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Monitoring Program Optimization

Geospatial methods can be used to optimize monitoring programs by identifying redundancies or gaps in monitoring well coverage, highlighting areas with higher contaminant concentrations for more aggressive remedial action, and determining the sampling schedule that most effectively balances data collection with budget constraints.

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Spatial optimization of long-term groundwater monitoring networks generally consists of evaluating how interpolation error increases when removing wells from the sampling program. Two commonly used software packages in the public domain that perform this spatial optimization are MAROS and VSP (see the MAROS case studies and VSP example). MAROS uses simple geospatial methods (Voronoi/Delaunay mesh, natural neighbor) to interpolate the data and evaluate the effects of data point removal, while VSP uses kriging to interpolate the data and evaluate the effects of data point removal. These iterative data point removal operations can also be performed manually using simple or advanced geospatial methods in an alternative contouring program.

An alternative approach is to evaluate prediction uncertainty using advanced methods, such as conditional simulation, to provide the basis for recommending additional monitoring locations or removing existing monitoring locations. Temporal optimization of long-term groundwater monitoring networks typically involves single-well variography to evaluate the range of temporal correlation at each well. This application is illustrated in the VSP example at the end of this section.

The results of spatial long-term monitoring optimization analysis as performed in MAROS and VSP provide a ranking of the relative importance of each well in terms of its impact on the interpolation, as well as quantification of the cumulative impact of removing less-important wells on the overall interpolation. This approach is similar to cross-validation. Analysis of the kriging variance and more robust uncertainty analysis using conditional simulation illustrate where prediction uncertainty is highest and lowest. Using professional judgment, appropriate threshold error or uncertainty metrics can then be applied to decide whether to remove or add monitoring locations. Programs such as MAROS recommend locations for removal based on default threshold values; however, these values can be changed based on professional judgment. It is often easier to conceptualize confidence limits on predictions for use in monitoring program assessment, which are only obtained from uncertainty analysis using advanced methods.

For temporal optimization, the range at which samples are no longer temporally correlated is often used as the basis for selecting the appropriate minimum time interval between independent sampling events. If the range of temporal correlation is greater than the current sampling frequency (for example, 180 days for semiannual frequency), it would be defensible to reduce the monitoring frequency and increase the time between sampling events.