INTRODUCTION

Cyclone Demoina hit the central Zululand area (Fig. 1) early on the morning of 31 January 1984. Heavy rain started falling at Mtubatuba at 08h00 on the day and continued non stop for about 20 hours. During this period an excess of 600mm (24 inches) of rain fell over most of the St. Lucia and Mfolozi catchment areas.

The Hlobane Dam on Hlobane stream burst early in the morning and these waters reached the Mtubatuba area around 18h00. At 21h00 this pulse of water evidently arrived at the estuary. Flood waters started to fall around 07h00 on 1 February.

On 8 and 9 February I had the opportunity to visit the St. Lucia and Mfolozi areas, by which time flood waters had mostly subsided. Aerial reconnaissance flights were made of the following areas:-

1) Mfolozi Game Reserve
2) Lake St. Lucia Reserve
3) St. Lucia/Mfolozi mouth areas.
4) Lower Mfolozi flats.

Field trips were made to various locations along the Mfolozi flats south of Mtuba, the coast north of St. Lucia and along the banks of the Black Mfolozi in Mfolozi Game Reserve.

Immediately apparant was that the storm had enhanced many natural processes. In addition, flood responses in the Mfolozi flats were similar to those documented in other coastal fluvial plains such as the Atchafalaya River Basin and Mississippi delta plains of Louisiana.

FLUVIAL AND COASTAL MARINE PROCESSES.

In order to better assess storm responses, the dominant natural processes active in the study area will first be reviewed.

a) River channel patterns and processes.

Channel pattern is defined as the configuration of a river in plan view. A river's pattern is a reflection of channel adjustment to channel gradient and cross-section, and seems to be strongly controlled by the size of the sediment load and its characteristics, and the amount and nature of its discharge. In addition local geology can have a strong control on the channel pattern. Most workers recognize three river channel patterns: straight, braided and meandering (Reineck and Singh 1973) (Fig 2A). The Black Mfolozi River in the Mfolozi Game Reserve displays a meandering pattern at bankful stages and floods, and appears braided at low stages. Within the study area, this situation characterizes most of the rivers west of the coastal plain.

A meandering pattern usually reflects a mature stage of river development. However, the relatively steep banks and undulatory topography of areas landward of the Zululand coastal plain is indicative of a more youthful river setting. The meander pattern of these rivers is therefore considered to be a relict feature representing an earlier mature river stage reached by the Mfolozi when sea level was some 10's of meters higher during the Tertiary Geological period, subsequent changes in sea level and down cutting preserving the meander pattern.

Even though the meander pattern may be a relict feature the processes of meandering continue specifically during major floods.

Typically in Mfolozi Game Reserve sediment is deposited on point bars while cut banks are eroded (Fig. 2). Lateral migration of point bars is enhanced during floods, maintaining the meander pattern.

While the overall pattern is one of meandering, at low water a braided channel pattern occurs within the confines of the Mfolozi river banks. Braided channels are marked by successive division and rejoining of the flow around alluvial islands or bars. Such features are of low relief and tend to build up at their downstream ends, the upstream ends being partly eroded.

Braided rivers are characterized by wide channels and develop in areas of steeper slopes. Leopold and Wolman (1957) demonstrated that braiding or meandering of river channels depends mainly on the relationship of channel slope to discharge. In the case of two rivers of the same discharge, braided channels develop on steeper slopes and meandering channels develop on more gentle slopes. The braided channel pattern of the Mfolozi at low water is a further indication of the river's relative youth.

Point bars (Fig. 2) are the most conspicuous geomorphic features of a meandering stream; at the same time deposition on point bars is the major process of sedimentation in meandering river channels. Deposits may be as thick as the river is deep during the flood. Lithology and grain size of point bar deposits depend upon the grain size available. Besides the channel lag deposits, point bars are composed of the coarsest sediment available in a stream. If a wide range of grain size is available, grain size decreases upward in a point bar sequence. Generally, a muddy or very fine-grained layer is present on the top as a thin veneer. This mud drape if present marks the top of a genetically related sequence. If rivers are carrying gravel-sand material, the change is from gravel, coarse sand to fine sand, and silt on the top. In rivers carrying fine-grained material the change is from fine sand layers near the bottom to muddy and clayey sediments near the top (Fig. 2).

b) Coastal Flood plain development.

River meandering most commonly occurs where channel slopes are low and suspended sediment load is high compared to bedload. Coastal plains are thus ideal locations for river meandering.

Meandering rivers show a more organized distribution of channel processes and a clearer separation of channel and overbank environments than the low sinuosity and braided rivers into which they grade. A meandering channel occupies only a small part of its alluvial plain at any one time (Fig. 3). It lies within a meander belt which is a complex of active channel, abandoned channels and near channel sub-environments. The meander belt does shift its position on the alluvial plain through time reflecting natural subsidence, and concentration of sedimentation.

Sedimentation is concentrated close to the meander belt and an 'alluvial ridge' is built above the level of the flood plain (Fisk 1952) (Fig. 3). This increasingly unstable situation is periodically relieved by the breaching of a channel bank during flood and the sudden shifting of the meander belt to a new position of the alluvial plain, a process known as 'avulsion'. The new course captures an increasing proportion of the flow and the old meander belt is abandoned.

Subsidence is the second important mechanism that forces channel switching in coastal fluvial plains. The term subsidence is applied to the relative rise in sea level and/or the relative lowering of base level in coastal environments. There are a number of mechanisms responsible for these apparent changes, including eustatic sea-level changes, continental downwarping, dewatering and compaction of sediments, and human activities. The first two are thought to be of minor importance in the St. Lucia, Mfolozi flat areas.

The Mfolozi Flats are apparently underlain by more than 30 metres of relatively fine grained sediments which were typically deposited from suspension, consist of silts and clays, and originally had high water contents. As sea level has risen the last 18,000 years, so has the level of the flood plain. Sediments in the deeper positions of the basin would have started to dewater and compact under the influence of continual loading.

Such compaction constitutes the dominant natural subsidence process in fluvial plains such as the Mfolozi Flats. In a similar type environment, Atchafalaya River Basin, Louisiana, subsidence rates of 3cm per year are recorded (van Heerden 1983). This continual process has a strong control on channel switching during floods.

Swamps and marshes more distant from the channel cannot maintain base level due to a sedimentation rate that does not balance subsidence. Thus topographic lows are created in inactive parts of fluvial plains. During floods, the river may break into such areas and occupy a new course to the sea. Associated with the new channel will be a new episode of levee building and meandering. As natural levee height decreases in a downstream direction on coastal plains, frequency of switching will increase in the same direction.

The channel switching process results in the flood plain being built up of juxta-positioned interfingering sediment lobes (Fig. 4).

c) Morphology of Lower Mfolozi Flats.

Figure 5, compiled from aerial photo mosaics and oblique air photos, reveals that channel switching has commonly occurred in the Mfolozi flats. However, the Mfolozi River had occupied its course between points A and B in the upper section of the flats (Fig. 5) for quite a long period. The river course was relatively deep and wide with well established confining natural levees. Traces of old crevasse channels displayed in earlier photography (1960) indicate that sedimentation in the upper section during this period occurred through overtopping of the natural levee system rather than through channel switching. River channel elevation would have progressively increased with each successive flood. High ground north of the channel section A-B (Fig. 5) is closer than that south of the channel. Inequality in flood plain width may explain why the area north of the channel generally had a higher elevation than that to the south, as is evidenced by the trend of the 50ft contour (Fig. 5).

Channel switching in the mid section of the Flat appears to have occurred chiefly at two locations. Major, fairly long term upstream diversions occurred in the upper reach of the mid section (Area C, Fig. 5) while switching was more common further downstream (Area D, Fig. 5). The well developed meander pattern of the channel between areas C and D indicates that this channel was in use for a long period. Using features such as abundance or lack of tree cover on old levees enables one to infer the chronological order of channel switching. Interestingly, the order of switching reveals that the southern half of the mid section has not been occupied by a major course of the Mfolozi for some time (Fig. 5).

Channel patterns and traces in the lower section of the Flat reveal that the confluence with St. Lucia Estuary has progressively migrated seawards. In this area, channels were never well defined, in terms of levee height, because sheet flow dominates during floods.

d) Human influences in Coastal Plains.

Human activities can greatly enhance the subsidence rate. Firstly, draining (dewatering) wetlands increases compaction and hence subsidence. Secondly channelization of rivers and creation of artificial levees impedes the spread of sediment to areas adjacent to the channel. Thus sedimentation will not balance local subsidence and lowering of base level will increase. Lastly, channelization and artificial levee construction, especially if levee material was dredged from the river floor, creates a situation where the local water table is lowered. Such dewatering increases the local subsidence rate.

Therefore, although channel switching is a natural process in subsiding coastal fluvial plains it can be enhanced by man's activities.

e) Coastal Processes.

The following review concerns the littoral zone (Fig.6) between Maphelane and First Rocks and includes the mouth of the Mfolozi River and St. Lucia Estuary.

i. Climatic and Oceanographic setting.

The most important physical force along this section of the coast is the wave climate. Although the south-east swells produced in the "roaring forties" becomes deflected and progressively weakened before reaching the Natal coast, wave processes force most sediment movement. The two most important characteristics of waves in terms of beach response is wave height and angle of swell approach. For 87 per cent of a two year period - March 1971 to February 1973 (CSIR 1973) the ocean swell along the Natal coast varied from 1 - 3 m, with 2 - 3 m swells occurring 35% of the time.

Direction of swell approach along the Natal Coast has two dominant modes (Fig. 7). Swells have a south easterly orientation about 40% of the time (CSIR 1973, Begg 1978). Onshore swells (northeasterly to easterly) in the St. Lucia area have a like frequency.

A climatic factor which has a strong influence upon coastal waters is the regular reversal of north-easterly and south-westerly winds (Fig. 7). The components of wind parallel to the coast are caused by a succession of low pressure cells (coastal lows) which move along the coast. Coastal lows originate off the West coast of southern Africa, travel round the Cape and depart the coast north of St. Lucia. The prevailing winds are spread fairly evenly over the twelve months of the year and are almost equally divided in frequency (Fig. 7) (Weather Bureau 1960, Orme 1973). Van Heerden (1976a) found that there was a strong correlation between angle of wave approach and wind direction. Southerly winds tend to enforce south easterly swells while northerly winds generally created conditions of onshore swells. Any marine process study should recognize that processes related to oblique south easterly swells may differ to those during onshore swells.

ii. Beach processes.

The large-scale crecentric beach configuration, between Maphelane and First Rocks, tends to approximate an equilibrium in which the wave climate provides precisely the energy and mean wave approach angles required to transport and redistribute the sediments supplied to the beach. The beach configuration, then, is controlled mainly by the curvature and orientation of the refracted wave crests and by the locations and relative importance of the beach sediment sources and losses (sinks).

At present there are 3 main sediment sources. The oblique south easterly wave approach sets up a northward directed surf zone current (Fig. 7) which transports sediment (some originally from the Tugela) around Maphelane. Similar surf zone currents are also responsible for transporting sediment out of the area past First Rocks. Additional inputs of at times large quantities of sediment are the Mfolozi river and St. Lucia estuary.

Rip currents between bars orientated obliquely to the coast, and parallel to wave approach (Fig. 8) may extend 2 km seaward and are responsible at times for transporting sediment out of the littoral zone, i.e. act as sinks.

The wide surf zone, presence of one or more bars, three dimensional inshore topography and different scales of rip cells are characteristic of a dissipative beach (Figs. 8 and 9). Here wave energy is mostly dissipated in the surf zone where there is high turbulent viscosity. Spatial variation in bar types reflect segregation into subregions of contrasting turbulent viscosity. Dissipative beaches, close to major deposition areas such as the Mfolozi River mouth are usually progradational features.

However, progradation is most marked in areas dominated by onshore winds. In the study area winds are either offshore or alongshore. Such conditions do not encourage hummocky dune growth and beach progradation in the study area. Rather they lead to subaerial wind erosion which annually appears to balance deposition on the beach.

In general, oblique wave approach encourages beach erosion and forces maximum sediment transport. The most commonly seen features are large cuspate horns with wavelengths greater than 100m (Fig. 8). Onshore swells result in beach cusp formation (wavelengths 20-40m), indicative of net sedimentation. Longshore sediment movement is generally low and numerous small rip current cells are generated (Fig. 9).

iii. River mouth processes.

St. Lucia Estuary and lower Mfolozi River each occupy drowned river valleys which are greater than 50m deep at the coast (inferred from Orme 1975, and van Heerden 1976b). Apparently both paleo-river systems had a common mouth at St. Lucia reflecting the lack of Pleistocene "beach rock" between Maphelane and First Rocks. Historical reports and surveys (Begg 1978) indicate that both systems had a common mouth until Man's intervention in the 1960's. In fact, St. Lucia estuary most likely existed as a shallow arm of a more dynamic, in terms of mouth maintenance, fluvially dominated Mfolozi estuary.

While the seaward position of the common estuary mouth has changed over time, the general location of the estuary has been stable. Stability of location reflects the "pegging" effect of the consolidated Pleistocene barrier material north of Honeymoon bend, and the buried, large oyster reef that occurs immediately south of Honeymoon Bend (Fig. 10).

The estuary mouth seems to have always had a northerly orientation, reflecting the influence of the south-easterly swells. Initially the Mfolozi connected to St. Lucia in the Honeymoon Bend area and appears to have had a more northerly trend (Figs. 5 & 10). Judging by the size of the dune field which built up from estuarine sediments north of the mouth, this location must have been stable for some time. The small cliff beneath the N.P.A. offices being the remnants of the north bank.

At a later stage the Mfolozi entered St. Lucia Estuary closer to the sea so that the north bank of the estuary shifted south creating the vlei that now occurs below the N.P.A. offices (Fig. 10). This move initiated another phase of coastal dune growth as sediments were moved north from the estuary bank. The size of the dunes present in 1937, and the lack of any mention of these in Crofts 1905 survey (Fig. 11, Begg 1970) suggests that the new orientation occurred around 1900.

All early surveys and maps reveal the combined system to have had an opening in the general area of the present mouth, with a shallow arm extending northwards from the estuary behind the beach (Fig. 12). Although very little historical coastal process data is available I believe that this central location was representative of low water months. During and immediately after floods, when large amounts of sediment were deposited in the near shore the mouth could well have migrated farther north along the arm north of the mouth. At such times the oblique southerly swell approach combined with a large littoral sediment pool would have forced the southern bank or spit of the estuary to extend rapidly northwards, while the estuary waters eroded the northern bank. Similar processes have been documented elsewhere on the Natal coast following major floods (van Heerden 1976a) and is schematically shown in Figure 13. Once the nearshore sediment supply had diminished the mouth would have been re-established in a more normal position (Fig.13) due to wave overwash erosion processes. Mouth migration forced by discharge fluctuations would explain why the northern spit was a "low barren" feature until stabilized by man (Fig. 11 and 13).

As mentioned earlier, beach configuration reflects an equilibrium between a number of factors. Creation of a separate mouth for the Mfolozi and stabilization of St. Lucia estuary mouth disrupted the equilibrium and subsequent nearshore sediment distribution. Firstly, creation of the groynes and associated sediment trapping caused shoreline progradation in the vicinity of St. Lucia mouth. Comparison of the 1966 and 1972 shorelines (Fig. 12) reveals seaward extension in excess of 300m. Such a situation leads to starving of sediment in areas farther north. Secondly, the siting of the heaviest groyne on the north bank of the estuary led to sediment trapping in St. Lucia Estuary mouth. That is, sediments supplied by the Mfolozi migrated along the coast to the estuary mouth where they "sat", necessitating near continuous and expensive dredging operations. Material from this operation being dumped south of the estuary mouth, as a permanent sediment sink. The result of groyne emplacement and associated sediment starvation through trapping and dredger losses meant that beach areas north of the mouth were no longer in equilibrium. The most dramatic effect of disturbance appears to have been the collapse of a large section of the Holocene dune barrier, south of First Rocks, as the fronting beach retreated.

Unfortunately, even the littoral with its high energy regime can be dramatically altered if the equilibrium between processes is adversely altered.

OBSERVATION OF STORM RESPONSES BY AREA.

A. Mfolozi Game Reserve.

Despite the drought this area is characterized by generally well managed veld. Flood waters had destroyed the riverine bush and forest on either side of the river to widths not exceeding 2 kms.

Erosion to bedrock had occurred on all cut banks of the river, while deposition had occurred on all point bars (Fig. 2). This natural process being greatly enhanced by the flood. At this point in time no conclusion could be made as to whether deposition of silt equalled or exceeded that eroded. Local game rangers were of mixed opinions although the majority (4 to 2) felt that deposition exceeded erosion. Where sampled, sediment deposited was mostly silt and high in particulate organic matter.

An important observation made by all game rangers was that there was no dramatic change in river base level indicating no net increase in channel lag material. Thus sediment carried by the river was not coarse enough to be deposited on the channel floor. Sedimentary structures examined in the top of point bar deposits suggest that most of the sediment carried by the Mfolozi was in the suspended mode. The significance of this observation will be discussed shortly.

B. Mfolozi Flats.

Depositional response was very dramatic in this area, mostly due to the Mfolozi River creating a new course (via the older Msunduze River) to the sea (Fig.5).

Extremely high flood levels forced the Mfolozi River to switch channels and occupy a course along the lower lying southern edge of the Mfolozi Flats. As discussed earlier, switching is a natural process brought on by subsidence and differential sedimentation in coastal plains. The diversion occurred in the upper section of the flat, an area where switching seldom occurs. For this reason the new channel has the potential to be a long-lived feature.

The Mfolozi River seaward of the new confluence with the Msunduze, is not presently carrying much water. Its upstream end is being sealed by subaqueous levee growth, typical of what occurs when older channels are abandoned.

