Adder *Vipera berus* hibernacula construction as part of a mitigation scheme, Norfolk, England

Christian Whiting* & Helen J. Booth
Halcrow Group Ltd. c/o Broadland Environmental Services Ltd, 3rd Floor Grosvenor House, 112 – 114 Prince of Wales Road, Norwich NR1 1NS, UK

*Corresponding author e-mail: WhitingC@Halcrow.com

SUMMARY

A significant adder, *Vipera berus*, population was identified within the Upper Thurne river catchment during baseline surveys in 2009. An adder bank (hibernacula) was constructed in the autumn 2009 in advance of flood defence works at Horsey in 2010 to mitigate any temporary loss of hibernation and natal den sites. Reptile fencing was erected around the adder banks and some adjacent grazing marshes in February 2010 to create reptile enclosures. During March to May 2010, 119 adders were moved to the adder banks from the flood banks that were then stripped of vegetation and topsoil to discourage animals from re-entering the working corridor. Sections of the adder fencing were removed in mid-May to allow animals to disperse to their summer foraging grounds. Surveys during summer 2010 indicated breeding success within the banks. Pre hibernation surveys in 2010 recorded a peak count of 22 animals, and a spring emergence survey of the adder bank in 2011 identified 17 individual adders. A further four were recorded using an adjacent store of rush, *Juncus*, bales. Monitoring through summer and autumn 2011 identified a further 16 individual animals on or close to the adder bank, including six gravid adders. Eighteen out of the 33 adders recorded using the adder banks in 2011 were recaptures. Fifteen 'new' adders (i.e. not relocated during the 2010 mitigation) were subsequently identified as using the adder banks to hibernate or give birth. The total cost of constructing the adder banks and erecting/dismantling the reptile fencing was £63,500.

BACKGROUND

The Broadland Flood Alleviation Project (BFAP) is a long-term project providing a range of flood defence improvements, maintenance and emergency response services within the tidal areas of the Rivers Yare, Bure, Waveney and their tributaries (Fig. 1) in Norfolk, eastern England. As part of the BFAP, Broadland Environmental Services Ltd. (BESL), a joint venture between Halcrow Group Ltd. (design, planning and environmental) and BAM Nuttall Ltd. (contractor), were appointed by the Environment Agency to deliver an integrated 20 year programme of flood risk management for over 250 km of flood defences within Broadland.

This paper describes the hibernaculum created on a section of floodbank from Horsey Boat Dyke (Ordnance Survey grid ref. TG4556422445) to the Brograve Pump along Waxham Cut (TG4483423552) as shown by Fig. 1.

ACTION

In 2008, BESL commenced detailed design for improvements to the flood defences in the upper Thurne at Horsey (north and south of Horsey Mere), West Somerton and Hill Common (Hickling). The proposed flood defence works at Horsey were comprised of rear bank strengthening of the existing floodbanks and the removal of a secondary bank adjacent to the soke dyke where present (Fig. 2). Material to strengthen the floodbanks was locally sourced by the widening of existing or excavation of new soke dykes up to 18 m wide.

Habitat suitability and historical records suggested that the floodbanks could support populations of reptiles, including adder *Vipera berus*, common lizard *Zootoca vivipara* and grass snake *Natrix natrix*. Baseline surveys were undertaken during February - May 2009 using a combination of walkover and artificial refugia (e.g. roofing felt 1 m x 0.5 m in size laid on the

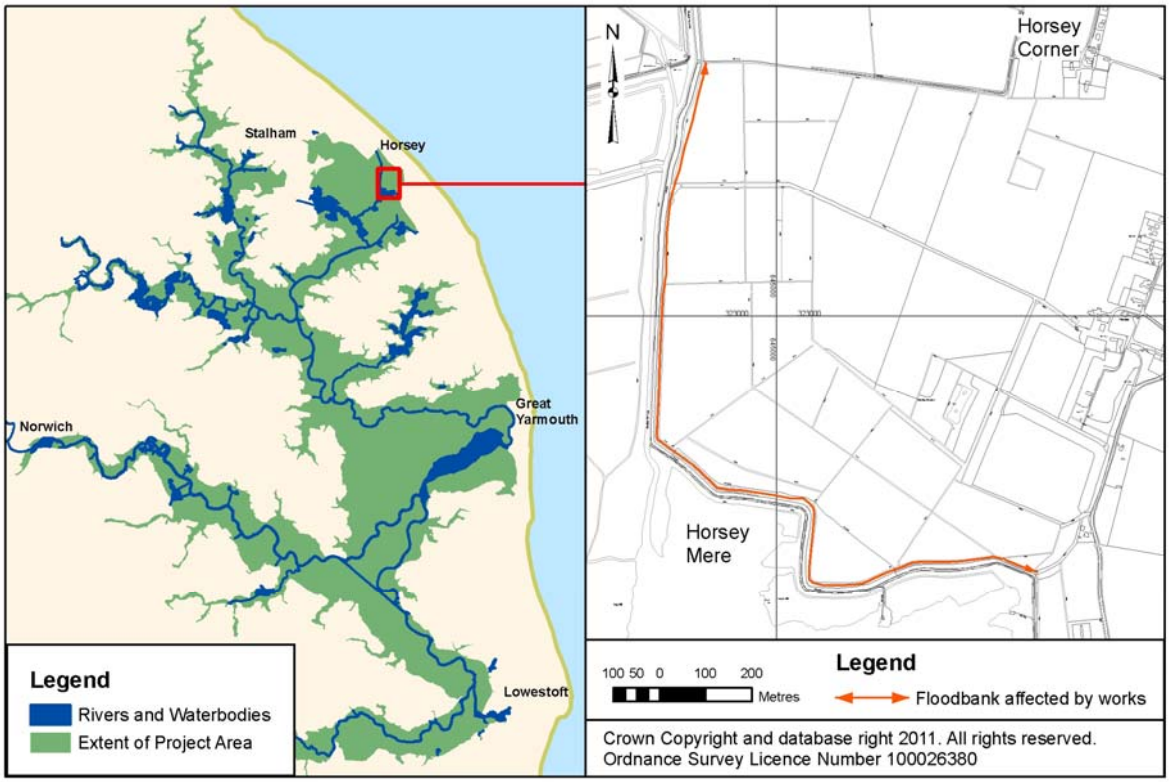

Figure 1. Project Area and proposed flood defence works at Horsey

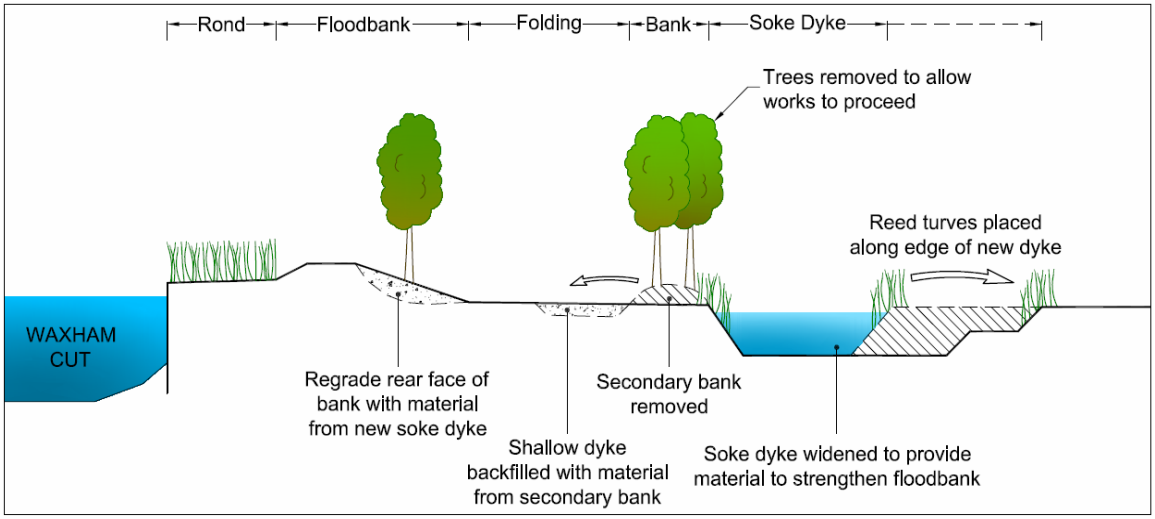

Figure 2. Proposed flood defence works – typical cross section

ground to provide cover and basking sites) methods. These recorded adder, common lizard and grass snake on the floodbanks and foldings (i.e. the area between the rear toe of the floodbank and the 'borrow' or 'soke' dyke, which runs parallel to the flood defence, see Fig. 2) indicating animals may have hibernated within the existing floodbank. The presence of neonate, juvenile (>1 years old) and female adders indicated that the floodbanks were also used as 'natal dens', whilst common lizard neonates and juveniles were also recorded.

Due to the significant population of adders, common lizard and grass snakes identified during the baseline surveys, the proposed flood defence works