



CREATING AND DELIVERING BETTER SOLUTIONS



Numerical Assessment of Monitored Attenuation Using Source Depletion as a Variable Loading Factor

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- Approach & Objective
- Environmental Setting & History
- Modeling
- Source Zone Loading
- Results & Next Steps





- A numerical groundwater model was developed for an upstream oil and gas facility in south central Alberta.
- Predict leaching & off-site transport.
- Hydrocarbons from a former underground storage tank.

- Determine whether intrusive remedial action was necessary to protect surrounding water resources.
- Site is transected by an ephemeral channel.
- Adjacent intermittent shallow water body.

Environmental Setting & History

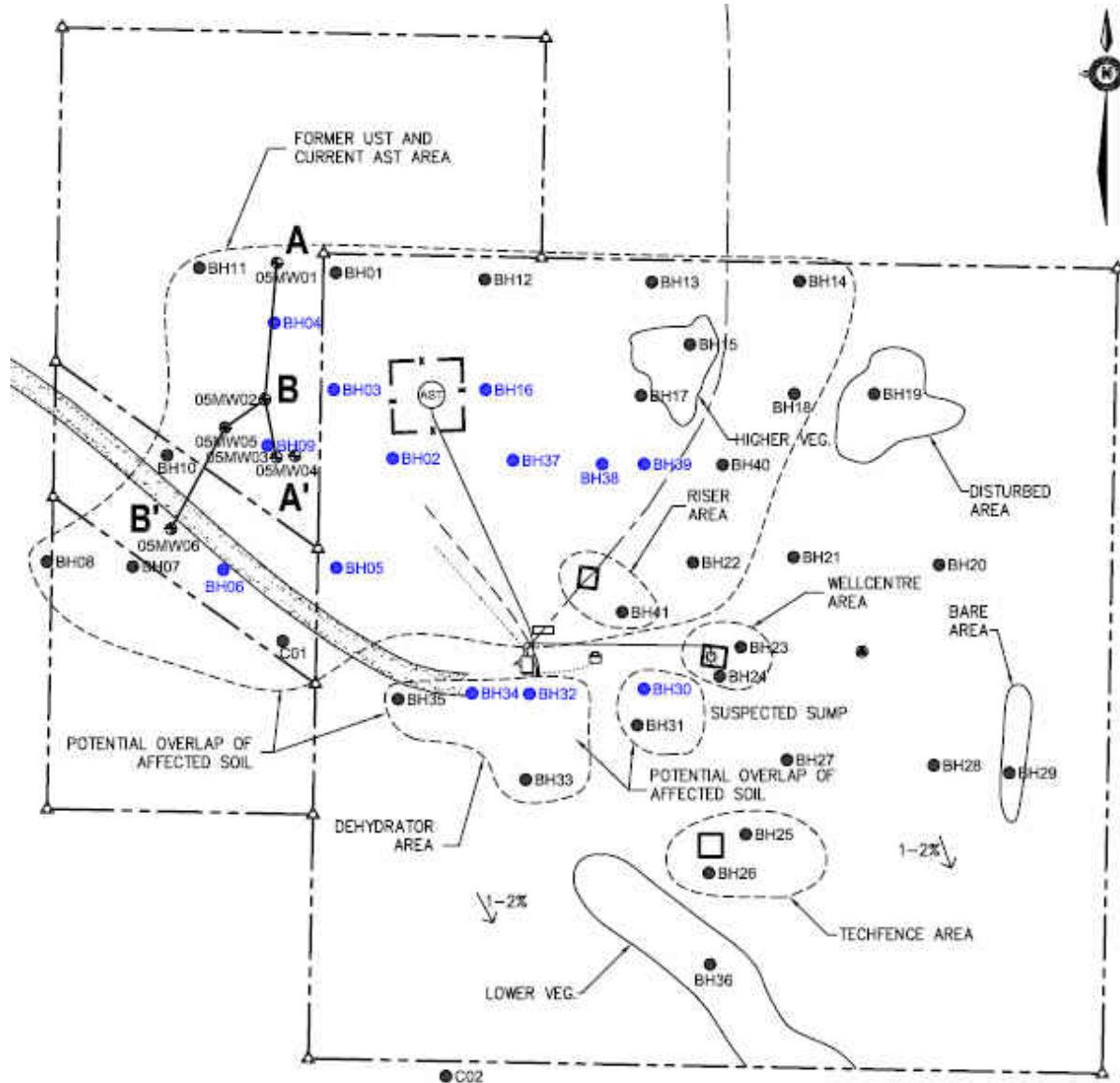


- Single gas well facility.
- Phase 1 and Phase 2 ESA.
- Soils and groundwater affected with hydrocarbons.
- Affected area extends off-lease.

