Liverpool City Region SDS SFRA - Climate Change Modelling

November 2023

Prepared for:
Liverpool City Region Combined Authority

www.jbaconsulting.com

Contents

List of Figures

List of Tables

Executive Summary

JBA were commissioned by the Liverpool City Region Combined Authority (LCRCA) in 2023 to deliver climate change uplifted models for various watercourses located in the LCRCA region. These deliverables focused upon updating the modelled results in accordance with current climate change guidance, as required by the latest UKCP18 values.

For the study, a list of 23 models were selected to be updated and to produce updated modelled results and outlines. Some of these models included both Defended and Undefended scenarios, increasing the number of individual models to 30. It was not considered part of the project scope to update the models themselves with the goal of producing updated results only, i.e., no changes were made to model geometry, structure representation or model schematisation.

The standard modelling method of representing the effects of climate change by increasing the hydrological inflows by values according to UKCP18 guidance in the North West region, which were applied to the 3.3% (4% or 5% if unavailable), 1% and 0.1% AEP design events. Some of the models supplied for this project were predominantly tidally influenced and as such these models were run for the 3.3% (4% or 5% if unavailable), 0.5% and 0.1% AEP design events. For these models, sea levels were risen by 11.2mm (Higher central) and 16.3mm (Upper end) for the 2096 to 2125 epoch, and by 1.01m (Higher central) and 1.41m (Upper end) for Cumulative Sea level rise in the 2000 to 2125 epoch.

Out of the requested models to update, some have been ruled out for various reasons, such as being outside of the Liverpool District area, unreferenced geometry, or missing data. A full list of the models that could not be run are listed in Section 6.2 of the SFRA report.

1 Liverpool City Region Climate Change Modelling

1.1 Introduction

In 2023, JBA were commissioned by the Liverpool City Region Combined Authority (LCRCA) to produce updated model outputs in line with current climate change guidance.

Previously, the effects of climate change (CC) on models were typically represented by increasing all the hydrological inflows by 20%. Current Guidance, released in March 2016, uses the location of the watercourse in relation to river basin districts to what the fluvial increases are to be applied[1]. Additionally, some of the models were predominantly influenced by tidal risk. As such, CC uplifts were applied to the tidal boundaries to represent the Upper End and Higher Central allowances for the 2096 to 2125 epoch.

Figure 1-1 shows the locations of available models that were considered for this study. 40 models in all were initially assessed for suitability. A geolocation was attempted with all these models and most of them could be placed on a map. Following this geolocation it was found that some were overlapping, or the same area is covered by more recent modelling. Some others were found mostly or entirely outside of the Liverpool District boundary, incomplete or not georeferenced. The ones with missing data files have been reported back to the Environment Agency, with some having been completed and updated. A few models could not be updated due to severe instabilities (especially with the more extreme Q1000 events which they had not been set up to run in the first place).

23 models were selected to be re-modelled with climate change uplifts. This figure omits the models which had been found as incomplete and for which the EA could not provide the missing data. The models supplied were of varying ages and types and have been reviewed and run where possible to produce the desired deliverables.

