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Multi-scale approach for 3D hydrostratigraphic and groundwater flow modelling of Milan (Northern Italy) urban aquifers.

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During the last century, urban groundwater was heavily exploited for public and industrial supply. As the water demands of industry have fallen, many cities are now experiencing rising groundwater levels with consequent concerns about localized flooding of basements, reduction of soil bearing capacities under foundations, soil internal erosion and the mobilization of contaminants. The city of Milan (Northern Italy) draws water for domestic and industrial purposes from aquifers beneath the urban area. The rate of abstraction has been varying during the last century, depending upon the number of inhabitants and the development of industrial activities. The groundwater abstraction raised to a maximum of about 350x106 m3/yr in the middle 1970s and has successively decreased to a value of about 230x106 m3/yr at present days. This caused a water table raise at an average rate of about 1 m/yr inducing infiltrations and flooding of deep constructions (e.g. building foundations and basements, underground subway excavations).

Starting from a large hydrostratigraphic database (8628 borehole logs), a multi-scale approach for the reconstruction of the aquifers geometry (unconfined and semi-confined) at regional-scale has been used. First, a three-level hierarchical classification of the lithologies (lithofacies, hydrofacies, aquifer groups) has been adopted. Then, the interpretation of several 2D cross-sections was attained with Target for ArcGIS exploration software. The interpretation of cross-sections was based on the characteristics of depositional environments of the analysed aquifers (from meandering plain to proximal outwash deposits), on the position of quaternary deposits, and on the distribution of geochemical parameters (i.e. indicator contaminants and major ions). Finally, the aquifer boundary surfaces were interpolated with standard algorithms.

The hydraulic properties of analysed aquifers were estimated through the analyses of available step-drawdown tests (Theis with the superimposition solution) and use of empirical relationships from grain-size distribution data, respectively for semi-confined and unconfined aquifers.

Finally, 3D Finite Element groundwater flow models have been developed both at regional and local "metropolitan" scale. The regional model covers an area of 3,135.15 km2, while the local model comprises the Milan metropolitan area with an extension of 457 km2. Both models were discretized into a triangular finite element mesh with local refinement in proximity of pumping wells. The element size ranges from 350 to 30 meters and from 200 to 2 meters, respectively for regional and local model. The calibration was done by the comparison with the available water level data for different years (from 1994 to 2016). The calibrated permeability values are consistent with the estimated ones and the sensitivity analysis on hydraulic parameters suggests a minor influence of the aquiclude layer separating the two aquifers.

The challenge is to provide the basis for new types of applied outputs so that they may better inform strategic planning options, ground investigation, and abstraction strategies.