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CSIR REPORT
EMA-C 8891

CSIR

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**DYNAMICS OF THE KLEIN RIVER WITH REFERENCE TO
THE
ARTIFICIAL BREACHING OF THE ESTUARY MOUTH**

submitted to
CHIEF DIRECTORATE: NATURE AND ENVIRONMENTAL CONSERVATION
GENERAL PROVINCIAL SERVICES BRANCH
PROVINCIAL ADMINISTRATION OF THE CAPE OF GOOD HOPE

October 1988

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EMA-C 8891

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C S I R

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DIVISION OF EARTH, MARINE AND ATMOSPHERIC SCIENCE AND TECHNOLOGY
COASTAL PROCESSES AND MANAGEMENT ADVICE PROGRAMME

DYNAMICS OF THE KLEIN RIVER WITH REFERENCE TO THE ARTIFICIAL
BREACHING OF THE ESTUARY MOUTH

SCOPE

Although it is considered to be best to let the Klein River mouth breach naturally, as is the present policy of the Chief Directorate of Nature and Environmental Conservation, the mouth has historically been artificially breached on several occasions since the turn of the century.

The rising water level prior to natural breaching creates a threat to private property located in low-lying areas and this fact usually leads to a premature, uncontrolled, artificial breaching of the mouth.

In this report the history of mouth breaching in relation to the river hydrology is investigated and recommendations regarding future artificial breaching are made.

The report was written by Mr L Barwell, with technical input by Messrs P Badenhorst, L van der Merwe and I Bickerton. Editing for technical content was done by Dr D H Swart.



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Stellenbosch, South Africa
October 1988

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1. INTRODUCTION

The Klein River is situated at the eastern end of Hermanus town within Walker Bay (Figure 1). The river has a total catchment area of 906 km² and an estimated Mean Annual Run-off (MAR) of 40 x 10⁶ m³ (CSIR, 1988).

Although it is considered to be best to let the Klein River breach naturally, as is the present policy of the Chief Directorate of Nature and Environmental Conservation, the mouth has historically been artificially breached on several occasions since the turn of the century. This has disturbed the natural equilibrium of the system and contributed to an increase in sedimentation in the mouth area.

In order for the mouth to breach naturally, the water level in the Klein Estuary must rise to such a level that the sandberm is overtopped. The rising water level prior to natural breaching poses a threat to private property located in low-lying areas, which usually results in premature, uncontrolled, artificial breaching of the mouth.

This report investigates the history of mouth breaching, compares the successfulness of the breaching to measured river run-off and rainfall figures and makes recommendations with regard to future artificial breaching should this become necessary.

2. PHYSICAL PROCESSES AND HISTORICAL DATA

The main factors influencing the duration that a river mouth remains open are the prevailing longshore sediment movement caused by longshore currents and the volume and flow rate of fresh water flowing through the mouth.

Waves and longshore sediment transport

Waves approaching the coastline at an oblique angle cause nearshore currents, of which the longshore currents are the most important for moving sediment (sand) into an estuary through the open mouth.

The mouth of the Klein Estuary is located within Walker Bay, which is fairly exposed to deep sea swells approaching from the S/SW sector. These swells predominate throughout the year and result in a NW longshore current. During winter, swells from the NW/W sectors predominate and result in a SW longshore current at the Klein River mouth.

The longshore currents move sediment into the open river mouth, building sandbanks and eventually blocking off the mouth completely. Longshore currents and sediment movement in Walker Bay are fairly well balanced between NW and SE components (Schoonees, pers. comm.). However, at times after the breaching of the mouth, additional wave refraction takes place over the offshore bar in the vicinity of the estuary mouth usually leading to a predominant movement of sediment from the NW in a SE direction (Van Heerden, pers. comm.).

The effect of the longshore sediment movement can clearly be seen in the growing of sandbanks similar to those marked A and B in Figure 8. These sandbanks eventually close off the river mouth completely, as was the case in 1987.

Wind and aeolian processes

The movement of sand by wind usually plays an important role in the fine balance that normally exists in most coastal ecosystems. Sand blowing into the estuary can contribute to the general sanding up of the estuary but can also cause a buildup of sand in the mouth during times when the mouth is closed. This could result in an unnaturally high sandberm. It can therefore be seen that it is very important to establish the prevailing wind conditions and resultant wind-blown sand movement in the study area.

Long-term statistics obtained from observations done by passing merchant shipping, the so-called VOS data, were correlated to data recorded on site over the period June 1985 to December 1986. A strong bimodal wind field with ESE/SE and NW/NNW orientations was found to exist (Figure 2).

An analysis of the data indicated that wind from the SE sector occurred for 32 % of the time while wind blowing from the NW sector prevailed for 28 % of the time.

The coastline has a NW/SE orientation, resulting in a movement of wind-blown sand up and down the Walker Bay coastline with a slight net movement towards the NW. It can be deduced that the aeolian sand movement has little effect on the functioning of the river mouth but the stabilisation of the sandspit at the south-eastern side of the mouth serves as a trap for sand blown into this vegetated area, resulting in a gradual buildup of the sandspit adjacent to this area. This could make breaching within this area more difficult.

Fresh water run-off

The volume and velocity of fresh water discharging through the mouth, especially during outgoing tides, oppose the blocking effect of the longshore current by removing sand brought in during the previous high tide.

It can therefore be seen that the volume of fresh water available to the system is the most important factor for ensuring that the mouth remains open for periods that are long enough to ensure the healthy and natural functioning of the estuary.

A histogram of measured flow and rainfall data for the Klein River catchment was prepared for the period 1948 to 1984 (Figure 3 and Appendix A).

Mouth breaching: Historical trend

Valuable information regarding the past positions of the artificial breaching, flow conditions within the mouth and period that the mouth remained open, was obtained for the period 1948 to 1984 (Notes by Mr Franks, Appendix B).

In order to quantify this information, values were allocated to the different comments made for each breaching, e.g. if Mr Franks's comments stated that the flow in the mouth was strong or the mouth remained open for longer than three months, a value of 2 points was allocated to the specific breaching. If the comments stated or implied that a breaching was unsuccessful or the mouth remained open for less than three months, a value of 1 point was allocated. If the breaching failed or was never attempted (i.e. the mouth remained closed) a value of 0 points was allocated (Appendix B, Table B1).

A histogram reflecting the position of the river mouth and the success of the breaching for the period 1948 to 1984 was drawn (Figure 4). (Although the coastline is orientated in a NW/SE

direction, the Hermanus side of the river is referred to as being "west" and similarly the Gansbaai side is referred to as the "eastern" side.)

From Figure 4 it can be deduced that for the period 1948 to 1984 a total of 36 breaches was attempted, of which 21 (58 %) were reasonably successful. Of the successful attempts, 15 (71 %) occurred on the eastern side, four (19 %) on the western side and two (10 %) in the centre.

Aerial photograph analysis

Tracings of the 1938, 1961, 1977 and 1987 aerial photographs were done with the use of a zoom transfer scope (Figures 5, 6, 7 and 8).

As these tracings are all to the same approximate scale, comparisons can be made of the actual mouth configurations, positions of channels and sandbanks, the extent of stabilised areas and other relevant factors.

Co-ordinates were traced from the 1977 orthophotomap series (3419 AD 16 and 17) produced by the Director General of Surveys, Mowbray, Cape Town. Co-ordinates for beacon PA100, situated on the sandberm in the river mouth, were determined by the CSIR with the use of standard survey techniques (CSIR, 1988).

The 1938 tracing (Figure 5) shows deeper channels on the western and eastern sides of the mouth with sandbanks in the centre. The lagoon appeared to be very full and it would seem as if the mouth would have breached naturally on the western side.

On the 1961 tracing (Figure 6) it can be seen that shallow channels and surrounding sandbanks formed the centre part of the mouth area. Deeper channels defined the eastern and western sides of the mouth. It would seem that the best position to have opened the mouth at that time would have been at beacon

PA100. According to the notes by Mr Franks (Appendix B), the mouth was actually opened in the centre of the sandbar in 1962. Good follow-up river flows were recorded and yet the mouth closed soon afterwards.

The 1977 tracing (Figure 7) shows the mouth open on the eastern side, just west of beacon PA100. Fairly deep channels draining the western and eastern sides of the lagoon existed. By superimposing Figure 7 on Figure 6, it can be seen that a substantial volume of sand had been removed and it can be deduced that good flushing took place. According to Mr Franks's notes (Appendix B), the mouth remained open for \pm three months during 1977. Good rains and run-off occurred during the 1977/78 hydrological year.

Although less rain fell during the following years, the mouth performed well until 1980, during which it functioned badly even though it had been opened on the eastern side. This was due to little rain and run-off.

The 1987 tracing (Figure 8) shows the mouth open just to the west of the centre of the sandbar. The mouth performed well and remained tidal for \pm four months but little effective scour took place.

By superimposing the high-water marks seen on the available aerial photographs, it can be deduced that the area around the Klein River mouth is in a state of natural equilibrium, as no long-term changes in the coastline can be detected.

Conclusions

Physical processes taking place within the immediate vicinity of a river mouth are directly responsible for the successful functioning of the river mouth and estuary as a whole. These processes include the interaction between the river hydrology (run-off), which opens the river mouth, and the longshore

currents and sediment movement, which serve as the blocking mechanism during mouth closure. An understanding of these processes is of the utmost importance when it is attempted to breach any river mouth artificially, should this be deemed necessary.

It is evident that the success of artificially breaching a river mouth also depends on the time within the hydrological cycle. A balance between the maximum and follow-up river flow through the mouth after breaching must be obtained to ensure the maximum removal of sediment from within the estuary, and the mouth must be kept open for as long as possible to ensure an ecologically healthy system.

By comparing the hydrological histogram (Figure 3) to the state of the mouth (Figure 4), it can be seen that the success of all the artificial breaches depended on the run-off generated by rainfall in the Klein River catchment area. By using hindsight, the following can be concluded on the interaction of the prevailing physical processes:

- * For high rainfall and run-off with good follow-up rains, the position of breaching was unimportant, as was seen in 1976 (centre), 1977 (centre), 1981 (east) and 1983 (west) (Appendix B).
- * For average and slightly above or below average run-off, the mouth could have been opened on the eastern or western side, depending on where the berm was narrowest opposite the deepest upstream channel. This occurred over the periods 1950 to 1956 and 1963 to 1967.
- * In theory no breaching should have been attempted when run-off below 90 % of the average for the year had occurred, since unsuccessful breaching only causes a further influx of marine sediment due to the unopposed tidal action through

the mouth. An influx of marine sediment leads to rapid sedimentation in the estuary and is therefore to the detriment of the whole ecosystem. Low rainfall and run-off occurred in 1960, 1968, 1969, 1975, 1978, 1980 and 1982.

Although the above conclusions are very theoretical, an attempt should be made to learn from history by following a good management plan based on past trends, as reflected in the comments previously discussed. This is done in the following section.

3. BREACHING OF THE MOUTH

Should it become necessary to breach the Klein River mouth artificially, the following guidelines are put forward to minimise the ecological impact.

Position

Ideally the mouth should be opened at a point that would result in an extension of a natural upstream channel into an existing rip current on the seaward side.

To lay down hard-and-fast rules about the position is very difficult, as many factors influence this decision. It would seem logical to decide on a position where the berm is at its lowest and narrowest, thus limiting the volume of sand to be moved and thereby minimising the cost.

Based on the high success rate obtained (Section 2) and on conclusions drawn from the study of aerial photographs, it is recommended that the mouth be opened at a point 50 to 150 m NW of existing beacon PA100 (Figure 6). This should result in a similar mouth configuration as to that attained in 1977. The natural meander of the river should erode the north-western bank

of the mouth, thus limiting the effect of the longshore sediment movement and thereby maintaining a deep channel for as long as possible.

By ensuring that the mouth regularly breaches within the predetermined area, the existing unnaturally high sandberm should maintain a lower level, thus enabling it eventually to breach naturally on average once a year.

Consideration should be given to encourage sand mining on the lagoon side of the sandberm within the recommended breaching area. Since a large volume of sand is usually washed out to sea (and out of the system) during a natural breaching of the mouth in above-average river flood conditions, the mining of sediment from the sandberm could similarly help to offset the natural buildup of sand in the estuary during interim low river flow periods.

The artificial removal of sand should reduce breaching costs and prevent the berm from growing too high due to the buildup of wind-blown sand and overwash during high seas. Scraping sand off the berm in layers would be preferable to excavating a large hole or trench, although care should be taken to prevent the sandberm from being lowered to below the breaching level, which is recommended below. The removal of sand should be controlled and monitored by a responsible body.

Time of year

Of prime importance in the consideration of the time of opening (both natural and artificial) the Klein River estuary to the sea is the movement of marine fish species between the lagoon and the sea.

Typically the migrant species spawn and complete their early stages of development in the sea. As juveniles they migrate to estuaries, where they remain for varying periods before returning

to the sea as adults to spawn. In addition, some adult marine fish species enter estuaries for short periods to feed, in many cases after spawning at sea. Many of the marine fish species that enter estuaries are much sought after by anglers, hence it is important that the Klein Estuary is open to the sea at that time of the year when marine fish normally enter estuaries on the south-western Cape coast.

Recent studies of the use of the nearby Bot River, Kleinmond and Palmiet estuaries by marine fish species have suggested that the recruitment of juveniles from the sea was most intense in the spring and summer months (Bennett et al., 1985). Data on the spawning seasons of some of the migrant species found in the Bot Estuary (Day, 1981; Van der Elst, 1981) show that, although most species have extended spawning seasons, peak activity is usually in the spring and early summer months (August to November). Recruitment could therefore be expected to take place in the summer months.

Bennett et al. (1985), however, suggested that the artificial breaching of the mouth of the Bot River estuary in the dry summer months would not be ideal, since river input is reduced and water levels in the estuary are lower. Furthermore, once breached, the outflowing water would not cut a channel sufficiently deep to remain open for more than a short time. Bennett et al. (1985) therefore proposed that, in order to cater for the requirements of migratory marine fish species, the best time for the estuary to be open would be in early summer before water levels decline, probably in October or November in most years.

In the case of the Klein Estuary, the same requirements as those found for the Bot River would apply. However, what is important is not that the lagoon be artificially opened at the beginning of summer but that good tidal exchange through the mouth from late spring (September or October) be maintained as far into the dry summer period as possible (up to January or February if possible). This will allow marine fish species to make optimal

use of the Klein Estuary, thereby maintaining the maximum angling potential of the lagoon.

The Klein Estuary should be open in late spring and early summer every year to accommodate the juvenile marine fish that are spawned annually. However, if it remains closed for longer than a year, this will not have serious consequences for the fish populations in the lagoon. Fish trapped there will grow to a larger size before moving back to sea when the mouth does open.

If salinities in the lower parts of the lagoon fall below approximately five parts per thousand, there is likely to be a die-off of marine fish species (as occurred in the Bot Estuary in October 1981). Hence the frequency of opening the Klein River mouth should be such that salinities in the lower reaches are maintained above approximately five parts per thousand.

Estuary water level

Although it is considered to be the best policy to let the mouth breach naturally, history has shown that the rising water level in the estuary after the rainfall period threatens private property and the mouth is subsequently breached artificially.

In order to pin-point the problem areas, a topographical survey of the mouth area was carried out on 28 June 1988 (Figure 9) and a survey of the relevant properties located within the danger area along the perimeter of the Klein Estuary was done on 26 July 1988. The floor levels of these structures were surveyed relative to mean sea level (MSL) and are indicated in Figures 10, 11, 12, 13, 14, 15 and 16. The observations are summarised in Table 1.

The survey showed the following:

- * The lowest point on the sandberm in the mouth area was at a level of +2,7 m MSL (Figure 9).

Embankments should be left on both the seaward and the lagoon side and the lagoon side embankment should be the first to be breached, thereby allowing the excavation to fill up slowly. The seaward side embankment should be breached soon afterwards but not earlier or later than two hours before spring low tide.

4. MONITORING OF THE ESTUARY MOUTH

The Klein River mouth is one of a number of river mouths being monitored by the CSIR on an annual basis (CSIR, 1988). Data obtained are available for future reference and are used in the research into a better understanding of the physical processes taking place in estuary mouths.

To augment these data, it is suggested that a record of the position of the mouth, maximum depth and width, flow conditions through the mouth at low and high tides, hydrological factors (e.g. rainfall, run-off and lagoon level prior to opening) and period that the mouth remained open be maintained by a responsible body. The data are important for ensuring the good management of the estuary as a whole.

The establishment of a Continuous Low-level Environmental Observation station (CLEO station) at the mouth could facilitate the suggested monitoring on a controlled, scientific basis. More information on CLEO is available from the CSIR, Stellenbosch.

5. CONCLUSIONS AND RECOMMENDATIONS

Although the present no-interference policy followed by the Chief Directorate of Nature and Environmental Conservation is considered to be best for the ecological well-being of the estuary, artificial breaching has taken place over many decades and during the last few years.

Long-term records of the observations of flow conditions and the success rate of the artificial breaching of the river mouth, correlated with available hydrological data, act as guidelines towards establishing a successful management strategy if an artificial breaching is deemed necessary.

Cognizance should be taken of the fact that should breaching be attempted under dry conditions with little chance of follow-up river flow, it would be most likely to cause a major influx of marine sediment, resulting in a net increase of the sedimentation of the estuary, which would be to the detriment of the system as a whole.

To assist Management in deciding when and whether to open the mouth, the following is suggested:

- * Observations of the water level in the lagoon, together with available flow and rainfall data, should be recorded on a weekly basis by a responsible body.
- * By comparing these data to past trends, a conclusion should be reached as to whether a normal rainfall pattern is developing or not (Appendix A).
- * If a normal pattern is developing and the water level in the lagoon is reasonably high but at least at the recommended minimum level, a decision regarding breaching should be made not later than July each year. This would ensure that, if the mouth was opened towards the end of July (at the latest), enough follow-up fresh water flow would result in the optimal functioning of the mouth.
- * If an abnormally wet pattern is developing with much run-off during April, May and June, a decision to breach the mouth before the end of July should be made.

- * If an abnormally dry pattern is developing with little rain and run-off during the months preceding the end of July, the mouth should not be breached even if late spring rains cause the lagoon level to rise. Should late spring rains cause the water level in the lagoon to rise to within the danger area and breaching is unavoidable, it is of the utmost importance that the mouth be opened at the recommended position and time of month, as discussed above.

Should it become necessary to breach the Klein River mouth artificially, the following is recommended:

- * The mouth should be opened at a point between 50 and 150 m north-west of existing beacon PA100, which is situated on the south-eastern side of the sand berm. The recommended method should be followed at all costs and the mouth should not be breached before or after two hours before spring low tide.
- * A lagoon water level of +2,1 m MSL should be the minimum level to be reached prior to breaching. Although a lagoon water level equal to the natural height of the sandberm is considered to be the optimum level for the good functioning of the estuary mouth, a large number of structures (houses and boat-houses) are located below this level and could thus be damaged by the rising water. A balance between required water level (as high as possible) and estimated damage to property would have to be maintained.

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TABLE 1: AREA A (FIGURE 11)

NO	TYPE	FLOOR LEVEL (MSL)
1	HOUSE	+2,6
2	HOUSE	+3,2
3	BOAT-HOUSE	+2,3
4	HOUSE	+3,2
5	HOUSE (PREFAB)	+2,6
6	HOUSE	+2,9
7	HOUSE/BOAT-HOUSE	+2,4
8	BOAT-HOUSE	+2,0
9	BOAT-HOUSE	+2,1
10	BOAT-HOUSE	+1,9
11	BOAT-HOUSE	+2,2
12	HOUSE	+2,4

TABLE 2: AREA B (FIGURE 12)

NO	TYPE	FLOOR LEVEL (MSL)
1	BOAT-HOUSE	+2,1
2	HOUSE	+2,7
3	BOAT-HOUSE	+2,2
4	BOAT-HOUSE (BRICK)	+2,9
5	BOAT-HOUSE	+2,6
6	BOAT-HOUSE	+3,2
7	BOAT-HOUSE	+2,8
8	HOUSE (NO 28)	+3,1
9	HOUSE	+3,0

TABLE 3: AREA C (FIGURE 13)

NO	TYPE	FLOOR LEVEL (MSL)
1	HOUSE	+3,5
2	BOAT-HOUSE	+2,4
3	HOUSE	+3,0

TABLE 4: AREA D (FIGURE 13)

NO	TYPE	FLOOR LEVEL (MSL)
1	HOUSE (MR MOSER)	+2,7
2	BOAT-HOUSE	+2,4
3	BOAT-HOUSE	+2,1

TABLE 5: AREA E (FIGURE 14)

NO	TYPE	FLOOR LEVEL (MSL)
1	BOAT-HOUSE	+2,5
2	BOAT-HOUSE	+2,5
3	HOUSE	+3,0
4	HOUSE	+2,9
5	HOUSE	+3,1
6	HOUSE	+2,7
7	HOUSE	+3,2
8	BOAT-HOUSE	+3,0

TABLE 6: AREA F (FIGURE 15)

NO	TYPE	FLOOR LEVEL (MSL)
1	HOUSE	+4,4
2	BOAT-HOUSE	+2,5

TABLE 7: AREA G (FIGURE 16)

NO	TYPE	FLOOR LEVEL (MSL)
1	HOUSE	+3,1
2	HOUSE (NEW)	+4,1

A1 (ii) : AVERAGE RAINFALL ON TERTIARY CATCHMENT G24

(MONTHLY RAINFALLS EXPRESSED AS A PERCENTAGE OF CATCHMENT M.A.P. OF 568 HILL METERS)

	YR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
G24	24	8.92	6.98	0.75	4.52	0.43	1.53	5.81	4.31	34.94	16.40	6.29	9.85	100.73
G24	25	11.39	6.58	1.52	0.65	3.52	1.66	2.35	11.98	6.85	23.07	12.08	7.22	88.87
G24	26	17.68	6.51	0.0	1.57	4.39	3.04	6.20	13.88	11.25	7.49	17.78	4.83	94.62
G24	27	3.71	10.86	4.75	4.83	1.67	6.77	0.75	1.31	20.77	6.53	15.80	13.51	91.26
G24	28	1.94	6.05	5.04	0.10	3.12	3.46	10.19	6.34	8.54	18.91	12.61	2.73	79.03
G24	29	1.83	3.67	6.63	7.08	5.64	6.61	4.78	5.31	4.32	7.74	13.97	21.65	89.22
G24	30	4.38	7.72	1.57	0.86	2.54	1.94	13.14	7.47	5.59	16.34	21.75	12.40	95.70
G24	31	14.85	0.57	5.93	3.94	8.34	1.25	1.76	13.70	13.97	14.16	6.98	20.17	105.62
G24	32	5.74	1.70	4.30	1.28	2.01	3.00	3.51	10.91	24.77	14.79	15.83	5.91	93.75
G24	33	4.81	2.59	1.16	2.03	3.10	1.84	1.06	9.87	10.32	12.07	14.63	14.28	77.76
G24	34	14.72	3.05	0.34	0.72	0.58	4.00	11.52	16.28	11.77	11.25	6.53	8.35	89.11
G24	35	3.32	11.40	2.61	10.70	2.37	4.71	2.75	13.72	7.47	11.15	9.81	10.67	90.68
G24	36	5.52	11.01	9.83	0.97	0.16	4.90	5.15	4.02	22.41	25.11	3.91	12.90	105.89
G24	37	5.17	4.77	5.31	4.10	1.04	6.29	9.06	12.86	8.29	9.45	12.83	21.99	101.16
G24	38	8.11	3.80	1.97	0.25	9.62	6.12	8.51	9.21	2.20	13.15	16.65	3.99	83.58
G24	39	5.49	5.35	2.61	2.06	15.80	4.10	14.35	6.40	17.41	8.02	3.03	7.39	92.01
G24	40	4.84	11.42	0.70	5.09	0.79	0.25	19.87	21.30	18.75	9.90	11.49	18.64	123.04
G24	41	8.40	4.54	3.66	2.48	1.62	2.51	3.68	16.25	16.57	4.32	10.18	6.74	80.95
G24	42	3.53	0.75	9.07	15.27	4.10	9.78	8.40	10.80	4.39	11.93	12.98	8.46	99.46
G24	43	4.85	12.71	3.11	2.74	0.07	1.80	5.06	17.27	30.17	5.99	17.93	18.90	120.60
G24	44	4.07	2.04	4.56	1.02	0.11	0.74	9.41	30.40	24.49	20.27	18.73	1.36	117.20
G24	45	17.08	4.41	1.00	1.02	0.88	12.79	3.71	5.47	8.49	9.32	8.38	14.59	87.14
G24	46	4.15	1.63	1.20	0.13	0.11	10.50	6.31	9.99	8.66	24.30	6.77	5.97	79.72
G24	47	7.58	4.33	0.92	1.56	1.40	10.82	5.59	8.68	8.18	13.77	3.69	11.73	78.25
G24	48	23.64	1.60	2.31	2.00	0.54	0.88	14.55	11.19	6.88	8.86	12.58	8.64	93.67
G24	49	5.25	12.53	2.44	0.44	0.06	0.47	13.79	3.18	4.74	22.26	2.32	14.08	81.56
G24	50	7.77	15.64	6.08	12.76	0.61	3.97	15.12	7.13	29.80	17.41	14.12	15.03	145.44
G24	51	3.84	3.89	0.56	0.51	3.14	2.81	5.80	11.52	9.21	14.17	17.16	12.36	84.97
G24	52	6.34	19.65	1.59	0.43	1.21	1.37	11.66	10.86	8.95	15.94	9.24	3.47	90.71
G24	53	5.28	13.37	1.51	1.91	2.79	5.52	8.68	29.63	17.22	26.74	22.85	5.83	141.33
G24	54	4.60	4.77	3.99	0.82	20.64	1.01	6.03	3.52	15.33	22.22	29.07	7.35	119.35
G24	55	13.39	5.52	1.01	0.71	3.15	5.08	5.69	20.50	20.09	10.71	15.68	4.48	106.01
G24	56	11.39	1.39	8.32	0.78	8.15	6.32	5.54	30.49	30.50	17.76	22.67	11.41	154.72
G24	57	23.03	0.70	0.05	0.64	5.01	10.87	9.26	22.07	11.48	0.70	24.92	2.78	111.51
G24	58	9.43	3.71	1.07	3.04	2.94	4.76	22.63	20.17	4.59	9.08	22.95	8.25	112.62
G24	59	13.37	0.63	2.65	3.44	0.70	5.63	4.06	10.65	18.60	9.55	5.25	6.11	80.64
G24	60	3.39	0.69	6.04	10.99	1.94	3.32	4.41	10.02	9.23	10.40	19.26	14.11	93.80
G24	61	8.11	0.05	1.57	6.88	3.75	9.47	9.22	4.68	26.06	10.06	29.02	5.39	114.26
G24	62	20.09	7.74	0.45	4.43	0.14	2.81	5.01	6.58	10.34	22.41	22.39	1.85	104.24
G24	63	3.98	9.43	6.82	2.42	3.15	8.87	4.51	6.47	22.14	15.00	19.93	6.33	109.05
G24	64	5.63	12.99	0.30	2.26	7.10	9.70	7.25	13.42	4.86	10.72	8.93	3.69	86.85
G24	65	8.05	4.98	6.88	1.56	0.98	5.77	6.16	5.93	6.82	12.57	18.07	11.90	89.67
G24	66	1.14	1.53	0.66	0.58	0.41	5.02	23.74	7.77	20.52	11.32	12.58	5.84	91.11
G24	67	9.12	6.16	1.25	2.54	3.53	1.72	5.47	15.89	16.94	9.15	13.12	2.14	87.03
G24	68	10.03	5.16	2.11	6.01	4.79	3.08	13.25	2.37	12.61	7.07	7.88	6.40	80.76
G24	69	9.49	3.56	0.50	1.41	5.13	1.07	0.68	11.35	17.54	15.34	18.94	7.94	92.95
G24	70	5.47	1.97	4.29	1.07	2.93	4.24	4.57	9.52	11.68	18.77	19.95	5.69	90.15
G24	71	6.78	4.90	8.40	4.17	6.06	3.98	13.79	10.19	9.04	8.52	15.06	7.27	98.16
G24	72	2.70	1.23	2.68	1.66	1.20	1.93	3.92	7.06	4.25	17.06	8.61	11.02	63.32
G24	73	3.94	3.54	3.29	1.15	1.15	4.19	0.55	13.88	8.69	7.82	39.87	13.10	101.17
G24	74	13.28	3.13	1.34	4.27	0.77	1.75	4.27	16.56	8.93	20.05	17.94	3.69	95.98
G24	75	9.96	2.72	0.25	0.03	2.60	5.33	12.10	7.40	30.88	15.59	11.09	9.49	107.44
G24	76	5.94	15.79	8.50	1.67	8.94	6.10	8.64	21.25	19.50	24.45	14.62	9.02	144.42
G24	77	2.28	6.45	7.21	2.28	1.84	4.21	6.75	3.86	5.52	10.07	18.94	7.79	77.20
G24	78	9.47	1.02	5.45	4.99	16.60	0.22	0.17	14.21	11.60	11.17	11.85	7.69	94.44
G24	79	10.17	0.27	0.37	4.89	1.91	0.0	5.52	8.89	16.75	0.81	7.29	2.94	59.81
MEAN		8.20	5.69	3.26	3.07	3.61	4.42	7.78	11.81	14.29	13.70	14.90	9.27	

FROM: PITMAN et al. (1981)

(KLEIN RIVER)

YEAR	RECORDED RUNOFF AT GAUGE CAM06	CATCHMENT AREA= 600.50.KM	SEP	AUG	JUL	JUN	MAY	APR	MAR	FEB	JAN	DEC	NOV	OCT	TOTAL	ACCUMULATED
1953	1.76	0.11	0.26	0.78	0.75	6.91	8.30	15.90	4.44	40.59					40.59	
1954	2.37	0.31	0.02	0.02	0.50	2.33	6.74	2.75	1.41	22.25					62.84	
1955	2.99	0.14	0.00	0.00	0.00	0.03	1.43	12.30	4.39	30.39					93.23	
1956	1.50	0.00	0.00	0.00	3.12	15.50	5.97	11.20	3.91	45.05					130.28	
1957	3.93	0.06	0.00	0.00	0.00	8.42	2.08	5.55	2.13	22.85					161.13	
1958	1.43	0.02	0.00	0.00	1.28	1.35	1.18	1.16	1.56	7.67					168.80	
1959	1.11	0.00	0.00	0.00	0.00	0.00	0.00	12.20	0.84	23.67					192.47	
1960	2.44	0.00	0.00	0.00	0.00	0.00	0.00	25.00	4.70	236.15					280.36	
1961	2.78	0.62	0.00	0.00	4.03	2.66	12.40	20.70	4.93	42.17					284.50	
1962	1.15	0.00	0.00	0.00	0.00	0.53	1.22	1.22	0.89	4.14					327.53	
1963	0.33	0.00	0.00	0.00	0.00	0.00	0.00	28.80	14.30	43.43					327.53	
1964	2.23	0.02	0.00	0.00	0.00	0.00	0.00	7.97	3.47	15.17					343.10	
Σ TOTAL	7.00	0.41	0.08	1.35	2.54	11.50	13.37	42.22	16.87	100.00						

MEAN(-JG)= 1.369244 STD. DEV.= 0.331626 MEAN ANNUAL RUNOFF= 28.59 MILLION CUBIC METRES

YEAR	RECORDED RUNOFF AT GAUGE G4M07	CATCHMENT AREA= 465.50.KM	SEP	AUG	JUL	JUN	MAY	APR	MAR	FEB	JAN	DEC	NOV	OCT	TOTAL	ACCUMULATED
1963	11.90	3.99	2.40	3.99	10.80	33.20	34.70	52.40	24.00	189.32					189.32	
1964	14.70	2.42	5.66	12.50	9.71	16.30	22.50	37.60	13.20	173.78					363.10	
1965	11.00	4.09	4.99	10.10	9.71	16.30	22.50	37.60	30.00	212.27					575.37	
1966	7.99	1.25	0.42	1.30	32.00	62.20	56.10	41.00	18.40	200.09					775.46	
1967	23.70	2.24	3.10	1.30	32.00	56.50	47.90	46.90	14.80	238.65					1014.11	
1968	28.70	2.12	3.89	8.17	6.40	13.70	21.50	21.20	20.40	146.55					1160.66	
1969	23.60	4.91	1.26	0.98	8.41	37.20	40.40	46.30	38.50	205.42					1366.08	
1970	15.60	1.56	1.26	1.64	4.56	8.04	43.40	42.50	18.40	146.28					1512.36	
1971	6.55	1.02	1.06	2.15	2.38	20.00	9.52	28.50	19.30	126.97					1512.36	
1972	11.80	2.10	1.74	2.38	4.13	31.70	31.70	28.50	33.20	105.01					1744.14	
1973	21.80	1.74	0.94	2.38	4.13	31.70	31.70	28.50	33.20	105.01					1744.14	
1974	14.57	1.51	0.21	1.64	4.30	19.00	11.80	51.00	39.80	265.82					2009.24	
1975	19.60	3.55	0.89	2.45	20.30	24.70	48.60	51.00	14.00	191.59					2400.83	
1976	12.30	2.24	0.89	1.95	6.66	47.85	34.11	26.60	26.80	422.04					2822.87	
1977	8.74	2.21	1.56	1.34	6.66	67.55	67.55	20.60	32.50	125.81					2948.69	
1978	23.30	1.99	0.97	1.95	18.80	40.40	25.90	23.50	19.10	173.90					3122.52	
1979	31.50	1.74	0.97	4.49	22.90	25.00	14.10	16.90	11.80	149.58					3272.16	
Σ TOTAL	9.09	1.66	0.94	3.15	9.20	16.49	17.64	23.63	11.74	100.00						

MEAN(-JG)= 2.261057 STD. DEV.= 0.141183 MEAN ANNUAL RUNOFF= 192.48 MILLION CUBIC METRES

YEAR	RECORDED RUNOFF AT GAUGE G5M08	CATCHMENT AREA= 302.50.KM	SEP	AUG	JUL	JUN	MAY	APR	MAR	FEB	JAN	DEC	NOV	OCT	TOTAL	ACCUMULATED
1964	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.05	0.41	
1965	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.41	
1966	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.41	
1967	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.41	
1968	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	
1969	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	
1970	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	
1971	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.41	
1972	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	
1973	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	
1974	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	
1975	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	
1976	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	
Σ TOTAL	14.39	0.75	0.05	3.49	3.58	27.52	24.87	19.21	6.13	100.00						

MEAN(-JG)= 0.429136 STD. DEV.= 1.762391 MEAN ANNUAL RUNOFF= 5.11 MILLION CUBIC METRES

TABLE BI Allocated points based on mouth performance as described
by Mr E G Franks.

YEAR	POSITION	POINT	YEAR	POSITION	POINT
1948	EAST	2	1966	EAST	2
1949	EAST	1	1967	EAST	2
1950	EAST	2	1968	WEST	1
1951	EAST	2	1969	WEST	1
1952	WEST	2	1970	EAST	2
1953	WEST	2	1971	EAST	2
1954	WEST	2	1972	MIDDLE	1
1955	EAST	2	1973	-	0
1956	EAST	2	1974	MIDDLE	1
1957	MIDDLE	1	1975	MIDDLE	1
1958	MIDDLE	1	1976	MIDDLE	2
1959	MIDDLE	1	1977	MIDDLE	2
1960	MIDDLE	1	1978	EAST	2
1961	MIDDLE	1	1979	EAST	2
1962	MIDDLE	1	1980	EAST	1
1963	EAST	2	1981	EAST	2
1964	EAST	2	1982	WEST	1
1965	EAST	2	1983	WEST	2
			1984	WEST	1

OPENING OF THE HERMANUS (KLEINRIVIER) LAGOON

OPENINGS

- 1948: On the "East": This was the year when a family was washed out to sea and two people drowned.
- 1949: On the East side:
- 1950: On the East side: This was the year when the writer started fishing on the Lagoon; at that time the out-flow was tremendous at Spring tides and the in-flow so great two anchors were needed to hold a small boat and the fishing was excellent.
- 1951: On the East side: The above remarks apply. One could see large steenbras standing on their heads feeding in shallow water as the tides came in (Kopstanders).
- 1952: On the West side: There was then a fairly deep channel leading to the sea on this side and the flow was almost as good as the East side openings and the fishing good but this channel has long since silted up due to "middle" openings.
- 1953: On the West side: The above remarks apply.
- 1954: On the West side: "
- 1955: On the East side: Again excellent out and in-flow and good fishing, etc.
- 1956: On the East side: Ditto. N.B. This opening remained open until March of the following year and the flow was so good that galjoen came in with the tide and were caught in large numbers.
- 1957 and 1958: In the Middle: This was the start of the "bad openings" and the eventual silting up of the West side channel and damage to the Lagoon. Only the surface water could run off and the Lagoon could not drain efficiently neither could large fish get in or out. The Middle opening was deliberately done with the object of obtaining the earliest possible closing of the mouth so that Jeeps etc could be driven across. One man is believed to have been responsible for this.
- 1957: In the Middle: Yes. This series of "Middle" openings brought about a rapid fall-off in the flow of water and scouring effect, an accumulation of weeds, and an almost complete lack of worth catching fish. This went on for the next five consecutive years until the angling public rose in protest and formed an association and pressure was brought to bear to have the lagoon properly opened.
- 1958: In the Middle: Yes.
- 1959: In the Middle: Yes.
- 1960: In the Middle: Yes.
- 1961: In the Middle: Yes.
- 1962: In the Middle: Yes.

An association was hurriedly formed and a deputation approached Mr. Milton the Forestry Officer, and asked him if he wouldn't open the Lagoon either on the East or West side. This he refused to do. The Association then called a meeting and, after much discussion, approached the Government and various bodies concerned with Conservation, inland waters, etc. etc., and a large meeting was held in situ and it was decided that the Lagoon should be opened for five consecutive years on the East side and the matter brought up for review after that period; unfortunately,
as/.....

as it turned out, this was construed by the protagonists of the West side, that this automatically meant that it would be opened there at the expiry of the five years and this was done and proved disastrous.

- 1963: The East side: The result of this opening exceeded all expectations and the flow was wonderful and the fishing spectacular.
- 1964: The East side: This was again a good year as were the following three.
- 1965: The East side:
- 1966: The East side:
- 1967: The East side: This was the last of the "good years" for some time and the flow and fishing excellent and lasting until well into April 1968.
- 1968: On the West side: Having decided that "the East had its turn" it was opened on the West side in spite of warnings that it would not flow and the net result was that only surface water drained off and no big fish could get in and there was practically no scouring effect to remove weeds and rubbish. Only one large fish was caught and the majority were undersize to minute.
- 1969: On the West side: On the principle that "it will take time to develop" it was opened again on the West side with very much the same result, although an artificial channel had been pre-dug before the Lagoon filled, and the mouth remained open for four weeks, as against one the previous season!!
- 1970: On the East side: Pressure having been brought to bear, the Lagoon was once more opened on the East side with again spectacular results as to flow and fishing and most people with any real knowledge of the Lagoon were satisfied.
- 1971: On the East side: This was again a very good opening with similar results to the previous year.
- 1972: In the Middle: After a great deal of controversy about the East or West side opening and on the excuse that "no one could make up their minds" it was opened in the Middle once more with the result that enormous damage was done and the West side was finally silted up for good. Only surface water was able to escape and no fish of any size were able to enter with the result that people were catching numerous under-sized fish.
- 1973: No opening: For the first time in living memory the winter rains were so poor that the Lagoon never filled up and could not be opened so the position remained static.
- 1974: In the Middle: It had been hoped that a lesson would have been learned from the 1972 opening but, in spite of this, it was again opened in the Middle and further damage, silting and weeding-up took place and no large fish could get in neither could they get out.

There the position remains and the power still seems to be in the hands of the one man who has the "say" and, in the writer's opinion, unless something is done soon the Lagoon will be ruined for good.

1975/.....

1975: In the Middle: Comments more or less in line with the 1974 opening. Opened 26.9.75 - closed 6.10.75.

1976: In the Middle: Ditto. Opened 21.6.76 - closed 31.12.76.

1977: In the Middle: Ditto. Opened 28.6.77 - closed 10.10.77.

It is believed that this coming opening is of vital importance if the lagoon is to be saved and the weeds washed away, but it is said that it will either be in the middle again, which will lead to the final ruination of the lagoon as a tourist attraction, or on the West side which cannot work owing to the complete sanding up of that old channel. Apart from every aspect of the opening it is a great pity that every year the lagoon is opened long before it is properly full, with the assistance of bulldozers, etc., at the behest of the Stanford farmers whose lagoon-side land becomes flooded, and the initial rush of water which would do much to clear the lagoon of weeds and rotting rubbish, is lost.

It is a great pity that the opening of the lagoon is undertaken by people who have little knowledge and less interest in it, or so it would appear.

1978: East side: Opened 5.9.78 - closed 15.1.79. Strong pressure was made by the anglers interested to open the lagoon this year as near to the sand dune in the East as possible. The Forest Officer, Mr. Fourie and Mr. Eksteen of the Divisional Council were in complete agreement with the above, and the lagoon was opened on September 5th 1978. The result was a great success. A large portion of the man-made dune was washed away and the channel moved more to the East. Angling was excellent, until illegal netters got busy at night and the fish catches tailed off. However, the lagoon remained open until 15th January 1979 leaving a large area of water and excellent yachting was experienced during the summer. The general feeling is that the lagoon should be left for nature to open it but failing this the next opening should be right next to the sand dune which will eventually lead to the opening being opposite the old and deep channel running in front of Winter Bay towards the Foresters' jetty and which never silts up.

1979: On the East side: Opened 24.7.79 - closed 22.3.80. As in 1978 it was agreed by the Divisional Council (Rep.) and the Forestry Officer that the opening be made next to the artificial man-made sand dune and this operation was a complete success. Many "old timers" stated that it was many years since such a rush of outgoing water had been seen, taking with it debris of all sorts which had accumulated in the lagoon.

Many metres of the artificial dune were washed away enabling the original Eastern channel to have a more direct route to the sea and so bringing the opening back to the way nature had made it many many years ago. The fact that the mouth remained open for nearly eight months during which excellent angling was experienced, plus first class yachting in the lagoon, more than justified the Easterly opening.

It is understood that the 1980 opening will be in the same position as 1979 which should guarantee another successful operation.

the 11th & 16th of March 1980 two unsuccessful attempts were made to open it but it appeared that it was not full enough for the volume of water to really get going on its outward rush and it closed on its own on March 22nd 1980. It remained closed until November 18th when another attempt was made to open it, this proved partially successful & it remained open until January 12th 1981 when it closed on its own accord through lack of sufficient rain.

1981. EAST SIDE.

Between January 13th & February 7th 192 mm of rain fell and the lagoon became fuller than it has been for decades. The result was that 'Papa Eksteen', the Divisional Council Representative & a couple of labourers were able to open the Bar with spades on February 7th. This opening proved to be another 'clean out' of the lagoon, & at the time of writing this record June 14th it is still open & running strongly from spring tide to spring tide. An excellent feature of this last opening is that the 'man made' dune on the East side of the mouth has been scoured away by some 50 or more meters, it means that nature has taken a hand again removing a lot of this dune which has been blocking the main channel ever since the Forestry Dept, consolidated the sand dunes all along the Plaat, too near the sea, some 10-15 years ago. Angling has been good but mostly small to medium sized White Steentbras plus eft & leervis in reasonable quantities. Unfortunately the local conservation officer resigned and plans are being made to replace him. In the meantime illegal trekkers are 'having a ball' and greatly disturbing the fish life.

Just prior to the end of June 1981 very heavy seas & swells were experienced caused by a S.W. Gale & vast quantities of sand was washed into the mouth of the lagoon with the result that a sand bar was formed & the mouth closed on June 27th. During the following spring tides a large volume of water poured over the sand bar & the level of the lagoon was raised quite a lot. Our rainy season is now upon us and the lagoon should fill rapidly. A new Nature Conservation Officer was appointed at the beginning of July 1981. 85 mm of rain fell during the first 12 days of July and the lagoon is just about full.

15/7/81.

OPENINGS

1981 EASTSIDE

Cwing to excellent rains during July (128 mm) the Divisional Council opened the Lagoon on the 25th July, 1981, and made an excellent job indeed. Further inroads were made by the strong volume of water rushing out on the man made dunes (Forestry Department) and many more metres disappeared. The result is that the original deep channel running across the front of Winter Bay has improved its outlet to the sea. This channel is now more in line with what it was some 50 years ago and is still running strongly in between tidal movements. After nearly nine months the Lagoon mouth closed naturally on April 18th 1982. During this period the Lagoon water was being refreshed every day with tidal sea water, and it remained clean and healthy right through the summer season. There was easy access to Die Pond by holiday makers and the general public. Angling was excellent and full scope was available for yachting.

August 23rd 1982. The Lagoon was closed for four months and was over three-quarters full. Another 50-60 mm of rain would have made it ready for opening again. It is hoped by those who have studied the Lagoon for many years, that an opening will be made on the eastern side again to ensure a repeat of the successful openings during the last four years.

1982 WEST SIDE

Alas, in spite of all the most satisfactory openings in the East in recent years, the Department of Nature and Environmental Conservation decided to open the mouth on the west side. This was carried out on September 4th, 1982. The Lagoon had been closed for four months and the latest opening only lasted for one month. A very weak outflow took place and compared to the easterly opening, much weed, bushes etc. were left in the Lagoon. In the eastern openings all this rubbish was usually washed out to sea. Many years ago, successful openings were made from the middle and west sides, but since the sand dunes all along Die Plaat were stabilised too close to the sea some 15 years ago by the Forestry Department, the level of the sand over Die Mond is much higher than it was. This movement of sand from Die Plaat, caused by a westerly drift, has silted up most of the popular fishing spots by covering up the black mussels, worms, red bait etc., which most fish feed upon.

The Forestry Department have agreed, through their representative, that when and as the sea erodes the consolidation, re-consolidation will only take place further inland out of reach of the sea. During the late 1930's there were no dunes next to the sea along Die Plaat and the beach was flat all along, past Soupie's Klip and beyond.

The Lagoon has now been closed for four months, but due to evaporation, lack of rain and mainly

DEC 1982

due to the fact that the Lagoon is not tidal, the level has not been so low for many, many years. Certain areas of the water are becoming stale and smelly and there is a general feeling that when the rains come the salinity of the water will be affected, causing fish to die, as in Lake Marina.

It has been observed that now the sand level is so high (near the sea) even spring tides and rough seas very rarely wash over into the Lagoon, as in previous years. This means that very little water overflows from the sea into the Lagoon.

On September 4th, 1982, it was decided to open the Lagoon from the west (the last time it was opened in the west was in 1969). It remained open for one month and closed on the 1st October 1982. It remained closed for eight months until July 1st, 1983. The Lagoon was very full then and partly with the assistance of a strong easterly wind, rough seas plus manual labour it was opened in the west again on 1st July 1983. It remained open for three months and closed on 1st October 1983.

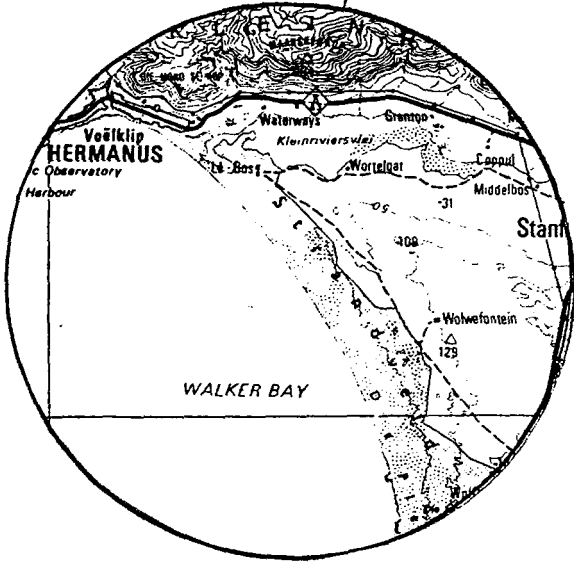
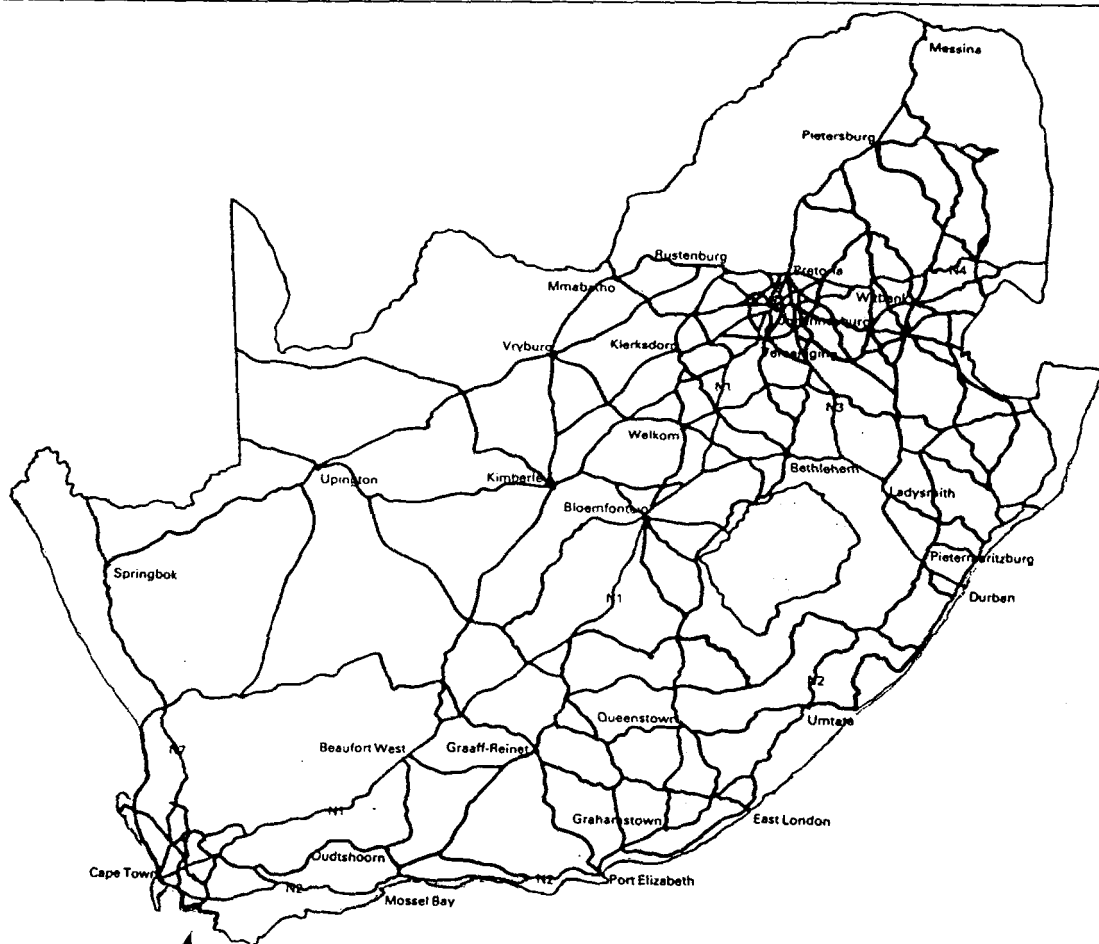
On 14th January 1984 it was decided to open the Lagoon on the western side in order to freshen up the Lagoon water. Thousands of harders had died and most of them were washed out to sea. The Lagoon was only approximately half full and there was not enough outflowing force to clean out the Lagoon thoroughly. The outflow lasted one week and it is now closed again - 21st January 1984.


During the closed period it is hoped that the builders will be instructed to take their sand from the eastern side to lower the level, as time has proved that the most successful openings have been made from the east. Records show that eastern openings remain open up to nine months. By lowering the sand level on the eastern side, spring tides will be able to wash over into the Lagoon and so keep the Lagoon cleaner for a longer period.

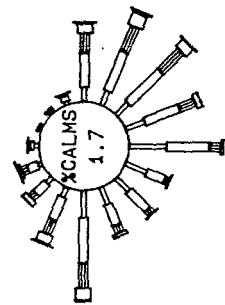
With an eastern opening the whole Mond is available to the holiday makers and their vehicles.

RAINFALL mm. WHEELKLIP AREA

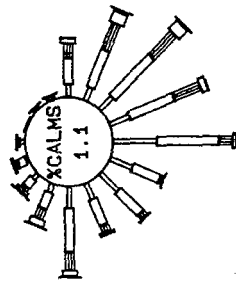
	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1973	24	6	10	47	64	79	59	41	58	13	36	31
1974	45	42	48	12	67	38	39	200	78	63	11	11.5
1975	35	3	21	53	63	37	77	97	43	93	29	6
1976	4	32	33	57	62.5	202	72	50	65	41	108	33
1977	23	108	54	85	112	98	131	84	60	20	66	56
1978	11	48	96	69	47	38	190	110	91	72	33	47
1979	40	163	11	3	142	91	75	55	54	39	17	25
1980	36	32	11	64	82	138	25	48	43	76	116	66
1981	135	72	52	148	15	53	126	136	82	28	35	22
1982	35	33	33	114	44	94	80	77	53	21	24	39
1983	16	112	52	40.5	138	140.5	111	81	61	41	22	14



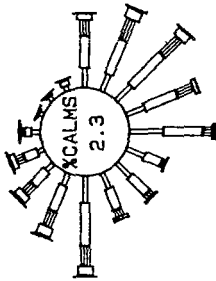
	<p>KLEIN RIVER</p> <p>LOCALITY PLAN</p> <p>CSIR-EMA</p>	<p>FIGURE</p> <p>1</p>
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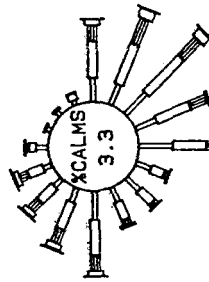
SPRING



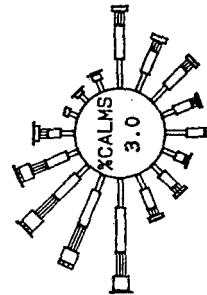
SUMMER



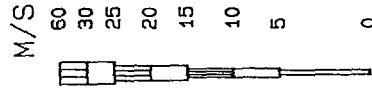
ALL YEAR



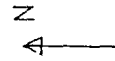
AUTUMN



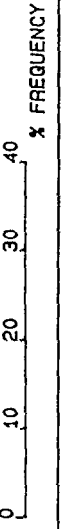
WINTER



WIND ROSE



AREA	34	0	-	35	0	LATITUDE (S)
	18	0	-	20	0	LONGITUDE (E)



KLEIN RIVER

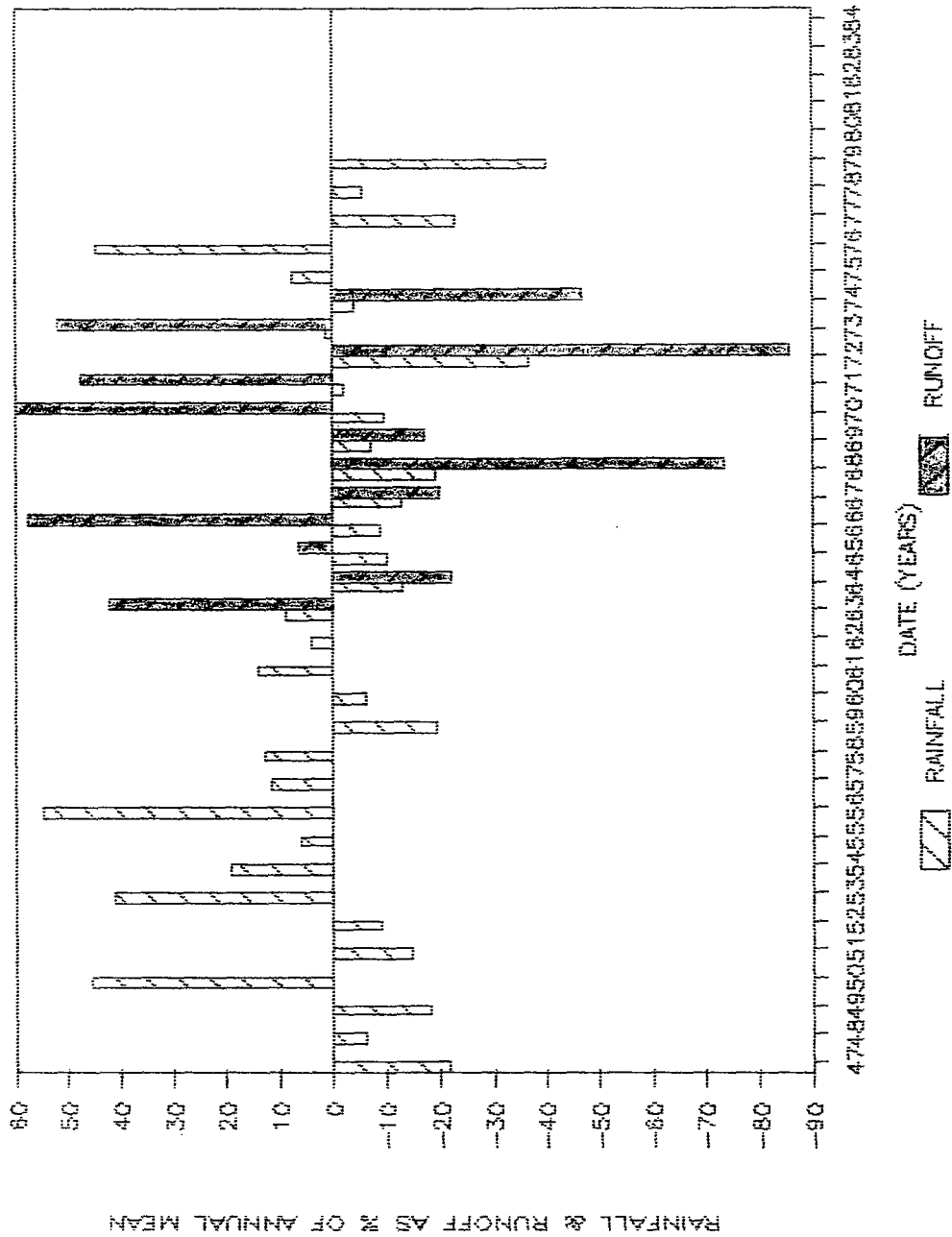
SEASONAL WIND ROSES (VOS)

FIGURE

2

KLEIN RIVER

TERTIARY CATCHMENT 624



KLEIN RIVER

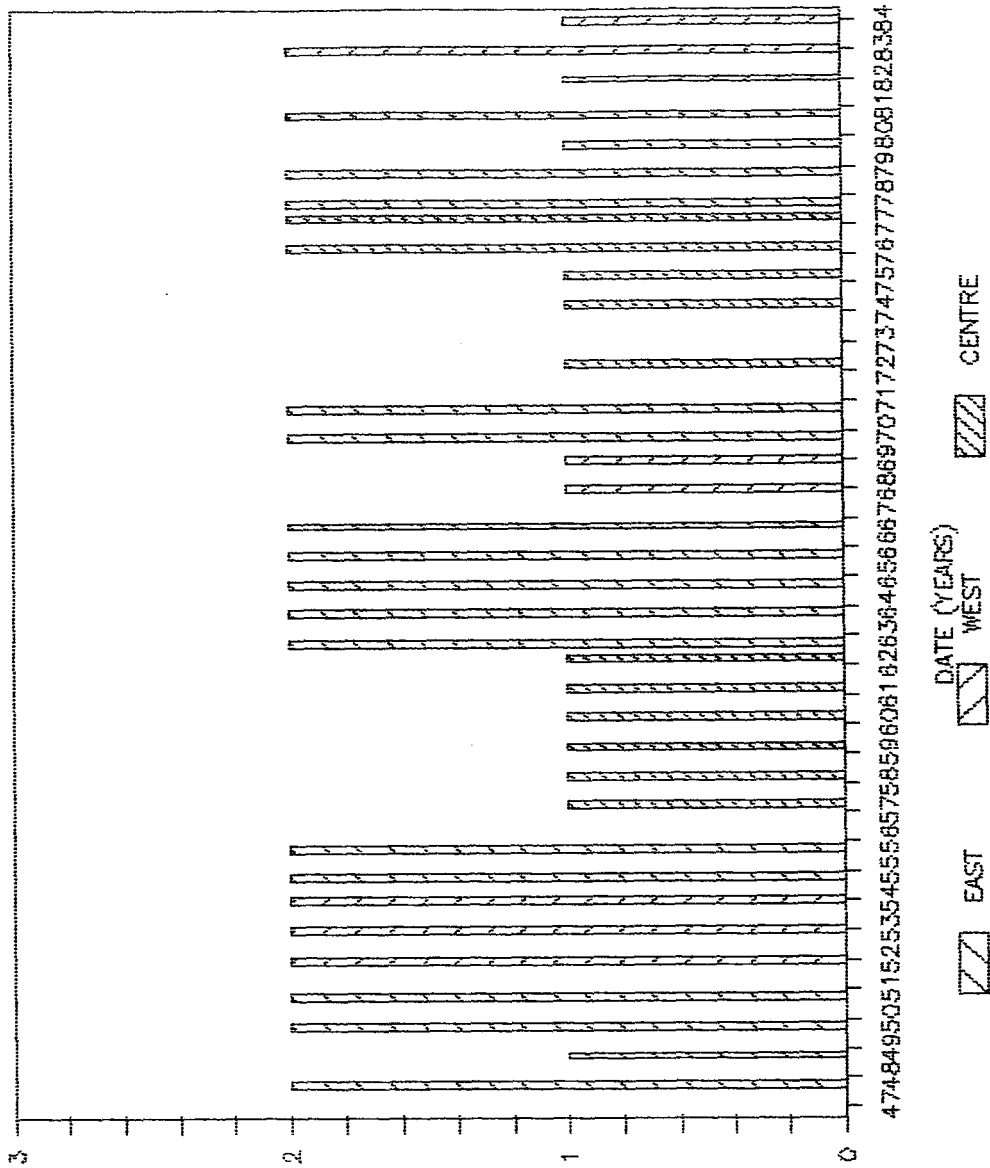
RIVER FLOW AND RAINFALL DATA

FIGURE

3

KLEIN RIVER

MOUTH CONDITION & POSITION

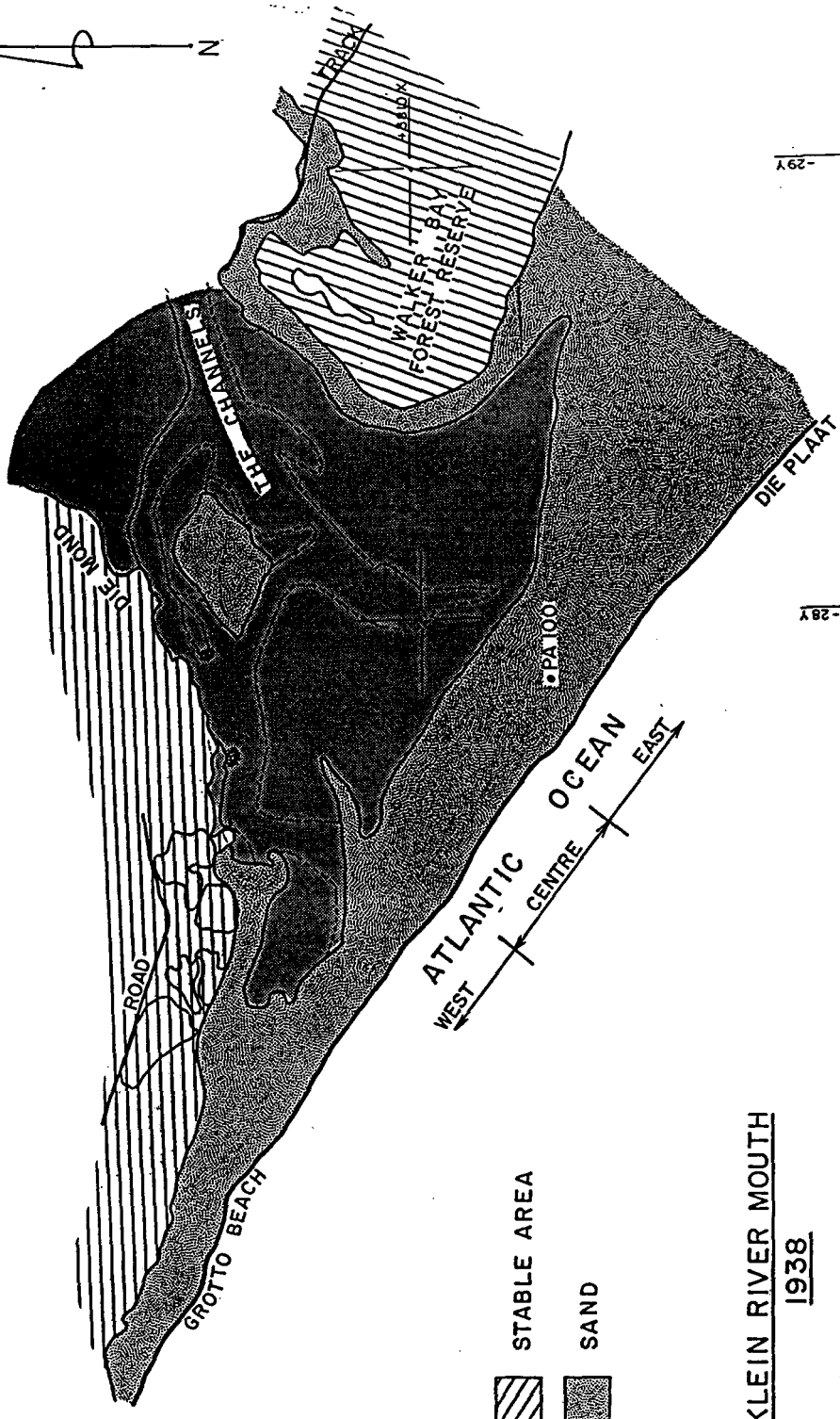
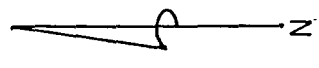


OPEN > 3 MONTHS = 2 , OPEN < 3 MONTHS = 1



KLEIN RIVER
MOUTH CONDITION AND POSITION

FIGURE
4



KLEIN RIVER MOUTH
1938

APPROXIMATE SCALE



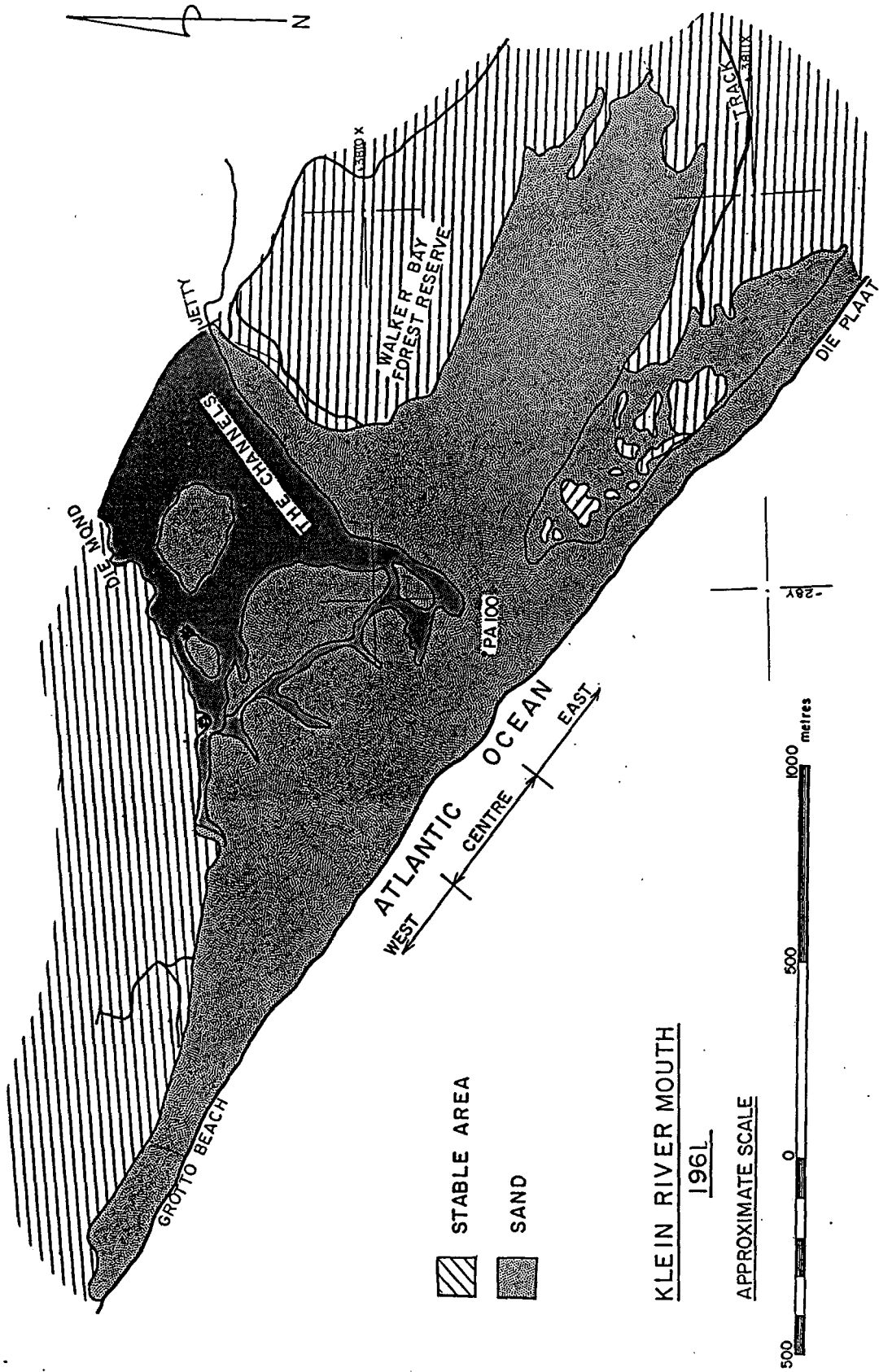
KLEIN RIVER

TRACING OF RIVER MOUTH: 1938

FIGURE

5

CSIR-EMA



KLEIN RIVER MOUTH

1961

APPROXIMATE SCALE



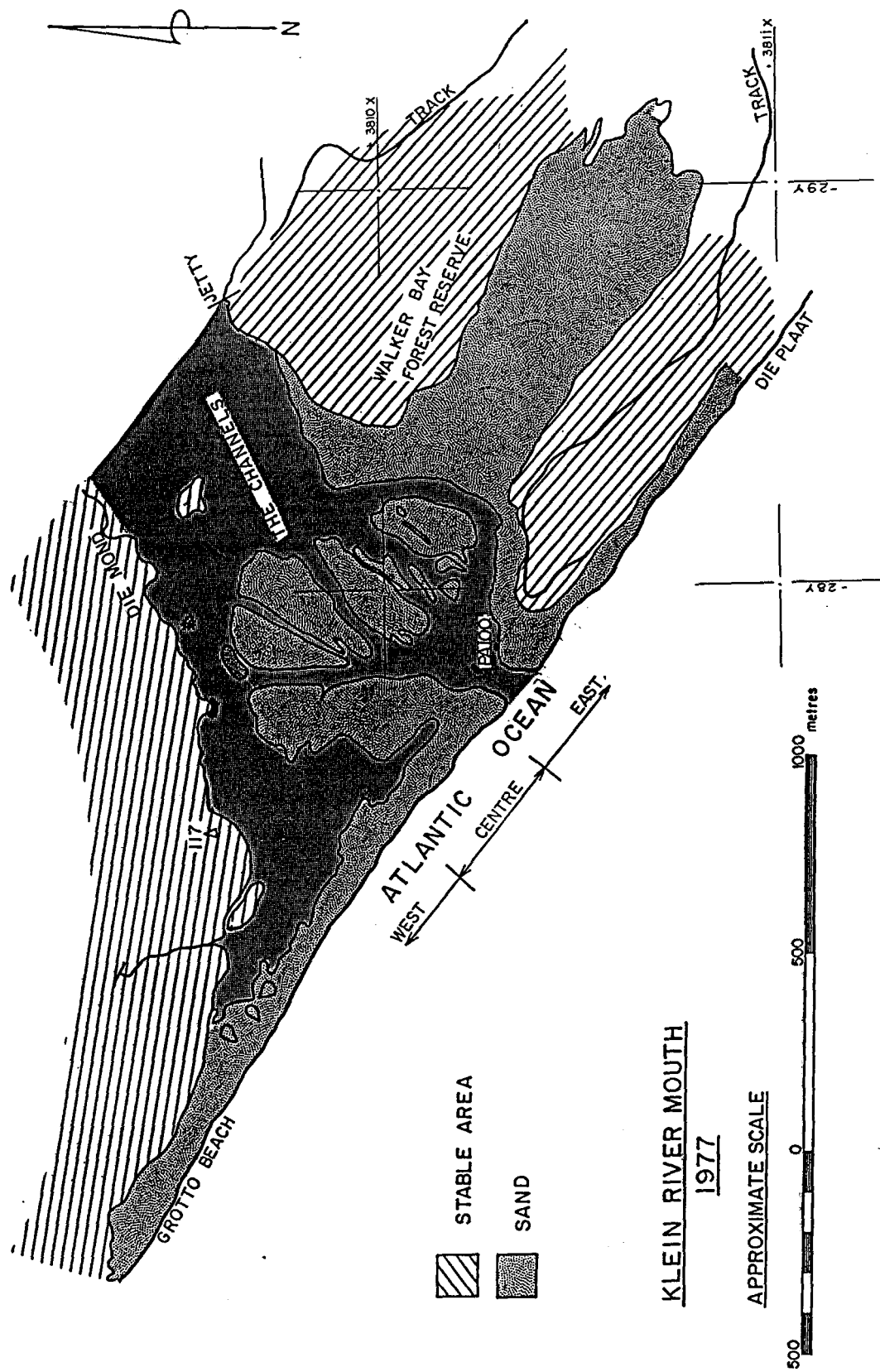
KLEIN RIVER

TRACING OF RIVER MOUTH: 1961

FIGURE

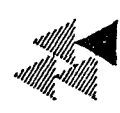
6

CSIR-EMA



KLEIN RIVER MOUTH
1977

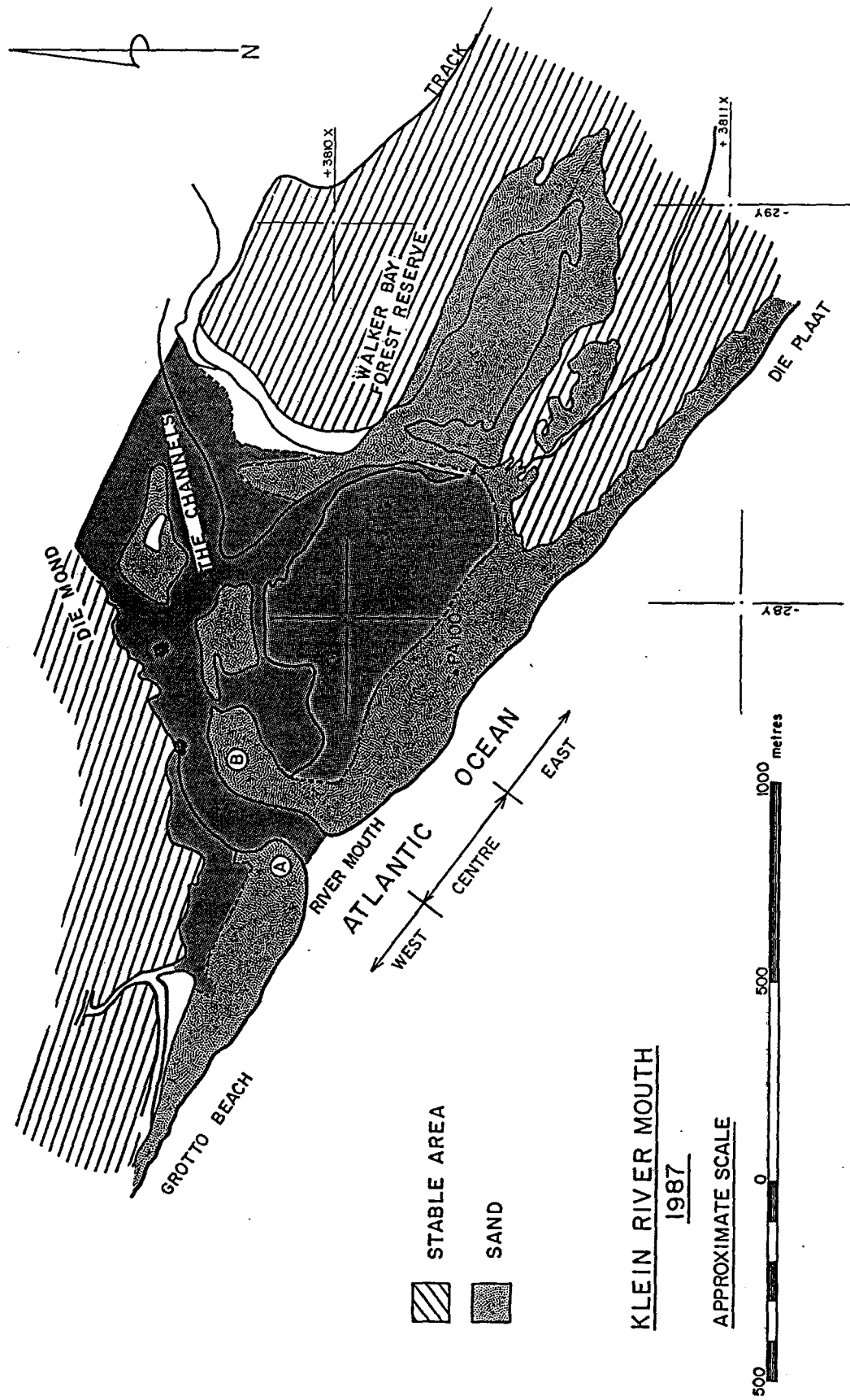
APPROXIMATE SCALE



KLEIN RIVER
TRACING OF RIVER MOUTH: 1977

FIGURE

7

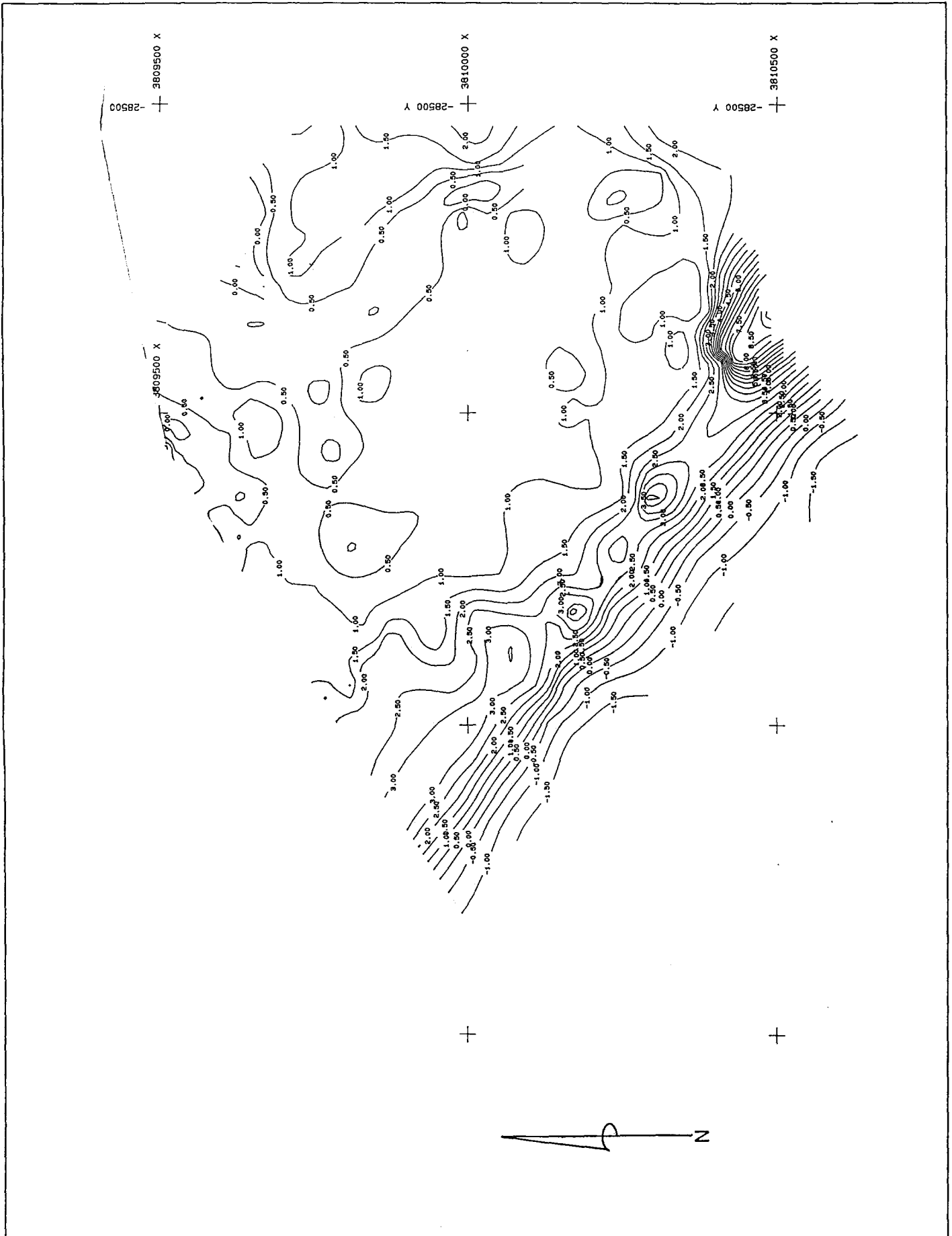



KLEIN RIVER MOUTH
1987
APPROXIMATE SCALE

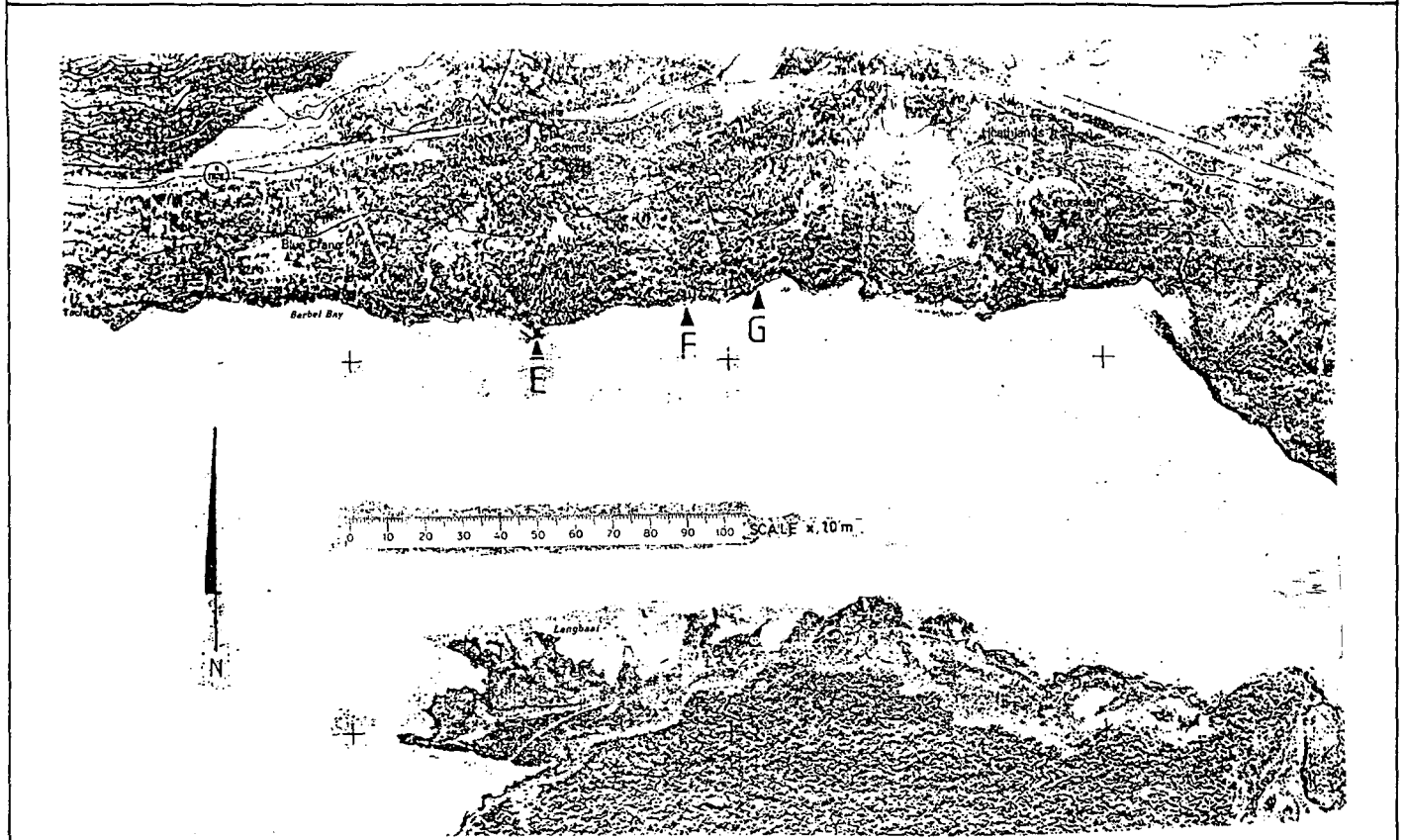
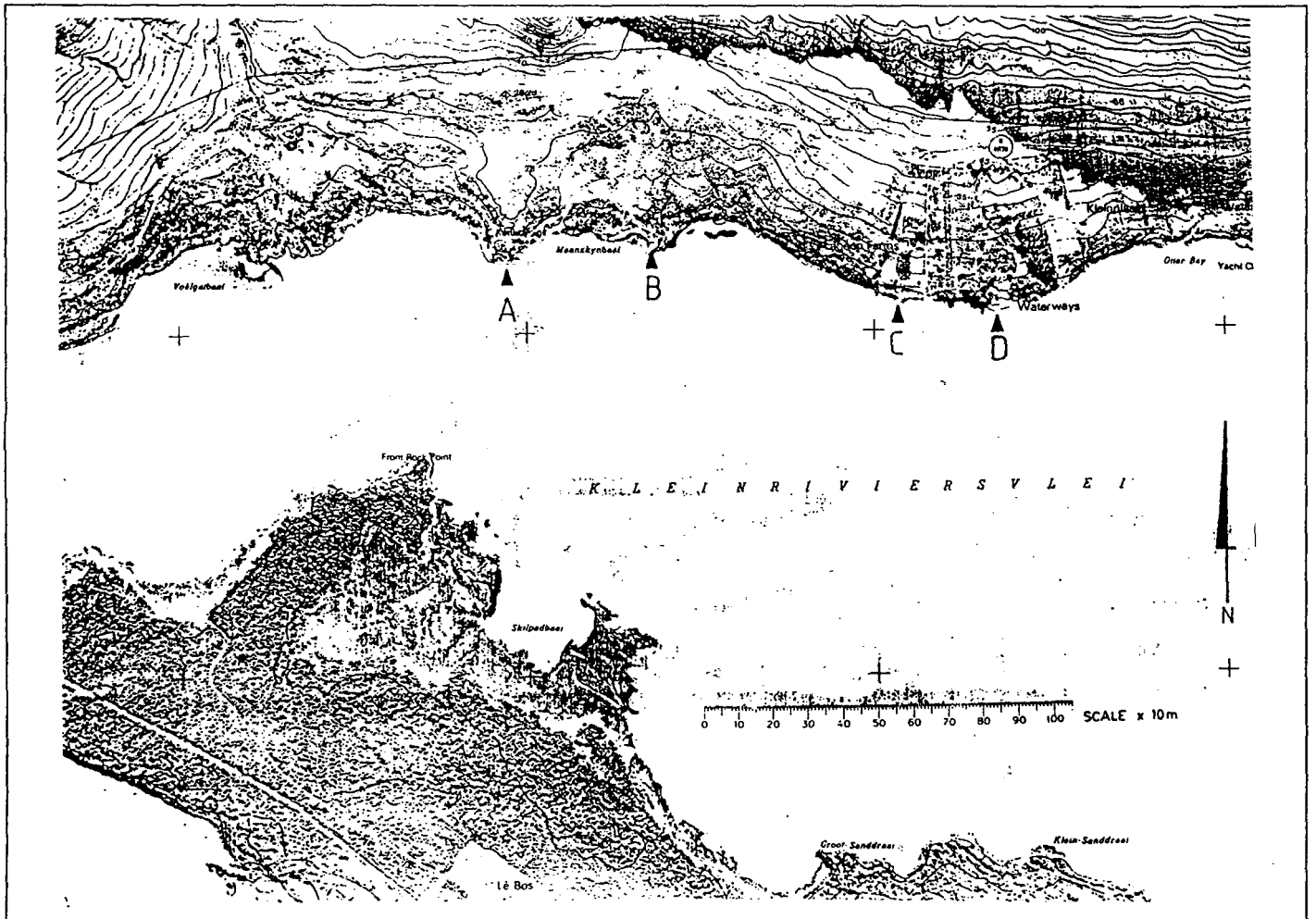



KLEIN RIVER
TRACING OF RIVER MOUTH: 1987

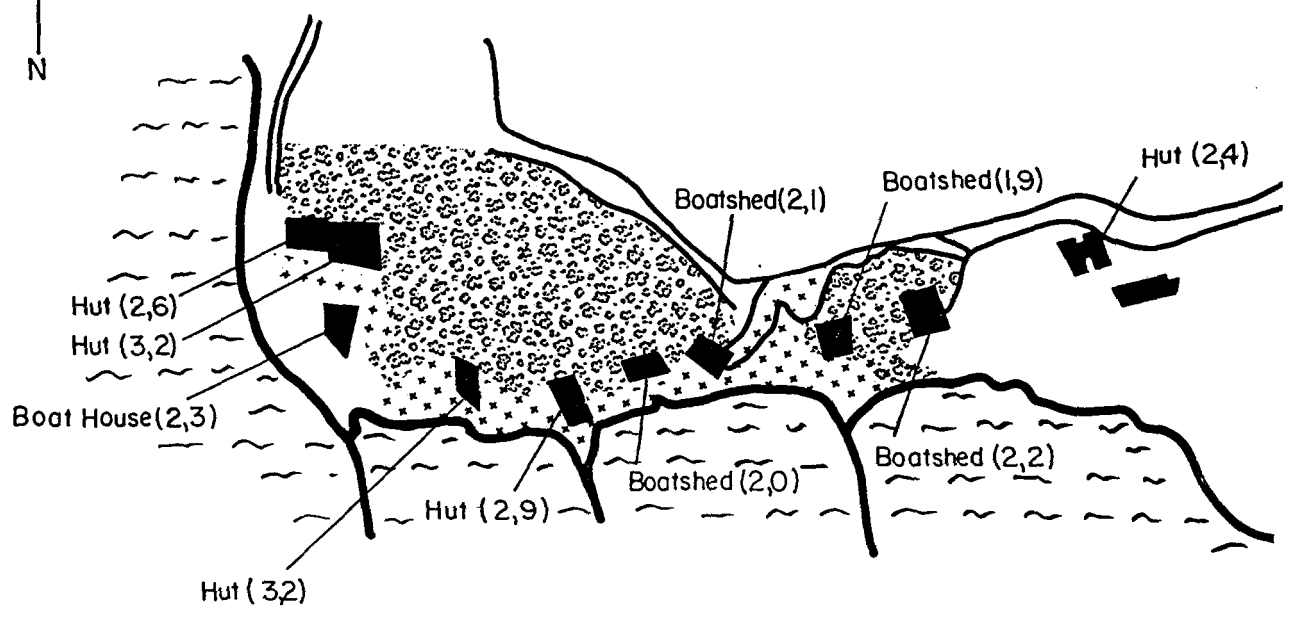
FIGURE
8






	<p style="text-align: center;">KLEIN RIVER</p> <p style="text-align: center;">CONTOUR MAP: 28 JUNE 1988</p>	<p style="text-align: center;">FIGURE 9</p>
<p>CSIR-EMA</p>		



	<p>KLEIN RIVER</p> <p>GENERAL PLAN OF ESTUARY</p> <p>CSIR-EMA</p>	<p>FIGURE</p> <p>10</p>
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-  Water
-  Sand
-  Vegetation



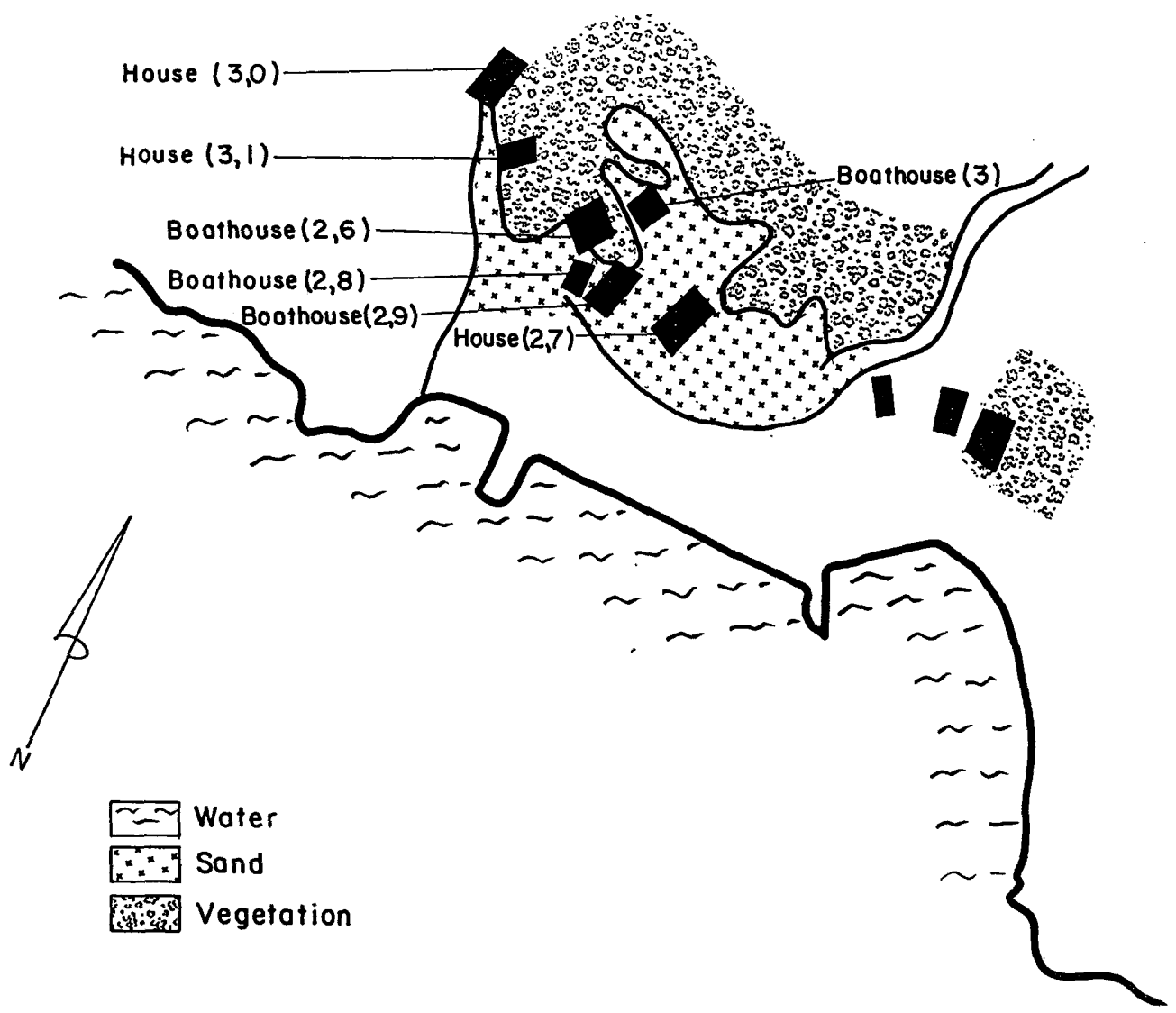
KLEIN RIVER




TRACING OF AREA A


FIGURE

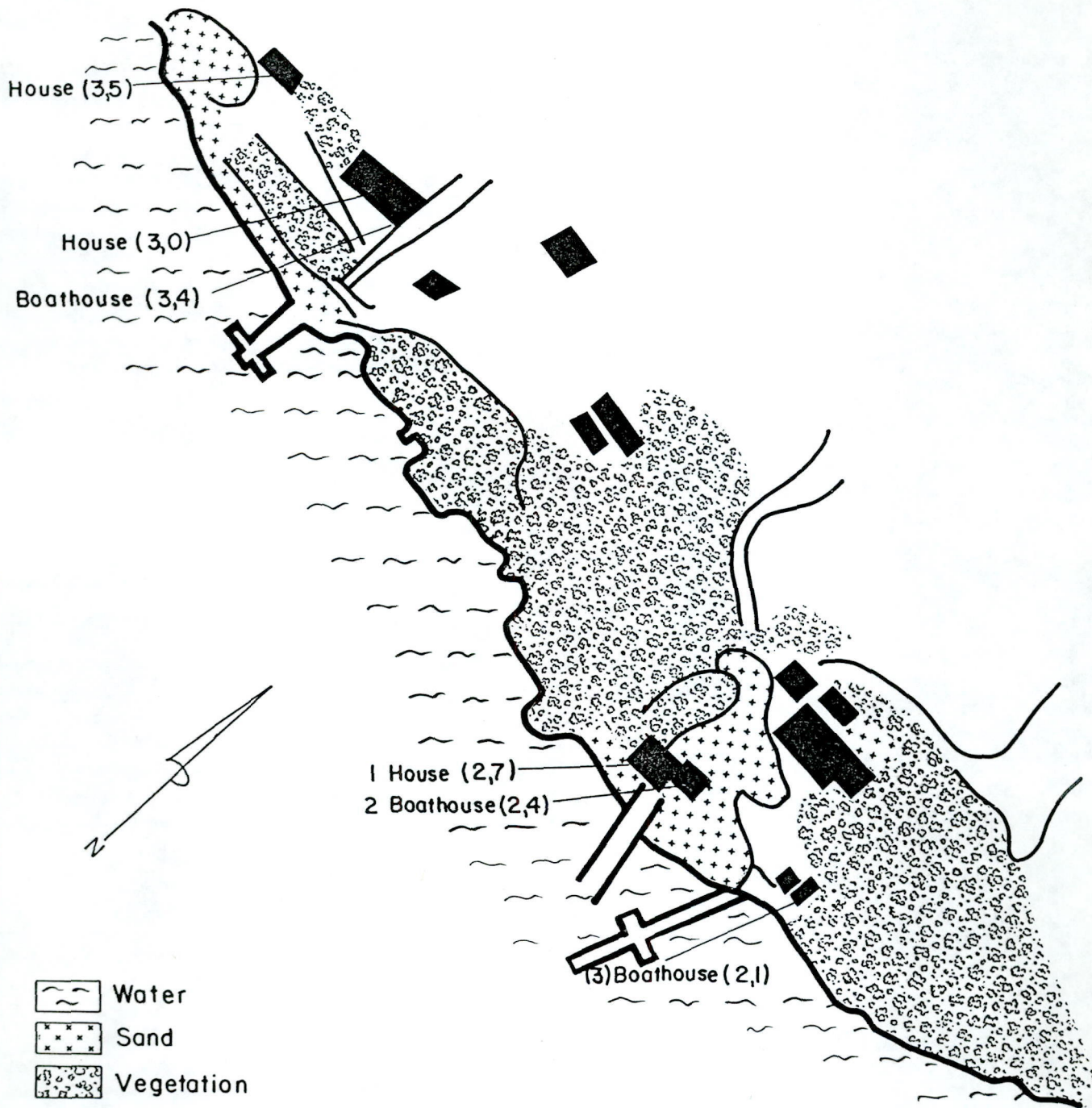
11

CSIR-EMA



-  Water
-  Sand
-  Vegetation

	<p>KLEIN RIVER</p> <p>TRACING OF AREA B</p> <p>CSIR-EMA</p>	<p>FIGURE</p> <p>12</p>
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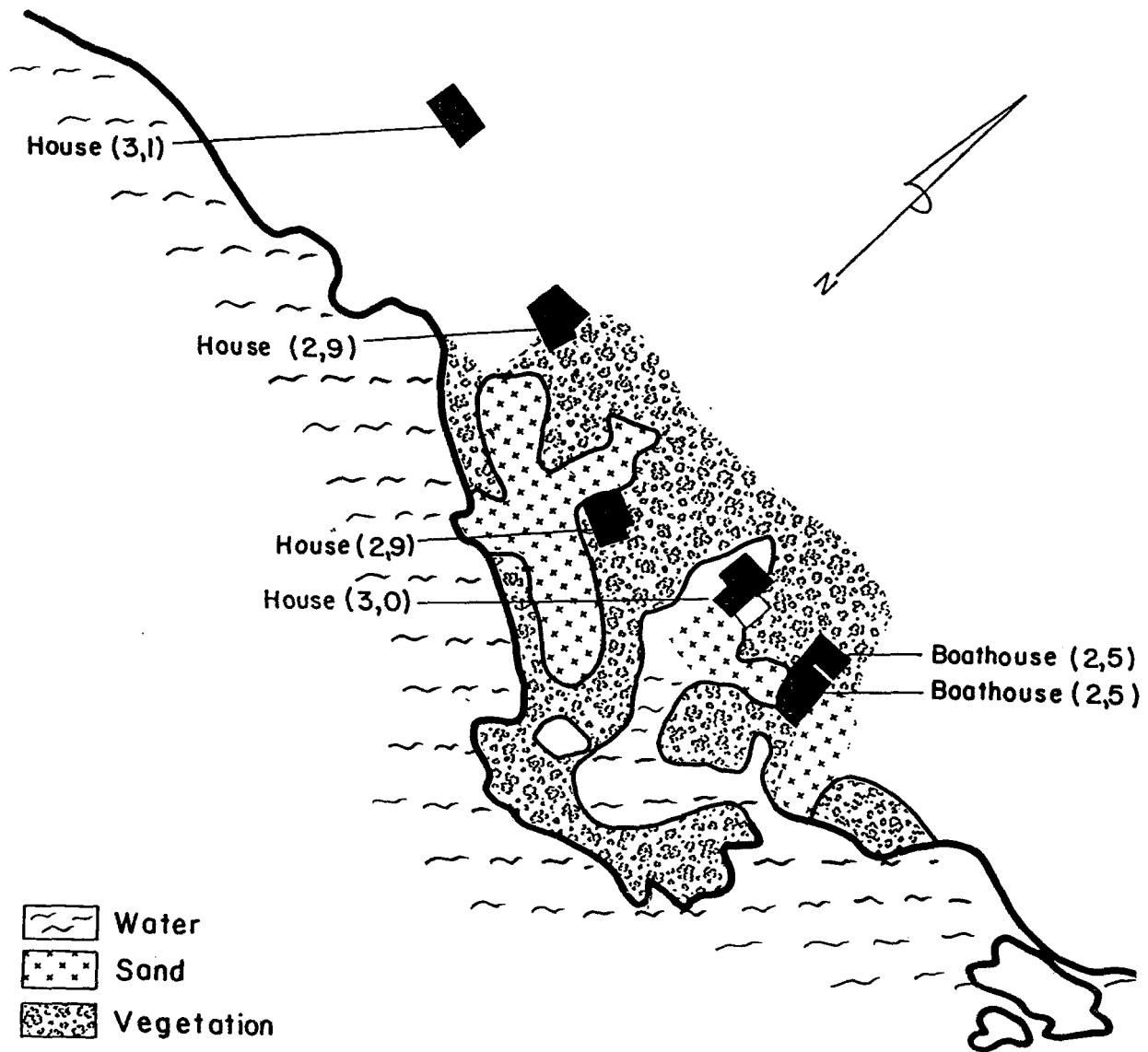


KLEIN RIVER

TRACING OF AREA C + D

FIGURE

13



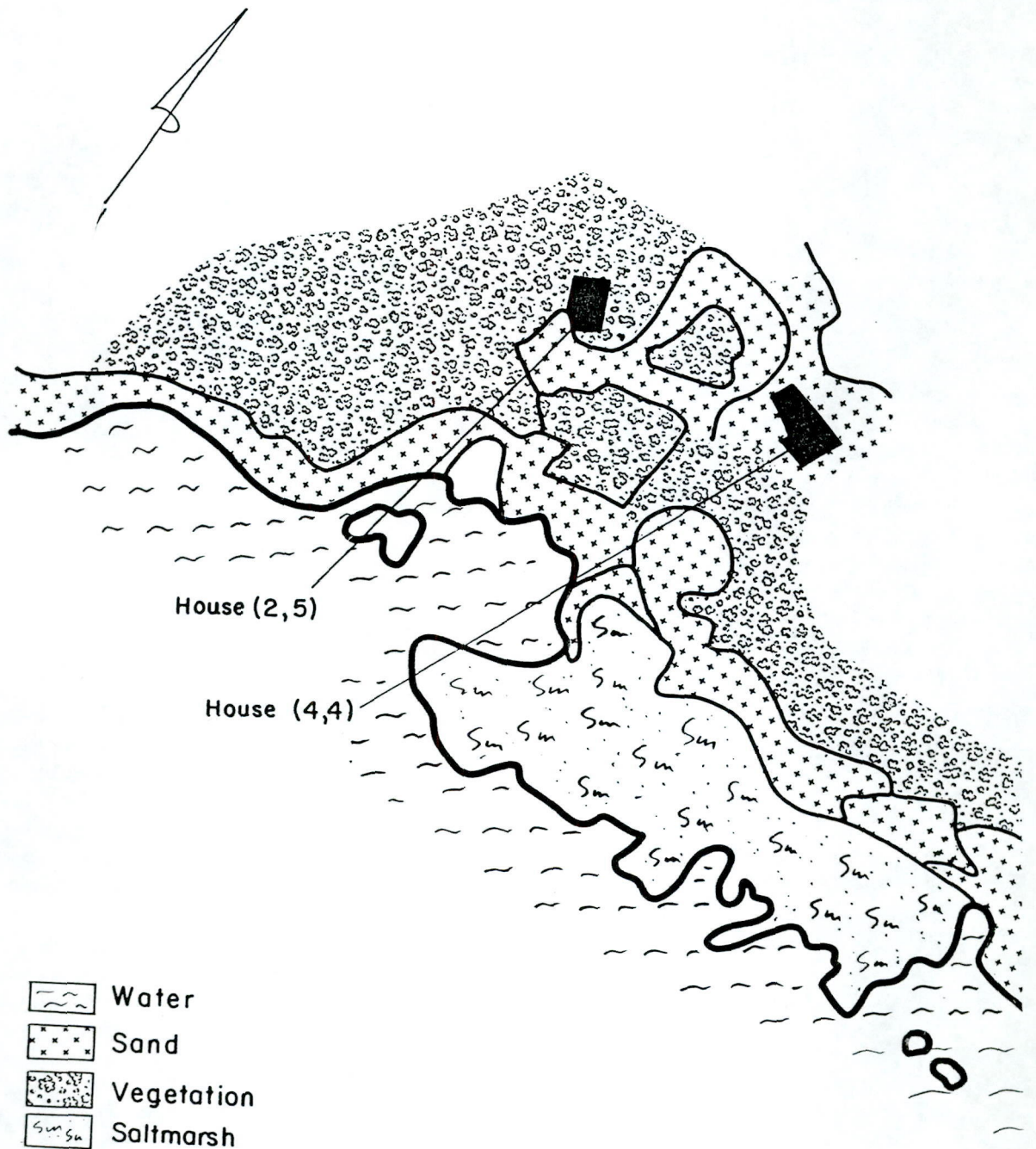
KLEIN RIVER

TRACING OF AREA E

FIGURE

14

CSIR-EMA

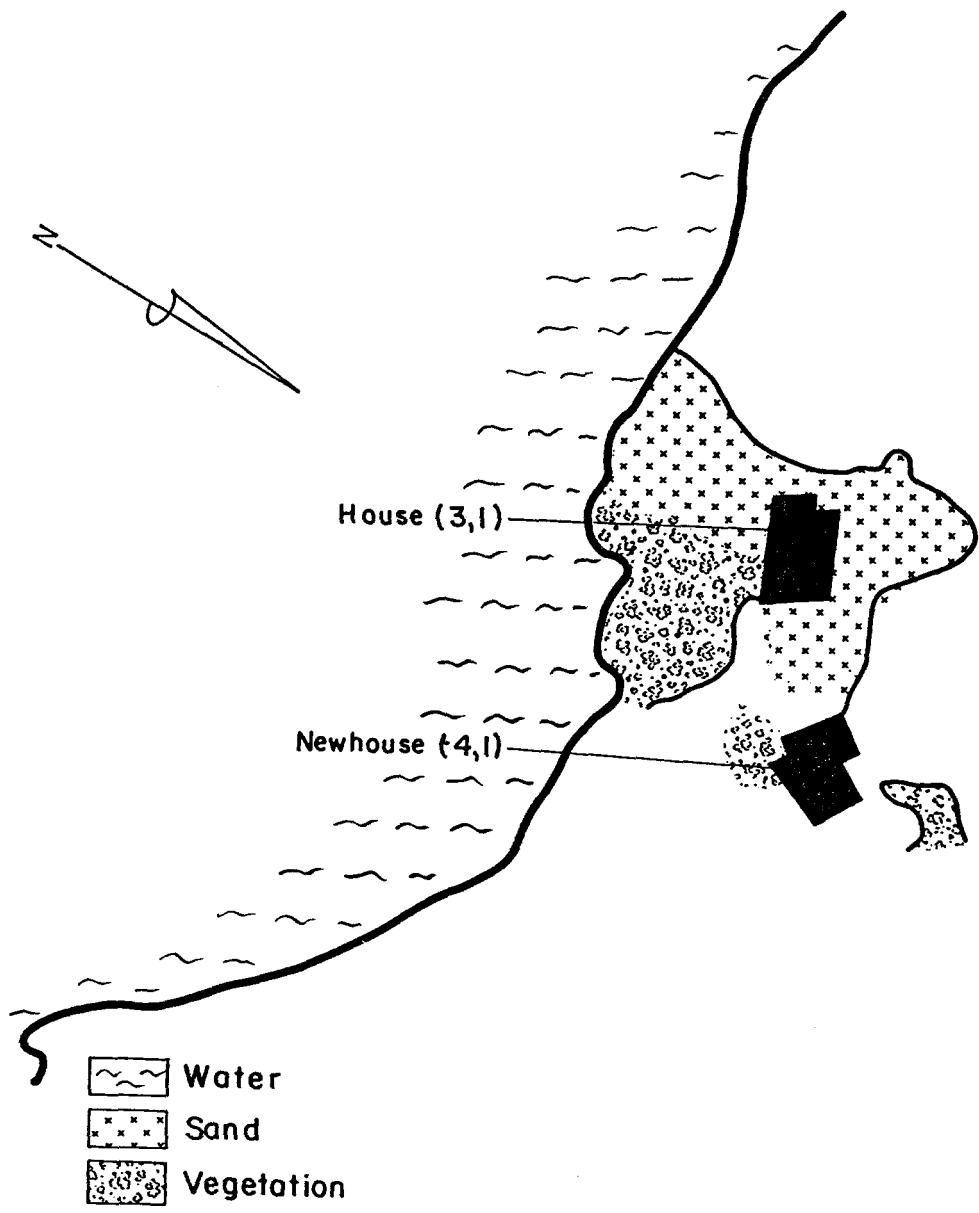



KLEIN RIVER

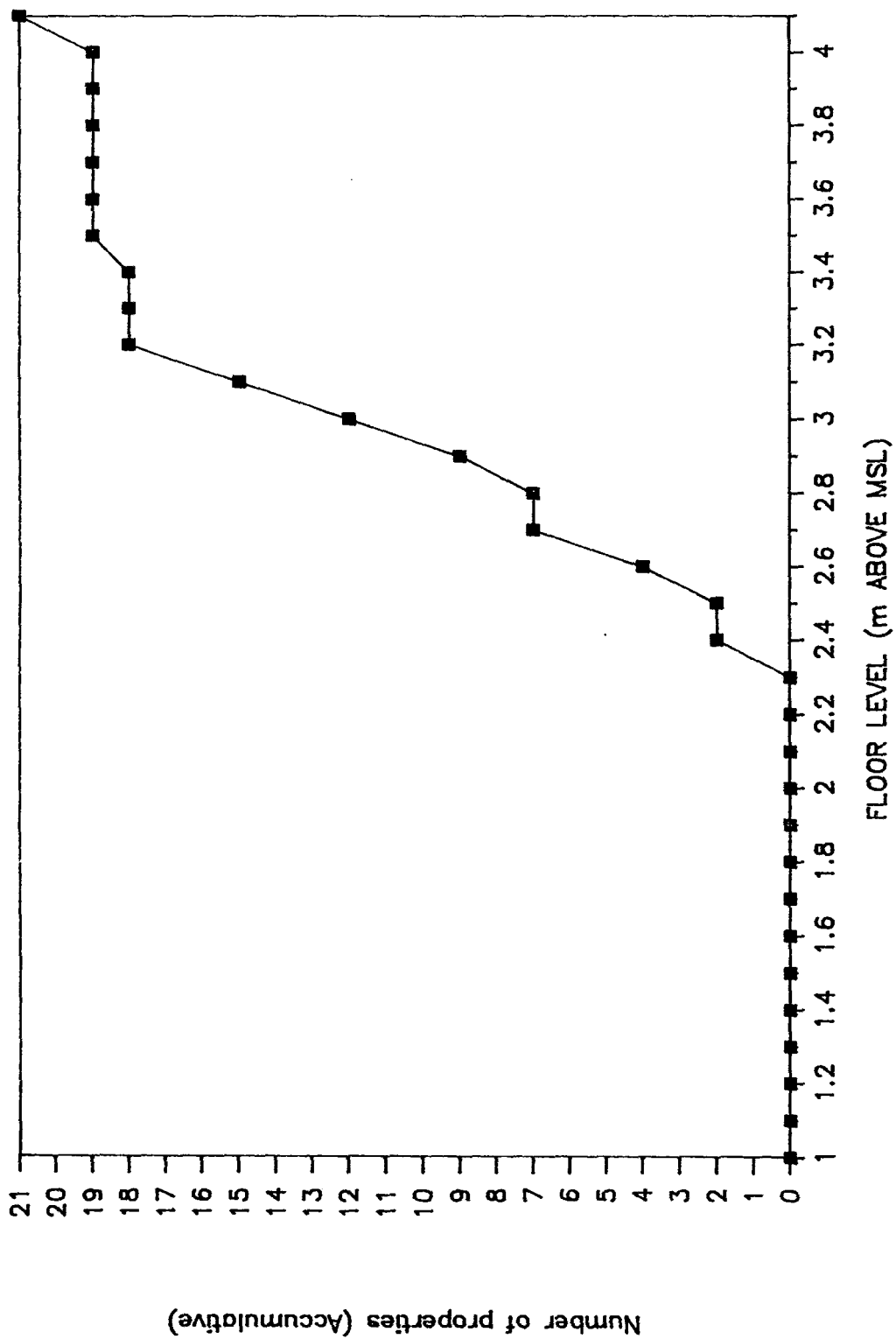
TRACING OF AREA F

FIGURE

15



	<p>KLEIN RIVER</p> <p>TRACING OF AREA G</p> <p>CSIR-EMA</p>	<p>FIGURE</p> <p>16</p>
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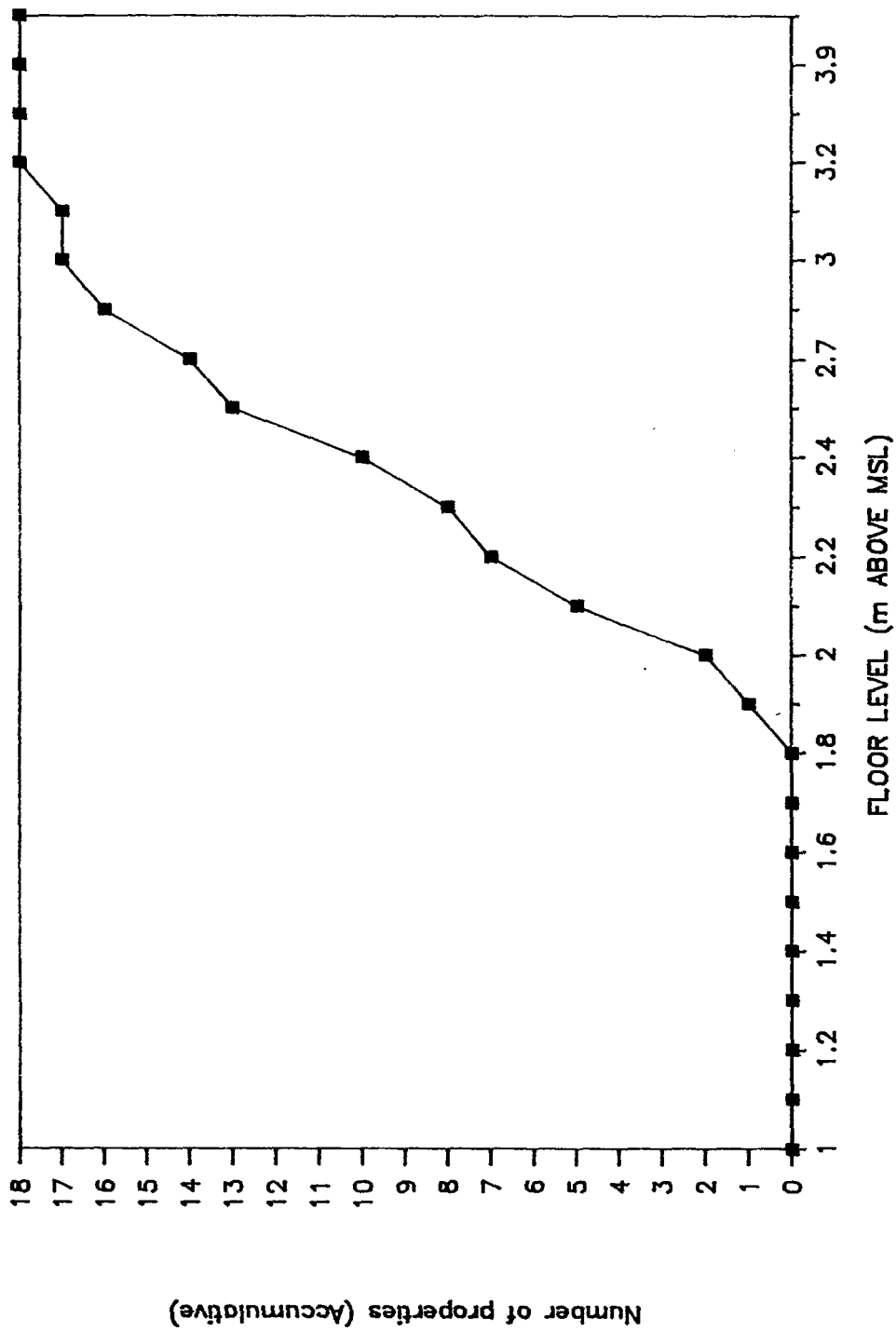


KLEIN RIVER

DISTRIBUTION OF HOUSES

FIGURE

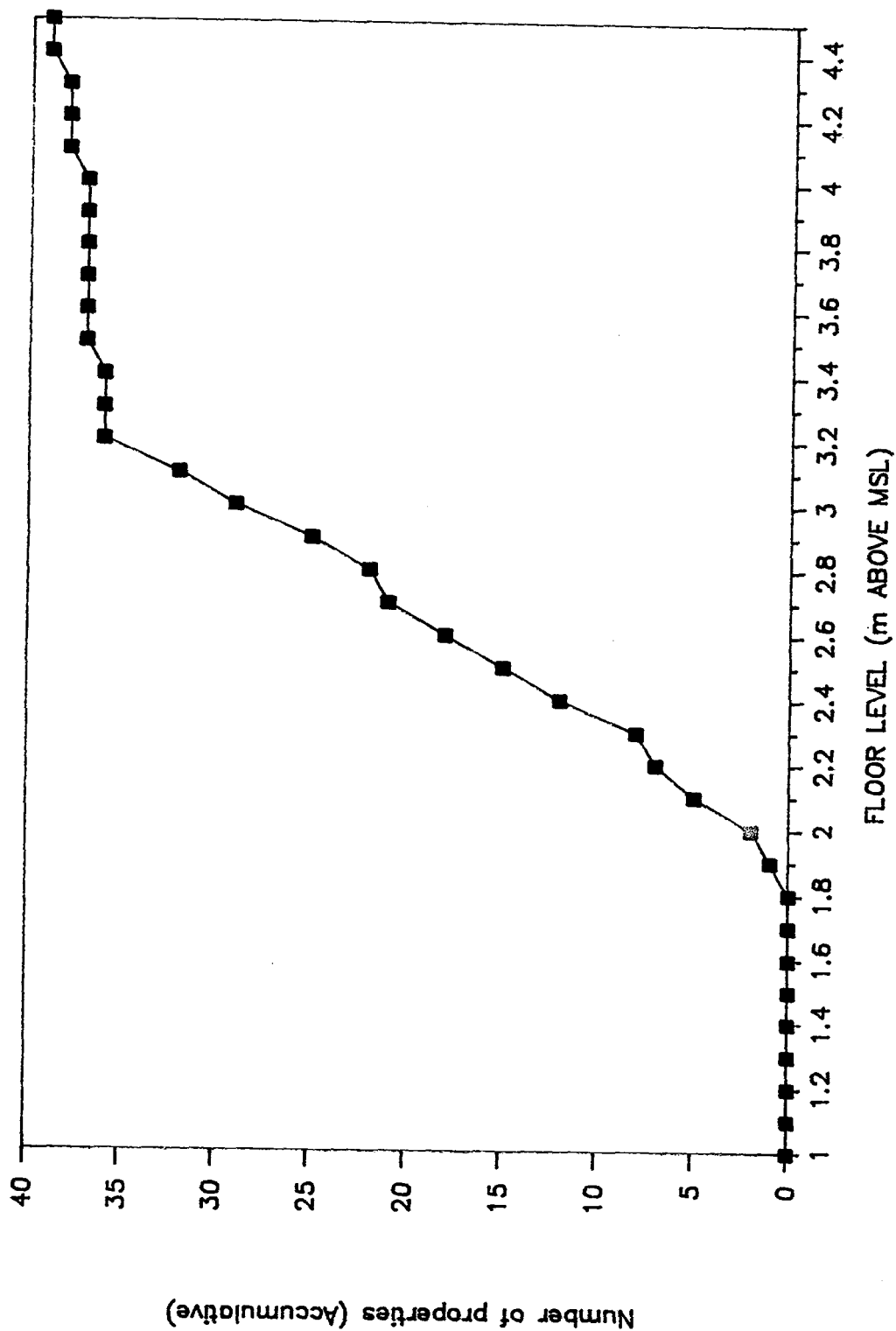
17



KLEIN RIVER

DISTRIBUTION OF BOATHOUSES

FIGURE
18



KLEIN RIVER

DISTRIBUTION OF ALL STRUCTURES

FIGURE

19