Policy Site H10, Banbury

Development Flood Risk Assessment

HALLAM LAND MANAGEMENT

&

GALLAGHER ESTATES

November 2003

Brookbanks Consulting

111 Hagley Road Edgbaston Birmingham B16 8LB
Tel: +44 (0) 121 452 5015 Fax: +44 (0) 121 452 5016
Email: mail@brookbanks.com

Document Control Sheet

Document Title: Development Flood Risk Assessment

Document Ref: 1071/DFS/01

Project Name: Policy Site H10, Banbury

Project Number: 1071

Client: Hallam Land Management Ltd & JJ Gallagher Ltd

Document Status

Rev	Issue Status	Prepared / Date	Checked / Date	Approved / Date
0	Draft	CjB27/11/03	PAB27/11/03	PAB 27/11/03

Issue Record

Name / Date & Revision	27/11/03					
Nick Duckworth - Hallam Land	0					
Andy Hawkes - JJ Gallagher	0					

CONTENTS

1 INTRODUCTION

1.1 Brookbanks Consulting Limited were appointed by Hallam Land Management Limited and JJ Gallagher Ltd to prepare a flood risk assessment (FRA), for a proposed residential and commercial development know as Policy Site H10, Banbury.

1.2 Plans showing the site location and the proposed development area are included in Appendix A as Figure 1 and drawing 1071/LP/01 respectively.

1.3 Photographs of the development area are shown in Appendix C.

2 BACKGROUND INFORMATION

Site Location & Details

2.1 The land of interest is located to the south of existing development within Banbury, near to Bodicote Village and approximately 600m west of the M40 motorway at the closet location. The proposed development is bounded to the north east by the Oxford Canal, to the south east by arable land and to the south west by the A4260 Oxford Road and existing development along this frontage. Residential development, known as Cherwell Heights, bounds the northern area of the site.

2.2 The land is historically undeveloped and is currently in arable agricultural usage.

2.3 The proposed site lies on the western bank of the Cherwell Valley, which is natural channel forming the catchment of the River Cherwell running in a north west to south east direction. Levels within the site fall from approximately 123m AOD at the western boundary down on Oxford Road, down to approximately 90m AOD to the east and adjacent to the canal.

Development Criteria

2.4 The site is identified in the Deposit Draft Cherwell Local Plan 2011 as Banbury Urban Extension: Land off Bankside, policy site H10 for residential and associated ancillary end use.

2.5 Concept master plans are in early stages of development. In establishing land use criteria, reference to the draft budget land use calculations, prepared by John Thompson & Partners, indicate the following:

Area 1 - Canal side	5.75 ha	300 residential units
Area 2 - Oxford Rd	31.40 ha	950 residential units
Area 3 - Oxford Rd	4.90 ha	B1 development (area not specified)
Totals	**37.2 ha**	**1,250 units**

The gross site area is approximately 80.5 ha (201.15 acres). Overall land use will be approximately as follows:

Residential / community	37.2 ha
Employment	4.9 ha
Country park / open space	38.0 ha
Total	**80.1 ha**

A plan showing the proposed development areas is shown in Appendix A.

Sources of information

2.6 The following statutory bodies were consulted during the preparation of this report:

Thames Water	-	Water supply & drainage
Environment Agency	-	Flood protection / storm water drainage
British Waterways	-	Canal and drainage issues

2.7 The following information has been available during the preparation of this report:

Cherwell District Local Plan 2011, Deposit Draft	Cherwell District Council December 2001
Ordnance Survey Superplan	Ordnance Survey, 2001
Site Survey Plan	Triway Consultants, 2003
Borehole Records SP/43NE/20, SP/43NE/16	British Geological Survey
Draft budget land-use calculations	John Thompson & Partners

Ground Conditions

2.8 Published geology for the site suggests a solid geology of Liassic clays of the Jurassic Period. The is no evidence of drift deposits, except for alluvium in the region of the River Cherwell.

2.9 Record borehole logs have been obtained from the British Geological Survey for the higher areas of the site, adjacent to the A4260 Oxford Road. The stratum adjacent to the site may be characterised as:

BH SP/43NE/20	Thickness (m)
Topsoil	0.23
Ironstone	0.18
Clay	0.48
Clay & Limestone	0.70
Ironstone	1.50
Clay	0.40
Clay & Ironstone	0.84
Siltstone	0.28
Sandy Clay	1.00
Hole terminated	

BH SP/43NE/16	Thickness (m)
Topsoil	0.15
Clay	0.25
Limestone	0.02
Clay	0.43
Light Brown Clay	0.20
Clay & Rotten Ironstone	0.30
Ironstone	2.44
Micasaeous Silty Clay	0.76
Ferr Siltstone	0.38
Light Brown Sandy Clay	0.96
Ferr Siltstone	0.07
Siltstone	0.50
LB Sandy Clay	0.13
Hole terminated	

3 FLOOD RISK ASSESSMENT

3.1 Allocation and planning of development should be considered against a risk based search sequence, as provided by PPG25: Development & Flood Risk. In terms of fluvial flooding, the guidance categorises flood zones in three levels of risk, as follows:

Flood Zone		Annual Probability of flooding
1	**Little or no risk**	<0.1 %
2	**Low to medium risk**	0.1 - 1.0 %
3	**High risk**	> 1.0 %

3.2 Using the sequential approach defined by the guidance, development of residential nature is considered appropriate in areas categorised by Zones 1 or 2. Put simply, the development should lie outside the envelope of the predicted 1 in 100 year flood event.

3.3 Hence, this section of the document addresses the requirements of the guidance in demonstrating that the proposed development lies within the acceptable flood risk parameters.

Available Flooding Data

3.4 In completing the FRA, the Environment Agency and the Land Drainage Authority have been contacted to ascertain any background information they may have on flooding in this area. The following information was requested:

- **Plans, photographs or other details of historic flooding at, or near, the site and views as to likely return period and the like.**
- **Plan of Indicative Floodplain Mapping for the site.**
- **Details of any recorded flood levels in the geographical area of the site.**
- **Details of any water level loggers near the site.**
- **Watercourse survey information.**
- **Results of any flood modelling completed in the vicinity of the site.**
- **Details of any flood alleviation measures in place for the Shottery Brook.**

- **Observations on recent flood trends which may be due to the potential effects of built development and the like.**

3.5 The Environment Agency (EA) have provided advance details of their draft Section 105, 1 in 100 year floodplain mapping. Reference to this document shows the proposed development to lie outside same. A plan showing the extent of the floodplain is shown on drawing 1071/FL/01in Appendix A.

3.6 The floodplain is seen to extend from the River Cherwell over much of the low lying land to the east of the canal. The 100 year flood levels are reported to be 88.3m AOD at the northern end of the site and 87.93m AOD at the south.

Topography

3.7 The three dimensional level survey completed by Triway Consultants in June 2003 has been used to establish terrain contour mapping for use in completing the FRA. Drawing 1071/SV/02 in Appendix A shows the site level contours.

3.8 It may be seen from the plan in Appendix A that the site rises at a steady gradient from a level of approximately 90m at the canal edge, to a plateau area adjacent to A4260 Oxford Road at about 123m AOD.

3.9 Accordingly, the existing terrain levels all lie above the draft S105, 1 in 100 year flood levels.

3.10 Water level in the canal, at time of survey, was recorded as 89.51m AOD. The water level is regulated to a maximum level of 89.77m by a side overflow weir. The weir is located some 0.7km along the canal, to the south east and close to the motorway. The weir overflows into drainage channels which eventually convey water into the River Cherwell.

3.11 Ground levels to the north of the canal are seen to be lower than the planned development site. Accordingly, any overflowing of the canal, due to blockage of the weirage or excess flows, will result in waters being conveyed in a northerly direction, towards the River Cherwell and away from the site.

Existing Drainage

3.12 An existing culvert beneath the canal connects the site to the River Cherwell. Levels of the culvert are such that out of bank flows in the the Cherwell could not be conveyed into the site which would result in flooding.

Anecdotal Information

3.13 The site is not known to have flooded.

Assessment

3.14 In endeavouring to bring objectivity to the FRA, the following risk matrix has been prepared.

	Data Source	Notional Risk Level			No Data
		Little / No <0.1%	**Low - Medium** 0.1% - 1.0% river 0.1 - 0.5% coastal	**High** > 1.0% river > 0.5% coastal	
Increasing confidence ⇒	Anecdotal information		●		
	Subjective view based on site topography		●		
	EA Indicative floodplain maps		●		
	Draft EA S105 floodplain maps		●		

Table 3a - FRA Risk Matrix

3.15 It can be seen that all available evidence suggests the site to lie outside the High Risk - Zone 3 as outlined in PPG25.

4 SURFACE WATER DRAINAGE

Existing Conditions

4.1 Thames Water have provided basic details of their storm water network in the vicinity of the site. Adopted sewers are present within the carriageways of the Cherwell Heights development. These sewers generally convey flows in a northerly direction and towards Bankside to reach an off-site main discharging flows to the River Cherwell approximately 350m from the football ground. The main outfall pipe is 1070mm ⌀.

4.2 The majority of the proposed development land lies within the catchment of the River Cherwell. At present, storm water is generally conveyed from the proposed site towards both the canal and the Cherwell River. A strip of land, near to Oxford Road, lies within the catchment of the Sor Brook and water in this area is conveyed in a southerly direction.

4.3 Within the site boundary, managed drainage by way of watercourses or sewers is limited. Where such are present, the majority take the form of watercourses discharging in a north easterly direction into the canal. However, surface water is not exclusively discharged to the canal. At one location, an existing watercourse is seen to discharge into a grated gully near to the eastern boundary of the site. Water collected from this point is discharged to a manhole, adjacent to canal, before passing beneath the canal and through the land to the east. No outfall can be located for this drain, but it is thought that the water is discharged to the existing watercourse running between the canal and the River Cherwell.

4.4 The indicative catchment areas and each identified outfall is contained on drawing 1071/LP/02 in Appendix A.

Design Criteria

4.5 Preliminary design and assessment of the requirements for storm drainage have been based on the following criteria:

Return Period	1 in 1 years
Flood Protection	1 in 100 years
M5-60	20mm
Ratio r	0.40

Impermeability factors	Area 1 - 0.70
	Area 2 - 0.45
	Area 3 - 0.75
Minimum cover to sewers	1.2 m
Minimum velocity	1.0 m/sec
Pipe ks value	0.6mm

Options

4.6 Current planning policy (PPG25) and EA guidance requires developments to employ sustainable urban drainage measures (SUDS) wherever feasible. Careful design of SUDS features can ensure that the site storm water drainage closely reflects the natural hydrology and hydrogeology of the site. Such systems can also improve the quality of water discharged from development prior to reaching the receiving watercourse.

4.7 Source Control is a key element of SUDS and is now identified in Part H of the Building Regulations 2002 as taking preference over convention drainage systems. Part H now states:

"Rainwater from a system provided pursuant to sub-paragraphs (1) or (2) shall discharge to one of the following, listed in order of priority -

(a) an adequate soakaway or some other adequate infiltration system; or where that is not reasonablely practicable,

(b) a watercourse; or where that is not reasonably practicable,

(c) a sewer. "

4.8 Source control systems treat water close to the point of collection, in features such as soakaways, porous pavements, infiltration trenches and basins. The use of same can have the benefit of discharging surface water back to ground rather than just temporarily attenuating peak flows before discharging it to the receiving watercourse.

4.9 As source control measures generally rely upon the infiltration of surface water to ground, it is a prerequisite that the ground conditions are appropriate for such. Published geology for the site suggests the sub-soil will be a clayey material, with low permeability. Hence the use of ground water recharge systems is likely to be limited.

4.10 Next in the search sequence, defined by Part H, is discharge to a watercourse. The site has several nearby watercourses by way of the adjacent canal and the River Cherwell. British Waterways (BW) have confirmed they have no objection to the proposed development discharging surface water to the canal. They will, however, wish to see the existing drainage regime maintained by way of a sustainable drainage scheme.

4.11 BW confirm that the existing culvert below the canal may also be employed. Same would discharge water from the development directly to the River Cherwell, rather than adopting a route via the canal. Initial calculations indicate that the culvert also has some 50% of the full capacity unutilised.

4.12 Last in the search sequence is discharge to a sewer. Same are known to be working at capacity and are hence considered no further.

4.13 The sequential search demonstrates that discharge to a watercourse is the most appropriate solution. Accordingly, initial drainage proposals have been developed employing the existing culvert as the preferred drainage solution.