The sedimentary wedge seaward of the S.A.R. bridge (Fig. 14) is a typical shallow water fluvial delta, displaying the characteristic branching and rejoining of channels around sand-rich lobes. No investigations were made as to the thickness of the "sand" deposited. Local farmers claim between 2 and 4 m. Fluvial delta sediments sampled near the S.A.R. bridge consisted of fine - to medium-grained, well sorted sand. Such sediments are usually deposited from suspension as flood waters pass from a confined to unconfined state. That is, as the flood waters moved out of the confines of the river valley, which ends at the railway bridge, they rapidly spread out over the flat with resultant drop in velocity. At this point the coarsest fraction of the suspended load would start to drop out, being the fine to medium grained sands sampled.

Flood waters would have continued their lateral spreading as they moved down the progressively broadening flat. As a result, a steady longitudinal reduction in velocity was set up such that even finer portions of the sediment load would have been deposited. Spreading of fluvial waters in passing from the confined to unconfined state and resultant sedimentation usually creates a sediment wedge that thins seaward and exhibits a progressive decrease in grain size. This is the reason that the seaward 1/3 of the flat was only covered by a few centimetres of silt and clay, although high discharges were experienced.

Once flood levels fell, such that most of the discharge was confined to the wide new course, coarse sediments would have started to flux through the system to the coast. A large portion of the sediment deposted seaward of the Mfolozi mouth would have only reached this area on the falling stage of the hydrograph. This phenomenon reflects an important characteristic of suspended sediment deposition in coastal plains that has significant consequences for management of the flat, as well as St. Lucia Estuary.

C. <u>St. Lucia and Mfolozi mouth.</u>

All man made structures have been washed away at St. Lucia estuary mouth. The estuary has assumed a more natural northward directed orientation. At present the mouth is deep as evidenced by the lack of breaking ocean waves. The Mfolozi mouth, which is separate from the estuary mouth, has a similar orientation.

Vast amounts of sediment have been deposited in the nearshore and exist as a large marine bar between the mouths, and as a continuous bar extending from north of the estuary mouth to Cape Vidal. Under the influence of south easterly swells and a large nearshore sediment pool, both mouths should migrate northwards.

On 9 February both mouths had started moving northwards. The north bank of St. Lucia Estuary consisted of a 2m cliff that was slowly cutting back into the old car park, the stabilized dunes (picnic area), and the beach. It is difficult to speculate as to how far each mouth will migrate as in each case stabilized dune and beach material could impede movement.

D. Lake St. Lucia.

The Lake is now almost completely fresh and is 2-3 m above sea level. All natural sponges and swamps surrounding the lake appear to be completely re-charged. As a result Lake levels could remain high for many months to come. This in turn could lead to much needed scouring of the sinuous channel that connects the Lake proper to the sea.

E. Link Canal.

The Link Canal appears to be an ecological disaster because firstly, the dredge spoil piles have acted to impound some marsh areas. Numerous studies in coastal Louisiana (for a review see Boesch 1982) have shown that marshes need continuous movement of water through the system to introduce nutrients and remove toxic accumulations. Secondly, the canal floor, especially near the intake works consists of fine to medium-grained well sorted sands. These white sands appear to be old dune material and are of a size that is easily entrained and transported as suspended load at relatively low velocities. Accumulations of very white sand on the banks of the canal where it crosses the Mtubatuba road no doubt represents sand that was scoured out of the canal farther upstream during the flood. There is a strong possibility that such sediments could have reached the estuary. If so, they could be a major problem as once in the estuary the sands would mix with the very cohesive estuarine muds, forming a mixture that would require some energy to be moved.

As the Mfolozi river is now cut off from the main river flow, (Fig. 14) estuarine waters could flow down the link canal, into the old river channel and thence to the sea. Such a condition reduces the potential energy for scouring of St. Lucia estuary, seaward of the link canal departure point. In addition, because of the nature of the bottom sediments in the canal, the cross sectional area could increase through scour, further reducing flow down the estuary.

F. Mkuze Swamps.

Water levels in this area are high. Sedimentation has occurred in the upper reaches of the swamp . However, water entering the northern compartment of the lake appears to be relatively sediment free, due to the natural filtering process of the swamps.

The swamp surface is naturally subsiding and thus appears to be able to accommodate vast amounts of sediment.

SOME POTENTIAL PROBLEMS IN FUTURE MANAGEMENT.

A. Farming.

An assessment of how much sand and its quality will be necessary, to determine if large scale farming will be possible in the upper reaches of the Mfolozi Flat. If another flood occurs in the near future the fluvial delta would be reactivated and downstream migration of such systems is typically very rapid.

B. Conservation needs.

The Lake St. Lucia's system of sponges and marshes are now well charged. Within a few months the lake could be in a pristine ecological condition. The major area of concern being the mouth. As lake levels fall so will the potential energy available to keep the mouth scoured. If any more sediment were introduced seaward of the present Mfolozi/Msunduze mouth, through man's activities such as large scale dumping further upstream, the St. Lucia estuary mouth would become severely degraded. The systems could however tolerate another flood, as although this would increase the nearshore sediment supply, it would also raise lake levels.

Should a decision be made to allow Mfolozi flats to revert back to nature, i.e. to become a swamp system such as the Mkuzi, barrages and such would be needed to enhance the transformation. In addition breaks in the existing artificial levees would have to be made. It is important to note that if the northern half of the system is left as it is, a wind blown dune field could result.

Lastly, if the recently abandoned lower Mfolozi River is to operate, major remedial measures will be necessary.

RESEARCH AND DATA GATHERING TASKS.

The dramatic change in the physical environment as a result of Demoina has given rise to the need for some important, urgent studies.

A. Mfolozi Flats.

1. Whether farming or conservation needs are to be satisfied, the quality and quantity of sediment deposited in the flats has to be determined.

2. A better understanding of the natural processes in the Mfolozi flats is needed, as is an assessment of the influence of man's activities on these processes. Such a study could show which natural process could be utilized to man's benefit.

B. Coastal processes in the Mfolozi/St. Lucia Estuary environs.

Previous attempts at St. Lucia Mouth stabilization were very expensive as they necessitated almost continuous dredging. This was because of continuous sedimentation in the mouth which reflected the wrong mouth configuration, as well as stabilization of the wrong flank of the channel. The more natural present conditions mean that a timely coastal process study could be undertaken at a time when sediment supply is in abundance. Synoptic monitoring now, will indicate the dominant marine processes responsible for shaping the two mouths.

C. Comparative study, Mfolozi flats and Mkuzi swamps.

Controversy has raged since the early 1920's as to the pros and cons of swamp clearing for sugar cane in the Mfolozi flats. A study of the response of each of the above systems to this major storm could indicate the major differences in response behaviour, and would be extremely useful to future management needs.

D. Catchment studies.

Many claims are made by various groups and organizations that effective catchment management could prevent major disasters such as the present one. However, very little is known as to how degraded are the catchments. Secondly, was all the sediment deposited in the flats directly derived from the catchment. From my short visit to Mfolozi Game Reserve it appeared that deposition equalled erosion. If this was the case - where did the vast amounts of sediment come from that were deposited in the Mfolozi Flats? Did this sedimentation reflect the consequences of natural and man induced changes in the Mfolozi Flats?

E. Baseline Studies - Lake St. Lucia.

Nature has given man a chance to undo all previous management ills, and to start afresh. However, baseline physical studies are of fundamental importance before management decisions can be made. Such studies should include,

1) Bathymetry of the system.
2) Nature of bottom sediment types, and
3) Principal circulation patterns.

There is no conclusive evidence as to whether the various lake compartments are undergoing major changes in depths. If major bathymetric changes are occurring, these could influence circulation patterns, and the erosive potential of wind waves, etc. The important mechanisms in defining bottom configuration include

1) Deposition or erosion due to currents.
2) Erosion of banks due to waves.
3) Progradation of shore/lines (storm beaches in particular).
4) Subsidence due to dewatering and compaction.

Fortunately, a suite of bottom sediment samples was collected by the Natal Parks Board in 1981, additional samples being collected by researchers since then. Such data could be compared to the present sedimentary regime. However, a sediment sampling and shallow coring program should be undertaken immediately, before wind waves mix any new sediment into older material. Typically, lake bottom material is composed of dark grey organic rich silts and clays. Any sediment introduced by rivers, although they may have a grain size distribution similar to lake sediments, would be brown in colour. Such stratification, easily recognized in shallow cores, would give an idea of thicknesses of flood derived sediments.

A base line map of bottom sediment types would be of considerable value to biologists, who would then have an idea of substrate variation within the lake.

Currents in Lake St. Lucia are forced by wind stress. A regular reversal of currents, reflecting changing wind patterns, thus characterizes the system. Such currents play an important part in reshaping islands, shorelines and the like. Secondly, knowledge of major circulation routes is fundamental to understanding movements of biological organisms.

