



CONFIDENTIAL

**HYDROLOGICAL/HYDRAULIC STUDY
OF NATAL ESTUARIES
DATA REPORT NO. 25
FAFA NS34**

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

NRIO DATA REPORT D8702

Stellenbosch, South Africa
March 1987

NS 34

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Basic diapositives and orthophoto maps for this study were obtained from the Chief Director, Surveys and Mapping, Mowbray.

The oblique colour aerial photograph inside the back cover was taken by F. Junor, Natal Parks Board, on 16 February 1985.

- NS34/1 23-06-76 (orthophoto)
- NS34/2 30-04-37 (12h20)
- NS34/3 June/July 1955
- NS34/4 06-06-59 (13h05)
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- NS34/9 02-08-83 (30-04-37 river course superimposed)
- NS34/10 Orthophoto (envelope of mobility, lines of measurement and lateral shift superimposed)
- NS34/11 16-02-85 (oblique photograph of the lower reach after breaching of the sand bar)

BRIEF NOTESFAFA NS34Location

The Fafa River discharges into the Indian Ocean on the Natal south coast at 30°27'S, 30°39'20"E. The head of the reach under review is the freeway bridge, 3,75 km from the mouth (Photograph NS34/1).

Hydro Data

The M.A.R. from the catchment area of 231 km² is $24,17 \times 10^6 \text{ m}^3$. The mean annual precipitation is 920 mm, which gives an average run-off/precipitation ratio of 11,4 per cent. Of particular interest to this study is the erratic nature of the run-off. This is quantified by the high coefficients of variation for monthly run-off (Table NS34/XI), ranging from 55,28 to 230,7 per cent ($\bar{V}\% = 149,3$) and by the wide spectrum of annual and monthly run-off, shown in Figures NS34/2 and 3. Figure NS34/4 shows the trends in the annual run-off for the period 1921-1975. The afore-mentioned tables and figures are based upon simulated run-off data for Tertiary catchments (Middleton et al., 1981).

The Fafa River is subject to frequent high monthly run-offs: major flood flows occurred in March 1925, June 1935, November 1949 and March and April 1976. Numerous lesser flood flows have occurred, those near the dates of the time slices under review having occurred in November 1936, October 1954, May 1959 and March 1963 (Figure NS34/3).

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 seven relevant photographs

- 1) 1937; Well below-average run-off. Recent run-off well above average within a wet phase generally. Flood flows five months previous.

- 2) 1955; Well below-average run-off. Recent run-off above average but following a dry phase overall. Flood flows six months previous.
- 3) 1959; Well above-average run-off. Recent run-off well above average, following a wet phase generally. Flood flows one month previous.
- 4) 1963; Below-average run-off. Recent run-off above average, following a dry phase. Flood flows two months prior.
- 5) 1967; Below-average run-off. Recent run-off below average, following approximately average conditions. Within a dry phase generally. No recent flood flows.
- 6) 1976; Above-average run-off. Recent run-off very high, following a dry phase generally. Major flood flows two and three months previously.
- 7) 1983; Well below-average run-off. Recent run-off well below average, following a long, dry phase. No recent flood flows.

N.B. Simulated run-off data are not available beyond hydro-year 1975. Therefore, the comments regarding the 1983 time slice are based upon local ground knowledge.

River Course

The course of the Fafa River for the reach under review is largely geomorphologically controlled. This is particularly the case in the lower and middle reaches, owing to the steep sides on the right bank in the lower reach and to a precipitous stretch on the left bank in the middle reach. The course of the river, which has a pronounced Z-shape, is therefore well entrenched, and consequently the flood plain is extremely narrow.

From a broad expanse of water near the mouth, the river narrows fairly uniformly along the extent of the reach. Beyond the second bend, the river is quite narrow and no longer occupies the greater part of the flood plain area.

Land use

Agriculture

The flood plain of the Fafa River is of limited extent and thus not conducive to agriculture. However, considerable portions of the valley sides, as well as the terrain above, have been under cultivation, mainly sugar cane, at different times. In the early seventies the cane fields on the left valley side in the lower part of the reach were replaced by gum plantations.

Structures

The first railway bridge was built across the river in approximately 1900. It ran diagonally from the mouth on the right bank to a point approximately 300 m up the left bank. It was destroyed in the 1959 floods, although the piers remained until 1976. In 1960, a new railway bridge was built straight across the mouth (Begg, 1984), involving stabilization of the sand bar on the left bank. A weir was constructed in 1967 between two piers of the railway bridge towards the right bank (Begg, 1984). The freeway bridge at the head of the reach was under construction in 1976.

Urbanization

Urbanization along the Fafa River and the terrain above was minimal until the 1970's, comprising scattered settlement associated with farming and some residential development at the river mouth.

In the 1970's the development of the Ifafa Marina commenced. It now occupies the greater portion of the right valley side in the middle and upper reaches. The natural vegetation and sugar cane fields have largely been replaced by a luxury caravan park, with terraced sites for caravans as well as roads and other facilities.

River Mouth

The mouth of the Fafa River is generally blocked by a sand bar which is usually only breached during major floods. After such events, the mouth closes from the north with the growth of the sand spit in a southerly direction, as may be seen in Photograph NS34/3. Further southward migration of the mouth is curtailed by rocks on the right bank.

The river mouth area has been subject to considerable human interference. The first railway bridge near the mouth resulted in the river being slightly confined, as well as slightly obstructed due to the piers. The second bridge, built in 1960, affects the river mouth more markedly in that it is constricted as a result of stabilization of the sand bar over a distance of approximately 100 m on the left bank.

When the bar is breached, the water levels in the lagoon drop virtually to sea level, leaving the lagoon practically empty (Photograph NS34/11). This is the only time that there is significant tidal exchange, although minor exchanges do occur due to washover from the sea and movement of sea water through the sand bar, especially at high tide and with low lagoon levels (Begg, 1976). Emptying of the lagoon is considered to be most undesirable from a recreational point of view. On the other hand, when the mouth is closed the water level behind the sand bar sometimes rises to the extent that low-lying developments are threatened with flooding.

These problems related to maintaining water levels have resulted in a considerable amount of artificial manipulation of the mouth. This is done as follows:

- By artificial breaching of the sand bar, to prevent inundation of low-lying developments (Begg, 1978).
- By artificially increasing the height of the sand bar by the construction of sand bunds. This is done to maintain the water level of the lagoon for recreational purposes.
- By the construction of a weir to facilitate control of the water level of the lagoon and particularly to prevent water levels rising behind the bar and thereby to reduce the possibility of breaching. The weir does not, however, prevent breaching of the bar during major floods. Nevertheless, by maintaining an artificially low water level, higher flood flows are required to breach the bar. It is probable, therefore, that fewer breaches occur now than would occur under natural conditions.

No records of the status of the mouth are available but, according to Begg (pers. comm.), the mouth is closed 96 per cent of the year. The physical characteristics of the Fafa River in fact suggest that the river should have a more estuarine character than it actually displays. The high closure rate thus probably reflects the artificial conditions prevailing, and a higher incidence of opening could be expected under natural conditions. (It may be noted that in two of the seven time slices selected, the mouth is open. As the photographs are generally taken at more or less the same time of year (in this case, between the end of April and the beginning of August), or immediately after flooding, these are not representative of the average status of the mouth. Also, in the 1976 time slice, the 'open mouth' is actually overflow from the weir, and therefore not representative of natural conditions).

Siltation

From a sediment production map of South Africa (Rooseboom, 1975) a sediment yield of 88 150 tons per year is derived for the Fafa River catchment. This represents a rate of 382 tons/km^2 , which, although high, is slightly below average for Natal rivers. *

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

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

- (a) Changes in areas of siltation over time

Photographs NS34/2-8 show changes in the river course from 1937-1983. Areal measurements of the flood plain quantify these changes and the results may be seen in the Abstract (Table NS34/I). It should be noted that changes in the composition of the flood plain through time are not only the result of long-term changes, but are also a reflection of difference in stage i.e. differing water levels owing to differing mouth conditions (open or closed), as well as current and antecedent run-off conditions. This is particularly applicable in the case of the Fafa River as the differences observed do appear to be largely a function of stage. For example, when the mouth is open the lagoon drains almost completely (Photograph NS34/11).

The change in siltation over time is quantified through comparison of siltation areas over time. For the purposes of comparison, the siltation area present in the 1937 photograph is taken as the baseline 'recent' siltation area. This comprises fluvial sand and silt, as well as swamp areas and constitutes eight per cent of the flood plain. This 'recent' siltation area is then compared with siltation areas occurring in each of the later time slices, also taking into account the changes in vegetated,

cultivated and built-up areas (eg. bridge embankments) which have occurred at the expense of the 1937 baseline 'recent' siltation areas.

In the case of the Fafa River, virtually the entire lengths of both banks are densely vegetated with fresh-water mangroves, forming a fringe of variable width (2-40 m, according to Begg, 1978). This swamp vegetation merges into coastal forest and the two are generally not distinguishable on the aerial photographs which means that an arbitrary demarcation line has had to be used to separate areas of siltation from those of coastal forest.

The recent areas of siltation, with open water areas given below, may be summarized as percentages of the flood plain area as follows:

	<u>1937</u>	<u>1955</u>	<u>1959</u>	<u>1963</u>	<u>1967</u>	<u>1976</u>	<u>1983</u>
Recent siltation	8	16	12	7	8	11	10
Open water	59	46	53	59	58	59	58

These figures again clearly reflect the effect of stage on changes in siltation and lagoon size.

Quantitatively, little significant long-term change in siltation area is evident. Nevertheless, the changes that are evident, although comparatively small, are of importance by virtue of their nature. For example, an increase in siltation area is noticeable at the mouth, particularly on the left bank. This area is now well covered with swamp vegetation, indicating the increasingly permanent nature of the siltation here.

Further, in the upper reach just downstream of the freeway bridge, small but significant spatial changes are observed. These are associated with the downstream progression of the sub-aerial delta, which is discussed more fully in (b) below.

Effectively, from the 1976 time slice onwards, the river in this vicinity changes from that of a narrow but bankfull channel, bordered by dense swamp vegetation, to a channel with less clearly defined banks, sand bars with developing vegetation, a poorly defined river course and altered and/or reduced bank vegetation. A 600 m stretch of the reach below the bridge was affected in this way by July 1985, according to a colour aerial photograph (not shown) taken at that time.

(b) Aggradation/degradation over time

Successive cross-sections at the same site are not available for the Fafa River and the aggradation can therefore not be quantified.

In 1973, according to the site plan for the freeway bridge, the water level at the bridge site was 3 m above MSL. A borehole drilled in the river bed showed that sand level was 2,7 m above MSL and bed rock 0,96 m above MSL. A bed level gradient of 1:1 360 over the last 3,75 km is thus indicated at that time.

Orme (1974) gives a gradient of 2,1 m/km (1:476) over the last seven kilometres.

In comparison with the overall rather steep river gradient of 1:72 the above values are low and demonstrate the rapid checking of the river upon approaching the mouth, and the attendant decrease in load-carrying capacity of the river.

Although changes cannot be assessed from aerial photographs directly, some features may be inferred. As mentioned previously, there are signs of aggradation in the reach, associated with the downstream progression of the subaerial delta. The progression of this delta since 1937 is distinguishable in the photographs, moving from approximately 60 m upstream of the freeway bridge (i.e. beyond the head of reach) in 1937 to approximately 80 m below the bridge by 1967. By 1976 the subaerial delta

extended approximately 200 m below the head of reach, and by 1983 to approximately 400 m, which corresponds with the 200 m loss of lagoon during this period noted by Begg (1984). By July 1985, the delta had extended by another 200 m. Thus the lagoon size, and thus the estuarine limit of the river (i.e. that point at which river water becomes impounded through direct or indirect action by the sea, as defined for describing the estuarine extent of Natal lagoons by Begg, 1976), relative to the extent of the reach under review, has decreased from +102 per cent prior to 1963, to 98, 95, 88 and 83 per cent in 1967, 1976, 1983 and 1985 respectively.

+102 → +83% in 20 yrs

The indications are that this loss of lagoon size through siltation will continue. The situation may be being aggravated by human influences such as the artificial manipulation of the mouth, as discussed previously, as well as the increased silt supply due to the extensive sugar cane cultivation in the catchment area. This could have important implications, particularly in view of the location of the Ifafa Marina and its dependence on an adequate body of water for recreational purposes.

Lateral Stability

For easy visual reference, an envelope of mobility, the lines of measurement and the lateral shift are superimposed on the orthophoto (Photograph NS34/10).

The geomorphological constraints on the Fafa River are reflected in the lateral stability of the river. The mostly confined nature of the river does not lend itself to substantial changes in river course. The reaction of the river to hydrological changes is mainly seen in the presence or absence of sand bars. These sand bars are fairly regular features of the system, occurring mostly in the same places, again in reaction to the confined nature of the system, and subject to flushing out during successive flood flows.

The lateral displacement as measured from the head of the reach to the mouth (Figure NS34/1) is fairly irregular and reflects the constraints on the system. For example, lateral displacement at the bends of the river is particularly low, whereas at some stations between, it is substantially higher. The latter can be chiefly attributed to the irregular appearance of sand bars at these points. The average lateral shift of 16,7 m, with a coefficient of variation of 18,1 per cent is relatively low, indicating only slightly unstable conditions.

The sinuosity of the whole reach remains fairly constant for the period under review, with an average of 1,46. The width of the river varies according to stage, with, for example, the particularly low average river width in the 1955 time slice (a low flow stage) being due mainly to the extensive sand bars in the lower half of the reach. The average river width is 84,4 m. No long-term changes are evident.

Over the period of the review, the balance between accumulation and flushing out of siltation has largely been maintained. There is nevertheless evidence to suggest that the siltation is increasing. The system has an inherently high sediment production rate which is further pressurized by extensive agricultural activity in the catchment area. Nevertheless, the dense mangal fringe along the banks of both the reach under review and the upstream reaches still affords a considerable degree of protection to the river in this respect.

A major source of man-made interference, however, is the artificial manipulation of the mouth, which is subject to artificial breaching to prevent inundation of low-lying properties and building up of the sand bar to prevent breaching and so to maintain water levels. Further, the weir situated at the mouth keeps the water level artificially low and thus prevents breaching of the bar as frequently and as extensively as it would under natural conditions. Major flood flows still breach the bar, but lesser flows, encountering an artificially low water

level near the mouth, may not result in breaching of the bar, or may only cause a minor breach, resulting in less effective scouring processes.

Overall, the Fafa River shows relatively little siltation in its very lowest reaches but exemplifies "classic" infilling at approximately 3 km from the mouth. It has been slightly unstable for the period under review (1937-1983).

Details of the classification may be found in Tables NS34/II-VIII and an abstract of results is given in Table NS34/I.

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ABBREVIATIONS/SYMBOLS/TERMS USED

MAR	Mean annual run-off
LB	Left bank
RB	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
NR	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 eg to facilitate demarcation of flood plain areas).

ABSTRACT

RIVER FAFA NS 34

MEASUREMENTS/CALCULATIONS FROM PHOTOGRAPHS

BASIC DATA/CALCULATIONS

Date	30-4-37	Jan/Jul '55	6-6-59	5-5-63	17-6-67	23-6-76	2-8-83
Reach							
thalweg (m)	3 538	3 520	3 620	3 525	3 508	3 751	3 556
% estuarine	7 100+	7 100+	7 100+	7 100+	98	95	88
% braided					2	5	12
aerial distance (m)	2 382	2 428	2 457	2 408	2 427	2 603	2 429
sinuosity	1,49	1,45	1,47	1,46	1,44	1,44	1,46
open water area (ha)	31,6	24,5	28,1	31,7	30,9	31,5	30,6
x river width (m)	89,7	67,5	81,3	89,9	86,9	90,9	84,7
Flood Plain/Valley							
% open water	59	46	53	59	58	59	58
% sand (marine)	6	8	7	6	6	4	6
% sand/silt (fluvial)	0,5	9	6	0	1	4,5	0,5
% swamp, marsh	7	7	6	7	7	6	9
% grass, trees, bush	23	22	22	23	20	17	17
% cultivated	0	4	4	3	4	0,5	0,5
% built-up	0,5	1	1	1	1	9	9
% grass, trees, bush	4	3	1	1	3	0	0
Valley Sides (L/R)							
% dune forest	L 66 R 59	L 74 R 53	L 51 R 56	L 84 R 52	L 77 R 54	L 83 R 47	L 78 R 50
% sand	L 1 R 1	L 6 R 4	L 5 R 5	L 5 R 5	L 3 R 1	L 10 R 10	L 10 R 10
% trees	L 22 R 38	L 13 R 23	L 6 R 12	L 2 R 25	L 3 R 8	L 18 R 12	L 12 R 12
% grass	L 10 R 2	L 6 R 19	L 6 R 30	L 21 R 36	L 36 R 12	L 12 R 12	L 12 R 12
% cultivated	L 1 R 1	L 1 R 1	L 2 R 1	L 2 R 1	L 7 R 1	L 7 R 23	L 12 R 26
% built-up							
.....							
L.B. & vegetated	100	86	90	100	99	74	88
R.B. & vegetated	99	63	80	98	95	67	83
Mouth							
open/closed (O/C)	C	C	O	C	C	O*	C
spit/bar:							
direction (°)	201	203	199	203	205	202	201
length (m)	360	345	225 + 75	370	360	395	370
width (m)	69,5	77	32,5	53,8	36	27,5	58,8

O* over flow from weir

Lateral displacement (1937-1983) $\bar{x}$ 16,7 m (19,8 & R width)
 Relative lateral stability (1937-1983) $\bar{v}$ 18,1 %
 Area of catchment 231 km²
 Area of flood plain/valley 53,1 ha
 Area of envelope of mobility 36,8 ha
 Simulated run-off ($\times 10^6$ m³) M.A.R. 24,17 s 16,42
 (1921-1975) $\bar{v}$ 67,95 %
 Major floods: March 1925, June 1935, November 1943, March & April 1976
 Some minor floods: November 1936, October 1954, May 1959 and March 1963

HUMAN INFLUENCES

Within the Reach

Cultivation: L.V.S. R.V.S. Flood Plain To Channel Edge
 Sugar cane Sugar cane Sugar cane Minimal
 Replaced by gum plantations
 Bridges & Embankments: Position (m from head of reach) Date
 Old railway bridge 3600 1900
 New railway bridge 3700 1960
 Freeway bridge 0 1976
 Canals: None

Urbanization/Industry: Large recreational development 'Ifafa Marina' on right bank in middle and upper reach
 Sandbar breaching: Weir at mouth used to facilitate control of water level. Artificial breaching of bar to protect low-lying developments. Construction of sand bunds to maintain water levels.

Others:

Upstream of the Reach

Dams: None

Construction/Canalization immediately upstream of reach: Road bridge 1,8 km upstream of head of reach
 Land-use malpractices/Silt supply: Sugar cane cultivation

STABILITY FOR PERIOD UNDER REVIEW (1937-1983)

Slightly unstable

TABLE NS 34/II

CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS

NRIO NS 34

RIVER FAFA, ? 100+ % ESTUARINE, REACH from Freeway bridge, 3.5 km from mouth. REF. DEA U803b
 AERIAL PHOTO DATE 30-4-37 SCALE 1:10 000 CATCHMENT AREA 231 km², M.A.R. 24.17 m³x10⁶, No. of DAMS Nil

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Valley Sides (~~Not~~ Well-defined)

Terrain	Vegetation	Land-use	Slumping	Vegetation and Land-use	Left	Right
mountainous	almost none	none	✓ none	coastal dune forest	66	59
✓ hilly	✓ grass	scattered cultivation	occasional	sand	1	
undulating	✓ sparsely forested (0-25%)	✓ partly cultivated	frequent	trees		
plains	moderately forested (25-75%)	mainly cultivated		grass	22	38
	heavily forested (75-100%)	✓ scattered settlement		cultivated	10	2
	✓ riverine forest: tributaries	partly built-up		built-up	1	1
		urbanized		Comments		

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length <u>3 500</u> m	none	not applicable	not applicable (no valley or free)	✓ bedrock
bottom width (av.) <u>145</u> m	indefinite	not obviously degrading	occasionally confined	lacustrine deposits
valley area <u>53.1</u> ha	✓ fragmentary	or aggrading	✓ frequently confined	✓ fluvial deposits
height at head	continuous	✓ partly entrenched	entrenched	aeolian
of reach _____ m to MSL		entrenched		
valley slope 1: _____		aggrading		
			Comments	

River Mouth

Characteristics

Measurements

✓ open/closed	right bank breakwater length _____ m		Comments
✓ natural/✓ artificial	left bank breakwater length _____ m		
canalized	rock sill level _____ m to MSL		
✓ sandy	cliffs on left bank: height _____ m to MSL		
✓ rocks on right/✓ left bank	✓ spit/bar: direction of growth <u>201</u> o		
outer bar	length of spit/bar <u>360</u> m		
silt plume (fluvial)	length stabilized _____ m		
suspended sediment (marine)	width <u>69.5</u> m		

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
none	none	open water <u>59</u>	swamp, marsh <u>7</u>
indefinite	average width <u>145</u> m	sand (marine) <u>6</u>	cultivated <u>0</u>
fragmentary	maximum width <u>45.5</u> m	sand, silt (fluvial) <u>0.5</u>	built-up <u>0.5</u>
✓ continuous	area <u>53.1</u> ha	trees, bush <u>23</u>	
		grass <u>4</u>	
		Comments	

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

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>3 538</u> m	none	✓ stagnant/still	✓ none
sinuous	*aerial length <u>2 387</u> m	✓ occasional	✓ uniform water surface	channel side bars
irregular	*sinuosity <u>1.49</u>	frequent	uniform with rapid in reach	point bars
regular meanders	*open water area <u>31.5</u> ha	split	irregular	channel junction bars
irregular meanders	perimeter <u>776.2</u> m	braided	pool and 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 $\bar{x}$ _____ m	s = <u>84.2</u> m		sand waves/large dunes
lagoon	river slope _____ m			
	river width $\bar{x}$ <u>89.7</u> m			
			Comments *whole reach	✓ incised meanders

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	R. obstructed and confined	3 440 m
boulders	major	causeway		
vegetation		weir/dam		
		fish traps		
		embankment/s		
Comments		groynes		
		canals		
		drainage furrows		
		others		

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
✓ not detectable	✓ alluvium	none	stable
downstream progression	natural levees	weak	✓ slightly unstable
progression and cut-offs	✓ rock/boulders	good	moderately unstable
mainly cut-offs	protected/stabilized	✓ very strong	unstable
entrenched loop development	cultivation to	left bank <u>100</u> %	highly unstable
irregular lateral activity	channel edge	right bank <u>99</u> %	Comments
avulsion			

TABLE NS 34/III

CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS

NRIO NS 34

RIVER FAFA

? 100+ % ESTUARINE, REACH from Freeway bridge, 3.5 km from mouth.

REF. DEA U803b

AERIAL PHOTO DATE Jun/July 1955 SCALE 1:10 000 CATCHMENT AREA 231 km², M.A.R. 24,17 m³x10⁶, 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 forest	74	53
✓hilly	✓grass	scattered cultivation	occasional	sand	6	4
undulating	✓sparsely forested (0-25%)	✓partly cultivated	frequent	trees	13	23
plains	moderately forested (25-75%)	mainly cultivated		grass	6	19
	heavily forested (75-100%)	✓scattered settlement		cultivated	1	1
	✓riverine forest: tributaries	partly built-up		built-up		
		urbanized		Comments		

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length 3 500 m	none	not applicable	not applicable (no valley or free)	✓bedrock
bottom width (av.) 145 m	indefinite	not obviously degrading	occasionally confined	lacustrine deposits
valley area 53,1 ha	✓fragmentary	or aggrading	✓frequently confined	✓fluvial deposits
height at head	continuous	✓partly entrenched	entrenched	aeolian
of reach m to MSL		entrenched		
valley slope 1:		aggrading		
			Comments	

River Mouth

Characteristics	Measurements	Comments
✓closed	right bank breakwater length _____ m	
✓natural/✓artificial	left bank breakwater length _____ m	
canalized	rock sill level _____ m to MSL	
✓sandy	cliffs on left bank: height _____ m to MSL	
✓rocks on right/left bank	✓spit/bar: direction of growth 203 °	
outer bar	length of spit/bar 345 m	
silt plume (fluvial)	length stabilized _____ m	
suspended sediment (marine)	width 77 m	

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
none	none	open water 46	swamp, marsh 7
indefinite	average width 145 m	sand (marine) 8	cultivated 4
fragmentary	maximum width 455 m	sand, silt (fluvial) 9	built-up 1
✓continuous	area 53,1 ha	trees, bush 22	
		grass 3	
		Comments	

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

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg 3 520 m	none	✓stagnant/still	none
sinuous	*aerial length 2 428 m	✓occasional	✓uniform water surface	✓channel side bars
irregular	*sinuosity 1,45	frequent	uniform with rapid in reach	✓point bars
regular meanders	*open water area 24,5 ha	split	irregular	channel junction bars
irregular meanders	perimeter 8270 m	braided	pool and 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	s = _____ m		sand waves/large dunes
lagoon	river slope			
	river width $\bar{x}$ 67,5 m	s = 63,6 m	Comments *whole reach	*** incised meanders

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	R. obstructed and confined	3 420 m
boulders	major	causeway		
vegetation		weir/dam		
		fish traps		
		embankment/s		
Comments		groynes		
		canals		
		drainage furrows		
		others		

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
✓not detectable	✓alluvium	none	stable
downstream progression	natural levees	weak	✓slightly unstable
progression and cut-offs	✓rock/boulders	good	moderately unstable
mainly cut-offs	protected/stabilized	✓very strong	unstable
entrenched loop development	cultivation to	left bank 86 %	highly unstable
irregular lateral activity	channel edge	right bank 63 %	Comments
avulsion			

TABLE NS 34/IV

CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS

NRIO NS 34RIVER FAFA? 100+ % ESTUARINE, REACH from Freeway bridge 3.6 km from mouth.REF. DEA 48036AERIAL PHOTO DATE 6-6-59SCALE 1:10 000CATCHMENT AREA 231 km², M.A.R. 24,17 m³x10⁶, No. of DAMS Nil

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Terrain	Vegetation	Land-use	Slumping	Valley Sides (Not Well-defined)	Vegetation and Land-use	Left	Right
mountainous	almost none	none	✓ none	coastal dune forest		81	56
✓ hilly	✓ grass	scattered cultivation	occasional	sand		5	1
undulating	✓ sparsely forested (0-25%)	✓ partly cultivated	frequent	trees			
plains	moderately forested (25-75%)	mainly cultivated		grass		6	12
	heavily forested (75-100%)	✓ scattered settlement		cultivated		6	30
	✓ riverine forest: tributaries	partly built-up		built-up		2	1
		urbanized					
Comments							

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length <u>3 500</u> m	none	not applicable	not applicable (no valley or free)	✓ bedrock
bottom width (av.) <u>145</u> m	indefinite	not obviously degrading	occasionally confined	lacustrine deposits
valley area <u>53.1</u> ha	✓ fragmentary	or aggrading	✓ frequently confined	✓ fluvial deposits
height at head of reach _____ m to MSL	continuous	✓ partly entrenched	entrenched	aeolian
valley slope 1: _____		entrenched		
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 left bank: height _____ m to MSL
✓ rocks on right/ left bank	spit/ bar : direction of growth <u>199</u> °
outer bar	length of spit/ bar <u>225 + 75</u> m
silt plume (fluvial)	length stabilized <u>100</u> m
suspended sediment (marine)	width <u>32.5</u> m
Comments	

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
Presence	none	open water <u>53</u>	swamp, marsh <u>6</u>
indefinite	average width <u>145</u> m	sand (marine) <u>7</u>	cultivated <u>4</u>
fragmentary	maximum width <u>455</u> m	sand, silt (fluvial) <u>6</u>	built-up <u>1</u>
✓ continuous	area <u>1</u> ha	trees, bush <u>22</u>	
		grass <u>1</u>	
Comments			

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

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>3 620</u> m	✓ none	✓ steep /still	none
sinuous	*aerial length <u>2 457</u> m	occasional	✓ uniform water surface	✓ channel side bars
irregular	*sinuosity <u>1.47</u>	frequent	uniform with rapid in reach	✓ point bars
regular meanders	*open water area <u>28.1</u> ha	split	irregular	channel junction bars
irregular meanders	perimeter _____ m	braided	pool and 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	s = _____ m		sand waves/large dunes
lagoon	river slope _____	s = <u>70.0</u> m		
	river width $\bar{x}$ <u>81.3</u> m			
Comments *whole reach <u>** incised meanders</u>				

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	<u>R. obstructed and confined</u>	<u>3 520</u>
boulders	major	causeway/stabilized spit	<u>R. obstructed and confined</u>	<u>3 620</u>
vegetation		weir/dam		
		fish traps		
		embankment/s		
Comments		groynes		
		canals		
		drainage furrows		
		others		

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
✓ not detectable	✓ alluvium	none	stable
downstream progression	natural levees	weak	✓ slightly unstable
progression and cut-offs	✓ rock/boulders	good	moderately unstable
mainly cut-offs	protected/stabilized	✓ very strong	unstable
entrenched loop development	cultivation to	left bank <u>90</u> %	highly unstable
irregular lateral activity	channel edge	right bank <u>80</u> %	Comments
avulsion			

TABLE NS 34/V

CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS

NRIO NS 34

RIVER FAFA, ? 100+ % ESTUARINE, REACH from freeway bridge, 3.5 km from mouth.

REF. DEA 48036

AERIAL PHOTO DATE 5-5-63 SCALE 1:10 000 CATCHMENT AREA 231 km², M.A.R. 24.17 m³/s x 10⁶, No. of DAMS Nil

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Valley Sides (Well-defined)

Terrain	Vegetation	Land-use	Slumping	Vegetation and Land-use	Left	Right
mountainous	almost none	none	✓ none	coastal dune forest	84	52
✓ hilly	✓ grass	scattered cultivation	occasional	sand	7	1
undulating	✓ sparsely forested (0-25%)	✓ partly cultivated	frequent	trees	5	2
plains	moderately forested (25-75%)	mainly cultivated		grass	2	25
	heavily forested (75-100%)	✓ scattered settlement		cultivated		21
	✓ riverine forest: tributaries	partly built-up		built-up	2	1
		urbanized		Comments		

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length 3500 m	none	not applicable	not applicable (no valley or free)	✓ bedrock
bottom width (av.) 145 m	indefinite	not obviously degrading	occasionally confined	lacustrine deposits
valley area 53.1 ha	✓ fragmentary	or aggrading	✓ frequently confined	✓ fluvial deposits
height at head of reach _____ m to MSL	continuous	✓ partly entrenched	entrenched	aeolian
valley slope 1: _____		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 left bank: height _____ m to MSL		
✓ rocks on right/left bank	spit/bar: direction of growth 203°		
outer bar	length of spit/bar 370 m		
silt plume (fluvial)	length stabilized 100 m		
suspended sediment (marine)	width 53.8 m		
			Comments

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
none	none	open water 59	swamp, marsh 7
indefinite	average width 145 m	sand (marine) 6	cultivated 3
fragmentary	maximum width 455 m	sand, silt (fluvial) 23	built-up 1
✓ continuous	area 53.1 ha	grass 1	
			Comments

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

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg 3 525 m	✓ none	✓ stagnant/still	✓ none
sinuous	*aerial length 2 408 m	occasional	✓ uniform water surface	channel side bars
irregular	*sinuosity 1.46	frequent	uniform with rapid in reach	point bars
regular meanders	*open water area 31.7 ha	split	irregular	channel junction bars
irregular meanders	perimeter _____ m	braided	pool and 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	s = _____ m		sand waves/large dunes
lagoon	river slope _____	s = 80.5 m		
	river width $\bar{x}$ 89.9 m			Comments *whole reach *** incised meanders

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 (piers)	R. confined and obstructed	3 425
boulders	major	causway railbridge and	R. confined and obstructed	3 525
vegetation		main/dm stabilized bar		
		fish traps		
		embankment/s		
		groynes		
		canals		
		drainage furrows		
		others		
Comments				

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
✓ not detectable	✓ alluvium	none	stable
downstream progression	natural levees	weak	✓ slightly unstable
progression and cut-offs	✓ rock/boulders	good	moderately unstable
mainly cut-offs	protected/stabilized	✓ very strong	unstable
entrenched loop development	cultivation to	left bank 100 %	highly unstable
irregular lateral activity	channel edge	right bank 98 %	Comments
avulsion			

TABLE NS 34/VI

CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS

NRIO NS 34RIVER FAFA? 98% ESTUARINE, REACH from freeway bridge, 3.5 km from mouth.REF. DEA U803bAERIAL PHOTO DATE 17-6-67SCALE: 10 000CATCHMENT AREA 231km², M.A.R. 24,17m³x10⁶, 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 forest	<u>77</u>	<u>54</u>
✓hilly	✓grass	scattered cultivation	occasional	sand	<u>3</u>	<u>1</u>
undulating	sparsely forested (0-25%)	✓partly cultivated	frequent	trees		
plains	✓moderately forested (25-75%)	mainly cultivated		grass	<u>3</u>	<u>8</u>
	heavily forested (75-100%)	✓scattered settlement		cultivated		<u>36</u>
	✓riverine forest: tributaries	partly built-up		built-up	<u>7</u>	<u>1</u>
		urbanized		Comments		

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length <u>3 500</u> m	none	not applicable	not applicable (no valley or free)	✓bedrock
bottom width (av.) <u>145</u> m	indefinite	not obviously degrading	occasionally confined	lacustrine deposits
valley area <u>53,1</u> ha	✓fragmentary	or aggrading	✓frequently confined	✓fluvial deposits
height at head	continuous	✓partly entrenched	entrenched	aeolian
of reach _____ m to MSL		entrenched		
valley slope 1: _____		aggrading		
			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 left bank: height _____ m to MSL	
✓rocks on right/left bank	spit/bar: direction of growth <u>205</u> o	
outer bar	length of spit/bar <u>360</u> m	
silt plume (fluvial)	length stabilized <u>100</u> m	
suspended sediment (marine)	width <u>35</u> m	
		Comments

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain	Presence	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
none	none		open water <u>58</u>	swamp, marsh <u>7</u>
indefinite	average width <u>145</u> m		sand (marine) <u>6</u>	cultivated <u>4</u>
fragmentary	maximum width <u>455</u> m		sand, silt (fluvial) <u>1</u>	built-up <u>1</u>
✓continuous	area <u>53,1</u> ha		trees, bush <u>20</u>	
			grass <u>3</u>	
			Comments	

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

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>3 508</u> m	✓none	✓ sluggish /still	✓none
sinuous	*aerial length <u>2 427</u> m	occasional	✓uniform water surface	channel side bars
irregular	*sinuosity <u>1,44</u>	frequent	uniform with rapid in reach	point bars
regular meanders	*open water area <u>30,9</u> ha	split	irregular	channel junction bars
irregular meanders	perimeter <u>7930</u> m	braided	pool and 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	s = _____ m		sand waves/large dunes
lagoon	river slope			
	river width $\bar{x}$ <u>86,9</u> m	s = <u>78,5</u> m	Comments *whole reach	*** incised meanders

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 (<u>piers</u>)	R. obstructed and confined	<u>3 410 m</u>
boulders	major	concrete rail bridge + stabilized bar	R. obstructed and confined	<u>3 310 m</u>
vegetation		weir/dam		
		fish traps		
		embankment/s		
Comments		groynes		
		canals		
		drainage furrows		
		others		

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
✓not detectable	✓alluvium	none	stable
downstream progression	natural levees	weak	✓slightly unstable
progression and cut-offs	✓rock/boulders	good	moderately unstable
mainly cut-offs	protected/stabilized	✓very strong	unstable
entrenched loop development	cultivation to	left bank <u>99</u> %	highly unstable
irregular lateral activity	channel edge	right bank <u>95</u> %	Comments
avulsion			

TABLE NS 34/VII

CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS

NR10 NS 34

RIVER FAFA, 95 % ESTUARINE, REACH from Freeway bridge, 3.75 km from mouth. REF. DEA U803b
 AERIAL PHOTO DATE 23-6-76 SCALE 1:10 000 CATCHMENT AREA 281 km², M.A.R. 24.17 m³x10⁶, No. of DAMS Nil
 (ortho photo series)

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley			Valley Sides (Well-defined)		
Terrain	Vegetation	Land-use	Slumping	Vegetation and Land-use	Left Right
mountainous	almost none	none	✓none	coastal dune forest	83 47
hilly	✓grass	scattered cultivation	occasional	sand	
undulating	sparsely forested (0-25%)	✓partly cultivated	frequent	trees	10 18
plains	✓moderately forested (25-75%)	mainly cultivated		grass	
	heavily forested (75-100%)	✓scattered settlement		cultivated	12
	✓riverine forest: tributaries	partly built-up		built-up	7 23
		urbanized		Comments	

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length <u>3 500</u> m	none	not applicable	not applicable (no valley or free)	✓bedrock
bottom width (av.) <u>145</u> m	indefinite	not obviously degrading	occasionally confined	lacustrine deposits
valley area <u>53.1</u> ha	✓fragmentary	or aggrading	✓frequently confined	✓fluvial deposits
height at head of reach <u>5</u> m to MSL	continuous	✓partly entrenched	entrenched	aeolian
valley slope 1: <u>1350</u>		aggrading		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 left bank: height _____ m to MSL	
✓rocks on right/ left bank	spit/ bar : direction of growth <u>202</u> °	
outer bar	length of spit/ bar <u>395</u> m	
silt plume (fluvial)	length stabilized <u>100</u> m	
suspended sediment (marine)	width <u>27.5</u> m	

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
Presence Extent		
none	open water <u>59</u>	swamp, marsh <u>6</u>
indefinite	sand (marine) <u>4</u>	cultivated <u>0.5</u>
fragmentary	sand, silt (fluvial) <u>4.5</u>	built-up <u>2</u>
✓continuous	trees, bush <u>17</u>	
	grass _____	
	Comments	

Channel Description	N.B. - Estimate of flow stage: ^{above} LOW/NEAR LONG-TERM MEAN/ ^{monthly} HIGH	Islands/Shoals	Type of Flow	Bar Type
Pattern	Measurements			
straight	*thalweg <u>3 751</u> m	none	✓stagnant/still	none
sinuous	*aerial length <u>2 603</u> m	occasional	✓uniform water surface	✓channel side bars
irregular	*sinuosity <u>1.44</u>	frequent	uniform with rapid in reach	✓point bars
regular meanders	*open water area <u>30.6</u> ha	split	irregular	channel junction bars
irregular meanders	perimeter <u>808.2</u> m	✓braided ***	pool and 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 $\bar{x}$ _____ m	s = <u>73.1</u> m		sand waves/large dunes
lagoon	river slope _____ m			
	river width $\bar{x}$ <u>90.9</u> m			
			Comments *whole reach	*** incised meanders
				*** 5% in upper reach

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
✓none	none	road bridge/s (under construction)	R. obstructed	0
logs	minor	rail bridge/stabilized spit	R. confined and obstructed	3 700
boulders	major	causeway		
vegetation		weir/dam	Artificial regulation of mouth	3 700
		fish traps		
		embankment/s		
		groynes		
		canals		
		drainage furrows		
		others		
Comments				

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
✓not detectable	✓alluvium	none	stable
downstream progression	natural levees	weak	✓slightly unstable
progression and cut-offs	✓rock/boulders	good	moderately unstable
mainly cut-offs	protected/stabilized	✓very strong	unstable
entrenched loop development	cultivation to	left bank <u>74</u> %	highly unstable
irregular lateral activity	channel edge	right bank <u>67</u> %	Comments
avulsion			

TABLE NS 34/VIII CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS NRIO NS 34
 RIVER FAFA, ? 88 % ESTUARINE, REACH from freeway bridge, 3.6 km from mouth. REF. DEA U803b
 AERIAL PHOTO DATE 2-8-83 SCALE 1:10 000 CATCHMENT AREA 231 km², M.A.R. 24.17 m³x10⁶, No. of DAMS Nil

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley			Valley Sides (not Well-defined)		
Terrain	Vegetation	Land-use	Slumping	Vegetation and Land-use	Left Right
mountainous	almost none	none	✓none	coastal dune forest	78 50
✓hilly	✓grass	scattered cultivation	occasional	sand	
undulating	sparsely forested (0-25%)	✓partly cultivated	frequent	trees	10
plains	✓moderately forested (25-75%)	mainly cultivated		grass	12
	heavily forested (75-100%)	✓scattered settlement		cultivated	12
	✓riverine forest: tributaries	partly built-up		built-up	12 26
		urbanized			
				Comments	

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length <u>3 500</u> m	none	not applicable	not applicable (no valley or free)	✓bedrock
bottom width (av.) <u>145</u> m	indefinite	not obviously degrading	occasionally confined	lacustrine deposits
valley area <u>53.1</u> ha	✓fragmentary	or aggrading	✓frequently confined	✓fluvial deposits
height at head	continuous	✓partly entrenched	entrenched	aeolian
of reach		entrenched		
valley slope 1:		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 left bank: height	m to MSL
✓rocks on right/left bank	split/bar: direction of growth	201 o
outer bar	length of split/bar	370 m
silt plume (fluvial)	length stabilized	100 m
suspended sediment (marine)	width	58.8 m
		Comments

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain		Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
Presence	Extent		
none	none	open water <u>58</u>	swamp, marsh <u>9</u>
indefinite	average width <u>145</u> m	sand (marine) <u>6</u>	cultivated <u>0.5</u>
fragmentary	maximum width <u>455</u> m	sand, silt (fluvial) <u>0.5</u>	built-up <u>9</u>
✓continuous	area <u>53.1</u> ha	trees, bush <u>17</u>	
		grass	
			Comments

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

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>3 556</u> m	none	✓stagnant/still	none
sinuous	*aerial length <u>2 429</u> m	occasional	✓uniform water surface	✓channel side bars
irregular	*sinuosity <u>1.46</u>	frequent	uniform with rapid in reach	✓point bars
regular meanders	*open water area <u>30.6</u> ha	split	irregular	channel junction bars
irregular meanders	perimeter <u>8082</u> m	✓braided ***	pool and riffle sequence	✓mid-channel bars
✓tortuous meanders	river X-sections available		turbid	diamond bars
bifurcated	channel slope	s =		diagonal bars
lake/s	channel width $\bar{x}$	m		sand waves/large dunes
lagoon	river slope			
	river width $\bar{x}$ <u>84.7</u> m	s = <u>78.7</u> m		
				Comments *whole reach *** incised meanders
				*** 12% in upper reach

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
✓none	none	road bridge/s	R. obstructed	0
logs	minor	rail bridge/s	R. contained + obstructed	3 700
boulders	major	causeway		
vegetation		weir/dam	Artificial regulation of mouth	3 700
		fish traps		
		embankment/s		
Comments		groynes		
		canals		
		drainage furrows		
		others		

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
✓not detectable	✓alluvium	none	stable
downstream progression	natural levees	weak	✓slightly unstable
progression and cut-offs	✓rock/boulders	good	moderately unstable
mainly cut-offs	protected/stabilized	✓very strong	unstable
entrenched loop development	cultivation to	left bank <u>74</u> %	highly unstable
irregular lateral activity	channel edge	right bank <u>67</u> %	
avulsion			Comments

TABLE NS 34/IX

RIVER WIDTHS

FAFA NS34

Station	Approx. distance along river course from freeway bridge	River widths (m)							$\bar{x}$	s	V%
		Date									
		30-4-37	Jun/Jul 1955	6-6-59	5-5-63	17-6-67	23-6-76	2-8-83			
1	0	22	14	22	15	18	19	6	16,6	5,6	33,8
2	200	15	14	28	22	22	24	11	19,4	6,2	31,7
3	400	18	18	27	22	22	31	7	20,7	7,7	36,9
4	600	22	18	28	27	29	32	18	24,9	5,6	22,3
5	800	28	28	33	41	38	42	43	36,1	6,5	17,9
6	1 000	43	39	39	40	39	49	52	43,0	5,4	12,5
7	1 200	44	28	42	40	33	33	34	36,3	5,8	16,0
8	1 400	74	63	63	68	62	65	66	65,9	4,1	6,3
9	1 600	80	37	52	74	74	70	73	65,7	15,4	23,5
10	1 800	87	56	85	86	83	86	82	80,7	11,0	13,7
11	2 000	83	55	43	78	76	34	70	62,7	18,9	30,2
12	2 200	65	58	58	69	67	56	66	62,7	5,2	8,3
13	2 400	130	91	129	146	132	128	134	127,1	17,1	13,4
14	2 600	128	106	128	134	133	126	132	126,7	9,6	7,6
15	2 800	105	98	107	115	110	107	111	107,6	5,3	5
16	3 000	194	121	171	198	187	194	196	180,1	27,6	15,3
17	3 200	253	223	239	245	243	238	243	240,6	9,2	3,8
18	3 400	313	217	238	289	284	263	266	267,1	32,3	12,1
19	3 600	0	0	13	0	0	130	0	20,4	48,6	237,7
$\bar{x}$		89,7	67,6	81,3	89,9	86,9	90,9	84,7	84,4		
s		84,2	63,6	70,0	80,5	78,5	73,1	78,7			
V%		93,9	94,1	86,1	89,5	90,3	80,4	92,8			

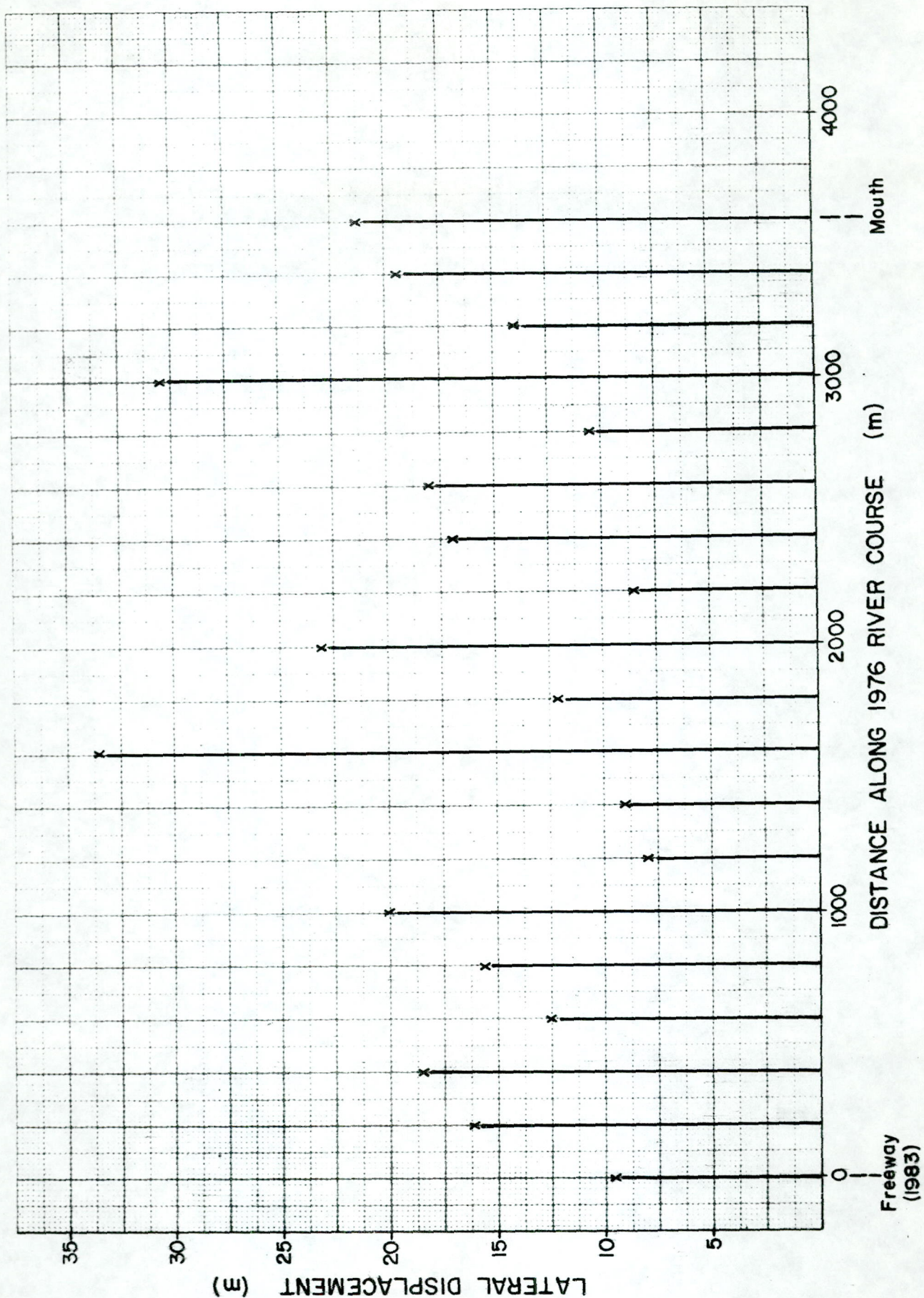
Station	Approx. distance along river course from freeway bridge	Distance from maximum observed L.B. position to mid-river (m)							Max-Min	$\bar{x}$	s	V%
		Date										
		30-04-37	Jun/Jul 1955	06-06-59	05-05-63	17-06-67	23-06-76	02-08-83				
1	0	15	<u>7</u>	11	<u>16,5</u>	13	<u>9,5</u>	8	9,5	11,4	3,6	31,2
2	200	16,5	18	14	13	<u>11</u>	27	<u>27,1</u>	16,1	18,1	6,5	36,1
3	400	14	23	13,5	<u>11</u>	12	<u>29,5</u>	28,5	18,5	18,8	8,0	42,6
4	600	18	22	18	<u>13,5</u>	14,5	<u>26</u>	25	12,5	19,6	4,9	25,0
5	800	29	<u>35</u>	<u>19,5</u>	20,5	20	21	21,5	15,5	23,8	5,9	24,8
6	1 000	27,5	38,5	22,5	<u>20</u>	35,5	39,5	<u>40</u>	20,0	31,9	8,5	26,5
7	1 200	<u>22</u>	<u>14</u>	21	20	16,5	16,5	17	8,0	18,1	2,9	16,0
8	1 400	39	<u>31,5</u>	<u>40,5</u>	37	33	32,5	33	9,0	35,2	3,6	10,1
9	1 600	<u>52</u>	<u>18,5</u>	37	42	47	44	47,5	33,5	41,1	11,0	26,8
10	1 800	54,5	<u>55</u>	48,5	46	46,5	<u>43</u>	48	12,0	48,8	4,4	9,1
11	2 000	41,5	46,5	54,5	39	<u>38</u>	<u>61</u>	42	23,0	46,1	8,6	18,7
12	2 200	<u>40,5</u>	36	38	38,5	33,5	<u>32</u>	33	8,5	35,9	3,2	8,9
13	2 400	<u>77</u>	<u>60,2</u>	69,5	73	66	71	67	16,8	69,1	5,4	7,8
14	2 600	<u>74</u>	<u>56</u>	67	67	66,5	73	66	18,0	67,1	5,9	8,8
15	2 800	<u>65,5</u>	56	55,5	57,5	<u>55</u>	58,5	55,5	10,5	57,6	3,7	6,4
16	3 000	<u>100</u>	<u>69,4</u>	86,6	99	95,5	97	98	30,6	92,2	11,0	11,9
17	3 200	<u>134,5</u>	<u>120,5</u>	123,5	125,5	121,5	134	125,5	14,0	126,4	5,7	4,5
18	3 400	<u>156,5</u>	158,5	<u>176</u>	159,5	158	168,5	167	19,5	163,4	7,2	4,4
19	3 600	NR	NR	53,5	NR	NR	74,8	NR	21,3	64,2	15,1	23,5
$\bar{x}$		54,3	48,1	51,0	49,9	49,1	55,7	52,8	16,7	52,0		18,1
s		41,2	38,2	41,8	41,6	40,5	41,1	40,7		51,6		11,4
V%		76,0	79,5	81,9	83,4	82,6	73,8	77,1				63,1

Average lateral displacement 1937-1983 = 16,7 m (i.e. 19,88R)

Average coefficient of variation 1937-1983 = 18,1%

TABLE NS 34/XI
SIMULATED RUN-OFF FOR FAFA NS 34
CATCHMENT AREA= 231.05Q.KM.

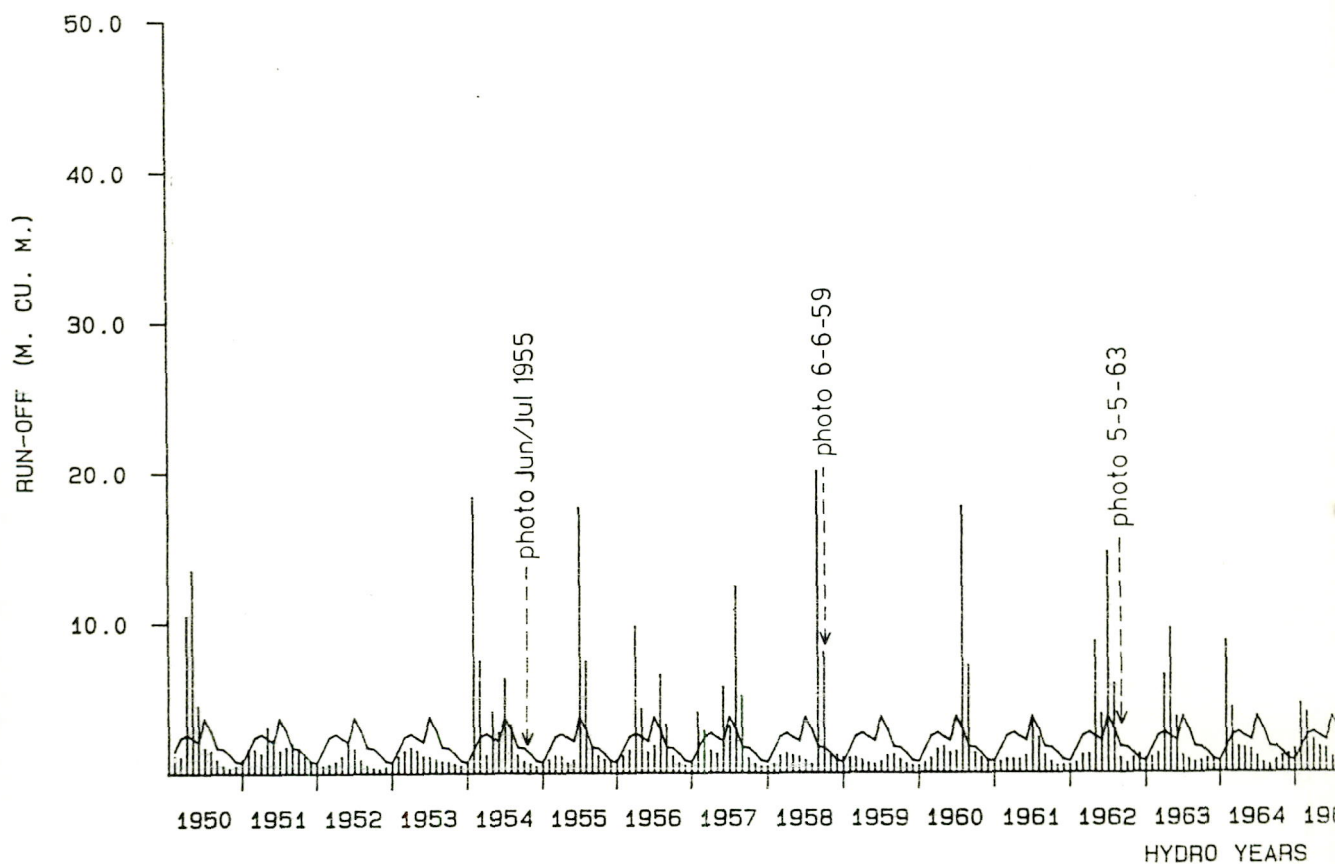
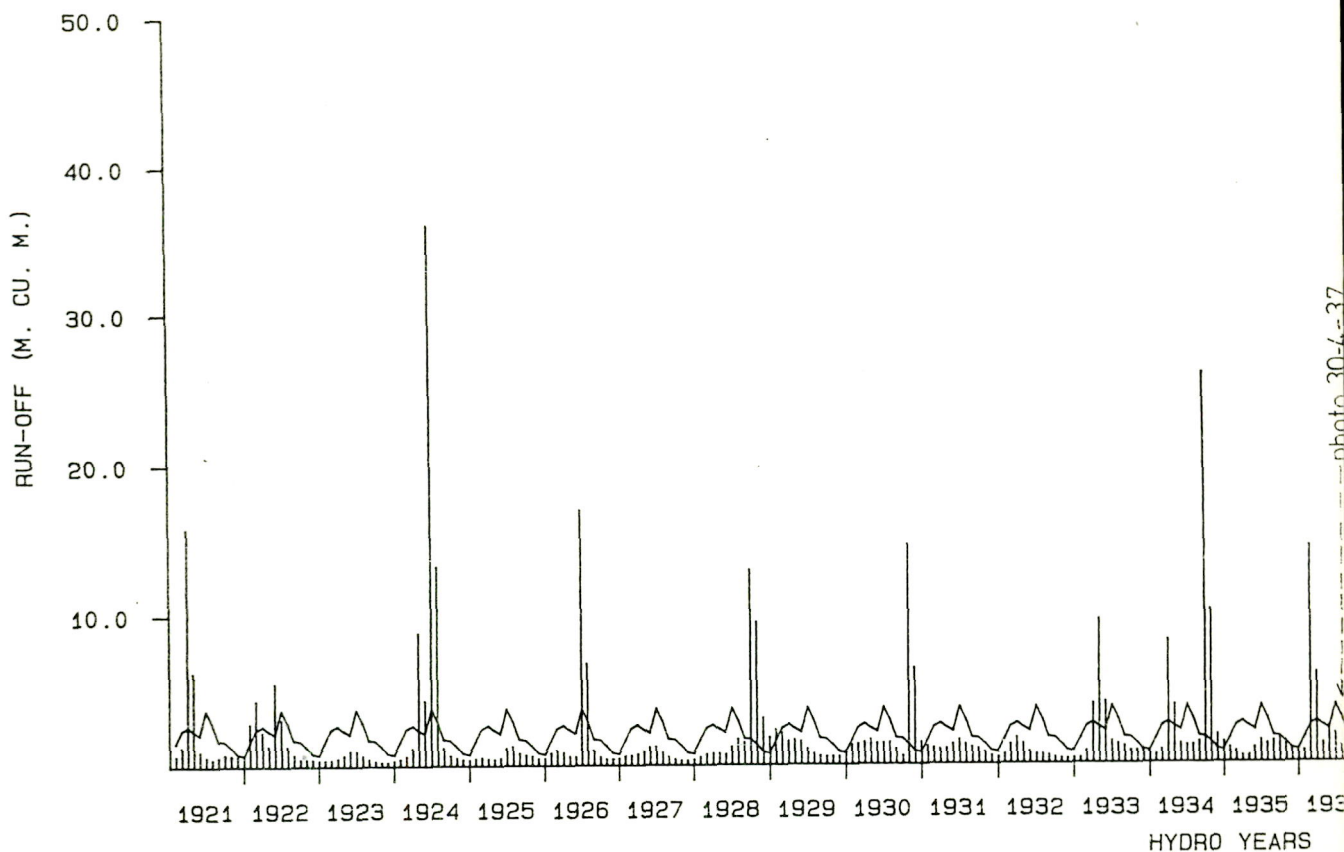
YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL	SM.A.R.
1921	.74	1.32	15.82	6.25	1.05	.68	.52	.64	.80	.72	.67	.68	29.91	123.75
1922	2.88	4.36	2.29	1.36	5.54	3.14	1.36	.79	.48	.48	.48	.39	23.56	97.46
1923	.39	.42	.53	.73	1.06	1.03	.71	.48	.33	.25	.25	.36	6.54	27.07
1924	.45	.66	1.19	8.83	4.36	36.09	13.22	1.19	.70	.52	.42	.36	67.99	281.28
1925	.46	.54	.41	.41	.50	1.14	1.26	.83	.69	.62	.45	.46	7.84	32.42
1926	.81	1.00	.87	.62	.55	16.97	6.78	.99	.59	.40	.41	.45	30.44	125.94
1927	.61	.65	.75	.91	1.19	1.21	.87	.57	.40	.28	.28	.34	8.05	33.31
1928	.51	.72	.78	.75	1.21	1.68	1.48	1.48	12.95	9.46	3.12	1.82	35.17	145.52
1929	2.32	2.14	1.55	1.63	1.54	1.03	.74	.55	.50	.52	.53	.81	13.87	57.39
1930	1.28	1.39	1.46	1.64	1.38	1.42	1.44	.97	.54	14.55	6.37	1.47	33.91	140.31
1931	1.18	1.03	.93	.98	1.31	1.57	1.28	1.09	.97	.72	.50	.41	11.97	49.52
1932	.59	1.26	1.72	1.31	.75	.60	.62	.53	.38	.31	.29	.28	8.63	35.69
1933	.29	.76	3.93	9.53	4.07	1.44	1.27	1.09	.78	.79	.83	.64	25.43	105.20
1934	.52	.82	8.12	3.83	1.26	1.14	1.16	1.36	25.86	10.13	1.82	1.33	57.36	237.30
1935	.95	.67	.39	.41	.91	1.45	1.21	1.39	1.61	1.16	.72	.57	11.44	47.32
1936	.68	14.32	5.85	1.21	2.34	1.87	1.06	.61	.39	.33	.43	.50	29.60	122.46
1937	.58	.66	.89	1.30	9.19	3.98	1.27	1.16	.82	.70	.68	.50	21.74	89.93
1938	.64	.94	1.19	1.27	5.31	3.14	1.46	.99	.71	.62	.65	1.11	18.04	74.63
1939	1.78	2.04	9.18	3.79	.65	.45	.47	1.12	1.70	1.36	.85	.59	23.99	99.24
1940	.48	2.85	2.31	1.37	.78	.66	.70	.52	.34	.29	.28	.35	10.92	45.16
1941	.48	.64	.62	1.05	1.28	1.48	1.59	1.24	.80	.50	.50	.63	10.82	44.76
1942	1.01	1.75	6.08	3.21	1.36	4.03	11.68	5.09	1.70	1.38	1.65	1.57	40.50	167.57
1943	4.08	8.01	3.74	1.51	1.14	1.14	1.06	.74	.54	.49	.41	.74	23.60	97.64
1944	1.53	1.52	.86	.49	.61	1.21	1.29	.94	.66	.48	.37	.29	10.22	42.30
1945	.46	.54	.39	.37	.52	.80	.88	.65	.42	.30	.23	.21	5.77	23.87
1946	.29	.55	.72	.69	.76	4.38	2.91	1.66	1.82	1.88	1.38	.93	17.96	74.30
1947	.72	9.76	6.68	2.63	2.02	2.08	2.01	1.54	.93	.56	.38	.30	29.61	122.49
1948	.86	1.22	.93	.65	.57	.77	.94	.79	.52	.36	.29	.33	8.22	34.02
1949	.90	27.40	10.48	1.68	1.58	1.37	1.10	1.03	.88	.75	1.10	1.32	49.60	205.22
1950	1.20	1.11	10.51	13.50	4.61	1.75	1.54	.94	.55	.36	.51	.94	37.51	155.20
1951	1.67	1.63	1.35	3.14	2.31	1.56	1.77	2.03	1.66	1.12	.76	.58	19.58	81.01
1952	.52	.60	.76	1.14	2.02	1.62	.90	.54	.36	.27	.42	.79	9.96	41.19
1953	1.14	1.52	1.76	1.54	1.15	1.07	.90	.77	.73	.60	.49	.65	12.31	50.94
1954	18.30	7.51	1.22	4.15	2.74	6.31	3.25	1.21	.79	.60	.43	.57	47.10	194.88
1955	.89	1.17	1.14	.68	.85	17.59	7.44	1.66	1.16	.90	.83	.89	35.20	145.63
1956	1.17	1.54	9.75	4.31	1.39	1.81	6.53	3.27	1.12	.67	.51	.82	32.88	136.05
1957	4.08	2.89	1.48	1.29	5.76	3.16	12.32	5.15	1.00	.62	.44	.43	38.60	159.70
1958	.60	1.14	1.34	1.20	1.09	.82	.58	19.96	8.00	1.38	1.20	1.04	38.35	158.66
1959	1.02	1.03	.86	.64	.57	.73	1.12	1.22	.89	.61	.48	.49	9.65	39.94
1960	.65	.95	1.54	1.74	1.34	1.41	17.58	7.10	1.32	.99	.76	.67	36.07	149.21
1961	.71	.87	.86	.86	1.11	3.60	2.34	1.15	.70	.45	.46	.50	13.61	56.32
1962	.64	1.16	1.23	8.65	3.89	14.52	5.88	.97	.62	.97	1.20	.91	40.63	168.08
1963	.99	1.26	6.45	9.52	3.70	1.16	.86	.67	.74	.88	.74	.64	27.60	114.19
1964	8.68	4.28	1.66	1.60	1.51	1.04	.61	.48	.77	1.02	1.15	1.50	24.31	100.57
1965	4.55	3.94	2.09	1.68	1.54	.98	.64	.83	1.00	.83	.62	.55	19.26	79.68
1966	.49	.57	.62	.73	1.09	1.55	4.43	2.50	1.04	.77	.62	.45	14.85	61.45
1967	.53	1.03	1.12	.90	.76	.78	.76	.58	.39	.27	.39	.65	8.17	33.80
1968	.88	.89	.67	.39	.35	.80	1.10	1.44	1.46	1.08	.86	.82	10.75	44.48
1969	1.46	2.09	2.31	1.72	1.04	.56	.30	.36	.63	.74	.86	1.02	13.06	54.05
1970	3.40	2.73	2.08	1.60	1.28	1.24	1.23	1.53	1.45	1.28	1.83	1.98	21.64	89.53
1971	1.79	1.63	1.77	1.75	4.32	2.49	1.01	.72	.73	.77	.70	.53	18.24	75.45
1972	.44	1.03	1.42	1.17	.88	.72	.73	.63	.41	.29	.39	.70	8.80	36.40
1973	.93	1.14	1.25	1.30	1.41	1.43	1.22	1.51	1.69	1.27	.82	.56	14.52	60.09
1974	.49	.62	1.23	4.44	3.88	2.18	1.27	.76	.48	.33	.25	.41	16.34	67.60
1975	.64	.62	.89	1.41	12.50	38.66	21.63	5.11	2.09	1.62	1.31	1.23	87.71	362.87
MEAN	1.57	2.45	2.69	2.39	2.13	3.76	2.92	1.73	1.66	1.30	.82	.73	24.17	
\$	2.69	4.25	3.27	2.76	2.25	7.49	4.40	2.83	3.84	2.53	.91	.40	16.42	
V%	171.56	173.40	121.43	115.49	105.22	190.08	150.95	163.61	230.69	194.12	110.79	55.28	67.95	
MEDIAN	.74	1.14	1.25	1.31	1.28	1.41	1.22	.99	.74	.62	.51	.59	19.26	



TRACED: MM
 CHECKED:
 DATE: 21. 11. 86
 REF:

NATAL ESTUARIES: FAFA
THALWEG DISPLACEMENT
 (1937 - 1983)

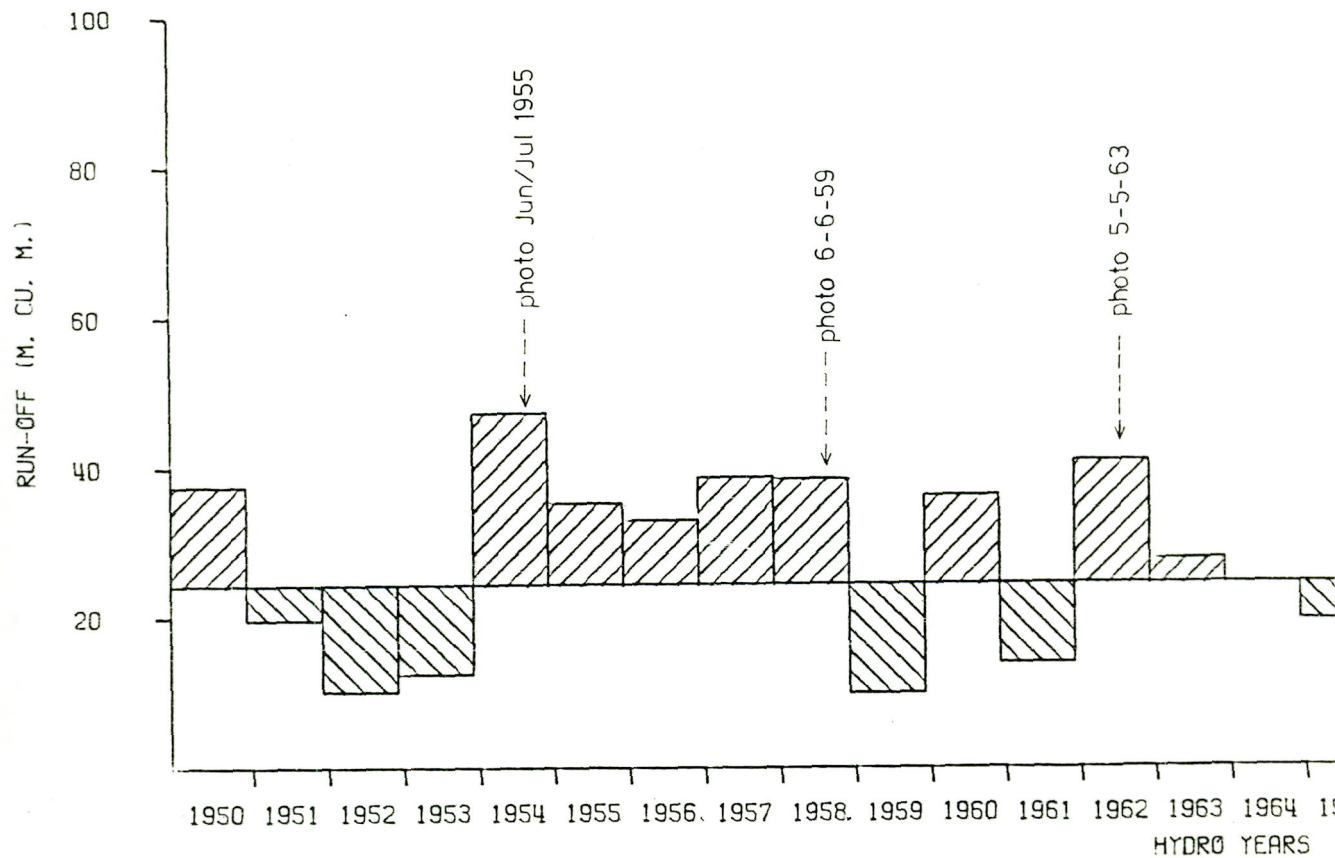
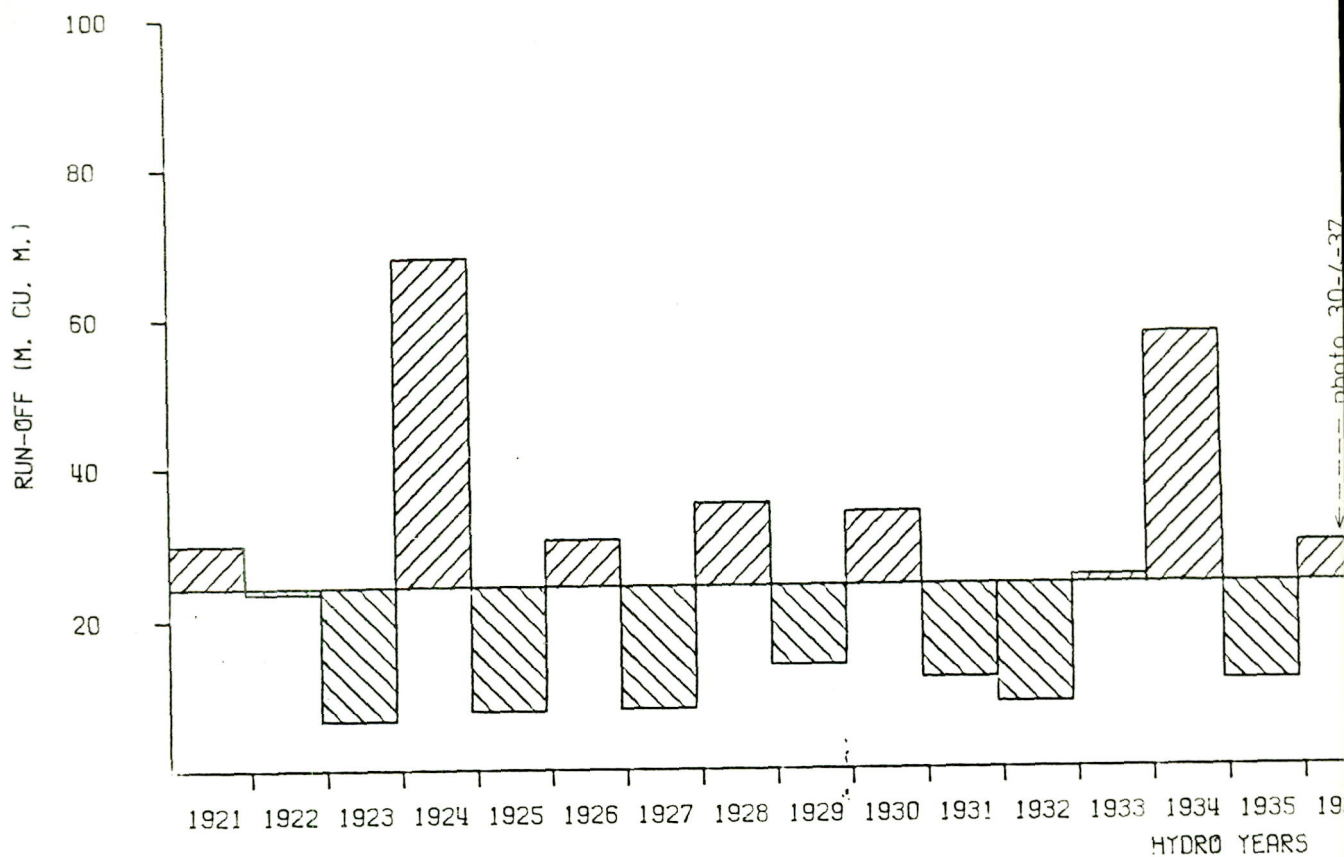
FIGURE
 NS 34/1



TRACED : COMPLIT
 CHECKED:
 DATE :
 REF. :

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

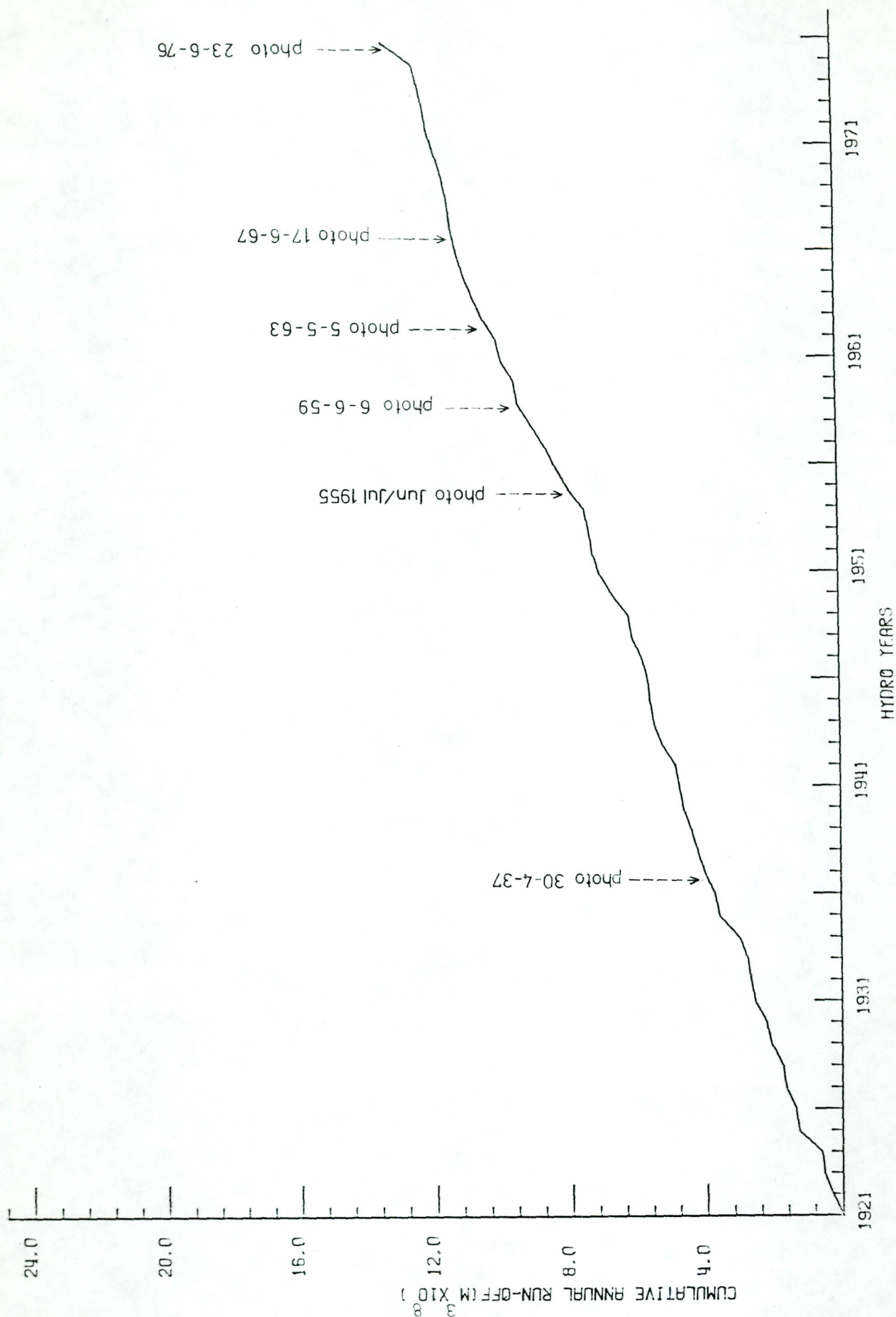
FIGURE
 NS 34/2



TRACED : COMPILOT
 CHECKED :
 DATE :
 REF. :

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

FIGURE
 NS 34/3



PLOTTED : COMPILOT
 CHECKED :
 DATE :
 REF. :

NATAL ESTUARIES: FAFA
 CUMULATIVE ANNUAL RUN-OFF

FIGURE
 NS 34/4



SCALE: 1:10 000 approx

TRACED: JGAN
CHECKED:
DATE:
REF:

NATAL ESTUARIES: FAFA
23-6-76 ORTHOPHOTO

PHOTOGRAPH
NS34/1

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



SCALE: 1:10 000 approx

TRACED: JGAN
CHECKED:
DATE:
REF.:

NATAL ESTUARIES: FAPA

30-4-37 (12h20)

PHOTOGRAPH

NS 34/2

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



SCALE: 1:10 000 approx

TRACED: JGAN
CHECKED:
DATE:
REF:

NATAL ESTUARIES: FAFA

JUNE / JULY 1955

PHOTOGRAPH

NS 34/3

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



SCALE: 1:10 000 approx

TRACED: JGAN
CHECKED:
DATE:
REF.:

NATAL ESTUARIES: FAFA

6-6-59 (13h05)

PHOTOGRAPH

NS34/4

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



SCALE: 1:10 000 approx

TRACED: JGAN
CHECKED:
DATE:
REF:

NATAL ESTUARIES: FAFA

5-5-63 (10h40)

PHOTOGRAPH

NS34/5

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



SCALE: 1:10 000 approx.

TRACED: JGAN
CHECKED:
DATE:
REF:

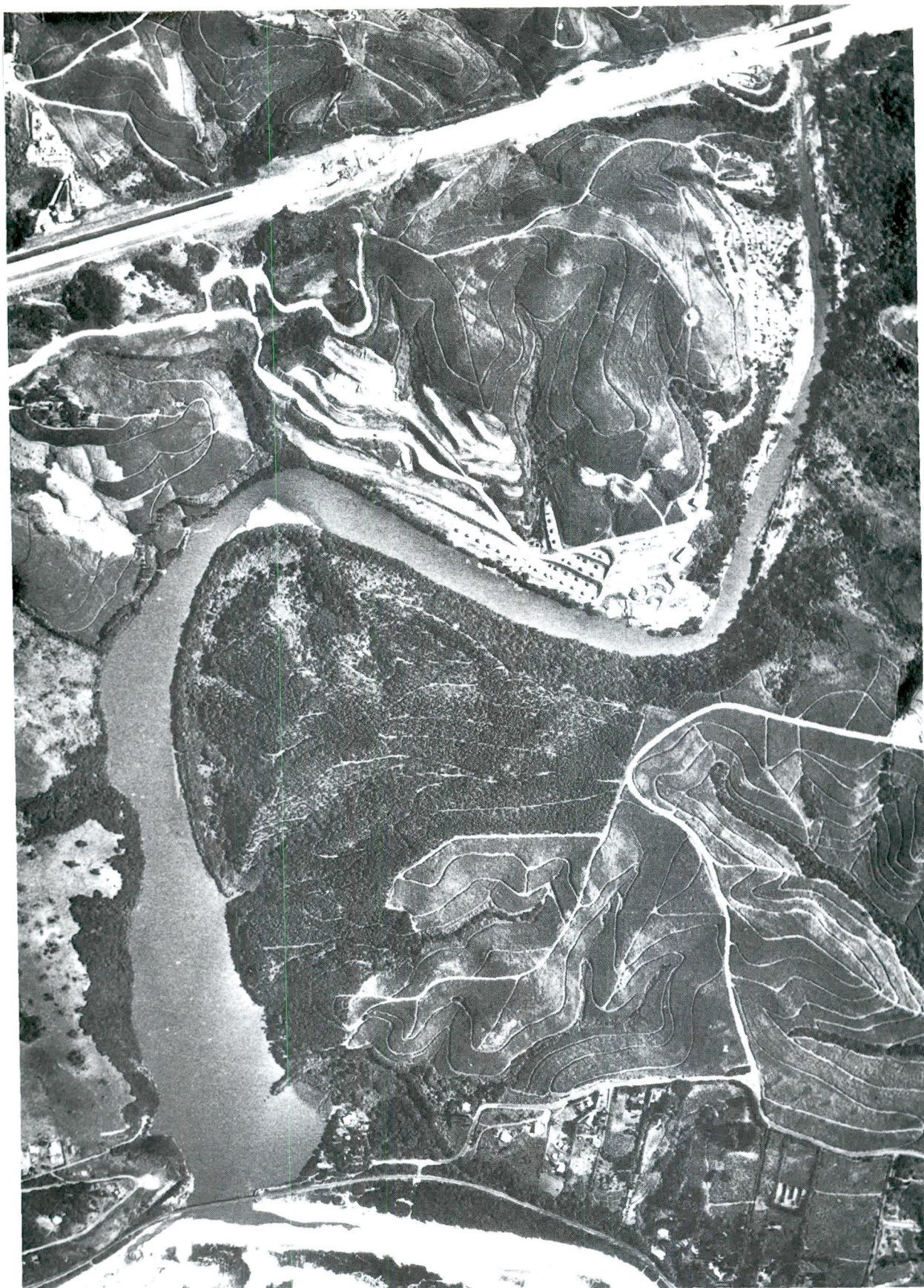
NATAL ESTUARIES: FAFA

17-6-67 (13h12)

PHOTOGRAPH

NS34/6

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



SCALE: 1:10 000 approx

TRACED: JGAM
CHECKED:
DATE:
REF:

NATAL ESTUARIES: FAFA

23-6-76 (10h32)

PHOTOGRAPH

NS34/7

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



TRACED: JGAN
CHECKED :
DATE:
REF. :

NATAL ESTUARIES : FAFA

2 - 8 - 83 (12h20)

PHOTOGRAPH

NS 34/8



SCALE: 1:10 000 approx.

TRACED: JGAN
CHECKED:
DATE:
REF:

NATAL ESTUARIES: FAFA
2-8-83
(30-4-37 RIVER COURSE SUPERIMPOSED)

PHOTOGRAPH
NS34/9

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



SCALE: 1:10 000 approx

TRACED: JGAM
CHECKED:
DATE:
REF:

NATAL ESTUARIES: FAFA
**ORTHOPHOTO (ENVELOPE OF MOBILITY, LINES OF
MEASUREMENT AND LATERAL SHIFT SUPERIMPOSED)**

PHOTOGRAPH
NS 34/10

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY