

Cruise 88401  
M/V Pholas  
21 September - 17 October

## INTRODUCTION

The Atlantic Geoscience Centre (AGC) jointly participated in Mobil Oil Canada Ltd's extensive borehole program to investigate the geotechnical properties of the sediments underlying the site of their proposed Gravity Based Structure production platform (GBS) at Hibernia, on the Grand Banks of Newfoundland. AGC participated in the program by providing geophysical data over the site and by collaboration on the M/V Pholas drillship. Onboard the ship, AGC conducted a geological research program which included lithological description, photo documentation, measurement of sediment acoustic compressional wave velocity, and subsampling for palaeomagnetic and biostratigraphic studies on all borehole samples.

In addition to participation in Mobil's site investigation boreholes, AGC contracted one additional drilling day in order to perform cone penetration tests at the Bowers Pit site (Moran and Mosher, 1988).

## OBJECTIVES

The Atlantic Geoscience Centre borehole investigations have two major objectives: (1) to evaluate the geological aspects and engineering properties on a regional basis; and (2) to verify the present geological interpretations on the Grand Banks which have been previously based primarily on high resolution seismic reflection data. Within the Hibernia region, the AGC objectives are to determine the age, depositional environment and physical properties of the seismostratigraphic units (Fader and King, 1981; Lewis et al., 1987). Lewis et al. (in prep.) have interpreted the region to be a deltaic deposit (up to 80 metres thick) of late Tertiary to early Pleistocene age which is overlain by thin sequences of recent reworked sands. On a previous borehole cruise (88400), AGC had selected the Bowers Pit site (Fig. 1) for investigation in order to address both major objectives. This site is the location of a 10m deep iceberg impact pit and is also located within the seismostratigraphic delta sequence. During cruise 88400, this site was drilled and discontinuously sampled to 84 metres below seafloor (mbsf) and intersected all major regional seismic reflectors (Moran and Mosher, 1988). Because the M/V Pholas drillship, which was mobilized for Mobil's program, is larger and specifically designed for geotechnical investigation, it is capable of performing in situ tests. Consequently, AGC decided to return to the Bowers Pit site in order to perform cone penetration tests

through the delta sediment. This data could then be used for continuous stratigraphic interpretation.

C-CORE of St. John's, Newfoundland also participated in the programme. Their objectives were to investigate the leading edge of the pit in order to define seabed modes of failure. Their work proposal included samples from two short boreholes in the berm and leading edge of the Bowers Pit feature.

CRUISE PARTICIPANTS

Scientific

The following personnel participated in the cruise on behalf of AGC:

- Robert Courtney..... velocity measurements, AGC
- Don Gillespie..... velocity measurements, AGC  
dilatometer operator rep. for NGI
- Michael Gipp..... core description, Memorial Univ.
- Kate Jarrett..... core description, AGC
- Kate Moran..... scientific authority for AGC  
cone penetrometer tests, AGC
- David Mosher..... core description, AGC

Drilling and Geotechnical

- Operator..... Newfoundland Geosciences Ltd.
- Client..... Mobil Oil Canada Ltd.
- Drillers..... SeaCore
- Navigation..... McElhanney
- Sampling and cone  
penetrometer testing..... Fugro-McClelland
- Dilatometer testing..... Norwegian Geotechnical Institute
- Geotechnical sampling  
and testing..... Jacques-Whitford & Assoc.
  
- Captain..... Trevor Faithfull
  
- Client representatives..... Peter Bryce (Mobil, St. John's)  
Louis Long (Mobil, Dallas)
  
- Newfoundland Geosciences,  
Jacques/Whitford..... Charles Rivette, John Brown,  
Grant Crouse, Dave Collins

## METHODS

### Ship

The ship used for this programme was the M/V Pholas, registered in Douglas, Isle of Mann and owned by Coe-Metcalf Shipping of Great Britain. It is a 6636 tonne (displacement) vessel which is 94.55 m long. The vessel has an 8.23 x 7.32 m<sup>2</sup> moonpool and a permanent 33 m derrick. The drilling system includes a 51 tonne capacity heave compensator. The compensator is a single suspended cylinder (pneumatic-hydraulic) with a 4.55 m stroke. Dynamic positioning is accomplished using a taut wire system with short base-line acoustic beacons as backup. The positioning system works to water depths of 450 metres. The positioning system controls four thrusters which are fitted with variable pitch propellers (360° rotation).

### Sampling and In Situ Testing

All in-situ testing and sampling was performed in downhole mode with the Fugro Seaclam Mk II seabed frame. The hard-tie system available aboard the Pholas was not used.

Sampling and in situ testing were accomplished with a seabed frame, the Seaclam. This frame rests on the seabed during drilling operations. To increase reaction forces required for in situ testing and for stabilizing the drillstring for both sampling and testing, the Seaclam is hydraulically clamped to the drillstring.

Two types of sampling tools were used. A 51 cm long, 6.3 cm ID, split spoon sampler was hammered into coarser sediments using a 100 kg hammer with a 1 m drop. A wireline push sampling device, the Wipsampler, was used to obtain 1 m long, 7.6 cm ID heavy-walled tube samples. The Wipsampler hydraulically pushes the sampling tubes into sediment using the seabed frame. The Wipsampler was used for the majority of sediment sampling.

Two types of in situ tests, cone penetrometer and dilatometer, were performed for Mobil's site investigations. In all phases of in-situ testing the drillbit was pulled up 1 metre from the bottom of the borehole and the tool, attached to an umbilical, was lowered down the casings until it latched into the bit. All tools, when latched, extended a distance of 1 metre below the bit which left the tool very close to the bottom of the borehole at the beginning of the test. After latching, which was verified with a contact

switch, the tool was advanced hydraulically at 20 mm/s. Hydraulic pressure was generated at the surface and was transmitted down the umbilical to the Wilson Mk III, a large diameter piston that reacted against and advanced the tool. Hydraulic pressure was controlled at the surface with a pressure relief valve which was used to limit the penetration force. The penetration depth at the start of each push was obtained from a flow meter that digitally measured the amount of oil flowing into the piston. This is considered to be reasonably accurate. With the Seabed reaction frame the pushing reaction is provided by the weight of the casing and the frame.

All cones used were designed and built by Fugro. Ten square centimetre tip area and 150 square centimetre sleeves were used. Pore pressure measurements were made at either one of two locations, the centre of the conical tip or just behind the cone tip at the beginning of the cylindrical section. Interpretation of the results is very sensitive to the location of the porous element used in the stiff sediment encountered. Porous elements were made of polypropylene and were saturated prior to deployment. The compliant filters may have resulted in the generation of excess pore pressures when measurements were made on the conical tip. Digital conversion was performed downhole. All plots were subsequently made by Fugro from the digital data.

Penetration was carried out at 20 mm/s to a maximum of either 80Kn thrust capacity or a specified penetration length. Generally the specified penetration was the maximum obtainable, three metres, but occasionally the program specified shorter penetrations of two metres. AGC used the cone penetrometer at the Bowers Pit site.

As is the convention in downhole mode all data was referenced to zeroes taken at the bottom of the borehole for each stroke. The reference procedure is shown at the bottom of all plots. All pressures are gauge ie. atmospheric pressure is zero.

### Sample Processing

The AGC core processing for this cruise included sediment description, whole and split core photography, acoustic velocity measurement, and subsampling for a variety of land-based measurements. Each sample was initially photographed, measured and labelled with cruise number, borehole and sample number, and sample interval depth. All subsequent measurements and subsamples were then identified with the sample number and depth on the labelled section. The sample then went to Newfoundland Geoscience Limited (NGL) for geotechnical testing and subsampling. Any remaining subsample not required by NGL for Mobil's site investigation were then analyzed by AGC. This subsample was photographed; described

for colour, texture, structure, and consistency. Where possible, the acoustic velocity of the sample was measured. If enough sediment was available, the subsample was split and rephotographed.

In addition, the following subsamples were taken from selected core samples: grain size, Atterberg limits, biostratigraphic and paleomagnetism. Each half was wrapped with plastic and bagged and sealed with black tape. The bags were labelled with cruise number, borehole number, sample number, depth, working or archive, and a top arrow.

The acoustic velocity measurements were made with the Dalhousie/AGC velocimeter. Measurements were made along the longitudinal axis (approximately 7 cm separation, large transducer type); the cored samples were trimmed to fit snugly between the two transducers. Velocity estimates were generally obtained for clays and silty clays with minor sand fractions while attempts on samples with a dominant sand component generally failed due to drainage of the pore fluid.

## RESULTS

The following is AGC's presentation of the results. Mobil Oil Canada Ltd. results are presented in the Newfoundland Geosciences Ltd. report submitted to Mobil. A total of 24 boreholes, which included sampling and in situ testing, were completed at and around the GBS site for Mobil Oil Canada Ltd. One hole was completed for the Atlantic Geoscience Centre at Bowers Pit. Table 1 lists the borehole names with location, water depth, and sample information. One cone penetrometer hole at the Bowers Pit site was completed for AGC. AGC sediment subsamples are listed in Appendix A for each borehole and core description summaries are in Appendix B. Appendix C lists the cone penetration test results for the Bowers Pit site.

Boreholes G1 and G1A were located at the same site and can be considered as one borehole. This is the deepest hole drilled during the study. A summary of the core recovery, AGC lithologic description and acoustic compressional velocity is shown in Fig. 2. The predominantly coarse nature of this borehole accounts for the small number of velocity measurements.

From a regional perspective, the holes drilled and sampled by Mobil are at one site. Consequently, in this report, the deepest hole drilled by Mobil at Hibernia will serve as the representative section for discussion.

The upper 5 metres of borehole G1 consists of medium to coarse sand with shell fragments and likely represents the recent reworked deposit (Fig. 2). Below this sand sequence, the sediment becomes

very poorly sorted and stiff and is described as a diamicton which may be interpreted as a basal till deposit. Below the diamicton, between 12 and 84.8 metres below seafloor (mbsf), the sediment consists predominantly of sand with intervals of silty clay, silt, and silty sand. Some intervals contain significant organics and a cobble layer was drilled and sampled at 72 mbsf. This sandy interval can be correlated with the delta deposits interpreted from airgun seismic data (Lewis et al., 1987). Below this deltaic sequence exists a stiff clay layer which may represent the base of the delta. Below the clay layer are intervals of sand and clay; and silt and sand of as yet unknown age and depositional environment. During recovery of the clay sequence and all sediment below, the samples gave off a strong odour of H<sub>2</sub>S (Appendix B). The acoustic compressional velocity data was limited at this site because of the significant percentage of coarse sediment. The data shows relatively high velocity within the siltier sediment (1.6 to 1.68 km/sec, Fig. 2) and lower values in the finer sediment (< 1.6 km/sec).

At Bowers Pit, cone penetration tests were performed continuously from 12 mbsf to 91 mbsf. This data set was collected in order to stratigraphically and geotechnically define the interpreted delta sequence previously sampled on cruise 88400 (Moran and Mosher, 1988). Initial interpretation of the cone data (Fig. 3) shows 6 stratigraphic sequences. From 12 to 21 mbsf, the stratigraphy is represented by cone bearing within the range of clay, but on the high end and positive excess pore pressure response which suggests an overconsolidated fine-grained deposit. Between 21 and 41 mbsf, the cone bearing is higher and the pore pressure response is excess negative, indicating a coarser deposit, but still showing undrained behaviour. Both the bearing and pore pressure in this interval also shows interbedding of fines within this coarse unit. This sequence is most likely predominantly silty sand. The third unit (41 to 57 mbsf) is characterized by very low bearing and high positive excess pore pressure, indicating a fine-grained deposit of lower strength than the first stratigraphic unit. Below this clay, the cone bearing increases to the highest values at this site while the pore pressure response is negative excess. This unit (57 to 70 mbsf) is coarse with some fine content and is also denser than unit 2. From 70 to 79 mbsf, the cone response is variable, but generally shows low bearing and excess pore pressure response which varies from positive to negative, indicating a predominantly fine-grained sequence with interbedding sands, clays and silts. At the base of the hole, from 79 to 91 mbsf, the cone bearing is at its lowest with a corresponding high positive excess pore pressure response. This lowest unit is predominantly clay.

#### SUMMARY AND RECOMMENDATIONS

The data collected in cooperation with Mobil will provide a significant improvement to the regional geological history of the

Northeastern Grand Bank. In addition, the cone penetrometer data collected at the AGC site now represents the only complete stratigraphic data set for interpretation of detailed Quaternary and Late Tertiary history.

Changes and improvements to the velocimeter frame and transducer configuration are required for future borehole programs. The configuration would be improved by constructing transducer mounts that easily allow for changing transducer separation. This would allow very stiff sediment to lithified materials to be tested.

It is highly recommended that cooperation and participation in industry programs continues. This recommendation also requires that budgets remain flexible enough to accommodate the short time response of industry programs. It also requires that AGC improve its portable laboratory core processing capability and train more of the technical staff for work on drilling programs.

#### ACKNOWLEDGEMENTS

We gratefully acknowledge Mobil Oil Canada Ltd. for the cooperation and participation onboard the M/V Pholas. We thank Captain Faithfull and the M/V Pholas crew; SeaCore Drillers; and Jacques-Fugro-McClelland engineers and technicians. Newfoundland Geosciences provided logistical support which was essential to the success of our program. McElhanney Group once again located us over the elusive iceberg pit efficiently and skilfully. Michael Gipp of Memorial University, provided core processing services with very short notice. We also thank Petro-Canada for their logistical support in transferring crew. Funding for the AGC program was provided by the Frontier Geoscience Program and the Panel on Energy Research and Development.

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- Moran K. and Mosher, D.C. 1988. Cruise Report 88400: M/V Balder Challenger. Atlantic Geoscience Centre, Bedford Inst. of Oceanography.
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- Lewis, C.F.M., Parrott, D.R., and Durling, P.W. 1987. Shallow Tertiary seismostratigraphy and engineering geology of the northeastern Grand Banks of Newfoundland, Geological Survey of Canada Open File Report No. 1437. 18p.



Table 1.  
88401 Borehole Summary

<u>Borehole No.</u>	<u>Latitude</u>	<u>Longitude</u>	<u>Water Depth</u>	<u>Total Penetration</u>	<u>Total Samples</u>
G1	46°45.830'	-48°45.579'	79.37	46.56	35
G1A	46°45.833'	-48°45.582'	79.43	118.86	36
G2	46°45.829'	-48°45.582'	79.25	2.32	2
G2A	46°45.831'	-48°45.583'	79.34	48.96	11
G3	46°45.828'	-48°45.587'	79.26	6.00	2
G4	46°45.838'	-48°45.566'	79.14	9.00	3
G5	46°45.817'	-48°45.584'	79.42	3.00	1
G6	46°45.840'	-48°45.601'	79.07	9.00	3
G7	46°45.860'	-48°45.582'	78.94	36.00	9
G8	46°45.821'	-48°45.549'	79.62	46.80	35
G9	46°45.83'	-48°45.61'	*	48.00	15
G10	46°45.851'	-48°45.541'	*	8.70	3
G11	46°45.81'	-48°45.58'	*	12.30	6
G12	46°45.86'	-48°45.62'	*	3.80	2
G12A	46°45.86'	-48°45.62'	*	5.00	3
G13	46°45.83'	-48°45.55'	*	0.07	1
G14	46°45.86'	-48°45.57'	80.28	16.00	7
G15	46°45.82'	-48°45.58'	80.13	13.00	5
NEA1	46°46.61'	-48°44.46'	83.88	35.00	10
NEA2	46°46.61'	-48°44.47'	*	13.00	8
NEA3	46°47.20'	-49°19.81'	83.58	12.00	4
SEA1	46°45.08'	-48°44.46'	83.98	15.52	5
SEA2	46°45.07'	-48°44.48'	82.78	39.00	18
SEA3	46°45.09'	-48°44.47'	82.78	27.52	12
022	46°45.830'	-48°45.580'	109.43	87.90	1

## LIST OF FIGURES

- Figure 1. Grand Banks of Newfoundland with the location of Hibernia and the AGC site at Bowers Pit.
- Figure 2. Summary of core description, acoustic velocity and core recovery for the deepest hole in the Hibernia region.
- Figure 3. Cone penetrometer data collected at the Bowers Pit site; data was collected from 12 to 91 metres below seafloor and intersected the interpreted delta sequence. The three channel cone data is cone bearing ( $Q_c$ ), cone friction ( $f_c$ ), and pore pressure response ( $u$ ). The units are in MegaPascals. The straight line on the pore pressure plot is the hydrostatic reference pressure.

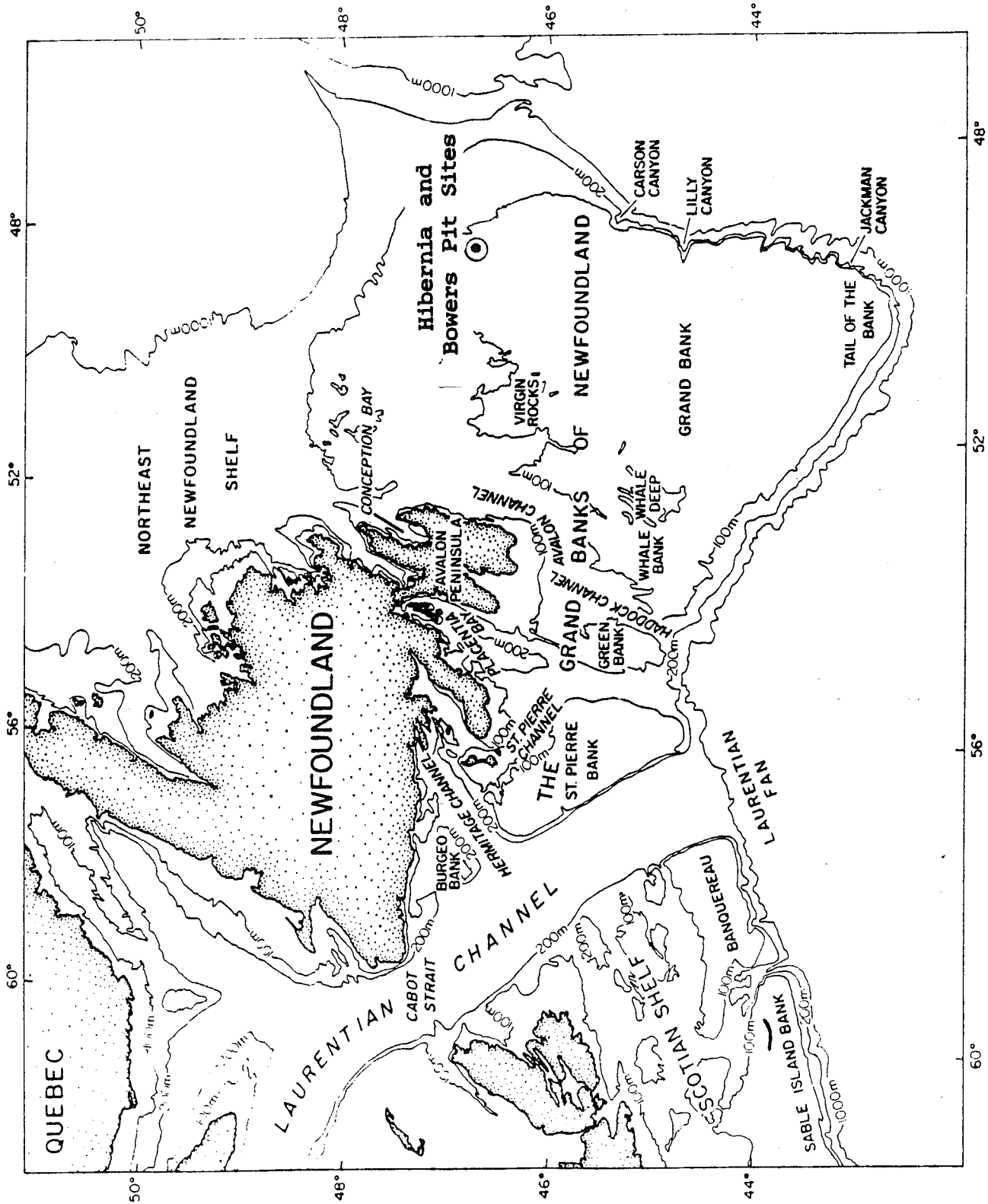


FIGURE 1

PHOLAS  
88401-G1/G1A

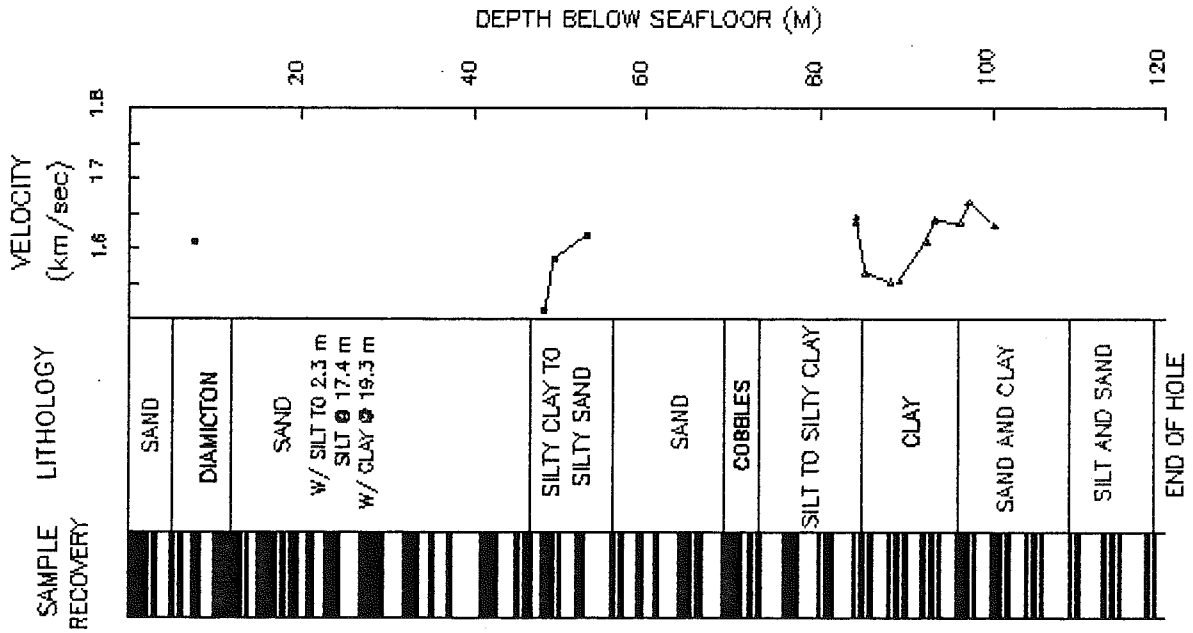


Figure 2

88401-022  
BOWERS PIT SITE

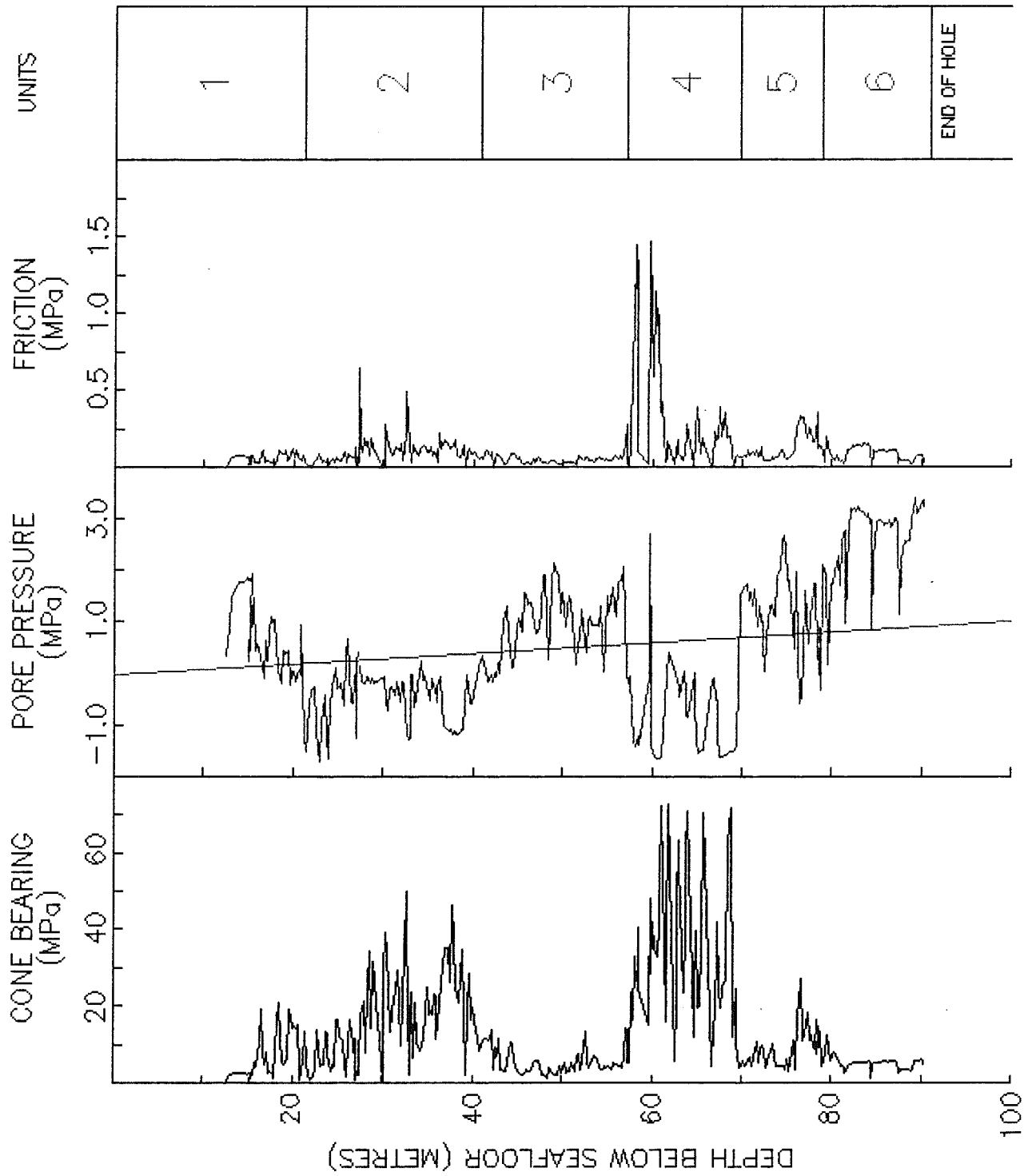


FIGURE 3

## APPENDIX A

## APPENDIX A

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Sediment Subsample Summary

PH - photograph  
 PM - paleomagnetism  
 VE - velocity measurement  
 FS - foram subsample  
 TOC - total organic carbon  
 BD - bulk density  
 WC - water content  
 GS - grain size  
 XR - x-ray subsample  
 SH - shells  
 AT - atterberg limits  
 CO - consolidation

## Borehole 88401 G1

Sample No.	Depth Interval (metres)	Subsamples
1	0.0-0.03	PH, GS
2	1.0-1.05	PH, GS
3	1.5-1.70	PH, GS
4	2.0-2.19	PH, GS
5	3.0-3.20	PH, FS
6	5.0-5.27	PH, GS
7	6.0-6.20	PH, WC
8	7.0-7.01	
9	7.5-7.88	PH, VE, FS, XR
10	8.0-8.20	PH, FS, GS
11	10.0-10.77	PH, FS, XR
12	11.0-11.50	PH, GS
13	12.0-12.50	PH, GS, XR, TOC
14	13.0-13.84	PH, XR
15	15.0-15.54	PH, GS
16	16.0-16.47	PH, XR, SH
17	17.0-17.84	PH, XR
18	18.0-18.92	PH, XR, GS
19	19.0-19.64	PH, XR
20	21.0-21.86	PH
21	22.0-22.86	PH, XR
22	23.0-23.32	PH, GS
23	24.0-24.45	PH, GS, XR, SH
24	27.0-27.27	PH

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25	28.0-28.38	PH
26	29.0-29.38	PH, GS
27	32.0-32.60	PH, GS, SH
28	33.0-33.33	PH
29	35.0-35.24	PH, XR
30	37.0-37.27	PH, XR
31	38.0-38.28	PH, XR, GS
32	41.0-41.51	PH, XR
33	42.0-42.61	PH
34	45.0-45.87	PH, XR
35	46.0-46.56	PH, FS, WC, PM, XR, GS

Borehole 88401 G1A

Sample No.	Depth Interval (metres)	Subsamples
1	48.0-48.64	PH, GS, FS, BD, WC, PM, VE, XR
2	49.0-49.89	PH, GS, PM, BD, WC, FS, XR, VE
3	52.0-52.60	PH, XR
4	53.0-53.89	PH, VE, XR, PM, BD, WC, FS, GS
5	56.0-56.17	PH
6	57.0-57.30	PH, GS
7	59.0-59.11	PH, GS
8	59.11-59.41	PH
9	61.0-61.20	PH, GS
10	64.0-64.35	PH, GS
11	65.0-65.45	PH, GS
12	66.0-66.18	PH
13	69.0-69.50	PH, XR, FS, BD, WC, GS
14	70.0-70.73	PH, TOC, WC, XR
15	72.0-72.07	PH
16	73.0-73.18	PH, TOC, SH
17	76.0-76.42	PH
18	77.0-77.39	PH
19	80.0-80.80	PH, XR, GS, AT, FS, WC
20	81.0-81.48	PH, GS, WC
21	84.0-84.80	PH, VE, FS, BD, WC, PM, TOC, GS, XR
22	85.0-85.90	PH, VE, FS, BD, WC, PM, GS, XR
23	88.0-88.94	PH, CO, VE, XR, BD,

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24	89.0-89.90	WC, PM, FS, GS PH, CO, VE, FS, BD, WC, PM, XR
25	92.0-92.90	PH, VE, XR, PM, BD, WC, GS
26	93.0-93.87	PH, VE, BD, WC, PM, FS, GS, XR
27	96.0-96.82	PH, VE, XR, PM, FS, BD, WC, GS
28	97.0-97.92	PH, VE, XR, FS, PM, BD, WC, GS
29	100.0-100.715	PH, XR, FS, BD, WC, PM
30	101.0-101.89	PH, XR, PM, FS, BD, WC, GS
31	104.0-104.89	PH, XR, PM, FS, BD, WC, GS
32	105.0-105.71	PH, XR, GS
33	109.0-109.90	PH, XR, FS, PM, BD, WC, GS
34	113.0-113.84	PH, GS
35	114.0-114.85	PH
36	118.0-118.84	PH, XR

Borehole 88401 G2

Sample No.	Depth Interval (metres)	Subsamples
1	0.0-0.10	PH
2	1.0-1.32	PH

Borehole 88401 G2A

Sample No.	Depth Interval (metres)	Subsamples
1	10.0-10.02	PH
2	10.5-10.52	PH
3	14.0-14.44	PH, GS
4	18.0-18.10	PH
5	22.0-22.30	PH, GS, SH
6	26.0-26.37	PH, GS
7	30.0-30.20	PH, GS
8	34.0-34.25	PH



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9	40.0-40.30	PH, GS
10	44.0-44.94	PH, GS, PM, XR
11	48.0-48.96	PH, CO, AT, VE, XR, FS, BD, WC, PM, GS

Borehole 88401 G3

Sample No.	Depth Interval (metres)	Subsamples
1	5.0-5.35	PH
2	5.5-6.03	PH, FS, BD, WC, XR, VE, GS, AT, PM

Borehole 88401 G4

Sample No.	Depth Interval (metres)	Subsamples
1	3.0	
2	7.0-7.15	PH
3	8.0-8.30	PH, GS, FS

Borehole 88401 G5

Sample No.	Depth Interval (metres)	Subsamples
1	3.0-3.14	PH, GS

Borehole 88401 G6

Sample No.	Depth Interval (metres)	Subsamples
1	3.0-3.47	PH, GS
2	7.0-7.10	PH
3	8.0-8.08	PH

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Borehole 88401 G7

Sample No.	Depth Interval (metres)	Subsamples
1	0.0-0.12	PH,GS
2	7.0-7.20	PH,GS
3	11.0-11.46	PH,GS,XR
4	15.0-15.16	PH,GS
5	19.0-19.57	PH,GS
6	24.0-24.40	PH,GS,XR
7	28.0-28.40	PH,GS
8	32.0-32.40	PH,GS
9	36.0-36.24	PH,GS

Borehole 88401 G8

Sample No.	Depth Interval (metres)	Subsamples
1	2.0-2.07	PH
2	6.0-6.20	PH,GS
3	11.0-11.43	PH,XR
4	16.5-16.52	PH
5	20.0-20.95	PH,GS,FS
6	25.0-25.13	PH
7	29.0-29.22	PH,GS
8	33.0-33.40	PH,GS,XR,WC
9	37.0-37.15	PH,GS
10	42.0-42.42	PH,GS
11	46.0-46.81	PH,XR

Borehole 88401 G9

Sample No.	Depth Interval (metres)	Subsamples
1	1.0-1.10	PH
2	1.5-1.54	PH
3	5.0-5.10	PH
4	5.1-5.30	PH
5	8.0-8.85	PH,XR,GS
6	9.0-9.54	PH,FS,GS
7	14.0-14.60	PH,GS
8	17.0-17.22	PH,GS
9	21.0-21.73	PH,XR,GS
10	25.0-25.42	PH
11	29.0-29.30	PH,GS

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12	33.0-33.35	PH,GS
Borehole 88401 G10		
Sample No.	Depth Interval (metres)	Subsamples
1	5.0-5.21	PH,GS

Borehole 88401 G11		
Sample No.	Depth Interval (metres)	Subsamples
1	3.0-3.15	PH,GS,SH
2	3.8-4.16	PH,GS,SH
3	7.0-7.21	PH,GS
4	9.5-	
5	11.0-11.30	PH,GS,SH
6	12.0-12.05	PH

Borehole 88401 G12		
Sample No.	Depth Interval (metres)	Subsamples
1	0.0-0.02	PH
2	3.8-4.26	PH,GS,SH

Borehole 88401 G12A		
Sample No.	Depth Interval (metres)	Subsamples
1	4.0-4.05	PH

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2	4.5-4.60	PH
3	5.0-5.15	PH

Borehole 88401 G13

Sample No.	Depth Interval (metres)	Subsamples
1	0-0.07	PH

Borehole 88401 G14

Sample No.	Depth Interval (metres)	Subsamples
3	5.0-5.03	PH, GS
4	6.0-6.28	PH, GS
5	7.0-7.30	PH, GS
6	8.0-8.20	PH, GS
7	10.0-10.10	PH

Borehole 88401 G15

Sample No.	Depth Interval (metres)	Subsamples
1	0.0-0.05	PH
2	4.0-4.23	PH, GS, SH
3	9.0-9.08	PH
4	9.08-9.13	PH
5	13.0-13.90	GS

Borehole 88401 NEA-1

Sample No.	Depth Interval (metres)	Subsamples
1	0.0-0.20	PH, GS
2	4.0-4.45	PH, GS
3	5.0-5.60	PH, GS, BD, WC
4	9.0-9.85	PH, GS, PM
6	13.0-13.55	PH, GS
7	17.0-17.92	PH, GS, BD, WC
8	21.0-21.57	PH, GS
9	25.0-25.23	PH, GS
10	29.0-29.36	PH, GS

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11 33.0-33.38 PH,GS

Borehole 88401 NEA-2

Sample No.	Depth Interval (metres)	Subsamples
1	6.0-6.70	PH,GS
2	7.0-7.30	PH,GS
3	8.0-8.26	PH,GS
4	9.0-9.55	PH,GS
5	10.0-10.83	PH,GS, BD, WC
6	11.0-11.94	PH, XR
7	12.0-12.96	PH,GS, VE, EM, BD, WC
8	13.0-13.82	PH,GS, TOC

Borehole 88401 NEA-3

Sample No.	Depth Interval (metres)	Subsamples
1	3.0-3.32	PH, SH
2	4.0-4.11	PH
3	8.0-8.14	PH,GS
4	12.0-12.18	PH,GS

Borehole 88401 SEA-1

Sample No.	Depth Interval (metres)	Subsamples
1	0. -0.30	PH,GS
2	-	PH
3	-	PH,GS
4	-	PH,GS
5	-	PH,GS

APPENDIX A

Borehole 88401 SEA-2

Sample No.	Depth Interval (metres)	Subsamples
1	0.00-20	PH, GS
2	1.0-1.25	PH, GS
3	2.0-2.20	PH, GS
4	3.0-3.28	PH, GS
5	4.0-4.25	PH, GS
6	5.0-5.38	PH, GS
7	6.0-6.55	PH
8	7.0-7.05	PH
9	8.0-8.20	PH, GS
10	8.5-8.95	PH, AT
11	9.0-9.60	PH, AT
12	12.0-12.54	PH, GS
13	16.0-16.63	PH, GS
14	20.0-20.42	PH, GS
15	24.0-24.40	PH, GS
16	28.0-28.33	PH, GS
17	32.0-32.49	PH, GS
18	36.0-36.38	PH, GS

Borehole 88401 SEA-3

Sample No.	Depth Interval (metres)	Subsamples
1	0.0-0.10	PH, GS
2	-	PH, GS
3	-	PH, SH
4	-	PH, GS
5	-	PH, GS
6	-	PH, BD, WC, GS
7	-	PH, GS
8	-	PH, GS
9	-	PH, GS
10	-	PH, GS
11	-	PH, GS

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-

PH,GS

Borehole 88401 022

Sample No.

Depth Interval  
(metres)

Subsamples

1

11.5-12.3

PH,AT,CO,XR

APPENDIX B

Borehole 88401 G1

<u>Depth (m)</u>	<u>Description</u>
00.00-00.03	Sand, med., 5Y6/2 light olive grey, well rounded, sea urchins and sand dollars.
01.00-01.05	Sand, med. to cse., 5Y5/2 olive grey, abundant shells.
01.50-01.70	Sand, med. to cse., 5Y5/2 olive grey, graded: gravel at base, increasing shell fragments towards base, pebbles up to 1 cm.
02.00-02.19	Sand, med. to cse., cse towards base, 5Y5/2 olive grey, maximum size of pebbles 2.5 cm, increasing shell fragments towards base.
03.00-03.10	Sand, fine, 2.5Y5/0 grey to 5Y4/1 dark grey, some silt and minor shell fragments, calcareous.
05.00-05.07	Sand, med, 5Y4/1 dark grey, some silt, 1 pebble, stiff, minor shell fragments, slightly calcareous.
06.00-06.20	Silty sand with clay, fine sand, 5Y3/1 very dark grey, very stiff.
07.00-	Cuttings
07.50-07.82	Sand and clay, very fine sand, 5Y4/1 dark grey, laminated, sand partings 1 cm apart, very stiff.
08.00-08.20	Sandy clay, very fine sand, 5Y3/1 very dark grey, very stiff.
10.00-10.20	Pebbly silt, clay and very fine sand, 5Y3/1 very dark grey, very poorly sorted, abundant shells in crude beds; diamicton.
10.20-10.60	Cuttings
10.60-10.77	Pebbly silt, clay and very fine sand, 5Y3/1 very dark grey, very poorly sorted, abundant shells in crude beds; diamicton.
11.00-11.50	Clay, 5Y3/1 very dark grey, minor silt, pebbles and shells. Pebbles and shells occur scattered and in crude layers. Cobble (mudstone) at base of sample



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- (10 cm). Sample highly disturbed due to extruder.
- 12.00-12.15 Sand, fine, 2.5Y4/2 dark greyish brown, some silt. Sand stained - iron oxide, organics apparent on split face give mottled appearance.
- 12.15-12.40 Sand with silt, 2.5Y3/2 very dark greyish brown, some clay, possibly inverse graded.
- 13.00-13.84 Sand with silt, fine sand, 5Y3/1 very dark grey, minor clay, occasional organic mottle.
- 15.00-15.54 Sand with silt, fine sand, cobble 15.00-15.10 cm. Cobble (mudstone) surrounded by clayey matrix.
- 16.00-16.08 Clayey sand, 5Y3/2 dark olive grey, soft, gravel, shell fragments, some organics, colour mottle. = wash???
- 16.08-16.47 Sand with silt, apparently massive.
- 17.00-17.12 Sand, fine to med., 5Y3/2 dark olive grey, poorly sorted, abundant organics on split face.
- 17.12-17.37 Sand, fine with silt and some med. sand, iron oxide staining of sand. 17.25-17.26 bed of fine pebble and coarse sand. Below 17.30 no med. sand = better sorted.
- 17.37-17.61 Silt, with very fine sand, 5Y3/2 dark olive grey.
- 17.61-17.84 Preserved in Shelby tube.
- 18.00-18.46 Sand, fine with some silt, 5Y3/2 dark olive grey.
- 18.46-18.92 Sand, fine to med., and silt, 5Y3/2 dark olive grey, coarser sand in patches and silt in patches giving a mottled bioturbated appearance.
- 19.00-19.05 Silty sand, 5Y3/2 dark olive grey, some clay laminae and clasts.
- 19.05-19.28 Sand, fine to med., some cse., 5Y3/2 dark olive grey, sharp irregular contact at base.
- 19.28-19.33 Sandy clay, fine to med. sand, 5Y3/2 dark olive grey, faint structures = pillar structures or sand dykes.
- 19.33-19.54 Sand and silt, fine to med. sand, 5Y3/2 dark olive

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- grey, clay nodules. Med. to cse sand from 19.50-19.54 m.
- 19.54-19.64 Sand and silt, fine to med. sand, buff colour, sharp dipping contact at top, dipping (15°) fine laminae structures.
- 21.00-21.08 Sand silt and clay, pebbles, shell fragments and cobble; possible wash.
- 21.08-21.30 Sand, silt and clay, 5Y3/1 very dark grey, graded: sand in silt and clay matrix at top to fine to med. sand with some cse. sand at base (21.20-21.30 m).
- 22.00-22.86 Sand, fine to med., 5Y3/2 dark olive grey, with minor silt, (to 22.12 m); fine to med. sand with cse. sand from 22.12 to 22.86 m), 1 cm pebble at 22.24m, Clay patch at 22.72-22.74 m.
- 23.00-23.32 Sand, med. to cse., 5Y3/2 dark olive grey, massive, poorly sorted sand.
- 24.00-24.10 Sand, med., 5Y3/2 dark olive grey, clay patch at 24.05 m. Sharp lower contact.
- 24.10-24.45 Sand, fine to med., 5Y3/2 dark olive grey, with clay matrix. Shells and pebble layer at 24.43 to 24.45 m.
- 27.00-27.27 Sand, med. to cse., 5Y3/2 dark olive grey, with occasional shell fragment.
- 28.00-28.38 Sand, med. to cse., 5Y3/2 dark olive grey, massive.
- 29.00-29.38 Sand, med. to cse., 5Y3/2 dark olive grey, massive.
- 32.00-32.40 Sand, med., 5Y3/2 dark olive grey, massive.
- 32.40-32.60 Gravel, fine to med., clay with small gravel layer at top (32.40-32.41 m); well rounded, well washed pebbles with abundant shells, and clay nodule.
- 33.00-33.33 Sand, med. to cse., 5Y3/2 dark olive grey, massive, trace gravel.
- 35.00-35.24 Sand, med., 5Y3/2 dark olive grey, 35.10-35.15 m laminated fine sand to silt that is iron stained.
- 37.00-37.11 Sand, med., 2.5Y3/2 very dark greyish brown (stain), laminated, laminae in very fine sand from 37.09 to

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- 59.00-59.11 Sand, med. to cse., some fine pebbles, 5Y3/2 very dark olive grey, apparently massive.
- 59.11-59.41 Cuttings, some med. to cse. olive grey sand.
- 61.00-61.20 Sand, med. to cse., minor fine, 5Y3/2 dark olive grey, massive, one shell fragment at 61.05 m.
- 64.00-64.25 Sand, fine to med., minor silt, mottled appearance between 64.04 and 64.11.
- 65.00-65.10 Sand, fine to med., minor silt, organic specks. 65.10-65.45 is cuttings ?.
- 66.00-66.18 Sand, fine, 5Y3/2 dark olive grey, 66.00-66.08 m a large cobble of sandstone with an apparently weathered surface??
- 69.00-69.50 Silty very fine sand at top grading to sandy silt with clay at base, 5Y3/2 dark olive grey, split sample shows bedding.
- 70.00-70.40 Silty sand, very fine sand, clay marbled throughout (obvious on split sample), 5Y3/2 dark olive grey, 70.38-70.40 m distinct sand bed.
- 70.40-70.73 Sand, fine 5Y2.5/1 black, possibly laminated, high organic content (abundant black traces), strong H<sub>2</sub>S odour.
- 72.00-72.07 Cobbles, sandstone fragments.
- 73.00-73.18 Silt, highly organic, soft, with shell fragments and scattered pebble, 5Y3/2 dark olive grey.
- 76.00-76.42 Silt, high organic content, abundant shell fragments (Wash??), 5Y3/2 dark olive grey, strong H<sub>2</sub>S odour. Abundant pebbles at top, decreasing downcore to occasional, some very fine sand.
- 77.00-77.39 Pebbles and shell hash (Wash?) from 77.00-77.26 m, organic Silt, soft and structureless from 77.26 to 77.39 m.
- 80.00-80.80 Silty sand, very fine sand, 5Y3/2 dark olive grey, small clay mottles, H<sub>2</sub>S odour.
- 81.00-81.48 Sand, very fine, 5Y3/2 dark olive grey, soft, abundant small clay mottles, strong H<sub>2</sub>S odour.

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- 84.00-84.80 Silty clay, 5Y3/1 very dark grey, less silt towards base, silt and very fine sand occurring in patches, black organic marbling at top, strong H<sub>2</sub>S odour.
- 85.00-85.90 Clay, 5Y3/2 dark olive grey, colour marbling, darker organics form pillar structures, strong H<sub>2</sub>S odour.
- 88.00-88.94 Clay, 5Y3/2 dark olive grey, colour marbling, H<sub>2</sub>S odour.
- 89.00-89.90 Clay, with minor silt, 5Y3/2 dark olive grey, colour marbling, H<sub>2</sub>S odour.
- 92.00-92.80 Clay, with minor silt, 5Y3/2 dark olive grey, colour marbling, amount of organics (black) appears to be decreasing, H<sub>2</sub>S odour.
- 93.00-93.87 Clay 93.00-93.08 m, grading to silt and clay, from 93.08-93.40 m, grading to very fine sand with silt, 5Y2.5/1 black, possibly bedded, parallel fabric obvious on fresh fracture surface, H<sub>2</sub>S odour apparent.
- 96.00-96.82 Sand and clay, fine sand, 5Y2.5/1 black, very stiff, apparently massive, H<sub>2</sub>S odour.
- 97.00-97.92 Sand and clay, fine sand, 5Y2.5/1 black, mottled appearance when split, strong H<sub>2</sub>S odour.
- 100.00-100.71 Sand and clay, fine sand, increasing sand down core, 5Y2.5/1 black, split surface appears mottled with sandy patches in clay.
- 101.00-101.89 Sand with clay, grading to sand and clay, colour mottling, clay mottles, 5Y2.5/1 black, H<sub>2</sub>S odour.
- 104.00-104.89 Sand and clay, colour mottling, clay mottles, 5Y2.5/1 black, H<sub>2</sub>S odour.
- 105.00-105.71 Clay, 5Y4/1 dark grey, very stiff to hard, near vertical sand dykes throughout, sand bed between 105.17-105.23 m.
- 109.00-109.90 Silt and sand with minor clay, 5Y2.5/1 black, clay laminae apparent on split surface, H<sub>2</sub>S odour.
- 113.00-113.12 Silt and sand with some clay, 5Y2.5/1 black.
- 113.12-113.60 Clay with silt and fine sand, 5Y3/1 very dark grey, clay blocks, bioturbation trails = sandy traces,

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from 113.22-113.60 m.

- 113.60-113.84 Sand and silt, minor clay, fine sand, 5Y2.5/1 black.
- 114.00-114.85 Silt with clay, abundant organics, 5Y2.5/1 black, highly disturbed sample from 114.0-114.65 m.
- 118.00-118.85 Silt with clay, 2.5Y2/0 black, silt and clay bed between 118.10 and 118.25 m, pyritized worm burrows between 118.10 and 118.25 m. Gradational change in colour to 5Y3/1 very dark grey at about 118.55 m.

Borehole 88401 G2

<u>Depth (m)</u>	<u>Description</u>
00.00-00.10	Sand and fine to med gravel, shell fragments
02.00-02.32	Sand, fine to medium, 10YR4/2 greyish brown, small shell fragments.

Borehole 88401 G2A

<u>Depth (m)</u>	<u>Description</u>
10.00-10.02	Clay, 5Y3/1 very dark grey, with fine sand, very stiff.
10.05-10.52	Clayey sand, 5Y3/1, very dark grey, med. to cse sand, with small angular rock fragments.
14.00-14.14	Sand, med. to cse., 5Y3/1 very dark grey, fine gravel, abundant shell fragments.
18.00-18.10	Sand, fine-med. 5Y3/1 very dark grey, few shell fragments, rare small pebbles.
22.00-22.06	Sand, med. to cse., iron staining, small shell fragments.
22.06-22.25	Sand and Gravel, cse. sand to fine gavel, heavily reworked shell fragments.
26.00-26.37	Sand, fine to med., 5Y4/1 olive grey, less med sand towards base, mafic grains of sand about 5%.

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30.00-30.20	Sand, fine to med., 5Y4/1 olive grey, trace gravel and shell fragments, gravel clasts 4 cm and 1.5 cm large (possibly cavings).
34.00-34.13	Sand, cse. to med., 5Y4/1 olive grey, with small gravel, shell fragments.
34.13-34.25	Sand, fine to med., 5Y4/1 olive grey.
40.00-40.30	Sand, fine, 5Y4/1 olive grey, with med. sand, mafic grains about 5%
44.00-44.94	Sand, very fine, 5Y2.5/2 black (very dark olive grey in appearance), minor silt increasing in content down core.
48.00-48.96	Clay, 5Y2.5/2 black, minor silt.

Borehole 88401 G3

<u>Depth (m)</u>	<u>Description</u>
05.00-5.35	Silty clay, 5Y3/1 very dark grey, minor fine to med. sand, abundant shell fragments.
05.50-6.03	Clay and silt, 5Y3/1 very dark grey, with some very fine sand, increasing silt down core, very stiff.

Borehole 88401 G4

<u>Depth (m)</u>	<u>Description</u>
03.00-	No sample recovered, traces of fine sand and shell fragments in split spoon tray.
07.00-07.10	Cobbles (cobble layer - have drilled through but not sampled in previous holes). Basalt and granite.
07.10-07.15	Sand, fine to cse., 5Y4/1 dark grey, with small gravel and shell fragments.
08.00-08.30	Sand, fine to med., 5Y4/1 dark grey, well sorted, abundant shell fragments, mafic grains, trace gravel and larger shell fragments at base.

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Borehole 88401 G5

<u>Depth (m)</u>	<u>Description</u>
00.00-00.14	Sand, fine to med. to coarse down core (graded), 5Y4/1 dark grey, shell fragments and granules from 10-14 cm.

Borehole 88401 G6

<u>Depth (m)</u>	<u>Description</u>
03.00-03.47	Sand, med. to cse., to fine gravel = graded, abundant shell fragments, probably all wash.
07.00-07.10	Cobble fragments, banded gneiss.
08.00-08.10	Cobble fragments, meta-sandstone or possible olivine basalt, and biotite gneiss.

Borehole 88401 G7

<u>Depth (m)</u>	<u>Description</u>
03.00-03.12	Sand, fine, 5Y4/1 dark grey, rare gravel, numerous shell fragments.
07.00-07.20	Sand, fine to medium, 5Y4/1 dark grey, small shell fragments.
11.00-11.46	Clay, with medium to coarse sand, shell fragments, 5Y3/1 very dark grey, 11.04-11.08 cm fractured rock.
15.00-15.16	Silt with clay, medium to coarse angular sand, shell fragments, with coarse sand to fine gravel, 5Y3/2 dark olive grey, shell fragments.
19.00-19.15	Sand with silt, fine grained, 5Y3/1 very dark grey.
19.15-19.36	Sand, medium to coarse, with silt, 5Y3/2 dark olive grey, abundant clay balls, 5Y4/1 dark grey.
19.36-19.57	Sand, medium to coarse with silt, coarsening down core, 5Y3/2 dark olive grey.
24.00-24.07	Sand, fine to medium with clay, 5Y3/1 very dark

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grey.

- 24.07-24.35 Sand, medium to coarse, coarsening downcore, 5Y3/2 dark olive grey, 24.07-24.20 cm patches of fine sand in clay.
- 24.35-24.40 Sand, fine to medium with clay, 5Y3/1 very dark grey.
- 28.00-28.40 Sand, medium to coarse, minor silt, 5Y3/2 dark olive grey.
- 32.00-32.40 Sand, medium to coarse, minor silt, 5Y3/2 dark olive grey, abundant 1-2 cm clay balls, 32.27-32.34 cm clay-silt pocket.
- 36.00-36.24 Sand, medium to coarse grading to fine to medium, trace of coarse sand, 5Y3/1 very dark grey.

Borehole 88401 G8

<u>Depth (m)</u>	<u>Description</u>
02.00-02.07	Sand, fine, shell fragments, lt grey, disturbed.
06.00-06.20	Silt, clayey with fine sand and cobbles, hard, 5Y3/1 very dark grey, fragmented rocks, disturbed sample.
11.00-11.43	Clay, clay with fine to medium grained gravel, 5Y3/1 very dark grey, shell fragments.
16.50-16.52	Silt, silt with fine gravel, 5Y3/1 very dark grey.
20.00-20.33	Silt, with fine to medium gravel, 5Y3/2 dark olive grey, abundant shell fragments, = cuttings.
20.33-20.95	Sand, medium grained with silt grading to fine to medium grained with silt, 5Y3/2 dark olive grey, 20.53-20.67 cm medium to coarse sand patches.
25.00-25.13	Sand, coarse sand and fine gravel, 5Y3/2 dark olive grey, abundant shell fragments, cuttings.
29.00-29.22	Sand, medium to coarse, 5Y3/2 dark olive grey, few shell fragments, 29.18-29.22 cm rock.
33.00-33.40	Sand, medium to coarse grained with silt, 5Y3/2 dark olive grey.



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37.00-37.15	Sand, medium grained, trace silt, apparently massive.
42.00-42.42	Sand, medium grained with increasing silt content downcore, 5Y3/2 dark olive grey, apparently massive.
46.00-46.09	Silt, silt and fine gravel, 5Y3/1 very dark grey, abundant shell fragments, = cuttings.
46.09-46.81	Silt, silt with fine sand, 5Y3/1 very dark grey, few organic specks.

Borehole 88401 G9

<u>Depth (m)</u>	<u>Description</u>
01.00-01.10	Sand, fine to medium, 5Y5/1 grey, shell hash, disturbed sample.
01.50-01.54	Sand, fine, 5Y5/1 grey, shell fragments.
05.00-05.10	Sand, fine with angular gravel, 5Y5/1 grey.
05.10-05.16	Sand, fine with trace of gravel, 5Y5/1 grey, shell fragments.
05.16-05.25	Gravel, angular.
05.25-05.30	Clay, silty with some sand and gravel, 5Y4/2 olive grey.
08.00-08.85	Clayey Silt, some sand, trace of fine gravel, 5Y3/2 dark olive grey, fining downcore, some sand partings.
09.00-09.54	Clayey Silt, some fine sand, trace of angular gravel, 5Y3/1 very dark grey, very stiff.
14.00-14.60	Sand, medium grained, trace of fine and coarse sand, 5Y3/1 very dark grey, some siltier pockets.
17.00-17.12	Sand, fine, 5Y3/1 very dark grey.
17.12-17.22	Sand, fine, mottled, 5Y3/2 dark olive grey.
21.00-21.14	Sand, medium to coarse, trace of fine gravel, 5Y3/2 dark olive grey.

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21.14-21.40	Sand, medium to coarse with a trace of silt, 2.5Y4/4 and 2.5Y3/2 mottled olive brown and very dark greyish brown.
21.40-21.73	Sand, medium to coarse, trace of silt, 21.63-21.73m patch of very dark grey clay and silt.
25.00-25.12	Sand, fine to medium sand, 2.5Y4/4 olive brown.
25.12-25.42	Sand, medium with a trace of coarse sand, 5Y3/2 dark olive grey, 25.32-25.38m clay patch.
29.00-29.24	Sand, coarse, with fine gravel and abundant shell fragments.
33.00-33.25	Sand, medium to coarse, minor silt, 5Y3/2 dark olive grey, silty patch 33.15-33.25.
40.00-40.62	Sand, medium grained with some silt, sl. increase in silt downcore, 5Y3/2 dark olive grey.
45.00-45.12	Sand, medium grained, some silt, 5Y3/2 dark olive grey. (5.11-45.12 cemented?) - sharp lower contact.
45.12-45.53	Silt, some fine sand, 5Y4/1 dark grey.
45.53-45.66	Sand, silty, fine sand, mottled dk grey and v. dk gy. 5Y3/1, 5Y4/1.
48.00-48.67	Silt, some clay, increase clay downcore, stiff, 5Y3/1 very dark grey. 48.59 sand lamina with wood fragment 1 cm above it.

Borehole 88401 G10

<u>Depth (m)</u>	<u>Description</u>
05.00-05.21	Sand, medium, with fine to medium gravel and abundant shell fragments, 5Y4/1 dark grey. Large rock from 5.00-5.04 m.
08.05-08.15	Clay, sandy, with sub-angular gravel, very stiff, 5Y3/1, very dark grey.
08.50-08.70	Silt, slightly sandy with angular cobbles 5-8 cm in length. Most of this sample was gravel and one large cobble, held together by a matrix of very dark grey (5Y3/1) silt.

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Borehole 88401 G11

<u>Depth (m)</u>	<u>Description</u>
03.00-03.15	Sand, fine to medium, with fine to medium gravel and abundant shell fragments, 5Y4/1 dark grey.
03.80-04.16	Sand, fine to medium, with fine to medium gravel and abundant shell fragments increasing in abundance and size downcore, 5Y4/1 dark grey.
07.00-07.21	Silt, with clay, fine to medium subrounded to subangular gravel and cobbles, and shell fragments, 5Y3/1 very dark grey. Lge rock 7.00-7.03 m.
09.50-*****	Silt, with fine sand, 5Y3/1 very dark grey (no sample - only what was on outside of tube).
11.00-11.30	Sand, medium grained, with fine gravel and abundant shell fragments, 5Y3/2 dark olive grey. Considered to be cuttings.
12.00-12.05	Sand, medium grained, with fine gravel and abundant shell fragments, 5Y3/2 dark olive grey.

Borehole 88401 G12

<u>Depth (m)</u>	<u>Description</u>
00.00-02.00	Sand, medium with one pebble and shell fragments, 2.5Y5/2, greyish brown (couldn't sample)
03.80-04.26	Sand, medium to coarse, with fine gravel and abundant shell fragments, dark grey. = cuttings?

Borehole 88401 G12a

<u>Depth (m)</u>	<u>Description</u>
04.00-04.05	Gravel, fine-grained and angular, and cuttings.
04.50-04.60	Clay, silty, with trace sand and gravel, 5Y3/1, very dark grey, low plasticity, hard.
05.00-05.15	Clay, silty with trace sand and angular gravel, 5Y3/1, very dark grey.

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Borehole 88401 G13

<u>Depth (m)</u>	<u>Description</u>
00.00-00.07	Cobbles, and fine sand.

Borehole 88401 G14

<u>Depth (m)</u>	<u>Description</u>
05.00-05.03	Gravel, and angular rock fragments.
06.00-06.05	Sand, coarse, with gravel and shell fragments, with rare clay pockets.
06.05-06.15	Sand, coarse, with gravel and shell fragments, in a matrix of fine to medium sand.
06.15-06.28	Sand, coarse, with gravel and shell fragments.
07.00-07.04	Gravel, with clay, 5Y3/1, very dark grey.
07.04-07.14	Sand, fine, muddy, with pebbles, 5Y3/1, very dark grey.
07.14-07.30	Sand, fine, muddy and gravelly, 5Y3/1, very dark grey.
08.00-08.20	Sand, coarse, muddy, with pebbles and shell debris, 2.5Y4/2, dark greyish brown.
10.00-10.10	Gravel, and cobbles. One cobble has some light brown mud.

Borehole 88401 G15

<u>Depth(m)</u>	<u>Description</u>
00.00-00.05	Sand, fine and clean, with shell fragments and gravel, 2.5Y3/2, greyish brown.
04.00-04.23	Sand, medium, with gravel and shell fragments, N4/0, dark grey. Becomes silty downcore.
09.00-09.08	Cobble, wedged in the sampling tube.

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- 09.10-09.15 Clay, with sand plastered to the outside of the sample, very dark grey.
- 13.00-13.?? Sand, medium, silty, 5Y3/1, dark grey. Sample is scraped from the bottom of the tube, as it could not be extruded.

Borehole 88401 NEA1

<u>Depth (m)</u>	<u>Description</u>
00.0-00.20	Sand, fine, clean, well-rounded to subrounded, with a heavy mineral content apparent <5%, 2.5Y5.5/2, light brownish grey.
04.00-04.07	Silty clay, with pebbles and minor amounts of fine sand, very stiff, N3/0, very dark grey.
04.07-04.40	Sand, slightly muddy with abundant rounded shell fragments and clayballs, N3/0, very dark grey.
04.40-04.45	Mud, slightly sandy, very stiff, 5Y3/1, very dark grey.
05.00-05.10	Mud, with coarse sand and gravel and shell hash, 5Y3/1, very dark grey.
05.10-05.23	Mud, with rounded pebbles and shell fragments, 5Y3/1, very dark grey.
05.23-05.29	Gravel, with pebbles and shell hash.
05.29-05.60	Mud, slightly sandy, very stiff, 5Y3/1, very dark grey.
09.00-09.85	Mud, slightly sandy, decrease silt and sand downcore, N3/0, very dark grey.
13.00-13.10	Sand, with clayballs, 5Y3/1, very dark grey, probably wash-in.
13.10-13.45	Sand, slightly silty, 5Y4/2, dark olive grey.
13.45-13.55	Sand, very loose, 2.5Y3/2, very dark greyish brown.
17.00-17.92	Sand, silty, grading downward to muddy sand, very stiff, 5Y3/1, very dark grey.
21.00-21.57	Sand, silty with occasional pebbles and clayballs,

APPENDIX B

grading to a less silty medium sand at the base, 5Y3/1, very dark grey.

- 25.00-25.23 Sand, slightly muddy, 2.5Y3/2, dark greyish brown.
- 29.00-29.36 Sand, medium, slightly muddy, grading to a slightly muddy coarse sand downcore, 2.5Y3/2, very dark greyish brown.
- 33.00-33.31 Sand, slightly muddy, 2.5Y3/2, very dark greyish brown.
- 33.31-33.38 Sand, slightly muddy, 2.5Y4/2, dark greyish brown.

Borehole 88401 NEA2

<u>Depth (m)</u>	<u>Description</u>
06.00-06.65	Sand, very coarse, slightly muddy with crushed shell fragments and some fine sand, very dark grey.
06.65-06.70	Sand, fine, slightly muddy, very dark grey.
07.00-07.15	Gravel, slightly muddy, probably wash.
07.15-07.22	Sand, fine, silty, with pebbles, 5Y2.5/1, very dark grey.
07.22-07.30	Sand, fine, silty, 5Y2.5/1, very dark grey, stiff.
08.00-08.05	Sand, fine, silty and gravelly, 5Y3/1, very dark grey.
08.05-08.26	Sand, fine, silty, well-sorted, with rare shell fragments, 5Y3/1, very dark grey.
09.00-09.50	Mud, sandy, 5Y2.5/1, very dark grey.
09.50-09.65	Mud, very stiff, 5Y2.5/1, very dark grey.
10.00-10.08	Clay, some silt with trace sand, 5Y2.5/1, very dark grey.
10.08-10.73	Clay, with sand and silt, 5Y2.5/1, very dark grey.
10.73-10.83	Clay, slightly silty, 5Y2.5/1, very dark grey.
11.00-11.94	Clay, with silt, 5Y2.5/1, very dark grey.

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12.00-12.48	Clay, very stiff, 5Y3/1, very dark grey, rare shell fragments.
12.48-12.59	Clay, with sand and silt, 5Y3/1, very dark grey.
12.59-12.85	Clay, sandy, grading downwards into muddy sand, 5Y3/1, very dark grey.
12.85-12.96	Sand, fine, muddy, coarsening downward to medium sand, 5Y3/1, very dark grey.
13.00-13.07	Clay, slightly silty, 5Y2.5/1, very dark grey.
13.07-13.37	Sand, slightly muddy, coarsening downcore, with occasional spots of organic detritus (wood fragments) and a clay lump (gypsum?), 5Y3/2, dark olive-grey.
13.37-13.65	Sand, medium, silty, with clay lamina, 5Y2.5/1, very dark grey.
13.65-13.69	Sand, coarse, slightly muddy, 5Y3/2, dark olive-grey.
13.69-13.82	Sand, slightly muddy, 5Y2.5/1, very dark grey.

Borehole 88401 NEA3

<u>Depth (m)</u>	<u>Description</u>
03.00-03.32	Gravel, sandy and silty, shell hash, very dark grey.
04.00-04.11	Gravel, shelly with coarse sand and silty lumps, very dark grey.
08.00-08.14	Silt, slightly sandy, with subrounded pebbles, 5Y3/1, very dark grey, very stiff.
12.00-12.19	Mud, very stiff, 5Y3/1, very dark grey.

Borehole 88401 SEA1

<u>Depth (m)</u>	<u>Description</u>
03.00-03.12	Sand, fine, silty, with shell fragments, 5Y3/1, very dark grey.

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03.12-03.17	Sand, coarse, with gravel and shell hash.
03.17-03.30	Clay, sandy, 5Y3/1, very dark grey., sharp upper contact.
04.00-04.10	Cobbles, with gravel and pebbles, and one clayball.
10.00-10.12	Clay, sandy, 5Y3/1, very dark grey.
10.12-10.17	Clay, gravelly, 5Y3/1, very dark grey.
10.17-10.55	Clay, sandy, 5Y3/1, very dark grey, grading downwards to a fine clayey sand.
10.55-10.59	Sand, fine, muddy, with coarse sand and degraded woody fragments, 2.5Y3/2, very dark greyish brown.
10.59-10.91	Sand, fine, silty, with medium sand, 5Y3/1, very dark brown.
12.00-12.18	Sand, medium, silty, with organic specs, 5Y3/1, very dark grey.
12.18-12.50	Sand, medium, silty, 2.5Y3/2, dark greyish brown.
12.50-12.71	Sand, medium, silty, 5Y3/1, very dark grey.
15.00-15.52	Sand, fine to medium, slightly muddy, 5Y3/2, very dark olive grey.

Borehole 88401 SEA2

<u>Depth (m)</u>	<u>Description</u>
00.00-00.20	Sand, with shell fragments, 2.5Y3/2, light greyish brown.
01.00-01.10	Sand, 5Y3/1, very dark grey.
01.10-01.25	Sand, medium, with gravel and abundant shell fragments, 5Y3/1, very dark grey.
02.00-02.20	Gravel, with sand, and abundant shell fragments.
03.00-03.17	Sand, fine, with pebbles and shell fragments, dark grey.
03.17-03.28 shell	Sand, coarse and fine, with gravel and fragments.



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04.00-04.06 Sand, fine, 5Y3/1, very dark grey.

04.06-04.25 Sand, medium, with gravel and shell fragments, 5Y3/1, very dark grey.

05.00-05.10 Gravel, coarse, with abundant shell debris.

05.10-05.21 Gravel, medium, sandy, with shell debris.

05.21-05.38 Gravel, coarse, with shell debris.

06.00-06.12 Clay, with gravel and pebbles, 5Y3/1, very dark grey.

06.12-06.45 Clay, 5Y3/1, very dark grey, very stiff.

06.45-06.55 Clay, sandy, 5Y3/1, very dark grey, very stiff.

07.00-07.05 Clay, with one large diorite cobble, 5Y3/1, very dark grey.

08.00-08.07 Clay, sandy, 5Y2.5/1, very dark grey.

08.07-08.20 Clay, 5Y2.5/1, very dark grey, stiff.

08.50-08.72 Clay, silty, with trace gravel, very dark grey.

08.72-08.95 Clay, badly deformed by a large cobble.

09.00-09.48 Clay, N3/0, very dark grey, very stiff.

09.48-09.60 Clay, sandy, N3/0, very dark grey, stiff.

12.00-12.54 Sand, fine, with pockets of brown sand, 5Y3/1, very dark grey.

16.00-16.30 Sand, fine, silty, very dark grey.

16.30-16.55 Sand, coarse, with pockets of dark grey clay, brown.

16.55-16.63 Sand, fine, with pockets of dark grey clay, very dark grey.

20.00-20.12 Sand, muddy, with clay pockets, 5Y3/2, very dark olive grey.

20.12-20.42 Sand, fine, muddy, with <10% coarse sand, 5Y3/2, very dark olive grey.

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24.00-24.05	Sand, fine, silty, with clay pockets and pockets of coarse brown sand, very dark grey.
24.05-24.17	Sand, coarse, brown.
24.17-24.40	Sand, fine, silty, with sandy and clayey pockets, very dark grey.
28.00-28.17	Sand, medium to coarse, with dark grey clay pockets, 2.5Y3/2, dark greyish brown.
28.17-28.25	Sand, with thin laminations of clay.
28.25-28.32	Sand, coarse, 2.5Y3/2, dark greyish brown.
32.00-32.30	Sand, medium, slightly muddy, with clay pockets, and coarse brown sand pockets, 5Y3/2, dark grey.
32.30-32.49	Sand, medium, with brownish coarse sand and clay pockets, 5Y3/1, very dark grey.
36.00-36.10	Sand, medium, muddy, 5Y3/2, dark olive grey.
36.10-36.38	Sand, fine, with pockets of medium light brown sand, 5Y3/2, dark olive grey.

Borehole 88401 SEA3

<u>Depth (m)</u>	<u>Description</u>
00.00-00.10	Sand, fine to medium, with shell fragments, 7.5YR5/2, light brown.
01.00-01.10	Sand, medium, muddy, with pebbles and shell fragments, N3/0, very dark grey.
01.10-01.20	Gravel, sandy, with shell hash.
02.00-02.29	Gravel, sandy, with shell hash, with <5% fine muddy sand.
02.29-02.30	Mud, slightly sandy, very dark grey.
06.00-06.05	Mud, sandy, with shell hash, 5Y3/1, very dark grey.
06.05-06.25	Mud, slightly sandy, with occasional shell fragments and gravel, 5Y3/1, very dark grey.
06.25-06.37	Sand, fine, muddy, 5Y3/1, very dark grey.

APPENDIX B

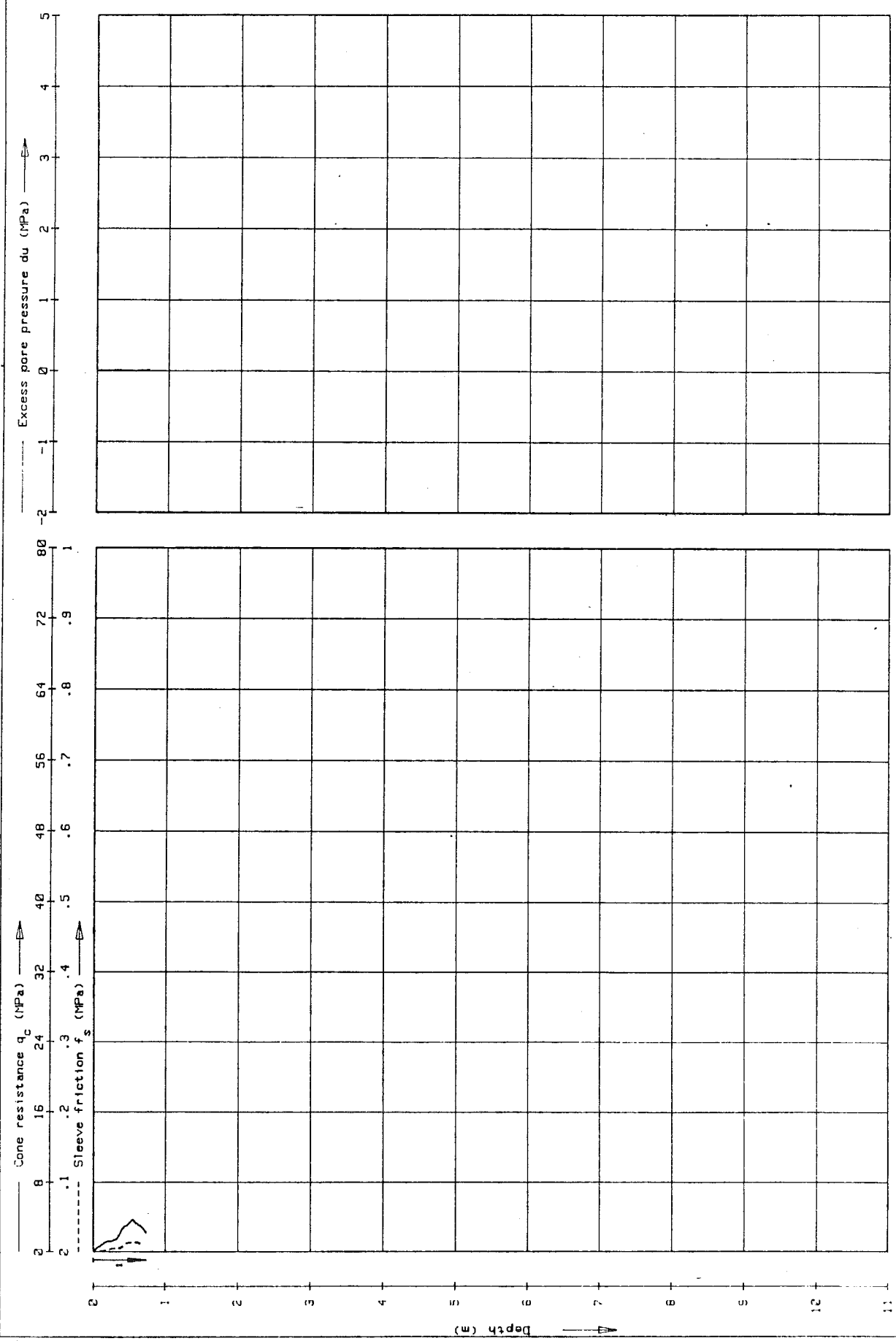
07.00-07.15	Silt, sandy, with cobbles, gravel, and shell fragments, 5Y2.5/1, very dark grey.
07.50-08.11	Clay, slightly sandy and gravelly, 5Y3/1, very dark grey.
08.50-09.30	Clay, slightly sandy, remoulded by a large cobble jammed during extrusion. Sample became silty sand downcore.
12.50-13.00	Sand, medium, with coal fragments and occasional brown muddy bands and mottling, 5Y3/1, very olive dark grey.
13.00-13.16	Sand, fine, 5Y3/1, very dark olive grey.
16.00-16.59	Sand, slightly muddy, 2.5Y3/2, olive grey.
16.59-16.80	Sand, muddy, 2.5Y3/2, olive grey.
19.00-19.25	Sand, medium, silty, coarsening downward, 2.5Y3/2, dark olive grey.
19.25-19.43	Sand, medium to coarse, with dark grey (5Y3/1) clay pockets, 2.5Y3/2, dark olive grey.
19.43-19.77	Sand, medium to coarse, 2.5Y3/2, dark olive grey.
23.00-23.30	Sand, medium, slightly silty, with some coarse sand, 5Y3/2, olive grey.
23.30-23.45	Sand, medium, slightly silty, with coarse sand, and large clayballs, 5Y3/2, olive grey.
23.45-23.55	Sand, medium, with very few clayballs, 5Y3/2, olive grey.
27.00-27.05	Sand, very coarse, 10YR3/2, dark brown.
27.05-27.15	Sand, with occasional dark grey clayballs, 2.5Y3/2, dark olive grey.
27.15-27.40	Clay, slightly sandy, with laminae of clay, dark grey.
27.40-27.52	Sand, medium, with clayballs, 5Y3/2, dark olive grey.

APPENDIX B

Borehole 88401-022

<u>Depth (m)</u>	<u>Description</u>
11.50-11.85	Clay, silty, very stiff, 5Y2.5/1, very dark grey.
11.85-11.90	Silt, sandy, 5Y2.5/1, very dark grey.
11.90-12.25	Clay, silty, very stiff, 5Y2.5/1, very dark grey.
12.25-12.30	Mud, silty, 5Y2.5/1, very dark grey.

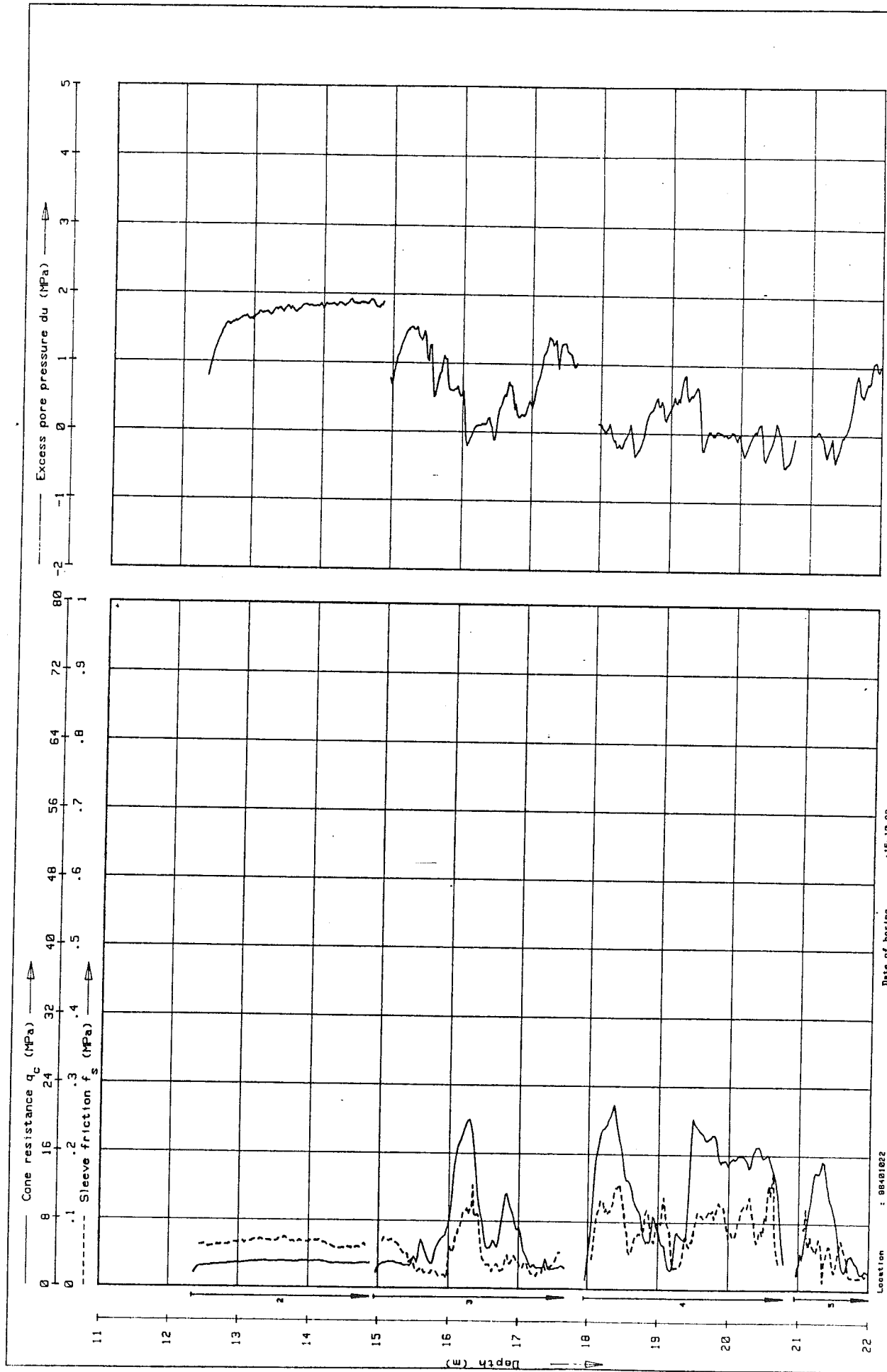
APPENDIX C



Location : 88401022  
 Coordinates : -483736.3 E - 464313.1 N  
 Water depth (m) :  
 Used cone(s) : F3CKE<sub>2</sub>V-e-61

Date of boring : 15-10-88  
 Date of plot : 15 Nov 1988  
 Processed / checked by : YSR / ...

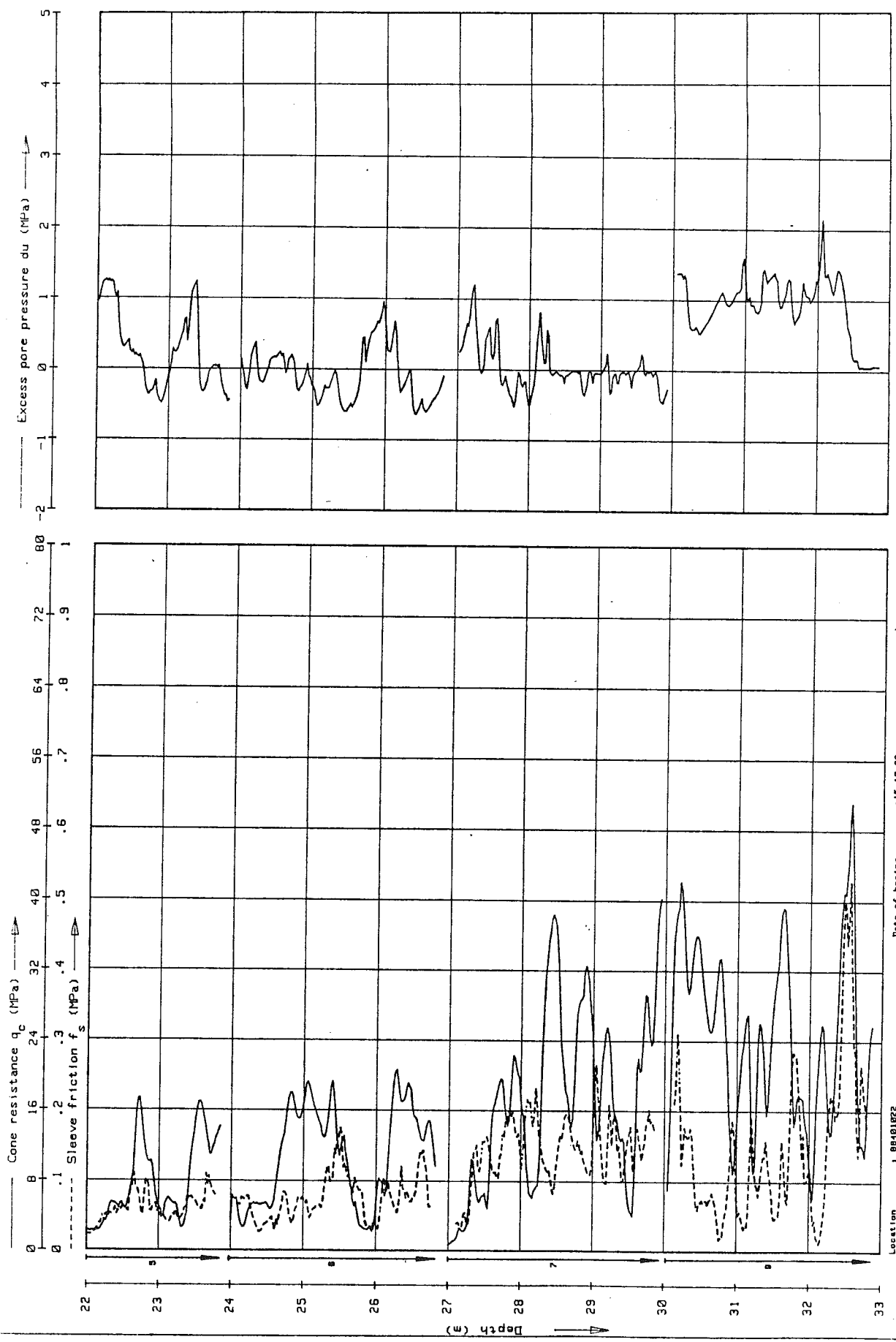
Values are plotted relative to start of test.



WISON CONE PENETRATION TESTS 88401022  
 RCC - BOWER'S PIT

Location : 88401022  
 Coordinates : -103736.3 E - 464313.1 N  
 Date of boring : 15-10-88  
 Date of plot : 15 Nov 1988  
 Processed / checked by : VSBR / J.S.  
 Values are plotted relative to start of test.

N-2625R/01

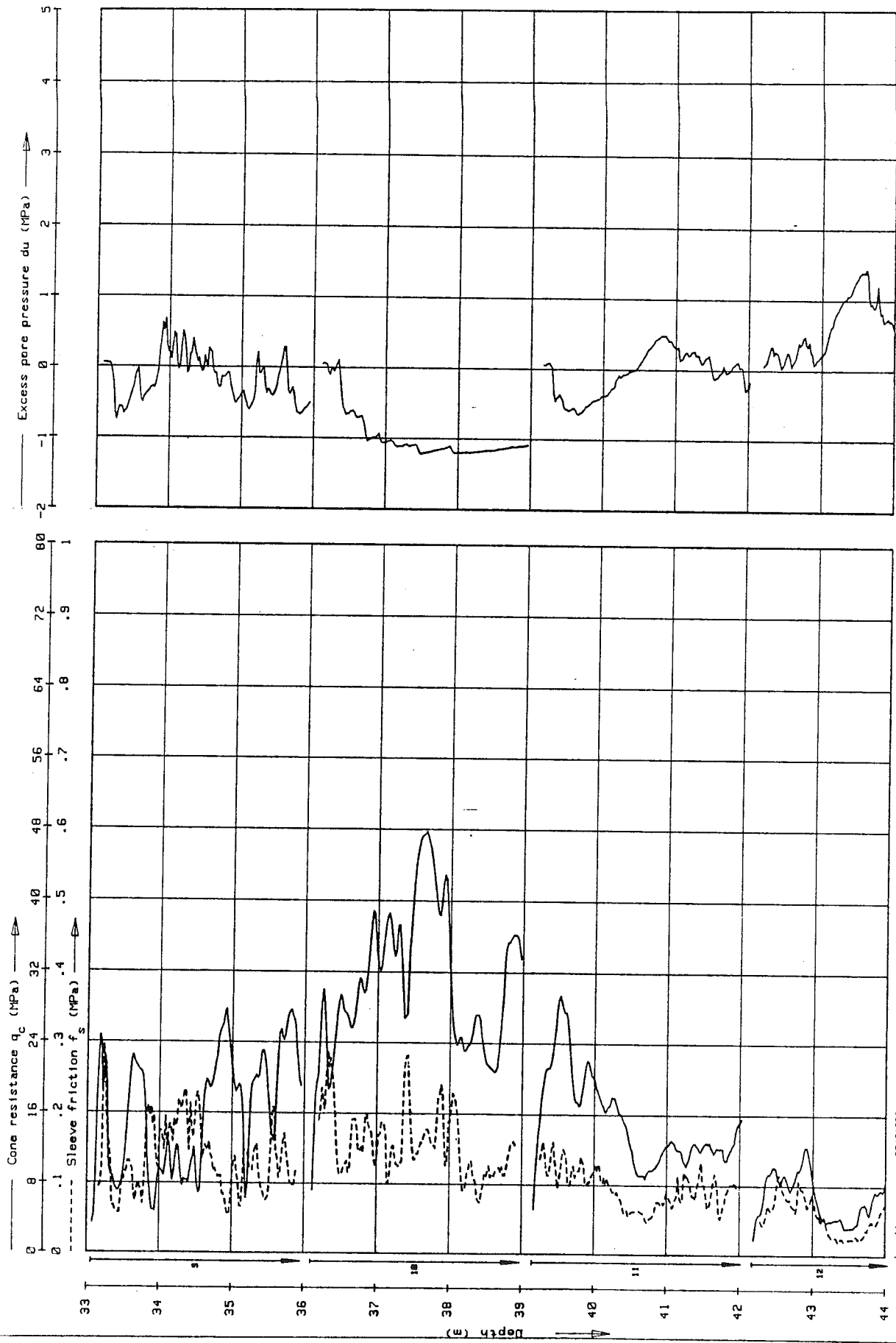


Location 1 88401022  
 Coordinates 1 -483736.3 E - 464313.1 N  
 Meter depth (m) 1  
 Used cone(s) 1 F3CKM<sub>2</sub>V-a-61

Date of boring 15-10-88  
 Date of plot 15 Nov 1988  
 Processed / checked by VSR / ...  
 Values are plotted relative to start of test.

WILSON CONE PENETRATION TESTS B8401022  
 RGC - BOMER'S PIT  
 N-2625R/01



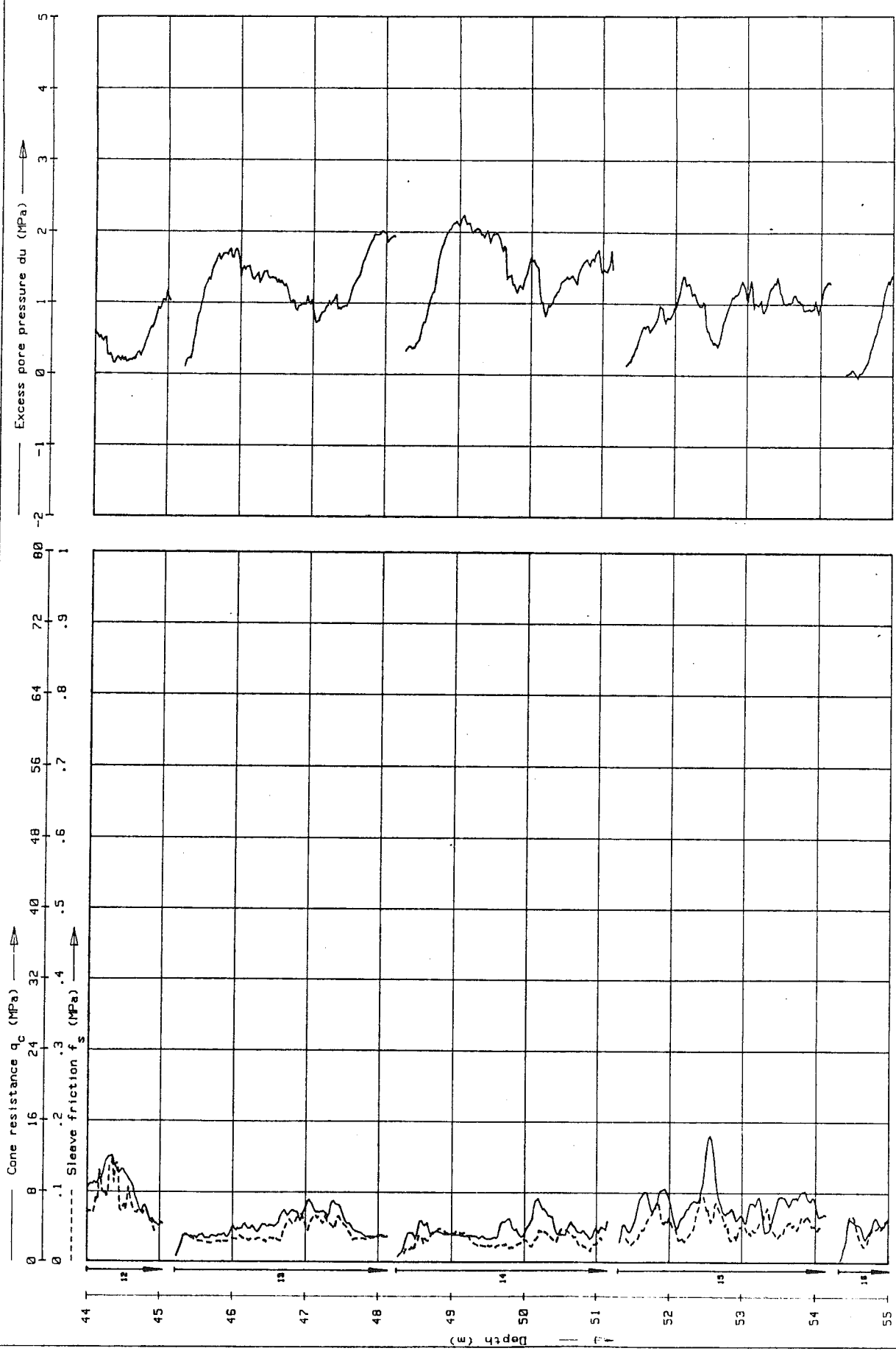


WISON CONE PENETRATION TESTS 88401022  
 RGC - BOMER'S PIT

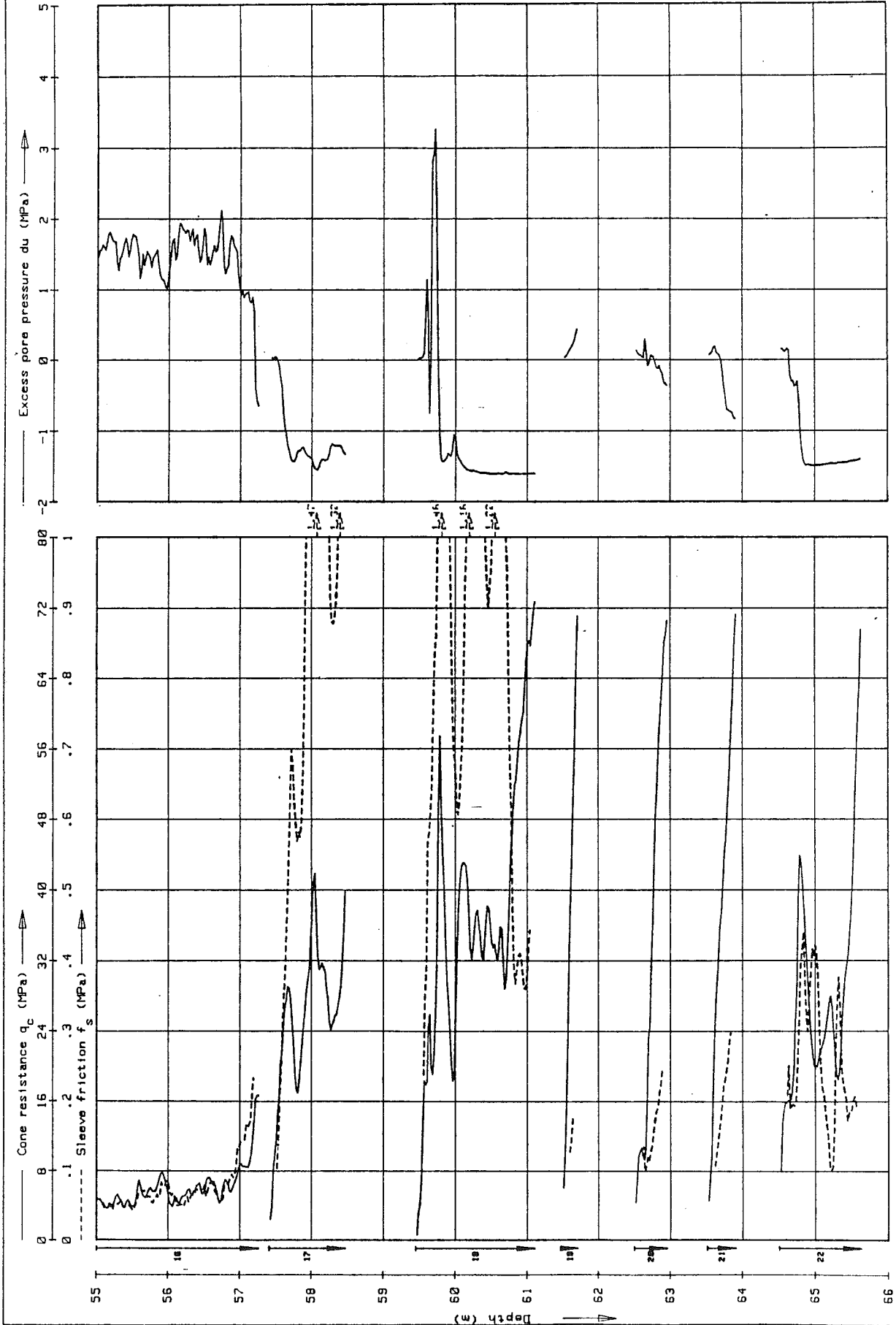
N-2625R/01

Values are plotted relative to start of test.

Location : 88401022  
 Coordinates : -082726.3 E - 464313.1 N  
 Water depth (m) :  
 Used cone(s) : FSKEN<sub>2</sub>(V-A-6)  
 Date of boring : 115-10-88  
 Date of plot : 115 Nov 1988  
 Processed / checked by : IVSR / .15

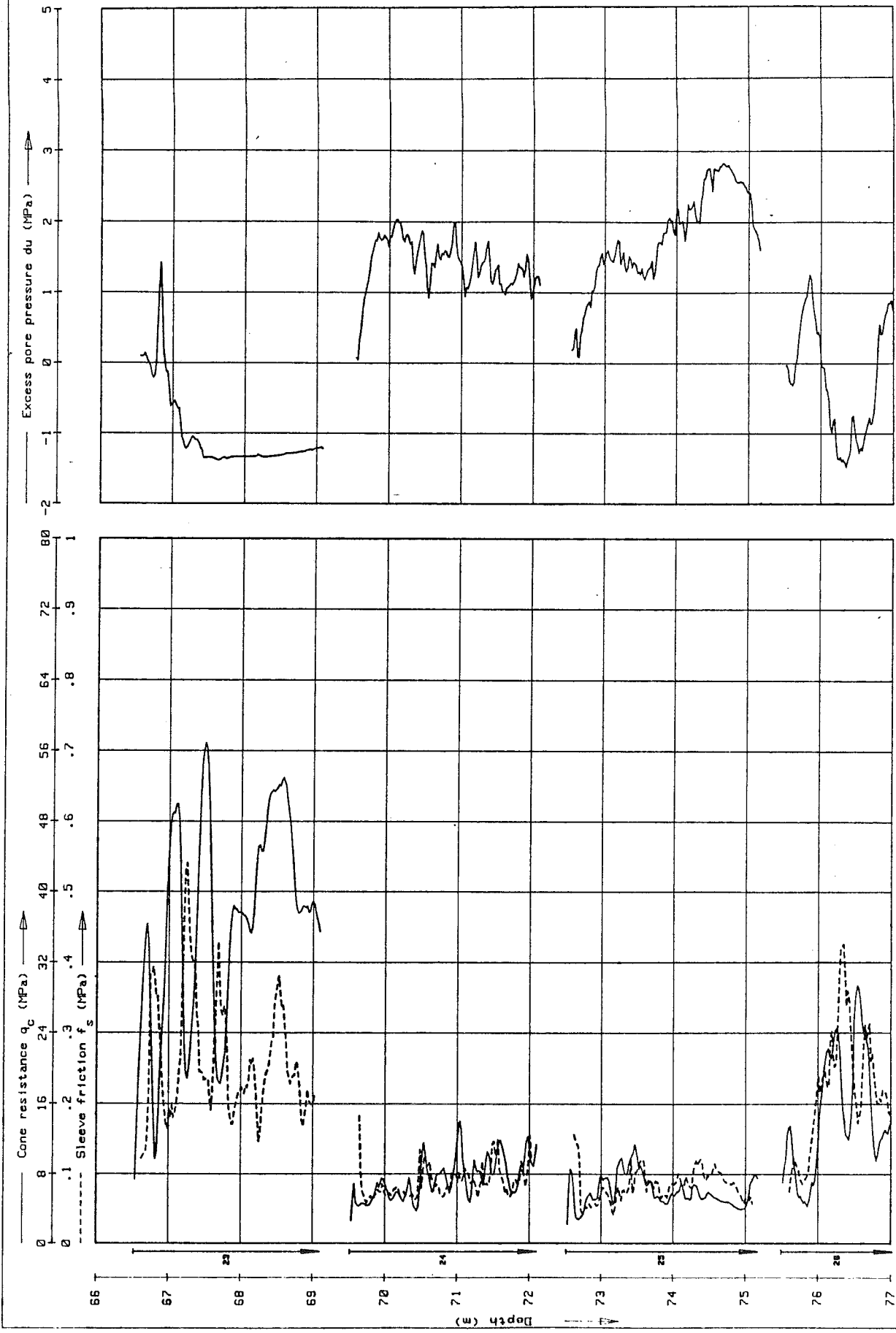


Location : 88401022  
 Coordinates : -48326.3 E - 464313.1 N  
 Date of boring : 15-10-88  
 Date of plot : 15 Nov 1988  
 Water depth (m) :  
 Processed / checked by : MSR / ...  
 Used cone(s) : 15CKEM<sub>2</sub>-a-61  
 Values are plotted relative to start of test.  
 N-2625A/01  
 WISON CONE PENETRATION TESTS 88401022  
 RGC - BOMER'S PIT  
 PLATE A5



WISON CONE PENETRATION TESTS 88401022  
 RGC - BOWER'S PIT

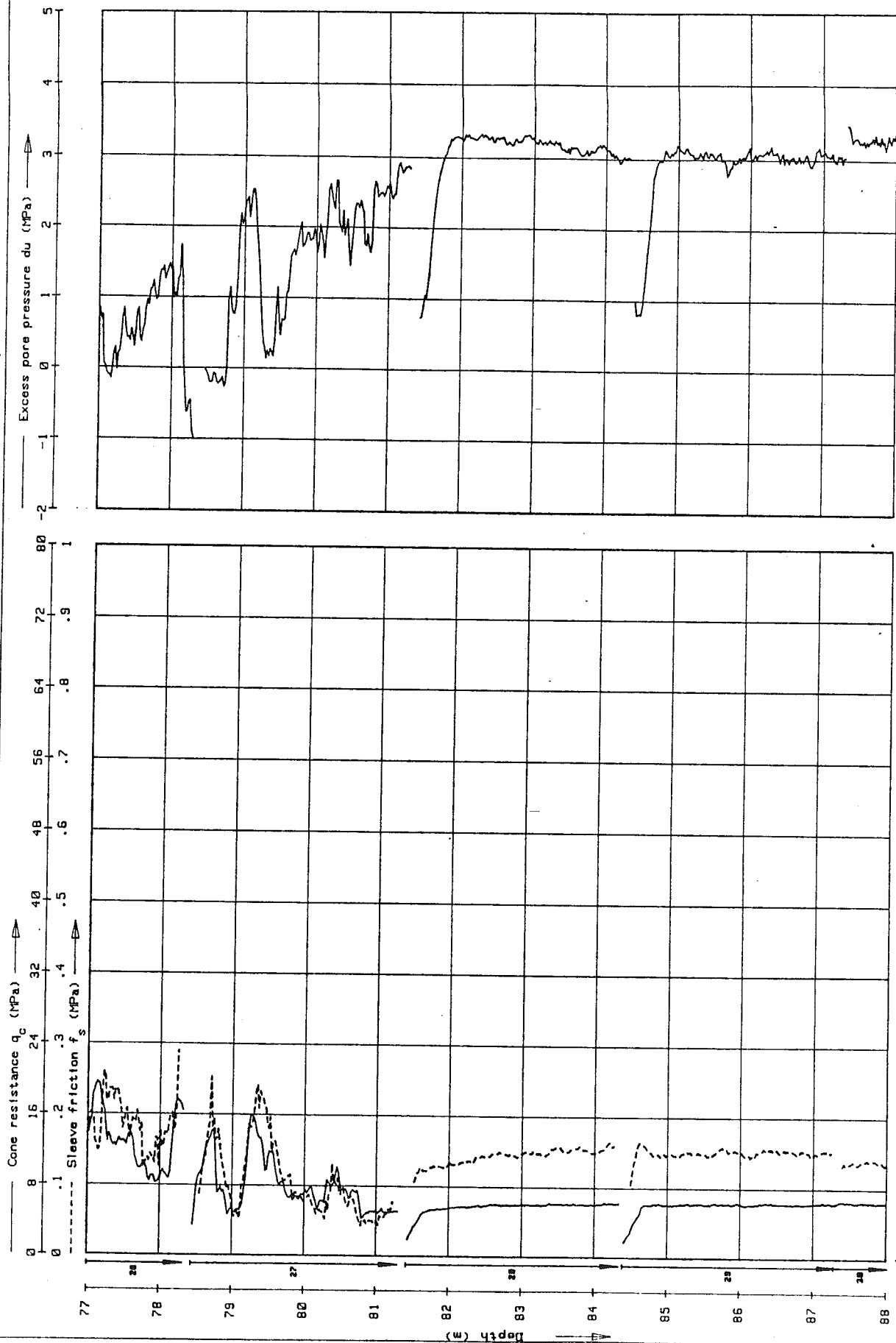
Location : 88401022 Date of boring : 115-10-88  
 Coordinates : -483236.3 E - 464313.1 N Date of plot : 115 Nov 1988  
 Mast depth (m) : Processed / checked by : VSRR / J.S.  
 Used cone(s) : F50KEX<sub>2</sub>/V-a-61 Values are plotted relative to start of test.



WISON CONE PENETRATION TESTS 88401022  
 RGC - BOMER'S PIT

Date of boring : 15-10-88  
 Date of plot : 15 Nov 1988  
 Processed / checked by : VSR / ...  
 Values are plotted relative to start of test.

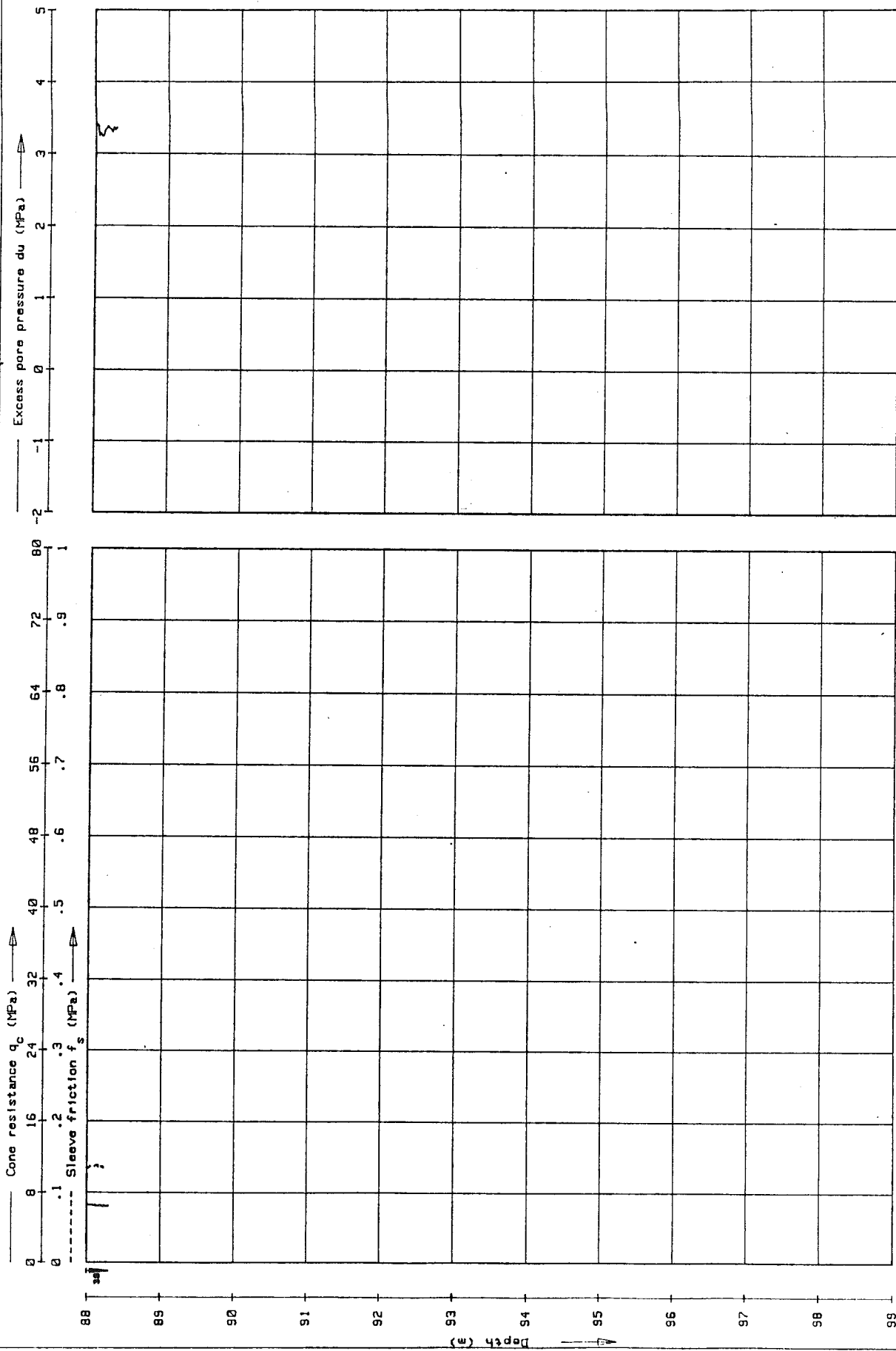
Location : 88401022  
 Coordinates : -483736.3 E - 484313.1 N  
 Meter depth (m) :  
 Used cone(s) : F30XCH<sub>2</sub>/V-e-61



Location : 88401022  
 Coordinates : -493728.3 E - 464313.1 N  
 Meter depth (m) :  
 Date of boring : 15-10-88  
 Date of plot : 13 Nov 1988  
 Processed / checked by : RSR / ...  
 Values are plotted relative to start of test.

WISON CONE PENETRATION TESTS 88401022  
 RGC - BOMER'S PIT

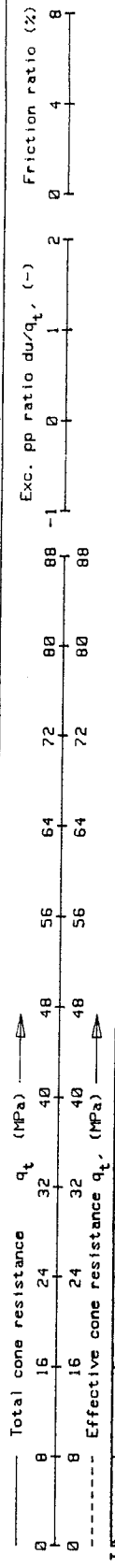
N-2625R/01



WISON CONE PENETRATION TESTS 88401022  
 RGC - BOMER'S PIT

Location : 88401022  
 Coordinates : -483736.3 E - 484313.1 N  
 Meter depth (m) :  
 Used cone(s) : FROCKEN/V-a-81  
 Date of boring : 115-10-88  
 Date of plot : 115 Nov 1988  
 Processed / checked by : IVER / ...  
 Values are plotted relative to start of test.

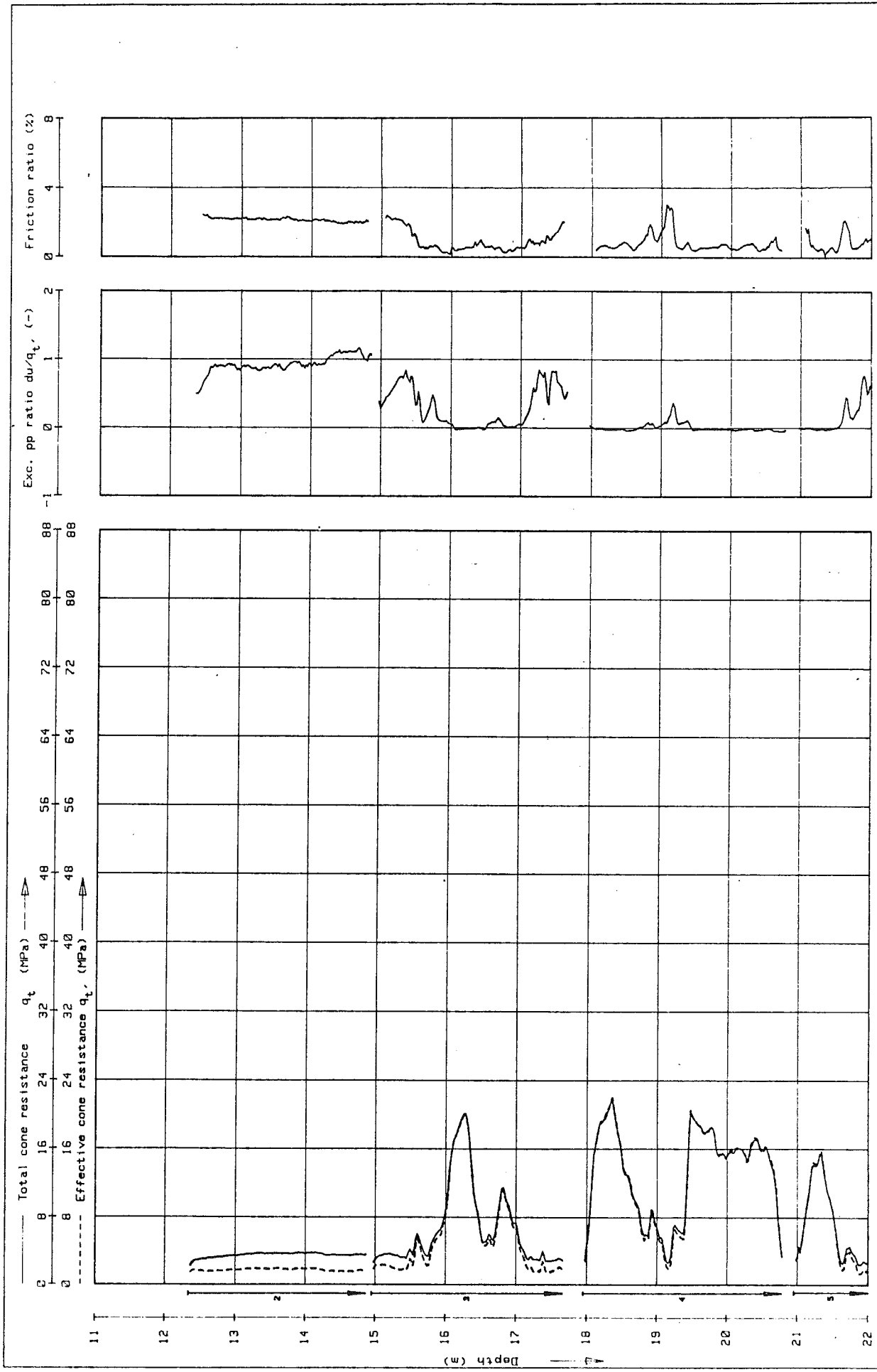
N-26258/01



Depth (m)	qt (MPa)	qt <sub>e</sub> (MPa)	Exc. pp ratio du/q <sub>t</sub> (-)	Friction ratio (%)
0	0	0	0	0
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0

Location : 88401022  
 Coordinates : -483736.3 E - 464313.1 N  
 Date of boring : 115-10-88  
 Date of plot : 15 Nov 1988  
 Water depth (m) :  
 Processed / checked by : VSR / ...  
 Used cone(s) : FSOCKE<sub>2</sub>/V-a-61  
 Values are plotted relative to mudline.

WISON CONE PENETRATION TESTS 88401022  
 AGC - BOWER'S PIT



Location : 88401022  
 Coordinates : -103736.3 E - 464313.1 N  
 Water depth (m) :  
 Used cone(s) : F30CKE4-V-0-61

Date of boring : 115-10-88  
 Date of plot : 15 Nov 1988  
 Processed / checked by : VSR / J.J.  
 Values are plotted relative to mudline.

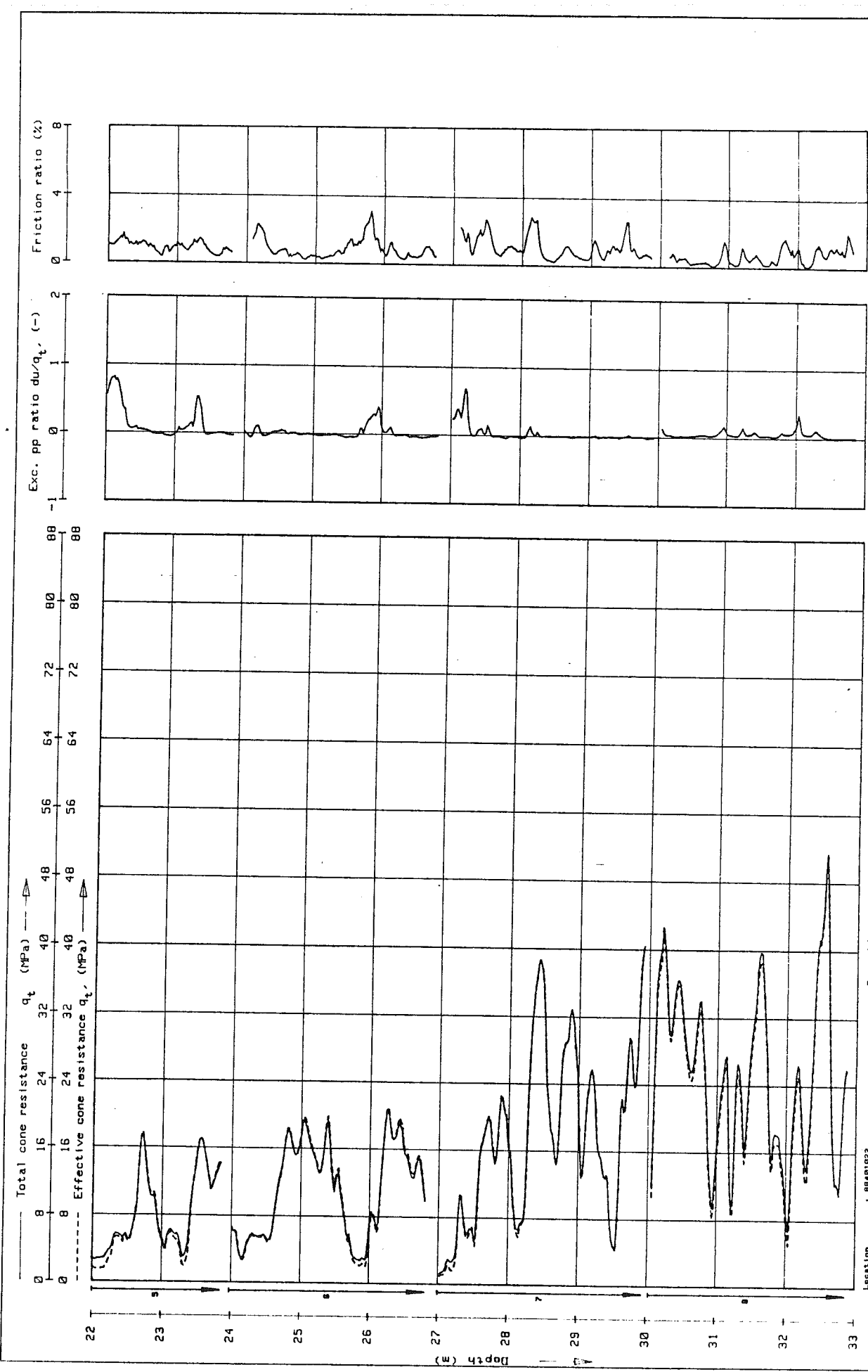
Location : 88401022  
 Coordinates : -103736.3 E - 464313.1 N  
 Water depth (m) :  
 Used cone(s) : F30CKE4-V-0-61

N-26258/01

PLATE A11

WISON CONE PENETRATION TESTS 88401022  
 RGC - BOMER'S PIT

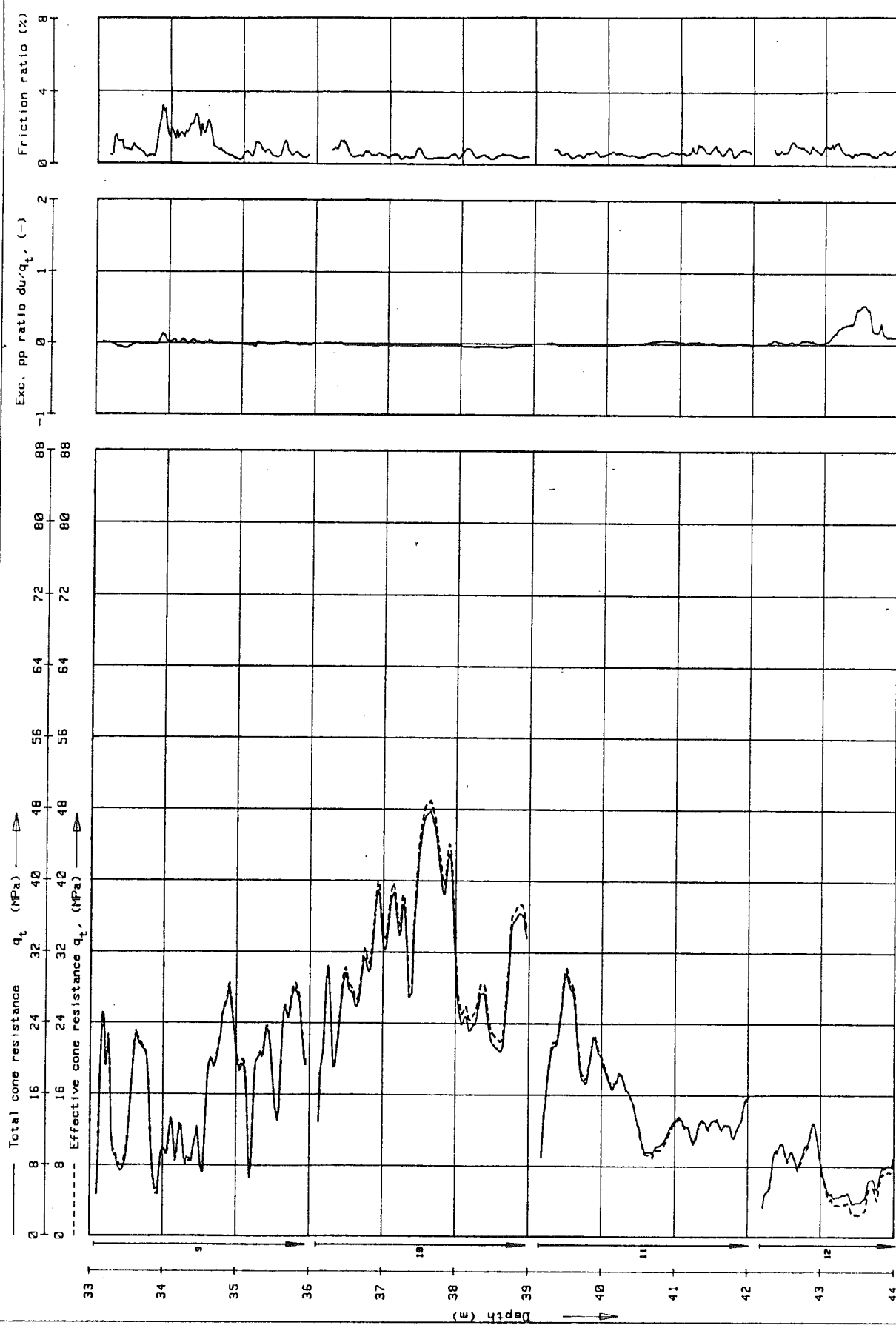




Location : 88401022  
 Coordinates : -482736.3 E - 464313.1 N  
 Meter depth (m) :  
 Used cone(s) : LKEH<sub>2</sub>V-a-61  
 Date of boring : 15-10-88  
 Date of plot : 15 Nov 1989  
 Processed / checked by : VSR / ...  
 Values are plotted relative to mudline.

WISON CONE PENETRATION TESTS 88401022  
 RGC - BOWER'S PIT

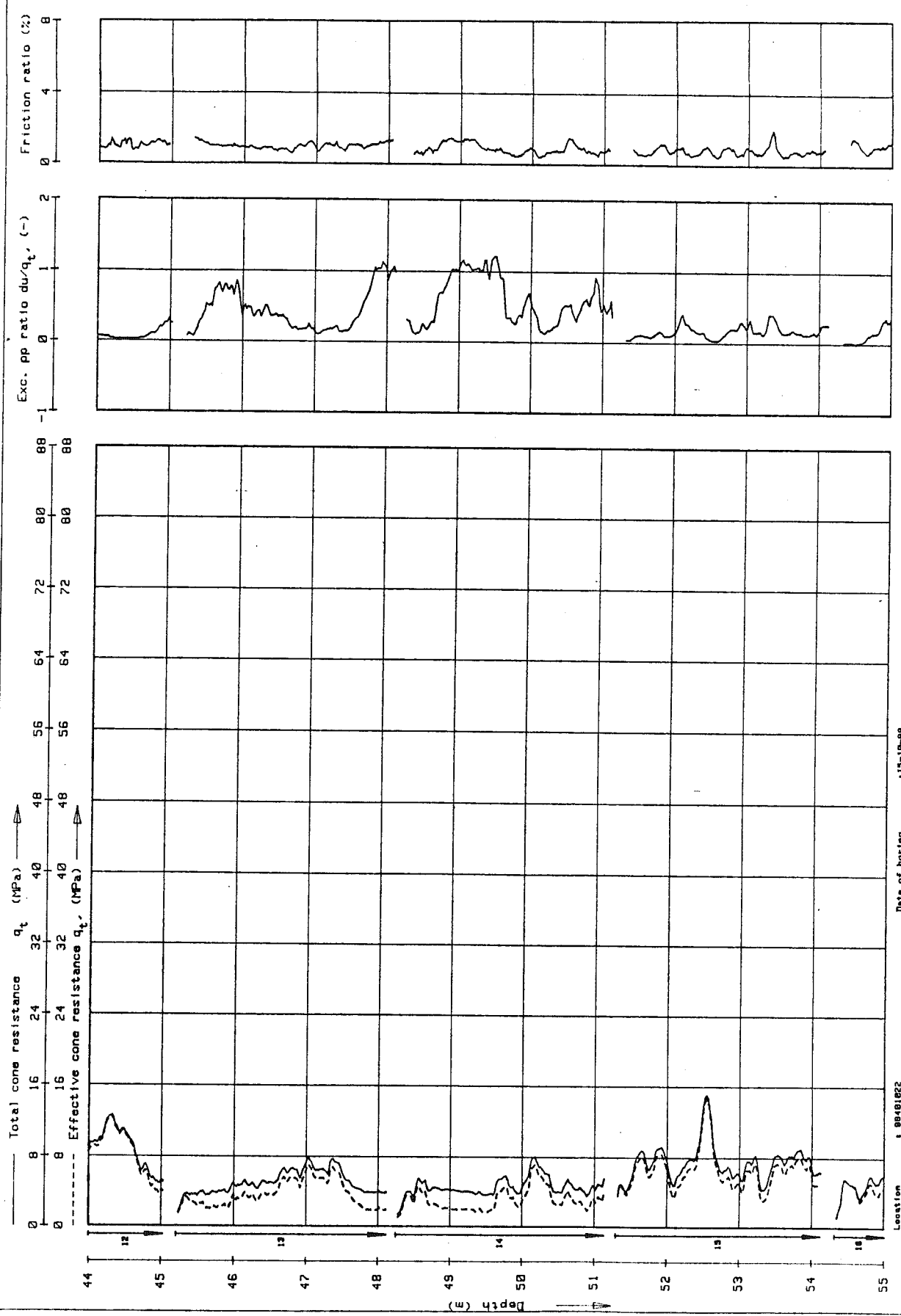
N-2625A/01



Location : 88401022  
 Coordinates : -48328.3 E - 464313.1 N  
 Water depth (m) :  
 Lead cone(s) : FCKEY-V-a-61  
 Date of boring : 115-10-80  
 Date of plot : 115 Nov 1988  
 Processed / checked by : VSR / ...  
 Values are plotted relative to mudline.

WISON CONE PENETRATION TESTS 88401022  
 RGC - BOWER'S PIT

N-2625R/01



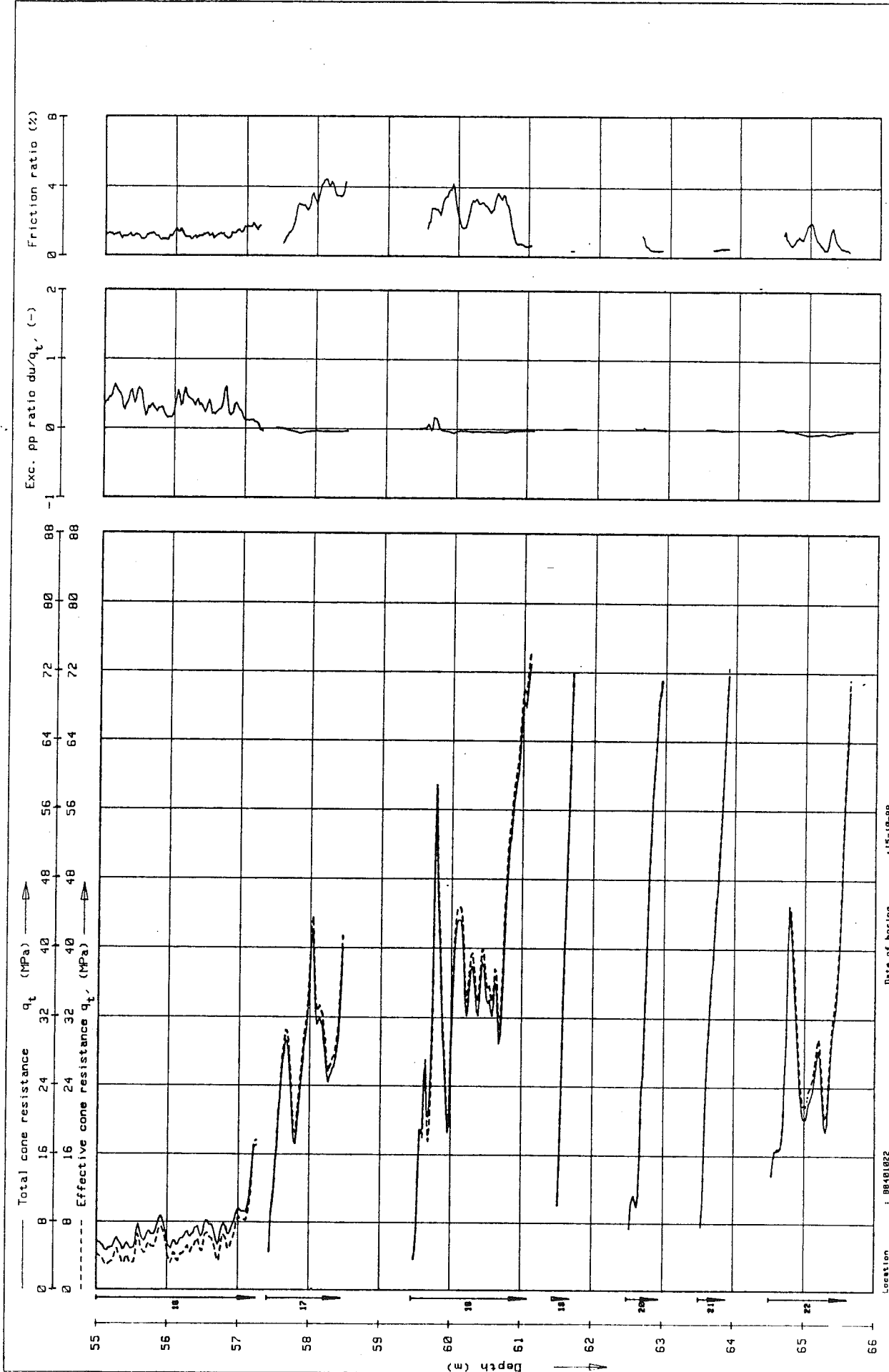
WISON CONE PENETRATION TESTS 88401022

FGC - BOWER'S PIT

N-2625R/01

Location : 88401022  
 Coordinates : -02738.3 E - 464313.1 N  
 Meter depth (m) :  
 Date of boring : 15-10-88  
 Date of plot : 15 Nov 1989  
 Processed / checked by : VBR / ...  
 Values are plotted relative to mudline.

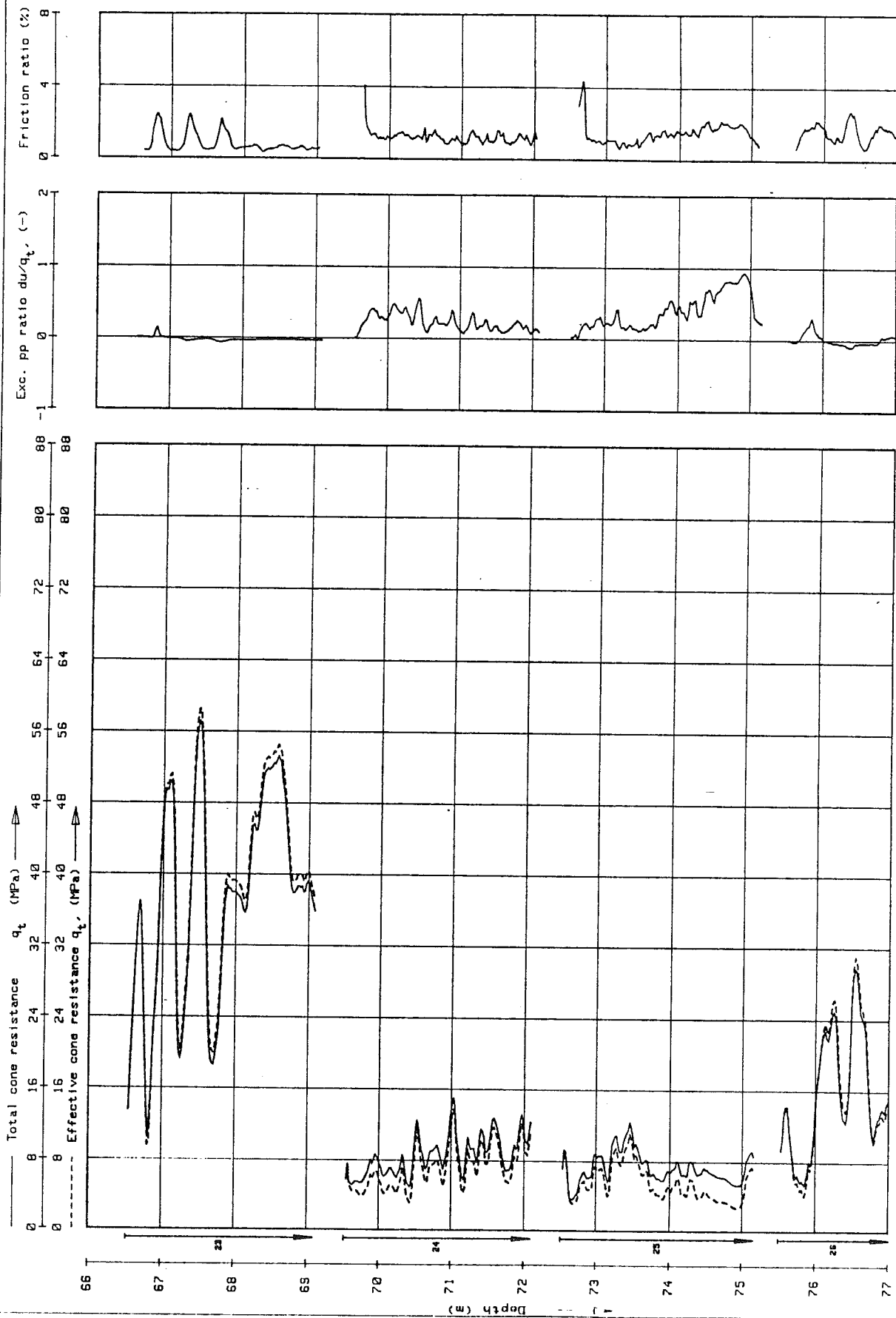
Used cone(s) : F5CKCH<sub>2</sub>/V-a-61



Location : 88401022  
 Coordinates : -683736.3 E - 464313.1 N  
 Water depth (m) :  
 Used cone(s) : SCKEM<sub>2</sub>/V-e-51  
 Date of boring : 15-10-88  
 Date of plot : 15 Nov 1988  
 Processed / checked by : VBR / ...  
 Values are plotted relative to mudline.

WISON CONE PENETRATION TESTS 88401022  
 RGC - BOMER'S PIT

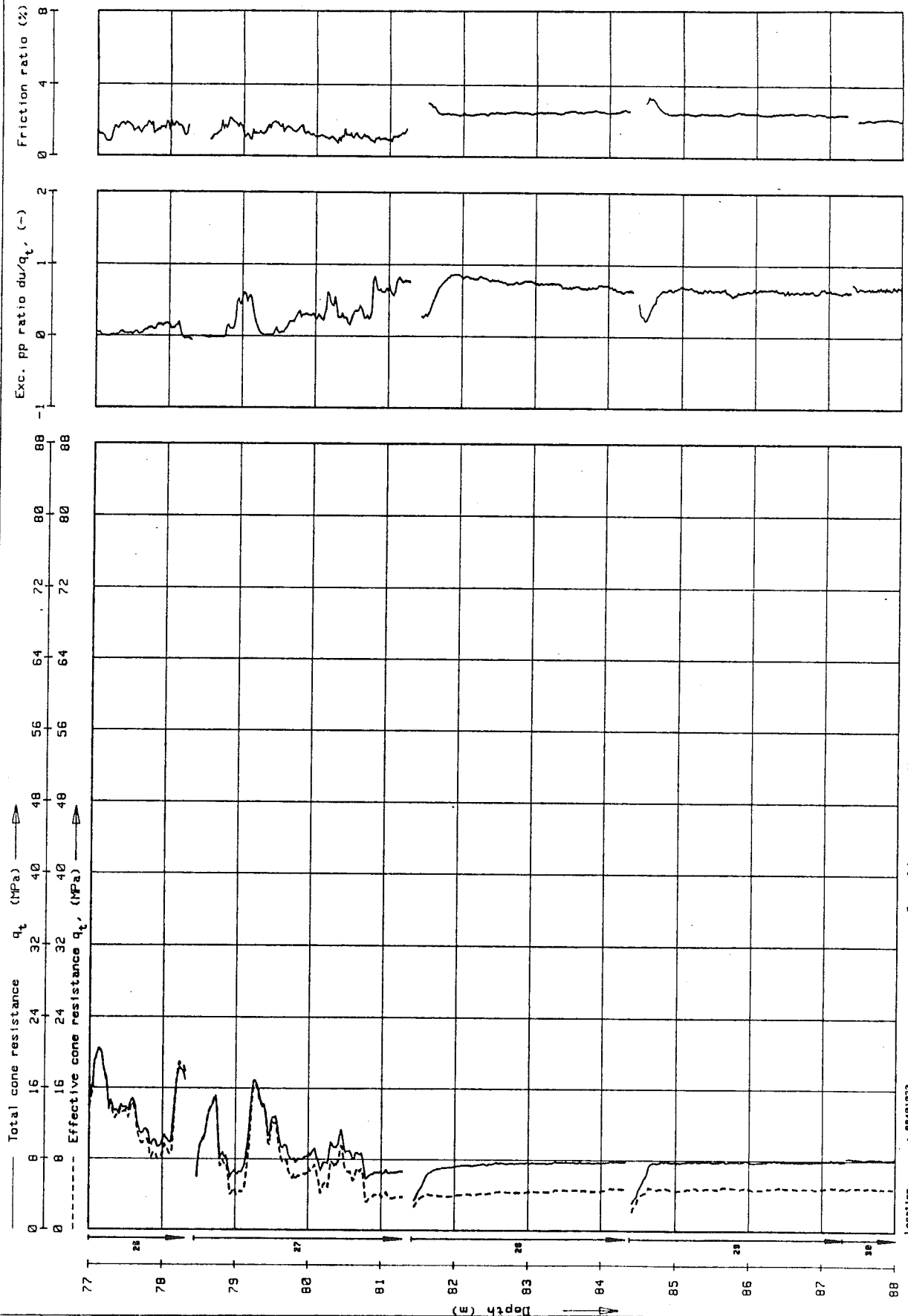
N-2625R/01  
 PLATE A15



Location : 88401022 / Date of boring : 115-10-88  
 Coordinates : -483736.3 E - 464313.1 N / Date of plot : 115 Nov 1988  
 Meter depth (m) : / Processed / checked by I/SR / ...  
 Used cone(s) : F5CKE4/V-a-61 / Values are plotted relative to mudline.

WISON CONE PENETRATION TESTS 88401022  
 AGC - BOWER'S PIT

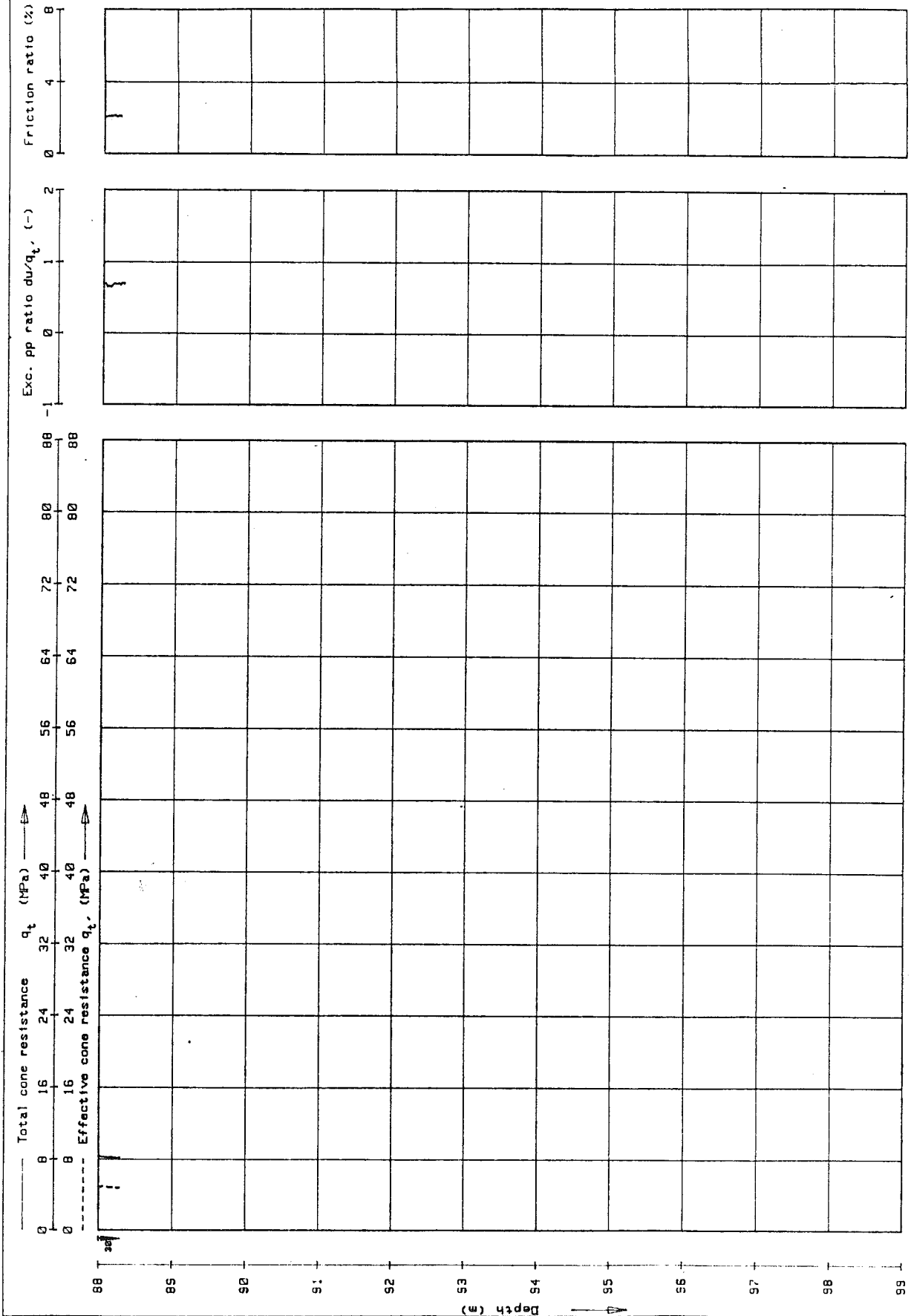
N-2625R/01



Location : 88401022  
 Coordinates : -483736.9 E - 464313.1 N  
 Meter depth (m) :  
 Used cone(s) : 150KCN<sub>2</sub>/V-51  
 Date of boring : 15-10-88  
 Date of plot : 15 Nov 1988  
 Processed / checked by : VSR / ...  
 Values are plotted relative to mudline.

WISON CONE PENETRATION TESTS 88401022  
 FCC - BOHER'S PIT

N-2625R/01



Location : 88401022      Date of boring : 15-10-88  
 Coordinates : -48735.3 E - 46413.1 N      Date of plot : 15 Nov 1988  
 Water depth (m) :      Processed / checked by : VSR / ...  
 Load sensor : F50KCH<sub>2</sub>/V-e-81      Values are plotted relative to mudline.

WISON CONE PENETRATION TESTS 88401022  
 ACC - BOMER'S PIT