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Proposed Gibraltar Rock Quarry
New Hanover Township, Pa

Fate and Transport Analysis and Assessment of Hoff VC Site Contaminant Migration

EarthRes Group, Inc.
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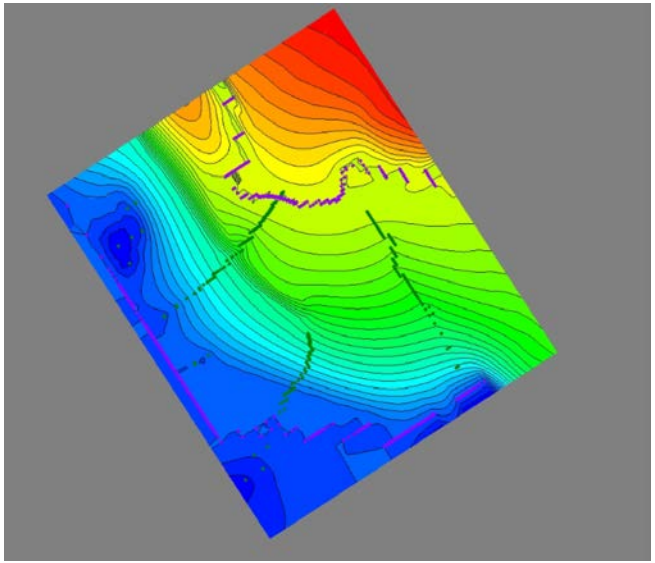

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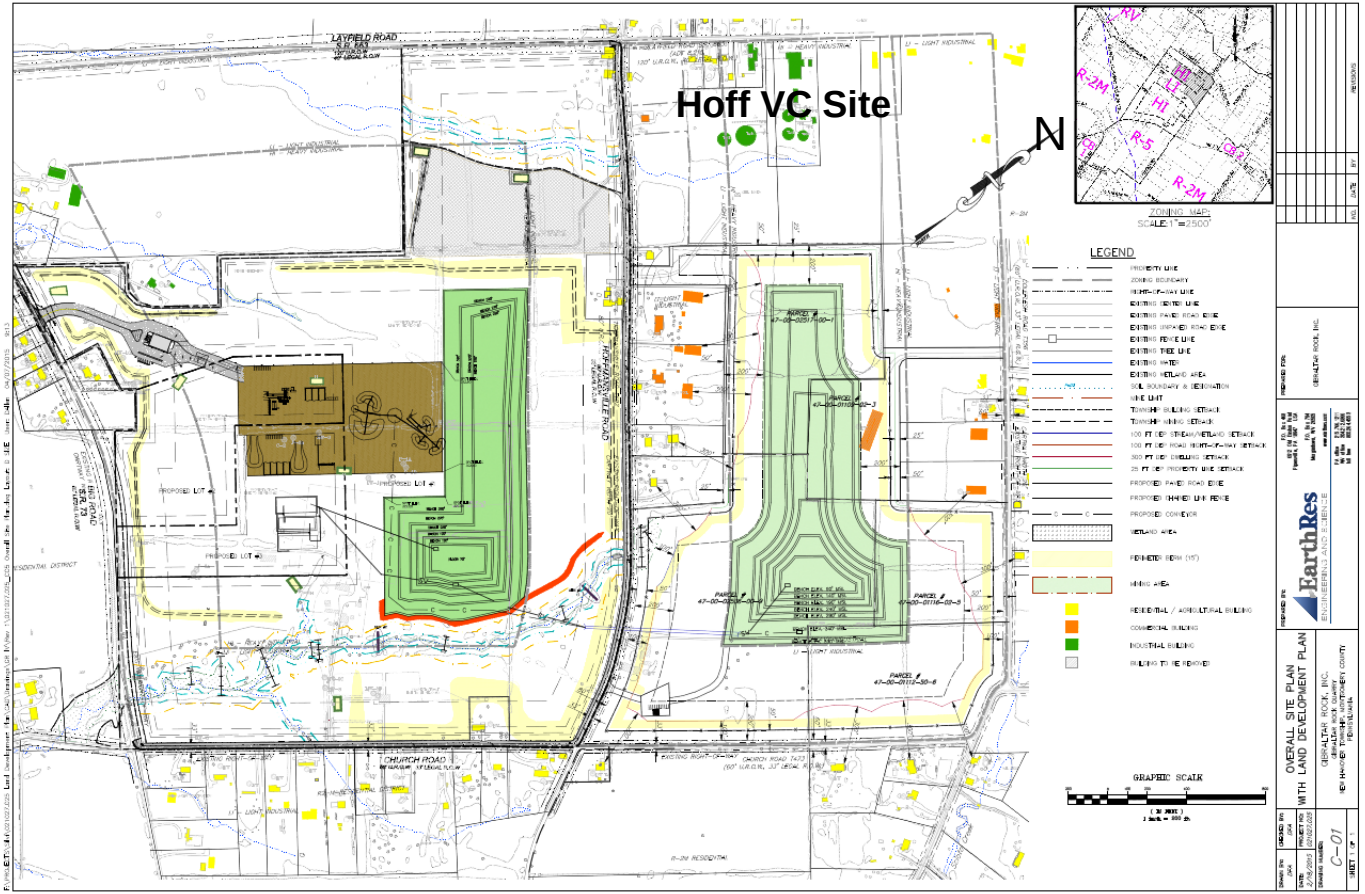
Proposed Quarry Layout



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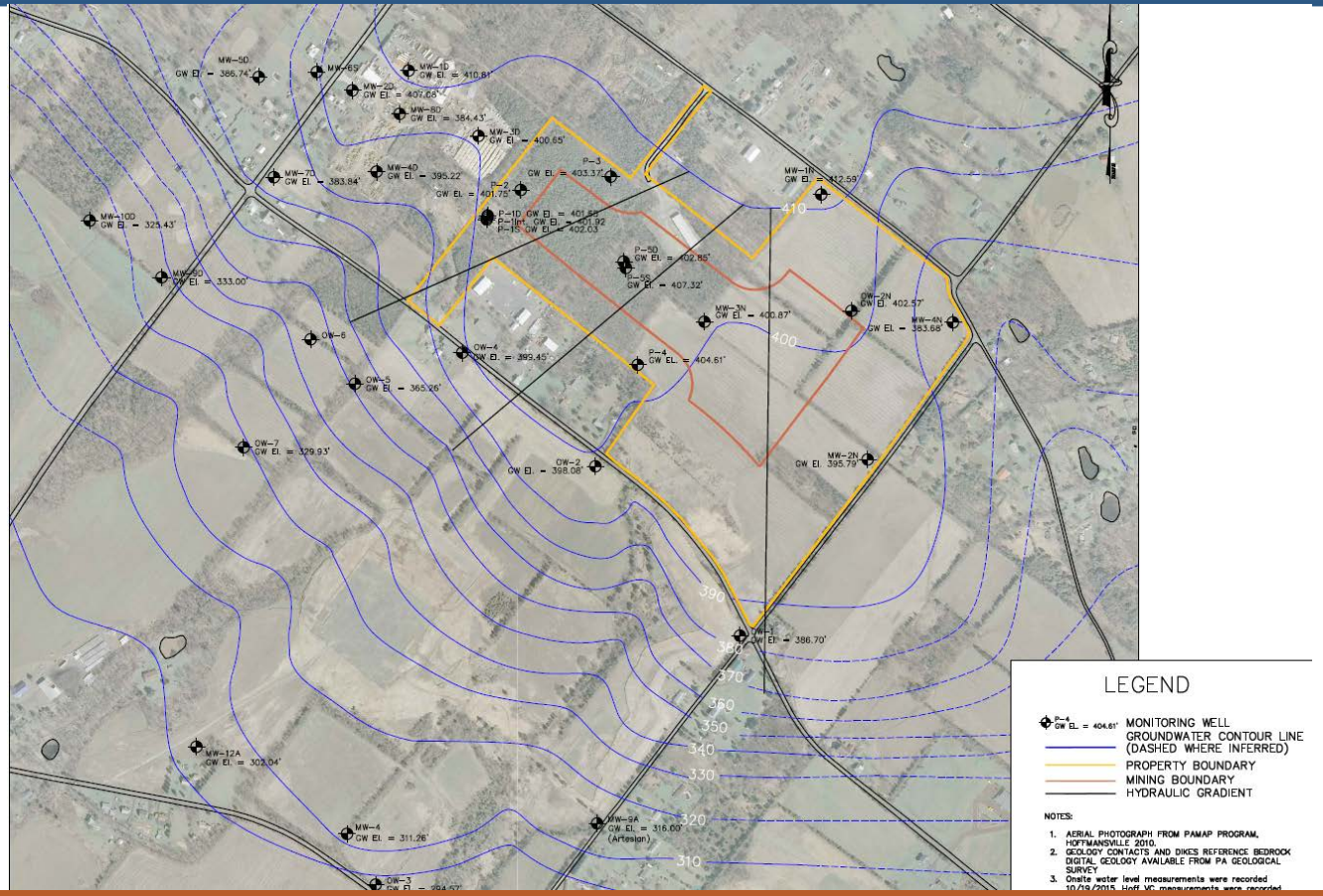
Groundwater Elevation and Gradient



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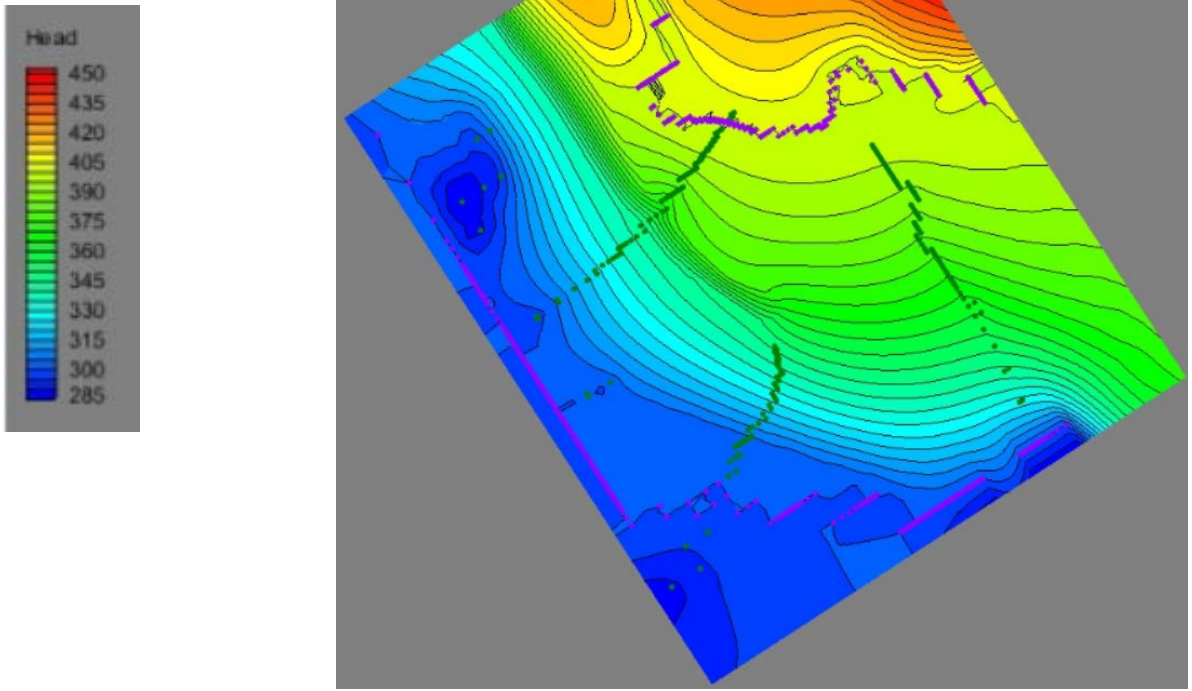
Initial Model Setup

- A fate and transport model was developed with a focus on the Hoff VC site and proposed quarries.
- The constructed model is one layer, thickness is from ground surface to 0 ft MSL, approximately 450 ft total.
- The site specific geology (Brunswick, Baked Brunswick and Diabase) was used to spatially zone horizontal conductivity, using data from the 2016 Groundwater Pumping Evaluation (GPR) for the GR-IV site and overall site area.
- A horizontal anisotropy of 2:1 was used.
- Model porosity was 5%, in line with general published values for fractured bedrock.

Initial Model Setup (Continued)

- Model boundary conditions include stream drains, specified quarry flows, and specified head arcs.
- Specified flow values are based on calculated quarry base flow values of 6,000 cfd and 16,000 cfd for the south and north quarry, respectively, as reported in the 2003 mine permit application. These are conservative overestimated pumping rates as the currently proposed quarries proposed are smaller and/or shallower.
- Recharge of 7.9” per year was used across the model.

Pre-pumping Quarry Water Elev. (msl)



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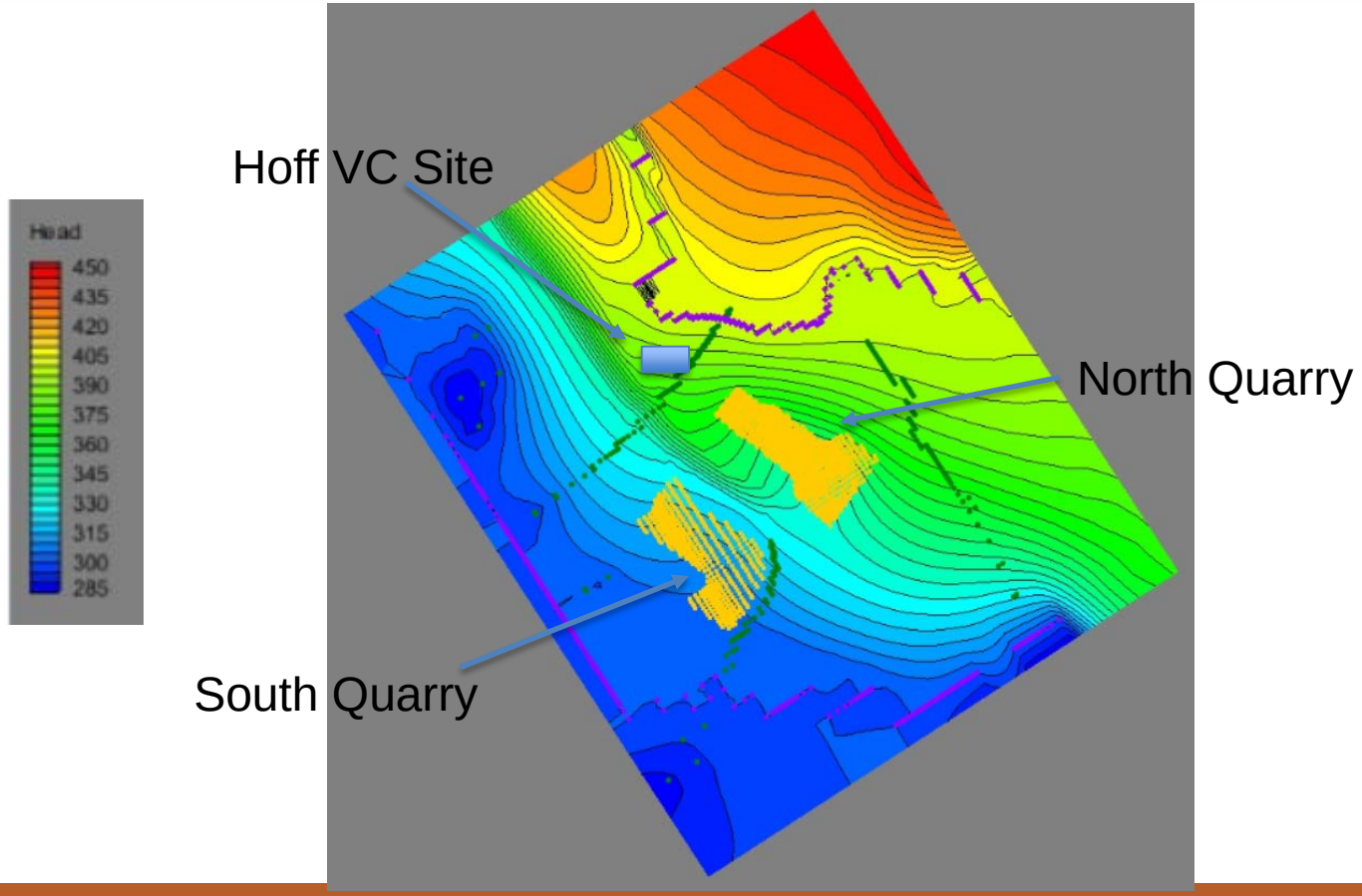
Pumping Water Elev. (msl) - Maximum Depth



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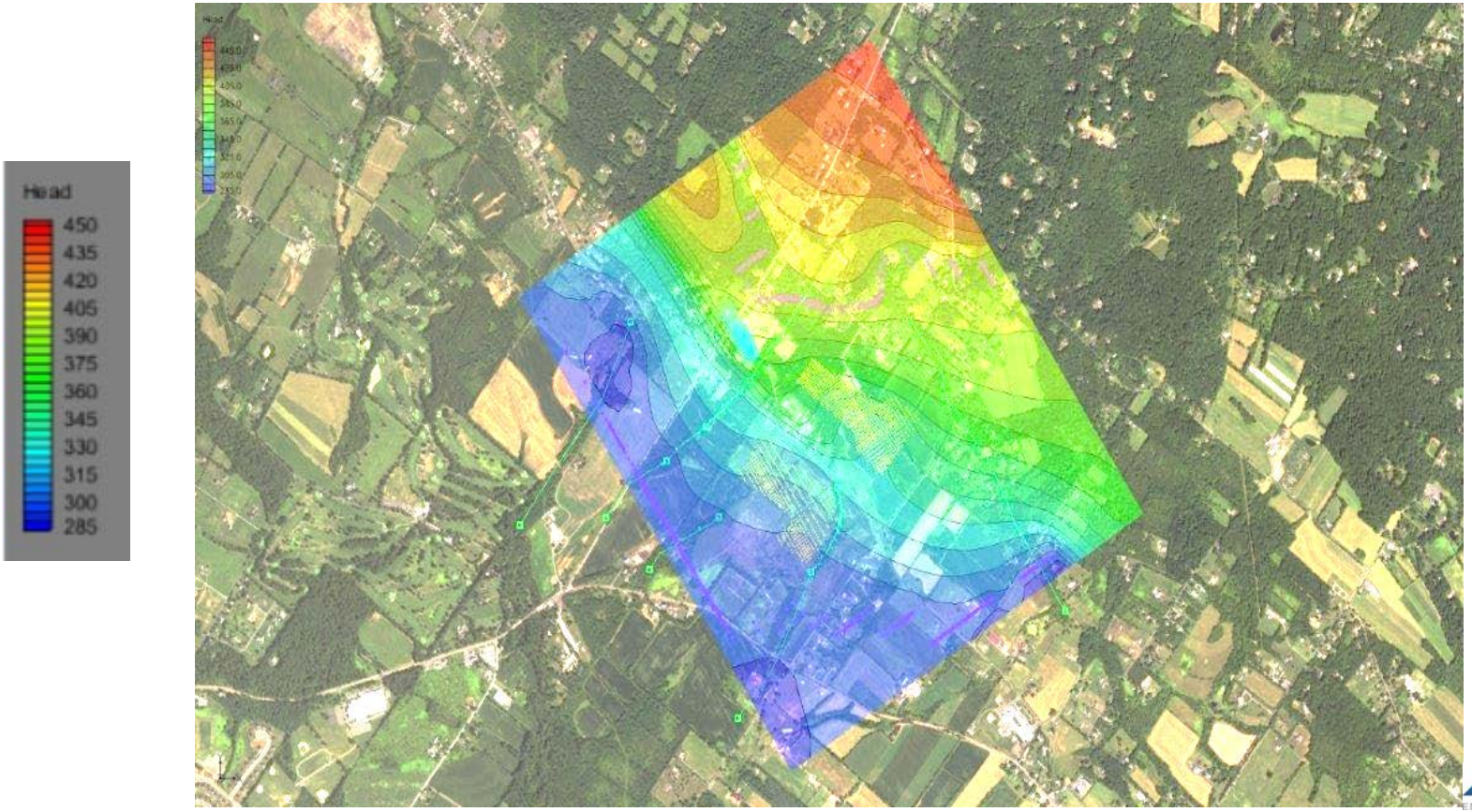
Pumping Water Elev. (msl) - Maximum Depth



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Fate and Transport Model (MT3D)

- The contaminant model parameters were based upon the Leidos analytical model.
- This model simulated 1,4-Dioxane, 1,2-DCB, TCE, and MTBE.
- All contaminants were modeled with a half-life of 13 years, which is a conservative rate compared to published estimates of half-lives for the modelled contaminants. The Leidos model used a half-life of 13 years for TCE and no degradation for the other three contaminants.
- The Tetra Tech model used these same rates, but used an initial concentration of contamination, whereas this model utilized a constant concentration source that never degrades.

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Fate and Transport Model (MT3D) (continued)

- The ‘Handbook of Environmental Degradation Rates’ (Howard, 1991) lists the following estimated maximum anaerobic half-lives for the modelled contaminants:
  - MTBE: 2 Years
  - 1,4-Dioxane: 1 Year
  - 1,2-DCB: 2 Years
  - TCE: 4.5 Years
- The model uses a contaminant half-life of 13 years for all contaminants which exceeds published estimates of all modeled contaminants.

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Fate and Transport Model (MT3D) (continued)

- Dispersivity inputs were kept consistent with previous Tetra Tech and Leidos reports for TCE, with longitudinal dispersivity at 40 ft, transverse to longitudinal ratio at 0.1, and vertical to longitudinal ratio of 0.05. Modeling of other contaminants were kept at this same set of dispersivity values as review of sample results do not indicate migration of other contaminants to the same degree as TCE.
- A soil bulk density of 1.7 g/cm3 was used, same as was used in the Leidos model for all parameters.

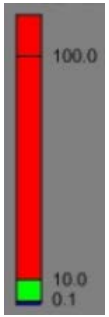
Models Runs

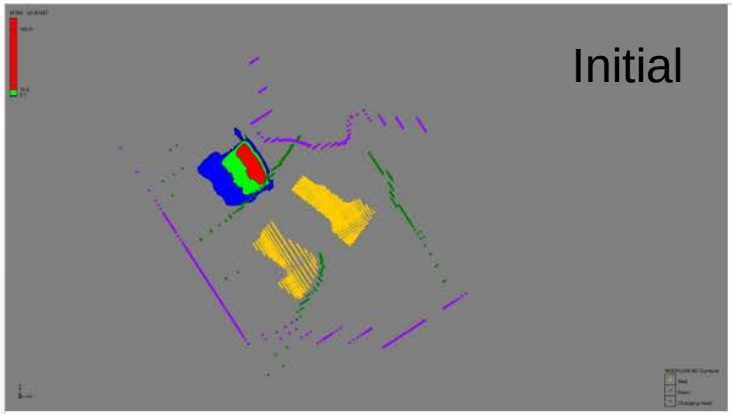
- Two calibrated steady state flow models were generated: one for a non-quarry pumping condition, and one with both quarry pits pumping at their proposed rates.
- Contamination was modeled using MT3DMS for a period of 50 years.
- Contamination modeling took part in two major steps: 1) a constant concentration contaminant source was run to equilibrium under natural conditions (no quarry pumping) to generate the maximum plume extent under natural conditions, and 2) the quarry was then activated with pumping simulated for 50 years while the contaminant source was held constant.

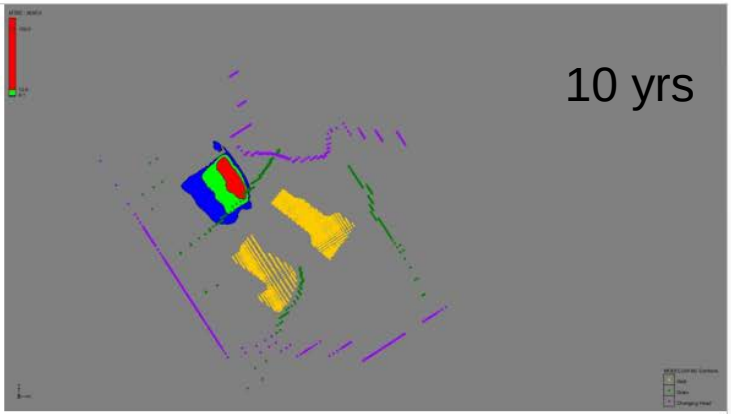
Modeling Results - MTBE

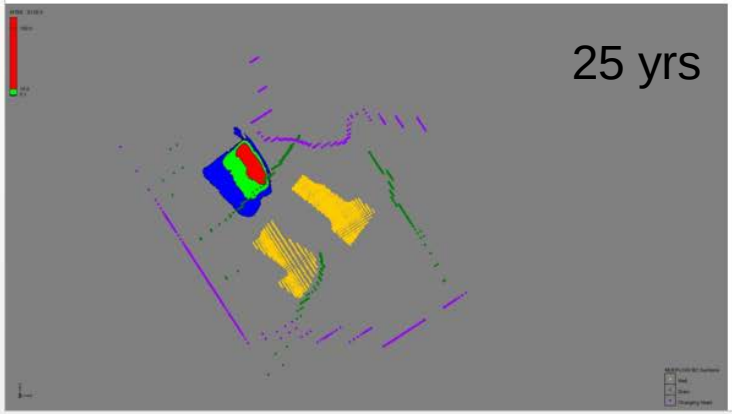
Legend:

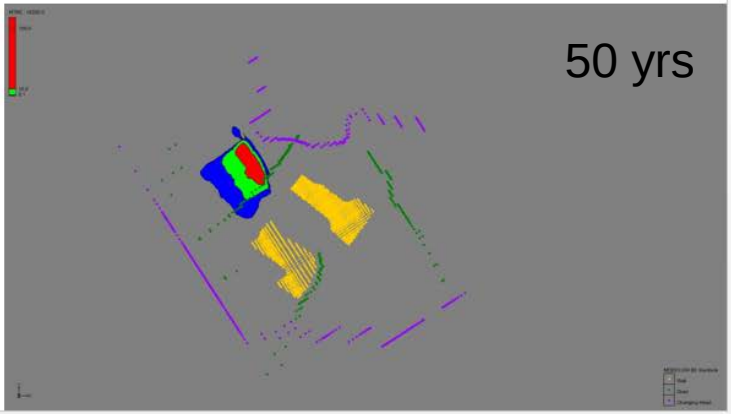
Blue: 0.1 ppb
Green: 0.1 -10 ppb
Red: 10 – 100+ ppb







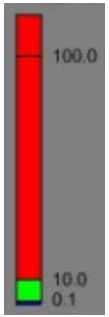


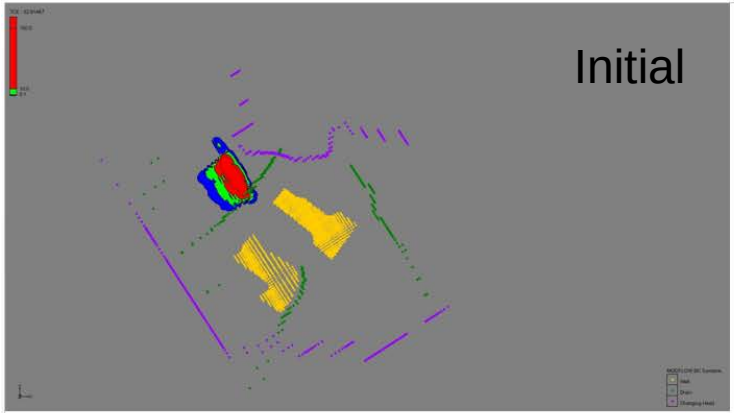


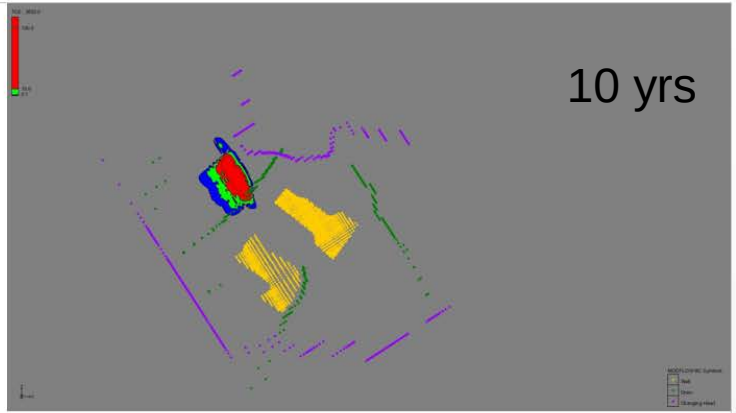
Modeling Results - TCE

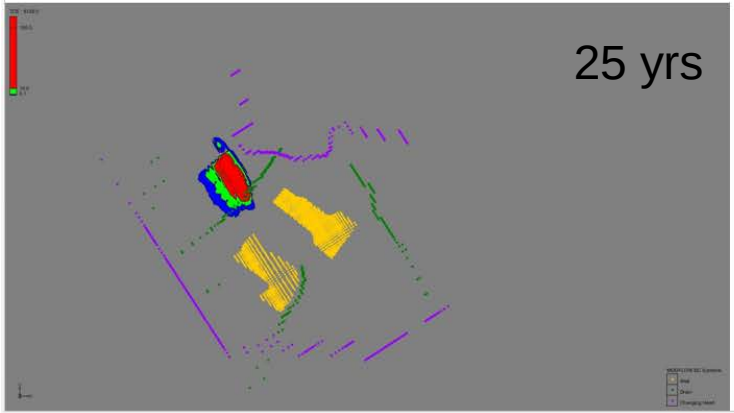
Legend:

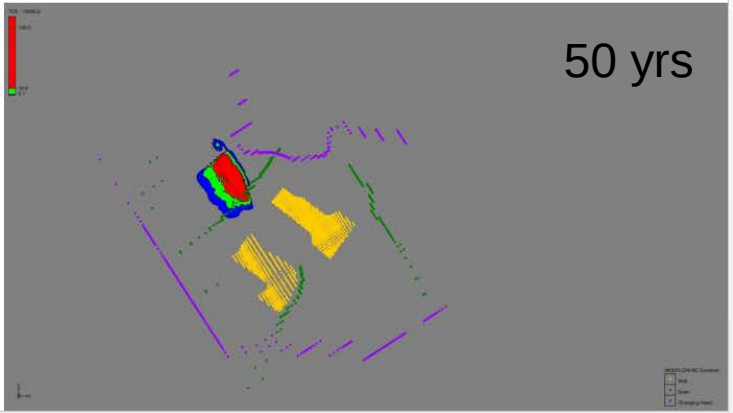
Blue: 0.1 ppb
Green: 0.1 -10 ppb
Red: 10 – 100+ ppb







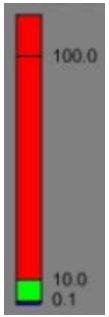


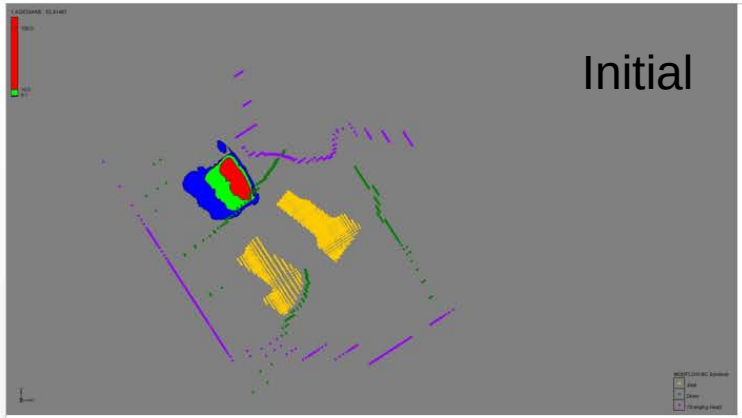


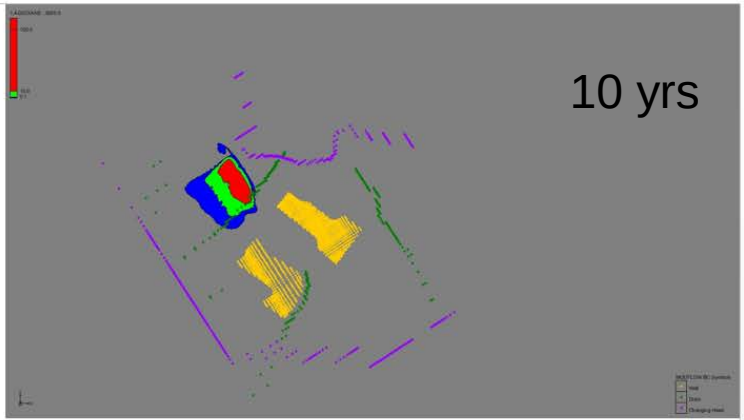
Modeling Results – 1,4-Dioxane

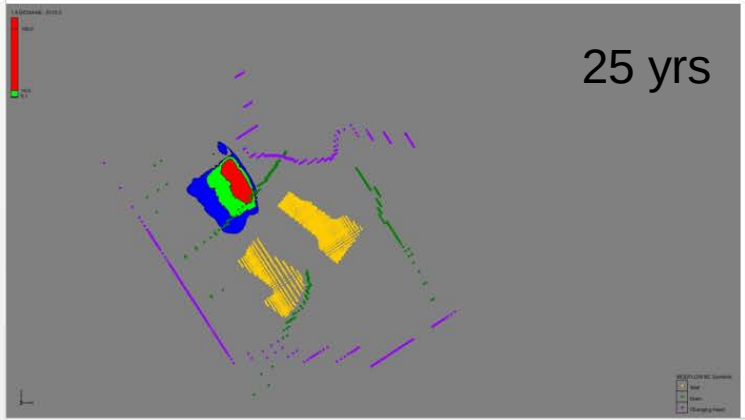
Legend:

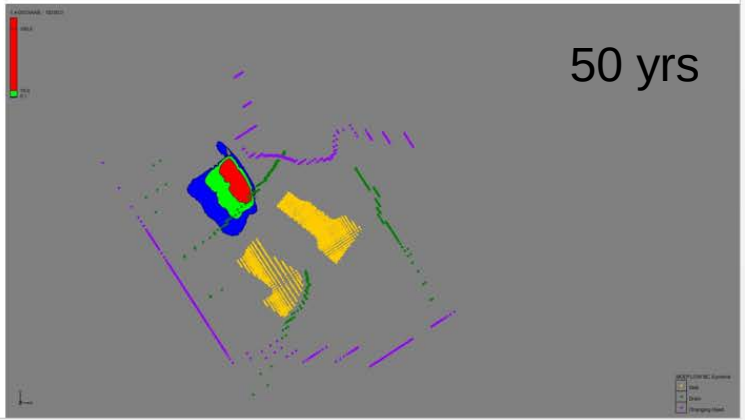
Blue: 0.1 ppb
Green: 0.1 -10 ppb
Red: 10 – 100+ ppb











Modeling Results – 1,2-DCB

Legend:

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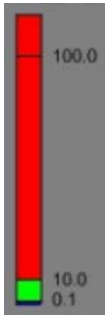
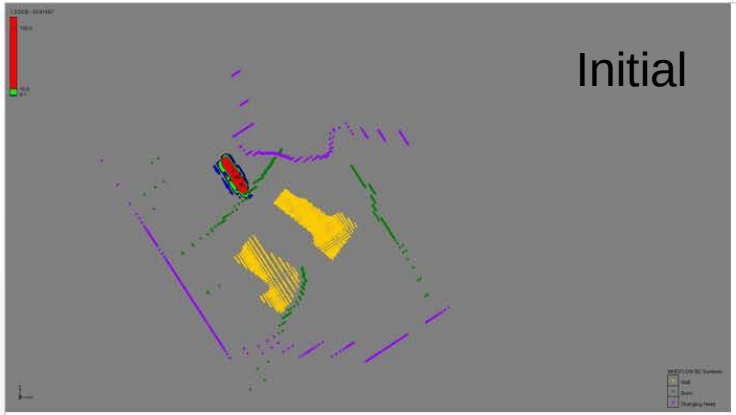
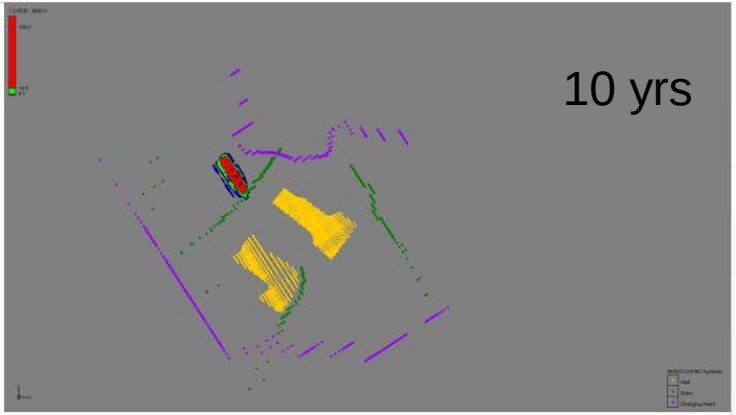
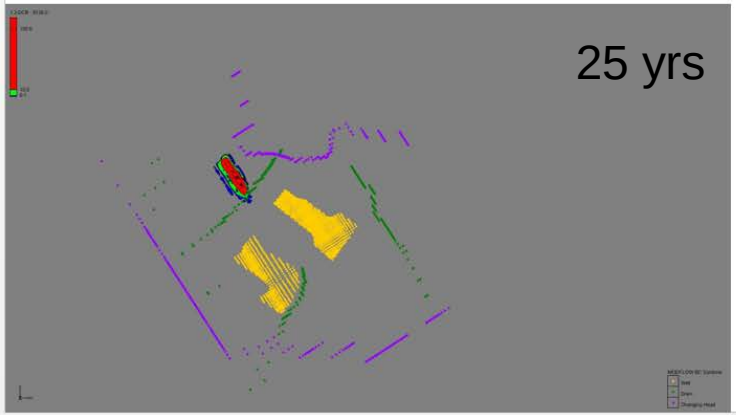
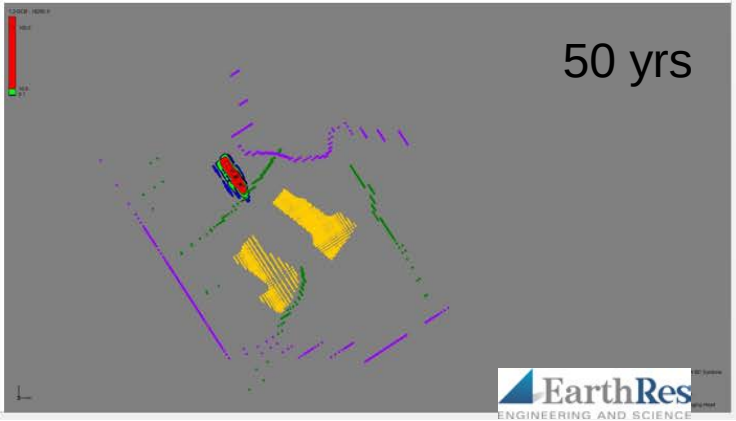
Green: 0.1 -10 ppb
Red: 10 – 100+ ppb











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Conservative Modeling Approach

- Model assumes no remediation is conducted at the Hoff VC site and source area concentrations remain constant.
- The quarry is built out to its full extent and depth immediately; and is currently pumping the maximum rate within the current contamination regime.
- The model is one layer. The contamination cannot sink into the aquifer and must expand horizontally. Therefore, quarry pumping will have the maximum impact on horizontal contaminant migration away from the Hoff VC site.

Conservative Modeling Approach

- The model uses a constant concentration source that does not allow contamination at the Hoff VC site to break down.
- Currently proposed remedial actions by the DEP will cause a decrease in source area contaminant levels in the short and long-term, that would cause the model to be highly over-predictive of contaminant levels on- and off-site.
- The model utilized the pumping rate from the prior 2003 GPE report, whereas the actual pumping rates will be less with the new proposed quarry layouts.

Modeling Results / Conclusions

- The conservative fate and transport modeling results indicate that contaminant capture due to quarry pumping is unlikely.
- Additionally, the quarry footprint will develop slowly, pumping of significant groundwater will not occur for approximately 15 years
- During this timeframe physical remediation and natural degradation will continue at the Hoff VC site.

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