Norwich Western Link

Drainage Strategy Report Appendix 8: Technical Note: NDR Basin 1A Drainage Analysis

Author: WSP

Document Reference: 4.04.08

Version Number: 00

Date: March 2024

Contents

1 Introduction

1.1.1 This document details the assessment undertaken on the capacity of the existing NDR basin 1A after applying updated climate change allowances. It concludes that there is capacity to contain the flows from the proposed NWL Basin 1 when discharged at 43 l/s rate and consequently infiltrate to the ground and that minimum freeboard requirements are met. It also confirms that the water quality assessment demonstrates that sufficient treatment has been provided for Basin 1 and Basin 1A.

1.1.2 We have included a summary of key information shown in this document in an accessible format. However, some users may not be able to access all technical details. If you require this document in a more accessible format please contact: norwichwesternlink@norfolk.gov.uk

TECHNICAL NOTE, Version 4

DATE:	02 August 2023	**CONFIDENTIALITY:**	Restricted
SUBJECT:	NDR Basin 1A Drainage Analysis, Revised		
PROJECT:	Norwich Western Link	**AUTHOR:**	Shiva Sharma
CHECKED:	Soledad Berbel Roman	**APPROVED:**	Simon Gilliland

INTRODUCTION

This Technical Note has been prepared as an addendum to that prepared by WSP in 2020 to support a planning application for the proposed Norwich Western Link (Report Reference: PK1002-RAM-HDG-MLE-SG-DZ-0001_Ver1 Appendix 6 - WSP Technical Note). A copy of the 2020 Technical Note has been included in Appendix A.

The 2020 Technical Note showed that there is capacity within the existing NDR Basin 1A to contain the flows from the proposed NWL Basin 1 when discharged at a 43l/s rate and consequently infiltrate to the ground. The LLFA did not object to this approach (Norfolk County Council Ref: FW2020_0409). Since then, new Climate Change allowances guidance has been released by the Environment Agency which should be considered for this assessment.

This Technical Note addendum looks at the suitability of the NDR Basin 1A based on the latest guidance updates. The following aspects will be checked:

- The capacity of Basin 1A should be sufficient to accommodate overland flows from the rural catchment considering updated Climate Change allowances as well as the flows from Basin 1 (43l/s).
- Design freeboards of 300mm should be achieved.
- The proposed surface water drainage design needs to address all four pillars of SuDS in line with Schedule 3 requirements for existing and proposed surface water drainage features.

This addendum also includes a review of the datasets, guidance and methods used in the 2020 Technical Note and will conclude whether the most up to date information and methodology has been used.

DESIGN STANDARD AND METHODOLOGY CHECK

As part of the 2020 Technical Note, the methodology used to assess the existing capacity of the NDR Basin 1A included:

1. *Review of the existing FRA, including the extent of the Flood Estimation Handbook[1] (FEH) catchment used for sizing NDR Basin 1A.*

This remains unchanged, this step is used to work out the capacity of the existing NDR Basin 1A, as calculated before.

[1] https://fehweb.ceh.ac.uk/

2. *Review of area and topography of the catchment draining into NDR Basin 1A using 1m DTM (Environment Agency data).*

A Google maps desktop analysis show no changes to the catchment. The area of the catchment draining into the NDR Basin 1A has been increased by 3.01 ha being the new total area of 117.01 ha.

3. *Updated the existing catchment descriptors for the NDR Basin 1A and adjusted in line with current land use.*

The catchment descriptors and land uses remain the same since 2020.

4. *Estimated the Greenfield run off received using the Revitalised flood hydrograph (ReFH) method.*

ReFH still applies. Later this year 2023 ReFH2 will be released, however for this current addendum, ReFH still applies.

5. *Modelled the catchment draining into the NDR Basin 1A using Micro-Drainage.*

The Micro-Drainage model has been updated using the latest Climate Change allowances.

6. *Estimation of the time to peak for the 1 in 100-year (1% Annual Exceedance Probability), 24 hour duration storm event (storm duration used in NDR FRA).*

The 2020 Technical Note states that an analysis in Micro-Drainage was performed to understand the capacity of the basin using the 1% Annual Exceedance Probability (AEP) including a 40% Climate Change allowance. Updated catchment-based climate change allowances[2] have been released by the Environment Agency. Basin 1 and Basin 1A are within the Broadlands Rivers Management Catchment. For this catchment a Climate Change uplift of 40% should be allocated to the 3.33% AEP rainfall event and a Climate Change uplift of 45% should be allocated to the 1% AEP rainfall event. Those changes have been modelled in Micro-Drainage to understand the capacity of the basin. Calculations have been included within Appendix C.

[2] Flood Risk Assessments: climate change allowances, EA 2022

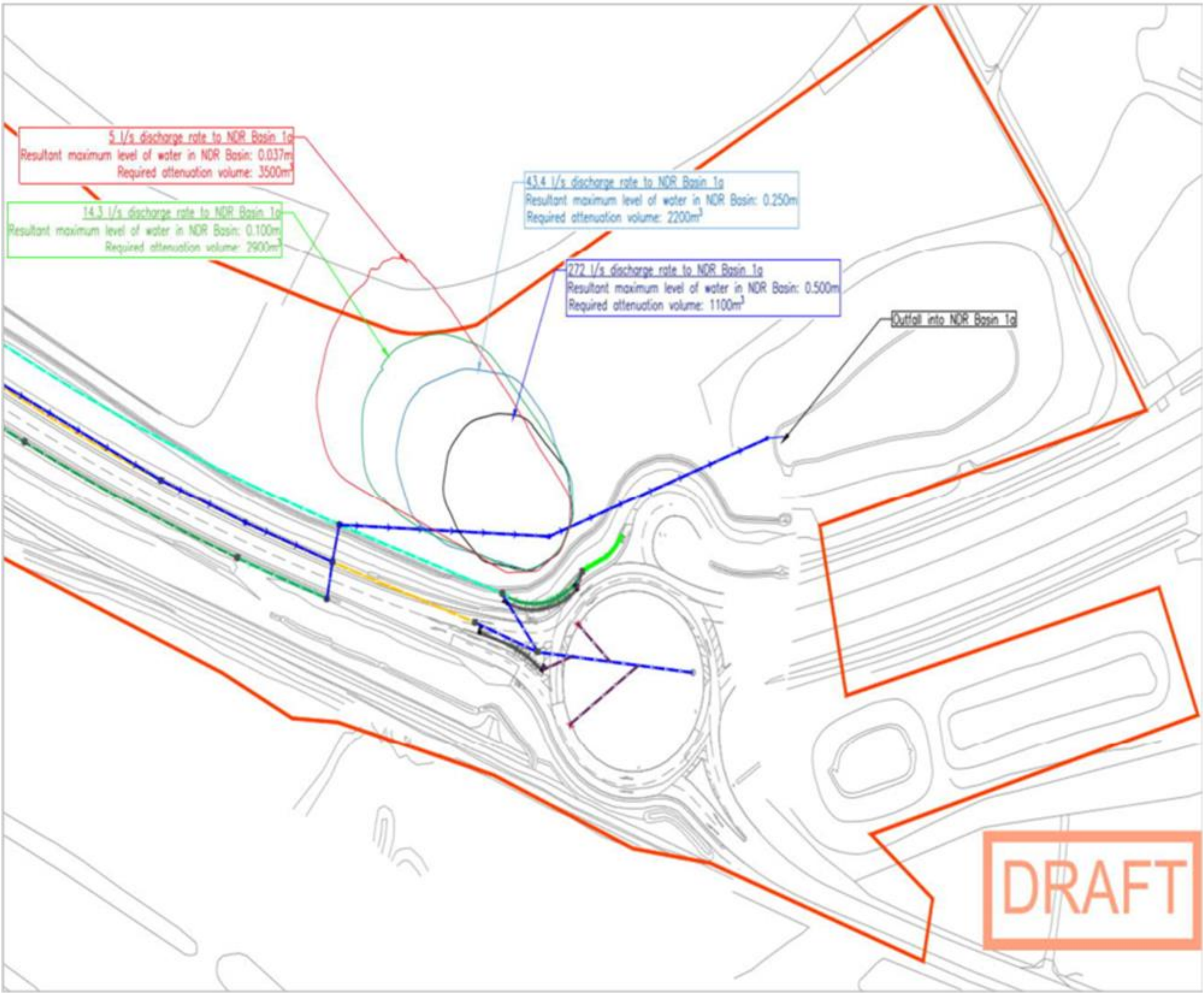


Figure 1 NDR Basin 1A and Basin 1. Plan showing location of these basins within the NWL scheme

RESULTS

The present analysis has evaluated the current capacity of NDR Basin 1A using the most up to date datasets. The Micro-Drainage assessment has been undertaken using the same parameters that were used in 2020 technical note and using the updated catchment area (catchment area of 117.01ha, discharge rate of 43l/s from NWL Basin 1 to Basin 1A, site-specific infiltration rate of 0.432 m/hr, factor of safety of 5 and excluded infiltration via the base of the basin). Latest EA Climate Change allowances have been applied for the calculations. The results show the following:

- Updated Greenfield runoff rates are shown in Table 1:

Table 1 – Greenfield runoff rates obtained for the catchment.

Return Period	Greenfield runoff rates (l/s)
Qbar	48.3
1 in 1 year	42.07
1 in 30 years	118.4
1 in 100 years	172.2
1 in 200 years	203.6

- The maximum volume for 3.33% AEP rainfall event with 40% Climate Change uplift is 2957.3m^3 (below existing basin capacity of 7665m^3) and the maximum water depth is 0.898m (below existing basin depth of 2m).
- The maximum volume for 1% AEP rainfall event with 45% Climate Change uplift is 4384.3m^3 and the maximum water depth is 1.262m. The half drain time is 1323 min (22 hours). This meets the LLFA requirement of half drain time below 24 hours. This confirms that the existing basin currently has a freeboard of approximately 0.74m, with additional capacity of approximately 3280.7m^3.

Discharge rates from NWL Basin 1 to Basin 1A has not changed since 2020. The modelled discharges from NWL Basin 1 to Basin 1A are shown in Table 2 below:

Table 2 – NWL Basin 1 and NDR Basin 1A design aspects

Flow Control (l/s)	Approximate attenuation volume (m^3) required in NWL Basin 1	Maximum depth of water (m) above base of NDR Basin 1A in critical storm - from controlled highway discharge (NWL Catchment 1)
5	3,500	0.04
14	2,900	0.1
43	2,200	0.25
272	1,100	0.5
Unrestricted	0	0.57

These outcomes indicate that a controlled discharge of 43 litres/ second would provide a reasonable balance between the required storage volume in NWL Basin 1 (sediment forebay) and the maximum depth of water in NDR Basin 1A. Accounting for the existing overland flow from the NDR (storage volume of 4384.3m^3 and water depth of 1.262m for the 1% AEP rainfall event with 45% Climate Change uplift) the available freeboard in NDR Basin 1A is approximately 0.488m in this scenario.

In addition to the capacity assessment, both basins should address all four pillars of SuDS in line with Schedule 3 requirements for existing and proposed surface water drainage features. The interim drainage network water quality assessment completed in March 2023 has evaluated Basin 1 describing the treatment provision and outfall mechanisms. According to this assessment the proposed drainage system provides sufficient treatment based on the justification and assessments that have been undertaken. Further details can be found within Appendix B.

CONCLUSION

The assessment has confirmed that NDR Basin 1A is still fit for purpose and has sufficient capacity after applying updated Climate Change allowances for both 3.33%AEP and 1%AEP flood events. The available freeboard is 0.488 m satisfying the minimum 300mm freeboard requirements.

The recent water quality assessment report undertaken in line with CIRIA Report 142: 'Control of Pollution from Highway Drainage Discharges' demonstrated that sufficient treatment has been provided for Basin 1 and Basin 1A.

APPENDIX A: 2020 TECHNICAL NOTE – NDR BASIN 1A DRAINAGE ANALYSIS

TECHNICA NOTE

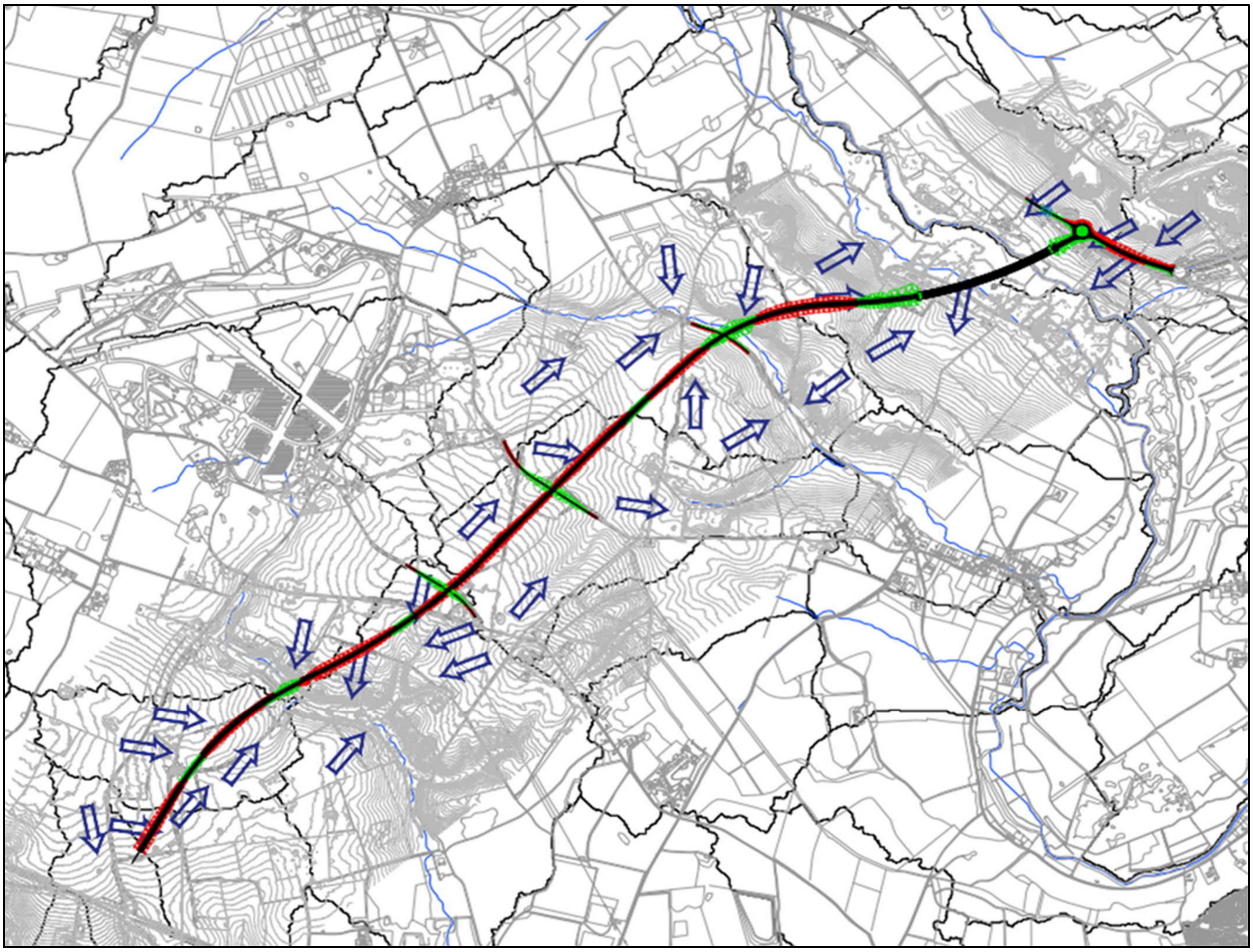
DA E:	14 May 2020	**CONFI ENTIALITY:**	Internal
SUBJECT:	NDR Basin 1A Drainage Analysis, V rsion 2		
PROJECT:	Norwich West rn Link	**AUTHOR:**	Amina Sh ikh- sman
CH CKE :	Sol dad B rb l Roman	**APPROV D:**	Simon Gilliland

INTRO UC ION

Th Norwich Western Link road (NWL) Scheme consists of a 3.9-mile dual carriageway link from the roundabout at the western end of Broadland Northway, formerly known as the Northern Distributor Road (NDR) to the A47 west of Norwich.

Th rout of the NWL pass s through a rural area and int rsects a number of hydrological catchments along its length. These hydrological catchments are defin d principally by local topography and existing drainage features such as wat rcourses or land drains. The existing catchments intersected by the NWL are shown on Figure 1 along with an indicative flow direction indicating the general fall of th catchment.

Figure 1 – Hydrological catchments along th NWL



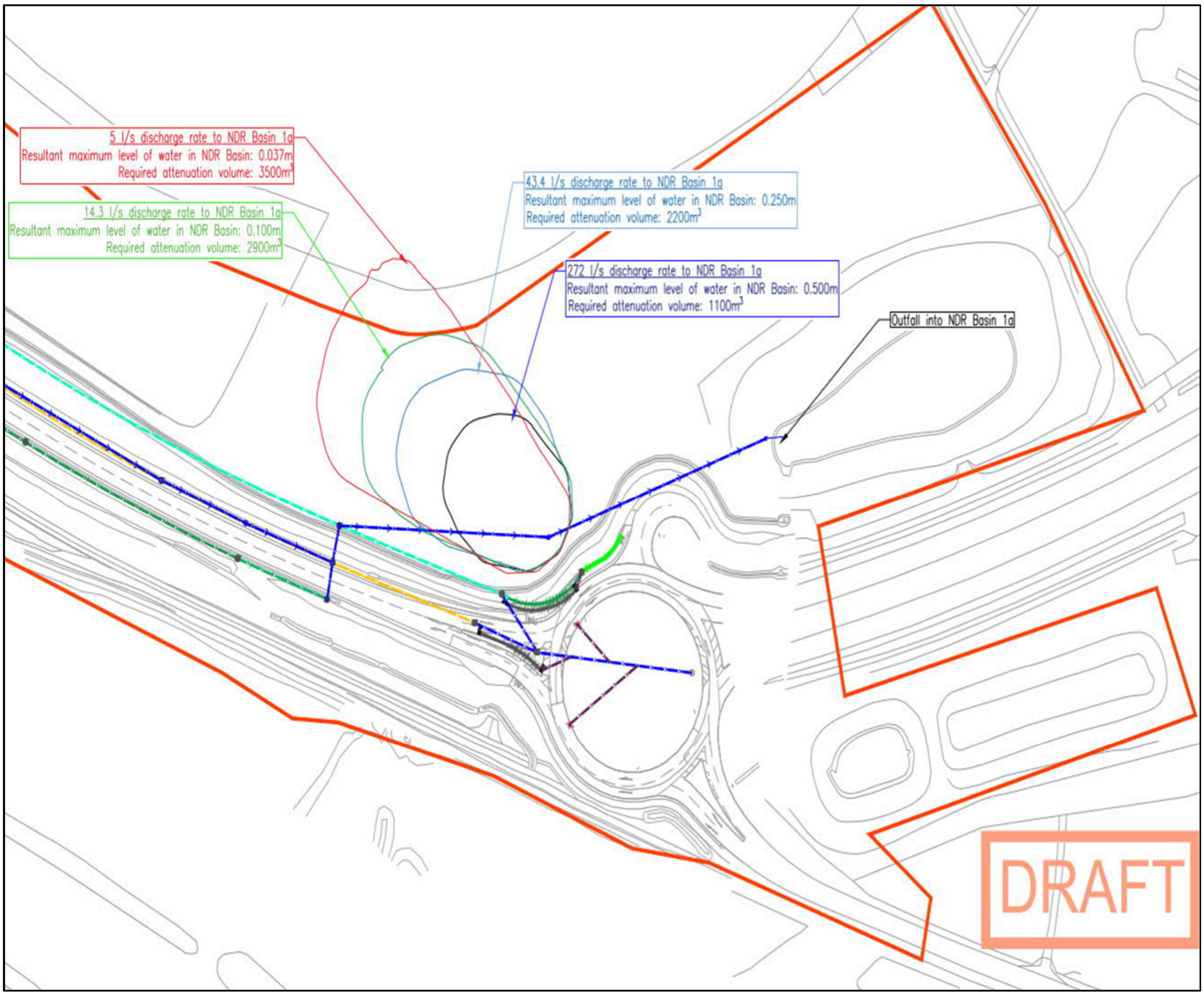
TECHNICA NOTE

DA E:	14 May 2020	**CONFI ENTIALITY:**	Internal
SUBJECT:	NDR Basin 1A Drainage Analysis, V rsion 2		
PROJECT:	Norwich West rn Link	**AUTHOR:**	Amina Sh ikh- sman
CH CKE :	Sol dad B rb l Roman	**APPROV D:**	Simon Gilliland

Du to the nvironm ntal s nsitivity of th River Wensum, an alternativ option of discharging to existing NDR drainage featur s was explored. This has identified that ther is scope to discharg to th existing 'NDR Basin (Lagoon) 1A' as d fined in the Flood Risk Assessment (FRA) for the Northern Distributor Road (NDR) prepared by Mott MacDonald in 2014 (ref. TR010015, Doc. 6.2). This basin was designed to contain overland flow only, with no contribution of runoff from th NDR.

This basin is preferred on the basis of accessibility; available land should the basin n ed to be upsized; and the potential for existing capacity within the basin to be utilised without the need for upsizing. An indicative plan showing how th existing NDR Basin 1A will be utilis d is shown in Figure 2.

Figure 2 – NDR Basin 1A, plan showing its incorporation with the NW schem



TECHNICAL NOTE

DATE:	14 May 2020	**CONFIDENTIALITY:**	Internal
SUBJECT:	NDR Basin 1A Drainage Analysis, Version 2		
PROJECT:	Norwich Western Link	**AUTHOR:**	Amina Sheikh-Osman
CHECKED:	Soledad Berbel Roman	**APPROVED:**	Simon Gilliland

Methodology

The following steps have been taken to assess existing capacity of NDR Basin 1A.

1. Review of the existing FRA, including the extent of the Flood Estimation Handbook[1] (FEH) catchment used for sizing NDR Basin 1A.
2. Review of area and topography of the catchment draining into NDR Basin 1A using 1m DTM (Environment Agency data).
3. Updated the existing catchment descriptors for the NDR Basin 1A and adjusted in line with current land use.
4. Estimated the Greenfield run off received using the Revitalised flood hydrograph (ReFH) method.
5. Modelled the catchment draining into the NDR Basin 1A using Micro-Drainage.
6. Estimation of the time to peak for the 1 in 100-year (1% Annual Exceedance Probability), 24 hour duration storm event (storm duration used in NDR FRA).

Results are discussed in the next section.

RESULTS

As stated within the FRA, NDR Basin 1A was designed to contain overland flow only, with no runoff contribution from the carriageway. The favourable infiltration rates obtained at this location allow the feature to drain via infiltration to ground. The basin was sized to accommodate a 100-year return period storm event with an additional allowance of 30% climate change, plus a minimum freeboard of 300mm.

The present analysis has evaluated the current capacity of NDR Basin 1A using up to date datasets, guidance and methods; and only follows a similar approach to that taken in the NDR FRA where appropriate. The catchment boundary has been digitised in QGIS using a DTM of 1m resolution. The initial analysis indicated a catchment draining area of approximately 100 ha. The catchment extent has been reviewed after conversations with the LLFA, and a conservative approach has been taken using a catchment of 114ha.

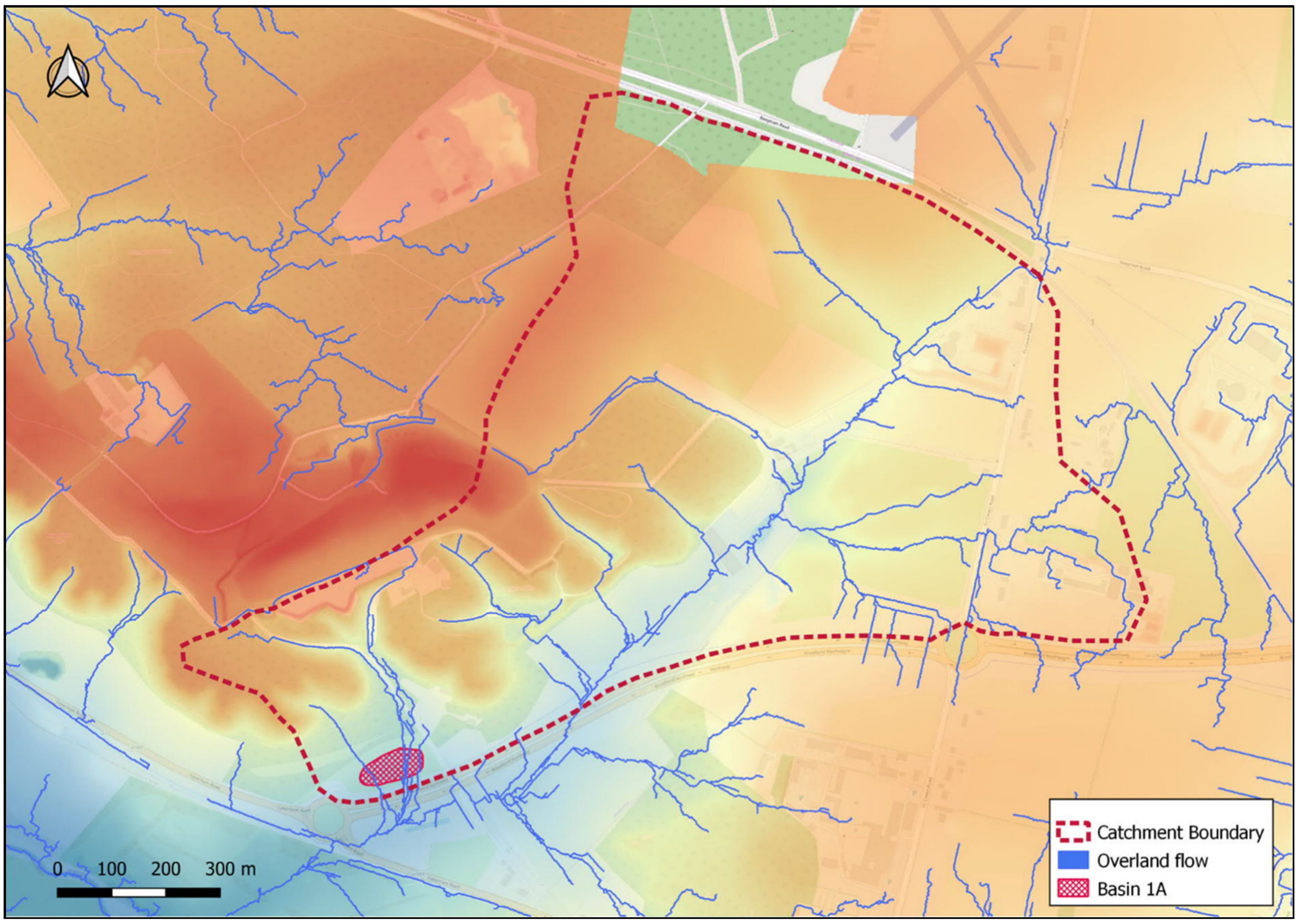
Figure 3 illustrates the location of this catchment and the overland flow generated by a GIS watershed analysis.

[1] https://fehweb.ceh.ac.uk/

TECHNICAL NOTE

DATE:	14 May 2020	**CONFIDENTIALITY:**	Internal
SUBJECT:	NDR Basin 1A Drainage Analysis, Version 2		
PROJECT:	Norwich Western Link	**AUTHOR:**	Amina Sheikh-Osman
CHECKED:	Soledad Berbel Roman	**APPROVED:**	Simon Gilliland

Figure 3 – NDR Basin 1A, plan showing its incorporation with the NWL scheme

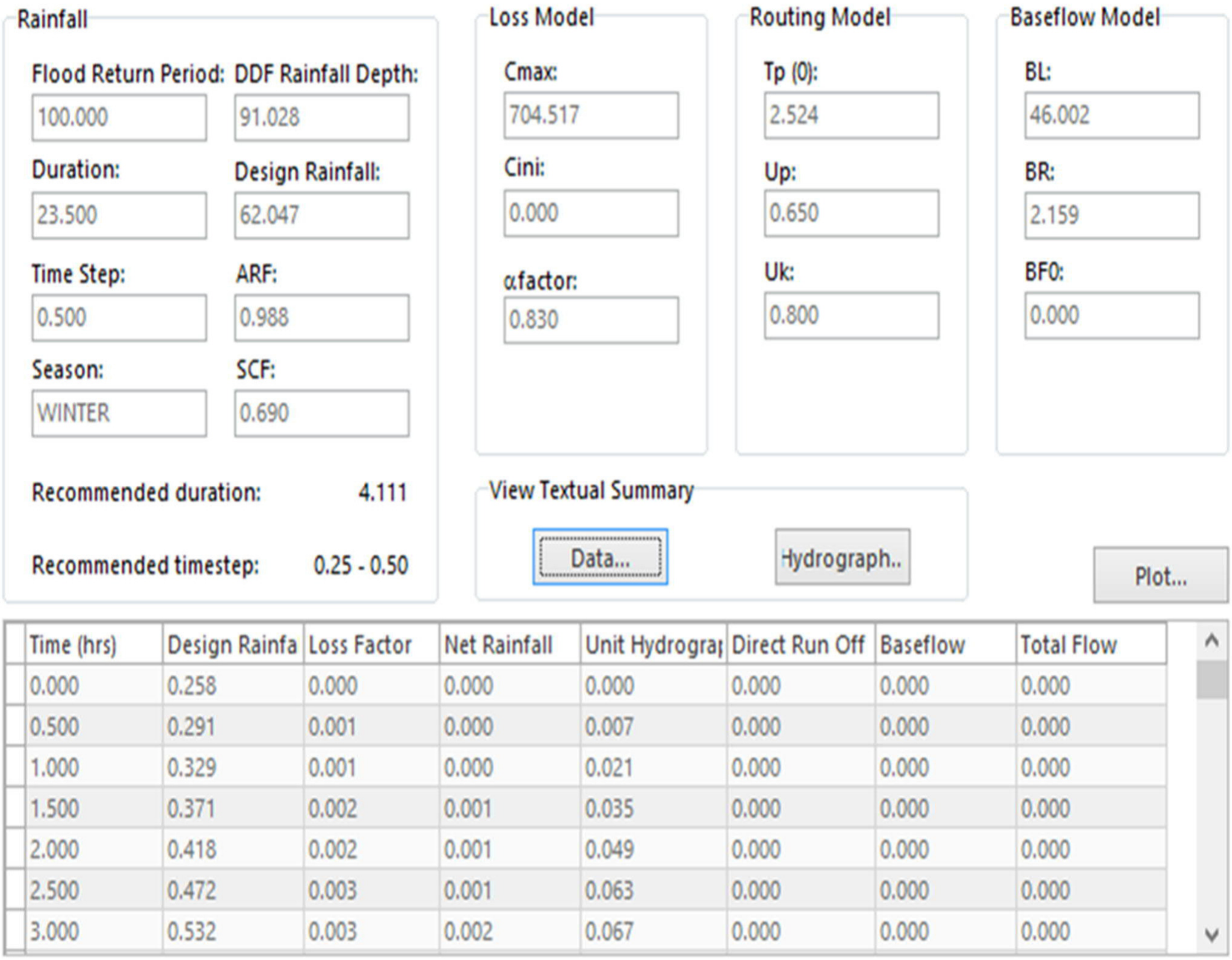


Up to date hydrological catchment descriptors were obtained from the FEH[2] Web service mapping. Catchment descriptors were checked against UK soil maps and the British Geological Survey[3] Geology of Britain viewer. The BFIHOST value of 0.886 indicates permeable underlaying strata – Geological lexicon: *Lewes Nodular Chalk Formation, Seaford Chalk Formation, Culver Chalk Formation and Portsdown Chalk Formation*. A review of existing Ordnance Survey (OS) mapping suggests minimal attenuation in the catchment, correlating well to the FEH's FARL value of 1. URBEXT2000 has been slightly adjusted to represent the increased urbanisation in the catchment. The revised catchment descriptors are presented within Appendix A.

The ReFH method has been used to generate the rainfall and the flood hydrograph for a 1 in 100-year, 24-hour storm duration event shown in Figure 4 (this is consistent with the storm event used in the NDR FRA). Greenfield runoff results for the catchment are presented in Table 1.

[2] https://fehweb.ceh.ac.uk/
[3] http://mapapps.bgs.ac.uk/geologyofbritain/home.html

Figure 4 – Parameters for the ReFH model (rural catchment) and hydrograph



DATE:	14 May 2020	**CONFIDENTIALITY:**	Internal
SUBJECT:	NDR Basin 1A Drainage Analysis, Version 2		
PROJECT:	Norwich Western Link	**AUTHOR:**	Amina Sheikh-Osman
CHECKED:	Soledad Berbel Roman	**APPROVED:**	Simon Gilliland

Table 1 – Greenfield runoff rates obtained for the catchment

Return Period	Greenfield runoff rates (l/s)
Qbar	47.1
1 in 1 year	41.0
1 in 30 years	115.4
1 in 100 years	167.8
1 in 200 years	198.4

The sizing of the existing NDR Basin 1A has been estimated using the site-specific infiltration rate (0.432 m/hr); a factor of safety of 5 for the analysis of the infiltration basin (as per the guidance in CIRIA C753); and infiltration via the base of the basin has also been excluded (further to discussions around best practice with the LLFA). This is consistent with the approach agreed with the LLFA for all infiltration basins on the NWL. The depth of the existing basin is 2m and the total storage volume is 7,665m^3 (including 0.3m freeboard).

An analysis in Micro-Drainage has been performed to understand the capacity of the basin. The results indicate that the half drain time of the basin is 1,379 minutes (23 hours); therefore, meeting the LLFA requirements of half drain time below 24 hours. The maximum volume required to contain a 1 in 100 year plus 40% climate change event is 4,632m^3, for the critical 720-minute (12 hour) storm, reaching a maximum water depth of 1.3m. Following the current guidance in C753, a 360-minute (6 hour) storm event would require a basin storage volume of 4,327 m^3 and generate a water depth of 1.25m.

Therefore, the above analysis confirms that the existing basin currently has a freeboard of approximately 0.7m, with additional capacity of approximately 3,350m^3. A summary of the results is shown in Figure 5. A detailed summary of the Micro-Drainage results is included in Appendix B.

DATE:	14 May 2020	**CONFIDENTIALITY:**	Internal
SUBJECT:	NDR Basin 1A Drainage Analysis, Version 2		
PROJECT:	Norwich Western Link	**AUTHOR:**	Amina Sheikh-Osman
CHECKED:	Soledad Berbel Roman	**APPROVED:**	Simon Gilliland

Figure 5 – Micro-Drainage results indicating required storage volume in NDR Basin 1A in a 1 in 100 year plus 40% climate change storm.

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m^3)	Status
30 min Winter	15.676	0.676	20.3	2153.7	O K
60 min Winter	15.820	0.820	23.0	2669.2	O K
120 min Winter	15.989	0.989	27.5	3298.4	O K
180 min Winter	16.092	1.092	30.2	3697.7	O K
240 min Winter	16.162	1.162	32.1	3976.7	O K
360 min Winter	16.248	1.248	33.9	4327.4	O K
480 min Winter	16.293	1.293	34.6	4510.7	O K
600 min Winter	16.315	1.315	34.9	4599.3	O K
720 min Winter	16.322	1.322	35.1	4631.6	O K
960 min Winter	16.314	1.314	34.9	4595.4	O K
1440 min Winter	16.269	1.269	34.2	4412.1	O K
2160 min Winter	16.205	1.205	33.2	4153.1	O K
2880 min Winter	16.145	1.145	31.7	3910.9	O K
4320 min Winter	16.041	1.041	28.9	3500.1	O K
5760 min Winter	15.956	0.956	26.6	3174.9	O K
7200 min Winter	15.892	0.892	24.9	2933.7	O K
8640 min Winter	15.840	0.840	23.6	2741.8	O K
10080 min Winter	15.796	0.796	22.5	2583.0	O K

The 'As Built' drawings for the existing NDR indicate that the catchment runoff is intercepted by a French drain (Pre-Earthworks Drainage, PED) running along the northern side of the NDR. It is expected that this feature will attenuate and support shallow infiltration prior to discharging into NDR Basin 1A. Attenuation and infiltration within the French drain has not currently been included in the model, due to; a lack of available data on the condition of the asset; and the presence of a trench lining along a short length of the drain. However, reasonably if included this would further reduce the required storage volume.

