

Technical Note: Naldretts Polo Pitch Surface Water Modelling



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Project: 4504 – Naldretts Polo Pitch

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1. Background Information

- 1.1. Environmental Protection Strategies Limited (EPS) has been commissioned to undertake numerical surface water flood modelling for the site near at Naldretts Farm, West Sussex, location shown in Figure 1.

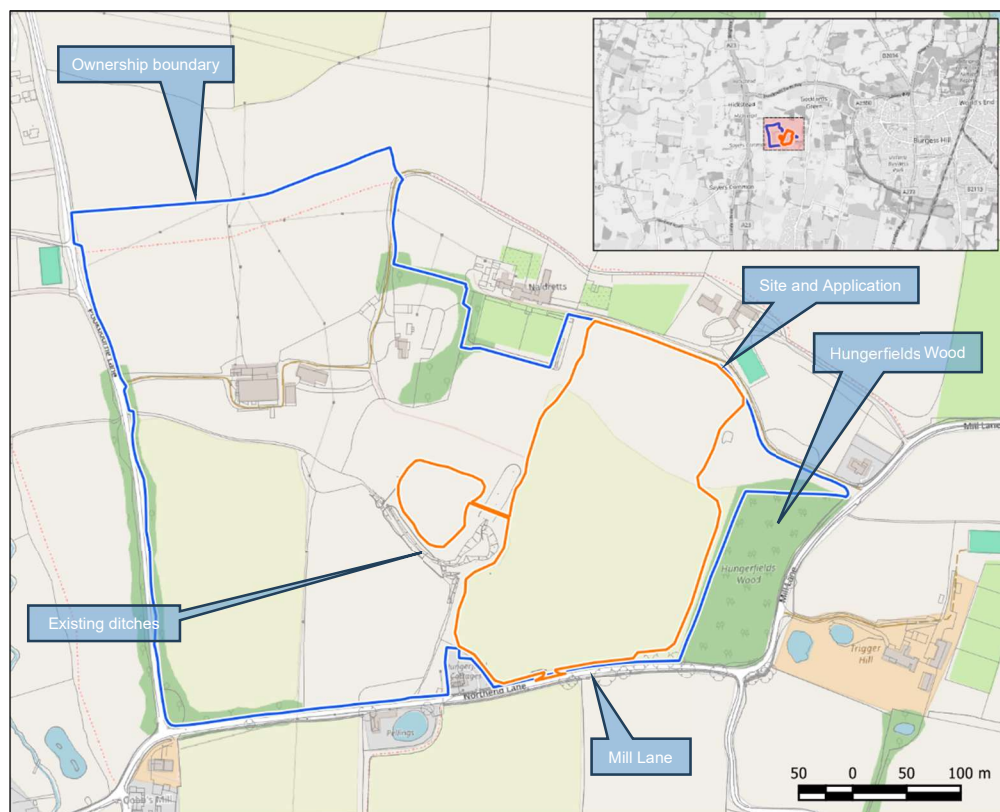


Figure 1 – Site location

- 1.2. The mitigation of existing overland surface water flow paths is a condition applied to the 2024 planning application for the change of use from grazing land to a polo pitch. This technical note details the setup of the model representing both the existing and proposed conditions.
- 1.3. Topographic survey from the site has been provided that includes the ditches and structures on the western part of the site and the entirety of Mill Lane (part of which is sometimes referred to as Northend Lane; 'Mill Lane' is used exclusively in this report).

- 1.4. Two existing overland flow paths affect the site, one from the east over Mill Lane and through Hungerfields Wood and another from the south and the open farmland crossing into the site, again, over Mill Lane. The farmland to the south has a limited network of field drains, and Mill Lane is partially served by highways gullies to the south of the site only. To the east of the site there is no notable highways drainage or network of field drains.

2. Numerical Flood Model - Technical Methodology

- 2.1. The model has been constructed using the TUFLOW 2-dimensional (2D) numerical flood modelling system, version TUFLOW 2025_2_2_w64. The model has 1-dimensional (1D) structures placed into the 2D domain, to represent both existing and proposed structures including the proposed sustainable drainage system and off-site surface water mitigation measures; these have been constructed in ESTRY (TUFLOW's 1D channel and pipe flow model). The most recent version of TUFLOW has been used to take advantage of TUFLOW's Highly Parallelised Computation (HPC) using Graphical Processing Unit (GPU). This approach uses the latest advances in the TUFLOW software to ensure the detail is captured and capitalises on improved model run times to allow the entire catchment to be modelled.
- 2.2. The extent of the model represents the catchment that generates the overland surface water flow paths that impact the site. The catchment has been delineated using QGIS, the Defra 1 m LiDAR elevations and a method following Van Der Kwast 2019. The elevations throughout the catchment and the extent of the catchment are shown in Figure 2.

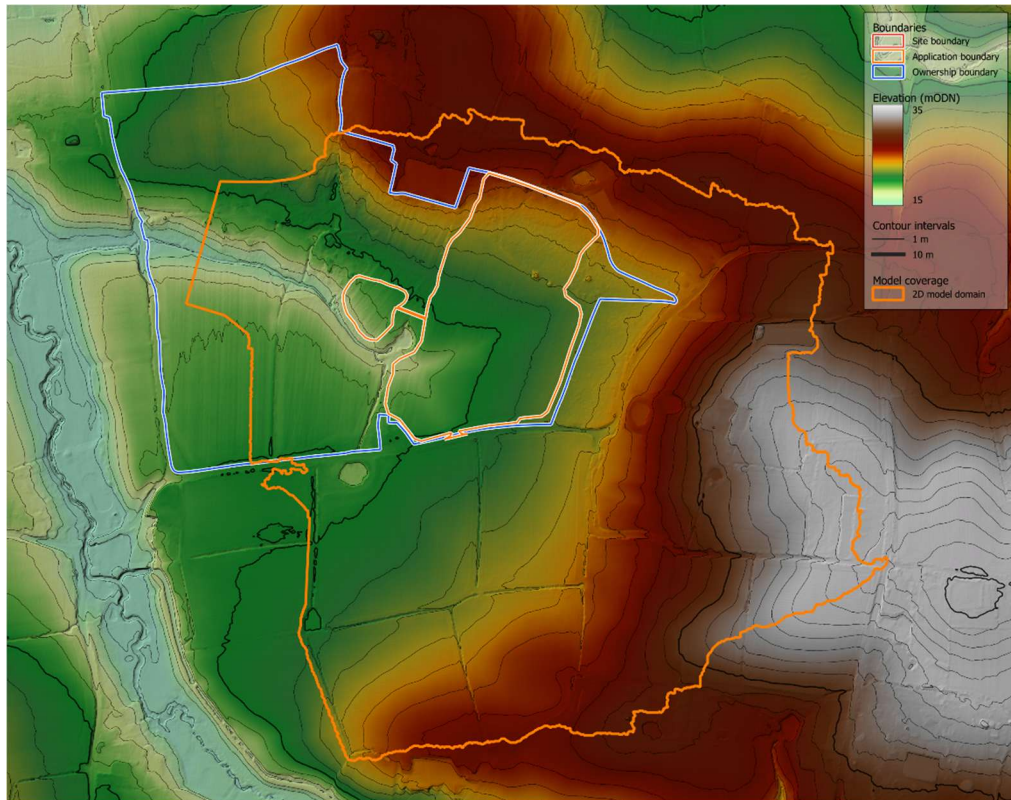


Figure 2 – Model coverage and catchment elevations.

- 2.3. The 2D Digital Elevation Model (DEM) of the catchment and floodplain uses a grid resolution of 8 m to represent the wider open areas of low detail, which tightens sharply to 2 m to represent roads, sloped areas and off-site ditches, tightening further to 1.0 m and 0.5 m in areas where proposed swales and pitch drainage are located. The ground elevations of the DEM are initially based upon the EA's 1 m LiDAR Digital Terrain Model (DTM) originating from the Composite LiDAR 2022. The grid elevations have been augmented with the topographic survey data where it is available. The spatially varying grid resolution is shown in Figure 3.

