

# ***Multiple Contaminant Case Studies***

Tom Sorg  
USEPA  
Cincinnati, OH

Workshop on Inorganic Contaminant Issues  
August 21-23, 2007  
Cincinnati, OH

## Demonstration Sites with Multiple Contaminants

Sites	Well Flow gpm	Contaminants	
		Arsenic – ug/L	Other
Homedale, ID	10 Homes	52	U – 31 ug/L, NO <sub>3</sub> – 11 mg/L
Lake Isabella, CA	38	35	U – 32 ug/L
Fruitland, ID	250	50	NO <sub>3</sub> – 14 mg/L
Vale, ID	525	17	NO <sub>3</sub> – 10 mg/L
STMGID Reno, NV	350	88	Sb – 16 ug/L
Greenville, WI	375	34	Ra – 7 pC/L
Carmel, ME	30	21	Sb – 14 ug/L
Lyman, NE	250	20	U – 38 ug/L
North Smithfield, RI	18	20	Ra – 7 pC/L



## ***Contaminant - Chemistry***

Contaminant	Symbol/ Formula	MCL mg/L	Occurrence in Water
Arsenic	As	0.010	Anion
Nitrate	NO <sub>3</sub>	10 as N	Anion
Uranium	U	0.030	Anion / Cation
Antimony	Sb	0.006	Anion
Radium	Ra	5 pC/L	Cation



## ***Contaminant – BAT and Other Technologies***

Contaminant	Anion Exchange	Cation Exchange	Coagulation/ Filtration	RO/ ED	Adsorptive Media
Arsenic	Yes	No	Yes	Yes	Yes
Nitrate	Yes	No	No	Yes	No
Uranium	Yes	No	yes	Yes	Yes
Antimony	?	No	?	Yes	Yes
Radium	No	Yes	No	Yes	No



## Demonstration Sites with Multiple Contaminants

Sites	Well Flow gpm	Contaminants	
		Arsenic – ug/L	Other
Homedale, ID	10 Homes	52	U – 31 ug/L, NO <sub>3</sub> – 11 mg/L
Lake Isabella, CA	38	35	U – 32 ug/L
Fruitland, ID	250	50	NO <sub>3</sub> – 14 mg/L
Vale, ID	525	17	NO <sub>3</sub> – 10 mg/L
STMGID Reno, NV	350	88	Sb – 16 ug/L
Greenville, WI	375	34	Ra – 7 pC/L
Carmel, ME	30	21	Sb – 14 ug/L
Lyman, NE	250	20	U – 38 ug/L
North Smithfield, RI		20	Ra – 7 pC/L



# *Sunset Ranch Development - Homedale, ID*

- Located 40 miles west of Boise
- Composed of ten homes with nine participating in study
- Served by a 10-inch, 130-ft-deep well equipped with a 15-hp submersible pump rated at 20 gpm
- No centralized water treatment, several having water softeners and/or RO units
- Water stored in a pressure tank located in community pump house



RESEARCH & DEVELOPMENT

*Building a scientific foundation for sound environmental decisions*

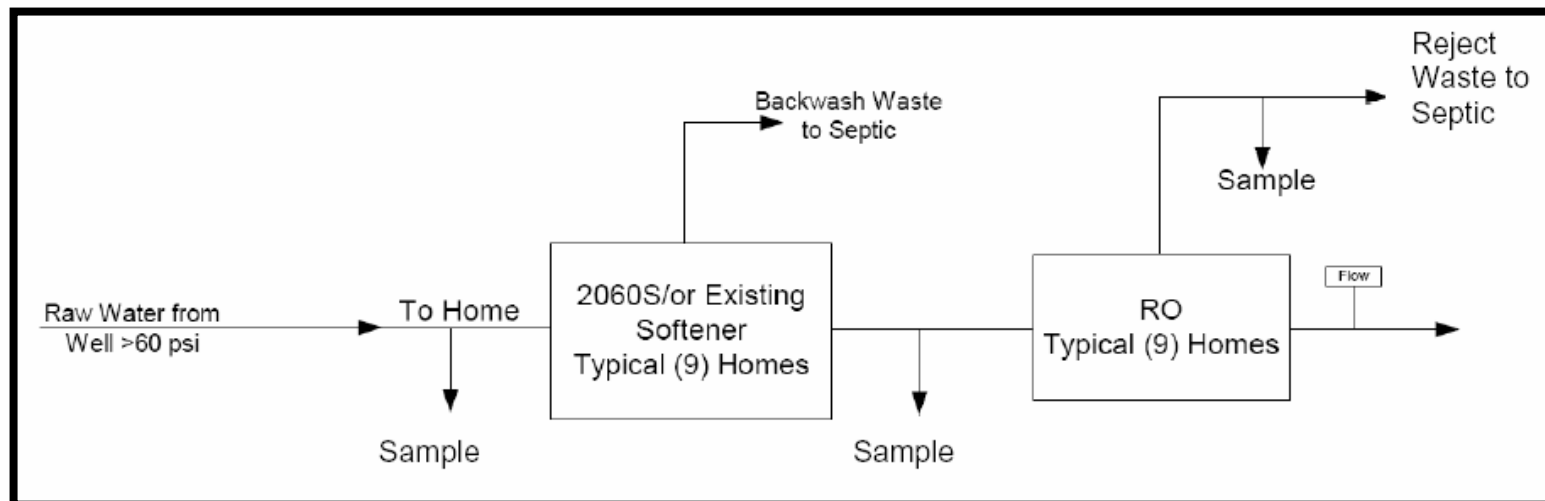
## **Homedale, ID - Source Water Quality**

Parameter	Unit	Sunset Ranch Development	Remarks
Total As (as As[V])	µg/L	46.5 – 62.6	Mostly As (V)
Nitrate (as N)	mg/L	5.8 – 13.6	-
Total Uranium	µg/L	23.4 – 31.0	~100% soluble
pH	S.U.	7.2 – 7.8	-
TDS	mg/L	648 – 730	-
Hardness (as CaCO <sub>3</sub> )	mg/L	216 – 251	-
Total Alk (as CaCO <sub>3</sub> )	mg/L	283 – 317	-
Sulfate	mg/L	151 – 210	-
Silica (as SiO <sub>2</sub> )	mg/L	59.8 – 95.9	-
Total Iron	µg/L	<25 – 568	Mostly particulate
Total Vanadium	µg/L	29.1 – 39.0	~100% soluble
Fluoride	mg/L	0.6 – 5.2	



## ***Nine POU Systems – Homedale, ID***

- Water softening to prevent scaling of RO membranes
- Kinetico RO Plus Deluxe As/NO<sub>3</sub> Removal System





