# The use of 'flight diverters' reduces mute swan *Cygnus olor* collision with power lines at Abberton Reservoir, Essex, England

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**SUMMARY**

Waterfowl and breeding bird surveys were conducted at Abberton Reservoir Special Protection Area between 2004 and 2006 as part of a study related to an environmental impact assessment. A secondary finding of these surveys revealed a significant level of mortality in spring for mute swans *Cygnus olor*, and other waterbirds that were colliding with nearby overhead power lines. In the spring of 2004, nine mute swans were killed through collision with the 132Kv power lines, while in spring 2006, 21 were killed. In the summer of 2006, over 500 red 'flight diverters' (320 mm long, 175 mm diameter) were installed at 5 m intervals along a 1.5 km length of the power lines. In the spring of 2007 only one mute swan was killed through power line collision, while in spring 2008 none were killed.

The perpendicular distances over which bird carcasses were found on the ground from under the overhead power cables ranged from 10-351 m. This should be taken into account when designing future collision mortality surveys for similar power lines. It is recommended that appropriate bird flight diverters are fitted as routine best practise when installing any new overhead power lines.

**BACKGROUND**

Abberton Reservoir is a 474 ha waterbody that was constructed in the 1930s. The site is designated a Special Protection Area (SPA) under the EU Birds Directive (79/409/EEC) on account of its large overwintering waterfowl populations, principally gadwall *Anas strepera*, shoveler *A.clypeata* and teal *A.crecca*. On behalf of Essex & Suffolk Water, *Cambridge Ecology Ltd.* have been conducting ecological surveys at Abberton Reservoir (Essex, southeast England) since 2004 in order to inform the impact assessment process associated with proposed developments at the site. As an outcome of this work, observations were made of mute swan collision with power lines at the western end of the reservoir.

The occurrence of mute swan collisions with overhead power lines is well documented. Rowell and Spray (2004) noted that since the reduction in deaths from lead poisoning, the main cause of mute swan deaths in the UK is collision with overhead wires. Perrins and Sears (1991), in a study using British and Irish ring recoveries, showed that 22% of reported deaths were due to collisions with overhead wires; birds 4-6 years old were killed more frequently than any other age group. Other studies have shown similar or higher numbers of casualties, with overhead wires accounting for between 30–40% of all recorded deaths in a Midlands study area (Coleman *et al.* 2001), and up to 46% of deaths in the Western Isles (Spray 1991). Elsewhere in Europe, power line collision induced mortality has also been recorded, for example, in Sweden between 19-38% of recovered ringed mute swans were killed by collision with electrical wires (Mathiasson 1993). Here the relative frequency of killed swans was found not to be related to the density or type of electrical wires in the landscape, but to where in the landscape the wires are positioned, and to the time when mass movements of swans occur. Various skeletal injuries were found in dead birds after collision but many of these injuries were considered non-lethal; most collision-birds ultimately died from liver damage, probably caused by their heavy bodies hitting the ground (Mathiasson 1993). These observations

suggest that swan mortality through collision with power lines is a serious issue but few studies have investigated the effectiveness of potential mitigation measures. The few published papers assessing the effectiveness of bird deflectors/wire markers (Koops 1982, Janss *et al*. 1998, 1999) show there is a high potential for collision reduction. This present study assessed whether deflectors ('flight diverters') reduced mute swan collision mortality at Abberton Reservoir.

**Status and population of mute swan at Abberton Reservoir:** The mute swan population at Abberton is important nationally and internationally and contributes to various conservation designations, e.g. cited as part of the site's SPA status (in winter it supports 1.9% of the UK population – an average of 496 individuals over-wintering during 1991/92-1995/6) and is a future candidate for contribution to the reservoir's Ramsar designation (JNCC 2005) and is cited as part of the site's SSSI status. Peak monthly counts of mute swans present at Abberton Reservoir during the period of this present study (2004 to 2007) are presented in Figure 1. Whilst only 3-5 pairs of mute swan bred annually at the reservoir during 2004-2006 (pers. obs.), large numbers use the site as a late summer moulting refuge and also during the winter months. By the end of the winter (February) through to mid-spring (May) the macrophyte food source in the reservoir becomes severely depleted. At the same time, spring growth of winter wheat on surrounding arable land provides a timely alternative food supply for the swans, resulting in large numbers flying out of the reservoir to feed in these fields (Fig. 2), returning to the reservoir for safe refuge when they cease feeding. At the western end of the reservoir this brings them into close proximity with the 132Kv power lines that lie between the reservoir and the arable land sown with winter wheat. From the middle of April onwards grazing of the winter wheat decreases as the crop becomes too tall and birds disperse to their breeding grounds.

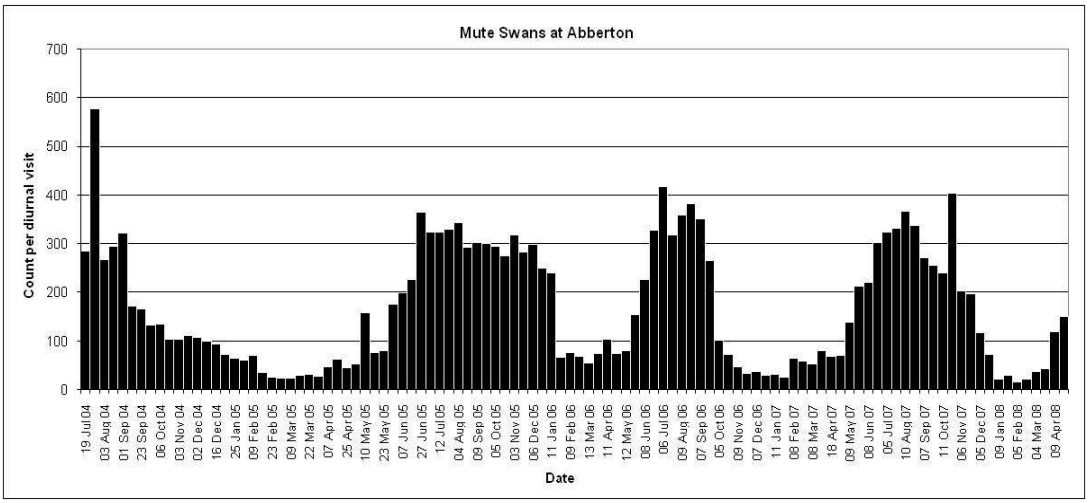


**Figure 1.** Monthly peak count of mute swans at Abberton Reservoir, 2004 to 2008 (source: Cambridge Ecology Ltd).

**Figure 2**. Mute swans feeding in cereal field adjacent to Abberton Reservoir with power lines in close proximity (© D.Frost www.eco-images.com).

**Mute swan collisions with the power lines:** Incidental observations of power line collision victims were made along the length of the power line during the scheduled waterfowl and breeding bird surveys that commenced in the spring of 2004. During the March-June period nine mute swan carcasses were noted at the western section of the reservoir (see Fig. 3 for carcass locations). Initial contact was made with EDF Energy (the power line owners) to make them aware of the situation, though no further action was taken at this time.

In 2005, no breeding bird surveys occurred so the area around the pylons was not visited. Overwintering waterfowl surveys were conducted but the area around the pylons was not surveyed. In 2006, overwintering waterfowl surveys recommenced and during early March mute swans were present in the fields to the northwest of the west end of the reservoir; a dead swan was also found under the nearby power lines. In order to obtain accurate mute swan numbers and to gain a better understanding of their use of the area where collisions were occurring, weekly surveys were conducted from the beginning of March to early April; 21 carcasses were found (locations shown Fig. 3). The number of carcasses found in 2004 and 2006, and the number of mute swans on the reservoir at the time of mortality count are given in Table 1.

