

FLOOD RISK ASSESSMENT

**PROPOSED RESIDENTIAL DEVELOPMENT
MILLFIELD NURSERIES
CRADGE BANK
SPALDING
LINCOLNSHIRE
PE11 3JZ**



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INTRODUCTION

The Government has placed increasing priority on the need to take full account of the risks associated with flooding at all stages of the planning and development process. This seeks to reduce the future damage to property and the risk to life from incidents of flooding. Their expectations relating to flooding are contained in the National Planning Policy Framework (NPPF) March 2012, which identify how the issue of flooding is dealt with in the drafting of planning policy and the consideration of planning applications by avoiding inappropriate development in areas at risk from flooding.

Inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere. Local Plans should apply a sequential, risk-based approach to the location of development to avoid where possible flood risk to people and property and manage any residual risk, taking account of the impacts of climate change.

The Environment Agency's flood maps show areas that are at risk, from fluvial and tidal flooding. These maps show the limits of the flood plain of the area which could be affected by flood events, over topping or breaching of flood defences. They are based on the approximate extent of floods with a 1% annual probability of exceedance (1 in 100-year flood) for rivers and 0.5% annual probability of exceedance (1 in 200-year flood) for coastal areas under present expectations or the highest known flood. However, they do not take into account of the presence of defences or the likelihood that flood return intervals will be reduced by climate change.

This Flood Risk Assessment has been prepared in support of the planning application and considers the risk of flooding from fluvial and tidal sources. It also considers the risks of localised flooding due to inadequate Foul and Surface Water Sewers, Failure of Reservoirs, Water Main pipe bursts, Sewer Blockages, Pump Failures or High Ground Water Table etc.

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APPLICATION SITE

The site is located at Millfields Nurseries, Cradge Bank, Spalding Common, Spalding Lincolnshire PE11 3JZ within the administrative area of South Holland District Council. The National Grid Reference for the middle of the site is TF23442 20038 with a site area 4.604Ha or thereabouts. **Plan 1**

The current outline planning application is for the erection of 133 No detached, semi-detached and terraced dwellings, on a brown field site, situated at land to the east of Spalding Common and west of Cradge Bank in Spalding Common. The site, which is irregular in shape is accessed from Spalding Common with an approximate frontage width of 74m increasing to approximately 300m, average depth of 202m and a site area of 4.604 Ha.

The Site would be classed as Major Development applying the National Planning Policy Guidance (NPPG) as the site is to be developed for more than 10 dwellings.

The National Planning Policy Framework NPPF defines three levels of flood risk depending upon the annual probability of fluvial flooding occurring.

Zone 1 – Low Probability (<0.1%)

Zone 2 – Medium Probability (0.1 – 1.0%)

Zone 3 – High Probability (>1.0%)

The proposed development site is shown to be within Flood Zone 3a 'High Probability' as detailed on the Environment Agency's Flood Zone Maps without defences, and as defined in Table 1 of NPPF. **Map1**

Table 1: Flood Zones Definition (Ignoring the presence of defences)

Zone 3a - high probability Definition This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year. Appropriate uses The water-compatible and less vulnerable uses of land (table 2) are appropriate in this zone. The highly vulnerable uses should not be permitted in this zone. The more vulnerable uses and essential infrastructure should only be permitted in this zone if the Exception Test is passed. Essential infrastructure permitted in this zone should be designed and constructed to remain operational and safe for users in times of flood. Flood risk assessment requirements All development proposals in this zone should be accompanied by a flood risk assessment. Policy aims In this zone, developers and local authorities should seek opportunities to: • reduce the overall level of flood risk in the area through the layout and form of the development and the appropriate application of sustainable drainage systems; • relocate existing development to land in zones with a lower probability of flooding; and • create space for flooding to occur by restoring functional floodplain and flood flow pathways and by identifying, allocating and safeguarding open space for flood storage.

Applying the Flood Risk Vulnerability Classification in Table 2 of NPPF the proposed residential development is classified as “More Vulnerable”, with Table 1 of NPPF stating that such uses are appropriate in this zone subject to the Exception Test.

Table 2: Flood Risk Vulnerability Classification

More vulnerable • Hospitals. • Residential institutions such as residential care homes, children’s homes, social services homes, prisons and hostels. • Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels. • Non-residential uses for health services, nurseries and educational establishments. • Landfill and sites used for waste management facilities for hazardous waste⁶. • Sites used for holiday or short-let caravans and camping, <i>subject to a specific warning and evacuation plan.</i>⁷

From the topographical survey the site is roughly an irregular rectangular in shape and reasonably level, levels on the southern boundary are circa 2.445mODN and on the northern boundary 2..20mODN, averaging 2.40m ODN. Spalding common is at a higher level of 3.44mODN and there is a fall across the site to a level on Cradge Bank at 2.60mODN.

It is proposed that the lowest ground floor level of the dwellings be raised 1000mm above the existing ground level to a minimum level of 3.50mODN.

DRAINAGE AUTHORITIES

Environment Agency

The Environment Agency is responsible for reducing the risk of flooding from designated main rivers and from the sea.

The following potential sources of flooding affecting the development site have been identified as:

- From the River Welland
- Welland and Deepings Internal Drainage Board system

The Flood Zone Maps identify river catchments over 3 sq. km. These maps are a theoretical estimate of areas that could be inundated should no defence exist. In practice current standards of protection would result in flood envelopes substantially less than shown by these maps. The maps make no allowance for local, site specific features.

The flood zone maps show that the site of the proposed development is considered at risk from flooding. These maps indicate that the area would be flooded without flood defences, which are in place, (with an annual probability of more than 0.5% i.e. return frequency of less than 1 in 200 years for tidal flooding or more than 1.33% return frequency of less than 1 in 100 years for fluvial flooding). **Map 1**

The National Flood Risk Assessment Map shows that the site is partly at a low risk of flooding and partly at a medium risk of flooding. Low means that each year, this area has a chance of flooding of less than 1 in 1000 (0.1%). This takes into account the effect of any flood defences that may be in this area. Flood defences reduce, but do not completely stop the chance of flooding as they can be overtopped or fail. **Map 2**

RIVER WELLAND

The River Welland lies some 60m from the eastern boundary of the site. The left bank of the River Welland 1km upstream of Little London Road bridge is 6.05mODN. the right bank is somewhat lower which would allow high flows to overtop into the adjacent Cowbit Washes, an area of designated flood storage area to protect Spalding.

The Environment Agency has provided fluvial flood levels for the 1 in 100-year with climate change for the River Welland, these are shown below. The fluvial defences consist of earth embankments to the Crowland and Cowbit flood storage reservoir which are in good condition and provide a defence for a flood event of 1 in 100-year event.

Datasheet [Ref: CCN-2016-15021]													
Fluvial Flood Levels (mODN)													
The fluvial flood levels for the model nodes shown on the attached map are set out in the table below. They are measured in metres above Ordnance Datum Newlyn (mODN).													
Node Label	Easting	Northing	Annual Exceedance Probability - Maximum Water Levels (mODN)										
			50% (1 in 2)	20% (1 in 5)	10% (1 in 10)	4% (1 in 25)	2% (1 in 50)	1.33% (1 in 75)	1% (1 in 100)	1% (1 in 100) inc 20% Climate Change	0.5% (1 in 200)	0.1% (1 in 1000)	0.1% (1 in 1000) inc 20% Climate Change
WELLAND 15344	524181	321070	4.00	4.24	4.33	4.39	4.43	4.45	4.45	4.67	4.47	4.47	4.68
WELLAND 16724	523645	319986	4.01	4.28	4.37	4.43	4.47	4.48	4.49	4.67	4.50	4.50	4.67
WELLAND 18224	523963	318521	4.02	4.32	4.41	4.47	4.51	4.52	4.53	4.67	4.54	4.54	4.67
Fluvial Flood Flows (m³/s)													
The fluvial flood flows for the model nodes shown on the attached map are set out in the table below. They are measured in metres cubed per second (m³/s).													
Node Label	Easting	Northing	Annual Exceedance Probability - Maximum Flows (m³/s)										
			50% (1 in 2)	20% (1 in 5)	10% (1 in 10)	4% (1 in 25)	2% (1 in 50)	1.33% (1 in 75)	1% (1 in 100)	1% (1 in 100) inc 20% Climate Change	0.5% (1 in 200)	0.1% (1 in 1000)	0.1% (1 in 1000) inc 20% Climate Change
WELLAND 15344	524181	321070	61.90	78.16	83.31	87.24	90.06	90.58	90.87	90.59	91.09	91.37	91.31
WELLAND 16724	523645	319986	60.92	77.45	82.77	87.35	90.12	90.59	90.87	90.47	91.07	91.29	91.27
WELLAND 18224	523963	318521	59.90	76.73	82.24	87.49	90.17	90.61	90.87	90.46	91.07	91.50	91.25

These levels are taken from the Welland Catchment FMI Model (2007) and are the most up to-date currently available. These levels are “in-channel” levels and therefore may not represent the flood level on the floodplain, particularly where the channel is embanked or has raised defences.

The greatest risk of flooding of the site would therefore be from a breach to the fluvial earth embankments.

The fluvial river level at Node point Welland 16724 for the 1 in 100-year with 20% climate change is 4.67mODN. Based upon the crest heights of the earth embankment flood defence at a minimum of 6.05mODN

the proposed site is protected with a freeboard of over 1.3m.

Interpolating the new climate change allowances issued 19th February 2016, using the river flow and level data issued by the Environment Agency it is assessed that for the climate change figures stated in Table 1 are as shown in Appendix A for the 1 in 100-year event Node Welland 17624.

From the results it is clear this is a location where the spreadsheet and interpolation will not work correctly, because of the upstream attenuation and the washes, etc.

Examination the numbers it is clear the River Welland has plateaued at around 4.5mODN for the present day at 4.67mODN for all the climate change scenarios.