## Water Softener



## POU RO System



RESEARCH & DEVELOPMENT

*Building a scientific foundation for sound environmental decisions*

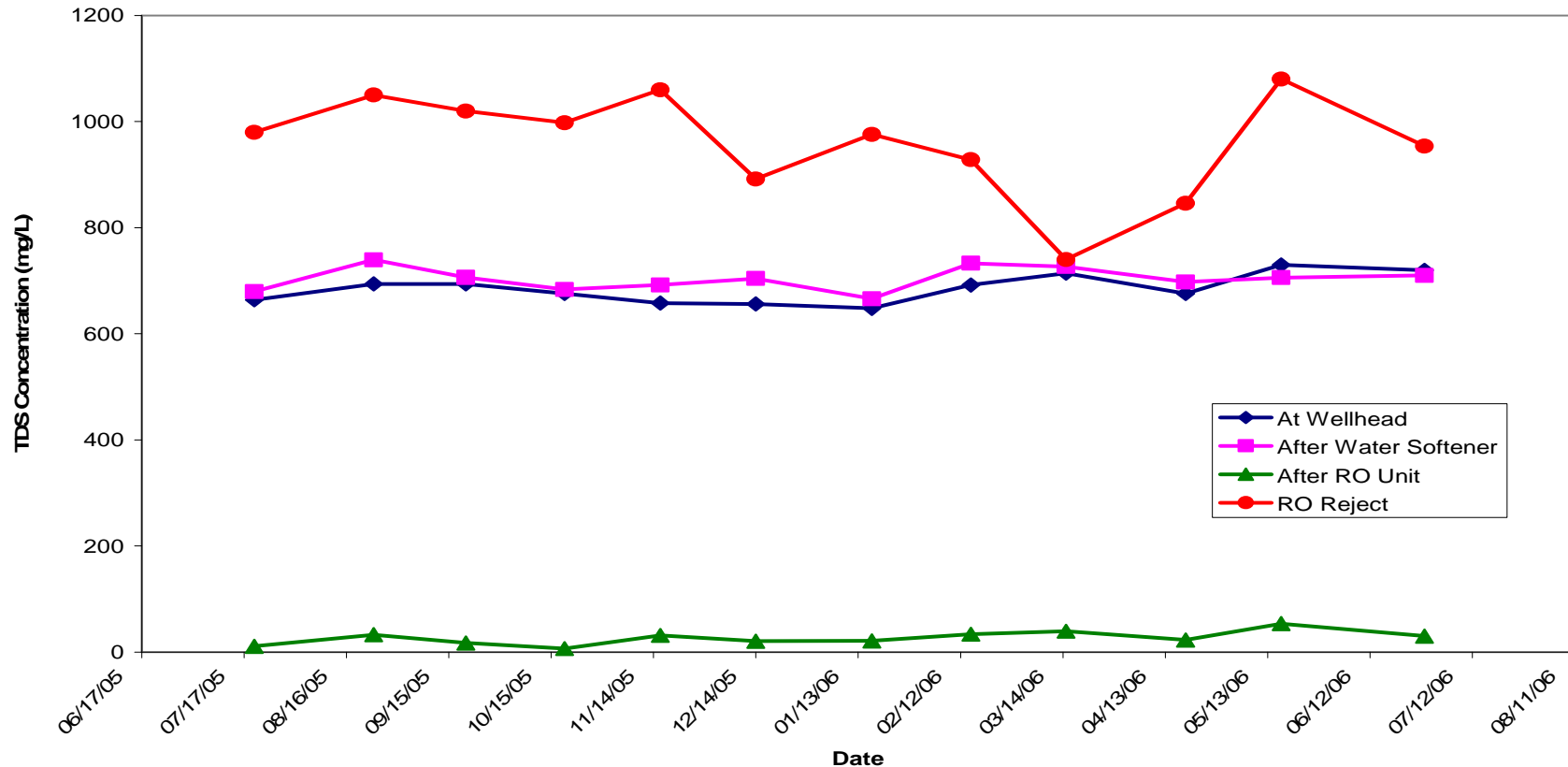
# ***POU RO System Sampling***

- 20 locations total
  - Wellhead (IN)
  - After water softener at each residence (WS1-9)
  - After reverse osmosis at each residence (RO1-9)
  - Reject water discharge line (RW1)
- Sampling Schedule
  - Monthly sampling from all locations
  - Speciation conducted quarterly at wellhead and R1 residence