TECHNICAL NOTE

DATE:	14 May 2020	**CONFIDENTIALITY:**	Internal
SUBJECT:	NDR Basin 1A Drainage Analysis, Version 2		
PROJECT:	Norwich Western Link	**AUTHOR:**	Amina Sheikh-Osman
CHECKED:	Soledad Berbel Roman	**APPROVED:**	Simon Gilliland

CONCLUSIONS

The assessment is based on the design work undertaken and considers the land available adjacent to the A1067. It demonstrates that is possible to discharge runoff from the NWL to NDR Basin 1A without altering the size of the basin. An additional proposed attenuation basin with integral sediment forebay (NWL Basin 1) adjacent to the A1067, will intercept runoff from NWL Catchment 1 and discharge this to NDR Basin 1A.

The modelled discharges shown in Table 2, indicate that a controlled discharge rate of 43 litres/ second would provide a reasonable balance between the required storage volume in NWL Basin 1 (sediment forebay) and the maximum depth of water in NDR Basin 1A. Accounting for the existing overland flow from the NDR (storage volume of 4,327 m^3 and water depth of 1.25m) the available freeboard in NDR Basin 1A is approximately 0.5m in this scenario.

Table 2 – NWL Basin 1 and NDR Basin 1A design aspects

Flow Control (l/s)	Approximate attenuation volume (m^3) required in NWL Basin 1	Maximum depth of water (m) above base of NDR Basin 1A in critical storm - from controlled highway discharge (NWL Catchment 1)
5	3,500	0.04
14	2,900	0.1
43	2,200	0.25
272	1,100	0.5
Unrestricted	0	0.57

The assessment doesn't account for the following factors which further strengthen the case for utilising the existing NDR Basin 1A for runoff from the NWL:

- The significant difference in times to peak (see Appendix C for NDR overland flow catchment) which would result in a lag time of approximately 6 hours between the two catchments;
- A basin half drain time of less than 24 hours;
- Attenuation and infiltration within the French drain (Pre-Earthworks Drainage) along the northern side of the NDR that intercepts overland flow and conveys it to NDR Basin 1A.

This option is subject to further design development and the discharge rate is subject to agreement with the LLFA. NWL Basin 1 is also subject to appropriate pollution control measures in line with CIRIA 142- "Control of pollution from highway drainage discharge will also be subject to a revised Highways England Water Risk Assessment Tool (HEWRAT).

TECHNICAL NOTE

DATE:	14 May 2020	**CONFIDENTIALITY:**	Internal
SUBJECT:	NDR Basin 1A Drainage Analysis, Version 2		
PROJECT:	Norwich Western Link	**AUTHOR:**	Amina Sheikh-Osman
CHECKED:	Soledad Berbel Roman	**APPROVED:**	Simon Gilliland

APPENDIX A: REVISED CATCHMENT DESCRIPTORS

Catchment Descriptors		**Value**
AREA	Catchment area (km^2)	1.14
ALTBAR	Mean catchment altitude (m above sea level), derived from the IHDTM	37
ASPBAR	Index representing the dominant aspect of catchment slopes (°)	217
ASPVAR	Index representing the invariability in aspect of catchment slopes (°)	0.15
BFIHOST	Base Flow Index derived using the HOST soil classification	0.886
DPLBAR	Mean of distances between each node on the IHDTM grid and the catchment outlet, in kilometres. Used to characterise catchment size and configuration	1.31
DPSBAR	FEH index of overall catchment steepness	27.4
FARL	FEH index of flood attenuation dur to reservoirs and lakes	1
FPEXT	Fraction of the catchment that is estimated to be inundated by a 100-year flood	0.0491
FPDBAR	The mean depth of water on floodplains in a 100-year event	0.167
FPLOC	The location of floodplains within the catchment is described using the same principles employed to derive values of the FEH index URBLOC	0.956
LDP	Longest drainage path (in kilometres), defined by recording the greatest distance from a catchment node to the defined outlet	2.67
PROPWET	FEH catchment wetness index	0.31
RMED-1H		11.3
RMED-1D		27.8
RMED-2D		36.1
SAAR	Average annual rainfall in the standard period (1961-1990) in millimetres. (SAAR4170 is from 1941 to 1970)	629
SAAR4170		638
SPRHOST	Standard percentage runoff (%) associated with each HOST soil class	15.44
URBCONC1990	Index of the concentration of urban and suburban land cover in 1990 expressed as a fraction.	0.389
URBEXT1990	Index of urban and suburban land cover in 1990 expressed as a fraction	0.0098
URBLOC1990	Index of the location of urban and suburban land cover in 1990 expressed as a fraction.	1.053

URBCONC2000	Index of the concentration of urban and suburban land cover in 2000 expressed as a fraction.	0.759
URBEXT2000	Index of urban and suburban land cover in 2000 expressed as a fraction	0.0311
URBLOC2000	Index of the location of urban and suburban land cover in 2000 expressed as a fraction.	1.09
C		-0.02364
D1		0.28686
D2		0.34361
D3		0.2507
E		0.31324
F		2.46977
C(1 km)		-0.024
D1(1 km)		0.284
D2(1 km)		0.359
D3(1 km)		0.248
E(1 km)		0.311
F(1 km)		2.478

Source: Institute of Hydrology. 1999. Flood Estimation Handbook, 5 volumes and associated software. Institute of Hydrology

TECHNICAL NOTE

DATE:	14 May 2020	**CONFIDENTIALITY:**	Internal
SUBJECT:	NDR Basin 1A Drainage Analysis, Version 2		
PROJECT:	Norwich Western Link	**AUTHOR:**	Amina Sheikh-Osman
CHECKED:	Soledad Berbel Roman	**APPROVED:**	Simon Gilliland

APPENDIX B: MICRO-DRAINAGE RESULTS

WSP Group Ltd		Page 1
. . .		Micro Drainage
Date 05/05/2020 11:13 File	Designed by SBR Checked by SG	
XP Solutions	Source Control 2019.1	

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 1379 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	15.477	0.477	16.3	1465.9	O K
30 min Summer	15.610	0.610	19.2	1921.4	O K
60 min Summer	15.740	0.740	21.5	2380.0	O K
120 min Summer	15.894	0.894	25.0	2940.2	O K
180 min Summer	15.987	0.987	27.4	3293.6	O K
240 min Summer	16.051	1.051	29.1	3539.6	O K
360 min Summer	16.129	1.129	31.2	3844.9	O K
480 min Summer	16.167	1.167	32.3	3998.1	O K
600 min Summer	16.184	1.184	32.7	4065.8	O K
720 min Summer	16.188	1.188	32.8	4083.0	O K
960 min Summer	16.176	1.176	32.5	4034.8	O K
1440 min Summer	16.145	1.145	31.7	3911.3	O K
2160 min Summer	16.096	1.096	30.3	3716.7	O K
2880 min Summer	16.051	1.051	29.1	3539.9	O K
4320 min Summer	15.975	0.975	27.1	3245.2	O K
5760 min Summer	15.913	0.913	25.5	3011.3	O K
7200 min Summer	15.867	0.867	24.3	2843.4	O K
8640 min Summer	15.832	0.832	23.3	2712.1	O K
10080 min Summer	15.803	0.803	22.6	2608.6	O K
15 min Winter	15.529	0.529	17.4	1642.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	148.960	0.0	27
30 min Summer	98.000	0.0	41
60 min Summer	61.180	0.0	70
120 min Summer	38.360	0.0	130
180 min Summer	29.087	0.0	188
240 min Summer	23.800	0.0	248
360 min Summer	17.757	0.0	366
480 min Summer	14.265	0.0	484
600 min Summer	11.953	0.0	602
720 min Summer	10.302	0.0	722
960 min Summer	8.081	0.0	860
1440 min Summer	5.688	0.0	1112
2160 min Summer	3.971	0.0	1500
2880 min Summer	3.080	0.0	1908
4320 min Summer	2.167	0.0	2732
5760 min Summer	1.703	0.0	3568
7200 min Summer	1.431	0.0	4336
8640 min Summer	1.252	0.0	5184
10080 min Summer	1.126	0.0	5952
15 min Winter	148.960	0.0	27

TECHNICA NOTE

DA E:	14 May 2020	**CONFI ENTIALITY:**	Internal
SUBJECT:	NDR Basin 1A Drainage Analysis, V rsion 2		
PROJECT:	Norwich West rn Link	**AUTHOR:**	Amina Sh ikh- sman
CH CKE :	Sol dad B rb l Roman	**APPROV D:**	Simon Gilliland

WSP Group Ltd		Page 2
Date 05/05/2020 11:13 File	Designed by SBR Checked by SG	
XP Solutions	Source Control 2019.1	

