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Cost Estimating Program for Arsenic Removal by Small Systems

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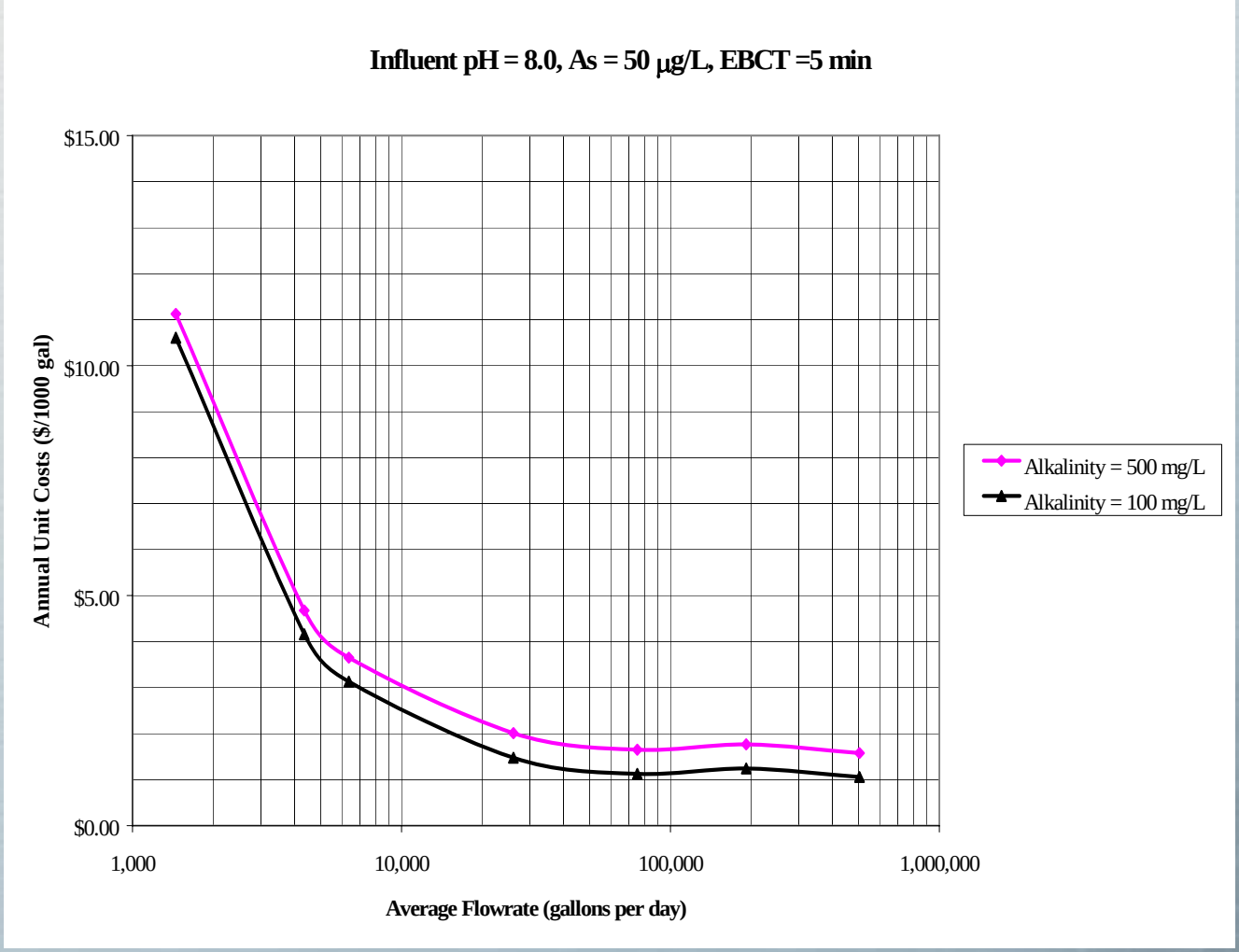
Objectives

- Develop a cost estimator for three arsenic removal processes
  - Adsorptive media throw-away system
  - Adsorptive media with media regeneration
  - Anion exchange
- Provide small systems with a useful tool for selecting a cost-effective treatment technology
- Applicable to systems with capacities ranging from 1,000 to 500,000 gallons per day (gpd)

General Assumptions

- System to be installed as part of an existing facility
- Cost model not including costs associated with:
  - Building
  - Water storage
  - Pre-oxidation to convert As(III) to As(V)
  - Waste disposal (waste production rate is provided)
- Single or multiple trains with two beds in series

Traditional Cost Curves



Key Features of Cost Estimator

- Graphic user interface (GUI) to allow input of key design and costing parameters
- One-step cost comparison using default parameters
- Step-by-step costing wizards
- Expandable to other arsenic removal media
- Unrestricted access to Microsoft Excel functions, menus, and spreadsheets
- Programming language: Microsoft Visual Basic
- Platform: Microsoft Excel 97 or a higher version for Windows 98, NT, or 2000 platform

System Components

- Adsorptive media throw-away system
  - Adsorptive system*
  - Optional pH adjustment system
- Adsorptive media with media regeneration
  - Adsorptive system*
  - Acid and base feed system
- Anion exchange system
  - IX system*
  - Brine regeneration system

*Including vessels, media/resin, piping, valving, and controls

Key Design Equations

- Design flow

  $Q_d = Q/1440 \times 24/TD \times 1.15$

  where Q_d = design flow (gal/min)

  Q = average daily flow (gal/day)

  TD = treatment duration or daily operational hours (hr/day)

- Media bed volume

  $V_m = Q_d \times EBCT/7.48$

  where V_m = media bed volume (ft^3)

  $EBCT$ = empty bed contact time (min) (for single vessel)

Key Design Equations (Cont'd)

- Replacement/regeneration frequency

  $RF = 365/(RL \times (Q_d/Q) \times EBCT)$

  where *RF* = No. of replacement/regeneration per year

  RL = media/resin run length (#BVs)

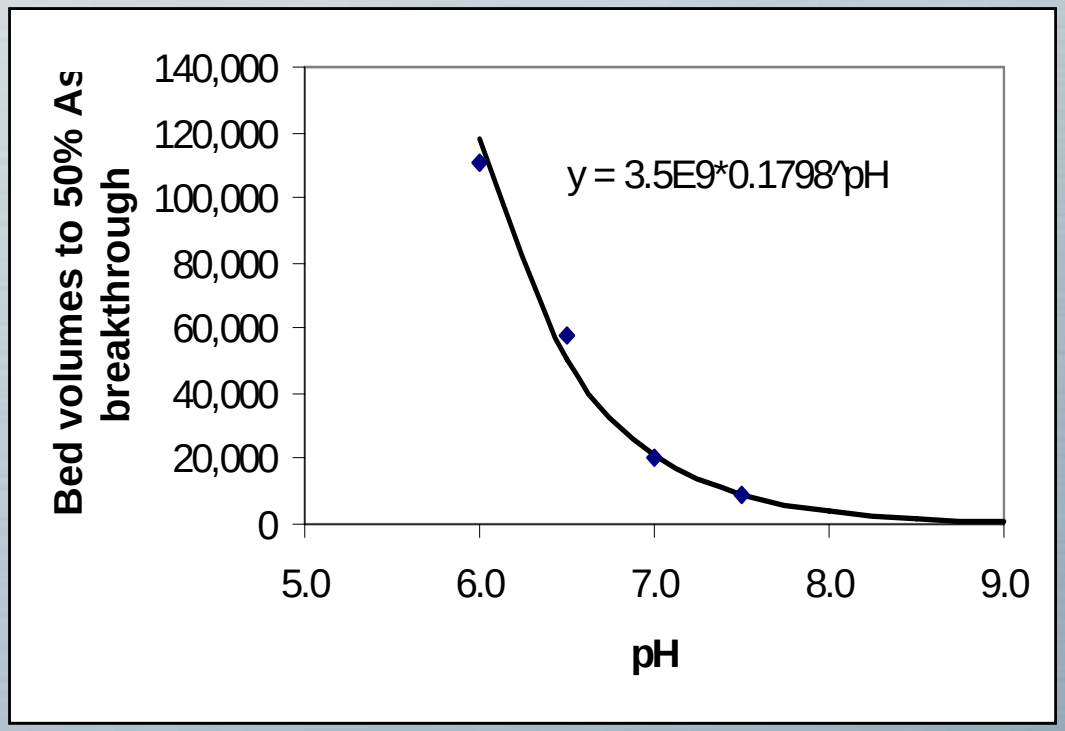
AA Run Length Estimation

$$RL = (3.5 \times 10^{9} \times 0.1798^{pH}) \times [3.5096 \times C_{As}^{(-0.3755)}]^{*}$$

Where *RL* = run length to 50% arsenic breakthrough (#BVs)

pH = raw water pH value

C_{As} = raw water As concentration (μg/L)



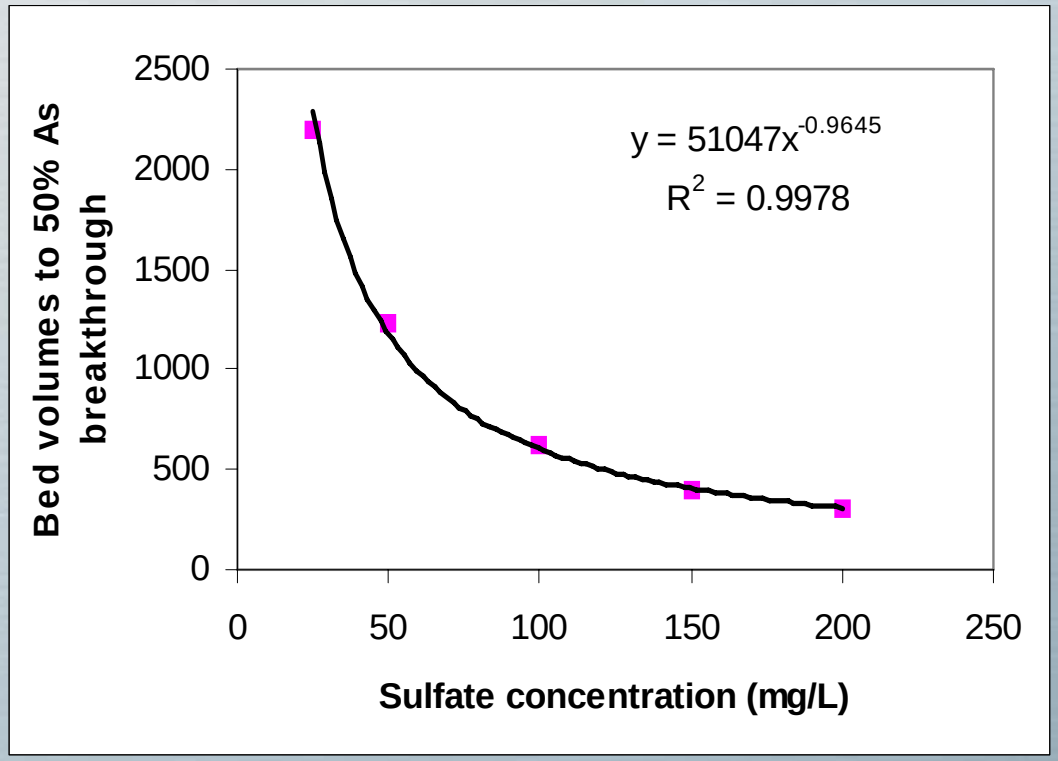
*Based on data from Simms & Azizian (1998)

AIX Resin Run Length Estimation

$$RL = 51{,}047x(C_{SO4})^{(-0.9645)*}$$

where *RL* = run length to 50% arsenic breakthrough (#BVs)

C_{SO4} = raw water sulfate concentrations (mg/L)



*Based on Clifford's study (1983)

Cost Breakdown

- Capital cost
  - Direct capital cost
    - Equipment
    - Materials
    - Installation
  - Indirect capital cost
    - Contractor/engineering
    - Permitting
    - Contingency
    - Working capital
    - Startup
- O&M Cost
  - Chemical and material
  - Electrical
  - Labor
- Unit cost ($/1000 gal)
  - Unit capital cost
    - Net interest rate
    - Years of investment
  - Unit O&M cost

Cost Scenario

- General design parameters

  average daily demand = 200,000 gpd

  daily operating time = 12 hr/day

  design flow = 320 gpm

- Raw water quality*

  pH = 7.8

  Alkalinity = 200 mg/L as $CaCO_3$

  As = 40 μg/L

  SO_4 = 4 mg/L

- Media type

Properties	Media 1	Media 2
Media price (per ft^3)	$150	$35
EBCT (min)	5	10
Media run length (#BV)	40,000*	5,000*

* Based on a pilot study at Licking Valley High School, Ohio

Cost Scenario 1

- Input Parameters

	Media 1	Media 2
Media price (per ft^3)	$150	$35
EBCT (min)	5	10
Media run length (#BV)	40,000	5,000

- Model Output

	Media 1	Media 2
Capital Cost	$257,400	$273,200
O&M Cost (per 1000 gal)	$0.63	$1.11
Media life (day)	330	79

Cost Scenario 2

- Input Parameters

	Media 1	Media 2
Media price (per ft^3)	$150	$35
EBCT (min)	5	5
Media run length (#BV)	40,000	5,000

- Model Output

	Media 1	Media 2
Capital cost	$257,400	$149,382
O&M Cost (per 1000 gal)	$0.63	$1.09
Media life (day)	330	40

Cost Comparison: An AIX System

- General design parameters

  average daily demand = 1,200 gpd

  daily operating time = 5 hr/day

  design flow = 5 gpm

  EBCT = 3.7 min

- Raw water quality

  pH = 7.5

  Alkalinity = 85 mg/L as $CaCO_3$

  As = 50 μg/L

  SO_4= 24 mg/L

- Comparison

	Model	**Actual**
Capital cost	$7,835	$11,942
O&M Cost (per 1000 gal)	$10.0	Not available
Media run length (#BV)	2,380	3,000