Appendix B – Pluvial Modelling Methodology

Model Coverage

The model coverage for Chippenham, Trowbridge and Salisbury is centred on the existing urban extent, but also encompasses land on the margins of each settlement where many of the preferred strategic site options are proposed. This model coverage allows a holistic appreciation of existing and future potential for flooding from surface water, groundwater, sewer, ordinary watercourse or a combination of these and helps inform the strategic planning process.

Model Setup

The latest double precision version of TUFLOW two-dimensional hydraulic modelling software (2010-iDP-w32) was used to create three separate models to assess surface water flood risk across the settlements of Chippenham, Trowbridge and Salisbury.

All three models have been developed using a grid size of 5m throughout the model to provide more detailed outputs across each of the settlements.

The initial 5m grids written by TUFLOW have been populated with ground level data from an underlying digital elevation model, derived using a 1m resolution digital terrain model (DTM), which is derived from filtered LiDAR (Light Detection And Ranging) data. A DTM provides topographical data with a vertical accuracy of approximately +/- 0.15m. It is filtered so therefore has removed all features such as trees and buildings to provide the ground level only.

At locations where DTM data was not available (e.g. north-west Chippenham), a digital surface model (DSM) has been used. The DSM is derived from unfiltered LiDAR data and therefore includes features such as trees, buildings and hedgerows. As a result the topographical data provided by a DSM is very undulating and irregular when compared to DTM.

Model Boundaries

Inflow Boundaries

Rainfall boundaries have been applied to the models based upon a rainfall analysis undertaken on the respective catchments. TUFLOW allows direct rainfall to be applied to an area covered by a GIS polygon. In the instance of the three settlements, the model boundary has been used as the polygon to apply direct rainfall. The polygon is then linked via a command in TUFLOW to a look-up spreadsheet which contains the relevant rainfall information (per time step). Additional information relating to the generation of rainfall profiles is provided below.

Downstream Boundary

The downstream boundary of both models has been set with a normal depth boundary in place, thus to prevent surface water from ponding at the edge of the model and essentially glass-walling and backing up levels in the lower reaches of the model. In addition to the downstream boundary, any of others at the edges of the models where un-natural ponding occurs (following an initial model run) have also had normal depth boundaries applied, once again to prevent un-natural levels of ponding.

Representation of Key Features

Structures

The results of the initial run of each model were interrogated to determine any areas of ponding behind structures, which may be as a result of the misrepresentation of structures causing an obstruction to flow.

Following the initial run and interrogation of initial results, the areas of ponding were visually verified via site reconnaissance walkovers. During these walkovers, the approximate dimensions of key structures were measured (where it was safe and appropriate to do so).

Using the information gathered during the site walkovers, the various key structures (culverts, bridges, railway crossings, subways etc.) were represented in the TUFLOW models as 1D structures. The 1D structures are linked to the 2D model domain via 2D boundary condition nodes.

Watercourses

Watercourses have been included in the model using the data contained within the primary DTM. Without any more detailed topographical data it has not been possible to further enforce river centrelines.

It would be considered prudent to supplement the DTM with detailed topographical survey for any further detailed modelling.

Manning's Roughness Coefficients

OS Mastermap data provided by Wiltshire Council has been used to determine Manning's roughness coefficients applied to the models. Topographic area layers have been queried in MapInfo and the land uses have been split into the following groups, with a Manning's roughness coefficient assigned to each land use category.

- Road and paths – 0.020,
- Buildings – 0.500,
- Lakes and ponds – 0.030,
- Railways – 0.200,
- Grass and gardens – 0.040,
- Roadside (paths and verges) – 0.035,
- Tress and scrub – 0.075

Infiltration and Sewer Network Modelling

The models did not include an allowance for infiltration of surface water into the underlying ground, or the interaction of the surface water drainage system in operation throughout the urban areas of Wiltshire. This was deemed to be a conservative approach that would provide results assuming no infiltration (i.e. saturated soils or hard standing areas) and that all surface water sewer gullies were blocked or surcharged. In addition, the decision to exclude these aspects was due to the absence of key data sets, such as:

- Details of the surface water sewer network capacities and maintenance regimes/ blockages; and
- Actual infiltration rates for the varying soil types throughout Wiltshire;

Rainfall Analysis

A fundamental aspect of pluvial modelling is the estimation of a rainfall profile that will enable the model to apply rainfall to the model for the various required storm events.

Rainfall profiles (hyetographs) were derived for each settlement during the 30, 30 plus climate change, 100, 100 plus climate change and 200 year return period events. In order to generate these rainfall profiles, Catchment Descriptors from the industry standard Flood Estimation Handbook (FEH) CD-ROM were obtained for Salisbury, Trowbridge and Chippenham. The Catchment Descriptors provide a reasonably accurate hydrological synopsis for each location or river catchment. They take into account variables within the catchment such as estimated annual average rainfall, urbanised coverage, infiltration capacity and slope. The Catchment Descriptors are deemed sufficient for use as part of strategic scale pluvial modelling, without further statistical analysis.