As both the 1 in 100-year flood level with 20% climate change and the 1 in 1000-year flood level with 20% climate change is the same 4.67mODN could be used for the other allowances up to 65%

Taking the precautionary approach, the Hazard Rating following a breach which in Flood Risk Assessment (FD 2320) Guidance for New Development Phase 2 R& D Technical Report these are classified as low <0.75, moderate 0.75 - 1.25, significant 1.25 - 2.50 and extreme >2.50 based upon an empirical measure of velocity and depth.

Flood Hazard value	Degree of flood hazard	Description	Indicative depth range
< 0.75	Low	Caution 'Flood zone with shallow flowing water or deep standing water'	Up to 0.25 m
0.75 – 1.25	Moderate	Danger for some (i.e. children) 'Danger: flood zone with deep or fast flowing water'	Up to 0.5 m
1.25 – 2.0	Severe	Danger for most 'Danger: flood zone with deep fast flowing water'	0.5 m to 3 m
> 2.0	Extreme	Danger for all 'Extreme danger: flood zone with deep fast flowing water'	0.5 m to over 3 m

Breach Analysis for a Breach to the Fluvial Flood Defences for The River Welland

$$HR = d \times (v + 0.5) + DF$$

Where V = Flood flow velocity (m/sec)

D = Flood depth (m)

DF = A debris factor included to represent the greater damage, or risk of injury to people, that can occur if debris is swept along with the water. = 0.5 for depths <0.25 or 1.0 for depths

Flood depth (m)	All areas (rural and urban)
≤ 0.25	0.5
> 0.25	1

For the degree of Flood Hazard to be classified as low HR has to be <0.75

The Fluvial River Welland lies some 60m east of the site.

1 in 100-year level with climate change (Upper End) in the River Welland is 4.67mODN

Lowest ground level rear of defences 2.60mODN. (Cradge Bank road level)

Length of Breach 40m (Earth Bank)

It is assumed that the defences will be similar to Broad Crested Weir.

Volume and velocity at the location of the breach is: -

$$Q = 1.7 \times B \times H^{3/2} = 1.7 \times 40 \times (4.67 - 2.60)^{3/2}$$

$$Q = 202.52 \text{ m}^3/\text{sec}$$

$$\text{Velocity at the breach } V = Q/A$$

$$V = 202.52 / 40 \times 2.07 = 2.45 \text{ m/sec}$$

From spread sheet below the HR at 60m from the breach, at the site is 2.69 (Danger for All), Velocity 1.54m/sec and depth 0.82m (2.6 + 0.82) = 3.42mODN therefore the as the site is subject to flooding from a breach to the River Welland (fluvial).

Hazard Rating				Site Name		Millfield Nurseries		Date		Jun-16				
Defence Type				Fluvial River - Earth Bank										
Ground Level at breach		2.6	mODN	Flood Level	4.67	mODN	Head at Breach		2.07	m				
Breach Width		40	m											
Increments from breach		5	m											
Debris Factor		Shallow	0.5	Deep	1	(note: shallow <0.26m)								
Hazard Ratings														
Danger for some														
Danger for most														
Danger for all														
DISTANCE FROM BREACH														
		0	5	10	15	20	25	30	35	40	45	50	55	60
DEPTH AT BREACH	1.77	5.91	4.99	4.36	3.91	3.57	3.31	3.09	2.92	2.77	2.64	2.54	2.44	2.36
	1.82	6.11	5.15	4.50	4.03	3.67	3.40	3.18	2.99	2.84	2.71	2.60	2.50	2.41
	1.87	6.31	5.31	4.63	4.15	3.78	3.49	3.26	3.07	2.91	2.77	2.66	2.55	2.47
	1.92	6.51	5.47	4.77	4.26	3.88	3.58	3.34	3.15	2.98	2.84	2.72	2.61	2.52
	1.97	6.71	5.63	4.91	4.38	3.99	3.68	3.43	3.22	3.05	2.91	2.78	2.67	2.57
	2.02	6.92	5.80	5.05	4.50	4.09	3.77	3.51	3.30	3.12	2.97	2.84	2.73	2.63
	2.07	7.13	5.97	5.19	4.63	4.20	3.87	3.60	3.38	3.20	3.04	2.91	2.79	2.69
	2.12	7.34	6.14	5.33	4.75	4.31	3.97	3.69	3.46	3.27	3.11	2.97	2.85	2.74
	2.17	7.55	6.31	5.48	4.87	4.42	4.06	3.78	3.54	3.35	3.18	3.03	2.91	2.80
	2.22	7.77	6.49	5.62	5.00	4.53	4.16	3.87	3.62	3.42	3.25	3.10	2.97	2.86

Velocity														
DISTANCE FROM BREACH														
		0	5	10	15	20	25	30	35	40	45	50	55	60
DEPTH AT BREACH	1.77	2.28	2.10	1.98	1.88	1.80	1.73	1.67	1.62	1.57	1.53	1.49	1.46	1.43
	1.82	2.31	2.13	2.01	1.91	1.82	1.75	1.69	1.64	1.59	1.55	1.51	1.48	1.45
	1.87	2.34	2.16	2.03	1.93	1.85	1.78	1.72	1.66	1.62	1.57	1.53	1.50	1.47
	1.92	2.37	2.19	2.06	1.96	1.87	1.80	1.74	1.68	1.64	1.59	1.55	1.52	1.49
	1.97	2.40	2.22	2.09	1.98	1.90	1.82	1.76	1.71	1.66	1.61	1.57	1.54	1.51
	2.02	2.43	2.25	2.11	2.01	1.92	1.85	1.78	1.73	1.68	1.63	1.59	1.56	1.53
	2.07	2.46	2.27	2.14	2.03	1.95	1.87	1.81	1.75	1.70	1.65	1.61	1.58	1.54
	2.12	2.49	2.30	2.17	2.06	1.97	1.89	1.83	1.77	1.72	1.67	1.63	1.60	1.56
	2.17	2.52	2.33	2.19	2.08	1.99	1.91	1.85	1.79	1.74	1.69	1.65	1.62	1.58
	2.22	2.55	2.36	2.22	2.11	2.01	1.94	1.87	1.81	1.76	1.71	1.67	1.63	1.60

Depth														
DISTANCE FROM BREACH														
		0	5	10	15	20	25	30	35	40	45	50	55	60
DEPTH AT BREACH	1.77	1.77	1.53	1.36	1.22	1.12	1.03	0.96	0.91	0.85	0.81	0.77	0.74	0.71
	1.82	1.82	1.57	1.39	1.26	1.15	1.06	0.99	0.93	0.88	0.83	0.79	0.76	0.73
	1.87	1.87	1.62	1.43	1.29	1.18	1.09	1.02	0.96	0.90	0.86	0.81	0.78	0.75
	1.92	1.92	1.66	1.47	1.33	1.21	1.12	1.05	0.98	0.93	0.88	0.84	0.80	0.76
	1.97	1.97	1.70	1.51	1.36	1.25	1.15	1.07	1.01	0.95	0.90	0.86	0.82	0.78
	2.02	2.02	1.75	1.55	1.40	1.28	1.18	1.10	1.03	0.97	0.92	0.88	0.84	0.80
	2.07	2.07	1.79	1.59	1.43	1.31	1.21	1.13	1.06	1.00	0.95	0.90	0.86	0.82
	2.12	2.12	1.83	1.62	1.47	1.34	1.24	1.16	1.08	1.02	0.97	0.92	0.88	0.84
	2.17	2.17	1.88	1.66	1.50	1.37	1.27	1.18	1.11	1.05	0.99	0.95	0.90	0.86
	2.22	2.22	1.92	1.70	1.53	1.40	1.30	1.21	1.14	1.07	1.02	0.97	0.92	0.88

As a sensitivity test taking the 2115 65% flood level of 5.19mODN given from the Discharge Relationship Curve interpolation, the hazard rating is 3.30 (Danger for All), flood depth would be 1.03m and velocity 1.73m/sec— as the site is within 60m from the washes, this would be worst case scenario.

The minimum mitigation measures required for developments that do not have any ground floor sleeping shall be determined by the flood depths arising from the 2115 breach scenario. The finished floor Level FFL of any new dwelling shall be informed by the flood depths. For flood depths between 1.0 – 1.6m deep the FFL shall be set at a minimum of 1000mm above the ground level and flood resilient construction incorporated to a minimum height of 300mm above the predicted flood levels and 600mm high flood barriers fitted to all external doors.

With the average site ground level being 2.40mODN, the minimum floor level will be set at 3.50mODN.

South Holland District Council

In order to inform the process of risk assessment and site selection the District Council commissioned Haskoning UK Ltd Consultants to prepare a Strategic Flood Risk Assessment in December 2002. They have carried out an update of this report and this report was published in January 2010

This Flood Risk Assessment has taken the results of the updated South Holland Strategic Flood Risk Assessment (SHSFRA) into account in its findings.

It was found that the actual risk from primary sources of flooding (taken as being rivers and the sea) was assessed as being the product of:

- Medium probability (assigned because the standards of the primary defences are variable) and
- Low consequence (assigned because of the District's generally rural nature and because any urban flooding is likely to be shallow with minimal impact).

The findings reflect the considerable protection afforded to the area by coastal and tidal & fluvial flood defences and by the extensive well organised system of lowland IDB fluvial drainage.

The computer modelling used in the SFRA to produce the Hazard, depth and velocity maps simulated the spread of flood waters over the land and allowed for the presence of locally raised features such as road embankments etc.

The potential flooding consequences shown on this map relate to flooding from the sea, main rivers and Internal Drainage Board systems taking into account the presence of current flood risk management measures such as flood defences.

The Environment Agency has not undertaken Hazard mapping for the River Welland upstream of Welland Bridge, therefore the Peak Residual Depth and Velocity Maps included in the South Holland SFRA Update 2010 have been assessed.

