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Analysis of Cross-Hole Tests in Fractured Systems

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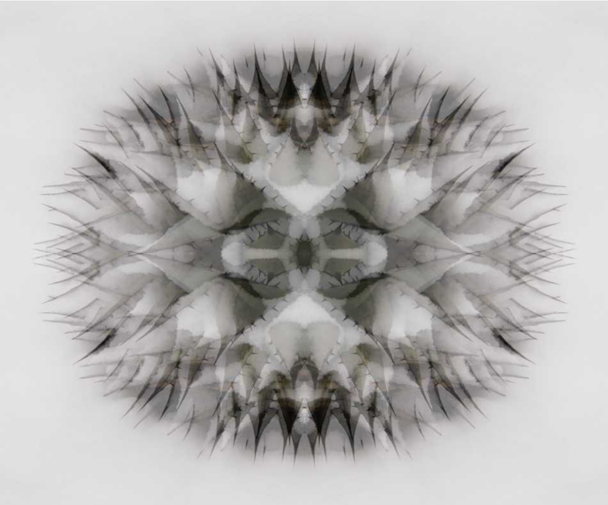

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Introduction

- **The estimates of transmissivity (*T*) and storativity (*S*) obtained from analysis of observation well responses to constant rate pumping tests are affected by the correlation between the flow rate, the pressure response, and the flow-path length**
- **The estimate of diffusivity (*D*) – the ratio of *T* to *S* – is typically assumed to be more robust than the individual *T* and *S* estimates**

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Heterogeneity in 1-D models

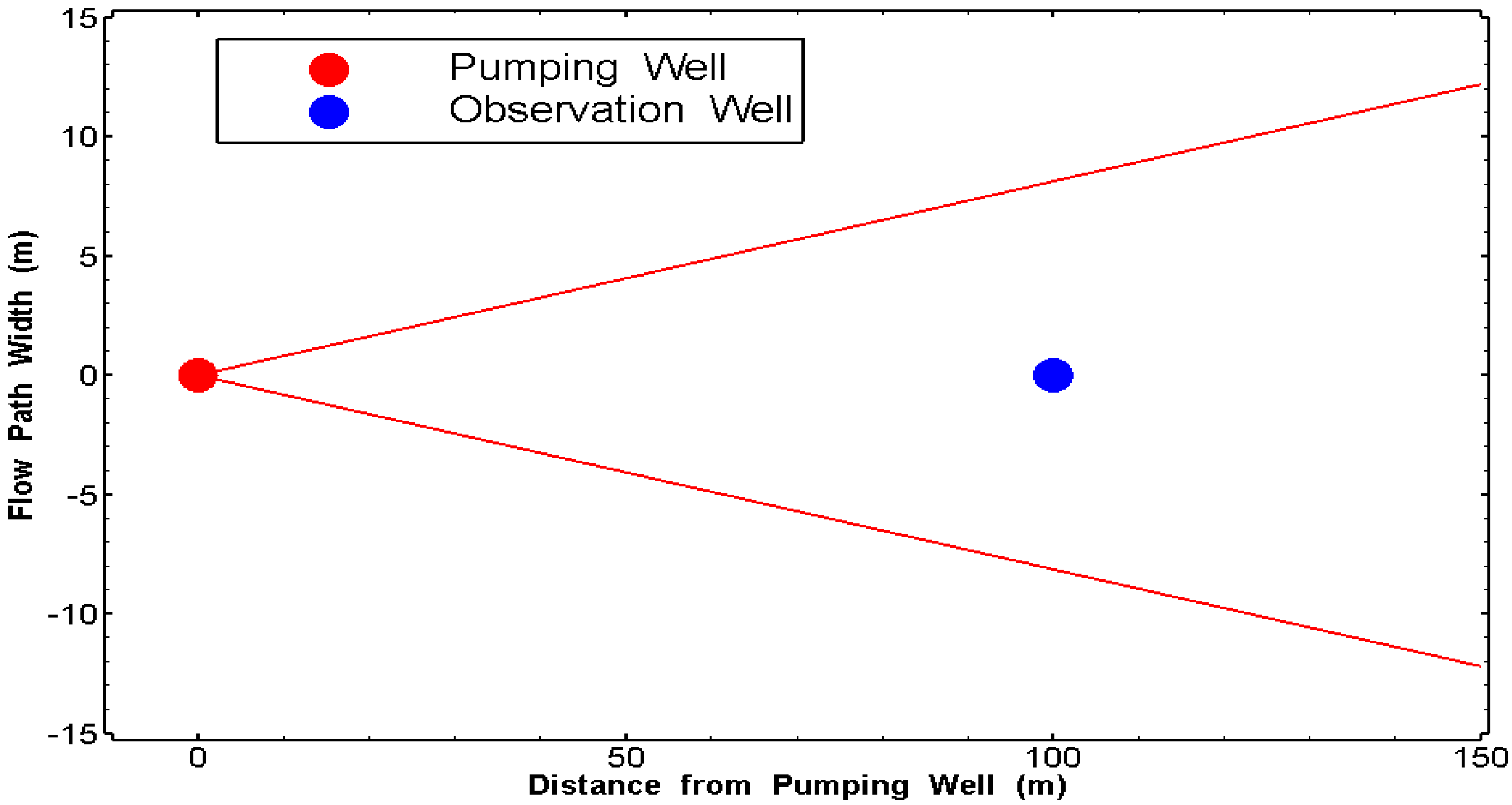
- Standard analysis practice assumes that the water being withdrawn during a constant-rate test is withdrawn equally from all directions within the domain

- In a heterogeneous/fractured system, drawdown will be unevenly distributed

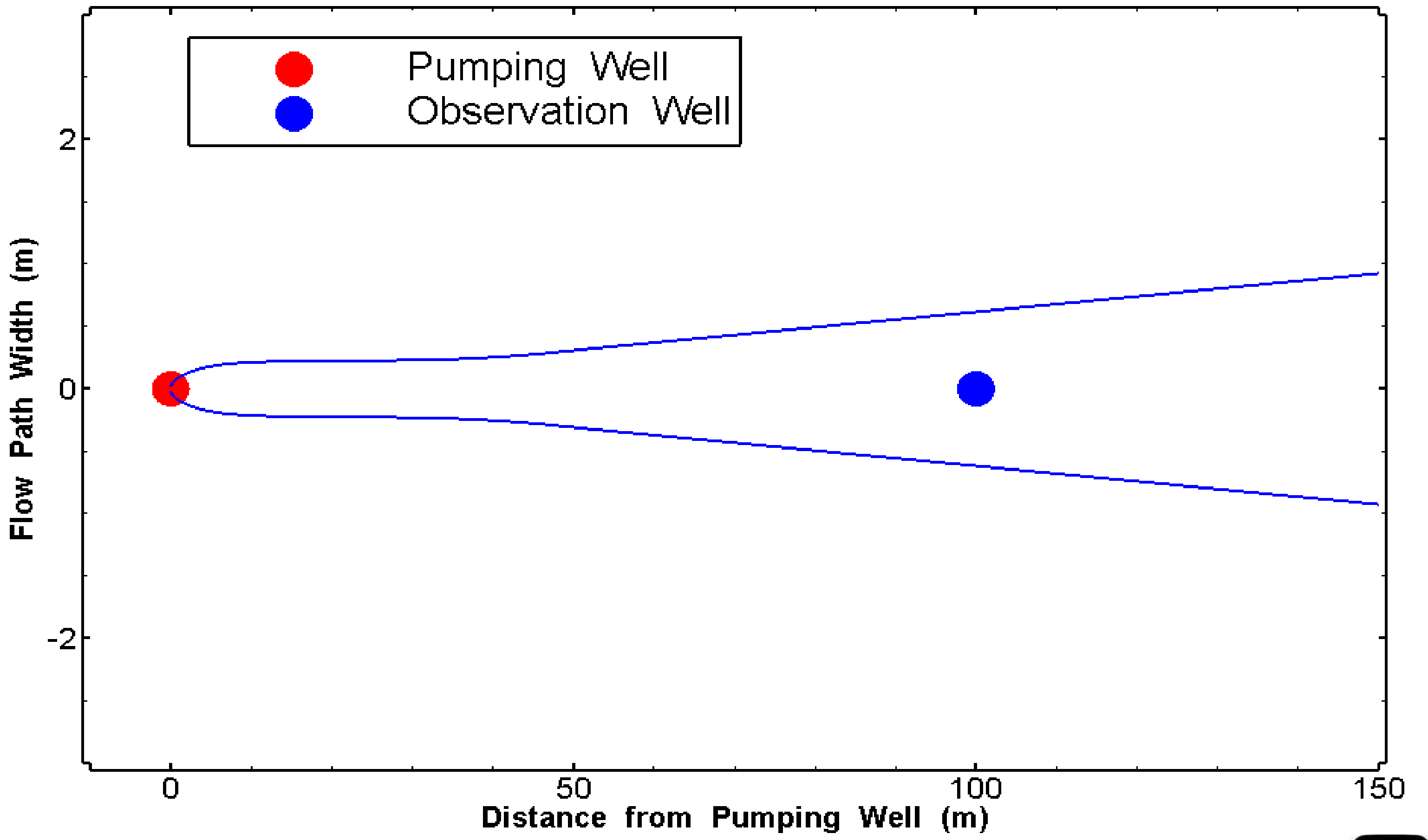
Heterogeneity in 1-D models (cont.)

- **This uneven distribution of drawdown often results in variable observation-well responses**
- **The one-dimensional aspect of well-test analysis codes typically necessitates a well-by-well analysis of cross-hole responses measured in fractured/heterogeneous systems due to the simplified ways in which the heterogeneities must be modeled.**
- **The potential for parameter-estimation error when applying this piecemeal approach is significant**

Geometry Issues



Geometry Issues (cont.)



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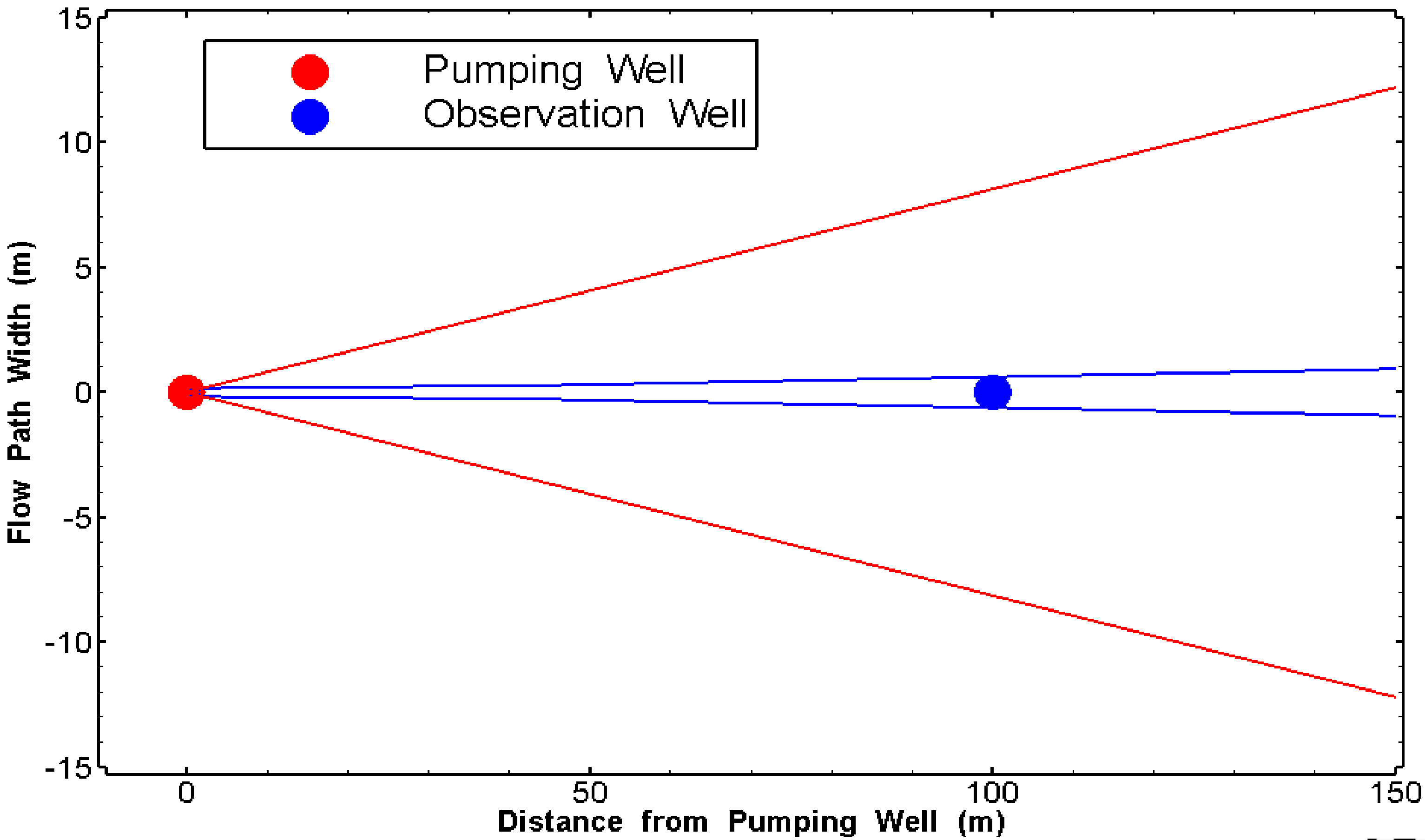
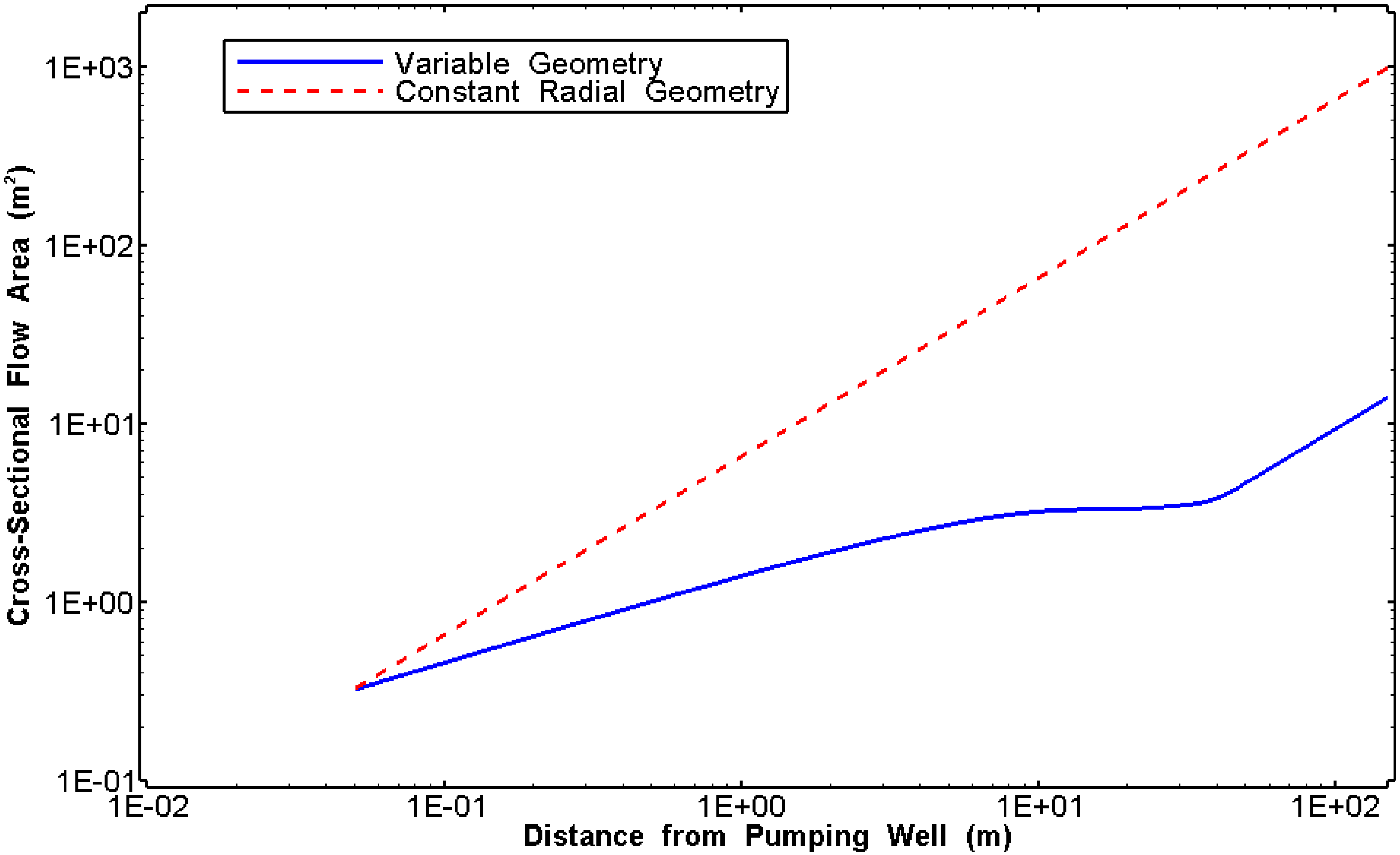
Geometry Issues (cont.)



Conceptual Model

- **Flow in both conduits will appear to be radial, but the actual flow areas will be very different**



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Conceptual Model (cont.)

- **Changes in flow-path geometry between the pumping well and observation well are not reflected in the shape of the observation-well response – only those geometry changes beyond the distance to the observation well will influence the choice of conceptual model**

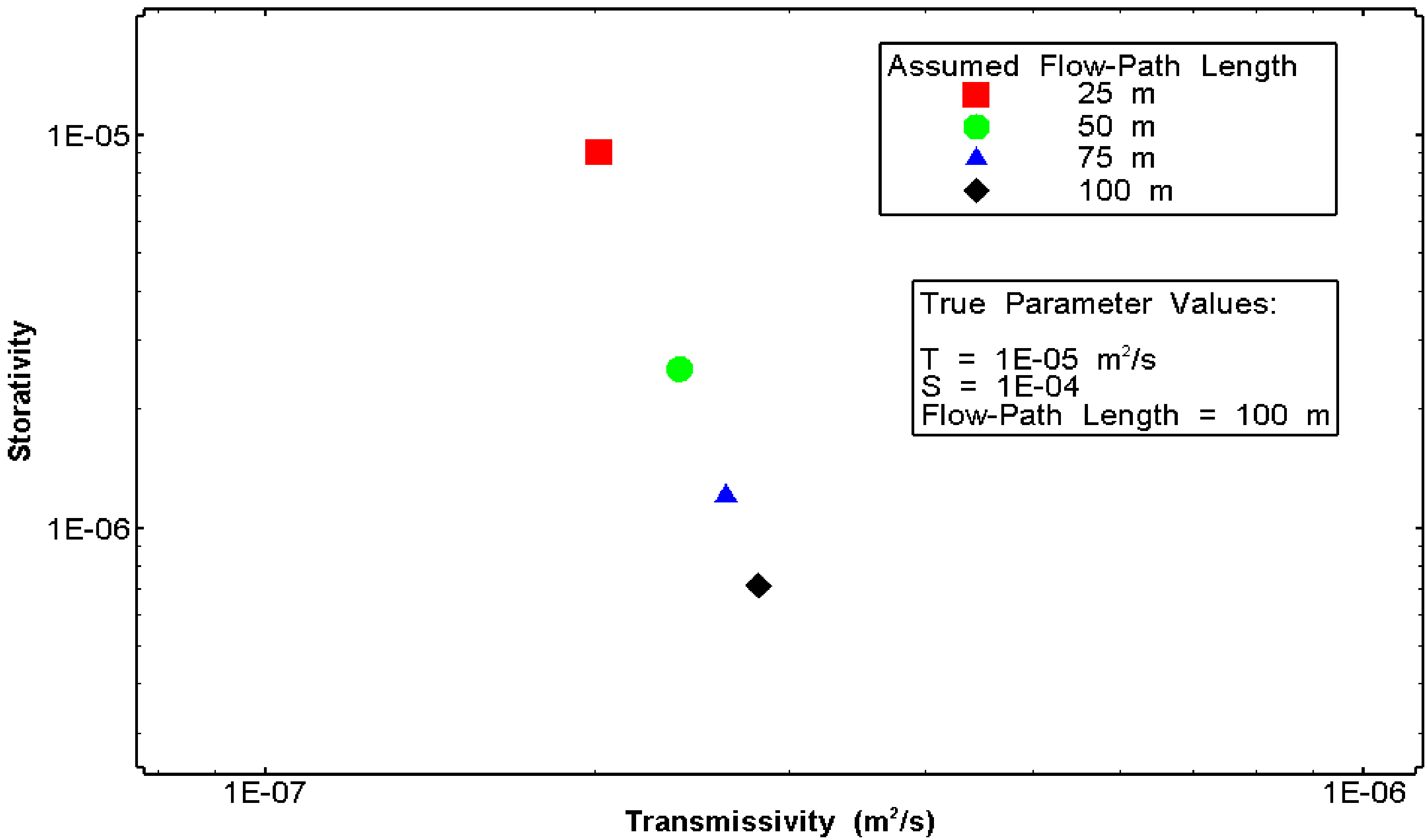
Flow-Path Length

- The assumed distance between testing and observation wells is typically the straight-line distance between these wells
- The actual flow-path length between testing and observation wells in a heterogeneous/fractured system may be greater than the simple straight line distance between them

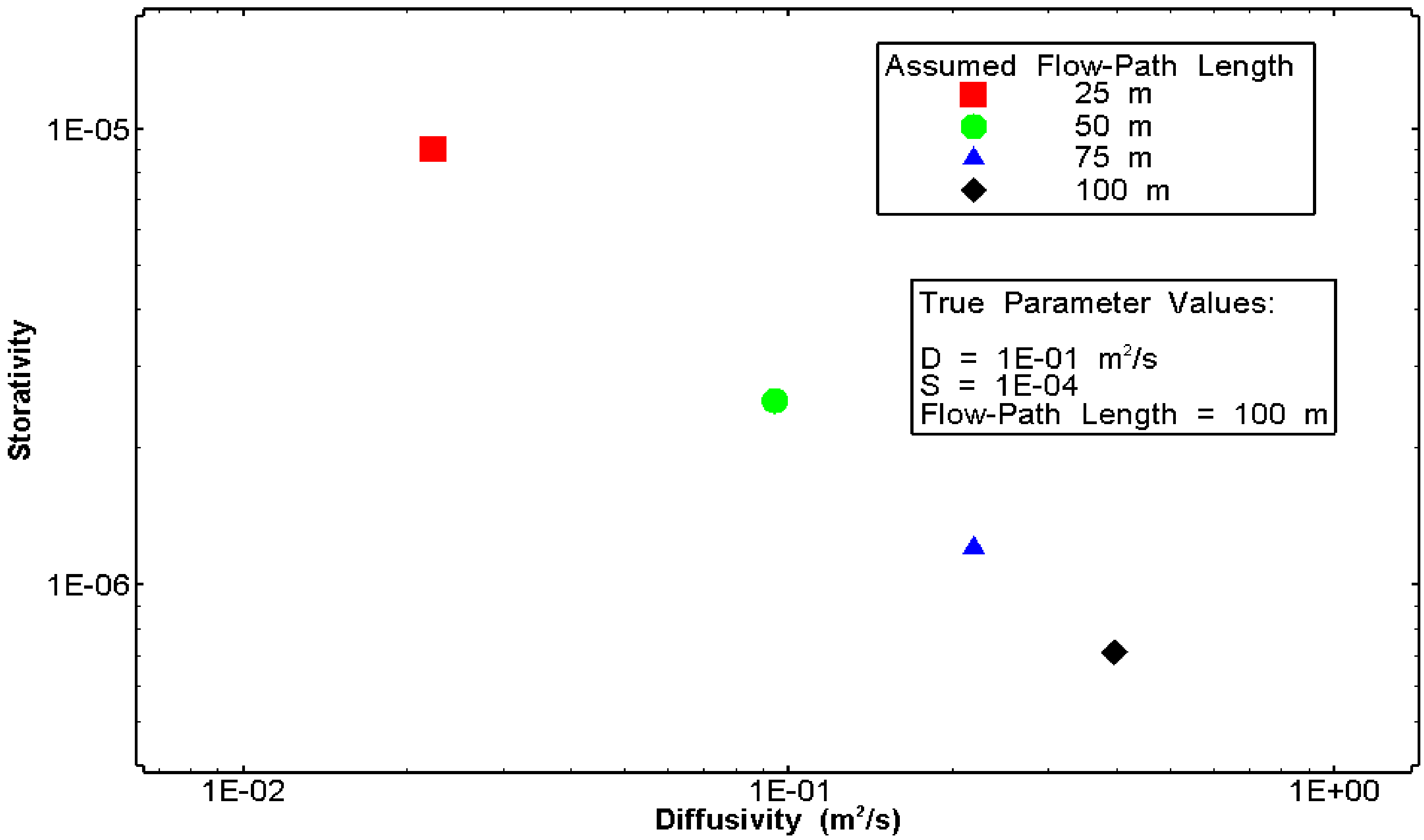
Parameter Estimates

- The observation-well response at 100 m in the variable-geometry conduit was simulated
- These data were matched using a radial model, i.e., the geometry reflected in the shape of the observation-well response
- Parameter estimates were obtained for each of four assumed distances to the observation well: 25, 50, 75, and 100 m.

Effects of Flow Area and Flow-Path Length Errors



Effects of Flow Area and Flow-Path Length Errors



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Diffusivity Estimates

- Diffusivity is generally assumed to be the parameter actually estimated from cross-hole analyses.
- However, given that the estimate of *S* is more affected by errors in flow-path lengths than the estimate of *T*, the subsequent estimate of *D* is also sensitive to errors in assumed flow-path lengths.

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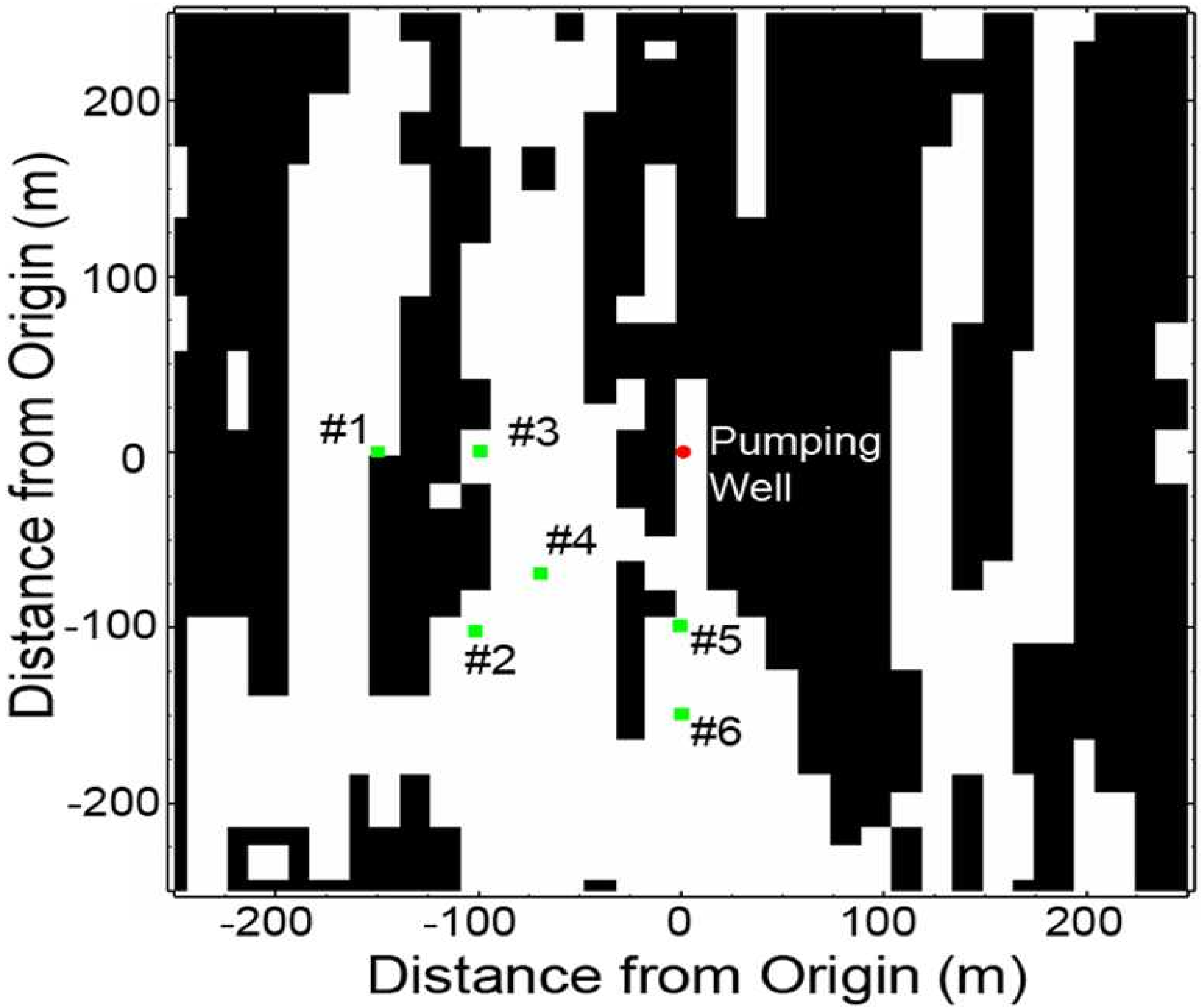
Binary Flow Field



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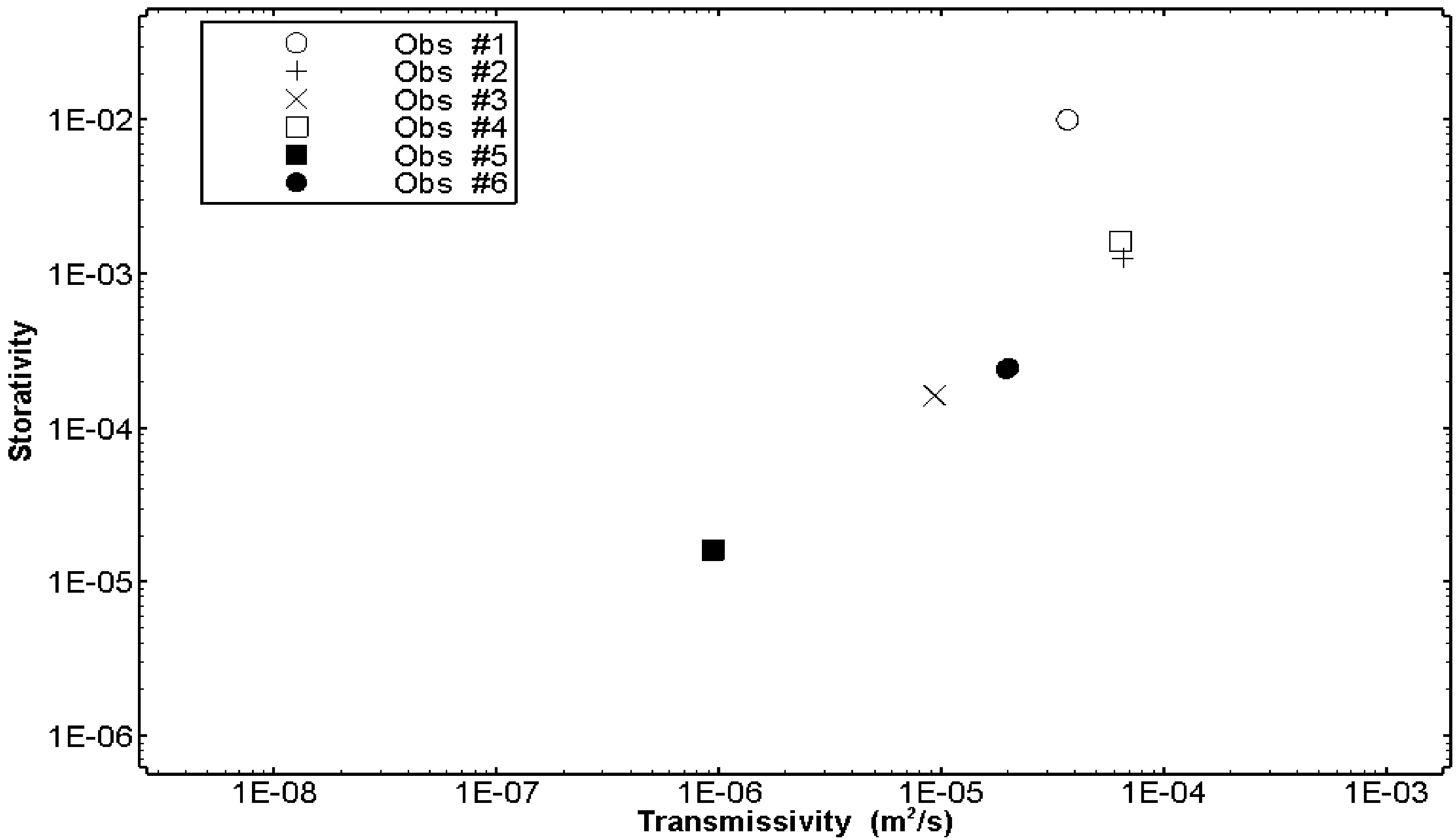
Analysis of Observation-Well Responses in Binary Field



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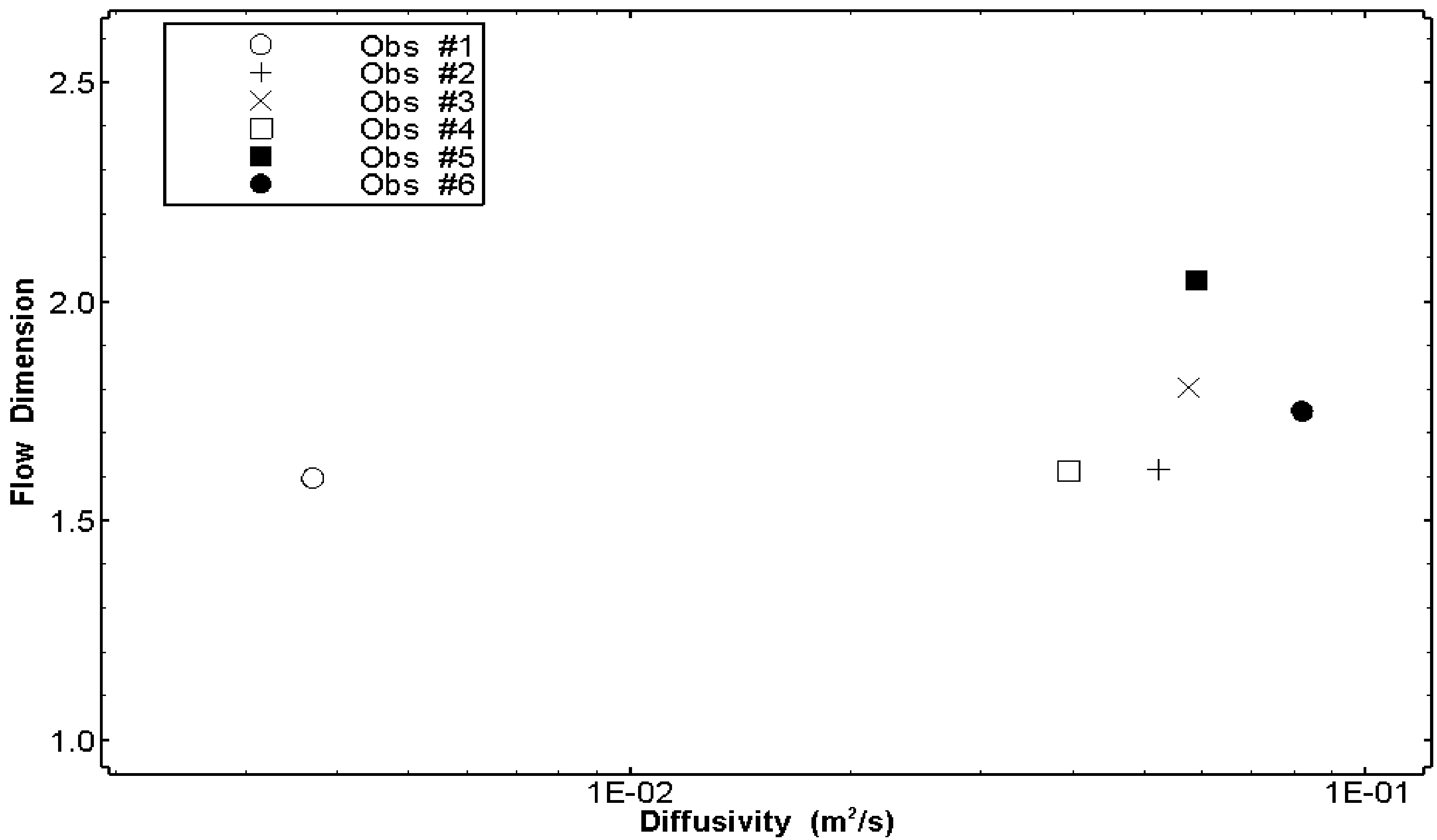
Analysis of Observation-Well Responses in Binary Field



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Summary and Conclusions

- Attempting to accurately estimate *T*, *S*, and *D* from observation-well data collected in heterogeneous/fractured systems using standard well-test analysis methods is a questionable (if not impossible) task
- An analyst may well obtain excellent matches to field pressure responses, but that can have little or nothing to do with the accuracy of the estimated parameters.
- Traditional well-test analysis of complex flow-system observation-well responses should be largely abandoned and the observed responses should instead be used to calibrate areal (2D or 3D) models.

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