Evaluating Remediation Completeness and Effects on Site Management Using CLOSES[SM]

~ presenter ~

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Acknowledgments

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Today's Discussion

- Case study of source area remediation progress data
- Demonstrate a weight-of-evidence approach using site monitoring data and screening-level models to assess remediation completeness

Summary of the CLOSES℠ Process

- CLOSES℠ – *Cleanup Operations and Site Exit Strategy*
- An approach for evaluating remedial processes at contaminant source areas
- A “tool box” of screening-level models and statistical evaluations
- Provides a basis for deciding when to turn systems off

Remediation Process Tools – TTCU Models

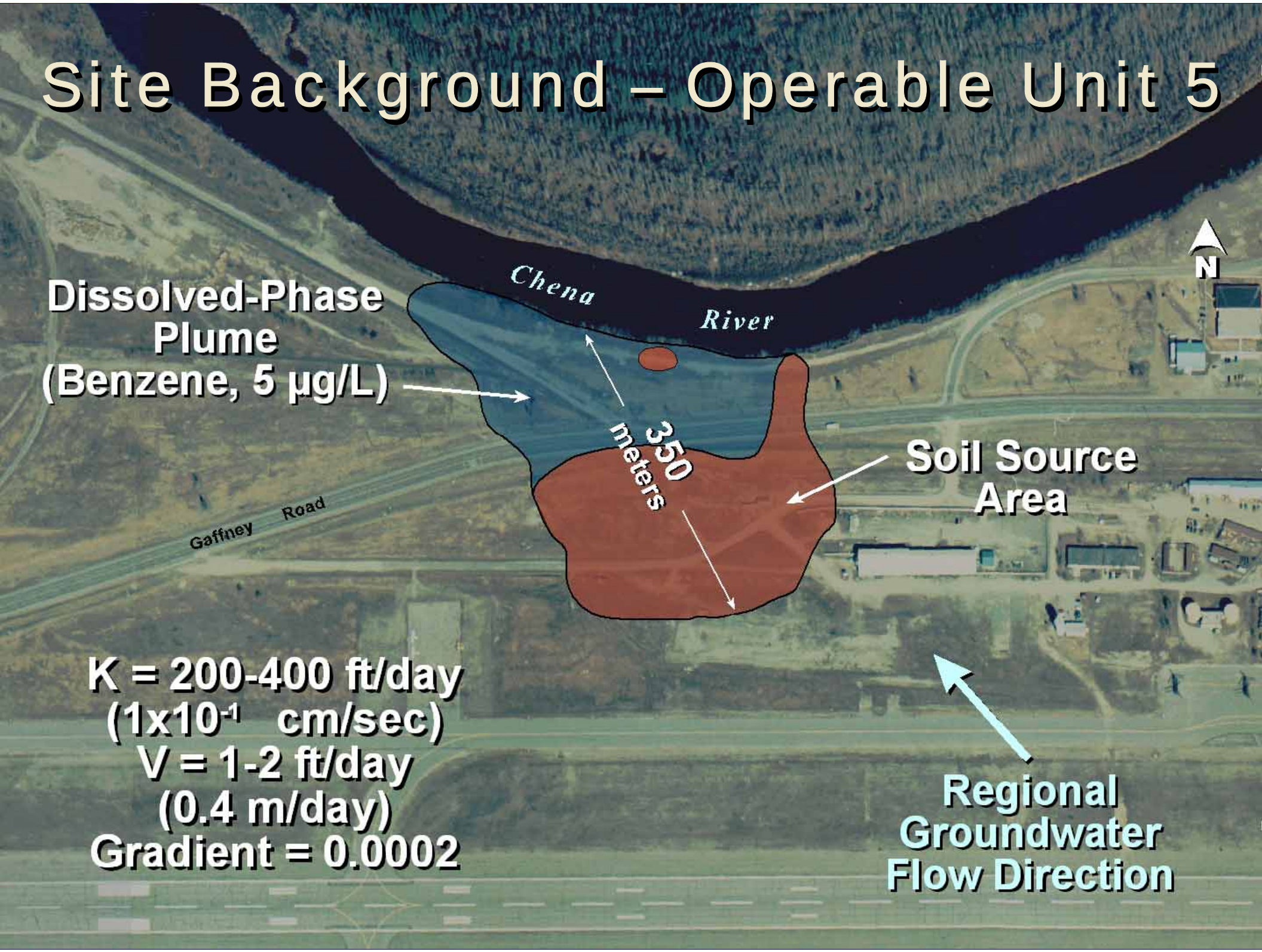
- Screening level tools that predict the effects of treatment in contaminant source areas
- Phase-partitioning calculations for hydrocarbon mixtures
- Predict changes in groundwater and soil contamination concentrations in response to treatment

TTCU = Time to Clean Up

Site Monitoring Tools

- Mann-Kendall trend analysis
- Cost-Effective Sampling (CES)
- Provide information used to improve monitoring program (monitoring frequency and location)

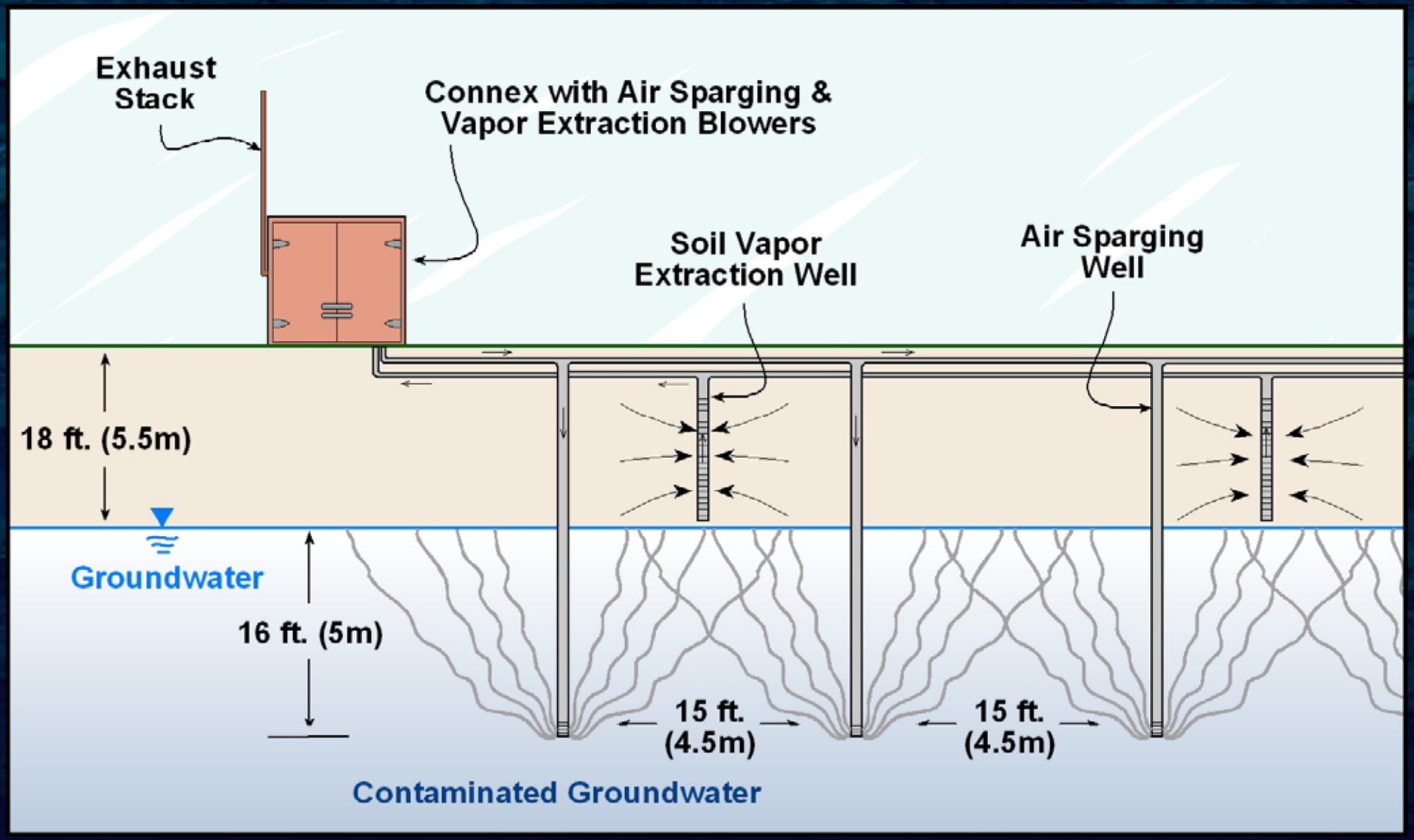
Site Background – Operable Unit 5



Summary of Treatment and Remediation Goals at OU5

- Remedial objective – protect the Chena River from influx of contaminants of concern
- Remedial approach – active treatment and natural attenuation
- Remediation goals
  - Benzene – 5 μg/L • Toluene – 1,000 μg/L • GRO – 1,300 μg/L
- Treatment of groundwater and soil by AS/SVE (386 AS and 70 SVE wells)

Air Sparging & Vapor Extraction



Expected Treatment Results

- Active treatment to remove volatile organic hydrocarbons
- Low volatility hydrocarbons not removed
- Significant residual hydrocarbon following active treatment

Comparison of Expected and Actual Remediation Costs

Cost Item	ROD Estimate (2002 $$)	Costs Updated for IRAR (2002 $$)
Capital cost	5,282,168	3,978,126
Annual operating cost	6,700,425	10,738,500
Total cost	11,982,593	14,716,626

IRAR = interim remedial action report

Monitoring Data Evaluations

- Source Area – 619 soil samples from 169 borings – pre-treatment
- NAPL – 4 samples pre-treatment and 4 after one year of treatment
- Soil – 3 rounds of 16 comparative borings
- Vapor – 134 offgas samples during treatment
- Groundwater – 295 samples from 64 wells

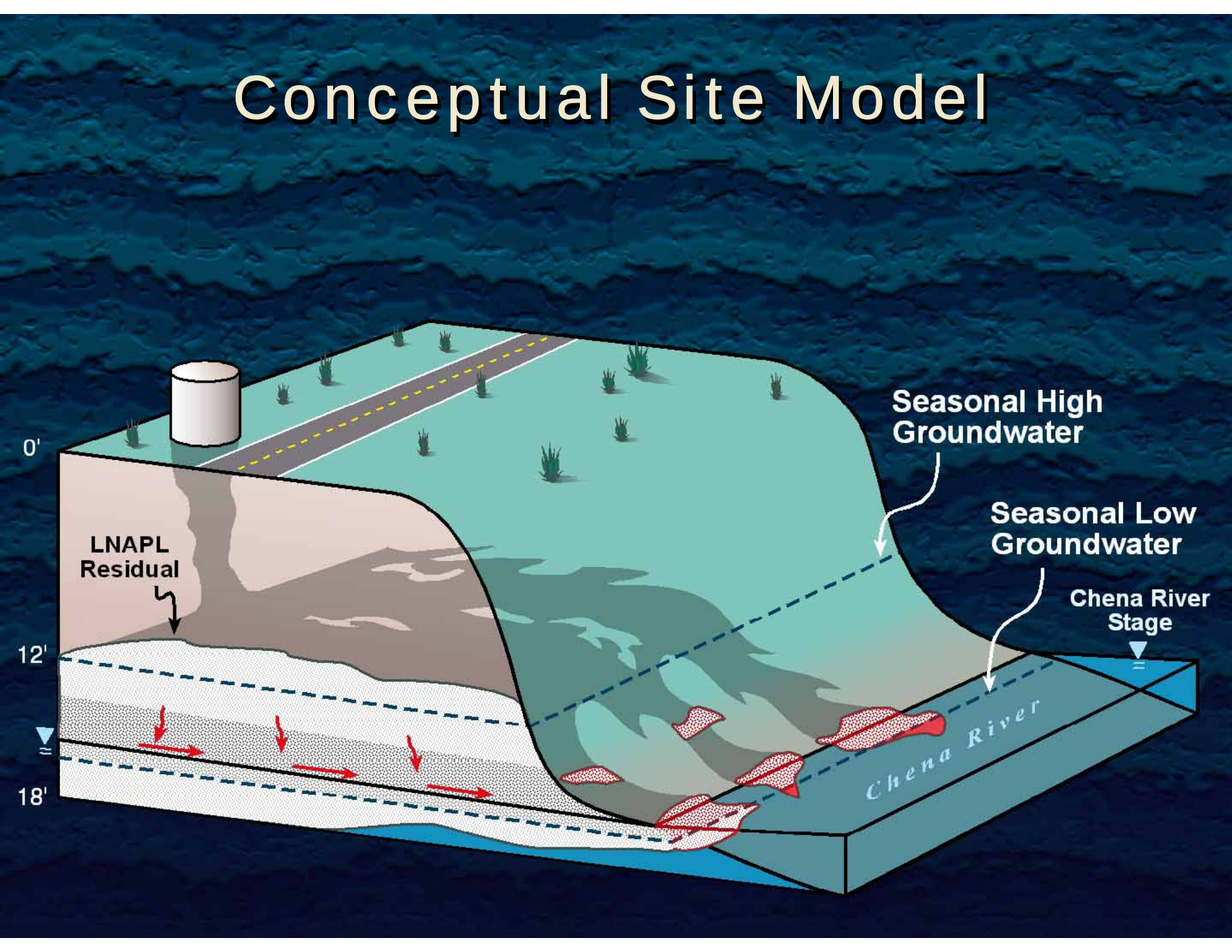
Media-Specific Evaluations

- Source Area
- NAPL
- Vapor
- Soil
- Groundwater

Source Area Assessment

- Estimation of areal extent of source area
- Calculation of contaminant mass present in source area
- 619 soil samples from 169 borings
- 295 water samples from 64 wells (over 10 years of sampling)
- Development of conceptual site model

Conceptual Site Model



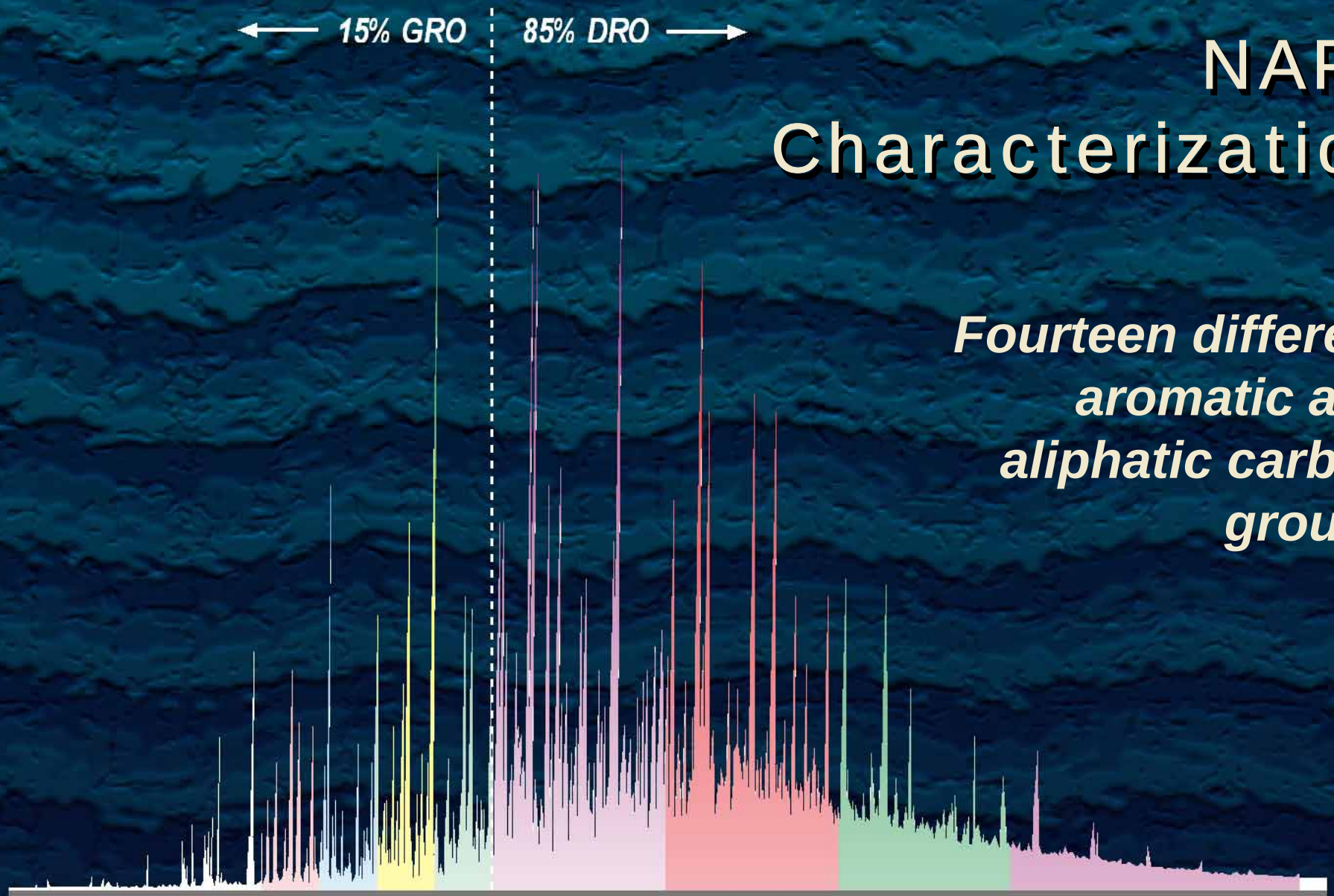
Source Area Assessment Results

- Extent of soil source area – 3.2 hectares (8 acres)
- Volume of contaminated soil – 100,000 m^3 (130,000 yds^3)
- Mass of total petroleum hydrocarbons – 900,000 kg (2,000,000 pounds)

NAPL Assessment

- Characterization of pre-treatment NAPL
- Changes in NAPL chemistry because of treatment

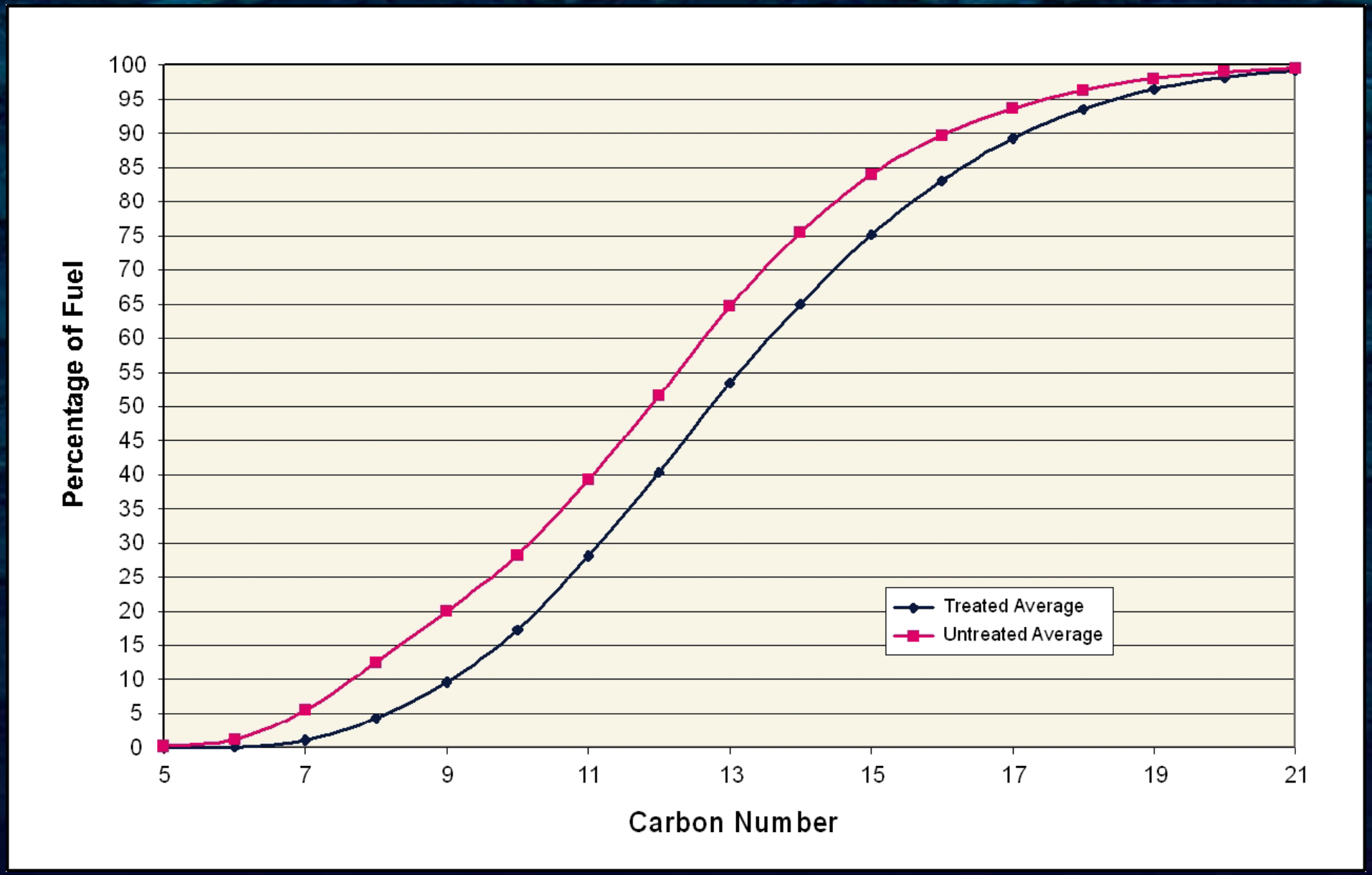
NAPL Characterization



Fourteen different aromatic and aliphatic carbon groups

	C5	C7	C8	C9	C10	C13	C16	C19	C24
Aromatics 18% in product	0.01% B	0.08% T	0.45% E&X	1.6% C9-C10	6.0% C10 - C13	6.5% C13 - C16	2.69% C16 - C19	0.0% C19 - C24	
Aliphatics 82% in product	C5 - C7 0.66%	C7 - C10 12.5%			C10 - C13 25.5%	C13 - C16 27.2%	C16 - C19 11.9%	C19 - C24 3.8%	

NAPL Changes Due to Treatment



NAPL Assessment Results

- Treatment of source has reduced volatile portion of NAPL
- Product is no longer detected in wells
- Both of these trends show that treatment systems are operating as expected

Soil Assessment

- Trends in soil concentrations due to treatment
- Reductions in vadose and saturated zones

Soil Assessment

Changes in Average Soil Concentrations Over Time of Treatment (mg/kg)

	GRO	BTEX	DRO
Pre-Treatment	1,800	250	6,900
3 Years Treatment	100	<4	3,000

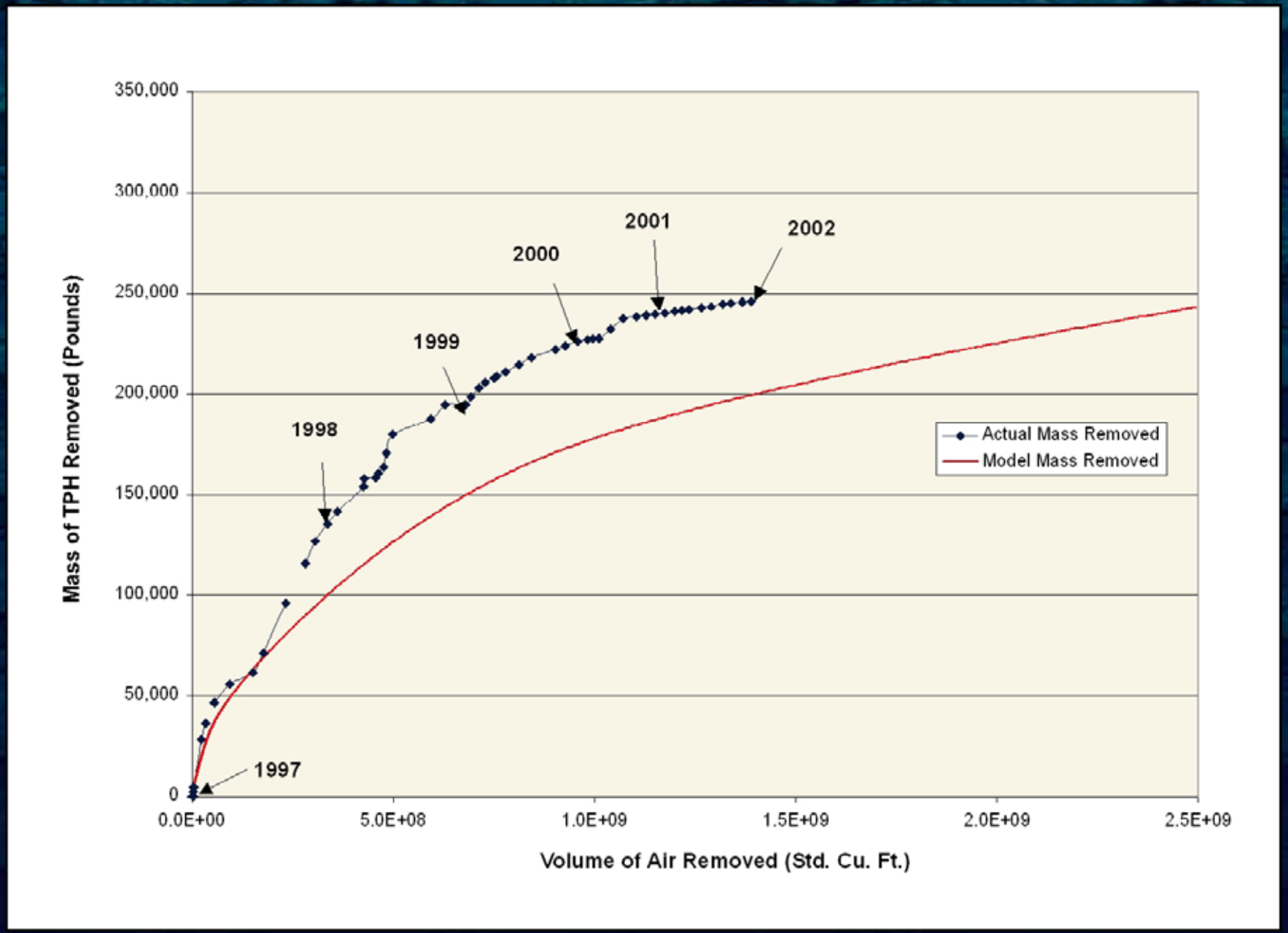
Soil Assessment Results

- Trends from 16 comparative borings show GRO and VOCs reduced >95%
- DRO reduced by >65%
- Reductions in both vadose and smear zones

Vapor Assessment

- Remedial progress based on contaminant removal
- Comparison of actual versus predicted mass removal concentrations

Vapor Assessment

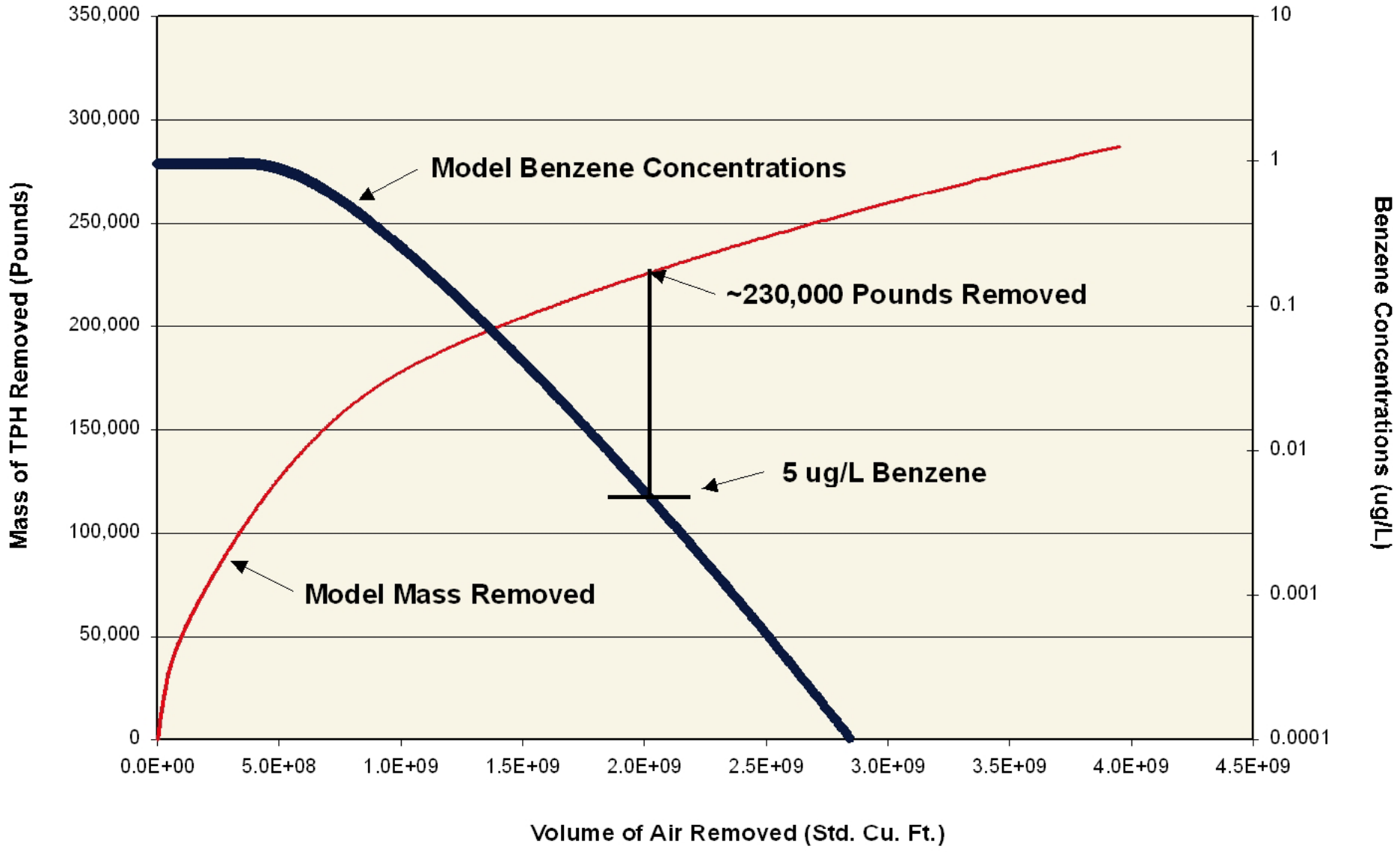


Vapor Assessment

Mass of TPH to Remove to Prevent Benzene Migration to Groundwater

	TPH Mass (lbs)	Soil Concentration (mg/kg)
Starting Mass	2,000,000	9,400
Treatment Required	320,000	1,500
Remaining Mass	1,680,000	7,900

Benzene Vadose Concentrations Vs. Mass Removed



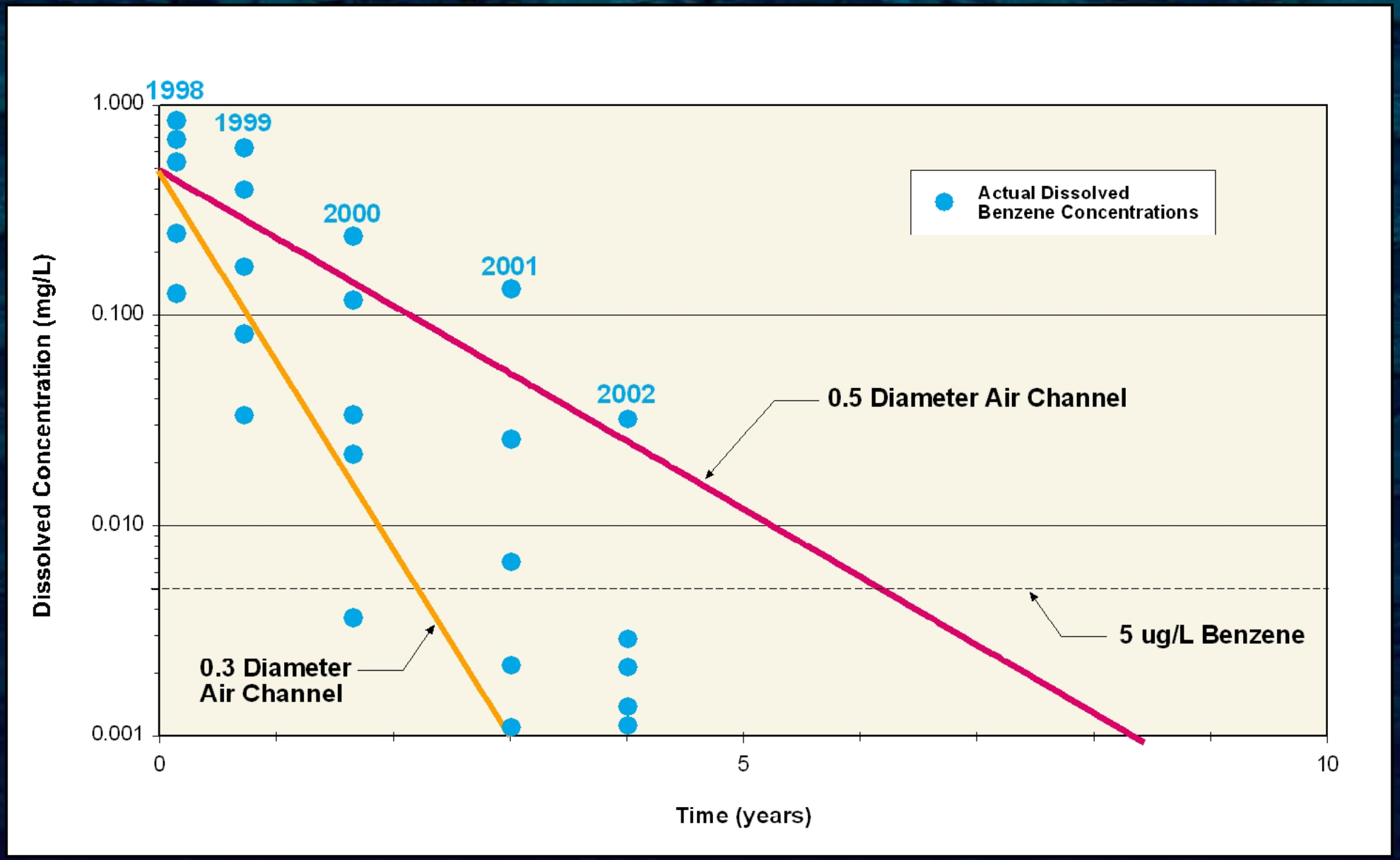
Vapor Assessment Results

- 200,000 kg (450,000 pounds) of TPH removed from the source area
- Mass removed greater than predicted to be protective of groundwater
- Actual mass removed is similar to model prediction

Groundwater Assessment

- Trends in groundwater concentrations due to treatment
- Comparison of actual versus predicted groundwater concentrations due to treatment

Benzene Concentrations

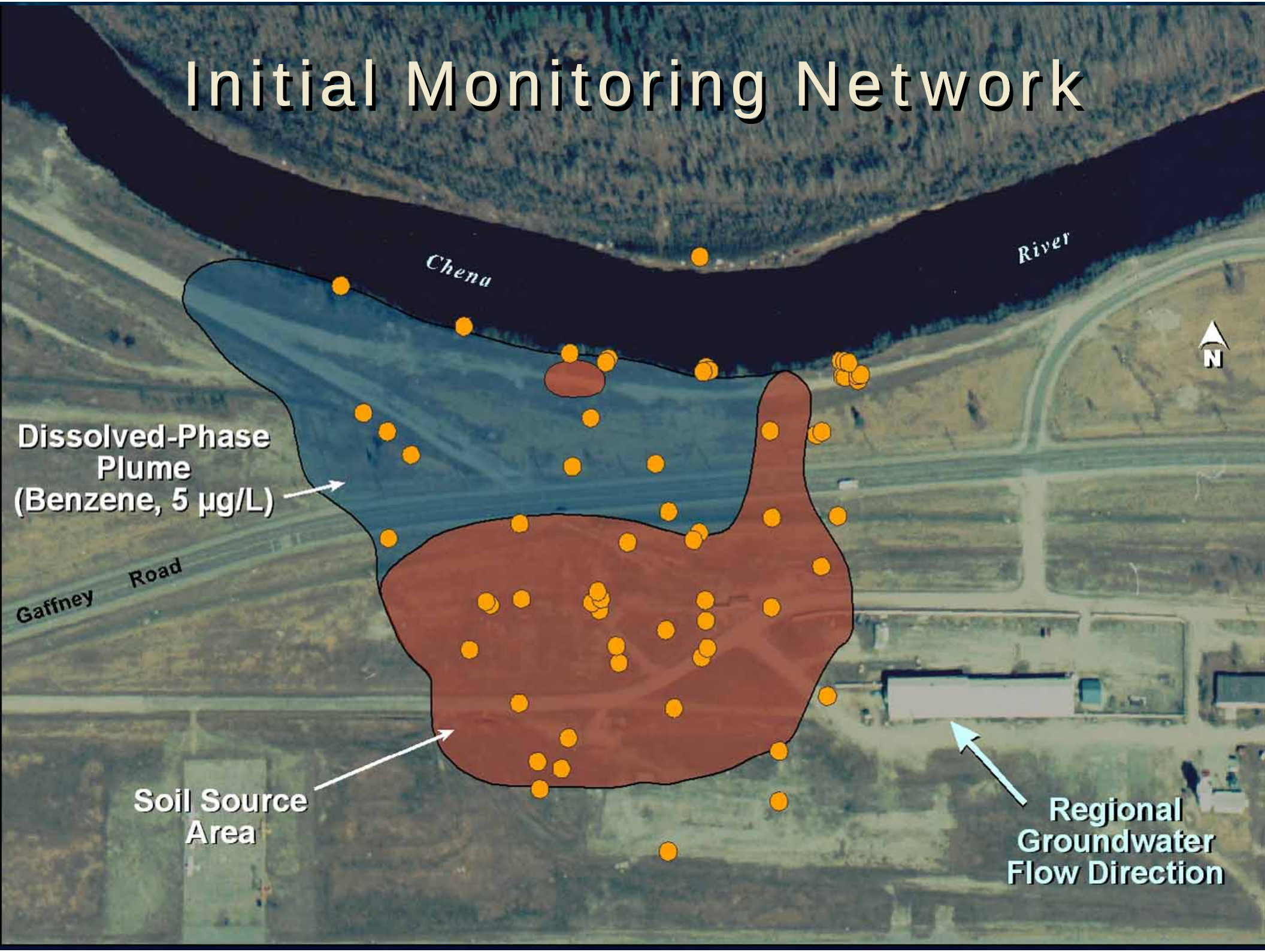


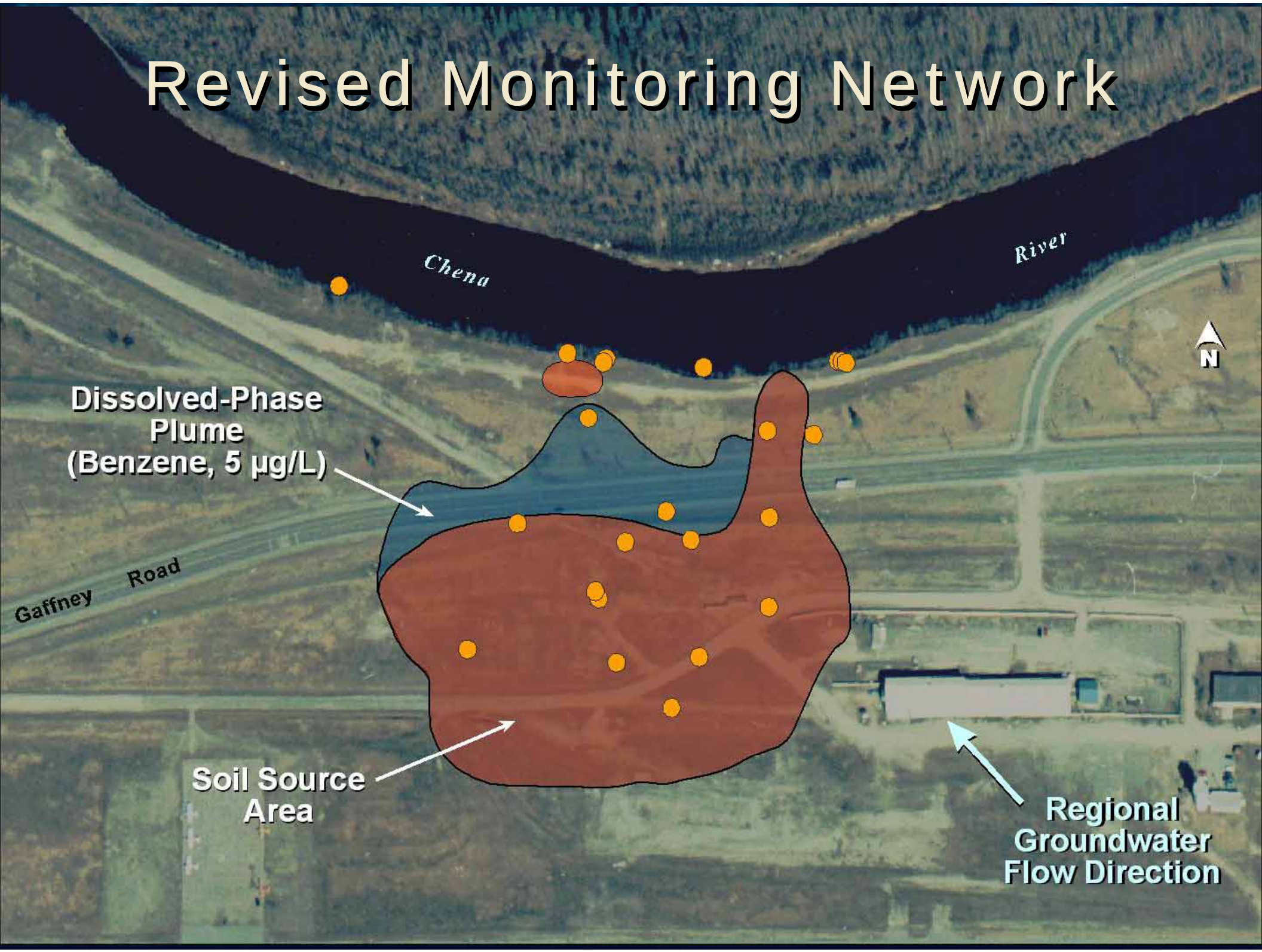
Groundwater Assessment Results

- Benzene concentrations in source areas and downgradient decreased by >95%
- Wells treated for >3 years are below cleanup levels
- Actual groundwater concentrations are similar to model predictions

System Monitoring Assessment

- Frequency and spatial orientation of groundwater and soil sampling
- Trends in both groundwater and soil concentrations


Initial Monitoring Network
Chena
River
N
Dissolved-Phase
Plume
(Benzene, 5 µg/L)
Gaffney
Road
Soil Source
Area
Regional
Groundwater
Flow Direction


Revised Monitoring Network
Chena
River
N
Dissolved-Phase
Plume
(Benzene, 5 µg/L)
Gaffney
Road
Soil Source
Area
Regional
Groundwater
Flow Direction

System Monitoring Results

- Discontinued comparative soil sampling –- $45,000/year
- Reduced groundwater sampling program by more than 40% – $120,000/year

System Operation Assessment

- Use of results from soil, NAPL, vapor, and groundwater to make system changes
- Use of both field data and supporting model data

System Operation Assessment

- Results from soil and vapor assessment show that SVE treatment is complete after 3 years
- Results from groundwater assessment show that AS treatment is still needed

System Operation Results

- Shut down SVE wells that have operated for 3 years – $170,000/year
- Shut down subarea WQFS3 AS/SVE system – $250,000/year
- Continue AS treatment

Summary Cost Savings

Cost Item	2002 IRAR Revised Estimate (1998 $$)	2003 Revised Estimate (2002 $$)	Cost Savings (2002 $$)
Capital Cost	3,978,126	3,978,126	0
Annual Operating Cost	10,738,500	8,145,900	2,592,600
Total Cost	14,716,626	12,124,026	2,592,600

Summary

- CLOSES℠ provides a framework for evaluating site data and making site management decisions
- Consistency between monitoring data and screening models provides confidence that site remedial processes are reasonably well understood

Summary

- Implementing the CLOSES℠ process resulted in regulatory approval for reducing the operation and monitoring effort, and improving cost-effectiveness of the remediation effort