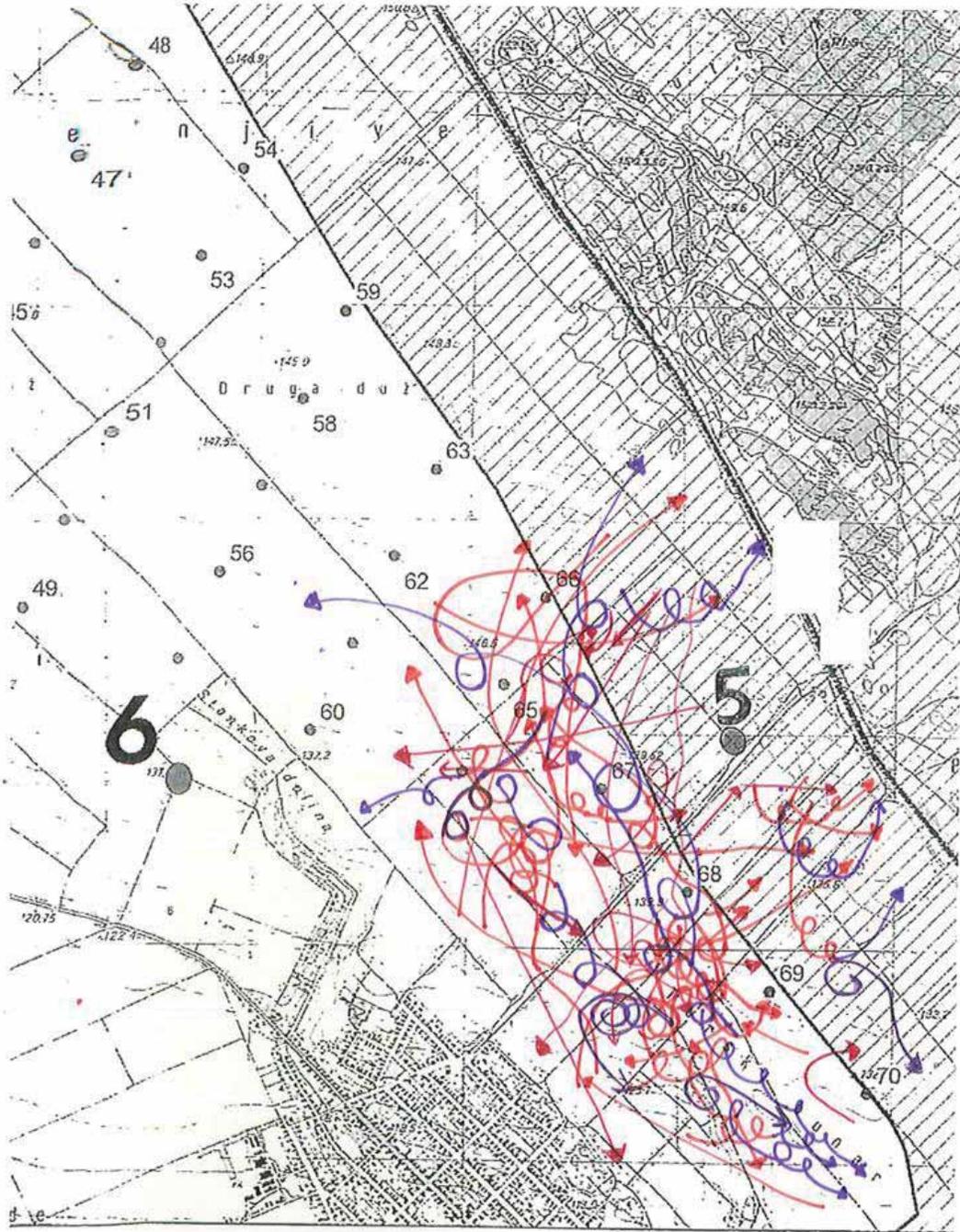
VP4: Circus Aeruginosus (Western Marsh Harrier)



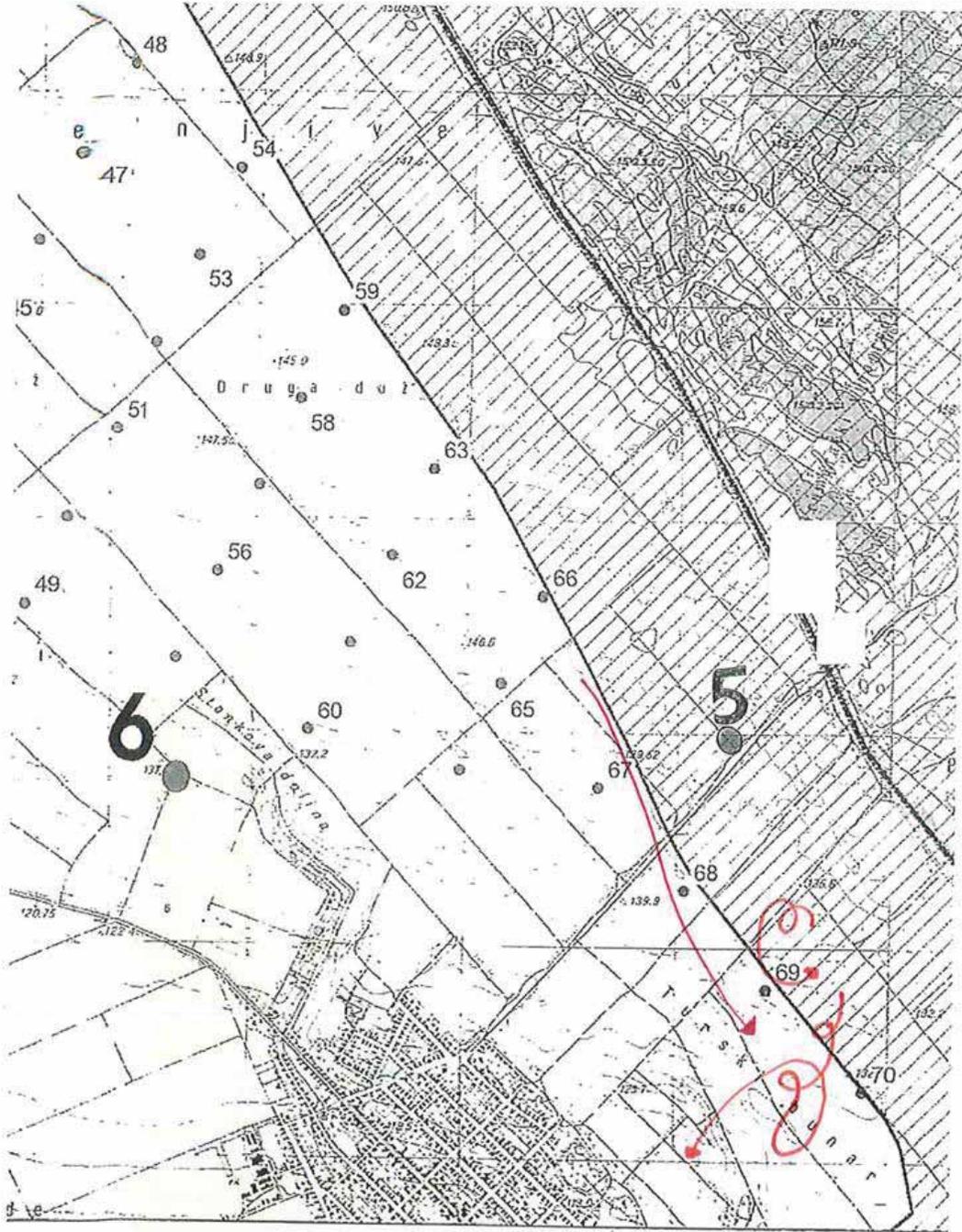
VP5: Milvus Migrans (Black Kite)



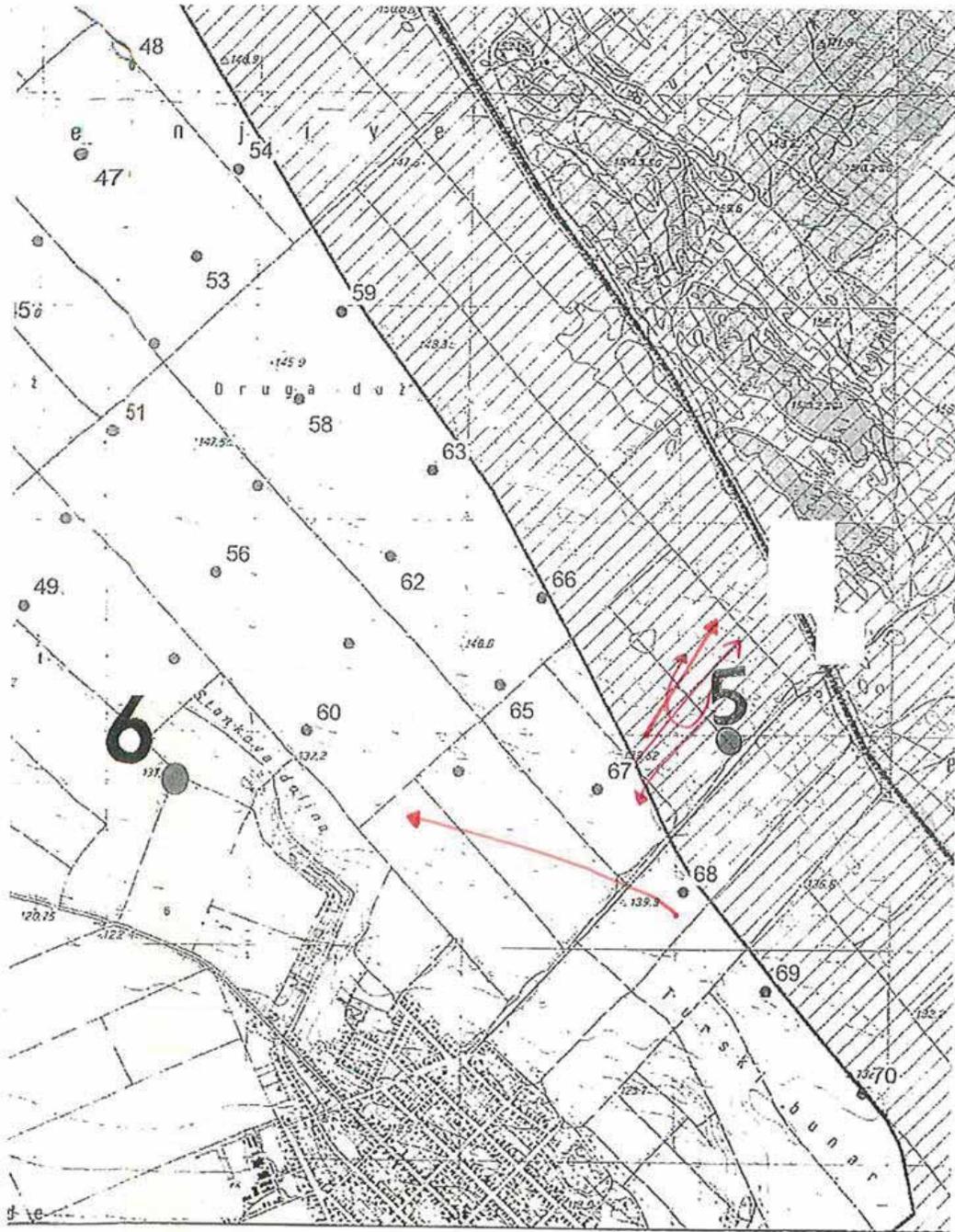
VP5: Buteo Buteo (Common Buzzard)



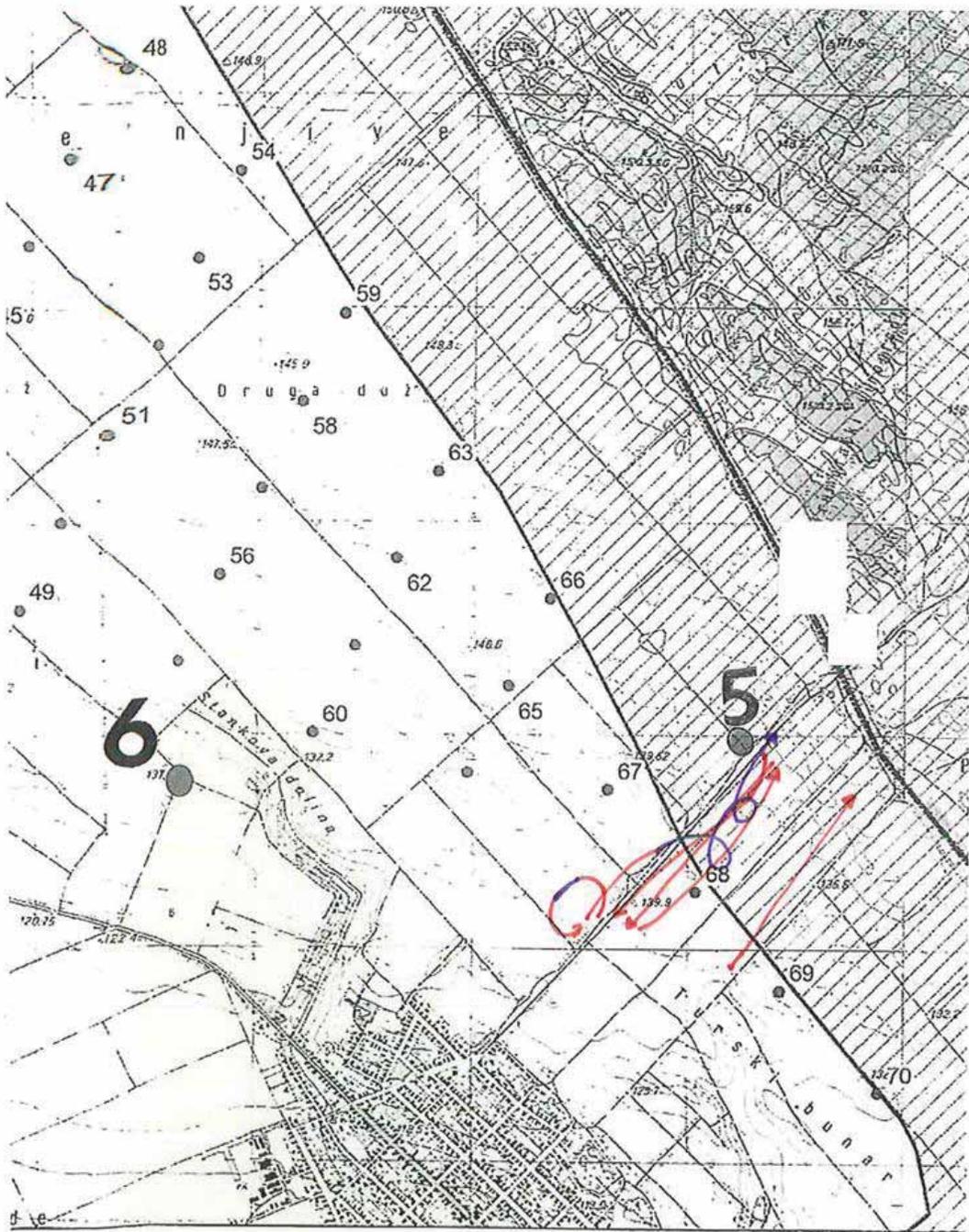
VP5: Falco Tinnunculus (Eurasian Kestrel)



