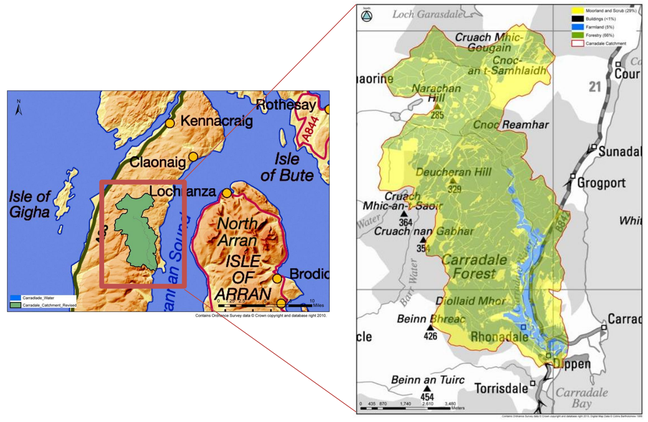
Catchment and Local Scale Restoration Challenges in a High Energy Scottish Catchment

Brief

The Carradale Water drains a 59km^2 catchment which initially flows through steep confined valleys cut into resistant Schist geology before exiting onto a wide floodplain composed of fluvio-glacial alluvium and discharging into the Kilbrannan Sound.

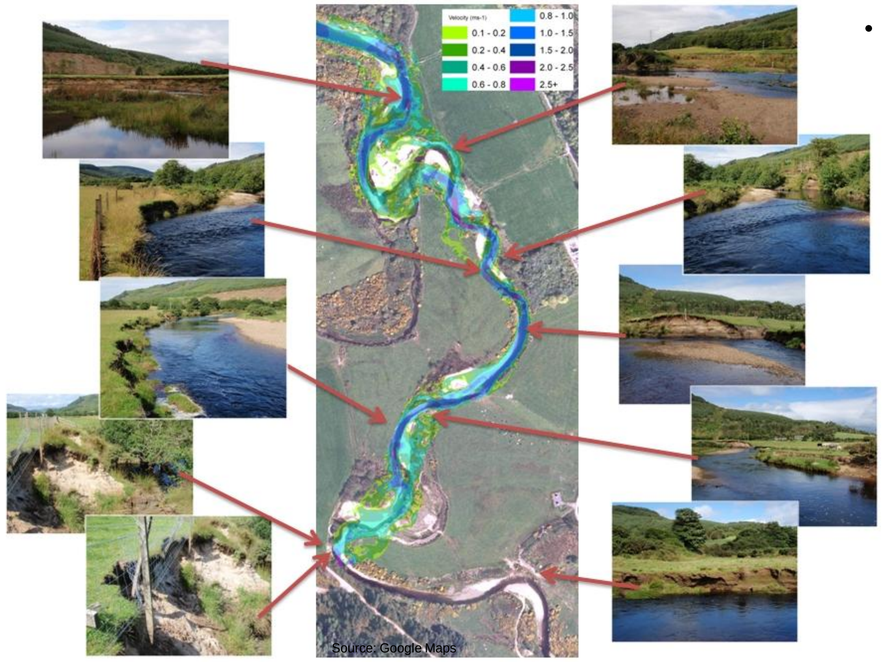
Under the **Water Framework Directive** the Carradale Water is currently classified as having a **moderate status**, where historical drainage and agricultural improvement activity, together with more recent local flow diversion and catchment intensive forestation has impacted on the flow and sediment balance within the watershed.



The river is a high energy system and is presently responding to these changes through intense local morphological adjustment. Concern exists over the currently unstable state of the watercourse with large scale sediment deposition and associated erosion and channel migration affecting valuable farm land and habitats in the lower reaches.

Methodology

The study has been developed through a catchment wide geomorphic audit and quantitative modelling of zones of high mobility using a 2D mobile bed approach which combines hydraulic and ecological predictions using the River2D flow model.



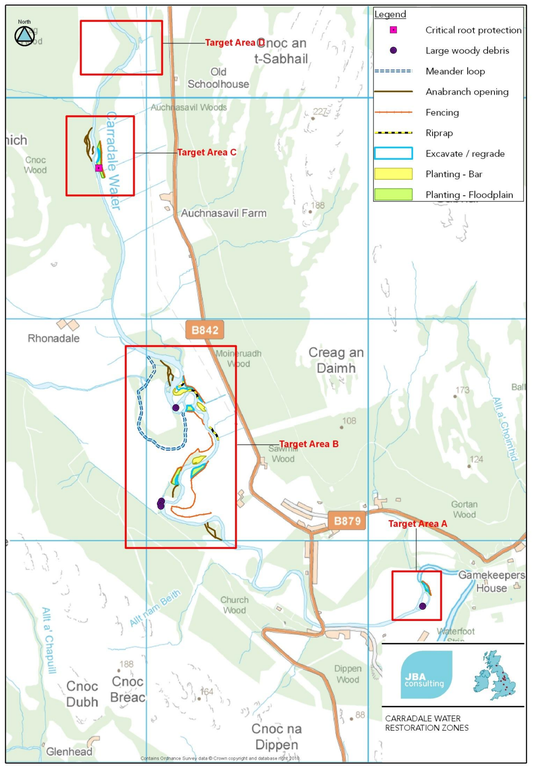
Results 20 Cumec Model Run– Velocity, Target Area B © Jeremy Benn Associates Limited 2011

Optioneering using the model simulations has facilitated the development of a long term high level catchment restoration plan linked to short and medium term local scale mitigation options to alleviate bank erosion along presently unstable reaches.

