Lincoln Eastern Bypass

Environmental Statement

Volume 2 – Supporting Information

December 2012

Produced by

Lincolnshire
COUNTY COUNCIL
HIGHWAYS ALLIANCE

Document Control Sheet

Project Title	Lincoln Eastern Bypass
Report Title	Environmental Statement
	Volume 2 - Supporting Information
Revision	1
	Document Reference Number: 1030171/R/001
Status	Final
Control Date	December 2012

Record of Issue

Issue	Status	Author	Date	Check	Date	Authorised	Date
1	Final	M Duffort	30/11/2012	S Newman	30/11/2012	F Symes	04/12/2012

Distribution

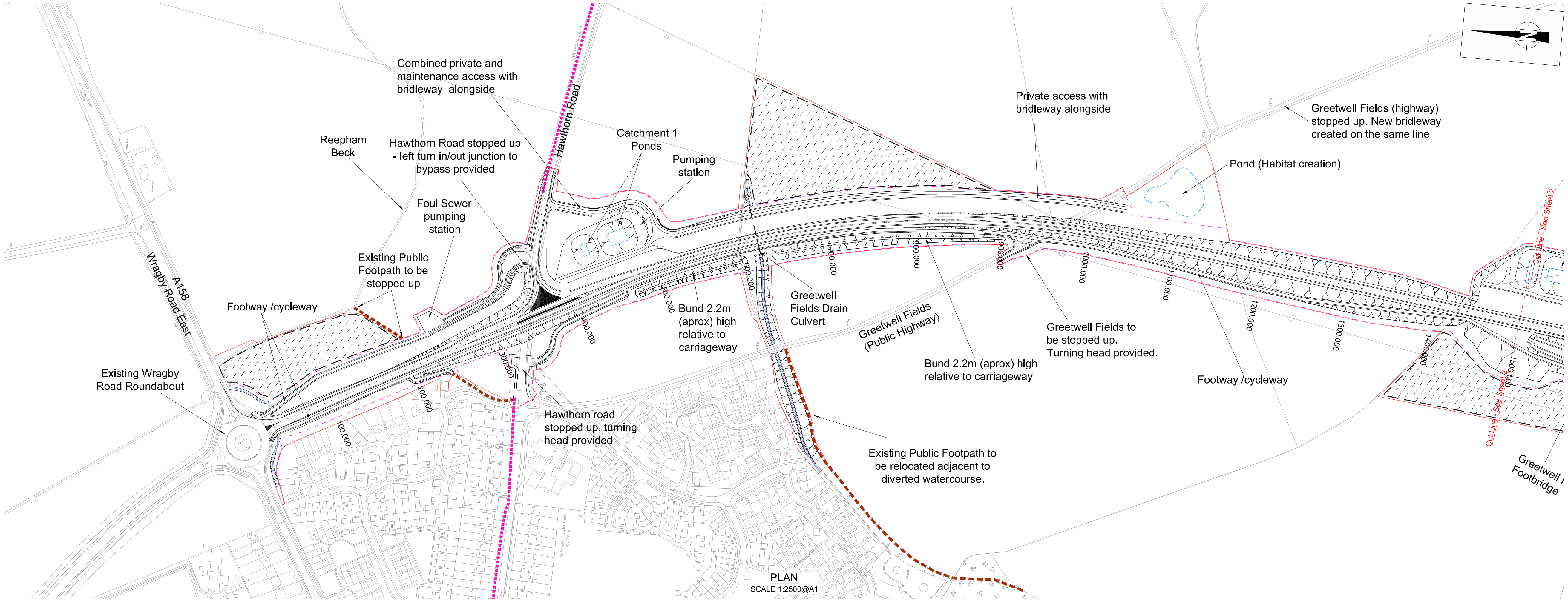
Organisation	Contact	Copies
John Pollard	Mouchel	1e

Contents

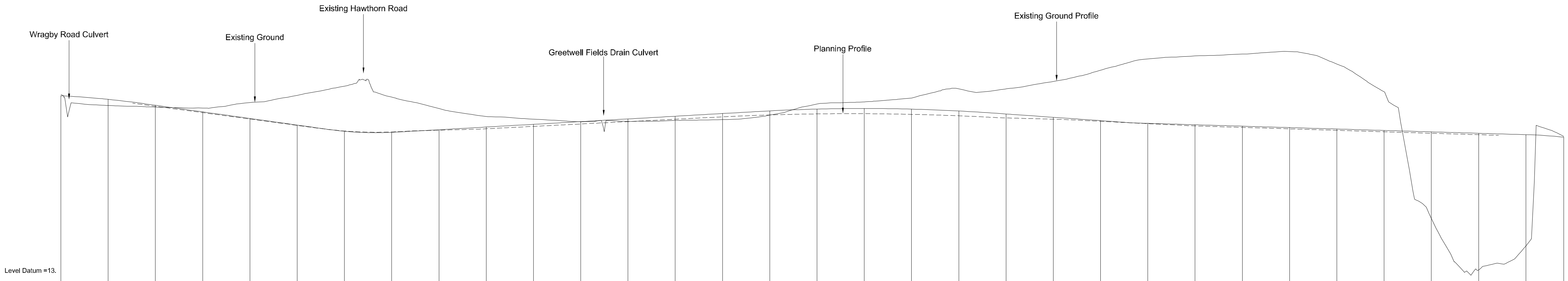
There is no supporting information for chapters 2, 3, 4, 5, 6, 8, 15,16,17.

1 Introduction

1.1 1030171-100-023C Plan and Profile Sheet 1



PLAN
SCALE 1:2500@A1



Level Datum =13.

Chainage	0.	50.	100.	150.	200.	250.	300.	350.	400.	450.	500.
PROPOSED LEVELS	32.855	32.472	31.847	31.150	30.454	29.757	29.103	28.983	29.265	29.550	29.834
EXISTING GROUND LEVELS	32.954	31.824	31.660	31.550	32.133	32.895	33.865	32.711	31.499	30.666	30.382
PLANNING SCHEME LEVELS	33.171	32.500	31.828	31.157	30.485	29.814	29.224	29.126	29.451	29.832	30.084
Gradient		-0.766	-1.251	-1.393	-1.393	-1.393	-1.308	-0.240	0.563	0.570	0.570

Chainage	550.	600.	650.	700.	750.	800.	850.	900.	950.	1000.	1050.
PROPOSED LEVELS	30.119	30.404	30.689	30.974	31.255	31.444	31.506	31.439	31.243	30.925	30.575
EXISTING GROUND LEVELS	30.107	30.149	30.248	30.333	30.808	31.969	32.203	32.604	33.570	33.583	34.363
PLANNING SCHEME LEVELS	30.336	30.588	30.840	31.091	31.291	31.401	31.422	31.354	31.197	30.938	30.535
Gradient	0.570	0.570	0.570	0.570	0.562	0.379	0.122	-0.134	-0.390	-0.636	-0.700

Chainage	1100.	1150.	1200.	1250.	1300.	1350.	1400.	1450.	1500.	1550.	1590.
PROPOSED LEVELS	30.225	29.940	29.790	29.640	29.490	29.340	29.190	29.040	28.890	28.740	28.472
EXISTING GROUND LEVELS	35.547	36.730	37.058	37.250	37.520	36.207	33.268	19.904	14.471	16.989	28.567
PLANNING SCHEME LEVELS	30.247	29.997	29.755	29.600	29.446	29.291	29.137	28.982	28.828	28.673	28.543
Gradient	-0.700	-0.570	-0.300	-0.300	-0.300	-0.300	-0.300	-0.300	-0.300	-0.300	-0.671

Horizontal: straight L=365.988m | transition L=69.979m | R=1050.m L=569.966m | transition L=69.979m | straight L=514.117m

Vertical: L=87.687m R=-10000.m | L=194.639m G=-1.393 | R=3700 L=72.616m | G=0.570 L=382.842m | L=247.591m R=-19500.m | L=141.022m G=-0.700 | R=3700 L=14.8 | L=413.408m G=-0.300 | L=35.4 R=4225

LONGITUDINAL SECTION
HORIZONTAL SCALE 1:2500@A1, VERTICAL SCALE 1:250@A1

X-Refs & Blocks used in this Drawing

NOTES:

Key

- Existing Public Footpath
- Existing Cycleway
- Indicative location of site compound / construction area
- Indicative location of topsoil storage area
- Proposed Planning Boundary
- Proposed Highway Boundary

Revision:	Description:	Drawn By:	CAD By:	Approved By:	Approval Date
D	Hawthorn Rd Junction layout altered	OM	OM	MB	05/12/2012
C	Minor verge alterations	OM	OM	MB	02/11/2012
B	Boundary line style ammended	OM	OM	MB	20/09/2012
A	First issue	OM	OM	MB	07/09/2012

Amendment Details

Drawing 1st Approval
1st Approval by: M.Bradshaw Date: 07/09/2012

Drawn/Designed by: O.Makarov
CAD Drawing Creation
Created By: O.Makarov Date: 07/09/2012

Scale@A1: 1:2500 for Plan; 1:250 for Profile

Lincolnshire COUNTY COUNCIL
Highways Alliance
TECHNICAL SERVICES PARTNERSHIP
WITHAM PARK HOUSE,
WITHAM PARK,
WATERSIDE SOUTH
LINCOLN LN5 7JN
Customer Service Centre : (01522) 782070

mouchel

Certificate No. FS20705

B/1030171/100/023
Paper Size Drawing Number
Rev. D
Revision

Project: Lincoln Eastern Bypass

Description:

MAIN CARRIAGEWAY
Plan & Profile (Sheet 1 of 5)

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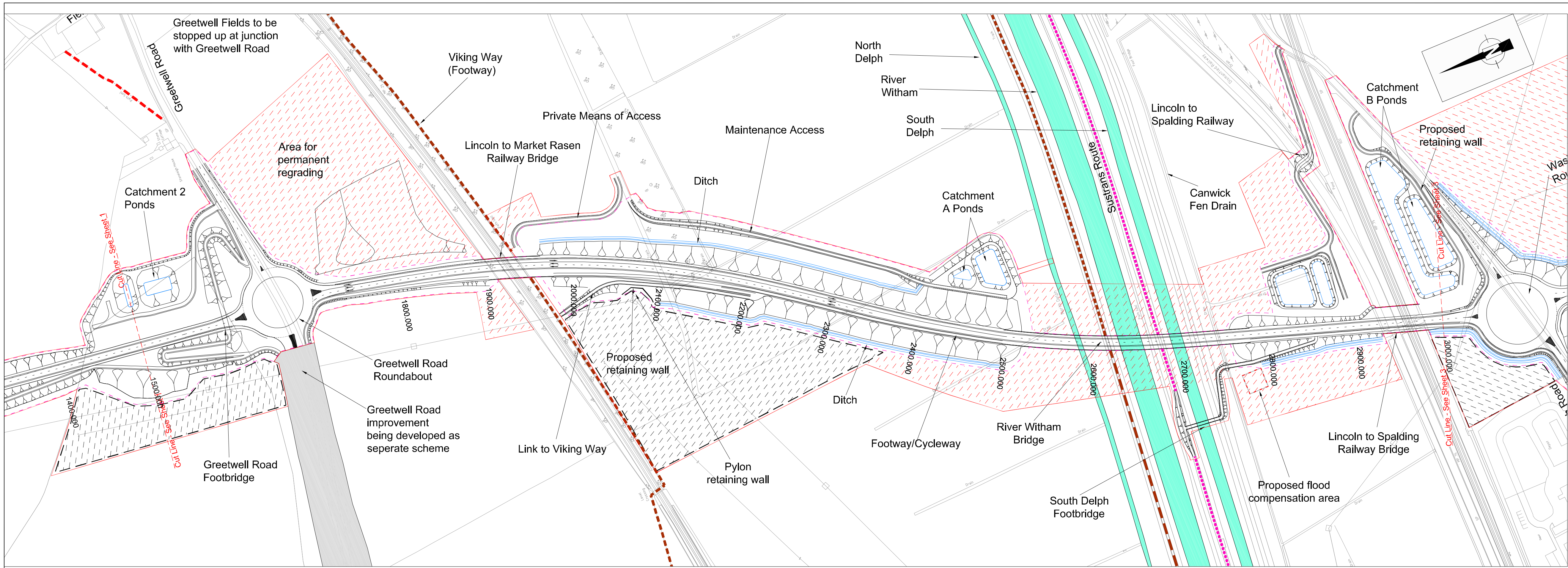
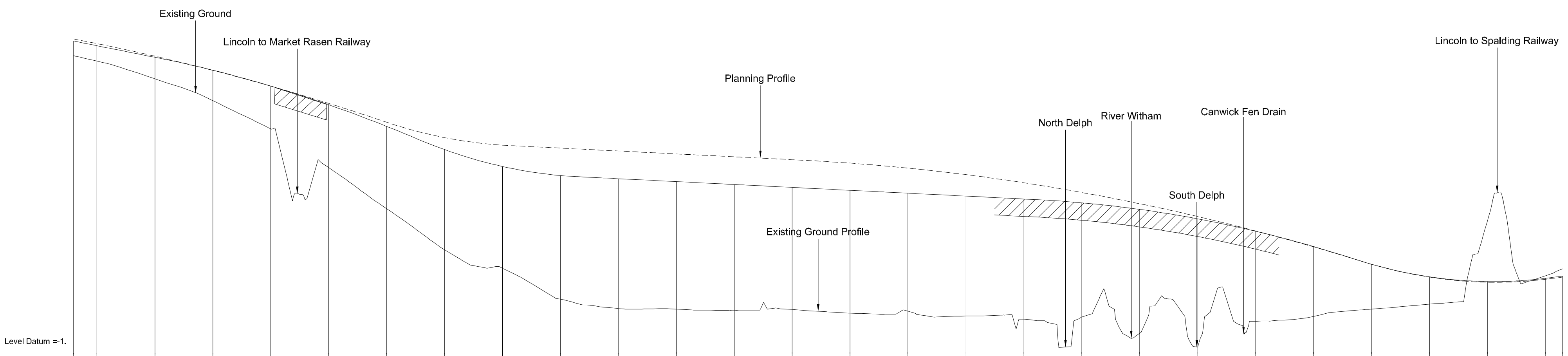
1.2 1030171-100-023C Plan and Profile Sheet 2

X-Refs & Blocks used in this Drawing



PLAN
SCALE 1:2500@A1



		1750.	1800.	1850.	1900.	1950.	2000.	2050.	2100.	2150.	2200.	2250.	2300.	2350.	2400.	2450.	2500.	2550.	2600.	2650.	2700.	2750.	2800.	2850.	2900.	2950.	3000.	3015.
PROPOSED LEVELS	26.286	25.884	24.884	23.770	22.407	20.794	18.931	16.926	15.472	14.693	14.416	14.166	13.916	13.666	13.416	13.166	12.916	12.666	12.342	11.774	10.956	-9.888	-8.570	-7.042	-5.958	-5.551	-5.819	6.028
EXISTING GROUND LEVELS	25.027	24.558	23.024	21.146	18.716	15.377	11.832	-8.301	-6.697	-4.029	-3.221	-3.168	-3.049	-3.138	-2.827	-2.993	-2.575	-2.293	-2.499	-1.099	-0.064	-2.120	-2.539	-3.178	-3.603	10.751	-6.042	6.638
PLANNING SCHEME LEVELS	26.464	26.063	24.979	23.758	22.401	20.909	19.283	17.958	17.308	17.056	16.806	16.556	16.306	16.056	15.759	15.330	14.765	14.066	13.231	12.261	11.155 11.155	-9.915	-8.540	-7.039	-5.928	-5.492	-5.732	5.939
Gradient		-2.	-2.	-2.227	-2.726	-3.226	-3.726	-4.011	-2.908	-1.557	-0.554	-0.500	-0.500	-0.500	-0.500	-0.500	-0.500	-0.500	-0.649	-1.136	-1.636	-2.136	-2.636	-3.056	-2.167	-0.815	0.536	1.397

Horizontal: straight L; transition L=120.922m; R=1020.m L=306.412m; transition L=120.922m; transition L=120.922m; R=−1020.m L=211.487m; transition L=120.922m; staright L=278.893m

Vertical: L=72.498m G=-2.00; L=223.519m R=-10000.m; R=3700.m L=138.202m; L=397.296m G=-0.500; L=273.912m R=-10000.m; R=3700.m L=175.346m

Chainage

LONGITUDINAL SECTION
HORIZONTAL SCALE 1:2500@A1, VERTICAL SCALE 1:250@A1

NOTES:

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- Existing Cycleway
- Indicative location of site compound / construction area
- Indicative location of topsoil storage area
- Proposed Planning Boundary
- Proposed Highway Boundary

Revision:	Description:	Drawn By:	CAD By:	Approved By:	Approval Date
C	Catchment Ponds A ammnded	OM	OM	MB	02/11/2012
B	Boundary line style ammended	OM	OM	MB	20/09/2012
A	First issue	OM	OM	MB	07/09/2012

Amendment Details

Drawing 1st Approval
1st Approval by: M.Bradshaw Date: 07/09/2012

Drawn/Designed by: O.Makarov

CAD Drawing Creation
Created By: O.Makarov Date: 07/09/2012

Scale@A1: 1:2500 for Plan; 1:250 for Profile

Lincolnshire COUNTY COUNCIL
Highways Alliance
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WATERSIDE SOUTH
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Customer Service Centre : (01522) 782070

mouchel

Certificate No. FS20705

B/1030171/100/024
Paper Size Drawing Number

Rev. C
Revision

Project: Lincoln Eastern Bypass

Description:

MAIN CARRIAGEWAY
Plan & Profile (Sheet 2 of 5)

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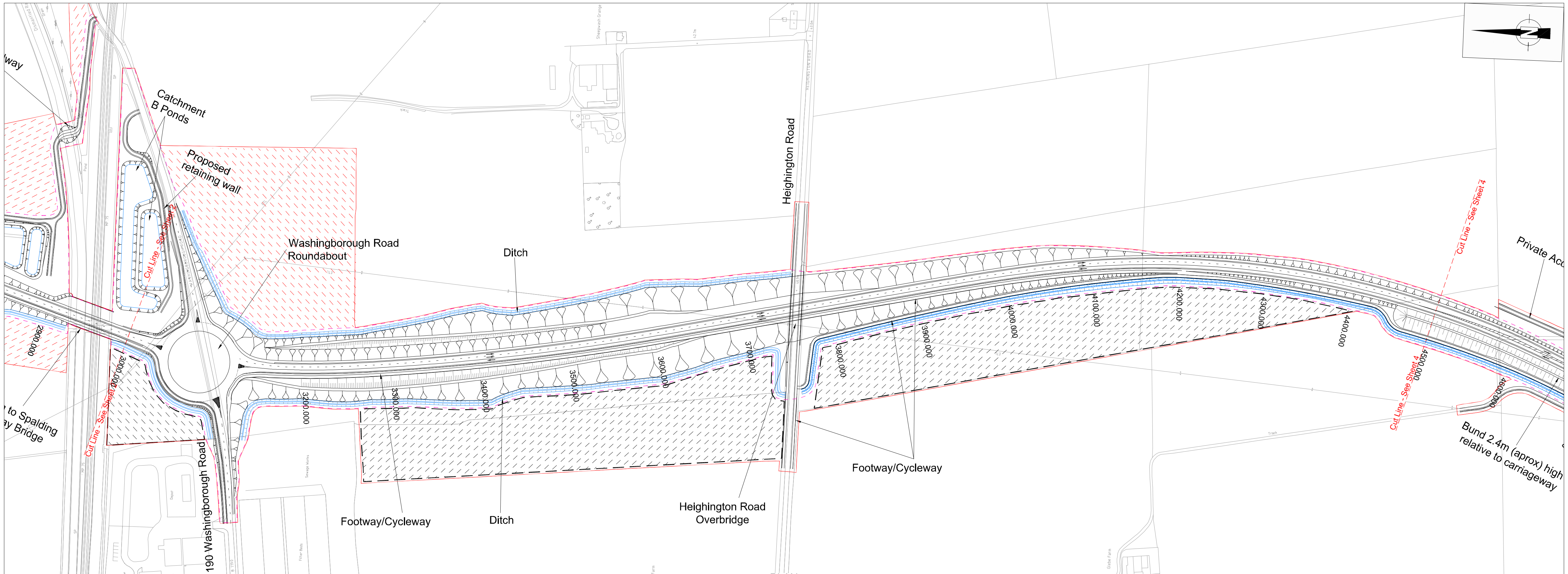
1.3 1030171-100-023C Plan and Profile Sheet 3