A circulation study should include not only current measurements, but also wind and water level data. In this way a predictive circulation model could be developed. Knowledge of present circulation patterns, when lake levels are high, could eventually be compared to such patterns during low water years.

A base line study, now, would point out the major physical features and driving forces in the Lake St. Lucia system.

CONCLUSIONS.

Nature has recently proved how powerful it is in reshaping man's environment. It has also provided us with the opportunity to re-asses man's activities in the Mfolozi/St. Lucia area and to develop a strict management plan. Lastly, the flood has emphasized that all things biological, are only a response to the physical environment.

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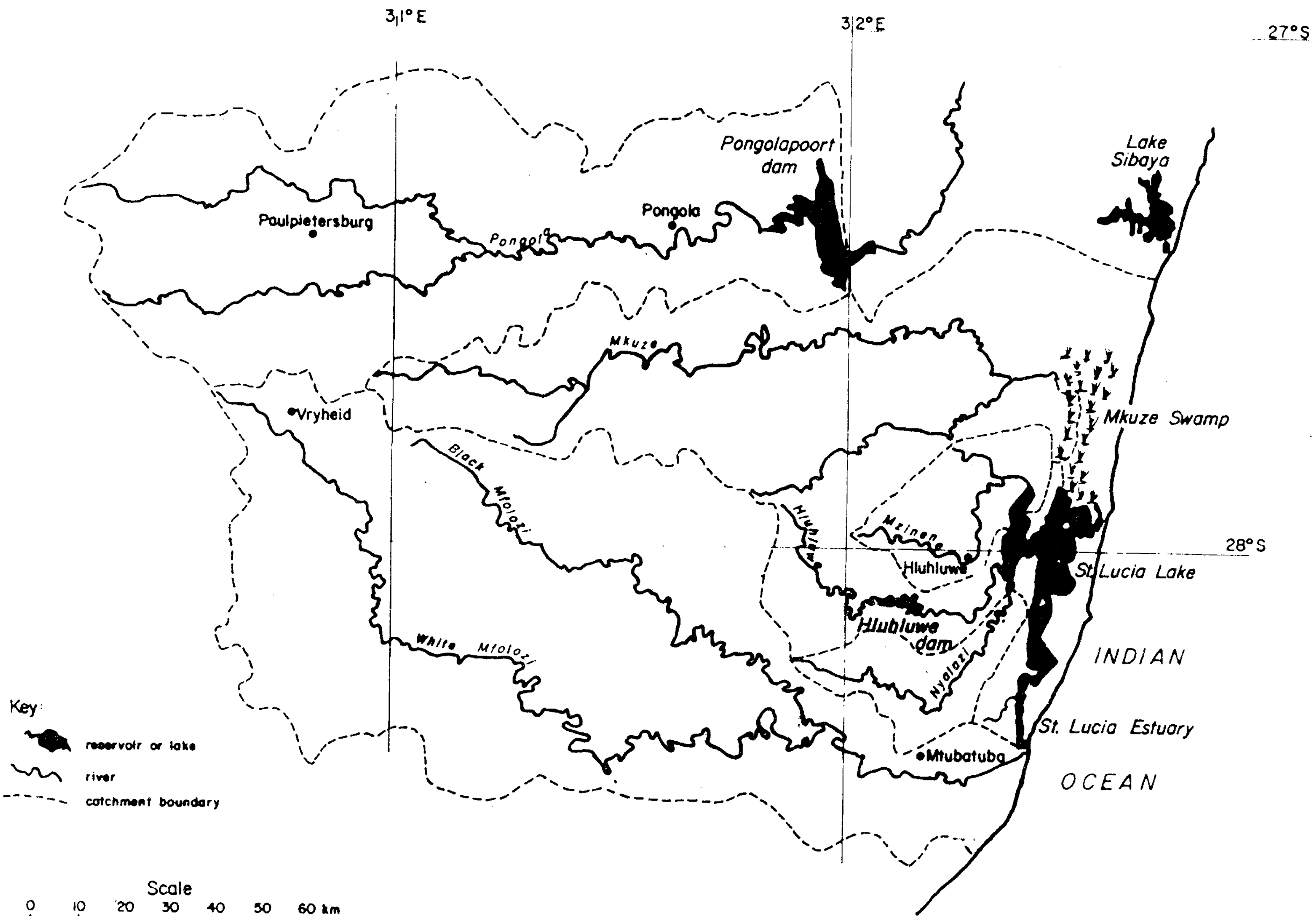
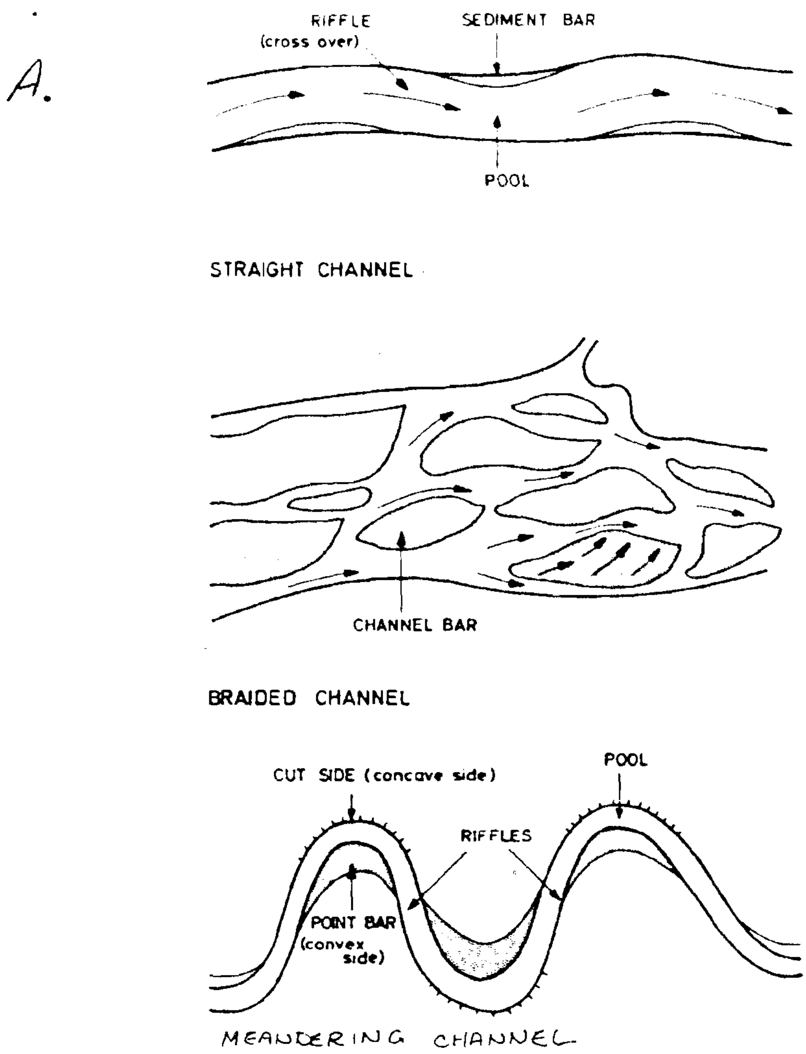


Fig. I THE ST. LUCIA LAKE SYSTEM



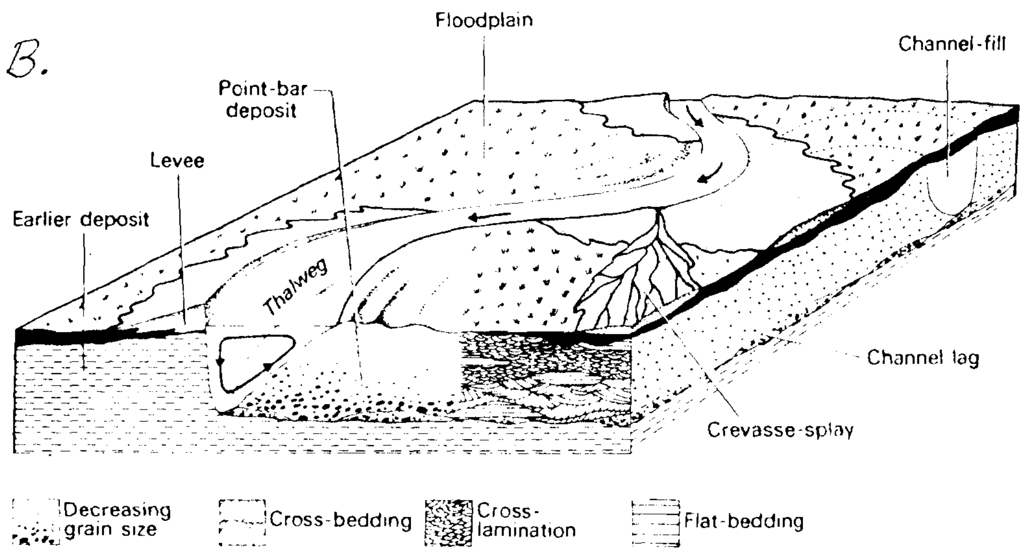


Figure 2.a) Straight, braided and meandering channel patterns. (From Reineck and Singh 1973).
b) Classical point bar model for meandering stream.

