Meridian Solar Farm

EN010169

Volume 6

Environmental Statement

6.3 ES Appendix 11-3: Flood Risk Assessment - Annex E

APFP Regulation 5(2)(a)

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Annex E – H++ Sensitivity Analysis

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1. Introduction

1.1. Background

1.1.1. Wallingford HydroSolutions Ltd (WHS) was commissioned by AECOM to undertake detailed hydraulic modelling to support the proposed Meridian Solar Farm (E: 527196, N: 313799). The modelling methodology[1] was agreed with the Environment Agency (EA) and undertaken to define the flood levels for Land Parcels A, B, C and D to inform the elevation of flood-sensitive infrastructure.

1.2. Scope

1.2.1. Following the submission of the DCO application, the EA submitted a relevant representation (RR-047, comment EA20) requesting additional assessment of the Credible Maximum Tidal Scenario using H++ climate change allowances. The issue raised noted:

"*A credible maximum tidal scenario (H++) has not been assessed in line with guidance*",

1.2.2. The EA also notes that sections within the Flood Risk Assessment:

"*provide details on the H++ scenario for sea level rise, however, the approach does not align with the approach for assessing a credible maximum scenario (H++) in the context of tidal flood risk described in the guidance on using climate change allowances for Flood Risk Assessment. The approach for assessing a credible maximum (H++) scenario for sea level rise is to apply 1.9 metres of sea level rise including an additional 2mm per year to account for storm surge*."

1.2.3. This technical note provides a response to the EA's comments, detailing the methodology and results of the H++ sensitivity analysis undertaken to address the EA's concerns regarding the assessment of the Credible Maximum Tidal Scenario.

1.2.4. The previous modelling work utilised three hydraulic models to assess the 'worst-case' flood risk:

- Postland Pump Catchment (PPC) Model
- River Welland Breach (RWB) Model

[1] JBA Consulting (2025). 2023s1210 Meridian Solar hydraulic modelling.

- South Holland Main Drain (SHMD) Model

1.2.5. As only the River Welland Breach and the SHMD models are tidally influenced, the H++ sensitivity analysis has only been undertaken on these two models. Therefore, this technical note should read in conjunction with the River Welland Modelling Methodology[2] and the South Holland Main Drain Hydraulic Modelling[3] reports.

1.3. Data Sources

1.3.1. The data sources used to inform the pump failure analysis are as follows:

- River Welland Hydraulic Model[4]
- River Welland Hydraulic Modelling Methodology Report[2]
- LIT 56413 Breach of Defence Guidance[5]
- Model data from the Tidal Nene Modelling Improvements[6]
- South Holland IDB Map Index[7]
- South Holland Main Drain Hydraulic Modelling Report[3]
- Flood risk assessment: climate change allowances[8] As of July 2021, the climate change allowances used in Flood Risk Assessments have changed, and now propose peak river flow allowances based on Water Framework Directive catchment areas, instead of nationwide allowances in previous iterations of guidance. The DEFRA mapping website 'Climate change allowances for peak river flow in England' has been reviewed to confirm the revised climate change allowances for the catchment areas that cover the Site.

[2] Wallingford HydroSolutions Ltd (2025). River Welland Hydraulic Modelling Methodology Report
[3] Wallingford HydroSolutions Ltd (2025). South Holland Main Drain Hydraulic Modelling Report.
[4] Environment Agency (2016). River Welland Hydraulic Modelling Report.
[5] Environment Agency (2021). Breach of Defence Guidance. LIT 56413
[6] JacksonHyder (2016). WEM Lot 1 Modelling, Mapping and Data. Tidal Nene Modelling Improvements.
[7] Water Management Alliance (2023). SHIDB_webmap2020 - South Holland IDB Map Index.
[8] Environment Agency (2022) Flood risk assessments: climate change allowances. Available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

- National LiDAR data[9]

