# *Arsenic: USEPA Demonstration Program and Latest Research Results*

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# *Topics*

- Short Summary of USEPA Arsenic Demonstration Program

- Latest Research

# *USEPA Arsenic Demonstration Program*

- $23 million will have been funded on the arsenic demonstration program. ($12M EPA; $11M Congress)

- Three sets of projects (50 sites):

  Round 1 – 12 demonstration projects

  Round 2 – 28 demonstration projects

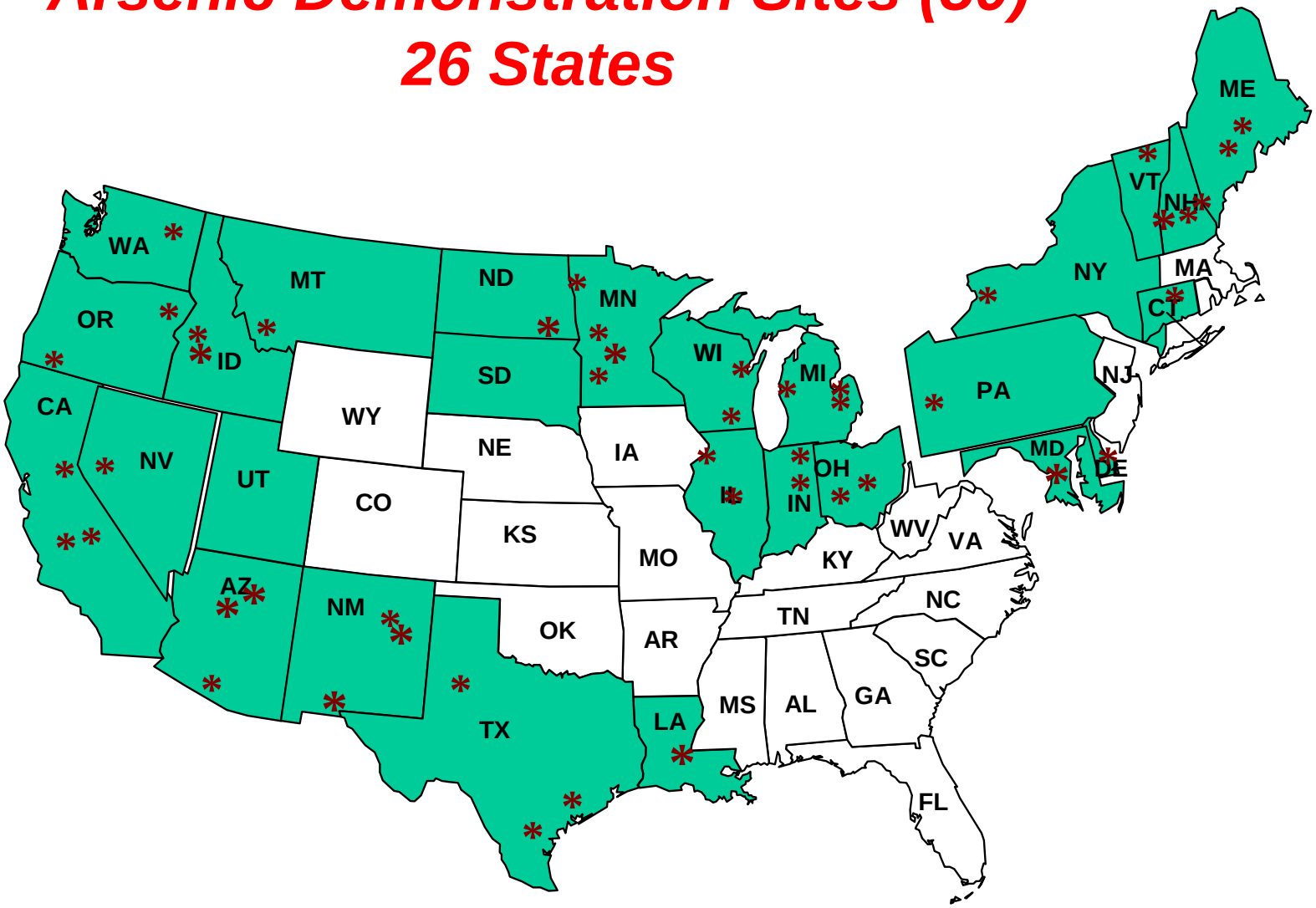
  Round 2a – 10 demonstration projects

- Focused on commercially ready technologies or engineering approaches

# *Arsenic Demonstration Projects*
# *50 projects – 26 States*

| States | No. of Sites | States | No. of Sites |
|---|---|---|---|
| ME | 3 | ND | 1 |
| NH | 3 | SD | 1 |
| VT | 1 | LA | 1 |
| CT | 2 | TX | 3 |
| NY | 1 | NM | 3 |
| DE | 1 | AZ | 3 |
| MD | 1 | UT | 1 |
| PA | 1 | ID | 2 |
| OH | 2 | NV | 1 |
| MI | 3 | MT | 1 |
| WI | 2 | WA | 1 |
| IL | 2 | OR | 2 |
| MN | 4 | CA | 3 |

# Arsenic Demonstration Sites (50)
# 26 States



# *Arsenic Removal Technologies – 50 projects (Rd 1& 2)*

| Technologies | Total |
|---|---|
| Adsorption media | **26** |
| Adsorptive media w/ Pretreatment (IR) | **2** |
| Iron Removal | **12** |
| Coagulation/Filtration | **3** |
| Ion Exchange ($NO_3$) | **2** |
| POU - RO | **1** |
| RO | **1** |
| System Modification (Iron Removal) | **1** |
| To be selected | **2** |

# *Adsorptive Media*

| Adsorption Media Products (10) |
|---|
| ***E33S & E33P*** |
| ***GFH*** |
| ***ATS Complex 2000*** |
| ***Isolux™*** |
| ***ArseneX$^{np}$*** |
| ***ARM 200*** |
| ***AAFS 50*** |
| ***G2*** |
| **ADSORBSIA** |
| **Kemlron** |

# *Arsenic Demonstration Program – 50 Projects*

| Program | Sites | Systems Installed | Studies Completed | Progress Reports | Final Reports |
|---|---|---|---|---|---|
| Round 1 | 12 | 12 | 7 | 10 | 2 |
| Round 2 | 28 | 25 | 14 | 11 | 2 |
| **Round 2a** | **10** | **0** | **0** | **0** | **0** |
| **TOTALS** | **50** | **37** | **21** | **21** | **4** |

Reports provided on EPA web page at:

http://www.epa.gov/ORD/NRMRL/wswrd/dw/arsenic/

# *Latest Research Results*

- Questions/Responses
- Future

# *Common Questions / Responses*

Question 1

What was basis for equipment selection?

