Hydrological modelling of river flood potential in SW England

[Excerpt only as this assignment likely to be set again for future MSc students]

INTRODUCTION

This paper will first analyse the hydrology behind the severe flooding in the River Parrett catchment in January 2014 (figure 1), before considering effects of upper reaches land use and related methods of reducing flooding.

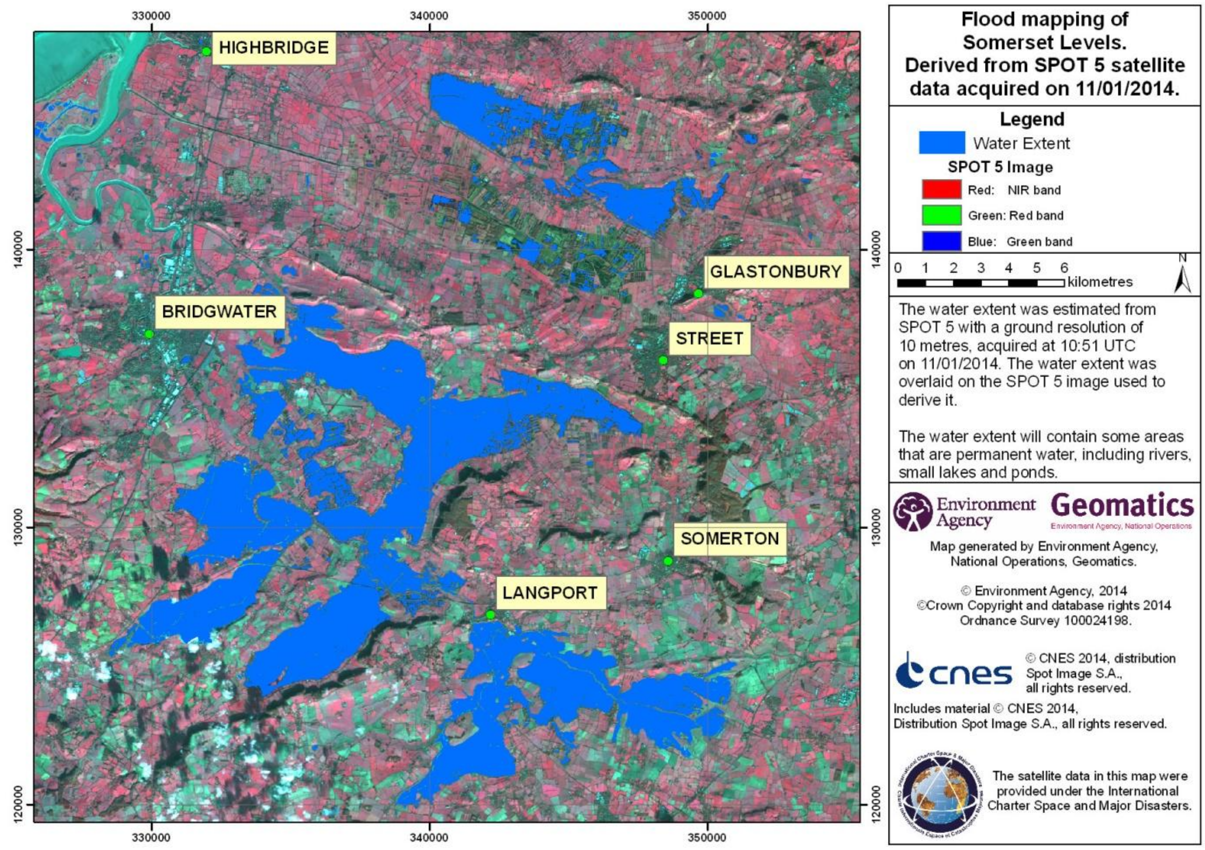

Figure 1: Location of Somerset Levels Flooding, January 2014

ANALYSIS

ArcGIS analysis using various data sources (table 1) produced location estimates for channels and watersheds. Figure 2 illustrates these, together with the actual river locations recorded in Ordnance Survey data; in the upper reaches of the watershed these are fairly consistent, but in flatter parts more errors emerge. For the adjacent River Brue catchment, the output can be seen to be quite unusable. This is partly due to the relatively low horizontal DEM resolution (50m), but more due to the lack of relief and presence of many man-made rhynes/drains.

