



CONFIDENTIAL

**HYDROLOGICAL/HYDRAULIC STUDY  
OF NATAL ESTUARIES**

**DATA REPORT NO. 18**

**MGABABA NS 45**

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

NRIO DATA REPORT D 8405

Stellenbosch, South Africa  
July 1984

NS 45

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BRIEF NOTES - uMGABABA NS 45**Location**

The uMgababa River discharges into the Indian Ocean on the Natal South coast at 30°09'S, 30°50'E. The head of the reach under review is the low-level causeway bridge of the old South Coast road, 4,4 km from the mouth (Photograph NS 45/1).

**Selection of Aerial Photographs**

For the study of this estuary, the unusual step has been taken of selecting two recent photographs (1983 and 1984). Compared with the spacing of earlier available photography, this is statistically not desirable and, furthermore, run-off data for 1983/84 are not available. However, the selection is justified for two reasons:

- (a) interest in assessing the impact of the recently constructed freeway, and
- (b) antecedent run-off conditions can be estimated for the 1983 and 1984 photographs.

**Hydro Data**

The M.A.R. from a catchment of 37 km<sup>2</sup> is 4,98 x 10<sup>6</sup> m<sup>3</sup>. Of particular interest to this study is the erratic nature of the run-off. This is quantified by the high coefficients of variation (V%) for the monthly run-off (Table NS 45/X) and by the wide spectrum of annual and monthly run-off shown in Figures NS 45/2 and 3. Figure NS 45/4 shows the trends 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 (Pitman et al., 1981). These simulated data generally reflect known conditions well but in this case, the run-off for May 1959 is spurious. The tertiary catchment of which the uMgababa is a small part, in fact experienced exceptionally high run-off with a major flood during May 1959. Although the

uMgababa is subject to floods, these will have been attenuated since the completion of the Umnini dam in 1958, and effects on the estuary will be less marked because the dam is only 4,6 km from the mouth.

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 within a dry phase.
2. 1959; near-average run-off, flood flows one month previous.
3. 1967; below-average run-off within a dry phase.
4. 1974; below-average run-off but 2nd and 3rd month previous run-off sufficiently high to breach the sandbar at the mouth.
5. 1983; below-average run-off within a very dry phase.
6. 1984; near/above average and previous three months above average.

#### **River Mouth**

The uMgababa is diverted northward for 1 000 m in its lowest reaches by an old barrier complex. This comprises both Pleistocene and Holocene components (Orme, 1974). At the mouth, however, growth of the modern spit is due South and when the mouth is open the river discharges into the ocean against rocks on the right bank. During research within a dry phase, 1979-1982, Begg (1983) found that the mouth was closed for 83 per cent of the time. More data are now available (Beesley pers. comm.) and for the period May 1978 to April 1984, the mouth was closed 79 per cent of the time (Table NS 45/XI). It is interesting to note that even if the mouth closes for the remainder of the current hydro-year the percentage closure for 1983/84 will be only

55 per cent. Assuming the percentages of 83 and 55 to be representative of below- and above-average run-off conditions respectively, an average closure of approximately 75 per cent may be derived from simulated run-off data for the last 60-year period. The sandbar at the mouth is not normally artificially breached but such action was taken on six occasions during construction of the freeway bridge.

### **Land-use**

The uMgababa catchment area is part of Kwazulu. The left valley side of the area under review is two-thirds under grass and a third tree-covered (in the upper part of the reach). Fifty per cent of the right valley side is under sugar cane cultivation and a third comprises coastal dune forest. The flood plain area is cultivated with sugar cane in the middle and upper reaches, sometimes to the channel edge, for 20-40 per cent of the area. Elsewhere sedges and grasses are found and the ncema grass is reaped extensively for use in the weaving/mat making industry (Begg, 1983).

Bridge building is a feature of the reach. At the head of the reach, 150 m downstream of the Umnini dam wall, is the low-level causeway bridge of the old South Coast road. This is overtopped during floods (Beesby pers. comm.). 1,25 km and 1,5 km from the mouth, respectively, are the National road and Freeway bridges: embankments for these bridges extend across the flood plain. There is a railway bridge near the mouth and embankments of the previous railway bridge 230 m from the mouth are still in situ. Remains of a causeway from the time of construction of the N.R. bridge are also still in situ.

About 600 m of the river channel course was realigned as part of the construction works for the new Freeway bridge, (see Photograph NS 45/1).

## Siltation

It is difficult to quantify siltation because

- (a) the differing bar areas on the photographs, for the most part, merely reflect open/closed mouth conditions;
- (b) successive x-sections at the same site are not available; and
- (c) only one measurement of estuarine length is available (Begg, 1978).

Begg (1983) noted reduced estuarine lengths during the construction of the freeway but this was a temporary situation and the present estuarine length is not known. However, the earliest 1937 photograph (NS 45/2) shows an active large point bar deposit but subsequent photographs show this and a few other silt areas near the mouth, already stabilized with sedges. By the time the next photograph (1959) (NS 45/3) was taken, the Umnini dam was already completed and this will have attenuated major floods and acted as a silt trap since 1958. Within the reach, though, there are several man-made factors to consider:

- (i) Embankments for the old railway bridge (still in situ) and remains of a causeway near the N.R. bridge have caused some siltation;
- (ii) Some cultivation of sugar cane to the channel edge.
- (iii) Bridge building operations. These have aggravated siltation in the past but during major works for the new freeway, a concerted effort was made to minimize these effects (Begg, 1983): for example "slippage" was removed when construction was completed. Nevertheless, the 1984 photograph (NS 45/7) shows wind actually blowing deposits into the river from areas recently exposed during realignment of the channel. It

will take a few years for these areas to stabilize. For the period under review, however, siltation appears to be only "slight", overall. It would be interesting to try to quantify this assumption by taking x-sections at all the bridge sites on the uMgababa in the near future.

### Stability

Using data from boreholes sunk prior to the building of the N.R. bridge in 1950, Orme (1974) compiled a river x-section which shows a bed level of +2,5 m to MSL and a scour channel of recent flood origin down to 8 m below this. Scour and fill of this magnitude, for such a small catchment, implies instability but for most of the period under review major floods have been attenuated by the Umnini dam. The upper part of the reach has remained stable and the lower part of the reach only slightly unstable. The middle part of the reach shows moderate instability owing to re-channelization in recent years. Table NS 45/IX gives full details of lateral stability.

The 1983 and 1984 photographs (NS 45/6 and 7) show the freeway bridge in situ under closed- and open-mouth conditions, respectively. It is interesting to note that for both these mouth conditions, open-water areas, thalweg lengths and sinuosity have remained similar to those existing in former years. It would appear, therefore, that by judicious planning and care during construction, the stability of the system has not been impaired by the building of the freeway.

The uMgababa shows slight siltation and has been slightly unstable for the period under review. Details of the classification may be found in Tables NS 45/II-VII and an abstract of results is given in Table NS 45/I.

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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). |

ABSTRACT

BASIC DATA / CALCULATIONS

Lateral displacement (1937 - 1984)  $\bar{x}$  26.2 m (64.9% R width)

Relative lateral stability (1937 - 1984)  $\bar{v}$  15.6 km<sup>2</sup>

Area of catchment 37 ha

Area of flood plain 38.6 ha

Area of envelope of mobility 31.6 ha

Simulated M.A.R. (1921 - 1975)  $\bar{x}$  4.98 x 10<sup>6</sup> m<sup>3</sup>

$s$  3.15 x 10<sup>6</sup> m<sup>3</sup>

$\bar{v}$  63.2

Dates of major floods: March 1925, June 1935, April 1943, Feb. 1958, May 1959(i), March 1976

MEASUREMENTS/CALCULATIONS FROM PHOTOGRAPHS

| Date                      | 30-4-37 | 6-6-59 | 17-6-67 | 18-4-74 | 2-8-83 | 6-2-84 |
|---------------------------|---------|--------|---------|---------|--------|--------|
| Thalweg (m)               | 4278    | 4455   | 4363    | 4425    | 4356   | 4428   |
| % Thalweg estuarine       | ?       | ?      | ?       | 58      | ?      | ?      |
| Aerial D (m)              | 1985    | 2055   | 2005    | 2053    | 2009   | 2053   |
| Sinuosity                 | 2.16    | 2.17   | 2.18    | 2.16    | 2.17   | 2.16   |
| $\bar{x}$ River width (m) | 55.1    | 21.1   | 53.0    | 36.3    | 56.2   | 20.5   |
| Open water area (ha)      | 24.0    | 9.5    | 21.8    | 14.8    | 24.0   | 10.0   |
| % envelope of mobility    | 75.9    | 30.1   | 70.0    | 46.8    | 75.9   | 31.6   |
| Bar/Island area (ha)      | NIL     | 9.9    | NIL     | 3.4     | NIL    | 12.7   |
| River braided % Thalweg   | NIL     | NIL    | NIL     | NIL     | NIL    | NIL    |
| % Flood plain cultivated  | 27      | 40     | 29      | 20      | 26     | 31     |
| Left valley side:         |         |        |         |         |        |        |
| % grass                   | 67      | 62     | 64      | 60      | 62     | 63     |
| % trees                   | 30      | 35     | 33      | 37      | 30     | 25     |
| % cultivated              | 3       | 3      | 3       | 3       | 3      | 5      |
| % built up                | NIL     | NIL    | NIL     | NIL     | 5      | 7      |
| Right valley side:        |         |        |         |         |        |        |
| % grass                   | 13      | 13     | 16      | 16      | 16     | 16     |
| % trees                   | 32      | 32     | 35      | 34      | 34     | 32     |
| % cultivated              | 55      | 55     | 49      | 50      | 50     | 52     |
| % built up                | NIL     | NIL    | NIL     | NIL     | NIL    | NIL    |
| L.B. % vegetated          | 26      | 23     | 28      | 24      | 28     | 23     |
| R.B. % vegetated          | 30      | 23     | 26      | 21      | 30     | 18     |
| Mouth open/closed o/c     | C       | O      | C       | O       | C      | O      |
| Spit/bar:                 |         |        |         |         |        |        |
| Direction (°)             | 180     | 180    | 180     | 180     | 180    | 180    |
| Length (m)                | 189     | 160    | 189     | 173     | 185    | 163    |
| $\bar{x}$ width (m)       | 63      | 51     | 58      | 62      | 72     | 58     |

HUMAN INFLUENCES

Within the Reach

1. Land-use

- (a) Cultivation: Valley sides L.V.S. 4% R.V.S. 51%
- Flood plain 20-40% (sugar cane)

To channel edge Yes, in some areas

- (b) Bridge building and embankments: Position Date of Construction
1. Old S. coast Rd. Br. head of reach 1897
  2. Old Railway Br. 230 m from mouth 1937
  3. Present Railway Br. 140 m from mouth 1937
  4. National Road Br. 1250 m from mouth 1950
  5. Freeway Br. 1500 m from mouth 1978-1981
- (c) Canals
- The river course was realigned (semi-canalization) for about 600 m in the vicinity of + upstream from the Freeway Br.
- (d) Urbanization/Industry Nil

2. Breaching of sandbar

Does not occur normally but during freeway construction operations, the bar was breached six times (Beg. 1983)

3. Others

Reaping nccma grass on the flood plain (Beg. 1983)  $\approx$  14ha

Upstream of Reach

- (a) Dams in the catchment Date of construction
- Umuni Dam, 150 m up head of reach, 25-6-58

(b) Building construction or canalization immediately upstream of reach

Nil

(c) Land-use malpractices/silt supply

Siltation generally slight & mostly the result of br. building within the reach for the period under review. Evidence of greater siltation formerly - Umuni Dam probably acts as a silt trap.

STABILITY FOR PERIOD UNDER REVIEW: the reach may be divided into 3 parts:

1. Upper section: stable
  2. Middle section: moderately unstable
  3. Lower section: slightly unstable
- } overall slightly unstable.

RIVER u MGABABA, ? % ESTUARINE, REACH from S. coast Road Bridge, 4,3 km from mouth. REF. DEA U 700b  
 AERIAL PHOTO DATE 30-4-37 SCALE 1:10 000 CATCHMENT AREA 37 km<sup>2</sup>, M.A.R. 4,98 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               |
|-------------|------------------------------|------------------------|
| 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 |
|             | swamp/bog                    | partly built-up        |
|             |                              | urbanised              |

Valley Sides (Not Well-defined)

| Slumping   | Vegetation and Land-Use | Left | Right |
|------------|-------------------------|------|-------|
| ✓ none     | coastal dune forest     | 3    | 32 %  |
| occasional | grass                   | 67   | 13 %  |
| frequent   | trees/bush              | 27   | - %   |
|            | cultivated              | 3    | 55 %  |
|            | built-up                | NIL  | NIL % |

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>3510</u> m     | none          | not applicable                                  | not applicable (no valley or free)                                  | bedrock                        |
| bottom width (av.) <u>306</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                                       |   | sand covered <u>NIL</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            | direction of growth <u>180</u> °            |
| outer bar                     | length of spit/bar <u>189</u> m             |
| silt plume (fluvial)          | length stabilized <u>50</u> m               |
| ✓ suspended sediment (marine) | width <u>63</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>306</u> m  | ✓ grass (nema)                | riverine:            | ✓ cultivated <u>27</u> % area  |
| fragmentary  | maximum width <u>665</u> m  | * reed swamp <u>12</u> % area | ✓ main channel**     | ✓ crop/s <u>sugar cane</u>     |
| ✓ continuous | aerial length <u>1985</u> m | sparsely forested             | tributaries          | partly built-up                |
|              | area <u>98,6</u> ha         | moderately forested           | mangroves            | mainly built-up                |
|              |                             | heavily forested              |                      | Comments * + sedges            |

\*\* upper reach.

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

| Pattern              | Measurements                                  | Islands/Shoals | Type of Flow                | Bar Type               |
|----------------------|---|----------------|-----------------------------|------------------------|
| straight             | thalweg <u>4,278</u> m                        | none           | stagnant/still              | none                   |
| sinuous              | * sinuosity <u>2,16</u>                       | occasional     | ✓ uniform water surface     | ✓ channel side bars    |
| irregular            | * open water area <u>24,0</u> ha              | frequent       | uniform with rapid in reach | ✓ point bars (old)     |
| regular meanders     | perimeter <u>15380</u> m                      | split          | irregular                   | channel junction bars  |
| ✓ irregular meanders | lake/lagoon area _____ ha                     | braided        | pool & riffle sequence      | mid-channel bars       |
| tortuous meanders    | river X-sections available                    |                | turbid                      | diamond bars           |
| bifurcated           | channel slope _____                           |                |                             | diagonal bars          |
| lake/s               | channel width x _____ m                       |                |                             | sand waves/large dunes |
| lagoon               | river slope _____                             |                |                             |                        |
|                      | river width x <u>55,1</u> m s = <u>59,0</u> m |                |                             |                        |

Comments \*whole reach

\*\* near mouth

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 (2)               |   |                                       |
| boulders   | major  | causeway <u>old S. coast Rd</u> | <u>confined</u>                             | <u>4,2 &amp; 4,3 km head of reach</u> |
| vegetation |        | weir/dam                        | <u>Overtopped during floods</u>             |                                       |
|            |        | fish traps                      |   |                                       |
|            |        | embankment/s                    | <u>for the 2 rhy bridges near the mouth</u> | <u>4,2 &amp; 4,3 km</u>               |
|            |        | 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 channel edge | ** left bank <u>26</u> %  | highly unstable     |
| irregular lateral activity  |                               | ** right bank <u>30</u> % |                     |
| avulsion                    |                               |                           | Comments * formerly |

\*\* sedges & swamps (±50%)  
 \*\*\* trees

RIVER MGABABA, ? % ESTUARINE, REACH from S. coast Road Bridge 4.5 km from mouth. REF. DEA U 700 b  
 AERIAL PHOTO DATE 6-6-59 SCALE 1:10 000 CATCHMENT AREA 37 km<sup>2</sup>, M.A.R. 4.98 m<sup>3</sup>x10<sup>6</sup>, No. of DAMS 1

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     | 3    | 32 %  |
| ✓ hilly     | ✓ grass                      | scattered cultivation     | occasional | grass                   | 62   | 13 %  |
| undulating  | ✓ sparsely forested (0-25%)  | ✓ partly cultivated       | frequent   | trees/bush              | 32   | - %   |
| plains      | moderately forested (25-75%) | mainly cultivated         |            | cultivated              | 3    | 55 %  |
|             | heavily forested (75-100%)   | ✓ scattered settlement    |            | built-up                | NIL  | NIL % |
|             | 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>3510</u> m            | none          | not applicable                                  | not applicable (no valley or free)                                  | bedrock                        |
| bottom width (av.) <u>306</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                                       |   | sand covered <u>NIL</u> % area |

Comments \_\_\_\_\_

River Mouth

| Characteristics                  | Measurements  |
|----------------------------------|---|
| ✓ open/ <del>closed</del>        | right bank breakwater length _____ m                    |
| ✓ natural/ <del>artificial</del> | 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/ <del>bar</del> : direction of growth <u>180</u> ° |
| outer bar                        | length of spit/ <del>bar</del> <u>160</u> m             |
| silt plume (fluvial)             | length stabilized <u>73</u> m                           |
| ✓ suspended sediment (marine)    | width <u>51</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 | ✓ <del>not cultivated</del> , not built-up |
| indefinite  | average width <u>306</u> m  | ✓ grass ( <i>ncena</i> )      | riverine:            | ✓ cultivated <u>40</u> % area              |
| fragmentary | maximum width <u>665</u> m  | * reed swamp <u>12</u> % area | ✓ main channel**     | ✓ crop/s <u>SUGAR CANE</u>                 |
| continuous  | aerial length <u>2055</u> m | sparsely forested             | tributaries          | partly built-up                            |
|             | area <u>98,6</u> ha         | moderately forested           | mangroves            | mainly built-up                            |
|             |                             | heavily forested              |                      | Comments * + sedges                        |

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>4455</u> m               | none           | stagnant/still              | none                   |
| sinuous              | * sinuosity <u>2.17</u>             | occasional     | ✓ uniform water surface     | ✓ channel side bars    |
| irregular            | * open water area <u>9.5</u> ha     | frequent       | uniform with rapid in reach | ✓ point bars (old)     |
| regular meanders     | perimeter <u>13370</u> m            | split          | irregular                   | channel junction bars  |
| ✓ irregular meanders | lake/lagoon area _____ ha           | braided        | pool & riffle sequence      | mid-channel bars       |
| tortuous meanders    | river X-sections available          |                | turbid                      | diamond bars           |
| bifurcated           | channel slope _____                 |                |                             | diagonal bars          |
| lake/s               | channel width $\bar{x}$ _____ m     |                |                             | sand waves/large dunes |
| lagoon               | river slope _____                   |                |                             |                        |
|                      | river width $\bar{x}$ <u>21.1</u> m |                |                             |                        |

Comments \*whole reach

\*\* near mouth

Obstructions/Constructions

| Natural    | Degree | Man-made         | Degree of Obstruction/Constriction for Each       | Position (from head of reach)     |
|------------|--------|------------------|---|-----------------------------------|
| ✓ none     | ✓ none | road bridge/s    | <u>National Rd. Br.</u> R, <u>confined</u>        | <u>3.2 km</u>                     |
| logs       | minor  | rail bridge/s    | R, <u>confined</u>                                | <u>4.3 km</u>                     |
| boulders   | major  | causeway         | <u>old S. coast Rd. overlapped during floods</u>  | <u>head of reach</u>              |
| vegetation |        | fish traps       | <u>causeway remains near N.R. Br.</u>             | <u>3.2 km</u>                     |
|            |        | embankment/s     | <u>for old &amp; new bluey &amp; N.R. bridges</u> | <u>3.2 &amp; 4.2 &amp; 4.3 km</u> |
|            |        | 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 channel edge | ** left bank <u>23</u> %   | highly unstable          |
| irregular lateral activity  |                               | *** right bank <u>23</u> % | Comments * formerly      |
| avulsion                    |                               |                            | ** = 50% sedges & swamps |

\*\*\* trees

RIVER UMGABABA, ? % ESTUARINE, REACH from S. Coast Road Bridge, 4.4 km from mouth. REF. DEA U 700b  
 AERIAL PHOTO DATE 17-6-67 SCALE 1:10 000 CATCHMENT AREA 37 km<sup>2</sup>, M.A.R. 4,98 m<sup>3</sup>x10<sup>6</sup>, No. of DAMS 1

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     | 3    | 35 %  |
| ✓ hilly     | ✓ grass                      | scattered cultivation  | occasional | grass                   | 64   | 16 %  |
| undulating  | ✓ sparsely forested (0-25%)  | ✓ partly cultivated    | frequent   | trees/bush              | 30   | - %   |
| plains      | moderately forested (25-75%) | mainly cultivated      |            | cultivated              | 3    | 49 %  |
|             | heavily forested (75-100%)   | ✓ scattered settlement |            | built-up                | NIL  | NIL % |
|             | 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>3510</u> m     | none          | not applicable                                  | not applicable (no valley or free)                                  | bedrock                        |
| bottom width (av.) <u>306</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                                       |   | sand covered <u>NIL</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>180</u> °  |
| outer bar                     | length of spit/bar <u>189</u> m             |
| silt plume (fluvial)          | length stabilized <u>73</u> m               |
| ✓ suspended sediment (marine) | width <u>58</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>306</u> m  | ✓ grass (ncama)              | riverine:            | ✓ cultivated <u>29</u> % area  |
| fragmentary  | maximum width <u>665</u> m  | + reed swamp <u>8</u> % area | ✓ main channel**     | ✓ crop/s <u>sugar cane</u>     |
| ✓ continuous | aerial length <u>2005</u> m | sparsely forested            | tributaries          | partly built-up                |
|              | area <u>98,6</u> ha         | moderately forested          | mangroves            | mainly built-up                |
|              |                             | heavily forested             |                      | Comments * + sedges            |

Comments \_\_\_\_\_

Channel Description N.B. Estimate of flow stage: LOW/MEDIUM/HIGH

| Pattern              | Measurements                              | Islands/Shoals | Type of Flow                | Bar Type               |
|----------------------|---|----------------|-----------------------------|------------------------|
| straight             | thalweg <u>4363</u> m                     | none           | stagnant/still              | none                   |
| sinuous              | * sinuosity <u>2,18</u>                   | occasional     | ✓ uniform water surface     | channel side bars      |
| irregular            | * open water area <u>21,8</u> ha          | frequent       | uniform with rapid in reach | ✓ point bars (old)     |
| regular meanders     | perimeter <u>14104</u> m                  | split          | irregular                   | channel junction bars  |
| ✓ irregular meanders | lake/lagoon area _____ ha                 | braided        | pool & riffle sequence      | mid-channel bars       |
| tortuous meanders    | river X-sections available                |                | turbid                      | diamond bars           |
| bifurcated           | channel slope _____ m s = _____ m         |                |                             | diagonal bars          |
| lake/s               | channel width x _____ m s = <u>56,2</u> m |                |                             | sand waves/large dunes |
| lagoon               | river slope _____                         |                |                             |                        |
|                      | river width x _____                       |                |                             |                        |

Comments \*whole reach

\*\* near mouth

Obstructions/Constructions

| Natural    | Degree | Man-made                                   | Degree of Obstruction/Constriction for Each     | Position (from head of reach)     |
|------------|--------|--|---|-----------------------------------|
| ✓ none     | ✓ none | road bridge/s                              | <u>National Rd. Br</u> R. confined              | <u>3,2</u> km                     |
| logs       | minor  | rail bridge/s                              | R. confined                                     | <u>4,3</u> km                     |
| boulders   | major  | causeway (i) <u>old S. coast Rd.</u>       | over topped during floods                       | head of reach                     |
| vegetation |        | (ii) <u>causeway</u> remains water N.R. Br |   | <u>3,2</u> km                     |
|            |        | fish traps                                 |   |                                   |
|            |        | embankment/s                               | <u>for old &amp; new rhy &amp; N.R. bridges</u> | <u>3,2 &amp; 4,2 &amp; 4,3</u> km |
|            |        | 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 <u>28</u> %  | highly unstable     |
| irregular lateral activity  | channel edge           | ** right bank <u>26</u> % |                     |
| avulsion                    |                        |                           |                     |

Comment \*\* = 50% sedges & swamps  
 \*\* trees

RIVER UMGABABA, ±58% ESTUARINE, REACH from S. coast Road Bridge, 4.4 km from mouth. REF. DEA U700b

AERIAL PHOTO DATE 18-4-74 SCALE 1:10000 CATCHMENT AREA 37 km<sup>2</sup>, M.A.R. 4,98 m<sup>2</sup>x10<sup>6</sup>, No. of DAMS 1  
(Orthophoto)

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     | 3    | 34 %  |
| ✓ hilly     | ✓ grass                      | scattered cultivation  | occasional | grass                   | 60   | 16 %  |
| undulating  | ✓ sparsely forested (0-25%)  | ✓ partly cultivated    | frequent   | trees/bush              | 34   | 2 %   |
| plains      | moderately forested (25-75%) | mainly cultivated      |            | cultivated              | 3    | 50 %  |
|             | heavily forested (75-100%)   | ✓ scattered settlement |            | built-up                | NIL  | NIL % |
|             | swamp/bog                    | partly built-up        |            |                         |      |       |
|             |                              | urbanised              |            |                         |      |       |

Comments \* 58% in 1976 (Req)

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>3510</u> m                        | none          | not applicable                                  | not applicable (no valley or free)                                  | bedrock                        |
| bottom width (av.) <u>306</u> m                    | indefinite    | ✓ not obviously degrading or aggrading          | ✓ occasionally confined   | lacustrine deposits            |
| valley slope <u>± 1:50</u>                         | ✓ fragmentary | partly entrenched                               | frequently confined   | ✓ fluvial deposits             |
| height at head of reach <u>+7</u> m to MSL approx. | continuous    | entrenched                                      | entrenched  | aeolian                        |
|  |               | aggrading                                       |   | sand covered <u>NIL</u> % area |

Comments

River Mouth

| Characteristics               | Measurements                                |
|-------------------------------|---|
| ✓ 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 <u>180</u> °  |
| outer bar                     | length of spit/bar <u>173</u> m             |
| silt plume (fluvial)          | length stabilized <u>73</u> m               |
| ✓ suspended sediment (marine) | width <u>62</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>306</u> m  | ✓ grass (ncema)              | riverine:            | ✓ cultivated <u>20</u> % area  |
| fragmentary  | maximum width <u>665</u> m  | * reed swamp <u>6</u> % area | ✓ main channel**     | ✓ crops/s <u>sugar cane</u>    |
| ✓ continuous | serial length <u>2053</u> m | sparsely forested            | tributaries          | partly built-up                |
|              | area <u>98,6</u> ha         | moderately forested          | mangroves            | mainly built-up                |
|              |                             | heavily forested             |                      | Comments * + sedges            |
|              |                             |                              |                      | ** upper reach                 |

Comments

Channel Description N.B. Estimate of flow stage: LOW/MID/HIGH

| Pattern              | Measurements                         | Islands/Shoals | Types of Flow               | Bar Type               |
|----------------------|--------------------------------------|----------------|-----------------------------|------------------------|
| straight             | thalweg <u>4425</u> m                | none           | stagnant/still              | none                   |
| sinuous              | * sinuosity <u>2,16</u>              | occasional     | ✓ uniform water surface     | ✓ channel side bars    |
| irregular            | * open water area <u>14,8</u> ha     | frequent       | uniform with rapid in reach | ✓ point bars (old)     |
| regular meanders     | perimeter <u>14250</u> m             | split          | irregular                   | channel junction bars  |
| ✓ irregular meanders | lake/lagoon area _____ ha            | braided        | pool & riffle sequence      | mid-channel bars       |
| tortuous meanders    | river X-sections available           |                | turbid                      | diamond bars           |
| bifurcated           | channel slope _____ m s = _____ m    |                |                             | diagonal bars          |
| lake/s               | channel width x _____ m s = _____ m  |                |                             | sand waves/large dunes |
| lagoon               | river slope _____ m s = <u>4,8</u> m |                |                             |                        |

Comments \* whole reach

\*\* near mouth

Obstructions/Constructions

| Natural    | Degree | Man-made   | Degree of Obstruction/Constriction for Each  | Position (from head of reach)     |
|------------|--------|--|--|-----------------------------------|
| none       | ✓ none | road bridge/s                                      | <u>National Rd. Br.</u> <u>R. confined</u>   | <u>3,2</u> km                     |
| logs       | minor  | rail bridge/s                                      | <u>R. confined</u>                           | <u>1,3</u> km                     |
| boulders   | major  | causeway (1) <u>old S. coast Rd.</u>               | <u>overtopped during floods</u>              | <u>head of reach</u>              |
| vegetation |        | causeway (2) <u>causeway remains near N.R. Br.</u> |  | <u>3,2</u> km                     |
|            |        | fish traps   |  |                                   |
|            |        | embankment/s                                       | <u>for old &amp; new flow + N.R. bridges</u> | <u>3,2 &amp; 4,2 &amp; 4,3</u> km |
|            |        | 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 <u>2,4</u> %  | highly unstable                                 |
| irregular lateral activity  | channel edge           | ***right bank <u>2,1</u> % |   |
| avulsion                    |                        |                            | Comments ** <u>± 50% to sedges &amp; swamps</u> |
|                             |                        |                            | *** <u>lees</u>                                 |

RIVER UMGABABA, ? % ESTUARINE, REACH from S. coast Road Bridge, 4.4 km from mouth. REF. DEA U 700 b  
 AERIAL PHOTO DATE 2-8-83 SCALE 1:10 000 CATCHMENT AREA 37 km<sup>2</sup>, M.A.R. 4,98 m<sup>3</sup>x10<sup>6</sup>, No. of DAMS 1

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     | 3    | 34 %  |
| ✓ hilly     | ✓ grass                      | scattered cultivation     | occasional | grass                   | 62   | 16 %  |
| undulating  | ✓ sparsely forested (0-25%)  | ✓ partly cultivated       | frequent   | trees/bush              | 27   | - %   |
| plains      | moderately forested (25-75%) | mainly cultivated         |            | cultivated              | 3    | 50 %  |
|             | heavily forested (75-100%)   | ✓ scattered settlement    |            | built-up                | 5    | NIL % |
|             | 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>3510</u> m            | none          | not applicable                                  | not applicable (no valley or free)                                  | bedrock                        |
| bottom width (av.) <u>306</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                                       |   | sand covered <u>NIL</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>180</u> °  |
| outer bar                     | length of spit/bar <u>185</u> m             |
| silt plume (fluvial)          | length stabilized <u>73</u> m               |
| ✓ suspended sediment (marine) | width <u>72</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 | ✓ <del>not cultivated</del> , not built-up |
| indefinite   | average width <u>306</u> m  | ✓ grass ( <i>Cynema</i> )   | riverine:            | cultivated <u>27</u> % area                |
| fragmentary  | maximum width <u>665</u> m  | *reed swamp <u>5</u> % area | ✓ main channel**     | ✓ crop/s <u>sugar cane</u>                 |
| ✓ continuous | aerial length <u>2009</u> m | sparsely forested           | tributaries          | partly built-up                            |
|              | area <u>98,6</u> ha         | moderately forested         | mangroves            | mainly built-up                            |
|              |                             | heavily forested            |                      | Comments * + sedges                        |

\*\* upper reach

Channel Description N.B. Estimate of flow stage: LOW/~~medium~~/HIGH

| Pattern              | Measurements                              | Islands/shoals | Type of Flow                | Bar Type               |
|----------------------|---|----------------|-----------------------------|------------------------|
| straight             | thalweg <u>4356</u> m                     | none           | stagnant/still              | none                   |
| sinuous              | *sinuosity <u>2,17</u>                    | occasional     | ✓ uniform water surface     | channel side bars      |
| irregular            | *open water area <u>24,0</u> ha           | frequent       | uniform with rapid in reach | ✓ point bars (old)     |
| regular meanders     | perimeter <u>1318,6</u> m                 | split          | irregular                   | channel junction bars  |
| ✓ irregular meanders | lake/lagoon area _____ ha                 | braided        | pool & riffle sequence      | mid-channel bars       |
| tortuous meanders    | river X-sections available _____          |                | turbid                      | diamond bars           |
| bifurcated           | channel slope _____ m s = _____ m         |                |                             | diagonal bars          |
| lake/s               | channel width x _____ m s = <u>58,4</u> m |                |                             | sand waves/large dunes |
| lagoon               | river slope _____                         |                |                             |                        |
|                      | river width x _____                       |                |                             |                        |

Comments \*whole reach  
\*\* near mouth

Obstructions/Constructions

| Natural    | Degree | Man-made   | Degree of Obstruction/Constriction for Each | Position (from head of reach)               |
|------------|--------|--|---|---|
| ✓ none     | ✓ none | road bridge/s <u>N.R. &amp; Freeway Bridges</u>        | R. confined                                 | <u>3,0 &amp; 3,2 km</u>                     |
| logs       | minor  | rail bridge/s _____                                    | R. confined                                 | <u>4,3 km</u>                               |
| boulders   | major  | causeway (i) <u>Old S. coast Rd</u>                    | overhopped during floods                    | <u>head of reach</u>                        |
| vegetation |        | causeway (ii) <u>causeway remains</u>                  | near N.A. dt.                               | <u>3,2 km</u>                               |
|            |        | fish traps _____                                       |   |   |
|            |        | embankment/s <u>for the 2 rwy &amp; 2 road bridges</u> |   | <u>3,0 &amp; 3,2 &amp; 4,2 &amp; 4,3 km</u> |
|            |        | groynes _____  |   |   |
|            |        | canals <u>R. realigned over ± 500 m</u>                |   | <u>± 2,5 - 3,0 km</u>                       |
|            |        | 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 levees                | weak                     | ✓ slightly unstable only, despite realignment |
| 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>28</u> %  | highly unstable                               |
| irregular lateral activity  |                               | ✓ right bank <u>30</u> % | Comments * formerly                           |
| avulsion                    |                               |                          | ** ± 50% sedges + swamps                      |
|                             |                               |                          | *** trees                                     |

RIVER MGAZABA, ? % ESTUARINE, REACH from S. coast Road Bridge, 4,4 km from mouth. REF. DEA U7006

AERIAL PHOTO DATE 6-2-84 SCALE 1:10000 CATCHMENT AREA 37 km<sup>2</sup>, M.A.R. 4,98 m<sup>2</sup>x10<sup>6</sup>, No. of DAMS 1

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     | 3    | 32 %  |
| ✓ hilly     | ✓ grass                      | scattered cultivation  | occasional | grass                   | 63   | 16 %  |
| undulating  | ✓ sparsely forested (0-25%)  | ✓ partly cultivated    | frequent   | trees/bush              | 22   | - %   |
| plains      | moderately forested (25-75%) | mainly cultivated      |            | cultivated              | 5    | 52 %  |
|             | heavily forested (75-100%)   | ✓ scattered settlement |            | built-up                | 7    | NIL % |
|             | 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>3510</u> m     | none          | not applicable                                  | not applicable (no valley or free)                                  | bedrock                        |
| bottom width (av.) <u>306</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                                      |   | sand covered <u>NIL</u> % area |
|                                 |               | aggrading                                       |   |                                |

Comments \_\_\_\_\_

River Mouth

| Characteristics               | Measurements                                |
|-------------------------------|---|
| ✓ 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 <u>180</u> °  |
| outer bar                     | length of spit/bar <u>163</u> m             |
| silt plume (fluvial)          | length stabilized <u>73</u> m               |
| ✓ suspended sediment (marine) | width <u>58</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 | ✓ <del>not cultivated</del> , not built-up |
| indefinite   | average width <u>306</u> m  | ✓ grass ( <i>ncema</i> )     | riverine:            | ✓ cultivated <u>32</u> % area              |
| fragmentary  | maximum width <u>665</u> m  | * reed swamp <u>5</u> % area | ✓ main channel**     | crop/s <u>sugar cane</u>                   |
| ✓ continuous | aerial length <u>2053</u> m | sparsely forested            | tributararies        | partly built-up                            |
|              | area <u>98,6</u> ha         | moderately forested          | mangroves            | mainly built-up                            |
|              |                             | heavily forested             |                      | Comments * + sedges                        |

\*\* upper reach

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>4428</u> m                         | none           | stagnant/still                 | none                   |
| sinuous              | * sinuosity <u>2,16</u>                       | occasional     | ✓ uniform water surface        | ✓ channel side bars    |
| irregular            | * open water area <u>10,0</u> ha              | frequent       | uniform with rapid in reach    | ✓ point bars (old)     |
| regular meanders     | perimeter <u>12070</u> m                      | split          | irregular                      | channel junction bars  |
| ✓ irregular meanders | lake/lagoon area _____ ha                     | braided        | pool & riffle sequence         | mid-channel bars       |
| tortuous meanders    | river X-sections available                    |                | ✓ turbid w/s & A/s freeway bt. | diamond bars           |
| bifurcated           | channel slope _____ m s = _____ m             |                | wind                           | diagonal bars          |
| lake/s               | channel width x _____ m s = _____ m           |                |                                | sand waves/large dunes |
| lagoon               | river slope _____                             |                |                                |                        |
|                      | river width x <u>20,5</u> m s = <u>19,9</u> m |                | Comments *whole reach          | ** near mouth          |

Obstructions/Constructions

| Natural    | Degree | Man-made                       | Degree of Obstruction/Constriction for Each | Position (from head of reach) |
|------------|--------|--------------------------------|---|-------------------------------|
| ✓ none     | ✓ none | road bridge/s                  | NR + Freeway Bridges                        | R. confined 3,0 & 3,2 km      |
| logs       | minor  | rail bridge/s                  |   | R. confined 4,3 km            |
| boulders   | major  | causeway (i) old S. coast Rd.  | overlapped during floods                    | head of reach                 |
| vegetation |        | causeway (ii) causeway remains | old N.R. bt                                 | 3,2 km.                       |
|            |        | fish traps                     |   |                               |
|            |        | embankment/s                   | for the 2 Hwy & 2 road bridges              | 3,0 & 3,2 & 4,2 & 4,3 km      |
|            |        | groynes                        |   |                               |
|            |        | canals                         | R. realigned over 500m                      | 2,5 - 3,0 km                  |
|            |        | 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 only despite realignment. |
| 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>23</u> %  | highly unstable                               |
| irregular lateral activity  |                               | *** right bank <u>18</u> % | Comments *x formerly                          |
| avulsion                    |                               |                            | *x = 50% sedges & swamps                      |
|                             |                               |                            | *** trees                                     |

TABLE NS45/VIII

## RIVER WIDTHS

MKGABABA NS45

| Station   | Approx. distance along 1974 R. course from old S. coast Rd. Br. (m) | River widths (m)   |                |                    |                    |                      |                  |          | $\bar{x}$ | s     | V% |
|-----------|---|--------------------|----------------|--------------------|--------------------|----------------------|------------------|----------|-----------|-------|----|
|           |   | Date               |                |                    |                    |                      |                  |          |           |       |    |
|           |   | 30.04.37           | 06.06.59       | 17.06.67           | 18.04.74           | 02.08.83             | 06.02.84         | 06.02.84 |           |       |    |
| 1         | 0   | 4                  | 4              | 4                  | 4                  | 4                    | 4                | 4        | 0         | 0     |    |
| 2         | 250   | 4                  | 4              | 4                  | 4                  | 4                    | 4                | 4        | 0         | 0     |    |
| 3         | 500   | 4                  | 4              | 4                  | 4                  | 4                    | 4                | 4        | 0         | 0     |    |
| 4         | 750   | 4                  | 4              | 4                  | 4                  | 4                    | 4                | 4        | 0         | 0     |    |
| 5         | 1 000   | 6                  | 6              | 6                  | 6                  | 6                    | 6                | 6        | 0         | 0     |    |
| 6         | 1 250   | 10                 | 10             | 10                 | 10                 | 10                   | 10               | 10       | 0         | 0     |    |
| 7         | 1 500   | 10                 | 10             | 8                  | 8                  | 8                    | 8                | 6        | 1,5       | 18,1  |    |
| 8         | 1 750   | 30                 | 15             | 34                 | 8                  | 30                   | 30               | 10       | 11,5      | 54,1  |    |
| 9         | 2 000   | 40                 | 15             | 30                 | 20                 | 36                   | 36               | 16       | 10,7      | 40,8  |    |
| 10        | 2 250   | 86<br>(20+5+35+26) | 34<br>(5+24+5) | 110<br>(4+8+44+14) | 42<br>(4+27+11)    | 132<br>(30+37+40+29) | 68<br>(20+32+16) | 68       | 38,3      | 48,7  |    |
| 11        | 2 500   | 78<br>(58+6+15)    | 54<br>(44+5+5) | 69<br>(50+5+14)    | 72<br>(30+20+6+16) | 71<br>(5+44+22)      | 48<br>(34+14)    | 48       | 11,7      | 17,8  |    |
| 12        | 2 750   | 62<br>(5+57)       | 19             | 62                 | 28                 | 68                   | 35               | 35       | 20,8      | 45,6  |    |
| 13        | 3 000   | 71<br>(16+55)      | 30             | 65<br>(20+45)      | 43                 | 85                   | 28               | 28       | 23,4      | 43,6  |    |
| 14        | 3 250   | 96                 | 12             | 90                 | 65                 | 94                   | 26               | 26       | 36,7      | 57,6  |    |
| 15        | 3 500   | 147                | 19             | 146                | 60                 | 150                  | 12               | 12       | 66,3      | 74,5  |    |
| 16        | 3 750   | 176                | 16             | 164                | 135                | 156                  | 17               | 17       | 74,2      | 67,0  |    |
| 17        | 4 000   | 164                | 115            | 144                | 130                | 150                  | 59               | 59       | 37,3      | 29,4  |    |
| 18        | 4 250 (month)   | 0                  | 8              | 0                  | 10                 | 0                    | 12               | 12       | 5,6       | 112,4 |    |
| $\bar{x}$ |   | 55,1               | 21,1           | 53,0               | 36,3               | 56,2                 | 20,5             | 20,5     | 40,4      |       |    |
| s         |   | 59,0               | 26,7           | 56,2               | 41,8               | 58,4                 | 19,9             | 19,9     |           |       |    |
| V%        |   | 107,1              | 127,0          | 106,1              | 115,2              | 103,9                | 96,8             | 96,8     |           |       |    |

## LATERAL STABILITY

TABLE NS45 IX

| Station   | Approx. distance along 1974 R. course from old S. coast Rd. Br. (m) | Distance from maximum observed L.B. position to mid-river (m) |          |          |          |          |          |       |       | Max - Min | $\bar{x}$ | s    | V%   |
|-----------|---|---|----------|----------|----------|----------|----------|-------|-------|-----------|-----------|------|------|
|           |   | Date  |          |          |          |          |          |       |       |           |           |      |      |
|           |   | 30.04.37  | 06.06.59 | 17.06.67 | 18.04.74 | 02.08.83 | 06.02.84 |       |       |           |           |      |      |
| 1         | 0   | 2   | 2        | 2        | 2        | 2        | 2        | 2     | 2     | 0         | 2         | 0    | 0    |
| 2         | 250   | 2   | 2        | 2        | 2        | 2        | 2        | 2     | 2     | 0         | 2         | 0    | 0    |
| 3         | 500   | 2   | 2        | 2        | 2        | 2        | 2        | 2     | 2     | 0         | 2         | 0    | 0    |
| 4         | 750   | 2   | 2        | 2        | 2        | 2        | 2        | 2     | 2     | 0         | 2         | 0    | 0    |
| 5         | 1 000   | 3   | 3        | 3        | 3        | 3        | 3        | 3     | 3     | 0         | 3         | 0    | 0    |
| 6         | 1 250   | 5   | 5        | 5        | 5        | 5        | 5        | 5     | 5     | 0         | 5         | 0    | 0    |
| 7         | 1 500   | 5   | 5        | 4        | 6        | 4        | 6        | 4     | 9     | 5         | 5,5       | 1,9  | 34,0 |
| 8         | 1 750   | 16  | 26       | 25       | 12       | 16       | 12       | 16    | 11    | 15        | 17,7      | 6,4  | 36,3 |
| 9         | 2 000   | 22  | 25       | 20       | 26       | 18       | 26       | 18    | 30    | 12        | 23,5      | 4,4  | 18,6 |
| 10        | 2 250   | 169,2   | 159,2    | 113,6    | 187,6    | 182,3    | 187,6    | 182,3 | 244,7 | 131,1     | 176,1     | 42,7 | 24,2 |
| 11        | 2 500   | 97,7  | 56,7     | 98,6     | 112,1    | 212,7    | 112,1    | 212,7 | 215   | 158,3     | 132,1     | 66,0 | 49,9 |
| 12        | 2 750   | 46,8  | 65       | 45       | 65       | 50       | 65       | 50    | 64    | 20        | 56,0      | 9,7  | 17,3 |
| 13        | 3 000   | 48,3  | 70       | 41,2     | 70       | 47       | 70       | 47    | 70    | 28,8      | 57,8      | 13,6 | 23,6 |
| 14        | 3 250   | 48  | 66       | 45       | 60       | 47       | 60       | 47    | 66    | 21        | 55,3      | 9,8  | 17,7 |
| 15        | 3 500   | 80  | 105      | 73       | 112      | 75       | 112      | 75    | 102   | 32        | 91,2      | 17,1 | 18,7 |
| 16        | 3 750   | 88  | 85       | 90       | 72       | 92       | 72       | 92    | 93    | 21        | 86,7      | 7,7  | 8,9  |
| 17        | 4 000   | 82  | 90       | 90       | 87       | 90       | 87       | 90    | 65    | 25        | 84,0      | 9,8  | 11,7 |
| 18        | 4 250 (contin)  | N.R.  | 4        | N.R.     | 5        | N.R.     | 5        | N.R.  | 6     | 2         | 5,0       | 1,0  | 20,0 |
| $\bar{x}$ |   | 42,3  | 43,0     | 38,9     | 46,2     | 50,0     | 46,2     | 50,0  | 55,1  | 26,2      | 44,8      |      | 15,6 |
| s         |   | 47,6  | 46,4     | 39,7     | 53,3     | 64,1     | 53,3     | 64,1  | 72,5  | 44,8      | 45,9      |      | 14,6 |
| V%        |   | 112,6   | 108,1    | 102,1    | 115,6    | 128,2    | 115,6    | 128,2 | 131,5 | 170,9     |           |      | 93,9 |

Average lateral displacement 1937-1984 = 26,2 m  
 Average coefficient of variation 1937-1984 = 15,6%

TABLE NS 45/X SIMULATED RUN-OFF FOR UMGARABA CATCHMENT AREA= 37,050 KM. TOTAL RM.A.

| YEAR | OCT    | NOV    | DEC    | JAN    | FEB    | MAR    | APR    | MAY   | JUN    | JUL    | AUG   | SEP   | TOTAL |
|------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|-------|-------|-------|
| 1921 | .14    | 1.44   | 4.10   | 1.46   | .25    | .19    | .14    | .13   | .16    | .15    | .15   | .15   | 8.47  |
| 1922 | .84    | 2.17   | .87    | .32    | 1.40   | .70    | .30    | .21   | .13    | .10    | .09   | .07   | 7.19  |
| 1923 | .06    | .07    | .13    | .25    | .48    | .37    | .26    | .24   | .18    | .11    | .09   | .11   | 2.34  |
| 1924 | .15    | .05    | .24    | 2.11   | 1.05   | 9.65   | 3.47   | .28   | .16    | .11    | .08   | .11   | 18.01 |
| 1925 | .22    | .26    | .24    | .24    | .20    | .31    | .28    | .17   | .14    | .13    | .09   | .10   | 2.35  |
| 1926 | .16    | .21    | .22    | .19    | .17    | 2.40   | 1.02   | .21   | .14    | .09    | .06   | .07   | 5.04  |
| 1927 | .13    | .12    | .15    | .35    | .44    | .37    | .24    | .16   | .11    | .07    | .05   | .07   | 2.32  |
| 1928 | .10    | .12    | .15    | .21    | .23    | .59    | .47    | .31   | .13    | 1.10   | .54   | .33   | 5.04  |
| 1929 | 1.04   | .82    | .91    | 2.00   | .83    | .26    | .19    | .10   | .13    | .08    | .08   | .10   | 6.55  |
| 1930 | .14    | .18    | .28    | 1.10   | .56    | .27    | .26    | .18   | .11    | .14    | .18   | .15   | 3.55  |
| 1931 | .13    | .13    | .17    | .24    | .34    | .42    | .35    | .27   | .21    | .15    | .11   | .08   | 2.60  |
| 1932 | .14    | .25    | .34    | .32    | .23    | .19    | .18    | .14   | .20    | .09    | .08   | .07   | 2.13  |
| 1933 | .07    | .18    | 1.58   | 2.88   | 1.07   | .36    | .61    | .45   | .26    | .24    | .24   | .19   | 8.12  |
| 1934 | .15    | .15    | .26    | .35    | .36    | .31    | .31    | .82   | 5.24   | 2.02   | .30   | .21   | 10.02 |
| 1935 | .16    | .12    | .07    | .09    | .89    | 1.21   | .53    | .82   | .25    | .25    | .16   | .13   | 4.94  |
| 1936 | .15    | 2.35   | 1.01   | .28    | .33    | .32    | .21    | .13   | .09    | .08    | .07   | .07   | 5.09  |
| 1937 | .08    | .10    | .20    | .34    | 1.61   | .72    | .29    | .28   | .20    | .17    | .12   | .12   | 4.28  |
| 1938 | .15    | .27    | .34    | .37    | 1.11   | 1.07   | .48    | .26   | .20    | .15    | .12   | .19   | 4.70  |
| 1939 | .28    | .31    | .41    | .35    | .26    | .22    | .19    | .71   | .52    | .30    | .18   | .12   | 3.85  |
| 1940 | .11    | .22    | .85    | .51    | .23    | .19    | .23    | .12   | .09    | .06    | .06   | .07   | 2.87  |
| 1941 | .09    | .13    | .16    | .25    | .37    | 1.34   | .72    | .39   | .29    | .19    | .16   | .17   | 4.26  |
| 1942 | .21    | .58    | 2.28   | .98    | .31    | .32    | 3.07   | 1.32  | .34    | .30    | .33   | .29   | 10.32 |
| 1943 | 1.11   | 2.47   | 1.49   | .49    | .29    | .32    | .28    | .18   | .12    | .11    | .08   | .12   | 7.07  |
| 1944 | .19    | .14    | .12    | .10    | .15    | 1.21   | .62    | .23   | .15    | .12    | .09   | .07   | 3.23  |
| 1945 | .08    | .09    | .09    | .15    | .23    | .31    | .32    | .24   | .15    | .10    | .07   | .07   | 1.89  |
| 1946 | .09    | .14    | .21    | .24    | 1.24   | 1.56   | .92    | .43   | .63    | .47    | .29   | .22   | 6.44  |
| 1947 | .18    | 1.26   | .91    | .68    | 1.17   | .65    | 2.09   | .90   | .20    | .12    | .07   | .06   | 8.30  |
| 1948 | .17    | .30    | .29    | .23    | .23    | .25    | .23    | .18   | .12    | .08    | .06   | .07   | 2.20  |
| 1949 | .13    | .64    | .51    | .36    | .37    | .35    | .24    | .17   | .13    | .10    | .11   | .12   | 3.28  |
| 1950 | .09    | .07    | .11    | .19    | .22    | .22    | .19    | .12   | .08    | .06    | .09   | .15   | 1.60  |
| 1951 | .20    | .17    | .15    | .27    | .32    | .27    | .30    | .28   | .20    | .14    | .10   | .08   | 2.47  |
| 1952 | .08    | .11    | .19    | .26    | .84    | .49    | .22    | .13   | .09    | .06    | .08   | .13   | 2.68  |
| 1953 | .19    | .22    | .32    | .41    | .40    | .33    | .25    | .21   | .19    | .15    | .12   | .14   | 2.93  |
| 1954 | 1.86   | .90    | .28    | 1.71   | .87    | .69    | .46    | .26   | .17    | .12    | .08   | .09   | 7.48  |
| 1955 | .13    | .18    | .22    | .16    | .21    | 3.38   | 1.40   | .29   | .15    | .12    | .12   | .17   | 6.57  |
| 1956 | .19    | .21    | 2.42   | 1.09   | .40    | 1.11   | 1.85   | .76   | .23    | .14    | .10   | .16   | 8.66  |
| 1957 | .28    | .30    | .27    | 1.35   | 4.16   | 1.54   | 2.31   | .98   | .22    | .14    | .09   | .09   | 11.72 |
| 1958 | .11    | .18    | .24    | .28    | .27    | .18    | .11    | 1.19  | .65    | .27    | .23   | .20   | 3.92  |
| 1959 | .20    | .23    | .22    | .17    | .18    | .24    | .28    | .23   | .14    | .09    | .07   | .07   | 2.11  |
| 1960 | .11    | .20    | 1.00   | 1.44   | .61    | .31    | 3.12   | 1.29  | .32    | .27    | .20   | .17   | 9.03  |
| 1961 | .18    | .14    | .18    | .21    | .23    | .55    | .42    | .24   | .15    | .09    | .09   | .09   | 2.62  |
| 1962 | .10    | .24    | .33    | 1.11   | .57    | .33    | .32    | .21   | .13    | .21    | .25   | .17   | 3.96  |
| 1963 | .16    | .17    | .19    | .45    | .36    | .22    | .14    | .04   | .10    | .10    | .08   | .08   | 2.24  |
| 1964 | .23    | .34    | .31    | .29    | .27    | .18    | .10    | .04   | .20    | .29    | .30   | .28   | 2.87  |
| 1965 | .31    | .34    | .37    | 1.69   | .40    | .23    | .13    | .14   | .18    | .16    | .14   | .12   | 4.65  |
| 1966 | .10    | .12    | .15    | .29    | .29    | 1.58   | 1.86   | .14   | .20    | .14    | .10   | .07   | 5.51  |
| 1967 | .09    | .22    | .27    | 1.35   | .70    | .38    | .35    | .23   | .13    | .09    | .10   | .15   | 4.06  |
| 1968 | .16    | .15    | .13    | .10    | .09    | .18    | .28    | .54   | .40    | .24    | .18   | .18   | 2.64  |
| 1969 | .30    | .46    | .42    | .31    | .20    | .12    | .07    | .08   | .12    | .13    | .14   | .20   | 2.55  |
| 1970 | .34    | .41    | .37    | .30    | .25    | .30    | .34    | .68   | .45    | .27    | .34   | .38   | 4.43  |
| 1971 | .32    | .20    | .21    | .31    | .31    | .31    | .22    | .16   | .15    | .15    | .13   | .09   | 2.49  |
| 1972 | .08    | .10    | .13    | .17    | .22    | .21    | .22    | .19   | .12    | .08    | .09   | .16   | 1.78  |
| 1973 | .21    | .27    | .26    | .67    | .67    | .43    | .31    | .23   | .17    | .14    | .10   | .07   | 3.53  |
| 1974 | .06    | .08    | .14    | .28    | 1.71   | .79    | .30    | .24   | .15    | .09    | .06   | .12   | 4.02  |
| 1975 | .17    | .15    | .40    | .40    | .59    | 5.85   | 2.42   | .44   | .24    | .16    | .15   | .16   | 10.93 |
| MEAN | .23    | .40    | .51    | .59    | .58    | .85    | .66    | .36   | .31    | .20    | .14   | .14   | 4.98  |
| S    | .31    | .54    | .70    | .61    | .63    | 1.53   | .84    | .31   | .70    | .29    | .09   | .07   | 3.15  |
| V8   | 130.44 | 136.83 | 134.18 | 103.95 | 108.12 | 179.09 | 127.04 | 86.85 | 224.22 | 145.69 | 66.17 | 52.70 | 63.18 |

4.98 MILLION CURIC METRES, COMPILED FROM HBU REPORT NO. 9/41 DATA

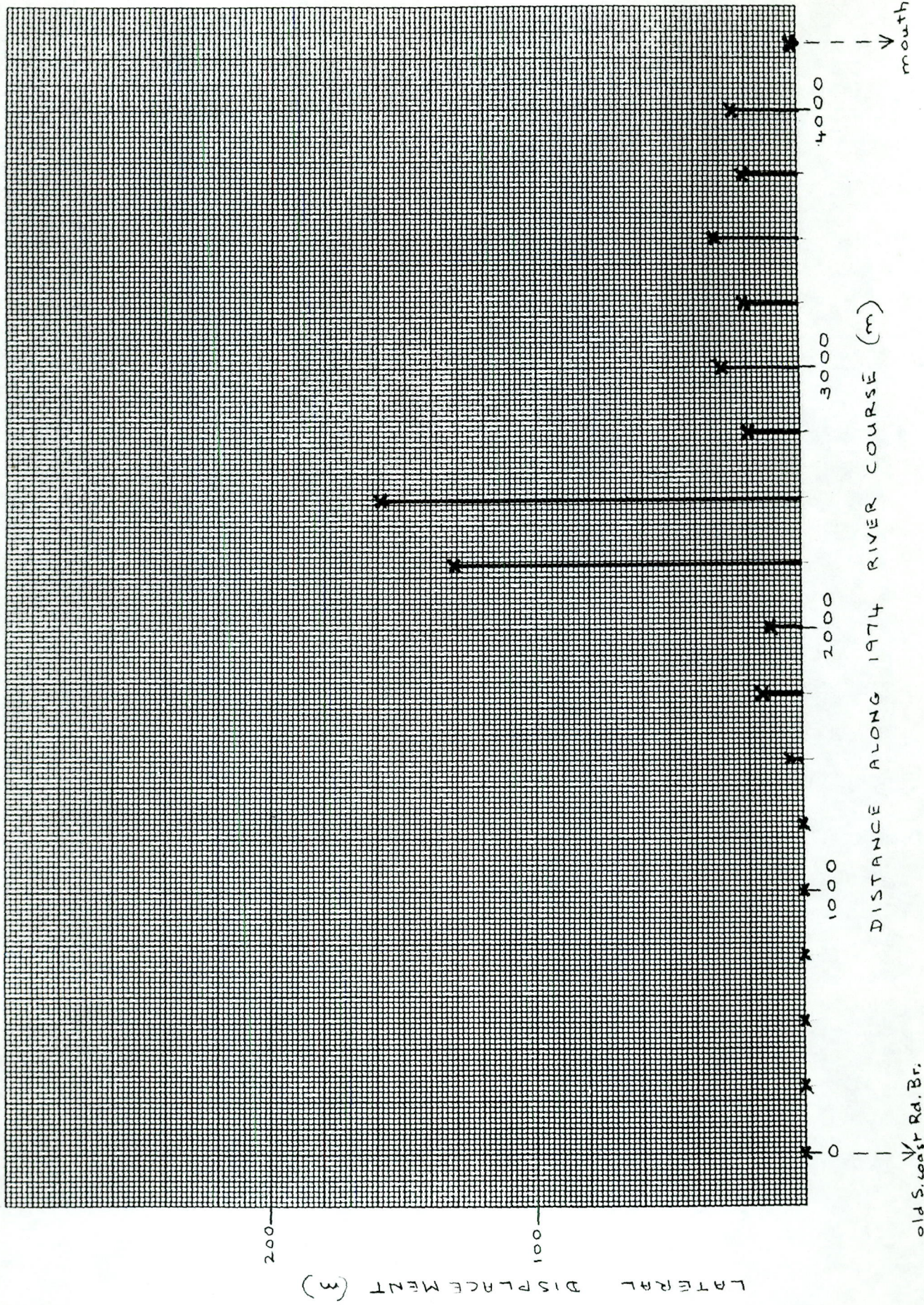
## RIVER MOUTH CONDITION

No. of days open/closed (O/C)

|           | 77/78 |      | 78/79 |     | 79/80 |     | 80/81 |     | 81/82 |     | 82/83 |     | 83/84 |     | % mo |    |
|-----------|-------|------|-------|-----|-------|-----|-------|-----|-------|-----|-------|-----|-------|-----|------|----|
|           | O     | C    | O     | C   | O     | C   | O     | C   | O     | C   | O     | C   | O     | C   | O    | C  |
| October   |       |      | 10    | 21  | 7     | 24  | 0     | 31  | 2     | 29  | 0     | 31  | 7*    | 24  | 14   | 86 |
| November  |       |      | 25    | 5   | 1     | 29  | 0     | 30  | 7     | 23  | 0     | 30  | 21    | 9   | 30   | 70 |
| December  |       |      | 21    | 10  | 0     | 31  | 0     | 31  | 23    | 8   | 0     | 31  | 29    | 2   | 39   | 61 |
| January   |       |      | 0     | 31  | 2     | 29  | 5     | 26  | 31    | 0   | 0     | 31  | 29    | 2   | 36   | 64 |
| February  |       |      | 0     | 28  | 0     | 29  | 27    | 1   | 4     | 24  | 0     | 28  | 29    | 0   | 35   | 65 |
| March     |       |      | 0     | 31  | 0     | 31  | 3     | 28  | 0     | 31  | 0     | 31  | 29    | 2   | 17   | 83 |
| April     |       |      | 0     | 30  | 0     | 30  | 0     | 30  | 0     | 30  | 0     | 30  | 21    | 9   | 12   | 88 |
| May       | 31    | 0    | 0     | 31  | 0     | 31  | 12    | 19  | 0     | 31  | 0     | 31  |       |     | 23   | 77 |
| June      | 4     | 26   | 0     | 30  | 0     | 30  | 6*    | 24  | 0     | 30  | 0     | 30  |       |     | 6    | 94 |
| July      | 0     | 31   | 0     | 31  | 0     | 31  | 0     | 31  | 4*    | 27  | 0     | 31  |       |     | 2    | 98 |
| August    | 0     | 31   | 11*   | 20  | 0     | 31  | 9     | 22  | 13*   | 18  | 0     | 31  |       |     | 18   | 82 |
| September | 11    | 19   | 0     | 30  | 0     | 30  | 18    | 12  | 3     | 27  | 0     | 30  |       |     | 18   | 82 |
|           | (46   | 107) | 67    | 298 | 10    | 356 | 80    | 285 | 87    | 278 | 0     | 365 | (165  | 48) |      |    |
| % year    | N.R.  |      | 18    | 82  | 3     | 97  | 22    | 78  | 24    | 76  | 0     | 100 | N.R.  |     |      |    |

\* mouth opened artificially.

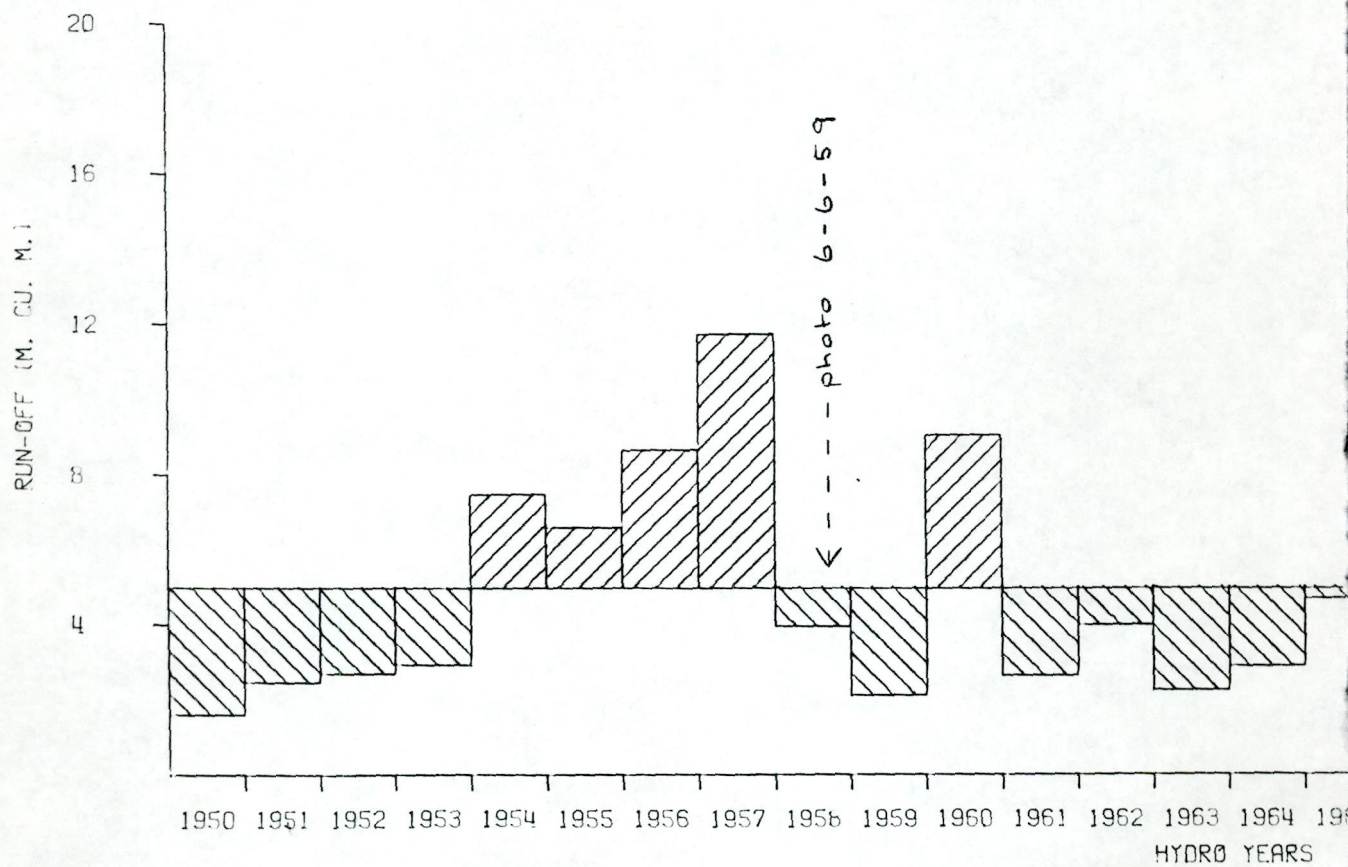
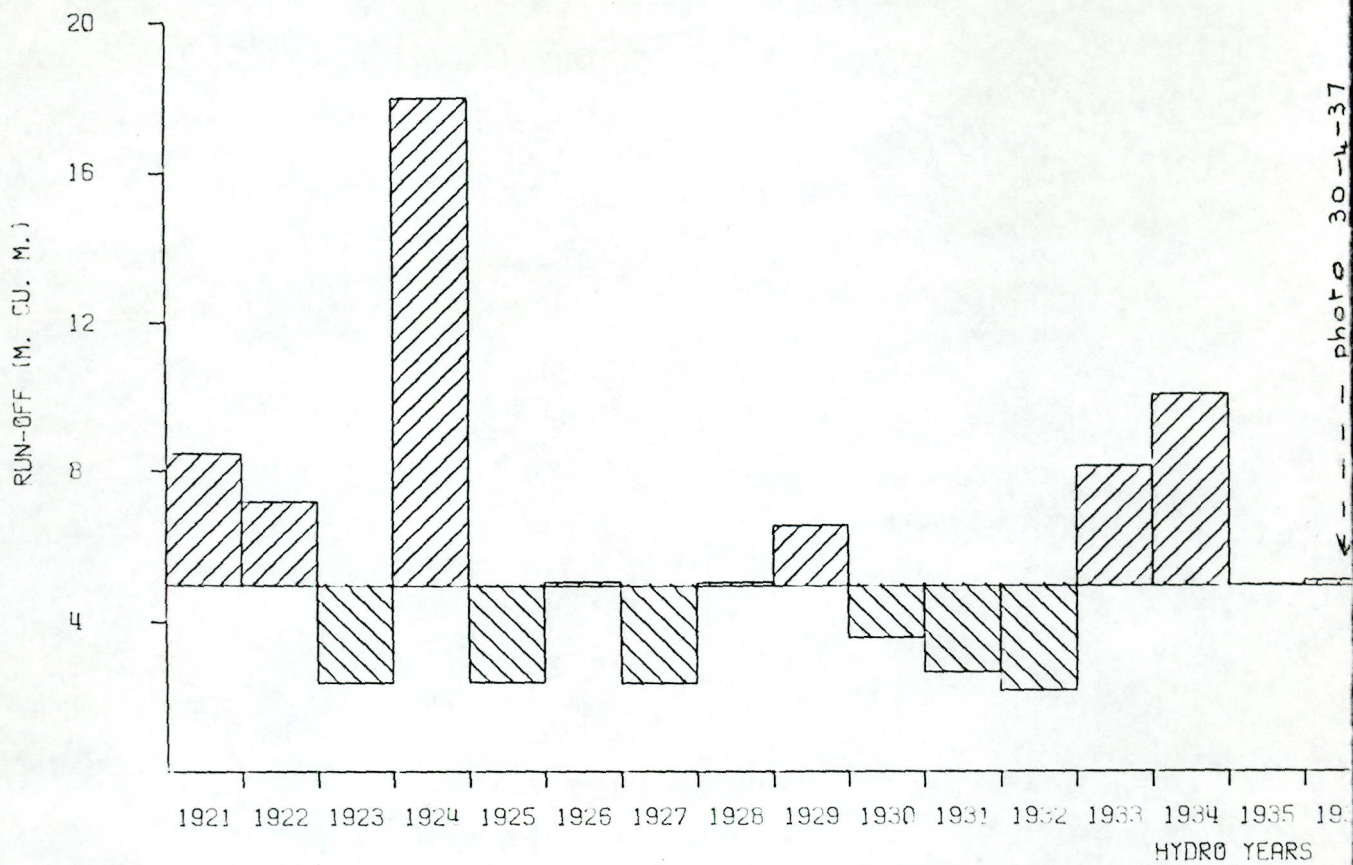
Mouth closed 79% of time from May 1978 - April 1984.



TRACED  
 CHECKED  
 DATE  
 REF

NATAL ESTUARIES: UMGABABA  
**THALWEG DISPLACEMENT**  
 (1937-1984)

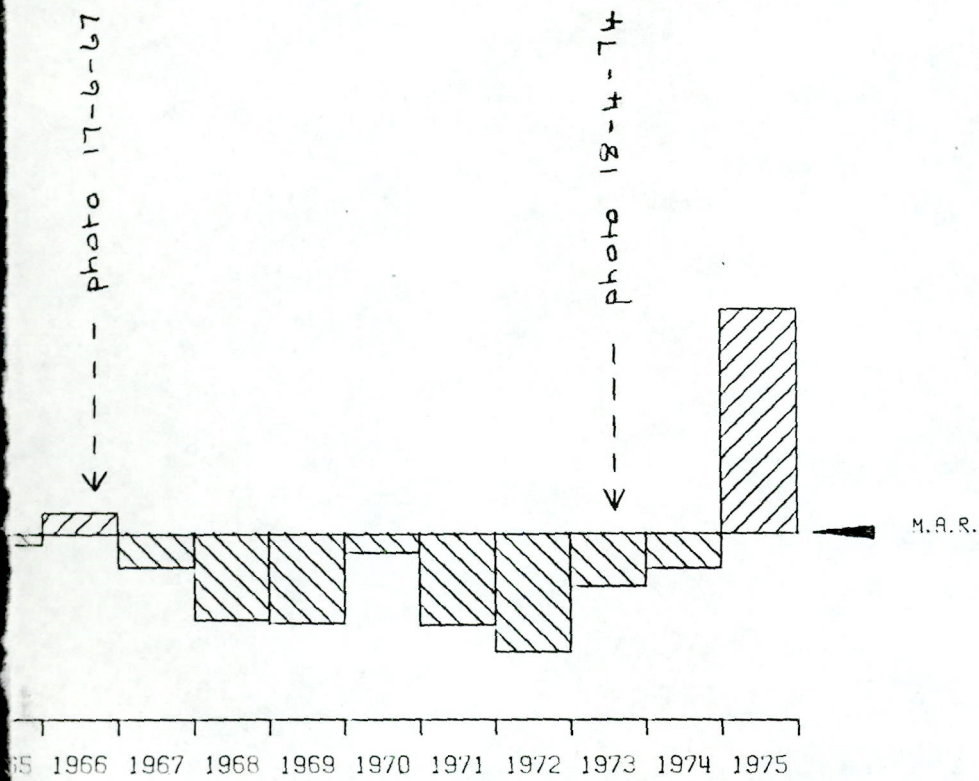
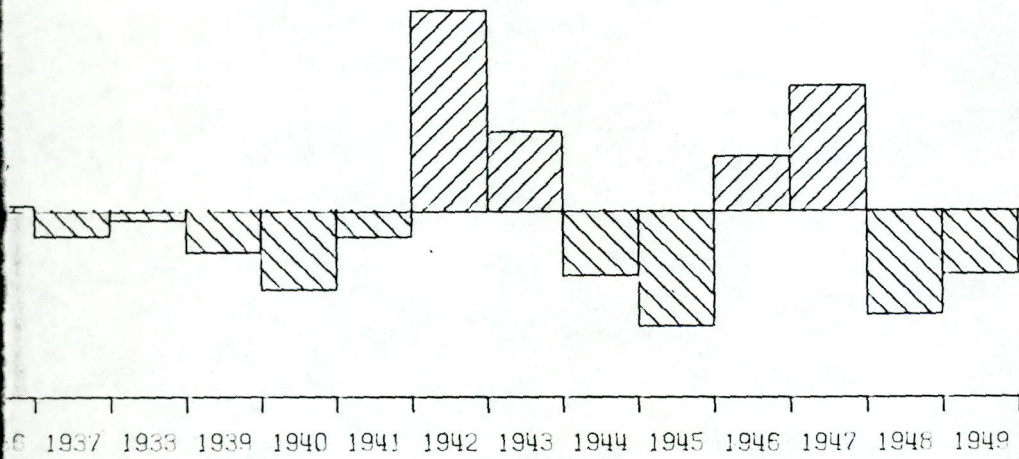
FIGURE  
 NS 45/1

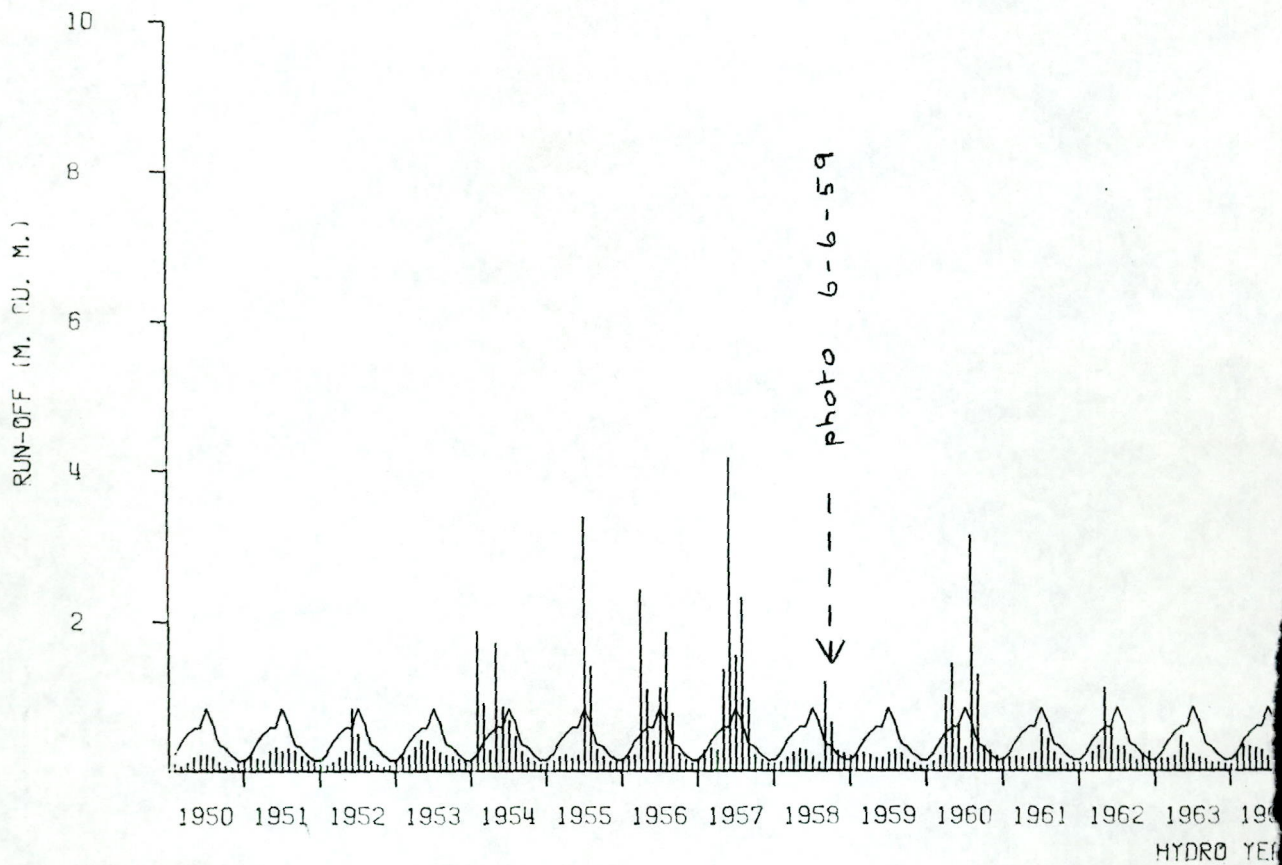
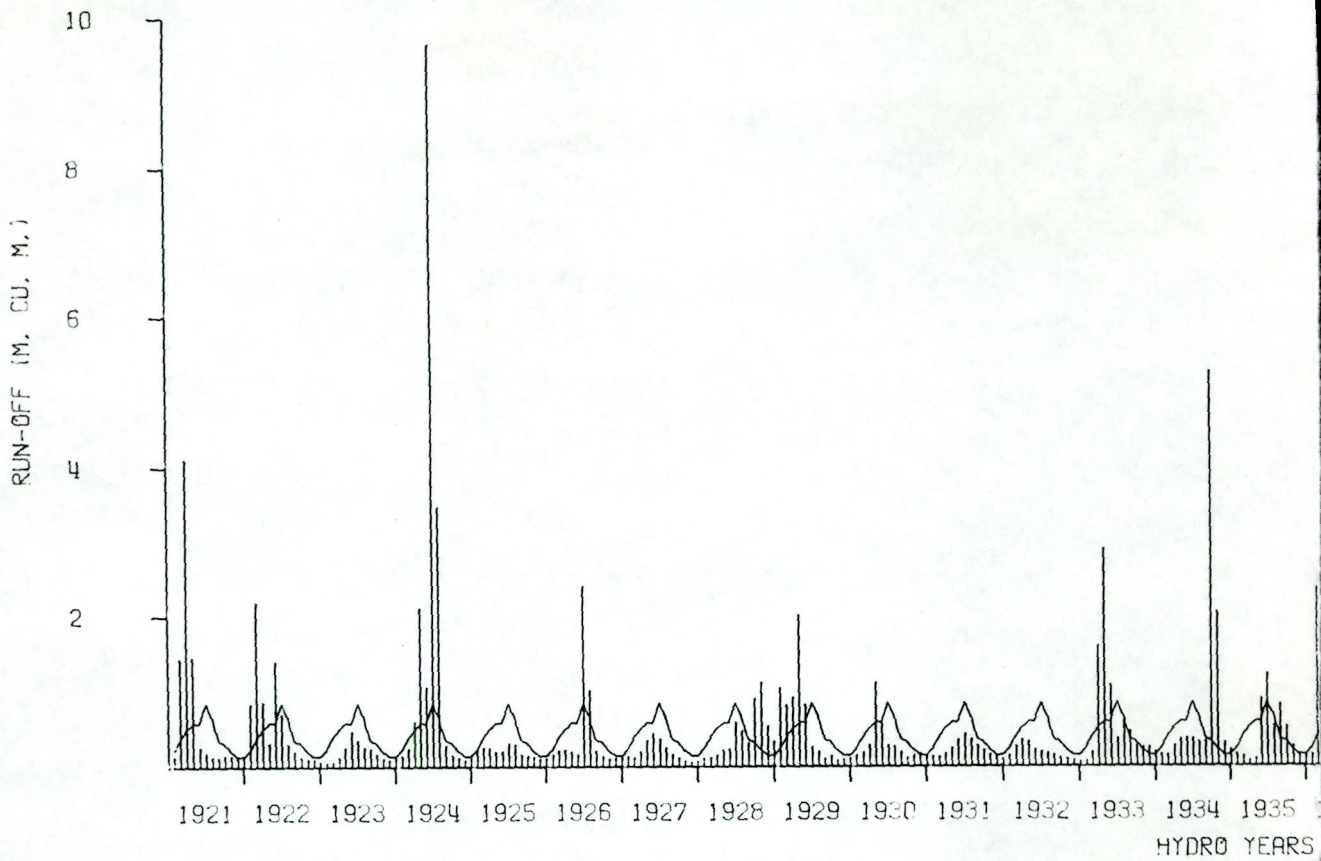


TRACED : COMPILOT  
 CHECKED:  
 DATE :  
 REF. :

NATAL ESTUARIES : UMGABABA  
 SIMULATED ANNUAL RUN-OFF  
 1921-1975

FIGURE  
 NS 45/2





TRACED : COMPILOT  
 CHECKED :  
 DATE :  
 REF. :

NATAL ESTUARIES : UMGABABA  
 SIMULATED MONTHLY RUN-OFF  
 1921-1975

FIGURE  
 NS 45/3

photo 30-4-37

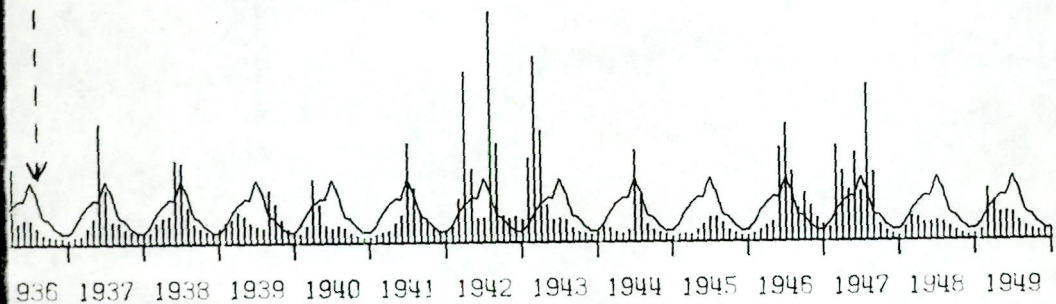
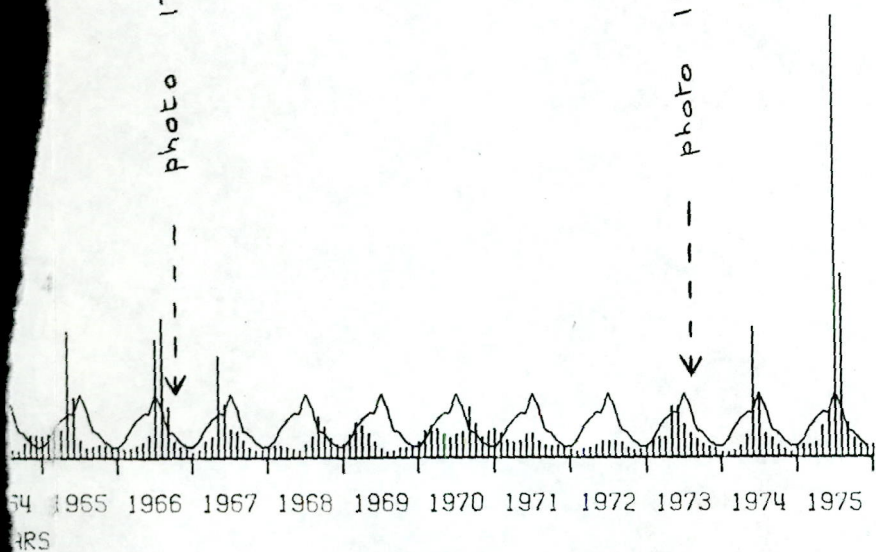
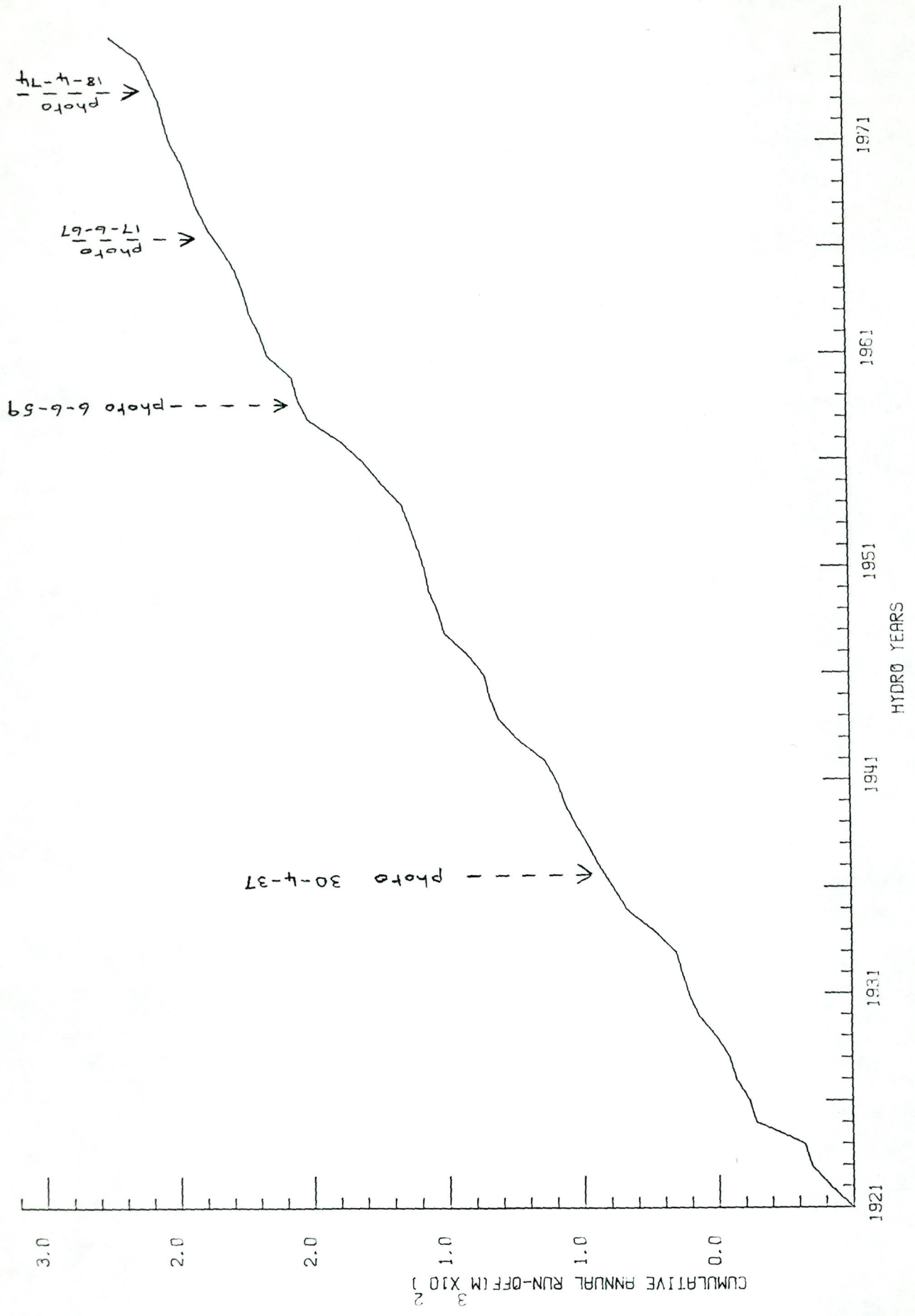


photo 17-6-67

photo 18-4-74



MONTHLY MEANS



TRACED : COMPLETE  
 CHECKED :  
 DATE :  
 REF :

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

FIGURE  
**NS 45/4**



head of reach →

SCALE: 1:10 000 approx.

TRACED :  
CHECKED :  
DATE :  
REF :

NATAL ESTUARIES : uMGABABA  
6-2-84  
(30-4-37 RIVER COURSE SUPERIMPOSED)

PHOTOGRAPH  
NS 45/1

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



SCALE: 1:10 000 approx.

TRACED :  
CHECKED :  
DATE :  
REF. :

NATAL ESTUARIES : uMGABABA

30-4-37 (12 h 36)

PHOTOGRAPH  
NS 45/2

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



SCALE: 1:10 000 approx.

TRACED :  
CHECKED:  
DATE:  
REF.:

NATAL ESTUARIES: UMGABABA

6-6-59 (12 h 57)

PHOTOGRAPH  
NS 45/3

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



SCALE: 1:10 000 approx.

TRACED:  
CHECKED:  
DATE:  
REF.:

NATAL ESTUARIES: uMGABABA

17-6-67 (11h 20)

PHOTOGRAPH

NS 45/4

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



SCALE: 1:10 000 approx.

TRACED :  
CHECKED :  
DATE :  
REF. :

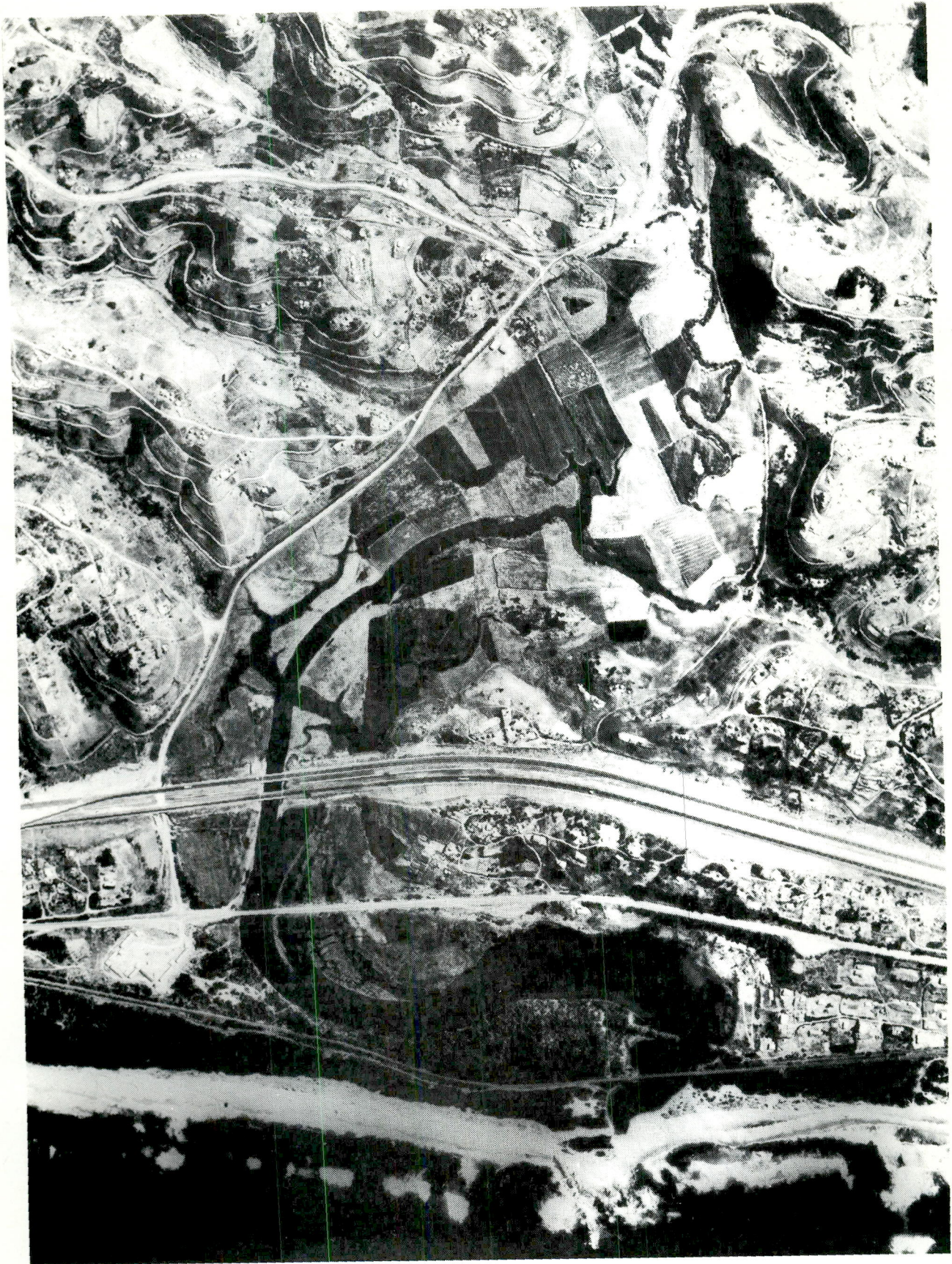
NATAL ESTUARIES : uMGABABA

18-4-74 (10h34)

PHOTOGRAPH

NS 45/5

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



SCALE: 1:10 000 approx.

TRACED :  
CHECKED :  
DATE :  
REF. :

NATAL ESTUARIES: uMGABABA

2-8-83 (12h 36)

PHOTOGRAPH  
NS 45/6

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



SCALE: 1:10 000 approx.

TRACED:  
CHECKED:  
DATE:  
REF.:

NATAL ESTUARIES: uMGABABA

6-2-84 (15 h 52)

PHOTOGRAPH  
NS 45/7

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



SCALE: 1:10 000 approx.

TRACED:  
CHECKED:  
DATE:  
REF.:

NATAL ESTUARIES: uMGABABA

18-4-74 (ORTHOPHOTO)

PHOTOGRAPH  
NS 45/8

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY