Westnewton Bridge Modelling and Design
Draft Report from cbec eco-engineering UK Ltd., June 2014

Peer Review by Professor Malcolm D Newson, River Catchment Services, Corbridge NE45 5PE

Declaration of interest: I am an occasional sub-contractor for river projects led by cbec UK

Introduction

The College Burn would, in a wild landscape such as the Rocky Mountains or South Island New Zealand, be avoided as a settlement and communications site, but in the UK's crowded and historic settlement pattern it has significant property and infrastructure risks from flooding and erosion.
I have been familiar with the site for over a decade and have professionally advised individual landowners and Tweed Forum on remedial actions from a geomorphological perspective.
The conservation interest and legal protections reduce the options for conventional engineering solutions and NCC Highways have shown due consideration for this dilemma in the new approach to protecting the road bridge. In turn, perhaps thanks to a tight project specification, cbec have used up-to-date, industry-standard geomorphological and hydraulic assessments over an appropriate scale above and below the bridge.

Engineering and geomorphological contexts for the bridge

The flood events of 2008 and 2009 illustrated the threat of flow volume/direction variation during 'large, rare' floods on the toe of an ancient alluvial fan. Thus, the bridge abutments were 'attacked' from high stream power being 'jetted' like a fire hose through the different arches, determined by flow level, efflux upstream and channel constrictions downstream (as well as the obvious constriction of the arches themselves).
Such hydraulic and sediment transport situations can never be exactly predicted but current knowledge allows a responsible risk-based approach to predicting and designing engineering interventions. The cbec draft report delivers the optimum level of responsible analysis currently available for a problematic site. Unlike many other geomorphology consultants, the cbec team are long experienced in high energy, coarse sediment systems. They are also experienced at practical channel restoration measures.

The detail

The draft report shows the following vital components:

- Historical context (p. 7) – vital to geomorphological prediction and design. The centreline maps are very useful background;
- Fluvial Audit (p. 10) – industry standard assessment technique and essential information to carry forward to modelling, mainly in terms of sediment sources (photos pp.12-14) and sediment sizes (p. 16);
- Topo survey (p.17) essential for modelling flow depths and shear stresses at the bridge;
- Hydrology/hydraulics: ReFH prediction of flood flow discharges vital in an ungauged catchment – again vital to the modelling;
- Manning 'n' values (pp. 20/21) – is this a cusp for debate – subtle changes here could alter the model outcomes – but I'm comfortable with the initial selection of values – where did they come from?
- Model outputs: Figures 2.14 to 2.17 are extremely useful and help create the NCC evidence base for intervention (given the ecological sensitivity);
- Design: the four target objectives on p. 29 are accurate. I've never seen an angle of approach analysis before – this is highly desirable but I'm sure laced with risks;

- Shear stress/particle size analysis (pp. 37 – 42) – some would argue (in the academic world) with a shear stress approach but it is defendable at this site;
- Appendix C – Log load calculators – vital in terms of the new government definitions of river channel management – 'dredging' is not any longer the answer and at West Newton has never brought a solution.

Conclusions

As is evident from my detailed comments above, I consider the cbec draft to represent the best predictive and designs going forward.
You may require some information on the precautions an engineer would build in given the uncertainty of modelling but the biggest remaining uncertainty consists of 'conditions on the day of the flood', for example delivery of material from landslides upstream and of fallen trees – under those conditions 'all bets are off' but the failure of any current engineering intervention can be countered by the good evidence base presented by cbec and the randomness of alluvial fan geomorphology!

I can recommend the cbec report from an objective position in professional geomorphology.

M.Newson 17.06.14

Appendix, requested by Don Brown (NCC) 29.07.14

Concerning NCC's understandable concerns about controlling the related issues of voluminous sediment accrual to the bridge reach and the changes of flow direction and hydraulics which would ensue at the bridge, I have now walked the site in its current (ever changing!) state, acco0mpanied by Peter Brewis who explained the concepts behind a broader intervention at this site.

Two items from the peer review are vital for risk management by NCC: cbec have assiduously followed industry standard techniques to predict the value and impacts of their proposals *at the bridge*. Secondly, there are no 'for-ever wins' at this site and thus NCC need to wrap the cbec study in a slightly *broader sediment management context*. The ideal would be to enagage in a catchment management programme addressing excessive erosion sources of sediment and riparian tree condition, both of which set the context for the engineering response at West Newton bridge. However, this is not possible and the only available agenda is to manage flow re-routing (in flood) and the resulting sediment transfer from an area upstream of the bridge to the formerly-dredged bridge environment. Cbec recommendations seek to manage the hydraulics of conveyance through the bridge but my observations approach from the angle of protecting against damaging channel change upstream (changing the hydraulic conditions modelled by cbec) and the delivery of a huge volume of sediments 'poised' there for transport on a 'large rare' flood (climate is changing and so cbec have gone up to the 200-year flood).

The College Burn at West Newton Bridge is a modern river on an ancient alluvial fan. Throughout the world (Las Vegas, Eilat etc.) life on alluvial fans is very risky: the UK is fortunate that its fans are now vegetated but that in itself can pose a problem (see below). The diversion of flood waters which occurred in 1948 – east towards Post Office Lane in Kirknewton – remains a flow option in extreme floods and was included in the cbec modelling (both operating and closed off). Hence it seems logical that use is made of 'temporary' spoil from clearing the bridge conveyance is used to raise the bank protection by 300mm. – so long as new flood spill vulnerability is not created and flow patterns not influenced in relation to remarks below.

An unintended consequence of sediment management in the bridge/downstream reach has been that subsequent flood-delivered gravel/cobble material has accrued in the upper part of the bridge reach and is 'waiting' to arrive and to frustrate engineering solutions to protect the bridge stability. Paradoxically, the growth of both herb/shrub vegetation on these deposits is not an answer guaranteeing sediment stability in extreme events (despite the fact that 'green engineering' is desirable in this habitat-sensitive site). Damaged, falling and deposited 'Large Woody Debris' (LWD) has local habitat benefits but these need to be considered against a flood-delivered chaos of Alder trees at the bridge. The other upstream danger is that, at two prominent sites, channel migration will occur if 'head cuts' (channel change occurs downstream – upstream, not the reverse) are not fixed in their current positions.

There are, therefore, two current engineering options available to NCC/EA upstream of the bridge reach (remembering that a catchment-scale solution is not available):

- Securing the recent depositional bar on the east side of the upstream channel in the area formerly protected by Tweed Forum log posts. Current vegetation colonization is a promising start but risks disruption in high flood until succession proceeds further. The biggest danger here is that flows diverted to the east bank will, via head cutting in flood, swing the flow approach to the bridge, undermining some of the assumptions of the cbec hydraulic model.
- Securing flows, possibly increased by the proposed flood bank upstream (see above) around another east bank route with a 2m vertical head cut exposing the true nature of the 'lurking sediment rush' to the bridge.

In both cases, 'green engineering' would suggest a mixture of wooden stake/ willow stake and creative use of dredging spoil to raise the level of deposits such that a diversionary flow does not establish during a rare flood and become established afterwards.

The most important message for stakeholders comes in two parts:
There are no guarantees of engineering stability to protect communities or land in a river like the College Burn;
An engineering solution will require flood-related maintenance, notably of trees (Alder prominent) to retain a balance between the habitat advantages of a 'wild' river and the established community infrastructure of a very risky site.

MN 05.09.14