# *Common Questions / Responses*

## Question 1 – Response

## Major Considerations

**Water Quality – Iron / Arsenic / Co-contaminants**

Residuals – Type/Quantity and Disposal Options Available

System Operating Cost

# *Arsenic Removal Technologies*

Major Player

**Iron**

"a very effective adsorber of arsenic"

# ***Rule of Thumb***

**Removal of 1 mg/L of iron**

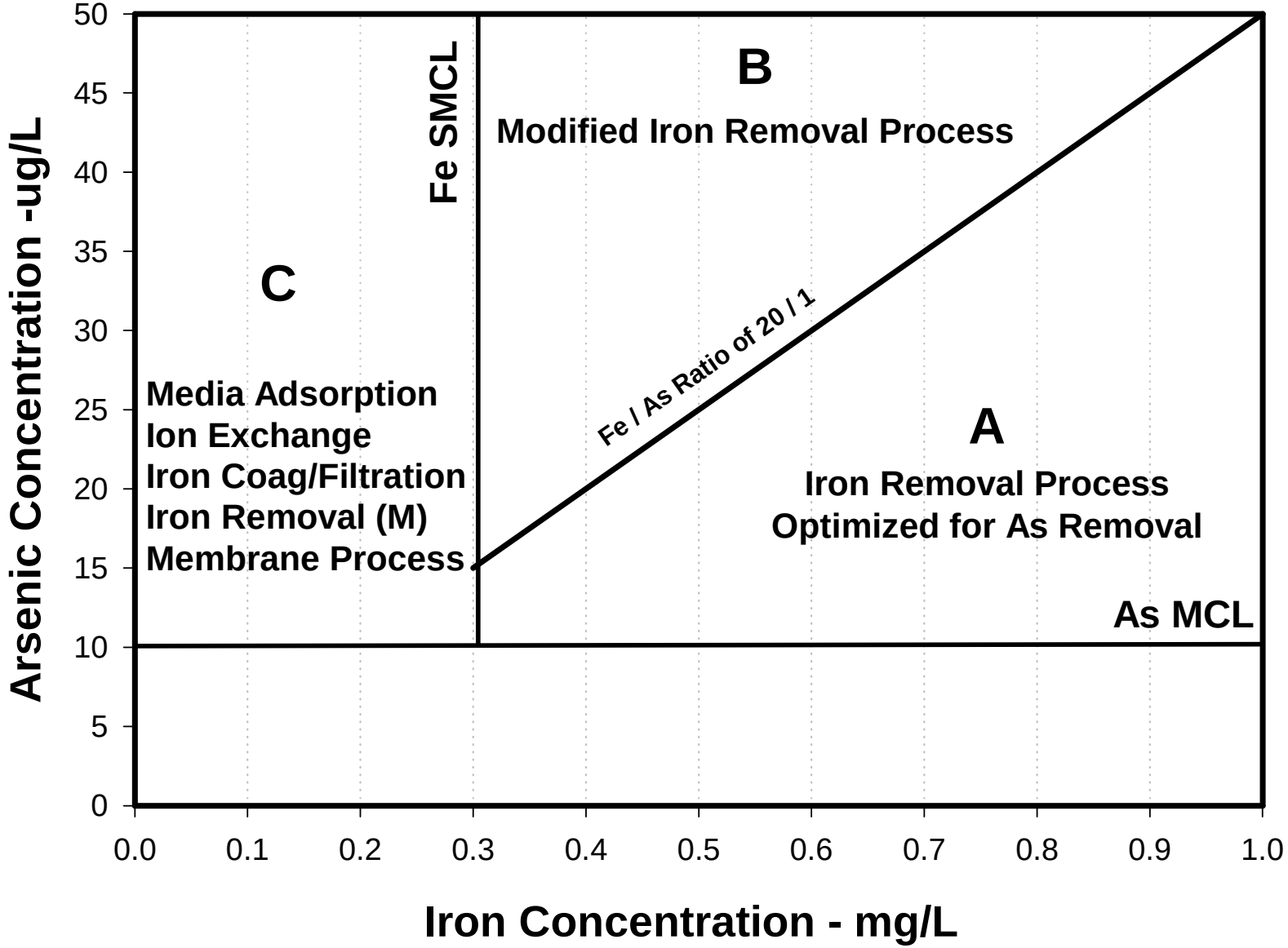
**achieves**

**removal of 50 ug/L arsenic**
**(Optimized condidtions)**

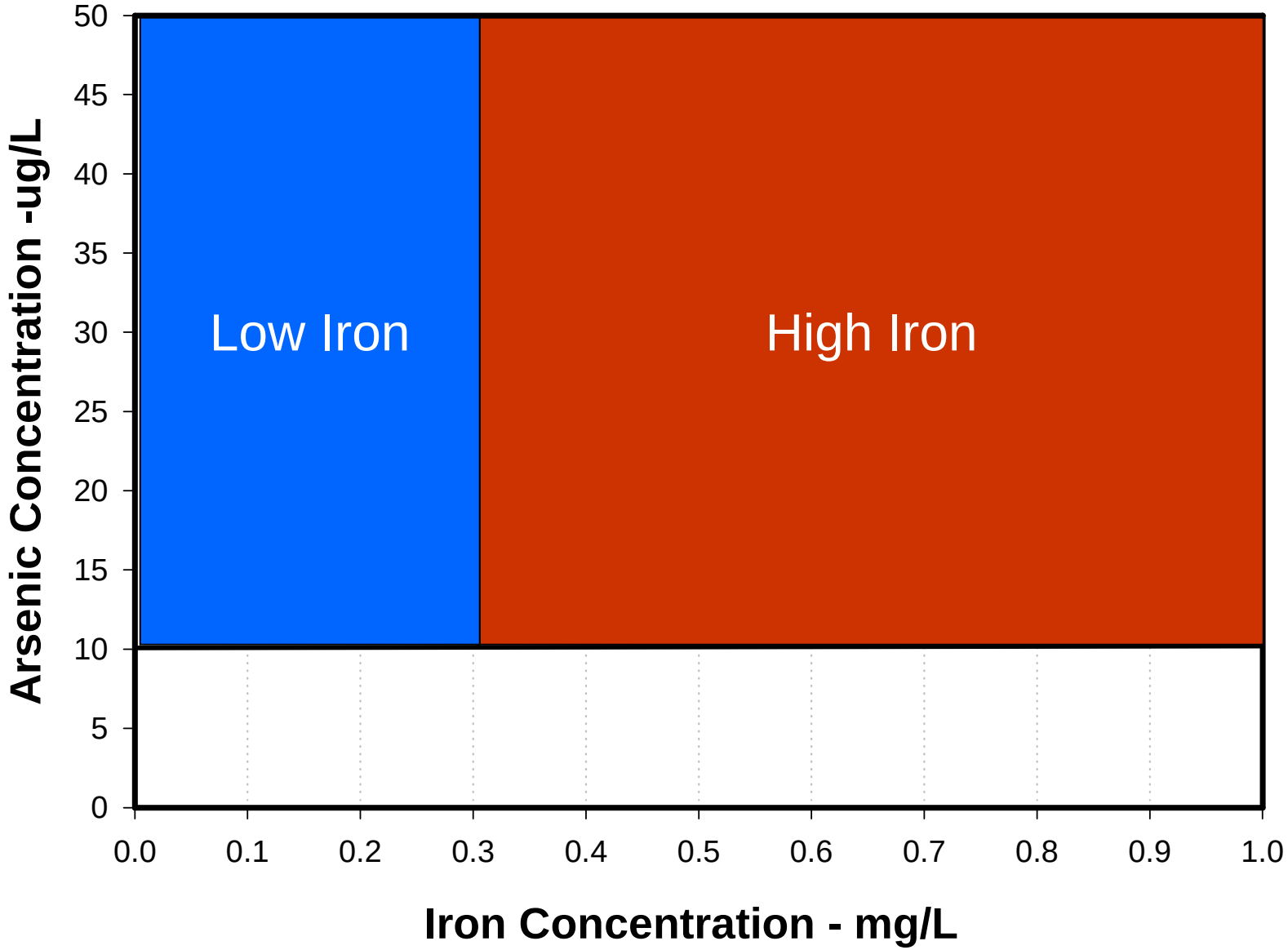
# Iron common to many ground waters!

