APPENDIX A – MODELLING METHODOLOGY

Table of Contents

1.1 Introduction

1.1.1 As part of the North Tyneside Surface Water Management Plan (SWMP), pluvial modelling has been undertaken across the North Tyneside Council (NTC) administrative boundary.

1.1.2 The pluvial modelling methodology was developed to determine the impact of various rainfall events across North Tyneside by assessing flow paths, areas of ponding and general catchment response.

1.1.3 In order to continue developing an understanding of the causes and consequences of potential surface water flooding in the study area, intermediate level[1] hydraulic modelling has been undertaken for a range of rainfall event probabilities. This hydraulic modelling will identify the need for future detailed assessments in areas identified as high risk.

1.1.4 A full methodology of the hydraulic modelling undertaken is described below.

1.2 Modelling Approach

1.2.1 A Direct Rainfall approach using the latest double precision version of 2-Dimensional (2D) hydraulic modelling software TuFLOW (build TuFLOW.2010-10-AA-w32) has been used. Using this approach and software, rainfall events of known probability are applied directly to the ground surface and are routed overland to provide an indication of potential flow path directions and velocities and areas where surface water will pond.

1.3 Model Coverage

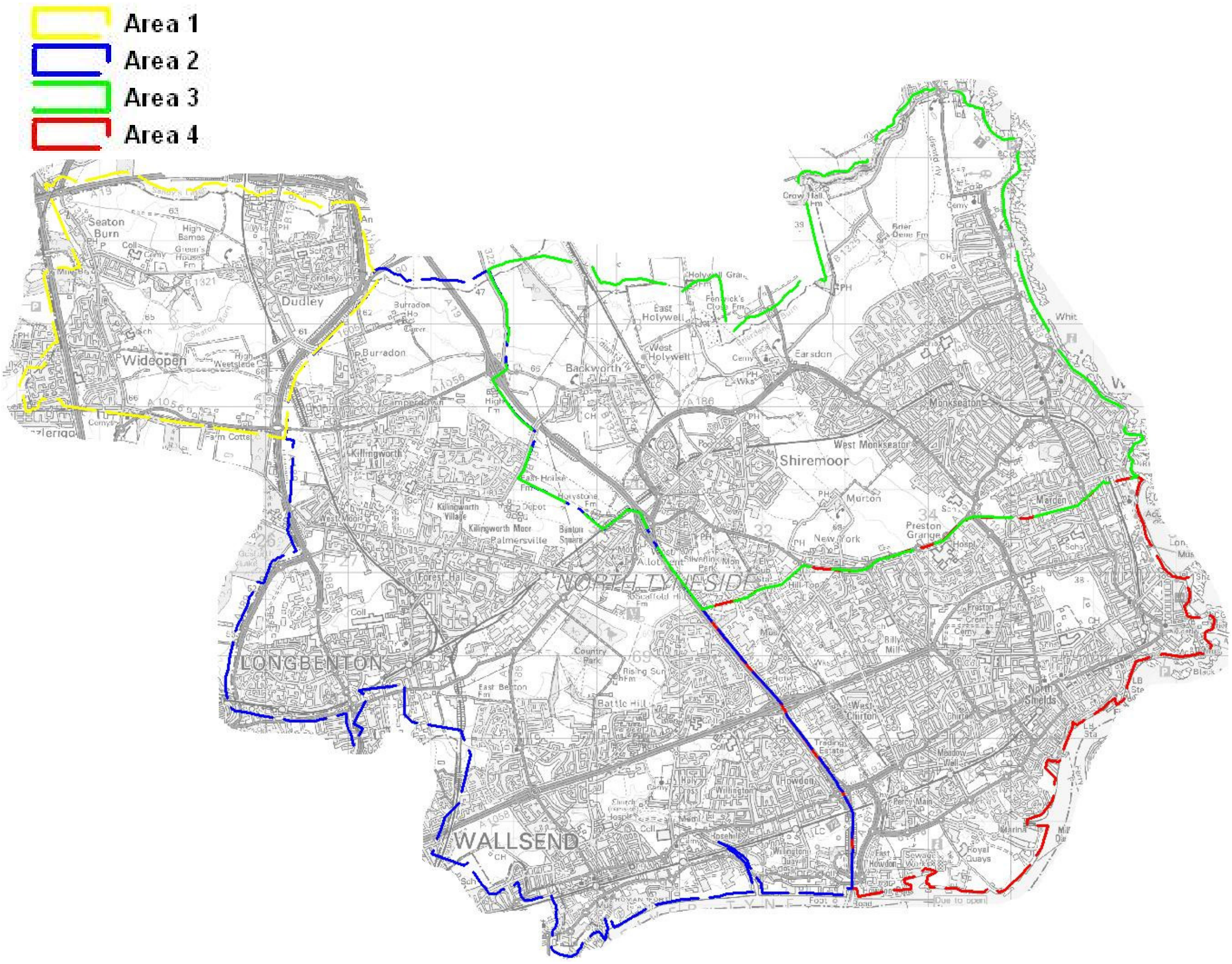
1.3.1 Due to the size of the study area and given the hydrological linkages across the city, it was necessary to divide the coverage into four smaller areas that, combined, cover the NCC administrative boundary.

1.3.2 The model boundaries were based on hydrological catchments defined through a review of the LiDAR topographic data, Main River centre lines, and the Environment Agency's (EA) 'Areas Susceptible to Surface Water Flooding' (AStSWF) maps and Flood Maps for Surface Water (FMfSW).

1.3.3 Figure C1 illustrates the four model extents.

[1] As defined in Department for Food and Rural Affairs (Defra). March 2010. Surface Water Management Plan Technical Guidance. Defra London.

Figure C1 Model Coverage across North Tyneside



© Crown copyright. Ordnance Survey. Licence Number 100019264. 2011

1.4 Topography

1.4.1 LiDAR[2] is a method of optical remote sensing which uses light reflections to determine vertical heights. LiDAR records the vertical heights of an area as the eye would see it from above, and therefore includes all buildings, structures and vegetation; this is known as the Digital Surface Model (DSM). Algorithms which detect the presence of buildings filter the LiDAR data to produce a Digital Terrain Model (DTM) where the majority of buildings, structures, and vegetation are removed/filtered to represent actual ground levels.

1.4.2 The LiDAR data was made available by NTC for this project (obtained from the EA) for use as the base information for the model topography. LiDAR DTMs with a horizontal resolution of approximately 1m and 5m were provided. LiDAR DSMs with a horizontal resolution of approximately 2m and 5m were also provided. Vertical accuracies of the LiDAR DTM/DSM

[2] Light Detection and Ranging.

coverage varies according to the specification to which the LiDAR collection was 'flown'. The 1m DTM typically has a vertical accuracy of +/- 0.25m.

1.4.3 The DTM is considered a more accurate representation of the ground topography and has therefore been used to create the 2D TuFLOW model domain. Where coverage of the 1m DTM was unavailable, the 5m DTM was used. Using the combined 1m and 5m LiDAR DTMs a 5 m grid was established.

1.4.4 Significant topographic features were identified and reinforced onto the grid in the model. Examples include railway embankments and embanked roads. This process also included identifying flow routes through raised topographic features such as culverts, underpasses and subways. Raised features were typically reinforced using z-lines, and flow routes were reinforced using z-lines and/or ESTRY culverts.

1.5 Roughness

1.5.1 Roughness values are used to allow the model to determine the nature of the flood flows across the surface of the ground as surface water will flow more slowly over vegetated areas than on roads. Manning's roughness coefficients for various surfaces, based on OS Master Map layers were standardised throughout the model.

1.5.2 Two (No.2) different roughness values were determined using the OS MasterMap land use categories so that a comprehensive coverage of the modelled area was achieved. These are shown in Table C1.

Table C1 Roughness Values based on OS MasterMap Land Use Types

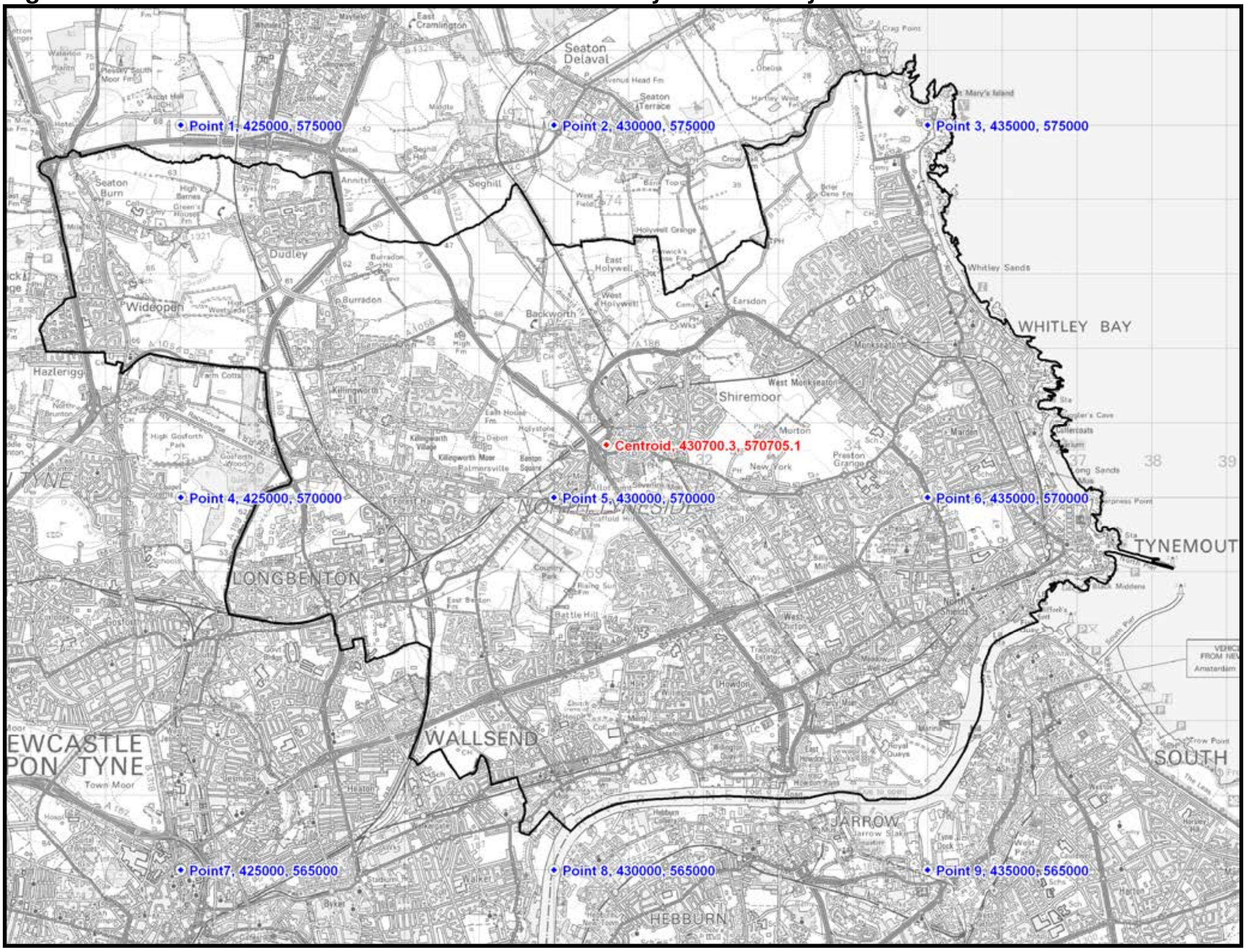
Manning's 'n' Value	Land Use Description
0.02	Roads Tracks and Paths (Default)
0.04	Grass and Parkland Surface

1.5.3 The varying roughness coefficients allow the effects of ground surface on flow and velocity to be represented.

1.6 Rainfall

1.6.1 Rainfall hyetographs required for the modelling were calculated using the Flood Estimation Handbook (FEH) Depth Duration Frequency (DDF) methodology. The study area covers approximately 100 km² as shown on Figure C2 below. To simplify the modelling a single rainfall hyetograph for each return period has been applied across the entire borough, determined through the assessment of rainfall at ten points as shown on Figure C2. Nine of these are situated on a 5 km grid spacing and the central point of the borough has also been assessed.

Figure C2 Selected Point Locations across the North Tyneside Study Area



1.6.2 At each of the ten points catchment descriptors were obtained from the FEH CD. The catchments in the North Tyneside study area are relatively small and reasonably steep. Therefore summer profiles were selected and the critical duration of 3 hours (180 minutes) was considered reasonable.

1.6.3 Rainfall intensity profiles were generated using the FEH catchment descriptors and Micro Drainage WinDes$^{®}$ software. Rainfall hyetographs were generated for the following return periods:

- 1 in 30 year
- 1 in 50 year
- 1 in 75 year
- 1 in 100 year
- 1 in 200 year

1.6.4 The hyetographs for the 1 in 100 year event were compared across the borough and also compared to the average rainfall and the central point. This comparison is shown in Figure C3 and the deviation from the average rainfall and the centroid rainfall is shown in Table C2.

Figure C3 Comparison of Rainfall Intensities for 1 in 100 year Return Period

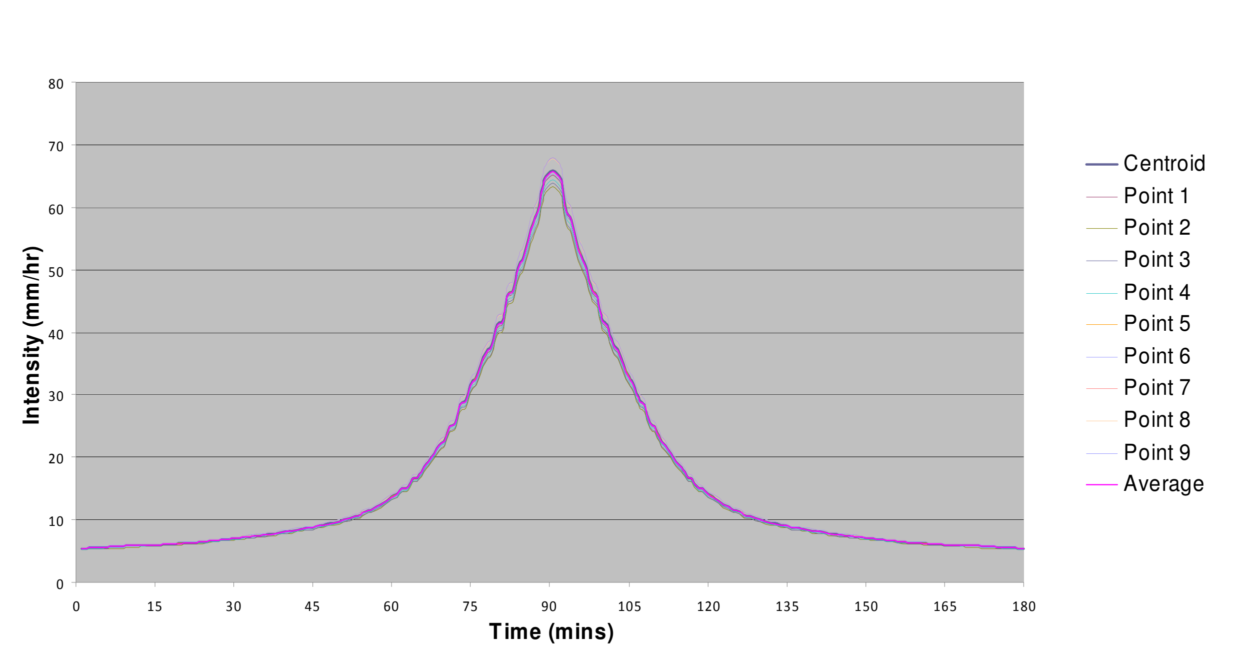


Table C2 Comparison of 1 in 100year Rainfall Depths

	Depth (mm)	Compared to Average	Compared to Centroid
Minimum depth	48.3	-3.7%	-3.9%
Maximum depth	51.8	+3.3%	+3.1%
Centroid depth	50.2	+0.2%	-
Average Depth	50.1	-	-0.2%

1.6.5 Given that the depths of rainfall produced from the 1 in 100 year event fall within +-4% of the mean and central point values the mean point rainfall profile was considered suitable for representing the rainfall across the whole borough. The final hyetographs for the various return period events are shown in Figure C4. The 100 year with Climate Change hyetograph includes an increase in intensity of 30%.

Figure C4 Final Hyetographs for Direct Rainfall Input into TuFLOW Model