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	15.676	0.676	20.3	2153.7	O K
60 min Winter	15.820	0.820	23.0	2669.2	O K
120 min Winter	15.989	0.989	27.5	3298.4	O K
180 min Winter	16.092	1.092	30.2	3697.7	O K
240 min Winter	16.162	1.162	32.1	3976.7	O K
360 min Winter	16.248	1.248	33.9	4327.4	O K
480 min Winter	16.293	1.293	34.6	4510.7	O K
600 min Winter	16.315	1.315	34.9	4599.3	O K
720 min Winter	16.322	1.322	35.1	4631.6	O K
960 min Winter	16.314	1.314	34.9	4595.4	O K
1440 min Winter	16.269	1.269	34.2	4412.1	O K
2160 min Winter	16.205	1.205	33.2	4153.1	O K
2880 min Winter	16.145	1.145	31.7	3910.9	O K
4320 min Winter	16.041	1.041	28.9	3500.1	O K
5760 min Winter	15.956	0.956	26.6	3174.9	O K
7200 min Winter	15.892	0.892	24.9	2933.7	O K
8640 min Winter	15.840	0.840	23.6	2741.8	O K
10080 min Winter	15.796	0.796	22.5	2583.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	98.000	0.0	41
60 min Winter	61.180	0.0	70
120 min Winter	38.360	0.0	128
180 min Winter	29.087	0.0	186
240 min Winter	23.800	0.0	244
360 min Winter	17.757	0.0	360
480 min Winter	14.265	0.0	474
600 min Winter	11.953	0.0	588
720 min Winter	10.302	0.0	700
960 min Winter	8.081	0.0	916
1440 min Winter	5.688	0.0	1154
2160 min Winter	3.971	0.0	1604
2880 min Winter	3.080	0.0	2052
4320 min Winter	2.167	0.0	2944
5760 min Winter	1.703	0.0	3808
7200 min Winter	1.431	0.0	4616
8640 min Winter	1.252	0.0	5448
10080 min Winter	1.126	0.0	6256

WSP Group Ltd		Page 3
. . .		Micro Drainage
Date 05/05/2020 11:13 File	Designed by SBR Checked by SG	
XP Solutions	Source Control 2019.1	

Model Details

Storage is Online Cover Level (m) 17.000

Infiltration Basin Structure

Invert Level (m) 15.000 Safety Factor 5.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 1.00
Infiltration Coefficient Side (m/hr) 0.43200

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	2697.0	1.400	4176.0	2.800	0.0	4.200	0.0
0.200	3050.0	1.600	4403.0	3.000	0.0	4.400	0.0
0.400	3301.0	1.800	4634.0	3.200	0.0	4.600	0.0
0.600	3480.0	2.000	4869.0	3.400	0.0	4.800	0.0
0.800	3619.0	2.200	0.0	3.600	0.0	5.000	0.0
1.000	3834.0	2.400	0.0	3.800	0.0		
1.200	4053.0	2.600	0.0	4.000	0.0		

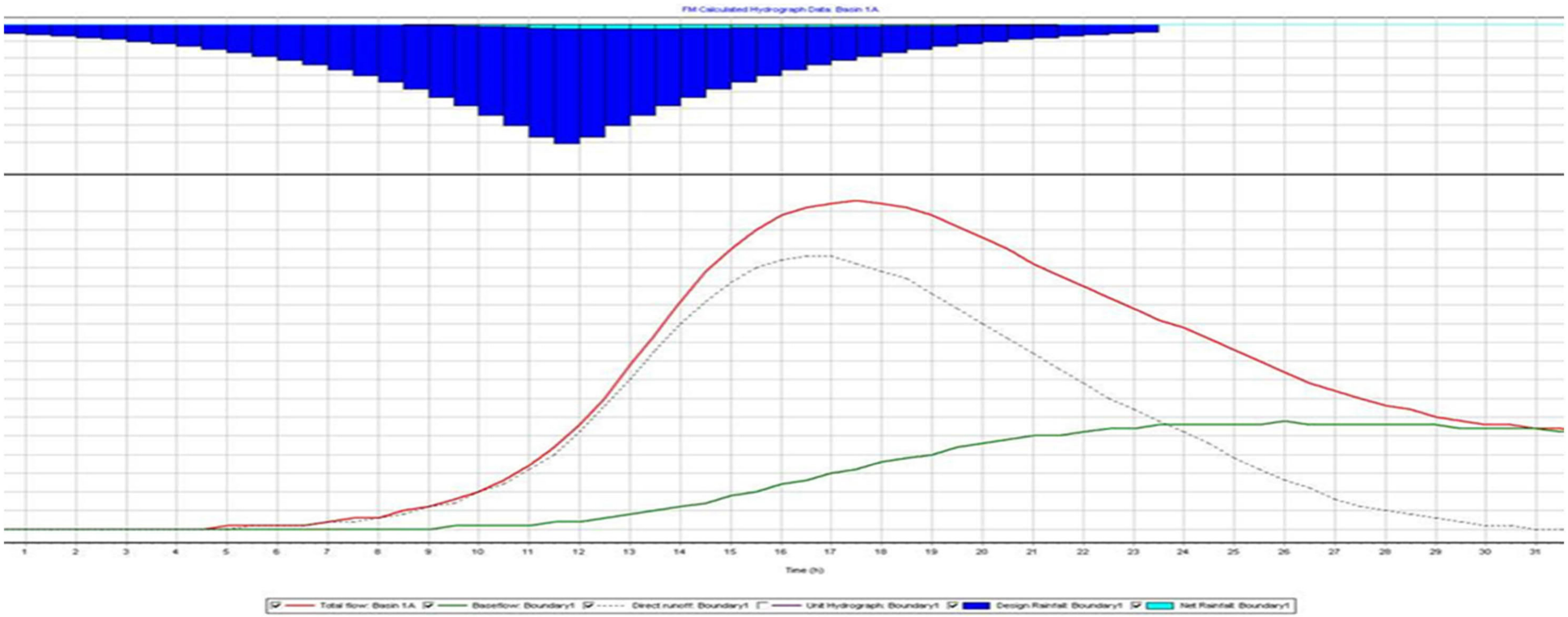
TECHNICAL NOTE

DATE:	14 May 2020	**CONFIDENTIALITY:**	Internal
SUBJECT:	NDR Basin 1A Drainage Analysis, Version 2		
PROJECT:	Norwich Western Link	**AUTHOR:**	Amina Sheikh-Osman
CHECKED:	Soledad Berbel Roman	**APPROVED:**	Simon Gilliland

APPENDIX C: HYDROGRAPH FOR NDR BASIN 1A

Time to peak: 17.5 hours

Lag time: 6 hours



APPENDIX B: 2023 INTERIM SUMMARY OF DRAINAGE NETWORK WATER QUALITY ASSESSMENT

TECHNICAL NOTE 1

DATE:	15 March 2023	**CONFIDENTIALITY:**	Restricted
SUBJECT:	Interim Summary of Drainage Network Water Quality Assessment		
PROJECT:	Norwich Western Link Road	**AUTHOR:**	Joanna Goodwin
CHECKED:	Thomas Eckhardt	**APPROVED:**	Chris Middleton

INTRODUCTION

This technical note briefly summarises the findings of the Drainage Network Water Quality Assessment for the Norwich Western Link Road for the purpose of supporting discussions between Ferrovial Construction, Norfolk County Council Infrastructure Delivery Team, and Norfolk County Council as Lead Local Flood Authority (LLFA).

This technical note is not intended to be included as part of the project deliverables or planning submission and is for the sole purpose as stated above.

DISCHARGE TO SURFACE WATERS

The Proposed Scheme proposes one direct discharge to Foxburrow Stream and one indirect discharge to the River Tud via the proposed drainage system serving the A47 North Tuddenham to Easton Dualling National Highways DCO Scheme.

The Drainage Network Water Quality Assessment for these outfalls used the Highways England[1] Water Risk Assessment Tool (HEWRAT). The proposed drainage design serving the Norwich Western Link Road was taken into consideration and is understood to comprise the following:

Basin	Outfall mechanism	Treatment provision
Basin 5	Outfall to Foxburrow Stream.	Grassed swales (lined) and catchpits to intercept silt and sediment at the edge of the carriageway. Sediment forebay with wetted area for planting. Penstock pollution control valve for spillage control.
Basin 6	Outfall to A47 surface water drainage system.	Grassed swales (lined) and catchpits to intercept silt and sediment at the edge of the carriageway. Sediment forebay with wetted area for planting. Penstock pollution control valve for spillage control.

The assessment demonstrates that these outfalls pass the HEWRAT with the inclusion of the proposed treatment measures.

[1] Now National Highways

TECHNICAL NOTE 1

DATE:	15 March 2023	**CONFIDENTIALITY:**	Restricted
SUBJECT:	Interim Summary of Drainage Network Water Quality Assessment		
PROJECT:	Norwich Western Link Road	**AUTHOR:**	Joanna Goodwin
CHECKED:	Thomas Eckhardt	**APPROVED:**	Chris Middleton

INFILTRATION TO GROUND

Surface water runoff from the remainder of the Proposed Scheme is proposed to be discharged to ground via infiltration basins.

The Drainage Network Water Quality Assessment for these outfalls followed the methodology set out in Appendix C of the Design Manual for Roads and Bridges (DMRB) (LA 113). This assessment takes into consideration traffic flow, drainage area, annual average rainfall, ground conditions and depth to the groundwater table. Treatment features and the sensitivity of groundwater resources are not included in the assessment methodology. Instead the assessment indicates the likely risk to groundwater (low, medium or high) and recommends further assessment where risks are indicated to be medium or high.