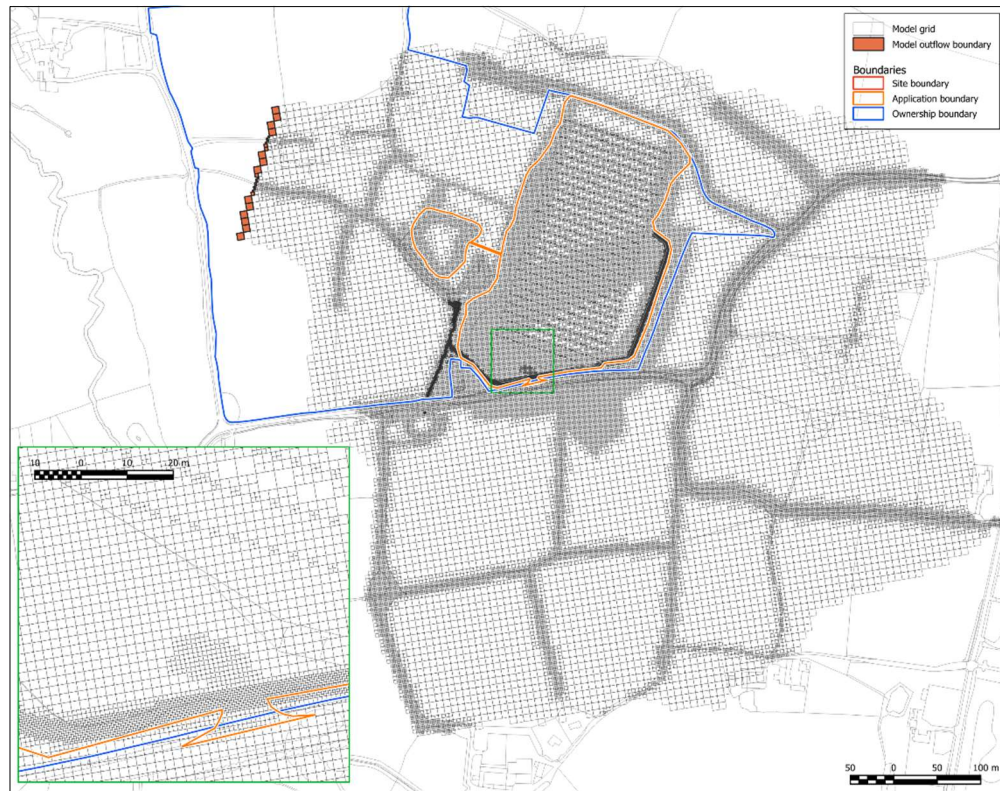


Figure 3 – Model grid resolution

- 2.4. The downstream limit of the model, also shown in Figure 3, is located ~200 m downstream of the application area. The downstream boundary is a stage-discharge (HQ) type with a specified water level surface gradient of 0.02 congruent with the gradient of the land levels in this area. A sensitivity test where the boundary has been assigned a gradient of 0.001 has been undertaken and the backwater impact determined to be 68 m upstream and does not reach the site. Therefore, the placement of the downstream boundary and the choice of gradient can be considered suitable while the model is not sensitive enough to gradient to affect the results on-site.
- 2.5. Structures such as pipes and culverts have been implemented in the model following the details available in the topographic survey. These included a ditch vehicle crossing on site and a pipe crossing beneath Mill Lane where the outlet dimensions were sufficient to represent the pipe.
- 2.6. The model applies a spatially varying Manning's n roughness based on the land use types of the Ordnance Survey MasterMap and the values proposed by Chow (1959). The land types and their corresponding Manning's n values are presented in Table 1.

Feature Code	Manning's n value	Representation
10021	0.1	Buildings
10053	0.05	Land
10054	0.025	Land
10056	0.04	Land
10062	0.1	Buildings
10089	0.03	Water
10096	0.03	Manmade embankment around ponds
10111	0.08	Land (thick vegetation and trees)
10119, 10123, 10185	0.03	Roads Tracks And Paths
10172, 10183	0.025	Roads Tracks And Paths
10187	0.1	Structure (manmade)
10093	0.03	Land

Table 1 – Manning's n roughness values (2D domain)

- 2.7. Four extreme flow events have been simulated within the model, including:
- 1 in 2 year return period event (50%AEP, Annual Exceedance Probability);
 - 1 in 30 year return period event (3.3%AEP) with and without climate change (+40%);
 - 1 in 100 year return period event (1%AEP) with and without climate change (45%); and
 - 1 in 1,000 year return period event (0.1%AEP) with and without climate change (+45%).
- 2.8. The model has been run as a direct rainfall model with the rainfall hyetographs calculated in ReFH2.3 based on FEH catchment data and the area of the catchment used from the catchment delineation and the definition of the model domain. The 'total' rainfall hyetograph has been applied as the model input with no losses for drainage or geology to represent the worst-case conditions.
- 2.9. The model simulates the flow input with no infiltration losses to the soils within the model domain. This approach is considered to represent the worst-case conditions, where the ground is either already saturated or the soils have a negligible infiltration rate.
- 2.10. Table 2 lists the models run for the TUFLOW baseline conditions and initial testing. All simulations use the TUFLOW control file *4504_Naldretts_~s1~_~e1~_~s2~.tcf*. All baseline simulations are designated *A1* while proposed conditions are designated *B6*.