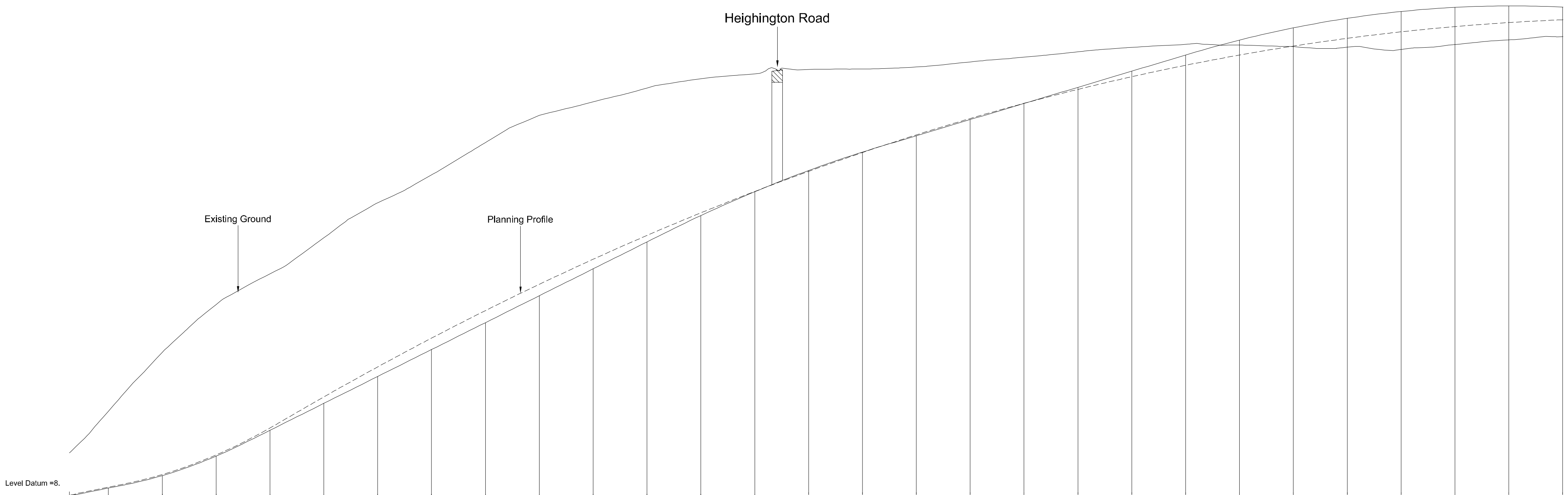
PLAN
SCALE 1:2500@A1

NOTES:

Key

- Existing Public Footpath
- Existing Cycleway
- Indicative location of site compound / construction area
- Indicative location of topsoil storage area
- Proposed Planning Boundary
- Proposed Highway Boundary

X-Refs & Blocks used in this Drawing



PROPOSED LEVELS	8.211	8.935	10.096	11.900	14.306	16.806	19.306	21.806	24.306	26.806	29.306	31.806	34.255	36.470	38.435	40.151	41.667	43.167	44.667	46.168	47.668	49.168	50.553	51.689	52.575	53.210	53.596	53.732	53.618
EXISTING GROUND LEVELS	12.211	16.069	21.541	25.994	28.839	32.184	35.438	38.026	41.030	43.565	44.826	46.103	46.953	47.415	47.821	47.869	48.058	48.527	48.970	49.466	49.876	50.157	50.095	49.953	49.892	49.675	50.144	50.573	50.872
PLANNING SCHEME LEVELS	8.262	9.021	10.194	12.016	14.514	17.407	20.195	22.868	25.425	27.868	30.196	32.409	34.507	36.490	38.358	40.111	41.750	43.273	44.681	45.975	47.153	48.217	49.165	49.999	50.717	51.321	51.810	52.184	52.443
Gradient		2.00	2.322	3.609	4.811	5.00	5.00	5.00	5.00	5.00	5.00	5.00	4.898	4.431	3.931	3.431	3.033	3.00	3.00	3.00	3.00	3.00	2.771	2.271	1.772	1.272	0.772	0.272	-0.228
Horizontal	R=-1020.m L=108.477m			transition L=78.096m				R=-2880.m L=310.405m						straight L=324.058m					transition L=120.922m						R=1020.m L=564.762m				
Vertical	G=2.00 L=51.0		R=3700.m L=111.m					G=5.00 L=391.614m						L=199.982m R=-10000.m					G=3.00 L=284.057m						L=348.260m R=-10001.680m				
Chainage	3113.	3150.	3200.	3250.	3300.	3350.	3400.	3450.	3500.	3550.	3600.	3650.	3700.	3750.	3800.	3850.	3900.	3950.	4000.	4050.	4100.	4150.	4200.	4250.	4300.	4350.	4400.	4450.	4500.

LONGITUDINAL SECTION
HORIZONTAL SCALE 1:2500@A1, VERTICAL SCALE 1:250@A1

Revision:	Description:	Drawn By:	CAD By:	Approved By:	Approval Date
B	Boundary line style ammended	OM	OM	MB	20/09/2012
A	First issue	OM	OM	MB	07/09/2012

Amendment Details

Drawing 1st Approval
1st Approval by: M.Bradshaw Date: 07/09/2012

Drawn/Designed by: O.Makarov
CAD Drawing Creation
Created By: O.Makarov Date: 07/09/2012

Scale@A1: 1:2500 for Plan; 1:250 for Profile

Lincolnshire COUNTY COUNCIL Highways Alliance
TECHNICAL SERVICES PARTNERSHIP
WITHAM PARK HOUSE,
WITHAM PARK,
WATERSIDE SOUTH
LINCOLN LN5 7JN
Customer Service Centre : (01522) 782070

Certificate No. FS20705

B/1030171/100/025
Paper Size Drawing Number
Rev. B
Revision

Project: Lincoln Eastern Bypass

Description:

MAIN CARRIAGEWAY
Plan & Profile (Sheet 3 of 5)

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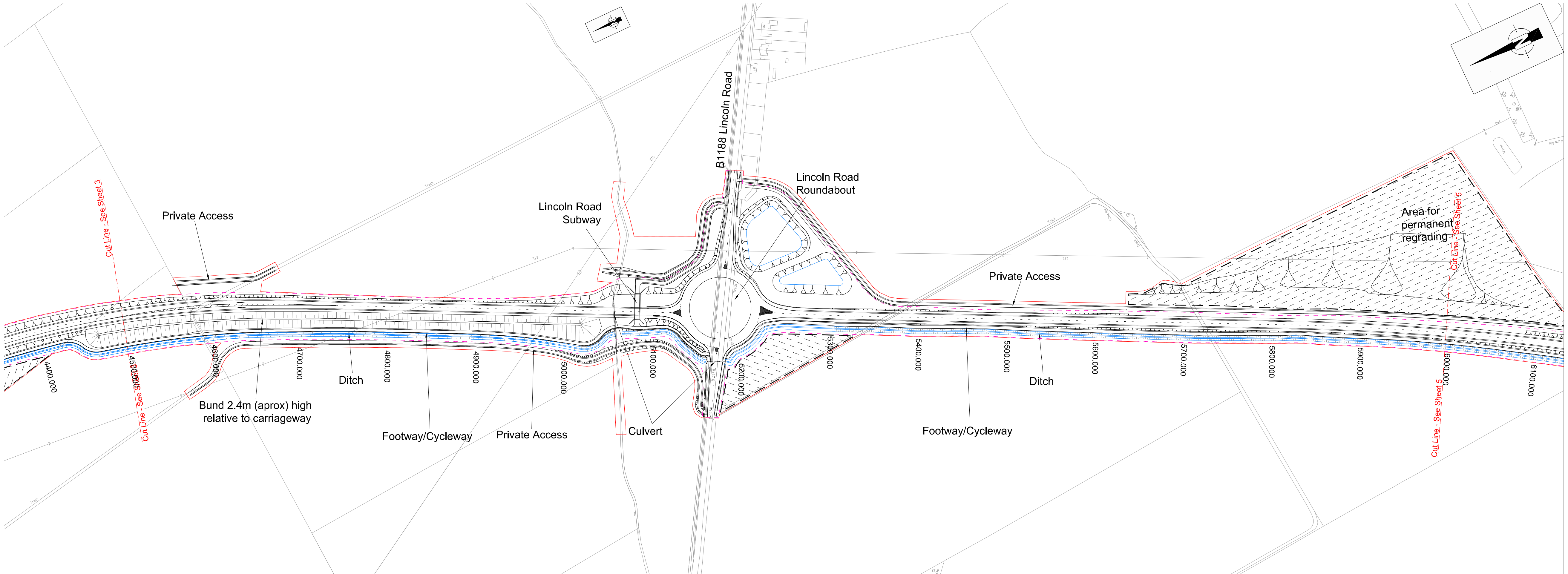
1.4 1030171-100-023C Plan and Profile Sheet 4

X-Refs & Blocks used in this Drawing

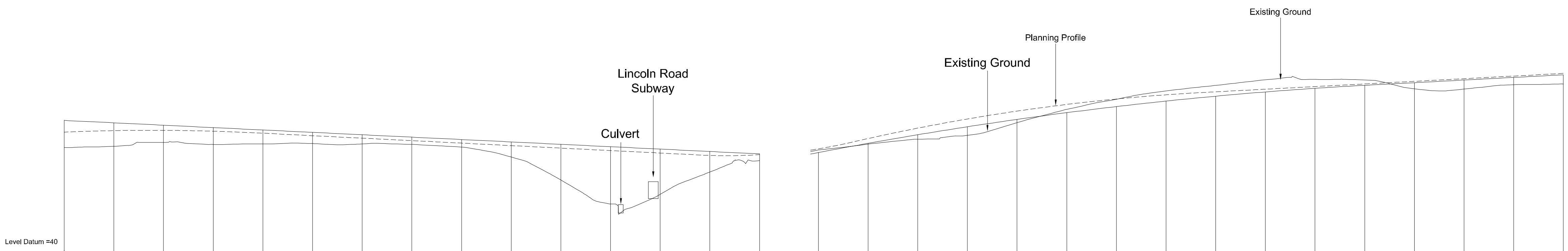


PLAN
SCALE 1:2500@A1

NOTES:

Key

- Existing Public Footpath
- Existing Cycleway
- Indicative location of site compound / construction area
- Indicative location of topsoil storage area
- Proposed Planning Boundary
- Proposed Highway Boundary



PROPOSED LEVELS	53.618	53.377	53.136	52.895	52.654	52.414	52.173	51.932	51.691	51.450	51.209	50.968	50.727	50.486	50.245
EXISTING GROUND LEVELS	50.872	51.008	51.407	51.188	51.250	51.288	51.242	51.199	50.935	49.922	47.607	45.193	46.162	48.416	49.552
PLANNING SCHEME LEVELS	52.443	52.587	52.616	52.530	52.329	52.079	51.829	51.579	51.329	51.079	50.829	50.579	50.329	50.086	50.168
Gradient	-0.228	-0.482	-0.482	-0.482	-0.482	-0.482	-0.482	-0.482	-0.482	-0.482	-0.482	-0.482	-0.482	-0.482	-0.482
Horizontal	R=1020.m L=564.762m			transition L=120.922m						straight L=458.529m					
Vertical								L=699.624m G=-0.482							
Chainage	4500.	4550.	4600.	4650.	4700.	4750.	4800.	4850.	4900.	4950.	5000.	5050.	5100.	5150.	5199.

LINCOLN ROAD ROUNDABOUT

PROPOSED LEVELS	50.229 50.381	51.309	52.175	52.979	53.719	54.398	55.014	55.567	56.058	56.486	56.852	57.155	57.421	57.686	57.951	58.216
EXISTING GROUND LEVELS	50.482 50.640	51.228	51.717	52.110	53.386	54.735	55.755	56.589	57.147	57.710	57.757	57.691	56.804	56.780	57.210	57.283
PLANNING SCHEME LEVELS	50.627 50.751	51.793	52.840	53.761	54.558	55.230	55.777	56.198	56.499	56.764	57.029	57.294	57.559	57.824	58.090	58.356
Gradient	1.929	1.857	1.732	1.607	1.482	1.357	1.232	1.107	0.982	0.857	0.732	0.607	0.531	0.530	0.530	0.530
Horizontal	R=-2880.001m L=97.948m							straight L=483.045m						R=2880.m L=580.092m		
Vertical						L=563.576m R=-40000.m										
Chainage	5250.	5300.	5350.	5400.	5450.	5500.	5550.	5600.	5650.	5700.	5750.	5800.	5850.	5900.	5950.	6000.

Slope Units =%
Horizontal Scale = 1:1000,Vertical Scale = 1:100

LONGITUDINAL SECTION
HORIZONTAL SCALE 1:2500@A1, VERTICAL SCALE 1:250@A1

Revision:	Description:	Drawn By:	CAD By:	Approved By:	Approval Date
B	Boundary line style ammended	OM	OM	MB	20/09/2012
A	First issue	OM	OM	MB	07/09/2012

Amendment Details

Drawing 1st Approval
1st Approval by: M.Bradshaw
Date: 07/09/2012

Drawn/Designed by: O.Makarov
CAD Drawing Creation
Created By: O.Makarov
Date: 07/09/2012

Scale@A1: 1:2500 for Plan; 1:250 for Profile

Lincolnshire COUNTY COUNCIL
Highways Alliance
TECHNICAL SERVICES PARTNERSHIP
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Customer Service Centre : (01522) 782070

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Certificate No. FS20705

B/1030171/100/026
Paper Size Drawing Number

Rev. B
Revision

Project: Lincoln Eastern Bypass

Description:

MAIN CARRIAGEWAY
Plan & Profile (Sheet 4 of 5)

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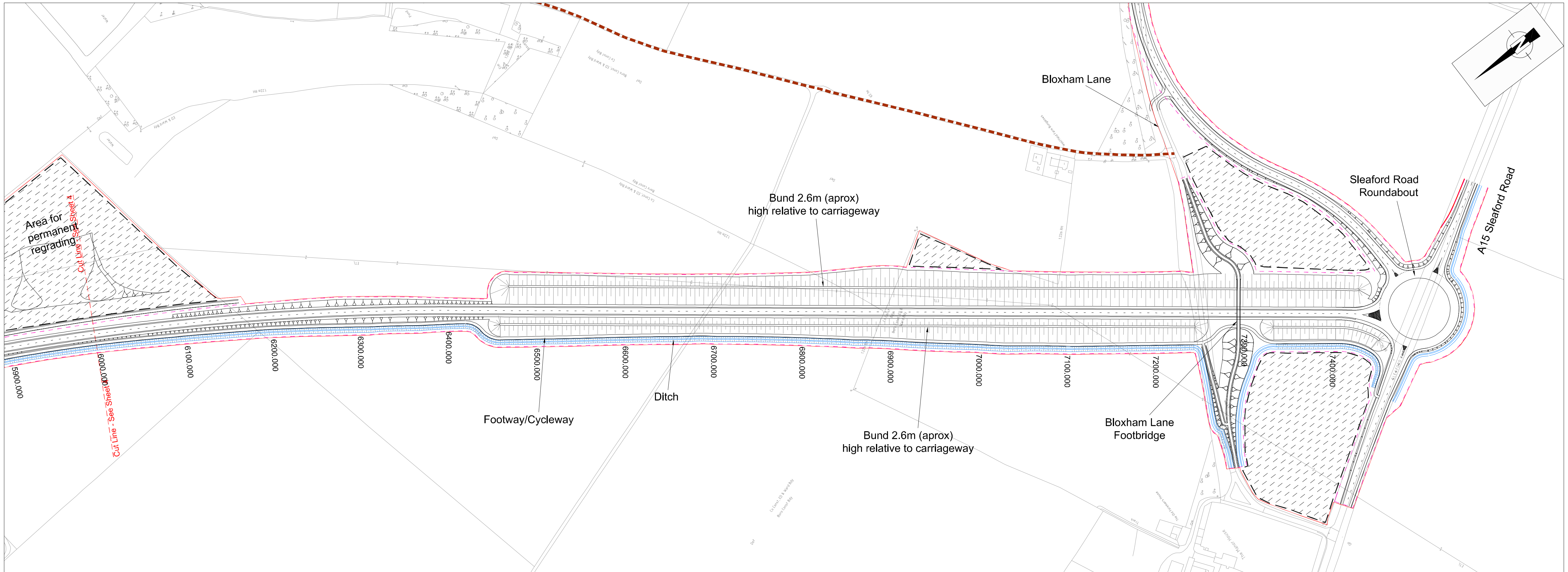
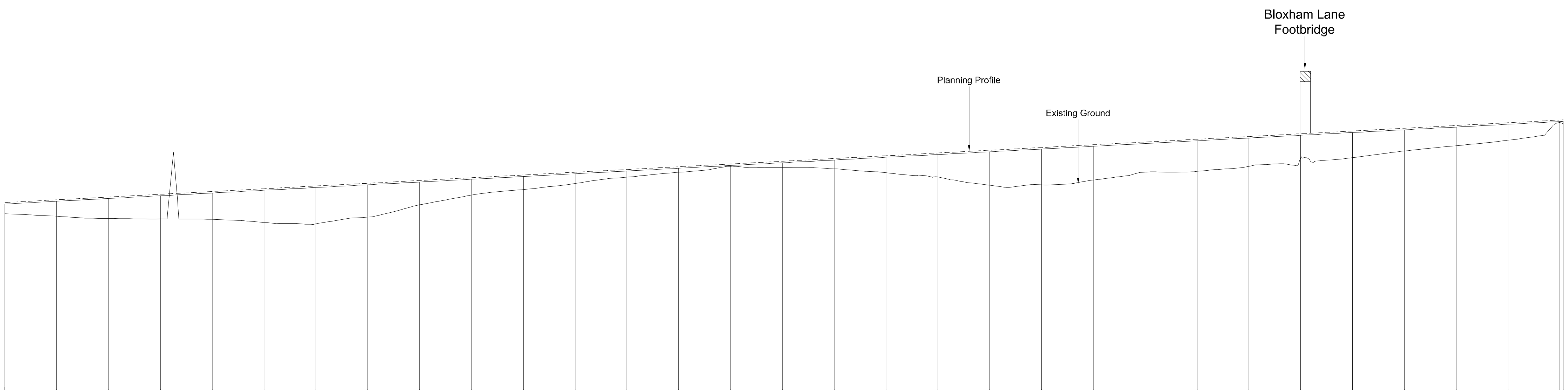
1.5 1030171-100-023C Plan and Profile Sheet 5

X-Refs & Blocks used in this Drawing



PLAN
SCALE 1:2500@A1



Level Datum =40.

Chainage	PROPOSED LEVELS	EXISTING GROUND LEVELS	PLANNING SCHEME LEVELS	Gradient
6000.	58.216	57.283	58.356	0.530
6050.	58.481	57.043	58.622	0.530
6100.	58.746	56.822	58.888	0.530
6150.	59.011	56.774	59.155	0.530
6200.	59.276	56.734	59.421	0.530
6250.	59.541	56.440	59.687	0.530
6300.	59.806	56.310	59.953	0.530
6350.	60.071	56.949	60.218	0.530
6400.	60.336	58.137	60.483	0.530
6450.	60.601	59.081	60.748	0.530
6500.	60.866	59.611	61.013	0.530
6550.	61.131	60.191	61.278	0.530
6600.	61.396	60.811	61.543	0.530
6650.	61.661	61.271	61.808	0.530
6700.	61.926	61.844	62.073	0.530
6750.	62.191	61.731	62.338	0.530
6800.	62.456	61.610	62.603	0.530
6850.	62.721	61.231	62.868	0.530
6900.	62.986	60.815	63.133	0.530
6950.	63.251	60.020	63.398	0.530
7000.	63.516	60.063	63.663	0.530
7050.	63.781	60.529	63.928	0.530
7100.	64.046	61.291	64.193	0.530
7150.	64.311	61.360	64.458	0.530
7200.	64.576	61.851	64.723	0.530
7250.	64.841	62.682	64.988	0.530
7300.	65.106	62.682	65.253	0.530
7350.	65.371	63.327	65.518	0.530
7400.	65.636	63.838	65.783	0.530
7450.	65.901	64.365	66.048	0.530
7500.	66.183	65.962	66.330	0.530

Horizontal: R=2880.m L=580.092m; straight L=1100.023m

Vertical: G=0.530 L=1697.532m

LONGITUDINAL SECTION
HORIZONTAL SCALE 1:2500@A1, VERTICAL SCALE 1:250@A1

NOTES:

Key

- Existing Public Footpath
- Existing Cycleway
- Indicative location of site compound / construction area
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- Proposed Planning Boundary
- Proposed Highway Boundary

Revision	Description	Drawn By	CAD By	Approved By	Approval Date
B	Boundary line style ammended	OM	OM	MB	20/09/2012
A	First issue	OM	OM	MB	07/09/2012

Amendment Details

Drawing 1st Approval

1st Approval by: M.Bradshaw Date: 07/09/2012

Drawn/Designed by: O.Makarov

CAD Drawing Creation
Created By: O.Makarov
Date: 07/09/2012

Scale@A1: 1:2500 for Plan; 1:250 for Profile

Lincolnshire COUNTY COUNCIL
Highways Alliance

TECHNICAL SERVICES PARTNERSHIP
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WITHAM PARK,
WATERSIDE SOUTH
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Customer Service Centre : (01522) 782070

mouchel

Certificate No. FS20705

B/1030171/100/027 Rev. B
Paper Size Drawing Number Revision

Project: Lincoln Eastern Bypass

Description:

MAIN CARRIAGEWAY
Plan & Profile (Sheet 5 of 5)

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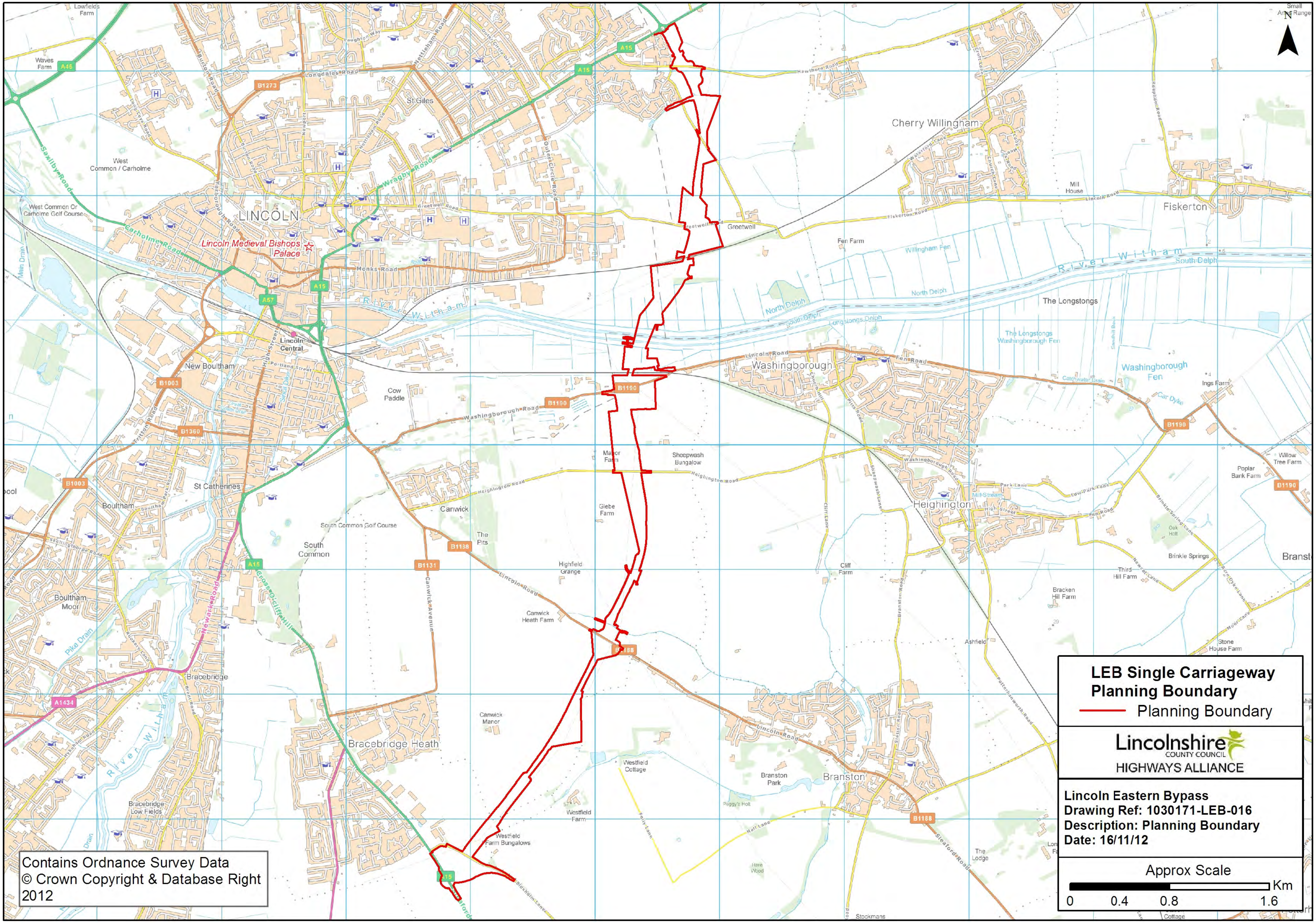
1.6 Red Line Plan


LEB Single Carriageway
Planning Boundary
Planning Boundary
Lincolnshire
COUNTY COUNCIL
HIGHWAYS ALLIANCE
Lincoln Eastern Bypass
Drawing Ref: 1030171-LEB-016
Description: Planning Boundary
Date: 16/11/12
Approx Scale
0 0.4 0.8 1.6 Km
Contains Ordnance Survey Data
© Crown Copyright & Database Right
2012
N
LINCOLN
Lincoln Medieval Bishops Palace
Cherry Willingham
Fiskerton
Greetwell
Fen Farm
Willingham Fen
River Witham
North Delph
South Delph
The Longstongs
Washingborough
Washingborough Fen
Heighington
Canwick
Cow Paddle
Manor Farm
Sheepwash Bungalow
Glebe Farm
Highfield Grange
Canwick Heath Farm
Canwick Manor
Westfield Cottage
Westfield Farm
Westfield Farm Bungalows
Branston
Branston Park
Bracebridge Heath
Bracebridge
South Common
South Common Golf Course
St Catherines
Boultham
Boultham Moor
New Boultham
Lincoln Central
St Giles
West Common / Carholme
West Common Or Carholme Golf Course
Waves Farm
Lowfields Farm
Mill House
Ings Farm
Willow Tree Farm
Poplar Bank Farm
Third Hill Farm
Bracken Hill Farm
Brinkle Springs
Stone House Farm
Cliff Farm
Ashfield
The Lodge
Bracebridge Low Fields
A15
A46
A57
A1434
B1190
B1188
B1131
B1003
B1360
B1273

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7 Road Drainage and the Water Environment

7.1 Introduction

7.1.1 No supporting information required for this section.

7.2 Scope of the Assessment

7.2.1 No supporting information required for this section.

7.3 Statutory and Planning Context

7.3.1 Whilst assessing the impacts and designing mitigation measures the following key legislation, policies, plans and guidance has been taken into account during the assessment.

Legislation

The Water Framework Directive (WFD) – Directive 2000/60/EC

7.3.2 The Water Framework Directive makes provision for the maintenance and improvement of the 'ecological and chemical status' of the water environment, which includes rivers, lakes, wetlands, groundwater, estuaries and coastal waters. Chemical status is determined from compliance with environmental standards for chemicals that are classed as 'priority hazardous substances'. The ecological status of a surface waterbody is measured through a range of biological quality elements, supported by measurements of physico-chemistry, hydromorphology and compliance with environmental standards for chemicals that are classed as 'specific pollutants'. For groundwater the overall status has a quantitative and a chemical component. The aim is for designated waterbodies to achieve 'good overall status' by 2015. Certain surface waterbodies may be designated as artificial/heavily modified and will have less stringent targets to meet, however these will still need to demonstrate 'good overall potential' by 2015.

The Freshwater Fish Directive (codified version) (FFD) – Directive 2006/44/EC

7.3.3 The Freshwater Fish Directive makes provision for the protection and improvement of the quality of fresh waters capable of supporting, or potentially capable of supporting certain fish species, should pollution be reduced or eliminated. The Directive requires that relevant waterbodies are classified as either Salmonid or Cyprinid waters. It also sets down minimum water quality criteria that must be met by such waters.

Groundwater Directives

7.3.4 There are currently a number of Directives with the aim of protecting groundwater against pollution and deterioration. The WFD and the Groundwater Daughter Directive (GDD) (2006/118/EC), which were enacted in 2003 and 2009 respectively, replace the original Groundwater Directive (80/68/EEC) which will be repealed in 2013. The GDD introduces procedures for assessing the 'Chemical Status' of groundwater as per the WFD, and protects groundwater by preventing direct discharge of 'hazardous pollutants' and limiting the direct discharge of non-hazardous pollutants.

Floods Directive (2007/60/EC)

7.3.5 The Floods Directive makes provision for the assessment of flood risk, mapping its potential impact and planning measures to reduce potential and significant flood risk.

UK Legislation

7.3.6 The objectives of the Directives discussed above that are relevant to this assessment are met through the following UK legislation:

- The Water Resources Act 1991 as amended;
- The Water Act 2003 as amended;
- The Flood and Water Management Act 2010;
- The Salmon and Freshwater Fisheries Act 1975 as amended;
- The Water Environment (Water Framework Directive) (England and Wales) Regulations 2003;
- The Groundwater (England and Wales) Regulations 2009;
- The Environmental Permitting (England and Wales) regulations 2010;
- The Surface Waters (Fishlife) (Classification) Regulations 1997 as amended;
- The Surface Waters (Fishlife) Direction 2007;
- The Control of Pollution (Oil Storage) (England) Regulations 2001;
- The Environmental Damage (Prevention and Remediation) Regulations 2009.

7.3.7 Under the various acts and regulations listed above consents will be required from the Environment Agency for temporary construction and permanent operational discharges; and any temporary abstractions, impoundments and in-channel works related to construction activities.

Planning Policy

7.3.8 The National Planning Policy Framework (NPPF) for England was published in March 2012 and replaces the majority of the previous National Planning Policy Statements. The NPPF states that planning authorities should adopt proactive strategies to mitigate and adapt to climate change, taking full account of flood risk. The NPPF and it's Technical Guidance document specify that a sequential, risk based approach should be taken to the location of development to avoid, where possible, flood risk to peoples and property. Additionally it is stated that the planning system should contribute to and enhance the natural environment by preventing both new and existing development from contributing to, being put at unacceptable risk from or being adversely affected by, unacceptable levels of soil, air, water, or noise pollution or land instability.

7.3.9 Common to all the authorities associated with the Proposed Scheme are policies relevant to the assessment of road drainage and the water environment, such as policies relating to protection of the environment, integration of sustainable drainage systems within new developments, restrictions on development within designated floodplain and recognition of the amenity and ecological value of watercourses and their future potential.

7.3.10 Specific East Midlands Regional Plan (2009) (RSS8) policies for the water environment are:

- 2 - Promoting Better Design: The layout, design and construction of new development should be continuously improved, including in terms of providing resilience to future climate change
- 28 - Regional Priorities for Environmental and Green Infrastructure: Local Authorities, statutory environmental bodies and developers should work with the voluntary sector, landowners and local communities to ensure the delivery, protection and enhancement of Environmental Infrastructure across the region
- 29 – Priorities for Enhancing the Region's Biodiversity: Local Authorities, statutory environmental bodies and developers should work with the voluntary sector, landowners and local communities to implement the Regional Biodiversity Strategy, and to deliver a major step change increase in the level of biodiversity across the East Midlands
- 32 – A Regional Approach to Water Resources and Water Quality: Protect and improve water quality and reduce risk of pollution, especially to vulnerable groundwater
- 33 - Regional Priorities for Strategic River Corridors: The natural and cultural environment of the Strategic River Corridors of the Witham, along with tributaries, and rivers which contribute to river corridors of a

strategic nature in adjoining Regions, should be protected and enhanced

- 35 - A Regional Approach to Managing Flood Risk: Development should not be permitted if, alone or in conjunction with other new development it would be at unacceptable risk from flooding or create such an unacceptable risk elsewhere
- SRS8 – Flood Risk and Water Management: Local Authorities, the Environment Agency, Internal Drainage Boards and other relevant bodies should adopt sustainable water and flood risk management throughout the Lincoln Policy Area, including coordinated infrastructure provision. Local Development Frameworks should take account of the best available information on flood risk (including climate change) and apply it in making decisions on the location and design of new development, and ensure that such development makes a positive contribution to flood risk management.

7.3.11 Specific North Kesteven Adopted Local Plan (2007) policies for the water environment are:

- C10 – Flood Risk: Planning permission will be granted for proposals, only if will not;
- 1. be at unacceptable risk of flooding; or
- 2. unacceptably increase flood risk elsewhere. Where possible, new developments should result in the overall reduction of flood risk. All relevant planning applications should be accompanied by a flood risk assessment.
- C11 – Pollution: Planning permission will be granted for developments that may be liable to pollute groundwater, a water body, a watercourse, air or soil only if;
- 1. the occupiers or users of the development or the occupiers or users of other land are not exposed to unacceptable risk;
- 2. the area's flora and fauna will not be adversely affected; and
- 3. the quality of water, air or soil resources will not be adversely affected.
- C14 – Surface Water Disposal: Planning permission will be granted for development, provided that it includes measures designed to safely manage surface water run-off and, where feasible, minimise the increase in surface water run-off.

7.3.12 Specific City of Lincoln Local Plan (1998) policy for the water environment is:

- 46B – Protecting the Water Environment: Planning permission will only be granted for development in, under, over or adjacent to lakes, ponds and watercourses if the Local Planning Authority is satisfied that adequate measures will be taken to:

- 1. safeguard the biodiversity and ecology of the area;
- 2. prevent pollution and other degradation of the water environment;
- 3. minimise flood risk;
- 4. mitigate against erosion;
- 5. protect the public; and
- 6. safeguard access for maintenance.

7.3.13 Specific West Lindsey Local Plan (First Review) (2006) policies for the water environment are:

- Sus 14 – Flood Risk Areas: Where a risk from flooding is identified from the Environment Agency or any relevant flood risk study new development, including the intensification of existing development or proposals to raise the level of the land, will not be permitted unless:
- 1. an adequate assessment has been made of that risk including whether the proposed development is likely to be affected by the risk of flooding and whether it will increase flood risk elsewhere;
- 2. where it would increase the risk of flooding elsewhere or there is flood risk to the development, its possible effects in terms of flood flows, flood storage capacity and run-off implications are acceptable;
- 3. any mitigation measures proposed to deal with these effects and risks are adequate, effective and acceptable and are appropriate to maintain or enhance the biodiversity value of any associated land and are implemented prior to development commencing;
- 4. any proposed mitigation is maintained for the lifetime of the development;
- 5. it is demonstrated that reasonable alternative sites are not available at a lower risk of flooding. Development generating surface water run-off likely to result in adverse effects, such as increased risk of flooding, changes in groundwater levels, or river channel instability will not be permitted unless:
- a. the development's surface water management system accords with sustainable drainage system principles and has been designed as an integral part of the development layout;
- b. the system will effectively control and adequately mitigate or attenuate any adverse effects from surface water run-off on the natural and built environment; and
- c. measures are in place to ensure maintenance of the drainage system, and the appropriate attenuation measures are in place prior to development commencing.
- CRT20 – Watercourse Corridors: Development will not be permitted which would lead to the unacceptable loss of or cause significant harm

to the landscape character, nature conservation importance or recreational roles of the watercourse corridors throughout the plan area, including the Trent, Ancholme, Rase, Witham, Fossdyke, Till, Eau and Barlings Eau watercourses and those minor watercourses which flow through urban areas.

- NBE14 – Waste Water Disposal: Development will not be permitted which would generate foul sewage or surface water run-off in excess of the capacity of the sewage system works or plant or ultimate receiving land drainage system.
- NBE15 – Water Quality and Supply: Development will not be permitted which would constitute a risk to the quality and quantity of water resources or to fisheries, amenity and nature conservation by means of:
- 1. pollution from development or as a result of the disturbance of contaminated land;
- 2. water abstraction unless adequate measures are taken to reduce this risk to an acceptable level.
- NBE16 – Culverting Watercourses: The culverting of watercourses, including as part of development proposals, will not be permitted unless it is essential for public safety or to provide for access across the watercourse. In all cases, where culverting is unavoidable, the developer must demonstrate that alternative proposals have been considered, and appropriate mitigating environmental enhancements should be incorporated into the development. Development which returns disused or neglected culverts back to open watercourses will be favoured.
- NBE17 – Control of Potentially Polluting Uses: Development that may be liable to cause pollution of water, air or soil, or pollution through noise, dust, vibration, light, heat or radiation will only be permitted if:
- 1. the health and safety and amenity of users of the site or surrounding land are not put at risk;
- 2. the quality and enjoyment of the environment would not be damaged or put at risk;
- 3. adequate protection and mitigation measures are implemented to ensure that any potential environmental receptors are not put at risk.

7.3.14 Central Lincolnshire Core Strategy (not yet adopted) policies specific to the water environment are:

- CL2 – Tackling Climate Change: Adaptation to climate change will be promoted in decisions regarding the use of land and development, including the management of urban and rural environments, green infrastructure provision, management of water resources and flood risk, and the design of new development.

- CL23 – A Quality Environment: Development proposals will be required to contribute positively to environmental quality and local character, and not have an unacceptable effect on the area's natural or historic assets.
- CL24 – Green Infrastructure & Biodiversity:
- 1. Green Infrastructure - The LDF and all development proposals, local investments, strategies and other planning documents, will:
- Contribute to, encourage and take opportunities to maximise the potential value of existing and new green infrastructure, public and other open spaces, through encouraging proposals that benefit: recreation; tourism; public accessibility; biodiversity; geo-diversity, flood and water management; the protection and enhancement of local landscape, landscape character and heritage (including proposals to protect, & increase, tree & woodland cover); and the adaptation to and mitigation of climate change. Improvements to links between green assets within and extending beyond the area will be considered.
- 2. Biodiversity - The LDF and other plans and strategies will also seek to conserve and enhance the natural assets of the area by:
- Promoting the appropriate management of features of the landscape of importance for wild flora and fauna; to prevent harm to geological conservation interests; to take into account the need for the continued protection, maintenance, restoration and re-creation of all the area's ecological, biological and geological assets; and to increase provision of, and access to, green infrastructure within the area.
- CL25 – Managing Water Resources & Flood Risk: Proposals should demonstrate that:
- 1. There is no increased risk of flooding to existing properties;
- 2. Any necessary flood mitigation measures have been agreed with the relevant body and that the development will be safe during its lifetime;
- 3. The adoption, ongoing maintenance and management of any mitigation measures have been considered and any necessary agreements are in place;
- 4. Proposals have taken a positive approach to reducing overall flood risk and the potential to contribute towards solutions for the wider area have been considered.
- 5. Every effort has been made to maximise the efficient use of water, including water storage wherever practical;
- 6. Sustainable Drainage Systems (SuDS) have been incorporated into the proposals unless they can be shown to be impractical;
- 7. Relevant site investigations and necessary mitigation measures for source protection zones around boreholes, wells and springs have

been agreed with the relevant bodies (e.g. the Environment Agency and relevant water companies);

- 8. Adequate provision is made to safeguard the future maintenance of water bodies to which surface water is discharged, preferably by an appropriate authority (e.g. Environment Agency, Internal Drainage Board, Water Company, British Waterways or local council);
- 9. No new combined sewer overflows are created and in areas served by combined sewers, foul and surface water flows are separated where possible;
- 10. Suitable access is safeguarded for the maintenance of water resources, flood defences and drainage infrastructure.
- Through this policy will ensure that developers and the Authorities, through early discussions with the relevant organisations, including the Environment Agency, can demonstrate compliance with the EU Water Framework Directive.

Guidance

7.3.15 The following guidance documents have also been taken into account:

- Environment Agency (EA) Pollution Prevention Guidelines (PPGs):
- PPG 1: General guide to the prevention of pollution
- PPG 2: Above ground oil storage tanks
- PPG 3: Use and design of oil separators in surface water drainage systems
- PPG 4: Treatment and disposal of sewage where no foul sewer is available
- PPG 5: Works and maintenance in or near water
- PPG 6: Pollution prevention guidance for working at construction and demolition sites
- PPG 7: Refuelling facilities
- PPG 8: Safe storage and disposal of used oils
- PPG 13: Vehicle washing and cleaning
- PPG 18: Managing fire water and major spillages
- PPG 20: Dewatering underground ducts and chambers
- PPG 21: Pollution incident response planning
- PPG 22: Dealing with spills
- PPG 26: Drums and intermediate bulk containers
- PPG 29: Safe storage – Combustible materials, prevent and control fire

- CIRIA Report C532 Control of water pollution from construction sites. Guidance for consultants and contractors.
- CIRIA Report C648 Control of water pollution from linear construction projects – technical guidance

7.4 Method of Assessment

7.4.1 The road drainage and the water environment assessment has involved the following key tasks:

- Consultations with the relevant statutory and non-statutory bodies to establish the principal water environment issues associated with the study area;
- Detailed desk studies and field surveys to ascertain the current baseline conditions on site;
- Assessment of the potential impacts related to the construction and operation of the proposed development; and
- Identification of measures to avoid, minimise or mitigate predicted impacts.

7.4.2 Further details on the baseline data collection and assessment methods used are provided below.

Baseline Data Collection

7.4.3 The desk study involved:

- Review of the Road Drainage and Water Environment chapter of the 2009 Environmental Assessment Report, prepared by Jacobs;
- Review of the 2009 Jacobs Flood Risk Assessment Report;
- Identification of all catchments, surface and groundwater bodies including watercourses, drains, ponds, wetlands and springs;
- Estimation of watercourse low, mean and peak flows using the software LowFlows 2000 and the Institute of Hydrology Flood Studies Report and Flood Estimation Handbook;
- Collation of Environment Agency data on water quality and Water Framework Directive status of waterbodies;
- Collation of data on existing abstractions and discharges; and
- Review of data on the existing road drainage systems provided by site visit visual assessment and Anglian Water asset location plans.

