CHANNEL CHANGES OF THE MIDDLE ZAMBEZI

C. Nugent

University of Zimbabwe

ENVIRONMENTAL CHANGES, SUCH AS geological faulting, crustal warping and climatic change, affect the behaviour of a river system over long periods of time. Artificial changes have been induced in the Zambezi by the Kariba and Kafue impoundments. These dams are changing the river downstream.

Along much of its course between Kariba and Mupata gorges, the Zambesi flows over discontinuous tracts of its own alluvium. The alluvium includes sand, characteristically deposited in the active channel as well as silt and clay which have been washed away from the active channel during flooding and have gradually filled the abandoned channels or pools.

The alluvium between Chirundu and the Chewore river confluence has been mapped (Stocklmayer 1979) as a series of terraces. On the Zimbabwean side, alluvium extends up to 7 km. from the present channel and as much as 20 metres above present water level. The lowest and most recent of the terraces consists of the constantly moving sand in the active channel. Sand bodies may become stabilised either along the banks or as islands. They are colonised by reeds such as *Phragmites* along the waterline and grasses such as *Vetiveria.* The first trees to gain a foothold on this new land are *Acacia albida.* This woodland forms the second terrace. The first 4 km of the main exit road from Mana Camp pass through *Acacia albida,* usually mixed with other tree species. Beyone the *A. albida* woodland, the road crosses the end of a pool, then rises up a distinct terrace step into woodland in which *A. albida* is much less common. It then passes through mopane woodland before entering Jesse bush growing beyond the alluvium. The pools (old channels which have been cut off and abandoned by the river) are clustered on the younger alluvium and record the lateral movement of the river northwards into Zambia.

Movement of the river channel and the creation of new land along the banks and as islands is a continuous and natural process which is affected by the river discharge and flow regime and by the input of sediment. The volume of sediment available in the Mana area has certainly been reduced. Rivers entering the Kariba and Kafue impoundments drop most of their sediment in the lakes. Water released through turbines and floodgates is much cleaner than that which formerly passed along the rivers. The only source of fresh sediment is through the few tributaries which enter the Zambezi below Kariba. As a result, the river now removes more sediment than it brings in.

Riverbank erosion in a 40 km alluvial stretch upstream of the Sapi confluence was studied by Guy (1981) from air photographs. Between 1954 and 1973, 1 030 hectares were lost in erosion while 210 hectares of semi-permanent sandbank were deposited. In 19 years the river channel had become dramatically wider. Guy suggested several reasons for this occurrence.

1) The maintenance of a fairly constant water level for long periods, through the regular release of water via the Kariba turbines causes notching and collapse of the bank.

2) A sudden drop in river level, resulting from the closure of floodgates, causes groundwater to flow rapidly into the channel. In 1966, when six floodgates were closed, "large blocks of bank fell into the river".

3) Out-of-season flooding, caused by heavy spillage from Kariba during times when water level should normally be low. Vegetation which has adapted to a natural flooding regime may be unable to stabilise the banks during an out-of-season flood.

Alluvial river channels can adjust to a reduction of their sediment supply by reducing their gradient. The river cuts into and, therefore, lowers its bed. A less steep gradient results in slower water velocities, so the river erodes and removes less and less sediment, until deposition and erosion stabilise at a new equilibrium slope.

THE ALLUVIAL RECORD

Changes in the height of the bed of the Zambezi have occurred in the past and are recorded in the alluvium. In places the river cuts through old alluvium whose character indicates it was deposited on a former flood plain during flooding. These ancient flood deposits, fine grained and presently supporting a mopane woodland, record a long period of sediment accretion which raised the channel from below its present level to around the height of the highest remnants of old alluvium. The river has since then been through an erosional phase, cutting back down to its present level.

These river changes, which have occurred over the last hundred thousand years, may have resulted from natural fluctuation in the supply of sediment precipitated by tectonic movements which are believed to have rejuvenated the Zambezi about three million years ago (King 1967). The recent erosive phase of the river could alternatively have resulted from crustal tilting and the development of sediment-trapping swamps around Chobe and the Barotse plain.

ALLUVIUM CHANGES SINCE KARIBA

Changes in the width of the river channel have been calculated from air photographs, which were taken in 1954 (pre Kariba), 1973 and 1981. The 40 km stretch between Kariba gorge and Chirundu bridge (Fig. 1) behaved in a complex fashion (Fig. 2) suggesting that its

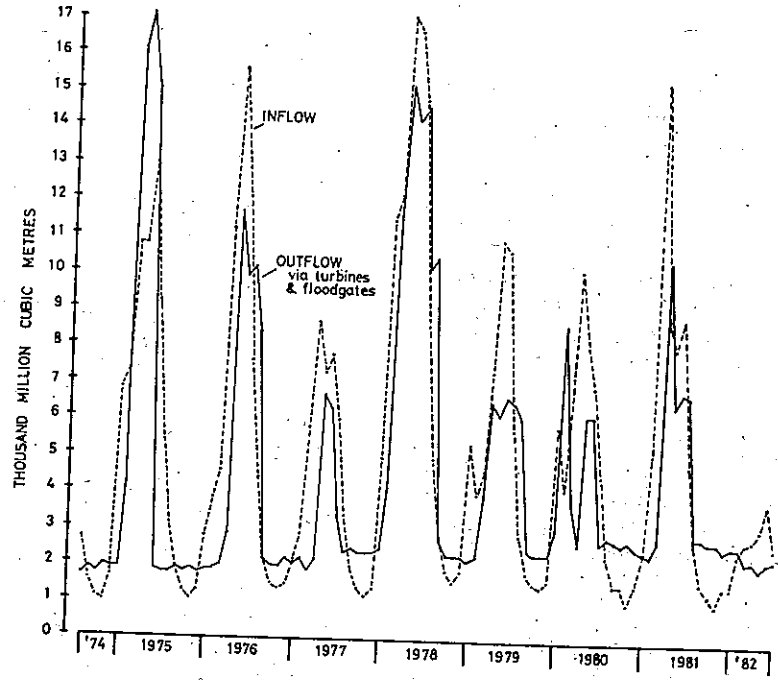

Fig. 6 Kariba's monthly inflows and discharges during period July 1974 to June 1982. (Original data from Central African Power Corporation Annual Reports).

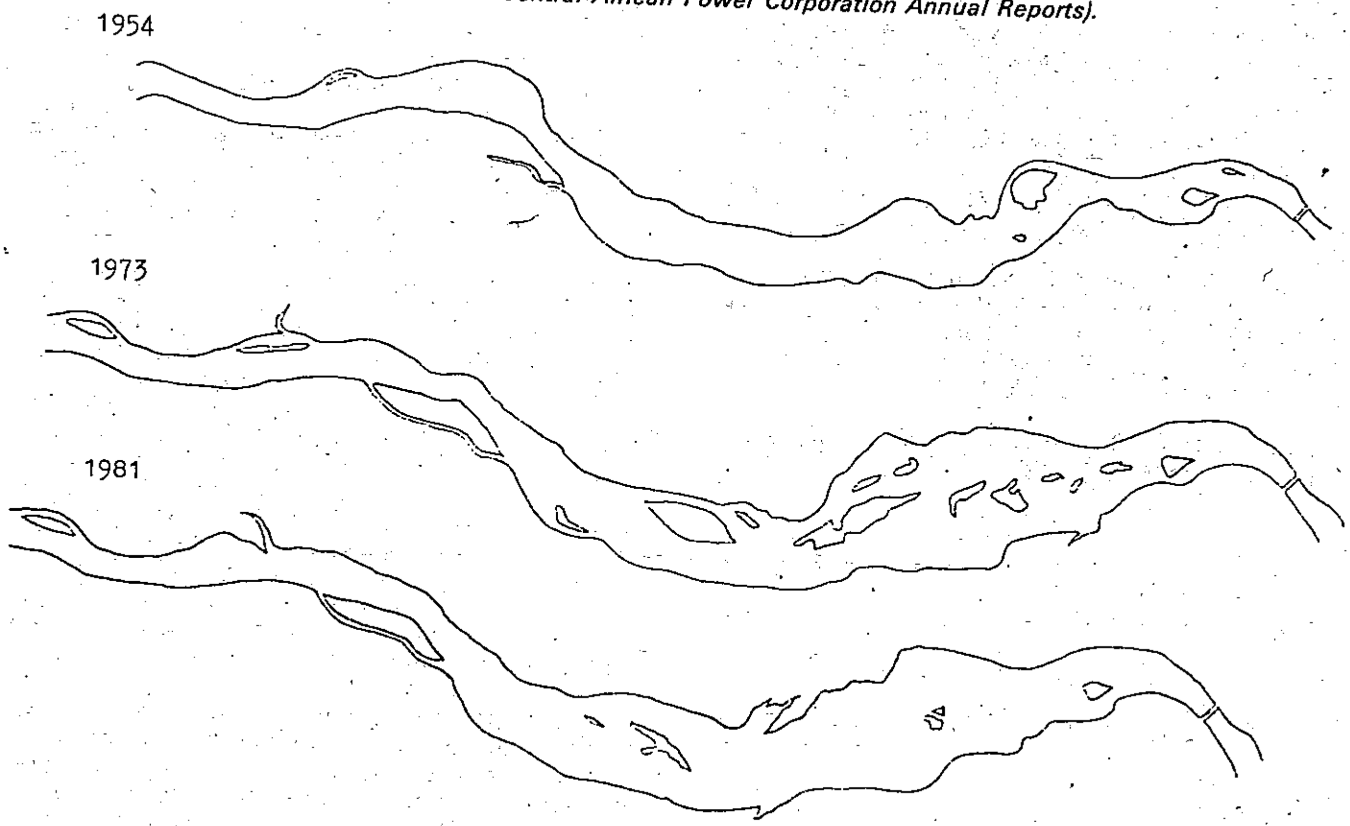

Fig. 1. The Zambezi river channel upstream of Chirundu bridge traced from a time series of air photographs. The channel includes areas identified both as open water and exposed, unvegetated sand banks (which are probably inundated during high discharge). The islands shown here and the banks are vegetated, sometimes supporting only grasses. The air photographs have different scales and the 1954 image has been enlarged relative to the others to help visual comparison. Changes in channel width calculated from these tracings are illustrated in Fig. 2.

upstream part crosses several rock outcrops. A stretch between about 2 km and 12 km upstream of the bridge appears to be an entirely alluvial channel. Changes in this stretch indicate what probably has occurred or will occur in alluvial stretches downstream.

Between 1954 and 1973 the upstream part of this alluvial stretch became narrower, while the downstream part widened considerably, in places doubling in width. Narrowing of the channel is caused by downcutting, which causes sand bars to be exposed as islands. Having reached its new profile, in equilibrium with the new conditions imposed by Kariba, the channel can cut down no further. The gradient has been reduced so the water moves more slowly and must spread out and widen its channel. This had happened by 1973 in the downstream part of this alluvial stretch. Between 1973 and 1981 the upstream part (which had previously been narrowing) became wider while, significantly, the channel downstream maintained its new width with little change. This indicates that a new stable or equilibrium width had been reached.

Once this sequence of channel adjustments has taken place (and it has already done so in the alluvium above Chirundu) normal channel processes such as lateral movements and island formation may be expected to continue, although more slowly due to the reduced water velocity and sediment supply. Channel adjustments should be less intense in alluvial stretches downstream, which receive sediment from tributaries.

ENVIRONMENTAL CHANGES

Ecological damage to the riverine habitats could result from excessive lowering of the water table as the channel cuts downward or from the subsequent removal of the banks. Fortunately, the erosion of alluvium is limited by underlying rock. Fig. 3 shows where rocks have been seen to outcrop along the sides of the channel. There may be other places where they lie near the surface. Erosion of these comparatively hard rocks by the river will proceed slowly. The maximum incision of the channel into its bed will occur between these rock bars. The present average river gradient between Kariba and Mupata gorges is 1:4000.

Table 1 gives the lowering of the channel that would occur midway between rock bars if the gradient stabilised at each of several positions. It assumes that the river could incise freely without hitting rock. The gradient at which the river will finally stabilise is not known. It is probable, however, that downcutting will be checked by rock before the maximum incision (shown in Table 1) is reached.

The widening of the river channel is potentially more damaging than downcutting, particularly as the alluvium near the channel often supports *Acacia albida* woodland. These trees feed a large and varied animal population during the dry season and seem to be responsible for maintaining high animal numbers throughout much of the valley. The alluvial tract above Chirundu demonstrates how, after a period of rapid widening, the channel stabilised to a new width, in equilibrium with the new conditions of slope, water velocities, sediment supply, etc. The other tracts of alluvium may be expected to respond in the same way. It is not yet possible to predict how much *Acacia albida* woodland will be lost in this widening phase.

THE FUTURE

It is now possible to see the direction but not the extent of changes in the Middle Zambezi. With further research, it should be possible to make more accurate prediction of the channel changes that are likely to occur and to plan remedial measures if necessary. Such effort will be worthwhile because Mana Pools constitutes an extensive and vibrant wildlife system that should remain relatively unaltered by man-induced river erosion for the forseeable future.

References

Guy P.R. (1981) River bank erosion in the Mid Zambezi valley, downstream of Lake Kariba. *Biological Conservation* Vol **19** pp 199 - 212.

King L.C. (1967) *Morphology of the earth.* 2nd Ed. Oliver and Boyd, Edinburgh.

Stocklmayer V. (1979). *Zambezi river terraces, Chirundu to Mupata gorge. Report to the Mupata gorge scheme, ecological committee.*

TABLE 1. THE MAXIMUM POSSIBLE INCISION OF THE ZAMBEZI INTO ITS ALLUVIAL BED BETWEEN ROCK BARS (Fig. 3.)

Rock bars - Limits of Alluvium	River distance over Alluvium (km)	Expected incision (metres) with different gradients		
		1:6000	1:8000	1:10000
A-B	40	1.7	2.5	3.0
B-C	21	0.9	1.3	1.6
C-D	19	0.8	1.2	1.4
D-E	50	2.1	3.1	3.8

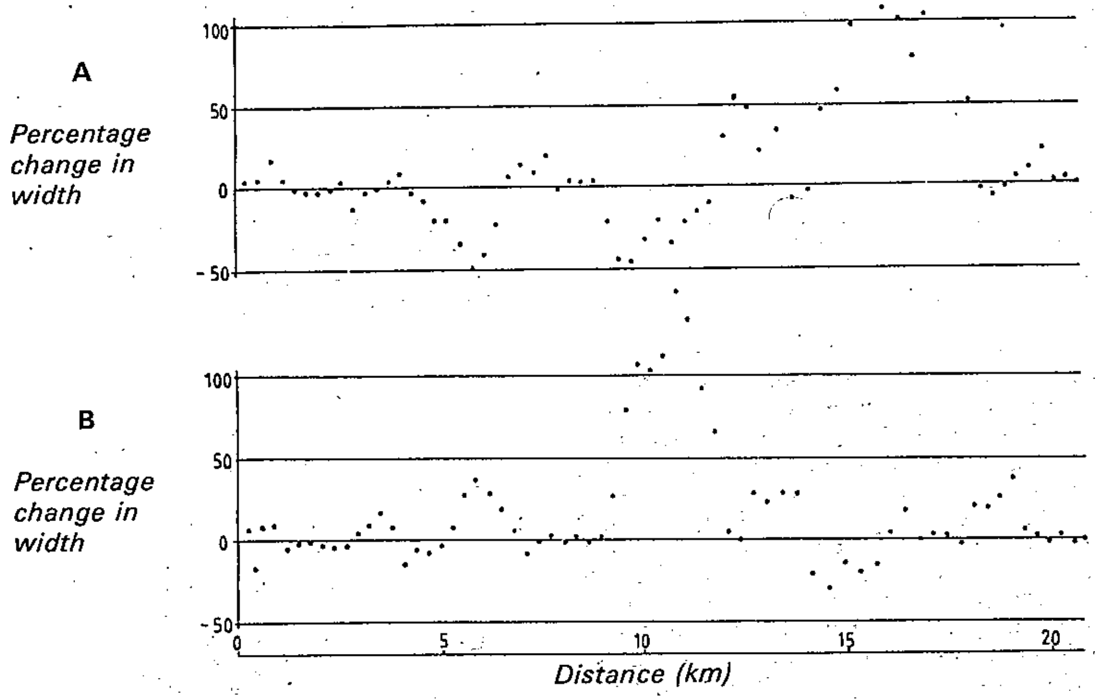

Fig. 2

Percentage changes in width of the river channel between air photographs taken in 1954 and 1973 (A) and 1973 and 1981 (B) for the stretch of the river upstream of Chirundu, shown in Fig. 1. A 100% increase indicates a doubling in width, which has occurred over some of the downstream parts of this stretch. Much of the first 9 km of this section changes width very little. This may be because the banks are composed of very resistant alluvium or rock.

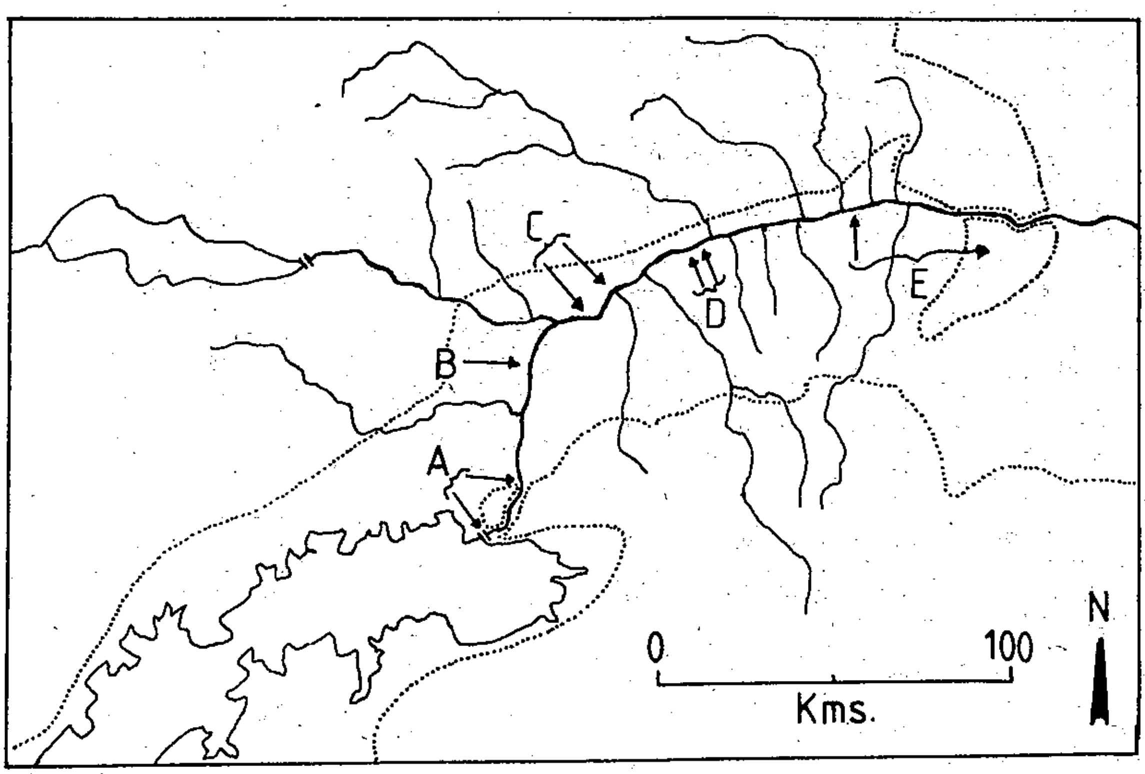

Fig.3

The Middle Zambezi and major tributaries. The river is divided into four alluvial stretches by rock outcrops A to E. More rock will probable be uncovered as the channel incises into its alluvial bed. A. Kariba gorge. Ancient metamorphic rocks which form the Zambezi escarpment. B. Chirundu, Karoo sediments. C. Small outcrop of Karoo basalt. D. Karoo sediments at "Vundu camp". E. Several outcrops of Karoo sediment and the ancient metamorphic rocks of Mupata gorge.