1.4. Assumptions and Limitations

1.4.1. The sensitivity analysis was undertaken based on the following assumptions and limitations:

- The H++ water levels along with River Welland and South Holland Main Drain were derived by applying downstream boundary uplifts and extrapolating the water levels upstream. This assumes the hydraulic gradient and relative water profile remain representative under elevated sea levels. Given the embankment containment along the River Welland and the SHMD channel capacity, this provides a conservative sensitivity assessment.
- The analysis considers extreme tidal sea level rise (H++) applied to the baseline downstream tidal boundaries. In line with the EA MIKE 11 modelling for the River Welland, continued operation of downstream tidal sluice gates on the river is assumed, preventing direct tidal surge entry into the upper river channel under normal operating conditions. Combining an extreme H++ tidal sea level rise allowance with high fluvial design events (1.0% AEP + climate change and 0.1% AEP plus climate change) represents a conservative coincidence of tidal and fluvial extreme events.
- For the SHMD catchments, the H++ sensitivity analysis assumes complete pump failure (Pump OFF), representing a worse-case scenario. Under normal operations, SHMD Internal Drainage Board pumping would maintain lower water levels within the catchments.
- The assessment uses downstream tidal conditions from 1D-only modelling, which does not dynamically simulate 2D overland flow paths. For this high-level sensitivity analysis and freeboard assessment, 1D model extrapolation combined with LiDAR ground levels provides a robust and conservative approach.
- Design crest levels used in the freeboard assessment were obtained from the EA's Assessment Information Management System database. It is assumed that existing flood defences along the River Welland will be maintained by

[9] Environment Agency (2025). National LiDAR Programme.

the EA at or above the current asset crest level throughout the lifetime of the development.

2. Methodology for H++ Sensitivity Analysis

2.1. Summary of the River Welland Defences

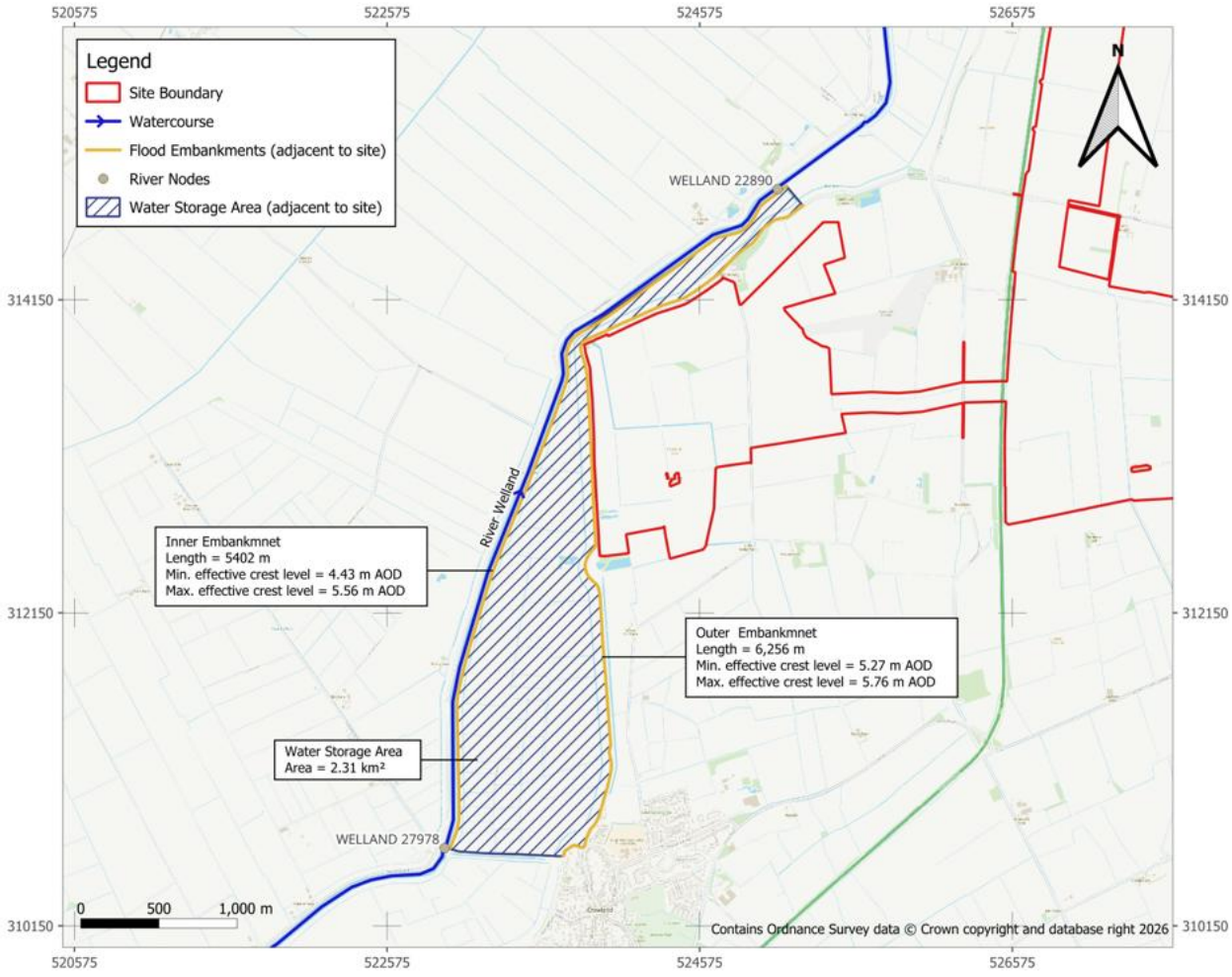
2.1.1. As part of the initial scope, breach modelling was undertaken to confirm and quantify residual flood risk to the proposed development, which currently benefits from existing flood defences along the River Welland. These defences include:

- Inner raised embankment (EA Asset ID: 510051)
- A Water Storage Area (EA Asset ID: 343253)
- An outer raised Embankment (EA Asset IDs: 124918, 503744, 503746, 503748, 503750, 124179, 503832).

2.1.2. The flood defences and designated Water Storage Area adjacent to the site are defined as the reach between Gravel Causeway (upstream node at WELLAND 27978) and the pump house access road (downstream node at WELLAND 22890).

2.1.3. This previous modelling completed for the FRA shows that while inner embankments are overtopped during the worst-case scenario (0.1% AEP plus climate change event), the outer embankment is not overtopped. The extent of the flood defences and Water Storage Area adjacent to site, informing this assessment is shown in Plate 2-1.

Plate 2-1 Flood defences adjacent to the site



2.2. Summary of the H++ Scenario

2.2.1. Boundary conditions for the breach model of the outer embankment were extracted from an existing 1D only MIKE 11 model of the River Welland and applied to a newly developed TUFLOW model. The modelling methodology is detailed in the River Welland Modelling Report1.

2.2.2. The H++ scenario represents an extreme climate change allowance corresponding to a total sea level rise of 1.90m to the 2100 epoch (referenced to a 1990 baseline). As such, applying the full H++ allowance provides a conservative sensitivity test, this is because:

- The operational design life of the solar farm is approximately 40 years (extending through to the ~2070s). During this period the projected sea level rise will be lower than the 2100 H++ ceiling.

- The baseline MIKE 11 model reflects 2015 baseline tidal condition, meaning that the model already contains some sea level rise between 1990 and 2015.

2.2.3. Notwithstanding the points above, the full 1.9m of sea level raise has been applied on top to the 2015 sea level as requested by the EA.

2.3. Methodology

2.3.1. The H++ extreme climate change scenario was assessed using the following methodology:

2.3.2. The downstream tidal levels from the Mike 11 model for the 1.0% AEP and 1.0% AEP plus climate change (2115 horizon) events were extracted to determine the amount of climate change already within the model.

- $\Delta h_cc = \Delta h_(100\ yr\ cc) - \Delta h_(100\ yr) = 5.35-4.24=1.11m$

2.3.3. To achieve the target 1.90m cumulative H++ sea level rise allowance, the required additional uplift to be applied on top of the 2115 climate change baseline was calculated by deducting the baseline allowance from the H++ allowance.

- Additional Uplift= $1.90 - \Delta h_cc = 1.90-1.11=0.79m$

2.3.4. In line with the EA guidance, an additional 2 mm for each year on top of the sea level rise allowances from 2017 for storm surge was applied to the target H++ sea level rise allowance. The duration for the storm surge allowance is 84-years (i.e., 2017-2100).

- Final Uplift= Additional Uplift+(84 ×0.002)=0.790 +0.168=0.958m

2.3.5. The derived H++ downstream level was then used to extrapolate the (H++) water levels for the 1.0% AEP plus climate change and 0.1% AEP plus climate change events at the key locations shown in Plate 2-1, i.e. nodes WELLAND 22890 and WELLAND 22978.

