



**FLOOD RISK ASSESSMENT
FOR
PROPOSED RESIDENTIAL DEVELOPMENT
LAND AT BELLS FIELD, ST. MARY BOURNE
ON BEHALF OF
HYDE HOUSING ASSOCIATION LIMITED**

JANUARY 2015

[Issue 6]

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CIVIL ENGINEERING ~ HIGHWAYS ~ TRANSPORTATION ~ FLOOD RISK

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COLE EASDON CONSULTANTS (CEC)

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File Reference:	3633 – St Mary Bourne – FRA – Issue 5	3633 – St Mary Bourne – FRA – Issue 6		



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DOCUMENT ISSUE RECORD

Client: Hyde Housing Association Limited

Project: Proposed Residential Development, Bells Field, St Mary Bourne

Job Number: 3633

Document Title: Flood Risk Assessment

Issuing Office: Bristol

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1.0 INTRODUCTION

- 1.1 This *Flood Risk Assessment* has been prepared by Cole Easdon Consultants on behalf of Hyde Housing Association Limited in respect of a Planning Application for a residential development on Bells Field, St Mary Bourne, Hampshire. Refer to CEC Figure 3633/500/Figure 1(A) [*Location Plan*] in Appendix 1.

Development Proposals

- 1.2 The new application is to comprise eleven affordable houses and associated access, parking areas and landscaping.
- 1.3 This study is based on Drawing Ref. 120909-150 prepared by Fowler Architecture and Planning, January 2015

Need for Study

- 1.4 The purpose of this assessment is to demonstrate that the development proposal outlined above can be satisfactorily accommodated without worsening flood risk for the area and without placing the development itself at risk of flooding, as per National guidance provided within the National Planning Policy Framework document (NPPF).
- 1.5 Accordingly, this study has been prepared to:
- i) assess flood risk to the development from fluvial sources;
 - ii) assess flood risk to the development from other potential sources, including ditches, sewers, groundwater and overland flows; and
 - iii) ensure that the proposed development will fully comply with the requirements of the Environment Agency's policy on the safeguarding of floodplains.
- 1.6 A topographical survey of the site (referenced to Ordnance Datum) has been undertaken by Dando Surveying Ltd and has been reviewed as part of this study.

Scope of Study

- 1.7 Pre-planning liaison has taken place with the Environment Agency. They have provided comment on the first issue of this report. Refer to Appendix 3. This report (Issue 6) amends the previously outlined surface water drainage strategy following the confirmation that infiltration potential exists at the site.



1.8 In Section 2.0, we describe the characteristics of the proposed development site and surrounding area. In Section 3.0, we assess flood risk issues. Finally, conclusions are presented in Section 4.0.

1.9 The following abbreviations are used in this report:

AOD	Above Ordnance Datum
EA	Environment Agency
FZM	Flood Zone Map prepared by the EA
NPPF	National Planning Policy Framework
SUDS	Sustainable Urban Drainage Systems

2.0 THE EXISTING SITE

Refer to CEC Plan 3633/500(A) [*Existing Site Layout*] in Appendix 7.

- 2.1 The proposed development site is a 0.41ha area of land located within St Mary Bourne, some 7km north east of Andover, Hampshire. The site is situated on the southern side of the B3048, with Finkley Road forming the sites western boundary. Residential properties are situated along the northern boundary of the site, with open rural adjacent to the other boundaries of the site.
- 2.2 The Bourne Rivulet is located on the north eastern side of the B3048 highway. Land use in the immediate vicinity of the site is primarily residential with agricultural land beyond.
- 2.3 The land within the site is relatively flat, sloping away from the highway on the western boundary towards the south east of the site. Existing levels within the site vary from 80.1m AOD at the highest point along the western boundary to 79.3m AOD at the south eastern corner of the site.

Existing Drainage

- 2.4 The site is comprised of greenfield land and features no formal drainage system. Greenfield runoff rates have been calculated to be 0.6 l/s for the 1:100 year event.

Nearby Watercourses/Drainage Features

- 2.5 The Bourne Rivulet, a tributary of the River Test, is located approximately 200m north east of the site, adjacent to the B3048 highway. The watercourse is designated as a 'main river' through the village. The watercourse flows past the site in a south easterly direction.
- 2.6 St Mary Bourne Lake is located 300m south east of the site. The lake is man-made and fed by groundwater from the surrounding area which causes its water level to vary throughout the year.

Existing Ground Conditions

- 2.7 Records from the British Geological Survey indicate Chalk Formation bedrock with superficial river terrace deposits of sand and gravel in the vicinity of the site. Borehole records in the vicinity of the site from previous developments corroborate the BGS assessment. Refer to Appendix 2. Preliminary site investigation works undertaken in January 2013, comprising three test pits to a depth of 1m established the existence of highly permeable flint strata.

3.0 FLOOD RISK ISSUES

Refer to CEC Plan 3633/501(E) [*Proposed Site Layout*] in Appendix 7.

3.1 This section presents an assessment of flood risk to the development from:

- a) external sources; and
- b) surface water discharge from the proposed development.

3.2 Recommended flood risk mitigation measures appropriate to the level of perceived risk are included in the assessment. The mitigation measures are summarised in Table 3.1 on page 9.

Flood History

3.3 In 2002, Halcrow Group Ltd prepared a report on the flooding of St. Mary Bourne on behalf of the EA. The report described the years 2000/2001 as the wettest water year (April – March) on record. Rainfall events over the year were classified as rarer than 1:100 year frequency events. Despite this, the flooding of 2000/2001 in St. Mary Bourne did not affect the development site. Refer to Appendix 6. In addition, according to local knowledge the site has not flooded in living memory.

A) Assessment of Flood Risk to the Development Site from External Sources

Ai) Assessment of Flood Risk from Fluvial Sources

3.4 The Flood Zone Map (FZM) for the locality as produced by the EA is shown on CEC Figure 3633/500/Figure 2(A) [*Flood Zone Map*] within Appendix 1. According to the FZM shows that the site partially lies within Flood Zone 2 (medium risk).

3.5 As the FZM is indicative only, 'J Flow' modelled 1:1000 year flood levels have been obtained from the EA. Refer to Appendix 3. The 'J Flow' levels suggest that a 1:1000 year flood conveyance route exists through the site to a typical depth of some 10 to 20mm. 1:100 year + 20% climate change flood levels are not available. However, based on the minor depths associated with the 1:1000 year flood conveyance route through the site, the site would not be anticipated to flood during the 1:100 year + 20% climate change event. Notwithstanding this, flood mitigation measures are proposed and these are detailed below.

Fluvial Sources Flood Risk Mitigation Measures

3.6 Flood protection measures have been selected in accordance with guidance published in the Communities and Local Government document 'Improving the Flood Performance of New Buildings – Flood Resilient Construction'. Refer to Appendix 5 for relevant extracts from this document.

- 3.7 The EA advise that due to the absence of definitive modelled flood levels for the site, a conservative approach should be taken when considering fluvial flood risk mitigation measures. Consequently, water resistance measures described within a 'Water Exclusion Strategy' will also be implemented. The Strategy will protect the proposed dwellings if flood waters exceed the design level. Water exclusion measures are described below. Refer to Appendix 5 for further details.

Flood Avoidance Strategy

- 3.8 Finished floor levels will be set at least 150mm above finished ground levels.

Flood Exclusion Strategy

- 3.9 The flood exclusion measures listed below should be considered. Refer to Appendix 5 for further details:
- In general, building materials with good resistance to water penetration, good drying ability and the ability to retain pre-flood characteristics should be selected up to floor slab level. Examples include engineering bricks and dense stone.
 - Where ground conditions are favourable, foundations should be ground supported not suspended types. Floodwater and waterborne contaminants can become trapped beneath suspended floors. If ground supported flooring is unsuitable, a suspended concrete slab floor as shown in Figure 6.5 in Appendix 5 is recommended.
 - Concrete blockwork should not be located below floor slabs. Blockwork provides a potential path for water ingress into wall cavities and into dwellings.
 - Where possible, masonry walls should be constructed using engineering bricks up to floor slab level. Blocks and dense facing bricks have much improved resistance to water penetration if rendered.
 - Insulation in the form of external insulated render or internal boards is preferable to cavity insulation.
 - Door thresholds should be raised, whilst complying with level access requirements. Sealed PVC external framed doors should be used where possible.
 - Periscopic air vents should be used.
 - Fittings that will not be significantly affected by water should be installed. Fittings should be easily cleaned. Fittings such as electrical appliances and gas ovens should be placed on plinths.
 - All service entries including electricity, communications, gas and water should be sealed with expanding foam or similar closed cell material.
 - Water, electricity and gas meters should be located above the predicted flood level.

- Electrical sockets should be installed above flood level. Electric ring mains should be installed at first floor level with drops to sockets and switches.
- Heating systems such as boilers should be located above the predicted flood level and preferably on the first floor of two storey properties.
- Non return valves are recommended in the drainage system to prevent back flow of diluted sewage resulting from potential foul sewer surcharging. Maintenance of these valves is required to ensure their effectiveness.

Aii) Assessment of Flood Risk from Existing Sewers/Highway Drains

- 3.10 Flooding of a number of domestic foul water drains and the public combined sewer located beneath the B3048 highway occurred in St. Mary Bourne during the winter of 2000/2001. However, the flooding was confined to properties a considerable distance from the site. The nearest sewer to the site is routed at a lower level than site ground levels.

Existing Sewer/Highway Drains Mitigation Measures

- 3.11 Flood risk is considered to be low and no mitigation measures are necessary.

Aiii) Assessment of Flood Risk from Overland Flow

- 3.12 Due to the existing site topography, there is potential for overland flow to enter the site at some points along its north and western boundaries in particular. Despite this, due to the nature of much of the surrounding land, which comprises primarily of gardens, only minimal flow in the form of localised greenfield runoff will be generated.
- 3.13 In extreme flood events it may be possible that surface water runoff may enter the site via the vehicular access from the Finkley Road highway.
- 3.14 The Halcrow/EA report relates that during the winter 2000/2001 storm event (which exceeded the 1 in 100 year magnitude), the nearby B3048 highway became a flow path for runoff from surrounding areas and out of bank flow issuing from the Bourne Rivulet. However, the report shows that flooding of the road was contained to a section of highway remote to the site.

Overland Flow Flood Risk Mitigation Measures

- 3.15 Finished floor levels will be set at least 150mm above ground level. The use of rumble strips within the access area will prevent the entry of overland flow into the site that may occur from the Finkley Road highway.

Aiv) Assessment of Flood Risk from Groundwater

- 3.16 The Halcrow/EA report identified 2000/01 as the wettest water year on record with unusually high groundwater levels being recorded during this period with peak levels the following winter. The high groundwater level and high river flows from the exceptional rainfall resulted in the internal and external flooding of low lying properties. Despite this, the site was not highlighted as an area which suffered flooding, within the Halcrow/EA report. Refer to Appendix 6.
- 3.17 Testpitting undertaken in January 2013 established groundwater levels at that time to be some 1m below ground level. Refer to CEC Plan 3633/501(E) [*Proposed Site Layout*] in Appendix 7. The summer of 2012 was significantly wetter than normal, followed by a wet winter. The groundwater level recorded at the site at that time (January 2013) is therefore considered to provide a reliable indication of highest groundwater level at the site. Groundwater flood risk is therefore considered to be moderate.

Groundwater Flood Risk Mitigation Measures

- 3.18 The flood proofing measures as described in paragraphs 3.8, 3.9 and 3.15 above will provide appropriate mitigation from this source of flooding.

Av) Assessment of Flood Risk from Ditches

- 3.19 There are no drainage ditches present on site or in the immediate vicinity. Therefore flood risk from this source is considered to be low.

Groundwater Flood Risk Mitigation Measures

- 3.20 No mitigation measures are required.

B) Assessment of Flood Risk Arising from Surface Water Discharge from the Proposed Development

Refer to CEC Plan 3633/501(E) [*Proposed Site Layout*] in Appendix 7.

- 3.21 In order to mitigate flood risk posed by post development runoff, adequate control measures will be required within the site.
- 3.22 The development site is currently greenfield land. The existing 1:100 year greenfield runoff rate has been calculated to be 0.6 l/s.

Bi) Surface Water Runoff Control

Refer to Appendix 4 for Calculations.

- 3.23 The proposed development will introduce impermeable surfaces in the form of access roads and roof areas of some 0.188ha. The additional runoff arising from development will need to be managed in accordance with sustainable drainage principles.

Infiltration Potential

- 3.24 An initial review of site investigation records indicates that the site may be suitable for an infiltration based drainage strategy. This has been confirmed by site testpitting undertaken in January 2013 which showed the presence of flint strata at a shallow depth below ground level. However, the potentially high seasonal groundwater table (groundwater was encountered at 1m below existing ground level during the site testpitting undertaken in January 2013) requires land raising to be undertaken to ensure an adequate buffer between infiltration facilities and the groundwater table.
- 3.25 The summer of 2012 was significantly wetter than normal, followed by a wet winter. The groundwater level recorded at the site at that time (January 2013) is therefore considered to provide a reliable indication of highest groundwater level at the site.

Drainage Strategy

- 3.26 All surface water from the proposed development impermeable areas (comprising roofs and highways) will be discharged to infiltration SuDS (soakaways and permeable paving/surfacing) located throughout the development. The surface water drainage scheme will be designed to accommodate and dispose of runoff from storms up to the 1:100 year + 30% climate change event.
- 3.27 Preliminary sizing of infiltration facilities has been undertaken using an assumed infiltration rate of $2.7 \times 10^{-3} \text{m/s}$ or 10m/hr, typical for flint strata. The actual infiltration rate will be confirmed by onsite infiltration testing, and the results used to inform detailed design.
- 3.28 All surface water runoff from the roof areas will be discharge to gravel filled trench soakaways constructed in permeable strata. Each dwelling contributes between some 43 - 64m² of impermeable area. Runoff from this area can be provided in a soakaways varying from 1.0m wide x 1.0m long x 0.3m deep to 1.0m wide x 1.2m long x 0.3m deep, with 0.5m cover. Refer to CEC Plan 3633/501(E) [*Proposed Site Layout*] in Appendix 7

- 3.29 Soakaways must be placed a minimum of 5m away from any building, including garages.
- 3.30 In order to accommodate the soakaways in the rear gardens of the dwellings land raising is required. Land raising of some 0.4m will ensure that a 0.5m buffer is maintained between the base of the soakaway and the highest groundwater level recorded in January 2013.
- 3.31 Surface water runoff from the private drives/ access and car parking areas will be disposed of via permeable paving/surfacing. Hard-surfaced areas (for example the bell-mouth access area adjacent to Finkley Road) will be drained via dedicated soakaways. Preliminary calculations indicate that the permeable paving subbase aquifer depth required is some 0.1m. Land raising of car park spaces and access areas of some 0.3m (assuming the highways are to be kerbed) will provide a 1m buffer from the base of the permeable paving to the highest groundwater level recorded in January 2013.
- 3.32 All calculations have been undertaken using WinDES software.

Adoption

- 3.33 It is proposed that all on-site drainage and SUDS facilities will be maintained privately.

Water Quality

- 3.34 The proposed development will utilise infiltration SuDS, comprising soakaways and permeable paving/surfacing. These devices are recognised pollutant removal facilities within the *CIRIA 697 The SuDS Manual*.

Table 3.1: Assessment of Flood Risk to the Development Site Arising from External Sources

Source of Potential Flooding to the Development Site	Flood Risk	Mitigation/Comments
▪ Bourne Rivulet	Low	▪ None required.
▪ Ditches	Low	- Finished floor slab to be at least 150mm higher than surrounding ground levels - Flood resilient construction measures to be incorporated into dwellings
▪ Sewers/Highway Drains	Low	
▪ Groundwater	Moderate	
▪ Overland Flow	Low	

4.0 DISCUSSION AND CONCLUSIONS

Assessment of Flood Risk from External Sources

- 4.1 Flood risk to the proposed development from various sources, such as fluvial, sewers, groundwater and overland flow has been considered in this study.
- 4.2 Flooding from groundwater has been identified as a moderate risk. Mitigation measures as proposed in paragraphs 3.8, 3.9 and 3.15 will mitigate any risk associated with flooding from this source.
- 4.3 Flood risk from fluvial, overland flow, ditches and sewers is considered to be low. However, precautionary mitigation measures as proposed in paragraphs 3.8, 3.9 and 3.15 will mitigate any risk associated with flooding from these sources.

Assessment of Flood Risk Arising from Surface Water Discharge from the Proposed Development

- 4.4 Surface water runoff will be discharged via infiltration SuDS in the form of soakaways and permeable paving/surfacing. Gravel filled trench soakaways are proposed in the rear gardens of the properties to dispose of roof runoff. Soakaways are to be constructed in permeable strata. Permeable paving/surfacing is proposed for the car parking spaces and private driveways. Any hard surfaced areas (for example the bell-mouth access area adjacent to Finkley Road) will be drained via dedicated soakaways.
- 4.5 The infiltration systems have been designed to contain and dispose of surface water runoff from the impermeable areas of the development for storms up to the 1:100 year + 30% climate change event without flooding.
- 4.6 An infiltration rate of $2.7 \times 10^{-3} \text{m/s}$ (10m/hr) has been assumed based on the observed presence of permeable flint strata. A high groundwater table was also observed, within 1m of the existing ground level.
- 4.7 In order to provide a buffer between the highest groundwater table and the base of the infiltration devices, land raising will be required on site. Rear gardens will need to be raised some 0.4m and areas of permeable paving will need to be raised by some 0.3m. Land raising will ensure that a buffer is provided between the base of the infiltration facilities

and the groundwater table. The buffer depth will be 0.5m for house soakaways and 1.0m for permeable paving and any highway soakaways.

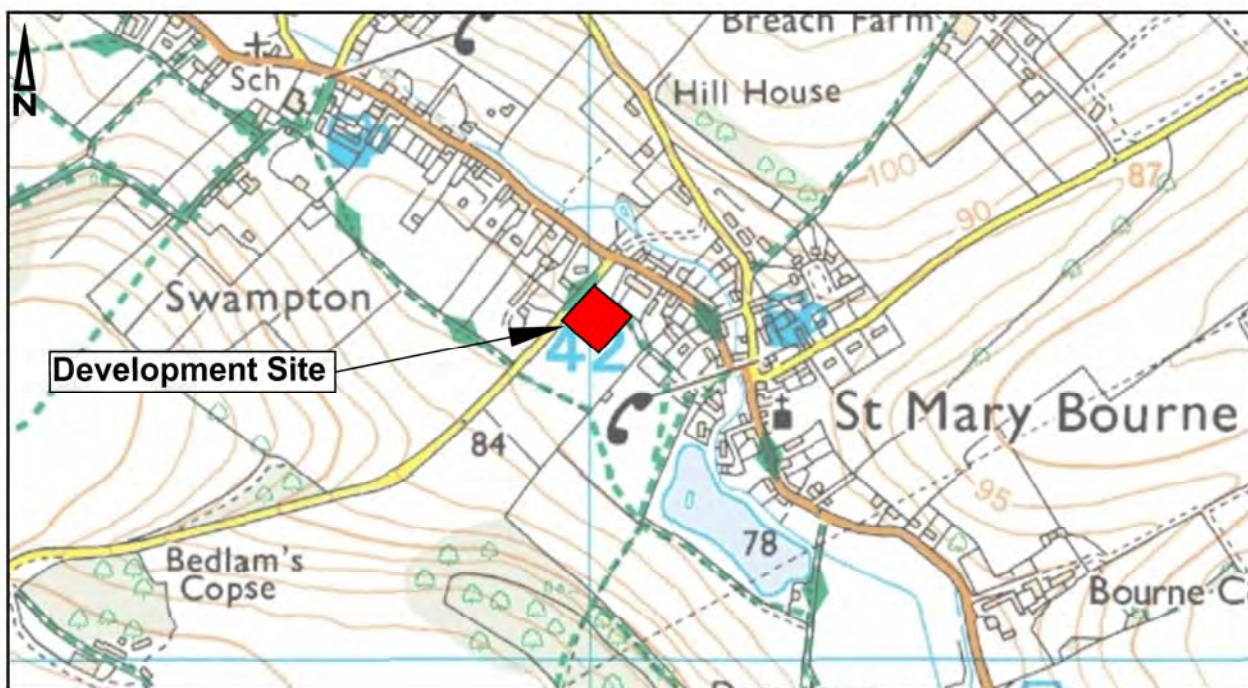
- 4.8 Infiltration SuDS (soakaways and permeable paving) are recognised pollutant removal facilities within the *CIRIA 697 The SuDS Manual*. The surface water drainage system is to be privately maintained.
- 4.9 This study has been undertaken in accordance with the principles set out in NPPF. We can conclude that providing the development adheres to the conditions advised in paragraphs 4.2 to 4.8 above, the said development proposals can be accommodated without increasing flood risk within the locality in accordance with objectives set by Central Government and the EA.

Cole Easdon Consultants Limited
January 2015

Appendix 1



Scale 1:50,000



Scale 1:10,000

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Job Title:

Proposed Residential Development
Land at Bells Field
St Mary Bourne
Hampshire

Drawing Title:

Location Plan

Rev.	Designed	JP
A	Drawn	JP
	Checked	DF
	Date	02.07.14

Client:

Hyde Housing Association Limited

Drawn By

PN

Checked By

DF

Date Drawn

November 2012

Drawing No.

3633/500/Figure 1

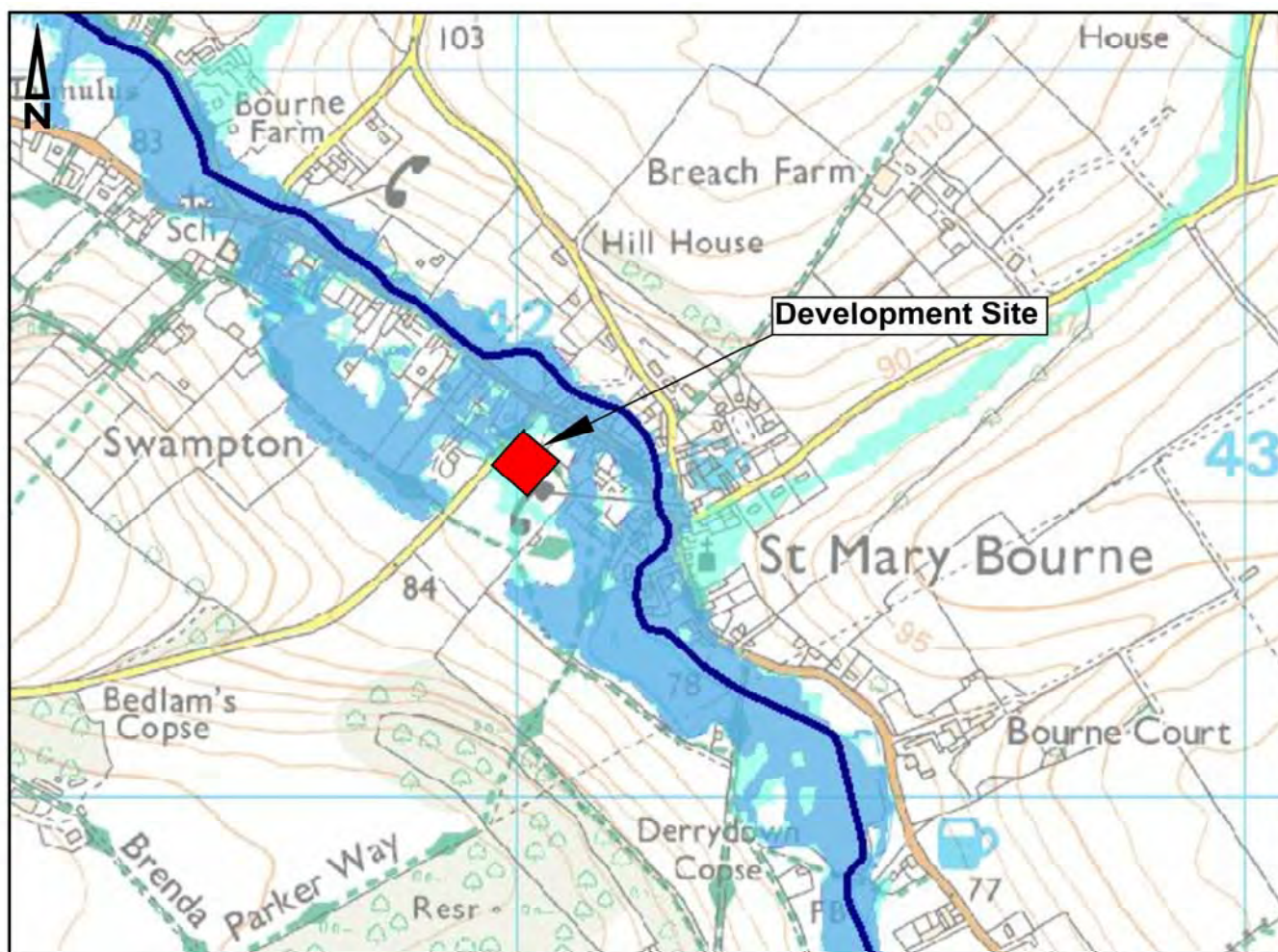
Scale

As shown (A4)

Revision

A

Revision Details
Site boundary amended
Drawing sheet details updated



KEY:



Flood Zone 1
- Low Risk



Flood Zone 2 -
Medium Risk



Flood Zone 3
- High Risk



Main River

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Job Title:

Proposed Residential Development
Land at Bells Field
St Mary Bourne
Hampshire

Drawing Title:

Flood Zone Map

Rev.	Designed	JP	Revision Details	
A	Drawn	JP	Site boundary amended Drawing sheet details updated	
	Checked	DF		
	Date	02.07.14		

Client:

Hyde Housing Association Limited

Drawn By

PN

Date Drawn

November 2012

Scale

1:10,000 @ A4

Checked By

DF

Drawing No.

3633/500/Figure 2

Revision

A

Appendix 2







**British
Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

BGS ID: 13324686 : BGS Reference: SU45SW70

British National Grid (27700) : 442060,150500

[Report an issue with this borehole](#)

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< Prev

Page 1 of 2

Next >

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Housing Development, St Mary Bourne, Hants				24th March 1979		TRIAL PIT: NUMBER 1	
DESCRIPTION	LEVEL m	LEGEND	SAMPLES	DEPTH m	THICKNESS m	S.P.T BLOWS	REMARKS
Stony TOPSOIL				0.0			
Medium dense stony GRAVEL (Maximum size 60 mm)				0.15	0.15		
					1.05		
				1.2			

British Geological Survey				British Geological Survey			British Geological Survey
U4=4" dia Undisturbed Sample, D=Disturbed Sample, SPT=Standard Penetration Test		PAGE					
W=Water Sample, CPT= Cone Penetration Test, V=Vane Test, B=Bulk Sample							
British Geological Survey		British Geological Survey		British Geological Survey			



**British
Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

BGS ID: 13324686 : BGS Reference: SU45SW70

British National Grid (27700) : 442060,150500

[Report an issue with this borehole](#)

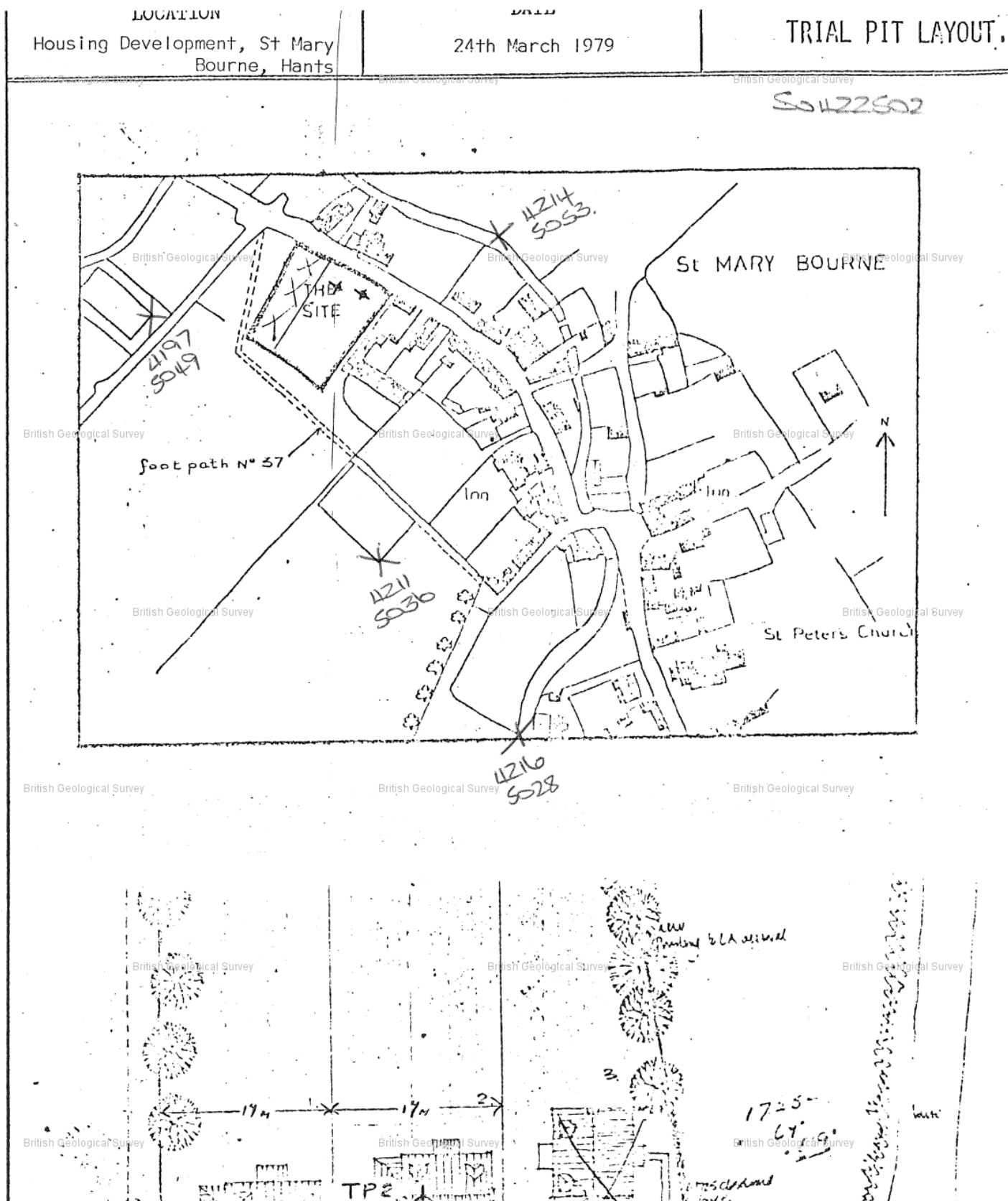
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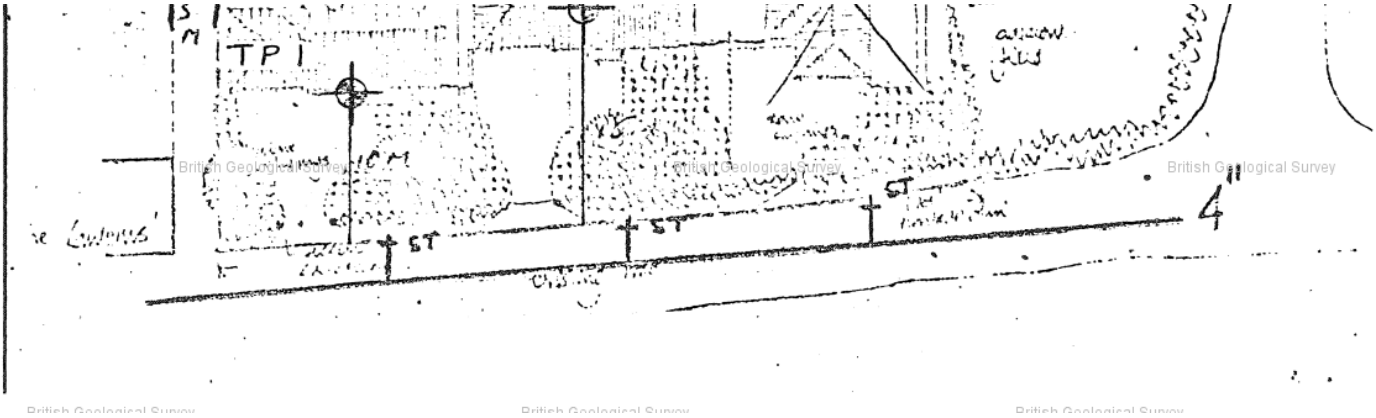
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Page 2 of 2

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British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

BGS ID: 13324687 : BGS Reference: SU45SW71
British National Grid (27700) : 442070,150500
[Report an issue with this borehole](#)

Housing Development, St Mary Bourne, Hants				24th March 1979		TRIAL PIT NUMBER 2	
DESCRIPTION	LEVEL m	LEGEND	SAMPLES	DEPTH m	THICKNESS m	S.P.T. BLOWS	REMARKS
Stony TOPSOIL Medium dense stony GRAVEL (Maximum size 80 mm)				0.0			
				0.2	0.2		
				1.3	1.1		

British Geological Survey				British Geological Survey			British Geological Survey
U4=4" dia Undisturbed Sample, D=Disturbed Sample, SPT=Standard Penetration Test		PAGE					
W=Water Sample. CPT= Cone Penetration Test. V=Vane Test. B=Bulk Sample							
British Geological Survey		British Geological Survey		British Geological Survey			

NATURAL ENVIRONMENT RESEARCH COUNCIL

[Report an issue with this borehole](#)

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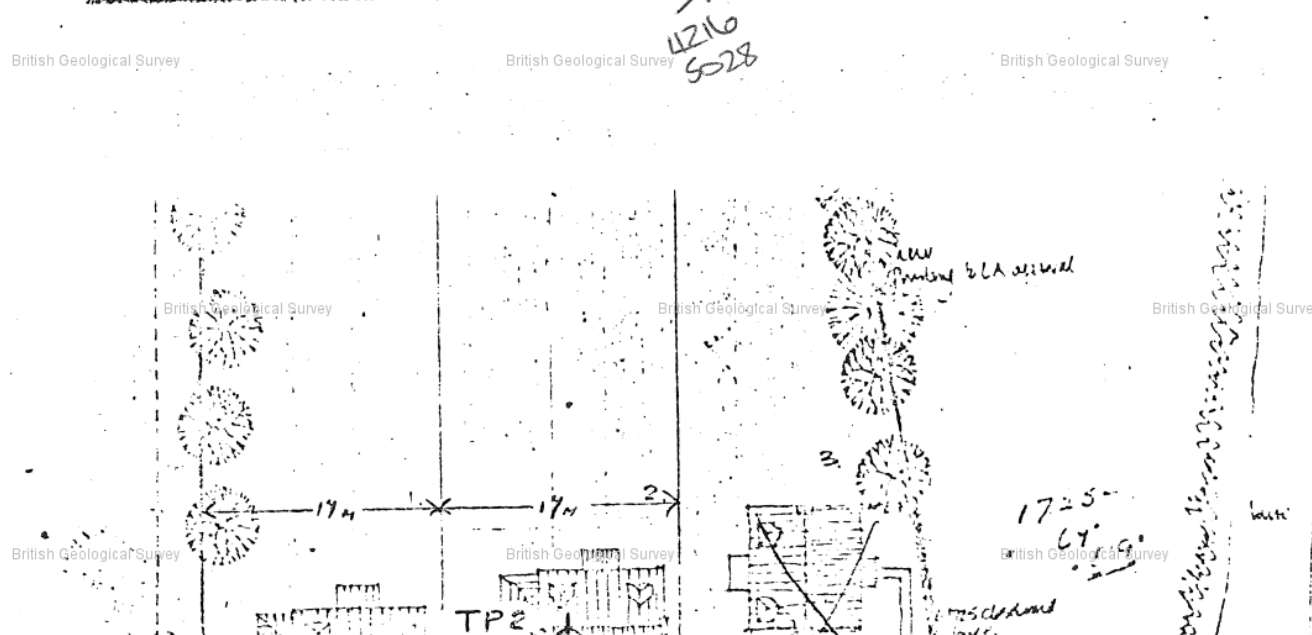
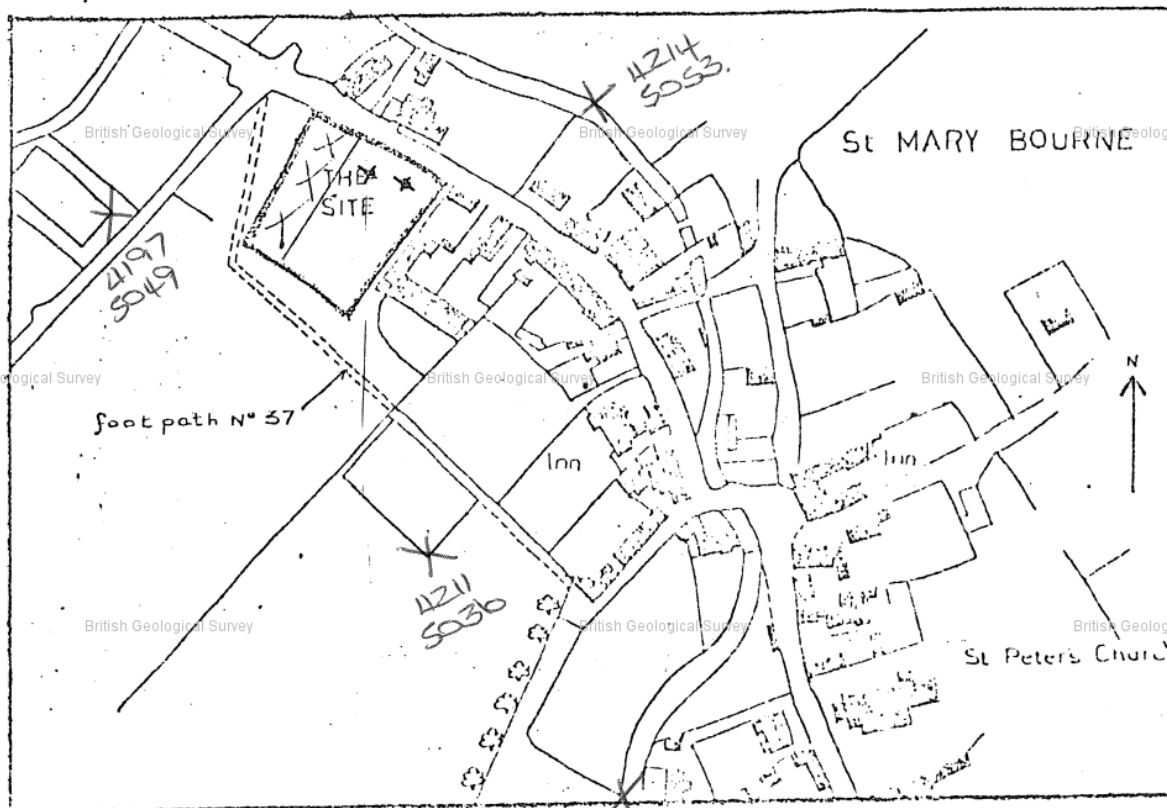
http://scans.bgs.ac.uk/sobi_scans/boreholes/13324

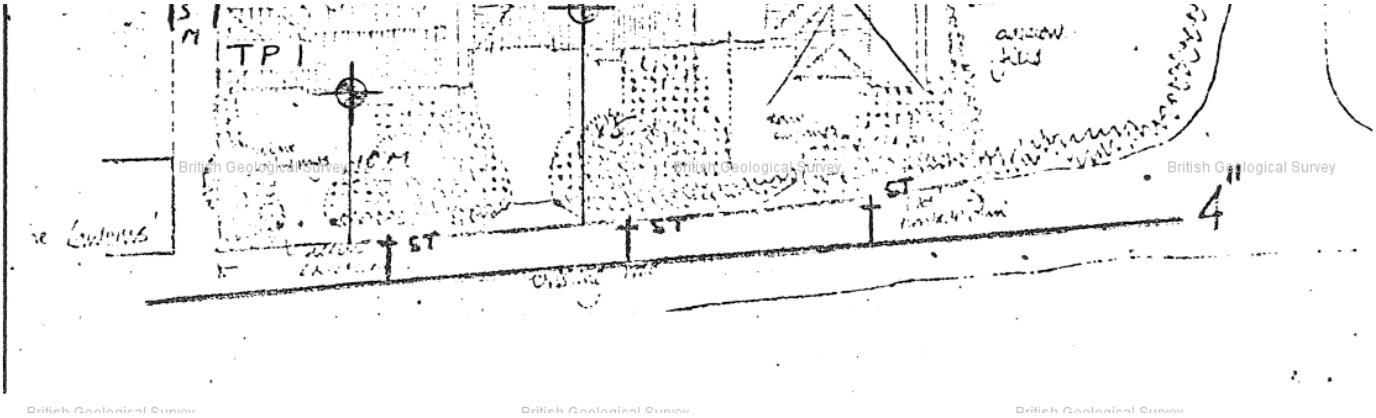
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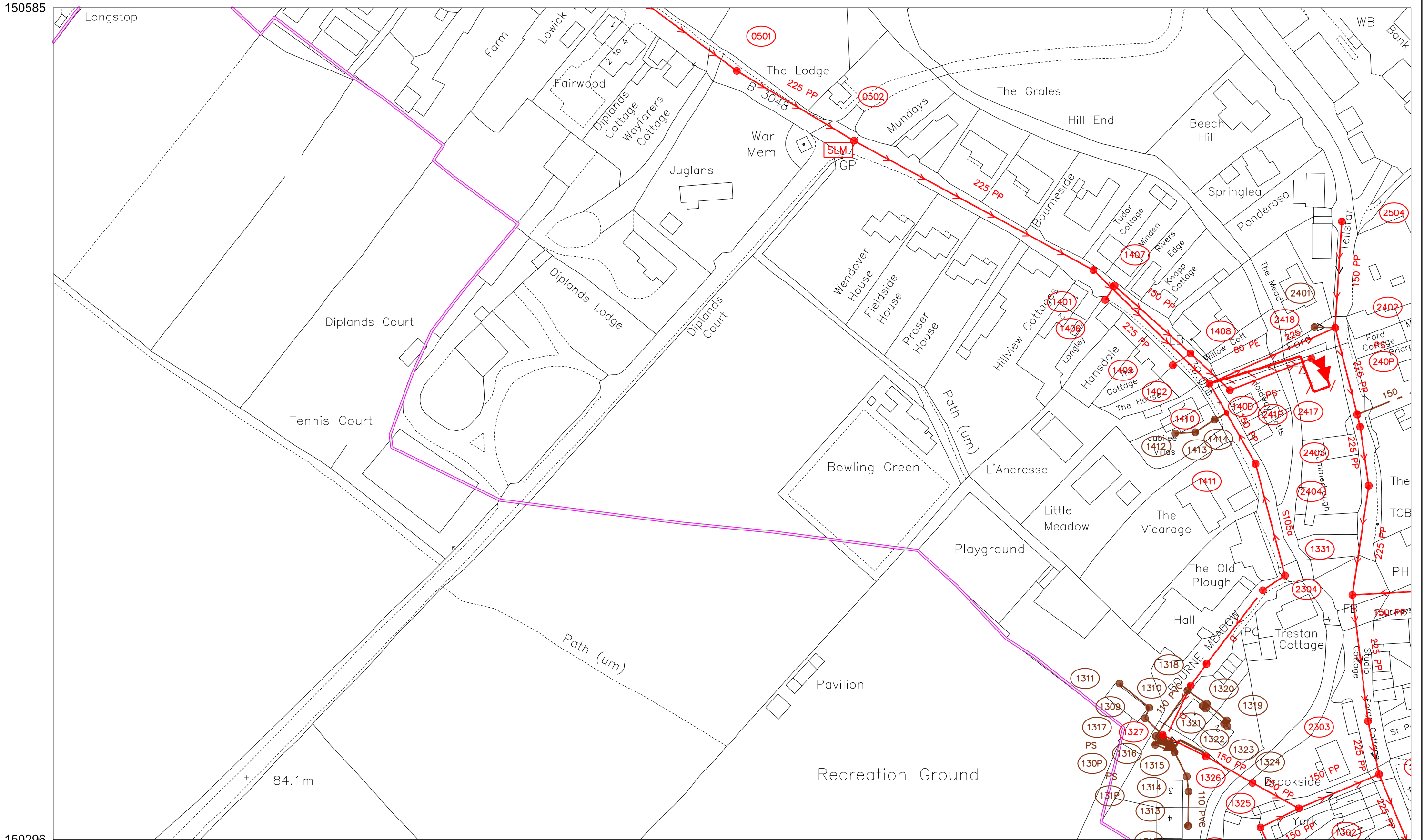
24th March 1979

TRIAL PIT LAYOUT.





SEWER RECORDS PAGE 1 OF 2

[illegible]

SU4250SW

Title: Land at Bells Field St Mary Bo

Drawn by: banerin

Scale: 1:1250

Date: 26/04/2014

The positions of pipes shown on this plan are believed to be correct, but Southern Water Services Ltd accept no responsibility in the event of inaccuracy.

WARNING: BAC pipes are constructed of Bonded Asbestos Cement
WARNING: Unknown (UNK) materials may include Bonded Asbestos Cement

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Southern
Water

SEWER RECORDS PAGE 2 OF 2

Node	Cover	Invert	Size	Material	Shape	Node	Cover	Invert	Size	Material	Shape	Node	Cover	Invert	Size	Material	Shape	Node	Cover	Invert	Size	Material	Shape
0501X	79.67	78.16	225	PP	CIRC																		
0502X	79.43	77.99	225	PP	CIRC																		
1301X	78.29	77.04	150	PP	CIRC																		
1302X	78.35		150	PP	CIRC																		
1309X			UNK	OTHER	CIRC																		
130PZ	78.6	76.2	OTHER	PE	CIRC	*																	
130PX	78.6	76.2	OTHER	PE	CIRC	*																	
130PY	78.6	76.2	OTHER	PE	CIRC	*																	
1310X			UNK	OTHER	CIRC																		
1311X			UNK	OTHER	CIRC																		
1312X	78.494	77.774	OTHER	PVC	CIRC																		
1313X	78.503	77.483	OTHER	PVC	CIRC																		
1314X	78.61	77.35	OTHER	PVC	CIRC																		
1315X	78.59	77.19	OTHER	PVC	CIRC																		
1316X	78.59	77.11	OTHER	PVC	CIRC																		
1317X	78.61	76.99	OTHER	PVC	CIRC																		
1318X	78.64	77.52	OTHER	PVC	CIRC																		
1319X	78.55	77.68	OTHER	PVC	CIRC																		
131PX	78.6	77.285	OTHER	PE	CIRC																		
1320X	78.61	77.55	OTHER	PVC	CIRC																		
1321X			OTHER	PVC	CIRC																		
1322X			OTHER	PVC	CIRC																		
1323X			OTHER	PVC	CIRC																		
1324X			OTHER	PVC	CIRC																		
1325X	78.41	77.13	150	PP	CIRC																		
1326X	78.485		150	PP	CIRC																		
1327X	78.57	77.38	150	PP	CIRC																		
1328X	78.87		UNK	UNK	CIRC																		
1329X	78.78	77.63	150	PP	CIRC																		
1330X	78.67	77.48	150	PP	CIRC																		
1331X			UNK	UNK	CIRC																		
1401X	78.97	77.63	225	PP	CIRC																		
1402X	78.864	77.44	225	UNK	CIRC																		
1406X			OTHER	PP	CIRC																		
1407X	78.96	78.11	150	PP	CIRC																		
1408X	78.858	77.66	150	PP	CIRC																		
1409X	78.827	78.367	100	UNK	CIRC																		
140DX			150	PP	CIRC																		
1410X	78.87	77.22	150	PP	CIRC																		
1411X	79.01	77.55	150	PP	CIRC																		
1412X			UNK	UNK	CIRC																		
1413X			UNK	UNK	CIRC																		
1414X			UNK	UNK	CIRC																		
2301X	78.71	76.63	225	PP	CIRC																		
2303X	78.73	76.65	225	PP	CIRC																		
2304X	78.93	76.82	225	PP	CIRC																		
2401X	79.53	78.68	150	UNK	CIRC																		
2402X	79.64	77.26	225	PP	CIRC																		
2403X	79.32		225	PP	CIRC																		
2404X	79.15	76.9	225	PP	CIRC																		
240PX	79.07		OTHER	PE	CIRC																		
2417X			225	PP	CIRC																		
2418X	78.97	77.06	150	PP	CIRC																		
241PX	79.16	78.225	OTHER	PE	CIRC																		
2504X	81.44	79.71	150	PP	CIRC																		

LINE STYLES / COLOURS

Brown	-----	Foul
	-----	Foul Syphon Sewer
	-----	Foul Vacuum Main
	-----	Foul Rising Main
Red	-----	Combined
	-----	Combined Syphon Sewer
	-----	Combined Rising Main
Orange	-----	Lateral Drain
Dark Blue	-----	Building Over Agreement Area
Purple	-----	Treated Effluent
	-----	Sludge
	-----	Sewer Catchment
	-----	Section 104 Area
Light Blue	-----	Surface Water
	-----	Surface Water Rising Main
Yellow	-----	Private
Green	-----	Access Shaft
	-----	Decommissioned

MATERIALS

AK	Alkathene
BAC	Bonded Asbestos Cement
BRC	Brick (Common)
BRE	Brick (Engineering)
CC	Concrete Box Culvert
CI	Cast Iron
CO	Concrete (In-Situ)
CP	Concrete (Pre-Cast)
CSB	Concrete Segments (bolted)
CSU	Concrete Segments (unbolted)
DI	Ductile Iron
GRC	Glass Reinforced Concrete
GRP	Glass Reinforced Plastic
MAC	Masonry in regular Courses
MAR	Masonry in random Courses
PE	Polyethylene
PF	Pitch Fibre
PP	Polypropylene
PVC	Polyvinyl Chloride
RPM	Reinforced Plastic Matrix
SI	Spun Iron
ST	Steel
VC	Vertical Clay
XXX	Other
ZZZ	Unknown

Manhole (SW)
Manhole (F&C)
Lamp hole (SW)
Lamp hole (F&C)
Pumping Station (SW)
Pumping Station (F&C)
Side entry manhole (SW)
Side entry Manhole (F&C)
Blind shaft (SW)
Blind shaft (F&C)
Ejector station (SW)
Ejector station (F&C)
Watertight door (SW)
Watertight door (F&C)
Flushing ch. Min-e (SW)
Flushing ch. Min-e (F&C)
Flushing ch. No-e (SW)
Flushing ch. No-e (F&C)
Demarcation Chamber

LEGEND - SEWERS

Washout (SW)
Washout (F&C)
Rodding Eye (SW)
Rodding Eye (F&C)
Gauging point (SW)
Gauging point (F&C)
Intercept chamber (SW)
Intercept chamber (F&C)
Storm Tank (SW)
Storm Tank (F&C)
Vortex chamber (SW)
Vortex chamber (F&C)
Label ellipse
Dummy/S24 manhole
Outfall
Penstock chamber
Damboards
Storm Overflow
Backdrop manhole

Other (s)
Other
Change in sewer (s)
Change in sewer
Reflex valve
Flap valve
Cascade
Anode
Valve
Closed Valve
Air Valve
Hatch box (SW)
Hatch box (F&C)
Direction arrow
Emptying valve
Catchpit
Soakaway
Inlet
Balancing Pond

Wastewater treatment works
Marine treatment works
Outfall headworks
Vent
Vent column
Tidal storage tank
Blank end
Head of Public Sewer
Micro Pumping Station

SHAPES (S)

A	Arched	R	Rectangular
B	Barrel	S	Square
C	Circular	T	Trapezoidal
E	Egg	U	U Shape
H	Horseshoe	X	Other

NODE REFERENCING SYSTEM

1st digit:	hundred metre easting identifier
2nd digit:	hundred metre northing identifier
3rd digit:	sewer type identifier
4th digit:	next sequential node

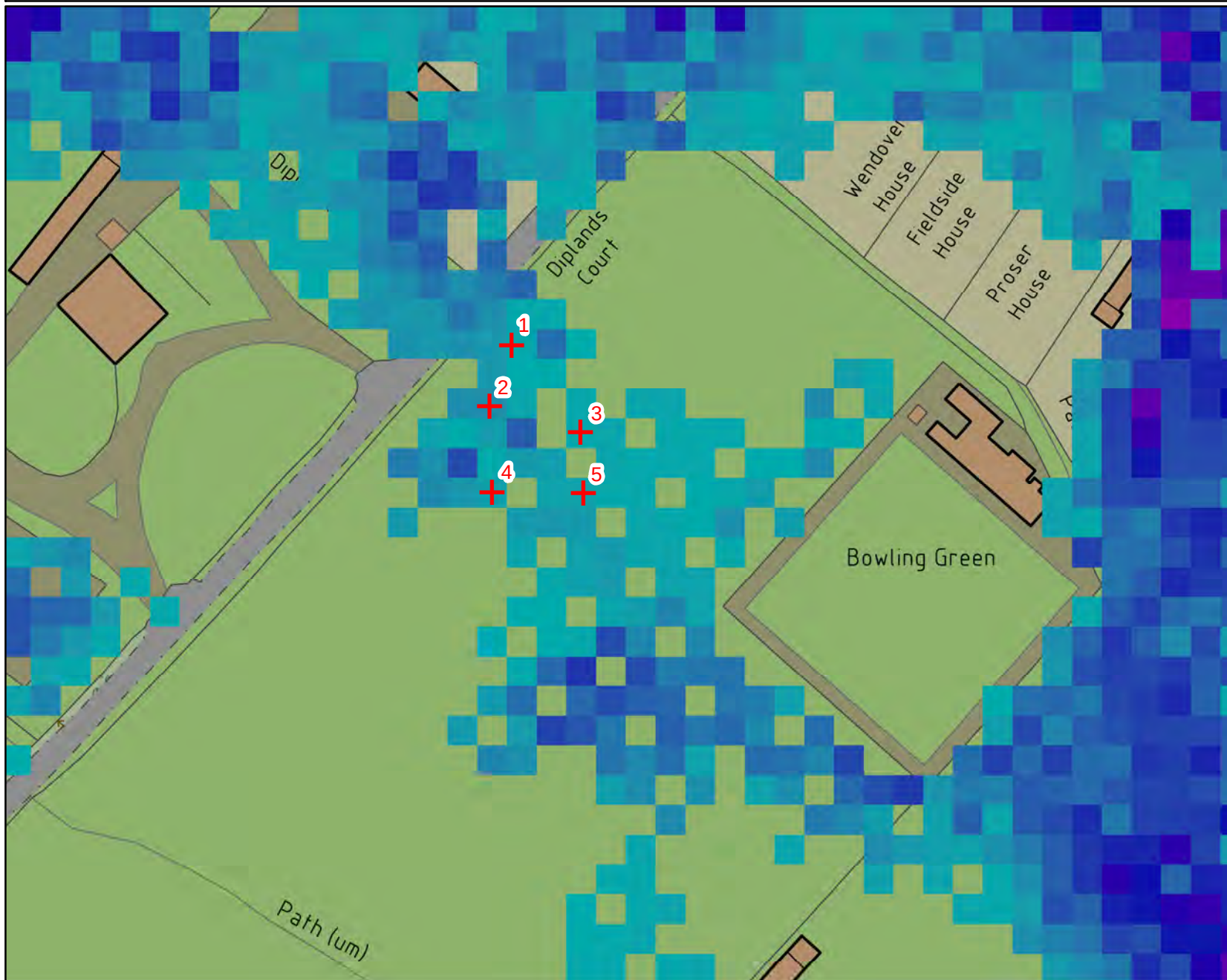
Drawn by: banerin

Title: Land at Bells Field St Mary Bo

Date: 26/04/2014



Appendix 3



Legend

 Location Points

Ground Level

Value

High : 3.40282e+038

Low : 1.17549e-038

1:1000 Modelled Flood Outline

Value

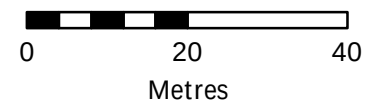
High : 2.74291

Low : 0

1:942

*

*when printed at A4.



JFLOW Levels for SU 41966 50399
in metres AOD

1:1000

Location Point	Ground Level	Water Depth	Total
1	79.90	0.01	79.91
2	79.72	0.06	79.78
3	79.90	0.01	79.91
4	79.87	0.02	79.89
5	79.75	0.02	79.77

Mr Dean Frosoni

Our ref: WA/2013/113874/01-L01

Your ref: 3633

Date: 04 January 2013

Dear Mr Frosoni

PROPOSED RESIDENTIAL DEVELOPMENT

BELLS FIELD, ST MARY BOURNE, HAMPSHIRE, SP11

Thank you for your enquiry re: draft Flood Risk Assessment (FRA) for a proposed residential development at the above site , which was received on 20 December 2012. We have the following comments to make:

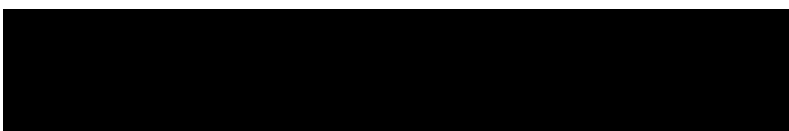
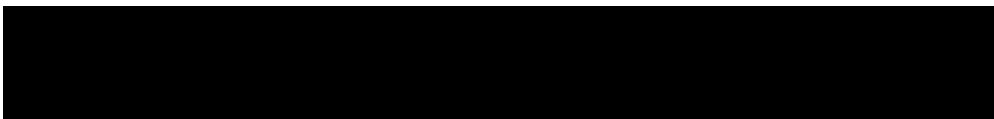
In principle, the Environment Agency would have no objection to the proposed development in terms of flood risk providing the mitigation measures as detailed in the draft FRA, dated December 2012 are carried out. We would also have no objection with regard to the proposed surface water drainage scheme.

Our comments have been made in response to the information submitted. Please be aware that we may raise additional issues when more detailed plans are submitted.

If you have any queries, please do not hesitate to contact me.

Yours sincerely

Mr Gareth Johns
Planning Officer
Sustainable Places



Appendix 4

Cole Easdon Consultants		Page 1
York House, Edison Park Dorcan Way Swindon, SN3 3RB	3633 St Mary Bourne Greenfield Runoff Rate	
Date 03/07/2014 11:51 File 100YR CC TRENCH SOAKAWA...	Designed by jpockett Checked by DF	
Elstree Computing Ltd Source Control 2014.1		

ICP SUDS Mean Annual Flood

Input

Return Period (years)	100	Soil	0.150
Area (ha)	0.410	Urban	0.000
SAAR (mm)	800	Region Number	Region 7

Results 1/s

QBAR Rural	0.2
QBAR Urban	0.2
Q100 years	0.6
Q1 year	0.2
Q30 years	0.4
Q100 years	0.6