Table 1: Data sources used

Source	Data set	Use in this paper
Met Office (2014)	Monthly regional rainfall measurements	The January total rainfall (166.4 mm) at the Yeovilton measuring station was used as an average figure to calibrate the model.
Ordnance Survey	Digital Elevation Model (DEM), vector data for river	Estimation and validation of modelling of river locations and behaviour.
NSRC	NATMAP soils dataset	Identification of soils at risk of erosion.
Centre for Ecology and Hydrology (CEH)	Land Cover Map 2007	Assessment of current use of upper reaches of the catchment basin.

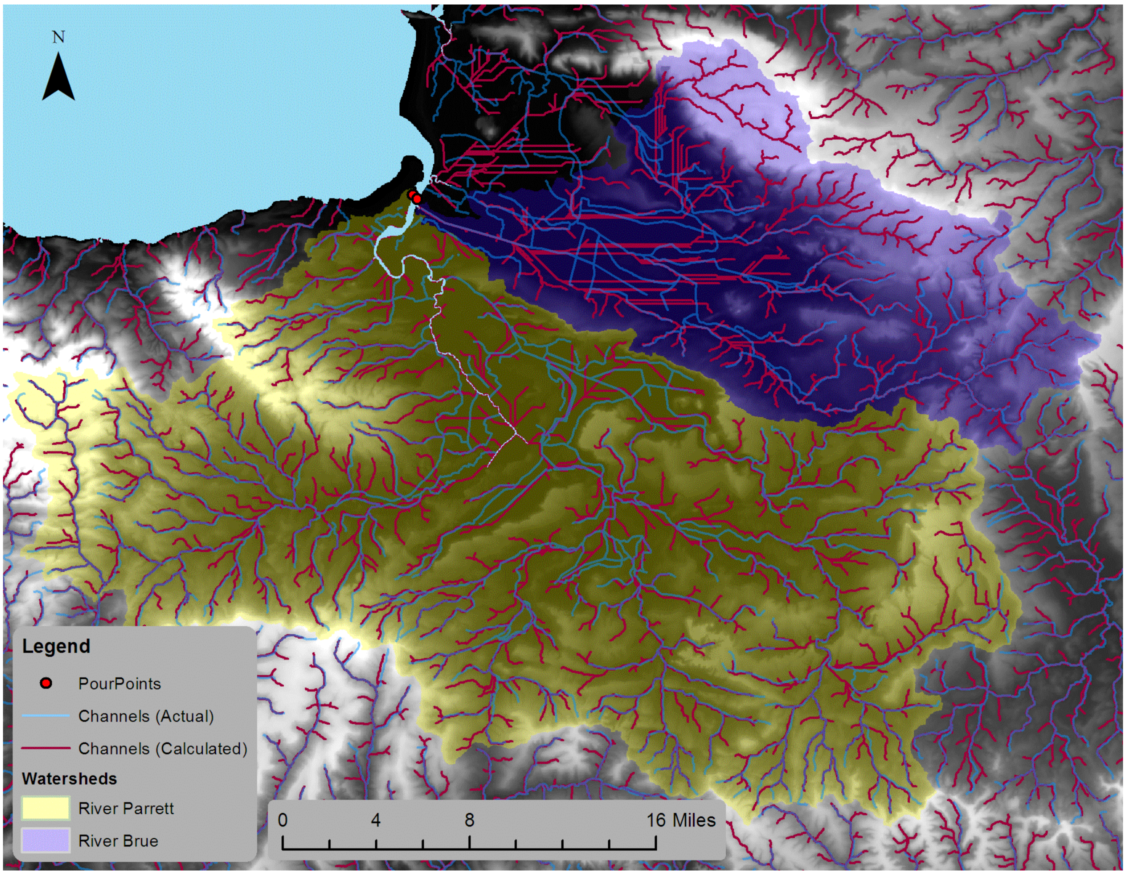

Figure 2: Somerset Levels calculated watersheds and stream networks (DEM and rivers copyright Ordnance Survey)

Calculations were then made to estimate discharge rate Q at different places across the watershed and flow time for rain falling anywhere in the basin to reach the output "pour point". Equations for this are derived in table [..CUT..], with details of ArcGIS operations required to implement them in table [..CUT..]. Results are illustrated in figures 3-5.

