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Downstream channel changes on a contracting, anabranching river: The Lachlan, southeastern Australia

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ABSTRACT

Downstream trends in flow, channel morphology, and sediments were investigated over 220 km of the middle and upper alluvial Lachlan River in southeastern Australia. The Lachlan is a perennial river that rises from temperate, humid highlands and flows inland into a semiarid low-gradient plain lacking perennial tributaries. Long daily stage records were used to calculate flow parameters and flood frequencies in single and anabranching channel reaches of the river. Morphological trends were based on cross section and height data compiled from new and water authority data, and from particle size trends constructed from bed and bank sediment samples. Mean and peak flows, channel size, and bed particle size all diminish in a downstream direction. In the partially confined piedmont zone, channel and floodplain morphology feature large flood effects and large channel dimensions that reflect extreme flow variability. On the alluvial plains, the unconfined, single-channel contracts with distance downvalley; and anabranches develop at high flow stages. The development of a full anabranching pattern is associated with large flood volume losses. Diminishing flood volumes, mean flows, and channel dimensions is attributed to storage of flood waters in lakes, floodways, and lagoons and through transmission losses during overbank flows. The frequency of bankfull discharge consistently decreases downstream, and may reflect the long duration and lower frequency of floods in the lower reaches of the river. Particle size of bed sediment fines downstream at rates consistent with those reported from sand-bed rivers elsewhere. This is attributed to a combination of hydraulic sorting and low rates of sediment supply from the catchment.

1. Introduction

The geomorphology of alluvial river channels and their floodplains are the product of diverse climatic and sedimentological characteristics, including runoff, sediment size and supply, topography and tectonic setting, and floodplain vegetation. Despite this, rivers in diverse physiographic settings display regular downstream trends in channel size and shape that may be used to develop empirical relationships between flow and channel dimensions (e.g., Wharton, 1995). Most studies of downstream trends have shown that rivers increase in bankfull cross-sectional area, width and depth at a rate proportional to the increase in their discharge, with sediment characteristics affecting channel shape to a lesser extent (Schumm, 1960; Knighton, 1974). The tendency for channels to increase in size downstream is not restricted to perennial streams: many ephemeral rivers or those that flow into arid areas display similar trends, although rates of change differ (Leopold and Miller, 1956; Wolman and Gerson, 1978). Channel dimensions have been observed to decrease downstream on some rivers, a phenomenon usually associated with large arid-zone rivers with low-gradient floodplains (see review in Tooth, 2000a). Downstream trends on anabranching rivers – defined by Makaske (2001) as rivers with two or more channels that enclose flood basins – have received less attention, possibly because of the difficulty of representing morphological or hydraulic parameters on multiple channel networks. Anabranching rivers have now been studied from different parts of the world and are relatively common in Australia on the stable, low-gradient plains of the Murray–Darling and Lake Eyre basins (Schumm, 1968; Riley, 1977; Nanson et al., 1986; Page, 1988; Rutherfurd, 1994; Nanson and Knighton, 1996; Schumm et al., 1996; Page et al., 2005). Sand-bed rivers are also poorly represented in the international literature, possibly because of difficulties of access to large, sandy, lowland channels. The inland Australian rivers have been regarded as a special case because of their low sediment loads and highly variable streamflow, which affects floodplain morphology and channel dimensions in diverse ways (Nanson, 1986; Finlayson and McMahon, 1988). In southeastern Australia, the inland rivers are characterized by a downstream decrease in channel dimensions that presents an unusual setting for examination of trends in flow magnitude and

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frequency, channel morphology, and downstream fining of bed and bank sediments. This study examines the sedimentological, morphological and hydrological changes downstream along 220 km of the Lachlan River, a perennial, mixed and suspended-load river with complex anabranching networks in its middle and lower reaches.

2. The Murray–Darling basin

The Lachlan River catchment spans 85,000 km^2 of central western New South Wales and forms part of the largely endorheic Murray–Darling basin (Fig. 1). Its eastern boundary lies along the Great Divide that extends along the eastern side of Australia. Low hills and plains define its northwestern and southern boundaries. Total basin relief from the highest peak at Mt Canobolas to its confluence with the Murrumbidgee River is 1318 m; however, the trunk stream has a total fall of only 680 m (Fig. 2). The upper catchment consists of folded and faulted Palaeozoic granites of the Lachlan Fold Belt that form gently undulating tablelands with ranges up to 1200 m asl. Uplift of the SE Australian highlands in the late Palaeozoic was enhanced in the late Cretaceous following rifting along the eastern continental margin (Bishop and Goldrick, 2000). Since mid-Miocene times the highlands have been tectonically stable with low rates of stream incision and denudation (Young, 1983; Taylor et al., 1985; Young and McDougall, 1985; Lambeck and Stephenson, 1986). The upper Lachlan exhibits a number of features diagnostic of flexure or faulting between the rising highlands and the subsiding Murray basin to the west, including a prominent "mountain front" and stream incision of <80 m that has produced terraces that converge downstream into low-gradient alluvial plains (Bishop and Brown, 1992; Bishop and Goldrick, 1992). In the lower Lachlan, up to 400 m of Tertiary fluviodeltaic and fluviolacustrine sediments are covered by Quaternary dunefields (last mobilised 12,000–20,000 years ago) and smaller, fluvial source-bordering dunes that are locally sourced (Bowler and Wasson, 1984; Wasson, 1984; Brown and Stephenson, 1986). Alluvial plains make up 78% of the basin, but most of the water and sediment to the river is supplied by its small highland catchment. Four major tributaries rise from this area, namely the Abercrombie, Belubula and Boorowa Rivers and Mandagery Creek. After leaving the highlands, the Lachlan has no perennial tributaries. The channel contracts with distance downstream and channel gradient decreases from 0.0006 at the highland slopes to 0.00003 on the lower plains. Downstream from Hillston, the Lachlan dissipates its remaining water in distributaries that terminate in ephemeral wetlands or lakes, failing in most years to reach its confluence with the Murrumbidgee (O'Brien and Burne, 1994). Repeated avulsion of the lower Lachlan has produced a network of distributaries that may have been active channels in the Pleistocene when higher discharges produced overflowing lakes and laterally active rivers in the western part of the basin (Adamson et al., 1987; Magee, 1991). In the Holocene, these channel belts became stable and most of the drainage and sedimentation is internal, although the

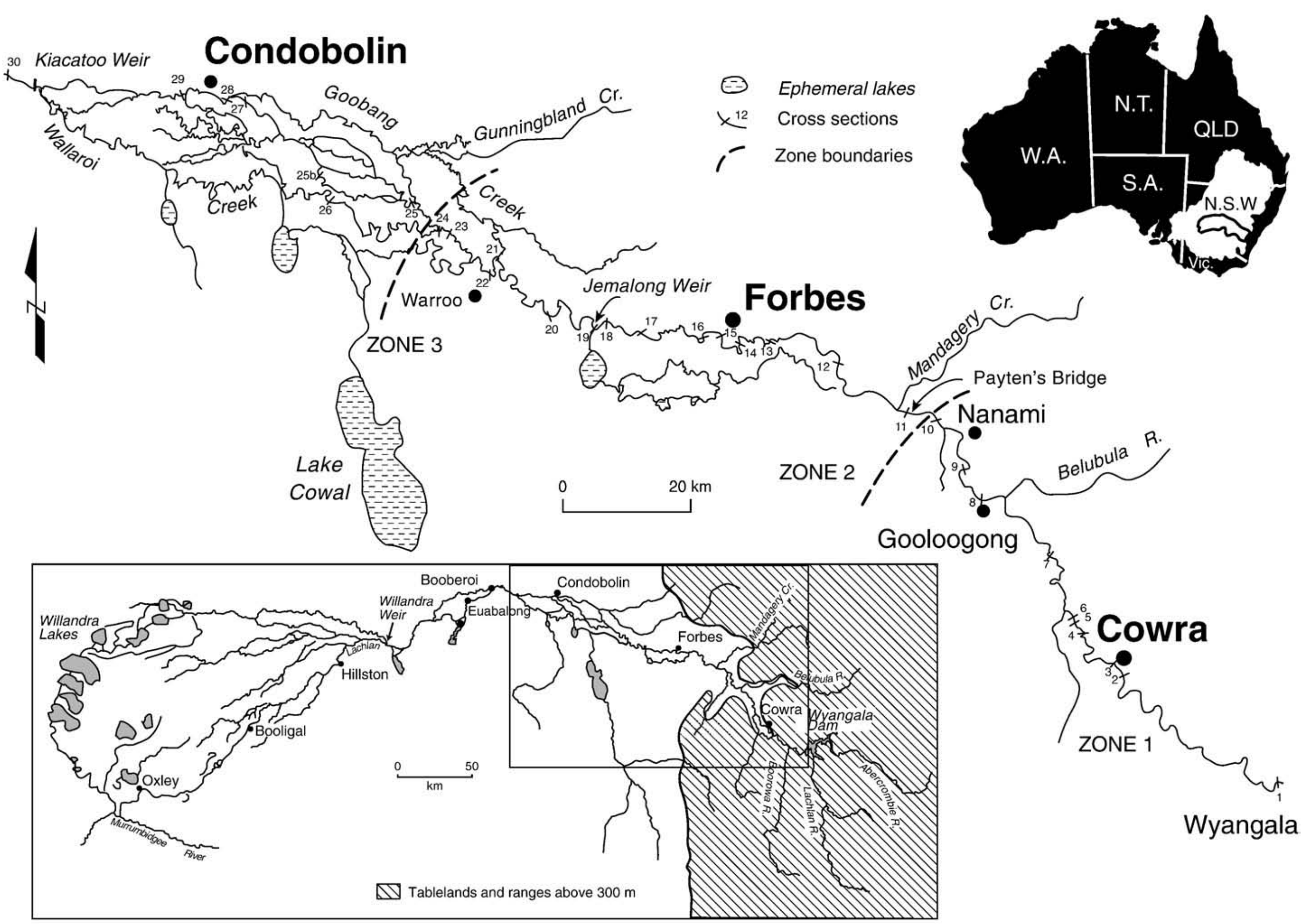

Fig. 1. The Lachlan River catchment and its position within the Murray–Darling basin (inset) showing locations of cross sections and major gauging stations.