



CONFIDENTIAL

**HYDROLOGICAL/HYDRAULIC STUDY  
OF NATAL ESTUARIES**

**DATA REPORT NO. 17  
MBIZANA NS 10**

SEDIMENT DYNAMICS DIVISION  
COASTAL ENGINEERING AND HYDRAULICS  
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY  
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

NRIO DATA REPORT 8402

Stellenbosch, South Africa  
April 1984

NS 10

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BRIEF NOTES - MBIZANA NS 10**Location**

The Mbizana River discharges into the Indian Ocean on the Natal South coast at 30° 55'S, 30° 20'E. The head of the reach under review is the national road bridge 2,6 km from the mouth (Photograph NS10/1).

**Hydro Data**

The M.A.R. from a catchment of 145 km<sup>2</sup> is 29,56 x 10<sup>6</sup> m<sup>3</sup>. Of particular interest to this study is the nature of the run-off which is very erratic; the Mbizana is subject to severe flash floods. This is quantified by the very high coefficients of variation (V%) for the monthly run-off (Table NS10/X) and the wide spectrum of annual and monthly run-off values shown in Figures NS10/2 and 3. Figure NS10/4 shows the trends in the annual run-off for the period 1921-1976. The aforementioned Table and Figures are based upon simulated run-off data for tertiary catchments (Pitman *et al.*, 1981) and although major widespread floods show up well, more localised floods may be masked. An example of this was the severe flood of February 1977 referred to by Begg (1978). For classification purposes, current and antecedent run-off conditions must be considered for each of the time slices covered by the aerial photographs. The following important facts emerge regarding the six relevant photographs:

- 1) 1937; below-average run-off for one month previous, before that above average run-off for 5 months with major flood flows in the 6th month previous.
- 2) 1943; near-average run-off, previous hydro year well above average.

- 3) 1955; below-average run-off, flood flows 5th and 7th months previous and major flood 8th month previous.
- 4) 1963; below-average run-off but well above average previous month and major flood flows two months previous.
- 5) 1969; near-average run-off but in a generally dry phase.
- 6) 1976; near-average run-off but above average two and three months previous (mouth was still open 11 days prior to photo).

#### **River Mouth**

Begg (1983) estimates the mouth to be closed for 68 per cent of the year. The six aerial photographs are representative of such conditions; three of them show the mouth completely blocked by a sandbar (Photographs NS10/4, 6 & 7). There are no aerial photographs available for the period during or immediately after severe floods showing the whole bar swept away. Soon after such an event, a sand-spit forms from the right bank and migrates northwards until the flood channel is closed. The lagoon then fills and eventually breaches the bar in its normal position against rocks on the right bank (Begg 1978). Photographs NS10/3 & 5 depict this normal open-mouth situation. The six time slices of photography under review show that the landward side of the spit/bar has migrated seawards since 1955. This is probably the result of the marked increase in bed levels (see paragraph below on "siltation").

#### **Land-use**

The valley sides have been mostly covered by forests or grass for the period under review. However, since 1943 about 35 per cent of the right valley side and 4 per cent of the flood plain

area have been under sugar cane. In the upper reach, on the right bank, there is some cultivation to the channel edge. Breaching of the bar has occurred with channels being dug at the "normal" exit point near the right bank, though this was generally not favoured by the local authority in the past. However, Begg (1983) reports of conflicting interests developing in recent years:

- 1) in January 1982 the mouth was artificially closed in order to maintain sufficient water depths for wind surfing; and
- 2) in October 1983 there were requests for breaching because the "Lagoon Cabanas" property near the mouth and the sand-winning site near the head of reach were being inundated.

#### Siltation

The six time slices of aerial photography under review all show evidence of a severely silted system. The Mbizana is subject to major floods and to frequent flash floods and the photographs under review have been taken sufficiently close to such events for the evidence of widespread fluvial silt deposits to be seen in the river channel area. Furthermore, the photographs taken at the lower flow stages show that approximately two-thirds of the measured open water areas comprise very shallow water where the river follows a braided pattern over the alluvium.

Trends in the siltation since 1937 cannot be readily quantified from the photographs because the river widths and changes in the open-water areas mostly reflect differing spit/bar conditions. However, reed-swamp areas have increased and the landward side of the spit/bar has migrated seawards. These factors reflect an increase in siltation and aggradation. The latter can be quantified for the head of the reach. Cross-sections for the old road bridge and the new freeway were taken on the following dates; 13/07/25 and 04/10/74. In 1925 the river bed level was

-0,7 m to MSL and by 1974 it was +4,2 m to MSL. Respective "normal" river water levels for the two dates were +1,1 m and +4,85 m to MSL.

Nine major floods and numerous minor floods occurred during this 49-year period and the net result of the scour and fill processes was a rise in bed level of approximately five metres. In 1925 the reach was 100 per cent estuarine. From estuarine lengths given by Begg (1983), this was reduced to 67 per cent by 1976 and to 44 per cent by 1983. The position at which velocities are markedly reduced, that is, where most siltation occurs in the area where the bed nears MSL, has been moving steadily towards the mouth during the last half century. The movement has accelerated in recent years. There must be an ample silt supply upstream of the reach under review and this suggests land-use malpractices in the catchment area.

### **Stability**

There is some geomorphological control over the river course and the flood plain is fairly narrow. Nevertheless, the course of the river shifted considerably during the period 1937 to 1976. The average lateral displacement of 54,5 m and average coefficient of variation of 37 per cent indicate unstable conditions.

The Mbizana shows severe siltation and has been unstable for the period under review. For an overall abstract of study results see Table NS10/I.

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 $\frac{s}{\bar{x}}$
MSL	Mean sea level
R	River
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 flood plain areas).

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d/s	Downstream
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—	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 flood plain areas).

BASIC DATA / CALCULATIONS

Lateral displacement (1937 - 1976)  $\bar{x}$  54.5 m  
 Relative lateral stability (1937 - 1976)  $\bar{v}$  37.0 %  
 Area of catchment 14.5 km<sup>2</sup>  
 Area of flood plain 45.4 ha  
 Area of envelope of mobility 27.7 ha  
 Simulated H.A.R. (1921 - 1976)  $\bar{x}$  29.56 x 10<sup>6</sup> m<sup>3</sup>  
 $\bar{v}$  15.31 x 10<sup>6</sup> m<sup>3</sup>  
 $\bar{v}$  51.5 %

Dates of major floods: July 1931, Nov. 1936, Oct. 1954, March 1963  
 less severe: March 1927, June 1929, May 1959, Jan 1964, Oct 1970

MEASUREMENTS/CALCULATIONS from PHOTOGRAPHS

Date	1925	2-5-37	Dec '43	Jan/July 1955	5-5-63	23-6-69	23-6-76	1983
Thalweg (m)	2533	2472	?	2422	2637	2487	2630	
% Thalweg estuarine 100	?	?	?	?	?	?	67	44
Aerial D (m)	1751	1744	1671	1761	1676	1714		
Sinuosity	1,45	1,42	1,45	1,50	1,48	1,53		
$\bar{x}$ River width (m)	48,1	63,1	58,4	43,7	54,7	51,9		
Open water area (ha)	12,2	14,5	14,1	11,2	12,0	13,8		
% envelope of mobility	44,0	52,3	50,9	40,4	43,3	49,8		
Bar/island area (ha)	6,3	8,7	4,2	10,6	6,6	9,8		
River braided (%thalweg)	72	72	58	67	78	65		
% Flood plain cultivated	NIL	4	3	3	5	4		
Left valley side:								
% grass	15	15	11	NIL	NIL	NIL		
% trees	85	85	89	100	100	100		
% cultivated	NIL	NIL	NIL	NIL	NIL	NIL		
% built up	NIL	NIL	NIL	NIL	NIL	NIL		
Right valley side:								
% grass	18	18	14	NIL	NIL	NIL		
% trees	82	51	51	65	65	65		
% cultivated	NIL	31	35	35	35	35		
% built up	NIL	NIL	NIL	NIL	NIL	NIL		
L.B. % vegetated } was	16	21	16	15	34	39		
R.B. % vegetated }	40	33	30	20	30	30		
Mouth open/closed o/c	0	0	C	0	C	C		
Spit/bar:								
Direction (°)	212	210	205	215	209	212		
Length (m)	415	433	448	423	465	458		
$\bar{x}$ width (m)	171	125	74	69	87	76		

Within the Reach

- Land-use  
 (a) Cultivation: Valley sides L.V.S. Nil R.V.S. = 35%  
 Flood plain = 4%  
 To channel edge Vary little  
 (b) Bridge building and embankments  
 NR bridge at head of reach (built between 1926 & 1936)  
 Freeway = 20m d/s old NR bridge (1977/78)

- Canals Nil
- Urbanization/Industry Nil

- Breaching of sandbar  
 Breaching has occurred (Beg 1978)
- Others  
 (i) Sand is excavated near head of reach  
 1979+ (ii) Wind surfing became popular in Jan 82 the mouth was artificially closed to maintain water depths (Beg 1983)

Upstream of Reach

- Dams in the catchment  
 Nil  
 (1 proposed at Bushyvalles, 4km ups of reach)  
 Date of construction
- Building construction or canalization immediately upstream of reach  
 Nil
- Land-use malpractices/silt supply  
 Severe siltation since 1925 is indicative of land-use malpractices in the catchment.

STABILITY FOR PERIOD UNDER REVIEW:

Unstable

RIVER MBIZANA, ? \* % ESTUARINE, REACH from Road Bridge, 2.5 km from mouth. REF. DEA T 402h

AERIAL PHOTO DATE 2-5-37 SCALE 1:10 000 CATCHMENT AREA 145 km<sup>2</sup>, M.A.R. 29,56 m<sup>3</sup>x10<sup>6</sup>, No. of DAMS NIL

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley			Valley Sides ( <del>Not</del> Well-defined)		
Terrain	Vegetation	Land-Use	Slumping	Vegetation and Land-Use	Left Right
mountainous	almost none	none	none	coastal dune	
✓ hilly	✓ grass	✓ scattered cultivation	✓ none	grass	<u>15</u> <u>18</u> %
undulating	✓ sparsely forested (0-25%)	partly cultivated	occasional	grass/bush	<u>85</u> <u>82</u> %
plains	moderately forested (25-75%)	mainly cultivated	frequent	cultivated	
	heavily forested (75-100%)	✓ scattered settlement		built-up	
	swamp/bog	partly built-up			
		urbanised			
				Comments	* 13-7-25 100%

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>2370</u> m	✓ none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) <u>85</u> m	indefinite	not obviously degrading or aggrading	occasionally confined	lacustrine deposits
valley slope _____	fragmentary	partly entrenched	frequently confined	✓ fluvial deposits
height at head _____	continuous	entrenched	entrenched	aeolian
of reach _____ m to MSL		✓ aggrading		silt/ sand covered <u>14</u> % area
				Comments

River Mouth

Characteristics	Measurements	Comments
✓ open/closed	right bank breakwater length _____ m	
✓ natural/artificial	left bank breakwater length _____ m	
canalized	rock sill level _____ m to MSL	
✓ sandy	cliffs on right bank: height _____ m to MSL	
✓ rocks on right bank	cliffs on left bank: height _____ m to MSL	
rocks on left bank	spit/bar: direction of growth <u>212</u> °	
outer bar	length of spit/bar <u>415</u> m	
silt plume (fluvial)	length stabilized <u>NIL</u> m	
✓ suspended sediment (marine)	width <u>171</u> m	
		Comments

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain	Presence	Extent	Vegetation	Forest Type	Land-Use
none	none	average width <u>185</u> m	almost none	not known/applicable	✓ not cultivated, not built-up
indefinite	none	maximum width <u>410</u> m	grass	✓ riverine:	cultivated <u>NIL</u> % area
fragmentary	none	aerial length <u>1751</u> m	reed swamp <u>NIL</u> % area	✓ main channel	crop/s
✓ continuous	none	area <u>45,4</u> ha	✓ sparsely forested	tributaries	partly built-up
			moderately forested	mangroves	mainly built-up
			heavily forested		Comments

Channel Description	N.B. Estimate of flow stage: LOW/NEAR-LONG-TERM-MEAN/HIGH	Measurements	Islands/Shoals	Type of Flow	Bar Type
Pattern	(Major flood 6 mo. previous)	thalweg <u>2533</u> m	none	stagnant/still	none
straight		* sinuosity <u>1,45</u>	occasional	uniform water surface	✓ channel side bars
sinuous		* open water area <u>12,2</u> ha	frequent	uniform with rapid in reach	✓ point bars
irregular		perimeter <u>5900</u> m	split	✓ irregular	✓ channel junction bars
regular meanders		lake/lagoon area _____ ha	✓ braided (72%)	pool & riffle sequence	mid-channel bars
✓ irregular meanders		xx river X-sections available		turbid	✓ diamond bars (i.e. braided)
tortuous meanders		channel slope _____			diagonal bars
bifurcated		channel width <u>x</u> _____ m			sand waves/large dunes
lake/s		river slope _____			
lagoon		river width <u>x</u> <u>48,1</u> m s = <u>34,2</u> m			
				Comments	* whole reach fine xx at Road Br. 13-7-25

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
✓ none	none	road bridge/s _____	<u>R. confined</u>	at head
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 (meas)	Lateral Stability	Comments
not detectable	✓ alluvium (silt/sand)	none	stable	
✓ downstream progression*	natural levées	weak	slightly unstable	
progression & cut-offs	rock/boulders	good	moderately unstable	
mainly cut-offs	protected/stabilized	very strong	✓ unstable	
entrenched loop development	✓ cultivation to channel edge xx	left bank <u>16</u> %	highly unstable	* restricted geomorphology
irregular lateral activity		right bank <u>40</u> %		xx a little
avulsion				

TABLE NS10/III

CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS

NR10 NS 10

RIVER MBIZANA, ? % ESTUARINE, REACH from Road Bridge, 2.5 km from mouth. REF. DEA T 402h  
 AERIAL PHOTO DATE Dec '43 SCALE 1:10 000 CATCHMENT AREA 145 km<sup>2</sup>, M.A.R. 29,56 m<sup>3</sup>x10<sup>6</sup>, No. of DAMS NIL

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		
✓ hilly	✓ grass	✓ scattered cultivation	occasional	grass	15	18
undulating	✓ sparsely forested (0-25%)	partly cultivated	frequent	trees/bush	85	51
plains	moderately forested (25-75%)	mainly cultivated		cultivated		31
	heavily forested (75-100%)	✓ scattered settlement		built-up		
	swamp/bog	partly built-up				
		urbanised				

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 2370 m	✓ none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) 185 m	indefinite	not obviously degrading	occasionally confined	lacustrine deposits
valley slope _____	fragmentary	or aggrading	frequently confined	✓ fluvial deposits
height at head _____	continuous	partly entrenched	entrenched	aeolian
of reach _____ m to MSL		entrenched		silt / sand covered 18 % area
		✓ aggrading		

Comments \_\_\_\_\_

River Mouth

Characteristics	Measurements	Comments
✓ open/natural	right bank breakwater length _____ m	
✓ natural/artificial	left bank breakwater length _____ m	
canalized	rock sill level _____ m to MSL	
✓ sandy	cliffs on right bank: height _____ m to MSL	
✓ rocks on right bank	cliffs on left bank: height _____ m to MSL	
rocks on left bank	spit/bar: direction of growth 210°	
outer bar	length of spit/bar 433 m	
silt plume (fluvial)	length stabilized NIL m	
suspended sediment (marine)	width 125 m	

Comments \_\_\_\_\_

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent	Vegetation	Forest Type	Land-Use
none	none	almost none	not known/applicable	✓ not cultivated, not built-up
indefinite	average width 185 m	grass	✓ riverine:	cultivated 4 % area
fragmentary	maximum width 410 m	reed swamp 2 % area	✓ main channel	crop/s sugar cane
✓ continuous	aerial length 1744 m	✓ sparsely forested	tributaries	partly built-up
	area 45,4 ha	moderately forested	mangroves	mainly built-up
		heavily forested		

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 2472 m	none	stagnant/still	none
sinuous	*sinuosity 1,42	occasional	uniform water surface	✓ channel side bars
irregular	*open water area 14,5 ha	frequent	uniform with rapid in reach	✓ point bars
regular meanders	perimeter 5500 m	split	✓ irregular	✓ channel junction bars
✓ irregular meanders	lake/lagoon area _____ ha	✓ braided (72%)	pool & riffle sequence	mid-channel bars
tortuous meanders	river X-sections available		turbid	✓ diamond bars (R. bordered)
bifurcated	channel slope _____			diagonal bars
lake/s	channel width x _____ m			sand waves/large dunes
lagoon	river slope _____			
	river width x 63,1 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	R. confused	at head
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 (silt/sand)	none	stable
✓ downstream progression*	natural levées	weak	slightly unstable
progression & cut-offs	rock/boulders	good	moderately unstable
mainly cut-offs	protected/stabilized	very strong	✓ unstable
entrenched loop development	cultivation to	left bank 21 %	highly unstable
irregular lateral activity	channel edge	right bank 33 %	
avulsion			

Comments \*restricted geomorphology

RIVER MBIZANA, ? % ESTUARINE, REACH from Road Bridge, 2.4 km from mouth. REF. DEA T402h  
 AERIAL PHOTO DATE June/July '55 SCALE 1:10 000 CATCHMENT AREA 145 km<sup>2</sup>, M.A.R. 2956 m<sup>3</sup>x10<sup>6</sup>, 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		%
✓ hilly	✓ grass	✓ scattered cultivation	occasional	grass	11	14 %
undulating	sparsely forested (0-25%)	partly cultivated	frequent	trees/bush	89	51 %
plains	✓ moderately forested (25-75%)	mainly cultivated		cultivated		35 %
	heavily forested (75-100%)	✓ scattered settlement		built-up		%
	swamp/bog	partly built-up				
		urbanised				

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>2370</u> m	none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) <u>185</u> m	indefinite	not obviously degrading	✓ occasionally confined	lacustrine deposits
valley slope _____	fragmentary	or aggrading	frequently confined	✓ fluvial deposits
height at head _____	continuous	partly entrenched	entrenched	aeolian
of reach _____ m to MSL		entrenched		silt/sand covered <u>6</u> % area
		✓ aggrading		Comments _____

River Mouth

Characteristics	Measurements
✓ open/closed	right bank breakwater length _____ m
✓ natural/artificial	left bank breakwater length _____ m
canalized	rock sill level _____ m to MSL
✓ sandy	cliffs on right bank: height _____ m to MSL
✓ rocks on right bank	cliffs on left bank: height _____ m to MSL
rocks on left bank	spit/bar: direction of growth <u>205</u> °
outer bar	length of spit/bar <u>448</u> m
silt plume (fluvial)	length stabilized <u>NIL</u>
✓ suspended sediment (marine)	width <u>74</u> m

Comments \_\_\_\_\_

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent	Vegetation	Forest Type	Land-Use
none	none	almost none	not known/applicable	not cultivated, not built-up
indefinite	average width <u>185</u> m	grass	✓ riverine:	✓ cultivated <u>3</u> % area
fragmentary	maximum width <u>410</u> m	reed swamp <u>3</u> % area	✓ main channel	crop/s <u>sugar cane</u>
✓ continuous	aerial length <u>1671</u> m	✓ sparsely forested	tributaries	partly built-up
	area <u>45,4</u> ha	moderately forested	mangroves	mainly built-up
		heavily forested		Comments _____

Channel Description

N.B. Estimate of flow stage: LOW/~~NEAR LOW FLOW~~ NEAR HIGH FLOW (Major Flood 8 mo. previous)

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	thalweg <u>2422</u> m	none	stagnant/still	none
sinuous	*sinuosity <u>1,45</u>	occasional	uniform water surface	✓ channel side bars
irregular	*open water area <u>14,1</u> ha	frequent	uniform with rapid in reach	✓ point bars
regular meanders	perimeter <u>5100</u> m	split	✓ irregular	✓ channel junction bar#
✓ irregular meanders	lake/lagoon area _____ ha	✓ braided (58%)	pool & riffle sequence	mid-channel bars
tortuous meanders	river X-sections available		turbid	✓ diamond bars (i.e. braided)
bifurcated	channel slope _____			diagonal bars
lake/s	channel width x _____ m			sand waves/large dunes
lagoon	river slope _____			
	river width x <u>58,4</u> 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	<u>R. confined</u>	at head
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 (Trees)	Lateral Stability
not detectable	✓ alluvium (silt/sand)	none	stable
✓ downstream progression*	natural levées	weak	slightly unstable
progression & cut-offs	rock/boulders	good	moderately unstable
mainly cut-offs	protected/stabilized	very strong	✓ unstable
entrenched loop development	✓ cultivation to	left bank <u>16</u> %	highly unstable
irregular lateral activity	channel edge	right bank <u>30</u> %	Comments *restricted geomorphology
avulsion			✓ a little

TABLE NS 10/X

CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS

NRIO NS 10

RIVER MBIZANA, ? % ESTUARINE, REACH from Road Bridge, 2.6 km from mouth. REF. DEA T 402h  
 AERIAL PHOTO DATE 5-5-63 SCALE 1:10 000 CATCHMENT AREA 145 km<sup>2</sup>, M.A.R. 29,56 m<sup>3</sup>x10<sup>6</sup>, No. of DAMS NIL

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		%
hilly	grass	scattered cultivation	occasional	grass		%
undulating	sparse forested (0-25%)	partly cultivated	frequent	trees/bush	100	65
plains	moderately forested (25-75%)	mainly cultivated		cultivated		35
	heavily forested (75-100%)	scattered settlement		built-up		%
	swamp/bog	partly built-up * urbanised				%

Comments \*mostly on R.B. near coast.

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 2370 m	none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) 185 m	indefinite	not obviously degrading or aggrading	occasionally confined	lacustrine deposits
valley slope	fragmentary	partly entrenched	frequently confined	fluvial deposits
height at head of reach ___ m to MSL	continuous	entrenched	entrenched	aeolian
		aggrading		silt / sand covered 21 % area

Comments

River Mouth

Characteristics	Measurements	Comments
open/natural	right bank breakwater length ___ m	
canalized	left bank breakwater length ___ m	
sandy	rock sill level ___ m to MSL	
rocks on right bank	cliffs on right bank: height ___ m to MSL	
rocks on left bank	cliffs on left bank: height ___ m to MSL	
outer bar	spit/ber: direction of growth 215°	
silt plume (fluvial)	length of spit/ber 423 m	
suspended sediment (marine)	length stabilized NIL m	
	width 69 m	

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent	Vegetation	Forest Type	Land-Use
none	none	almost none	not known/applicable	not cultivated, not built-up
indefinite	average width 185 m	grass	riverine:	cultivated 3 % area
fragmentary	maximum width 410 m	reed swamp 2 % area	main channel	crop/s
continuous	aerial length 1761 m	sparse forested	tributaries	partly built-up
	area 45,4 ha	moderately forested	mangroves	mainly built-up
		heavily forested		

Comments

Channel Description N.B. Estimate of flow stage: LOW/ ~~near long flow stage~~ but just after 2mo. well above average

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	thalweg 2637 m	none	stagnant/still	none
sinuous	*sinuosity 1,50	occasional	uniform water surface	channel side bars
irregular	*open water area 11,2 ha	frequent	uniform with rapid in reach	point bars
regular meanders	perimeter 5430 m	split	irregular	channel junction bars
irregular meanders	lake/lagoon area ___ ha	braided (67%)	pool & riffle sequence	mid-channel bars
tortuous meanders	river X-sections available		turbid	diamond bars (R. braided)
bifurcated	channel slope ___			diagonal bars
lake/s	channel width x ___ m			sand waves/large dunes
lagoon	river slope ___			
	river width x 43,7 m			

Comments \*whole reach

Obstructions/Constructions

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

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation (weas)	Lateral Stability	Comments
not detectable	alluvium (silt/sand)	none	stable	
downstream progression*	natural levées	weak	slightly unstable	
progression & cut-offs	rock/boulders	good	moderately unstable	
mainly cut-offs	protected/stabilized	very strong	unstable	
entrenched loop development	cultivation to channel edge**	left bank 15 %	highly unstable	
irregular lateral activity		right bank 20 %		
avulsion				*retreated geomorphology ** a lagoon

RIVER MBIZANA, ? % ESTUARINE, REACH from Road Bridge, 2,5 km from mouth. REF. DEA T 402 h  
 AERIAL PHOTO DATE 24-6-69 SCALE 1:10 000 CATCHMENT AREA 145 km<sup>2</sup>, M.A.R. 29,56 m<sup>3</sup>x10<sup>6</sup>, No. of DAMS NIL

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley			Valley Sides ( <del>Not</del> Well-defined)			
Terrain	Vegetation	Land-Use	Slumping	Vegetation and Land-Use	Left	Right
mountainous	almost none	none	✓ none	coastal dune		
✓ hilly	grass	✓ scattered cultivation	occasional	grass		
undulating	sparsely forested (0-25%)	partly cultivated	frequent	trees/bush	<u>100</u>	<u>65</u>
plains	✓ moderately forested (25-75%)	mainly cultivated		cultivated		<u>35</u>
	heavily forested (75-100%)	scattered settlement		built-up		
	swamp/bog	✓ partly built-up + urbanised				
Comments *near coast R.B.						
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>2370</u> m	✓ none	not applicable	not applicable (no valley or free)	bedrock		
bottom width (av.) <u>185</u> m	indefinite	not obviously degrading or aggrading	✓ occasionally confined	lacustrine deposits		
valley slope	fragmentary	partly entrenched	frequently confined	✓ fluvial deposits		
height at head of reach ___ m to MSL	continuous	entrenched	entrenched	aeolian		
		✓ aggrading		silt/ sand covered <u>10</u> % area		
Comments						
River Mouth						
Characteristics	Measurements					
✓ open/closed	right bank breakwater length ___ m					
✓ natural/artificial	left bank breakwater length ___ m					
canalized	rock sill level ___ m to MSL					
✓ sandy	cliffs on right bank: height ___ m to MSL					
✓ rocks on right bank	cliffs on left bank: height ___ m to MSL					
rocks on left bank	spit/bar: direction of growth <u>209</u> °					
outer bar	length of spit/bar <u>465</u> m					
silt plume (fluvial)	length stabilized <u>NIL</u> m					
✓ suspended sediment (marine)	width <u>87</u> m					
Comments						

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain		Vegetation	Forest Type	Land-Use
Presence	Extent			
none	none	almost none	not known/applicable	✓ not cultivated, not built-up
indefinite	average width <u>185</u> m	grass	✓ riverine:	✓ cultivated <u>5</u> % area
fragmentary	maximum width <u>410</u> m	reed swamp <u>5</u> % area	✓ main channel	crop/s <u>sugar cane</u>
✓ continuous	aerial length <u>1676</u> m	✓ sparsely forested	tributaries	partly built-up
	area <u>45,4</u> ha	moderately forested	mangroves	mainly built-up
		heavily forested		
Comments				

Channel Description	N.B. Estimate of flow stage: <del>LOW</del> / NEAR LONG-TERM MEAN / <del>HIGH</del>		Islands/Shoals	Type of Flow	Bar Type
Pattern	Measurements				
straight	thalweg <u>2487</u> m		none	stagnant/still	none
sinuous	* sinuosity <u>1,48</u>		occasional	uniform water surface	✓ channel side bars
irregular	* open water area <u>12,0</u> ha		frequent	uniform with rapid in reach	✓ point bars
regular meanders	perimeter <u>5400</u> m		split	✓ irregular	✓ channel junction bars
✓ irregular meanders	lake/lagoon area ___ ha	✓ braided (78%)		pool & riffle sequence	✓ mid-channel bars
tortuous meanders	river X-sections available			turbid	✓ diamond bars (C.R. braided)
bifurcated	channel slope ___				diagonal bars
lake/s	channel width x ___ m				sand waves / large dunes
lagoon	river slope ___				
	river width x <u>54,7</u> m				
Comments *whole reach					

Obstructions/Constructions		Man-made		Position (from head of reach)
Natural	Degree		Degree of Obstruction/Constriction for Each	
✓ none	none	road bridge/s	<u>R. confined</u>	<u>at head</u>
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 (weirs)	Lateral Stability
not detectable	✓ alluvium (silt/sand)	none	stable
✓ downstream progression*	natural levées	weak	slightly unstable
progression & cut-offs	rock/boulders	good	moderately unstable
mainly cut-offs	protected/stabilized	very strong	✓ unstable
entrenched loop development	✓ cultivation to channel edge **	left bank <u>34</u> %	highly unstable
irregular lateral activity		right bank <u>30</u> %	
avulsion			
Comments *restricted geomorphology ** a little			

RIVER MBIZANA, 67% ESTUARINE, REACH from Road Bridge, 2.6 km from mouth. REF. DEA T402b

AERIAL PHOTO DATE 23-6-76 SCALE 1:10 000 CATCHMENT AREA 145 km<sup>2</sup>, M.A.R. 29,56 m<sup>3</sup>x10<sup>6</sup>, No. of DAMS NIL  
(orthophoto)

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		
hilly	grass	scattered cultivation	occasional	grass		
undulating	sparingly forested (0-25%)	partly cultivated	frequent	trees/bush	100	65
plains	moderately forested (25-75%)	mainly cultivated		cultivated		35
	heavily forested (75-100%)	scattered settlement		built-up		
	swamp/bog	partly built-up**				
		urbanised				

Comments \* 1983 44%  
\*\* near coast R.B.

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 2370 m	none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) 185 m	indefinite	not obviously degrading or aggrading	occasionally confined	lacustrine deposits
valley slope < 1:521	fragmentary	partly entrenched	frequently confined	fluvial deposits
height at head of reach +4.55 m to MSL	continuous	entrenched	entrenched	aeolian
		aggrading		silt / sand covered 14% area

Comments \* R. bank W.L. from 1974 X-section

River Mouth

Characteristics

Measurements

open/closed	right bank breakwater length			
natural/artificial	left bank breakwater length			
canalized	rock sill level			
sandy	cliffs on right bank: height			
rocks on right bank	cliffs on left bank: height			
rocks on left bank	spit/bar: direction of growth	212°		
outer bar	length of spit/bar	458 m		
silt plume (fluvial)	length stabilized	NIL m		
suspended sediment (marine)	width	76 m		

Comments

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence

Extent

Vegetation

Forest Type

Land-Use

none	none	almost none	not known/applicable	not cultivated, not built-up
indefinite	average width 185 m	grass	riverine:	cultivated 4% area
fragmentary	maximum width 410 m	reed swamp 8% area	main channel	crop/s sugar cane
continuous	aerial length 1714 m	sparingly forested	tributaries	partly built-up
	area 45.4 ha	moderately forested	mangroves	mainly built-up
		heavily forested		

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	2630 m	none	stagnant/still	none
sinuous	sinuosity	1.53	occasional	uniform water surface	channel side bars
irregular	open water area	13.8 ha	frequent	uniform with rapid in reach	point bars
regular meanders	perimeter	5964 m	split	irregular	channel junction bars
irregular meanders	lake/lagoon area	available	braided (65%)	pool & riffle sequence	mid-channel bars
irregular meanders	river X-sections	available		turbid	diamond bars (R. braided)
irregular meanders	channel slope				diagonal bars
irregular meanders	channel width x				sand waves/large dunes
irregular meanders	river slope	1:542			
irregular meanders	river width x	71.6 m			

Comments \*whole reach from \*\* Proposed Freeway Br. 4-10-74

Obstructions/Constructions

Natural

Degree

Man-made

Degree of Obstruction/Constriction for Each

Position (from head of reach)

none	none	road bridge/s	R. confined	at head
logs	minor	rail bridge/s		
boulders	major	causeway		
vegetation		weir/dam		
		fish traps		
		embankment/s		
		groynes		
		canals		
		drainage furrows		
		others	Construction for new Freeway Br. ± R. width	0-40m

Lateral Channel Activity

Lateral Activity

Nature of Banks

Bank Vegetation (trees)

Lateral Stability

not detectable	alluvium (silt/sand)	none	stable
downstream progression*	natural levées	weak	slightly unstable
progression & cut-offs	rock/boulders	good	moderately unstable
mainly cut-offs	protected/stabilized	very strong	unstable
entrenched loop development	cultivation to channel edge**	left bank 39%	highly unstable
irregular lateral activity		right bank 30%	
avulsion			Comments * restricted geomorphology ** a little

TABLE NS 10/VIII

## RIVER WIDTHS

MBIZANA NS 10

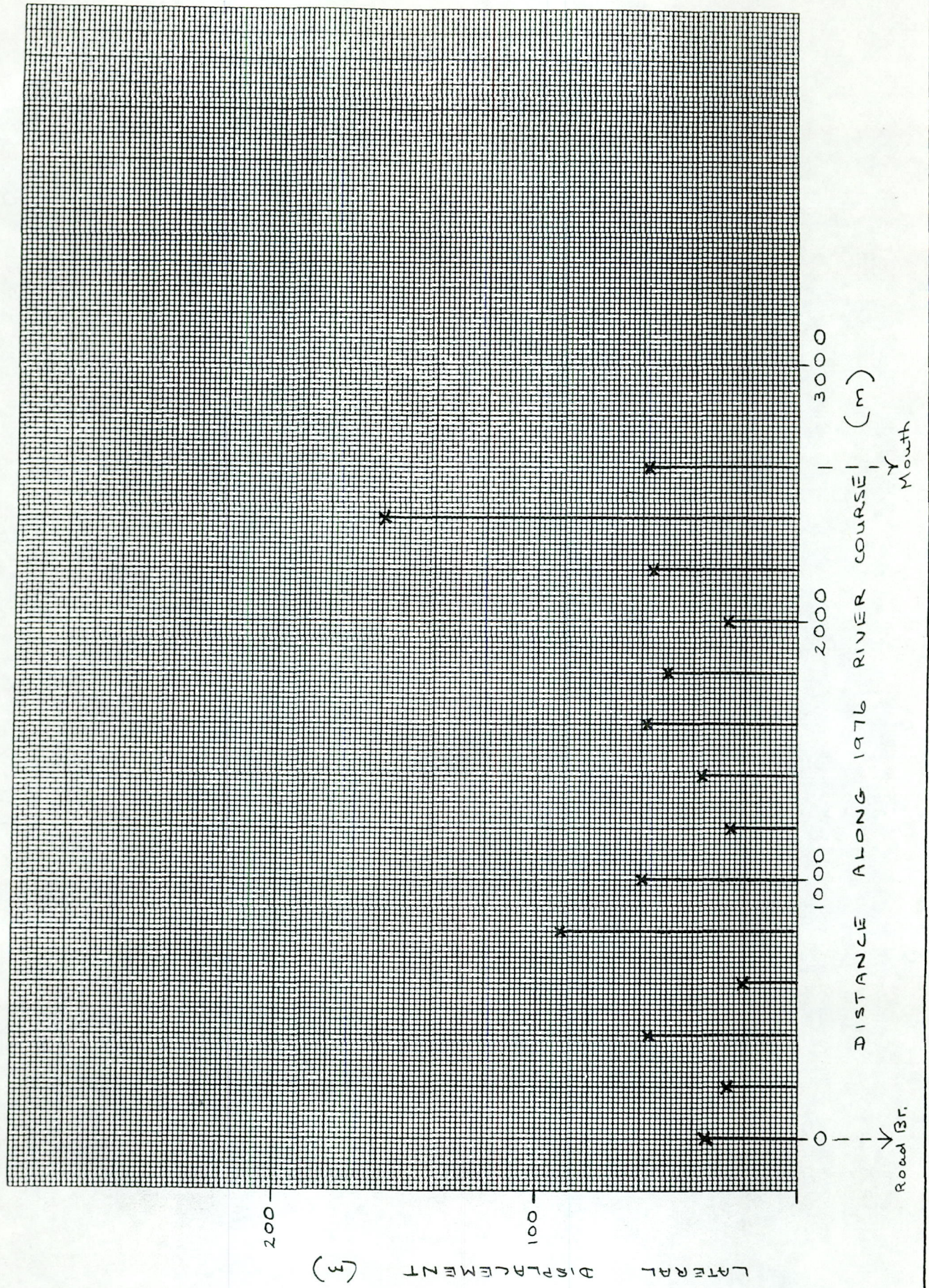
Station	Approx. distance along 1976 R. course from road bridge (m)	River widths (m)							$\bar{x}$	s	V%
		Date									
		02.05.37	Dec 1943	Jun/Jul '55	05.05.63	24.06.69	23.06.76				
1	0	35	38	22	20	20	8	23,8	11,0	46,3	
2	200	20	54	18	28	25	16	26,8	14,0	52,2	
3	400	20	70	18	32	30	30	33,3	18,9	56,6	
4	600	24	36	23	30	25	38	29,3	6,4	22,0	
5	800	44	82	28	25	30	35	40,7	21,3	51,2	
6	1 000	18	90	34	34	40	28	40,7	25,3	62,2	
7	1 200	40	50	35	40	20	48	38,8	10,8	27,8	
8	1 400	46	55	32	39	28	40	40,0	9,7	24,2	
9	1 600	92	73	25	30	26	44	48,3	28,0	57,9	
10	1 800	64	60	54	42	18	64	50,3	17,9	35,5	
11	2 000	57	86	94	55	73	64	71,5	15,9	22,2	
12	2 200	130	180	250	84	148 (18+730)	92	147,3	61,6	41,8	
13	2 400	79	5	185	148 (105+43)	283	220 (174+46)	153,3	99,8	65,1	
14	2 600 (mouth)	4	5	0	5	0	0	2,3	2,6	110,7	
$\bar{x}$		48,1	63,1	58,4	43,7	54,7	51,9	53,3			
s		34,2	42,8	71,9	35,0	74,8	53,9				
V%		71,1	67,9	123,0	80,0	136,6	103,9				



TABLE NS 10 SIMULATED RUN-OFF FOR BRIZANA NS 10 CATCHMENT AREA= 145.0SQ.KM. %M.A.R.

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL	%M.A.R.
1921	0.97	1.52	9.81	4.30	1.28	0.88	1.72	1.14	1.33	0.98	0.76	0.86	24.55	83.04
1922	7.41	6.84	2.48	1.36	8.79	4.61	1.60	0.76	0.47	1.00	1.28	1.04	37.65	127.35
1923	1.09	1.42	2.21	2.33	1.89	1.09	0.65	0.49	0.35	0.27	0.29	0.49	12.58	42.55
1924	0.77	1.12	1.53	1.98	1.91	1.41	5.85	1.12	0.74	0.61	0.48	0.77	31.05	105.05
1925	1.43	1.53	1.12	0.81	0.96	5.38	2.79	1.00	1.21	1.24	0.82	0.76	19.05	64.43
1926	1.45	1.83	1.52	0.93	0.66	16.93	6.87	0.95	0.47	0.32	0.39	0.54	32.86	111.15
1927	0.88	0.86	0.81	1.48	1.64	1.25	0.70	0.49	0.45	0.35	0.40	0.47	9.94	33.62
1928	0.71	0.94	0.81	0.88	0.87	1.58	2.36	2.05	18.06	11.78	3.65	4.64	48.32	163.47
1929	7.45	7.47	3.06	2.64	1.86	0.87	0.47	0.41	0.63	0.79	0.89	1.72	28.23	95.51
1930	2.54	2.38	2.29	2.40	2.27	5.95	3.17	1.14	1.14	22.57	9.18	1.76	56.22	190.19
1931	1.87	1.79	1.29	0.99	1.46	3.21	2.21	1.61	1.43	1.06	0.79	4.13	21.83	73.86
1932	5.74	11.59	9.52	3.19	0.96	1.20	1.38	1.02	0.69	0.55	0.43	0.44	36.70	124.14
1933	0.56	6.84	5.62	7.48	3.54	1.47	1.29	1.08	0.70	0.88	0.97	0.68	31.12	105.27
1934	0.52	0.90	10.88	4.71	1.27	1.31	1.61	6.12	12.18	5.13	1.99	1.55	48.16	162.92
1935	1.11	0.94	0.61	0.62	7.92	4.74	1.77	2.62	2.25	1.47	0.94	0.99	25.99	87.92
1936	1.62	23.14	9.02	3.35	7.31	3.59	1.35	0.73	0.44	0.60	0.79	0.74	52.66	178.16
1937	0.97	1.18	4.18	3.48	3.41	1.99	5.38	3.06	1.40	1.32	1.28	0.91	28.57	96.67
1938	0.79	1.11	2.46	2.17	5.66	3.43	1.66	1.11	0.79	0.75	0.81	1.59	22.33	75.56
1939	2.38	2.05	3.88	2.15	0.79	0.52	0.57	5.68	3.36	1.30	0.55	0.71	24.14	81.68
1940	0.81	1.51	1.68	1.04	0.51	0.48	0.57	0.43	0.34	0.38	0.55	0.83	9.15	30.94
1941	1.34	1.50	1.21	7.29	3.59	1.80	1.90	1.70	1.21	0.71	0.77	1.04	24.08	81.66
1942	1.64	15.04	13.75	4.16	1.17	6.68	7.50	3.35	1.52	1.17	1.60	1.70	59.28	200.55
1943	3.63	2.91	3.03	2.07	1.45	1.14	0.95	0.76	0.69	0.69	0.50	1.50	19.36	65.51
1944	5.11	2.83	0.98	0.55	0.94	1.79	1.59	0.94	0.59	0.48	0.42	0.38	16.60	56.16
1945	7.83	3.74	0.81	1.64	1.47	5.76	3.66	3.70	7.68	3.79	1.43	0.31	30.20	64.95
1946	0.63	3.48	2.60	1.64	1.47	5.76	3.66	3.70	7.68	3.79	1.43	0.31	30.20	64.95
1947	0.83	10.56	5.36	2.25	2.95	7.03	3.66	1.41	0.73	0.42	0.38	0.43	36.02	121.85
1948	5.84	3.37	1.23	0.68	0.95	1.63	1.64	1.17	0.72	0.47	0.39	0.55	18.65	63.10
1949	1.21	7.59	3.84	3.06	2.22	1.36	1.71	2.71	2.17	1.53	1.90	1.97	31.26	105.75
1950	1.58	1.31	1.64	1.86	1.33	1.01	0.74	0.66	0.37	0.31	0.36	0.53	11.50	38.89
1951	3.43	2.21	1.64	5.76	3.13	1.17	0.86	1.05	0.96	0.74	0.55	0.71	22.31	75.48
1952	1.02	1.07	1.25	6.75	12.06	4.40	0.90	0.52	0.32	0.23	0.41	0.83	29.74	100.61
1953	1.53	6.57	3.65	1.47	1.07	1.46	1.32	1.03	0.94	0.72	0.56	1.01	21.33	72.16
1954	24.29	9.65	1.22	9.88	4.98	3.79	2.25	0.98	0.68	0.57	0.43	0.99	59.70	201.96
1955	1.66	2.03	1.65	0.80	0.74	9.40	8.63	3.17	1.38	1.06	1.01	1.21	32.75	110.79
1956	3.73	7.70	12.27	4.66	1.30	1.74	8.61	4.05	1.14	0.72	0.57	1.52	48.01	162.40
1957	6.91	5.35	2.23	1.75	8.91	4.75	7.58	3.54	0.94	0.72	0.72	0.70	44.09	149.14
1958	1.16	2.22	2.14	1.46	1.13	0.87	0.66	18.70	7.74	1.39	1.21	1.25	39.94	135.11
1959	1.69	1.77	1.41	1.19	1.16	1.64	2.05	2.02	1.47	0.90	0.65	0.75	16.74	56.64
1960	1.05	1.58	2.12	1.85	1.10	2.33	11.46	5.01	1.31	1.68	1.71	1.56	32.76	110.83
1961	1.72	4.48	2.61	1.54	1.25	8.31	3.96	1.16	0.71	0.45	0.50	0.63	27.32	92.43
1962	1.60	2.12	1.53	6.94	3.27	29.00	11.05	1.30	1.00	3.44	2.57	1.47	65.30	220.90
1963	2.50	2.63	15.71	18.11	6.04	1.72	1.32	0.99	12.34	5.71	1.46	1.03	69.57	235.33
1964	13.04	5.84	1.37	1.09	1.06	0.64	0.34	0.42	1.46	2.25	2.26	2.91	32.72	110.68
1965	6.76	4.36	2.23	2.00	1.64	0.86	0.58	1.06	1.52	1.29	0.89	0.85	28.04	81.33
1966	0.93	1.16	1.31	1.86	1.87	2.51	8.39	3.47	1.23	1.17	1.05	1.71	26.08	88.21
1967	0.76	1.42	1.56	1.09	1.02	1.91	2.01	4.95	2.88	1.26	0.87	1.22	11.45	38.75
1968	1.78	1.78	1.45	0.94	1.02	1.91	2.01	4.95	2.88	1.26	0.87	1.22	11.45	38.75
1969	1.48	2.37	2.18	2.73	1.71	1.12	0.98	1.62	1.65	1.64	6.65	3.65	53.17	179.88
1970	17.33	9.63	4.46	2.73	1.71	1.12	0.98	1.62	1.65	1.64	6.65	3.65	53.17	179.88
1971	7.51	4.09	1.91	1.14	1.46	1.47	0.79	0.47	0.49	0.59	0.59	0.51	21.03	71.13
1972	0.49	1.33	1.85	1.33	0.73	0.49	0.43	0.33	0.21	0.18	0.38	0.90	8.60	29.11
1973	1.14	0.47	0.56	0.32	0.48	0.68	0.90	1.43	2.17	1.51	0.88	0.63	11.96	40.47
1974	0.55	0.81	3.14	2.34	1.39	1.04	0.72	0.46	0.36	0.29	0.23	1.21	12.56	42.48
1975	1.40	1.20	1.34	1.65	1.90	9.57	4.74	2.08	1.53	1.10	0.89	0.70	28.49	96.38
1976	1.17	1.23	0.73	0.44	0.39	0.32	0.21	0.20	0.26	0.27	0.27	0.40	5.88	19.89
MEAN	3.18	3.48	3.27	2.73	2.38	3.51	2.68	2.01	1.97	1.69	1.15	1.16	29.56	
S	4.34	4.16	3.48	2.95	2.48	4.85	2.87	2.70	3.32	3.36	1.49	0.88	15.21	
V%	136.54	108.50	106.49	108.17	104.58	136.12	107.10	134.46	168.81	199.10	128.72	75.99	51.45	

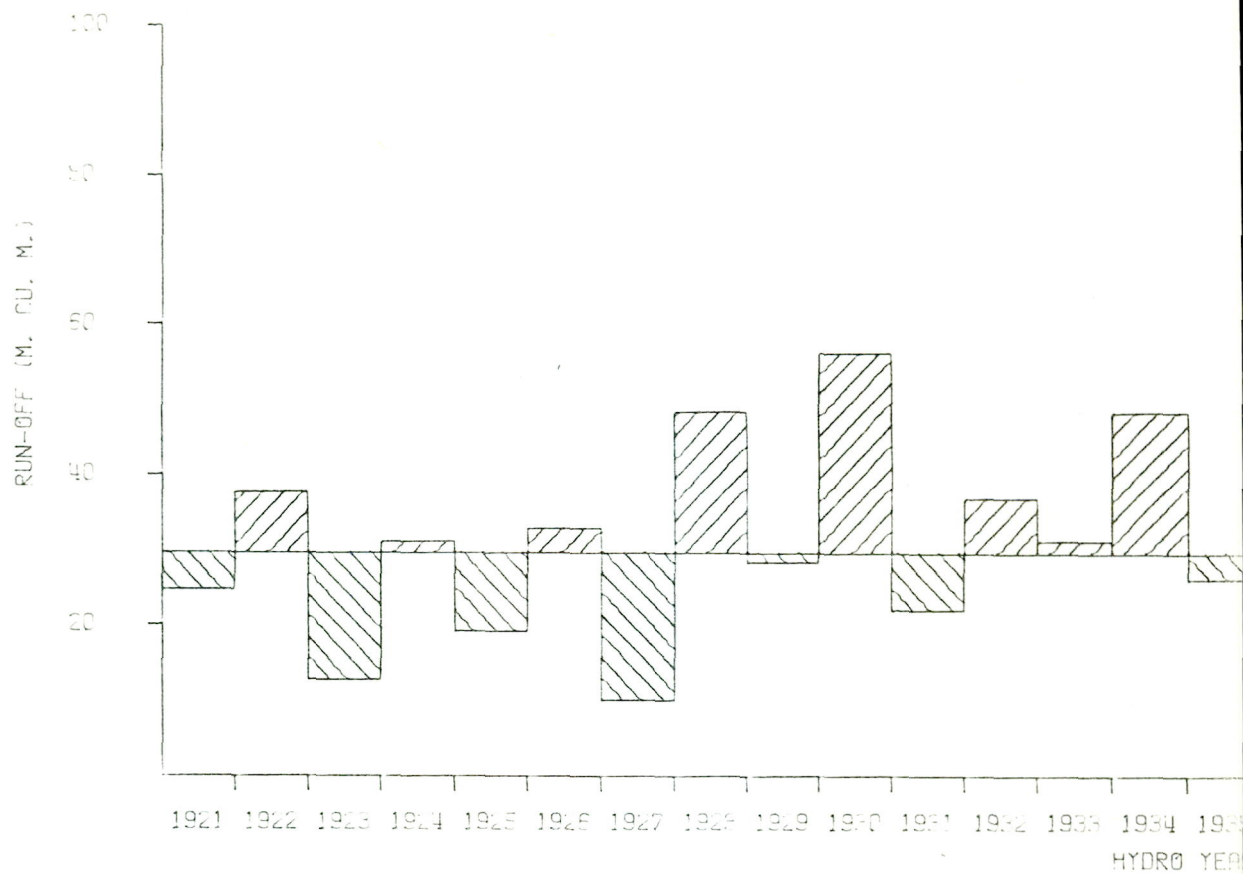
MEAN ANNUAL RUN-OFF= 29.56 MILLION CUBIC METRES. COMPILED FROM HRU REPORT NO.9/HI DATA



TRACED  
 CHECKED  
 DATE  
 REF.

NATAL ESTUARIES: MBIZANA  
**THALWEG DISPLACEMENT**  
 (1937 - 1976)

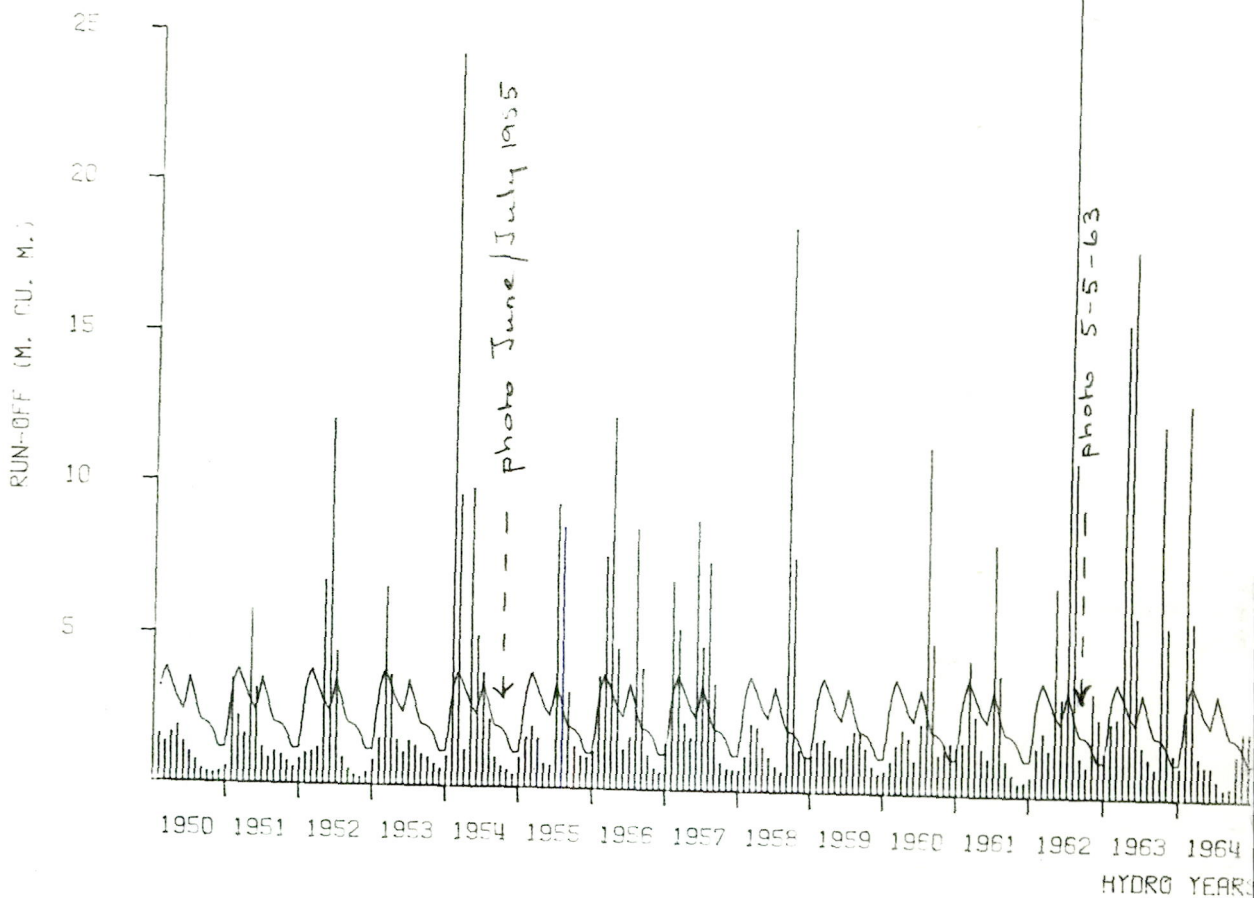
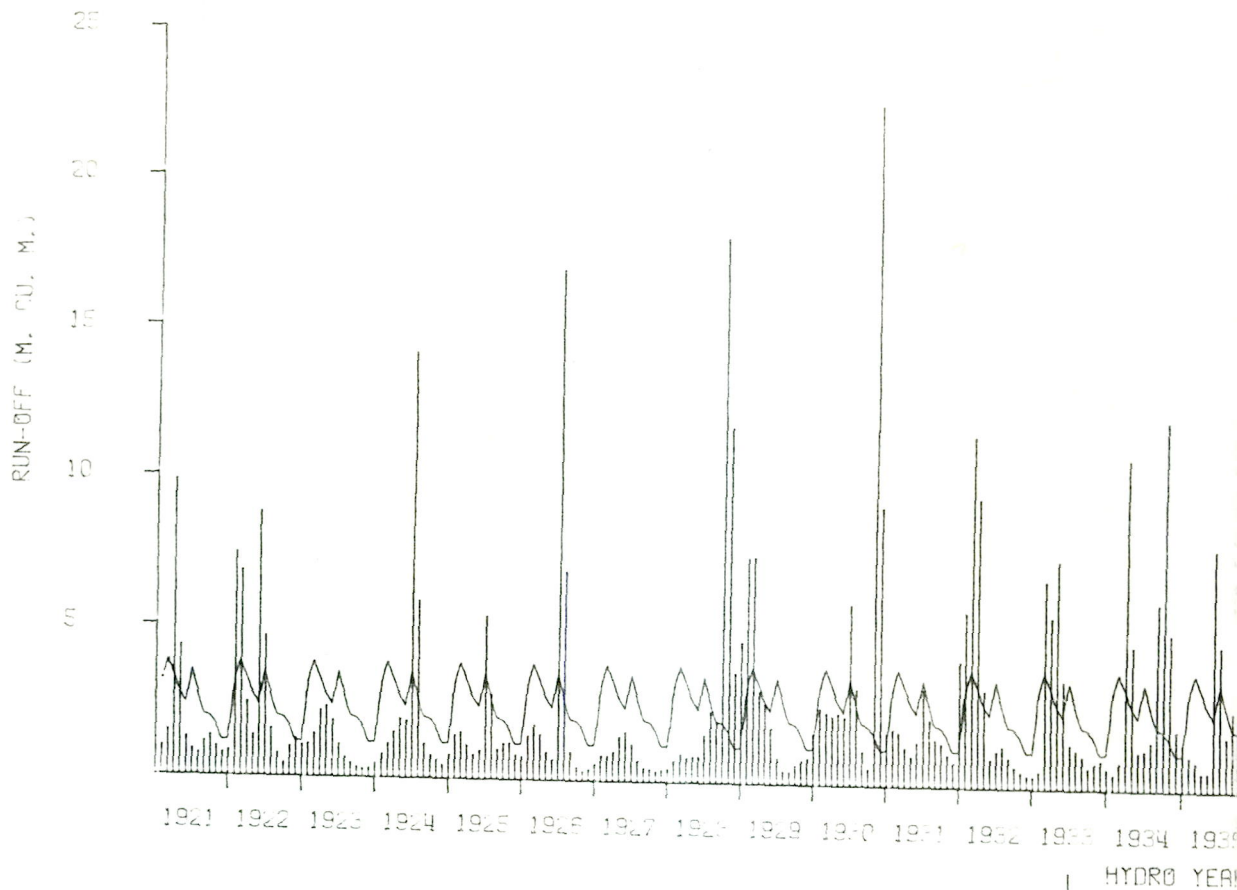
FIGURE  
 NS 10/1



DRAWN: TEMPLET  
 CHECKED:  
 DATE:  
 REF:

NATAL ESTUARIES : MBIZANA  
 SIMULATED ANNUAL RUN-OFF  
 1921-1976

FIGURE  
 NS 10/2



TRACED: COMPLETE

CHECKED:

DATE:

REF.:

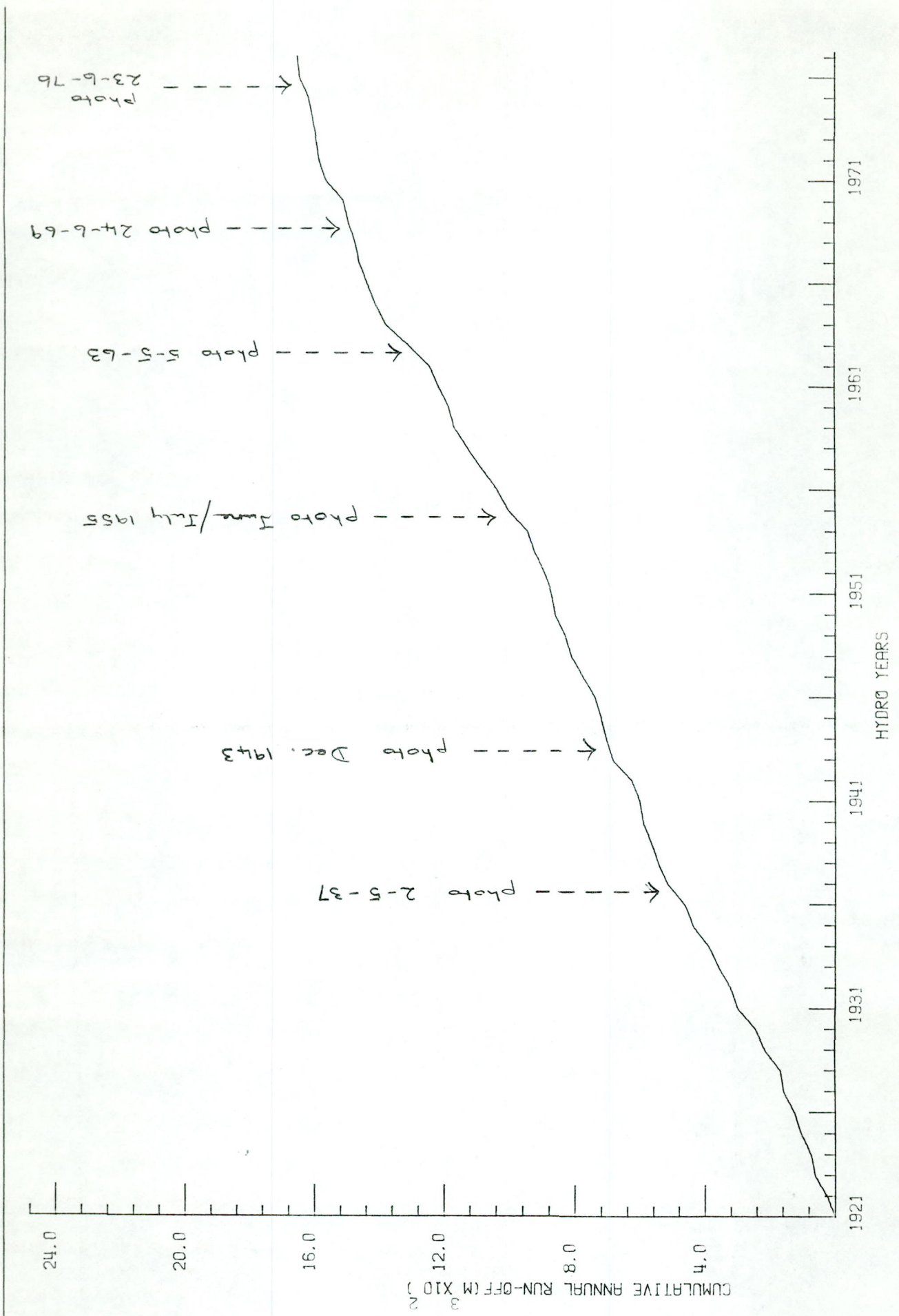
NATAL ESTUARIES: MBIZANA

SIMULATED MONTHLY RUN-OFF

1921-1976

FIGURE

NS 10/3



TRACED : COMPILOT  
 CHECKED :  
 DATE :  
 REF. :

NATAL ESTUARIES : MBIZANA  
**CUMULATIVE ANNUAL RUN-OFF**

FIGURE  
**NS 10/4**



SCALE : 1:10 000 approx.

TRACED  
CHECKED  
DATE  
REF

NATAL ESTUARIES : MBIZANA

PHOTOGRAPH

23.6.76 (2.5.37 RIVER COURSE SUPERIMPOSED)

NS 10/1

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



SCALE : 1:10 000 approx.

TRACED  
CHECKED  
DATE  
REI

NATAL ESTUARIES : MBIZANA

2.5.37 (10 h 50)

PHOTOGRAPH

NS 10/2



SCALE : 1:10 000 approx.

TRACED  
CHECKED  
DATE  
REF

NATAL ESTUARIES : MBIZANA  
DECEMBER 1943 (10 h 14)

PHOTOGRAPH

NS 10/3



SCALE : 1:10 000 approx.

TRACED  
CHECKED  
DATE  
REF

NATAL ESTUARIES : MBIZANA

JUNE / JULY 1955 ( 10 h 28 )

PHOTOGRAPH

NS 10/4



SCALE 1:10 000 approx.

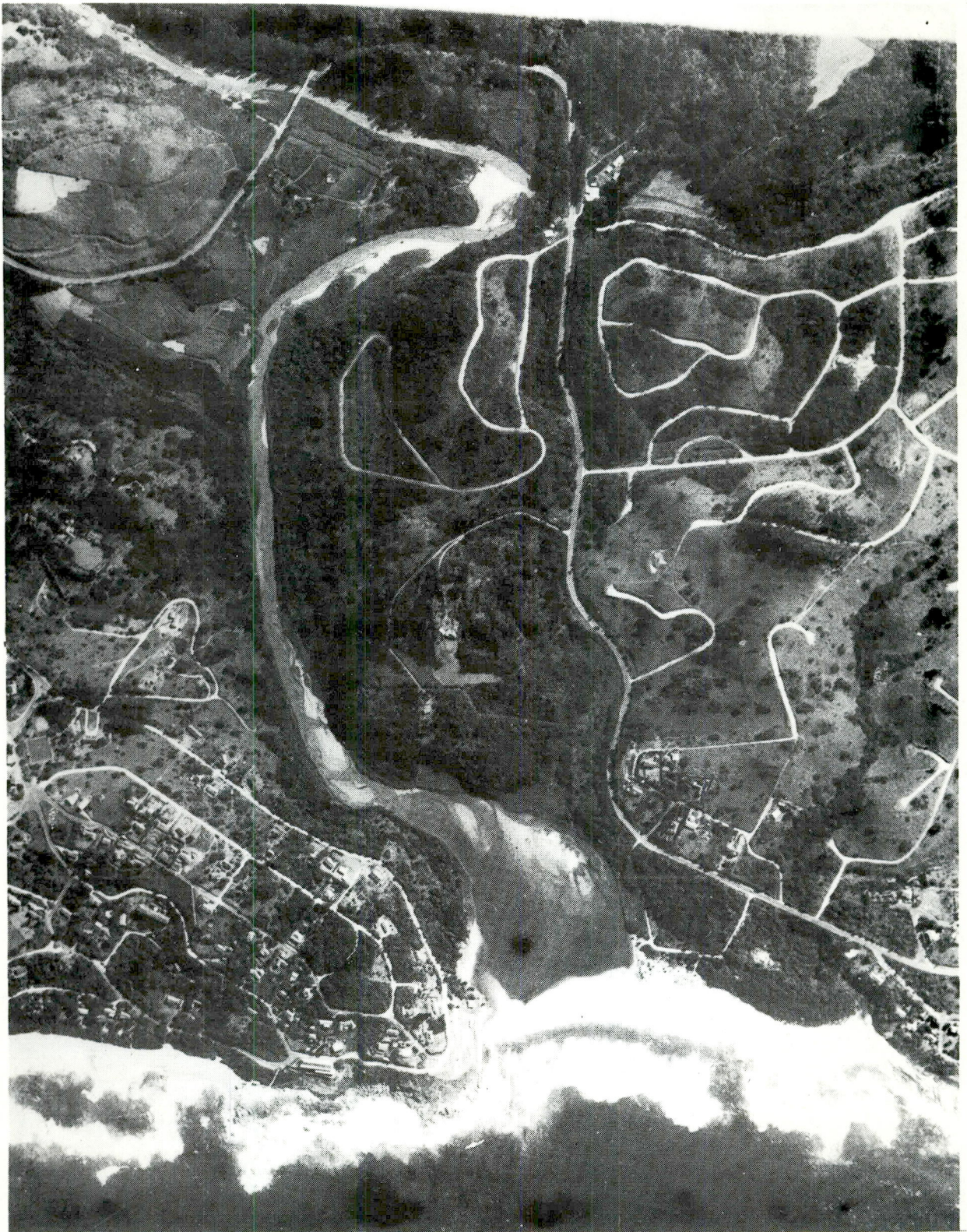
TRACED  
CHECKED  
DATE  
REI

NATAL ESTUARIES : MBIZANA

5 · 5 · 63 (10 h 30)

PHOTOGRAPH

NS 10/5



SCALE : 1:10 000 approx.

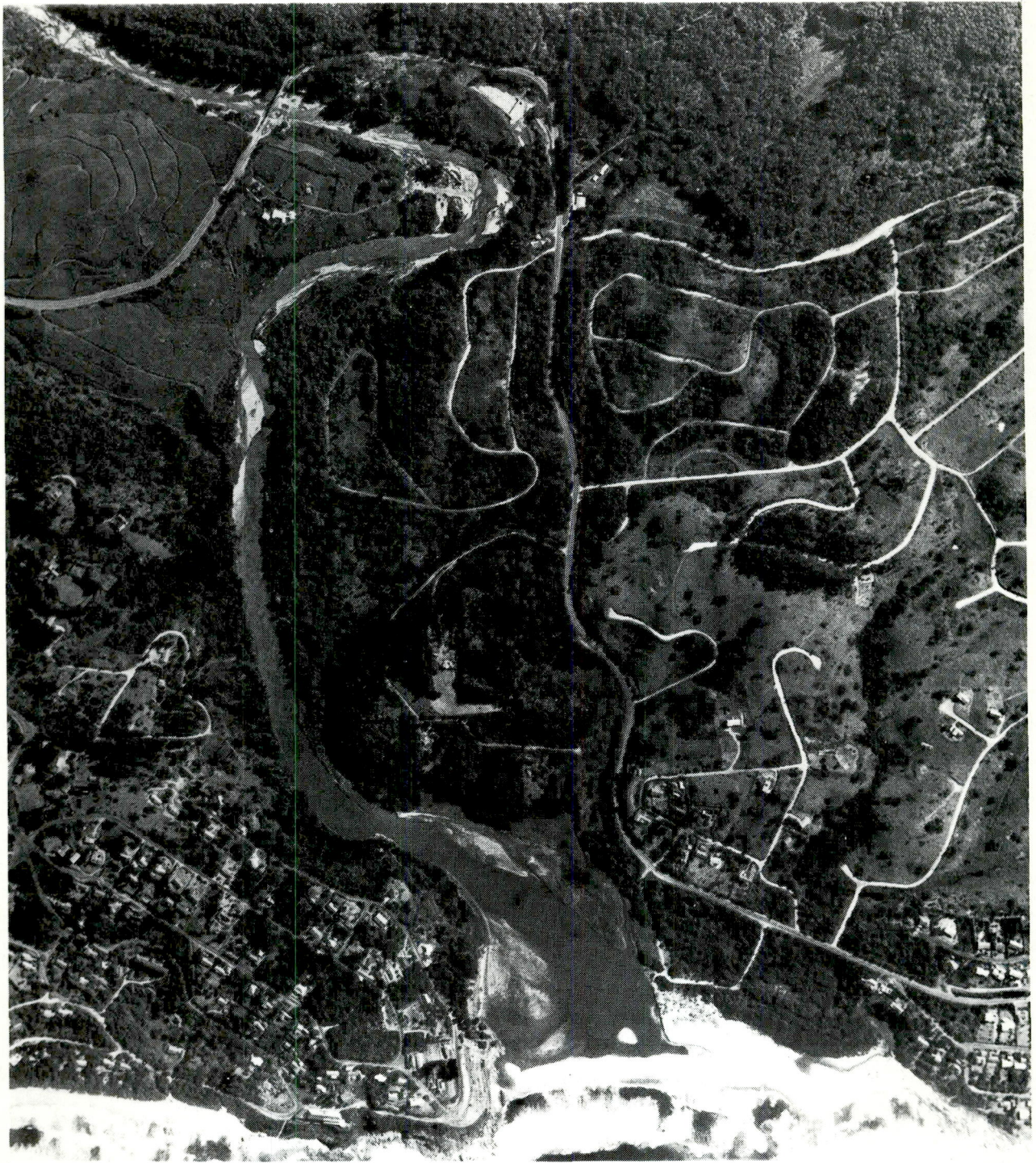
TRACED  
CHECKED  
DATE  
REI

NATAL ESTUARIES : MBIZANA

24 · 6 · 69 (12 h 19)

PHOTOGRAPH

NS 10/6



SCALE : 1:10 000 approx.

TRACED  
CHECKED  
DATE  
REI

NATAL ESTUARIES : MBIZANA

23 · 6 · 76 (11 h 30)

PHOTOGRAPH

NS 10/7



SCALE : 1:10 000 approx.

TRACED  
CHECKED  
DATE  
REI

NATAL ESTUARIES : MBIZANA  
23 · 6 · 76 ( ORTHOPHOTO )

PHOTOGRAPH

NS 10/8

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