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**HYDROLOGICAL/HYDRAULIC STUDY OF NATAL
ESTUARIES**

**DATA REPORT NO 28
UMHLANGANKULU NS 8**

submitted to:

Town & Regional Planning Commission, Natal

January 1990

NS 8

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EMA-D 9002

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CSIR

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Keywords:

Hydro-classification

Estuaries

Lateral stability

Siltation

January 1990

FOREWORD

The basic work for this report was done by M. Anderson. The joint authors are J.E. Perry and M. Anderson.

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LIST OF PHOTOGRAPHS

N.B. Basic diapositives and orthophoto maps for this study were obtained from the following sources.

* The Chief Director, Surveys and Mapping, Mowbray

** Aerial Photographic Service, Pietermaritzburg

* NS8/1	23-06-76 (orthophoto)
* NS8/2	02-05-37 (13h08)
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* NS8/8	02-08-83 (11h52)
**NS8/9	02-10-87 (11h50)
**NS8/10	02-10-87 (02-05-37 river course superimposed)
* NS8/11	Orthophoto (envelope of mobility, lines of measurement and lateral shift superimposed)

BRIEF NOTESUMHLANGANKULU NS 8Location

The Umhlangankulu river discharges into the Indian Ocean on the Natal South Coast at 30°57'S, 30°18'E. The head of the reach under review is 0,95 km from the mouth (Photograph NS8/1). This position is an arbitrary line, selected at the first point upstream of the maximum known estuarine limit which could be identified on all the available aerial photographs. Although this is not ideal, it is the best possible selection under the circumstances because there is no bridge in the vicinity which could confine the flow.

Selection of Aerial Photographs

For the study of this "estuary", eight aerial photographic time slices were selected, covering a period of fifty years from 1937 to 1987.

Hydro Data

The M.A.R. from a catchment area of 9,0 km² is $2,0 \times 10^6$ m³ (21,3 % of the precipitation). Of particular interest to this study is the erratic nature of the run-off. This quantified by

- (a) the high coefficients of variation for monthly run-off (Table NS8/XII) ranging from 74,8 to 198,6 per cent ($\bar{V} = 125,6$ %)
- (b) the cyclical variations in M.A.R. (Figure NS8/1)
- (c) the wide spectrum of monthly run-off (Figure NS8/2) and
- (d) median run-off values well below the mean (Table NS8/XII).

Figure NS8/3 shows the trend in the annual run-off for the period 1921-1975. The aforementioned Table and Figures are based upon simulated run-off data for tertiary catchments (Middleton et al 1981).

The Umhlangankulu is subject to frequent, high monthly run-off periods: major flood flows occurring in July 1930, November 1936, October 1954, March 1962 February 1977 (not reflected in the simulated run-off) and September 1987. Lesser flood flows occurred during March 1926, June 1928, November 1942, May 1958, December/January 1963, October 1970, January/April/May 1978 and February 1985. (Table NS8/XII and Figure NS8/2). Data for the post-1976 hydro period were obtained from Begg (1978 & 1984) and local ground knowledge. Detailed discharge data are not available.

There is a gauge plate below the hotel complex of San Lameer from which daily water levels were read from September 1979 to December 1983. Levels are tied in to M.S.L. (gauge zero = M.S.L.) and readings were resumed in September 1988. Water level fluctuations are discussed in the section below "River Mouth".

For classification purposes, current and antecedent conditions must be considered for each of the time slices covered by the aerial photographs:

- 1) 1937 below-average run-off, likewise for the previous month. Six months previous, there were major flood flows
- 2) 1943 near-average run-off, previous hydro-year well above average
- 3) 1955 below-average run-off, likewise for two months previous. These were major flood flows eight months previous
- 4) 1963 below-average run-off. Well above-average run-off the previous month and a major flood two months previous
- 5) 1969 slightly above-average runoff, likewise for the previous month. Prior to this, three years of very dry conditions

- 6) 1976 near-average run-off, likewise for the previous month. Above-average run-off two and three months previous but prior to this, four years of drought
- 7) 1983 below-average run-off, within a severe drought period
- 8) 1987 above-average run-off following a major flood

N.B. Simulated run-off data are not available beyond hydro year 1976. Therefore the comments above for the 1983 and 1987 time slices are based upon local ground knowledge.

River Mouth

The various mouth positions for the eight time slices under review are mapped in Figure NS8/4.

Near the mouth, the Umhlangankulu is diverted by a northerly-extending spit: i.e. in the direction of the littoral drift. This is atypical for Natal south of the Tugela and is due to the lack of rocks on the right bank/southern side of the mouth. Rocks outcrop on the left bank, approximately 100 m landwards of the normal high water line. There is also a rocky promontory, known as Centre Rocks, 100 m seawards and to the north of the normal mouth position (see Figure NS8/4).

Daily observations by San Lameer staff of mouth open/closed conditions from October 1979 to December 1984 show the mouth to be closed for 93 per cent of the year. The low run-off from this small catchment cannot maintain an open mouth condition. In order to understand (i) the conditions under which the mouth will open and (ii) what controls the position of the mouth when open, one needs to consider the following:

- (a) low/medium flow, dry season/phase conditions and
- (b) high flows and floods.

In the following discussions on (a) and (b), all water levels mentioned refer to the gauge plate at the hotel complex or its immediate vicinity and they are given to M.S.L. datum.

(a) **Low/medium flow, dry season/phase conditions**

Under these conditions, particularly during prolonged droughts such as those of the 1960s and the early 1980s, a substantial sandbar builds up at the mouth. Super-elevated water levels (i.e. higher than the normal seasonal flood flows), higher than +4 m, may then occur in the lagoon. Under "normal" seasonal conditions the bar will breach naturally at water levels between +3,6 m and 4,2 m. The rocks on the left bank near the mouth influence the initial direction of the flow straight out to sea. Given overflow channel conditions or medium flow conditions the flow will be diverted northwards by the littoral drift, towards Centre Rocks. There is an approximate 150 m range within which the mouth position oscillates under these conditions (Figure NS8/4 and Photographs NS8/2, 3, 7 and 8). N.B. the 1976 time slice (Photograph NS8/7) while depicting a closed mouth condition, shows remnants of a mouth position close to Centre Rocks.

It should be noted that without any human influences, the mouth only remains open for short while (2-12 days usually). With the dredging of the lagoon (see Section below on "Siltation"), completed in August 1989 (R. Ouldcott, pers. comm.), the mouth may remain open for slightly longer periods owing to increased tidal influence. The planned future monitoring by San Lameer staff will quantify this change. N.B. In this regard, it would be advantageous to establish gauge plates nearer the mouth (e.g. at the pump station) to record water levels.

(b) **High flows and floods**

Widespread soaking rains over the catchment for five days in September 1987 resulted in major floods on the 29th September. Peak flood flow levels reached +4 m. These high discharges occurred at the end of the dry season when the mouth had been closed for a long period and the water level in the lagoon behind the sandbar was already high. Under such circumstances the flood path follows the direction of the river course in its lowest downstream bend, over the rocks on the left bank (elevation +3,2 m) discharging into the ocean to the north of the Centre

Rocks (Photograph NS8/9). At such times the dunes and dune vegetation on the left bank are eroded (see photographs inside back cover). From supplementary vertical or oblique photos and ground observations, the Umhlangankulu is known to have flowed out to sea north of Centre Rocks in January and March 1978, February 1985 and January 1989.

While the mechanical dredging was taking place (March to August 1989), dredged material was used to re-build and build up the left bank area near the mouth. The mouth itself was re-instigated in a position directly out to sea from the left bank rocks, in August 1989. It has now (January 1990) migrated 60 m to the north (R. Ouldcott, pers. comm.).

Land-use

(a) Agriculture

There is no evidence of any cultivation on the limited flood plain or valley sides for the period under review.

(b) Structures

Aerial photographs from 1963 to 1976 show a groyne/jetty type structure extending ≈ 70 m into the lagoon on the right bank of Copper's Creek, just upstream of the confluence with the Umhlangankulu. This "structure" was composed of sand and was removed during earlier dredging operations in 1977 associated with the building of the San Lameer resort.

(c) Urbanization

Building of the San Lameer resort commenced in 1976. This residential township development is expanding with plans to double the number of villas in the next 10 to 15 years (Weekend Argus, 24-7-88). All buildings are above the limited flood plain area.

Siltation

Aerial photographs taken when the water levels are very low (mouth open conditions e.g. Photograph NS8/9) clearly show areas

of heavy siltation, especially channel junction bars. This is understandable because the gradients of the rivers feeding the lagoon are steep (1:36 overall) and the first major check on their gradients is when they enter the lagoon. With the consequent check in river velocities, silt is deposited in these areas, particularly during the recession limb of any flood flows e.g. February 1977, May 1978 and September 1987.

For a sediment source, one must look to erodible soils and land-use malpractices in the catchment. From a sediment production map of S. Africa (Rooseboom, 1975), a maximum sediment yield of 3600 tons per year is derived for the Umhlangankulu catchment. This represents a rate of 400 tons/km²/yr, which is high. Sixteen per cent of the catchment is KwaZulu (Begg, 1978) and there are banana plantations upstream of Copper's Creek. Regarding the latter, San Lameer have recently bought two of these banana plantation farms and plan to build a golf course in the area (R. Ouldcott, pers. comm.). Road and bridge building in the catchment are also probably currently (but temporarily) the source of additional silt supplies.

Bearing in mind that the rate of siltation in the lower reaches is not steady but is mainly the result of major hydro-events, one should study the changes from two viewpoints:

- (a) spatially (area-changes over time) and
- (b) vertically (aggradation/degradation over time).

- (a) Changes in siltation areas over time

Areal measurements of the flood plain (Table NS8/I) from the eight time slices of aerial photography can be used to quantify the changes in siltation areas from 1937 to 1987. However, care must be taken in studying the changes in composition of the flood plain: some changes are stage dependent (i.e. they depend upon the water level in the lagoon). The "recent" siltation areas comprise the fluvial sand/silt plus the swamp areas (e.g. 18% of the flood plain in 1937).

For the selected time slices, recent areas of siltation (with open water areas given in brackets below) are summarized as percentages of the flood plain area as follows:

<u>1937</u>	<u>1943</u>	<u>1955</u>	<u>1963</u>	<u>1969</u>	<u>1976</u>	<u>1983</u>	<u>1987</u>
18	19	10	5	9	12	15	29
(25)	(27)	(34)	(34)	(37)	(38)	(31)	(19)

Allowing for differences in stage, as indicated by the open water areas, the above table shows that there has been a slight increase in siltation areas since 1969.

(b) Aggradation/degradation over time

These changes naturally cannot be assessed quantitatively from aerial photographs. However, from the aerial photograph NS8/9, taken when the water level was at its lowest (September 1987) aggradation can be inferred, particularly in areas showing channel junction bars. Furthermore the steps taken to dredge the lagoon (1977 and 1989) imply aggradation.

Cross-sections have been taken in 1976 by Hill, Kaplan, Scott and in 1988 by Bruinette, Kruger, Stoffberg. The two sets of cross-sections are not directly comparable as they were not taken in exactly the same positions but several pertinent facts emerge regarding the bed levels from these surveys:

- (i) original bed levels in the lagoon ranged from +1,5 to +2,0 m to M.S.L. in both sets of surveys
- (ii) probes taken during the earlier surveys revealed on the average a 1,5 m depth of silty material
- (iii) dredging in the main part of the lagoon in 1977 resulted in bed levels excavated to M.S.L.
- (iv) levels were again dredged to M.S.L. in 1989. (N.B. neither in 1977 nor in 1989 did dredging occur near the mouth where bed levels range from +1 m to +1,2 m to M.S.L.).

From the above, it is apparent that unless the silt supply into the lagoon is checked, the dynamic equilibrium bed levels in the lagoon will average +1,5 m to M.S.L. approximately. Such levels preclude tidal influence. There have been several attempts to try to prevent siltation in the lagoon. Pre-1976, the private owner had built silt traps on the inflowing rivers. These were only partially successful and therefore dredging was deemed necessary in 1977. The floods of early 1978, February 1985 and September 1987 were probably mostly responsible for the aggradation of bed levels approximately to those of 1976. Concurrent with the 1989 dredging, the wall level of a silt trap on the Umhlangankulu (≈ 2 km from the mouth) was raised. Subsequent flood flows, with log debris, damaged this structure. There are plans to build new silt traps once construction of the National Road bridge, further upstream, is completed (R. Ouldcott, pers. comm.). Such measures are vital if the benefits from increased tidal exchange and/or increased water depths are to be maintained.

Lateral Stability

For easy visual reference, an envelope of mobility, lines of measurement and lateral shift are superimposed on an orthophoto (Photograph NS8/11).

The Umhlangankulu is generally fairly stable and the reach under review shows some geomorphological control. The slight lateral instability is due to floods causing bank erosion (left bank, near the mouth) and siltation (channel junction and side bar formations). Furthermore, there is a large lateral shift at the mouth (see River Mouth section above and Figure NS8/5). The average lateral shift for the whole reach is 55,2 m (128,4 % of the $\bar{R}$ width) with a coefficient of variation of 29,6 per cent (Table NS8/XI). This indicates slightly unstable conditions.

Variations in river widths at each station are stage-dependent, mainly governed by mouth open/closed conditions (Table NS8/V). The sinuosity has been variable, ranging from 1,57 to 1,73 (Table NS8/I). This also reflects differing flow stages and mouth condition/positions.

Overall the Umhlangankulu shows considerable siltation and has been slightly unstable for the period under review: 1937 - 1987.

Details of the classification may be found in Tables NS8/II-IX and an abstract of results is given in Table NS8/I.

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2. Mr E. Cerff (CSIR, Durban) for very useful on-site discussions.

ABBREVIATIONS/SYMBOLS/TERMS USED

M.A.R. Mean annual run-off

L.B. Left bank

R.B. Right bank

P Perimeter

$\bar{x}$ Arithmetic mean

s Standard deviation

V Coefficient of variation $\frac{s}{\bar{x}}$

M.S.L. Mean sea level

R Downstream

d/s Downstream

u/s Upstream

— Maximum value

--- Minimum value

N.R. No record

Head of reach An arbitrary control point selected at the first convenient place u/s of the maximum known limit of saline penetration/tidal influence where the R is confined (preferably a bridge e.g. to facilitate demarcation of dflood plain areas).

ABSTRACT

BASIC DATA/CALCULATIONS

Lateral displacement (1937-1987) $\bar{x}$ 55.2 m (128.4 $\times$ R width)
Relative lateral stability (1937-19) $\bar{V}$ 29.6 %
Area of catchment 9.0 km²
Area of flood plain/valley 15.2 ha
Area of envelope of mobility 8.5 ha
Simulated run-off ($\times 10^6$ m³) M.A.R. 2.0 s 1.02
(1925-1987) $\bar{V}$ 51.92 %

Major floods: JUN 1930, NOV 1936, OCT 1954, MARCH 1962, FEB 1977, SEPT/OCT 1987
LESSER FLOODS: MARCH 1926, JUNE 1928, NOV 1942, MAY 1958, DEC/JAN 1963, OCT 1970

HUMAN INFLUENCES

Within the Reach

Cultivation: L.V.S. R.V.S. Flood Plain To Channel Edge
NONE

Bridges & Embankments: Position (m from head of reach) Date

Canals:

NONE
Urbanization/~~RESORT~~
SAN LAMUK HOLIDAY RESORT

Sandbar breaching:

NONE

Others:

Upstream of the Reach

Dams:

A SMALL FARM DAM D/O EXIST PRIOR TO BEING WASHED AWAY BY FLOODS IN 1977

Construction/Canalization immediately upstream of reach:

Land-use malpractices/Silt supply:

CONSTRUCTION ON NATIONAL ROAD FURTHER UPSTREAM A POSSIBLE SOURCE OF SILT.

STABILITY FOR PERIOD UNDER REVIEW (1937-1987)

SLIGHTLY UNSTABLE

MEASUREMENTS/CALCULATIONS FROM PHOTOGRAPHS

Date	2-5-37	DEC 1943	JUN/JULY 55	5-5-63	24-6-69	23-6-76	2-8-83	2-10-87
Reach								
thalweg (m)	917	993	753	788	870	935	1010	1097
% estuarine	?	?	?	?	?	91	?	? N/A
% braided								63
aerial distance(m)	572	608	468	455	554	581	590	666
sinuosity	1.60	1.63	1.60	1.73	1.57	1.60	1.71	1.65
open water area(ha)	3.7	4.1	5.1	5.2	5.7	5.8	4.71	2.94
$\bar{x}$ river width(m)	33.3	51.85	39.25	44.6	52.65	52.15	49.8	20.4
Flood Plain/Valley								
% open water	25	27	34	34	37	38	31	19
% sand(marine)	13	16	18	18	12	10	11	3
% sand/silt(fluvial)	9	11	2	N/A	N/A	N/A	5	17
% swamp,marsh	9	8	8	5	9	12	10	12
% grass,trees,bush	44	38	38	43	42	40	40	46
% cultivated	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
% built-up	N/A	N/A	N/A	N/A	N/A	N/A	3	3
Valley Sides (L/R)								
% dune forest	L 23 R 50	L 26 R 59	L 26 R 62	L 29 R 63	L 32 R 63	L 34 R 69	L 32 R 69	L 27 R 69
sand	8 16	8 16	8 16	8 19	8 16	8 16	5 16	5 16
trees	N/A 6	N/A 9	5 6	13 9	18 9	18 9	5 6	5 6
grass	68 28	66 16	50 16	39 9	32 9	29 3	N/A 3	N/A 3
cultivated	N/A N/A	N/A N/A	N/A N/A	N/A N/A	N/A N/A	N/A N/A	N/A N/A	N/A N/A
built-up	N/A N/A	N/A N/A	11 N/A	11 N/A	10 3	11 3	58 6	63 6
L.B. % vegetated	T 9	T 7	T 8	T 7	T 7	T 7	T 7	T 7
R.B. % vegetated	21 8	16 7	42 83	37 11	55 13	62 15	54 10	33 13
Mouth	25 10	41 23	17 63	36 48	37 52	28 59	23 38	15 18
open/closed (O/C)	O	O	C	C	C	C	O*	O
spit/bar:	SPT	SPT	BAR	BAR	BAR	BAR	SPT	SPT
direction (°)	15°	23°	29°	29°	29°	29°	29°	29°
length (m)	240	350	490	490	490	490	300	450
width (m)	178	92	72	114	85	77	96	73

TABLE VS 8/12

CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS

REF. CSIR VS 8

RIVER UNIAKANGANI KUKU, ? % ESTUARINE, REACH from RIVERMOUTH, 9.90 km from mouth. REF. DWA 11100
 AERIAL PHOTO DATE 2-5-37 TIME 13:08 CATCHMENT AREA 9.0 km², M.A.R. 3.0 m³x10⁶, No. of DAMS N/L

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Valley Sides (Not Well-defined)

Terrain	Vegetation	Land-use	Slumping	Vegetation and Land-use	Left	Right
mountainous	almost none	none	✓ none	coastal dune forest	23	50
✓ hilly	✓ grass	scattered cultivation	occasional	sand	8	16
undulating	sparsely forested (0-25%)	partly cultivated	frequent	trees	N/L	6
plains	moderately forested (25-75%)	mainly cultivated		grass	68	28
	heavily forested (75-100%)	✓ scattered settlement		cultivated	N/L	N/L
	✓ riverine forest: tributaries	partly built-up		built-up	N/L	N/L
		urbanized		Comments		

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length <u>950</u> m	none	not applicable	not applicable (no valley or free)	✓ bedrock
bottom width (av.) <u>120.5</u> m	indefinite	not obviously degrading	✓ occasionally confined	lacustrine deposits
valley area <u>15.2</u> ha	✓ fragmentary	or aggrading	frequently confined	✓ fluvial deposits
height at head of reach <u>5</u> m to MSL	continuous	partly entrenched	entrenched	aeolian
valley slope 1: <u>190</u>		entrenched		
		✓ aggrading/		Comments

River Mouth

Characteristics	Measurements
✓ open/	right bank breakwater length _____ m
✓ natural/	left bank breakwater length _____ m
canalized	rock sill level _____ m to MSL
✓ sandy	cliffs on left bank: height _____ m to MSL
✓ rocks on right/left bank	spit/ direction of growth <u>15</u> a
outer bar	length of spit/ <u>240</u> m
silt plume (fluvial)	length stabilized <u>170</u> m
suspended sediment (marine)	width <u>178</u> m
	Comments

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
Presence		
none	open water <u>25</u>	swamp, marsh <u>9</u>
indefinite	sand (marine) <u>13</u>	cultivated <u>N/L</u>
fragmentary	sand, silt (fluvial) <u>9</u>	built-up <u>N/L</u>
✓ continuous	trees, bush <u>37</u>	sea <u>N/L</u>
	grass <u>7</u>	Comments

Channel Description N.B. - Estimate of flow stage: LOW/NEAR LONG-TERM MEAN/HIGH

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>917</u> m	✓ none	✓ uniform /still	none
sinuous	*aerial length <u>572</u> m	occasional	✓ uniform water surface	✓ channel side bar
✓ irregular	*sinuosity <u>1.6</u>	frequent	uniform with rapid in reach	✓ point bar
regular meanders	*open water area <u>3.7</u> ha	split	irregular	channel junction bars
irregular meanders	perimeter <u>3121</u> m	braided	pool and riffle sequence	mid-channel bars
tortuous meanders	river x-sections available	shoals	✓ turbid	diamond bars
bifurcated	channel slope 1: _____			diagonal bars
lake/s	river slope 1: _____			sand waves/large dunes
✓ lagoon	river width $\bar{x}$ = <u>33.5</u> m	s = _____ m		Comments *whole reach

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
✓ none	✓ none	road bridge/s		
logs	minor	rail bridge/s		
boulders	major	causeway		
vegetation		weir/dam		
		fish traps		
		embankment/s		
		groynes		
		canals		
		drainage furrows		
		others		
Comments				

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
✓ not detectable	✓ alluvium	none	stable
downstream progression	natural levees	LB RB	✓ slightly unstable
progression and cut-offs	rock/boulders	reeds <u>8</u> <u>10</u> %	moderately unstable
mainly cut-offs	protected/stabilized	trees <u>27</u> <u>35</u> %	unstable
entrenched loop development	cultivation to	----- %	highly unstable
irregular lateral activity	channel edge		Comments
avulsion			

TABLE NS 8/III

CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS

REF. CSIR NS 8

RIVER UNHLANGANKULU, ? % ESTUARINE, REACH from RIVERSEND, 0.95 km from mouth.
 AERIAL PHOTO DATE DEC 1943 TIME 12:12 CATCHMENT AREA 9.0 km², M.A.R. 2.0 m³x10⁶, No. of DAMS N/A
 REF. DWA U 100

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Terrain Vegetation Land-use
 mountainous almost none none
 ✓ hilly ✓ grass scattered cultivation
 undulating sparsely forested (0-25%) partly cultivated
 plains moderately forested (25-75%) mainly cultivated
 heavily forested (75-100%) ✓ scattered settlement
 ✓ riverine forest: tributaries partly built-up
 urbanized

Valley Sides (Not Well-defined)

Slumping Vegetation and Land-use Left Right
 ✓ none coastal dune forest 26 59
 occasional sand 8 16
 frequent trees NIL 9
 grass 66 16
 cultivated NIL NIL
 built-up NIL NIL
 Comments

Valley Characteristics

Measurements

valley length 950 m
 bottom width (av.) 20.5 m
 valley area 15.2 ha
 height at head of reach 5 m to MSL
 valley slope 1: 190

Terraces

none
 indefinite
 ✓ fragmentary
 continuous

Relation of Channel to Valley Bottom (Vertical)

not applicable
 not obviously degrading or aggrading
 partly entrenched
 entrenched
 ✓ aggrading/degrading

Relation of Channel to Valley Sides or Resistant Terraces (Lateral)

not applicable (no valley or free)
 ✓ occasionally confined
 frequently confined
 entrenched

Surface Geology

✓ bedrock
 lacustrine deposits
 ✓ fluvial deposits
 aeolian

Comments

River Mouth

Characteristics

✓ open/tidal
 ✓ natural/tidal
 canalized
 sandy
 rocks on right/left bank
 outer bar
 silt plume (fluvial)
 suspended sediment (marine)

Measurements

right bank breakwater length _____ m
 left bank breakwater length _____ m
 rock sill level _____ m to MSL
 cliffs on left bank: height _____ m to MSL
 spit/_____ direction of growth _____ m
 length of spit/_____ 350 m
 length stabilized 175 m
 width 92 m

Comments

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence Extent
 none none
 indefinite average width 20.5 m
 fragmentary maximum width 250 m
 ✓ continuous area 15.2 ha

Areal Measurements: % Flood Plain/Valley

open water 27 swamp, marsh 8
 sand (marine) 16 cultivated N/A
 sand, silt (fluvial) 17 built-up N/A
 trees, bush 35 sea N/A
 grass 3

Crops, Animal Husbandry

N/A

Comments

Channel Description N.B. - Estimate of flow stage: LOW/NEAR LONG-TERM MEAN/HIGH

Pattern Measurements Islands/_____ Type of Flow Bar Type
 straight *thalweg 993 m none ✓ uniform/still none
 sinuous *aerial length 609 m ✓ occasional ✓ uniform water surface ✓ channel side bar
 ✓ irregular *sinuosity 1.63 frequent ✓ uniform with rapid in reach ✓ point bar
 regular meanders *open water area 4.1 ha split irregular channel junction bars
 irregular meanders perimeter 4001 m braided pool and riffle sequence mid-channel bars
 tortuous meanders river x-sections available shoals ✓ turbid diamond bars
 bifurcated channel slope 1: _____ diagonal bars
 lake/s river slope 1: _____ sand waves/large dunes
 ✓ lagoon river width $\bar{x}$ = 51.85 m s = _____ m

Comments *whole reach

Obstructions/Constructions

Natural _____ Degree Man-made _____ Degree of Obstruction/Constriction for Each Position (from head of reach)
 ✓ none ✓ none road bridge/s _____
 logs minor rail bridge/s _____
 boulders major causeway _____
 vegetation weir/dam _____
 fish traps _____
 Comments groynes _____
 canals _____
 drainage furrows _____
 others _____

Lateral Channel Activity

Lateral Activity Nature of Banks Bank Vegetation Lateral Stability
 ✓ not detectable ✓ alluvium none stable
 downstream progression natural levees LB RB
 progression and cut-offs rock/boulders reeds 7 23 %
 mainly cut-offs protected/stabilized trees 16 41 %
 entrenched loop development cultivation to _____ %
 irregular lateral activity channel edge
 avulsion

Comments

TABLE NS 8/IV

CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS

REF. CSIR NS 8

RIVER UMKANGANKUKU, ? % ESTUARINE, REACH from RIVERSEND, 0.95 km from mouth. REF. DWA U100
 AERIAL PHOTO DATE JUNE/JULY 1955 TIME 10:36 CATCHMENT AREA 9.0 km², M.A.R. 2.0 m³ x 10⁶, No. of DAMS NK

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Terrain	Vegetation	Land-use	Slumping	Vegetation and Land-use	Left	Right
mountainous	almost none	none	✓none	coastal dune forest	26	62
✓hilly	✓grass	scattered cultivation	occasional	sand	8	76
undulating	✓sparsely forested (0-25%)	partly cultivated	frequent	trees	5	0
plains	moderately forested (25-75%)	mainly cultivated		grass	50	16
	heavily forested (75-100%)	✓scattered settlement		cultivated	NK	NK
	✓riverine forest: tributaries	partly built-up		built-up	11	NK
		urbanized		Comments		

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length <u>950</u> m	none	not applicable	not applicable (no valley or free)	✓bedrock
bottom width (av.) <u>120.5</u> m	indefinite	not obviously degrading	occasionally confined	lacustrine deposits
valley area <u>15.2</u> ha	✓fragmentary	or aggrading	frequently confined	✓fluvial deposits
height at head of reach <u>5</u> m to MSL	continuous	partly entrenched	entrenched	aeolian
valley slope 1: <u>190</u>		✓aggrading		Comments

River Mouth

Characteristics	Measurements	Comments
closed	right bank breakwater length _____ m	
natural/	left bank breakwater length _____ m	
canalized	rock sill level _____ m to MSL	
sandy	cliffs on left bank: height _____ m to MSL	
rocks on right/left bank	bar: direction of growth <u>27</u> m	
outer bar	length of bar <u>290</u> m	
silt plume (fluvial)	length stabilized <u>175</u> m	
suspended sediment (marine)	width <u>72</u> m	

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
none	none	open water <u>34</u>	swamp, marsh <u>8</u>
indefinite	average width <u>120.5</u> m	sand (marine) <u>18</u>	cultivated <u>NK</u>
fragmentary	maximum width <u>250</u> m	sand, silt (fluvial) <u>2</u>	built-up <u>NK</u>
✓continuous	area <u>15.2</u> ha	trees, bush <u>33</u>	sea <u>NK</u>
		grass <u>5</u>	Comments

Channel Description N.B. - Estimate of flow stage: LOW/NEAR LONG-TERM MEAN/HIGH

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>753</u> m	✓none	✓stagnant/still	none
sinuous	*aerial length <u>468</u> m	occasional	✓uniform water surface	✓channel side bars
✓irregular	*sinuosity <u>1.00</u>	frequent	uniform with rapid in reach	point bars
regular meanders	*open water area <u>5.1</u> ha	split	irregular	channel junction bars
irregular meanders	perimeter <u>3.00</u> m	braided	pool and riffle sequence	mid-channel bars
tortuous meanders	river x-sections available	shoals	✓turbid	diamond bars
bifurcated	channel slope 1: _____			diagonal bars
lake/s	river slope 1: _____			sand waves/large dunes
✓lagoon	river width $\bar{x}$ = <u>39.25</u> m	s = _____ m		Comments *whole reach

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
✓none	✓none	road bridge/s		
logs	minor	rail bridge/s		
boulders	major	causeway		
vegetation		weir/dam		
		fish traps		
		embankment/s		
		groynes		
		canals		
		drainage furrows		
		others		

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
✓not detectable	✓alluvium	none	stable
downstream progression	natural levees	LB RB	✓slightly unstable
progression and cut-offs	rock/boulders	reeds <u>8.3</u> <u>63</u> %	moderately unstable
mainly cut-offs	protected/stabilized	trees <u>42</u> <u>17</u> %	unstable
entrenched loop development	cultivation to		highly unstable
irregular lateral activity	channel edge		Comments
avulsion			

TABLE NS 8/5 CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS REF. CSIR NS 8
 RIVER UMHLANGANYAMA, ? % ESTUARINE, REACH from RIVERBEND, 0.95 km from mouth. REF. DMA U 100
 AERIAL PHOTO DATE 5-5-63 TIME 10:30 CATCHMENT AREA 40 km², M.A.R. 2.0 m³x10⁶, No. of DAMS NK

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Terrain	Vegetation	Land-use	Slumping	Vegetation and Land-use	Left	Right
mountainous	almost none	none	✓ none	coastal dune forest	29	63
✓ hilly	✓ grass	scattered cultivation	occasional	sand	8	17
undulating	✓ sparsely forested (0-25%)	partly cultivated	frequent	trees	15	9
plains	moderately forested (25-75%)	mainly cultivated		grass	39	9
	heavily forested (75-100%)	✓ scattered settlement		cultivated	NK	NK
	✓ riverine forest: tributaries	partly built-up		built-up	11	NK
		urbanized				

Comments

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length <u>950</u> m	none	not applicable	not applicable (no valley or free)	✓ bedrock
bottom width (av.) <u>120.5</u> m	indefinite	not obviously degrading	✓ occasionally confined	lacustrine deposits
valley area <u>15.2</u> ha	✓ fragmentary	or aggrading	frequently confined	✓ fluvial deposits
height at head of reach <u>5</u> m to MSL	continuous	partly entrenched	entrenched	aeolian
valley slope 1: <u>190</u>		entrenched		
		✓ aggrading		

Comments

River Mouth

Characteristics	Measurements	Comments
✓ closed	right bank breakwater length _____ m	
✓ natural/	left bank breakwater length _____ m	
canalized	rock sill level _____ m to MSL	
✓ sandy	cliffs on left bank: height _____ m to MSL	
rocks on right/left bank	bar: direction of growth <u>29</u> o	
outer bar	length of bar <u>490</u> m	
silt plume (fluvial)	length stabilized <u>175</u> m	
suspended sediment (marine)	width <u>114</u> m	

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
none	none	open water <u>34</u>	swamp, marsh <u>5</u>
indefinite	average width <u>120.5</u> m	sand (marine) <u>18</u>	cultivated <u>NK</u>
fragmentary	maximum width <u>250</u> m	sand, silt (fluvial) <u>NK</u>	built-up <u>NK</u>
✓ continuous	area <u>15.2</u> ha	trees, bush <u>36</u>	sea <u>NK</u>
		grass <u>7</u>	

Comments

Channel Description N.B. - Estimate of flow stage: LOW/NEAR LONG-TERM MEAN/HIGH

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>788</u> m	✓ none	✓ uniform /still	none
sinuous	*aerial length <u>455</u> m	occasional	✓ uniform water surface	✓ channel side bars
irregular	*sinuosity <u>1.73</u>	frequent	uniform with rapid in reach	point bars
regular meanders	*open water area <u>5.2</u> ha	split	irregular	channel junction bars
irregular meanders	perimeter <u>3138</u> m	braided	pool and riffle sequence	mid-channel bars
tortuous meanders	river x-sections available	shoals	✓ turbid	diamond bars
bifurcated	channel slope 1: _____			diagonal bars
lake/s	river slope 1: _____			sand waves/large dunes
✓ lagoon	river width $\bar{x}$ = _____ m	s = _____ m		

Comments *whole reach

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
✓ none	✓ none	road bridge/s		
logs	minor	rail bridge/s		
boulders	major	causeway		
vegetation		weir/dam		
		fish traps		
		embankment/s		
		groynes		
		canals		
		drainage furrows		
		others	<u>FISHING JETTY/QUAY</u>	<u>RIVER CONFINED</u>

240 m

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
✓ not detectable	✓ alluvium	none	stable
downstream progression	natural levees	LB RB	✓ slightly unstable
progression and cut-offs	rock/boulders	reeds <u>11</u> <u>48</u> %	moderately unstable
mainly cut-offs	protected/stabilized	trees <u>39</u> <u>36</u> %	unstable
entrenched loop development	cultivation to	----- %	highly unstable
irregular lateral activity	channel edge		Comments
avulsion			

TABLE NS 8/VI

CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS

REF. CSIR NS 8

RIVER UNHANGANKULU, ? % ESTUARINE, REACH from RIVERSEN, 0.95 km from mouth. REF. DWA U100
 AERIAL PHOTO DATE 24-6-69 TIME 12:20 CATCHMENT AREA 9.0 km², M.A.R. 2.0 m³ x 10⁶, No. of DAMS NIL

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Valley Sides (Not Well-defined)

Terrain	Vegetation	Land-use	Slumping	Vegetation and Land-use	Left	Right
mountainous	almost none	none	✓ none	coastal dune forest	32	63
✓ hilly	✓ grass	scattered cultivation	occasional	sand	8	16
undulating	sparsely forested (0-25%)	partly cultivated	frequent	trees	18	9
plains	✓ moderately forested (25-75%)	mainly cultivated		grass	82	7
	heavily forested (75-100%)	scattered settlement		cultivated	NIL	NIL
	✓ riverine forest: tributaries	✓ partly built-up		built-up	10	3
		urbanized		Comments		

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length <u>950</u> m	none	not applicable	not applicable (no valley or free)	✓ bedrock
bottom width (av.) <u>120.5</u> m	indefinite	not obviously degrading	✓ occasionally confined	lacustrine deposits
valley area <u>15.2</u> ha	✓ fragmentary	or aggrading	frequently confined	✓ fluvial deposits
height at head of reach <u>5</u> m to MSL	continuous	partly entrenched	entrenched	aeolian
valley slope 1: <u>190</u>		✓ aggrading/		Comments

River Mouth

Characteristics	Measurements	Comments
✓ closed	right bank breakwater length _____ m	
✓ natural/	left bank breakwater length _____ m	
canalized	rock sill level _____ m to MSL	
✓ sandy	cliffs on left bank: height _____ m to MSL	
rocks on right/left bank	bar: direction of growth _____ o	
outer bar	length of bar <u>20</u> m	
silt plume (fluvial)	length stabilized <u>170</u> m	
suspended sediment (marine)	width <u>85</u> m	

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
Presence		
Extent		
none	open water <u>37</u>	swamp, marsh <u>9</u>
indefinite	sand (marine) <u>12</u>	cultivated <u>NIL</u>
fragmentary	sand, silt (fluvial) <u>NIL</u>	built-up <u>NIL</u>
✓ continuous	trees, bush <u>37</u>	sea <u>NIL</u>
	grass <u>5</u>	
	Comments	

Channel Description N.B. - Estimate of flow stage: LOW/NEAR LONG-TERM MEAN/HIGH

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>870</u> m	✓ none	✓ uniform /still	✓ none
sinuous	*aerial length <u>554</u> m	occasional	uniform water surface	channel side bars
irregular	*sinuosity <u>15.7</u>	frequent	uniform with rapid in reach	point bars
regular meanders	*open water area <u>5.7</u> ha	split	irregular	channel junction bars
irregular meanders	perimeter <u>3500</u> m	braided	pool and riffle sequence	mid-channel bars
tortuous meanders	river x-sections available	shoals	✓ turbid	diamond bars
bifurcated	channel slope 1: _____			diagonal bars
lake/s	river slope 1: _____			sand waves/large dunes
✓ lagoon	river width $\bar{x}$ = _____ m			

Comments *whole reach

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
✓ none	none	road bridge/s		
logs	minor	rail bridge/s		
boulders	major	causeway		
vegetation		weir/dam		
		fish traps		
		embankment/s		
		groynes		
		canals		
		drainage furrows		
		others		
Comments				

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
✓ not detectable	✓ alluvium	none	stable
downstream progression	natural levees	LB RB	✓ slightly unstable
progression and cut-offs	rock/boulders	reeds <u>13</u> <u>52</u> %	moderately unstable
mainly cut-offs	protected/stabilized	trees <u>55</u> <u>37</u> %	unstable
entrenched loop development	cultivation to	----- %	highly unstable
irregular lateral activity	channel edge		Comments
avulsion			

TABLE NS 8/VII

CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS

REF. CSIR NS 8

 RIVER UNHLANGHANKULU, 91 % ESTUARINE, REACH from RIVERBEND, 0.95 km from mouth.
 AERIAL PHOTO DATE 23-6-76 TIME 10:50 CATCHMENT AREA 9.0 km², M.A.R. 2.0 m³ x 10⁶, No. of DAMS N/L
REF. DWA U 100

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Valley Sides (Not Well-defined)

Terrain	Vegetation	Land-use	Slumping	Vegetation and Land-use	Left	Right
mountainous	almost none	none	✓ none	coastal dune forest	34	69
✓ hilly	✓ grass	scattered cultivation	occasional	sand	8	16
undulating	sparsely forested (0-25%)	partly cultivated	frequent	trees	18	9
plains	✓ moderately forested (25-75%)	mainly cultivated		grass	29	3
	heavily forested (75-100%)	scattered settlement		cultivated	N/L	N/L
	✓ riverine forest: tributaries	✓ partly built-up urbanized		built-up	11	3

Comments

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length <u>950</u> m	none	not applicable	not applicable (no valley or free)	✓ bedrock
bottom width (av.) <u>120.5</u> m	indefinite	not obviously degrading or aggrading	✓ occasionally confined	lacustrine deposits
valley area <u>15.2</u> ha	✓ fragmentary	partly entrenched	frequently confined	✓ fluvial deposits
height at head of reach <u>5</u> m to MSL	continuous	entrenched	entrenched	aeolian
valley slope 1: <u>190</u>		✓ aggrading/		

Comments

River Mouth

Characteristics

Measurements

✓ closed	right bank breakwater length	_____ m
✓ natural/	left bank breakwater length	_____ m
canalized	rock sill	_____ level
✓ sandy	cliffs on left bank: height	_____ m to MSL
rocks on right/left bank	bar: direction of growth	<u>29</u> o
outer bar	length of bar	<u>490</u> m
silt plume (fluvial)	length stabilized	<u>175</u> m
suspended sediment (marine)	width	<u>77</u> m

Comments

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent	Areal Measurements: % Flood Plain/Valley
none	none	open water <u>38</u>
indefinite	average width <u>120.5</u> m	sand (marine) <u>10</u>
fragmentary	maximum width <u>250</u> m	sand, silt (fluvial) <u>N/L</u>
✓ continuous	area <u>15.2</u> ha	trees, bush <u>35</u>
		grass <u>5</u>

Crops, Animal Husbandry

Comments

Channel Description N.B. - Estimate of flow stage: LOW/NEAR LONG-TERM MEAN/HIGH

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>935</u> m	✓ none	✓ uniform /still	✓ none
sinuous	*aerial length <u>581</u> m	occasional	✓ uniform water surface	channel side bars
irregular	*sinuosity <u>4.60</u>	frequent	uniform with rapid in reach	point bars
regular meanders	*open water area <u>5.8</u> ha	split	irregular	channel junction bars
irregular meanders	perimeter <u>3690</u> m	braided	pool and riffle sequence	mid-channel bars
tortuous meanders	river x-sections available	shoals	✓ turbid	diamond bars
bifurcated	channel slope 1: _____			diagonal bars
lake/s	river slope 1: _____			sand waves/large dunes
✓ lagoon	river width $\bar{x}$ = <u>52.15</u> m	s = _____ m		

Comments *whole reach

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
✓ none	none	road bridge/s		
logs	minor	rail bridge/s		
boulders	major	causeway		
vegetation		weir/dam		
		fish traps		
		embankment/s		
		groynes		
		canals		
		drainage furrows		
		others	<u>FISHING JETTY/QUAY</u>	<u>240 m</u>

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
✓ not detectable	✓ alluvium	none	stable
downstream progression	natural levees	LB RB	✓ slightly unstable
progression and cut-offs	rock/boulders	reeds <u>15</u> <u>59</u> %	moderately unstable
mainly cut-offs	protected/stabilized	trees <u>62</u> <u>28</u> %	unstable
entrenched loop development	cultivation to	_____ %	highly unstable
irregular lateral activity	channel edge		
avulsion			Comments

TABLE NS 8/VIII

CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS

REF. CSIR NS 8

RIVER UMKANGA/KUKU, ? % ESTUARINE, REACH FROM RIVERBEND, 0.95 km from mouth.REF. DWA U100AERIAL PHOTO DATE 2-8-83 TIME 11:52 CATCHMENT AREA 9.0 km², M.A.R. 2.0 m³x10⁶, No. of DAMS NIL

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Terrain Vegetation Land-use

mountainous almost none none

✓hilly ✓grass scattered cultivation

undulating sparsely forested (0-25%) partly cultivated

plains ✓moderately forested (25-75%) mainly cultivated

heavily forested (75-100%) scattered settlement

✓riverine forest: tributaries ✓built-up urbanized

Valley Sides (Not Well-defined)

Slumping Vegetation and Land-use Left Right

✓none coastal dune forest 32 69

occasional sand 5 16

frequent trees 5 6

grass 41 3

cultivated 41 3

built-up 58 6

Comments SAN LAMBER, HOLIDAY RESORT
ON LEFT VALLEY SIDE.

Valley Characteristics

Measurements Terraces Relation of Channel to Valley Bottom (Vertical) Relation of Channel to Valley Sides or Resistant Terraces (Lateral) Surface Geology

valley length 950 m none not applicable not applicable (no valley or free) ✓bedrock

bottom width (av.) 120.5 m indefinite not obviously degrading ✓occasionally confined lacustrine deposits

valley area 15.2 ha ✓fragmentary or aggrading frequently confined ✓fluvial deposits

height at head continuous partly entrenched entrenched aeolian

of reach 5 m to MSL

valley slope 1: 190 ✓aggrading/

Comments

River Mouth

Characteristics

Measurements

✓open/✓natural/artificial canalized

✓sandy

rocks on right/left bank

outer bar

silt plume (fluvial)

suspended sediment (marine)

right bank breakwater length _____ m

left bank breakwater length _____ m

rock sill level _____ m to MSL

cliffs on left bank: height _____ m to MSL

spit/bar: direction of growth 29 o

length of spit/bar 300 m

length stabilized 225 m

width 96 m

Comments * MOUTH BARELY OPEN

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence Extent

none none

indefinite average width 120.5 m

fragmentary maximum width 250 m

✓continuous area 15.2 ha

Areal Measurements: % Flood Plain/Valley

open water 31 swamp, marsh 10

sand (marine) 11 cultivated 41

sand, silt (fluvial) 5 built-up 3

trees, bush 40 sea 41

grass NIL

Crops, Animal Husbandry

Comments

Channel Description N.B. - Estimate of flow stage: LOW/NEAR LONG-TERM MEAN/HIGH

Pattern Measurements Islands/Shoals Type of Flow Bar Type

straight *thalweg 1010 m ✓none ✓uniform/still none

sinuous *aerial length 590 m occasional ✓uniform water surface ✓channel side bars

irregular *sinuosity 1.71 frequent uniform with rapid in reach ✓point bars

regular meanders *open water area 4.71 ha split irregular channel junction bars

irregular meanders perimeter 3548 m braided pool and riffle sequence mid-channel bars

tortuous meanders river x-sections available shoals ✓turbid diamond bars

bifurcated channel slope 1: _____ diagonal bars

lake/s river slope 1: _____ sand waves/large dunes

✓lagoon river width $\bar{x}$ = 49.5 m s = _____ m

Comments *whole reach

Obstructions/Constructions

Natural Degree Man-made Degree of Obstruction/Constriction for Each Position (from head of reach)

✓none none road bridge/s _____

logs minor rail bridge/s _____

boulders major causeway _____

vegetation weir/dam _____

fish traps _____

embankment/s _____

Comments HAIR OF THE JETTY
HAS DISAPPEARED

groynes _____

canals _____

drainage furrows _____

others _____

Lateral Channel Activity

Lateral Activity Nature of Banks Bank Vegetation Lateral Stability

✓not detectable ✓alluvium none stable

downstream progression natural levees LB RB

progression and cut-offs rock/boulders reeds 10 38 %

mainly cut-offs protected/stabilized trees 54 23 %

entrenched loop development cultivation to channel edge ----- %

irregular lateral activity avulsion

Comments

TABLE NS 8/17

CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS

REF. CSIR 158

RIVER UHLANGANKULU, ? NIL * % ESTUARINE, REACH from RIVERSEND, 0.95 km from mouth. REF. DWA 1100
 AERIAL PHOTO DATE 2-10-87 TIME 11:50 CATCHMENT AREA 90 km², M.A.R. 20 m³x10⁶, No. of DAMS NIL

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Terrain	Vegetation	Land-use
mountainous	almost none	none
✓hilly	✓grass	scattered cultivation
undulating	sparsely forested (0-25%)	partly cultivated
plains	✓moderately forested (25-75%)	mainly cultivated
	heavily forested (75-100%)	scattered settlement
	✓riverine forest: tributaries	✓ built-up built-up urbanized

Valley Sides (Not Well-defined)

Slumping	Vegetation and Land-use	Left	Right
✓none	coastal dune forest	<u>27</u>	<u>69</u>
occasional	sand	<u>5</u>	<u>16</u>
frequent	trees	<u>5</u>	<u>6</u>
	grass	<u>NIL</u>	<u>3</u>
	cultivated	<u>NIL</u>	<u>NIL</u>
	built-up	<u>63</u>	<u>6</u>

Comments % ESTUARINE PROBABLY NILDUE TO FLOOD FLOWS

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length <u>950</u> m	none	not applicable	not applicable (no valley or free)	✓bedrock
bottom width (av.) <u>120.5</u> m	indefinite	not obviously degrading or aggrading	✓occasionally confined	lacustrine deposits
valley area <u>15.2</u> ha	✓fragmentary	partly entrenched	frequently confined	✓fluvial deposits
height at head of reach <u>5</u> m to MSL	continuous	entrenched	entrenched	aeolian
valley slope 1: <u>190</u>		✓aggrading/		

Comments _____

River Mouth

Characteristics

- ✓open/~~_____~~
 ✓natural/artificial canalized
 ✓sandy
 * ✓rocks on right/~~_____~~ bank
 outer bar
 silt plume (fluvial)
 suspended sediment (marine)

Measurements

right bank breakwater length	_____ m
left bank breakwater length	_____ m
rock sill level	_____ m to MSL
cliffs on left bank: height	_____ m to MSL
spit/ _____ : direction of growth	<u>29</u> o
length of spit/ _____	<u>450</u> m
length stabilized	<u>235</u> m
width	<u>73</u> m

Comments * UNUSUAL DEVIATIONOF RIVER COURSE

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent
none	none
indefinite	average width <u>120.5</u> m
fragmentary	maximum width <u>250</u> m
✓continuous	area <u>15.2</u> ha

Areal Measurements: % Flood Plain/Valley

open water	<u>19</u>	swamp, marsh	<u>12</u>
sand (marine)	<u>3</u>	cultivated	<u>NIL</u>
sand, silt (fluvial)	<u>17</u>	built-up	<u>3</u>
trees, bush	<u>46</u>	sea	<u>NIL</u>
grass	<u>NIL</u>		

Crops, Animal Husbandry

Comments _____

Channel Description N.B. - Estimate of flow stage: LOW/NEAR LONG-TERM MEAN/HIGH

Pattern	Measurements	Islands/ _____	Type of Flow	Bar Type
straight	*thalweg <u>1097</u> m	none	stagnant/still	none
sinuous	*aerial length <u>666</u> m	occasional	uniform water surface	✓channel side bars
irregular	*sinuosity <u>1.65</u>	frequent	uniform with rapid in reach	✓point bars
regular meanders	*open water area <u>2.94</u> ha	split	✓irregular	✓channel junction bars
irregular meanders	perimeter <u>4123</u> m	✓braided	pool and riffle sequence	mid-channel bars
tortuous meanders	river x-sections available	shoals	✓turbid	diamond bars
bifurcated	channel slope 1: _____			diagonal bars
lake/s	river slope 1: _____			sand waves/large dunes
✓lagoon	river width $\bar{x}$ = <u>20.4</u> m	s = _____ m		

Comments *whole reach

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
✓none	none	road bridge/s		
logs	minor	rail bridge/s		
boulders	major	causeway		
vegetation		weir/dam		
		fish traps		
		embankment/s		
		groynes		
		canals		
		drainage furrows		
		others		

Comments REMAINS OF JETTY,DISAPPEARED

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
✓not detectable	✓alluvium	none	stable
downstream progression	natural levees	LB RB	✓slightly unstable
progression and cut-offs	rock/boulders	reeds <u>13</u> <u>18</u> %	moderately unstable
mainly cut-offs	protected/stabilized	trees <u>33</u> <u>15</u> %	unstable
entrenched loop development	cultivation to	_____ %	highly unstable
irregular lateral activity	channel edge		
avulsion			

Comments _____

RIVER WIDTHS

TABLE NS8/X

Stn	Approx. distance along 1976 river course	Distance from maximum observed L.B. position to mid-river (m)										$\bar{x}$	s	V%
		Date												
		2-5-37	Dec 43	Jun/Jul 1955	5-5-63	24-6-69	23-6-76	2-8-83	2-10-87					
1	0	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	0	0	0
2	100	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	0	0	0
3	200	45 (30+15)	90 (60+15+15)	102,5 (95+7,5)	102,5 (72,5+15+15)	96 (75+12+9)	96 (78+12+6)	102,5 (90+12,5)	42	42	84,6	25,7	30,4	30,4
4	300	67,5	66	75	67	72	72,5	55,5 (43+12,5)	7,5	7,5	60,4	22,2	36,8	36,8
5	400	92,5	115	120	125	120	117	120	20 (17+3)	20	103,7	35,2	33,9	33,9
6	500	42	45	25	52,5	58	62	57	28	28	46,2	13,9	30,1	30,1
7	600	62,5	115	65	61	58	58	57	27	27	62,9	24,2	38,5	38,5
8	700	7,5	65	0	33	60	60	50	42,5	42,5	39,8	24,6	61,8	61,8
9	800	5	12,5	0	0	57,5	51	36	20	20	22,8	22,8	100,0	100,0
10	900	6	5	0	0	0	0	15	12	12	4,8	6,0	125,7	125,7
$\bar{x}$		33,3	51,9	39,3	44,6	52,7	52,2	49,8	20,4	20,4	43,0			
s		33,1	45,3	47,1	45,1	40,5	40,0	39,0	14,7	14,7				
V%		99,3	87,3	120,0	101,1	76,8	76,7	78,4	71,9	71,9				

LATERAL STABILITY

TABLE NS8/XI

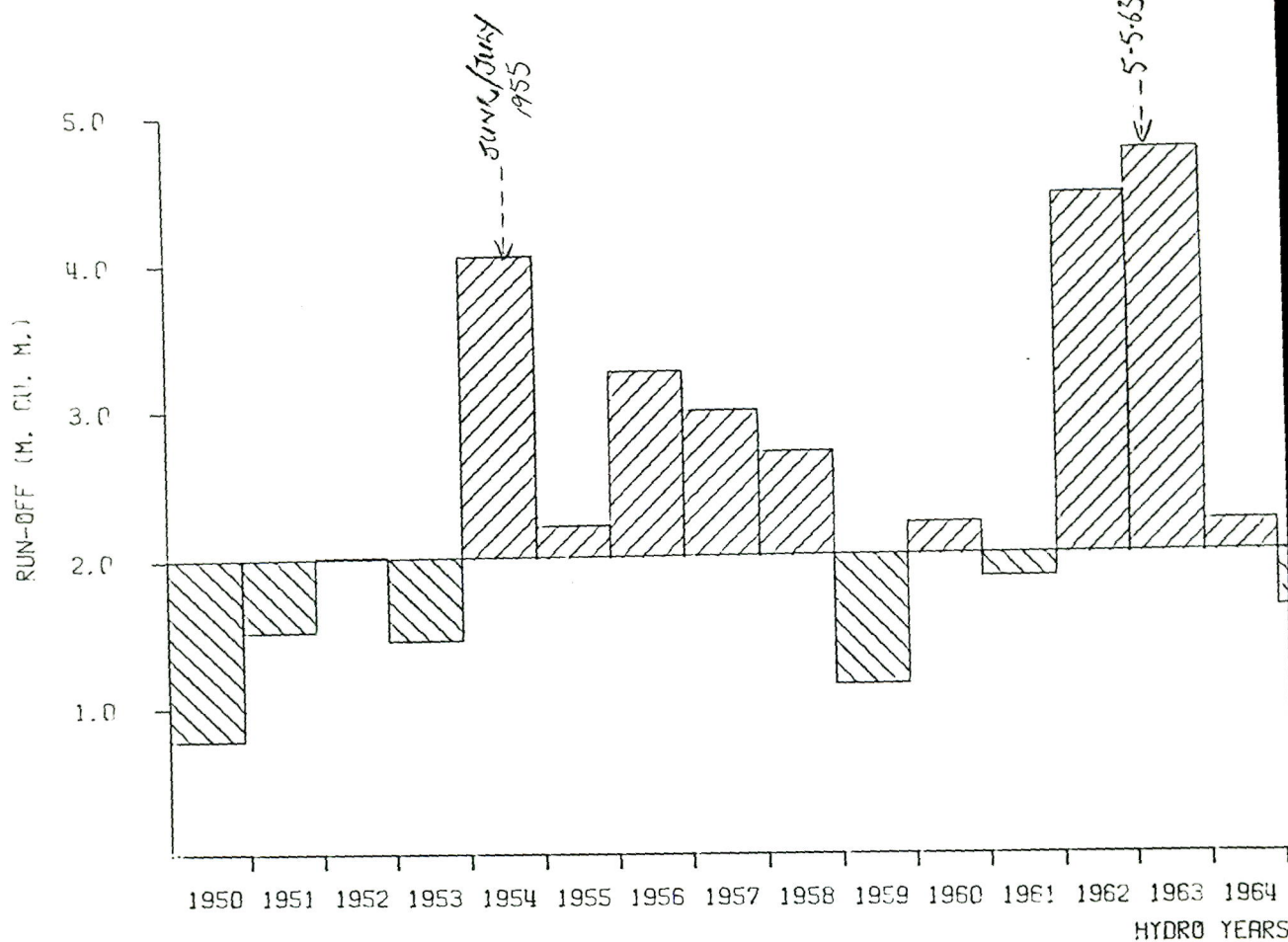
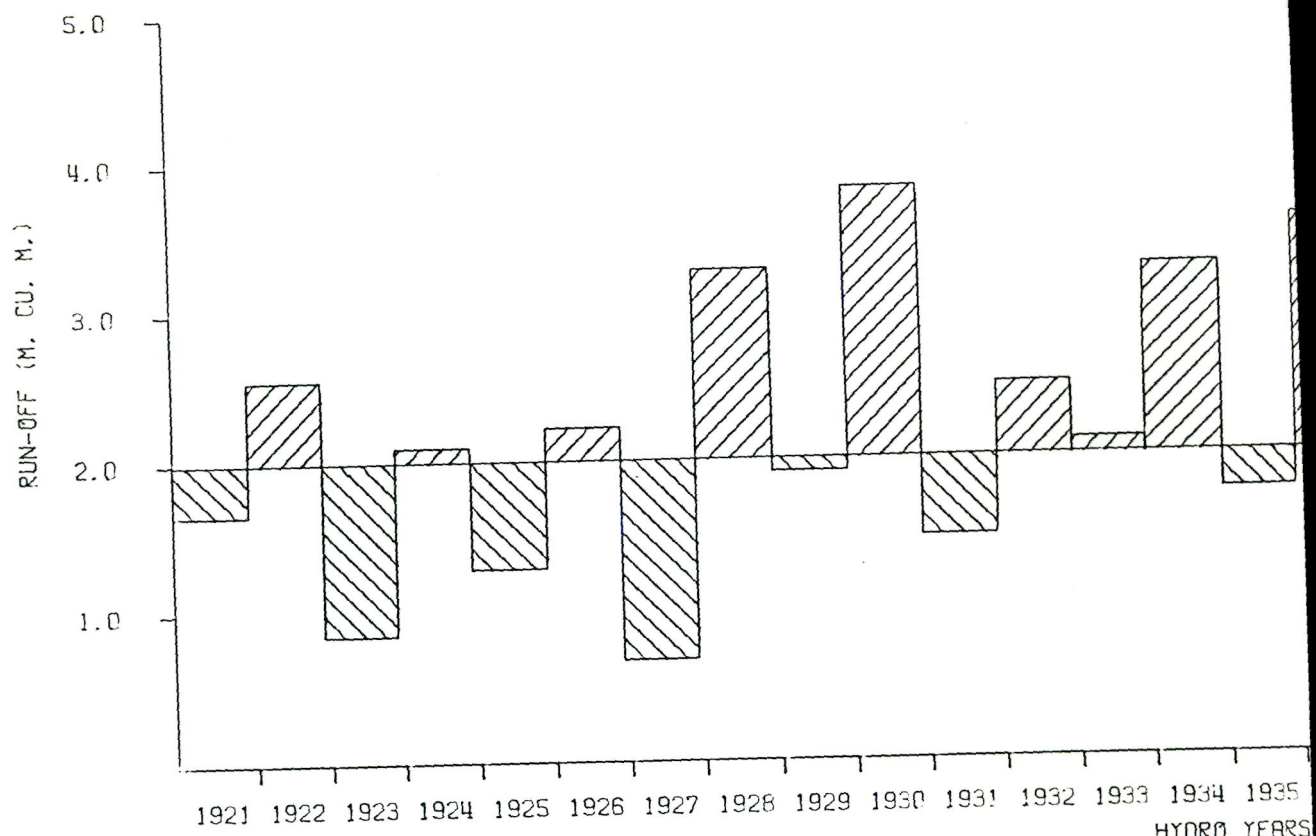
Stn	Approx. distance along 1976 river course	Distance from maximum observed L.B. position to mid-river (m)										Max-Min	$\bar{x}$	S	V%
		Date													
		2-5-37	Dec 43	Jun/Jul 1955	5-5-63	24-6-69	23-6-76	2-8-83	2-10-87						
1	0	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3	0	1,3	0	1,3	0	0
2	100	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3	0	1,3	0	1,3	0	0
3	200	<u>69</u>	59	52	68	55	67,2	58	<u>44</u>	25	<u>44</u>	25	59,0	8,8	14,9
4	300	45	40	45	45	37	<u>47,5</u>	35	<u>12</u>	35,5	<u>12</u>	35,5	38,3	11,5	30,0
5	400	<u>94,5</u>	57,5	67	65	60	66	62	<u>15</u>	79,5	<u>15</u>	79,5	60,9	21,8	35,8
6	500	<u>55</u>	48	45	<u>26,3</u>	31,5	33	45	52,5	28,7	52,5	28,7	42,0	10,5	25,0
7	600	52,5	48	104	<u>30,5</u>	42,5	39	65	82	73,5	82	73,5	57,9	24,6	42,5
8	700	<u>50</u>	38	N.R.	<u>16,5</u>	40	40	45	40	33,5	40	33,5	38,5	10,5	27,4
9	800	<u>72,5</u>	<u>7,5</u>	N.R.	N.R.	42,5	52,5	55	37	65	37	65	44,5	21,9	49,2
10	900	<u>217,5</u>	117	N.R.	N.R.	N.R.	N.R.	162,5	<u>6</u>	211,5	<u>6</u>	211,5	125,8	89,8	71,4
x		65,9	41,8	45,1	31,7	34,6	38,6	53,0	29,1	55,2	29,1	55,2	47,2		29,6
S		60,7	34,6	36,2	26,0	20,8	24,2	44,8	26,5	61,6	26,5	61,6	42,5		21,9
V%		92,1	82,8	80,3	82,0	60,1	62,7	84,5	91,1	111,6	91,1	111,6			74,1

Average lateral displacement 1937 - 1987 = 55,2 m (that is, 128,4% $\bar{R}$ width)
 Average coefficient of variation 1937 - 1987 = 29,6%

TABLE NS 8 ~~XII~~ SIMULATED RUN-OFF FOR UMHLANGANKULU NS 8 CATCHMENT AREA= 9.05Q.KM. *****

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL	MM.A.R.
1921	.07	.10	.66	.29	.09	.06	.05	.08	.09	.07	.05	.06	1.66	83.04
1922	.50	.46	.17	.09	.59	.31	.11	.05	.03	.07	.09	.07	2.55	127.35
1923	.07	.10	.15	.16	.13	.07	.04	.03	.02	.02	.02	.03	.85	42.55
1924	.05	.08	.10	.13	.13	.96	.40	.08	.05	.04	.03	.05	2.10	105.05
1925	.10	.10	.08	.05	.06	.36	.19	.07	.08	.08	.06	.05	1.29	64.43
1926	.10	.12	.10	.06	.04	1.15	.47	.06	.03	.02	.03	.04	2.22	111.15
1927	.06	.06	.07	.10	.11	.08	.05	.03	.03	.02	.03	.03	.67	33.62
1928	.05	.06	.06	.06	.06	.11	.16	.14	1.22	.80	.25	.31	3.27	163.47
1929	.50	.51	.21	.18	.13	.06	.21	.03	.04	.05	.06	.12	3.80	190.19
1930	.17	.16	.15	.16	.15	.40	.15	.08	.10	.07	.05	.28	1.48	73.86
1931	.13	.12	.09	.07	.10	.22	.09	.11	.10	.04	.03	.03	2.48	124.14
1932	.39	.78	.64	.22	.06	.08	.09	.07	.05	.06	.13	.10	2.11	105.27
1933	.04	.46	.38	.51	.24	.10	.09	.07	.82	.35	.07	.07	3.26	162.92
1934	.04	.06	.74	.32	.04	.09	.11	.18	.15	.10	.06	.05	1.76	87.92
1935	.08	.06	.61	.23	.49	.32	.12	.18	.05	.10	.05	.06	3.56	178.16
1936	.11	1.57	.08	.23	.23	.13	.09	.05	.03	.04	.05	.05	1.93	96.67
1937	.07	.08	.17	.15	.38	.23	.36	.21	.09	.09	.09	.06	1.51	75.56
1938	.05	.08	.26	.15	.05	.04	.11	.08	.05	.05	.06	.11	1.63	81.68
1939	.16	.14	.08	.07	.03	.03	.04	.38	.23	.09	.05	.05	.62	30.94
1940	.06	.10	.11	.07	.03	.03	.04	.03	.02	.03	.04	.06	1.63	81.46
1941	.09	.10	.08	.49	.24	.12	.13	.12	.08	.05	.05	.11	4.01	200.55
1942	.11	1.02	.93	.28	.08	.45	.51	.23	.10	.08	.11	.10	1.31	65.51
1943	.25	.20	.21	.14	.10	.08	.06	.05	.05	.05	.04	.03	1.12	56.16
1944	.35	.19	.07	.04	.06	.12	.10	.06	.04	.03	.03	.02	1.30	64.95
1945	.53	.26	.05	.03	.05	.08	.25	.08	.05	.26	.10	.06	2.49	124.44
1946	.04	.24	.18	.11	.10	.39	.25	.25	.52	.03	.03	.03	2.44	121.85
1947	.06	.71	.36	.15	.20	.48	.25	.10	.05	.03	.03	.04	1.26	63.10
1948	.40	.23	.08	.05	.06	.11	.11	.08	.05	.10	.13	.13	2.12	105.75
1949	.08	.51	.26	.21	.15	.09	.12	.18	.15	.10	.02	.04	.78	38.89
1950	.11	.09	.11	.13	.09	.07	.05	.03	.03	.02	.02	.06	1.51	75.48
1951	.23	.15	.11	.39	.21	.08	.06	.07	.06	.02	.04	.06	2.01	100.61
1952	.07	.07	.08	.46	.82	.30	.06	.04	.02	.02	.03	.06	1.44	72.16
1953	.10	.44	.25	.10	.07	.10	.15	.07	.06	.05	.04	.07	4.04	201.96
1954	1.64	.65	.08	.67	.34	.26	.58	.21	.09	.07	.03	.07	2.22	110.79
1955	.11	.14	.11	.05	.05	.64	.58	.27	.08	.05	.04	.10	3.25	162.40
1956	.25	.52	.83	.12	.09	.12	.51	.24	.06	.05	.05	.05	2.98	149.14
1957	.47	.36	.15	.12	.60	.32	.51	.27	.06	.05	.08	.08	2.70	135.11
1958	.08	.15	.14	.10	.08	.06	.04	1.27	.52	.09	.04	.05	1.13	56.64
1959	.11	.12	.10	.08	.08	.11	.14	.14	.10	.06	.04	.11	2.22	110.83
1960	.07	.11	.14	.12	.07	.16	.78	.34	.09	.11	.12	.04	1.85	92.43
1961	.12	.30	.18	.10	.08	.56	.27	.08	.05	.03	.03	.10	4.42	220.90
1962	.11	.14	.10	.47	.22	1.96	.75	.09	.07	.23	.17	.07	4.71	235.33
1963	.17	.18	1.06	1.23	.41	.12	.09	.07	.83	.39	.10	.20	2.21	110.68
1964	.88	.40	.09	.13	.07	.04	.02	.03	.10	.15	.15	.06	1.63	81.33
1965	.46	.30	.15	.13	.11	.06	.04	.07	.10	.09	.06	.05	1.76	88.21
1966	.06	.08	.09	.13	.13	.17	.57	.26	.08	.08	.07	.05	.77	38.75
1967	.05	.10	.11	.07	.05	.07	.09	.06	.04	.02	.04	.08	1.48	73.80
1968	.12	.12	.10	.06	.07	.13	.14	.33	.20	.09	.06	.12	.96	47.98
1969	.11	.16	.15	.09	.05	.03	.07	.11	.05	.07	.45	.25	3.60	179.88
1970	1.17	.65	.30	.08	.12	.08	.05	.03	.11	.04	.04	.03	1.42	71.13
1971	.51	.28	.13	.08	.10	.10	.05	.03	.03	.04	.04	.06	.58	29.11
1972	.03	.09	.12	.09	.05	.03	.06	.12	.15	.10	.06	.04	.81	40.47
1973	.08	.06	.04	.02	.03	.05	.06	.12	.05	.10	.02	.08	.85	42.48
1974	.04	.06	.21	.16	.09	.07	.05	.10	.02	.02	.02	.05	1.93	96.38
1975	.12	.08	.11	.13	.13	.65	.32	.14	.10	.07	.06	.03	.40	19.89
1976	.08	.08	.05	.03	.03	.02	.01	.01	.02	.02	.02	.03	2.00	
MEAN	.22	.26	.22	.18	.16	.24	.18	.14	.13	.11	.08	.08	1.04	
S	.29	.28	.23	.20	.17	.33	.19	.18	.22	.23	.10	.06	51.92	
V%	135.87	107.65	105.64	107.33	103.70	137.46	106.25	133.78	168.27	198.64	128.01	74.79		
MEAN ANNUAL RUN-OFF=	.11	.14	.13	.12	.09	.11	.11	.08	.06	.05	.05	.06	1.76	

2.00 MILLION CUBIC METRES. COMPILED FROM HRU REPORT NO.12/81 DATA



TRACED : COMPILOT

CHECKED :

DATE :

REF. :

NATAL ESTUARIES : UMHLANGANKULU

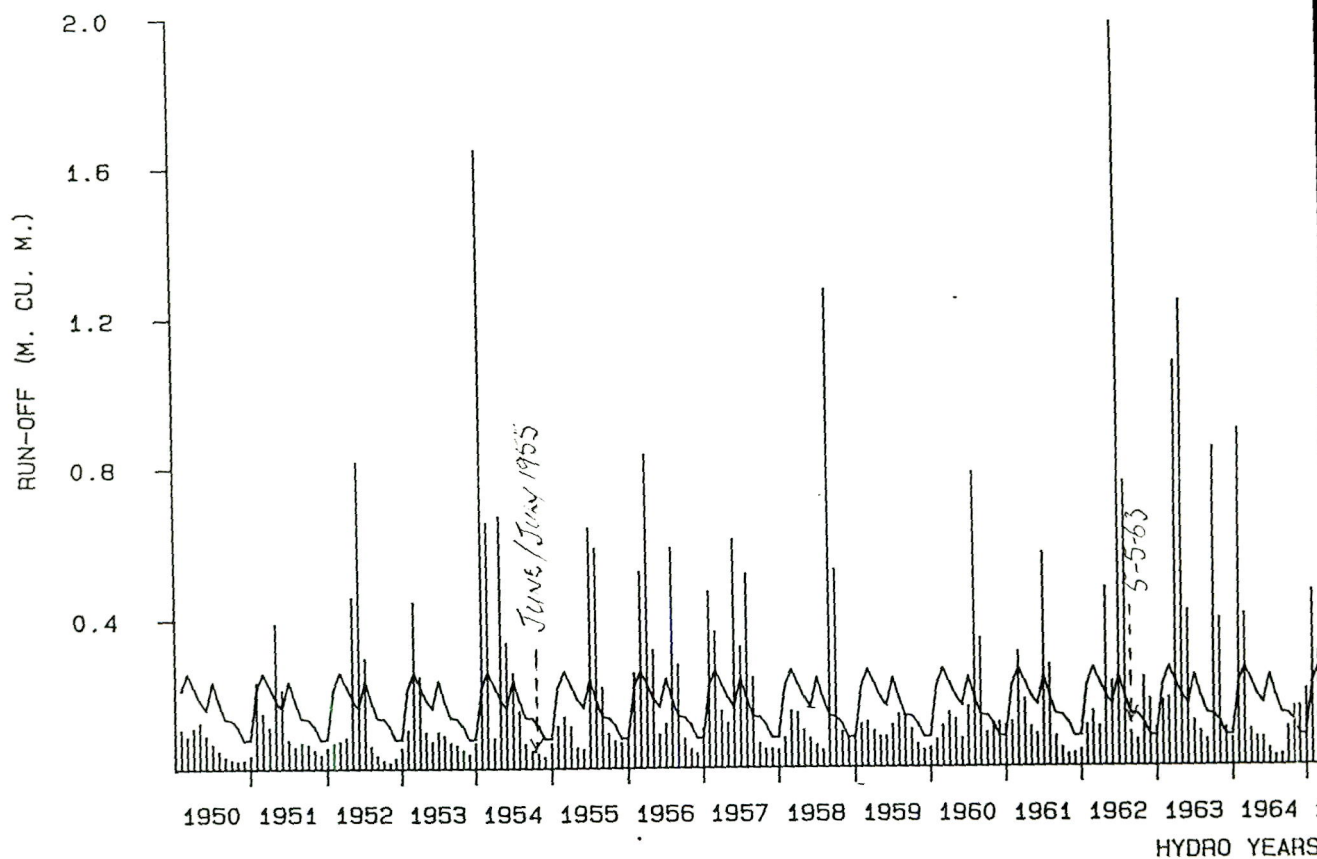
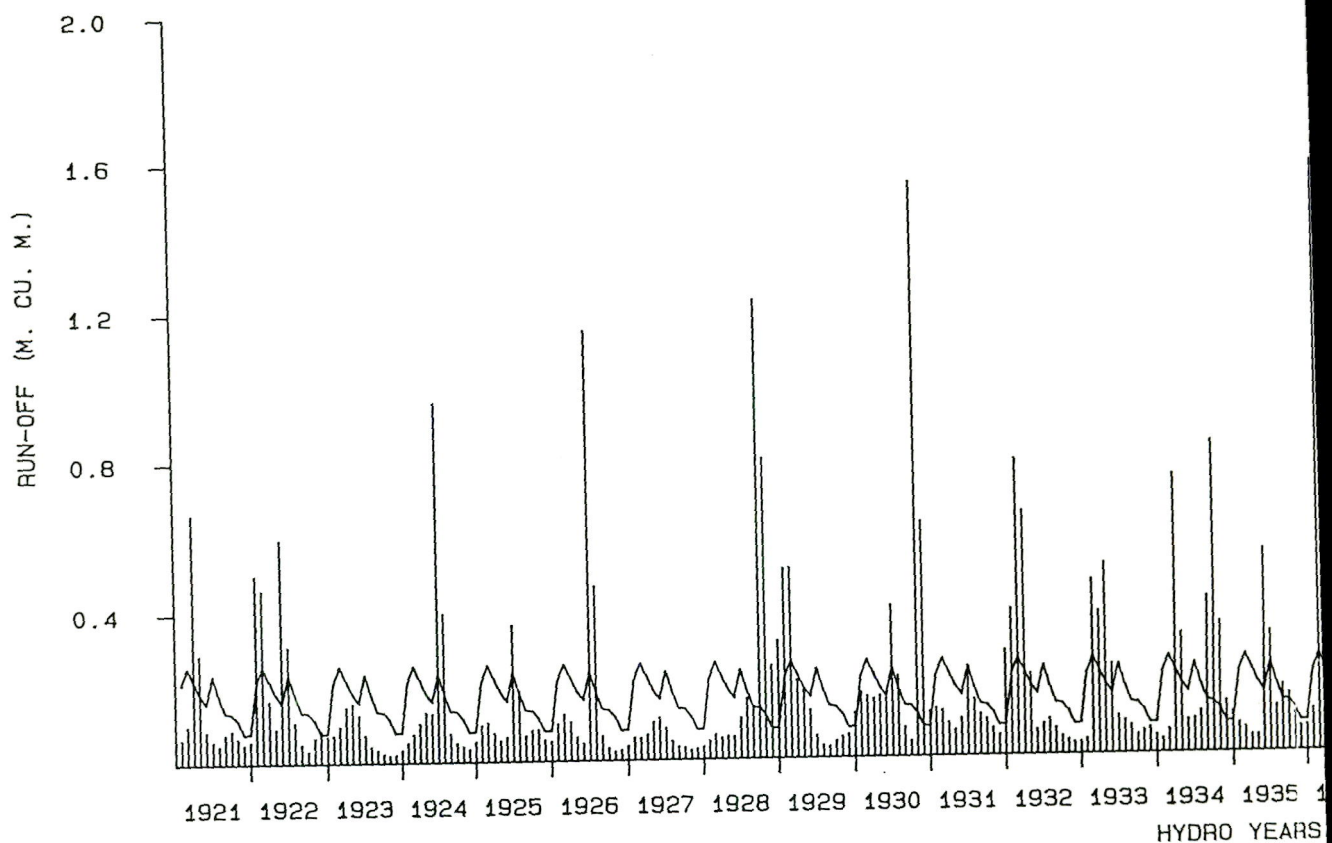
SIMULATED ANNUAL RUN-OFF