From the Residual Peak Hazard Rating, Depth & Velocity Spalding - Year 2115 1% Fluvial / 0.5% Tidal Event Probability maps from the update of Strategic Flood Risk Assessment for South Holland District Council have been used in this assessment. Maps 4, 5 & 6.

The peak depth maps show that part of the site is within the band depth 0.5 - 1.0m and the peak velocity map shows part of the site is within band velocity greater than 0.25m/sec. Hazard Rating between 1.25 -2.0 (Danger for Most)

Welland and Deepings Internal Drainage Board

The proposed development site is located within Catchment area of Welland and Deepings Internal Drainage Board. The Board is responsible to operate and maintain the arterial fluvial system.

The site lies within the Boards 1st District catchment and the Board have a watercourse alongside the eastern boundary ref. Welland Soak dyke (1st District) 226. **Map 6**

The Board' s Engineer has confirmed that as the majority of the site currently discharges surface water into the soak-dyke un-attenuated, then an attenuated discharge of 10 litres/sec from the developed site into the soak-dyke would be acceptable.

FLOODING FROM OTHER SOURCES

Flooding is a natural process and can happen at any time from sources other than watercourses and the sea.

- Flooding from land can occur from intense rainfall, often over short duration of time that is unable to soak into the ground or enter the drainage system. However, with the natural topographic nature of the ground being flat, with no high ground around the site this will not cause any rapid inundation of the site and is likely only lead to local ponding of shallow depth and low velocity following the natural land contours. The properties are also raised 1000mm above the average ground level. The updated SFRA concluded that flooding from this source is limited to minor isolated cases and is not of strategic significance as regards to flood risk.
- The area is not known to suffer from any groundwater problems and therefore is taken as having no strategic significance as regards to flood risk.
- Flooding from sewers can occur from over loading from heavy rainfall caused by blockages or having inadequate capacity. However, with the natural topographic nature of the ground being flat, with no high ground around the site this will not cause any rapid inundation of the site and is likely only lead to local ponding of shallow depth and low velocity following the natural land contours. The properties are also raised 1000mm above the average ground level. The updated SFRA concluded

that flooding from this source is limited to minor isolated cases and is not of strategic significance as regards to flood risk.

- Non-natural or artificial sources of flooding such as reservoirs, lakes or canals where water is stored above natural ground level could cause flooding if the structure fails or is over topped. There are no known facilities close to the proposed development.

SEQUENTIAL APPROACH

When applying the sequential approach for flood risk in accordance NPPF the site would fall into Zone 3a (High Probability) as the site is shown to be within the tidal flood plain as shown on the Environment Agency's Flood Map without defences in place.

However, the results of the updated SHSFRA shows that the site is located within a low/medium probability flood zone but the area is reliant on protection by flood defences providing a standard of protection of 1 in 100 years return period.

Applying the Flood Risk Vulnerability Classification in Table 2 of NPPF, the proposed residential development is classified as "More Vulnerable", with Table 1 of NPPF stating that such uses are appropriate in this zone (as summarised in Table 3 NPPF).

TABLE 3: Flood risk vulnerability and flood zones 'compatibility'

Flood risk vulnerability classification (see table 2)		Essential infrastructure	Water compatible	Highly vulnerable	More vulnerable	Less vulnerable
Flood zone (see table 1)	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test required	✓	✓
	Zone 3a	Exception Test required	✓	✗	Exception Test required	✓
	Zone 3b functional floodplain	Exception Test required	✓	✗	✗	✗

Sequential Test & Exception Test

The aim of the Sequential Test is to steer new development to areas with the lowest probability of flooding. The NPPF states that development should not be permitted if there are reasonably available sites appropriate for the proposed development in areas with a lower probability of flooding. It is important to note that the Sequential Test does not specifically mean that sites such as this cannot be developed, rather that sites at less risk should be developed first.

A Sequential and Exception Test has been prepared by the Robert Doughty Consultancy Ltd., and for the purpose of this Flood assessment it is concluded that both the Sequential and Exception Tests are satisfied.

With the properties being two storeys there is a safe haven for residents to await the flood level to recede or to be rescued. Also the ground floor levels have been raised above the predicted flood level.

CLIMATE CHANGE

Global warming is now recognised that it is likely to affect the frequency and severity of extreme events as both tidal and fluvial flooding. The Climate change allowances in the NPPF Guidance was updated on the 19th February 2016.

The site is located within the Anglian River Basin, for sites within Flood Zone 3a and for “More vulnerable” land uses the Higher Central and Upper End river flow allowances figures in Table 1 should be used.

Table 1 Peak river flow allowances by river basin district (1961 to 1990 baseline)				
River basin District	Allowance category	Total potential change anticipated for '2020s' (2015 to 2039)	Total potential change anticipated for '2050s' (2040 to 2069)	Total potential change anticipated for '2080s' (2070 to 2115)
Anglian	Upper End	25%	35%	65%
	Higher central	15%	20%	35%
	Central	10%	15%	25%

The effect of global warming on peak rainfall allowances is given in Table 2.

Table 2 Peak rainfall intensity allowance in small and urban catchments (1961 to 1990 baseline)			
Applies across all of England	Total potential change anticipated for 2010 to 2039	Total potential change anticipated for 2040 to 2059	Total potential change anticipated for 2060 to 2115
Upper End	10%	20%	40%
Central	5%	10%	20%

The annual sea rise due to climate change is given in NPPF and the recommended contingency allowances are stated in Table 3.

Table 3 Peak sea level allowance for each epoch in (mm) per year with cumulative sea level rise for each epoch in brackets (use 1990 baseline)					
Area of England) (Use River Basin maps	1990 to 2025	2026 to 2050	2051 to 2080	2081 to 2115	Cumulative Rise 1990 to 2115 (m)
East, Midlands, London, South East	4 (140mm)	8.5 (212.5mm)	12 (360mm)	15 (525mm)	1.24m

HISTORIC FLOOD EXTENT

The Historic flood map produced by the Environment Agency shows the extent of the March 1947 flood. The site is shown not to have been affected. **Map**

MANAGEMENT OF SURFACE WATER RUN-OFF

In accordance with the House of Commons Written Statement (HCWS161 – 18th December 2014) there is an expectation for SuDS to be incorporated in all residential developments of 10 houses or more (major developments) unless demonstrated to be inappropriate.

Furthermore, in accordance with recognised guidance, Part H of the Building Regulations 2010 and National Planning Policy Framework 2012, there is a hierarchy of where surface water should discharge.

This hierarchy should be followed where practicable, and is as follows:

- 1) Infiltration
- 2) Watercourse
- 3) Public sewer

The drainage strategy prepared by Hall Infrastructure Design Ltd, dated 16.05.16 (See separate Document for the site design & Microdrainage calculations), is the preliminary overview and will be subject to the detailed design being undertaken when planning permission and final layout has been determined. It is proposed to utilise source control techniques to reduce the storm water discharge from the proposed development in order to minimise the impact of the development on the surrounding area and to comply with EA guidelines, which require at least one workable solution for managing surface water.

The development site is a brown field site situated at land to the east of Spalding Common and west of Cradge Bank in Spalding Common, as shown on the topographical survey drawing AS2129/1 rev B (**doc 1**). The site, which is irregular in shape is accessed from Spalding Common with an approximate frontage width of 74m increasing to approximately 300m, average depth of 202m and a site area of 4.604 Ha. The existing impermeable area is 2.861 Ha (62%). The site currently discharges surface water at an unrestricted rate through a number of 100mm dia and 150mm dia pipes to an existing riparian drain which in turn is connected to the River Welland Soke Dyke by a 300mm dia culvert beneath Cradge Bank, all as shown on the topographical survey drawing

The proposal includes for the construction of a network of adopted roads and footpaths serving 133 detached, semi-detached and terraced dwellings. The proposed impermeable area has been calculated based on the roof areas of proposed dwellings (0.843 Ha – 18%), the adopted access road and footpaths (0.440 Ha – 10%), domestic curtilage private access roads and courtyards (0.195 Ha – 4%) and domestic curtilage driveways (0.389 Ha – 8%) totalling 1.867 Ha which represents 41% (including an allowance for development creep) of the total site area as shown on the schematic concept drainage plan drawing no 1608/01 (**doc 2**). It is proposed that roof areas will discharge to adjacent domestic curtilage driveways and / or domestic curtilage private access roads and courtyards will in turn will discharge to a network of under-drained roadside swales connected to an on-line storage / balancing pond through to the agreed outfall point.

Existing green field conditions.

Existing green field runoff values, calculated in accordance with the H R Wallingford greenfield runoff

estimation for sites in accordance with DEFRA / Environment Agency Report SC030219 rev E and Interim National Procedure Principle 17, confirm that the impermeable area (1.867 Ha) of the site generates a 1 year run off value of 5.00 l/s, 30 year of 6.42 l/s and 100 year of 9.33 l/s. The client has confirmed that they have permission to discharge at a maximum rate of 10.00 l/s to the existing River Welland Soke Dyke on the east side of Cradge Bank. This is shown on the Welland & Deepings IDB asset plan

Assuming only 50% of the existing greenhouses discharge to the existing riparian drain through the network of existing 100mm and 150mm outlets, based on 50mm / hr rainfall, these would generate existing flows in the region of 145 l/s.

Infiltration

Soil infiltration testing for the site has been undertaken by Ground Engineering Ltd, ref C13746 March 2016.

This report confirms that soakaways are not practicable on this site due to negligible / nil infiltration rates and high water table.

Grass areas and soft landscaping areas are proposed in the development totalling 2.737 Ha (59%), as shown on the schematic concept drainage plan, drawing no 1608/01

There are no proposals for any other surface water to discharge to infiltration at this stage given the findings of the ground investigation report.