# POU RO System Performance – TDS Removal

TDS Results for Sunset Ranch Development



**Note: Average concentration for nine water softeners and RO units.**

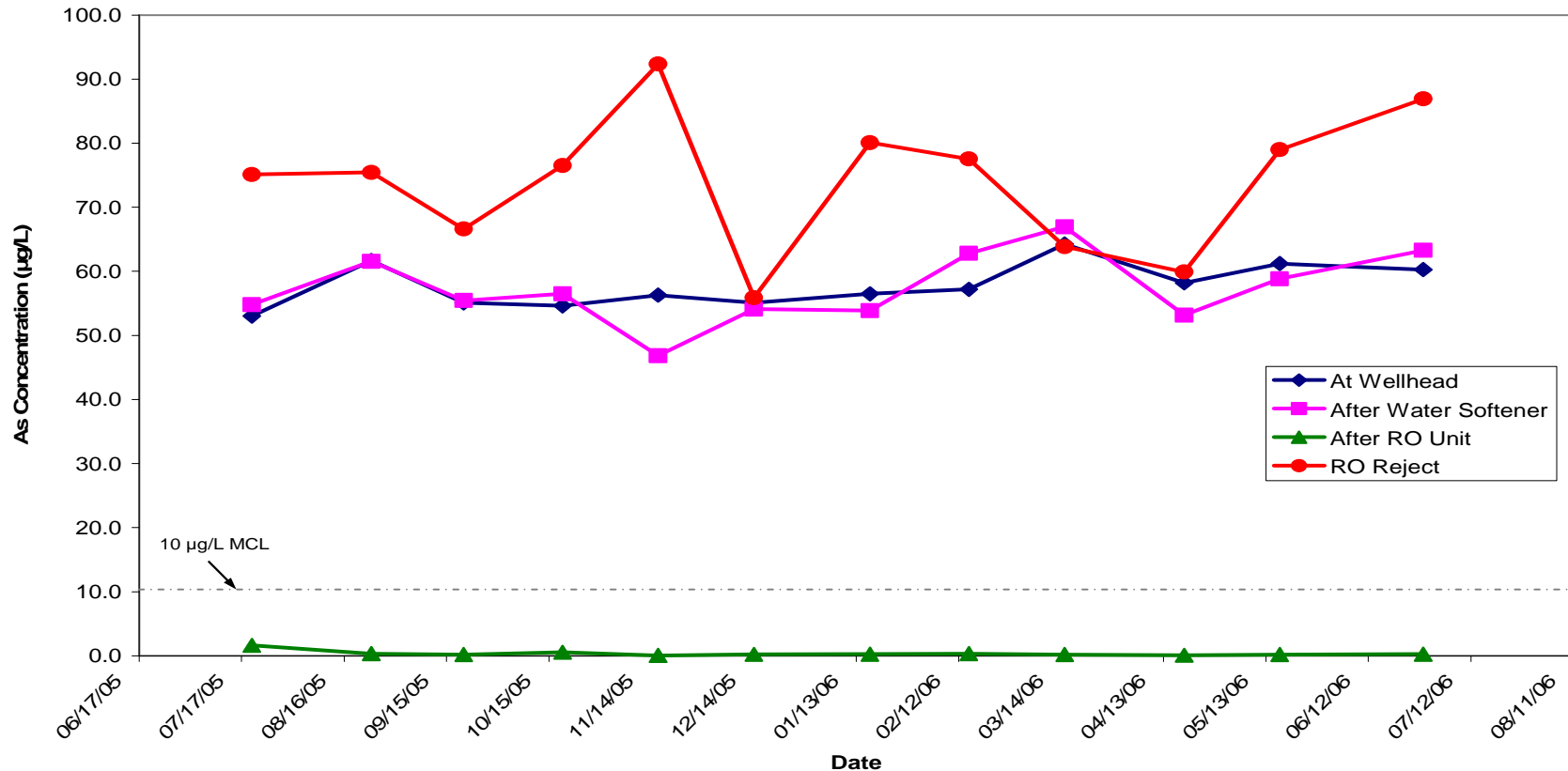


RESEARCH & DEVELOPMENT

*Building a scientific foundation for sound environmental decisions*

# POU RO System Performance – Arsenic Removal

Total Arsenic Results for Sunset Ranch Development



**Note: Average concentration for nine water softeners and RO units.**

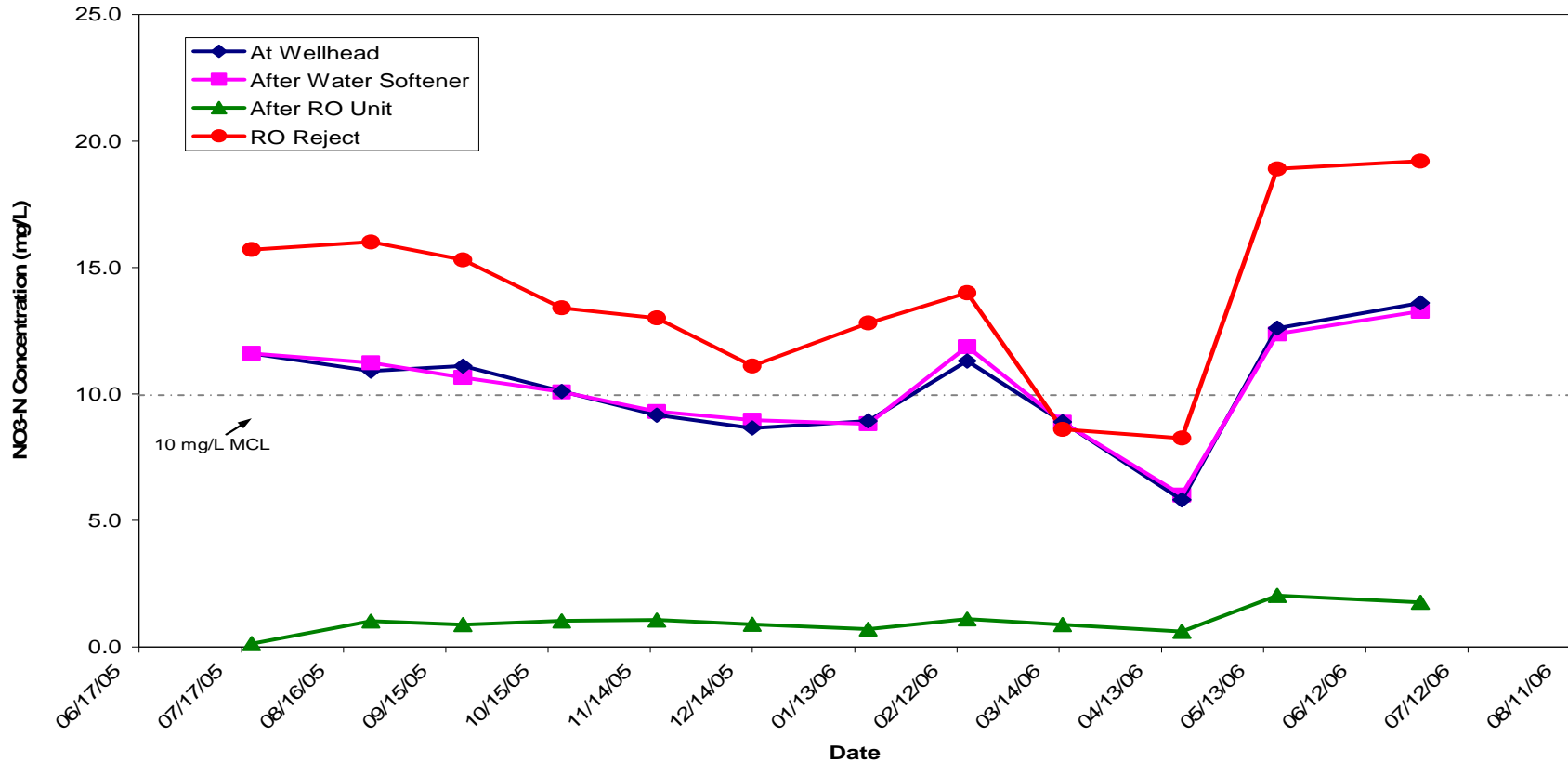


RESEARCH & DEVELOPMENT

*Building a scientific foundation for sound environmental decisions*

# POU RO System Performance – Nitrate Removal

Nitrate (as N) Results for Sunset Ranch Development



**Note: Average concentration for nine water softeners and RO units.**

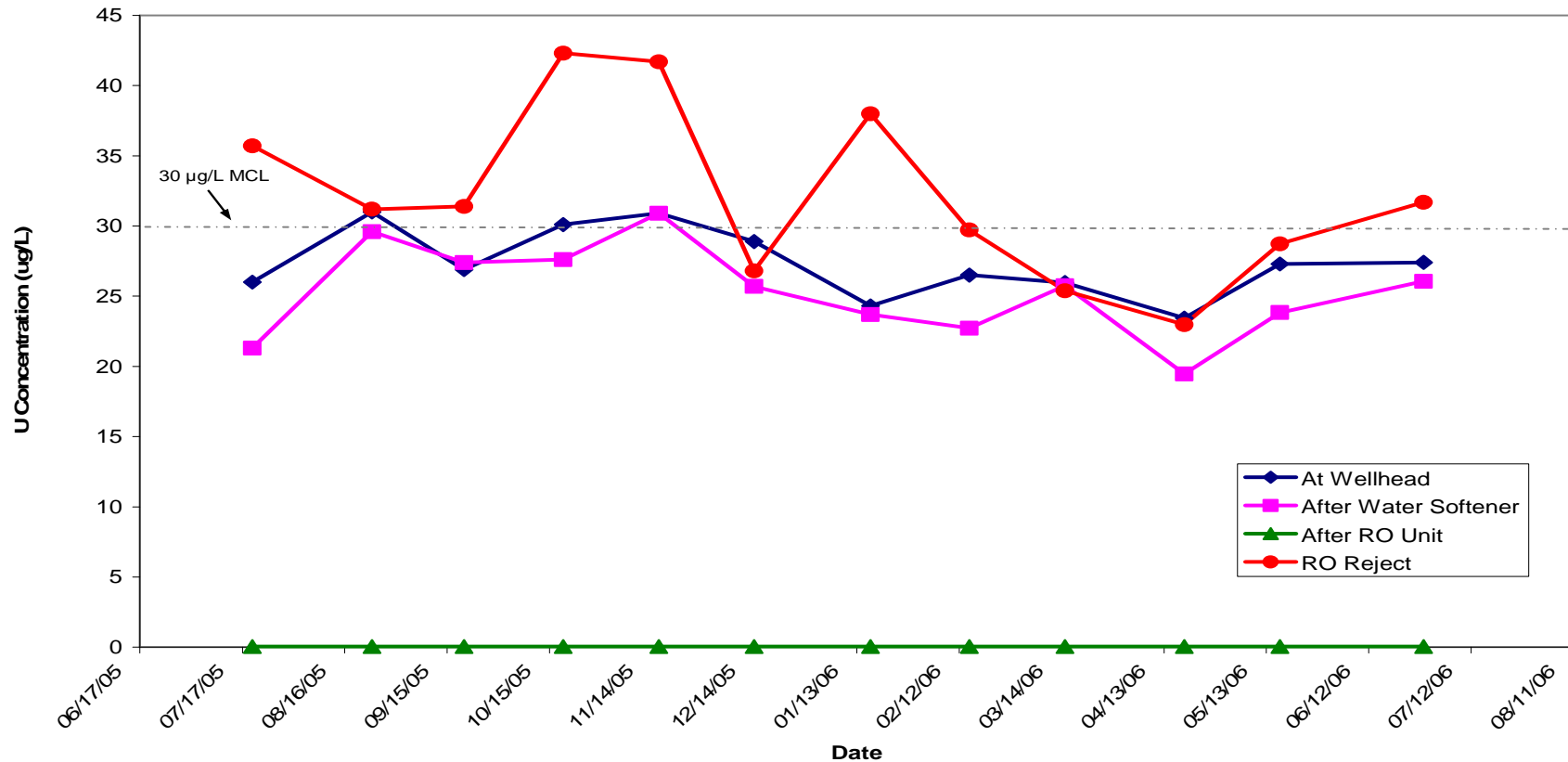


RESEARCH & DEVELOPMENT

*Building a scientific foundation for sound environmental decisions*

# POU RO System Performance – Uranium Removal

Total Uranium Results at Sunset Ranch Development



Note: Average concentration for nine water softeners and RO units.

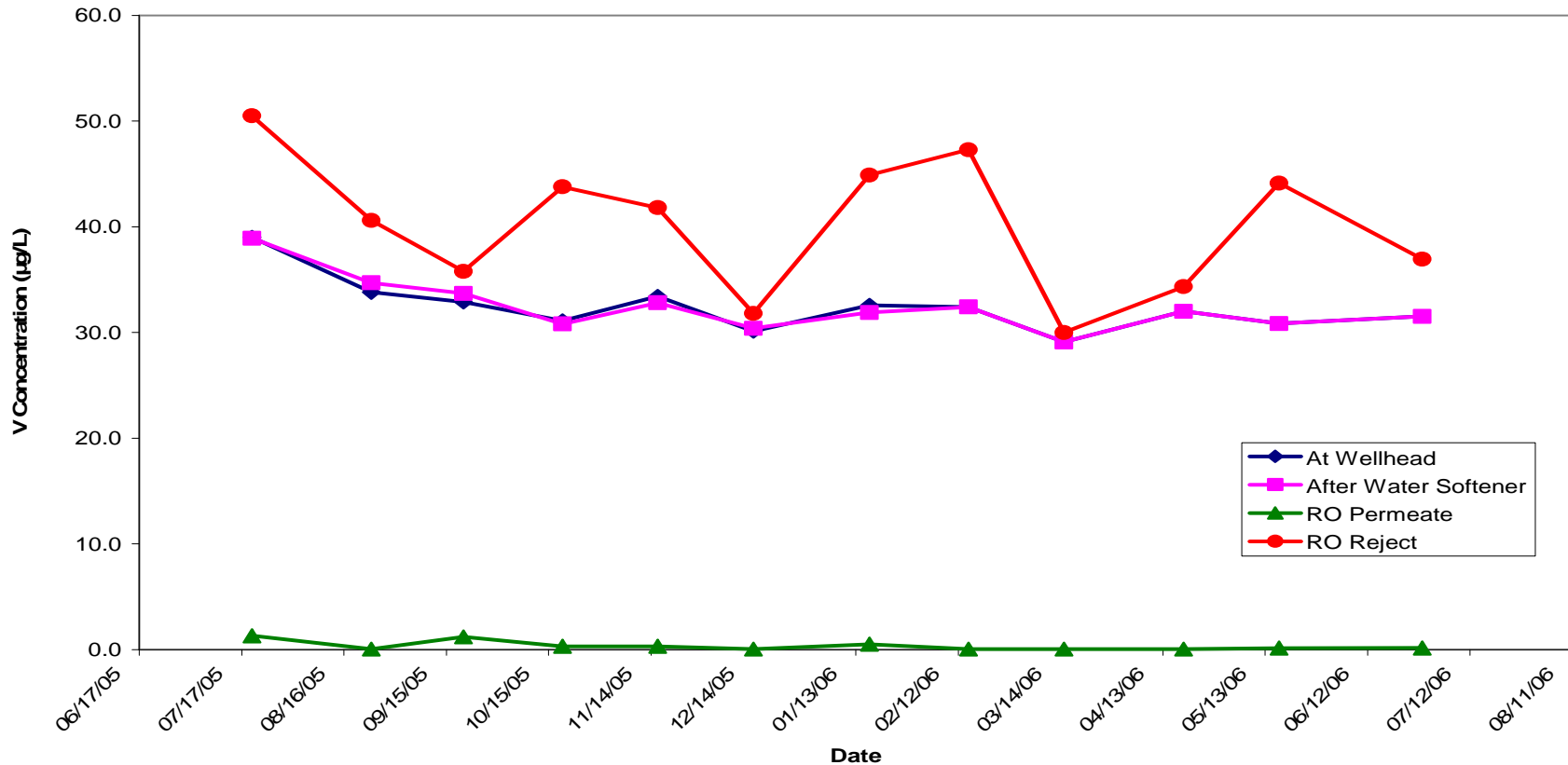


RESEARCH & DEVELOPMENT

*Building a scientific foundation for sound environmental decisions*

# POU RO System Performance – Vanadium Removal

Total Vanadium Results at Sunset Ranch Development



**Note: Average concentration for nine water softeners and RO units.**



RESEARCH & DEVELOPMENT

*Building a scientific foundation for sound environmental decisions*

## Homedale, ID – RO System Results

Parameter	Unit	Sunset Ranch Development	RO Treated Water*	Percent Removal
Total As (as As[V])	µg/L	46.5 – 62.6	0.4	99
Nitrate (as N)	mg/L	5.8 – 13.6	1.0	90
Total Uranium	µg/L	23.4 – 31.0	<0.1	99
TDS	mg/L	648 – 730	26.2	96
Hardness (as CaCO <sub>3</sub> )	mg/L	216 – 251	0.5	99
Total Alk (as CaCO <sub>3</sub> )	mg/L	283 – 317	12.4	96
Sulfate	mg/L	151 – 210	167	99
Silica (as SiO <sub>2</sub> )	mg/L	59.8 – 95.9	2.8	96
Total Iron	µg/L	<25 – 568	< 0.025	>78
Total Vanadium	µg/L	29.1 – 39.0	0.2	99
Fluoride	mg/L	0.6 – 5.2	0.1	92