had the potential to adversely affect the long-term viability of the populations present. Impacts during the construction phase could injure or kill reptiles as a result of vegetation clearance, topsoil stripping and the placing of material to strengthen the banks and infill existing soke dykes. As the existing reptile populations hibernate and give birth on or within

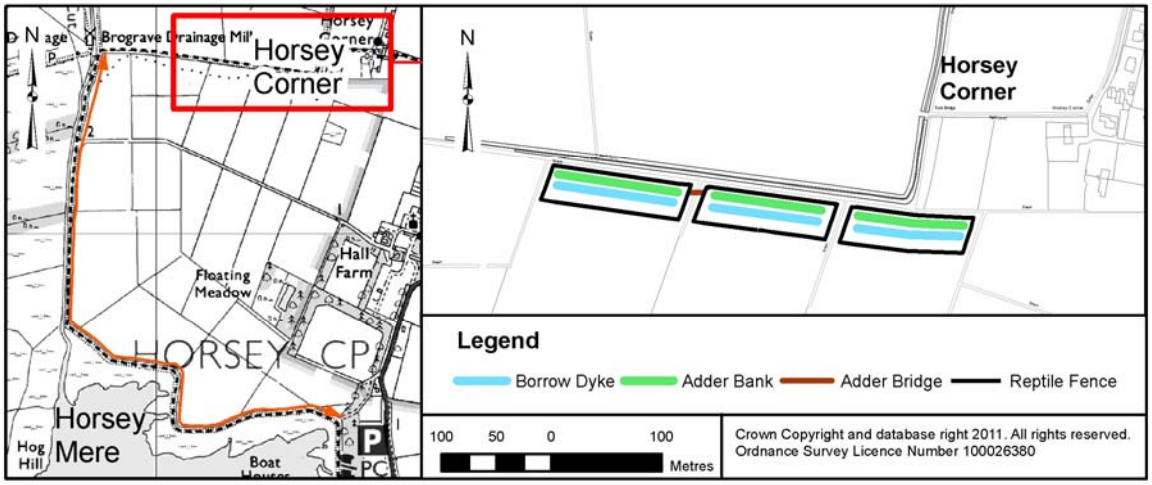

Figure 3. Adder bank and reptile fencing location at Horsey

the floodbanks, the proposed works would also result in the temporary loss of reptile hibernacula and natal dens until the banks had re-vegetated and cavities developed to allow access for hibernation or giving birth. Therefore the protection of, or compensation for the loss of, existing hibernation and natal dens sites was imperative for the preservation of the long-term population viability and to prevent local extinctions.

A secondary bank existed that had been created by historic placement of soke dyke slubbings (removal of plant matter and detritus as part of ditch maintenance works) for much of the floodbank length. At the time of the baseline survey, this bank had extensive tree and scrub cover that made access difficult, but no adders were recorded on those areas that were accessible. However, the bank had potential to support hibernating adders and other reptiles. As the flood defence proposals included the removal of this bank (Fig. 2), tree and scrub clearance was required that would enable the bank to be checked for adders and other common reptiles. Any adders or common lizards present could then be moved to prevent them being injured or killed during the works. If significant numbers of adders were subsequently recorded, then the existing proposals could be amended to retain all or part of the secondary bank.

Many reptile mitigation schemes involve the translocation of animals to receptor sites often several miles away from the donor site, usually because the original site is being lost to development. In this case the aim was to move the animals locally so that once the works are completed the reinstated floodbanks can be re-

colonised over time as suitable habitat develops. The mitigation strategy developed for the Horsey North section of floodbank consisted of the construction of hibernacula (subsequently referred to as the ‘adder banks’) and the use of reptile fencing around the hibernacula and adjacent grazing marshes to create enclosures.

Adders would be temporarily held within the enclosures to prevent injury to animals during vegetation and topsoil stripping required to denude the floodbanks of suitable foraging and refuge habitat in order to discourage animals from returning to the floodbank. Holding the adders within the enclosures would also minimise disruption to their breeding cycle by ensuring that adult adders had the opportunity to mate to maximise recruitment. Once mating had occurred, the fencing would be removed to allow animals to disperse to their summer foraging grounds.

The mitigation was comprised of the following six stages:-

Landowner consultation: The Horsey Estate has a long-term lease from the National Trust for land to the north of Horsey Mere to the Brograve Pump, which receives protection from the existing defences. BESL consulted the Horsey Estate regarding the need to construct an ‘adder bank’ to compensate for the short to medium term loss of hibernation and natal den niches. A location was agreed within existing grazing marshes to the west of Horsey Corner (Fig. 3), which are currently within the Broads Environmental Sensitive Area scheme. As the proposed site for the ‘adder bank’ comprised of three grazing marshes separated by drainage ditches, three separate adder banks (the ‘adder banks’) were constructed.

In order to ensure that the ‘adder banks’ were available for adders and other reptiles until other

suitable hibernation sites developed within the improved floodbank, a 5 year management agreement was agreed with the Horsey Estate. This requires BESL to manage the adder bank and 3.4 ha of adjoining land. It also allows access for ecologists to monitor the use of the site by reptiles, and to manage the habitat, including the strimming of paths to provide basking areas.

The existing Environmental Sensitive Area agreement ends in 2012 and the Horsey Estate plans to enter the land (including the grazing marshes where the adder bank is located) into the Higher Level Stewardship (HLS) agri-environmental scheme administered by Natural England. The presence of an adder hibernation bank would aid any application to enter land into HLS and provide long-term protection of the adder bank beyond the end of the 5 year agreement between BESL and the Horsey Estate.

Hibernacula design: It is recommended that reptile hibernacula should be in full or partial sun so that animals emerging from hibernation have maximum basking opportunities in the spring prior to sloughing and attempting to mate. Hibernation sites are designed to be humid (but not wet), safe from flooding and predators, with shelter from frost penetration (though adders are relatively tolerant of low winter temperatures).

'Traditional' amphibian and reptile hibernacula designs (e.g. Stebbings, 2000; Showler *et al*., 2005) include trenches filled with material such as building rubble to aid drainage. This has the added benefit of reducing the height above ground of the structure. Pipes have been used to provide access to the hibernacula. However, the general consensus is that reptiles prefer to use 'natural' access points, whilst rats and small mustelids could predate reptiles via artificial access routes (Edgar *et al*., 2010).

A design (see www.bfap.org) was agreed with the Horsey Estate that used natural materials sourced locally, including wood brash and logs from the floodbanks, rush bales from adjoining grazing marshes, reed bundles from reedbeds on the estate and soil from borrow pits dug adjacent to the adder banks. This allowed the banks to be dismantled at a later date if necessary without any issues relating to the disposal of imported crushed materials etc. The adder banks were 1.5 m high by 3 m wide on average with 45º front and rear slopes.

