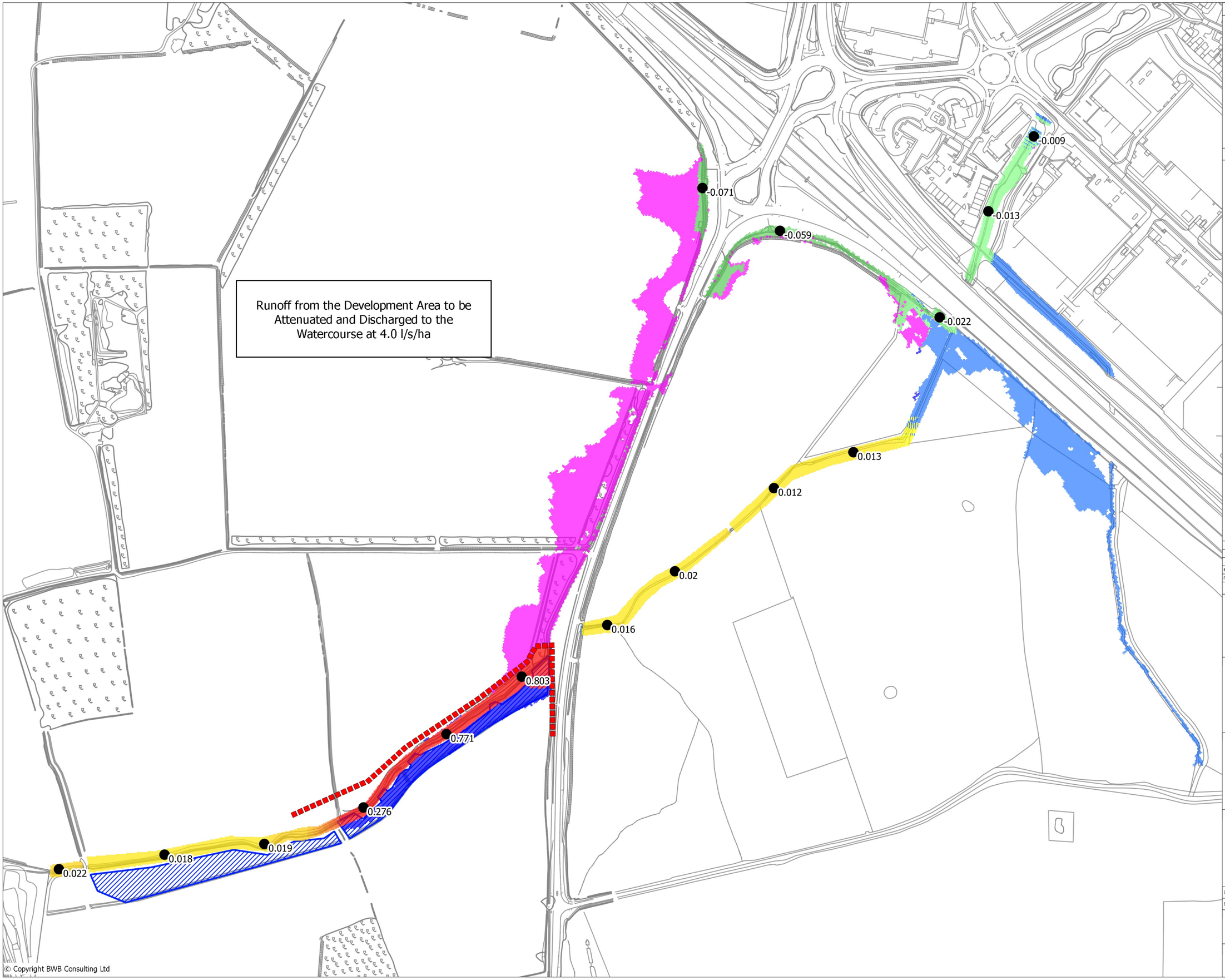
ANNEX 4

Post-Development Impact Analysis



Notes

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

Key

Illustrative Raised Development Feature
Illustrative Floodplain Areas

Change in Floodplain Extent

Former Wet Areas Now Dry
Former Dry Areas Now Wet

Change in Flood Level (m)

< -0.18
-0.18 to -0.16
-0.16 to -0.14
-0.14 to -0.12
-0.12 to -0.10
-0.10 to -0.08
-0.08 to -0.06
-0.06 to -0.04
-0.04 to -0.02
-0.02 to -0.01
NO CHANGE
0.01 to 0.02
0.02 to 0.04
0.04 to 0.06
0.06 to 0.08
0.08 to 0.10
0.10 to 0.12
0.12 to 0.14
0.14 to 0.16
0.16 to 0.18
> 0.180

Rev	Date	Details of issues/ revision	Drw	Rev
P1	20.11.17	PRELIMINARY ISSUE	RG	CD

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Client

Roxhill

Project Title

Northampton Gateway Rail Freight Interchange

Drawing Title

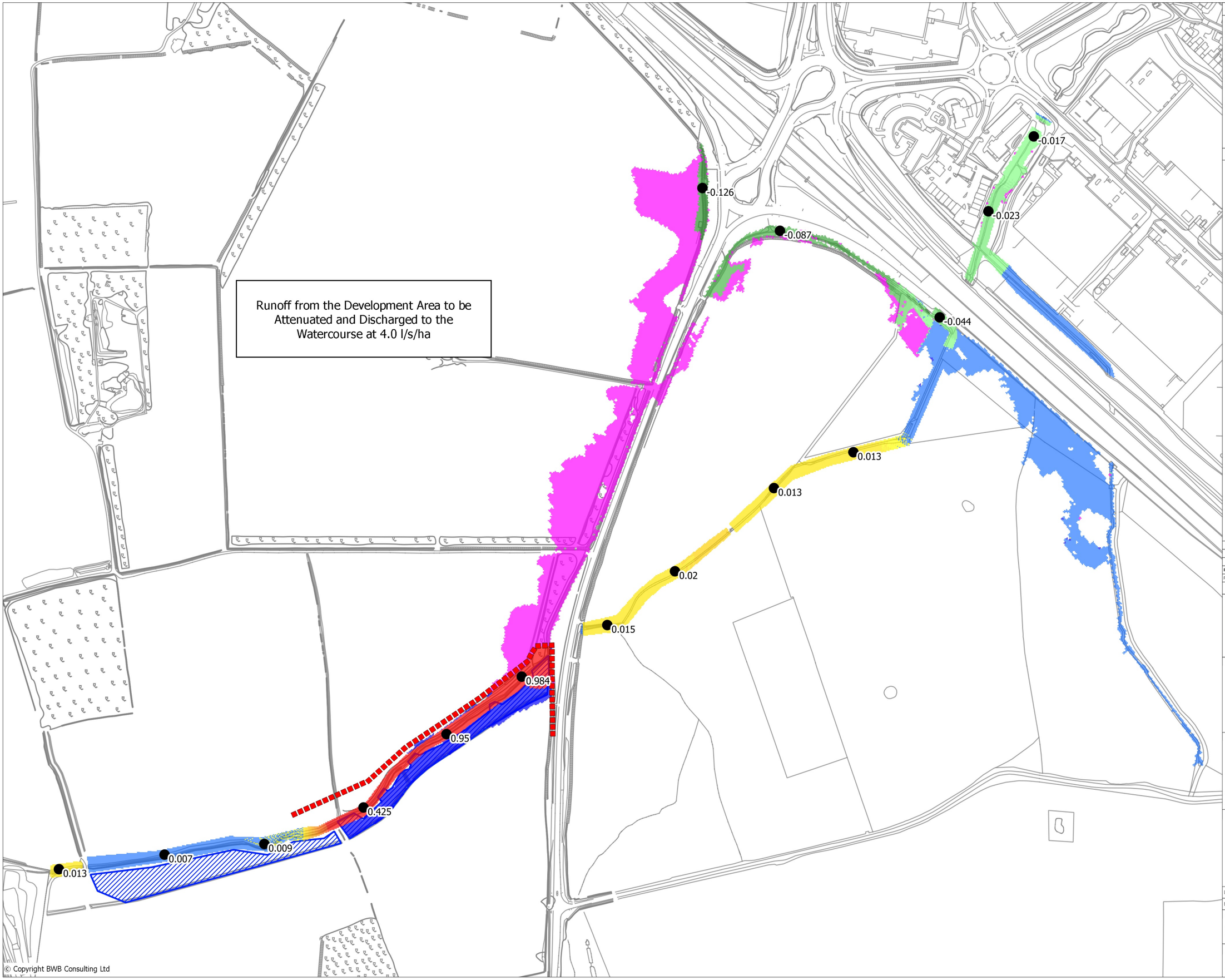
Courteenhall Brook Illustrative Flood Mitigation Impact: 10% AEP

Drawn:	R Green	Reviewed:	C Dodd		
BWB Ref:	NTH 2315	Date:	20/11/17	Scale@A3:	NTS

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
NGW-BWB-EWE-XX-DR-YE-0110	S2	P1



Notes

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

Key

- Illustrative Raised Development Feature
- Illustrative Floodplain Areas

Change in Floodplain Extent

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Flood Level (m)

- < -0.18
- -0.18 to -0.16
- -0.16 to -0.14
- -0.14 to -0.12
- -0.12 to -0.10
- -0.10 to -0.08
- -0.08 to -0.06
- -0.06 to -0.04
- -0.04 to -0.02
- -0.02 to -0.01
- NO CHANGE
- 0.01 to 0.02
- 0.02 to 0.04
- 0.04 to 0.06
- 0.06 to 0.08
- 0.08 to 0.10
- 0.10 to 0.12
- 0.12 to 0.14
- 0.14 to 0.16
- 0.16 to 0.18
- > 0.180

Rev	Date	Details of issue/ revision	Drw	Rev
P1	20.11.17	PRELIMINARY ISSUE	RG	CD

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Client

Roxhill

Project Title

Northampton Gateway Rail Freight Interchange

Drawing Title

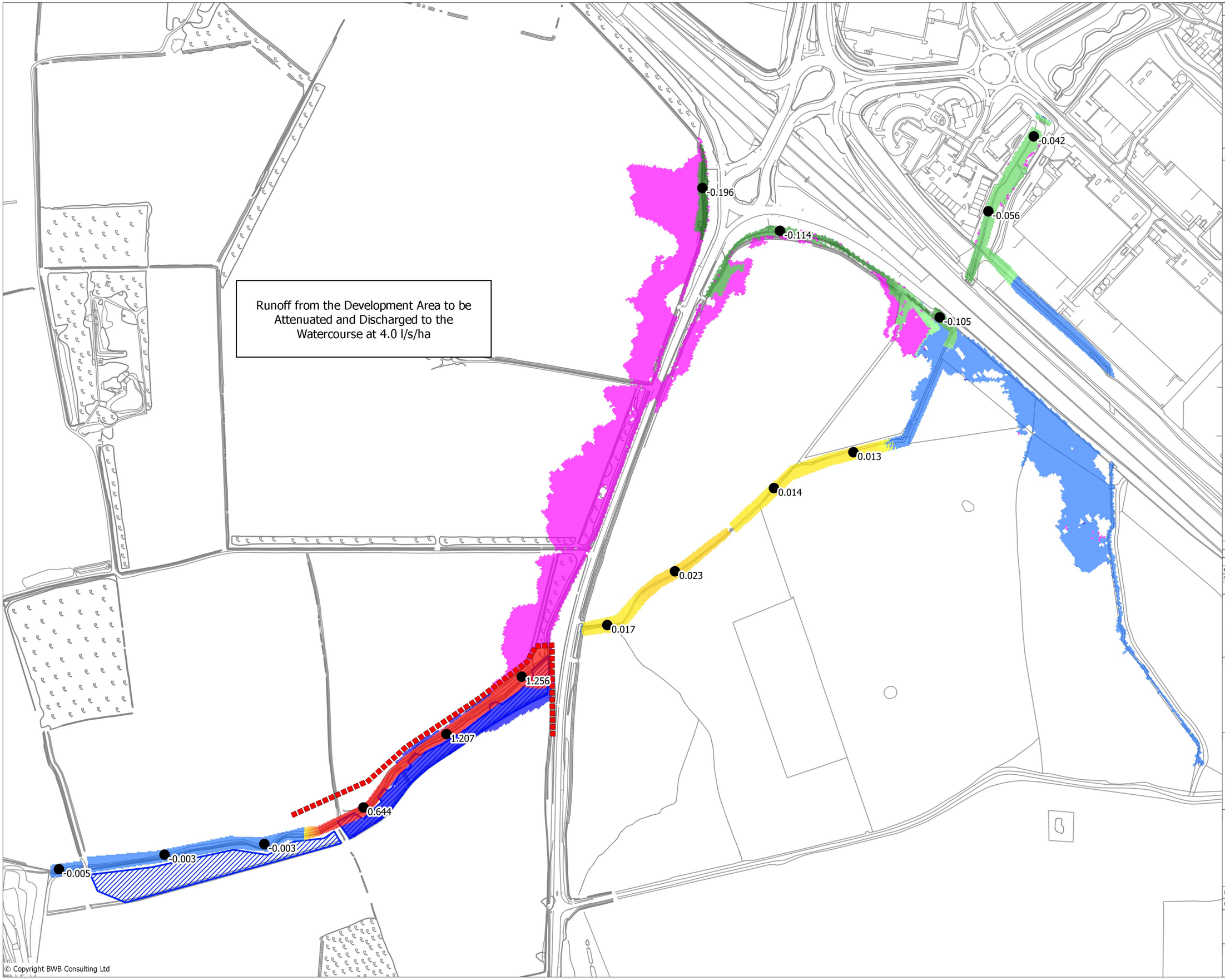
Courteenhall Brook Illustrative Flood Mitigation Impact: 5.0% AEP

Drawn:	R Green	Reviewed:	C Dodd		
BWB Ref:	NTH 2315	Date:	20/11/17	Scale@A3:	NTS

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
NGW-BWB-EWE-XX-DR-YE-0111	S2	P1



Notes

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

Key

- Illustrative Raised Development Feature
- Illustrative Floodplain Areas

Change in Floodplain Extent

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Flood Level (m)

- < -0.18
- -0.18 to -0.16
- -0.16 to -0.14
- -0.14 to -0.12
- -0.12 to -0.10
- -0.10 to -0.08
- -0.08 to -0.06
- -0.06 to -0.04
- -0.04 to -0.02
- -0.02 to -0.01
- NO CHANGE
- 0.01 to 0.02
- 0.02 to 0.04
- 0.04 to 0.06
- 0.06 to 0.08
- 0.08 to 0.10
- 0.10 to 0.12
- 0.12 to 0.14
- 0.14 to 0.16
- 0.16 to 0.18
- > 0.180

Rev	Date	Details of issues/ revision	Drw	Rev
P1	20.11.17	PRELIMINARY ISSUE	RG	CD

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Client

Roxhill

Project Title

Northampton Gateway Rail Freight Interchange

Drawing Title

Courteenhall Brook Illustrative Flood Mitigation Impact: 2.0% AEP

Drawn:	R Green		Reviewed:	C Dodd	
BWB Ref:	NTH 2315	Date:	20/11/17	Scale@A3:	NTS

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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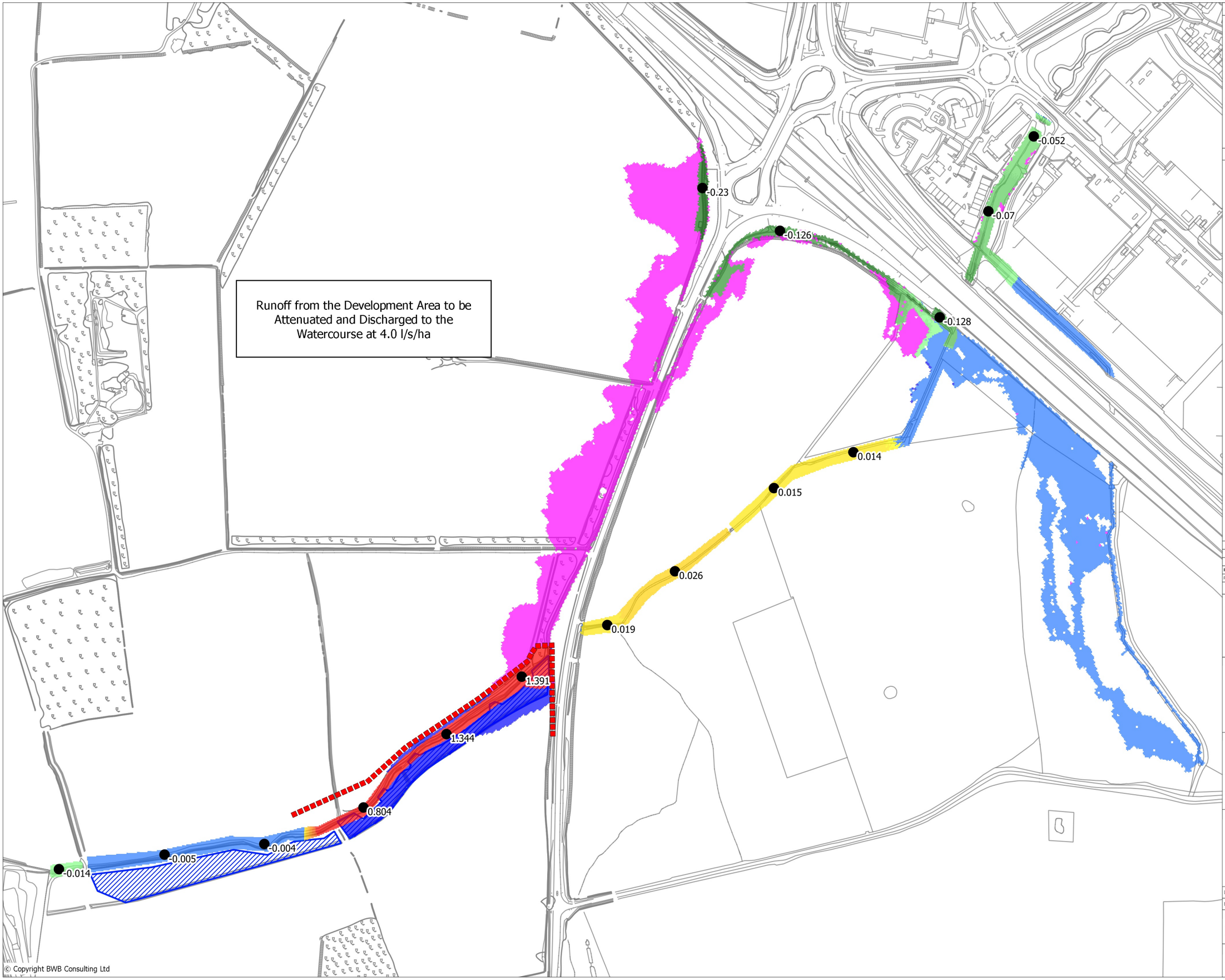

Notes

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

Key

- Illustrative Raised Development Feature
- Illustrative Floodplain Areas

Change in Floodplain Extent

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Flood Level (m)

- < -0.18
- -0.18 to -0.16
- -0.16 to -0.14
- -0.14 to -0.12
- -0.12 to -0.10
- -0.10 to -0.08
- -0.08 to -0.06
- -0.06 to -0.04
- -0.04 to -0.02
- -0.02 to -0.01
- NO CHANGE
- 0.01 to 0.02
- 0.02 to 0.04
- 0.04 to 0.06
- 0.06 to 0.08
- 0.08 to 0.10
- 0.10 to 0.12
- 0.12 to 0.14
- 0.14 to 0.16
- 0.16 to 0.18
- > 0.180

Rev	Date	Details of issues/ revision	Drw	Rev
P1	20.11.17	PRELIMINARY ISSUE	RG	CD

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Project Title

Northampton Gateway Rail Freight Interchange

Drawing Title

Courteenhall Brook Illustrative Flood Mitigation Impact: 1.3% AEP

Drawn:	R Green	Reviewed:	C Dodd
BWB Ref:	NTH 2315	Date:	20/11/17	Scale@A3:	NTS

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
NGW-BWB-EWE-XX-DR-YE-0113	S2	P1

Runoff from the Development Area to be Attenuated and Discharged to the Watercourse at 4.0 l/s/ha

-0.255
-0.134
-0.057
-0.077
-0.143
0.014
0.015
0.026
0.02
1.489
1.437
0.882
0.021
-0.007
-0.02

Notes

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

Key

- Illustrative Raised Development Feature
- Illustrative Floodplain Areas

Change in Floodplain Extent

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Flood Level (m)

- < -0.18
- -0.18 to -0.16
- -0.16 to -0.14
- -0.14 to -0.12
- -0.12 to -0.10
- -0.10 to -0.08
- -0.08 to -0.06
- -0.06 to -0.04
- -0.04 to -0.02
- -0.02 to -0.01
- NO CHANGE
- 0.01 to 0.02
- 0.02 to 0.04
- 0.04 to 0.06
- 0.06 to 0.08
- 0.08 to 0.10
- 0.10 to 0.12
- 0.12 to 0.14
- 0.14 to 0.16
- 0.16 to 0.18
- > 0.180