Watercourse

Watercourse can be used as the method of disposal of the surface water from the development. Domestic curtilage roof areas totalling 0.843 Ha (18%), including an allowance for development creep, are proposed to discharge to the sub base reservoir layers of adjacent individual domestic curtilage permeable paved driveways, as shown on the schematic concept drainage plan drawing no 1608/01

Permeable materials (e.g. permeable block paving) are proposed to the individual domestic curtilage driveways totalling 0.389 Ha (8%), with sub base reservoir layer connected to the adopted access road swale under-drain as shown on the schematic concept drainage plan drawing no 1608/01

Permeable materials (e.g. permeable block paving) are proposed to the domestic curtilage private access road and courtyards totalling 0.195 Ha (4%), with sub base reservoir layer connected to the adopted access road swale underdrain as shown on the schematic concept drainage plan drawing no 1608/01

Permeable materials (e.g. permeable block paving) are proposed to the adopted shared surface road totalling 0.092 Ha (2%) with sub base reservoir layer under-drained and connected to an on-line storage / attenuation pond as shown on the schematic concept drainage plan drawing no 1608/01.

Traditional materials (tarmac) are proposed to the adopted access roads / footpaths totalling 0.348 Ha (8%) with an under-drained swale conveying runoff to an on-line storage / attenuation pond as shown on the schematic concept drainage plan drawing no 1608/01

Anglian Water Services Ltd's October 2013 requirements with regard to surface water storage are that the preferred method should be an adoptable on-line system with an adopted or Management Company Ltd maintained off-line storage pond being acceptable.

Conflicting with this preference – the SUDS Lead Local Flood Authority (LLFA) which, at the time of the development's anticipated construction date, is Lincolnshire County Council, have confirmed at the Lincolnshire LLFA Consultants & Developers Seminar (April 2015) that their preference is for under-drained swales to be used for conveyance of surface water to an on-line storage pond.

The suggested locations of proposed under-drained swales and the balancing pond are shown on the schematic concept drainage plan 1608/01. These together with the use of permeable materials within domestic curtilage provides source control (quality) and storage volume (quantity) together with amenity and biodiversity SUDS.

Surface water from the adoptable road (0.348 Ha) (which will comprise one footway to the high side and a single cross-fall carriageway) will shed directly into a 300mm deep adjacent under-drained swale to the low side, providing highway water with an initial treatment stage, with domestic curtilage roof areas (0.843 Ha), individual domestic curtilage permeable paved driveways (0.389 Ha), domestic curtilage private access roads and courtyards (0.195 Ha) and permeable paved adopted access road (0.092 Ha) being collected along the way, connected in to the perforated under-drain pipework. Typical construction details for the source control outlets from domestic roof water to permeable paved individual driveway and under-drained conveyance swale are shown on the schematic concept drainage plan drawing no 1608/01.

Roof water will be collected in underground pipes, where required, within domestic curtilage with silt traps incorporated prior to connecting to adjacent permeable paved individual driveways wherever practicable by way of proprietary diffusers which in turn are connected to the under-drained swale. Where roof water downpipes are located either over or immediately adjacent to permeable paved individual driveways these will surface discharge to the permeable paving with proprietary rainwater shoes with no underground pipework being required. This provides an "on-plot" source control treatment stage for all domestic curtilage runoff prior to entering the adoptable system.

An on-line surface water detention and attenuation balancing pond provides additional storage and a second treatment stage at the flow control location. The pond will be wet (maximum 600mm depth) under normal conditions (unless infiltration results in the water level further reducing) with a normal water area of 663m², normal water level of 1.125m ODN and 1:3 side slope batters, as shown on the schematic concept drainage plan 1608/01

A Hydrobrake Optimum flow control device together with a higher level small diameter orifice plate

attenuate flows down to the permitted discharge rates for 1 year, 30 year and up to the 1:100 year plus 30% climate change standard to permitted discharge rates. Flows in excess of these figures are stored in the on-line detention and attenuation balancing pond where they are stored for a period of time before draining back down again to normal water level.

The final outfall from the development is proposed at invert level (1.066m ODN) which is the invert level of an existing 300mm diameter culvert pipe connecting to the existing River Welland Soke Dyke as shown on the schematic concept drainage plan 1608/01. This existing culvert pipe is 500mm above the invert level of the Soke Dyke. The invert level of the development discharge at the balancing pond is proposed at 1.125m ODN.

The normal water level in the balancing pond being set at 1.125m ODN is at least 1.425m below the carriageway level of Cradge Bank (2.550m ODN) thereby enabling a maximum 1.101m of storage depth and 0.324m freeboard.

Microdrainage calculations, using FEH rainfall data, have been prepared to demonstrate that the surface water design operates satisfactorily for the given return periods whilst keeping discharges lower than or equal to existing green field values, confirms the Microdrainage calculations with 1-year outflow restricted to 4.3 l/s with the water level in the balancing pond raising by 356mm to a level of 1.481mODN, 30-year outflow restricted to 6.3 l/s with the water level in the balancing pond raising by 806mm to a level of 1.931mODN and 100-year plus 30% climate change outflow restricted to 10.0 l/s with the water level in the balancing pond raising by 1101mm to a level of 2.226m ODN. Top of bank of the surface water balancing pond and lower plateau of the public open space area will be set at 2.525m ODN with the lower plateau area being set at 1.925m ODN therefore providing an additional 299mm freeboard above the 100 year plus 30% climate change level.

Sewers

There are no proposals to discharge surface water to any public sewer.

Foul Water Drainage

It is anticipated, that a gravity foul water solution will be achievable and the network of foul sewers will be included in a section 104 agreement with Anglian Water Services Ltd to ensure the foul water infrastructure can be monitored and maintained to ensure it will continue to function correctly for the lifetime of the development.

As there is a positive drainage system capable of receiving flows from the development there is no likely impact on neighbouring property.

FLOOD PROTECTION

Any impact of damage to the properties can be foreseen and mitigated against by relatively simple design and construction techniques. There are two forms of flood protection works: -

- **Flood-resistance or proofing works:** - these try to reduce the amount of water actually entering a building.
- **Flood-resilient works:** - these reduce the amount of damage caused by water entering the building.

The proposed property will have the following resilient measures incorporated in the construction in accordance with “Improving the flood performance of new buildings” CLG (2007).

- The ground floor to be constructed with a solid concrete floor with no voids beneath and no low level wall vents. However, if a beam type floor is to be used, provision should be incorporated for draining the under floor void.
- The lowest ground floor level for the properties is to be raised 1000mm above existing average ground level. and 600mm high flood barriers installed to all ground floor doors, with flood resilient construction 300mm above maximum flood level.
- Avoid the use of absorbent cavity insulation to the ground floor level.
- Treated and sealed timber skirting and architraves.
- Arrange for all service circuits to be routed at first floor level where practical socket outlets, boilers etc. to be a minimum of 0.5m above the raised upper ground floor level.
- It is recommended that “Flood Angel doors” or similar are fitted to the entrance doors to the properties as when these are locked they provide a flood barrier for a depth of 600mm.
- As this site is in an area that is capable of receiving flood warnings from the Environment Agency Floodline Warning Direct system. It is recommended that the property Owner contact the Environment Agency’s Floodline on 0845 988 1188 to register the property to receive advance warning of flooding by telephone, mobile, fax, SMS text, email or pager. The Environment Agency aim to issue a ‘severe flood warning’ approximately 2 hours before existing defences are overtopped.

CONCLUSION

- o The proposed development site is shown to be within Flood Zone 3a ‘High Probability’ as detailed on the Environment Agency’s Flood Zone Maps without defences.
- o The site does have the protection of fluvial/ tidal flood defences which are well maintained by the Environment Agency for both the present day and also for climate change.
- o

- o The lowest ground floor level for the properties is to be raised 1000mm above existing average ground level. and 600mm high flood barriers installed to all ground floor doors, with flood resilient construction 300mm above maximum flood level.
- o The proposed residential development is classified as “More Vulnerable”, with Table 1 of NPPF Technical Guide stating that such uses are appropriate in this zone, subject to the exception test.
- o The Sequential and Exception Tests are considered to be passed for the proposed development.
- o A drainage strategy for the development has been proposed which is outlined in this report. This has now made an allowance of an additional 30% for climate change.
- o Any impact of damage to the properties can be foreseen and mitigated against by relatively simple design and construction techniques. They will be constructed using materials which are flood resilient construction as outlined in the report
- o Flooding from other sources is unlikely to affect the site.

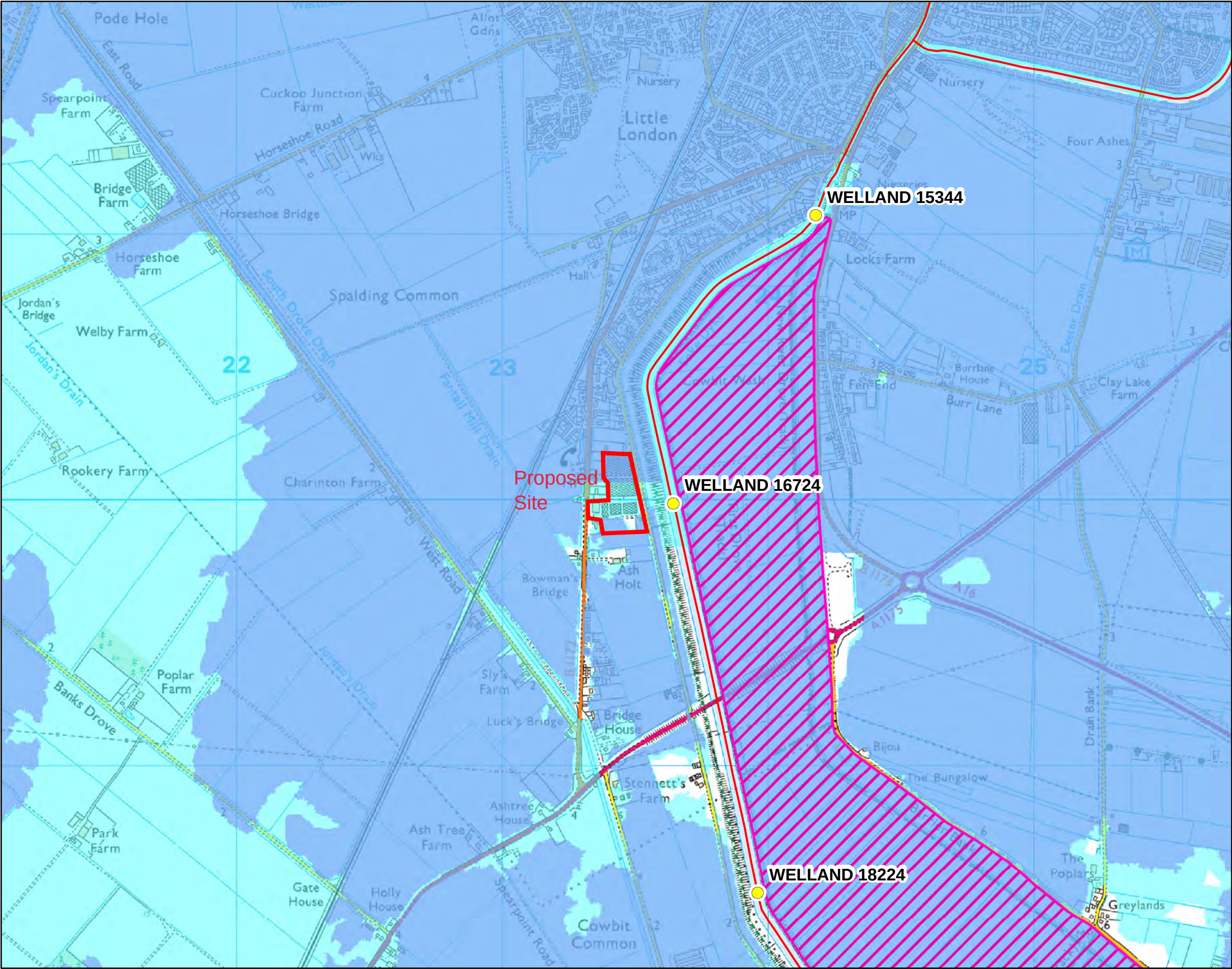
APPENDIX

Map 1	Extract from Environment Agency Flood Zone & Node Map
Map 2	NaFRA Map
Map 3	Historic Flood Map
Map 44	Residual Peak Hazard Rating, Spalding - Year 2115 1% Fluvial / 0.5% Tidal Event
Map 55	Residual Peak Depth Spalding - Year 2115 1% Fluvial / 0.5% Tidal Event
Map 66	Residual Peak Velocity Spalding - Year 2115 1% Fluvial / 0.5% Tidal Event
Map 77	Welland & Deepings IDB Drainage Plan
Plan 1	Location Plan
Plan 2	Proposed Layout
Plan 3an 3	Drainage Layout Plan
Plan 4	Topographical Survey
Appendix A	Discharge Relationship Curve for Climate Change Allowances

NOTE: -

The Drainage Statement prepared by Hall Infrastructure Design Ltd dated 16 May 2016 should be read in conjunction with this Flood Risk Assessment

Basic FRA Map
Map centred on TF 23428 20073 - created June 2016 [Ref: CCN-2016-15021]



Scale 1:15,000

- Welland_Nodes
- Main River
- Flood Storage Areas
- Area at Risk of Flooding from Rivers or The Sea
- Extreme Flood Outline

Dark blue shows the area that could be affected by flooding, either from rivers or the sea, if there were no flood defences. This area could be flooded:

- from the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year.

- or from a river by a flood that has a 1% (1 in 100) or greater chance of happening each year.

Light blue shows the extent of the Extreme Flood Outline, which represents the extent of a flood event with a 0.1% chance of occurring in any year, or the highest recorded historic extent if greater.

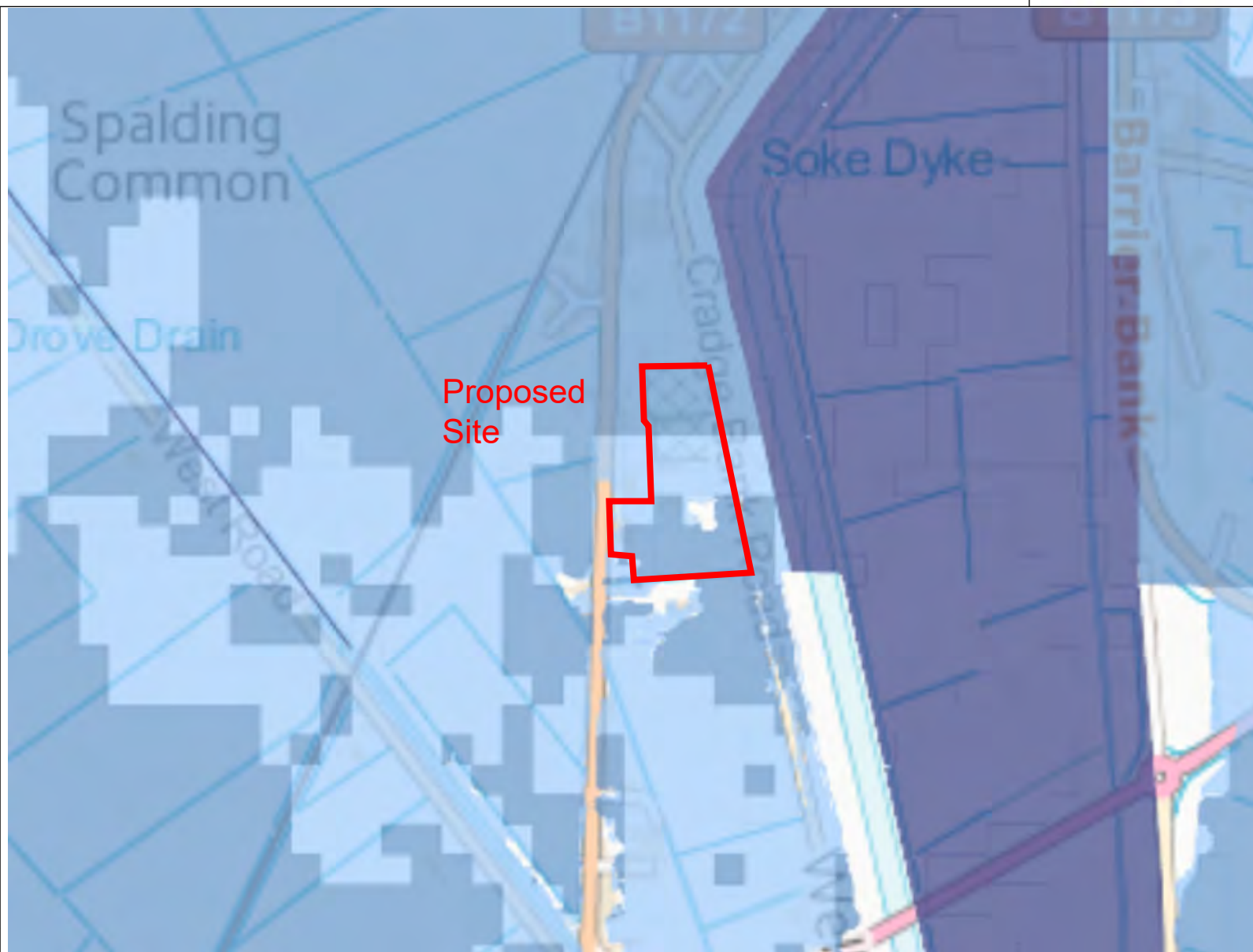
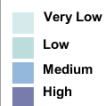
These two colours show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements. Sites outside the two extents, but behind raised defences, may be affected by flooding if the defences are overtopped or fail.

Created by the Partnerships & Strategic Overview Team, Kettering

Nafra FM centred on

Legend

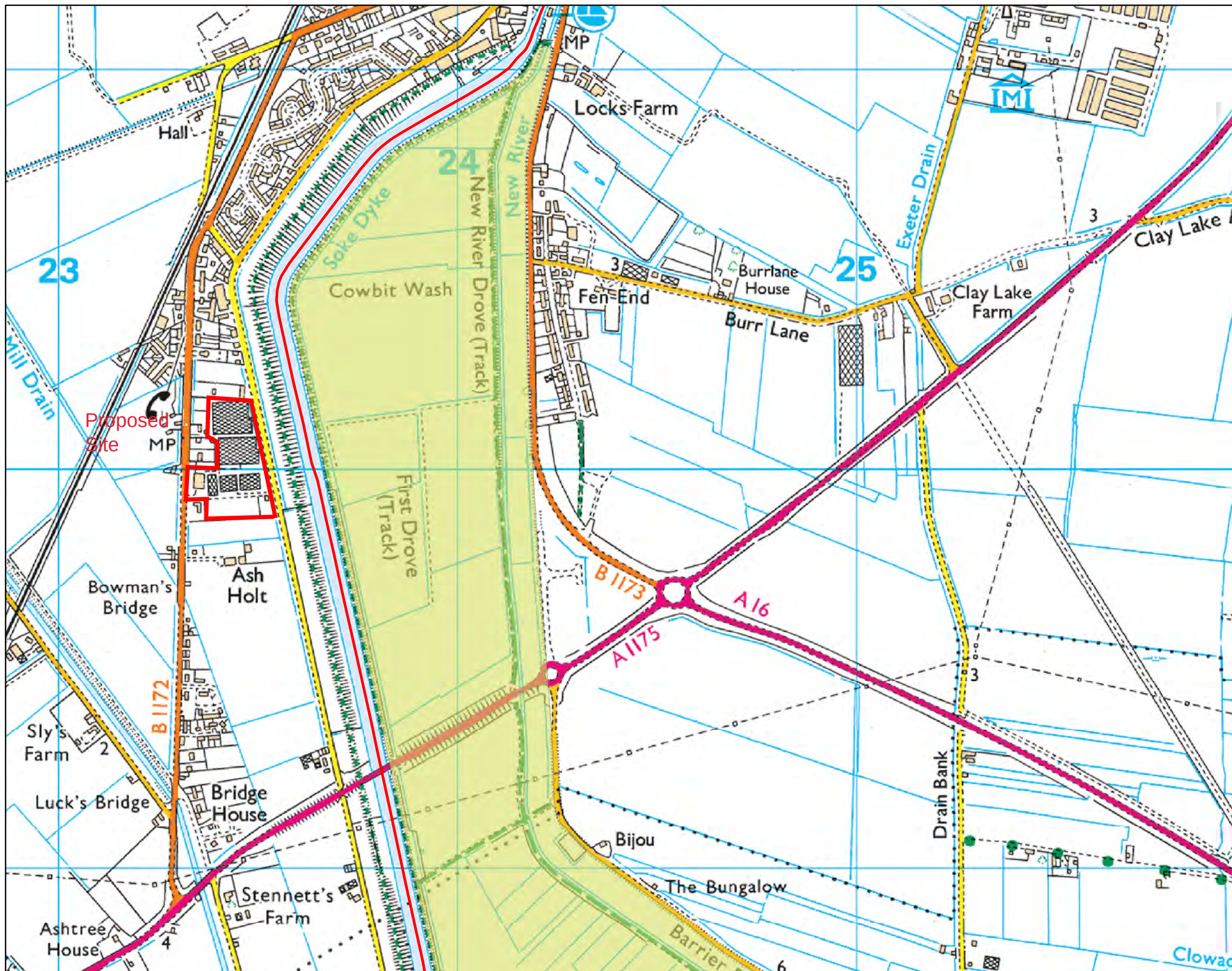
National Flood Risk Assessment (NaFRA)



