Scotland England Green Link 2 - English Onshore Scheme

Appendix 11-C Hydraulic Modelling Technical Note

National Grid Electricity Transmission

May 2022

Quality information

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1. Introduction

1.1 Requirement

Capita has been commissioned by National Grid (NG), to undertake modelling to understand the impact of building a converter station in proximity to Drax Power Station. This work is to support the planning application for the Scotland England Green Link 2 (SEGL2) English Onshore Scheme (EOS). The model results would be used to identify the volume amount of floodplain compensation storage required to satisfy Environment Agency (EA) Flood Risk Assessment (FRA) guidance.

1.2 Development Proposals

This technical note relates only to the proposed designs of the converter station within Section 4 of the EOS of SEGL2.

The converter station is described in more detail in section 3.2 of this report.

1.3 Technical Note Objectives

This technical note includes:

- Updates made to the existing 1D/2D Flood Modeller (FM) – TUFLOW Upper Humber (2018) hydraulic model (Ref 1);
- Approach taken to represent the converter station footprint design;
- Calculation method and reporting of required floodplain compensation; and
- Discussion of possible locations for floodplain compensation.

1.4 Limitations and Assumptions

This report relies on publicly available information and information from suppliers which Capita assumes to be correct. Capita cannot and does not verify accuracy of this data, and it is outside the scope of this commission to do so.

2. Data Collection

2.1 Input Data

The input data used in the modelling was collected from various sources and reviewed as required. The main sources of input data used for the updated modelling is included in Table 1.

Table 1: Modelling Input Data

Data Received	Provided by	Comments
Upper Humber Model (2018)	Environment Agency (EA)	Product 5 and 7 modelling data provided by the EA on 5th August 2021.
Humber 2100+ Strategy Extreme Water Levels (EWL) Model (2020)	EA	Product 5 and 7 modelling data provided by the EA March 2022.
Light Detection and Ranging (LIDAR) data	EA	LIDAR flown in 2020. Used to sense check LIDAR used in Upper Humber Modelling Study
Converter station Footprint	National Grid	Footprint extent of the converter station was provided and converted into a modelling format.
Climate Change Allowances (Ref 2)	EA	Latest updated climate change allowances for the management catchment which were used to calculate appropriate inflows uplift for the 2080s Higher Central epoch.

2.2 Previous Modelling

The Upper Humber Model (2018) ran multiple joint-probability scenarios for multiple return periods. The joint-probability scenarios provided weighted importance to ‘Fluvial-dominated’ inflows and ‘Tidal-dominated’ downstream boundary hydrographs. The Upper Humber Model (2018) report explains the methodology and combination of joint-probability scenarios in Section 5.25 ‘Model boundaries and joint probability’.

Following discussions with the Environment Agency in March 2022 they advised that hydrology should be extracted from the Humber 2100+ Strategy EWL Model (2020). The 2020 model was not suitable for use to undertake the assessment as it is a 1D only flood modeller model that represents floodplains as a series of reservoir units so would not provide accurate flood levels in the floodplain. The inflow locations in the 2020 model did not directly correspond with the 2018 model. Therefore the 2020 model was re-run and flow extracted at the location of the 2018 model inflows to be used within the model for the Rivers Ouse, Aire, Don and Trent. Additionally, a downstream boundary was extracted from the 2020 model at the downstream extent of the 2018 model and used to update the model.