1 Flood risk assessments: climate change allowances

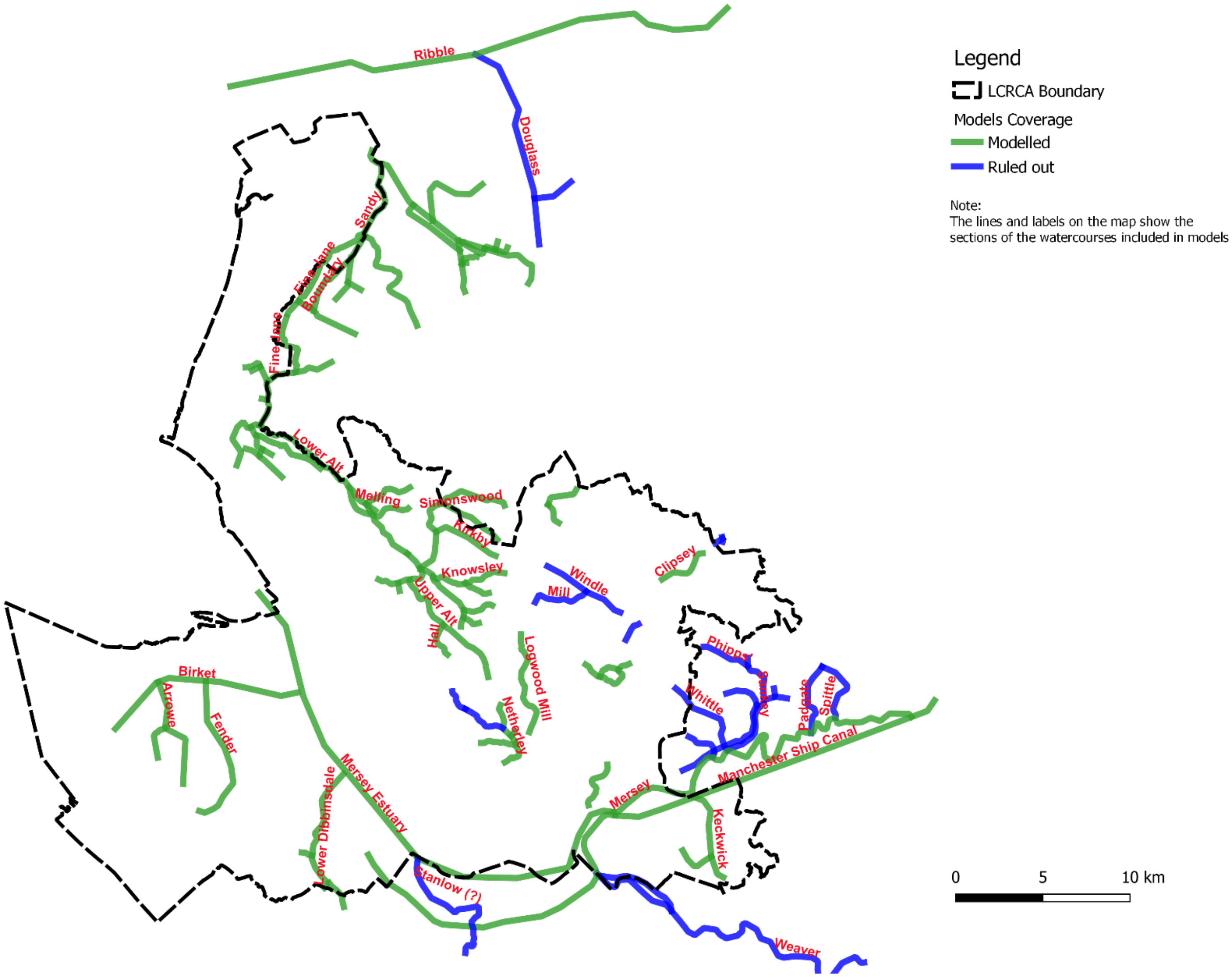

Figure 1-1 Location of models within LCRCA

1.2 Initial model screening

All models were subject to an initial screening to ascertain whether there were any obvious reasons as to why the model would be unlikely to run or produce appropriate results. This included:

- Missing model files (i.e., both 1D run and results, geometry files)
- Missing units (i.e. hydrological boundaries)
- Unclear modelling units or methods (i.e. anything not clearly explained in the accompanying reports relating to how certain aspects of the model were built)
- Incompatible modelling software

For all models we tried to run the Q100 present day event in a QA process meant to identify any issues, like high instabilities, crashes, or missing data. During this QA process we checked for:

- water level progression in the long profile for the 1D models, looking for unusual variations

- model convergence, particularly where convergence and iterations tolerances reported in the .bmp files for the 1D models were exceeded, unusual spikes in inflows/outflows
- inspected the 1D results files (.zzd) for warnings and errors that could lead to erroneous water level calculation
- water level contained in cross-sections for the 1D models, dflood variable exceedance
- compared flood outlines against existing runs
- particularly for the 2d models or domains, checked on mass error and negative depths occurrences
- unusual bumps in the water level and velocity rasters for the 2d models or domains

The initial screening revealed that several models were unable to be run. For some models, missing files were able to be generated upon further investigation, so no further actions were required. Where missing files were not able to be generated, these were requested from the Environment Agency (EA). Other reasons as to why a model may not be able to run were only discovered through further interrogation of the supplied data, most often when trying to run them, i.e., stability issues.

Some common issues which were encountered in multiple models:

- Lack of georeferenced model nodes/structures including any supplied gxy
- Limited or no use of scenarios/events in TUFLOW, which are now commonplace and often standard in contemporary modelling methods
- Path length issues i.e. too long, non-connected directories and drives
- Missing files, i.e., both. ief and .zzd files (.ief could be recreated where .zzd present), MapInfo mif/mid files or ESRI shapefiles essential to model's geometry
- Missing key commands in TUFLOW used for outputting ASCII grids and other desired 2D outputs

Where possible, missing files were re-created based on existing data and re-runs, i.e., initial conditions. Some issues related to software updates or models having been moved from their original location were sorted by editing the simulation control files, most commonly to avoid TUFLOW error 0004 reporting on outdated MI files.

1.3 Model simulations

The model simulations followed a broadly similar process outlined below:

- General check of which data has been supplied, acts as an additional check if anything was missed in the initial screening and to familiarise the modeller with the folder structure.
- Create new inflow boundaries from the existing 3.3% (4% or 5% if unavailable), 1% and 0.1% AEP with the appropriate peak flow increases applied, typically by multiplying the scaling factors. Any previous factors were multiplied by the same values before being applied to the inflows.

- Any models using bc_dbase repositories were updated also by the appropriate values.
- For tidal models, CC uplifts were applied to the tidal boundaries to represent the Upper End and Higher Central allowances for the 2096 to 2125 epoch. These uplifts level rises were added to the 3.3% (4% or 5% if unavailable), 0.5% and 0.1% AEP events. The updated tidal curves include the rises due to storm surges, to comply with the new requirements. The inflow additions due to wave overtopping have also been modelled, however preserving the estimated in the existing models.
- Present day events were re-modelled with the latest version of the software. New model run files were created in all cases.
- Folder structure and naming convention was kept the same to match the original model format as close as possible.
- Checks were performed on the completed models, comparing maximum stage, final cumulative mass balance (MB), 2D water level grids, flood extents and animation plots across the scenarios and events of the same model.
- Post-processing of results is further detailed in Section 1.4.

1.3.1 Climate change uplifts

Table 1-1 notes the recommended peak flow uplifts for the management catchments covering the LCRCA area. The location of each model was assessed and assigned a management catchment, and the respective peak flow uplift percentages were applied.

Table 1-1 Recommended peak river flow allowances for the Lower Mersey, Alt and Crossens and Weaver Gowy management catchments

Management catchment	Allowance category	Total potential change anticipated for peak river flows (based on a 1981 to 2000 baseline)		
		2020s (2015-2039)	2050s (2040-2069)	2080s (2070-2125)
Lower Mersey	Upper end	32%	55%	90%
	Higher central	22%	35%	57%
	Central	18%	27%	44%
Alt and Crossens	Upper end	31%	56%	95%
	Higher central	21%	33%	58%
	Central	16%	25%	44%
Weaver Gowy	Upper end	36%	64%	106%
	Higher central	24%	40%	67%
	Central	19%	30%	52%
Dee	Upper end	26%	32%	50%

Management catchment	Allowance category	Total potential change anticipated for peak river flows (based on a 1981 to 2000 baseline)		
		2020s (2015-2039)	**2050s (2040-2069)**	**2080s (2070-2125)**
Lower Mersey	Upper end	32%	55%	90%
	Higher central	22%	35%	57%
	Central	18%	27%	44%
	Higher central	16%	19%	30%
	Central	12%	14%	22%

For the tidal models, the tidal curves have also been updated for the present day (re-calculated for the year 2023). For climate change, tidal curves were generated for the year 2123 (present day +100yr), in line with the recommended best practice.

1.4 Results

Post-processing of results consisted in:

- Converting the raster grids into flood outlines as shapefiles, for the 2D models.
- For the 1D models (where a raster grid is not output through modelling), we first extended some of the cross-sections in the model's geometry to ensure enough coverage of the DTM around the 1D domain, then the peak water levels calculated at each 1D node were interpolated into a continuous water surface and intersected with the DTM, retaining the surface water above the DTM elevation. The newest and most accurate available DTM was used (1m resolution), publicly available on gov.uk. As a last step, all unconnected patches in the water surface were carefully inspected and removed where we found there would be no natural connectivity to the main body water in the 1D domain.

Typically, for each model resulted 9 different outlines (3 events, each with present day and 2 climate change). For models where Defended /Undefended scenarios were modelled separately, there resulted 18 different flood outlines (9 as described above for each scenario).

The climate change uplifted flood outlines are shown on the SFRA interactive maps.

1.4.1 Model results files

The main outputs of this study consist of the updated model results, including outputs from Flood Modeller/TUFLOW, these being 2D ASCII grids for depth, water level, velocity, and hazard.

1.4.2 GIS outlines

GIS polygons in shapefile format were derived for each modelled design event, scenario, and model. These were produced by converting ASCII grids into polygons using QGIS for the 1D-2D models or using the 1D Mapping Tool in Flood Modeller for the 1D only models.

1.5 Limitations, recommendations, and conclusions

This study has produced updated flood extents for both 1D and 2D models.

The main limitation to this study is that the models and model results have not been formally reviewed by the Environment Agency, at this stage. Additionally, the hydrology for each model has not been updated for this study. With some of the models dating as far back as 2003, it is not the ideal starting point from which to run new CC uplifts, however it was beyond the scope of this study to update the hydrology for each model. Also, the older the model the higher the chances that the geometry may have changed (cross-sections geometry may have altered due to new works, natural channel aggradation or degradation or even river restoration projects, structures may have been added or removed). The DTM also is updated periodically, expecting more accurate flood estimates with the newer, more accurate DTM.

In some instances, the 3.3% AEP hydrology was not available with the provided (existing) model so the closest available was used, typically 4% AEP or 5% AEP as a proxy.

Particularly for the 1D only models, the intersection between the peak water surface calculated in the 1D model and the DTM gives far less accurate results than the actual 2d modelling using the same DTM, therefore we recommend using these results as a proxy only, envisaging to reconstruct the model as 1D-2D (outside the scope of this project).

For several of the models, the 0.1% AEP events plus climate change simulations were unstable and could not be run. Best efforts were made to run these models without drastically altering the existing mode for these events, however the models would require too much work to stabilise them, which was beyond the scope of the study. Some did have issues with regards to missing data, unclear scaling factors used in the original hydrology or severe instability within the model. With these cases, further investigation of these models was required for them to be run.

JBA consulting

Offices at

Bristol
Coleshill
Doncaster
Dublin
Edinburgh
Exeter
Glasgow
Haywards Heath
Leeds
Limerick
Newcastle upon Tyne
Newport
Peterborough
Portsmouth
Saltaire
Skipton
Tadcaster
Thirsk
Wallingford
Warrington

Registered Office
1 Broughton Park
Old Lane North
Broughton
SKIPTON
North Yorkshire
BD23 3FD
United Kingdom

+44(0)1756 799919
info@jbaconsulting.com
www.jbaconsulting.com
Follow us:

Jeremy Benn Associates Limited

Registered in England
3246693

JBA Group Ltd is certified to:
ISO 9001:2015
ISO 14001:2015
ISO 27001:2013
ISO 45001:2018