Hibernacula construction: Works commenced in late July 2009 to clear trees and scrub from the floodbank and a secondary bank to provide material for the hibernacula. The adder bank, 315 m in length, was completed on 4 September 2009. Logs and brash generated from the clearance were used to provide structure within the adder banks. A 360º excavator with a timber grab was used to move cut material and to fill a tracked dumper that transported the material to the adder bank site. A separate 360º excavator was used to dig the borrow pits and construct the adder banks.

A description of the construction process is as follows:

The footprint of the adder banks and the borrow dykes were marked out using a Trimble GPS. The turves and topsoil were then stripped (Fig. 4a) and stored for use on the bank once the structure was constructed. Rush bales were unrolled to create a 30 cm depth of straw. Reed bundles (laid longitudinally) were then placed on top (Fig. 4b) to create a central core to the bank. Logs were placed over the central core and covered by brash (Fig. 4c) to create a roof-like structure to support the soil and turves placed on top so that cavities would remain within the adder bank. Reed bundles and larger timbers were placed along the south-facing edge to ensure access points were maintained once the bank was covered with topsoil, which originated from digging a shallow dyke adjacent to the bank. Large timbers were also placed at right angles to the bank alignment to support longitudinal timbers to further maintain/provide access points. Over time, as the logs and brash decompose, the bank will collapse to some degree, but additional niches will also be created as a result of bank movement. The bank was covered with spoil from a shallow dyke excavated adjacent to the adder banks (Fig. 4d). Topsoil and turves were placed on the bank to aid vegetation establishment, whilst the borrow pits vegetated quickly and provided ephemeral habitats for amphibians and invertebrates. The final stage was to expose the timbers, brash and reed bundles placed along the front edge of the adder bank to create access points (Figs. 4f, 4h). This was initially undertaken by a 360º excavator (Fig. 4e) and then by hand using spades.

The bank and any areas of disturbed ground were then seeded with a rough grassland seed mix to aid vegetation re-establishment and to minimise weeds such as thistles establishing and then spreading into adjacent arable fields. The seed mix included chewings fescue, *Festuca nigrescens* (30%), red fescue, *Festuca rubra* (20%), Cock's foot, *Dactylis glomerata* (10%), creeping bent, *Agrostis stolonifera* (10%), false oat-grass, *Arrhenatherum elatius* (10%), rough meadow grass, *Poa trivialis* (10%) and Yorkshire fog, *Holcus lanatus* (10%).

Figure 4. The creation of the hibernaculum (a) vegetation and topsoil stripping; (b) rush round bales (unrolled) and reed bundles to create a central core; (c) timber logs and brash placed over the central core; (d) shallow dykes excavated parallel to the adder banks to provide spoil to cover the banks; dykes vegetated quickly and provide ephemeral habitat for amphibians, invertebrates etc.; (e) excavator trimming the south facing bank to expose brash and reed bundles to provide access points; (f) access points into the adder bank provided by brash, timbers and reed bundles along the edge of the bank; (g) habitat piles within the grazing marsh to provide cover and areas to bask; (h) adder enclosure and an 'Adder bridge' constructed over a marsh dyke to connect sites.

To reduce the risk of predation of reptiles by birds of prey, the banks were covered with piles of bramble cuttings as a temporary measure until the planted bramble has established. Habitat piles consisting of bramble cuttings, unrolled rush bales and reed bundles were placed within the adjacent marshes to provide additional cover and basking areas until the vegetation grew following winter dieback.

Reptile fencing: The main objective of the mitigation strategy was to remove reptiles from the working corridor and move them to the adder bank enclosures. As adders are site faithful to their hibernation sites and breeding grounds, without fencing off the entire floodbank working corridor (40 m wide by 1.8 km) it was considered that most adders would return to the floodbanks to search for potential mates. Therefore, semi-permanent PVC reptile fencing was used to create 'reptile enclosures' around the three adder banks and some adjacent grazing marshes (1ha in total).

The fence panels were strengthened with wooden battens placed on the inside of the panels and screwed through into the posts to prevent adders escaping where wind buffeting caused the overlapping panels to flex and create holes.

Juvenile adders and common lizards were released within the most easterly adder enclosure, whilst adult and sub-adult snakes were released onto the central and western sections of the adder banks which were linked together by a purpose built adder bridge (Fig. 1h) so that the movement of adders could be monitored (see **Relocation of adders**).

The plan was to retain adders for the duration of the peak spring mating to allow mating to occur, after which, the fencing would be removed to allow animals to disperse to their summer foraging grounds.

Relocation of adders: Adder relocation commenced on the 8 March 2010 following surveys in February that confirmed emergence from hibernation had begun. Once the adders had been removed, the floodbanks were stripped of vegetation and topsoil to discourage animals from returning whilst the flood defence improvement works were ongoing.

Head scale photos were also taken to allow the identification of any individuals recaptured during mitigation, construction or post-construction phases. Prior to release on the adder banks, adders were dorsally paint marked towards the tail area using non toxic bee-keeping paint pens (using different colours for different sites) to allow the rapid identification of escapees.

Hibernacula retention: Results of baseline surveys indicated that the majority of hibernation sites were located within the existing floodbank. In addition to the floodbank, a secondary bank existed along the edge of the soke dyke where dyke slubbings had been placed over time. This bank had become colonised with silver birch *Betula pendula*, occasional pedunculate oak *Quercus robur* and bramble. Tree and scrub cover made surveying the bank problematic; no reptiles were recorded for areas that were accessible.

Subsequent mitigation checks of the secondary bank identified a significant number of adders including adult males and females suggesting use of the bank for hibernation and as potential natal den sites. Following discussions with the design engineers, contractors and the landowners, it was agreed that the secondary bank could be retained. It was left undisturbed apart from the digging of drainage grips (circa 1 m wide) every 50m along the bank to prevent flooding of the folding in the event of seepage through or overtopping of the floodbank. The works were supervised by trained ecologists to minimise the risk of animals being injured or killed. Any animals caught would be moved along the secondary bank to areas already worked.

CONSEQUENCES

Use of the hibernacula – during relocations: A total of 119 adders were moved to the hibernation banks comprised of 56 adult males, 18 adult females, 11 sub-adult males, 2 sub-adult females, 9 sub-adults (sex indeterminate) and 23 juveniles.

During the construction period, the adder banks were extensively used by adders to bask and seek refuge with peak counts of 43 adders observed basking on one day. Early captured adult males often attempted to escape; they were observed moving along the fence line trying to find an opening. Adders are good climbers as illustrated by one male adder using a corner post to climb up to the top of the fence panel, but prevented from escaping by the overhang on the fencing.

Some animals escaped early in the mitigation works when wind buffeting caused the panels to flex and create gaps where they met on a post. This problem was resolved by screwing sections

of wooden batten through the panels into the post on the outside of the fencing.

Male behaviour changed significantly once female adders were placed in the enclosures, with animals less inclined to attempt to escape. Males were regularly observed basking close to females and adder combat was observed on 2 occasions, mate guarding on 7 occasions, and mating on 6 occasions.

Following the removal of some fence panels in mid-May, the majority of adders had left the hibernation banks by the end of May. However, monitoring showed that a small number of female adders had remained, indicating the possibility that they might use the banks as natal dens to give birth.

Use of the hibernacula – post construction: Following completion of the flood defence improvements in early autumn 2010, surveys of the adder banks from late September to mid-October recorded a peak daily count of 22 animals basking on the adder banks. A single neonate was observed next to a female adder basking on the eastern adder bank indicating breeding success.

2011 surveys: An extensive survey of the adder hibernation banks and the working corridor (floodbank, folding and a 'secondary bank' adjacent to the soke dyke) was undertaken in the spring 2011 (March - May), whilst an autumn survey (July - September inclusive) concentrated on use of the adder banks and the rush bales nearby.

During the 2011 surveys, 53 individual adders were identified from head scale patterns (Table 1). A further eight adders were caught which could not be identified due to the poor photos taken and/or the presence of mud on the heads suggesting recent emergence, whilst a number of others were seen but evaded capture.

Of the 53 adders identified, 33 were recorded using the adder banks (7 adult females, 20 adult males, 4 sub-adults and 2 juveniles). Four adders were also recorded adjacent to a store of excess rush bales produced for use as central fill within the adder banks. Elsewhere, four adult males were caught during the spring from a raised footpath bank that runs parallel with the adder banks. Of these, 3 had been previously caught during the 2010 mitigation from the working corridor. Therefore, they had hibernated close to the adder banks rather than return to their previous hibernation sites.

Comparison of the head scale photos taken in spring 2011 with those taken in 2010, showed that 18 of the 33 snakes, moved to the adder banks and subsequently recorded using the adder banks, were recaptures. Three of four adders recorded along the footpath less than 20 m from the adder banks were also 2010 recaptures. Therefore, 15 'new' adders (i.e. not relocated during the 2010 mitigation) were now using the adder banks to hibernate with four 'new' adders using the rush bales.

Adult viviparous lizards and grass snakes were also recorded on the adder bank and around the rush bales during the spring 2011 survey; numerous juvenile lizards were observed on the banks and the bales in September.

Future maintenance: The adder banks and 3.4 ha of adjacent grazing marshes are currently maintained by BESL as part of a 5 year agreement, whilst activities such as rush cutting etc. are prohibited to prevent accidental killing of adders and other reptiles. Grazing is also prohibited to prevent damage to the adder bank and overgrazing of the existing tussocky sward that provides good foraging and basking habitat.

Table 1. Adder age class and capture locations (Horsey North, 2011)

	Adult		**Sub-Adult**			**Juvenile**		
Location	*Female*	*Male*	*Female*	*Male*	*Unknown*	*Neonates*	*Other*	**Total**
Adder banks	7	20		3	1	1	1	**33**
Rush bales	1	1		1			1	**4**
Footpath Bank		4						**4**
Floodbank*	1	3			1		1	**6**
Secondary bank		4					2	**6**
Sub-total	***9***	***32***		***4***	***2***	***1***	***5***	**53**

**Includes floodbank and folding, excluding the raised secondary bank where adjacent to the soke dyke*

Costs: The adder bank cost £41,368 (Table 2) to construct over 6 weeks, with majority of the costs being for plant hire and labour. This equates to a rate of approximately £130/m. The overall cost would have been less if the woody material used to create the bank structure had been located adjacent to where the bank was constructed rather than having to be transported to site. The hand placing of timbers and reed bundles to help construct access points also added considerably to the cost of the bank construction. Some professional fees were incurred through having to employ a land agent to negotiate a management agreement with the Horsey Estate.

A further £22,750 was spent on the purchase (£2,250), erection (£14,000) and dismantling (£6,500) of 850 m of semi-permanent reptile fencing and the construction of an adder bridge. The total cost of the project was therefore slightly in excess of £64,000.

Table 2 Adder bank construction costs

Item	Qty	Cost
Plant hire, operators and fuel		
Tracked dumper	5 wks	£3730
13T 360º excavator and operator	4 wks	£5100
5T 360º excavator and operator	4 wks	£1500
Telehandler	5 wks	£1000
4x4 hire	6 wks	£1500
Fuel bowser	5 wks	£150
Fuel – plant	6 wks	£4688
Staff costs		
BAM Nuttall Staff	6 wks	£15000
Halcrow (CAD)	1 day	£300
Halcrow (Ecologists)	6 days	£2400
Professional Fees	1 No.	£1000
Other		
Reed bundles and *Juncus* bales		£5000
TOTAL		£41368

ACKNOWLEDGEMENTS

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Note that the adder banks are on private land; there is no public access

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