CHAPTER 6 NATURAL CONDITIONS IN AND AROUND THE PORT

During the Field Surveys in Romania, data and project-related information on the natural conditions in and around Constantza Port area were collected. Additionally, soil investigation was conducted by the study team in order to supplement the existing soil data. The data and information will be used as the basis for port planning, conceptual zoning, facility arrangement and preliminary design of the port facilities.

The major items discussed in this chapter are the following five fields:

- Topography and Bathymetry
- Climate and Meteorology
- Oceanography
- Geotechnical Condition and
- Coastal Stability

The study team as shown in Appendix IC surveyed environmental data relating to marine conditions.

6.1 Location

The Port of Constantza is situated on the western coast of the Black Sea, at 179 nautical miles (nM) from the Bosphorus, and at 85 nM from the mouth of Sulina Branch, through which the Danube flows into the Sea. Its geographical coordinates are:

- Latitude: 44°06' N
- Longitude: 28°39' E

The Romanian coastline is generally north-south oriented, having a length of 244 km and a cliff height of 25 to 30 m within the range of the Port of Constantza.

6.2 Topography and Bathymetry

6.2.1 Topography

In general the Port was constructed by land reclamation filling in the sea to the east of a cliff running from north to south. Therefore the ground surface is very flat with the elevation varying from 2m to 15m above Mean Sea Level. The wharves were designed to 2.5m/3.5m above Mean Sea Level, major structures of which are shown in Appendix IA.

Along the coast in the north of city of Constantza lie sandy beaches which were formed from an immense volume of sand supplied by Danube River and transported by coastal current

towards the south. The land forms change near Constantza and its southern part is hilly with small beaches trapped among calcareous cliffs. To the western side of the port is Constantza and other surrounding cities, which are situated on hills with elevations varying from 20 to 40m.
Access to the port from the city is rather limited due to: 1) the difference in elevation between the city and the port and 2) railways laid alongside the hill. At present, there are 9 accesses in the north of the Danube – Black Sea Canal (out of which 6 are in North Port) connect the hill and the port.

The port has 133 berths with a total quay length of 25km and total land area of 1094 ha.

Since the port was gradually expanded from north to south, some of the berths are constructed on the rocks or blocks originally utilized as breakwater.

6.2.2 Topographic Map

Within the port area, topographic maps covering the area of 10 km x 4 km with 300 bench marks are established and periodically maintained by CPA.

The elevation and coordinates for the constructions and detailed layout of the Port of Constantza are expressed in a stereographic projection system formally in use all over Romania, called Stereo 70. The system is based on Krasovsky ellipsoid.

It uses a cutting plane, with the pole of the cut hemisphere located almost in the middle of the country. The pole for Romanian system is located near Brasov and marks coordinates (500,000, 500,000). It follows that all points in Romania hold positive coordinates.

Local coordinate system for the port uses benchmarks located on the Port Administration building. The conversion to National Coordinates is classified.

For different dedicated projects, topographic maps are available from the Cadastru Department of CPA, using coordinates expressed as the said project specifies.

- in national stereographic 70 coordinates or
- in local stereographic coordinates or
- in geographic coordinates.

As for height coordinates, Romania used , until recently, a reference to Baltic Sea water mark. All projects now use reference to Black Sea water mark.
Matters of national security cause some map related items to be classified. Such items include topographic maps of great objectives in Romania, such as the Port of Constantza. Topographic maps of cities and towns also stand as classified.

Particular objectives in Romanian territory that feature matters related to national security are the same as the Port of Constantza but include local coordinate systems and stereographic system as well.
For the above reasons, the topographic maps of the entire port with detailed dimensions and elevation (unless specific individual project is planned) could not be provided to the Study Team and are not available for the Master Plan Study. Instead, a general layout plan is presented in Figure 6.2.1.

6.2.3 Bathymetry

The Port is surrounded by North breakwater (approx. 8.9Km) and South breakwater (approx. 5.6 Km). The basin is divided into 34 basins according to the information obtained from CPA, of which B1 – B26 are in North Port, B28 – B34 are in South Port. B27 is an Access Channel, with a total superficial area of 2,532 ha.

The original seabed elevations were inclining toward east with a slope of between 1:200 to 400. See Figure 6.2.2 for the original seabed elevation. Currently, the basin is maintained at between – 6m and –13m in the north port, between –6m and –16m in the south port, and between –17 and –20 m at the Access Channel. A bathymetric map with planned depths is shown in Figures 6.2.3a and 6.2.3b.

According to the information, there are no essential sources of siltation in the water area in the Port of Constantza and no maintenance dredging work is ongoing.

The South port encompasses the entrance into the Danube-Black Sea canal which is part of the important navigable corridor of Danube-Rhine-Main.

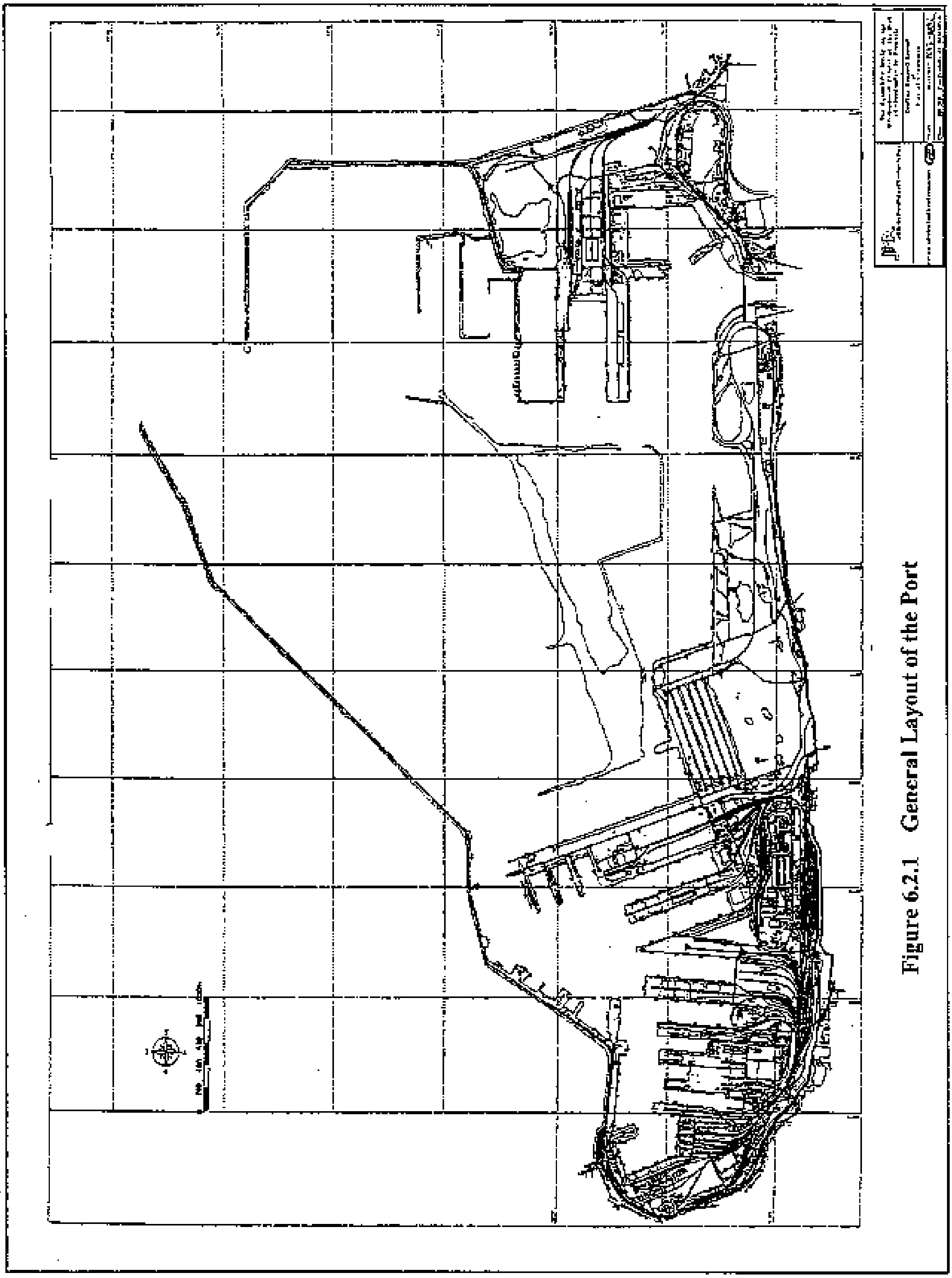

Figure 6.2.1 General Layout of the Port

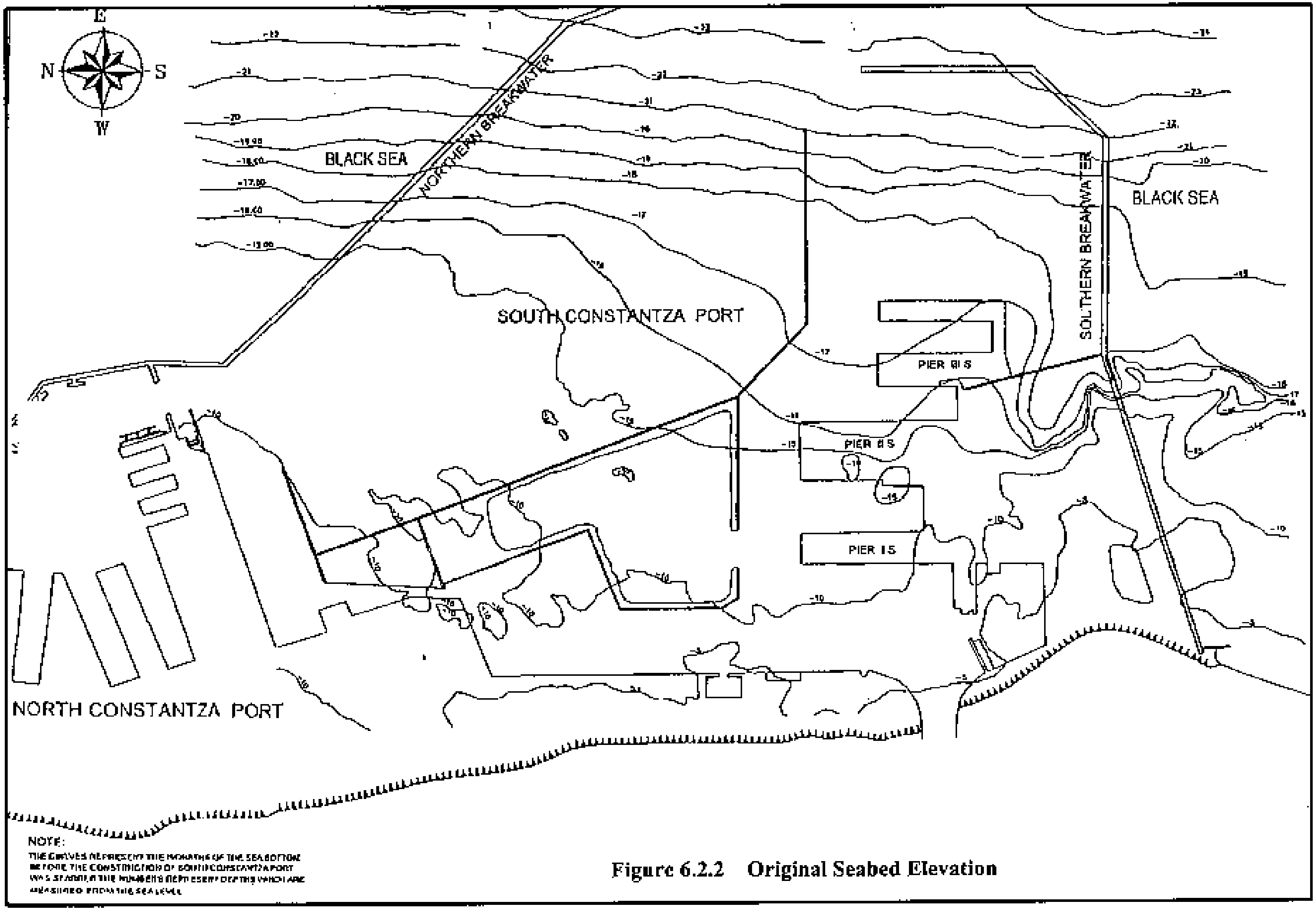

Figure 6.2.2 Original Seabed Elevation

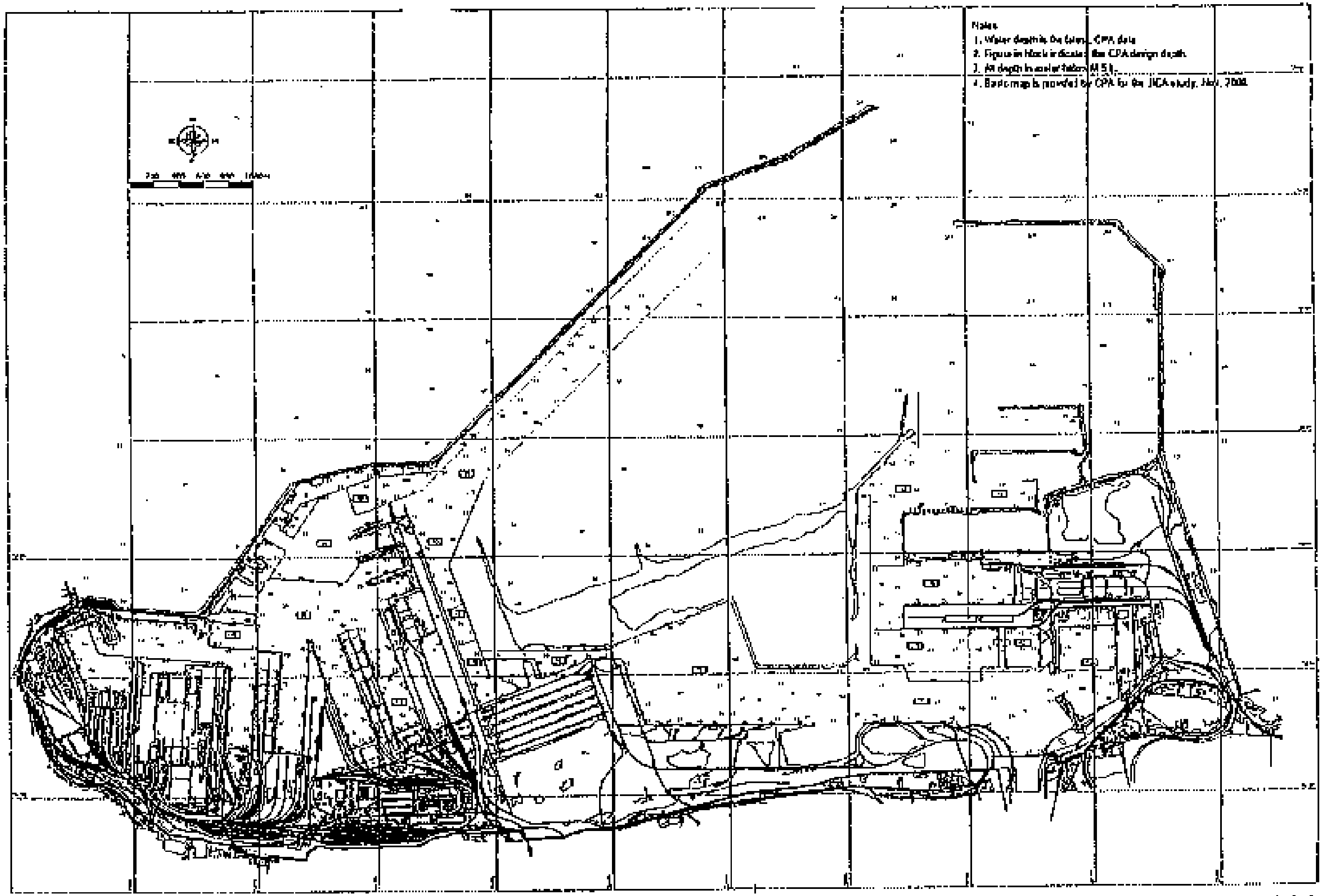

Figure 6.2.3a Bathymetric Map (1)

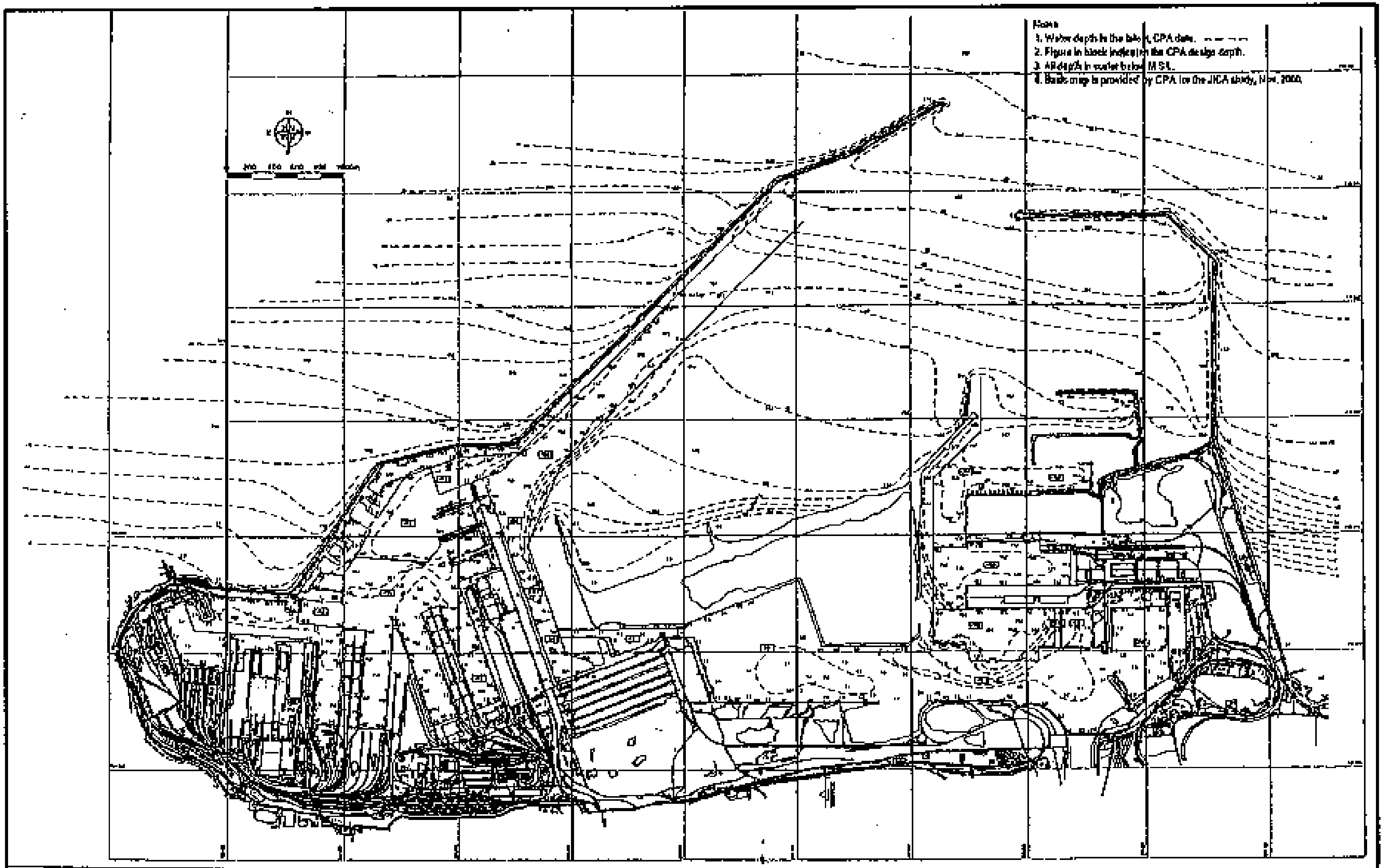

Figure 6.2.3b Bathymetric Map (2)

6.3 Climate and Meteorology

Meteorological conditions such as temperature, precipitation, wind condition are measured at Centrul Meteorologic Regional Constantza (CMRC) in Mamaia and published in Romanian Statistical Yearbook. There are also many sections about climate and meteorology in the previous study reports on Port of Constantza. Their summaries are described below.

6.3.1 Temperature

Due to the influence of sea, the climate is rather milder than other parts of Romania. The annual average temperature is around 11°C. It is very cold in winter and hot in summer with monthly average temperature below 0°C and about 20°C respectively.

Temperatures recorded at Constantza are reproduced from the latest national statistics[1] as shown in Table 6.3.1 below.

Table 6.3.1 Temperature at Constantza (Unit: °C)

	Monthly Average (Celsius centigrade)		Monthly Extreme (Celsius centigrade)					
			from 1901 to 1990				in 1997	
	from 1901 to 1990	in 1997	Maximum	Year Recorded	Minimum	Year Recorded	Maximum	Minimum
January	0.0	-1.2	18.8	1988	-24.7	1942	5.7	-8.8
February	1.1	2.2	23.3	1990	-25.0	1929	13.1	-12.6
March	4.4	4.9	30.8	1952	-12.8	1929	17.0	-3.2
April	9.5	7.5	31.9	1985	-4.5	1923	17.5	-0.7
May	15.1	17.4	36.5	1969	1.8	1915	30.7	8.4
June	19.6	21.0	36.9	1982	6.4	1913	31.8	8.9
July	22.1	22.2	38.5	1927	7.6	1942	33.0	14.6
August	21.9	21.0	36.8	1902	8.0	1936/1949	28.0	14.3
September	18.2	16.1	34.8	1987	1.0	1931	25.7	6.4
October	13.2	11.5	31.0	1928	-12.4	1920	30.0	-3.0
November	7.6	7.9	26.5	1990	-11.7	1953	22.2	-1.7
December	2.8	3.0	21.0	1903	-21.6	1948	13.9	-12.6
Average	11.3	11.1	30.6		-7.3		22.4	0.8
Maximum	22.1	22.2	38.5	Jul. 10, 27			33.0	14.6
Minimum	0.0	-1.2			-25.0	Feb. 9, 29	5.7	-12.6
Difference	22.1	23.4					27.3	27.2

6.3.2 Precipitation

The annual average precipitation is about 380 mm, which is smaller than other parts of the countries. Seasonal variations are small and monthly average is between 23 mm and 42 mm.

[1] Romanian Statistical Yearbook 1998, Comisa Nationala pentru Statistica.

Snow in winter is common. Normally the first snow falls in November and last one in March or April.

Rainfalls recorded at Constantza are also reproduced from the latest national statistics as shown in Table 6.3.2 below.

Table 6.3.2 Monthly Rainfall (Precipitation) at Constantza(Unit: mm)

Period	Jan.	Feb.	Mar.	April.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
from 1901 to 1990	29.4	27.1	23.5	27.9	36.0	41.7	33.4	29.5	28.0	33.7	38.4	34.0	382.6
in 1997	9.4	15.0	31.5	89.0	108.0	47.2	124.5	79.2	4.8	42.7	53.7	37.2	642.2
Maximum	46.7	31.4	31.0	35.7	49.3	75.0	112.3	84.0	62.0	65.7	49.0	36.0	
No. of Days with Snow.	4.1	3.6	2.5	0.3							0.8	2.9	14.2

6.3.3 Humidity

Annual average of the humidity at Constantza is approximately 80 %. In December, the monthly average is 87 to 89 %, while in June it is lower about 70 to 72 %. Very dry days are estimated about 2.3 days in a year, when the relative humidity becomes lower than 30 %. Wetter days are 129.8 days when the humidity exceeds 80 %.

6.3.4 Winds

Wind is observed at Mamaia station, which is located in a residential area some 7 km north of the port and started operation some 150 years ago. Wind data observed at Constantza from 1971 to 1994 are available[2] as shown in Table 6.3.3 and in Figure 6.3.1 in the form of wind roses. It should be noted that the following data are not sufficient for complete reproduction of the wind rose, due to lack of details, i.e. hourly wind direction and its velocity.