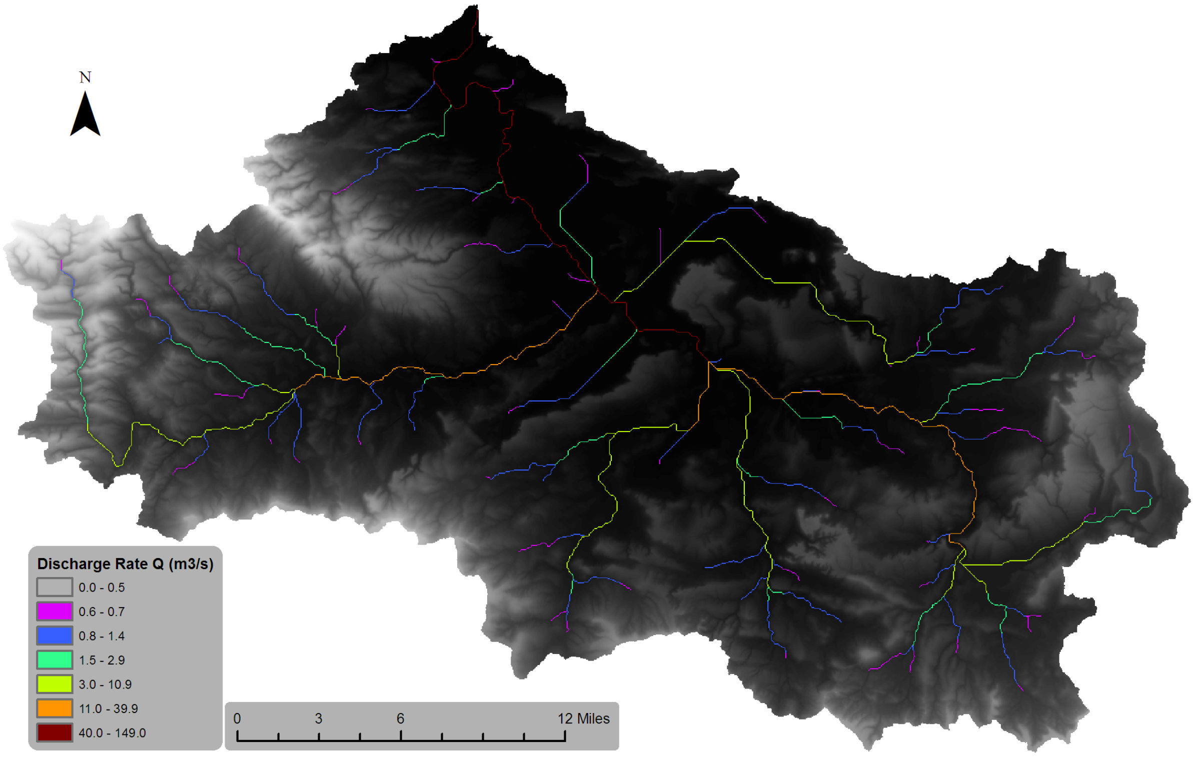

Figure 3: Estimated channel discharge rates (Q) for River Parrett watershed

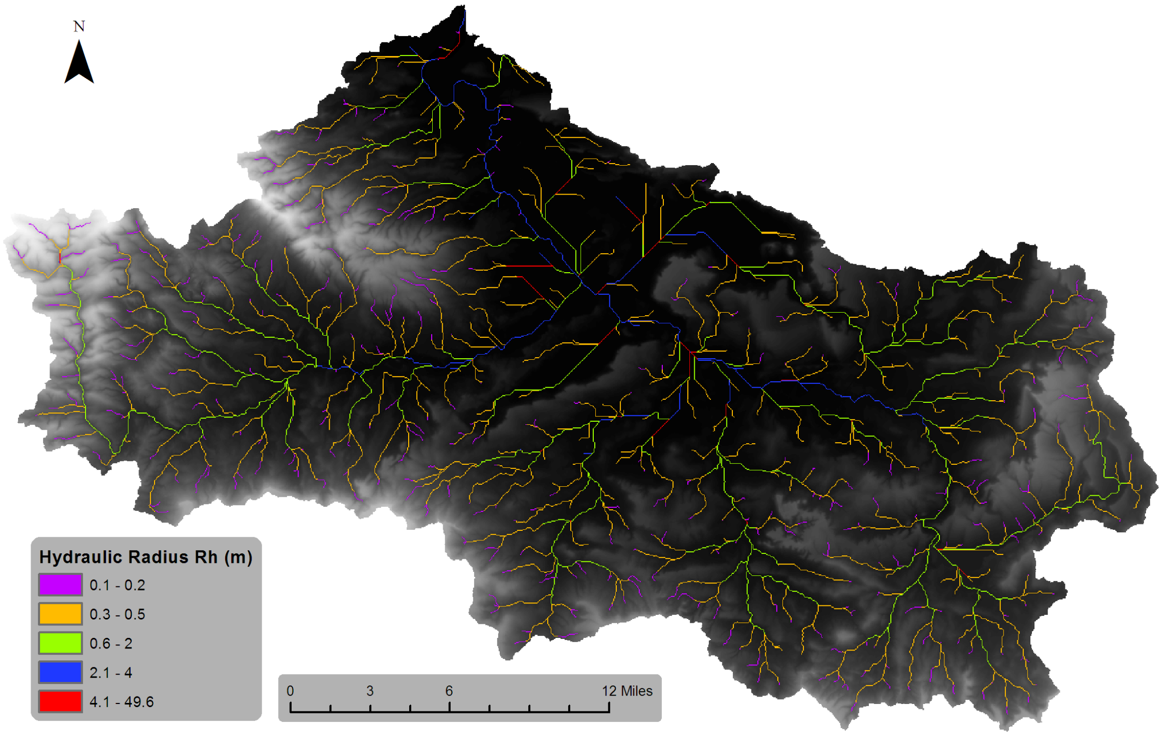

Figure 4: Estimated channel hydraulic radii (Rh) for River Parrett watershed

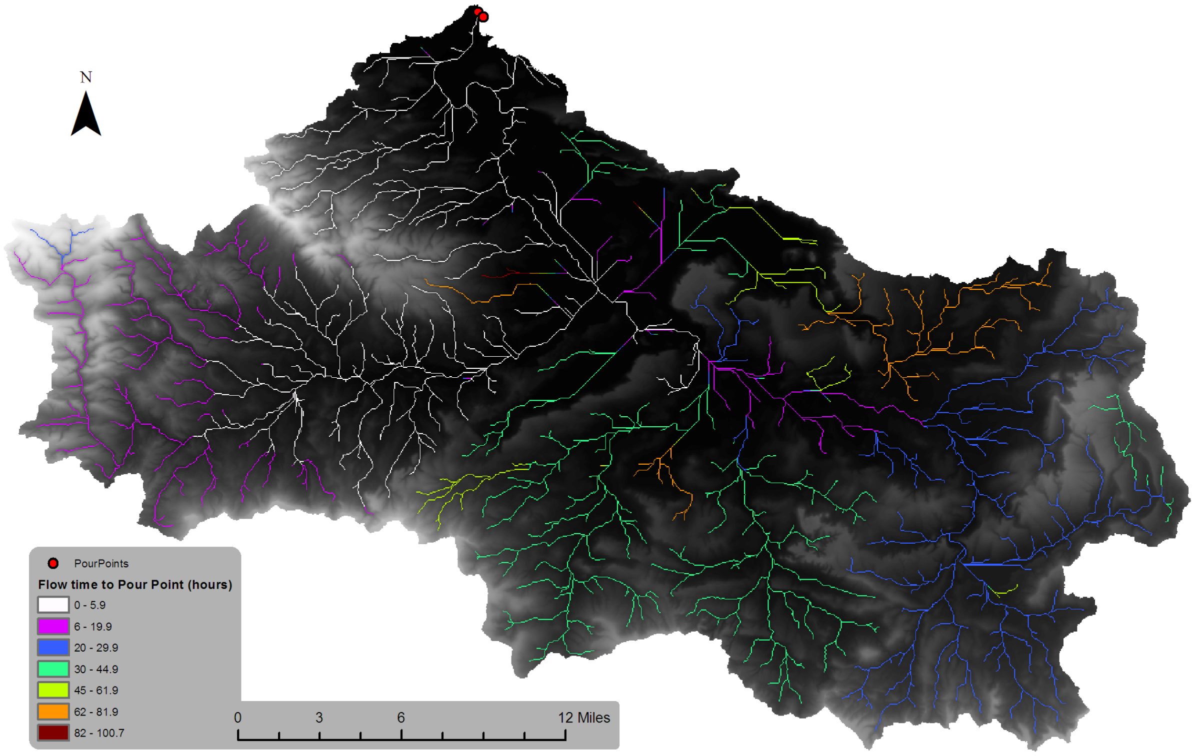

Figure 5: Estimated flow times to pour point at different places across the River Parrett watershed

Looking at discharge rates, it is clear that Q suddenly gets much larger just as the land flattens out, with lots of tributaries merging. Rh is notably at its widest (red) in several other relatively flat places further upstream – suggesting points of likely flood risk. The flow map suggests that it can take 20-40 hours to cross the watershed (about 20 miles) which seems a long time!