All of the basins serving the Proposed Scheme were concluded to have a medium risk. Undertaking more detailed quantitative analysis of the Proposed Scheme was not considered likely to change the findings of this assessment and instead a qualitative review of the Proposed Scheme and sensitivity of receiving waters is recommended. This has been undertaken, taking the following information into account:

- Sensitivity of underlying groundwater resources
- Proposed treatment measures and existing drainage regime (where relevant)
- Sensitivity of downstream receptors

<u>Proposed treatment measures and existing drainage regime</u>

The proposed drainage design is understood to comprise the following:

Basin	Outfall mechanism	Treatment provision
Basin 1 (attenuation)	Outlet discharges into the existing Northern Distributor Road (NDR) Basin 2 which then discharges to ground.	50% of runoff passes through grassed swales (lined) upstream of basin and all runoff passes through catchpits to intercept silt and sediment at the edge of the carriageway. Sediment forebay with wetted area for planting. Pollution control valve for spillage control.
Basin 2	Infiltration to ground.	Grassed swales (lined) and roadside drainage ditches with attenuation to intercept silt and sediment at the edge of the carriageway. The drainage along the viaduct includes catchpits instead of grassed swales due to spatial constraints. Separate sediment forebay with wetted area for planting. Pollution control valve (isolation penstock) for spillage control.

TECHNICAL NOTE 1

DATE:	15 March 2023	**CONFIDENTIALITY:**	Restricted
SUBJECT:	Interim Summary of Drainage Network Water Quality Assessment		
PROJECT:	Norwich Western Link Road	**AUTHOR:**	Joanna Goodwin
CHECKED:	Thomas Eckhardt	**APPROVED:**	Chris Middleton

Basin	Outfall mechanism	Treatment provision
Basin A1067	Infiltration to ground.	Catchpits and deep-pot gullies to intercept silt and sediment at the edge of the carriageway. Separate sediment forebay with wetted area for planting. Pollution control valve (isolation penstock) for spillage control.
Basin 3	Infiltration to ground.	Grassed swales (lined), catchpits and roadside drainage ditches with attenuation to intercept silt and sediment at the edge of the carriageway. Separate sediment forebay with wetted area for planting. Pollution control valve (isolation penstock) for spillage control.
Basin 4	Infiltration to ground.	Grassed swales (lined), catchpits and roadside drainage ditches with attenuation to intercept silt and sediment at the edge of the carriageway. Separate sediment forebay with wetted area for planting. Pollution control valve (isolation penstock) for spillage control.

Surface water runoff from new sections of highway is understood to pass through two vegetated treatment trains (grassed swales and infiltration basin with sediment forebay) which will provide robust treatment of runoff. The base of the basins is assessed to remain a minimum of 1m above highest recorded groundwater levels and, as such, provides treatment via percolation through the soil layers as required by the DMRB and standard design practices. Features such as catchpits and gullies are not typically recognised as a treatment train. Spillage control measures are also not typically recognised as a treatment train but will be in place to manage spillage risks.

Grassed swales are not proposed for the section of highway that is realigning the existing A1067 road network, noting that this comprises a c.200m length of the existing carriageway. However, a review of the existing drainage regime serving this section of road indicates that surface water runoff currently infiltrates directly to ground via an unlined filter drain. It is also understood that this feature is unlikely to be well maintained and access for maintenance is poor. The proposed drainage system for this section of road comprises an infiltration basin with sediment forebay and with dedicated maintenance access. An additional 300mm depth of topsoil is also understood to be included in the base of this basin to provide additional treatment. The proposed drainage system is therefore not considered to pose greater risk to receiving waterbodies when compared to the current regime and may provide some benefit.

TECHNICAL NOTE 1

DATE:	15 March 2023	**CONFIDENTIALITY:**	Restricted
SUBJECT:	Interim Summary of Drainage Network Water Quality Assessment		
PROJECT:	Norwich Western Link Road	**AUTHOR:**	Joanna Goodwin
CHECKED:	Thomas Eckhardt	**APPROVED:**	Chris Middleton

Sensitivity of underlying groundwater resources and downstream surface waters

The Proposed Scheme is located within Zone 3 (Total Catchment) of a Source Protection Zone. This is associated with the Chalk Principal Aquifer that underlies the study area and not the shallow superficial deposits. The sensitivity of shallow groundwater in superficial deposits is deemed to be relatively low when considered in isolation, although the importance of these resources is elevated due to their connectivity with the underlying Principal Aquifer and River Wensum.

When considering the findings of the DMRB risk assessment, infiltration from Basins 1 and 2 and Basin A1067 is most likely to flow towards the River Wensum and not percolate to the Principal Aquifer. Infiltration from Basins 3 and 4 is more likely to percolate to the Principal Aquifer, but this is located at significant depth below the basins and therefore additional treatment will be provided in the overlying soils layers. The risk to the Principal Aquifer is therefore considered to be low and the proposed treatment systems are appropriate.

Hydrogeological assessments undertaken as part of the EIA show a high connectivity between surface water in the River Wensum, shallow groundwater in superficial deposits and the deeper Chalk aquifer in proximity of the Wensum. The River Wensum is the main and the most sensitive receptor of groundwater flow in this area. The potential risk of pollutants migrating towards the River Wensum via groundwater flow has therefore been assessed by applying HEWRAT and treating the discharge as a point source surface water outfall to the Wensum. The assessment demonstrates that these outfalls (independently and cumulatively) would pass the HEWRAT with the inclusion of the proposed treatment measures, noting that this has not considered the additional treatment provided by migration through soil layers and dilution in the shallow aquifer.

It is understood that a high-level overflow is proposed in Basin A1067 that would discharge surface water from the basin towards the River Wensum. It is understood that this is a risk management measure that would only come into use in the unlikely scenario that the basin exceeds design capacity and overflows, noting that exclusion of the overflow could pose risk to the safety of the carriageway. It is also understood that the overflow would discharge to a vegetated ditch upstream of the River Wensum and not to the Wensum itself. Given the findings of the HEWRAT assessment above and noting that this is a risk management measure that would occur during high flows (i.e. diluted discharge) the potential risk to the River Wensum is considered to be low.

SUMMARY

HEWRAT was applied to assess risks associated with the discharge of surface water runoff to surface water features and this assessment was passed with the inclusion of proposed treatment measures.

The assessment of risks to groundwater does not provide a pass/fail result as per the assessment of risks to surface waters, but instead provides a low, medium or high risk score that prompts the need for further assessment. All basins were indicated to be medium risk. Qualitative review and further adoption of the

DATE:	15 March 2023	**CONFIDENTIALITY:**	Restricted
SUBJECT:	Interim Summary of Drainage Network Water Quality Assessment		
PROJECT:	Norwich Western Link Road	**AUTHOR:**	Joanna Goodwin
CHECKED:	Thomas Eckhardt	**APPROVED:**	Chris Middleton

HEWRAT methodology has however indicated that the risk to the Principal Aquifer and River Wensum (as the sensitive receptors that could be affected by infiltration) is low; and based on professional judgement the proposed treatment measures are deemed to be sufficient to prevent unacceptable risk to the water environment.

As discussed with Ferrovial Construction and Norfolk County Council Infrastructure Delivery Team during our call on Monday 13th March, there is no known prescriptive guidance that stipulates the number of SuDS treatment trains required prior to discharge to surface water or groundwater. There therefore remains a risk that the relevant authorities may request additional treatment given the sensitivity of the identified receptors. In our opinion the proposed drainage system provides sufficient treatment based on the justification provided above and the assessments that have been undertaken.

APPENDIX C: MICRO-DRAINAGE RESULTS

Summary of Results for 100 year Return Period (+45%)

Half Drain Time : 1339 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	15.455	0.455	15.8	1392.0	O K
30 min Summer	15.582	0.582	18.6	1824.3	O K
60 min Summer	15.706	0.706	20.9	2259.4	O K
120 min Summer	15.853	0.853	23.9	2791.0	O K
180 min Summer	15.943	0.943	26.3	3126.2	O K
240 min Summer	16.004	1.004	27.9	3359.4	O K
360 min Summer	16.079	1.079	29.9	3648.1	O K
480 min Summer	16.116	1.116	30.9	3792.4	O K
600 min Summer	16.131	1.131	31.3	3855.6	O K
720 min Summer	16.135	1.135	31.4	3870.7	O K
960 min Summer	16.123	1.123	31.1	3823.9	O K
1440 min Summer	16.094	1.094	30.3	3705.7	O K
2160 min Summer	16.046	1.046	29.0	3519.1	O K
2880 min Summer	16.002	1.002	27.8	3349.5	O K
4320 min Summer	15.927	0.927	25.8	3066.6	O K
5760 min Summer	15.867	0.867	24.3	2841.3	O K
7200 min Summer	15.822	0.822	23.1	2678.6	O K
8640 min Summer	15.786	0.786	22.3	2547.8	O K
10080 min Summer	15.758	0.758	21.8	2444.5	O K
15 min Winter	15.505	0.505	16.9	1559.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	154.280	0.0	27
30 min Summer	101.500	0.0	41
60 min Summer	63.365	0.0	70
120 min Summer	39.730	0.0	130
180 min Summer	30.126	0.0	188
240 min Summer	24.650	0.0	248
360 min Summer	18.391	0.0	366
480 min Summer	14.774	0.0	484
600 min Summer	12.380	0.0	602
720 min Summer	10.670	0.0	722
960 min Summer	8.369	0.0	878
1440 min Summer	5.891	0.0	1110
2160 min Summer	4.113	0.0	1496
2880 min Summer	3.190	0.0	1908
4320 min Summer	2.245	0.0	2732
5760 min Summer	1.764	0.0	3568
7200 min Summer	1.483	0.0	4336
8640 min Summer	1.297	0.0	5184
10080 min Summer	1.166	0.0	5952
15 min Winter	154.280	0.0	27