The frequency of collision victims in 2006 provides a good record of the number of mute swans being killed by the power lines during this period. Mute swans are large species whose carcasses remain obvious for some time (more than one week). Evidence, in the form of an extensive area of plucked feathers and skeletal remains persist, even after foxes *Vulpes vulpes* have scavenged the carcasses.

From the data collected in 2006, the level of mute swan morality appears high compared to the population cited as part of the Abberton Reservoir SPA (>4% of the SPA population in 2006 - 21/496). The level of significance and the potential effect on the integrity of the SPA is likely to be high.

Particularly in late winter and spring, mute swans fly from feeding areas to and from the reservoir crossing the route of the power lines, which run roughly north to south across the site; dawn and dusk are likely to be the most vulnerable times, when the sun is low in the sky and the birds are flying east to west and visa versa in and out of the reservoir. At this time the visibility of the power lines to the birds is likely to be reduced, particularly the thinner earth wire, which runs between the tops of the pylons.

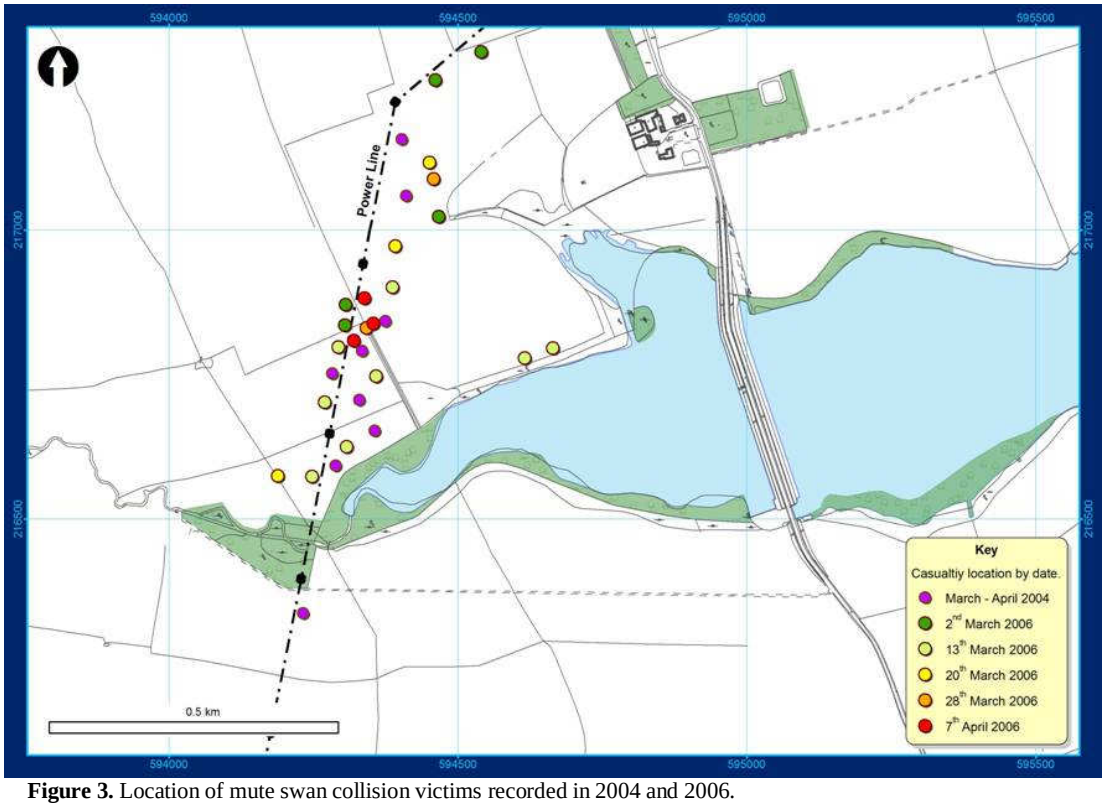


**Figure 3.** Location of mute swan collision victims recorded in 2004 and 2006.

**Table 1**. Number of mute swan collision victims recorded during surveys in 2004 and 2006.

| 2004 | Number of collision victims | Number of mute swans on reservoir at the time of mortality count | Total bird days in 2006 |
|---|---|---|---|
| March/April 2004 | 9 | 23 | (mean no. of living mute swans at the reservoir between January-April x total no. of days, i.e. 120) |
| **2006** | | | |
| 26 January | 0 | 67 | |
| 9 February | 0 | 77 | |
| 20 February | 0 | 69 | |
| 2 March | 5 | 69 | |
| 13 March | 8 | 54 | |
| 20 March | 3 | 54 | |
| 28 March | 2 | 74 | |
| 2 April | 3 | 103 | |
| 11 April | 0 | 103 | |
| 26 April | 0 | 74 | |
| **Total in 2006** | **21** | **Mean 2006 count = 74** | **8,880** |