Removal of iron leads to removal of arsenic!

## Arsenic Removal Technology Selection Guide Based Upon the Arsenic and Iron Concentration in the Source Water.



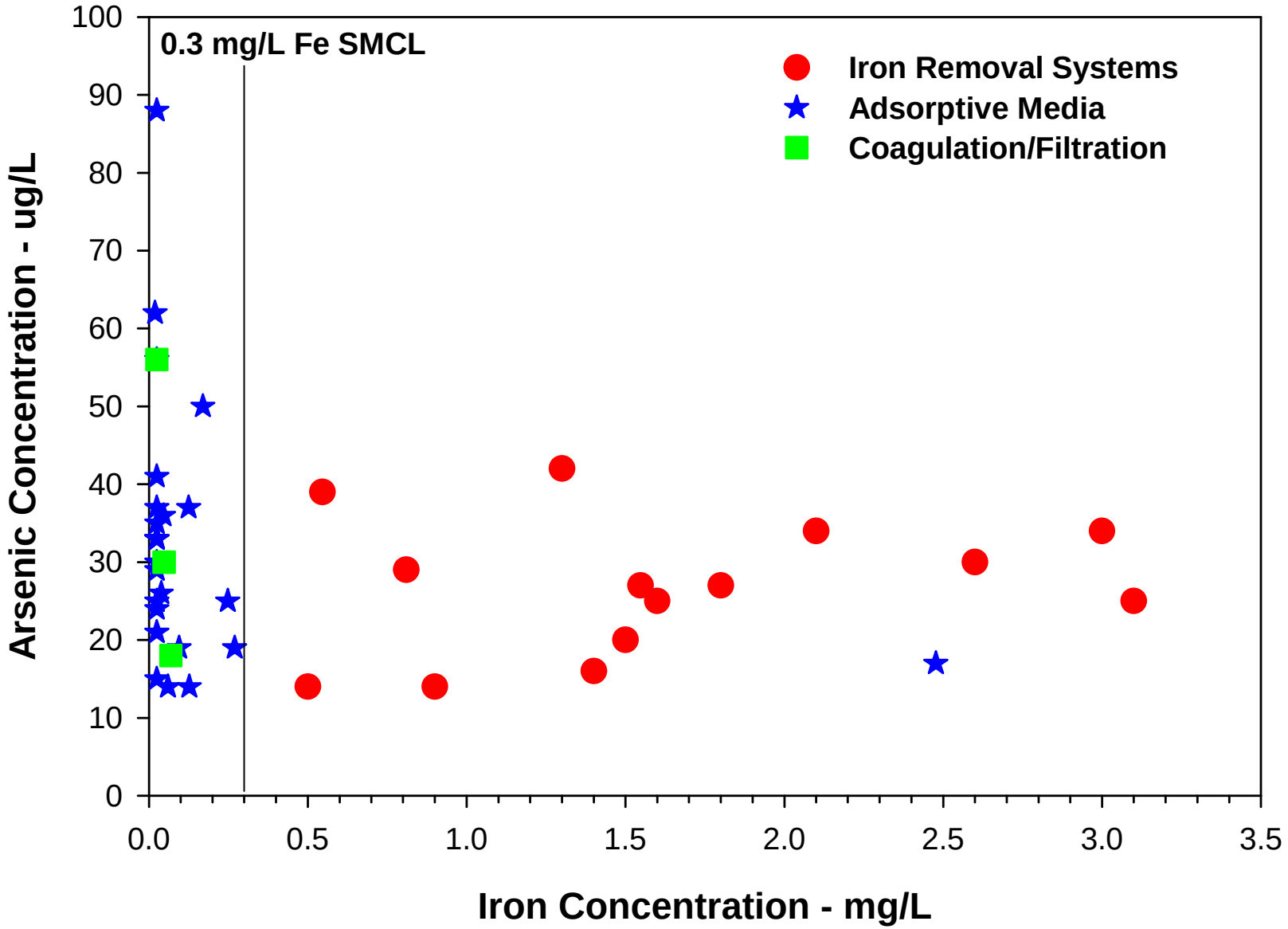
## Arsenic Removal Technology Selection Guide Based Upon the Arsenic and Iron Concentration in the Source Water.



# Technologies – Raw Water Arsenic/Iron Concentrations

| Site | As ug/L | Fe mg/L | Tech. | Site | As ug/L | Fe mg/L | Tech. | Site | As ug/L | Fe mg/L | Tech. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **25** | **3.10** | **IR** | 18 | **19** | **0.27** | **AM** | 35 | **35** | **0.02** | **AM** |
| 2 | **34** | **3.00** | **IR** | 19 | **25** | **0.25** | **AM** | 36 | **15** | **0.02** | **AM** |
| 3 | **30** | **2.60** | **IR** | 20 | **50** | **0.17** | **AM** | 37 | **56** | **0.02** | **CF** |
| 4 | **17** | **2.48** | **AM** | 21 | **28** | **0.16** | | 37 | **33** | **0.02** | **AM** |
| 5 | **34** | **2.10** | **IR** | 22 | **52** | **0.13** | **POU** | 39 | **17** | **0.02** | **IE** |
| 6 | **27** | **1.80** | **IR** | 23 | **14** | **0.13** | **AM** | 40 | **37** | **0.02** | **AM** |
| 7 | **25** | **1.60** | **IR/AM** | 24 | **37** | **0.13** | **AM** | 41 | **29** | **0.02** | **AM** |
| 8 | **27** | **1.55** | **IR** | 25 | **19** | **0.10** | **AM** | 42 | **33** | **0.02** | **AM** |
| 9 | **20** | **1.50** | **IR** | 26 | **18** | **0.07** | **CF** | 43 | **41** | **0.02** | **AM** |
| 10 | **16** | **1.40** | **IR** | 27 | **14** | **0.06** | **AM** | 44 | **44** | **0.02** | **IE** |
| 11 | **146** | **1.33** | **IR** | 28 | **30** | **0.05** | **CF** | 45 | **88** | **0.02** | **AM** |
| 12 | **42** | **1.30** | **IR/AM** | 29 | **36** | **0.05** | **AM** | 46 | **21** | **0.02** | **AM** |
| 13 | **14** | **0.90** | **IR** | 30 | **26** | **0.40** | **AM** | 47 | **25** | **0.02** | **AM** |
| 14 | **29** | **0.81** | **IR** | 31 | **56** | **0.03** | **AM** | 48 | **25** | **0.02** | **RO** |
| 15 | **39** | **0.55** | **IR** | 32 | **30** | **0.02** | **AM** | 49 | **24** | **0.02** | **AM** |
| 16 | **14** | **0.50** | **IR** | 33 | **33** | **0.02** | **AM** | 50 | **62** | **0.02** | **AM** |
| 17 | **15** | **0.33** | | 34 | **33** | **0.02** | **AM** | | | | |

# Technology Selection Verses Raw Water As/Fe Concentrations



# *Common Questions / Responses*

## Question 1 – Response

## Major Considerations

**Water Quality – Iron / Arsenic / Co-contaminants**

Residuals – Type/Quantity and Disposal Options Available

System Operating Cost

# *Residuals*

| Technology | Residuals | |
|---|---|---|
| | Liquids | Solids |
| Adsorptive Media | Backwash Water w/ Solids (Possible) | Exhausted Media |
| Iron Removal | Backwash Water w/ Solids | |
| Coagulation/Filtration | Backwash Water w/ Solids | |
| Ion Exchange | Regeneration Brine | |
| Reverse Osmosis | Reject Water | |

# *Residuals Disposal Options*

Backwash Water
- Sewer
- Ground - Direct
- Septic System
- Recycle
- Evaporation/Holding Pond

IE Brine/ RO Reject Water
- Sewer
- Septic System
- Evaporation/Holding Pond

Adsorptive Media (Exhausted)
- Landfill
- Regeneration (on /off site)


Recycle Tank
2004/ 5/ 6 6:27pm

# Residual Disposal Methods Used

| Residuals | Disposal Method |
|---|---|
| Iron Removal Backwash Water | Sewer – 8<br>Ground – 1<br>Septic System – 1 |
| Coagulation/ Filtration Backwash Water | Recycle / Sewer – 2 |
| Adsorptive Media Backwash Water | No BW – 6<br>Ground – 5<br>Sewer – 5<br>Recycle – 2<br>Septic System – 1 |
| Ion Exchange Brine | Sewer – 1<br>Holding Pond - 1 |

# *Common Questions / Responses*

## Question 1 – Response

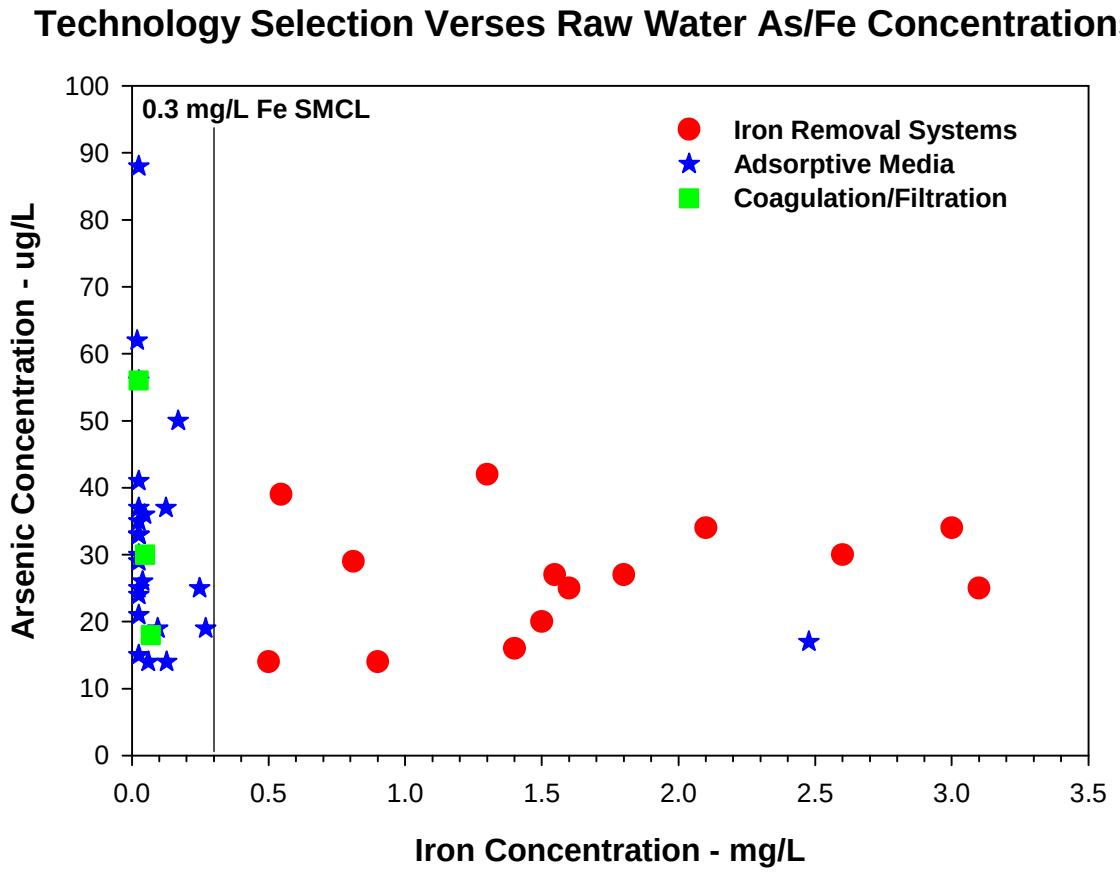
## Major Considerations

Water Quality – Iron / Arsenic / Co-contaminants

Residuals – Type/Quantity and Disposal Options Available

System Operating Cost

# Operational Cost Major Factor in Selection of Coagulation/Filtration Systems!



# *Common Questions / Responses*

Question 2

Are adsorptive media arsenic removal capacities meeting manufacturers estimates?

# *Common Questions / Responses*

## Question 2 – Response

Base upon experience of the arsenic demo program some are, but many are not!

# Performance Adsorptive Media (As V)

| Site | As ug/L | pH Units | $SiO_2$ mg/L | $PO_4$ mg/L | BVs to 10 ug/L |
|---|---|---|---|---|---|
| A | 39 | 8.3 | 11 | <0. 05 | 5,500 |
| B | 45 | 7.8 | 13 | <0.05 | 5,400 |
| C | 31 | 8.4 | 14 | <0.03 | 6,000 |
| D | 88 | 7.4 | 69 | <0.1 | 7,500 |
| E | 33 | 7.9 | 30 | <0.03 | 12,000 |
| F | 33 | 6.9 | 26 | <0.1 | 20,000 |
| G | 41 | 7.7<br>6.9 | 19 | <0.1 | 7,000<br>25,000 |
| H | 64 | 7.1 | 25 | <0.1 | 40,000 |
| I | 23 | 7.7 | 35 | <0.1 | 40,000 ($1^{ST}$)<br>41,000 ($2^{nd}$) |
| J | 19 | 7.3 | 14 | <0.1 | >62,000 |
| K | 14 | 7.3 | 8 | <0.1 | >68,000 |

# *Common Questions / Responses*

## Question 3

If adsorptive media process has been selected for the treatment system, how does one select the adsorptive media?

# *Common Questions / Responses*

## Question 2 – Response

## Major Considerations

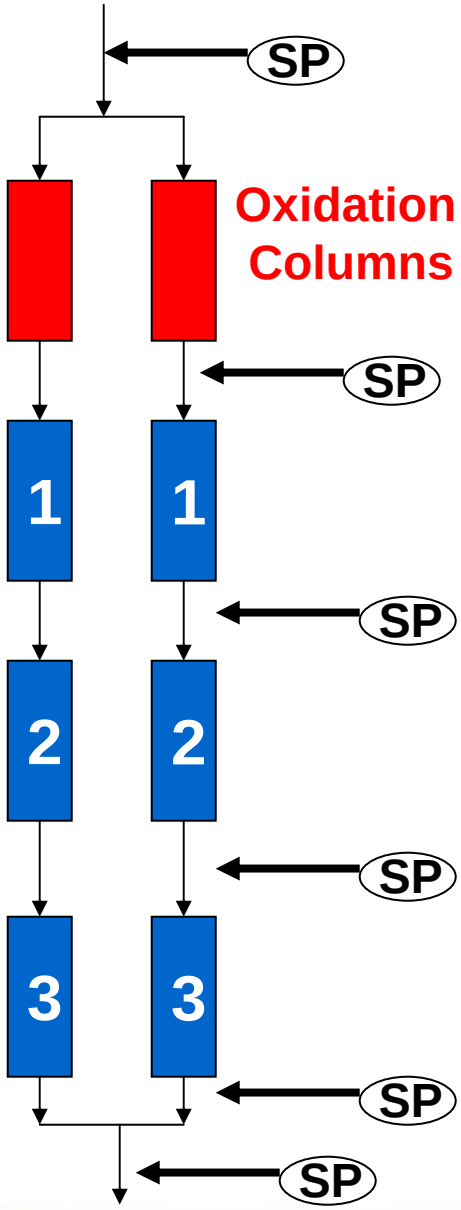
Performance – BVs (removal capacity)

- Time (replacement)

Cost – Media & media replacement

Residuals – Backwash water disposal options

# Spring Brook MHP, Wales, ME (ATS Media)



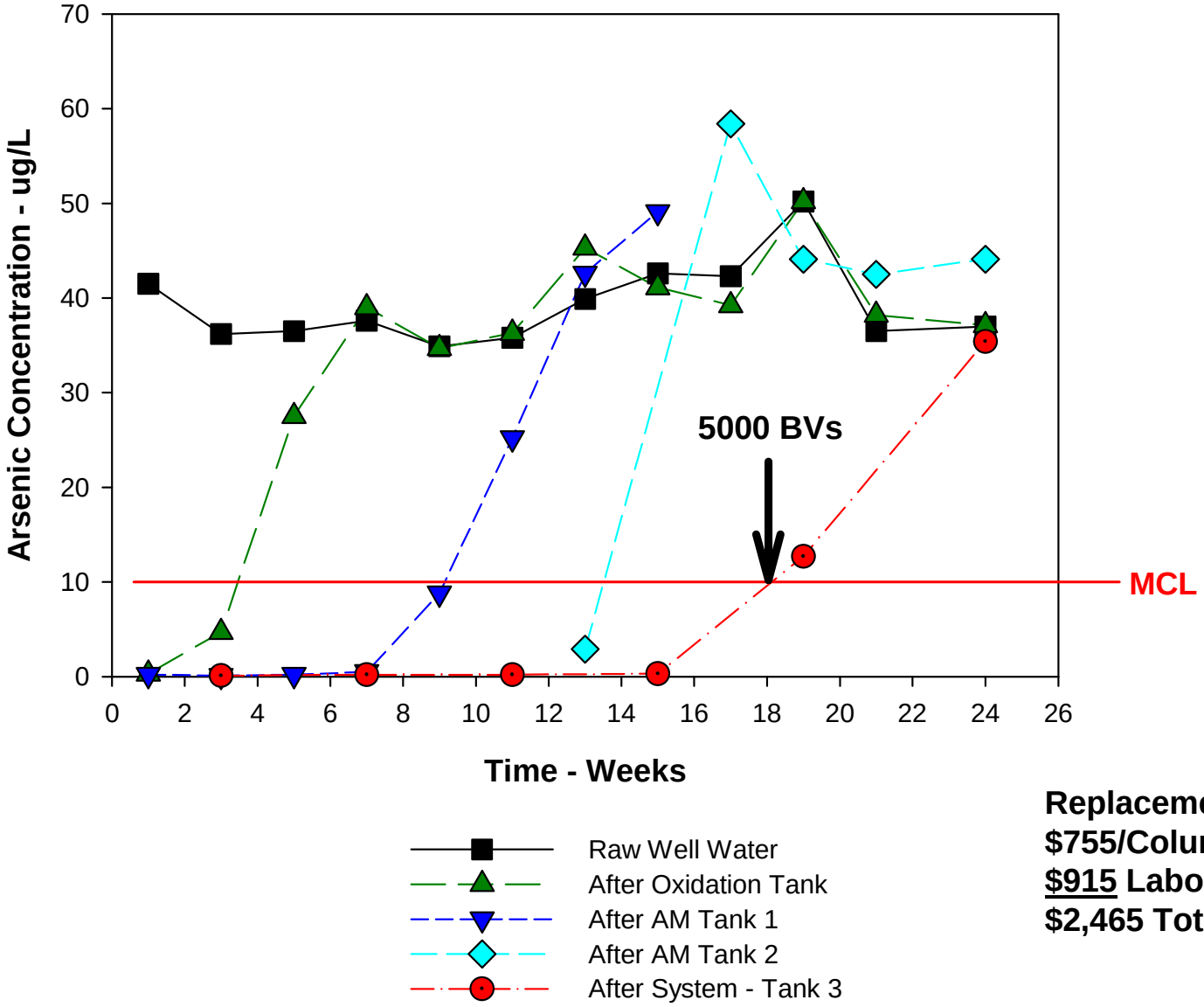

| Tanks | BV Cu ft | EBCT min |
|---|---|---|
| 1 | 1.5 | 2.2 |
| 1+2 | 3.0 | 4.4 |
| 1+2+3 | 4.5 | 6.6 |

**Design flow – 14 gpm**
**Actual flow - 10.4 gpm**
**Backwash water - none**

**As – 38 ug/l (90% As III)**
**pH – 8.5**

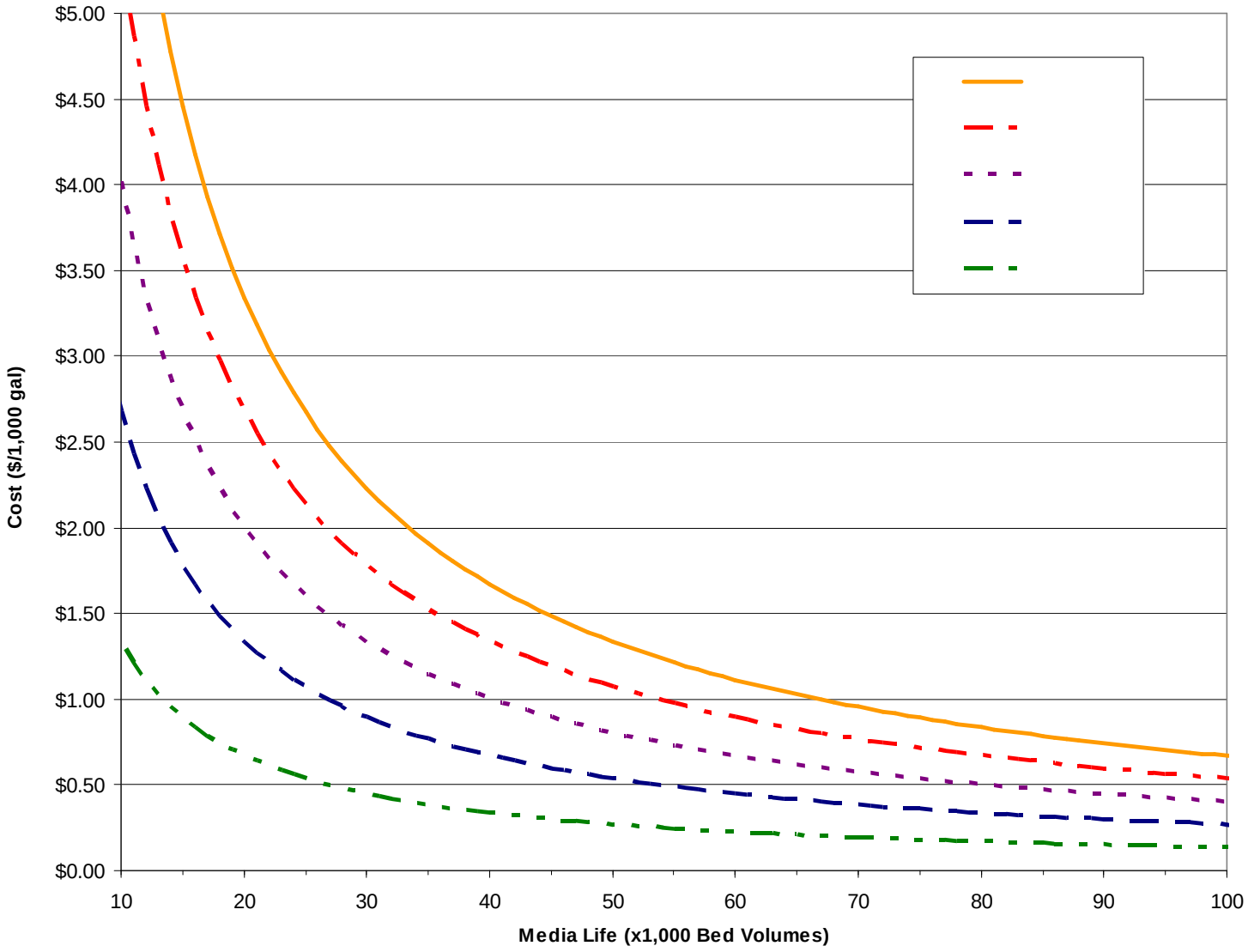

WELL-X-TROL

# Arsenic III Removal by Adsorptive Media (ATS) at Spring Brook MHP, Wales, ME

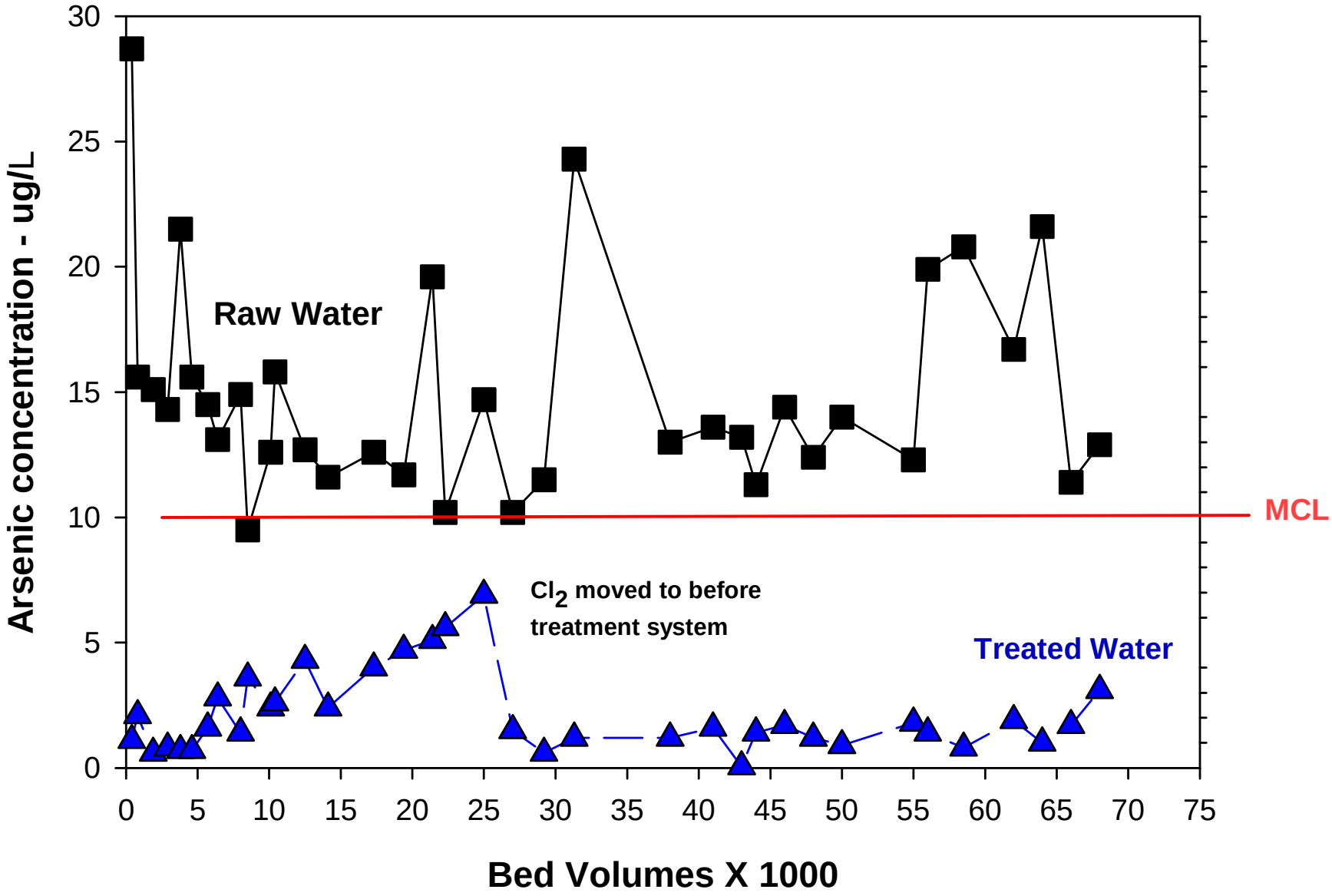



**Replacement Cost**
**$755/Column**
**$915 Labor/travel**
**$2,465 Total**

# Media Cost


$5.00
$4.50
$4.00
$3.50
$3.00
$2.50
$2.00
$1.50
$1.00
$0.50
$0.00
Cost ($/1,000 gal)
10
20
30
40
50
60
70
80
90
100
Media Life (x1,000 Bed Volumes)

# Arsenic III Removal by Adsorptive Media (E33) at Brown City, MI (May, 2004 to May, 2007)



# *Common Questions / Responses*

## Question 2 – Response

## Major Considerations

Performance – BVs/Time

Cost – Media & media replacement

Residuals – Disposal of backwash water

No disposal option – Consider media/system that does require backwashing or 100% recycle

# *Latest Research Results*

- Questions/Responses
- Future

# *Adsorptive Media Systems Future*

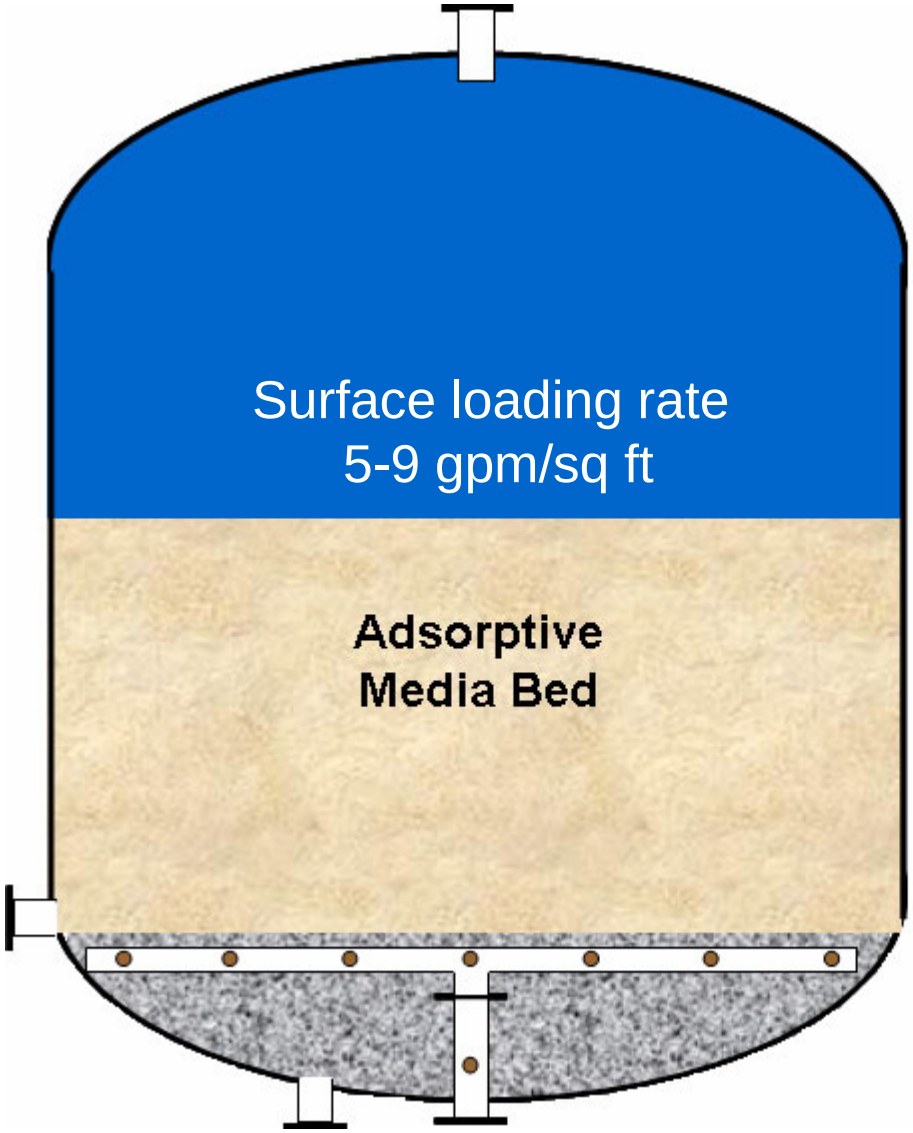
System designs/equipment (most) allows for the use of a variety of media products. (EBCT major factor)

Utilities will be switching to lower cost media products

or

to lower cost process (Coagulation/Filtration).

# Adsorptive Media Pressure Tank



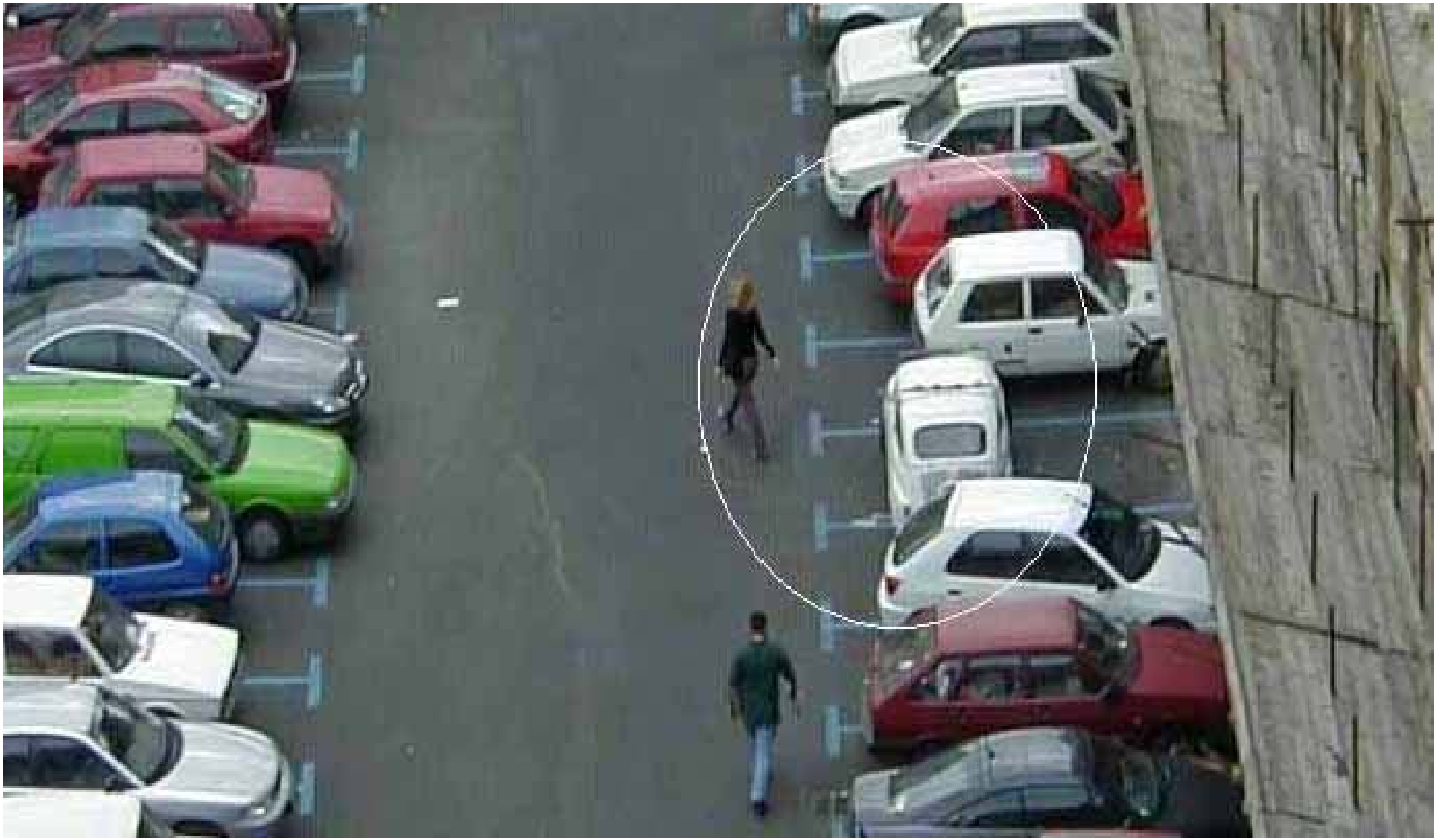

Freeboard

Bed expansion
15 -50 %

Bed depth
3-6 ft

Media

EBCT
3 – 10 min



# Adsorptive Media System

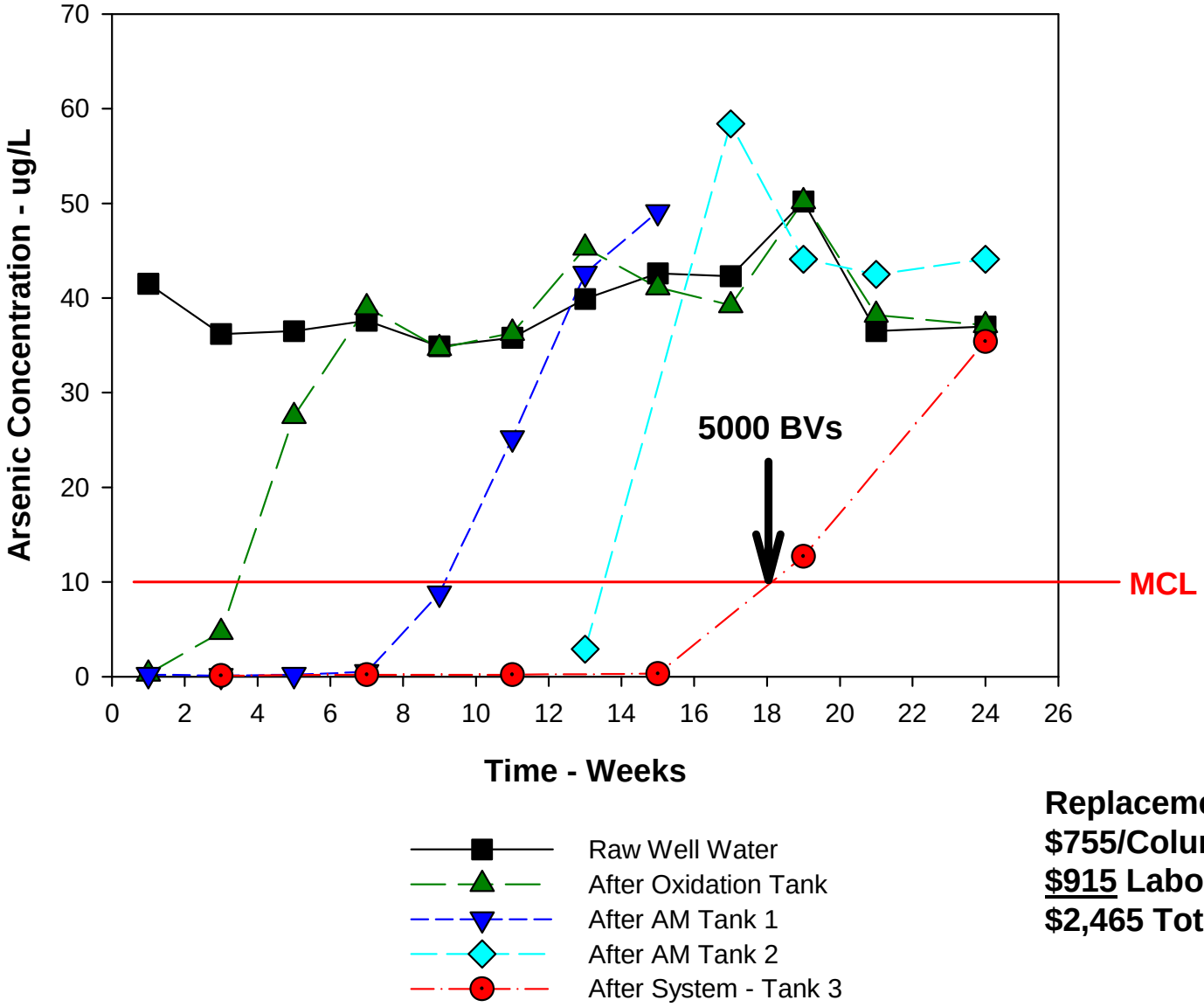
# *Results*
# *AM System Operational Cost - $/1000 gal*

| Category | NH | VT | NM | MD | NV |
|---|---|---|---|---|---|
| Flow - gpm | 10 | 22 | 320 | 320 | 350 |
| Media - cf | 5 | 3 | 160 | 160 | 240 |
| Media Replacement | Lead TK | 2 tanks | (40K BVs) | (80K BVs) | (7.5K BVs) |
| Media | $1,500 | $1,550 | $24,000 | $24,000 | $57,000 |
| Disposal | $200 | | $680 | 680 | |
| Labor | $2,345 | $1,235 | $2,120 | $2,120 | $12,950 |
| Total Cost | $4,045 | $2,785 | $26,800 | $26,800 | $70,550 |
| Electricity $/1000 gal | 0.001 | 0.001 | 0.001 | 0.05 | 0.001 |
| Labor $/1000 gal | 0.33 | 1.80 | 0.05 | 0.07 | 0.18 |
| Media $1000 gal (est) | 6.00 | 15.00 | 0.60 | 0.30 | 5.00 |
| **Total $1000 gal** | **6.33** | **16.80** | **0.65** | **0.43** | **5.18** |

# *Adsorptive Media (Cost Range - $70 to $500 cf)*

| Adsorption Media Products (10) |
|---|
| *E33S & E33P* |
| *GFH* |
| *ATS Complex 2000* |
| *Isolux™* |
| *ArseneX$^{np}$* |
| *ARM 200* |
| *AAFS 50* |
| *G2* |
| ADSORBSIA |
| Kemlron |

# Arsenic III Removal by Adsorptive Media (ATS) at Spring Brook MHP, Wales, ME




**Replacement Cost**
**$755/Column**
**$915 Labor/travel**
**$2,465 Total**

# *RSSCT Study – Spring Brook NHP Site (As 38 ug/L – pH 8.5)*

| Media | RSSCT BVs to 10 ug/L | Full Scale System BVs to10 ug/L |
|---|---|---|
| KemIron | 25,000 | 11,500 |
| GFH | 23,000 | 8,500 |
| Adsorbia GTO | 12,500 | |
| ARM 200 (Old)<br>ARM 200 (New) | 17,500<br>13,000 | |
| E33 | 20,000 | |
| ArsenXnp | 18,000 | |
| AAFS50 | 6,700 | |
| A/Complex 2000 | | 5,000-6,500 |

# *Adsorptive Media System Changes*

| Site | Original Media | New Media/Process |
|---|---|---|
| Spring Brook MHP | ATS | KemIron & GFH |
| Bow, NH | G2 | AAFS50 |
| STMIGID | GFH ( 3 Tanks) | GFH (1) KemIron (2)<br>May convert to Coagulation/Filtration |
| Valley Vista | AAFS50 | ARM 200<br>(Trial Run) |
| Rollinsford, NH | E33 | Coagulation/Filtration |
| Desert Sands, NM | E33 | Shut down because of high cost |
| Lake Isabella, CA | ArsenX$^{np}$ | Shut down because of uranium (disposal) |

# *Results*
# *IR System Operational Cost - $/1000 gal*

| Site | System | Flow gpm | Chemicals | Electricity | Labor | **Total** |
|---|---|---|---|---|---|---|
| MN | IR | 20 | 0.12 ($KMnO_4$) | 0.04 | 0.27 | **0.43** |
| WI | IR | 45 | 0.16 ($Cl_2$) | 0.07 | 0.11 | **0.33** |
| MN | IRw/Fe add | 140 | 0.03 ($FeCl_3$) | 0.04 | 0.22 | **0.29** |
| MI | IRw/Fe add | 150 | ? | 0.07 | 0.15 | **0.22** |

Note - Disposal of residuals not included

# *Adsorptive Media Systems Future*

Some adsorptive media products can be regenerated

There are other products, particularly the iron based products, that are not currently being regenerated.

Research starting on the regeneration of these products. Preliminary tests indicating that up to 85% of arsenic can be stripped off with caustic solution. Regeneration could lead to lower operating cost.

# Media Regeneration

- Spent Media including:
- GFH (2)
- KemIron (1)
- E33 (2)
- ARM 200 (1)

- Use 4% caustic solution

## *Results – Arsenic Demonstration Program*

Performance

- Systems shown ability to reduced arsenic to below MCL
- Utilities have found most systems easy to operate
- Many systems have improved the general distribution water quality
- Change in water quality has not resulted in any Pb/Cu issues

# *Results – Arsenic Demonstration Program*

Performance

All spent throw-away media has passed TCLP tests

Utility can switch adsorptive media products with out having to change adsorptive media equipment.

Utility can switch adsorptive media system over to coagulation/ filtration system.

# *Acknowledgements*


- Battelle Memorial Institute – Columbus OH

- Water utilities participating in the arsenic demonstration program

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