APPENDIX 5: BAT SURVEY DATA

Location	Species	2002		2004	
		Visit 1	Visit 2	Visit 1	Visit 2
Location 1	*P. pipistrellus*	1 bat foraging	No observations	Not Surveyed	1 bat foraging
Location 2	*P. pipistrellus*	2 bats foraging	No observations	Not Surveyed	Minimum of 2 bats foraging
	N. noctula	1 distant bat	No observations		No observations
	Myotis sp.	2 bats foraging amongst cover	1 bat foraging		No observations
Location 3	*Myotis* sp.	1 bat commuting	1 bat foraging in willow canopy	Not Surveyed	No observations
	Pipistrellus sp.	No observations	No observations	No observations	Faint recording to the east of Langford Brook
Location 4	*N. noctula*	1 distant bat	No observations	Not Surveyed	No observations
	Pipistrellus sp.	No observations	1 probable pipistrelle heard v. briefly, activity unknown.		No observations
Location 5	*P. pipistrellus*	No observations	2 bats foraging	Not Surveyed	1 bat commuting east to west
Location 6	*P. pipistrellus*	No observations	1 bat foraging	Not Surveyed	No observations
Location 7	*P. pipistrellus*	1 bat foraging	No observations	Not Surveyed	No observations
	Myotis sp	1 bat foraging	No observations		No observations
Location 8	No observations	No observations	No observations	Not Surveyed	No observations
Location 9	*P. pipistrellus*	1 bat foraging	No observations	1 bat	Not Surveyed
Location 10	*P. pipistrellus*	1 bat foraging	1 probable pipistrelle heard v. briefly	No observations	Not Surveyed
Location 11	*P. pipistrellus*	1 bat foraging	1 bat foraging	No observations	Not Surveyed
Location 12	*N. noctula*	No observations	1 bat heard briefly, activity unknown	No observations	Not Surveyed
	Pipistrellus sp	No observations	No observations	1 distant bat	
Location 13	*P. pipistrellus*	1 bat foraging	No observations	No observations	Not Surveyed
	N. noctula	No observations	1 bat heard briefly, activity unknown	No observations	
	Myotis sp.	No observation	No observation	1 distant bat	
Location 14	*P. pipistrellus*	1 bat foraging	1 bat foraging	No observations	Not Surveyed
Location 15	*P. pipistrellus*	No observations	1 bat foraging	No observations	Not Surveyed
Location 16	*Myotis* sp	1 bat foraging in ash canopy	No observations	1 bat, probably Myotis sp. Heard briefly	Not Surveyed
	P. pipistrellus	No observations	1 bat foraging	1 bat	

APPENDIX 6: COUNTY WILDLIFE SITE CITATION FOR GAVRAY DRIVE MEADOWS

Oxfordshire Wildlife Site Citation

SITE NAME: Gavray Drive Meadows
SITE CODE: p52W01
AREA: 15.6 ha
GRID REF: SP595226
DISTRICT: Cherwell
Photos: 8
EN NATURAL AREA: Thames and Avon Vales
VISIT DATES:
21 June 2002, 24 June 2002, 26 June 2002, 19 August 2002, 18 September 2002, 16 January 2003
Also: 5 visits, 26 April through 17 July 2002

SITE DESCRIPTION:
These meadows form a mosaic of small damp fields with ponds, divided by thick hedges with old trees. Most of the fields are probably former hay meadows over medieval ridge and furrow field patterns, and have a sward mostly dominated by tufted hair-grass with some meadow foxtail and meadow barley. However, fields 5 and 6 appear to be old pasture, with ragged robin, dropwort, devil's-bit scabious and common spotted orchid. Fields 7, 11 and 12 contain devil's-bit scabious and betony. Great burnet is frequent in fields 7 and 11, and scattered in fields 12, 14 and 16. Sneezewort and pepper saxifrage were only found in field 11. Common marsh bedstraw, bugle, greater bird's-foot trefoil, common knapweed and short-fruited willowherb are occasional throughout the fields. There is a very good range of rushes and sedges across the site, with nine species of sedge: glaucous, common, carnation, brown, hairy, false fox, spiked, slender tufted and oval. Grasses include yellow oat-grass, sweet vernal grass, tall fescue, meadow fescue and red fescue. In the drier areas, slightly acid conditions are indicated by frequent tormentil, lesser stitchwort and sweet vernal grass, especially in fields 5, 6, 14 and 15.

Most of the ponds in the western half of the site are shaded and./or only damp in summer. They have a species-poor vegetation of compact rush, plicate sweet-grass and tufted water-forget-me-not. CPM surveyed the ponds on the west side of the north-south road and reported great crested newt (a priority Biodiversity Action Plan species) in 3 ponds and a channel. Smooth newts were found in all ponds and the channel, and one palmate newt was recorded in field 9. The large water-filled pond in field 14 (on the eastern side of the road) contains greater reedmace, gypsywort, marsh foxtail, tufted water-forget-me-not, sharp-flowered rush and soft rush. The brook running along the western margin of the County Wildlife Site contains reed canary-grass, redshank, water chickweed and greater water plantain.

The hedges across the entire site are mostly tall and thick, and contain hawthorn with bramble, blackthorn and elder, as well as occasional crack willow, field maple, oak, ash, crab apple, English elm, dogwood, holly, wayfaring tree, guelder rose, buckthorn, hop and honeysuckle. They are probably post-medieval, as they dissect the ridge and furrow pattern that runs through most of the fields. The hedge that separates fields 5 and 6 from fields 7 and 12 is a double hedge, with black bryony, mature oak, ash and crack willow, including one large collapsed crack willow pollard. The hedge that runs along the eastern edge of fields 11 and 12 is also double. These double hedge lines include Midland hawthorn, wood meadow-grass, great hairy brome and three-nerved sandwort; all four are ancient woodland indicator species (characteristic of woodlands more than 400 years old). The gappy hedge line between fields 11 and 12 contains five large mature oaks. The hedges around fields 8 and 9 contain abundant English elm suckers, as well as hawthorn and bramble. The bullace plum (*Prunus domestica* ssp. *insititia*), a rare and declining species in the county, is found in the hedge between fields 8 and 9.

Numerous birds are using the proposed County Wildlife Site, including reed bunting (which was seen flying across the road between fields 14 and 4), willow warbler, garden warbler, blackcap, whitethroat, lesser whitethroat, chiffchaff, bullfinch, linnet, song thrush, yellowhammer, sedge warbler, hobby and kestrel. Common pipistrelle, noctule, *Myotis sp.* and, possibly, serotine bats were recorded foraging over the site (CPM). Butterflies include large skipper, ringlet, common blue, small heath and marbled white. Twenty-six species of ground beetles were found in fields 5, 6, 11 and 12, including the nationally scarce *Bembidion gilvipes*.

UK PRIORITY BAP HABITATS: lowland meadows (hay meadow)

UK PRIORITY BAP SPECIES: Reed bunting (3 or 4 singing males), song thrush (2 or 3 singing males), bullfinch, linnet; great crested newt.

RED DATA BOOK SPECIES:

NATIONALLY SCARCE SPECIES: *Bembidion gilvipes* a ground beetle

OXFORDSHIRE BIODIVERSITY CHALLENGE SPECIES: Cuckooflower, devil's-bit scabious, great burnet, meadow barley, ragged robin. Song thrush, sedge warbler, linnet.

BIRDS OF CONSERVATION CONCERN:
Red list: Bullfinch, reed bunting, song thrush, yellowhammer, linnet.
Amber list: Dunnock, willow warbler.

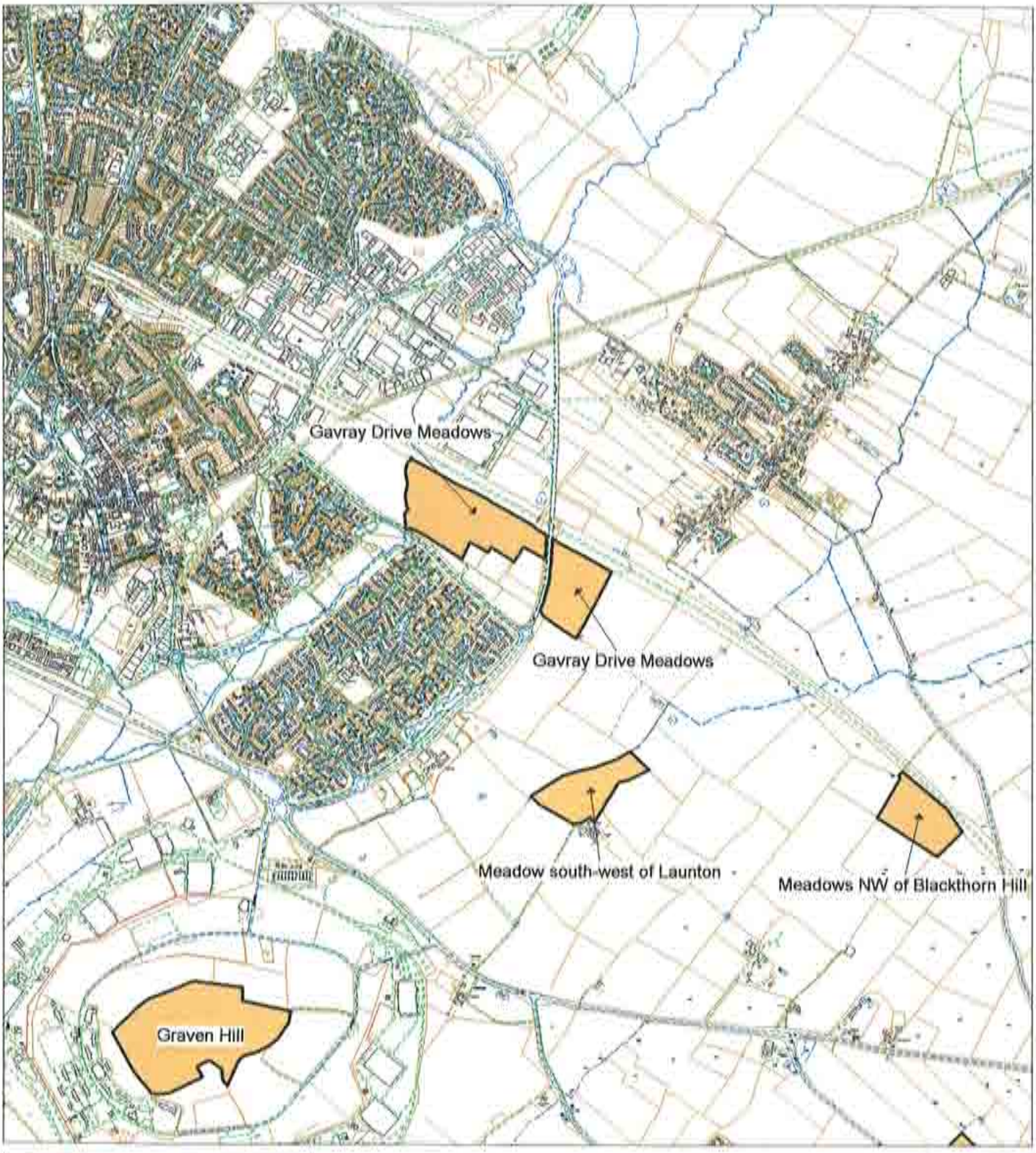
TYPICAL SPECIES: Great burnet, greater bird's-foot trefoil, betony, cuckooflower, devil's-bit scabious, sneezewort, pepper saxifrage, brown sedge, carnation sedge, common sedge and meadow barley. Midland hawthorn, bullace plum, black bryony, honeysuckle, wood meadow-grass, three-nerved sandwort. Sedge warbler, chiffchaff, willow warbler, whitethroat, lesser whitethroat, blackcap, yellowhammer, linnet, kestrel. Marbled white butterfly.

CURRENT MANAGEMENT: Unmanaged for at least one season.

IDEAL MANAGEMENT: Fields 7, 11, 12, 14 and 16 should be cut for hay (as indicated by the presence of great burnet). Although fields 8, 9, 15 and 17 do not contain these notable hay meadow species, the current species list indicates their former management as hay meadows, and so this management could be re-instated in some sections, leaving other areas tall for invertebrates and birds (e.g. cut rotationally over several years). Fields 5 and 6 appear likely to have been a permanent pasture and therefore should be grazed. The tall herb flora in field 4 provides important cover and nectar for invertebrates, along with a critical winter seed supply for birds. This field requires only occasional scrub clearance to prevent eventual dominance by grey willow. The silted up and shaded ponds in fields 5, 7, 8 and 9 should be carefully restored. The hedgerows require some management in the long term, but should be cut sensitively to maintain their current thick cover for both breeding and wintering songbirds.

APPENDIX 7: THAMES VALLEY ENVIRONMENTAL RECORDS CENTRE PLAN

Land at Bicester: Designated Sites



County Wildlife Sites

Scale 1:20000

Produced by TVERC

APPENDIX 8: GRASSLAND SPECIES LIST

APPENDIX 8: GRASSLAND SPECIES LIST

Species	Field Number												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Aegopodium podagraria	R												
Acer campestre										R			
Achillea millefolium				R									
Agrostis capillaris			O				R						
Agrostis capillaris					O	O							
Agrostis stolonifera	LD	A	A			F	O	F	LA	R	LA	A	A
Ajuga reptans					R								
Alopecurus geniculatus	R	LF	R			R					R	R	
Alopecurus myosuroides													O
Alopecurus pratensis		LF	O		R	O	O	O	A	O	O	O	
Anisantha sterilis													O
Anthoxanthum odoratum	O	O	LF		O	F	R	O	A		R	F	
Arrhenatherum elatius	LD	A				LF				A		R	LA
Artemisia vulgaris													O
Bromus hordeaceus ssp *hordeaceus*													O
Calliergonella cuspidata	LD												
Cardamine pratensis							R	R					
Carex acuta						R							
Carex acutiformis						R							
Carex disticha						R							
Carex flacca	R					O						R	R
Carex hirta	O		O	R		O	R					O	
Carex otrubae	O			R		O				R			R
Carex ovalis	R												
Carex spicata	R												
Centaurea nigra	R	O	R		O	R					O	R	
Cerastium fontanum	R	R	R		R	O		R			R	R	
Cirsium arvense	LA	LA	R	O	LA	LA	R	R		LA		R	LA
Cirsium palustre	R		O	F	O	F	R					R	
Cirsium vulgare	R						R						
Convolvulus arvensis	O			LA									R
Crataegus monogyna	R									R			R
Cynosurus cristatus	R		LF		O			O			O		R
Dactylis glomerata	O	O	O		R		F	R			O	R	F

Species	Field Number												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Dactylorhiza fuchsii					R	O						R	
Deschampsia cespitosa	O	LA	A	A	D	LA	A	A	A	R	A	A	R
Dipsacus fullonum				R									
Elytrigia repens	LD									LA			LD
Epilobium ciliatum	O		R	R	R								
Epilobium hirsutum	O	O		LA		R				LA			
Festuca arundinacea		O				O						R	
Festuca pratensis						R					R	R	
Festuca rubra	R	O	R	LF	O	F	LA				F	A	
Filipendula ulmaria		O				R					O	R	
Fragaria vesca													R
Galium aparine		R		R	R					R			
Galium palustre ssp. *palustre*		R		R		R	R						
Galium verum							R				R		
Geranium dissectum	O						R						R
Glechoma hederacea							R						
Glyceria fluitans	R	LF	LA			R						R	
Heracleum sphondylium					R	R				O			
Holcus lanatus	A	A	A	O	F	F	F	A	A	F	A	A	A
Hordeum secalinum		R	R			O	R	O	A	R	R	R	
Hypericum hirsutum	R												R
Hypericum perforatum				R									
Hypochaeris radicata	R												
Juncus articulatus	R					R							
Juncus conglomeratus	LA	LF	O	A	R	R	O			R			
Juncus effusus	O	LF	R			O	R						R
Juncus inflexus	O		R	R		LA				R			R
Lathyrus pratensis	O	O				R					O	R	
Leucanthemum vulgare	O	R	R	O									
Lolium perenne	R		R			O		R		R	O		A
Lotus corniculatus					O	R					R		
Lotus pedunculatus	O	R		O	R	R	R						
Luzula campestris						O							
Lythrum salicaria				R									
Medicago lupulina	R			R									
Melilotus sp.				R									

