**The new Beach Management System at Lido Adriano, Ravenna, Italy**

A new drainage system has been recently installed at the mouth of the Fiumi Uniti, south of Ravenna (Fig. 1). The system is installed on behalf of ENI (Ente Nazionale Idrocarburi), the Italian national agency for oil exploration. ENI has agreed to build this experimental site to provide information to local and regional authorities (the Ravenna Municipality, the County Council and the Regione Emilia-Romagna) on the feasibility of such a solution for stabilisation of beaches adjacent to river mouths. River mouth erosion is indeed a widespread problem in the northern Adriatic, partially due to a decrease in bedload which has affected Italian rivers since the 1970s, following stabilisation of hillslopes. Additionally the drainage system is of interest to ENI as this may provide a sea-water intake for reinjection into reservoirs. The Consorzio Ferrara Ricerche is monitoring the site under the direction of the research group headed at the University of Ferrara by Prof. Paolo Ciavola (http://web.unife.it/ricerca/copru/copru.htm) while Prof. Diego Vicinanza from the Second University of Naples (http://dic.dnsalias.net/index.php?sezione=persone&id=dievicin) was appointed by the regional authorities as an independent witness to judge the efficiency of the system.


Fig. 1. Location of the new BMS site at the mouth of the Fiumi Uniti, between the resorts of Lido Adriano and Lido di Dante (GoogleEarth image)

The drainage system was installed by IMPRESUB (http://www.bms-on-line.com/index.asp) after a long and comprehensive feasibility study, which included numerical wave modelling, topographic and bathymetric surveys, geotechnical studies. The geological environment of the studied beach represents a challenge, as because of its location at the mouth of the river the sand wedge of the beach includes clay lenses at depths around mean sea level, corresponding to former river channels (Fig. 2). These at times become exposed at low tide in periods when the beach sand stock is depleted (Fig. 3). Clearly the presence of these clay layers causes an average low permeability of the site, in the order of $10^{-5}$-$10^{-6}$ cm $s^{-1}$.

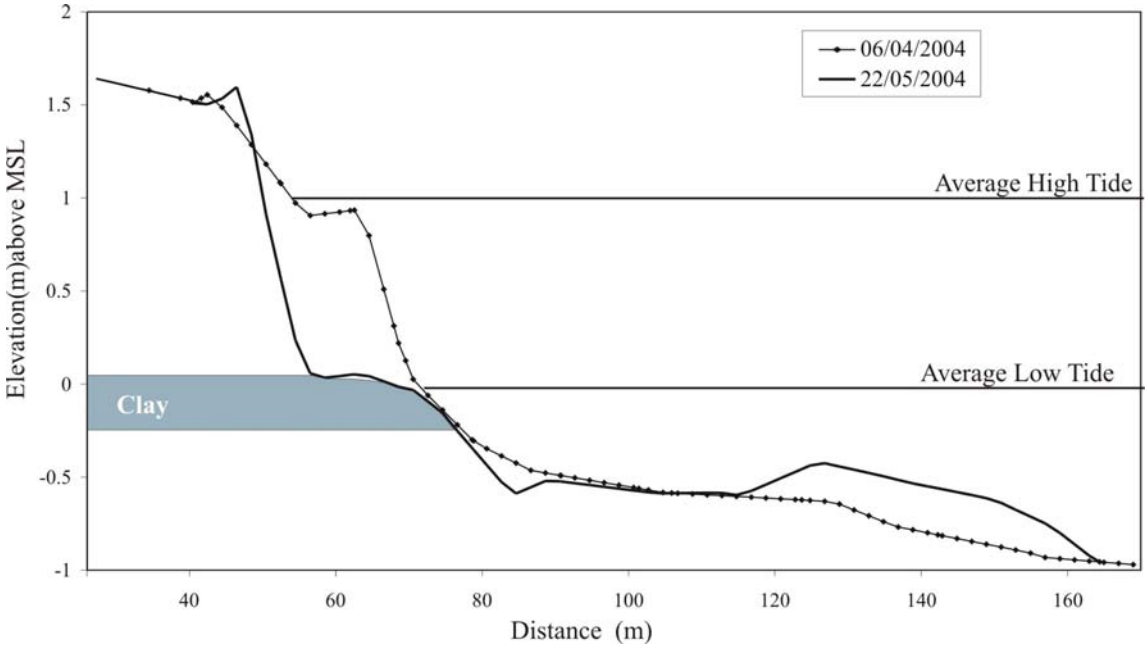


Fig. 2 Profile variability and location of clay layers at the study site


Fig. 3 View looking south across the site. The letter (A) indicates outcropping clay layers, the letter (B) indicates the approximate location of the drain. Photograph of 22 May 2004.

The drainage system consists of two parallel drains (100 m long) parallel to the shore and connected to two pumps located in the upper part of the beach. The pumps transfer water into a distribution network that currently discharges the water back at sea at the base of a sea-wall. The system was designed for an average discharge of 12 l $s^{-1}$

The system became operative on 21 April 2004. Since then the University of Ferrara has carried out monitoring at different scales and in particular:

1. Direct monitoring of nearshore waves and currents during the start-up of the system, locating two multiparametric platforms (currents and directional waves) at the base of the foreshore and at a depth of – 3 m below MSL (Fig. 4). Wave and currents were measured on-site at these two points for a period of 87 hours after the beginning of system operation. Later only one wave measuring station was maintained for a period of six months.

Fig. 4. View of one of the directional wave gauges after retrieval for maintenance

2. A line of three self-logging piezometers was installed across the drains to monitor the efficiency of the system during the initial phases of operation (Fig. 5). The system went into a fully operation regime after about 5 hours from power-up and the piezometers indicated a positive influence of the drain on the water table around it. The seaward piezometer still exhibits a tidal signal possibly because of the low permeability of the intermediate sea-bed, while the upper piezometer is registering freshwater lenses.

3. High precision beach DGPS surveys (RTK) have been carried out since installation at a variable frequency from days to weeks. One bathymetric survey was also undertaken at installation and was recently repeated (summer 2005) to evaluate movement of sand banks and the subsequent feed-back mechanisms with the drained beach.

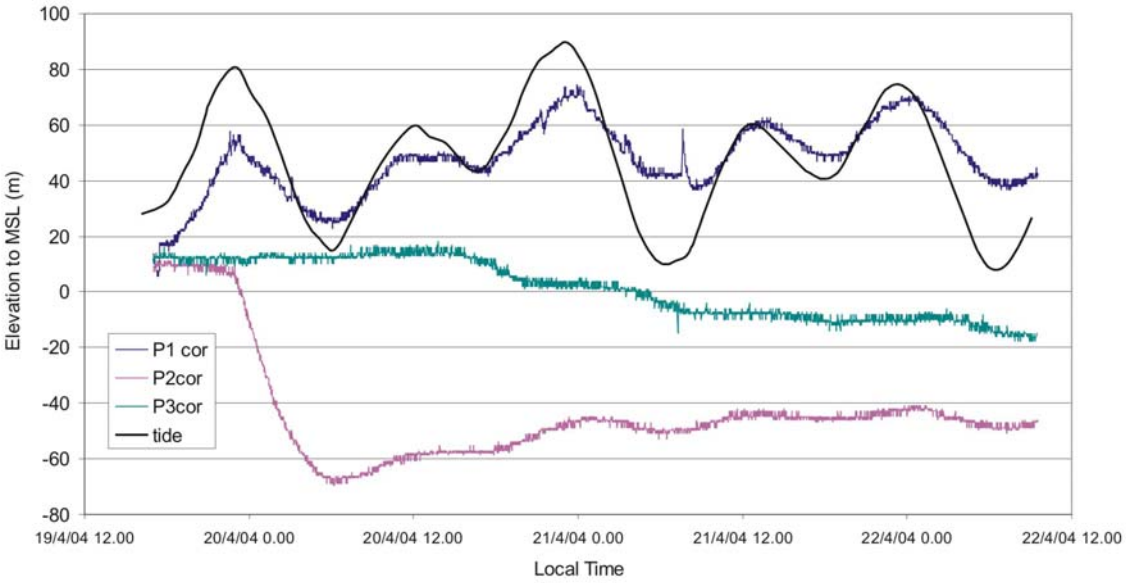


Fig. 5. Oscillations in the water table during the first few days of operation (coloured lines) and tidal curve (black line). The suffix P indicates the piezometers: P1 is at the seaward side of the drain, P2 is on the drain, P3 is on the upper beach away from the drain.

**Preliminary results**

Initially the system only worked up to mid November 2004 when a particularly strong storm (coupled with a storm-surge) undermined the pumping tank on the upper beach causing an electrical failure and power surge. To notice that when the system was initially installed the beach was in a critical erosive state and the new installation was suffering from minor tune-up problems to the pumps. There were weak signs of shoreline advance when the system was operative but these are not considered significant as they were outside the winter season.

The drainage system was finally repaired in February 2005 and a small amount of sand was transferred from the upper beach to the top of the drain to evaluate the ability of the system to stabilise the profile. The system was switched on again on 3 March 2005.

The availability of frequent topographic surveys allows the computation of volume variations between surveys. There is a clear volume increase when the system starts operating (Fig. 6), the arrival of several storms in April-May causes a loss but after that the sand stock seems to become stable.

Monitoring of topographic changes is still on-going on a monthly basis or after high energy events. A self-logging piezometer will also be installed on the drain to monitor the response of the system to storm surges.

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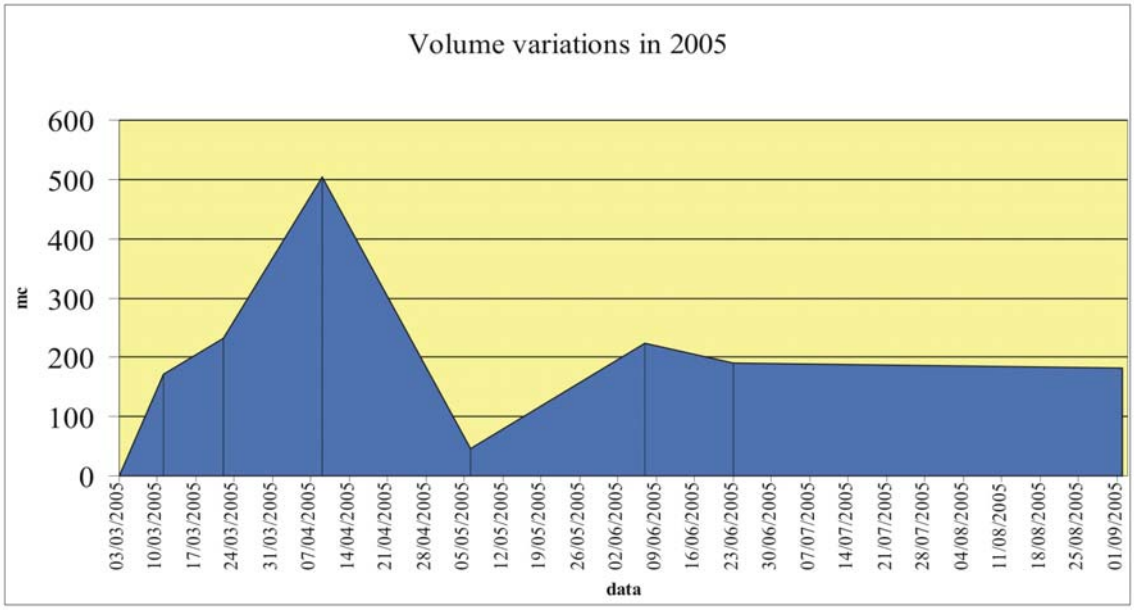


Fig. 6 Relative volume variations between surveys in 2005. The volume is calculated for the sand stock located between mean sea level and the +1 m contour.

Further details on the project may be obtained from:

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