THE IMPACT OF THE SEPTEMBER 1987 FLOODS ON THE ESTUARIES OF NATAL/KWAZULU

A HYDRO-PHOTOGRAPHIC PERSPECTIVE

Earth, Marine and Atmospheric Science and Technology

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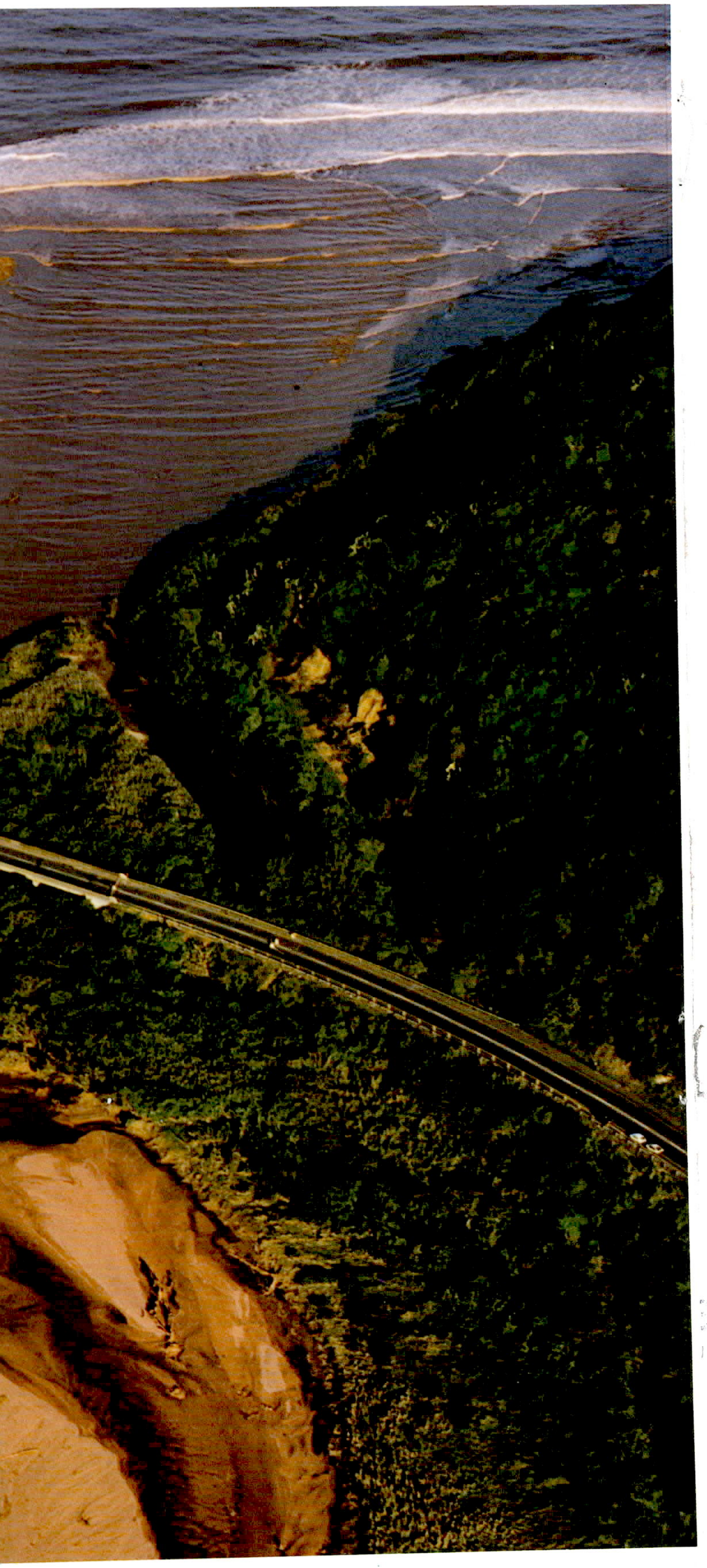

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- Mr C J H Armstrong of Aerial Photographic Service (APS), Pietermaritzburg, took all the 1:30 000 vertical aerial photographs. His 1987 photography, done at the instigation of CSIR, Stellenbosch, was undertaken in far from ideal flying conditions and provides an excellent record of the floods in all the "estuaries" from the Mtamvuna (NS 1) to Kosi Bay (NN 21). The 1985 photography shows pre-flood conditions.
- Mr F Junor (FJ) of Natal Parks Board, Congella, took a series of oblique colour aerial photographs of the "estuaries" from the Mtamvuna (NS 1) to the Mhlatuze (NN 16). They provide a superb complementary record to the vertical photographs of flood conditions.
- Mr E Beesley (EB) of SAPPI-SAICCOR, Umkomaas, took excellent photographs of the Lovu (NS 47) and the Mkomazi (NS 43) during and after the floods. His series of photographs taken at the Old South Coast Road Bridge over the Mkomazi provide an invaluable record of the characteristics of the flood.
- Dr G Begg (GB) of Environmental Advisory Services, Durban, took a valuable series of photographs of the Mdloti (NN 3) and the Tongati (NN 4) while being "trapped" between rivers at the height of the floods on his way to work!
- Mr I Stewart (IS) of Strydom, Newmark and Anthony, Umtentweni, took a few photographs of the Mzimkulu (NS 20) and an interesting series of the Mzumbe (NS 26) in full spate.
- Messrs A McMillan (AM) of the Natal Mercury and L Bloomfield (LB) of the Daily News took the spectacular colour oblique aerial photographs of the Mgeni (NN 1) and the Tugela (NN 11) respectively.
- Mr R Huntington (RH) took the photograph of the bridge over the Mpambanyoni (NS 40).
- Tony Smith Photography (TS), Durban, took the spectacular colour oblique aerial photograph of the SAPPI-SAICCOR factory, Mkomazi (NS 43).
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- The remaining few photographs selected were taken by the writer and colleagues (CSIR).
- Mr Z P Kovács of DWA, Pretoria, kindly made his assessment of peak discharges available to the writer. Further details will be available in the *Documentation of the 1987 Natal Floods* being published by the Department of Water Affairs, Pretoria.

BASIC PHYSICAL GEOGRAPHY

Natal Estuaries

REF.	RIVER	CATCHMENT AREA (km^2)	RIVER LENGTH (km)	ELEVATION OF SOURCE (m above MSL)	RIVER GRADIENT (1:)
NS 1	MTAMVUMA	1 553	162	1 920	84
NS 2	ZOLWANE	7	6,5	259	25
NS 3	SANDLUNDLU	16	7,5	282	27
NS 4	KU-BOBOYI	3	4	107	37
NS 5	TONGAZI	17	8,5	385	22
NS 6	KANDANDLOVU	9	8	290	28
NS 7	MPENJATI	100	18	480	38
NS 8	UMHLANGANKULU	9	6,5	180	36
NS 9	KABA	11	9	220	41
NS 10	MBIZANA	145	26	480	54
NS 11	MVUTSHINI	7	6,5	180	36
NS 12	BILANHLOLO	21	12	240	50
NS 13	UVUZANA	8	2,5	130	19
NS 14	KONGWENI	20	6	180	33
NS 15	VUNGU	124	24	610	39
NS 16	uMHLANGA	38	12,5	340	37
NS 17	ZOTSHA	57	20	415	48
NS 18	BOBOYI	32	14	370	38
NS 19	MBANGO	13	8	139	58
NS 20	MZIMKULU	6 745	329	2 440	135
NS 21	MTENTWENI	50	20	340	59
NS 22	MHLANGAMKULU	11	7	185	38
NS 23	DAMBA	25	11	300	37
NS 24	KOSHWANA	11	6,3	200	32
NS 25	ıNTSHAMBILI	33	12,5	210	60
NS 26	MZUMBE	536	84	933	90
NS 27	MZIMAYI (South)	47	16	240	67
NS 28	MHLUNGWA	32	18	222	81
NS 29	MFAZAZANA	16	10,5	278	38
NS 30	KWA-MAKOSI	16	7	183	38
NS 31	MNAMFU	16	9	233	39
NS 32	MTWALUME	565	85	985	86
NS 33	MVUZI	8	6,5	178	37
NS 34	FAFA	231	66	918	72
NS 35	MDESINGANE	6	5,2	76	68
NS 36	SEZELA	20	12	180	67
NS 37	MKUMBANE	28	14	300	47
NS 38	MZINTO	149	37	520	71
NS 39	MZIMAYI (North)	31	20	178	112
NS 40	MPAMBANYONI	562	100	962	104
NS 41	MAHLONGWA	92	23	430	53
NS 42	MAHLONGWANA	15	6	218	27
NS 43	MKOMAZI	4 310	298	2 650	112
NS 44	NGANE	16	8	219	37
NS 45	uMGABABA	37	14,5	244	59
NS 46	MSIMBAZI	35	16	244	66
NS 47	LOVU	893	135	1 280	105
NS 48	LITTLE MANZIMTOTI	18	15	165	91
NS 49	MANZIMTOTI	39	11,6	274	42
NS 50	MBOKODWENI	283	59	732	81
NS 51	SIPINGO	51	27	328	82
NS 52	MLAZI	972	82	914	90
NS 53	NATAL BAY				
NN 1	MGENI	4 432	232	1 829	127
NN 2	OHLANGA	118	28	324	86
NN 3	MDLOTI	527	81	854	95
NN 4	TONGATI	436	50	747	67
NN 5	MHLALI	304	46,5	580	80
NN 6	SETENI	16	5	61	82
NN 7	MVOTI	2 829	197	1 479	133
NN 8	MDLOTANE	43	13	122	107
NN 9	NONOTI	210	37,5	488	77
NN 10	ZINKWASI	73	22	229	96
NN 11	TUGELA	29 101	405	3 109	130
NN 12	NYONI				
NN 13	MATIGULU	995	96	762	126
NN 14	SIYAYA	18	8	59	136
NN 15	MLALAZI	492	54	549	98
NN 16	RICHARDS BAY				
	MHLATUZE	3 670	209	1 265	165
NN 17	NHLABANE	104	12	43	279
NN 18	MFOLOZI	10 075	395	1 646	240
NN 19	ST. LUCIA				
NN 20	MGOBEZELENI	33	6	15	400
NN 21	KOSI	≈500	30	75	≈400

Flats before discharging into the sea at the mouth of the Sipingo river). The canal structures themselves may be damaged and/or overtopped with resulting inundation (see, for example, NS 52 photos).

Channelling measures, for example those involving the protection of one bank as in the case of the approaches to the new freeway bridge on the Lovu (see NS 47 photos) are less restrictive in times of major floods and, like groynes, can usefully do their protective jobs. However, they also have an effect on the river course and scouring upstream, locally and downstream of the structure.

■ Dams

Dams are not a major factor at this stage of development in Natal/Kwazulu. Only 15 (21%) of the rivers are affected and in several of these cases the dams are small and/or are situated in the upper reaches of the catchment. On two smaller rivers (NS 37 and NS 45) there are dams close to the "estuary" which effectively trap silt loads during major floods. The few dams on larger rivers are further upstream, allowing sufficient length of river course downstream for picking up ample silt supplies.

The attenuation of floods is negligible if the flood volume exceeds the storage capacity of the dam, as was the case with the Hazelmere Dam on the Mdloti (NN 3) during the September 1987 floods. No dam had a marked influence on the Natal "estuaries" during the September 1987 floods. There are two that might have a marked effect during future major floods, these being: (i) the Inanda Dam at present under construction on the Mgeni (NN 1) and the proposed Mvumase/Sunbury dams on the Tugela (NN 11). Once these dams are full, the effect on the "estuaries" will depend upon management release policies.

N.B. Regarding human influences on floods, it should be noted that most of the effects of major floods on the "estuaries" of Natal happen with or without man's influence. However, the rate of some responses to floods, such as siltation and aggradation in the lowest river reaches, has increased with the spread of agriculture. Furthermore, there is damage to property and structures – even loss of life during major floods with conurbation, industry and supporting network of roads and railways etc.

CONCLUSION

The September 1987 major floods affected many of Natal/Kwazulu's "estuaries", in particular 11 of those which are fed by larger catchments. Although in detail no two floods have the same characteristics, the fairly frequent major floods to which these "estuaries" are subject show a predictable pattern of behaviour according to antecedent soil moisture conditions and flood-producing rains over the catchments. Human factors such as land-use and structures must also be considered.

Aerial photography of these fluvio-dominated "estuaries" reflects their geomorphology and hydrology, providing a detailed record of forces affecting the "estuaries" – especially the dominant influence of MAJOR FLOODS.

J. E. PERRY
CSIR, STELLENBOSCH JUNE 1989

ABBREVIATIONS

DWA	Department of Water Affairs
MSL	Mean Sea Level (Land levelling datum)
cumecs	cubic metres per second

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INTRODUCTION

These brief notes are intended to give some background information for the photographs that follow. It has been endeavoured to place these floods in perspective both temporally and spatially and to provide information that may be of use to town and regional planners

The following questions are addressed:

- how severe were the floods?
- how normal/abnormal were they?
- which were the worst hit "estuaries"?
- are the hydrological effects of the floods temporary or permanent?

A locality map and a list of the "estuaries" of Natal/Kwazulu appear on page 1. Of the 74 "estuaries" listed, one is an embayment (Natal Bay, NS 53), another is now a concrete-lined canal (Mlazi, NS 52) while the Matigulu (NN 13) captured the Nyoni (NN 12) in a previous flood in 1971. Of the remaining 71, only 13 are estuaries in the true sense of the word, while a further five display "estuary" and "river mouth" characteristics. The latter differentiation is important with regard to the recent major floods. An "estuary" may become a "river mouth" temporarily during seasonal and/or episodic floods when its high discharge precludes any marine, saline influence. Or, the scour and fill process during many floods over the years will – given the ample silt supply of Natal's rivers and steep gradients near the coast – result in aggradation of the bed of the "estuary". When bed levels reach + 1m to MSL near the mouth, tidal influence and resulting salinity are precluded and the "estuary" is better called a "river mouth". The remaining 53 so-called estuaries only show estuarine characteristics to a limited degree because their mouths are closed for 20-99 per cent of the year. They are known as "lagoons"

The eighteen "estuaries" selected for this report, with the exception of the Mlazi Canal, all show estuarine characteristics to some degree and include those 11 "estuaries" where damage and/or inundation were the most severe (see page 1). The photographs are arranged according to their NS/NN reference number.

EXTENT AND SEVERITY OF THE FLOODS

Widespread heavy sustained rainfall for five days from the 25th September 1987 resulted in major flood flows by the afternoon of the 29th September 1987. The rivers most severely affected were those with larger catchments extending well inland between the Mzimkulu (NS 20) and the Mhlatuze (NN 16). Catchment areas, together with allied physical geography data, are given on the inside front cover. Spatially, how do previous major floods compare? Cyclones generally affect the northern "estuaries" more severely and during cyclone Domoina in January 1984 the Mfolozi (NN 18) and St Lucia (NN 19) estuaries were the worst hit. The March 1976 floods were fairly widespread as were those of March 1925, October 1917 and April 1856. The floods of July 1963 mainly affected the "estuaries" from the Mhlatuze (NN 16) northwards while the major floods of May 1959 affected the whole Natal South Coast (NS 1-NS 52).

The principal criterion by which to judge the severity of a flood is the peak discharge. With the exception of the Mzumbe (NS 26) all peak discharges shown with the photographs in this report have been derived for the whole of each catchment area from assessments at DWA stations by Kovács (pers comm). An estimate for the Mzumbe is given by the writer in the light of water levels and an earlier physical model study. In order to place the 1987 peak discharges (given in bold, in parentheses below) in perspective with earlier floods the following brief notes are given for each selected "estuary".

Mtamvuna, NS 1 ($\approx$2680 cumecs): similar flood flows occurred in March 1976 and November 1936. The peak flow in May 1959 was higher, $\approx$3340 cumecs.

Mzimkulu, NS 20 ($\approx$5600 cumecs): the May 1959 peak was again higher, $\approx$6510 cumecs and flood flows similar to those of 1987 were probably reached in March 1976 and March 1925.

Mzumbe, NS 26 ($\approx$1200 cumecs): the May 1959 peak was again higher ($\approx$1320 cumecs). Similar major floods occurred in October 1917, March 1925 and March 1976.

Mtwalume, NS 32 ($\approx$850 cumecs): the February 1985 flood is the maximum on record, $\approx$1000 cumecs and the May 1959 peak discharge was $\approx$992 cumecs. Similar major floods occurred in April 1856, October 1917, March 1925 and March 1976.

Mpambanyoni, NS 40 ($\approx$1240 cumecs): the May 1959 flood was once again higher, $\approx$1350 cumecs. Similar major floods occurred in April 1856, October 1917, March 1925 and March 1976.

Mkomazi, NS 43 ($\approx$6900 cumecs): the April 1856 flood is the maximum on record, $\approx$7000 cumecs, and the May 1959 flood peak discharge was $\approx$6200 cumecs. From peak water levels indicated on cross-sections at the Old South Coast Road Bridge (5,5 km from the mouth), similar major floods occurred in March 1925 and in 1868. Records in the Natal Archives refer to a major flood in October 1917 but there are no data to indicate its magnitude. The March 1976 peak discharge was considerably lower, $\approx$2140 cumecs.

Lovu, NS 47 ($\approx$1800 cumecs): the March 1976 flood is the maximum on record, $\approx$2000 cumecs, and the May 1959 peak discharge was similar to that of 1987, 1760 cumecs. A 1928 cross-section of the Steel Bridge at the Illovo Sugar Mill gives a highest known flood level, probably that of March 1925, which indicates a peak flood discharge a little lower than those of 1959 and 1987. Archival data give reference to a major flood in 1869 but no information to indicate its magnitude.

flood (a matter of days or at the most a few weeks). In the longer rivers, following the formation of the outer bars, spits often form in an atypically northerly direction. These spits then migrate shorewards and the more normal southerly-extending spits re-form. This may take some months. It may, therefore, be a matter of days, weeks or even months before "normal" siltation patterns are seen again in the "estuaries" after major floods and before natural beach replenishment occurs in the vicinity of the mouths.

A RÉSUMÉ OF HUMAN FACTORS AFFECTING FLOODS

■ Bridges and Embankments

Bridges constrict the river width during major flood-flow conditions. The resultant deeper scour affects piers and can present a design problem in the "estuaries" of Natal where bedrock often occurs at depths exceeding 50 m below MSL (see NS 47 and NN 3 photos). Bridge embankments across the flood plain lead to an increase in meander development upstream of the bridge under normal flow conditions (see NN 3 pre-flood photo) and during floods they inhibit the downstream progression of meanders. Furthermore, siltation is increased.

■ Stabilization of the Sand-spit at the Mouth

If structural stabilization is carried out to protect bridge approaches, the natural flood course straight out to sea is inhibited, beneficial flushing out is restricted and siltation increased (see NS 26 photos).

■ Loss of Natural Vegetation

The destruction of riverine vegetation anywhere in the catchment leads to bank erosion during floods and increased siltation in the "estuaries". The drainage of swamp areas has led to a loss of natural sediment traps in times of major floods. This in turn has had the detrimental effect of increased siltation in the "estuaries" (see, for example, NN 16 photos).

■ Land-use (Abuse!)

Land-use malpractices in the whole catchment include cultivation to the river banks and random removal of bush/tree vegetation. These factors, linked with those in the paragraph above, affect river discharge (increasing flood magnitude and frequency) as well as river courses and cause increased siltation in the "estuaries".

■ Canalization, Channelling and Groynes

A river does not welcome these restrictions to its course. It needs "room" for some lateral shift, progression of meanders and for siltation areas during major floods. Straight earth canals were dug on the Mzumbe (NS 26) and Lovu (NS 47) in the 1960s to protect structures. These were soon silted up and the rivers reverted to their natural meandering courses. Where canals are vital for the protection of major structures such as airports and planned industrial development (as on the Mlazi, NS 52 and the Mgeni, NN 1) they are concrete-lined and more permanent. However, during major floods, allowances must be made for the increased velocities resulting from the shortened river course, and increased siltation – often in a more restricted area (the Mlazi, for example, used to be able to deposit much of its silt load over the Isipingo degradation of the channel bed; debris etc. What is the duration of these effects/results? Some, such as standing waves and inundation of the limited flood plain areas are, understandably, relatively short-lived. However, these effects together with the damage to property and bridges are felt long afterwards in terms of human suffering and financial loss. These aspects are outside the scope of this review but a few hydrological comments are pertinent. The "estuaries" of Natal and their limited associated flood plain areas are in a belt which is popular for human settlement, tourism and sugar cane cultivation. It should be remembered that these flood plains are indeed active. The land, especially areas below approximately + 6 m to MSL, is at flood risk. The construction of permanent dwellings (of which there are fortunately few) should not be allowed in such areas. Farmers, naturally wanting to take advantage of rich alluvial stretches, must allow for fairly frequent flooding. In the same way, allowances must be made by land owners and personnel involved with tourism regarding their semi-permanent buildings and structures near the rivers. Conurbation and industrialization in areas such as Durban can present costly planning problems in the aftermath of major floods. There is a high price to pay for canalization and development in such areas as the Isipingo and Springfield Flats.

Some of the effects of the floods are not so dramatic but are none the less important. Changes in river courses may be short-lived but in several cases during the "wet floods" of September 1987 the newer straighter courses (see NS 47 and NN 7 photos) may persist for years. This changes the direction of flow towards bridge piers and channelling structures. Where approach embankments for bridges across the flood plain lie in the flood path of a river such as in the Mdloti (NN 3) estuary, breaching of the embankments can be expected during major floods. Protection measures may be deemed necessary such as those existing on the stabilized spit at the mouth of the Mzumbe (NS 26). The "normal" more sinuous/meandering river course of e.g. the Lovu (NS 47) and Mdloti (NN 3) will re-develop, given a few "normal" seasons.

The scour and fill process leading to net aggradation/degradation has been described and referred to several times in the sections above. The importance of the net aggradation/degradation in the aftermath of the floods should be stressed. In the short term, any lowering of the bed levels will result in a longer estuarine length (more salinity, increased tidal influence). Cross-sections surveyed by my CSIR colleague Mr L van der Merwe in the Mvoti (NN 7) estuary after the September 1987 floods showed some degradation. However, as already stated above, these effects will probably be short-lived. Furthermore, subsequent aerial photography in May 1988 reveals that the well-established, vegetated islands in the lowest reaches of the Lovu (NS 47) and Mgeni (NN 1) which were eroded and washed away during the September 1987 floods are already reforming. Planners should bear in mind that the apparent rejuvenation of some "estuaries" caused by the flushing out during the recent floods will be short-lived. The general long-term trend of a net aggradation after floods in Natal still holds good. They therefore have a "resource" for planned development and/or conservation which is becoming progressively more fluvio/fresh water dominated. The sub-aerial deltas in the upper reaches of the "estuaries" are progressing closer to the mouth with each major flood. Conditions at the mouth also affect the siltation processes in the "estuaries". In approximately 70 per cent of the "estuaries" the mouths will soon close again after a major

Mlazi, NS 52 (≈ 1430 cumecs): this 1987 discharge was similar to that of May 1959, ≈1400 cumecs, the maxima on record. Major flood flows occurred in March 1925, October 1917 and April 1856. Lesser floods occurred in March 1976, November 1943, June 1935 and March 1925.

Mgeni, NN 1 (≈ 5250 cumecs): the October 1917 flood was slightly higher, ≈5700 cumecs but the maximum on record is probably April 1856, ≈6000 cumecs. Lesser floods occurred in March 1976, November 1943, June 1935, 1893 and 1868.

Mdloti, NN 3 (≈ 2130 cumecs): this 1987 flood is probably a maximum. Lesser flood flows occurred in March 1976 (≈ 550 cumecs). Major floods occurred in June 1935 and March 1925 but details are lacking.

Tongati, NN 4 (≈ 1520 cumecs): the October 1917 peak discharge was the maximum on record, ≈ 2854 cumecs. Flood flows similar to those of 1987 occurred in February 1985, March 1978, March 1976, January 1953, June 1935 and March 1925.

Mvoti, NN 7 (≈ 5530 cumecs): this 1987 flood is the maximum on record. A flood of ≈ 3200 cumecs occurred in January 1974 and a flood of ≈ 2150 cumecs occurred in 1913. Major flood flows occurred in December 1944 but no peak discharge is available. Lesser flood flows occurred in March 1976, June 1940, March 1925 and October 1917.

Tugela, NN 11 (≈ 9440 cumecs): the March 1925 flood was higher, ≈15170 cumecs. Other major flood flows occurred in December 1956, January 1934 and November 1921. Lesser floods occurred in March 1976, February 1955, February 1953, April 1943 and February 1939.

Nyoni/Matigulu, NN 12/13 (≈ 4780 cumecs): this 1987 flood was probably a maximum. Other major flood flows occurred in March 1976, May 1971 (when the Matigulu captured the Nyoni), December 1956, May 1940 and March 1925 but details are lacking. In January 1984 the peak discharge was ≈1431 cumecs.

Mlalazi, NN 15 (≈ 1600 cumecs): the 1987 flood is probably a maximum, although possibly the March 1925 flood was similar. A major flood also occurred in February 1932 and lesser floods occurred in June 1935, May 1940, December 1956, December 1960, April 1961 and March 1976.

Mhlatuze, NN 16 (≈ 4440 cumecs): this 1987 flood is probably a maximum. During cyclone Domoina, January 1984, a peak of ≈ 2960 cumecs occurred and similar peaks were reached in February 1977 and July 1963. Other major flood flows occurred in December 1956, March 1925 and April 1856 but details are lacking.

Mfolozi, NN 18 (≈ 4700 cumecs): during cyclone Domoina, January 1984, the maximum peak on record occurred, ≈16730 cumecs. The February 1977 and July 1963 floods were also higher than the September 1987 flood (≈ 8000 cumecs). Lesser flood flows occurred in October 1957, March 1925 and April 1856.

Kosi Bay NN 16 No discharge or simulated run-off data available and Kosi Bay is outside of the area seriously affected by the September 1987 floods: the photo of this northernmost estuary was selected to show a lake-linked system which is well able to absorb lesser floods.

From the above it is clearly seen that major floods are a far from uncommon occurrence in Natal/Kwazulu: in general four or five have occurred in all rivers over the last 100 years. Regarding the severity of the September 1987 floods, only in three "estuaries" were the peak discharges the maxima on record (Mlazi – joint maximum, Mdloti, and Mvoti). In three others (Nyoni/Matigulu, Mlalazi and Mhlatuze), the 1987 peak discharges were probably also maxima or joint maxima. However, the affects were doubtless felt more severely because (i) since the earlier devastating floods of for example 1856 and 1917, the population had greatly increased and the infrastructure (roads, railways, bridges etc.) had markedly developed and (ii) the floods occurred in more densely populated and more developed areas of Natal.

ANTECEDENT CONDITIONS AND THE HYDROGRAPH SHAPE

These criteria are as important as peak discharge when considering the nature, severity and effects of major floods. For any given major peak discharge, flood characteristics will vary as follows:

■ **Antecedent conditions in the catchment**
In dry conditions, particularly after a prolonged drought, there is more sediment available for removal by the rivers. In the case of Natal, with steep gradients and a virtual lack of coastal plain, the first major check on river flood-flow velocities is close to the coast. Here deposition occurs, deposition which is greater during these so-called **"dry floods"** (incongruous yet apt!). The floods of May 1959 and Domoina (1984) fall into this category.

By contrast **if catchment antecedent soil moisture conditions are wet** (following period of sustained heavy rainfall, particularly in a wet phase) there will be less sediment available for removal by the rivers. There will still be some deposition on the limited plain areas of the "estuaries" but these so-called **"wet floods"** are characterized by deeper scouring of the river bed. The September 1987 major floods were of this type as were those of April 1856, March 1925 and March 1976.

■ **The shape of the hydrograph**
It is not only the overall duration of the flood which is important but also the duration of the rising limb, near-peak conditions and the recession limb.

Duration of the rising and falling limbs of the hydrograph is of special importance to the river banks and to structures on or channelling of the banks. Our physical river model studies have shown that the maximum "attack" on the outer bend of any meander occurs approximately two thirds up the hydrograph, i.e. before (and after) the river course has straightened when maximum velocities then occur "mid valley"/"mid-flood path". If the recession is prolonged, outer river banks are particularly vulnerable as the ground is then saturated. The 1987 floods were of this type. By contrast, the rising and falling limbs of the May 1959 floods were of short duration.

The duration of peak and near-peak conditions is of prime importance. In the relatively narrow "estuaries" of Natal, major floods result in the whole valley being inundated. The havoc wreaked by inundation for one or two days is considerable (sugar cane fields, roads and in some cases badly-sited buildings!). Furthermore, if near-peak flow conditions are prolonged, there is a subsequent longer period of maximum velocities, standing waves

(often 1-3 m high) and debris-laden rivers in full spate. This can cause problems at bridges where major flood peaks are often at or near girder bed level (see, for example, photos for NS 43 and NN 3). At river bed level the position may be even more serious as a result of deep scouring, particularly in the case of the prolonged "wet flood" of September 1987 (see the several photos of damage to bridge structures). Prolonged near-peak conditions may also bring about considerable changes in a river course – again particularly during a prolonged "wet flood" (see for example, NS 47 and NN 7 vertical photos). In the case of shorter duration major floods, the river usually returns to its pre-flood course fairly quickly.

RIVER MOUTH CONDITIONS

Man-made constructions allowing, rivers tend to take the shortest possible course to the sea during major floods. Therefore the sand-spits which divert the courses of many of Natal's rivers are breached, resulting in:

■ wide-open mouth conditions in approximately the same position as under "normal" conditions (e.g. see NN 1 and NN 16 photos) or

■ a new temporary mouth quite far to the North or South of the "normal" position (e.g. see NN 7 and NN 12/13 photos). If near-peak and/or falling limb conditions are of long duration, as in September 1987, the wide-open mouth or new mouth conditions will understandably also persist longer.

Two characteristics of all major floods in Natal with a marked visual impact in the environs of the river mouths are:

■ silt plumes and ■ debris.

The silt plumes often extend more than a kilometre out to sea and several kilometres along the coast, usually in a northerly direction with the dominant littoral drift (see, for example, NS 20 and NN 3 photos). Initially, however, during the September 1987 floods the silt plumes extended to the South owing to prevailing wind and swell conditions along the Natal North Coast (see NN 4 photo). Huge piles of debris brought down by the rivers are deposited on the beaches at, or in the vicinity of, the river mouths (see, for example, NN 1 and NN 4 photos).

At the mouths of the longer rivers, such as the Mkomazi (NS 43), Mgeni (NN 1) and Tugela (NN 11) a substantial outer bar forms as fluvial silt is deposited with the check on velocities where the river meets the ocean. Subsequent bar development is discussed in the following section.

THE AFTERMATH OF THE FLOODS

The photographs show many of the hydrological effects and results of the 1987 floods mentioned in this brief review: changes in river courses; river mouth position; standing waves; "attack" on river banks, structures and buildings; inundation and siltation on the flood plain; scour and fill processes leading to net aggradation or

THE POWER OF NATAL'S MAJOR FLOODS

Major floods are a dominant feature of the estuaries of Natal/Kwazulu.
This review, prompted by the September 1987 floods, aims to:

- provide a documentary record;
- try to place these floods in perspective both temporally and spatially;
- provide information for town and regional planners.

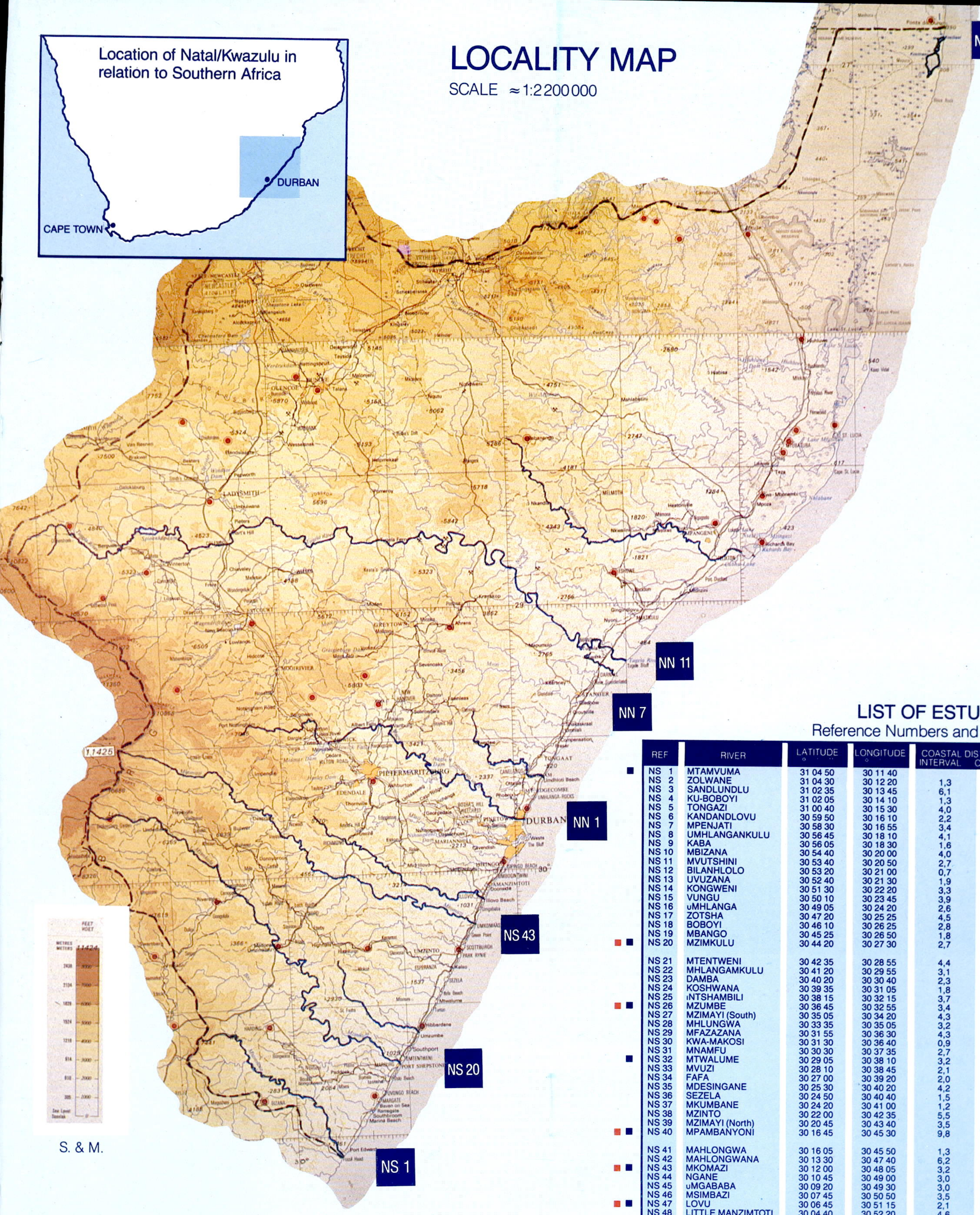
A.M.

MGENI (NN 1) IN FULL SPATE

≈5250 CUMECS (PLUS SEDIMENT) DISCHARGING INTO THE OCEAN

LOCALITY MAP

SCALE ≈1:2 200 000



S. & M.

LIST OF ESTUARIES

Reference Numbers and Position

	REF	RIVER	LATITUDE ° ' "	LONGITUDE ° ' "	COASTAL DISTANCE (km) INTERVAL	CUMULATIVE
■	NS 1	MTAMVUMA	31 04 50	30 11 40		0
	NS 2	ZOLWANE	31 04 30	30 12 20	1,3	1,3
	NS 3	SANDLUNDLU	31 02 35	30 13 45	6,1	7,4
	NS 4	KU-BOBOYI	31 02 05	30 14 10	1,3	8,7
	NS 5	TONGAZI	31 00 40	30 15 30	4,0	12,7
	NS 6	KANDANDLOVU	30 59 50	30 16 10	2,2	14,9
	NS 7	MPENJATI	30 58 30	30 16 55	3,4	18,3
	NS 8	UMHLANGANKULU	30 56 45	30 18 10	4,1	22,4
	NS 9	KABA	30 56 05	30 18 30	1,6	24,0
	NS 10	MBIZANA	30 54 40	30 20 00	4,0	28,0
	NS 11	MVUTSHINI	30 53 40	30 20 50	2,7	30,7
	NS 12	BILANHLOLO	30 53 20	30 21 00	0,7	31,4
	NS 13	UVUZANA	30 52 40	30 21 30	1,9	33,3
	NS 14	KONGWENI	30 51 30	30 22 20	3,3	36,6
	NS 15	VUNGU	30 50 10	30 23 45	3,9	40,5
	NS 16	uMHLANGA	30 49 05	30 24 20	2,6	43,1
	NS 17	ZOTSHA	30 47 20	30 25 25	4,5	47,6
	NS 18	BOBOYI	30 46 10	30 26 25	2,8	50,4
	NS 19	MBANGO	30 45 25	30 26 50	1,8	52,2
■ ■	NS 20	MZIMKULU	30 44 20	30 27 30	2,7	54,9
	NS 21	MTENTWENI	30 42 35	30 28 55	4,4	59,3
	NS 22	MHLANGAMKULU	30 41 20	30 29 55	3,1	62,4
	NS 23	DAMBA	30 40 20	30 30 40	2,3	64,7
	NS 24	KOSHWANA	30 39 35	30 31 05	1,8	66,5
	NS 25	iNTSHAMBILI	30 38 15	30 32 15	3,7	70,2
■ ■	NS 26	MZUMBE	30 36 45	30 32 55	3,4	73,6
	NS 27	MZIMAYI (South)	30 35 05	30 34 20	4,3	77,9
	NS 28	MHLUNGWA	30 33 35	30 35 05	3,2	81,1
	NS 29	MFAZAZANA	30 31 55	30 36 30	4,3	85,4
	NS 30	KWA-MAKOSI	30 31 30	30 36 40	0,9	86,3
	NS 31	MNAMFU	30 30 30	30 37 35	2,7	89,0
■	NS 32	MTWALUME	30 29 05	30 38 10	3,2	92,2
	NS 33	MVUZI	30 28 10	30 38 45	2,1	94,3
	NS 34	FAFA	30 27 00	30 39 20	2,0	96,3
	NS 35	MDESINGANE	30 25 30	30 40 20	4,2	100,5
	NS 36	SEZELA	30 24 50	30 40 40	1,5	102,0
	NS 37	MKUMBANE	30 24 20	30 41 00	1,2	103,2
	NS 38	MZINTO	30 22 00	30 42 35	5,5	108,7
	NS 39	MZIMAYI (North)	30 20 45	30 43 40	3,5	112,2
■ ■	NS 40	MPAMBANYONI	30 16 45	30 45 30	9,8	122,0
	NS 41	MAHLONGWA	30 16 05	30 45 50	1,3	123,3
	NS 42	MAHLONGWANA	30 13 30	30 47 40	6,2	129,5
■ ■	NS 43	MKOMAZI	30 12 00	30 48 05	3,2	132,7
	NS 44	NGANE	30 10 45	30 49 00	3,0	135,7
	NS 45	uMGABABA	30 09 20	30 49 30	3,0	138,7
	NS 46	MSIMBAZI	30 07 45	30 50 50	3,5	142,2
■ ■	NS 47	LOVU	30 06 45	30 51 15	2,1	144,3
	NS 48	LITTLE MANZIMTOTI	30 04 40	30 52 20	4,6	148,9
	NS 49	MANZIMTOTI	30 03 35	30 53 00	2,4	151,3
	NS 50	MBOKODWENI	30 00 40	30 56 05	7,5	158,8
	NS 51	SIPINGO	29 59 40	30 57 10	2,9	161,7
■ ■	NS 52	MLAZI	29 58 10	30 58 45	3,7	165,4
	NS 53	NATAL BAY	29 52 15	31 03 30	13,6	169,0
■ ■	NN 1	MGENI	29 48 40	31 02 30	9,0	178,0
	NN 2	OHLANGA	29 42 25	31 05 55	13,6	191,6
■ ■	NN 3	MDLOTI	29 39 05	31 07 40	7,5	199,1
■	NN 4	TONGATI	29 34 25	31 11 10	10,8	209,9
	NN 5	MHLALI	29 27 40	31 16 40	16,0	225,9
	NN 6	SETENI	29 25 45	31 17 10	4,7	230,6
■ ■	NN 7	MVOTI	29 23 30	31 20 10	5,8	236,4
	NN 8	MDLOTANE	29 21 10	31 22 30	6,2	242,6
	NN 9	NONOTI	29 19 00	31 24 35	5,4	248,0
	NN 10	ZINKWASI	29 16 50	31 26 40	6,5	254,5
■ ■	NN 11	TUGELA	29 13 25	31 29 55	8,5	263,0
	NN 12	NYONI				
■	NN 13	MATIGULU	29 05 05	31 38 25	21,9	284,9
	NN 14	SIYAYA	28 58 00	31 45 40	17,4	302,3
■ ■	NN 15	MLALAZI	28 56 45	31 48 40	5,6	307,9
	NN 16	RICHARDS BAY				
■		MHLATUZE	28 50 40	32 03 00	26,5	334,4
	NN 17	NHLABANE	28 39 40	32 15 30	29,4	363,8
■	NN 18	MFOLOZI	28 24 05	32 25 25	36,2	400,0
	NN 19	ST. LUCIA	28 23 05	32 25 20	1,8	401,8
	NN 20	MGOBEZELENI	27 32 20	32 40 45	55,5	457,3
■	NN 21	KOSI	26 53 40	32 52 50	125,6	582,9

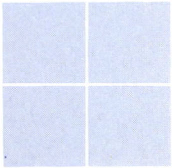
KEY

Selected Estuaries ■

Severe flood damage and/or inundation ■

≈ 1:30 000

A.P.S.



F.J.

MTAMVUNA (NS 1)

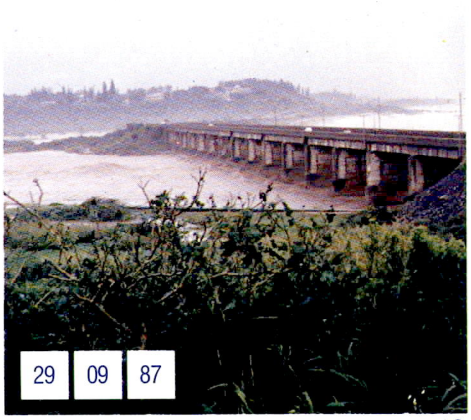
Peak discharge ≈ 2680 cumecs

≈ 1:30 000 A – LOW-LEVEL BRIDGE WASHED AWAY B – MASSIVE SILT PLUME A.P.S.

MZIMKULU (NS 20) Peak discharge ≈ 5600 cumecs

ROAD & RAIL BRIDGE AT THE MOUTH

F.J.



I.S.

GOLF COURSE NEAR THE MOUTH, INUNDATED

I.S.

≈ 1:30 000

A.P.S.

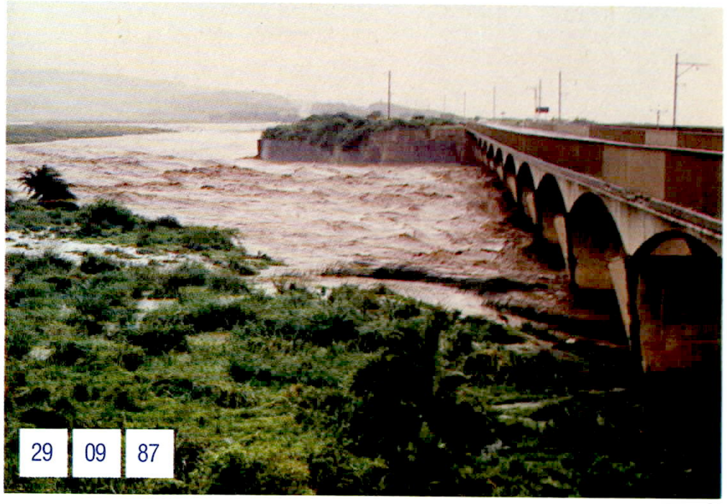
ROAD & RAIL BRIDGES NEAR THE MOUTH, STABILIZED SPIT

F.J.

FLOOD PLAIN INUNDATED

F.J.

STANDING WAVES NEAR THE ROAD BRIDGE DURING THE FLOOD I.S.



I.S.

'ISLAND' NEAR THE MOUTH DURING & AFTER THE FLOOD I.S.

CSIR

MZUMBE (NS 26) Peak discharge ≈1 200 cumecs

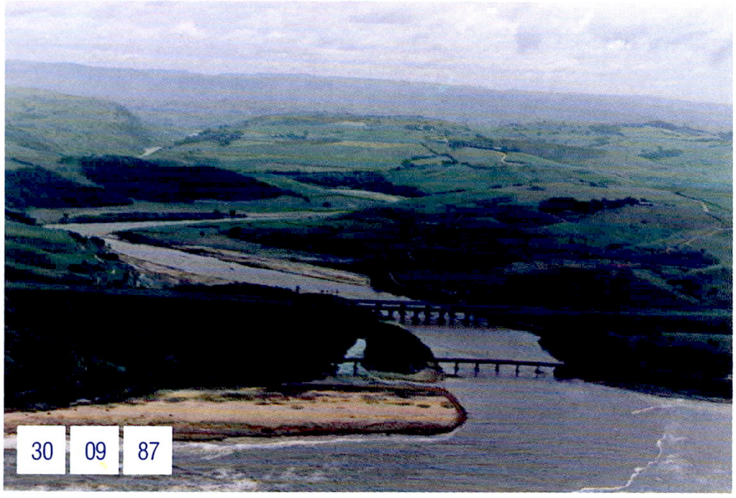
NEW FREEWAY BRIDGE SITE, DURING & AFTER THE FLOOD

I.S.

CSIR

≈ 1:30 000

A.P.S.



F.J.

MTWALUME (NS 32)

Peak discharge ≈ 850 cumecs

≈ 1:30 000

A.P.S.

MPAMBANYONI (NS 40) Peak discharge ≈ 1 240 cumecs

DAMAGE TO THE ROAD BRIDGE

F.J.

R.H.

≈ 1:30 000 A.P.S.

MKOMAZI (NS 43)

Peak discharge ≈ 6 900 cumecs

≈ 1:30 000 PRE-FLOOD CONDITIONS A.P.S.

E.B.

E.B.

LOOKING DOWNSTREAM FROM THE FREEWAY BRIDGE: PRE & POST FLOOD. NB: VANISHED SUGAR CANE FIELDS & DAMAGE TO THE EFFLUENT CONDUIT

10:30 CONSTRUCTION JETTY, EFFLUENT PIPELINE E.B.

08:00 E.B.

17:30 STANDING WAVES NEAR THE BRIDGE AT THE MOUTH E.B.

11:45 E.B.

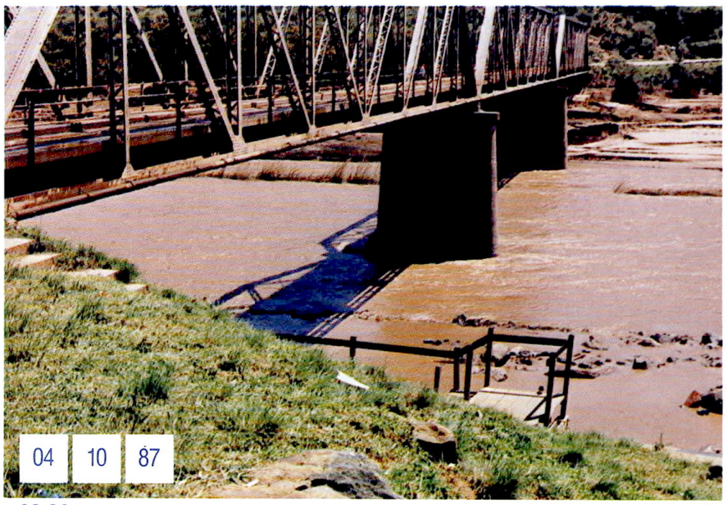
11:45 ROAD & RAIL BRIDGE AT THE MOUTH E.B.

CSIR

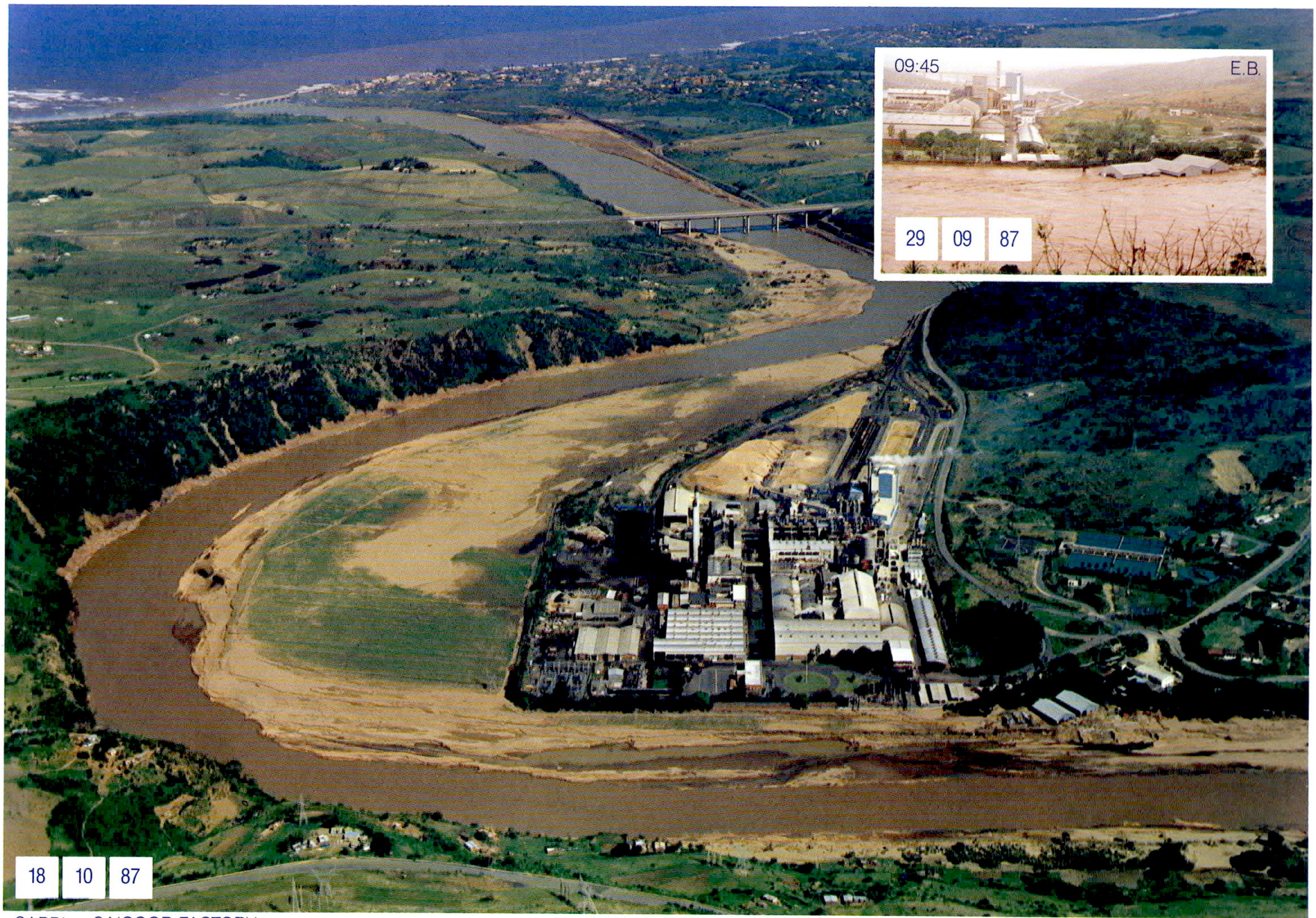
09:45 NB: MKOMAZI MAINTAINED THESE NEAR-PEAK LEVELS FOR 24 HRS

11:15 E.B.

08:30 OLD SOUTH COAST ROAD BRIDGE (5.5 km FROM THE MOUTH) E.B.



09:30 E.B.



SAPPI – SAICCOR FACTORY T.S.

≈1:30 000 NB: (i) CHANGE IN RIVER COURSE
(ii) 'ISLAND' NEAR MOUTH SWEPT AWAY A.P.S.

LOVU (NS 47)

Peak discharge ≈1 800 cumecs

≈1:30 000 PRE-FLOOD CONDITIONS A.P.S.

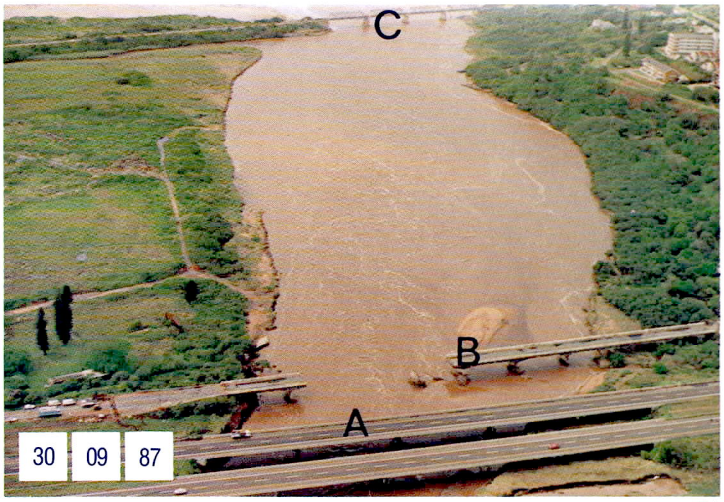
LOVU (NS 47) CONTINUED

NB: INUNDATION OF FLOOD PLAIN BEHIND CHANNELLING FOR THE FREEWAY BRIDGE

08:00 E.B.

F.J.

15:00 E.B.



F.J.

LOVU BRIDGES:
A. FREEWAY
B. R-102 DAMAGED
C. RAILWAY

CSIR

ERODED CANAL OUTFALL A.P.S.

≈ 1:30 000

A.P.S.

SIPINGO (NS 51) AND MLAZI (NS 52) Peak discharge ≈ 1 430 cumecs

MLAZI CANAL AND INUNDATED AREAS: NEAR PEAK DISCHARGE

F.J.

ERODED CANAL OUTFALL

F.J.

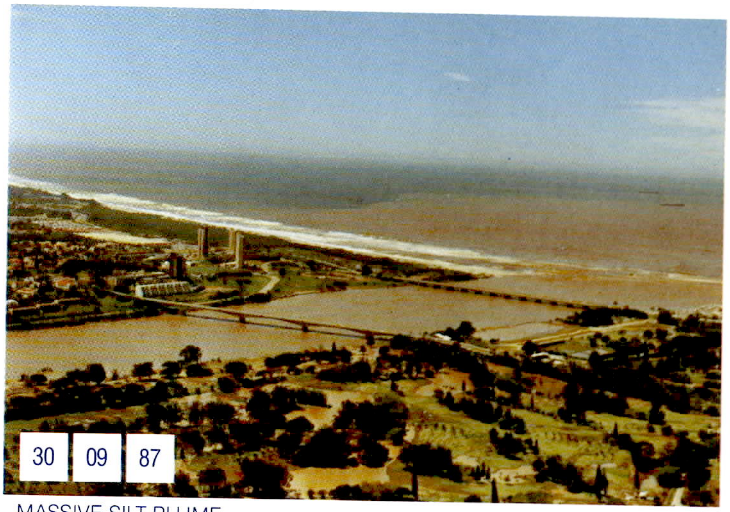
≈1:30 000 NB: 'ISLAND' SWEPT AWAY A.P.S.

MGENI (NN 1)

Peak discharge ≈ 5 250 cumecs

≈1:30 000 PRE-FLOOD CONDITIONS A.P.S.

ABOVE & BELOW: TREES DENOTING REMNANTS OF THE 'ISLAND' F.J.



MASSIVE SILT PLUME F.J.

DEBRIS FROM THE MGENI (NEAR THE MOUTH & ALONG DURBAN BEACHES) A.P.S.

CSIR

CSIR

≈1:30 000 FLOOD-FLOW RIVER COURSE: FLOOD FLOWS ATTACK LEFT BANK BRIDGE STRUCTURES A.P.S.

DAMAGE TO THE ROAD BRIDGE NEAR MOUTH OF MDLOTI

F.J.

MDLOTI (NN 3)

Peak discharge ≈ 2 130 cumecs

≈ 1:30 000 PRE-FLOOD CONDITIONS A.P.S.

DAMAGE TO THE ROAD BRIDGE
NEAR THE MOUTH OF THE MDLOTI, DURING THE FLOOD G.B.

AFTER THE FLOOD CSIR

MDLOTI AT VERULAM

NB: PEAK FLOOD LEVEL MARK ON THE HOUSE G.B.

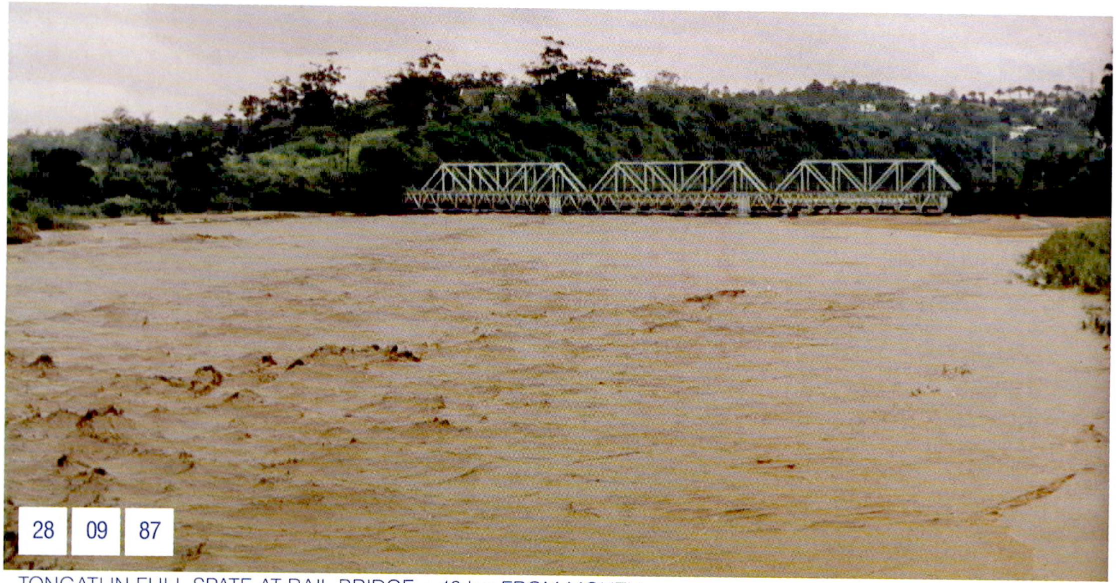
≈ 1:30 000

A.P.S.

F.J.

TONGATI (NN 4)

Peak discharge ≈ 1 520 cumecs



TONGATI IN FULL SPATE AT RAIL BRIDGE ≈ 10 km FROM MOUTH G.B.

ROAD BRIDGE, NEAR THE MOUTH, DURING & AFTER THE FLOOD G.B.

CSIR

G.B.

DEBRIS FROM THE TONGATI ON THE BEACH AT TINLEY MANOR

MVOTI (NN 7)

Peak discharge ≈ 5 530 cumecs

THE MOUTH OF THE MVOTI

≈ 1:30 000

A.P.S.

F.J.

THE MOUTH OF THE MVOTI F.J.

DAMAGE TO THE ROAD BRIDGE 3.6 km FROM MOUTH F.J.

≈ 1:30 000 PRE-FLOOD CONDITIONS A.P.S.

cf.: (i) NORMAL AND FLOOD-FLOW RIVER COURSES
(ii) SUGAR CANE AREAS ON THE FLOOD PLAIN

≈ 1:30 000

A.P.S.

TUGELA (NN 11)
Peak discharge ≈ 9 440 cumecs

F.J.

NB: (i) MASSIVE SILT PLUME
(ii) INUNDATED SUGAR CANE FIELDS

≈ 1:30 000 PRE-FLOOD CONDITIONS A.P.S.

TUGELA IN FULL SPATE, JOHN ROSS BRIDGE SITE L.B.

The bridge that was!

≈ 10 km FROM THE MOUTH

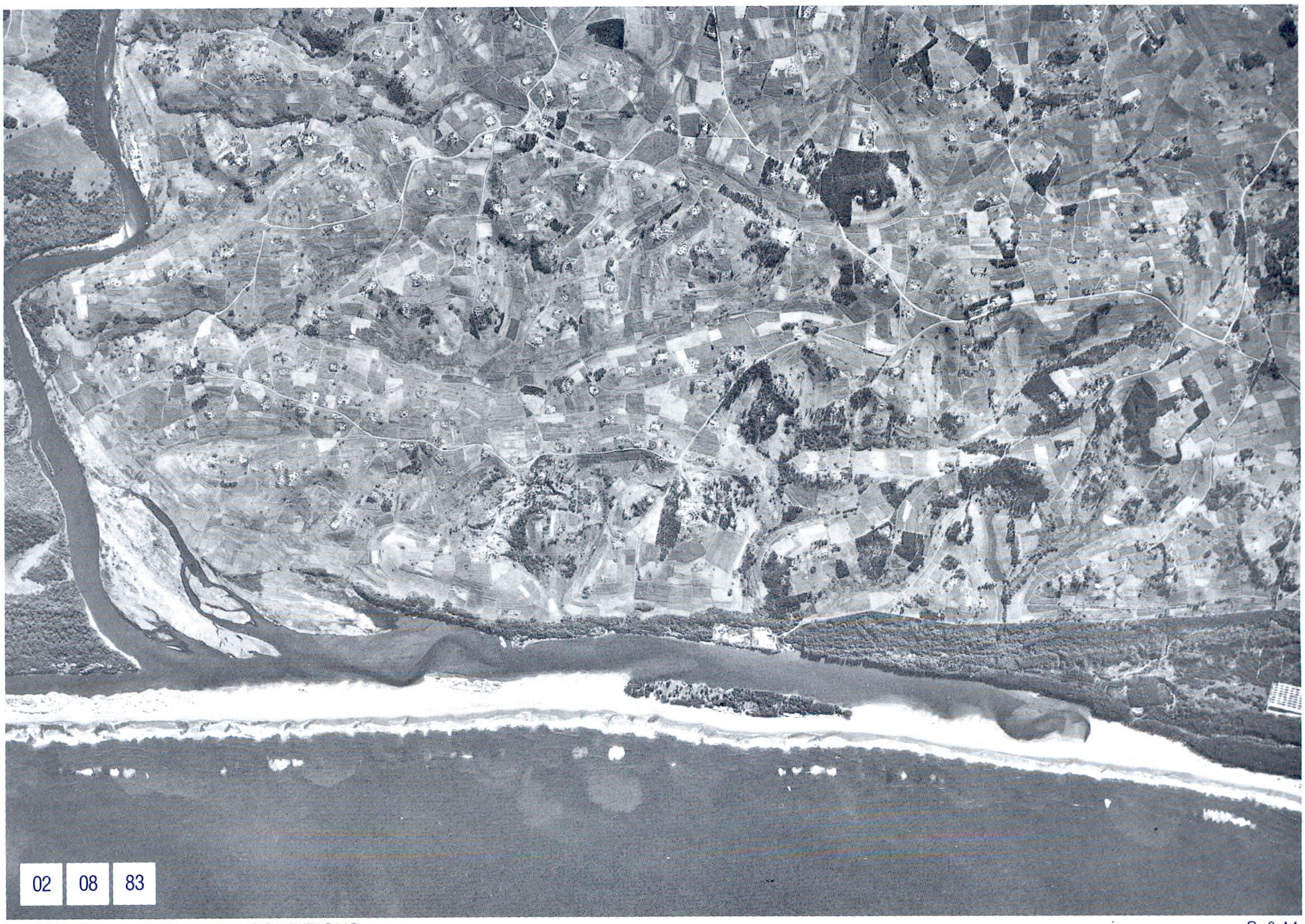
POST-FLOOD CONDITIONS CSIR

NYONI/MATIGULU (NN 12/13)

Peak discharge ≈ 4780 cumecs

NB: THE TWO MOUTHS

≈ 1:30000 A.P.S.



≈ 1:30000 PRE-FLOOD CONDITIONS S. & M.

MLALAZI (NN 15)

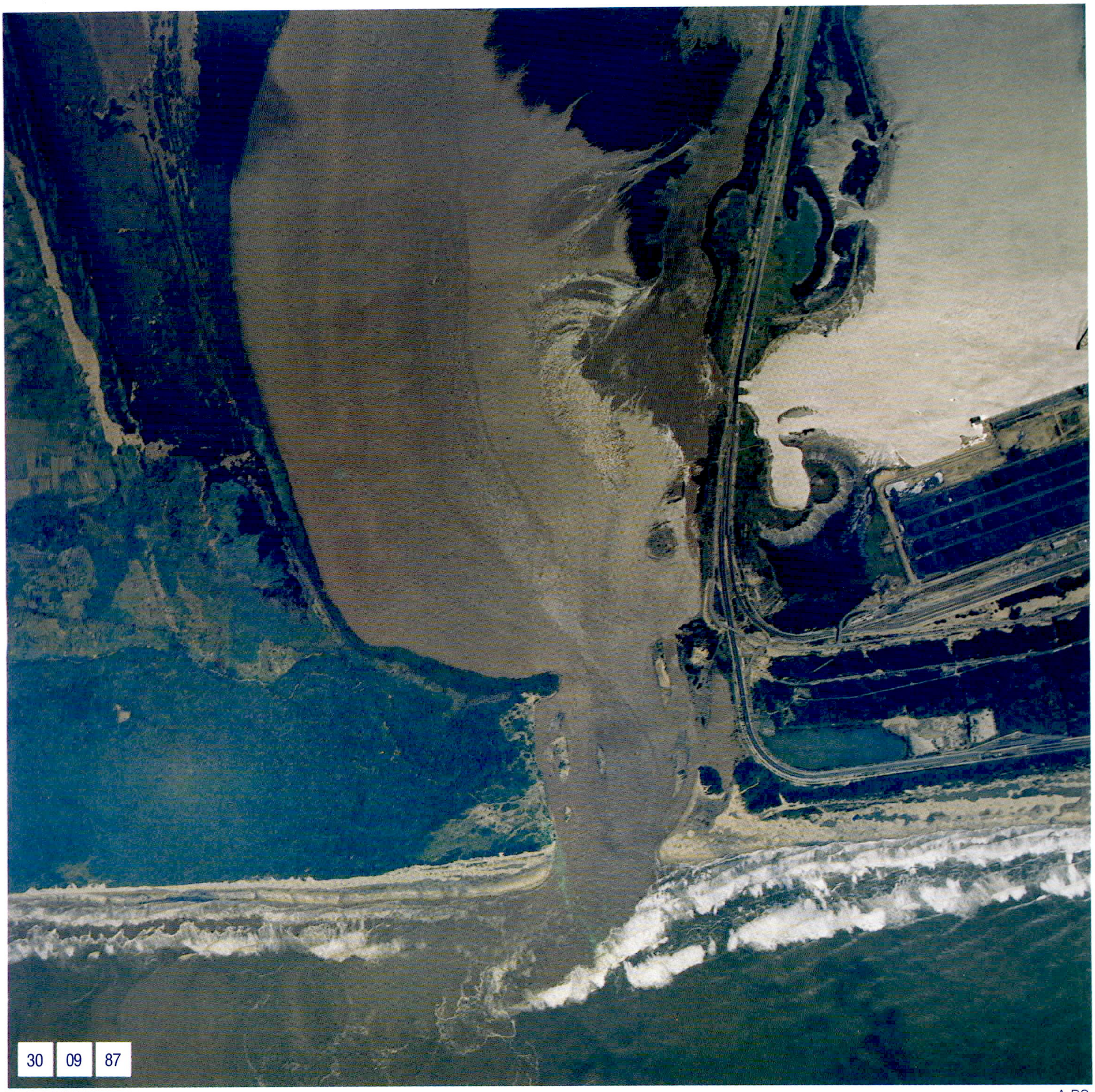
Peak discharge ≈1 600 cumecs

≈1:30 000

A.P.S.

≈1:30 000 PRE-FLOOD CONDITIONS

S. & M.



≈ 1:30 000 A.P.S.

RICHARDS BAY SANCTUARY, MHLATUZE (NN16) Peak discharge ≈ 4 440 cumecs

NB: FLOOD ATTENUATED BY THE GOEDERTROUW DAM (≈ 80 km FROM MOUTH. INFLOW PEAK 3 760 CUMECS; OUTFLOW PEAK 592 CUMECS

NORTH SIDE: FLUVIAL DELTA F.J.

SOUTH SIDE: REED SWAMP F.J.

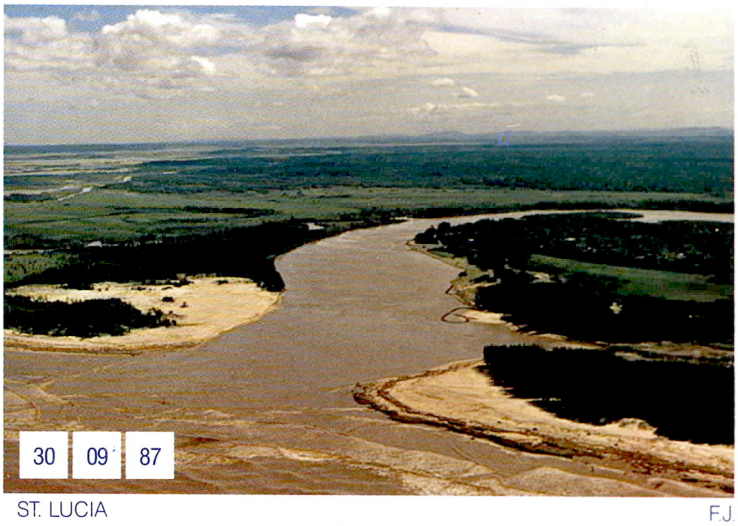
≈ 1:30 000

A.P.S.

MFOLOZI/ST. LUCIA (NN 18/19) Mfolozi peak discharge ≈ 4 700 cumecs

MFOLOZI

F.J.



ST. LUCIA

F.J.

≈1:30 000 PRE-DOMOINA S. & M.

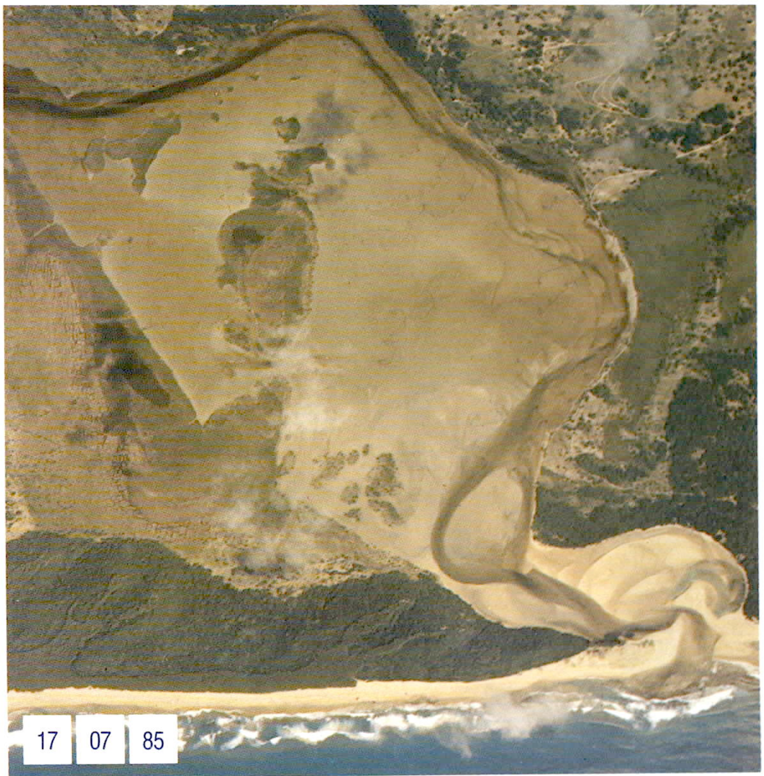
MFOLOZI ST. LUCIA

CONTINUED

≈1:30 000 POST-DOMOINA A.P.S.

≈ 1:30 000 A.P.S.

LAKE-LINKED SYSTEM
WELL ABLE TO ABSORB
LESSER FLOODS



≈ 1:30 000 A.P.S.

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