3. Hydraulic Model

3.1 Model Updates

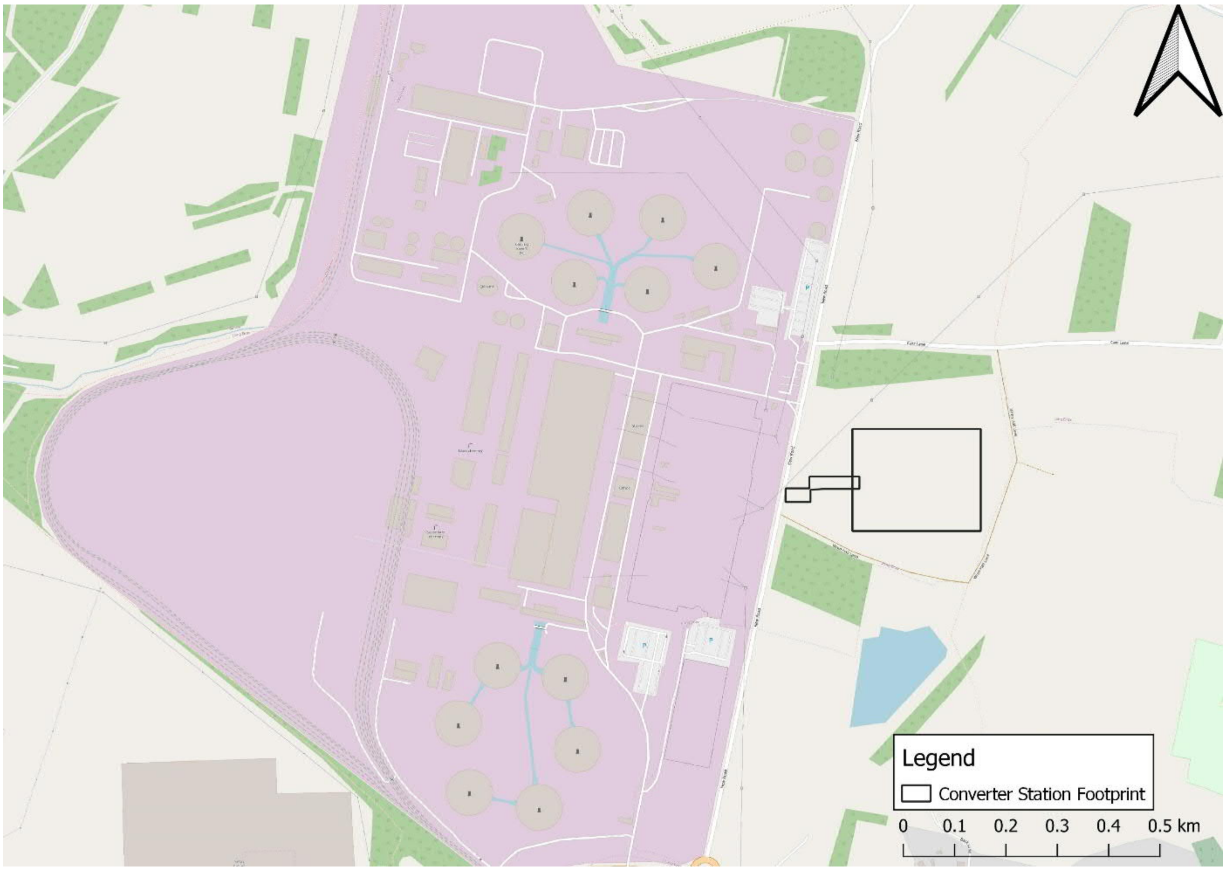
Model updates were undertaken to improve model stability in the higher return periods for the upper model reach, this included:

- Ensuring all 1D model notes are connected to the 2d_hx lines on the right bank of the River Humber;
- Lowering the 2d_bc HX line 'b' factor from 4 to 2 between model nodes 'CS15' and 'CS20'. The 'b' factor adjusts the Weir Factor (WrF) with a value >1 acting to decrease flow efficiency;
- Representing the right bank floodplain between model nodes 'CS15' and 'CS17' using a 1D reservoir unit. Surface Area/Volume relationship was extracted with a buffered converter station polygon using the QGIS 'Zonal Statistics' tool; and
- Updating inflows and downstream boundary to match those extracted from the 2020 model.

3.2 Converter Station

The Drax Power Station converter station footprint, provided by National Grid, was represented within the TUFLOW 2D model domain as a 2d_zsh polygon, see Figure 1. The elevation of the polygon was set to 10 mAOD with this value chosen to ensure that the converter station footprint remained dry in all modelled events. Peak water level was then extracted using the QGIS 'Zonal Statistics' tool.

Figure 1: Proposed Converter Station Footprint



3.3 Floodplain Compensation Methodology

Floodplain compensation was calculated using the QGIS 'Volume Calculation' which requires the following files and information:

- Polygon of volume area (converter station footprint);
- Digital Elevation Model (DEM) height layer (DEM_Z_flt check layer); and
- Manually entered base level (peak water level taken from modelled scenarios).

The calculations assumed that the area indicated in Figure 1 is to be raised to the specified height in its entirety with vertical sides. However, it is noted that the actual design may vary, and it is expected that 1 in 3 batters will be used to form the sides, where space allows, and that the development footprint currently sets out a maximum area which may be reduced at detailed design. The specific volumes should be reassessed against the final detailed design when this has been made available.

3.4 Climate Change Allowances

Climate change allowances applied in the previous Upper Humber Model (2018) were represented as a 20% increase on all peak inflows. The Humber 2100+ Strategy EWL Model (2020) modelling used updated climate change values based on the latest EA published guidance available at the time of preparing the hydrology for the study (July 2021). For climate change runs additional inflows and downstream boundaries were extracted from the 2020 climate change models for use in this study. Flow scenarios were available for present day (2021), 2040s, 2070s and 2121s for the Medium (Higher Central), High (Upper End), and Extreme (HPP) Climate Change scenarios. The 2020 model approach to climate change is set out further in the Humber EWL user guidance report.

Since the Humber 2100+ strategy (2020 report), EA climate change guidance has been further updated to apply management catchment uplifts. The guidance also states that if the dominant source of flooding will be from a neighbouring management catchment, the allowances from the neighbouring catchment should be applied instead. Having reviewed the updated guidance the following uplifts were identified for the Higher Central 2080 epoch,

- 31% increase in flow (Aire and Calder management catchment, where the proposed converter station is located); and
- 39% increase in flow (Lower Trent and Erewash management catchment, located downstream of Drax and which drains into the Humber).