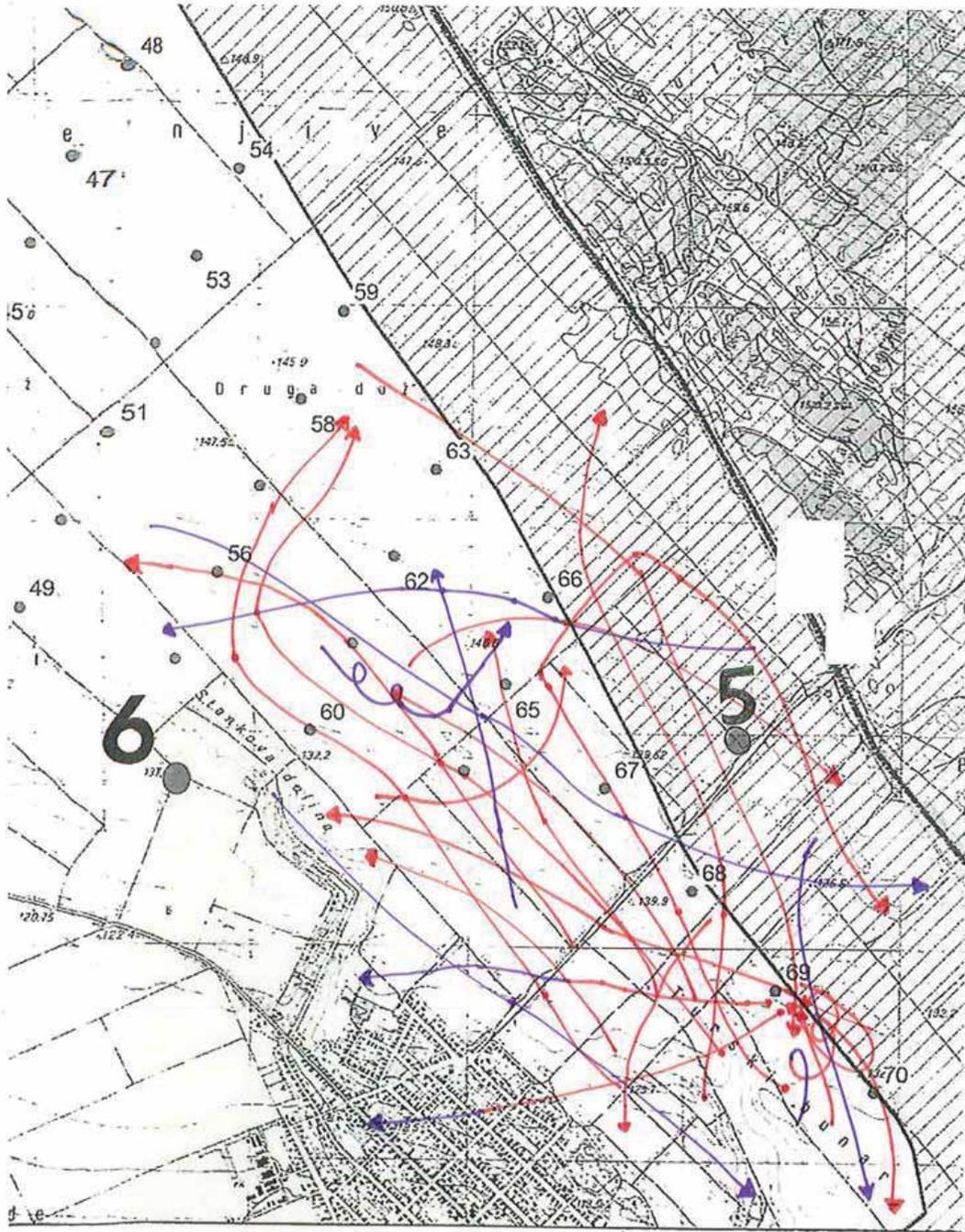
VP5: Accipiter Nisus (Eurasian Sparrowhawk)



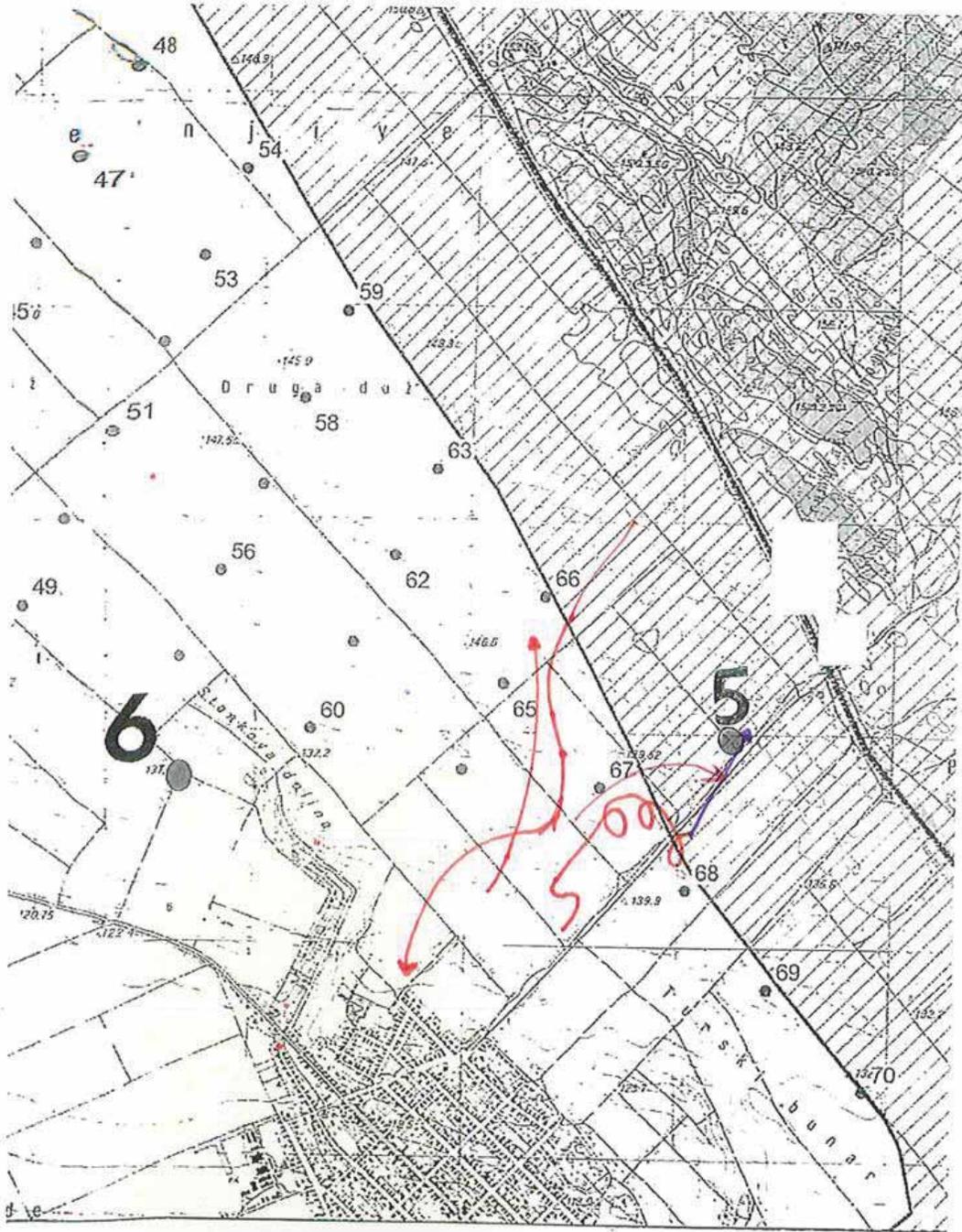
VP5: Merops Apiaster (European Bee-eater)



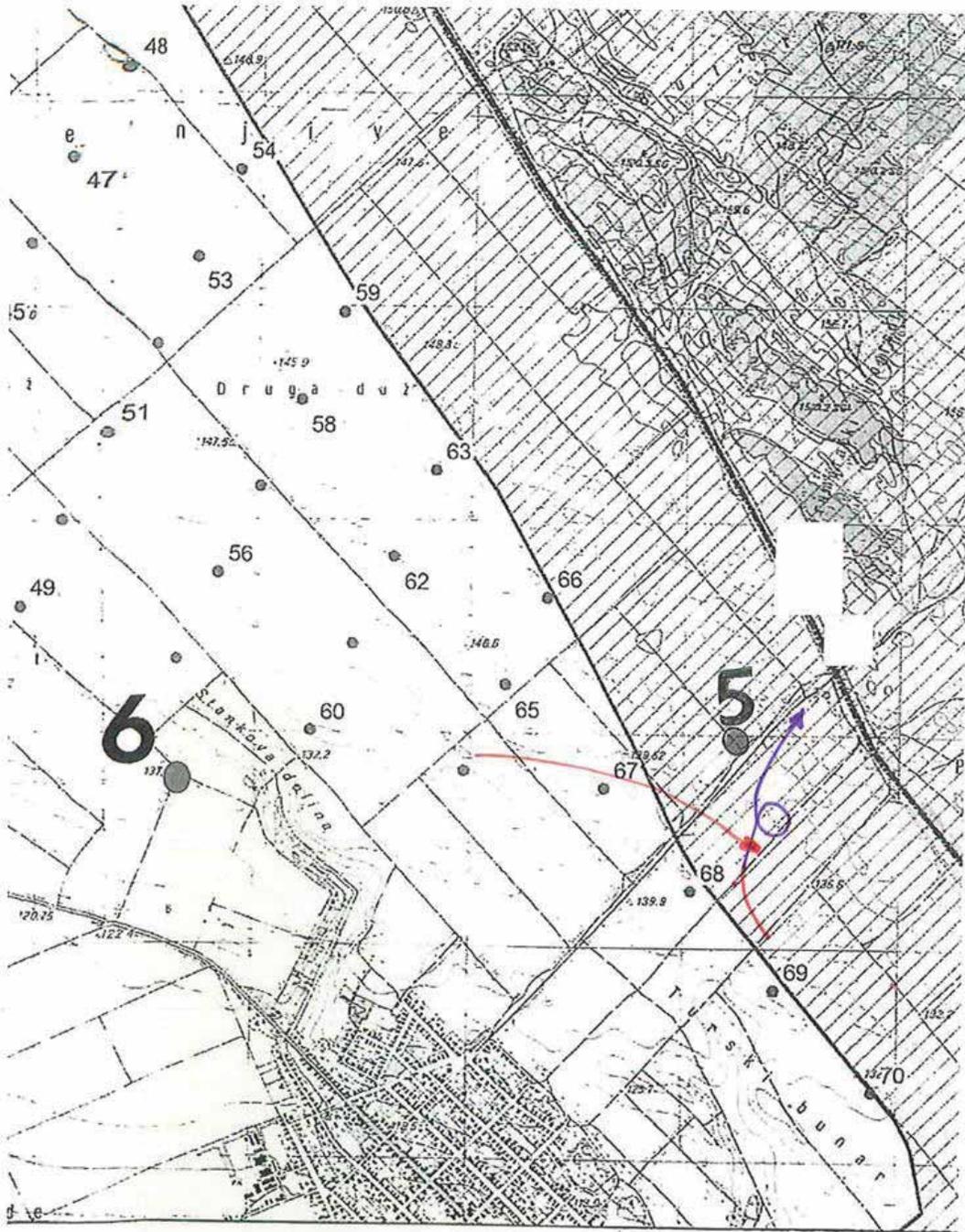
VP5: Anser Anser & Anser Albifrons (Grey Geese (greylag goose and greater white-fronted goose))



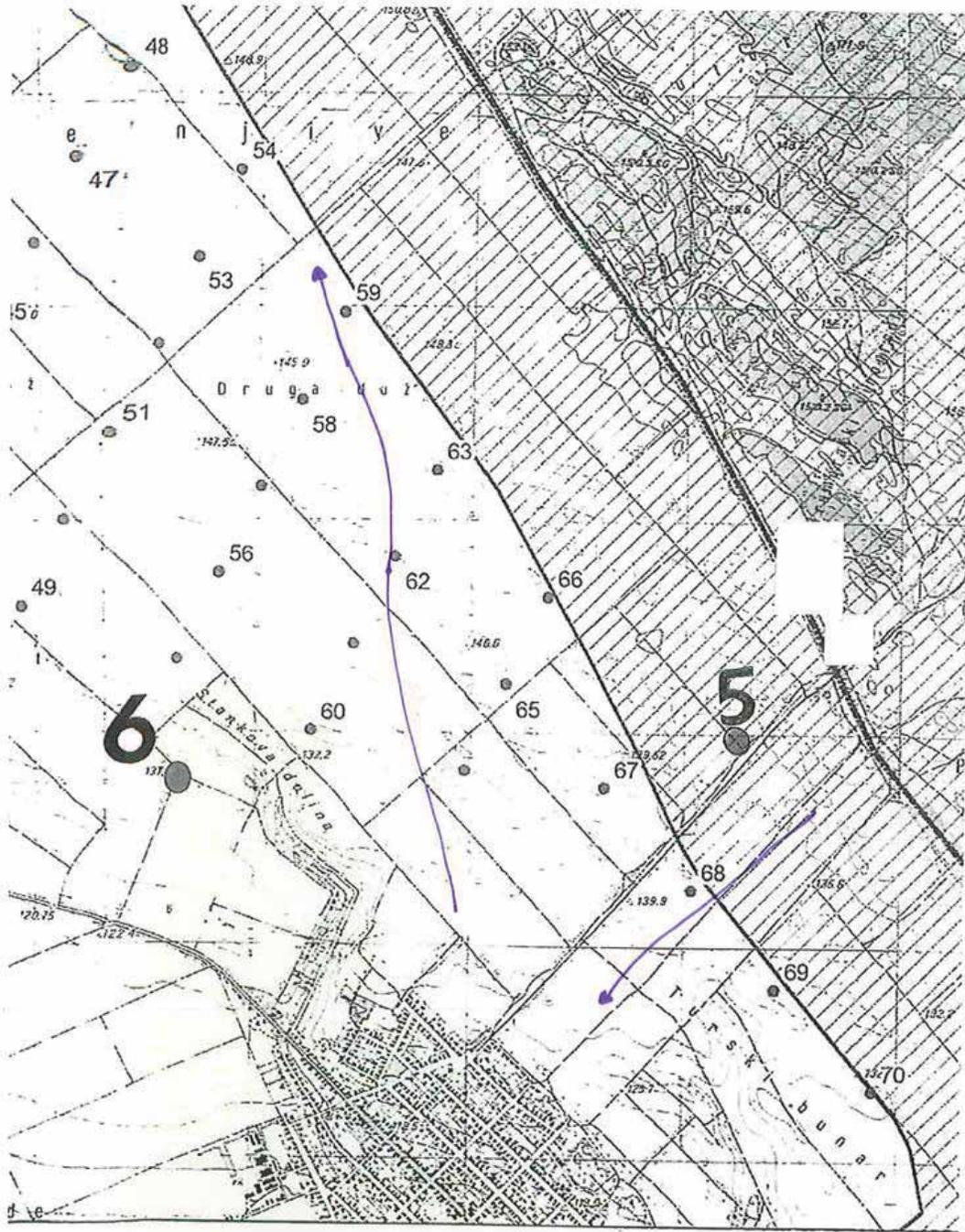
VP5: Accipiter Gentilus (Northern Goshawk)



