Remedial Timeframe Assessment

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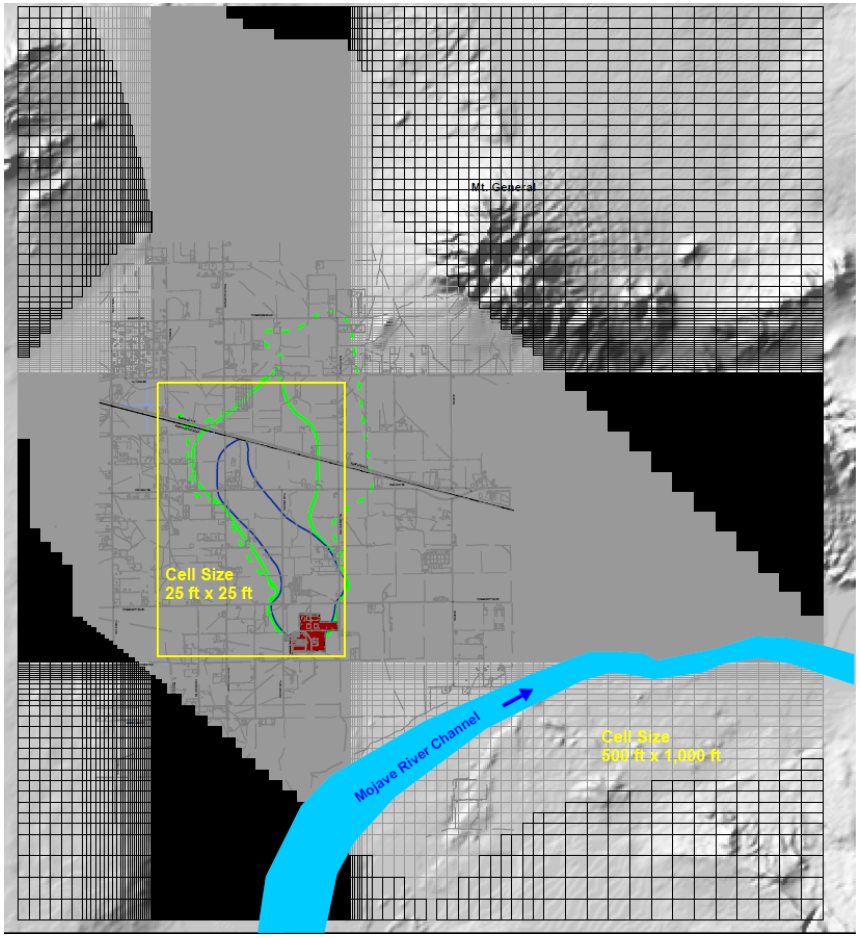
What is a model?

- A simplified representation of a system or process

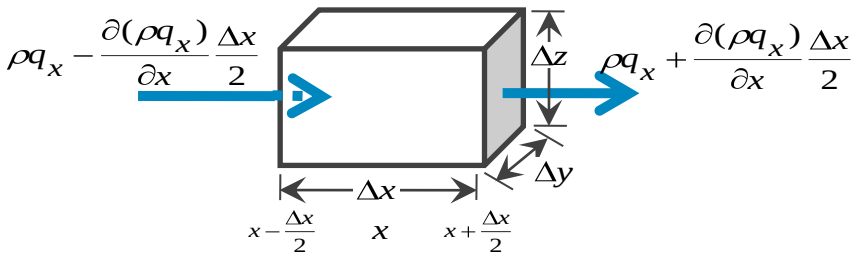
We've used the model for two very similar, but different purposes:

- Feasibility Study (2010-2011)
  - To compare required infrastructure and treatment times among remedial alternatives
- Remedial Timeframe Assessment (2014)
  - To set expectations for treatment times to guide remedy implementation and optimization
  - To guide establishment of clean up requirements
  - 2014 work began with 'recalibration', to use latest site information

What is a groundwater flow and solute transport model for chromium remediation?

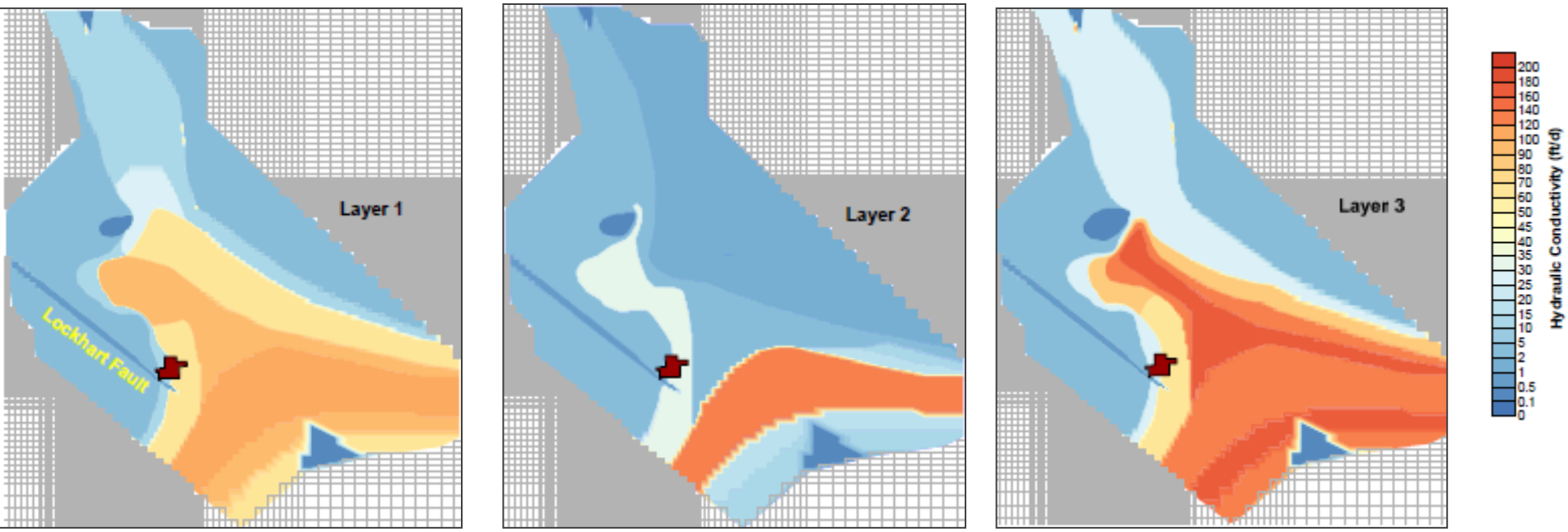


- Describes the site hydrogeology in 3D as a set of cubes
- Uses equations to describe flow of water through set of cubes
- Uses another set of equations to describe the processes that affect chromium, etc.



