CHAPTER 43

THE INFLUENCE OF SHORE PROTECTION WORKS ON GULLIES

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When studying charts showing the bottom-topography of estuaries in the South-West of Holland, it is striking that in the longitudinal development of gullies local depths occur, which are much greater than the average depth. From a closer consideration it appears that the deepest points are always situated near protective works against erosion of the shore.

The connection between the shore protection works and the deep scourholes and its influence on the gully-system will be dealt with in this paper.

INTRODUCTION

It appears that on sandy shores the construction of shore-protection often causes rapid erosion, which gradually develops more or less parallel to the shore. Thus unprotected nearby parts of the shore are often attacked with increasing force, necessitating an extension of the shore protection works. This will lead to further scouring of both the unprotected part of the shore and the gully in front of it; the result of the latter will be a trough of considerable length. The location of the gully will as a consequence be fixed for a long time.

THE DEVELOPMENT OF SOME SCOUR-HOLES

The gullysystem in the south-west of the Netherlands has been reproduced on figure 1, on which depths greater than N.A.P. - 10 m have been shaded, while scour holes are indicated as black spots. (The Netherland ordnance datum N.A.P. is practically equal to mean sea level). Shore-protection works are shown as fat parts on the shoreline. The connection between shore protectionworks and scour-holes is clearly visible.

In case of erosion of the shore the construction of shore protection works is generally thought necessary. An unsuitable shape of those constructions often causes progressive erosion.
This statement will be supported by a number of examples. The areas dealt with in detail are indicated on figure 1.

JONG BRESKENS POLDER

In past century the tidal-channel Wielingen has changed its location. The section near Nieuwe Sluis advanced to the shore. The eastern and (especially) the western reaches moved to the north. See figures nos. 2, 3, 4 and 5 with the situations of 1825, 1865, 1875 and 1952/1958.

The changing of the adjoining gully system and (for the western section) the sanding of the Zeeuwsch Vlaanderen coast influenced the displacement of the Wielingen. It is surprising however that the gully near Nieuwe Sluis moved southward instead of northward.

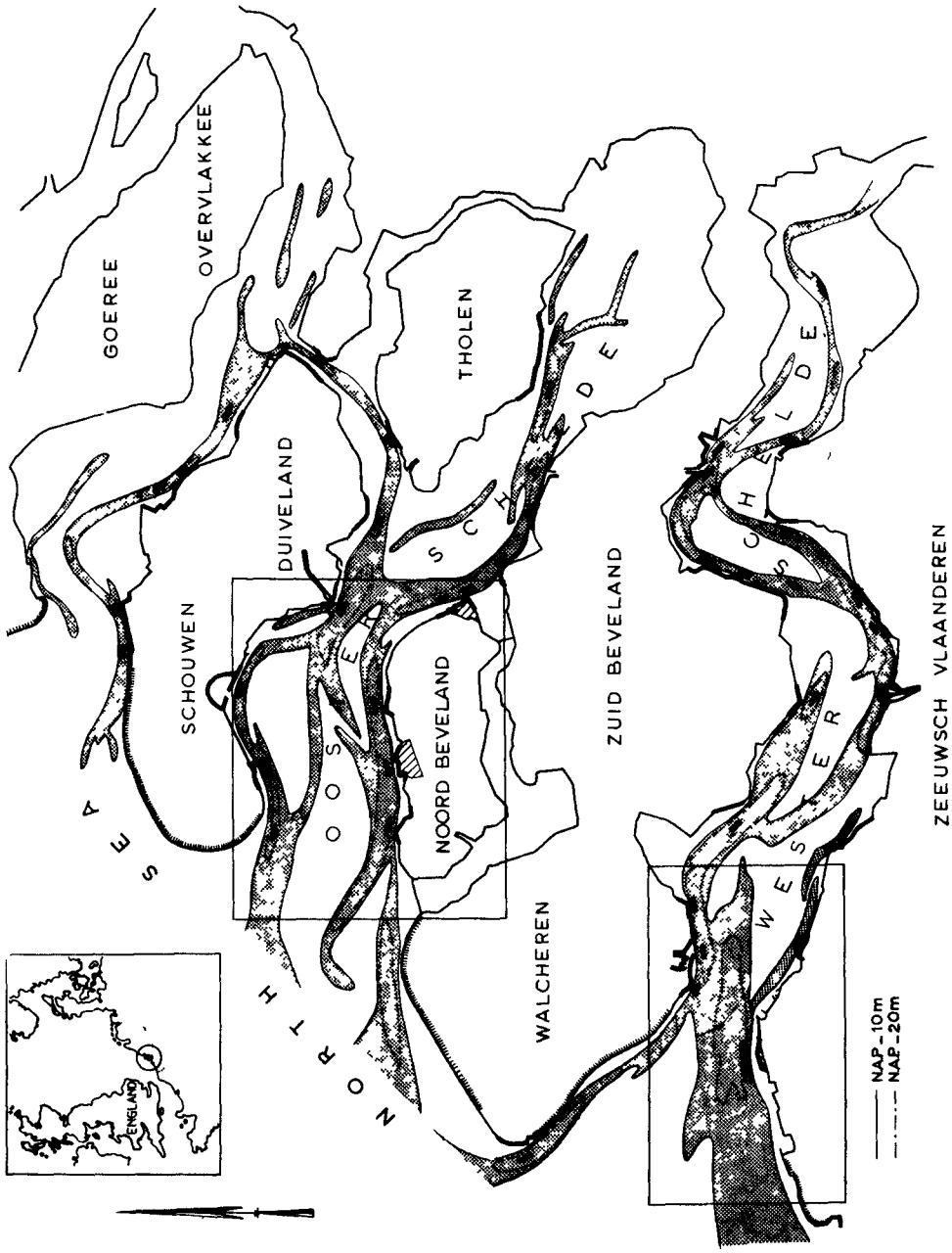

Fig. 1. Shore-protection works and scourholes in the south-west of the Netherlands.

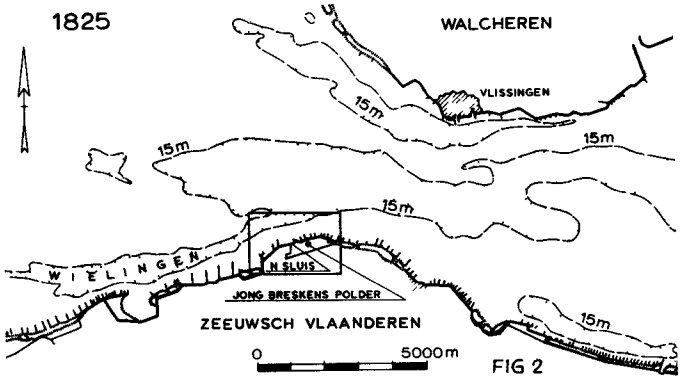

Fig. 2. Depth-contours in the Westerschelde-mouth (1825).

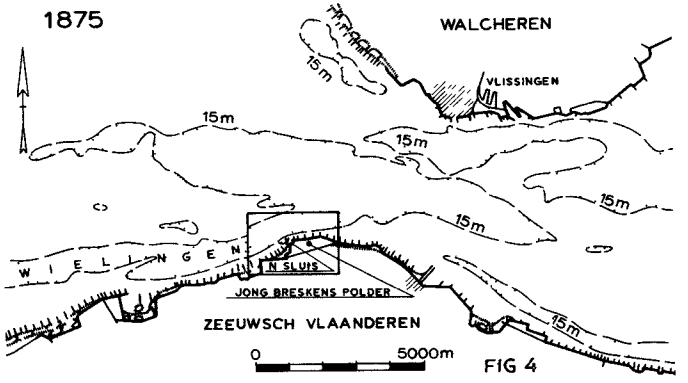

Fig. 4. Depth-contours in the Westerschelde-mouth (1875).

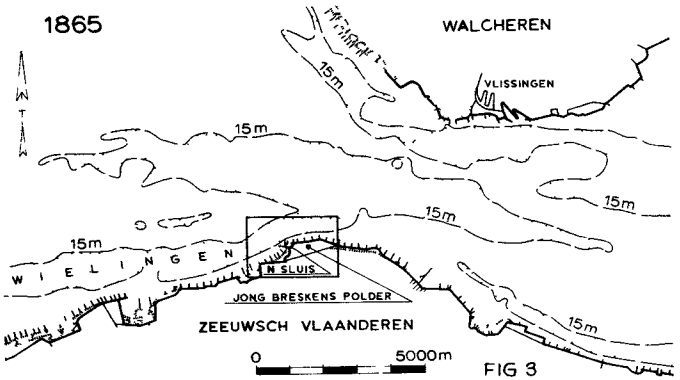

Fig. 3. Depth-contours in the Westerschelde-mouth (1865).

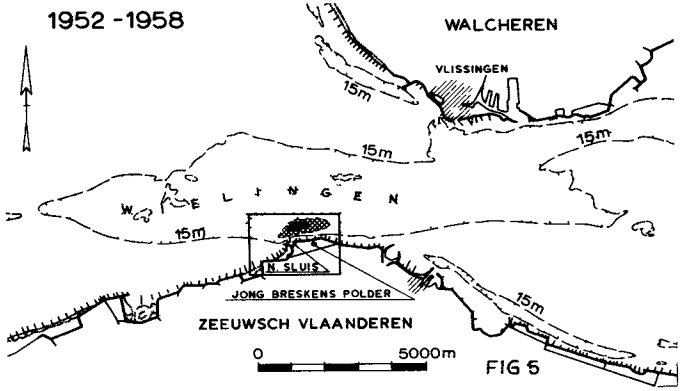

Fig. 5. Depth-contours in the Westerschelde-mouth (1852-1958).

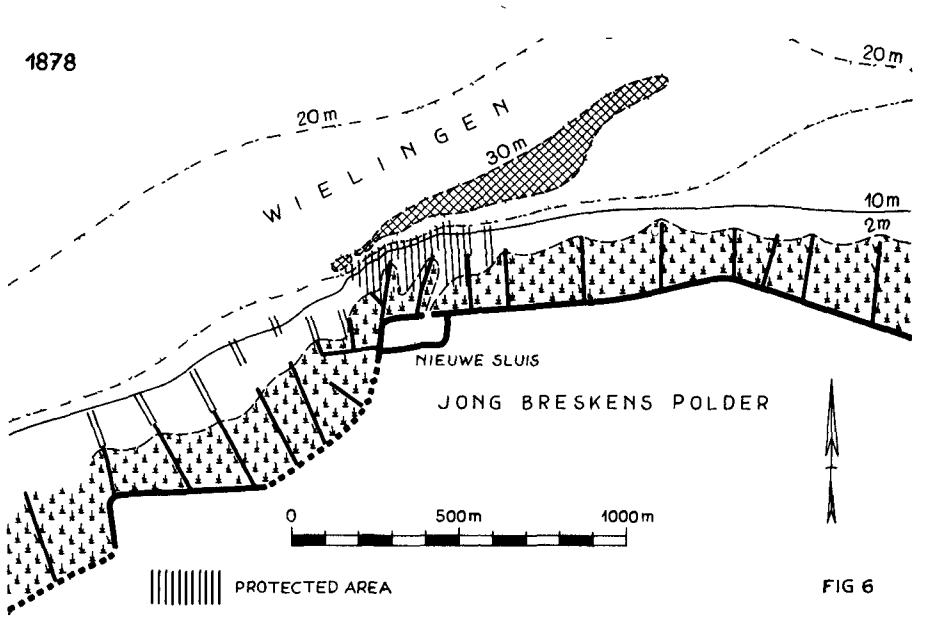

Fig. 6. Early-development near Nieuwe Sluis (1878).

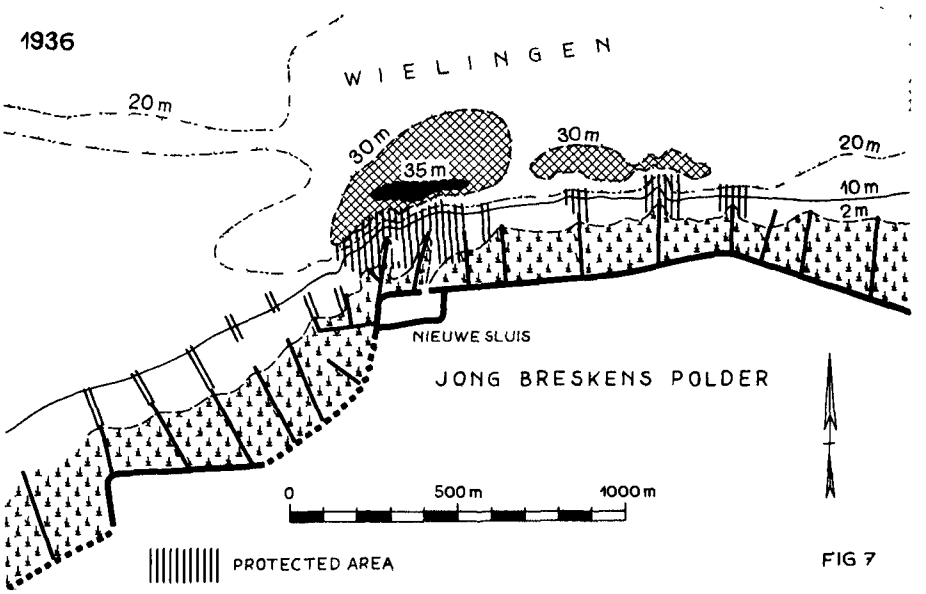

Fig. 7. Scourholes near Nieuwe Sluis caused by badly shaped shore-protection works (1936).

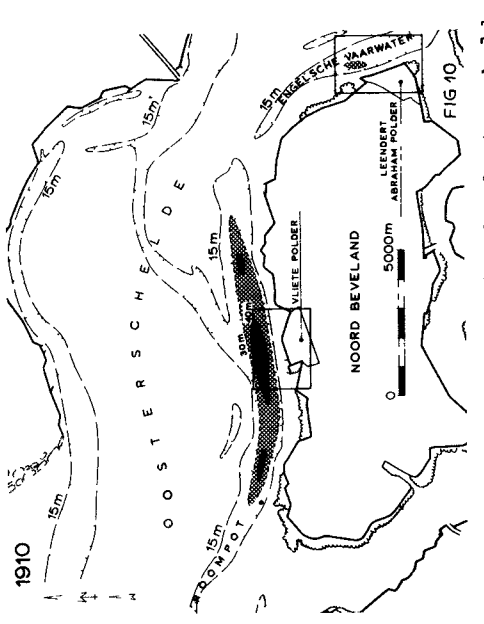

Fig. 10. Depth-contours in the Oosterschelde (1910).

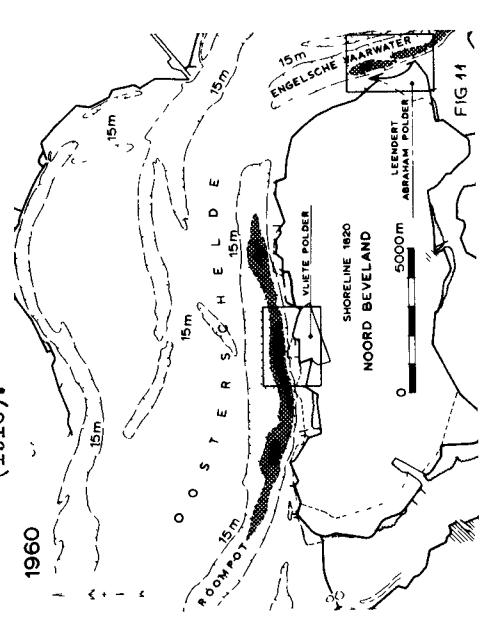

Fig. 11. Depth-contours in the Oosterschelde

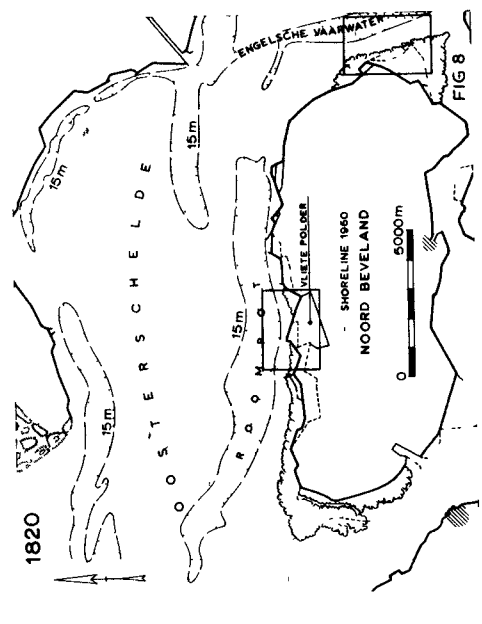

Fig. 8. Depth-contours in the Oosterschelde (1820).

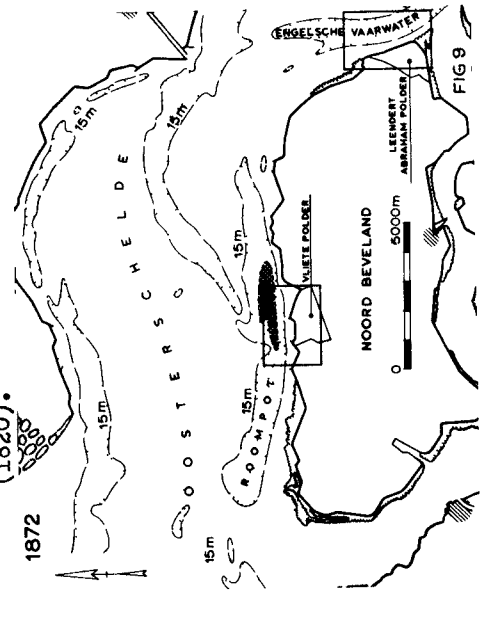

Fig. 9. Depth-contours in the Oosterschelde

THE INFLUENCE OF SHORE PROTECTION WORKS ON GULLIES

At the end of the 18th and at the beginning of the 19th century some polders west of Nieuwe Sluis were flooded. Owing to this Nieuwe Sluis got a relatively more advanced situation with probably some contraction of the stream.

Before 1830 the shore was already protected at some points by means of rip-rap. At several points mattresses (willow mattings) have since then been placed. They are indicated on the figures nos. 6 and 7.

Because of the irregular shape of these constructiόns the currentpattern was unfavourably influenced, causing considerable deepenings to the adjacent unprotected shore, which were attended with dozens of falls and slides. Parts of the protectionworks were thus lost. Extension proved to be necessary.

About 1880 an uninterrupted protection was reached. Some 90.000 m2 of the underwatershore had been covered with matresses and with 65.000 tons of rip-rap.

This bastion has influenced the stream in the gully. Local scouring of the sand-bed occurred; see the figures nos. 6 and 7 with the situations of 1878 and 1936. The bottom topografy shows that the scourholes are due to turbulence and not to the normal tidal stream.

VLIETE POLDER

Early in the 19th century some parts of the northern shore of Noord Beveland were affected partly because of the irregular shore line; see figure no. 8.

The first protection was introduced about 1820 in front of the Vlietepolder, where some attacked places were protected with small mattresses covered with rubble-stone. Later on these constructions were connected to the shore by means of submerged rubble-dams. This way of protecting the shore caused considerable erosion up to N.A.P. - 40 m, where formerly a depth of 15 m was sounded.

After some time 60.000 m2 of the underwater shore was covered with mattresses and with 80.000 tons of rip-rap. Also because the mattresses were placed over the existing constructions (so far as still present) a very irregular and unequal topography of the protection works developed.

The gully in front, the Roompot, moved to the shore, causing local depths of N.A.P. - 45 to 50 m; these pits enlarged in the longitudinal direction of the gully; see the figures nos. 8, 9, 10 and 11 with the situations of 1820, 1872, 1910 and 1960.

Owing to the southward movement of the gully many falls and slides occurred, through which the shoreline drew back; see the figures nos. 12, 13 and 14.

LEENDERT ABRAHAM POLDER

The above mentioned development led to the enlargement of the Roompot's profile. This may have caused an increasement of the gully's capacity which will have influenced the development of the adjacent gullies by changing the distribution of the tidal-water in the different gullies of the sea-arm. The changing of the slope of

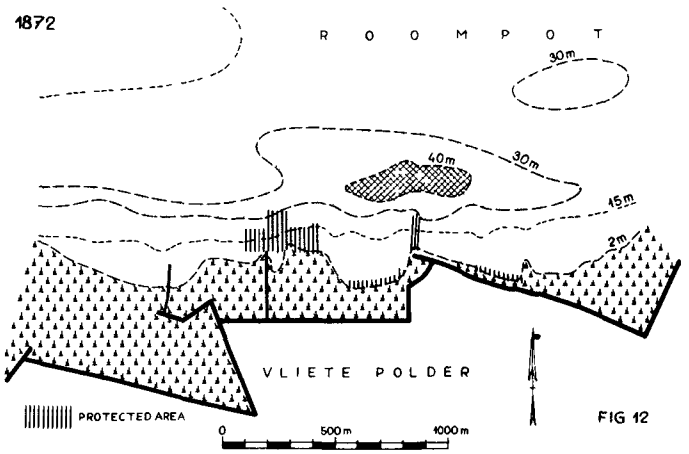

Fig. 12. Early development near Vliete Polder (1872).

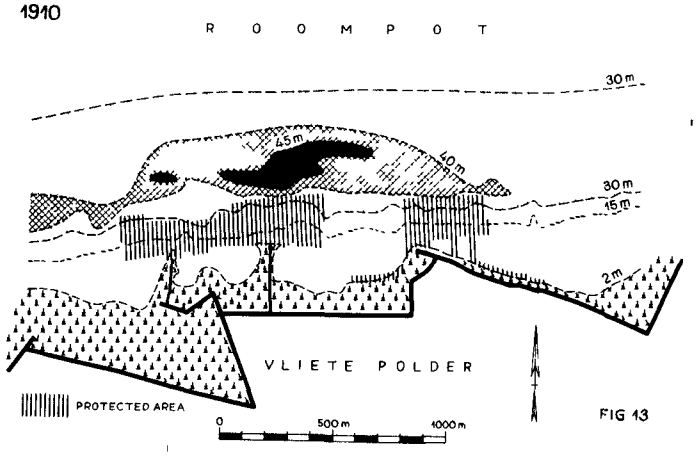

Fig. 13. Protection-works-caused erosion near Vliete Polder (1910).

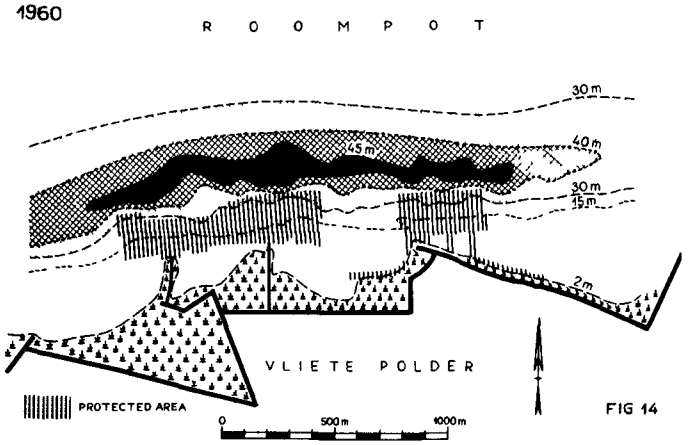

Fig. 14. Further erosion near Vliete Polder (1960)

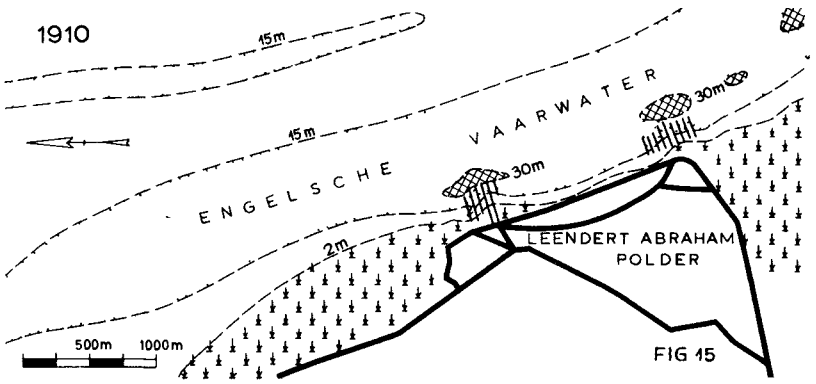

Fig. 15. Early development near Leendert Abraham Polder (1910).

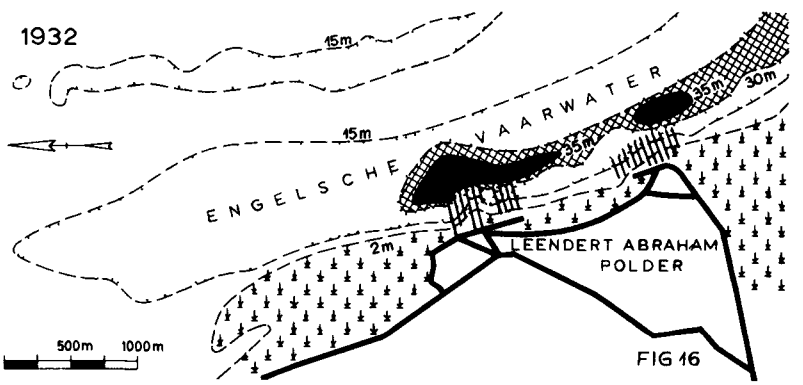

Fig. 16. Protection-works-caused erosion near Leendert Abraham Polder (1932).

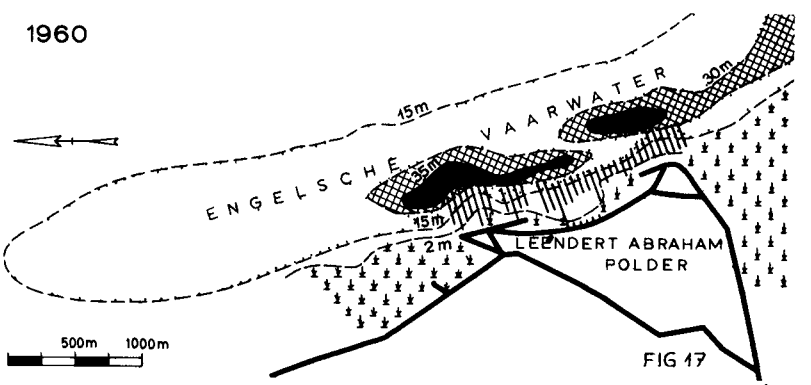

Fig. 17. Further erosion near Leendert Abraham Polder (1960).

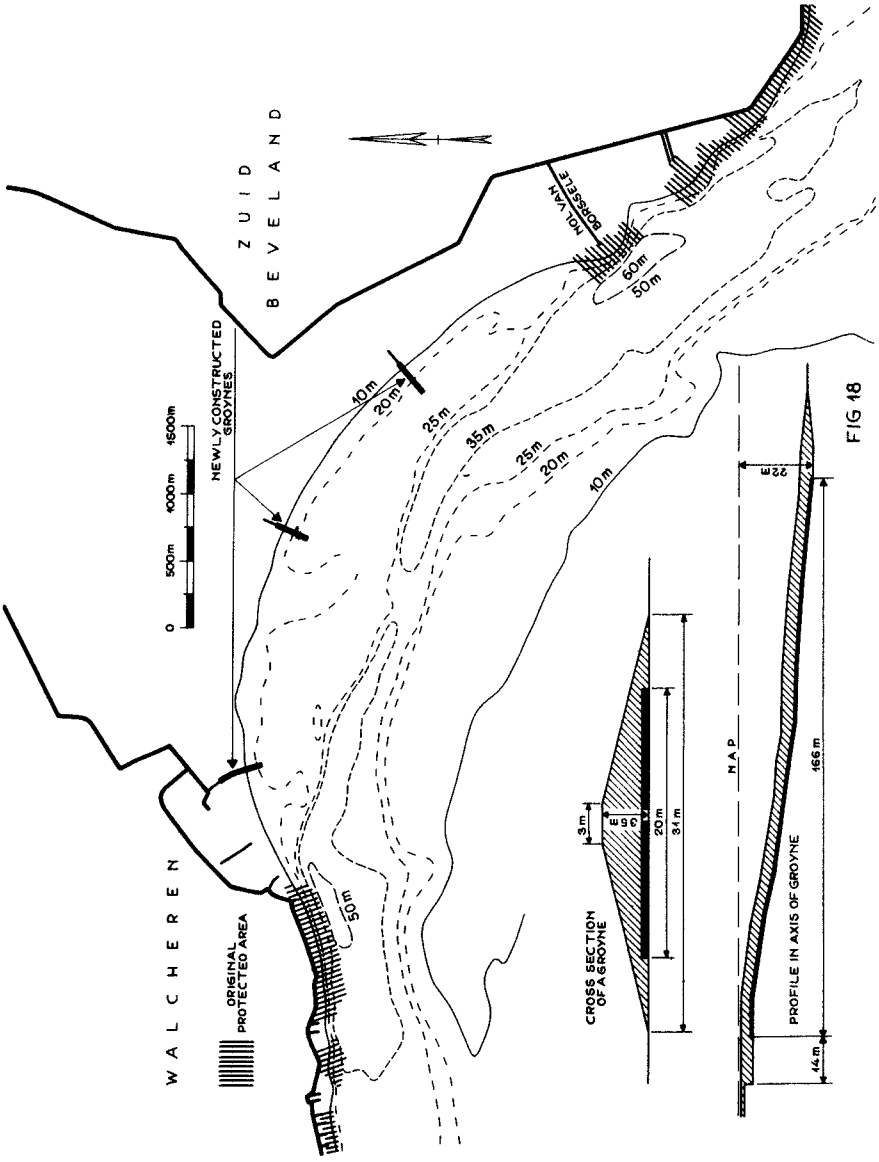

Fig. 18. Protection-works between Walcheren and Zuid-Beveland.

the watersurface between the gullies Roompot and Engelsche Vaarwater forced the latter to move westward, though some curve-effect cannot be neglected; see the figures 8, 9, 10 and 11. Other developments may be noticed too, which will not be dealt with in this paper.

The Engelsche Vaarwater moved to the west, attacking the most eastern part of Noord-Beveland, the so-called Leendert Abraham Polder.

About 1880 it was thought necessary to protect the shore. Two extensive shore protection works were built.

Near these works scourholes were formed, necessitating an expansion of the protection: 300.000 m2 of the shore were covered with mattresses and with 300.000 tons of rip-rap.

After this local scouring up to N.A.P. - 45 m took place. The gully moved to the shore and was held there.

A picture of the development is given by the figures nos. 15, 16 and 17, which also show the retiring of the shoreline, owing to numerous falls and slides, causing the destruction of the initial dike.

SUPPLEMENTARY REMARKS

Shore protection works are built to divert the stream from an attacked shore or to reduce the effect of the stream.

With the construction of a shore protection work of rip-rap with of without mattresses the watermovement next to the work will be disturbed by turbulence near the bottom.

By the building of groynes moreover the velocity gradient in a cross-section of a stream will increase.

In both cases the result is erosion of the unprotected parts of the shore. After some time these parts will have to be protected too. In this way a bastion of rip-rap or an extended series of groynes will be obtained in due course.

In front of both such a bulwark and such groynes the velocity-gradient will be so great that deep pits will be formed. By the turbulent stream these pits will be eroded to troughs in the direction of the stream.

A great part of the discharge which passes through the total cross-section of the sea-arm will take its way via this deepened gully which will in general develop into a main gully at the expense of the by-gullies.

The influence of shore-protectionworks appears to be effective even when built in deteriorating gullies.

The developments described are due to an imperfect design of the defenceworks. A badly shaped construction causes a strongly turbulent currentpattern, as a result of which powerfull erosive forces come into being. This can be prevented by giving a better design to the defence-works.

A protection made of rip-rap will have to be constructed in such a way that it doesn't show high and irregular elevations.

When the shore is not steep yet, it will be best to build groynes under a mild slope, equal to the slope of the shore, through which in fact a submerged stoneridge is created.

Laboratory-tests proved that with a slope of 1 : 8 the deepening in front of the groyne is small, while little regression of the shore between the groynes takes place. Steeper slopes than 1 : 8 are not to be recommended. This subject is treated in detail in (1) and (2).

Recently the slightly eroding shore between Walcheren and Zuid-Beveland has been fixed over a length of about 5 km between the existing protective works by means of three groynes, sloping under 1 : 8 from the lowwaterline to a depth of N.A.P. - 20 m; see figure no. 18. The results seem satisfactory.

The bastion to the east of this, called Kol van Borssele (a spurdike, i.e. a remainder of a former dike), has caused a very deep scourhole of more than N.A.P. - 60 m. In the laboratory it was found possible to get a sanding-up of the scour-hole up to a depth of N.A.P. - 40 m by reconstructing the bastion. To this end the originally high bastion was bevelled in the laboratory to 1 : 8 from N.A.P. - 20 m upwards.

CONCLUSIONS

It may be said that on sandy shore the design of a shore protection work is of the greatest importance for the erosion of the shore, for the generation of deeply scoured troughs and for the development of the gully-system. The influence of these constructions is by no means restricted to the immediate vicinity.

Groynes constructed under a slope of 1 : 8 will reclaim the shore, while the current-pattern is hardly disturbed.
This will also have a favourable influence on the stability of slopes in areas which are sensitive to slides.

Rip-rap defenceworks extending over a large area are expensive and should therefore be avoided. If nevertheless constructed they should have a regular surface.

Some existing shoreworks had rather be reconstructed, to which a milder slope is generally recommended. Further studies and especially detailed laboratory-tests are in most cases necessary to solve these problems

ACKNOWLEDGEMENT

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3. Scour around obstructions, mrs Garde, Subramanya and Nambudripad; Irrigation and Power nr. 18. 1961, nr. 7.
4. Local scour in rivers, Tison; Journal of Geophys. Res. 66, 1961, nr. 12.