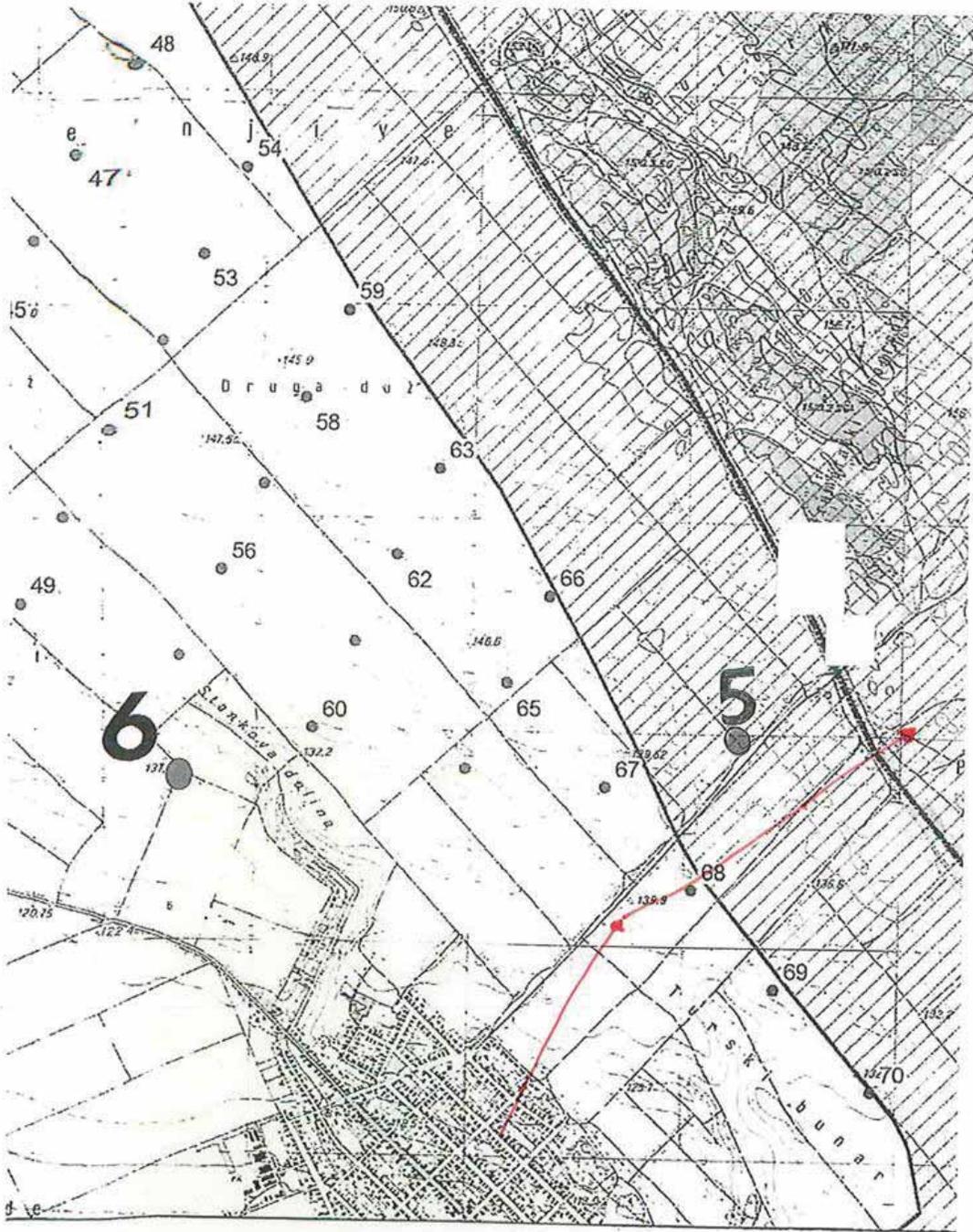
VP5: Falco Cherrug (Saker Falcon)



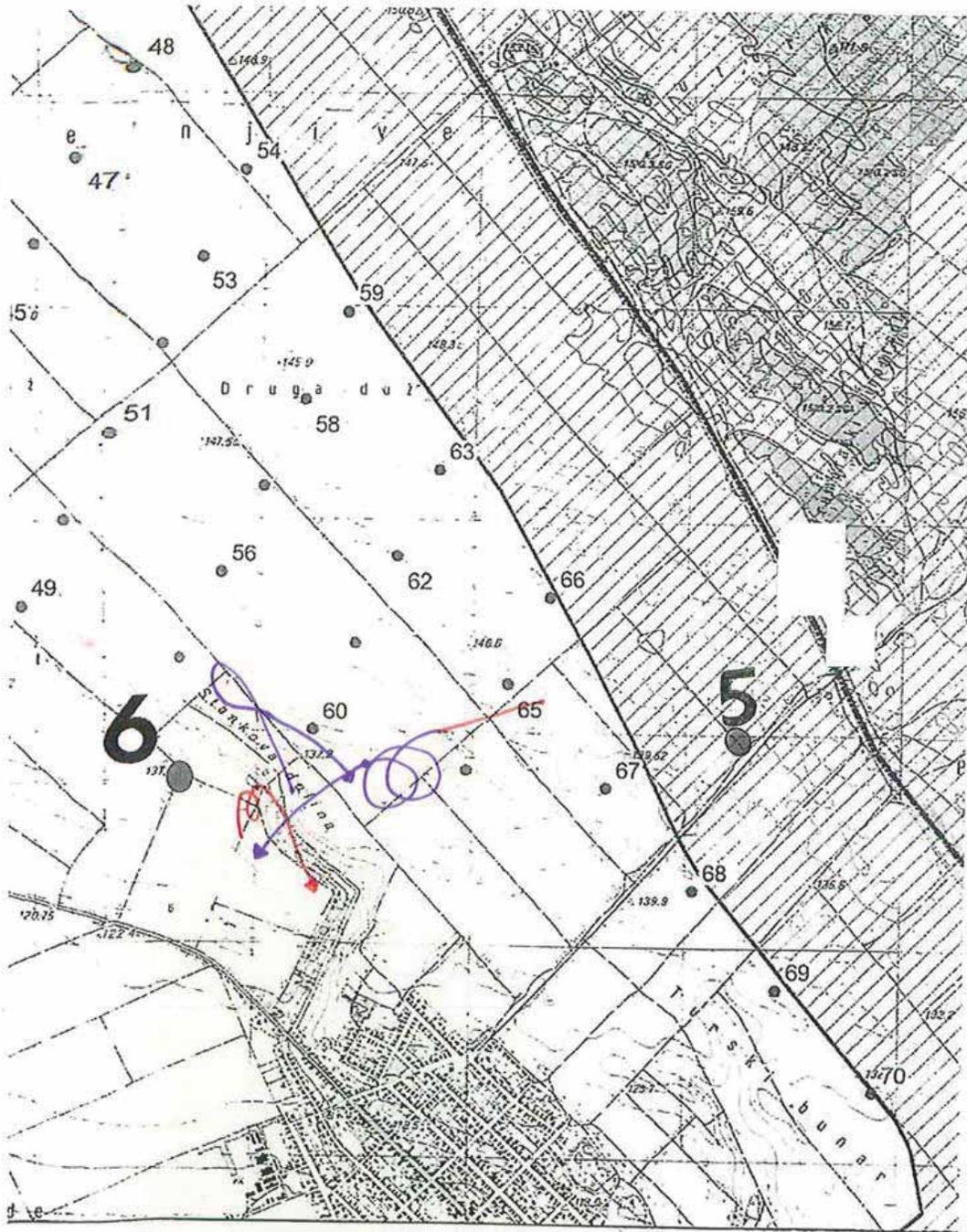
VP5: Ciconia Ciconia (White Stork)



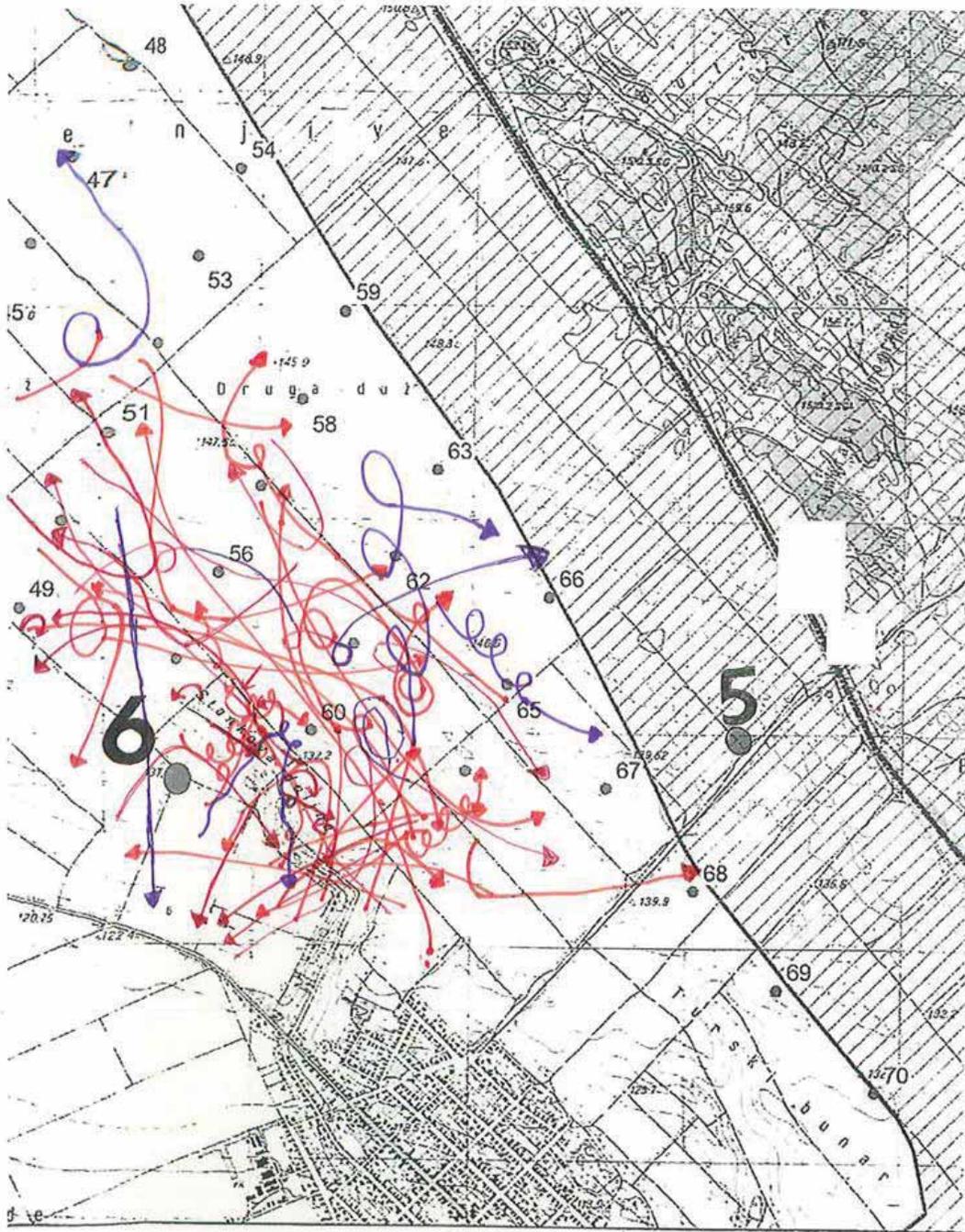
VP5: *Haliaeetus alba* (White-tailed Eagle)



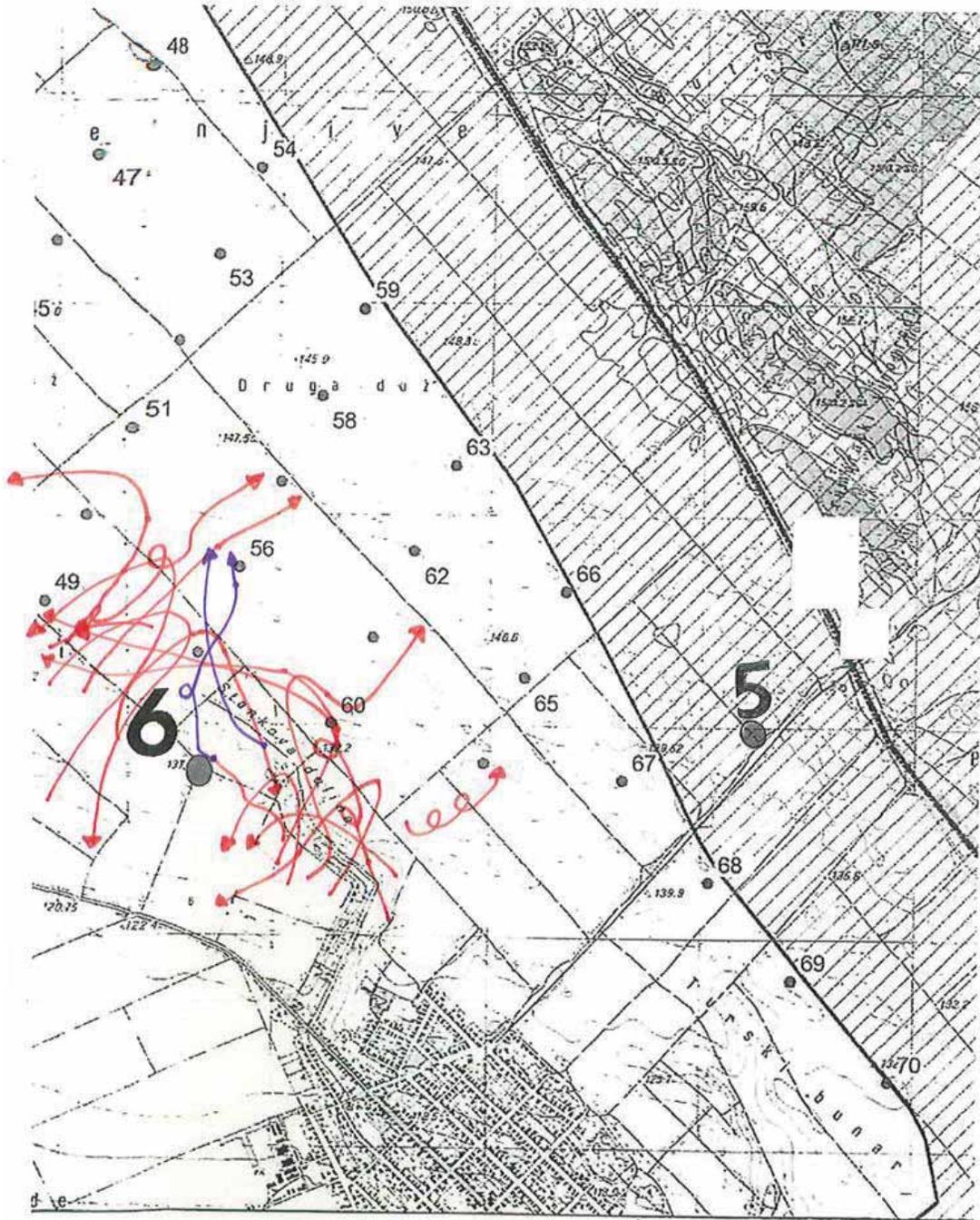
VP6: Ciconia Nigris (Black Stork)



