Natural England Research Report NERR001

Field assessment of great crested newt *Triturus cristatus* mitigation projects in England

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Project details

This report results from research commissioned by English Nature in order to inform future mitigation practice. The work was undertaken by DICE under contract VT0410.

A summary of the findings covered by this report, as well as Natural England's views on this research, can be found within Natural England Research Information Note RIN001 - Field assessment of great crested newt *Triturus cristatus* mitigation projects in England.

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Summary

The status of great crested newts at 13 sites that have been subjected to mitigation before 2002 was assessed by standardized surveys carried out during March-May 2005. Ponds on the mitigation sites (*n*=31 in total) were each surveyed four times over this period by a combination of torch counts, bottle trapping and mark-recapture population estimates.

The quality of pre-development information on the sites was extremely variable. Moreover, because of (1) the paucity of standardized pre-development population assessment data; and (2) changes in the aquatic and terrestrial habitats at the sites, comparisons of the current population assessments with historical data were difficult.

A combination of the English Nature (2001) and Griffiths and others. (1996) scoring systems suggested that four of the sites contained 'small' populations; four sites contained 'small-medium' populations; four sites contained 'medium' populations; and one site contained a 'medium-large' population. In terms of presence or absence of newts, those ponds and associated terrestrial habitats that had relatively high Habitat Suitability Indices (HSIs) generally contained great crested newts. However, as some sites with high HSIs had low counts of newts by torching or trapping, the relationship between HSIs and newt counts was weak. Although many of the sites contained appropriate aquatic and terrestrial habitats for newts, the majority were very isolated by development and had poor connectivity to other suitable habitats. Nevertheless, two ponds at different sites supported 'medium to large' numbers of newts despite high levels of fragmentation, development and connectivity to just one and two other ponds respectively. The level of ongoing survey and management at the sites varied, with some sites suffering from a lack of both activities.

The data show that great crested newt populations can be maintained at sites subject to development mitigation. However, further surveys are needed to assess the long-term viability of these populations. Equally, more attention needs to be placed on ensuring habitat connectivity and long-term management plans for such sites.

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1 Introduction

1.1 The great crested newt is fully protected under the Wildlife & Countryside Act 1981 and the Conservation (Natural Habitats & c.) Regulations 1994. Great crested newts often occur on land subject to development threats, and if development proceeds, a mitigation plan is frequently implemented. Typically, such mitigation involves the capture and exclusion of newts, and their removal to areas that have been subject to habitat creation, enhancement or restoration. The Department for Environment Food and Rural Affairs (Defra) licences such work, and guidance on methods is given in the English Nature publication *Great crested newt mitigation guidelines* (English Nature 2001).

1.2 Most previously published studies of great crested newt mitigation have focused on documenting individual case studies (eg Horton & Branscombe 1994; Cooke 1997; Taylor and others 1999; Oldham & Humphries, 2000). However, previous reviews of mitigation projects have all highlighted the need for more rigorous pre- and post-development monitoring of great crested newts (Oldham and others 1991; May 1996; Edgar & Griffiths 2005). Equally, comparing the population status of great crested newts pre- and post-development – as well as comparing population status between different sites – is currently problematical because of the lack of standardized survey protocols. Moreover, nearly all newt surveys currently carried out in mitigation projects employ the assessment of presence/absence or simple counts. Such methods may be inappropriate as indices of population status because they do not take account of temporal or spatial variation in newt detectability (Schmidt 2004). Capture-mark-recapture models can circumvent this problem while also providing estimates of population size and associated confidence limits.

1.3 A report published in August 2004 by the Office of the Deputy Prime Minister (ODPM) suggests planning for 24,800 new dwellings a year in the south and eastern regions of England and nearly 500,000 estimated by the year 2025 (BBC 2005). This sustained growth in land development on a national scale means that conflict between development and conservation is likely to increase – rather than decrease – over the next two decades. Consequently there is an urgent need to further refine population assessment methodologies so that pre- and post-development surveys are rigorous, cost-effective, and informative from both ecological and legal viewpoints.

2 Objectives

2.1 This project had the following objectives:

a) To evaluate great crested newt population status and habitat status pre- and post-development at a selection of completed mitigation sites.

b) To use these data to assess the value of mitigation measures for the great crested newt.

c) To make recommendations for additions and/or amendments to good practice in mitigation.

3 Methodology

Site selection

3.1 A previous review of great crested newt mitigation projects carried out between 1990 and 2001 revealed that the number of projects per year increased almost exponentially over this period (Edgar & Griffiths 2004). However, the quality of information available on mitigation projects varied considerably, with particular scanty data available for the older projects and with follow-up surveys carried out on less than half of the cases. For the purpose of this report 13 sites were selected from 59 projects carried out up until 2002 and for which questionnaire returns were received in the previous project.

3.2 Using the previous questionnaire as a framework, a 'best practice' scoring system was devised for all sites for which data were available (ie all 59 existing questionnaire sites plus any others for which appropriate data could be obtained). Points were allocated to the questionnaire answers based on how well the project met best practice guidelines. In order to obtain proportionate data for each of the questionnaires each section was weighted equally ie a 100% score was equal to a score of 1.00. Thus despite differing numbers of questions and responses per section, each section became an equal proportion of the final score.

3.3 Initially, it was hoped to assess a range of 'successful' and 'less successful' projects by selecting the highest and lowest scoring projects. They were then checked to ensure that a number of both in-situ and ex-situ projects were included within the samples before deciding upon a short list. Landowners and local surveyors were then contacted about access issues concerning the sites. If access to a site was refused or was otherwise considered problematical, that site was dropped from the list and a replacement obtained by working down the list (for 'successful') projects and up the list (for 'less successful') projects. As this resulted in a final short list of sites in which the distinction between 'successful' and 'less successful' sites was marginal, these two categories are not considered separately in the analyses.

3.4 Geographical location was also considered in the selection of sites in order to minimize travel expenses, but as a particularly high number of mitigation projects had been conducted in Cheshire and Lancashire, it was important to include those areas in the survey sample. The geographical location of sites is shown in Figure 1. Only one previous mitigation project had attempted to use capture-mark-recapture techniques and that site was also included on merit. A total of 11 in-situ projects and two ex-situ projects (Cambridgeshire and West Midlands) were examined.

Mitigation project descriptions

Site A – West Midlands

3.5 Site A was subject to mitigation for great crested newts in 1998 when commercial development occurred. The initial planning application was granted for the 5 ha site and did not take into account a pond later found to contain a breeding population of great crested newts. Mitigation ensued and the newts were relocated to an ex-situ location using both netting and the collection of animals once the pond was drained. A total of 159 adult newts and 5 sub-adults were translocated as part the project as well as a small number of eggs. The original pond was destroyed as part of the development.

3.6 The receptor site is a Local Nature Area (LNA) approximately 10–15 km from the development site and consists of 1 pond in 50 hectares of deciduous woodland, semi-improved grassland and mixed scrub hedgerows. The receptor pond was excavated in 1994 and lined with bentonite, and smooth newts were known to be present prior to the translocation. Following the translocation, the pond suffered from desiccation problems and it was subsequently drained and relined with butyl. Today the pond suffers from regular disturbance by dogs, which creates high levels of turbidity. The local Borough Council in conjunction with working parties and local volunteers are responsible for management work carried out on the site.

Site B – Bedfordshire

3.7 Site B was subject to mitigation for great crested newts in 2001 when a pipeline/temporary linear development occurred. No planning permission was required for this development, but because great crested newts were known to occur within the site boundary, pre-development surveys were undertaken using a variety of methods including torch counts, bottle trapping, netting and egg searches. A total of 40 undistinguished adults were observed from pre-development surveys only. The nature of the development meant that the ponds containing great crested newts were not directly affected by the development. However, attempts to capture/exclude great crested newts from the development site included hand searches, destructive searches and night-time searches.

3.8 The total length of the pipeline development was approximately 26 km with over 90% running through arable farmland. No work was undertaken to manage or improve the existing ponds but all data obtained during the survey effort were supplied to the Highways Agency for the anticipated development of a bypass. The construction of the bypass started during the 2005 surveys and is expected to have a much greater impact on the great crested newt population status through fragmentation of the landscape. No post development survey work was carried out prior to this 'new' development.

Site C – West Midlands

3.9 Site C was subject to mitigation for great crested newts in 1999 when a residential housing development occurred. The initial planning application was granted for the

3.10 2 ha site and did not take into account two ponds later found to contain a breeding population of great crested newts. Mitigation ensued with use of drift net fencing, pitfall traps and artificial cover objects to capture/exclude the newts from the development site. A total of only 1 adult newt and 3 sub-adults newts were translocated as part of the mitigation process. Despite efforts to enhance the great crested newt habitat and ponds, the area has become isolated by the development with adjacent habitat consisting of roadways, paths and housing with little or no opportunity for colonization from the surrounding area. The Borough Council is responsible for management work at the site, although apparently little work has been carried out since the mitigation.

Site D – Hertfordshire

3.11 Site D was subject to mitigation for great crested newts in 2000 when a residential housing development occurred. Planning consent was granted to develop existing farm buildings into residential housing. Great crested newts had been confirmed on the site prior to planning approval and mitigation ensued. Surveys included the use of torch counts, day counts and netting and a total of two undistinguished adult newts were seen. During the development, pitfall trapping, netting and night searches were conducted in an attempt to capture/exclude great crested newts from the site. A total of only 1 adult male and 1 adult female were translocated as part of the project. Of the two ponds on the site only one pond was directly affected by the development. The surrounding habitat consisted of unimproved grassland and scrub vegetation. Improvements were made to existing ponds including enlargement, vegetation clearance, reduction of shade, de-silting, re-profiling, clearance of rubbish and debris, treatment of pollution effects and the planting of native, wetland plants. In addition, a new pond was created on the development with access to other ponds via suitable habitat. No follow-up survey work has been conducted on this site.

Site E – Cheshire

3.12 Site E was subject to mitigation for great crested newts in 1996 when commercial development occurred. Survey work to detect the presence/likely absence of great crested newts was carried out prior to outline planning permission using both netting and egg searches. However, only eggs were found during these surveys. Approximately 23 ha of land including two ponds were destroyed as part of the development. Pitfall traps, drift fencing, artificial refugia, netting, bottle traps, hand and destructive searches and draining of ponds were all deployed as part of the mitigation process. A further three ponds were created on adjacent grassland habitat. In total, 7 undistinguished adult newts, 5 sub-adults and approximately 12 larvae were translocated as part of the project. Follow-up surveys and post-development monitoring included a six-year plan to undertake torch, netting and bottle trap surveys and egg searches. Eggs were found in one pond in 1998, and in all three ponds in 1999. In 2000, eggs and/or larvae were observed in two ponds, four adults were trapped in one pond, and one adult in a second pond. No other plans have been produced for the future management of the site. In the latter stages of post-development monitoring it was noted that fish had been introduced in to the ponds.

Site F – Cambridgeshire

3.13 Site F was subject to mitigation for great crested newts in 1999 when a residential housing development occurred. A total of 1.3 ha of disused land and buildings was destroyed as part of the development. Only one pond containing a breeding population of great crested newts was identified on the development site and was retained in situ, with some improvements made to its condition. Preliminary surveys were conducted before outline planning permission was granted using torch counts, bottle trapping and egg searches. A total of 38 undistinguished adult and 4 sub-adult newts were recorded as part of the pre-development survey. A mark-recapture study yielded a population estimate of 575 (± 290) adult great crested newts (Swan *pers. comm*.). During the mitigation process a series of methods were used to capture/exclude newts from the development area, including pitfall traps, drift fencing, artificial refugia, bottle traps and destructive and night-time searches. Also, measures were taken to improve existing terrestrial habitat including some woodland, scrub and hedgerow management, re-seeding and grassland management, provision of artificial hibernacula and other refugia.

3.14 A five-year monitoring period was agreed with further surveys conducted in 2002 using methods as described above. A total of 133 undistinguished adults/immature newts and also larvae were caught. Future work on the development site includes ongoing mark-recapture surveys, however it is thought that further development of adjacent, suitable great crested newt habitat will take place and may cause further isolation of the existing pond.

Site G – Cambridgeshire

3.15 Site G was subject to mitigation for great crested newts in 1993 when a residential housing development occurred. The development area consisted of approximately

3.16 2.5 ha of unimproved grassland, hedgerows and some built land, of which approximately 2 ha were deemed suitable great crested newt habitat. Great crested newt surveys were conducted pre-development using night-time searches and refugia searches, and over 100 great crested newts, of undistinguished life stages, were recorded. Despite the absence of ponds on the development site, attempts to capture/exclude newts from the area included terrestrial searches by hand. In total, 44 adult and 29 juvenile animals were translocated as part of the project. Some management of existing terrestrial habitat post-development included that of woodlands, scrub, hedgerows and grassland. The provision of artificial hibernacula and refugia was also undertaken. All great crested newts captured during the mitigation process were released into an adjacent garden and ponds – known to contain an existing breeding population – appx. 250–500 m from the development site. There was no post-development management agreed for the site and no post development surveys have been carried out.

Site H – Surrey

3.17 Site H was subject to mitigation for great crested newts in 1999 when a golf course development occurred. The total amount of land destroyed to create the golf course was approximately 55–60 ha of which 15–20 ha were considered suitable great crested newt habitat and ponds. The land consisted of coniferous woodland, mixed scrub, hedgerows, amenity grassland, pasture and wetland/aquatic habitats. A total of six ponds were recorded on site of which two were destroyed as part of the development. Surveys for newts were carried out pre-development and included the use of torch counts and bottle traps. However, only two adult newts were recorded during these surveys.

3.18 In order to capture/exclude newts during the mitigation, a variety of methods were used including pitfall traps, drift fencing, artificial refugia, hand and destructive searches. A total of 3 male and 3 female great crested newts were translocated as part of this project. Also, another large pond was created as part of the mitigation process. Post development monitoring includes a ten-year plan to monitor population levels of great crested newts, and methods deployed include torch counts of ponds and egg searches. It is hoped that the development will eventually provide a heathland environment similar to that found throughout the rest of the county.

Site I – Cambridgeshire

3.19 Site I ponds were subject to mitigation for great crested newts in 1987 when a residential housing development occurred. The land set aside for the ponds consists of approximately 1 ha of amenity grassland (including ponds) with scrub boundaries and secondary hedgerows. Pre-development surveys were conducted following consultation with NCC (later English Nature) in 1986 when it was established that there was a good breeding population of great crested newts in two of the three ponds, east pond and west pond. Torch counts in 1986 revealed a total of 93 and 9 (during a single survey only) great crested newts, and in 1987 28±0 and 1±1 (mean +SD of two surveys) respectively. Initially it was thought that the ponds would become isolated by the development, but it was agreed that 'block' fencing would not be used in order to allow dispersal of newts into surrounding gardens. However, in subsequent years homeowners have erected such fences and newt dispersal is now questionable in some areas.

3.20 Part of the mitigation agreement also included the installation of a tap to provide water to the ponds at times of low water levels. This was done to mitigate the effects of the development on the local water table. The north pond dried out in subsequent years due to lack of management of the adjacent amenity ground. The local Wildlife Trust, which is responsible for maintaining its wildlife interest of the site, now owns the area containing both east and west ponds. However, recent surveys found that little or no management on the ponds has meant that a succession of emergent vegetation from the pond margins has encroached on the water bodies leading to increased desiccation, probably on a number of years.

3.21 Despite efforts of a few volunteers to safeguard the future of the newt population, it is thought that in their current state the ponds will continue to decline in terms of their wildlife interest. Post development surveys were carried out between 1989 and 1995, the results of which can be found in Cooke (1997). More recent surveys have been conducted on an informal basis in order to maintain records on population status.

Site J – Gloucestershire

3.22 Site J ponds were subject to mitigation for great crested newts in 1999 when a residential housing development occurred. The development destroyed an area of open grassland, but the existing ponds and a band of terrestrial habitat 20–150 m wide were retained at one corner of the site. The site consists of three ponds of varying wildlife interest. Pond 1 is adjacent to a main road and entrance to the development site. The pond is well established with good terrestrial habitat as well as aquatic and emergent pond vegetation. Ponds 2 and 3 are deep flooded railway cuttings situated on the eastern boundary of the site. Both have steep banks with thick, overhanging vegetation with little or no emergent or aquatic vegetation apart from duckweed, which covers most of the surface.

3.23 Pond 2 has been used by local residents as a dumping ground for the disposal of household and garden waste. Initially an amphibian fence was erected around the ponds to prevent newts from dispersing into the development area. Preliminary searches within the development area (outside the area enclosed by amphibian fencing) were not productive in detecting newts. However, in order to mitigate for loss of great crested newt habitat, a variety of management tasks were deployed in the winter of 2000, including tree felling, clearance both terrestrial and aquatic vegetation, clearance of rubbish and debris and the re-profiling of ponds. A series of artificial hibernacula and refugia were also placed about the site.

3.24 Surveys carried out in 2001 using both bottle trapping and torch counts revealed the presence of great crested newts in all ponds. In pond 1, a total of 82 newts were observed by torchlight and 36 were caught in traps. Similarly in ponds 2 and 3, 38 and 12 newts were observed by torchlight respectively. A single survey carried out in April 2004 using 30 × 2 m sampling points along the shoreline revealed 22 newts by torch counts and 10 newts by trapping. Management proposals for the site included erection of boardwalks around pond 1 and education boards showing the wildlife interest of the site. Also, ongoing vegetation management was suggested in the management proposals, but recent visits have shown that neither of these criteria have been met or implemented in any way since the development. The installation of a permanent, rigid amphibian fence has been undertaken to prevent newts from dispersing onto the adjacent roadway, but this was overgrown by vegetation by May.

Site K – Cheshire

3.25 Site K was subject to mitigation for great crested newts in 1992 when the development of a bypass occurred. The bypass affected a large number of ponds and wetland habitat but not all contained great crested newts. In total, the project covered 15 km of roadways, which affected ten ponds considered suitable for great crested newts. The mitigation programme included the excavation of replacement ponds and the capture and translocation of other species of amphibians. Works were implemented from December 1992 to June 1993 in advance of the main contract for the road construction that commenced in October 1993. The remainder of the mitigation scheme including measures to exclude amphibians from the road works, monitoring, and permanent provision and fine-tuning was undertaken during the road construction period. The bypass was opened to the public in 1995.

3.26 At Site K initial surveys were carried out on four ponds using egg searches, torch counts and netting of ponds. Also ‘egg traps’ were used to help identify possible breeding sites. The preliminary surveys revealed only six adult great crested newts and eggs within the only pond surveyed. All four ponds were destroyed as part of the development, but two new ponds were created. The two new ponds are situated on land between a mainline railway and a footpath to the west, and the bypass, footpath and cycle lane to the east. Permanent drift fencing has been installed along some edges of the site to prevent newts wandering on to the bypass. The terrestrial habitat comprises unimproved grassland with scrub vegetation and birch stands. To the south the site is also bordered by a main road and development, while to the north the site opens out into a small recreation area adjacent to housing development. It would therefore appear that these ponds are isolated, with limited opportunities for newt dispersal along a sparsely vegetated railway embankment or through the recreation area to the north. Additional terrestrial features have been added to the site including artificial hibernacula and refugia as well as transplanted aquatic vegetation. During the development a total of 43 great crested newts were captured and translocated to new ponds as part of the mitigation project.

Site L – Cheshire

3.27 Site L was subject to mitigation for great crested newts in 1992 when the development of a bypass occurred. The bypass affected a large number of ponds and wetland habitat but not all contained great crested newts. In total, the project covered 15 km of roadways, which affected ten ponds considered suitable for great crested newts. The mitigation programme included the excavation of replacement ponds and the capture and translocation of many other species of amphibians. Works were implemented from December 1992 to June 1993 in advance of the main contract for the road construction that commenced in October 1993. The remainder of the mitigation scheme including measures to exclude amphibians from the road works, monitoring, and permanent provision and fine-tuning was undertaken during the road construction period. The bypass was opened to the public in 1995.

3.28 At Site L initial surveys were carried out on one pond using egg searches, torch counts and netting of ponds. Also ‘egg traps’ were used to help identify possible breeding sites. Only eggs were detected at this site during preliminary surveys. This pond was also destroyed as part of the development and a further two ponds were created on the edge of an adjacent playing field and bordering open grassland. During the development a total of 84 great crested newts were captured and translocated to new ponds as part of the mitigation project.

3.29 The two new ponds are situated in a peat-based wetland habitat with areas of scrub grassland and some mature, standard tree species. Also, willow stands surround much of the pond margins. The ponds are adjacent to open farmland to the south with the bypass approximately 150 m to the west. A major link road is approximately 300 m to the north of the ponds, across a playing field.

3.30 Post development management of both Site K and Site L does not include a management plan. However, some recommendations were made to implement monitoring of amphibians through a ‘Pond Warden’ scheme as designed by Pondlife. Also some further monitoring work needed to be done in order to control the introduction of fish into the ponds and future colonisations. Considering the proximity of the site to housing development, there appears to be rather little disturbance, although some evidence of fires and litter was observed. Earlier reports also suggest that monitoring of water levels at each site should be undertaken due to the ongoing development around the bypass.

Site M – Lancashire

3.31 Site M was subject to mitigation for great crested newts in 2000 when a sports field development occurred. The development land comprised of approximately 3 ha of pasture with inter-dispersed hedgerows and aquatic habitats. It is unclear from available information whether any pre-development surveys were carried out specifically for the project, but great crested newts were known to be present pre-development. Of the two ponds on the development site one was completely destroyed to make way for a new pavilion and the other was improved as part of the mitigation process. Capture and exclusion of great crested newts was carried out using pitfall traps, drift fencing, artificial refugia, netting, bottle traps, hand and destructive searches and the capture of newts when the pond was drained. A total of 37 great crested newts, of undistinguished age and sex, were translocated as part of the mitigation project.

3.32 Other work undertaken included the removal of fish from an existing pond, clearance of rubbish and debris and the treatment of pollution effects. Grazing pressure from horses was also removed from the receptor site. Two small ponds, approximately 50 m^2, were created and habitat management works were also undertaken. Post development monitoring of the site was agreed for a total of five years and surveys were conducted, but only eggs were recorded. Post development management of the site was agreed in principle but subsequent management and monitoring appears to have been piecemeal.

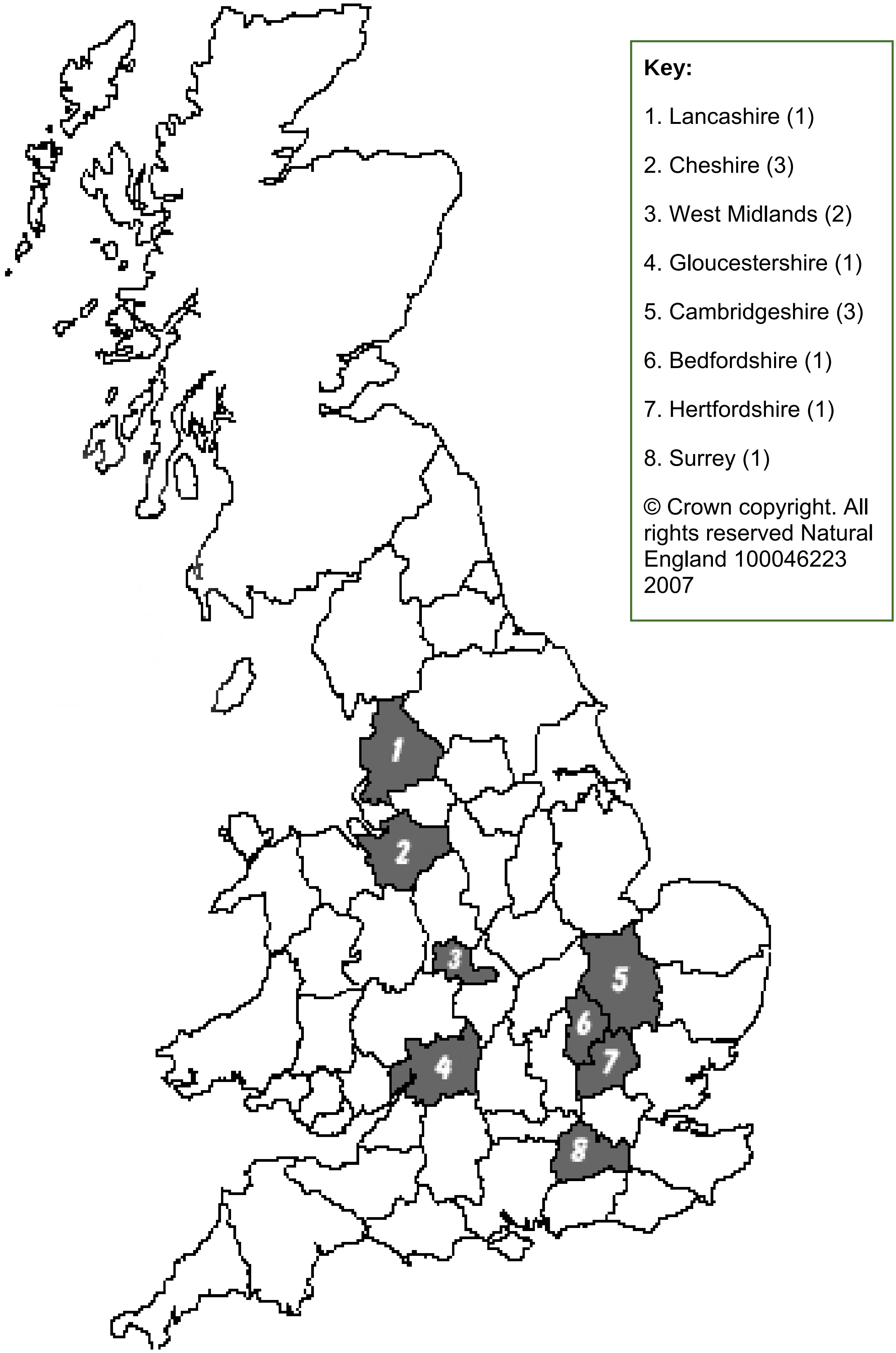

Figure 1. Map showing location of mitigation projects assessed (*n*=13).

Field survey protocol

3.33 Field survey protocols followed Gibson & Gent in JNCC (2003), with a total of four torching/trapping nights conducted at each water body at each site. The surveys were all carried out at peak season (ie from March-May) and repeated surveys at each site were separated by a few days or weeks whenever possible. Surveys were designed to enable (1) direct comparisons between bottle trapping and torch counts; (2) newt densities to be calculated by either method; (3) total counts of newts by either method; and (4) mark-recapture population estimates where this was possible. Whenever possible, surveys were carried out during optimal weather condition ie no/little wind or rain, and at temperatures above 5o C.

Bottle trapping

3.34 Bottle trap construction and placement was undertaken using guidelines outlined by Gibson & Gent in JNCC (2003). Large, transparent, 2 litre bottles were used to construct the traps. Garden canes were passed through the bottles and secured in the substrate to anchor the bottles and to ensure an adequate air bubble above the water surface. In water bodies where a butyl liner was present and canes were not appropriate, anchorage was achieved by attaching the trap to the shoreline using string. All traps had corks attached to them by string so that they could be easily located if they sunk (this did not occur with any traps in the current study).

3.35 At each pond a maximum of 30 sampling points were established at 2 m intervals around accessible areas of shoreline, following the protocol described by Griffiths and others. (1996). One trap was placed at each sampling point, enabling newt density to be calculated as the number of newts captured per 2 m. Traps were set between 21.30–23.30 hrs and checked between 07.00–09.30 hrs the following day, depending on the site, resulting in a trapping period of about 10 hrs.

Figure 2. Great crested newt belly pattern. © Brett Lewis

Torch surveys

3.36 For the purpose of this study 'Clulite' 500,000-candle power torches were used throughout. The 30 × 2 m sampling points established for bottle trapping around the accessible shoreline (see above) were used for torch counts. Each 2 m section was surveyed by moving the torch in and out as a series of non-overlapping scans perpendicular to the shoreline and in the general direction of the previous sampling point. This method allowed newt density to be calculated (ie no. newts per 2 m of shoreline) in a way that was directly comparable to the bottle trapping densities. If there were additional sections of accessible shoreline outside the 30 × 2 m sampling points, these were also surveyed in the same way, so as to yield a 'total count' for the whole pond.

Egg searches

3.37 Egg searches were conducted during daytime visits to each of the water bodies and, where appropriate, at night under torchlight. Torchlight encounters with individual newts laying eggs were often noted. Search effort was based on submerged or floating vegetation around the water body margins.

Individual newt identification

3.38 The identities of newts captured in the bottle traps in the morning were individually recorded using a simple photographic recording system. Newts were placed into a small, transparent plastic dish and restrained by a cover of damp foam rubber. Photographs were taken and catalogued using a digital camera (Figure 2). Newts were sexed and numbered individually for later analysis using mark-recapture methodologies.

Population assessment

3.39 As the survey involved multiple marking and release occasions at peak season, the Schnabel Method for closed populations was considered to be the most appropriate model for estimating the size of populations in the study areas (Schnabel, 1938 in Krebs, 1999). The Schnabel Method was used to determine only two types of individuals: '*marked*' = caught in one or more prior samples and '*unmarked*' = never caught before. On each sampling occasion (t) the following was determined:

Ct = Total number of individuals caught at sample t.

Rt = Number of individuals already marked when caught in sample t.

Mt = Total number of marked animals still at large when sample t is taken.

N = Population estimate.

The population estimate for Schnabel Method was then calculated as follows:

$$N = \frac{\sum t\,(Ct\,Mt)}{\sum t\,Rt + 1}$$

The variance of the Schnabel estimator was calculated as the reciprocal of *N*:

$$\text{Variance} = \frac{\sum t\,Rt}{\left(\sum Ct\,Mt\right)^2}$$

A Poisson frequency distribution table (Krebs, 1999) was used to calculate upper and lower 95% confidence limits.

$$\text{Standard Error} = \sqrt{\text{Variance}}$$

Habitat assessment

3.40 Habitat assessment was carried out at each water body using the Habitat Suitability Index (HSI) method described by Oldham and others. (2000). This system involves assessing the parameters shown in Table 1.

Table 1. Habitat suitability indices, table of factors.

SI	Factor	"Units"	Derivation of SI value
1	Location	Measured as map location	Refer to Figure 2 in Oldham and others. (2000) Area A, Optimal & SI = 1 Area B, Marginal & SI = 0.5 Area C, Unsuitable & SI = 0.01.
2	Pond area	m^2	Measure pond surface area. Read off SI value from Figure 1; chart SI2 in Oldham and others. (2000).
3	Pond	Years	Years out of ten that pond dries out during the spring or early summer. This is dependent on access to long-term knowledge of the site. Read off SI value from Figure 1; chart SI3 in Oldham and others. (2000).
4	Water quality	Subjective scale	Water quality scored on a 4-point scale where: 4 = good quality, SI = 1 3 = Moderate quality, SI = 0.67 2 = Poor quality, SI = 0.33 1 = Bad water, SI = 0.01
5	Shade	%	Estimate of the % of perimeter shaded (usually by trees). Include those close enough to shade water to at least 1 m from shore. Read off SI value from Figure 1; chart SI5 in Oldham and others. (2000).
6	Fowl	Count	Number of waterfowl seen per pond or per 1000 m^2 in large ponds. Read of SI value from Figure 1, chart SI6 in Oldham and others. (2000).
7	Fish	Subjective scale	Subjective based on clues or local knowledge: 4 point scale: 4 = Absent, SI = 1 3 = Possible, SI = 0.67 2 = Minor, (crucian carp, sticklebacks) SI = 0.33 1 = Major, (other species or carp/sticklebacks in dense populations) SI = 0.01
8	Pond	Count	Number of ponds occurring within 1 km of target site (excluding target site ponds and ponds on distal side of important barriers). Divide the number of ponds by π (=3.14). Read off SI value from Figure 1; chart SI8 in Oldham and others. (2000).

Table continued...

SI	Factor	“Units”	Derivation of SI value
9	Terrestrial	Map	OS map with 500 m radius around pond shaded to indicate ‘newt-friendly’ habitat. Viz: habitat judged as woodland, scrub, long grass, meadow or gardens. Calculate the area shaded (ha). Also mark good hedges and ditches on the map and estimate length. Calculate total area of linear features (using 2.5 m as hedge and ditch width, unless determined otherwise). The resulting value (A, in ha.) is multiplied by the Barrier factor (B), described below. The value AB is read off as an SI value from Figure 1, chart SI9 in Oldham and others. (2000). Barriers subjective. Barriers scored on a 5-point scale, where: 5 = No serious barriers within 500 m, factor B = 1 4 = Minor barriers within 500 m, factor B = 0.8 3 = Moderate barriers within 500 m, factor B = 0.6 2 = Major barriers within 500 m, factor B = 0.4 1 = Almost total barrier, newts confined to pond and its immediate vicinity, factor B = 0.2
10	Macrophyte	%	Estimate the % of pond surface-area occupied by macrophyte cover (sum of emergents, floating plants and submerged plants reaching the surface, except duckweed). Estimate with help of chart 2 between May and the end of September. Read off SI value from Figure 1; chart SI10 in Oldham and others. (2000).

3.41 For the purpose of this report the SI factor ‘Terrestrial’ (9) was scored according to a subjective scale whilst in the field and a five-point numbering system was used, taking into account all available ‘newt-friendly habitat’ and possible dispersal barriers within 500 m of the water body. As a result the ‘value’ was not multiplied by the ‘barrier’ factor as described in Oldham and others. (2000) but was simply scored as shown in Table 2.

Table 2. Alternative HSI factor ‘Terrestrial’.

Score	‘Unit’	SI Value
5	Good available habitat with no serious barriers within 500 m	1.00
4	Good available habitat with minor barriers within 500 m	0.80
3	Moderate available habitat with moderate barriers within 500 m	0.60
2	Poor available habitat with major barriers within 500 m	0.40
1	Newts confined to pond area, almost total barrier	0.20

3.42 These factors are based on the criteria of SI-9 in Oldham and others. (2000)

3.43 The habitat suitability index was then calculated as a geometric mean of the individual suitability scores (see above) resulting in a number between 0 (unsuitable habitat) and 1 (optimal habitat).

The geometric mean is calculated as follows:

HSI = (SI1 * SI2 * SI3 * SI4 * SI5 * SI6 * SI7 * SI8 * SI9 * SI10) 1/10

Where :

HIS = Habitat suitability index

SI = Suitability indices for each of the factors.

Data analysis

Total Counts

3.44 Total counts were obtained by adding the total numbers of newts observed over four visits at all ponds within each site. Counts included newts observed within the sampling areas, plus those counted along other areas of accessible shoreline. A further analysis was carried out by calculating the mean ± SD total count over the four survey nights for each pond.

3.45 The 'peak count' was based on the highest count of great crested newts at each site for both torchlight and trapping surveys over the four survey visits. This count was then compared to the scoring system devised for estimating population class sizes in English Nature (2001) and is rated as follows:

3.46 Counts were summed across ponds only on the visit that yielded the highest count of all four visits (English Nature 2001).

Densities

3.47 Mean ± SD newt density was calculated as no. newts per 2 m of shoreline, using data collected from the standardized sampling points over the four torch/trapping events throughout the survey period. Each pond surveyed was then scored for population status using the table devised by Griffiths and others. (1996). In addition, the mean density of great crested newts at ponds on mitigation sites was compared to the mean density of newts at the natural (ie ponds not subjected to mitigation) sites surveyed by Griffiths and others. (1996) using a t-test.

4 Results

Presence-absence of newts

4.1 Great crested newts were detected by bottle-trapping at 20 (65%) of the ponds surveyed. Similarly, great crested newts were detected by torch counts at 21 of the 31 ponds (ie 68%) that were surveyed. In some cases, where there were few sampling points, trapping was the better method for surveying because of surface vegetation coverage.

4.2 In terms of the 13 development/mitigation sites (rather than individual ponds), great crested newts were detected by trapping at 11 sites (85%). Likewise, great crested newts were detected at 12 (92%) out of the 13 sites by torching, albeit with very low numbers at three sites (1, 2 and 3 newts respectively over the four sampling occasions). Egg searches did not reveal the presence of great crested newts at any of the ponds where trapping and torch counts failed.

4.3 As Griffiths and others. (1996) calculated that the probability of missing great crested newts when they are actually present is 1.2% if four methods are used, it would be prudent to assume that false negatives were unlikely in the present study (although a fourth method – netting – was not used, this is a poor method for detecting the species). Nevertheless, it is possible that some water bodies may be used in different years to that those surveyed.

Total counts, peak counts and mean counts over four days

4.4 Counts of newts by torchlight at the sampling points were correlated with the numbers trapped along the same shorelines (r=0.89, df=30, P<0.001; Tables 3,4). The discrepancy between torch and trap counts varied between ponds, but generally torch counts detected more newts than trapping, and this was marginally statistically significant (paired t-test: t=2.08, df=30, P=0.046).

4.5 In terms of mean torch counts over the four sampling sessions, six (46%) out of the 13 sites had up to 10 newts per visit; six (46%) sites had between 11 and 100 newts, and one (8%) site had more than 100 newts (Table 5).

4.6 When considered in terms of the 'peak count' over four sampling sessions, the site ratings were five (38%) sites with up to10 newts, seven (54%) sites with between 11 and 100 newts, and one (8%) site with more than 100 newts (Table 5).

Table 3. The number of great crested newts encountered through bottle trapping. Mean ± SD total captures over the four sampling sessions are shown.

	No. of sampling points per visit	No. of newts trapped				Total	*Peak	Mean	SD
		Visit 1	Visit 2	Visit 3	Visit 4				
Site A - Pond 1	0-12	0	16	9	7	32	16	8	6.58
Site B - Pond 1	10	2	0	0	0	2	2	0.5	1.00
Site B - Pond 2	0	0	0	0	0	0	0	0	0.00
Site B - Pond 3	0-10	0	0	0	0	0	0	0	0.00
Site B - Pond 4	10	1	0	0	0	1	1	0.25	0.50
Site B - Total		**3**	**0**	**0**	**0**	**3**	**3**	**0.75**	**1.5**
Site C - Pond 1	8	1	1	2	2	6	2	1.5	0.58
Site C - Pond 2	10-11	0	2	1	1	4	2	1	0.82
Site C - Total		**1**	**3**	**3**	**3**	**10**	**3**	**2.5**	**1.39**
Site D - Pond 1	10	0	0	0	0	0	0	0	0.00
Site D - Pond 2	10	0	0	0	0	0	0	0	0.00
Site D - Pond 3	10	0	0	0	0	0	0	0	0.00
Site D - Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.00**
Site E - Pond 1	0-20	0	0	0	0	0	0	0	0.00
Site E - Pond 2	0-5	0	0	0	0	0	0	0	0.00
Site E - Pond 3	0-5	0	0	0	0	0	0	0	0.00
Site E - Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.00**
Site F - Pond 1	30	14	1	15	6	36	15	9	6.68
Site G - Pond 1	17	2	2	0	3	7	3	1.75	1.26
Site G - Pond 2	5	0	2	2	0	4	2	1	1.15
Site G - Pond 3	0	0	0	0	0	0	0	0	0.00
Site G - Pond 4	8	5	8	3	1	17	8	4.25	2.99
Site G - Total		**7**	**12**	**5**	**4**	**28**	**12**	**7**	**5.40**
Site H - Pond 1	10-15	0	0	1	1	2	1	0.5	0.58
Site H - Pond 2	15	3	3	0	0	6	3	1.5	1.73
Site H - Total		**3**	**3**	**1**	**1**	**8**	**3**	**2**	**2.31**

Table continued …

	No. of sampling points per visit	No. of newts trapped				Total	*Peak	Mean	SD
		Visit 1	Visit 2	Visit 3	Visit 4				
Site I - Pond 1	6-10	0	1	0	0	1	1	0.25	0.50
Site I - Pond 2	7-16	7	3	0	1	11	7	2.75	3.10
Site I - Total		**7**	**4**	**0**	**1**	**12**	**7**	**3**	**3.60**
Site J - Pond 1	30	10	20	28	24	82	28	20.5	7.72
Site J - Pond 2	8	0	7	11	3	21	11	5.25	4.79
Site J - Pond 3	10	0	1	8	1	10	8	2.5	3.70
Site J - Total		**10**	**28**	**47**	**28**	**113**	**47**	**28.25**	**16.21**
Site K - Pond 1	0-20	0	29	31	11	71	31	17.75	14.86
Site K - Pond 2	0-7	0	3	6	5	14	6	3.5	2.65
Site K - Total		**0**	**32**	**37**	**16**	**85**	**37**	**21.25**	**17.51**
Site L - Pond 1	0-14	0	0	1	0	1	1	0.25	0.50
Site L - Pond 2	0-10	0	0	0	0	0	0	0	0.00
Site L - Total		**0**	**0**	**1**	**0**	**1**	**1**	**0.25**	**0.50**
Site M - Pond 1	20	0	0	0	0	0	0	0	0.00
Site M - Pond 2	10	0	0	1	0	1	1	0.25	0.50
Site M - Total		**0**	**0**	**1**	**0**	**1**	**1**	**0.25**	**0.50**

Variation in sampling points throughout the survey period was due to desiccation of ponds as the season progressed.

* Peak figures are as follows: for individual ponds, the peak count is the highest count attained on a single night; for sites, the peak count is the highest total count (counts for all ponds summed) attained on a single night.

Table 4. The number of great crested newts encountered by torchlight during counts made within the same 2 m sampling points used for trapping.

	No. of sampling points per visit	No. of newts torched (within sample area)				Total	*Peak	Mean	SD
		Visit 1	Visit 2	Visit 3	Visit 4				
Site A - Pond 1	0-12	7	4	3	5	19	7	4.75	1.71
Site B - Pond 1	10	0	2	2	2	6	2	1.50	1.00
Site B - Pond 2	0	0	0	0	0	0	0	0.00	0.00
Site B - Pond 3	0-10	0	0	0	0	0	0	0.00	0.00
Site B - Pond 4	10	4	6	2	0	12	6	3.00	2.58
Site B - Total		**4**	**8**	**4**	**2**	**18**	**8**	**4.50**	**3.58**
Site C - Pond 1	8	0	0	0	0	0	0	0.00	0.00
Site C - Pond 2	10-11	0	0	0	0	0	0	0.00	0.00
Site C - Total		**0**	**0**	**0**	**0**	**0**	**0**	**0.00**	**0.00**
Site D - Pond 1	10	0	2	0	0	2	2	0.50	1.00
Site D - Pond 2	10	0	0	0	0	0	0	0.00	0.00
Site D - Pond 3	10	0	0	0	0	0	0	0.00	0.00
Site D - Total		**0**	**2**	**0**	**0**	**2**	**2**	**0.50**	**1.00**
Site E - Pond 1	0-20	1	0	0	2	3	2	0.75	0.96
Site E - Pond 2	0-5	0	0	0	0	0	0	0.00	0.00
Site E - Pond 3	0-5	0	0	0	0	0	0	0.00	0.00
Site E - Total		**1**	**0**	**0**	**2**	**3**	**2**	**0.75**	**0.96**
Site F - Pond 1	30	24	9	31	8	72	31	18.00	11.34
Site G - Pond 1	17	0	6	2	0	8	6	2.00	2.83
Site G - Pond 2	5	6	0	0	0	6	6	1.50	3.00
Site G - Pond 3	0	8	7	5	13	33	13	8.25	3.40
Site G - Pond 4	8	5	2	4	5	16	5	4.00	1.41
Site G - Total		**19**	**15**	**11**	**18**	**63**	**19**	**15.75**	**10.65**
Site H - Pond 1	10-15	0	5	31	8	44	31	11.00	13.74
Site H - Pond 2	15	2	2	8	11	23	11	5.75	4.50
Site H - Total		**2**	**7**	**39**	**19**	**67**	**39**	**16.75**	**18.24**

Table continued …

	No. of sampling points per visit	No. of newts torched (within sample area)				Total	*Peak	Mean	SD
		Visit 1	Visit 2	Visit 3	Visit 4				
Site I - Pond 1	6-10	10	11	0	0	21	11	5.25	6.08
Site I - Pond 2	7-16	12	6	7	6	31	12	7.75	2.87
Site I - Total		**22**	**17**	**7**	**6**	**52**	**22**	**13.00**	**8.95**
Site J - Pond 1	30	69	117	132	27	345	132	86.25	47.77
Site J - Pond 2	8	0	0	0	0	0	0	0.00	0.00
Site J - Pond 3	10	0	0	0	0	0	0	0.00	0.00
Site J - Total		**69**	**117**	**132**	**27**	**345**	**132**	**86.25**	**47.77**
Site K - Pond 1	0-20	29	72	59	35	195	72	48.75	20.21
Site K - Pond 2	0-7	4	13	13	30	60	30	15.00	10.86
Site K - Total		**33**	**85**	**72**	**65**	**255**	**85**	**63.75**	**31.07**
Site L - Pond 1	0-14	1	7	20	7	35	20	8.75	8.02
Site L - Pond 2	0-10	0	2	1	0	3	2	0.75	0.96
Site L - Total		**1**	**9**	**21**	**7**	**38**	**21**	**9.50**	**8.97**
Site M - Pond 1	20	0	0	0	0	0	0	0.00	0.00
Site M - Pond 2	10	1	0	0	0	1	1	0.25	0.50
Site M - Total		**1**	**0**	**0**	**0**	**1**	**1**	**0.25**	**0.50**

Mean ± SD total counts over the four sampling sessions are shown. Variation in sampling points throughout the survey period was due to desiccation of ponds as the season progressed.

* Peak figures are as follows: for individual ponds, the peak count is the highest count attained on a single night; for sites, the peak count is the highest total count (counts for all ponds summed) attained on a single night.

Table 5. The number of great crested newts encountered by torchlight counts around the complete accessible shoreline (ie trapping sampling points + any additional areas).

	No. of sampling points per visit	No. of newts torched (whole available shoreline)				Total	*Peak	Mean	SD
		Visit 1	Visit 2	Visit 3	Visit 4				
Site A - Pond 1	12	7	4	3	5	19	7	4.75	1.71
Site B - Pond 1	10	0	2	2	2	6	2	1.50	1.00
Site B - Pond 2	1	0	0	0	0	0	0	0.00	0.00
Site B - Pond 3	10	0	0	0	0	0	0	0.00	0.00
Site B - Pond 4	18	4	6	2	0	12	6	3.00	2.58
Site B - Total		**4**	**8**	**4**	**2**	**18**	**8**	**4.50**	**3.58**
Site C - Pond 1	0-8	0	0	0	0	0	0	0.00	0.00
Site C - Pond 2	10-11	0	0	0	0	0	0	0.00	0.00
Site C - Total		**0**	**0**	**0**	**0**	**0**	**0**	**0.00**	**0.00**
Site D - Pond 1	10	0	2	0	0	2	2	0.50	1.00
Site D - Pond 2	10	0	0	0	0	0	0	0.00	0.00
Site D - Pond 3	10	0	0	0	0	0	0	0.00	0.00
Site D - Total		**0**	**2**	**0**	**0**	**2**	**2**	**0.50**	**1.00**
Site E - Pond 1	21	1	0	0	2	3	2	0.75	0.96
Site E - Pond 2	23	0	0	0	0	0	0	0.00	0.00
Site E - Pond 3	24	0	0	0	0	0	0	0.00	0.00
Site E - Total		**1**	**0**	**0**	**2**	**3**	**2**	**0.75**	**0.96**
Site F - Pond 1	30	24	9	31	8	72	31	18.00	11.34
Site G - Pond 1	25	0	6	2	0	8	6	2.00	2.83
Site G - Pond 2	5	6	0	0	0	6	6	1.50	3.00
Site G - Pond 3	12	8	7	5	13	33	13	8.25	3.40
Site G - Pond 4	8	5	2	4	5	16	5	4.00	1.41
Site G - Total		**19**	**15**	**11**	**18**	**63**	**30**	**15.75**	**10.65**
Site H - Pond 1	10-15	0	5	31	8	44	31	11.00	13.74
Site H - Pond 2	15	2	2	8	11	23	11	5.75	4.50
Site H - Total		**2**	**7**	**39**	**19**	**67**	**42**	**16.75**	**18.24**

Table continued …

	No. of sampling points per visit	No. of newts torched (whole available shoreline)				Total	*Peak	Mean	SD
		Visit 1	Visit 2	Visit 3	Visit 4				
Site I - Pond 1	10-12	10	11	0	0	21	11	5.25	6.08
Site I - Pond 2	19	12	6	7	6	31	12	7.75	2.87
Site I - Total		**22**	**17**	**7**	**6**	**52**	**23**	**13.00**	**8.95**
Site J - Pond 1	40	118	127	158	34	437	158	109.25	47.77
Site J - Pond 2	1	0	5	9	2	16	9	4.00	0.00
Site J - Pond 3	1	0	0	0	0	0	0	0.00	0.00
Site J - Total		**118**	**132**	**167**	**36**	**453**	**167**	**113.25**	**47.77**
Site K - Pond 1	28-42	48	73	59	35	215	72	53.75	20.21
Site K - Pond 2	11-24	4	13	13	30	60	30	15.00	10.86
Site K - Total		**52**	**86**	**72**	**65**	**275**	**102**	**68.75**	**31.07**
Site L - Pond 1	14-22	1	7	24	7	39	20	9.75	8.02
Site L - Pond 2	15-20	0	2	1	0	3	2	0.75	0.96
Site L - Total		**1**	**9**	**25**	**7**	**42**	**22**	**10.50**	**8.97**
Site M - Pond 1	42	0	0	0	0	0	0	0.00	0.00
Site M - Pond 2	22	1	0	0	0	1	1	0.25	0.50
Site M - Total		**1**	**0**	**0**	**0**	**1**	**1**	**0.25**	**0.50**

Mean ± SD total captures over the four sampling sessions are shown. Variation in sampling points throughout the survey period was due to desiccation of ponds as the season progressed.

* Peak figures are as follows: for individual ponds, the peak count is the highest count attained on a single night; for sites, the peak count is the highest total count (counts for all ponds summed) attained on a single night.

Table 6. Population size classes according to the Great crested newt mitigation guidelines (English Nature 2001).

Site	Population size class based on peak count (English Nature 2001)
Site – A	Medium
Site – B	Small
Site – C	Small
Site – D	Small
Site – E	Small
Site – F	Medium
Site – G	Medium
Site – H	Medium
Site – I	Medium
Site – J	Large
Site – K	Medium
Site – L	Medium
Site - M	Small

'Small' population <10; 'Medium' population >11-100; 'Large' population >100. Site totals were obtained for maximum adult counts for all ponds on the same visit using either torch surveys or bottle-trapping.

Population Densities

Population status of newts at mitigation sites

4.7 In terms of the number of newts trapped per 2 m of shoreline (Table 7), the majority of ponds surveyed (ie 53%) scored 'below average', while all remaining ponds scored as 'average', using the scoring system devised by Griffiths and others. (1996). Moreover, mean population density of all the sites was significantly lower than that given for 'average' populations in the table devised by Griffiths and others. (1996) (t=2.18, df=45, P<0.05). It was not possible to compare the densities obtained by torch counts with the scoring system devised by Griffiths and others. (1996) as the present study used a higher powered torch than the original system was based upon.

Comparisons with pre-development surveys

4.8 Comparisons between the present data and those obtained in pre-development surveys are very difficult because (1) the methods used pre-development used a variety of non-standardized methods; and (2) the numbers, sizes and locations of water bodies may have changed pre- and post-development (Table 8). Information on the pre-development status of the populations was available for 10 out of the 13 sites surveyed. Of these, no newts were detected at one site and presence-absence only (using egg surveys) was recorded at two sites. This left six sites where counts of newts were made, but these were by a variety of methods. Where surveys were carried out post-development but prior to the present surveys (n=6 sites), newts were detected at all of the sites surveyed.

Table 7. The density of great crested newts (no. newts per 2 m) calculated for bottle trapping surveys, based on average density over the four sampling sessions at each pond.

Site Name	No. Sample Points	Mean newts/ trap	Rating
Site A - Pond 1	0-12	0.67	Average
Site B - Pond 1	10	0.05	Below Average
Site B - Pond 2	0	0.00	Below Average
Site B - Pond 3	0-10	0.00	Below Average
Site B - Pond 4	10	0.03	Below Average
Site C - Pond 1	8	0.19	Average
Site C - Pond 2	10-11	0.10	Average
Site D - Pond 1	10	0.00	Below Average
Site D - Pond 2	10	0.00	Below Average
Site D - Pond 3	10	0.00	Below Average
Site E - Pond 1	0-20	0.00	Below Average
Site E - Pond 2	0-5	0.00	Below Average
Site E - Pond 3	0-5	0.00	Below Average
Site F - Pond 1	30	0.30	Average
Site G - Pond 1	17	0.10	Average
Site G - Pond 2	5	0.20	Average
Site G - Pond 4	8	0.53	Average
Site H - Pond 1	10-15	0.03	Below Average
Site H - Pond 2	15	0.10	Average
Site I - Pond 1	6-10	0.03	Below Average
Site I - Pond 2	7-16	0.19	Average
Site J - Pond 1	30	0.68	Average
Site J - Pond 2	8	0.66	Average
Site J - Pond 3	10	0.25	Average
Site K - Pond 1	0-20	0.89	Average
Site K - Pond 2	0-7	0.55	Average
Site L - Pond 1	0-14	0.02	Below Average
Site L - Pond 2	0-10	0.00	Below Average
Site M - Pond 1	20	0.00	Below Average
Site M - Pond 2	10	0.025	Below Average

The scores obtained are compared to the table devised by Griffiths and others. (1996) for scoring great crested newt populations. (n=30).

Table 8. The number of great crested newts observed during 2005 surveys, using highest number of newts recorded by either torch or trapping survey methods, compared to newts recorded during pre-development surveys (varied or unknown methods) and number of newts translocated during the mitigation process.

	No. Newts encountered pre-development	No. Newts translocated	Post-development surveys carried out (Yes or No)	Great crested newts encountered (Yes or No)	No. of newts recorded (Peak counts) in 2005
Site A	n/a	164	No	No	16
Site B	40	0	No	No	8
Site C	n/a	4	No	No	3
Site D	2	2	No	No	2
Site E	eggs	12	Yes	Yes	2
Site F	42	0	Yes	Yes	31
Site G	100+	73	No	No	19
Site H	2	6	Yes	Yes	39
Site I	102	0	Yes	Yes	22
Site J	0	0	Yes	Yes	167
Site K	n/a	37	Yes	Yes	86
Site L	6	43	No	No	25
Site M	eggs	84	No	No	1

Pre-development information is based on data presented in questionnaires, submitted and used in Edgar & Griffiths (2004) as well as extra documentary evidence supplied by consultants and landowners etc.

Where ‘n/a’ is shown there is no evidence from the questionnaires regarding pre-development survey work being carried out and in some cases newts were detected during the development so pre-development surveys were not conducted.

Population estimates using Schnabel Method

4.9 Recaptures of photographed newts were only made at five ponds, with mark-recapture data for a further site being supplied by an independent surveyor. Schnabel mark-recapture population estimates are therefore given for six ponds (Table 9). The populations fell into three broad size classes: one site with a population estimate of around 800, two with estimates of around 100 and the remaining three sites all had populations estimated at <32. All population estimates had extremely wide confidence intervals.

Table 9. Schnabel mark-recapture population estimates ±95% confidence intervals for those ponds where recaptures were made.

Site Name	N	95% confidence intervals	
		Lower	Upper
Site A - Pond 1	104.00	46.66	878.87
Site C - Pond 1	6.50	2.44	254.90
Site F - Pond 1	101.75	50.23	497.56
Site G - Pond 4	17.80	9.27	65.15
Site J - Pond 1	810.67	363.75	6850.70
Site K - Pond 2	31.50	11.84	1235.29

Habitat suitability

4.10 A total of 31 ponds and associated terrestrial habitat were assessed using the indices described by Oldham and others. (2000). A total of 14 (45%) scored >0.80; 9 (29%) scored between 0.70-0.79; 3 (10%) scored between 0.60-0.69; 4 (13%) scored between 0.50-0.59 and 1 (3%) scored <0.50.

4.11 The majority of sites therefore contained ponds and associated terrestrial habitat that were apparently suitable for great crested newts. Without exception, though, all ponds had suffered from habitat fragmentation by the building of roads or other developments that had resulted in habitat loss. In one case newts were translocated to an isolated pond at the top of a hill with no apparent adjoining water bodies within a 500 m radius. Furthermore, the pond remains highly disturbed by the public and their dogs. The nearest water bodies to this site (0.75 km distant) are a canal and a reservoir, the latter separated by a major road and housing estate.

4.12 Indeed, even the two ponds that appeared to support relatively large populations of great crested newts (ie Site J, pond 1 and Site K, pond 1) were each connected by suitable terrestrial habitat to just two and one pond respectively, and were otherwise highly isolated by major roads and/or mainline railways.

4.13 A total of 13 out of 14 (93%) of ponds that scored >0.80 on the HSI contained great crested newts. Similarly, 6 out 9 (67%) ponds that scored >0.7<0.80 contained great crested newts and 3 out of 3 (100%) that scored >0.6<0.70 contained great crested newts. One out of 4 (25%) ponds that scored <0.60 contained great crested newts respectively. Consequently, most ponds with high scoring HSI values contained great crested newts.

4.14 Although one water body at 'site A' scored 0.46 (ie <0.50) using the HSI, the population of crested newts rated 'medium' according to English Nature (2001). This is because the pond has recently undergone redevelopment because of a leaking liner. Thus water was still very turbid and the surrounding habitat had been greatly disturbed by heavy machinery. The lack of sunlight able to penetrate the water column because of turbidity meant that macrophyte cover was also very poor. The index may score differently if carried out in future years.

4.15 There were no relationships between torch counts or trap captures and HSI scores (Figures. 3-6). This may have been due to the relatively high number of ponds with zero or very low counts by either trap and/or torch survey methods but which had high HSI scores.

Table 10. Scoring of sites surveyed using the Habitat Suitability Index system devised by (Oldham and others 2000) and detection of great crested newts recorded during the 2005 surveys.

Site Name	HSI Value	Great crested newts recorded
Site A - Pond 1	0.46	Yes
Site B - Pond 1	0.89	Yes
Site B - Pond 2	0.52	No
Site B - Pond 3	0.53	No
Site B - Pond 4	0.81	Yes
Site C - Pond 1	0.62	Yes
Site C - Pond 2	0.76	Yes
Site D - Pond 1	0.82	Yes
Site D - Pond 2	0.90	No
Site D - Pond 3	0.79	No
Site E - Pond 1	0.93	Yes
Site E - Pond 2	0.77	No
Site E - Pond 3	0.59	No
Site F - Pond 1	0.81	Yes
Site G - Pond 1	0.80	Yes
Site G - Pond 2	0.70	Yes
Site G - Pond 3	0.70	Yes
Site G - Pond 4	0.70	Yes
Site H - Pond 1	0.52	Yes
Site H - Pond 2	0.80	Yes
Site I - Pond 1	0.95	Yes
Site I - Pond 2	0.79	Yes
Site J - Pond 1	0.93	Yes
Site J - Pond 2	0.64	Yes
Site J - Pond 3	0.69	Yes
Site K - Pond 1	0.84	Yes
Site K - Pond 2	0.81	Yes
Site L - Pond 1	0.88	Yes
Site L - Pond 2	0.87	Yes
Site M - Pond 1	0.72	No
Site M - Pond 2	0.78	Yes

Table 11. Summary of data and Suitability Indices (SI) collected from 31 water bodies across 13 mitigation sites.

Parameters	"Units"	Range of values recorded	Median value	Range of SI recorded	Median SI
Location	3 point scale (0.01, 0.5, 1.0)	1-1	1	1	1.00
Area	m^2	4680-9	296	1-0.01	0.40
Permanence	Years of drought per decade	10-0	0	1-0.10	0.90
Water quality	Rule base on extent of eutrophication	4-2	4	1-0.33	1.00
Shade	% of perimeter affected	100-0	3	1-0.20	1.00
Waterfowl	No. of birds per ponds (Size scale)	7-0	0	1-0.35	1.00
Fish	Evaluation of impact	4-2	4	1-0.33	1.00
Pond dispersion	Pond density per km^2	8-0	2	1-0.05	0.83
Terrestrial habitat	Newt friendly habitat adjusted for existence of barriers	5-1	4	1-0.68	1.00
Macrophyte cover	% Plants reaching water surface	90-0	2	1-0.30	0.60
HSI	Habitat Suitability Indices	0.95-0.46	0.79		

Parameters can be found in Oldham and others. (2000).

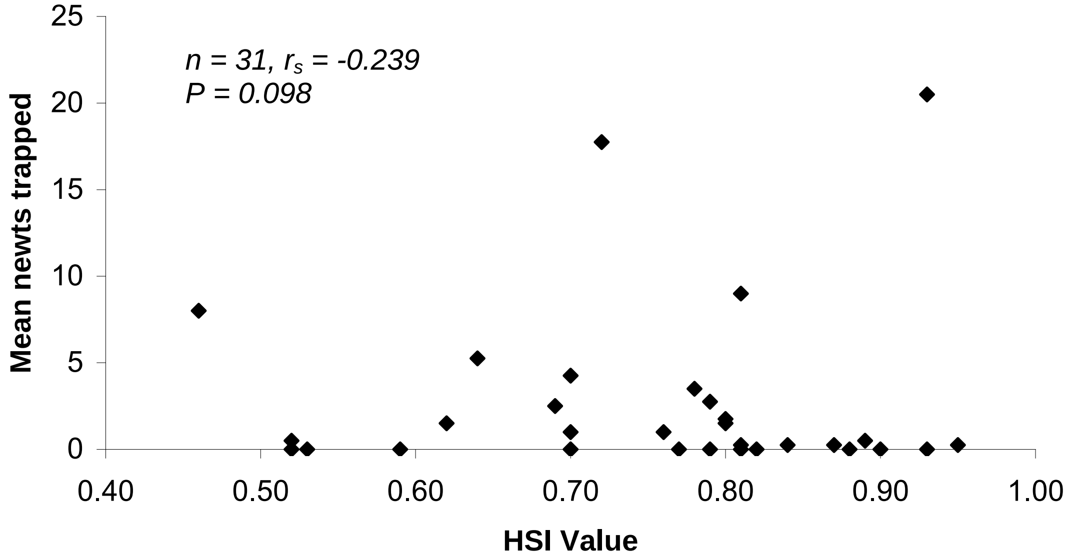

Figure 3. Mean trapping observation of great crested newts in relation to Habitat Suitability Indices (HSI) values.

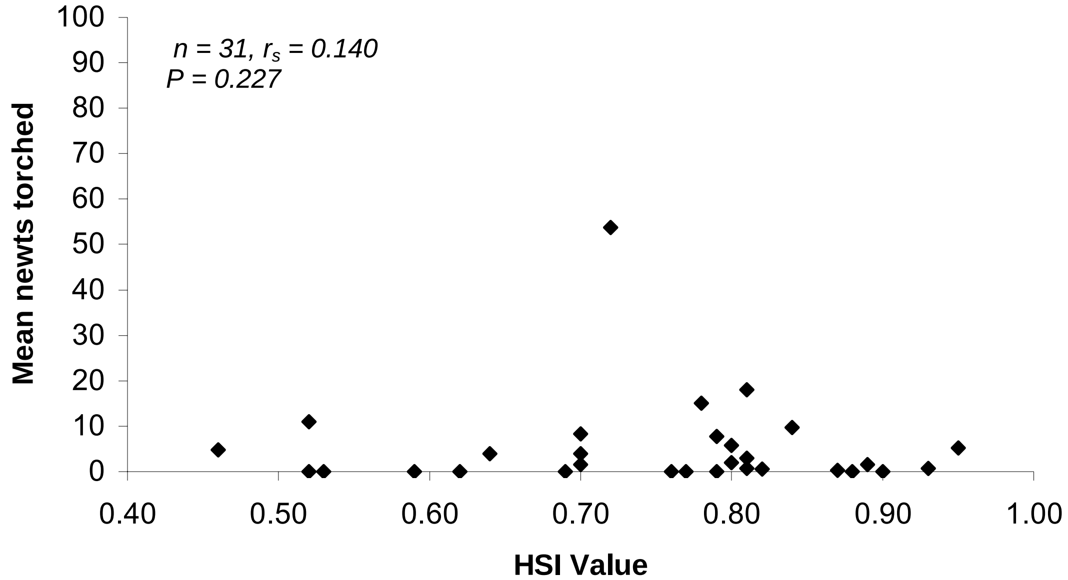

Figure 4. Mean torching observation of great crested newts in relation to Habitat Suitability Indices (HSI) values.

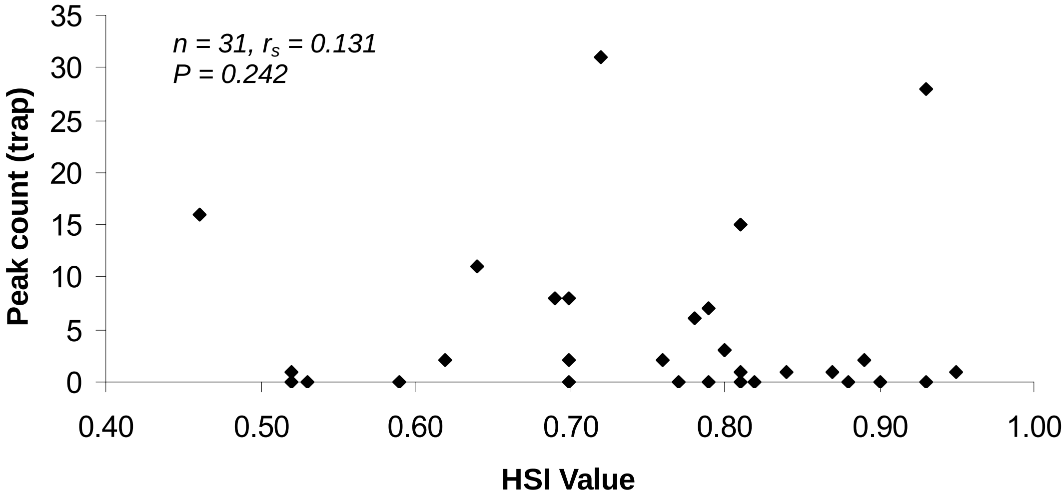

Figure 5. Peak trap counts of great crested newts in relation to Habitat Suitability Indices (HSI) values.

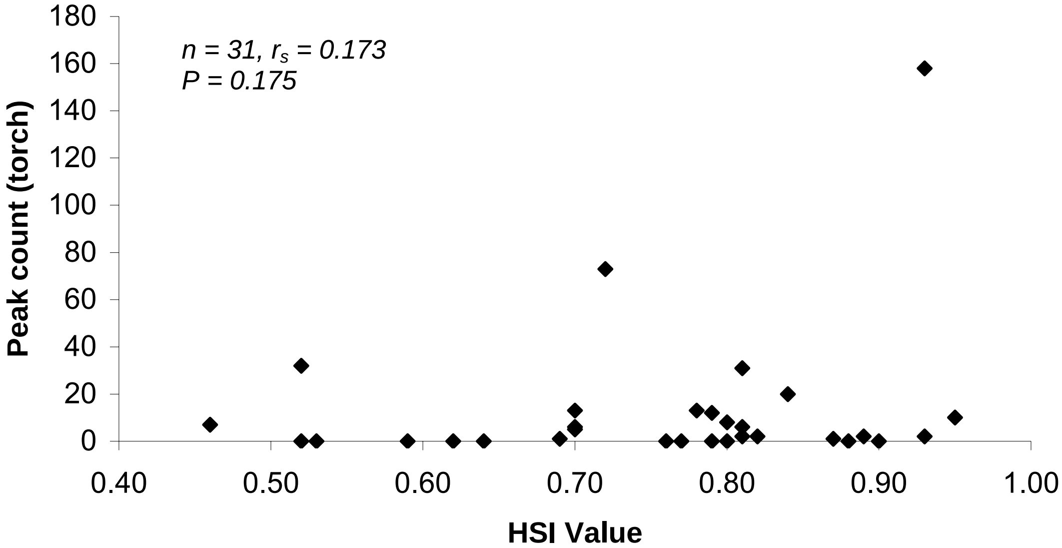

Figure 6. Peak torch counts of great crested newts in relation to Habitat Suitability Indices (HSI) values.

Table 12. The impact of development and mitigation on the numbers of ponds at each site.

No. of Ponds	Total	Mean	SD
On development sites	39	3.00	2.08
Affected	26	2.00	1.68
Lost	11	0.85	1.21
Retained	23	1.77	1.59
Enhanced	17	1.31	1.25
Created	11	0.85	1.14
Surveyed	31	2.38	0.96

Terms within this table are taken from the questionnaires (Edgar and Griffiths, 2004) and are defined as: 'On development sites' – the total number of ponds recorded on the questionnaires; 'Affected' – those water bodies that were thought to be used by breeding great crested newts; 'Lost' – those water bodies that were destroyed as part of the development process; 'Retained' – those water bodies that were retained in-situ without disturbance or management; 'Improved' – those water bodies, both in-situ and-ex situ that were improved as part of the mitigation project; 'Created' – new water bodies created to compensate for those lost on the development site and; 'Surveyed' – those water bodies known to contain great crested newts and were surveyed for this report.

4.16 Some two-thirds of all ponds on the sites surveyed were considered to be affected by the developments, with just under one third lost altogether (Table 12). The overall number of ponds created equalled the number of ponds lost, and about three-quarters of those ponds retained underwent some enhancement to improve their quality for great crested newts.

5 Discussion

Baseline levels for mitigation sites and survey methodologies

5.1 How does mitigation affect the population status of great crested newts? In order to answer this question, comparisons with sites unaffected by mitigation need to be made, and this is potentially possible in two ways. Firstly, comparisons with the same population(s) pre-development can be made. As this will allow changes in population status at the same site to be determined this is the most powerful design but, unfortunately, it is also fraught with difficulties. As the present study has shown, pre-development surveys are highly variable in their design and in the quality of data that they generate. In some cases, only presence-absence data have been recorded, and in others no pre-development data other than the number of newts translocated are available. Furthermore many of the projects were undertaken pre- great crested newt mitigation guidelines (English Nature 2001) and although considerable effort to mitigate such problems 'best-practice' varied from site to site. This makes a direct comparison between pre- and post-mitigation survey data tenuous and possibly extremely misleading.

5.2 A second approach is to therefore compare the current post-mitigation survey data with that obtained at a number of 'control' sites that have not been subject to mitigation. This is less preferable to carrying out 'before' and 'after' comparisons at the same site, as between-site variability will inflate the error term in any statistical comparisons. Nevertheless, there are data available from great crested newt sites that have not been subject to development and which have been collected in a standardized way that allows comparisons with the present data. These data are inherent within the scoring system devised by Griffiths and others. (1996). This system was developed by surveying a sample of natural great crested newt sites using standardized methods and applying a statistical method to classify populations as 'below average', 'average', 'above average' etc, based on the number of newts observed per 2 m of shoreline by trapping, torching or netting. This density-based system has the disadvantage that small populations at high density may score higher than much larger populations at low density, although Griffiths and others. (1996) recognise this and suggest that such density measures can be multiplied up to give an overall count for the shoreline (assuming that the complete accessible shoreline is not otherwise surveyed).

5.3 If mark-recapture population estimates have been made (in the current study such estimates were possible at six ponds) then it is also possible to make comparisons with mark-recapture estimates made at 'control' ponds. Unfortunately, there are few mark-recapture studies in the UK, although a moderate sample of such studies is available for Europe (eg Arntzen & Teunis, 1993). Difficulties here lie in whether great crested newt populations outside the UK are comparable with those in Europe, and whether the populations studied – which have been used mainly for ecological research – are typical of all natural great crested newt populations.

5.4 A third approach – which is not based upon a matched or unmatched comparison with actual 'control' sites – is to compare the current data with baselines devised by 'experts'. Essentially, this is the system contained within the current great crested newt mitigation guidelines (English Nature 2001) which classifies great crested newt populations as 'small' (maximum counts up to 10), 'medium' (maximum counts between 11 and 100), and 'large' (maximum counts over 100). The origin of this system is unclear, but it seems to be a development of that previously proposed for SSSI designation of amphibian assemblages (eg Beebee & Grayson, 2003). Maximum counts can be made by either torch counts or trapping. Unlike the density system proposed by Griffiths and others. (1996) which scores individual ponds, this system is based on site totals obtained by summing across all ponds. This system suffers from the fact that (1) the categories are not based upon any rigorous analysis of existing great crested newt population data; and (2) the method for making ‘counts’ is not standardized. Surveyors using different torches – or different numbers of traps – at the same site could therefore come up with very different ‘counts’.

5.5 In addition to these design-specific caveats, there are also some more general survey issues that need to be considered before proceeding to interpretations of the current data. As has been shown by several previous studies, newt populations display wide year-to-year fluctuations in population size that are entirely natural, and single year ‘snapshot’ surveys therefore need to be interpreted cautiously, particularly when comparisons are being made with other sites or with the same site at different times. Moreover, English Nature (2001) recommend six or more ‘counts’ to be carried out should be conducted at each site within a season: because of logistical constraints the present data are based on only four sampling occasions. Sewell and others. (2005) have confirmed that six sampling occasions is the minimum required to minimise between-sample variation in trapping data. A further problem is the fact that with the exception of mark-recapture analysis, none of the methods used here control for variability in the detectability of great crested newts. Simple counts of amphibians may therefore be a very poor measure of population status (Schmidt 2004) and Sewell and others. (2005) have shown that the detectability of great crested newts varies, spatially, temporally and between individual animals.

5.6 Because of these numerous caveats, we have adopted a multifaceted – but cautious – approach to interpreting the current data. We have endeavoured to compare the current survey data with (1) pre-development data (as far as this is possible); (2) density estimates for a sample of sites not subjected to mitigation; (3) the population size class system (English Nature 2001); and (4) mark-recapture estimates for a sample of sites in Europe. Our approach is therefore to determine what general patterns seem to emerge collectively from several systems, all of which have caveats.

Table 13. A comparison of two systems for assessing the status of great crested newt mitigation sites.

Site	Peak Count	Population size class (English Nature 2001)	Population density size class (Griffiths and others., 1996)
Site A	16	Medium	Medium
Site B	8	Small	Small
Site C	3	Small	Medium
Site D	2	Small	Small
Site E	2	Small	Small
Site F	31	Medium	Medium
Site G	19	Medium	Medium
Site H	39	Medium	Medium/Small
Site I	22	Medium	Medium/Small
Site J	167	Large	Medium
Site K	86	Medium	Medium
Site L	25	Medium	Small
Site M	1	Small	Small

As the English Nature (2001) is based on ‘sites’ whereas the Griffiths and others. (1996) system is based on ‘ponds’, status assessments using the latter system have been collated by site to allow a comparison. ‘Below average’ = ‘small’; ‘average’ = ‘medium; ‘above average’ = ‘large’.

Status of great crested newts at the mitigation sites

5.7 The surveys revealed the presence of great crested newts at all mitigation sites – but not at in all ponds within mitigation sites. Counts and captures of newts varied between ponds, but in terms of peak torch counts per site, most sites scored ‘small’ or ‘medium’ using the great crested newt mitigation guidelines scoring system (English Nature 2001). Equally, most of the ponds scored ‘below average’ using the population density system described by Griffiths and others. (1996), and mean population density of all the ponds was significantly below that observed at a sample of ponds not subjected to mitigation. Despite the fact that the English Nature (2001) and Griffiths and others. (1996) systems have different caveats (see above), there was a high degree of correspondence in site assessments when the two methods were applied and compared (Table 13): the two systems gave 10 out of the 13 sites broadly the same population assessment. Taken together, the assessments suggest that four of the sites contained ‘small’ populations; four of the sites contained ‘small-medium’ populations; four sites contained ‘medium’ populations; and one site contained a ‘medium-large’ population. Population estimates were only possible at six ponds where recaptures of newts were made. Although confidence intervals were wide, these estimates suggested that five ponds contained populations of close to 100 or less, with one pond containing just over 800 newts. Compared to the population estimates of the great crested newt populations reviewed by Arntzen & Teunis (1993) – which themselves may be biased towards smaller populations – these population estimates are relatively low.

5.8 There were no significant relationships between population assessments – as assessed by count data by torching and trapping – and HSI scores. This is probably a reflection of the variability between ponds and sites as well as between detection probabilities (Schmidt 2004; Sewell and others, 2005). Indeed, with a larger sample of sites (n=72) Oldham and others. (2000) did obtain significant correlations between population counts and HSI scores. As the same authors point out, however, predictions based on such relationships must be treated with caution given the high variation between sites and number of outliers observed. Furthermore, the use of the HSI model is based upon the premise that the quality of the great crested newt habitat is reflected in the population it supports (Oldham and others 2000). Whilst there are good reasons to believe this is true, as Oldham and others. (2000) point out the system cannot replace genuine expertise, as it cannot cover all eventualities. An example of this is ‘Site A’, whereby the pond did not score highly with regard to HSI value yet it retained a comparative density of great crested newts in relation to ponds that scored highly. Similarly Site D, pond 2 scored highly using HSI criteria but great crested newts were not detected.

5.9 HSI’s displayed a stronger relationship with presence or likely absence, as 13 out of 14 ponds that scored >0.8 contained great crested newts. The poor relationship with count data is a reflection of the fact that some of these ‘highly suitable’ ponds yielded low counts by torching and trapping. Application of the HSI system to evaluating the habitat of mitigation sites may therefore be appropriate for determining presence or likely absence, but it is inappropriate for assessing population status at the level of the individual pond.

5.10 Like the present study, Oldham and others.’s (2000) sample of 72 ponds that were used for evaluating the HSI system may not have represented a random sample of ponds from the wider countryside, and displayed wide variation in HSI scores and in individual SI’s for the different variables. Nevertheless, the median HSI score of 0.66 is rather lower than that obtained for the mitigation sites analysed here (HSI = 0.79). This suggests that the quality of great crested newt aquatic and terrestrial habitats at mitigation sites after development was generally good. It would be worthwhile to carry out a more rigorous statistical comparison of HSIs between mitigation and non-mitigation sites to explore this tendency further.

5.11 Collectively, the combination of standardized counts and population estimates suggest that the population status of great crested newts at sites subjected to mitigation is mainly ‘medium/average’ or below. Nevertheless, the data also show that at two sites – Site J, pond 1 and Site K 1 – moderate to good counts (ie >50) of great crested newts can be obtained in sites that have been subjected to mitigation despite relatively high degrees of habitat fragmentation caused by development and road building. At one of these sites (Site J, pond 1), many of the breeding newts appeared to be of small body size. This suggests they are recruits from recent (ie post development) breeding episodes, rather than ageing individuals recruited prior to the mitigation. However, although newt breeding populations would appear to be successful in the short to medium term they are more susceptible to many of the stochastic and genetic episodes that would lead to the extinction of an otherwise isolated population (Taylor and others 1999).

5.12 Because of the problems in making meaningful comparisons between pre-development and post-development population status, inferences concerning the fate of the population had no development proceeded are difficult. Assuming that the pre-development status of the populations were typical of those in the wider countryside, however, the overall 'small/below average' or 'medium/average' status of most of the populations post-development suggests that had the affected sites been left intact the populations might have been higher than they are now. On the other hand, if the developments had proceeded without any mitigation, further losses of both aquatic and terrestrial habitat would have occurred and it is likely the populations would be much lower than they are now, and in some cases possibly extinct. The overall impact of the mitigation projects therefore seems to have been to maintain great crested newts at something of an intermediate level. Only long-term surveys will determine whether such population levels are viable.

5.13 Some potentially good great crested newt sites were obviously suffering from a lack of management, leading to succession, overgrowth of trees around the shoreline or dumping of refuse. Equally, permanent drift fencing that was intended to retain amphibians within conservation areas was overgrown at two sites, thereby reducing its effectiveness. Even when responsibility of the management of such sites is transferred from a developer to a conservation group, a lack of manpower or resources to support ongoing management may mean such sites are unable to sustain their wildlife interest. Although transferring the management of a site to a local conservation group may ensure that licensing conditions are met, a long-term management plan – with adequate resources for its execution – also needs to be in place. Information regarding post-development management and surveillance work for each project is discussed in section 3.2 of this report. From a majority of the questionnaires carried out by Edgar and Griffiths (2004) it would appear that post-development management was not undertaken or part of any future plan for the sites. In some case where follow-up surveys were undertaken, such as Site J and Site F population levels would appear to remain stable.

5.14 Ongoing management work was undertaken at one site by one or two individual volunteers and the great crested newt population continued to remain stable. However, due to unforeseen circumstances work on that site stopped and as a result the ponds have become over-vegetated to the extent that early desiccation may become a problem for the breeding population in future years.

5.15 It is difficult to evaluate the type of mitigation activities that will result in 'large to medium' rather than 'small' great crested newt populations. This is because of (1) the small number of sites surveyed; (2) the short-term nature of the surveys; (3) the considerable variability in the landscapes and mitigation activities involved; and (4) the variability in the quality of pre-development population and habitat data. However, HSI scores indicated that most of the sites had good potential for supporting great crested newt populations. Most sites contained ponds of appropriate size and water quality, and suitable terrestrial habitat was usually available in the immediate vicinity of the water bodies. The main problem at most of the sites surveyed was that the ponds and surrounding habitats were located in highly fragmented and disturbed landscapes, with poor connectivity to other suitable habitats within the wider landscape. Perhaps larger areas of terrestrial habitat and better connectivity to adjacent habitats will result in fewer ponds being classified in the 'small/below average' population status categories. Furthermore, if it was a condition of the licensing that fixed term funding was made available by developers for the ongoing management and surveillance of ponds, this might help maintain populations of crested newts and the wildlife value of the site concerned.

6 Recommendations

6.1 The following section gives suggestions for further research (points 1 and 2) and mitigation practice (points 3 to 7).

1) With mark-recapture databases now established at six sites through records of individual newts, further follow-up surveys are recommended at these sites to determine long-term population trends and temporal variability in detectability of newts.

2) Further research should include a comparison of habitat suitability at sites subject to mitigation with that observed at a sample of sites not subject to mitigation. This comparison could be made using habitat suitability indices or a more quantitative analysis of relevant variables using multivariate analysis.

3) Further standardization of surveys is needed to enable (a) comparisons between pre- and post-development; and (b) comparisons between mitigated populations and natural populations. These surveys should consist of torch counts (using 500,000 candlepower torches) and/or bottle trapping (see section 5.6, Field survey methods in English Nature, 2001) at 2 m intervals around the accessible shoreline for a minimum of six visits at peak season, coupled with total counts by torch for the whole of the accessible shoreline. If necessary, density estimates can be converted to estimates of total counts by extrapolation (Griffiths and others., 1996). The combination of total counts and densities can be compared with existing scoring systems to evaluate population status (see section 5.8.3, 'Population size class assessment' in English Nature, 2001).

4) Capture-mark-recapture analysis should be combined with standardized counts wherever possible during both pre- and post-development surveys (see section 5.8.3.2, Assessment of actual population size in English Nature, 2001). Further mark-recapture studies of mitigation populations and natural populations are needed to compare the performance of populations subject to mitigation with those in the wider countryside.

5) Habitat suitability indices combined with standardised detection methods should be carried out pre-development as a tool for predicting presence and/or likely newt absence (see section 5.8.2, 'Terrestrial habitat use' in English Nature, 2001). An evaluation of ponds and associated 'newt-friendly habitat' should be combined with standardised detection methods in order to help quantify likely presence and/or absence of newts from the development site (see section 5.7.1, 'Presence/absence survey' in English Nature 2001). It is important to note however that HSIs should not be used to predict great crested newt population status. This would then be submitted along with any licence application or in advance of pond destruction in the case of likely newt absence.

6) Greater emphasis needs to be placed on maintaining habitat connectivity between ponds both within and between sites (see section 6.3, Temporal and spatial considerations in English Nature 2001). Connectivity should be maintained between a minimum of four ponds that score 'good' to 'excellent' using the HSI criteria. This should be undertaken at a licensing level.

7) Where responsibilities for management and monitoring have been handed over to local conservation groups, adequate resources need to be in place alongside a long-term management plan so that sites do not become degraded through neglect.

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