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- 4-B1. Low-flow investigations, by H.C. Riggs: USGS-TWRI book 4, chap. B1. 1972. 18 p.
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- 6–A2. Documentation of a computer program to simulate aquifer-system compaction using the modular finite-difference ground-water flow model, by S.A. Leake and D.E. Prudic: USGS–TWRI book 6, chap. A2. 1991. 68 p.
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