TERTIARY WWT PILOT STUDY RESULTS
for
PHOSPHOROUS REMOVAL
at the
INLAND EMPIRE PAPER COMPANY

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Tertiary Pilot Projects Studied at IEP

- Blue Water Technologies – Vandal Ion Sand Filter (Oct. 2004)
  - Inadequate results:
    - Unable to achieve low level Total P (0.14 to 0.28)
    - Excessive Chemical Usage (Alum, Ferric & PAC)
    - Solids Overload
- Parkson – DynaSand Filter (June – July 2005)
- U.S. Filter – Trident Technology (June – July 2005)
- Zenon – ZeeWeed Membrane Filtration (June – July 2005)
- Kruger – Actiflo Technology (Bench Scale Jar Tests, June 2005) Similar results to above pilots.

Tertiary P Removal Facts

- Precipitation (chemical solids) and Adsorption/Filtration
- Phosphorous Speciation:
  - Insoluble Reactive - Filterable
  - Insoluble Non-Reactive - Filterable
  - Soluble Reactive – Precipitation & Filtration
  - Soluble Non-Reactive – difficult/impossible
- Metal Ion Based Coagulants – Aluminum & Iron
- Many competing reactions
- Not all Effluents are alike (lignin, tannin, calcium carbonate,...)
- All Technologies had a very difficult time w/IEP Effluent
- Required significant chemical dosages to achieve low level P

IEP Testing Protocol

- Concurrent Testing of 3 Technologies
- Achieve lowest “Total P” possible
- Testing w/Alum, Ferric Chloride & PAC Coagulants
- Evaluate Chemical Performance (Type & Usage)
- Laboratory Testing by IEP, Independent Lab & DOE

Parkson Corporation
Duel Sand Filtration

- Dual, Up-Flow Sand Filters
- Lamella Separator for Rejects
- 50 gpm Flow Rate
- Used Coagulant + Polymer

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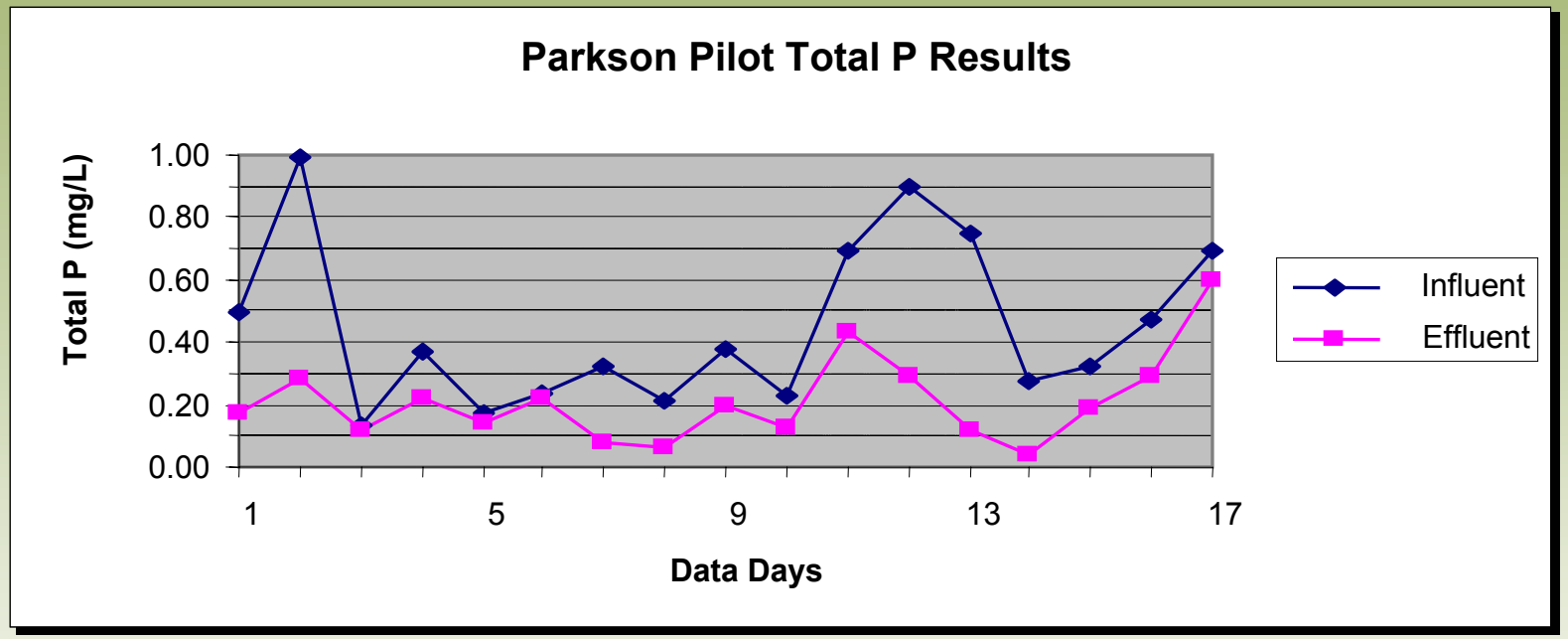
Parkson Corporation
Duel Sand Filtration