Species	Field Number												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Myosotis scorpioides						R							
Persicaria maculosa		LF											
Phalaris arundinacea						O						O	
Pheum pratense										O			
Phleum bertolonii			R				R						
Picris echioides	O			O									
Plantago lanceolata						R						R	
Plantago major													R
Poa pratensis							R						
Poa trivialis	F		O	R		R				O		R	LA
Potentilla anserina				O		R						LA	
Potentilla erecta				LF	O		O						
Potentilla reptans	R	O	O			O						R	
Prunella vulgaris						R						R	
Prunus spinosa		O			R							R	
Pulicaria dysenterica	O												R
Quercus robur		F			R	R	R			R	O	R	
Ranunculus acris	R	R	A	A	O	LA	O	A	A	R	O	LA	R
Ranunculus ficaria											R		
Ranunculus repens	LA	R	LF		O	LA		A				LA	LA
Rosa arvensis		R											
Rosa canina				R						R			
Rubus fruticosus agg	LD	LD		F	LA		O	R					R
Rumex acetosa	R	O	A	R	O	F	O	F	A		F	LA	
Rumex crispus	O	O								R		R	LA
Rumex obtusifolius	R			R			R	R				R	
Rumex sanguineus	R	R		R		R	R						LA
Salix cinerea	O	R		LF						O			
Sanguisorba officinalis		R		R		R	O				L A	R	
Scrophularia auriculata													R
Senecio erucifolius	O			R						R			
Senecis jacobaca				R									R
Silene latifolia	R												
Solanum dulcamara		R		R			R						
Sonchus arvensis	R												

Species	Field Number												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Sonchus asper	R									R			
Stachys betonica							O						
Stachys sylvatica	R	R		R									
Stellaria graminea		O	R		O		O	R		R			
Succisa pratensis							O				R		
Taraxacum agg.	R		R										O
Trifolium campestre				R									
Trifolium dubium	R									R			
Trifolium pratense	O			R	O	R		R		R	R		
Trifolium repens	O		R	R	O	O	R	O		R		R	
Trisetum flavescens												R	
Tussilago farfara	R			R									
Typha latifolia	R			R									
Ulmus sp.										R			
Urtica dioica	R			R	R		R			O			R
Veronica chamaedrys		R				R							
Vicia cracca	O	O		O			R						
Vicia hirsuta	R												
Vicia sativa ssp. *nigra*	O									R			
Vicia tetrasperma	R	R											
x Festulolium loliaceum						R		R					

APPENDIX 9: QUADRAT SURVEY DATA

Species	Domin Estimates									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Agrostis capillaris	1	/	/	/	/	/	/	/	/	/
Agrostis stolonifera	3	3	/	4	4	5	7	4	5	/
Alopecurus pratensis	/	/	1	/	/	/	7	8	4	7
Anthoxanthum odoratum	1	/	1	/	/	3	1	/	1	3
Arrhenatherum elatius	/	/	/	/	/	/	/	1	/	/
Carex flacca	/	1	/	/	/	/	/	/	/	/
Carex hirta	1	/	/	/	1	/	/	1	/	/
Cirsium arvense	/	1	3	3	/	/	/	/	/	/
Cirsium palustre	/	/	/	1	/	/	/	/	/	/
Dactylis glomerata	/	/	/	/	/	/	/	4	1	3
Deschampsia cespitosa	9	10	10	9	6	8	/	/	4	5
Festuca rubra	4	3	3	4	6	/	/	/	/	/
Festuca pratensis	/	/	/	/	/	/	1	/	/	2
Holcus lanatus	3	1	1	2	4	5	6	4	4	5
Juncus conglomeratus	/	/	2	/	/	/	/	/	/	/
Juncus effusus	2	/	/	/	/	/	/	/	/	/
Lathyrus pratensis	/	/	1	/	/	2	/	/	3	2
Luzula sp. (? *campestris*)	/	/	/	/	/	/	/	4	/	/
Potentilla erecta	4	4	3	4	5	/	/	/	/	/
Potentilla reptans	/	/	/	/	/	/	/	/	/	1
Quercus robur (seedling)	/	1	/	/	1	/	/	/	/	1
Ranunculus acris	/	/	1	/	/	1	/	1	/	/
Ranunculus repens	/	/	/	/	/	3	2	/	/	/
Rubus fruticosus (seedling)	/	1	1	/	/	/	/	/	/	/
Rumex acetosa	2	2	3	3	2	1	5	5	1	4
Sanguisorba officinalis	4	3	4	1	3	6	5	3	9	5
Stachys betonica	3	4	2	/	1	/	/	/	/	/
Stellaria graminea	/	/	/	1	/	/	/	/	/	/
Succisa pratensis	2	4	/	3	5	/	/	/	/	/
Taraxacum agg.	/	/	/	/	/	/	/	/	/	1
Bare ground (burnt)	/	/	/	/	/	/	4	4	/	4
TOTAL NUMBER OF SPP.	13	14	14	12	12	9	8	10	9	12

APPENDIX 10: AMPHIBIAN SURVEY RESULTS

APPENDIX 10: AMPHIBIAN SURVEY RESULTS

Great Crested Newt Survey Results

Location & species		2002						2004					
		09/05/02	15/05/02	21/05/02	22/05/02	06/06/02	14/06/02	18/03/04	01/04/04	27/04/04	29/04/04	06/05/04	12/05/04
Pond P1	GCN f	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/1
	GCN m	0/0	0/0	0/0	0/0	0/0	0/0	0/0	1/0	0/0	0/0	0/0	0/0
	SN	1/1	0/1	0/0	0/1	0/0	0/0	0/1	6/1	0/2	0/0	0/0	0/0
	PN	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
Pond P2	GCN f	0/0	0/0	0/0	0/0	0/0	1/0	0/1	0/0	0/0	0/0	0/0	0/0
	GCN m	0/0	0/1	0/0	0/0	0/0	0/0	0/0	0/1	0/0	0/0	0/0	0/0
	SN	1/0	0/0	0/0	0/0	0/0	0/0	3/0	0/2	0/3	1/0	0/0	0/0
	PN	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
Pond P3	GCN f	0/1	0/2	1/0	0/1	0/0	0/0	1/0	0/1	0/0	0/0	0/1	1/0
	GCN m	0/0	0/0	0/0	0/0	0/0	0/0	2/0	0/0	0/3	0/0	0/1	8/2
	SN	3/0	1/0	1/0	0/0	0/1	0/1	1/0	4/1	0/3	0/0	0/1	1/0
	PN	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
Pond P4	GCN f	0/0	0/0	0/0	0/0	0/1	0/0	1/2	3/5	1/1	0/2	1/1	0/0
	GCN m	1/0	0/0	0/0	0/1	0/2	0/0	0/0	1/0	0/2	0/3	0/1	2/2
	SN	0/7	0/9	2/0	2/8	3/1	0/1	3/2	3/7	0/7	0/12	0/4	1/0
	PN	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	2/1
Pond P5	GCN f	0/0	0/0	0/0	0/0	0/0	Pond dried up	0/0	0/0	0/0	0/0	0/0	0/0
	GCN m	0/0	0/0	0/0	0/0	0/0		0/0	0/0	0/0	0/0	0/0	0/1
	SN	35/0	3/0	0/0	0/0	0/0		0/0	10/0	2/4	0/0	0/0	0/0
	PN	0/0	0/0	0/0	0/0	0/0		0/0	0/0	0/0	0/0	0/0	0/0
Pond P6	GCN f	0/0	0/1	0/1	3/1	0/1	0/0	0/0	0/0	0/1	0/0	0/2	0/0
	GCN m	0/0	0/0	0/0	1/0	0/0	0/0	0/0	0/0	0/0	0/1	0/1	0/2
	SN	1/0	0/6	2/3	1/8	0/1	0/2	0/0	¼	0/2	6/3	1/0	1/0
	PN	0/0	0/1	0/0	0/1	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
Channel	GCN f	1/3	0/1	0/0	0/0	0/0	1/1	0/0	0/0	0/0	0/0	0/0	0/1
	GCN m	0/0	0/1	0/0	0/0	0/0	0/1	0/0	0/0	0/0	0/0	0/0	0/0
	SN	2/2	1/2	0/1	1/1	1/0	4/0	0/0	0/0	0/0	0/2	0/0	0/2
	PN	0/0	?2/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0

Results of Torching, Netting and Bottle Trapping Surveys for Amphibians. Species abbreviations are as follows: GCN = great crested newt (further separated into female (f) and male (m)), SN = smooth newt and PN = palmate newt. Two numbers are given in each cell (e.g. 2/8). The first refers to the number of animals seen during the torching and netting surveys. The second refers to the number of animals captured in the bottle trapping survey.

APPENDIX 11: OUTLINE WILDLIFE MANAGEMENT PLAN (WMP)

08 November 2004

Land North of Gavray Drive, Bicester, Oxfordshire

Outline Wildlife Management Plan

C2172_06a

Quality Assurance – Approval Status

This document has been Prepared and checked in accordance with CPM's IMS (BS EN ISO 9001: 2000 and BS EN ISO 14001: 1996)

Author	Date
Approved	
QA Checked	

cpm

environmental planning and design

Contents

Section 1 Introduction

1.1 CPM Environmental Planning and Design Ltd (CPM) have been commissioned by Gallagher Estates Ltd & London and Metropolitan to prepare an Outline Wildlife Management Plan (OWMP) to accompany the proposals for residential development at Gavray Drive, Bicester, Oxfordshire. The OWMP forms an appendix of the ecology Environmental Statement (ES) which accompanies an Outline Planning Application for the proposed development.

1.2 The OWMP forms a key part of the strategy to mitigate the partial loss of the Gavray Drive Meadows County Wildlife Site (CWS). It is considered that the ecological value of the CWS is declining through natural processes, particularly successional processes as a result of a change in management. One of the key aims of the OWMP is to mitigate the partial loss of Gavray Drive Meadows CWS through the implementation of appropriate management measures of the retained area of CWS to maintain and increase the ecological vale of the retained area. It is considered that unless appropriate management is implemented the retained CWS will, gradually, lose its ecological features for which it has been designated.

1.3 The key area of retained CWS has been agreed during a series of meetings in 2003 with the CWS Steering Group, which includes the Oxfordshire County Ecologist and representatives from English Nature, the Buckinghamshire, Berkshire and Oxfordshire Wildlife Trust (BBOWT) and the local records office. This area is supplemented by the retention of additional green corridors and open space in excess of that agreed with the steering group.

1.4 The OWMP sets out outline recommendations for the ecological management, maintenance and monitoring of areas of retained and created habitats within the Phase 1 development. The OWMP form the basis for the development of a detailed wildlife management plan at a later stage, possible as a condition of planning consent. The implementation of the management plan will be secured through a Section 106 Agreement. The management plan will be implemented through a financial contribution by Gallagher Estates Ltd and London and Metropolitan.

1.5 The OWMP will be developed in consultation with the CWS selection panel.

1.6 The proposed duration of the outline management plan will initially be for a 5 year period. The effectiveness of the outline WMP will be continually monitored for its effectiveness during its implementation. It is proposed that the WMP be reviewed on a 5 yearly basis.

1.7 This WMP has been prepared following the principles set out in English Nature guidance[1].

[1] Lambert, D. (2000). *Management Plan Format* – a working guide. English Nature.

Section 2 Site Summary and Evaluation

Name

2.1 Gavray Drive, Bicester, Oxfordshire

Location

2.2 The site is centred on Ordnance Survey Grid Reference SP596223 (OS Coverage 1: 25000 Explorer 169), within the administrative area of Cherwell District Council, Oxfordshire.

Site Area

2.3 The OWMP covers all areas of open space, including the area of retained CWS. This includes approximately 7.5ha of retained CWS. The existing habitats within the management area are illustrated on **Plan CPM2172/01h** – *Habitat Features*, including grassland, hedgerows, mature trees, scrub and ponds. The management compartments are illustrated on **Plan CPM2172/46a** – *Outline Wildlife Management Plan Compartments.*

Land Tenure

2.4 The site is currently controlled by Gallagher Estates Ltd & London and Metropolitan.

Site Context

2.5 The site at Gavray Drive is located within the English Nature Thames and Avon Vales Natural Area (number 63). This natural area comprises the central section of a huge belt of low-lying land though south central England. Much of the area comprises a river valley landscape with a mixture of arable and pasture landuse surrounded by thick hedgerows and interspersed with small woodlands.

2.6 No sites of statutory importance lie within or close to the site. There are three Sites of Special Scientific Interest within 5km of the site, details of these are provided in the main chapter. Part of the site is designated as a CWS known as the Gavray Drive Meadows. The citation for the CWS is included as **Appendix CPM 1**.

2.7 The notable ecological features of the CWS, as identified by the site citation, as summarised as follows:

Features of Interest Within Gavray Drive Meadows
• Supports lowland meadow which is a UK priority BAP habitat; • Supports reed bunting, song thrush, bullfinch, linnet and great crested newts which are UK Priority BAP species; • Supports the nationally scarce ground beetle, *Bembidion gilvipes*; • Supports cuckooflower, devil's-bit scabious, great burnet, meadow barley, ragged robin, song thrush, sedge warbler and linnet, which are Oxfordshire Biodiversity Challenge Species; and • Supports Birds of Conservation Concern[2], namely: bullfinch, reed bunting, song thrush, yellow hammer, linnet, dunnock and willow warbler.

Table CPM 1: Notable Ecological Features of the CWS

[2] Gregory RD, Wilkinson NI, Noble DG, Robinson JA, Brown AF, Hughes J, Proctor DA, Gibbons DW, and Galbraith CA (2002) The population status of birds in the United Kingdom, Channel Islands and Isle of Man: an analysis of conservation concern 2002 – 2007. *British Birds* 95:410 – 450.

Section 3 Summary of Evaluation and Objectives

Site Status and Potential

3.1 Part of the site has been designated as a non-statutory County Wildlife Site, known as the Gavray Drive Meadows CWS. It is considered that the primary reason for designating the CWS, namely the grassland interest, is currently in decline due to natural succession processes. If these processes continue, it is considered that the grassland interest will be lost in the medium term (10 to 15 years).

Identification of Important Features

Feature		Comment / Trends
Habitats	Grassland	Designated as CWS, but habitat in decline due to natural succession processes. Lowland meadows are priority UK Biodiversity Action Plan (BAP) habitat. Factors currently affecting low land meadows include agricultural improvement, abandonment, supplementary stock feeding, application of herbicides/pesticides, atmospheric pollution, hydrological change and floristic impoverishment due to heavy grazing pressure and changes in stock species and breeds[3].
	Hedgerows and Trees	Some of the hedgerows qualify as 'important' hedgerows in accordance to the ecology criteria of The Hedgerows Regulations 1997. Ancient and species-rich hedgerows are priority UK and Oxfordshire BAP habitats. Factors affecting habitat include significant loss of hedgerows through neglect and removal, particularly since 1945, too frequent/badly timed cutting, loss of hedgerow trees, use of herbicides/pesticides, increased stocking rates and removal for agricultural and development purposes.
	Scrub	Scrub gradually increasing through natural succession processes to the detriment of the grassland habitats within the site. Scrub provides habitat for birds.
	Ponds	Ponds support populations of amphibians including great crested newts. Suitability of ponds for supporting great crested newts declining due to natural succession processes of siltation and shading. Unless appropriately managed, ponds will eventually be lost within the site.
Species	Reptiles	Site supports common and widespread reptile species. Natural succession processes, particularly the formation of rank grassland and scrub encroachment has increased habitat opportunities within the site for reptiles.
	Amphibians	The site supports a number of amphibian species including great crested newts, with a population intermediate between a 'small' and 'medium'[4] in size. The site supports a number of ponds, which due to natural succession processes are declining in their suitability for supporting amphibians particularly great crested newts. In terms of terrestrial habitat, natural succession process have increased their suitability for great crested newts for foraging, refuge and hibernation.
	Bats	The mature trees provide potential for roosting bats, however bat activity within the site was unexpectedly low.
	Birds	The habitats within the site provide habitat for a range of birds including some notable species.

Table CPM 2: Retained Habitats and Protected/Notable Species

[3] http://www.ukbap.org.uk/UKPlans.aspx?ID=10
[4] English Nature (2001) *Great Crested Newt Mitigation Guidelines*, English Nature, Peterborough

Section 4 Management Aims and Objectives

4.1 The aims and objectives of the OWMP are to maintain and enhance the nature conservation value of the retained habitats, particularly with respect to reversing the natural succession processes which are leading to the decline and gradual loss of the ecological interest of the retained Gavray Drive Meadows CWS.

4.2 The timing and associated costs of implementing the management plan will be prepared during the development of the detailed wildlife management plan.

Objectives

4.3 The main objectives of the OWMP are as follows:

- To prevent further decline and enhance the ecological value of the retained CWS through the implementation of appropriate management and monitoring measures;
- To maintain and enhance hedgerows and mature trees;
- To maintain and enhance retained and created ponds, particularly in relation to maintaining and increasing the population of great crested newts within the site;
- To maintain and monitor populations of notable species within the site;
- To manage the recreational pressure on areas of ecological interest within the site, particularly the retained sections of County Wildlife Site; and
- To provide interpretive material for the public in relation to the ecological value of the site.