Strong winds occur at the end of autumn and in winter (January) with storms, sometimes up to Beaufort 9 to 10 (20 to 30 m/s). Calm weather is typical for the end of the summer season and the beginning of autumn. The maximum recorded wind velocity for 10 min average is approximately 40m/s (January 31, 1962) and the maximum instantaneous wind velocity is 55 m/s according to CMRC[3].

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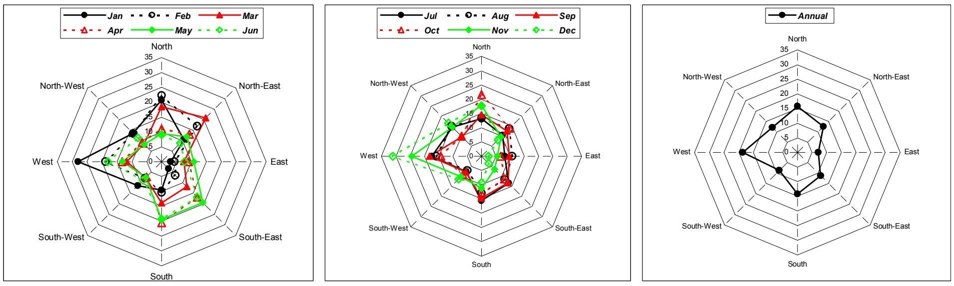
[2] Studiul privind parametrii caracteristici ai furtunilor si consecinte ale acestora asupra tarmului si constructiilor portuare, Institutul Roman de Cercetari Marine, Constanta, 1994.

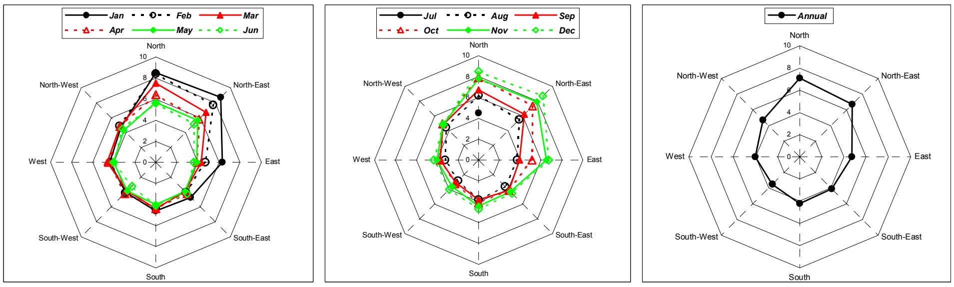
[3] Centrul Meteorologic Regional Constantza; Meteorological County Centre of Constantza.

Table 6.3.3 Winds at Constantza at Constantza

Month	North		North-East		East		South East		South		South West		West		North West		Average
	Freq. %	V (m/s)	Freq. %	V (m/s)	Freq. %	V (m/s)	Freq. %	V (m/s)	Freq. %	V (m/s)	Freq. %	V (m/s)	Freq. %	V (m/s)	Freq. %	V (m/s)	V (m/s)
January	20.7	8.5	10.5	8.7	3.0	6.3	3.3	4.7	9.6	4.6	11.3	4.0	28.0	4.4	13.6	4.7	5.7
February	22.2	8.4	16.8	7.7	4.3	4.7	6.4	4.0	10.3	4.4	7.8	4.1	18.8	4.3	13.4	4.9	5.3
March	18.4	7.5	20.9	6.7	7.4	4.3	11.9	3.9	13.8	4.4	7.6	3.8	11.7	4.6	8.4	4.8	5.0
April	11.0	6.4	13.1	5.8	9.0	3.9	16.9	4.2	20.5	4.4	7.1	4.2	13.3	4.5	9.3	4.8	4.8
May	9.5	5.7	11.9	5.6	10.8	3.9	19.4	3.9	19.4	4.0	7.4	3.8	13.2	4.0	8.3	4.3	4.4
June	9.1	5.6	8.8	5.1	7.7	3.6	16.9	4.2	19.3	4.1	8.9	3.2	18.0	4.0	11.3	4.5	4.3
July	13.2	5.7	10.4	5.1	8.1	3.7	13.3	3.7	15.6	3.8	7.6	2.7	17.4	3.5	14.4	4.5	4.1
August	13.3	6.2	13.7	5.5	10.7	3.7	11.5	3.6	13.0	3.8	7.0	2.8	15.9	3.2	14.9	4.4	4.2
September	14.5	6.7	12.5	6.2	9.7	3.9	13.0	4.1	14.7	3.8	7.7	3.1	18.1	3.7	9.7	4.8	4.5
October	21.6	7.9	13.9	7.3	6.7	5.1	11.3	4.1	13.1	4.1	9.2	3.2	14.2	3.7	9.9	4.9	5.0
November	17.9	7.8	9.7	7.9	5.8	6.5	6.4	4.3	11.3	4.4	10.3	3.6	24.4	4.0	14.4	4.8	5.4
December	17.7	8.5	8.0	8.7	2.4	6.7	3.7	4.5	9.3	4.7	11.4	4.0	31.0	4.3	16.4	4.8	5.8
Average	15.8	7.1	12.5	6.7	7.1	4.7	11.2	4.1	14.2	4.2	8.6	3.5	18.7	4.0	12.0	4.7	4.9



(a) Frequency of Wind Direction in a Year (%)



(b) Avarage Wind Velocity in each Direction in a Year (m/s)

Figure 6.3.1 Wind Roses at Constantza

The predominant wind directions in the western part of the Black Sea vary during the various seasons, as presented in Table 6.3.4.

Table 6.3.4 Predominant Wind Directions at Constantza

Season	Predominant Wind Directions
Winter	W – NW
Spring	N – NE
Summer	NW – NE
Autumn	N - NE

6.3.5 Ice

The waters in and around the Port of Constantza do not freeze, although the specific density of the salt water is relatively low (1.012 t/m3). Buoys are sometimes frozen due to spraying water. In those conditions the visibility of buoys is significantly reduced.

6.3.6 Visibility

The condition of visibility or fog is presented in the final report of Port of Constantza Strategy Plan[4]. The following is a reproduction from the report.

The average number of days with fog at the Port of Constantza is 50 days per year. The maximum number recorded is 68 days. Fog is most frequent during the winter season with an average of 8 days per month and a recorded maximum of 16 days per month. Fog can be rather persistent in this area, particularly during the winter season.

The visibility at Constantza the year round is summarized in Table 6.3.5

Table 6.3.5 Visibility at Constantza

Visibility Class	Visibility Range (km)	Frequency % of Time/Year
I	Above 10 km	77
II	Between 1 and 10 km	19
III	Below 1 km	4

The maximum recorded monthly frequency of fog in Class III was 10% during January and February, the frequency in Class II was 38% during the months December to February.

6.4 Oceanography

As described in Section 6.3, generally in Constantza the weather is calm in summer and can be rough in winter. Storms usually occur between October and March, and normally extreme ocean conditions are also in this period.

Oceanographic data are measured and analyzed in National Institute for Marine Research and Development (IRCM). Data on water level fluctuation, current and wave can be purchased from the said institute. Old data can be found in Oceanographic Yearbook.

6.4.1 Water Levels

There are no distinct tidal motions in the Black Sea. Along the coast, occasional fluctuations of the water surface are observed due to wind set-up. For its deeper waters, the wind set-up is

[4] 1993, Frederic R. Harris B.V.

compensated by return flow and the fluctuation of the water surface is not expected to be larger than 1 m between high and low water levels. Also, due to the absence of tidal motion, the mean sea level (designated as MSL) is used for the reference elevation of the water surface and the chart datum level (CDL) in the Black Sea.

Water level fluctuation is continuously recorded by IRCM with sea-graph recorders installed inside the port. The data on 1981 are extracted from Oceanographic Yearbook as shown in Table 6.4.1.

Table 6.4.1 Record of Daily Average Water Level at Constantza in 1981 (cm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Min	-4.6	2.9	10.0	14.4	16.0	13.4	7.3	-0.2	-22.0	-9.3	-25.3	-0.3	-25.3
Max	65.2	44.4	39.9	37.6	32.2	32.5	28.0	16.5	10.5	9.8	33.6	37.4	65.2

Note: Datum is 13cm above Mean Sea Level.

6.4.2 Current

Current is measured 1.6 km offshore of Mamaia every 15 minutes in summer season. Along the coast in Constantza area, the prevailing current is from north to south and the (maximum) velocity is about 1 knot.

6.4.3 Waves

Waves are of primary importance for the prediction of conditions within the port area for different layouts and for design of breakwaters.

(1) Wave Data from IRCM

The wave conditions have been recorded since 1966 by IRCM with a wave meter installed some 5 km offshore of Tomis Harbor. Waves, in fact, should be measured in deep water, where they are not distorted to a significant extent by shoaling or refraction. However, the water depth at the meter is approximately 12m, which is quite shallow, therefore care must be taken in the use of its data.

(2) Previous Wave Studies

There have also been many studies on wave assessment in the Port of Constantza, e.g., study reports prepared by Frederic R. Harris B.V. (FRH, 1997)[5]. FRH have collected data from the British Meteorological Office which include data from:

[5] Constantza Port Rehabilitation Project, Phase I, Review Original Breakwater Design, Frederic R. Harris B.V., August 1997

a. Ship observations between 28° – 32°E and 42° – 46°N
b. Computed wave heights from the European Waters Model at a coastal point near Constantza

From the above data, the 1 in 50 year wave heights have been calculated as shown in Table 6.4.2.

Table 6.4.2 Offshore Wave Height at Constantza (Unit: m)

Wave Direction	**Ship Observation Hs (m)**	Computed Hs (m)
All directions	10.8	7.5
15° – 75°	9.8	
45° – 105°		6.9

Note: wave period was not observed

FRH also estimated the wave heights at the shallower water with different wave period for the use of breakwater design. The result is shown in Table 6.4.3.

Table 6.4.3 Estimates of the Statistical Waves at Constantza (Unit: m)

Water Depth from MSL (m)	Estimated from Ship Observation			Estimated from the European Waters Model	Old Breakwater Design
	T = 9 sec	T = 10 sec	T = 12 sec	-	T = 9.05 sec
-16	5.52	6.16	6.86		6.22
-18	5.68	6.38	7.13	6.9	6.30
-20	5.81	6.54	7.29		6.35
-22	5.96	6.76	7.49		6.40
-24	6.11	6.95	7.62		6.44

Note: T: Wave period

With regards to the coastal environment around the project site, it is understood that there is no siltation in the waterfront. While erosion of the natural beach has been a serious concern along the shoreline of Romania, the Port of Constantza is basically well sheltered by the seawalls and the wave dissipating blocks within the breakwaters.

As shown in Part III Chapter 4 ans Appendix IIIA, wave calmness study was conducted based on the proposed new layout plan.

(3) Visual Wave Observations

On November 27 and 28, six visual observations of wave conditions were carried out near Gate No. 1 by the study team. The result is shown in Table 6.4.4.

Table 6.4.4 Visual Observation of Wave Conditions at Constantza, Out of Breakwater

Date	Time	Wave Period (Sec)	Wave Height: H_0'(m)
November 27,2000	9:00 am	9.0	1.5 - 2.5
	Noon	7.0	
	4:00 pm	8.1	
November 28,2000	9:00 am	7.0	2.5 - 3.5
	Noon	7.5	
	4:00 pm	7.5	

6.5 Geotechnical Conditions

A thorough understanding of site geotechnical conditions is of extreme importance. As the Port of Constantza has a long history of development and operation, a great amount of valuable soil data has been accumulated. Previous site investigation data together with historic charts of seabed topography, geological maps and exposed geological features were collected and are presented in this section, while previous construction records have already been presented in Appendix IA. All this data will contribute to the understanding of site conditions.

Although rough subsoil profiles are known, some soil profiles at specific locations and additional data such as mechanical features of soil are necessary for the planning stage. The detail descriptions of the above data are shown in the separate volume. In this section, a brief summary is presented.

It is recommended to undertake localized and detailed investigations during the final design.

6.5.1 General

Natural ground of Constantza Port is composed of a calcareous relief and sedimentary deposit formed in Sarmatian period and quaternary sand layer with various depths.
The deep Sarmatian deposit are formed in two different periods:

1. The medium Sarmatian, with two distinct layers:
   a surface layer of gray – brown clay, without stratification
   a deep layer of organogenous limestone, very old, mixed with ooloitic limestone, calcareous sandstone, sand and clays

2. The superior Sarmatian with limestone, oolitic limestone with clay lens.

Geological features around Constantza and stratification are shown in Figures 6.5.1 and 6.5.2.

The elevation lines of limestone in the Port have been established based on various boring results and shown in Figures 6.5.3a and 6.5.3b. The profile of limestone layer which is the bearing layer however is very complicated. Generally the limestone surface is also inclining toward the East from -10 to -20m however, along Danube-Black Sea Canal, there is an old valley and in other places there are a lot of spots where limestone is not found. In the north port it is found around –7 to 8m.

The port is constructed by dumping filling materials on existing seabed with enclosures of quaywalls. The filling materials are of clay, silty clay or calcareous fragment with sizes from gravel to big blocks.

The filling of south port was carried out mainly between 1986 and 1989. Main materials used were excavated during the Danube – Black Sea Canal construction, which had been piled in a disposal site at about 10 km from the present project site. The other source of the reclamation is a borrow quarry nearby Constantza. In addition, as encountered in the previous soil investigations and noticed by some local engineers, the reclamation fill contains many construction disposals, like debris of concrete blocks. From these origins, the characteristics of the reclamation materials are inhomogeneous and significantly vary over the area as shown in the soil profiles.

In expansion of the port, old breakwaters and temporary dikes, constructed with rocks and concrete blocks, have been buried under the new fill materials. Therefore, such materials are found in various locations especially in South Port and Oil Berth.

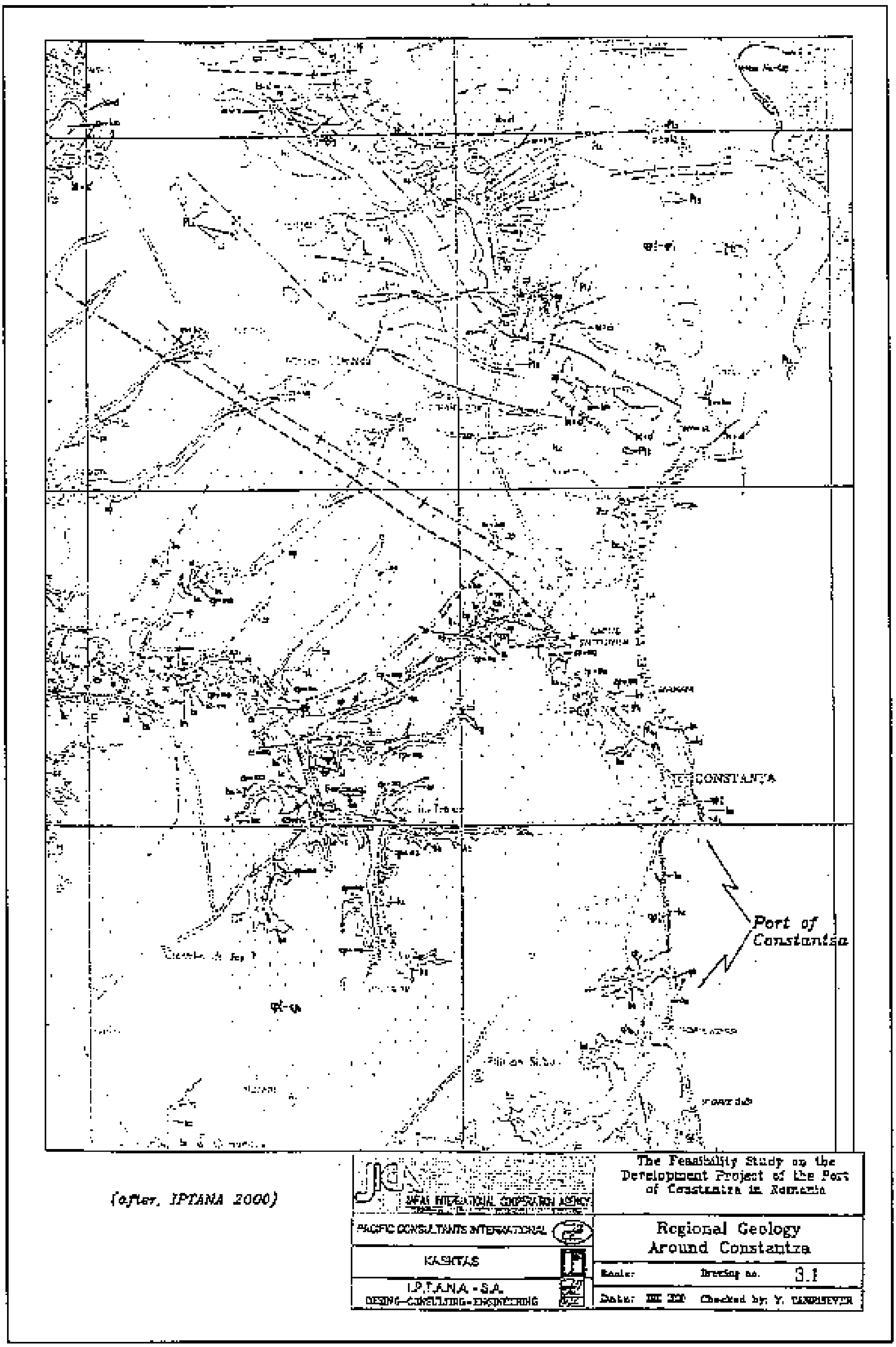
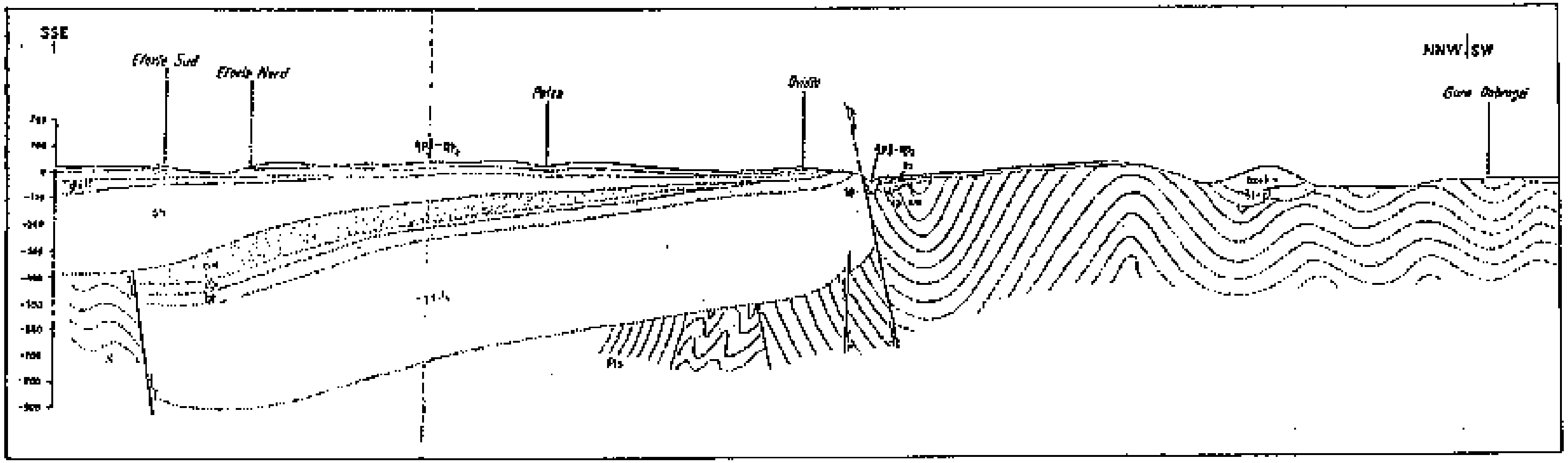


Figure 6.5.1 Exposed Geological Features around Constantza



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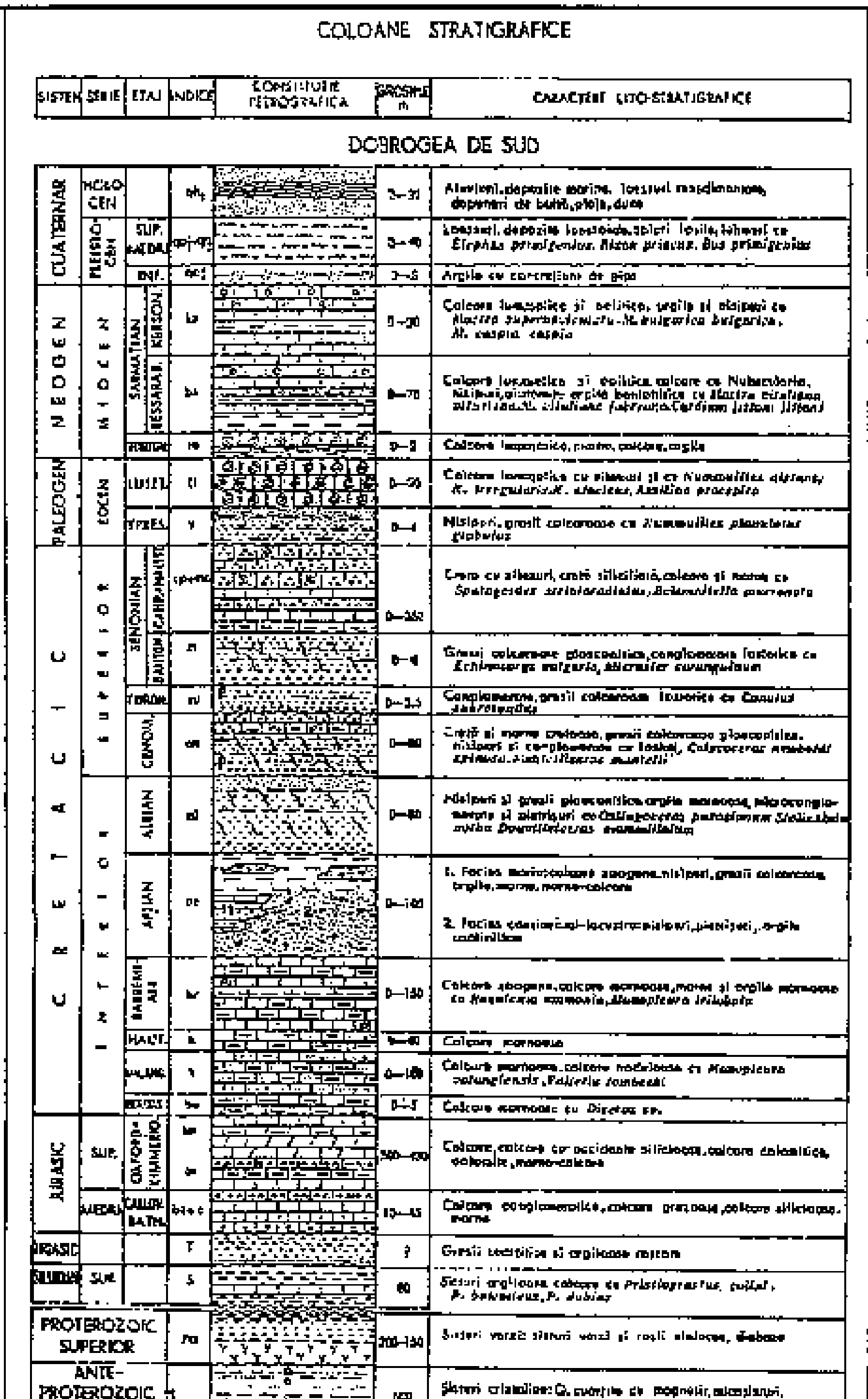
The Feasibility Study on the Development Project of the Port of Constantza in Romania