This scenario was not available from the 2020 study therefore the nearest approximation was used. This was the 2071 Higher Central and Upper End scenarios that used +30% and +50% flows respectively. The 2071 Higher Central and Upper End scenarios additionally included +0.42 m and +0.54 m of sea level rise to the downstream boundary respectively.

3.5 Modelled Scenarios

The model was run for the 1%, 0.5% and 0.1% Annual Exceedance Probability (AEP) events plus climate change allowances based on the 2020 modelling.

3.6 Joint Probability

The approach to joint probability used in the existing 2020 study have been retained. A coincident (combined) 0.1% AEP fluvial and 0.1% AEP tidal event has not been modelled as the joint probability of this event is far in excess of the design requirements. The flood extent would cover the majority of the west/south-west floodplain of the River Ouse to the Railway line, resulting in an additional 300mm of flooding. Additional flooding would be recorded on the floodplain of the River Aire between Rawcliffe and Goole, as well as flooding along the north banks of the Ouse between Bamby-on-Marsh and Howendyke.

The values quoted in Section 4 are from the fluvially dominated modelled scenarios, rather than the tidally dominated scenario, as this source of risk provided the highest flood levels across the proposed site.

3.7 Model Limitations

This section highlights the limitations of the modelling approach and any restrictions that might apply to the specific model that was constructed.

The application of the 2020 Humber 2100+ Strategy EWL Model flows to the 2018 1D-2D model resulted in small areas of glass walling in two upper reaches of the River Trent and the River Ouse as noted below for the 0.1% AEP + climate change results.

- The modelling shows glass walling within the 1D only domain on the upper reach of the River Trent. This has resulted in increased in-channel water levels local to this area. From review of long section water surface profiles it is concluded not to impact the converter site. However the glass walling results in an underrepresentation of floodplain attenuation in the upstream reach, and this is likely to result in a minimally conservative result downstream at the converter station site. Given the significant extent of the downstream floodplain the scale of this impact is not likely to be discernible.
- The modelling shows glass walling on the left bank within the upper extent of the River Ouse, near the inflow boundary. Updates were made to reduce the impact of this 1D channel glass walling by inclusion of two reservoir units. The glass walling would have an impact on floodplain local stage / attenuation and water levels. This is likely to result in minimally conservative result downstream at the converter station site.
- As a result of the identified glass walling the dmax value was increased from 10 to 15 for the 0.1% climate change scenarios.

4. Modelled Results

4.1 Design Footprint Results

The modelled results for the converter station footprints are included below, see Table 2.

Table 2: Model results converter station footprint

Event (fluvially dominated)	Peak water level (mAOD)	Mean flood depth (m)	Volume of converter station footprint (m^3)
1% AEP+CC (50%)	5.02	1.22	63,254
0.5% AEP+CC (50%)	5.65	1.75	94,502
0.1% AEP+CC (50%)	6.18	2.17	119,798

5. Identifying Potential Floodplain Compensation Areas

5.1 Impact of development

From review of modelling outputs from baseline and with development excluding any floodplain compensation scenarios the impact on flood water levels, hazard mapping and time of inundation has been reviewed to assess the impact of the proposed land raising.

The results of this are set out in the Figures below.

Figure 2: Modelled Peak Water Level – Baseline Scenario - 1% AEP+CC (50%)

