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Ground penetrating radar surveys of embankments on the Reno River and its tributaries (North-Eastern Italy)

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The present study focused on the use of Georadar for the detection of river bank local non-homogeneities (mainly stratigraphic contacts, cavities, conduits), taking into account supplementary data collected with traditional methods, both destructive (boreholes, piezocone penetration test etc.) and non-destructive (geoelectric 2D-resistivity and Multi-channels Analysis of Surface Waves). The research is part of a survey for the detection of the hydraulic and geotechnical conditions of the dikes funded by the Reno River Basin Regional Technical Service of the Regione Emilia-Romagna. The hydraulic safety of the Reno River, one of the main rivers in North-Eastern Italy is in fact of primary importance to the Emilia Romagna regional administration. This concern is reasonable since, in the last decades, several hydro-meteorological events induced structural failures of the embankments. Some of them have been particularly serious, such as the dike breakages of Reno in 1990, Samoggia in 1996, and Quaderna in 2005. In spite of the well developed system of embankments of the Reno River and its tributaries dating in some cases over one hundred years, there is a lack of knowledge on their structural status. Many geotechnical surveys were planned to investigate their structure, but there is still a lack of detailed information. The large longitudinal extent of the banks (several hundreds of kilometres) has placed great interest in non-destructive geophysical methods, which, compared to other methods such as drillings, allow for faster and often less expensive acquisition of high-resolution data. Therefore, the main scope of this research is to highlight advantages and drawbacks in the use of Georadar compared to other methods. The paper presents the results of pre-

liminary Georadar survey campaigns, with data collected using Radar SYR 3000 by GSSI with antenna setting of 100 MHz, 500 MHz, and RIS-MF system, by IDS, made up of multi-frequency and multi-polarisation arrays, equipped with 200 and 600 MHz antennas. Profiles have been implemented mostly along top, flank and base of the river banks, stretching a distance of about 100 m each; they were processed and plotted with Seismic Unix and GRESWIN 2 software. Using 100 and 200 MHz antennas a depth of 3,5 - 4 meters has been reached, while using 500 and 600 MHz antennas a shallower penetration (about 2 - 3 meters), but with optimal vertical and horizontal resolution, has been yielded. Preliminary interpretation of the collected data reveal that the antenna frequency has to be strongly related to the aim of the analysis: antennas with frequency around 100-200 MHz are suitable to acquire information about different layers and horizons inside older embankments, on the other hand relatively high frequencies (500 - 600 MHz) seem to be optimal to detect cavities, pipelines in the first 2-3 meters under the ground surface. Some factors, related to the complicate estimation of wave velocity in the ground as well as the attenuation losses of wave propagation, due to different content in clay, silt, and sand, limit the correlation between Georadar profiles and classical 1D geotechnical information (boreholes, piezocone penetration test). Finally, non-homogeneities in soil saturation and different sediment compaction complicate the interpretation. As far as the Georadar survey is suitable for checking up geotechnical river dike conditions, more field test are needed along the whole extension of embankments, especially to face future severe flood events.