

Removal of Perchlorate and RDX in Groundwater

National Groundwater Association
2005 Conference on MTBE and Perchlorate

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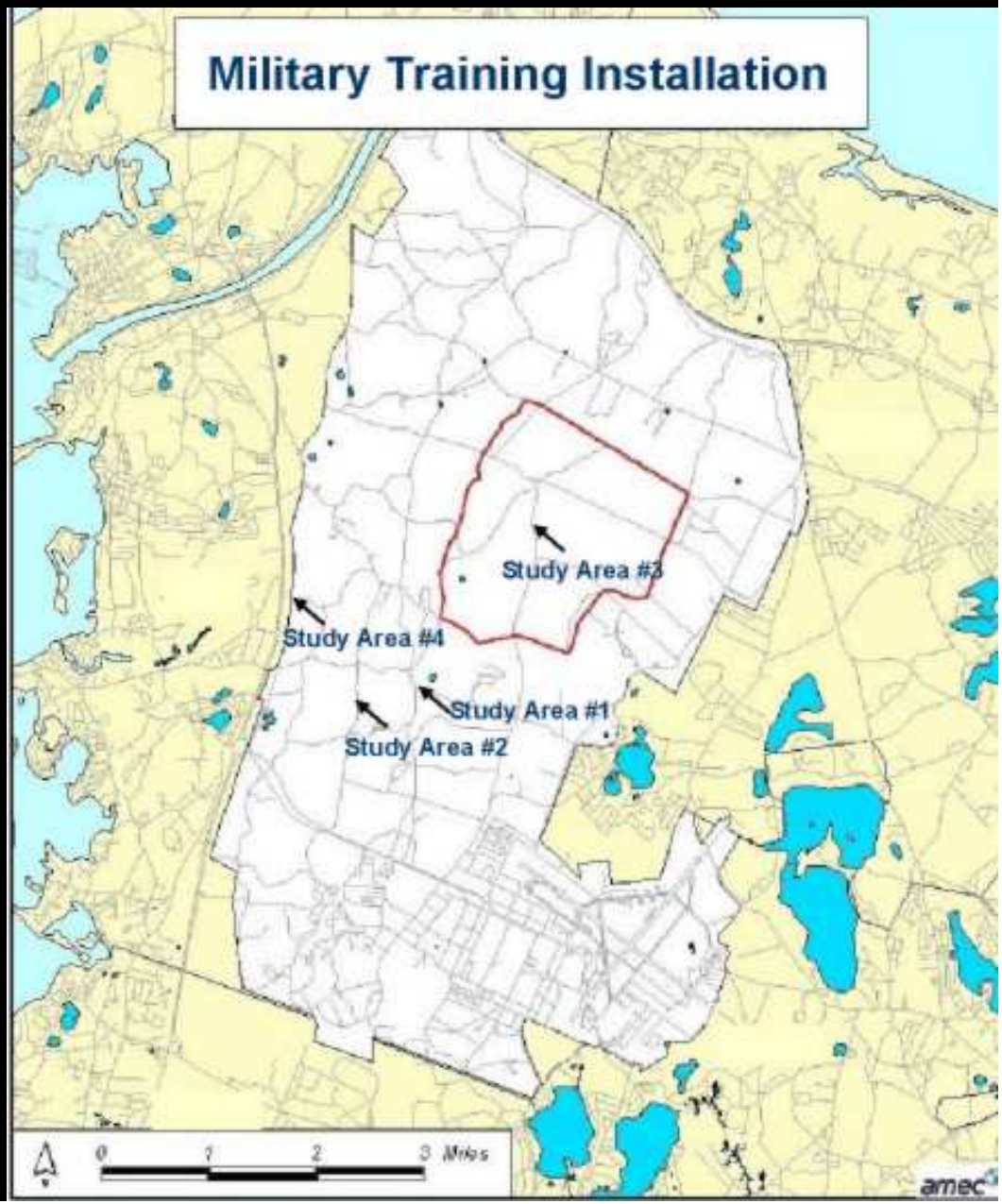
Acknowledgements