©1982-2014 XP Solutions

Cole Easdon Consultants				Page 1																																																																																																																																																																																																																			
160 Aztec Aztec West Bristol BS32 4TU		3633 St Mary Bourne Prelim Trench Soakaway Dwelling 1,3,8,9,10,11																																																																																																																																																																																																																					
Date 13/01/2015 15:04 File 100YR CC TRENCH SOAKAWA...		Designed by jpockett Checked by DF																																																																																																																																																																																																																					
XP Solutions		Source Control 2014.1.1																																																																																																																																																																																																																					
<u>Summary of Results for 100 year Return Period (+30%)</u> Half Drain Time : 0 minutes. <table><thead><tr><th>Storm Event</th><th>Max Level (m)</th><th>Max Depth (m)</th><th>Max Infiltration (l/s)</th><th>Max Volume (m³)</th><th>Status</th></tr></thead><tbody><tr><td>15 min Summer</td><td>11.474</td><td>0.274</td><td>3.3</td><td>0.1</td><td>O K</td></tr><tr><td>30 min Summer</td><td>11.422</td><td>0.222</td><td>3.0</td><td>0.1</td><td>O K</td></tr><tr><td>60 min Summer</td><td>11.285</td><td>0.085</td><td>2.2</td><td>0.0</td><td>O K</td></tr><tr><td>120 min Summer</td><td>11.239</td><td>0.039</td><td>1.5</td><td>0.0</td><td>O K</td></tr><tr><td>180 min Summer</td><td>11.229</td><td>0.029</td><td>1.2</td><td>0.0</td><td>O K</td></tr><tr><td>240 min Summer</td><td>11.224</td><td>0.024</td><td>1.0</td><td>0.0</td><td>O K</td></tr><tr><td>360 min Summer</td><td>11.218</td><td>0.018</td><td>0.7</td><td>0.0</td><td>O K</td></tr><tr><td>480 min Summer</td><td>11.215</td><td>0.015</td><td>0.6</td><td>0.0</td><td>O K</td></tr><tr><td>600 min Summer</td><td>11.212</td><td>0.012</td><td>0.5</td><td>0.0</td><td>O K</td></tr><tr><td>720 min Summer</td><td>11.211</td><td>0.011</td><td>0.4</td><td>0.0</td><td>O K</td></tr><tr><td>960 min Summer</td><td>11.209</td><td>0.009</td><td>0.3</td><td>0.0</td><td>O K</td></tr><tr><td>1440 min Summer</td><td>11.207</td><td>0.007</td><td>0.3</td><td>0.0</td><td>O K</td></tr><tr><td>2160 min Summer</td><td>11.205</td><td>0.005</td><td>0.2</td><td>0.0</td><td>O K</td></tr><tr><td>2880 min Summer</td><td>11.205</td><td>0.005</td><td>0.2</td><td>0.0</td><td>O K</td></tr><tr><td>4320 min Summer</td><td>11.203</td><td>0.003</td><td>0.1</td><td>0.0</td><td>O K</td></tr><tr><td>5760 min Summer</td><td>11.202</td><td>0.002</td><td>0.1</td><td>0.0</td><td>O K</td></tr><tr><td>7200 min Summer</td><td>11.202</td><td>0.002</td><td>0.1</td><td>0.0</td><td>O K</td></tr><tr><td>8640 min Summer</td><td>11.202</td><td>0.002</td><td>0.1</td><td>0.0</td><td>O K</td></tr><tr><td>10080 min Summer</td><td>11.201</td><td>0.001</td><td>0.0</td><td>0.0</td><td>O K</td></tr><tr><td>15 min Winter</td><td>11.478</td><td>0.278</td><td>3.4</td><td>0.1</td><td>O K</td></tr></tbody></table> <table><thead><tr><th>Storm Event</th><th>Rain (mm/hr)</th><th>Flooded Volume (m³)</th><th>Time-Peak (mins)</th></tr></thead><tbody><tr><td>15 min Summer</td><td>122.433</td><td>0.0</td><td>10</td></tr><tr><td>30 min Summer</td><td>82.239</td><td>0.0</td><td>18</td></tr><tr><td>60 min Summer</td><td>52.662</td><td>0.0</td><td>32</td></tr><tr><td>120 min Summer</td><td>32.503</td><td>0.0</td><td>62</td></tr><tr><td>180 min Summer</td><td>24.118</td><td>0.0</td><td>94</td></tr><tr><td>240 min Summer</td><td>19.386</td><td>0.0</td><td>124</td></tr><tr><td>360 min Summer</td><td>14.268</td><td>0.0</td><td>186</td></tr><tr><td>480 min Summer</td><td>11.460</td><td>0.0</td><td>244</td></tr><tr><td>600 min Summer</td><td>9.659</td><td>0.0</td><td>304</td></tr><tr><td>720 min Summer</td><td>8.396</td><td>0.0</td><td>366</td></tr><tr><td>960 min Summer</td><td>6.724</td><td>0.0</td><td>484</td></tr><tr><td>1440 min Summer</td><td>4.907</td><td>0.0</td><td>732</td></tr><tr><td>2160 min Summer</td><td>3.573</td><td>0.0</td><td>1068</td></tr><tr><td>2880 min Summer</td><td>2.849</td><td>0.0</td><td>1400</td></tr><tr><td>4320 min Summer</td><td>2.067</td><td>0.0</td><td>2208</td></tr><tr><td>5760 min Summer</td><td>1.644</td><td>0.0</td><td>3752</td></tr><tr><td>7200 min Summer</td><td>1.377</td><td>0.0</td><td>2744</td></tr><tr><td>8640 min Summer</td><td>1.193</td><td>0.0</td><td>5000</td></tr><tr><td>10080 min Summer</td><td>1.056</td><td>0.0</td><td>4024</td></tr><tr><td>15 min Winter</td><td>122.433</td><td>0.0</td><td>10</td></tr></tbody></table>						Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status	15 min Summer	11.474	0.274	3.3	0.1	O K	30 min 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min Summer	14.268	0.0	186	480 min Summer	11.460	0.0	244	600 min Summer	9.659	0.0	304	720 min Summer	8.396	0.0	366	960 min Summer	6.724	0.0	484	1440 min Summer	4.907	0.0	732	2160 min Summer	3.573	0.0	1068	2880 min Summer	2.849	0.0	1400	4320 min Summer	2.067	0.0	2208	5760 min Summer	1.644	0.0	3752	7200 min Summer	1.377	0.0	2744	8640 min Summer	1.193	0.0	5000	10080 min Summer	1.056	0.0	4024	15 min Winter	122.433	0.0	10
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15 min Winter	122.433	0.0	10																																																																																																																																																																																																																				
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Cole Easdon Consultants				Page 2	
160 Aztec Aztec West Bristol BS32 4TU		3633 St Mary Bourne Prelim Trench Soakaway Dwelling 1,3,8,9,10,11			
Date 13/01/2015 15:04 File 100YR CC TRENCH SOAKAWA...		Designed by jpockett Checked by DF			
XP Solutions		Source Control 2014.1.1			
<u>Summary of Results for 100 year Return Period (+30%)</u>					
Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	11.365	0.165	2.7	0.1	O K
60 min Winter	11.246	0.046	1.8	0.0	O K
120 min Winter	11.229	0.029	1.2	0.0	O K
180 min Winter	11.222	0.022	0.9	0.0	O K
240 min Winter	11.218	0.018	0.7	0.0	O K
360 min Winter	11.214	0.014	0.5	0.0	O K
480 min Winter	11.211	0.011	0.4	0.0	O K
600 min Winter	11.209	0.009	0.4	0.0	O K
720 min Winter	11.209	0.009	0.3	0.0	O K
960 min Winter	11.207	0.007	0.3	0.0	O K
1440 min Winter	11.205	0.005	0.2	0.0	O K
2160 min Winter	11.204	0.004	0.2	0.0	O K
2880 min Winter	11.204	0.004	0.2	0.0	O K
4320 min Winter	11.202	0.002	0.1	0.0	O K
5760 min Winter	11.202	0.002	0.1	0.0	O K
7200 min Winter	11.201	0.001	0.0	0.0	O K
8640 min Winter	11.201	0.001	0.0	0.0	O K
10080 min Winter	11.201	0.001	0.0	0.0	O K
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)		
30 min Winter	82.239	0.0	18		
60 min Winter	52.662	0.0	34		
120 min Winter	32.503	0.0	60		
180 min Winter	24.118	0.0	92		
240 min Winter	19.386	0.0	120		
360 min Winter	14.268	0.0	192		
480 min Winter	11.460	0.0	262		
600 min Winter	9.659	0.0	304		
720 min Winter	8.396	0.0	384		
960 min Winter	6.724	0.0	494		
1440 min Winter	4.907	0.0	792		
2160 min Winter	3.573	0.0	1164		
2880 min Winter	2.849	0.0	1600		
4320 min Winter	2.067	0.0	2308		
5760 min Winter	1.644	0.0	3992		
7200 min Winter	1.377	0.0	2672		
8640 min Winter	1.193	0.0	2864		
10080 min Winter	1.056	0.0	5752		
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Cole Easdon Consultants		Page 3
160 Aztec Aztec West Bristol BS32 4TU	3633 St Mary Bourne Prelim Trench Soakaway Dwelling 1,3,8,9,10,11	
Date 13/01/2015 15:04 File 100YR CC TRENCH SOAKAWA...	Designed by jpockett Checked by DF	
XP Solutions	Source Control 2014.1.1	

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.006

Time (mins)	Area
From:	To: (ha)

0	4 0.006
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160 Aztec Aztec West Bristol BS32 4TU	3633 St Mary Bourne Prelim Trench Soakaway Dwelling 1,3,8,9,10,11	
Date 13/01/2015 15:04 File 100YR CC TRENCH SOAKAWA...	Designed by jpockett Checked by DF	
XP Solutions	Source Control 2014.1.1	
Model Details Storage is Online Cover Level (m) 12.000 Trench Soakaway Structure Infiltration Coefficient Base (m/hr) 10.00000 Infiltration Coefficient Side (m/hr) 10.00000 Safety Factor2.0 Porosity0.30 Invert Level (m)11.200 Trench Width (m)1.0 Trench Length (m)1.2 Slope (1:X)1000.0 Cap Volume Depth (m)0.300 Cap Infiltration Depth (m)0.300		
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Cole Easdon Consultants				Page 1																																																																																																																																																																																																																			
160 Aztec Aztec West Bristol BS32 4TU		3633 St Mary Bourne Prelim Trench Soakaway Dwelling 2,4,5,6,7																																																																																																																																																																																																																					
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<u>Summary of Results for 100 year Return Period (+30%)</u> Half Drain Time : 0 minutes. <table><thead><tr><th>Storm Event</th><th>Max Level (m)</th><th>Max Depth (m)</th><th>Max Infiltration (l/s)</th><th>Max Volume (m³)</th><th>Status</th></tr></thead><tbody><tr><td>15 min Summer</td><td>11.456</td><td>0.256</td><td>2.8</td><td>0.1</td><td>O K</td></tr><tr><td>30 min Summer</td><td>11.406</td><td>0.206</td><td>2.5</td><td>0.1</td><td>O K</td></tr><tr><td>60 min Summer</td><td>11.280</td><td>0.080</td><td>1.8</td><td>0.0</td><td>O K</td></tr><tr><td>120 min Summer</td><td>11.239</td><td>0.039</td><td>1.3</td><td>0.0</td><td>O K</td></tr><tr><td>180 min Summer</td><td>11.230</td><td>0.030</td><td>1.0</td><td>0.0</td><td>O K</td></tr><tr><td>240 min Summer</td><td>11.224</td><td>0.024</td><td>0.8</td><td>0.0</td><td>O K</td></tr><tr><td>360 min Summer</td><td>11.218</td><td>0.018</td><td>0.6</td><td>0.0</td><td>O K</td></tr><tr><td>480 min Summer</td><td>11.215</td><td>0.015</td><td>0.5</td><td>0.0</td><td>O K</td></tr><tr><td>600 min Summer</td><td>11.213</td><td>0.013</td><td>0.4</td><td>0.0</td><td>O K</td></tr><tr><td>720 min Summer</td><td>11.211</td><td>0.011</td><td>0.4</td><td>0.0</td><td>O K</td></tr><tr><td>960 min Summer</td><td>11.209</td><td>0.009</td><td>0.3</td><td>0.0</td><td>O K</td></tr><tr><td>1440 min Summer</td><td>11.207</td><td>0.007</td><td>0.2</td><td>0.0</td><td>O K</td></tr><tr><td>2160 min Summer</td><td>11.205</td><td>0.005</td><td>0.2</td><td>0.0</td><td>O K</td></tr><tr><td>2880 min Summer</td><td>11.204</td><td>0.004</td><td>0.1</td><td>0.0</td><td>O K</td></tr><tr><td>4320 min Summer</td><td>11.205</td><td>0.005</td><td>0.2</td><td>0.0</td><td>O K</td></tr><tr><td>5760 min Summer</td><td>11.203</td><td>0.003</td><td>0.1</td><td>0.0</td><td>O K</td></tr><tr><td>7200 min Summer</td><td>11.202</td><td>0.002</td><td>0.1</td><td>0.0</td><td>O K</td></tr><tr><td>8640 min Summer</td><td>11.202</td><td>0.002</td><td>0.1</td><td>0.0</td><td>O K</td></tr><tr><td>10080 min Summer</td><td>11.202</td><td>0.002</td><td>0.1</td><td>0.0</td><td>O K</td></tr><tr><td>15 min Winter</td><td>11.460</td><td>0.260</td><td>2.8</td><td>0.1</td><td>O K</td></tr></tbody></table> <table><thead><tr><th>Storm Event</th><th>Rain (mm/hr)</th><th>Flooded Volume (m³)</th><th>Time-Peak (mins)</th></tr></thead><tbody><tr><td>15 min Summer</td><td>122.433</td><td>0.0</td><td>10</td></tr><tr><td>30 min Summer</td><td>82.239</td><td>0.0</td><td>18</td></tr><tr><td>60 min Summer</td><td>52.662</td><td>0.0</td><td>32</td></tr><tr><td>120 min Summer</td><td>32.503</td><td>0.0</td><td>62</td></tr><tr><td>180 min Summer</td><td>24.118</td><td>0.0</td><td>92</td></tr><tr><td>240 min Summer</td><td>19.386</td><td>0.0</td><td>122</td></tr><tr><td>360 min Summer</td><td>14.268</td><td>0.0</td><td>176</td></tr><tr><td>480 min Summer</td><td>11.460</td><td>0.0</td><td>240</td></tr><tr><td>600 min Summer</td><td>9.659</td><td>0.0</td><td>298</td></tr><tr><td>720 min Summer</td><td>8.396</td><td>0.0</td><td>360</td></tr><tr><td>960 min Summer</td><td>6.724</td><td>0.0</td><td>480</td></tr><tr><td>1440 min Summer</td><td>4.907</td><td>0.0</td><td>724</td></tr><tr><td>2160 min Summer</td><td>3.573</td><td>0.0</td><td>1076</td></tr><tr><td>2880 min Summer</td><td>2.849</td><td>0.0</td><td>1496</td></tr><tr><td>4320 min Summer</td><td>2.067</td><td>0.0</td><td>2176</td></tr><tr><td>5760 min Summer</td><td>1.644</td><td>0.0</td><td>3088</td></tr><tr><td>7200 min Summer</td><td>1.377</td><td>0.0</td><td>4488</td></tr><tr><td>8640 min Summer</td><td>1.193</td><td>0.0</td><td>3824</td></tr><tr><td>10080 min Summer</td><td>1.056</td><td>0.0</td><td>4080</td></tr><tr><td>15 min Winter</td><td>122.433</td><td>0.0</td><td>10</td></tr></tbody></table>						Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status	15 min Summer	11.456	0.256	2.8	0.1	O K	30 min Summer	11.406	0.206	2.5	0.1	O K	60 min Summer	11.280	0.080	1.8	0.0	O K	120 min Summer	11.239	0.039	1.3	0.0	O K	180 min Summer	11.230	0.030	1.0	0.0	O K	240 min Summer	11.224	0.024	0.8	0.0	O K	360 min Summer	11.218	0.018	0.6	0.0	O K	480 min Summer	11.215	0.015	0.5	0.0	O K	600 min Summer	11.213	0.013	0.4	0.0	O K	720 min Summer	11.211	0.011	0.4	0.0	O K	960 min Summer	11.209	0.009	0.3	0.0	O K	1440 min Summer	11.207	0.007	0.2	0.0	O K	2160 min Summer	11.205	0.005	0.2	0.0	O K	2880 min Summer	11.204	0.004	0.1	0.0	O K	4320 min Summer	11.205	0.005	0.2	0.0	O K	5760 min Summer	11.203	0.003	0.1	0.0	O K	7200 min Summer	11.202	0.002	0.1	0.0	O K	8640 min Summer	11.202	0.002	0.1	0.0	O K	10080 min Summer	11.202	0.002	0.1	0.0	O K	15 min Winter	11.460	0.260	2.8	0.1	O K	Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)	15 min Summer	122.433	0.0	10	30 min Summer	82.239	0.0	18	60 min Summer	52.662	0.0	32	120 min Summer	32.503	0.0	62	180 min Summer	24.118	0.0	92	240 min Summer	19.386	0.0	122	360 min Summer	14.268	0.0	176	480 min Summer	11.460	0.0	240	600 min Summer	9.659	0.0	298	720 min Summer	8.396	0.0	360	960 min Summer	6.724	0.0	480	1440 min Summer	4.907	0.0	724	2160 min Summer	3.573	0.0	1076	2880 min Summer	2.849	0.0	1496	4320 min Summer	2.067	0.0	2176	5760 min Summer	1.644	0.0	3088	7200 min Summer	1.377	0.0	4488	8640 min Summer	1.193	0.0	3824	10080 min Summer	1.056	0.0	4080	15 min Winter	122.433	0.0	10
Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status																																																																																																																																																																																																																		
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Cole Easdon Consultants				Page 2	
160 Aztec Aztec West Bristol BS32 4TU		3633 St Mary Bourne Prelim Trench Soakaway Dwelling 2,4,5,6,7			
Date 13/01/2015 15:07 File 100YR CC TRENCH SOAKAWA...		Designed by jpockett Checked by DF			
XP Solutions		Source Control 2014.1.1			
<u>Summary of Results for 100 year Return Period (+30%)</u>					
Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	11.352	0.152	2.2	0.0	O K
60 min Winter	11.246	0.046	1.5	0.0	O K
120 min Winter	11.229	0.029	1.0	0.0	O K
180 min Winter	11.222	0.022	0.7	0.0	O K
240 min Winter	11.217	0.017	0.6	0.0	O K
360 min Winter	11.213	0.013	0.4	0.0	O K
480 min Winter	11.210	0.010	0.3	0.0	O K
600 min Winter	11.209	0.009	0.3	0.0	O K
720 min Winter	11.208	0.008	0.3	0.0	O K
960 min Winter	11.206	0.006	0.2	0.0	O K
1440 min Winter	11.205	0.005	0.2	0.0	O K
2160 min Winter	11.204	0.004	0.1	0.0	O K
2880 min Winter	11.203	0.003	0.1	0.0	O K
4320 min Winter	11.203	0.003	0.1	0.0	O K
5760 min Winter	11.202	0.002	0.1	0.0	O K
7200 min Winter	11.202	0.002	0.1	0.0	O K
8640 min Winter	11.202	0.002	0.1	0.0	O K
10080 min Winter	11.202	0.002	0.1	0.0	O K
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)		
30 min Winter	82.239	0.0	18		
60 min Winter	52.662	0.0	32		
120 min Winter	32.503	0.0	60		
180 min Winter	24.118	0.0	92		
240 min Winter	19.386	0.0	126		
360 min Winter	14.268	0.0	180		
480 min Winter	11.460	0.0	250		
600 min Winter	9.659	0.0	318		
720 min Winter	8.396	0.0	364		
960 min Winter	6.724	0.0	486		
1440 min Winter	4.907	0.0	748		
2160 min Winter	3.573	0.0	1156		
2880 min Winter	2.849	0.0	1380		
4320 min Winter	2.067	0.0	2084		
5760 min Winter	1.644	0.0	3576		
7200 min Winter	1.377	0.0	2392		
8640 min Winter	1.193	0.0	5424		
10080 min Winter	1.056	0.0	5096		
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160 Aztec Aztec West Bristol BS32 4TU	3633 St Mary Bourne Prelim Trench Soakaway Dwelling 2,4,5,6,7	
Date 13/01/2015 15:07 File 100YR CC TRENCH SOAKAWA...	Designed by jpockett Checked by DF	
XP Solutions	Source Control 2014.1.1	

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.005

Time (mins)	Area
From:	To: (ha)

0	4 0.005
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160 Aztec Aztec West Bristol BS32 4TU	3633 St Mary Bourne Prelim Trench Soakaway Dwelling 2,4,5,6,7	
Date 13/01/2015 15:07 File 100YR CC TRENCH SOAKAWA...	Designed by jpockett Checked by DF	
XP Solutions		
Source Control 2014.1.1		
Model Details Storage is Online Cover Level (m) 12.000 Trench Soakaway Structure Infiltration Coefficient Base (m/hr) 10.00000 Infiltration Coefficient Side (m/hr) 10.00000 Safety Factor2.0 Porosity0.30 Invert Level (m)11.200 Trench Width (m)1.0 Trench Length (m)1.0 Slope (1:X)1000.0 Cap Volume Depth (m)0.300 Cap Infiltration Depth (m)0.300		
©1982-2014 XP Solutions		

Cole Easdon Consultants		Page 1
York House Edison Park Dorcan Way Swindon SN3 3RB	3633 St Mary Bourne Permeable Paving Prelim	
Date 150213 File 100YR CC PRELIMIN...	Designed By JP Checked By	
Elstree Computing Ltd	Source Control W.12.4	

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 0 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m ³)	Status
15 min Summer	9.902	0.002	6.3	0.1	Flood Risk
30 min Summer	9.902	0.002	6.3	0.1	Flood Risk
60 min Summer	9.902	0.002	4.9	0.1	Flood Risk
120 min Summer	9.901	0.001	3.5	0.1	Flood Risk
180 min Summer	9.901	0.001	1.6	0.1	Flood Risk
240 min Summer	9.901	0.001	1.6	0.0	Flood Risk
360 min Summer	9.901	0.001	1.6	0.0	Flood Risk
480 min Summer	9.901	0.001	1.6	0.0	Flood Risk
600 min Summer	9.901	0.001	1.6	0.0	Flood Risk
720 min Summer	9.901	0.001	1.6	0.0	Flood Risk
960 min Summer	9.900	0.000	0.2	0.0	Flood Risk
1440 min Summer	9.900	0.000	0.2	0.0	Flood Risk
2160 min Summer	9.900	0.000	0.2	0.1	Flood Risk
2880 min Summer	9.900	0.000	0.2	0.1	Flood Risk
4320 min Summer	9.900	0.000	0.0	0.0	Flood Risk
5760 min Summer	9.900	0.000	0.0	0.0	Flood Risk
7200 min Summer	9.900	0.000	0.0	0.0	Flood Risk
8640 min Summer	9.900	0.000	0.0	0.0	Flood Risk

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Summer	122.433	9
30 min Summer	82.239	16
60 min Summer	52.662	28
120 min Summer	32.503	58
180 min Summer	24.118	92
240 min Summer	19.386	110
360 min Summer	14.268	176
480 min Summer	11.460	256
600 min Summer	9.659	308
720 min Summer	8.396	288
960 min Summer	6.724	412
1440 min Summer	4.907	830
2160 min Summer	3.573	1132
2880 min Summer	2.849	1400
4320 min Summer	2.067	0
5760 min Summer	1.644	0
7200 min Summer	1.377	0
8640 min Summer	1.193	0

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Elstree Computing Ltd		Source Control W.12.4			
<u>Summary of Results for 100 year Return Period (+30%)</u>					
Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
10080 min Summer	9.900	0.000	0.0	0.0	Flood Risk
15 min Winter	9.902	0.002	6.3	0.1	Flood Risk
30 min Winter	9.902	0.002	4.9	0.0	Flood Risk
60 min Winter	9.902	0.002	4.9	0.1	Flood Risk
120 min Winter	9.901	0.001	1.6	0.1	Flood Risk
180 min Winter	9.901	0.001	1.6	0.0	Flood Risk
240 min Winter	9.901	0.001	1.6	0.0	Flood Risk
360 min Winter	9.901	0.001	1.6	0.0	Flood Risk
480 min Winter	9.901	0.001	1.6	0.0	Flood Risk
600 min Winter	9.900	0.000	0.2	0.0	Flood Risk
720 min Winter	9.900	0.000	0.2	0.0	Flood Risk
960 min Winter	9.900	0.000	0.2	0.0	Flood Risk
1440 min Winter	9.900	0.000	0.2	0.0	Flood Risk
2160 min Winter	9.900	0.000	0.2	0.1	Flood Risk
2880 min Winter	9.900	0.000	0.0	0.0	Flood Risk
4320 min Winter	9.900	0.000	0.0	0.0	Flood Risk
5760 min Winter	9.900	0.000	0.0	0.0	Flood Risk
7200 min Winter	9.900	0.000	0.0	0.0	Flood Risk
8640 min Winter	9.900	0.000	0.0	0.0	Flood Risk
Storm Event			Rain (mm/hr)	Time-Peak (mins)	
10080 min Summer			1.056	0	
15 min Winter			122.433	10	
30 min Winter			82.239	21	
60 min Winter			52.662	34	
120 min Winter			32.503	68	
180 min Winter			24.118	170	
240 min Winter			19.386	108	
360 min Winter			14.268	164	
480 min Winter			11.460	330	
600 min Winter			9.659	232	
720 min Winter			8.396	430	
960 min Winter			6.724	578	
1440 min Winter			4.907	908	
2160 min Winter			3.573	1192	
2880 min Winter			2.849	0	
4320 min Winter			2.067	0	
5760 min Winter			1.644	0	
7200 min Winter			1.377	0	
8640 min Winter			1.193	0	
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Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m ³)	Status
10080 min Winter	9.900	0.000	0.0	0.0	Flood Risk

Storm Event	Rain (mm/hr)	Time-Peak (mins)
10080 min Winter	1.056	0

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Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time / Area Diagram

Total Area (ha) 0.010

Time (mins)	Area (ha)
0-4	0.010

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Model Details

Storage is Online Cover Level (m) 10.000

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	10.00000
Membrane Percolation (mm/hr)	1000
Max Percolation (l/s)	27.8
Safety Factor	2.0
Porosity	0.30
Invert Level (m)	9.900
Width (m)	10.0
Length (m)	10.0
Slope (1:X)	10000.0
Depression Storage (mm)	5
Evaporation (mm/day)	3
Cap Volume Depth (m)	0.100

Appendix 5

6 Guidance on flood resilient design and construction

6.1 General principles

Management of flood risk can be achieved during the planning and outline design stages for any new development as discussed in Chapters 3 (Planning Policy and Building Standards) and Chapter 4 (Design Strategies). This chapter is concerned with measures aimed at achieving flood resilience that can be applied at the building design level. This chapter provides technical guidance on building materials and forms of construction (and to a lesser extent, on fittings) that are appropriate for improving the flood resilience of buildings. It is the result of a synthesis of information from a number of different sources: published literature, review of existing practice, experiential information, and laboratory testing. Some recommendations in this Guidance naturally differ from current standards, such as those contained in the NHBC, in order to address the severity of exposure to flood water which hitherto has not been considered.

Any resilience measures should be designed so that the building can be occupied safely over its proposed lifetime taking climate change into account.

It is generally accepted that total prevention of water ingress or 'dry proofing' to a building is very difficult to achieve. The strategies that are recommended to minimise flood impact to buildings and their occupants are described in Figures 4.2 to 4.4 of Chapter 4. In terms of achieving resilience, there are two main strategies, whose applicability is dependent on the water depth the property is subjected to (see Chapter 4).

- **Water exclusion strategy** – where emphasis is placed on *minimising* water entry whilst maintaining structural integrity, and on using materials and construction techniques to facilitate drying and cleaning. This strategy is favoured when low flood water depths are involved (not more than 0.3m). According to the definitions adopted in this Guidance, this strategy can be considered as a resistance measure but it is part of the aim to achieve overall building resilience
- **Water entry strategy** – where emphasis is placed on allowing water into the building, facilitating draining and consequent drying. Standard masonry buildings are at significant risk of structural damage if there is a water level difference between outside and inside of about 0.6m or more. This strategy is therefore favoured when high flood water depths are involved (greater than 0.6m).

Other important factors that should be considered for resilient design and construction, but not addressed in this guidance, are:

- cost
- durability

- ease and practicability of construction
- environmental, social and aesthetic acceptability.

Guidance is provided in the following sections:

Section 6.2 – building materials

Section 6.3 – foundations

Section 6.4 – floors

Section 6.5 – walls

Section 6.6 – doors and windows

Section 6.7 – fittings

Section 6.8 – services.

In each section dealing with construction elements (e.g. materials, foundations, floors, and walls) there is a brief discussion of the design issues, followed by general advice on resilience. Some illustrative sketches are also included which provide information on general arrangements but do not cover construction details.

6.2 Building materials

The recommendations given in this section on building materials are based primarily, but not exclusively, on recent laboratory investigations (permeability and drying tests on 13 typical building materials subjected to 1m head of flood water). An illustrative example of testing is given in Figure 6.1.

Figure 6.1 Pressed facing bricks being tested



Although this guidance covers the main types of building material commonly in use in the UK for typical domestic construction, it should be borne in mind that other materials also may prove to be suitable for resilient constructions. It should also be noted that there is variability within materials that may affect their resilience performance. As expected, the denser materials such as concrete and engineering bricks were found to have good resilience characteristics. In general, the findings of the materials testing confirmed existing knowledge and experience but provided new quantitative data on construction material behaviour.

Table 6.1 presents the characteristics of common building materials, tested in the laboratory, classified as having good, medium or poor performance with regard to water penetration, drying ability and integrity.

Definitions of the characteristics used in Table 6.1 are:

- water penetration – the seepage (rate and volume) through the material (note that this is different from “water absorption”)
- drying ability – the capability to regain its original moisture condition (assessed by the average drying rate and the time taken to reach the original value)
- retention of pre-flood dimensions, integrity – the lack of deformation or change in form or appearance of the material

Table 6.1 Flood resilience characteristics of building materials (based on laboratory testing)

Material	Resilience characteristics*		
	Water penetration	Drying ability	Retention of pre-flood dimensions, integrity
Bricks			
Engineering bricks (Classes A and B)	Good	Good	Good
Facing bricks (pressed)	Medium	Medium	Good
Facing bricks (handmade)	Poor	Poor	Poor
Blocks			
Concrete (3.5N, 7N)	Poor	Medium	Good
Aircrete	Medium	Poor	Good
Timber board			
OSB2, 11mm thick	Medium	Poor	Poor
OSB3, 18mm thick	Medium	Poor	Poor
Gypsum plasterboard			
Gypsum Plasterboard, 9mm thick	Poor	Not assessed	Poor
Mortars			
Below d.p.c. 1:3(cement:sand)	Good	Good	Good
Above d.p.c. 1:6(cement:sand)	Good	Good	Good

* Resilience characteristics are related to the testing carried out and exclude aspects such as ability to withstand freeze/thaw cycles, cleanability and mould growth

Clearly other factors affect the choice of resilient building materials, namely their insulating properties, ease of handling, availability, aesthetics, cost, etc. and these should also be considered when specifying materials for construction in flood-prone areas.

Building materials that are effective for a 'water exclusion strategy' include: engineering bricks, cement-based materials including water retaining concrete and dense stone.

Building materials that are suitable for a 'water entry strategy' include: facing bricks, concrete blocks, sacrificial or easily removable external finishes or internal linings.

6.3 Foundations

Foundations are designed to suit site conditions, namely the local geotechnical characteristics and the building design. Strip and trench-fill foundations are generally used where no special problems are identified, whereas raft, pile, pier and beam foundations may be necessary in other cases. In general, the choice of foundation type will be dictated by ground conditions, rather than resilience considerations. However, improvements can be made to increase the resilience.

For typical two-storey dwellings shallow footings are likely to be appropriate in most cases. It is common practice to use concrete blocks as substructure elements in typical cavity wall buildings but laboratory work has shown that groundwater can penetrate through the blocks into the wall cavity (and from there into the building) if care is not taken to minimise the passage of water. There is a general recommendation in the NHBC Standards, (2006) to allow a clear cavity of at least 225mm below damp proof course (d.p.c.) to prevent the build up of any mortar dropped during construction from having a detrimental effect on the performance of the wall. However, this unsealed void may be an entry point for rising ground water into the property via the blockwork.

Basements are a separate category of construction which can benefit from various types of tanking methods to provide an effective barrier to flood water. Guidance on tanking can be found, for example, in publications such as CIRIA Report 139 'Water-Resisting Basement Construction – A Guide' (CIRIA, 1995), NHBC Standards (2006). It is not advisable to design for living accommodation in basements, where there is a risk of flooding.

6.3.1 *Water exclusion strategy*

A general principle for flood resilient design where predicted flood water depths are relatively small (no greater than 0.3m above floor level) is to minimise the entry of water through permeable elements of the foundation. Any concrete blocks placed below ground-bearing concrete floor slabs provide a potential path for water to ingress into wall cavities, as these blocks are considerably more permeable than concrete slabs. Figures 6.2 and 6.3, illustrating a ground bearing slab and a concrete suspended floor slab, show a potential flow path from the

ground adjacent and under a dwelling, through porous substructure and into the wall cavity. The use of concrete or another impermeable material to seal the blocks may resolve this problem. The figures highlight the fact that measures taken above ground level may not fully prevent the ingress of water.

Figure 6.2 Water ingress into properties through the ground – ground bearing floor

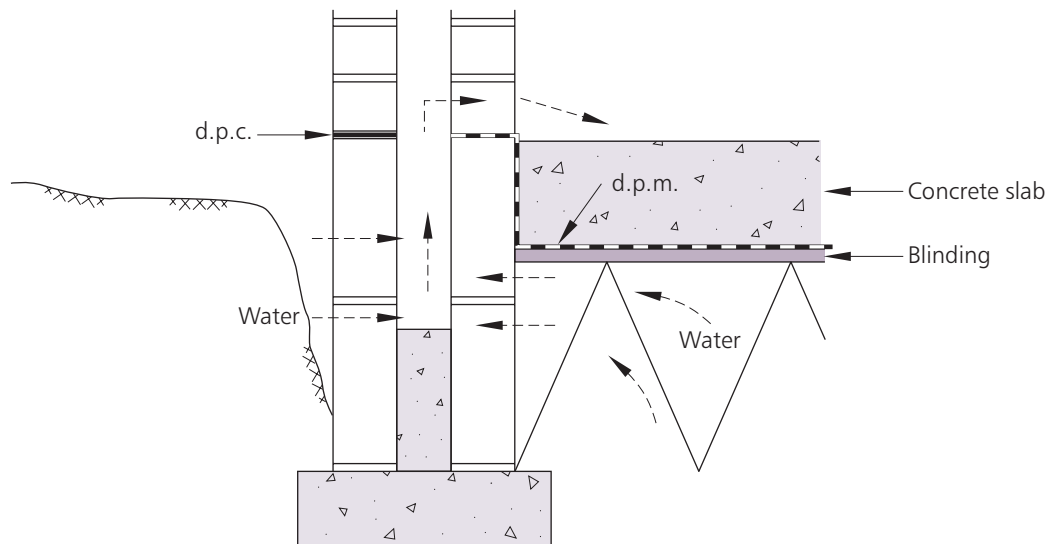
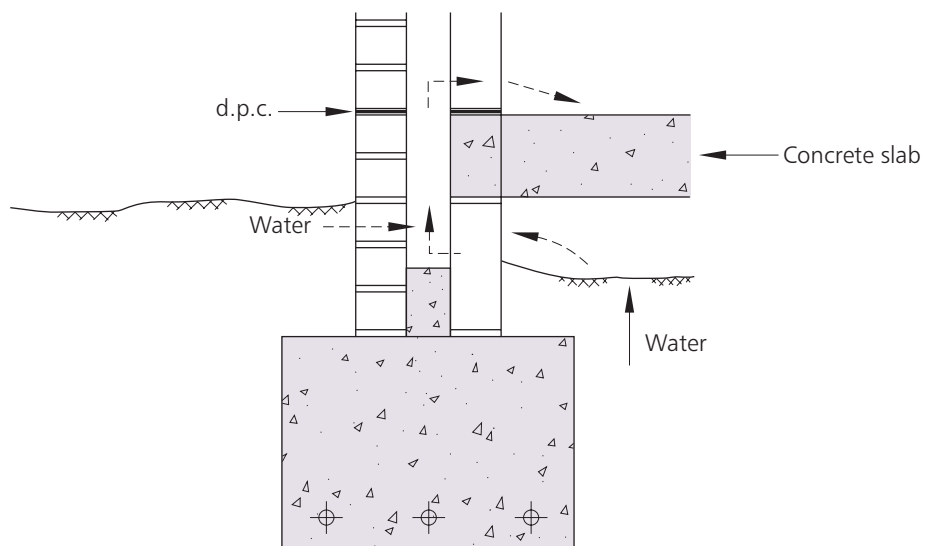


Figure 6.3 Water ingress into properties through the ground – suspended floor



General advice for resilient design

Where concrete ground floor slabs are used, the blockwork substructure is often the weakest point in terms of water penetration from the ground into a dwelling. Whereas there is a general perception that water can ingress through the blockwork structure of the external face of a wall into the property, it is less apparent, but equally possible, that water will penetrate from the ground on the inside of the property. Figures 6.2 and 6.3 illustrate these flow paths for two types of ground floor (ground bearing floor and suspended concrete floor), and different types of foundation (typical for construction in England).

Concrete blocks used in foundations should be sealed with an impermeable material or encased in concrete to prevent water movement from the ground to the wall construction.

6.3.2 Water entry strategy

General advice for resilient design

A general principle for flood resilient design where predicted flood water depths are high is to provide durable materials that will not be affected by water and use construction methods and materials that promote easy draining and drying.

Standard methods and good quality building materials will generally comply with these requirements but good workmanship is essential.

6.4 Floors

The behaviour of ground floors in floods can be influenced by two different conditions:

- water ingress from the ground (potentially resulting in uplift pressures), and
- exposure to standing water.

Of the above two situations (which can occur simultaneously), water ingress from the ground is potentially more severe as it is more likely to affect the structural integrity of the floor. Structural calculations may need to be carried out to ensure that the floor (including any lateral support provided at the perimeter) has the necessary strength to resist uplift forces without excessive deformation or cracking.

6.4.1 Water exclusion strategy

When applying a “water exclusion strategy” (i.e. minimising water ingress through ground floor slabs), for predicted water depths above the floor of greater than 0.3m, it is important to carry out structural checks assuming a flood depth of 1m minimum above the slab, even in areas where the design flood water depth is lower. Usual safety factors must be applied in all such calculations (floors and walls). Laboratory evidence on small slabs (0.5m by 0.5m) indicated that 150mm thick concrete slabs on supporting soil can withstand such forces without allowing water ingress. However, for larger slabs, uplift forces may cause deformation and induce cracking and lead to preferential paths for water ingress.

General advice for resilient design

Ground supported floors are the preferred option and concrete slabs of at least 150mm thickness should be specified for non-reinforced construction. Hollow slabs are not suitable if the elements are not effectively sealed.

Suspended floors may be necessary where ground supported floors are not suitable, namely in shrinkable/expanding soils (e.g. clay) or where the depth of fill is greater than 600mm. Uplift forces caused by flood water may affect the structural performance of a floor. Suspended floors are generally not recommended in flood-prone areas, for the following reasons:

- the sub-floor space may require cleaning out following a flood, particularly a sewer flood. In order to aid this process and where accumulation of polluted sediment is expected, the sub-floor space should slope to an identified area and be provided with suitable access
- if cleaning is required, floor finishes may need to be removed to provide access to the sub-floor space. Cheaper, sacrificial, finishes would be the best option.
- the steel reinforcement in the concrete beams of 'beam and block' floors may be affected by corrosion and its condition may need to be assessed following repeated or prolonged floods.

Suspended timber floors, particularly when including timber engineered joists, are not generally recommended in flood prone areas because most wooden materials tend to deform significantly when in contact with water and therefore may require replacement. Rapid drying can also cause deformation and cracking.

Reinforced concrete floors are acceptable but may be prone to corrosion of any exposed steel in areas of prolonged flooding.

Hardcore and blinding: good compaction is necessary to reduce the risk of settlement and consequential cracking.

Damp Proof Membranes (d.p.m.) should be included in any design to minimise the passage of water through ground floors. Impermeable polythene membranes should be at least 1200 gauge to minimise ripping. Effective methods of joining membrane sections are overlaps of 300mm, and also taping (mastic tape with an overlap of 50mm minimum). Care should be taken not to stretch the membrane in order to retain a waterproof layer. Experience in Scotland has indicated that welted joints in the d.p.m. are an effective jointing solution.

Insulation materials: Water will lower the insulation properties of some insulation materials. Floor insulation should be of the closed-cell type to minimise the impact of flood water. The location of insulation materials, whether above or below the floor slab, is usually based on either achieving rapid heating of the building or aiming for more even temperature distribution with reduced risk of condensation. Insulation placed above the floor slab (and underneath the floor finish) rather than below would minimise the effect of flood water on the insulation properties and be more easily replaced, if needed. However, water entry may cause insulation to float (if associated with low mass cover) and lead to debonding of screeds.

No firm guidance can be provided on best location for insulation where the primary source of flooding is from groundwater. For other types of flooding, placing insulation below the floor slab may be adequate but it is important to recognise that the characteristics of the insulation may be affected by the uplift forces generated by the flood water.

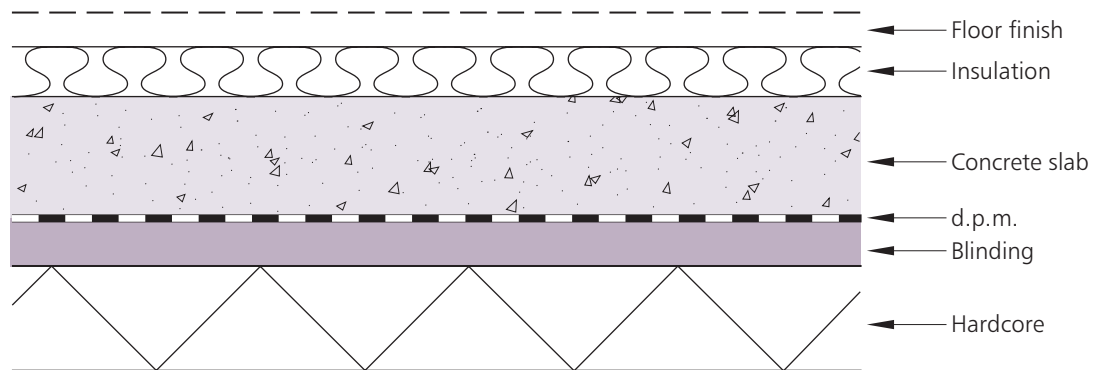
Floor finishes: suitable floor finishes include ceramic or concrete-based floor tiles, stone, and sand/cement screeds. All tiles should be bedded on a cement-based adhesive/bedding compound and water resistant grout should be used. Concrete screeds above polystyrene or polyurethane insulation should be avoided as they hinder drying of the insulation material. Suitable materials for skirting boards include ceramic tiles and PVC. Ceramic tiles are likely to be more economically viable and environmentally acceptable.

Floor sump: provision of a sump and small capacity automatic pump at a low point of the ground floor is recommended in cases where the expected probability of flooding in any one year is 20% or a frequency of flooding of more than once in five years (see Section 4). This system will help the draining process and speed up drying but it may only be effective for shallow depth flooding. The dimensions of the sump and its operational procedure would be calculated and agreed with the planning authority based on the predicted volumes of water to be drained.

Services: under floor services using ferrous materials should be avoided.

Recommended ground-supported and acceptable suspended floor arrangements are presented in Figures 6.4 to 6.6. If suspended timber flooring is a favoured option, then a combination of construction elements that is likely to minimise problems associated with flooding is shown in Figure 6.6. This is referred to as a “Restricted option”

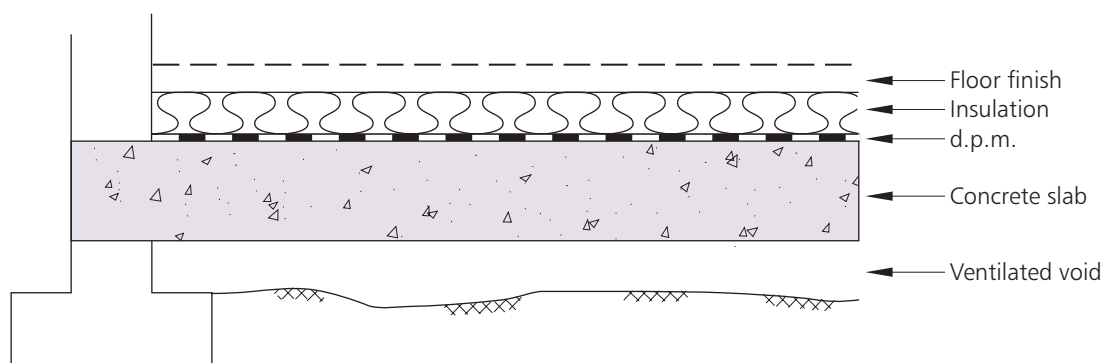
Figure 6.4 Ground-supported floor – Preferred option



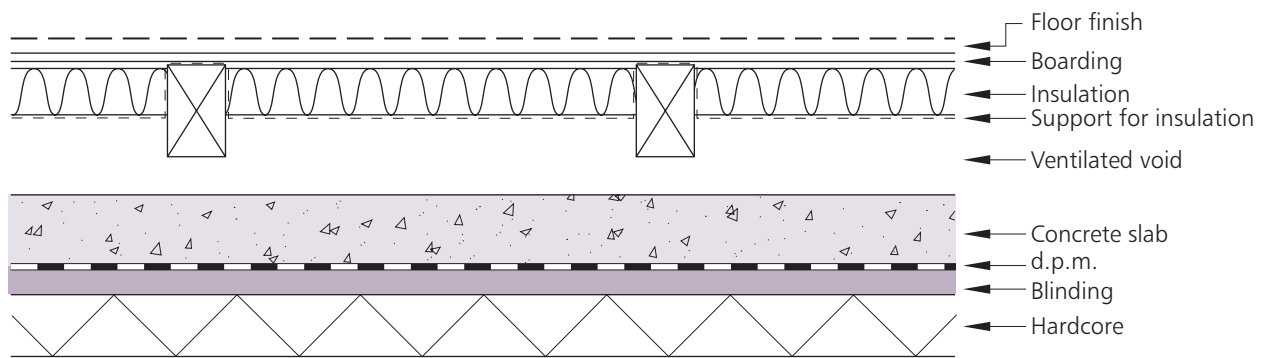
- Hardcore bed at least 100mm thick of well compacted inert material, blinded with fine inert material to provide a smooth base
- Damp proof membrane of polythene at least 1200 gauge
- Concrete slab at least 150mm thick
- Insulation as rigid closed-cell material
- Ceramic tiles or stone floor finishes and skirting boards.

Figure 6.4 shows floor insulation above slab and there is laboratory evidence to support this location but there is currently no sound evidence to prevent the use of below slab insulation.

Figure 6.5 Suspended Concrete Floor – Acceptable option



- Reinforced concrete slab at least 150mm thick and complying with structural requirements for uplift forces
- Damp proof membrane of polythene at least 1200 gauge
- Insulation as rigid closed-cell material
- Ceramic tiles or stone floor finishes and including skirting boards.

Figure 6.6 Suspended Timber Floor – Restricted option

- Hardcore bed at least 100mm thick of well compacted inert material, blinded with fine inert material to provide a smooth base
- Concrete slab at least 150mm thick
- Insulation as rigid, closed cell material and supported with battens, plastic mesh or corrosion-resistant fixings
- Boarding consisting of WBP Plywood and preservative treated timber
- Stainless steel hangers

6.4.2 Water entry strategy

General advice for resilient design

Materials that retain their integrity and properties when subjected to flood water (such as concrete) or those that can be easily replaced (sacrificial materials), should be specified. Construction should allow easy access for cleaning, (e.g. below suspended floors), and drainage.

Concrete ground-supported floors are the preferred option and concrete slabs of at least 100mm thickness should be specified.

Suspended floors may be necessary where ground-supported floors are not suitable, namely in shrinkable/expanding soils (e.g. clay soils) or where the depth of fill is greater than 600mm. In cases of prolonged floods, where flood water is heavily silted, or from sewer flooding, the sub-floor space may require cleaning out following a flood; to aid this process, it should slope to an identified low point and be provided with suitable access. If cleaning is required, floor finishes may need to be removed to provide access to the sub-floor space and therefore cheaper, sacrificial, finishes would be the best option. Alternatively, external access to the sub-floor space can be considered as a design option.

Suspended steel floors may be adequate provided they incorporate resilient features such as anti-corrosion properties and comply with required structural capability.

Suspended timber floors, particularly when including timber engineered joists, are not generally recommended in flood prone areas because most wooden materials tend to deform significantly when in contact with water and therefore may require replacement. Rapid drying can also cause deformation and cracking.

Hardcore and blinding: good compaction should be achieved to reduce the risk of settlement and consequential cracking.

Damp Proof Membranes (d.p.m.) should be included in any design to minimise the passage of water through ground floors. Impermeable polythene membranes should be at least 1200 gauge to minimise ripping. Effective methods of joining membrane sections are: overlaps of 300mm or taping with mastic tape with an overlap of 50mm minimum. Care should be taken not to stretch the membrane in order to retain a waterproof layer. Experience in Scotland has indicated that welted joints in the d.p.m. are an effective jointing solution but the quality of the welts is very dependent on workmanship.

Insulation materials: Water will lower the insulation properties of some insulation materials. Floor insulation should be of the closed-cell type to minimise the impact of flood water. The location of insulation materials, whether above or below the floor slab, is usually based on either achieving rapid heating of the building or aiming for more even temperature distribution with reduced risk of condensation. It is recommended that insulation be placed above the floor slab (and underneath the floor finish) rather than below would minimise the effect of flood water on the insulation properties and be more easily replaced, if needed.

Floor finishes: there are two possible approaches that depend on an assessment of the likely frequency of flooding and cost of material and installation: use of sacrificial materials or reliance on high quality durable materials – see Section 4. Sacrificial floor finishes can include timber flooring and soft furnishings such as carpets. Materials that are likely to withstand exposure to floodwater without significant deterioration are ceramic or concrete-based floor tiles, marble or stone. All tiles should be set on a bed of sand and cement render and water resistant grout should be used. Concrete screeds above polystyrene or polyurethane insulation should be avoided as they hinder drying of the insulation material due to the relative impermeability.

Suitable materials for skirting boards include ceramic tiles and PVC. Ceramic tiles are likely to be more economically viable and environmentally acceptable. Replacement timber may be a suitable option, for cases where a strategy to use of sacrificial materials is adopted.

Floor sump: provision of a sump and small capacity pump in the floor at a low point of the ground floor is recommended in cases where the expected frequency of flooding is high; this system will help the draining process and speed up drying but it may only be effective for shallow depth flooding. The dimensions of the sump and its operational procedure would be calculated and agreed with the Planning Authority based on the predicted volumes of water to be drained.

Services: under floor services using ferrous materials should be avoided.

Figures 6.4 and 6.5 illustrate recommended floor designs for the water-entry strategy.

6.5 Walls

The recommendations given in this section on wall construction are based primarily on recent laboratory investigations, but are supported by expert opinion and experience from the building industry – see Chapter 7. The laboratory tests covered 16 wall panels (approximately 1.1m high by 1m wide) of composite construction subjected to 1m head of water and then allowed to dry naturally. This is not an exhaustive list of constructions and other wall designs may also have adequate resilience characteristics.

Table 6.2, based on the laboratory evidence, classifies wall components as good, medium or poor with regard to water penetration, surface drying and structural integrity.

Definitions of the characteristics used in Table 6.2 are:

- water penetration – the leakage (rate and volume) through the entire wall thickness (note that this is different from “water absorption”)
- drying ability – the capability to regain its original surface moisture condition (assessed by the average drying rate and the time taken to reach the original value)
- retention of pre-flood dimensions, integrity – the lack of deformation or change in form or appearance of the wall panel.

Table 6.2 Flood resilience characteristics of walls (based on laboratory testing)

Material	Resilience characteristics*		
	Water penetration	Drying Ability	Retention of pre-flood dimensions, integrity
External face			
Engineering bricks (Classes A and B)	Good	Good	Good
Facing bricks (pressed)	Medium	Medium	Good
Internal face			
Concrete blocks	Poor	Medium	Good
Aircrete	Medium	Poor	Good
Cavity insulation			
Mineral fibre	Poor	Poor	Poor
Blown-in expanded mica	Poor	Poor	Poor
Rigid PU foam	Medium	Medium	Good
Renders/Plaster			
Cement render – external	Good	Good	Good
Cement/lime render – external	Good	Good	Good
Gypsum Plasterboard	Poor	Not assessed	Poor
Lime plaster (young)	Poor	Not assessed	Poor
* Resilience characteristics are related to the testing carried out and exclude aspects such as ability to withstand freeze/thaw cycles, cleanability and mould growth			

6.5.1 Water exclusion strategy

This strategy is applicable to design flood depths of up to 0.3m or up to 0.6m, if allowed by the structural assessment of the design.

General advice for resilient design

Ensure high quality workmanship at all stages of construction.

Masonry walls:

Ensure mortar joints are thoroughly filled to reduce the risk of water penetration. If frogged bricks are used, they should be laid frog up so that filling becomes easier and coverage more certain. Bricks manufactured with perforations should not be used for flood resilient design.

Where possible, use engineering bricks up to predicted flood level plus one course of bricks to provide freeboard (up to maximum of 0.6m depth above floor level); this will increase resistance to water penetration. Blocks (and dense facing bricks) have much improved performance when covered with render.

Aircrete blocks allow less leakage than typical concrete blocks but concrete blocks dry more quickly. Therefore, design of blockwork walls needs to take into account these two opposite types of behaviour and consider whether drying or resistance to water is most relevant in each situation. For a "water exclusion strategy", the expected amount of leakage is minimal and therefore, Aircrete blocks are recommended, although they may retain moisture for longer than concrete blocks. Compared with heavier blocks, Aircrete may offer less restraint to floor/slab edges which under the action of uplift forces could promote the opening up of floor/wall junctions.

Do not use highly porous bricks such as hand made clay bricks.

Solid masonry walls are a good option but will need to be fitted with internal or external wall insulation in order to comply with Building Regulations.

Clear cavity walls, i.e. with no insulation in the cavity, have better flood resilience characteristics than filled or part filled cavity walls as they dry more quickly. The requirements for insulation can be satisfied by external insulated renders or internal thermal boards.

There is evidence that thin layer mortar construction (or thin joint, as it is also commonly known) is a good flood resilience option.

Framed walls: Avoid timber framed walls containing construction materials that have poor performance in floods, for example oriented strand board and mineral fibre insulation. Timber framed walls are not recommended in a "water exclusion strategy". Steel framed walls may offer a suitable alternative option but specialist advice needs to be sought on how to incorporate resilient materials/construction methods in the design, in particular with regard to the insulation.

Reinforced concrete wall/floor construction should be considered for flood-prone areas, i.e. where the frequency of flooding is predicted to be high (see Chapter 4). This form of construction is effective at resisting forces generated by floodwater and will provide an adequate barrier to water ingress (provided service ducts and other openings into the building are adequately sealed). Design details for this type of construction are beyond the scope of this document.

External renders are effective barriers to water penetration and should be used with blocks (or bricks) at least up to the predicted flood level plus the equivalent of a course of bricks as freeboard. Structural checks may be necessary to ensure stability, because of the external water pressures that could occur for design flood depths above 0.3m. External cement renders with lime content (in addition to cement) can induce faster surface drying.

Insulation:

External insulation is better than cavity insulation because it is easily replaced if necessary.

Cavity insulation should preferably incorporate rigid closed cell materials as these retain integrity and have low moisture take-up. Other common types, such as mineral fibre batts, are not generally recommended as they can remain wet several months after exposure to flood water which slows down the wall drying process. Blown-in insulation can slump due to excessive moisture uptake, and some types can retain high levels of moisture for long periods of time (under natural drying conditions).

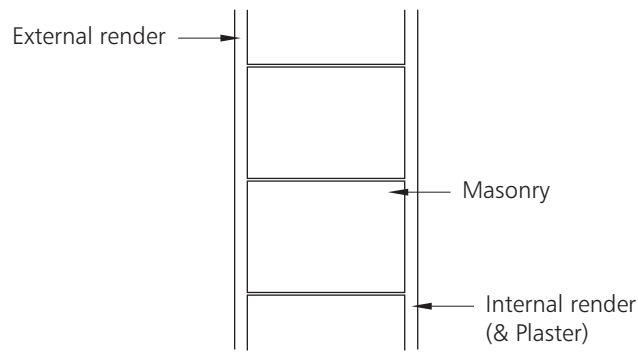
Internal linings:

Internal cement renders (with good bond) are effective at reducing flood water leakage into a building and assist rapid drying of the internal surface of the wall. The extent to which render prevents drying of other parts of the wall is not currently clear. This may be important, particularly for solid wall construction. This applies also to external renders.

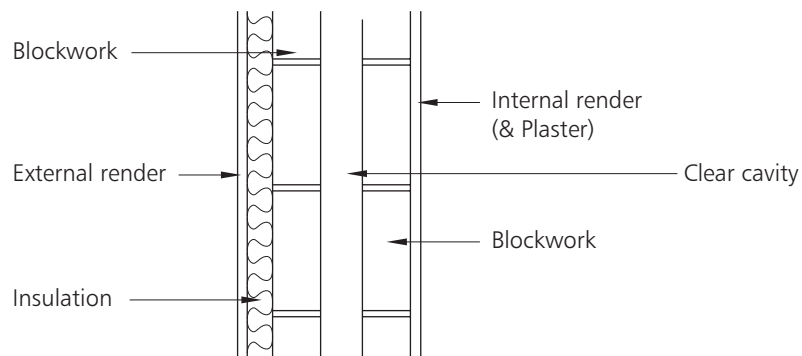
Avoid standard gypsum plasterboard as it tends to disintegrate when immersed in water. Splash proof boards do not necessarily offer protection against flood waters, which may remain for some time and exert pressure on the board.

Anecdotal evidence suggests that internal lime plaster/render can be a good solution. Lime plaster depends on contact with the air to set and harden. Because of this, full strength lime plaster, which typically requires over 6 months, was not possible to test. Consequently, no assurance can be given for its performance. Tests performed when young showed that it crumbles very easily under high water pressure.

Examples of recommended wall arrangements are presented in Figures 6.7 to 6.9 below.

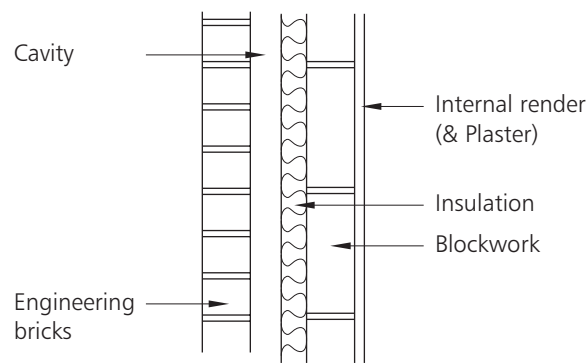
Figure 6.7 Solid External Walls

- External cement based render, preferably with lime content. Composition depends on masonry. The following mixes have good resilient properties:
 - 1 cement : 6 sand on bricks;
 - 1 cement : 4 sand: 1/2 lime on concrete blockwork or bricks;
 - 1 cement : 6 sand: 1 lime on Aircrete blocks.
 - Masonry with minimum thickness of 300mm (thin mortar joint construction using Aircrete blocks is effective as demonstrated in laboratory tests) or alternatively reinforced concrete wall
 - Internal cement-based render, preferably with lime content. Composition depends on masonry; the following mix is effective for flood resilience:
 - 1 cement : 6 sand: 1 lime on Aircrete.
- Apply external and internal renders, following good practice guidance, ensuring minimum total thickness of 20mm and at least two coats.
- Use external insulation in preference to internal insulation.

Figure 6.8 Cavity External Walls – Clear cavityClear cavity

- External cement based render, preferably with lime content. Composition depends on masonry; the following mixes are effective for flood resilience:
 - 1 cement: 4 sand: 1/2 lime on concrete blockwork (or bricks);
 - 1 cement: 6 sand: 1 lime on Aircrete.
- Apply render following good practice guidance, ensuring minimum total thickness of 20mm and two coats.
- Internal cement based render, preferably with lime content. Composition depends on masonry. The following mix works well:
 - 1 cement: 6 sand: 1 lime on Aircrete.
 - Stainless steel wall ties should be used to minimise corrosion and consequent staining.

Figure 6.9 Cavity External Walls – Part-filled cavity

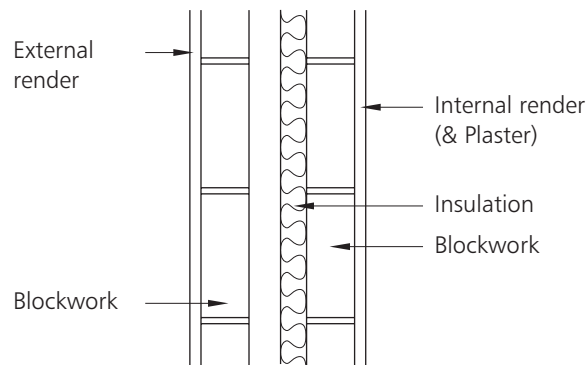


Option A

Part-filled cavity

Part-filled cavity – Option A

- External face consisting of engineering bricks up to required level for flood protection (up to 0.6m maximum above floor level plus one course). Other external facing materials can be used above this level, but ensure interface is watertight.
- Rigid insulation.
- Internal face consisting of blocks.
- Internal cement based render, preferably with lime content. Composition depends on masonry; the following mix is effective:
1 cement : 6 sand: 1 lime on Aircrete.
- Ensure stainless steel wall ties are used to minimise corrosion and consequent staining.
- Sacrificial plasterboard can be used, but it needs to be removed between ground floor and flood level. The board should be fitted horizontally to make removal easier. In some cases a dado rail can be used to cover the joints.



Option B

Part-filled cavity – Option B

- External cement based render, preferably with lime content. Composition depends on masonry; the following mixes are effective:
1 cement : 4 sand: 1/2 lime on concrete blockwork
1 cement : 6 sand: 1 lime on Aircrete.
- External face consisting of blocks.
- Rigid insulation.
- Internal face consisting of blocks.
- Internal cement based render, preferably with lime content. Composition depends on masonry; the following mix is effective for flood resilience:
1 cement : 6 sand: 1 lime on Aircrete.
- Ensure stainless steel wall ties are used to minimise corrosion and consequent staining.

6.5.2 Water entry strategy

This strategy is applicable to design flood depths above 0.6m, or above 0.3m if the structural assessment of the design shows that the integrity of the building would be compromised by a “water exclusion strategy”.

General advice for resilient design

Ensure high quality workmanship at all stages of construction.

Masonry walls:

Use good quality facing bricks for the external face of cavity walls.

Do not use soft bricks, such as hand made clay bricks, which can easily crumble when subjected to water.

Concrete blocks dry more quickly than Aircrete blocks. However, Aircrete blocks allow less leakage. Therefore, design of blockwork walls needs to take into account these two opposite types of behaviour and consider whether drying or resistance to water is most relevant in each situation. For a “water entry strategy” which is aimed at allowing water passage through the property, concrete blocks are recommended.

Clear cavity walls, i.e. with no insulation, have better resilience characteristics than filled or part filled cavity walls as they dry more quickly.

Framed walls: Avoid timber framed walls containing construction materials that have poor performance in floods, namely oriented strand board and mineral fibre insulation. Timber framed walls are generally not recommended, unless a sacrificial approach is adopted whereby some materials will be stripped to allow drying.

Steel framed walls may offer a suitable alternative option but specialist advice needs to be sought on how to incorporate resilient materials/construction methods in the design. The possible use of bituminous paint on steel plates may be a means of preventing corrosion.

External renders should not be used as they provide a barrier to water penetration and may induce excessive differences in depth between outside and inside of the property resulting in possible structural problems.

Insulation:

External insulation is better than cavity insulation because it is easily replaced if necessary; however it is generally protected by rigid lining which may create a barrier to water.

Cavity insulation should incorporate rigid closed cell materials as these retain integrity and have low moisture take-up. Other common types, such as mineral fibre batts, are not generally recommended as they can remain wet several months after exposure to flood water which slows down the wall drying process. Blown-in insulation can slump due to excessive moisture uptake, and some types can retain high levels of moisture for long periods of time (under natural drying conditions).

Internal linings:

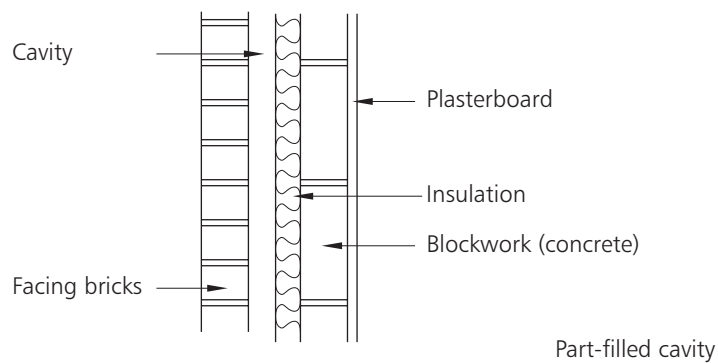
Avoid internal cement renders as these can prevent effective drying.

Use standard gypsum plasterboard up to the predicted flood level (plus freeboard of 50mm) as a sacrificial material. For this purpose, the use of a dado rail to separate the above and below flooded area may be useful. Splash proof boards do not necessarily offer better protection against flood waters, which may remain for some time and exert pressure on the board.

Above predicted flood level (plus freeboard) the use of plasterboard or internal cement renders is appropriate.

Anecdotal evidence suggests that internal lime plaster/render can be a good solution. Lime plaster depends on contact with the air to set and harden. Because of this, full strength lime plaster, which typically requires over 6months, was not possible to test. Consequently, no assurance can be given for its performance. Tests performed when young showed that it crumbles very easily under high water pressure.

Figure 6.10 Cavity External Walls – Part-filled cavity with sacrificial plasterboard



Part-filled cavity

- External face consisting of engineering bricks up to required level for flood protection (up to d.p.c.). Other external facing materials can be used above this level, but ensure transition is watertight.
- Rigid insulation
- Internal cement based render, preferably with lime content. Composition depends on masonry; the following mix is effective:
1 cement : 6 sand: 1 lime on concrete blocks.
- Stainless steel wall ties should be used to minimise corrosion and consequent staining.
- Sacrificial plasterboard can be used, but it needs to be removed between ground floor to flood level. The board should be laid horizontally to make removal easier.

6.6 Doors and windows

Doors, windows and air vents are potential flow paths into properties.

General advice for resilient/resistant design

Doors: Raising the threshold as high as possible, while complying with level access requirements, should be considered as the primary measure. In addition, sealed PVC external framed doors should be used and, where the use of wooden doors is a preferred option, all effort should be made to ensure a good fit and seal to their frames.

Hollow core timber internal doors should not be used where the predicted frequency of flooding is high. Where sufficient flood warning is given, butt hinges, that allow internal doors to be easily removed and stored in dry areas prior to a flood, should be used. Where the frequency of predicted flooding is low or where there is no warning (e.g. overland or sewer flooding) it may be necessary to replace the doors after the flood.

Windows/patio doors: Windows and patio doors are vulnerable to flood water and similar measures to those used for doors should be taken. Special care should be taken to ensure adequate sealing of any PVC window/door sills to the fabric of the house. Of particular concern would be excessive water pressure on the glazing of patio doors. Double glazing conforming to the relevant standards would in principle adequately resist the pressures generated by flood waters; debris carrying flows may cause damage.

Air vents: special designs of air vent are available in the market to prevent water ingress in circumstances where the predicted flood depth is low (i.e. < 0.3m); e.g. periscopic air vent, see Figure 6.11. Careful consideration should be given to effectively sealing any associated joints.

Figure 6.11 Periscopic air vent (courtesy Severn Trent Water)



6.7 Fittings

6.7.1 Water exclusion strategy

General advice for resilient design

The main principle is to use durable fittings that are not significantly affected by water and can be easily cleaned (e.g. use of plastic materials or stainless steel for kitchen units). The cost of these units may need to be balanced against the predicted frequency of flooding.

Place fittings (e.g. electrical appliances, gas oven) on plinths as high as practicable above floor so that they are out of reach of flood water.

Ensure adequate sealing of joints between kitchen units and surfaces to prevent any penetration of water behind fittings.

Ensure high quality workmanship in the application of fittings.

An illustrative example of a resilient kitchen is given in Figure 6.12, e.g. raised oven and fridge/freezer on plinth and use of ceramic tiles on the floor. In this figure it can be seen that the kitchen units are made of stainless steel. Due to its relatively high cost this is a suitable solution only in cases where the predicted frequency of flooding is high (see Chapter 4).

More details are given in 'Standards for the repair of buildings following flooding' (CIRIA, 2005a) or in web sites such as the 'Guide to flood resilient repairs', promoted by Norwich Union (Norwich Union, web site).

Figure 6.12 Main kitchen appliances (such as oven and fridge/freezer) placed above floor level (courtesy of Norfolk County Council and FLOWS Project)



6.7.2 *Water entry strategy*

General advice for resilient design

Although a sacrificial approach can be adopted whereby fittings are designed to be replaced after a flood, it is advisable to specify durable fittings that are not appreciably affected by water and can be easily cleaned (e.g. use of plastic materials or stainless steel for kitchen units). The cost of these units may need to be balanced against the predicted frequency of flooding. Avoid wood fibre based carcasses and use easily removable solid wood doors and drawers.

Place fittings (e.g. electrical appliances, gas oven) as high as practical above floor to minimise the risk of being affected by flood water.

When allowing water in, it is important to provide means for effective drainage and cleaning. Providing gaps behind kitchen units will facilitate drainage and will allow access for forced drying, if proved to be necessary.

Ensure high quality workmanship in the application of fittings.

More details are given in ‘Standards for the repair of buildings following flooding’ (CIRIA, 2005a) or in web sites such as the ‘Guide to flood resilient repairs’, promoted by Norwich Union (Norwich Union web site).

6.8 Services

General advice for resilient design

Where possible, all service entries should be sealed (e.g. with expanding foam or similar closed cell material).

Pipework: Closed cell insulation should be used for pipes which are below the predicted flood level.

Drainage services: Non-return valves are recommended in the drainage system to prevent back-flow of diluted sewage in situations where there is an identified risk of the foul sewer surcharging. Maintenance of these valves is important to ensure their continued effectiveness.

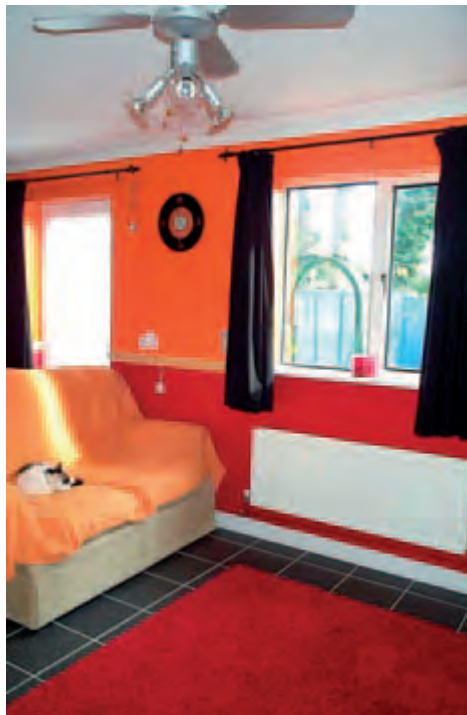
Water, electricity and gas meters: should be located above predicted flood level.

Electrical services: electrical sockets should be installed above flood level for ground floors to minimise damage to electrical services and allow speedy re-occupation (see Figure 6.13. Note a dado rail which provides a limit for replacement of any wall covering). Electric ring mains should be installed at first floor level with drops to ground floor sockets and switches.

Heating systems: boiler units and ancillary devices should be installed above predicted flood level and preferably on the first floor of two-storey properties. Underfloor heating should be avoided on ground floors and controls such as thermostats should be placed above flood level. Conventional heating systems, e.g. hot water pipes are unlikely to be significantly affected by flood water unless it contains a large amount of salts. The less common, hot air duct heating would remain effective provided it is installed above the design flood level.

Communications wiring: wiring for telephone, TV, Internet and other services should be protected by suitable insulation in the distribution ducts to prevent damage. Any proposed design solution for flood insulation on all potentially vulnerable wiring should be discussed with the relevant service providers.

Figure 6.13 Raised sockets (courtesy of Norfolk County Council and FLOWS project); note also PVC skirting board and tiled floor



Appendix 6

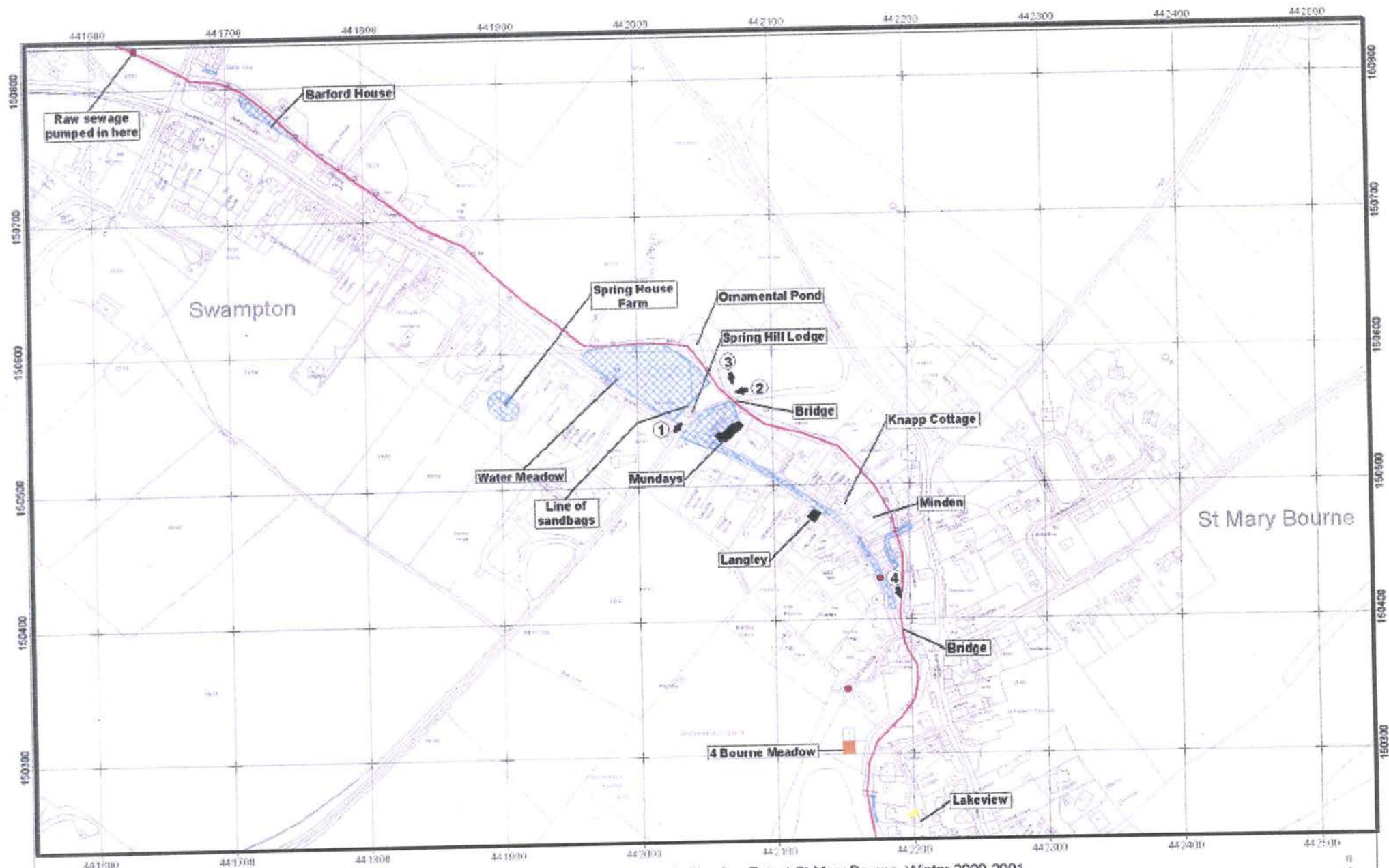


Figure 2 Flooding Extent St Mary Bourne, Winter 2000-2001 and plate locations

Halcrow



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- Approximate flooding extent
- External water/sewage flooding
- Internal flooding and sewage

① Plate number

Difficulty with toilet flushing

Sewage Manhole Covers

Direction of view

Main River

0 50 100

Meters Scale 1:2,500

**Environment Agency - Southern Region
Hampshire and Isle of Wight Area**

**Winter 2000 – 2001 Flooding in Hampshire
St Mary Bourne
August 2002**



Groundwater Flooding in Hampshire

Halcrow



**ENVIRONMENT
AGENCY**

Environment Agency

Winter 2000/2001 Groundwater and Fluvial
Flooding in Hampshire

St Mary Bourne

August 2002

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Environment Agency

Winter 2000/2001 Groundwater and Fluvial Flooding in Hampshire St Mary Bourne

Contents Amendment Record

This report has been issued and amended as follows:

Issue	Revision	Description	Date	Signed
1	0	Draft	12/02	PJH
2	0	Final	04/02	JDS

GROUNDWATER AND FLUVIAL FLOODING – WINTER 2000/01

ADDENDUM SHEET

Report: St Mary Bourne

Addendum 1 (made on 11 April 2005)

(Addendum issued due to further information received from the resident of Knapp Cottage)

Section 2.2, page 5, 1st paragraph, 3rd line

Delete 'Knapp Cottage'

Figure 2

Delete reference to 'Knapp Cottage'

Executive Summary – St Mary Bourne

- The Environment Agency has a supervisory duty for all flood defence matters and this duty should be used to influence other agencies into making appropriate flood defence improvements.
- The Agency provides a flood warning service to Parish Councils, resident associations and individual property owners who have registered to receive flood warnings by telephone, fax or pager within designated areas which are predominantly adjacent to main river. Whilst groundwater flooding is not presently covered by a formal flood warning service, the Environment Agency provides information on groundwater levels and the risk of flooding by e-mail, on the internet and through Floodline..
- The Environment Agency and Hampshire County Council supports Village Flood Plans and Flood Action Groups, where communities have an active role in preparing for, and responding to, flooding.
- At St Mary Bourne, 1 property suffered internal sewage flooding and 4 properties suffered from external contaminated water flooding or impeded foul water drainage during the winter 2000-01.
- Numerous properties suffered from external flooding in the village.
- The floodwaters were constricted by two road bridges in the village that caused backing up of the Bourne Rivulet, classified as “main river” through the village, and inundation of the ornamental pond.
- Flooding/groundwater ingress caused the public foul sewerage system serving the village to surcharge, Southern Water had to implement emergency measures and pump sewage into the Bourne Rivulet.
- During the event sandbags were used extensively and proved effective in containing most of the water in bank, and preventing worse flooding in the centre of St Mary Bourne
- Flooding was experienced in St Mary Bourne in 1960, 1980 and 1995. The 2000/2001 event is reported to have been very similar to that of 1995. However, problems with the foul sewerage system are reported to occur much more frequently, with tankering from manholes in the village having been necessary for varying periods every winter over the last few years.
- 2000/01 was the wettest water year (April-March) on record with a probability of occurrence that was less frequent (rarer) than once in 100 years. As a result, groundwater levels during the summer of 2000 were unusually high, and then rose to previously unrecorded levels locally during the following winter. This led to exceptional springflows within the village. Runoff from periodic episodes of heavy rainfall further increased surface flows.
- A report was produced for the National Rivers Authority following flooding in St Mary Bourne in 1995. The report recommended improving the Bourne Rivulet flow gauge at Hurstbourne Priors, which has been implemented, and constructing a floodwall which is currently being investigated.

Recommended Actions – St Mary Bourne

- The following actions are recommended:
 - 1 **Residents** should register with the **Environment Agency** to receive river flood warnings direct. In addition, the **Agency** should continue to review and enhance its groundwater flooding information service, and **Residents** affected by groundwater flooding should register to receive information by e-mail, by contacting the Hampshire and Isle of Wight Area Office of the Environment Agency on 01962 764904.
 - 2 **St Mary Bourne Parish Council** should work with **Hampshire County Council** Emergency Planning Unit to develop a Village Flood Plan so that the community is prepared to respond to future events.
 - 3 In liaison with the **Environment Agency** and **Basingstoke and Deane Borough Council**, **St Mary Bourne Parish Council** should set up a Flood Action Group so that the community plays an active role in reducing the risk of flooding. The Group's activities should include a watercourse inspection programme to identify and assess land drainage concerns and resolve issues locally.
 - 4 **Southern Water** should continue to review the foul drainage system through the villages it serves, implement outstanding improvement works on the public sewer system as appropriate, and provide details via **Basingstoke and Deane Borough Council** of the private sewer laterals which **property owners** need to repair.
 - 5 **Basingstoke and Deane Borough Council**, in consultation with **Test Valley Borough Council**, should maintain liaison with **Southern Water**, and lead and co-ordinate the formulation and implementation of an action plan for remedial works to the private sewer laterals in the villages of Ibthorpe, Hurstbourne Tarrant, Stoke, Swampton and St Mary Bourne. Repairs to the private sewer laterals are to be carried out by the **property owners**.
 - 6 **Southern Water** should support this process by making available relevant information from their surveys of the system, and providing technical advice as necessary to **Basingstoke and Deane Borough Council**.
 - 7 The **Environment Agency** should review the needs for a permanent floodwall alongside changes to their maintenance regime for the Bourne Rivulet, and implement as appropriate.
 - 8 **Basingstoke and Deane Borough Council**, **Hampshire County Council** and **St Mary Bourne Parish Council**, in conjunction with **Riparian owners**, should review the maintenance and provision of the surface water drainage system.

ACTION PLAN

Town/Parish: **ST MARY BOURNE**

Action	Statutory Authority (Lead/ Assisting)	Comments (including timescale)	Agreement/ Disagreement
Residents should register with the Environment Agency to receive river flood warnings direct.	Environment Agency to liase with residents	The Environment Agency, through the national mailing, will contact residents in the flood plain by November 2002.	EA: Agree
Continue to review and enhance the groundwater flooding information service.	Environment Agency	The review of the groundwater flooding information service will be completed by November 2002, and will be continually enhanced. The Agency is proposing to install a borehole at Upton.	EA: Agree
Residents affected by groundwater flooding should register to receive information by e-mail by contacting the Environment Agency	Environment Agency to liase with St Mary Bourne Parish Council and residents	The Environment Agency will contact the Parish Council and residents by November 2002 & encourage them to receive groundwater flooding information.	EA: Agree
The Parish Council should work with Hampshire County Council Emergency Planning Unit (EPU) to develop a Village Flood Plan	St Mary Bourne Parish Council, <i>Hampshire County Council (EPU)</i>		PC: Agree <i>HCC: Agree</i>
In liaison with the Environment Agency and local authority, the Parish Council should set up a Flood Action Group. The Group's activities should include a watercourse inspection programme to identify and assess land drainage concerns and resolve issues locally.	St Mary Bourne Parish Council, <i>Environment Agency,</i> <i>Basingstoke and Deane BC</i>	<i>The Environment Agency will assist when requested.</i>	PC: Agree <i>EA: Agree</i>

Action	Statutory Authority (Lead/ Assisting)	Comments (including timescale)	Agreement/ Disagreement
Continue to review the foul drainage system, implement outstanding improvement works on the public sewer system as appropriate, and advise Basingstoke and Deane Borough Council of the private sewer laterals which property owners need to repair.	Southern Water		SW: Agree
Lead and co-ordinate the formulation and implementation of an action plan to improve the performance of the private sewerage system, including customers' laterals in all the villages it serves, Ibsthorpe, Hurstbourne Tarrant, Stoke, Swampton and St Mary Bourne	Basingstoke and Deane BC, <i>Test Valley Borough Council, Southern Water, St Mary Bourne Parish Council to liaise with property owners*</i>	- As of date of publication, agreement is yet to be made with Basingstoke and Deane Borough Council. However the Environment Agency will continue to seek agreement. - PC note that Riparian owners are responsible and will bear any costs associated with improvements	BDBC: SW: Agree PC: Agree
Southern Water should support the formulation and implementation of an action plan (see above) by making available relevant information from their surveys of the system, and providing technical advice as necessary to Basingstoke and Deane Borough Council	Southern Water, <i>Basingstoke and Deane BC</i>	Basingstoke and Deane BC have been advised of the locations of the leaking laterals.	SW: Agree
Review the needs for a permanent floodwall alongside changes to the maintenance regime, and implement as appropriate.	Environment Agency	Maintenance regime will be reviewed, and river strategy will review if any capital works are required.	EA: Agree
Review the maintenance and provision of the surface water drainage system.	Basingstoke and Deane BC, <i>Hampshire County Council, St Mary Bourne PC in conjunction with Riparian owners*</i>	As of date of publication, agreement is yet to be made with Basingstoke and Deane Borough Council. However the Environment Agency will continue to seek agreement.	BDBC: HCC: Agree PC: Agree

* Riparian owners/property owners are responsible and will bear any costs associated with improvements.

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Appendices

A Flood defence powers and responsibilities

1

Introduction

1.1

Background

Very high rainfall was experienced across Hampshire for extended periods over the winter of 2000/2001. Numerous incidents of flooding were reported, many of which related to elevated groundwater levels and high springflows; often they lasted for extended periods. The Environment Agency (the Agency) commissioned Halcrow Group Limited (Halcrow) to assess the more significant of these incidents in March 2001, with a view to analysing the mechanisms of flooding in each case, and identifying and assessing possible mitigation works wherever these are likely to be feasible.

Halcrow is investigating all 100 or so Hampshire incidents drawn to the Agency's attention that entailed:

- flooding in cellar/basement used either for (a) storage or (b) living space;
- other internal flooding;
- flooding leading to the deposition of sewage in domestic gardens;
- flooding leading to financial loss for commercial enterprises (severed access, damaged stock or equipment etc).

Output from our work includes:

- an initial findings report, which describes our preliminary review of all sites and its main outcomes (September 2001);
- a site-specific report for each of the flooding incidents investigated;
- opportunity for residents, parish councils and other local authorities who have suffered directly as a result of the floods, or who have any other interest in them, to comment on draft versions of the site specific reports before they are finalised;
- overview report, pulling together key findings from the investigation work and public awareness campaign.

This document is the site-specific report relating to the flooding at St Mary Bourne.

Approach

The studies have been undertaken by means of reviewing, supplementing and interpreting available information, to set the flood event in perspective and thus to assess the scope and viability of potential mitigation works.

Information was obtained from a number of sources, including:

- Agency questionnaires returned by residents of flood-affected areas;
- contact with parish council representatives;
- discussions with the local authority;
- discussions with other third parties involved in specific flood works in a number of villages;
- site visits to interview residents, supplemented as appropriate by telephone discussions;
- reference to photographs supplied by the Agency or village residents;
- follow-up visits to selected villages by a river engineer;
- A report on the 1995 flood event in the village, commissioned by the then National Rivers Authority (now the Environment Agency), and prepared by Messrs Posford Duvivier (now Posford Haskoning).

2

Flooding at St Mary Bourne

2.1

Location

The village of St Mary Bourne lies some 7 kilometres north east of Andover, in the upper catchment of the River Test, at an elevation of around 80m above sea level (see Figure 1). Local geology comprises predominantly Upper Chalk. Within the base of the valley the Chalk is overlain by a thin drift of River and Valley gravels, in turn overlain by alluvium. Clay with Flints cap the slopes to the east of St Mary Bourne.

The principal local watercourse is the Bourne Rivulet, which flows through the centre of the village, and is perennial there. The Bourne Rivulet is classified as “main river” through the village, so that the Environment Agency has permissive powers enabling it to carry out flood alleviation work there. The Agency may also carry out works to limit the risk of flood from the river, subject to technical, environmental and economic feasibility, and to the availability of funding.

The parish council for the village is St Mary Bourne Parish Council and the local authority is Basingstoke and Deane Borough Council. Hampshire County Council has powers that enable it to maintain all adopted roads and their associated drainage. The local authority also has permissive powers that enable it to carry out flood prevention work on all watercourses that are not “main river”. In addition, individual property owners are responsible for the drainage of their own land, and for dealing with and accepting the natural catchment flows from adjoining land. They must not permit an obstruction to the natural flow. It should also be noted that part of the sewer system within the local catchment is within the administrative area of Test Valley Borough Council.

Further information on flood defence powers and responsibilities is included in Appendix A.

The properties investigated by Halcrow are all connected to a public sewerage system owned and operated by Southern Water. Whilst Southern Water maintains the sewers themselves, householders are responsible for maintaining the full length of the laterals by which their properties are connected to those sewers. The same public sewer system also serves a number of other villages upstream, including Ibthorpe, Hurstbourne Tarrant, Stoke and Swampton, some of which lie within

the administrative area of the adjoining local authority, Test Valley Borough Council.

2.2

Winter 2000/2001 Flooding

Exceptionally high groundwater levels caused internal and external flooding of properties in St Mary Bourne and Swampton in December 2000. Flooding was caused by emerging groundwater, overtopping of the Bourne Rivulet and surcharging sewers.

Agency data and the findings of our consultations with local residents have been used to prepare Table 1 and Figure 2, which describe what we have been able to establish about the nature of the flooding at St Mary Bourne and the properties affected.

Table 1 Available Details of Flooding per Halcrow Criteria at St Mary Bourne, Winter 2000-01

Location	Nature of flooding	Dates/ duration	Sources of information
Mundays, St Mary Bourne	External surface water flooding and toilet flushing impossible.	Flooding commenced early December 2000, and receded in March 2001	Agency questionnaire
Spring Hill Lodge, St Mary Bourne	12 inches (300mm) of water outside property from the Bourne Rivulet	Mid-December to February	Agency questionnaire
Langley, St Mary Bourne	External surface water, groundwater flooding, and toilet flushing impossible.	December 2000 and January 2001 for about 6 weeks	Agency questionnaire

Location	Nature of flooding	Dates/ duration	Sources of information
4 Bourne Meadow, St Mary Bourne	Internal flooding due to sewage surcharge on two separate occasions. This flooded the bathroom.	Little detailed information is available, however toilet flushing was impossible for 6 weeks on one occasion.	Agency questionnaire
5 Applegate, St Mary Bourne	Downstairs toilet inoperable	No data	Agency questionnaire
Lakeview, St Mary Bourne	External surface water and the manhole overflowed outside property causing sewage flooding	Mid January 2001 for about 2 weeks	Agency questionnaire

Internal sewage flooding occurred at one property. Numerous properties suffered external flooding; only those most seriously affected are mentioned in Table 1. Barford House, Spring Farm House, Minden, Knapp Cottage were all also affected by external flooding to a lesser degree, as were many other properties.

In general terms, the unusually wet summer and winter of 2000-01 caused high groundwater levels and surface flows in the village. The latter resulted both from springs within and above the village, and from runoff associated with periodic rainfall events (see Section 3). High groundwater levels and surface flows also caused the foul sewerage system to become surcharged, rendering some toilets inoperable and in some cases causing raw sewage to overflow from it. This aspect of the flooding caused most distress to residents of St Mary Bourne.

The problems with the foul sewer system led Southern Water to pump sewage to a temporary overflow into the Bourne Rivulet under emergency provisions. This took place from early January 2001 to mid June 2001; raw sewage was pumped into the Bourne Rivulet just upstream of the village (see Figure 2) It is understood that the Company was also pumping sewage from manholes in the village into

tankers to lower water levels in the sewers over a period from November 2000 to May 2001. Residents found the noise and intrusion during these pumping operations to be very disruptive, and were particularly concerned with both the discharge of untreated sewage to the river for extended periods, and health and safety aspects of the pumping operations (it was suggested that manholes that were left open were not well marked as a hazard). Residents also report that such emergency provisions have been employed over the last few years in St Mary Bourne; Southern Water confirm that tankering from the system has recently been necessary every year (duration depending on groundwater level behaviour), and pumping to river in winter 1995 and winter 2000-01.

The problems are believed to be due to ingress of groundwater into the sewerage system which, as noted in Section 2.1, also serves other villages upstream of St Mary Bourne. Southern Water has investigated the system and has relined several sections of it. In the course of these investigations, 65 leaking lateral connections were located, of which 8 are within St Mary Bourne itself and the remainder in villages upstream.

Maintenance and repair of private sewer laterals are the responsibility of the owners of the properties they serve, and local authorities have powers of enforcement if circumstances warrant. Southern Water therefore plans to provide the information it has on leaking laterals to the relevant local authorities (in this case, Test Valley Borough Council as well as Basingstoke and Deane Borough Council) to follow up.

The Bourne Rivulet, known locally as the River Swift, also overtopped its banks in the village. Unusually high flows (see Section 3) backed up at two bridges in the village (see Figure 2). The bridge just downstream of the ornamental pond has a sluice structure attached to it (see plate 1). Although the sluice gates were open, the capacity of the structure was insufficient for the flow experienced, so that flooding occurred upstream. The road bridge near the George Inn (see plate 2) was also of insufficient capacity for the flow, with a similar result.

Spring Hill Lodge and Mundays, near the ornamental pond, were most affected by this river flooding (see Figure 2). The peak period of flooding at these properties, arising from the out of bank flow of the river and groundwater seepage, occurred in February 2001. The external flooding did not recede from them until late March 2001. Such flooding also occurred in 1995, when Mundays was flooded internally by groundwater.

Extensive use of sandbags to raise the river bank locally, and to protect properties such as Spring Hill Lodge, proved effective in containing most of the water in bank, and preventing worse flooding in the centre of St Mary Bourne (see Plates 3 and 4).

Flows from springs, and other local problems related directly to high groundwater levels, were also experienced within St Mary Bourne. The street became a flowpath for both the excess springwater and a limited amount of flow from the Bourne Rivulet that was not contained by the sandbags. However, the road remained in use, and residents along it were very concerned that the bow-waves caused by some vehicles might lead to internal flooding of some properties.

Road flooding can give rise to:

- Safety risks, where vehicles come upon unexpected flooded areas at speed;
- Damage to verges, mud being deposited onto roads and consequent increased risk of minor accidents, where closures cause traffic to divert along unsuitable and/or narrow alternative routes;
- Costs and delays associated with detours around closed sections of road, particularly where diversion signing is inadequate.

Flooding was experienced in St Mary Bourne in 1960, 1980 and 1995. The 2000/2001 event was very similar to that of 1995. The then National Rivers Authority (now the Environment Agency) commissioned a study of the 1995 event in St Mary Bourne; this noted that construction of a flood wall had a benefit/cost ratio above unity, and also recommended that the (Agency) should consider improving the measurement capacity of the Bourne gauging station at Hurstbourne Priors. The gauging station has been improved, and construction of a floodwall is currently being investigated.

3 Context of Flood

3.1

Rainfall

The nearest available long-term rainfall record is located at Hurstbourne Tarrant (NGR SU 3821 5323, see Figure 1) approximately 2.5 km north west of St Mary Bourne, where daily rainfall records are available for the period 1968 to 2001. Data from it are presented on Figure 4 in histogram format as follows:

- Annual amounts, by water year (April-March);
- Winter amounts (October-March);
- Amount in month of maximum rainfall for each water year.

The plots indicate that rainfall during the year April 2000 to March 2001 and during the winter of October 2000 to March 2001 far exceeded the next highest annual rainfall (1994 – 95) and winter rainfall (1994 - 95). The maximum 1-month rainfall for the year 2000 – 01 (bottom plot of Figure 4) is the third highest on record.

For a limited number of rainfall stations throughout Hampshire frequency analyses have been carried out to estimate how often rainfall events of the type experienced in 2000-01 may be expected to occur. Not all rainfall stations have a long or complete enough data set for this exercise to be carried out. Data for the long-term record (54 years) at Andover Water Works, approximately 7 km to the south (NGR SU 3680 4670), are presented in Table 2 below.

Table 2 Frequency of occurrence of 2000-01 rainfall events

Period over which rainfall measured (relates to 2000-01)	Total rainfall recorded in period (mm)	Estimated frequency of occurrence of comparable events
Water year (April 00-March 01)	1199	Rarer than once in 100 years
Winter (October 00-March 01)	745	Rarer than once in 100 years
Wettest month (November 00)	180	About once in 10 years

For the purposes of this report, “frequency of occurrence” and “return period” relate to the *average* number of times an event may be expected to occur within the stated period, by reference to how often it is known to have occurred within the period of an existing record. Thus an event (such as total annual rainfall) that has been equalled or exceeded 5 times in 100 years of recorded data may be said to have a frequency of occurrence of once in 20 years (5% chance in any given year). This presumes of course that the pattern of such events in the future will be similar to that in the past, as reflected in the available record.

It should also be noted that the frequency of occurrence of flooding at a particular location cannot be inferred by reference to the frequency of the rainfall event with which it coincided. Lesser rainfall events could also lead to flooding in the same area, although it may be expected to be less severe. Furthermore flooding is as much a reflection of the performance of the local drainage network as of antecedent rainfall.

The Andover Water Works rainfall record is close enough to St Mary Bourne to be relevant to the flood events that occurred there in winter 2000-2001. Depending on the duration of event considered, therefore, rainfall in 2000-01 at Andover, and in the vicinity of St Mary Bourne, was at least unusual, and in some cases an extremely rare event.

Rainfall data for a number of stations in Hampshire have also been analysed for evidence of a changing trend. Possible change points were detected in the 1990's for the majority of records examined. However, given the short duration of the record since that time, there is no clear evidence yet to suggest that recent events are the result of Climate Change. It cannot be confirmed that these change points herald a change in rainfall patterns.

3.2

River Flow

There is a river flow gauging station on the Bourne Rivulet just prior to its confluence with the River Test. Records at Bourne (NGR SU 4410 4629) only commenced in 1993 and some months were not recorded at the end of 1999 due to weir replacement. The daily flow at Bourne is plotted against date in Figure 5. This shows that:

- a rapid rise in discharge during November and December 2000 culminating with;
- the highest peak flow recorded on Christmas Day 2000 at 3.989 m³/s. This was 0.7m³/s more than the previous recorded maximum on 9/3/95

- there was a prolonged period of high flows during the winter of 2000

Figure 6 compares daily rainfall at Hurstbourne Tarrant with mean daily flow at Bourne for the water year April 2000 to March 2001. This shows that:

- there is generally a delay of approximately one day between rainfall events and peak flow response in Bourne Rivulet;
- this response is generally greater in the winter months (October to March) than the summer months (April to September); this contrast is due to factors such as reduced crop cover and evapotranspiration in the winter months which, along with seasonally wetter conditions, result in greater surface run-off. There is also a larger groundwater contribution from springflow and baseflow in winter, which results in a slower decline in flows after rainfall;
- heavy rainfall occurred on 29th October, 5th and 6th November and between 25th November and 12th December 2000;
- maximum mean daily flow occurred between 18th December 2000 and 4th January 2001;
- an additional peak flow event occurred between 23rd and 28th February 2001.

3.3

Groundwater Levels

As noted in Section 2.1, St Mary Bourne is underlain by Upper Chalk, with a thin drift of recent terrace gravel, in turn overlain by alluvium, overlaying a layer of Middle Chalk above the Upper Chalk along the course of the Bourne Rivulet. Clay with Flints cap the slopes to the east of St Mary Bourne. The Upper Chalk is a good aquifer, which means it has storage potential to absorb excess rainfall for extended periods. The additional amount it can store at any time, and the rate of release to river systems via springs and seepage (known as baseflow), are a function of the water level within it relative to the ground surface as well as the storage and transmission properties of the aquifer itself.

Groundwater records have been examined from two observation boreholes as shown in Figure 1:

- Stokehill Farm (NGR SU 3935 5135), approximately 3km north west of St Mary Bourne at 161.51 mOD; data are available since 1964.

- Woodside, Vernham Dean (NGR SU 3315 5645) approximately 11km north west of St Mary Bourne at 135.15 mOD; data are available since 1959.

The record at Stokehill Farm and Woodside can be considered representative of the Upper Chalk aquifer of the Upper Test catchment feeding springs, winterbournes and seepage to the Bourne Rivulet. There are other boreholes located within the Bourne Rivulet river valley, notably St Mary Bourne (NGR SU 4255 4955), which are less representative because they shows very little fluctuation during 2000 as groundwater appears to be at or very close to ground level and hence not used in this analysis.

The well hydrographs (plots of groundwater level against date) for the boreholes are shown in Figures 7 and 8. The hydrographs show:

- a relatively large range of water level fluctuation between winter and summer levels, typical of the upland catchment area of the Upper Chalk;
- the peak groundwater in Stokehill Farm occurs on 21 February 2001 which also has the highest groundwater levels on record – this delayed response corresponds to the movement of groundwater down through the valley, however this is 30 –50% greater than what would be expected from normal groundwater fluctuation and occur about 2 to 3 months earlier;
- Woodside peaked in December 2000.
- both the borehole maxima follow an extreme rise in groundwater levels during the preceding recharge period
- the 'summer' minimum groundwater level in 2000 was one of the highest on record and is preceded by a progressive rise in summer minima since 1997;
- the high groundwater levels were sustained until April / May 2001;

Figure 9 plots the groundwater hydrographs for both boreholes against average monthly rainfall for Hurstbourne Tarrant for the last two years. With relatively few groundwater level readings and the damped response of groundwater to infiltrating rainfall, the monthly rainfall record is sufficient to demonstrate impact upon groundwater levels. This shows:

- peak groundwater level occurring approximately one month after peak rainfall in Woodside and approximately three months after peak rainfall in Stokehill Farm;
- sustained high groundwater levels following three consecutive months of high rainfall;
- increased hydraulic gradient between Stoke Hill Farm and the borehole located further up the river valley, Woodside. This would contribute to the movement of emergent streams further up dry valleys where the groundwater intercepts with ground levels.

According to the Hydrogeological Map of Hampshire and the Isle of Wight (IGS/Southern Water Authority 1979) and based on groundwater elevations during October 1973, groundwater flow in the St Mary Bourne area is in a south easterly direction, convergent into the Bourne Rivulet valley.

3.4

Discussion

The flooding at St Mary Bourne was caused by the following events:

- 2000/01 was the wettest water year (April-March) on record, with the highest antecedent (summer) groundwater levels on record;
- during September 2000 – December 2000, the cumulative effect of 3-4 months of the heaviest rainfall on record led to significant increases in groundwater levels, which reached their highest recorded values locally,
- peak groundwater level occurred earlier than usual, in December;
- groundwater levels were raised to exceptional highs both in the valley and in the inter-fluvial areas but the distribution of groundwater recharge appears to accentuate the contrast between groundwater levels in the valleys and those in the inter-fluvial areas, so that there is also an increased hydraulic (groundwater) gradient from high ground to the valleys;
- high groundwater levels and gradients led to the emergence of new springs and the upstream migration of winterbournes in the chalk valleys;
- any additional rainfall received during this period will have contributed directly to the flooding in the form of direct runoff, as the “buffering” effect normally imposed by the infiltration of rainfall to groundwater (and its subsequent release) will have been minimised due to the lack of available groundwater storage
- a rapid rise in flow occurred in early November 2000 in response to very heavy rainfall on 29th October and 5th / 6th November;

- the Bourne Rivulet continued to rise in response to a combination of rainfall and baseflow / springflow with flows peaking in mid December 2000 and mid February 2001;
- the combination of high groundwater and high river flows resulted in the internal and external flooding of low lying properties, surcharge of the drainage and sewerage systems and the out of bank flow of the Bourne Rivulet during the flood event.

4 Scope for Mitigation

4.1 *Introduction*

The type of flooding and possible mitigation measures are described in Table 3 (at back of text). Various details of potential flood mitigation are described below.

4.2 *Details*

4.2.1 *Flood Information*

The Agency provides a flood warning service to Parish Councils, residents' associations and individual property owners who have registered to receive flood warnings by telephone, fax or pager within designated areas including St Mary Bourne that are predominantly adjacent to main river. Whilst groundwater flooding is not presently covered by a formal flood warning service, the Environment Agency provides information on groundwater levels and the risk of flooding by email, on the internet and through Floodline. Residents can contact Floodline on 0845 988 1188 and use the Quick Dial Code 01226 to find out the latest groundwater information. Details are also available on the Environment Agency web site at www.environment-agency.gov.uk. Residents can also register to receive the information by e-mail, by contacting the Hampshire and Isle of Wight Area Office of the Environment Agency on 01962 764904.

The Agency plans to install a borehole at Upton in order to improve the groundwater flooding information service further.

Such information is very useful in enabling people to prepare adequately, provided they receive and react to it in good time. Property owners can receive river flood warnings direct to their home or work by phone, fax or pager. However people have to request or 'opt in' to receive warnings, and despite successive flood awareness campaigns since 1996, only 1 in 4 properties at risk have registered to receive flood warnings. In addition to the automatic receipt of warnings, residents can call Floodline on 0845 988 1188 and use the quick dial code 0122211 for the Upper Test, including the Bourne Rivulet, for the latest information.

In addition to residents taking full advantage of the current flood warning system and groundwater flooding information service, the Agency should continue to review and enhance it, for example by extending it to note when groundwater

levels are approaching values that may lead to flooding. Such enhancement should ensure that:

- all properties known by the Agency to be vulnerable to groundwater flooding are made aware of the Agency's groundwater flooding information service, and encouraged to register to receive it by e-mail. Also Parish Councils and/or Flood Action Groups (see below) are encouraged to register to receive groundwater flooding information, and disseminate it to residents in the village;
- the most efficient and effective means that technology reasonably allows for communicating with occupiers are being used for issuing flood warnings and disseminating groundwater flooding information.

These measures may be of value in reducing any adverse impacts at the properties that suffered groundwater-related internal flooding in St Mary Bourne, should similar incidents occur in the future.

Individual property owners may also wish to consider making provision to improve surface water drainage in the immediate vicinity of their houses. Where flooding is associated with high local groundwater levels, pumping may be effective in solving the problem (for example, from a sump constructed beneath floor level within or immediately outside the house). Groundwater pumping from cellars may similarly be effective in maintaining flood levels below the ground floor; however, lowering of the water table within the property in this way should be approached with caution and kept to a minimum relative to surrounding groundwater levels. There is a risk that cellar walls could be damaged if the water level (pressure) outside exceeds that on the inside by more than a small amount.

Surface drainage improvements or sump/cellar pumping would require an effective water disposal route and, if the discharge is to a main river, consent from the Environment Agency (see Appendix A). Also discharge should not be disposed of via the public sewerage system, as it may cause further problems elsewhere in the system. Even with an effective disposal route, such measures are not always successful in controlling flooding.

St Mary Bourne Parish Council should work with Hampshire County Council Emergency Planning Unit to develop a Village Flood Plan, so that the community is prepared to respond to future events. In liaison with the Environment Agency and Basingstoke and Deane Borough Council, St Mary Bourne Parish Council