Management Prescriptions

4.4 This section highlights management prescriptions for the objectives stated above. The site has been divided into three compartments to aid in the implementation of the scheme. The extent of each compartment is illustrated in **Plan CPM2172/46**.

- **Compartment 1:** comprises the three central fields of the site, designated as CWS;
- **Compartment 2:** comprises an area proposed for retention of scrub and creation of ponds; and
- **Compartment 3:** comprising the remaining area to be retained as Public Open Space.

Objective 1: To prevent further decline and enhance the ecological value of the retained CWS through the implementation of appropriate management and monitoring measures.

4.5 The grassland within the site needs to be appropriately managed to prevent further decline and enhance the ecological value of the habitat. The following outline measures are recommended:

4.6 Grassland in Compartment 1 to be cut for hay annually during July/August once the majority of species have set seed. All arising to be removed.

4.7 Grassland in Compartments 2 and 3 to be cut biennially to allow and maintain rank grassland habitats, particularly for great crested newts and reptiles.

4.8 No fertilisers, herbicides or pesticides will be used within or immediately adjacent to grassland habitats.

4.9 All scrub encroachment to be removed and chipped. Arisings to be left as 'eco-piles' close to retained or created ponds.

4.10 If possible, grazing by cattle or horses will be implemented to increase ecological diversity within the grassland sward.

4.11 If possible, arisings from other CWS meadow habitats within the locality will be strewn and re-collected within the grassland habitat in order to introduce species which may have been lost from the sward and increase the diversity of the sward.

4.12 Monitoring baseline to be established within monitoring surveys undertaken every five years. Management to be reviewed upon completion of monitoring surveys to ensure that objective is being achieved.

Objective 2: To maintain and enhance hedgerows and mature trees.

4.13 All retained hedgerows to be cut on a rotational basis to allow structural diversity of hedgerows to be increased while also preventing a decline in hedgerow habitats.

4.14 Any gaps within hedgerows will be planted using standard hedgerow planting methods using a range of native species, where possible, of local provenance.

4.15 All hedgerow management will occur outside the bird breeding season (March to August, inclusive) and that management techniques are sympathetic to the needs to the breeding birds (i.e. the thickness of hedgerows is maintained without encroaching into nearby fields).

4.16 The health of all retained mature trees should be inspected every five years. If any mature trees require surgery or removal for health and safety reasons a bat survey will be conducted prior to removal. If bats are found relevant licences should be sought from DEFRA and surgery should be conducted under the supervison of a licenced bat handler. All dead wood from tree surgery will be kept on site and placed as 'eco-piles' close to retained or new ponds.

4.17 Scrub within Compartment 2 will be retained. The scrub in compartment 2 should be annually checked and cut on a rotational basis to ensure that it continues to provide opportunities for amphibians, reptiles and birds.

4.18 All willows to be pollarded on a rotational basis.

Objective 3: To maintain and enhance retained and created ponds, particularly in relation to maintaining and increasing the population of great crested newts within the site.

4.19 All existing ponds to be restored through de-silting and removing/reducing shading trees and shrubs. Restoration works to be implemented under DEFRA license as part of the implementation of the overall development.

4.20 New ponds to be excavated under DEFRA license as part of the implementation of the overall development.

4.21 Monitoring baseline to be established within monitoring surveys undertaken every five years. Monitoring baseline to include an amphibian survey in accordance to English Nature's standard methodology. Management to be reviewed upon completion of monitoring surveys to ensure that objective is being achieved.

Objective 4: To maintain and monitor populations of notable species within the site.

4.22 Populations of amphibians, reptiles, bats and birds to be monitored every five years. Management to be reviewed following completion of monitoring surveys.

4.23 Bat boxes (summer roosting and winter hibernation) to be erected on mature trees. Condition of bat boxes to be monitored every five-years. Any damaged or lost boxes to be replaced.

4.24 Bird boxes (range of types) to be erected on mature trees. Condition of boxes to be monitored every five-years. Any damaged or lost boxes to be replaced.

4.25 Refugia and hibernacula for reptiles and amphibians to be constructed and maintained. Condition to be monitored every five years and any remedial measures undertaken (e.g. replacement, restoration).

Objective 5: To manage the recreational pressure on areas of ecological interest within the site, particularly the retained sections of County Wildlife Site.

4.26 Perimeter of the retained CWS to be fenced with post and rail/stock proof fencing.

4.27 Public pathways will be created and maintained around the perimeter of the CWS to discourage public entry into the CWS and the subsequent impacts of trampling and vandalism.

Objective 6: To provide interpretive material for the public in relation to the ecological value of the site.

4.28 Wildlife interpretation boards will be prepared in consultation with the CWS Selection Panel and erected at strategic points around the retained CWS. These will provide information on the nature conservation value of the area, the type of species known to occur and the required need for management and the sensitivity of the wildlife site.

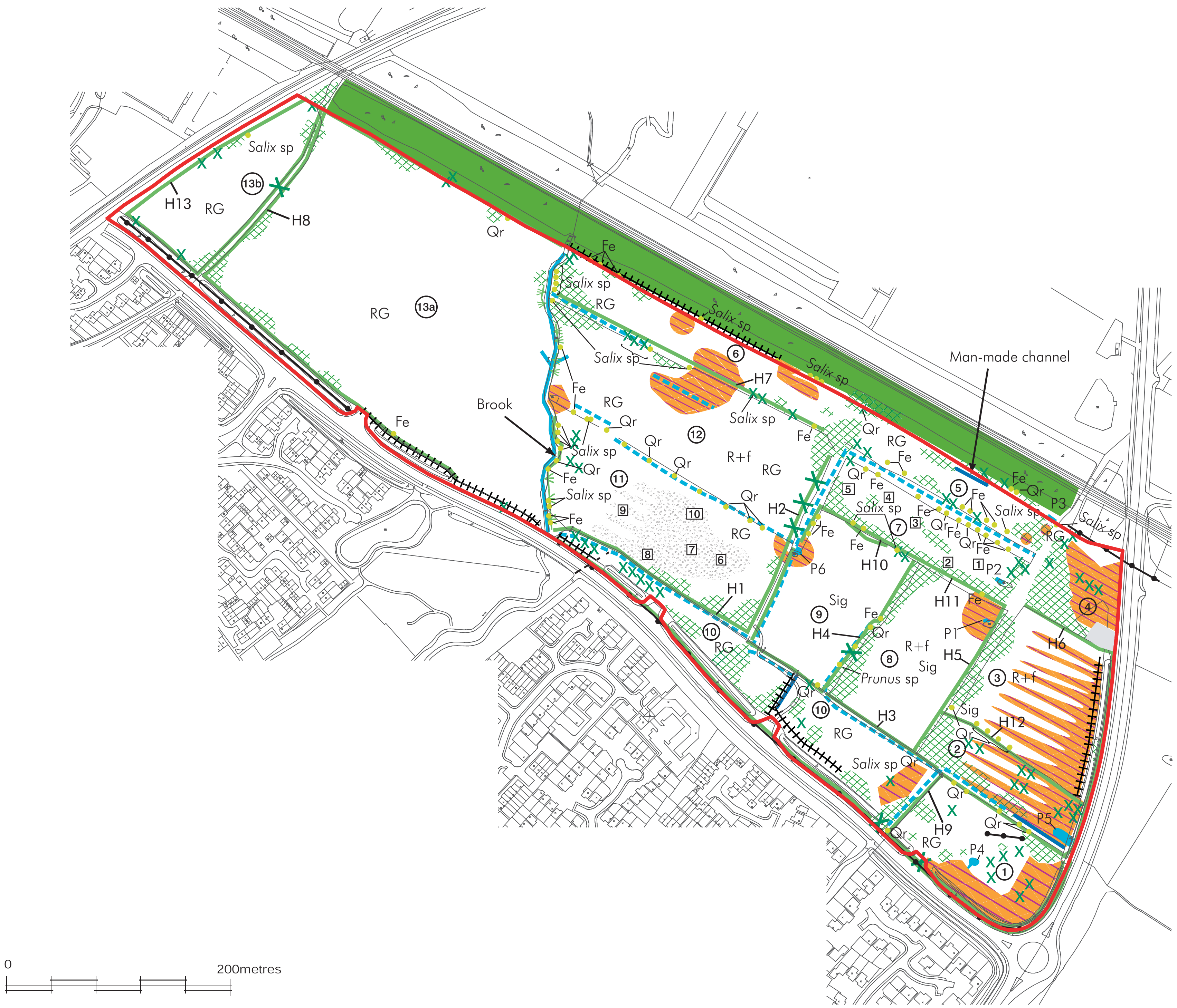
4.29 The proposed local school (to be implemented during Phase 2) will be encouraged to use the CWS as an educational resource.

Appendix CPM 1 County Wildlife Site Citation for Gavray Drive Meadows

Plans

Habitat Features
(CPM2172/01h 11/04 LM/MP)

Outline Wildlife Management Plan Compartments
(CPM2172/46a 11/04 RR/LS)



Redline boundary
Running water
Standing water
Bank
Intact hedge
Mature tree
Continuous scrub
Scattered scrub
Bare ground/rubble
Damp grassland

R+f Ridge and furrow
Seasonal/dry ditch
Wet ditch
Fence
RG Rough grassland
Ig Semi-improved grassland
Tree belt
Woodland tree belt/strip
Burnt ground with dense regeneration of great burnet

1 etc = Quadrat number
1 etc = Field number

H1 etc = Hedge number
P1 etc = Pond

Species Abbreviations

Fe = Ash (*Fraxinus excelsior*)
Qr = Oak (*Quercus robur*)
Salix sp = Willow (*Salix sp*)

Drawing Title	**Habitat Features**
Client	Gallagher Estates Ltd & London and Metropolitan
Project	Land North of Gavray Drive, Bicester, Oxfordshire
Drawing No	CPM2172/01h
Date	11/04 LM/MP
Checked	

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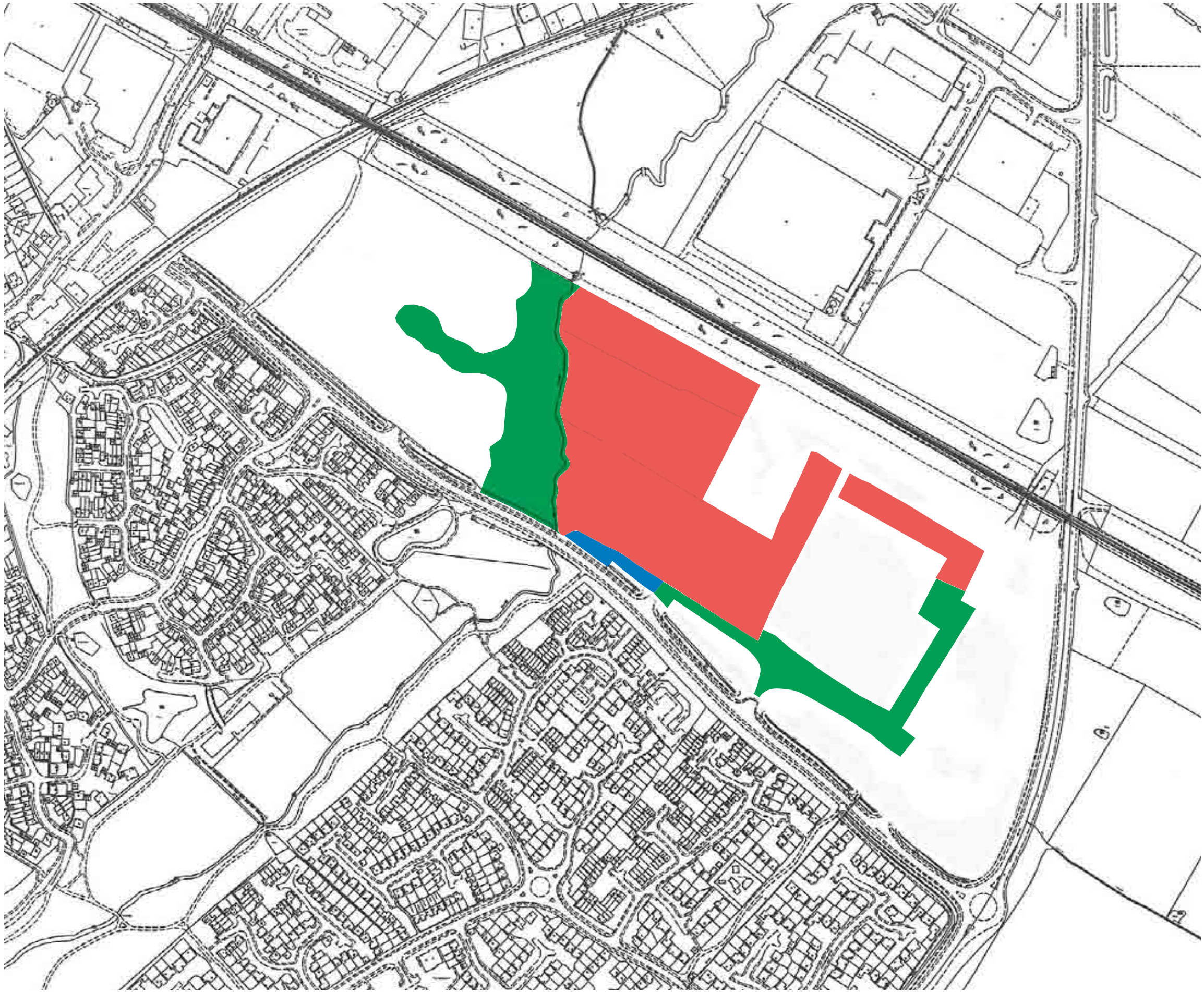

N

Drawing Title **Outline Wildlife Management Plan Compartments**

Client Gallagher Estates Ltd & London and Metropolitan

Project Land North of Gavray Drive, Bicester, Oxfordshire - Phase 1

Scale Not to scale

Drawing No CPM2172/46a

Date 11/04 RR/LS

Checked

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Appendix 1: Flood Risk Assessment

Gallagher Estates

Gavray Drive, Bicester

Flood Risk Assessment

November 2004

FINAL REPORT

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REVISION HISTORY

Revision Ref./ Date Issued	Amendments	Issued to
Draft Report 27th July 2004		Andrew Hawkes – Gallagher Estates 1 copy (PDF Format via email)
Final Report 28th July 2004	Text amendments	Andrew Hawkes – Gallagher Estates 2 copies (PDF Format via email, 1 paper copy) Ian Tiller – Environment Agency 1 copy
Final Report 8th November 2004	Amendments to flood outline, compensation calculations & text, following EA comments	Andrew Hawkes – Gallagher Estates 1 copy (PDF Format via email) David McKnight – Environment Agency 1 copy

CONTRACT

This report describes work commissioned by Gallagher Estates under letter dated 10h January 2004. Gallagher Estates representative for the contract was Andrew Hawkes. Rachel Huitson, Philip Soar and Adam Bryan of JBA Consulting carried out the work.

Prepared by: ..... Rachel Huitson
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Approved by: ..... David Pettifer, CEng FICE FCIWEM

Director

Date : NOVEMBER 2004

DISCLAIMER

This document has been prepared solely as a Flood Risk Assessment for Gallagher Estates. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

EXECUTIVE SUMMARY

JBA were commissioned by Gallagher Estates in January 2004, to undertake a Flood Risk Assessment for a proposed development site at Gavray Drive, Bicester. The main flood risk to the site is considered to be from the Langford Brook, which flows through the centre of the site. This Flood Risk Assessment and the report follow the relevant guidelines in Appendix F of PPG25.

The site is shown to be within the Environment Agency's 2004 Flood Risk Zone Maps, information for which is available from the local council. These maps however, are only based on a limited assessment. A steady state hydraulic model, using HEC-RAS v3.1.1 modelling software package has been constructed to enable a more accurate representation of the 1% Annual Exceedance Probability (AEP) flood outline to be derived.

A topographical survey of the channel and structures was carried out by K.V. Surveys on behalf of JBA in June 2004, for input into the model. A land survey of the site, from which a digital terrain model could be derived, was provided to JBA by the Client for use in this study.