Rev	Date	Details of issues/ revision	Drw	Rev
P1	20.11.17	PRELIMINARY ISSUE	RG	CD

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Roxhill

Project Title

Northampton Gateway Rail Freight Interchange

Drawing Title

Courteenhall Brook Illustrative Flood Mitigation Impact: 1.0% AEP

Drawn:	R Green	Reviewed:	C Dodd		
BWB Ref:	NTH 2315	Date:	20/11/17	Scale@A3:	NTS

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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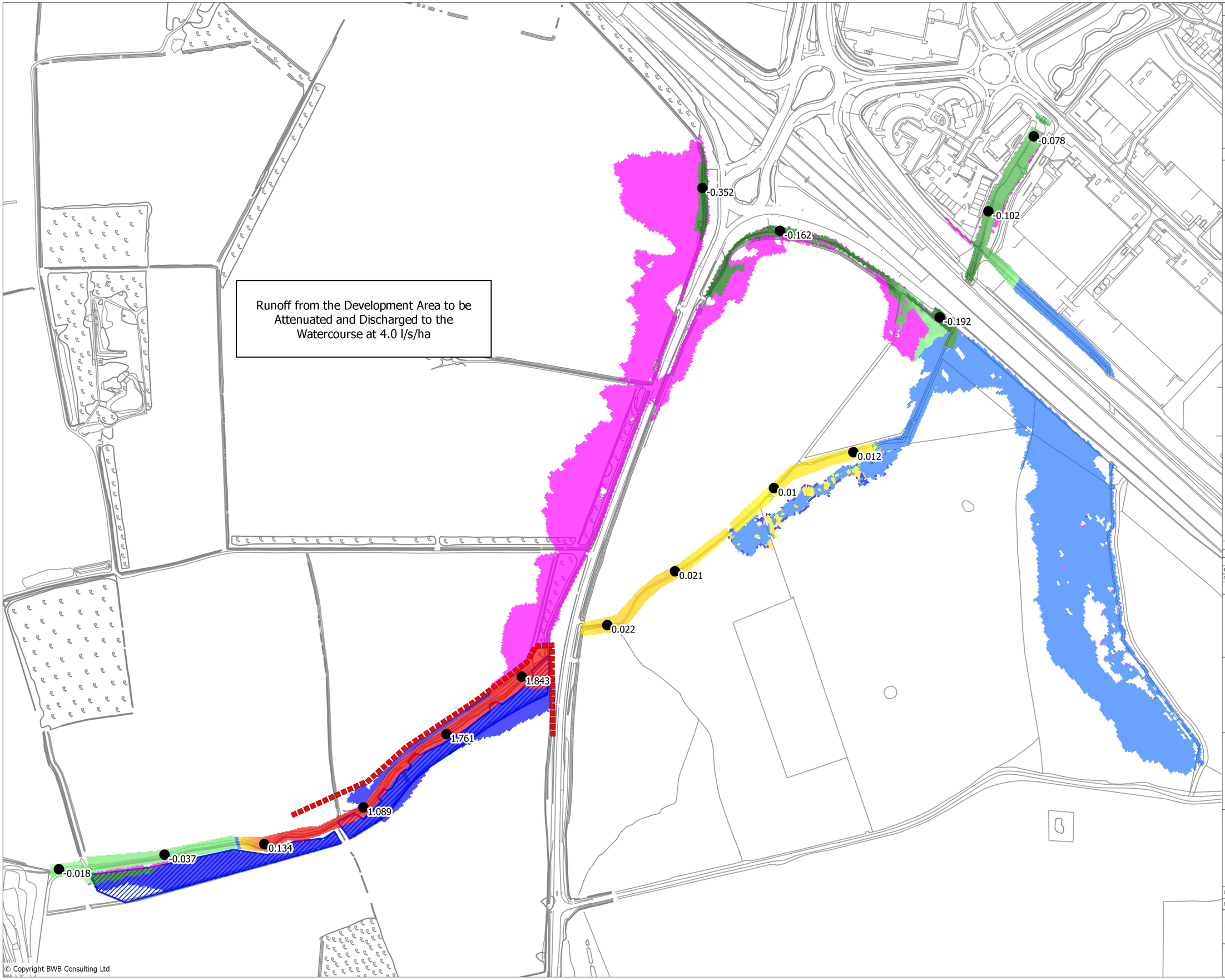

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Key

- Illustrative Raised Development Feature
- Illustrative Floodplain Areas

Change in Floodplain Extent

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Flood Level (m)

- < -0.18
- -0.18 to -0.16
- -0.16 to -0.14
- -0.14 to -0.12
- -0.12 to -0.10
- -0.10 to -0.08
- -0.08 to -0.06
- -0.06 to -0.04
- -0.04 to -0.02
- -0.02 to -0.01
- NO CHANGE
- 0.01 to 0.02
- 0.02 to 0.04
- 0.04 to 0.06
- 0.06 to 0.08
- 0.08 to 0.10
- 0.10 to 0.12
- 0.12 to 0.14
- 0.14 to 0.16
- 0.16 to 0.18
- > 0.180

Rev	Date	Details of issues/ revision	Drw	Rev
P1	20.11.17	PRELIMINARY ISSUE	RG	CD

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Client

Roxhill

Project Title

Northampton Gateway Rail Freight Interchange

Drawing Title

Courteenhall Brook Illustrative Flood Mitigation Impact: 1.0% AEP + 25%

Drawn:	R Green	Reviewed:	C Dodd		
BWB Ref:	NTH 2315	Date:	20/11/17	Scale@A3	NTS

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
NGW-BWB-EWE-XX-DR-YE-0115	S2	P1

Runoff from the Development Area to be Attenuated and Discharged to the Watercourse at 4.0 l/s/ha

-0.392
-0.184
-0.082
-0.105
-0.202
0.011
0.009
0.019
0.022
1.965
1.874
1.185
0.164
-0.055
-0.019

Notes

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4. Any discrepancies noted on site are to be reported to the engineer immediately.

Key

- Illustrative Raised Development Feature
- Illustrative Floodplain Areas

Change in Floodplain Extent

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Flood Level (m)

- < -0.18
- -0.18 to -0.16
- -0.16 to -0.14
- -0.14 to -0.12
- -0.12 to -0.10
- -0.10 to -0.08
- -0.08 to -0.06
- -0.06 to -0.04
- -0.04 to -0.02
- -0.02 to -0.01
- NO CHANGE
- 0.01 to 0.02
- 0.02 to 0.04
- 0.04 to 0.06
- 0.06 to 0.08
- 0.08 to 0.10
- 0.10 to 0.12
- 0.12 to 0.14
- 0.14 to 0.16
- 0.16 to 0.18
- > 0.180

Rev	Date	Details of issues/ revision	Drw	Rev
P1	20.11.17	PRELIMINARY ISSUE	RG	CD

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Client
Roxhill

Project Title
Northampton Gateway Rail Freight Interchange

Drawing Title
Courteenhall Brook Illustrative Flood Mitigation Impact: 1.0% AEP + 35%

Drawn:	R Green	Reviewed:	C Dodd	
BWB Ref:	NTH 2315	Date:	20/11/17	Scale@A3: NTS

Drawing Status
PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
NGW-BWB-EWE-XX-DR-YE-0116	S2	P1

Runoff from the Development Area to be Attenuated and Discharged to the Watercourse at 4.0 l/s/ha

-0.508
-0.219
-0.095
-0.113
-0.231
0.01
0.007
0.019
0.023
2.278
2.162
1.429
0.244
-0.086
-0.026

Notes

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4. Any discrepancies noted on site are to be reported to the engineer immediately.

Key

- Illustrative Raised Development Feature
- Illustrative Floodplain Areas

Change in Floodplain Extent

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Flood Level (m)

- < -0.18
- -0.18 to -0.16
- -0.16 to -0.14
- -0.14 to -0.12
- -0.12 to -0.10
- -0.10 to -0.08
- -0.08 to -0.06
- -0.06 to -0.04
- -0.04 to -0.02
- -0.02 to -0.01
- NO CHANGE
- 0.01 to 0.02
- 0.02 to 0.04
- 0.04 to 0.06
- 0.06 to 0.08
- 0.08 to 0.10
- 0.10 to 0.12
- 0.12 to 0.14
- 0.14 to 0.16
- 0.16 to 0.18
- > 0.180

Rev.	Date	Details of issues/ revision	Drw	Rev.
P1	20.11.17	PRELIMINARY ISSUE	RG	CD

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Client

Roxhill

Project Title

Northampton Gateway Rail Freight Interchange

Drawing Title

Courteenhall Brook Illustrative Flood Mitigation Impact: 1.0% AEP + 65%

Drawn:	R Green	Reviewed:	C Dodd		
BWB Ref:	NTH 2315	Date:	20/11/17	Scale@A3	NTS

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
NGW-BWB-EWE-XX-DR-YE-0117	S2	P1

ANNEX 5

Sensitivity Tests

Runoff from the Development Area to be Attenuated and Discharged to the Watercourse at 4.0 l/s/ha

0.006
0.003
0.006
0.047
0.064
0.069
0.029
0.032
0.059
-0.003
0.05
0.138
0.13
0.132
0.062

Notes

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4. Any discrepancies noted on site are to be reported to the engineer immediately.

Key

- Illustrative Raised Development Feature
- Illustrative Floodplain Areas

Change in Floodplain Extent

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Flood Level (m)

- < -0.18
- -0.18 to -0.16
- -0.16 to -0.14
- -0.14 to -0.12
- -0.12 to -0.10
- -0.10 to -0.08
- -0.08 to -0.06
- -0.06 to -0.04
- -0.04 to -0.02
- -0.02 to -0.01
- NO CHANGE
- 0.01 to 0.02
- 0.02 to 0.04
- 0.04 to 0.06
- 0.06 to 0.08
- 0.08 to 0.10
- 0.10 to 0.12
- 0.12 to 0.14
- 0.14 to 0.16
- 0.16 to 0.18
- > 0.180

Rev	Date	Details of issues/ revision	Drw	Rev
P1	20.11.17	PRELIMINARY ISSUE	RG	CD

Issues & Revisions

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Client
Roxhill

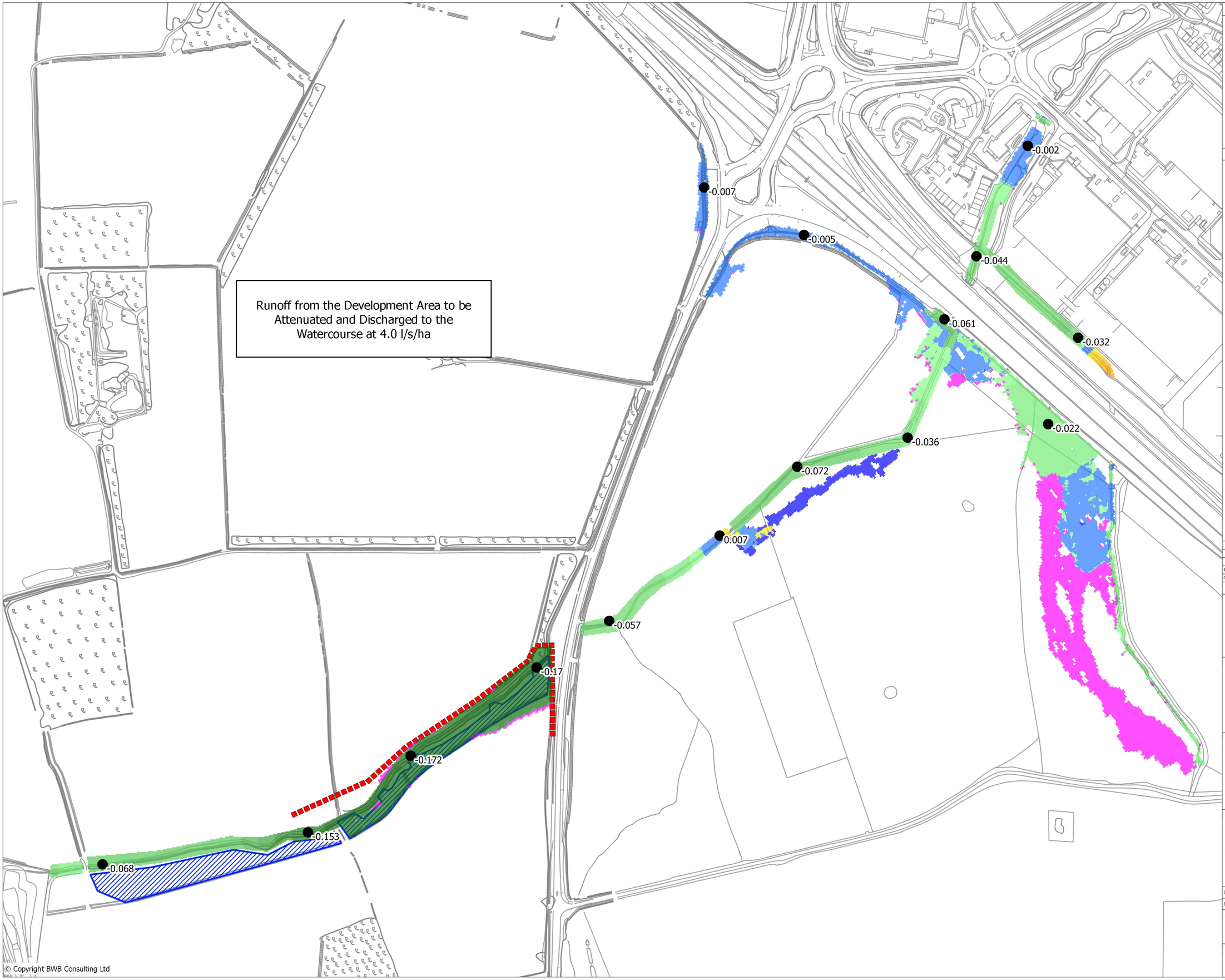
Project Title
Northampton Gateway Rail Freight Interchange

Drawing Title
Courteenhall Brook Post-Development Sensitivity Tests: Roughness + 20%

Drawn:	R Green	Reviewed:	C Dodd	
BWB Ref:	NTH 2315	Date:	20/11/17	Scale@A3: NTS

Drawing Status
PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
NGW-BWB-EWE-XX-DR-YE-0118	S2	P1



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4. Any discrepancies noted on site are to be reported to the engineer immediately.

Key

- Illustrative Raised Development Feature
- Illustrative Floodplain Areas

Change in Floodplain Extent

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Flood Level (m)

- < -0.18
- -0.18 to -0.16
- -0.16 to -0.14
- -0.14 to -0.12
- -0.12 to -0.10
- -0.10 to -0.08
- -0.08 to -0.06
- -0.06 to -0.04
- -0.04 to -0.02
- -0.02 to -0.01
- NO CHANGE
- 0.01 to 0.02
- 0.02 to 0.04
- 0.04 to 0.06
- 0.06 to 0.08
- 0.08 to 0.10
- 0.10 to 0.12
- 0.12 to 0.14
- 0.14 to 0.16
- 0.16 to 0.18
- > 0.180

Rev	Date	Details of issues/ revision	Drw	Rev
P1	20.11.17	PRELIMINARY ISSUE	RG	CD

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Roxhill

Project Title

Northampton Gateway Rail Freight Interchange

Drawing Title

Courteenhall Brook Post-Development Sensitivity Tests: Roughness - 20%

Drawn:	R Green	Reviewed:	C Dodd		
BWB Ref:	NTH 2315	Date:	20/11/17	Scale@A3:	NTS

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
NGW-BWB-EWE-XX-DR-YE-0119	S2	P1

Runoff from the Development Area to be Attenuated and Discharged to the Watercourse at 4.0 l/s/ha

0
0
1.634
1.482
0.294
1.4
0.513
0.034
0
0
0
0
0
0
0

Notes

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

Key

- Illustrative Raised Development Feature
- Illustrative Floodplain Areas

Change in Floodplain Extent

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Flood Level (m)

- < -0.18
- -0.18 to -0.16
- -0.16 to -0.14
- -0.14 to -0.12
- -0.12 to -0.10
- -0.10 to -0.08
- -0.08 to -0.06
- -0.06 to -0.04
- -0.04 to -0.02
- -0.02 to -0.01
- NO CHANGE
- 0.01 to 0.02
- 0.02 to 0.04
- 0.04 to 0.06
- 0.06 to 0.08
- 0.08 to 0.10
- 0.10 to 0.12
- 0.12 to 0.14
- 0.14 to 0.16
- 0.16 to 0.18
- > 0.180

Rev	Date	Details of issues/ revision	Drw	Rev
P1	20.11.17	PRELIMINARY ISSUE	RG	CD

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Roxhill

Project Title

Northampton Gateway Rail Freight Interchange

Drawing Title

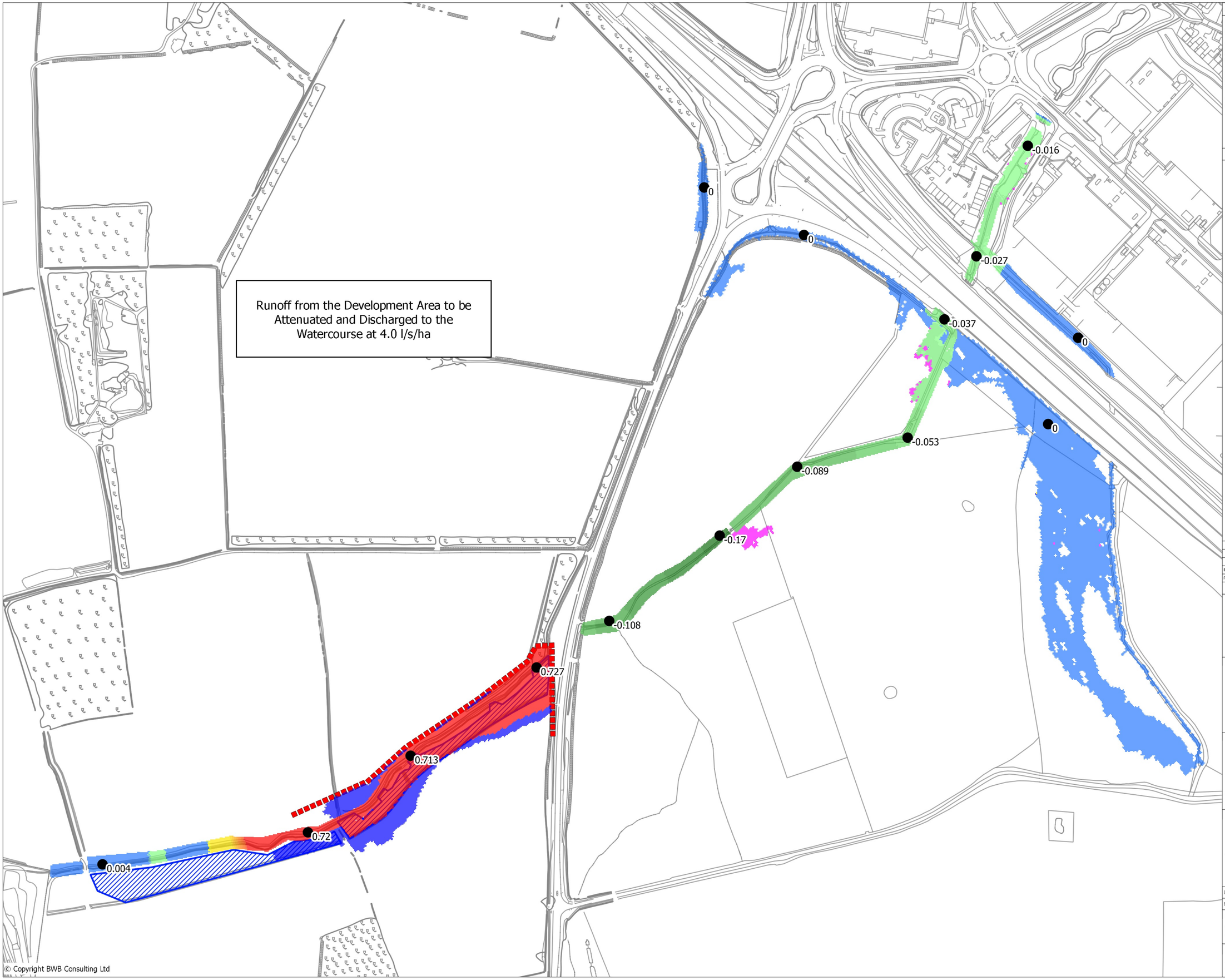
Courteenhall Brook Post-Development Sensitivity Tests: Downstream Boundary

Drawn:	R Green		Reviewed:	C Dodd	
BWB Ref:	NTH 2315	Date:	20/11/17	Scale@A3	NTS

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
NGW-BWB-EWE-XX-DR-YE-0120	S2	P1



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4. Any discrepancies noted on site are to be reported to the engineer immediately.

