

# Scroby Sands Offshore Windfarm

Why use a three piece solution if two works?



The foundations for the **Scroby Sands Windfarm** were installed in 2004. The windfarm is situated off Great Yarmouth in South Eastern England on a strange subsea sand bank. The wind park comprises 30 x 2 MW Vestas wind turbines. The 30 monopile foundations were designed by **LICEngineering A/S** and included several ground breaking new features. The monopiles were pre-fitted with welded flanges on the top for connection to the turbine (WTG) and were installed in a pure pile driving operation, leaving the piles immediately ready for installation of access arrangement and tower after piling. It is the first time this highly cost-efficient design has been used, simplifying offshore operations and avoiding the requirement for grouting operations.

## Project Details

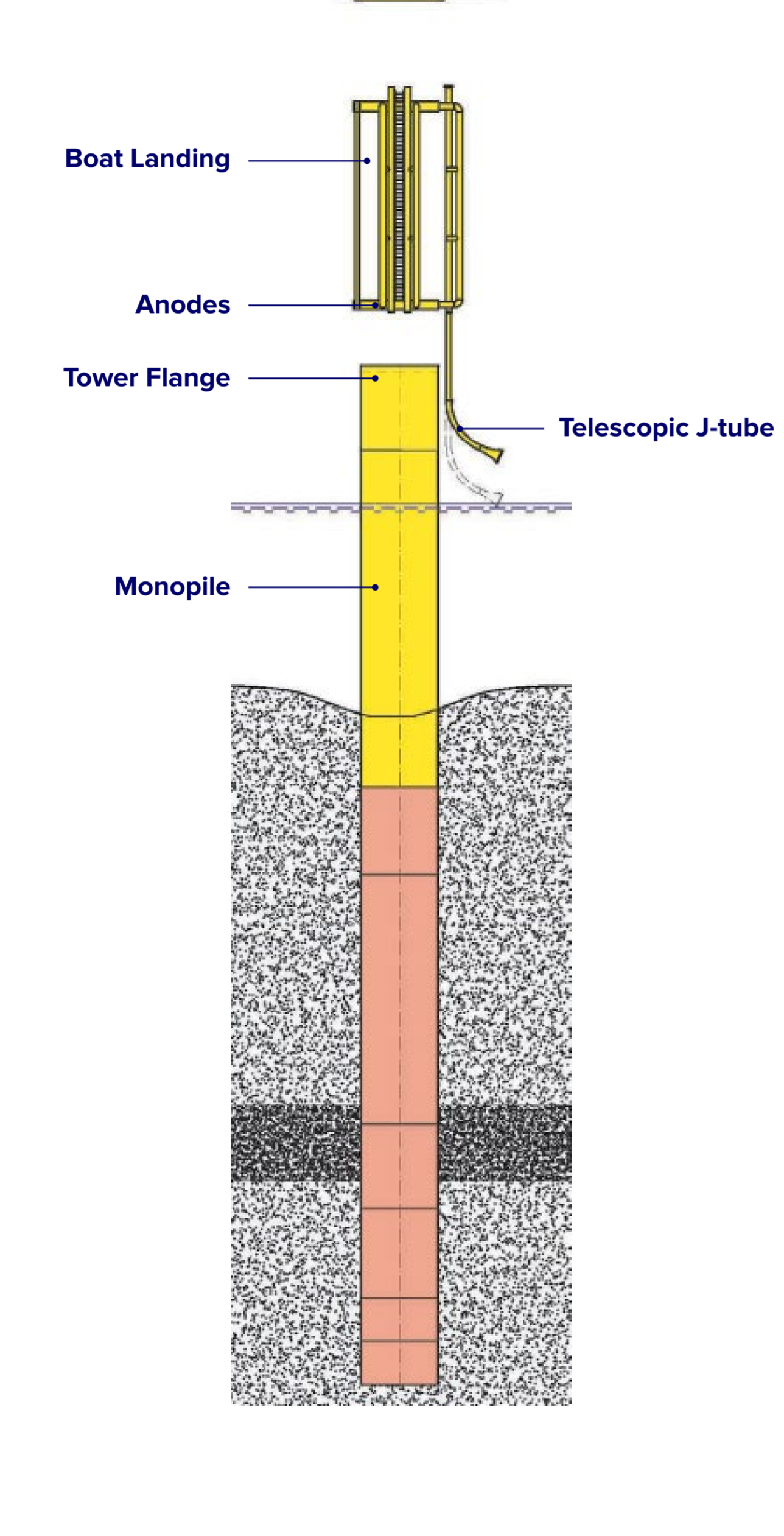
The windfarm was developed by Vestas Celtic for Powergen Renewables Offshore. LICEngineering A/S carried out detailed design of the foundations and associated structures. Structures were fabricated by Isteburn. The installation of the turbine foundations including installation of scour protection was undertaken by Mammoet Van Oord. Today the windfarm is operated by E.ON Climate & Renewables Ltd.

## Design Analysis

The design analyses were carried out by LICEngineering to determine the required wall thickness and penetration depth for the monopile. Dynamic analyses were carried out including the vibrational behaviour of the pile and tower subjected to combined wave and wind loads. The pile was designed to resist ultimate storm loads and fatigue loads in the operational lifetime. The integrated boat landing and J-tube arrangement was analysed for waves and current on the location.

Already in 1998 LICEngineering initiated the test program for the flanged monopile and the fatigue conditions during piling. Many other features were investigated in this study including vibration studies, tolerances studies for hammer and monopile.

Much of this work then later became the basis for the design on Scroby Sands Offshore Windfarm. Work was funded by Danish Energy Agency and a summary of the work can be found [here](#) or issued if contacting LIC directly.



## Installation Aspects

The design simplifications, especially the driving operation with the top flange in place, reduced the foundation installation costs very significantly with total installation times for one foundation of around 24 hours or below. The piles (up to 200 T per pile) and steel structures were transported directly on the jack-up rig to the field, thereby simplifying the logistics and number of offshore operations.

## Foundation Layout

The foundation consists of a steel monopile with a diameter of 4.2 m and with a welded flange for tower connection at the top. A number of doubler plates are welded to the outside of the pile for attachment of boatlanding and access platform. Near the top of the pile is hung off a flexible strap internally in the pile. This platform was placed off in a work platform arrangement during pile installation and finally bolted in position following the pile installation.

## Geotechnical Conditions

The soil on Scroby Sands mainly consists of sand with some clay and silt layers embedded. Four survey boreholes were drilled initially and the soil samples analysed in the laboratory. The sand on the location generally has a high relative density. The specific site is centered at 52.646 degree LAT and 1.788 degree LONG in a 4 km<sup>2</sup> area at about 3.5 km from shore.

## Driving of Pile with Flange and Internal Bulkhead

The monopiles were installed by a pure pile driving operation. The hammer anvil was placed directly on the welded flange on the top of the pile. Driving installed pile of this size is believed to be the first time done. However, all piles were driven successfully within tolerances and without damage to the flanges.

An internal platform near the top of the pile was installed in order to carry out installation of boatlanding and access platform immediately after pile driving. It was decided to design a platform, which could be pre-installed before pile driving. LICEngineering A/S designed the platform, which was hung off in robust strapping and rubber shock absorber arrangements during pile driving. The 30 pile driving operations were completed successfully with the bulkheads in

## Scour Design

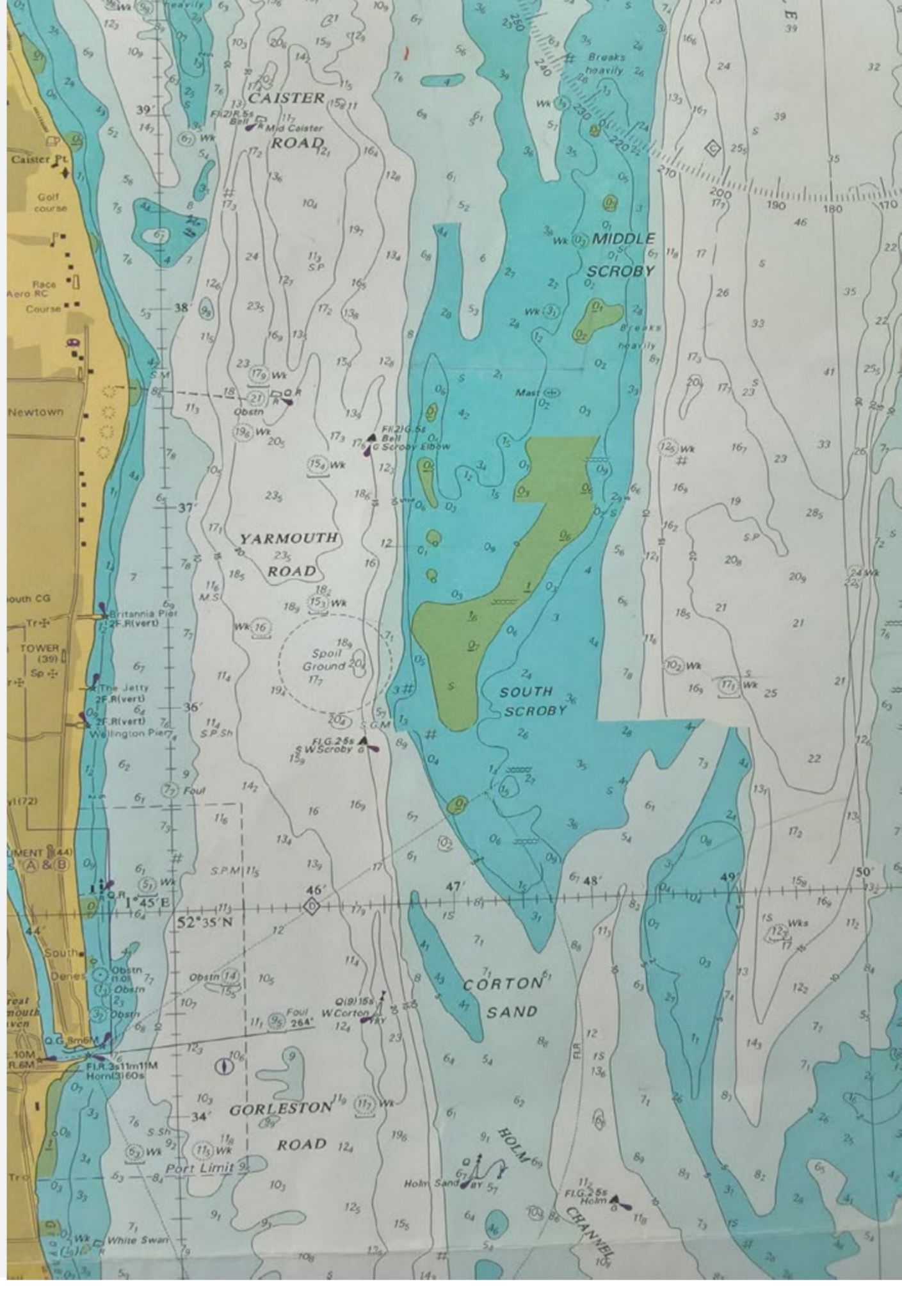
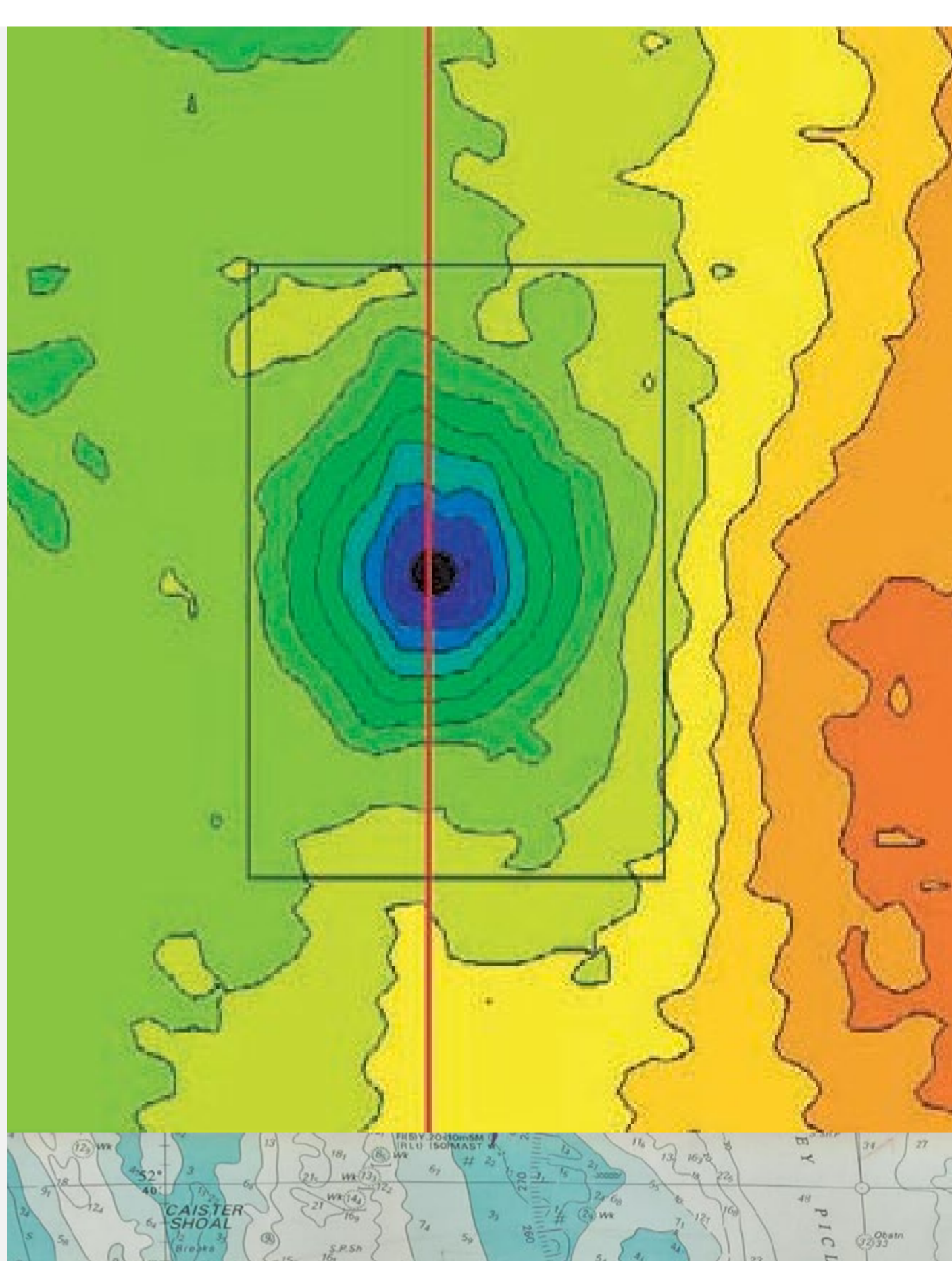
Due to very high scour potential the scour protection design was very important. The J-tubes were designed to accept variations in actual water depth. Scour analysis was carried out and the scour development envelopes predicted. The actual scour development corresponded very well with design analysis and the fully developed scour holes were filled with rock graded scour protection materials, also protecting the J-tubes and cables exits.

## Hydrographics

The Scroby Sands is a sand bank situated 3 km East of the Great Yarmouth Borough coastline in Norfolk. The seabed is sand, which shows high local variations over time. The water depth at the site is around 10 m but can vary at one location with up to 5 m, depending mainly on high currents. The sand banks are oriented mainly North-South with seabed slopes running East-West. The 30 foundations are placed at water depths from 5-10 m

## Access and J-Tube Arrangement

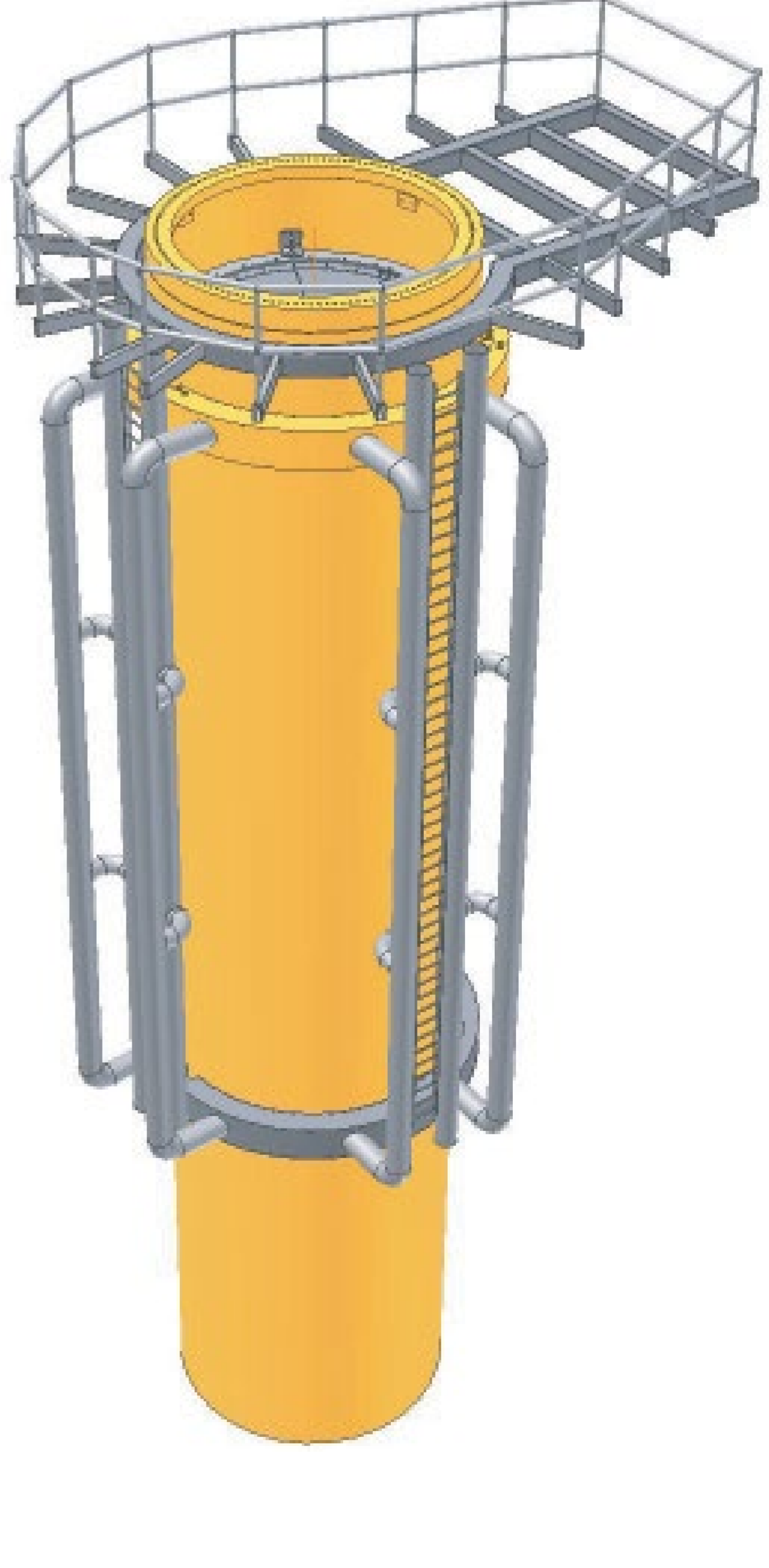
The boatlanding includes two access ladders to accommodate boat approach from different directions. The unit is a separate item also including fenders and J-tubes. The access is locked in position with doubler plates and adjustable bolt arrangements. Cathodic protection in the form of anodes is placed on the lower fender ring. The J-tubes are of adjustable of the final exit elevation and exit angle including a telescopic connection, which is locked after installation.



## The Scroby Sands Farm comprises 30 Vestas Turbines

Type of Structure	Wind Turbine Generator Vestas V80-2MW. Hub height 60 m and Rotor diameter 80 m.
Location	Central North Sea, Great Yarmouth
Maximum Water Depth	21 m (10 m average) <sup>1</sup>
Pile Diameter At Seabed	4.2 m
Installed	2003-2004
Installation Method	Driving with hydraulic hammer (IHC 1200)
Number of Foundations	30 (Fully commissioned)
Maximum Pile Penetration Below Seabed	31 m
Connection Tower/Pile	Flange connection
Special Feature	Pile driven with flange (no transition piece).
Scour Protection	Stones placed in fully developed scour holes and base of piles.
LIC Engineering Tasks	<ul style="list-style-type: none"> <li>• Concept development.</li> <li>• Tender design, detailed design.</li> <li>• Specifications</li> <li>• Installation design</li> <li>• Engineering follow-up</li> <li>• Special supervision.</li> </ul>

<sup>1</sup> Design water depth. The turbine foundations are designed for large long term variations in the seabed level, up to 9 m.



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