7.4.4 A site visit carried out on the 5th October 2012 concentrated on gaining a good overall understanding of the water environment of the study area. Visual inspections and geomorphological assessments of the main watercourses were also undertaken. The photographs taken during the site visit are presented in Table 7-10.

Construction Assessment

7.4.5 A qualitative assessment of construction impacts was carried out, which involved a review of areas where construction is proposed in close proximity to waterbodies and the proposed mitigation measures targeted at avoiding or minimising the risk of construction pollution.

Routine Runoff Assessment

7.4.6 The Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 10, HD 45/09 – Road Drainage and the Water Environment specifies procedures for the assessment of pollution impacts from routine runoff on surface waters and groundwaters, known as Method A and Method C respectively.

7.4.7 In this instance only Method A has been used as all proposed road drainage outfalls have been designed to discharge to surface waters, and therefore there will be no pollution impact on groundwaters from routine runoff.

7.4.8 The Method A assessment comprises two separate elements:

- Highways Agency Water Risk Assessment Tool (HAWRAT) Assessment: the HAWRAT is a Microsoft Excel application designed to assess the short-term risks related to the intermittent nature of road runoff. It assesses the acute and chronic pollution impacts on aquatic ecology associated with soluble and sediment bound pollutants respectively;
- Environmental Quality Standards (EQS) Assessment: EQS are the maximum permissible annual average concentrations of potentially hazardous chemicals, as defined under the WFD. The long-term risks over the period of one year are assessed through comparison of the annual average concentration of pollutants discharged with the published EQS for those pollutants.

7.4.9 These assessments are carried out for each proposed road drainage outfall.

HAWRAT Assessment

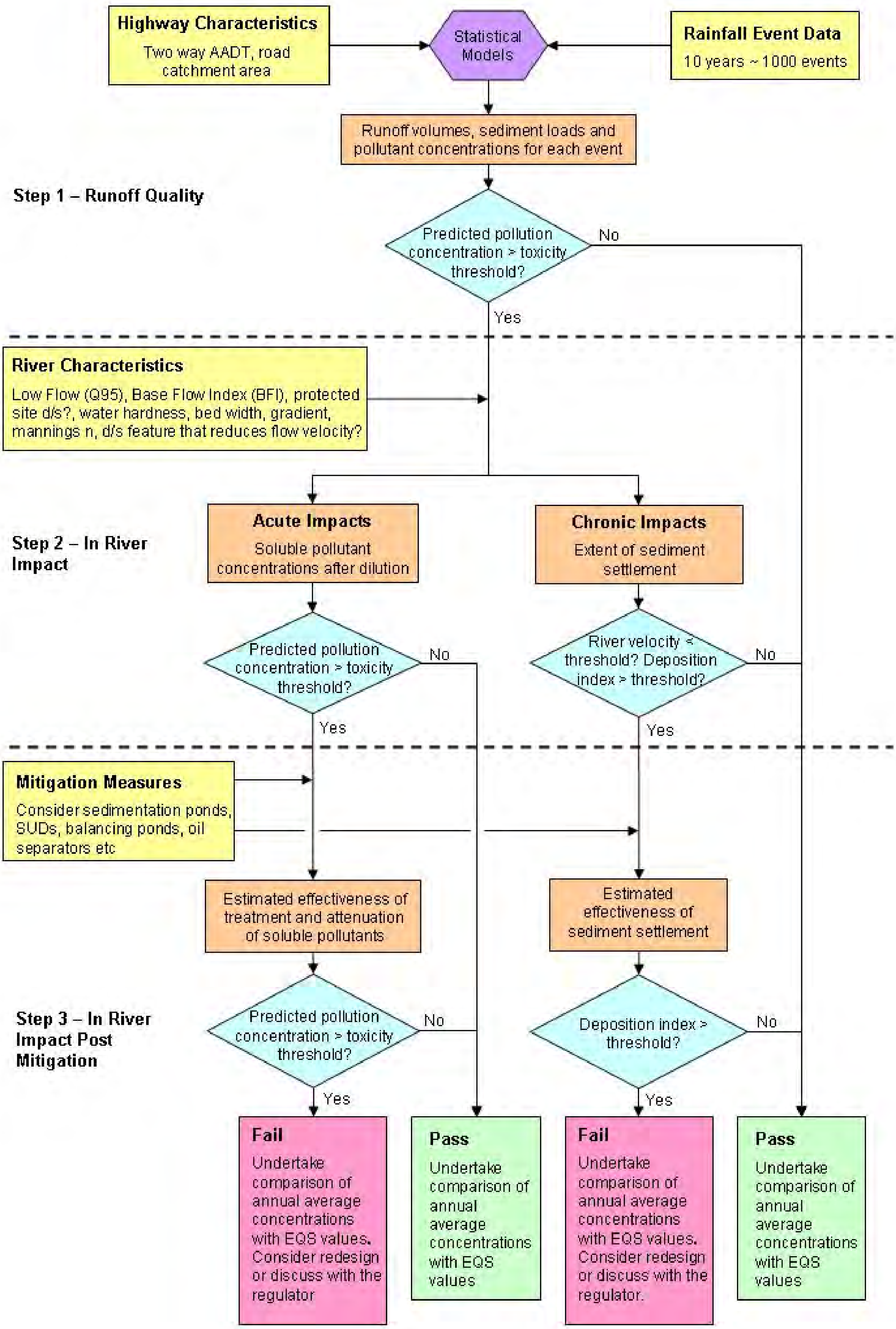
7.4.10 HAWRAT is a tiered consequential system which involves up to three assessment stages, as can be seen in Table 7-1. Stage 1 uses statistical models to determine pollutant concentrations in raw road runoff prior to any treatment or dilution in the receiving watercourse. Stage 2 assesses in-river pollutant concentrations after dilution and dispersion but without active mitigation. Stage 3 considers the in-river pollutant concentrations with active mitigation.

7.4.11 As can be seen in Table 7-1 acute impacts due to soluble pollutants and chronic impacts due to sediment bound pollutants are assessed separately. For an individual outfall to pass the HAWRAT assessment, it must pass both elements.

7.4.12 The underlying algorithms for assessing pollutant concentrations are based on recent research undertaken by the Highways Agency (HA) and the Environment Agency (EA) on road runoff quality under a range of traffic and weather conditions. Recent ecological research has determined the toxicity thresholds for the typical pollutants in road runoff, and this is used in the tool to evaluate whether predicted concentrations are acceptable or not.

7.4.13 Full details on the development and use of HAWRAT can be found in DMRB 11.3.10 HD 45/09 and in the HAWRAT Users Manual, which includes background information on the research programme behind the tool, derivation of the toxicity thresholds used and explanation of the background calculations.

Table 7-1: HAWRAT Tiered Flow Diagram



7.4.14 The HAWRAT parameters that must be entered by the user at each stage of the assessment are summarised in Table 7-2 with details of the respective data sources.

Table 7-2: HAWRAT User Parameters

Parameter	Data Source
Step 1	
AADT	Annual Average Daily Traffic flow data has been provided by the Mouchel LEB Highways Design Team. One of three broad ranges of AADT must be selected within HAWRAT. All of the road drainage catchments within the Proposed Scheme have an AADT in the range of >10,000 and < 50,000 vehicles (the lowest band).
Climatic Region	Four options are available to choose from: Colder Wet, Colder Dry, Warmer Wet and Warmer Dry. In this instance the Colder Dry option was selected.
Rainfall Site	Having selected a Climatic Region a restricted list of rainfall sites are available to choose from. The Lincoln rainfall site was chosen in this instance as it was geographically closest to the road scheme.
Step 2	
Impermeable road area drained (ha)	The single carriageway drained areas within each drainage network have been provided by the Mouchel LEB Highways Design Team. As the scheme is an outline design there is insufficient information to differentiate the impermeable and permeable areas, therefore it is assumed that the entire drained area is impermeable (worst case).
Permeable road area drained (ha)	
Annual 95%ile river flow (m3/s)	The 95%ile (Q95) river flows have been calculated for each outfall location using the software LowFlows 2^{TM}. Derivation of the Q95 requires the upstream catchment of the receiving watercourse to be defined. This has been done based on data from the Flood Estimation Handbook CD-ROM, OS mapping and professional judgement. As there has been significant alteration of the watercourses and natural drainage of the study area there was some uncertainty regarding the extent of some of the catchments, in particular the Canwick Fen Drain.
Baseflow Index (BFI)	The baseflow index for each receiving watercourse has been taken from the LowFlows 2 software.
Conservation Area Proximity	The locations of downstream conservation sites has been collated from the 2009 Environmental Assessment Report produced by Jacobs. There are no water related conservation sites within 1km of the proposed outfalls.
Water Hardness	One of three broad ranges of water hardness must be chosen within HAWRAT. Given the prevalence of limestone geology within the study area it is assumed that the water hardness is high in each of the receiving watercourses.
Downstream Structure Proximity	The location of downstream structures, lakes, pond and canals has been determined from map and aerial photo interpretation.
Estimated River Width (m)	Used in the Tier 1 assessment of chronic sediment impacts, this was derived from map and aerial photo interpretation.
Bed Width (m) / Side Slope (m/m) / Long Slope (m/m) / Manning's n	Used in the Tier 2 assessment of chronic sediment impacts, this information was estimated from maps, site photographs, aerial photography, past experience and professional judgement. There was no topographic survey data available for the receiving watercourse channels.
Step 3	

Proposed Mitigation Measures	Text description of the proposed mitigation measures. Appropriate mitigation measures have been identified through an iterative design & assessment process undertaken by the Mouchel LEB Drainage Design and Water Environment teams. Further information on specific routine runoff mitigation is provided in the Mitigation section below.
Treatment for Solubles (%)	An estimate of the probable effectiveness of the mitigation measures in reducing soluble pollutant concentrations is entered. See the Mitigation section below for further details.
Restricted Discharge Rate (l/s)	Restriction of the road runoff discharge rate has not been used as a mitigation measure for the Proposed Scheme outfalls. It is typically found that where mitigation is required, the receiving watercourses are generally small with low 95%ile flows. In these instances the discharge rate would have had to be restricted to an impractically low rate for attenuation to be effective. Treatment of soluble pollutants was considered the only practical solution in these cases.
Settlement of Sediments (%)	An estimate of the probable effectiveness of the mitigation measures in reducing sediment concentrations is entered. See Mitigation section below for further details.

7.4.15

7.4.16 Where more than one outfall discharges into the same reach of a watercourse the combined impacts will be more significant. In these circumstances the outfalls should be aggregated for the purposes of aggregate assessment in HAWRAT.

7.4.17 To aggregate the outfalls the drained areas are simply added together. The location on the watercourse used for the cumulative assessment should be positioned downstream of the last outfall in the reach. For this purpose a reach is defined as a length of watercourse between two confluences, the reason being that the available dilution and stream velocity will naturally change at confluences and influence the assessment.

7.4.18 However watercourse reaches can vary greatly in length. Therefore for the assessment of the impacts of soluble pollutants only outfalls within 1km of each other along the length of a watercourse were aggregated for cumulative assessment. When assessing the combined impact of sediment bound pollutants outfalls within 100m of one another are assessed. Beyond 100m the road runoff sediment, if it settles at all, is likely to be sufficiently diluted with natural sediments so as not to have an adverse impact.

7.4.19 As with the assessment of individual outfalls, if the cumulative assessment fails mitigation should be applied to one or more of the outfalls and the calculations re-run.

EQS Assessment

7.4.20 The EQS Assessment provides an assessment of the long-term risks to receiving water ecology from soluble pollutants. The annual average concentrations for dissolved copper and zinc are calculated and compared with the published Environmental Quality Standards (EQS), shown in Table 7-3 to assess whether there is likely to be a long-term impact. It should be noted that at present there are published EQS values for total zinc, but not dissolved zinc. The values quoted for dissolved zinc are proposed and are likely to be adopted before 2013.

Table 7-3: Environmental Quality Standards for Dissolved Copper and Zinc

<table>
<tr><th>Water Hardness Bands (mg/l $CaCO_3$)</th><th>EQS for Dissolved Copper ((μg/l)</th><th>EQS for Dissolved Zinc (μg/l)</th></tr>
<tr><td>0 - 50</td><td>1</td><td rowspan="4">7.8</td></tr>
<tr><td>>50 – 100</td><td>6</td></tr>
<tr><td>>100 – 250</td><td>10</td></tr>
<tr><td>> 250</td><td>28</td></tr>
</table>

7.4.21 The annual average concentrations are calculated within HAWRAT at both Step 2 and Step 3. In calculating the annual average concentrations for dissolved copper and dissolved zinc, HAWRAT assumes that the background/upstream concentrations are zero. This enables an assessment of the added risk rather than the total risk ie the additional risk to organisms in the receiving water when they are exposed to road runoff.

7.4.22 Where multiple outfalls discharge into the same reach of a watercourse a cumulative EQS assessment is required as per the cumulative HAWRAT assessment.

Accidental Spillage Assessment

7.4.23 Spillages resulting from road traffic accidents or other causes could occur anywhere along the Proposed Scheme road network. Although the Proposed Scheme has been designed to minimise the risk of collision, it is important to assess the risk of serious pollution incident occurring. This assessment has carried out in accordance with Method D as detailed in DMRB Vol. 11 Section 3, Part 10 Road Drainage and the Water Environment.

7.4.24 The assessment takes the form of a risk assessment, where the risk is expressed as the annual probability of a serious pollution incident occurring. This risk is the product of two probabilities:

- The probability that an accident will occur, resulting in a serious spillage of a polluting substance on the carriageway; and
- The probability that, if such a spillage did occur, the polluting substance would reach the receiving watercourse and cause a serious pollution incident.

7.4.25 Factors which influence the overall probability within a road drainage network are:

- The type of road ie motorway, rural trunk road or urban trunk road. In this case the Proposed Scheme has been assessed as rural trunk road.
- The road components within each road drainage network ie no junction, slip road, roundabout, crossroad and side road. This data has been determined from GIS files of the scheme layout.
- The length of each road component within the road drainage network, again determined from GIS files of the scheme layout.
- The AADT (annual average daily traffic) two way flow, provided by the Mouchel LEB Highways Design Team.
- The percentage of the AADT flow that comprises Heavy Goods Vehicles (HGV's), also provided by the Mouchel LEB Highways Design Team.
- The response time of the emergency services. Given the location of the study area on the urban fringe of Lincoln, a conservative estimate of a response time of less than 1 hour is considered appropriate.
- The receiving waterbody. In this case all outfalls are designed to discharge to surface watercourses.

7.4.26 The annual probability of a spillage occurring on any road component within the drainage catchment is calculated as:

- Spillage Probability = road length x spillage rate x (AADT x 365 x 10-9) x (percentage HGV's / 100)

7.4.27 Where the spillage rate is determined from Table 7-4 below.

Table 7-4: Spillage Rates for Serious Spillages (Billion HGV km/year)

Road Component	Road Type		
	Motorway	Rural Trunk Roads	Urban Trunk Roads
No Junction	0.36	0.29	0.31
Slip Road	0.43	0.83	0.36
Roundabout	3.09	3.09	5.35
Crossroad	-	0.88	1.46
Side Road	-	0.93	1.81

7.4.28 The spillage probabilities for each road component type within the road drainage network are summed to give the overall spillage probability for the drainage network under assessment.

7.4.29 The probability of a serious pollution incident occurring as a result of a serious spillage is determined from Table 7-5 below.

Table 7-5: Probability of a Serious Pollution Incident Occurring as a Result of a Serious Spillage

Receiving Waterbody	Urban(response tine to site < 20 mins)	Rural (response time to site <1 hour)	Remote (response time to site > 1 hour)
Surface Water	0.45	0.6	0.75
Groundwater	0.3	0.3	0.5

7.4.30 Finally the overall annual probability of a serious pollution incident as a result of accidental spillage is calculated by multiplying the spillage probability and response time probability together. Within HAWRAT this probability is expressed as a return period such as 1 in 50 years ie there is a 1 in 50 (2%) probability of such an event occurring in any one year.

7.4.31 The DMRB guidance recommends that the receiving watercourses are protected such that the risk of a serious pollution incident has an annual probability of less than 1% (or 1 in 100 year return period). However where outfalls are to discharge within 1km of a protected site a higher level of protection will be required such that the annual probability is less than 0.5% (or a 1 in 200 year return period).

7.4.32 If any outfalls are found to fail these criteria then mitigation, such as oil separators, penstocks or ponds, should be designed into the drainage network, which will capture and contain any potential pollutant before it reaches the watercourse. The accidental spillage calculations should be re-run applying the appropriate risk reduction factors from Table 7-6.

Table 7-6: Risk Reduction Factors for Drainage Systems

Drainage System	Optimum Risk Reduction Factor
Filter Drain	0.6
Grassed Ditch/Swale	0.6
Pond	0.5
Wetland	0.4
Soakaway/Infiltration Basin	0.6
Sediment Trap	0.6
Unlined Ditch	0.7
Penstock/Valve	0.4
Notched Weir	0.6
Oil Separator	0.5

Channel Geomorphology Assessment

7.4.33 A qualitative fluvial geo-morphological assessment was carried out using data collated through a desk study and field survey. Previous reports and historic mapping was studied for evidence of historic channel change in the relevant watercourses. The field survey undertaken involved a river survey, which identified channel morphology, areas of channel instability and the wider geo-morphological setting.

7.4.34 From this baseline assessment a qualitative estimation can be made of both how ‘active’ the river is and the likely effect the Proposed Scheme proposals (such as culverts, bridges and watercourse realignments) may have on the existing status of the water environment.

Groundwater Assessment

7.4.35 To determine the likely impact of dewatering of cuttings on groundwater flows and levels the drawdown distance/area of influence has been calculated for the cuttings that intercept groundwater.

7.4.36 There is no published formula for the distance of influence from linear features such as cuttings, therefore the empirical formula of Sichardt for calculating the radius of influence of groundwater abstractions has been used:

$$L = C(H-h)\sqrt{K}$$

Where L = distance/radius of influence, K = permeability, H-h = groundwater table drawdown ie penetration of the cutting beneath the water table and C = 2000, where C is a constant.

7.4.37 Water table elevations were determined from available ground investigation data and in the absence of permeability determinations a conservative generic permeability value was used.

7.4.38 A qualitative assessment was then made of the impact on the groundwater aquifer and nearby groundwater dependent receptors, such as public water supply boreholes and wetlands.

7.4.39 The impact due to impermeable surface of the carriageway was assessed by considering the likely loss of rainfall infiltration and comparing this to the overall volume of licensed abstractions for public water supplies to the east. The impact of the loss of groundwater recharge on the baseflow to surface water bodies was assessed qualitatively.

7.4.40 The impact of structures and their foundations on groundwater flow was assessed qualitatively.

Flood Risk Assessment

7.4.41 The Flood Risk Assessment has been carried out by Mouchel in accordance with the NPPF and it’s Technical Guidance document.

7.4.42 The objectives of the FRA were to:

- Assess the risk to the development from all potential sources of flooding;

- Assess the risk of increasing flooding elsewhere as a consequence of the development; and
- Determine appropriate mitigation measures to limit the impact of flooding on the development and offsite flooding due to increased runoff.

7.4.43 The flood risk baseline was established through desk study, site walkover and consultation, and collated data on principal watercourses and field drains, existing flood defences, EA flood zones, public water mains and sewers, artificial waterbodies, existing private and highway drainage, geology and hydrogeology and details of historic flooding.

7.4.44 A preliminary assessment for surface water drainage, including the use of Sustainable Drainage Systems (SUDS), has been carried out which seeks to demonstrate that the proposed development is able to discharge surface water flows without increasing the flood risk both on and off site. This assessment considered: existing and proposed drainage arrangements; the implications of climate change; and the mitigation measures needed for surface water disposal, including the surface water drainage strategy to be implemented and the use of SUDS.

7.4.45 A detailed hydraulic assessment of the River Witham and Delph system has been undertaken by Jacobs as part of the 2009 FRA due to the existing fluvial flood risk indicated on the EA Flood Map and the proximity of the Proposed Scheme to the River Witham and Delph system.

7.4.46 A number of small watercourses and land drains will be bisected by the Proposed Scheme. A case-by-case assessment of culverting and realignment requirements has been carried out as part of the Jacobs 2009 planning application studies for these waterbodies.

7.4.47 An assessment of flood risk from all sources has been undertaken using all the information gathered from the above assessments, and practical mitigation measures identified where necessary.

7.4.48 Full details of the Flood Risk Assessment methodology are provided in the Flood Risk Assessment Report in Volume 3.

Impact Assessment Criteria

7.4.49 The predicted significance of impacts on surface waters and groundwaters has been based on the importance or sensitivity of the relevant waterbody and the magnitude of the impact from the proposed development, as recommended in DMRB document HD 45/09.