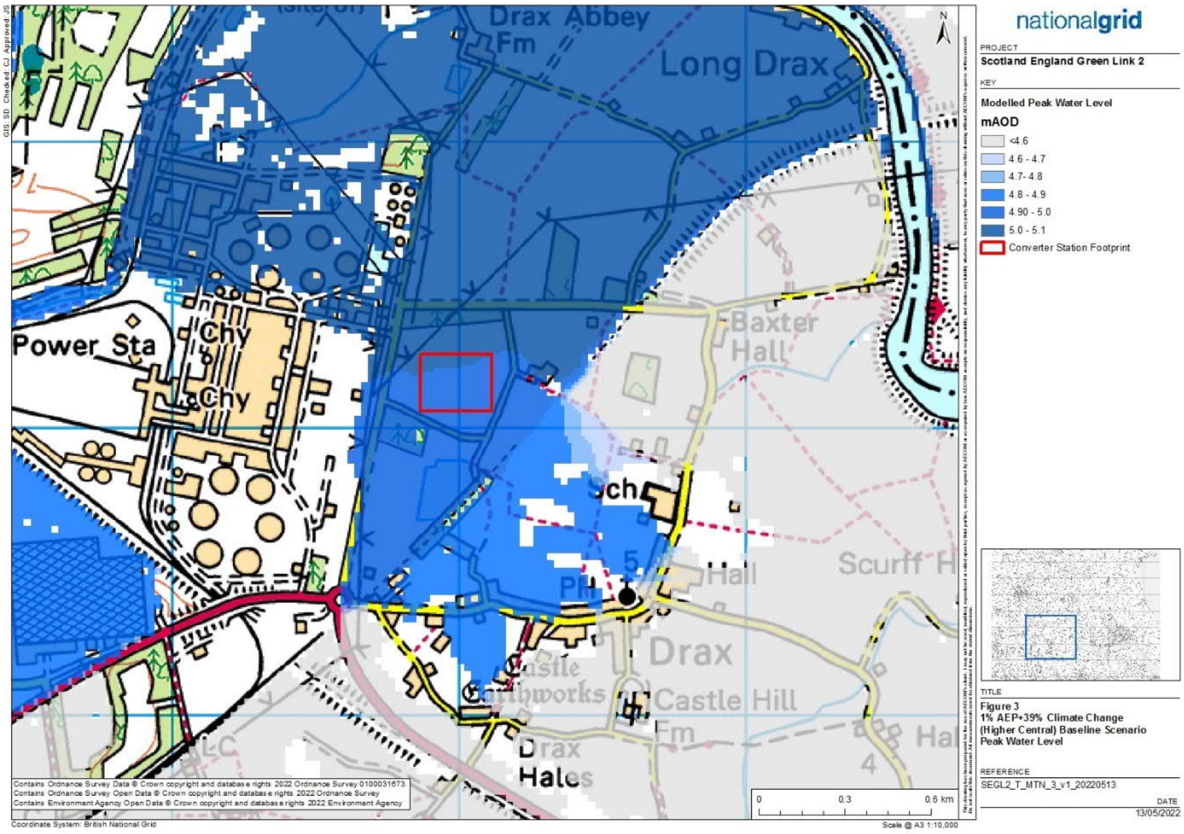


Figure 3: Modelled Peak Water Level – Development Scenario - 1% AEP+CC (50%)

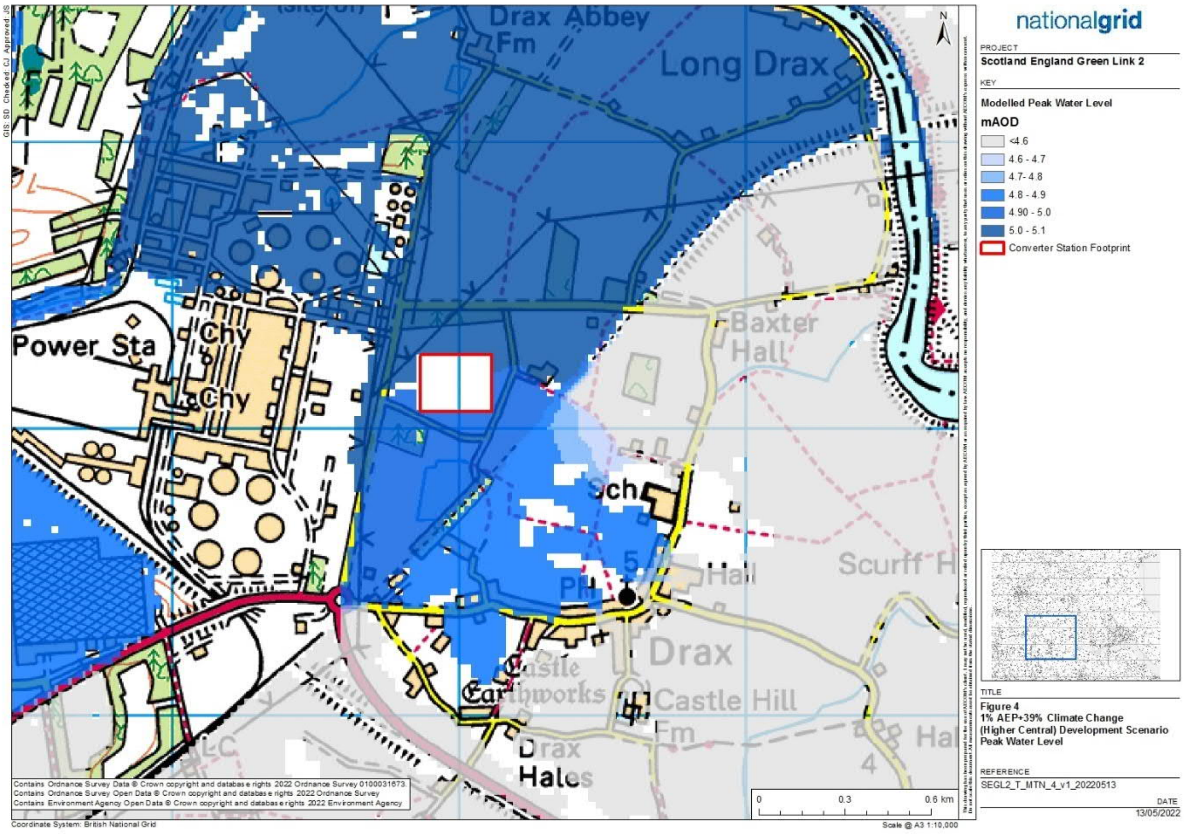


Figure 4: Modelled Peak Flood Depth – Baseline Scenario - 1% AEP+CC (50%)

