The Importance of Independent Access To Individual Fractures

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Research projects sponsored by the US EPA developed hydraulic fracturing as a soil and groundwater remediation tool. During the course of that work, the performance of fractures during fluid delivery and recovery was examined in great detail. The consequences of creating several fractures at different elevations from the same well are summarized in the attached sequence of figures.

The upper section of *Figure 1* shows a profile of pressure contours and streamlines developed around an actual conventional well during the application of soil vapor extraction (SVE) to low permeability glacial till. The details within these profiles were drawn from outputs of AirFlow (an early variant of ModFlow). The computer model was carefully calibrated to match the data collected from more than a dozen tri-level or quad-level piezometers as well as discharge rates and pressures. The locations of these control points are not shown on this figure. This figure, and its companions below, are photographs of the computer monitor.

The tics along the border of photograph are at intervals of 1 foot. The well, which is depicted on the right edge of the picture in the upper section of *Figure 1*, was composed of three 1-foot sections of 2-inch slotted screen in a 4-inch borehole. Bentonite plugs isolated the screen sections. The magnitude of absolute pressure is depicted by color. The vacuum blower affected approximately 70 inches of water suction on each screen. The transition from green to blue, which corresponds to about 10% of suction, occurs within two feet of the conventional well.

The lower section of *Figure 1* shows the greatly expanded pressure field created around three hydraulic fractures that were actually created at the same site and at the same elevations as the screen sections depicted in the upper photograph. The physical location and extent of each fractures was verified by collection of several core samples after fracturing. The fractures proved to be symmetrical and flat lying. For the purposes of numerical simulation, the fractures were modeled as disks with 8 ft radius and 3/8 inch thickness – dimensions that corresponded to the average of field measurements.

In the lower photograph of *Figure 1* the transition of color that indicates 10% of suction occurs almost 20 ft from the center of the fractures – more than twice the physical extent of the fractures. Clearly fractures extend the radius of influence of extraction wells and allow substantially greater volumes of soil to be treated from one well location.

Although the effect upon pressure certainly appears encouraging, the true performance of any extraction process depends upon flux. Since the carefully calibrated numerical model rigorously developed the pressure contours with fine resolution, computation of flux was easily accomplished by computing the local pressure gradient. The results are displayed in *Figure 2*. As in *Figure 1*, the upper picture depicts the situation around a conventional well while the lower picture shows the results of three fractures. As with pressure, significant flux around the conventional well is confined to the first foot or two around the well. In contrast, significant flux is observed at approximately twice the radius of the fractures.

The principal and most important lessons from this work were the ramifications of applying the same suction to each fracture. In the excitement of modeling the pressure field and flux extending twice the radii of the fractures, the absence of flux between the fractures seemed a distracting anomaly. However prudent consideration quickly explained this result: the fractures were sufficiently efficient to transmit nearly 100% suction to the large portions of the formation between fractures, so no local gradient existed to instill flow. Thus the central portion of the target volume was less swept by air than soil at the tips of the fractures. Should this concept not be included in project designs, fractures might be created that do very little to treat the very hot spots where they might be located.

Consequently, stacks of hydraulic fractures can enhance fluid extraction or injection projects if alternate fractures are used as sources or sinks for fluid flow. In order to control these flows, **independent access** needs to be maintained to each fracture during the remediation project.

References:

Murdoch, L.C., D. Wilson, K. Savage, W. Slack, and J. Uber. “Alternative Methods for Fluid Delivery and Recovery”. USEPA/625/R-94/003. 1995.

USEPA. Risk Reduction Laboratory and The University of Cincinnati. “Hydraulic Fracturing Technology - Applications Analysis and Technology Evaluation Report” USEPA/540/R-93/505. 1993.

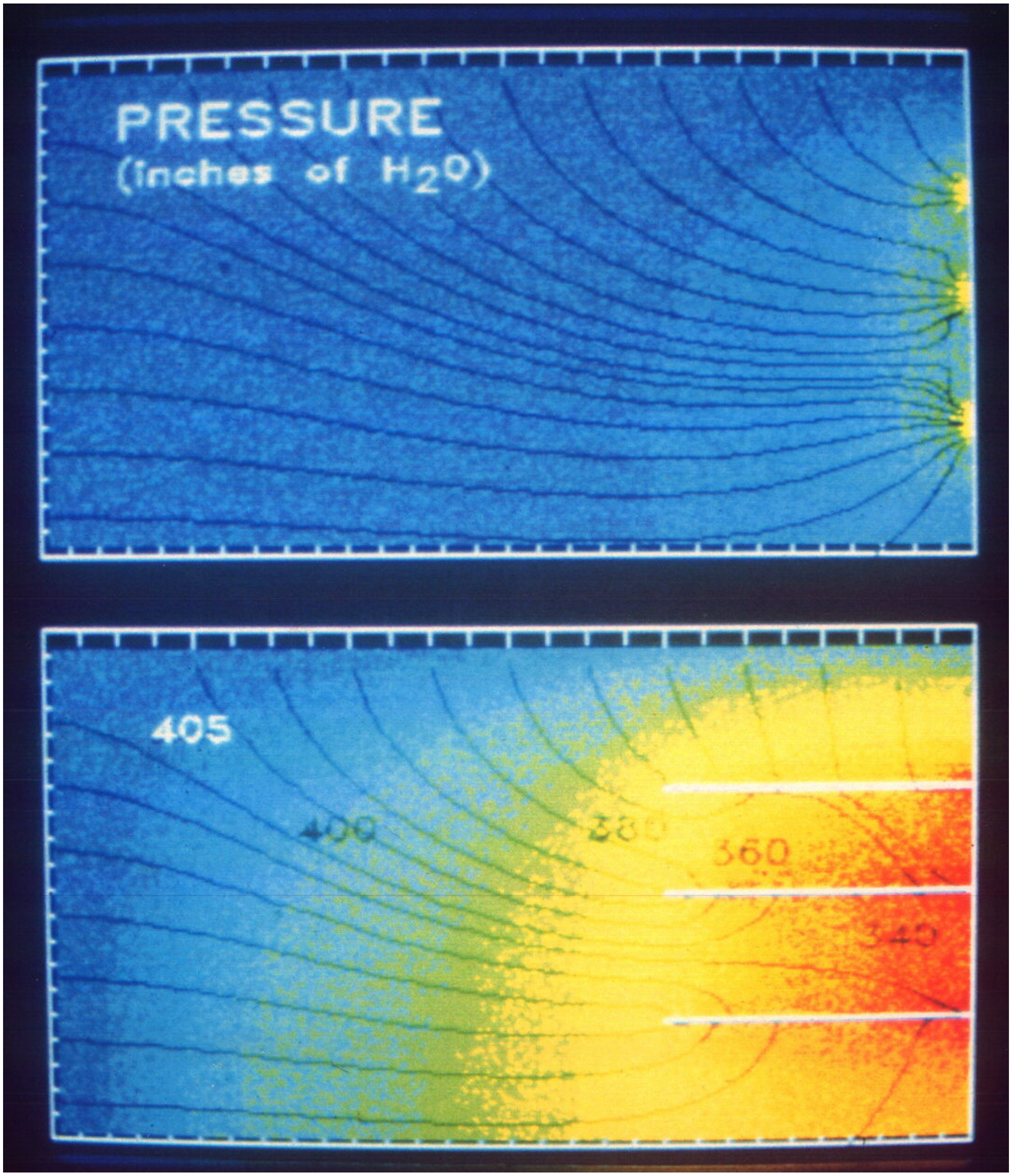

Figure 1 – Pressure and Streamlines During Soil Vapor Extraction Through a Conventional Well and Through Hydraulic Fractures.

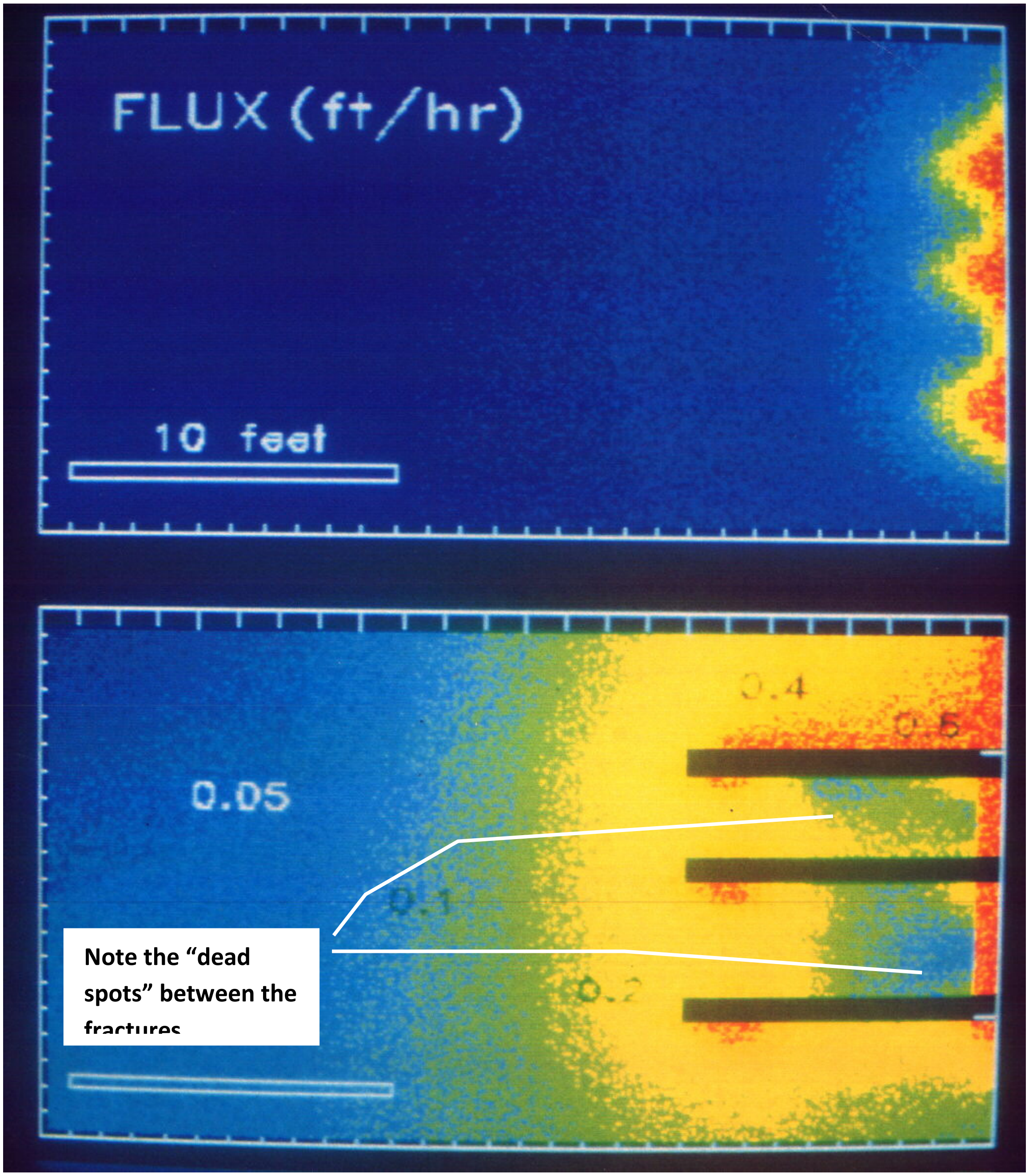

Figure 2. Flux Developed In Soil Surrounding a Conventional Well and Around Fractures During Soil Vapor Extraction