Scenario	s1	e1	s2	Comment
Existing conditions	A1	P2	000	50%AEP
Existing conditions	A1	P30	000	3.3%AEP
Existing conditions	A1	P30cc40	000	3.3%AEP+40% climate change
Existing conditions	A1	P100	000	1%AEP
Existing conditions	A1	P100cc45	000	1%AEP+45% climate change
Existing conditions	A1	P1000	000	0.1%AEP
Existing conditions	A1	P1000cc45	000	0.1%AEP+45% climate change
Sensitivity tests	A1	P100cc45	nUP	Manning's n roughness +20%
Sensitivity tests	A1	P100cc45	nDN	Manning's n roughness -20%
Sensitivity tests	B6	P100cc45	BLK	Partially blocked (50%) diversion pipe
Sensitivity tests	A1	P100cc45	CNF	Control number factor = 0.8
Sensitivity tests	A1	S100	01h	Alternative rainfall duration test: 1 hour (Summertime)
Sensitivity tests	A1	S100	03h	3 hours (Summertime)
Sensitivity tests	A1	W100	01h	1 hours (Wintertime)
Sensitivity tests	A1	W100	03h	3 hours (Wintertime)

Table 2 – List of model simulations with corresponding events

3. Post Development Scenario

- 3.1. The post-development condition is shown in the enclosed drawing 'D2334-101-P04 Proposed Drainage.pdf' and includes land raising to create a polo pitch with associated vehicle access from Mill Lane, on-site parking (grassed). The pitch includes a system of sub-surface drains and an attenuation pond. The attenuation pond has an outlet into the existing drainage ditch with a flow control device to control the rate. The attenuation pond has been sized by BP Civils Ltd as part of the drainage design, as has the specification for the flow control device which has a restricted rate of 16.2 L/s.
- 3.2. The design also includes a swale/channel system that captures the overland surface water flowing from the east and south and routes it around the land raising of the pitch area to the existing ditch network on-site to the west. To further support the routing of surface water the mitigation includes a pipe that runs from the extremity of the swale beneath the polo pitch to, again, the existing ditches to the west.
- 3.3. The swale is 5 m wide (bank-to-bank), has 1:2 side slopes and a 1 m wide channel bed, and is 1 m deep. The swale switches to a 2 m wide U-shaped channel while running parallel with Mill Lane. The swale has been represented in the 2D model grid with grid resolution of 0.5 m.
- 3.4. The pitch drainage has been proposed as sub-surface pipework bedded into typical pitch construction substrates (mixed sand and gravel) purposefully selected to achieve good soakage from the surface. To represent this in the model the pitch grid resolution has been set to 1 m and a string of gullies added to align with the pipe routing. The gullies have then been assigned an inflow rate equivalent to the average soakage rate of 'sandy gravel' following the

CIRIA SUDS manual at 3×10^{-3} m/s. (Variations in this rate have not been sensitivity tested as the efficacy of the drainage design is not the focus of this report). The pitch drainage gullies route via the proposed pipework to the proposed SuDS attenuation basin.

4. Sensitivity Testing

4.1. Several sensitivity tests have been undertaken to ensure a full understanding of model behaviour. These have included:

- Rainfall duration/season tests (1 hour, 3 hour, summertime and wintertime);
- Manning's n roughness value +20%;
- Manning's n roughness value -20%;
- Timestep sensitivity test (control number factor [CNF] = 0.8 instead of 1.0);
- Partial blockage (50%) of the proposed diversion pipe that runs beneath the pitch (Residual Risk).

4.2. **Rainfall duration/season testing** – These tests are a general requirement of the modelling process to determine the worst-case event season and duration. These are the two main variables of hyetograph calculation in the ReFH2.3 software. These tests have been undertaken on the 1% present day event (not the event including climate change) as they exclusively pre-date the generation of the full set of event estimates.