\* Average



RESEARCH & DEVELOPMENT

*Building a scientific foundation for sound environmental decisions*



## Demonstration Sites with Multiple Contaminants

Sites	Well Flow gpm	Contaminants	
		Arsenic – ug/L	Other
Homedale, ID	10 Homes	52	U – 31 ug/L, NO <sub>3</sub> – 11 mg/L
Lake Isabella, CA	38	35	U – 32 ug/L
Fruitland, ID	250	50	NO <sub>3</sub> – 14 mg/L
Vale, ID	525	17	NO <sub>3</sub> – 10 mg/L
STMGID Reno, NV	350	88	Sb – 16 ug/L
Greenville, WI	375	34	Ra – 7 pC/L
Carmel, ME	30	21	Sb – 14 ug/L
Lyman, NE	250	20	U – 38 ug/L
North Smithfield, RI	18	20	Ra – 7 pC/L



# Upper Bodfish at Lake Isabella, CA

- 50 gpm HIX system by VEETech
- Influent:
  - As 35  $\mu\text{g/L}$
  - U 32  $\mu\text{g/L}$
  - pH 7.5
- Vendor anticipated working capacity 15,000 to 20,000 BV



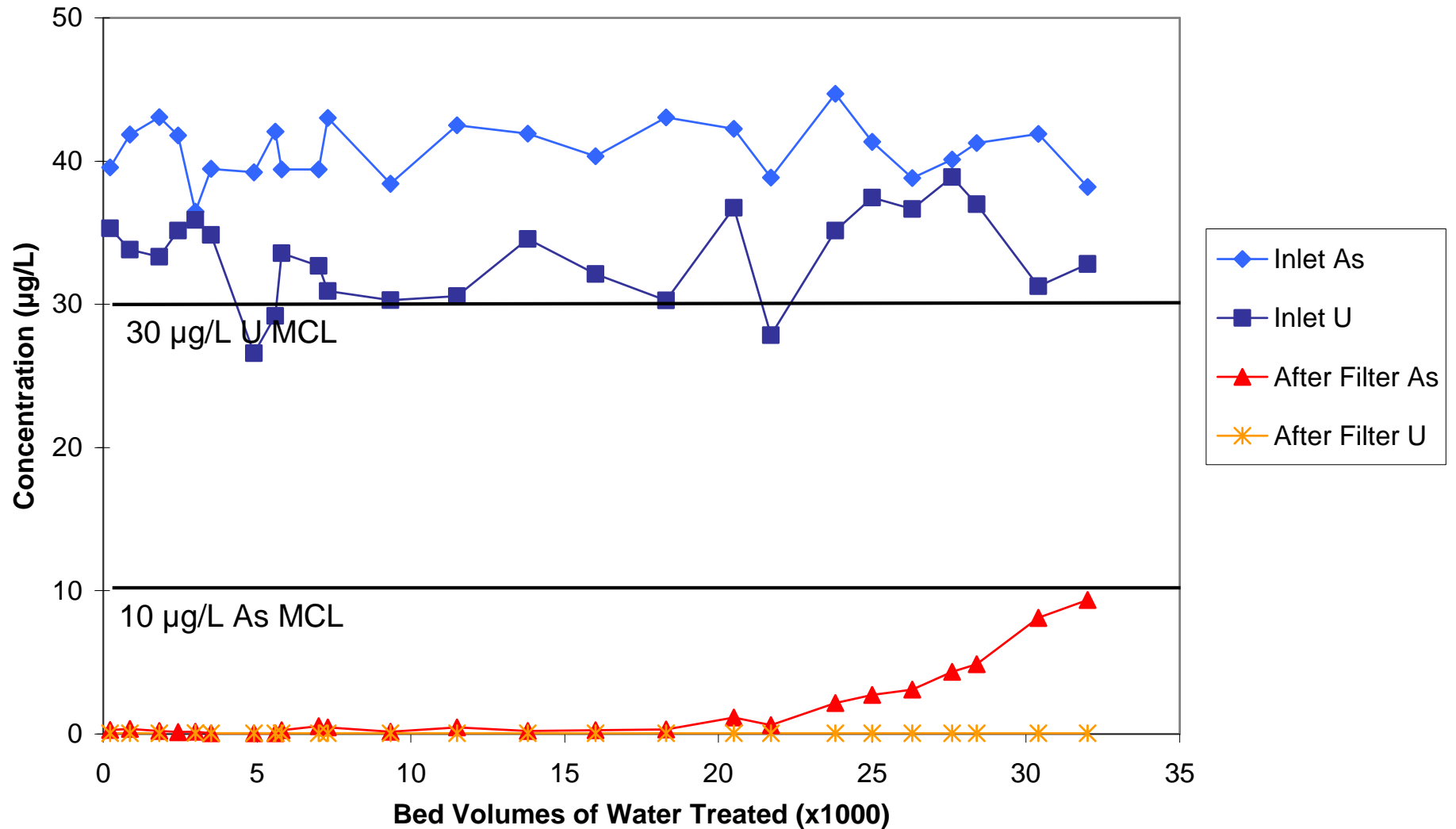
## **Lake Isabella, CA - Source Water Quality**

<b>Parameter</b>	<b>Unit</b>	<b>Source Water Concentration*</b>	<b>Remarks</b>
Total As (as As[V])	µg/L	36.5 – 47.3	Mostly As (V)
Total Uranium	µg/L	27– 39	~100% soluble
TDS	mg/L	234	-
pH	S.U.	6.8 – 7.2	-
Hardness (as CaCO <sub>3</sub> )	mg/L	70 – 96	-
Total Alk (as CaCO <sub>3</sub> )	mg/L	88 – 145	-
Sulfate	mg/L	36 – 41	-
Silica (as SiO <sub>2</sub> )	mg/L	40 – 48	-
Total Iron	µg/L	<25	Mostly particulate

\*Range of 28 – 29 samples during study



# Arsenic and Uranium Removal at Lake Isabella, CA



RESEARCH & DEVELOPMENT

*Building a scientific foundation for sound environmental decisions*

## Lake Isabella, CA – RSSCT/Full Scale System Test Results

Test	Media	Media Run Length (BV)	
		10- $\mu$ g/L Arsenic	30- $\mu$ g/L Uranium
Full-Scale	ArsenX <sup>np</sup>	33,100	> 33,100
RSSCT	ArsenX <sup>np</sup>	28,000	> 50,000
	E33	44,000	12,000
	GFH	50,000	25,000
	MetsorbG	21,000	> 24,000*
	Adsorbsia GTO	16,000	26,000

\* Column failed due to pressure buildup and bed compaction.



# ***Lake Isabella, CA – Media Disposal Issue***

## **Uranium Concentration on ArsenX<sup>np</sup>**

**Uranium on the media calculated to be 0.13% by weight and, therefore, above the 0.05% “unimportant limit.”**

**Media classified as low level radioactive waste.**

**Disposal options investigated:**

- 1. Partial onsite regeneration**
- 2. Complete off site regeneration**
- 3. Disposal and replacement**

**Utility returning treatment system to EPA. Closing well down.**





## Demonstration Sites with Multiple Contaminants

Sites	Well Flow gpm	Contaminants	
		Arsenic – ug/L	Other
Homedale, ID	10 Homes	52	U – 31 ug/L, NO <sub>3</sub> – 11 mg/L
Lake Isabella, CA	38	35	U – 32 ug/L
Fruitland, ID	250	50	NO <sub>3</sub> – 14 mg/L
Vale, ID	525	17	NO <sub>3</sub> – 10 mg/L
STMGID Reno, NV	350	88	Sb – 16 ug/L
Greenville, WI	375	34	Ra – 7 pC/L
Carmel, ME	30	21	Sb – 14 ug/L
Lyman, NE	250	20	U – 38 ug/L
North Smithfield, RI		20	Ra – 7 pC/L



## Fruitland, ID & Vale, OR - Source Water Quality

Parameter	Unit	Fruitland, ID 	Vale, OR 
Population		4,000	1,976
Flow	gpm	250 (D)/160 (A)	540 (D)
Total As (as As[V])	µg/L	42.1	16.5-20
Nitrate (as N)	mg/L	14	8-12
Sulfate	mg/L	53	75-84
pH	unit	7.6	7.5
Total Alk (as CaCO <sub>3</sub> )	mg/L	379	158
TDS	mg/L	651	446
Uranium	µg/L	22.4	6.1
Vanadium	µg/L	34.0	46.8
TOC	mg/L	2.2	2.1

D = design, A = actual





**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*



D = design, A = actual

## IX System Design

Parameter	Unit	Fruitland, ID 	Vale, OR 
Resin Type		Purolite A-300E (SBA)	Purolite Arsenex II (SBA)
Resin Quantity	ft <sup>3</sup>	50 (per tank) 100 (total)	110 (per tank) 220 (total)
Resin Vessels	gpm	2, 48"Dx72"H in parallel	2, 63"Dx86"H in parallel
Hydraulic Loading	gpm/ft <sup>2</sup>	10(D)/6.3(A)	12.5(D)
EBCT	min	3.0(D)/4.7(A)	3.0(D)
Estimated Run Length	BV	400-500	550
Salt Saturator		1, 15-ton	2, 11-ton
Regeneration Level	lb/ft <sup>3</sup>	10	8
Brine Recycle		No	Yes



RESEARCH & DEVELOPMENT

*Building a scientific foundation for sound environmental decisions*

Fruitland, ID



**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*



**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*

# ***System Performance***

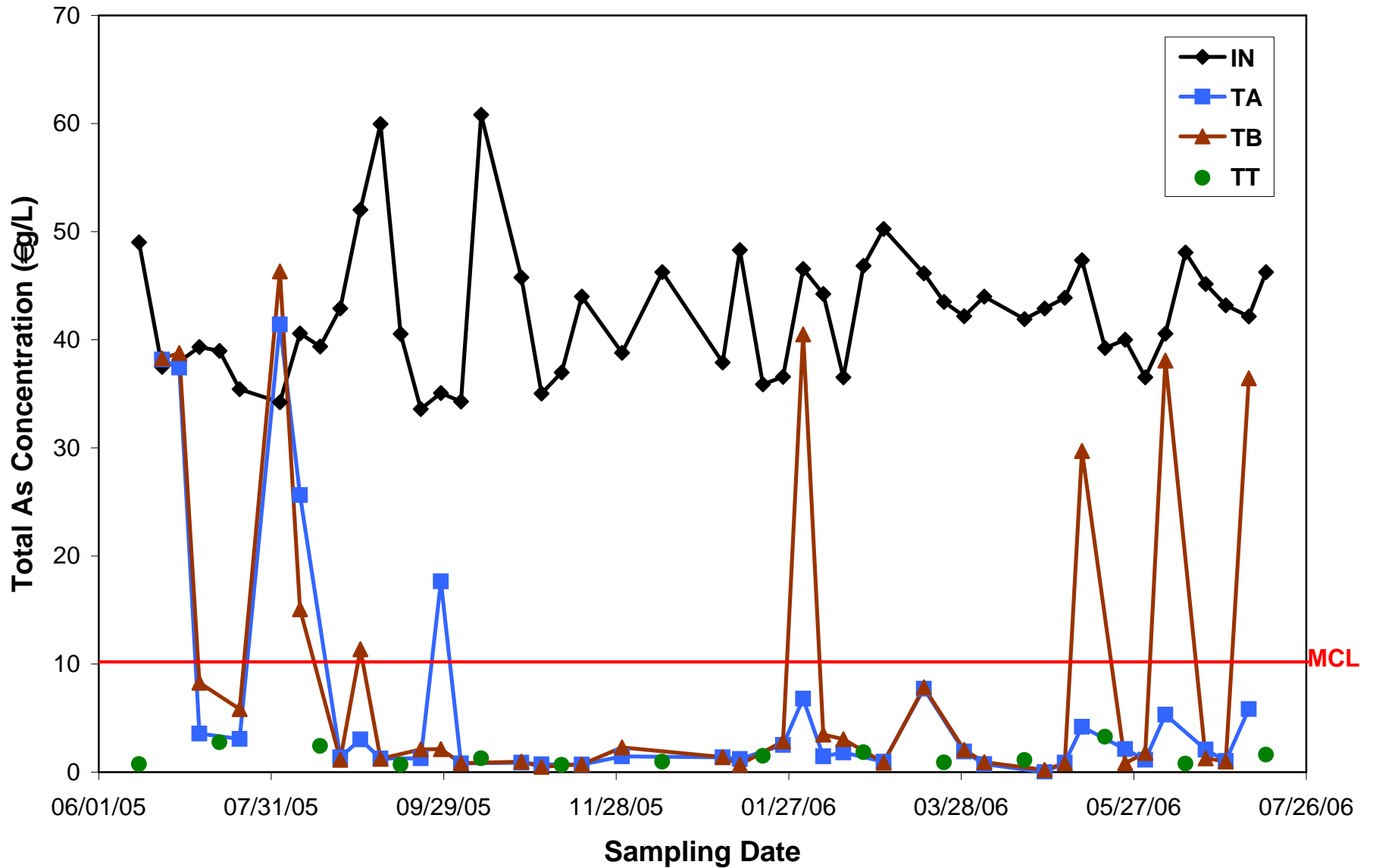
## ***Fruitland, ID***



**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*

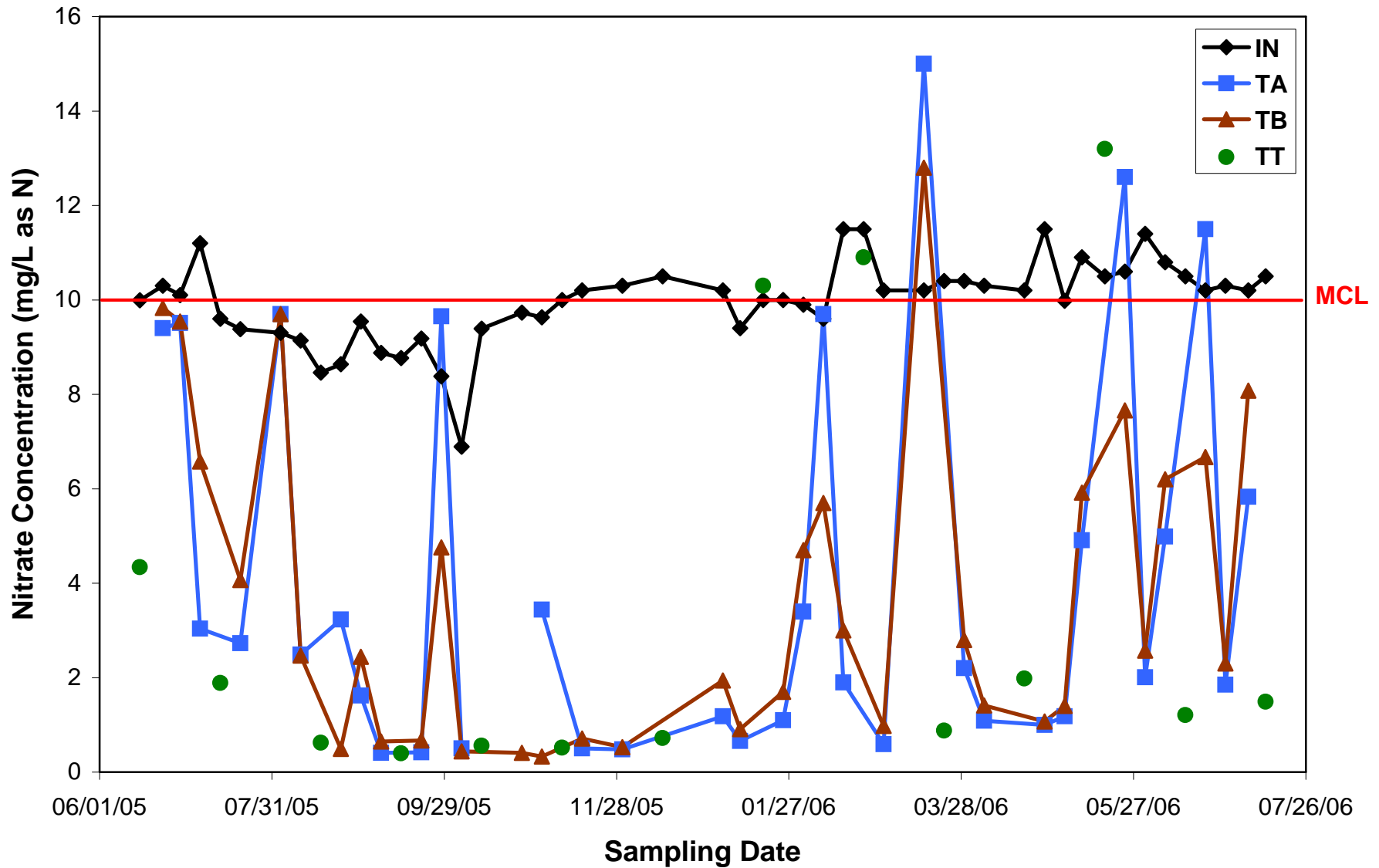
# Fruitland, ID - Total Arsenic Removal



RESEARCH & DEVELOPMENT

*Building a scientific foundation for sound environmental decisions*

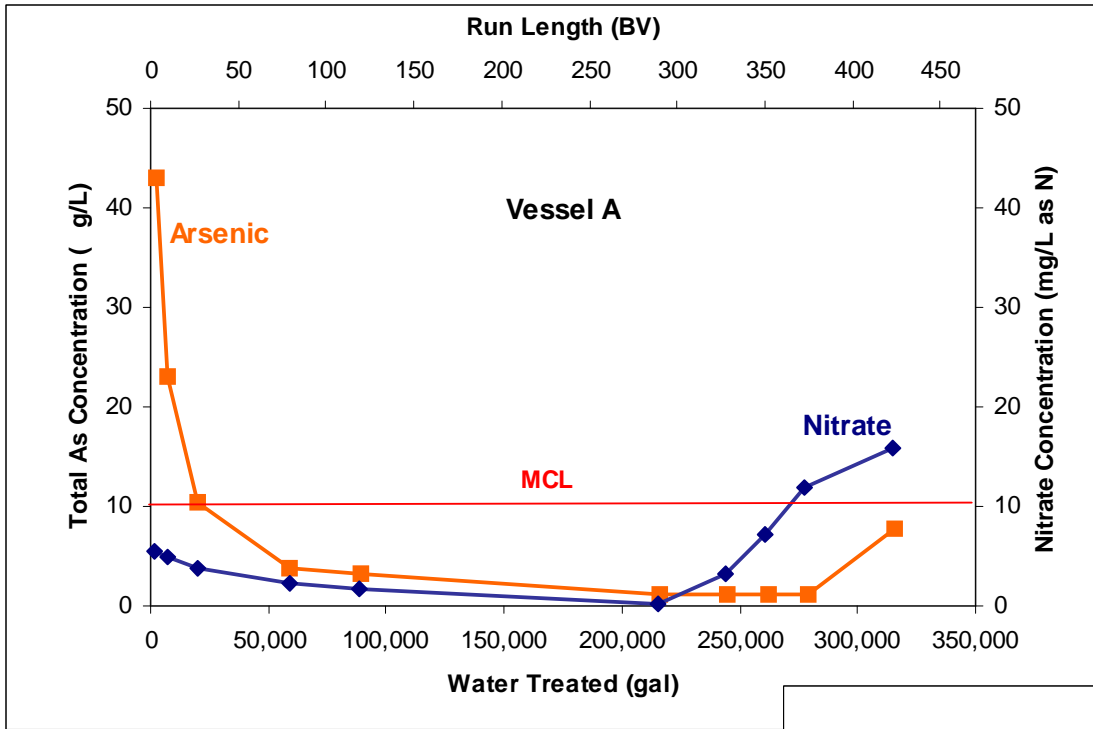
# Fruitland, ID - Total Nitrate Removal



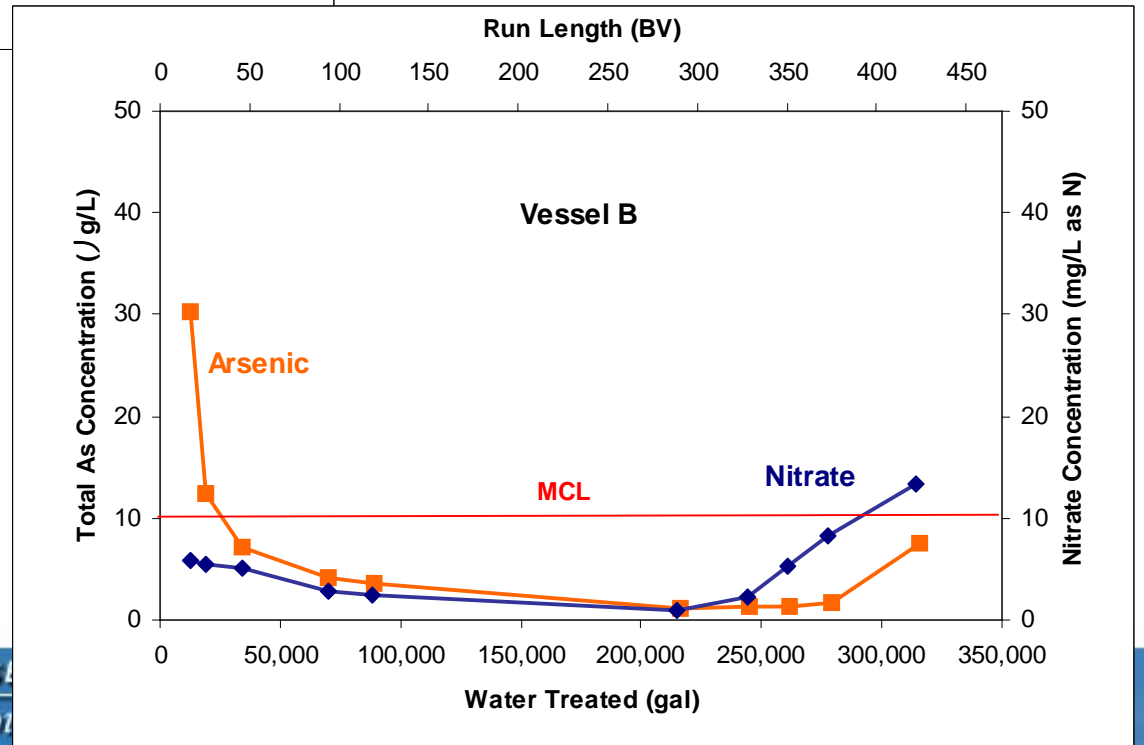
RESEARCH & DEVELOPMENT

*Building a scientific foundation for sound environmental decisions*

## Fruitland, ID - Total As/Nitrate Breakthrough Curves



Raw water  
 Total As = 37.7 µg/L  
 Nitrate = 8.6 mg/L as N



# ***Fruitland, ID – System Problems***

Performance (IX Runs)

Early projections – 400 - 500 BVs

Actual performance – 285 -315 BVs

Early leakage of arsenic

No removal of either As or NO<sub>3</sub>

Public notification require (NO<sub>3</sub>)





# ***Fruitland, ID – System Problems***

## Equipment

Regeneration system – improper and incomplete regeneration.

(Brine: 0 - 4 - 8%)

(Settings: Co-current/Counter-current)

Ultimate problem: Fouling of resin that reduced length of runs and increased salt usage.



**Trace Detect  
Continuous  
Arsenic  
Monitor**

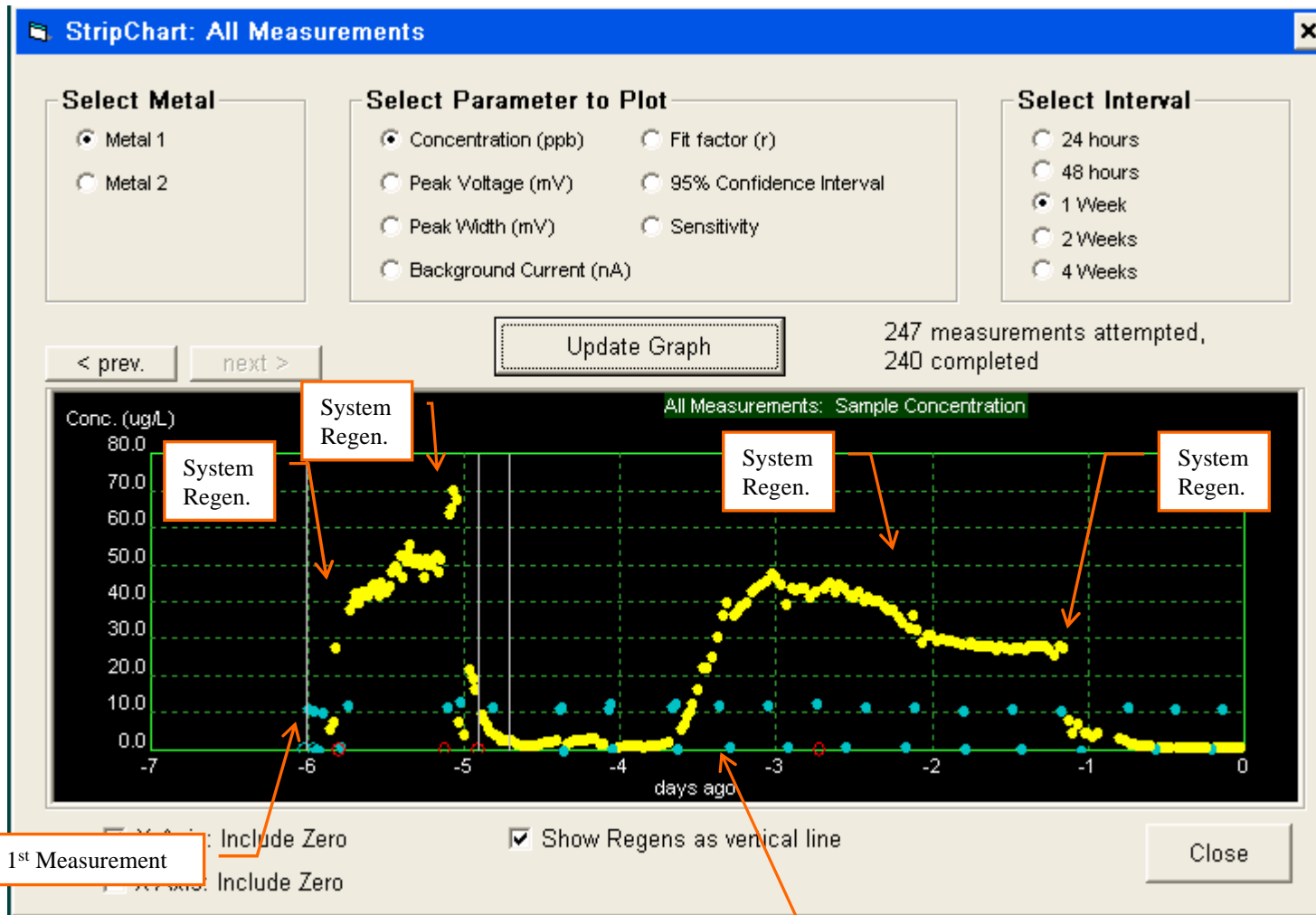
**Fruitland, ID**



**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*

# Fruitland Well #6 - First Six Days of Operation



KEY:

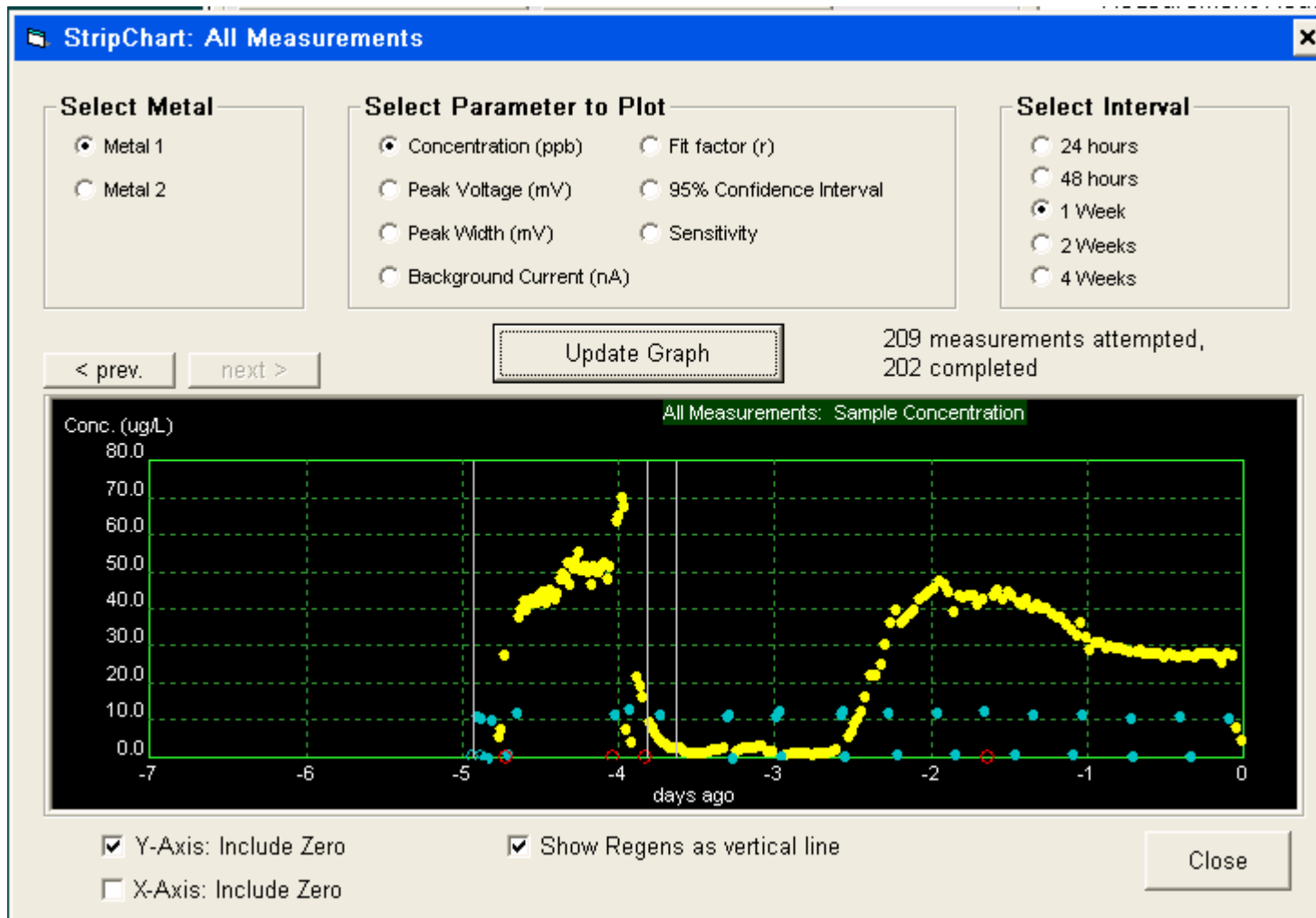
Yellow	Treated Water
Blue	Check sample (10 or 0 ppb)
Red	failed or aborted measurement

Media Breakthrough?



RESEARCH & DEVELOPMENT

*Building a scientific foundation for sound environmental decisions*



**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*

# ***Vale, OR – System Problems***

Performance (IX Runs)

Early projections – 550 to 680 BVs

Actual performance – 150 to 365 BVs



# ***Vale, OR – System Problems***

## Equipment

Regeneration system – High use of salt.

(Brine: 12%)

Ultimate problem: Fouling of resin that reduced length of runs and increased salt usage.



## Demonstration Site with Multiple Contaminants

Sites	Well Flow gpm	Contaminants	
		Arsenic – ug/L	Other
Homedale, ID	10 Homes	52	U – 31 ug/L, NO <sub>3</sub> – 11 mg/L
Lake Isabella, CA	38	35	U – 32 ug/L
Fruitland, ID	250	50	NO <sub>3</sub> – 14 mg/L
Vale, ID	525	17	NO <sub>3</sub> – 10 mg/L
STMGID Reno, NV	350	88	Sb – 16 ug/L
Greenville, WI	375	34	Ra – 7 pC/L
Carmel, ME	30	21	Sb – 14 ug/L
Lyman, NE	250	20	U – 38 ug/L
North Smithfield, RI		20	Ra – 7 pC/L



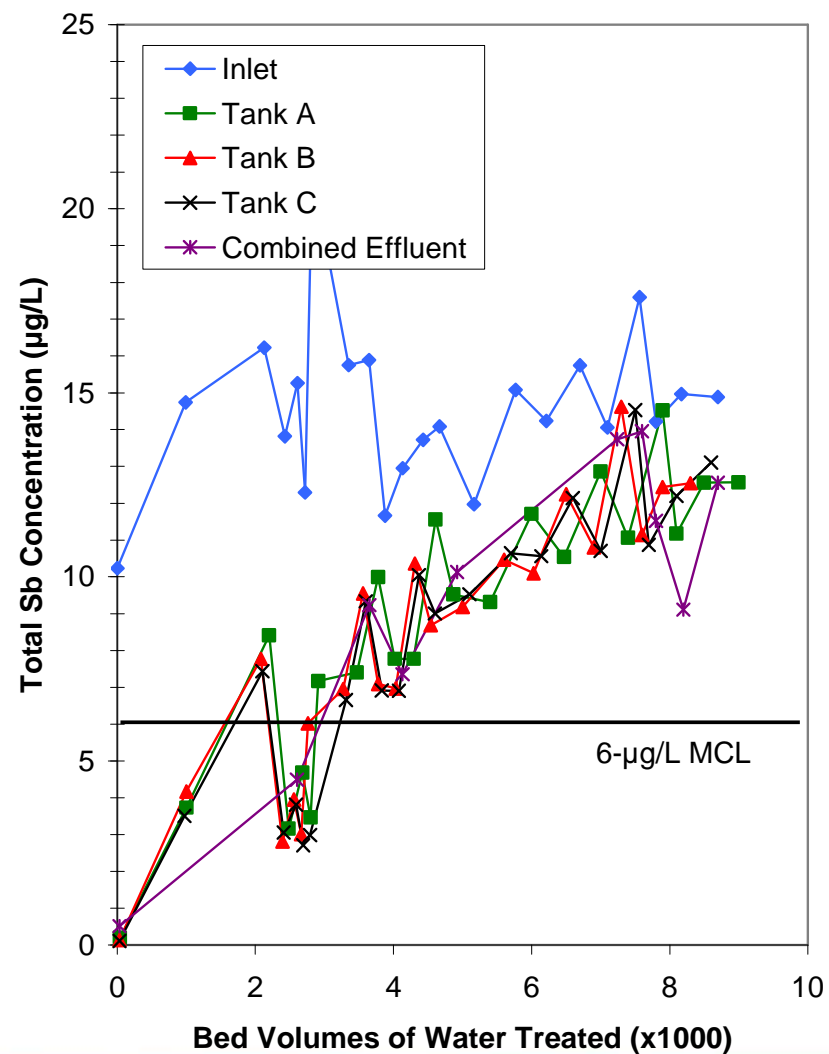
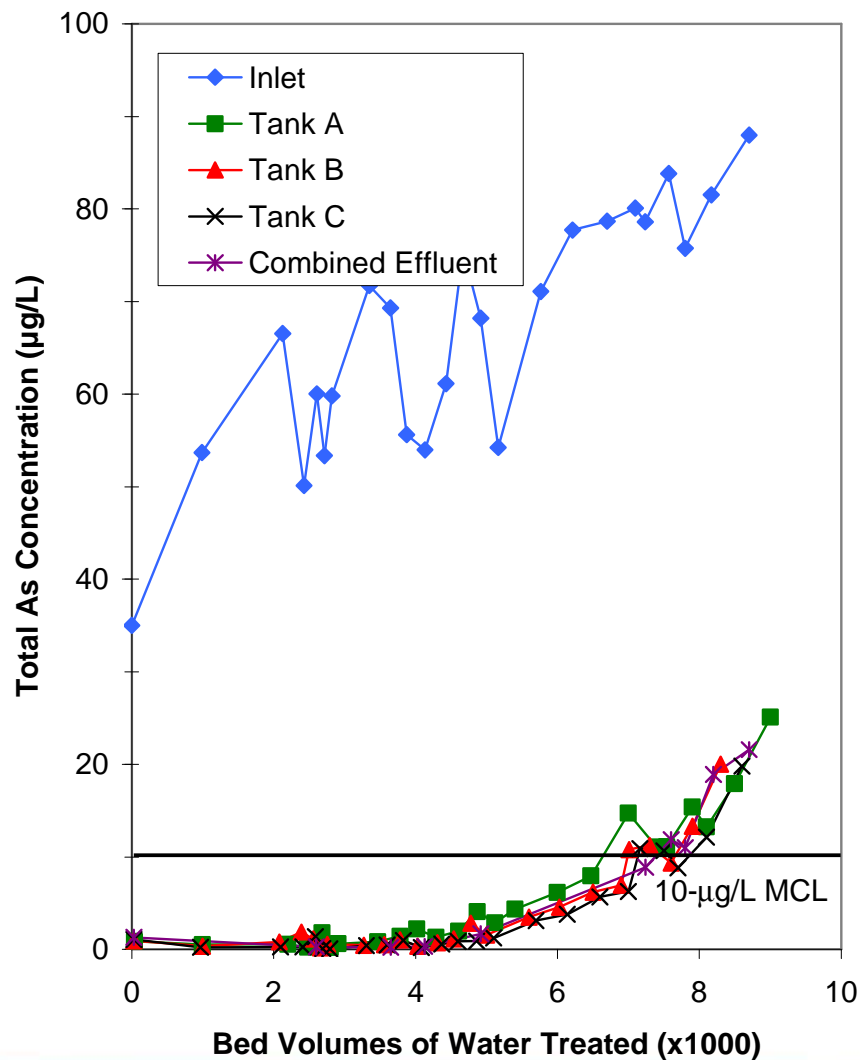
## ***STMGID, Reno, NV Treatment Plant***

- 350 gpm GFH system by USFilter
- Influent:
  - As 39  $\mu\text{g/L}$
  - Sb 15  $\mu\text{g/L}$
  - SiO<sub>2</sub> 69 mg/L
  - pH 7.4
- Vendor anticipated working capacity 38,000 BV





# Arsenic and Antimony Removal Using GFH at STMGID, Reno, NV



RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions



*Building a scientific foundation for sound environmental decisions*

**Arsenic RSSCT Study – STMGID Site**  
**(As 39 ug/L, pH 7.4 , SiO<sub>2</sub> – 69 mg/L)**

<b>Media</b>	<b>Lab Test BVs to 10 ug/L</b>	<b>Field Test BVs to 10 ug/L</b>
GFH	11,000	16,200
E33	NA	8,700
KemIron (1)	NA	12,400
KemIron (2)	NA	9,400
Adsorbia GTO	4,500	NA
ARM 200	7,900	NA
ArsenX <sup>np</sup>	7,900	NA
Metsorb G	NA	5,200



**Antimony RSSCT Study – STMGID Site**  
**(As 39 ug/L, pH 7.4 , SiO<sub>2</sub> – 69 mg/L)**

<b>Media</b>	<b>Lab Test (BVs) to 10 ug/L</b>	<b>Field Test (BVs) T0 10 ug/L</b>
GFH	<2,000	3,000
E33	NA	2,800
KemIron (1)	NA	4,900
KemIron (2)	NA	8,000
Adsorbia GTO	NA	NA
ARM 200	Low	NA
ArsenX <sup>np</sup>	Low	NA
Metsorb G	NA	4,500



## ***STMGID – Media Change (330 cf)***

Media Replacement (\$60,000)

GFH – 1 tank

KemIron - 2 tanks

Arsenic break through to 10 ug/L at 3,700BV's

Utility considering the conversion of adsorptive media process to coagulation/filtration





**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*



RESEARCH & DEVELOPMENT

*Building a scientific foundation for sound environmental decisions*



**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*



# ***Response to Call for Help To Remove Toilet Seat***

Response to call for help to remove toilet seat!

Two policemen

Two EMS staff

Two firemen

Two volunteer firemen

Response for help on water treatment plant problem.

Equipment manufacturer - ?



## Demonstration Site with Multiple Contaminants

Sites	Well Flow gpm	Contaminants	
		Arsenic – ug/L	Other
Homedale, ID	10 Homes	52	U – 31 ug/L, NO <sub>3</sub> – 11 mg/L
Lake Isabella, CA	38	35	U – 32 ug/L
Fruitland, ID	250	50	NO <sub>3</sub> – 14 mg/L
Vale, ID	525	17	NO <sub>3</sub> – 10 mg/L
STMGID Reno, NV	350	88	Sb – 16 ug/L
Greenville, WI	375	34	Ra – 7 pC/L
Carmel, ME	30	21	Sb – 14 ug/L
Lyman, NE	250	20	U – 38 ug/L
North Smithfield, RI	18	20	Ra – 7 pC/L



**Carmel ES, Carmel, ME**

**RO Pilot Study**



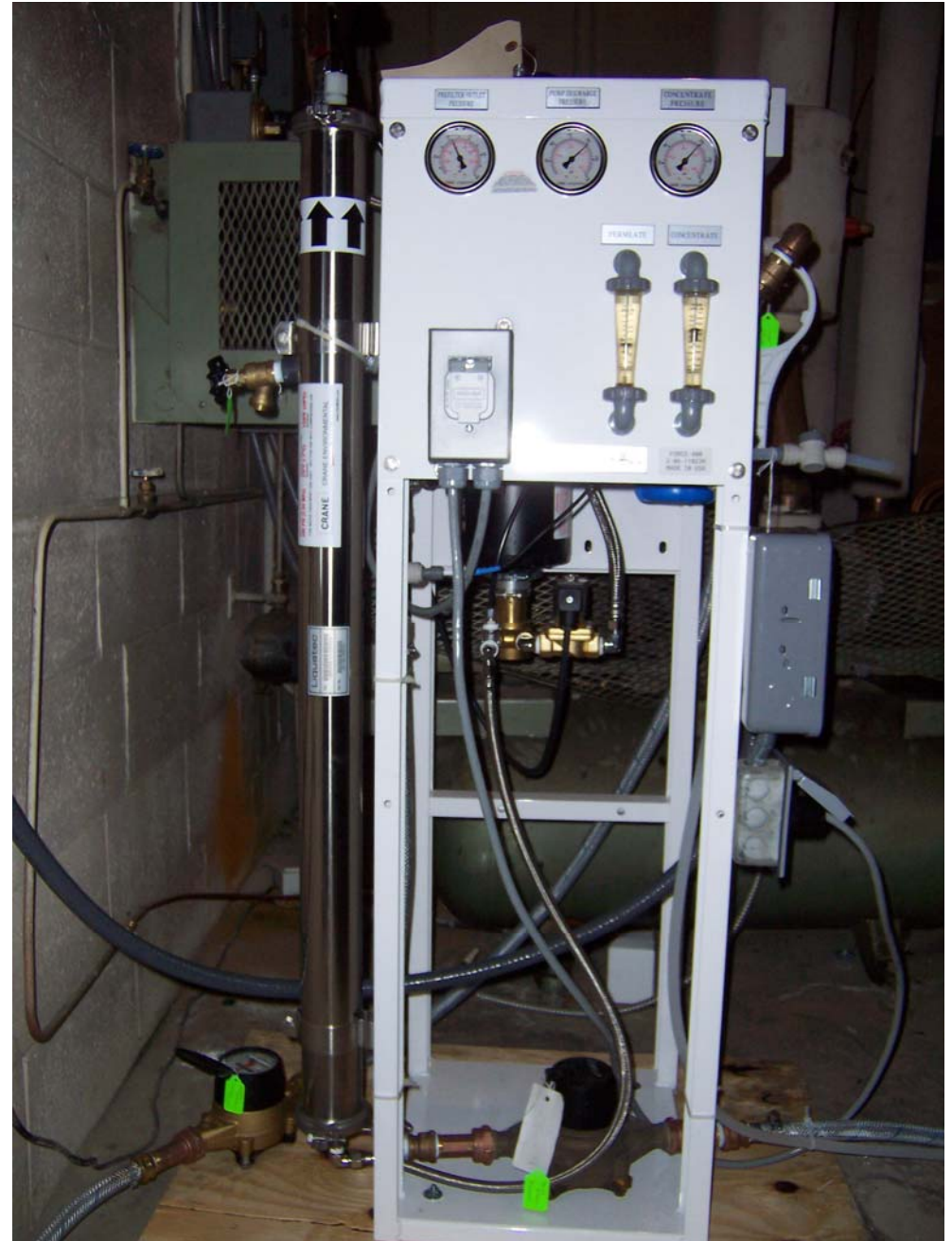
Source water

AsV 21-30 ug/L

Sb 10 – 12 ug/L

TDS 240 – 250 mg/L

pH 7.5



RESEARCH & DEVELOPMENT

*Building a scientific foundation for sound environmental decisions*

***Carmel ES, Carmel, ME - RO Pilot Study  
March, 2006 – July, 2007***

Substance	Source Water	RO Treated Water
As – ug/L	21 – 30	0.2
Sb – ug/L	10 – 12	<0.1
TDS – mg/L	240 – 250	4
pH - units	7.5	5.6


**Plan to install RO system under arsenic demonstration study**



# ***Acknowledgements***

- Battelle Memorial Institute – Columbus OH
- Water utilities participating in the arsenic demonstration program



The background of the slide is a solid blue color with a large, faint, circular seal of the United States Environmental Protection Agency (EPA) centered behind the text. The seal features a stylized flower with three leaves and a central sun-like symbol, surrounded by the words "ENVIRONMENTAL PROTECTION AGENCY" and "UNITED STATES OF AMERICA".

**Tom Sorg**

**513/ 569-7370**

**[sorg.thomas@epa.gov](mailto:sorg.thomas@epa.gov)**