An important aspect of estimating a rainfall profile is that of the critical storm duration. In order to ensure that the worst case scenario is assessed and that the entire catchment is contributing surface water runoff, the critical storm duration should be estimated. In order to achieve this, the Revitalised Flood Estimation handbook (ReFEH, Centre for Hydrology, 2005) method was used, based on the following assumptions and parameters:

- Hydrological inputs derived from the 'Catchment Descriptors' function of the FEH CD-ROM,
- Area of the Chippenham is approximately 90km^2,
- Area of Trowbridge is approximately 75km^2;
- Area of Salisbury is approximately 90km^2;
- Given that the model assumed no infiltration of rainfall into underlying ground the summer rainfall profile was used to provide a more conservative estimate;
- The storm duration for each settlement area was calculated to be approximately 6.5 hours (360 minutes).

The Catchment Descriptors and storm durations were input into the Rainfall Profile function of WinDes® Version 12.5 software, Source Control module, for each return period. The Rainfall Profile provides rainfall intensity (in mm/hr) for each minute of the 360 minute storm. However, TUFLOW operates more effectively when provided with a volume of rainfall per time step (in this case, 10 minute intervals were used). Therefore, the rainfall intensity values obtained from the Rainfall Profile were converted to a volume of rainfall per 10 minute time step using a simple spreadsheet. In addition, the Rainfall Profile function of WinDes® is unable to include an addition for climate change. Therefore, the spreadsheet was used to add 30% (i.e. the figure provided by PPS25 to account for climate change for rainfall over the next 100 years, commensurate with all development types, including residential) to each minute and therefore timestep in the hyetograph and rainfall profile.

Figure B.1 below provides an example of a rainfall profile generated from WinDes software and updated using the basic spreadsheet.

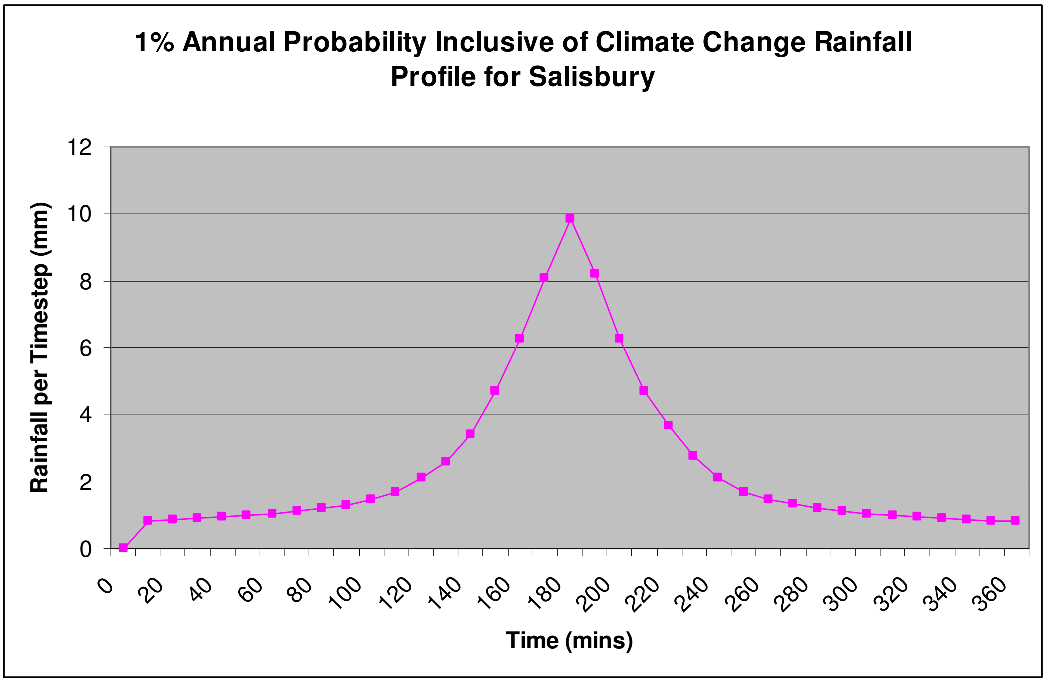

Figure B.1 Rainfall profile for Salisbury derived using WinDes software and basic spreadsheet analysis

Design Runs

The models developed as part of this study have been run for the following design (direct rainfall) events:

- 3.33% annual probability (1 in 30 year return period);
- 3.33% annual probability plus climate change;
- 1.33% annual probability (1 in 75 year);
- 1.33% annual probability plus climate change;
- 1% annual probability (1 in 100 year);
- 1% annual probability plus climate change; and
- 0.5% annual probability (1 in 200 year).

Model Outputs

TUFLOW outputs data in a format which can be easily exported into GIS. As part of the Wiltshire pluvial modelling a series of ASCII grids and MapInfo TAB files has been created (for all model runs):

ASCII Format

- Depth Grids; and
- Hazard Grids.

MapInfo TAB Format

- Velocity Vectors.

Although all of these have not been mapped as part of this study, they are in a format ready for transfer to Wiltshire Council for upload onto their in-house systems.