Restoration Options

Restoration options include:

- Encourage natural bar development processes,
- promote chute channel cutoff processes,
- facilitate riparian vegetative sediment stabilisation,
- allow flood flows to be redistributed along wooded secondary channels,
- reduce the magnitude and frequency of spate flows through upstream forestry management.



Restoration Plan © Jeremy Benn Associates Limited 2011

Caroline Anderton[1] & George Heritage[2]

[1]Port Neuk, 1 Longcraig Road, Edinburgh, EH30 9TD
[2]Bank Quay House, Sankey Street, Warrington, WA1 1NN

Client Project Manager – Jane Wright, Argyll District Salmon Fishery Board (on behalf of Carradale Catchment Management Planning Group)

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JBA Consulting
Port Neuk
1 Longcraig Road
SOUTH QUEENSFERRY
Edinburgh
EH30 9TD
www.jbaconsulting.co.uk
Tel: 0131 319 2940
caroline.anderton@jbaconsulting.co.uk

JBA consulting

Contrasting hydromorphological systems: Differences between engineered and near natural reaches of the River Dee at Braemar.

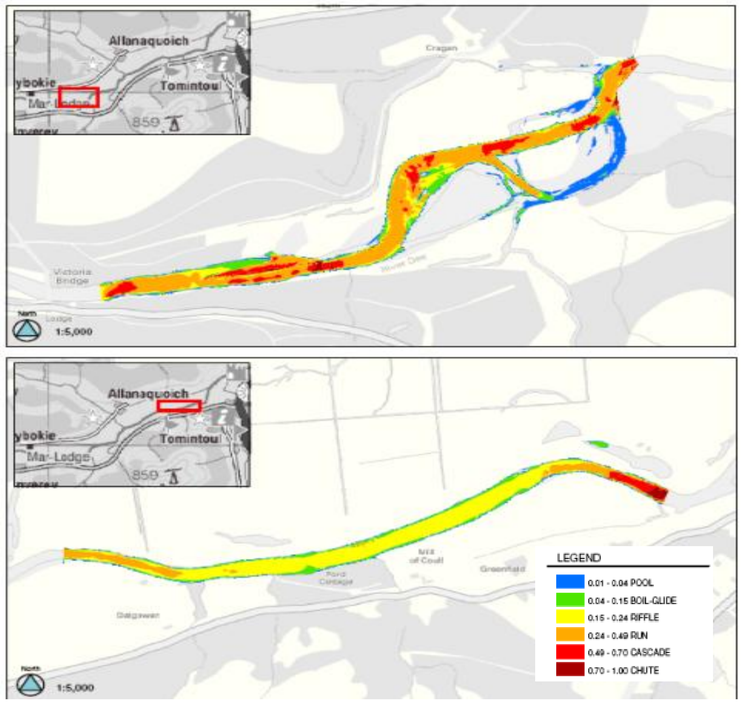
Brief

The hydromorphic variation of the majority of UK rivers has been altered as a result of flow modification, engineering works and land management. These effects are investigated on the River Dee upstream of Braemar in Scotland. Aerial LIDAR and Acoustic Doppler Velocity Profiling provided the baseline morphologic and hydraulic validation data for a River2D flow model of an unconstrained wandering section flowing across a more natural floodplain and a single thread reach subject to channel training.

River Dee reach types © Jeremy Benn Associates Limited 2011 © Aberdeenshire Council 2011.

Methodology

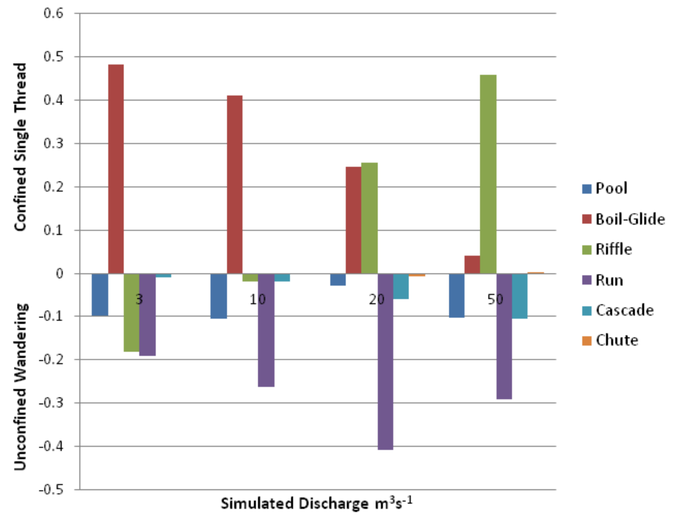
The River2D model was used to simulate a series of flows from 4 (baseline survey) up to 100 m^3s^{-1} (approximately bankfull discharge) and depth and velocity data were extracted to generate the Froude number for each wetted cell in the 2m grid cell model arrangement. These data were then categorised according to biotope unit based on published Froude number limits allowing biotope variety, variability and dominance to be calculated and compared between sites for each flow.



