# Remedial Timeframe Assessment

Kevin Sullivan, PG&E

September 10, 2014
Lahontan RWQCB Meeting, Barstow, CA

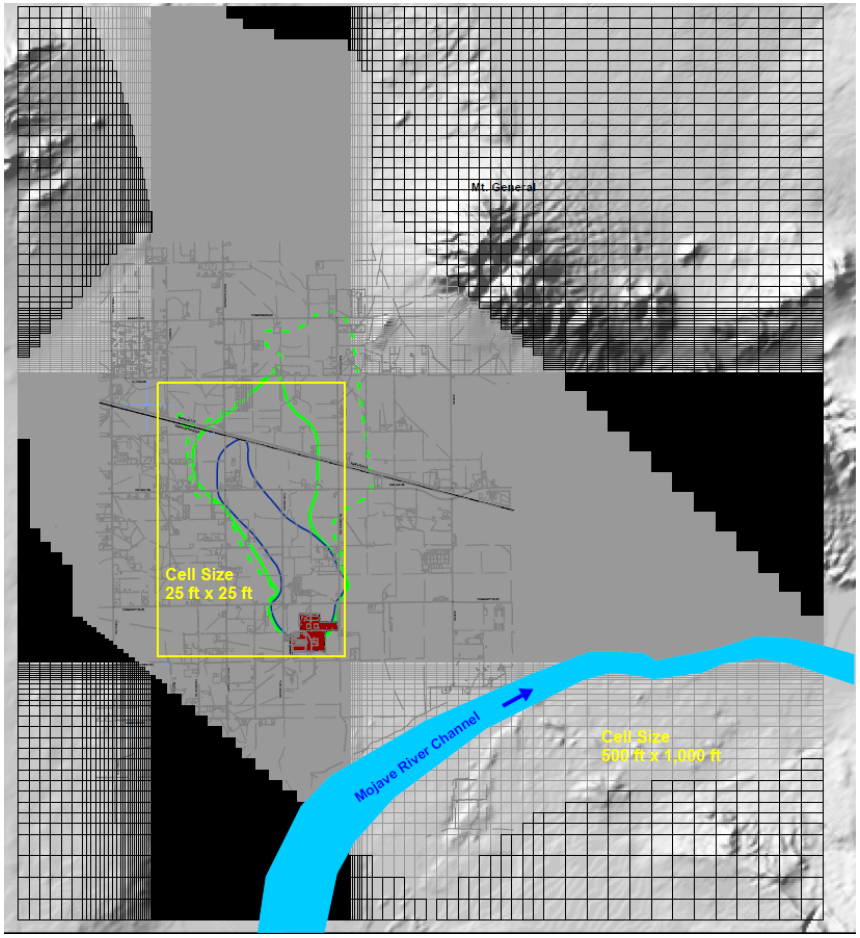
# What is a model?

- A simplified representation of a system or process

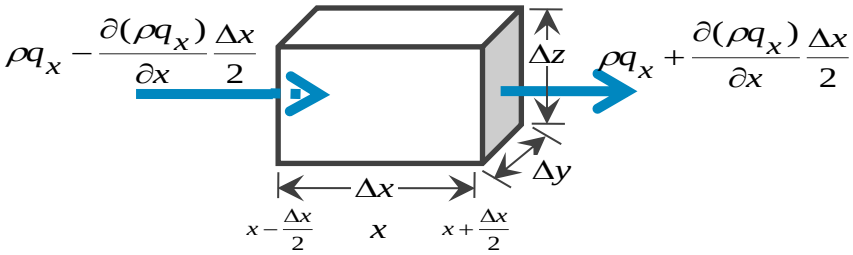

# We've used the model for two very similar, but different purposes:

- 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?