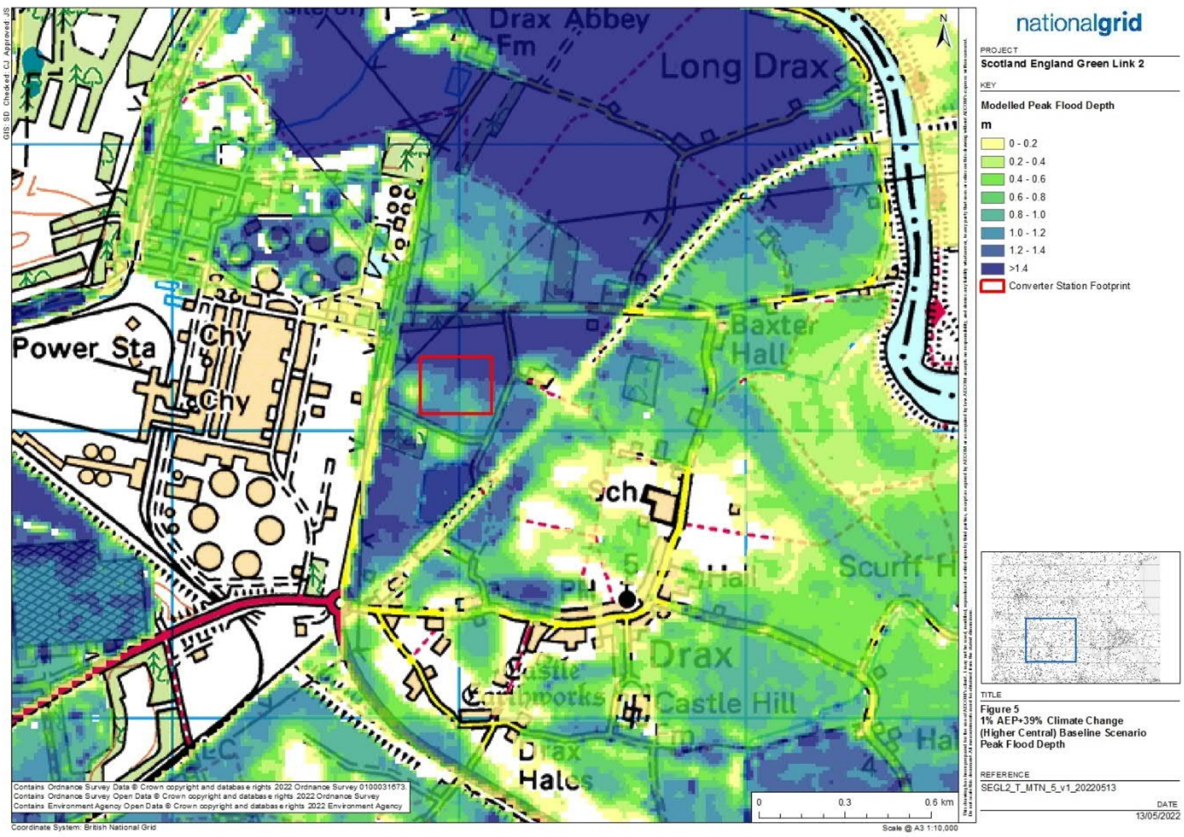


Figure 5: Modelled Peak Flood Depth – Proposed Scenario - 1% AEP+CC (50%)