Key

- Illustrative Raised Development Feature
- Illustrative Floodplain Areas

Change in Floodplain Extent

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Flood Level (m)

- < -0.18
- -0.18 to -0.16
- -0.16 to -0.14
- -0.14 to -0.12
- -0.12 to -0.10
- -0.10 to -0.08
- -0.08 to -0.06
- -0.06 to -0.04
- -0.04 to -0.02
- -0.02 to -0.01
- NO CHANGE
- 0.01 to 0.02
- 0.02 to 0.04
- 0.04 to 0.06
- 0.06 to 0.08
- 0.08 to 0.10
- 0.10 to 0.12
- 0.12 to 0.14
- 0.14 to 0.16
- 0.16 to 0.18
- > 0.180

Rev	Date	Details of issues/ revision	Drw	Rev
P1	20.11.17	PRELIMINARY ISSUE	RG	CD

Issues & Revisions

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Project Title

Northampton Gateway Rail Freight Interchange

Drawing Title

Courteenhall Brook Post-Development Sensitivity Tests: A508 Blockage

Drawn:	R Green		Reviewed:	C Dodd	
BWB Ref:	NTH 2315	Date:	20/11/17	Scale@A3	NTS

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
NGW-BWB-EWE-XX-DR-YE-0121	S2	P1

Runoff from the Development Area to be Attenuated and Discharged to the Watercourse at 4.0 l/s/ha

0
0
-0.001
0.002
-0.046
0.012
0.022
0.001
0
0
0
0
0
0
0
0

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Rev	Date	Details of issues/ revision	Drw	Rev
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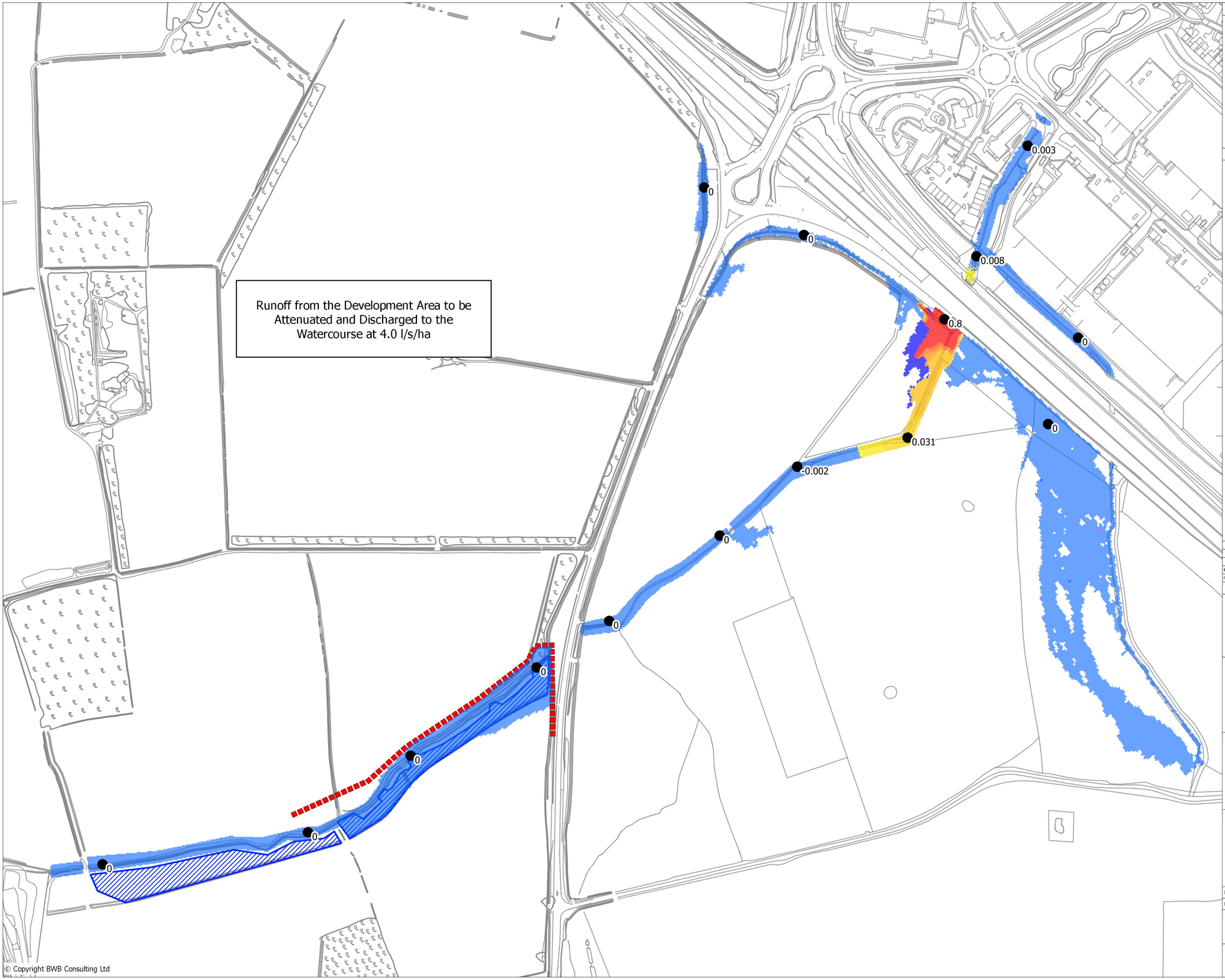
Project Title
Northampton Gateway Rail Freight Interchange

Drawing Title
Courteenhall Brook Post-Development Sensitivity Tests: M1 South Blockage

Drawn:	R Green	Reviewed:	C Dodd	
BWB Ref:	NTH 2315	Date:	20/11/17	Scale@A3: NTS

Drawing Status
PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
NGW-BWB-EWE-XX-DR-YE-0122	S2	P1



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- 0.16 to 0.18
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Rev	Date	Details of issues/ revision	Drw	Rev
P1	20.11.17	PRELIMINARY ISSUE	RG	CD

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Project Title

Northampton Gateway Rail Freight Interchange

Drawing Title

Courteenhall Brook Post-Development Sensitivity Tests: M1 North Blockage

Drawn:	R Green		Reviewed:	C Dodd	
BWB Ref:	NTH 2315	Date:	20/11/17	Scale@A3	NTS

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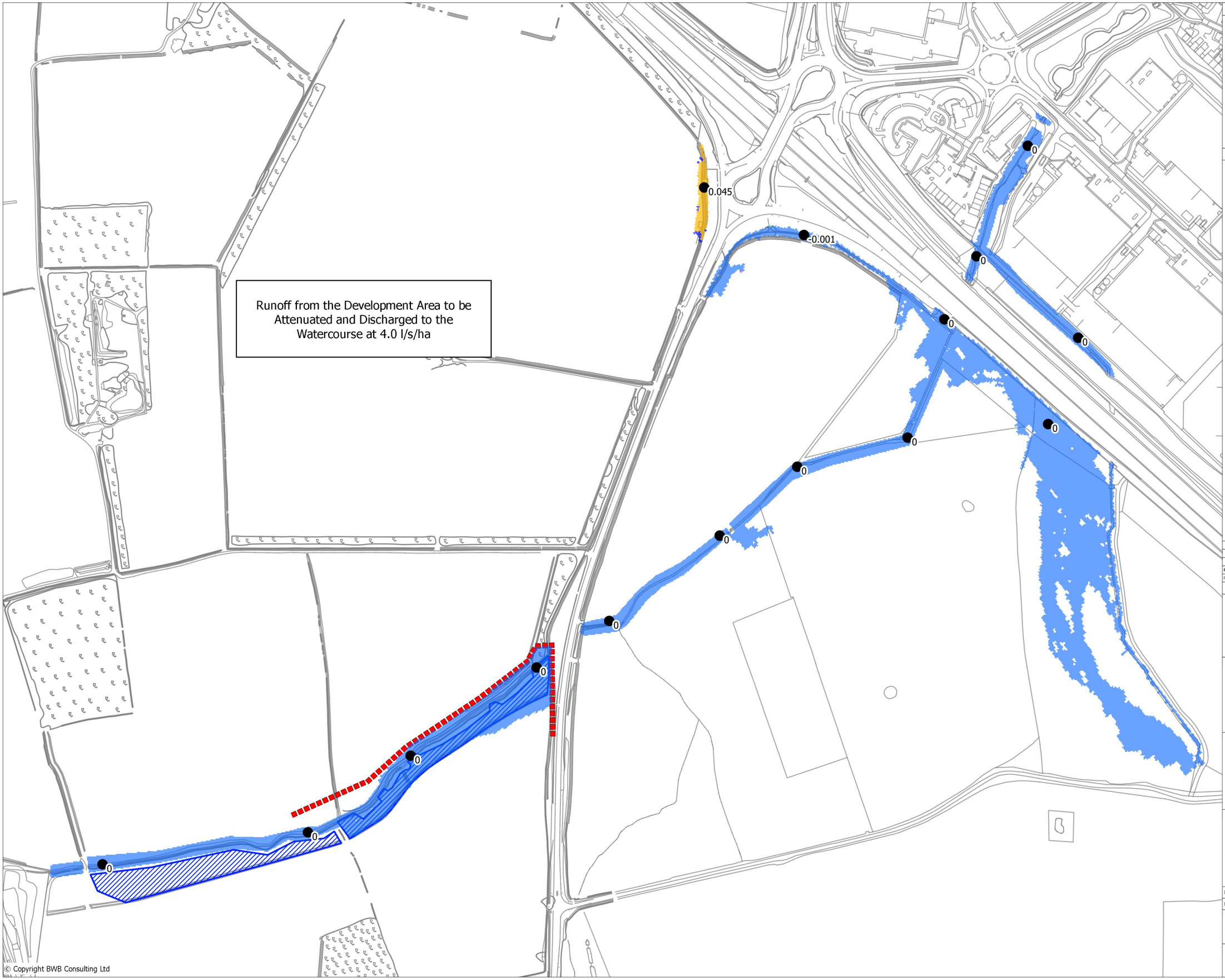
Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
NGW-BWB-EWE-XX-DR-YE-0123	S2	P1



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Rev	Date	Details of issues/ revision	Drw	Rev
P1	20.11.17	PRELIMINARY ISSUE	RG	CD

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Project Title

Northampton Gateway Rail Freight Interchange

Drawing Title

Courteenhall Brook Post-Development Sensitivity Tests: J15 Blockage

Drawn:	R Green		Reviewed:	C Dodd	
BWB Ref:	NTH 2315	Date:	20/11/17	Scale@A3	NTS

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
NGW-BWB-EWE-XX-DR-YE-0124	S2	P1

APPENDIX 4

Roade Brook Technical Note

Project	Northampton Gateway-Roade Bypass		
Document Number	NGW-BWB-EWE-XX-RP-EN-0003	**BWB Ref**	NTH2315
Author	Elijah Salami	**Status**	S2
Checked	Joel Read	**Revision**	P1
Approved	Robin Green	**Date**	08/12/17

1.0 INTRODUCTION

1.1 BWB Consulting Ltd has been commissioned by Roxhill Ltd to undertake a hydraulic modelling exercise of an Unnamed Ordinary Watercourse (UOW) flowing through the village of Roade, south of Northampton. This is to identify the potential fluvial floodplain extents of the watercourse, for the purpose of informing the design of a proposed highway bypass around the village.

1.2 For the purposes of this report the UOW will be referred to as the Roade Brook.

Study Site Description

1.3 The study site is located to the west of Roade and represents the proposed route of a new highway, and crossing of the watercourse. The study site is centred at National Grid coordinates 474669, 251740. The approximate location of the study site is shown in **Figure 1.1**. It should be noted that this represents planning application boundary, and does not reflect the extent of proposed development.

1.4 The study site is currently used for agricultural pasture and arable fields. The Roade Brook flows through the central and southern proportion of the site, from north-west to south-east. The channel network of the watercourse is identified within **Figure 1.1**.

The Roade Brook

1.5 The Roade Brook is a tributary of the River Tove, which is located 2.5km downstream of the study site. The Roade Brook has a total catchment area of approximately 8.36km^2. For comparison, the River Tove's catchment area is in the region of 163km^2 at their confluence.

1.6 The study site is located near the headwaters of the Road Brook. The watercourse rises approximately 800m to the north-west of the study site in the region of Knock Lane/Blisworth Road.

1.7 The watercourse flows for 2.2km in a south-easterly direction through the farmland to the south-east of Roade. It passes through a number of minor hydraulic structures on its route, but its first piece of large infrastructure is its culvert under the A508 (Northampton Road), located downstream of the village and on the southern edge of the study site.

1.8 The watercourse is joined by a tributary from the north, 800m downstream of the A508, after which the watercourse flows south past the village of Aston, before outfalling to the River Tove.

Previous Studies & Available Data

1.9 The Environment Agency (EA) Flood Map for Planning identifies the study site to be located within Flood Zone 1. However, the Roade Brook is understood to be too small to have been included in the national scale Flood Mapping. The Flood Zone Maps for Planning are therefore not considered suitable to confirm flood risk at a site level.

1.10 It is understood that the EA and Lead Local Flood Authority (LLFA) do not hold detailed modelled flood data of the watercourse.

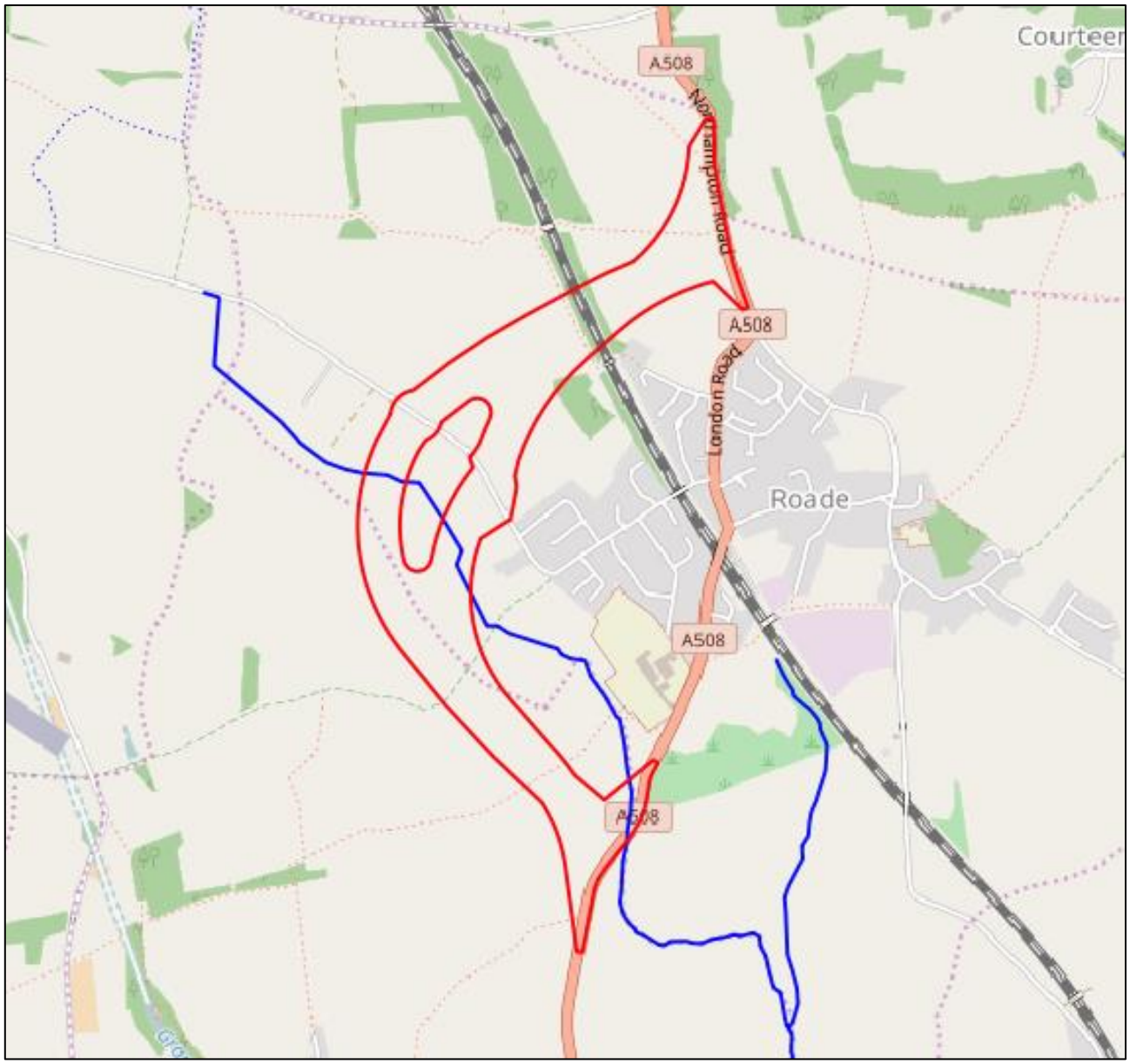


Figure 1.1 - Site Location Plan

1.11 The Environment Agency do hold a hydraulic river model of the River Tove, and a copy of the model has been obtained for use in this exercise. This takes the form of 1D-2D TUFLOW model. The model does not include any geometry for the Roade Brook, nor does it include a specific point inflow for flood flows generated within the Roade Brook catchment.

1.12 EA surface water flood risk mapping identifies the potential areas at risk of flooding if rain water does not enter the drainage system or infiltrate into the ground. While not strictly a fluvial source, this mapping can provide an indication of the potential flood risk associated with minor watercourses where detailed modelling has not been undertaken. An extract of the EA surface water flood risk mapping is illustrated within **Figure 1.2**.

1.13 The surface water flood risk mapping illustrates a well-defined pluvial flow route which correlates with the Roade Brook as it passes through the site in a south-easterly direction.

1.14 The EA do not have any records of flooding within the area of the study site, and no historic flooding incidents are reported within the Strategic Flood Risk Assessment (SFRA) or Preliminary Flood Risk Assessment (PFRA).

1.15 An internet search revealed that in November 2012 inundation of the highway was reported within the local media, but no specific details or locations were identified.

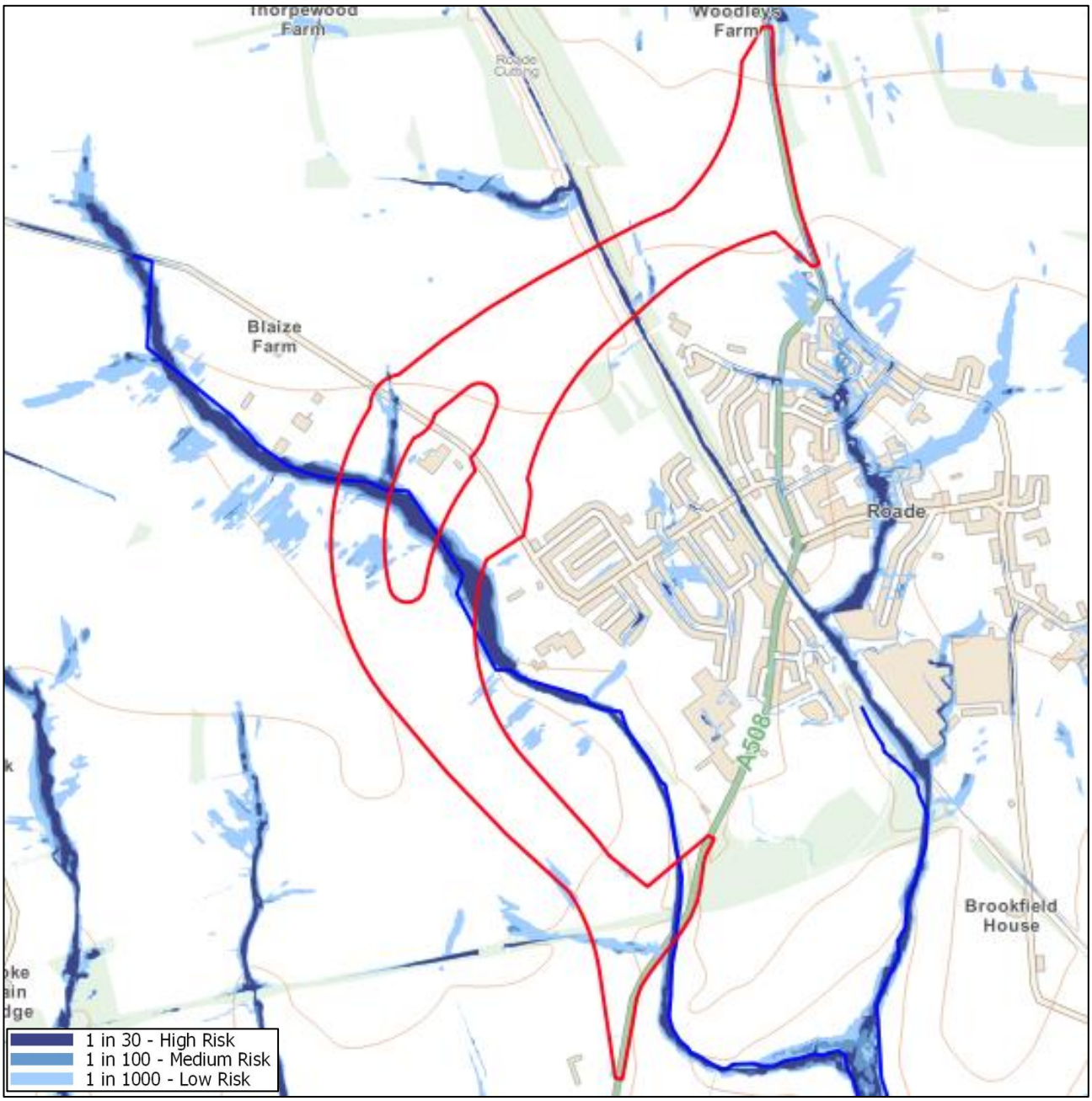


Figure 1.2 - Environment Agency Risk of Flooding from Surface Water Maps

1.16 A review of available LiDAR (Light Detection and Ranging) data has revealed that there is very limited coverage for most of the Roade Brook catchment within the vicinity of the study site.

Other Sources of Data

1.17 The following additional datasets were used within the hydraulic modelling exercise:

- A topographic survey of the study site, undertaken in May 2016 – **Annex 2**
- A watercourse survey of the Roade Brook, undertaken in May 2016 – **Annex 3**
- Ordnance Survey 1:1,250 scale mapping
- Ordnance Survey 1:50,000 scale mapping
- Flood Estimation Handbook catchment descriptors
- Hi-Flows Database
- Ordnance Survey NextMap Digital Terrain Model (DTM)

Aim & Objectives

1.18 The primary aim of this modelling exercise is to establish a good hydrological and hydraulic representation of the Roade Brook within the study site. The model will be used to identify the current extent of floodplain and peak flood levels, which will inform the design of a proposed highway crossing of the watercourse.

1.19 To achieve this aim, the following objectives were identified:

i. Create a one-dimensional (1D) hydraulic model of the reach of the Roade Brook which could influence the site.

ii. Create a two-dimensional (2D) floodplain representation of the site and surrounding floodplain.

iii. Undertake a hydrological assessment of the Roade Brook catchment to estimate peak flood flows and generate flood hydrograph profiles.

iv. Simulate fluvial flood events within the combined 1D-2D model to establish a set of baseline conditions.

v. Define current extent of floodplain and peak flood levels which will aid the design of a proposed highway crossing of the watercourse.

vi. Simulate sensitivity tests and residual risks within the model, which would include roughness coefficients, blockage scenarios and climate change.

2.0 HYDROLOGICAL ASSESSMENT

Method Statement

2.1 Flood flows estimates are required to support a hydraulic modelling exercise of the Roade Brook. The hydraulic assessment will model unsteady flood flows, therefore hydrographs as well as peak flood levels are required.

2.2 To inform the hydraulic modelling the following return period events are required: 1 in 20, 1 in 100, and 1 in 1000-year.

2.3 The Roade Brook is un-gauged therefore there are no hydrometric records of river flows or levels on which a hydrological assessment of flood flows can be made.

2.4 This hydrological analysis is therefore based around the industry standard methodologies which utilise the Flood Estimation Handbook (FEH) catchment descriptors: the FEH Statistical Analysis; and the ReFH2 (Revitalised Flood Hydrograph) rainfall-runoff model.

2.5 Other methodologies such as IH124, and the Modified Rational method were dismissed due to the size and rural nature of the catchment. The FEH rainfall-runoff hydrological model was not utilised as this has been superseded by the ReFH2 model.

2.6 The catchment as delimited at the downstream extent of the study site (the catchment at the A508) was assessed in this analysis; a catchment area of 1.41km^2. This approach means that only flows generated upstream or within the study site will be applied to the hydraulic model.

2.7 A lumped approach will be adopted within the hydraulic model, whereby the estimated flood flows are all applied to the upstream extent of the model.

2.8 As the flow estimates will be supporting a Flood Risk Assessment a conservative approach to the decision making will be made where applicable.

Review of the Catchment

2.9 A review of the Roade Brook watershed was undertaken against Ordnance Survey mapping, this is illustrated within **Figure 2.1**. Generally, the FEH catchment showed a fair correlation with the Ordnance survey contours, and mapped features.

2.10 British Geological Society (BGS) geological mapping indicates that the brook flows through a variety of geologies as it flows towards the A508. The headwaters rise within Blisworth Limestone Formation overlain with Oadby Member Diamicton and Glacio-fluvial superficial deposits. As the watercourse approaches the A508 it transitions through Rutland Formation Mudstone, into Wellingborough Limestone Member. This underlying geology suggests that the BFI_{HOST} and SPR_{HOST} values from the FEH descriptors are reasonable (as shown in **Table 2.1**).

2.11 Despite the underlying potentially permeable geologies, the BFI_{HOST} and SPR_{HOST} values identify that the catchment is not classified as especially permeable. These values do not necessitate any special measures in the FEH procedures, nor do they prohibit the use of either the ReFH or FEH Statistical Approach.

2.12 URBEXT values are low indicating a predominantly rural catchment, these values do not necessitate any special measures in the application of the FEH procedures, nor do they prohibit the use of either the ReFH or FEH Statistical Approach.

2.13 Key catchment descriptors are summarised within **Table 2.1**.

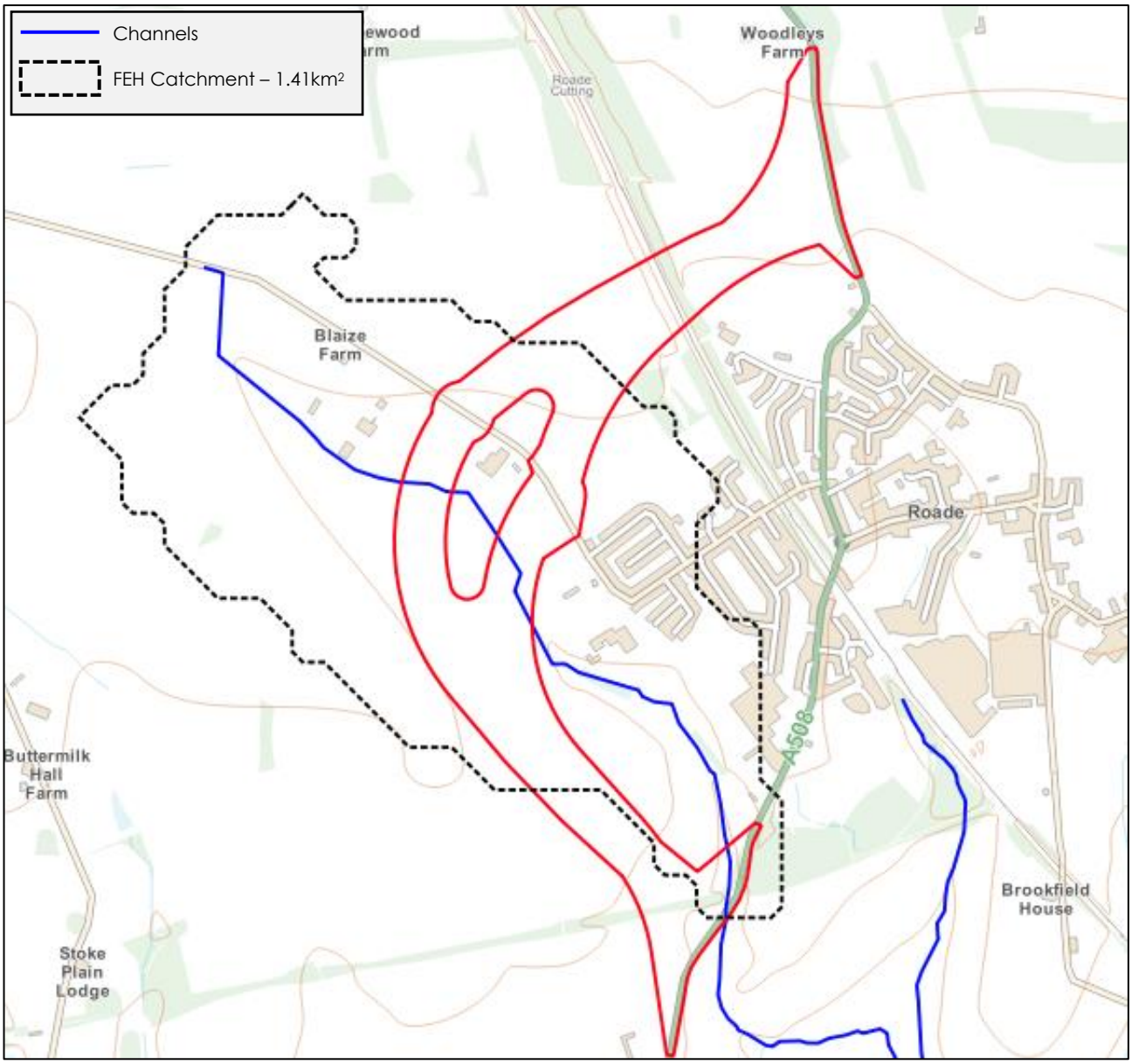


Figure 2.1 - FEH Study Catchment

Table 2.1 - Key Catchment Descriptors

Descriptor	
AREA (km²)	1.41
BFI_{HOST} – Base Flow Index	0.539
FARL – Flood attenuation from reservoirs & lakes	1.000
FPEXT – Floodplain extent	0.0355
PROPWET – Proportion of time that soils are wet	0.3
SAAR – Standard Average Annual Rainfall	634
SPR_{HOST} – Standard Percentage Runoff (Host soils classification)	32.34
$URBEXT_{1990}$ – Fraction of Urban Extent	0.0249
$URBEXT_{2000}$ – Fraction of Urban Extent	0.0417

FEH-Statistical Analysis

2.14 WINFAP version 3 was utilised to undertake a statistical analysis of the catchment using a hydrometric record of gauged catchments with similar catchment descriptors. Version 4.1 (May 2016) of the Hi-Flow dataset was used to provide a hydrometric record. **Annex 1** contains extracts from WINFAP procedure illustrating the methodology and detailing the composition of the pooling group.

2.15 A group of hydrologically similar gauged sites was generated by the software from the 'OK for Pooling' dataset. The group was identified as 'heterogeneous' - this does not mean that it is inappropriate, just that it should be reviewed.

2.16 The group was reviewed to identify sites which may be inappropriate due to being significantly hydrologically dissimilar to the study site, or if they have any inaccuracies, uncertainties or limitations in their data record.

2.17 Bollingey Stream (49005) was removed from the pooling group due to its 5-year record length falling below the recommended 8-year minimum.

2.18 Two stations within the pooling group were identified as highly permeable catchments (BFIHOST>0.80, SPRHOST<20%): Brompton Beck (27073) and Gypsey Race (26802). Given their permeability is considerably different from the study catchment they were removed from the pooling group, and replaced with other sites to meet the minimum record length target.

2.19 All other stations in the pooling group were considered to be acceptable: they were all identified as having sufficient record length, and to be of sufficient hydrological similarity for the purpose of this study (i.e.: no other sites within the Hi-Flows dataset are believed to be more representative). The sites were of a rural nature, had similar flood seasonality, and were not of a highly permeable nature. It is believed that the heterogeneous nature of the pooling groups is a result of the limited number of small gauged sites which are available in the record.

2.20 The resultant record length for the pooling group totalled 521 years, which meets the recommended guidelines on required record length.

2.21 In line with the generally accepted approach, the 'generalised logistic' distribution (regarded as the best fit for most UK catchments) was selected to derive a growth curve from the pooling group. No other distribution was identified to give an acceptable fit.

2.22 The $URBEXT_{2000}$ value was updated from 0.0417 to an estimate of the 2017 coverage using the national average model of urban growth: 0.0432.

2.23 The updated catchment descriptors from **Table 2.1** were initially used to estimate the rural QMED of the study site ($QMED_{CDS}$) using the revised equation from Science Report SC050050[1]. $QMED_{CDS}$ was estimated at 0.237m^3/s.

2.24 The Hi-Flows dataset was used to generate a list of potential donor sites from the "OK for QMED & Pooling" dataset. It is the recommended procedure to use a 'Donor Station' to validate $QMED_{CDS}$. In this instance station 33018 (Tove at Cappenham Bridge) was identified as being the most appropriate station to act as a donor. However, as this would result in an adjusted rural QMED of 0.225m^3/s ($QMED_{ADJ}$), the higher $QMED_{CDS}$ was retained.

2.25 An urban adjusted factor (UAF) of 1.068 was applied to the $QMED_{CDS}$, to estimate an urban QMED value ($QMED_{URB}$): 0.253m^3/s. An adjustment to the pooled growth curves was also made in the software using the latest methods.

2.26 The $QMED_{ADJ}$ was applied to the pooled growth curve to derive a flood frequency curve. The peak flood flow estimates are detailed in **Table 2.2**.

[1] Kjeldsen, T.R., Jones, D. A. and Bayliss, A.C. (2008) Improving the FEH statistical procedures for flood frequency estimation. Science Report SC050050, Environment Agency.

Revitalised Flood Hydrograph Analysis

2.27 The ReFH2 Revitalised Flood Hydrograph Modelling tool (version 2.2) was utilised to undertake an estimation of the peak flows from the catchment. This makes use of the latest changes to the rainfall-runoff model to incorporate the FEH13 Depth Duration Frequency rainfall model, and urban/rural catchment sub-divisions[2].

2.28 A critical duration of 5.5hrs was identified at a 0.5hr timestep, and due to the rural nature of the catchment a winter storm profile was adopted; all other parameters were left as default.

2.29 The resultant peak flood flow estimates are detailed in **Table 2.2**.

Discussion

2.30 The peak flows from both methods are summarised in **Table 2.2.**

Table 2.2 - Summary of Peak Flow Estimates

Return Period (Yrs.)	Annual Probability (AP)	Peak Flows (m^3/s)	
		FEH Statistical Analysis	ReFH2
2	50.0%	0.253	0.31
10	10.0%	0.405	0.54
20	5.0%	0.479	0.63
50	2.0%	0.595	0.79
75	1.3%	0.655	0.87
100	1.0%	0.701	0.93
200	0.5%	0.826	1.09
1000	0.1%	1.21	1.57

2.31 The ReFH2 provides the worst-case flows of the two methodologies, and to promote a conservative assessment these will be adopted within this hydraulic model.

2.32 The ReFH2 derived a 100-year pooled growth factor of 3.00, this falls with the typical range of 2.1 to 4.0 and so seems reasonable.

2.33 The ReFH2 flow estimates equate to a QMED runoff rate of 2.2l/s/ha, and a 100-year runoff rate 6.6l/s/ha.

Climate Change

2.34 In February 2016 the predicted future change in peak river flows were updated by the Environment Agency[3]. This replaced the previous national 20% allowance with a range of projections applied to regionalised 'river basin districts'.

2.35 The Roade Brook catchment falls within the Anglian river basin district. **Table 2.3** identifies the relevant peak river flow allowances.

Table 2.3 - Peak River Flow Allowance for the Anglian River Basin District

Allowance Category	Total potential change anticipated for '2020s' (2015 to 39)	Total potential change anticipated for '2050s' (2040 to 69)	Total potential change anticipated for '2080s' (2070 to 2115)
Upper End	25%	35%	65%
Higher Central	15%	20%	35%
Central	10%	15%	25%

[2] Kjeldsen, T.R., Miller, J.D. and Packman, J.C., (2013). Modelling design flood hydrographs in catchments with mixed urban and rural land cover. Hydrology Research, 44 (6), pp. 1040-1057.
[3] Environment Agency. 2016. Flood risk assessments: climate change allowances. [ONLINE] Available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-1. [Accessed 24 February 16].

2.36 When determining the appropriate allowance for use in a Flood Risk Assessment the Flood Zone classification, the flood risk vulnerability, and the anticipated lifespan of the development should be considered. **Table 2.4** provides a matrix summarising the Environment Agency's guidance on determining the appropriate allowances.

Table 2.4 – Environment Agency Guidance on the Application of Climate Change Allowance

Flood Zone	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
2	use the higher central and upper end to assess a range of allowances	use the higher central and upper end to assess a range of allowances	use the central and higher central to assess a range of allowances	use the central allowance	use none of the allowances
3a	use the upper end allowance	development should not be permitted	use the higher central and upper end to assess a range of allowances	use the central and higher central to assess a range of allowances	use the central allowance
3b	use the upper end allowance	development should not be permitted	development should not be permitted	development should not be permitted	development should not be permitted
*If development is considered appropriate when not in accordance with flood zone vulnerability categories, then it would be appropriate to use the upper end allowance.					

2.37 The proposed development is for a new highway (essential infrastructure) with an anticipated lifespan of over 60 years, therefore the total potential change for the '2080s' will be adopted. The study site currently falls entirely within Flood Zone 1. However, given the proximity of the watercourses to the site, and the uncertainties associated with estimating flows on ungauged catchments, it is considered prudent to follow a precautionary approach. Therefore, for the purposes of this hydraulic modelling exercise it is proposed to view the site as if it were within Flood Zone 3a. Therefore, the higher central (35%) and the upper end (65%) allowances will be considered.

The Design Flood

2.38 New developments should be designed to provide adequate flood risk management, mitigation, and resilience against the 'design flood' for their lifetime. The design event for fluvial flooding is generally taken as the 1 in 100-year event (1% AEP)[4].

2.39 To allow the development's flood risk management strategy to be adequately designed for its lifetime the climate change the allowances discussed previously will be applied to the baseline (present day) 1 in 100-year hydrograph.

[4] Planning Practice Guidance. http://planningguidance.planningportal.gov.uk/. Paragraph: 054 & 055

3.0 THE HYDRAULIC MODEL

3.1 A dynamically linked 1D-2D modelling approach was adopted to represent the Roade Brook: the open channel and hydraulic structures were modelled within a one-dimensional (1D) ESTRY domain; and the out of bank flow routing and floodplain was modelled within a two-dimensional (2D) TUFLOW domain.

3.2 Both ESTRY and TUFLOW are standard hydraulic modelling packages widely used in the UK and have been benchmarked by the Environment Agency.

3.3 In a similar manner to the hydrological assessment, a conservative approach to the modelling was adopted.

ESTRY: The 1D Model Domain

3.4 A cross-sectional survey of the watercourse network within the vicinity of the site was completed in May 2016. The survey extended from Roade Brook's headwaters (NGR:473983, 252311) approximately 800m upstream of the site in the region of Knock Lane/Blisworth Road, to Ashton Road (NGR:475707, 250295) 700m downstream of the site.

3.5 Channel cross-sections were surveyed at regular intervals of between 50m to 125m in locations which captured the general condition and shape of the open watercourse.

3.6 Additional sections were taken on the upstream and downstream face of hydraulic structures. The watercourse survey is included as **Annex 3** for reference.

3.7 The surveyed channel was found to be relatively narrow, and the channel width could fall as low as 3m between banks. Truncating the whole 1D domain to top-of-bank would have necessitated an overly high resolution within the 2D domain, which would have increased simulation times needlessly. Also, due to the limited coverage of detailed LiDAR DTM, the full surveyed cross-section width for the majority of the Roade Brook was retained, this extended 5 to 8m into the floodplain beyond top-of-bank.

3.8 The in-channel conditions were generally observed to be moderately vegetated with some coarse bed sediments. Bank top vegetation was fairly dense; however, flows were observed to be relatively free flowing. A Manning's 'n' roughness value of 0.04 was adopted to represent these in-channel conditions.

3.9 Approximately 3.2km of the channel was modelled within the 1D domain. This included 70 open channel cross-sections and 14 hydraulic structures. A summary of hydraulic structures is provided within **Table 3.1.**

Table 3.1- Summary of Hydraulic Structures

Model Ref.	NGR	Type	Dimensions	Manning's n	Comments
ROADE_5-C1	474057, 252090	Circular Pipe	0.5m diameter	0.02	Concrete pipe under access track/footpath. Flows over culvert modelled within 1D domain using a weir.
ROADE_11-C2	474232, 251951	Circular Pipe	0.35m diameter	0.02	Concrete pipe under access track/footpath. Flows over culvert modelled within 1D domain using a weir.
ROADE_15-C3	474269, 251911	Circular Pipe	0.5m diameter	0.02	Concrete pipe under access track/footpath. Flows over culvert modelled within 1D domain using a weir.

ROADE_18-C40	474329, 251852	Circular Pipe	0.7m diameter	0.02	Concrete pipe beneath Plainwood Centre car park (474342, 251847).
ROADE_18-C41	474339, 251851	Circular Pipe	0.3m diameter	0.02	Concrete pipe beneath Plainwood Centre car park (474342, 251847).
ROADE_23-C5	474625, 251774	Circular Pipe	0.45m diameter	0.02	Concrete pipe under access track/footpath. Flows over culvert modelled within 1D domain using a weir.
ROADE_28-C6	474754, 251560	Circular Pipe	0.5m diameter	0.02	Concrete pipe under access track/footpath. Flows over culvert modelled within 1D domain using a weir.
ROADE_30-C7	474774, 251488	Circular Pipe	0.5m diameter	0.02	Concrete pipe under access track/footpath. Flows over culvert modelled within 1D domain using a weir.
ROADE_33-C8	474836, 251369	Circular Pipe	0.5m diameter	0.02	Concrete pipe under access track/footpath. Flows over culvert modelled within 1D domain using a weir.
ROADE_37-C9	474865, 251371	Circular Pipe	0.5m diameter	0.02	Concrete pipe under access track/footpath. Flows over culvert modelled within 1D domain using a weir.
ROADE_41-C10	474879, 251360	Circular Pipe	0.3m diameter	0.02	Concrete pipe under access track/footpath. Flows over culvert modelled within 1D domain using a weir.
ROADE_49-C11	475094, 251275	Circular Pipe	0.5m diameter	0.02	Concrete pipe under access track/footpath. Flows over culvert modelled within 1D domain using a weir.
ROADE_55-C12	475253, 250848	Circular Pipe	0.8m diameter	0.02	Concrete pipe under access track/footpath. Flows over culvert modelled within 1D domain using a weir.
ROADE_59-C13	475252, 250837	Circular Pipe	0.9m diameter	0.02	Circular pipe under the A508 (Northampton Road).

TUFLOW: The 2D Floodplain Model Domain

3.10 A DTM (Digital Terrain Model) created from the site topographical survey was used as a base for the 2D floodplain. This provides coverage for all the floodplain within the study site.

3.11 Outside of the study site NEXTMap elevation data was used to set floodplain levels. This was used as the next best alternative, in the absence of LiDAR coverage. Although the accuracy of this data is limited, it is not being used to set elevations within the study site, and it will still provide a generalised representation of the topography surrounding the site. The NEXTMap DTM was updated with 2.0m resolution LiDAR DTM data where possible, but this was restricted to land downstream of the A508.

3.12 The DTM has undergone a filtering process to remove buildings and vegetation to provide a 'bare earth' ground model.

3.13 A 4m resolution grid was adopted for the TUFLOW model domain; this is considered to be more than sufficient given the semi-rural nature of the floodplain, but necessary due to the narrow channel width in certain locations.

3.14 Although the 4m cell size will pick up most of the significant topographic features, key features were reinforced using a 'Z-line'. This included the surveyed ground levels at the end of the watercourse cross-sections, this ensured a smooth interface between the 1D and 2D domains.

3.15 The 2D domain was deactivated between 1D cross-sections to avoid double counting floodplain conveyance and storage.

3.16 Ordnance survey 1:1250 scale mapping was used to digitise land use areas within the floodplain and apply suitable Manning's 'n' roughness values.

3.17 Buildings, walls, and other structures were modelled at ground level with an elevated roughness value, in line with best practise.

Boundary Conditions

Inflows

3.18 The flood flow hydrographs described in **Section 2.0** were applied to the upstream extent of the 1D ESTRY domain as a flow-time (QT) boundary.

Downstream Boundary

3.19 A head-time(HT) boundary was used at the downstream extent of the 1D domain. A fixed level of 83.4mAOD was adopted, which is roughly equivalent to the water level at the time of survey.

3.20 For comparison the modelled 1 in 1000-year plus climate change allowance level in the downstream River Tove is 73.9mAOD.

1D-2D Interface

3.21 The ESTRY-TUFLOW interface followed the end of the 1D cross-sections. A 'HX' (External Head) boundary was adopted as the interface type in line with best practise.