**Observations of swan reactions to the wires:** Incidental observations indicated that upon their approach to the reservoir the swans flew at the same level as the main power lines. Frequently the swans saw the wires at sufficient distance enabling them to comfortably redirect their flight over the wires (Fig. 4). However, on many occasions the swans appeared to see the six main power lines when very close, resulting in the birds' taking rapid avoiding action. While the birds successfully manoeuvred over of the six main power cables, this brought them into close proximity of the earth wire, which is thinner and hence harder to see; this resulted in drastic evasive action causing the swans to almost stall in mid-air. While no observations of actual collisions were made, it is considered that the collision victims were birds that hit the earth wire rather than the main power lines. All observations were of birds flying over the power lines, with no attempts made to fly through or under the wires.

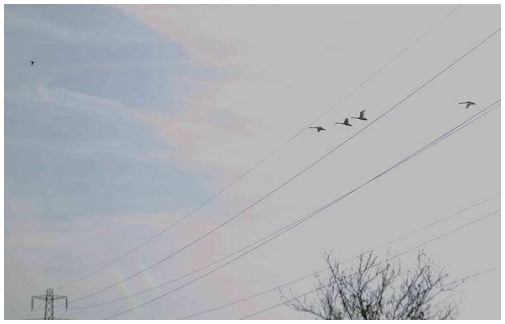

**Figure 4.** Mute swans flying over power lines. Note the seven wires with the thin earth wire at the top (© D.Frost www.eco-images.com).

**Mute swan injuries:** The injuries to presumed power line collision victims found were varied but were consistent with collision injuries including broken wings and necks. Both adults and juveniles were victims; while most of the dead birds recorded were adults (18 adults, six juveniles and seven of unknown age) the actual proportion of specific age groups could not be established due to the poor condition of some of the carcases. There were signs to show that death was not always instantaneous, e.g. marks behind a carcass indicating that the bird had dragged itself along the ground for a few metres or more. Figures 5-6 show two dead mute swans associated with collisions with the power lines.

**Other waterfowl collisions with the power lines:** Mute swans were not the only collision victims; carcasses of other species found were cormorant *Phalacrocorax carbo* (1), gadwall (1), tufted duck *Aythya fuligula* (1) and grey heron *Ardea cinerea* (1) (Fig. 7). The power lines were therefore causing mortality to a number of SPA cited species for Abberton Reservoir, not solely mute swan. The level of mortality being experienced by these other waterfowl remains unclear as they are smaller, have less obvious plumage colouration and are probably quickly consumed by scavengers, thereby reducing their rate of detection.

**Figure 5.** Adult mute swan with broken wing; carcass located some distance from the power lines; footprints and drag marks suggest death was not instantaneous (© D.Frost www.eco-images.com).

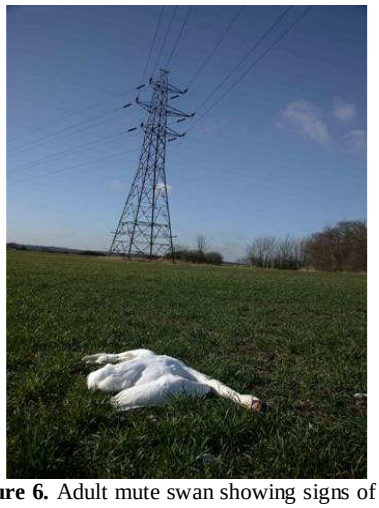

**Figure 6.** Adult mute swan showing signs of injury consistent with power line collision. Carcass located under wires suggesting instant death (© D.Frost www.eco-images.com).

**Figure 7.** Carcass of grey heron another species vulnerable to power line collision at Abberton Reservoir (© Darren Frost www.eco-images.com).

The existence of the power lines within the SPA could be considered to be at variance with the objectives of the Habitats Directive and the conservation objectives of the site. It was also considered likely that the collision rate and mortality would increase, as shallow water habitat was required to be provided for waterfowl under the Habitats Directive in association with the planned development for the raising of the reservoir water levels. It was therefore necessary to initiate a course of action that would address the potential collision effects on waterfowl populations; it was thus decided to install flight diverters on the overhead wires.

## ACTION

Essex & Suffolk Water staff initiated a meeting with EDF, Darren Frost and Natural England and agreed a course of action. This comprised a week long project to attach approximately 500 spiral shaped bird flight diverters, at 5 m intervals to more than 1.5 km of the earth wire along the top of the 132kV overhead power line network at the western end of the reservoir. The aim was to increase the visibility of the earth wire. This task required diverting the electricity away from the overhead power lines, lowering the earth wire that runs between the top of each pylon and then hand fitting the spiral bird flight deflectors to the wires (Fig. 8).

The design of the diverter used is shown in Figures 9 and 10, each was red in colour. The dimensions of the deflectors were 320 mm for the gripping section and 175 mm for the outside diameter of the coil (catalogue no. BFD5249065: Preformed Line Products (GB) Ltd). This design and spacing was chosen as tests in the Netherlands indicated that when installed at 5 m intervals the collision rate decreased by 80% (Koops 1982). Note that the specification for the diverter will be specific to the conditions encountered e.g. lines and pylon specifications, weather conditions and the species at risk.

**Figure 8.** Bird deflector installation at Abberton, summer 2006 (© D.Frost www.eco-images.com).

## CONSEQUENCES

Prior to flight diverter installation, surveys indicated that in the spring of 2004, nine mute swans were killed through collision with the power lines, while in spring 2006, 21 were killed. After flight diverter installation, spring surveys in 2007 found only one mute swan collision victim (locality shown in Fig. 11); in 2008 none were recorded. The results are summarised in Tables 3. Additionally for other bird species collision mortality appeared to have been reduced as no other species have been recorded as collision victims during the 2007-2008 surveys (although as indicated above, other species are smaller, less obvious

and more likely to be quickly consumed or removed by scavengers such as foxes).

**Discussion:** There was a marked reduction in swan collision rate in response to fitting flight diverters of 95% in 2007 compared to 2006; 21 birds suffered mortality in 2006 over a total of 8,880 'bird days' for the period 26/1/06 to 26/4/06. Over a similar period in 2007 (25/1/07 to 30/4/07) only one swan suffered collision mortality during a total of 7,200 'bird days'. The differences in the percentages (proportions) suffering mortality were significantly different (equality of proportions test: *ts* = 5.92, *P* <0.0001; Sokal & Rohlf 1969). This reduction in mortality is comparable to that after installation of identical markers at the same spacing in the Netherlands (Koops 1982).

The distance at which swan carcasses were found from the point impact range from 10-351 m; some birds were clearly injured (rather than being killed outright) and able to crawl away from below the collision point before dying. This should be taken into consideration when identifying the appropriate area of coverage when developing future collision monitoring programmes.