2.3.6. Note, as detailed in the MIKE 11 Welland Catchment modelling report[10], the EA's River Welland Model uses a normal tidal cycle, and extreme tidal events were not investigated. This approach was based on the operation of tidal sluice gates which prevent tidal waters entering the River Welland. Downstream of these

[10] Mott MacDonald (2016). River Welland Hydraulic Modelling Report

sluices, the watercourse has embankments to a height required to defend against extreme tidal surges.

Results and Analysis

Peak Levels in the River Welland

2.3.7. Table 2-1 summarises the peak water levels at key locations along the river channel, including the levels at the upstream and downstream extents of the water storage area adjacent to the site. The results confirm that applying a 1.10 m (for the 2115 climate change horizon) and 1.90 m + the cumulative storm surge allowance (for the H++ extreme climate change scenario) at the downstream tidal boundary, results in only minor increases in the river levels adjacent to the proposed development.

Table 2-1 Summary of Peak Levels in the River Welland for the 1.0% AEP + CC events

Return Period	Downstream Tidal Boundary	WELLAND 22890	WELLAND 27978
1.0% AEP	4.244	4.683	4.939
1.0% AEP + CC (2115)*	5.353	4.727	4.952
1.0% AEP + CC (H++)	6.311+	4.765	4.963

Table 2-2 Summary of Peak Levels in the River Welland for the 0.1% AEP + CC events

Return Period	Downstream Tidal Boundary	WELLAND 22890	WELLAND 27978
0.1% AEP	4.244	4.689	4.945
0.1% AEP + CC (2115)*	5.353	4.728	4.955
0.1% AEP + CC (H++)	6.311+	4.765	4.963

*At the downstream tidal boundary, the modelled change in water level between the 1.0% AEP present-day and 1.0% AEP + CC (2115 horizon) scenario is 1.11 m.

+ H++ downstream boundary level was calculated by adding an additional 0.958 m, i.e., 0.79 m uplift to achieve the target 1.90 m H++ sea level rise allowance plus a cumulative storm surge allowance based on 2

mm storm surge each year from 2017. The derived H++ water level was then used to extrapolate the water level at the key locations along river.

Outer Embankment Freeboard Analysis

2.3.8. For a conservative assessment, the peak water level for the H++ scenario adjacent to the site is taken as 4.963 m AOD, i.e., the maximum level extrapolated at the upstream extent of the Water Storage Area for both the 1.0% AEP plus climate change and 0.1% AEP plus climate change events.

2.3.9. Based on the EA's Assessment Information Management System (AIMS)[11], the minimum effective crest level along the outer embankment adjacent to the site is 5.27 m AOD. Therefore, the outer embankment provides a minimum 0.31m freeboard above the peak H++ water level at key locations adjacent to the site, see Table 2-3. Any floodwaters overtopping the inner embankment will be contained within the Water Storage Area without overtopping the outer defence. Therefore, the breach scenario previously evaluated in the baseline assessment remains the critical worst-case flood mechanism for the site-specific flood risk assessment.

Table 2-3 Freeboard Analysis along Outer Embankment

Location	H++ Peak Water Level (m AOD)	Minimum Crest Level (m AOD)	Freeboard (m)	Status / Defence Overtopping Risk
Upstream Storage Area (WELLAND 27978)	4.96	5.27	0.31	No overtopping into site
Downstream Storage Area (WELLAND 22890)	4.76	5.27	0.51	No overtopping into site

[11] Environment Agency (2026). AIMS Spatial Flood Defences (inc. standardized attributes).

2.4. South Holland Main Drain

2.4.1. A 1D hydraulic model was developed of the South Holland Main Drain (SHMD), which covers three pumped catchments managed by South Holland Internal Drainage Board (SHIDB). Hydrological inputs and downstream tidal boundary conditions at the River Nene outfall were derived from EA data. The full modelling methodology and baseline results are detailed in the hydraulic modelling report[3] located in Annex B of the **ES Appendix 11-3 Flood Risk Assessment** (Doc Ref 6.3 Rev 1), which was submitted as part of the DCO application.