Model Schematic

3.22 An illustrative schematic of the model is presented within **Figure 3.1.**

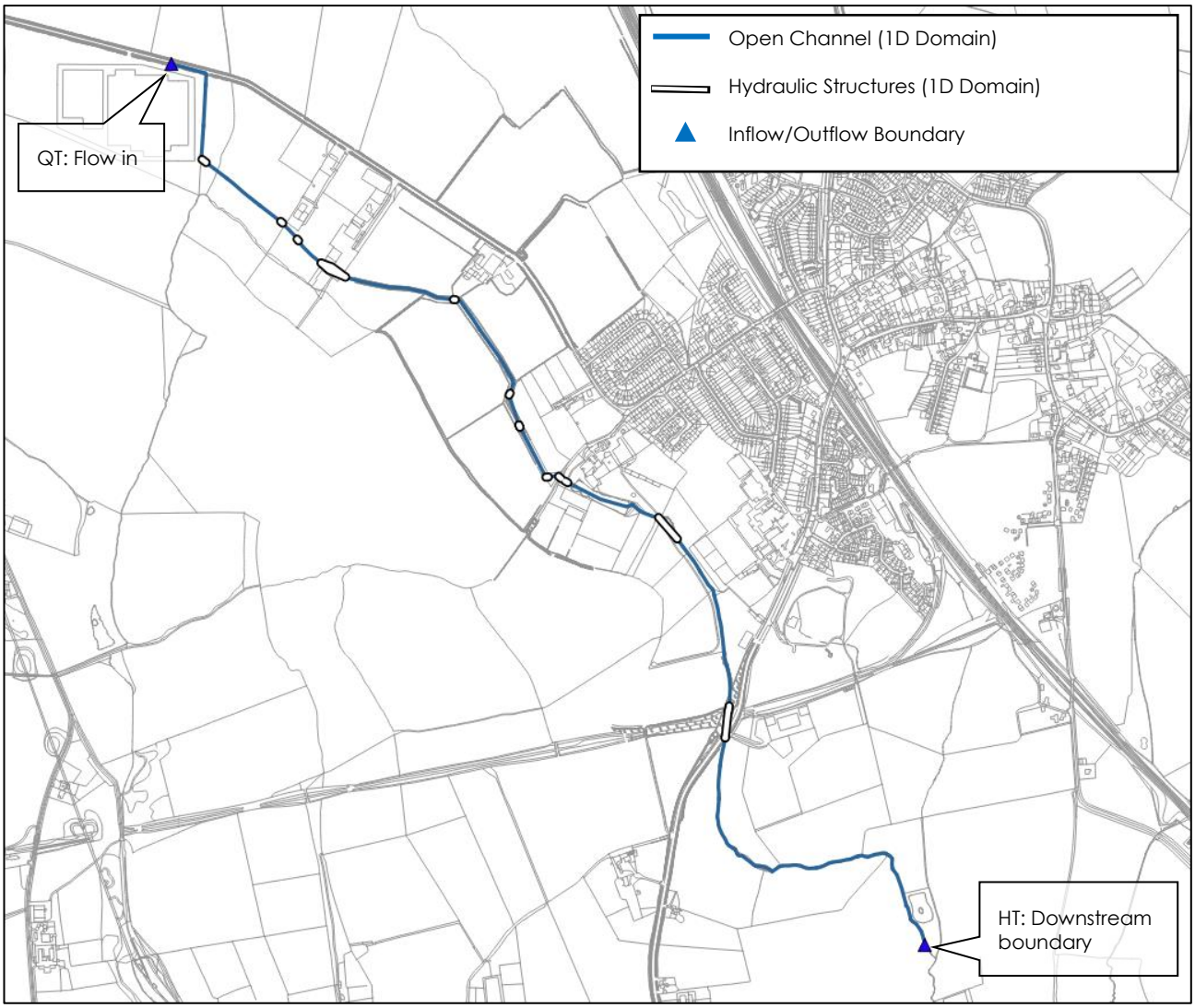


Figure 3.1-Model Schematic

Model Calibration

3.23 As there was no hydrometric data, historic flood mapping, or representative strategic flood maps available, the model could not be directly calibrated against existing data.

3.24 However, it is believed that the conservative approach to the model build should offer a sufficiently robust model for the purposes of assessing flood risk at the site.

Model Parameters and Stability

Simulation Parameters

3.25 TUFLOW version 2016-AC-iDP-w64 was used in all the simulations. All parameters were retained as default.

3.26 A time step of 0.5 second was adopted for the ESTRY domain and 1.0 second for the TUFLOW domain.

Results Parameters

3.27 TUFLOW maximum results were output for water levels, depths, and UK Hazard Rating. UK Hazard rating was derived from the following equation[5]:

$$Hazard\ Rating = D * (V+0.5) + DF$$

Where:
D = depth
V = velocity
DF = Debris Factor

3.28 **Table 3.2** identifies the recommended debris factors from FD2321/TR1. The debris factor has been set at 'Woodland', which is considered to be representative of the catchment.

Table 3.3 - Guidance Debris Factors (Ref: FD2321/TR1)

Depths	Pasture/Arable	Woodland	Urban	Conservative*
0 to 0.25 m	0	0	0	0.5
0.25 to 0.75 m	0	0.5	1	1
d>0.75 m and/or v>2	0.5	1	1	1

**an additional category in TUFLOW*

3.29 **Table 3.3** identifies the thresholds of the flood hazard categories as identified within DEFRA guidance document FD2320 and the "*Supplementary Note on Flood Hazard Ratings and Thresholds for Development Planning and Control Purpose*" (DEFRA, 2008) which have been adopted within this exercise.

Table 3.4 - Hazard to People[6]

Threshold for Flood Hazard Rating	Degree of Flood Hazard	Description
< 0.75	Low	**Caution** - "Flood zone with shallow flowing water or deep standing water"
0.75 - 1.25	Moderate	**Danger for some (i.e.: children)** - "Danger: Flood Zone with deep or fast flowing water"
1.25 - 2.0	Significant	**Danger for most people** - "Danger: Flood Zone with deep fast flowing water"
2.0 >	Extreme	**Danger for all** - "Extreme Danger: Flood Zone with deep fast flowing water"

Model Stability

3.30 No negative depths were reported throughout the different model simulations, and the model flux (flow in and out) did not show any significant evidence of an unstable/fluctuating ESTRY-TUFLOW interface.

3.31 The ESTRY-TUFLOW mass error remains within 1 to 3% for all the simulations, which is within the acceptable range.

Limitations

3.32 The modelling exercise has made use of the available data at the time of construction and simulation.

3.33 The model contains no formal representation of the conveyance within minor watercourses or ditches other than that captured by the model grid and within the ESTRY model domain.

[5] DEFRA R&D Outputs: Flood Risks to People Phase Two Draft FD2321/TR1 and TR2
[6] 2008, DEFRA. Supplementary Note on Flood Hazard Ratings and Thresholds for Development Planning and Control Purposes.

3.34 As no hydrometric data or recorded flood levels were available, the model has not been verified or calibrated. However, a conservative approach to the model build has been adopted where appropriate, and a range of sensitivity tests have been undertaken to help to compensate for this limitation.

3.35 The 4.0m resolution of the model may negate any small scale topographic features, although all the significant features are believed to have been captured.

3.36 The model uses a detailed DTM derived from a topographical survey within the study site, but due to the lack of LiDAR coverage, the floodplain in the wider domain has utilised NEXTMap elevation data. While this should not significantly affect the results in the study site or the aim of this exercise, the results outside of the study site should be treated with caution.

3.37 The bare earth DTM does not include for the presence of minor walls or other structures. Buildings have been modelled at ground level with an elevated roughness level.

3.38 This modelling exercise has been undertaken to produce a good representation of flood risk mechanisms in and around the study site. It has not been designed to accurately map flooding in the wider catchment.

4.0 BASELINE RESULTS

4.1 The baseline hydraulic model was simulated against key return period events. Due to the insignificant floodplain extents, detailed flood maps have not been produced. Flooding mechanisms are discussed below, with floodplain extents illustrated within **Figure 4.1.**

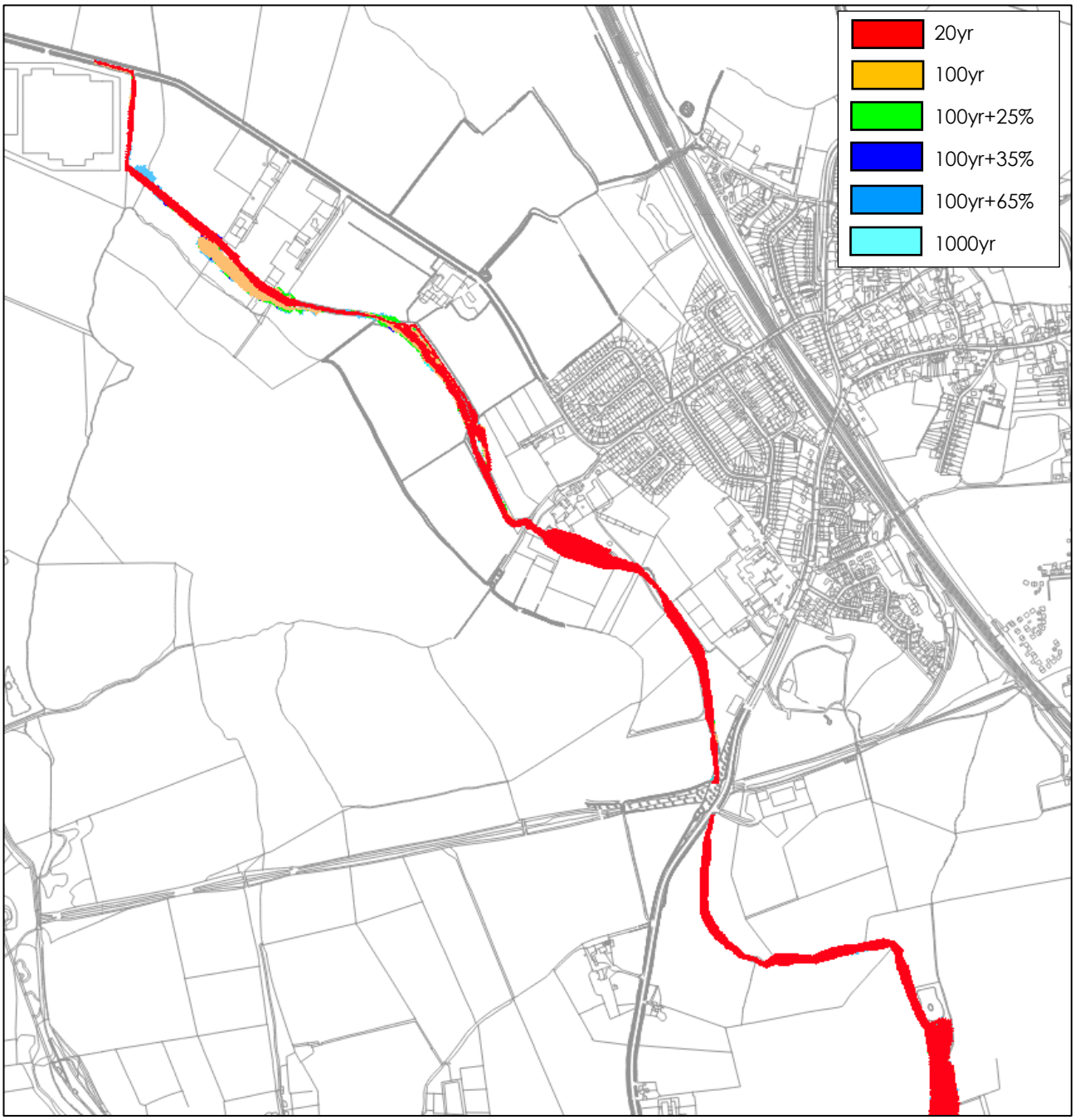


Figure 4.1 - Baseline Floodplain Extents

4.2 The model results shown that flood levels largely remain within the 1D domain; either within bank or within 5-10m from top of bank. Any flood water which is transmitted to the 2D domain also stays within close proximity to the channel, and is of a relatively shallow nature.

4.3 The majority of modelled culverts are shown to have limited capacity and are overwhelmed in most instances. This leads to excess flood water bypassing the structures either by overtopping the deck or by routing around the structure via the floodplain. However, any flooding is kept within close proximity to the channel.

4.4 The exception to this is the culvert under the A508, as flood water cannot bypass the structure due to the highway's elevated position. Instead, water builds up behind the road embankment until flood flows recede to normal levels. The extent of the backwater effect generated by the A508 is limited due to the gradient of the watercourse.

Sensitivity Tests

4.5 To account for the seasonal variations in vegetation, uncertainties in the downstream boundary, and the residual risk of blockages at significant hydraulic structures, a series of sensitivity tests were conducted using the 1 in 100-year flows.

4.6 The difference in peak waters between the tests and the design 1 in 100-year event are discussed within the forthcoming section.

Roughness

4.7 The modelling has shown that a 20% reduction in channel and floodplain roughness (representative of winter seasonal conditions, or following a period of maintenance) results in a general decrease of in-channel flood levels, of between 10 to 90mm. This does not result in a significant change in floodplain extent.

4.8 A 20% increase in Manning's 'n' (representative of summer seasonal conditions, and a period without maintenance) is shown to result in a general increase of in-channel flood levels of between 10 to 145mm. However, the increase is shown to not significantly affect floodplain extents.

Downstream Boundary

4.9 The downstream boundary of the model is located 700m south east of Stratford road. The adopted downstream water level of 83.4mAOD is the water level taken from the watercourse survey. For comparison, the modelled 1 in 1000-year plus climate change allowance level in the downstream River Tove is 73.9mAOD.

4.10 The adopted downstream water level exceeds the River Tove 1 in 1000-year plus climate change level, hence an arbitrary increase of 1m was applied to the adopted downstream water level to understand the potential extent of backwater.

4.11 The 1m increase resulted in an increase in flood levels and floodplain extents over a reach of 750m. However, flood levels were unaffected within the location of the proposed highway. This shows that the downstream boundary was located appropriately.

Blockage Scenarios

4.12 Blockage scenarios were undertaken on 2 culverts which could have the potential to affect flood risk within the development, these are located within **Figure 4.2.** A blockage scenario of a minor culvert within the site boundary at the start of an overland flow route, and the A508 culvert were assessed. The other hydraulic structures within the model could be easily bypassed and so were omitted from the analysis.

4.13 A 95% blockage of each structure was assessed individually.

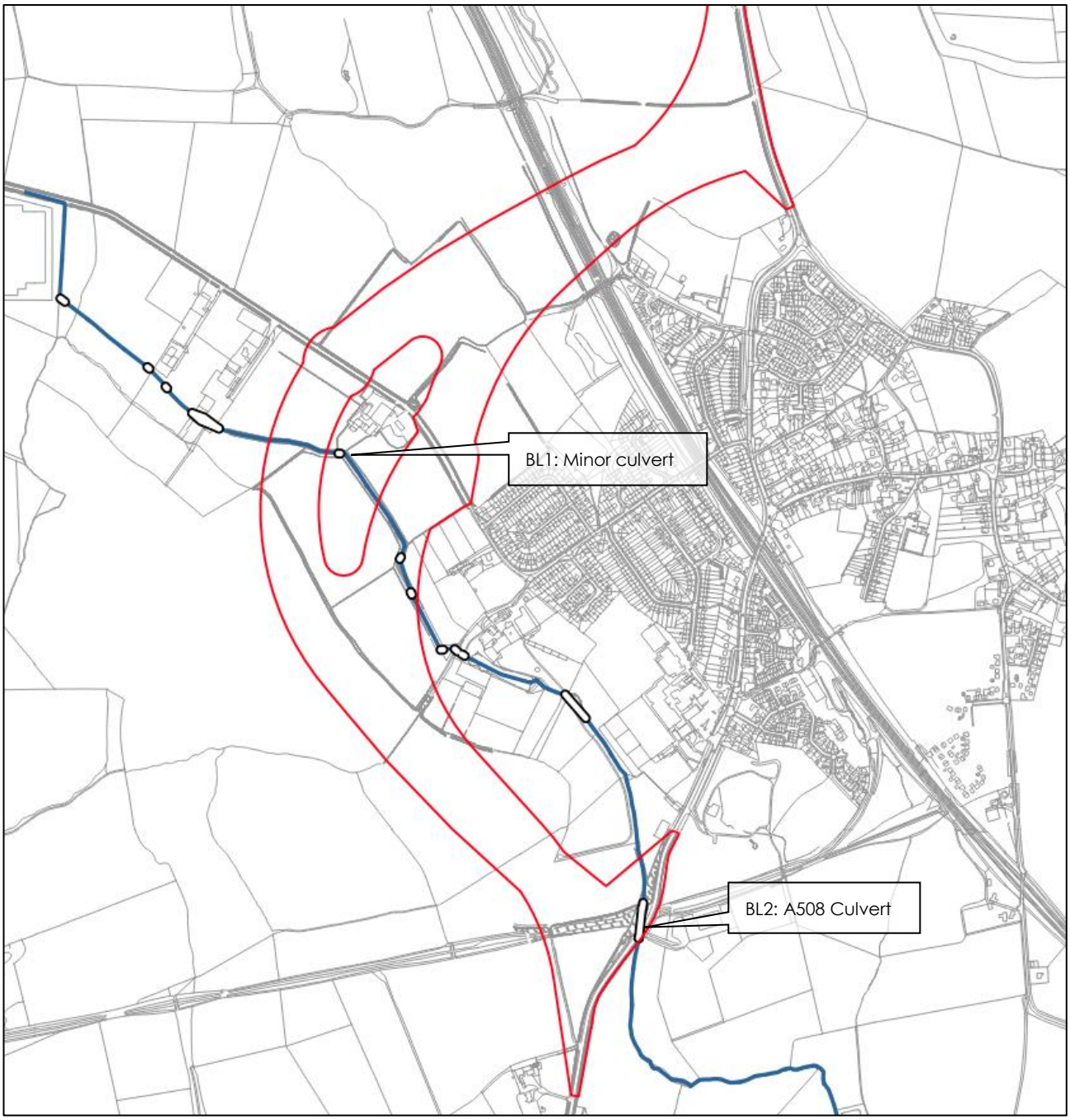


Figure 4.2- Blockage Scenario Locations

4.14 A 95% blockage of the culvert within the site was shown to increase flood levels by 10mm, and to have essentially no impact on floodplain extents. This is because the culvert is already bypassed by much of the predicted flood flows.

4.15 A 95% blockage of the culvert under the A508 resulted in an increase of up to 1920mm within the upstream channel. The increase in flood levels was shown to be sufficient to overtop the A508 embankment leading to shallow floodplain of the carriageway. The resultant floodplain extents are not shown to be excessive as floodwater simply flows into the downstream channel – this is shown within **Figure 4.3**.

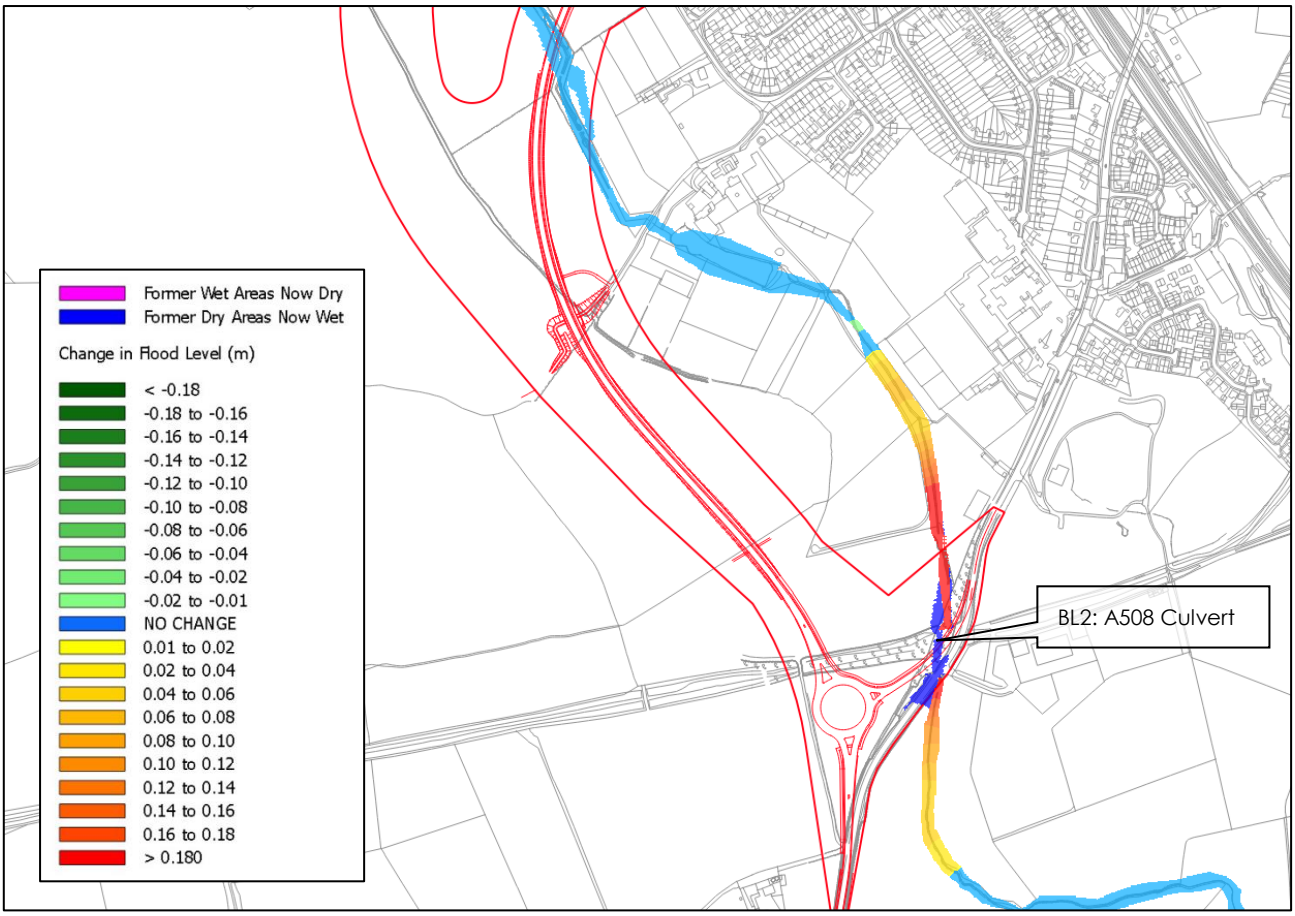


Figure 4.3 - Change in Peak Water Level Resulting from a Complete Blockage of the A508 Culvert

Tabulated Results

4.16 Peak water levels from selected points through the site are detailed within **Table 4.1**. Interrogation locations are identified within **Figure 4.3**.

Table 4.1-Peak Modelled Flood Levels (mAOD)

	Flood Events	1	2	3	4	5	6	7	8	9
Baseline	1 in 20	114.75	114.11	112.60	112.30	112.42	112.05	110.57	94.93	93.69
	1 in 100	114.98	114.19	112.67	112.37	112.44	112.11	110.83	95.35	93.97
	1 in 100 + 25%	115.03	114.21	112.74	112.41	112.45	112.13	110.86	95.51	94.03
	1 in 100 + 35%	115.03	114.21	112.74	112.41	112.45	112.14	110.87	95.54	94.06
	1 in 100 + 65%	115.06	114.22	112.79	112.45	112.45	112.15	110.90	95.74	94.11
	1 in 1000	115.06	114.22	112.80	112.45	112.45	112.15	110.91	95.79	94.12
Sensitivity Tests	Roughness + 20%	115.02	114.20	112.72	112.40	112.45	112.12	110.71	95.49	94.03
	Roughness - 20%	114.93	114.17	112.61	112.33	112.44	112.10	110.85	95.32	93.91
	D/S Boundary	114.98	114.19	112.67	112.37	112.44	112.11	110.83	95.35	93.97
	Blockage Scenario BL1	114.98	114.18	112.68	112.37	112.44	112.12	110.83	95.38	93.97
	Blockage Scenario BL2	114.98	114.19	112.67	112.37	112.44	112.11	110.83	97.19	94.15

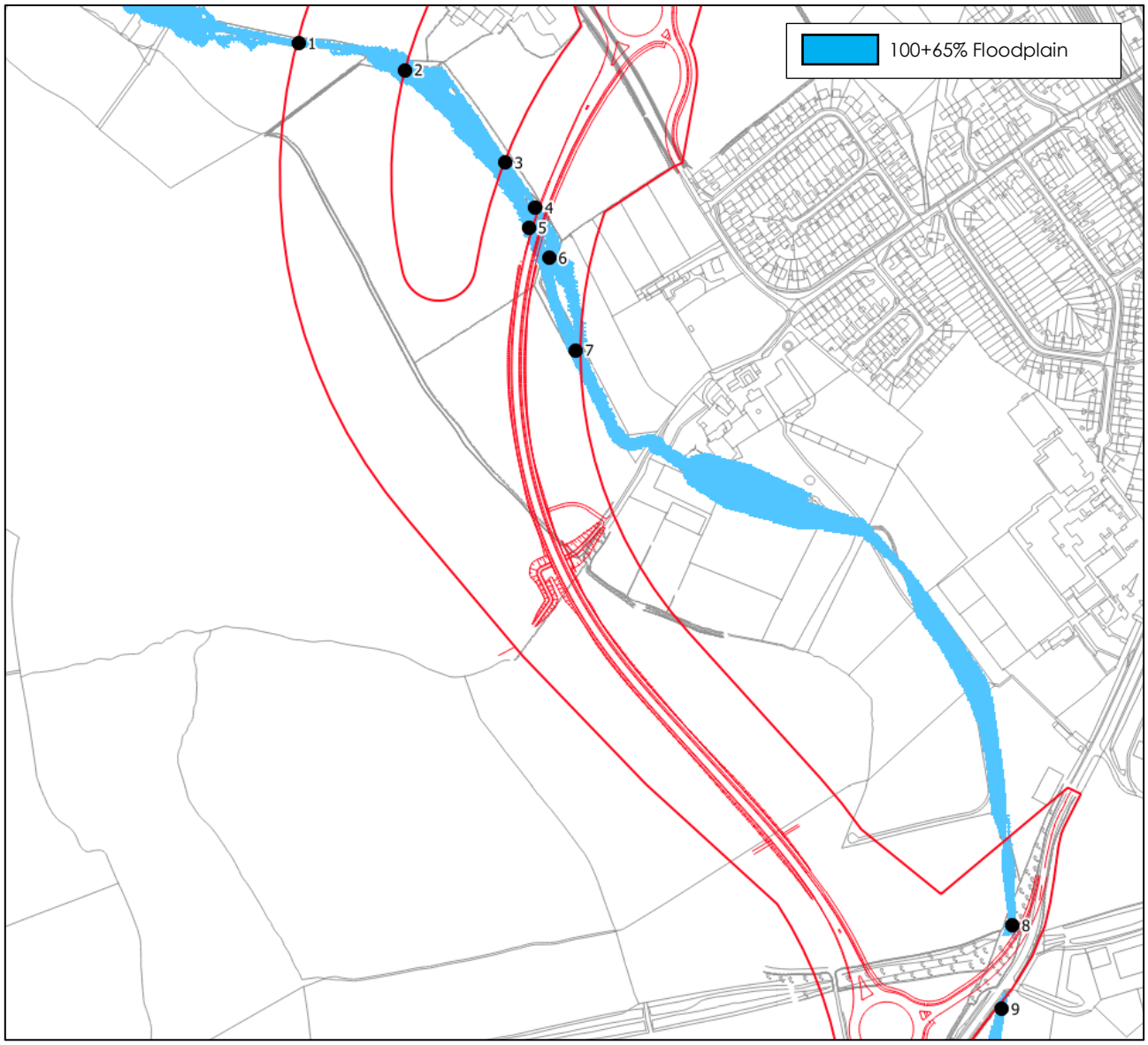


Figure 4.4 - Flood Level Interrogation Locations

5.0 CONCLUSIONS & RECOMMENDATIONS

5.1 The primary aim of this exercise was to establish a good hydrological and hydraulic representation of the Roade Brook to identify the fluvial flood risk posed to the proposed development area, and identify peak flood levels and floodplain extents to inform the design of the new highway.

5.2 The modelling has shown that the existing hydraulic structures are generally undersized for the predicted flood flows. This leads to excess flood water bypassing the structures either by overtopping the deck or by routing around the structure via the floodplain. However, any flooding is kept within close proximity to the channel and is of a relatively shallow nature.

5.3 The flood levels on the watercourse have been shown to be sensitive to changes in roughness, but the predicted change in water level are shown to have limited impact on floodplain extents.

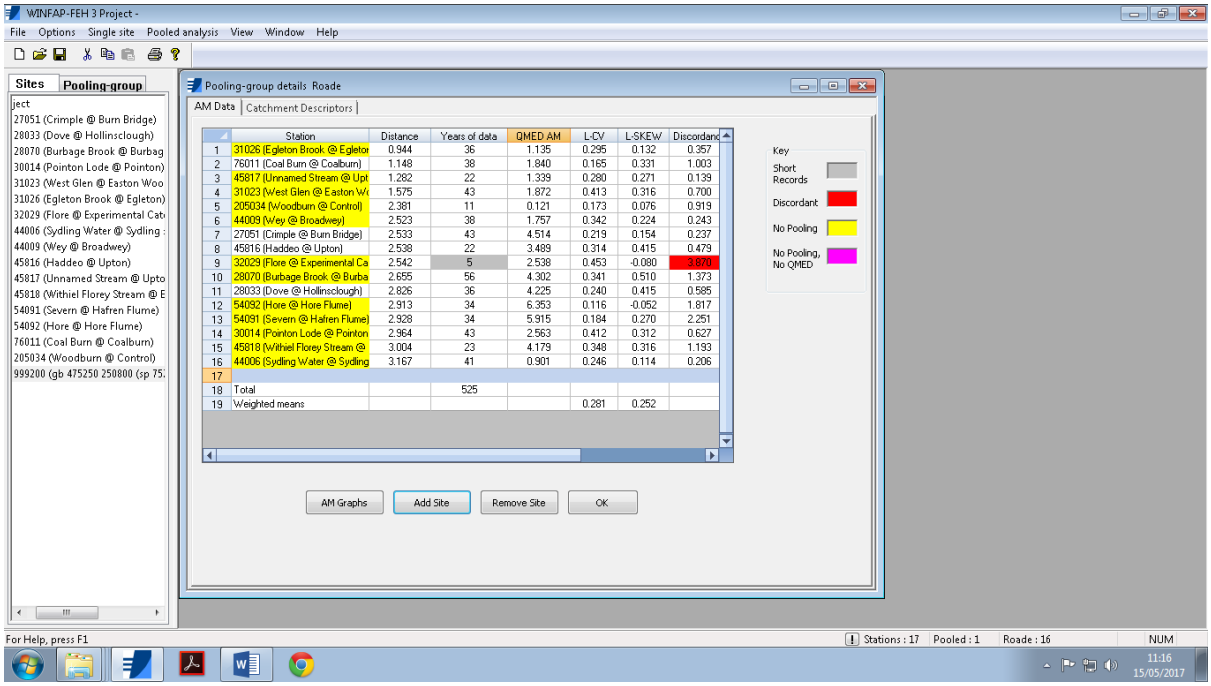
5.4 A potential blockage of the culvert under the A508 has been shown to significantly affect local flood levels, potentially leading to shallow flooding of the A508 carriageway.

5.5 The formation of the proposed highway will require the installation of a new culvert to convey the watercourse beneath the embankment and carriageway. The culvert should be designed to offer a minimum of a 600mm freeboard between the design flood level and the soffit. It should also be designed in a manner to not significantly impact flood risk in the wider area.

5.6 It is recommended that the proposed highway culvert is verified within the flood model to ensure that these parameters are fulfilled.

ANNEX 1

WINFAP Audit Trail & Pooling Group Composition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Sites Pooling-group
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AM Data Catchment Descriptors
Station Distance Years of data QMED AM L-CV L-SKEW Discordanc
1 31026 (Egleton Brook @ Egleto 0.944 36 1.135 0.295 0.132 0.357
2 76011 (Coal Burn @ Coalburn) 1.148 38 1.840 0.165 0.331 1.003
3 45817 (Unnamed Stream @ Upt 1.282 22 1.339 0.280 0.271 0.139
4 31023 (West Glen @ Easton W 1.575 43 1.872 0.413 0.316 0.700
5 205034 (Woodburn @ Control) 2.381 11 0.121 0.173 0.076 0.919
6 44009 (Wey @ Broadwey) 2.523 38 1.757 0.342 0.224 0.243
7 27051 (Crimple @ Burn Bridge) 2.533 43 4.514 0.219 0.154 0.237
8 45816 (Haddeo @ Upton) 2.538 22 3.489 0.314 0.415 0.479
9 32029 (Flore @ Experimental Ca 2.542 5 2.538 0.453 -0.080 3.870
10 28070 (Burbage Brook @ Burba 2.655 56 4.302 0.341 0.510 1.373
11 28033 (Dove @ Hollinsclough) 2.826 36 4.225 0.240 0.415 0.585
12 54092 (Hore @ Hore Flume) 2.913 34 6.353 0.116 -0.052 1.817
13 54091 (Severn @ Hafren Flume) 2.928 34 5.915 0.184 0.270 2.251
14 30014 (Pointon Lode @ Pointon 2.964 43 2.563 0.412 0.312 0.627
15 45818 (Withiel Florey Stream @ 3.004 23 4.179 0.348 0.316 1.193
16 44006 (Sydling Water @ Sydling 3.167 41 0.901 0.246 0.114 0.206
17
18 Total 525
19 Weighted means 0.281 0.252
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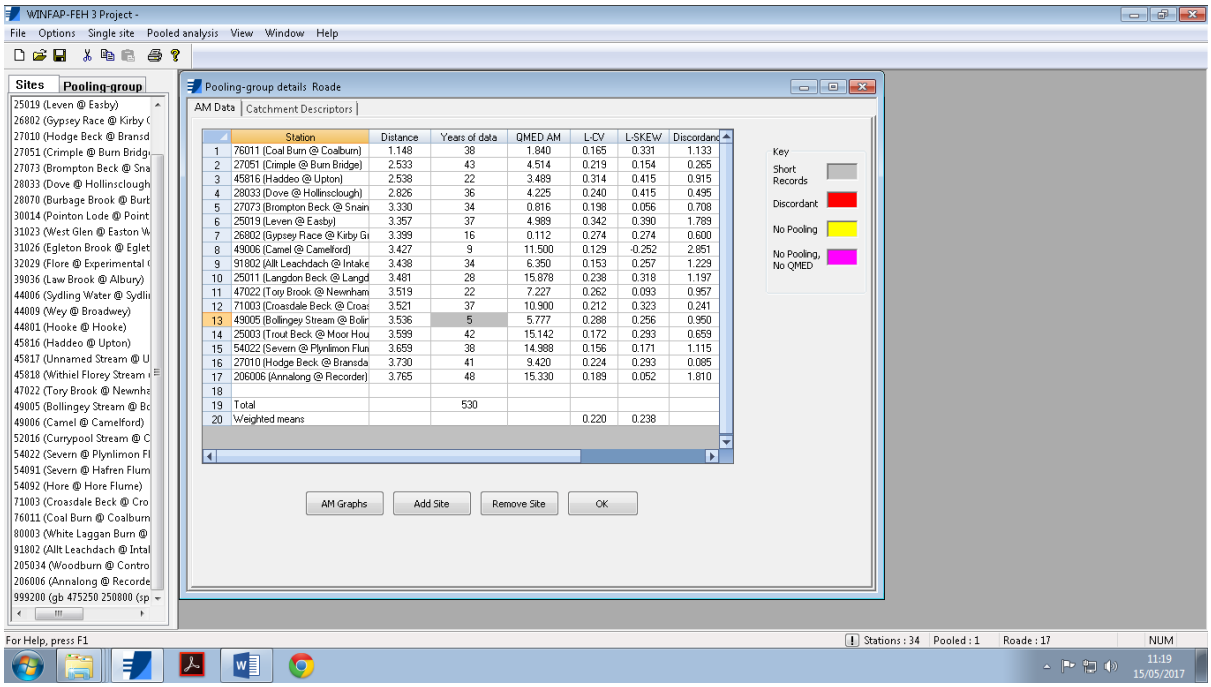
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2 27051 (Crimple @ Burn Bridge) 2.533 43 4.514 0.219 0.154 0.265
3 45816 (Haddeo @ Upton) 2.538 22 3.489 0.314 0.415 0.915
4 28033 (Dove @ Hollinsclough) 2.826 36 4.225 0.240 0.415 0.495
5 27073 (Brompton Beck @ Snain 3.330 34 0.816 0.198 0.056 0.708
6 25019 (Leven @ Easby) 3.357 37 4.989 0.342 0.390 1.789
7 26802 (Gypsey Race @ Kirby Gi 3.399 16 0.112 0.274 0.274 0.600
8 49006 (Camel @ Camelford) 3.427 9 11.500 0.129 -0.252 2.851
9 91802 (Allt Leachdach @ Intake 3.438 34 6.350 0.153 0.257 1.229
10 25011 (Langdon Beck @ Langd 3.481 28 15.878 0.238 0.318 1.197
11 47022 (Tory Brook @ Newnham 3.519 22 7.227 0.262 0.093 0.957
12 71003 (Croasdale Beck @ Croa 3.521 37 10.900 0.212 0.323 0.241
13 49005 (Bollingey Stream @ Boli 3.536 5 5.777 0.288 0.256 0.950
14 25003 (Trout Beck @ Moor Hou 3.599 42 15.142 0.172 0.293 0.659
15 54022 (Severn @ Plynlimon Flu 3.659 38 14.988 0.156 0.171 1.115
16 27010 (Hodge Beck @ Bransda 3.730 41 9.420 0.224 0.293 0.085
17 206006 (Annalong @ Recorder) 3.765 48 15.330 0.189 0.052 1.810
18
19 Total 530
20 Weighted means 0.220 0.238
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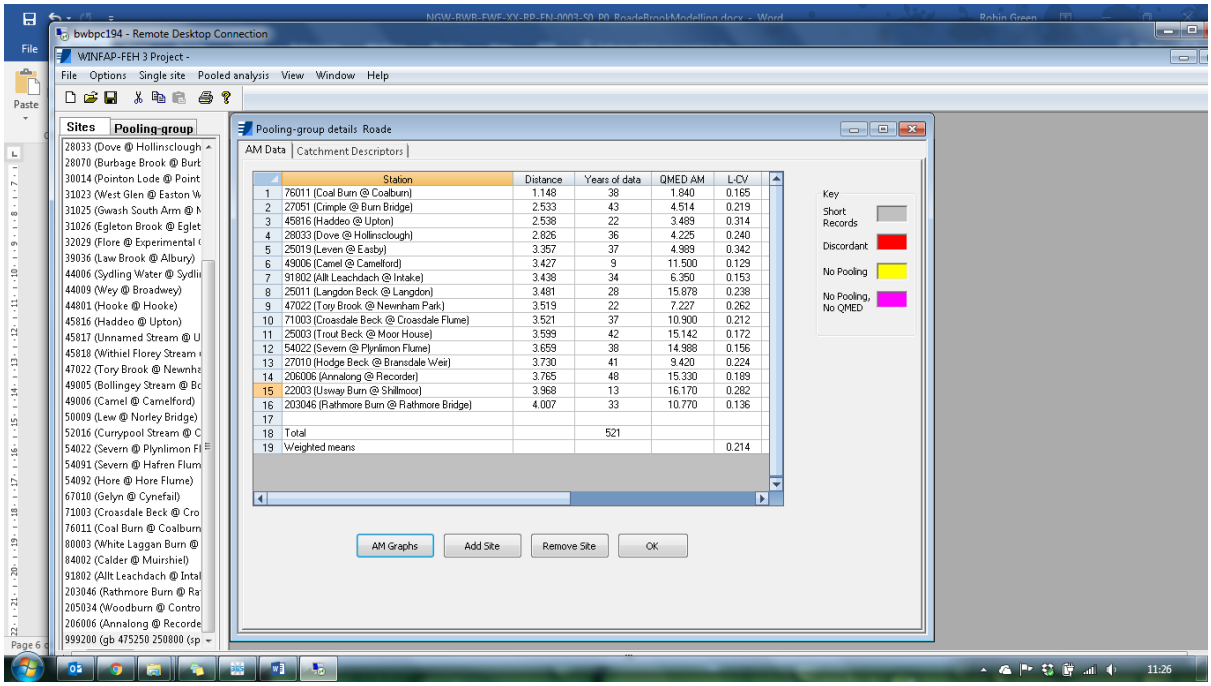
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Pooling-group details Roade
AM Data Catchment Descriptors
Station Distance Years of data QMED AM L-CV
1 76011 (Coal Burn @ Coalburn) 1.148 38 1.840 0.165
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4 28033 (Dove @ Hollinsclough) 2.826 36 4.225 0.240
5 25019 (Leven @ Easby) 3.357 37 4.989 0.342
6 49006 (Camel @ Camelford) 3.427 9 11.500 0.129
7 91802 (Allt Leachdach @ Intake) 3.438 34 6.350 0.153
8 25011 (Langdon Beck @ Langdon) 3.481 28 15.878 0.238
9 47022 (Tory Brook @ Newnham Park) 3.519 22 7.227 0.262
10 71003 (Croasdale Beck @ Croasdale Flume) 3.521 37 10.900 0.212
11 25003 (Trout Beck @ Moor House) 3.599 42 15.142 0.172
12 54022 (Severn @ Plynlimon Flume) 3.659 38 14.988 0.156
13 27010 (Hodge Beck @ Bransdale Weir) 3.730 41 9.420 0.224
14 206006 (Annalong @ Recorder) 3.765 48 15.330 0.189
15 22003 (Usway Burn @ Shillmoor) 3.968 13 16.170 0.282
16 203046 (Rathmore Burn @ Rathmore Bridge) 4.007 33 10.770 0.136
17
18 Total 521
19 Weighted means 0.214
Key
Short Records
Discordant
No Pooling
No Pooling, No QMED
AM Graphs
Add Site
Remove Site
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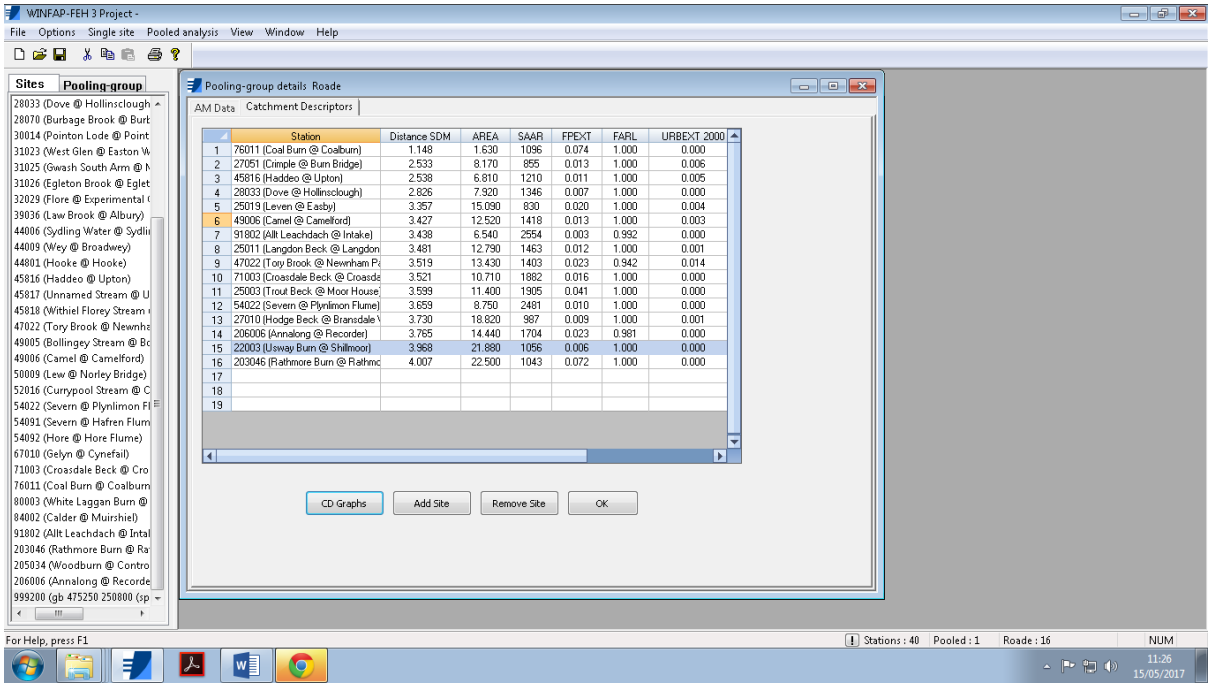
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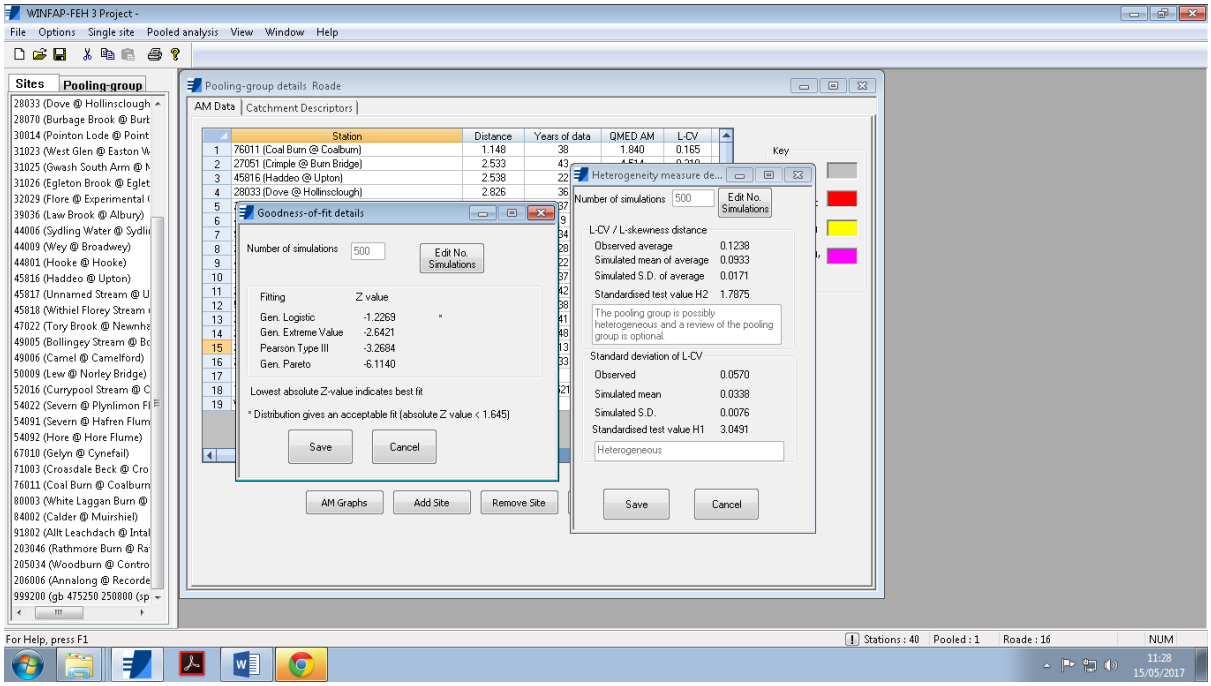
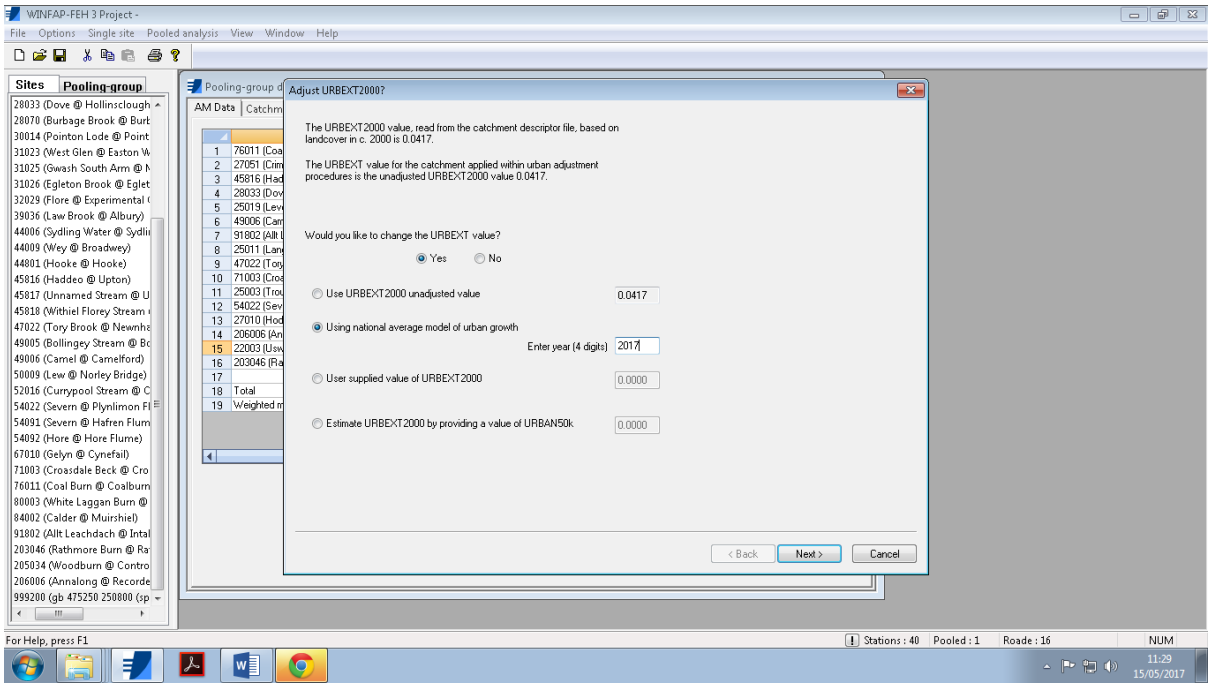
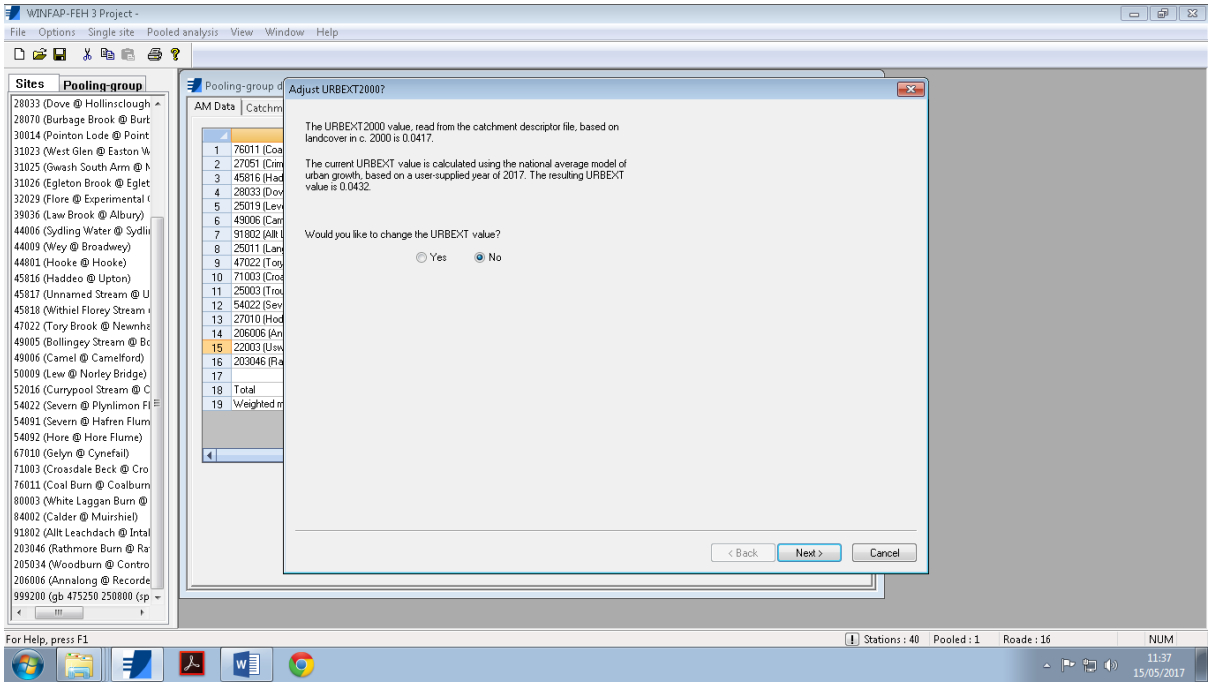
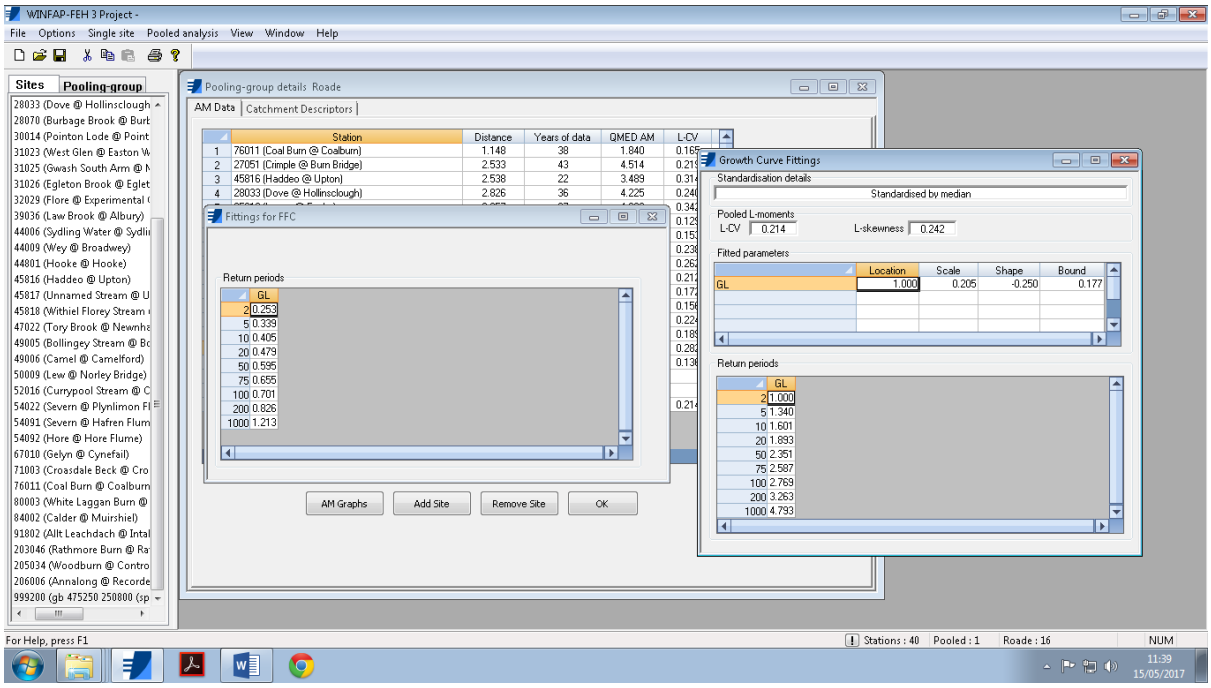
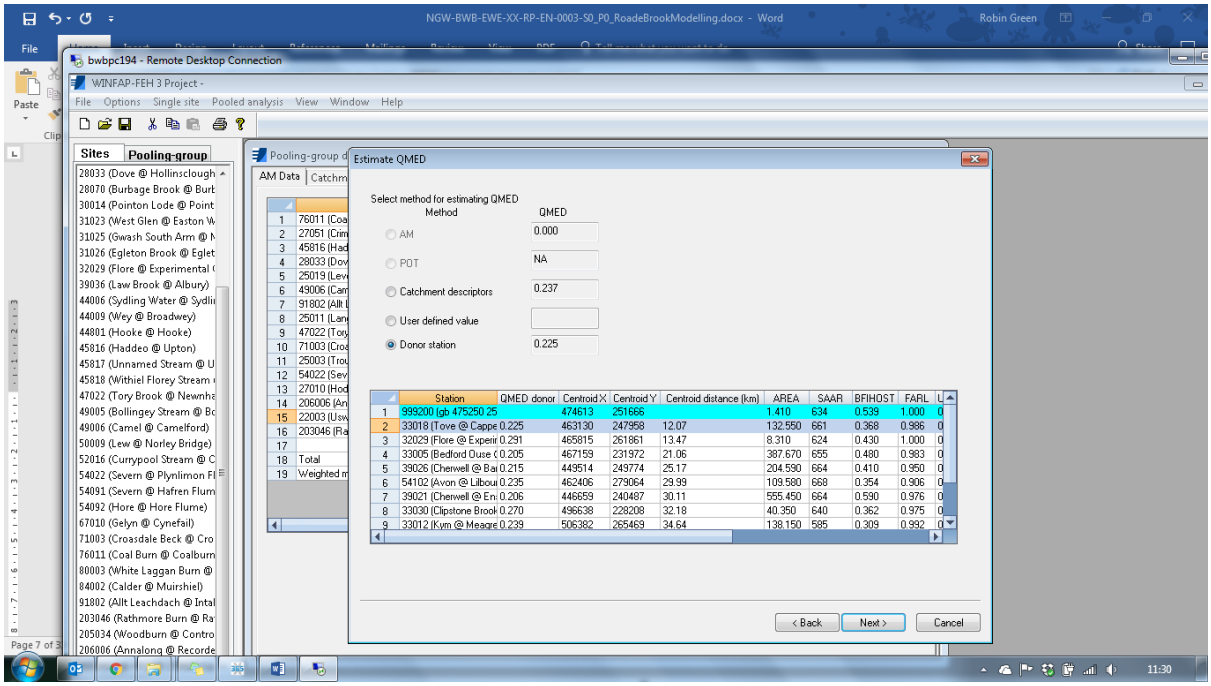
Sites Pooling-group
Pooling-group details Roade
AM Data Catchment Descriptors
Station Distance SDM AREA SAAR FPEXT FARL URBEXT 2000
1 76011 (Coal Burn @ Coalburn) 1.148 1.630 1096 0.074 1.000 0.000
2 27051 (Crimple @ Burn Bridge) 2.533 8.170 855 0.013 1.000 0.006
3 45816 (Haddeo @ Upton) 2.538 6.810 1210 0.011 1.000 0.005
4 28033 (Dove @ Hollinsclough) 2.826 7.920 1346 0.007 1.000 0.000
5 25019 (Leven @ Easby) 3.357 15.090 830 0.020 1.000 0.004
6 49006 (Camel @ Camelford) 3.427 12.520 1418 0.013 1.000 0.003
7 91802 (Allt Leachdach @ Intake) 3.438 6.540 2554 0.003 0.992 0.000
8 25011 (Langdon Beck @ Langdon 3.481 12.790 1463 0.012 1.000 0.001
9 47022 (Tory Brook @ Newnham Pa 3.519 13.430 1403 0.023 0.942 0.014
10 71003 (Croasdale Beck @ Croasds 3.521 10.710 1882 0.016 1.000 0.000
11 25003 (Trout Beck @ Moor House 3.599 11.400 1905 0.041 1.000 0.000
12 54022 (Severn @ Plynlimon Flume) 3.659 8.750 2481 0.010 1.000 0.000
13 27010 (Hodge Beck @ Bransdale V 3.730 18.820 987 0.009 1.000 0.001
14 206006 (Annalong @ Recorder) 3.765 14.440 1704 0.023 0.981 0.000
15 22003 (Usway Burn @ Shillmoor) 3.968 21.880 1056 0.006 1.000 0.000
16 203046 (Rathmore Burn @ Rathmo 4.007 22.500 1043 0.072 1.000 0.000
17
18
19
CD Graphs
Add Site
Remove Site
OK
For Help, press F1
Stations : 40
Pooled : 1
Roade : 16
NUM
11:26
15/05/2017


WINFAP-FEH 3 Project -
File Options Single site Pooled analysis View Window Help
Sites Pooling-group
Pooling-group details Roade
AM Data Catchment Descriptors
Station Distance Years of data QMED AM L-CV
1 76011 (Coal Burn @ Coalburn) 1.148 38 1.840 0.165
2 27051 (Crimple @ Burn Bridge) 2.533 43
3 45816 (Haddeo @ Upton) 2.538 22
4 28033 (Dove @ Hollinsclough) 2.826 36
Key
Goodness-of-fit details
Number of simulations 500
Edit No. Simulations
Fitting Z value
Gen. Logistic -1.2269 *
Gen. Extreme Value -2.6421
Pearson Type III -3.2684
Gen. Pareto -6.1140
Lowest absolute Z-value indicates best fit
* Distribution gives an acceptable fit (absolute Z value < 1.645)
Save Cancel
Heterogeneity measure de...
Number of simulations 500
Edit No. Simulations
L-CV / L-skewness distance
Observed average 0.1238
Simulated mean of average 0.0933
Simulated S.D. of average 0.0171
Standardised test value H2 1.7875
The pooling group is possibly heterogeneous and a review of the pooling group is optional.
Standard deviation of L-CV
Observed 0.0570
Simulated mean 0.0338
Simulated S.D. 0.0076
Standardised test value H1 3.0491
Heterogeneous
Save Cancel
AM Graphs Add Site Remove Site
For Help, press F1
Stations : 40 Pooled : 1 Roade : 16 NUM
11:28 15/05/2017


WINFAP-FEH 3 Project -
File Options Single site Pooled analysis View Window Help
Sites Pooling-group
Adjust URBEXT2000?
The URBEXT2000 value, read from the catchment descriptor file, based on landcover in c. 2000 is 0.0417.
The URBEXT value for the catchment applied within urban adjustment procedures is the unadjusted URBEXT2000 value 0.0417.
Would you like to change the URBEXT value?
Yes No
Use URBEXT2000 unadjusted value 0.0417
Using national average model of urban growth
Enter year (4 digits) 2017
User supplied value of URBEXT2000 0.0000
Estimate URBEXT2000 by providing a value of URBAN50k 0.0000
< Back Next > Cancel
For Help, press F1
Stations : 40 Pooled : 1 Roade : 16 NUM
11:29 15/05/2017


WINFAP-FEH 3 Project -
File Options Single site Pooled analysis View Window Help
Sites Pooling-group
Adjust URBEXT2000?
The URBEXT2000 value, read from the catchment descriptor file, based on landcover in c. 2000 is 0.0417.
The current URBEXT value is calculated using the national average model of urban growth, based on a user-supplied year of 2017. The resulting URBEXT value is 0.0432.
Would you like to change the URBEXT value?
Yes
No
< Back
Next >
Cancel
For Help, press F1
Stations : 40
Pooled : 1
Roade : 16
NUM
11:37
15/05/2017


WINFAP-FEH 3 Project -
File Options Single site Pooled analysis View Window Help
Sites Pooling-group
Pooling-group details Roade
AM Data
Catchment Descriptors
Station
Distance
Years of data
QMED AM
L-CV
76011 (Coal Burn @ Coalburn) 1.148 38 1.840 0.165
27051 (Crimple @ Burn Bridge) 2.533 43 4.514 0.211
45816 (Haddeo @ Upton) 2.538 22 3.489 0.314
28033 (Dove @ Hollinsclough) 2.826 36 4.225 0.240
Fittings for FFC
Return periods
GL
2 0.253
5 0.339
10 0.405
20 0.479
50 0.595
75 0.655
100 0.701
200 0.826
1000 1.213
AM Graphs
Add Site
Remove Site
OK
Growth Curve Fittings
Standardisation details
Standardised by median
Pooled L-moments
L-CV 0.214
L-skewness 0.242
Fitted parameters
Location
Scale
Shape
Bound
GL 1.000 0.205 -0.250 0.177
Return periods
GL
2 1.000
5 1.340
10 1.601
20 1.893
50 2.351
75 2.597
100 2.769
200 3.263
1000 4.793
For Help, press F1
Stations : 40
Pooled : 1
Roade : 16
NUM
11:39
15/05/2017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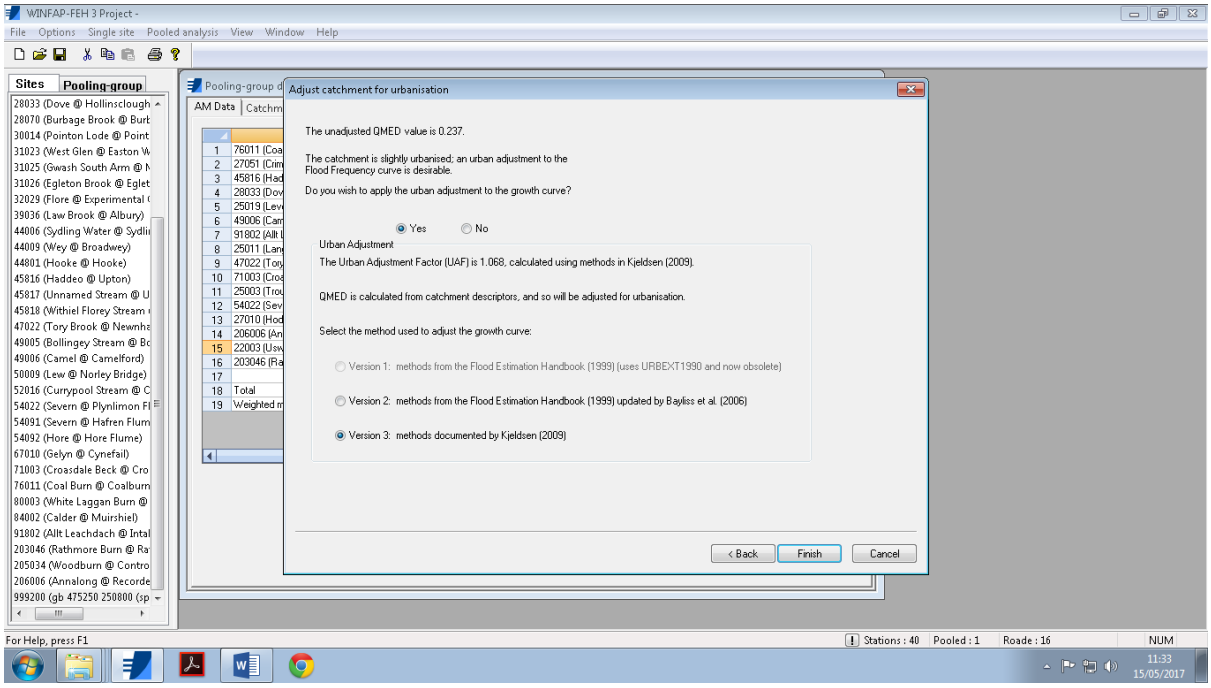
Robin Green
bwbpc194 - Remote Desktop Connection
WINFAP-FEH 3 Project -
File Options Single site Pooled analysis View Window Help
Sites
Pooling-group
Estimate QMED
Select method for estimating QMED
Method
QMED
AM
0.000
POT
NA
Catchment descriptors
0.237
User defined value
Donor station
0.225
Station
QMED donor
Centroid X
Centroid Y
Centroid distance (km)
AREA
SAAR
BFIHOST
FARL
999200 (gb 475250 25
474613
251666
1.410
634
0.539
1.000
33018 (Tove @ Cappe 0.225
463130
247958
12.07
132.550
661
0.368
0.986
32029 (Flore @ Experir 0.291
465815
261861
13.47
8.310
624
0.430
1.000
33005 (Bedford Ouse (0.205
467159
231972
21.06
387.670
655
0.480
0.983
39026 (Cherwell @ Bai 0.215
449514
249774
25.17
204.590
664
0.410
0.950
54102 (Avon @ Lilbour 0.235
462406
279064
29.99
109.580
668
0.354
0.906
39021 (Cherwell @ En 0.206
446659
240487
30.11
555.450
664
0.590
0.976
33030 (Clipstone Brook 0.270
496638
228208
32.18
40.350
640
0.362
0.975
33012 (Kym @ Meagre 0.239
506382
265469
34.64
138.150
585
0.309
0.992
< Back
Next >
Cancel
11:30