4.2.1. Commensurate with a small and flashy catchment the tests identify that the summertime 1 hour event yields the greatest depths of surface water on-site, and therefore this was the event used throughout the rest of the model study.

4.3. **Manning's n values $\pm 20\%$** – the surface roughness in the model represents typical conditions with respect to seasonal vegetative growth. However, vegetation can change significantly between summer and winter, and therefore greatly affect the speed at which flood water may transit through an area.

4.3.1. To represent the seasonal variation, the Manning's n value has been varied by $\pm 20\%$ in two separate simulations for high growth in summer (+20%) and die-back in winter (-20%).

4.3.2. The results of the two tests are shown in Figure 4. These results show that the variance of Manning's n by +20% and -20% results in flood levels varying in the ditches near the location of the proposed SuDS basin (where they peak) by 0.07 m and -0.08 m respectively. However, elsewhere differences are in the order of +0.015 m and -0.015 m for the +20% and -20% tests, respectively.

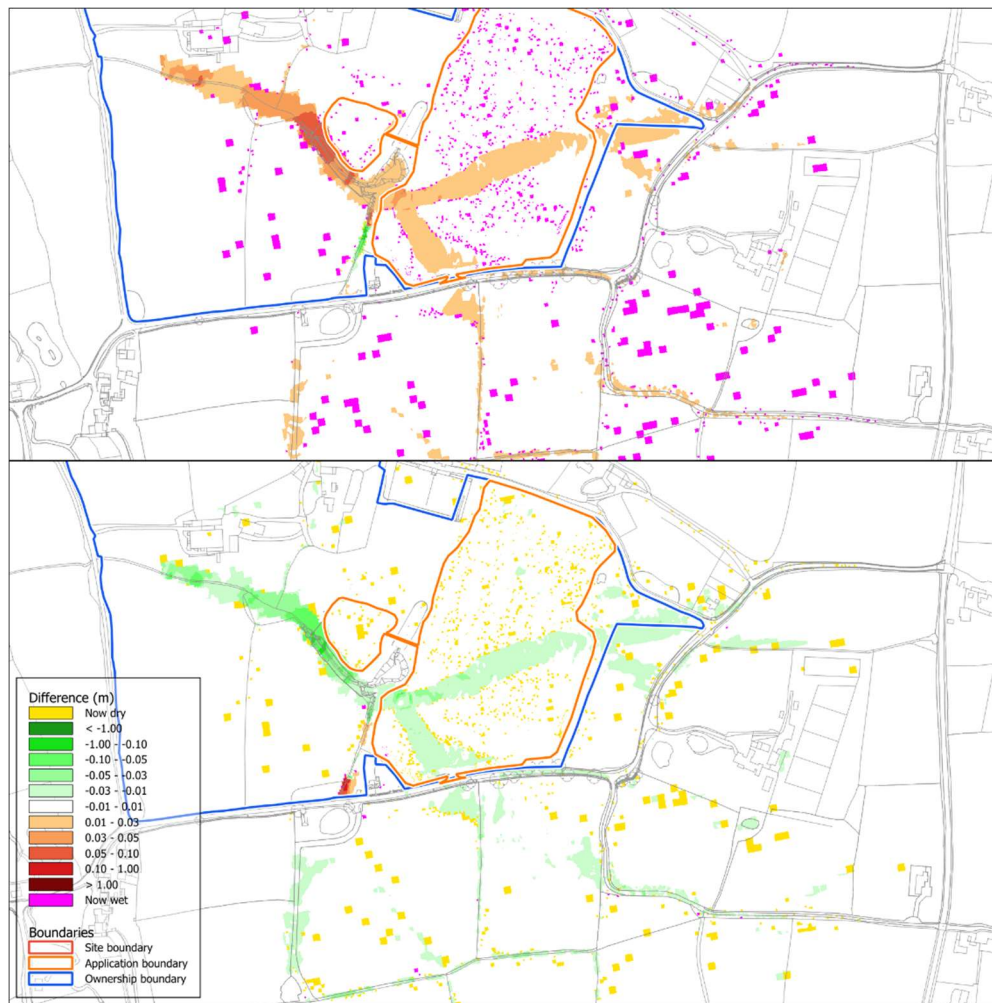


Figure 4 – Impacts of varying Manning's n value (top = +20%, bottom = -20%)

4.3.3. On the basis of these results, the seasonal growth and variation in vegetation is not considered to be significant and therefore, no further adjustment has been made or investigated.