- Average Feed Total P = 0.45 mg/L
- Average Effluent from Parkson = 0.21 mg/L (53%)
- Only 3 Data Points below 0.10 mg/L
- Lowest Data Point = 0.04 mg/L

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Parkson Corporation
Duel Sand Filtration

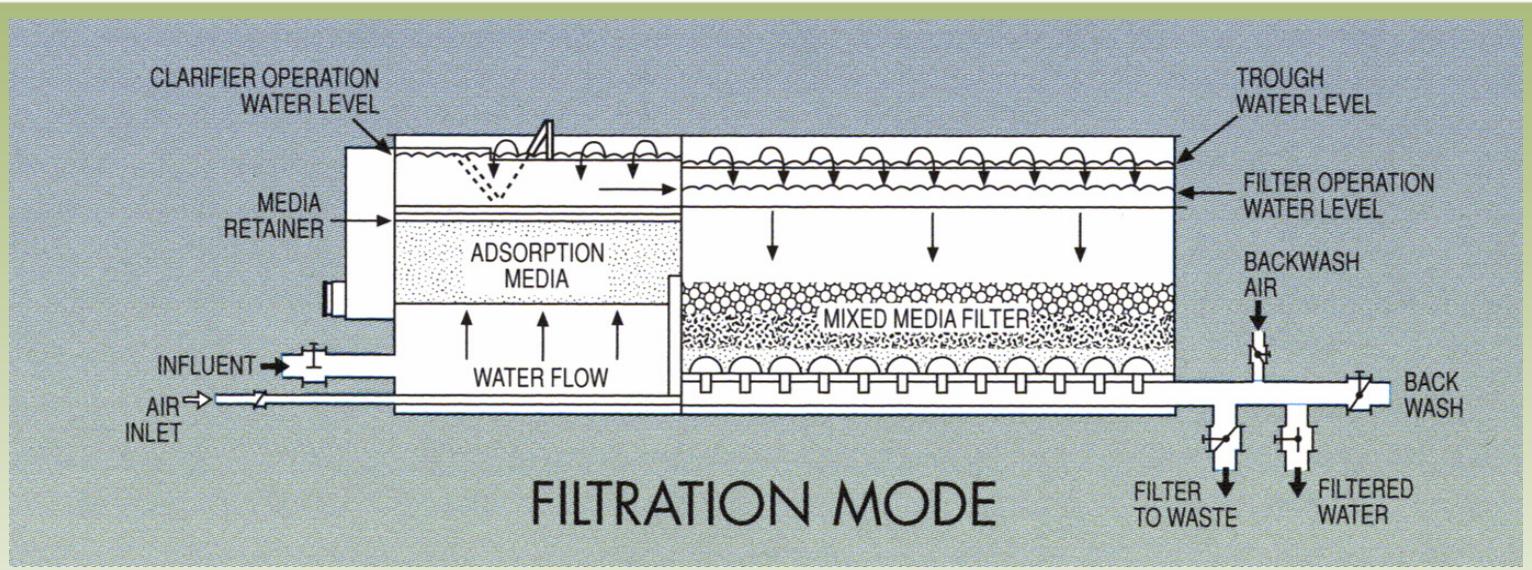
Pros:

- Continuous cleaning of rejects
- Relatively simple operating system

Cons:

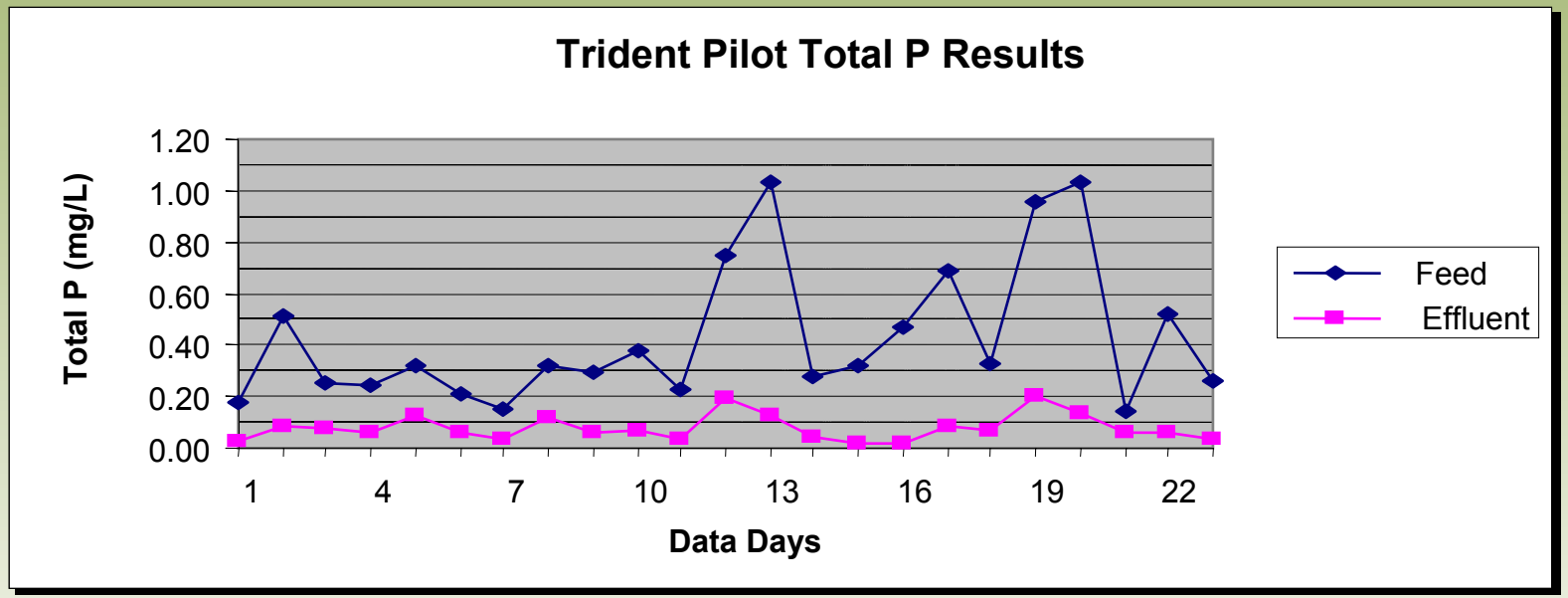
- Pilot Operational Problems (chemical pumping/dosing, solids overload, algae build-up, flow balancing)
- Sub-par & inconsistent performance

U.S. Filter
Trident Technology



- Pre-Flocculation Tanks
- Up-Flow Adsorption Clarifier (bed of plastic beads)
- Down-Flow Mixed Media Filter (mixed bed of Anthracite, Silica Sand & Garnet)
- 20 gpm flow rate
- Used Coagulant + Polymer + Acid for pH

U.S. Filter
Trident Technology



- Average Feed Total P = 0.43 mg/L
- Average Effluent from Trident = 0.078 mg/L (82%)
- 74% of Data Points below 0.10 mg/L
- 30% of Data Points below 0.05 mg/L
- Lowest Data Point = 0.02 mg/L

U.S. Filter
Trident Technology

Pros:

- Very Simple Operation
- Small Footprint
- One of the Best Overall Performers

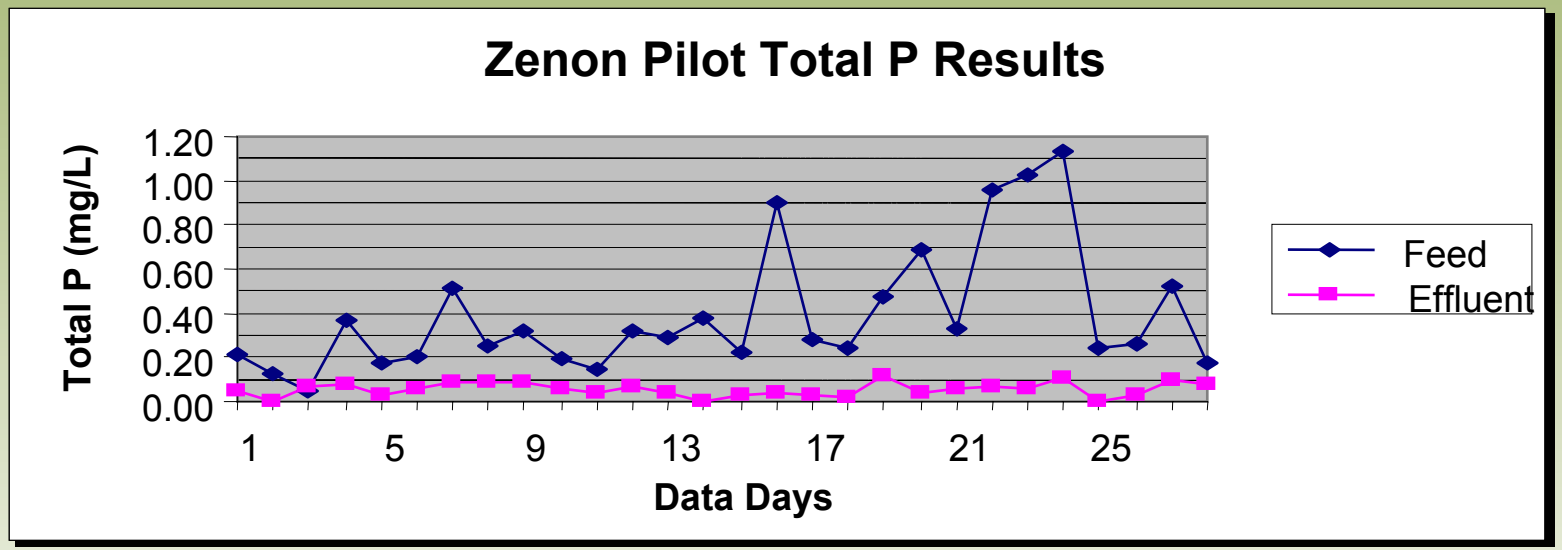
Cons:

- Frequent flushing and backwashing due to high solids (76 to 81% net production time)
- Requires redundancy for full-scale operation
- Significant Chemical Usage (Coagulant, Polymer, and Acid)
- Significant Reject Rate (18 to 21% reject water w/2,400 ppm solids during Flush & 350 ppm solids during B/W)

Zenon Environmental Corporation Membrane Technology

- Pre-Flocculation Tank
- Membrane Filter with 0.04 micron pore size
- 10 gpm flow rate
- Used Coagulant + Acid for pH control

Zenon Environmental Corporation
Membrane Technology



- Average Feed Total P = 0.45 mg/L
- Average Effluent from Zenon = 0.054 mg/L (88%)
- 93% of Data Points below 0.10 mg/L
- 43% of Data Points below 0.05 mg/L
- Lowest Data Point = 0.026 mg/L

Zenon Environmental Corporation
Membrane Technology

Pros:

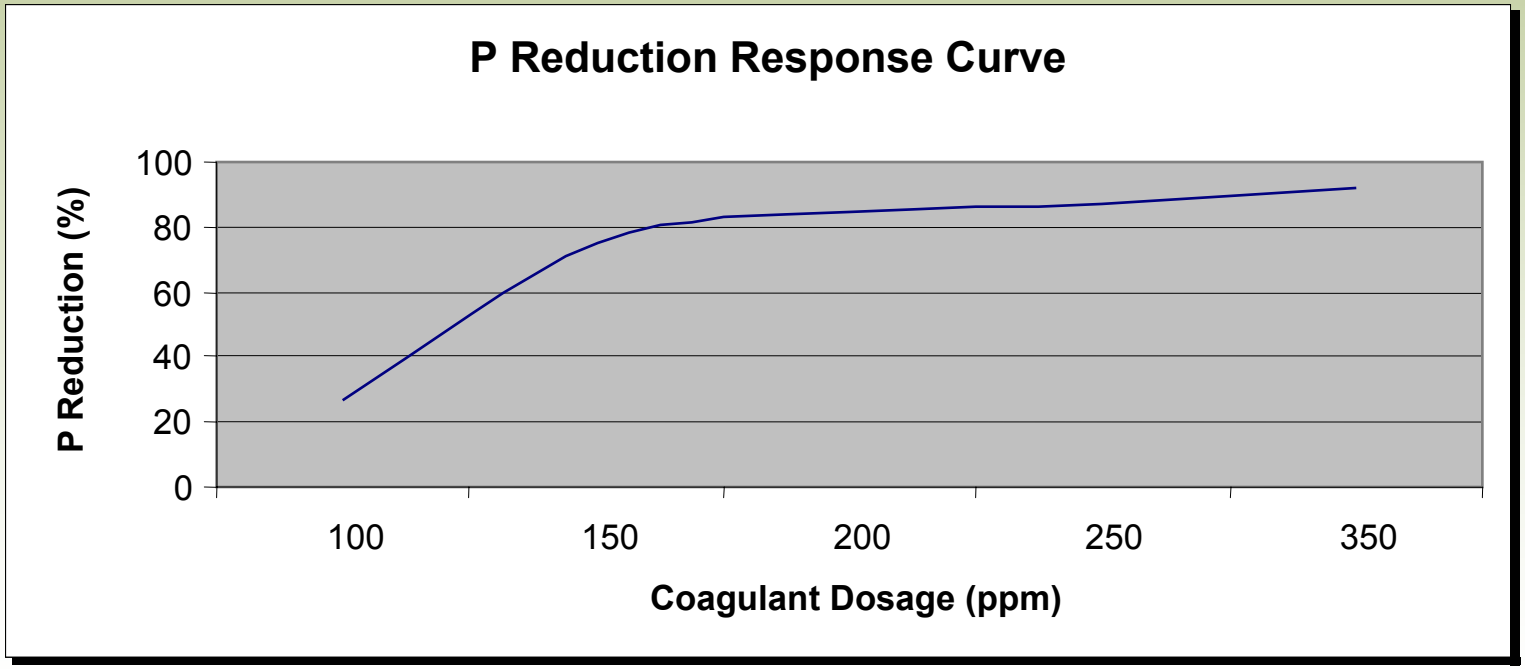
- Least Chemical Usage (Only Coagulant & Acid)
- Overall Best Performer for P Reduction
- Most consistent operation

Cons:

- More complex operation
- Most energy intensive
- Highest capital and O & M cost (membrane replacement)
- Frequent backwashing due to high solids (250 to 1,000 ppm solids in rejects)
- Requires redundancy for full-scale operation
- Potential for fouling of membrane (extended shut-down for cleaning of membranes)

Other Interesting Results

Approximately 150 ppm Coagulant Feed results in 80% reduction of Total P – diminishing returns thereafter.



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Other Interesting Results

Concern about reliability of measurements at this low level of detection.

	IEP	Anatek	DOE	Difference
D.L.	**0.02**	**0.005**	**0.005**	
	.08	0.055	0.027	104%
	.06	**1.040**	0.032	3150%
	.11	**1.070**	0.039	2644%
	.13	0.225	0.267	19%
	.03	0.026	0.040	54%
	.07	0.032	0.049	53%
	.04	0.105	0.087	21%
	.10	0.081	0.044	84%
	.06	0.027	0.027	0%
	.06	0.031	1.035	13%

Remaining Questions and Concerns

- Able to achieve consistent "Average Total P" operation between 0.05 to 0.10 mg/L with 2 out of 4 technologies – But at a Significant Cost.
- Excessive Chemical Usage required to obtain this low level Total P (300 to 400 ppm Coagulant + Polymers + Acid).
  - This equates to approximately 1,200 to 1,600 gallons/day of Coagulant Feed for full-scale operation.
  - Any adverse affects of excess soluble metal ions (aluminum or iron) in effluent?
  - Creates a significant amount of chemical sludge – need to determine how to handle, dispose and assure that it does not return to the environment.
  - Using Acid to drive down pH that will likely require additional chemical usage to increase pH prior to discharge?

Remaining Questions and Concerns

- What will the Technology Suppliers be willing to guarantee?
- How will an operating facility obtain reliable on-line measurement for control and compliance?

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