# HYDROGEOLOGIC CHARACTERIZATION OF FRACTURED ABO AND MADERA FORMATION AQUIFERS, HYDROCARBON CONTAMINATION AND TRANSPORT ALONG THE ZUZAX FAULT, TIJERAS CANYON, NEW MEXICO

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**Abstract**—Three separate water producing zones and two localized perched zones were identified within approximately 240 ft of ground surface in the Abo Formation and uppermost Madera Formation during an investigation into gasoline contamination of ground water conducted by the authors for the New Mexico Environment Department (NMED) at the Indian Hills site in the vicinity of Zuzax and Tijeras, New Mexico. Ground-water flow beneath the site occurs in fractured sandstone and limestone beds that are separated by leaky mudstone and shale aquitards. Two separate hydrocarbon plumes located along the Zuzax fault have migrated into both unconfined and leaky-confined aquifers and have contaminated several domestic and commercial wells in the area. A 0.75-mi-long benzene, toluene, ethylbenzene, xylenes (BTEX) and methyl-tert-butyl ether (MTBE) plume and a 500-ft BTEX/EDC (dichloroethane) plume originate from separate locations. Under the influence of down-gradient pumping stresses, contamination of the aquifer located below the BTEX/MTBE source at a depth of 60–80 ft has migrated vertically along a structure perpendicular to the Zuzax fault into a leaky-confined aquifer located at a depth of 110–190 ft below ground surface. The BTEX/MTBE plume has subsequently migrated down-gradient along the northeast trending Juniper Ridge half-graben that parallels the Zuzax fault. Pumping test data and contaminant plume geometry indicate that bounding faults are impermeable or low-permeability barriers to horizontal ground-water flow and contaminant migration, and likely act as pathways for vertical ground-water flow and contaminant migration. Pumping tests conducted on wells completed into each aquifer show strong boundary effects from graben bounding faults, demonstrate communication between the Abo and upper Madera formations aquifers underlying the site, and indicate that the aquifer matrix contributes relatively little water to the aquifer system.

## INTRODUCTION

A hydrogeological investigation into hydrocarbon contamination of fractured bedrock aquifers in the lower Abo and upper Madera formations in Tijeras Canyon between Tijeras and Zuzax, NM (Fig. 1) has been conducted by the authors and Glorieta Geoscience, Inc. (GGI) for the New Mexico Environment Department (NMED). The Indian Hills site (Fig. 1) is located approximately 15 mi east of Albuquerque along the Tijeras fault zone, a series of northeast-striking, high-angle faults extending over a distance of more than 50 mi from southwest of Albuquerque to the Cañoncito area south of Santa Fe (Abbott and Goodwin, 1995). The investigation was initiated after a local resident reported tasting gasoline in water pumped from her domestic supply well. Subsequent sampling and water quality testing confirmed the presence of hydrocarbon constituents in several domestic and commercial supply wells in the area. Initial sampling indicated that contaminated domestic wells 120–160 ft deep were located adjacent to relatively shallow (85-ft deep) domestic wells which exhibited little or no hydrocarbon contamination (Drakos et al., unpubl. report for NMED, 1992). Two separate hydrocarbon plumes and sources were identified during the course of the site investigation; (1) a large benzene, toluene, ethylbenzene, xylenes (BTEX) and methyl-tert-butyl ether (MTBE) plume originating from the Canyon Auto source area; and (2) a smaller BTEX/EDC plume originating from the Turner Branch (TB) source area (Fig. 5).

In conjunction with the NMED, GGI conducted an investigation utilizing (1) geologic mapping, (2) measurement of fracture orientations, (3) installation and sampling of monitoring wells, and (4) aquifer testing. The authors supervised a drilling program wherein wells were completed into three separate aquifers and localized overlying perched water zones between 30 and 240 feet below grade. Well screen intervals and surface casing depths were selected based on lithologies and fracture zones observed in continuously cored samples. Wells were drilled and completed into discrete water-bearing zones with overlying aquifers sealed off to prevent cross-contamination of aquifers. Pumping tests ranging in length from one to seven days were then conducted on the three aquifers underlying the site. Water levels were monitored regularly during pilot scale remediation tests up to seven weeks in length.

## HYDROGEOLOGIC SETTING

The Indian Hills Site lies along the northeast trending Zuzax and Juniper Ridge faults and is underlain by Quaternary alluvium and upper Paleozoic sedimentary rocks (Fig. 2). Ground-water flow occurs in fractured sandstone and limestone beds that are separated by leaky aquitards composed of mudstone and shale. Due to facies changes and pinching out of channel sandstone beds within the Abo and Madera formations, correlating between individual boreholes, and between boreholes and outcrops, is problematic. Analysis of slickensides in core samples and in outcrops indicates a predominance of normal and right-

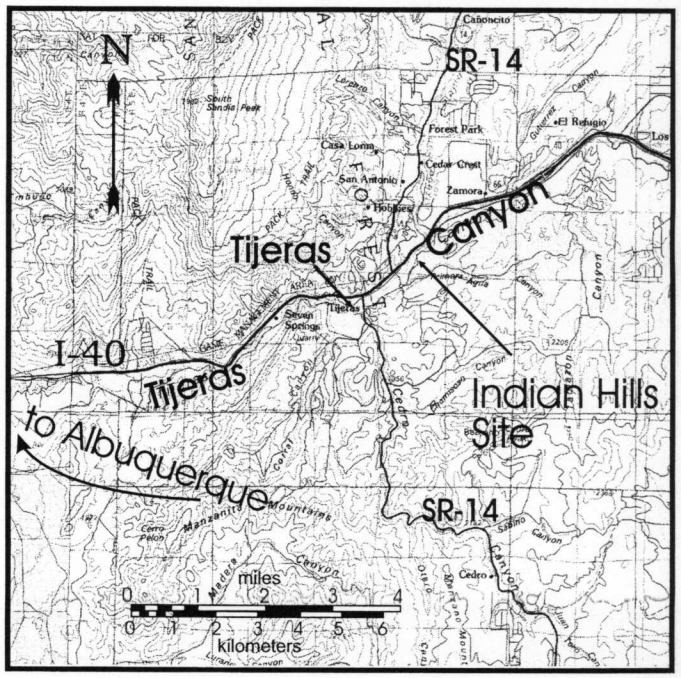


FIGURE 1. Site location map.