2.4.2. As part of the initial sensitivity testing, downstream tidal boundary levels were varied by ±0.5 m for the joint 0.1% AEP plus climate change pump failure (Pump OFF) design event. The +0.50m sensitivity run effectively represented the present-day 0.1% AEP plus a sea level rise of 1.60 m, as the 0.1% AEP climate change tidal boundary that was extracted from the River Nene[12] includes a 1.10 m sea level rise allowance.

2.4.3. To evaluate the H++ extreme climate change scenario (1.90 m total sea level rise to 2100)[8]:

- The simulated peak water levels at the downstream tidal boundary for the 0.1% AEP + climate change Pump OFF scenario ($h_{PumpOFF}$) and the +0.50 m boundary sensitivity scenario ($h_{+0.50}$) scenario were extracted from the model.
- The H++ downstream boundary level was derived by applying an additional uplift of +0.30 m (i.e., the difference between the 1.90 m and 1.60 m sea level rise allowances) to the $h_{+0.50}$ model run.
- An additional 2 mm for each year on top of sea level rise allowances from 2017 for storm surge was also applied. Duration for storm surge allowance was calculated as 84 years (2017-2100), which resulted in a cumulative storm surge uplift of +0.168 m.
- The derived downstream H++ water level was then used to extrapolate peak water levels along the reach within the pumped catchments.

[12] JacksonHyder (2016). Tidal Nene Modelling Improvements.

2.4.4. The estimated peak flood level has been compared directly against existing ground levels at the site to establish the overall flood risk during the credible maximum scenario.

Results and Analysis

Peak Levels

2.4.5. Table 2-4 summarises the peak water levels across the three SHIDB pumped catchments under the pump failure design event, sensitivity and extrapolated H++ climate change scenarios.

Table 2-4 Summary of Peak Levels for each pumped catchment

Location	Water Level (m AOD)			
	D/S Tidal Boundary	Fleet Fen	Gotts	Wiseman
0.1% AEP + CC (2115 Horizon)	7.085	1.090	1.254	1.662
0.1% AEP + CC (DS Bdy +500mm)	7.585	1.185	1.554	1.662
0.1% AEP + CC (H++) [7.585 + 0.3 + 0.168]	8.053	1.277	1.845	1.662

2.4.6. Applying the +0.30 m boundary uplift and a 0.168 storm surge uplift to reflect the 1.90 m total H++ sea level rise and storm surge allowance increase to the downstream tidal boundary results in a conservative boundary level of 8.053 m AOD. This additional +0.468m increase in tidal level results in the following increases in flood level at each location:

- Fleet Fen – Peak level increases from 1.185 m AOD to 1.277 m AOD (+0.092m).
- Gotts – Peak level increases from 1.554 m AOD to 1.845 m AOD (+0.291m).
- Wiseman – Water levels are controlled by the internal catchment storage and pumping dynamics rather than changes to the downstream boundary, as such there is no change in level.

Site Impact Analysis

Design Levels

2.4.7. The peak flood level for H++ sensitivity scenario was evaluated against the design levels across the Fleet Fen and Gotts pumped catchment. These design levels were informed by the submitted Flood Risk Assessment[13] for the development.

Freeboard analysis – H++ Scenario

- *Fleet Fen* – Table 2-4 shows that under the H++ scenario, there is an +0.092 m increase in flood level within the catchment, resulting in flood depths reaching up to 0.50 m within the site boundary. As the PV panels will be raised to a minimum of 0.80 m and solar stations will be protected by plinths up to a height of 0.8m, the critical infrastructure will be elevated above the H++ peak flood level. Where solar stations are located within the flood extent and plinths alone would not raise them above the worst-case flood depths with the required 0.3m freeboard, additional protection in the form of a flood defence wall or bund will be provided. Therefore, residual flood risk is considered low as critical infrastructure will be sufficiently raised above the H++ peak level, providing a minimum height of 0.30m above the maximum flood depth for infrastructure, predicted under the H++ scenario.
- Gotts – Table 2-4 shows that under the H++ scenario, there is an +0.291 m increase in flood level within the catchment, resulting in flood depths up to 0.80 m within the site boundary. As the PV panels will be raised to a minimum of 0.80 m and solar stations will be raised 1.35 m above ground levels, the critical infrastructure within Land Parcel D-1 will be sufficiently raised above the H++ peak level, providing a minimum height of 0.55m above the maximum flood depth for solar stations. The lower edge of the PV panels will have a minimum height above ground of 0.80m to remain operational in times of flood, and will be raised up to a maximum of 1.30m above ground to ensure upper panels will remain operational in times of flood. Therefore, the PV panels will be raised sufficiently above the H++ peak level, providing a maximum height of 0.50m above the maximum flood depth predicted under the H++ scenario. As the critical infrastructure is sufficiently raised above the H++ peak level, with a minimum freeboard of 0.55 m for the solar

[13] Meridian Solar (2026). Meridian Solar Farm (EN010169). 6.3 ES Appendix 11-3: Flood Risk Assessment.

stations and no indicated inundation of the PV panels (with freeboard ranging from 0-0.50 m across the lower to upper end of the panels), the residual flood risk associated with this event is considered low.

2.4.8. Overall, the H++ sensitivity analysis demonstrates that under the extreme boundary uplift (1.90 m total sea level rise plus cumulative storm surge uplift) and conservative pump failure scenario, the proposed freeboard for critical infrastructure provides the sufficient protection from water damage.

3. Conclusions

3.1.1. A sensitivity analysis was undertaken to evaluate the impact of the H++ sea level rise allowance of 1.90 m and storm surge allowance of 2mm/yr to the 2100 horizon across the River Welland and South Holland Main Drain (SHMD) hydraulic models.

3.1.2. For the River Welland model, downstream tidal levels for the present-day 1.0% AEP and 1.0% AEP + climate change (2115 horizon) events were extracted from the EAs 1D MIKE 11 model to calculate the baseline climate change increase. The H++ downstream boundary level was derived by applying a net uplift to the 2115 model baseline. The derived H++ level was then used to extrapolate peak 1.0% AEP plus climate change and 0.1% AEP climate change water levels along the river network and evaluate freeboard against outer embankment crest levels.

3.1.3. The results of the sensitivity analysis indicate that:

- The extrapolated H++ downstream tidal level for the River Welland model resulted in a peak H++ water level of 4.96 m AOD in the River Welland, resulting in overtopping of the inner flood embankment. The outer embankment (minimum crest level 5.27 m AOD) maintains a minimum freeboard of +0.31 m (310 mm), confirming zero overtopping risk into the proposed development.
- As the outer embankment is not overtopped during the H++ scenario, the baseline breach modelling scenario remains the worst-case design event for River Welland at the site.

3.1.4. For the South Holland Main Drain (SHMD) model, baseline 0.1% AEP plus climate change Pump OFF levels and +0.50 m boundary sensitivity levels (i.e., the present-day 0.1% AEP + 1.60 m sea level rise) were extracted from the 1D model. An additional +0.468 m boundary uplift was applied directly to the +0.50 m boundary sensitivity scenario level to derive the H++ downstream boundary peak level. The derived H++ water level was extrapolated across the internal drainage network and compared spatially against site ground levels.

3.1.5. The results of the sensitivity analysis indicate that:

- Peak levels with the Fleet Fen pumped catchment increase by +0.092 m under H++ conditions, keeping flood inundation < 0.50 m and confined to existing field drains and localized depressions.
- Peak levels within the Gotts pumped catchment increase by +0.291 m; however, the site footprint only overlaps 11% of the catchment along its southern perimeter, isolating the development area from major storage with depths up to 0.80 m.
- For the Wiseman pumped catchment, water levels are governed by internal catchment storage and pumping dynamics rather than changes to the downstream boundary, indicated by no net changes in levels between the 0.1% AEP + CC Pump OFF and +0.50 m sensitivity events.

3.1.6. The H++ sensitivity analysis confirms that the conclusions of the Exception Test within the Environmental Statement and Flood Risk Assessment remain unchanged. The H++ sensitivity analysis demonstrates that the proposed mitigation and allowed freeboard for critical infrastructure provides the sufficient protection from flood depths predicted under the H++ scenario, ensuring that the development will remain safe and operational throughout its lifetime, with no additional mitigation required. Therefore, the Exception Test conclusions remain valid, and therefore represent no change to the significance of effects assessed within **ES Chapter 11: Hydrology and Flood Risk** (Doc Ref 6.1 Rev 1).