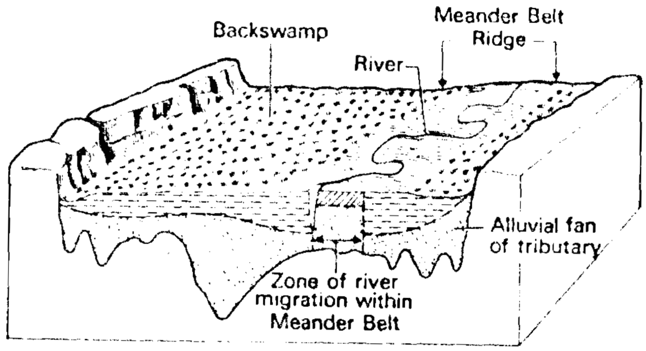


Figure 3. Morphology of coastal fluvial plain.

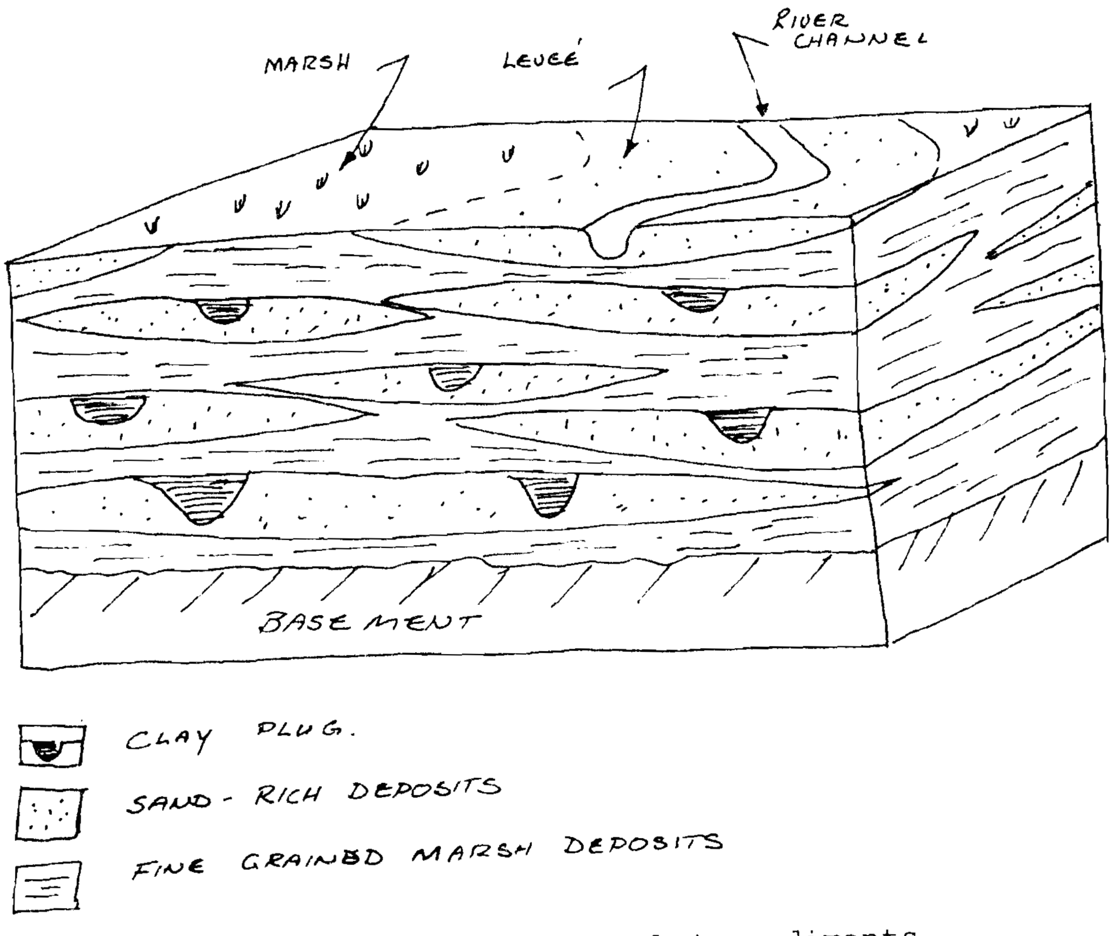


Figure 4. Section of fluvial plain sediments.

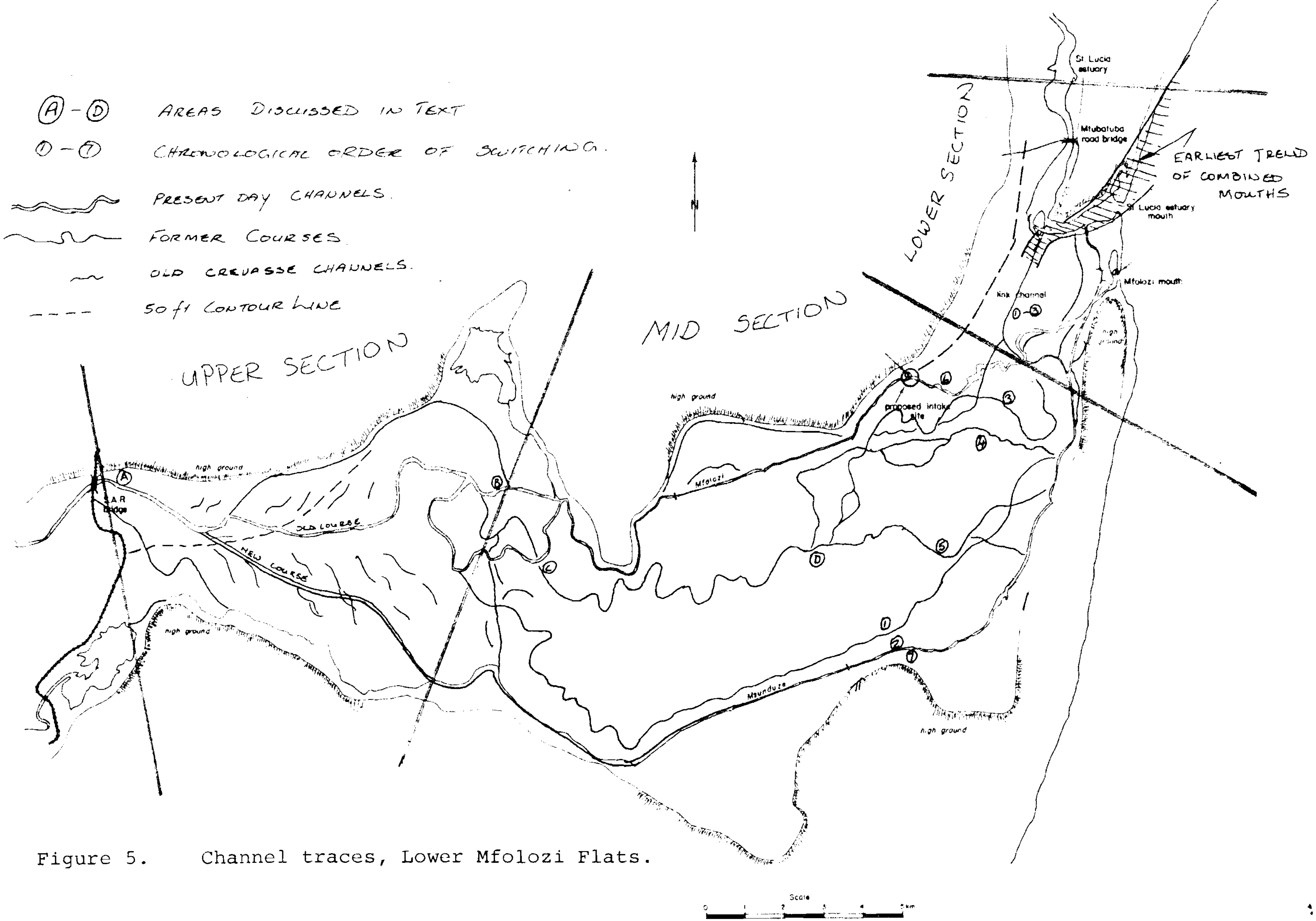


Figure 5. Channel traces, Lower Mfolozi Flats.

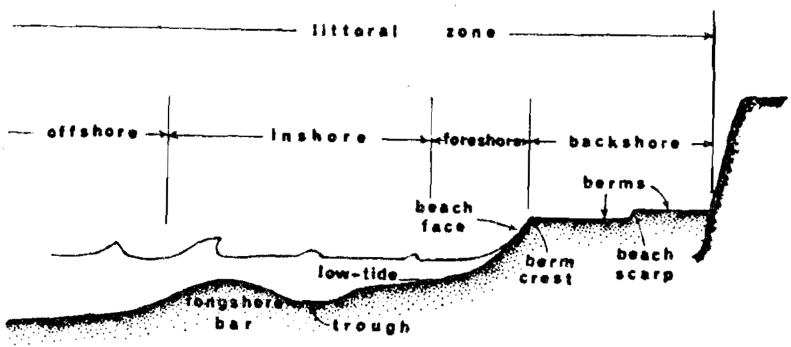


Figure 6. Features of the littoral zone.

