

APPENDIX D

GEOMORPHIC PROCESS ASSESSMENT

1 INTRODUCTION

Field survey data on extents and rates of bank erosion, areas of sediment deposition and sediment input from tributaries were collected for the water bodies of the Dee that were surveyed as part of this project (Lower Feugh, Beltie Burn and Dee main stem from Banchory to Peterculter). This information, together with an assessment of the specific stream power (i.e. the capacity of the river to perform geomorphic work), allowed the continuous description of the 'geomorphic process regime' (the relative balance of the supply of sediment to the system and the capacity of the river to transport that supply) and prediction of likely rates of morphological adjustment (including lateral migration and avulsion of the channel) within these water bodies. The dominant geomorphic process and degree of channel dynamic behaviour allowed identification of the likely sensitivity of a given reach to engineering or other pressures through a quantitative means, thus enhancing the qualitative MImAS assessment of reach sensitivity. The approach taken is described here.

2 REACH DELINEATION

The surveyed water bodies were subdivided into reaches of approximately a kilometre in length. These formed the units on which further assessment was based. The chosen reach length was determined to be at a spatial scale that allowed appropriate interpretation and resolution of geomorphic variables, while being manageable in terms of the data analysis process.

3 SPECIFIC STREAM POWER ASSESSMENT

Specific stream power is the unit rate at which energy is applied to the bed of a river and is closely related to processes of dynamic channel behaviour (including lateral migration and avulsion of the channel) and sediment transport regime. It is defined as:

$$\omega = \frac{\rho \cdot g \cdot S \cdot Q_{bf}}{w}$$

where ρ is the density of water, g is gravitational acceleration, S is slope (typically indexed to channel bed or water surface slope), Q_{bf} is bankfull discharge (typically indexed to the 2-year return interval flow) and w is bankfull channel width. System-scale analysis of specific stream power provides a quantitative measure of the geomorphic energy regime of the system which, together with sediment input and storage, is an important element of the geomorphic process regime. The mean specific stream power in each reach was calculated from values of specific stream power averaged over 50 m lengths, supplied by SEPA. This had been derived from remotely sensed channel slope and width data and discharge values estimated from the Flood Estimation Handbook.

Spatial variation in specific stream power in the three water bodies is shown in Figure D1. Specific stream power shows the expected pattern with the highest values found in the steep upper reaches of the Beltie Burn. The lower Feugh generally has a low specific stream power, except for its lower, confined section upstream of the confluence with the Dee. The Dee main stem has a relatively low specific stream power, as would be expected for a river of its nature.

4 SEDIMENT INPUT INDEX

The volumetric rate of sediment input to a reach, and the dominant size of this sediment, is important in determining how the energy of the flow (i.e. as indexed by specific stream power) is translated into geomorphic 'work' (i.e. dynamic channel behaviour) and the channel morphology that results. Sources of sediment input include bank erosion and tributaries.