1921-1976

FIGURE

NS 8/1

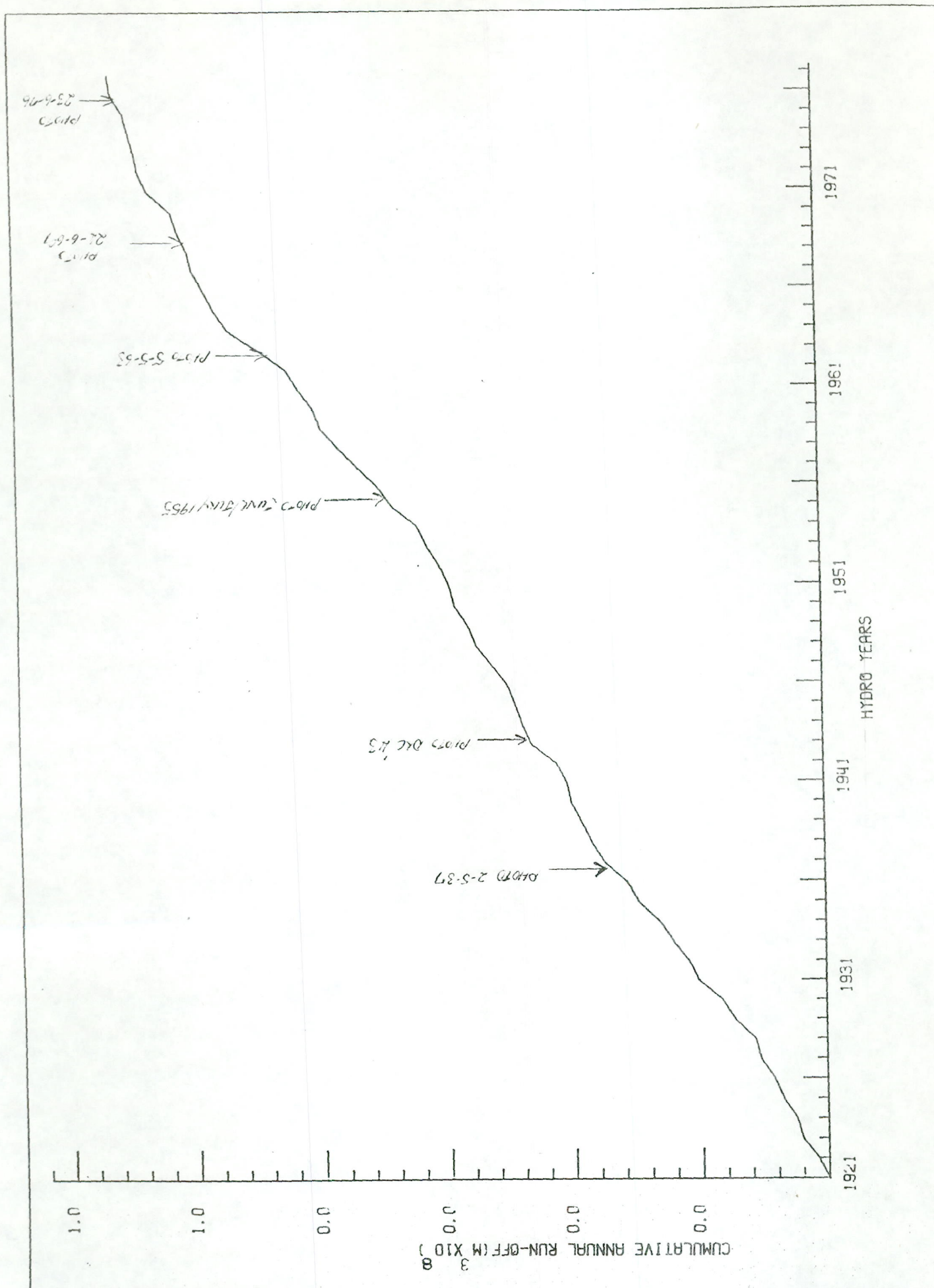
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



TRACED : COMPLIT
 CHECKED:
 DATE :
 REF. :

NATAL ESTUARIES : UMHLANGANKULU
 SIMULATED MONTHLY RUN-OFF
 1921-1976

FIGURE
 NS 8/2



TRACED : COMPILOT
 CHECKED :
 DATE :
 REF. :

NATAL ESTUARIES: UMHLANGANKULU
 CUMULATIVE ANNUAL RUN-OFF

FIGURE
 NS 8/3

KEY

RIVER COURSE

xxxxxxx 2-5-37

-x-x- OCT 43

-o-o- JUNE / JULY 55

ΔΔΔΔΔΔΔΔ 5-5-63

□□□□□□□□ 24-6-69

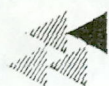
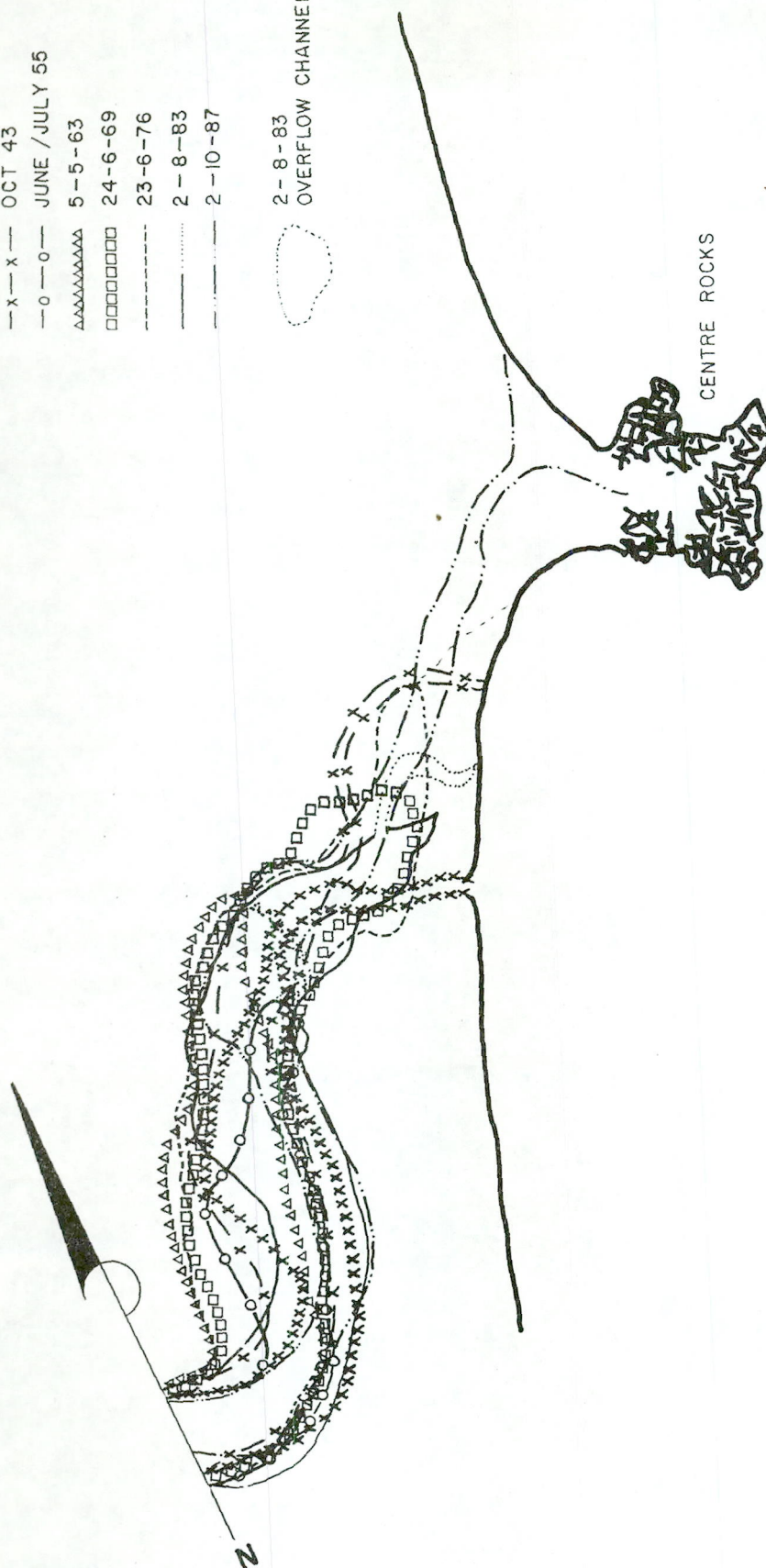
----- 23-6-76

..... 2-8-83

----- 2-10-87

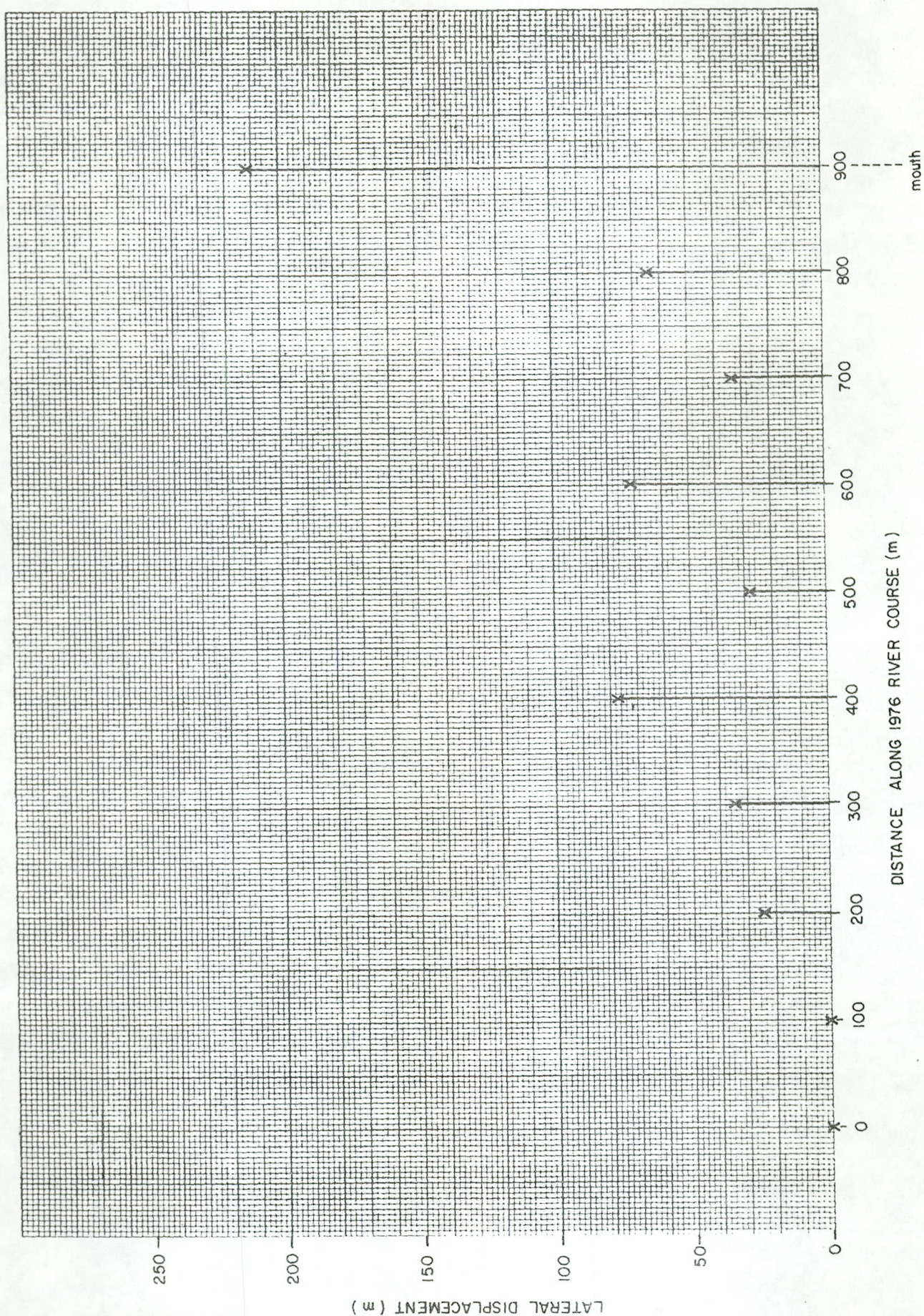
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OVERFLOW CHANNEL



NATAL ESTUARIES : UMHLANGANKULU
HIGH WATER LEVEL AND RIVER MOUTH
POSITIONS (1937 - 1987)

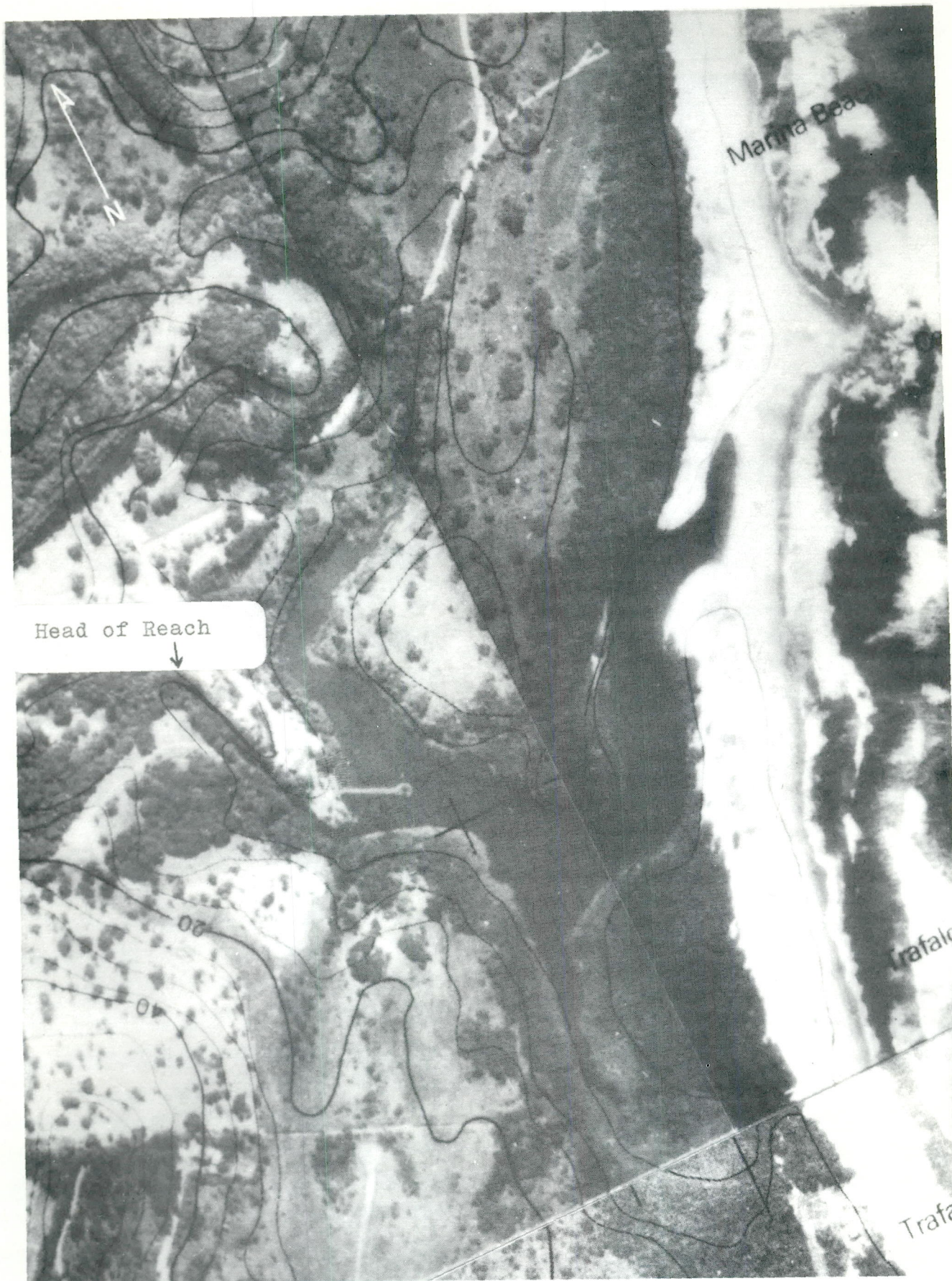
FIGURE
NS 8/4



NATAL ESTUARIES : UMHLANGANKULU

THALWEG DISPLACEMENT
(1937-1987)

FIGURE
NS 8/5



SCALE: 1 : 5000 approx



NATAL ESTUARIES · UMHLANGANKULU

23 - 06 - 76 (ORTHOPHOTO)

PHOTOGRAPH

NS 8 / 1



SCALE: 1 : 5000 approx.



NATAL ESTUARIES : UMHLANGANKULU

02-05-37 (13h08)

PHOTOGRAPH

NS 8 / 2



SCALE: 1 : 5000 approx



NATAL ESTUARIES : UMHLANGANKULU

DECEMBER 1943 (10h12)

PHOTOGRAPH

NS 8/3



SCALE: 1 : 5000 approx



NATAL ESTUARIES : UMHLANGANKULU

JUNE / JULY 1955 (10h36)

PHOTOGRAPH

NS 8 / 4



SCALE: 1 : 5000 approx.



NATAL ESTUARIES : UMHLANGANKULU

05 - 05 - 63 (10h30)

PHOTOGRAPH

NS 8 / 5



SCALE: 1 : 5000 approx



NATAL ESTUARIES : UMHLANGANKULU

24-06-69 (12h20)

PHOTOGRAPH

NS 8 / 6



SCALE: 1 : 5000 approx

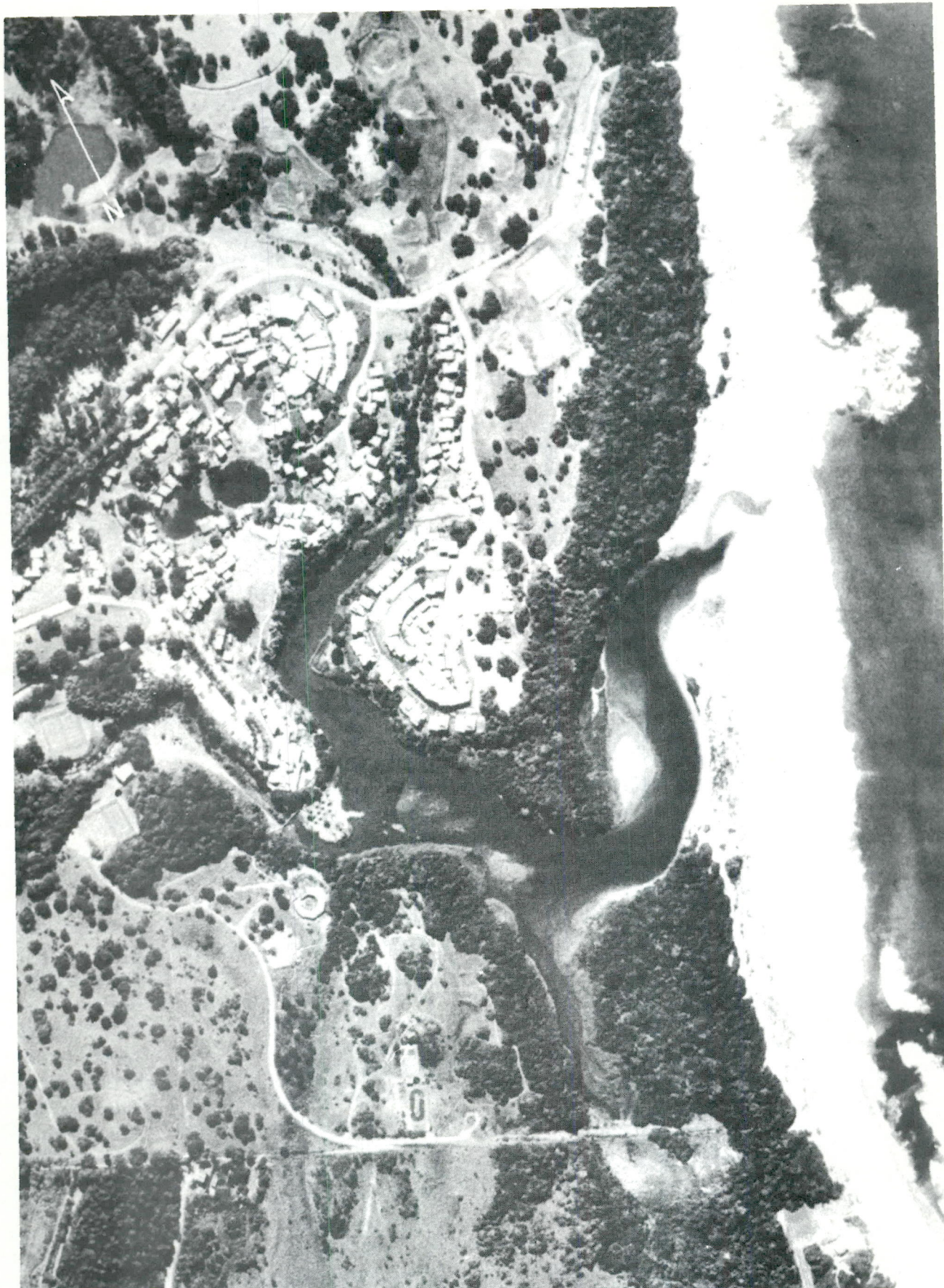


NATAL ESTUARIES : UMHLANGANKULU

23-06-76 (10h50)

PHOTOGRAPH

NS 8 / 7



SCALE: 1 : 5000 approx



NATAL ESTUARIES : UMHLANGANKULU

02-08-83 (11h52)

PHOTOGRAPH

NS 8 /8



SCALE: 1 : 5000 approx



NATAL ESTUARIES : UMHLANGANKULU

02-10-87 (11h50)

PHOTOGRAPH

NS 8 / 9

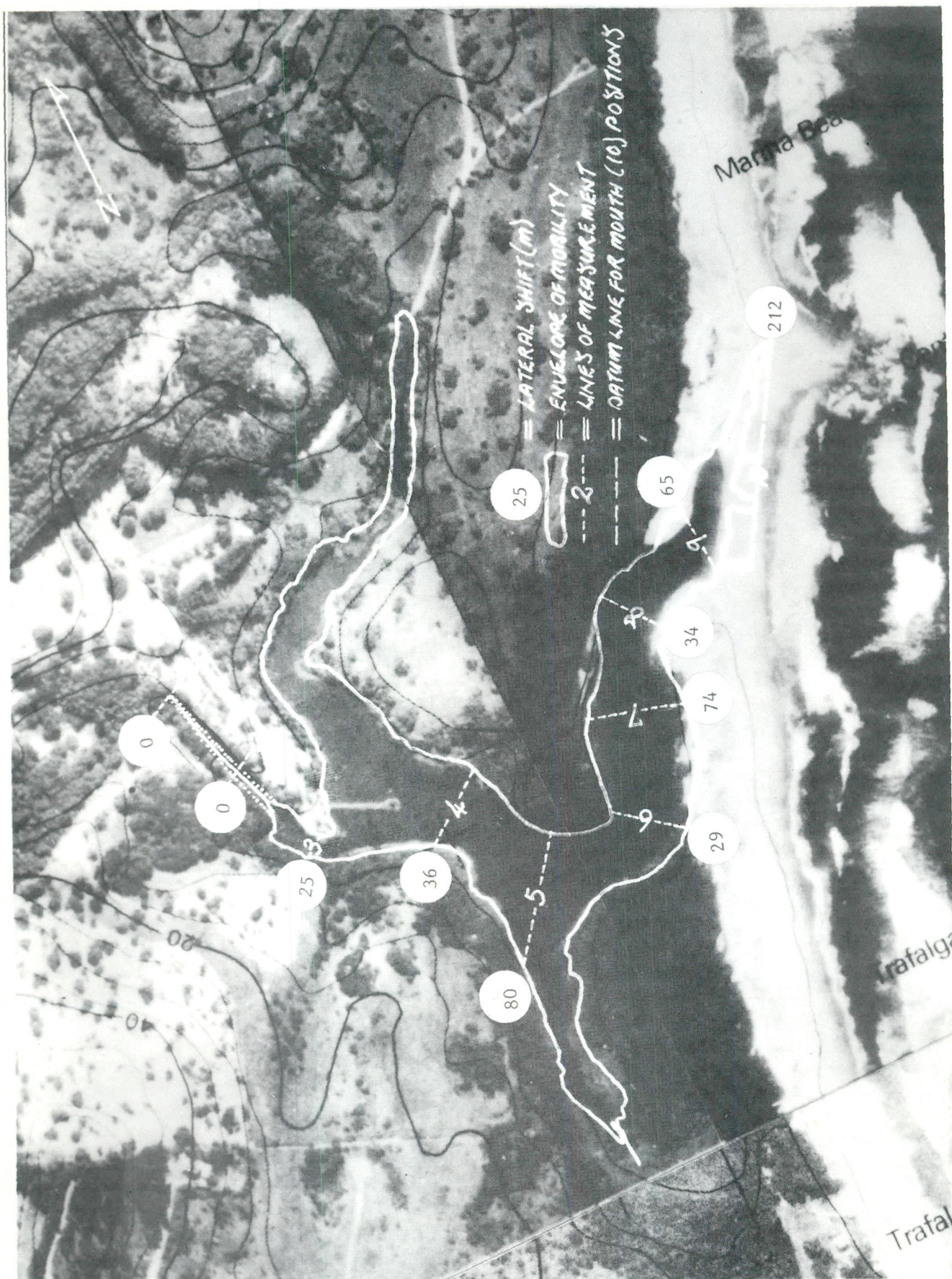


SCALE: 1 : 5000 approx



NATAL ESTUARIES : UMHLANGANKULU
02 - 10 - 87
(02 - 05 - 37 RIVER COURSE SUPERIMPOSED)

PHOTOGRAPH
NS 8 / 10



SCALE: 1 : 5000 approx



NATAL ESTUARIES: UMHLANGANKULU
 ORTHOPHOTO (ENVELOPE OF MOBILITY
 LINES OF MEASUREMENT & LATERAL SHIFT
 SUPERIMPOSED)

PHOTOGRAPH
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