Importance/Sensitivity

7.4.50 The importance or sensitivity of the waterbodies has been evaluated taking into account their quality, rarity, scale and substitutability. The criteria used in determining the importance of each waterbody are shown in Table 7-7 below.

Table 7-7: Importance Criteria

Importance	Criteria
Very High	Large or medium watercourses with pristine / near pristine water quality High WFD Overall Status Watercourses Watercourse supporting major/critical public water supplies Designated Salmonid fisheries Sites protected under EU or UK wildlife legislation (SAC, SPA, Ramsar, SSSI sites) Water dependent ecosystems of international/national biodiversity value Watercourses supporting a wide range of significant species and habitats sensitive to changes in suspended sediment concentrations and turbidity such as salmon or freshwater pearl mussels Watercourses with diverse morphological features such as pools and riffles Dynamic watercourses showing evidence of channel migration and other morphological changes such as bar evolution Watercourses or floodplains, with direct flood risk to adjacent populated areas and/or presence of critical infrastructure such as schools and hospitals etc, which are highly sensitive to increased flood risk by the possible increase in water levels Watercourses or floodplains that provide critical flood alleviation benefits Principal groundwater aquifer supporting public water supply Groundwater Source Protection Zone (SPZ) 1 – Inner Protection Zone or 2 – Outer Protection Zone Good WFD Overall Status Groundwaters
High	Medium or small watercourses with minor degradation of water quality as a result of anthropogenic factors Good WFD Overall Status Watercourses Watercourses supporting minor/non-critical public drinking water supplies Designated Cyprinid fisheries with imperative and guideline limit passes Water dependent ecosystems of regional/county biodiversity value Watercourses supporting some species and habitats sensitive to changes in suspended sediment concentrations and turbidity Watercourses with some morphological features such as pools and riffles Watercourses showing some evidence of historic channel migration and other morphological changes Watercourses or floodplains, with a possibility of direct flood risk to less populated areas without critical infrastructure, which are sensitive to increased flood risk by the possible increase in water levels Watercourses or floodplains that provide significant flood alleviation benefits Principal groundwater aquifer supporting private water supply or secondary groundwater aquifer supporting public/private water supply Groundwater SPZ 3 – Source Catchment Protection Zone Good WFD Overall Status Groundwaters

Medium	Small watercourses with degradation of water quality as a result of anthropogenic factors Moderate WFD Overall Status Watercourses Watercourses supporting private drinking water supplies or for agricultural/industrial use Designated Cyprinid fisheries with imperative limit passes but guideline limit failures Water dependent ecosystems of county/district biodiversity value Watercourses supporting limited species and habitats sensitive to changes in suspended sediment concentrations and turbidity Watercourses with limited morphological diversity Watercourses showing limited evidence of historic channel migration and other morphological changes Watercourses or floodplains, with a possibility of direct flood risk to high value agricultural areas, which are moderately sensitive to increased flood risk by the possible increase in water levels Watercourses or floodplains that provide some flood alleviation benefits Principal/secondary A groundwater aquifer not currently supporting a drinking water supply Poor WFD Overall Status Groundwaters
Low	Small heavily modified watercourses or drains with poor water quality as a result of anthropogenic factors Poor/Bad WFD Overall Status Watercourses Watercourses not supporting water abstractions Water dependent ecosystems of local/less than local biodiversity value Watercourses which do not support any significant species and habitats sensitive to changes in suspended sediment concentrations and turbidity Watercourses with no morphological diversity Watercourses showing no evidence of active fluvial processes and unlikely to be affected by modification to boundary conditions Watercourses or floodplains passing through low value agricultural areas, which are less sensitive to increased flood risk by the possible increase in water levels Watercourses or floodplains that provide limited flood alleviation benefits Secondary B aquifers / unproductive strata / no aquifers Poor WFD Overall Status Groundwaters

Impact Magnitude

7.4.51 The magnitude of impacts are evaluated using the criteria shown in Table 7-8.

Table 7-8: Impact Magnitude Criteria

Magnitude	Criteria
Major Adverse	High risk of pollution during construction, significant temporary or long-term change in water quality, resulting in a permanent change in WFD status Failure of both soluble and sediment bound pollutants in HAWRAT and EQS compliance failure Risk of pollution from accidental spillage during operation > 2% annually Major change in geomorphological conditions ie major changes in sediment patterns due to deposition or erosion, major reduction in morphological diversity, or major interruption to fluvial processes such as channel planform evolution, all with significant consequences for ecological quality Major groundwater flow changes with significant consequences on nearby groundwater dependent habitats/abstractions Increase in the peak flood level of >100mm for the 1% annual probability (1 in 100 year) flood Significant increase in extent of Zone 2 and 3 flood risk areas as defined in NPPF and EA strategic flood maps.
Moderate Adverse	Moderate risk of pollution during construction, moderate temporary change in water quality, resulting in a temporary change of WFD status Failure of both soluble and sediment bound pollutants in HAWRAT but compliance with EQS limits Risk of pollution from accidental spillage during operation > 1% annually Moderate change in geomorphological conditions ie moderate changes in sediment patterns due to deposition or erosion, moderate changes in morphological diversity, or moderate interruption to fluvial processes such as channel planform evolution, all with moderate consequences for ecological quality Moderate groundwater flow changes with minor consequences on nearby groundwater dependent habitats/abstractions Increase in the peak flood level of >50mm for the 1% annual probability (1 in 100 year) flood Moderate increase in extent of Zone 2 and 3 flood risk areas as defined in NPPF and EA strategic flood maps.
Minor Adverse	Minor risk of pollution during construction, relatively minor temporary changes in water quality such that ecology is temporarily affected. Equivalent to a temporary minor, but measurable, change within WFD status class Failure of either soluble and sediment bound pollutants in HAWRAT but compliance with EQS limits Risk of pollution from accidental spillage during operation > 0.5% annually Minor change in geomorphological conditions ie minor changes in sediment transport, minor changes in morphological diversity, or minor interruption to fluvial processes such as channel planform evolution, all with minimal impact on ecological quality. Any changes are likely to be highly localised Minor groundwater flow changes with minimal impact on nearby groundwater dependent habitats/abstractions Increase in the peak flood level of >10mm for the 1% annual probability (1 in 100 year) flood Minor increase in extent of Zone 2 and 3 flood risk areas as defined in NPPF and EA strategic flood maps, magnitude of change similar to the errors associated with the estimate of the extent

Negligible	Negligible risk of pollution during construction, very slight temporary change in water quality with no discernible effect on watercourse ecology All elements of HAWRAT and EQS assessments passed Risk of pollution from accidental spillage during operation < 0.5% annually Negligible change in geomorphological conditions ie No discernible changes in sediment patterns, negligible changes in morphological diversity, no change to fluvial processes, all with no discernible impact on ecological quality. Any changes are likely to be highly localised Negligible groundwater flow changes with no discernible impact on nearby groundwater dependent habitats/abstractions Increase in the peak flood level of <10mm for the 1% annual probability (1 in 100 year) flood No discernible increase in extent of Zone 2 and 3 flood risk areas, as defined in NPPF and EA strategic flood maps, the magnitude of change being much less than errors associated with the estimate of the extent.

Impact Significance

7.4.52 The estimation of the impact significance has been arrived at by combining the estimated importance of the affected waterbodies and the magnitude of the impacts using the matrix shown in Table 7-9 below. Where the significance is shown as being one of two alternatives a single description is provided based upon reasoned judgement of the specific case.

Table 7-9: Impact Significance Matrix

Importance of Waterbody	Magnitude of Impact			
	Major	Moderate	Minor	Negligible
Very High	Very Large	Large/Very Large	Moderate/Large	Neutral
High	Large/Very Large	Moderate/Large	Slight/Moderate	Neutral
Medium	Large	Moderate	Slight	Neutral
Low	Slight/Moderate	Slight	Neutral	Neutral

7.5 Baseline Environment

Context

7.5.1 The Proposed Scheme corridor lies on the eastern edge of Lincoln, running broadly north to south. The northern and southern ends of the scheme lie on the gently undulating higher ground of the limestone escarpment known as the Lincoln Edge, while the central section crosses the valley of the River Witham, where it flows through the Lincoln Gap. Elevations to the northern end of the Proposed Scheme are approximately 35mAOD, falling to less than 5mAOD in the River Witham valley and rising to approximately 55mAOD to the southern end of the Proposed Scheme.

7.5.2 The Proposed Scheme lies within an area of predominantly agricultural land on the urban fringe of Lincoln.

7.5.3 The principal watercourses of the study area comprise the Reepham Beck and Greetwell Fields Drain in the north; the North Delph, River Witham, South Delph, and Canwick Fen Drain which flow parallel to each other in the River Witham valley; and the Branston Brook Tributary and Ashfield Beck in the south of the study area. All of these watercourses eventually drain in to the River Witham and Delph system.

7.5.4 The photographs taken during the site visit (05/12/2012) are presented in Table 7-10.

Table 7-10: Site Visit Photographs

Photograph Number	Photograph	Approximate Grid Reference	Comment
1 – picture taken 05/12/2012		500715, 373225	Reepham Beck
2 – picture taken 05/12/2012		500715, 373225	Reepham Beck
3 – picture taken 05/12/2012		500612, 373300	Field to the south of Wragby Road and west of Reepham Beck

Photograph Number	Photograph	Approximate Grid Reference	Comment
4 – picture taken 05/12/2012		500567, 373385	Surface water runoff outfall into Reepham Beck, upstream of Wragby Road
5 – picture taken 05/12/2012		500567, 373385	Upstream face of Reepham Beck culvert under Wragby Road
6 – picture taken 05/12/2012		500567, 373385	Upstream face of crossing over Reepham Beck for access (see Photograph 7)
7 – picture taken 05/12/2012		500567, 373385	Access crossing over Reepham Beck

Photograph Number	Photograph	Approximate Grid Reference	Comment
8 – picture taken 05/12/2012		500594, 373355	Surface water outfall in to Reepham Beck, upstream of Wragby Road. Likely to convey flows from southern side of Wragby Road roundabout
9 – picture taken 05/12/2012		500594, 373355	Downstream face of Reepham Beck culvert under Wragby Road
10 – picture taken 05/12/2012		500594, 373355	Reepham Beck along Wragby Road before turning south
11 – picture taken 05/12/2012		500594, 373355	Reepham Beck along Wragby Road before turning south

Photograph Number	Photograph	Approximate Grid Reference	Comment
12 – picture taken 05/12/2012		500714, 373042	View from Hawthorn Road looking towards Wragby Road
13 – picture taken 05/12/2012		500714, 373042	View along Hawthorn Road towards Reepham – shows existing surface water road drainage manhole
14 – picture taken 05/12/2012		501446, 371739	Railway from bridge over railway along Greatwell Road / Fiskerton Road
15 – picture taken 05/12/2012		501533, 370931	South Delph looking towards Lincoln, taken from foot bridge at Ferry Lane

Photograph Number	Photograph	Approximate Grid Reference	Comment
16 – picture taken 05/12/2012		501513, 370971	River Witham looking towards Lincoln
17 – picture taken 05/12/2012		501335, 370921	River Witham looking towards Lincoln
18 – picture taken 05/12/2012		501012, 370826	South Delph. Eastern face of now unused crossing
19 – picture taken 05/12/2012		500892, 370808	South Delph. Western face of now unused crossing

Photograph Number	Photograph	Approximate Grid Reference	Comment
20 – picture taken 05/12/2012		500004, 370903	River Witham looking towards Lincoln
21 – picture taken 05/12/2012		500269, 370878	South Delph and rural land beyond to the south
22 – picture taken 05/12/2012		500964, 370848	River footpath that crossing piers are proposed to be placed
23 – picture taken 05/12/2012		501341, 370738	View of / from B1190 towards South Delph /Witham/North Delph inc existing surface water drainage provision in kerb

Photograph Number	Photograph	Approximate Grid Reference	Comment
24 – picture taken 05/12/2012		499676, 368720	View of "spring" location to the south of Lincoln Road
25 – picture taken 05/12/2012		499821, 368650	Branston Brook tributary downstream of "spring" and Lincoln Road
26 – picture taken 05/12/2012		499906, 368640	Branston Brook tributary downstream of "spring" and Lincoln Road
27 – picture taken 05/12/2012		500081, 367400	View across field towards water body

Photograph Number	Photograph	Approximate Grid Reference	Comment
28 – picture taken 05/12/2012		500456, 367535	Private pond/lake of Ashfield House
29 – picture taken 05/12/2012		500531, 367535	Private pond/lake of Ashfield House
30 – picture taken 05/12/2012		500566, 367555	View, looking upstream, of the watercourse from pond/lake before it flows under Ashfield House access road
31		500591, 367530	View, looking downstream, of the watercourse from pond/lake downstream of Ashfield House access road

Rainfall

7.5.5 East Anglia has a temperate maritime climate characterised by cool summers and mild, wet winters. Rainfall in the Lincoln area is relatively low due to the 'rain shadow' effect of the high ground of the Peak District. The standard annual average rainfall (SAAR) for the site has been estimated from the Flood Estimation Handbook (FEH) CD-ROM as 600mm. To put this into context these values can be compared with annual totals of about 500mm in the drier parts of eastern England and over 4000mm in the western Scottish Highlands. The seasonal rainfall pattern of the study area can be seen in the average monthly rainfall data collected at the Waddington gauging station, shown in Table 7-11.

Table 7-11: Average Monthly Rainfall at Waddington (68m AOD)

Time Period	Rainfall (mm)
January	49.18
February	39.29
March	42.25
April	43.93
May	47.00
June	53.88
July	56.93
August	63.42
September	49.86
October	50.77
November	55.41
December	51.21
Year	603.15

7.5.6

Surface Watercourses

7.5.7 The key surface water and features of the study area are shown in Figure 1030171-LEB-HYD-001.

Hydrology & Flood Risk

7.5.8 The principal watercourses from north to south of the Proposed Scheme comprise the Reepham Beck, Wragby Road Ditch, Greetwell Fields Drain, North Delph, River Witham, South Delph, Canwick Fen Drain, Branston Brook Tributary and Ashfield Beck. Most of these watercourses eventually drain in to the River Witham and Delph system.

7.5.9 In addition to the principal watercourses there is a network of small streams, drains and ditches throughout or within close proximity of the corridor, including the land drainage ditches within the River Witham and Delph system corridor.

Due to historic land use and urbanisation many of the surface waters of the study area are heavily modified due to realignment, straightening and culverting. This, in addition to the generally flat topography, has resulted in poorly defined catchment boundaries for some of the watercourses.

Reepham Beck/Wragby Road Ditch

7.5.10 The Reepham Beck/Wragby Road Ditch is located adjacent to the A15/A158 roundabout. The Reepham Beck crosses under Wragby Road from north to south. This watercourse flows from the urban edge of Lincoln towards and through Reepham to the east. It has a combination of straight, man-made and naturally meandering sections and is not associated with notable flood risk in proximity of the Proposed Scheme.

Greetwell Fields Drain

7.5.11 The Greetwell Fields Drain is located to the south of Hawthorn Road. It receives surface water runoff from the surrounding agricultural land and drains south west into a large pond on the edge of Greetwell Quarry. It is not associated with notable flood risk in proximity of the Proposed Scheme.

North Delph, River Witham, South Delph and Canwick Fen Drain

7.5.12 The North Delph is a large drain administered by the Witham Third District Internal Drainage Board and is located within the floodplain for the 1 in 100 year flood event associated with the River Witham and Delph system corridor in the area of the Proposed Scheme. It originates near works at NGR SK 990711 and runs parallel to the River Witham until Bardney. Flows in the North Delph are controlled by pumps at Greetwell and Short Ferry which discharge into the River Witham.

7.5.13 The River Witham flows northwards along the foot of the Lincoln Edge escarpment before turning eastwards through the Lincoln Gap at an elevation of below 5mAOD. Downstream of Lincoln, the river gradually turns southwards and flows through Boston before discharging to the Wash. The River Witham is a main river with a substantial natural floodplain, upon which most of the southern part of Lincoln lies. All of the waterways surrounding Lincoln have a long history of modification, indicated by the almost straight path of the Witham from Lincoln to Bardney.

7.5.14 The South Delph is a man-made channel on the south side of the River Witham, and is classed as a main river. It originates to the south of Lincoln at the point where the Catchwater Drain meets the River Witham at NGR SK 969 695. At this point, the watercourse is known as the Sincil Dyke. It branches off to the east, before flowing north and then east again at New Boultham, where it becomes the

South Delph. The watercourse then runs approximately 50m south of and parallel to the River Witham until Bardney Lock.

7.5.15 Canwick Fen Drain (also known as Soak Dyke), is administered by the Witham First Internal Drainage Board. This drain becomes Longstrongs Delph approximately 1km east of the proposed bypass before discharging into the South Delph via a pumping station at NGR TF 042 714. The Canwick Fen Drain is maintained by the Witham First IDB and flows are controlled by pumps at Sandhill Beck which discharge into the River Witham.

7.5.16 Fluvial flooding is currently well managed in the River Witham catchment, meaning there is a limited number of people and properties at flood risk. The fluvial defences protecting this area consist of earth embankments and upstream flood storage reservoirs. Consultation with the Environment Agency indicated that the raised defences are in good/fair condition with an official Standard of Protection (SoP) (that includes calculated freeboard for the defence) against a flood event with a 20% chance of occurring in any year (1 in 5) and with an Annual Exceedance Probability (AEP) of over topping against a flood event with 1% chance of occurring in any year (1 in 100). The Environment Agency inspects these defences regularly to ensure that any potential defects are identified early.

7.5.17 The SoP and AEP differ for the defence embankment as the SoP considers defence strength while the AEP is based on comparison of water level against embankment crest level for any given flood event. The embankments are historic flood defences that have not been built to current day structural strength standards for flood defences. As such there is a reduction in bank strength with rising water levels beyond the 1 in 5 year flood event. In theory the embankments crests are high enough to provide protection for the 1 in 100 year flood event but once water levels are above the 1 in 5 year flood event there is increasing risk of breach of the defence.

7.5.18 With these defences in place the 1 in 100 year flood event flows are retained within channel for the North Delph and River Witham, however, overtopping of the southern bank of the South Delph occurs. These flows enter the Canwick Fen Drain, but do not extend into the wider floodplain in the location of the Proposed Scheme embankments.

7.5.19 However, when taking climate change into account, flood defences might provide less than the 1% AEP protection. The main findings of the Environment Agency broad scale modelling in the River Witham catchment area are: very little flooding expected for the 1 in 10 year event (no flooding was predicted for this event in current conditions) and an increase in the 1 in 100 year flood extent.

7.5.20 The Anglian Water Canwick Sewage Treatment Works (STW) is located to the south of the Witham Valley watercourses, between the Washingborough Road and the railway line (NGR 499922, 370472). Under normal conditions and less severe storm events the treated effluent and storm water pumps discharge into the South Delph. However, during a severe storm event, the discharge is restricted due to high water levels within the South Delph. Under these circumstances we believe that the storm water overflows inundate the floodplain between the Canwick Fen Drain and the railway embankment. Anglian Water have no additional contingency plans for severe storm conditions.

Branston Brook Tributary and Ashfield Beck

7.5.21 The Branston Brook and Ashfield Beck are two watercourses that dissect the southern limestone plateau and lie in the vicinity of the route. These both flow eastwards and form part of a series of streams draining off the plateau and into a network of channels and ditches in the fens area further east.

7.5.22 Branston Brook is the most northerly of the streams which arises near Canwick Heath Farm close to the Lincoln Road. The more southerly stream, Ashfield Beck, arises south west of Westfield Farm.

7.5.23 Neither of these watercourses are associated with notable flood risk in proximity of the Proposed Scheme.

Geomorphology

7.5.24 The Reepham Beck is characterised as a small stream that has been artificially modified. Insignificant flow was observed on the day of the survey. The watercourse flows south east flowing along the boundary of an agricultural field up to a culvert. The watercourse at this point is approximately 2.0m wide and 1.5m deep with over steepened channel sides. The river channel is heavily vegetated on all sides. The bed material comprises of muds and silts with very little geomorphological diversity. At the culvert under the A158 the Reepham Beck has been increased in width and depth. The bed of the watercourse comprises of muds and silts, however the channel sides comprised of reinforced concrete and masonry brick. Immediately downstream of the A158 the watercourse is directed north east for approximately 20m, before being redirected again south east. The watercourse beyond the culvert narrows and is heavily vegetated on both sides. The bed material comprises of muds and silts with very little geomorphological diversity.

7.5.25 The Greetwell Fields Drain was concealed by dense vegetation and was difficult to access on the day of the survey. However the drain appears to be a small stream flowing approximately west to east. Topographic data identifies the drain to be marginally smaller than the Reepham Beck to the north. Given the proximity of the Reepham Beck and the similarity of catchment characteristics, the Greetwell Fields Drain is expected to be of a similar condition. Therefore, geomorphological diversity is considered to be low.

7.5.26 The North Delph could not be accessed during the site visit. However, based on the data collated during the desk study exercise, the North Delph is understood to be a large, straight, man-made drain approximately 5m in width. It is assumed that the drain has relatively steep banks and a low longitudinal gradient, and is likely to have a bed of mud and silt. The North Delph is maintained by the Witham First District IDB, it is assumed that the maintenance regime includes regular bankside and channel vegetation clearance and dredging. Therefore it is assumed that the North Delph has limited geomorphological diversity.

7.5.27 The River Witham has been heavily modified, artificially straightened and is confined by the North and South Delph watercourses in the valley bottom. The river channel is approximately 25m - 30m wide and 2m deep, with a very low gradient, at the proposed highway bridge crossing; and is maintained as a navigable waterway. Flood embankments have been constructed along the length of the riverbanks. The riverbanks are well vegetated and gently sloping. The watercourse is restricted and unable to migrate across the associated flood plain. There is very little geomorphic activity on this watercourse within the study area.

7.5.28 The South Delph is a man-made, straight channel in the valley bottom. The river channel is approximately 10m wide and approximately 2m deep at the proposed highway bridge crossing. Flood embankments have been constructed along the length of the riverbanks. The riverbanks are well vegetated and are relatively steep. There is very little geomorphic activity on this watercourse within the study area.

7.5.29 The Canwick Fen Drain is also man-made and used to capture seepage through the flood embankment in times of flood, in addition to draining a small area of agricultural land. The drain channel is approximately 1-2m wide and approximately 0.5m deep at the proposed highway bridge crossing. The drain is maintained by the Witham Third District IDB, it is assumed that the maintenance regime included regular bankside and channel vegetation clearance. There is very little geomorphic activity on this watercourse within the study area.

7.5.30 The Branston Brook Tributary is characterised as a small stream rising and flowing through agricultural land. Low flow was observed on the day of the survey. The watercourse flows north west to east flowing along the boundary of an agricultural field. The watercourse at this point is approximately 1-2m wide and 0.5m deep with over steepened channel sides. The river channel is heavily vegetated on all sides concealing the river channel. The bed material comprises of muds and silts and gravels. There is very little geomorphological diversity within the river channel.

7.5.31 The Ashfield Beck, in common with the Branston Brook Tributary, is a small stream flowing through agricultural land. Sections of the channel have been modified, straightened and dammed to create small ponds and reservoirs used for irrigation. In the vicinity of the Proposed Scheme the watercourse is approximately 1-2m wide and 0.5m deep, with over steepened banks which are heavily vegetated. The bed material comprises silt, sand and gravel. There is little geomorphological diversity within the river channel.

7.5.32 In summary, based on the information presented above, all watercourses in the study area have been assessed as having low importance for geomorphology.

Surface Water Quality & Biodiversity

7.5.33 The River Witham and the South Delph within the study area have been designated as part of the Lower Witham WFD waterbody (GB105030062420) and are classed as heavily modified waterbodies, due to extensive historical modifications to the channel for land drainage and navigation. The current WFD ecological status of the Lower Witham waterbody is ‘Moderate Potential’, due to reduced levels of fish, macrophytes and phytobenthos, and elevated levels of phosphorous. This is likely as a result of diffuse pollution from agricultural fertilizers and point source pollution from sewage discharges. The chemical status of the waterbody is ‘Good’.

7.5.34 The River Witham is designated under the FFD as a Cyprinid fishery ie capable of supporting species such as tench, roach, chub and minnow. Under the FFD there are two levels of compliance - guideline and imperative. The imperative limits are essentially a minimum water quality standard that must be achieved for the watercourse to achieve its fisheries potential, while the guideline limits are an optimum to aim for. The River Witham in the vicinity if the Proposed Scheme is passing the imperative water quality limits, but failing the guideline limits. The South Delph is not designated under the FFD.

7.5.35 Both the River Witham and the South Delph are important resources for local anglers, with significant populations of Roach, Common Bream and Pike. Spined Loach are also abundant in the Witham and are of particular interest as they are nationally rare, being restricted to slow-flowing East Midlands rivers.

7.5.36 The River Witham is also designated under the Nitrates Directive and Urban Waste Water Directive.

7.5.37 The Reepham Beck, Greetwell Fields Drain, North Delph, Canwick Fen Drain, Branston Brook Tributary and Ashfield Beck are not designated under the WFD, however they are all tributaries of the Lower Witham (the Reepham Beck via Barlings Eau). The water quality of these watercourses, in common with the Lower Witham, is likely to be affected by diffuse pollution from agricultural fertilisers, although point source pollution from sewage discharges is unlikely. It is therefore assumed that the water quality of these watercourses is broadly similar ot the Lower Witham, and if designated under the WFD would be classified as ‘Moderate’ status.

7.5.38 None of these smaller watercourses are designated under the FFD and no information is available on their fisheries interests.

7.5.39 The North Delph, River Witham, and South Delph lie within the Witham Corridor Local Wildlife Site (LWS) and as such the project ecologists have assessed these watercourses as having a biodiversity value at County level.

7.5.40 The remaining watercourses are considered to have as having a biodiversity value at Local or less than Local level.

7.5.41 Based on the information presented above the water quality and biodiversity of all the watercourses in the study area is considered to be of medium importance.

Surface Water Resources

7.5.42 There are several licensed abstractions on the North Delph for agricultural spray irrigation. Due to the nature of these abstractions water is abstracted from multiple points along a reach of the watercourse which extends both upstream and downstream of the Proposed Scheme.

7.5.43 Similarly there are a number of abstraction licences for the Branston Brook Tributary and Ashfield Beck for irrigation water. These are located downstream of the LEB, the closest located approximately 200m downstream on the Branston Brook Tributary.

7.5.44 There is also one abstraction from the River Witham in the vicinity of the LEB, this is located approximately 1km upstream and is used for industrial process water.

7.5.45 There are no known abstractions from the remaining watercourses within the study area.

7.5.46 There is one known discharge into the North Delph, located approximately 1km upstream of the LEB, for surface water runoff from an industrial site.

7.5.47 There are two discharges on the South Delph within the study area, one an effluent discharge from Canwick Sewage Treatment Works, the other a storm water sewage discharge.

7.5.48 There are no known discharges to the remaining watercourses of the study area within 1km of the Proposed Scheme.

7.5.49 Therefore the water resource attribute of the North Delph, River Witham, Branston Beck Tributary and Ashfield Beck is considered to be of medium importance.

7.5.50 The water resource attribute of the Reepham Beck, Greetwell Fields Drain, South Delph and Canwick Fen Drain is considered to be of low importance.

Standing Waters

7.5.51 There are several small ponds within the study area. The Greetwell Fields Drain links two ponds, one which lies within the Proposed Scheme footprint and the other which lies approximately 400m west of the Proposed Scheme. There is also a large pond within Greetwell Quarry, which lies within 250m of the Proposed Scheme. In addition there are several small ponds scattered within the low lying area immediately north of the North Delph.

7.5.52 There is no water quality data available for these ponds, nor are they designated under the WFD, due to their small size.

7.5.53 Ponds support populations of common toad, common frog and smooth newt and are considered to have a biodiversity value at a local level.

7.5.54 Consequently the water quality and biodiversity of the standing waters is considered to be of medium sensitivity.

Groundwater

Geology

7.5.55 The geology of the area of the proposed route is shown on Figure 1030171-LEB-HYD-002. The geology of the study area is summarised below and described in detail in Chapter 8.

7.5.56 In the study area superficial deposits are present only along the watercourses. Recent alluvium and river terrace deposits are associated with the floodplain of the River Witham, between the Lincoln to Market Rasen railway and Washingborough Road, Ch. 2100 to Ch. 3100. Other occurrences of recent alluvium are two narrow bands along the Branston Brook Tributary and the Ashfield Beck.

7.5.57 The bedrock geology is entirely Jurassic in age. The oldest rocks in the succession are Lower Lias clays and shales, Upward in the sequence are the Middle Jurassic strata of the Northampton Sand Formation, the Grantham Formation (thin or absent in the area) and the Lincolnshire Limestone Formation. The Lincolnshire Limestone is overlain by the Middle Jurassic strata including the Rutland Formation, the Blisworth Limestone Formation, the Blisworth Clay

Formation, the Cornbrash Formation, the Kellaways Formation and the Oxford Clay Formation.

7.5.58 Due to the dip of the strata, the succession broadly outcrops in bands orientated north-south, with the strata becoming progressively younger towards the east. The older rocks of the Lower Lias outcrop in the lower ground to the west of the study area, and in the valley of the River Witham where it passes through the Lincoln Gap. The Lincolnshire Limestone forms the escarpment and high plateau of the Lincoln Edge, with the Northampton Sand Formation outcropping at the feet of the escarpment and River Witham valley. To the east of the study area the more steeply dipping younger strata of the Rutland, Blisworth etc formations outcrop in thinner bands.

7.5.59 To the north of the River Witham the full succession is cut and exposed by a group of faults known as the Washingborough-Scopwick fault belt.

7.5.60 Therefore, travelling from north to south, the Proposed Scheme will cross outcrops of the younger Rutland, Blisworth etc formations on the higher ground between Ch. 0 and Ch. 1400, the Lincolnshire Limestone between Ch.1400 and Ch. 2100, the Northampton Sands and Ironstones and Lower Lias Clay between Ch. 2100 and Ch. 3300 where the route drops into and back out of the River Witham valley, and finally the Lincolnshire Limestone on the high ground south of Ch. 3300. Lias Clay is also revealed in the bed of the Branston Brook Tributary, Ch. 5050, where the watercourse has cut down through the overlying limestone.

7.5.61 The Lincolnshire Limestone is subdivided into Upper and Lower Lincolnshire Limestone. The Upper Lincolnshire Limestone is predominantly a coarse, shelly cross-bedded oolite and the Lower Lincolnshire Limestone is mainly fine-grained, micritic and peloidal (BGS/EA 2006). The Lincolnshire Limestone has a variable thickness, typically about 30m and up to 40m in the south (BGS 1997). Borehole logs from the site 2009 investigation data (Jacobs, 2009) demonstrate that beneath the proposed route the Lincolnshire Limestone is at least 10m thick.

Hydrogeology, Aquifer Classification and Groundwater Vulnerability

7.5.62 The groundwater vulnerability of the study area is shown in Figure 1030171-LEB-HYD-003.

7.5.63 The alluvium and river terrace deposits in the floodplain of the River Witham are designated as Secondary A type aquifers of High Vulnerability due to their relative permeability and importance as the source for river base flow. There are no licensed groundwater abstractions from the alluvium and river terrace deposits, however there are licensed surface water abstractions from the River Witham.

7.5.64 The alluvial deposits associated with the Branston Brook Tributary and Ashfiled Beck are not included in the aquifer designation. However the deposits associated with the Branston Brook Tributary (Ch. 5050) are classified as having Intermediate Vulnerability.

7.5.65 The Lincolnshire Limestone is a Principal Aquifer of High Vulnerability. The older strata (Lias Clay Formation and Northampton Sand Formation) and the younger strata (Rutland Formation, Blisworth Limestone Formation, Blisworth Clay Formation, Cornbrash Formation and the Kellaways Formation) are a succession of aquifers and aquitards grouped together and classified as Secondary Aquifers. The Rutland and the Blisworth Clay Formations are Non-Aquifers, while the Blisworth Limestone, Cornbrash and Kellaways Formations are Secondary B type aquifers of High Vulnerability. The high vulnerability is due to the lack of drift deposits to attenuate potential pollutants infiltrating from the surface. The Oxford clay formation is classified as non-productive strata or Non-Aquifer.

7.5.66 The Northampton Sand and Ironstone is expected to be in hydraulic continuity with the overlying Lincolnshire Limestone.

7.5.67 The Lincolnshire Limestone is a hard, fractured aquifer and groundwater movement occurs almost exclusively via fracture flow. It is unconfined to the south of the River Witham valley where it outcrops, and confined in the area of faulting to the north of the Witham valley where it is overlain by the younger formations. Groundwater recharge in the Lincolnshire Limestone is mainly through direct rainfall infiltration in the outcrop areas but also focussed recharge through swallow holes and seepage from rivers and streams. The general groundwater flow direction is down-dip ie west to east with a hydraulic gradient of 0.006m/m (BGS/EA 2006). To the east, where the aquifer is confined by the Middle Jurassic clays, it becomes increasingly artesian in nature. The rest of the groundwater discharges through springs and provides baseflow for streams (BGS/EA 2006, BGS 2007).

7.5.68 To the north the groundwater levels are approximately 30mAOD, falling to approximately 1-2mAOD in the River Witham floodplain, as confirmed by the 2008 LEB site investigation (Jacobs 2009).

7.5.69 To the north of the River Witham the discharge of groundwater from springs at the outcrop of the boundary between the Lincolnshire Limestone/Northampton Sand and the Lias Clay provides the source of the Greetwell Beck (northern side of Greetwell Road at the south west corner of a former limestone quarry). The two other surface watercourses in the north of the study area, the Reepham Beck and the Greetwell Fields Drain, are located at a higher topographical elevation than the Greetwell Beck, on younger, less permeable strata and are unlikely to be hydraulically connected to the main groundwater body (Jacobs 2009). As the alluvial deposits of the River Witham are in contact with the Lias

Clays it is considered unlikely that they are receiving significant quantities of groundwater baseflow from bedrock in the vicinity of the Proposed Scheme.

7.5.70 To the south of the River Witham groundwater flows towards the east/north east with levels falling from 60mAOD at Bracebridge Heath, west of the proposed route, to 30mAOD where the route crosses the Heighington Road, the groundwater levels broadly confirmed by successive site investigations (Jacobs 2009). The levels are also consistent with the springs of the Branston Brook Tributary and the Ashfield Beck. To the east of the Proposed Scheme, data from the EA monitoring borehole at Cliff Lane (Figure 1030171-LEB-HYD-004) from 1983-2012 show a seasonally varying groundwater level between approximately 16.5 and 18.2mOD. Observations from the site investigations in the unconfined part of the Lincolnshire Limestone recorded variation of the groundwater levels between 0.07-2.67m (Jacobs 2009).

7.5.71 In terms of the WFD status the Lincolnshire Limestone (Witham Limestone Unit A) is of good quantitative status and good but deteriorating chemical status, being at risk from drinking water abstractions and from pesticides. Water quality data was provided from the EA for one groundwater monitoring location in the Lincolnshire Limestone (Cliff Lane monitoring borehole, Figure 1030171-LEB-HYD-004). Between 1991 and 2012 the nitrate (as N) concentrations were between 11 and 24mg/l, consistently above the UK DWS of 11.3mg/l. Similar results were recorded for another monitoring location, Ashfield Spring (Figure 1030171-LEB-HYD-004).

Groundwater Abstractions and Source Protection Zones

7.5.72 Groundwater abstractions and public water supply source protection zones are shown in Figure 1030171-LEB-HYD-003.

7.5.73 There is one groundwater abstraction consisting of four wells within 250m of the Proposed Scheme, at the Manor House in Bracebridge Heath (4 wells at NGR SK 9870 6680, SK 9875 6685, SK 9865 6680, and SK 9880 6680). The groundwater abstraction has a deregulated license for 286m^3/yr for general agricultural and domestic use. The depths of the boreholes are unknown but it is considered that the source of the groundwater is from the Lincolnshire Limestone or the underlying Northampton Sand.

7.5.74 Within a 2km radius of the southern section of the Proposed Scheme there are further licensed abstractions, one groundwater and one springwater, identified in the previous assessments of the route as shown in Figure 1030171-LEB-HYD-004, reproduced from the previous study (Jacobs 2009). The groundwater abstraction license is for less than 500m^3/yr for general farming and domestic supply and the source is likely to be from near the base of the Lincolnshire Limestone Formation or underlying Northampton Sand Formation.

7.5.75 Based on the Jacobs, 2009 assessments there are no private, unlicensed abstractions (of less than 20m^3/day) within a 2km radius of the route registered with the various local authorities: West Lindsay District Council, North Kesteven District Council and Lincoln City Council (Jacobs, 2009).

7.5.76 There are two Public Water Supplies (PWS) to the east of the proposed route, Moor Farm and Branston Booth. The Moor Farm PWS is located 3.8km east from the nearest part of the route, while Branston Booth PWS is further away, some 5.1km west of the closest part of the route. Details of the boreholes are not known, but the source of the water is likely to be the confined part of the Lincolnshire Limestone/Northampton Sands, which was estimated to lie at a depth of 30 to 40m. The licensed annual abstraction rates are 1,642,500 and 1,659,318m^3/yr respectively.

7.5.77 The Proposed Scheme is almost entirely within the outer groundwater protection zone (SPZ 2) for these abstractions, with the exceptions of the section between Washingborough Road and Sheepwash Grange where the route passes through the total catchment (SPZ 3), and the floodplain of the River Witham which is outside the SPZ.

7.5.78 The previously undertaken risk assessment (Jacobs 2009) considered the two PWS, in addition to the streams that are considered to be in hydraulic continuity with the groundwater ie the Greetwell Beck, Branston Brook Tributary and the Ashfield Beck.

Groundwater Importance

7.5.79 For the purposes of thus assessment the various geological strata have been grouped where, based on the information presented above, they have similar groundwater characteristics.

7.5.80 Therefore the Alluvium and River Terrace Deposits are considered as a single water feature, which has been assessed as having medium importance, based on their classification as Secondary A aquifers of high vulnerability.

7.5.81 The Blisworth, Cornbrash and Kellaway formations are considered to have a medium importance, due to their classification as Secondary B aquifers of high vulnerability.

7.5.82 The Lincolnshire Limestone is considered to be of high importance, based on its classification as a Principal aquifer of high vulnerability and due to the presence of several groundwater abstractions and SPZs in this aquifer.

7.5.83 The Northampton Sand is considered to be of medium importance due to its classification as a Secondary aquifer in hydraulic continuity with the Lincolnshire Limestone.

Summary of Importance of Water Environment Features

7.5.84 Table 7-12 below summarises the importance of each feature of the water environment identified along the Proposed Scheme.

Table 7-12: Importance of Water Environment Features along Proposed Scheme

Feature	Attribute	Comment	Importance
Reepham Beck/Wragby Road Ditch	Water Quality & Biodiversity	Assumed ‘Moderate’ WFD status, no FFD designation, local biodiversity value	Medium
	Water Resources	No abstractions, one drainage discharge	Low
	Hydrology and Flood Risk	Small watercourses, primarily receives runoff from surrounding agricultural fields. No notable flood risk is associated with this watercourse in proximity to the Proposed Scheme	Low
	Channel Geomorphology	Small, moderately modified watercourse, low geomorphological activity	Low
Greetwell Fields Drain	Water Quality & Biodiversity	Assumed ‘Moderate’ WFD status, no FFD designation, less than local biodiversity value	Medium
	Water Resources	No abstractions or discharges	Low
	Hydrology and Flood Risk	Small watercourses, primarily receives runoff from surrounding agricultural fields. No notable flood risk is associated with this watercourse in proximity to the Proposed Scheme	Low
	Channel Geomorphology	Small, modified watercourse, low geomorphological activity	Low
North Delph	Water Quality & Biodiversity	Assumed ‘Moderate’ WFD status, no FFD designation, county biodiversity value	Medium
	Water Resources	Several agricultural abstractions, one industrial site surface water runoff discharge	Medium
	Hydrology and Flood Risk	Pumped system with limited capacity for additional runoff; the Proposed Scheme crosses the 1 in 100 year return period floodplain of River Witham and Delph system corridor	High
	Channel Geomorphology	Assumed small, heavily modified watercourse, low geomorphological activity.	Low
River Witham	Water Quality & Biodiversity	‘Moderate’ WFD status, FFD Cyprinid fishery with imperative pass but guideline fail, locally important for angling, county biodiversity value	Medium
	Water Resources	One industrial water abstraction, no discharges	Medium
	Hydrology and Flood Risk	Limited capacity, complex operation and interaction with North and South Delphs; the Proposed Scheme crosses the 1 in 100 year return period floodplain of River Witham and Delph system corridor.	High

Feature	Attribute	Comment	Importance
	Channel Geomorphology	Medium sized, heavily modified watercourse, low geomorphological activity.	Low
South Delph	Water Quality & Biodiversity	‘Moderate’ WFD status, no FFD designation, locally important for angling, county biodiversity value	Medium
	Water Resources	No abstractions, two sewage discharges	Low
	Hydrology and Flood Risk	Limited capacity for additional runoff, complex operation and interaction with the River Witham; the Proposed Scheme crosses the 1 in 100 year return period floodplain of River Witham and Delph system corridor	High
	Channel Geomorphology	Medium sized, heavily modified watercourse, low geomorphological activity.	Low
Canwick Fen Drain	Water Quality & Biodiversity	Assumed ‘Moderate’ WFD status, no FFD designation, local biodiversity value	Medium
	Water Resources	No abstractions or discharges	Low
	Hydrology and Flood Risk	Close proximity to the River Witham and South Delph, interaction with the South Delph; the Proposed Scheme crosses the 1 in 100 year return period floodplain of River Witham and Delph system corridor	Medium
	Channel Geomorphology	Small, artificial watercourse, no geomorphological activity.	Low
Branston Brook Tributary	Water Quality & Biodiversity	Assumed ‘Moderate’ WFD status, no FFD designation, local biodiversity value	Medium
	Water Resources	Several agricultural abstractions, no discharges	Medium
	Hydrology and Flood Risk	Small water course, main purpose of a land drain to carry runoff from surrounding agricultural fields; No notable flood risk is associated with this watercourse in proximity to the Proposed Scheme	Low
	Channel Geomorphology	Small, modified watercourse, low geomorphological activity.	Low
Ashfield Beck	Water Quality & Biodiversity	Assumed ‘Moderate’ WFD status, no FFD designation, local biodiversity value	Medium
	Water Resources	Several agricultural abstractions, no discharges	Medium

Feature	Attribute	Comment	Importance
	Hydrology and Flood Risk	Small watercourse, main purpose of a land drain to carry runoff from surrounding agricultural fields; No notable flood risk is associated with this watercourse in proximity to the Proposed Scheme	Low
	Channel Geomorphology	Small, modified watercourse, low geomorphological activity	Low
Standing Waters	Water Quality & Biodiversity	Several small ponds scattered within the study area, no water quality data, do not support abstractions or discharges,	Medium
Alluvium/River Terrace Deposits	Base Flow to Rivers, Groundwater Flow	Secondary B aquifers, high vulnerability WFD – good status for Blisworth Limestone and Cornbrash Formations; Kellaways and Oxford Clay Formations – not classified No abstractions within the study area	Medium
Blisworth, Cornbrash, Kellaways Formations	Groundwater Flow, River Base Flow	Principal aquifer, high vulnerability WFD – good status, at risk for drinking water and for pesticides One licensed groundwater abstraction within 1km of the proposed route The proposed route is within SPZ2 and SPZ3	Medium
Lincolnshire Limestone	Water Supply, Water Quality, Groundwater Flow, Base Flow to Rivers	Secondary Aquifer in hydraulic continuity with the Lincolnshire Limestone; WFD – not classified	High
Northampton Sand	Groundwater Flow, Base Flow to Rivers	Secondary Aquifer in hydraulic continuity with the Lincolnshire Limestone; WFD – not classified	Medium

7.6 Predicted Impacts

Construction Impacts

7.6.1 No supporting information required for this section.

Operational Impacts

Pollution Related to Routine Runoff & Accidental Spillages

7.6.2 The routine runoff HAWRAT worksheets and accidental spillage worksheets for each of the road drainage networks are presented overleaf.

7.6.3 It should be noted that the impermeable road areas used in the HAWRAT calculations are for the currently proposed single carriageway scheme. If in the future the road is to be upgraded to dual carriageway these calculations would need to be re-visited.

Network A

HIGHWAYS AGENCY

Highways Agency Water Risk Assessment Tool version 1.0 November 2009

Soluble - Acute Impact

Annual Average Concentration

	Copper	Zinc	
Step 2	0.13	0.57	ug/l
Step 3	0.09	0.40	ug/l

Copper: Pass
Zinc: Pass

Sediment - Chronic Impact

Pass

Sediment deposition for this site is judged as:

Accumulating?	Yes	0.05	Low flow Vel m/s
Extensive?	No	37	Deposition Index

Location Details

Road number	Lincoln Eastern Bypass	HA Area / DBFO number	
Assessment type	Non-cumulative assessment (single outfall)		
OS grid reference of assessment point (m)	Easting 500495	Northing	370927
OS grid reference of outfall structure (m)	Easting 500495	Northing	370927
Outfall number	Network A (1, 2, A)	List of outfalls in cumulative assessment	
Receiving watercourse	North Delph		
EA receiving water Detailed River Network ID		Assessor and affiliation	S Sutherland, Mouchel
Date of assessment	07/11/2012	Version of assessment	V2
Notes			

Step 1 Runoff Quality

AADT: >10,000 and <50,000 | Climatic region: Colder Dry | Rainfall site: Lincoln (SAAR 600mm)

Step 2 River Impacts

Annual 95%ile river flow (m^3/s): 0.012 (Enter zero in Annual 95%ile river flow box to assess Step 1 runoff quality only)

Impermeable road area drained (ha): 4.38 | Permeable area draining to outfall (ha): 0

Base Flow Index (BFI): 0.933 | Is the discharge in or within 1 km upstream of a protected site for conservation? No

For dissolved zinc only — Water hardness: Medium = 50-200 CaCO3/l

For sediment impact only — Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge? No

Tier 1 — Estimated river width (m): 5.5

Tier 2 — Bed width (m): 3.5 | Manning's n: 0.035 | Side slope (m/m): 2 | Long slope (m/m): 0.0001

Step 3 Mitigation

	Brief description	Estimated effectiveness: Treatment for solubles (%)	Attenuation for solubles - restricted discharge rate (l/s)	Settlement of sediments (%)
Existing measures		0	Unlimited	0
Proposed measures	2 Attenuation Ponds in series	30	Unlimited	80

Predict Impact

Show Detailed Results

Exit Tool

Back To Top | Return To Interface

Summary of predictions

Prediction of impact	Soluble - Acute Impact: Copper	Zinc	Sediment - Chronic Impact: Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Step1										
Step2										
Step3										

DETAILED RESULTS

In Runoff

Step 1 (Soluble)

RST24	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	24.20	32.80
No. of exceedances/worst year	34	42

RST6	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	4.40	10.70
No. of exceedances/worst year	7	18

		Copper (ug/l)	Zinc (ug/l)
Thresholds	RST24	21	92
Thresholds	RST6	42	184
Event Statistics	Mean	14.88	55.59
	90%ile	29.19	115.45
	95%ile	38.78	151.67
	99%ile	56.45	355.01

Step 1 (Sediment)

Toxicity Threshold

	Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Allowable Exceedances/year	1	1	1	1	1	1	1	1
No. of exceedances/year	42.50	68.30	1.10	34.80	82.10	34.80	16.10	67.10
No. of exceedances/worst year	49	77	4	41	87	41	22	72

	Copper (mg/kg)	Zinc (mg/kg)	Cadmium (mg/kg)	Total PAH (ug/kg)	Pyrene (ug/kg)	Fluoranthene (ug/kg)	Anthracene (ug/kg)	Phenanthrene (ug/kg)
Toxicity	197	315	3.5	16770	875	2355	245	515
Mean	213	806	1	15514	2684	2575	164	726
90%ile	508	1940	1	28184	4876	4679	299	1319
95%ile	662	2637	2	35481	6138	5890	376	1661
99%ile	963	4492	3	89125	15419	14795	945	4171

In River (no mitigation)

Step 2 (Soluble)

RST24	Copper	Zinc
Allowable Exceedances/year	2	2
No. of exceedances/year	0	0.3
No. of exceedances/worst year	0	2
No. of exceedances/summer	0	0.1
No. of exceedances/worst summer	0	1

RST6	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	0	0.1
No. of exceedances/worst year	0	1
No. of exceedances/summer	0	0.1
No. of exceedances/worst summer	0	1
Annual average concentration (ug/l)	0.13	0.57

		Copper (ug/l)	Zinc (ug/l)
Thresholds	RST24	21	92
Thresholds	RST6	42	184
Event Statistics	Mean	0.59	2.72
	90%ile	1.58	5.75
	95%ile	2.54	10.59
	99%ile	5.72	27.55

Step 2 (Sediment)

Velocity	0.05	m/s
DI	184.11	
% settlement needed	46	%

Tier 2 is used for the calculation

In River (with mitigation)

Step 3

		Copper	Zinc
		RST24	
Allowable Exceedances/year		2	2
No. of exceedances/year		**0.00**	**0.30**
No. of exceedances/worst year		0	2
No. of exceedances/summer		0	0.1
No. of exceedances/worst summer		0	1
		RST6	
Allowable Exceedances/year		1	1
No. of exceedances/year		**0.00**	**0.00**
No. of exceedances/worst year		0	0
No. of exceedances/summer		0	0
No. of exceedances/worst summer		0	0
Annual average concentration (ug/l)		0.09	0.40
		(ug/l)	*(ug/l)*
Thresholds hresholds	***RST24***	21	92
Thresholds	***RST6***	42	184
Event Statistics Mean		0.41	1.90
90%ile		1.10	4.02
95%ile		1.78	7.41
99%ile		4.01	19.29

DI	36.82

Details of the chosen rainfall site	
SAAR (mm)	**600**
Altitude (m)	**40**
Easting	**4976**
Northing	**3718**
Coastal distance (km)	**55**

Assessment of Priority Outfalls

Method D - assessment of risk from accidental spillage

Additional columns for use if other roads drain to the same outfall: B, C, D, E, F

		A (main road)	B	C	D	E	F	Totals	Return Period (years)
D1	Water body type	Surface watercourse	Surface watercourse	Surface watercourse					
D2	Length of road draining to outfall *(m)*	2,087	940	249					
D3	Road Type *(A-road or Motorway)*	A	A	A					
D4	If A road, is site urban or rural?	Rural	Rural	Rural					
D5	Junction type	No junction	Roundabout	Side road					
D6	Location	< 1 hour	< 1 hour	< 1 hour					
D7	Traffic flow (AADT two way)	31,210	46,944	22,738					
D8	% HGV	5	6	3					
D8	Spillage factor *(no/10^9 HGVkm/year)*	0.29	3.09	0.93					
D9	Risk of accidental spillage	0.00034	0.00299	0.00006	0.00000	0.00000	0.00000		
D10	Probability factor	0.60	0.60	0.60					
D11	Risk of pollution incident	0.00021	0.00179	0.00003	0.00000	0.00000	0.00000		
D12	Is risk greater than 0.01?	**No**	**No**	**No**					
D13	Return period without pollution reduction measures	0.00021	0.00179	0.00003	0.00000	0.00000	0.00000	0.0020	492
D14	Existing measures factor	1	1	1					
D15	Return period with existing pollution reduction measures	0.00021	0.00179	0.00003	0.00000	0.00000	0.00000	0.0020	492
D16	Proposed measures factor	1	1	1					
D17	Residual with proposed Pollution reduction measures	0.00021	0.00179	0.00003	0.00000	0.00000	0.00000	0.0020	492

Justification for choice of existing measures factors:

Justification for choice of proposed measures factors:

Table D1

Location	Serious Accidental Spillages *(Billion HGV km/ year)*	Motorways	Rural Trunk	Urban Trunk
	No junction	0.36	0.29	0.31
	Slip road	0.43	0.83	0.36
	Roundabout	3.09	3.09	5.35
	Cross road	-	0.88	1.46
	Side road	-	0.93	1.81
	Total	0.37	0.45	0.85

Table 7.1

System	Optimum Risk Reduction Factor
Filter Drain	0.6
Grassed Ditch / Swale	0.6
Pond	0.5
Wetland	0.4
Soakaway / Infiltration basin	0.6
Sediment Trap	0.6
Unlined Ditch	0.7
Penstock / valve	0.4
Notched Weir	0.6
Oil Separator	0.5

Network B

HIGHWAYS AGENCY

Highways Agency Water Risk Assessment Tool version 1.0 November 2009

Soluble - Acute Impact

Annual Average Concentration

	Copper	Zinc	
Step 2	0.73	3.07	ug/l
Step 3	0.51	2.15	ug/l

Copper: Pass
Zinc: Pass

Sediment - Chronic Impact

Pass

Sediment deposition for this site is judged as:

Accumulating?	Yes	0.03	Low flow Vel m/s
Extensive?	No	97	Deposition Index

Location Details

Road number	Lincoln Eastern Bypass	HA Area / DBFO number	
Assessment type	Non-cumulative assessment (single outfall)		
OS grid reference of assessment point (m)	Easting 500395	Northing	370780
OS grid reference of outfall structure (m)	Easting 500395	Northing	370780
Outfall number	Network B	List of outfalls in cumulative assessment	
Receiving watercourse	Carwick Fen Drain		
EA receiving water Detailed River Network ID		Assessor and affiliation	S Sutherland, Mouchel
Date of assessment	07/11/2012	Version of assessment	V2
Notes			

Step 1 Runoff Quality

AADT: >10,000 and <50,000 | Climatic region: Colder Dry | Rainfall site: Lincoln (SAAR 600mm)

Step 2 River Impacts

Annual 95%ile river flow (m^3/s)	0.001	(Enter zero in Annual 95%ile river flow box to assess Step 1 runoff quality only)	
Impermeable road area drained (ha)	3.96	Permeable area draining to outfall (ha)	0
Base Flow Index (BFI)	0.966	Is the discharge in or within 1 km upstream of a protected site for conservation?	No

For dissolved zinc only Water hardness: Medium = 50-200 CaCO3/l

For sediment impact only Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge? No

Tier 1	Estimated river width (m)	2					
Tier 2	Bed width (m)	1.5	Manning's n	0.035	Side slope (m/m)	2	Long slope (m/m) 0.0001

Step 3 Mitigation

	Brief description	Estimated effectiveness: Treatment for solubles (%)	Attenuation for solubles - restricted discharge rate (l/s)	Settlement of sediments (%)
Existing measures		0	Unlimited	0
Proposed measures	2 attenuation ponds in series	30	Unlimited	80

Predict Impact

Show Detailed Results

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Summary of predictions

Prediction of impact	Soluble - Acute Impact: Copper	Zinc	Sediment - Chronic Impact: Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Step1										
Step2										
Step3										

DETAILED RESULTS

In Runoff

Step 1 (Soluble)

RST24		Copper	Zinc
Allowable Exceedances/year		1	1
No. of exceedances/year		**24.20**	**32.80**
No. of exceedances/worst year		34	42

RST6		Copper	Zinc
Allowable Exceedances/year		1	1
No. of exceedances/year		**4.40**	**10.70**
No. of exceedances/worst year		7	18

		Copper *(ug/l)*	Zinc *(ug/l)*
Thresholds	***RST24***	21	92
Thresholds	***RST6***	42	184
Event Statistics	Mean	14.88	55.59
	90%ile	29.19	115.45
	95%ile	38.78	151.67
	99%ile	56.45	355.01

Step 1 (Sediment)

Toxicity Threshold

	Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Allowable Exceedances/year	1	1	1	1	1	1	1	1
No. of exceedances/year	**42.50**	**68.30**	**1.10**	**34.80**	**82.10**	**34.80**	**16.10**	**67.10**
No. of exceedances/worst year	49	77	4	41	87	41	22	72

	Copper *(mg/kg)*	Zinc *(mg/kg)*	Cadmium *(mg/kg)*	Total PAH *(ug/kg)*	Pyrene *(ug/kg)*	Fluoranthene *(ug/kg)*	Anthracene *(ug/kg)*	Phenanthrene *(ug/kg)*
Toxicity	197	315	3.5	16770	875	2355	245	515
Mean	213	806	1	15514	2684	2575	164	726
90%ile	508	1940	1	28184	4876	4679	299	1319
95%ile	662	2637	2	35481	6138	5890	376	1661
99%ile	963	4492	3	89125	15419	14795	945	4171

In River (no mitigation)

Step 2 (Soluble)

RST24		Copper	Zinc
Allowable Exceedances/year		2	2
No. of exceedances/year		**1.3**	**1.8**
No. of exceedances/worst year		3	6
No. of exceedances/summer		0.7	0.7
No. of exceedances/worst summer		2	2

RST6		Copper	Zinc
Allowable Exceedances/year		1	1
No. of exceedances/year		**0.2**	**0.5**
No. of exceedances/worst year		1	3
No. of exceedances/summer		0.1	0.2
No. of exceedances/worst summer		1	1
Annual average concentration (ug/l)		0.73	3.07

		Copper *(ug/l)*	Zinc *(ug/l)*
Thresholds	***RST24***	21	92
Thresholds	***RST6***	42	184
Event Statistics	Mean	3.08	13.01
	90%ile	8.71	31.16
	95%ile	11.55	50.84
	99%ile	21.91	121.52

Step 2 (Sediment)

Velocity	**0.03**	m/s
DI	**485.67**	
% settlement needed	80	%

Tier 2 is used for the calculation

In River (with mitigation)

Step 3

		Copper	Zinc
		RST24	
Allowable Exceedances/year		2	2
No. of exceedances/year		**0.40**	**1.10**
No. of exceedances/worst year		1	5
No. of exceedances/summer		0.1	0.4
No. of exceedances/worst summer		1	1
		RST6	
Allowable Exceedances/year		1	1
No. of exceedances/year		**0.00**	**0.20**
No. of exceedances/worst year		0	1
No. of exceedances/summer		0	0.1
No. of exceedances/worst summer		0	1
Annual average concentration (ug/l)		0.51	2.15
		(ug/l)	*(ug/l)*
Thresholds hresholds	***RST24***	21	92
Thresholds	***RST6***	42	184
Event Statistics Mean		2.16	9.11
90%ile		6.10	21.81
95%ile		8.09	35.59
99%ile		15.34	85.07

DI 97.13

Details of the chosen rainfall site	
SAAR (mm)	**600**
Altitude (m)	**40**
Easting	**4976**
Northing	**3718**
Coastal distance (km)	**55**

Assessment of Priority Outfalls

Method D - assessment of risk from accidental spillage

Additional columns for use if other roads drain to the same outfall: B, C, D, E, F

		A (main road)	B	C	D	E	F	Totals	Return Period (years)
D1	Water body type	Surface watercourse	Surface watercourse						
D2	Length of road draining to outfall *(m)*	1,779	665						
D3	Road Type *(A-road or Motorway)*	A	A						
D4	If A road, is site urban or rural?	Rural	Rural						
D5	Junction type	No junction	Roundabout						
D6	Location	< 1 hour	< 1 hour						
D7	Traffic flow (AADT two way)	31,210	41,807						
D8	% HGV	4	6						
D8	Spillage factor *(no/10^9 HGVkm/year)*	0.29	3.09						
D9	Risk of accidental spillage	0.00024	0.00188	0.00000	0.00000	0.00000	0.00000		
D10	Probability factor	0.60	0.60	0.60					
D11	Risk of pollution incident	0.00014	0.00113	0.00000	0.00000	0.00000	0.00000		
D12	Is risk greater than 0.01?	**No**	**No**	**No**					
D13	Return period without pollution reduction measures	0.00014	0.00113	0.00000	0.00000	0.00000	0.00000	0.0013	787
D14	Existing measures factor	1	1						
D15	Return period with existing pollution reduction measures	0.00014	0.00113	0.00000	0.00000	0.00000	0.00000	0.0013	787
D16	Proposed measures factor	1	1						
D17	Residual with proposed Pollution reduction measures	0.00014	0.00113	0.00000	0.00000	0.00000	0.00000	0.0013	787

Justification for choice of existing measures factors:

Justification for choice of proposed measures factors:

Table D1

	Serious Accidental Spillages *(Billion HGV km/ year)*	Motorways	Rural Trunk	Urban Trunk
Location	No junction	0.36	0.29	0.31
	Slip road	0.43	0.83	0.36
	Roundabout	3.09	3.09	5.35
	Cross road	-	0.88	1.46
	Side road	-	0.93	1.81
	Total	0.37	0.45	0.85

Table 7.1

System	Optimum Risk Reduction Factor
Filter Drain	0.6
Grassed Ditch / Swale	0.6
Pond	0.5
Wetland	0.4
Soakaway / Infiltration basin	0.6
Sediment Trap	0.6
Unlined Ditch	0.7
Penstock / valve	0.4
Notched Weir	0.6
Oil Separator	0.5

Network C

HIGHWAYS AGENCY

Highways Agency Water Risk Assessment Tool version 1.0 November 2009

Soluble - Acute Impact

Annual Average Concentration

	Copper	Zinc	
Step 2	0.31	1.33	ug/l
Step 3	0.22	0.93	ug/l

Copper: Pass
Zinc: Pass

Sediment - Chronic Impact

Pass

Sediment deposition for this site is judged as:

Accumulating?	No	0.25	Low flow Vel m/s
Extensive?	No	-	Deposition Index

Location Details

Road number	Lincoln Eastern Bypass	HA Area / DBFO number	
Assessment type	Non-cumulative assessment (single outfall)		
OS grid reference of assessment point (m)	Easting 500189	Northing	368513
OS grid reference of outfall structure (m)	Easting 500189	Northing	368513
Outfall number	Network C	List of outfalls in cumulative assessment	
Receiving watercourse	Branston Brook Tributary		
EA receiving water Detailed River Network ID		Assessor and affiliation	S Sutherland, Mouchel
Date of assessment	07/11/2012	Version of assessment	V2
Notes			

Step 1 Runoff Quality

AADT: >10,000 and <50,000 | Climatic region: Colder Dry | Rainfall site: Lincoln (SAAR 600mm)

Step 2 River Impacts

Annual 95%ile river flow (m^3/s): 0.005 (Enter zero in Annual 95%ile river flow box to assess Step 1 runoff quality only)

Impermeable road area drained (ha): 5.25 | Permeable area draining to outfall (ha): 0

Base Flow Index (BFI): 0.966 | Is the discharge in or within 1 km upstream of a protected site for conservation? No

