CHAPTER TWO HUNDRED ELEVEN

OPTIMIZING DUMPING SITES NEAR DREDGED CHANNELS

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ABSTRACT

To maintain the depth of the deepwater channel of the Elbe-Waterway extensive dredging has to be done permanently. Dumping should be optimized, choosing sites near the dredging area but with a small risk of recirculation of the dumped material. In order to estimate this risk field measurements with current meters and radioactive tracer tests in field and model were carried out.

1.0 INTRODUCTION

The deepwater channel of the river Elbe from Hamburg to the North Sea has been deepened to an average depth of 13.5 m below chart datum. The mean tidal range is about 3 m.

The channel has to be kept free by constant dredging. A volume of 8 to 10 $\cdot$ 10^6 m^3 fine and medium sand has to be dredged annually from the North Sea up to Hamburg. The dredged volume has increased the last three years nearly up to twice the amount before. This caused the Board of Waterway in Cuxhaven to look for the most economical way of dredging. The dredged material could be dumped near the dredging

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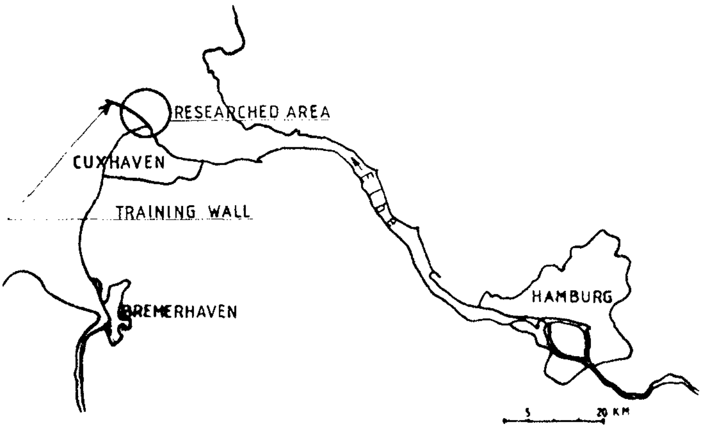

fig. 1 geographical location

sites as very deep areas are situated on both sides of the deepwater channel. But this method is only acceptable if there is no recirculation of dumped material into the deepwater channel within a short time. One of the main dredging sites with a dredging volume up to $2.8 \cdot 10^6\ m^3$ p.a. is the training wall area near Cuxhaven (Fig. 1). This area has been researched to find out the reasons of accretion, especially as two dumping sites had been opened up on both sides of the dredging area. Recognizing a constant depth at the two dumping sites a flux of the dumped material is evident.

The dumping sites were checked for their suitability. For this, measurements in field using current meters and several investigations with radioactive tracers in a hydraulic model and in field were carried out with the aim to get informations of direction of the sediment transport. The influence of wave pressure and direction was neglected, because the wave height is very small in comparison with the water depth.

2.0 PRELIMINARY SURVEY

The sounding maps (fig. 2) of this area gives a picture of the sites of accretion and of the depht situation below mean spring low water. By investigations it was found that the heighest inflow was from the south. Most dredging had to be done there. A comparison between the dredged and the dumped volume in this area of the year 1983 shows, that the dredged volume was up to 2,4 times the amount of the volume dumped in the vicinity. Therefore the dumping of the material on both sides of the deepwater channel cannot be the only reason of the increased sedimentation.

3.0 INVESTIGATION OF THE DUMPING SITE I

3.1 MEASUREMENTS WITH CURRENT METERS

At first field measurements with recording current meters were carried out. The aim of this investigations was determine the direction of sediment transport and also to estimate the amount of accretion

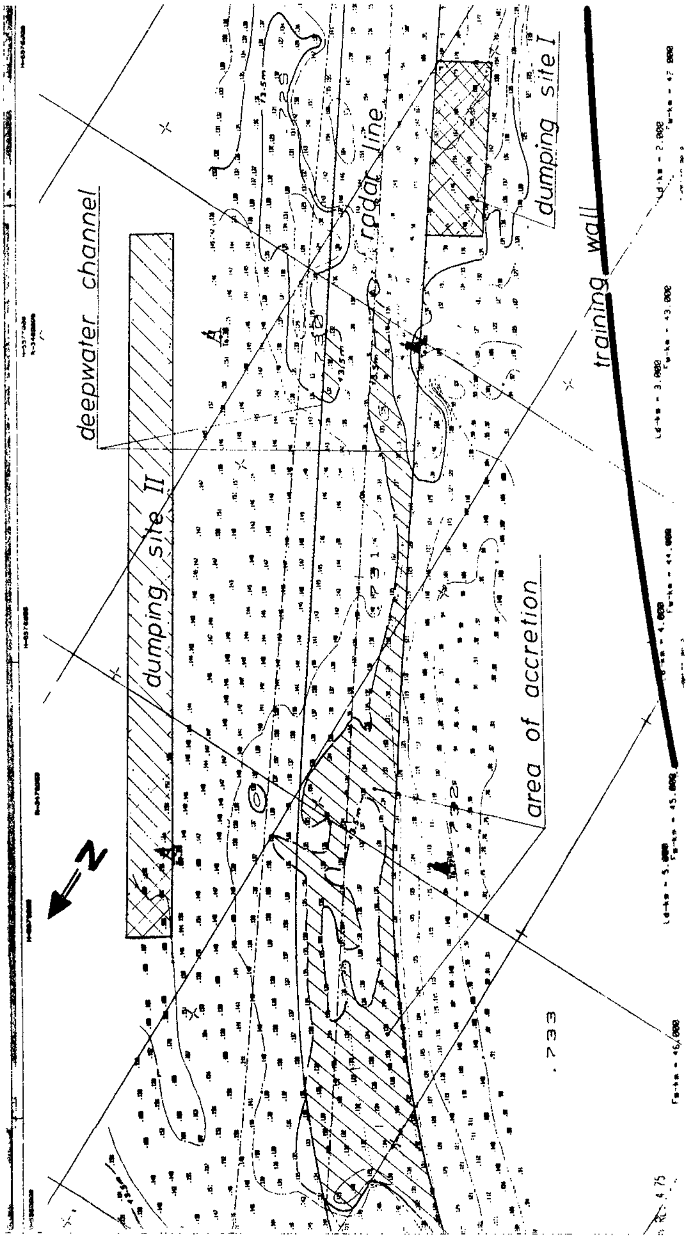

fig. 2 Sounding map with dumping and dredging areas

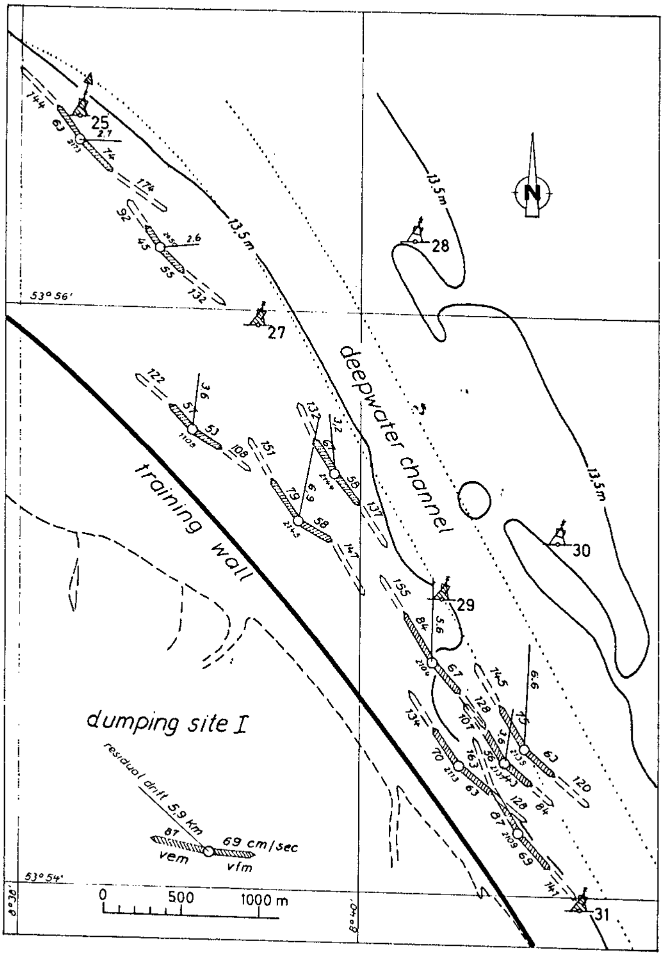

fig. 3 Bed current measurements in field, I

dependant on conditions of ebb- and flood current. The velocity and direction of current are recorded with current meters, moored 0,5 m above the bed. The currents measured at that level are regarded as relevant for sediment transport in this case. The results are stored on magnectic tapes. Mostly the measurements were carried out continuously. The 14 days measurements took into account the effect of the mean, the spring and the neap tides.
The data showed, that up to 1000 m downstream from buoy 29 the ebb current dominates, but from buoy 27 onwards the mean ebb and flood velocities are equal. Downstream from buoy 27 the mean flood velocity prevails (fig. 3).

The ebb- and flood-current in this area reaches 45 - 87 cm/s. The highest rate 84 - 174 cm/s. There is a residual drift of 2.6 - 6.9 km/tide towards downstream or upstream and towards the deepwater channel depending on the dominating ebb or flood current. The residual drift is calculated from the vectoral additions of the ebb and flood current data measured in 5 minutes intervals.
All measurements were evaluated by means of tapereader, desk-top computer and plotter. A good overall picture of the expected sediment transport can be obtained by consulting the current velocity rose, which shows the current velocity and directions (fig. 4). The direction of ebb- and flood currents oscillates in an angle-scope of 25 degrees. The ebb current dominates in this case, ebb and flood direction diametrically opposed to each other. The residual drift vector calculated of it, shows the direc-

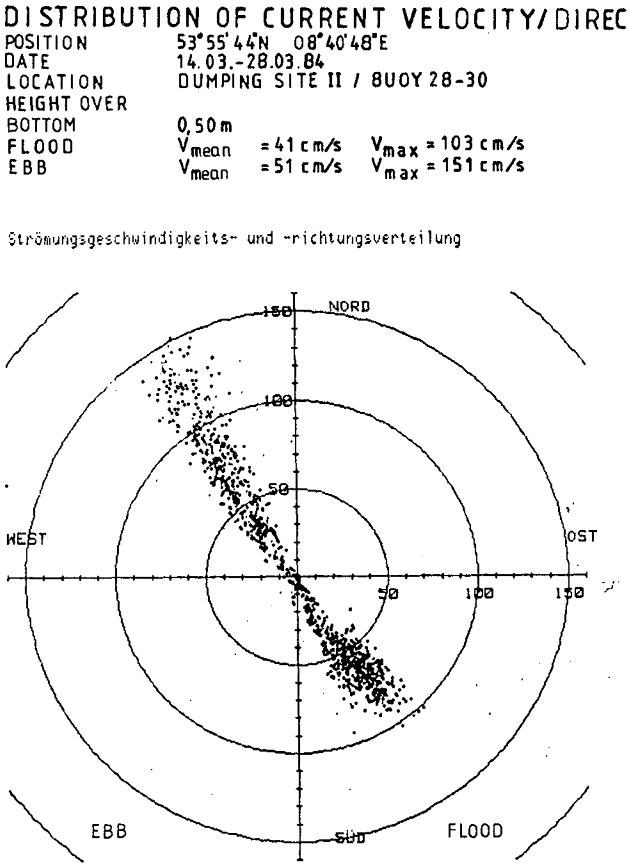

fig. 4 current velocity rose

tion of the mean ebb current from which one can deduce that the sediment is transported in this case in the direction of ebb current. The measurements of the individual measuring points were compared with the results of neighbouring points.
By this the following overall result was reached:

Because of the prevailing ebb current upstream from buoy 27 and the prevailing flood current downstream from this buoy and the respective residual drifts towards the deepwater channel, sediment transport must be exp‿ected from the south into the deepwater channel up- and downstream from buoy 27.
The direction of the residual drift indicates, that the greater part of the dumped material from dumping site I moves back into the deepwater channel between buoy 27 and 29. This assumption is confirmed by comparing the grain sizes of the material (d_{50} = 0.16 mm) dumped in dumping site I and being dredged on the southern sides of the dredging area between buoy 27 and 29.

3.2 MEASUREMENTS WITH RADIOACTIVE TRACERS IN MODEL

The results of the field measurements were confirmed by investigations in a hydraulic model with movable bed using a radioactive tracer. This model of the Elbe estuary is managed by the Bundesanstalt für Wasserbau in Hamburg. The model scales are 1 : 800 horizontal and 1 : 100 vertical. The hydrodynamic time-scale is non Froudian; one tidal period of semi-diurnal type lasts 13.03 min. The bed material consists of polystirene grains with d_m = 2.0 mm and a density of 1.035 g/cm^3. The theory is refered to Vollmers/Giese, (2) and aims in a natural simulation of dune structures.
The γ-radiating isotope Br 82 with a half-life of 36 hours was used to label 25 g of the polystirene-grains, which were put into the model at high water

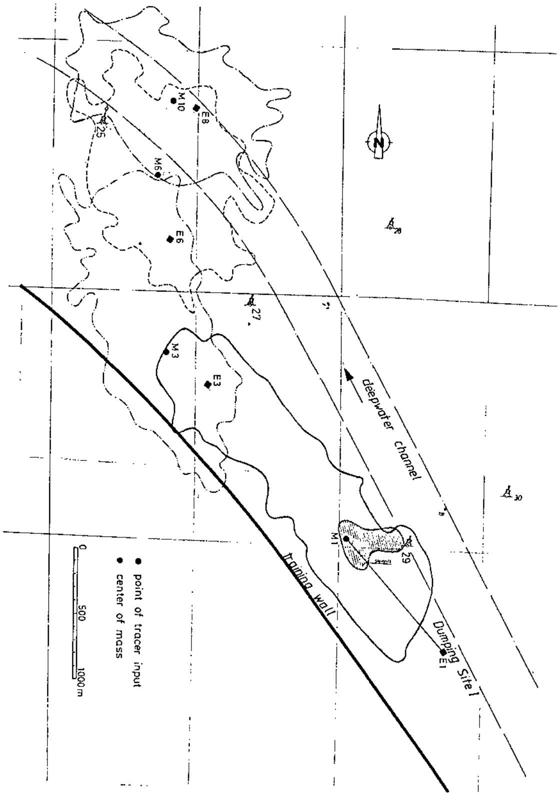

fig. 5 Radioactive tracer spreading in model, I

slack. After a run of 150 tides in model the tracer has spread over an area of several square meters due to current and turbulence activities. The spreading area was scanned in a grid of 10 to 15 cm using a radiation detector and a scintillation counter. Detailed informations about this subject were given by Rohde, (1).
Between training wall and navigation channel 4 investigations were carried out in the model. (fig. 5). The spreading figures of the tracer-only the lines of the weakest radiation with 20 impulses per minute are depicted - can be interpreted in two ways. The one is to consider the direction of the longer main axis of the figures and the other is to draw the vectors from the input points to the centers of mass.

The results are in good conformance with the current measurements in field. The dominating ebb-current moves the material from dumping site I first parallel to the training wall. 2000 m downstream from the point of tracer input it sweeps round towards the deepwater channel and causes here a considerable accretion.

3.3 CONCLUSION

The results of the investigations led to the conclusion the recirculation -rate between dumping site and dredging area to be very high. Therefore the dumping activities at point I were stopped.

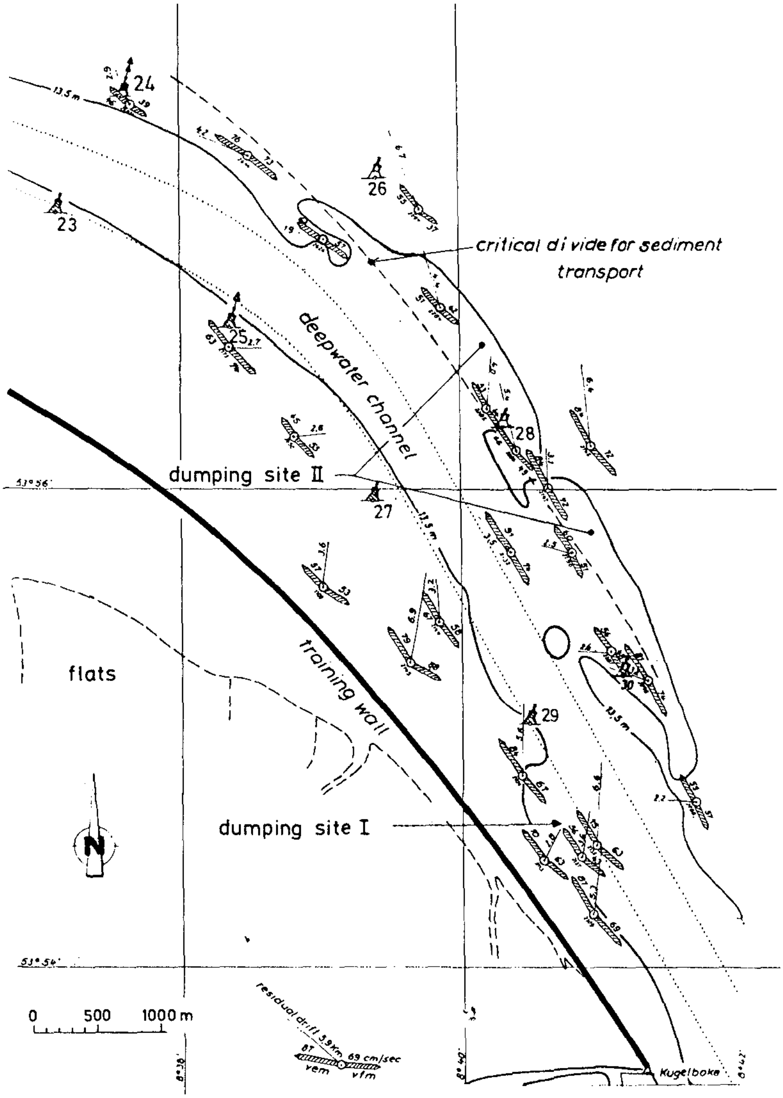

fig. 6 Bed current measurements in field, II

4.0 INVESTIGATION OF THE DUMPING SITE II

The dumping site II was investigated by current measurements in the field and radioactive tracers experiments in model and the field.

4.1 MEASUREMENTS WITH CURRENTS METERS

The results of the current measurements can be assumed as following (Fig. 6):

1. The mean and maximum ebb current velocities are higher than the corresponding flood velocities.
2. The residual drifts are clearly directed downstream, but one is directed to the north and the other towards the deepwater channel. The residual drift vectors are directed on the one hand to the north and on the other hand towards the deepwater channel separated by a dividing line.
3. In all cases the ebb current dominates and a dominating ebb-transport can be suggested.

4.2 TRACER TESTS IN MODEL

This general tendency obtained with current meters is confirmed by research with radioactive tracers in the model. The tracer dumped in the middle of dumping site II spreads out to buoy 28 in a very soft angle towards the deepwater channel, from there it moves more steeply towards the deepwater channel and reaches it at buoy 25. The paths of the mass-centers are shown in fig. 7. A general tendency of decreasing vector lengths can be recognized.

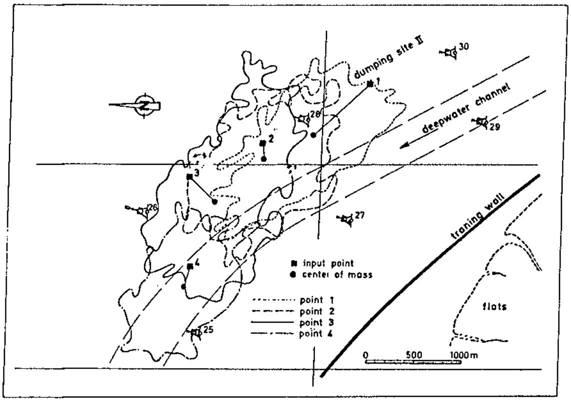

fig. 7 Radioactive tracer spreading in model, II

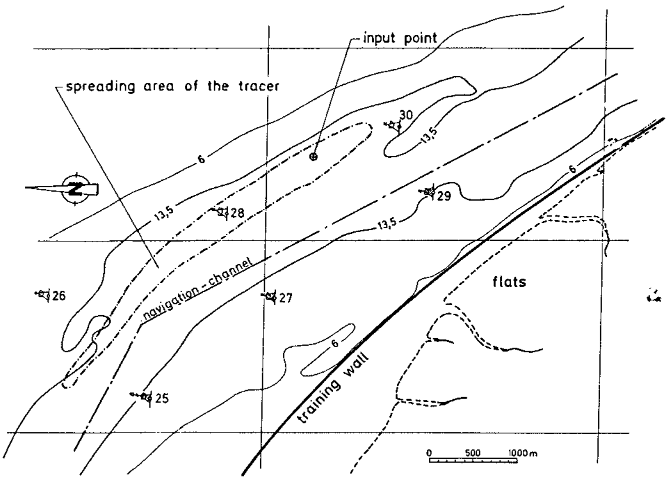

fig. 8 Radioactive tracer spreading in field

4.3 MEASUREMENTS WITH RADIOACTIVE TRACERS IN NATURE

For better estimation of the suitability of the dumping site an additional investigation with radioactive sand was carried out in the field.

To prepare the tracer 10 kg fine to medium sand with a d_{50}= 0.26 mm was taken from the river bottom and with the help of waterglass labelled with scandium (halflife 84 days). A heavy sledge with a scintillation detector was used to measure the radiation. The sledge was pulled over the river bed by a towing boat. The radioactivity was recorded by a scintallation counter. Hifix digital navigation system was employed for the location. More details about the tracer experiment are published by Rohde, (1).

The radioactive sand was introduced into the center of dumping site II. The area in which radioactive material could be found is shown on Fig. 8. In the first stages the tracer spread from the point of input downstream in a small plume, almost parallel to the axis of the deepwater channel.From buoy 28 on, the material moved towards the northern side of the waterway. The spreading of the tracer in lateral direction did not extend more than 300 m. It was possible to keep track of the tracer for about 3500 m downstream from the input point only. The tracer was suggested to be transported into the deepwater channel and passing on its northern side.

4.4 CONCLUSION

These results of the different measurements led to the following procedure of dumping: The dumping site is restricted to an area downstream from buoy 28 and very close to the 13.5 m -line. It is supposed the transported sediment will not affect the deep-water channel essentially.

5.0 RÉSUMÉ

Current measurements in field, radioactive tracer test in the field and in a model with movable bed are good tools in optimizing dredging and dumping procedure. These three methods have to complete each other as long as there is no better understanding of the complex physical process of sediment transport in tidal areas.

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