Modeling the Market for Long Term Monitoring

Accelerating Site Closeout, Improving Performance and Reducing Cost Through Optimization

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Outline

- Opportunities to optimize Long Term Monitoring (LTM) through better technologies
- Remedies requiring LTM in Superfund
- P&T and MNA, the lion's share of LTM
- Approach to modeling LTM demand in Superfund
- Preliminary results
- Conclusion and next steps

What is Long Term Monitoring?

- Routine, scheduled environmental and treatment system monitoring
- Occurs over multiple years (minimum 5 years used for this analysis)
- Includes collection and analysis
- Does not include well installation, or treatment system capital and O&M costs
- Limited to groundwater for this analysis
- Monitoring for which an innovative technology or approach may provide cost savings or better data

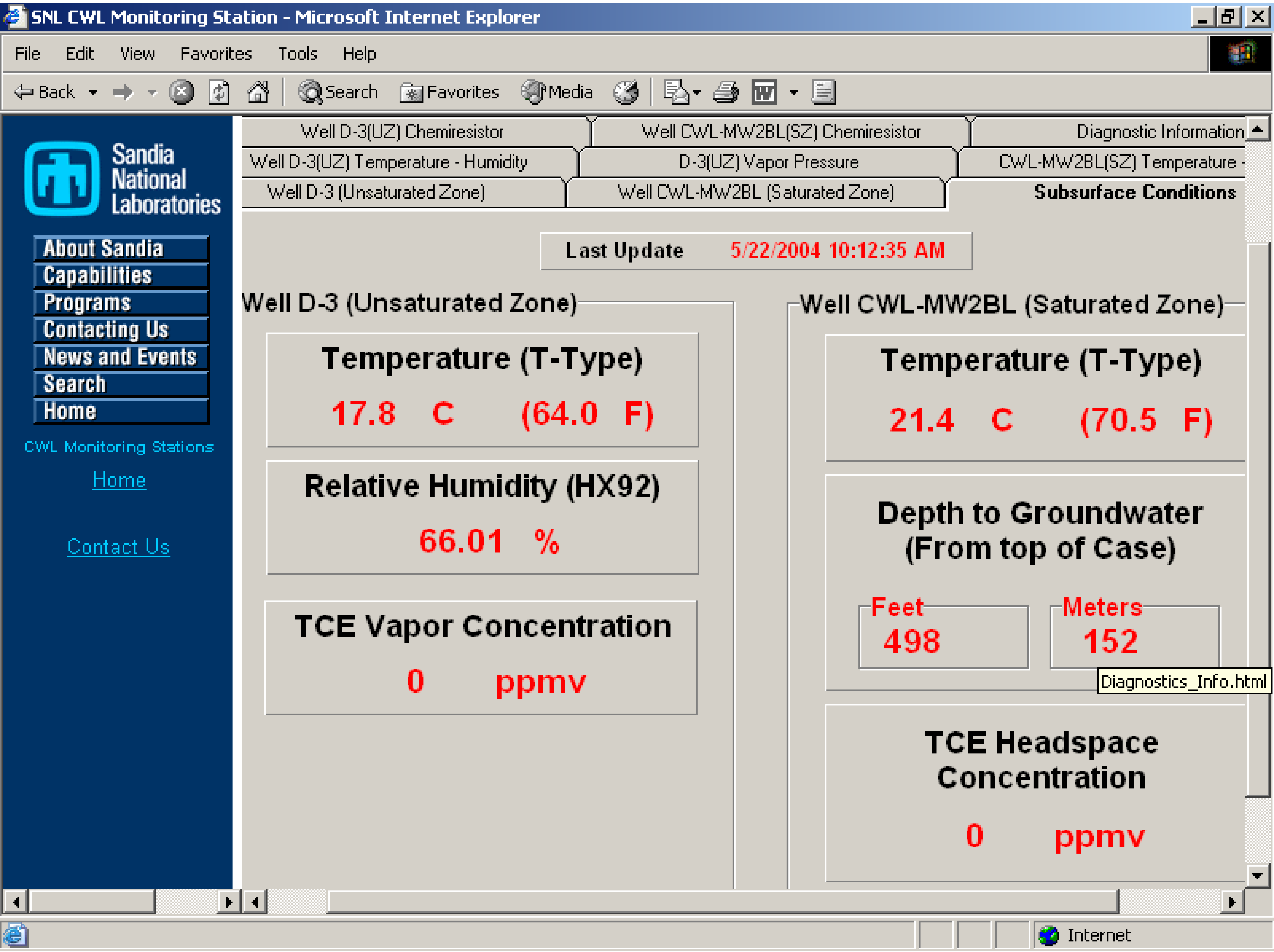
Opportunities to Optimize LTM Through Better Technologies

- **Better data for environmental control, system operation, and treatment monitoring**
- **Improved inputs for predictive modeling**
- **Reduction in labor costs**
- **Reduction in analytical costs**
- **Higher sampling frequency at lower cost**
- **Real time feedback loop for system optimization**
- **Shorter decision timeframes**

Emerging Technologies for LTM

Sensors – Reduce need for off-site analysis, provide real-time data

- Nanoscale sensors
  - Lab on a Chip
  - Fiber optic
  - Electrochemical
  - Optical
  - Surface acoustic wave
  - Programmable diffraction grating
  - Quartz crystal microbalances
- Biosensors
- Submersible Macro-scale Sensors
  - Colorimetric
  - Multi-pollutant sensors (classical pollutant parameters such as salinity, pH, chloride, nitrate)


SNL CWL Monitoring Station - Microsoft Internet Explorer
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Sandia National Laboratories
About Sandia
Capabilities
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CWL Monitoring Stations
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Well D-3(UZ) Chemiresistor
Well CWL-MW2BL(SZ) Chemiresistor
Diagnostic Information
Well D-3(UZ) Temperature - Humidity
D-3(UZ) Vapor Pressure
CWL-MW2BL(SZ) Temperature -
Well D-3 (Unsaturated Zone)
Well CWL-MW2BL (Saturated Zone)
Subsurface Conditions
Last Update 5/22/2004 10:12:35 AM
Well D-3 (Unsaturated Zone)
Temperature (T-Type)
17.8 C (64.0 F)
Relative Humidity (HX92)
66.01 %
TCE Vapor Concentration
0 ppmv
Well CWL-MW2BL (Saturated Zone)
Temperature (T-Type)
21.4 C (70.5 F)
Depth to Groundwater (From top of Case)
Feet 498
Meters 152
Diagnostics_Info.html
TCE Headspace Concentration
0 ppmv
Internet

Emerging Technologies for LTM

Other LTM Cost Reduction

- Samplers – reduce sampling labor
  - Passive Diffusion Bag Samplers
  - Micropurge wells
  - Bladder pumps
- Data Collection and Telemetry
  - Satellite-based remote telemetry
  - Dataloggers
- Data analysis – decision support tools
- Optimization – reductions in monitoring points, monitoring frequency, or analytes
  - Remedial System Evaluation
  - Capture zone analysis

Emerging Technologies for LTM

Technical Challenges Remaining

- Communication from sensor to user not available or reliable, particularly for below ground sensors
- Sensors not available for many contaminants
- Sensors not sufficiently robust for field use
- Data management tools not available
- Full benefit of real time data not attained without feedback loop for above ground system optimization

Superfund Remedies Requiring LTM

Remedy	Number of Projects*
Monitoring	763
Pump and Treat	743
On-site Containment	455
MNA	234
Soil Vapor Extraction	224
Bioremediation (in situ)	88
Air Sparging (in situ) - Groundwater	58
Vertical Engineered Barriers (VEB)	51
Solidification/Stabilization (in situ)	48
Dual-Phase Extraction	20
Passive Treatment Wall (Permeable Reactive Barrier)	17
Phytoremediation	9
In-Well Air Stripping	5
Vitrification	2
Total Projects (Some sites have more than one project)	**2717**

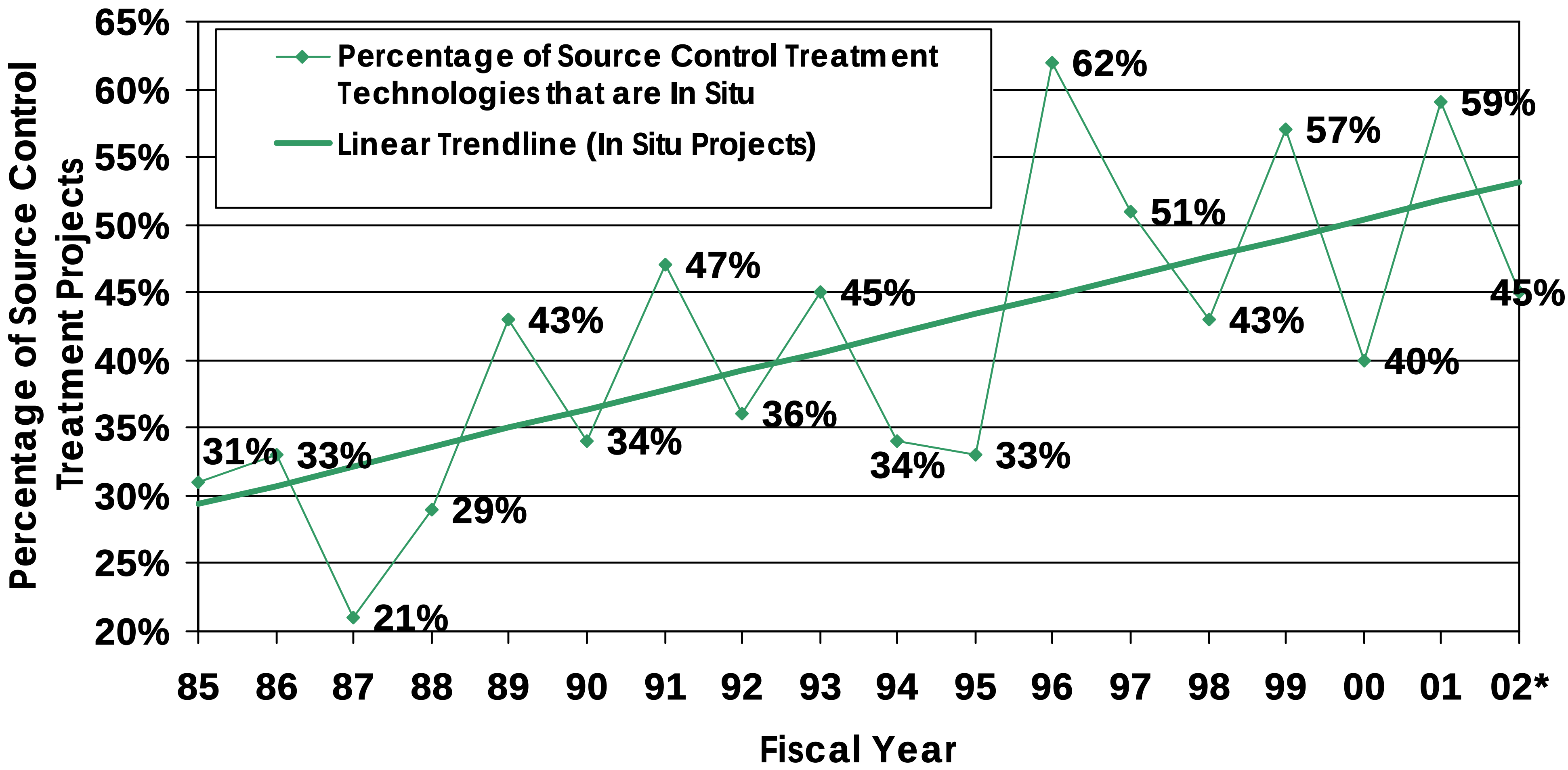
Superfund LTM Remedies

- **Types of Remedies with LTM**
  - P&T
  - MNA
  - Containment
  - Long-term In Situ Treatment
- **Monitoring intensity and frequency vary by remedy, site conditions, and goal**
  - More toxic contaminant or near a sensitive receptor - more frequent monitoring
  - Complex hydrogeology - more monitoring wells
  - Containment goal – fewer monitoring wells than restoration
- **Information more “readily” available for projects in Superfund**
- **Focus on GW – most common media subjected to LTM**

Superfund In Situ Remedies

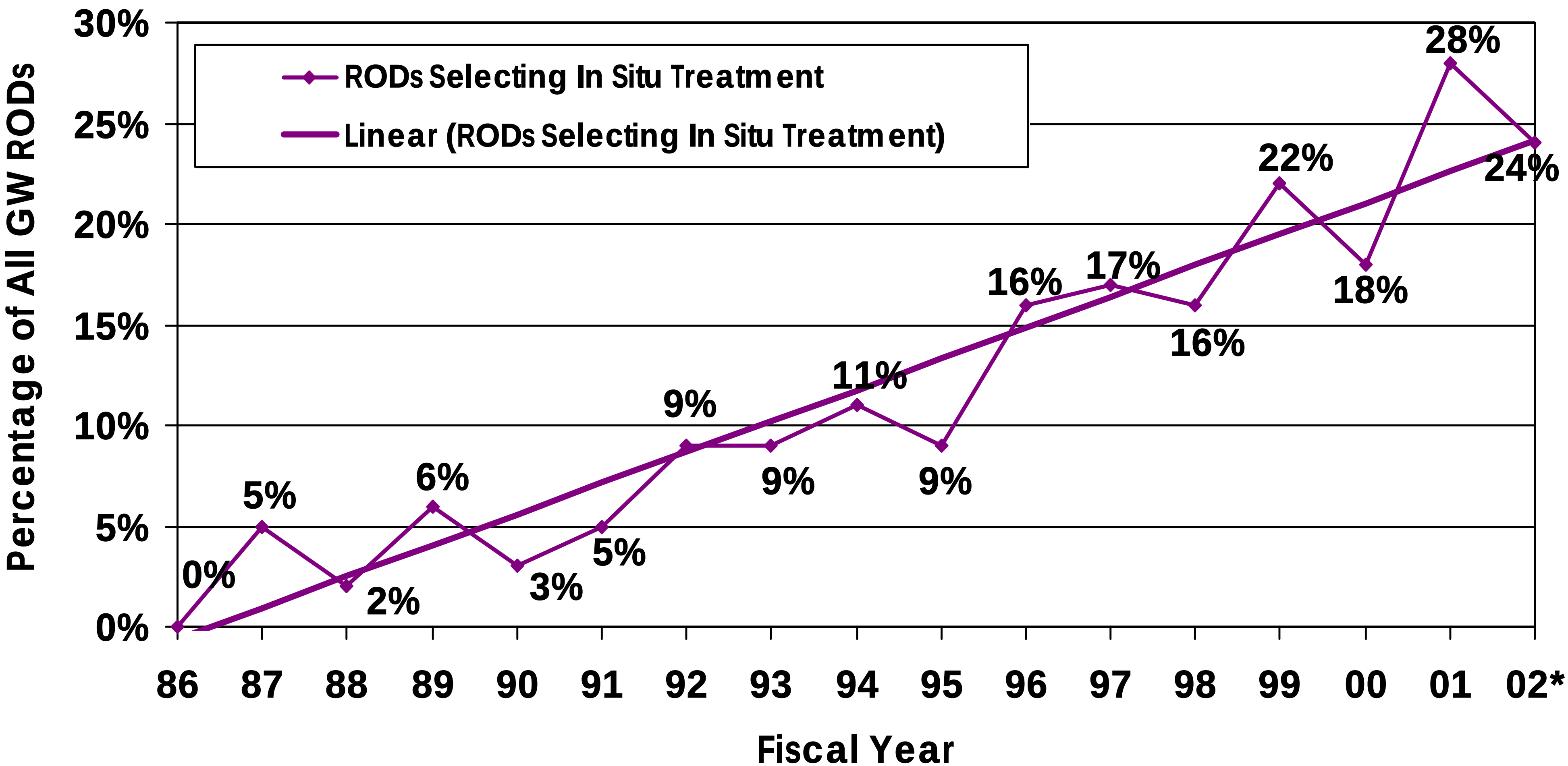
- Importance of monitoring physical, chemical, and biological processes below ground
- Generally longer operating periods than above ground
- Increasingly common in Superfund
- Often have above ground treatment units that might also benefit from real time feedback for operational optimization
- Indication of the monitoring equipment that will be needed (sensors, M2M, etc)

In Situ Technologies for Source Control (FY 1985 - 2002)*



* Includes information from an estimated 70% of FY 2002 RODs.

Trends in the Selection of In Situ Treatment for Groundwater (FY 1986 - 2002)*



* Includes information from an estimated 70% of FY 2002 RODs.

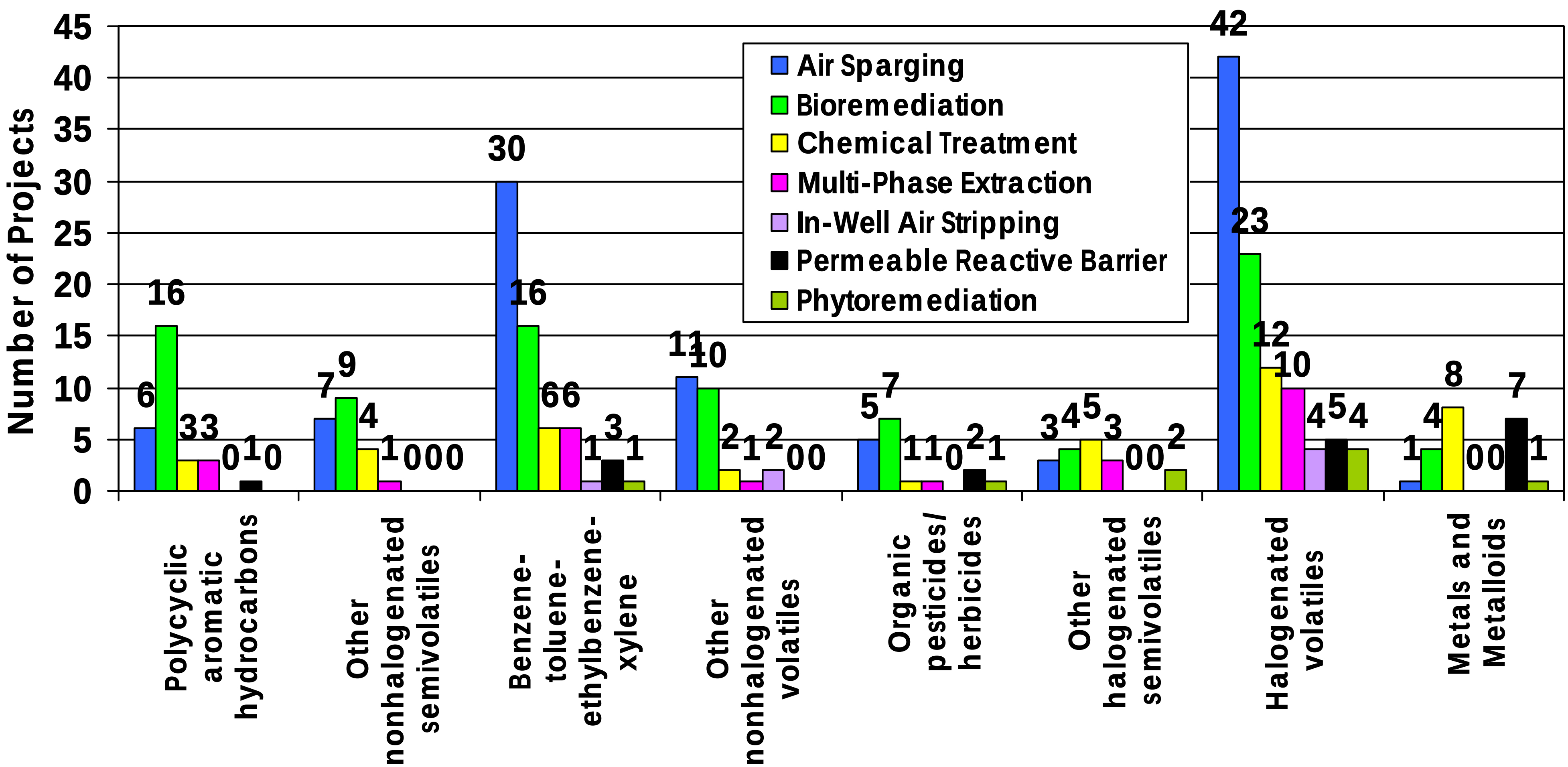
In Situ Groundwater Treatment Projects Selected in FY 2000, 2001, and 2002*

Total Projects = 66

Technology	*Number of New Projects*
Bioremediation	21
Chemical Treatment	15
Air Sparging	10
Permeable Reactive Barrier	7
Multi-Phase Extraction	4
In-Well Air Stripping	3
Phytoremediation	3
Flushing	2
In Situ Thermal Treatment	1

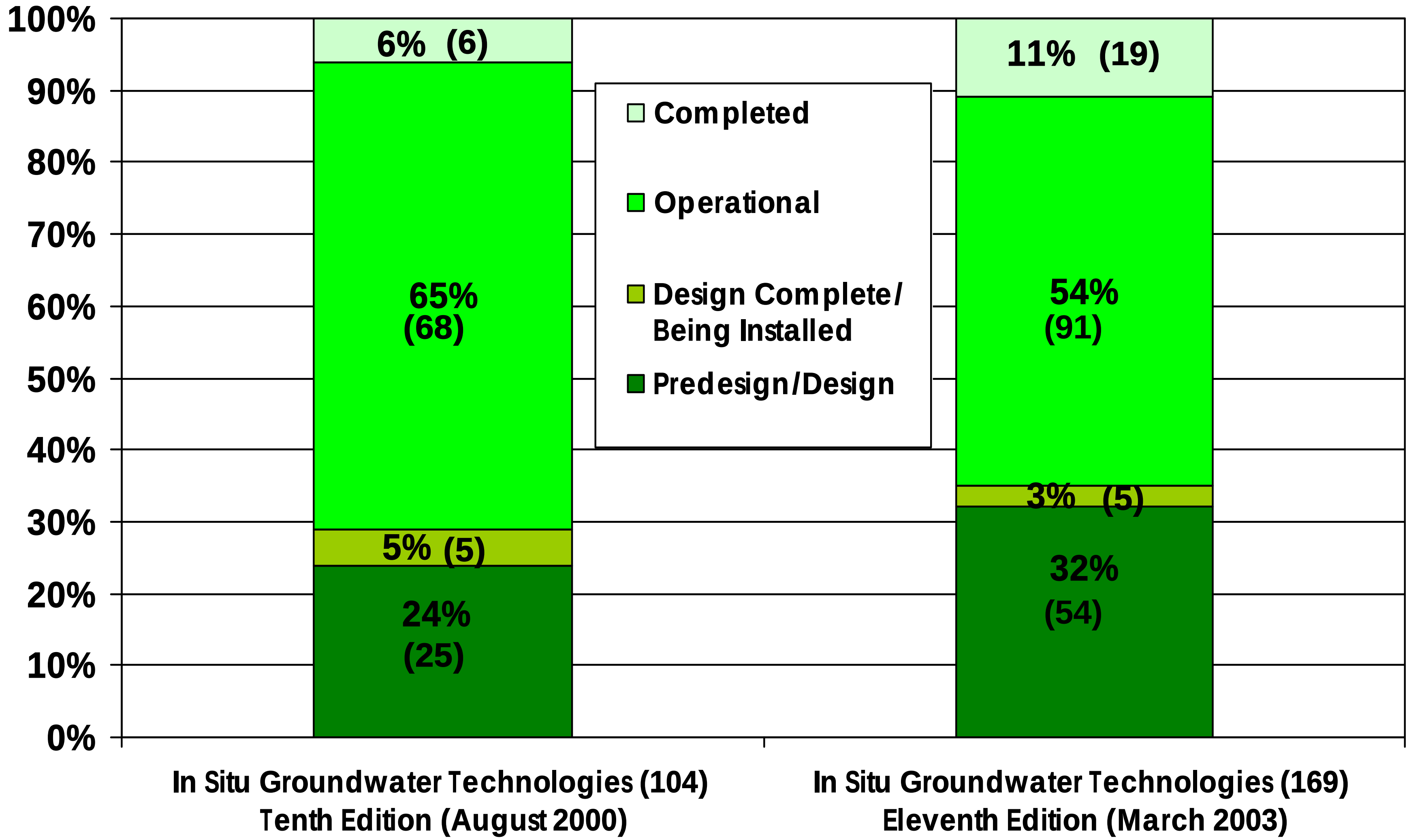
*Includes information from an estimated 70% of FY 2002 RODs.

Contaminants Treated by In Situ Groundwater Technologies (FY 1982 - 2002)*



* Includes information from an estimated 70% of FY 2002 RODs.
Other nonhalogenated semivolatiles do not include polycyclic aromatic hydrocarbons.
Other nonhalogenated volatiles do not include benzene, toluene, ethylbenzene, and xylene.
Other halogenated semivolatiles do not include organic pesticides and herbicides.

Status of In Situ Groundwater Treatment Projects (FY 1982 - 2002)*

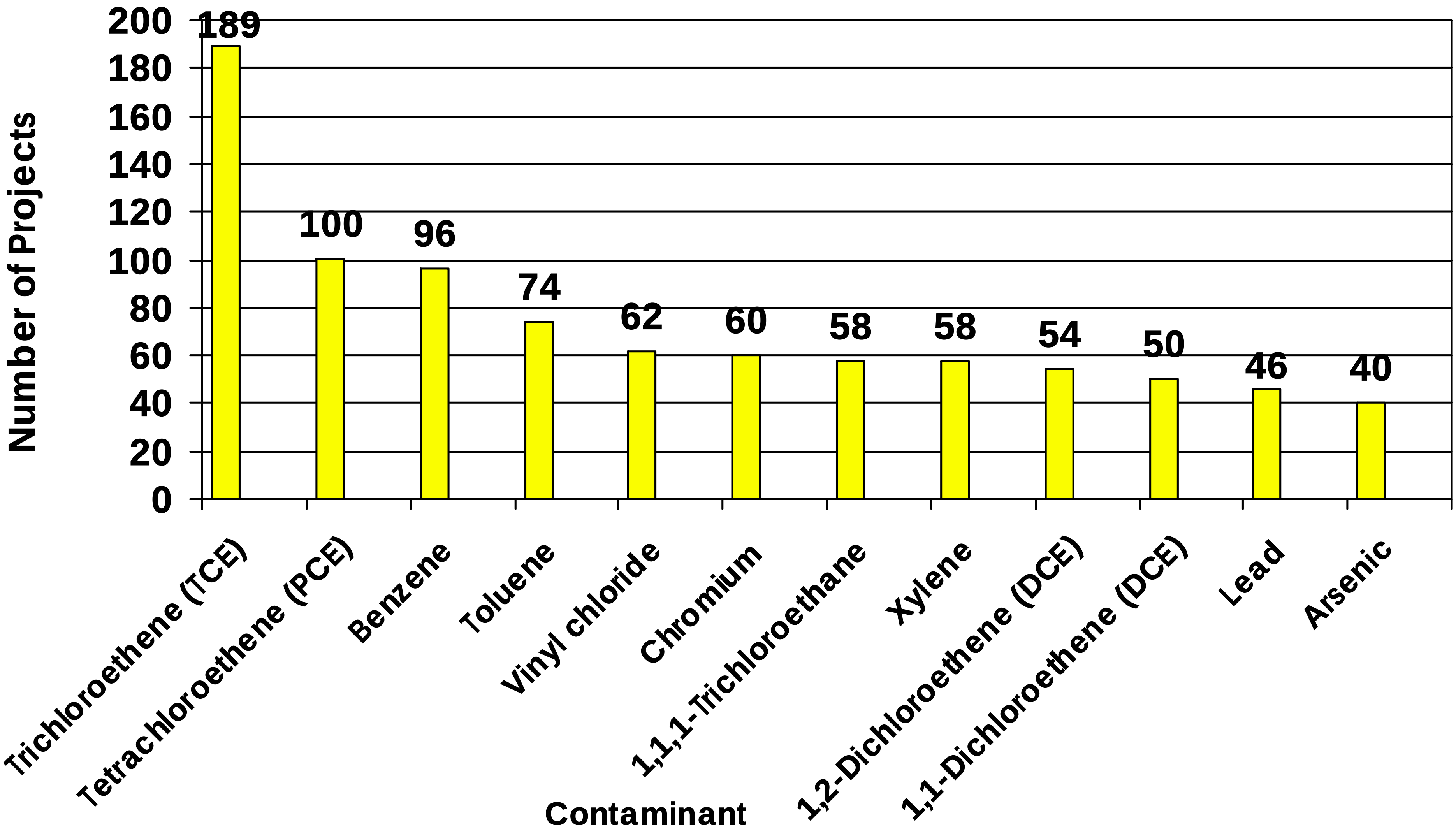


*Includes information from an estimated 70% of FY 2002 RODs.

Superfund P&T LTM

- The model used in presentation was based on a known population of ongoing pump and treat projects.
- Information discussed in the following slides was obtained from these projects:
  - Contaminants
  - Above ground technologies
  - Status

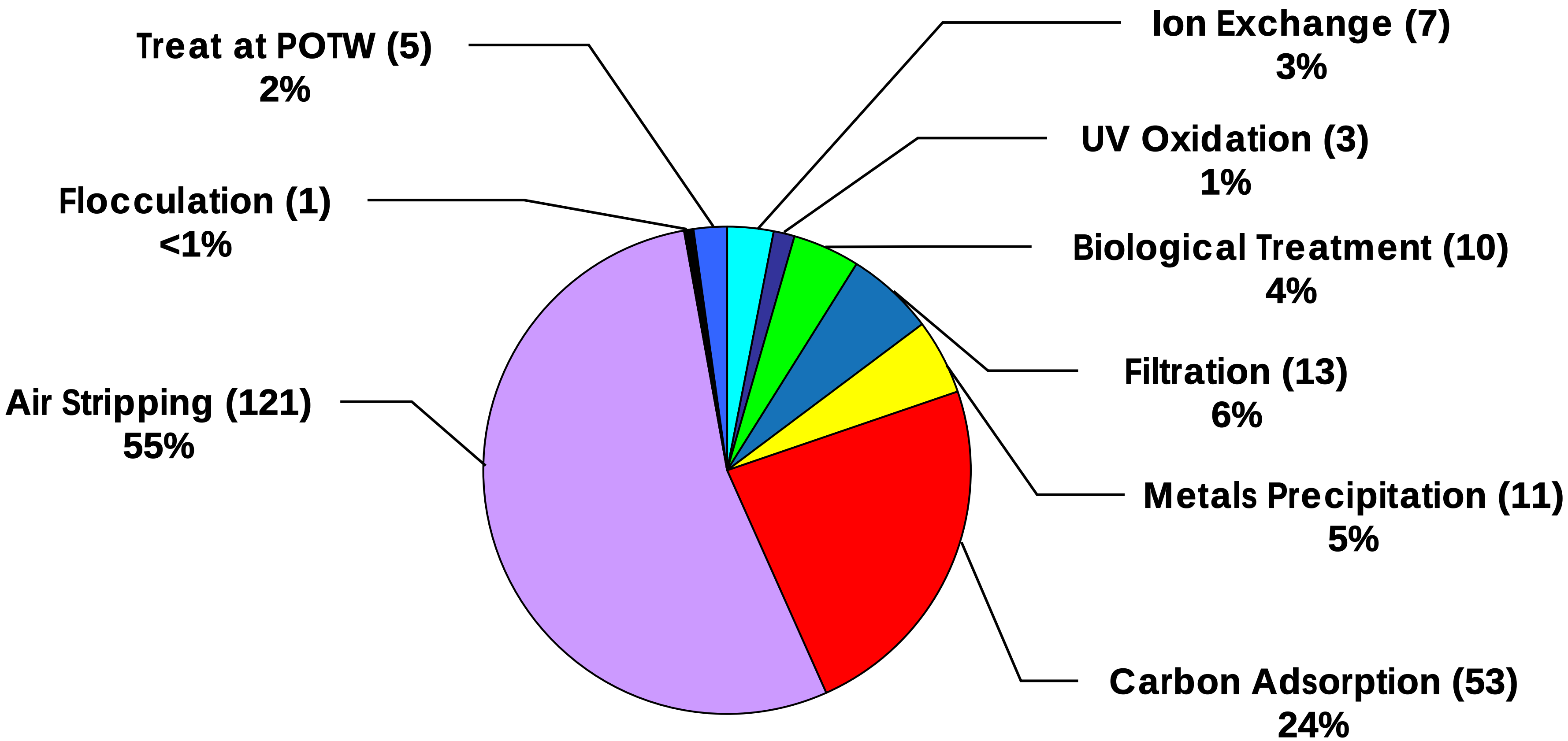
Contaminants Treated by Pump and Treat Systems (FY 1982 - 2002)



Pump and treat (P&T) projects from FY 1998 through 2002 are not included on this figure, because P&T systems do not generally become operational within 5 years of signing the ROD.

Above Ground Components of Groundwater Pump and Treat Projects (FY 1982 - 2000)

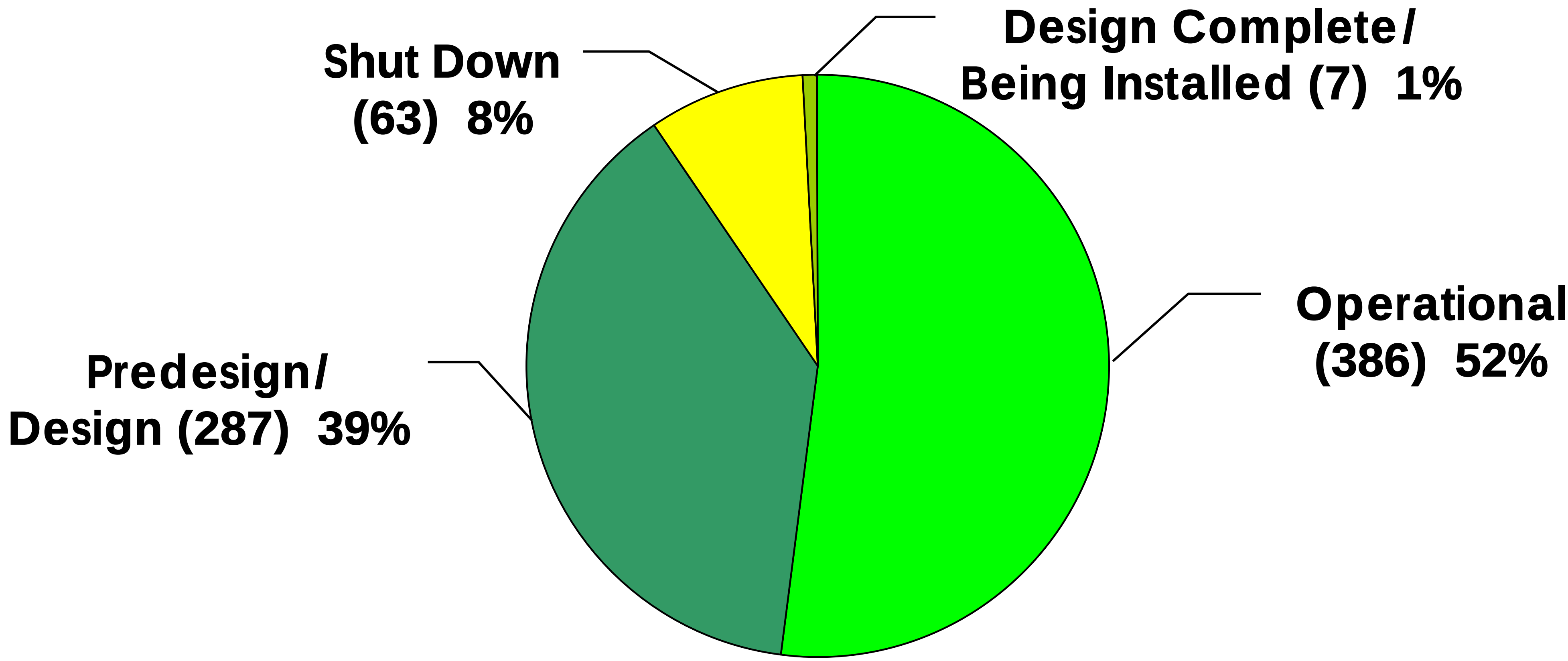
Pump and Treat Projects[a] = 171



POTW = Publicly-owned treatment works

(a) Of 743 pump and treat projects, 171 had a technology selected. Projects may include more than one technology type.

Status of Groundwater Pump and Treat Projects (FY 1982 - 2002)*



*Includes information from an estimated 70% of FY 2002 RODs.

LTM Cost Model

- Data sources
- Key design assumptions
- Key variables
- Limitations
- Strong points
- Results

LTM Model Key Design Assumptions - 1

- **Aquifer Monitoring, MNA, and Remedies**
  - Hand-bailing of wells
  - 4 monitoring wells sampled by 2 samplers each day (1 event)
  - Labor cost of $320 per well sampled
  - Equipment and supplies cost of $1,500 per event

- **P&T System Monitoring**
  - Collection of samples from centralized location
  - Up to 32 samples collected by 2 samplers each day (1 event)
  - Operator rate of $70 per hour
  - Equipment and supplies cost $600 per event

LTM Model Key Design Assumptions - 2

- **P&T systems**
  - 5 years from ROD signature to startup
  - Systems operate for 30 years
  - 24 new projects each year
  - Aquifer monitoring conducted from 1 year before startup through 1 year after shut down
- **MNA**
  - 1 year from ROD signature to startup
  - Systems operate for 16 years
  - 10 new projects each year
- **Other Remedies**
  - Model assumes that the number of operational remedies will not change over next 30 years (i.e., as old projects are completed, a similar number of new projects will begin)

LTM Model
Key Input Variables

- **Aquifer Monitoring**
  - 2 – 4 sampling events per year
  - 9 – 25 wells sampled per event
  - 1 – 4 contaminant groups analyzed at off-site laboratory
- **P&T System Monitoring**
  - 12 - 24 sampling events per year
  - 1 - 2 monitoring points
  - 1 – 5 contaminant groups analyzed at off-site laboratory
- **MNA Monitoring**
  - Hand-bailing of wells
  - 1 sampling event per year
  - 11 – 18 wells sampled per event
  - 2 analyses conducted at off-site laboratory
- **Contaminants analyzed**
  - From 1 – 4 analytes per site (VOCs, SVOCs, Metals, or PAHs)
  - Based on analysis of contaminants of concern at Superfund sites

Results: P&T LTM Cost Model

Annual and 30 year LTM cost estimate @ NPL sites

	25 percentile	75 percentile	Median
Groundwater Monitoring ($million)			
Yearly cost	$8	$39	$12
30 Year cost	$170	$810	$260
Treatment System Monitoring ($million)			
Yearly cost	$12	$29	$14
30 Year cost	$290	$660	$330

Results: P&T LTM Cost Model

Median Costs ($million)

Yearly cost	Groundwater Monitoring	Treatment System Monitoring
Total Cost (median)	$12	$15
Labor Cost	$5.5	$4.1
% Labor	45%	28%
Analytical Cost	$6.7	$11
% Analytical	55%	72%

Results: MNA LTM Cost Model

Total Monitoring Cost ($million)

Variable	25 percentile	75 percentile	Median
Yearly cost	$2.5	$3.7	$2.9
30 Year cost	$200	$300	$240

Simplified Extrapolation to Other Remedies

- 1,740 Superfund projects (not including P&T and MNA) may require LTM.
- Assumed all projects required aquifer monitoring similar to that of a P&T system and that a similar number of projects would require LTM over the next 30 years.

Monitoring Cost ($million)

Variable	25 percentile	75 percentile	Median
Yearly cost	$32	$150	$48
30 Year cost	$960	$4,6B	$1.4B

Results: Total LTM Costs in Superfund

Total System Monitoring ($million)

Variable	25 percentile	75 percentile	Median
Yearly cost	$55	$225	$77
30 Year cost	$1.6B	$6.4B	$2.3B

LTM Model Limitations

- Estimated cost ranges based on 25th, median, and 75th percentile values
- Data set may not be representative, most sites are fund-lead
- No economies of scale for larger sites – cost increases were assumed to be linear
- Limited information on technologies other than P&T, aquifer monitoring, and MNA
- Does not account for other major cleanup markets (UST, RCRA-CA, State VCP/Brownfields,etc)
- Costs at some sites driven by contract and site issues rather than actual cost to perform LTM

LTM Cost Model Strong Points

- Based on actual number of wells, analytes, and monitoring frequency for 81 out of 387 operational P&T sites
- Based on existing cost models and labor and cost assumptions standard in industry
- Shows parameters that may help influence technology development and investment decisions
  - Total Superfund LTM market
  - Breakdown between labor and analytical costs
  - Number of sites conducting LTM by analyte
- Can estimate savings from applications of sensors and optimization

Assumptions for Passive Diffusion Bag (PDB) Savings

- Applied only to aquifer monitoring at all Superfund P&T sites with VOCs
- Can sample five times the number of wells as hand-bailing with the same labor, resulting in lower labor costs
- Additional savings result from fewer total sampling days, lower travel costs, fewer QA/QC samples
- Additional costs to purchase PDBs and associated equipment

Saving Estimates with the Use of Passive Diffusion Bag Samples

PDB Labor Savings ($million, Based on Median Costs)

Variable	$ Saved	% Saved
Yearly Savings	$2.2	56%
30 Year Savings	$72	56%

Upcoming Work on the Model

- **Collect additional data**
  - **Incorporate CLP analytical and cost data**
  - **Additional case studies**
- **Develop cost curves for labor and analytical costs to account for economies of scale**
- **Develop cost modules for more remedy types**
- **Develop cost modules for more innovative LTM technologies**
- **Conduct empirical comparisons of model costs to actual sites**
- **Analyze the market implications of contaminants, labor, analytical costs, and other factors in more detail**

LTM Cost Model Data Sources

- Superfund sites performing LTM for aquifer monitoring (82 sites), P&T (24 sites), and MNA (7 sites)
- Existing Cost Models
  - ITRC model - http://diffusionsampler.itrcweb.org/common/default.asp
  - RACER
- EPA Contract Laboratory Program
- Experienced Field Personnel
- Remedial System Evaluations - http://www.cluin.org/rse
- FRTR Case Studies - www.frtr.gov
- Databases
  - ASR
  - CERCLIS