Accelerating Site Closeout, Improving Performance and Reducing Costs Through Optimization, June 15-17, 2004, Dallas, Texas

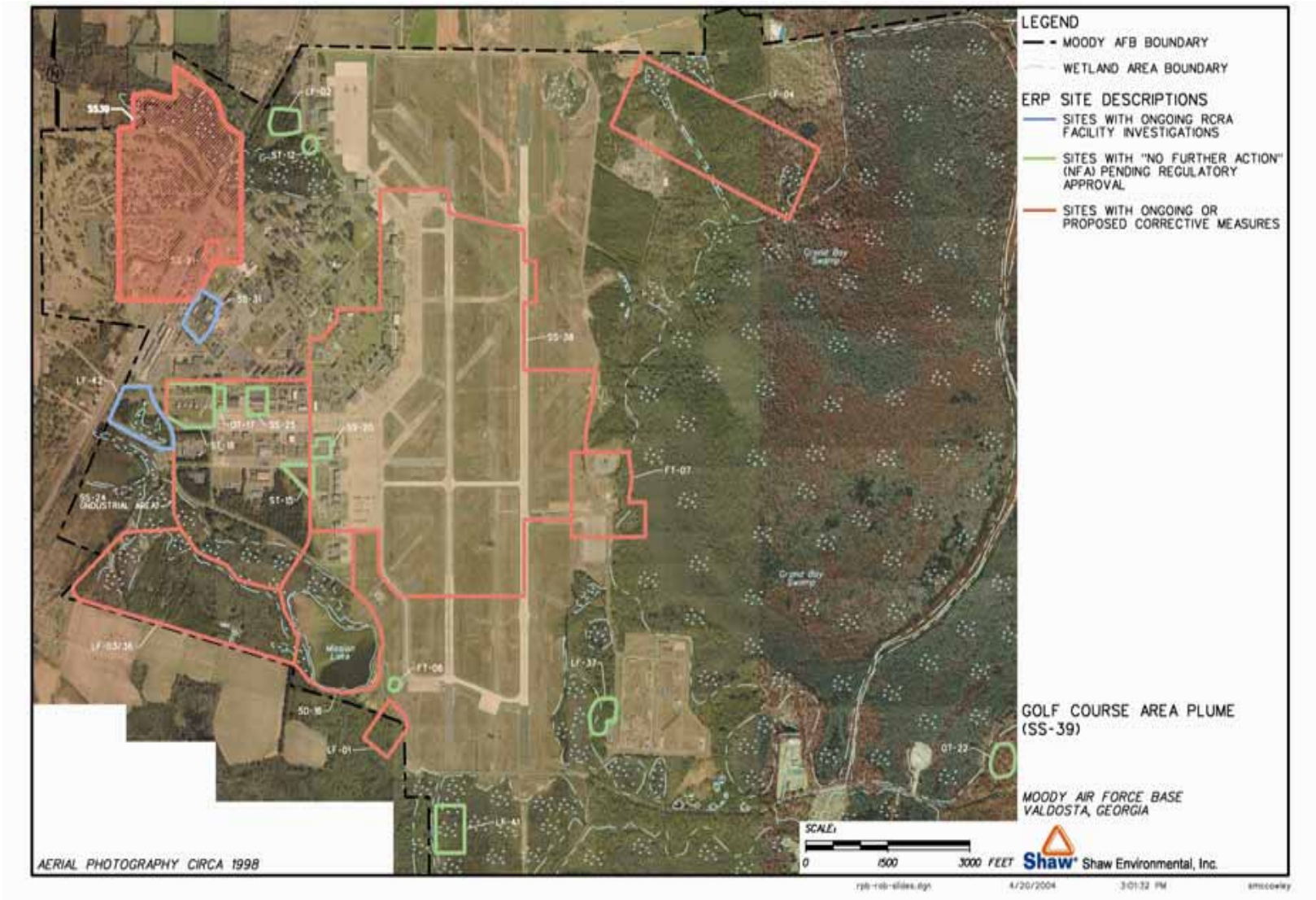
Optimizing Groundwater Corrective Action Utilizing 3D Flow and Solute Transport Modeling at Moody Air Force Base, Valdosta, GA

Belinda K. Price, Song-Kai Yan,
Randy J. Kurth, Jeffrey G. Johnson,
Jing Li, Lori M. Combass, and Leonard J. Havel

Introduction

- Purpose to determine appropriate optimized corrective action for groundwater remediation at site SS-39 at Moody Air Force Base, Valdosta, GA
- Groundwater flow and solute transport modeling was used to simulate corrective action alternatives and to predict their effectiveness

Moody Air Force Base and SS-39

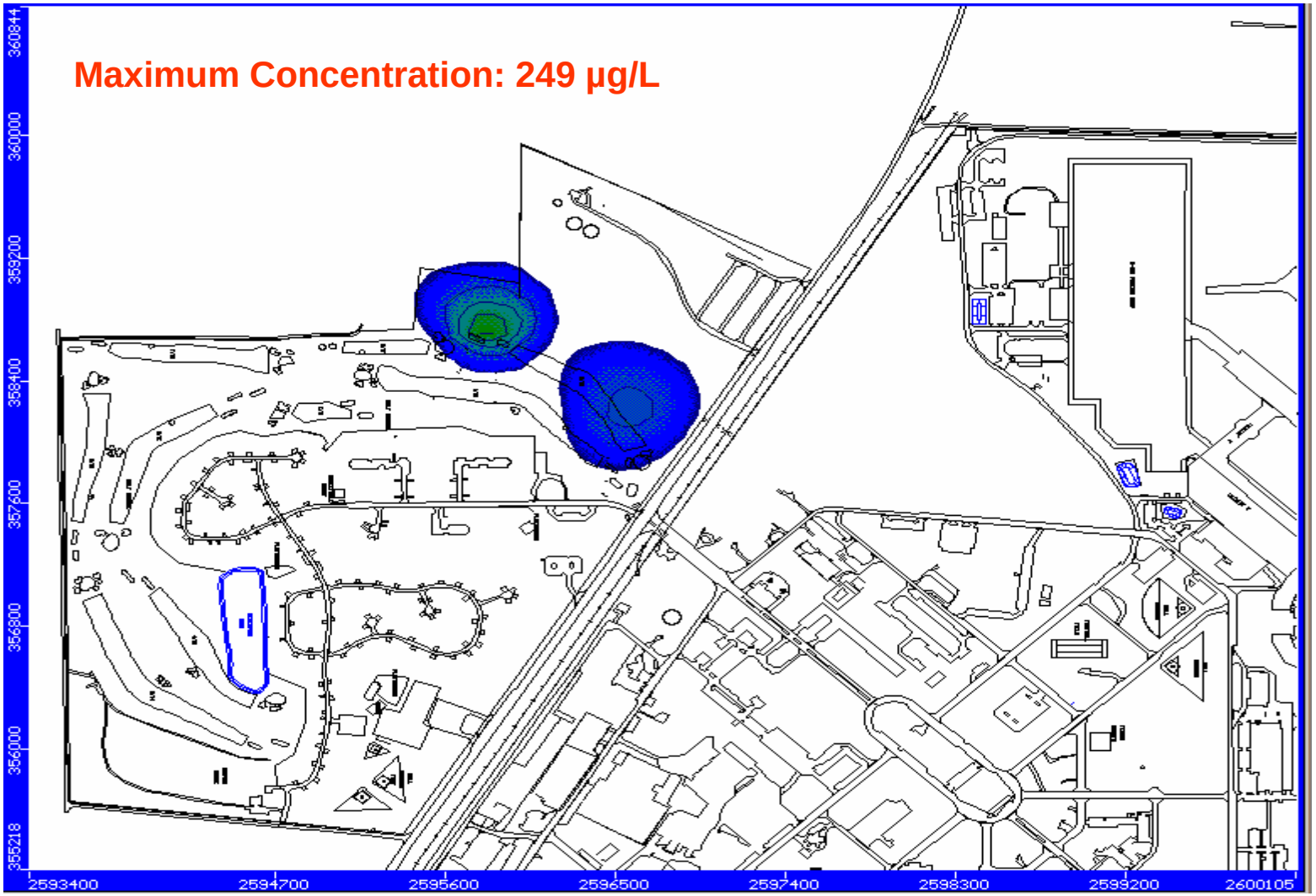


Nature and Extent of Contamination

- No surface water, soil or sediment contamination
- Chlorinated solvents detected above MCLs and are COCs in groundwater are:
  - trichloroethylene (TCE)
  - carbon tetrachloride (CT)
  - tetrachloroethylene (PCE)
  - vinyl chloride (VC)
  - methylene chloride (MC)
  - cis-1,2-dichloroethylene (DCE)
- TCE is most prevalent contaminant in groundwater

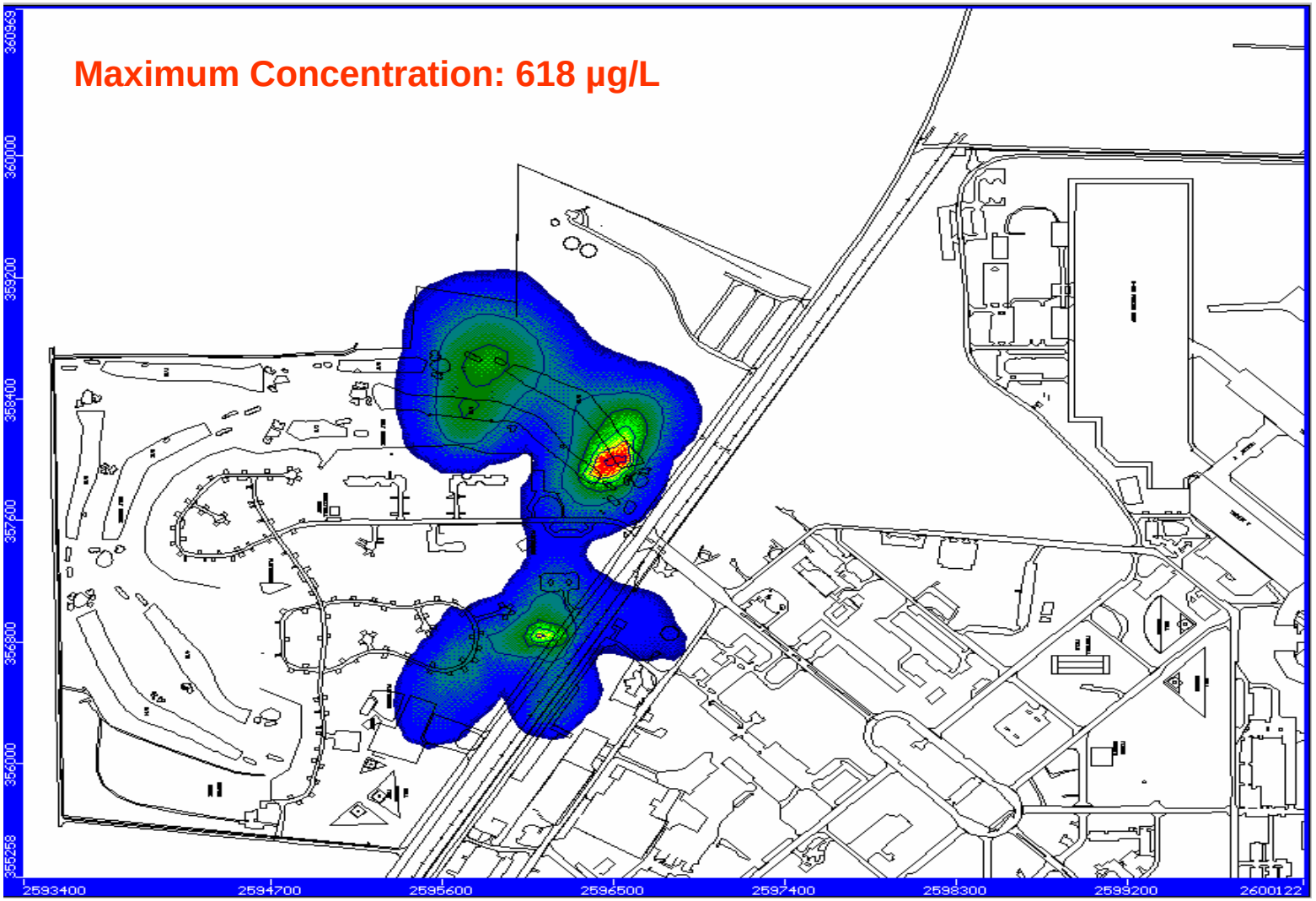
TCE in Groundwater at SS-39

Layer 1 - Upper Intermediate Zone (0 - 45 feet bgs)



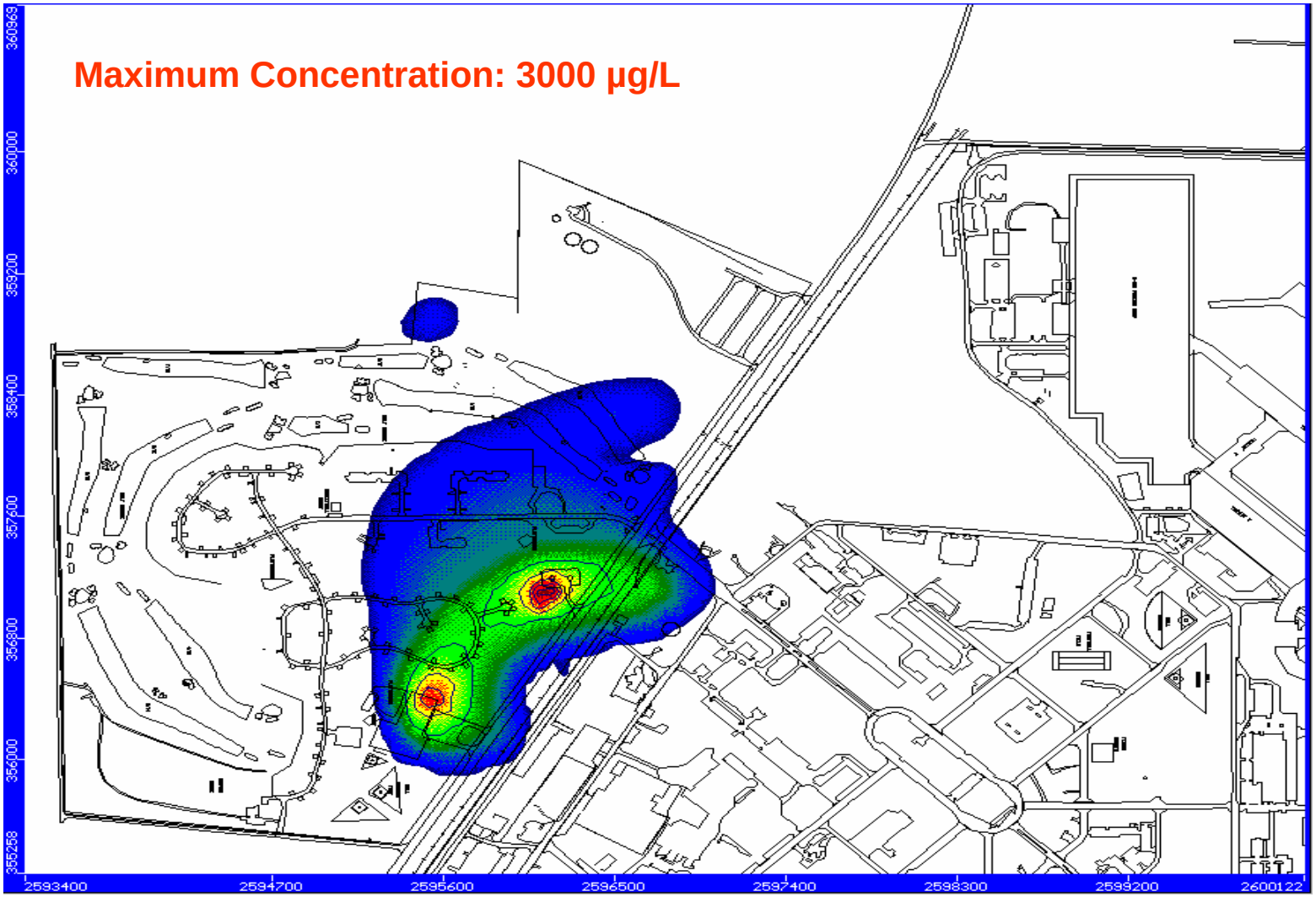
TCE in Groundwater at SS-39

Layer 2 - Lower Intermediate Zone (45 - 60 feet bgs)



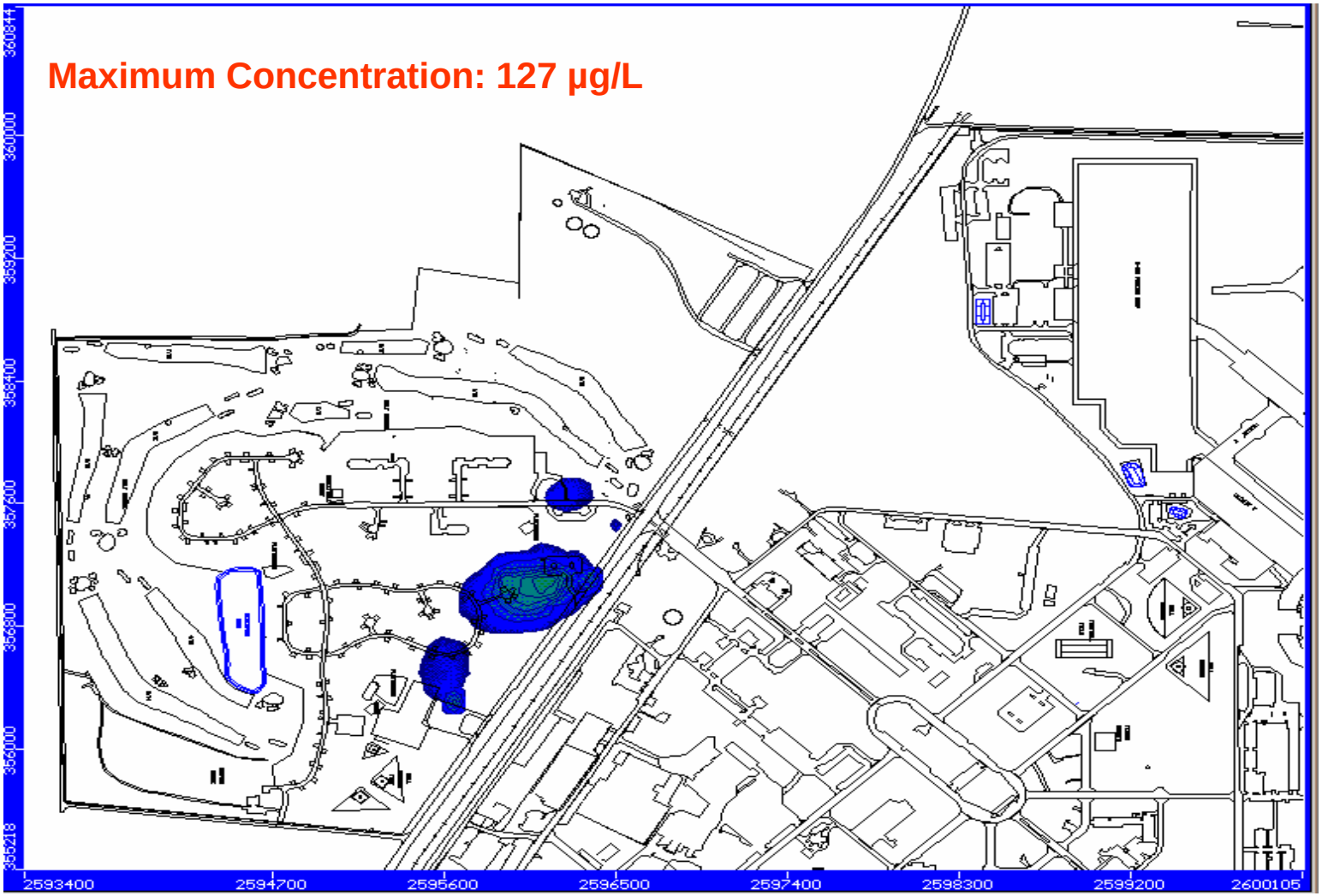
TCE in Groundwater at SS-39

Layer 3 - Upper Deep Zone (61 - 80 feet bgs)



TCE in Groundwater at SS-39

Layer 4 - Lower Deep Zone (81-95 feet bgs)



Current Activities

- Interim Measure (IM)
  - > Boundary control (BC) pump and treat (P&T) at northern base boundary
- Pilot Tests
  - > Potassium permanganate treatment at hot spot 1
  - > In situ enhanced bioremediation with bioaugmentation (ISEB) at hot spot 2

Corrective Action Technologies

- Screened 10 technologies for potential remedial alternative development
- Retained 5 technologies for alternative development
  - > No action
  - > Monitored natural attenuation (MNA) with long term monitoring (LTM)
  - > Hot spot treatment with in situ chemical oxidation using potassium permanganate
  - > Hot spot treatment with anaerobic in situ enhanced bioremediation and bioaugmentation (ISEB)
  - > Groundwater extraction and treatment (P&T)

Corrective Action Alternatives

- Developed 6 corrective action alternatives for detailed evaluation
  - > Alternative 1 – No Action
  - > Alternative 2 – MNA and LTM
  - > Alternative 3 – Optimized IM P&T for BC and MNA/LTM
  - > Alternative 4 – Hot spot treatment with ISEB, BC and MNA/LTM
  - > Alternative 5 - Hot spot treatment with P&T, BC and MNA/LTM
  - > Alternative 6 - Hot spot treatment with ISEB and P&T, BC and MNA/LTM

General Approach

- Develop and calibrate a Base-wide flow model
- Add site solute transport model component
- Run MNA baseline case for comparison
- Use model to test corrective action (CA) alternatives and establish optimized CAs
- Develop a CAP that considers the optimized CAs and makes a recommendation taking all appropriate factors into consideration

GOAL: Use an active remedy to remove the greatest chemical mass (cost effectively) in the shortest period of time such that MNA can complete cleanup

Modeling Approach

Run MNA case:

- As baseline for comparison of alternatives
- Determine if TCE will migrate or if plume is at steady state
- Determine if hydraulic containment is necessary
- Determine if active remediation is warranted

Test (and optimize at the same time) different technologies:

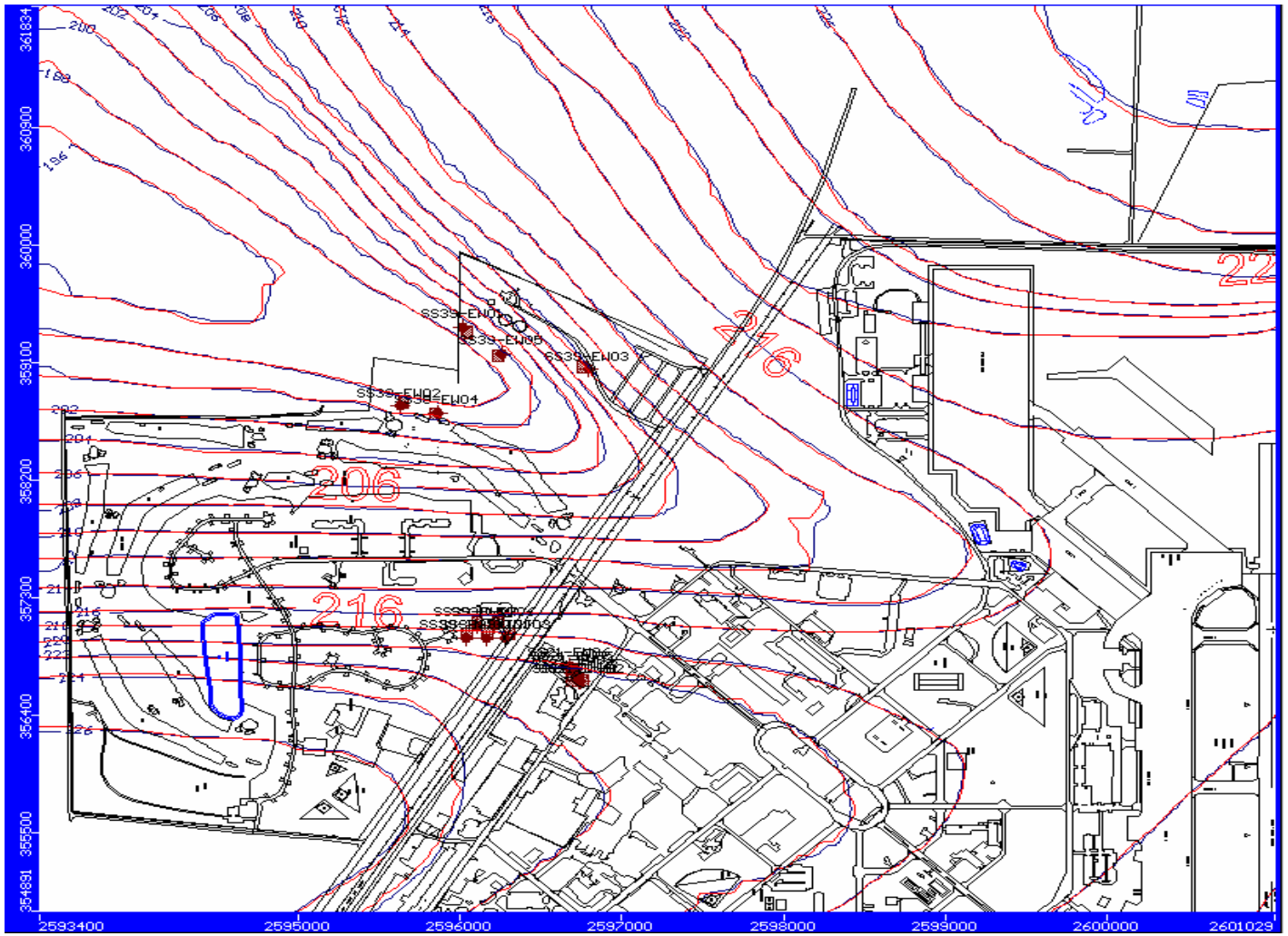
- P&T – different configurations/pumping rates for wells are simulated to remove water and chemical mass
- Hot spot treatment – starting chemical concentrations (representing values greater than a certain amount) are reduced at start of model run to a specified amount

Model Calibration – Example Intermediate Zone

Legends:

Observed Head Contour

Simulated Head Contour



Alternative 1 – No Action

Alternative 2 – MNA with LTM

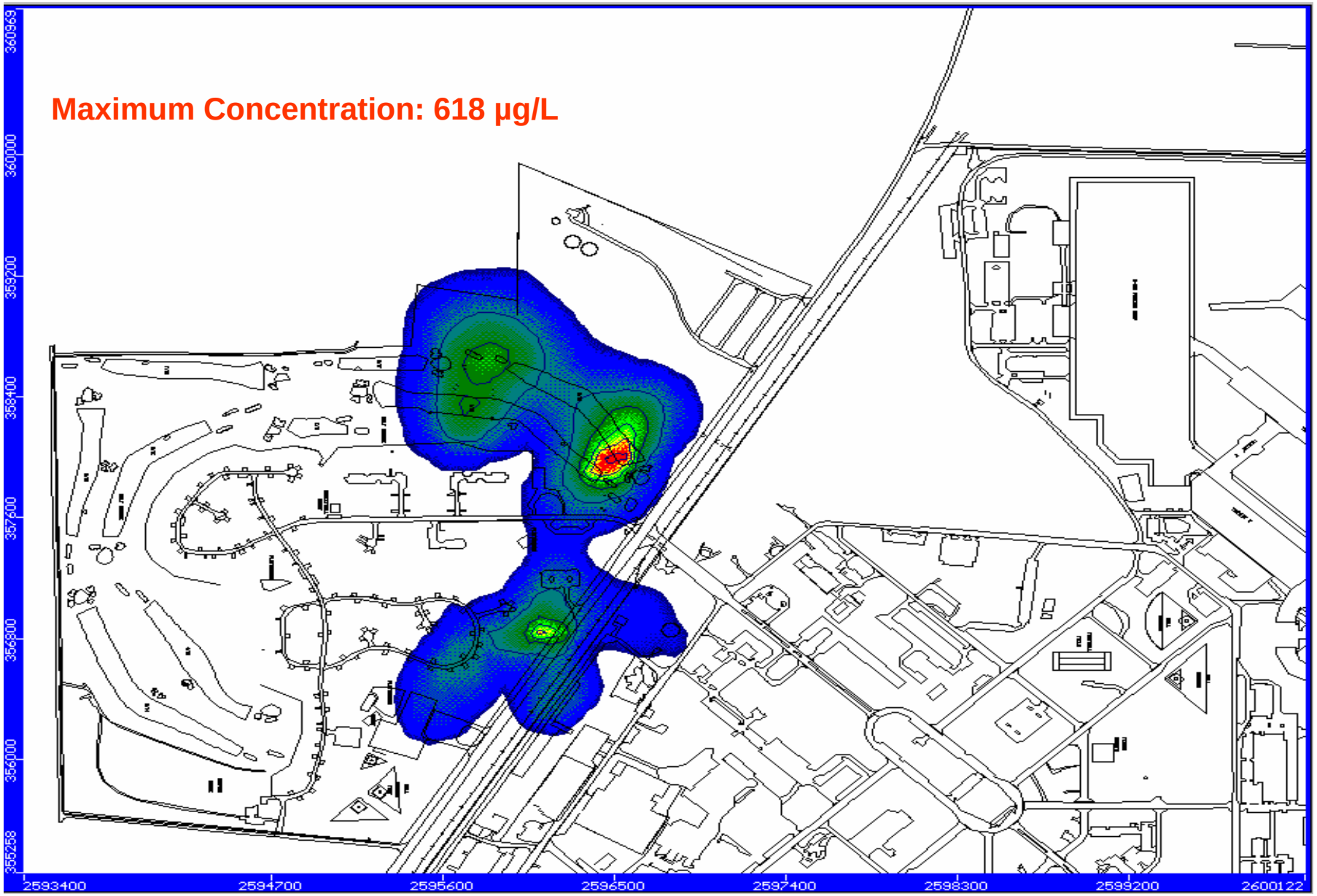
- Alternative 1 – No Action
  - > Provided as a baseline for comparison
  - > Will not achieve Corrective Action Objectives (CAOs) within 100 years
- Alternative 2 – MNA with LTM
  - > Install 17 additional monitoring wells

Alternatives 1 and 2 – No Action or MNA/LTM

Simulated TCE Plume
Layer 2 - Lower Intermediate Zone (46 - 60 feet bgs)

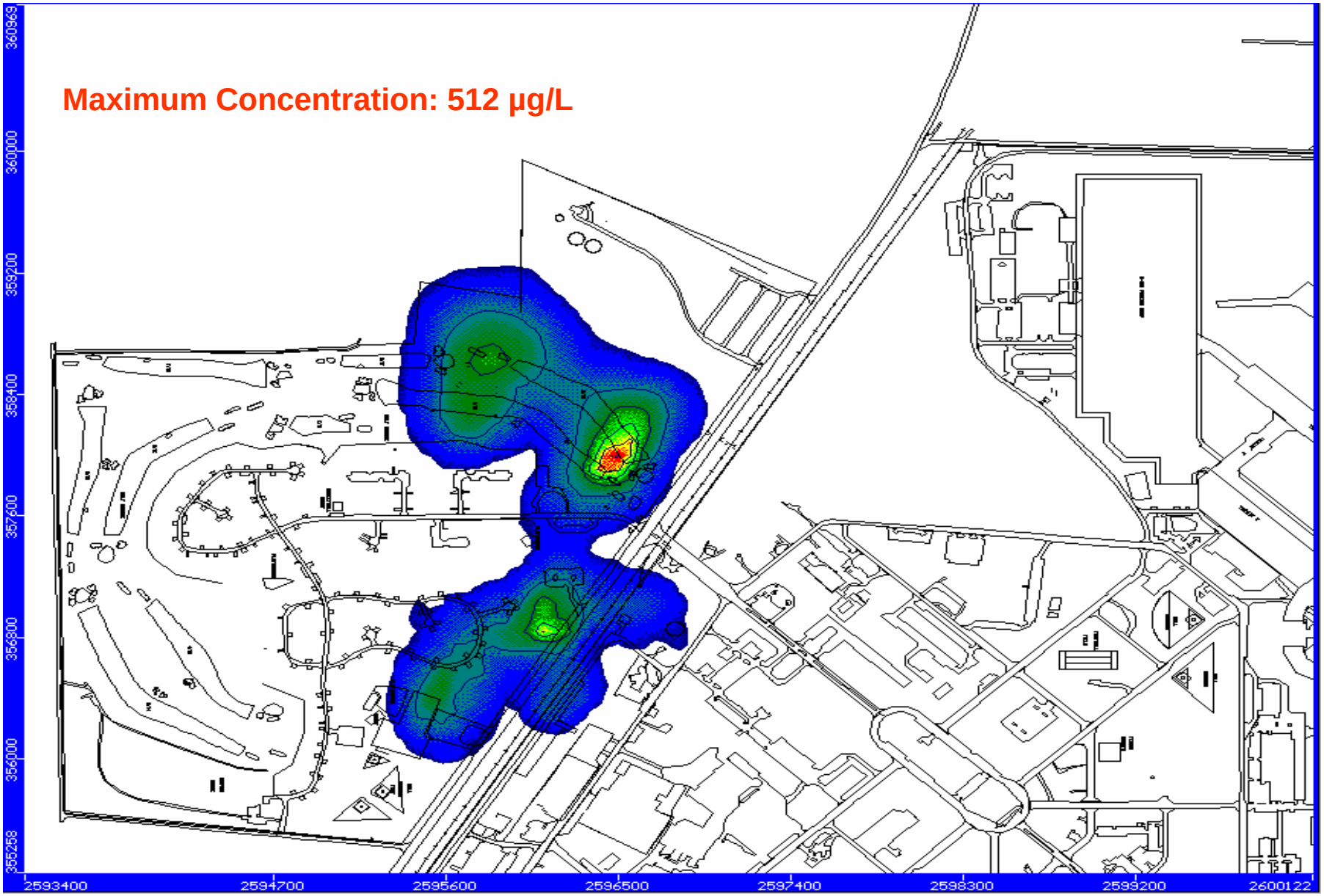
Simulation Time: 0 Year

Initial TCE Mass: 448.2 kg
Current Mass: 448.2 kg
Percent Reduction: 0.0 %



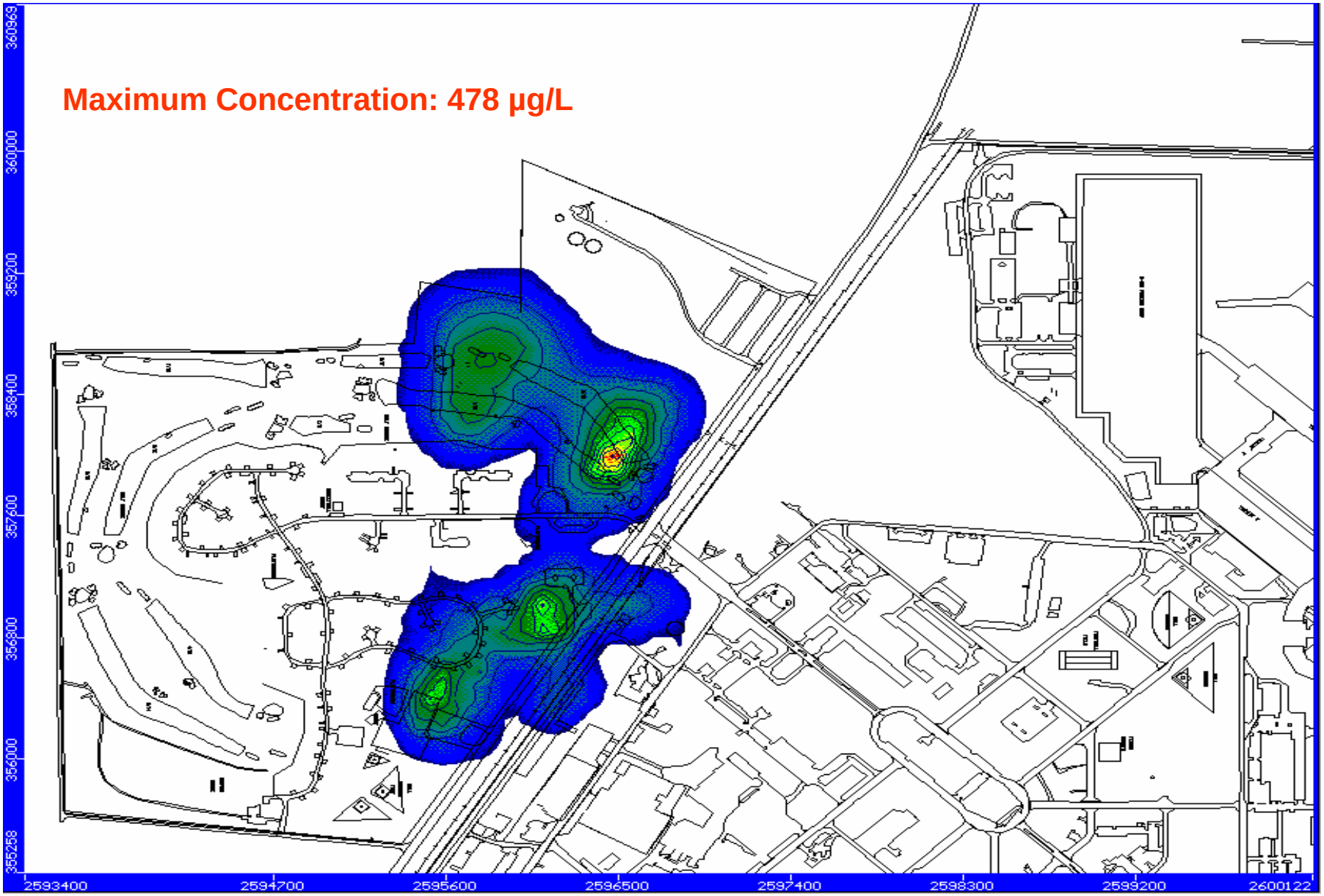
Simulation Time: 5 Year

Initial TCE Mass: 448.2 kg
Current Mass: 423.3 kg
Percent Reduction: 5.6 %



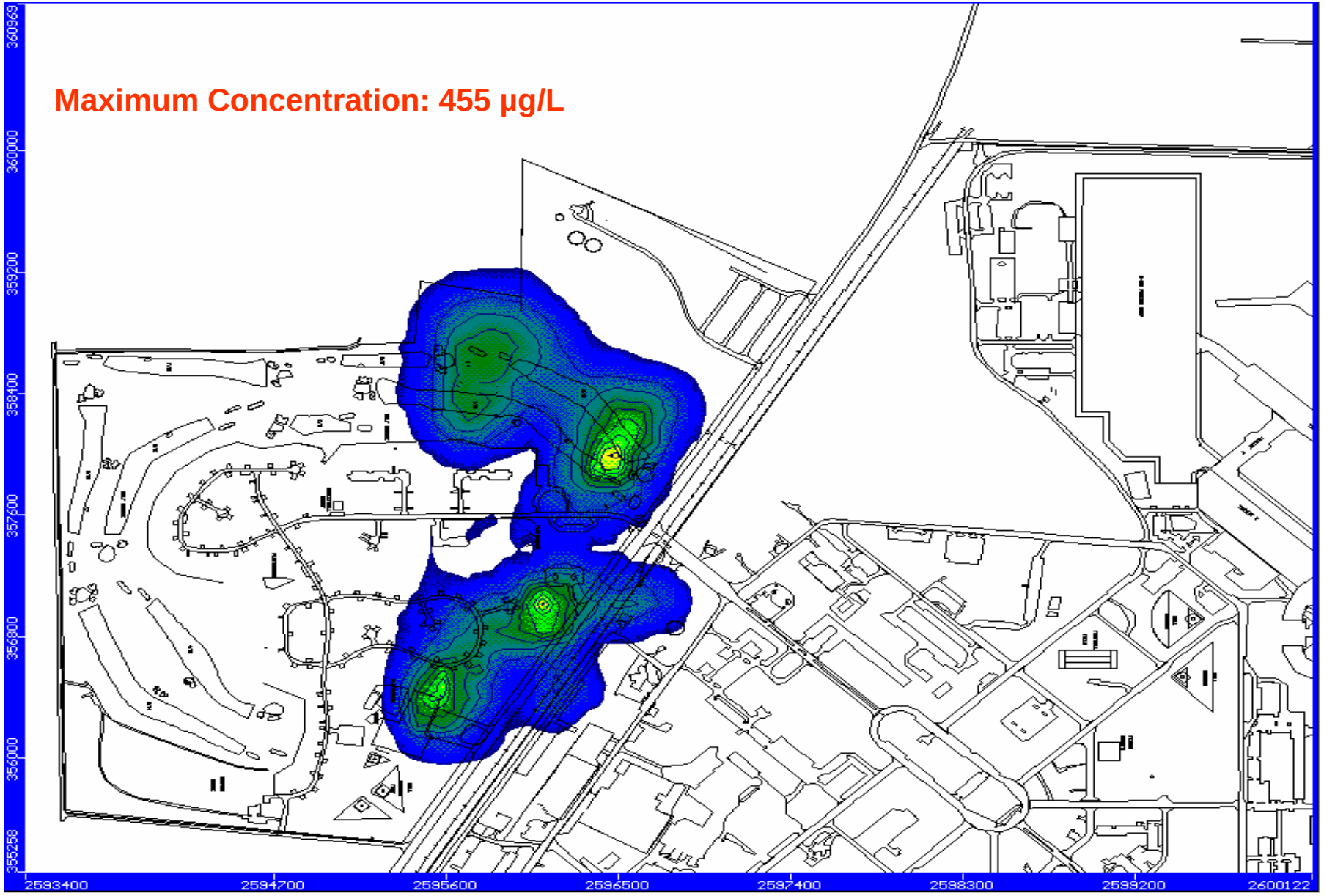
Simulation Time: 10 Years

Initial TCE Mass: 448.2 kg
Current Mass: 407.4 kg
Percent Reduction: 9.1 %



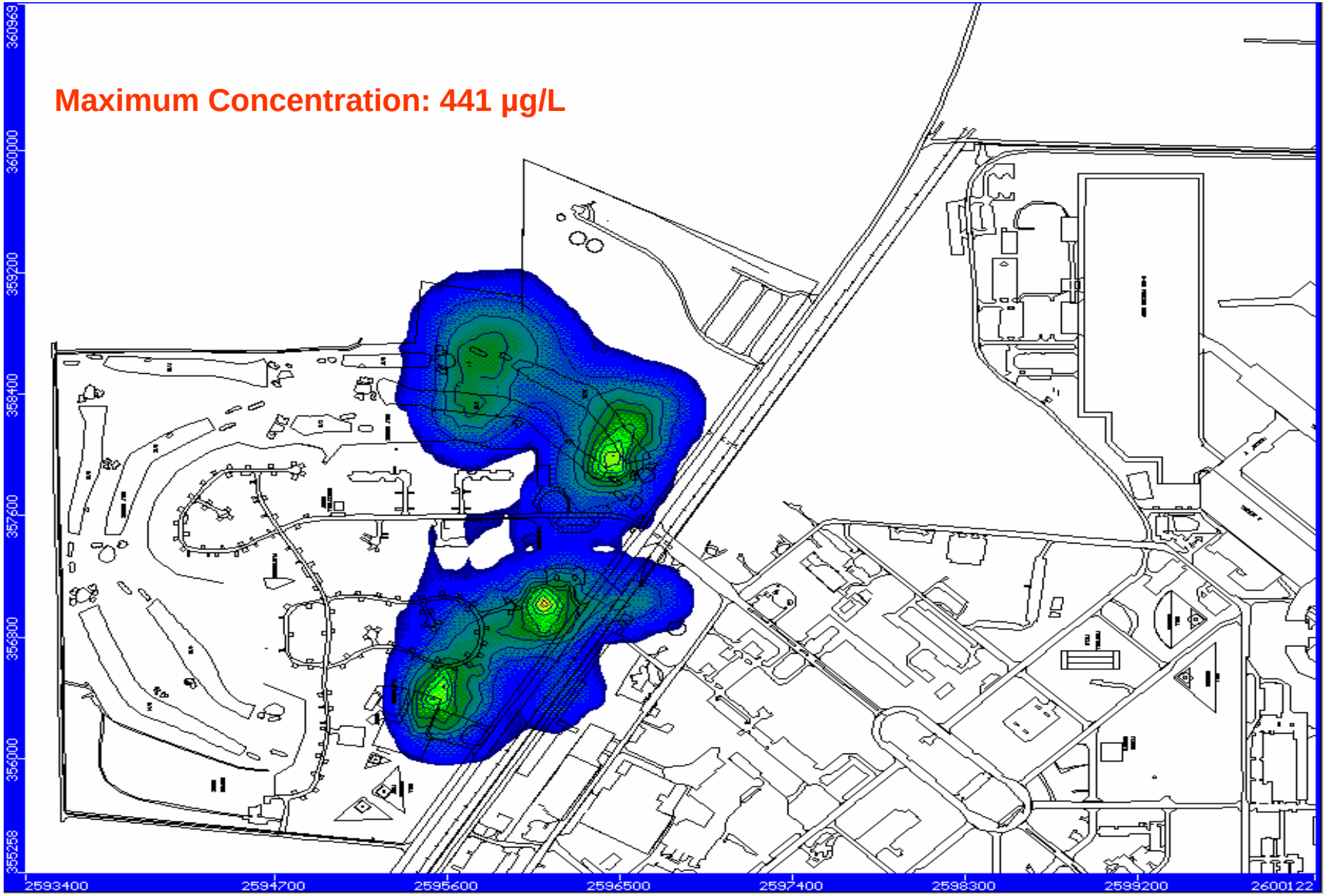
Simulation Time: 15 Years

Initial TCE Mass: 448.2 kg
Current Mass: 394.1 kg
Percent Reduction: 12.1 %



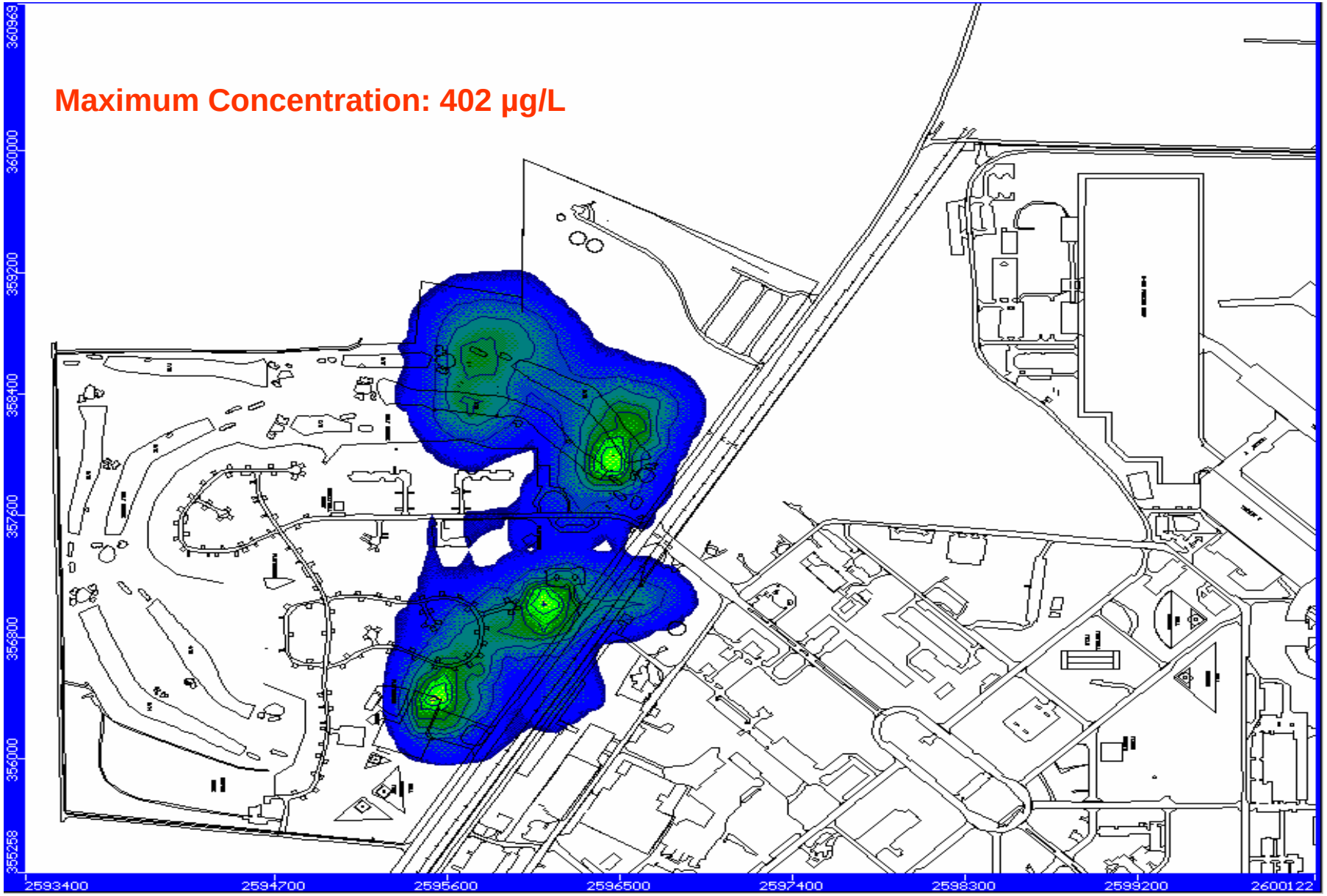
Simulation Time: 20 Years

Initial TCE Mass: 448.2 kg
Current Mass: 382.5 kg
Percent Reduction: 14.7 %



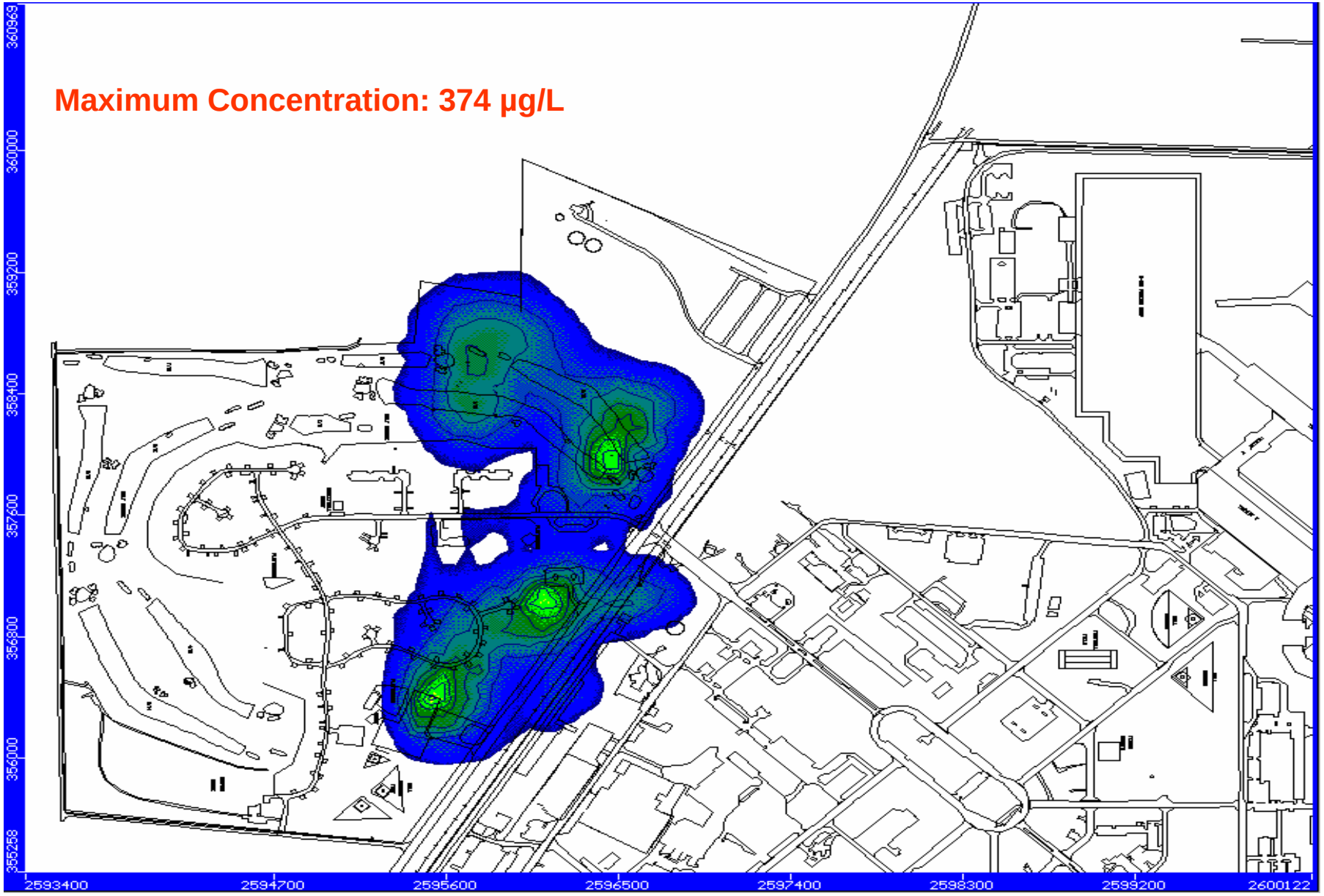
Simulation Time: 25 Years

Initial TCE Mass: 448.2 kg
Current Mass: 372.0 kg
Percent Reduction: 17.0 %



Simulation Time: 30 Years

Initial TCE Mass: 448.2 kg
Current Mass: 362.3 kg
Percent Reduction: 19.2 %

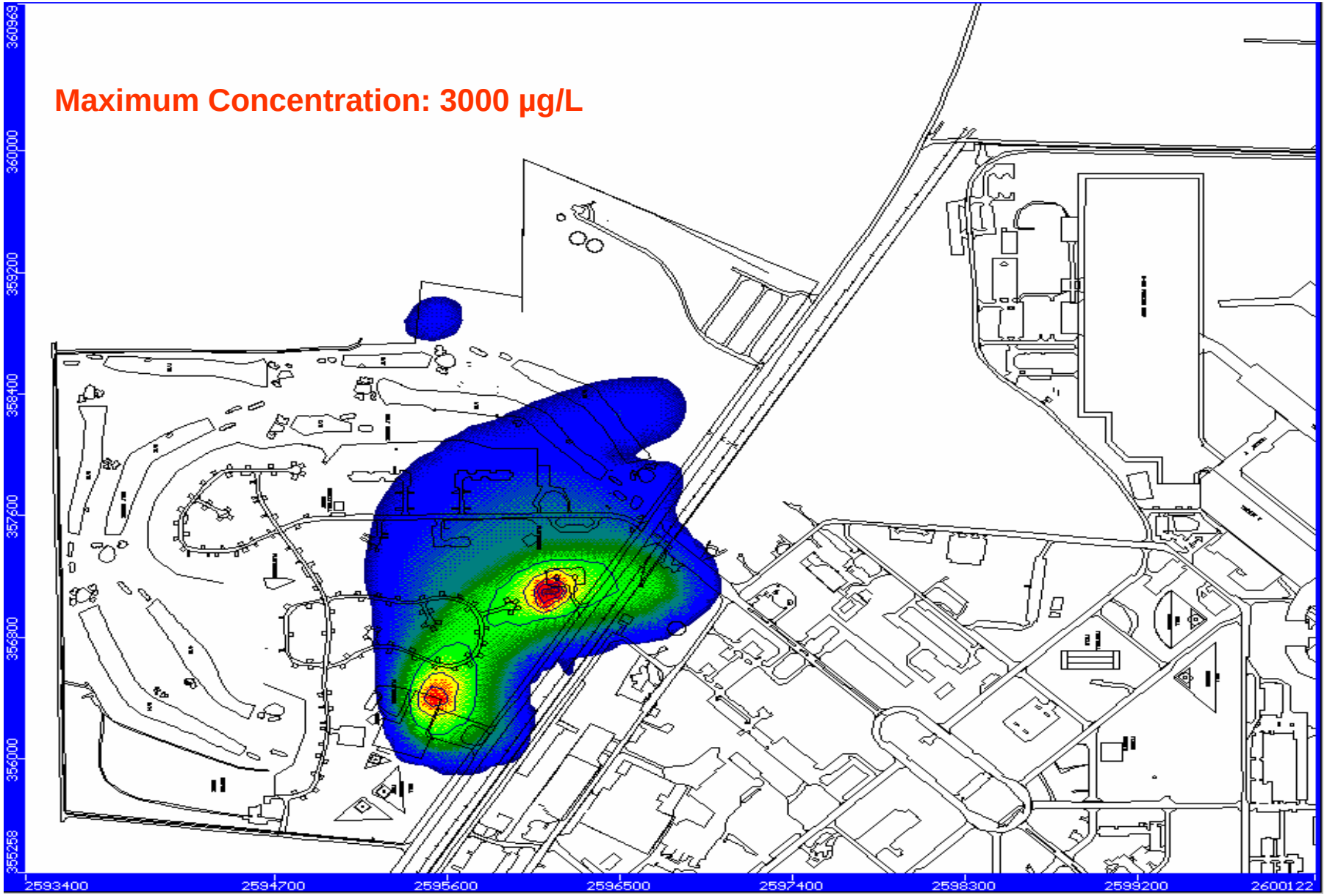


Alternatives 1 and 2 – No Action or MNA/LTM

Simulated TCE Plume
Layer 3 - Upper Deep Zone (61 - 80 feet bgs)

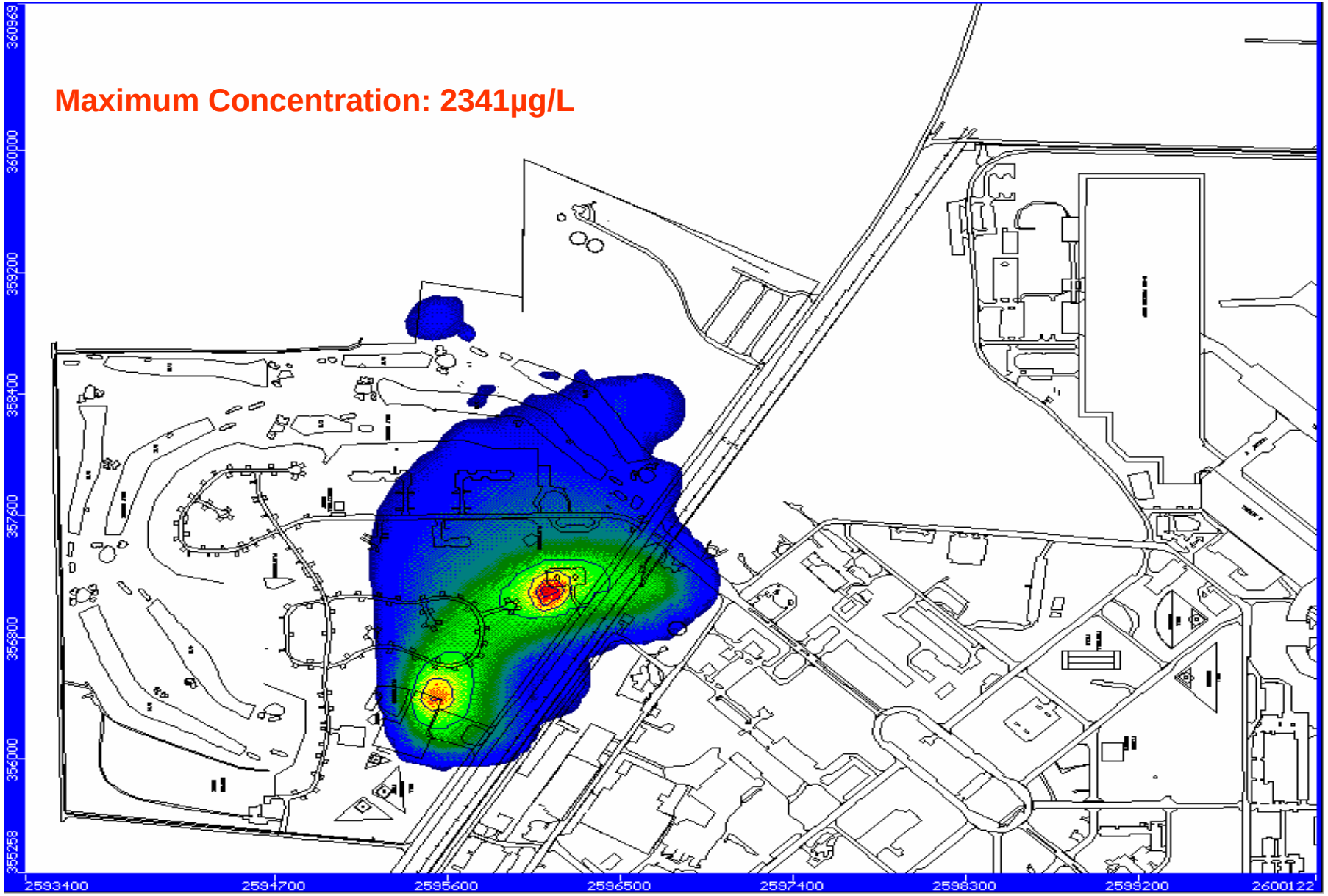
Simulation Time: 0 Year

Initial TCE Mass: 448.2 kg
Current Mass: 448.2 kg
Percent Reduction: 0.0 %



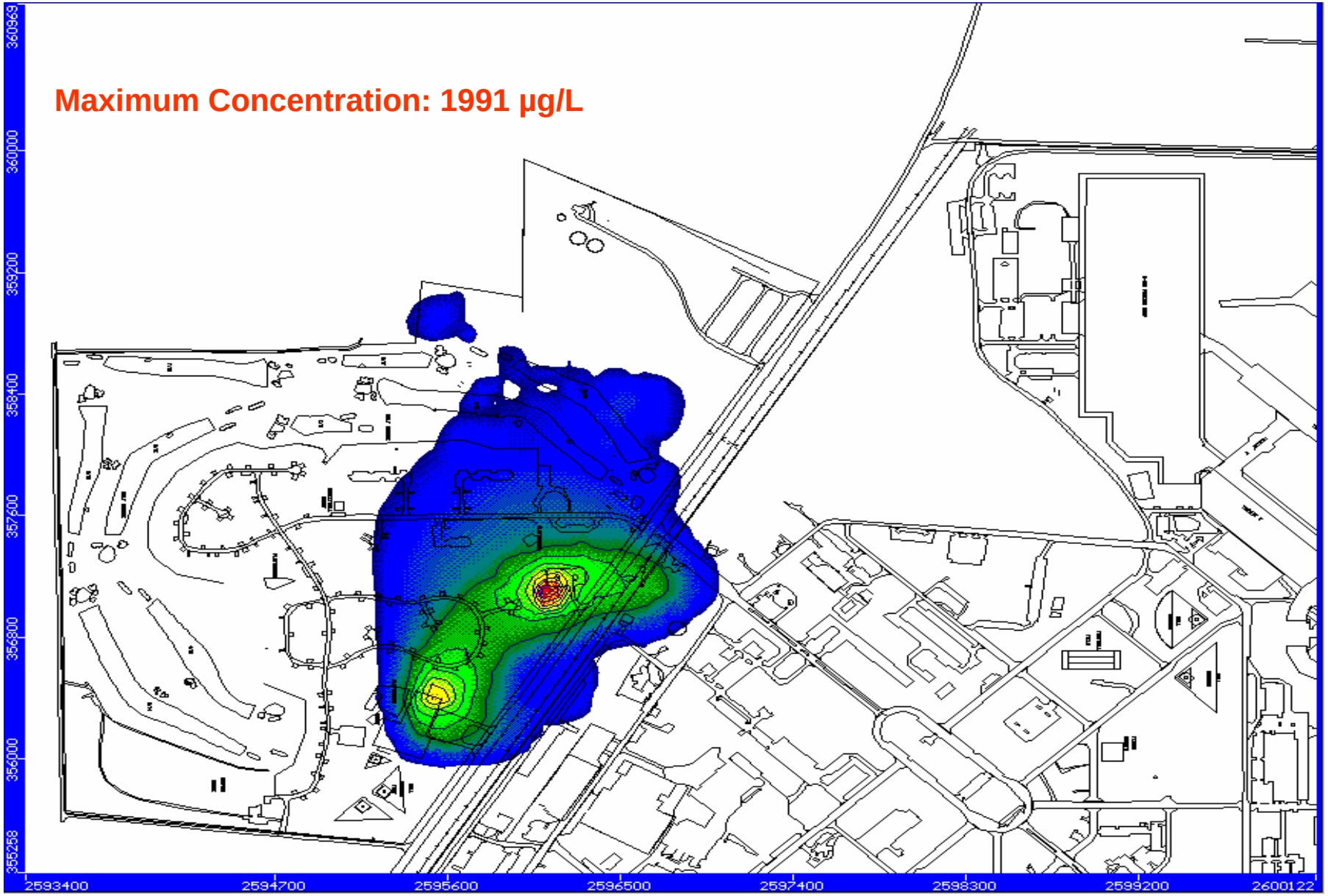
Simulation Time: 5 Year

Initial TCE Mass: 448.2 kg
Current Mass: 423.3 kg
Percent Reduction: 5.6 %



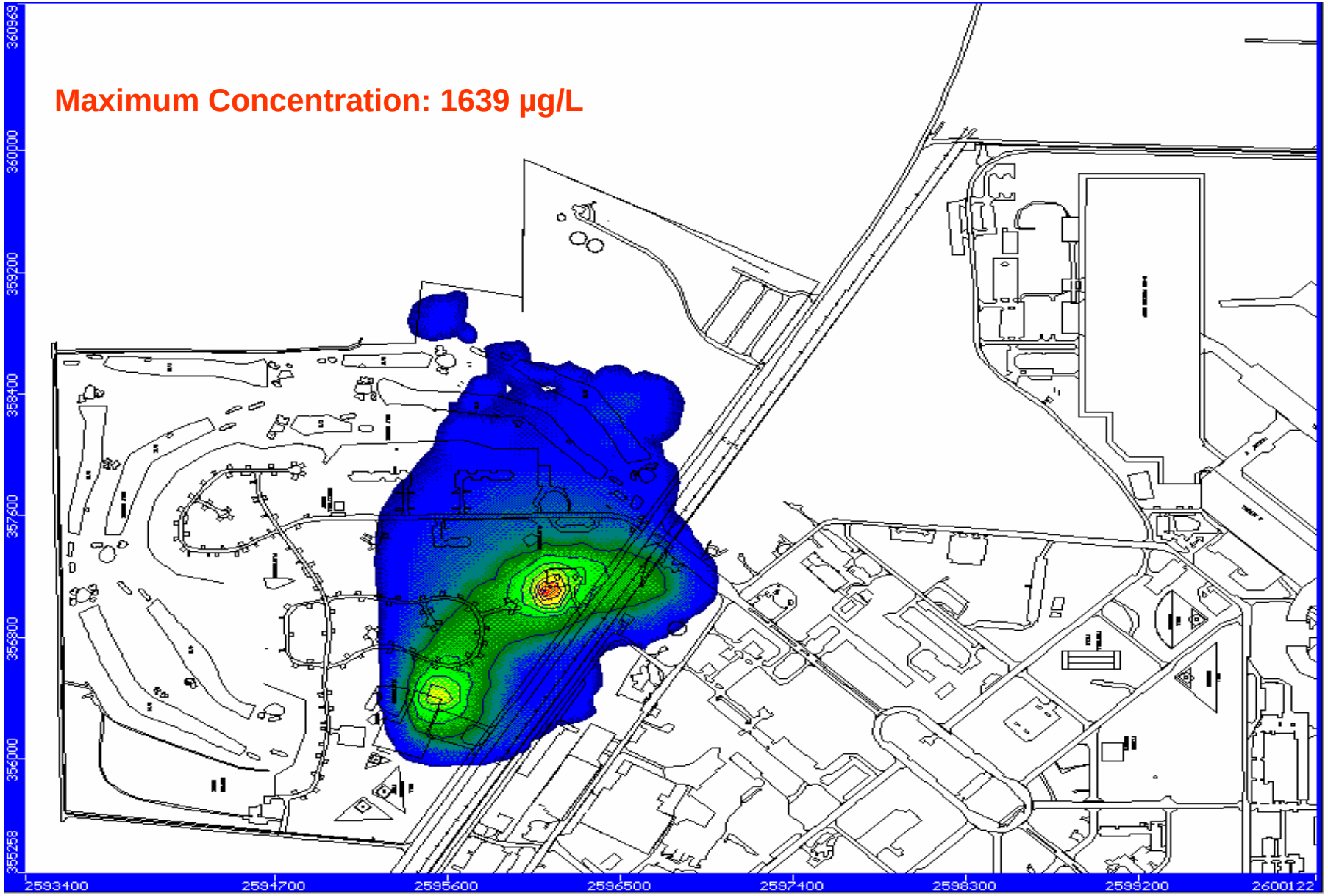
Simulation Time: 10 Years

Initial TCE Mass: 448.2 kg
Current Mass: 407.4 kg
Percent Reduction: 9.1 %



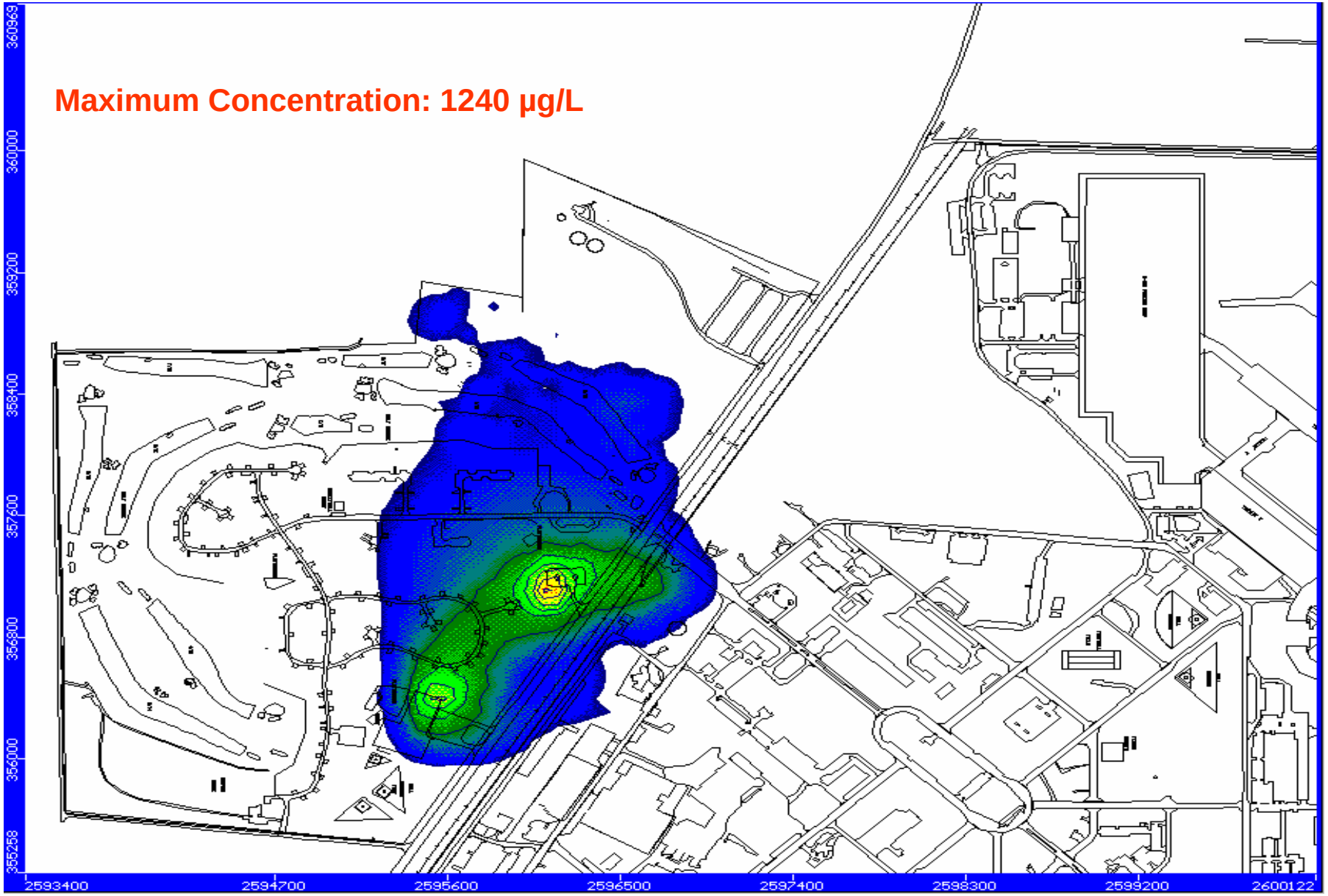
Simulation Time: 15 Years

Initial TCE Mass: 448.2 kg
Current Mass: 394.1 kg
Percent Reduction: 12.1 %



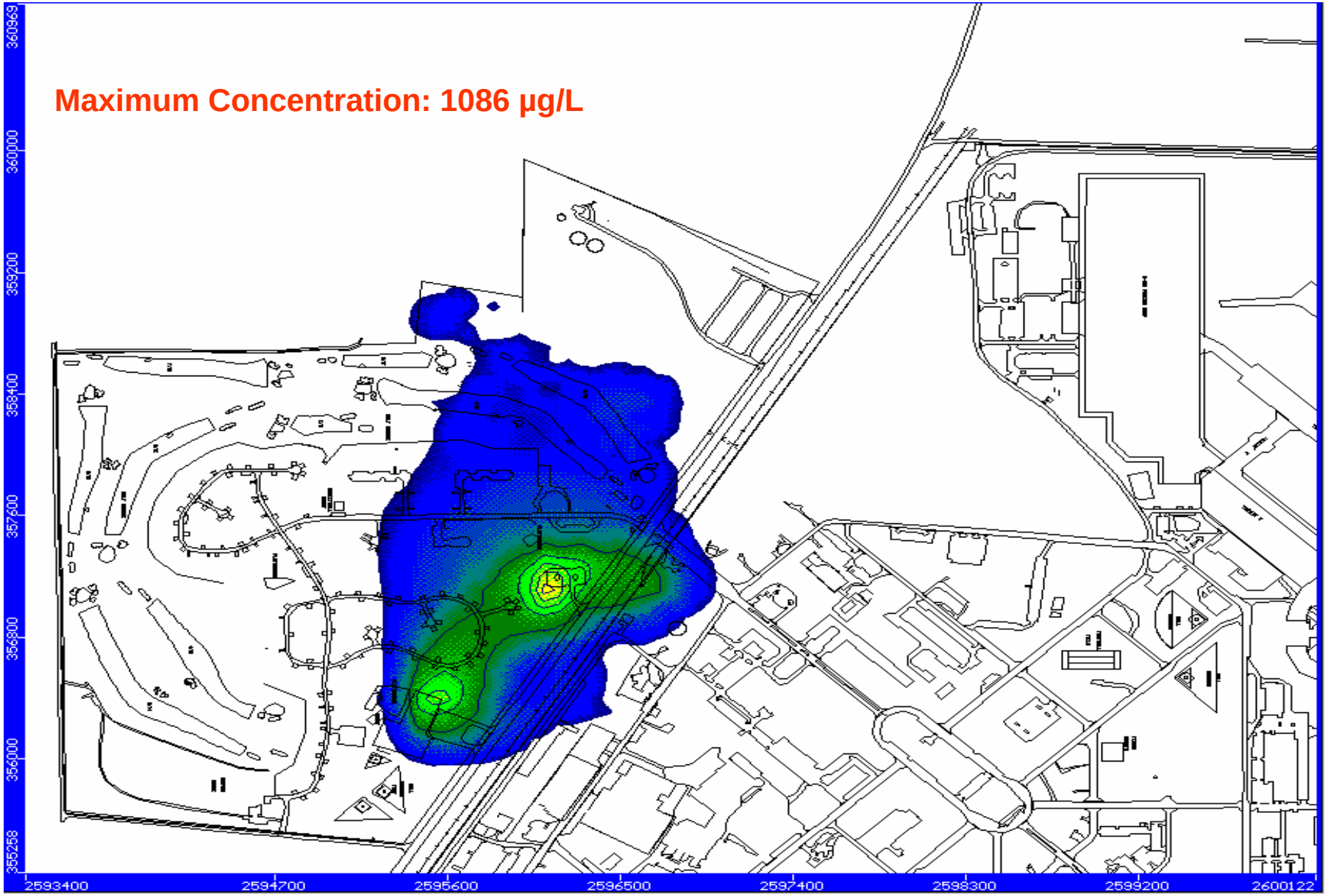
Simulation Time: 20 Years

Initial TCE Mass: 448.2 kg
Current Mass: 382.5 kg
Percent Reduction: 14.7 %



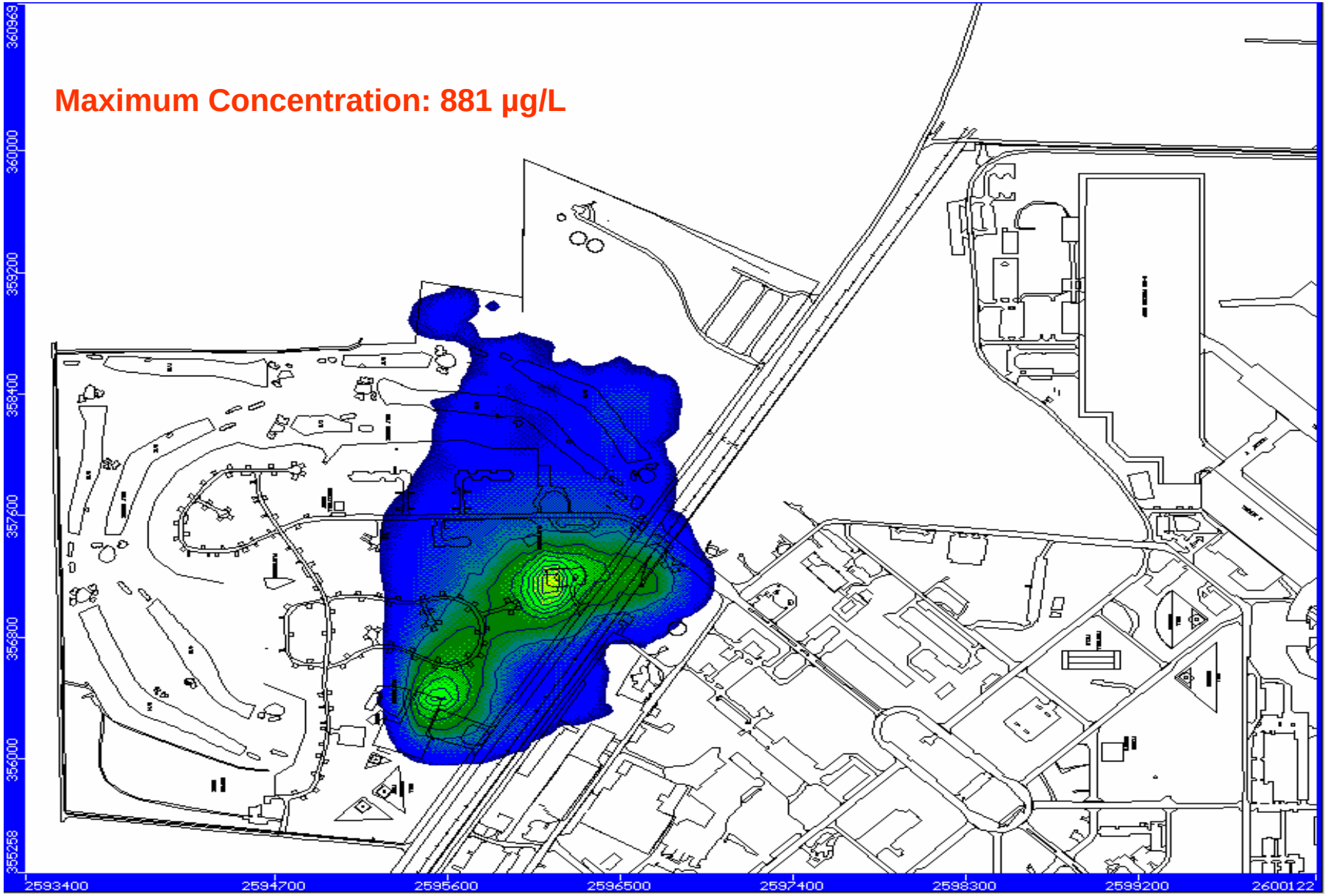
Simulation Time: 25 Years

Initial TCE Mass: 448.2 kg
Current Mass: 372.0 kg
Percent Reduction: 17.0 %



Simulation Time: 30 Years

Initial TCE Mass: 448.2 kg
Current Mass: 362.3 kg
Percent Reduction: 19.2 %



Alternative 3 – Optimized IM P&T for BC and MNA/LTM

Goal: Achieve plume containment avoid offsite migration

Evaluated:

- 1, 2, 3, 5, 6 and 7 well configurations (feasible locations only)
- Pumping rates 2 – 20 gpm

Optimized IM:

- Turn off 3 extraction wells
- Increase pumping rate at 2 extraction wells to 20 gpm
- Reduce TCE at boundary < MCLs in 15 years

Alternative 3 incorporated into subsequent alternatives

Alternative 4 – Hot Spot Treatment with ISEB, BC and MNA/LTM

Goal: Remediate hot spots so MNA can be used for final CAOs

Evaluated:

- Reducing hot spots >1,000 µg/l or >500 µg/l
- Assumed reduction <50 µg/l

Optimized ISEB hot spot treatment:

- Use existing recirculation cell at hot spot 2
- Construct recirculation cells at hot spots 1 and 3
- Quench residual permanganate at hot spot 1
- Bioaugmentation at all three hot spots
- Reduce hot spots >500 µg/l to <50 µg/l within 5 years
- MNA for final CAOs

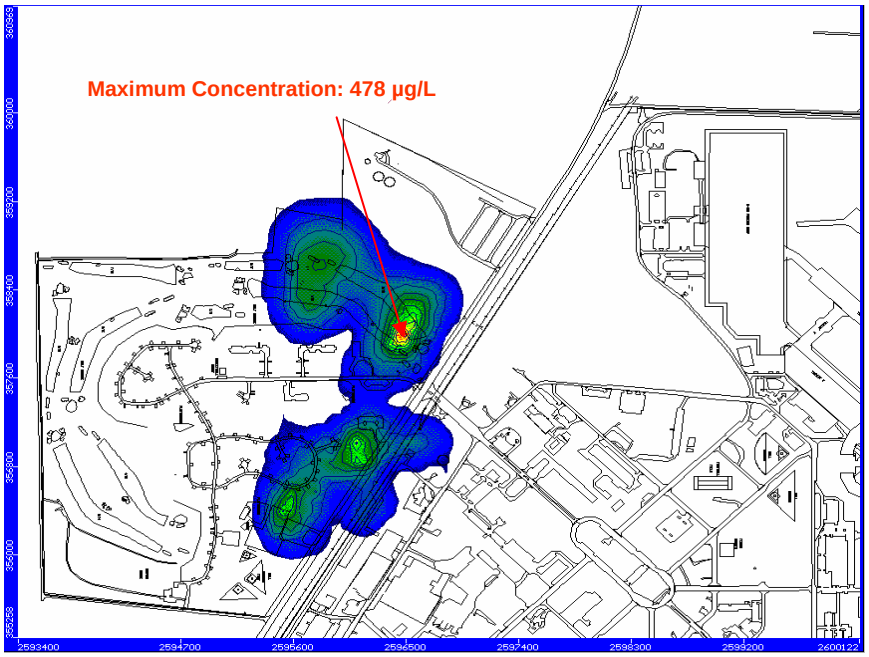
Alternative 4 - Simulated TCE Plume at 10 years

Layer 2 - Lower Intermediate Zone (46 - 60 feet bgs)

Hot Spot Treatment with ISEB, BC and MNA/LTM

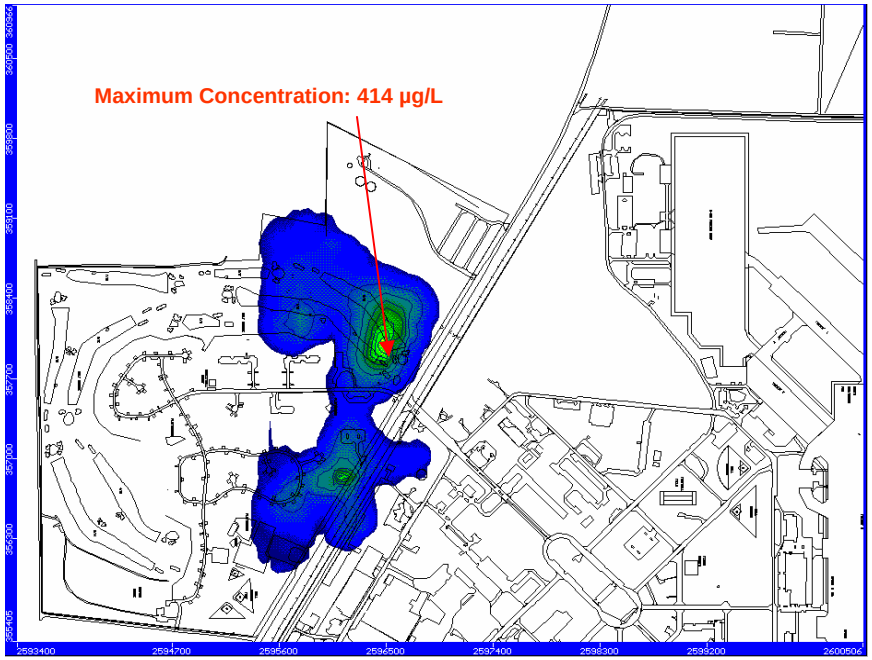
MNA

Initial TCE Mass: 448.2 kg
Current Mass: 407.4 kg
Percent Reduction: 9.1 %



Hot Spot Treatment with ISEB, BC and MNA/LTM

Initial TCE Mass: 448.2 kg
Current Mass: 181.8 kg
Percent Reduction: 59.5 %



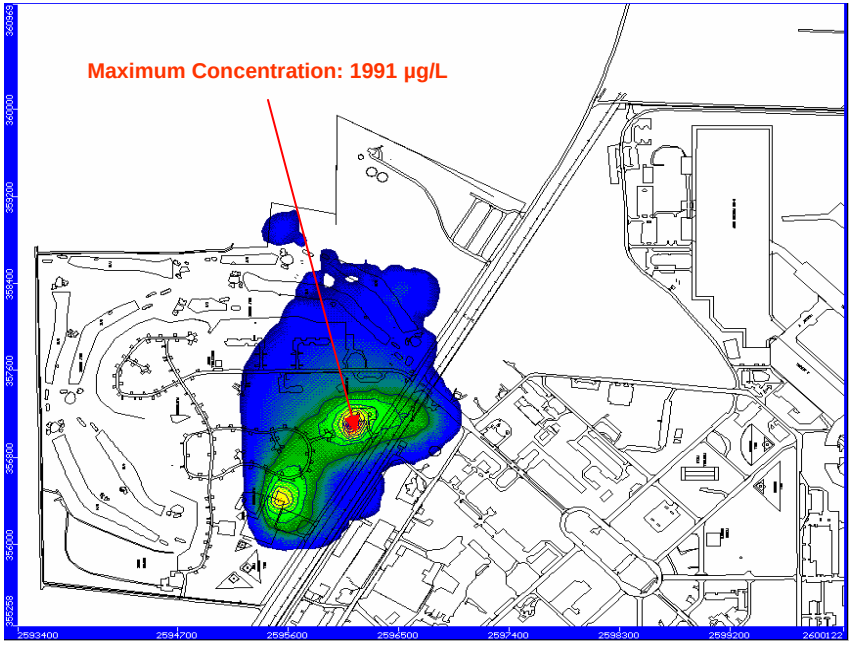
Alternative 4 - Simulated TCE Plume at 10 years

Layer 3 - Upper Deep Zone (61 - 80 feet bgs)

Hot Spot Treatment with ISEB,BC and MNA/LTM

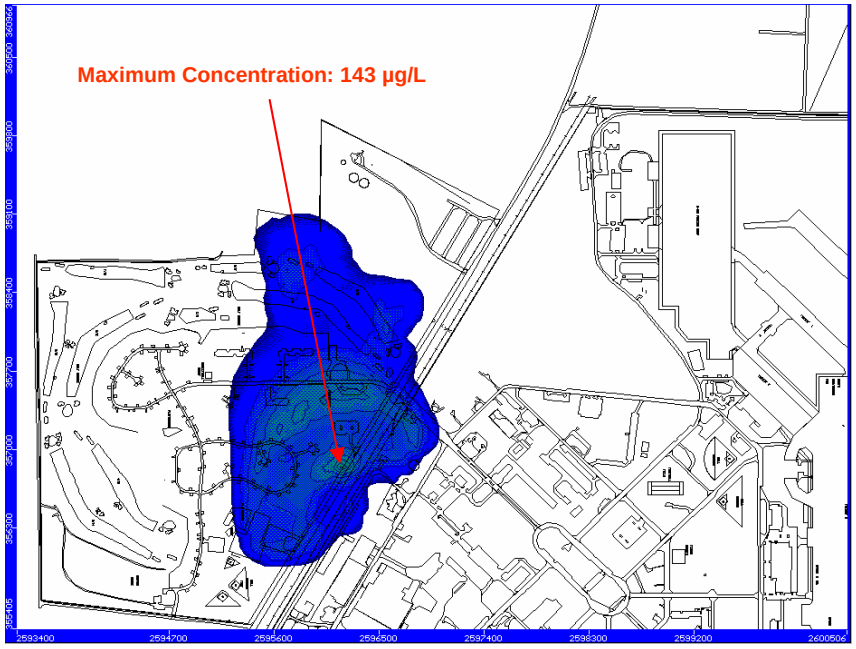
MNA

Initial TCE Mass: 448.2 kg
Current Mass: 407.4 kg
Percent Reduction: 9.1 %



Hot Spot Treatment with ISEB, BC and MNA/LTM

Initial TCE Mass: 448.2 kg
Current Mass: 181.8 kg
Percent Reduction: 59.5 %



Alternative 5 – Hot Spot Treatment with P&T, BC and MNA/LTM

Goal: Remediate hot spots so MNA can be used for final CAOs

Evaluated:

- 4, 6 and 8 well configurations (feasible well locations)
- Pumping rates 5 – 20 gpm

Optimized P&T hot spot treatment:

- Use existing extraction wells at hot spot 2
- Install extraction wells in hot spots 1 and 3
- Use existing treatment system for BC for hot spot 3
- Construct treatment system for hot spots 1 and 2
- Reduce hot spots >500 µg/l to <50 µg/l within 5 years
- MNA for final CAOs

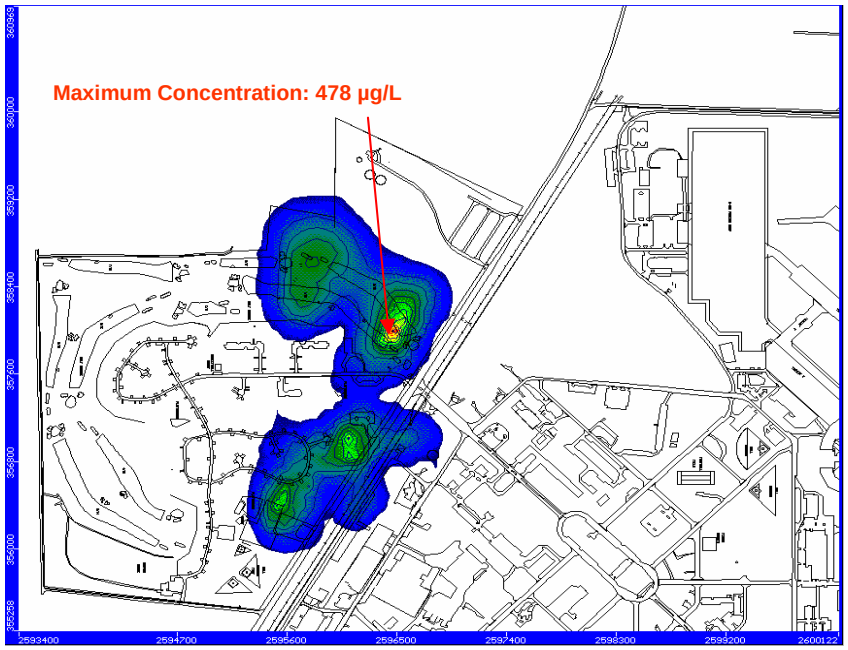
Alternative 5 - Simulated TCE Plume at 10 years

Layer 2 - Lower Intermediate Zone (46 - 60 feet bgs)

Hot Spot Treatment with P&T, BC and MNA/LTM

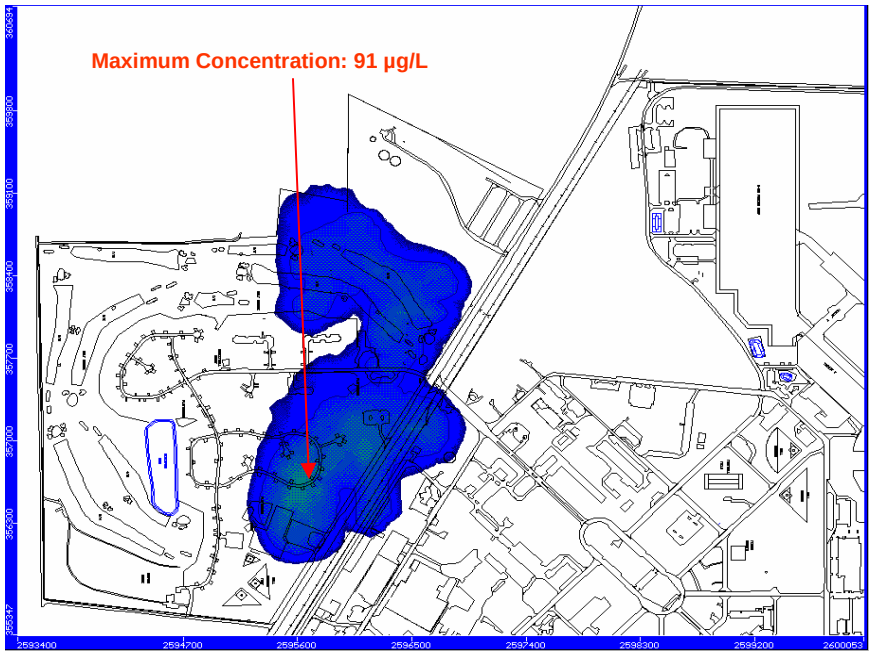
MNA

Initial TCE Mass: 448.2 kg
Current Mass: 407.4 kg
Percent Reduction: 9.1 %



Hot Spot Treatment with P&T, BC and MNA/LTM

Initial TCE Mass: 448.2 kg
Current Mass: 268.6 kg
Percent Reduction: 40.1 %



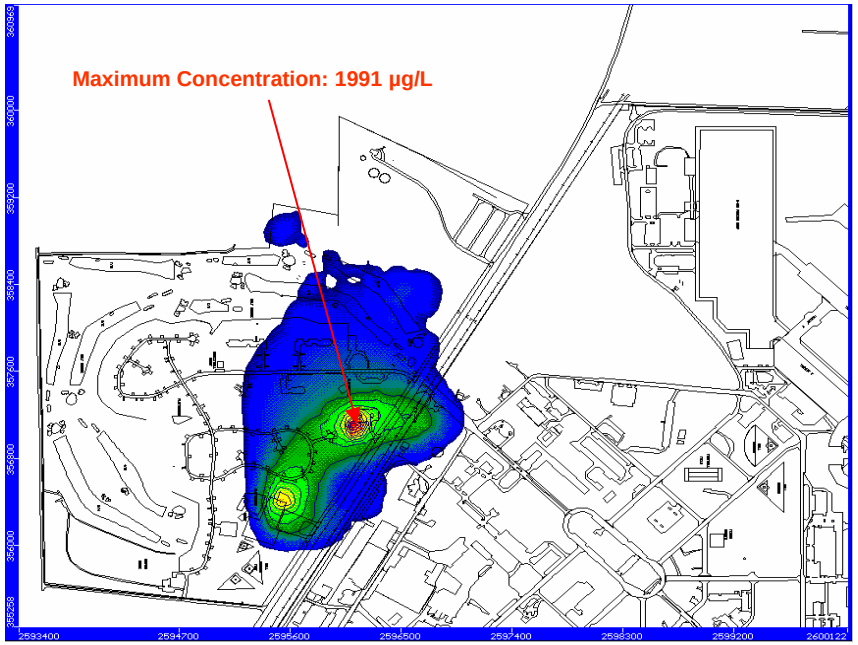
Alternative 5 - Simulated TCE Plume at 10 years

Layer 3 - Upper Deep Zone (61 - 80 feet bgs)

Hot Spot Treatment with P&T, BC and MNA/LTM

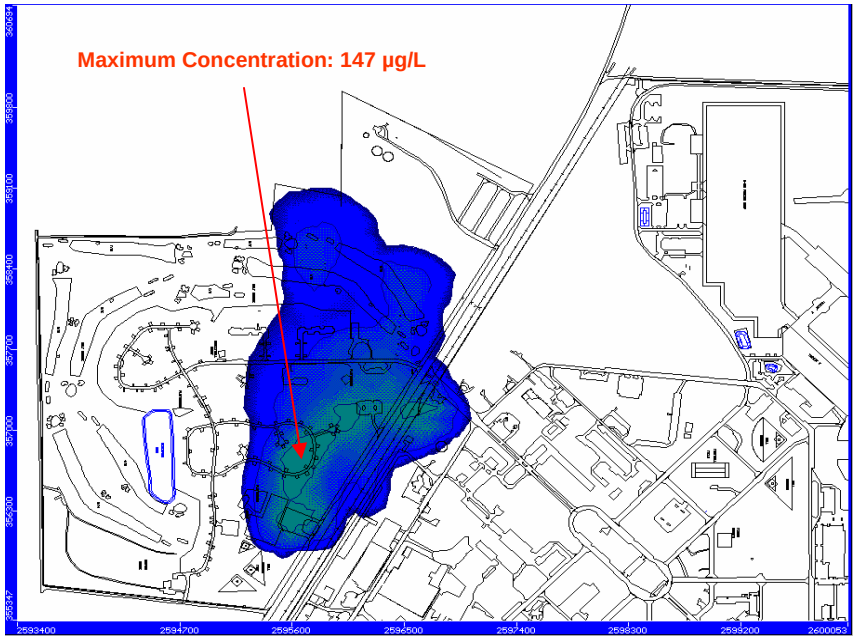
MNA

Initial TCE Mass: 448.2 kg
Current Mass: 407.4 kg
Percent Reduction: 9.1 %



Hot Spot Treatment with P&T, BC and MNA/LTM

Initial TCE Mass: 448.2 kg
Current Mass: 268.6 kg
Percent Reduction: 40.1 %



Alternative 6 – Hot Spot Treatment with ISEB and P&T, BC and MNA/LTM

Goal: Remediate hot spots so MNA can be used for final CAOs

Incorporated best of Alternatives:

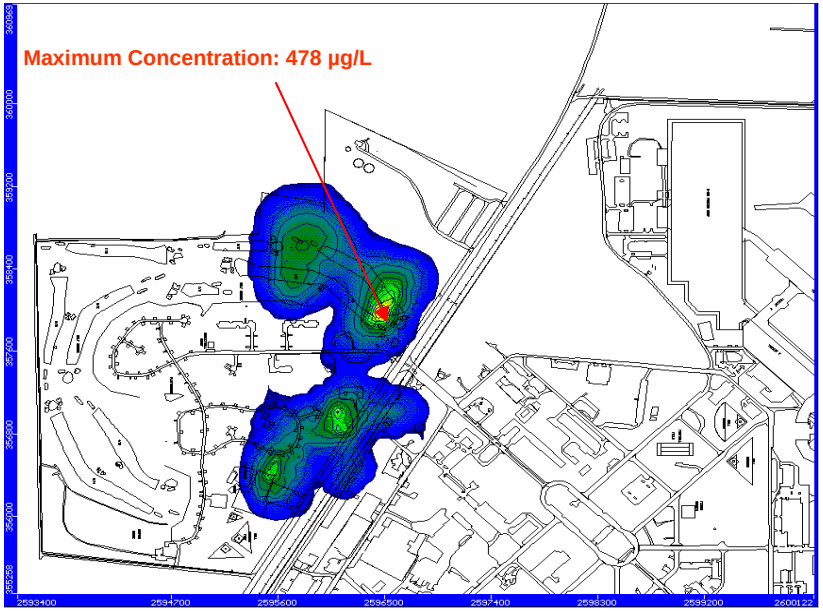
- BC per Alternative 3
- ISEB per Alternative 4 for hot spots 1 and 2
- P&T per Alternative 5 for hot spot 3
- BC for 10 years
- Hot spot treatment for 5 years for one order of magnitude reduction
- MNA for final CAOs

Alternative 6 - Simulated TCE Plume at 10 years

Layer 2 - Lower Intermediate Zone (46 - 60 feet bgs)
Hot Spot Treatment with ISEB and P&T, BC and MNA/LTM

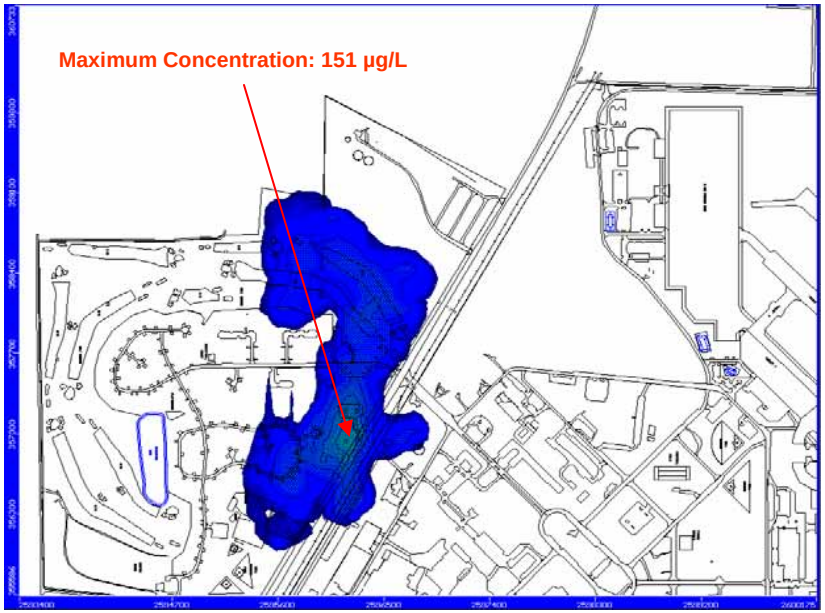
MNA

Initial TCE Mass: 448.2 kg
Current Mass: 407.4 kg
Percent Reduction: 9.1 %



Hot Spot Treatment with ISEB for Hot Spots 1 and 2 and P&T for Hot Spot 3, BC and MNA/LTM

Initial TCE Mass: 448.2 kg
Current Mass: 155.8 kg
Percent Reduction: 65.3 %



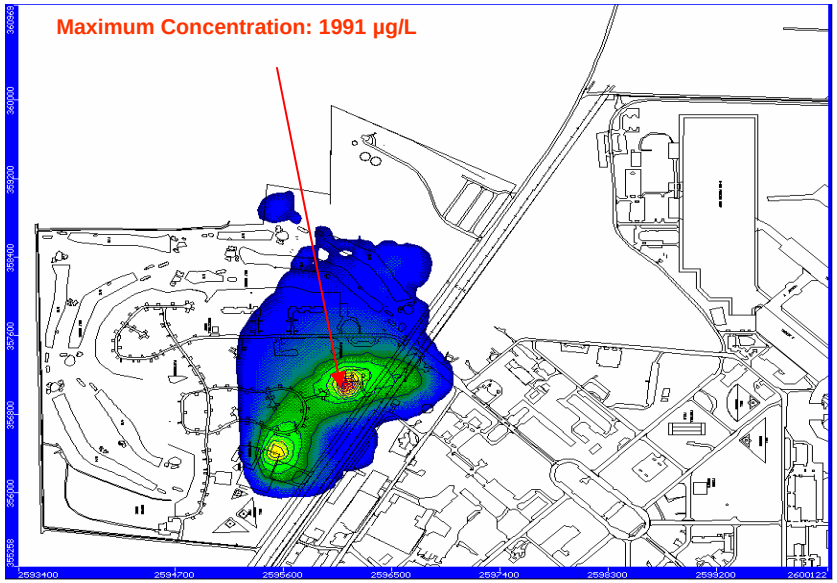
Alternative 6 - Simulated TCE Plume at 10 years

Layer 3 - Upper Deep Zone (61 - 80 feet bgs)

Hot Spot Treatment with ISEB and P&T, BC and MNA/LTM

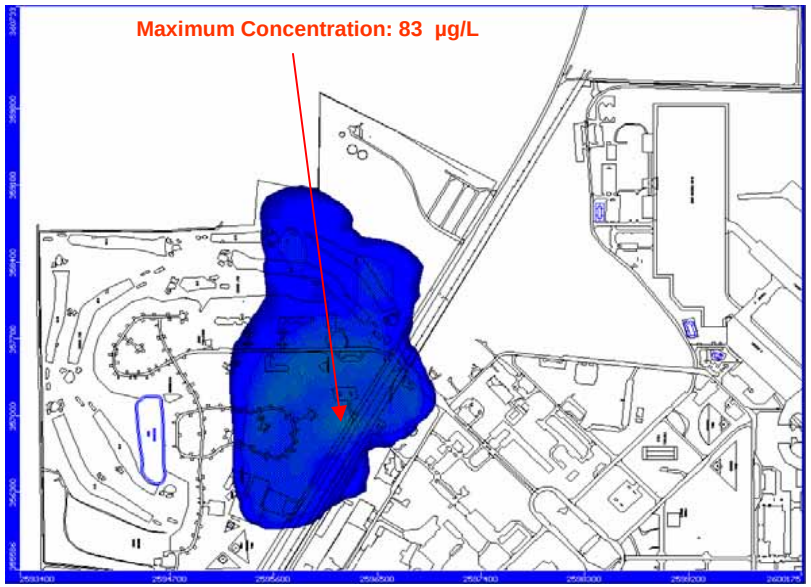
MNA

Initial TCE Mass: 448.2 kg
Current Mass: 407.4 kg
Percent Reduction: 9.1 %



Hot Spot Treatment with ISEB for Hot Spots 1 and 2 and P&T for Hot Spot 3, BC and MNA/LTM

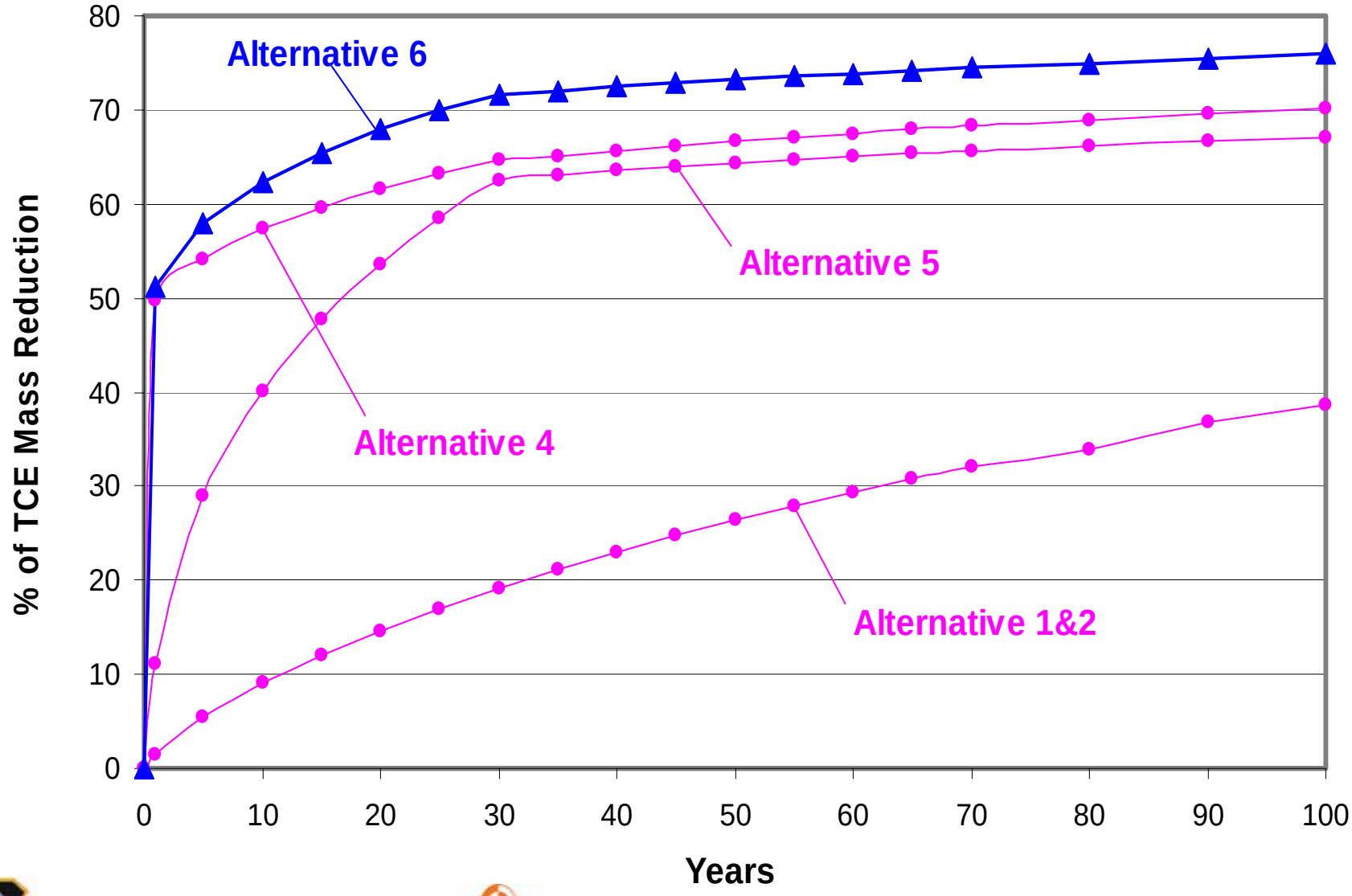
Initial TCE Mass: 448.2 kg
Current Mass: 155.8 kg
Percent Reduction: 65.3 %



Considerations

- None of the alternatives will achieve CAOs in less than 100 years
- Active clean up of the plume to MCLs not practical
- No current or continuing source of contamination is present
- IM and 2 pilot studies currently being conducted
- Plume is near natural equilibrium (steady state) with limited off site impact

Percent Mass Reduction of TCE for Alternatives



Conclusions

- Proposed CA is Alternative 6
- Active remediation to remove contaminant mass in hot spots to preliminary CAOs followed by MNA to achieve final CAOs
- Understanding that CAOs will not be met within 100 years
- Use of Groundwater modeling allowed upfront optimization of alternatives
- Proposed alternative is a hybrid that:
  - > Uses the best of several remedial alternatives
  - > Takes advantage of actions that have already taken place
  - > Works with site constraints
- Approach accepted by GA EPD at other sites at MAFB