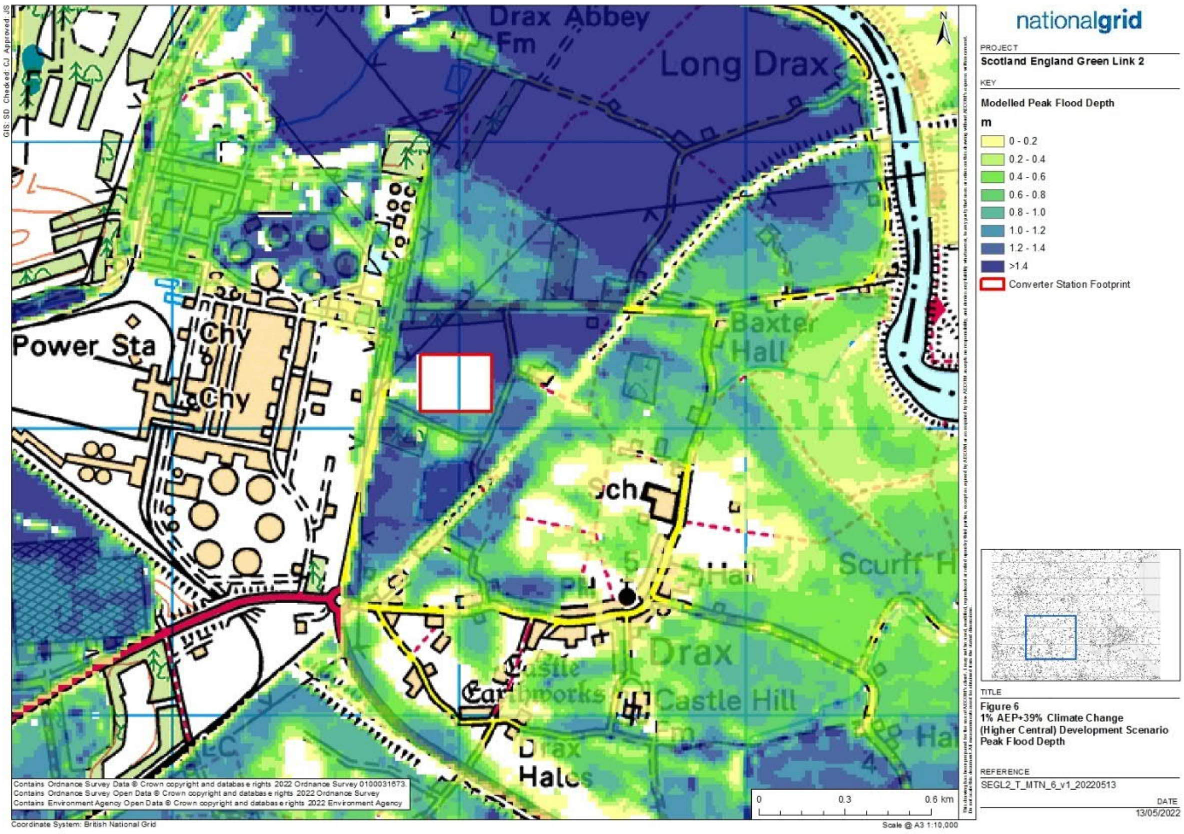


Figure 6: Modelled Hazard Risk – Baseline Scenario - 1% AEP+CC (50%)

