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Dipolic Flows Relevant to Aquifer Storage and Recovery: Strack's Sink Solution Revisited

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Abstract Steady, 2-,3-D Darcian flows generated by a dipole (a pair of horizontal or vertical injection–abstraction wells closely placed one above another), with circulation of fresh water inside an interface confined lens or "bubble" underneath an impermeable caprock, surrounded by a static saline groundwater, are analytically studied. For 2-D dipole, the complex potential domain is a plane with a horizontal cut. This domain is conformally mapped onto a reference half-plane where the Keldysh–Sedov formula is used to obtain the complex physical coordinates. Explicit closed-form expressions for the vase-shaped interface, flow net, isohypses, magnitudes of the Darcian velocity and Riesenkampf's resultant force are obtained, depending on the dipole moment, its position with respect to the caprock, and the ratio of densities of the two fluids. It is shown that for sufficiently small injection-pumping rates the fresh water "vase" separates from the caprock and becomes a circle, inside which streamlines are Newtons' loops of monodiametral degenerate hyperbolae (cubics). Two numerical codes, MT3DMS and SEAWAT, are also used for delineation of isoconcentric lines, which qualitatively corroborate the analytical solutions in delineation of the "bubble" in the part where the sharp interface model predicts stable free boundaries and evidencing "dimples" on the boundary of the "bubble" where the saline water overlies the fresh one. For 3-D dipole not bounded by the caprock, the analytical fresh water "bubble" is a sphere and solution follows, *mutatis mutandis*, from the textbook formulae for flow of an ideal fluid past an impermeable sphere. The Stokes streamlines inside the sphere are sixtics; isotachs are plotted in an axial section. Stability of the soil matrix near the wells is also discussed.

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