The Flood Estimation Handbook (FEH) which describes two different approaches to flood estimation; the Statistical method and the Rainfall-Runoff method was adopted for use in this study. The Statistical method is based on the estimation of an index flood, and uses information from hydrologically similar sites for flood frequency analysis. The Rainfall-Runoff method is a conceptual unit hydrograph-based model, which derives flood frequency curves from rainfall characteristics. The 1% AEP flow using the Statistical analysis was derived as 3.5m^3/s and the Rainfall-Runoff 1% AEP flow was 7.5m^3/s. Although the pooling group derived for the Statistical analysis was considered to be homogeneous and therefore a good representation in relation to the subject site, the 1% AEP flow of 3.5m^3/s was considered to be too low for a catchment with an area of 17.02km^2. From the catchment descriptors there was nothing unusual concerning the flow hydrology which would bring about such a low flow, therefore it was considered more appropriate to use the Rainfall-Runoff 1% AEP flow of 7.5m^3/s as the input for the model.

The 1% AEP (1 in 100-year) water level estimates, derived from the Langford Brook model, were used to plot the 1% AEP flood outline across the site. This process was achieved by firstly creating a digital terrain model (DTM) of the study area based on the land survey supplied to JBA by the Client. Secondly, the maximum stage results from the hydraulic model were combined with the DTM to create a water surface, detailing the extent of the flood event.

Following discussions with the Environment Agency, it was considered appropriate to derive the flood outline using the water levels corresponding to the model with +20% Manning's 'n' values. Deriving the outline with these slightly higher water levels would incorporate uncertainty in the survey data and sensitivity within the model runs. The final flood outline across the site is illustrated below.

Flood Extent across the Site

Due to the topography of the area, a small proportion of the site will be affected by flooding during a 1% AEP flood event.

The flood outline derived represents the worst case scenario, as to create the outline the water levels from the model were projected across the floodplain until the topography of the site is equal to the 1% AEP water level +20% increase in Manning's 'n'. In reality there may not be sufficient volume of water to reach these extents. The steady state model developed provides a conservative robust estimate of the flood potential on the site, assuming that all undersized culverts upstream of the site are replaced in the future.

The proposed site at Gavray Drive, Bicester lies within PPG25 flood risk zones 2 and 3 – medium to high risk. The area of the site which lies outside of the 1% AEP (1 in 100-year) flood extent is considered to be suitable for most development.

The Environment Agency states that during times of flooding in a 1% AEP (1 in 100-year) flood event, a dry means of access must be available to the site. A dry means of access would be available to the site from all main access roads, particularly the A4421.

The Environment Agency recommends that floor levels of all new developments be set a minimum of 600 mm above the 1 in 100-year flood levels. The modelled 1 in 100-year water level in the vicinity of the site is 66.74 m AOD. Floor levels of the proposed development should therefore be constructed at a minimum elevation of 67.34 m AOD.

Floodplain rationalisation has been considered and it is proposed to rationalise the floodplain on the site rather than have a layout that fits around the existing floodplain outline. It was considered appropriate to provide a like for like compensation, as depths of flooding, apart from a small area, were less than 0.3m.

Spreadsheets were used to undertake the compensation calculations and the total volume of water which will need to be compensated for was calculated to be 673.40m^3.

Calculations showed that by lowering the area to a level of 66.6m AOD would provide a storage capacity of 742.2m^3, which is sufficient to compensate for the area being raised and will slightly increase the floodplain volume.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

AEP	Annual Exceedance Probability
AMAX	Annual maximum series
BF	Baseflow
D	Critical Storm Duration
DEFRA	Department of Environment, Food and Rural Affairs
DTM	Digital Terrain Model
FEH	Flood Estimation Handbook
FEH CD-ROM	FEH computer database package
FEH-RR	FEH Rainfall-Runoff method
FEH-Stat	FEH Statistical method
HEC-RAS	1 dimensional modelling software package developed by the US Army Corps of Engineers
IFM	Indicative Floodplain Map
ISIS	Unsteady state modelling software developed by the joint venture of Halcrow and HR Wallingford
JBA	Jeremy Benn Associates Ltd
JFLOW	2 Dimensional Model
MAFF	Ministry of Agriculture, Fisheries and Food
m AOD	Meters above ordnance datum
ODPM	Office of the Deputy Prime Minister
OS NGR	Ordnance survey national grid reference
POT	Peaks over Threshold
PPG25	Planning Policy Guidance Note 25
QMED	Median annual maximum flow
SPR	Standard percentage runoff (%)
Tp	Time to peak of unit hydrograph
WINFAP FEH	FEH flood frequency package

1 INTRODUCTION

1.1 Background

Gallagher Estates commissioned JBA consulting to undertake a Flood Risk Assessment for a proposed development at Gavray Drive, Bicester. This Flood Risk Assessment provides information on the nature of the flood risk to the proposed development site.

The main flood risk to the site is considered to be from one source; the Langford Brook, which flows through the middle of the site.

1.2 Planning Policy Guidance Note 25

Planning Policy Guidance Note 25 (PPG25[1]) was issued by the ODPM in July 2001. This introduced the sequential tests and the risk based approach to flood risk and development and priorities based on flood zones as outlined in PPG25. In accordance with PPG25, the main study requirement is to identify flood risk zones for the proposed development site, based on assessments for both current conditions and in 50 years time (to take into account the effects of possible climate change).

1.3 Site Description

The proposed housing development is located in Bicester, bounded to the south and east by Gavray Drive and to the north by the railway, and covers an area of approximately 24 hectares. The Langford Brook flows in a southerly direction through approximately the centre of the site.

The current site is open fields (Figure 1-1), which is under various ownership including Gallagher's. The location of the site is shown in Figure 1-2.

Figure 1-1 Representative Site Photographs, 23 June 2004

Photograph 1-1

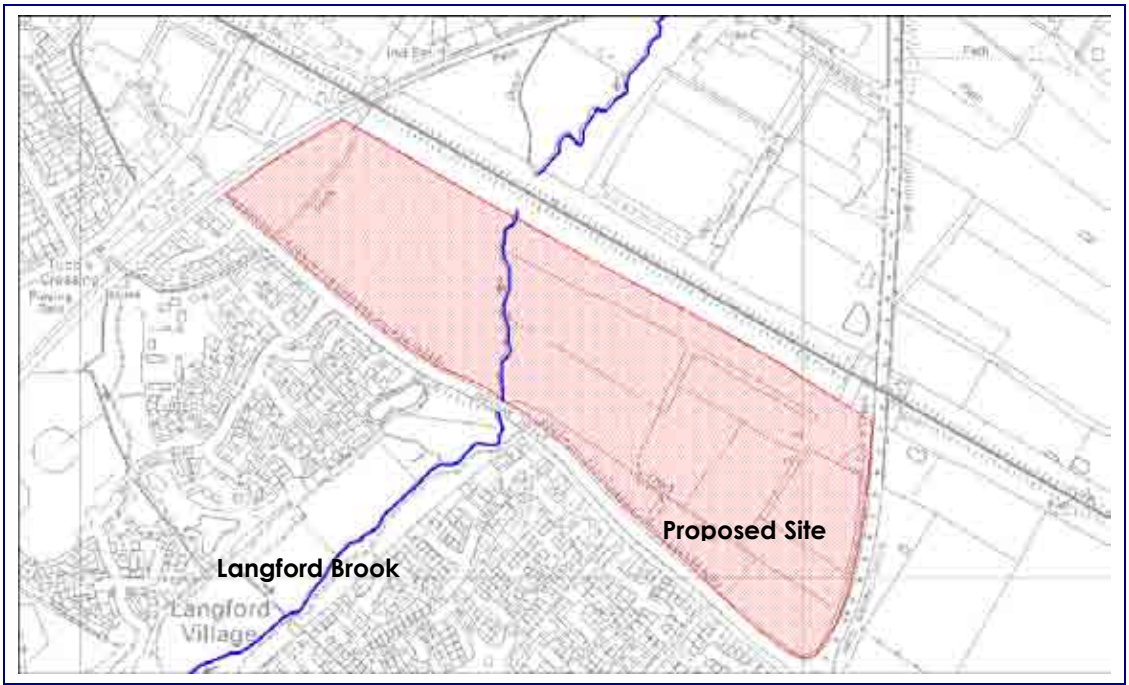
Description: View standing on Gavray Drive, looking at the proposed development site to the west of the Langford Brook

[1] Planning Policy Guidance – Development and Flood Risk (PPG25). Office of the Deputy Prime Minister. July 2001

Photograph 1-2

Description: View standing on Gavray Drive, looking at the proposed development site to the east of the Langford Brook

Figure 1-2 Location of Site, Gavray Drive, Bicester



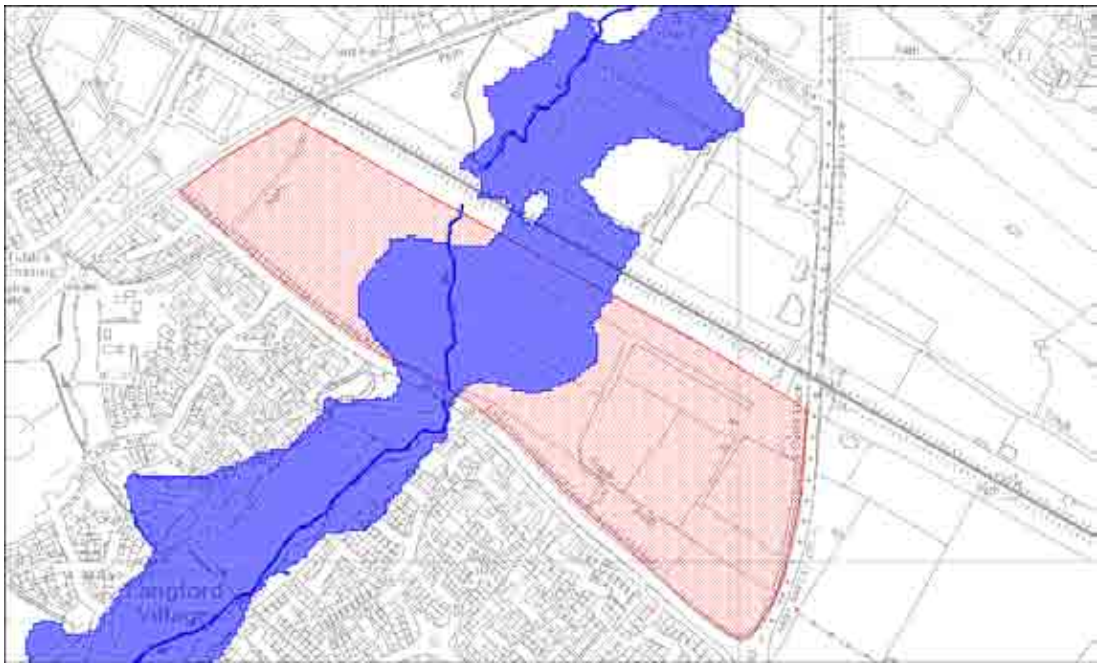
Note: Watercourses – blue polyline
Proposed site – hatched red

1.4 The Environment Agency

The Environment Agency is a statutory consultee for all planning applications and will give comments and recommendations to the planning authority for any proposed developments affecting a watercourse.

The Indicative Floodplain Maps (IFMs) were superseded on 1st July 2004 with the 2004 Flood Zone Maps, derived using JFLOW 2-dimensional modelling and currently have been issued to all councils. The flood extents of these maps, available for viewing at the local council, have been reproduced below in Figure 1-3. These maps show quite extensive flooding of the site, extending to 250m on the left bank of the Langford Brook and up to 150m to the right bank. Although being produced using more technologically advanced methodologies than the previous Indicative Floodplain Maps (IFMs), they are still only a guide and a detailed assessment is required to determine an accurate 1% AEP (1 in 100-year) flood outline across the site. As such, a comprehensive hydrological and hydraulic modelling analysis was undertaken for the Langford Brook, using a detailed land survey to produce a digital terrain model (DTM), from which the flood outline could be derived.

Figure 1-3 2004 Flood Zone Maps



Note: Watercourses – blue polyline
1% AEP Flood Extent (Zone 3) – blue hatched
Site – red hatched

1.5 Hydrological and Hydraulic Modelling Approach

The Flood Estimation Handbook (FEH) is the methodology recommended by the Environment Agency for hydrological modelling. The handbook consists of two main methods of flow estimation, namely the Statistical method (FEH-Stat) and the Rainfall-Runoff method (FEH-RR). Both methods have been used in the study. The methods rely on catchment descriptors taken from the FEH CD-ROM. Full analysis is shown in Chapter 2.

As no previous model exists for the Langford Brook, JBA developed a new steady state HEC-RAS hydraulic model, reported in Chapter 3.

1.6 Topographic Survey

JBA commissioned K.V. Surveys of Malvern, Worcestershire, to undertake a topographical survey of the Langford Brook. Details of river structures were also recorded. The cross sections, to Ordnance Datum, were surveyed in July 2004.

The Client supplied JBA with a land survey of the site.

1.7 Climate Change

The period October to December 2000 ranks as the second wettest three-month sequence for England and Wales in the last 200-years. Unusual though recent climate change patterns have been, several broadly comparable wet episodes can be identified. These include the October to January periods of 1960/61, 1929/30 and 1952/53. Also, although the high storm rainfall totals recorded, for example in mid-October 2000, are rare; they are by no means unprecedented. The recorded rainfalls are well within the envelope of meteorological fluctuations that characterise the climate of England and Wales.

Recent research by the Environment Agency suggests that over the next 30 to 50 years the probability of occurrence of severe flood flows will increase. Unfortunately, this increase in severity cannot, as yet, be accurately quantified and analyses of the annual maximum flood series at the longer term gauging stations do not provide compelling evidence for any climate driven trend. Without such a trend or other quantifiable increase in flood magnitudes it is impractical to incorporate the possible effects of climate change into the design of flood alleviation schemes.

Various organisations have addressed the need to take a precautionary approach to the possibility of enhanced risks due to climate change by adopting an arbitrary percentage increase in the flood estimates computed from historic data sets. For example MAFF (now DEFRA) recommends "sensitivity analysis of river flood alleviation schemes should take account of potential increases of up to 20% in peak flows over the next 50 years". DEFRA do not make clear however, whether both design flood peaks and flood volumes should be increased by 20%. For some larger rivers the impact of such an increase might involve a shift from a 100-year event to a 1000-year event, in today's terms, depending on the slope of the relevant frequency curve(s).

Therefore, while we endorse the need to consider the implications of the occurrence of a flood larger than the design event, and we do not rule out the possibility that climate change may affect future flood flows; an agreed value for climate change is not available. As a precautionary measure we recommend the DEFRA guideline of a 20% increase in flow be used as part of the sensitivity analysis.

2 HYDROLOGICAL ANALYSIS

2.1 Approach to the Hydrology

The hydrological assessment has been undertaken to derive the 1% AEP (1 in 100-year) flow for the Langford Brook, which flows through the centre of the proposed development site.

A flow estimate was made for the following inflow point of the Langford Brook:

- OS NGR SP 459636 222565

2.2 Methodology

The Flood Estimation Handbook (FEH) describes two different approaches to flood estimation; the Statistical method and the Rainfall-Runoff method. The Statistical method is based on the estimation of an index flood, and uses information from hydrologically similar sites for flood frequency analysis. The Rainfall-Runoff method is a conceptual unit hydrograph-based model, which derives flood frequency curves from rainfall characteristics.

The Langford Brook at the above flow estimation point has a catchment area of 17.02 km^2. No gauging stations are located within the catchment. The hydraulic model used to estimate the flood risk to the site is a steady-state model, which requires peak flow estimates.

2.3 Catchment Descriptors

The FEH CD-ROM provides catchment boundaries derived from a digital terrain model (DTM). The DTM uses information from 1:50,000 OS maps to position likely drainage paths on a grid of 50m x 50m. The catchment descriptors are then computed digitally from this information. The major descriptors used in this report are shown in Table 2-1.

Table 2-1 Definition of Selected FEH Catchment Descriptors

Descriptor	Description
AREA	Catchment area (km^2).
BFIHOST	Baseflow index derived from the HOST soil classification system.
DPLBAR	Mean drainage path length (km).
DPSBAR	Mean drainage path slope (m/km).
FARL	Index to describe the attenuation due to lakes and reservoirs within the catchment area. A value of 1 indicates no attenuation.
PROPWET	Index to describe the proportion of time when soil moisture deficit (SMD) was below 6mm during the period 1961-90.
SAAR	Standard average annual rainfall, taken from the period 1961-90.
SPRHOST	Standard percentage runoff derived from the HOST soil classification system (%).
URBEXT$_{1990}$	Extent of urbanisation. This has been taken from an index of urban and suburban land cover formulated in 1990.

It is generally accepted that urbanisation augments flow. Therefore, adjustments to flow estimates can be made on the strength of the $URBEXT_{1990}$ descriptor. If $URBEXT_{1990}$ is greater than 0.025, an adjustment is required for the Statistical method, whereas for the Rainfall-Runoff method an adjustment should be made if $URBEXT_{1990}$ is greater than 0.125. $URBEXT_{1990}$ has been updated using the urban expansion factor noted in Equation 2-1.

Equation 2-1

$$UEF = 0.8165 + 0.2254 \tan^{-1} \{ (Year - 1967.5) / 21.25 \}$$

where UEF = urban expansion factor
Year = subject year

Table 2-2 shows the catchment descriptors for the Langford Brook catchment and the two analogue catchments discussed in section 2.4.

Table 2-2 Selected Subject Site and Analogue Site Catchment Descriptors

Descriptor	Catchments		
	Langford Brook (subject site)	29009 Ancholme @ Toft Newton	30017 Witham @ Colsterworth
NGR	4596 2225	5033 3877	4929 3246
AREA (km^2)	17.02	29.55	50.23
FARL	0.990	1.000	1.000
PROPWET	0.32	0.26	0.27
BFIHOST ($m^3/s/km^2$)	0.684	0.628	0.657
DPLBAR (km)	4.43	5.39	7.38
DPSBAR (m/km)	15.6	12.42	22.59
SAAR (mm)	634	616	641
SPRHOST (%)	23.3	25.6	22.6
$URBEXT_{2004}$	0.046	0.005	0.007

2.4 Hydrological Data

The catchment areas defined by the DTM were verified with boundaries derived manually from topographical maps. No discrepancies were identified.

In flood hydrology, observed data are preferable to improve flow estimates. In the absence of gauged data within the catchment, donor or analogue catchments can be used to transfer data to the subject site. No suitable donor catchments were identified; instead analogue catchments were selected to improve the subject site QMED estimate. The top four stations selected in the pooling group were analysed for their suitability with respect to the subject catchment. Dowles Brook @ Dowles was considered unsuitable because the permeability of the catchment is lower than that of the subject site catchment and below the FEH permeability threshold of 20%. River Foulness @ Holme Farm was not used as the area of the catchment is too large, following guidelines outlined in FEH, which state that a factor of 4 to 5 is appropriate.

Ancholme @ Toft Newton and Witham @ Colsterworth, although located in the Anglian region, were considered suitable analogue catchments having similar catchment descriptors to that of the subject catchment. The suitability of analogue catchments is not

easy to judge, and therefore both analogue catchments have been used instead of placing reliance on one alone. A summary of the gauging stations can be found in Table 2-3 below.

Table 2-3 Summary of Analogue Catchments

Station name	FEH Number	OS NGR	Catchment area (km^2)	Period of record	Comments on data quality
Ancholme @ Toft Newton	29009	5033 3877	29.55	1974-2001	Flat V weir (3.03m wide) with theoretical calibration confirmed by check gaugings. There is no drowning or bypassing, and the station is immediately u/s of entry point of flows from Toft Newton reservoir. No major abstractions or returns.
Witham @ Colsterworth	30017	5629 2233	50.23	1978-2001	Flat V weir 4.996m wide; theoretical calibration. Summer flows very heavily augmented by transfers from Rutland Water until Jun 1985, when direct Rutland/Saltersford pipeline opened. *Notes: 3 summer flows prior to June 1985 excluded from the AMAX dataset due to flows being heavily augmented.*

2.5 Statistical Analysis - Methodology

The FEH Statistical methodology is based on the analysis of annual maximum flows, and the index flood is the median annual maximum (AMAX), denoted by QMED. For gauged sites QMED is the median value of either the AMAX or POT series. Where sites are not gauged, the index flood is estimated from catchment descriptors or by data transfer. The index flood (QMED) is then scaled by a growth factor derived from either a mathematical distribution of flow data at the site or a 'pooling group' of gauged UK catchments if the site is ungauged. This pooling group is selected using similar hydrological characteristics to the subject site, and the attributes of their flood data are statistically combined to produce a growth curve, from which growth factors are extracted.

2.6 Statistical Analysis – Index Flood

QMED for the site under consideration was derived for all the analogue catchments, using Equation 2-2 shown below. Equation 2-3 calculates $QMED_{CD}$. Note that an adjustment for urbanisation was required as the subject site catchment had an $URBEXT_{2004}$ value of 0.046. The index floods of the two analogue catchments are shown in Table 2-4, whilst the index flood values for the ungauged site can be seen in Table 2-5.

Equation 2-2

$$QMED_{s,adj} = QMED_{s,cds} \times (QMED_{g,obs} / QMED_{g,cds})$$

where $QMED_{s,adj}$ = adjusted QMED for subject site
$QMED_{s,cds}$ = QMED derived by catchment descriptors for subject site
$QMED_{g,obs}$ = QMED of donor site from observed data
$QMED_{g,cds}$ = QMED of donor site from catchment descriptors

Equation 2-3

$$QMED_{rural} = 1.172\, AREA^{\left(1-0.0150\ln\left(\frac{AREA}{0.5}\right)\right)} \left(\frac{SAAR}{1000}\right)^{1.560} FARL^{2.642} \left(\frac{SPRHOST}{100}\right)^{1.211} 0.0198^{RESHOST}$$

where $QMED_{RURAL}$ = as-rural index flood (m^3/s)
AREA = catchment area (km^2)
AE = 1 - 0.015 ln (AREA/0.5)
SAAR = standard average annual rainfall (mm)
FARL = index to show attenuation by lakes
SPRHOST = standard percentage runoff derived from HOST soil classification (%)
RESHOST = BFIHOST + 1.3 (SPRHOST/100) - 0.987
BFIHOST = baseflow index derived from HOST soil classification

Table 2-4 Index Flood (QMED) for the Analogue Catchments

Gauging Station	$QMED_{AMAX}$ (m^3/s)	$QMED_{CD}$ (m^3/s)	Ratio
29009 Ancholme @ Toft Newton	1.8	2.8	0.66
30017 Witham @ Colsterworth	5.8	4.3	1.35

Table 2-5 Index Flood for the Ungauged Catchment

Location	Donor Catchment	$QMED_{s,cds}$ (m^3/s)	Ratio	$QMED_{s,adj}$ (m^3/s)
L_Sub1	Toft Newton	1.5	0.66	1.0
L_Sub1	Colsterworth	1.5	1.35	2.0

In this instance it is necessary to apply the multi-site adjustment procedure as outlined in FEH Volume 3, Chapter 4. Using this methodology, the final QMED estimate is obtained as a weighted average of the individually transferred estimates (using Equation 2-4).

Equation 2-4

$$\ln QMED_{s,adj} = \sum_{i=1}^{M} w_i \ln(QMED_{s,adj})$$

where W_i = relative weights

The choice of weights Wi reflects the similarity of the gauged sites to the subject site. Both analogue sites had similar catchment descriptors to that of the subject site, as shown in Table 2-2. Greater emphasis was applied to the analogue catchment Ancholme @ Toft Newton, as the catchment area was more similar to that of the subject site. The final weightings applied are shown in Table 2-6.

Table 2-6 Multi-Site Adjustment Procedure Weightings

Location	Weights (W_i)
29009 Ancholme @ Toft Newton	0.6
30017 Witham @ Colsterworth	0.4

The final $QMED_{s,adj}$ derived using the methodology outlined above was calculated to be;

$QMED_{s,adj} = 1.3m^3/s$

2.7 Statistical Analysis – Growth Curve

The pooling group is a group of hydrologically similar catchments whose combined growth curves produce the growth factors with which to scale the index flood. The number of sites within the pooling group is dictated by the target return period (T), where the combined station record of all the pooling sites within the group should be greater than 5T. Therefore, if the target return period is 100-years then the total record length for the whole pooling group should be greater than 500 years.

Sites for the pooling group are selected by hydrological similarity using three catchment descriptors; namely AREA, SAAR, and BFIHOST, and is carried out by the WINFAP-FEH database. Once chosen, the pooling group can be altered. Stations can be added or taken away if desired. This is determined by a measure of discordancy and record length amongst others.

A pooling group was constructed for the subject site. The initial pooling group consisted of 22 gauging stations with a total of 501 years of AMAX data. The initial pooling group was characterised as heterogeneous, and thus the entire pooling group was reviewed. Several stations had to be removed due drowning and bypassing of the gauge. The revised pooling group consisted of 20 gauging stations and included 502 years of AMAX data and was characterised as homogeneous and therefore, a further review of the pooling group was not required. WIN FAP-FEH selected the General Logistic (GL) distribution as the most suitable to construct the pooled flood frequency curve, as it closely weighted the average L-Kurtosis and L-Skewness of the pooling group sites.

The final 1% AEP (1 in 100-year) Statistical design flow estimate is shown in Table 2-7.

Table 2-7 Final Statistical Design Flow Estimates

Catchment	Return Period/AEP	
	100-year (1%)	100-year +20% (Climate Change)
L_Sub1	3.5	4.2

2.8 Rainfall-Runoff Method

The FEH Rainfall-Runoff method is a conceptual model that uses a hypothetical unit hydrograph and design rainfall to produce a flow hydrograph. Whereas the Statistical method uses a growth curve to estimate flood frequency, the Rainfall-Runoff method

estimates the flood frequency curve by factoring the design rainfall for the appropriate return period. These rainfall frequency statistics can be obtained directly from the FEH CD-ROM.

There are three main parameters that govern the Rainfall-Runoff method. These are:

- Time to peak (Tp)
- Standard percentage runoff (SPR)
- Baseflow (BF)

These can be estimated using catchment descriptors. However, it is stated in the FEH that flow estimation is greatly improved if parameters (in particular SPR and Tp) are identified directly from observed data or adjusted by data from a suitable donor or analogue catchment.

Using the UK Event Archive, published in Volume 4, Appendix A, flood event data was only available for one of the analogue catchments (30017 Witham @ Colsterworth). It was considered inappropriate to derive Rainfall-Runoff estimates from observed data using only one analogue catchment where the records available are only for a period in the 1980's. Therefore, the Rainfall-Runoff 1% AEP flow was derived using catchment descriptors only.

The FEH Rainfall-Runoff model has been implemented in the iSIS modelling software v2.2. This modelling software is capable of performing all the required calculations.

Due to the catchment being classified as 'essentially rural' a time step of Δt = 1.0 hours was chosen.

The extent of urbanisation in the catchment is low (URBEXT < 0.125 for Rainfall-Runoff threshold) and therefore a winter storm profile was chosen.

The critical storm duration was estimated as in Equation 2-5.

Equation 2-5

$$D = Tp(1 + SAAR/1000)$$

A storm duration of 13.0 hours was chosen.

2.9 Design Flow Estimates

Using the iSIS FEH module, the 1% AEP (100-year) design flow estimate for the Langford Brook using catchment descriptors is shown in Table 2-8.

Table 2-8 Final Rainfall-Runoff Design Flow Estimates

Catchment	Return Period/AEP	
	100-year (1%)	100-year +20% (Climate Change)
L_Sub1	7.5	9.0

2.10 Choice of Method

The 1% AEP flow estimates using both the Statistical and Rainfall-Runoff methodologies were;

- 7.5m^3/s (Rainfall-Runoff)
- 3.5m^3/s (Statistical)

As shown, the two methods produced different results. Although the pooling group created using the Statistical analysis was considered to be homogeneous and therefore quite a good representation in relation to the subject site. The subject site had an URBEXT value of 0.046 the Statistical method is generally considered to be suitable for essentially rural catchments.

The subject catchment is also small; 17.02km^2, and the FEH favours the Rainfall-Runoff method for smaller catchments.

In choosing the final methodology, it was considered that 3.5m^3/s Statistical derived flow estimate was too low for a 100-year estimate for a catchment of 17.02km^2, for which there were no apparent reasons. It was therefore thought that the flow of 7.5m^3/s was more representative for this study catchment.

3 HYDRAULIC MODELLING

3.1 General

In the absence of an existing model of the Langford Brook at Bicester, JBA constructed a steady state model of the brook using the HEC-RAS version 3.1.1 hydraulic modelling software. The software was developed by the US Army Corps of Engineers and was released in May 2003. HEC-RAS can simulate water levels in open channels as well as in various types of structures, and will also resolve the transition from sub-critical to super-critical flow.

The Langford Brook model extends for just over 1200m, from its upstream extent approximately 300m downstream of the A4421 Charbridge Lane (OS NGR SP 599 230), to approximately 200m downstream of Gavray Drive at OS NGR SP 594 221. Both upstream and downstream boundary conditions were set at the 'normal depth', calculated from the gradient of the river bed.

Where structures are present in the model, HEC-RAS requires there to be a cross-section at both the upstream and downstream face of the structure, therefore some of the sections had to be duplicated, as the surveyor did not always survey both the faces of the structure, if they were seen to be very similar. On structures that appeared to differ from upstream to downstream, or where complex structures were present, for example Gavray Drive bridge, both the upstream and downstream faces of the structure were surveyed.

3.2 Hydraulic Modelling Methodology

Two hydraulic modelling methodologies were available for use in this study, namely steady state modelling and unsteady state hydrodynamic modelling. The choice of methodology utilised is dependent on engineering judgements made on the nature of the watercourse in question and associated flood routing.

The main limitation of steady state modelling is that it does not simulate time-varying behaviour such as flood wave attenuation due to storage and time-based operation of control structures and pumps. A hydrodynamic model directly calculates these effects and also provides the opportunity to distinguish between such issues as areas of floodplain serving as purely static storage and those actively conveying flow (functional floodplain).

For this study, a steady state model was thought to be appropriate, as due to the short model length, the attenuation of flow in the floodplain was considered to be low.

It was also thought appropriate to use a steady state model to ensure that if the structures at Charbridge Way (upstream of the site) were modified or removed in the future, the model would represent this, as a steady state model assumes the same flow throughout the reach, and ignores any online flood storage due to undersized culverts.

3.3 Data Collection

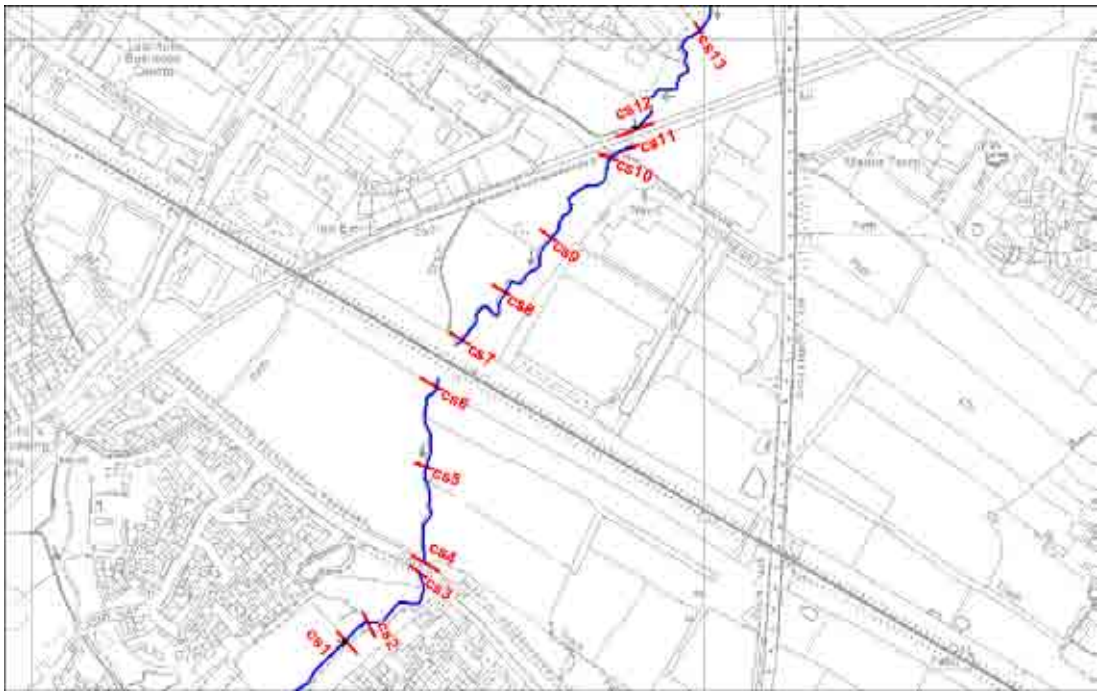
JBA appointed K.V. Surveys of Malvern to undertake a topographical channel and floodplain survey of the Langford Brook at Gavray Drive, Bicester. This survey consisted of 13 watercourse sections from grid reference OS NGR SP 599 230 at the upstream extent of the model, to grid reference OS NGR 594 221 downstream of the site, and included details of all the structures present along the modelled stretch of watercourse. The survey, to ordnance datum, was undertaken in July 2004.

JBA staff, with experience in hydrology and hydraulic modelling, undertook a walkover survey during July 2004. Details of watercourse and floodplain roughness values, structures and possible flow routes were assessed and recorded during this survey. This information provided a starting point to develop the hydraulic model.