Regional Geology Around Constantza

Drawing No. 3.4

Figure 6.5.2 Stratification



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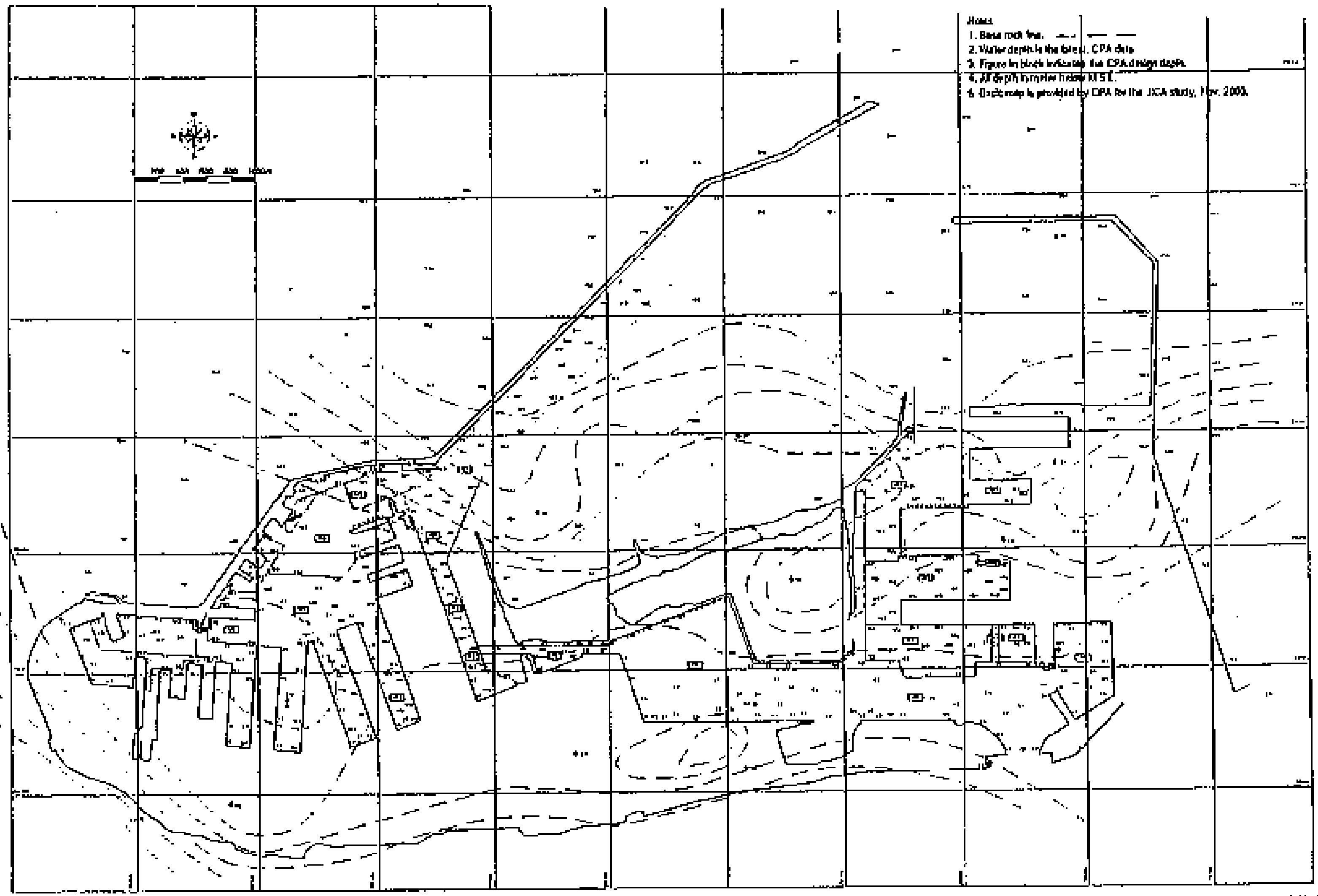


Figure 6.5.3a Lime-stone Elevations

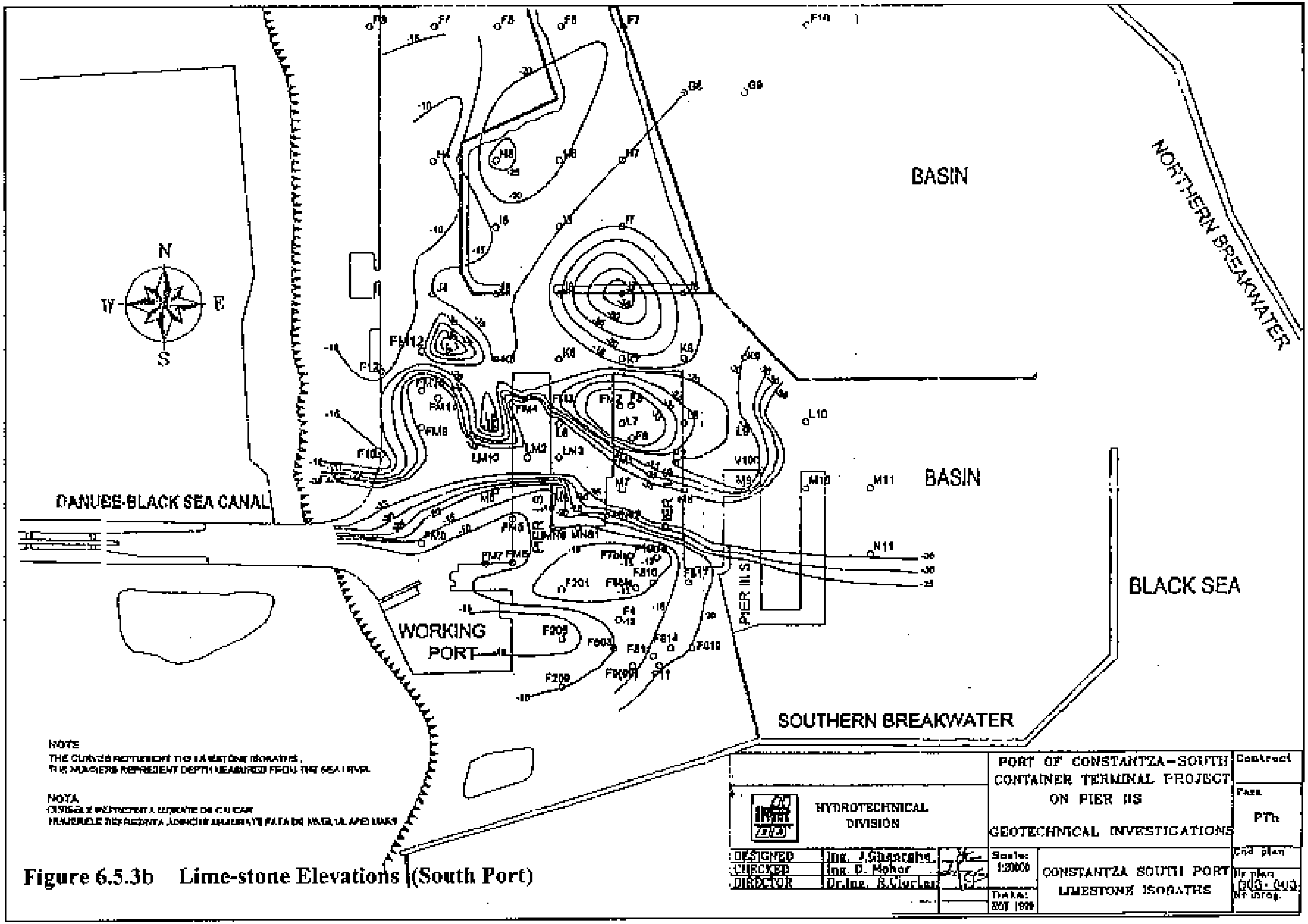


Figure 6.5.3b Lime-stone Elevations (South Port)

6.5.2 Soil Investigations

(1) General Descriptions

Soil investigations are necessary for the design of foundations for all port structures including breakwaters, quaywalls and buildings. They are also necessary for planning and design of dredging and reclamation including evaluation of settlement. In order to supplement the existing soil data, new boring survey was conducted under the supervision of study team.

(2) Previous Geotechnical Studies

In Port of Constantza, even after the modern technologies were introduced, more than 100 berths were designed and constructed. As a consequence, more than 150 borings have been carried out and the data are possessed by IPTANA. As a pert of new survey results, the study team has intended to obtain general soil profiles. For this consideration 15 cross sections, 9 West-East and 6 North – South of the soil information were created by IPTANA.

(3) New Soil Investigation by the Study Team

In addition to studying the old data, new soil investigations with 16 borings were carried out since many of the old data lacks the parameters needed for design work, such as strengths and N-values. Necessary laboratory tests were also carried out.

The locations of borings are shown in Figure 6.5.4. The boring works were carried out between November 9 and 16 by a Turkish boring company Kasktas and samples were tested at the laboratory of Technical University of Civil Engineering Bucharest, supervised by IPTANA. Tables 6.5.1 through 3 show the quantity and particulars of bore holes, samples and laboratory test. The results of the soil investigation are reported in the separate volume.

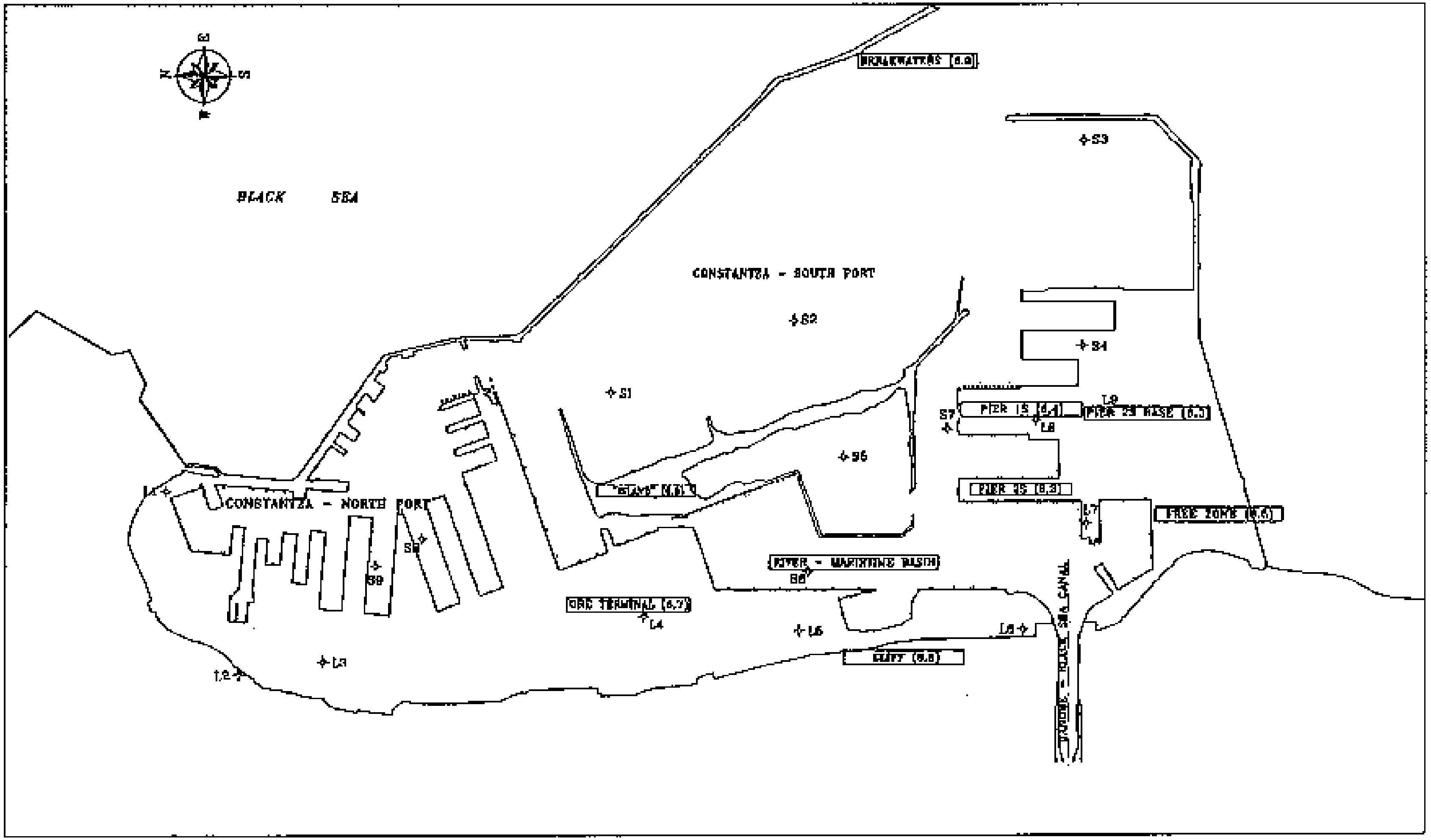


Figure 6.5.4 Location of Borings

Table 6.5.1 Particulars of Boreholes/ November 2000

Borehole No.		Coordinates (Romanian Local Grid)		Ground Elevation	Location
		Easting	Northing		
Onshore	L1	792434.87	303570.14		Near Berth D12
	L2	790835.35	302948.93		Near Gate 4
	L3	790955.95	302228.45		Near Gate 5
	L4	791359.66	299370.65		Near Stock Pile
	L5	791237.94	297950.47		Near Berth D96
	L6	791250.51	295948.03		Near outlet of DBS Canal
	L7	792182.65	295381.41		Near Berth D106
	L8				Pier IIS near lake
	L9				Root of Pier IIS
Offshore	S1	793317.98	299682.68		East of Central Island
	S2	793990.87	297988.47		East of Central Island
	S3	795013.39	295443.86		South Port
	S4	793733.58	295417.49		Root of Pier IIIS
	S5	792790.22	297540.20		Middle of Central Island
	S6	791786.00	297874.60		Near Berth D97

Table 6.5.2 Summary of Undisturbed Samples/ November 2000

Sample no		Borehole no	Depth (m)	Soil Classification
Onshore	UD1	L5	6.00 – 6.50	CLAY, silty, brown, hard
	UD2	L5	16.00 – 16.50	CLAY, silty, brown, hard
	UD3	L6	3.50 – 4.00	CLAY, silty, plants, greenish brown – light brown
	UD4	L6	8.50 – 9.00	CLAY, silty, plants, greenish brown – light brown
Offshore	UD5	S4	24.00 – 24.50	CLAY, silty, slightly fine gravelly, plant roots, greenish gray, blackish gray, soft
	UD6	S4	27.50 – 28.00	CLAY, silty, slightly fine gravelly, plant roots, greenish gray, blackish gray, stiff
	UD7	S5	23.50 – 24.00	CLAY, slightly fine gravelly, very stiff
	UD8	S5	25.00 – 25.50	CLAY, slightly fine gravelly, very stiff

Table 6.5.3 Summary of Laboratory Test, /November 2000

Test Item	Quantity
Grain Size Analysis	157
Specific Gravity	175
Natural Moisture Content	157
Unit Weight	180
Atterberg Limits	118
Uniaxial Compression	10
Consolidation	9
Permeability	1
Direct Shear	7
Swell Test	82
Point Load	41

6.5.3 Soil Investigation Results in November 2000

Detail discussions of soil investigation results are given in the separate volume. General soil profiles, boring logs and physical and mechanical properties obtained from new and old data are briefly described below.

(1) General Soil Profiles

15 cross-sectional profiles created from mixing between the old data and new ones are provided as shown in Figure 6.5.6 through Figure 6.5.21, presented at the end of this chapter.

As can be observed in the profiles, in the entire area the top layers are filling materials with various characteristics.

(2) Boring Logs

The boring logs created in the new investigation are shown in Figures 6.5.22 through 6.5.27, presented at the end of this chapter.

(3) Laboratory Test Results

1) Consolidation Test

Results of consolidation test are summarized in Table 6.5.4.

Table 6.5.4 Results of Consolidation Test/ November 2000

Sample	BH No	Depth (m)	Natural Water Content: w (%)	Initial Unit Weight: γ_0 (tf/m^3)	Specific Gravity: Gs	M2-3 (kPa)	Cv (cm^2/s)
UD1	L5	6.00 - 6.50	17.8	1.87	2.73	3846	2.8×10^{-4}
UD2	L5	16.00 - 16.50	38.4	1.71	2.72	14285	8.5×10^{-5}
UD3	L6	3.50 - 4.00	27.7	1.83	2.72	9090	8.7×10^{-5}
UD4	L6	8.50 - 9.00	28.6	1.90	2.66	11111	8.8×10^{-5}
UD5	S4	24.00 - 24.50	26.0	1.90	2.73	6250	1.3×10^{-4}
UD6	S4	27.50 - 28.00	22.5	2.00	2.73	7692	2.5×10^{-4}
						10000	1.8×10^{-4}
UD7	S5	23.50 - 24.00	26.0	1.70	2.73	7142	5.1×10^{-5}
UD8	S5	25.00 - 25.50	24.0	1.85	2.72	5882	5.9×10^{-5}

2) Unconfined Compression Test

Results of unconfined compression test are summarized in Table 6.5.5.

Table 6.5.5 Results of Unconfined Compression and Direct Shear Test/ November 2000

Sample	BH No	Depth (m)	Initial Unit Weight: γ_0 (tf/m3)	Unconfined Compressive Stress	Direct Shear Test		Remarks
				qu (kPa)	ϕ (°)	c (kPa)	
UD1	L5	6.00 – 6.50	1.87	71.38	25	38	CL
UD2	L5	16.00 – 16.50	1.71	157.1 211.9	12	93	CH
UD3	L6	3.50 – 4.00	1.83	47.2	-	-	CH
UD4	L6	8.50 – 9.00	1.90	81.5	-	-	CH
UD5	S4	24.00 – 24.50	1.90	33.2	15	33	CL
UD6	S4	27.50 – 28.00	2.00	56.3	15 11	12 59	CL
UD7	S5	23.50 – 24.00	1.70	185.8 240.7	15	16	CH
UD8	S5	25.00 – 25.50	1.85	121.8	21	12	CH

Note: 98.1 kPa = 1 kgf/cm^2

6.5.4 Seismic Condition

Romania is situated on the Transasian Volcanic Belt passing over Himalayan arch, Afghanistan, Iran, Iraq, Caucasus, Asia Minor, Balkan Mountains, Sicily, Spain and north-west Africa. Due to this geological nature, 15 seismic sources have been identified in Romania. Among those, one identified in Vrancea located at the southeast bend of the Carpathian Mountains, is the most active seismic source inducing big earthquakes as recorded in the history of seismic hazards in Romania.

As shown below in the geological map of Romania and explained from the theory of plate tectonics, the earthquakes from Vrancea are generated by subduction of three plates, i.e., east European, Moesic and Carpathian plates. About 10 million years ago, this subduction was initiated by the movement of the east European plate from east to west under the Carpathian plate, which formed a rise of the oriental Carpathian.

This movement has been still prolonged and the resultant energy has been continuously accumulated with intermittent release by large earthquakes.

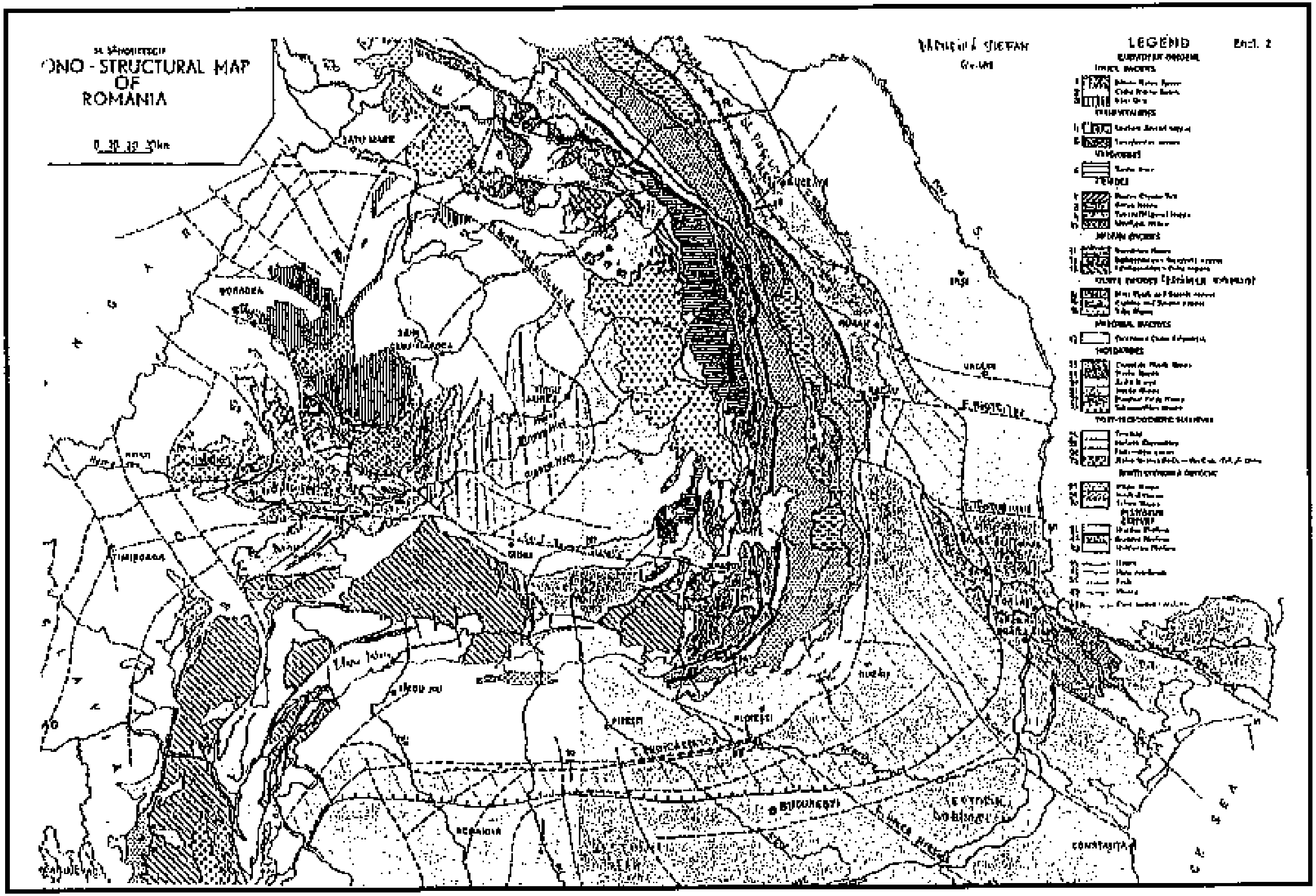


Figure 6.5.5 Geological Map of Romania

The large earthquakes generated in Vrancea are characterized by the following:

- The earthquakes affect a considerable area with its maximum intensity;
- The seismic movements are perceived in remote areas, reaching St. Petersburg, Moscow and Greece;
- Vertical component of the seismic movements propagates to areas at a distance of 160 km from the epicenter;
- There are two zones of the maximum intensity, symmetrically located to the epicenter, somewhere in Moldavia and Muntenia, while the epicentral zone is less affected; and
- Depth of the seismic focus varies from 20 to 185 km, mostly at about 100 km.

Among the past earthquakes originated in Vrancea, one of the recent events occurred in March 1977 involved serious damages in Romania. The magnitude of this earthquake recorded was 7.2 on the Richter scale. After this event, national seismic code was revised as found in STAS 2923 representing macro seismic zone for seismic design intensity, where regional seismicity was classified by Medvedev Sponheuer Karnik (MSK) scale.

The characteristics of major earthquakes in Romania are listed in the Table 6.5.6.

Table 6.5.6 Characteristics of Major Earthquakes in Romania

Date	Depth (km)	Magnitude (Mw)	Remarks
August 19, 1681		7.1	
June 11, 1738		7.7	
October 26, 1802		7.9	
November 23, 1829		7.3	
November 10, 1940	150-180	7.7	267 death
March 4, 1977	90-110	7.5	1570 death
August 30, 1986	130-150	7.2	2 death, 558 injury
May 30, 1990	70-90	6.9	9 death, 700 injury

However, Constantza is normally quite far from the epicenters (approximately 250 km) and the subsoil in Dobruja region is solid, therefore, until now no major damage due to earthquake is recorded.

6.6 Coastal Stability

In the Romanian coast of the Black Sea, sedimentation is remarkable. Great amount of sand carried in Danube River is deposited where the river meets the sea, and a delta has formed. The deposited sand is further transported to the south by a southward current.

Accumulation of sand along the coast has been continuing and as a consequence, Histria, an important port 2000 years ago, located some 50 km to the north of Constantza, is now trapped in a lake.

However, recently, the west coast of Black Sea is experiencing serious problems of coastal erosion. The main causes for the erosion are considered by local experts as described below.

1) Hydrotechnical works on Danube and its tributary streams

Dams and retention lakes both on Danube and its tributary streams (Olt, Arges) reduced Danube driven sediment.

2) Jetties on Sulina Branch

Danube outlet to the Black Sea is a delta of three branches. The Sulina Branch is a waterway, to allow sea-river ports in the Lower Danube to call for sea going vessels.

Navigation depth is maintained by scheduled dredging at Sulina Bar, between a pair of jetties. Required depth marks 23 feet (7.32 m) and is charged to Romanian authorities.

Said jetties have been extended seaward during last decades up to the present length of 8 km. It thus made a severe change in the pattern of current and sediment transport. Dredged volume amounting to 800-900 million m^3 per year result in loss in supply of sand.

3) Expansion of seaports (Midia, Constantza and Mangalia)

Development of Romanian seaports has also disturbed equilibrium of sediment transport. Long breakwaters in the Port of Midia and in the Port of Constantza have severely induced beach erosion at Mamaia resort (North to Constantza) and at Eforie resorts to south.

Groins and dikes intended to diminish or avoid degradation have been constructed at various locations. However, they only serve to protect local erosions. Further study may be needed in this subject.

6.7 Recorded Natural Disasters at Constantza

6.7.1 Earthquakes

As presented in subsection 6.5.4, no damage was recorded in modern times (last two centuries) to the Port of Constantza.

6.7.2 Storms

Heavy storms of the Black Sea usually cause the port to close, but do not alter the breakwater. No damage to the breakwaters caused only by storms has been recorded during the development of the port in all the stages.

6.7.3 Oil Spill

No oil spill disaster has been recorded near the Romanian coast of Black Sea, to cause the Port to close.

6.7.4 Other Causes

Other kinds of man-made disaster has produced serious damage to the Port.

In January 1995, due to a winter storm, the Harbor Master notified all ships in the strait and recommended they leave their anchorage at once. All ships departed but two: You Xiou and Paris.

The violent storm drove the two ships astray so they struck against the North Breakwater. Repeated strikes during the storm crushed the Breakwater armor in hit areas and finally induced failure of the structure. Two breaks occurred at km 2+200 and 3 + 500. The ship sunk at the breakwater toe.

It took more than a year for Romania to collect finance (as part of EBRD) and proceed to repair the two damages and to build a rock cover over the two wrecks to avoid the danger of waves washing out the breakwater toe.

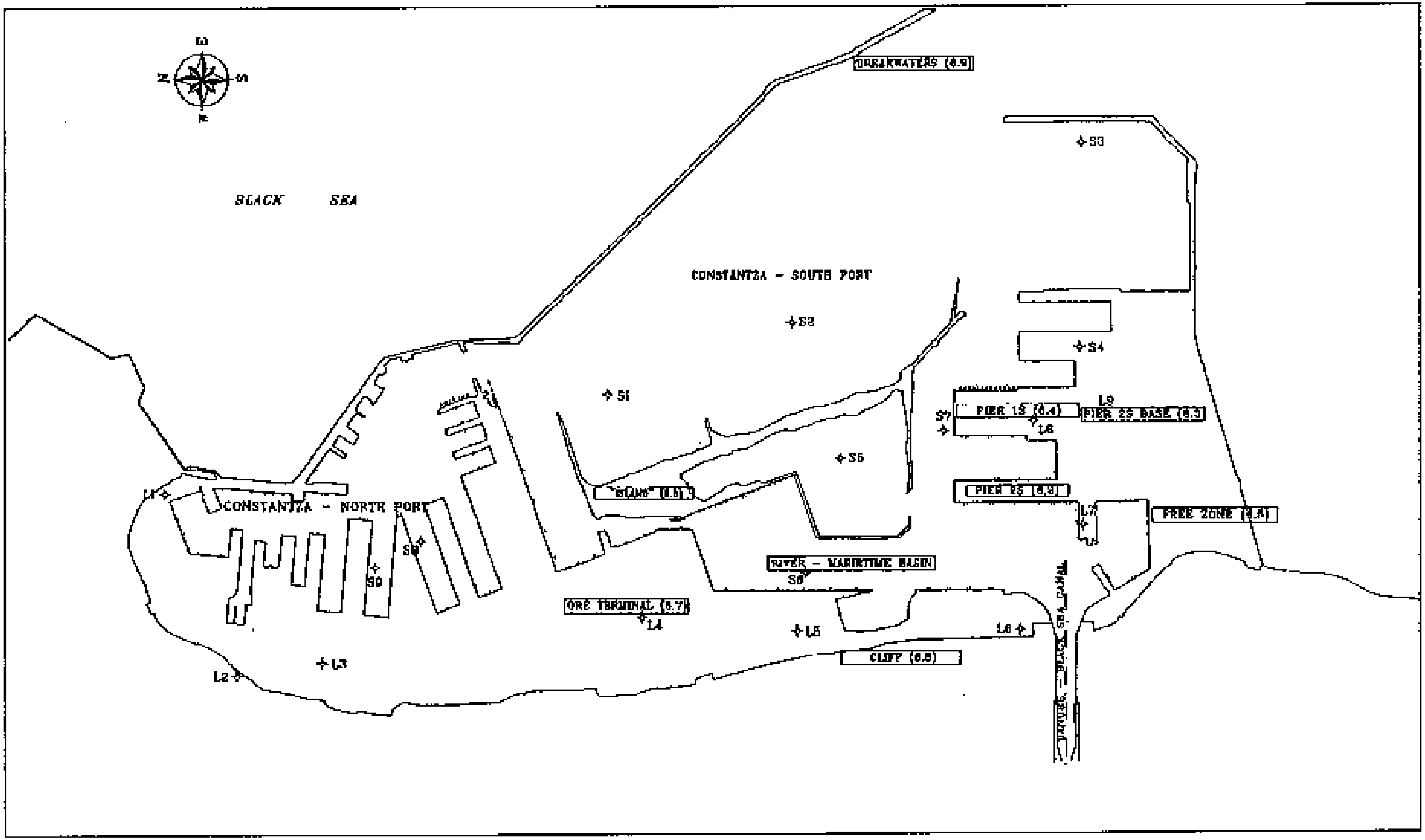


Figure 6.5.6 Location Plan of Previous Borings

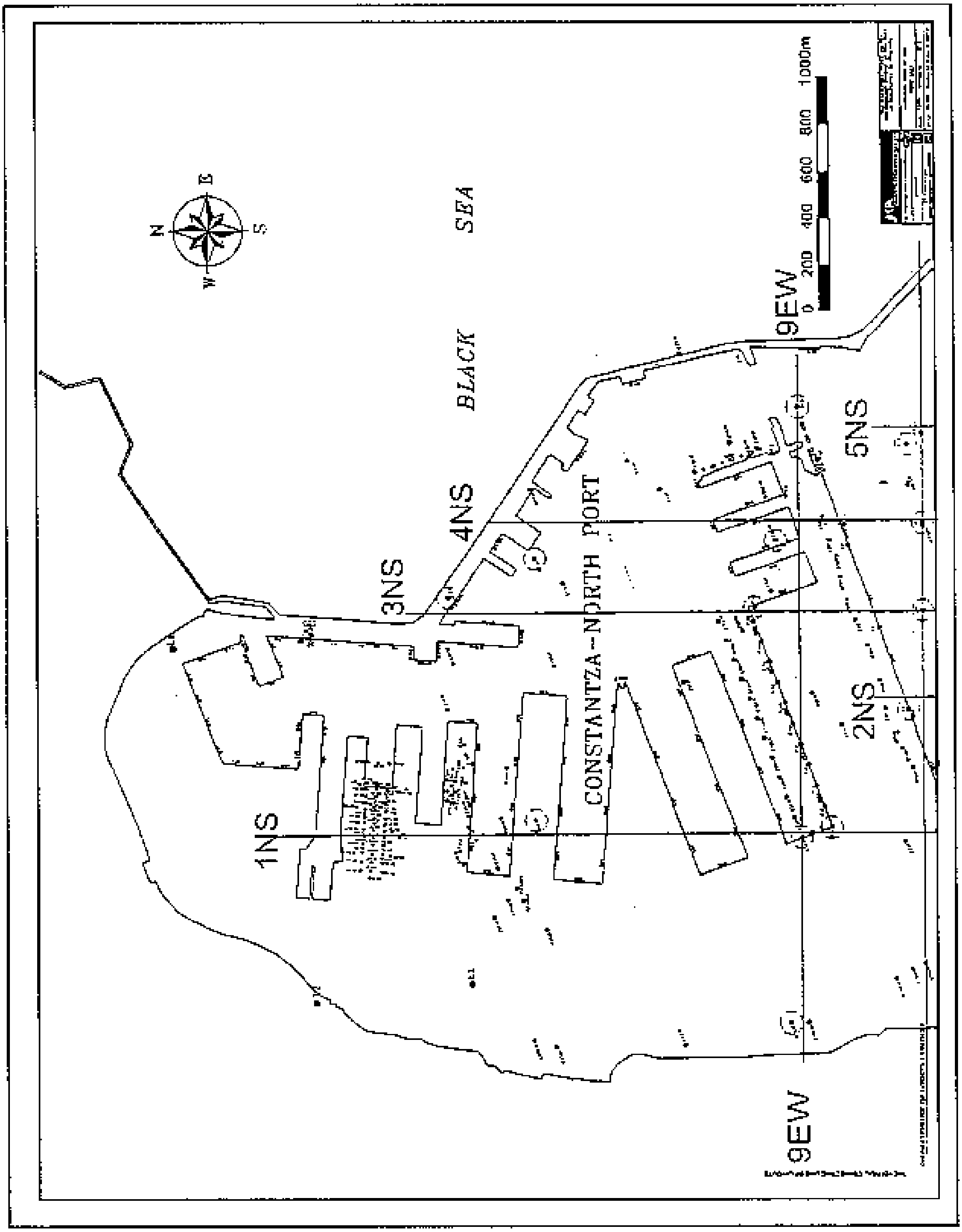


Figure 6.5.7 Location Plan of Previous Borings (1)

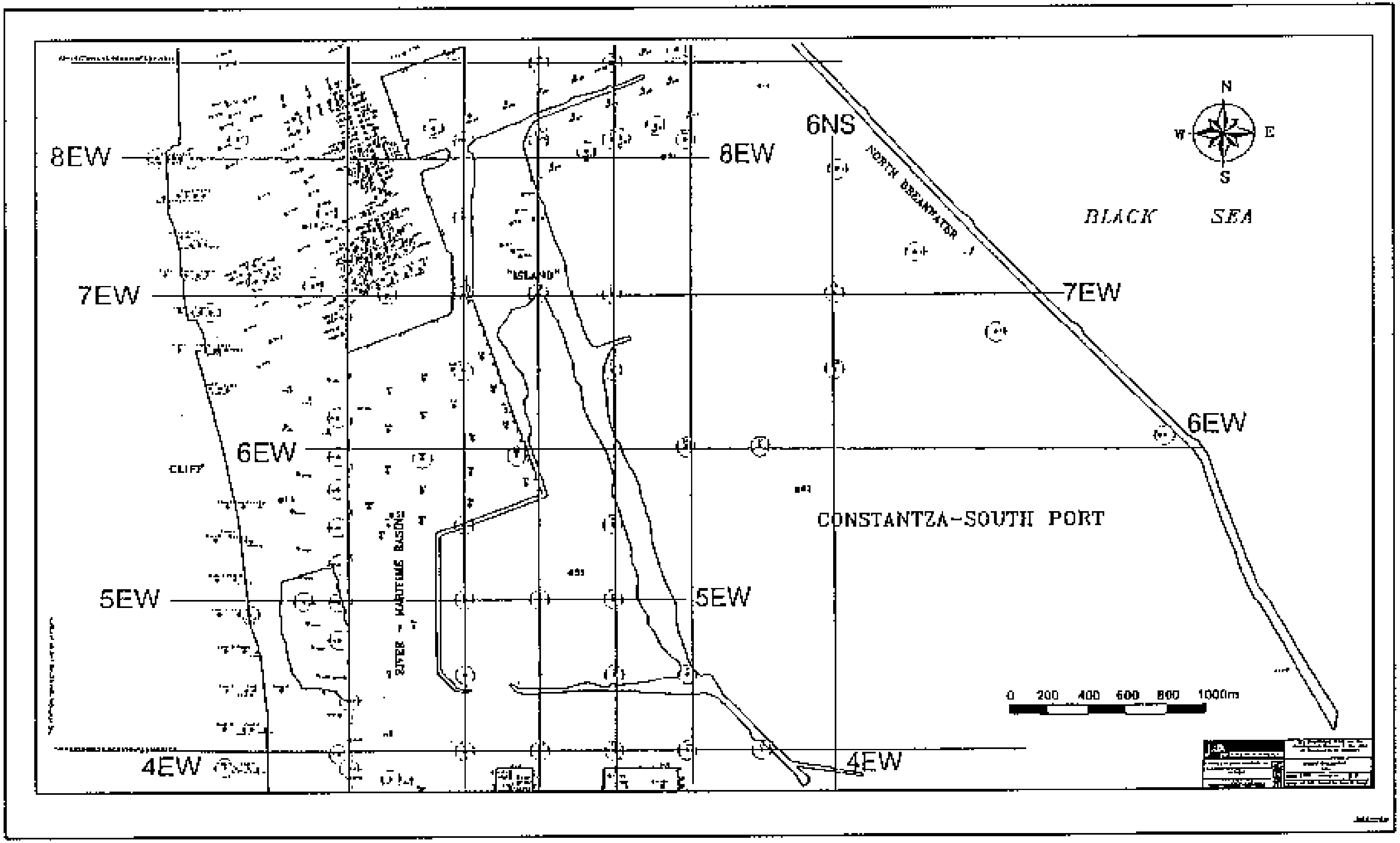


Figure 6.5.8 Location Plan of Previous Borings (2)

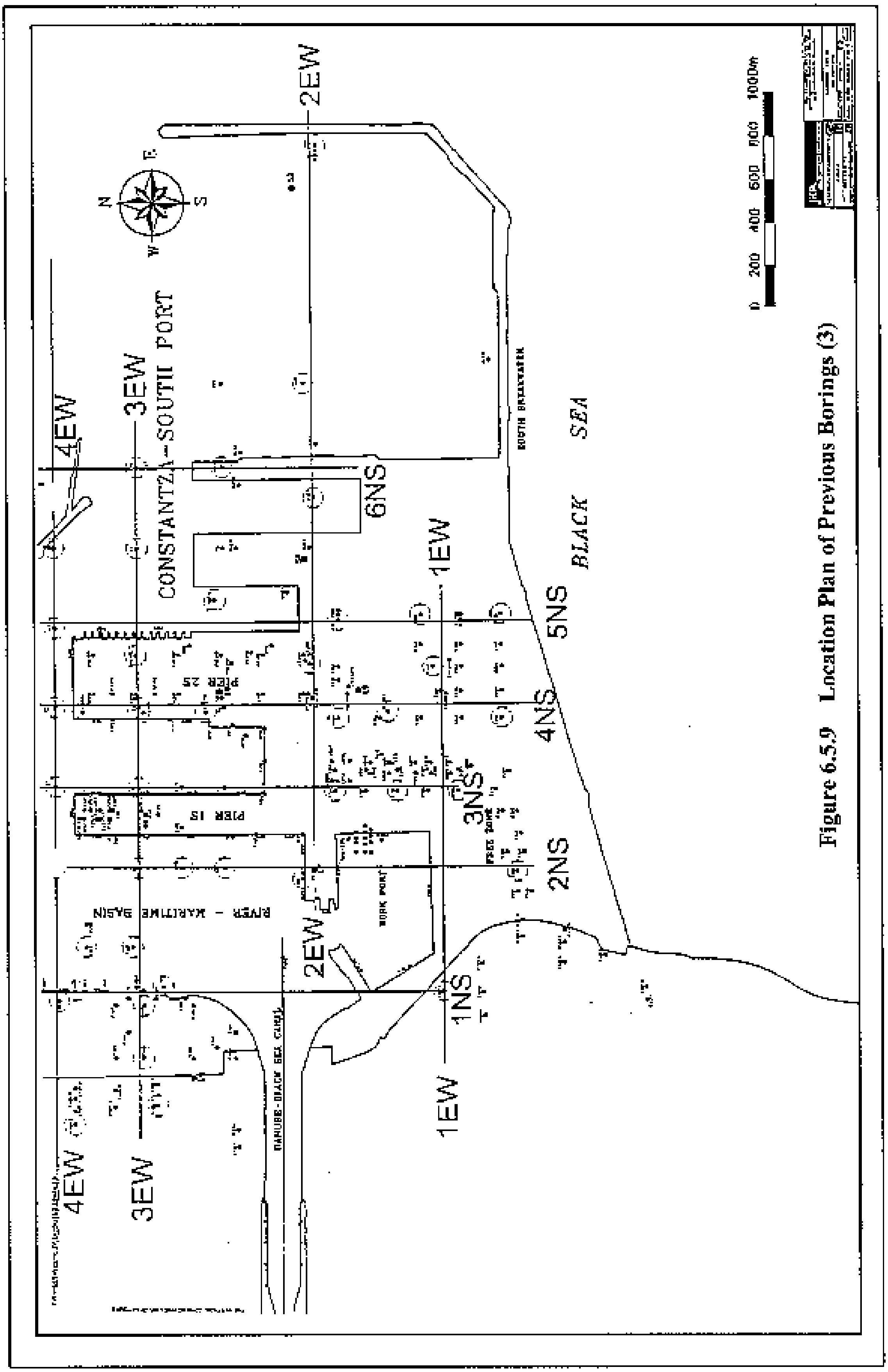


Figure 6.5.9 Location Plan of Previous Borings (3)

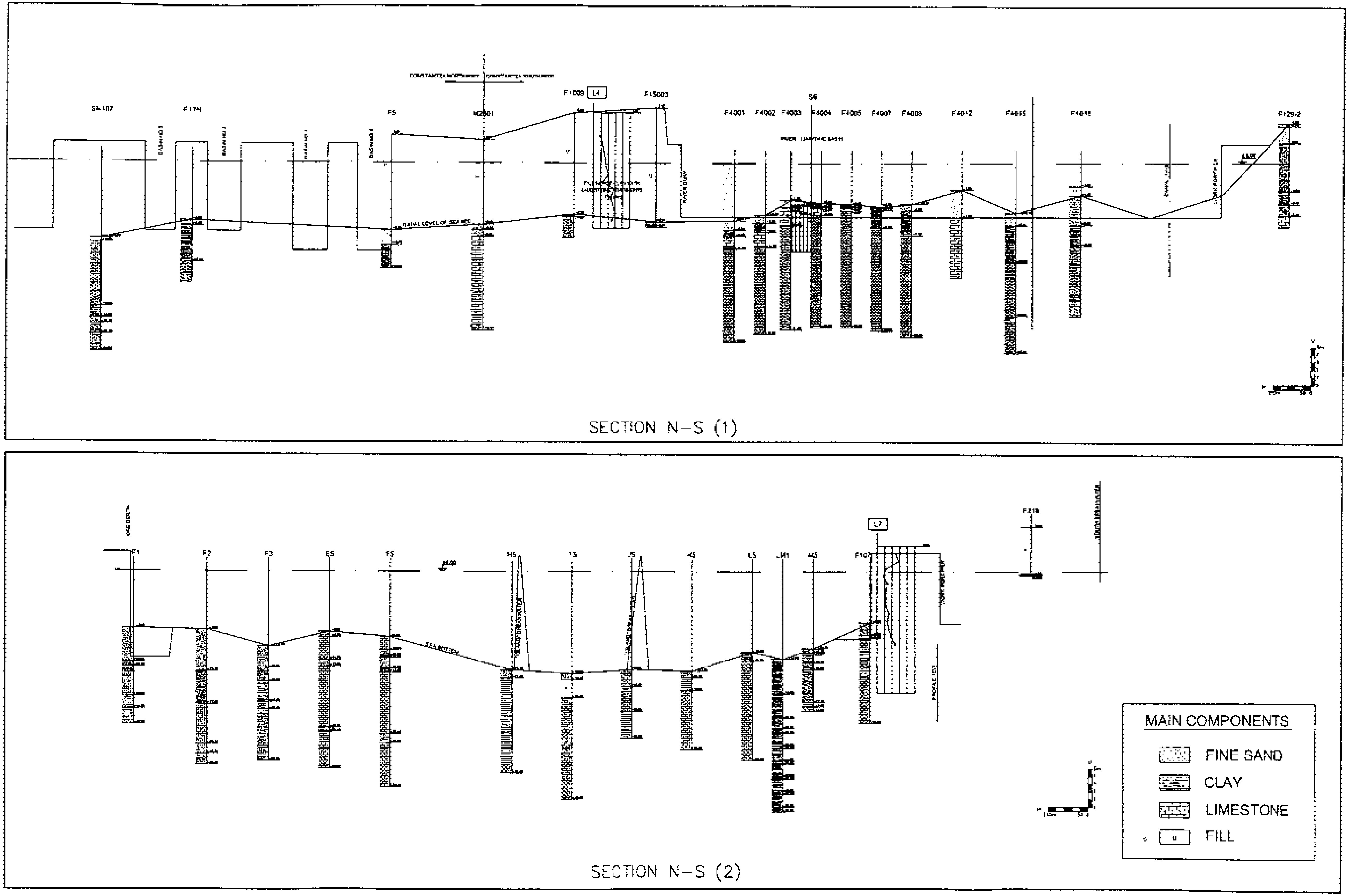


Figure 6.5.10 Soil Profile N–S (1) and (2)

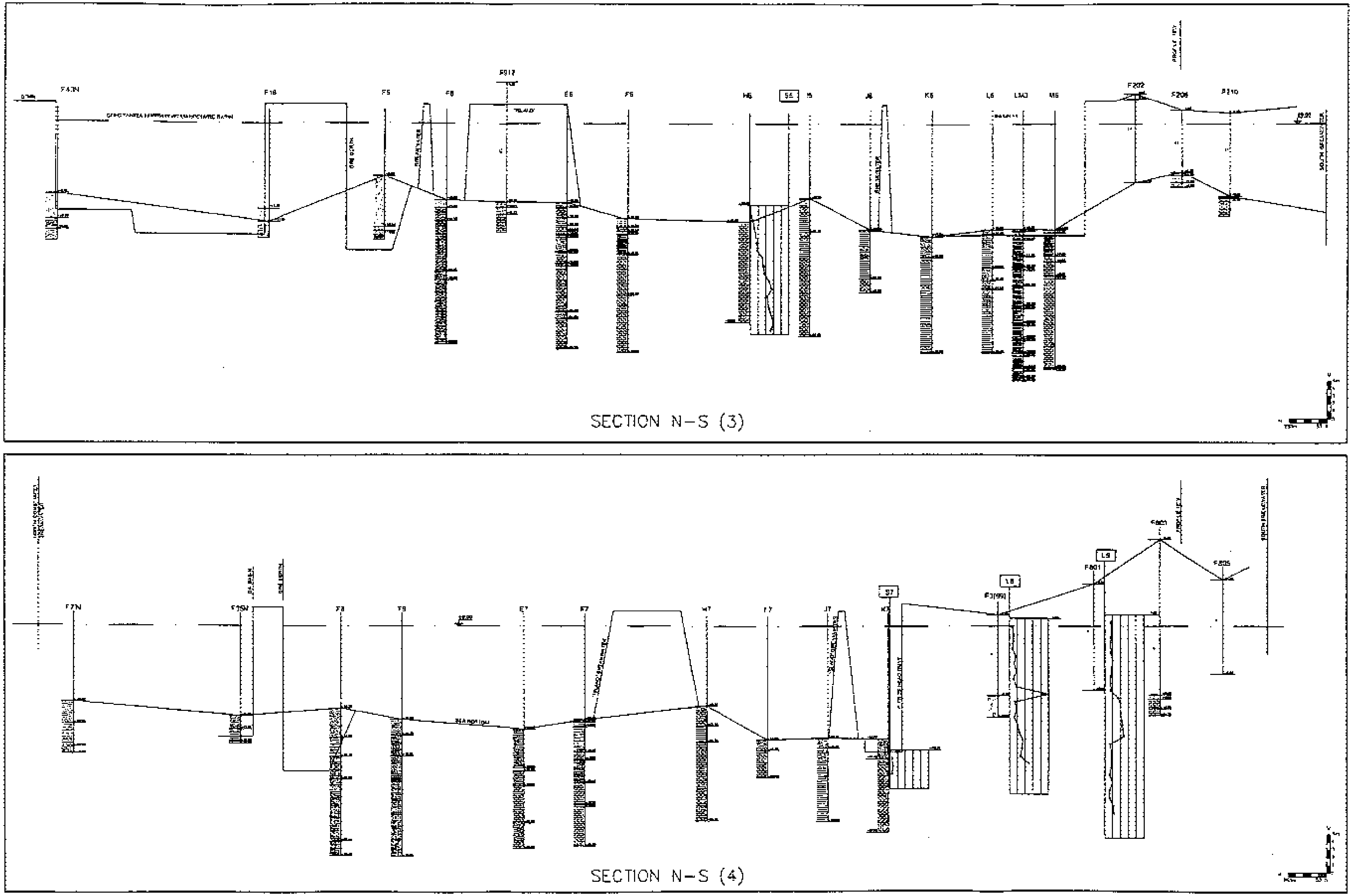
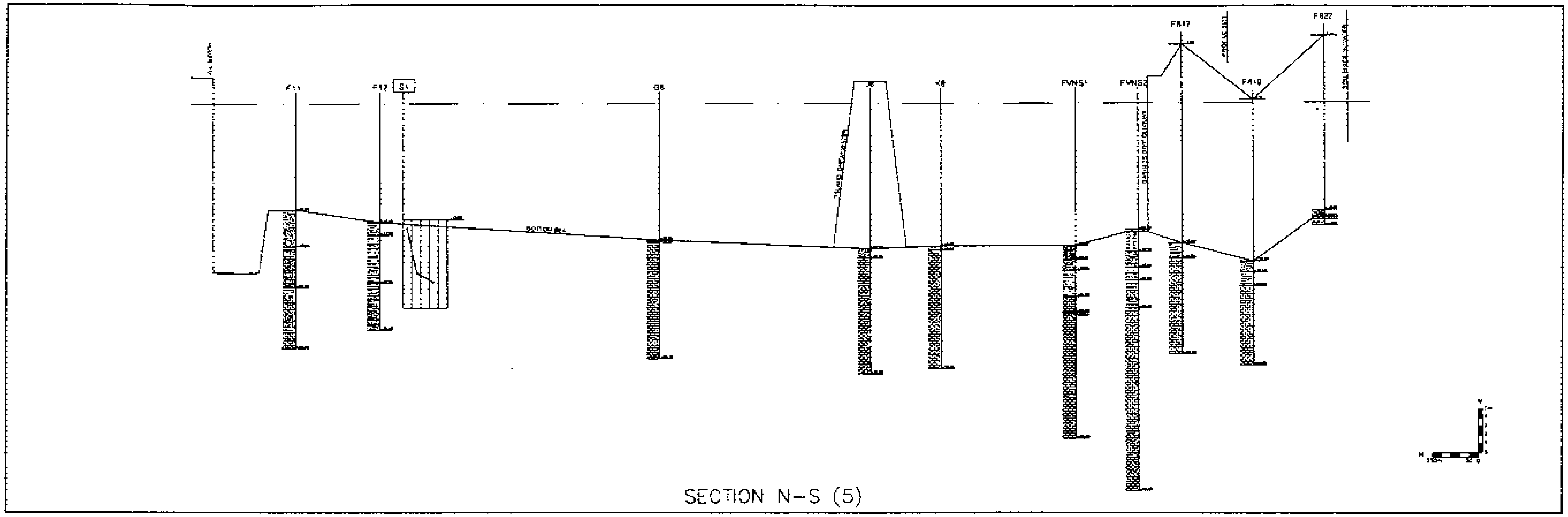


Figure 6.5.11 Soil Profile N–S (3) and (4)



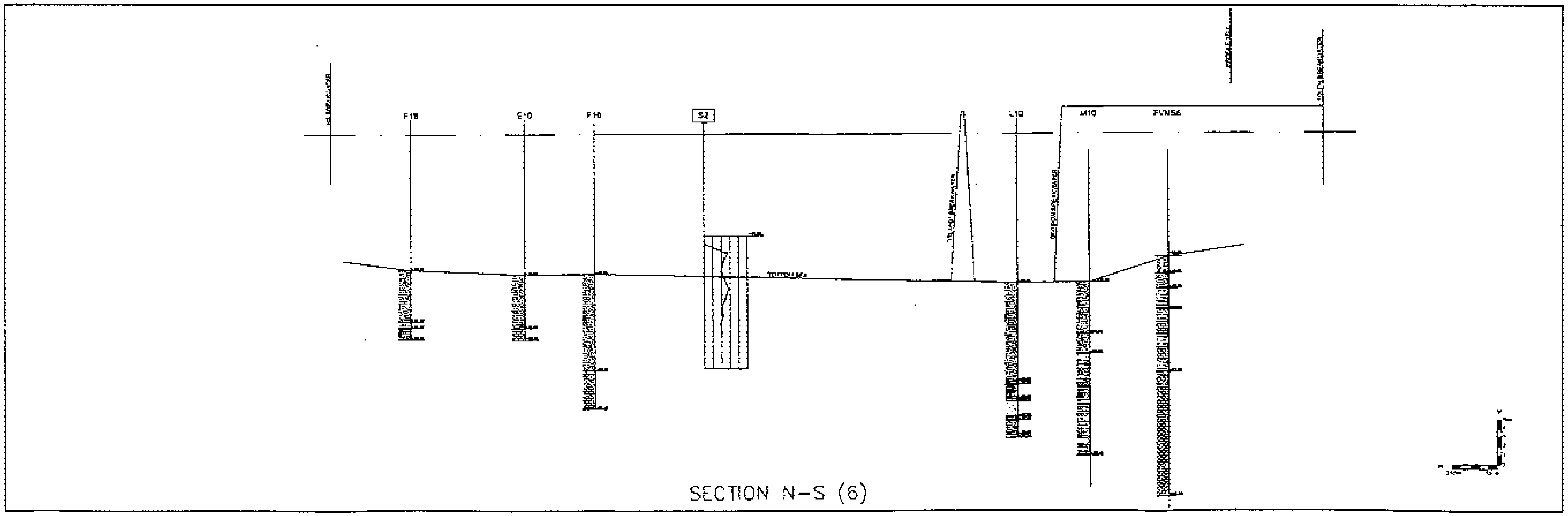


Figure 6.5.12 Soil Profile N–S (5) and (6)

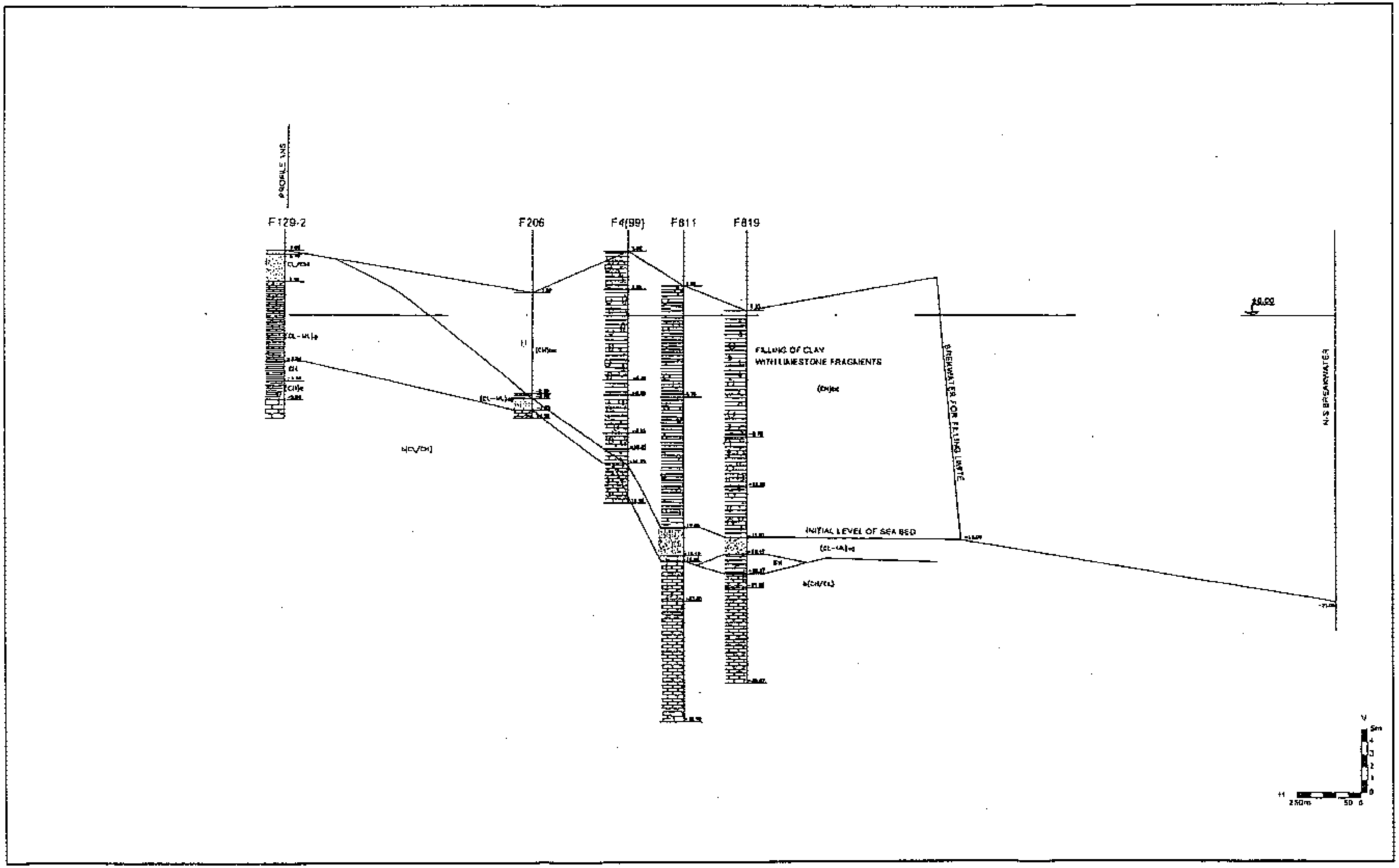


Figure 6.5.13 Soil Profile E-W (1)

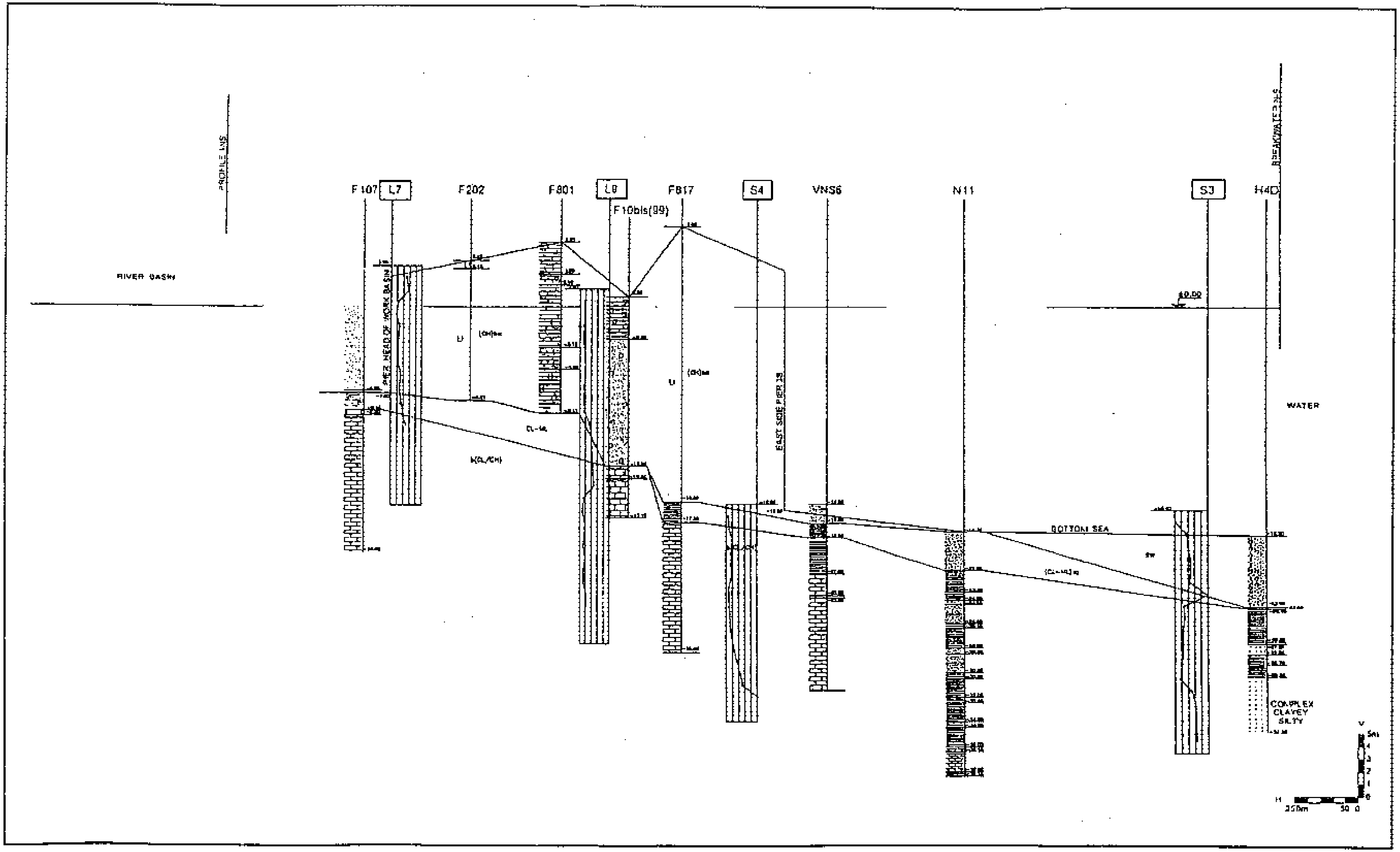


Figure 6.5.14 Soil Profile E-W (2)

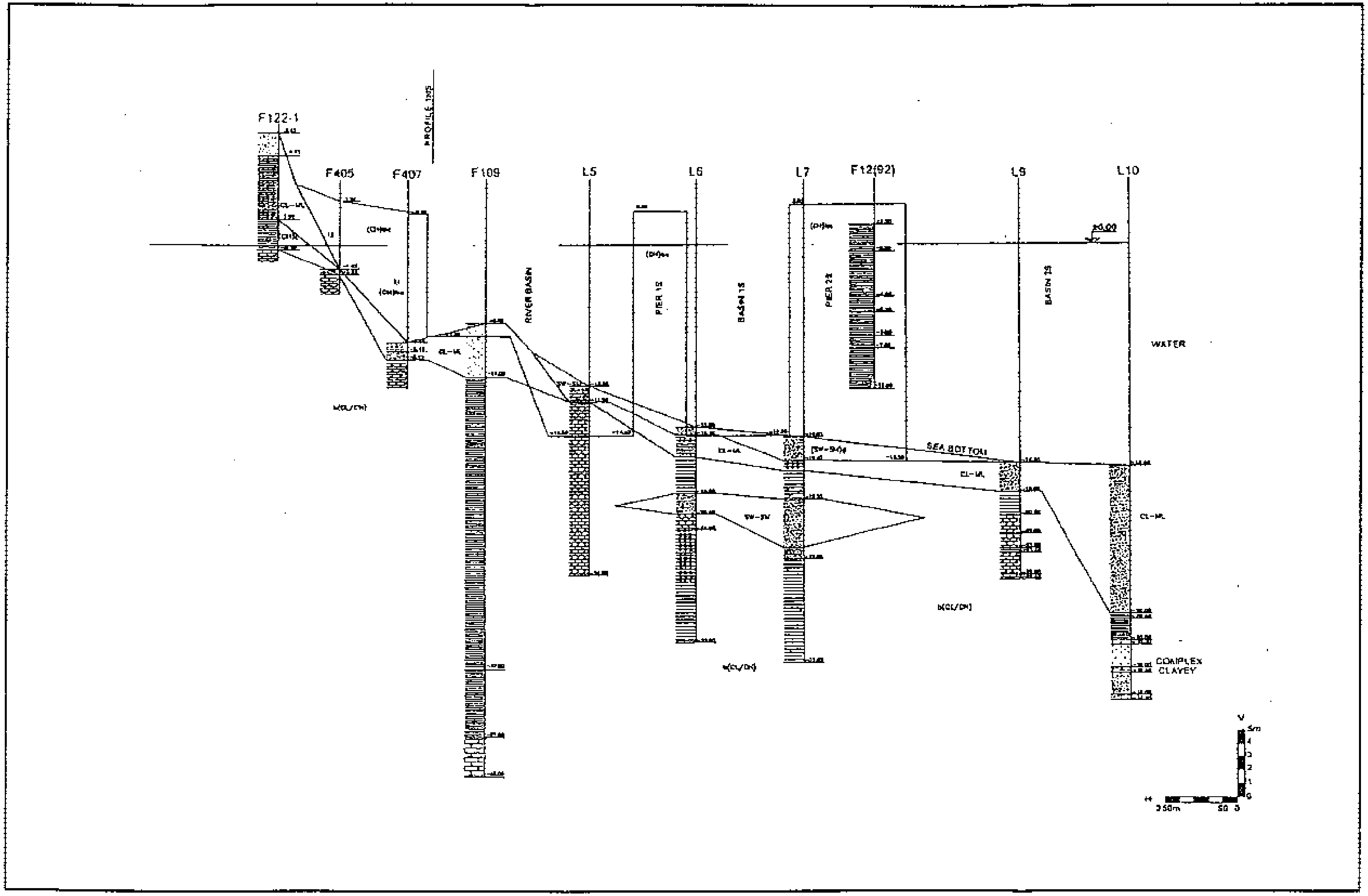


Figure 6.5.15 Soil Profile E-W (3)

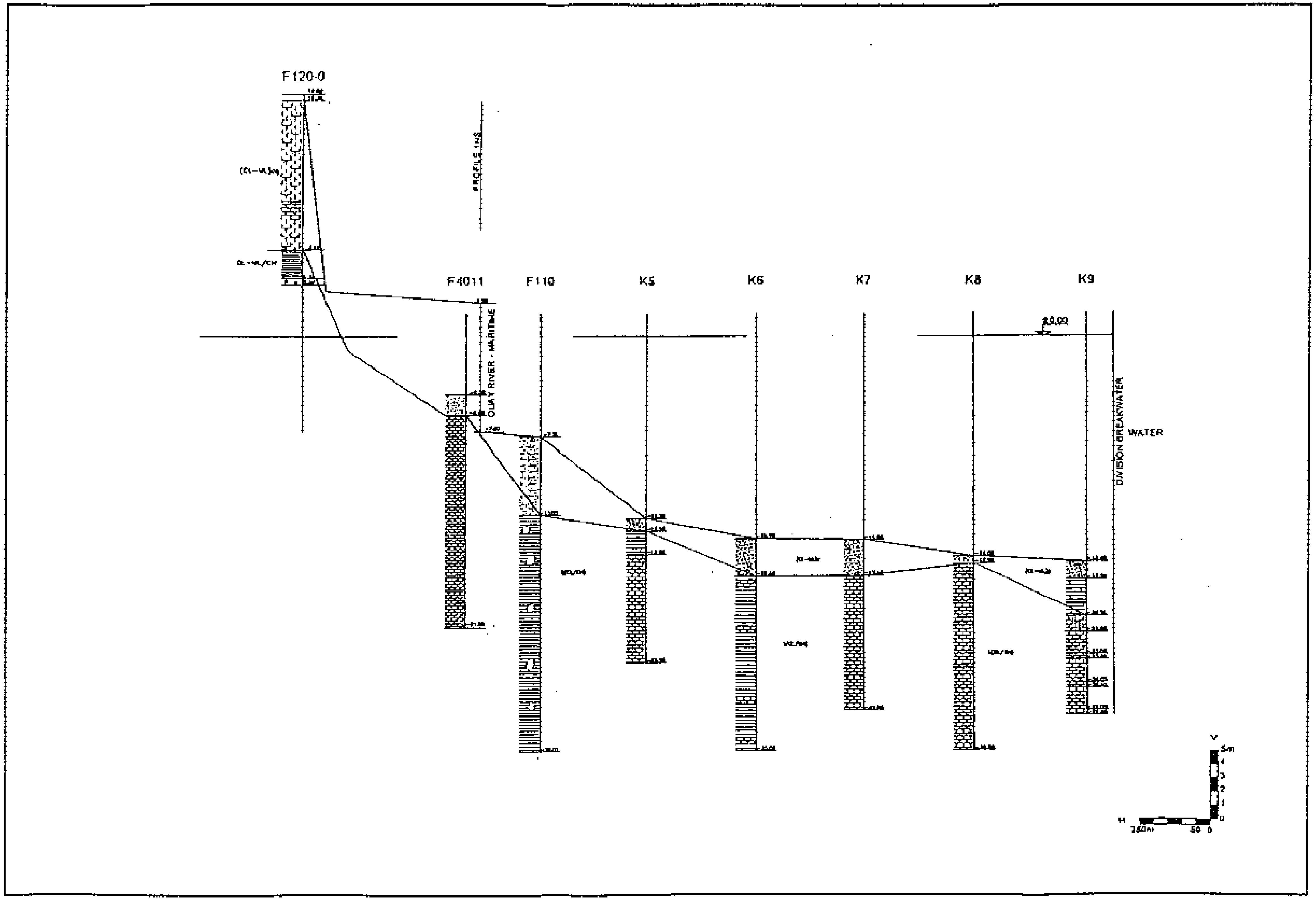


Figure 6.5.16 Soil Profile E-W (4)

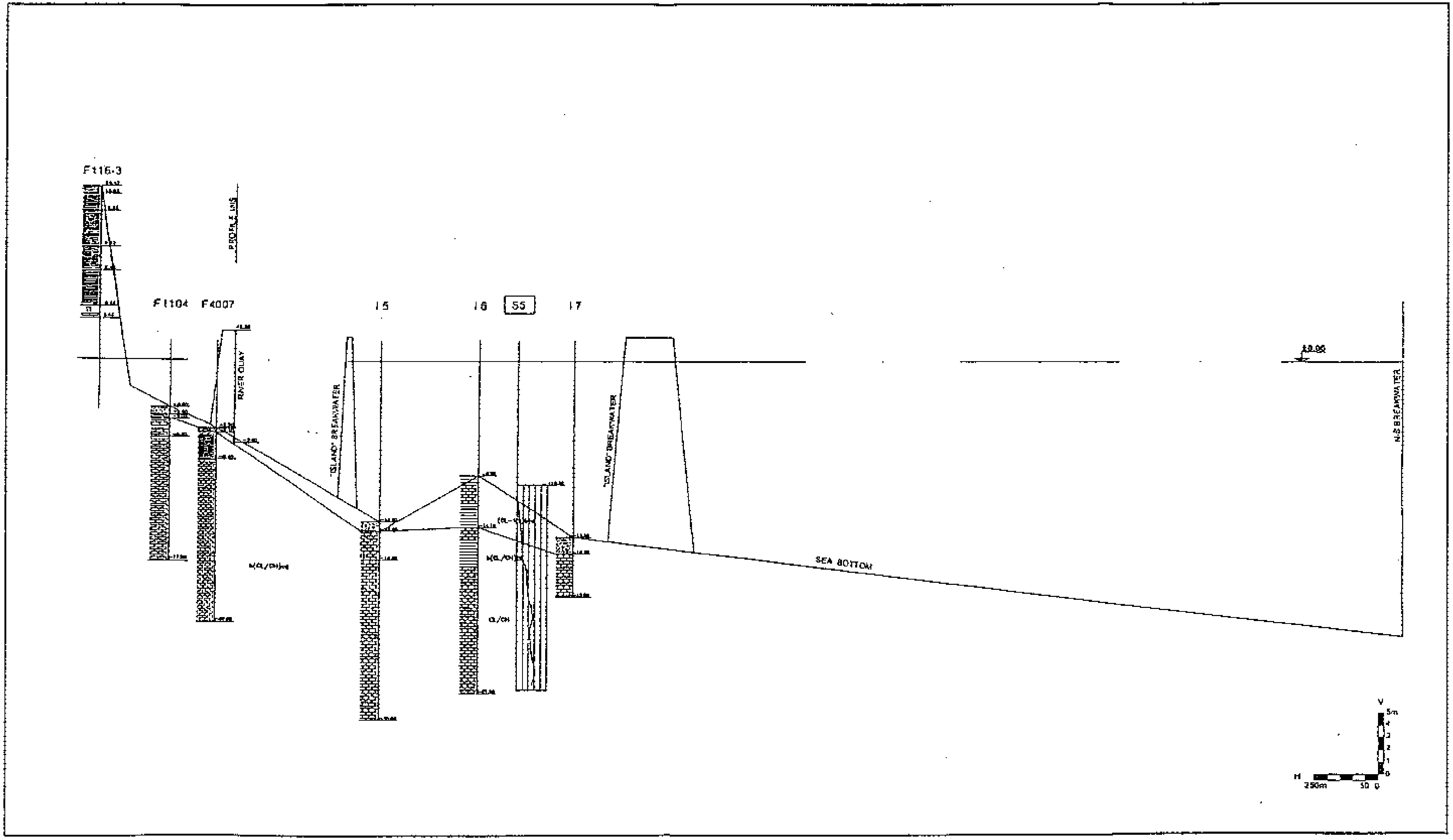


Figure 6.5.17 Soil Profile E-W (5)

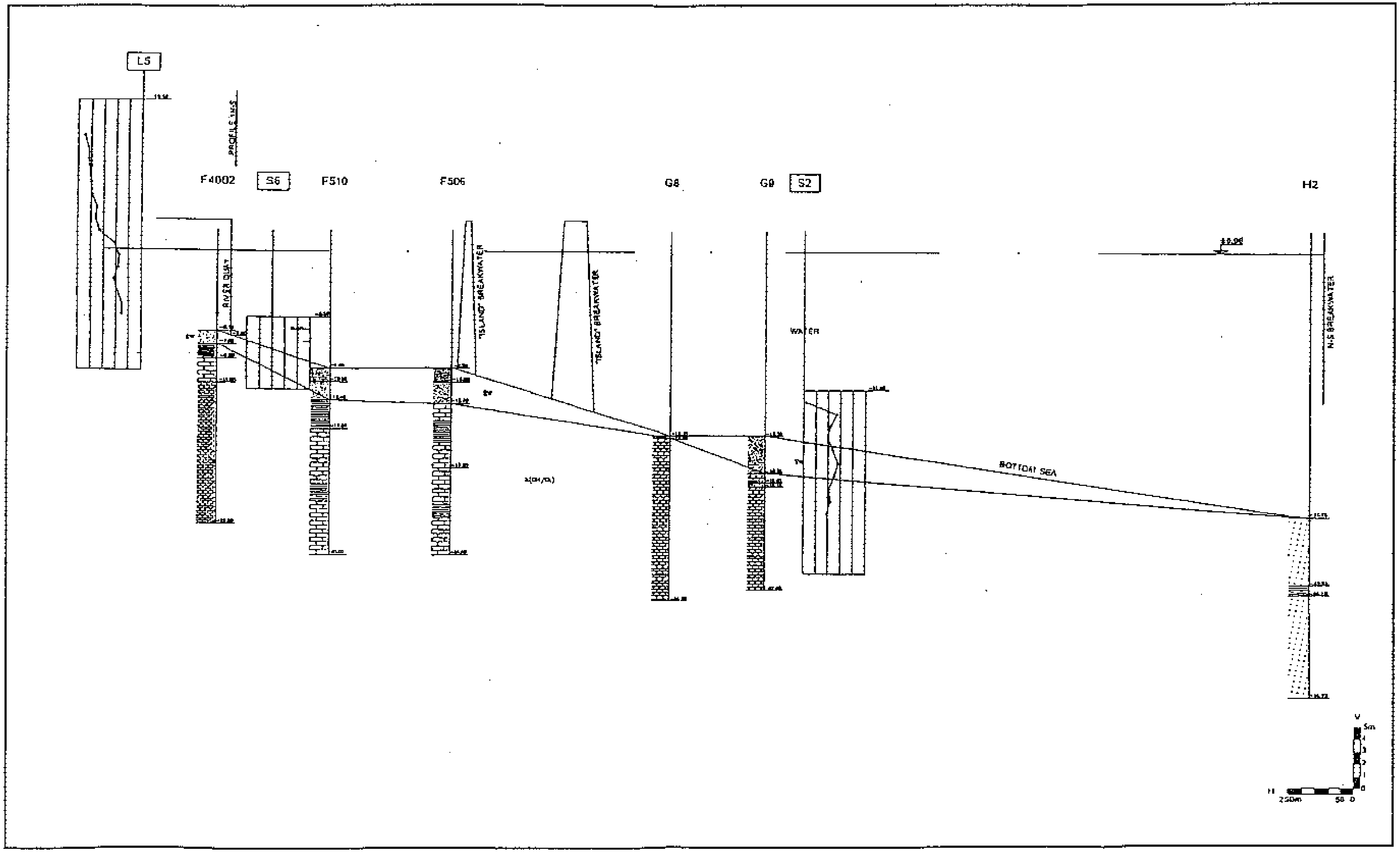


Figure 6.5.18 Soil Profile E-W (6)

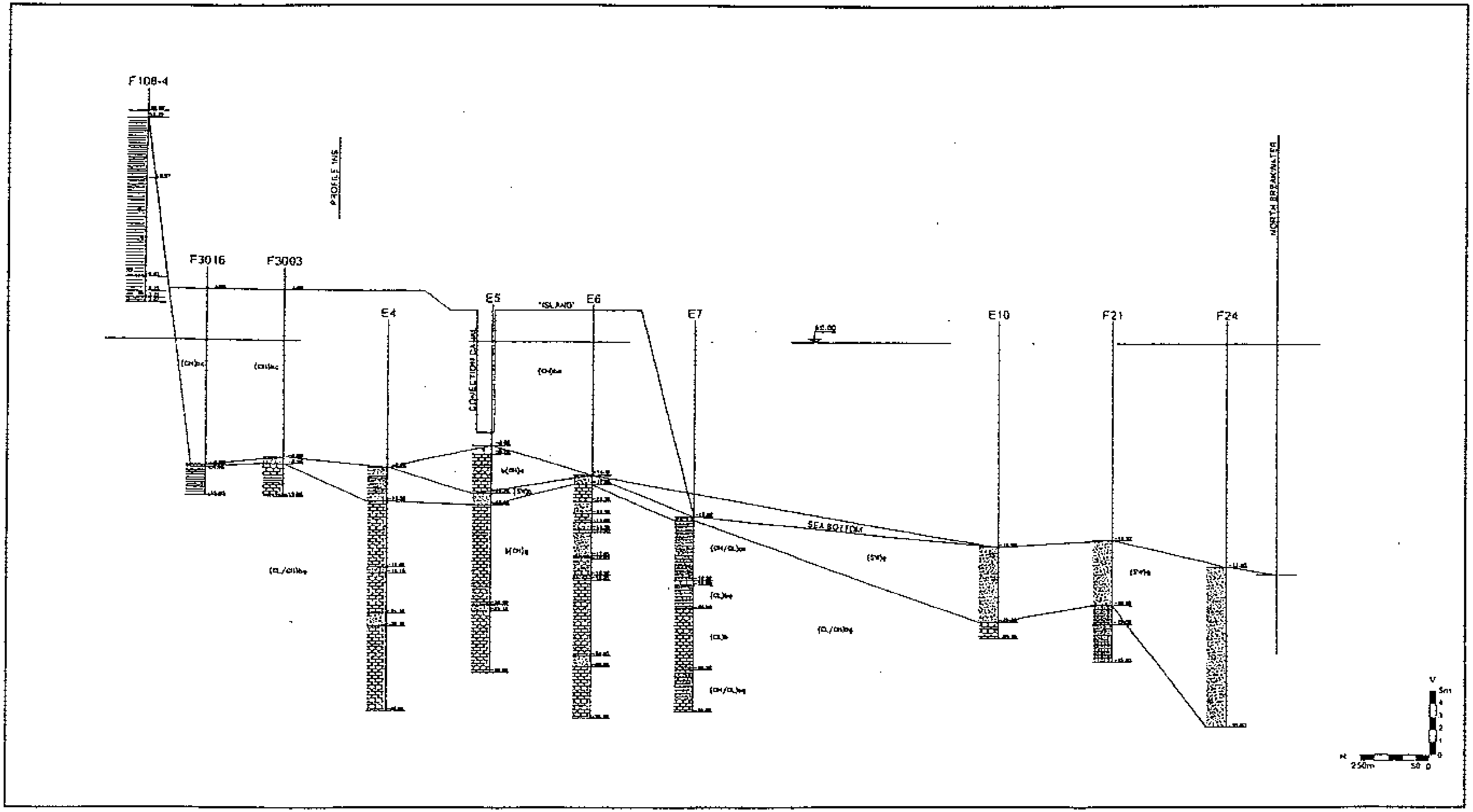


Figure 6.5.19 Soil Profile E-W (7)

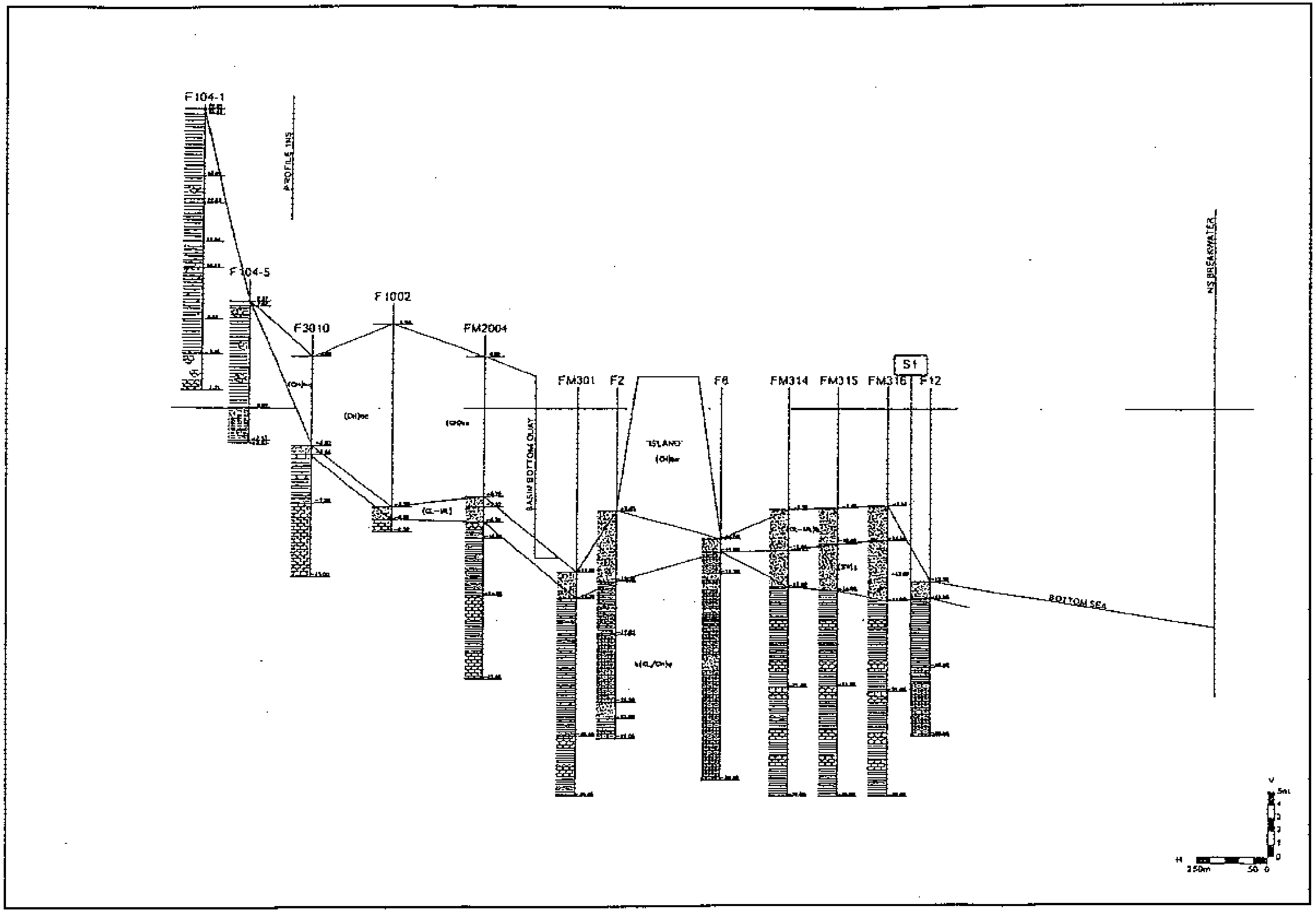


Figure 6.5.20 Soil Profile E-W (8)

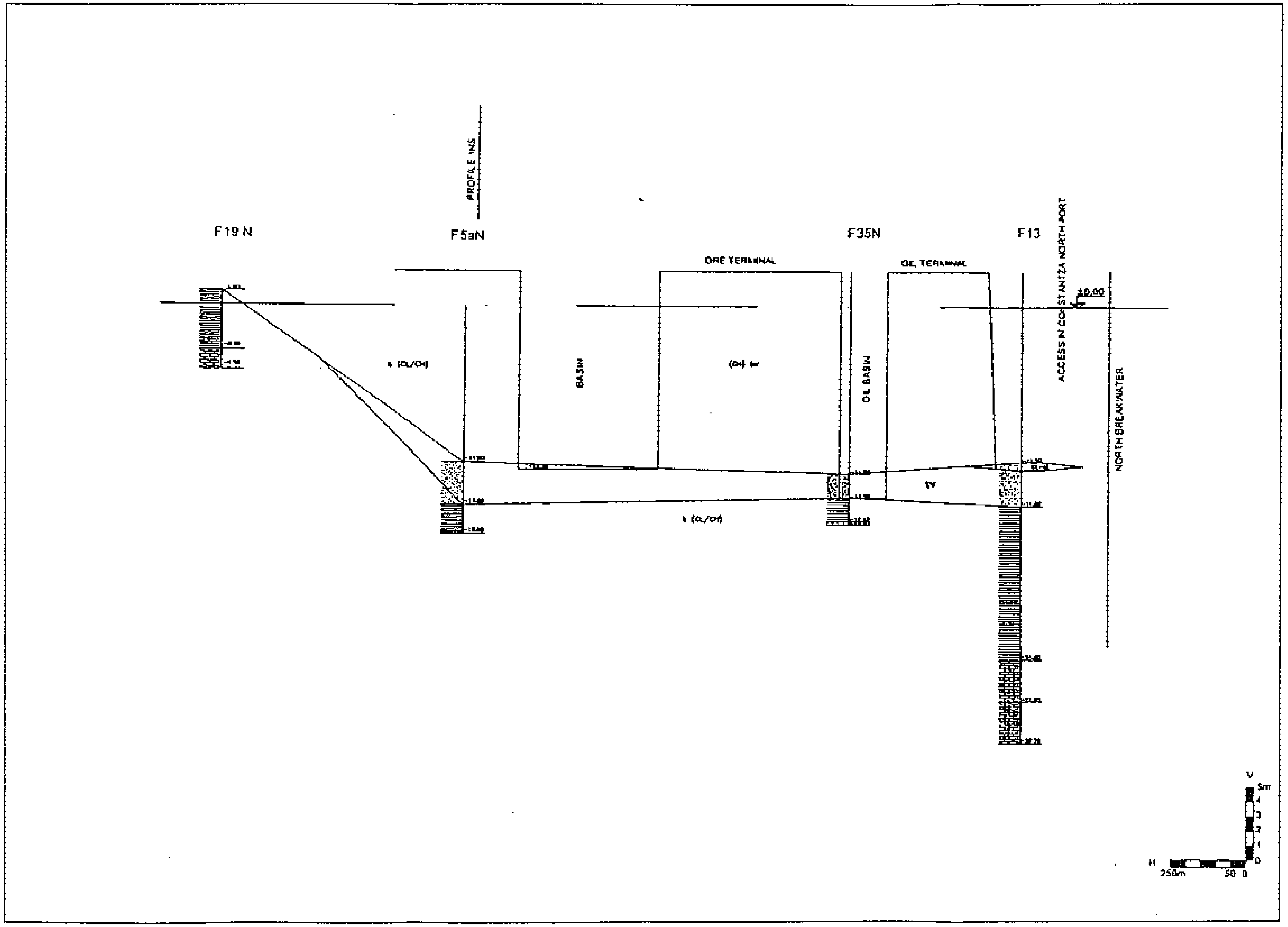
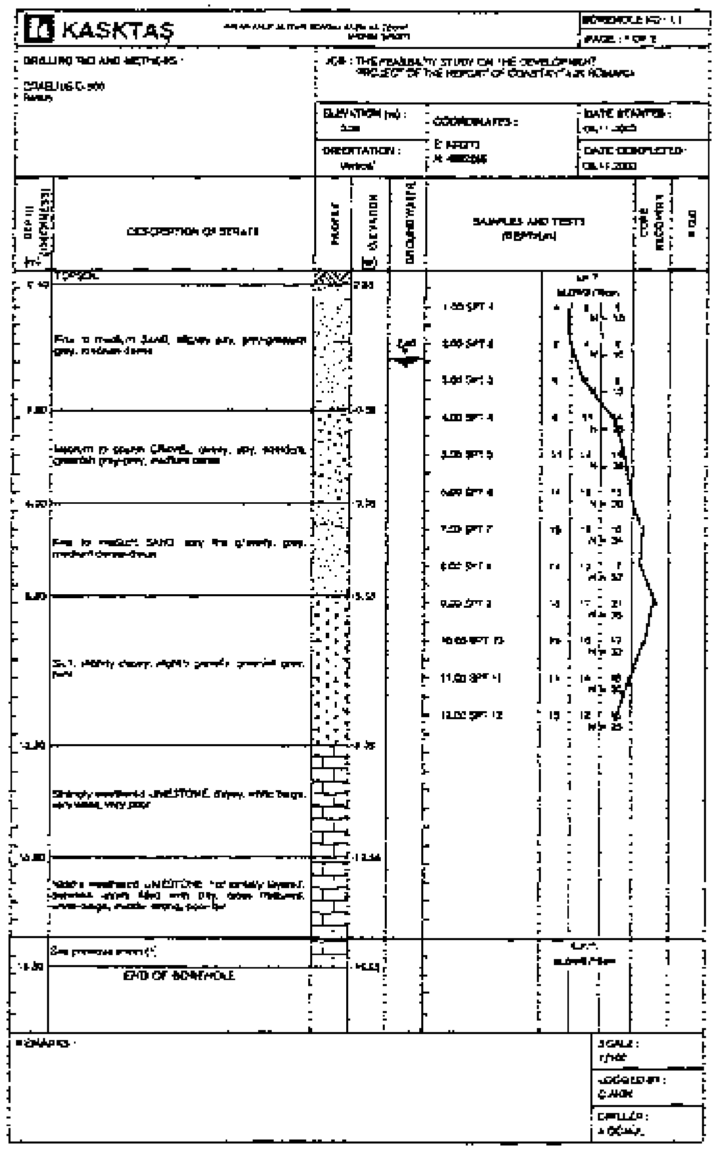
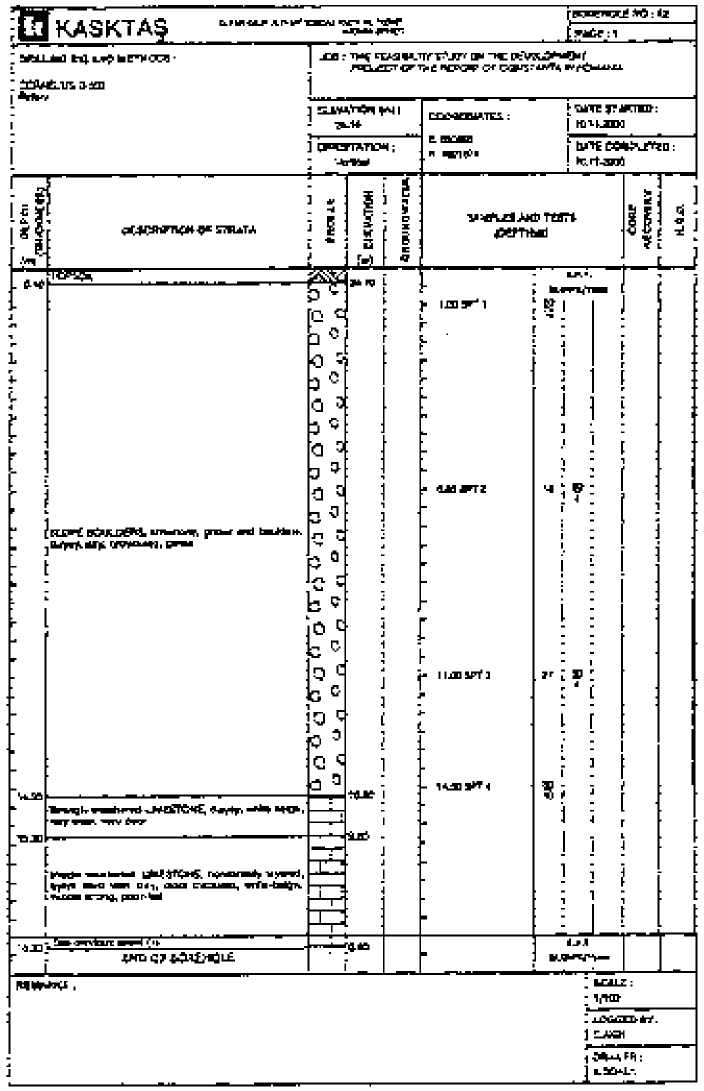


Figure 6.5.21 Soil Profile E-W (9)

L1



L2



L3

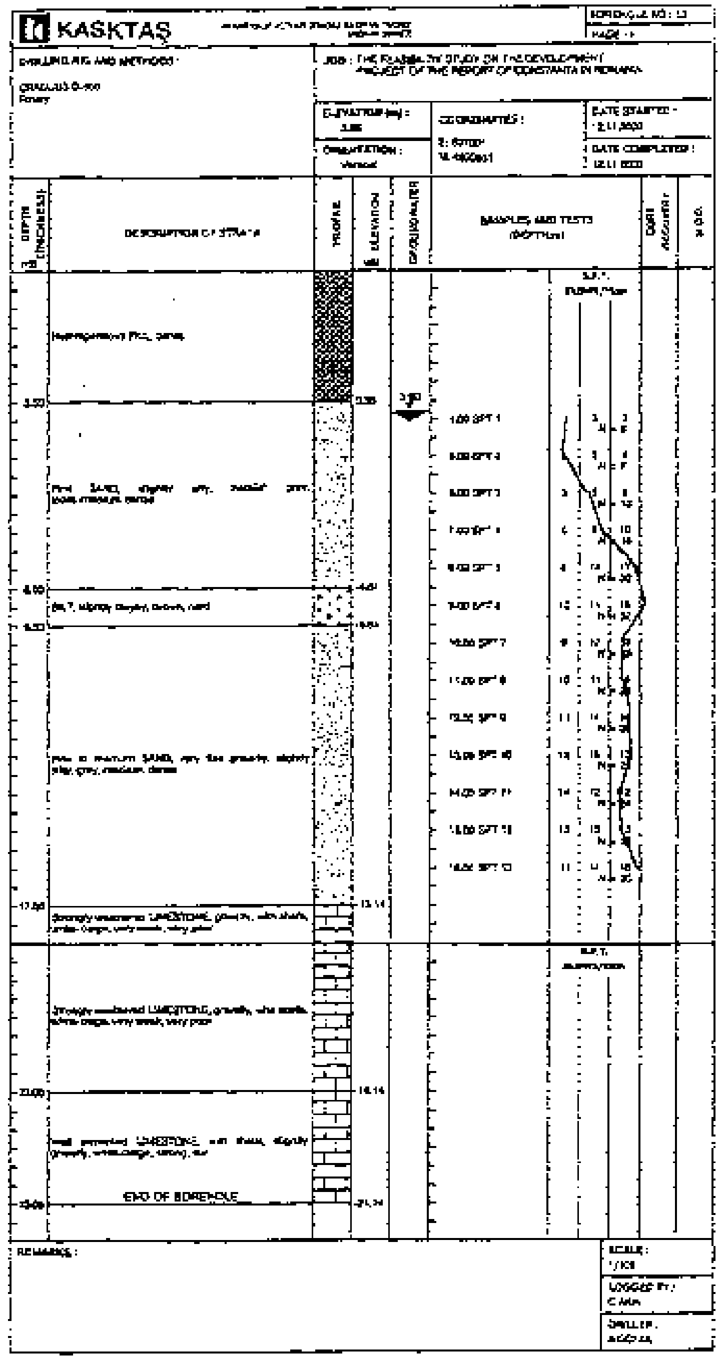
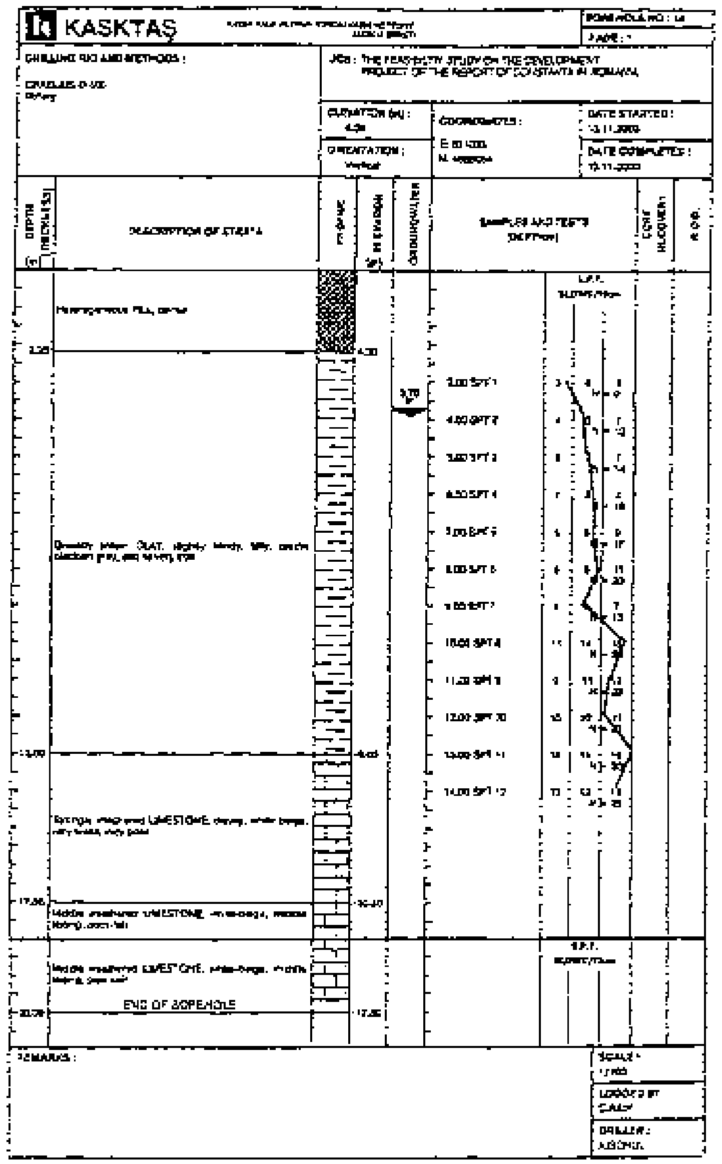
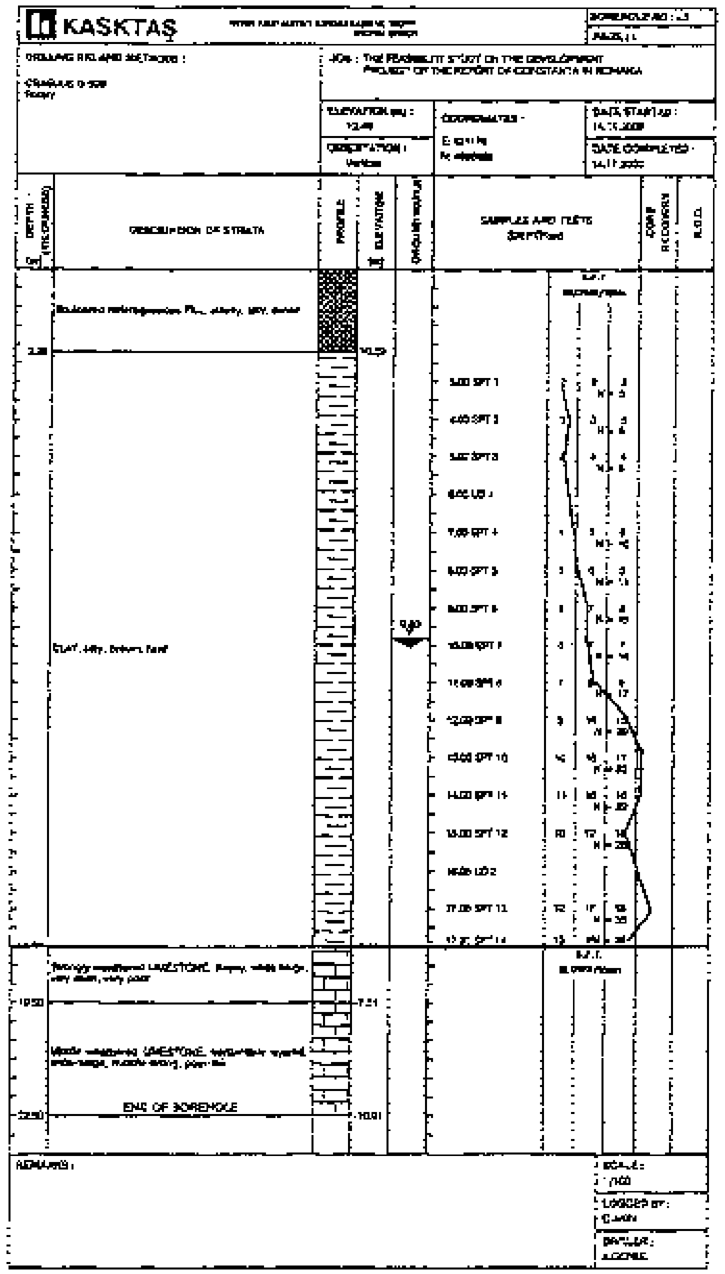


Figure 6.5.22 Boring logs L1 – L3

L4



L5



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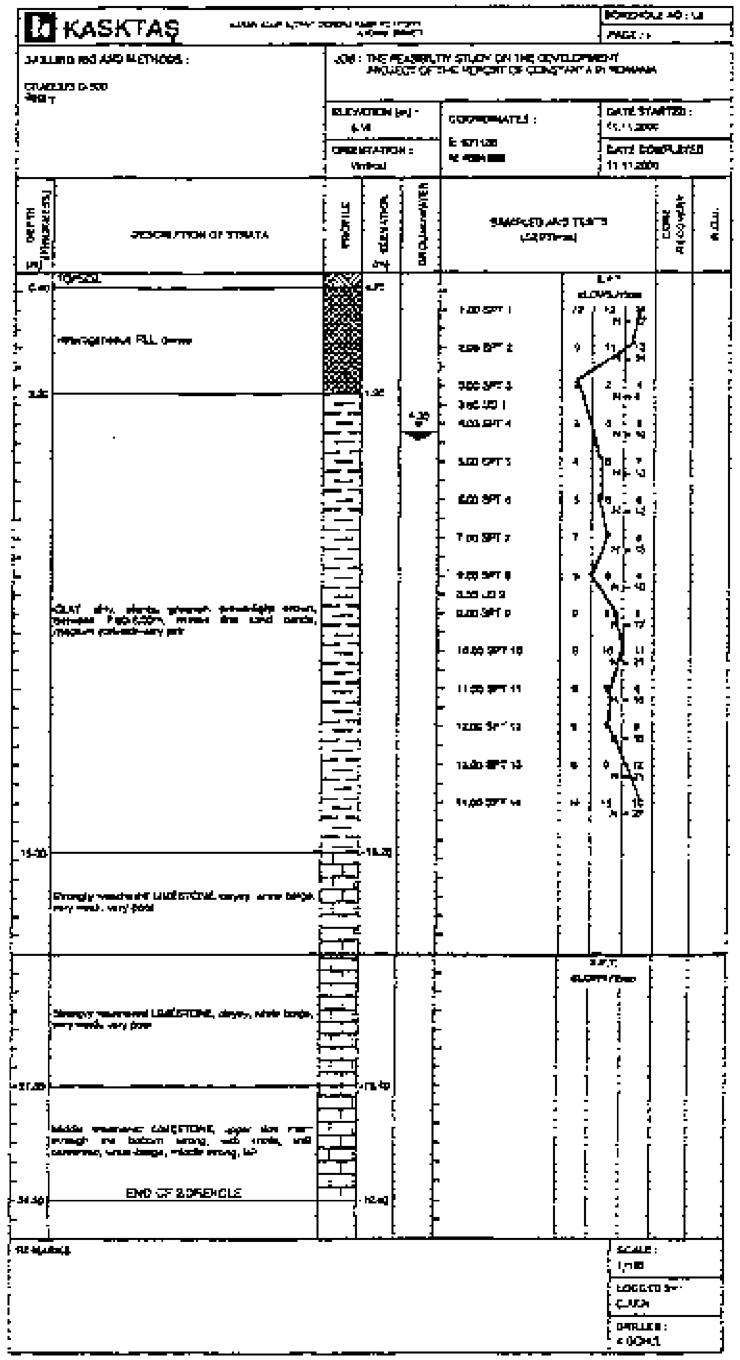
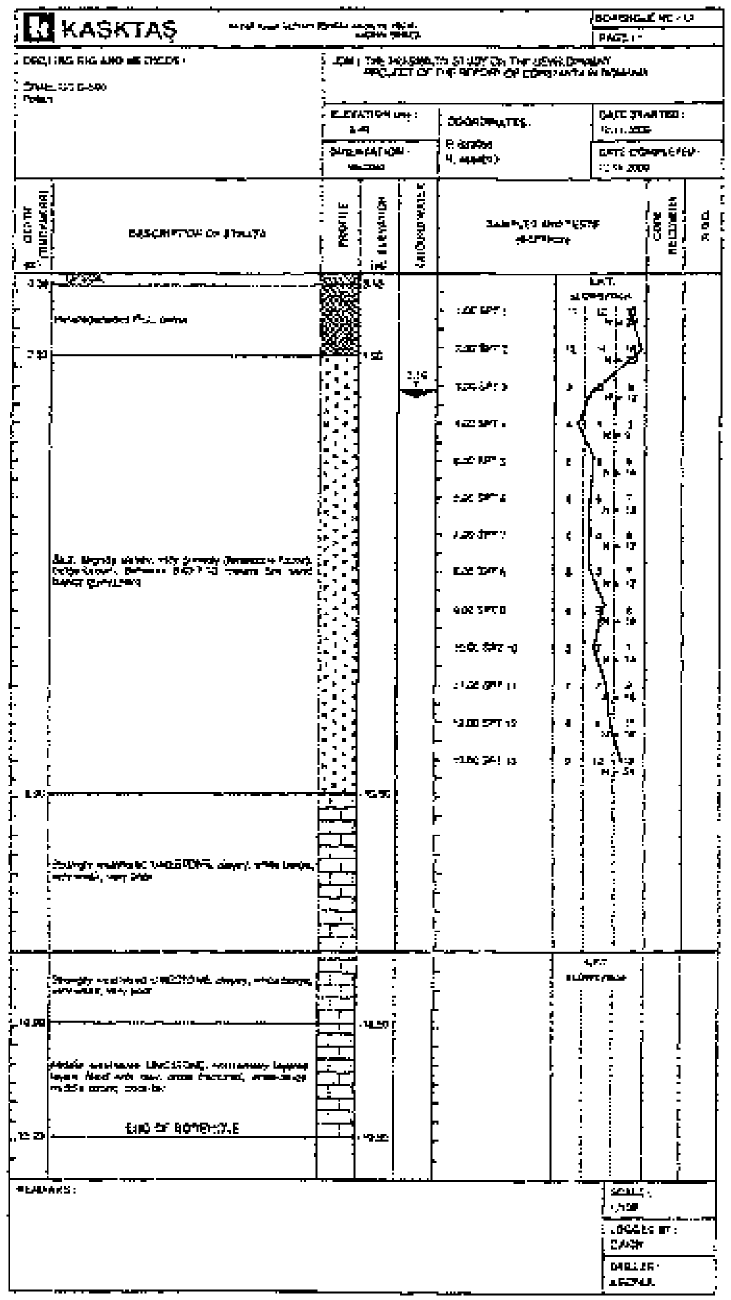
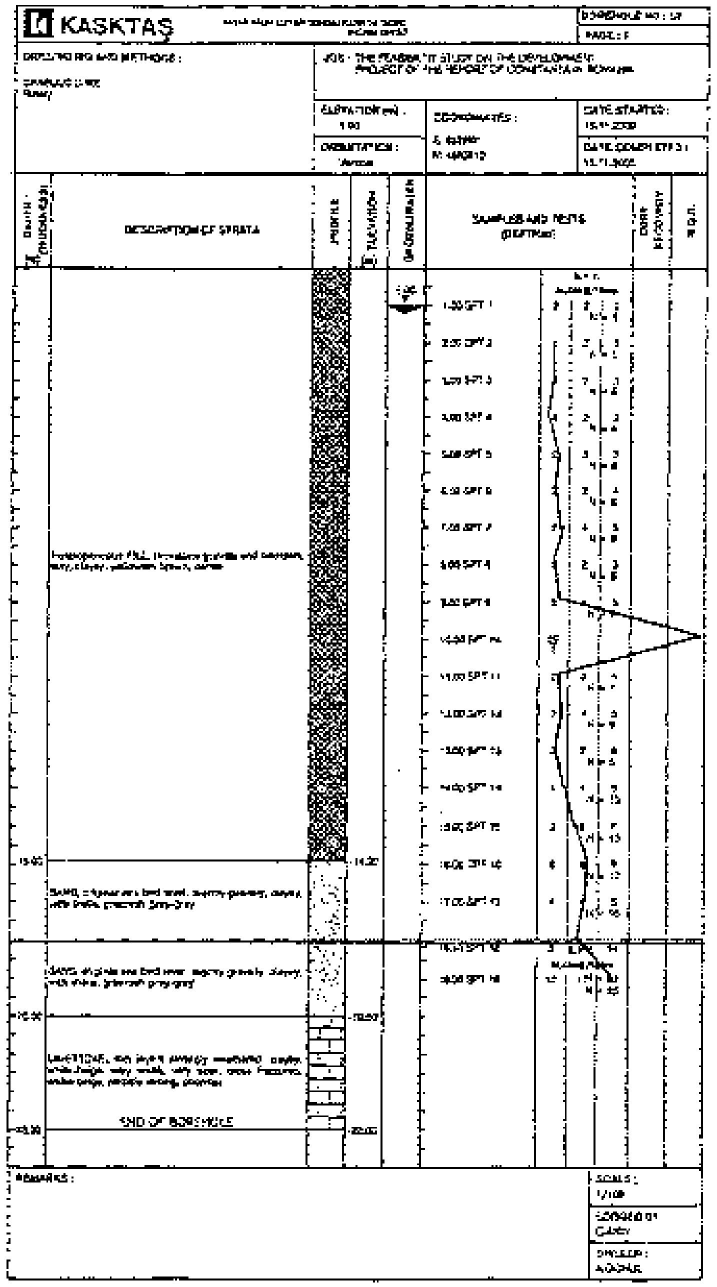


Figure 6.5.23 Boring logs L4 – L6

L7



L8



L9

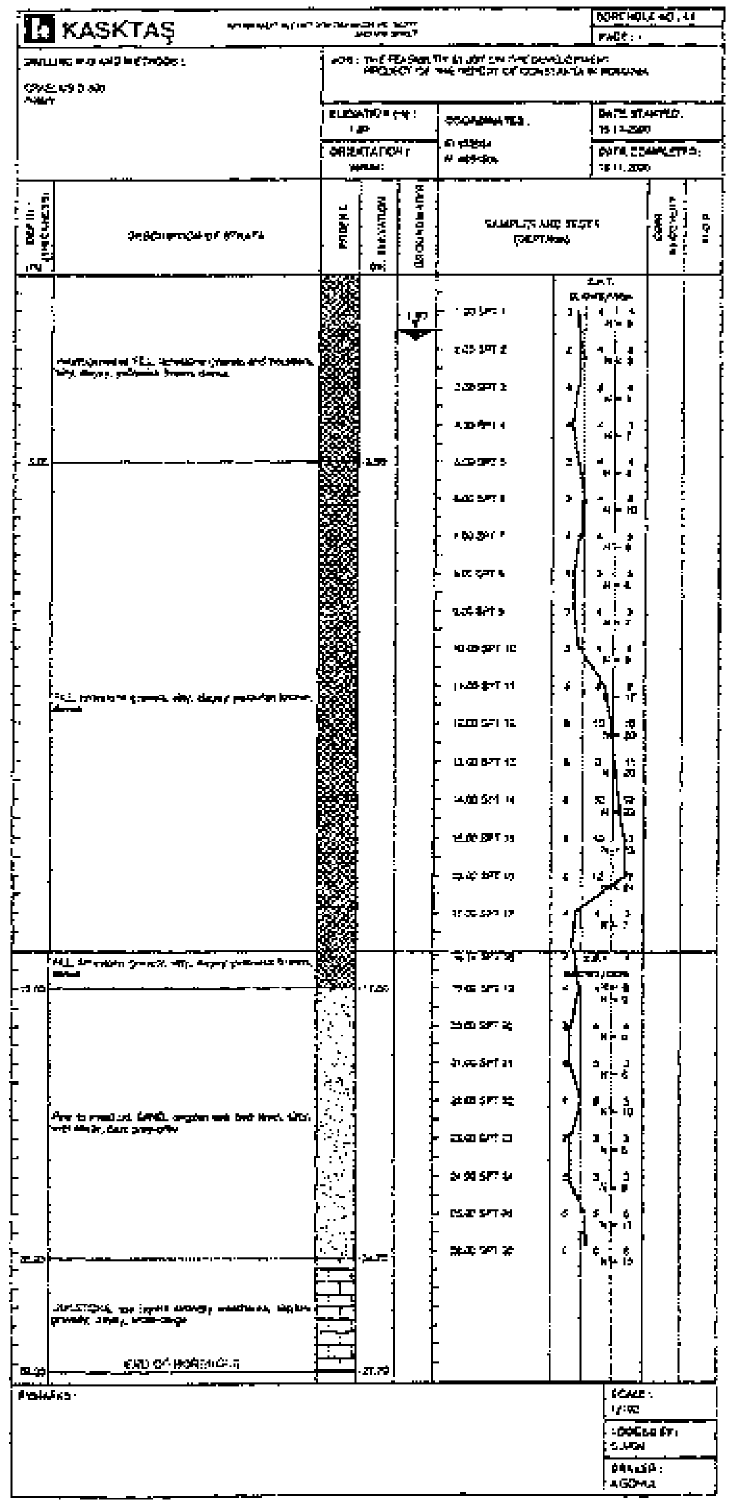
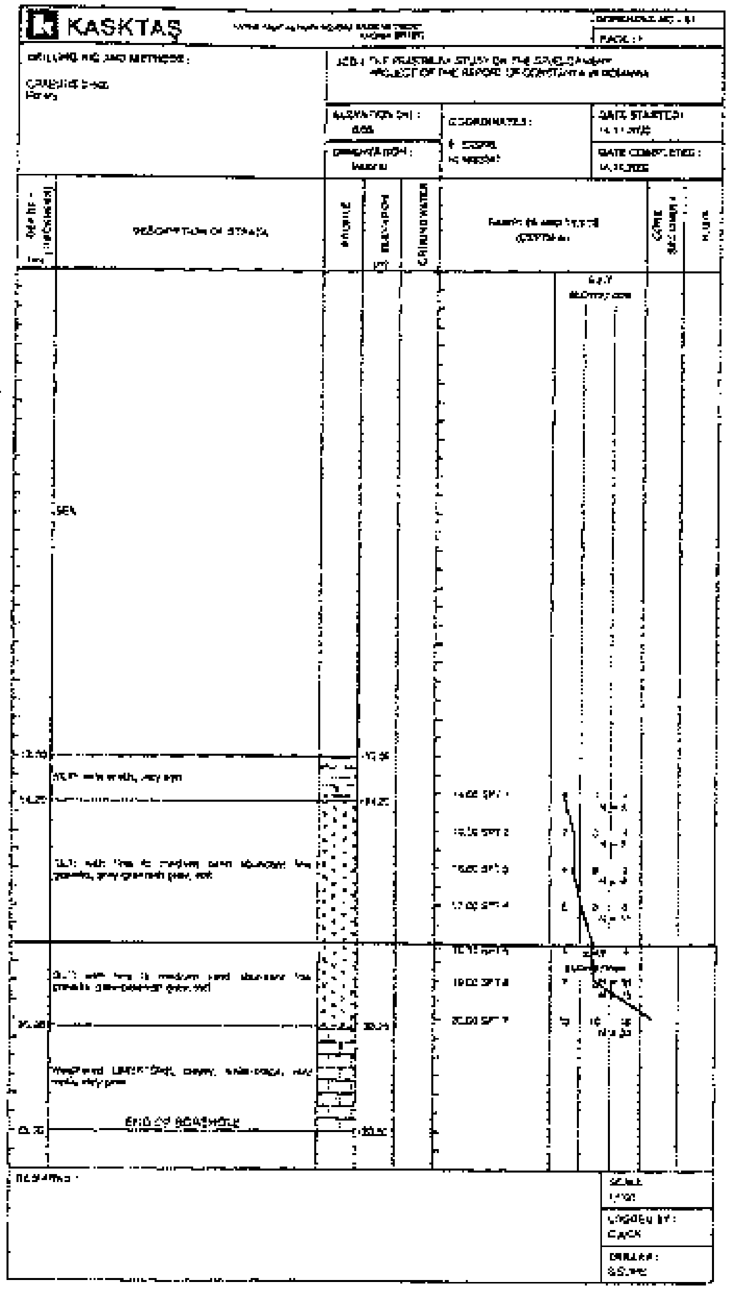
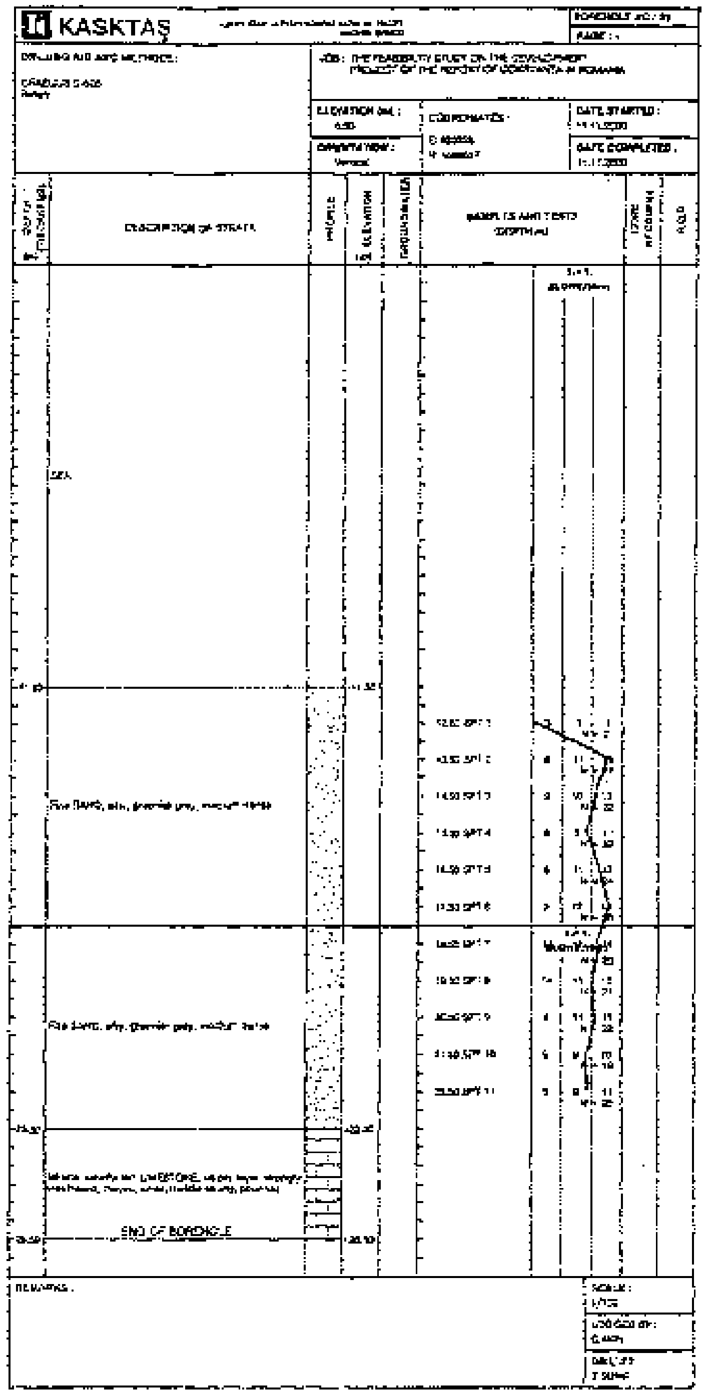


Figure 6.5.24 Boring logs L7 – L9

S1



S2



S3

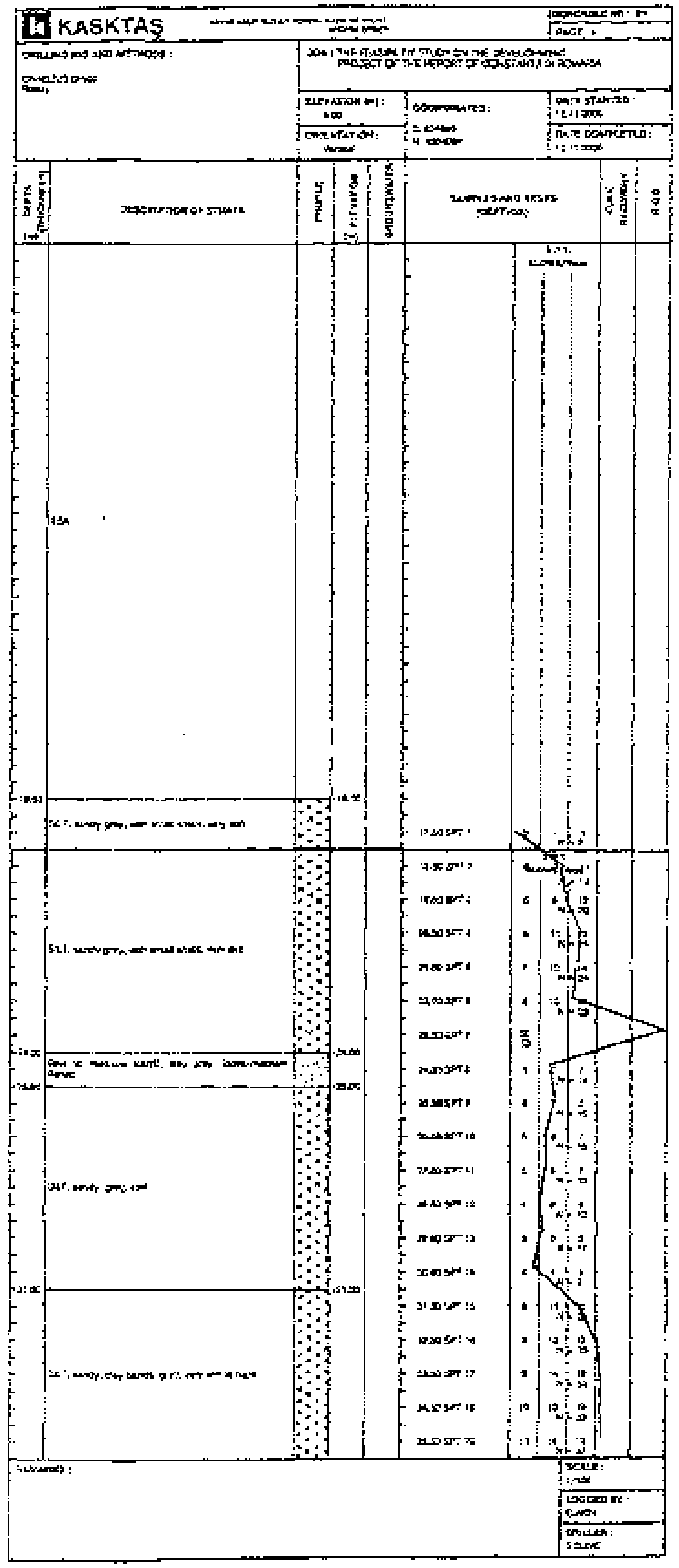
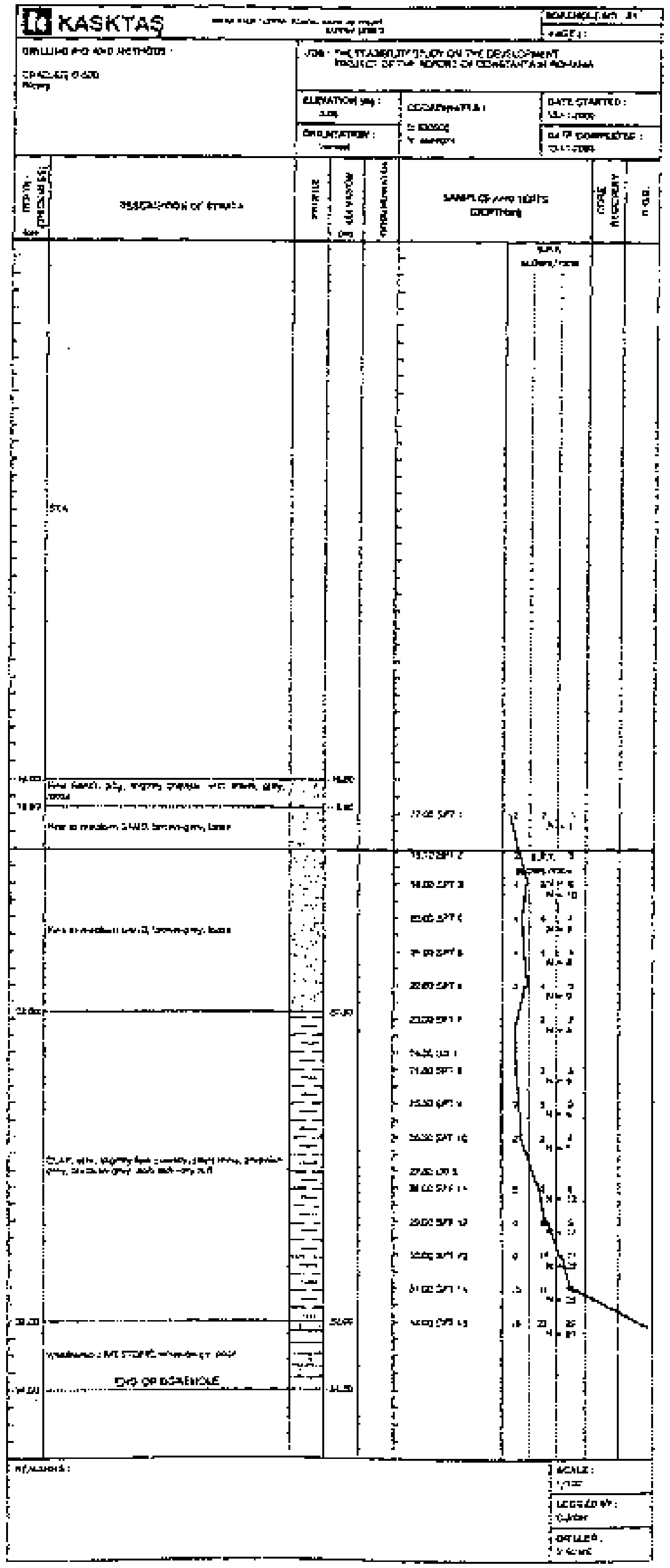
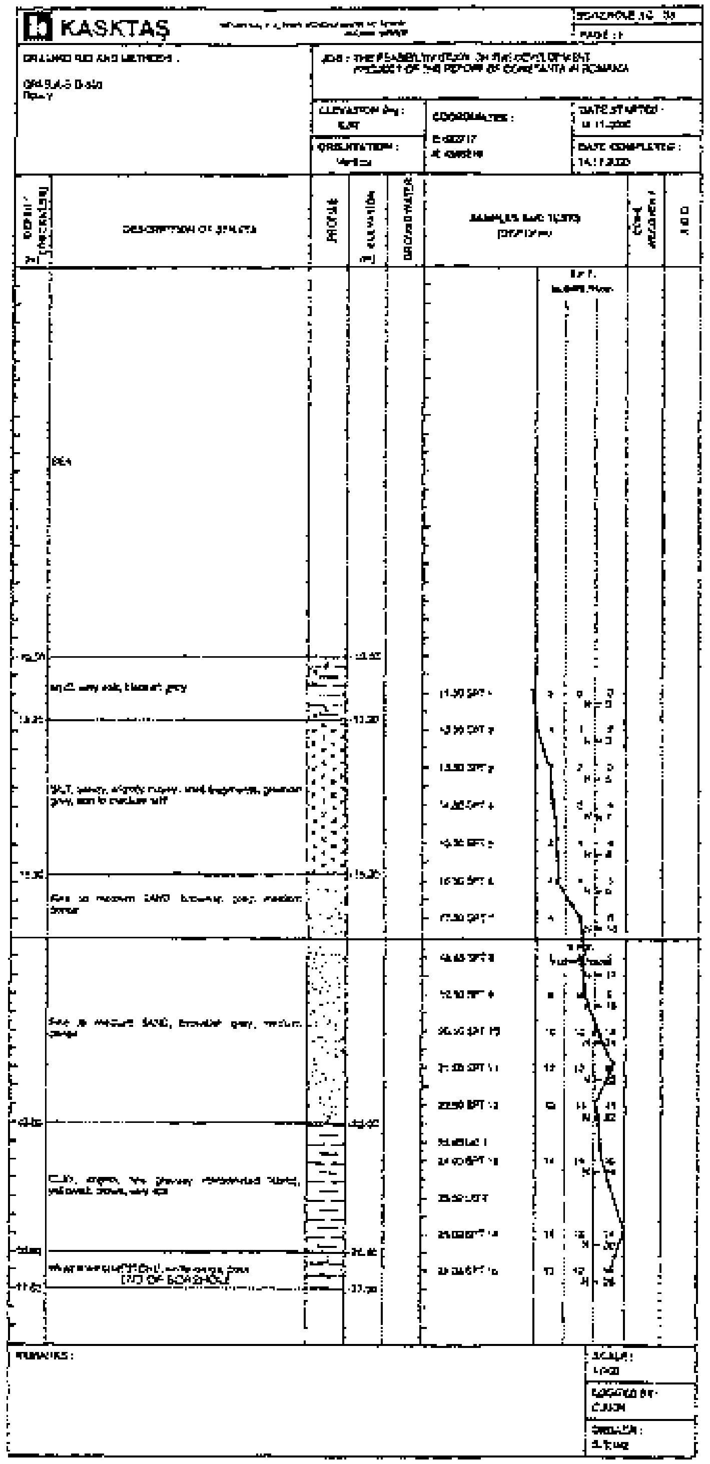


Figure 6.5.25 Boring logs S1 – S3

S4



S5



S6

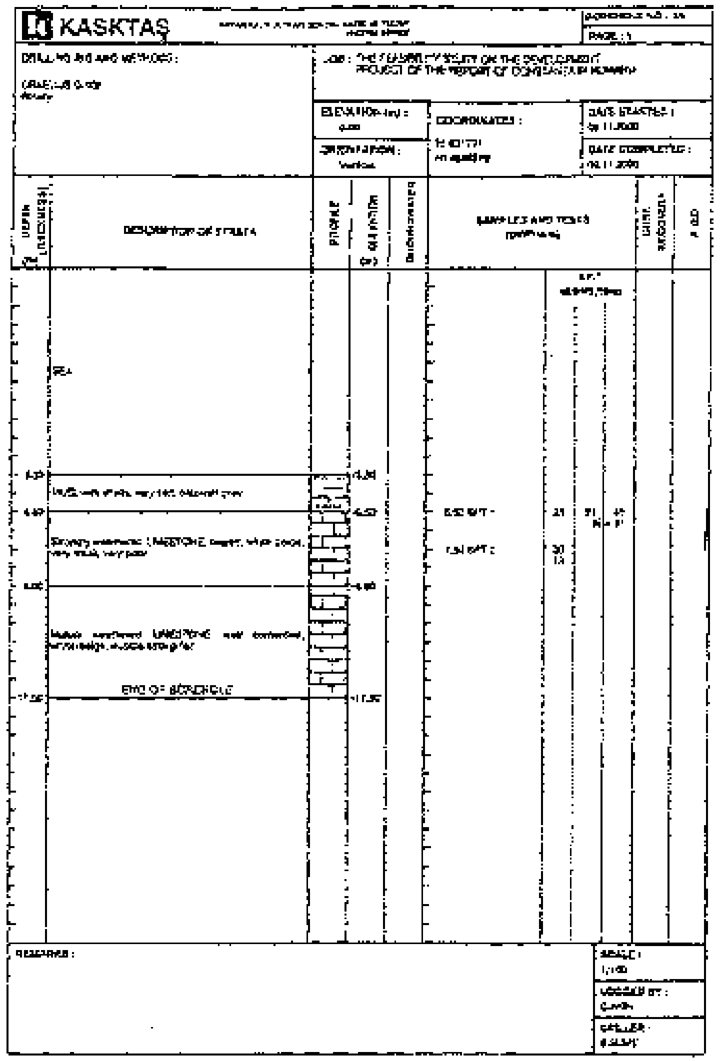
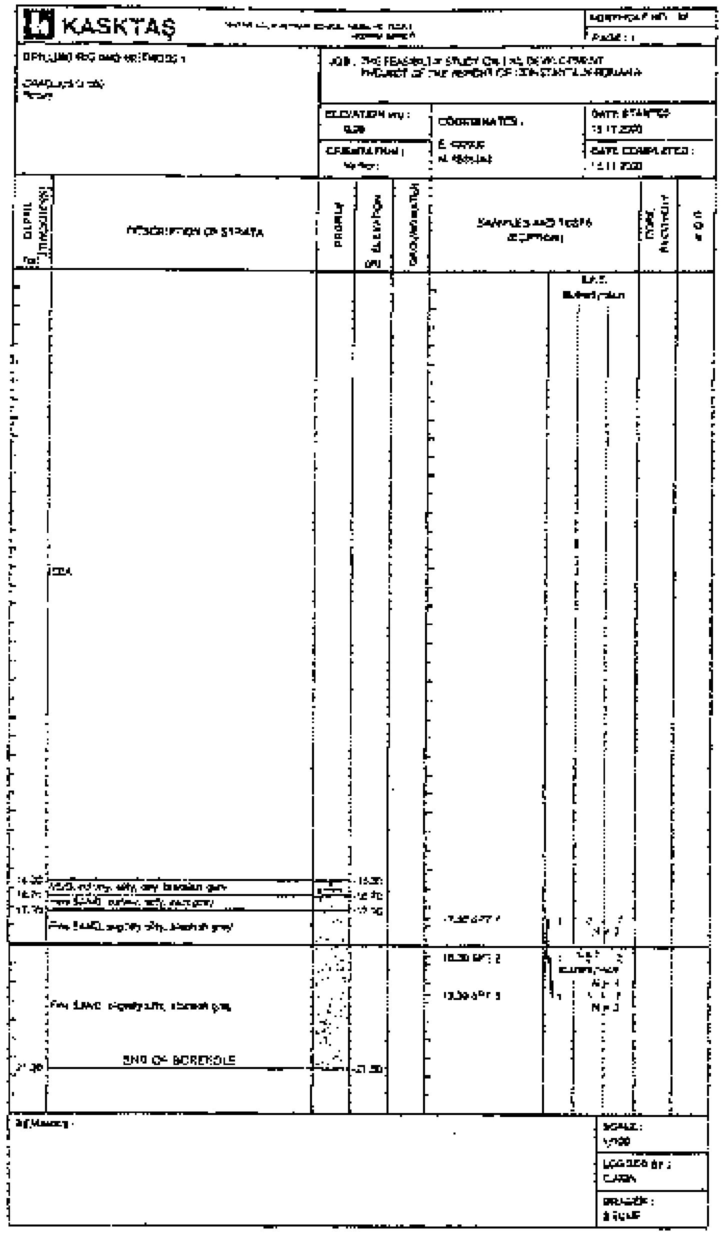
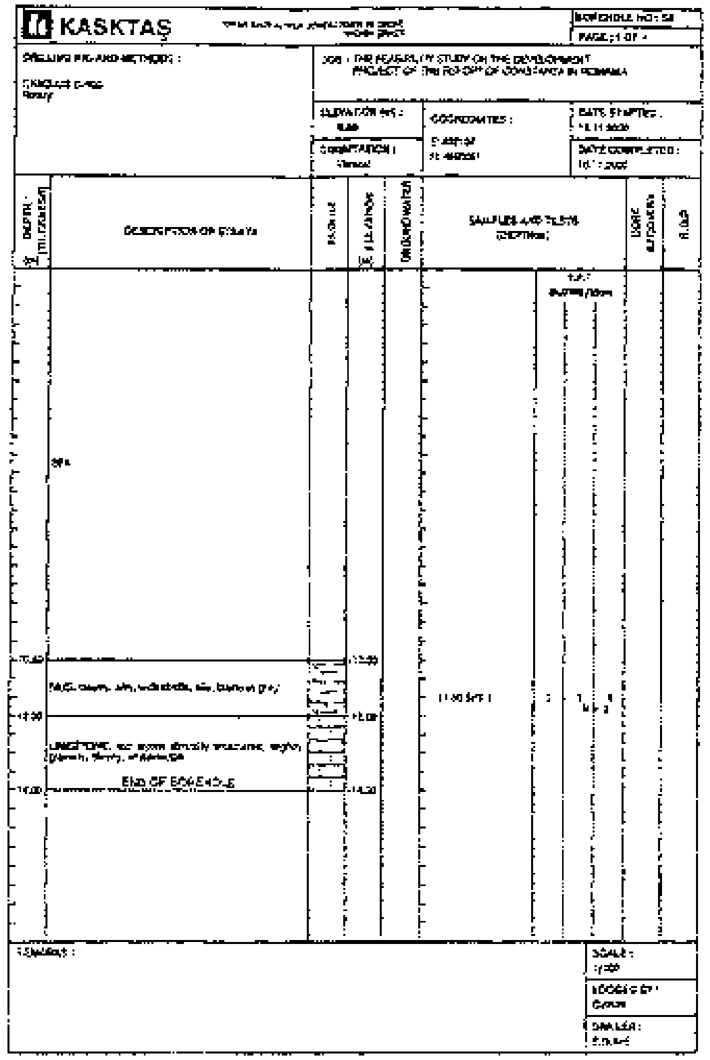


Figure 6.5.26 Boring logs S4 – S6

S7



S8



S9

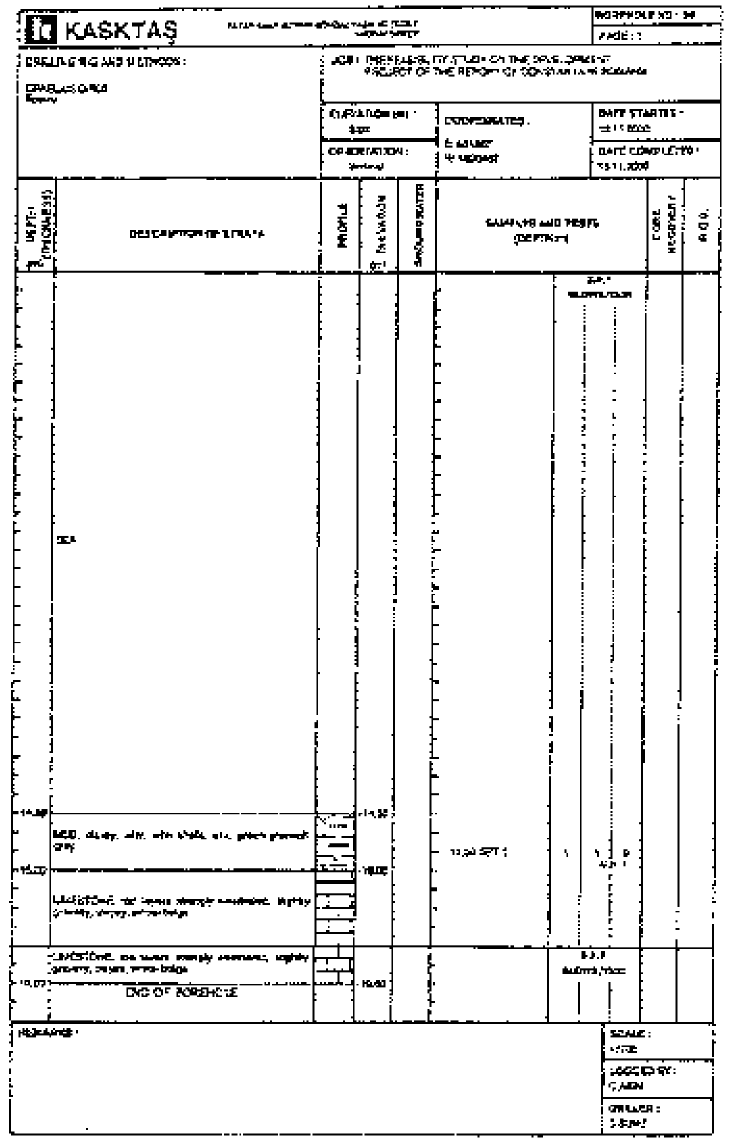


Figure 6.5.27 Boring logs S7 – S9