Smaller birds are harder to find and likely to be quickly consumed or removed by scavengers, though the distances over which these victims fall after impact are not expected to range any greater than those of mute swan. Therefore it was not possible to gain a clear picture of power line collision induced mortalities for other species.

Different sized deflectors are available in a wide selection of dimensions and colours, to fit a variety of overhead power and communications lines. They could also be installed on the guy wires that hold up various types of communications masts and towers. The following web links provide a source of suitable bird diverters/deflectors:
http://www.preformed-gb.com (UK);
http://www.birdtex.com (USA).

**Recommendations:** It is recommended that appropriate bird flight diverters (suitable to meet the local conditions) are fitted as routine best practise when installing any new overhead power lines. This is particularly topical in the UK, as now as more wind farms are being constructed, these need to be connected to the National Grid, some inevitably via overhead power lines. Deflectors are available for a wide range of overhead wires, aerials and communications masts. It is more cost effective to install deflectors at the time of construction rather than as a retrospective action.

**Table 2.** Distance of mute swan collision victims from nearest point along the power line.

| Date | Distance of collision victim from nearest perpendicular point of power lines (m) |
|---|---|
| 03/04/2004 | 16 |
| 03/04/2004 | 21 |
| 03/04/2004 | 76 |
| 03/04/2004 | 40 |
| 03/04/2004 | 28 |
| 03/04/2004 | 15 |
| 03/04/2004 | 57 |
| 03/04/2004 | 50 |
| 03/04/2004 | 24 |
| 02/03/2006 | 30 |
| 02/03/2006 | 16 |
| 02/03/2006 | 113 |
| 02/03/2006 | 10 |
| 02/03/2006 | 16 |
| 13/03/2006 | 306 |
| 13/03/2006 | 351 |
| 13/03/2006 | 58 |
| 13/03/2006 | 14 |
| 13/03/2006 | 19 |
| 13/03/2006 | 60 |
| 13/03/2006 | 15 |
| 13/03/2006 | 34 |
| 20/03/2006 | 74 |
| 20/03/2006 | 79 |
| 20/03/2006 | 49 |
| 28/03/2006 | 28 |
| 28/03/2006 | 91 |
| 07/04/2006 | 38 |
| 07/04/2006 | 14 |
| 07/04/2006 | 10 |
| **Mean distance** | 58 |
| **Minimum distance** | 10 |
| **Maximum distance** | 351 |
| **Standard error** | 14.3 |

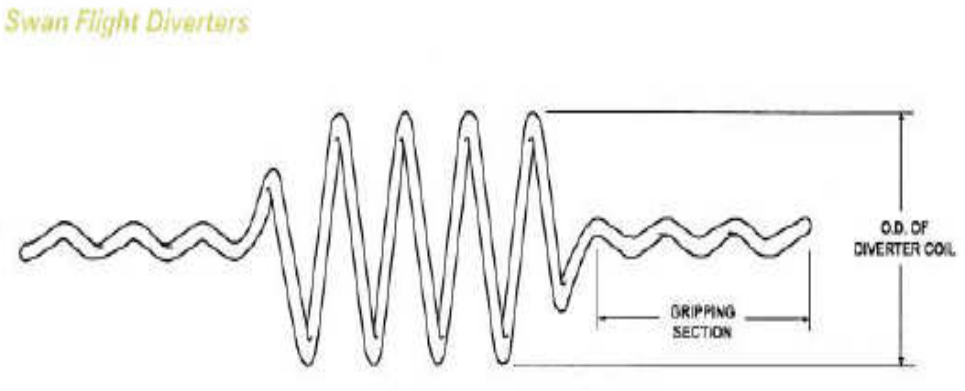


**Figure 9.** Design of swan flight diverter installed on overhead wires at Abberton Reservoir.

**Figure 10.** Flight diverter installed on overhead wire at Abberton Reservoir (© D.Frost).

**Table 3**. Number of mute swan collision victims and number of swans on reservoir recorded during winter-spring surveys in 2007 and 2008.