Note that these are channel flow times and do not include time for runoff from the land (or through ground flow) into the channels. To model this properly, ...

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INVESTIGATING EFFECTS OF UPSTREAM LAND USE

Excessive run-off from upland slopes can be a major contributor to lowland flooding but also causes serious problems due to soil erosion in upland areas ([REF]), with the Universal Soil Loss Equation (USLE) (proportional to Sediment Transport Index) a good quantitative measure for estimating likelihood of such erosion.

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Certain types of soil are particularly vulnerable to erosion. [REF] identifies a few specific types that are at great risk and for which farming practices should be considerate of. Using the detailed maps of the NATMAP soils data set, such soils in the Somerset area (also in the uplands) have been highlighted in figure 6.

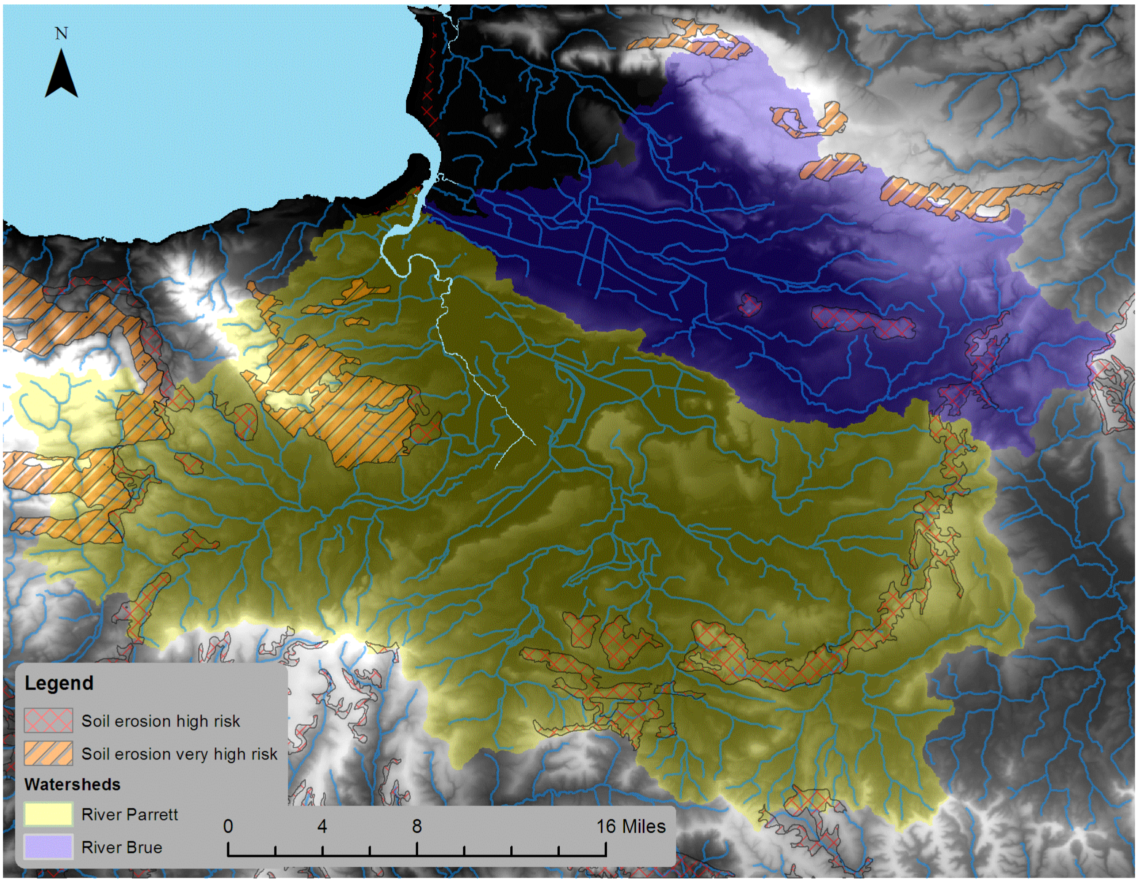

Figure 6: Somerset soils identified as at high erosion risk by [REF] using the NATMAP soils data set

Given these findings, I reworked my model to simulate switching all higher ground from arable farming to woodland.

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