Appraisal

4.14 Greenfield discharge rates are typically in the range of 4-8 l/s/ha. In establishing the permitted discharge from the development areas, an appraisal has been completed in accordance with ADAS 345, the generally accepted method for same. A copy of the calculations are contained in Appendix D. Taking into account the indicative catchment areas, and the likely site impermeability ratios, the permitted discharges from the site will be in the order of:

Discharge to	Area 1	Area 2	Area 3	Total
River Cherwell	2.8 l/s	0 l/s	0 l/s	2.8 l/s
Oxford Canal	29.4l/s	37.3 l/s	0 l/s	66.7 l/s
Sor Brook	0 l/s	11.3 l/s	12.4 l/s	23.7 l/s
Total	**32.2 l/s**	**48.6 l/s**	**12.4 l/s**	**93.2 l/s**

4.15 As existing flows to the canal are within the River Cherwell's catchment, the existing flow regime to the canal, if maintained and discharged through the culvert, will ensure that the site hydrology is materially unaffected. Accordingly, the following baseline flow rates have been used in appraising the attenuation requirements:

Area 1	2.8 + 29.4	=	32.2l/s
Area 2 & 3	0 + 37.3	=	37.3l/s

4.16 Preliminary proposals have been developed to demonstrate the site surface water management scheme. The proposals are shown on drawing 1071/LP/02 contained in Appendix B.

4.17 The outline scheme provides for pre-treatment ponds as part of a surface water management train in accordance with current guidance. Such proposals will encourage passive treatment of surface waters before discharge to the receiving watercourse.

4.18 Calculations demonstrate that detention basins, or the like, extending to approximately 10,500m^3 will be required to maintain the existing surface water regime. The preliminary calculations are contained in Appendix D. Levels of the existing culvert are such that it will be necessary to incorporate a pumped outfall to the balancing ponds.

5 DISCUSSION OF RESULTS & CONCLUSION

5.1 The development area lies outside the draft EA S105, 1 in 100year floodplain.

5.2 Should the canal flood, due to blockage or the like, waters will be discharged away from the proposed development, in a north easterly direction

5.3 It is recommended that the Precautionary Principle is adopted by selecting a conservative minimum floor slab level for all built development units adjacent to the canal. A building slab freeboard of 300mm is recommended above the canal bank. Same will provide a freeboard in the order of one metre above the draft S105 flood level on the River Cherwell.

5.4 A preliminary storm water drainage scheme has been developed to demonstrate the feasibility of employing sustainable drainage systems at the site. Surface waters will be attenuated to a rate equivalent to the existing undeveloped conditions and discharged to the canal, or River Cherwell via an existing culvert beneath the canal.

5.5 The findings of this report demonstrate that the proposed development can fully comply with the requirements of PPG25: Development & Flood Risk.

APPENDIX A

Site Location, Survey and Floodplain Drawings

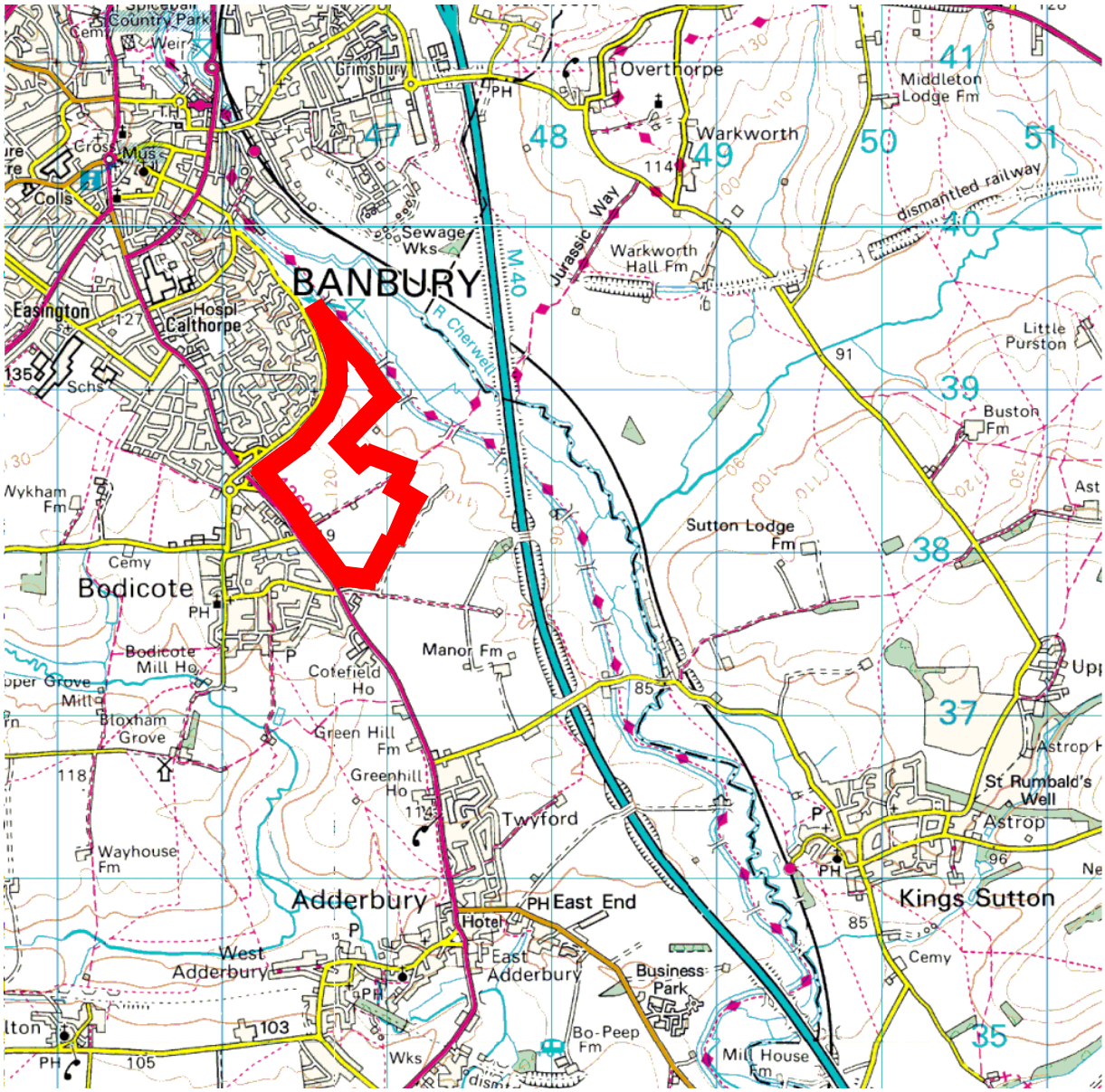


Figure 1 - Site Location

1071/LP/01

Area No. 1
Residential development
covering 5.75 Hectares
(14.2 Acres)

Area No. 2
Residential development
covering 31.4 Hectares
(77.6 Acres)

Area No. 3
Commercial development
covering 4.9 Hectares
(12.1 Acres)

Country Park
covering 38 Hectares
(93.4 Acres)

GENERAL NOTES

1 Do not scale from this drawing.

2 This drawing is based on Ordnance Survey digital data produced 18th March 2001 ©Crown Copyright 2001 and reproduction in whole or part is prohibited without the prior permission of Ordnance Survey.