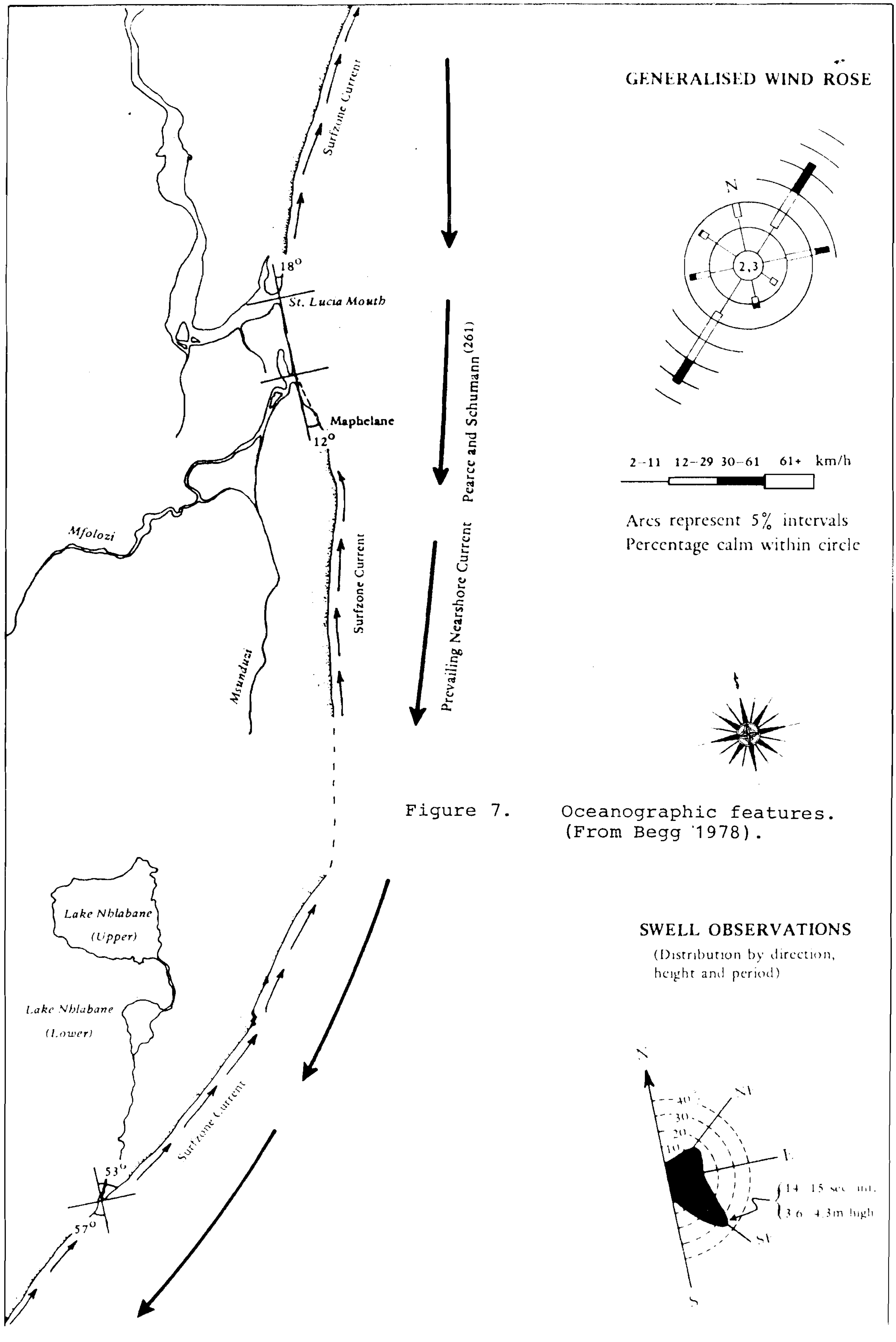


Figure 7. Oceanographic features. (From Begg 1978).

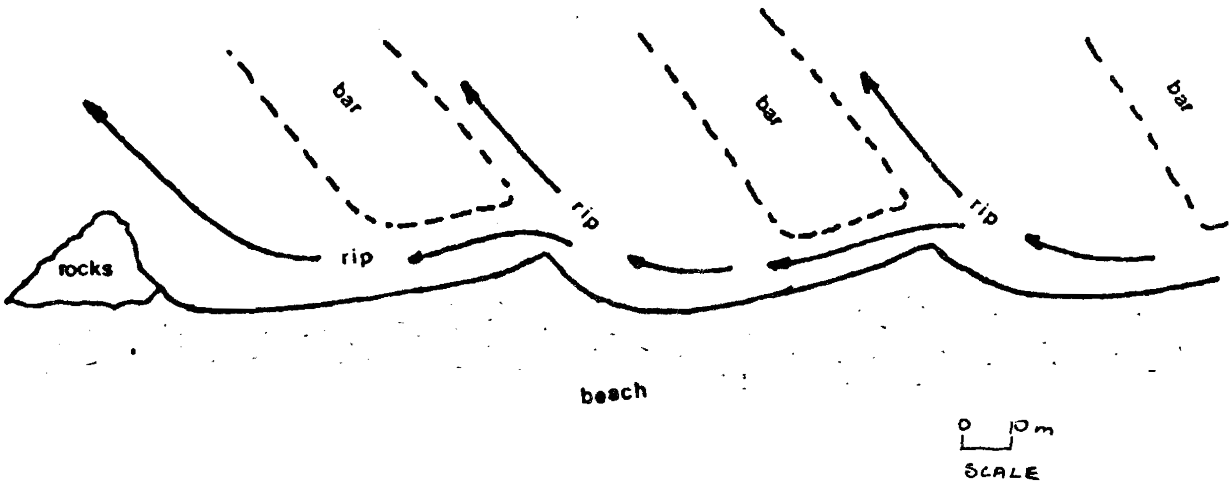


Figure 8. Diagramatic sketch of relationship between rip currents, longshore bars and cuspate horns under the influence of southerly swells.

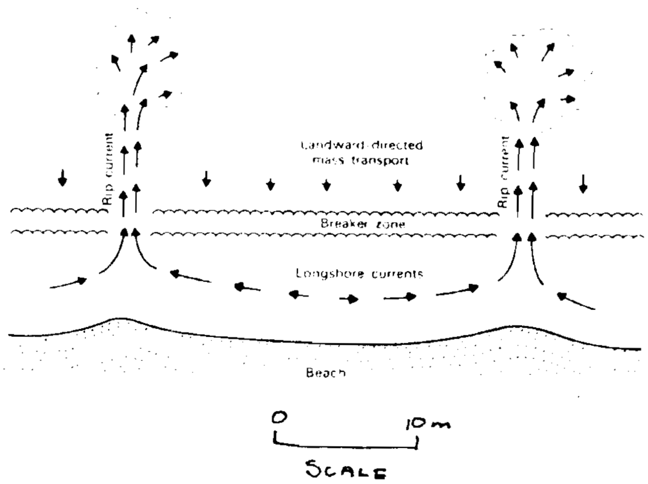


Figure 9. Diagrammatic sketch of relationship between rip currents, longshore bars and beach cusps under the influence of onshore swells.

