DREDGING-DEPOSITION, A TWO LAYER GROUND PROBLEM IN MF-RADIO WAVE PROPAGATION

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A limited area in close proximity to an MF broadcasting station was foreseen for deposition of dredging material. The influence that the lossy material with finite height might have on MF propagation was studied.

I. INTRODUCTION

The subject that is presented here is classified to the topic: Ground Interface Effects.

Figure 1 illustrates the problem: A limited area in close proximity to a medium wave broadcasting station was foreseen for deposition of dredging material.

System 1 represents a VHF concrete tower of about 300m,
System 2 is a two mast MF aerial for omnidirectional propagation by day and with a directional pattern at night,
System 3 is an active MF installation in parallel operation.

The limited area marked out with the solid line was foreseen for deposit of dredging material. The effects of this deposition on the performance of the MF antennas are studied.

II. PRELIMINARY CONSIDERATIONS

Several questions arise for the deposition effects on the MF-antenna performance:

1. How does the deposition affect the MF propagation?
2. Which permissible deviations of the MF propagation characteristics are definable?
3. What shape of the deposition should be preferred?
4. What is the minimum permissible distance to the MF antennas?
5. What is the maximum permissible height of the deposition?

The foregoing is an example where the NEC code could help. The two medium ground approximation (cliff model) was the starting option for using the code.

Figure 2 shows the well known view of this cliff model. For this model the parameters for a second

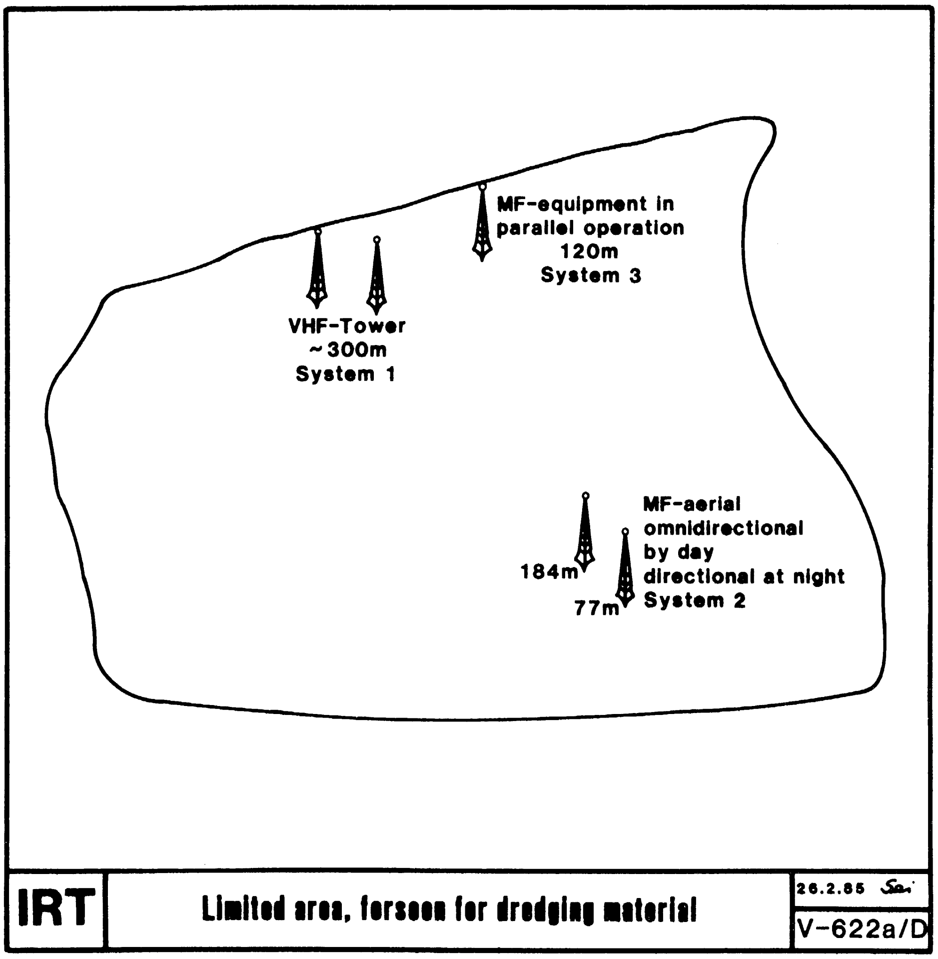


Figure 1.

ground medium are fixed by the GD card (s. NOSC, Techn. Doc. 116, Vol. 2). The restrictions to this approximate model are:

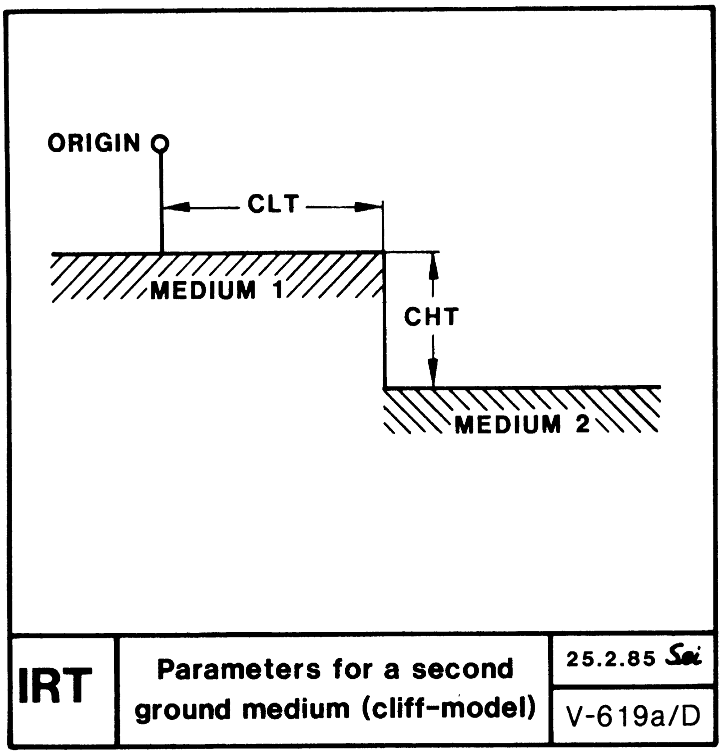


Figure 2.

1. The use of the GD card does not require recalculations of the matrix,
2. the ground parameters of a second medium are only effective beyond the immediate vicinity of the antenna,
3. the parameters for the second medium are used only in the far field calculation,
4. no edge diffraction by the cliff is taken into account.

In mind of this, the cliff model is modified for the deposition effects on the performance of the MF antennas in the following way (s. Fig. 3):

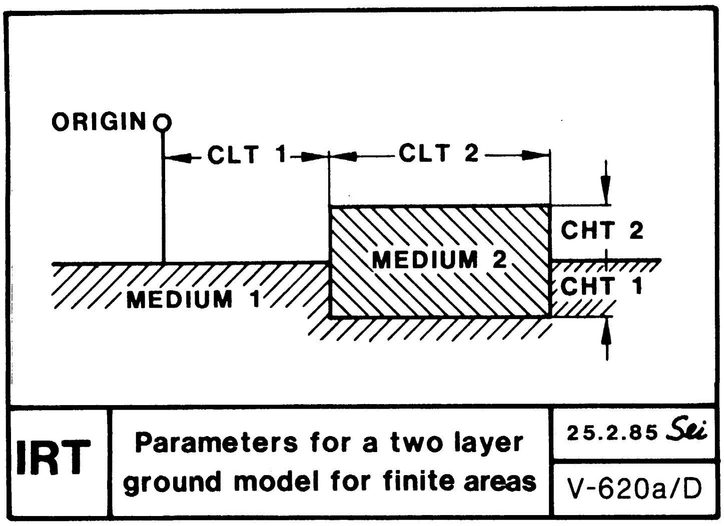


Figure 3.

For the stratified (two layer) region, fixed by CLT1, CLT2 and CHT1, CHT2 the effect of stratification on the reflection of waves is indicated in a simple way according to Wait /1/.

III. TWO LAYER CLIFF MODEL

According to Wait the surface impedance Z_1 for any angle of incidence is represented by the relation:

$$Z_1 \cong Q \cdot K_1$$

with

$$Q = \frac{(\gamma_1/\gamma_2) + \tanh \gamma_1 h_1}{1 + (\gamma_1/\gamma_2) \cdot \tanh \gamma_1 h_1} \qquad \text{for } \mu_1 = \mu_2 = \mu$$

and

$\gamma_m = (i\mu\omega(\sigma_m + i\varepsilon_m\omega))^{1/2}$ = propagation const.

Z_1 = surface impedance at the air-ground interface

K_1 = characteristic impedance of the upper layer

Q = correction to K_1 to account for the presence of the lower layer

For radio frequencies and moderate conducting ground ($\sigma \sim 10^{-2}$ S/m) a suitable formula is given by:

$$Q = \frac{(\sigma_1/\sigma_2)^{1/2} + \tanh\left(\sqrt{i} \cdot V\right)}{1 + (\sigma_1/\sigma_2)^{1/2} \tanh\left(\sqrt{i} \cdot V\right)}$$

where

$$V = (\sigma_1 \mu\omega)^{1/2} h_1 \text{ with } h_2 \longrightarrow \infty$$

This function Q and its argument q are plotted as a function of V for various values of the ratio (σ_1/σ_2) in Fig. 4.

IV. NEC MODIFICATIONS

A subroutine called QZRQ was inserted into the NEC code and permits the determination of this Q factor to correct the surface impedance ZRATI2 in the common block /GND/ of the code. In Fig. 5 a part of the modified linkage chart is shown. Therefore, the contribution of each image segment as it is modified by the reflection coefficient for cliff problems will be taken into account by this correction factor. The values of Z (ZRATI2 in the code) are assigned in subroutine RDPAT, and in the subroutine FFLD the reflection coefficients are calculated for ground areas fixed by the new two layer ground model.

V. RESULTS

Detailed pattern calculations for the three MF systems were made. Various shapes of the deposition and different values for the conductivity of the dredging material were taken into account.

As an example the vertical and horizontal patterns of a 0.6λ monopole (system 2 by day) affected by the deposition are shown in Figures 6 and 8. The thick line represents the pattern without additional dredging material. The shape of the deposition is toroidal with abrupt walls. The conductivity of the upper layer, the muddy material, is changed. Fixed parameters are the dimensions of CH, CLT1 and CLT2. As can be seen the vertical pattern is strongly affected by interaction with the deposition.

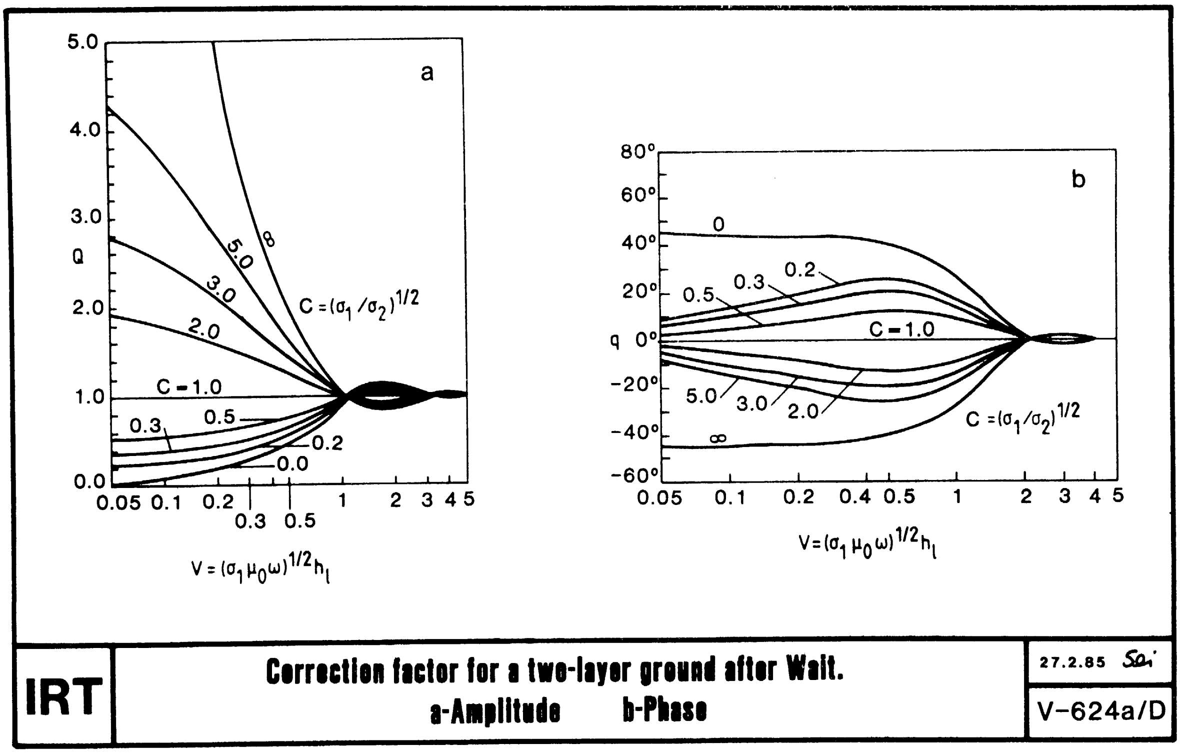


Figure 4.

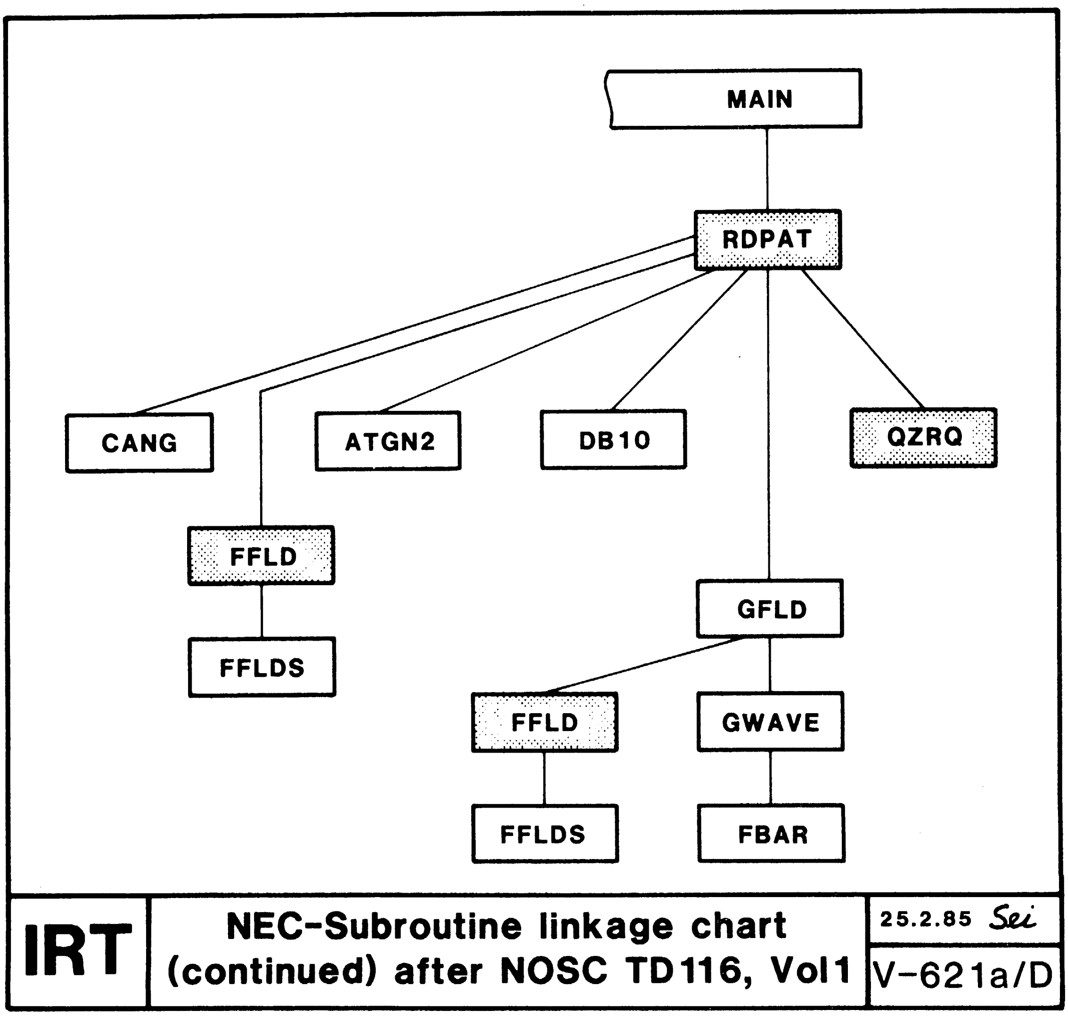


Figure 5.

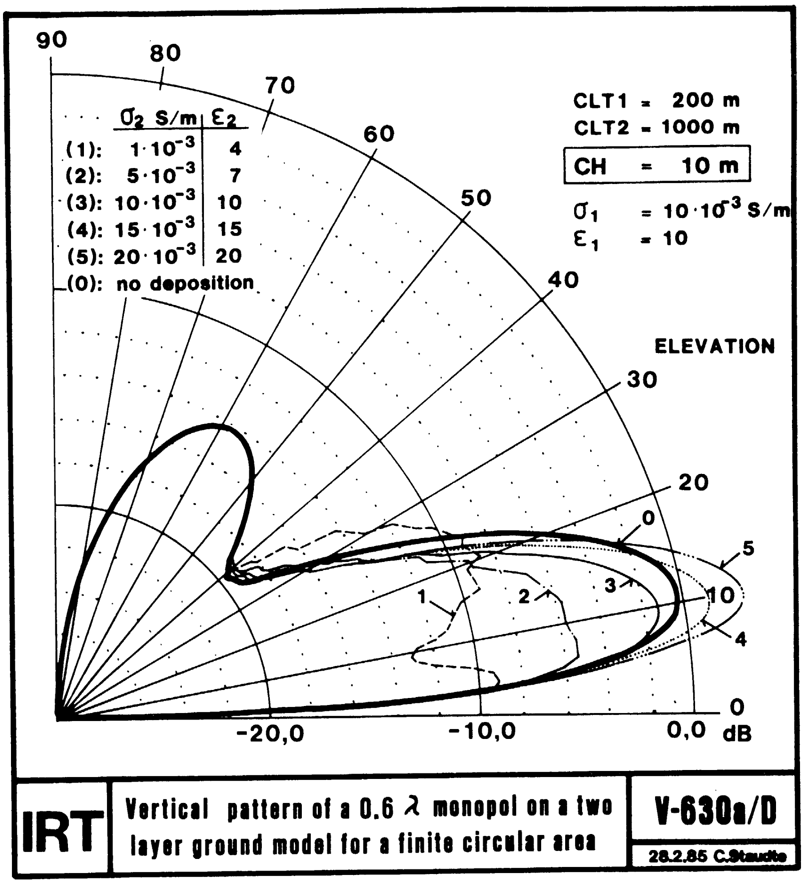


Figure 6a.

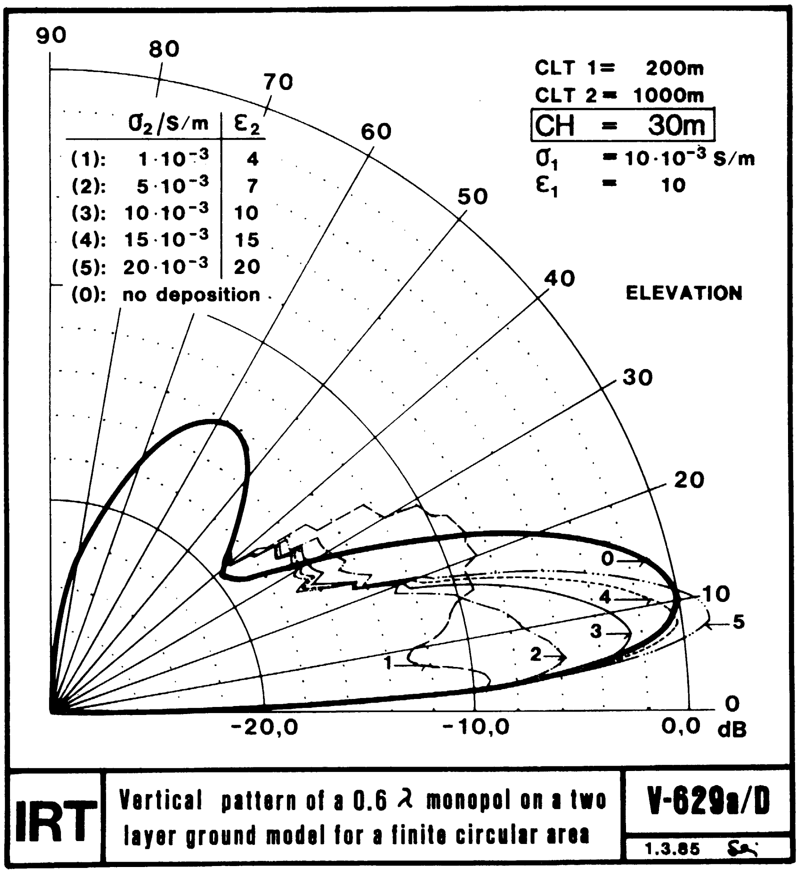


Figure 6b.

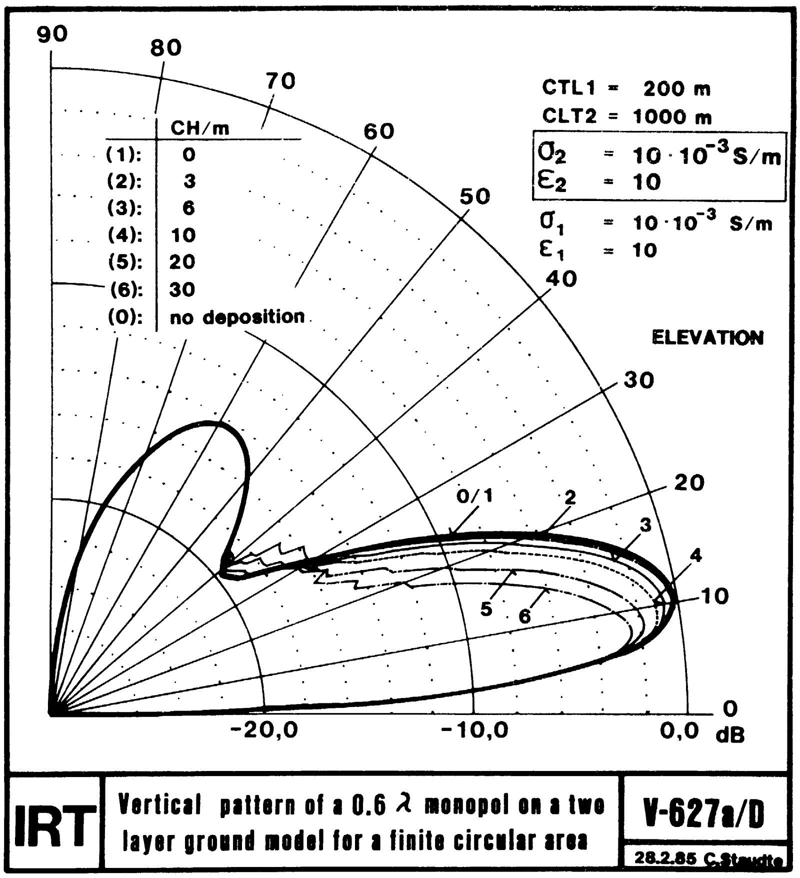


Figure 6c.

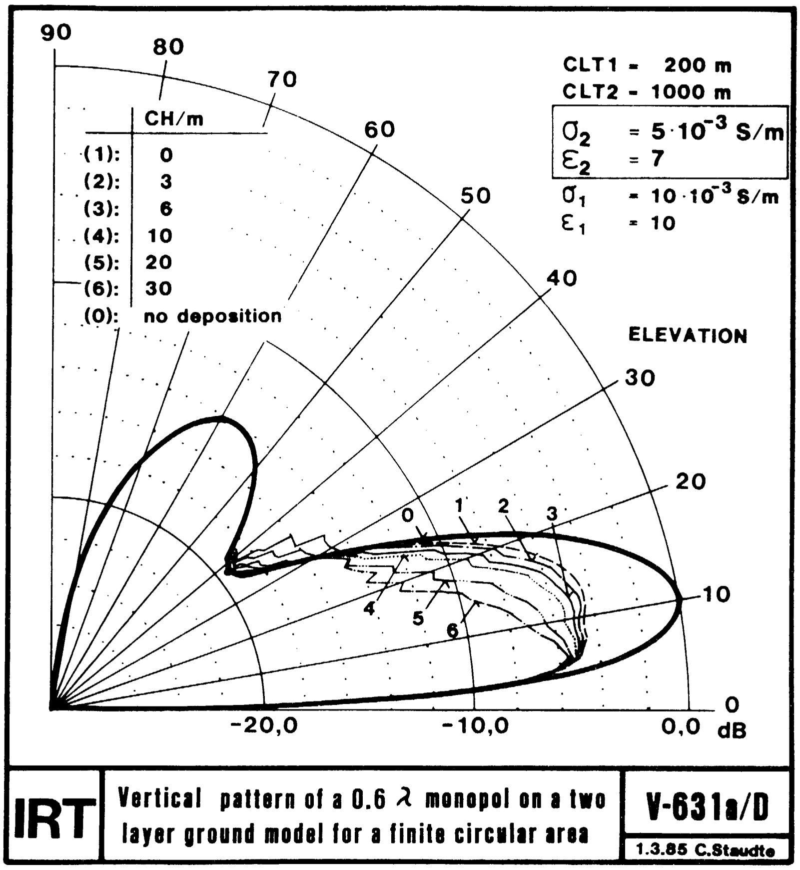


Figure 6d.

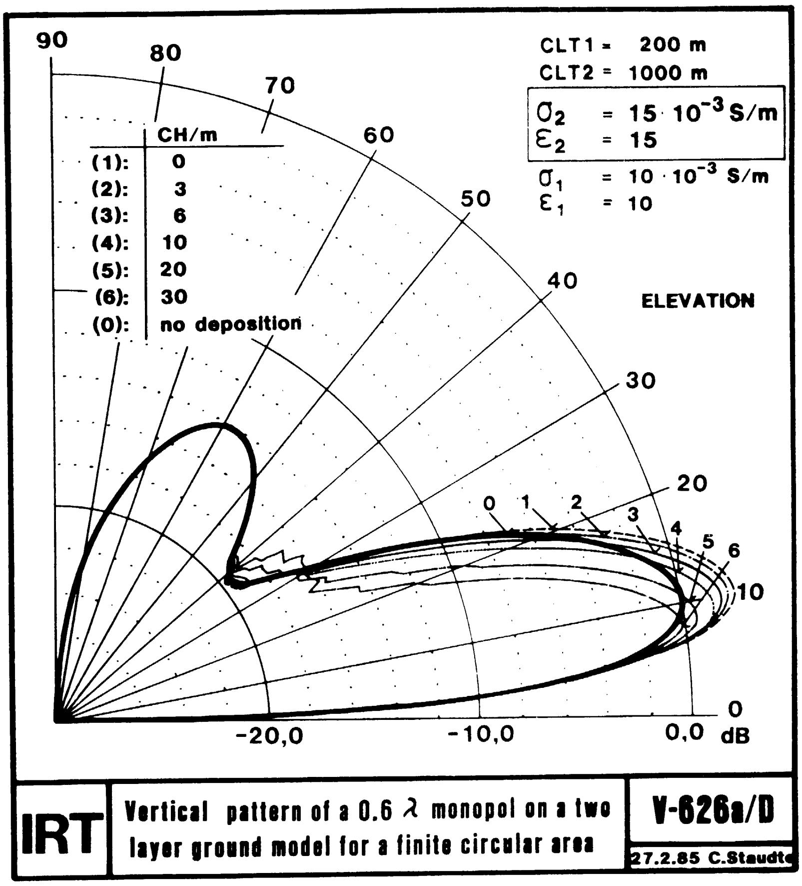


Figure 6e.

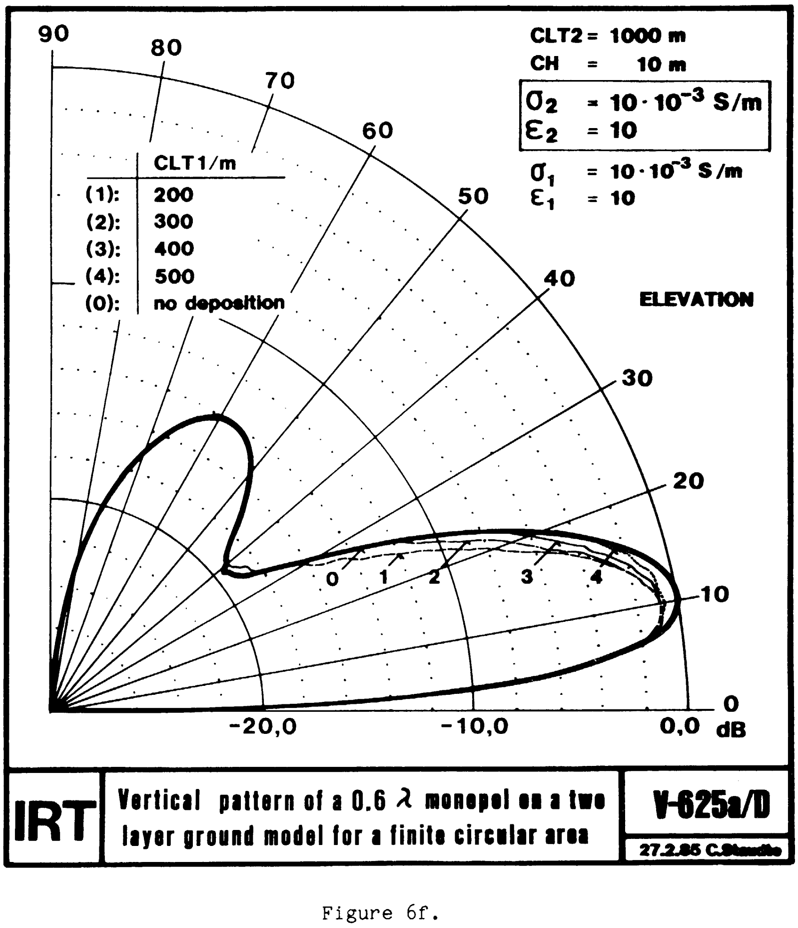


Figure 6f.

More or less, the effect caused by the deposition of dredging material changes the main beam of the vertical pattern.

To calculate the horizontal pattern (surface pattern) the limited area was sectorized. In Fig. 7 this sectorization of the limited area is shown. Since the surface wave is not included in the reflection coefficient approximation in NEC the horizontal pattern was computed at a small angle above the horizon to obtain a nonzero space wave.

In Fig. 8a and 8b the horizontal pattern as a function of the sectorized area for various conductivities of the dredging material and different values of CH are shown. The deviation of circularity should be noted.

VI. CONCLUSION

One main purpose of this study is to get permissible deviations of the MF propagation characteristics by dredging deposition effects.

From the pattern calculation pointed out, limiting values for such deviation can be derived:

1. the reduction of field strength should not yield more than 1 dB,
2. the elevation angle of the direction of maximum radiation should not change by more than 1 degree,
3. the deviation from circularity should not be more than 1 db.

With these permissible deviations in mind a deposition of dredging material on the limited area is tolerated only for conductivities of the dredging material close to or better than those of the lower ground. Furthermore, a distance of about 1λ should be maintained between the antennas and the nearest edge of the deposition. Finally the height of the deposition should not be more than 10 m.

With only small modifications of the NEC code the problem of affecting MF propagation by dredging deposition could be solved to our full satisfaction.

REFERENCE

/1/ Wait, J. R., "Electromagnetic Waves in Stratified Media," Pergamon Press (1962).

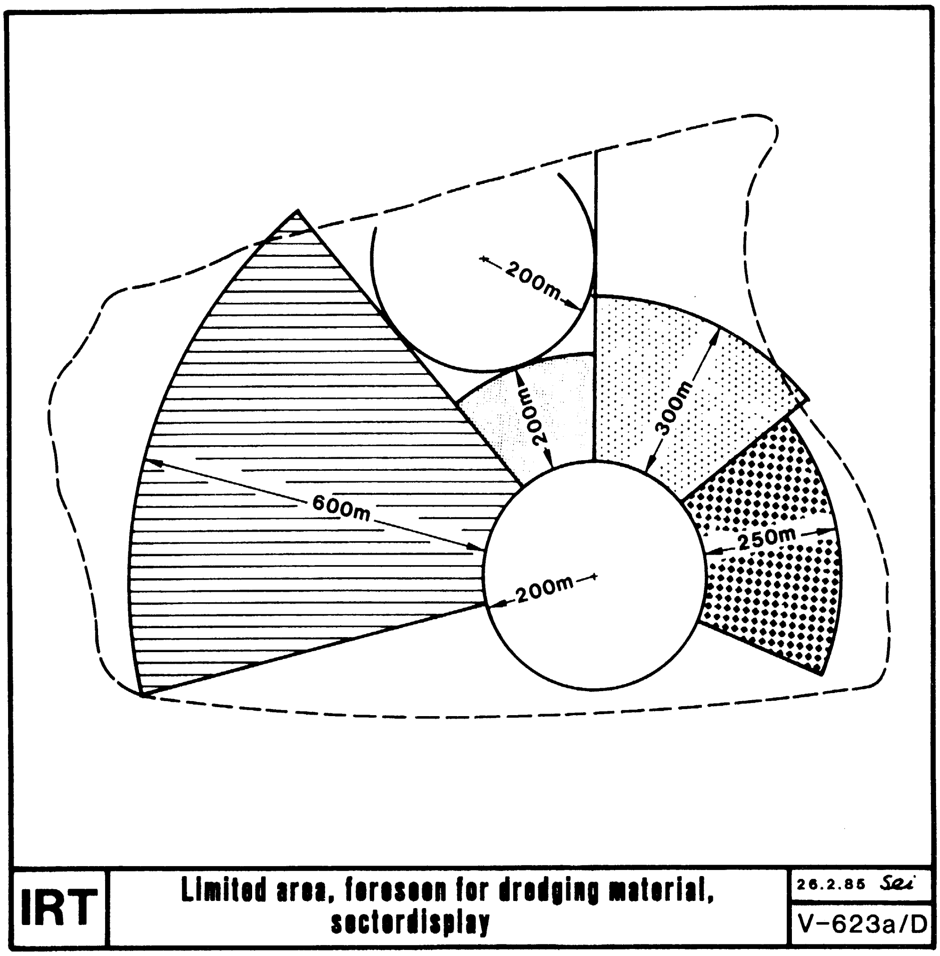
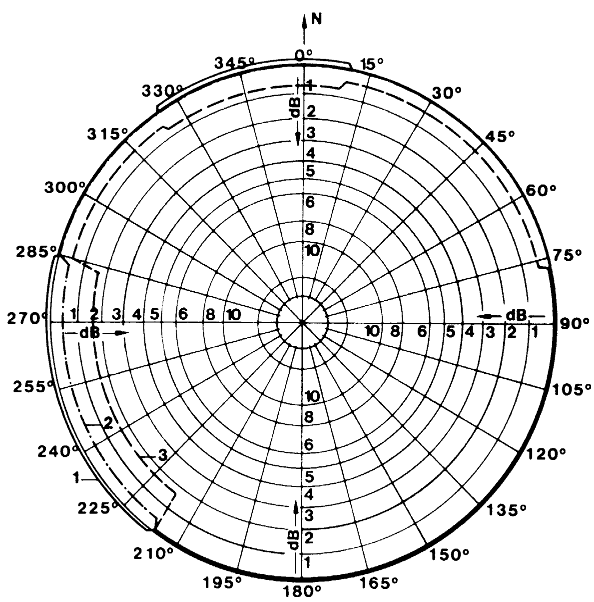


Figure 7.



CH-10m

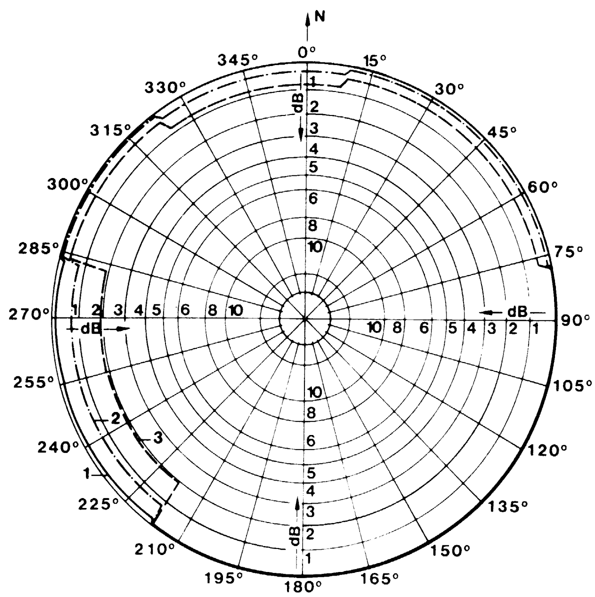
σ_1 = $10 \cdot 10^{-3}$ S/m

ε_1 = 10

	σ_2/S/m	ε_2
(1):	$15 \cdot 10^{-3}$	15
(2):	$10 \cdot 10^{-3}$	10
(3):	$5 \cdot 10^{-3}$	7

IRT	Horizontal pattern of a 0.6λ monopol on a two layer ground model for finite sectorial areas	28.2.85 V-633a/D

Figure 8a.



CH-30m

σ_1 = $10 \cdot 10^{-3}$ S/m

ε_1 = 10

	σ_2/S/m	ε_2
(1):	$15 \cdot 10^{-3}$	15
(2):	$10 \cdot 10^{-3}$	10
(3):	$5 \cdot 10^{-3}$	7

IRT	Horizontal pattern of a 0.6λ monopol on a two layer ground model for finite sectorial areas	28.2.85 V-632a/D

Figure 8b.