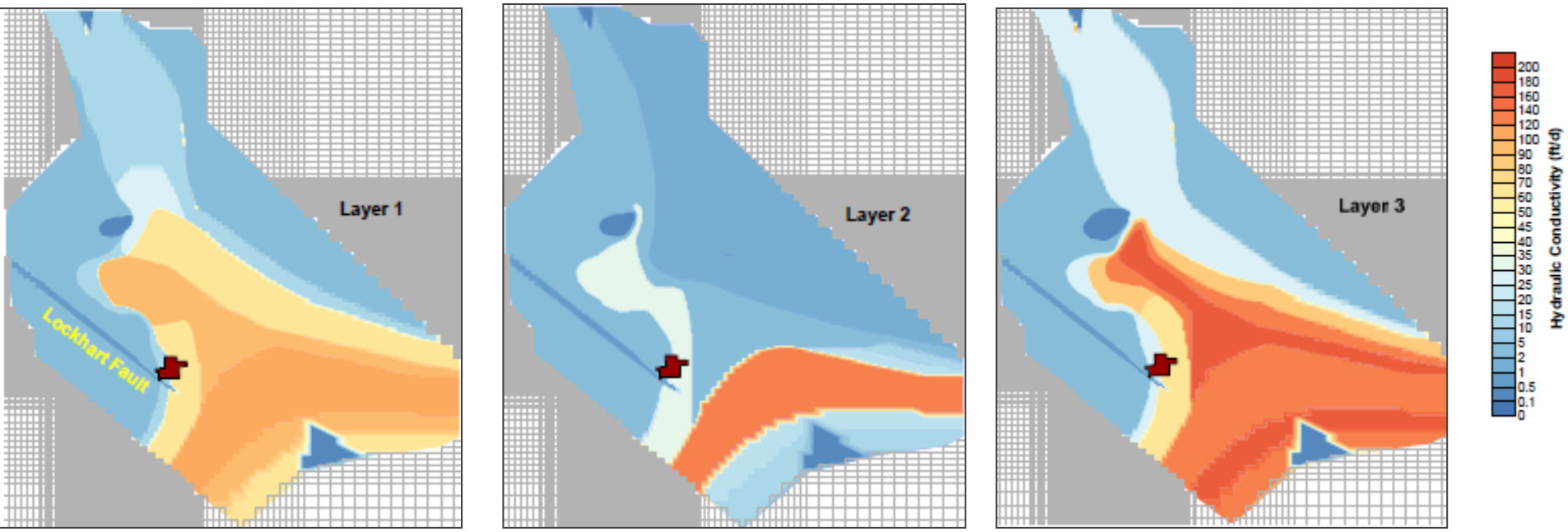



- Describes the site hydrogeology in 3D as a set of cubes
- Uses equations to describe flow of water through set of cubes
- Uses another set of equations to describe the processes that affect chromium, etc.



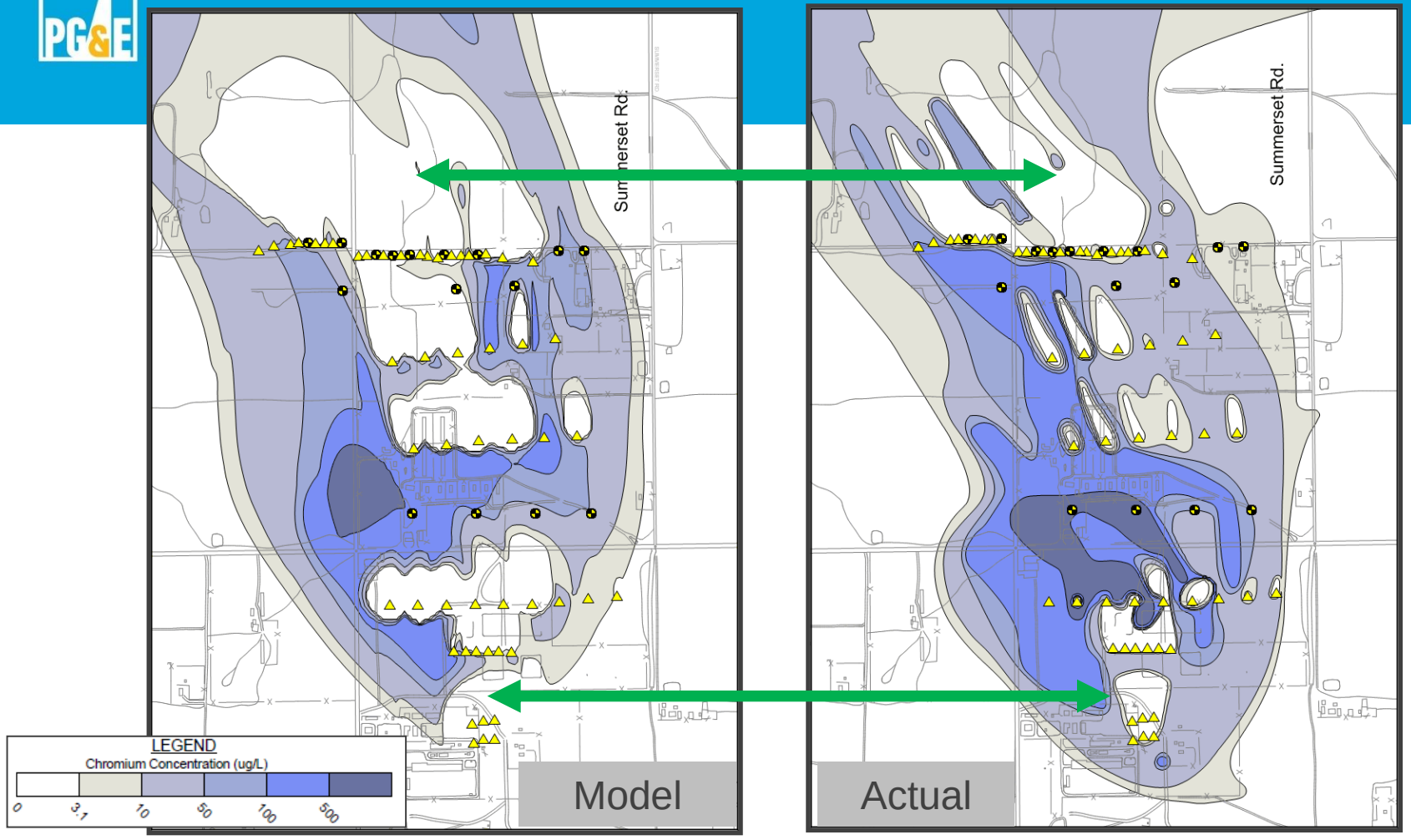
# Model layers

- 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?