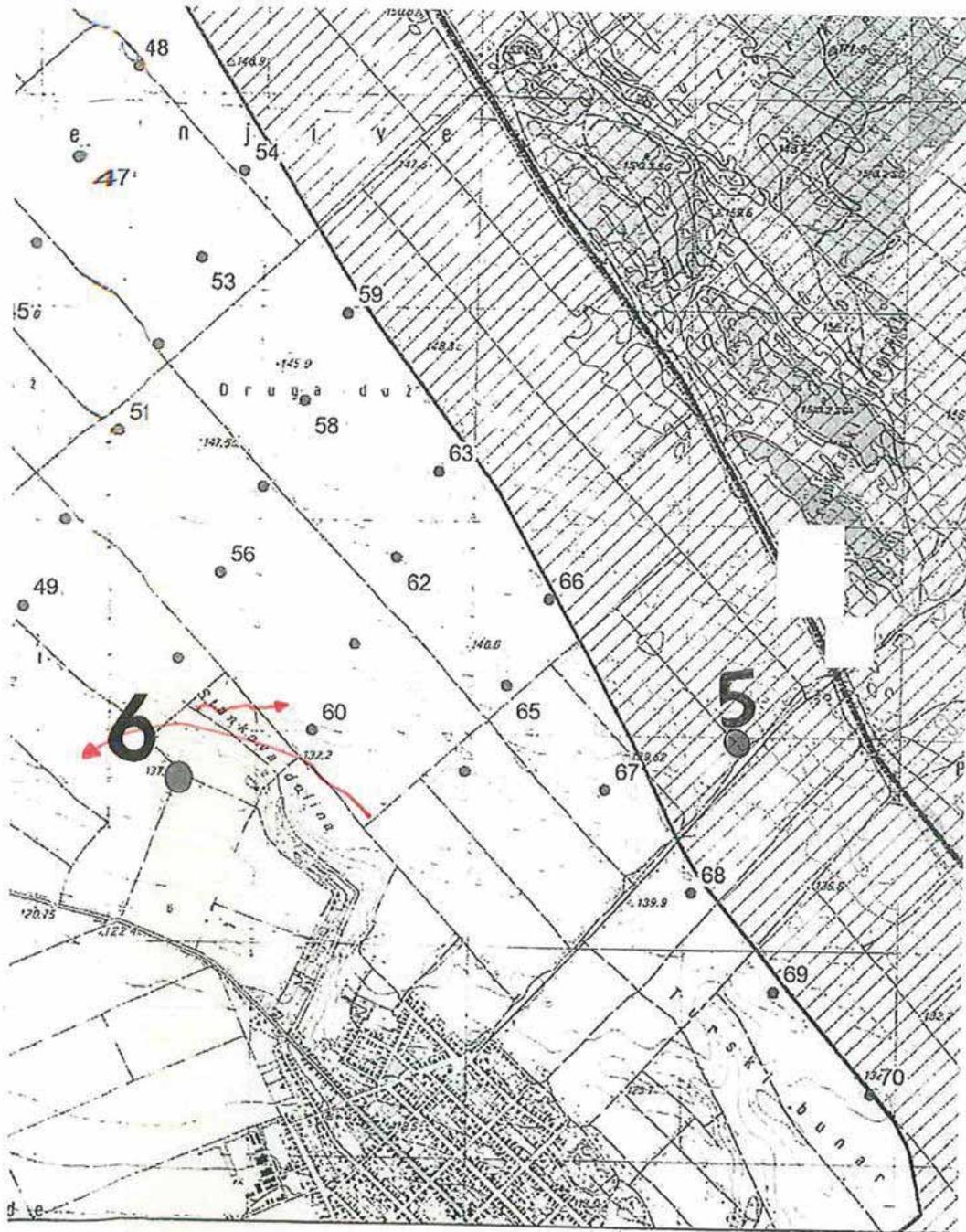
VP6: Buteo Buteo (Common Buzzard)



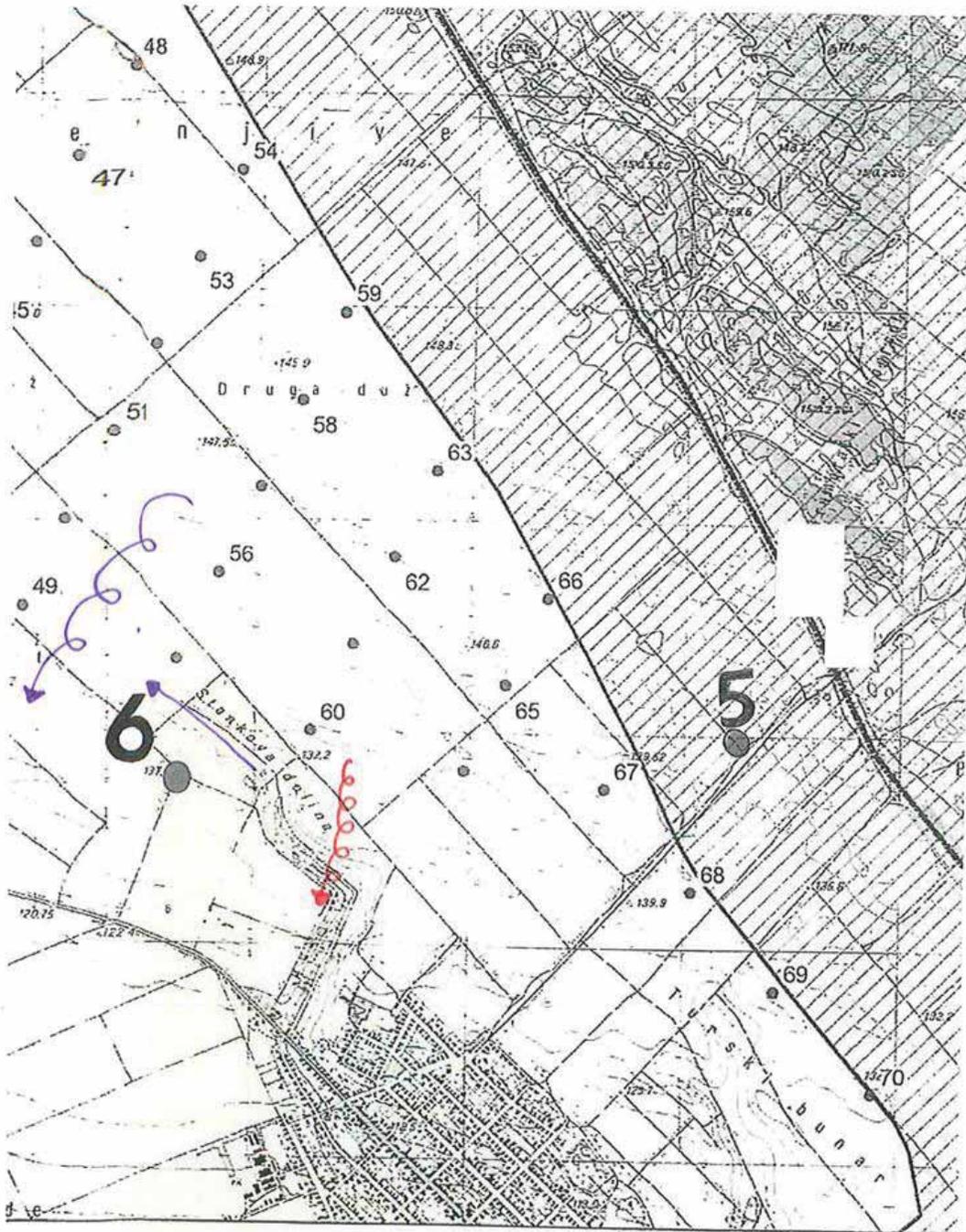
VP6: Falco Tinnunculus (Eurasian Kestrel)



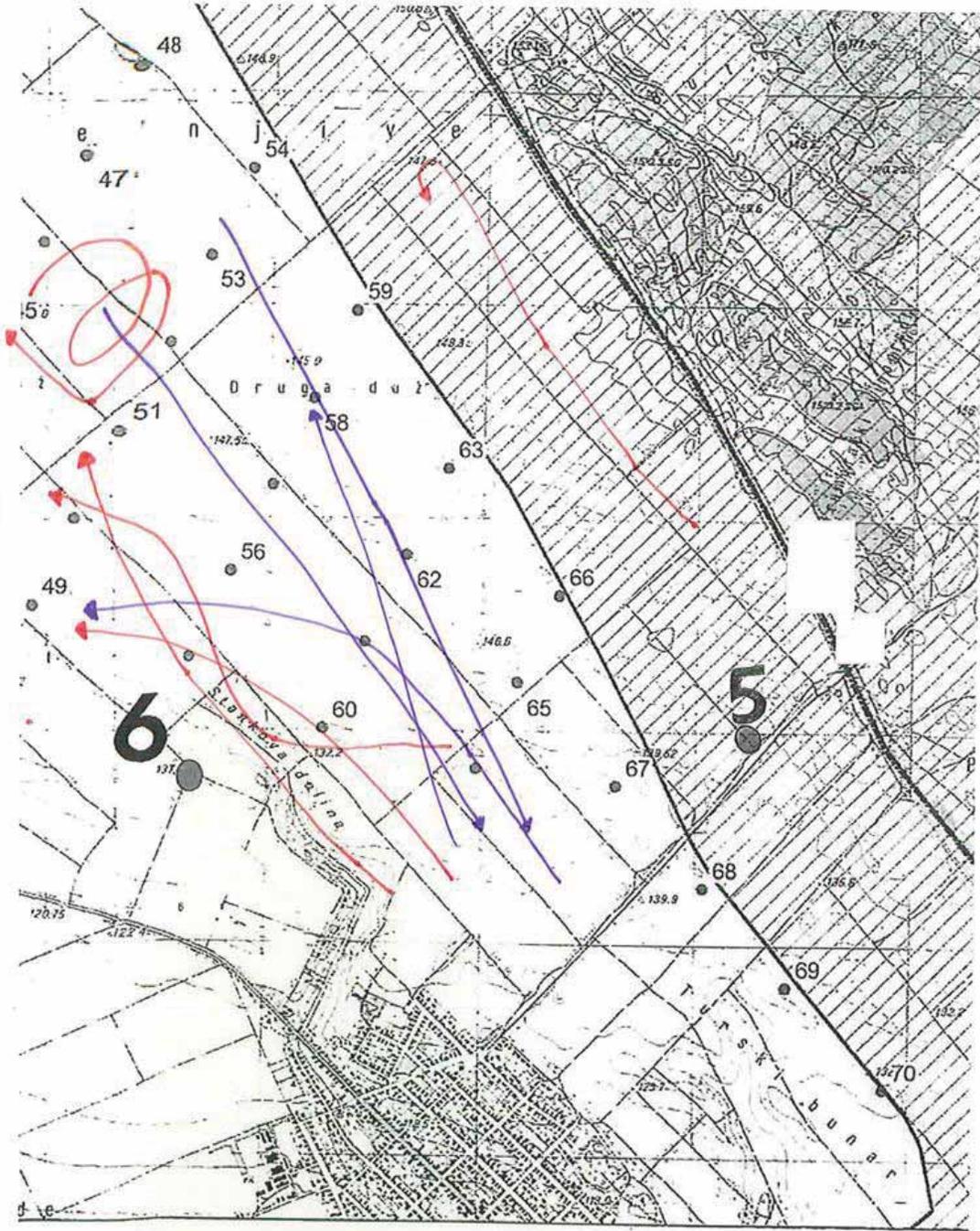
VP6: Accipiter Nisus (Eurasian Sparrowhawk)



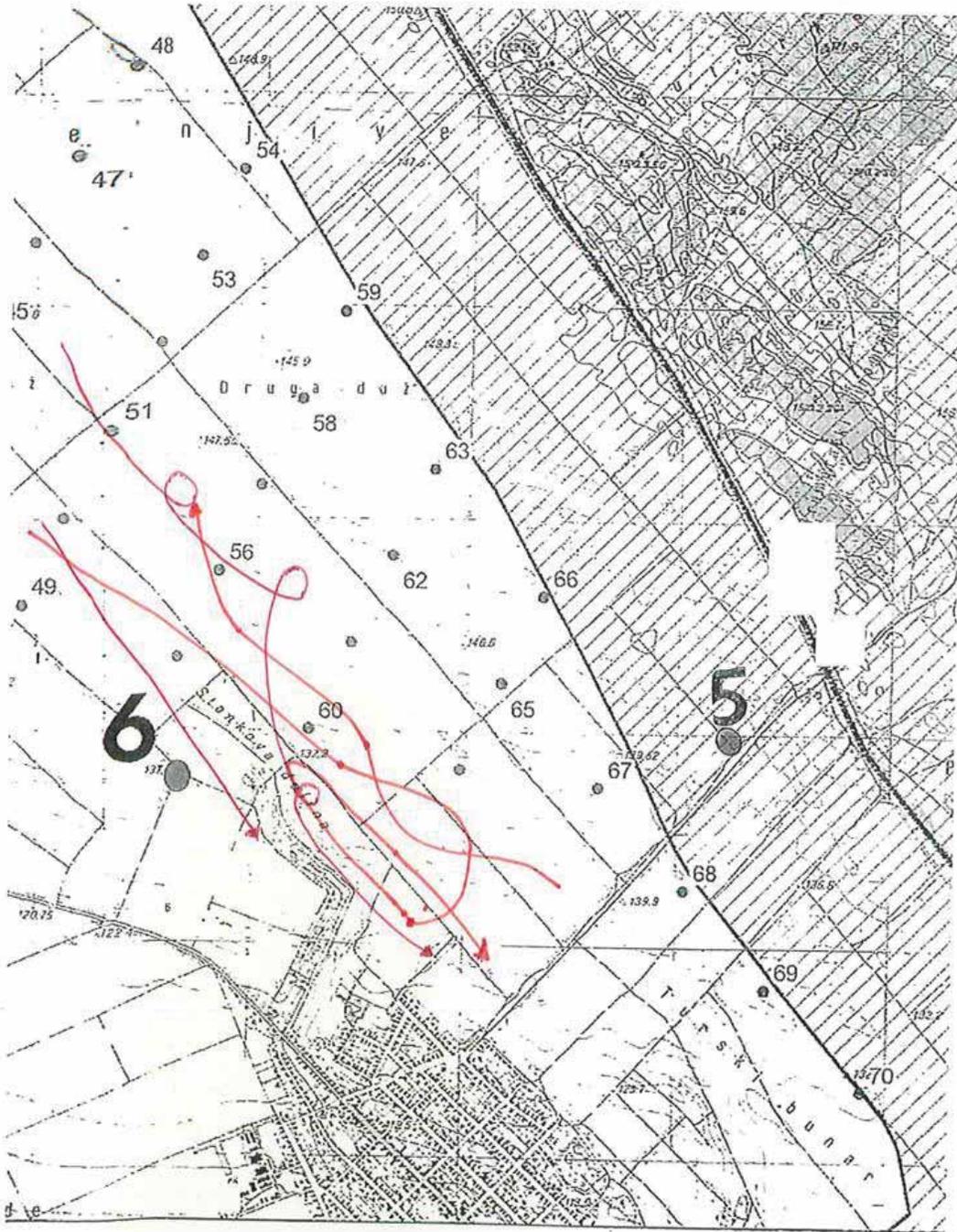
VP6: Merops Apiaster (European Bee-eater)



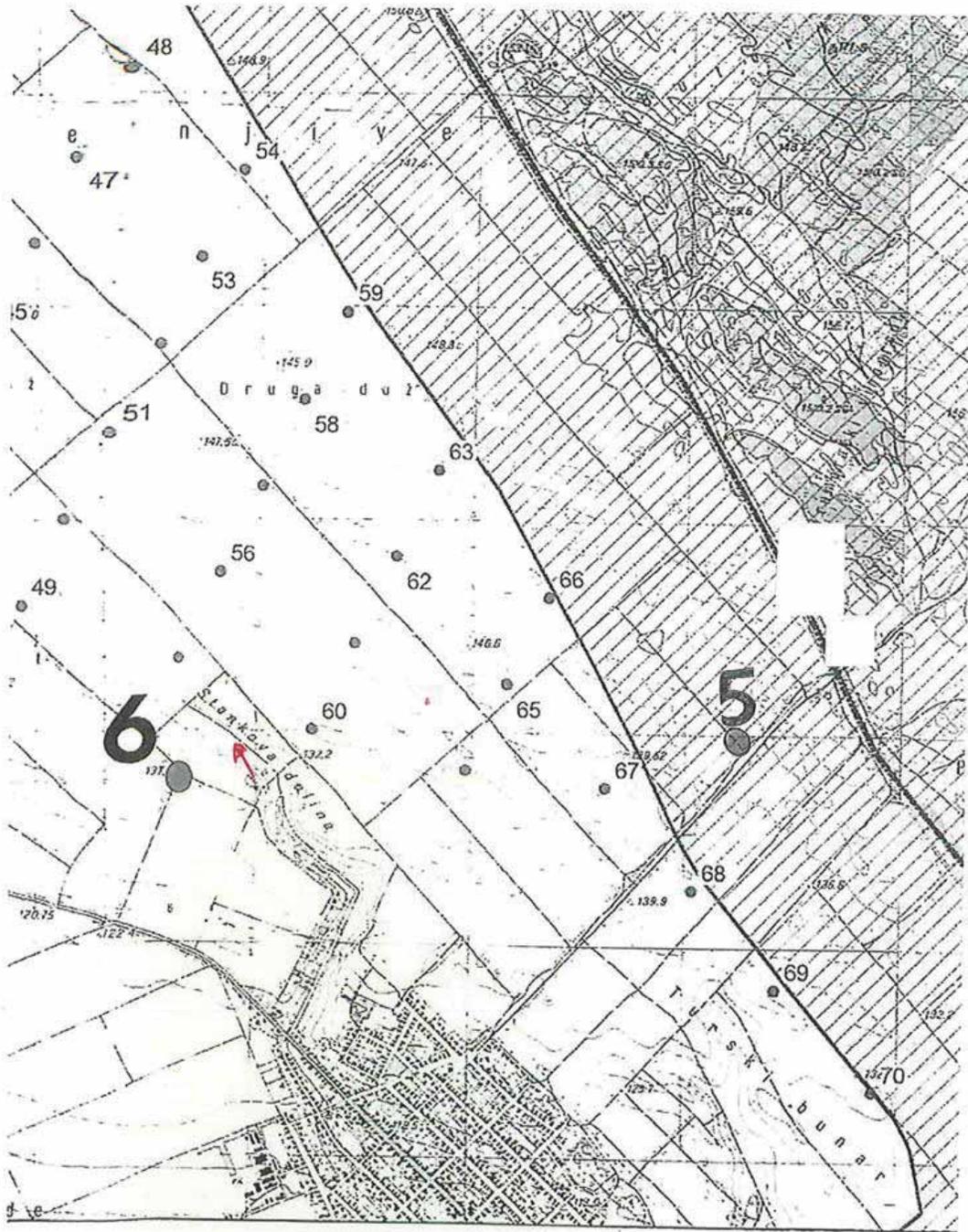
VP6: Anser Anser & Anser Albifrons (Grey Geese (greylag goose and greater white-fronted goose))



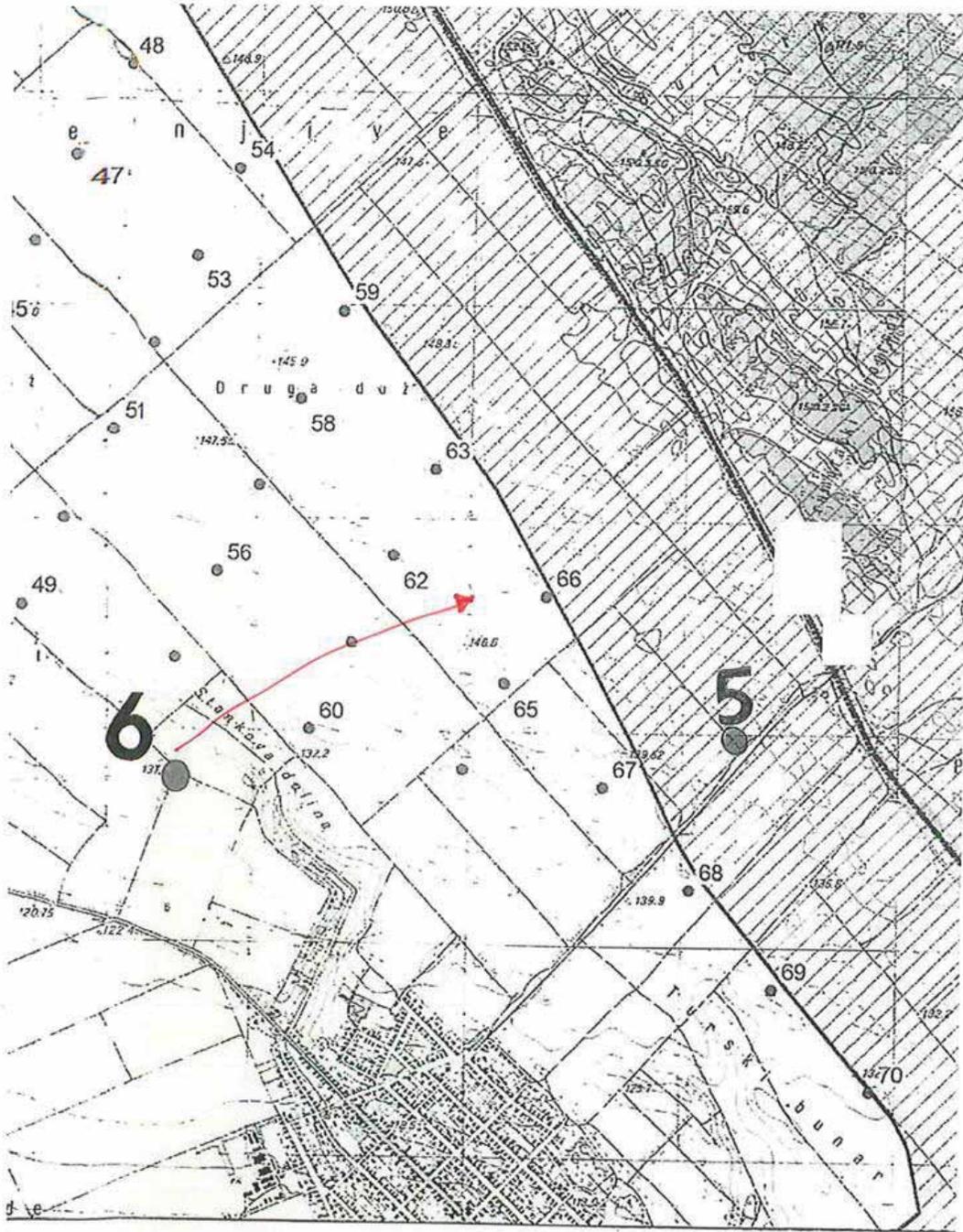
CP6: Circus Cyaneus (Hen Harrier)



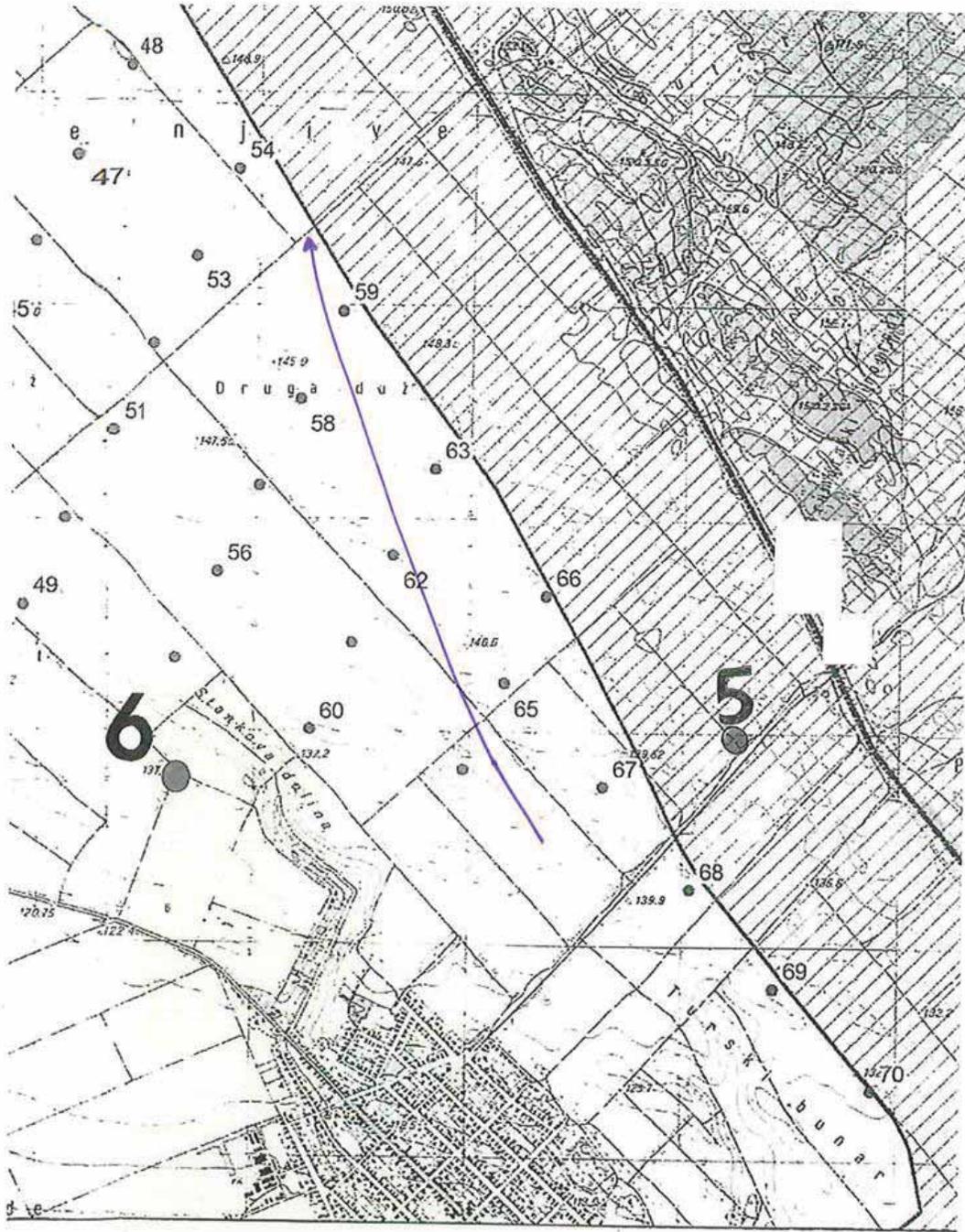
VP6: Falco Columbarius (Merlin)



VP6: *Circus Aeruginosus* (Western Marsh Harrier)



VP6: Ciconia Ciconia (White Stork)





# Appendix C. Collision Risk Analysis

## Methodology

The collision risk calculations followed the methodology outlined in the Scottish Natural Heritage (SNH) guidance *Windfarms and Birds: Calculating a theoretical collision risk assuming no avoiding action* (SNH, 2000<sup>13</sup>).

Thirteen target bird species were recorded flying at rotor height (the height between the upper and lower turbine blades): northern goshawk, European sparrowhawk, hen harrier, Eurasian kestrel, saker falcon, black kite, common buzzard, greylag goose, white-fronted goose, white stork, common crane, European bee-eater and great cormorant.

It was not always possible to differentiate between white-fronted geese and greylag geese (although flocks that could be identified suggested proportions of at least 90% greylag geese to 10% white-fronted geese). Therefore, both species have been recorded and analysed as a single group: 'grey geese'.

An additional species, black stork, was not on the target species list, but was recorded during the vantage point surveys and has been treated as a target species. Black stork was also recorded flying at rotor height.

All 14 target species (including black stork) were recorded within the survey area during surveys undertaken between November 2011 and July 2012. A further 5 target species (Western marsh harrier, pallid harrier, merlin, Eurasian hobby and white-tailed eagle) were recorded within the survey area, but not at rotor height and were therefore not at collision risk and were excluded from the collision risk calculations.

The volume of airspace within the vantage point visual envelopes at rotor height is known as the collision risk zone. For the target species recorded at collision risk height, the amount of time spent within the collision risk zone was calculated. Each recorded flight time within the collision risk zone was multiplied by the number of birds recorded during that flight. These flight times were then added together to give a total flight time within the collision risk zone for all target species over the 9 month survey period (November 2011 to July 2012).

All recorded flights within the collision risk zone are averaged across this volume of airspace. The proportion of this airspace taken up by the turbine blades is used to calculate the amount of time that each target species spends within the rotor sweep volume<sup>14</sup> over the course of the survey period.

SNH (2000) describes two methods of calculating collision risk:

1. For birds that make regular flights through a windfarm, and
2. For birds using the whole windfarm space.

As can be seen from the target species flight maps in Appendix B, the majority of flights did not follow regular paths, and so method 2 was chosen to estimate collision risk for target species.

The calculation of potential collision risk involves four stages:

**Stage 1.** The first stage is to calculate the amount of time each target species was present throughout the year within the rotor sweep volume of the proposed turbine. This is based on the observed flight activity during the survey period (in this case November 2011 – July 2012) and the parameters and design of the wind turbine. Based on the amount of time each target species spends

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<sup>13</sup> Scottish Natural Heritage. (2000). *Windfarms and Birds: Calculating a Theoretical Collision Risk Assuming no Avoiding Action*

<sup>14</sup> This is the space that the turbine blades occupy and can be taken as the diameter of turbine blades x the width of turbine blades (see Fig 2, SNH 2000).

within the rotor sweep volume, and their known average flight speeds, it is possible to estimate the number of transits through the rotor sweep volume that each target species would make over the survey period (264 days). This can be extrapolated to estimate the number of transits through the rotor sweep volume per year.