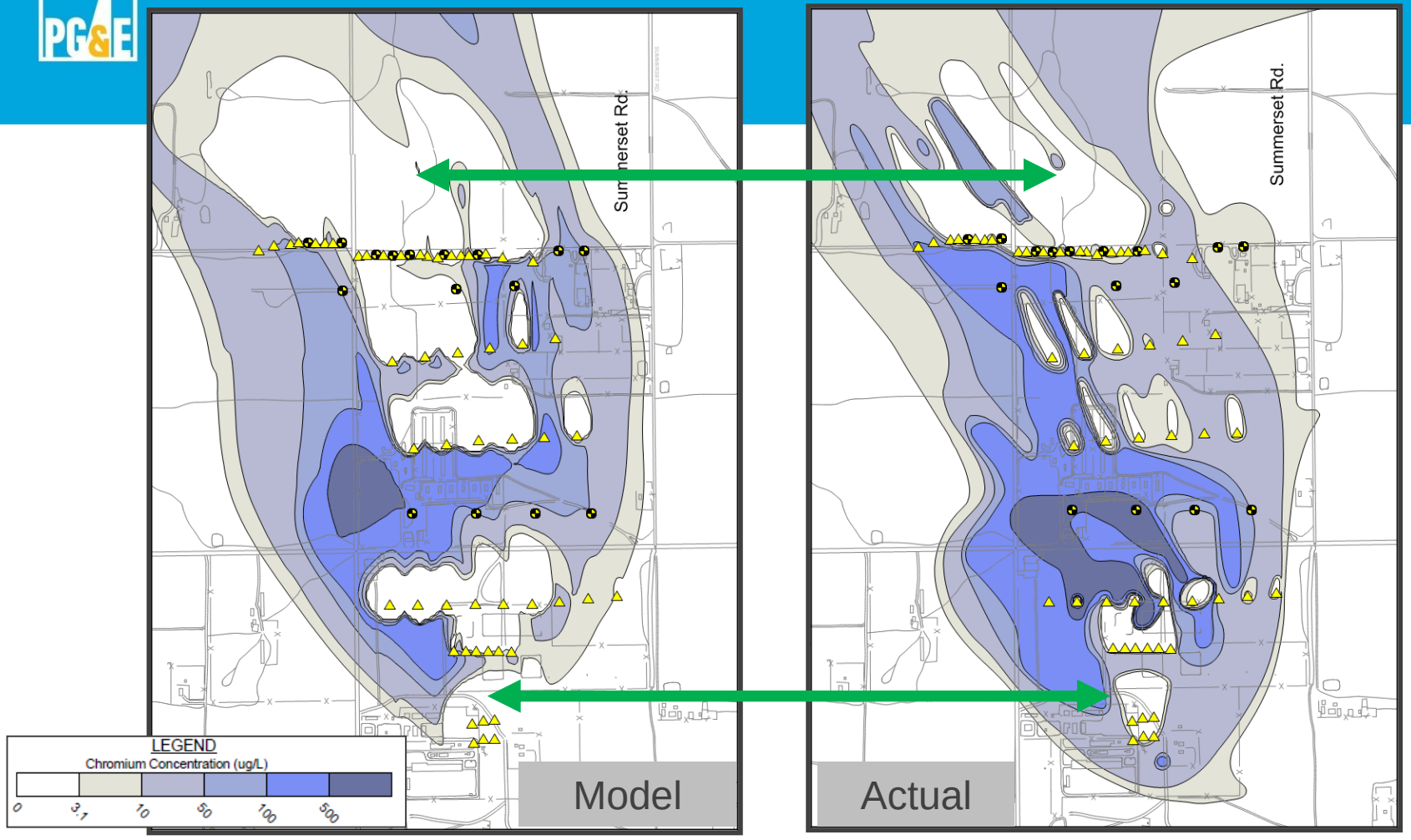
Model layers

- Within model, the aquifer is broken into several layers, each with different properties



Layers of Upper Aquifer shown here.

How well does the model predict remediation?

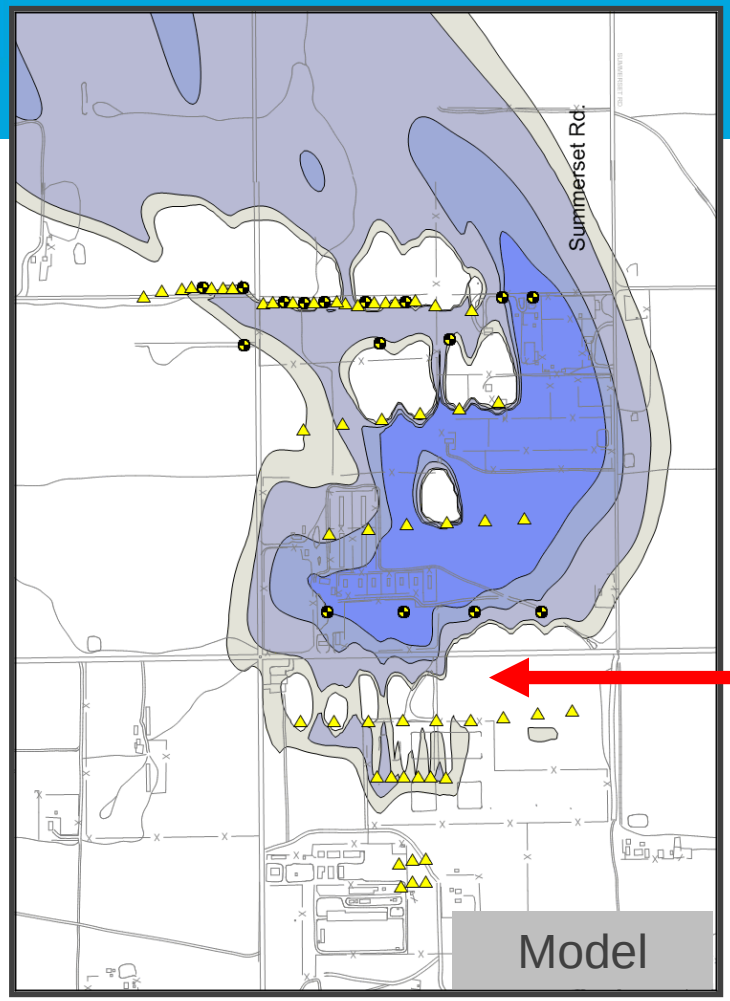


Model Run with Actual Operations , 6.25 years
(from 4Q07 baseline, shallow)

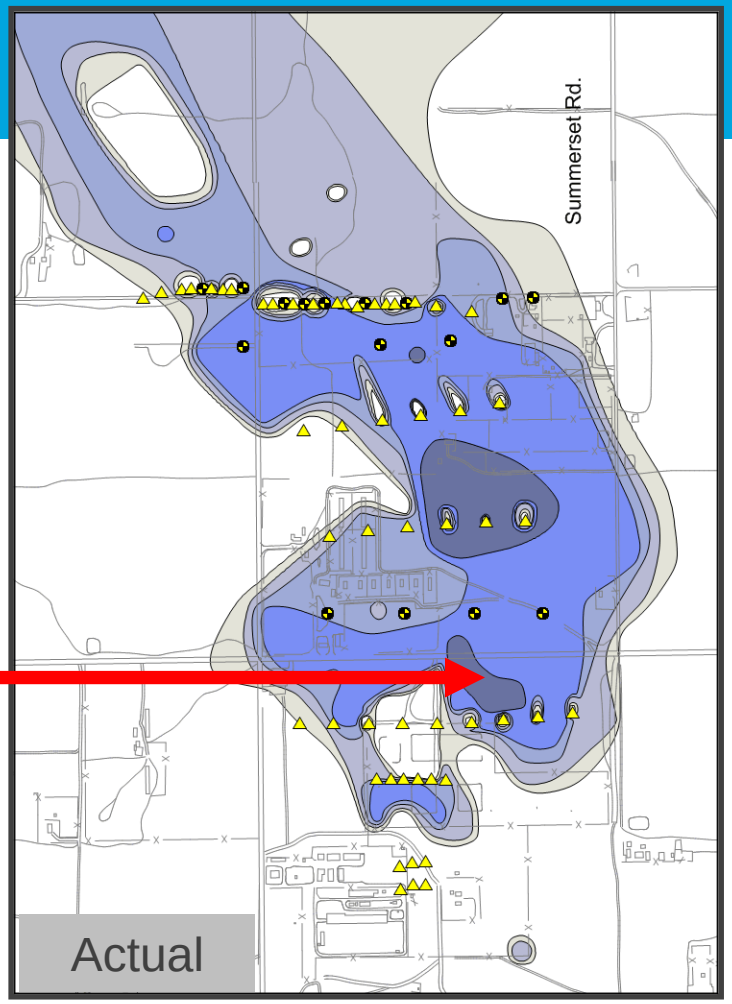
Actual Jan 2014
(6.25 years from baseline, shallow)

- Overall, modeling does excellent job of predicting areas of treatment and migration of treated water (i.e. accurate time, distance)

How well does the model predict remediation?



Model Run with Actual Operations, 6.25 years
(from 4Q07 baseline, deep)

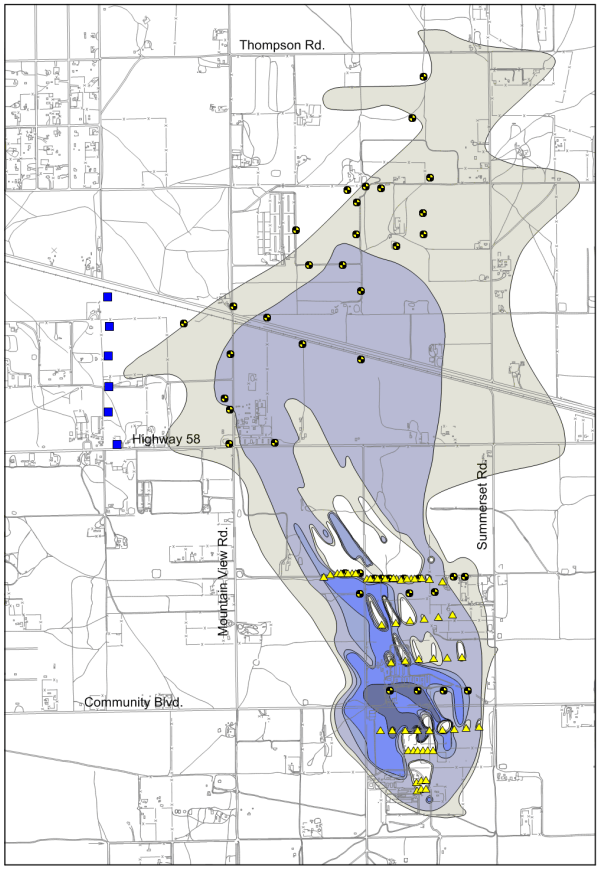


Actual Jan 2014
(6.25 years from baseline, deep)

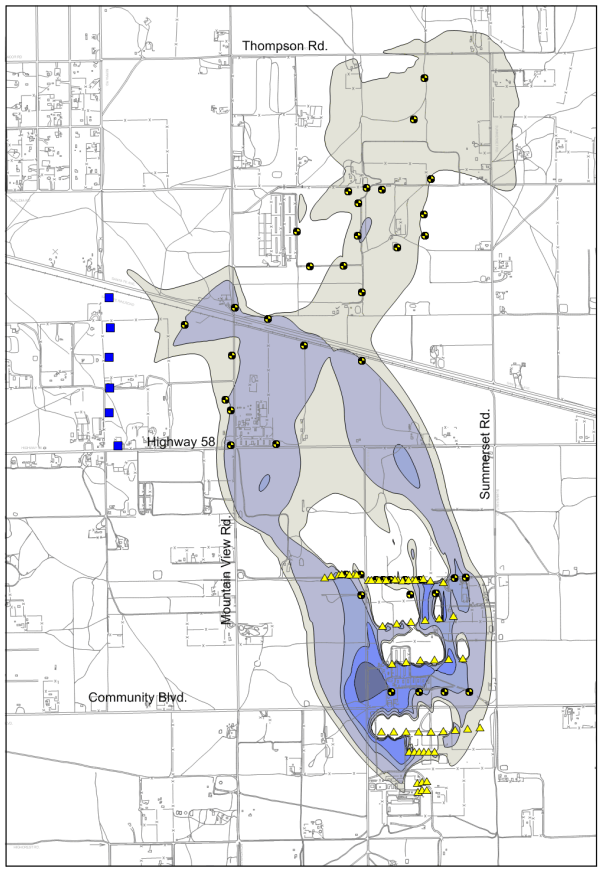
- While the model does a good job of predicting remediation overall, it can not capture all of the heterogeneities that exist in the aquifer

How do model assumptions affect the results?

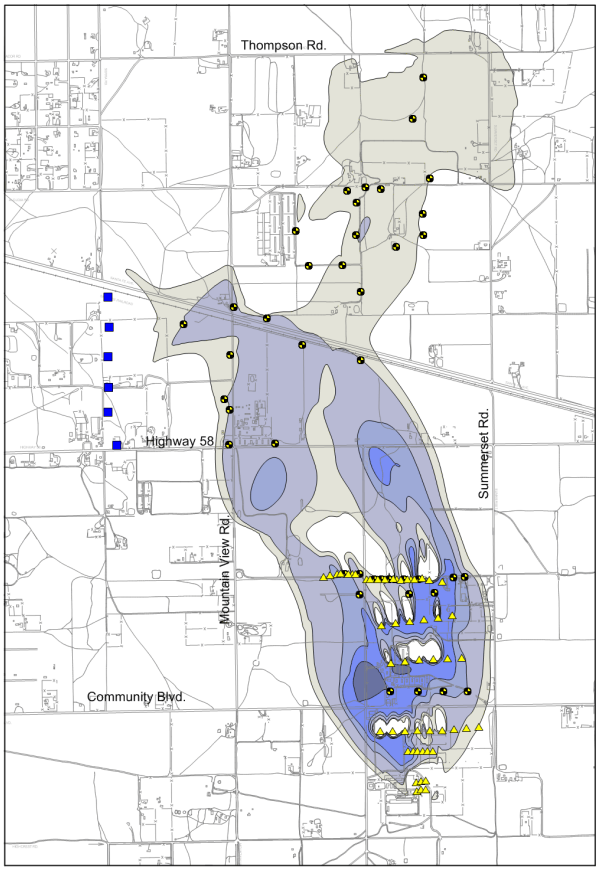
Actual
CONTOURED FROM MONITORING DATA



Modeled
0.1 mg/L TOTAL ORGANIC CARBON THRESHOLD



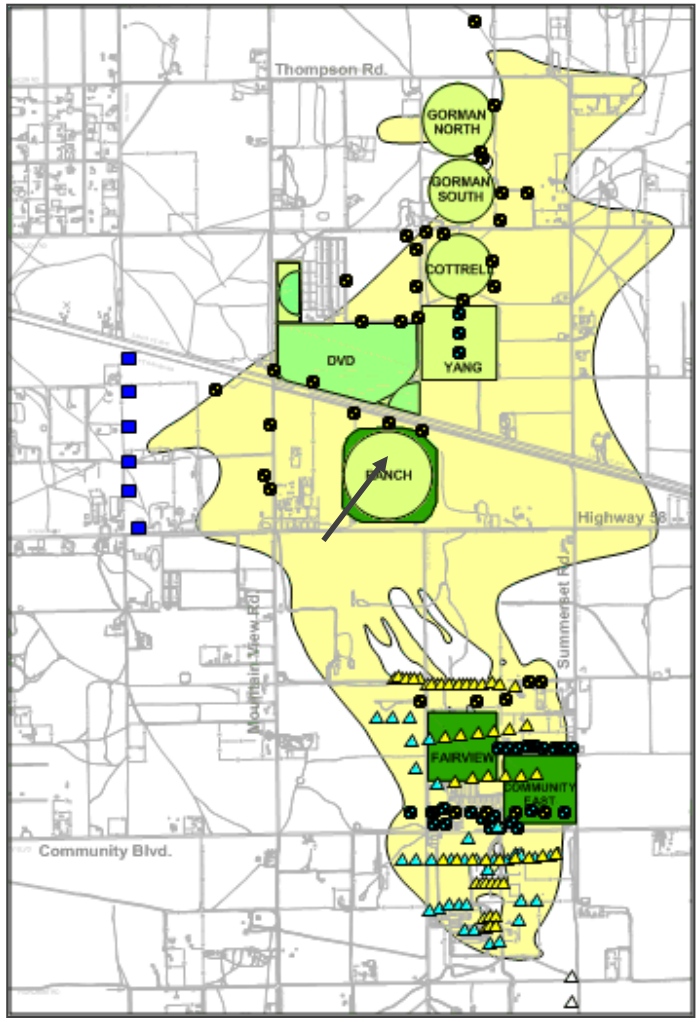
Modeled
1.0 mg/L TOTAL ORGANIC CARBON THRESHOLD



- Variation of this modeling parameter improves prediction of some aspects of remediation progress, worsens predictions of other aspects

2014 Remedial Timeframe Assessment Modeling

- Evaluated remedial plan similar to FS alternative 4C-2
  - Extraction and agricultural treatment
  - Freshwater Injection
  - IRZ treatment
- Updated layout based on current plans
- Incorporated biological permitting and construction schedules

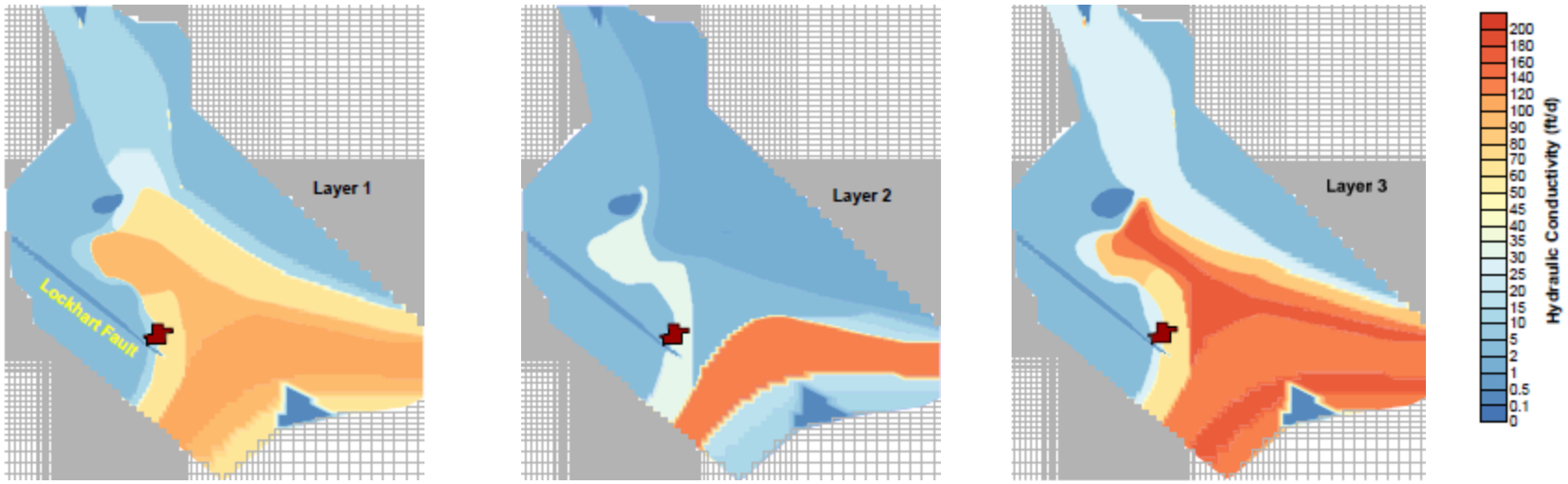


Range of Estimates Provided by Remedial Timeframe Assessment

- Key modeling parameter (TOC threshold) was varied to evaluate range of potential timeframes:
  - Scenario 1: FS Alternative 4C-2
    - Provided for reference point to Feasibility Study (not to guide remedial goal development)
  - Scenario 2: Updated Remedy Design, Low TOC Threshold
  - Scenario 3: Updated Remedy Layout, High TOC Threshold

Range of Estimates Provided by Remedial Timeframe Assessment

- Range of estimates from model layers evaluated as representation of aquifer heterogeneity

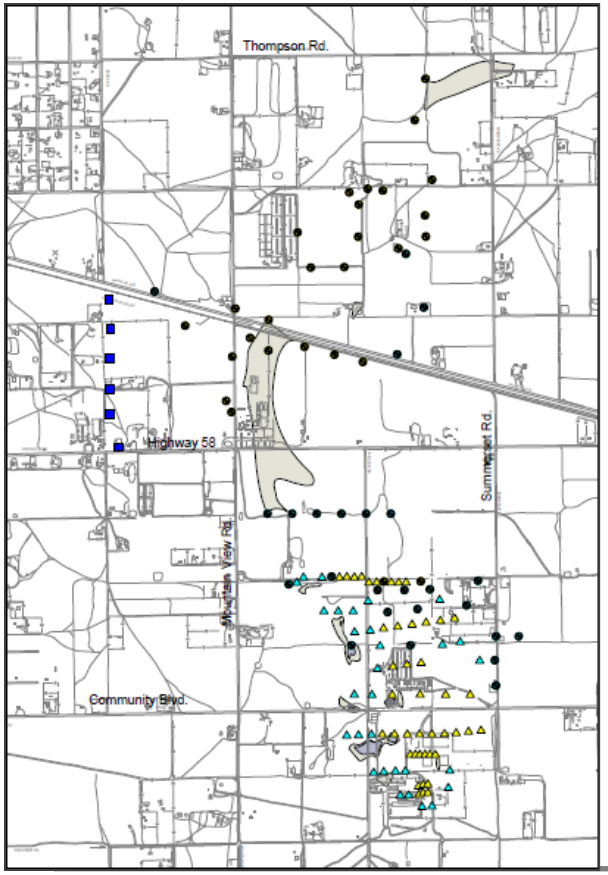


Layers of Upper Aquifer shown here.

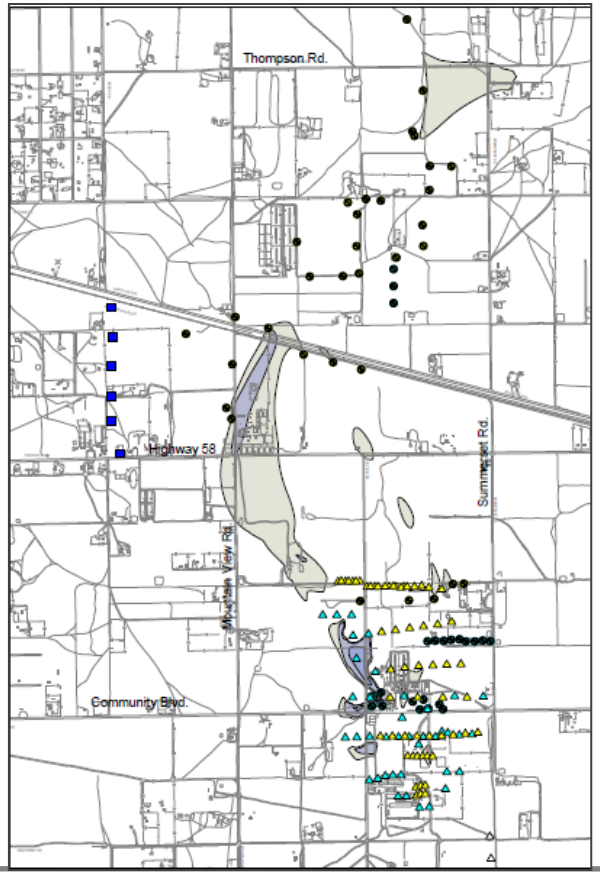
Results of 3 Modeling Runs

Layer 1, 8 years

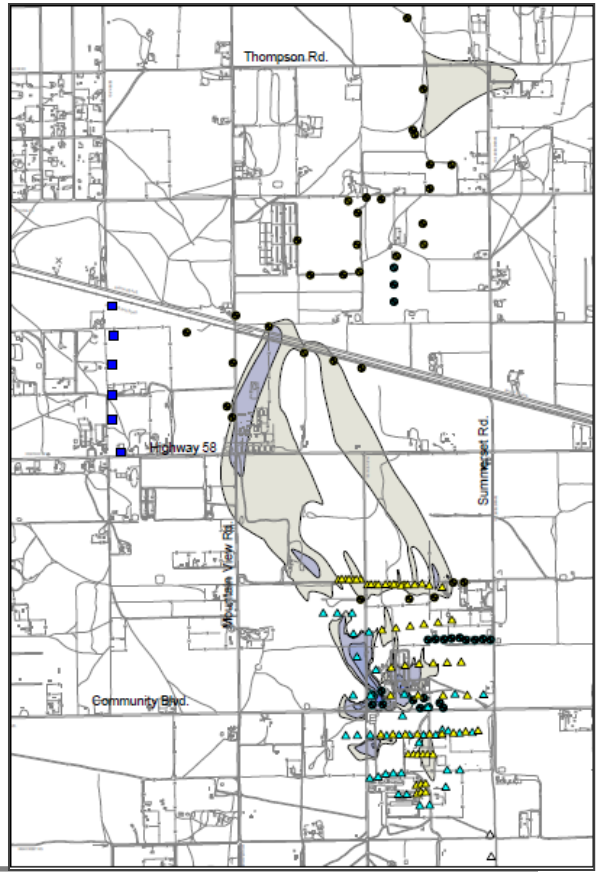
Run 1: Baseline FS 4C-2



Run 2: Design Update, Low TOC Threshold



Run 3: Design Update, High TOC Threshold



LEGEND

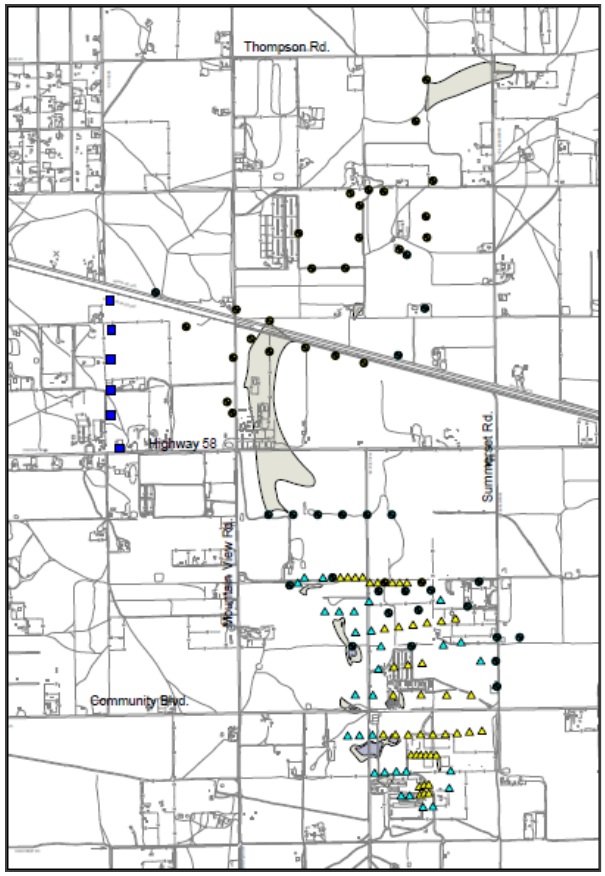
Chromium Concentration (ug/L)

0 3.1 10 50 100 500

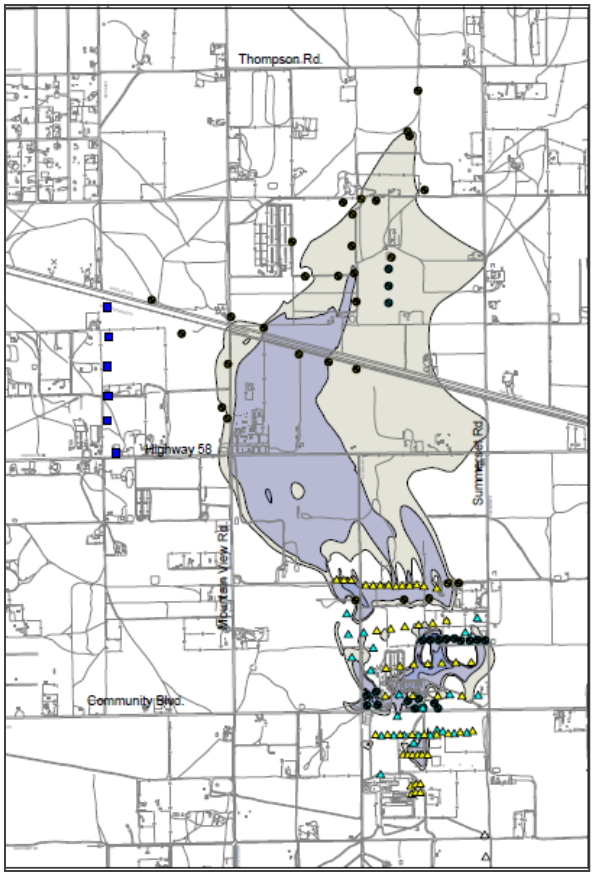
Results of Modeling Scenario 2

8 years

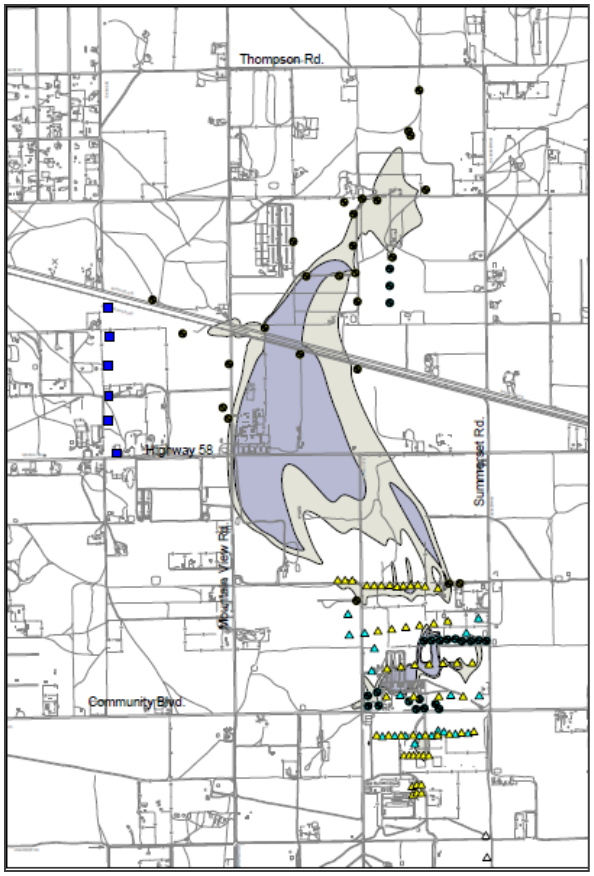
Layer 1



Layer 2



Layer 3



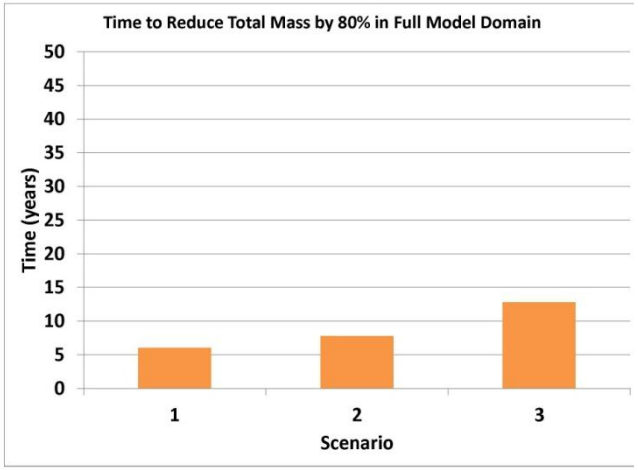
LEGEND

Chromium Concentration (ug/L)

0 3.1 10 50 100 500

Range of Timeframe Estimates

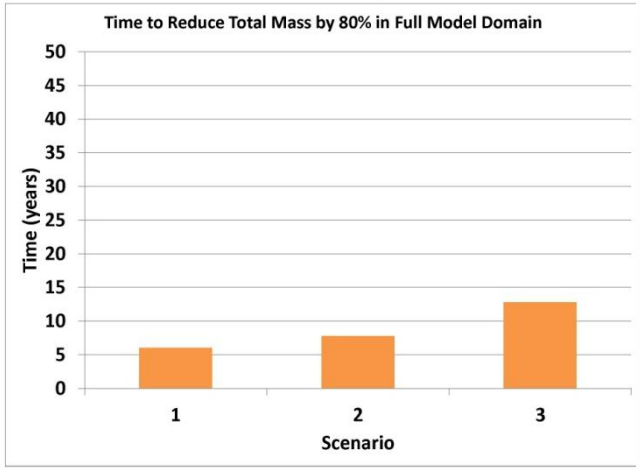
80% Mass Removal



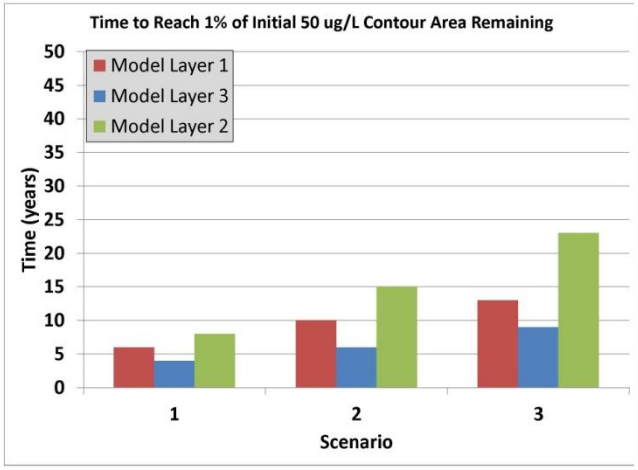
Scenario	Time to Reduce Total Mass by 80% (years)
Scenario 1: FS Alternative 4C-2, First Quarter 2014 Baseline	6
Scenario 2: Updated Remedy Layout	8
Scenario 3: Updated Remedy Layout, Increased TOC threshold	13

