

An Operational Model for Managing the Effect of Land Treatment of Wastewater on Groundwater Quality

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Land treatment of wastewater

- the process

- Wastewater (or solid) is irrigated onto a crop
- The crop is harvested and removed from the site
- Fates of waste constituents are:
 - removal in the harvested crop
 - long term storage in the soil
 - leaching to groundwater
 - gaseous products to atmosphere

Land treatment of wastewater - principal environmental issues

- Leaching of nitrate to groundwater
- Effect of sodium ions on soil chemistry and structure
- Increase in salinity of groundwater
- The present model focuses on the management of nitrate leached to groundwater

Operational management issues

- Groundwater monitoring is too late because of transport time through the vadose zone
- Operational management requires monitoring of water quality just beneath the biologically active soil layer
- These data are highly variable and received sequentially, causing uncertainty in decision making

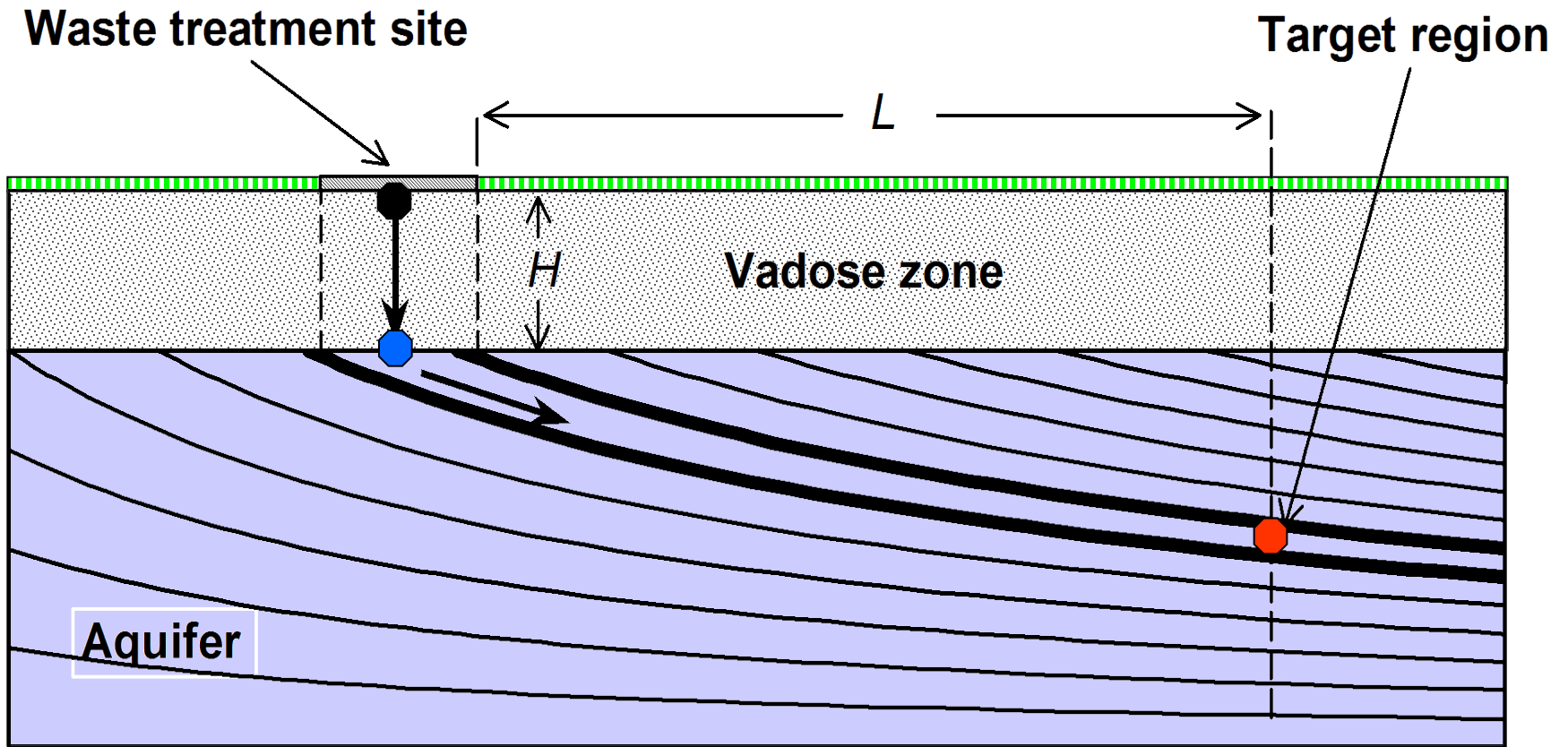
The role of the model

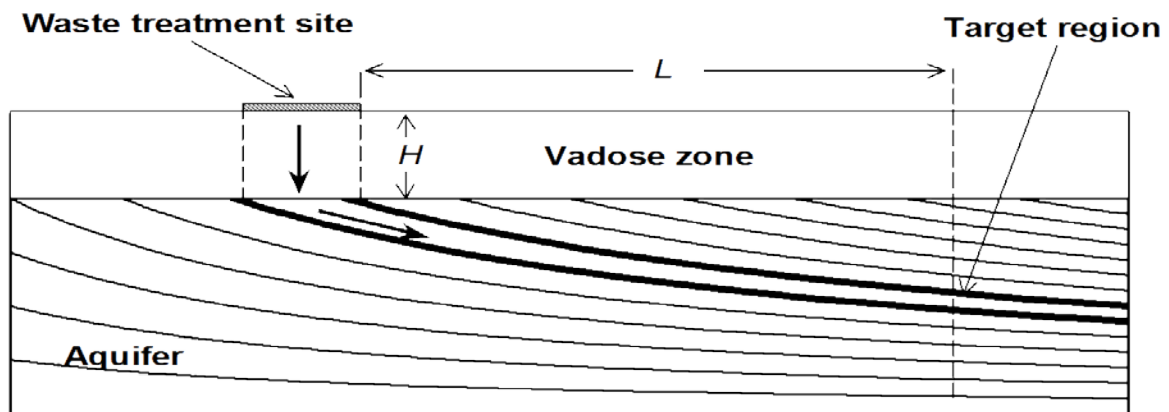
- The model translates these data into updated forecasts of effects on groundwater quality
- These “effects” data form a smoothed time series suitable for operational management
- Similar to statistical process control in the manufacturing industries
- Contributes to environmental quality assurance
- Model is based on realistic physical concepts

Physical concepts and assumptions

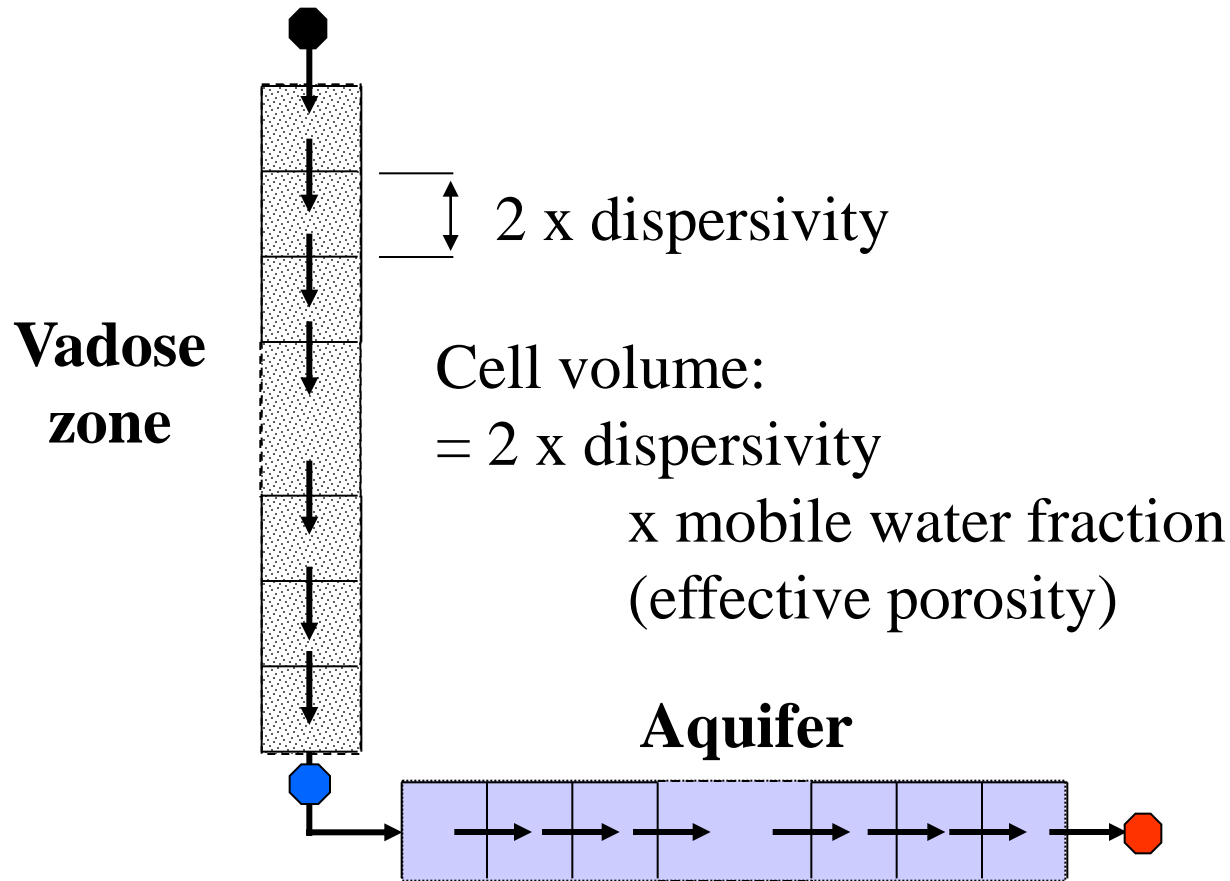
- Nitrate transport is by advection-dispersion in the vadose zone and aquifer
- No dilution in groundwater - only longitudinal dispersion
- Dispersion described by cumulative water flux and dispersivity - “steady-state” contaminant transport
- Streamtube approach enables a 1-D transport model for both vadose zone and aquifer

Physical model





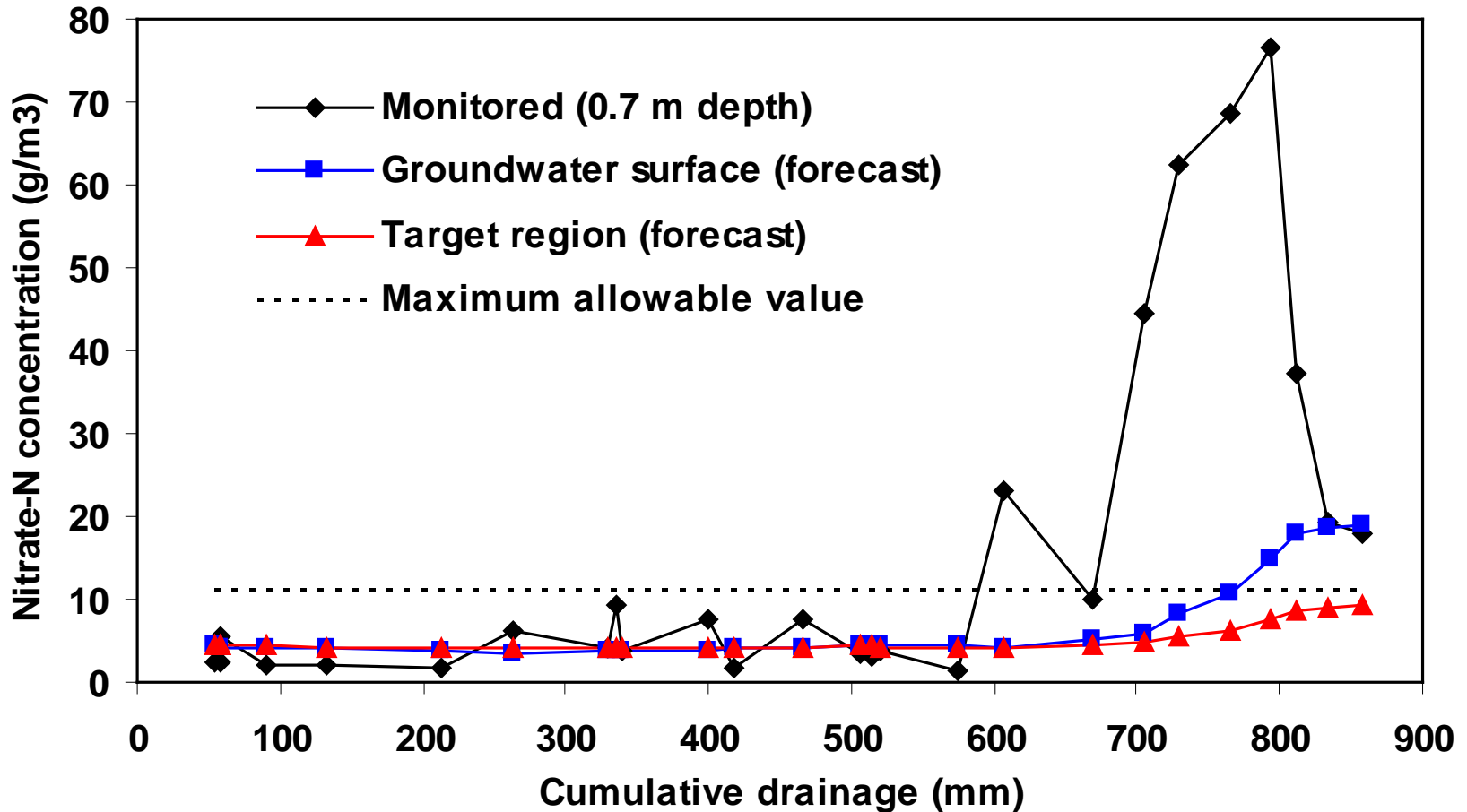
Mixing-cell analogue model of advection-dispersion



Demonstration example

- Meat processing wastewater irrigated onto pasture
- Monthly data for nitrate-N concentration and soil water drainage from monolith soil lysimeters
- Vadose zone:
thickness $H = 10$ m; mobile water fraction = 0.1
- Aquifer:
distance $L = 100$ m; effective porosity = 0.3
- Dispersivity = 0.05 x transport distance

Demonstration results



Summary

- The model is a process-based, credible method for “on-line” smoothing of highly variable monitoring data from a waste treatment site
- Model output provides unambiguous information for operational management decisions
- This information can also be a component of an environmental quality assurance system
- Suitable for spreadsheet implementation