| **2007** | **Number of collision victims** | **Number of mute swans on reservoir at the time of mortality count** | **Total bird days** (mean no. of living mute swans at the reservoir between January-April x total no. of days, i.e. 120) |
|---|---|---|---|
| 25 January | 0 | 26 | |
| 8 February | 0 | 65 | |
| 22 February | 0 | 58 | |
| 8 March | 1 | 53 | |
| 23 March | 0 | 79 | |
| 18 April | 0 | 68 | |
| 30 April | 0 | 71 | |
| **Total** | **1** | **Mean = 60** | **7,200** |
| | | | |
| **2008** | | | |
| 9 January | 0 | 22 | |
| 24 January | 0 | 29 | |
| 5 February | 0 | 15 | |
| 18 February | 0 | 21 | |
| 4 March | 0 | 38 | |
| 28 March | 0 | 42 | |
| 9 April | 0 | 119 | |
| **Total** | **0** | **Mean = 41** | **4,903** |

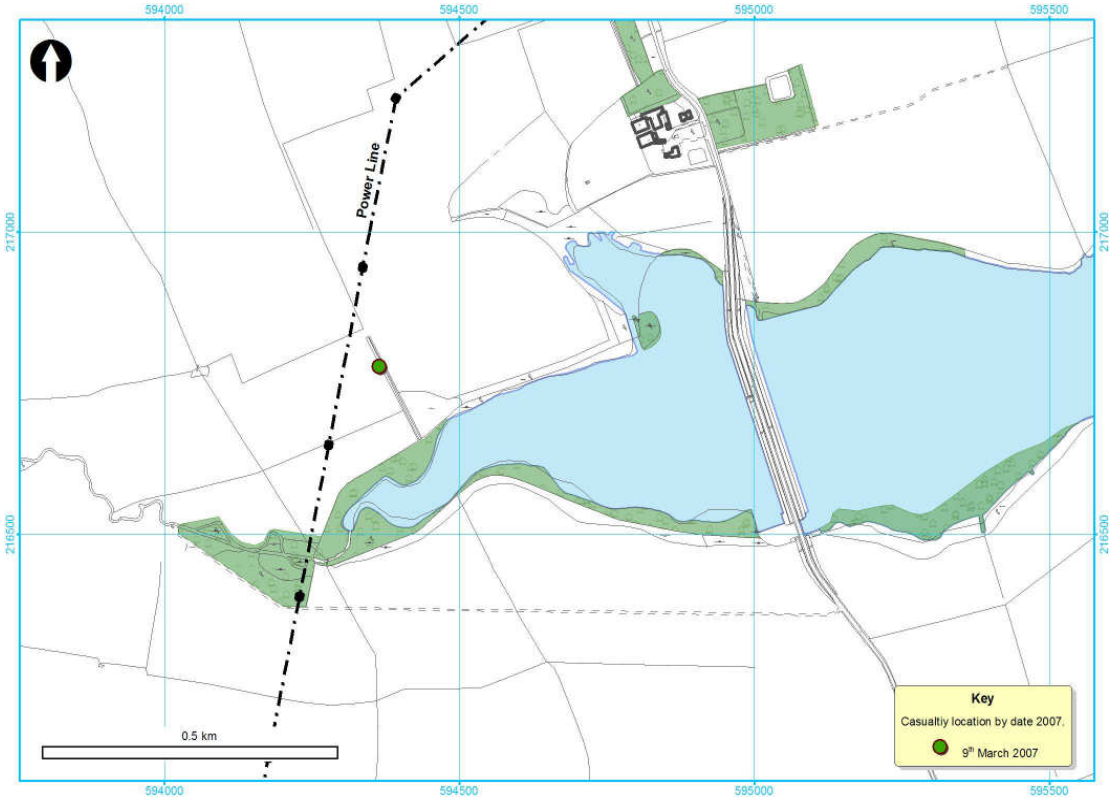


**Figure 11.** Location of mute swan collision victim recorded in 2007.

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