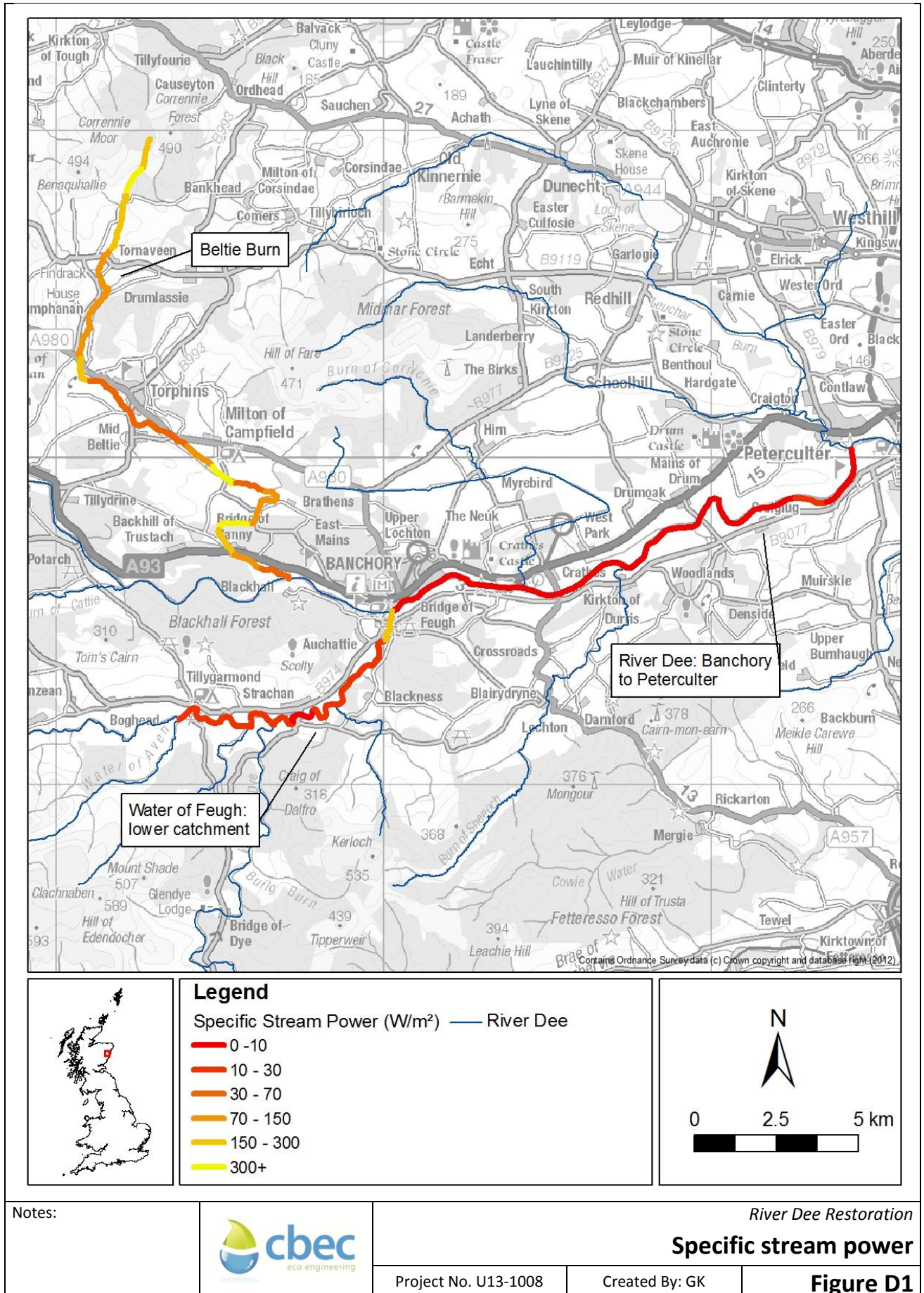
Absolute volumes of sediment input could not be determined with sufficient accuracy, given the constraints on time spent in the field. Therefore, relative levels of sediment input from bank erosion were estimated from the fluvial audit data, using a non-dimensional method of assessment. This allowed reaches to be compared with each other in terms of the level of sediment input. Incidences of bank erosion were given a weighting based on the recorded severity of the erosion and the height of the bank. The weighting was then multiplied by the length of the feature. Sediment inputs from tributaries were scored based on the size of the tributary as recorded in the fluvial audit (minor/moderate/major) and whether any evidence of sediment supply was observed in the field (e.g. confluence bar features).

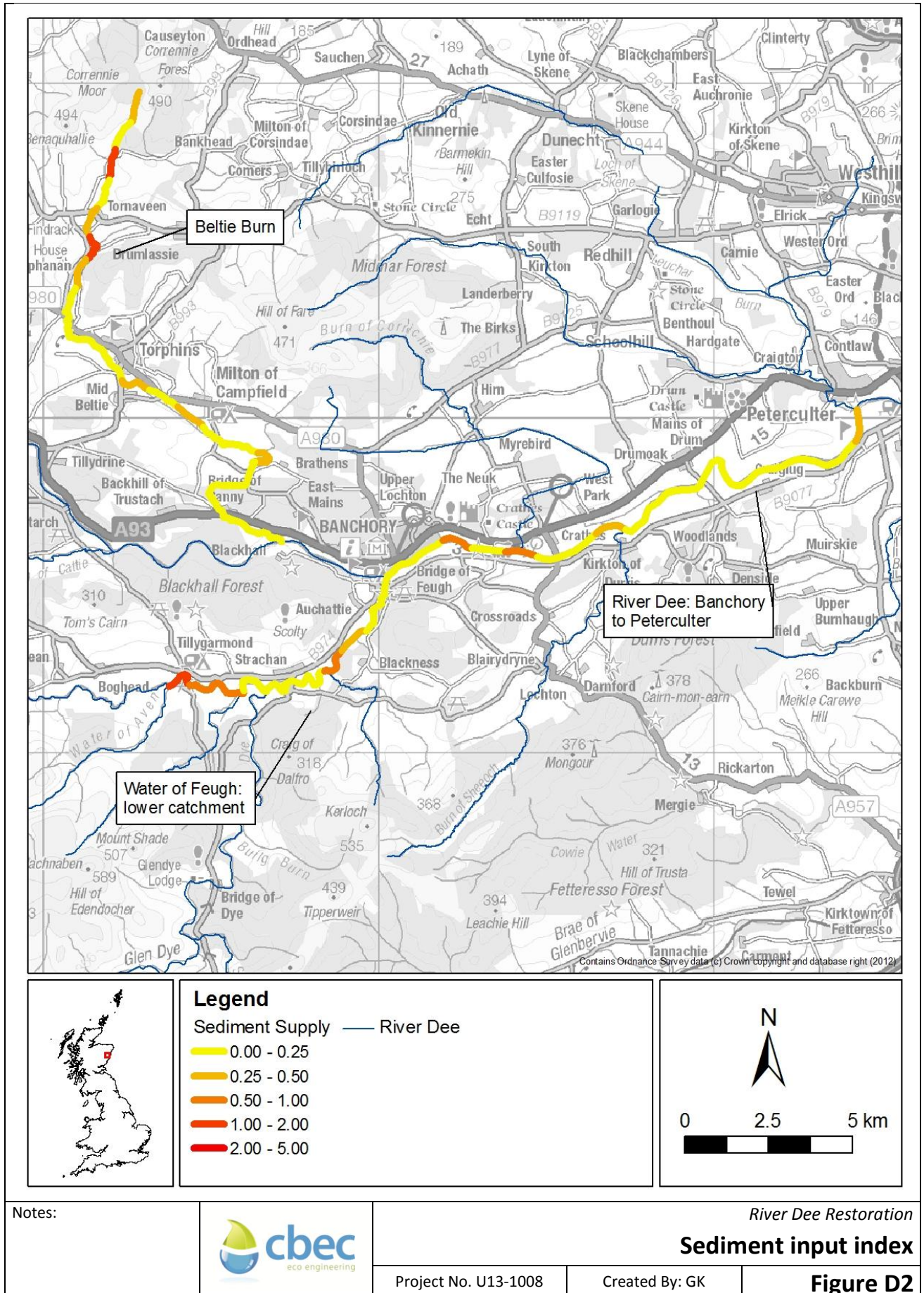
Scores for bank erosion and tributary input were standardised in relation to each other so that sediment input values were comparable. The total scores for bank erosion and tributary input were then summed for each reach to give a dimensionless index of sediment input. The spatial variation in this variable is shown in Figure D2. Sediment supply shows a high spatial variability at relatively small spatial scales, with no strong trends apparent at the water body scale.