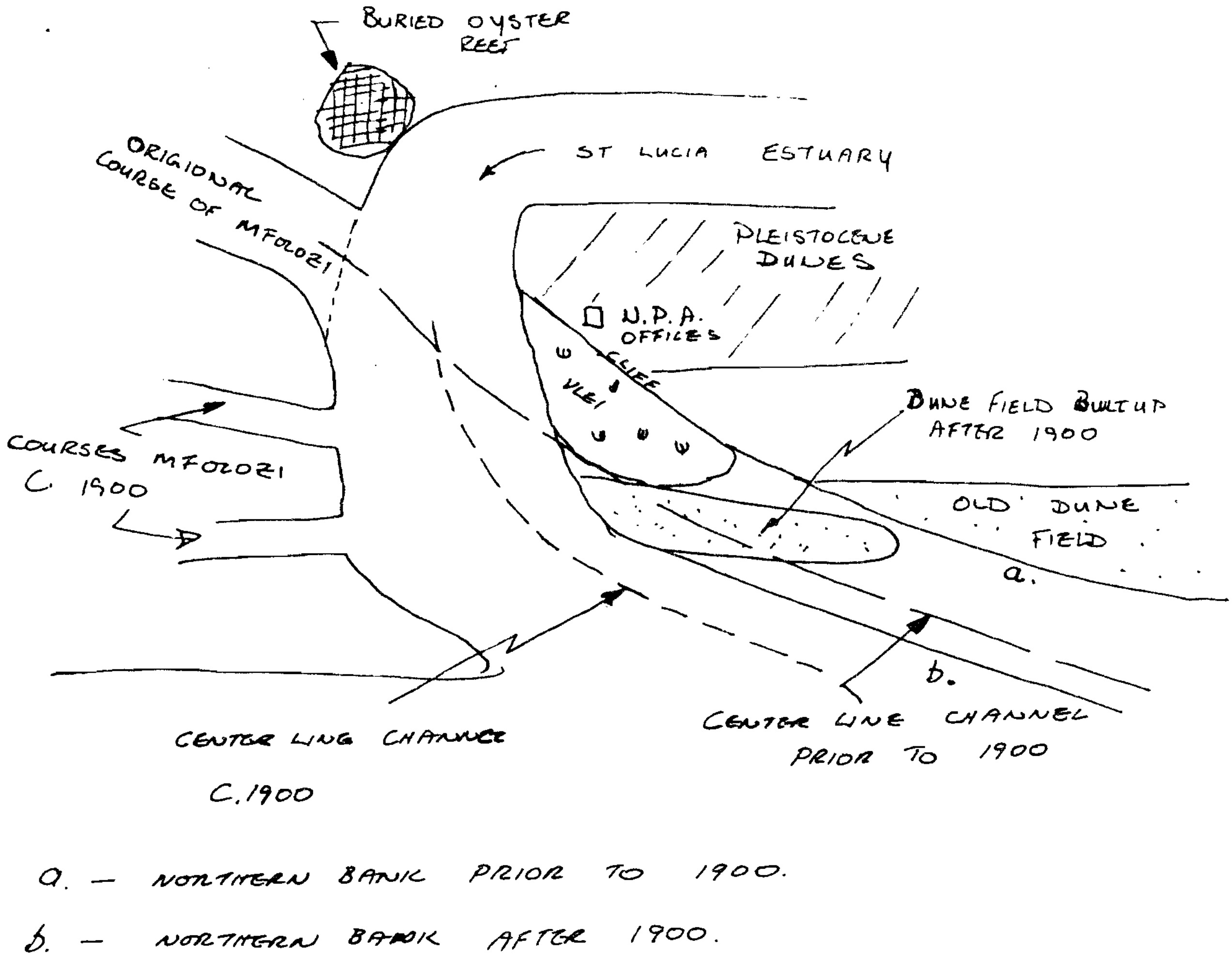


Figure 10. Sketch of changing locations in estuary mouth.

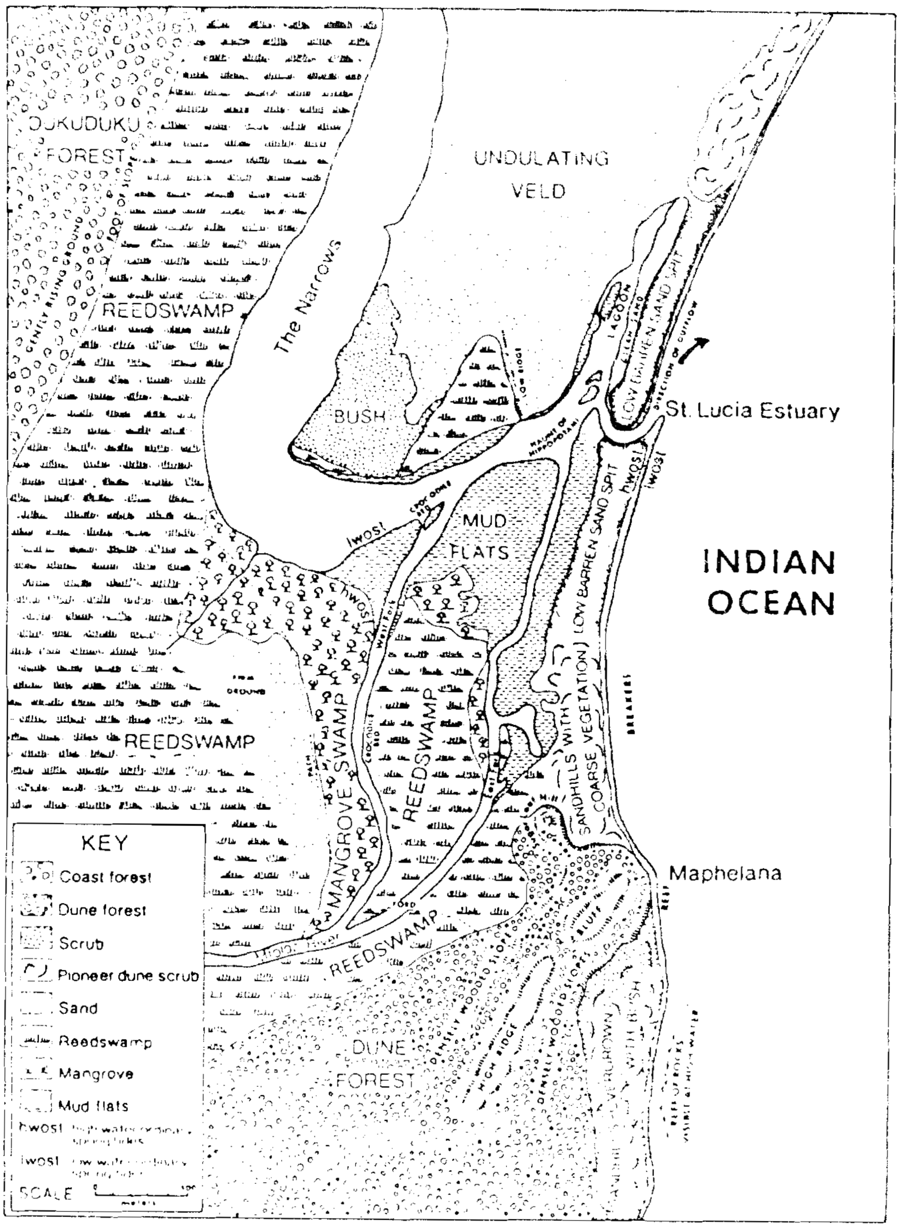


Figure 11. Crofts survey, 1905 (From Begg 1978).

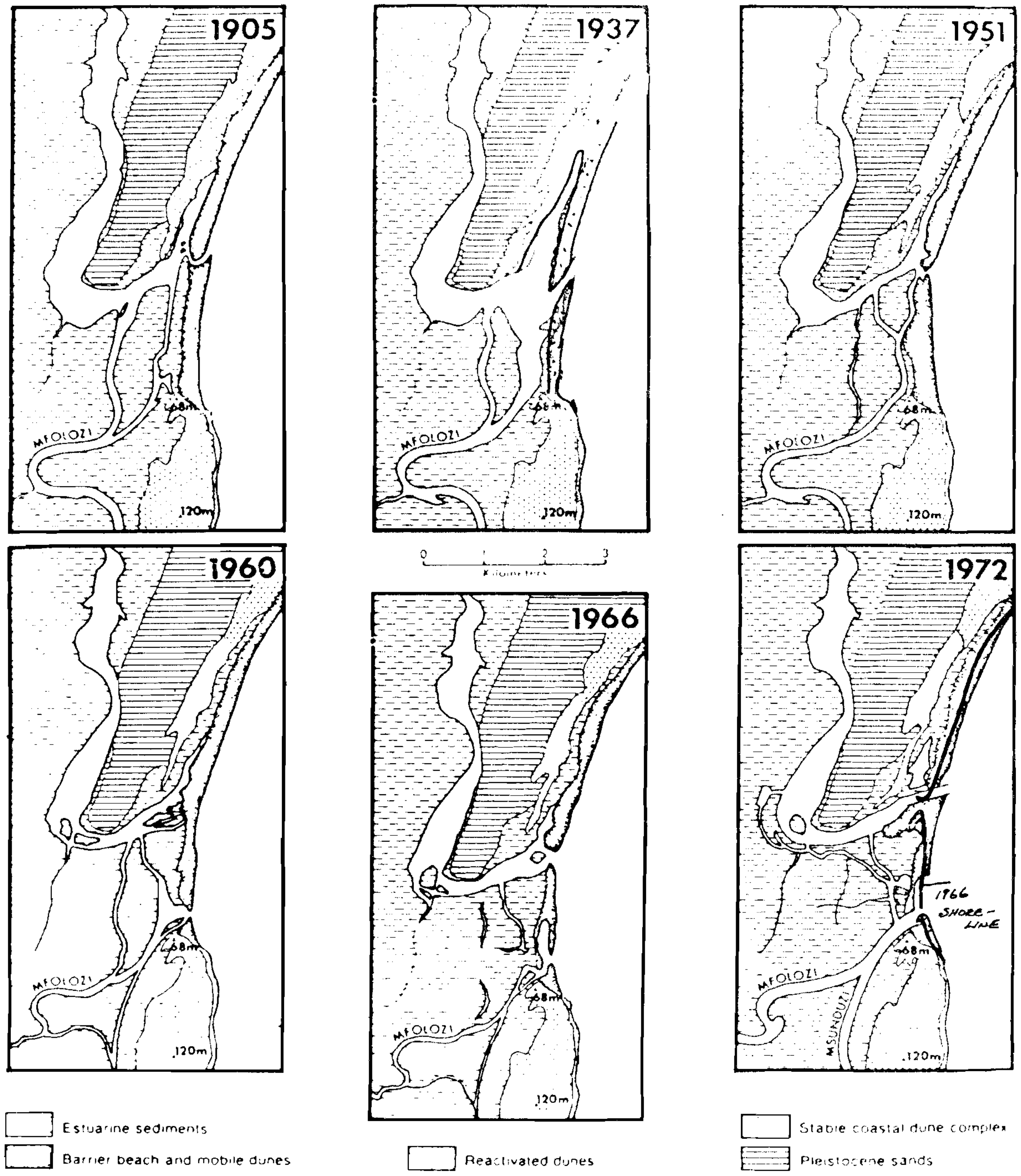


Figure 12. Natural and man-made changes in the St. Lucia and Mfolozi Estuaries; 1905 to 1972 (Modified from Begg 1978).

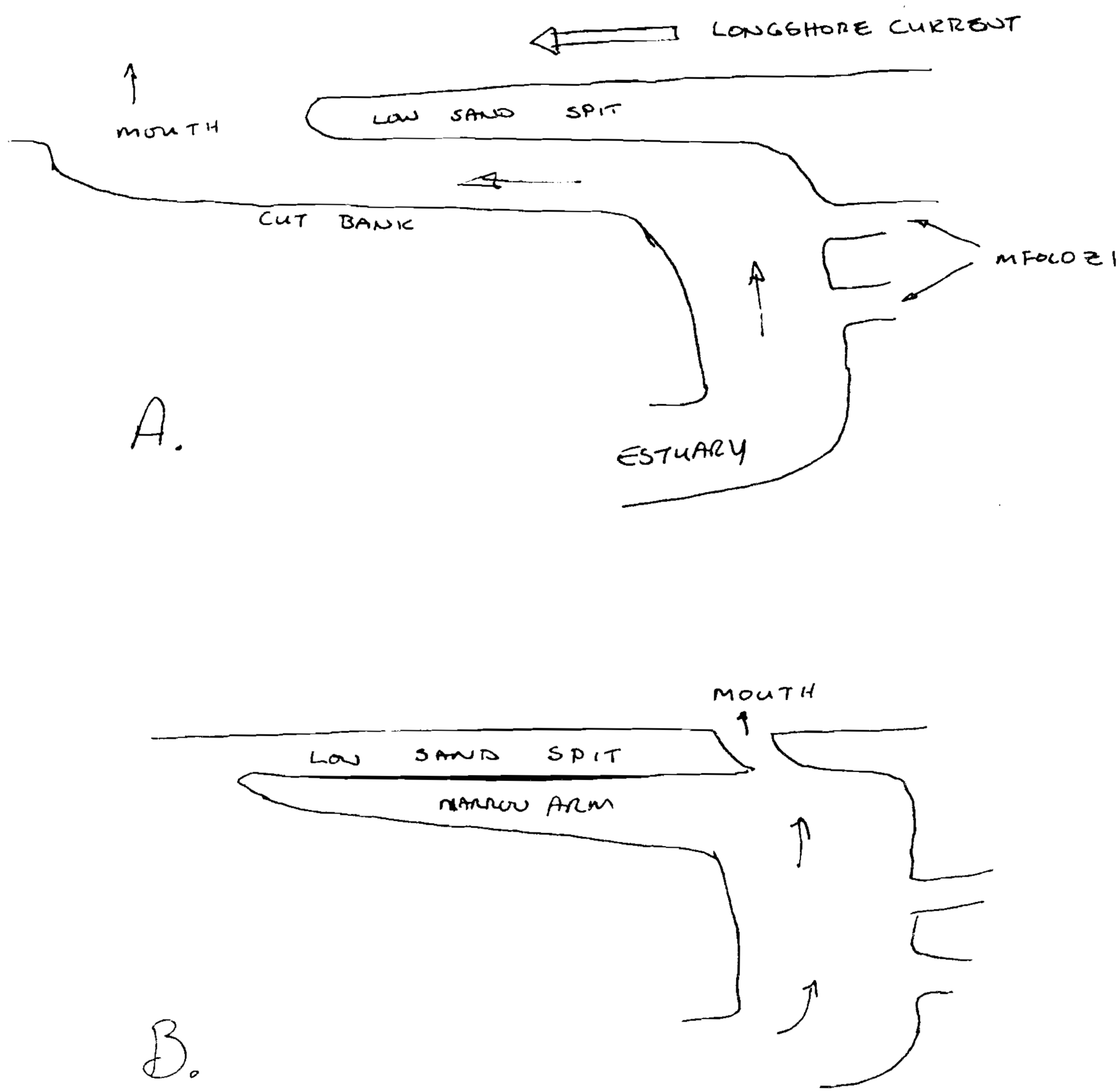


Figure 13. Suggested locations of estuary opening

a. Following large floods.
b. During low flow months.

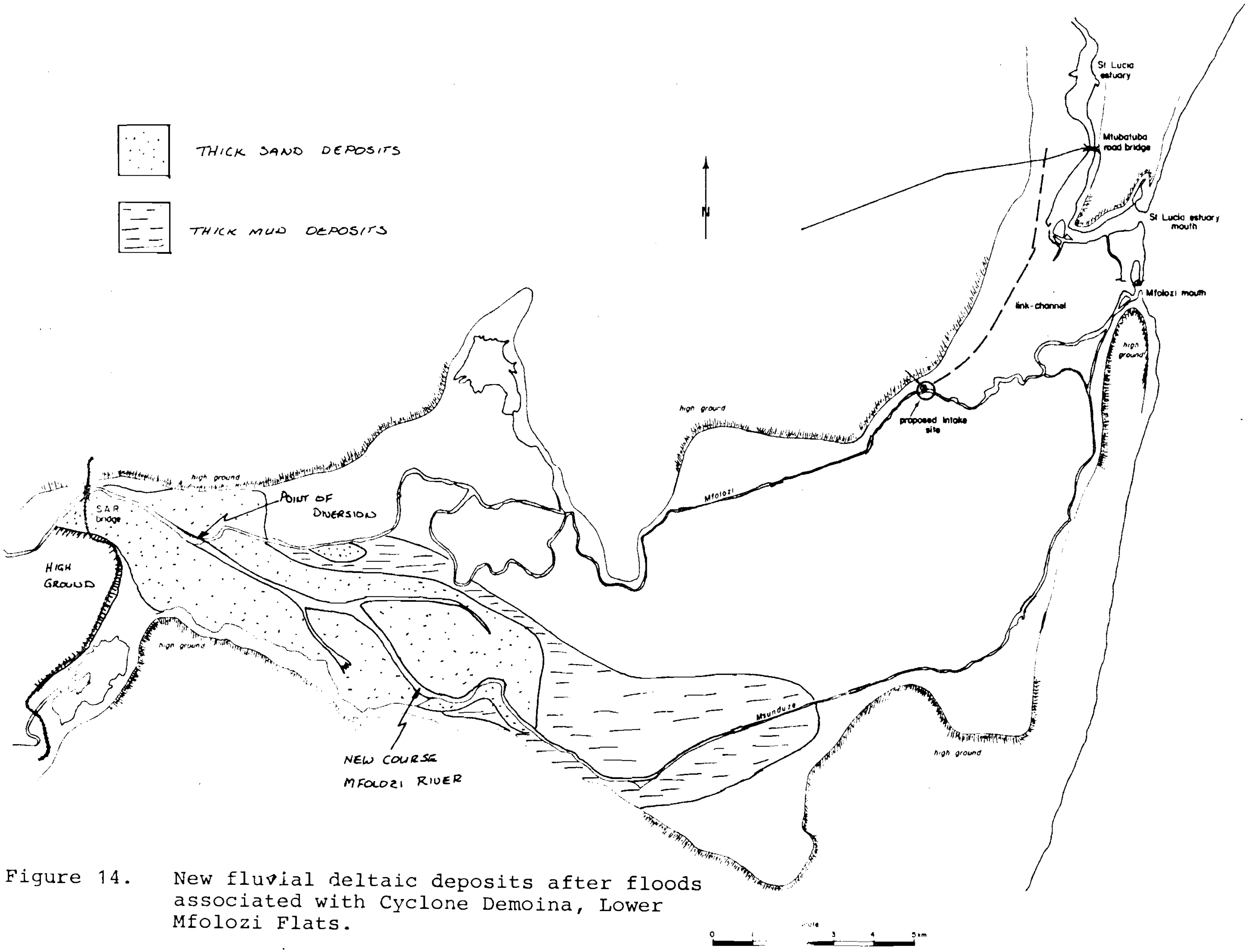


Figure 14. New fluvial deltaic deposits after floods associated with Cyclone Demoina, Lower Mfolozi Flats.