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Historic Flood Extent Map

Map centred on TF 23428 20073 - created June 2016 [Ref: CCN-2016-15021]



Scale 1:10,000



- Main River
- March 1947 on the River Welland near Cowbit

Created by the Partnership & Strategic Overview Team,
Kettering

Extract From South Holland District Council SFRA

UPDATE OF STRATEGIC
FLOOD RISK ASSESSMENT
Residual Flood Hazard
Spalding - Year 2115
1% Fluvial / 0.5% Tidal Event Probability

Map Legend

Peak Hazard

Low



Moderate



Significant



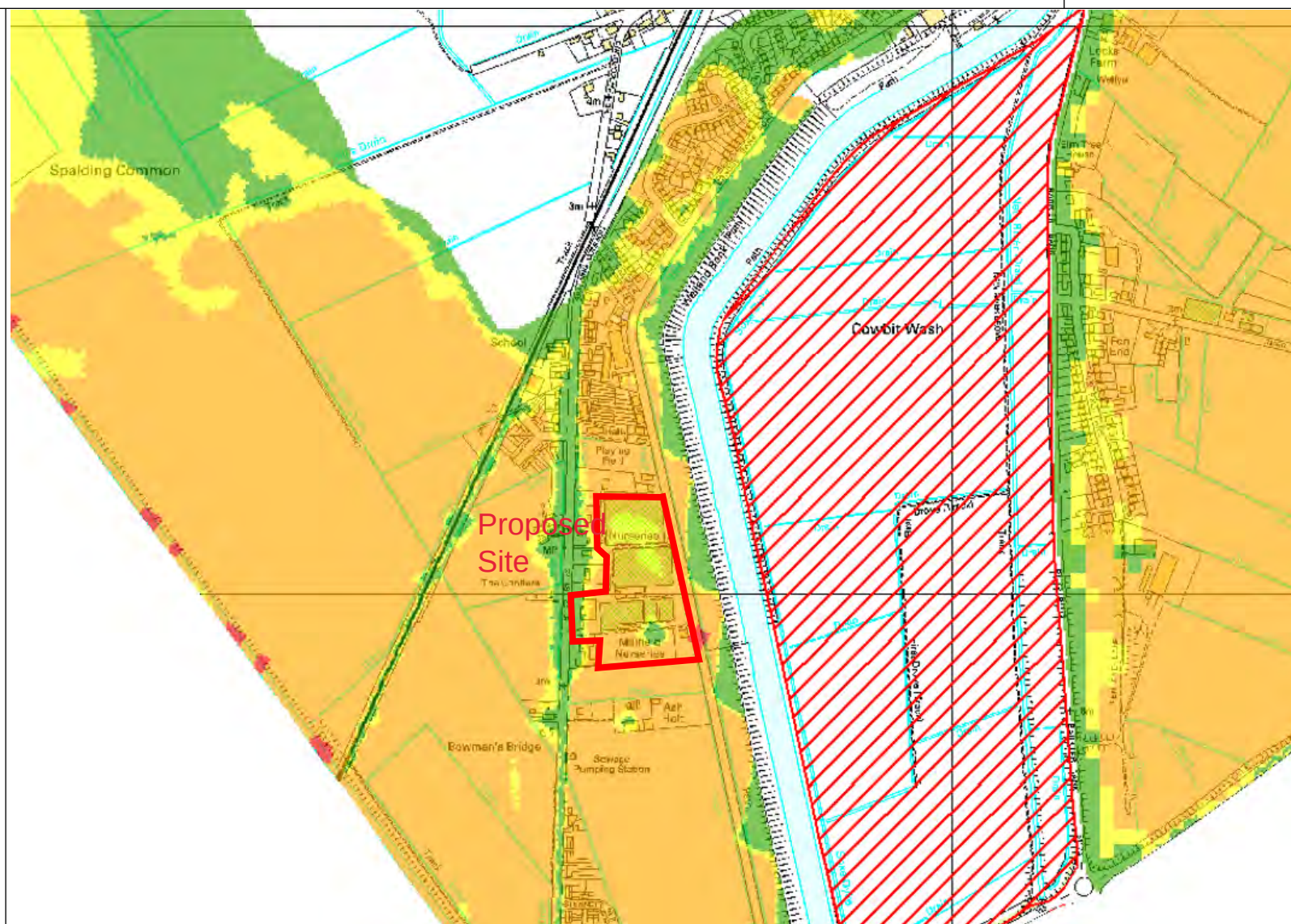
Extreme



Functional Floodplain



South Holland District
Boundary



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Extract From South Holland District Council SFRA

UPDATE OF STRATEGIC
FLOOD RISK ASSESSMENT
Residual Peak Depth
Spalding - Year 2115
1% Fluvial / 0.5% Tidal Event Probability

Legend

Peak Depth

0m - 0.5m



0.5m - 1m



1m - 1.5m



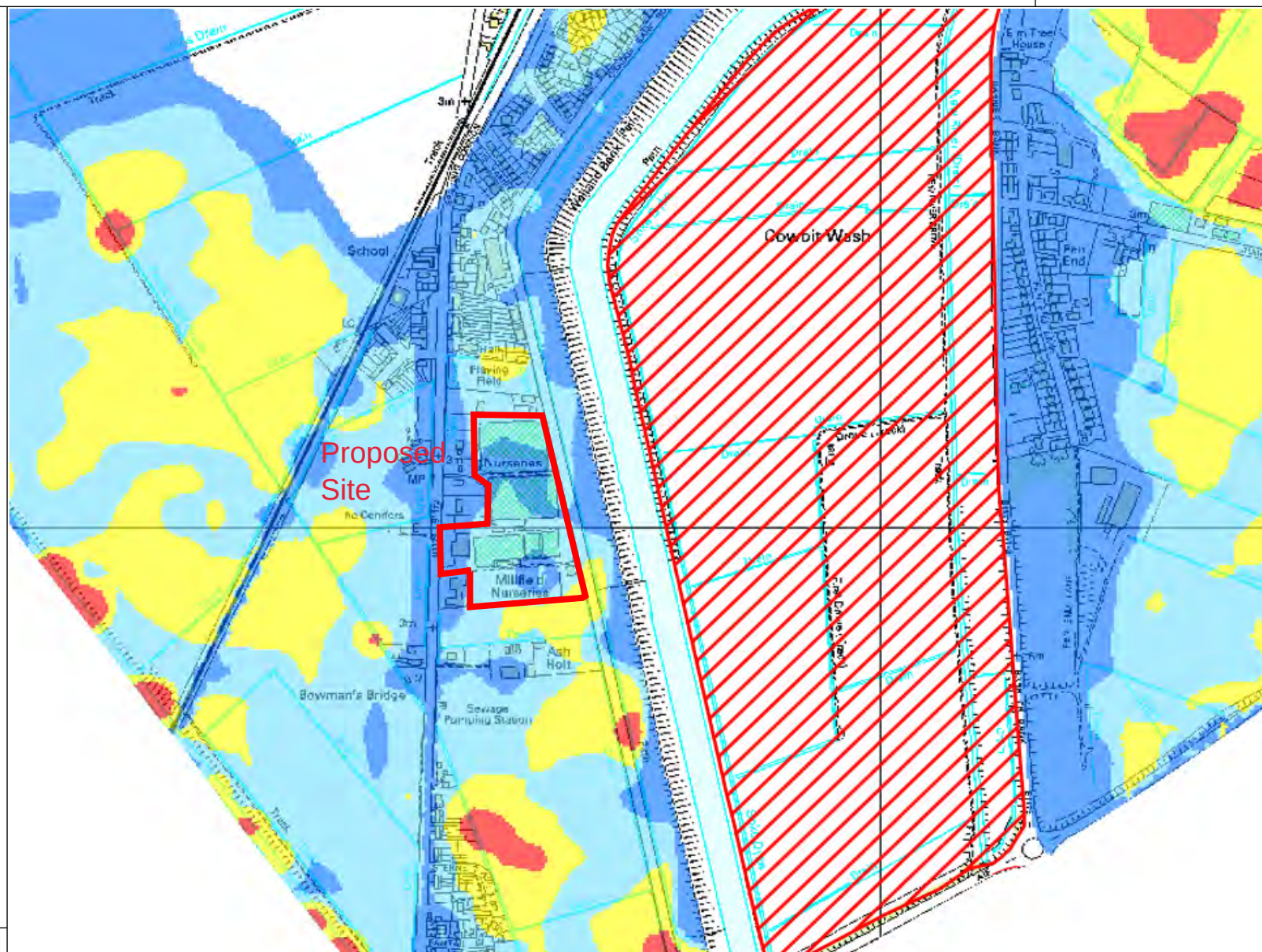
>1.5m



Functional Floodplain



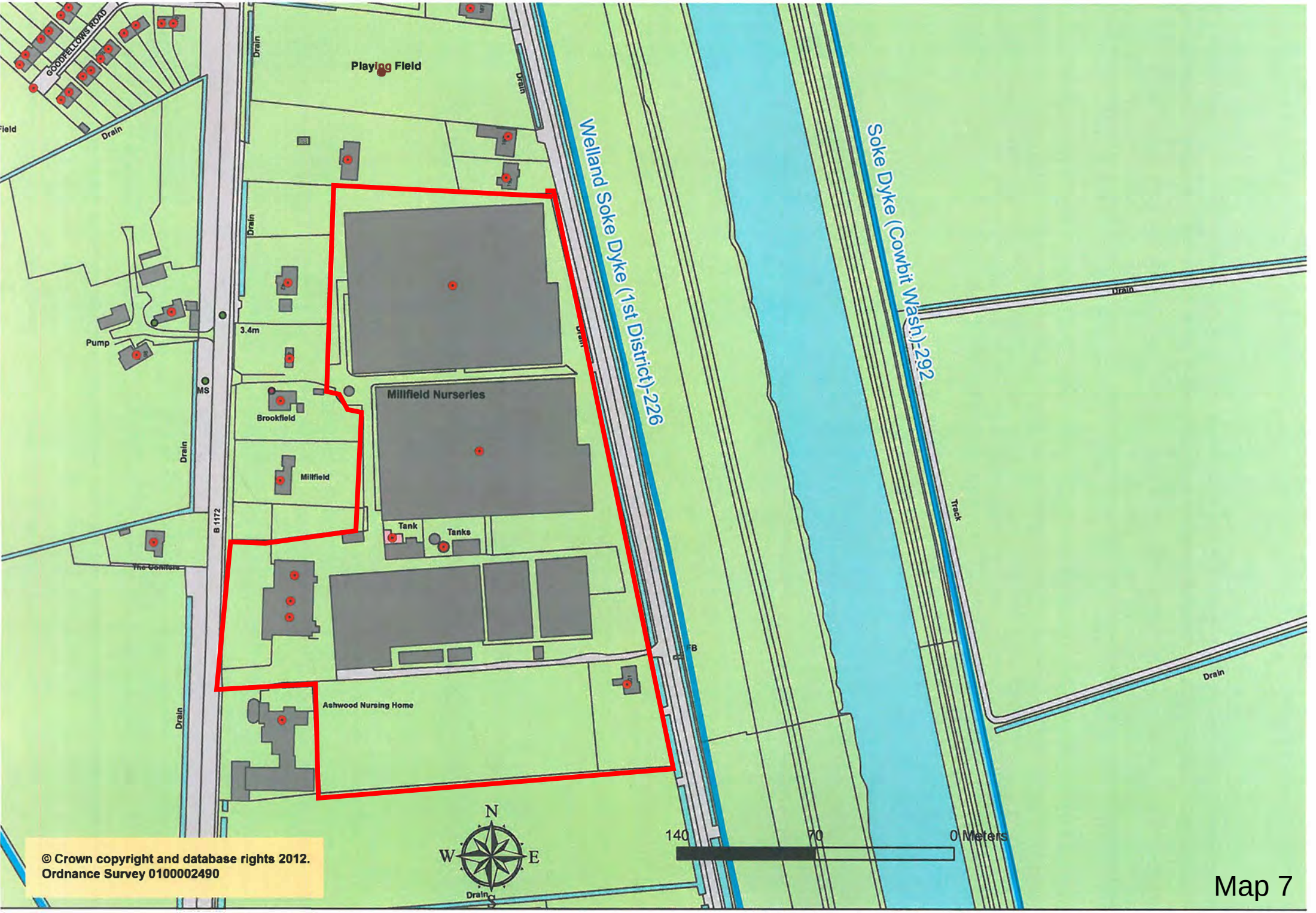
South Holland District
Boundary



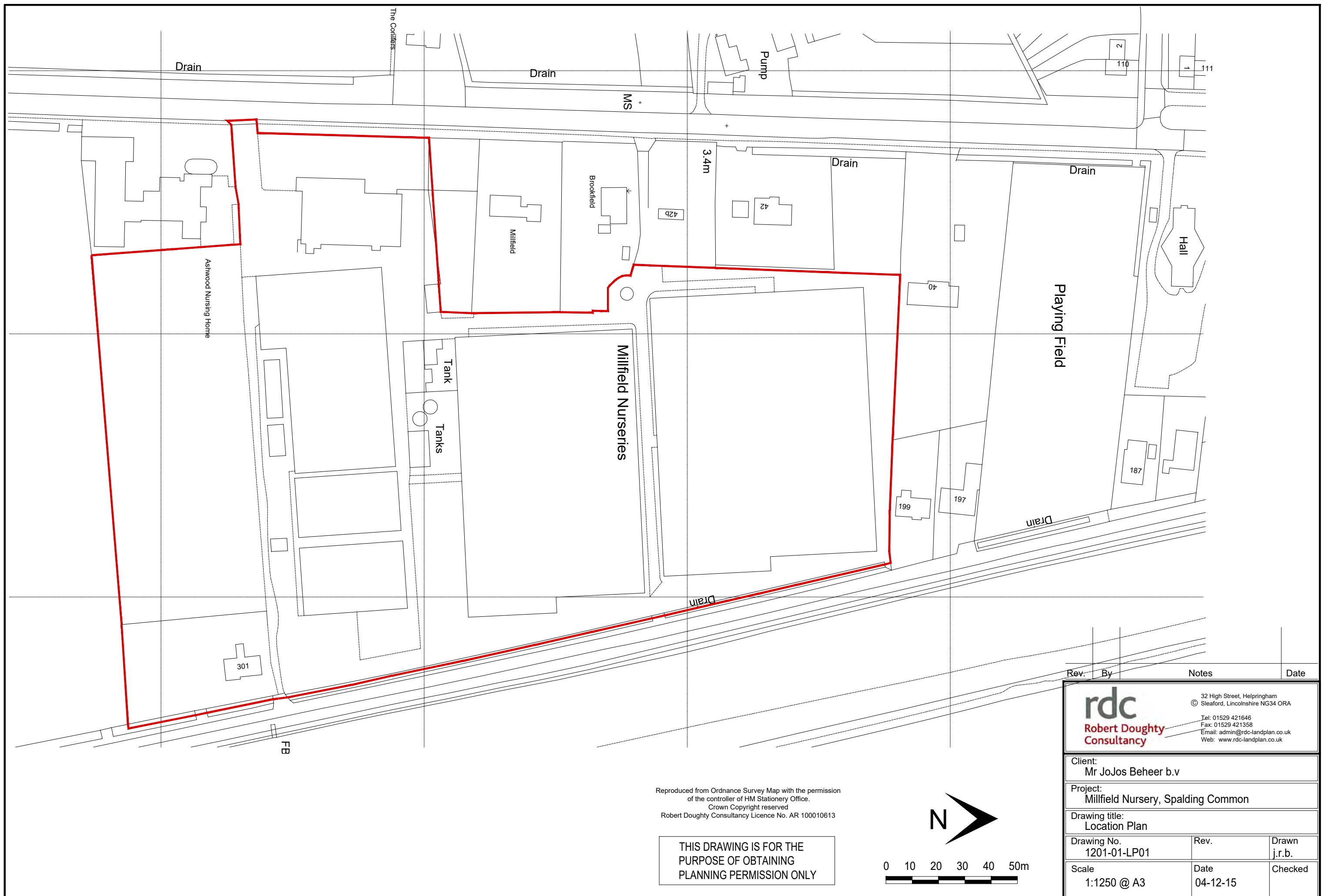
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**UPDATE OF STRATEGIC
FLOOD RISK ASSESSMENT**
Residual Peak Velocity
Spalding - Year 2115
1% Fluvial / 0.5% Tidal Event Probability