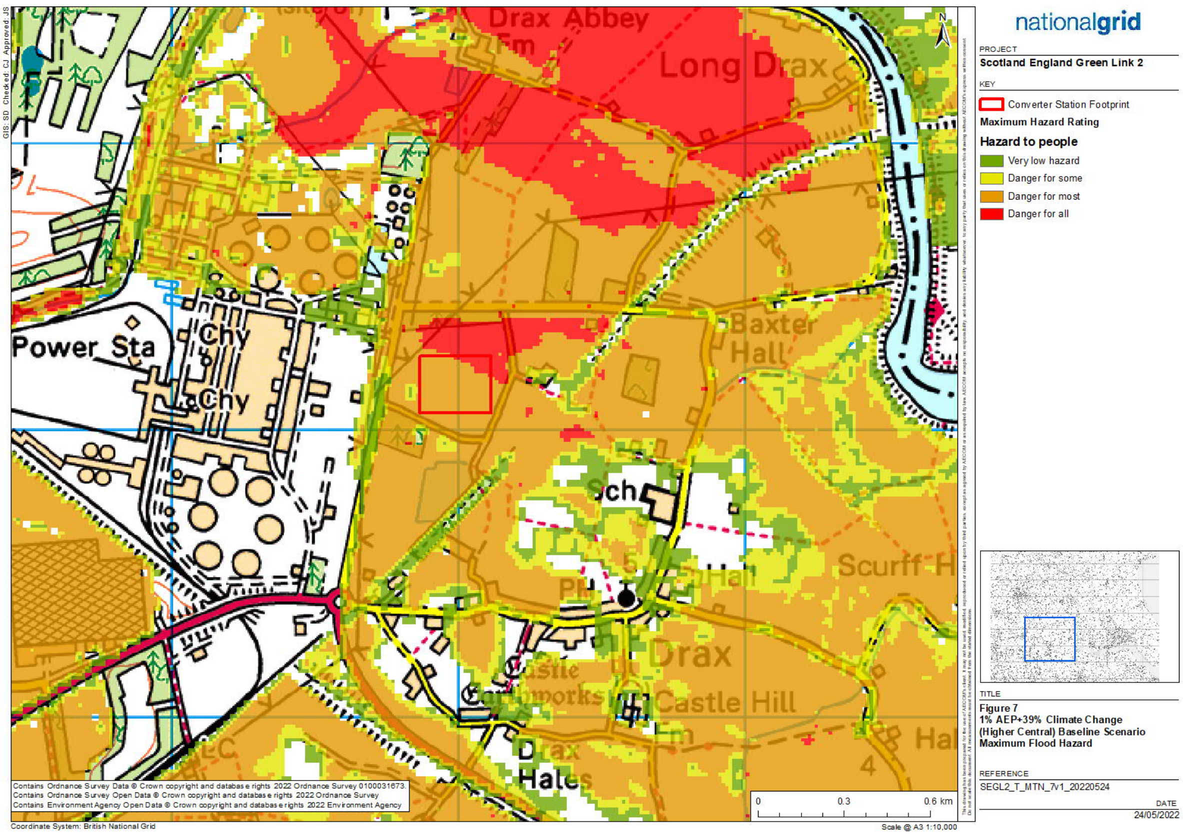
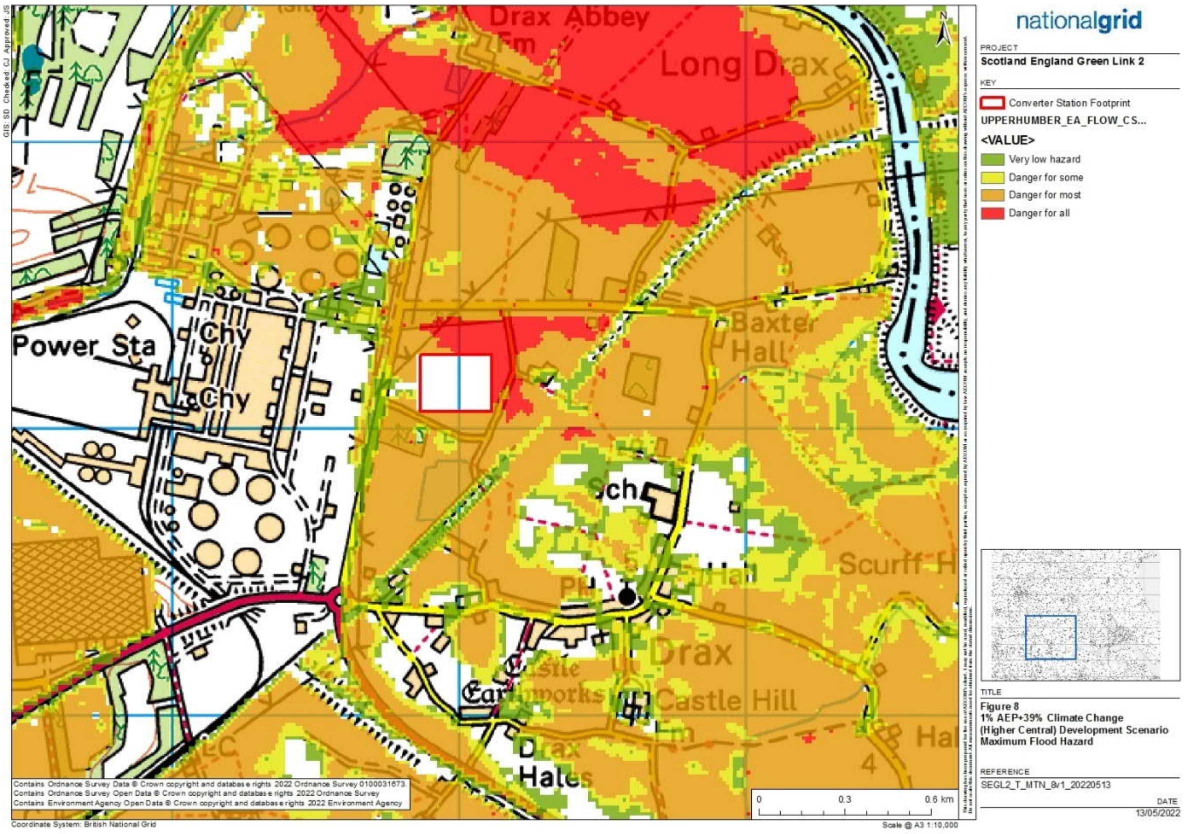


Figure 7: Modelled Hazard Risk – Proposed Scenario - 1% AEP+CC (50%)



- Peak water levels (Figure 3; Figure 4) and depths (Figure 5; Figure 6) around the site are similar in both the baseline and development scenarios to an accuracy of 2.d.p (Decimal Places). On inspection to 3.d.p, the difference in peak water levels is approximately 20mm around the perimeter of the development.
- Hazard mapping identifies the hazard risk to people for a given flood event (Figure 7; Figure 8). The results show that the Hazard rating for the north section of the development, and north of the converter station for the baseline scenario is ‘Danger for most’. The south section of the development, and south of the converter station, predicts a hazard rating of between ‘Very Low Hazard’ and ‘Danger for Some’ hazard.
- Comparison of the hazard mapping shows that the hazard band extents are essentially similar between the baseline and development across the wider area. In the immediate vicinity of the proposed development there is a small area of increase danger for all (previously danger for some) immediately adjacent to the toe of the proposed ground level changes.

Peak water level and depth around the site occurs at 408 hours and 10 minutes for the baseline scenario. Peak water level and depth around the site occurs at 408 hours and 15 minutes for the development scenario. As such the peak occurrence are essentially similar between both scenarios. Based on these results it is assessed that the proposed development has a de minimis impact on flood risk to the site and third party land. Therefore it is expected that floodplain compensation will not be required for this scheme.

5.2 Compensation Requirements

Notwithstanding the assessed impact on flood risk above and the position that due to the de minimis impact of the scheme floodplain compensation is not proposed , the floodplain compensation requirements up to the 1% AEP+CC event have been estimated following a level-for-level, volume-for-volume review for policy compliance. The floodplain compensation requirements were determined for the converter station footprint in its proposed location. Calculations were undertaken using 0.2 m slices that were taken of the raised mass to break down the fill volume up to the 1% AEP+CC (50%) water level, see Table 3 **Error! Reference source not found.**.