4.4. **Sensitivity to timestep** – The model self-governs its own timestep according to Courant number which is a measure of model stability. Default parameters include the variation of model timestep with a target Control Number Factor (CNF) of 1.0, with calculations being repeated with a smaller timestep if this criterion becomes exceeded. A test has been undertaken with a CNF of 0.8 to check the sensitivity of the model results to varying timestep.

4.4.1. A singular small patch (~30 m²) of increased flood level (+0.06 m) occurs in the model results in an inconsequential location during this test. This small patch represents an unsustainable difference that cannot propagate through any of the rest of the model domain. Therefore, the existing model results can be considered stable and representative of real impacts and are not 'model effects'.

4.4.2. The standard CNF value of 1.0 has been retained throughout all model runs.

4.5. **Proposed diversion pipe blockage (Residual Risk)** – The pipe beneath the pitch that connects the extremity of the swale to the existing ditch provides additional conveyance that is important to ensure that negative impacts continue to be contained on-site only. Therefore, the sizing of the pipe has the potential to alter the flood risk.

4.5.1. The results of this test showed that the partial blockage of the pipe does not significantly affect anywhere off-site negatively. A very slight negative impact is observed on the edge of the entrance road and verge nearby, as shown in Figure 5. However, this can be considered insignificant as no notable receptor is impacted compared to the existing situation.

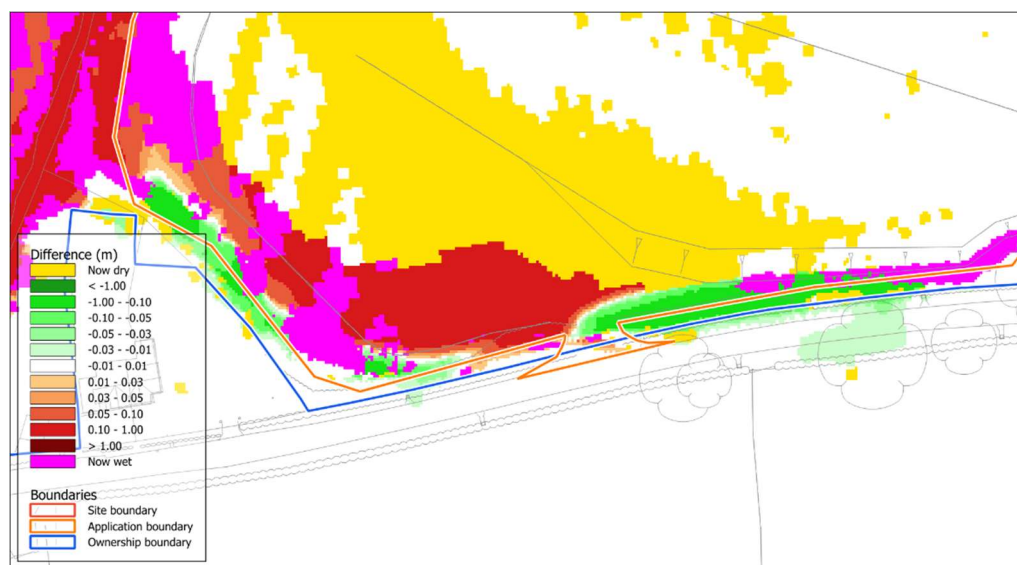


Figure 5 – Residual risks, insignificant impacts on the verge near the entrance road.

4.6. The conclusion from this test is that the suggested pipe size of 0.9 m diameter is sufficient to prevent an off-site residual flood risk in the event that it experiences a typical blockage.

5. Simulation Messages

5.1. The model simulation reports several checks and warnings which have been investigated and found not to have any implications for the model results. There are no warnings recorded during the simulation itself. Therefore, no further investigation has been required of the model logs.

6. Results

6.1. The full graphical model results are appended to this technical report and are listed in Table 3. Each page of mapping includes the depth of surface water for the existing conditions, the depth of surface water for the proposed conditions, and the impact of the proposed development

(calculated from the difference in flood level). The depth of surface water flooding is reported on each map on a dense grid of labelled points (zoom in to read the depth value [m])

Model result no.	Scenario	Event	Scenario	Output	Figure No.
1	Existing, Proposed and Impact	50%AEP, present day		Max depth, Impact	A.1
2	Existing, Proposed and Impact	3.3.%AEP, present day		Max depth, Impact	A.2
3	Existing, Proposed and Impact	3.3.%AEP, +40% climate change		Max depth, Impact	A.3
4	Existing, Proposed and Impact	1%AEP, present day		Max depth, Impact	A.4
5	Existing, Proposed and Impact	1%AEP, +45% climate change	Design condition	Max depth, Impact	A.5
6	Existing, Proposed and Impact	1%AEP, +25% climate change	Residual risk (partially blocked pipe)	Max depth, Impact	A.6
7	Existing, Proposed and Impact	0.1%AEP, present day		Max depth, Impact	A.7
8	Existing, Proposed and Impact	0.1%AEP, +45% climate change		Max depth, Impact	A.8

Table 3 – List of appended figures

- 6.2. The typical impact of the proposed development is shown in Figure 6 and shows that all negative impacts are contained within the ownership boundary for this event. Similar results are found for all other events up to and including the design event and the 0.1%AEP event, and the residual risk event which simulates the half blockage of the pipe that runs beneath the pitch, here again, all negative impacts are kept within the ownership boundary.
- 6.3. The benefit of the proposed development's sustainable drainage is apparent in the reduced flood levels in the existing ditch network downstream of the pitch, where flood levels reduce by ~0.05 m.

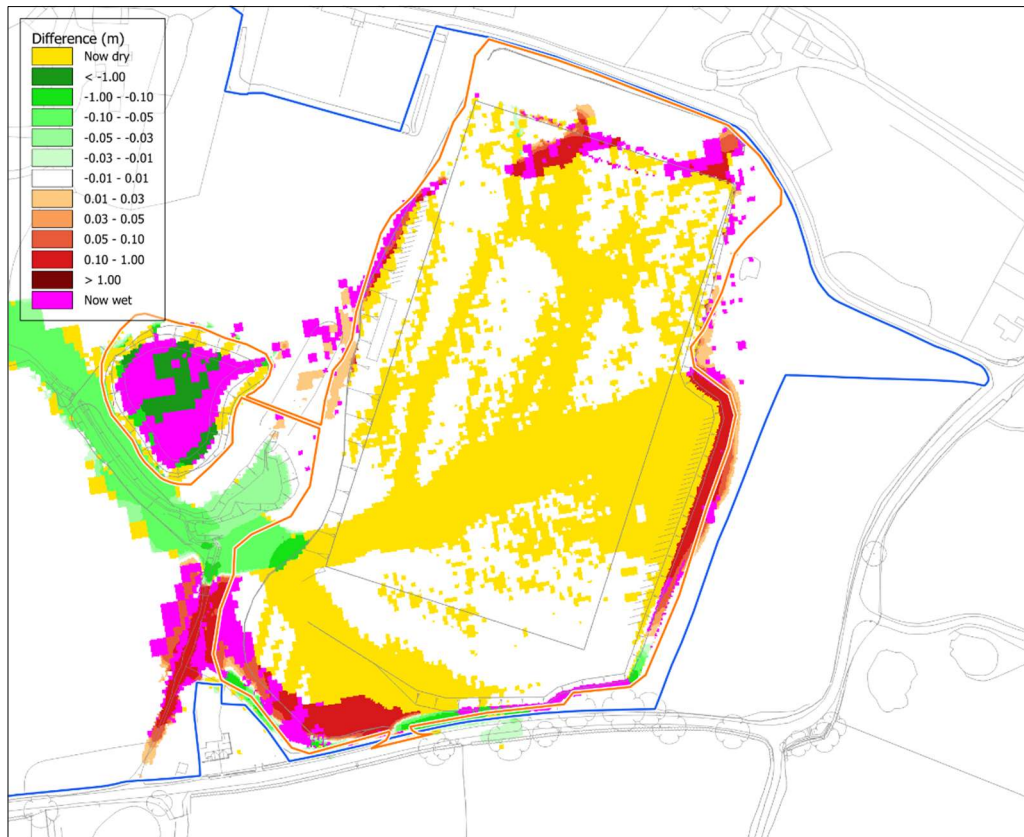


Figure 6 – Impact of the proposed development under 1%AEP +45% climate change event conditions

7. Enclosed Documents

7.1. The following documents have been enclosed with this technical note:

- Topographic survey;
- Proposed drawings; and
- Modelling results.