**Stage 2.** The proportion of transits through the rotor sweep volume that will result in a collision between the bird and a wind turbine blade are then estimated, based on the size of turbine blades, the rotor period (time for one revolution of rotor), the size of the bird and the average speed of the bird. All predicted collisions are presumed to be fatal. This provides an estimate of the number of fatalities per season (or per year) for the wind farm but assumes that there is no avoidance action to prevent a collision.

**Stage 3.** The third stage of the calculation involves applying an avoidance factor. Avoidance rates are still unknown for many species. However, guidance by Scottish Natural Heritage (*Use of Avoidance Rates in the SNH Wind Farm Collision Risk Model*, SNH, 2010<sup>15</sup>) proposes that a default avoidance rate of 98% should be used. For some species where detailed analysis has been undertaken, the guidance provides more specific avoidance values: 'grey geese' (greylag geese and greater white-fronted geese) and hen harriers have an avoidance rate of 99%, whereas kestrels have a lower avoidance rate of 95%.

**Stage 4.** The final stage of the calculation involves applying an estimate of downtime for the turbines, and reducing the predicted collisions per year accordingly.

The output from each table is identified by a letter in bold, which is carried through to subsequent tables within this analysis.

### **Stage 1 –**

The data from this study has been used to calculate the number of transits through the rotor sweep volume that each target species would make for the 9 month survey period. Thirty-six hours of survey have been undertaken for the summer and winter periods, giving a total of 72 hours.

The proposed turbines will have a maximum rotor diameter of 126m and will occupy a height range between 60-80m and 180-200m. All birds recorded within the height range of 50m – 200m were considered to be at collision risk. As such, some birds recorded within the collision risk height range will not be within the rotor height range of the chosen turbine design, and so collision risk value will be overestimated for some species. A correction factor of 0.84 (126m rotor diameter ÷ 150m collision risk range) is applied to reduce this overestimation.

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<sup>15</sup> Scottish Natural Heritage. (2010). Use of Avoidance rates in the SNH Wind Form Collision Risk Model.

**Table 1: Calculating total flight time within the collision risk zone**

| Species   |         |      |  |  |  |  |  |  |  |  |  |  |  |
|---|---------|------|--|--|--|--|--|--|--|--|--|--|--|
| 'Grey geese'  | 835,335 |      |  |  |  |  |  |  |  |  |  |  |  |
| Common buzzard  | 10,585  | 2.47 |  |  |  |  |  |  |  |  |  |  |  |
| Common crane  | 9,420   | 2.32 |  |  |  |  |  |  |  |  |  |  |  |
| White stork   | 2,955   | 0.82 |  |  |  |  |  |  |  |  |  |  |  |
| Great cormorant   | 1,740   | 0.48 |  |  |  |  |  |  |  |  |  |  |  |
| European bee-eater  | 1,230   | 0.34 |  |  |  |  |  |  |  |  |  |  |  |
| Eurasian kestrel  | 750     | 0.21 |  |  |  |  |  |  |  |  |  |  |  |
| Hen harrier   | 465     | 0.13 |  |  |  |  |  |  |  |  |  |  |  |
| Northern goshawk  | 345     | 0.10 |  |  |  |  |  |  |  |  |  |  |  |
| Black kite  | 300     | 0.08 |  |  |  |  |  |  |  |  |  |  |  |
| European sparrowhawk  | 120     | 0.03 |  |  |  |  |  |  |  |  |  |  |  |
| Black stork   | 90      | 0.03 |  |  |  |  |  |  |  |  |  |  |  |
| Saker falcon  | 45      | 0.01 |  |  |  |  |  |  |  |  |  |  |  |
| Total flight time within collision risk zone (seconds)          |         |      |  |  |  |  |  |  |  |  |  |  |  |
| Total flight time within collision risk zone (hours)            | 232.04  |      |  |  |  |  |  |  |  |  |  |  |  |
| Flight time in hours per survey hour                            | 3.22    | 0.04 |  |  |  |  |  |  |  |  |  |  |  |
| Flight time in hours per survey hour with correction factor (a) | 2.71    | 0.03 |  |  |  |  |  |  |  |  |  |  |  |

N.B. The 'grey geese' category above refers to greylag and white-fronted geese combined.

**Table 2: Flight Data**

Using the flight time per survey hour (a) calculated above in Table 1, the predicted daily flight time of each species, and the duration of the study, Table 2 below extrapolates the bird occupancy within the collision risk volume.

All target species recorded are diurnal and are generally only active (and therefore flying) during daylight hours. For the purpose of this assessment, it was assumed that these species are active for an average of up to 12 hours per day over the survey period.

| Species  | Grey geese' | Common buzzard | Common crane | White stork | Great cormorant | European bee-eater | Eurasian kestrel | Hen harrier | Northern goshawk | Black kite | European sparrowhawk | Black stork | Saker falcon |
|--|-------------|----------------|--------------|-------------|-----------------|--------------------|------------------|-------------|------------------|------------|----------------------|-------------|--------------|
| Flight time in hours per survey hour (a)   | 2.71        | 0.03           | 0.03         | 0.01        | 0.01            | 0.00               | 0.00             | 0.00        | 0.00             | 0.00       | 0.00                 | 0.00        | 0.00         |
| Average daylight flight period (in hours) per day during study (estimated)           | 12          | 12             | 12           | 12          | 12              | 12                 | 12               | 12          | 12               | 12         | 12                   | 12          | 12           |
| Duration of study (days)   | 264         | 264            | 264          | 264         | 264             | 264                | 264              | 264         | 264              | 264        | 264                  | 264         | 264          |
| Assumed activity during the study in hours (b)                                       | 3,168       | 3,168          | 3,168        | 3,168       | 3,168           | 3,168              | 3,168            | 3,168       | 3,168            | 3,168      | 3,168                | 3,168       | 3,168        |
| Predicted occupancy time (hours) within visual envelope collision risk volume: a x b | 8576        | 109            | 97           | 30          | 18              | 13                 | 7.7              | 4.8         | 3.5              | 3.1        | 1.2                  | 0.9         | 0.5          |
| Bird occupancy (seconds) within visual envelope collision risk volume                | 30,873,982  | 391,222        | 348,163      | 109,217     | 64,310          | 45,461             | 27,720           | 17,186      | 12,751           | 11,088     | 4,435                | 3,326       | 1,663        |



**Table 4: Biometric Data**

Body length (including tail) and wingspan measurements taken from Svensson (2009)<sup>16</sup>.

The values of Body length (L), Wingspan (W) and Flight speed (v) have been treated as fixed values. The majority of flight speeds have been taken from Bruderer and Boldt (2001)<sup>17</sup>, although grey geese, merlin and saker falcon have been taken from alternate sources, referenced in Table 4 below. Calculations have typically been derived from small data sets, and assume birds are flying at constant speed. However, it should be noted that flight speeds may only have a limited influence on collision estimates<sup>18</sup>.

| Species                   | Grey geese <sup>19</sup> | Common buzzard | Common crane | White stork | Great cormorant | European bee-eater | Eurasian kestrel | Hen harrier | Northern goshawk | Black kite | European sparrowhawk | Black stork | Saker falcon <sup>20</sup> |
|---------------------------|--------------------------|----------------|--------------|-------------|-----------------|--------------------|------------------|-------------|------------------|------------|----------------------|-------------|----------------------------|
| Flight speed m/s (v)      | 18.9                     | 11.0           | 14.5         | 13.5        | 16.7            | 12.2               | 12.3             | 11.4        | 9.7              | 12.1       | 11.5                 | 15.4        | 14.4                       |
| Body length average m (L) | 0.79                     | 0.52           | 1.08         | 1.03        | 0.86            | 0.27               | 0.34             | 0.5         | 0.57             | 0.53       | 0.35                 | 0.98        | 0.51                       |
| Wingspan average m (W)    | 1.59                     | 1.2            | 2.01         | 1.99        | 1.35            | 0.38               | 0.73             | 1.08        | 1.05             | 1.43       | 0.69                 | 1.89        | 1.17                       |

<sup>16</sup> Svensson, L., Mullaney, K. and Zetterstrom, D. (2009) Collin Bird Guide: 2<sup>nd</sup> Edition. Collins:Italy.

<sup>17</sup> Bruderer, B. and Boldt, A. (2001) *Flight characteristics of bird: I radar measurements of speeds*. Ibis, 143, 178-204.

<sup>18</sup> Madders and Whitfield. (2006). *Upland raptors and the assessment of wind farm impacts*. Ibis, 148, 43-56.

<sup>19</sup> Speakman, J.R. and Banks, D. (1998) *The function of flight formations in grey/lag geese: energy saving or orientation?* Ibis, 140, 280-287.

<sup>20</sup> Based on peregrine falcon flight speed, taken from Cochran, W. (1986) *Speed of flapping flight of merlins and peregrine falcons* The Condor, 88, 397-398.

**Table 5: Wind turbine Parameters**

The volume of airspace within the wind farm site at rotor height is known as the collision risk zone.

| Measurement  | Symbol    | Value         | Comments  |
|--|-----------|---------------|---|
| Wind farm site area (m <sup>2</sup> )              | <b>A</b>  | 37,160,000    | Difference between upper and lower rotor height     |
| Rotor height (m)                                   | <b>h</b>  | 126           |   |
| Collision risk zone (m <sup>3</sup> ) <b>A x h</b> | <b>Vw</b> | 4,682,160,000 |   |
| Number of turbines                                 | <b>N</b>  | 57            |   |
| Rotor blade radius (m)                             | <b>r</b>  | 63            | Specification provided by Continental Wind Partners |
| Width of rotor blade (m)                           | <b>d</b>  | 4.0           | Specification provided by Continental Wind Partners |

Calculation of the number of bird transits through the rotors over the 9 months of survey is based on the 'Birds using windfarm airspace' approach outlined in Stage 1 of *Windfarms and Birds: Calculating a theoretical collision risk assuming no avoiding action* (SNH, 2000) using data from Tables 3, 4 and 5 above. Results of this calculation can be viewed in Table 6 below.

**Table 6: Collision Risk Calculation**

| Species  | Grey geese | Common buzzard | Common crane | White stork | Great cormorant | European bee-eater | Eurasian kestrel | Hen harrier | Northern goshawk | Black kite | European sparrowhawk | Black stork | Saker falcon |
|--|------------|----------------|--------------|-------------|-----------------|--------------------|------------------|-------------|------------------|------------|----------------------|-------------|--------------|
| Combined volume swept out by the wind turbine rotors<br>$Vr = N \times \pi r^2 \times (d+L)$ | 3,404,847  | 3,212,925      | 3,607,432    | 3,571,891   | 3,451,051       | 3,035,219          | 3,084,977        | 3,198,708   | 3,244,912        | 3,220,033  | 3,092,085            | 3,536,350   | 3,205,817    |
| Bird occupancy in seconds within collision risk volume (c)                                   | 30,431,755 | 385,618        | 343,176      | 107,652     | 63,389          | 179,334            | 109,350          | 16,940      | 12,569           | 10,929     | 17,496               | 3,279       | 6,561        |
| Bird occupancy (sec) of the volume swept by the rotors<br>$d = c \times Vr/Vw$               | 22,130     | 265            | 264          | 82          | 47              | 116                | 72               | 12          | 9                | 8          | 12                   | 3           | 4            |
| Bird flight speed v (m/s)  | 18.9       | 11.0           | 14.5         | 13.5        | 16.7            | 12.2               | 12.3             | 11.4        | 9.7              | 12.1       | 11.5                 | 15.4        | 14.4         |
| Time for bird to make a transit through the rotor (sec)<br>$t = (d + L) / v$                 | 0.25       | 0.41           | 0.35         | 0.37        | 0.29            | 0.35               | 0.35             | 0.39        | 0.47             | 0.37       | 0.38                 | 0.32        | 0.31         |
| Number of bird transits through the rotors over 9 months<br>$e = d / t$                      | 87,318     | 644            | 755          | 221         | 161             | 332                | 204              | 29          | 19               | 20         | 31                   | 78          | 14           |

**Table 7: Annual estimates**

The calculations so far have estimated the number of bird transits over the nine month period (264 days) over which the surveys were carried out. The original baseline data collected by Ecoda established that the site is not important for migratory birds, with the majority of birds being resident (e.g. common buzzard, Eurasian kestrel) or over-wintering (e.g. grey geese). Therefore the bird activity over the months not covered in the additional bird surveys (August – October) are considered to have similar or reduced bird activity to those included in the additional bird survey period (November 2011 to July 2012, which included the spring migration period).

The number of bird transits through the rotors over the 9 month period (264 days) can therefore be extrapolated (multiplied by 1.38) to calculate the number of bird transits in a single year.

Due to the presence of grey geese being restricted purely to January and February, no records would be expected in the months of August to October. Therefore the number of grey geese transits has not been extrapolated, as the existing value is already considered to be an annual total.

| Species  | Grey geese | Common buzzard | Common crane | White stork | Great Cormorant | European Bee-eater | Eurasian Kestrel | Hen harrier | Northern goshawk | Black kite | European sparrowhawk | Black stork | Saker falcon |
|--|------------|----------------|--------------|-------------|-----------------|--------------------|------------------|-------------|------------------|------------|----------------------|-------------|--------------|
| Number of bird transits through the rotors over 9 months<br><b>e = d / t</b> | 87,318     | 644            | 755          | 221         | 161             | 332                | 204              | 29          | 19               | 20         | 31                   | 8           | 14           |
| Number of bird transits through the rotors over 1 year                       | 87,318     | 890            | 1,044        | 305         | 222             | 459                | 282              | 41          | 26               | 28         | 42                   | 11          | 20           |

**Stage 2 - Estimation of collision risk assuming no avoiding action**

The information in the Table 7 below is input into the Band Model (SNH, 2000<sup>21</sup>) to generate a collision probability for each bird species (**P**) in Table 8 below, based on the bird size, flight speed and the turbine dimensions and details.

**Table 7: Details required for the Band Model to calculate the probability of a bird being hit when flying through the rotor**

| Measurement         | Value | Comments  |
|---------------------|-------|---|
| Number of blades    | 3     |   |
| Maximum chord (m)   | 4.0   | Specification provided by Continental Wind Partners |
| Pitch (degrees)     | 6     | Specification provided by Continental Wind Partners |
| Flapping or gliding | 0     | 0 = flapping (1 = gliding)                          |
| Rotor diameter (m)  | 126   | Specification provided by Continental Wind Partners |
| Rotor period (sec)  | 6.5   | Specification provided by Continental Wind Partners |

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<sup>21</sup> Band, W., Madders, M. and Whitfield, D.P. (2006) Developing field and analytical methods to assess avian collision risk at wind farms; cited in De Lucas, M., Janss, G. and Ferrer, M. 'Birds and Wind Power' Barcelona, Spain: Lynx Edicions

**Table 8: Estimate of number of collisions assuming no avoiding action**

| Species              | Average collision probability (P) [SNH 2000] | Estimated number of collisions per year without avoidance $e \times P / 100$ |
|----------------------|--|--|
| Grey geese           | 6.4  | 5,588  |
| Common buzzard       | 6.3  | 56   |
| Common crane         | 7.8  | 81.5   |
| White stork          | 7.8  | 23.8   |
| Great cormorant      | 6.5  | 14.4   |
| European bee-eater   | 4.9  | 22.5   |
| Eurasian kestrel     | 5.3  | 11   |
| Hen harrier          | 6.1  | 2.5  |
| Northern goshawk     | 6.7  | 1.7  |
| Black kite           | 6.3  | 1.8  |
| European sparrowhawk | 5.4  | 1.7  |
| Black stork          | 7.3  | 0.77   |
| Saker falcon         | 5.9  | 0.9  |

### **Stage 3 – Applying the avoidance factor**

Table 9 shows the predicted number of collisions per year for all species (the collision risk). Collision avoidance rates are taken from SNH (2010). A default avoidance rate of 98% has been used, with the exception of three target species, where the guidance provides more specific avoidance values: 'grey geese' (greylag geese and greater white-fronted geese) and hen harriers have an avoidance rate of 99%, whereas kestrels have a lower avoidance rate of 95%.

