Sediment source contributions and downstream mixing in a rural catchment, Coolbaggie Creek, New South Wales

Adam Wethered

2012

A thesis submitted as partial fulfilment of the requirements for the degree of Bachelor of Environment (Hons) in the Department of Environment and Geography, Macquarie University, NSW 2109 Australia.

Abstract

Widespread land clearance and disturbance in Australian river catchments have led to an increase in sediment availability, mobilisation and delivery to tributary and trunk stream channels. Sediment supplied by major tributaries to the lower Macquarie River, in central New South Wales, is a critical factor for geomorphology and ecosystem health in the river and its floodplain wetlands. However, historical suspended sediment gauging data is rare and the little that is available shows consistently high turbidity levels in Coolbaggie Creek, the last major tributary in the catchment. This research investigated contemporary sediment sources and downstream sediment mixing in Coolbaggie Creek in order to understand the importance of catchment source types and connectivity on sediment dynamics. Fallout radionuclides (^{137}Cs and ^{210}Pb$_{ex}$) and geochemical properties (e.g. manganese and sulphur) were used to characterise and trace key sediment source types in the system. Representative samples were taken of surface soils from various land use units across the catchment (e.g. forested and cleared surface sites), as well as sediment from sub-surface sources (e.g. channel banks and gullies). Fine-grained deposited sediment from reaches of Coolbaggie Creek was also sampled to enable proportional contributions of the source types to be determined with a mathematical mixing model.

Radionuclides were able to clearly discriminate between forested surface (^{137}Cs 11.28 $\pm$ 0.75 Bq/kg; ^{210}Pb$_{ex}$ 181.87 $\pm$ 20.00 Bq/kg), cleared surface (^{137}Cs 3.21 $\pm$ 0.26 Bq/kg; ^{210}Pb$_{ex}$ 29.59 $\pm$ 10.94 Bq/kg) and sub-surface (^{137}Cs 1.45 $\pm$ 0.47 Bq/kg; ^{210}Pb$_{ex}$ 4.67 $\pm$ 1.93 Bq/kg) sediment sources. Downstream hydrogeomorphic trends, radionuclide concentrations and mixing model results indicate that a rapid shift in dominant sediment source type occurs in the upper reaches of Coolbaggie Creek. Cleared surface areas account for 95% of fine sediment entering the channel in the uppermost reach, however, for the remaining ~50 km of the river, sub-surface (i.e. gully and bank) sediment accounts for 90 to 100% of sediment entering and being transported in the system. This shift in dominant source material coincided with a significant increase in channel cross-sectional area (from ~20 to >200 m^2), highlighting the role of channel expansion and gullies in contributing sub-surface sediment to the system, and a lack of surface sediment supply to the channel. This also indicates a lack of lateral connectivity between topsoil and the trunk stream channel in all but the uppermost parts of the catchment. The significant enlargement and entrenchment of the channel downstream has also resulted in lateral disconnection between the channel and floodplain, while coarse sediment transfer is impeded by a sediment slug in the lower reaches. Altogether, these findings are important because the highlight the dominant source of suspended sediment entering the lower reaches of the Macquarie River from Coolbaggie Creek and have implications for water and land management. Gully and bank erosion control will help reduce the excess sediment supply and land degradation within the Coolbaggie Creek catchment.

Acknowledgements

This project was funded by a Science and Industry Endowment Fund (SIEF) Honours Scholarship to T. Ralph, H. Smith and A. Wethered, and by an Australian Institute of Nuclear Science and Engineering (AINSE) grant (ALNGRA12090) to T. Ralph and H. Smith. H. Heijnis, A. Zawadzki and D. Fierro of the Australian Nuclear Science and Technology Organisation (ANSTO) are acknowledged for assistance with gamma spectrometry.