Environmental Setting & History

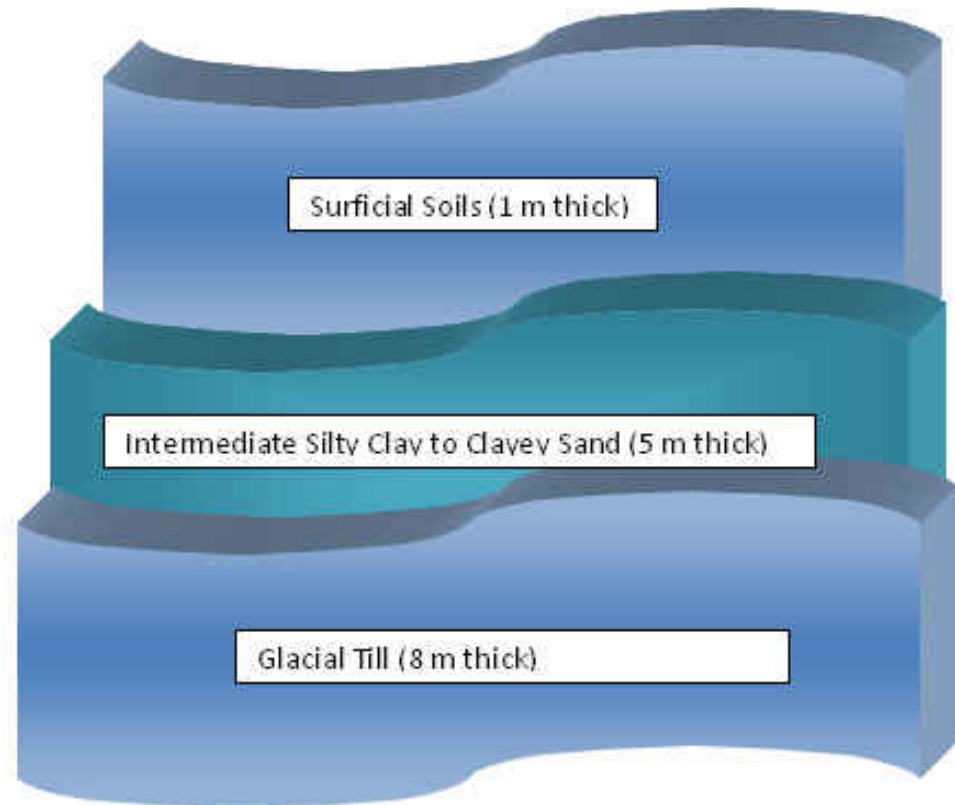


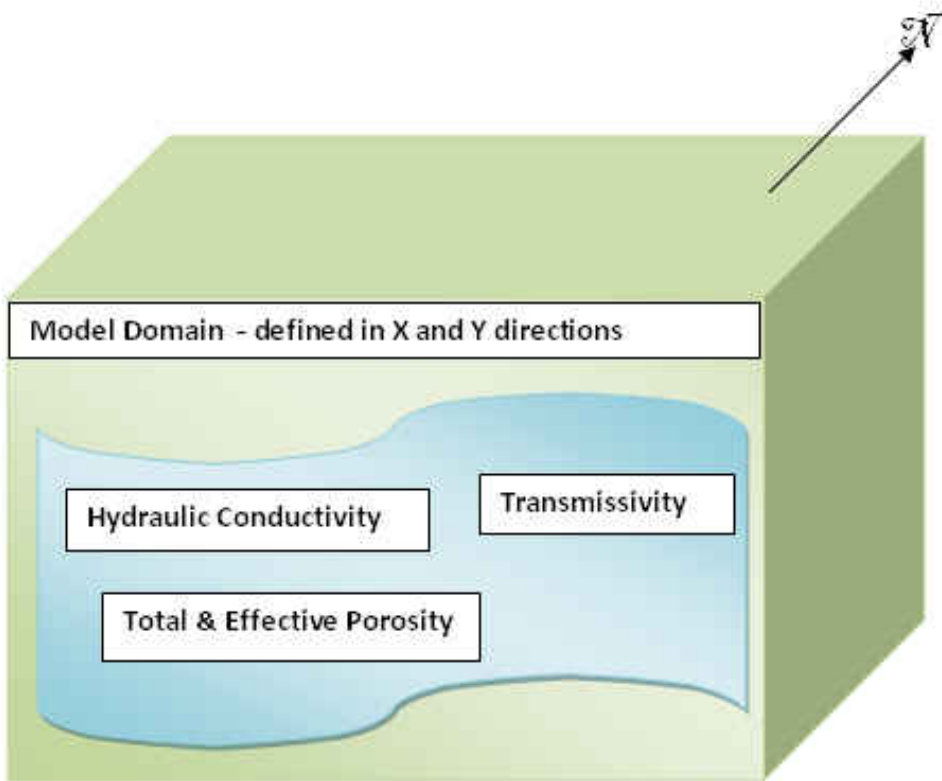
Environmental Setting & History



Environmental Setting & History

- Soils encountered at the site were stratified and variable.
- The upper units were coarser grained material.

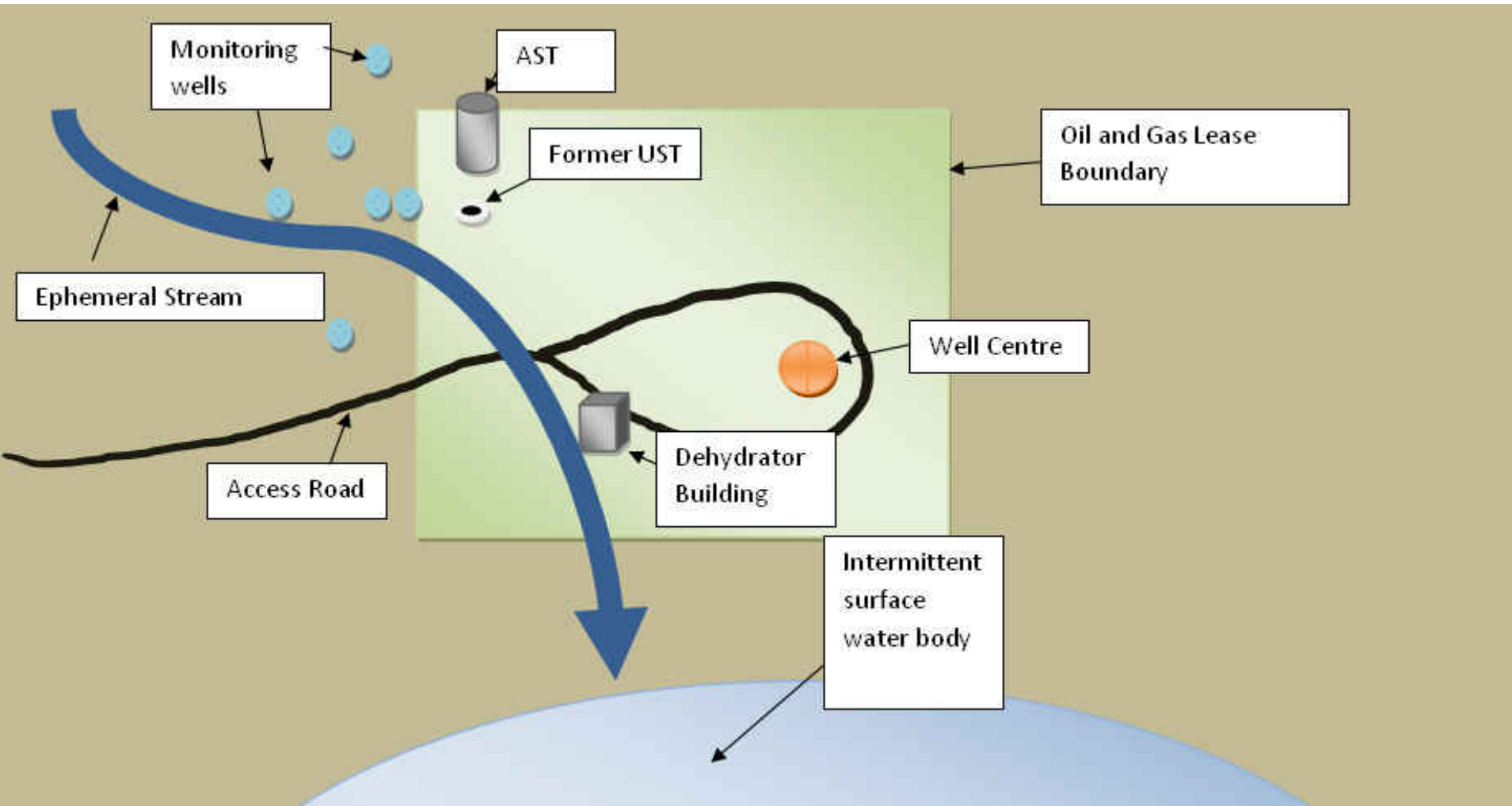




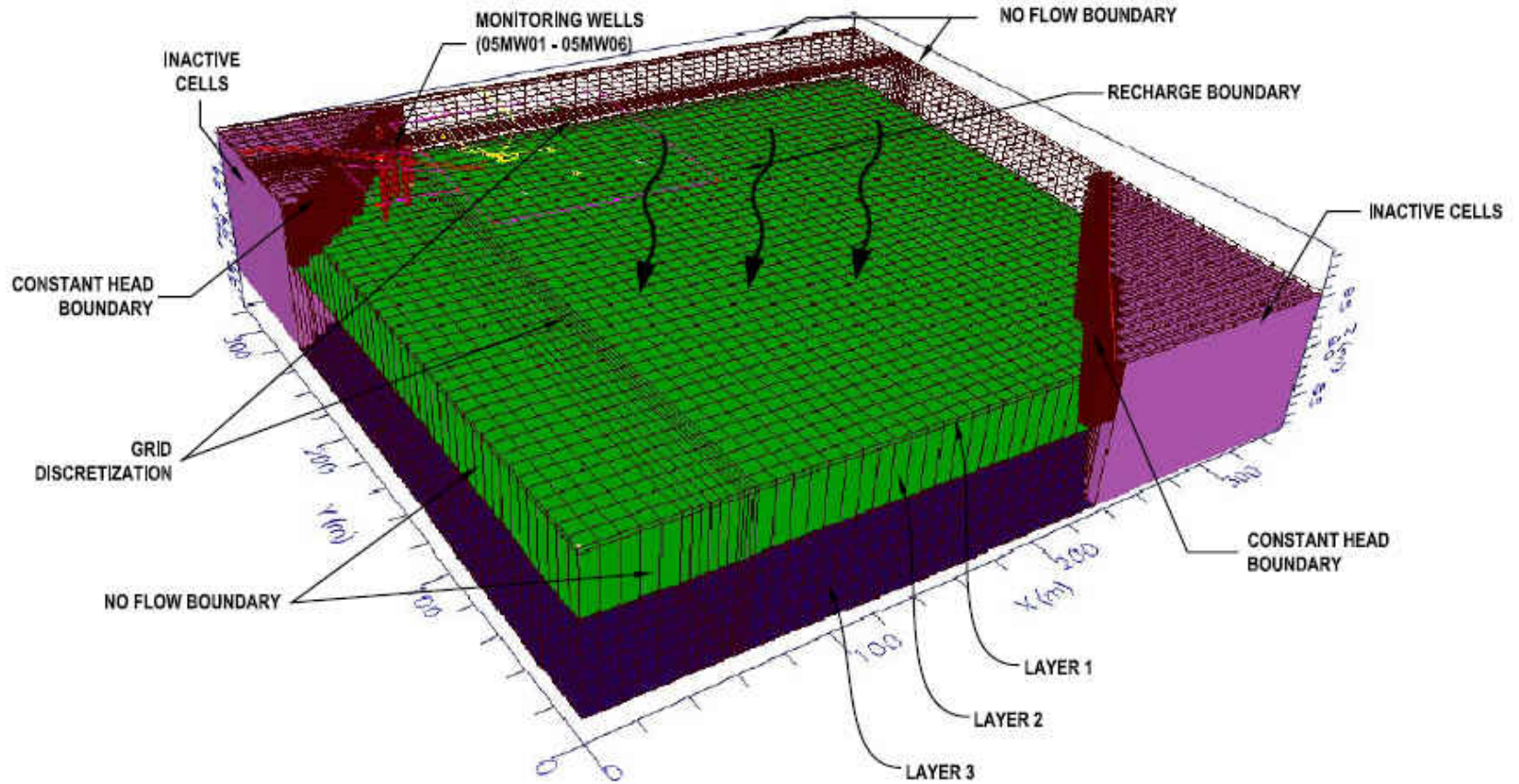
Model Domain –
355 m x-direction,
327 m y-direction.

Hydraulic parameters
-Hydraulic Conductivity
-Transmissivity
-Total & Effective Porosity

Modeling



Modeling





- Upper model layer was a recharge boundary.
- Ephemeral channel was treated as a recharge area.

- Model sensitivity and calibration.
- Model sensitivity analysis was conducted for different values of recharge and hydraulic conditions.
- Sensitivity analysis assessed if changing input parameters will affect the model results and cause model predictions to be invalid.



- Dissolved hydrocarbons, benzene, toluene and ethylbenzene are the target compounds identified by the former assessments.
- Simulation of contaminant transport by use of MT3DMS transport engine.

- MODFLOW model does not simulate vertical transport within the unsaturated zone.
- Loading of hydrocarbons was accomplished with dilution factors used by CCME and AENV Tier 2 Guidelines

Required degradation time to meet AENV criteria

$$t \text{ (year)} = \text{Ln} (M_i/M_o) / -\lambda$$

Where

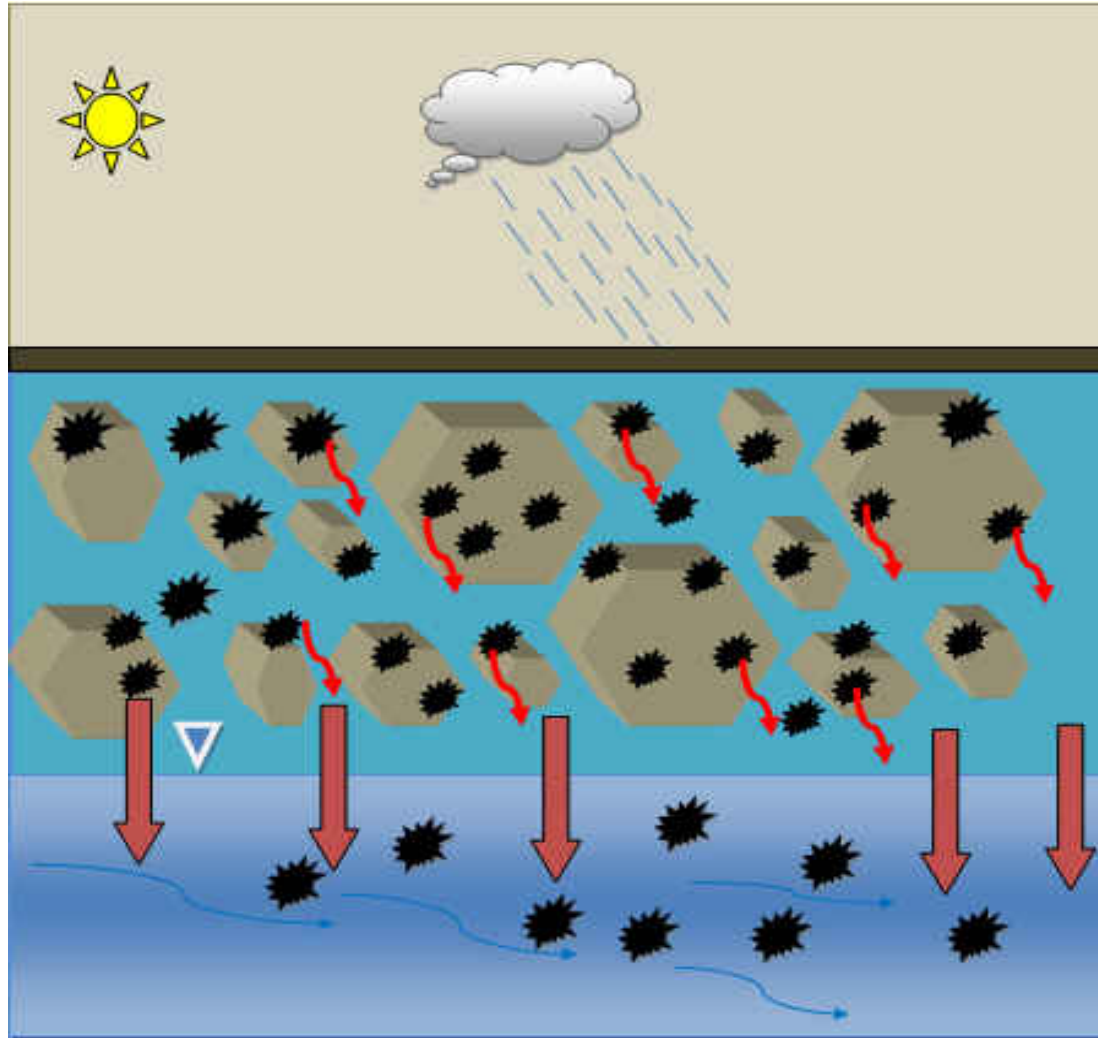
M_i = Required mass of chemical to meet AENV criterion

M_o = Initial mass of chemical present in soil (above criterion)

λ = Decay constant (1/year)

DF = Dilution Factor (one through three)

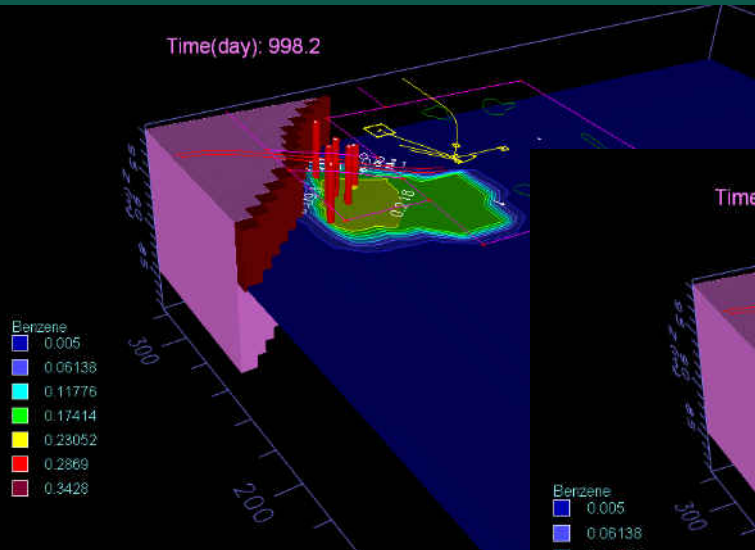
Source Zone Loading



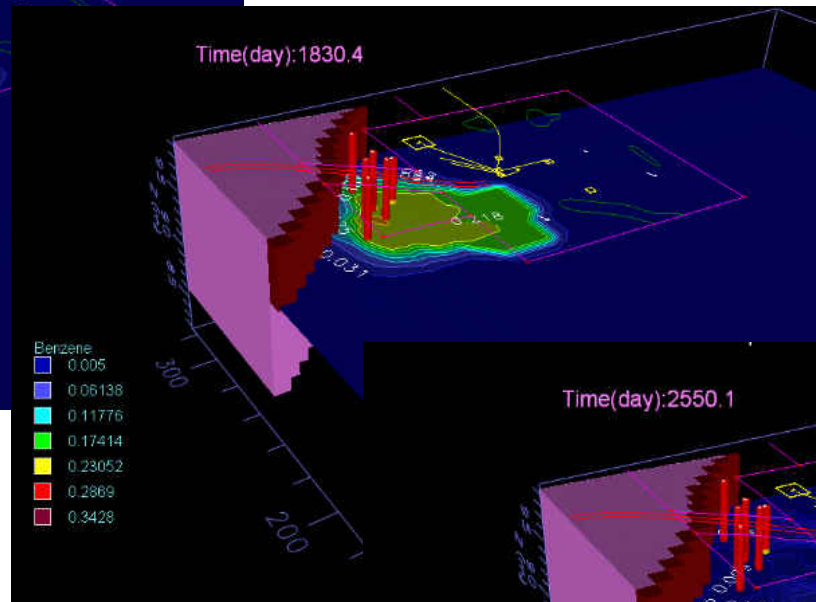
- The loading factor calculated from the source zone was added to the model as a variable source.
- Results were predicted for time frames of 3 years, 5 years and 7 years for benzene, toluene and ethylbenzene.

Benzene

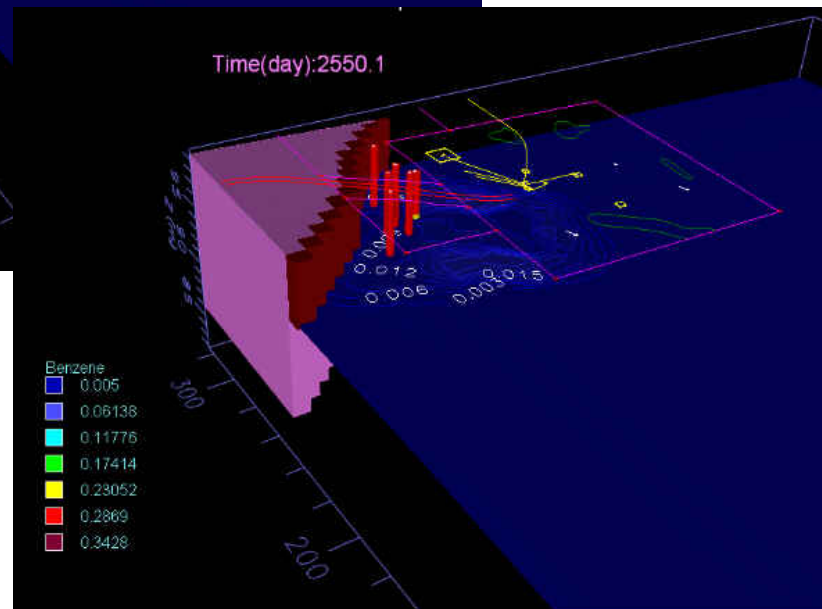
Time(day): 998.2



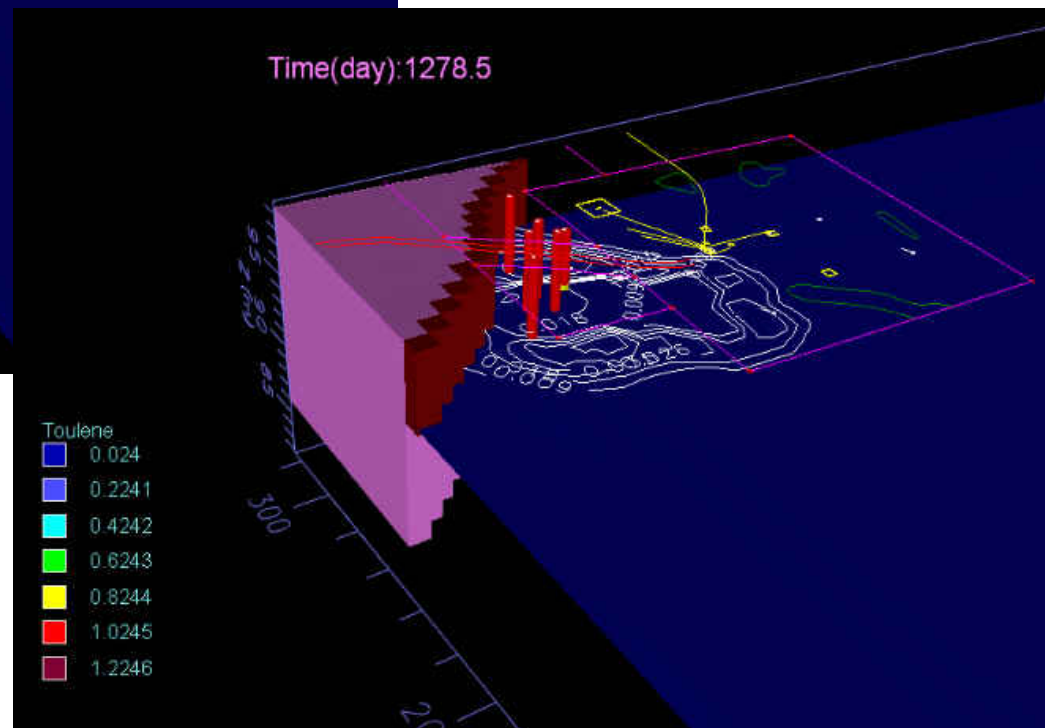
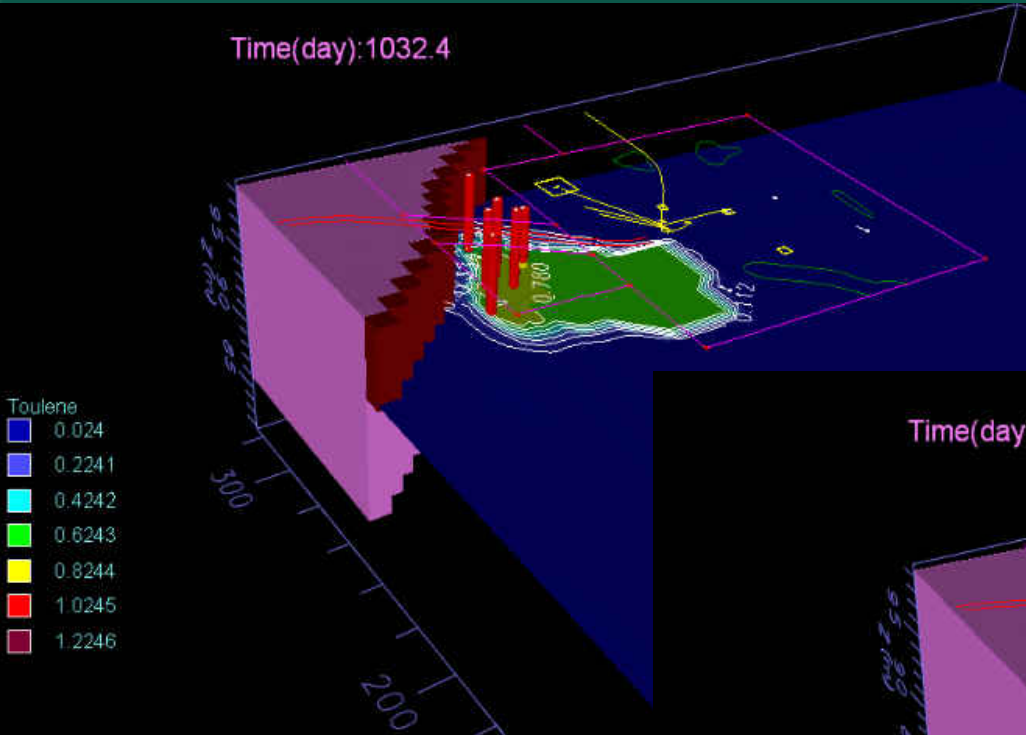
Time(day): 1830.4



Time(day): 2550.1

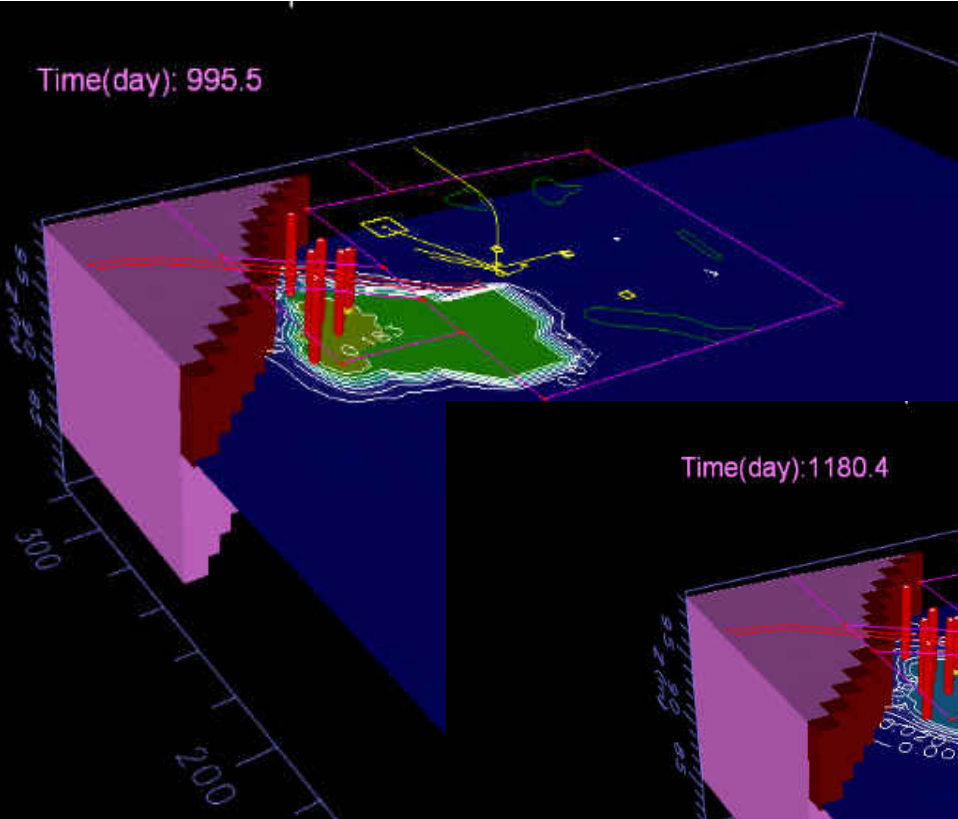


Toluene



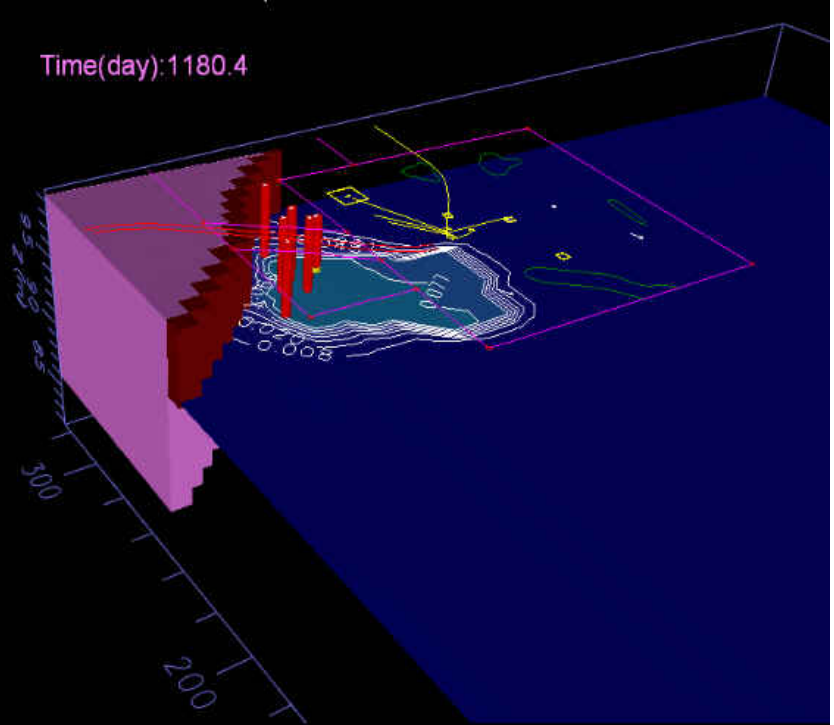
Ethylbenzene

Time(day): 995.5



- Ethylbenzene
- 0.0024
 - 0.050383
 - 0.098367
 - 0.14635
 - 0.194333
 - 0.242317
 - 0.2903

Time(day): 1180.4



- Ethylbenzene
- 0.0024
 - 0.050383
 - 0.098367
 - 0.14635
 - 0.194333
 - 0.242317
 - 0.2903



- The model predicted that the concentrations for benzene, toluene and ethylbenzene would degrade to values less than their respective guidelines in approximately 7 years, 4 years and 4 years, respectively.
- The estimated range of cleanup is on the order of five to ten years based on the model predictions.

- The model suggests that intrusive remedial actions are not necessary at this site.
- The time frame estimated for the contaminant concentrations to degrade to levels less than guidelines is reasonable.
- Based on model data, the water quality of the adjacent shallow lakes is protected by natural attenuation processes.
- Groundwater monitoring at this site continues to verify the model predictions.



- Questions?



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