Table 9: Application of the collision avoidance rate

| Species  | Grey geese | Common buzzard | Common crane | White stork | Great cormorant | European bee-eater | Eurasian kestrel | Hen harrier | Northern goshawk | Black kite | European sparrowhawk | Black stork | Saker falcon |
|--|------------|----------------|--------------|-------------|-----------------|--------------------|------------------|-------------|------------------|------------|----------------------|-------------|--------------|
| Estimated number of collisions per year without avoidance <b>e x P</b> / 100 | 5,588      | 56             | 81.5         | 23.8        | 14.4            | 22.5               | 11               | 2.5         | 1.7              | 1.8        | 1.7                  | 0.77        | 0.9          |
| Avoidance rate taken from SNH (2010)   | 99%        | 98%            | 98%          | 98%         | 98%             | 98%                | 95%              | 99%         | 98%              | 98%        | 98%                  | 98%         | 98%          |
| Average number of predicted collisions per year using avoidance rate (f)     | 55.88      | 1.1            | 1.6          | 0.48        | 0.29            | 0.45               | 0.54             | 0.02        | 0.03             | 0.04       | 0.03                 | 0.02        | 0.02         |

Atkins

Atkins  
 2010年11月，Atkins公司受委托对阿曼的Saker Falcon保护区进行了调查。调查的目的是评估保护区的碰撞避免率。调查方法包括对保护区的巡逻、对保护区的监测以及对保护区的评估。调查结果表明，保护区的碰撞避免率达到了98%。这主要是由于保护区采取了严格的保护措施，包括限制人类活动、限制车辆进入以及限制牲畜放牧等。此外，保护区还采取了其他措施，如设置警示标志、设置围栏以及设置障碍物等，以进一步降低碰撞风险。这些措施有效地保护了保护区的Saker Falcon种群，使其数量得到了恢复和增长。

**Stage 4 - Adjustment for rotor downtime and unsuitable flight conditions**

The predicted number of collisions per year for each species per year has been adjusted to allow for rotor downtime and unsuitable flight conditions. High and low wind speeds will reduce the operational time of the turbine to approximately 80% (g) of its life. Estimates have been provided by Continental Wind Partners

**Table 10: Predicted collisions for each species per year using a 20% estimate for rotor downtime**

| Species                       | Adjusted average number of predicted collisions per year f x g |      |      |
|-------------------------------|--|------|------|
| Grey geese                    | 44.71  | 0.90 | 1.1  |
| Common buzzard                | 0.90   | 1.3  | 0.77 |
| White stork                   | 0.38   | 0.23 | 2.63 |
| Great cormorant               | 0.23   | 0.36 | 4.3  |
| European bee-eater            | 0.36   | 0.43 | 2.78 |
| Eurasian kestrel              | 0.43   | 0.02 | 2.3  |
| Hen harrier                   | 0.02   | 0.03 | 51   |
| Northern goshawk              | 0.03   | 0.03 | 36   |
| Black kite                    | 0.03   | 0.03 | 36   |
| European sparrowhawk          | 0.03   | 0.01 | 38   |
| Black stork                   | 0.01   | 0.01 | 81   |
| Saker falcon                  | 0.01   |      | 74   |
| Number of years per collision | 0.02   | 1.1  |      |





Cibuk wind farm – additional vantage point survey

|                             |                                     |  |   |
|-----------------------------|-------------------------------------|--|---|
| Corn bunting                | <i>Emberiza calandra</i>            | Breeding within wind farm site                 | Vantage point survey and breeding bird survey |
| Crested lark                | <i>Galerida cristata</i>            | Breeding within wind farm site                 | Vantage point survey and breeding bird survey |
| Eurasian collared dove      | <i>Streptopelia decaocto</i>        | Breeding within or just outside wind farm site | Vantage point survey and breeding bird survey |
| Eurasian golden oriole      | <i>Oriolus oriolus</i>              | Breeding within or just outside wind farm site | Vantage point survey and breeding bird survey |
| Eurasian hobby              | <i>Falco subbeteo</i>               | Breeding near wind farm site                   | Vantage point survey and breeding bird survey |
| Eurasian hoopoe             | <i>Upupa epops</i>                  | Breeding within or just outside wind farm site | Vantage point survey and breeding bird survey |
| Eurasian jay                | <i>Garrulus glandarius</i>          | Breeding within or just outside wind farm site | Vantage point survey                          |
| Eurasian kestrel            | <i>Falco tinninculus</i>            | Breeding within wind farm site                 | Vantage point survey and breeding bird survey |
| Eurasian linnet             | <i>Carduelis cannabina</i>          | Breeding within wind farm site                 | Vantage point survey                          |
| Eurasian magpie             | <i>Pica pica</i>                    | Breeding within wind farm site                 | Vantage point survey and breeding bird survey |
| Eurasian siskin             | <i>Carduelis spinus</i>             | Wintering/passage only                         | Vantage point survey                          |
| Eurasian skylark            | <i>Alauda arvensis</i>              | Breeding within wind farm site                 | Vantage point survey and breeding bird survey |
| Eurasian sparrowhawk        | <i>Accipiter nisus</i>              | Breeding near wind farm site                   | Vantage point survey and breeding bird survey |
| Eurasian tree sparrow       | <i>Passer montanus</i>              | Breeding within wind farm site                 | Vantage point survey and breeding bird survey |
| European bee-eater          | <i>Merops apiaster</i>              | Breeding within wind farm site                 | Vantage point survey and breeding bird survey |
| European golden plover      | <i>Pluvialis apricaria</i>          | Passage only                                   | Vantage point survey                          |
| European goldfinch          | <i>Carduelis carduelis</i>          | Breeding within or just outside wind farm site | Vantage point survey and breeding bird survey |
| European greenfinch         | <i>Carduelis chloris</i>            | Breeding within or just outside wind farm site | Vantage point survey and breeding bird survey |
| European sand martin        | <i>Riparia riparia</i>              | Breeding within or just outside wind farm site | Vantage point survey and breeding bird survey |
| European serin              | <i>Serinus serinus</i>              | Wintering/passage only                         | Vantage point survey and breeding bird survey |
| European stonechat          | <i>Saxicola torquata</i>            | Breeding within wind farm site                 | Vantage point survey and breeding bird survey |
| European turtle dove        | <i>Streptopelia turtur</i>          | Breeding within wind farm site                 | Vantage point survey and breeding bird survey |
| Feral pigeon                | <i>Columba livia (domesticated)</i> | Breeding within wind farm site                 | Vantage point survey                          |
| Fieldfare                   | <i>Turdus pilaris</i>               | Wintering/passage only                         | Vantage point survey                          |
| Great cormorant             | <i>Phalacrocorax carbo</i>          | Passage only                                   | Vantage point survey and breeding bird survey |
| Great grey shrike           | <i>Lanius excubitor</i>             | Wintering/passage only                         | Vantage point survey                          |
| Great reed warbler          | <i>Acrocephalus arundinaceus</i>    | Passage only                                   | Vantage point survey                          |
| Great spotted woodpecker    | <i>Dendrocops major</i>             | Breeding within or just outside wind farm site | Vantage point survey                          |
| Great tit                   | <i>Parus major</i>                  | Breeding within or just outside wind farm site | Vantage point survey                          |
| Great white egret           | <i>Egreta alba</i>                  | Passage only                                   | Vantage point survey                          |
| Greater white-fronted goose | <i>Anser albifrons</i>              | Wintering/passage only                         | Vantage point survey                          |

Cibuk wind farm – additional vantage point survey

|                       |                                      |  |   |
|-----------------------|--------------------------------------|--|---|
| Grey heron            | <i>Ardea cineria</i>                 | Passage only                                   | Vantage point survey and breeding bird survey |
| Grey partridge        | <i>Perdix perdix</i>                 | Breeding within or just outside wind farm site | Vantage point survey                          |
| Greylag goose         | <i>Anser anser</i>                   | Wintering/passage only                         | Vantage point survey                          |
| Hawfinch              | <i>Coccothraustes coccothraustes</i> | Wintering/passage only                         | Vantage point survey                          |
| Hen harrier           | <i>Circus cyaneus</i>                | Wintering/passage only                         | Vantage point survey                          |
| Hooded crow           | <i>Corvus cornix</i>                 | Breeding within or just outside wind farm site | Vantage point survey and breeding bird survey |
| House sparrow         | <i>Passer domesticus</i>             | Breeding within wind farm site                 | Vantage point survey and breeding bird survey |
| Lesser grey shrike    | <i>Lanius minor</i>                  | Passage only                                   | Vantage point survey and breeding bird survey |
| Lesser whitethroat    | <i>Sylvia curruca</i>                | Passage only                                   | Vantage point survey                          |
| Long-tailed tit       | <i>Aegithalos caudatus</i>           | Breeding within or just outside wind farm site | Vantage point survey                          |
| Mallard               | <i>Anas platyrhynchos</i>            | Passage only                                   | Vantage point survey                          |
| Marsh warbler         | <i>Acrocephalus palustris</i>        | Passage only                                   | Breeding bird survey                          |
| Meadow pipit          | <i>Anthus pratensis</i>              | Wintering/passage only                         | Vantage point survey and breeding bird survey |
| Merlin                | <i>Falco columbarius</i>             | Wintering/passage only                         | Vantage point survey                          |
| Mistle thrush         | <i>Turdus viscivorus</i>             | Wintering/passage only                         | Vantage point survey                          |
| Montagu's harrier     | <i>Circus pygargus</i>               | Passage only                                   | Breeding bird survey                          |
| Northern goshawk      | <i>Accipiter gentilis</i>            | Breeding near wind farm site                   | Vantage point survey and breeding bird survey |
| Northern lapwing      | <i>Vanellus vanellus</i>             | Passage only                                   | Vantage point survey and breeding bird survey |
| Northern pintail      | <i>Anas acuta</i>                    | Passage only                                   | Vantage point survey                          |
| Northern wheatear     | <i>Oenanthe oenanthe</i>             | Passage/probably breeding near wind farm site  | Vantage point survey and breeding bird survey |
| Pallid harrier        | <i>Circus macrourus</i>              | Wintering/passage only                         | Vantage point survey                          |
| Red-backed shrike     | <i>Lanius collurio</i>               | Breeding within wind farm site                 | Vantage point survey and breeding bird survey |
| Redwing               | <i>Turdus iliacus</i>                | Wintering/passage only                         | Vantage point survey                          |
| Reed bunting          | <i>Emberiza schoeniclus</i>          | Breeding within or just outside wind farm site | Vantage point survey                          |
| Rook                  | <i>Corvus frugilegus</i>             | Probably breeding near wind farm site          | Vantage point survey and breeding bird survey |
| Ruff                  | <i>Philomachus pugnax</i>            | Passage only                                   | Vantage point survey                          |
| Saker falcon          | <i>Falco cherrug</i>                 | Breeding near wind farm site                   | Vantage point survey                          |
| Spotted flycatcher    | <i>Muscicapa striata</i>             | Passage/probably breeding near wind farm site  | Vantage point survey and breeding bird survey |
| Tawny pipit           | <i>Anthus campestris</i>             | Breeding within wind farm site                 | Vantage point survey and breeding bird survey |
| Western jackdaw       | <i>Corvus monedula</i>               | Breeding within or just outside wind farm site | Vantage point survey                          |
| Western marsh harrier | <i>Circus aeruginosus</i>            | Wintering/passage only                         | Vantage point survey and breeding bird survey |
| Whinchat              | <i>Saxicola rubetra</i>              | Possibly breeding within wind farm site        | Vantage point survey and breeding bird survey |
| White stork           | <i>Ciconia ciconia</i>               | Passage only                                   | Vantage point survey                          |
| White wagtail         | <i>Motacilla alba</i>                | Breeding within wind farm site                 | Vantage point survey                          |
| White-tailed eagle    | <i>Haliaeetus alba</i>               | Wintering/passage only                         | Vantage point survey                          |

Cibuk wind farm – additional vantage point survey

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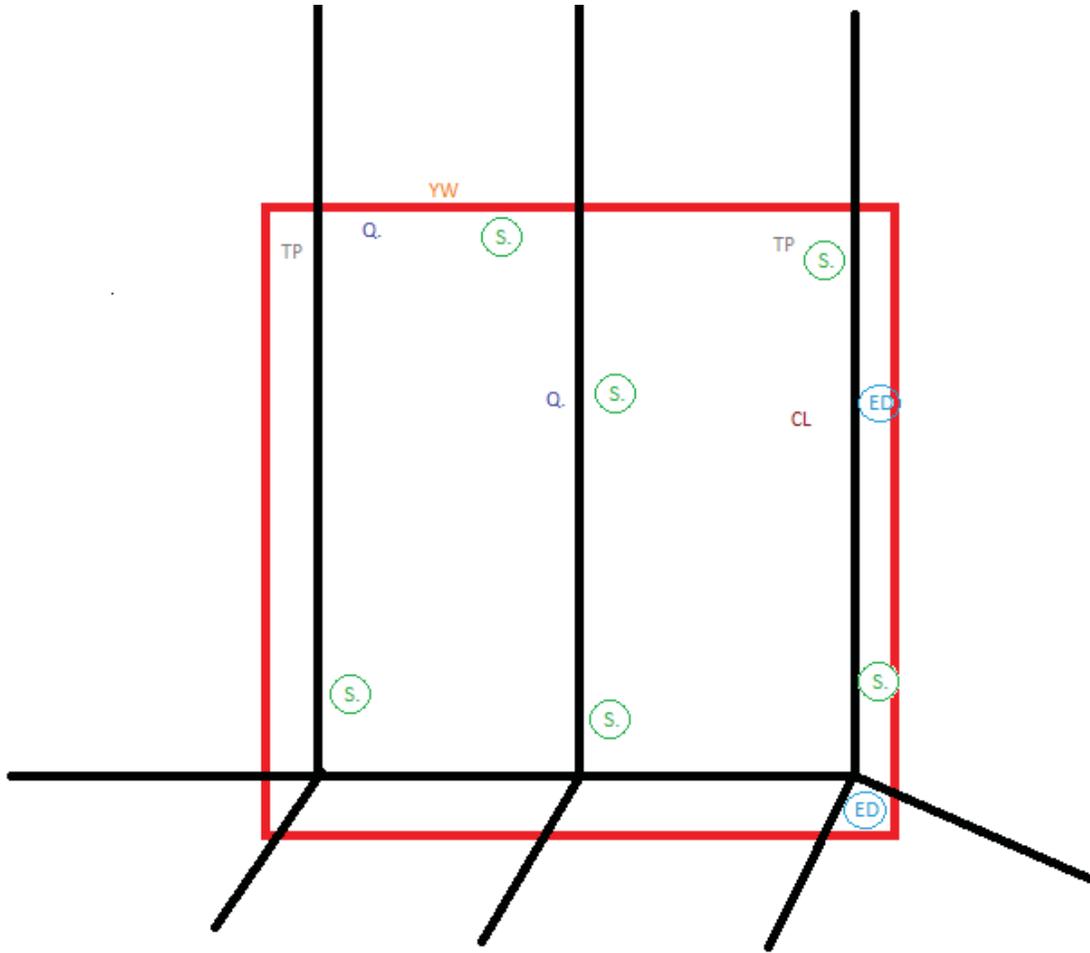
|                |                            |  |   |
|----------------|----------------------------|--|---|
| Woodlark       | <i>Lullula arborea</i>     | Passage only                                   | Vantage point survey                          |
| Woodpigeon     | <i>Columba palumbus</i>    | Breeding within wind farm site                 | Vantage point survey                          |
| Yellow wagtail | <i>Motacilla flava</i>     | Breeding within wind farm site                 | Vantage point survey and breeding bird survey |
| Yellowhammer   | <i>Emberiza citrinella</i> | Breeding within or just outside wind farm site | Vantage point survey and breeding bird survey |

## Appendix E. Breeding bird square territory maps

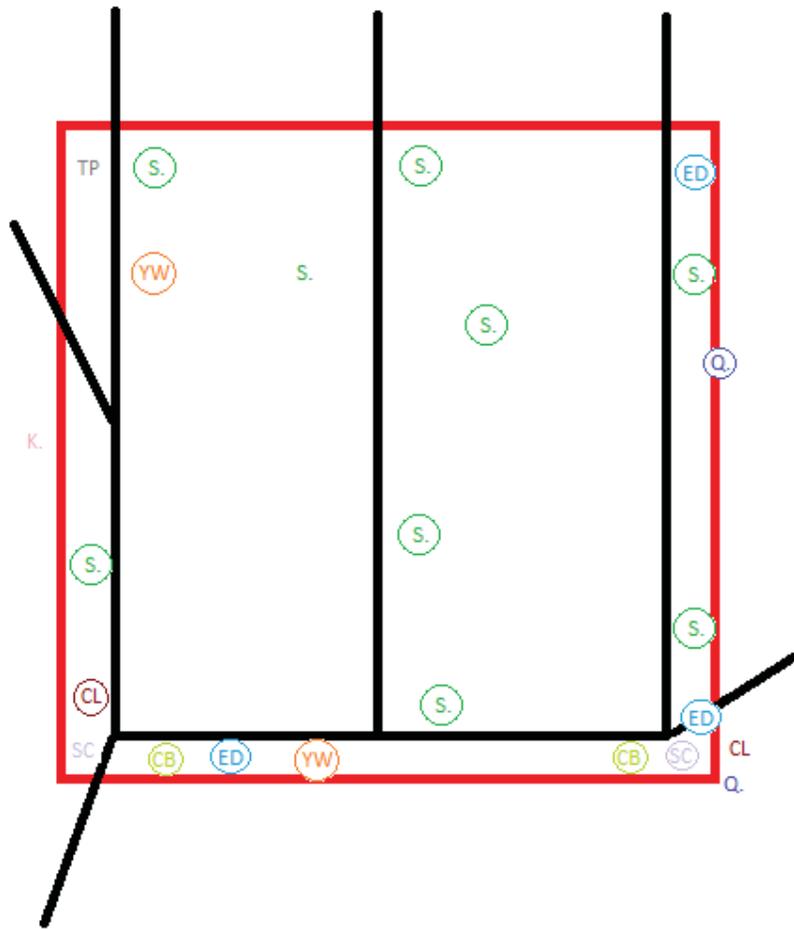
### Key

-  = Blackcap
-  = Corn bunting
-  = Common chaffinch
-  = Crested lark
-  = Red-backed shrike
-  = House sparrow
-  = Eurasian kestrel
-  = European bee-eater
-  = Common quail
-  = Eurasian skylark
-  = European stonechat
-  = Tawny pipit
-  = Eurasian tree sparrow
-  = Yellow wagtail
-  = Common whitethroat
  
- BC = possible territory
-  = confirmed territory
  
-  = Survey square boundary
-  = Access track (survey route)

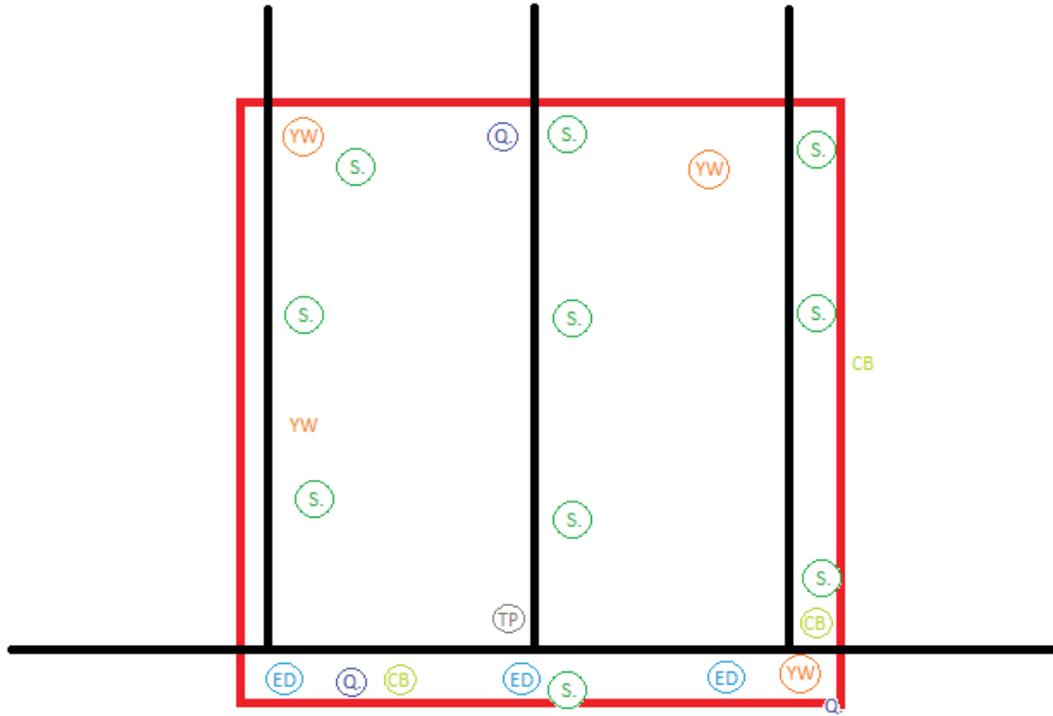
### Breeding square 1



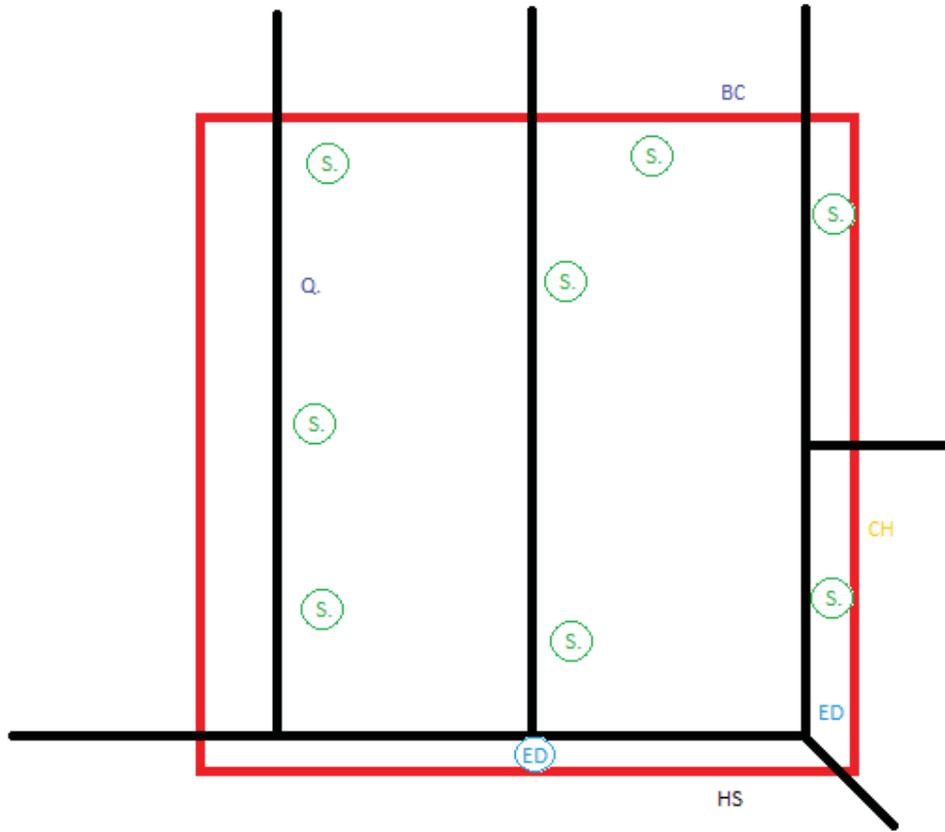
## Breeding Square 2



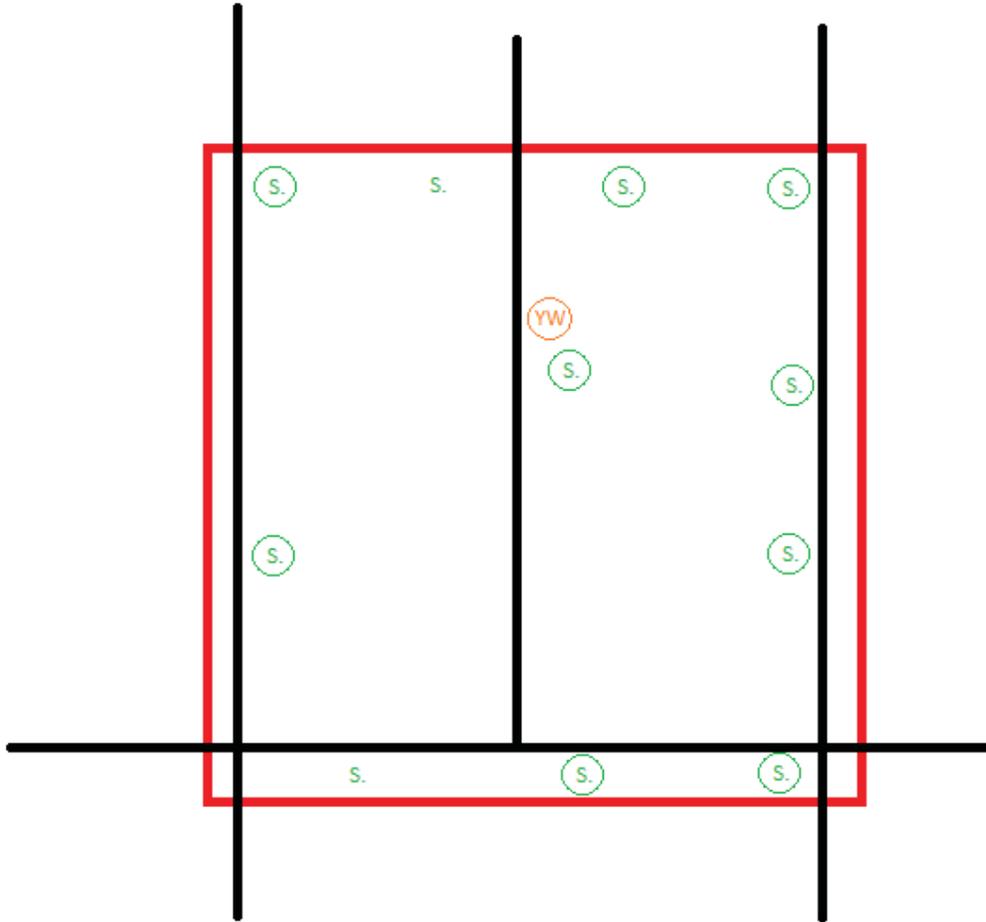
### Breeding square 3



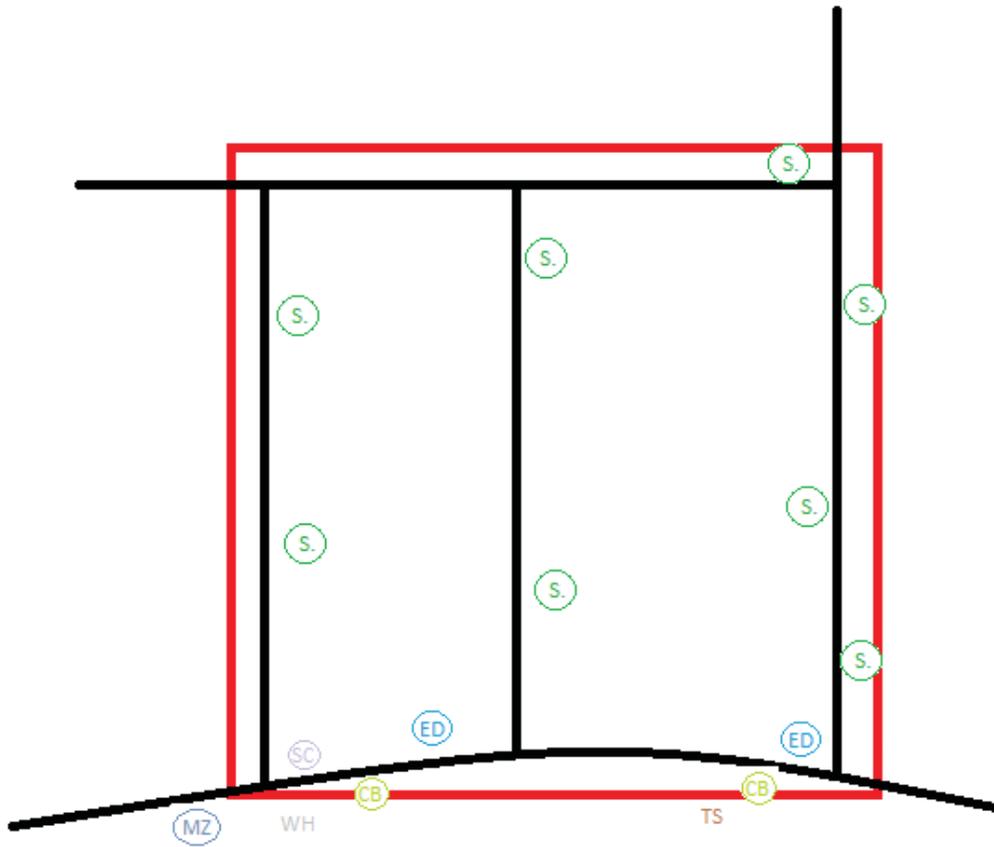
### Breeding square 4



**Breeding square 5**



### Breeding square 6



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