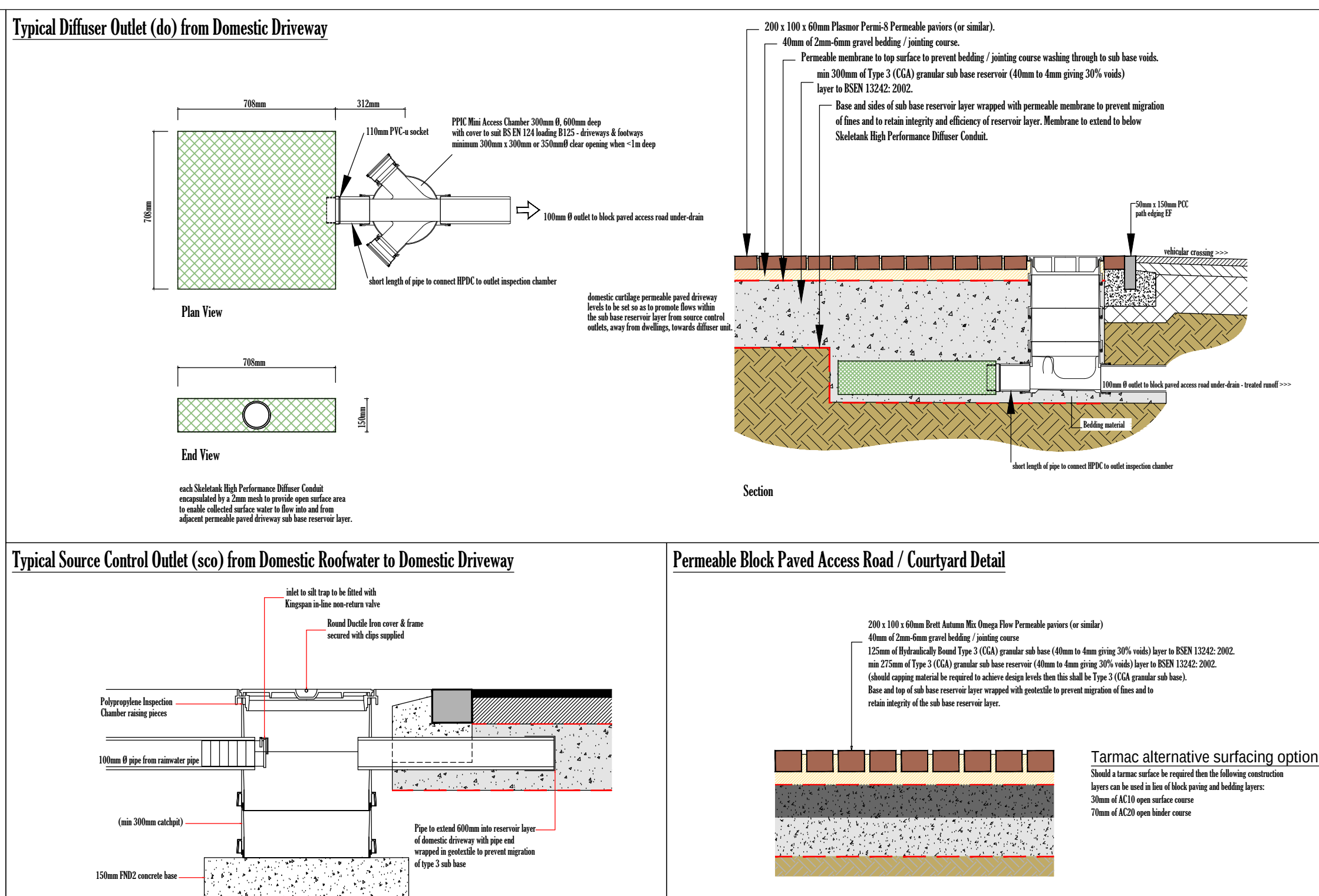
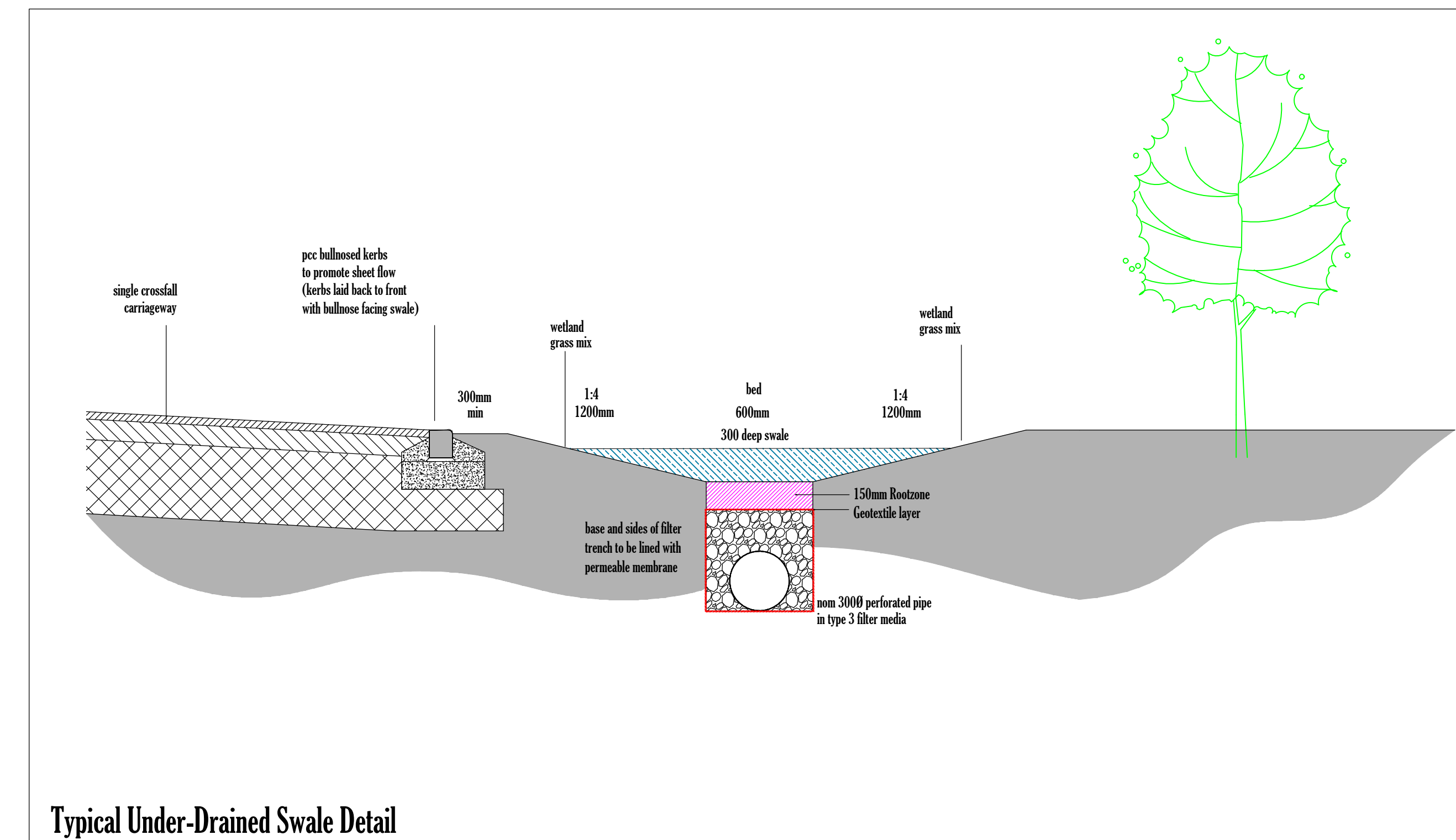
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Impermeable Area Schedule.

- Development Site (this application).
Total Area = 4.604 Ha.
Ai = 1.867 Ha. (41% including development creep)
- Domestic Carriage Road Areas:
Ai = 0.795 Ha. (17%) plus 6% development creep Ai = 0.843 Ha. (18%)
to be connected to adjacent permeable paved individual
driveways with base reservoir layers.
- Domestic Carriage Individual Driveways (road category 1).
Ai = 0.389 Ha. (8%)
To be paved with permeable materials with levels set to shed
towards diffuser outlets / flow control positions.
- Domestic Carriage Private Access Road / Courtyards (road category 3).
Ai = 0.195 Ha. (4%)
To be paved with permeable materials with levels set to shed
towards diffuser outlets / flow control positions.
- Permeable Paved Adopted Access Roads / Footpaths (block paving).
Ai = 0.092 Ha. (2%)
To be paved in permeable block paving with surface water
run-off to perforated under-drain pipe.
- Impermeable Paved Adopted Access Roads / Footpaths (tarmac).
Ai = 0.348 Ha. (8%)
To be paved in traditional impermeable materials with surface water
run-off to adjacent under-drained swales / filter strips.
- Proposed route of under-drained swale with pipe linking
treated surface water drainage to balancing pond and agreed outfall position.



DO NOT SCALE. USE FIGURED DIMENSIONS ONLY.
CHECK ON SITE AND ALL DISCREPANCIES TO BE
REPORTED TO HALL infrastructure DESIGN Ltd.

AMENDMENTS:

REV	DESCRIPTION	DATE	BY

CLIENT:
Mr & Mrs [Name]
c/o [Address]

PROJECT:
[Project Name]
[Project Address]

TITLE:
Schematic Concept Drainage Plan

SCALE: 1:500 DATE: May 2016 SIZE: A0

DRAWING NO: 1000-01 DRAWN BY: [Name] CHECKED BY: [Name]

HALL
infrastructure-
DESIGN

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website: www.hall-infrastructure-design.co.uk

Appendix A

NODE LABEL > Welland 16724

INPUTS >	FLOW	LEVEL
2	60.92	4.01
5	77.16	4.28
10	82.77	4.37
25	87.24	4.43
50	90.12	4.47
75	90.59	4.48
100	90.87	4.49
100+20	90.47	4.67
200	91.07	4.50
1000	91.29	4.50
1000+20	91.27	4.67

FILL IN THE BLUE CELLS WITH LEVELS AND FLOWS
INTERPOLATED LEVELS IN GREEN
EXTRAPOLATED LEVELS IN RED - USE WITH CAUTION

EQUATION > 0.018 2.9025

ATTENUATION 18.57 20.53 % FOR 1:100
FACTOR 18.28 20.03 % FOR 1:1000

100	1	90.87	4.54
20%	1.2	109.04	4.87
25%	1.25	113.59	4.95
35%	1.35	122.67	5.11
40%	1.4	127.22	5.19
65%	1.65	149.94	5.60

OUTPUTS

1000	1	91.29	4.55
20%	1.2	109.55	4.87
25%	1.25	114.11	4.96
35%	1.35	123.24	5.12
40%	1.4	127.81	5.20
65%	1.65	150.63	5.61

FULL CURVE	
60.92	4.01
77.16	4.28
82.77	4.37
87.24	4.43
90.12	4.47
90.59	4.48
90.87	4.49
91.07	4.50
90.47	4.67
109.04	4.87
91.29	4.50
113.59	4.95
122.67	5.11
127.22	5.19
109.55	4.87
114.11	4.96
149.94	5.60
123.24	5.12
127.81	5.20
150.63	5.61