- Army National Guard
- Army Environmental Center
- US Filter Corporation
- The Purolite Company
- Ceimic Laboratories
- Severn Trent Laboratories
- Shaw Environmental & Infrastructure, Inc.
- DL Maher (div. of Boart Longyear, Inc.)
- National Environmental Systems

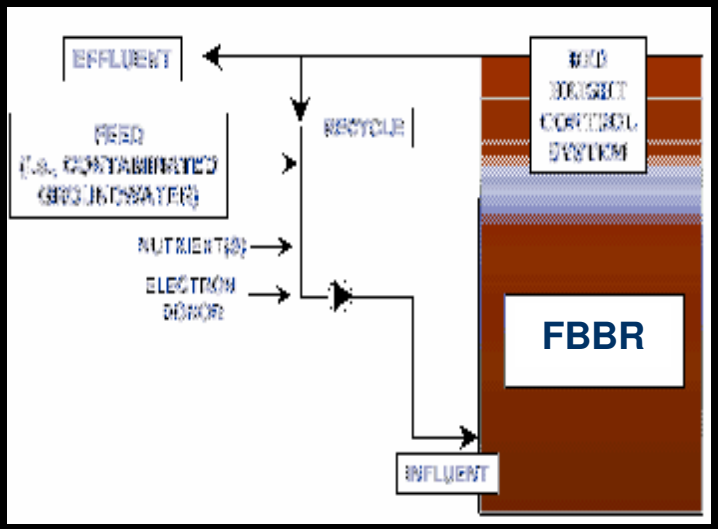
Site History

- History - Impact Area and Ranges at Site used for training since 1911
- Mission - Evaluate innovative remediation technologies to treat low levels of perchlorate and explosives in soil and groundwater



Ex Situ Groundwater Treatment Technology Evaluation

- Fluidized Bed Bioreactor (FBBR)
  - Vessel contains fluidized granular medium
  - Bacteria biologically degrades contaminants
- Ion Exchange Resin (IX Resin)
  - Removes contaminants using anion exchange
- Granular Activated Carbon (Standard GAC)
  - Removes contaminants through sorption
- Tailored GAC
  - Addition of proprietary cationic monomer
  - Acts like ion exchange resins



