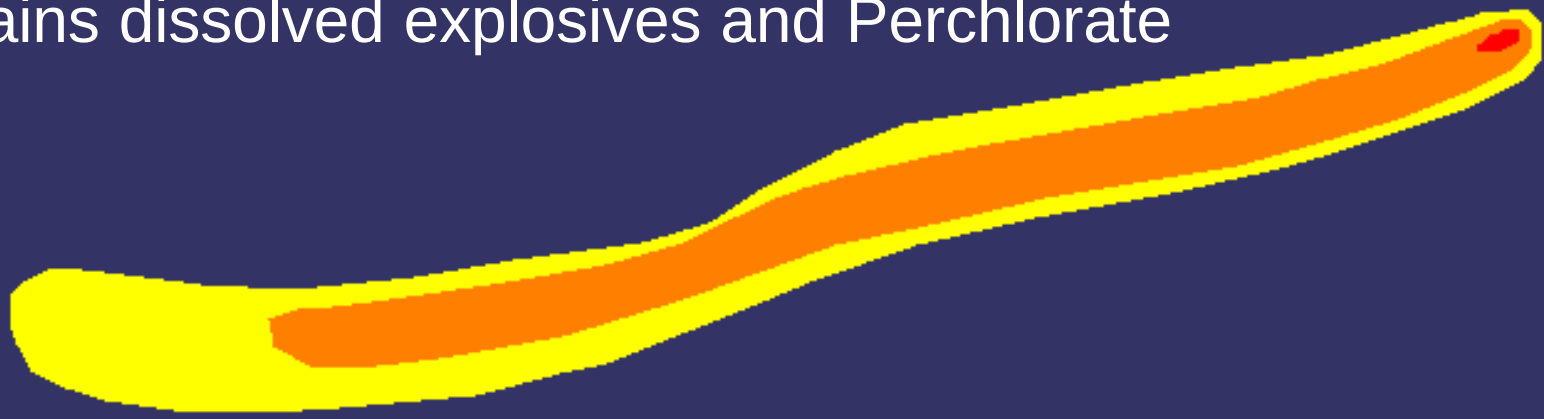
USE OF OPTIMIZATION MODELING FOR DESIGN OF THE DEMO 1 SITE WELL FIELD

Al Laase (AMEC)

Presented at the 2/5/02 IAGWSP Modeling meeting to the USEPA, MADEP, USACE, NGB, USGS, Jacobs Eng, and AEC (IAGWSP Contact Dave Hill 508-968-5621).

DEMO 1 SITE PLUME

- Mile long
- 600 feet wide
- 100 feet thick
- Up to 200 feet below ground surface
- Contains dissolved explosives and Perchlorate

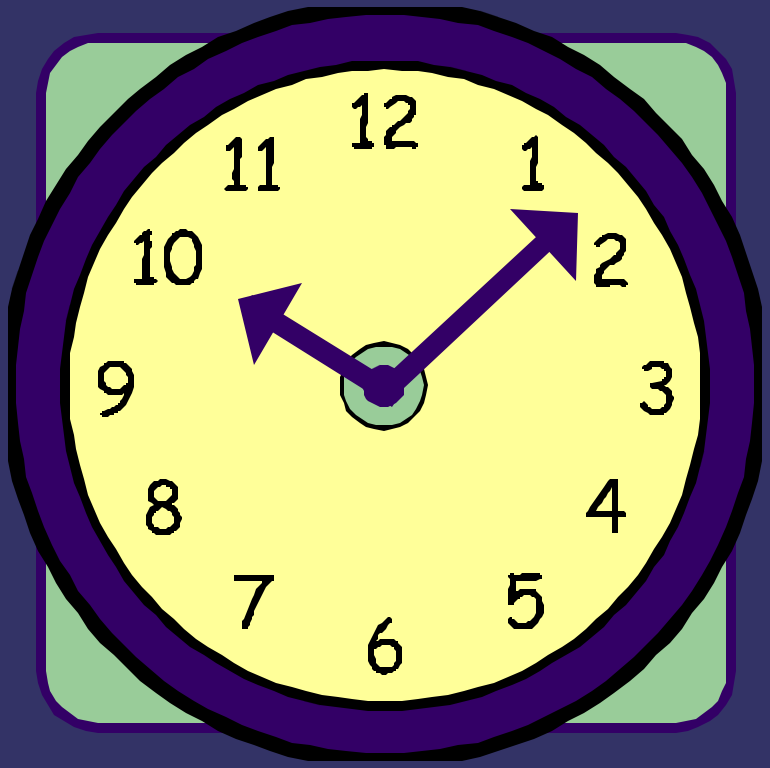


DEMO 1 SITE
WELL FIELD DESIGN CRITERIA

- Contain contamination
- Remove contamination within specified time criteria

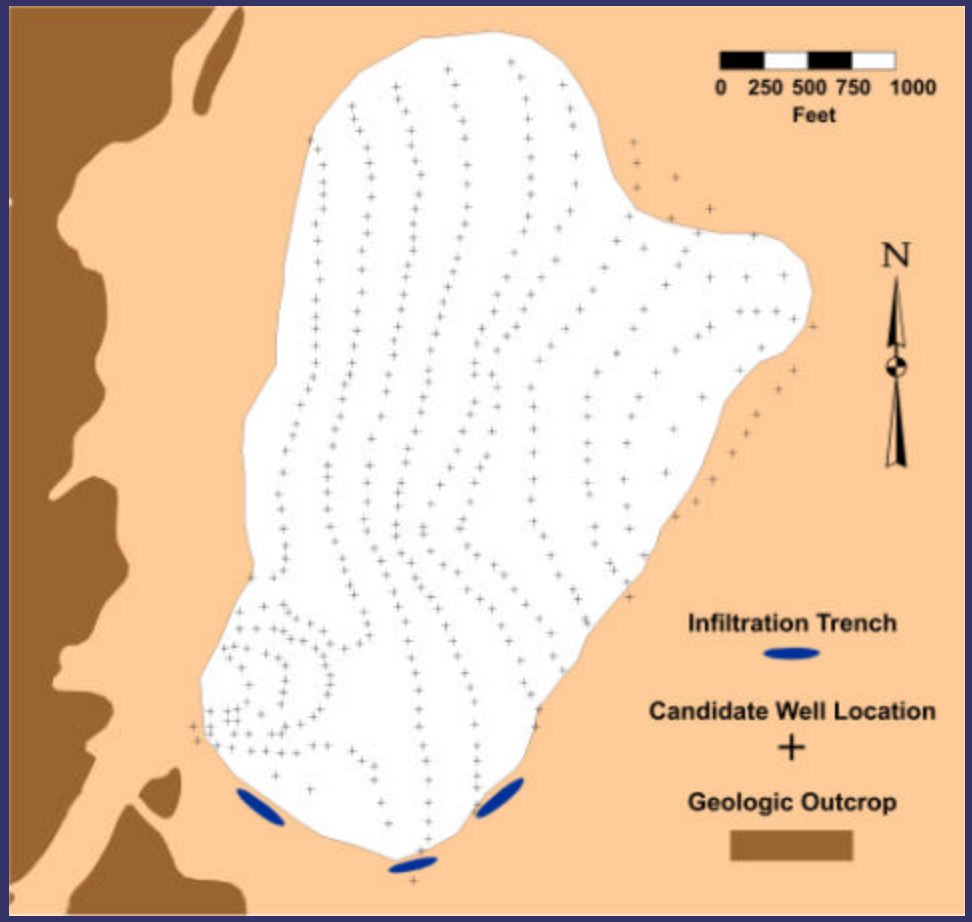
OPTIMIZATION CODE

- Because time is a design criteria, particle tracking optimization was selected for well field design



IMPLEMENTNG PARTICLE TRACKING OPTIMIZATION

- Identify potential well locations; assign initial pumping rates and weights
- Identify injection well locations
- Assign drawdown and maximum and minimum pumping rate criteria

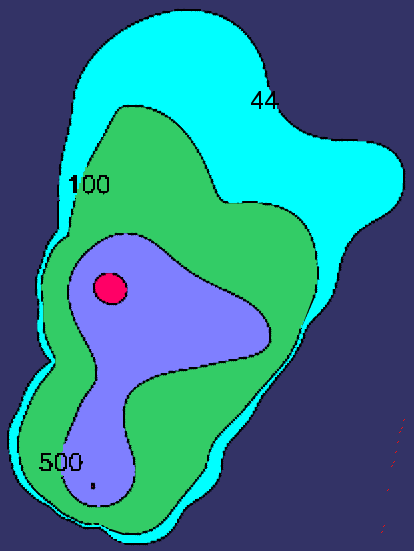


IMPLEMENTING PARTICLE TRACKING OPTIMIZATION

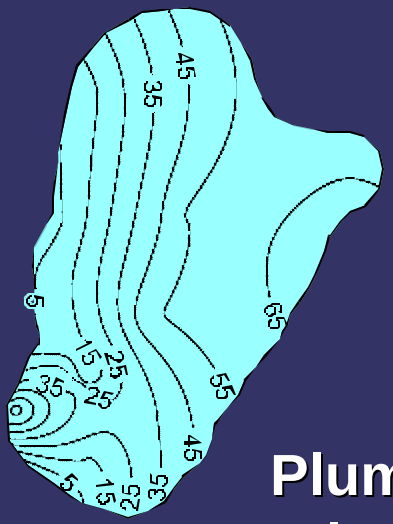
- Locate particles to be captured
- Assign particle weights and capture times
- Define percentage of particles requiring capture

PARTICLE WEIGHTS

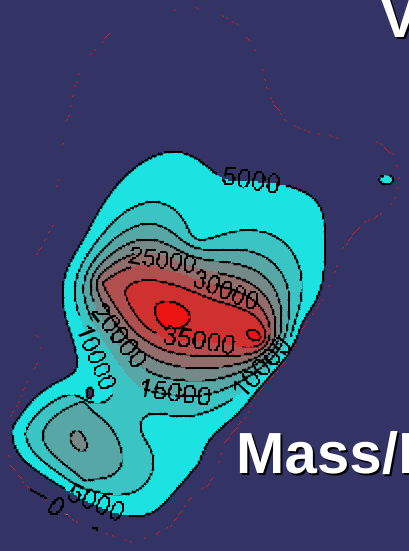
- Weight particles to reflect contaminant mass



Contaminant Concentration



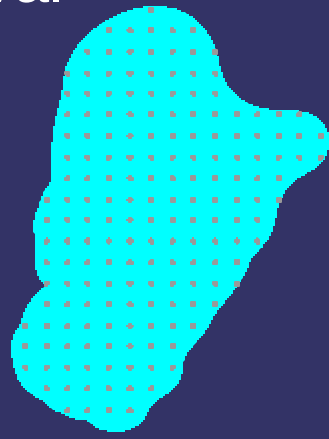
Plume Volume



Mass/Node

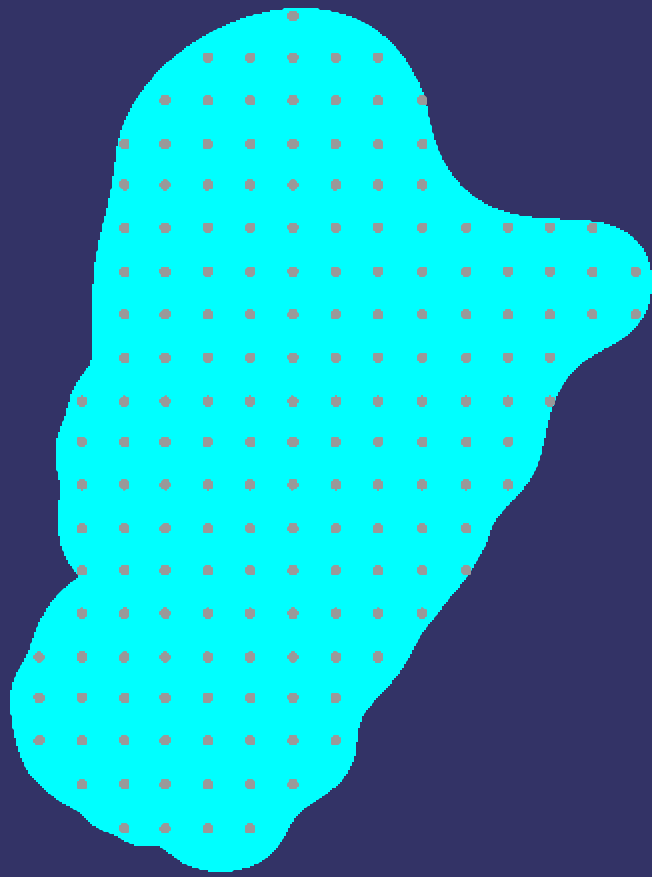
PARTICLE CAPTURE TIMES

- Large capture times result in containment designs
- Small particle capture times result in decreased pore volume removal rates
- Mixing large and small particle capture times results in designs for both containment and hot spot removal

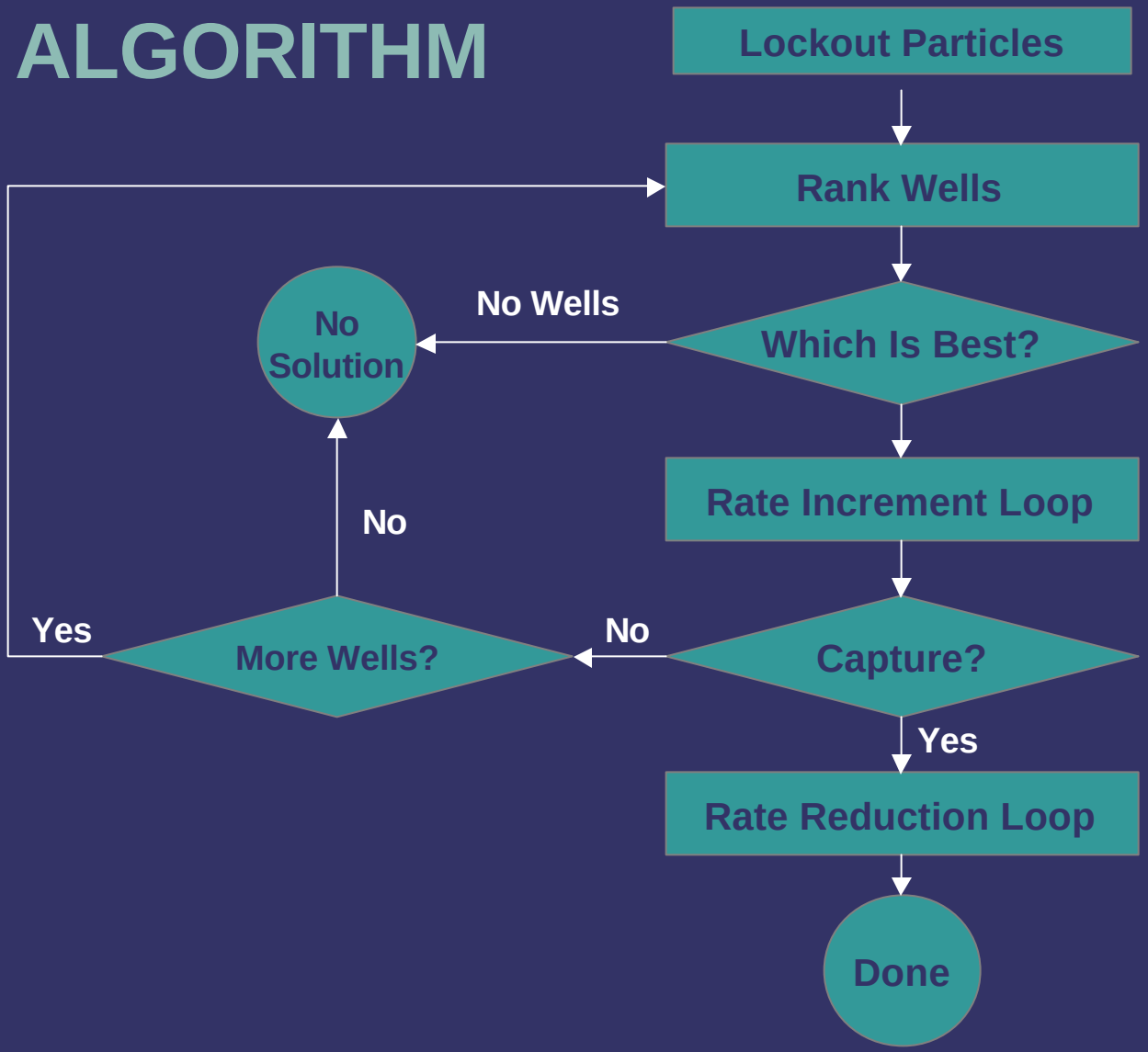


PARTICLE CAPTURE REQUIREMENTS

- Percentage particles requiring capture
- Percentage of particles captured within a specified time



PARTICLE TRACKING OPTIMIZATION ALGORITHM



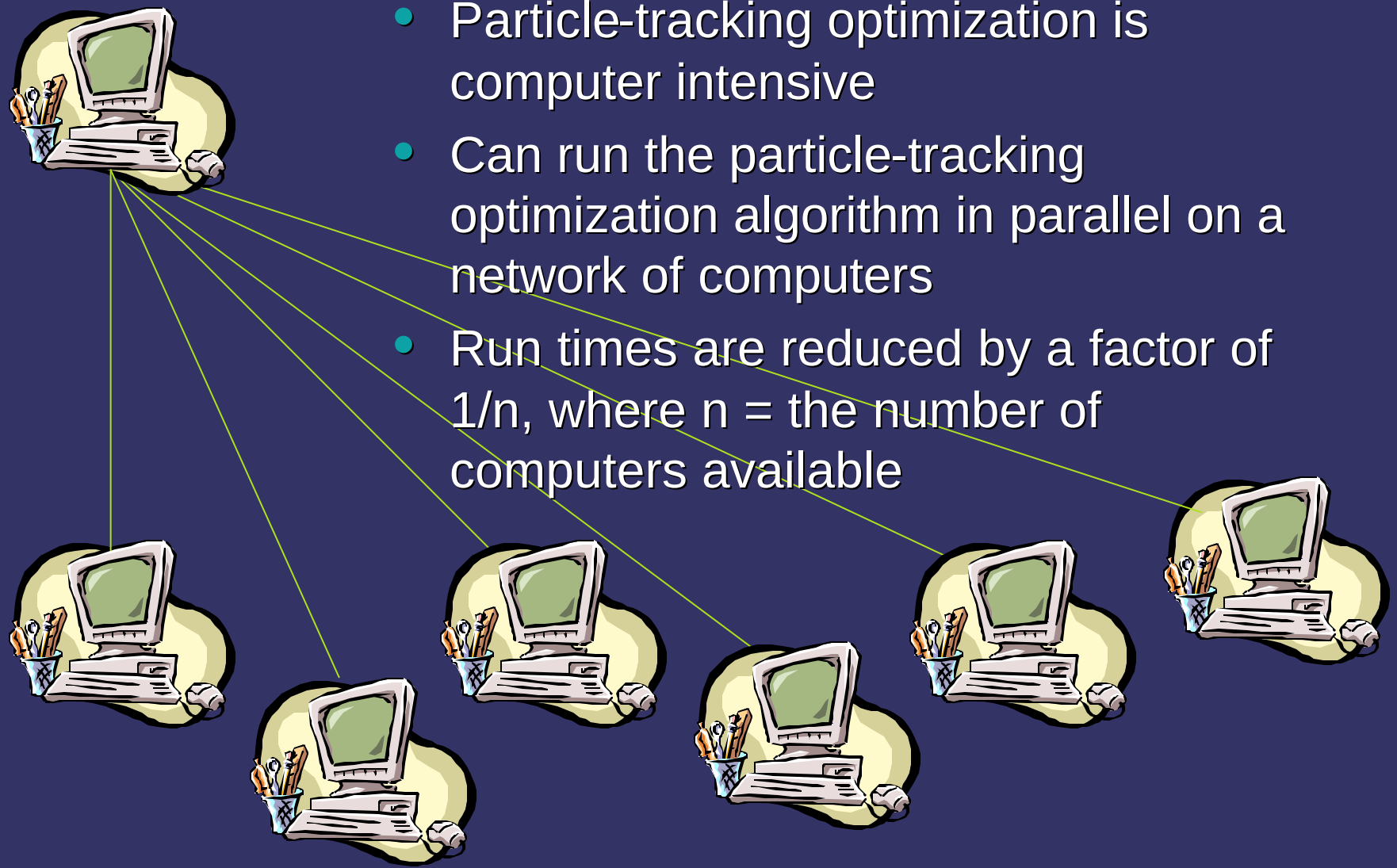
Find the well that captures the most particles with one simulation per well.

Gradually increment the rate for the chosen well to see if complete capture can be achieved.

Gradually decrease the rate for all chosen wells to see if capture can be maintained at lower pumping rate.s

PARALLEL COMPUTER CODE

- Particle-tracking optimization is computer intensive
- Can run the particle-tracking optimization algorithm in parallel on a network of computers
- Run times are reduced by a factor of 1/n, where n = the number of computers available



APPLICATION TO DEMO 1 SITE

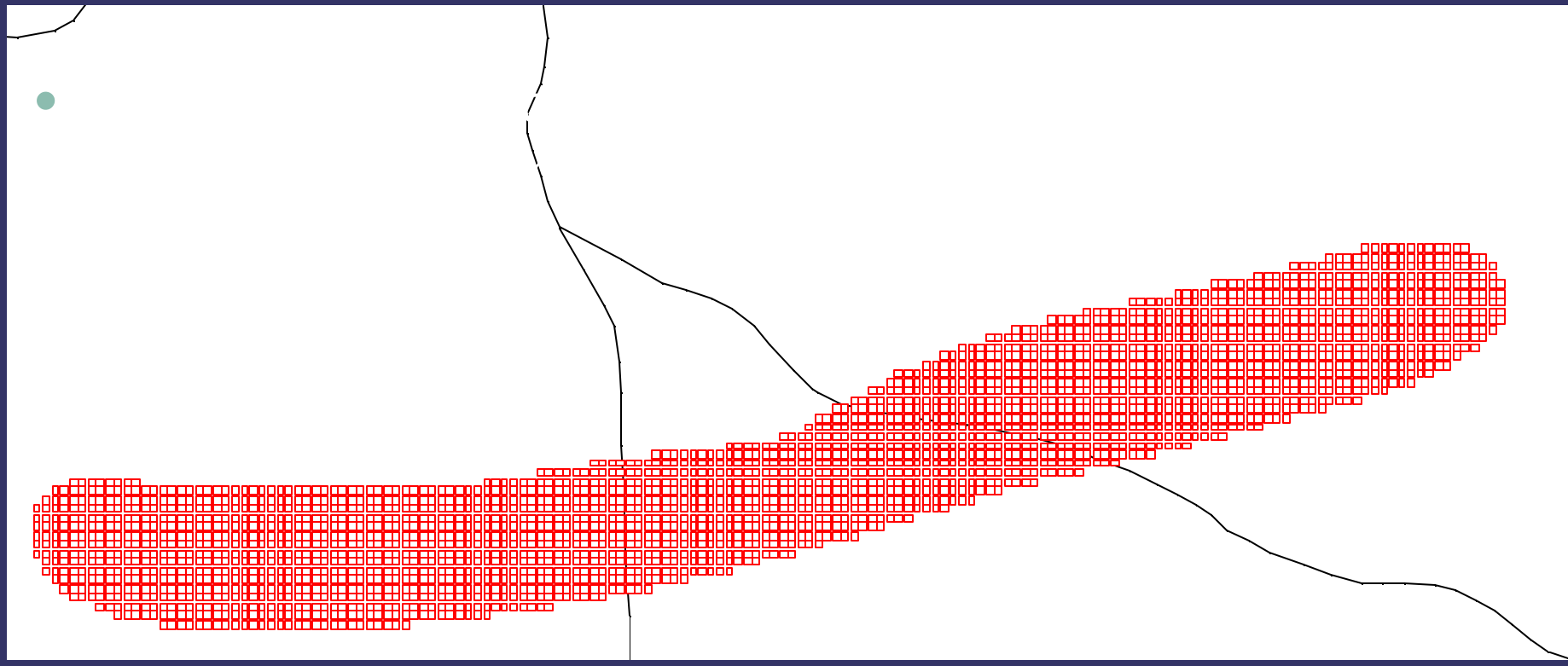
Designs

1. Containment
2. 10-Year Removal

Constraints

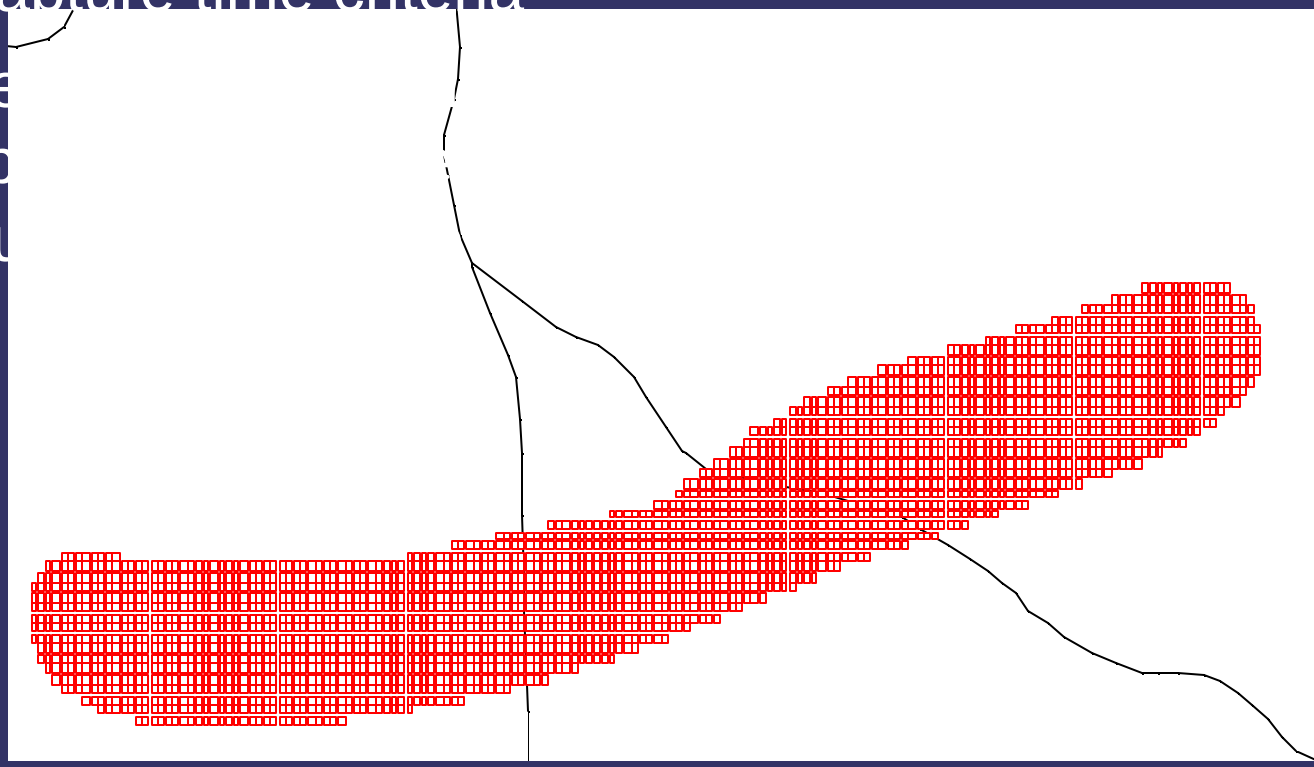
1. Optimize for removal of all COCs

DEMO 1 SITE
PARTICLE WEIGHTS



DEMO 1 SITE
PARTICLE CAPTURE TIMES

- For containment design, all particles assigned 100 million day capture time criteria
- For the 10-ye
  assigned cap
  volumes requ
  standards



PORE VOLUMES

$$n = \ln(C_S/C_i)/\ln(1-1/R)$$ (Duetsch 1997)

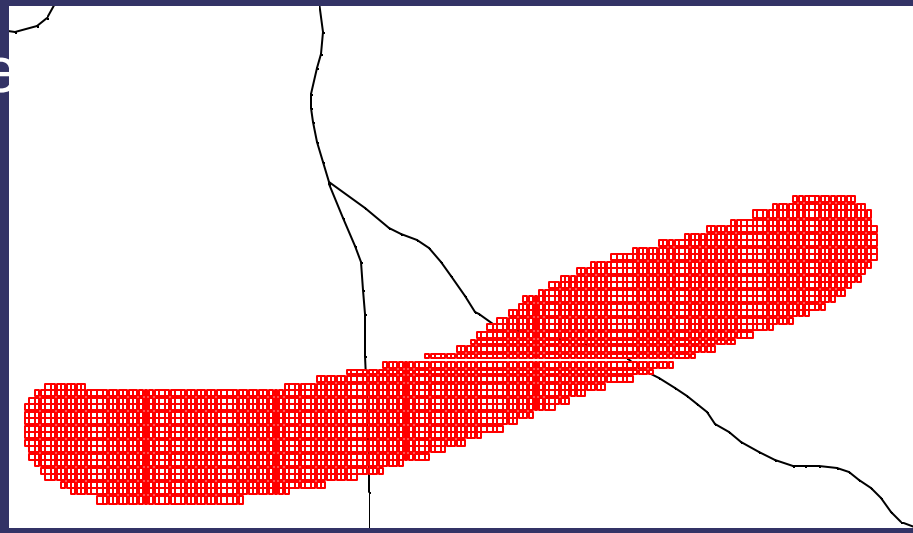
where:

n = number of pore volume achieve standard

C_S = groundwater standard

C_i = initial concentration

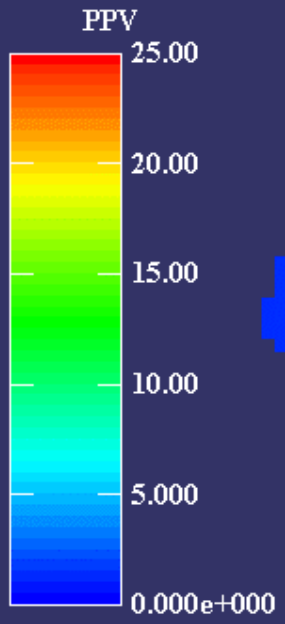
R = retardation factor

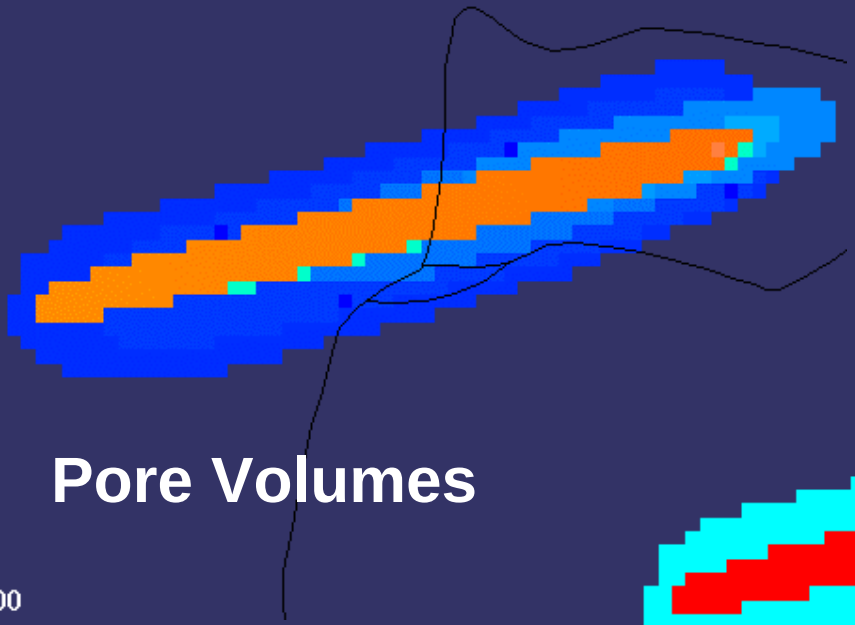


COMPARISON OF PORE VOLUMES REQUIRING REMOVAL TO ACHIEVE STANDARD

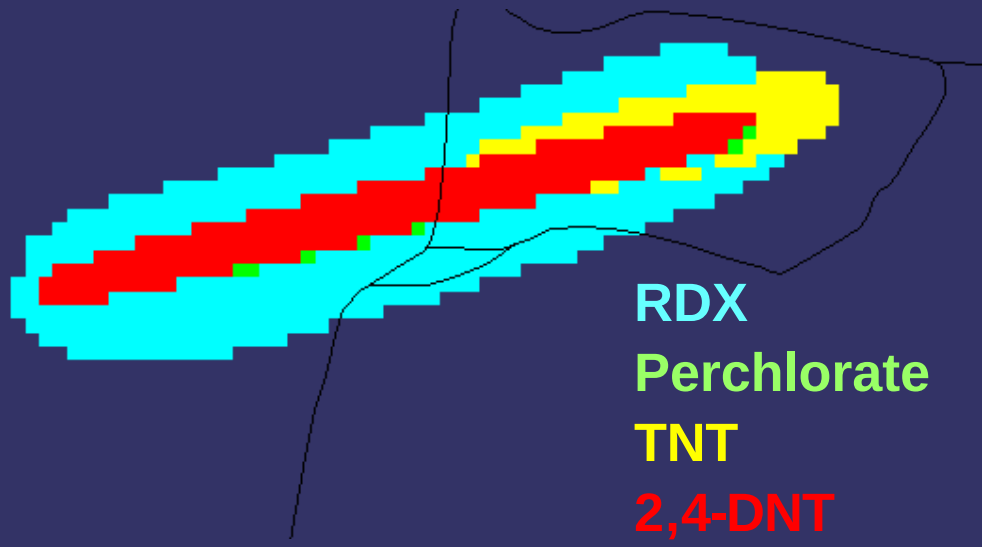
Contaminant	Initial Concentration ug/L	Groundwater Standard, ug/L	Retardation Factor	Pore Volumes Requiring Removal to Achieve Standard	Required Days to Remove 1 Pore Volume for 10-Year Cleanup
RDX	100	0.20	1.17	3.22	1133
TNT	100	0.20	2.07	9.42	388
Perchlorate	100	0.35	3.14	14.75	247
2,4-DNT	100	0.20	16.51	99.46	37

LAYER 1 – PORE VOLUMES REQUIRING REMOVAL TO ACHIEVE STANDARD





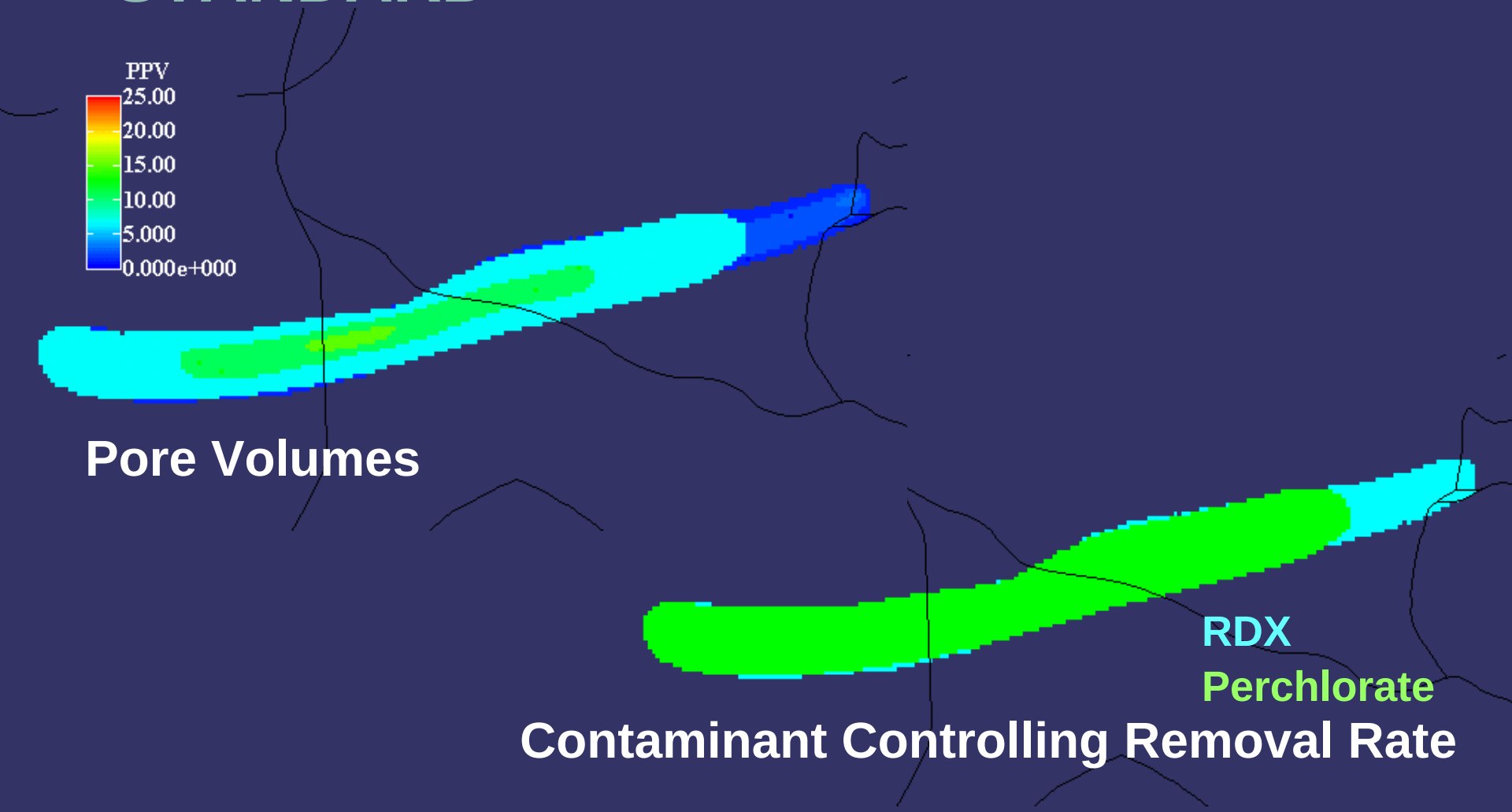
Pore Volumes



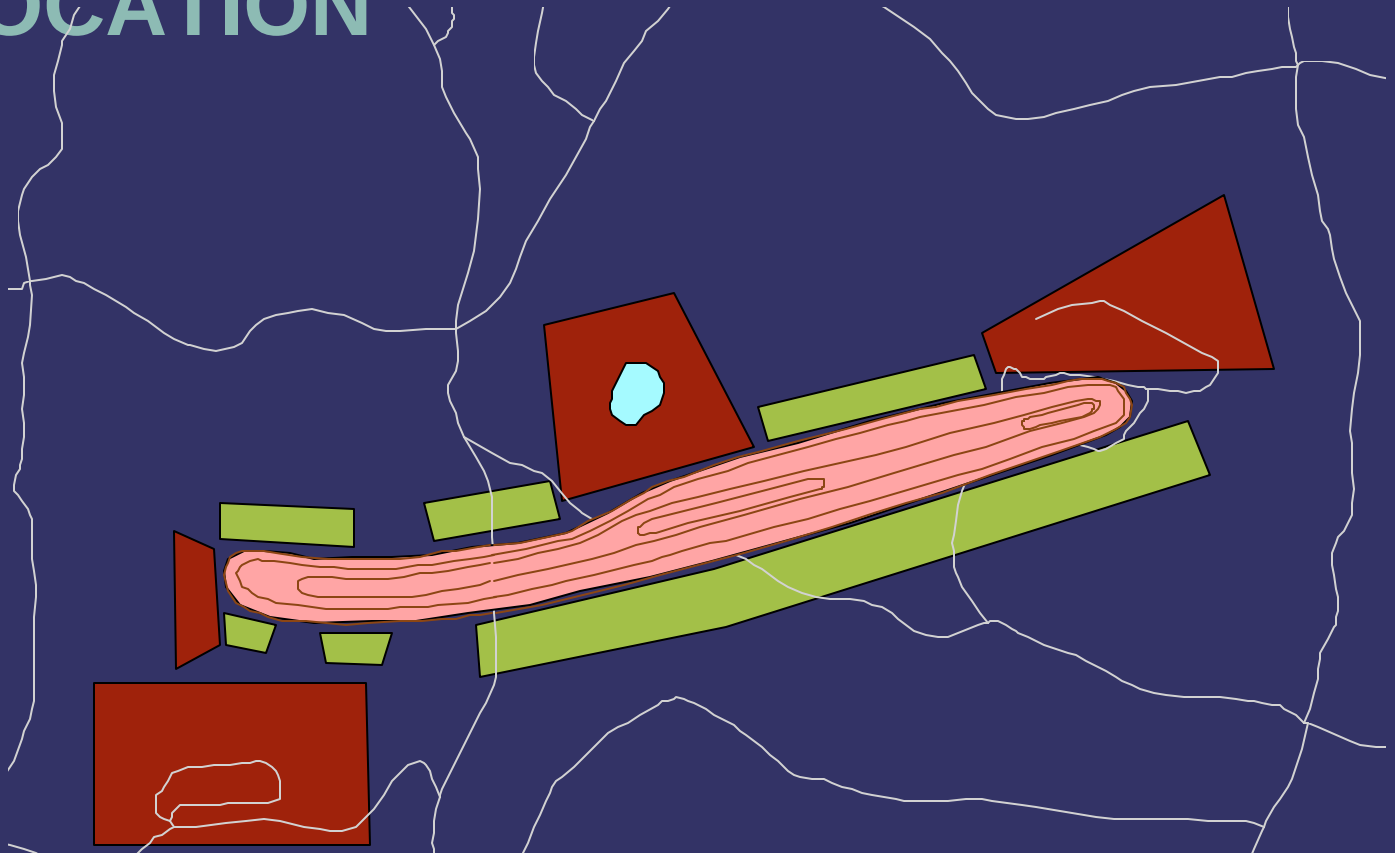
RDX
Perchlorate
TNT
2,4-DNT

Contaminant Controlling Removal Rate

LAYER 6 – PORE VOLUMES REQUIRING REMOVAL TO ACHIEVE STANDARD



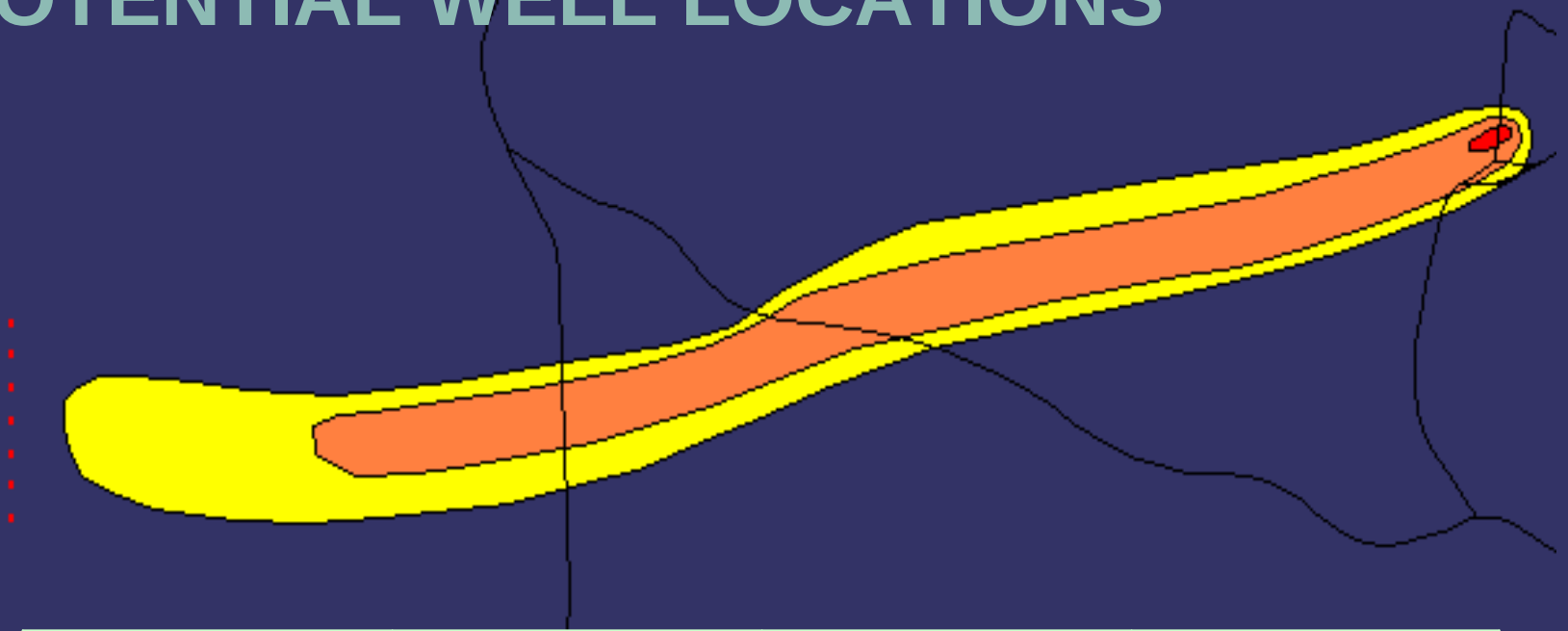
DEMO 1 SITE
POTENTIAL INFILTRATION GALLERY LOCATION



Potential Infiltration Gallery Location

Infiltration Gallery Exclusion Area

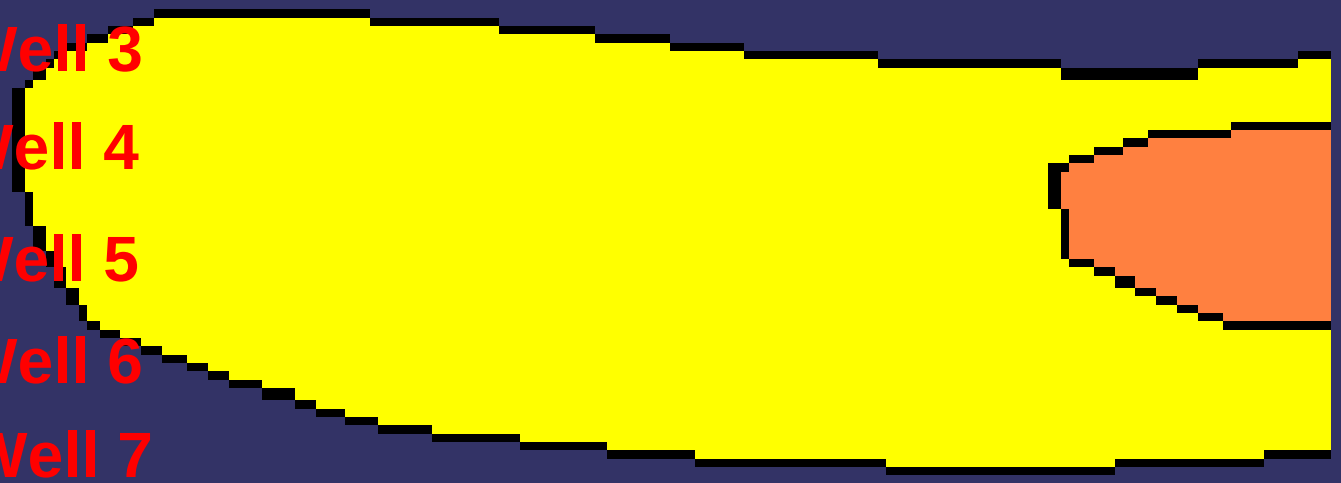
DEMO 1 SITE CONTAINMENT DESIGN POTENTIAL WELL LOCATIONS



Screen Length, ft	Unit Stimuli, gpm	Minimum Q, gpm	Maximum Q, gpm
80	160	99	258

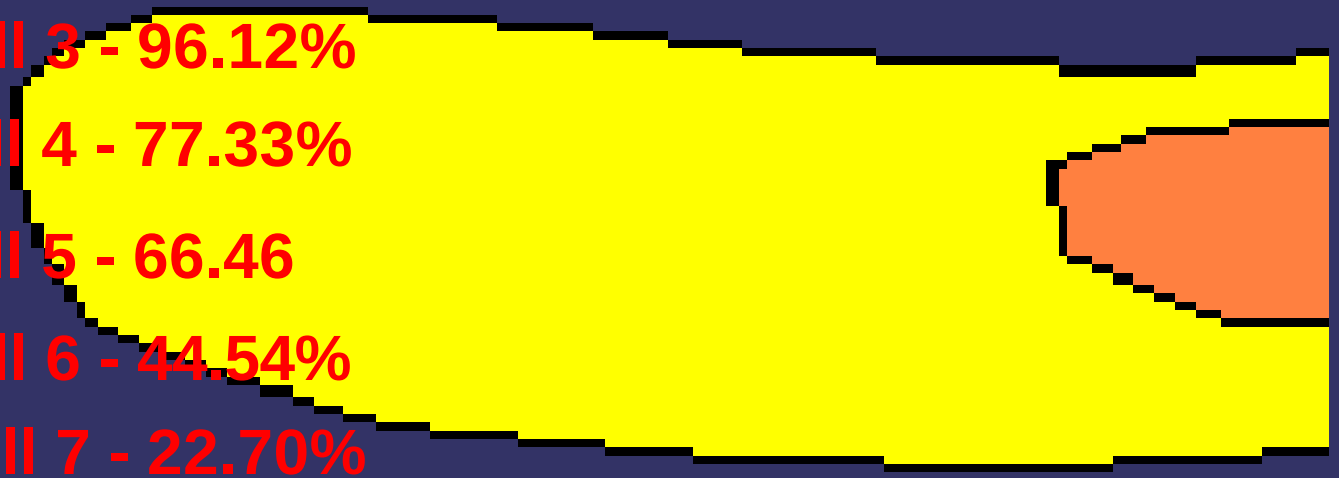
DEMO 1 SITE
CONTAINMENT DESIGN
POTENTIAL WELL LOCATIONS

- Well 1
- Well 2
- Well 3
- Well 4
- Well 5
- Well 6
- Well 7



DEMO 1 SITE CONTAINMENT DESIGN MASS CAPTURE RESULTS

- Well 1 - 100.00%
- Well 2 - 99.97%
- Well 3 - 96.12%
- Well 4 - 77.33%
- Well 5 - 66.46
- Well 6 - 44.54%
- Well 7 - 22.70%



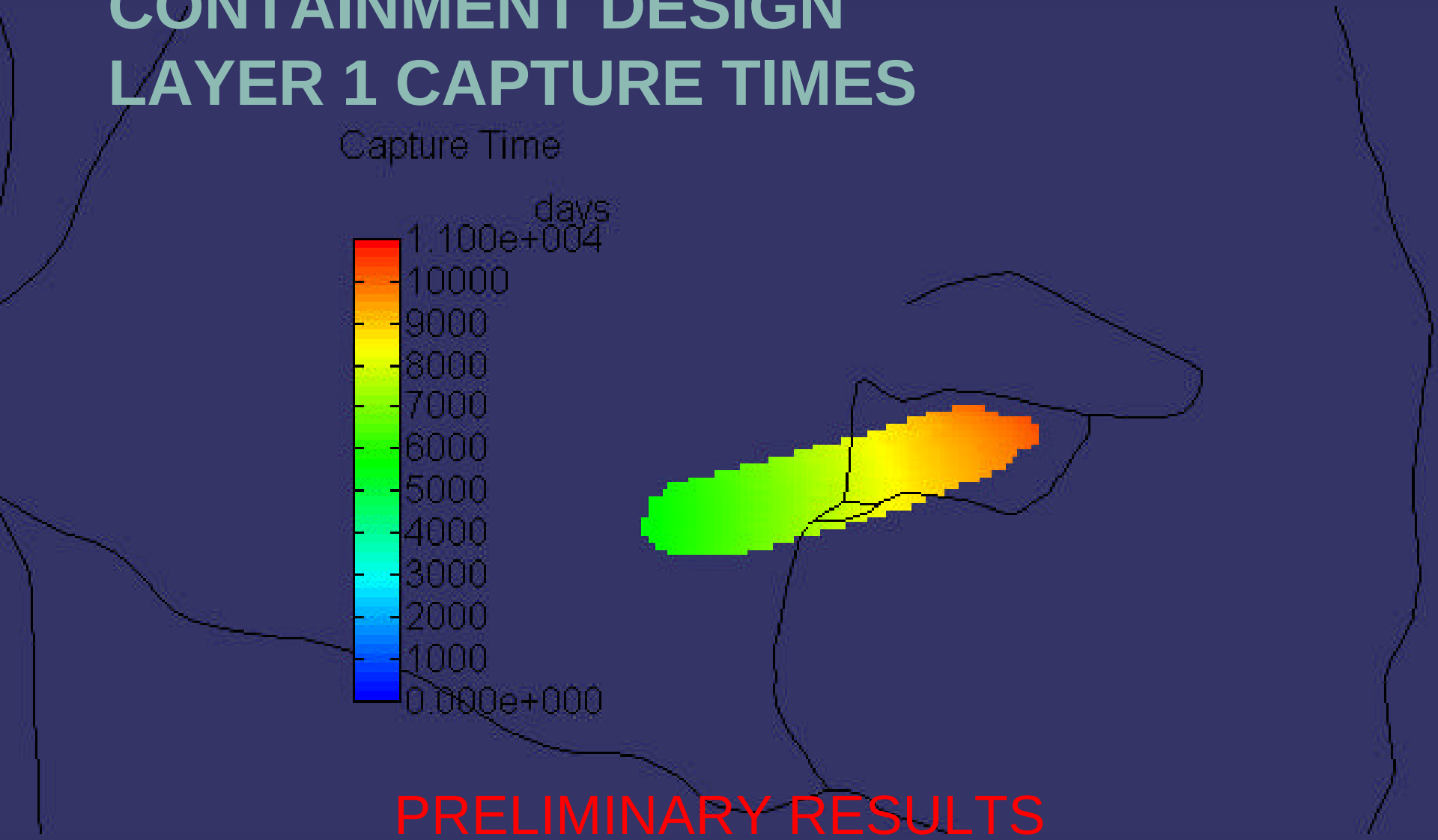
PRELIMINARY RESULTS

DEMO 1 SITE CONTAINMENT DESIGN OPTIMAL WELL LOCATION AND PUMPING RATE

- **?** 160 gpm

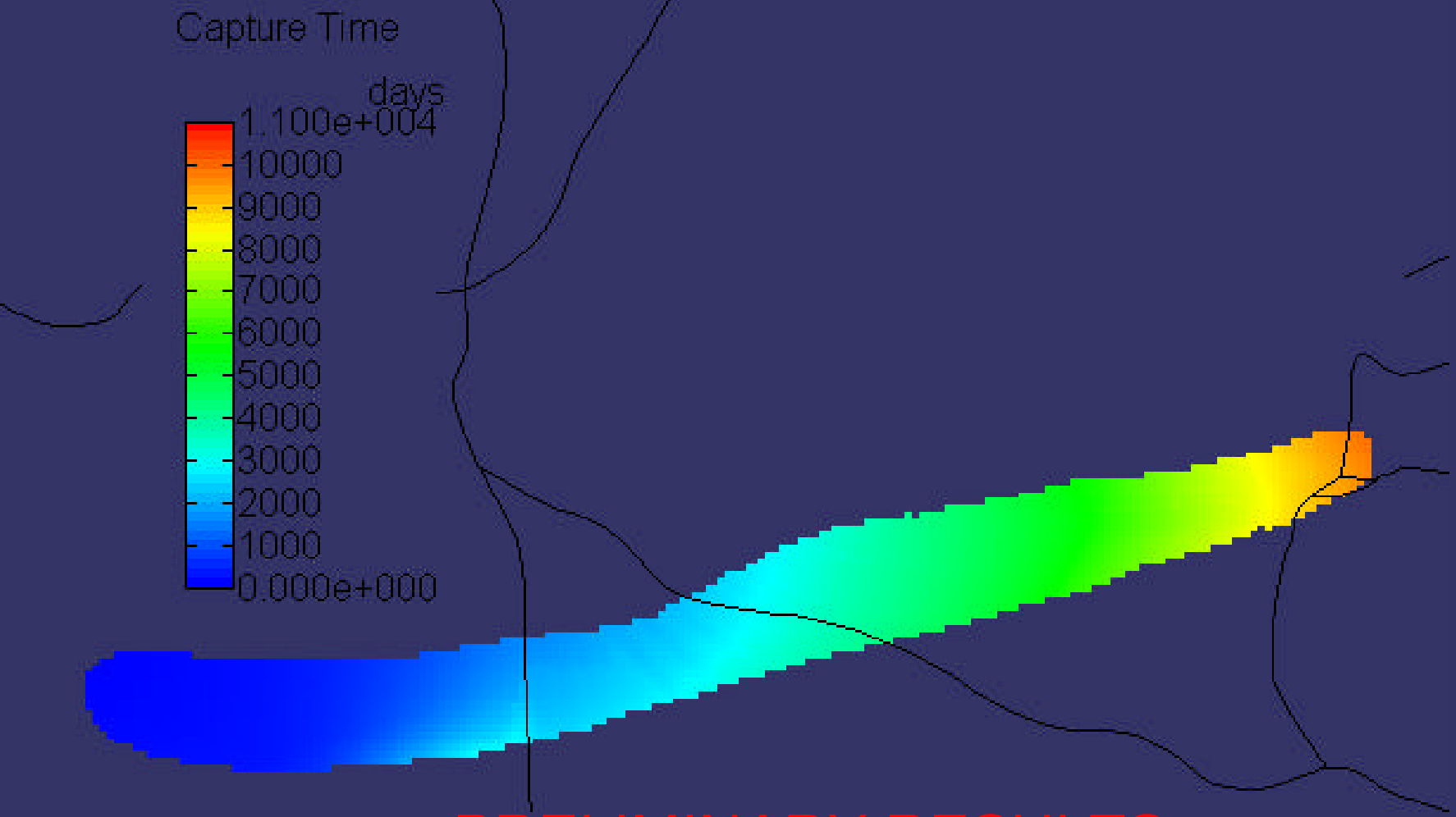
PRELIMINARY RESULTS

DEMO 1 SITE
CONTAINMENT DESIGN
LAYER 1 CAPTURE TIMES



PRELIMINARY RESULTS

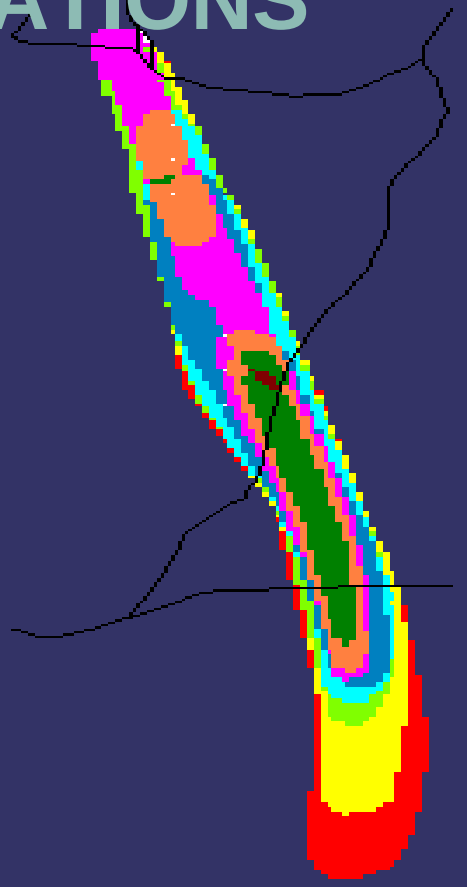
DEMO 1 SITE CONTAINMENT DESIGN LAYER 6 CAPTURE TIMES



PRELIMINARY RESULTS

DEMO 1 SITE
10-YEAR REMOVAL DESIGN
POTENTIAL WELL LOCATIONS

Screen Length, ft	Unit Stimuli Q, gpm	Minimum Q, gpm	Maximum Q, gpm
10	10	4	26
20	20	8	52
30	30	12	78
40	40	16	104
50	50	20	130
60	60	24	156
70	70	28	182
80	80	32	208
90	90	36	234



3695 Potential Well Locations

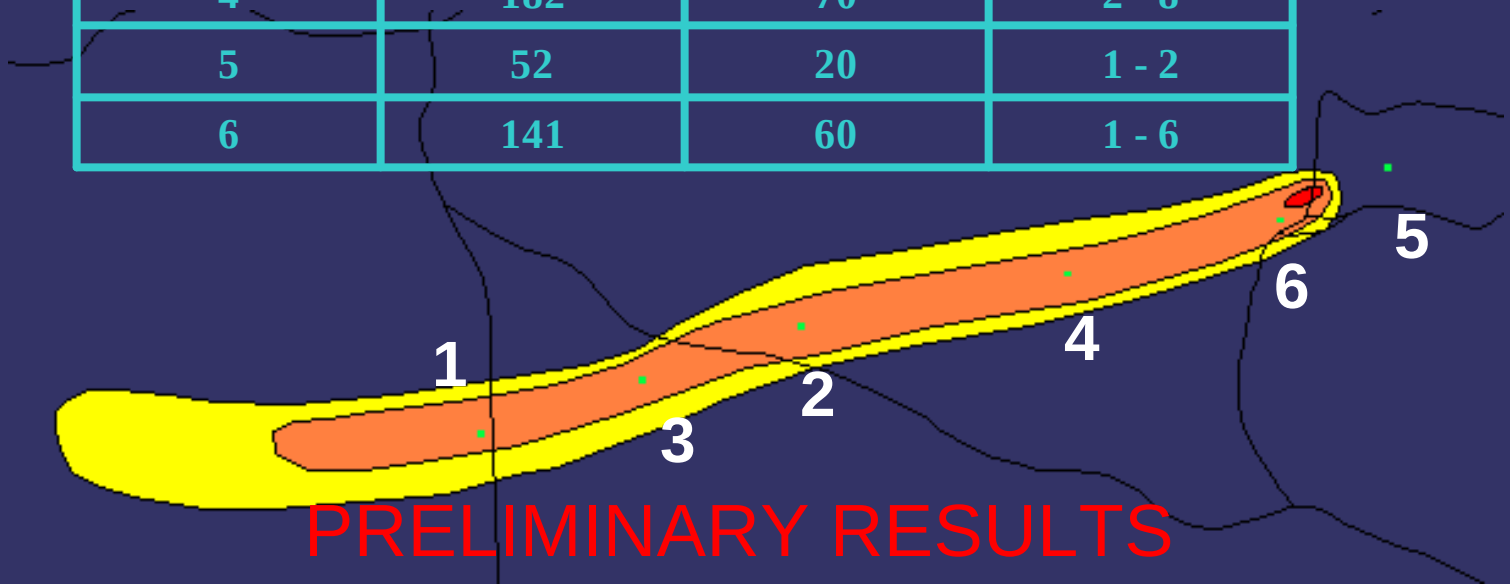
Model Layer 6

DEMO 1 SITE
10-YEAR DESIGN
POTENTIAL WELL LOCATIONS USED FOR DEMONSTRATION

54 Well Locations

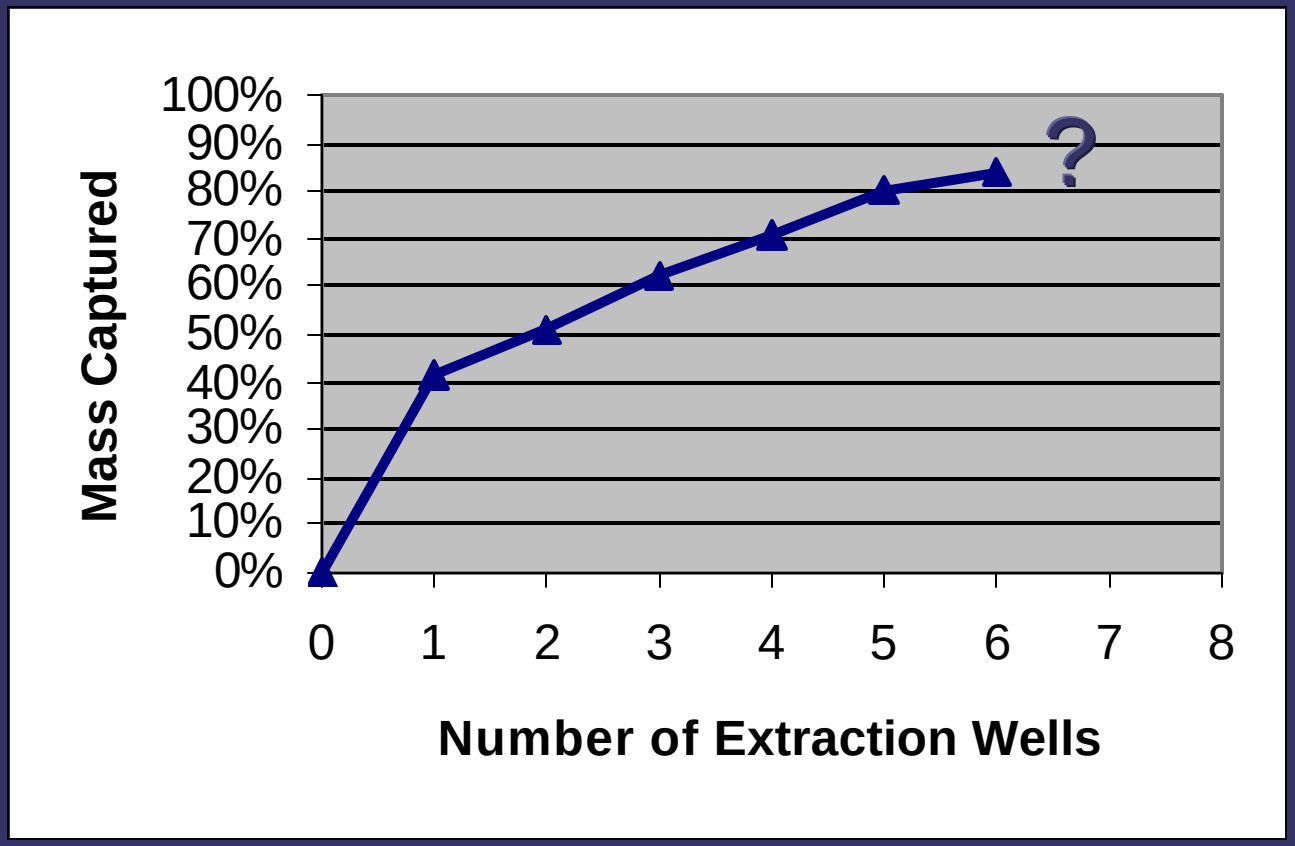
DEMO 1 SITE
10-YEAR REMOVAL DESIGN
OPTIMUM WELL LOCATIONS AND PUMPING RATES

Well	Q, gpm	Screen Length	Model Layers
1	189	90	4 - 11
2	189	90	4 - 11
3	189	90	4 - 11
4	182	70	2 - 8
5	52	20	1 - 2
6	141	60	1 - 6



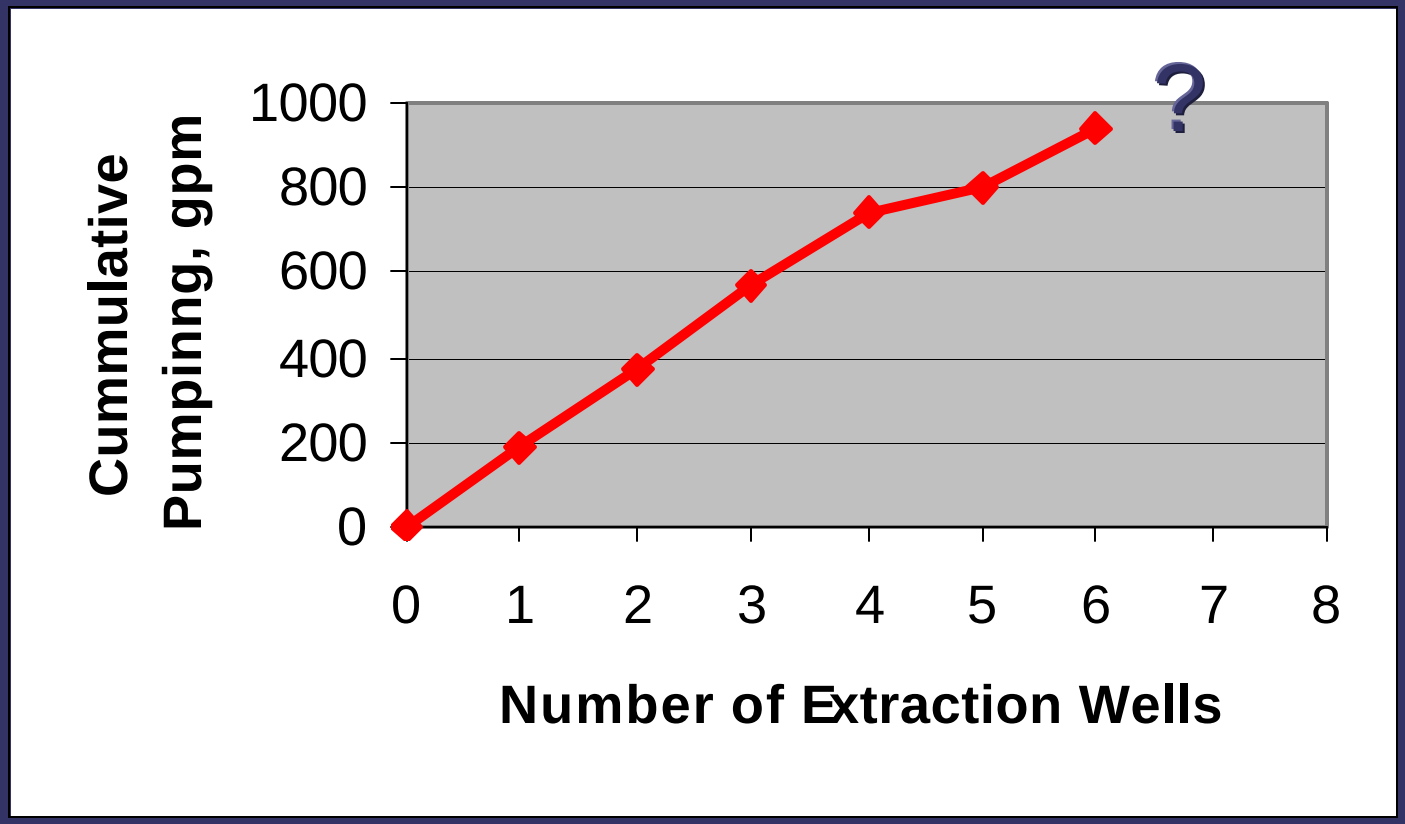
PRELIMINARY RESULTS

DEMO 1 SITE
10-YEAR REMOVAL DESIGN
PERCENTAGE MASS REMOVAL



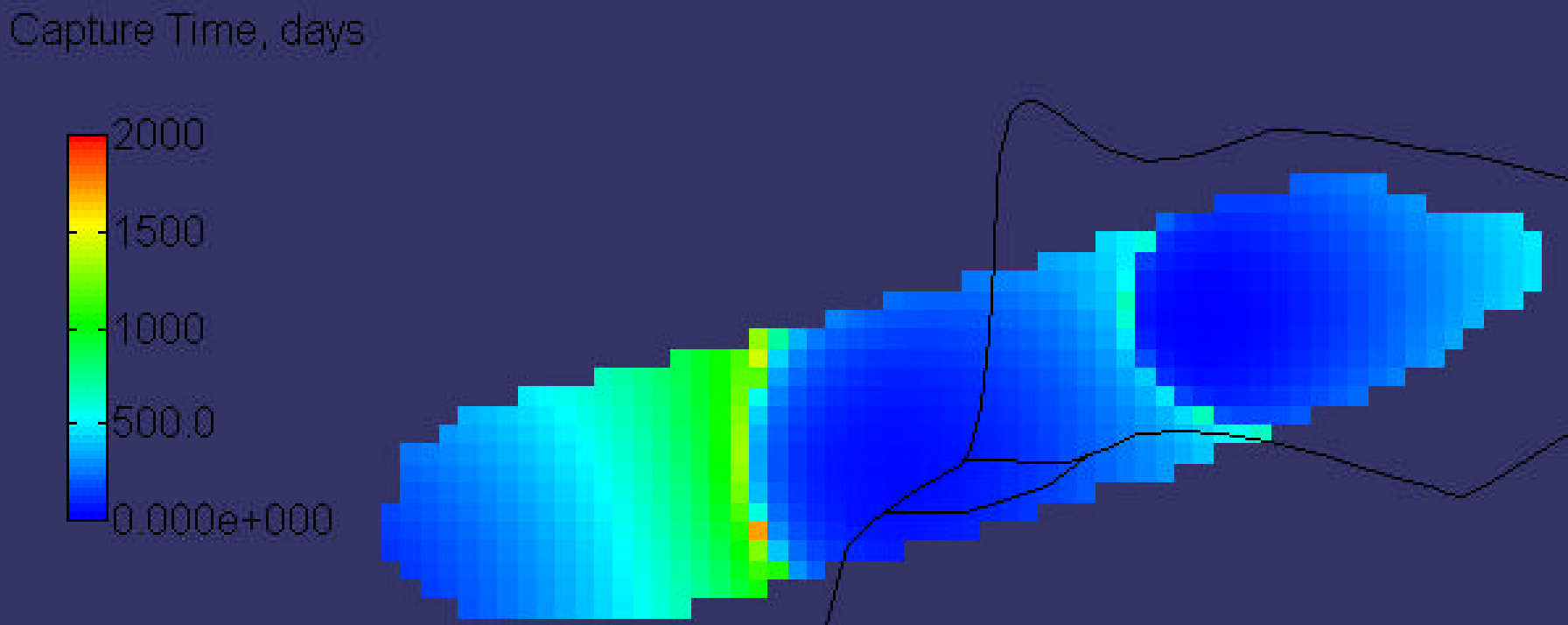
PRELIMINARY RESULTS

DEMO 1 SITE
10-YEAR REMOVAL DESIGN
CUMMULATIVE PUMPING



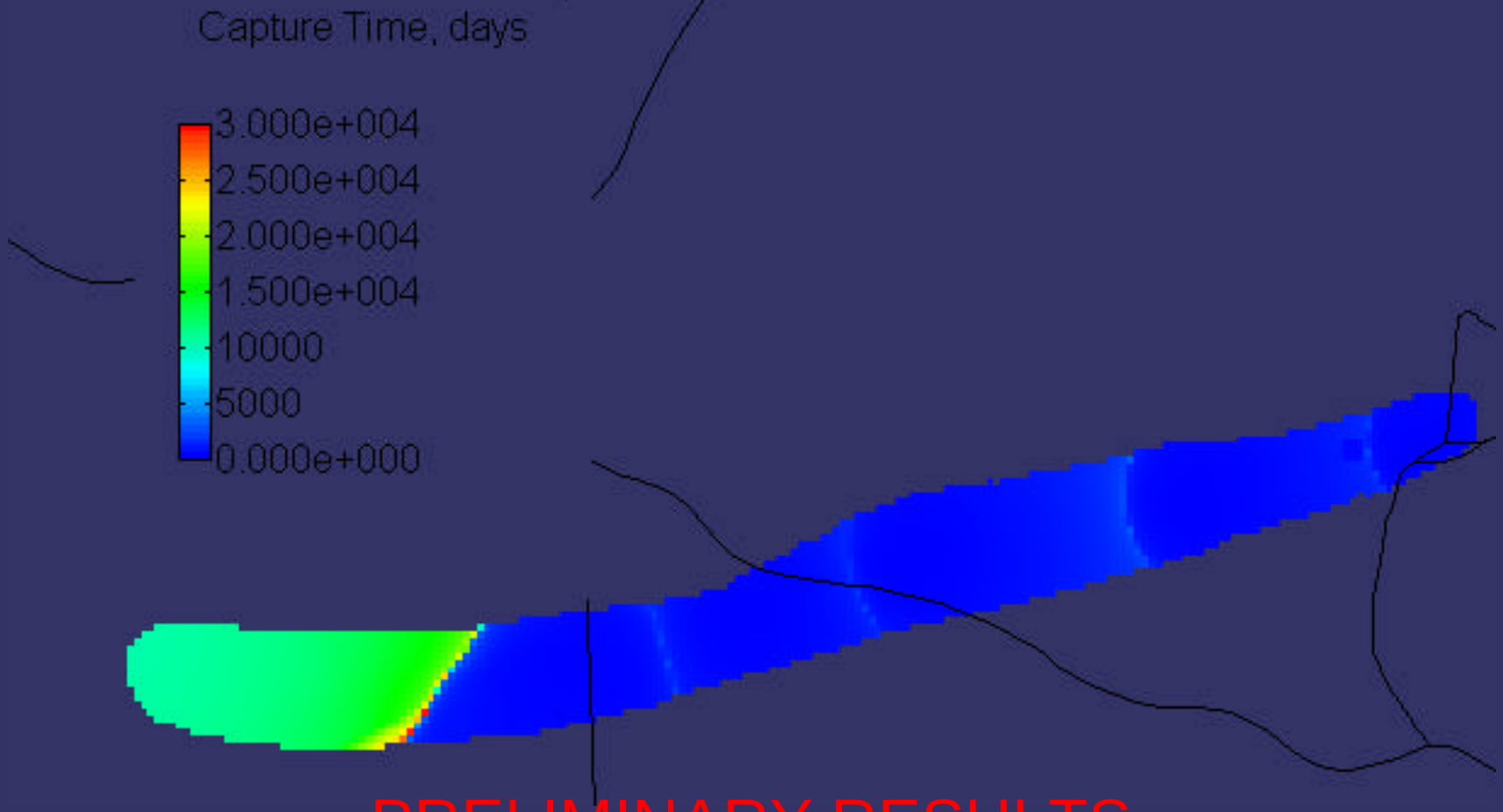
PRELIMINARY RESULTS

DEMO 1 SITE
10-YEAR REMOVAL DESIGN
LAYER 1 CAPTURE TIMES



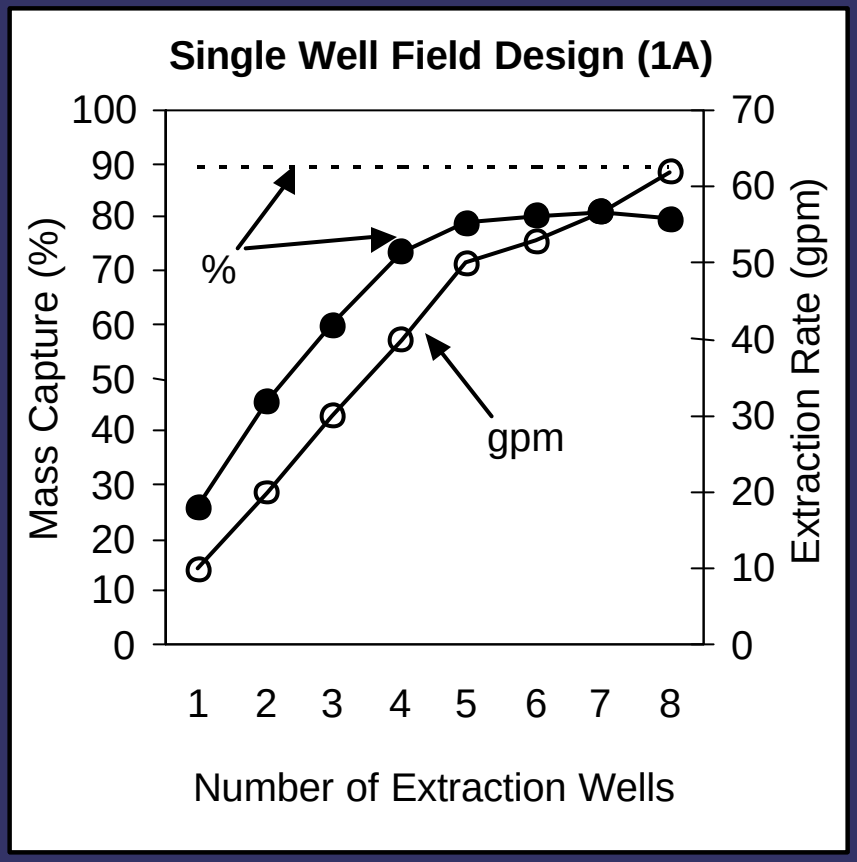
PRELIMINARY RESULTS

DEMO 1 SITE
10-YEAR REMOVAL DESIGN
LAYER 6 CAPTURE TIMES



PRELIMINARY RESULTS

ASYMTPOTIC RESULTS



SUMMARY

Particle Tracking Optimization:

1. Determines optimum well field configuration for varying contaminant removal rates
2. Can design well fields for removal of multiple contaminants of concern
3. Easy to implement