3.4 Open Channel Sections

The hydraulic model of Langford Brook contained a total of 16 open channel sections (three of the original survey sections had been duplicated as a result of the presence of structures). Survey sections six, five and four were extended to approximately 500m on both the left and right banks, using a topographic spot level survey which was provided to JBA by the client. Figure 3-1 shows the locations of the cross-sections in the HEC-RAS model.

Figure 3-1 Cross-Section Locations in the HEC-RAS Model



Note: Watercourses – blue polyline
Cross-sections – red polyline

3.5 Roughness Coefficients

Channel and floodplain roughness is represented by Manning's 'n' values in the model. Initial values were determined by experience and by reference to published literature (e.g. Chow 1959[2]). Geomorphological and hydraulic literature documents the general case that in most rivers, the 'n' value decreases with increasing stage and discharge. During periods of relatively low flow, irregularities on the bed (form roughness) and the effects of bed and bank vegetation tend to elevate the 'n' value, whereas during periods of flood with significant depths above the main channel and floodplain, the value of 'n' is dramatically diminished as bathymetric and topographic irregularities are 'drowned' out and vegetation cover is submerged. The latter is particularly the case between Autumn and Spring when floods are most common and vegetation cover declines.

[2] Open Channel Hydraulics – Chow V T 1959

The final values were chosen following a walkover survey by an experienced modeller and consideration of the above commentary. As Langford Brook is winding with some weeds and stones, a value of 0.035 was used in the model for the main channel (below the bankfull reference level). When the floodplain is inundated, changes in vegetation within the main channel are considered unlikely to have a marked effect on the stage of flow. For the floodplain a value of 0.040 was adopted, as the land adjacent to the channel consists of light brush and trees in summer.

A Manning's 'n' value of 0.014 was chosen for the three culverts under the Gavray Drive Bridge. A Manning's 'n' value of 0.011 represents a smooth, concrete culvert, straight and clear of debris, therefore a slightly higher Manning's 'n' of 0.014 was deemed appropriate for these culverts.

3.6 Structures

The modelled reach of the Langford Brook contains a large number of structures, details of which were obtained from the topographical survey. The following details the location of the structures:

- Structure 11.5 – Railway bridge at grid reference OS NGR SP 598 228.
- Structure 10.25 – Bridge near Charbridge Way at grid reference OS NGR SP 592 228.
- Structure 7.95 – Wooden footbridge at grid reference OS NGR SP 596 226.
- Structure 6.5 – Railway bridge at grid reference OS NGR SP 596 225.
- Structure 3.5 – Gavray Drive bridge at grid reference OS NGR SP 595 225.
- Structure 1.7 – Wooden bridge at grid reference OS NGR SP 595 221.

Figure 3-2 Representative Photographs of Modelled Structures

Photograph 3-1 Structure 11.5

Photograph 3-2 Structure 10.5

Photograph 3-3 Structure 6.5

Photograph 3-4 Structure 3.5

Contraction and expansion coefficients are essential in the hydraulic model computations, to determine the energy losses due to the expansion and contraction of flow, between two adjacent cross-sections during the standard step profile calculations. These coefficients were determined using the HEC-RAS manual[3]. The manual suggests that typical values of contraction and expansion coefficients are 0.1 and 0.3 respectively for a gradual transition along an open channel. These values therefore have been adopted for the open channel section. However, the values 0.3 and 0.5 are recommended for the bridge contraction and expansion coefficients respectively in all the relevant HEC-RAS publications. The same values were therefore used in this study.

3.7 Floodplains

The floodplains of the Langford Brook are represented in the model as single cross-sections which extend either side of the main channel. For the sections which flow past the site, the floodplain was extended to approximately 500m from both the left and right banks, using information from a topographical spot level survey, which had been provided by the client.

3.8 Model Runs and Results

The HEC-RAS model of Langford Brook was run for a range of scenario's, detailed below:

- 1% AEP (1 in 100-year) flow.
- Sensitivity to flow - 1% AEP flow + 20% (climate change scenario).
- Sensitivity to variations in Manning's 'n'.
- Sensitivity to changes in downstream boundary.

The Rainfall-Runoff derived 1% AEP (1 in 100-year) peak flow of 7.5m^3/s was used for the Langford Brook. DEFRA recommend that a 20% increase in this value is used as a sensitivity analysis, and also to assess possible enhanced risks due to climate change. The 20% flow increase, gives a 'climate change' flow of 9.0m^3/s.

Summary results from the model are shown in Table 3-1 and cross sections adjacent to the site and the model longitudinal section are shown in Figure 3-3 and Figure 3-4 respectively..

Table 3-1 Summary of Model Results

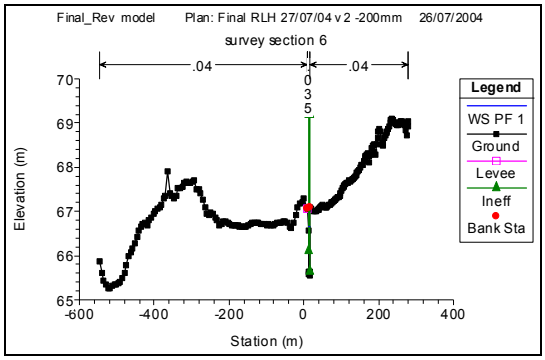
HEC-RAS Label	1% AEP Water Level (m AOD)	1% AEP + 20% Water Level (m AOD)

[3] US Corps of Engineers (1993), HEC-RAS River Analysis System US Corps of Engineers

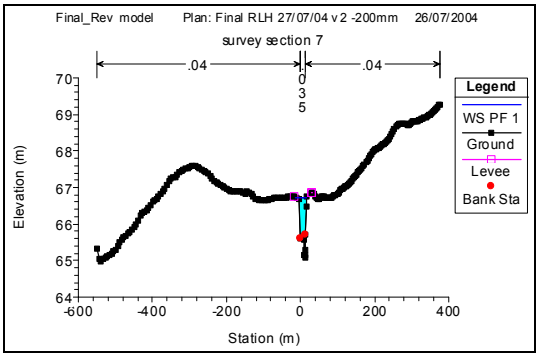
13	69.44	69.55
12	69.22	69.31
11	68.70	68.77
10.5	68.63	68.66
10	67.90	68.06
9	67.90	68.00
8	67.75	67.87
7.9	67.61	67.80
7	67.31	67.50
6	***66.65***	***66.64***
5	***66.74***	***66.86***
4	***66.69***	***66.85***
3	66.67	66.82
2	66.54	66.67
1.5	66.48	66.57
1	66.41	66.51
Notes: Bold & italic text are the cross sections which are adjacent to the site		

Figure 3-3 HEC-RAS Cross Sections Adjacent to the Site

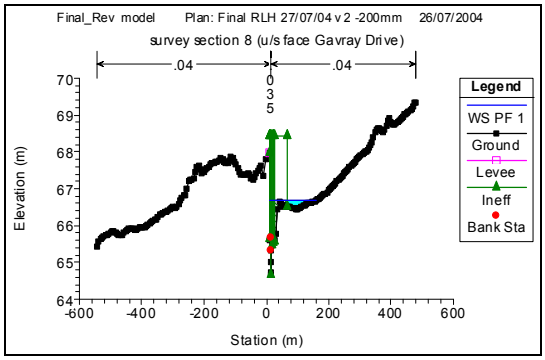
HEC-RAS Section 6



HEC-RAS Section 5

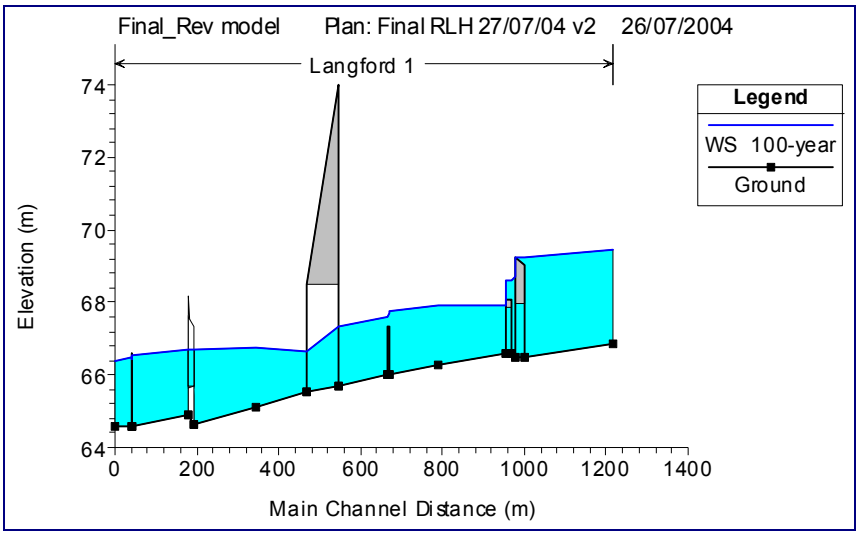


HEC-RAS Section 4



The effect of the 1% AEP (1 in 100-year) modelled water levels on the site, are discussed in section 4.3.

Figure 3-4 HEC-RAS Model Longitudinal Section



As shown in Figure 3-4 the structures in the location of Charbridge Way, upstream of the site, are a restriction on flow. The downstream structure at Gavray Drive is surcharged but does not have a significant head loss.

3.9 Sensitivity Analysis

Flow

A sensitivity analysis to flow has been carried out for the Langford Brook HEC-RAS model, by increasing the 1% AEP (1 in 100-year return period) flow by 20%. The flow used was 9.0m^3/s. The model results for the flow sensitivity analysis can be seen in Table 3-1.

Roughness

A sensitivity analysis was carried out on the Manning's 'n' values that were chosen to represent the channel of the watercourse. Manning's 'n' values were altered by both -20% and +20%. Results are shown in Table 3-2.

The results illustrated that the model is sensitive to change in Manning's 'n', and it is therefore recommended that the channel is regularly maintained to ensure that particularly between Autumn and Spring, when larger flood events are more likely to occur, the channel does not become overgrown or obstructed.

Downstream Boundary

In the absence of known stage-discharge information for the downstream boundary, a sensitivity analysis was carried out on the downstream boundary. This was done by varying the water depth by +/- 200mm. On completion of the 1% AEP (1 in 100-year) flow model run, the water surface elevation of the last cross-section (section 1), was noted. This value was modelled to be 66.41m AOD. Results are shown below in Table 3-2.

Table 3-2 Sensitivity Analysis on Mannings 'n' and Downstream Boundary

HEC-RAS Label	Mannings 'n' -20% Water Level (m AOD)	Mannings 'n' +20% Water Level (m AOD)	Downstream Boundary -200mm Water Level (m AOD)	Downstream Boundary +200mm Water Level (m AOD)
13	69.41	69.47	69.44	69.44
12	69.21	69.24	69.22	69.22
11	68.68	68.73	68.70	68.70
10.5	68.63	68.65	68.63	68.63
10	67.90	67.97	67.90	67.90
9	67.86	67.95	67.90	67.90
8	67.74	67.80	67.75	67.75
7.9	67.50	67.73	67.61	67.61
7	67.18	67.44	67.31	67.30
6	***66.49***	***66.65***	***66.65***	***66.70***
5	***66.62***	***66.80***	***66.74***	***66.84***
4	***66.58***	***66.80***	***66.69***	***66.83***
3	66.55	66.79	66.67	66.81
2	66.41	66.64	66.54	66.71
1.5	66.37	66.57	66.48	66.64
1	66.29	66.51	66.41	66.61

Notes: Bold & italic text are the cross sections which are adjacent to the site

4 FLOOD RISK

4.1 Planning Policy Guidance Note 25 (PPG25)

In July 2001 the DTLR issued Planning Policy Guidance note 25 (PPG25), now published by the ODPM. This introduced the sequential tests and the risk based approach to flood risk and development. Development priorities are to be based on flood zones as outlined in PPG25. The flood zones are shown in Table 4-1.

Table 4-1 PPG25 Flood Risk Zones

FLOOD ZONE (see note a)	Appropriate Planning Response
Zone 1: Little or No Risk Annual probability of river flooding 0.1% (1 in 1000-year)	No constraints due to river flooding.
Zone 2: Low to Medium Risk Annual probability of river flooding 0.1% to 1.0% (1 in 1000-1 in 100-year)	Suitable for most development. For this and higher flood risk zones, flood risk assessment is required appropriate to the scale and nature of the development. Subject to operational requirements in terms of response times, these and higher risk zones are not generally suitable for essential civil infrastructure, such as hospitals, fire stations, emergency depots etc.
Zone 3: High Risk (see note b) Annual probability of flooding with defences where they exist 1% or greater (less than a 1 in 100-year protection).	
Zone 3a: Developed Areas	These areas may be suitable for residential, commercial, and industrial development providing the appropriate minimum standard of flood defence (including suitable warning and evacuation procedures) can be maintained for the lifetime of the development.
Zone 3b: Undeveloped and sparsely developed areas	These areas are generally not suitable for residential, commercial and industrial development unless a particular location is essential, eg for navigation and water based recreation uses, agriculture and essential transport and utilities infrastructure, and alternative lower-risk location is not available.
Zone 3c: Functional floodplains	These areas may be suitable for some recreation, sport, amenity and conservation uses (providing adequate warning and evacuation procedures are in place). Built development should be wholly exceptional and limited to essential transport and utilities infrastructure that has to be there. Such infrastructure should be designed and constructed so as to remain operational even in times of flood.

Notes:
Zone 3 is split into three sub-zones.
Tidal flooding risks have not been included in this table.
Appropriate Planning Responses have been limited to those relevant to this flood risk assessment.

Note a: All risks relate to the time at which a land allocation decision is made or an application submitted. The Environment Agency will publish maps of these flood zones. Flood Zones should be identified from Agency flood data ignoring the presence of flood defences. Local Authorities should, with the Agency, identify those areas currently protected by those defences and the standard of protection provided by those defences.

Note b: Development should not be permitted where existing sea or river defences, properly maintained, would not provide an acceptable standard of safety over the lifetime of the development, as such land would be extremely vulnerable should a flood defence embankment or sea wall be breached, in particular because of the speed of flooding in such circumstances (see PPG25 paragraph 69).

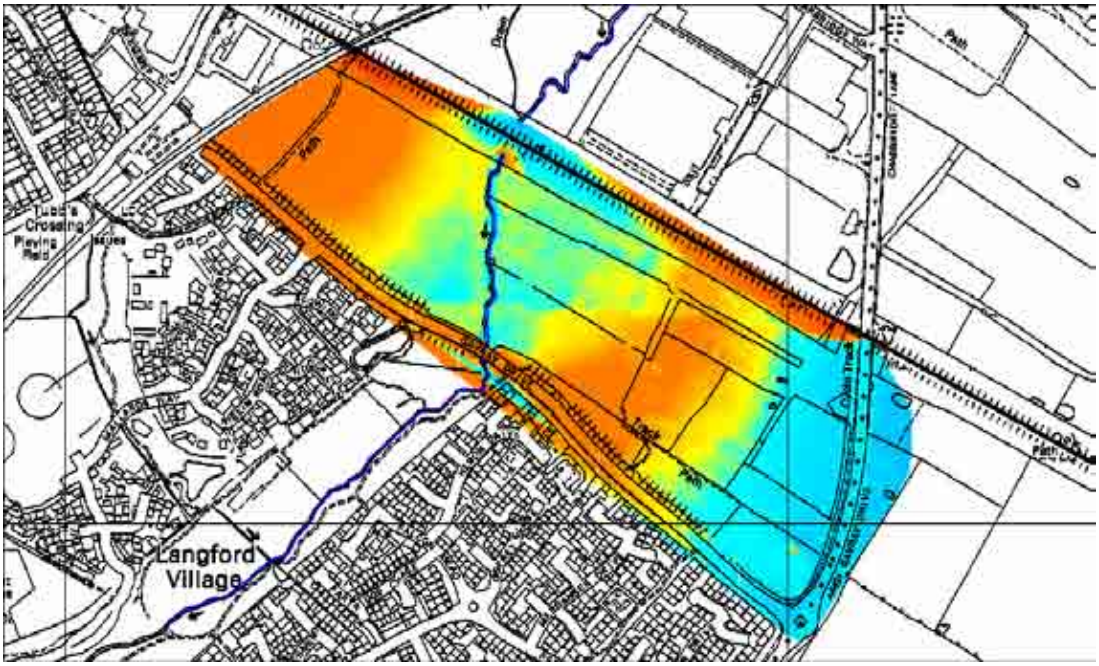
4.2 Flood Risk to the Site

Flood risk to the site is considered to be from one main source; the Langford Brook. The appropriate standard for flood protection is 1% AEP (1 in 100-year).

4.3 Derivation of the 1 in 100-year Flood Outline

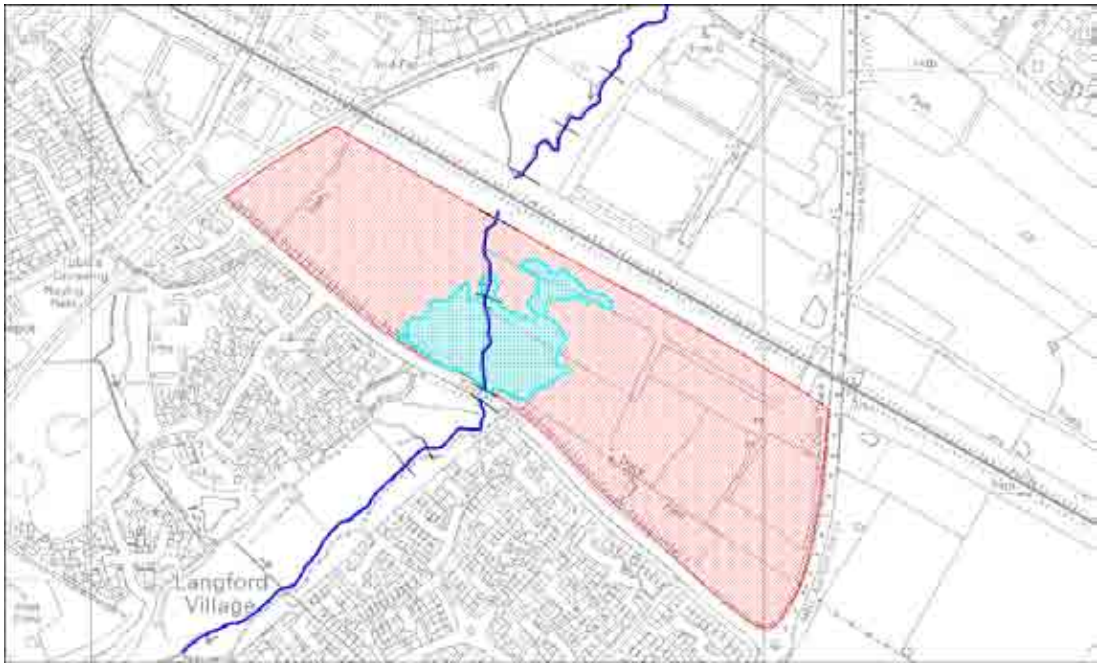
The 1% AEP (1 in 100-year) water level estimates, derived from the Langford Brook model, have been used to plot the 1% AEP flood outline across the site. This process was achieved by firstly creating a digital terrain model (DTM) of the study area (illustrated in Figure 4-1) based on the land survey supplied to JBA by the Client. Secondly, the maximum stage results from the hydraulic model were combined with the DTM to create a water surface, detailing the extent of the flood event. The 1% AEP (1 in 100-year) flood extent across the site is shown in Figure 4-2.

Figure 4-1 Digital Terrain Model of the Site



Note: Watercourses – blue polyline

Figure 4-2 1% AEP (1 in 100-year) Flood Extent



Note: Watercourses – blue polyline
Site – red hatched
1% AEP Flood Extent - Cyan

As shown in Figure 4-2, due to the topography of the area, a small area of the site will be affected by flooding during a 1% AEP flood event. At CS 6, the model is in bank and therefore the northern area of the site should not be affected by flooding. At CS 5 the model is slightly out of bank and at CS 4, at the southern part of the site, the model shows increased out of bank flooding. The maximum water level across the site is 66.74m AOD, with the lowest spot level being approximately 66.39m AOD. The maximum depths of flooding could therefore be approximately 0.35m.

The 1% AEP (1 in 100-year) outline derived represents the worst case scenario, as to derive the outline the water levels from the model were projected across the floodplain until the topography of the site is equal to the 1% AEP water level. In reality there may not be sufficient volume of water to reach these extents.

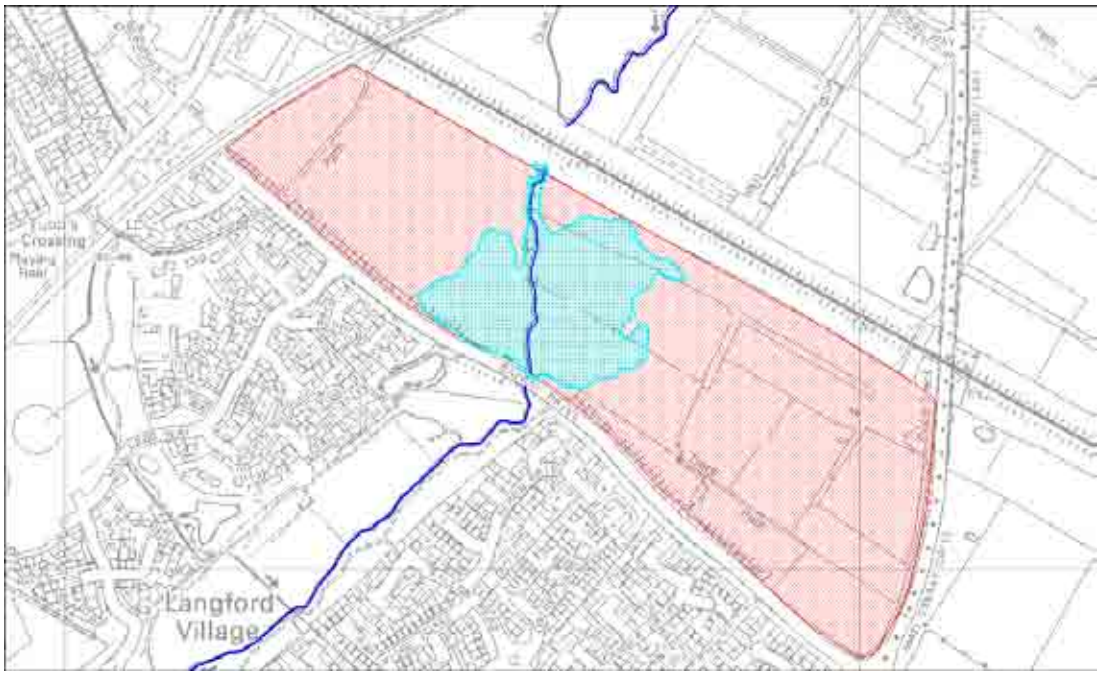
Note that, as shown in Figure 4-1, on the left bank of the Langford Brook, the topography of the site is lower immediately adjacent to the watercourse (blue/green shading), rising gently to an area of higher ground. It is this area of higher ground which protects the very eastern part of the site, which is lower, from being affected by flooding.

Environment Agency

Following discussions with the Environment Agency, it was considered appropriate to derive the flood outline using the water levels derived running the model with +20% Manning's 'n' values. Deriving the outline with these slightly higher water levels would incorporate intolerances in the survey data and sensitivity within the model runs.

The flood extent was derived in the same way as outlined above and the final flood outline across the site is illustrated in Figure 4-3.

Figure 4-3 Final 1% AEP (1 in 100-year) Flood Extent



Note: Watercourses – blue polyline
Site – red hatched
1% AEP Flood Extent - Cyan

4.4 Flood Zone of the Proposed Site

The proposed site at Gavray Drive, Bicester, lies within PPG25 flood risk zones 2 and 3 – medium to high risk. The area of the site which lies outside of the 1% AEP (1 in 100-year) flood extent is considered to be suitable for most development.

4.5 Proposed Finished Floor Levels

The Environment Agency recommends that floor levels of all new developments be set a minimum of 600 mm above the 1 in 100-year flood levels.

The maximum estimated 1 in 100-year water level in the vicinity of the site was 66.74 m AOD. Floor levels of the proposed development should therefore be constructed at a minimum elevation of 67.34 m AOD.

4.6 Flood Risk Downstream of the Site

At this stage, the exact details of the site drainage are unknown, however it is envisaged that surface water from the development will discharge into the existing public surface

water sewers. It will be necessary to demonstrate that adequate surface water sewers exist and that the surface water runoff from the development site will be no more than existing runoff.

4.7 Dry Access

The Environment Agency states that during times of flooding in a 1% AEP (1 in 100-year) flood event, a dry means of access must be available to the site. A dry means of access would be available to the site from all main access roads, particularly the A4421.

4.8 Climate Change

PPG25 states that '… best estimates, based on the most up-to-date findings, should also be made of climate change impact on probabilities. The assessment should ensure that the development meets an acceptable standard of flood defence for the design life of a development.'

The HEC-RAS model developed by JBA was run with a 20% increase n flow, to assess the affect of climate change. Discussion and model results for this are shown in section 3.9.

5 FLOODPLAIN COMPENSATION

5.1 General

Part of the proposed development site lies within the flood outline and it is proposed to rationalise the floodplain on the site rather than have a layout that fits around the existing floodplain outline. In order to undertake this, floodplain compensation calculations have been carried out to ensure that the new development does not reduce the floodplain capacity.

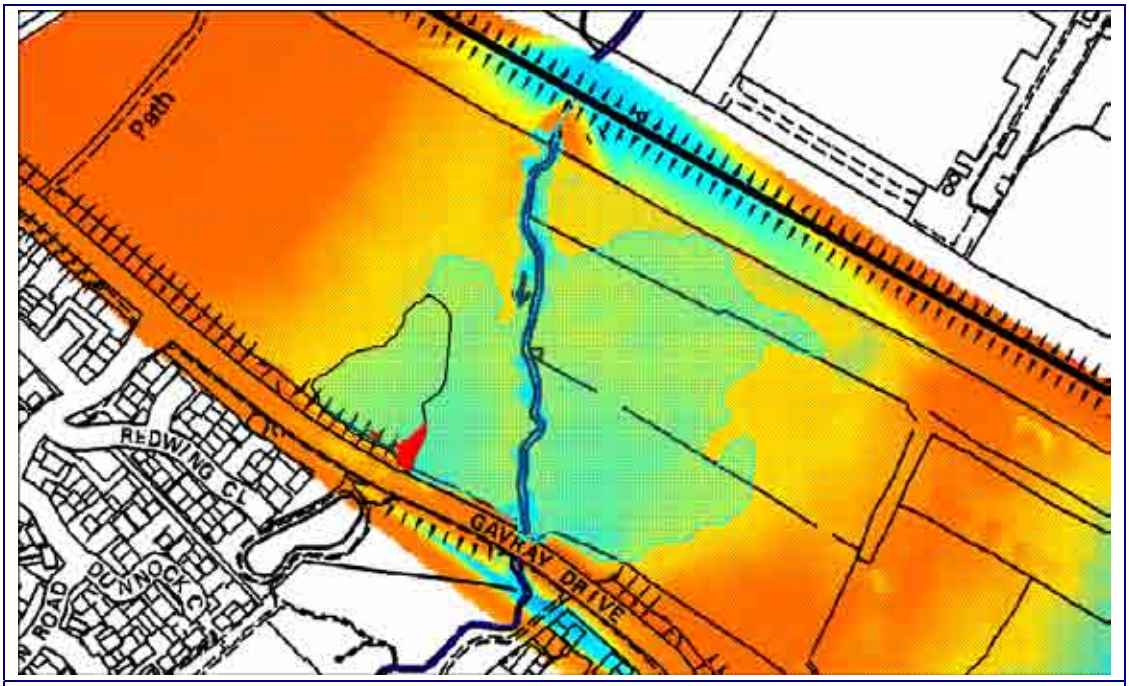
An extract of the proposed development plans are illustrated in Figure 5-1, with the full plan being shown in Appendix A. The area of land to be raised is 0.5 hectares and the land available for compensation is 0.9 hectares.

Figure 5-1 Site Development Proposals

Hatched dark blue area – 1% AEP Flood Outline
Cyan & Magenta hatching – Primary School & Local Facilities – area which lies within the flood outline and therefore will require floodplain compensation.

The floodplain compensation calculations have been undertaken by spreadsheet calculations. Using Vertical Mapper (VM), the ground levels within the area to be raised were extracted to determine the depths of flooding. All depths within the area, apart from two small areas illustrated in Figure 5-2, were lower than 300mm and therefore it was considered necessary to compensate in one band only and provide a like for like compensation.

Figure 5-2 Depths of Flooding



Black outline – Area to be filled and will therefore require floodplain compensation
Red areas within the site – areas where depths are greater than 300mm

The volume was derived by using the cell size of the grid of 2.5m. The total volume within the area to be developed was calculated to be 673.40m^3, for the derived flood outline.

It was considered feasible to use only 0.4 hectares (hatched area on Figure 5-1) of the available land for compensation, the area immediately adjacent to the Langford Brook. Using the methodology outlined above, grounds levels within this compensation area were extracted. To provide sufficient compensation it is considered necessary to lower the ground levels to a constant level of 66.6m AOD.

By lowering the area to a level of 66.6m AOD this will provide a storage capacity of 742.2m^3, which is sufficient to compensate for the area being raised and will slightly increase the floodplain volume.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

JBA were appointed by Gallagher Estates in June 2004, to undertake a Flood Risk Assessment for a proposed site at Gavray Drive, Bicester. The existing site is open fields.

The study has considered flooding from the Langford Brook, which flows through the centre of the site. This Flood Risk Assessment and this report follow the relevant sections of the guidelines in Appendix F of PPG25 – Planning Guidance Development and Flood Risk.

The Environment Agency's 2004 Flood Zone Maps which were obtained from the local council were initially used to determine the flood risk to the site.

JBA commissioned K.V. Surveys of Malvern to undertake a topographical survey of the watercourse. This survey provided information on the shape of the channel and the dimension of any structures found along the watercourse, and was undertaken in June 2004.

Flows for input in the model were obtained using the FEH Rainfall-Runoff methodology. The 1% AEP flow was estimated to be 7.5m^3/s, and the +20% increase in flow, to take into account the possible effects of climate change, was taken to be 9.0m^3/s.

A steady state HEC-RAS model was developed using the new topographic survey, with the cross sections adjacent to the site being extended across the floodplain using the land survey provided to JBA by the Client.

A DTM of the site was created using the land survey, from which the 1% AEP (1 in 100-year) flood extent was derived. Following discussions with the Environment Agency it was considered appropriate to derive the flood outline using the water levels when the model was ran with a 20% increase in Manning's 'n' values. This would to take into account any intolerance in the survey data and sensitivity of the model runs. The model results indicated that an area of the site would be at risk from flooding with all but a small area of the site experiencing depths of flooding less than 300mm.

The proposed site at Gavray Drive, Bicester lies within PPG25 flood risk zones 2 and 3 – medium to high risk. The area of the site which lies outside of the 1% AEP (1 in 100-year) flood extent is considered to be suitable for most development.

The Environment Agency states that during times of flooding in a 1% AEP (1 in 100-year) flood event, a dry means of access must be available to the site. A dry means of access would be available to the site from all main access roads, particularly the A4421.

6.2 Recommendations

The Environment Agency recommends that floor levels of all new developments be set a minimum of 600 mm above the 1 in 100-year flood levels. The estimated 1 in 100-year water level in the vicinity of the site was 66.74 m AOD. Floor levels of the proposed development should therefore be constructed at a minimum elevation of 67.34 m AOD.

Floodplain rationalisation has been considered and it is proposed to rationalise the floodplain on the site rather than have a layout that fits around the existing floodplain outline.

APPENDICES

Appendix 2: Flood Compensation

1 FLOODPLAIN COMPENSATION

1.1 Background

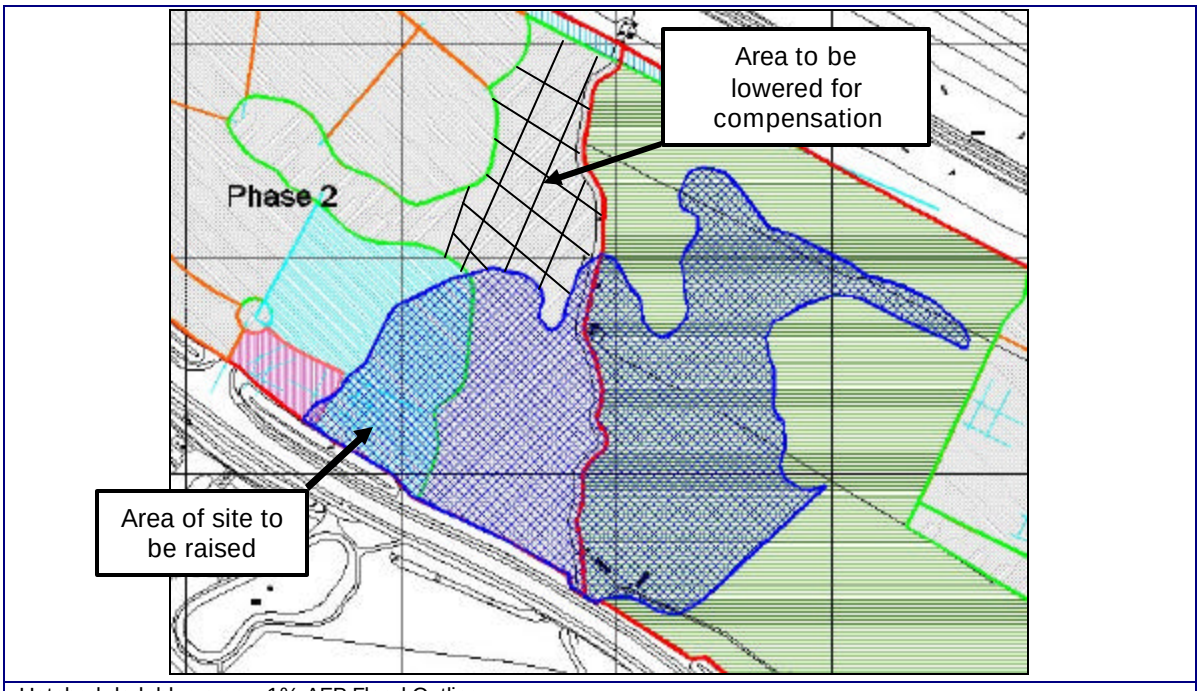
Gallagher Estates Ltd (GE) is proposing to develop the site at Gavray Drive, Bicester. The site is currently a greenfield site, and the Langford Brook flows in a southerly direction through the centre of the site. Development proposals for the site include residential areas and a primary school. Part of the site has been shown to lie within the 1% AEP (1 in 100-year) floodplain.

1.2 Previous Studies

In January 2004, JBA Consulting was commissioned by JJ Gallagher's Ltd to undertake a Flood Risk Assessment (FRA) of the site at Bicester. The study incorporated new hydrological analysis and the construction of a new hydraulic model. The 1% AEP (1 in 100-year) flood outline across the site was derived. The results of the FRA were presented in a report dated July 2004[1]. In summary, it is proposed to rationalise the floodplain on the site rather than have a layout that fits around the existing floodplain outline. In order to undertake this, floodplain compensation calculations have been carried out to ensure that the new development does not reduce the floodplain capacity.

An extract of the proposed development plans are illustrated in Figure 1-1, with the full plan being attached to this document. The area of land to be raised is 0.4 hectares and the land available for compensation is 0.9 hectares.

Figure 1-1 Site Development Proposals

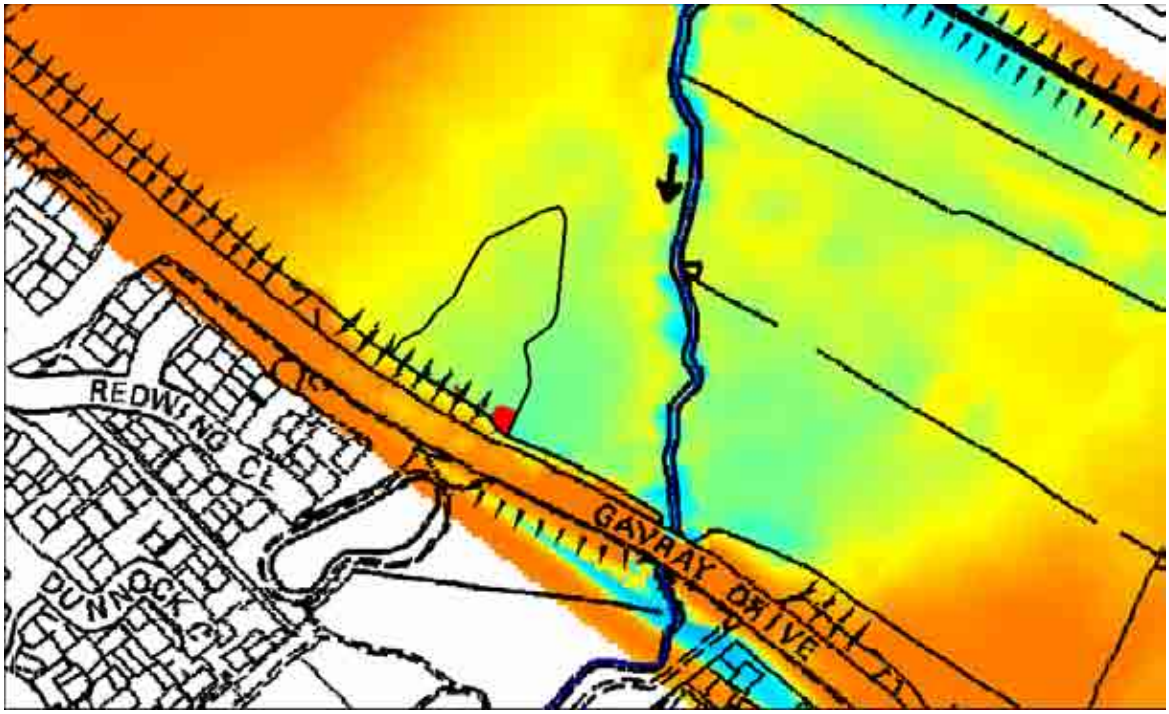


Hatched dark blue area – 1% AEP Flood Outline
Cyan & Magenta hatching – Primary School & Local Facilities

[1] Flood Risk Assessment - Gavray Drive Bicester, Final Report, JBA July 2004

The floodplain compensation calculations have been undertaken by spreadsheet calculations. Using Vertical Mapper (VM), the ground levels within the area to be raised were extracted to determine the depths of flooding. All depths within the area, apart from two small areas illustrated in Figure 1-2, were lower than 300mm and therefore it was considered necessary to compensate in one band only.

Figure 1-2 Depths of Flooding



Black outline – site to be compensated
Red areas within the site – areas where depths are greater than 300mm

The volume was derived by using the cell size of the grid of 2.5m. The total volume within the area was calculated to be 158.17m^3, for a 1% AEP (1 in 100-year) flood event.

It was considered feasible to use only 0.5 hectares (hatched area on Figure 1-1) of the available land for compensation, the area immediately adjacent to the Langford Brook. Using the methodology outlined above, grounds levels within this compensation area were extracted. To provide sufficient compensation it is considered necessary to lower the ground levels to that of the average of the existing ground levels of the area to be raised, which has been calculated to be 66.64m AOD.

By lowering the area to a level of 66.64m AOD this will provide a storage capacity of 210.49m^3, which is sufficient to compensate for the area being raised and will slightly increase the floodplain volume.

Appendix 1: Air Quality Assessment Technical Report

JJ Gallagher Ltd

Gavray Drive, Bicester

Air Quality Assessment
Technical Report

JJ Gallagher Ltd

Gavray Drive, Bicester

Air Quality Assessment Technical Report

December 2004

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		Name	Nicole Rogers	Michael Bull	Peter Braithwaite
		Signature			
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		Name	Nicole Rogers	Michael Bull	Peter Braithwaite
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		Name	Nicole Rogers	Michael Bull	Peter Braithwaite
		Signature			
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CONTENTS

1. INTRODUCTION

In recent years, air quality has become of increasing importance in national and European Union environmental legislation, reflected in policies involving the management of local air quality to reduce human health risks, improve quality of life and minimise harm to the surrounding natural environment. The proposed development of the Gavray Drive site in Bicester, Oxfordshire has the potential to affect local air quality. An air quality assessment, therefore, needs to be undertaken in order to taken into account the likely effects of the proposed development.

This chapter summarises the most recent national and European air quality standards, explains the methodology employed in assessing potential impacts occurring due to the proposed development, examines the existing (baseline) air quality conditions surrounding Bicester and illustrates the magnitude of any likely impacts to local air quality following the methodology in the *Design Manual for Roads and Bridges (DMRB)* "screening" method. The potential air quality impacts have then been compared to national and European air quality standards and objectives to establish their importance. The significance of the impacts have been determined by the proximity and number of residential properties and people affected, the duration of effects and likelihood of occurrence.

1.1 Air Quality Objectives and Limit Values

Air quality objectives and limit values are the standards against which potential changes in local air quality as a result of the proposed development are assessed. They are standards, which are set in place to protect the most vulnerable groups in society in terms of human health (i.e. the very young, the elderly and the infirm) and also for the protection of vegetation and ecosystems.

European Union (EU) air quality policy provides the basis for UK national air quality policy. The EU Air Quality Framework Directive on Ambient Air Quality Assessment and Management came into force in September 1996, with subsequent daughter directives setting Europe-wide standards for air quality. Within the UK, the Environment Act (1995) brought about the instigation of the National Air Quality Strategy (1997) (NAQS), forming air quality standards and objectives for specific pollutants and highlighting measures for local authorities under Local Air Quality Management (*'LAQM'*) to work towards meeting these standards and objectives. The NAQS was revised in 2000 as the Air Quality Strategy for England, Scotland, Wales and Northern Ireland (DETR, 2000a) and an addendum published in 2002 (DEFRA, 2003a). The objectives relevant to local air quality management have been set in the Air Quality Regulations (England) (2000 and 2002).

Each of the priority pollutants set down in the National Air Quality Strategy has a set target level to be achieved by specific years. Some pollutants have standards expressed as long-term averages (i.e. annual means), due to chronic health effects occurring after a prolonged exposure to elevated concentrations. Other pollutants have short-term averages (i.e. either 24 hour, 15 minute or 1 hour means) due to acute health effects arising after short-periods of elevated exposure. For short-term standards, an allowable number of exceedances of the standard are often incorporated, usually expressed as a number of hours or days per year for which the standard may be exceeded or as its percentile equivalent. The pollutants relevant to this assessment are shown below in Table 1.

The achievement or likely achievement of an air quality objective is determined by reference to the quality of air at locations –

(a) which are situated outside of buildings or other natural or man-made structures above or below grounds; and
(b) where members of the public are regularly present.

The Government provides guidance on locations where the objectives should and should not apply.

Table 1: UK Air Quality Objectives

Pollutant	Averaging Period	UK Objectives/ Limit Values	Year for Compliance	EU Limit Values	Year for Compliance
Benzene	Running annual mean	16.25 µg/m^3	31 Dec 2003	5 µg/m^3	1st Jan 2010
	Annual mean (Eng & Wales)	5 µg/m^3	31 Dec 2010		
1,3-butadiene	Running annual mean	2.25 µg/m^3	31 Dec 2003	N/A	N/A
Carbon monoxide	Maximum daily running 8 hour mean	10.0 mg/m^3	31 Dec 2003	10.0 mg/m^3	2005
Nitrogen dioxide	1 hour mean	200 µg/m^3 (not to be exceeded more than 18 times per year)	31 Dec 2005	200 µg/m^3 (not to be exceeded more than 18 times per year)	2010
	Annual mean	40µg/m^3	31 Dec 2005	40µg/m^3	2005
PM_{10} (gravimetric)	24 hour mean	50 µg/m^3 (not to be exceeded more than 35 times per year)	31 Dec 2004	50 µg/m^3 (not to be exceeded more than 35 times per year)	2005
	Annual mean	40 µg/m^3	31 Dec 2004	40 µg/m^3	2005

2. ASSESSMENT METHOD

The screening method outlined in *Version 1.02 (Environmental Assessment)* of the *Design Manual for Roads and Bridges (DMRB) (Highways Agency, November 2003)* was used to assess the changes in local air quality as a result of changes in traffic flows associated with the proposed development. Given the relatively small scale of the development, its residential nature as opposed to industrial or commercial and the existing forecast that air quality standards and objectives will be met by the relevant dates, it was considered that this was an appropriate approach to be taken for the assessment.

The DMRB screening method recommends the examination of five key pollutants: carbon monoxide, benzene, 1,3-butadiene, nitrogen dioxide (NO_2) and particulate matter (PM_{10}). The method outlined in the DMRB is designed to estimate concentrations of these five key pollutants at discrete receptors in order to highlight any locations where there may potentially be an air quality problem. The screening methodology takes into account changes in traffic

flows and speeds and changes in the number of heavy duty vehicles (HDVs) on the local road network. This purpose of the methodology is not, however, for use as an indicator of exact pollutant concentrations, but identifies where further, more detailed assessment could be necessary. It also provides a useful tool to make a comparison between various scenarios, as it does in this assessment, to compare the existing 2004 scenario, and the future (2006, 2010 and 2016) scenarios with and without the development in place.

2.1 Receptors

In assessing pollutant concentrations surrounding the Gavray Drive site, receptors in close proximity to the site and that are representative of other properties in the immediate vicinity were chosen. Pollutant concentrations decrease significantly with distance from a road source and, provided there are no other major sources nearby, would be lower at properties located further from roads than the receptors chosen for this assessment.

Four receptors were chosen around the vicinity of the site in order to assess impacts on local air quality as a result of the proposed development. Two further proposed residential properties were also chosen as receptors with the development in place and have only been considered in the assessment for the "do something" scenarios (i.e. with the proposed development in place). The most sensitive receptors are residential properties and therefore these are the receptors that have been selected in this case.

The receptors used in the DMRB assessment are:

1. Residential property with rear façade backing centre of Gavray Drive (7 Heron Court);
2. Residential property at the corner of Gavray Drive and the Eastern Distributor Road (Rear façade of property backing onto Shearwater Drive);
3. Residential property between Peregrine Way entrance and exit (rear façade of property on Ravenscroft backing onto Eastern Distributor Road);
4. Residential property on Peregrine Way (property on the northern 'exit' portion of the road);
5. Proposed residential property on-site, property at the corner of Gavray Drive turning north onto the Eastern Distributor Road;
6. Proposed residential property on-site, property at the northern most limit of the eastern portion of the site (adjacent to railway line).

It should be noted that the receptors have been assumed to be at ground floor level since the DMRB method does not provide a means to differentiate receptor heights. This approach should therefore be interpreted as a worst-case scenario, since receptors at a higher vertical level will generally be exposed to reduced concentrations compared with those at ground level.

2.2 Traffic Data

Existing (2004) and predicted future traffic flows for 2006, 2010 and 2016 with and without the proposed developments in place for roads surrounding the site were calculated and provided by Colin Buchanan and Partners. Traffic data provided were in the form of AADT (Annual Average Daily Traffic) flows calculated from AM peak and AADT flows calculated from PM peak and an average was taken from the two figures to provide the data used in the assessment (Appendix A)

All calculated traffic flows for the present and estimated traffic flows used in the air quality assessment are shown in Table 2.

Table 2: Traffic Data for Gavray Drive site

Road Link	Average AADT Flows							Speed Limit (kph) (same for each scenario)
	2004 (Existing)	2006 DM	2006 DS	2010 DM	2010 DS	2016 DM	2016 DS	
Gavray Drive	1263	1667	5820	1771	5924	1938	6091	32
% HGVs	2	2	3	2	3	2	3	-
Eastern Dist Rd (betw Gavray Drive & Peregrine Way)	9358	12922	14709	13722	15509	10024	16810	64
% HGVs	10	9	8	9	8	3	8	-
Eastern Dist Rd (south of Peregrine Way)	11630	12015	15610	12759	16354	13968	17564	64
% HGVs	11	11	11	11	11	11	11	-
Peregrine Way	4913	5075	5092	5390	5406	5901	5307	32
% HGVs	2	2	2	2	2	2	2	-
Eastern Distributor Road (north of Gavray Drive)	14171	13378	13646	14206	14474	15553	15821	64
% HGVs	9	8	8	8	8	8	8	-

* DM = Do Minimum (i.e. without development), DS = Do something (i.e. with development)

2.3 Background Pollutant Concentrations

The screening method requires annual mean background concentrations for each pollutant assessed. The background concentrations for all pollutants were taken from the background pollution tables for Cherwell District Council available in the Government's National Air Quality Archive (http://www.airquality.co.uk/archive/laqm/tools.php?tool=background) at National Grid Reference 462500, 224500. These were obtained for the present scenario of 2004 and for 2006, 2010 and 2020 using the procedures detailed on the National Air Quality Archive website.

Background concentrations used in the DMRB screening assessment are shown below in Table 3.

Table 3: Annual Average Background Pollutant Concentrations

Pollutant	Annual Average Concentration (μgm^{-3})			
	2004	2006	2010	2016
CO	0.19	0.16	0.12	0.11
Benzene	0.21	0.19	0.18	0.17
1,3-butadiene	0.09	0.07	0.06	0.06
NO_2	19.37	17.72	15.4	13.97
PM_{10}	17.8	17.58	16.4	16.4