Brookbanks Consulting accept no responsibility for the accuracy of this information.

Public House

Canal Basin

N

0 50 100 150 200 250
METRES

Rev.	Revision Details	Drawn	Checked	Approved	Date
A	Area's Updated	RD	CJB	CJB	27.11.03

INFORMATION — Issue Status — Drawn — Checked — Approved — Date — Date 19:3:01 — Date 20:4:01

Brookbanks Consulting

111 Hagley Road Edgbaston Birmingham UK B16 8LB
Tel (0121) 452 5015 Fax (0121) 452 5016

GALLAGHER

HALLAM LAND MANAGEMENT

Policy Site H10
Banbury

Development Site Areas

Scale	Drawing No.	Rev.
1:2500	1071/LP/01	A

Original Drawing Size A1

1071/LP/02

DRAINAGE NOTES

1. Drained directly into canal
2. Outfall into canal via pipe
3. Drained into ditch then piped under canal to assumed outfall in river
4. Drained to hedgeline and discharged to canal
5. Two streams join ditch along hedgeline and discharge to canal
6. Drained into ditches and discharged at outfalls into canal
7. Drained into canal at various points
8. Drained across road into watercourse
9. Drained to canal

GENERAL NOTES

1) Do not scale from this Drawing.
2) Surveyed for Hallam Land Management by Triway Consultants. Brookbanks Consulting accepts no responsibility for the accuracy of the survey.
3) All levels are based upon OS Datum Benchmark.
4) This Drawing in based on Ordnance Survey digital photo data produced 16th March 2001. © Crown Copyright 2001 and reproduction in whole or part is prohibited without the prior permission of Ordnance Survey.
5) Ordnance Survey Data is correct to National Grid, Survey Data has been prepared to a local Grid and has been inserted to give a "Best Fit".

Gully

See figure 5, Appendix C

See figure 6, Appendix C

See figure 7, Appendix C

0 50 100 150 200 250
METRES

Rev.	Revision Details	Drawn	Checked	Approved	Date
A	Areas revised following topographic survey	CJB	CJB	CJB	21.11.03
	INFORMATION	DAB			26:4:01

Issue Status | Approved | Date

Drawn JM | Checked AJB | Date 26:4:01

Brookbanks Consulting
111 Hagley Road Edgbaston Birmingham UK B16 8LB
Tel (0121) 452 5015 Fax (0121) 452 5016

GALLAGHER

HALLAM LAND MANAGEMENT

Policy Site H10
Banbury

Indicative Existing Surface Water Catchment Arrangement

Scale	Drawing No.	Rev.
1:2500	1071/LP/02	A

Original Drawing Size A1

1071/SV/01

GENERAL NOTES

1) Do not scale from this Drawing.

2) Surveyed for Hallam Land Management by Trivoy Consultants. Brookbanks Consulting accepts no responsibility for the accuracy of the survey.

3) All levels are based upon OS Datum Benchmark.

4) This Drawing is based on Ordnance Survey digital photo data produced 16th March 2001. © Crown Copyright 2001 and reproduction in whole or part is prohibited without the prior permission of Ordnance Survey.

5) Ordnance Survey Data is correct to National Grid, Survey Data has been prepared to a local Grid and has been inserted to give a "Best Fit".

Rev.	Revision Details	Drawn	Checked	Approved	Date
A	Additional survey information added	RD	PAB	PAB	09/03

Issue Status		Approved	Date
Drawn RD	Checked PAB	Date JUN 03	

Brookbanks Consulting

111 Hagley Road Edgbaston Birmingham UK B16 8LB
Tel (0121) 452 5015 Fax (0121) 452 5016

GALLAGHER

HALLAM LAND MANAGEMENT

Policy Site H10
Banbury

Site Survey
Contours

Scale	Drawing No.	Rev.
1:2500	1071/SV/01	A

0 50 100 150 200 250
METRES

Original Drawing Size A1

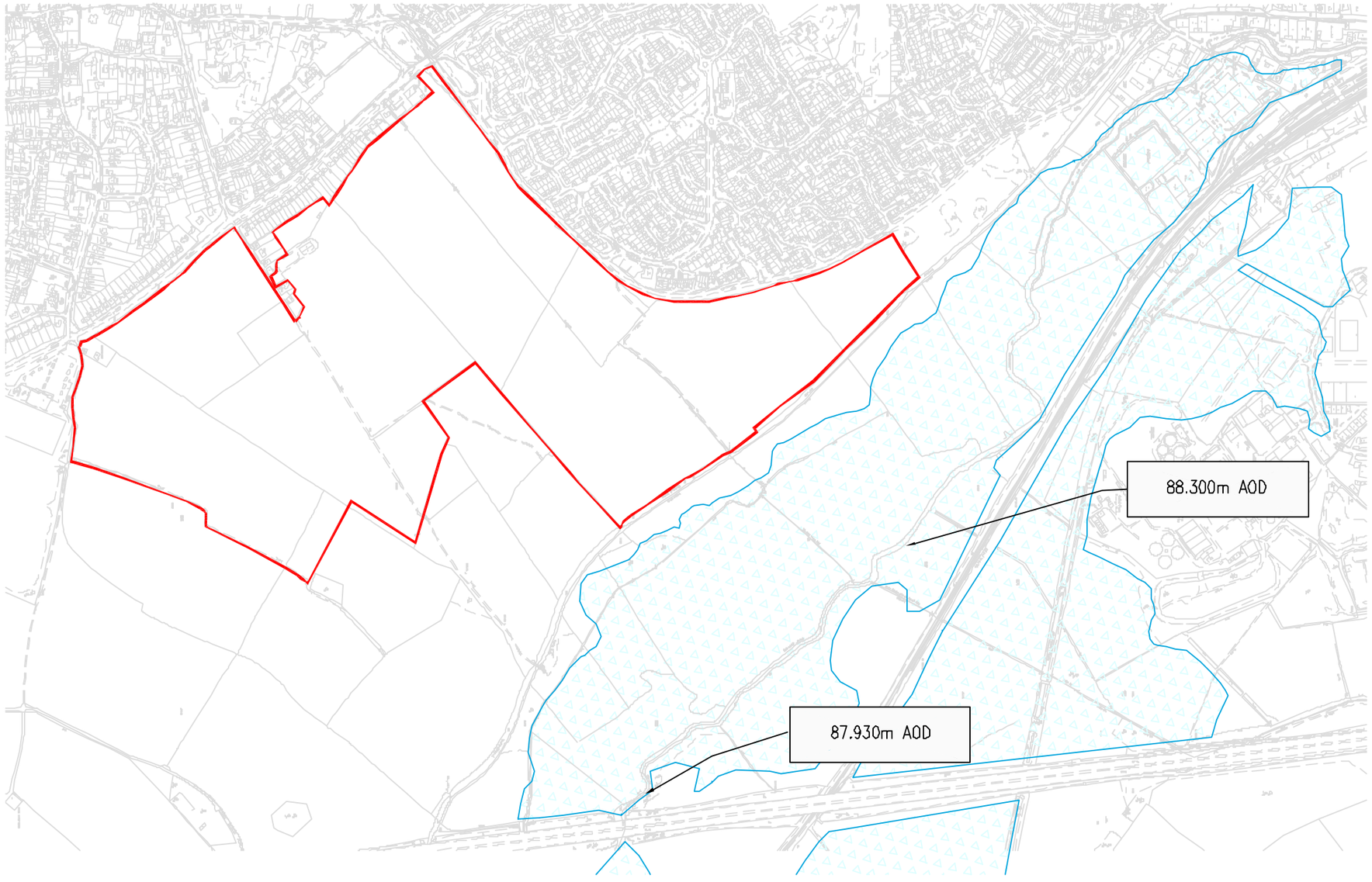
1071/FL/01

Notes

1.) Mapping from Ordnance Survey Land Ranger

2.) from Environment Agency Section 105 mapping.

1 in 100 year Draft
EA Flood Plain



0 200 400 600 800 1000
METRES

Original Drawing Size A1

Rev.	Revision Details	Drawn	Checked	Approved	Date
	Preliminary				Nov 03
Issue Status				Approved	Date
Drawn RD		Checked CJB		Date Nov 03	

Brookbanks
Consulting
111 Hagley Road Edgbaston Birmingham UK B16 8LB
Tel (0121) 452 5015 Fax (0121) 452 5018
Email mail@brookbanks.com

GALLAGHER

HALLAM LAND MANAGEMENT

Policy Site H10
Banbury

Draft Section 105
1 in 100
Year Flood Plain

Scale at A1	Drawing No.	Rev.
1:1000	1071/FL/01	

APPENDIX B

Indicative Drainage Scheme

1071/LP/03

Area No. 1
Residential development
covering 5.75 Hectares
(14.2 Acres)

Area No. 2
Residential development
covering 31.4 Hectares
(77.6 Acres)

Area No. 3
Commercial development
covering 4.9 Hectares
(12.1 Acres)

Country Park
covering 38 Hectares
(93.4 Acres)

Detention Pond

Reed Bed

GENERAL NOTES

1) Do not scale from this Drawing.

2) Surveyed for Hallam Land Management by Triway Consultants. Brookbanks Consulting accepts no responsibility for the accuracy of the survey.

3) All levels are based upon OS Datum Benchmark.

4) This Drawing in based on Ordnance Survey digital photo data produced 16th March 2001. © Crown Copyright 2001 and reproduction in whole or part is prohibited without the prior permission of Ordnance Survey.

Bodicote

Drainage channel from upper to lower pond

Area 1 Outfall

First flush, settlement and biodegradation treatment train ponds

Public House

Canal Basin

1500m² detention pond average depth 1m.

First flush, settlement and biodegradation treatment train ponds

9000m² detention pond average depth 1m.

Area 2 & 3 Outfall

Pumped Outfall to Canal/Culvert from pond

110

100

90

N

0 50 100 150 200 250
METRES

Rev.	Revision Details	Drawn	Checked	Approved	Date
A	Contours and Drainage layout Amended	RD	CJB	CJB	28.11.03

INFORMATION — DAB 26:4:01

Issue Status — Approved — Date

Drawn — Checked — Date 26:4:01

Brookbanks Consulting

111 Hagley Road Edgbaston Birmingham UK B16 8LB
Tel (0121) 452 5015 Fax (0121) 452 5016

GALLAGHER

HALLAM LAND MANAGEMENT

Policy Site H10
Banbury

Indicative Drainage Areas and Scheme

Scale	Drawing No.	Rev.
1:2500	1071/LP/03	A

Original Drawing Size A1

APPENDIX C

Photographs

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

Figure 8

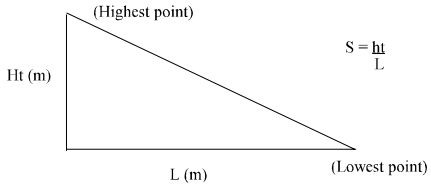
Figure 9

Figure 10

APPENDIX D

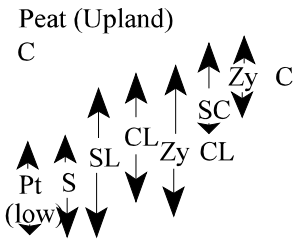
Rainfall Runoff & Preliminary Detention Calculations

ADAS 345 - DETERMINATION OF DESIGN FLOW - AREA 1, CANAL SIDE

1	Locate a suitable map of the area and determine the catchment area A in hectares. (Assuming development impermeability of 50% of total land area)	A (ha)	5.75
2	Determine the maximum length of catchment L in metres	L (m)	180
3	Determine the average slope of the catchment S 	S	0.0644
4	Determine the catchment of characteristics C $C = 0.0001 \frac{L}{S}$	C (m)	0.279
5	Determine the dominant crop type Grass Arable Horticulture		Grass
6	Determine the average annual rainfall AAR in mm from Appendix I	AAR (mm)	663
7	Determine the soil type factor St	St	1.0
8	At Appendix 6 enter the graph at C. Move across (left) TO crop type, down to average annual rainfall (AAR), across (right) to the standard line and up to F number.	F	8.0
9	Peak Flood Flow Qo = St x F x A	Qo (l/s)	46.0
10	For each per cent of paved areas add 1% to the derived Peak Flood Flow. (Where paved area exceeds 10% of the catchment, this method is not appropriate)	Total Qo (l/s)	46.0

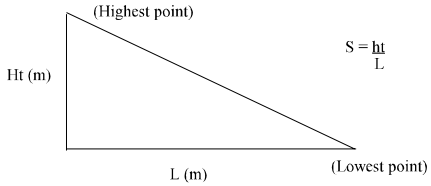
Class	Range (m/day)	St
-		
Very Slow	<0.01 - 0.1	1.3
Slow - Mod	0.1 - 0.3	1.0
Moderate	0.3 - 1.0	0.8
Mod - Rapid	1.0 - 10.0	0.5
Very Rapid	>10	0.1

Ranges for soil textures



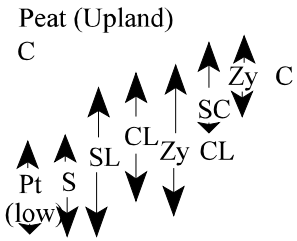
Hence: Given 70% impermeable surface, permitted discharge => 46.0 x 0.7 = 32.2l/s

ADAS 345 - DETERMINATION OF DESIGN FLOW - AREA 2 & 3 - OXFORD ROAD

1	Locate a suitable map of the area and determine the catchment area A in hectares. (Assuming development impermeability of 50% of total land area)	A (ha)	36.65
2	Determine the maximum length of catchment L in metres	L (m)	905
3	Determine the average slope of the catchment S 	S	0.005
4	Determine the catchment of characteristics C C = 0.0001 L / S	C (m)	15.8
5	Determine the dominant crop type — Grass / Arable / Horticulture		Grass
6	Determine the average annual rainfall AAR in mm from Appendix I	AAR (mm)	663
7	Determine the soil type factor St	St	1.0
8	At Appendix 6 enter the graph at C. Move across (left) TO crop type, down to average annual rainfall (AAR), across (right) to the standard line and up to F number.	F	3.4
9	Peak Flood Flow Qo = St x F x A	Qo (l/s)	128
10	For each per cent of paved areas add 1% to the derived Peak Flood Flow. (Where paved area exceeds 10% of the catchment, this method is not appropriate)	Total Qo (l/s)	

Class	Range (m/day)	St
Very Slow	<0.01 - 0.1	1.3
Slow - Mod	0.1 - 0.3	1.0
Moderate	0.3 - 1.0	0.8
Mod - Rapid	1.0 - 10.0	0.5
Very Rapid	>10	0.1

Ranges for soil textures



Hence:

Area 2 Sor Catchment, permitted discharge 0.45% x 7.4 x 3.4 = 11.32l/s,
Area 2 Canal Catchment, permitted discharge 0.45% x 24.4 x 3.4 = 37.33l/s
Area 3 Sor Catchment, permitted discharge 0.75% x 4.85 x 3.4 = 12.37l/ s

Brookbanks Consulting

111 Hagley Road Edgbaston Birmingham B16 8LB
Tel (0121) 452 5015 Fax (0121) 452 5016
Email: mail@brookbanks.com

Contract:	BANBURY - AREA 1 BANKSIDE		
Calcs by:	CJB	**Date:**	14.07.03
Checked by:	PAB	**Sheet:**	1 Rev 2
Notes:	Total Storage Requirement		

STORM WATER STORAGE DESIGN - INPUT DATA (SHEET 1)

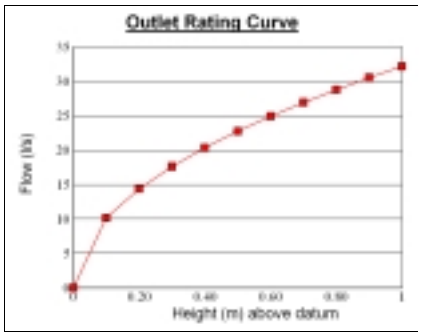
Calculations in accordance with Wallingford Procedure

BASIC SITE INFORMATION

Site Area =	57,500	m^2
M5-60 =	20	mm
Ratio r =	0.4	
Return period =	100	years
Impermeability ratio =	0.7	
Volumetric runoff (Cv) =	0.75	
Maximum height of storage =	1.0	m

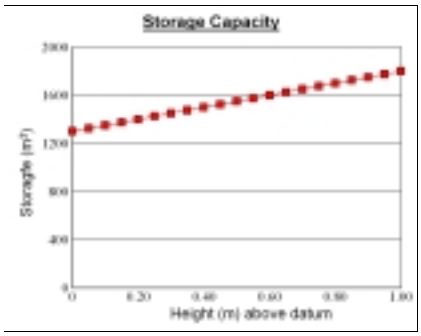
OUTLET CHARACTERISTICS

$Q_{(0\%)}$ =	0.00 m	⇒	0.00 l/s
$Q_{(10\%)}$ =	0.10 m	⇒	10.18 l/s
$Q_{(20\%)}$ =	0.20 m	⇒	14.40 l/s
$Q_{(30\%)}$ =	0.30 m	⇒	17.64 l/s
$Q_{(40\%)}$ =	0.40 m	⇒	20.37 l/s
$Q_{(50\%)}$ =	0.50 m	⇒	22.77 l/s
$Q_{(60\%)}$ =	0.60 m	⇒	24.94 l/s
$Q_{(70\%)}$ =	0.70 m	⇒	26.94 l/s
$Q_{(80\%)}$ =	0.80 m	⇒	28.80 l/s
$Q_{(90\%)}$ =	0.90 m	⇒	30.55 l/s
$Q_{(100\%)}$ =	1.00 m	⇒	32.20 l/s
$Q_{(200\%)}$ =	2.00 m	⇒	45.54 l/s



STORAGE CHARACTERISTICS

$H_{(0\%)}$ =	0.00 m	⇒	Plan area =	1,300 m^2
$H_{(5\%)}$ =	0.05 m	⇒	Plan area =	1,325 m^2
$H_{(10\%)}$ =	0.10 m	⇒	Plan area =	1,350 m^2
$H_{(15\%)}$ =	0.15 m	⇒	Plan area =	1,375 m^2
$H_{(20\%)}$ =	0.20 m	⇒	Plan area =	1,400 m^2
$H_{(25\%)}$ =	0.25 m	⇒	Plan area =	1,425 m^2
$H_{(30\%)}$ =	0.30 m	⇒	Plan area =	1,450 m^2
$H_{(35\%)}$ =	0.35 m	⇒	Plan area =	1,475 m^2
$H_{(40\%)}$ =	0.40 m	⇒	Plan area =	1,500 m^2
$H_{(45\%)}$ =	0.45 m	⇒	Plan area =	1,525 m^2
$H_{(50\%)}$ =	0.50 m	⇒	Plan area =	1,550 m^2
$H_{(55\%)}$ =	0.55 m	⇒	Plan area =	1,575 m^2
$H_{(60\%)}$ =	0.60 m	⇒	Plan area =	1,600 m^2
$H_{(65\%)}$ =	0.65 m	⇒	Plan area =	1,625 m^2
$H_{(70\%)}$ =	0.70 m	⇒	Plan area =	1,650 m^2
$H_{(75\%)}$ =	0.75 m	⇒	Plan area =	1,675 m^2
$H_{(80\%)}$ =	0.80 m	⇒	Plan area =	1,700 m^2
$H_{(85\%)}$ =	0.85 m	⇒	Plan area =	1,725 m^2
$H_{(90\%)}$ =	0.90 m	⇒	Plan area =	1,750 m^2
$H_{(95\%)}$ =	0.95 m	⇒	Plan area =	1,775 m^2
$H_{(100\%)}$ =	1.00 m	⇒	Plan area =	1,800 m^2
$H_{(200\%)}$ =	2.00 m	⇒	Plan area =	1,825 m^2



Brookbanks Consulting

111 Hagley Road Edgbaston Birmingham B16 8LB
Tel (0121) 452 5015 Fax (0121) 452 5016
Email: mail@brookbanks.com

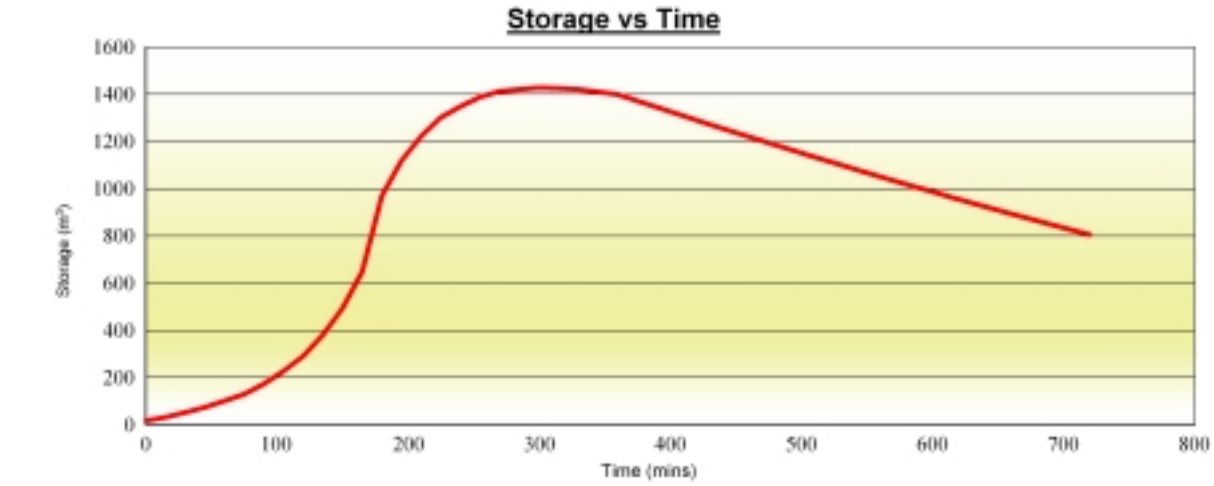
Contract:	BANBURY - AREA 1 BANKSIDE		
Calcs by:	CJB	**Date:**	14.07.03
Checked by:	PAB	**Sheet:**	2 Rev 2
Notes:	Total Storage Requirement		

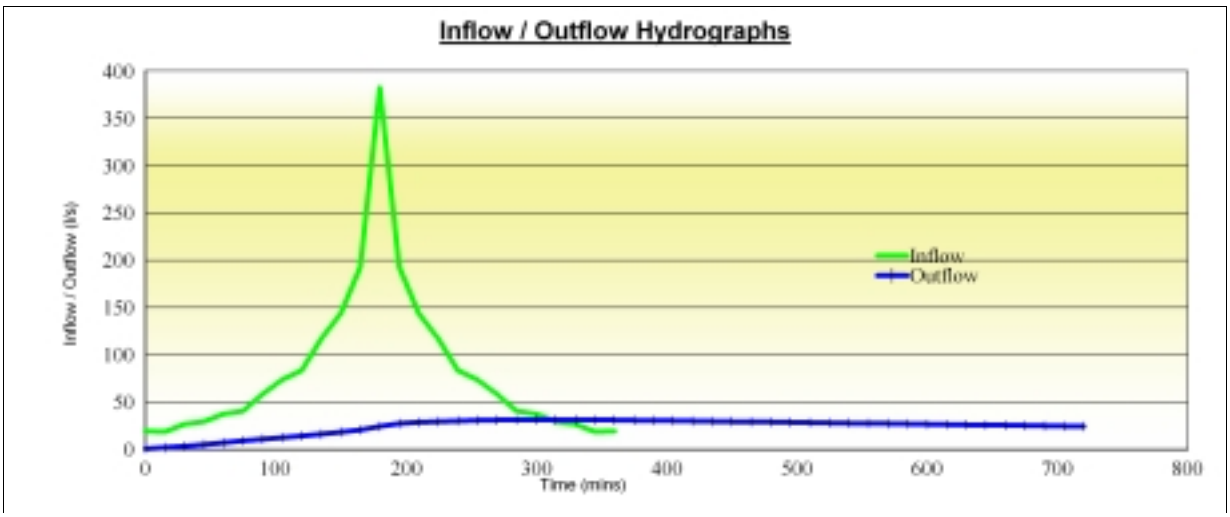
STORM WATER STORAGE DESIGN - RESULTS (SHEET 2)

RESULTS - SUMMARY

Storm duration (mins)	Peak inflow (l/s)	Peak outflow (l/s)	Peak level above datum (m)	Total storage (m^3)
30	2,327.2	25.36	0.621	912
60	1,500.1	28.12	0.763	1,147
120	890.6	29.70	0.852	1,299
240	520.2	30.63	0.905	1,392
360	382.3	30.95	0.924	1,427
600	252.8	30.61	0.904	1,391
1440	125.7	28.70	0.795	1,174
2880	72.9	25.04	0.605	886
5760	42.1	20.00	0.387	545
360	**2,327.2**	**30.95**	**0.924**	**1,427**

RESULTS - GRAPHICAL DETAIL FOR CRITICAL STORM





Brookbanks Consulting

111 Hagley Road Edgbaston Birmingham B16 8LB
Tel (0121) 452 5015 Fax (0121) 452 5016
Email: mail@brookbanks.com

Contract:	BANBURY - AREA 2 & 3 OXFORD ROAD		
Calcs by:	CJB	**Date:**	14.07.03
Checked by:	PAB	**Sheet:**	1 Rev 1
Notes:	Total Storage Requirement		

STORM WATER STORAGE DESIGN - INPUT DATA (SHEET 1)

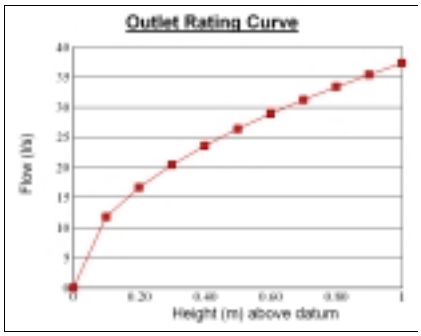
Calculations in accordance with Wallingford Procedure

BASIC SITE INFORMATION

Site Area =	366,500	m^2	
M5-60 =	20	mm	
Ratio r =	0.4		
Return period =	100	years	
Impermeability ratio =	0.49		Mean of Area 2 & 3 => (0.45x31.8 + 0.75x4.85)/36.65
Volumetric runoff (Cv) =	0.75		
Maximum height of storage =	1.0	m	

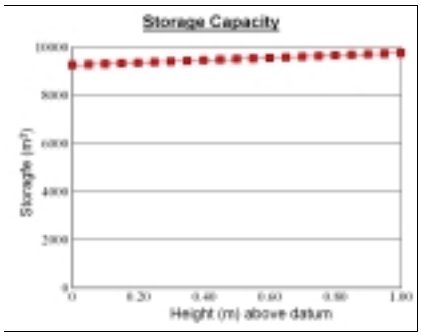
OUTLET CHARACTERISTICS

$Q_{(0\%)}$ =	0.00 m	⇒	0.00 l/s
$Q_{(10\%)}$ =	0.10 m	⇒	11.80 l/s
$Q_{(20\%)}$ =	0.20 m	⇒	16.69 l/s
$Q_{(30\%)}$ =	0.30 m	⇒	20.45 l/s
$Q_{(40\%)}$ =	0.40 m	⇒	23.61 l/s
$Q_{(50\%)}$ =	0.50 m	⇒	26.40 l/s
$Q_{(60\%)}$ =	0.60 m	⇒	28.92 l/s
$Q_{(70\%)}$ =	0.70 m	⇒	31.23 l/s
$Q_{(80\%)}$ =	0.80 m	⇒	33.39 l/s
$Q_{(90\%)}$ =	0.90 m	⇒	35.41 l/s
$Q_{(100\%)}$ =	1.00 m	⇒	37.33 l/s
$Q_{(200\%)}$ =	2.00 m	⇒	52.79 l/s



STORAGE CHARACTERISTICS

$H_{(0\%)}$ =	0.00 m	⇒	Plan area =	9,250 m^2
$H_{(5\%)}$ =	0.05 m	⇒	Plan area =	9,275 m^2
$H_{(10\%)}$ =	0.10 m	⇒	Plan area =	9,300 m^2
$H_{(15\%)}$ =	0.15 m	⇒	Plan area =	9,325 m^2
$H_{(20\%)}$ =	0.20 m	⇒	Plan area =	9,350 m^2
$H_{(25\%)}$ =	0.25 m	⇒	Plan area =	9,375 m^2
$H_{(30\%)}$ =	0.30 m	⇒	Plan area =	9,400 m^2
$H_{(35\%)}$ =	0.35 m	⇒	Plan area =	9,425 m^2
$H_{(40\%)}$ =	0.40 m	⇒	Plan area =	9,450 m^2
$H_{(45\%)}$ =	0.45 m	⇒	Plan area =	9,475 m^2
$H_{(50\%)}$ =	0.50 m	⇒	Plan area =	9,500 m^2
$H_{(55\%)}$ =	0.55 m	⇒	Plan area =	9,525 m^2
$H_{(60\%)}$ =	0.60 m	⇒	Plan area =	9,550 m^2
$H_{(65\%)}$ =	0.65 m	⇒	Plan area =	9,575 m^2
$H_{(70\%)}$ =	0.70 m	⇒	Plan area =	9,600 m^2
$H_{(75\%)}$ =	0.75 m	⇒	Plan area =	9,625 m^2
$H_{(80\%)}$ =	0.80 m	⇒	Plan area =	9,650 m^2
$H_{(85\%)}$ =	0.85 m	⇒	Plan area =	9,675 m^2
$H_{(90\%)}$ =	0.90 m	⇒	Plan area =	9,700 m^2
$H_{(95\%)}$ =	0.95 m	⇒	Plan area =	9,725 m^2
$H_{(100\%)}$ =	1.00 m	⇒	Plan area =	9,750 m^2
$H_{(200\%)}$ =	2.00 m	⇒	Plan area =	9,775 m^2



Brookbanks Consulting

111 Hagley Road Edgbaston Birmingham B16 8LB
Tel (0121) 452 5015 Fax (0121) 452 5016
Email: mail@brookbanks.com

Contract:	BANBURY - AREA 2 & 3 OXFORD ROAD		
Calcs by:	CJB	**Date:**	14.07.03
Checked by:	PAB	**Sheet:**	2 Rev 1
Notes:	Total Storage Requirement		

STORM WATER STORAGE DESIGN - RESULTS (SHEET 2)

RESULTS - SUMMARY

Storm duration (mins)	Peak inflow (l/s)	Peak outflow (l/s)	Peak level above datum (m)	Total storage (m^3)
30	10,383.4	24.86	0.445	4,171
60	6,693.3	28.13	0.569	5,350
120	3,973.8	30.47	0.667	6,290
240	2,320.9	32.58	0.763	7,209
360	1,705.6	33.89	0.825	7,807
600	1,128.1	34.93	0.876	8,309
1440	560.9	36.14	0.938	8,877
2880	325.4	36.15	0.939	8,914
5760	187.7	34.65	0.862	8,170
2880	**10,383.4**	**36.15**	**0.939**	**8,914**

RESULTS - GRAPHICAL DETAIL FOR CRITICAL STORM