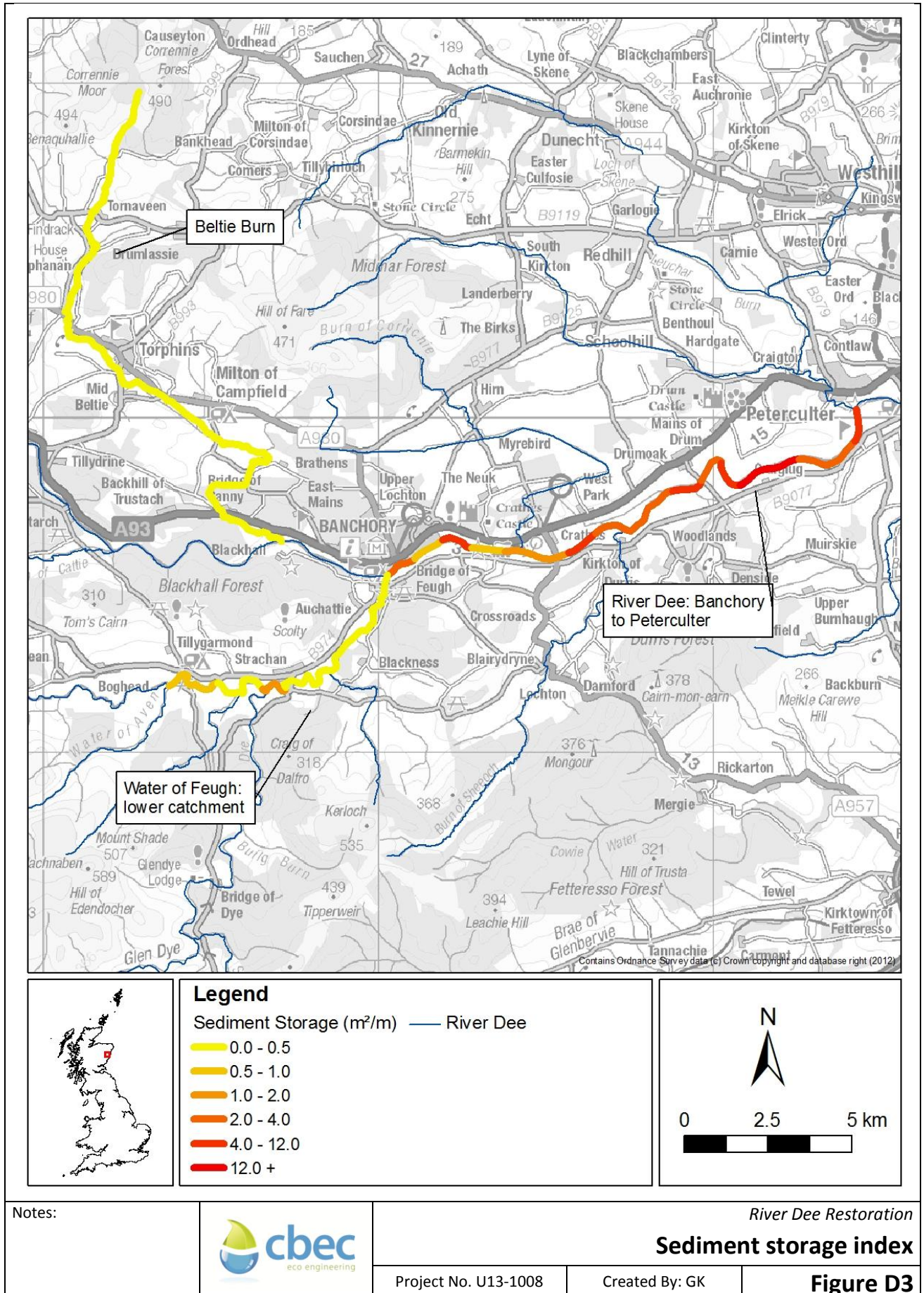
5 SEDIMENT STORAGE INDEX

In-channel storage of sediment provides a further indication of the balance between sediment supply and the transport capacity of the flow and whether the sedimentary processes in the reach are supply-limited or transport-limited.

The approximate area of each alluvial bar feature recorded during the fluvial audit was calculated from the product of its width and length. The total area of alluvial bars in each reach was then calculated and divided by reach length to give an index of sediment storage (in m^2m^{-1}). The spatial variation in this variable is shown in Figure D3. There is a strong trend to increasing levels of deposition and sediment storage with distance downstream in the catchment. Low levels of storage are found throughout the Beltie Burn, which has a generally high stream power and therefore sediment transport capacity. The highest levels of storage are found in the lower reaches of the Dee main stem, where a lower specific stream power results in increased sediment deposition.







6 GEOMORPHIC PROCESS REGIME

The relationships between sediment input, sediment storage and specific stream power define the dominant geomorphic process in a given reach, whether the reach is a zone of net sediment supply, transfer or storage, and, together with the intensity of these processes, its likely rate of morphological adjustment.

Geomorphic behaviour was simplified to three processes: sediment transport, sediment supply and sediment storage, with the intensity of each process taken to be represented by specific stream power, sediment input index and sediment storage index, respectively. The dominant geomorphic process in each reach was derived from the relative magnitudes of these three values. The values within each index were standardised (to make them comparable with each other) by dividing by the mean index value across all reaches. In each reach the index with the highest normalised value was then taken to indicate the dominant process. The product of standardised specific stream power, standardised sediment input index and standardised sediment storage index (i.e. $SSP*SSI*SII$) was calculated for each reach, to provide a measure of 'geomorphic process intensity'. This indicates the overall level of geomorphic activity in the reach and was used as an indication of channel dynamic behaviour. In other studies (cbec, 2012) this has been shown to be significantly related to independent data on measured historical rates of lateral channel migration, perhaps the most obvious symptom of dynamic geomorphic activity.

Ideally this analysis would be performed at the catchment scale, rather than the water body scale, in order to allow a catchment-scale analysis of geomorphic process. However, the lack of data for the other water bodies on the Dee precluded this. It should be stressed that the approach to characterisation assesses the rates of sediment supply, storage and transport in relative terms across the catchment. In this study the rates of each of the variables is expressed relative to the values within the three water bodies assessed, rather than the whole catchment. The results cannot, therefore, be used to say anything about the processes in these water bodies relative to the rest of the Dee catchment.

The dominant geomorphic process and the geomorphic process intensity together provide a quantitative description of the nature of geomorphic behaviour within the three surveyed water bodies on the Dee. This is depicted in map form in Figure D4, which indicates zones of sediment supply, transfer and storage, together with the degree of channel dynamic behaviour or stability (i.e. geomorphic process intensity).

The most dynamic reaches in the are those with combinations of high values for all three parameters (sediment storage, supply and transport). These include the upper reaches of the Beltie Burn, where high stream power results in transport-dominated process, and bank erosion further downstream gives rise to sediment supply dominance. On the Feugh the upper surveyed reach has a high process intensity, dominated by sediment supply. On the Dee main stem there are a series of supply dominated reaches in the upper section of the water body, while the process switches to sediment storage further downstream.