For dissolved zinc only Water hardness: Medium = 50-200 CaCO3/l

For sediment impact only Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge? No

Tier 1 Estimated river width (m): 1.5

Tier 2 Bed width (m): 0.75 | Manning's n: 0.035 | Side slope (m/m): 1 | Long slope (m/m): 0.008

Step 3 Mitigation

	Brief description	Treatment for solubles (%)	Attenuation for solubles - restricted discharge rate (l/s)	Settlement of sediments (%)
		Estimated effectiveness		
Existing measures		0	Unlimited	0
Proposed measures	2 attenuation ponds in series	30	Unlimited	80

Predict Impact

Show Detailed Results

Exit Tool

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Summary of predictions

	Soluble - Acute Impact: Copper	Zinc	Sediment - Chronic Impact: Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Prediction of impact Step1										
Step2										
Step3										

DETAILED RESULTS

In Runoff

Step 1 – Soluble

	Copper	Zinc
RST24		
Allowable Exceedences/year	1	1
No. of exceedances/year	**24.20**	**32.80**
No. of exceedances/worst year	34	42
RST6		
Allowable Exceedences/year	1	1
No. of exceedances/year	**4.40**	**10.70**
No. of exceedances/worst year	7	18
	(ug/l)	(ug/l)
Thresholds RST24	21	92
Thresholds RST6	42	184
Event Statistics Mean	14.88	55.59
90%ile	29.19	115.45
95%ile	38.78	151.67
99%ile	56.45	355.01

Step 1 – Sediment

	Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Toxicity Threshold								
Allowable Exceedences/year	1	1	1	1	1	1	1	1
No. of exceedances/year	**42.50**	**68.30**	**1.10**	**34.80**	**82.10**	**34.80**	**16.10**	**67.10**
No. of exceedances/worst year	49	77	4	41	87	41	22	72
	(mg/kg)	(mg/kg)	(mg/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Toxicity	197	315	3.5	16770	875	2355	245	515
Event Statistics Mean	213	806	1	15514	2684	2575	164	726
90%ile	508	1940	1	28184	4876	4679	299	1319
95%ile	662	2637	2	35481	6138	5890	376	1661
99%ile	963	4492	3	89125	15419	14795	945	4171

In River (no mitigation)

Step 2

	Copper	Zinc
RST24		
Allowable Exceedences/year	2	2
No. of exceedances/year	**0.3**	**0.5**
No. of exceedances/worst year	1	3
No. of exceedances/summer	0.3	0.4
No. of exceedances/worst summer	1	2
RST6		
Allowable Exceedences/year	1	1
No. of exceedances/year	**0**	**0.3**
No. of exceedances/worst year	0	2
No. of exceedances/summer	0	0.3
No. of exceedances/worst summer	0	2
Annual average concentration (ug/l)	0.31	1.33
	(ug/l)	(ug/l)
Thresholds RST24	21	92
Thresholds RST6	42	184
Event Statistics Mean	1.35	6.00
90%ile	3.61	13.87
95%ile	5.72	23.03
99%ile	12.49	60.92

Step 2

Velocity 0.25 m/s

Tier 2 is used for the calculation

DI -

% settlement needed - %

In River (with mitigation)

Step 3

		Copper	Zinc
		RST24	
Allowable Exceedances/year		2	2
No. of exceedances/year		**0.00**	**0.30**
No. of exceedances/worst year		0	2
No. of exceedances/summer		0	0.3
No. of exceedances/worst summer		0	2
		RST6	
Allowable Exceedances/year		1	1
No. of exceedances/year		**0.00**	**0.10**
No. of exceedances/worst year		0	1
No. of exceedances/summer		0	0.1
No. of exceedances/worst summer		0	1
Annual average concentration (ug/l)		0.22	0.93
		(ug/l)	*(ug/l)*
Thresholds hresholds	***RST24***	21	92
Thresholds	***RST6***	42	184
Event Statistics Mean		0.95	4.20
90%ile		2.53	9.71
95%ile		4.00	16.12
99%ile		8.75	42.65

DI -

Details of the chosen rainfall site

SAAR (mm)	**600**
Altitude (m)	**40**
Easting	**4976**
Northing	**3718**
Coastal distance (km)	**55**

Assessment of Priority Outfalls

Method D - assessment of risk from accidental spillage

		A (main road)	B	C	D	E	F	Totals	Return Period (years)
			Additional columns for use if other roads drain to the same outfall						
D1	Water body type	Surface watercourse	Surface watercourse						
D2	Length of road draining to outfall *(m)*	2,483	1,174						
D3	Road Type *(A-road or Motorway)*	A	A						
D4	If A road, is site urban or rural?	Rural	Rural						
D5	Junction type	No junction	Roundabout						
D6	Location	< 1 hour	< 1 hour						
D7	Traffic flow (AADT two way)	22,047	34,929						
D8	% HGV	4	5						
D8	Spillage factor *(no/10^9 HGVkm/year)*	0.29	3.09						
D9	Risk of accidental spillage	0.00023	0.00231	0.00000	0.00000	0.00000	0.00000		
D10	Probability factor	0.60	0.60	0.60					
D11	Risk of pollution incident	0.00014	0.00139	0.00000	0.00000	0.00000	0.00000		
D12	Is risk greater than 0.01?	**No**	**No**	**No**					
D13	Return period without pollution reduction measures	0.00014	0.00139	0.00000	0.00000	0.00000	0.00000	0.0015	655
D14	Existing measures factor	1	1						
D15	Return period with existing pollution reduction measures	0.00014	0.00139	0.00000	0.00000	0.00000	0.00000	0.0015	655
D16	Proposed measures factor	1	1						
D17	Residual with proposed Pollution reduction measures	0.00014	0.00139	0.00000	0.00000	0.00000	0.00000	0.0015	655

Justification for choice of existing measures factors:

Justification for choice of proposed measures factors:

Table D1

	Serious Accidental Spillages *(Billion HGV km/ year)*	Motorways	Rural Trunk	Urban Trunk
Location	No junction	0.36	0.29	0.31
	Slip road	0.43	0.83	0.36
	Roundabout	3.09	3.09	5.35
	Cross road	-	0.88	1.46
	Side road	-	0.93	1.81
	Total	0.37	0.45	0.85

Table 7.1

System	Optimum Risk Reduction Factor
Filter Drain	0.6
Grassed Ditch / Swale	0.6
Pond	0.5
Wetland	0.4
Soakaway / Infiltration basin	0.6
Sediment Trap	0.6
Unlined Ditch	0.7
Penstock / valve	0.4
Notched Weir	0.6
Oil Separator	0.5

Increased Flood Risk

7.6.4 The proposed scheme could potentially increase flood risk as a result of development within the floodplain, increased runoff rates and volumes from hardstanding areas and proposed channel modifications such as watercourse realignments.

7.6.5 The scheme has been designed to minimise impinging on floodplain wherever possible. The proposed road crossing of the North Delph, River Witham, South Delph and Canwick Fen Drain has been designed as a five span bridge, with piers located on the banks between the parallel watercourses and abutments set back from the channel banks. The foot bridge across the South Delph will be similarly constructed. However the road bridge abutments and a short (less than 50m) section of road embankment will lie within the 1 in 100 year floodplain of the Witham Valley. Floodplain volume will be lost due to the footprint of the Proposed Scheme embankment and therefore floodplain volume compensation for 1,110m^3, on a level for level basis, is to be provided to mitigate this volume loss.

7.6.6 The peak water levels in the River Witham and South Delph vary between 4.69m to 4.76mAOD for the 100 year event with climate change. The deck level of the bypass bridge is over 9.0mAOD therefore the deck level would not constrict the flow.

7.6.7 The breach analysis was completed by Jacobs in 2009 to the EA requirements on flooding to examine the impact of the development proposals on the flooding experienced in the unlikely event of flood embankment failure. The breach locations assumed are just upstream of the proposed bypass location with peak velocities of 6.4m/s and 3.9m/s occurring at the North Breach location and the South Breach location respectively. The results illustrate that under breach conditions flooding occurs in the north and south floodplain areas respectively, however the breach floodplain does not extend into the urban areas, being retained in the adjacent rural floodplain of the Witham valley.

7.6.8 The LEB proposals will involve the creation of additional impermeable surface area which will be drained by separate road drainage catchments. The proposed discharges from the overall surface water drainage system is to be attenuated to equivalent of greenfield runoff rates to prevent any increase in runoff rate or volume.

7.6.9 Culverts are proposed on the Reepham Beck/Wragby Road Ditch, Greetwell Fields Drain, Canwick Fen Drain and Branston Brook Tributary. These culverts will be designed to accommodate the 1 in 100 year flows plus climate change, thereby minimising the risk of upstream flooding.

7.6.10 The proposed realignments of the Reepham Beck and Greetwell Fields Drain will be designed to maintain the current channel capacities as a minimum.

7.6.11 The Proposed Scheme will intercept overland flow and a number of minor land drains and open ditches. The earthworks drainage has been designed to accommodate these flows and route them appropriately such that they will not present a flood risk to the new road, or increase flood risk in the surrounding area.

7.6.12 With the above proposed measures in place the overall magnitude of the impact on the hydrology and flood risk of the relevant waterbodies would be negligible, resulting in a potential significance of neutral.

Geomorphological Changes

7.6.13 No supporting information required for this section.

Loss of Standing Waters

7.6.14 No supporting information required for this section.

Groundwater Changes

Impact of Cuttings

7.6.15 Four road cuttings are proposed as part of the scheme. Where these cuttings are deep they have the potential to intersect the groundwater table, resulting in dewatering effects such as changes to groundwater flows and levels in the surrounding area. These effects can subsequently impact on nearby groundwater dependant features, such as wetlands and groundwater abstractions.

7.6.16 A groundwater assessment has been carried out for each of the four proposed road cuttings.

7.6.17 The locations and lengths of the cuttings were identified from the long sections provided by the LEB design team. The maximum depth of the cutting was estimated from the topographical profiles for existing ground level and proposed new ground level. Water table elevations were determined from available ground investigation data (Jacobs 2009).

7.6.18 Only one location was identified where the groundwater is expected to be intercepted, in the alluvium/river terrace deposits on the southern bank of the River Witham, where the highest groundwater level was recorded at 1.8mbgl (14.5mOD in BH618, Jacobs 2009). In Cutting 3 the alluvium/river terrace deposits are located between the embankment of the Lincoln to Spalding Railway and Washingborough Road, approximately Ch. 2990-3200. At Ch. 3150 the proposed level of the cutting base is 8.93mOD ie it is expected that the cutting may intercept the groundwater table by more than 5m.

7.6.19 Further to the south from approximately Ch. 3200 to Ch. 4185, Cutting 3 passes through the Lias Clay, the overlying Northampton Sands and Lincolnshire Limestone. In this section of the cutting groundwater was recorded close to the base of the Northampton Sands but more than 4m below the base of the cutting (BH624, BH625, BH626, BH630, BH631 and BH635 from the 2008 ground investigation, in Jacobs 2009).

7.6.20 No site specific permeability testing was carried out as part of the ground investigations and a generic medium/high permeability value of 1x10-5m/s was used for the alluvium/river terrace deposits based on professional judgement in order to account for the gravels and sands of the river terrace deposits.

7.6.21 The radius of influence was calculated as shown in Table 7-13.

Table 7-13: Radius of Influence & Parameters Used in Groundwater Calculations

Water Feature	Chainage (m)	Cutting No.	Length (m)	Max. depth below water table (m)	Permeability rating (m/s)	Radius of influence (m)
Alluvium / River Terrace Deposits	2990 - 3200	3	210	5	1 x 10^{-5}	32
Blisworth, Cornbrash, Kellaways Formations	125 - 550	1	425	Water table below new ground level	n/a	0
	775 - 1350	2	575	Water table below new ground level	n/a	0
Lincolnshire Limestone	1350 - 1420	2	70	Water table below new ground level	n/a	0
	3365 - 4185	3	820	Water table below new ground level	n/a	0
	5470 - 5825	4	355	Water table below new ground level	n/a	0
Northampton Sand	3200 - 3365	3	165	Water table below new ground level	n/a	0

7.6.22 As can be seen the calculated radius of influence for the section of Cutting 3 within the alluvium/river terrace deposits is 32m, however this is not based on detailed ground investigation results and depending on the presence of high silt content alluvial deposits the radius of influence may be considerably smaller.

7.6.23 Following the determination of radii of influence, an assessment has been made of the significance of this effect on the potential receptors. Receptors considered were nearby surface watercourses, waterbodies or wetlands with important groundwater contribution, public or private water supply abstractions, water abstractions for non-potable usage and the superficial and bedrock aquifers themselves.

7.6.24 All four cuttings lie within the SPZ 2 of a PWS, with the exception of the sections of Cutting 3 which are located in the alluvium/river terrace deposits and the Northampton Sand. The Northampton Sand lies within SPZ 3 and the alluvium /river terrace deposits are outwith the SPZ. The identified receptor for the section of Cutting 3 within the alluvium/river terrace deposits is the aquifer itself.

7.6.25 Table 7-14 summarises the impact assessment from the cuttings on groundwater.

Table 7-14: Groundwater-Cutting Assessment Results

Water Feature	Importance	Cutting No.	Radius of influence (m)	Magnitude	Significance
Alluvium / River Terrace Deposits	Medium	3	32	Minor Adverse	Slight
Blisworth, Cornbrash, Kellaways Formations	Medium	1	0	Negligible	Neutral
		2	0	Negligible	Neutral
Lincolnshire Limestone	High	2	0	Negligible	Neutral
		3	0	Negligible	Neutral
		4	0	Negligible	Neutral
Northampton Sand	Medium	3	0	Negligible	Neutral

7.6.26 As can be seen the cuttings which do not intercept groundwater were assigned “negligible” magnitude of impact. The section of Cutting 3 that intercepts the groundwater in the floodplain (alluvium/river terrace) results in partial loss or changes to an aquifer. The lowering of the groundwater levels in that area is expected to be more than 5m and the groundwater gradient towards the River Witham will be reduced. However the groundwater flow direction will not change substantially as the groundwater level below the base of the cutting will still be higher than the groundwater levels at the River Witham. The 2008 investigation data (Jacobs 2009) indicate that between the river and the railway embankment (Lincoln to Spalding) the groundwater gradient in the alluvium is almost flat (BH616, BH619, BH620, BH622) indicating that the contribution of groundwater as baseflow to the River Witham is unlikely to be significant at this location. It is therefore considered that, due to the lowering of the groundwater levels in this part of the cutting, the impact is of minor magnitude and neutral significance.

7.6.27 It is recommended that as part of the detailed design phase further ground investigation works are undertaken to gather groundwater and permeability data for Cutting 3. The groundwater assessment for the cuttings should be re-visited as more data becomes available.

Impacts due to Impermeable Carriageway

7.6.28 The creation of impermeable carriageway would lead to a loss of groundwater recharge to the aquifer, due to the impermeable road surface intercepting rainfall and the road drainage networks discharging this runoff to nearby watercourses. The loss of groundwater recharge was estimated to approximately 20,000m^3 annually based on annual effective rainfall of 147mm and 135,901m^2 of impermeable surface area. This equates to 0.6% of the annual licensed abstraction of the nearby PWS. However it was considered that the effective recharge was overestimated due to the presence of less permeable strata on the surface of the northern section of the study area. Also, in the southern section the Branston Brook Tributary and Ashfield Beck already intercept the groundwater and therefore the loss of recharge will have a lesser effect on the source protection zone (SPZ 2). The currently proposed road is single carriageway and therefore the impact will be even less due to the smaller area of the impermeable surface.

7.6.29 Since the loss of effective rainfall to the total catchment of the PWS is estimated to be less than 0.6% of the annual licensed abstraction volume, the impact of the impermeable surface of the LEB is considered to be of negligible magnitude and neutral significance. This conclusion is also relevant to the loss of baseflow to streams due to the impact of the impermeable carriageway, which is also considered negligible.

Impacts due to Structures

7.6.30 The structures that are expected to intercept groundwater are the piled foundations of the River Witham Bridge. The piles will penetrate the full thickness of the river plain deposits to reach the bedrock. As the Lias Clay is not an aquifer there is no risk of creating a pathway. The piles and partly the concrete pads on top of the piles will be below the water table, however it is considered that they will have a negligible impact on the groundwater flow due to their relatively small extent.

7.6.31 Sheet piles will be installed on both sides of the North Delph, and although they may have a localised effect it is considered that the impact on groundwater levels will not be significant.

7.6.32 Therefore the risk of sub-surface structures impacting the groundwater levels and flow is qualitatively assessed as being of negligible magnitude and neutral significance.

7.7 Proposed Mitigation

Pollution Related to Routine Runoff

7.7.1 Where preliminary HAWRAT and EQS calculations indicate that a road drainage outfall will fail these assessments and that a significant impact will result, treatment will be provided wherever practicable.

7.7.2 The water quality mitigation proposed for each drainage network has been dictated by the level and type of treatment required, for soluble and/or sediment bound pollutants. The preliminary calculations indicated that concentrations of soluble pollutants discharged from each network were acceptable and therefore did not require specific treatment. However two of the three networks were failing the sediment bound pollutants element of HAWRAT, with Network A and Network B requiring 46% and 80% reductions in sediment loads respectively.

7.7.3 There are a variety of sustainable urban drainage systems (SUDS) that can provide varying levels of treatment for soluble pollutants. However the information available on the pollutant removal efficiency of these systems is highly variable. Most guidance provides a general indication of overall water quality performance, which does not differentiate clearly the performance against different types of pollutants. Often performance levels are presented using low, moderate and high categories which correspond to broad efficiency ranges of typically <30%, 30%-60% and >60% reductions respectively.

7.7.4 The HAWRAT assessment requires a single numerical figure for efficiency to be entered into the software for the different pollutant types. For the purposes of this assessment single figures have been derived following a literature review of widely accepted SUDS guidance, as shown in Table 7-15.

Table 7-15: Indicative SUDS Pollutant Removal Efficiencies

SUDS Component	Pollutant Removal Efficiency (%)		
	Suspended Solids & Sediment Bound Pollutants	Dissolved Copper	Dissolved Zinc
Swales and Grassed Channels	80	50	50
Dry/Detention Ponds	50	0	0
Wet/Retention Ponds	60	40	30
Wetlands	60	30	50
Vortex Grit Separators	40	0	15
Sediment Tanks	40	0	0
Oil Separators	0	0	0
Porous Paving	50	0	0
Vegetated Filter Strips	25	15	15
Filter Drains	60	0	45

Ditches	25	15	15

7.7.5 The SUDS components used for the LEB drainage networks has been dependant on both the pollution removal efficiency required and the flow attenuation required in relation to flood risk management.

7.7.6 All three networks have required flow attenuation, which the drainage designers have provided through the inclusion of attenuation ponds. The design principles of these are based on the previously promoted dual carriageway scheme, which included two attenuation ponds for each drainage network.

7.7.7 The first attenuation pond has been designed as a permanently wet retention pond, with optional reedbed/wetland planting, which is sized to accept the first flush flows. During a rainfall event the build-up of pollutants on the road surface is generally washed off the road early in the event, and therefore the runoff from the first 10mm of rain is often the most seriously polluted. This is referred to as the 'first flush' effect. The wet pond has been designed to drain down to the permanent water level over a period of at least 24 hours. This provides adequate time for the majority of suspended solids to settle out. This pond will discharge into the second attenuation pond, providing additional settlement time. The second attenuation pond has been designed as a dry detention pond, which will accept storm flows over and above the first flush flows. The discharge rate for the second pond will be equivalent to the greenfield runoff rate.

7.7.8 As can be seen from Table 7-15 above the wet and dry ponds are estimated to provide 60% and 50% removal of sediments respectively. As the LEB drainage design has these ponds working in series it is estimated that combined they will provide approximately 80% removal of sediments overall; more than or equal to that required, based on the preliminary HAWRAT calculations. In addition, although reduction of soluble pollutants is not required, the wet ponds will provide the additional benefit of between 30% and 40% reduction in soluble pollutants.

7.7.9 It should be noted that although the proposed attenuation ponds will provide sufficient treatment for the single carriageway networks, if the LEB is to be upgraded to dual carriageway in the future it is highly likely that further treatment would be required, particularly on Network B.

7.7.10 It should also be noted that neither the HAWRAT or EQS assessments considers the impacts from insoluble hydrocarbons which float on the water surface, and therefore does not consider the need for bypass oil separators or similar treatment requirements. The research conducted by the Highways Agency when developing the HAWRAT assessment found that in general this fraction of hydrocarbons in routine runoff is very small, and therefore specific treatment was not required unless it was found that there was a high risk of accidental spillage associated with the relevant network. As there is a very low risk of accidental spillage within each of the LEB drainage networks bypass oil separators are not proposed. However the networks will have shut valves incorporated, which will allow the attenuation ponds to be isolated in the event of an accidental spillage.

7.8 Residual Effects

7.8.1 No supporting information required for this section.

7.9 Summary and Conclusions

7.9.1 No supporting information required for this section.