Summary of Results for 100 year Return Period (+45%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	15.645	0.645	19.8	2044.9	O K
60 min Winter	15.783	0.783	22.2	2534.1	O K
120 min Winter	15.945	0.945	26.3	3131.3	O K
180 min Winter	16.043	1.043	28.9	3510.0	O K
240 min Winter	16.111	1.111	30.7	3774.2	O K
360 min Winter	16.194	1.194	33.0	4104.8	O K
480 min Winter	16.235	1.235	33.7	4275.2	O K
600 min Winter	16.255	1.255	34.0	4356.2	O K
720 min Winter	16.262	1.262	34.1	4384.3	O K
960 min Winter	16.253	1.253	34.0	4345.7	O K
1440 min Winter	16.211	1.211	33.3	4173.8	O K
2160 min Winter	16.150	1.150	31.8	3930.6	O K
2880 min Winter	16.092	1.092	30.2	3698.4	O K
4320 min Winter	15.990	0.990	27.5	3304.2	O K
5760 min Winter	15.907	0.907	25.3	2991.7	O K
7200 min Winter	15.844	0.844	23.7	2758.4	O K
8640 min Winter	15.792	0.792	22.4	2568.3	O K
10080 min Winter	15.748	0.748	21.6	2409.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	101.500	0.0	41
60 min Winter	63.365	0.0	70
120 min Winter	39.730	0.0	128
180 min Winter	30.126	0.0	186
240 min Winter	24.650	0.0	244
360 min Winter	18.391	0.0	358
480 min Winter	14.774	0.0	474
600 min Winter	12.380	0.0	588
720 min Winter	10.670	0.0	700
960 min Winter	8.369	0.0	914
1440 min Winter	5.891	0.0	1144
2160 min Winter	4.113	0.0	1604
2880 min Winter	3.190	0.0	2052
4320 min Winter	2.245	0.0	2944
5760 min Winter	1.764	0.0	3808
7200 min Winter	1.483	0.0	4616
8640 min Winter	1.297	0.0	5448
10080 min Winter	1.166	0.0	6256

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 614750 315400 TG 14750 15400
Data Type	Catchment
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+45

Time Area Diagram

Total Area (ha) 4.860

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	1.620	4	8	1.620	8	12	1.620

Model Details

Storage is Online Cover Level (m) 17.000

Infiltration Basin Structure

Invert Level (m) 15.000 Safety Factor 5.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 1.00
Infiltration Coefficient Side (m/hr) 0.43200

Depth (m)	**Area (m²)**	**Depth (m)**	**Area (m²)**	**Depth (m)**	**Area (m²)**	**Depth (m)**	**Area (m²)**
0.000	2697.0	1.400	4176.0	2.800	0.0	4.200	0.0
0.200	3050.0	1.600	4403.0	3.000	0.0	4.400	0.0
0.400	3301.0	1.800	4634.0	3.200	0.0	4.600	0.0
0.600	3480.0	2.000	4869.0	3.400	0.0	4.800	0.0
0.800	3619.0	2.200	0.0	3.600	0.0	5.000	0.0
1.000	3834.0	2.400	0.0	3.800	0.0		
1.200	4053.0	2.600	0.0	4.000	0.0		

Summary of Results for 30 year Return Period (+40%)

Half Drain Time : 1200 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	15.344	0.344	12.9	1027.4	O K
30 min Summer	15.438	0.438	15.5	1336.2	O K
60 min Summer	15.530	0.530	17.5	1644.8	O K
120 min Summer	15.637	0.637	19.7	2015.3	O K
180 min Summer	15.697	0.697	20.7	2228.5	O K
240 min Summer	15.736	0.736	21.4	2367.7	O K
360 min Summer	15.781	0.781	22.2	2528.3	O K
480 min Summer	15.799	0.799	22.5	2592.7	O K
600 min Summer	15.805	0.805	22.6	2613.5	O K
720 min Summer	15.803	0.803	22.6	2609.7	O K
960 min Summer	15.794	0.794	22.4	2575.8	O K
1440 min Summer	15.774	0.774	22.1	2502.2	O K
2160 min Summer	15.744	0.744	21.5	2395.8	O K
2880 min Summer	15.717	0.717	21.1	2299.6	O K
4320 min Summer	15.675	0.675	20.3	2149.8	O K
5760 min Summer	15.640	0.640	19.7	2027.8	O K
7200 min Summer	15.610	0.610	19.2	1920.7	O K
8640 min Summer	15.585	0.585	18.7	1834.1	O K
10080 min Summer	15.564	0.564	18.2	1764.3	O K
15 min Winter	15.382	0.382	14.1	1151.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	113.960	0.0	27
30 min Summer	74.449	0.0	41
60 min Summer	46.246	0.0	70
120 min Summer	28.825	0.0	130
180 min Summer	21.605	0.0	188
240 min Summer	17.498	0.0	248
360 min Summer	12.862	0.0	366
480 min Summer	10.214	0.0	484
600 min Summer	8.505	0.0	602
720 min Summer	7.308	0.0	720
960 min Summer	5.740	0.0	840
1440 min Summer	4.064	0.0	1082
2160 min Summer	2.879	0.0	1476
2880 min Summer	2.265	0.0	1884
4320 min Summer	1.644	0.0	2720
5760 min Summer	1.325	0.0	3520
7200 min Summer	1.127	0.0	4320
8640 min Summer	0.993	0.0	5096
10080 min Summer	0.898	0.0	5848
15 min Winter	113.960	0.0	26

Summary of Results for 30 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	15.486	0.486	16.5	1497.7	O K
60 min Winter	15.588	0.588	18.8	1844.6	O K
120 min Winter	15.707	0.707	20.9	2262.9	O K
180 min Winter	15.775	0.775	22.1	2505.2	O K
240 min Winter	15.818	0.818	23.0	2664.3	O K
360 min Winter	15.869	0.869	24.3	2849.1	O K
480 min Winter	15.890	0.890	24.9	2925.8	O K
600 min Winter	15.897	0.897	25.1	2954.8	O K
720 min Winter	15.898	0.898	25.1	2957.3	O K
960 min Winter	15.889	0.889	24.8	2922.9	O K
1440 min Winter	15.861	0.861	24.1	2818.6	O K
2160 min Winter	15.821	0.821	23.1	2673.0	O K
2880 min Winter	15.782	0.782	22.2	2531.7	O K
4320 min Winter	15.717	0.717	21.1	2298.5	O K
5760 min Winter	15.663	0.663	20.1	2107.0	O K
7200 min Winter	15.616	0.616	19.3	1943.0	O K
8640 min Winter	15.578	0.578	18.5	1810.7	O K
10080 min Winter	15.546	0.546	17.8	1702.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	74.449	0.0	41
60 min Winter	46.246	0.0	70
120 min Winter	28.825	0.0	128
180 min Winter	21.605	0.0	186
240 min Winter	17.498	0.0	242
360 min Winter	12.862	0.0	358
480 min Winter	10.214	0.0	474
600 min Winter	8.505	0.0	586
720 min Winter	7.308	0.0	696
960 min Winter	5.740	0.0	906
1440 min Winter	4.064	0.0	1128
2160 min Winter	2.879	0.0	1588
2880 min Winter	2.265	0.0	2048
4320 min Winter	1.644	0.0	2904
5760 min Winter	1.325	0.0	3752
7200 min Winter	1.127	0.0	4544
8640 min Winter	0.993	0.0	5360
10080 min Winter	0.898	0.0	6152

Rainfall Details

Rainfall Model	FEH
Return Period (years)	30
FEH Rainfall Version	2013
Site Location	GB 614750 315400 TG 14750 15400
Data Type	Catchment
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 4.860

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	1.620	4	8	1.620	8	12	1.620

Model Details

Storage is Online Cover Level (m) 17.000

Infiltration Basin Structure

Invert Level (m) 15.000 Safety Factor 5.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 1.00
Infiltration Coefficient Side (m/hr) 0.43200

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	2697.0	1.400	4176.0	2.800	0.0	4.200	0.0
0.200	3050.0	1.600	4403.0	3.000	0.0	4.400	0.0
0.400	3301.0	1.800	4634.0	3.200	0.0	4.600	0.0
0.600	3480.0	2.000	4869.0	3.400	0.0	4.800	0.0
0.800	3619.0	2.200	0.0	3.600	0.0	5.000	0.0
1.000	3834.0	2.400	0.0	3.800	0.0		
1.200	4053.0	2.600	0.0	4.000	0.0		