WINFAP-FEH 3 Project -
File Options Single site Pooled analysis View Window Help
Sites
Pooling-group
Adjust catchment for urbanisation
The unadjusted QMED value is 0.237.
The catchment is slightly urbanised; an urban adjustment to the Flood Frequency curve is desirable.
Do you wish to apply the urban adjustment to the growth curve?
Yes
No
Urban Adjustment
The Urban Adjustment Factor (UAF) is 1.068, calculated using methods in Kjeldsen (2009).
QMED is calculated from catchment descriptors, and so will be adjusted for urbanisation.
Select the method used to adjust the growth curve:
Version 1: methods from the Flood Estimation Handbook (1999) (uses URBEXT1990 and now obsolete)
Version 2: methods from the Flood Estimation Handbook (1999) updated by Bayliss et al. (2006)
Version 3: methods documented by Kjeldsen (2009)
< Back
Finish
Cancel
For Help, press F1
Stations : 40
Pooled : 1
Roade : 16
NUM
11:33
15/05/2017

ANNEX 2

Topographical Survey

N

Legend:

Fence types:

Rev	Date	Description	Drawn	Q. Ref
9	21.11.17	Additional areas added	BG	GH1964
8	08.11.17	Additional roads added	BG	GH1863
7	31.10.17	Knock Lane Added	BG	GH1829
6	01.09.17	Roade Rail Cutting added	GJR	E1193
5	12.06.17	Sections & OS Added	BG	GH0953
4	*31.05.17*	*Areas complete + Rail Ivls*	*BG*	*GH0953*
3	*25.01.17*	*Additional Survey*	*BG*	*GH0261*
2	*09.05.16*	*LiDar data added*	*CS*	*E0919*
1	*08.09.14*	*Sections*	*FB*	*E0919*

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Newcastle: 24 Riverside Studios, Amethyst Road, Newcastle Bus. Park, Newcastle-U-Tyne NE4 7YL, t. (01912) 736391

Poland: ul. Panewnicka 91, 40-761 Katowice, Poland, t. 0048 32 202 2292, www.greenhatch.pl

CLIENT
Roxhill Management Ltd

PROJECT
Northampton Gateway Roade Bypass

TITLE
Topographical Survey

SCALE	DATE
A0@ 1: 2500	Aug 14
DRAWN: FB	QUALITY REF: E0916

Level datum	See note
Grid orientation	See note
Job number	19595
Drawing No.	19595_T
Rev.	9

Comments
This plan should only be used for its original purpose. Greenhatch Group accepts no responsibility for this plan if supplied to any party other than the original client.

All dimensions should be checked on site prior to design and construction.

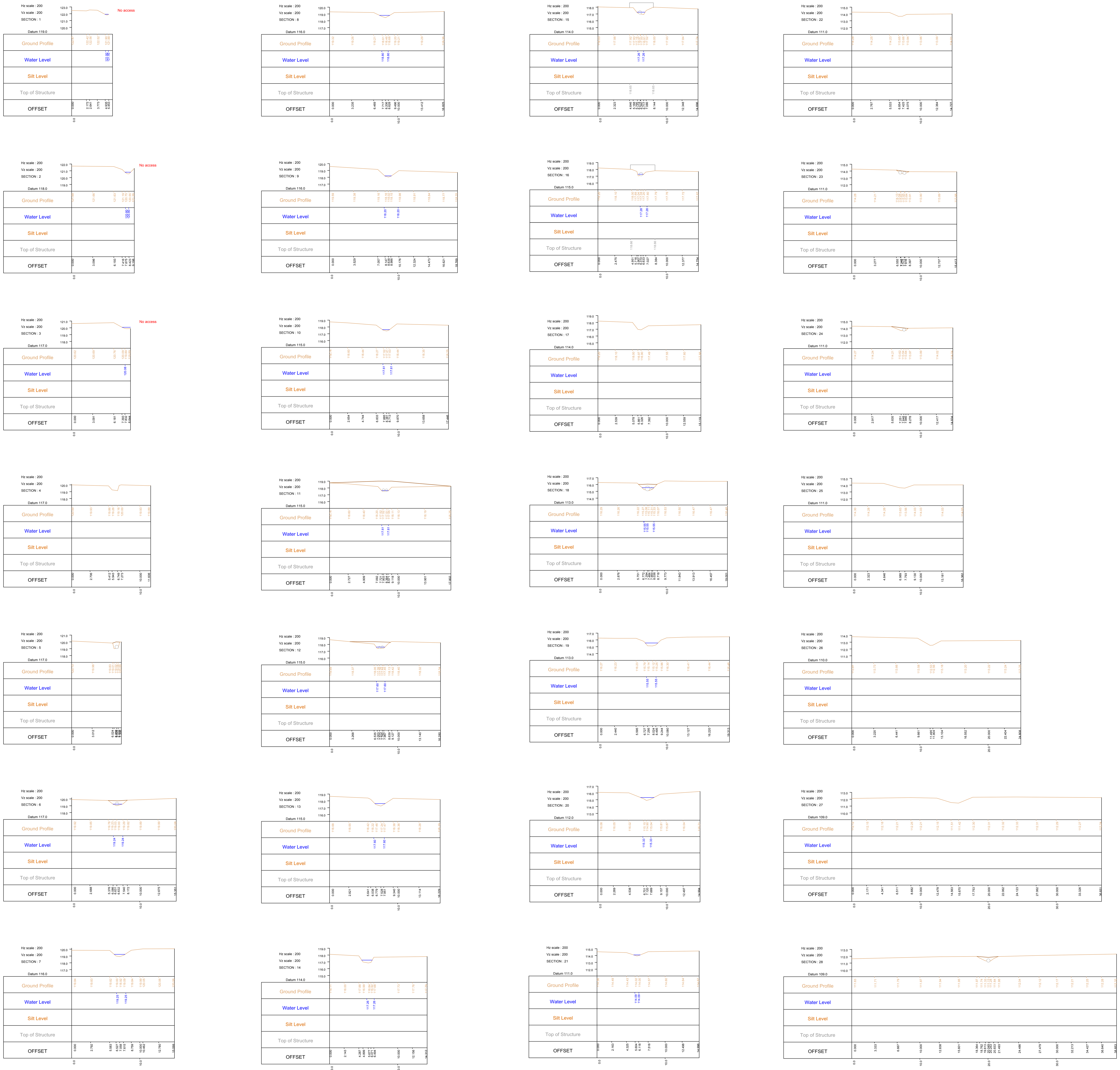
Drainage information (where applicable) has been visually inspected from the surface and therefore should be treated as approximate only.

Notes:

ANNEX 3

Watercourse Survey

ROADE BYPASS SECTIONS 1 - 28



OS Note:

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OS Buildings | *Surveyed Buildings*

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No scale factor has been applied to the survey therefore the coordinates shown are arbitrary & not true O.S. Coordinates which have a scale factor applied.

Please refer to Survey Station Table to enable establishment of the on-site grid and datum.

Legend:

Rev	Date	Description	Drawn	Q. Ref

greenhatch group

Topographical Surveys | Site Engineering | Utility / CCTV Surveys | Measured Building Surveys | 3D Laser Scanning | Revit & BIM Models

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Poland: ul. Panewnicka 91, 40-761 Katowice, Poland. t. 0048 32 202 2292, www.greenhatch.pl

CLIENT: **Roxhill Management Ltd**

PROJECT: **Northampton M1 J15**

TITLE: **Section Survey**

SCALE	DATE
A0@ 1: 200	20.01.17
DRAWN: BG	QUALITY REF:

Level datum	See note
Grid orientation	See note
Job number	19595
Drawing No.	Main Site Sections
Rev.	0

Comments

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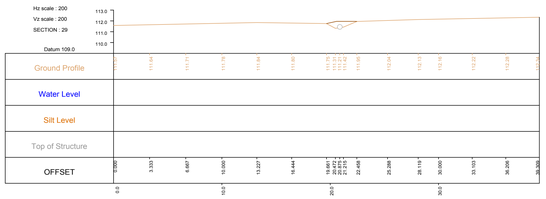
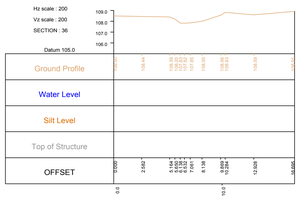
All dimensions should be checked on site prior to design and construction.

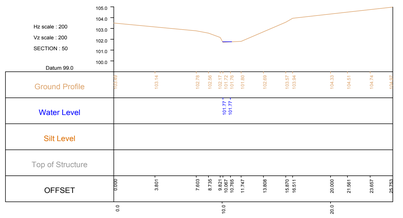
Drainage information (where applicable) has been visually inspected from the surface and therefore should be treated as approximate only.

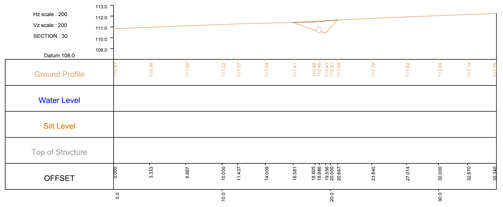
Notes:

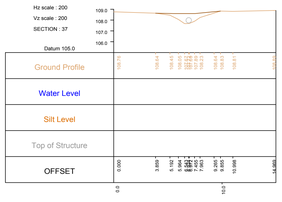
ROADE BYPASS SECTIONS 29 - 56

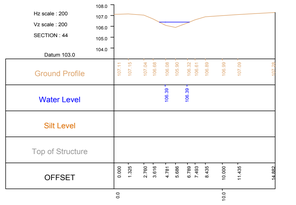


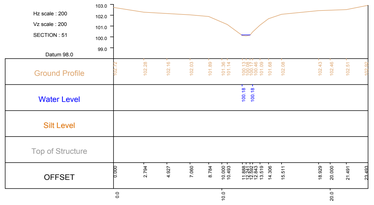


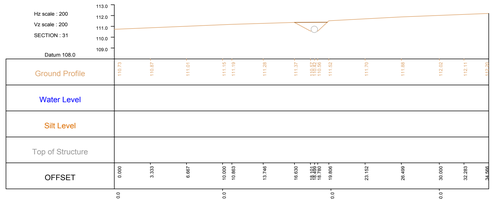


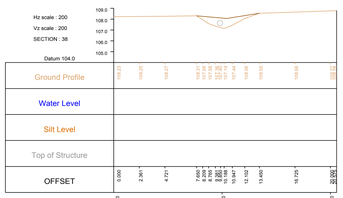


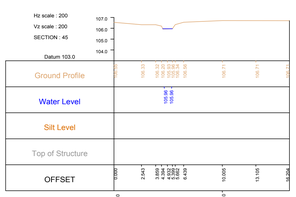


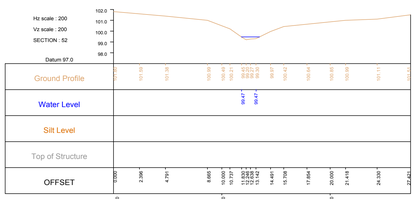


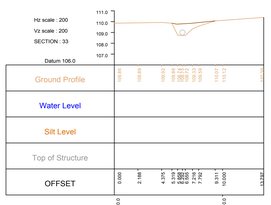


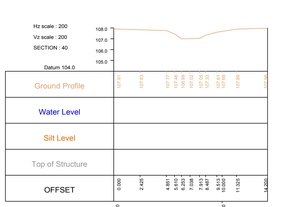


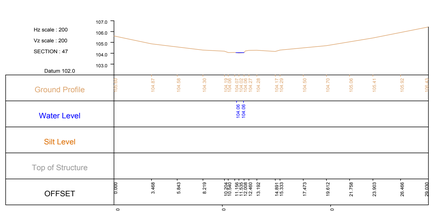


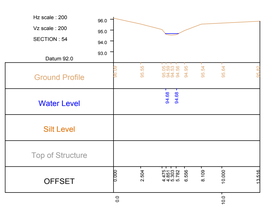


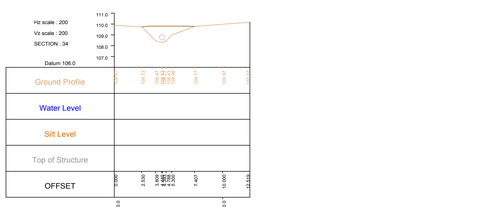


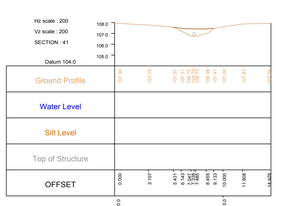


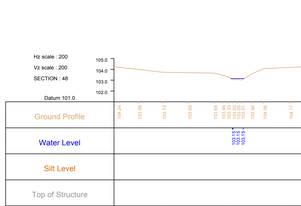


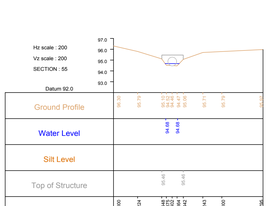


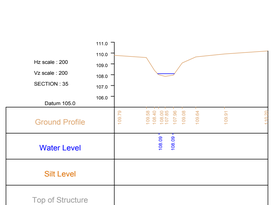


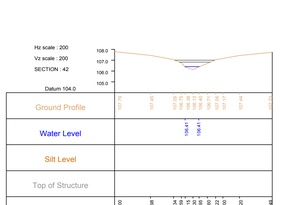


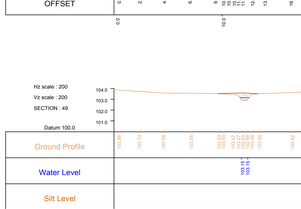


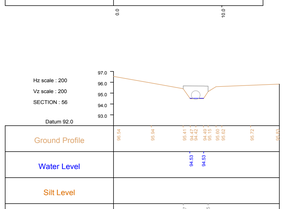












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Legend:

Buildings, Wall, Kerb line, Line marking, Drop kerb, Centre line, Overhead Cable, Concrete edge, Concrete step, Tarmac edge, Grass edge, Canopy/Overhang, Verge

Station and Name, Station Level, Ridge Level, Eaves Level, Flat Roof Level, Gate

Fence types: SW, Intervision, Iron Railings, WIM, Wire Mesh, PVR, Post & Rail, PVW, Post & Wire, CHL, Chain Link, WDP, Wooden Panels, CNP, Concrete Panels, SBP, Steel Palisade

IC	Inspection chamber	Bls	Bollard
Pinv	Pipe invert	Il	Illuminated bollard
Gy	Gully	Bin	Rubbish bin
Bg	Back gully	Vp	Vent pipe
Dp	Down pipe	Gri	Ground light
Pipe	Pipe above ground	Llox	Letter box
MH	Manhole	Ldr	Ladder
WL	Water level	Sty	Stile
Fl	Flood light	FL	Internal floor level
Lp	Lamp post	THL	Threshold level
Tp	Telegraph post	Sp	Sign post
Ep	Electricity post	Tri	Trialhole
Ti	Traffic light	BH	Borehole
Bus	Bus stop	ELC	Electric
Sv	Stop valve	BT	British Telecom
Str	Stop tap	CTele	Control box
Er	Earth rod	TT	Tactile
Wm	Water meter	BP	Brick paved
Gas	Gas valve	CPS	Concrete paving slab
Av	Air valve	CVR	Cover
ICU	Unidentified inspection	IC	Inspection chamber
Ws	Wash out	Rwall	Retaining wall
Re	Rodding eye	UTL	Unable to lift
BB	Bellsha beacon	TCL	Tree canopy level
CTV	Cable tv	G	Girth
Mkr	Marker post	MS	Multi girth
Gmkr	Gas marker post	Stmp	Tree Stump
So	Soffit	CL	Cover level
		IL	Invert level

Rev	Date	Description	Drawn	Q. Rev

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CLIENT
Roxhill Management Ltd

PROJECT
Northampton M1 J15

TITLE
Section Survey

SCALE	DATE
A0@ 1: 200	20.01.17
DRAWN	QUALITY REF
BG	

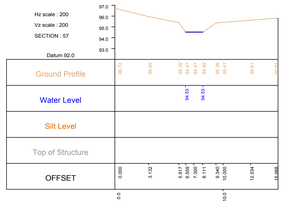
Level datum	See note
Grid orientation	See note
Job number	19595

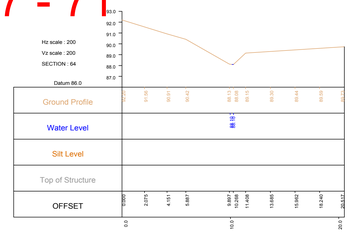
Drawing No. **Main Site Sections** Rev. **0**

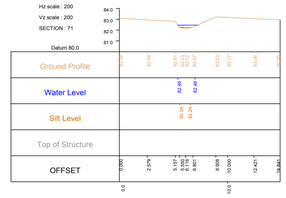
Comments
This plan should only be used for its original purpose. Greenhatch Group accepts no responsibility for this plan if supplied to any party other than the original client.
All dimensions should be checked on site prior to design and construction.
Drainage information (where applicable) has been visually inspected from the surface and therefore should be treated as approximate only.

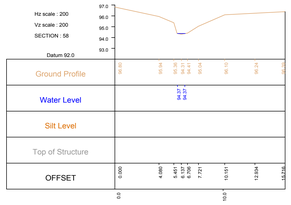
Notes:

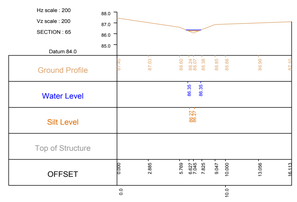
ROADE BYPASS SECTIONS 57 - 71

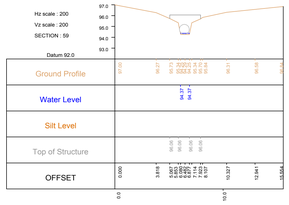


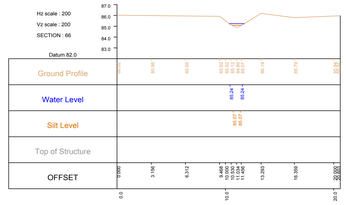


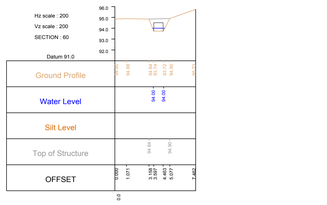


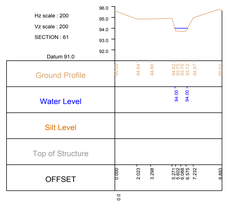


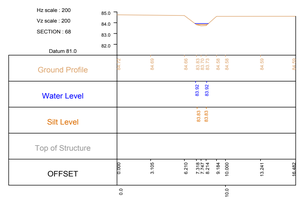


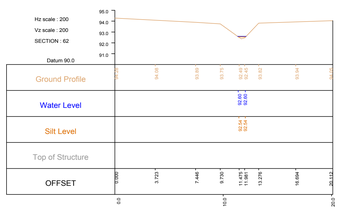


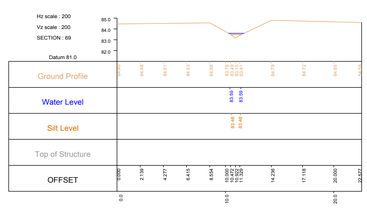


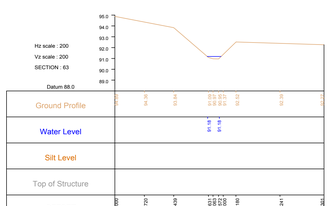


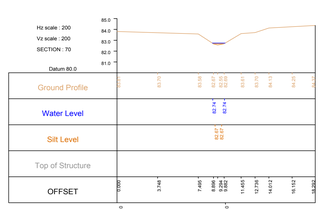












OS Note:

Some services may have been omitted due to parked vehicles. The Ordnance Survey tile is to be used as a guide only.

OS Buildings *Surveyed Buildings*

This survey has been orientated to the Ordnance Survey (O.S) National Grid (OSGB36) via Global Navigationat Satellite Systems (GNSS) and the O.S. Active Network (OS Net).

A true OSGB36 coordinate has been established near to the site centre via a transformation using the OSTN02 & OSGM02 transformation models.
The survey has been correlated to this point and a further one or more OSGB36 points established to create a true O.S. bearing for angle orientation.

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Please refer to Survey Station Table to enable establishment of the on-site grid and datum.

Legend:

Buildings
Wall
Kerb line
Line marking
Drop kerb
Centre line
Overhead Cable
Concrete edge
Tarmac edge
Glass edge
Canopy/Overhang
Verge
Station and Name
100.000 Station Level
Tree / Bush / Sapling
Area of Undergrowth
Woodland
Ridge Level
Eaves Level
Flat Roof Level
Gate
Fence types:
Interwoven
Iron Railings
Wire Mesh
Post & Rail
Post & Wire
Chain Link
Wooden Panels
Concrete Panels
Steel Palisade

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Pinv	Pipe invert	Bl	Illuminated bollard
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CLIENT
Roxhill Management Ltd

PROJECT
Northampton M1 J15

TITLE
Section Survey

SCALE	DATE
A0@ 1: 200	20.01.17
DRAWN	QUALITY REF
BG	

Level datum	See note
Grid orientation	See note
Job number	19595
Drawing No.	Rev.
Main Site Sections	0

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BWB