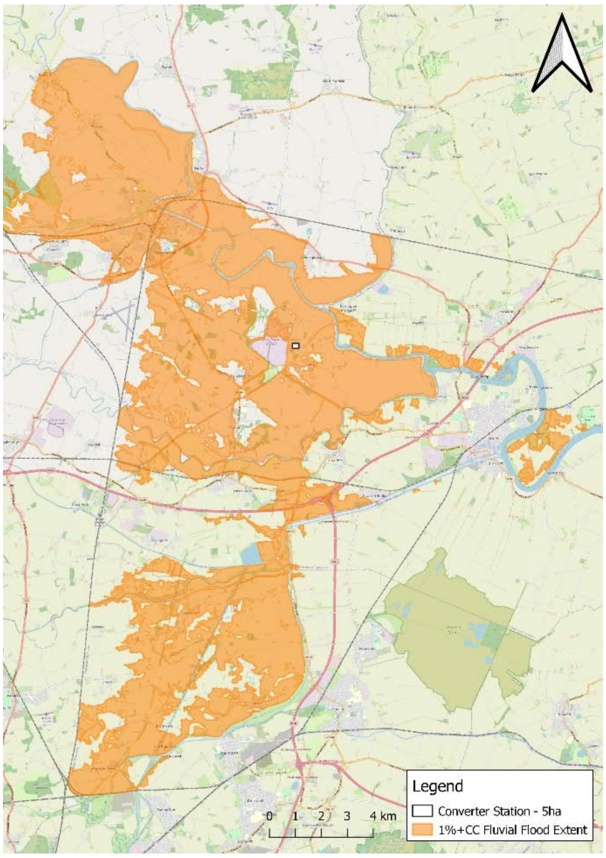
Table 3: Floodplain compensation volume requirements

Elevation slice (mAOD)	Compensation volume requirement (m^3)	Cumulative compensation volume requirement (m^3)
<3.11	0	0
3.11-3.31	364	364
3.31-3.51	1,344	1,708
3.51-3.71	2,930	4,638
3.71-3.91	5,772	10,410
3.91-4.11	8,194	18,604
4.11-4.31	9,480	28,083
4.31-4.51	9,875	37,958
4.51-4.71	9,920	47,878
4.71-4.91	9,920	57,798
4.91-5.02	4,464	63,254

The high-level calculations show that the baseline flood plain volume shown below in Figure 8 for the 1% AEP+CC (50%) fluvial dominated event is 187,932,406m^3. The volume of the proposed land raising below the 1%AEP +CC (50%) is 63,254m^3 as noted in the table above. This represents 0.03% of the available floodplain storage. This shows that the proposed scheme would have a de minimus impact on floodplain storage.

LIDAR data for the area surrounding the proposed converter station was reviewed to identify area suitable to provide compensation storage, if required. It has been confirmed that there exists a variety of site outside the application (red line) boundary that could provide viable options for floodplain compensation schemes for the elevation and volume ranges set out in Table 4. It is assumed that if a floodplain compensation scheme were advanced it would be subject to a planning condition and possible supplementary permission.

Figure 8: Floodplain extent used to for comparison of floodplain availability between baseline and proposed scenarios (Flood Extent limited to proposed 'Finish Floor Level' of 5.02m AOD)



6. Conclusion

This modelling technical note outlines the methodology and processes undertaken to calculate the modelled impact of the converter station on peak water level within the floodplain in addition to calculating required floodplain compensation. Modelling used in the assessment are based on flows extracted from the 2020 Humber Strategy EWL study combined with the hydraulic model from the Upper Humber Model 2018 study. Fluvial climate change allowances based on the uplift values within the latest EA Climate Change guidance for the Central and Higher scenarios are 31% and 39% respectively. The nearest equivalent in the 2020 study were 30% and 50% and these have been used in the assessment.

The modelled peak water level for the 1% AEP with a climate change uplift of 50% (1% AEP+ Higher Climate Change Allowance) was calculated as 5.02 mAOD. This level would be recommended finished floor level (FFL) of the converter station based on the modelling, to design to the 1% AEP+CC (50%). Should the enhanced standard of protection be required then the 0.1% AEP +CC (50%) modelled flood level of 6.18 mAOD can be used.

The assessment shows that there is a negligible impact as a result of the proposed converter station site land raising and consequently no floodplain compensation is proposed.

If higher finished platforms levels (above the 1 % AEP + CC flood level) where to be proposed this does not increase the quantum of floodplain compensation storage required as this is limited to the 1% AEP + CC flood level and is therefore limited to 63,254m^3.

7. References

Ref 1 Environment Agency. Upper Humber Model 2018

Ref 2 UK Government. Flood risk assessments: climate change allowances, updated May 2022. Available online at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances