Estimating Leaching Behavior of Arsenic-Bearing Solid Residuals

Rio Rico Workshop

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Background

- **2001revised arsenic in D.W. standard**
  - **10 ppb MCL (from 50 ppb)**
- **Estimated impacts**
  - **4000 new utilities impacted (>95% small)**
  - **~ 400 Arizona utilities impacted**
  - **6 - 24M lb solid residuals annually**
  - **~ 30,000 # As /yr**
  - **arsenic-bearing solid residuals (ABSR) pass TCLP**
  - **ABSR suitable for non-hazardous landfill disposal**

    (California exception: WET & TTLC)

ABSR

Spent Solid Sorbents

- Alumina-based Media (Alcan AA)
- Iron-based Media (GFH, Sorb 33, greensand)
- Zeolites (Z33)
- Other Sorbents (SAMMS, Mn Oxides, TiO_2)

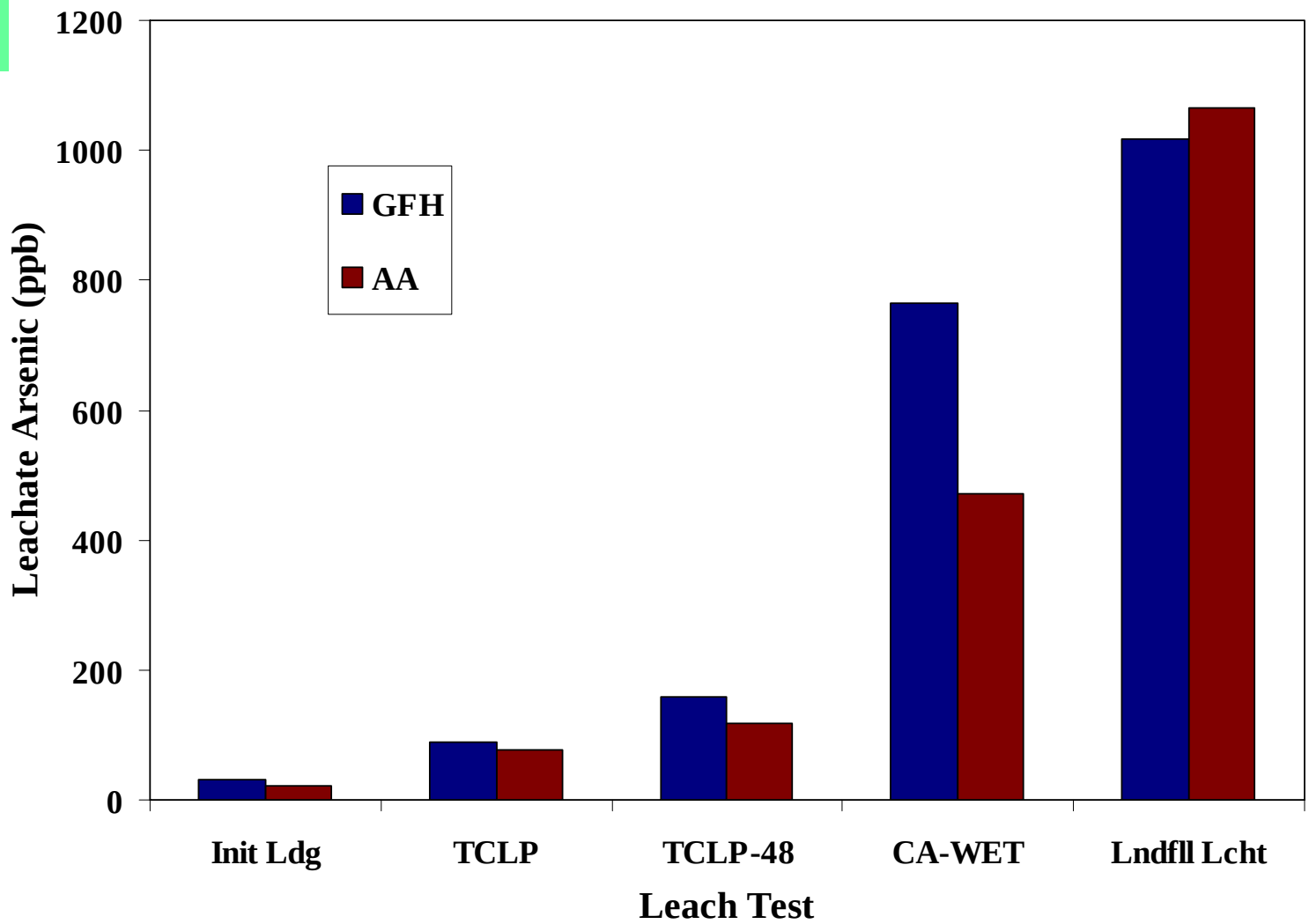
Precipitated Sludges

- **Direct**
  - Precipitation/Softening
  - Conventional coagulation / flocculation
  - Coagulation assisted microfiltration
- **Indirect**
  - Anion exchange (incl. enhanced media & recovery*)
  - Regenerable sorbents (ArsenX^{np}, AA)
  - Reverse osmosis

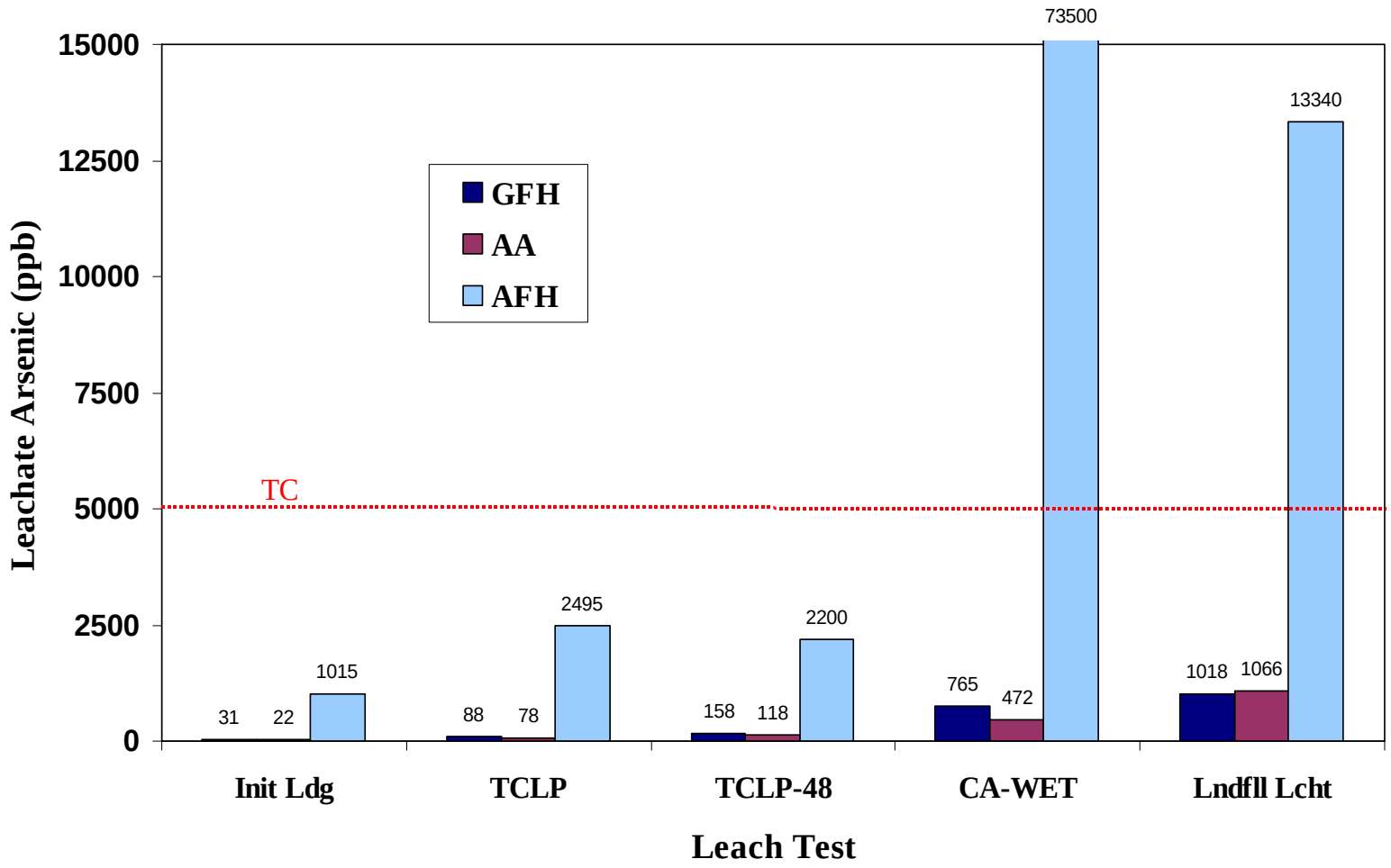
Leaching Estimation Tools

- **Batch "Equilibrium" Tests**
  - **Standard (TCLP, WET), Alternative (LL, SL, tiered)**
- **Bench/Pilot Column Tests**
- **Full-scale Tests**
- **Empirical and Mechanistic Models**
  - **Kinetic, equilibrium, hybrid**

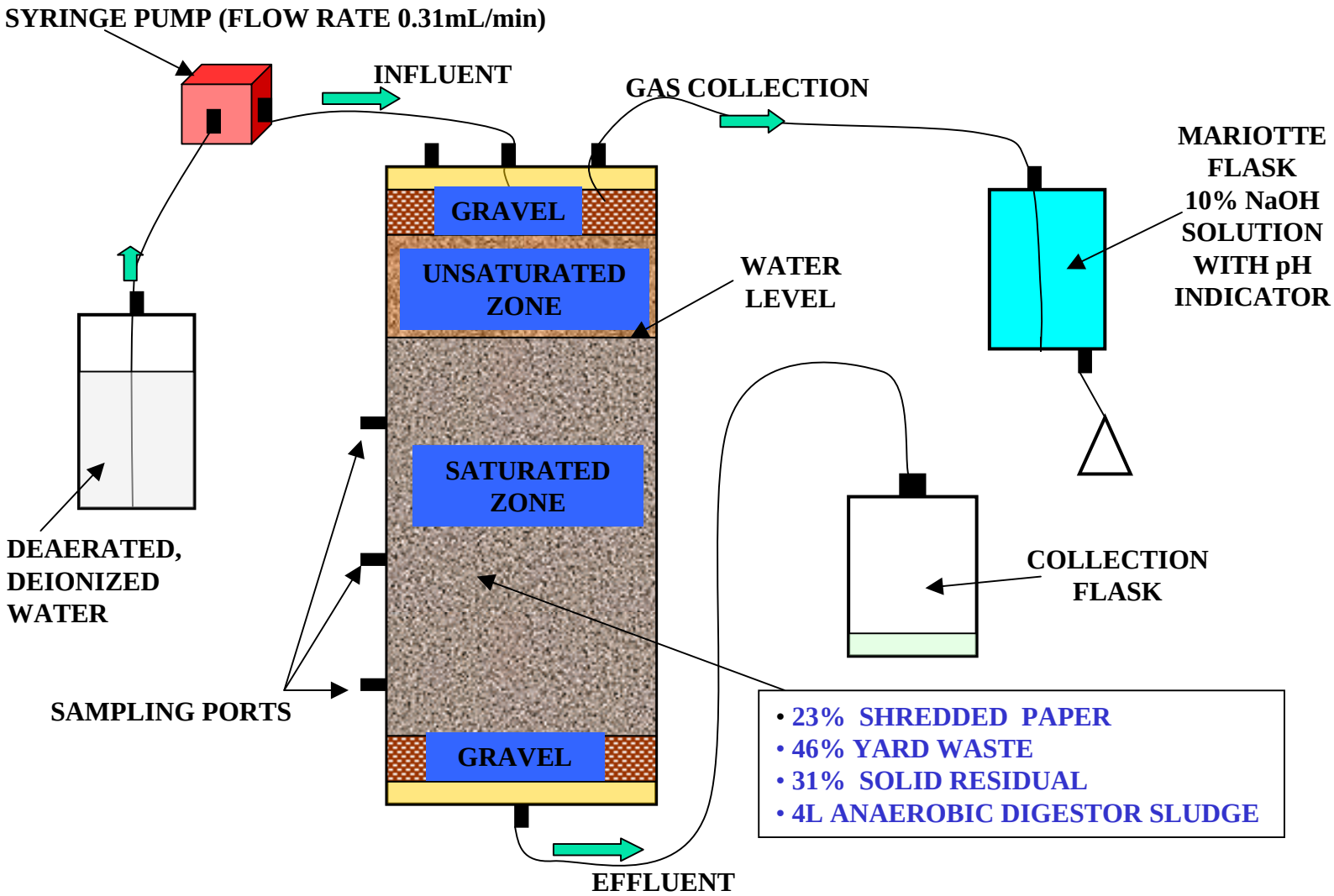
Spent Sorbent Leaching



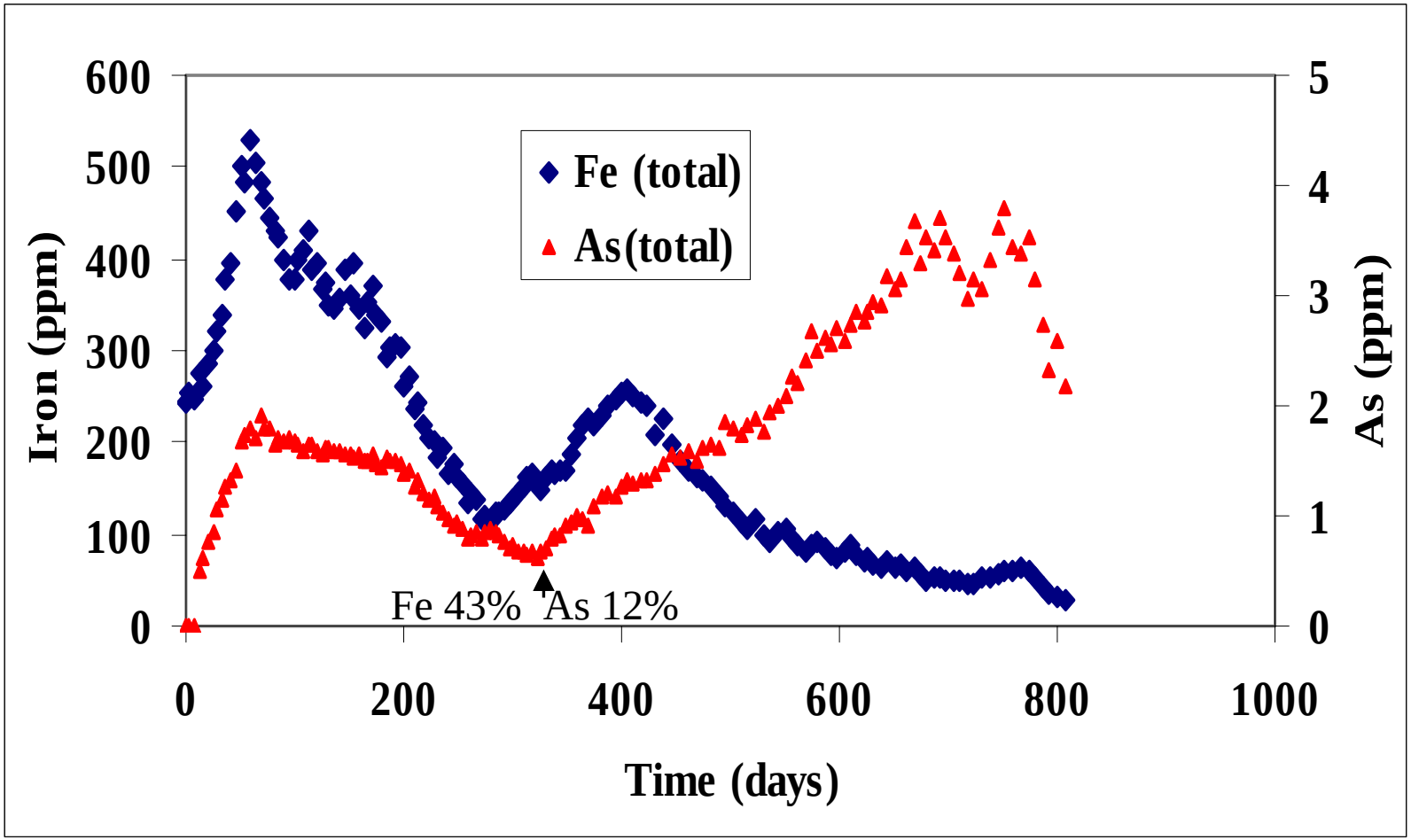
Precipitated Sludge Leaching



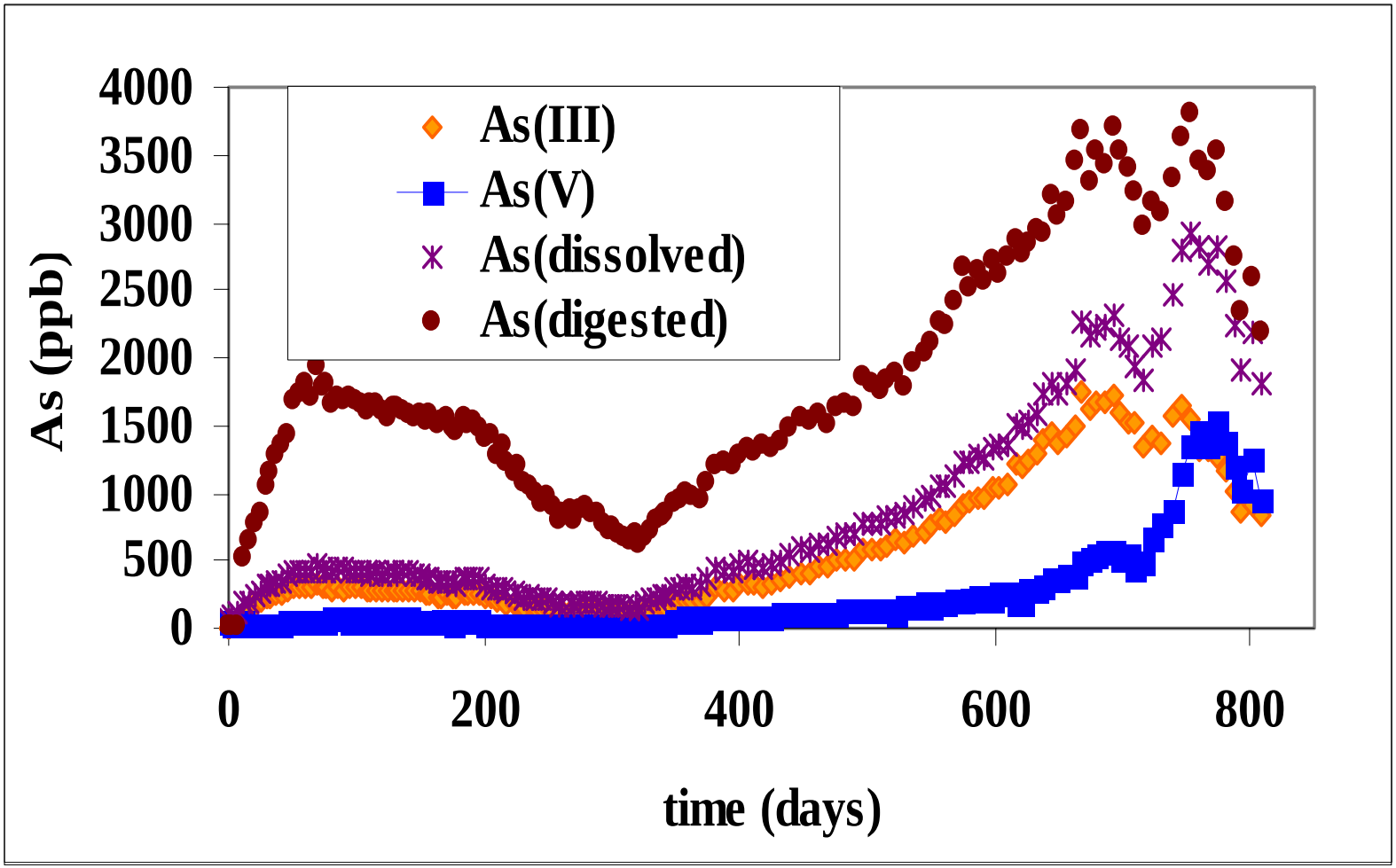
Landfill Simulation Columns



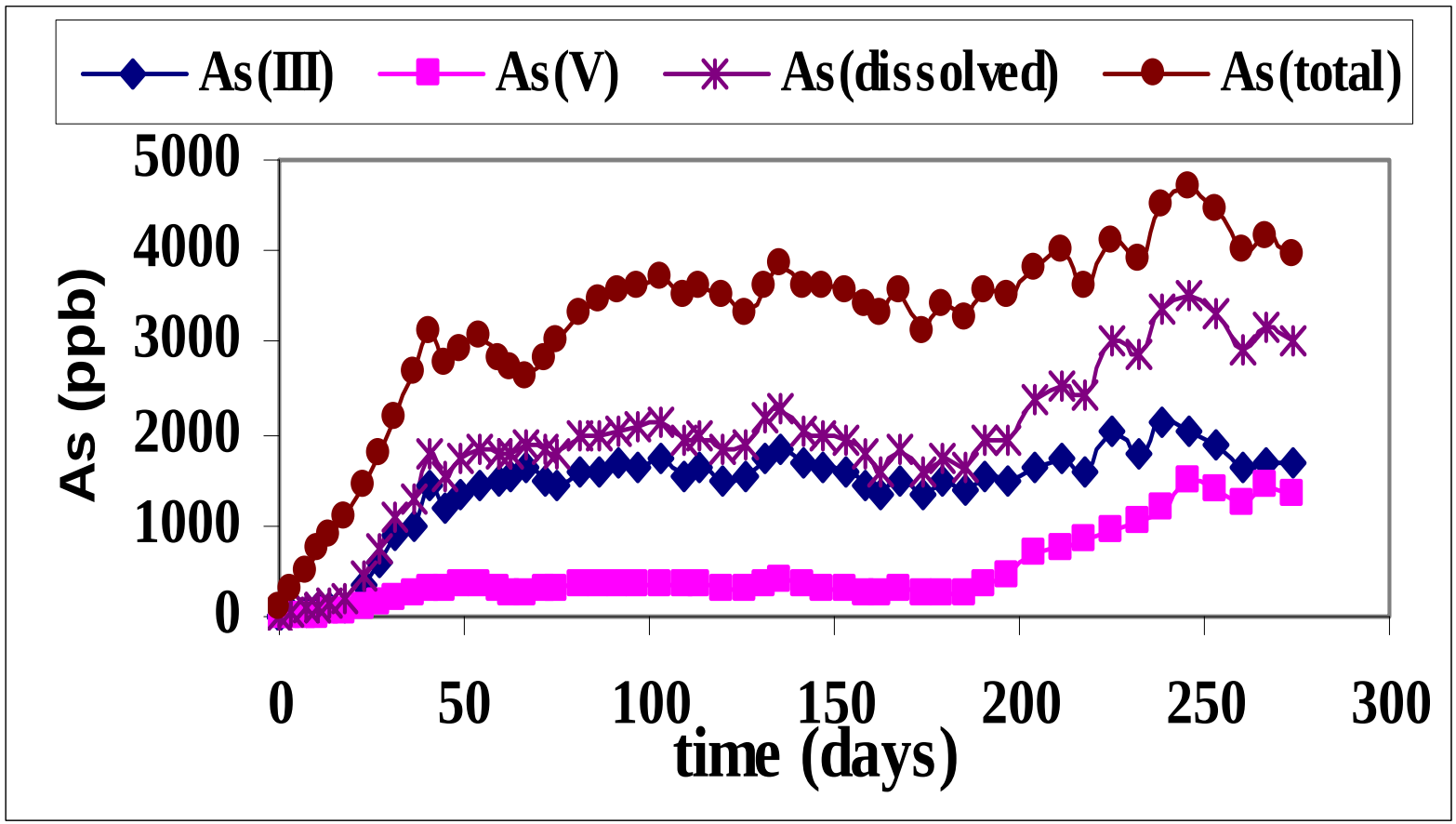
GFH Column Effluent Totals



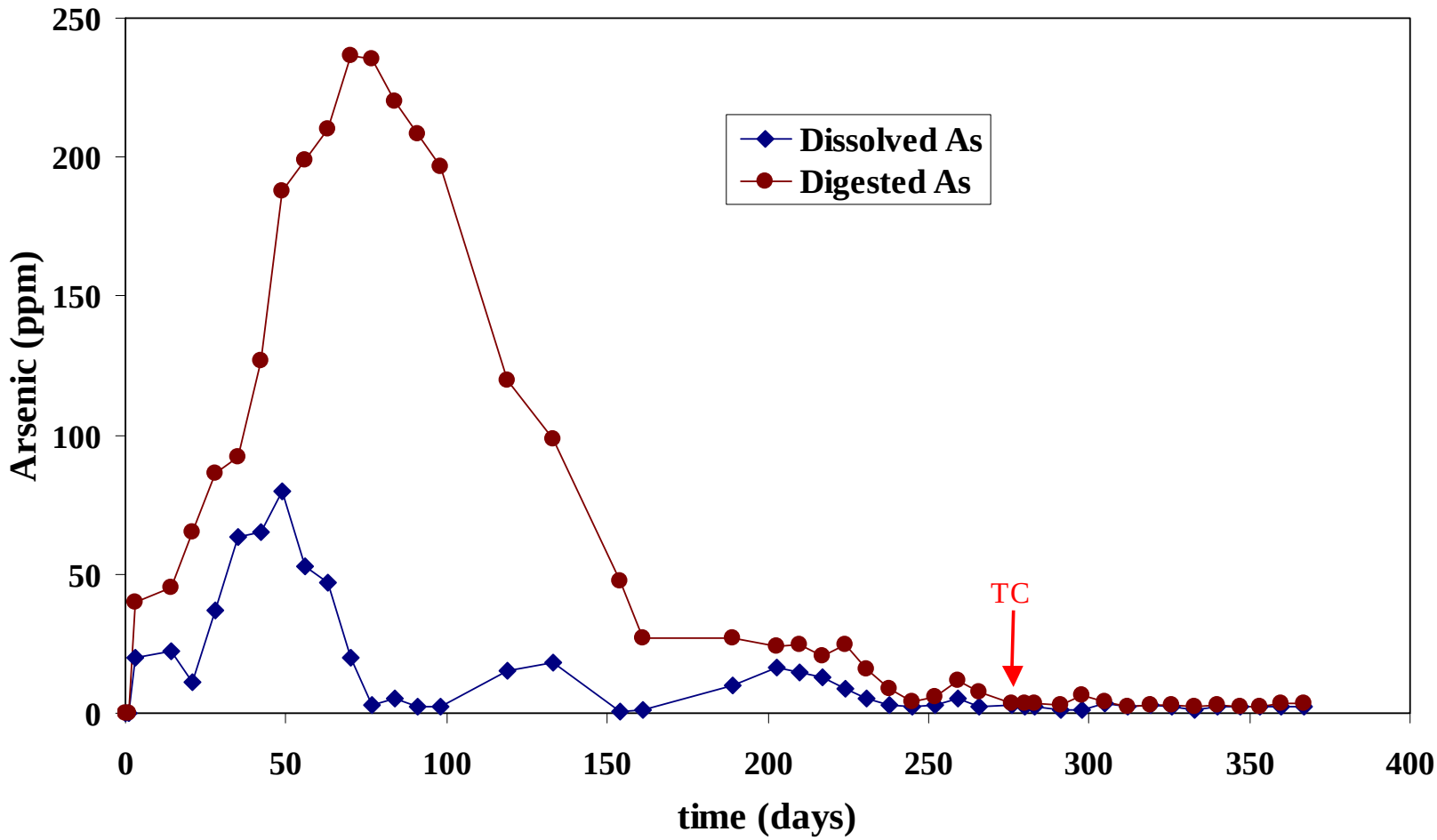
GFH Column Effluent Arsenic



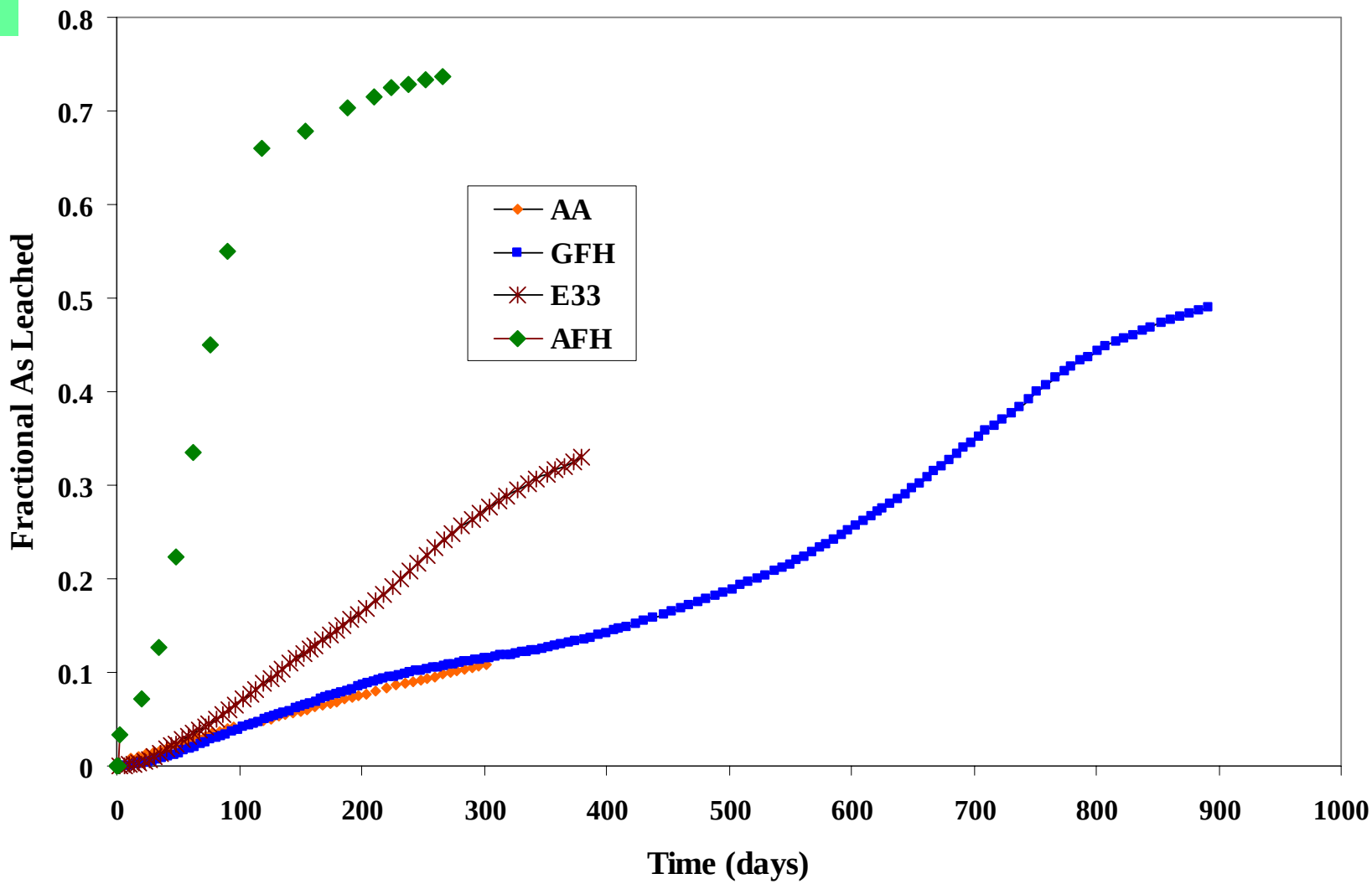
Sorb-33 Column Leachate



AFH Column Effluent Arsenic



Cumulative As Leaching



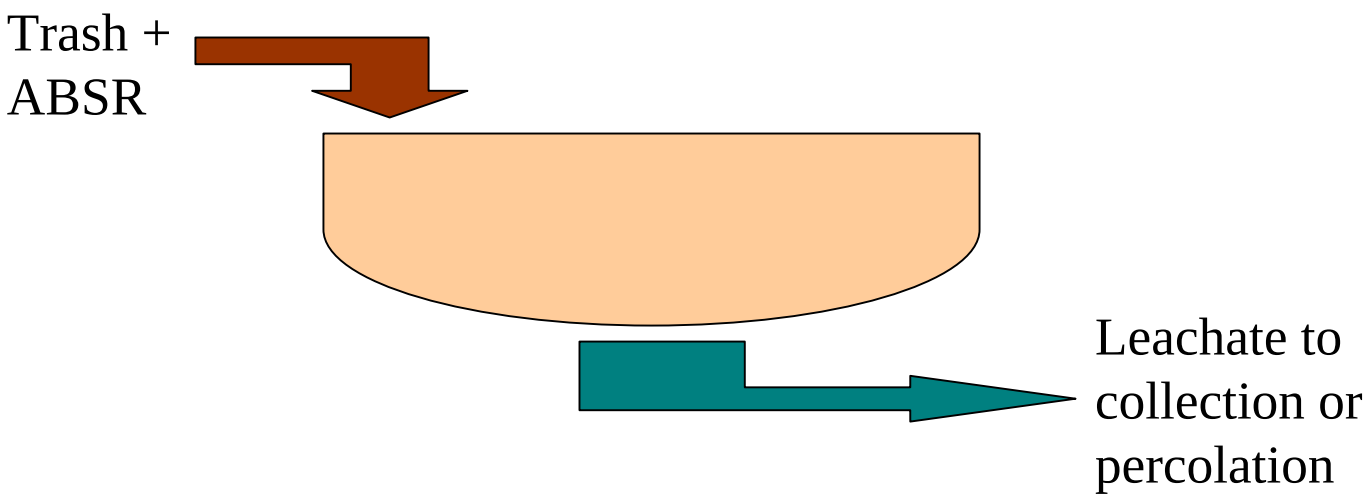
Critical Influences

Guiding Premise: test induces leaching as or more aggressively than conditions of non-hazardous waste disposal

	TCLP	WET	Mature Landfill
pH	4.95	5.05	7-9
Bioactivity	abiotic	abiotic	biotic
Duration	18 hr	48hr	weeks/months
Particles & Colloids	filtered	filtered	downflow, heterogeneous
Redox Condition	oxidizing	neutral	reducing

Simple Blackbox Mass Balance

- Steady State ($ABSR_{As}$ In = $Leachate_{As}$ Out) after residuals dumping in landfill for **???** years.

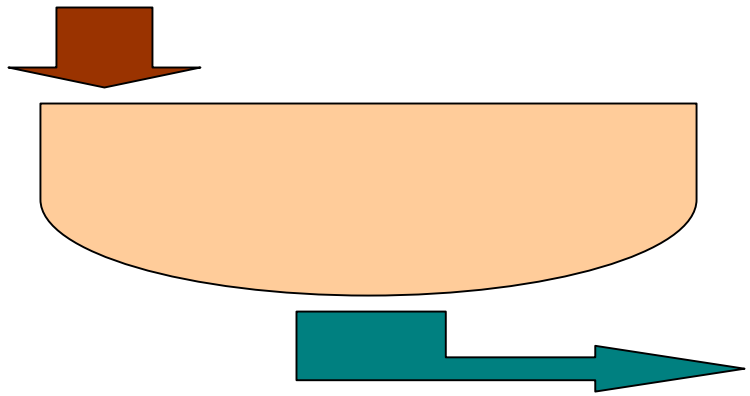


Blackbox Assumptions

- Final drinking water arsenic concentration of 8.0 ppb
- Range of leachate production rates
  ($0.15 – 1.60\ L_{leachate}/kg_{waste}$)
- ABSR are only source of arsenic to landfill
- Source water concentration and population impacted follows EPA final rule estimates
- Landfill only services population impacted by new MCL

Simple Blackbox Estimate

- **2.24 g_{As}/cap•yr**
- **560 kg_{waste}/cap•yr**
- **0.15 – 11 $L_{leachate}$/kg_{waste}**



26.7 – 0.36 ppm

Questions and Comments

TABLE 1. Characteristics of the Synthetic Extractants and Landfill Leachates

test	pH	ORP (mV)	alkalinity (mg/L as $CaCO_3$)	TOC (mg/L)	TDS (mg/L)	ionic strength (M)
TCLP	4.95	103.5	766	38.6	1480	0.08
WET	5.05	74	7940	55.8	5160	0.10
SL1	7.03	121.4	1500	1050	5200	0.03
SL2	7.55	−37	12 500	1310	8600	0.49
LL[1]	6.82	36.1	1100	160	3600	0.33
LL[2]	4.5−9.0	N/R*	300−11 500	30−29000	2000−60000	N/R
LL[3]	6.5−8.2	N/R	1250−8050	N/R	1960−16800	N/R
LL[4]	6.2−7.1	N/R	N/R	236−3160	N/R	N/R

N/R*: Values Not Reported. LL[1]: Leachate collected from Tangerine Road Landfill, Tucson, AZ. LL[2]: Leachate composition reported in Christensen et al., (*21*). LL[3]: Leachate composition reported in Jang et al. (*22*). LL[4]: Leachate composition reported in Hooper et al. (*5*).

Next Steps for As Residuals

S1. Simulate landfills/repositories to determine appropriate performance bar

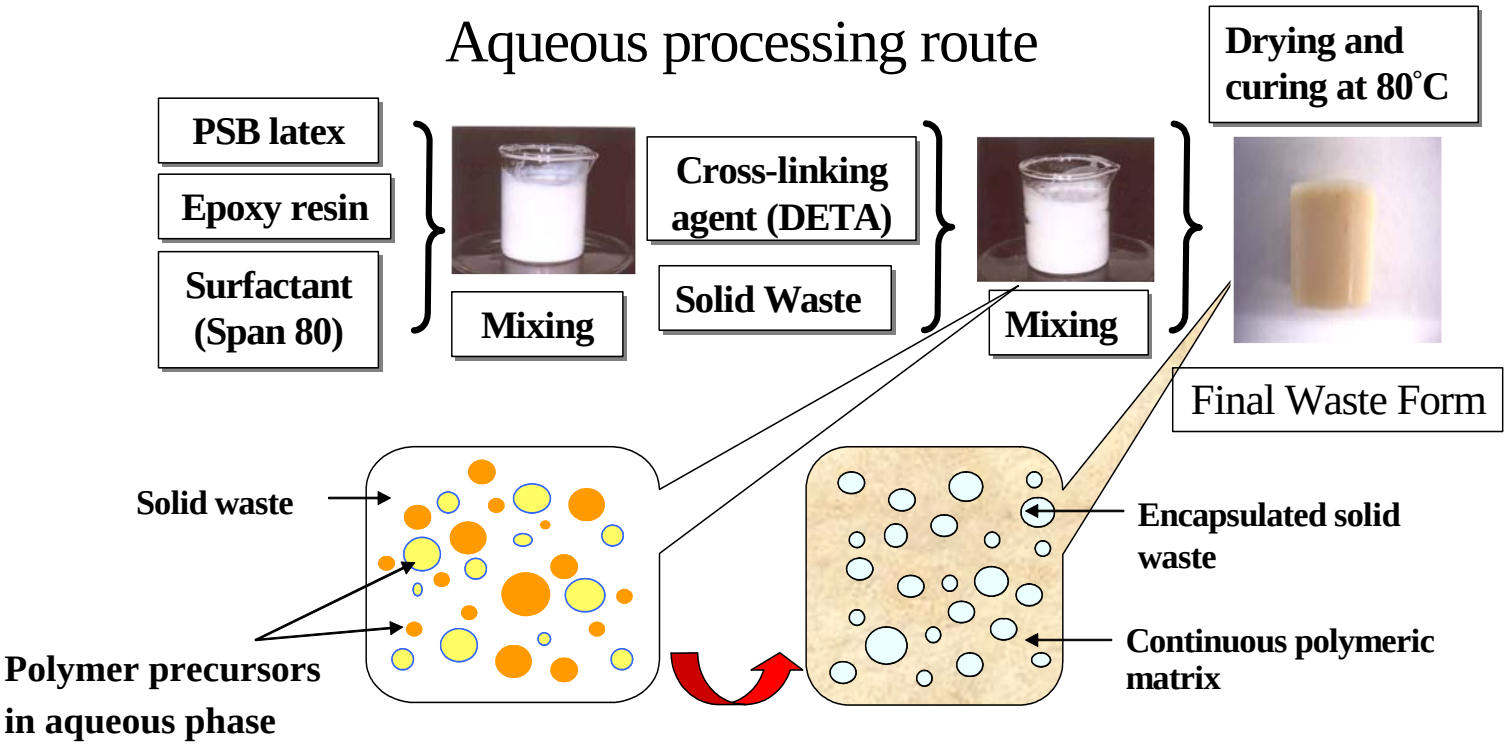
S2. Develop tractable protocols based on engineering critical leaching mechanisms to clear bar

S3. Evaluate (technically & economically) treatment options, including potential for stabilization

S4. Develop and evaluate hybrid (conventional & innovative) disposal options

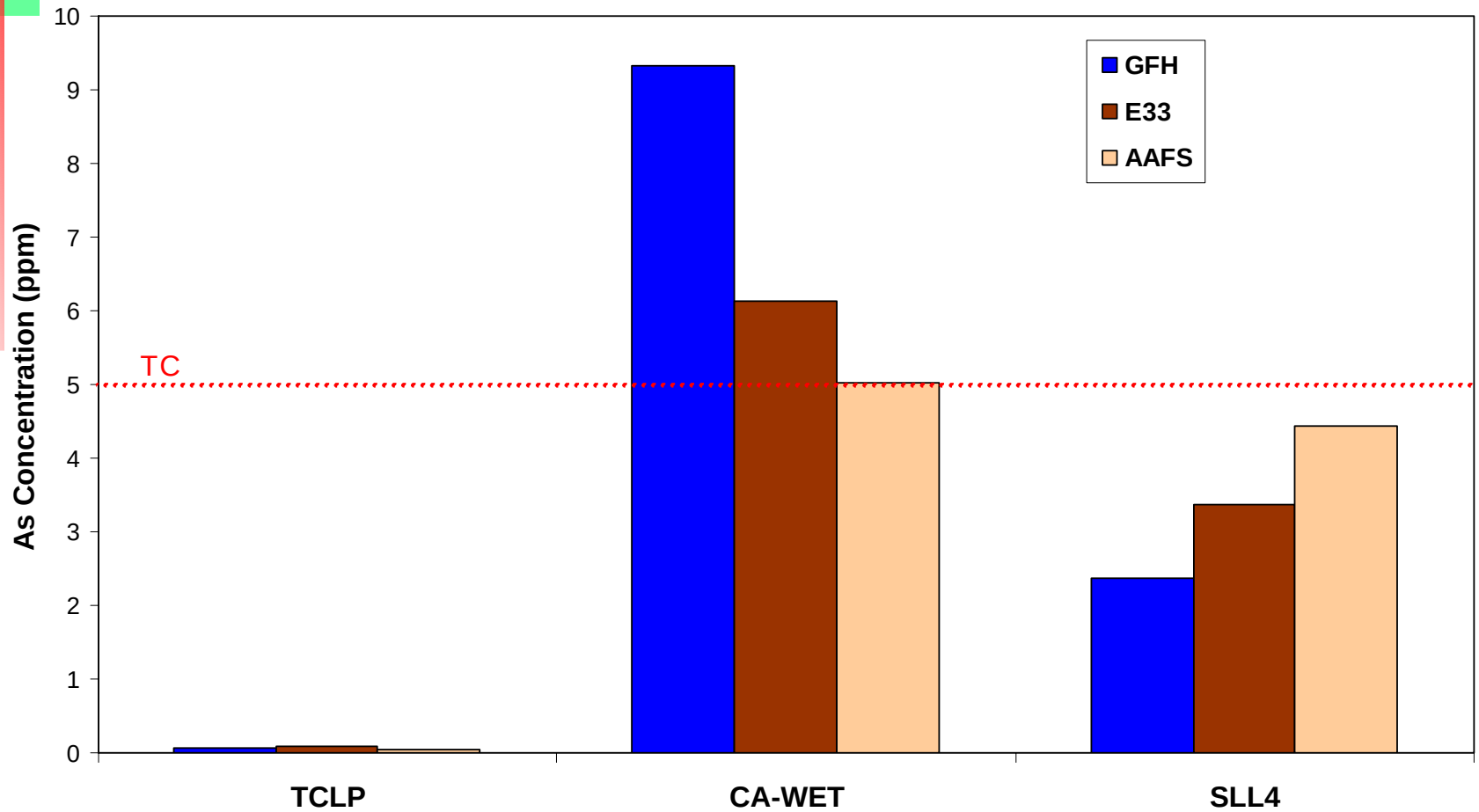
Polymeric Encapsulation

Polymeric Waste Form Synthesis

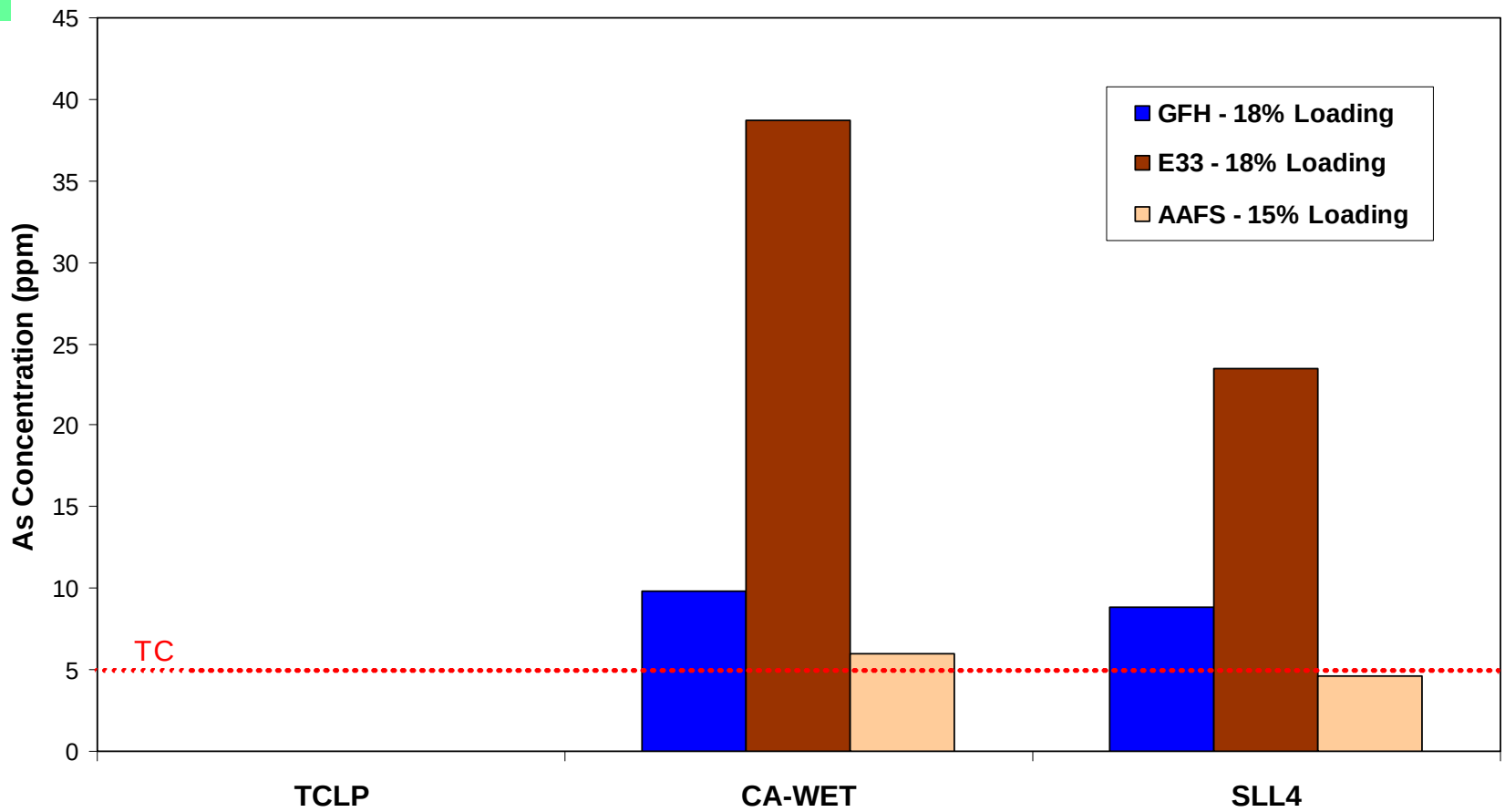


Phase inversion: polymers go from being the discontinuous phase to being the continuous phase, encapsulating solid waste

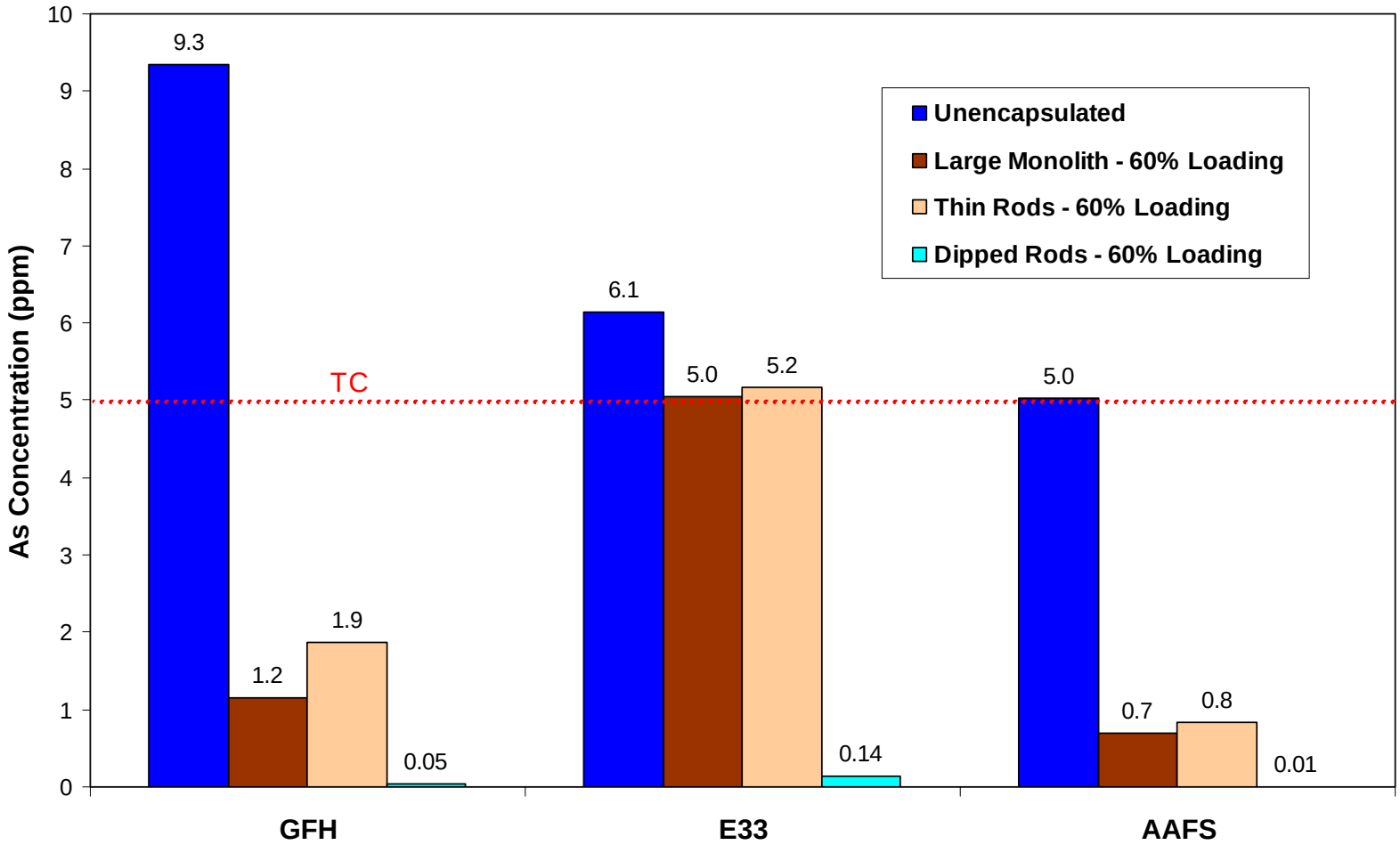
Unencapsulated Leaching



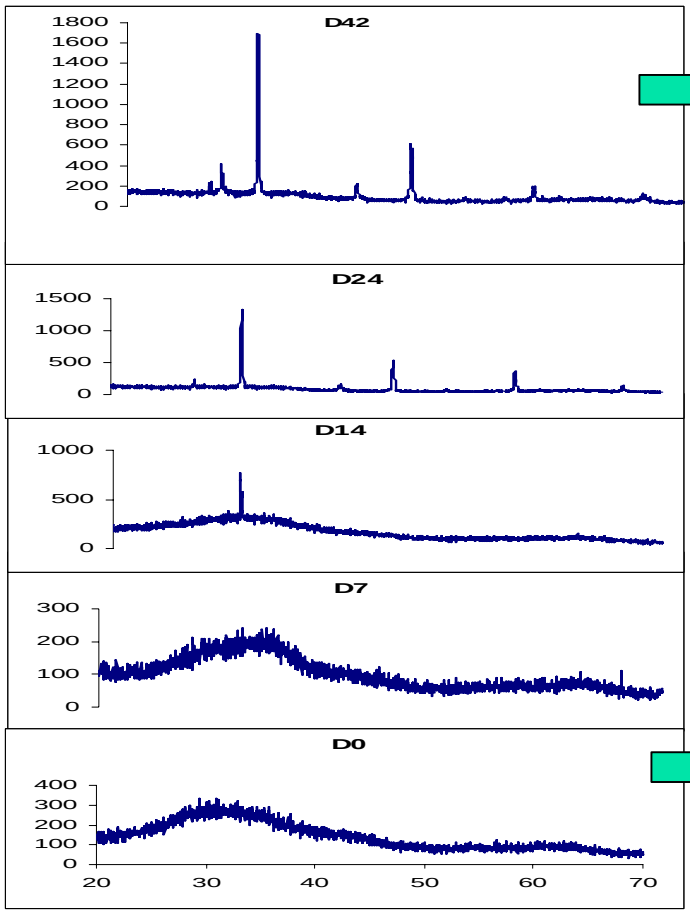
Cement Encapsulated Leaching



Polymer Encapsulated Leaching



Crystallization



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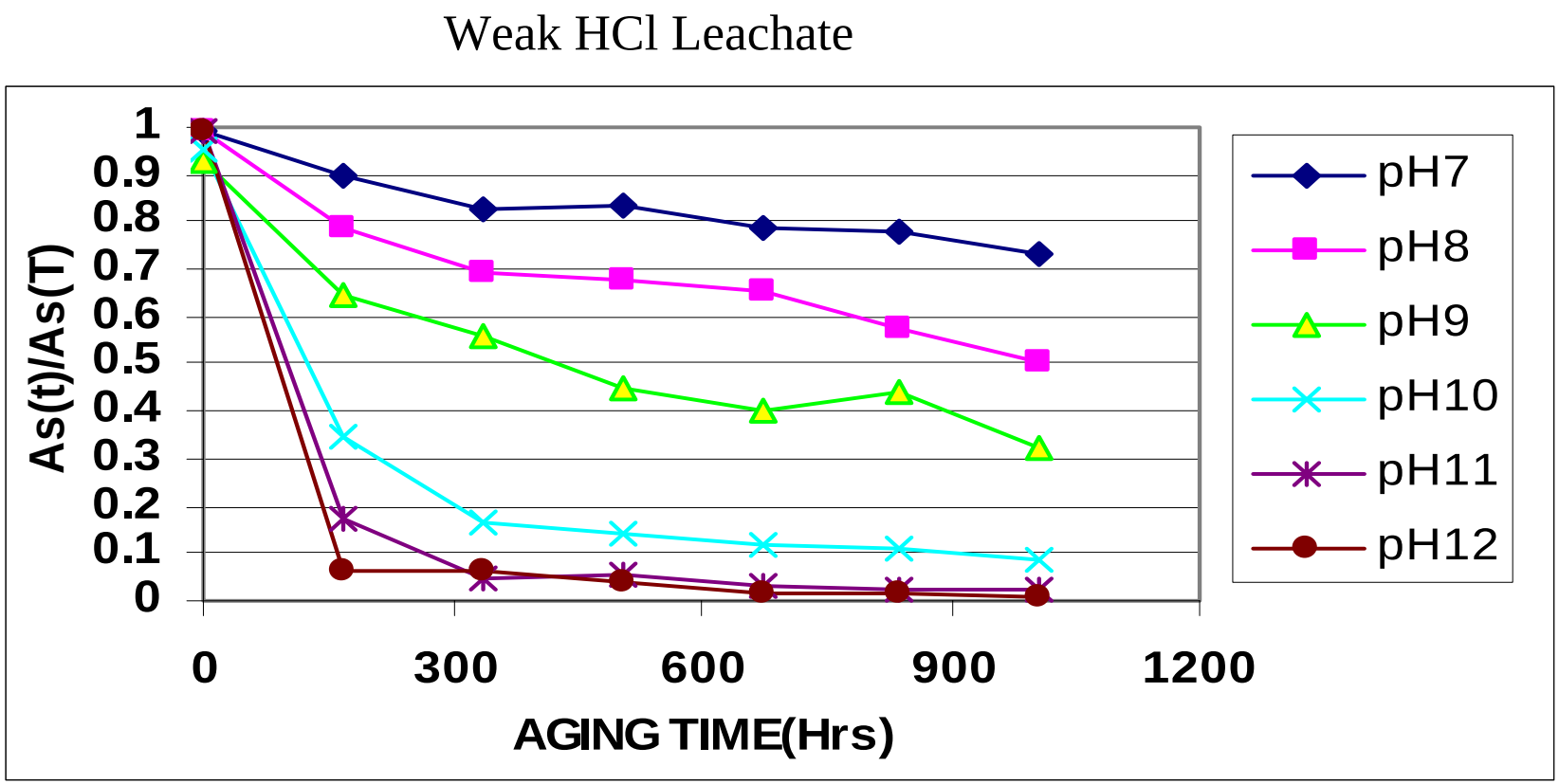
AFH

Crystallization Leaching



Residuals Recommendations

- Push for appropriate leaching test
- Avoid mass loading based standards
- Investigate organic free, contained landfills
- Develop stabilization technologies
- Involve wastewater/solid waste utilities
- Avoid drying bed type options w/out resuspension and final fate controls
- Consign as hazardous waste or hold on-site