Range of Timeframe Estimates

80% Mass Removal



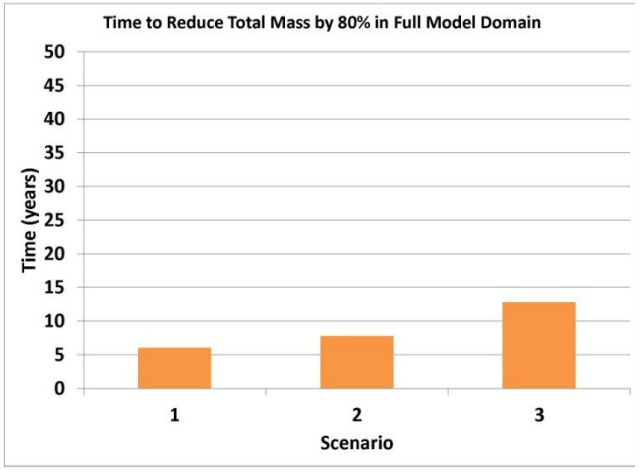
50 µg/L



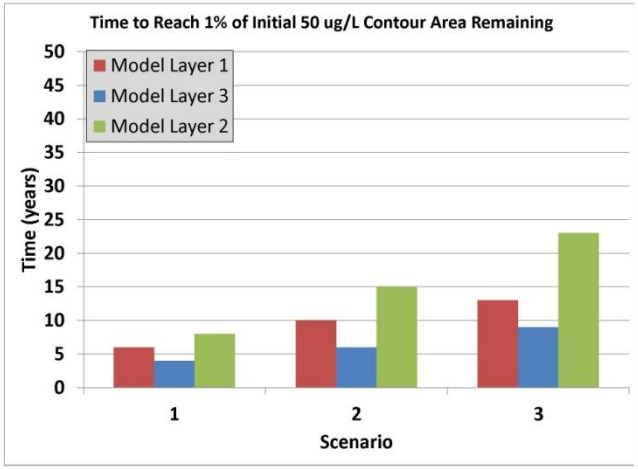
Scenario	Time to Reduce Total Mass by 80% (years)	Time to Reach 1% of Initial 50 µg/L Contour Area Remaining (years)		
		Model Layer 1	Model Layer 3	Model Layer 2
Scenario 1: FS Alternative 4C-2, First Quarter 2014 Baseline	6	6	4	8
Scenario 2: Updated Remedy Layout	8	10	6	15
Scenario 3: Updated Remedy Layout, Increased TOC threshold	13	13	9	23

Range of Timeframe Estimates

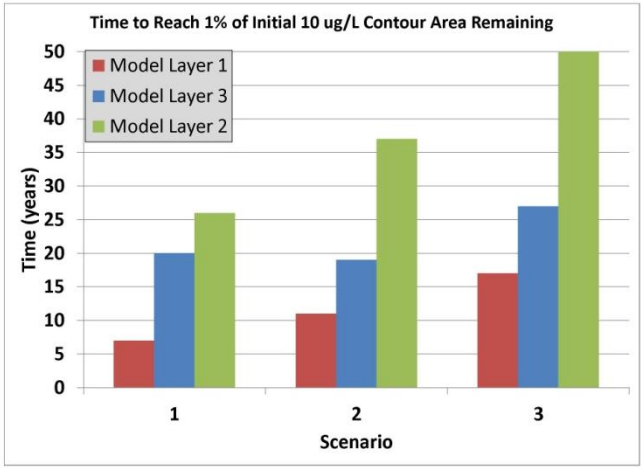
80% Mass Removal



50 µg/L



10 µg/L



Scenario	Time to Reduce Total Mass by 80% (years)	Time to Reach 1% of Initial 50 µg/L Contour Area Remaining (years)			Time to Reach 1% of Initial 10 µg/L Contour Area Remaining (years)		
		Model Layer 1	Model Layer 3	Model Layer 2	Model Layer 1	Model Layer 3	Model Layer 2
Scenario 1: FS Alternative 4C-2, First Quarter 2014 Baseline	6	6	4	8	7	20	26
Scenario 2: Updated Remedy Layout	8	10	6	15	11	19	37
Scenario 3: Updated Remedy Layout, Increased TOC threshold	13	13	9	23	17	27	50

Remedial Timeframe Assessment Results

- "The model estimated treatment times for the Cr(VI) contiguous plume core south of Thompson Road were:
  - Time to reduce the total mass by 80 percent ranges from 8 to 13 years.
  - Time to reduce Cr(VI) concentrations to less than 50 µg/L across 99 percent of the initial 50 µg/L footprint range:
    - From 6 to 13 years in given layers across the majority of the aquifer represented by model layers 1 and 3
    - From 15 to 23 years in less permeable portions of the aquifer predicted by model layer 2
  - Time to reduce Cr(VI) concentrations to less than 10 µg/L across 99 percent of the initial 10 µg/L footprint range:
    - From 11 to 27 years in given layers across the majority of the aquifer represented by model layers 1 and 3
    - From 37 and 50 years in less permeable portions of the aquifer predicted between represented by model layer 2"

Uncertainty in Estimates

- The modeling analysis presented in this remedial timeframe assessment provides a guide for evaluation of remedy performance over time
- There is uncertainty in the model predictions due to a number of factors, including:
  - Scale
  - Accuracies in model parameters and assumptions
  - Heterogeneity in the aquifer and Cr(VI) distribution within the aquifer
- The modeling results do not provide definitive predictions and should not be used in cleanup orders with the expectation of certainty

Technical Questions?

(Recommendations follow)

Recommended Remedial Goals Approach

- Establish **remediation forecast** based on modeling assessment that can be used for periodic evaluations every 4 years
- Example:

Time	Remediation Forecast
4 Years	• Anticipate average Cr(VI) concentrations less than 10 ppb across 75-80% of shallow zone and 20-40% of the deep zone of Upper Aquifer • Areas may remain above goals where remedial infrastructure was not installed pending biological permitting • Areas may remain above goals due to aquifer heterogeneity.
8 years	…….
12 years	…….

Recommended Framework for Evaluation of Progress Toward Remedial Goals

- Given the uncertainty in the remedial timeframe predictions, an **adaptive management approach** to promote efficient remediation over the life of the remediation project is recommended:
  - Conduct reviews on a 4 year cycle
    - Suggested based on IRZ design/build/operate/assess life cycle
  - Review report will assess the progress toward remediation forecast. Could include:
    - Comparison of treated areas to model predictions
    - Evaluation of concentration trends of Cr(VI) and other redox indicators
  - If remedial progress is not within expectations, report will identify actions to improve treatment and a timeframe for implementation.