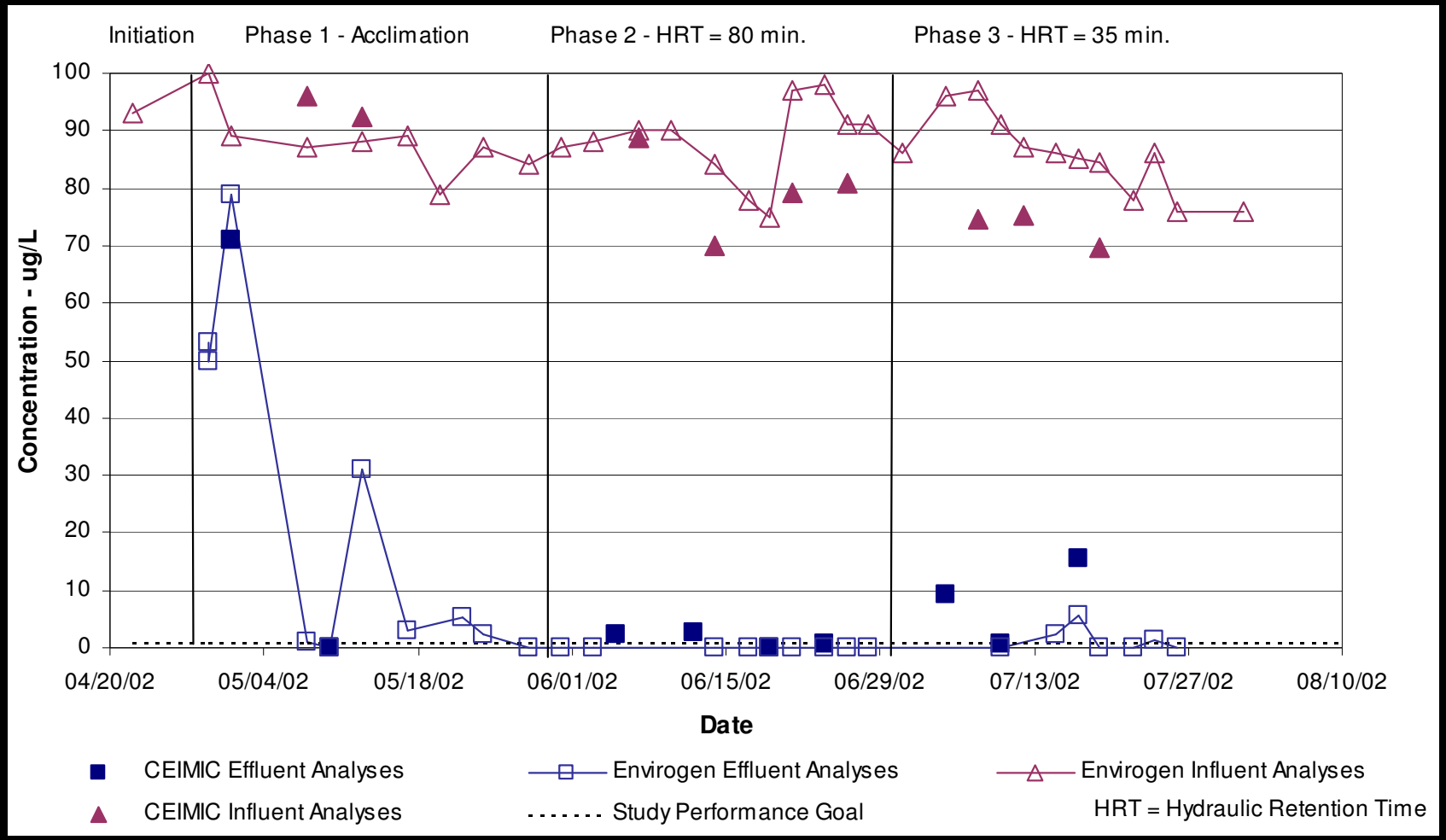
FBBR Process Flow
Courtesy of Shaw E&I

Ion Exchange Resin
Courtesy of The Purolite Company

Site Contaminant and Aquifer Characteristics

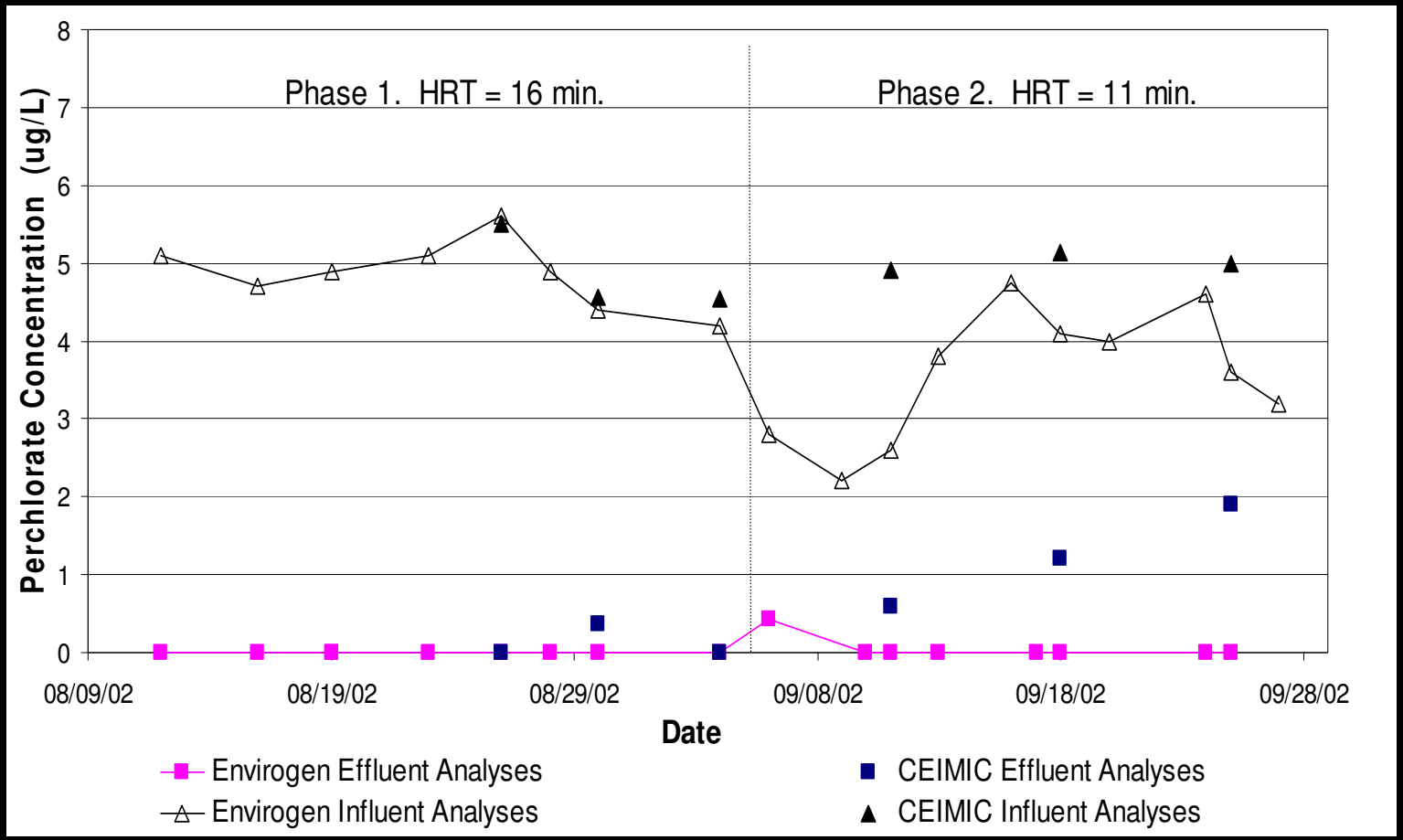
Parameter	Area #1	Area #2	Area #3	Area #4
Perchlorate (µg/L)	100	3 - 5	1	1
RDX & HMX (µg/L)	200	0	6	0
Nitrate (mg/L)	2.2	<0.12	0.05	0.1
Sulfate (mg/L)	4.6	6.1	4.4	5.0
Chloride (mg/L)	7.6	7.9	7.2	8.7
pH (S.U.)	5.8	6.3	5.4	5.7
Dissolved Oxygen (mg/L)	9.8	9.4	10.6	9.2
TOC (mg/L)	<1.0	<1.0	0.59	0.68

FBBR Study Results – Study Area 1



FBBR (Acetic Acid) Effluent Perchlorate vs. Time

FBBR Study Results – Study Area 2



FBBR (Acetic Acid) Effluent Perchlorate vs. Time

Standard GAC RSSCT Results

Test	Test 1	Test 2	Test 3
Source Study Area	#4	#1	#3
Perchlorate (µg/L)	1	5	1
RDX & HMX (µg/L)	0	0	6
EBCT (min)	20	5	10
BV to Perchlorate BT	30,000	22,000	43,000
BV to RDX BT	N/A	N/A	308,000
Effective Bed Life (mo)	13	3 - 4	9 – 10

EBCT = Empty Bed Contact Time BV = Bed Volumes BT = Breakthrough
Effective Bed Life = time between media change-outs (months)

Tailored GAC RSSCT Results

Test	Test #4	Test #5
Source Study Area	#2	#3
Perchlorate (µg/L)	5	1
RDX & HMX (µg/L)	0	6
EBCT (min)	5	9
Tailored GAC BV to Perchlorate BT	170,000	270,000
Tailored GAC BV to RDX BT	N/A	8,000
Straight GAC BV to RDX BT	N/A	308,000
Effective Bed Life (mo)	9 - 19	56

EBCT = Empty Bed Contact Time BV = Bed Volumes BT = Breakthrough
Effective Bed Life = time between media change-outs (months)
Bed Life applies only to perchlorate treatment, not RDX treatment

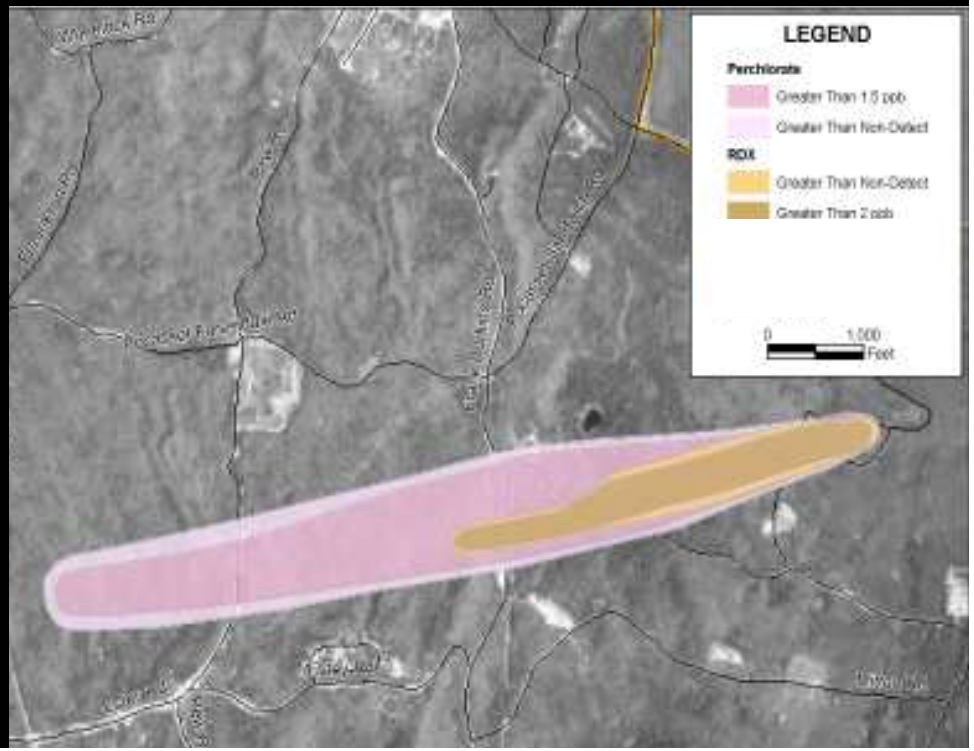
Field Study - Tailored GAC, IX Resins

Media	Tailored GAC	A520E Resin	A600E Resin
Source Study Area	#2	#2	#2
Perchlorate (µg/L)	3	3	3
Explosives (µg/L)	0	0	0
EBCT (min)	5	5	5
Bed Volumes Processed	60,000	60,000	60,000
Predicted Bed Volumes	150,000	72,000	15,000
Predicted Bed Life (months)	> 16	> 8	> 3

A520E = Purolite Nitrate Selective ion exchange resin
A600E = Purolite Type I Styrenic ion exchange resin
EBCT = Empty Bed Contact Time BV = Bed Volumes
Predicted Bed Life = time between change-outs

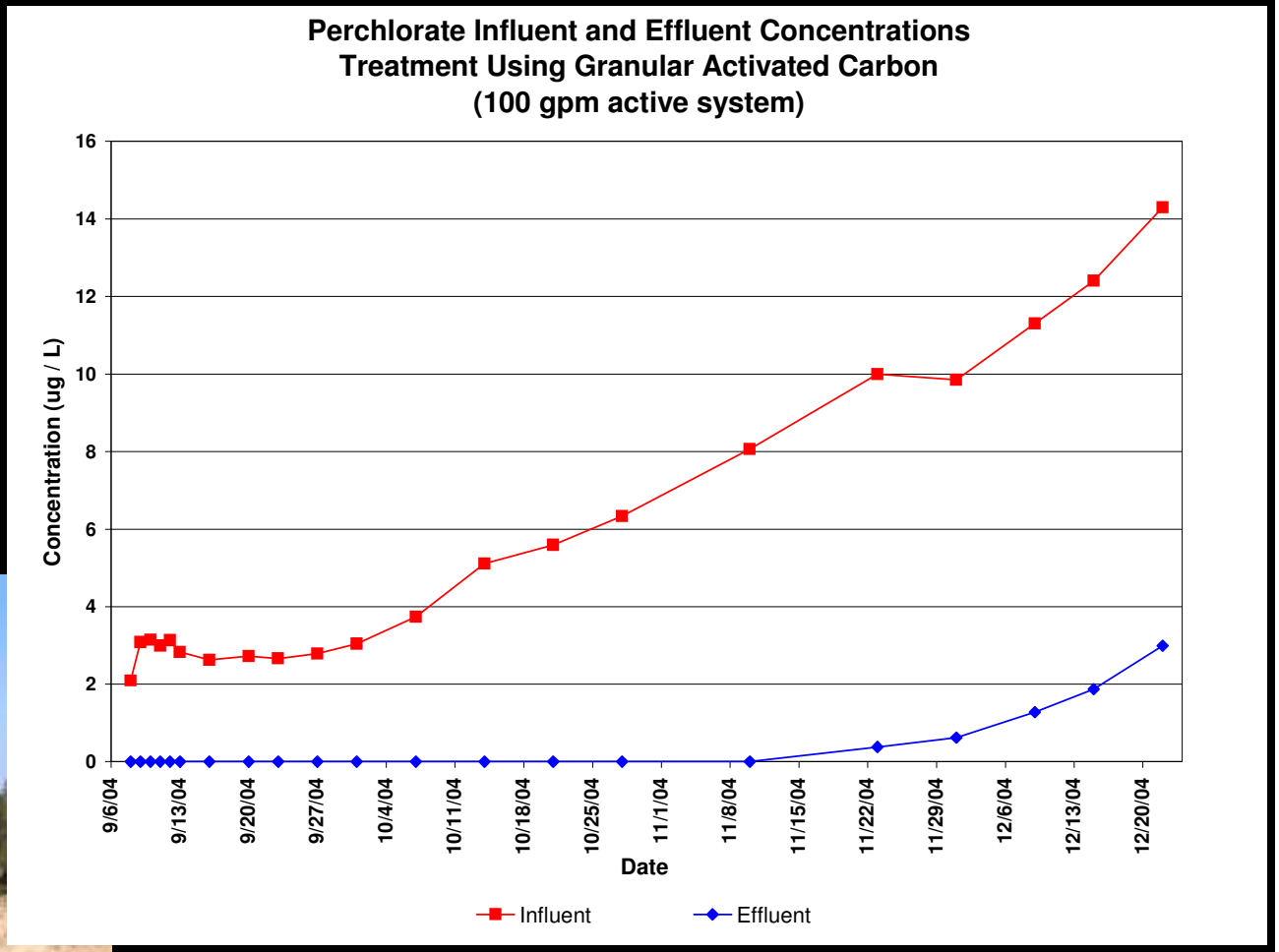
Pilot Study Implementation

- First full scale perchlorate remediation system in New England
- Plume 1,000 feet wide, 10,000 feet long
- Total 320 gpm treated
- 5 minute EBCT
- Perchlorate 3 – 37 ug/L
- RDX 0 – 5 ug/L



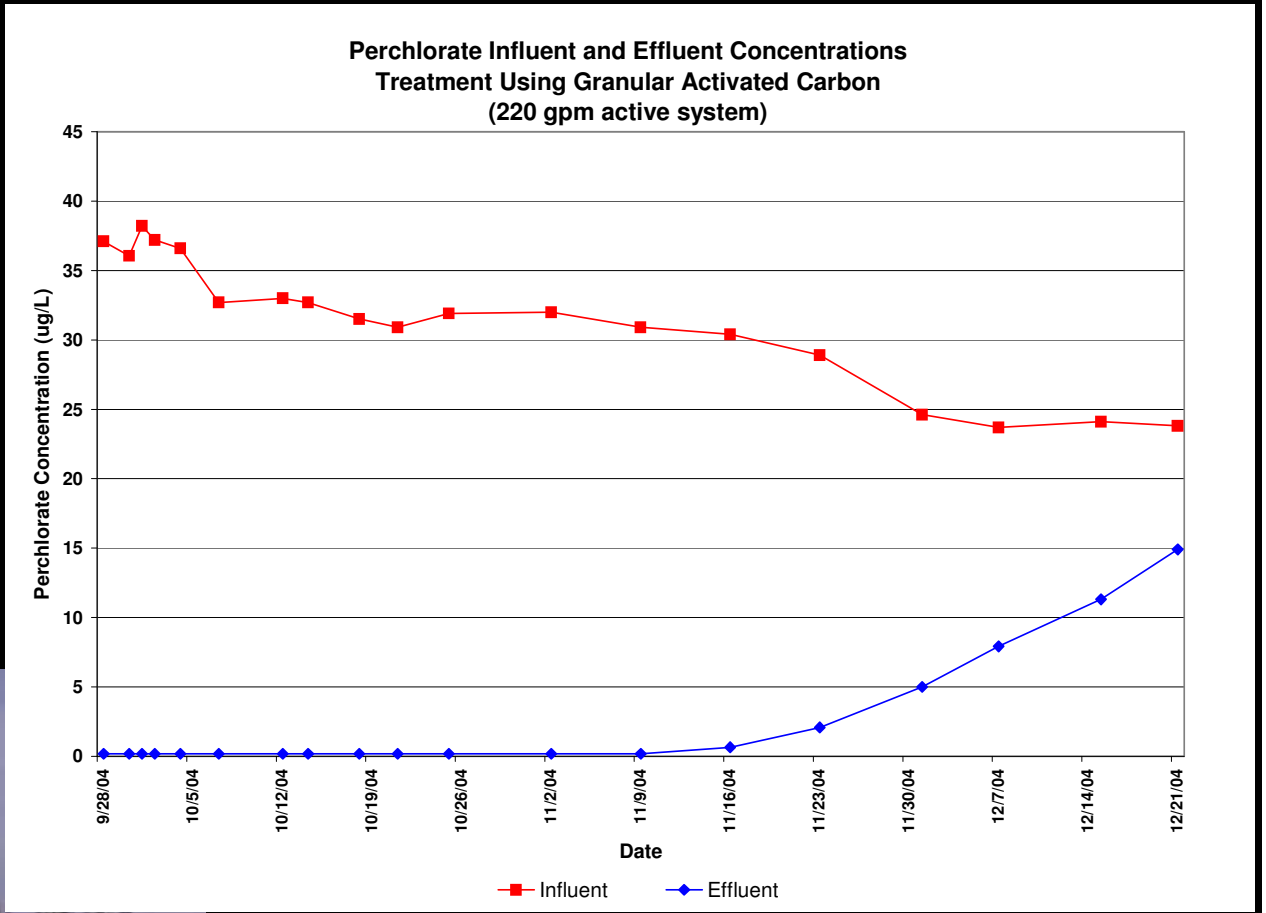
Implementation – System A

- 100 gpm treated
- Perchlorate average 7 ug/L
- Standard GAC
- Breakthrough at 17,000 Bed Volumes



Implementation – System B

- 220 gpm treated
- Perchlorate average 33 ug/L
- Standard GAC, IX Resin
- Breakthrough at 9,000 Bed Volumes



Implementation Cost Comparison

Treatment Scenario	Comparative Cost
1 µg/L perchlorate, 6 µg/L explosives	
Standard GAC	1X
Tailored GAC	2.5X
Nitrate Selective IX Resin	4.5X
5 µg/L perchlorate	
Tailored GAC	1.5X
Standard GAC	2x
Nitrate Selective IX Resin	4x

Assumptions:

- Costs are for media only, except for Tailored GAC, where extra analytical costs are added. When Tailored GAC is NSF approved, costs are reduced by 0.5X
- Tailored GAC & IX systems requires extra Standard GAC vessel to treat explosives

Conclusions

- FBBR can be cost effective for perchlorate > 500 µg/L
- IX resins still the workhorse for perchlorate 10 – 1000 µg/L
- Standard GAC is cost effective for perchlorate at 1 - 7 µg/L
  - May change when Tailored GAC gets NSF approval
  - May change if IX resin costs keep dropping
- Competition will be good for the end users