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**RIVER MOUTH SURVEYS OF THE WEST AND SOUTH WEST CAPE COAST  
(ORANGE, OLIFANTS, BERG, DIEP, PALMIET AND THE KLEIN RIVER)**

**DATA REPORT NO 1**

by  
L van der Merwe

STELLENBOSCH

June 1988

*V. d. Merwe.*

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COASTAL PROCESSES AND MANAGEMENT ADVICE PROGRAMME  
DIVISION OF EARTH, MARINE AND ATMOSPHERIC SCIENCE AND TECHNOLOGY  
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

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Stellenbosch, South Africa  
June 1988

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

RIVER MOUTH SURVEYS OF THE WEST AND SOUTH WEST CAPE COAST  
DATA REPORT NO 1

SCOPE

Baseline data for future research in the understanding of river mouth processes, are being collated and placed in a central data bank on the CSIR mainframe computer. In this way it is hoped to in time be able to correlate river mouth changes with the driving forces namely, wind, waves, tidal action and runoff. Data obtained will be available for future reference and can be used to plan river mouth management.

Selected river mouths on the South-African coastline are being surveyed annually and a series of computer programs was adapted to accommodate this data and it is now possible to compare and produce figures, plans and calculations from the data bank.

This report contains the produced contour plans, fair charts, loss-and-gain maps and cross-sections emanating from surveys done on the Orange, Olifants, Berg, Diep, Palmiet and the Klein River.

The report was written by Mr L van der Merwe under the technical supervision of Dr D.H. Swart, head of the Sediment Dynamics Division. Miss. J.B. Crowley was responsible for production of computer printouts.

D H SWART  
PROGRAMME MANAGER

Stellenbosch  
May 1988

COASTAL PROCESSES AND MANAGEMENT ADVICE

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## 1. ORANGE RIVER MOUTH SURVEY

### 1.1 GENERAL BACKGROUND ON THE ORANGE RIVER

The Orange River is the most comprehensive river system in South Africa. It flows through four rainfall regimes, namely, the summer, late summer, bimodal and winter rainfall areas. The river enters the Atlantic Ocean in a wetland type estuary with a double spit. (Figure 1). The major tributaries are the Vaal, Modder, Caledon, Brak, Hartz and Fish Rivers. Three major dams, the Vaal Dam, Hendrik Verwoerd Dam and the P.K. Le Roux Dam help to control and subdue flooding and ensure a consistent supply of water to areas under irrigation. The Orange and the Great Fish Rivers are linked by a 82,5 km long tunnel between the Hendrik Verwoerd Dam and the Teebus Spruit, a tributary of the Great Fish River.

A CSIR Report in press quote the catchment as 549 700 km<sup>2</sup> and the annual run-off as 11,67 x 10<sup>9</sup> m<sup>3</sup>. These figures exclude run-off from catchment areas located on the South West African side of the river.

### 1.2 Topographical Survey of the Orange River Mouth

A survey of the mouth area was done during the period 31-08-87 to the 04-09-87. Levels were based on a control bench mark S6 of the Alexander Bay Mining Department and horizontal control was obtained from a trigonometrical station named "Muno" on the northern bank of the estuary.

A tachemetical traverse was run between S6 and Muno. The coordinates of these stations are:

Muno + 53 709,57y + 3 167 864,36x height 11,66 m (M.S.L)

S6 + 52 475,46y + 3 168 898,41x height 5,33 m (M.S.L)

S6 is located on the southern side of the sand spit. The exposed tidal sand and mudflats were surveyed at low tide and the deeper areas were surveyed by using a small boat and lead-line. The positions were fixed by theodolite from the survey stations on the spit. The surveyed area falls in the degree square 2816 and

is based on the South African Survey Grid (GAUSS CONFORM PROJECTION) system L017 degree. The heights of the beacons are relative to mean sea level (M.S.L). The topography was surveyed using standard tache survey methods. Instruments used were a Kern DKM2 single second theodolite and a 4 m tache staff. The field observations were processed by utilising the CSIR Mainframe Computer (CYBER) and a fair Chart (Figure 3) and Contour Plan (Figure 4) of the mouth area were produced. The mouth was open and was subject to tidal action and normal river flow.

### 1.3 Sand Samples

Sand samples were taken on 02-09-87 at each survey station on the spit. (Figure 4) the samples were analysed by means of a settling tube and results are shown in Table 1.

Table 1 shows that the median grain diameters (D50) of the samples predominantly fall within the coarse sand limits (1.0-0,5) of the shore protection manual size classification. The longshore variation in median grain size shows no apparent trend except for a slight decrease in grain size at positions 5510, 5511 and 5512.

### 1.3 Interpretation of the Orange River Mouth Data

The contour plan of the survey showing the survey stations and the positions of the sand samples can be seen in Figure 4. From the contour plan it can be seen that the deepest point in the Mouth is at - 1,0m (MSL) and that the width is approximately 50 m at the narrowest position between the 0,0 m contour lines.

The mouth was in the most north-western corner of the spit on 01-09-87, as can be seen in Figure 4. Figure 2 shows that during the period from 1937 to 1987 the estuary mouth migrated either northwest or southeast along the 1,6 km sandspit.

Mechanisms for tidal inlet migration include:

Longshore drift, wave refraction at inlets with large ebb tidal deltas, storm-induced shifts, flow round a bend in the channel at the mouth and cross-channel asymmetry in outflow inertia. All these mechanisms can operate, either simultaneously or individually under different environmental conditions. (I van Heerden, March 1986). A bermwall was built on the southern side at survey station 56 to protect the diamond mining activities on the floodplain near Alexander Bay. Vegetation in the floodplain died as a result of this. Fresh water was tasted during the outgoing tide in the mouth.

The mouth will be surveyed annually in future, as well as after major flood events.

#### 1.5 Conclusion on the Orange River Mouth Survey

- (1) The mouth was open and in the most north-western corner of the sand spit on 01-09-87.
- (2) The deepest point in the surveyed estuary area was -3,98 m(MSL) and on the sand-bar in the mouth approximately 0,0 m (MSL).
- (3) The 1,6 km sandspit was on average 150 m wide and 4 m high.
- (4) Gwano Islands formed near the sandspit on the estuary side. (Figure 4).
- (5) The mouth channel depth was roughly -1 m (MSL) and 50 m wide between 0,0 m contour lines.
- (6) The median grain diameters (D50) of the sand samples taken on 02-09-87 fall within the coarse sand limits of the shore protection manual size classification.

## 2. OLIFANTS RIVER MOUTH SURVEY

### 2.1 General Background of the Olifants River

Two major dams are situated in the Olifants River system namely. the Clanwilliam Dam and the Bulshoek Dam. The Olifants estuary lies at 31 degree 42'south and 18 degree 12' east some 250 km north-northwest of Cape Town (Figure 1). It is generally accepted that the Olifants forms the southern boundary of Namaqualand.

The Olifants River catchment is the second largest in South Africa. Heydorn and Tinley (1980) give the catchment area as 46 625 Km<sup>2</sup>. 1100 Km of major rivers and tributaries form the Olifants system. Jubb (1964, 1965) cited Howell and Bourliere (1964) who postulated a previous link between the Olifants River system and the Orange River system on the basis of the similarity of their modern Fish Faunas. Marine Diamond Mining takes place along the Atlantic shores of both systems. The proposed link between the two systems was by means of the Krom River part of the Sout.

The mean annual run-off of the entire Olifants River catchment is  $122 \times 10^7 \text{ m}^3$  (Midgley and Pitman, 1969). A CSIR Report (in press) gives the catchment of the Olifants as 46 220 Km<sup>2</sup> and the annual runoff as  $1015,80 \text{ m}^3 \times 10^6$ . The mouth of the Olifants River is permanently open and its position is determined by the rocky coastline and sill on its north-western side called "The Point". During an ECRU survey in August 1983 the mouth was about 150 m wide but Coward (1981) reports a "narrow channel" of only 80 m in width during the summer of 1980/81. The sand spit is 2,5 Km long and some 250 m wide. The mouth is used by a marine Diamond Mining boat that is launched, at a slipway indicated on Figure 5, under calm conditions.

### 2.2 Topographical Survey of the Olifants River Mouth

#### 2.2.1 Position fixing

A 50 mm pipe in concrete named 01 was co-ordinated by intersection using beacons 73 "Viswater" and 194 "Papendorp", their co-ordinates are:

73 Viswater + 73 340,08y + 3505 106,42x height 150,1 m (MSL)  
 194 Papendorp + 73 911,37y + 3511 139,73x height 66,7 m (MSL)

The check rays were:

58 Pieterskop + 71 183, 38y + 3513 422,04x height 117,8 m (MSL)  
 212 Doringbaai noord + 70 690, 28y + 3519 614,46x height 121,6 m  
 (MSL)

The final co-ordinate of 01 is + 76 999, 65y + 3508 499,76x height 13,0 m (MSL). The height of 01 was determined by trigonometrical levelling and is therefore accurate to one decimal of a meter only and must be regarded as provisional. The level was calculated using trigonometrical stations 73 and 194 some 4990,75 m and 4062,86 m away respectively. A more accurate height can be obtained by precise levelling from a bench mark 37A, a brass stud on the pedestal of Beacon 194 Papendorp some 4,1 km from 01. The value (height) of the brass stud 37A is 65,485 m (MSL). All the above co-ordinates fall in degree square 3118, system Lo 17 degree on the South African grid. The heights of the beacons are relative to mean sea level. 01 is situated on a rocky ledge on the north-western side of the estuary mouth. (Figure 6)

### 2.3 Sand Samples

Sand samples were taken at positions indicated on Figure 6. Summaries of the grain sizes are shown in Table 2. The analysis was done using a settling tube.

Table 2 shows that the median grain Diameters (D50) of the samples predominantly fall within the medium sand limit (0.5-0,25) of the shore protection manual size classification.

The longshore variation in median grain size shows an increase in grain size from the river mouth in a south - easterly direction. (SS1 to SS3).

### 2.4 Interpretation of the Olifants River Mouth Data

A Fair Chart of the 05-09-87 survey showing the survey beacons

can be seen in Figure 5. The general height of the sand bar is between 3,5 and 4 m (MSL) and the depth of the channel at the mouth at 2,0m (MSL). Between the 2 m contours the spit was on average 200 m wide.

From Contour Plan (Figure 6) the width at the narrowest position between the 0,0 m contours in the channel measures 80 m.

The mouth has a single spit with a rock headland on the north-western bank of the mouth. The mouth stays open permanently and is kept in the same position by the dominant wave direction which is south-southwest.

#### 2.5 Conclusions on the Olifants River Mouth Survey

- 1) The mouth is open permanently and remains in the same position.
- 2) The mouth consists of a single spit with rock on the north-western bank.
- 3) The deepest point within the mouth was at a level of -2,5 m (MSL).
- 4) The distance between the 0,0 m contours at the narrowest point in the mouth was 80 m.
- 5) The sandspit was at an average height of +4 m (MSL) and was about 200 m wide on average.
- 6) The median grain diameters (D50) of the sand samples taken on 05-09-87 fall within the medium sand limit of the shore protection manual size classification.

### 3. BERG RIVER MOUTH SURVEYS

#### 3.1 General Background of the Berg River

The Berg rises in the Franschoek Mountains and flows past the towns of Paarl, Wellington, Hermon, Gouda, Piketberg, Hopefield to enter the Atlantic Ocean at St Helena Bay (Velddrift), about 120 km north of Cape Town (Figure 1). It falls within the winter rainfall area with high precipitation taking place at its source in the Franschoek Mountains.

At present a scheme is under construction to interlink the Riviersonderend River and the Berg River. This inter-basin linkage comprises the Theewaterskloof Dam on the Riviersonderend River, the Franschoek Mountain tunnel between the dam and the Upper Berg River Valley, the Jonkershoek tunnel system through the Groot Drakenstein and Jonkershoek Mountains, the Stellenbosch tunnel through the Stellenboschberg, the Assegaaibos and Kleinplaas dams and the Banhoek and Wolwekloof Weirs and shaft connections to the tunnel (figure 7).

The purpose of the project is to provide storage for surplus water from the Riviersonderend catchment, plus surplus water diverted from the Berg River catchment, into the Theewaterskloof dam, from where it will be distributed via the tunnel system to be used for irrigation and industrial purposes. The tunnel system serves for both adduction and distribution.

On the northern bank of the Berg River estuary several fish-processing factories have been established. To provide a stimulus for the rapid growth of the fishing villages at Laaiplek and Velddrift, breakwaters were built to create a new permanently open entrance to allow bigger craft to pass through from the Atlantic into the Berg River. At the completion of the breakwaters very low flows passed through the existing mouth and as a result the old mouth closed due to sediment movement. The average winter flow along the Berg River at Misverstand has been estimated at  $300 \times 10^6 \text{ m}^3$  per annum (WPK - 1974). At completion of the Riviersonderend - Berg River project it is planned to divert  $90 \times 10^6 \text{ m}^3$  per annum into the Theewaterskloof dam. This

dam has a capacity of  $482 \times 10^6 \text{ m}^3$ . It is planned to release  $153 \times 10^6 \text{ m}^3$  per annum for summer irrigation along the Berg River, (WPO - 1973). This will result in a return flow of  $40 \times 10^6 \text{ m}^3$  to  $60 \times 10^6 \text{ m}^3$  per annum. The total catchment area of the Berg amounts to  $7715 \text{ Km}^2$  and is the most important source of water supply in the Western Province sustaining extensive agricultural, industrial and urban water requirements. The mean annual runoff calculated for the existing Berg catchment is  $1035,48 \times 10^6 \text{ m}^3$  (CSIR Report D8705).

### 3.2 TOPOGRAPHICAL SURVEY OF THE BERG RIVER MOUTH

The Department of Environment Affairs (Fisheries) has a comprehensive triangulation network on the breakwater system. These coordinates and levels were used to survey the mouth area on 06-06-1986 and again on 25-06-1987. The coordinates are based on system L019 (degree square 3218) on the South African survey grid. The levels as determined by Sea-Fisheries, are based on lowest astronomical tide (LAT). LAT for Saldanha equals - 0,06m chart datum (CD) and chart datum is -0,900 m relative to land levelling datum (MSL) in the South African Survey Grid. Thus to convert the Berg River breakwater levels (LAT) to MSL the factor -0,96m must be used.

The survey stations used:

Light north	+80 197,52y + 3627 053,59x	
Light south	+80 068,75y + 3627 394,26x	
T14	+80 061,95y + 3627 598,90x	1,17 m (MSL)
T5N	+80 183,07y + 3627 352,22x	5,10 m (MSL)
T4	+80 320,97y + 3627 433,94x	4,66 m (MSL)
T3	+80 443,22y + 3627 516,45x	5,61 m (MSL)
T2	+80 565,14y + 3627 606,86x	5,09 m (MSL)
ZN	+80 716,26y + 3627 716,30x	4,68 m (MSL)
L1	+79 979,31y + 3627 185,62x	3,94 m (MSL)
L3	+79 945,26y + 3627 283,04x	2,43 m (MSL)
L3a	+79 706,26y + 3627 282,79x	2,14 m (MSL)
L4	+80 333,08y + 3627 439,12x	4,97 m (MSL)
L5	+80 716,11y + 3627 716,87x	4,55 m (MSL)

The positions of the survey beacons can be seen in Figure 8

### 3.3 SAND SAMPLES

Sand samples were taken at positions indicated of Figure 9. The grain size analysis of the samples can be seen in Table 3. These were obtained using a settling tube.

Table 3 shows that the median grain diameters (D50) of the sand samples fall within the medium sand limits of the shore protection manual size classification.

Sample SS1 taken on the south-easterly side of the breakwater and SS2 and SS3 on the north-western side.

### 3.4 INTERPRETATION OF THE BERG RIVER MOUTH DATA

The Fair Charts of the 06-06-86 and the 24-06-87 surveys can be seen in Figures 8 and 10. Figures 9 and 11 show the contour plans and Figure 12 the difference map of Berg River mouth 24 June 87 relative to 6 June 86. During the survey on 24 June 1987, it was not possible to take soundings from a boat between the breakwaters due to a heavy sea and waves running into the harbour mouth, but soundings were taken along the breakwaters edges. Soundings taken of 06-06-1986 show that a depth in the mouth between the breakwater exceeded -4,0 m mean sea level at the time of the survey (Figure 12). The difference map reveals virtually no change in the dead arm of the old river bed. The spit built up by nearly a meter between positions T2 and T5N. Overtopping at high tide on 24-06-87 occurred 150m south-east of Beacon ZN on the spit but this was due to a big swell and a tidal level of 0,72 m MSL at 15h45 that afternoon. Figure 13 shows that the lowest level on the spit is 3.0 m (MSL), and that highest astronomical tide (HAT) is 1,19 m (MSL) in that region. This gives the spit a free board of less than 2 meters, this coastline however is not a high energy coastline as it is sheltered from south westerly storms by Cape Columbine and the overtopping due to runup is, therefore, not considered to be serious. The beach north west of the breakwater remained unchanged.

### 3.5 CONCLUSIONS ON THE BERG RIVER MOUTH SURVEY

1. Very little change occurred in the "Blind Arm" of the old riverbed.
2. The spit increased in height along a distance of 450 m adjacent to the eastern breakwater.
3. The north-west beach at the mouth remained unchanged between surveys 06-06-86 and 24-06-87.
4. The spit was overtopped during high seas on 24-06-87.
5. The deepest point in the mouth was at a level of -4,0 m.
6. Sand samples taken on 06-06-86 fall within the medium sand limits of the shore protection manual size classification.

#### 4. DIEP RIVER MOUTH SURVEY

##### 4.1 General Background of the Diep River

The history of the Diep estuary can be traced back for nearly 200 years. To monitor the effects of hard engineering on the estuarine system it was decided to survey the mouth area up to the wooden road bridge annually.

The source of the Diep River (Figure 14) is in the Riebeeck Kasteel Mountains north of Malmesbury and it flows in a south-westerly direction to reach the Atlantic Ocean at Milnerton. The catchment area amounts to about 1495 km<sup>2</sup> and the estimated annual runoff is in the region of  $80 \times 10^6$  m<sup>3</sup> (CSIR D8705) at table view township the river channel widens to a 3 Km long basin that was dredged in 1970 to supply material for the Cape Town container harbour. This basin is known as Rietvlei. At the downstream end of Rietvlei, a road embankment and a bridge which form part of the Otto du Plessis Drive were built downstream of the bridge. The flood plain narrows until it reaches the wooden golf course road bridge. A new concrete road bridge less than 100 m downstream of the wooden structure was constructed recently. Downstream of the new bridge the right bank of the lagoon was armoured with Gabions (Figure 16) and a concrete retaining wall was constructed near the mouth on the right bank. This construction was done to protect the new development called Woodbridge Island. On the Milnerton side (left bank) a concrete retaining wall was built and part of an old weir across the mouth of the Diep River was recently removed. The lagoon is subject to tidal action when the river mouth is open. Poor farming practices in the upper catchment, which lies largely on clayey Malmesbury shales, have resulted in erosion of the topsoil and heavy sediment loads in the River. It was noted that in the seventeenth century the Diep was navigable for several kilometres upstream of the mouth (Green 1948). The Rietvlei basin nowadays acts as a stilling chamber where the siltation settles. (Personal observation during diving exercise.) A small volume of water way moving through the mouth on each tide cycle during the June'87 survey and it was expected that the mouth would close rapidly and stay closed during the summer months. However, as a result of the dredging done in the estuary as part of the

Woodbridge Island development, the mouth has remained open until the present (February 1988).

#### 4.2 TOPOGRAPHICAL SURVEY OF THE DIEP RIVER MOUTH

Topographical surveys of the beach and the lagoon up to the wooden bridge were done on 5 June 1986 with the mouth closed and on 26 June 1987 with the mouth open.

The survey's were based on system L019 degree using co-ordinates on the South African Survey Grid (Gauss conform projection) degree square 3318. Level heights were obtained from a town survey bench mark (5A107A = 3,102 m MSL) based on mean sea level (Figure 16).

Three beacons D1, D2 and D3 were coordinated by resection using a Kern DKM2 single second theodolite (Figure 16). The trigonometrical survey beacons used were:

51 Leeukop	+56 418,44y +3 756 332,32x
23 Robben island	+57 887,61y +3 742 981,58x
413 Milnerton Light House	+47 324,15y +3 750 358,06x
265 TBN1	+47 795,04y +3 751 481,50x

The topography was covered with a tache-survey using the DKM2 and a 4 m staff. In the deep water area, the position and level of a small boat, with the staff fixed up right on the deck, was fixed from the survey station on land and a leadsounding was added to the boat level. The method was simple and proved to be ideal in a small estuary such as the diep river system.

The field brook observations were entered into the Cyber Data Bank and a series of computer programs were adapted to accommodate this information and to produce fair charts (Figures 15 and 17), contour plans (Figure 16 and 18) and a loss-and-gain plan (Figure 19) for the period 05-06-86 to 26-06-87. Profiles at the new and wooden bridges were also compared (Figures 20 and 21).

#### 4.3 SAND SAMPLES

Sand samples were taken on 05-06-86 and 26-06-87 at positions marked on Figures 16 and 18. The samples were analysed by means of a settling tube and results are shown in Tables 4 and 5.

The median grain diameters (D50) of the sand samples taken on the 05-06-86 and 26-06-87 both fall within the medium sand limits of the shore protection manual size classification.

The longshore variation in median grain size shows no apparent trend.

#### 4.4 INTERPRETATION OF THE DIEP RIVER MOUTH DATA

A Fair Chart of the 05-06-86 survey (Figure 15) was plotted by the cyber (CSIR Computer Network). The mouth of the lagoon was closed, with a sand bar height of 1,72 m (MSL) measured at the lowest point on the bar. The beach was surveyed from opposite Trig. Beacon 265, at 50 m intervals, up to the Zonnekus House in the north using reference beacon D1. The contour map (Figure 16) of the same survey presenting detail of the concrete retaining walls, gabions and bridge structures, is shown in Figure 16.

Figures 17 and 18 are a similar presentation of the 26-06-87 survey. The mouth was open and the lowest point of overflow on the sandbar was 1.00 m (MSL).

Figure 19 is the loss-and-gain map for the period 05-06-86 to 26-06-87. The contours are in 0,5 m intervals and show that sediment was deposited and eroded due to tidal volume flux and runoff in the lagoon.

Figures 20 and 21 indicate cross-sections of the lagoon bed under the new Bridge and the wooden bridge. It reflects the small changes in sediment transport during the year in the upper part of the lagoon.

The beach north of the mouth shows little to no change between the surveys. The primary dune vegetation is carefully fenced off

and nets for windbreakers were erected to prevent any trampling of the area and to control wind-blown sand. These primary dunes are a more resilient defence for the beach than any concrete sea wall. Once erosion of the primary dunes takes place the whole Woodbridge Island development is endangered. The harbour extensions at Table Bay seems to have not increased erosion in the area monitored during the year June 86 to June 87.

#### 4.5 CONCLUSIONS ON THE DIEP RIVER MOUTH SURVEY

1. Little to no erosion took place in the monitor area between the surveys on June 86 and June 87.
2. The primary dunes are well maintained and form a resilient defence against the sea.
3. The mouth remained open during the last year possibly as a result of increased fresh water runoff and dredging of the lagoon as part of the Woodbridge Island development.
4. No influence due to Cape Town harbour expansions could be detected in the monitored area during the period June '86 to June 87.
5. Sand samples taken on 05-06-86 and 26-06-87 shows that the median diameters (D50) fall within the medium sand limits.

## 5. PALMIET ESTUARY MOUTH SURVEY

### 5.1 GENERAL BACKGROUND OF THE PALMIET RIVER

The Palmiet River mouth is situated between Kleinmond and Bettys Bay (LAT 34 degree.20'.40" LONG 18 degree 59'50"), about 75 Km south east of Cape Town (Figure 1). The Palmiet River is 72,5 Km in length and has a catchment area of 536 Km<sup>2</sup> (Pitman 1981). Although neither the estuary nor its catchment area is large, it is the only estuary between the Berg and the Breede River that is normally open to the sea and which receives a large almost continuous inflow of freshwater from its river. The estuary mouth has a single spit with rock on the opposite bank. In the upper region of the Palmiet, the Department of Water Affairs and ESCOM are constructing a pumped storage scheme (Figure 22). The Palmiet pumped storage scheme is situated in the Hottentots Holland Mountains where the potential of the fluvial system is virtually untapped. The catchment area of the Palmiet River could supply sufficient water, according to the Department of Water Affairs (DWA) for four more dams in addition to Kogelberg. Palmiet acts not only as a hydro-electric pumped storage scheme, but also as a water transfer scheme.

The scheme comprises two new dams, the lower Kogelberg Dam on the Palmiet River south of Grabouw and the upper Rockview Dam on the watershed between the Steenbras and the Palmiet Rivers. A conduit between the two reservoirs conveys water to the reversible pump-turbines in the 400 MW powerstation on the bank of the Kogelberg Reservoir. During the offpeak period, water will be pumped from Kogelberg to Rockview reservoir. From here water allocated to the DWA for water supply will flow by gravity into the Steenbras Reservoir via a separate conduit. Initially, this will supplement Cape Town's annual water supply by an average  $30 \times 10^6 \text{ m}^3$ , which will ultimately be increased to  $140 \times 10^6 \text{ m}^3$  (ESCOM 1985).

The median annual run-off of the Palmiet is  $176,63 \times 10^6 \text{ m}^3$  (Pitman W V et al 1981). The average catchment sediment yield

for the Palmiet River is 80250 tons per year based on a figure of 150 tons/Km<sup>2</sup>/yr. The figures quoted does not take the Palmiet pumping scheme into consideration.

## 5.2 TOPOGRAPHICAL SURVEY OF THE PALMIET RIVER MOUTH

Three surveys of the Palmiet River mouth were undertaken on the 21-08-86, 01-09-86 (after a minor flood) and on 16-03-87. Levels were carried over from a bench mark on the slipway of the Palmiet Boat Club with a Wild NA20 auto level to the top of a memorial on a rock of the west bank of the mouth. The level on the top of the cross is 6,16 m (MSL). The horizontal control was done with a resection using triangulation beacons on system Lo19 of the South African Grid (3419) and (3418):

134 Blomhuis	+ 3 045,18y	+3 802 546,44x	height 413,8 m (MSL)
35 Palmietrivier	- 952,03y	+3 799 326,92x	height 635,5 m (MSL)
59 Lekkerwater	- 7 855,22y	+3 798 571,05	height 369,2 m (MSL)
31 Mudge Point	-13 749,09y	+3 807 542,76x	height 482,3 (MSL)

During the surveys noticeable changes occurred along the beach and in the mouth. A strong westerly longshore current prevailed and a sandbar  $\pm$ 50 m offshore was evident.

## 5.3 SAND SAMPLES

On 15 March 1987 6 sand samples were taken at positions marked on Figure 27. These samples were analysed by means of a settling tube and the results are shown in Table 6. Samples 1,5 and 6 shows that the median grain diameters (D50) fall within the coarse sand limits of the shore protection manual size classification while samples 2, 3 and 4 are medium sand.

## 5.4 INTERPRETATION OF THE PALMIET RIVER MOUTH DATA

Figure 23 shows the fair chart of the 21-08-86 survey. The mouth was open with a depth of -1,5 m and a width of 32 m measured from the 0 m MSL line at the narrowest point in the mouth. The spits average height was 3,0m (MSL).

Figure 24 is the contour map of the 21-08-86 survey.

Figures 25 and 27 are the Fair Chart Maps of the 02-09-86 and the 15-03-87 surveys. The September 86 survey was done shortly after a minor flood and the mouth was wider and had been scoured deeper by the runoff. The depth at the last section of the mouth was -1,86 and 50 m wide measured from the mean sea level line. The beach had eroded and was steep in profile, due to off shore sediment transport by the storm waves. The 15-03-87 survey (Figure 27) shows the beach in equilibrium again. The mouth has sanded up to a level of -0,54 m MSL and 15 m wide at the last section in the mouth. This is normal because of the relatively dry season preceding the 15-03-87 survey.

Figures 26 and 28 are the contour maps of the September 86 and March 1987 surveys.

The loss-and-gain map (Figure 29) shows how the mouth and beach had eroded after the flood on 28/29 August 86. The contours are in 0,5 m intervals and show how the spit had been eroded by storm wave conditions coinciding with the flood. Figure 30 is the Palmet River difference map for the period, 24 March 1987 relative to 21 August 1986. The sand spit had built up at the mouth to +2,5 m and a sand bank had formed offshore on the north-westerly side of the mouth. This phenomenon is due to tidal flow that brings sediment into the estuary mouth. The sandspit had, therefore, recovered during the calmer summer period.

Figure 31 relates the survey after the storm damage on the 02-09-86 with that on 24-03-87. The beach accreted by 1,5 m in places and the spit at the mouth extended to make the mouth smaller. The crest of the spit was unaltered. During summer the run-off reaches a minimum and in winter the Largier volume of fresh water run-off causes the mouth to scour deeper and wider.

#### 5.5 WAVE DATA AND LONGSHORE SEDIMENT MOVEMENT

Deep-sea wave data, a wave refraction study and breaker line wave data were used to compute the longshore sediment movement (CSIR, 1987), and the results imply that a net eastbound transport of

$1,0 \times 10^6 \text{ m}^3$  per year could potentially take place. Because of the Palmiet's situation within a rocky coastline and a lack of available moveable sediment within the area, a longshore sloshing mode is predicted, with a resultant net transport of zero at the centre of the beach. This tendency was confirmed by the topographical surveys that material lost on the beach is replaced during calm conditions with on-offshore sediment movement.

#### 5.6 CONCLUSIONS ON THE PALMIET RIVER MOUTH SURVEYS

1. The Palmiet is a single spit estuary with a rocky promontory on the western bank.
2. The stability of the estuary mouth is vastly affected by freshwater input. During the drier summer period the mouth functions as an unstable overflow channel whereas in winter the mouth width and depth varies in response to run-off.
3. The beach is stable with virtually no longshore transport due to enclosure of the beach by a rocky coastline.
4. Sand samples taken on 15-03-87 shows that sample number 1, 5 and 6 fall within the coast sand limits and 2, 3 and 4 in the medium sand range for median grain diameters (D50).

## 6. KLEIN RIVER MOUTH SURVEY

### 6.1 GENERAL BACKGROUND OF THE KLEIN RIVER

The Klein River enters the Atlantic Ocean immediately south east of the suburb Voelklip of Hermanus. The lagoon called Kleinriviersvlei (Figure 32) is approximately 9 Km long and about 2 Km at the widest point. Natural sand bar formation closes the mouth, resulting in the eventual flooding of vast areas of mudflats on the southern side of the lagoon. The lagoon which is subjected in increasing human pressure such as power boating, angling, yachting and swimming, has been artificially breached in the past but a policy of allowing only natural openings has recently been adopted by the Cape Department of Nature and Environmental Conservation, although illegal artificial breachings still occur. The catchment area amounts to approximately 906 Km<sup>2</sup> and the river length is 65,8 Km. With the river source at an elevation of 580 m above mean sea level. This gives the river an average gradient of 1 in 113. The average catchment sediment yield is 150 tons per Km<sup>2</sup> per year and that gives a total of 22 650 tons/year. The simulated median annual runoff is 40,01 m<sup>3</sup>x10<sup>6</sup>. (NRIO DATA REPORT No D8705).

Several management problems have arisen in the Klein River system. The main problems are: (Miranda Waldron March 1986).

The uncertainty about appropriateness of water levels, marine sand influx and accumulation, flooding of low lying developments, flooding of agricultural lands, decrease in fish catches and indecision about the ideal position of the estuary mouth in the sand berm.

By monitoring the river mouth and sandspit, it is hoped that the data obtained will help in solving the above-mentioned problems.

### 6.2 Survey Method

#### 6.2.1 Levels

The town survey benchmark on the corner of 10th street and 15th

avenue (24G3 = 15,015 m(MSL)) was used to level and check level beacon PA101 on the right bank of the river mouth. From PA101 the levels were transferred to the other stations at the mouth by means of trigonometrical reciprocal vertical observations. The heights of the beacons are based on mean sea level.

### 6.2.2 Co-ordinates

Beacon PA101 on the right bank and PA100 on the left bank (Figure 33) were co-ordinated by means of resection using the following list of co-ordinates on the South African survey grid (GAUSS conform projection) in system Lo19 degree.

211 Voelklip	-27 357,31y +3 807 988,07x	height 571,7m
208 Danger Point Light House	-27 788,89y +3 833 329,24x	(no level)
115 FM Tower Beacon	-20 442,61y +3 908 255,04x	height 234,6m
113 Hermanus C	-22 480,11y +3 810 216,01x	height 18,9m
28 Maanskynekop	-31 650,10y +3 807 066,08x	height 964,9m
18 Hermanus	-22 828,38y +3 807 784,56x	height 259,4m
7 Danger Point	-34 857,16y +3 829 122,82x	height 357,1m

The permanent survey stations used in the Klein River mouth survey are the following:

PA100(200mm Concrete)	-27 857,6y +3 810 282,2x	height 3,00m(MSL)
PA101(cylindrical pillar)	-26 969,8y+3 809 505,1	height 5,00m(MSL)

The temporary survey stations (2 September 1986) were

V1	-27 059,7y + 3 809 538,8x	height 6,14 m(MSL)
V2	-27 521,7y + 3 810 029,8x	height 2,97 m(MSL)

The temporary stations for 24 March 1987 were

A1a	-26 982,1y + 3 809 642,1x	height 5,35 m(MSL)
A1	-27 058,2y + 3 809 538,3x	height 6,42 m(MSL)
A2	-27 334,1y + 3 809 831,2x	height 1,93 m(MSL)
A3	-27 409,4y + 3 809 612,4x	height 1,20 m(MSL)

### 6.2.3 Tache Survey

Tache surveys were done on 02-09-86 and on 24-03-87. On both occasions the Klein River mouth was open to the sea and the estuary subject to tidal action. The spit survey lines were spaced 100m apart and in the irregular dune area on the Grotto Beach side the spacing was narrowed to 50 m, and care was taken to observe irregularities. The Kern DKM 2, single second theodolite was used for the tachework. The layout of the surveys done on 2 September 1986 and 24 March 1987 can be seen in the fair charts, Figures 33 and 35,

## 6.3 Survey Results

### 6.3.1 Fair charts

Figures 33 and 35 show the spot heights obtained by the surveys on September 86 and March 87 respectively. According to Mr Visagie of the Dept of Nature Conservation, the Klein River mouth opened on 30 August 1986 and closed during the period 21 to 30 May 1987. The 1986 survey shows that the river mouth was wider and deeper than in the case of March 1987. On 02-09-86 the gap between the high water mark on either side of the mouth was 160 m apart with a depth of -1,00 m (MSL) against the 140 m wide and 0,0m depth on 24-03-87. The mouth was closed by the sea shortly afterwards and was still closed on 12 August 1987 when a profile of the spit at Beacon PA100 was surveyed to determine the difference between the lagoon water level and the average spit (rest height (see Figure 38)). It was found that the water level was 1,76 m (MSL) in the lagoon and the average height of the crest of the spit about 3 m (MSL). A later personal observation shows that in the area flooded near Le-Bos on the left bank, large areas of fynbos died as a result of the flooding.

Levels taken from the fair charts of September 86 and March 87 and a long-section surveyed on the 21-10-87 give the mouth's position relative to the beacon PA100 on the north easterly bank. Distances measured are positive towards Grotto Beach and negative towards the dunes of Walker Bay, (Figure 39) with chainage 0m,

the position of PA100. In this long-section (Figure 39) it can be seen that the river mouth was not opened at the same position.

### 6.3.2 Contour Plans

The contour plans starts in the north western bank of the Grotto Beach side in the dune area, this area is mined by the municipality for sand and ends in the south eastern side where the frontal dunes of the Walker Bay Beach start. It shows that the river course is modified seasonally by floods, scouring and sediment deposition. The tidal sand and mudflats is inundated and exposed daily by tides if the mouth is open to the sea. The floodplains on the sides of the estuary are seasonally flooded when rain floods coincide with the mouth closed to the sea which dam up the river waters. The two surveys show that the sandspit is constantly changing in form due to wind and sediment transport by wave action, river run-off and tidal action. The Klein River is usually opened manually to the sea due to impediment of man made structures on the estuary that prevent the water level in the estuary to rise sufficiently to break naturally out to sea.

### 6.3.3 Difference map

Fig. 37 shows a difference map that was drawn of the Klein River to compare the March 1987 survey relative to the September 1986 survey. The only significant change was in the river mouth due to scouring and sediment deposition by tidal, wave and river-flow action.

Sediment deposits of up to 2 metres occurred in the mouth channel, probably due to the low runoff and tidal action. The mouth was opened manually on 30-08-86 and closed up during the period 21 to 30 May 1987. This information was obtained from the Department of Nature Conservation.

The effect of sand mining and wind action is notably in the south westerly dune area near Grotto Beach (see Figure 37). The spit on the north easterly side changed insignificantly.

#### 6.3.4 Sand samples

Sand samples were taken at 7 positions as indicated in Figure 36. The result of the settling tube analyses can be seen in Table 7. The samples taken on 24-03-87 shows that the median grain diameters (D50) fall within the fine sand limits of the shore protection manual size classification except samples O3 and W2 that falls in the lower range of medium sands with their D50 values of 255 and 261 micron. (see Table 8).

#### 6.3.5 Conclusions on the Klein River mouth survey

- 1) The August 1986 survey shows that the river mouth was wider and deeper than in the case of March 1987.
- 2) The average height of the crest of the south-eastern sandspit is 3,0 m (MSL) and is approximately 130 wide.
- 3) Comparison between the 02-09-86, 24-03-87 and the 21-10-87 surveys shows that the mouth was not opened at the same position.
- 4) The Klein River is usually opened manually to the sea due to impediment of manmade structures on the estuary.
- 5) Sediment deposits of up to 2 metres occurred in the mouth channel, probably due to the low runoff and tidal action.
- 6) The effect of sand mining is notable in the south westerly dune area.
- 7) The spit on the north easterly side changed insignificantly.

7. CONCLUSION

- 1) A system of routine surveying on an annual basis has been instigated in the six estuaries discussed in this report, that is, the Orange, Olifants, Berg, Diep, Palmiet and the Klein.
- 2) These routine surveys are providing a valuable data set to assist in our understanding of estuarine processes and will in time be an invaluable aid in management studies.

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BASIC PHYSICAL GEOGRAPHY/HYDRO DATA FOR THE ESTUARIES OF THE SOUTH WESTERN CAPE. (CSW 1 to CSW 26) NRIO DATA REPORT (in press). Report No D8705.

TABLE 1: ORANGE RIVER MOUTH SAND SAMPLES (SEE POSITIONS IN FIG. 4)

SAMPLES TAKEN ON 02-09-87														
DIAMETER IN MICRONS ( $10^6\text{M}$ ) (ORANGE RIVER MOUTH)														
SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SS9	SS10	SS11	SS12	SS13	SS14	
D05	327	345	341	388	303	323	394	404	306	275	258	208	415	375
D10	367	383	391	454	350	370	451	470	356	312	297	253	477	433
D16	404	418	436	513	393	409	495	522	402	342	340	285	524	481
D25	448	463	474	581	439	462	547	580	454	381	387	320	581	541
D35	492	505	519	637	485	514	597	630	505	417	438	353	636	601
D50	513	524	539	663	504	537	622	653	530	435	464	368	662	629
D60	551	562	579	713	543	589	669	700	582	469	514	397	715	689
D65	617	620	644	792	600	698	748	789	662	526	625	444	818	801
D75	671	673	695	860	642	814	816	870	727	577	751	479	923	960
D84	730	756	770	940	695	951	908	993	831	655	917	520	1067	1155
D90	795	858	848	1019	761	1083	1004	1136	924	760	1043	566	1232	1341
D95	936	1025	969	1146	903	1280	1165	1390	1093	973	1187	637	1466	1613

TABLE 2			
SEE POSITIONS ON FIG. 6			
SAMPLES TAKEN ON 05-09-87			
DIAMETER IN MICRONS			
OLIFANTS RIVER MOUTH			
	SS1	SS2	SS3
D05	220	200	236
D10	244	230	261
D16	264	258	283
D25	289	290	312
D35	314	320	340
D50	326	335	354
D60	349	363	382
D65	383	405	430
D75	405	429	460
D84	428	455	493
D90	449	483	529
D95	484	523	604

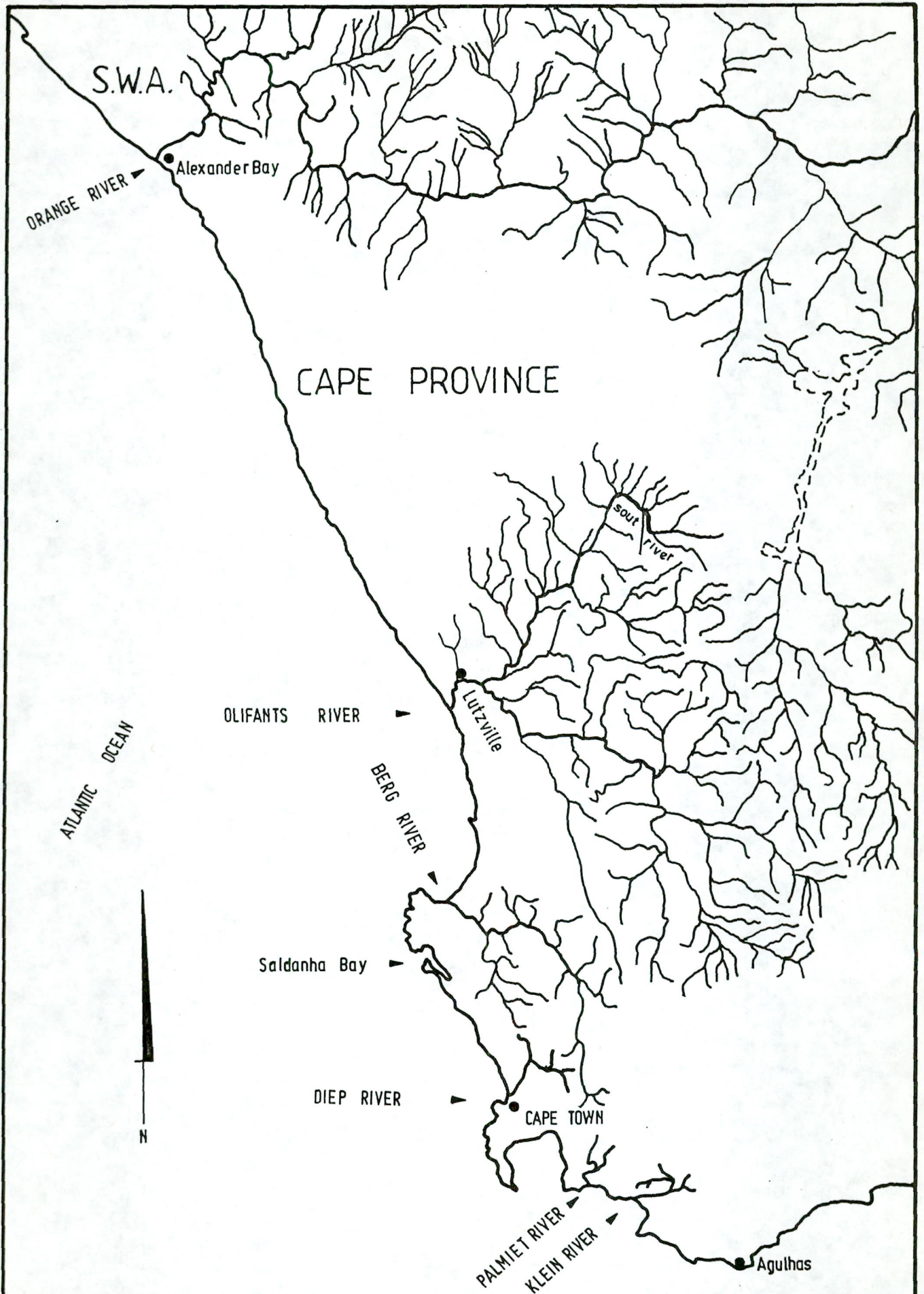
TABLE 3			
SEE POSITIONS ON FIG. 9			
SAMPLES TAKEN ON 06-06-86			
DIAMETER IN MICRONS			
BERG RIVER MOUTH			
	SS1	SS2	SS3
D05	-	-	-
D10	247	248	216
D16	294	289	256
D25	349	329	304
D35	408	357	351
D50	482	394	414
D60	-	-	-
D65	562	427	477
D75	635	450	526
D84	755	472	582
D90	880	493	654
D95	-	-	-

TABLE 4					TABLE 5							
SEE POSITIONS ON FIG. 16					SEE POSITIONS ON FIG. 18							
SAMPLES TAKEN ON 05-06-86					SAMPLES TAKEN ON 26-06-87							
DIAMETER IN MICRONS					DIAMETER IN MICRONS							
DIEP RIVER MOUTH					DIEP RIVER MOUTH							
	S2	S1	M	N1	N2	<sup>S</sup> S1	S2	S3	S4	S5	<sup>N</sup> S6	
D05	-	-	-	-	-	D05	145	148	162	173	156	152
D10	201	210	172	202	171	D10	166	177	177	205	177	171
D16	225	238	186	229	190	D16	193	200	194	234	199	190
D25	256	276	213	264	215	D25	245	221	213	273	225	217
D35	293	316	252	304	244	D35	344	249	241	313	257	243
D50	384	382	348	368	286	D50	386	261	254	330	276	257
D60	-	-	-	-	-	D60	477	287	286	372	300	289
D65	517	468	443	459	330	D65	694	318	326	467	338	332
D75	647	540	527	552	371	D75	834	340	354	582	376	369
D84	799	642	630	719	432	D84	962	363	381	779	506	404
D90	926	759	758	842	513	D90	1112	425	417	955	510	433
D95	-	-	-	-	-	D95	1306	723	506	1176	582	472

TABLE 6							TABLE 7							
SEE POSITIONS ON FIG. 27							SEE POSITIONS ON FIG. 36							
SAMPLES TAKEN ON 15-03-87							SAMPLES TAKEN ON 24-03-87							
DIAMETER IN MICRONS							DIAMETER IN MICRONS							
PALMIET RIVER MOUTH							KLEIN RIVER MOUTH							
1	2	3	4	5	6		04	03	02	01	W1	W2	W3	
D05	342	270	255	267	269	334	D05	158	159	150	148	153	156	148
D10	396	302	305	300	342	375	D10	174	176	164	157	168	173	159
D16	441	329	350	333	401	410	D16	190	192	176	167	187	192	169
D25	498	358	391	367	452	499	D25	211	215	193	179	213	220	182
D35	560	387	430	403	507	502	D35	233	242	209	192	235	249	196
D50	584	399	447	419	535	521	D50	245	255	217	199	244	261	204
D60	632	423	481	450	588	557	D60	266	286	233	213	264	284	219
D65	712	457	536	497	685	610	D65	301	342	260	244	307	324	244
D75	788	481	582	531	782	652	D75	334	388	283	261	359	364	265
D84	882	508	653	574	896	711	D84	417	462	314	300	441	430	290
D90	987	535	728	624	988	778	D90	548	544	362	404	543	497	322
D95	1135	582	841	716	1120	889	D95	721	658	438	656	678	593	374

TABLE 8	
GRAIN SIZE CLASSIFICATION	
GRAIN SIZE	MICRON
very coarse sand	1000 - 2000
coarse sand	500 - 1000
medium sand	250 - 500
fine sand	125 - 250
very fine sand	63 - 125
silt/clay	< 63

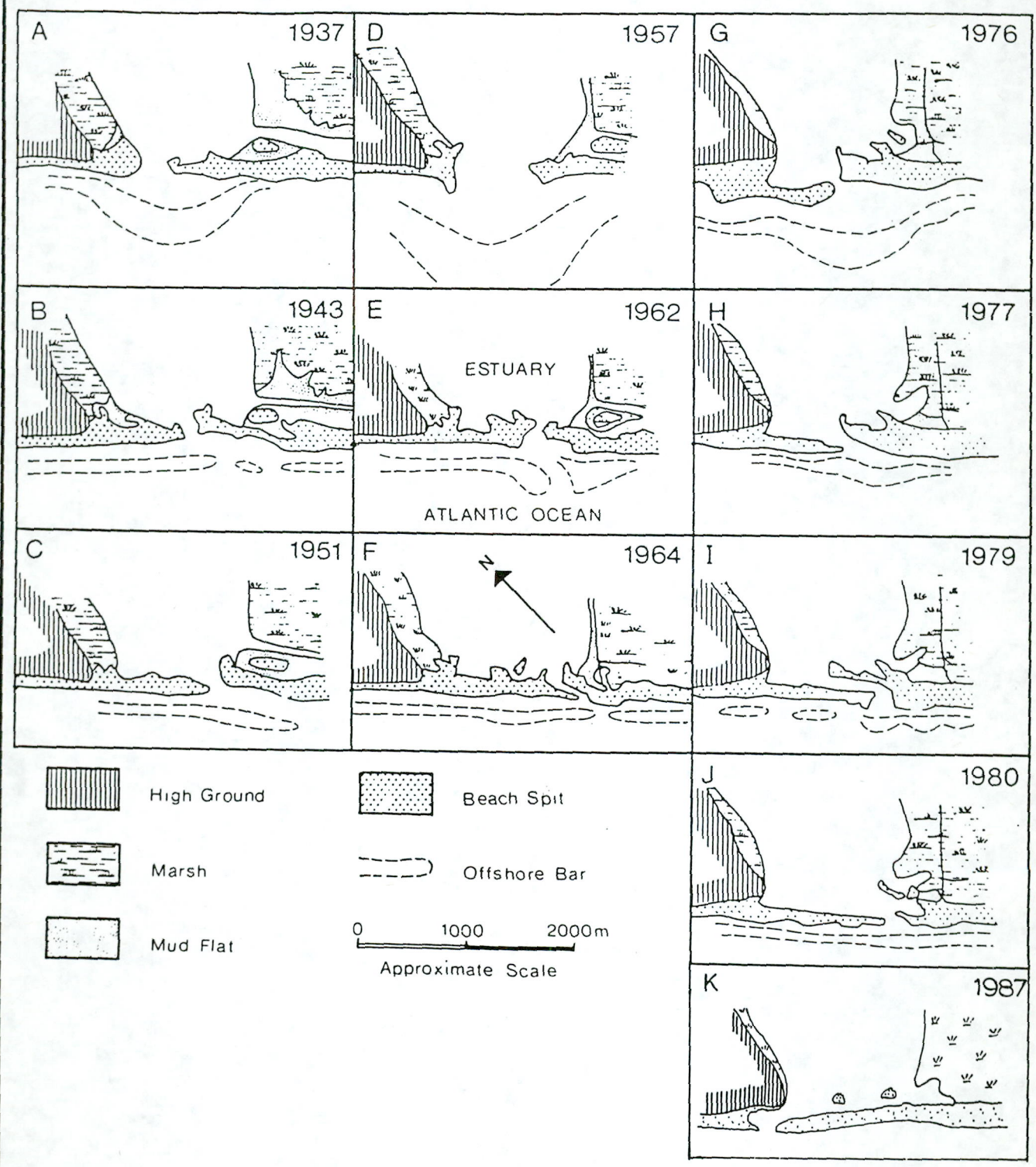
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 REF.:

# KEY-PLAN

FIGURE  
 1



Source : I.v.Heerden (1986)

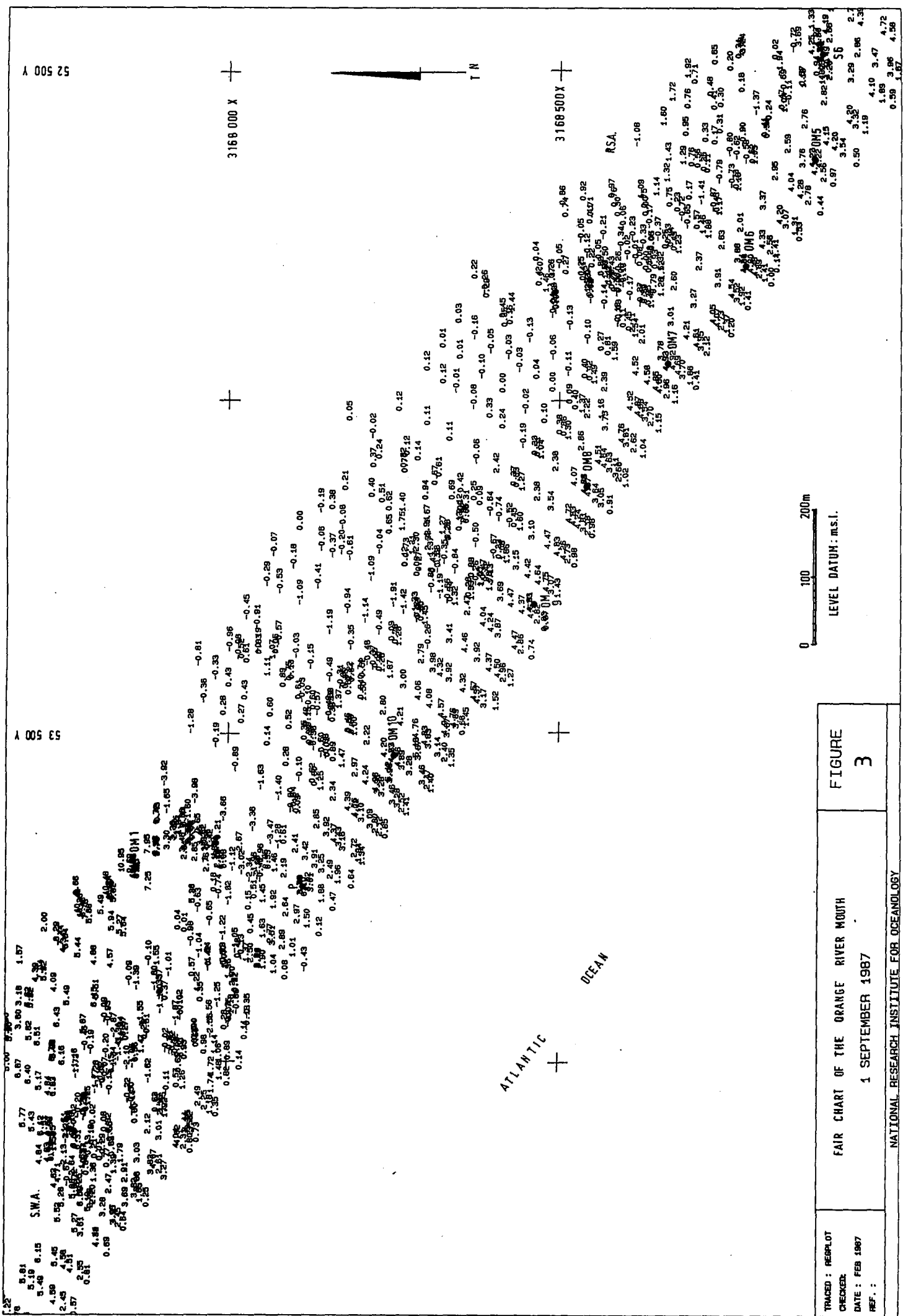
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LOCATION OF THE MOUTH OF THE ORANGE ESTUARY 1937 to 1987

FIGURE  
 2

52 500 Y

500 Y



TRACED : RESPLOTT  
 CHECKED:  
 DATE : FEB 1987  
 REF. :

FAIR CHART OF THE ORANGE RIVER MOUTH  
 1 SEPTEMBER 1987  
 NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY

FIGURE  
 3

LEVEL DATUM : m.s.l.

0 100 200m

OCEAN

ATLANTIC

RSA.

3168 500 X

3168 000 X

T N

4.10 3.47  
 1.89 3.86 4.72  
 0.59 1.67

0.50 3.30 3.29 2.86 2.7  
 1.19 4.10 3.47  
 0.59 1.67

0.44 2.56 2.86 2.86 1.9  
 0.97 4.20 2.86 2.86 1.9  
 3.54 4.20 2.86 2.86 1.9

0.33 1 4.04 2.59 2.76 2.76 3.65  
 2.76 4.20 2.86 2.86 1.9  
 0.44 2.56 2.86 2.86 1.9

0.33 1 4.04 2.59 2.76 2.76 3.65  
 2.76 4.20 2.86 2.86 1.9  
 0.44 2.56 2.86 2.86 1.9

0.33 1 4.04 2.59 2.76 2.76 3.65  
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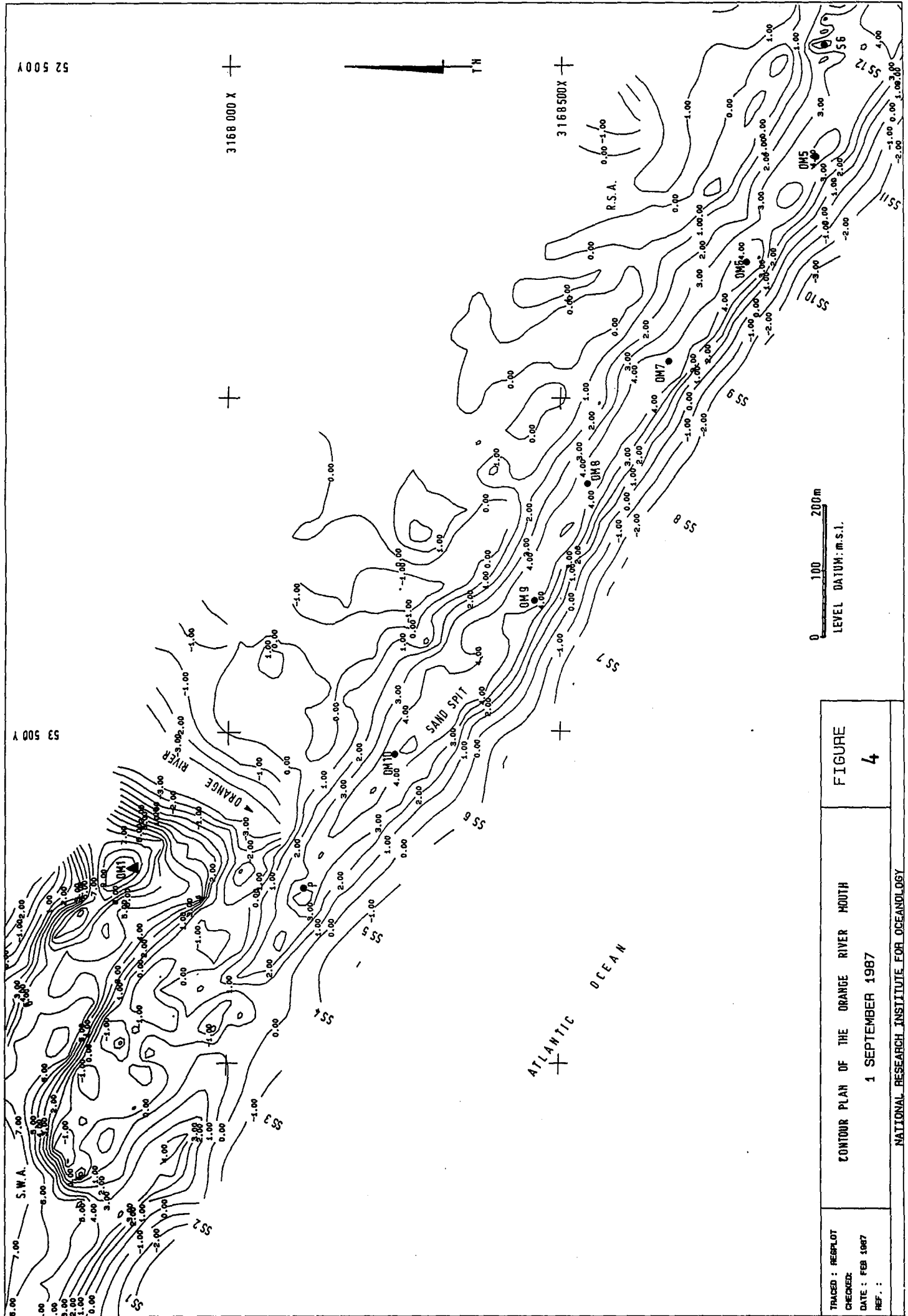
0.33 1 4.04 2.59 2.76 2.76 3.65  
 2.76 4.20 2.86 2.86 1.9  
 0.44 2.56 2.86 2.86 1.9

0.33 1 4.04 2.59 2.76 2.76 3.65  
 2.76 4.20 2.86 2.86 1.9  
 0.44 2.56 2.86 2.86 1.9

0.33 1 4.04 2.59 2.76 2.76 3.65  
 2.76 4.20 2.86 2.86 1.9  
 0.44 2.56 2.86 2.86 1.9

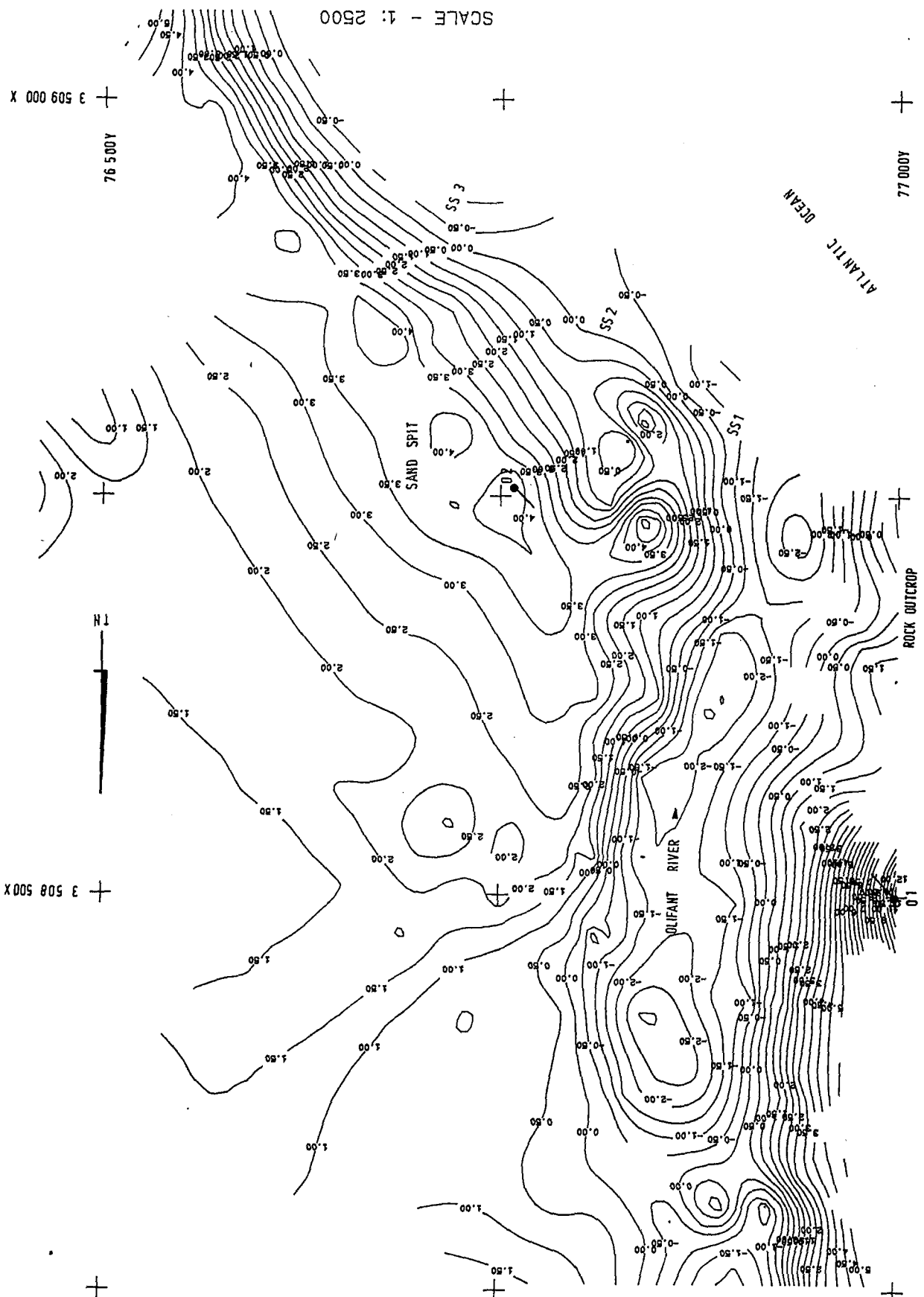
0.33 1 4.04 2.59 2.76 2.76 3.65  
 2.76 4.20 2.86 2.86 1.9  
 0.44 2.56 2.86 2.86 1.9

0.33 1 4.04 2.59 2.76 2.76 3.65  
 2.76 4.20 2.86 2.86 1.9  
 0.44 2.56 2.86 2.86 1.9

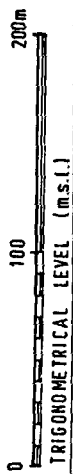


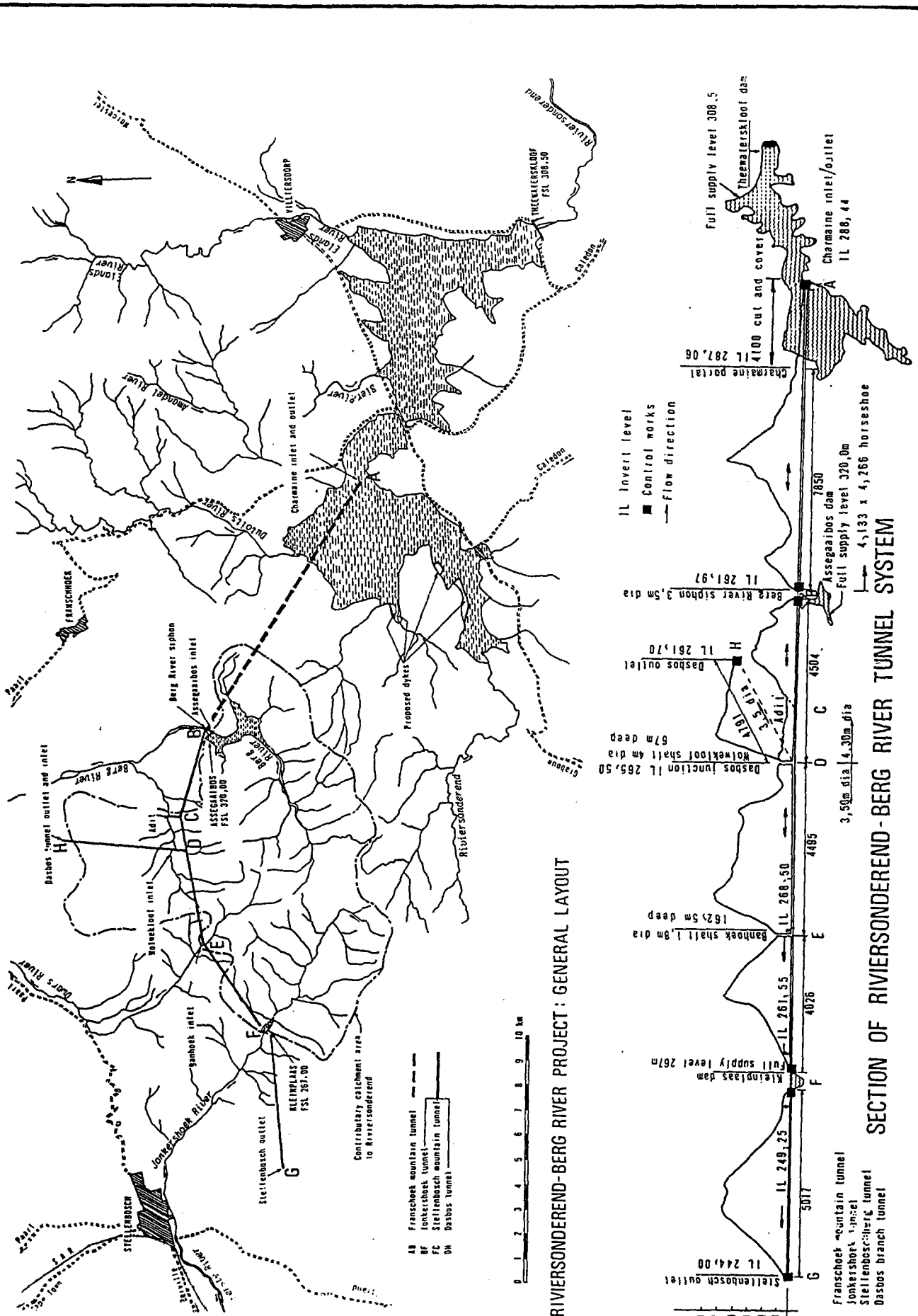
TRACED : RESPLOT CHECKED: DATE : FEB 1987 REF. :	CONTOUR PLAN OF THE ORANGE RIVER MOUTH 1 SEPTEMBER 1987	FIGURE 4
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TRACED : REPLOT  
 CHECKED :  
 DATE : FEB 1987  
 REF :  
 NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY  
 5 SEPTEMBER 1987  
 OLIFANT RIVER MOUTH  
 CONTOUR PLAN  
 FIGURE 6





Source: DEPARTMENT OF WATER AFFAIRS

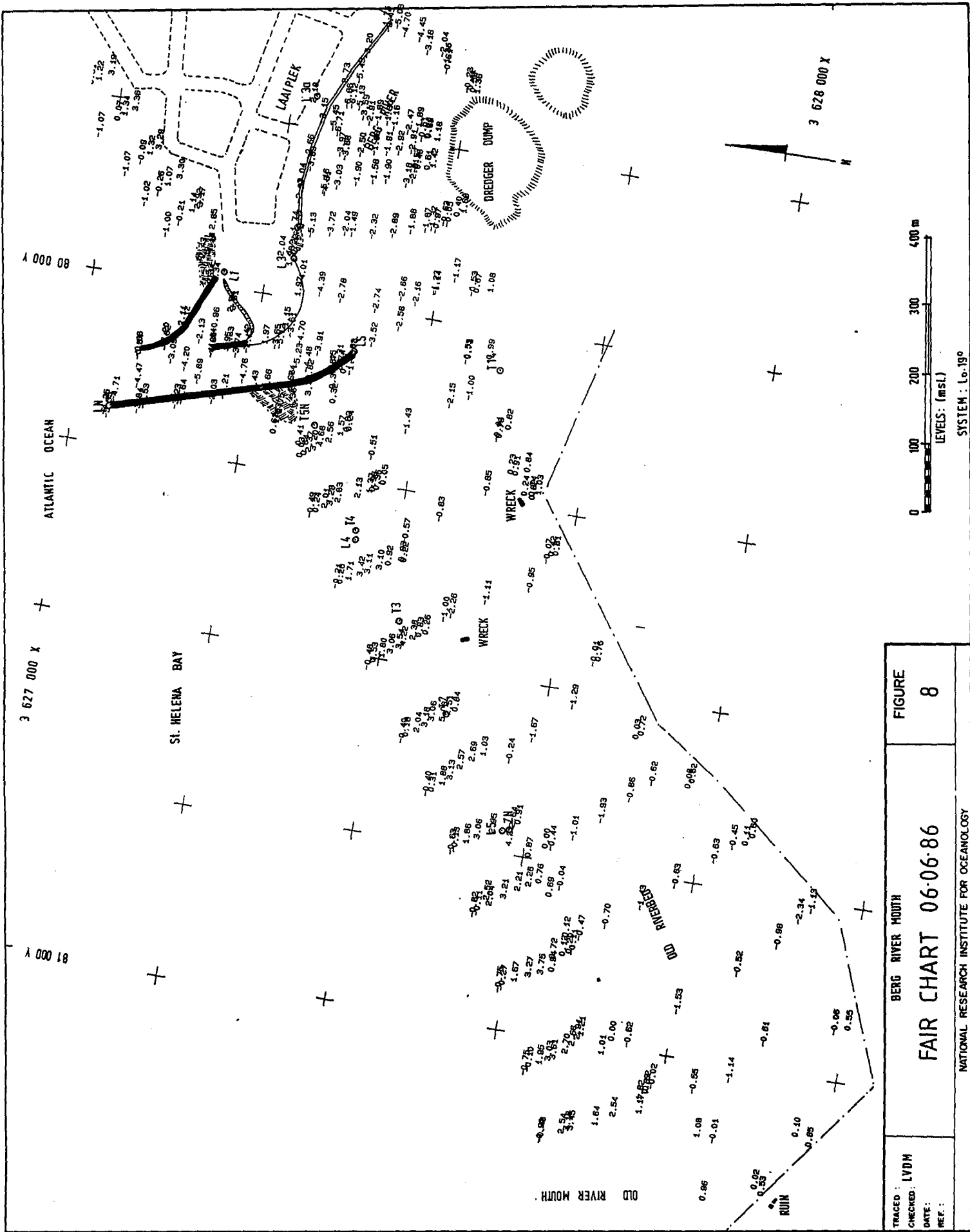
RIVIERSONDEREND-BERG RIVER PROJECT: GENERAL LAYOUT

SECTION OF RIVIERSONDEREND-BERG RIVER TUNNEL SYSTEM

TRACED:  
 CHECKED:  
 DATE:  
 REF.:

RIVIERSONDEREND — BERG RIVER PROJECT

FIGURE  
 7



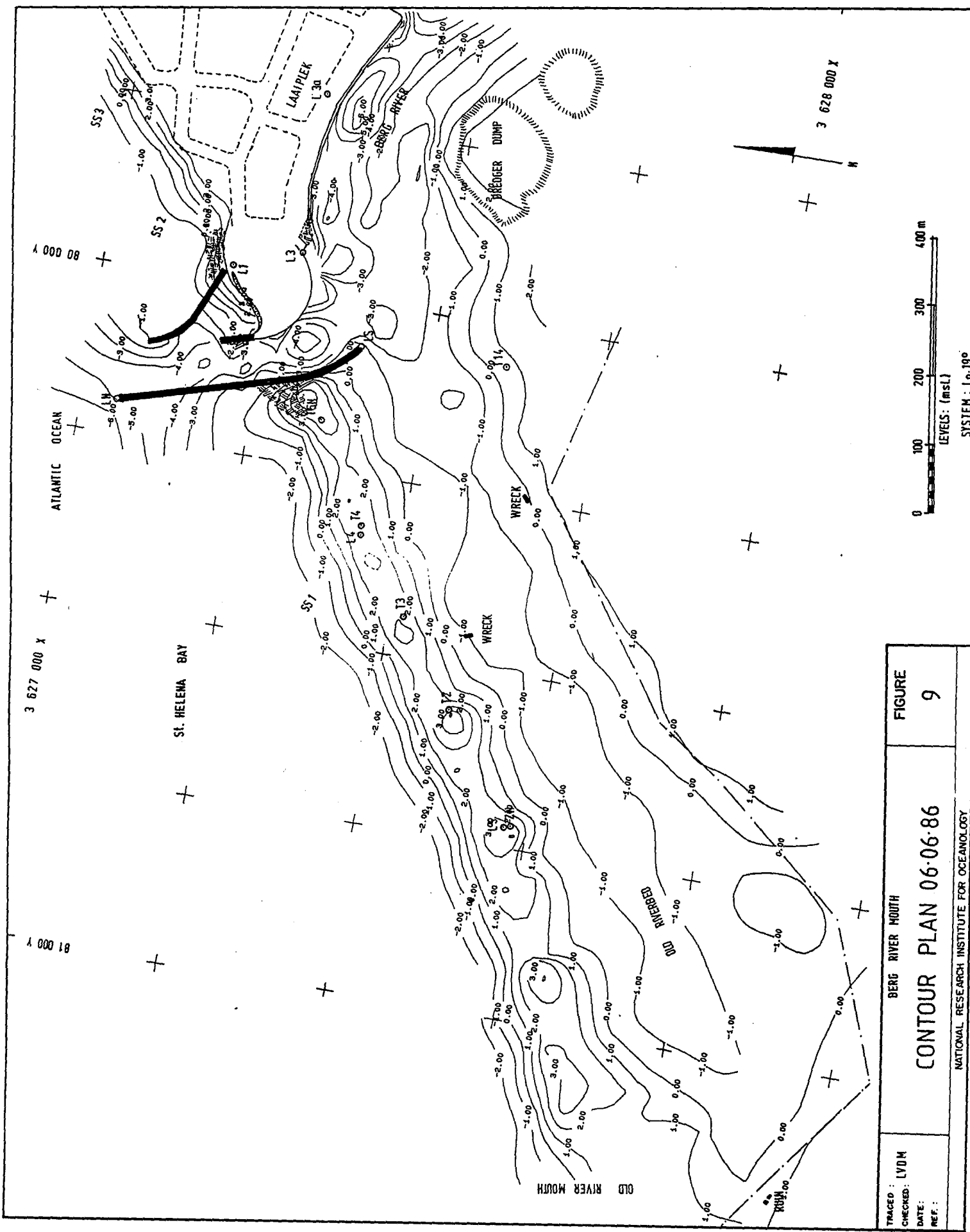
TRACED: LVDM  
 CHECKED: LVDM  
 DATE:  
 REF:

BERG RIVER MOUTH

**FAIR CHART 06-06-86**

FIGURE 8

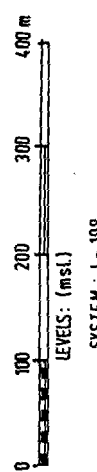
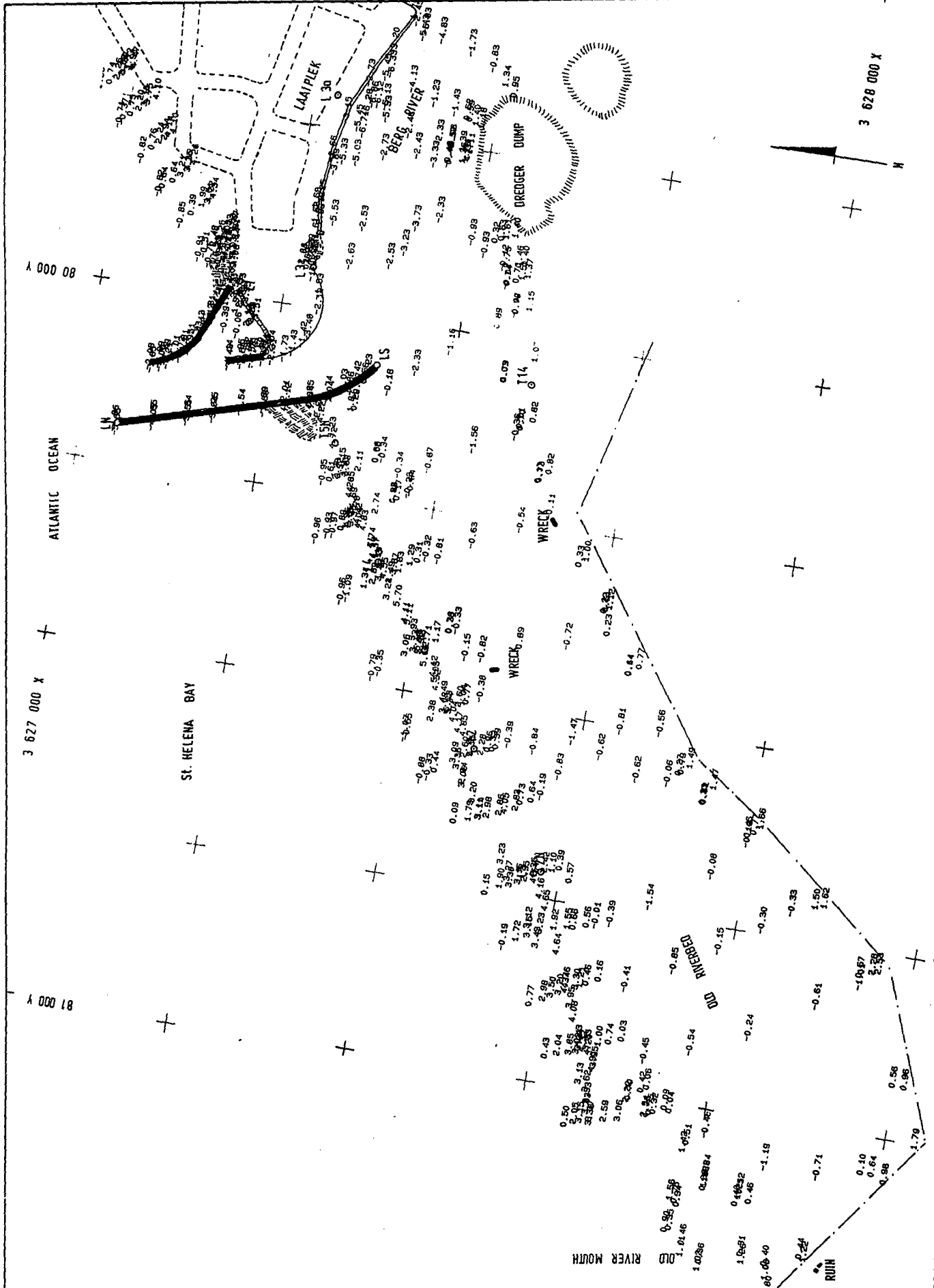
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



TRACED : LYDM	BERG RIVER MOUTH	FIGURE
CHECKED: LYDM		
DATE :	CONTOUR PLAN 06-06-86	
REF. :		



SYSTEM: Lo-19°



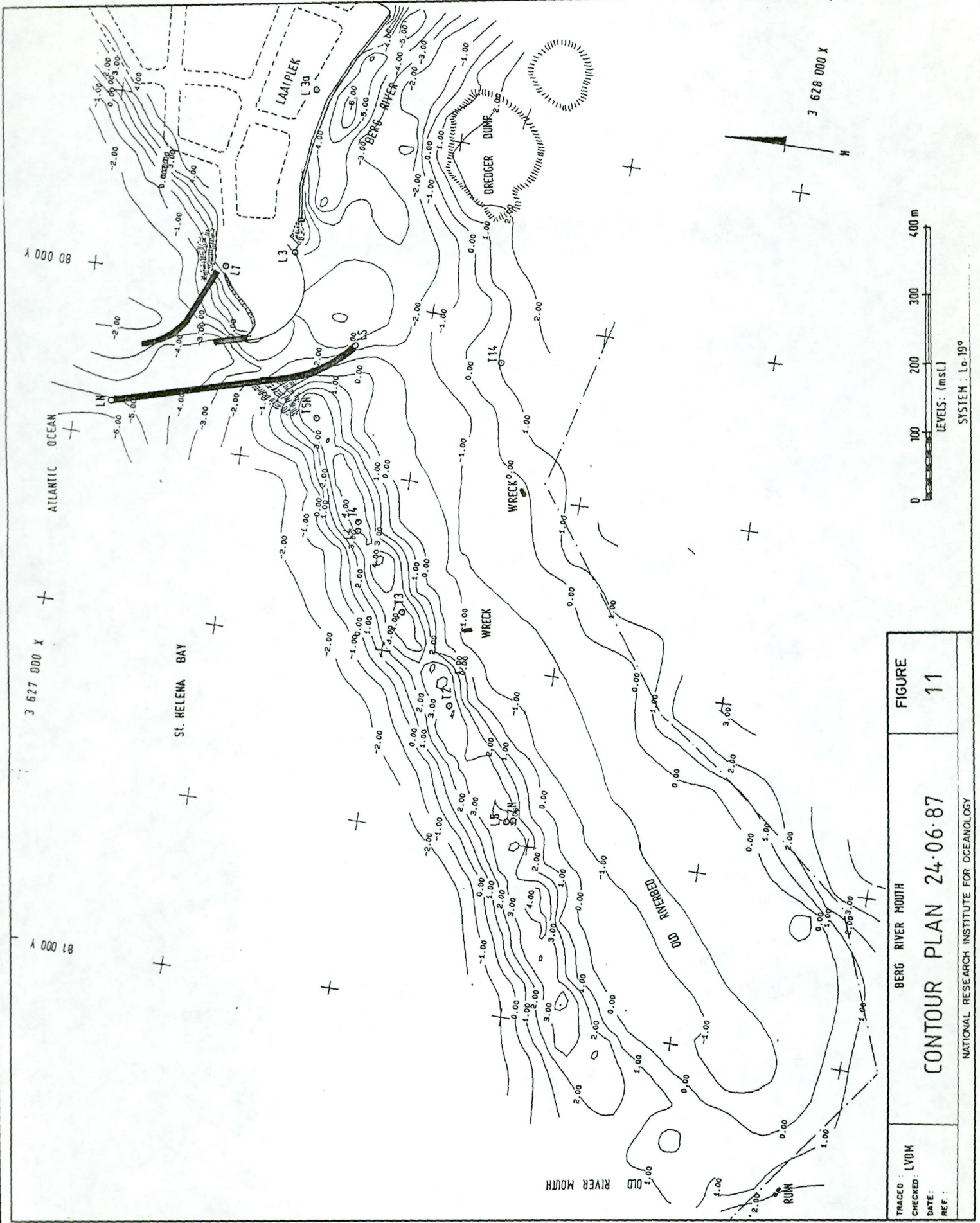
TRACED: LVD M  
 CHECKED:  
 DATE:  
 REF:

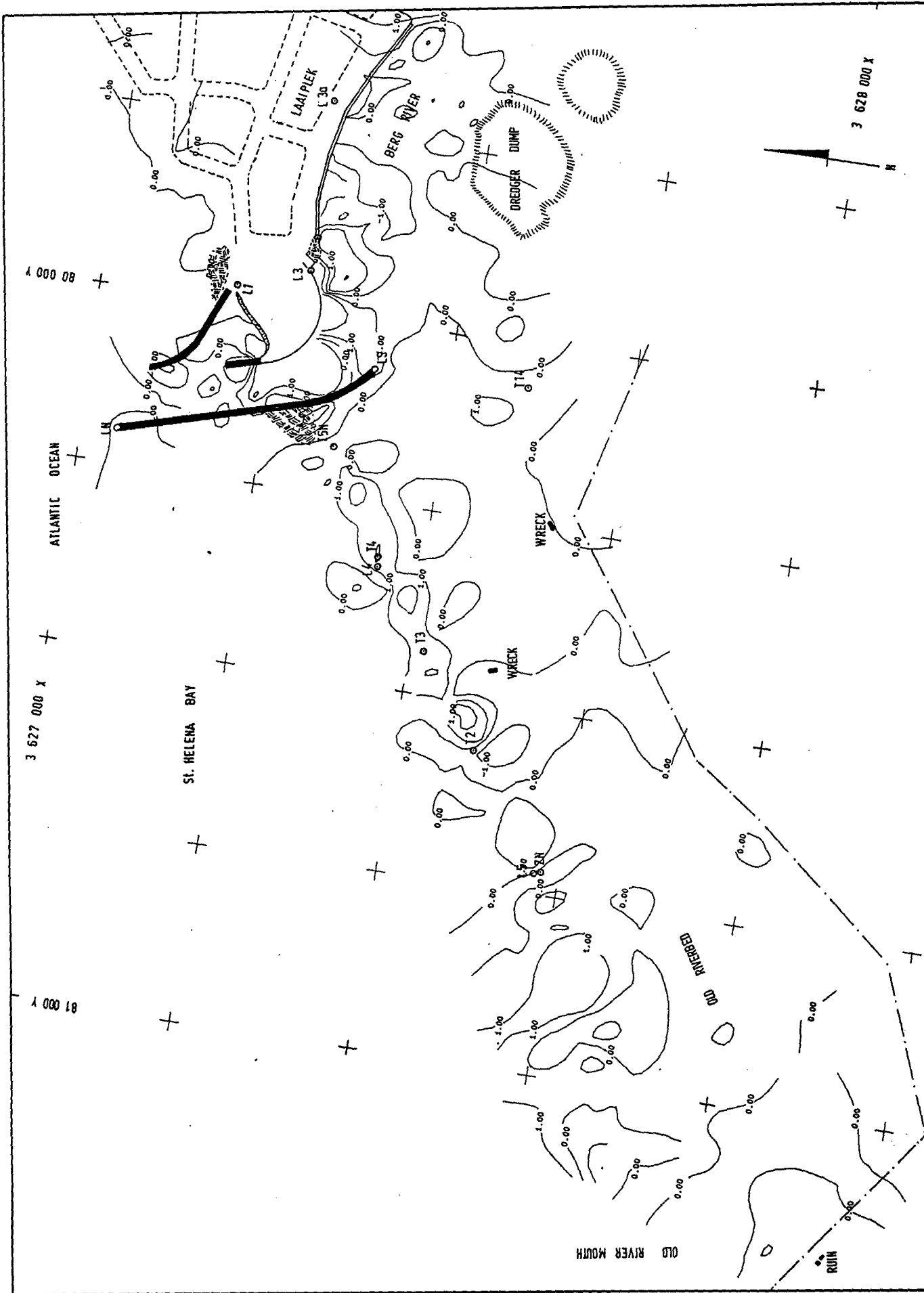
BERG RIVER MOUTH

**FAIR CHART 24-06-87**

FIGURE 10

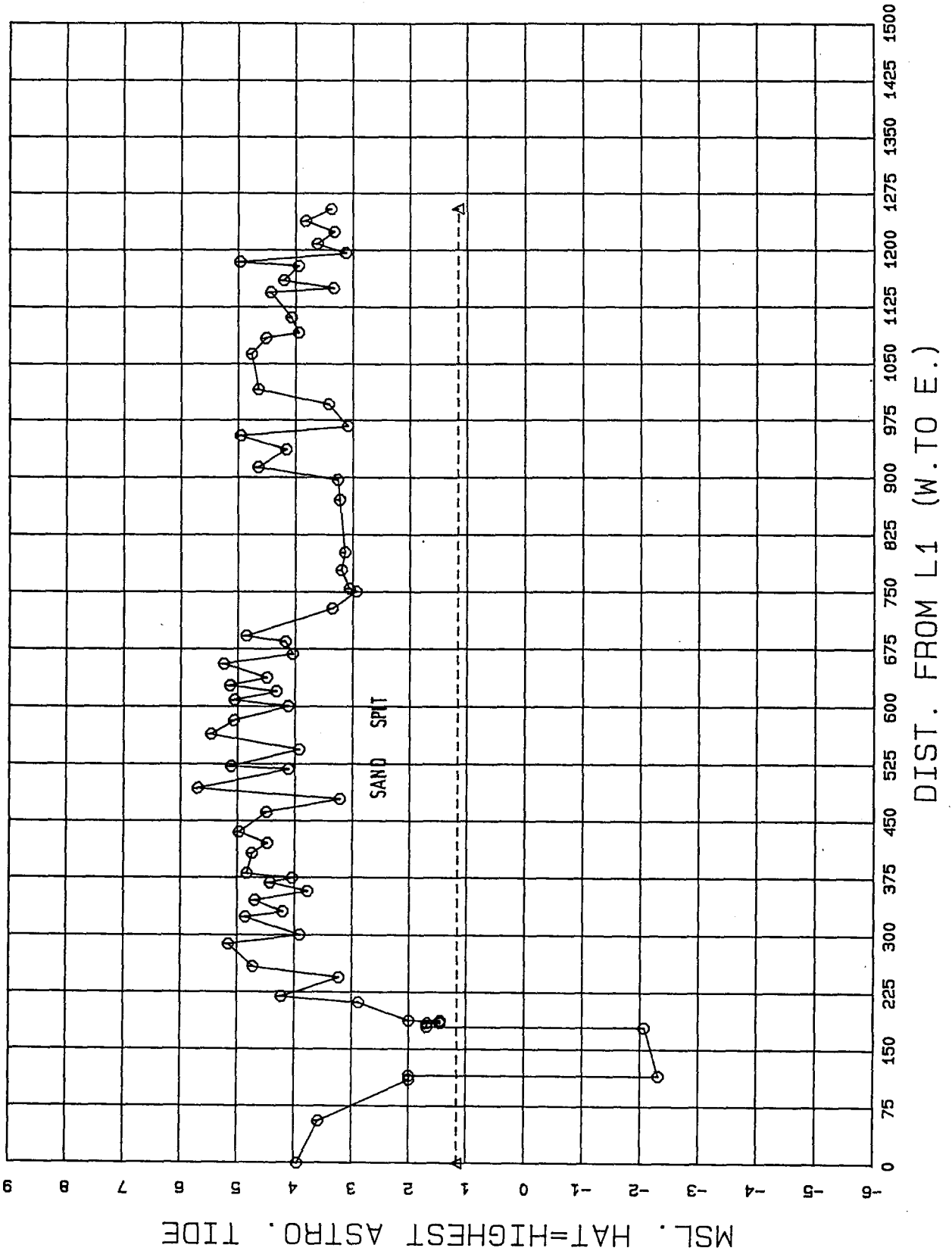
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY  
 SYSTEM: L-19°





TRACED: LVOM	BERG RIVER MOUTH	FIGURE
DATE:	BERG RIVER MOUTH DIFFERENCE MAP	12
REF.:	24 JUNE 1987 RELATIVE TO 6 JUNE 1986	
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY		

SYSTEM: L-0-190

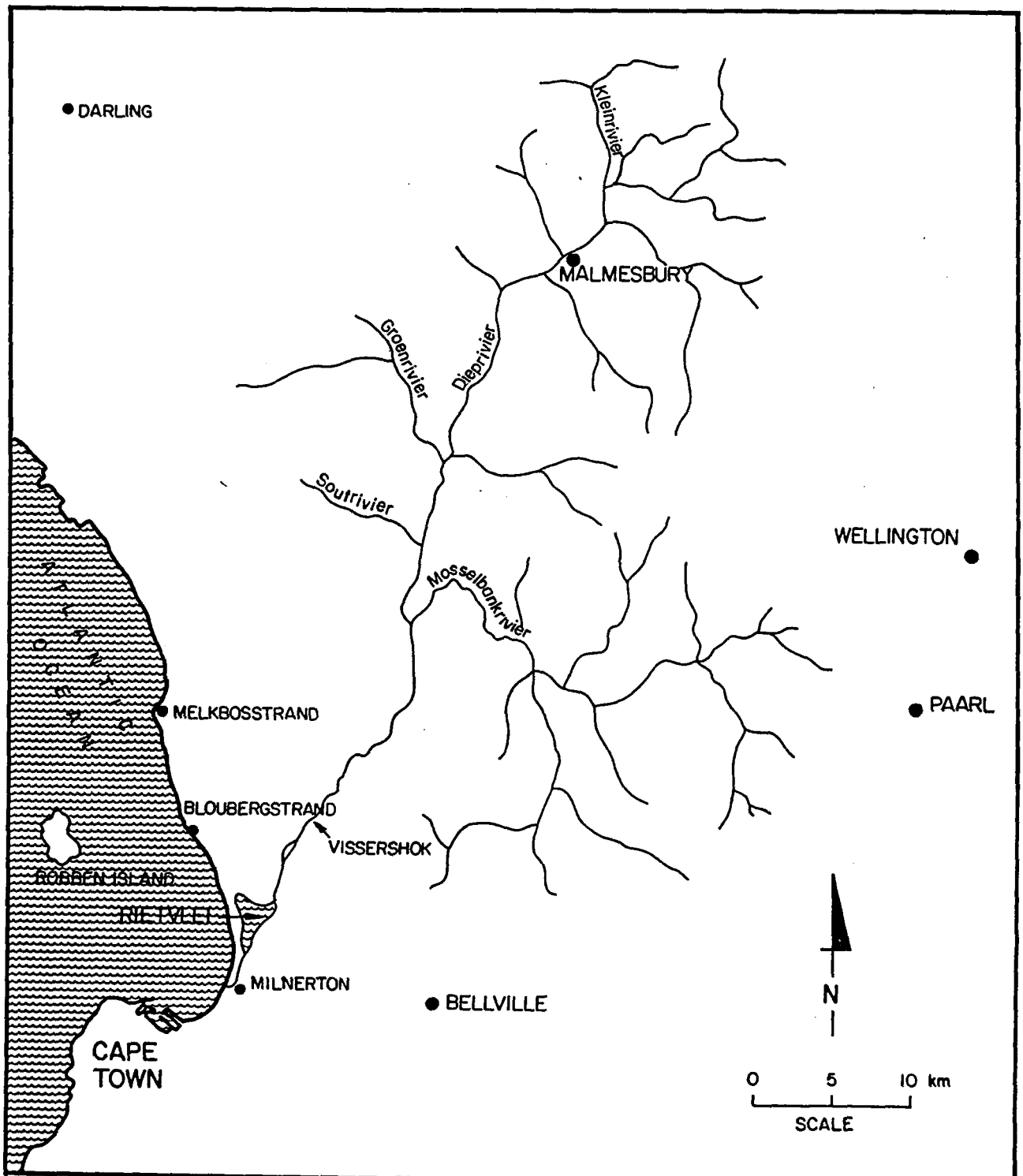


LEGEND : ○—○ 24-06-87  
 ▲---▲ HAT

CHECKED : LVDM  
 DATE :  
 REF. :

BERGRIVIERMOND  
 PROFILE OF CHANNEL AND SPIT

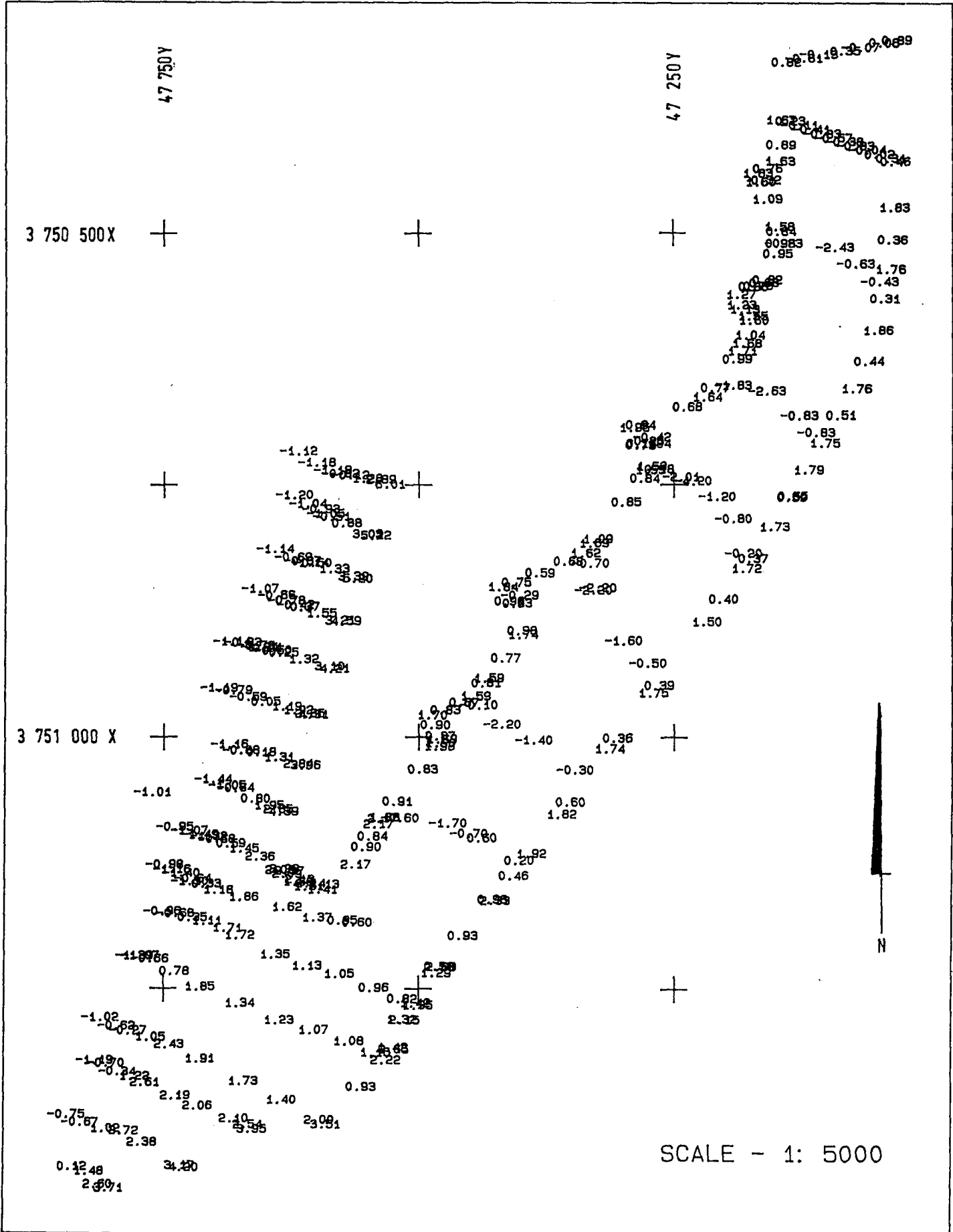
FIGURE  
 13



THE DIEP RIVER CATCHMENT AREA.

FIGURE

14

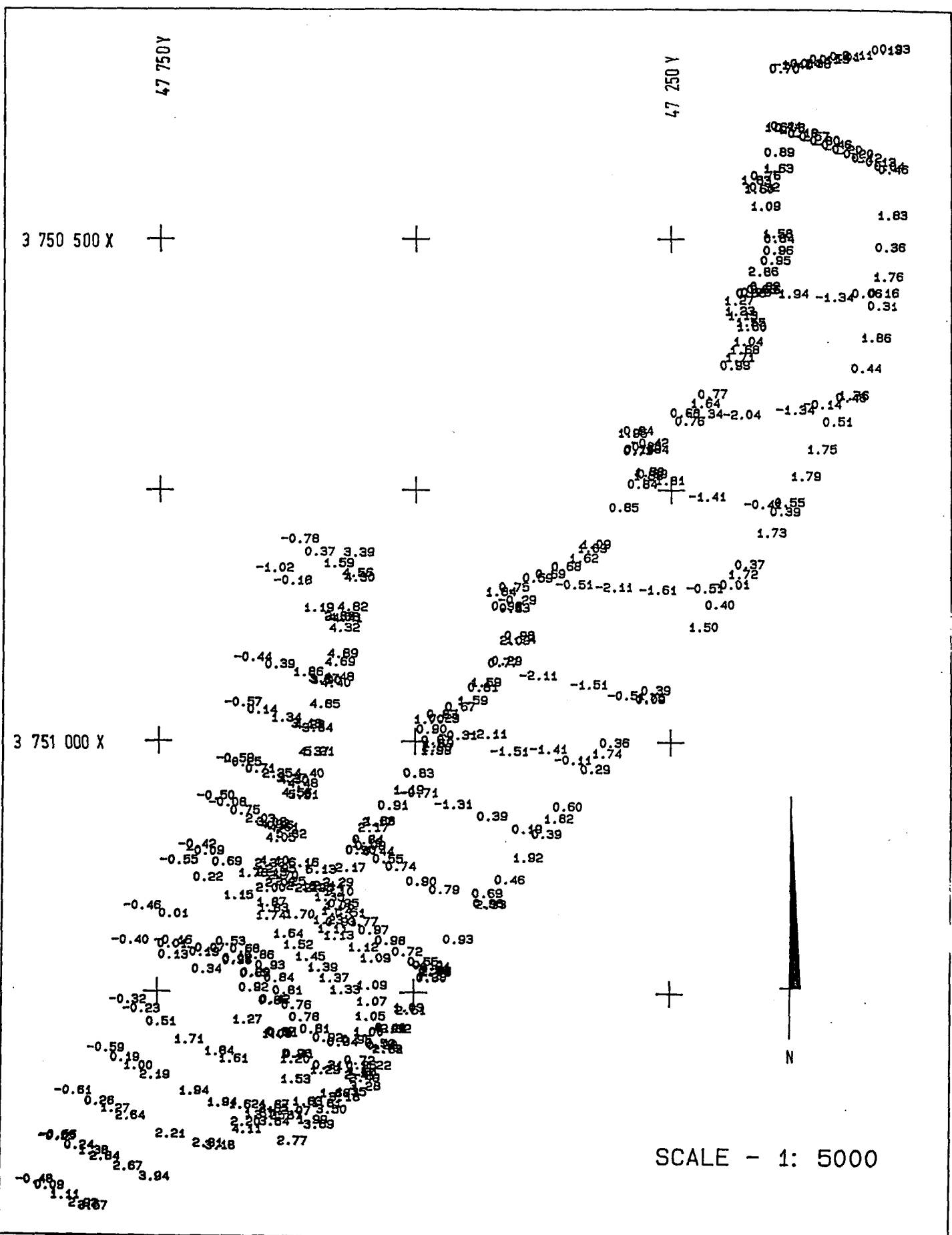


TRACED : REGPLOT  
 COMPILED:  
 DATE : JUNIE 1987  
 REF. : 720 93677

FAIR CHART  
 DIEP RIVER MOUTH  
 5 JUNE 1986

FIGURE  
 15





TRACED : REGPLOT COMPILED: DATE : JUNIE 1987 REF. : 720 83677	FAIR CHART DIEP RIVER MOUTH 26 JUNE 1987	FIGURE 17
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY		



BEACONS	CO-ORDINATES (S 19)		HEIGHT m (MSL)
	Const. Y 0,00	X 3750 000,00	
<u>Trig. Beacons</u>			
Milnerton			
Lighthouse	47 324,15	358,06	
265 (TBN 1)	47 795,04	1 481,50	
<u>Survey Stations</u>			
*D1	47 641,4	1 111,8	+ 4,10
*D2	47 410,3	903,1	+ 2,07
*D3	47 161,8	536,4	+ 2,56



LIGHTHOUSE  
413

WOOD BRIDGE  
0.00

NEW BRIDGE  
JETTY

0.50 3 750 500X+

D3

0.50

0.00

0.50

0.50

0.50

0.50

0.50

0.50

0.50

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0.50

ATLANTIC OCEAN

TABLE BAY

N2

NI

ZONNEKUS  
HOUSE

D2

JETTY

JETTY  
gabions  
DIEP RIVER

SW

D1

0.50

0.00

0.50

0.00

0.50

0.00

0.50

0.00

0.50

0.00

0.50

0.00

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M

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0.00

-0.50

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-1.00

0.00

0.50

0.00

0.50

0.00

SI

0.00

S2

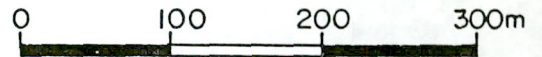
265

47 500Y

RUGBY

MILNERTON

N



+

47 000Y

3 751 500X

SURVEYED:

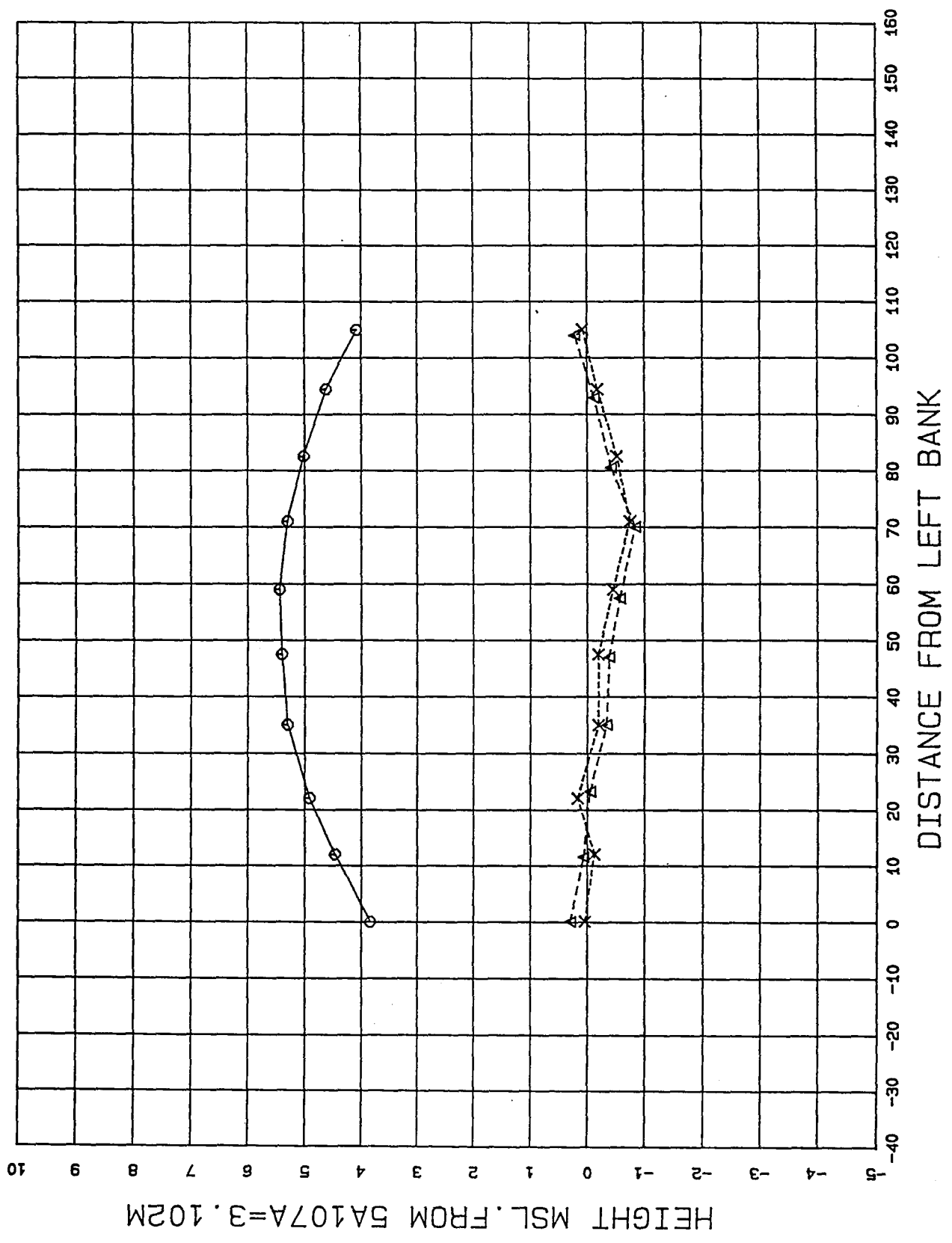
DIEP RIVER MOUTH

FIGURE

DATE:

LOSS AND GAIN BETWEEN 05-06-86 AND 26-06-87

19

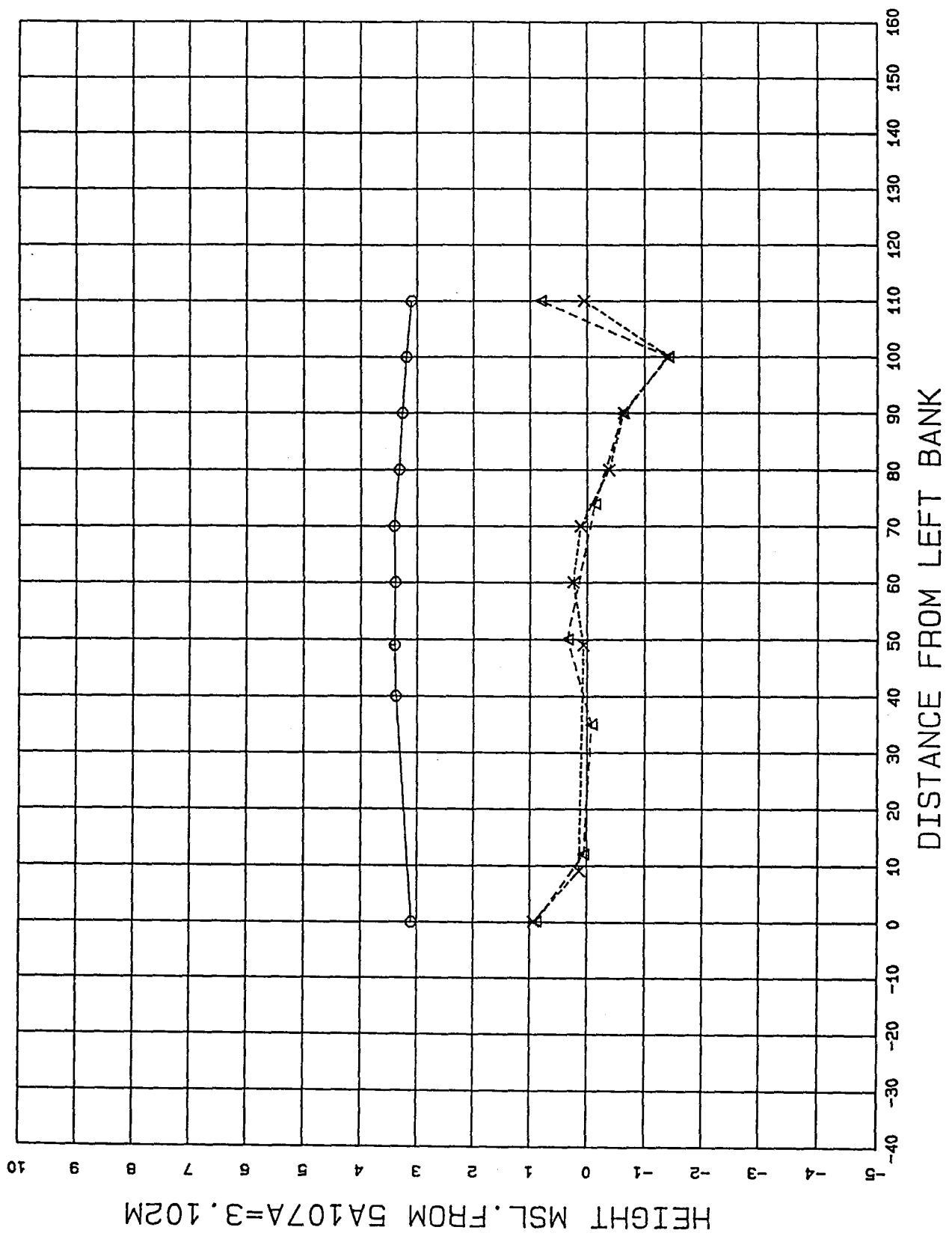


LEGEND : ○—○ DECKLEVEL  
 △---△ 05-06-86  
 X-----X 26-09-87

CHECKED :  
 DATE :  
 REF. :

DIEP RIVER  
 PROFILE OF NEW BRIDGE.

FIGURE  
 20

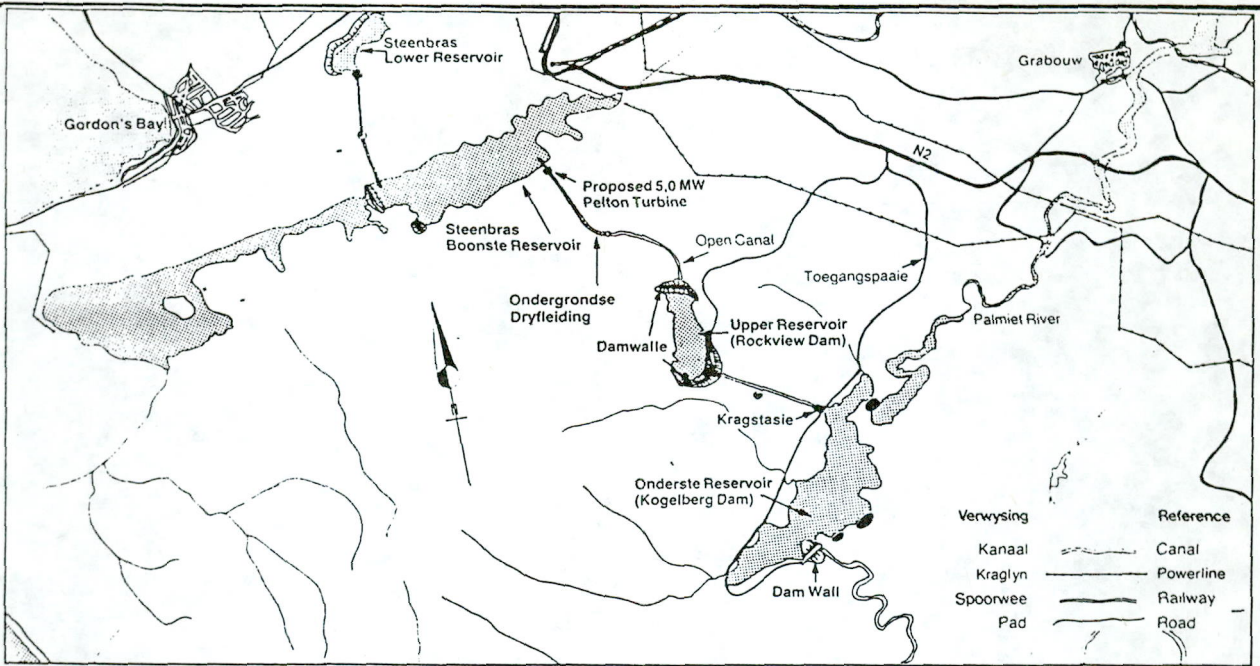


LEGEND : ○—○ DECKLEVEL  
 ▲---▲ 05-06-86  
 ×-----× 26-06-87

CHECKED :  
 DATE :  
 REF. :

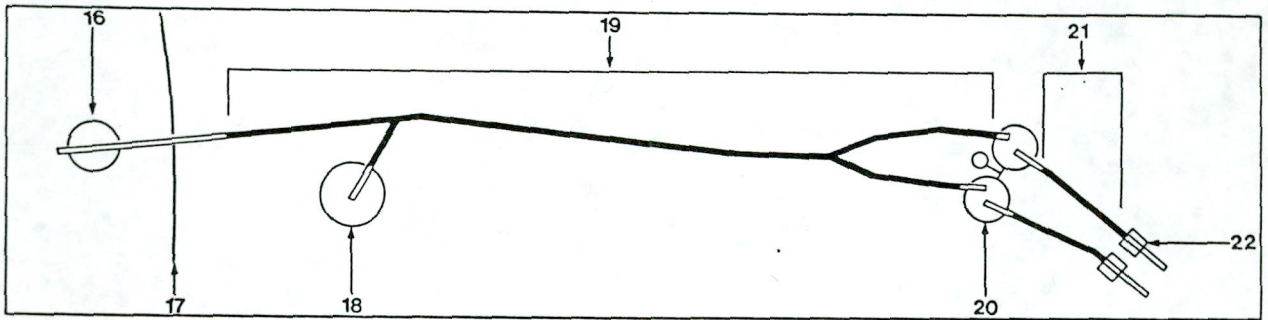
DIEP RIVER  
 PROFILE OF WOOD BRIDGE.

FIGURE  
 21



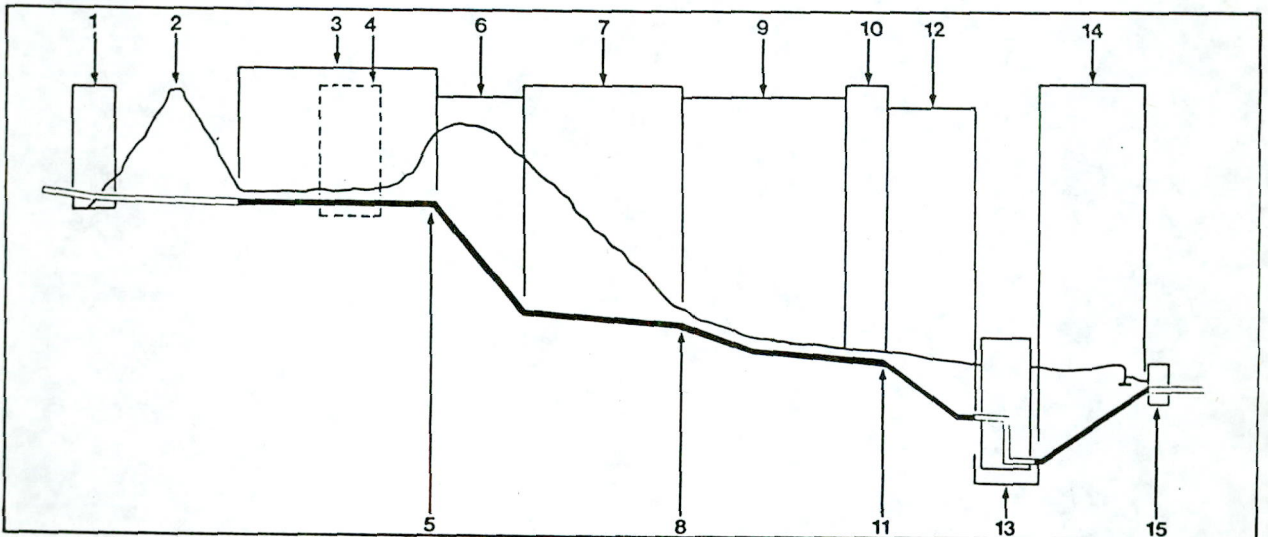
Plan

Plan



Dwarsnit

Longitudinal section



- 1. Aanloopwerke toring
- 2. Rockviewdam
- 3. Aanloop tunnel
- 4. Stutenk
- 5. Portaal
- 6. Skuins skag
- 7. Druktonnel
- 8. Portaal
- 9. Dryfleiding
- 10. Vertakking
- 11. Portale

- 12. Dryfleidingskagte
- 13. Masjien saal
- 14. Onderloopkagte
- 15. Onderloopwerke
- 16. Aanlooptoring
- 17. Rockviewdam
- 18. Stutenk
- 19. Waterweë
- 20. Masjien- en diensskagte
- 21. Waterweë
- 22. Onderlooptorings

- 1. Headworks tower
- 2. Rockview dam
- 3. Headrace tunnel
- 4. Surge tank
- 5. Portal
- 6. Inclined shaft
- 7. Pressure tunnel
- 8. Portal
- 9. Penstock
- 10. Bifurcation
- 11. Portals

- 12. Penstock shafts
- 13. Machine hall
- 14. Tailrace shafts
- 15. Tailworks
- 16. Headrace tower
- 17. Rockview dam
- 18. Surge tank
- 19. Waterways
- 20. Machine and service shafts
- 21. Waterways
- 22. Tailrace towers

TRACED:  
CHECKED:  
DATE:  
REF.:

**General layout of Palmiet Pumped Storage Scheme**

**FIGURE**

**22**

+ 500 Y

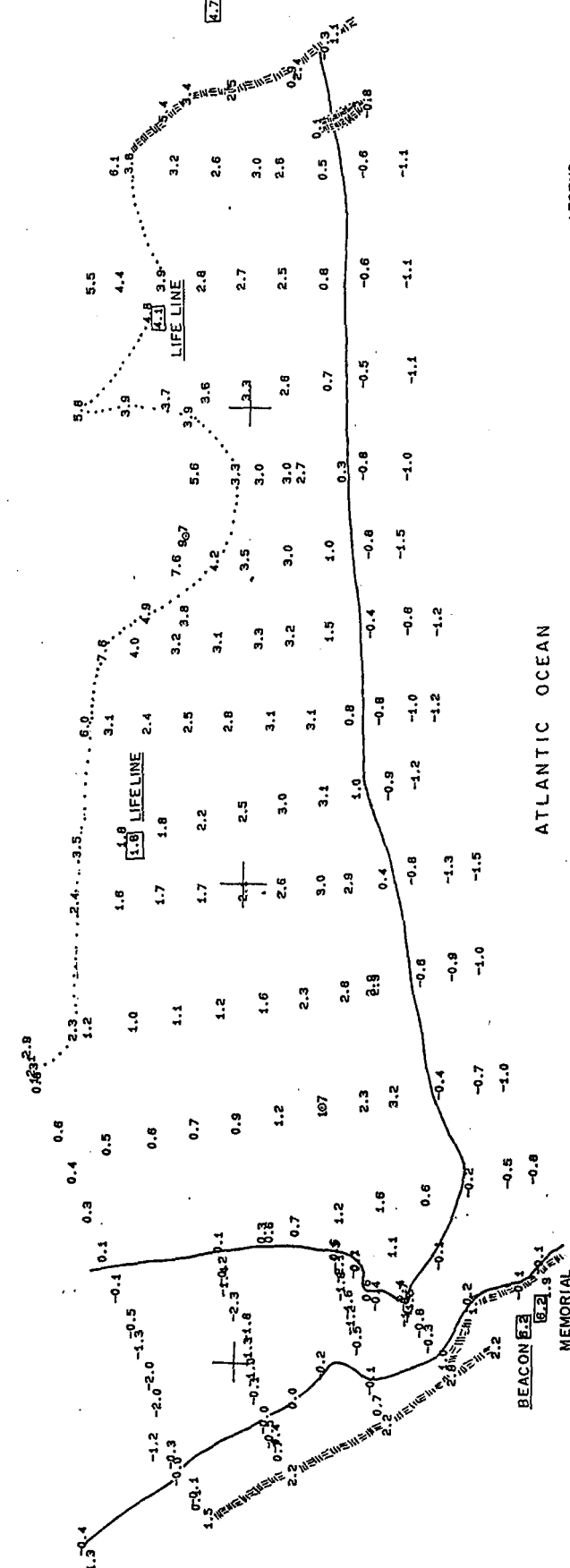
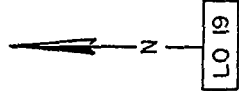
+ 250 Y

000 Y

+ 250 Y

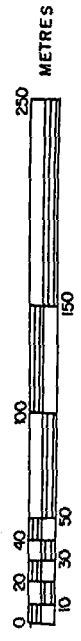
+ 380 I 250 X

+ 380 I 500 X



ATLANTIC OCEAN

- LEGEND
- ▬ ROcks
  - MEAN SEA LEVEL
  - ..... EDGE OF VEGETATION
  - ⊙ SURVEY STATION



LEVEL DATUM : msl.

SURVEYED : L M CHECKED : LB TRACED : REF : 720 92943	PALMIET RIVER MOUTH SURVEY MAP OF THE MOUTH AREA 21 AUGUST 1986	FIGURE 23
	NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY	

500 Y + 3801250 X

250 Y + 3801250 X

0 Y + 3801250 X

-250 Y + 3801250 X



+ 3 801 500 X



LEVEL DATUM : msl.

TRACED : REGPLOT CHECKED: DATE : AUG 1986 REF. :	CONTOUR PLAN PALMIET RIVER 21 AUGUST 1986	FIGURE 24
---	---	--------------

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



+ 500 Y

+ 250 Y

+ 0 Y

+ 3 801 250 X  
- 250 Z

+ 3 801 500 X

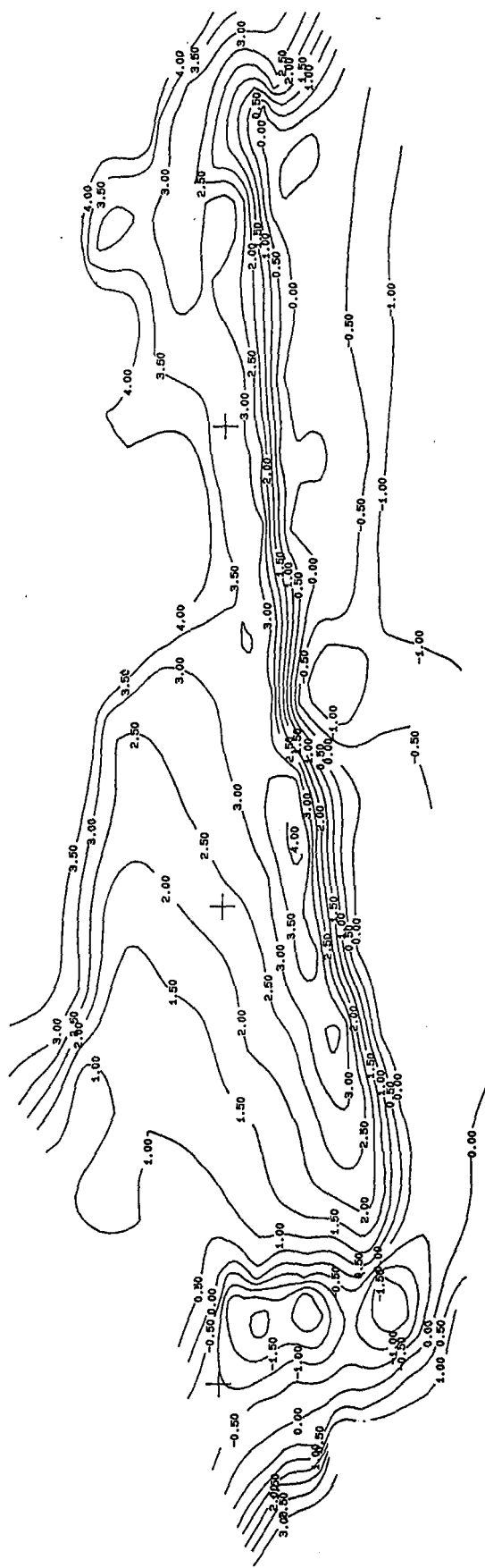


FIGURE 26

CONTOUR PLAN  
PALMIET RIVER MOUTH  
2 SEPTEMBER 1986

TRACED : REBPLT  
CHECKED:  
DATE : FEB 1987  
REF. :



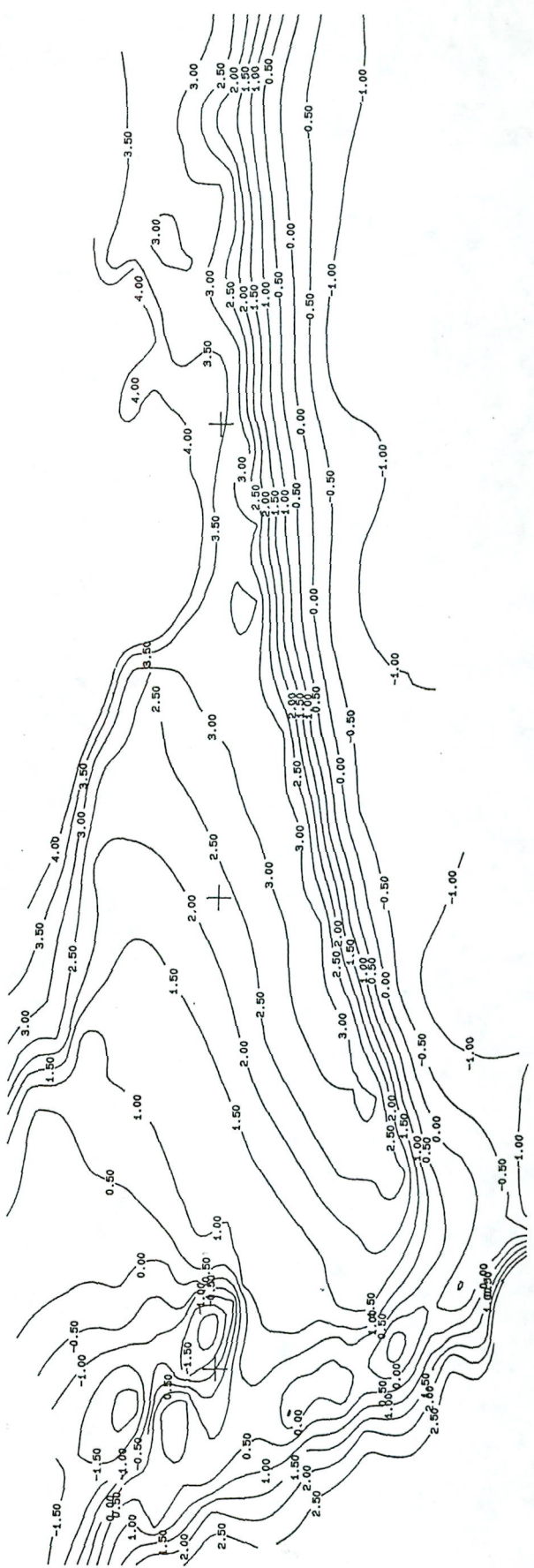
+ 500 Y      + 250 Y      + 0 Y      + 3 801 250 X

+ 3 801 500 X



+ 250 Y

+ 500 Y



LEVEL DATUM : m s l.

TRACED : REGPLOT CHECKED: DATE : FEB 1987 REF. :	CONTOUR PLAN PALMIET RIVER MOUTH 15 MARCH 1987 NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY	FIGURE 28
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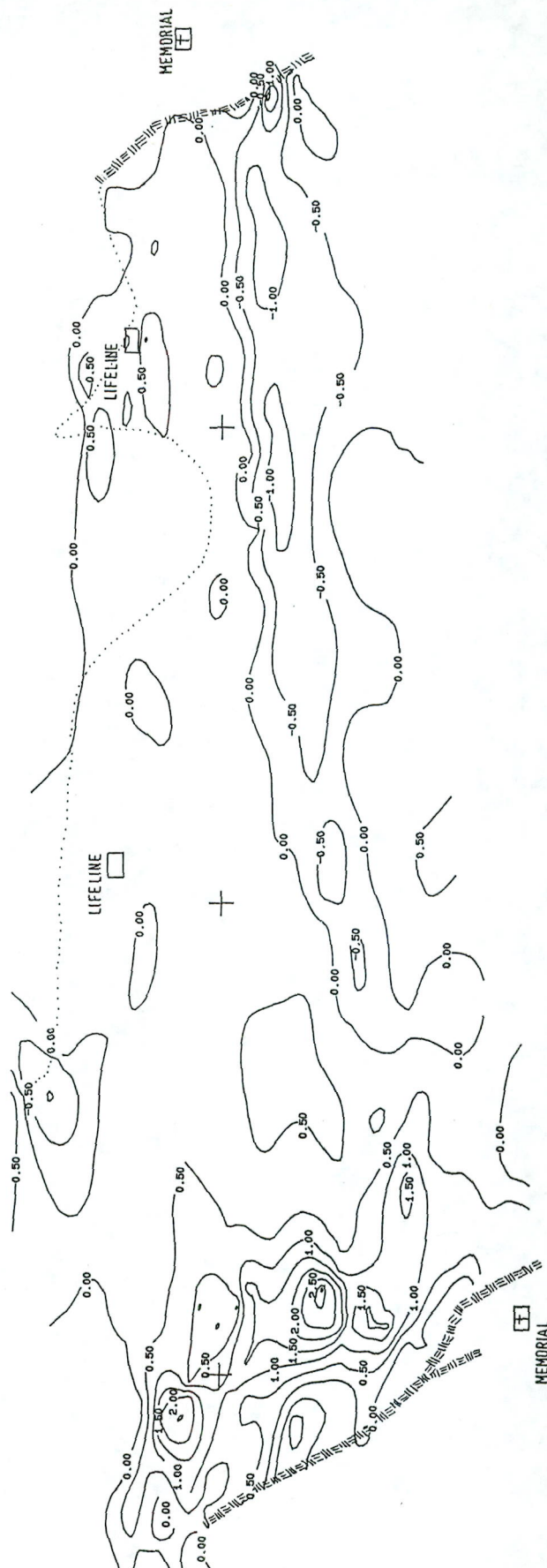
3 801 250 X  
+ 0 Y

3 801 500 X



3 801 250 X

3 801 500 X



FIGURE

30

PALMETTO RIVER DIFFERENCE MAP

MARCH 1987 RELATIVE TO AUGUST 1985

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY

TRACED : REPLOT  
CHECKED:  
DATE : FEB 1987  
REF. :

3 801 250 X  
+ 250 Y

3 801 500 X

0 Y

+ 250 Y

+ 500 Y

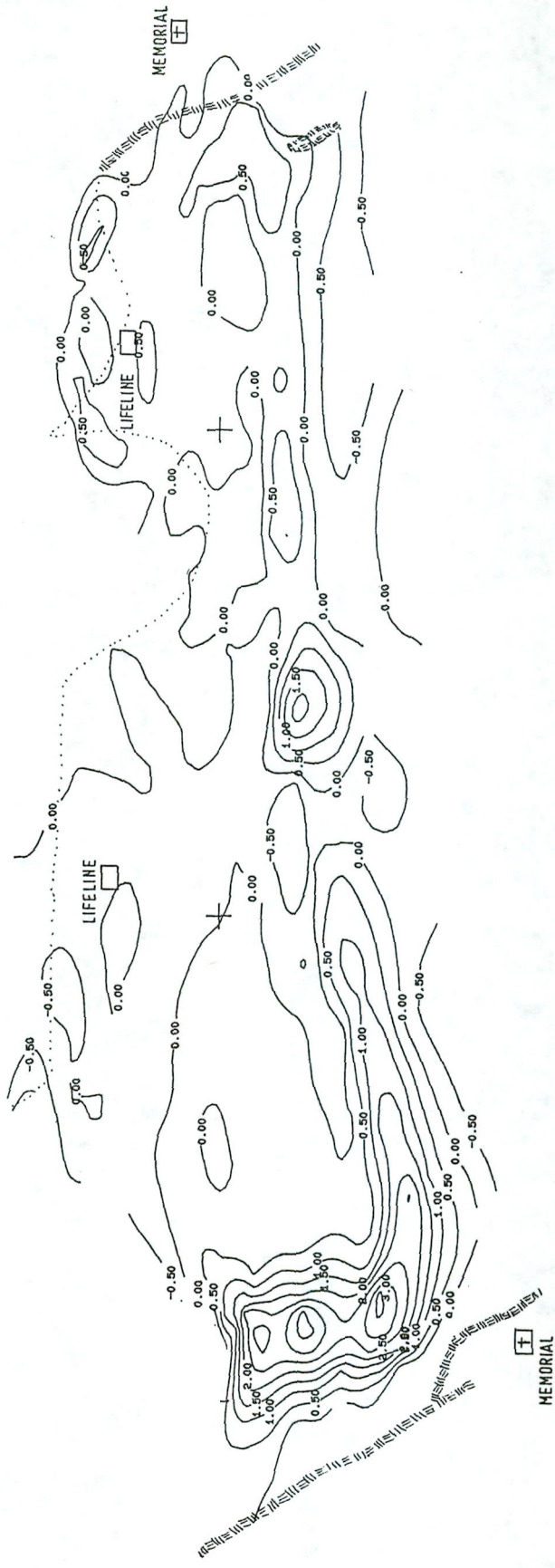
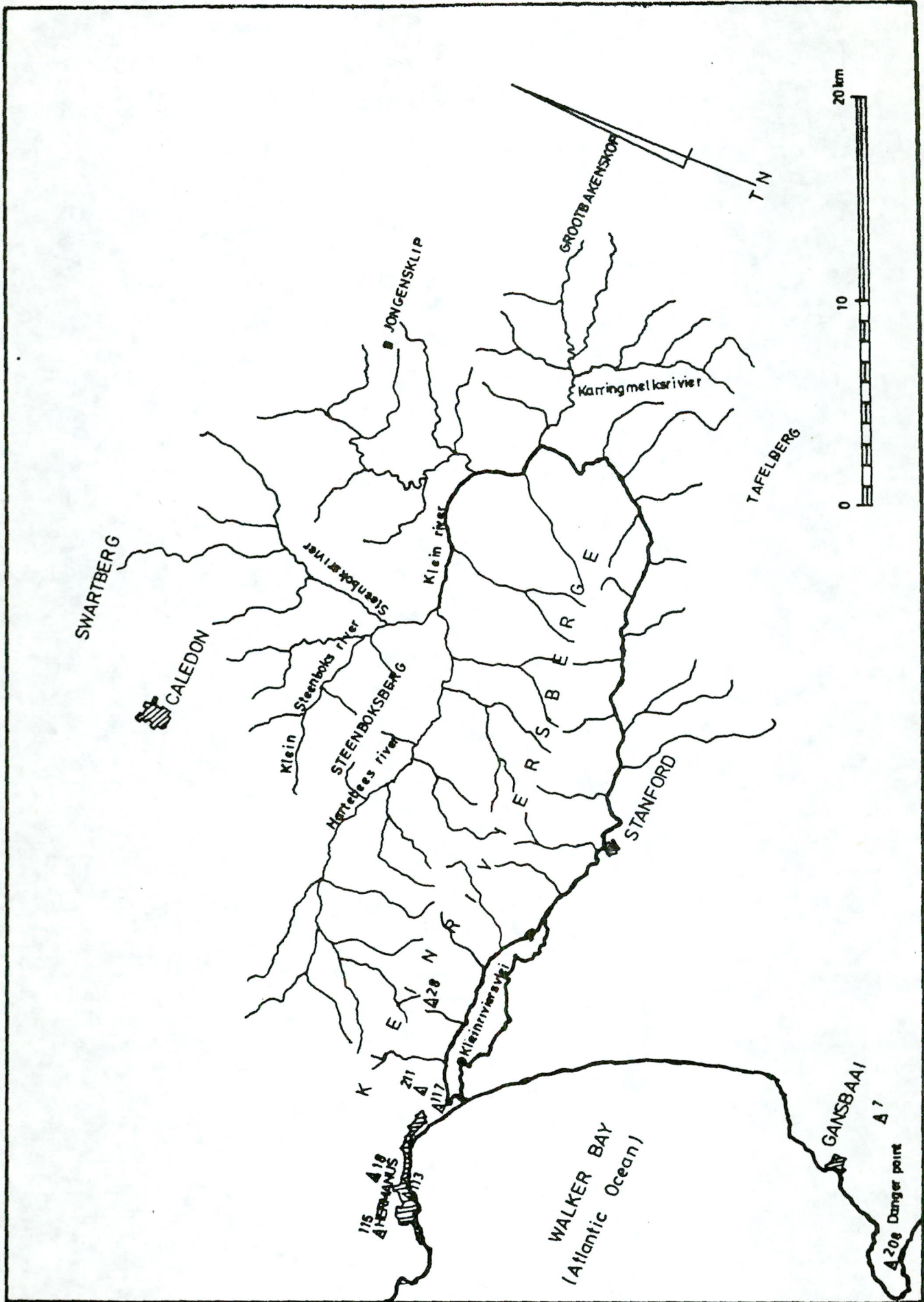


FIGURE 31

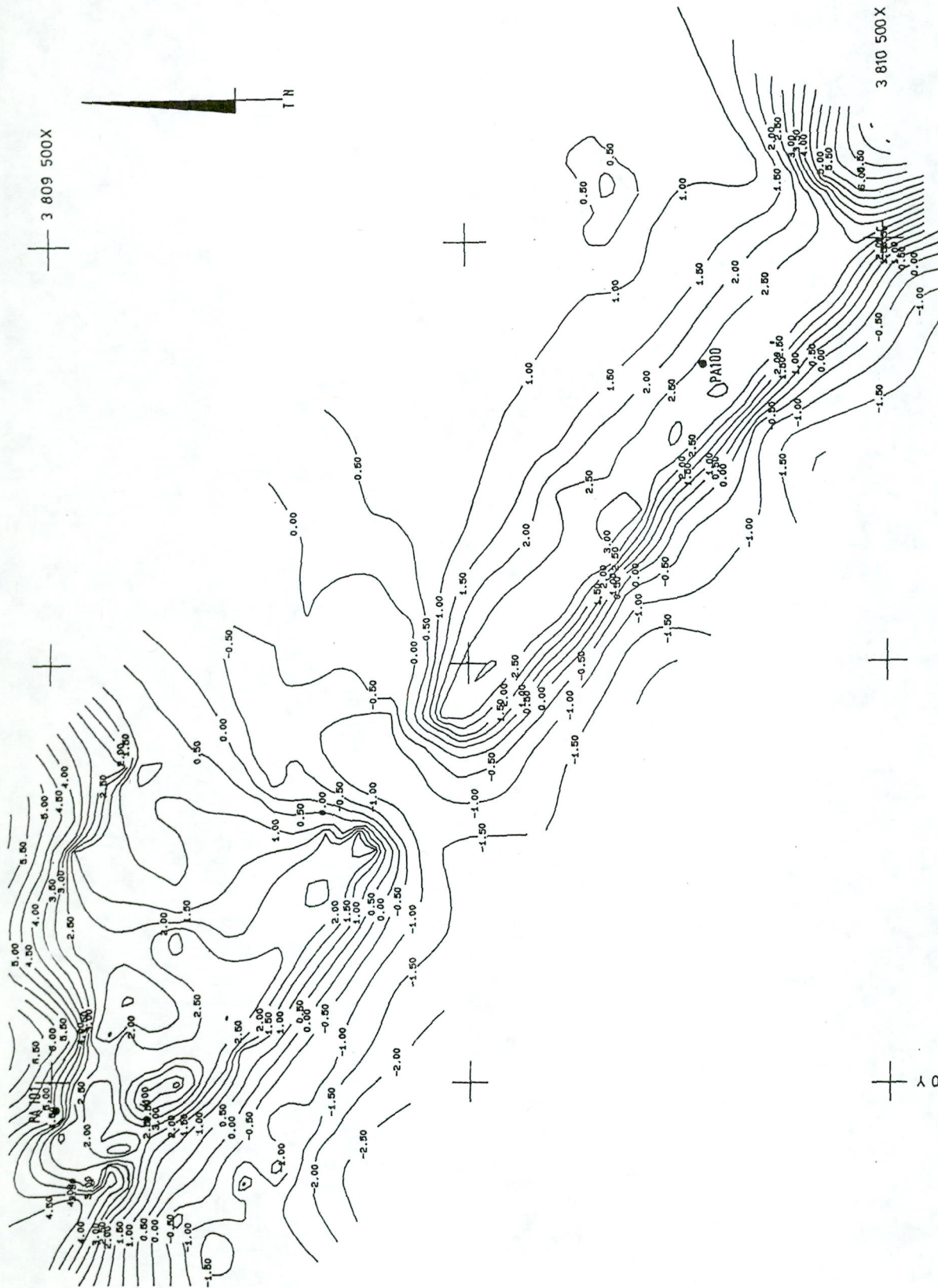
PALMIET RIVER DIFFERENCE MAP  
MARCH 1987 RELATIVE TO SEPTEMBER 1986

TRACED : REBPLOT  
CHECKED:  
DATE : FEB 1987  
REF. :



TRACED: CHECKED: DATE: REF.:	<b>KLEIN RIVER CATCHMENT AREA</b>	<b>FIGURE</b>  <b>32</b>
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY		





TRACED : REBLOT  
 CHECKED:  
 DATE : FEB 1987  
 REF :

CONTOUR PLAN  
 KLEIN RIVER  
 2 SEPTEMBER 1986

FIGURE  
 34

L° 19°  
 LEVEL DATUM : M.S.L.

3 809 500 X

2.48

1.25

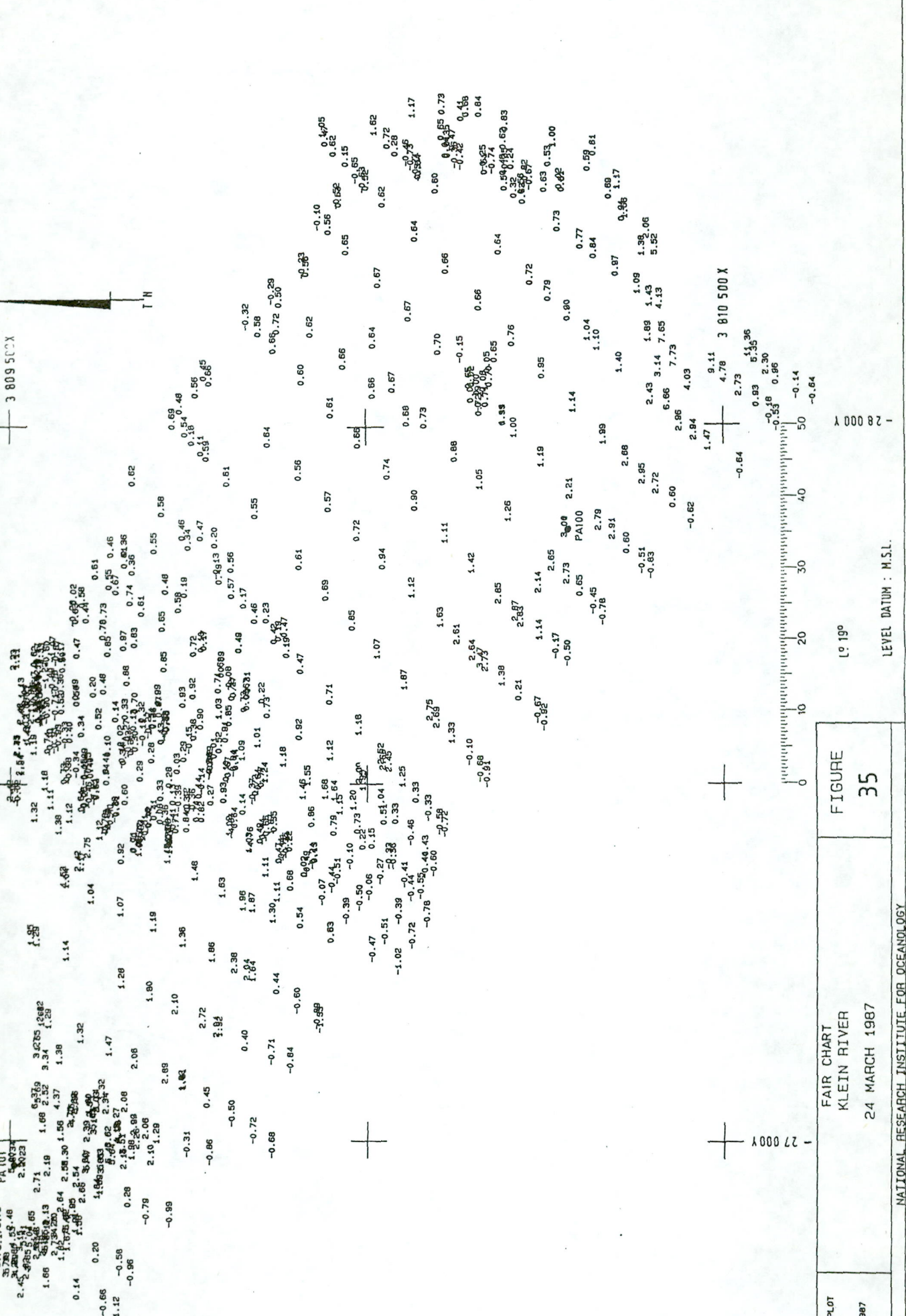
1.25

1.32

1.38

1.42

1.47



TRACED : REPLOT  
 CHECKED:  
 DATE : FEB 1987  
 REF. :

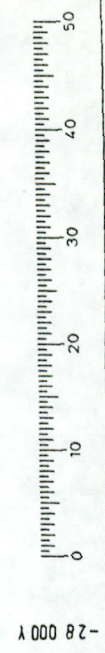
FAIR CHART  
 KLEIN RIVER  
 24 MARCH 1987

FIGURE  
 35

LEVEL DATUM : M.S.L.

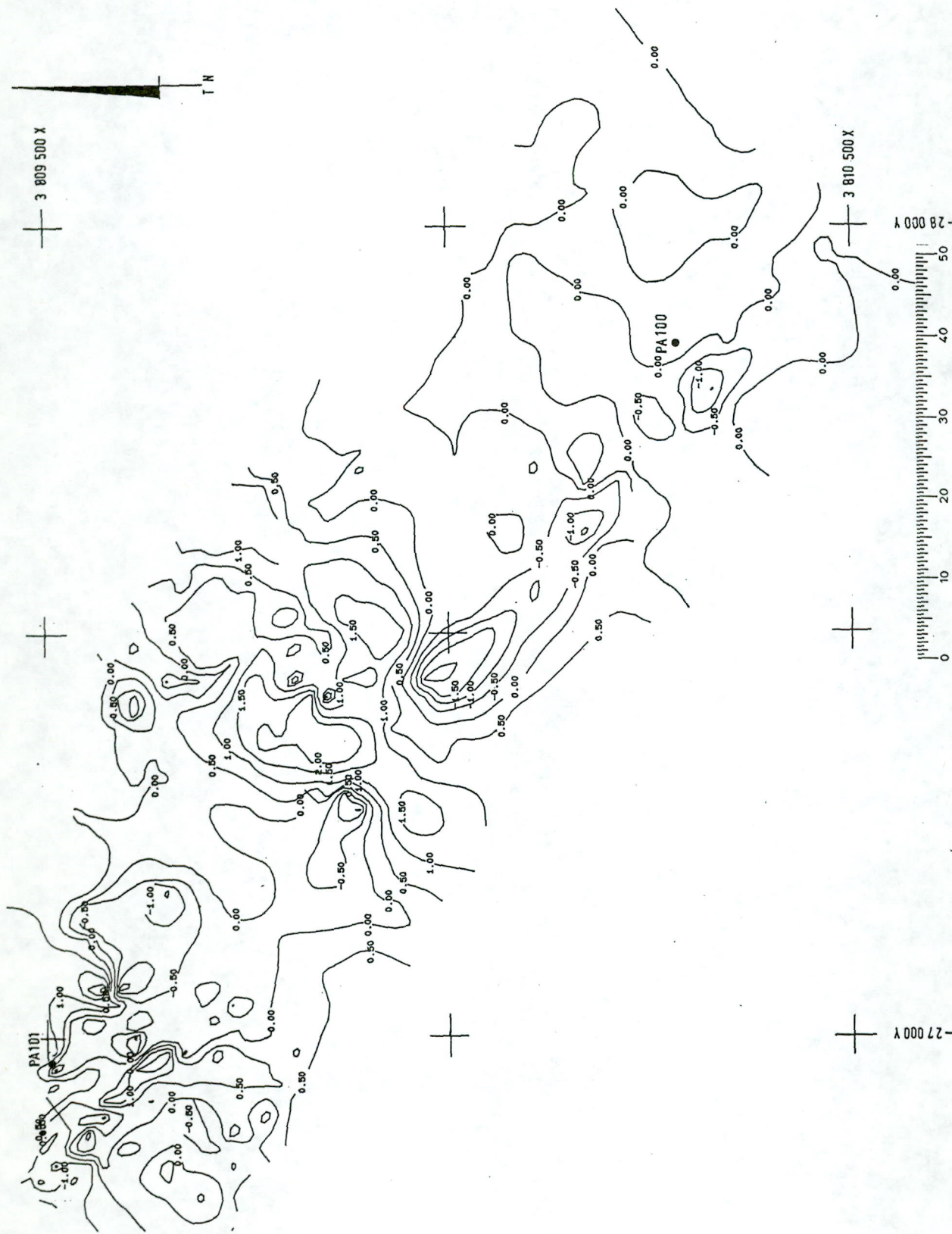
28 000 Y

3 810 500 X



19°  
LEVEL DATUM: N.S.L.

TRACED : REBLOT CHECKED: DATE : FEB 1987 REF. :	CONTOUR PLAN KLEIN RIVER 24 MARCH 1987	FIGURE 36
--	--	--------------



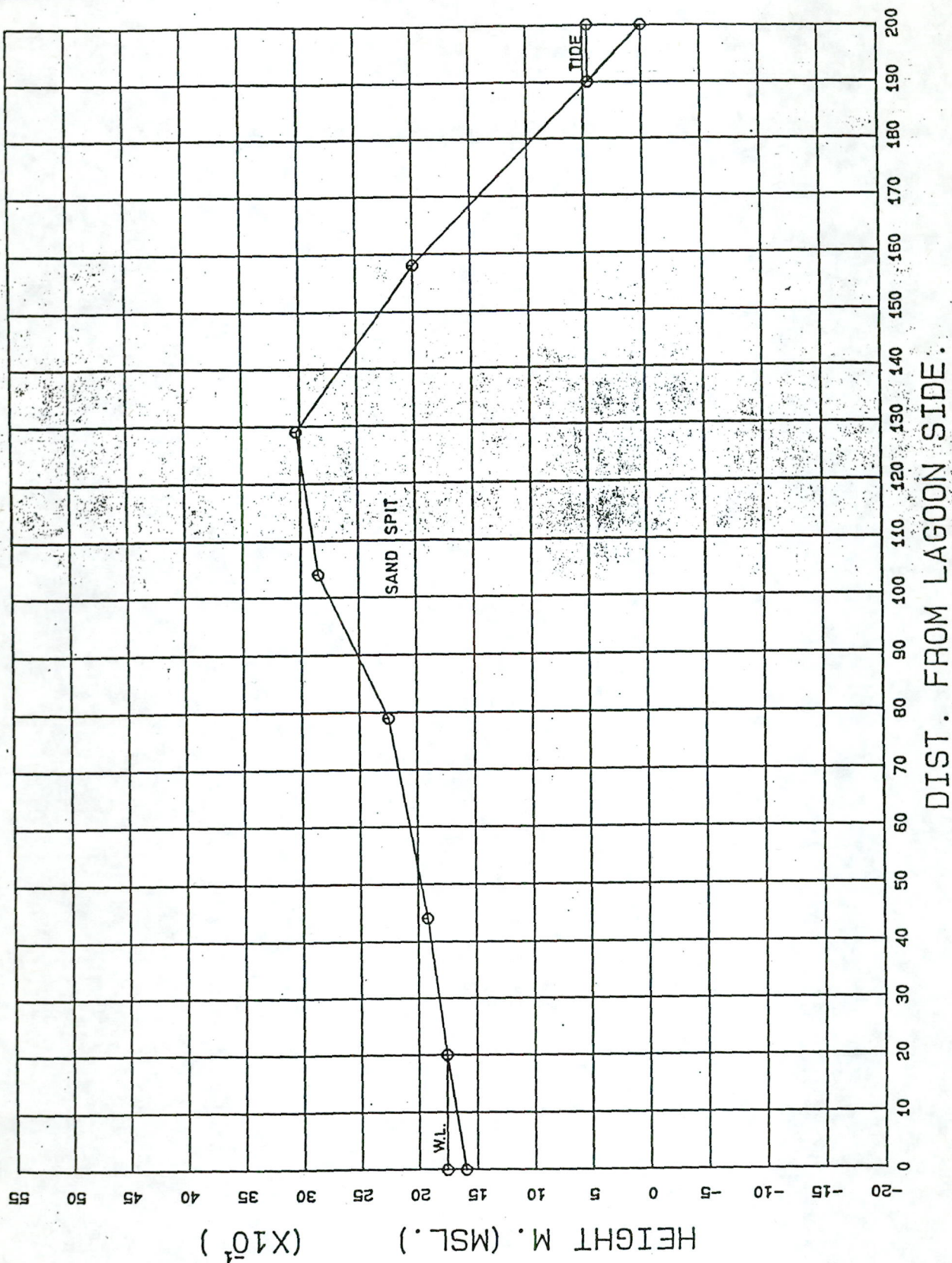
TRACED : REGPLOT  
 CHECKED:  
 DATE : FEB 1987  
 REF. :

KLEIN RIVER DIFFERENCE MAP  
 24 MARCH 1987 RELATIVE TO 2 SEPTEMBER 1986

FIGURE  
 37

1° 19'

Contours = m

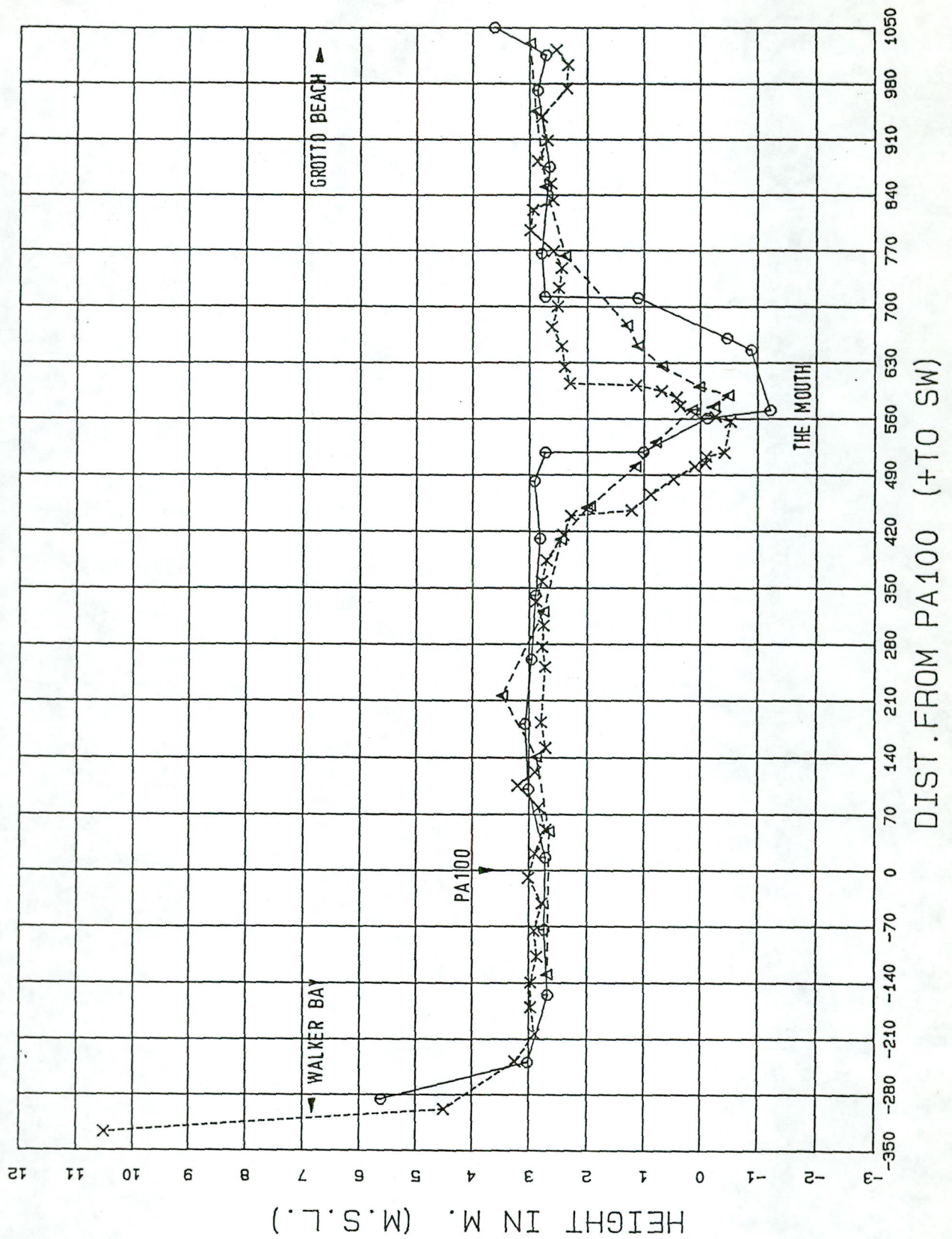


LEGEND : ○ — 12-08-87

CHECKED :  
DATE :  
REF. :

KLEIN RIVER LAGOON  
PROFILE OF SPIT ON 12-08-87

FIGURE  
38



LEGEND : ○——○ 02-09-86  
 ▲---▲ 24-03-87  
 X---X 21-10-87

CHECKED :  
 DATE :  
 REF. :

KLEIN RIVER MOUTH  
 LONG-SECTION OF THE SAND SPIT.

FIGURE  
 39