R. INFANTA AND BREEDE

Desk Note R3b. Breede River Estuary – Hydrology and bathymetry

Oblique aerial view to the southeast on the Breede River Mouth.
Source: The Internet

R. INFANTA AND BREEDE

Desk Note R3b. Breede River Estuary – Hydrology and bathymetry

The information in this Desk Note is taken verbatim (with several necessary omissions and text adjustments) from: The Breede River Estuary (Cape Province, South Africa): A historical perspective on hydrology, geomorphology and sedimentology. By Burg Flemming and Keith Martin. In Geo-Marine Letters (2021) 41: 15].

Hydrology

The observations at several stations together with some supplementary measurements at other locations were used to reconstruct some relevant hydrological trends along the length of the estuary namely tidal delay and elevation, salinity, and light transmittance (turbidity). The reconstructed trends of these parameters, as a function of distance from the mouth up to km 35, are illustrated in Figure.1. In all cases, they have been successfully subjected to regression analyses with coefficients of determination (r^2) exceeding 0.99.

Tidal delay

During the surveys, an up-estuary delay in the occurrence of both the ebb and the flood tide was observed. Initially, the delays increase gradually before adopting almost linear trends from about km 14.5 onward towards the estuary head 52-km upstream (Figure. 1a). The delay for the ebbing tide was observed to be substantially greater than that for the flooding tide, amounting to 7 h and 3 min at the estuary head (km 52), i.e., the subsequent flood tide entered the estuary mouth about 50 min before the low tide level was attained at the estuary head. The corresponding delay of the flooding tide at the estuary head, by contrast, amounted to only 4 h and 31 min.

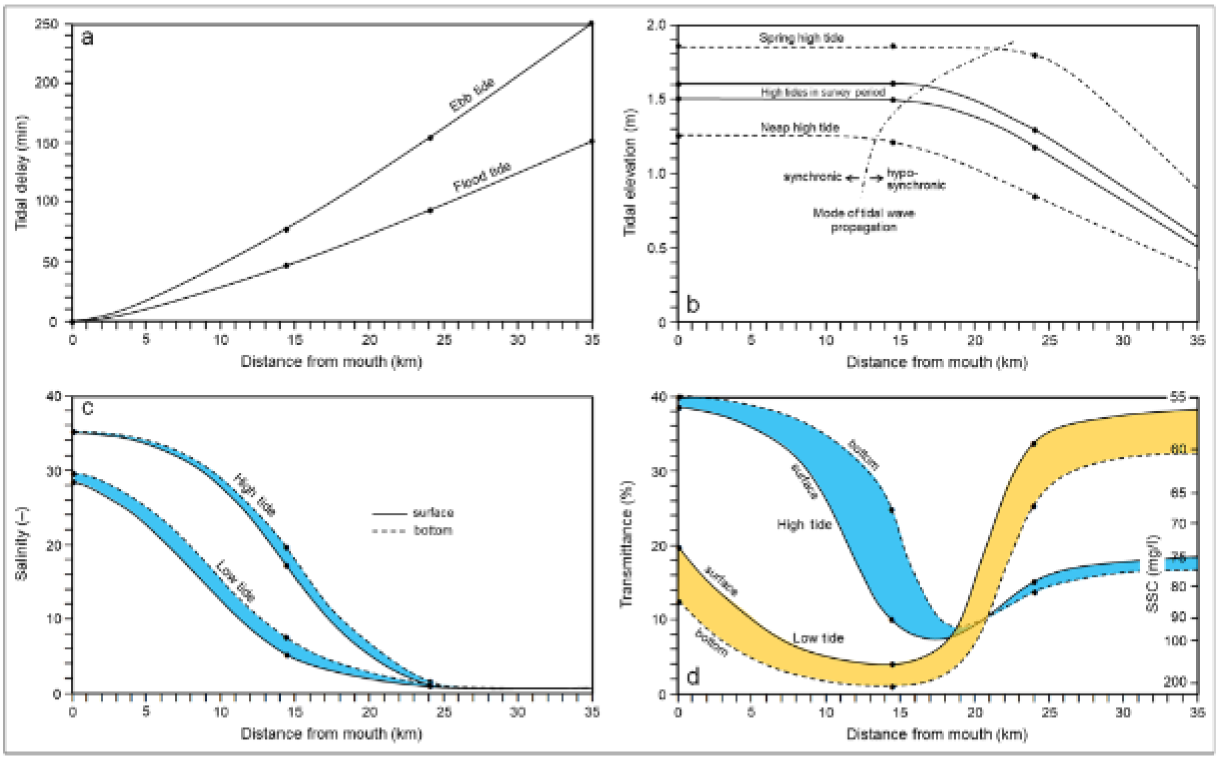

Figure 1. Interpolated along-estuary hydrological trends between the mouth and the Malgas ferry crossing (km 35): (a) tidal delay (min); (b) tidal elevation (m); (c) salinity; (d) light transmittance (%) and suspended sediment concentration (mg/l).

Tidal elevation

After entering the estuary mouth, the tidal wave initially progressed in synchronic mode (i.e., maintaining a constant elevation) for a considerable distance along the estuary. This applied to all tides from spring to neap (Figure. 1b). It continued in this mode up to about km 21 at spring tide and up to about km 13 at neap tide before adopting a hyposynchronic mode (i.e., progressive decrease in height) towards the estuary head. The synchronicity reflects the interplay between shoreline convergence, which causes the tidal range to increase, and friction along the river bed, which causes the tidal wave to slow down and the range to decrease in height. The synchronic mode thus indicates that convergence and friction were balanced, whereas the hyposynchronic mode signified a progressive dominance of friction over convergence.

From these trends, the tidal prisms for spring and neap tides were determined. They amounted to approximately 19×10^6 m^3 on spring tides and 3.9×10^6 m^3 on neap tides, the latter thus barely reached 20% of the spring tide volume. The large difference in volume is due to the pronounced difference in the potential ranges of the spring (ca. 1.8 m) and neap tides (ca. 0.4 m) entering the river mouth. To be noted here is that the measured maximum / minimum tidal elevations were in good general agreement with those predicted by the interpolated astronomical tidal curve which, in turn, suggests that, at the time of the observations, water levels were not noticeably influenced by other factors such as wind set-up/draw-down or water level variations caused by coastal trapped waves.

Salinity

The salinity decreases progressively upstream from the mouth (Figure. 1c), both at high tide and at low tide, albeit starting from different values (high tide: ~35 at the surface and the bottom; low tide: ~28 at the surface, 29.5 at the bottom). Up-estuary the trends, both at high tide and low tide, as well as at the surface and the bottom, followed converging sigmoidal shapes to eventually meet at the background salinity of about 1 at km 25. Salinities were marginally higher at the bottom along most of the estuary, both at high tide and low tide. For this reason, regressions were only calculated for the surface salinities at high and low tide.

Turbidity

In comparison to the other three parameters, the along-estuary trend of turbidity shows a more complex pattern (Figure. 1d). As to be expected, the lowest turbidity (SSC) is recorded at the mouth at high tide (~56 mg/l at the surface; ~55 mg/l at the bottom) after the influx of open ocean water reaches its peak. From here, the turbidity increases progressively up-estuary in a sigmoidal trend until it reaches values around 100 mg/l at km 18.5. Notable is the fact that, at high tide, the turbidity was consistently lower at the bottom in comparison to the surface up to about km 22. The maximum difference amounted to about 23 mg/l near Station 2 (km 14.5). Upstream of km 18.5, by contrast, the turbidity decreased again and the vertical turbidity gradient reversed, highest values being now recorded at the bottom (~77 mg/l), although the difference to the surface was not very large (~2 mg/l).

Quite different was the trend observed at low tide. Starting at the estuary mouth with SSCs of ~74 mg/l at the surface and ~85 mg/l at the bottom, the turbidity increased progressively up to about Station 2 (km 14.5), where the overall highest values were recorded at the bottom (200 mg/l). From here, the turbidity decreased rapidly up-estuary to reach its lowest low-tide value of ~56 mg/l at the surface and ~61 mg/l at the bottom at km 35 and beyond. Notable is the distinct cross-over of the high-tide and low-tide trends between km 18.5 and km 21, i.e., around the upstream limit of the mixed sand/mud reach. Here, the SSC remained practically constant over the entire tidal cycle (90–100 mg/l), while the range increased both towards the head and the mouth of the estuary.

Bathymetry

Flemming and Martin ran 36 cross-river bathymetry transects (Figure 2).

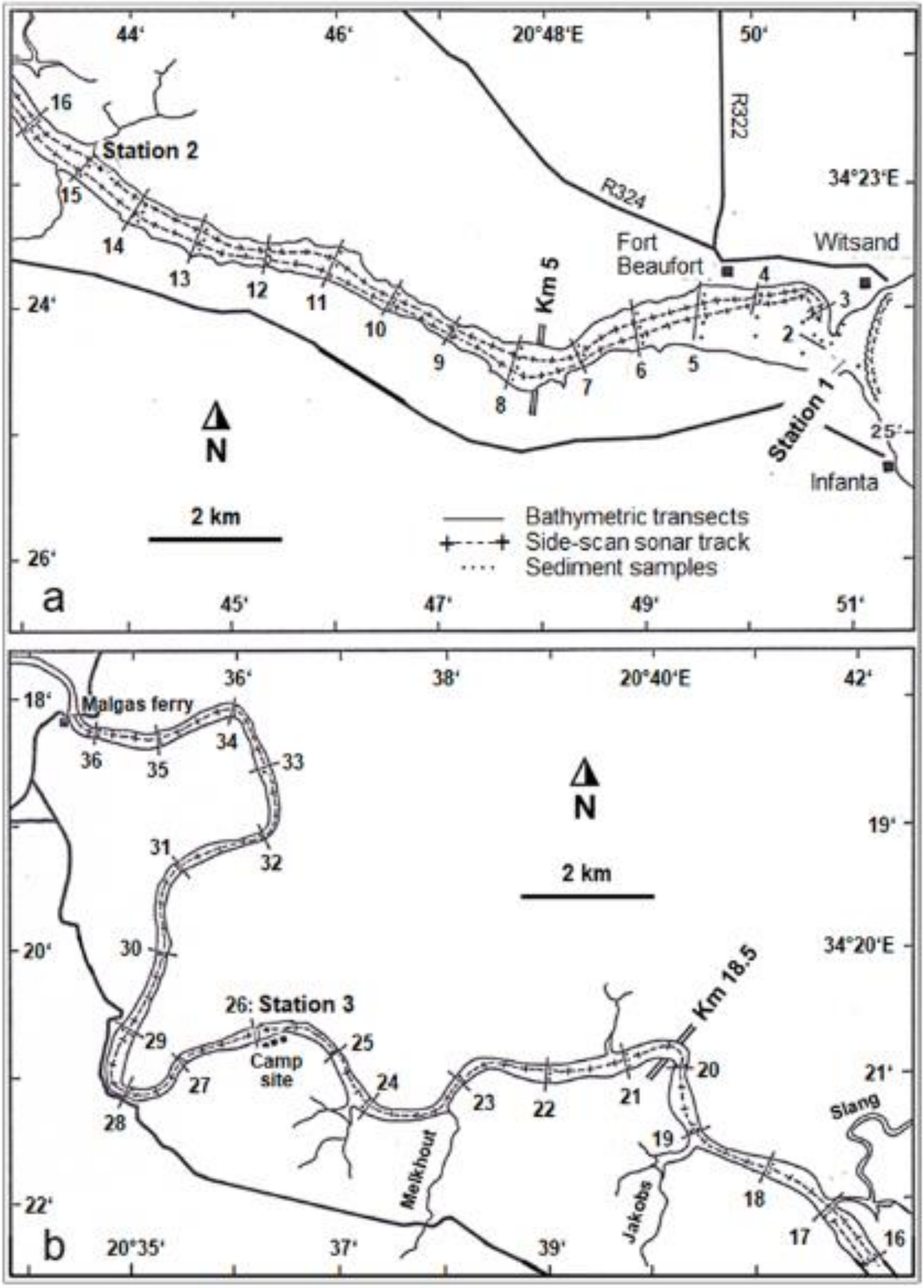

Figure 2. Plan view of the Breede River Estuary up to the Malgas ferry crossing (km 35) showing the location of hydrological stations, side-scan sonar profiles, bathymetric transects, and sampling stations (for technical details see Electronic Supplementary Material). Note that the remaining 17 km of the estuary beyond km 35 were not surveyed.

When considering the cross-sectional geometry, the estuary can be subdivided into three domains, characterized by progressive downstream widening and shoaling of the river channel (Figure 3). Thus, the maximum width and depth of the estuary upstream of km 18.5 are ~260 m and ~18 m, respectively, whereas the corresponding values are ~400 m and 12 m for the section from km 5–18.5, and 600 m and 9 m for the final section up to the estuary mouth. The maximum depths relate to those measured in scour pools (see below). Furthermore, the cross-sectional geometry of the estuarine channel is rarely symmetrical (e.g., transects T-36 and T-32 [Figure 3, upper panel]) but is instead mostly skewed towards either the left or the right river bank (e.g., transects T-24 and T-34 [Figure 3, upper panel] and transects T-18 and T-16 [Figure 3, middle panel]). The cross-sectional geometry of the lower section (from km 5 to the mouth) is by nature asymmetrical because of the large, partly intertidally exposed flood delta that is attached to the right river bank (viewed downstream towards the mouth). It takes up more than 60% of the funnel- shaped area of this section, the remaining area being occupied by the ebb-dominated channel that hugs the left bank. A particular feature of the estuary is the occurrence of deep scour pools (depressions) which are particularly frequent upstream from T-17 (the Slang River confluence). Overall, 21 scour pools have been identified up to the Malgas ferry crossing, and more scour pools may exist beyond the ferry crossing not surveyed during this study.

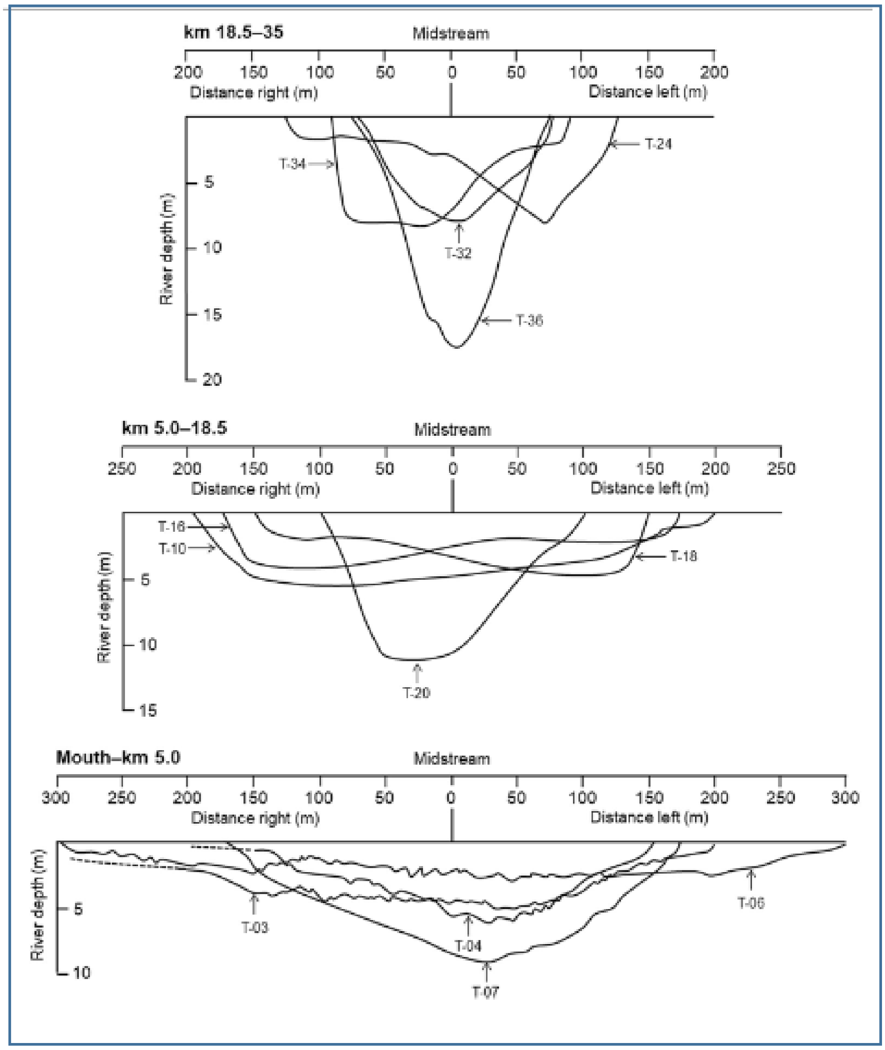

Figure 3. Selection of typical bathymetric river cross-sections characterising the fluvial sand reach from km 18.5–35 (upper panel), the mixed sand/mud reach from km 5–18.5 (middle panel), and the marine sand reach from the mouth to km 5 (lower panel). Note the progressive widening of the estuary from head to mouth.