Hydromorphological diversity. © Jeremy Benn Associates Limited 2011 © Aberdeenshire Council 2011.

Contrasts

It is clear from the results that the engineered section is generally biotope poor with low variety and variation even at low flows. This contrasts markedly with the pattern and types of unit modelled for the more natural reach. In contrast to previous research on more uniform rivers there was also an increase in biotope variety as flows increased due to the activation of chute channels and the inundation of bar surfaces to generate new hydraulic units within the wandering channel boundary. Engineering has had a major affect on the hydromorphology of the River Dee across all flows impacting adversely on in-stream habitats and biology.



Contrasting reach hydromorphology © Jeremy Benn Associates Limited 2011 © Aberdeenshire Council 2011.

Caroline Anderton[1] & George Heritage[2]

[1]Port Neuk, Longcraig Road, South Queensferry, Edinburgh, EH30 9TD
[2]Bank Quay House, Sankey Street, Warrington, WA1 1NN

Client Project Manager – Stephen McFarland. Aberdeenshire Council (on behalf of project steering group)

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JBA Consulting
Port Neuk
1 Longcraig Road
SOUTH QUEENSFERRY
Edinburgh
EH30 9TD
www.jbaconsulting.co.uk
Tel: 0131 319 2940
caroline.anderton@jbaconsulting.co.uk

JBA consulting

USING SIMPLE 2D MODELLING AND GEOMORPHOLOGY - HABITAT ASSOCIATIONS TO ASSIST IN FLOODPLAIN RESTORATION.

Brief

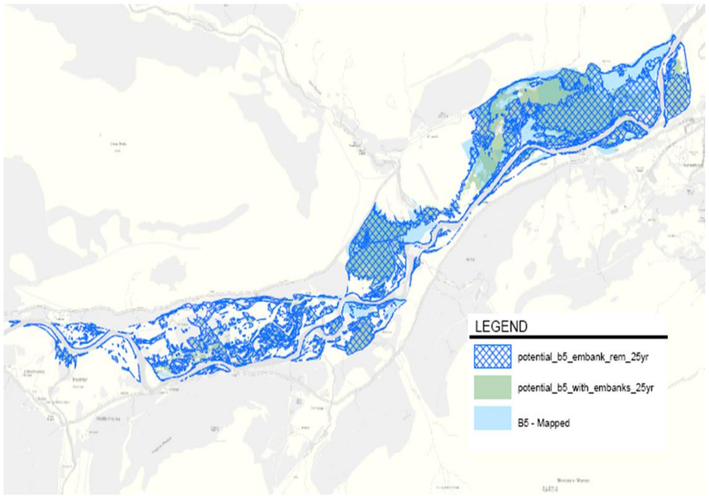
The reinstatement of channel and floodplain process alongside that of form is recognised as fundamental for sustainable river restoration. A simple methodology is proposed to identify natural floodplain features and to predict the ecological gains generated by their restoration on the River Dee upstream of Braemar, Royal Deeside.

River Dee geomorphology © Jeremy Benn Associates Limited 2011 © Aberdeenshire Council 2011.

Methodology

Identification of palaeo-features present across the floodplain was initially achieved using aerial imagery facilitating targeted field survey of their geomorphology and ecology.

A 1D-2D linked hydraulic model constructed in ISIS-TUFLOW was used to model surface water flood extent and frequency based on an aerial LIDAR DTM and flows from the Mar Lodge gauging station. This established the present flood regime and the potential regime following selective defence removal. Associations between the present flood regime, morphological features and vegetative assemblages were then established and these were transferred to the modelled scenarios to predict altered floodplain community structure.



Example prediction of habitat change on the River Dee. © Jeremy Benn Associates Limited 2011 © Aberdeenshire Council 2011.

Results

It is clear from the results for the River Dee simulations that floodplain geomorphological diversity is high but process diversity is low due to poor hydrological connectivity. Process diversity is seen to increase dramatically once flood connectivity is re-established. Palaeo-features presently subject to a flood-poor, relatively uniform, over-dry hydrological regime become subjected to spatially variable flood flows dependent on proximity and connectivity to the active channel network. This diversity in form and process recreates floodplain physical habitats lost to the system providing conditions for the spread of species previously highly restricted in their distribution.

River Dee floodplain habitats© Jeremy Benn Associates Limited 2011 © Aberdeenshire Council 2011.

Caroline Anderton[1] & George Heritage[2]

[1]Port Neuk, Longcraig Road, South Queensferry, Edinburgh, EH30 9TD
[2]Bank Quay House, Sankey Street, Warrington, WA1 1NN

Client Project Manager – Stephen McFarland. Aberdeenshire Council (on behalf of project steering group)

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Edinburgh
EH30 9TD
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Tel: 0131 319 2940
caroline.anderton@jbaconsulting.co.uk

JBA consulting