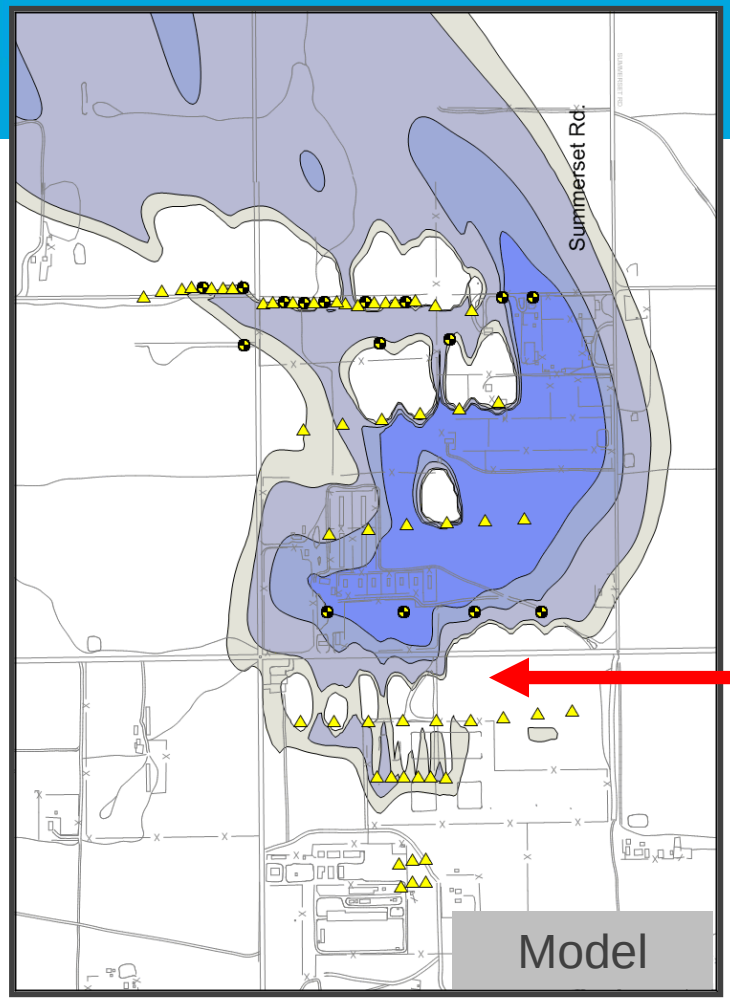



Model Run with Actual Operations , 6.25 years
(from 4Q07 baseline, shallow)

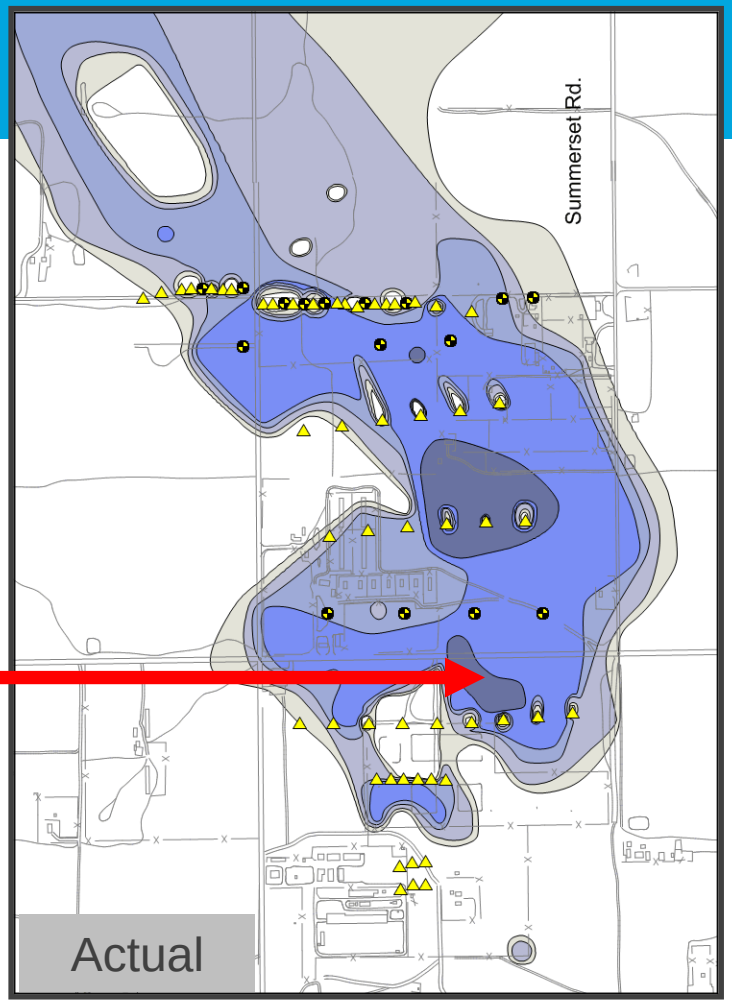
Actual Jan 2014
(6.25 years from baseline, shallow)

- 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)

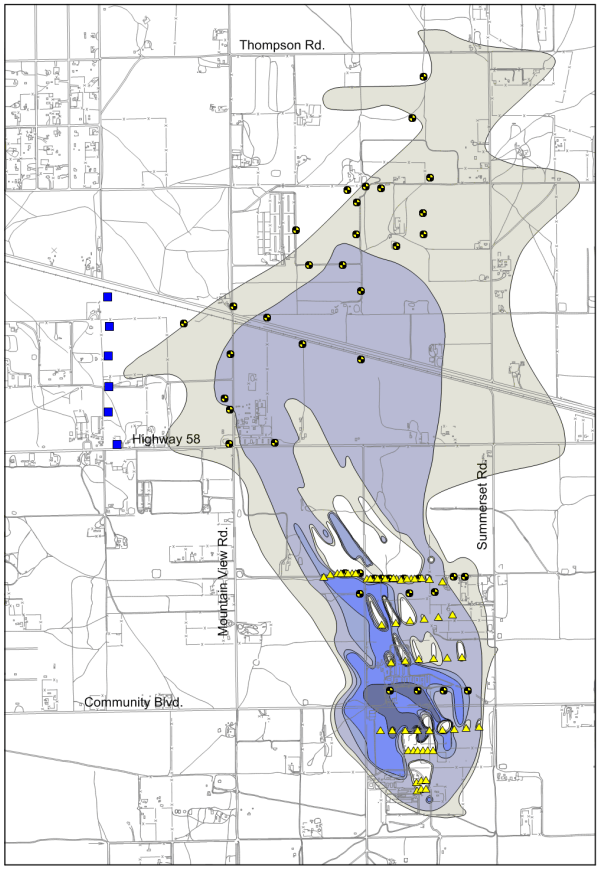



Actual Jan 2014
(6.25 years from baseline, deep)

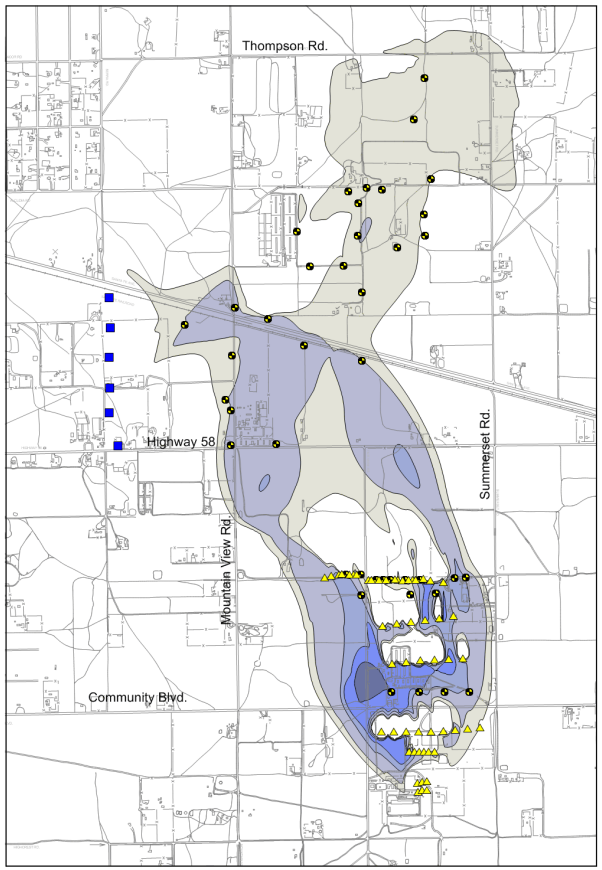
- While the model does a good job of predicting remediation overall, it can not capture all of the heterogeneities that exist in the aquifer

# How do model assumptions affect the results?

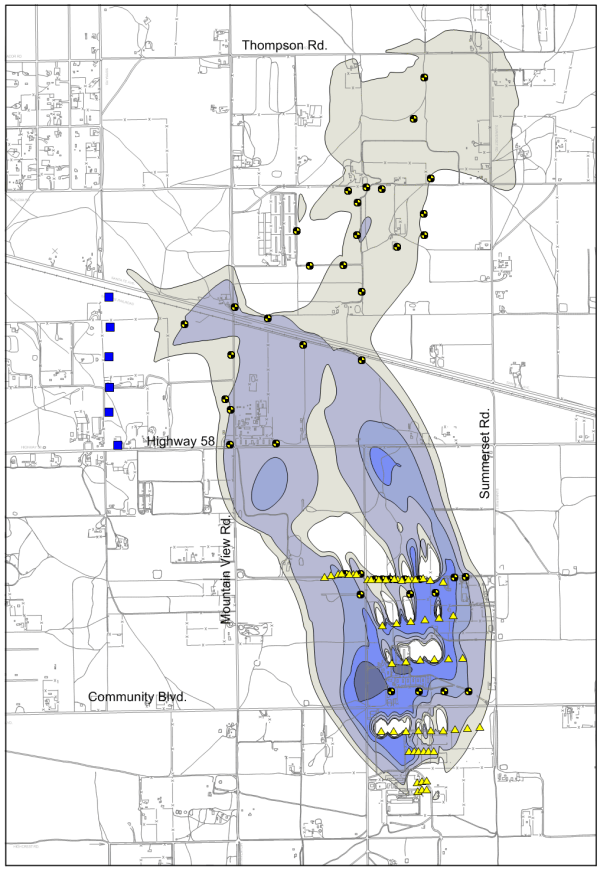
## Actual
CONTOURED FROM MONITORING DATA




## Modeled
0.1 mg/L TOTAL ORGANIC CARBON THRESHOLD



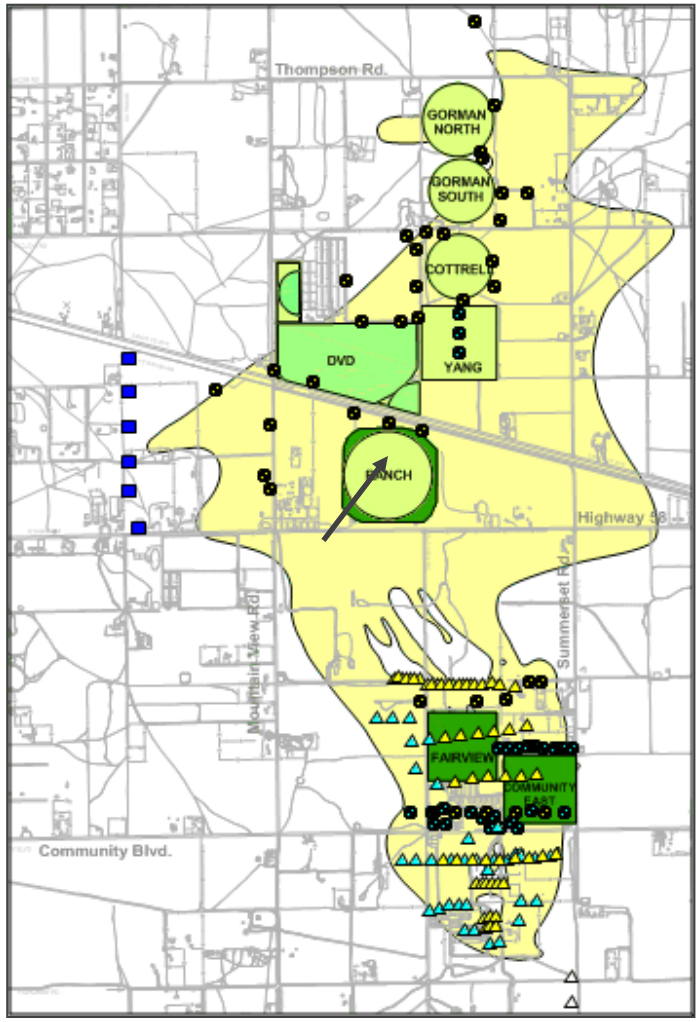

## Modeled
1.0 mg/L TOTAL ORGANIC CARBON THRESHOLD




- 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

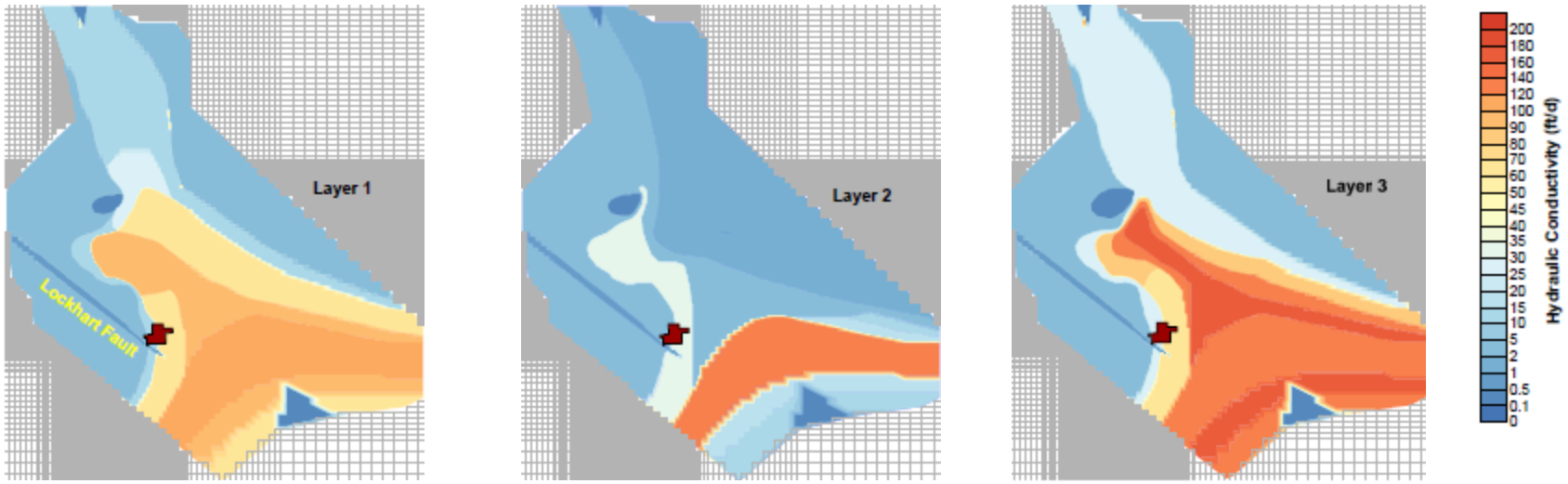


# Range of Estimates Provided by Remedial Timeframe Assessment

- 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

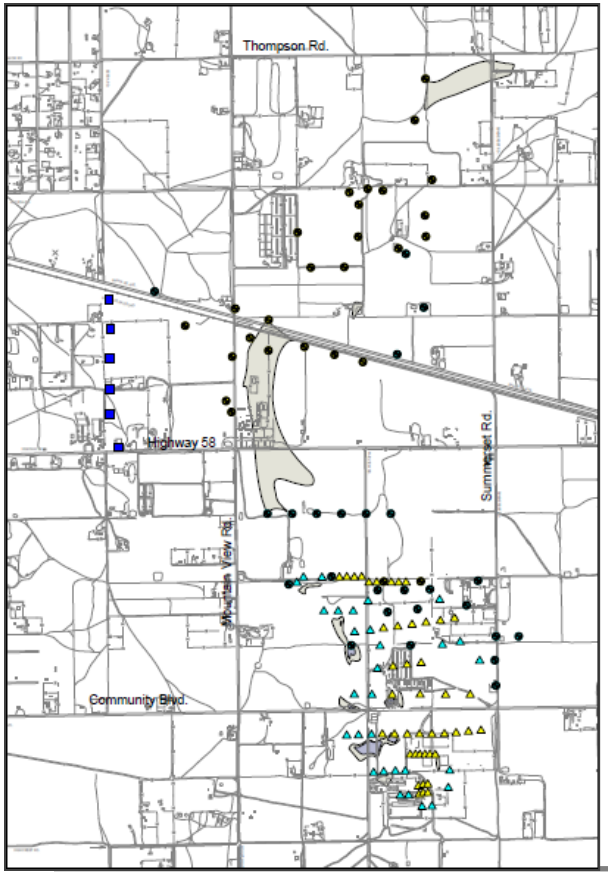



Layers of Upper Aquifer shown here.

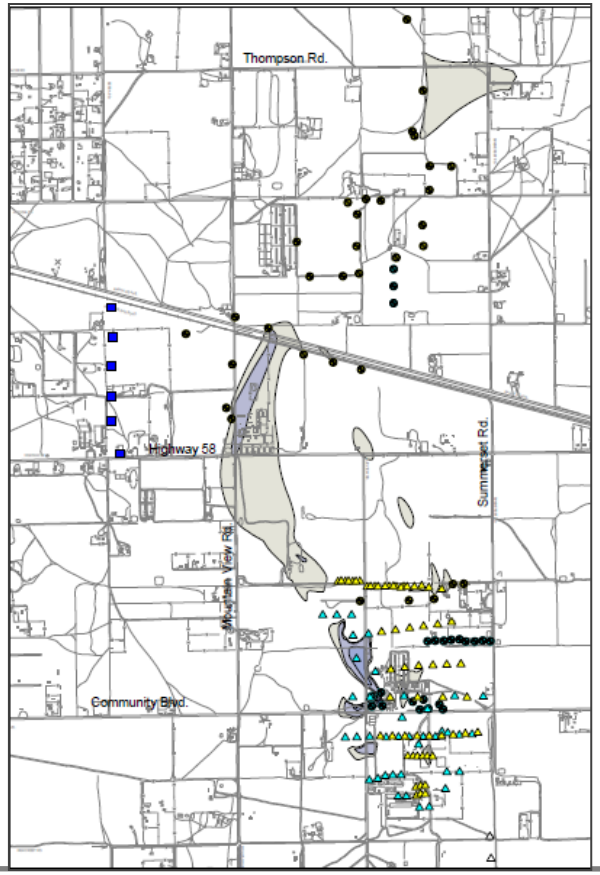
# Results of 3 Modeling Runs

## Layer 1, 8 years

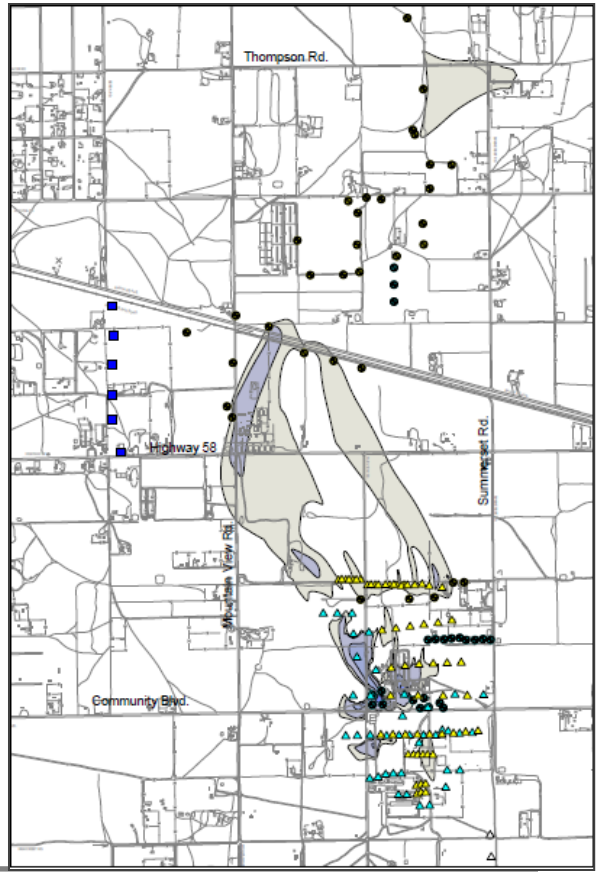
### Run 1: Baseline FS 4C-2

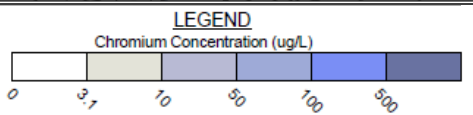



### Run 2: Design Update, Low TOC Threshold




### Run 3: Design Update, High TOC Threshold

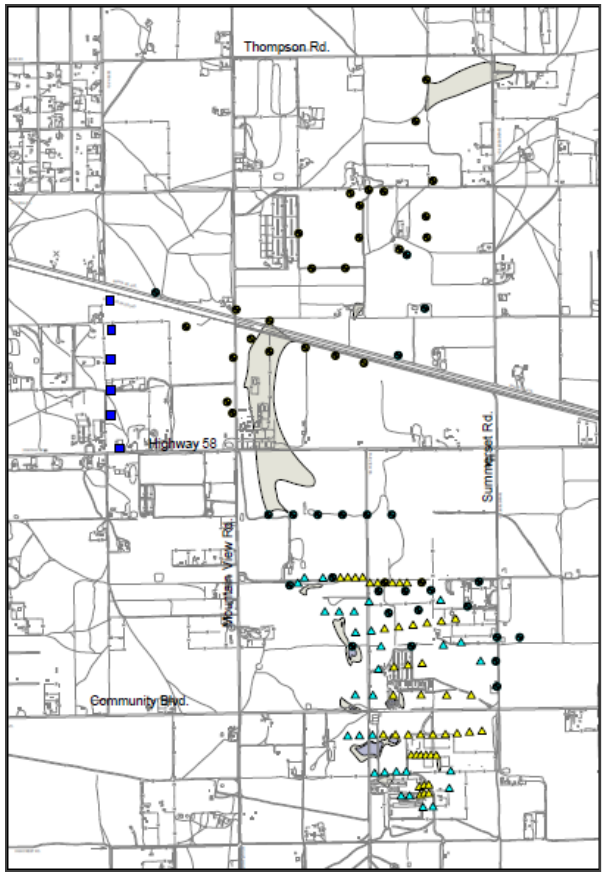


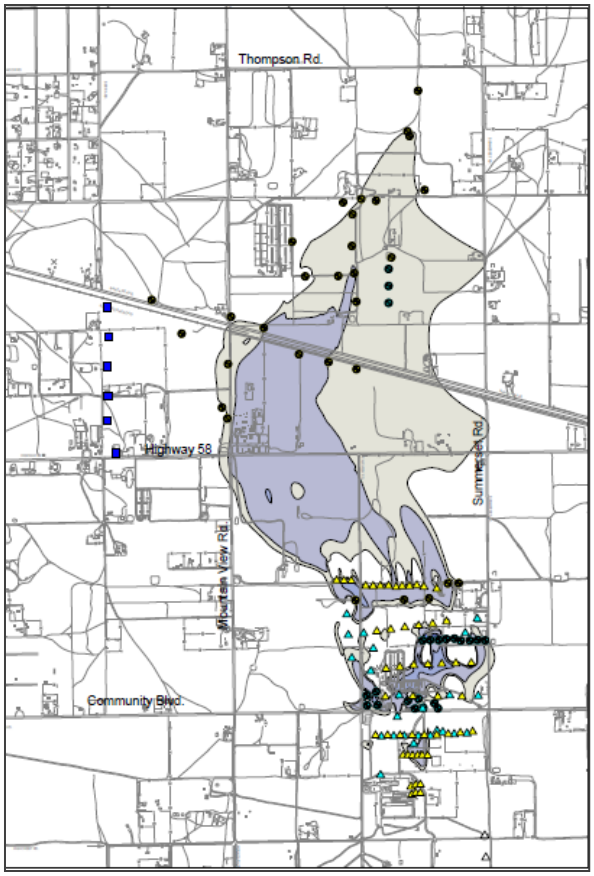
# Results of Modeling Scenario 2

## 8 years

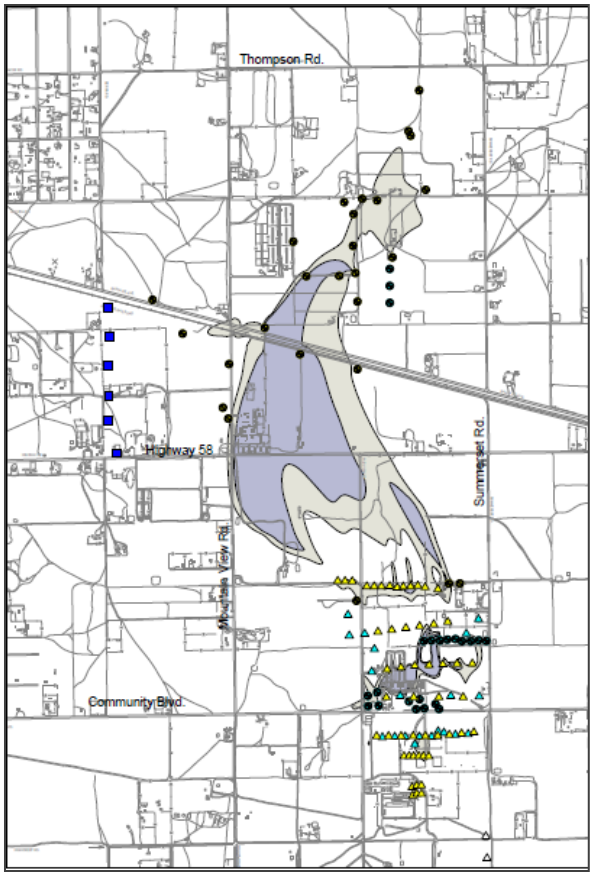
Layer 1




Layer 2




Layer 3



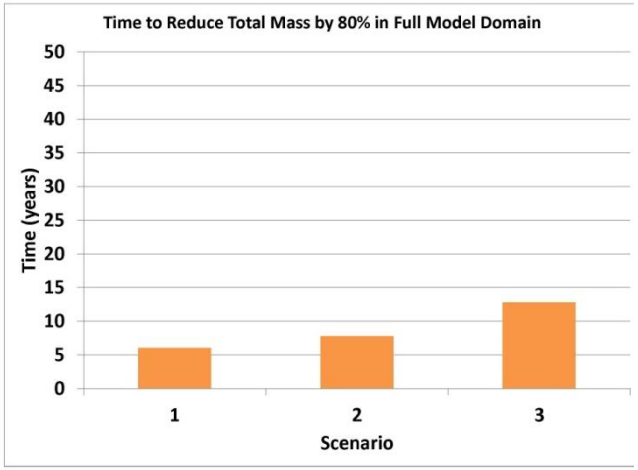

LEGEND

Chromium Concentration (ug/L)

0 3.1 10 50 100 500

# Range of Timeframe Estimates

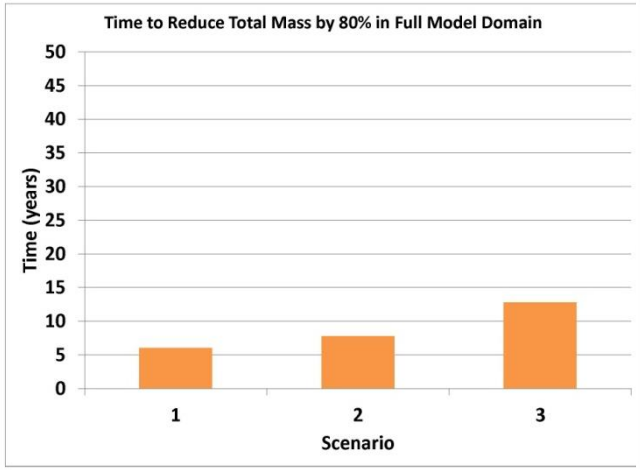
## 80% Mass Removal



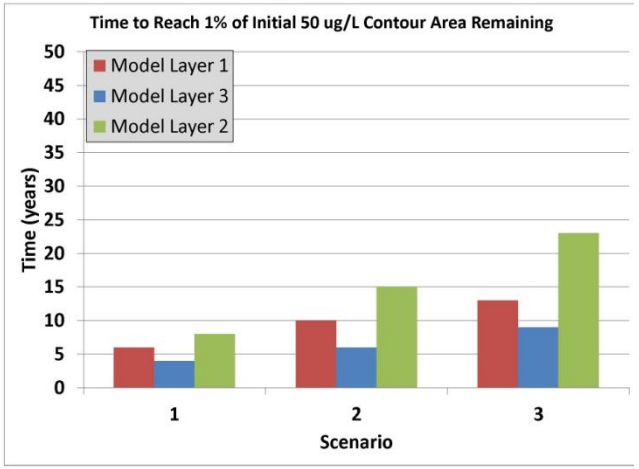

| Scenario | Time to Reduce Total Mass by 80% (years) |
|---|---|
| Scenario 1: FS Alternative 4C-2, First Quarter 2014 Baseline | 6 |
| Scenario 2: Updated Remedy Layout | 8 |
| Scenario 3: Updated Remedy Layout, Increased TOC threshold | 13 |

# Range of Timeframe Estimates

80% Mass Removal



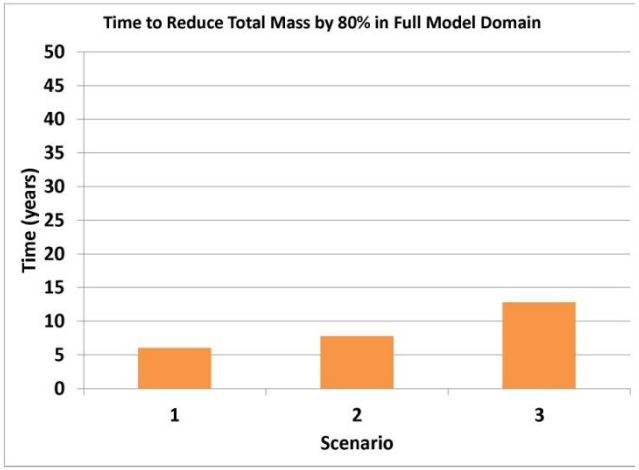

50 µg/L



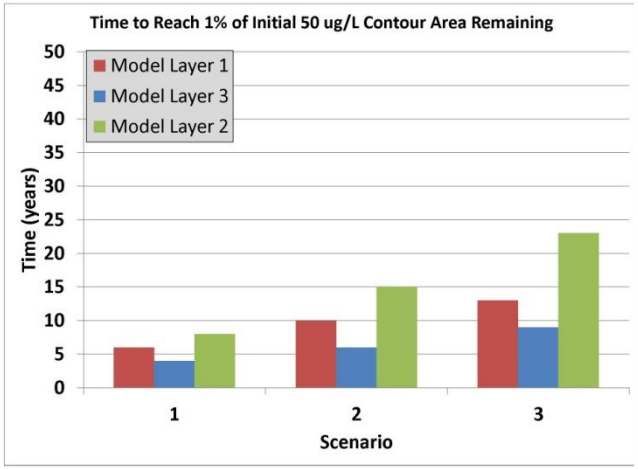

| Scenario | Time to Reduce Total Mass by 80% (years) | Time to Reach 1% of Initial 50 µg/L Contour Area Remaining (years) | | |
|---|---|---|---|---|
| | | Model Layer 1 | Model Layer 3 | Model Layer 2 |
| Scenario 1: FS Alternative 4C-2, First Quarter 2014 Baseline | 6 | 6 | 4 | 8 |
| Scenario 2: Updated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

# Range of Timeframe Estimates

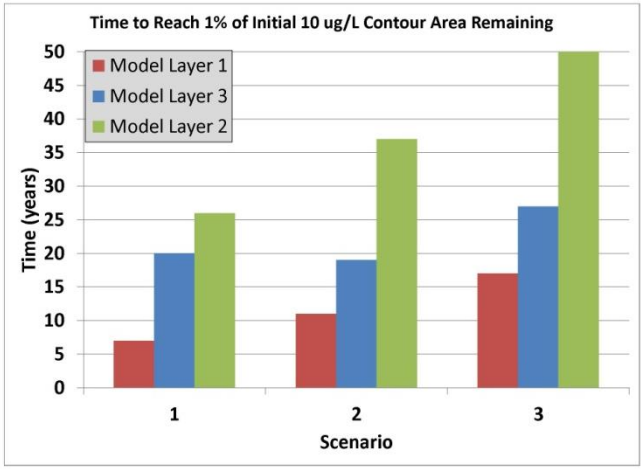
80% Mass Removal




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<br>• Areas may remain above goals where remedial infrastructure was not installed pending biological permitting<br>• 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.