Development of an Algorithm for Dosing PAC to Remove NOM and Control DBP Formation

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Topics

Introduction

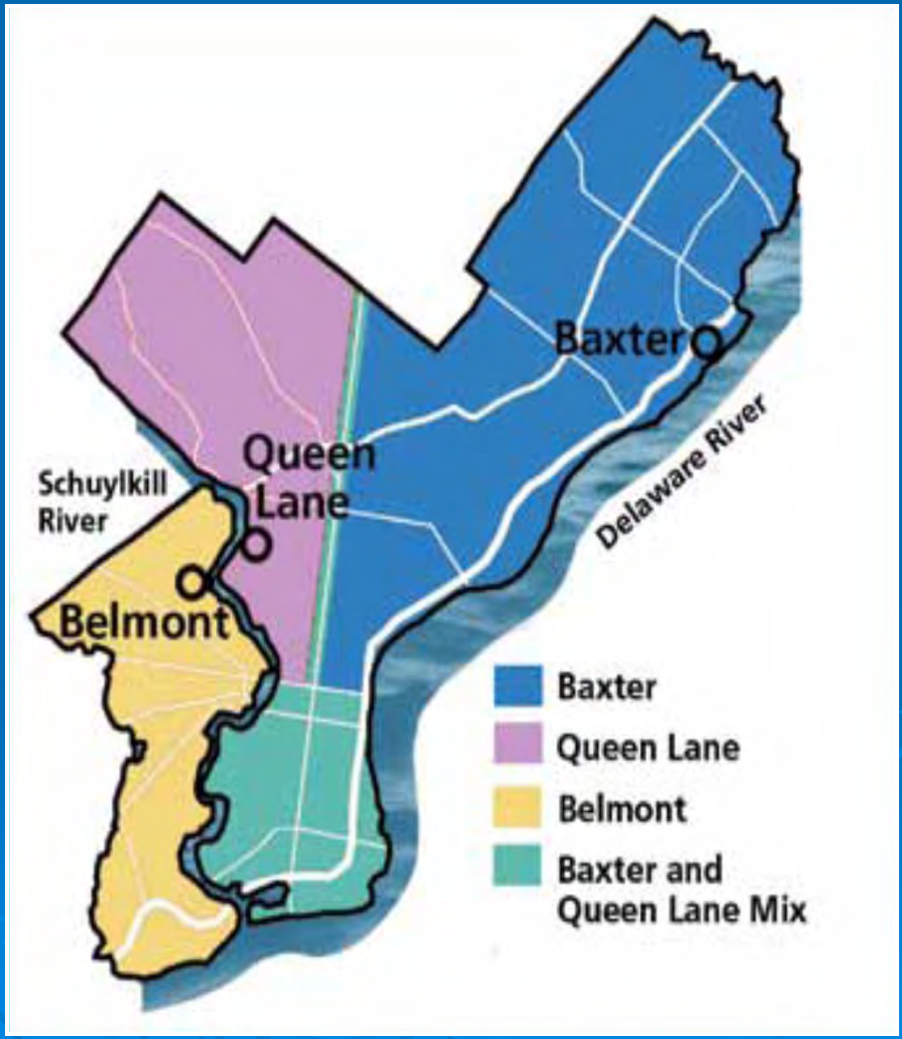
Study Design
- Formation Potential
- PAC

Development of Algorithm

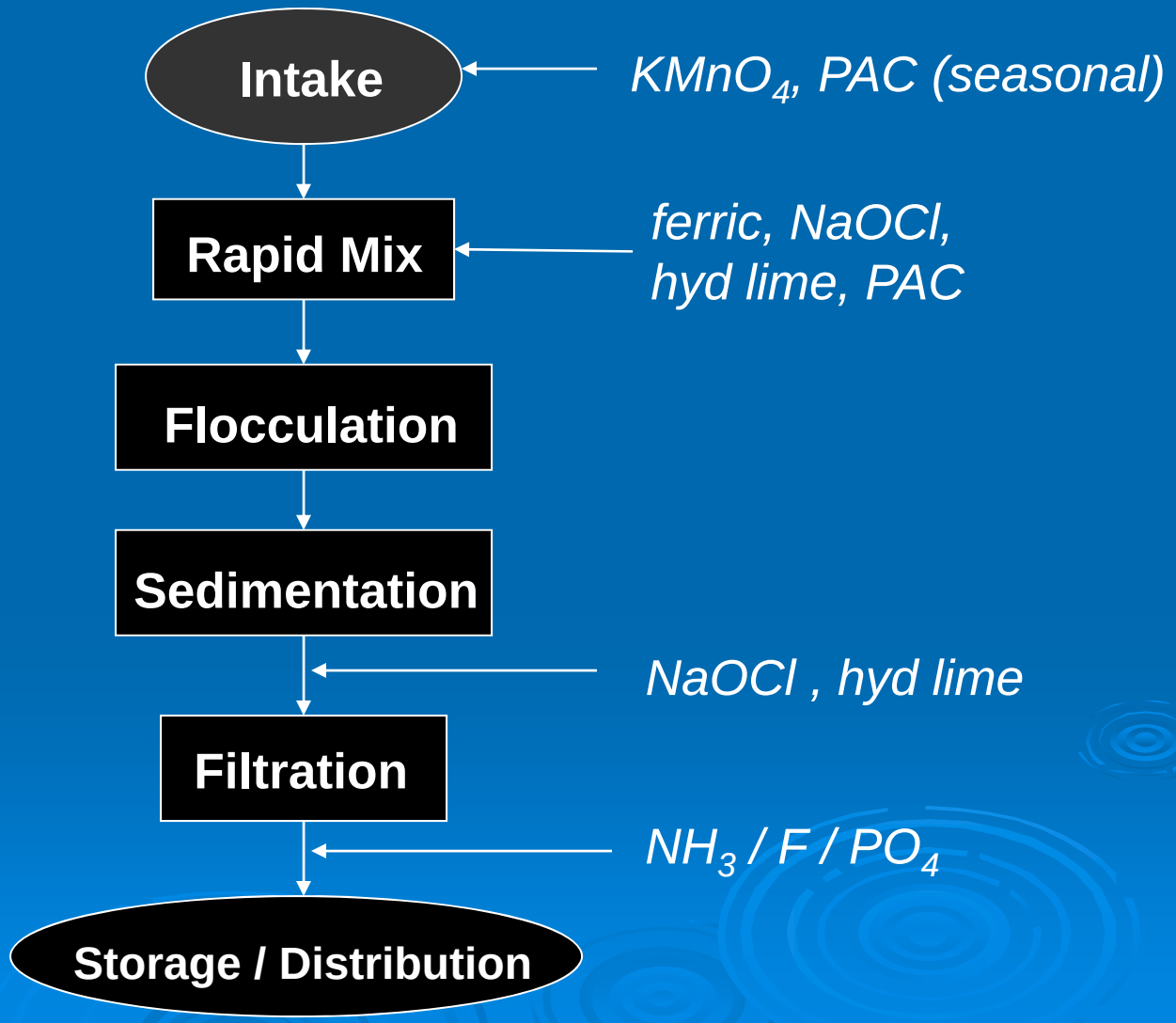
Summary

Philadelphia Water Department (PWD) Municipal Water & Wastewater Utility

- Two surface water sources: Schuylkill and Delaware Rivers
- Three water treatment plants:
  Queen Lane, Belmont, and Baxter
- 13 pressure districts
- Over 3,000 miles of main
- Supply over 250 MGD to a population of 1.738 million
- Chloraminated system



PWD WTPs practice conventional treatment.



DBP Monitoring

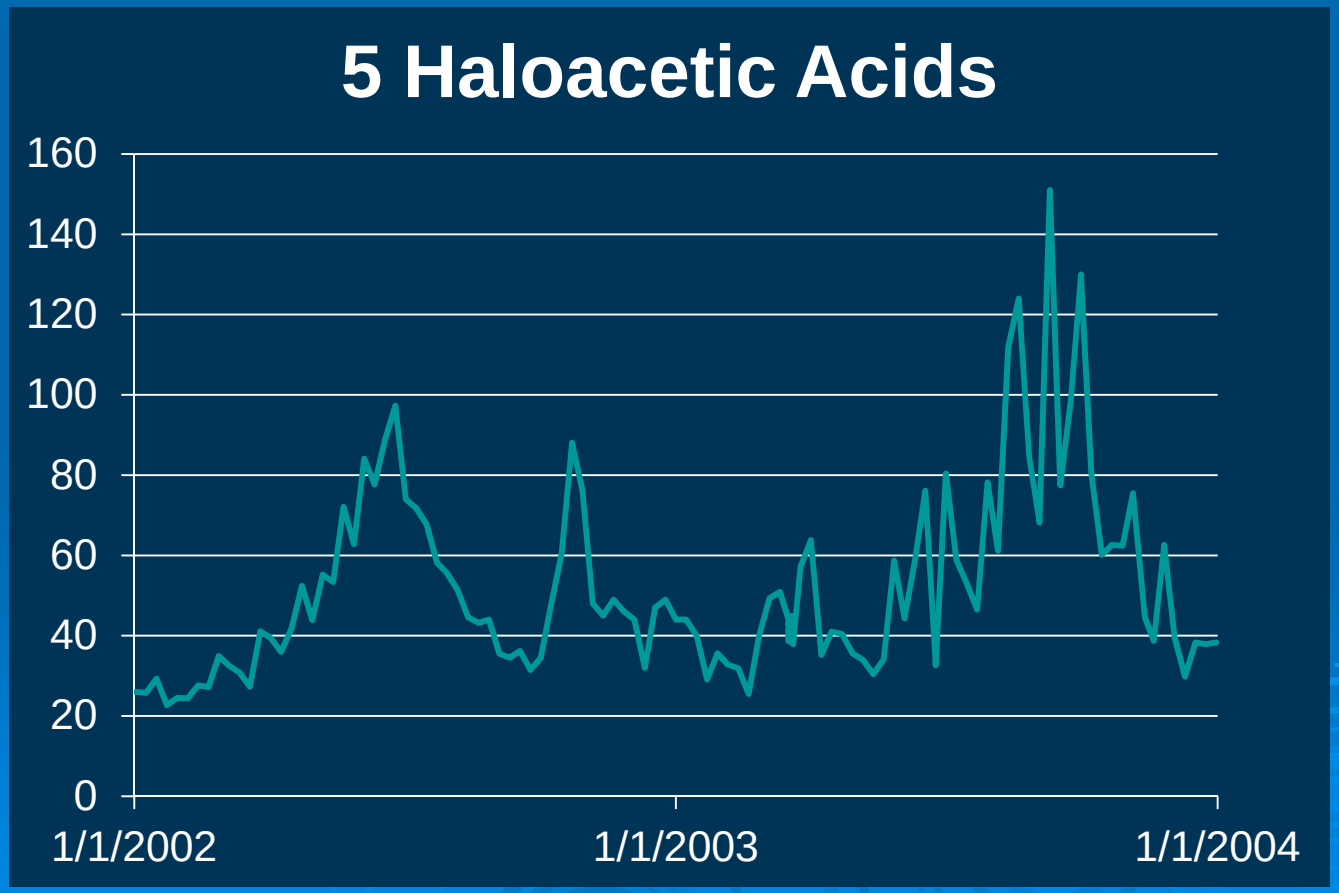
12 locations for THM Rule and Stage 1

16 locations for Stage 2 (monthly)

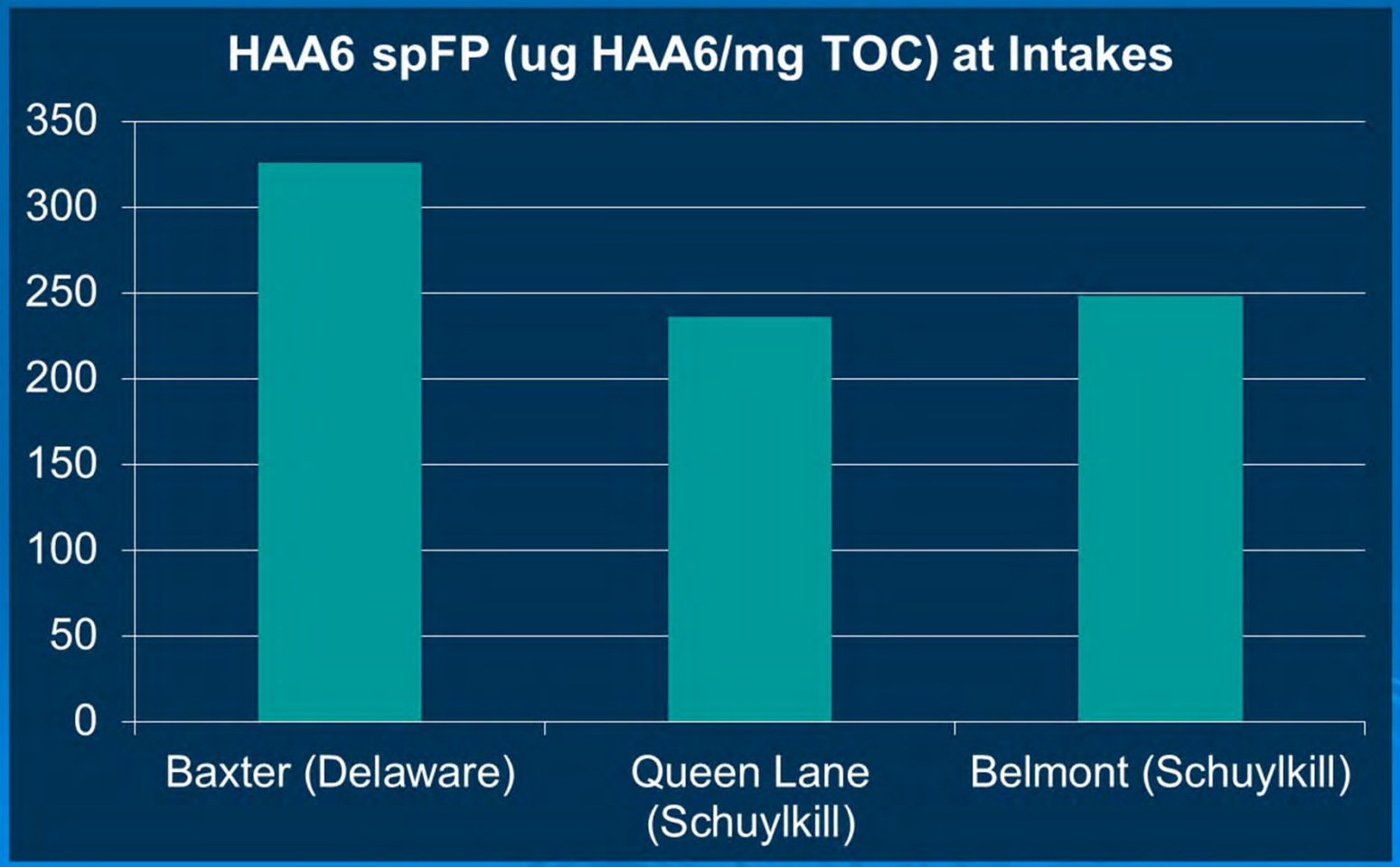
Weekly (non-regulatory) at WTP effluents to gauge levels in the system

Since Stage 1 started…

Spikes in HAA5 levels at Baxter WTP have been of concern.



Work just a few years earlier showed that Delaware River NOM had a higher reactivity to produce HAAs than Schuylkill.



Studies were performed to address DBP concerns at Baxter WTP:

Formation Potential in 2004

NOM Removal with PAC in 2006

Goal: Identify and use a convenient water quality parameter to anticipate and prevent DBP issues.

Study 1: Formation Potential

Study Design

1) River water collected weekly

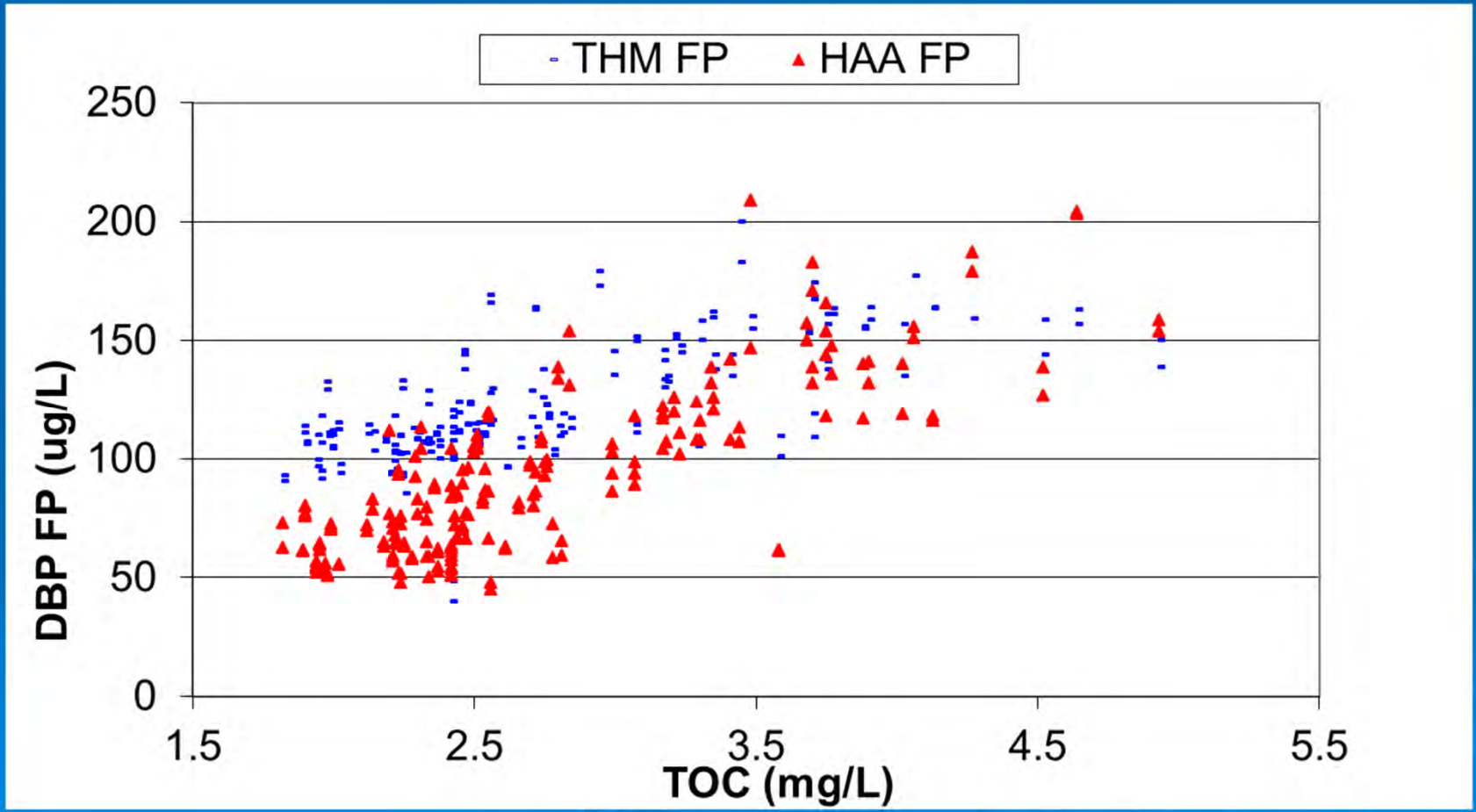
2) Water filtered with 1 and 0.47 μm filters

3) Filtered water dosed with 5 mg/L Cl_2 and incubated at 20°C for 24 hours

Aliquots of water before and after filtering were measured for TOC, DOC, and UV254. DBPs were analyzed after incubation.

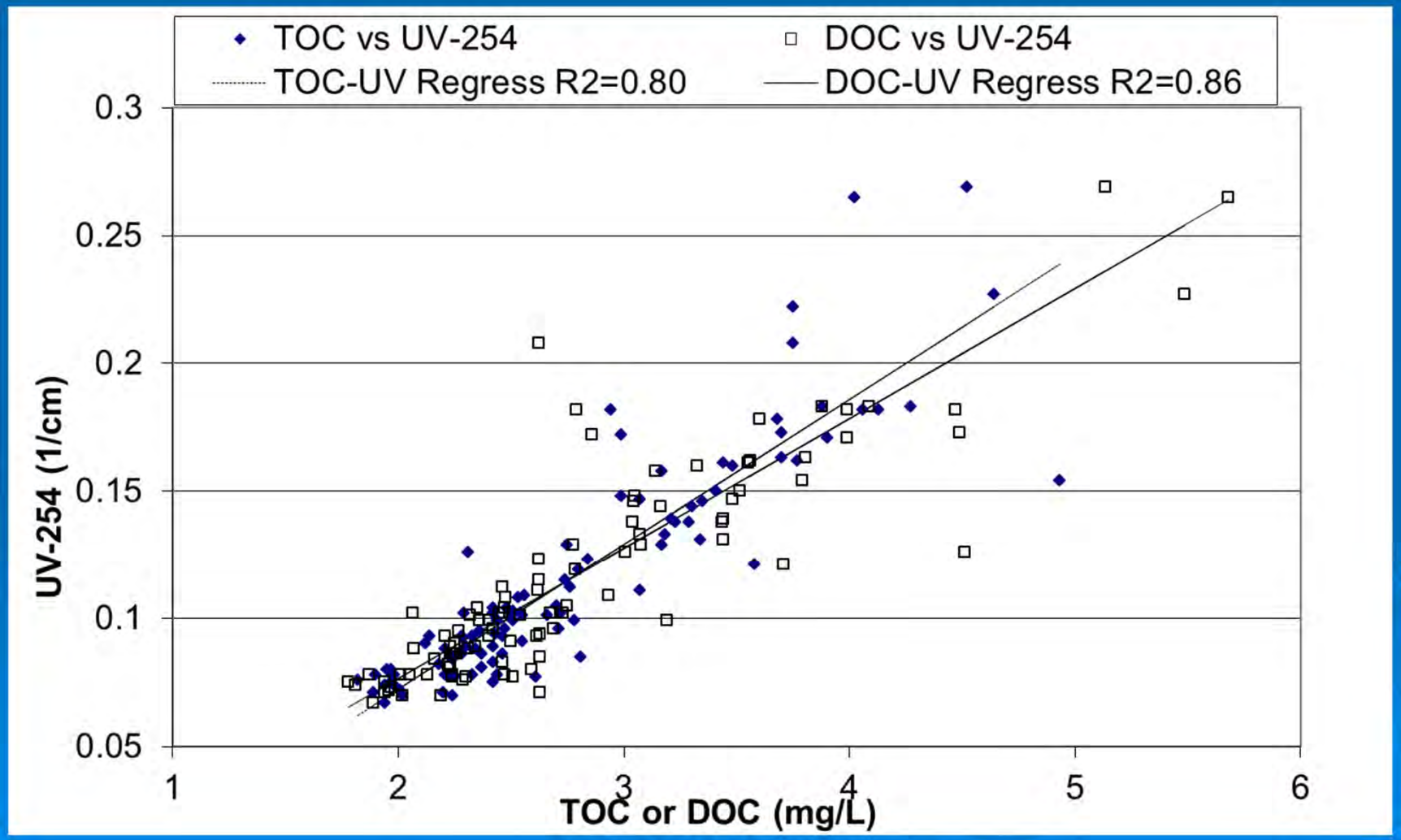
Formation Potential Results

Good relationship between DBP FP and TOC
(chlorine depleted at high TOC)



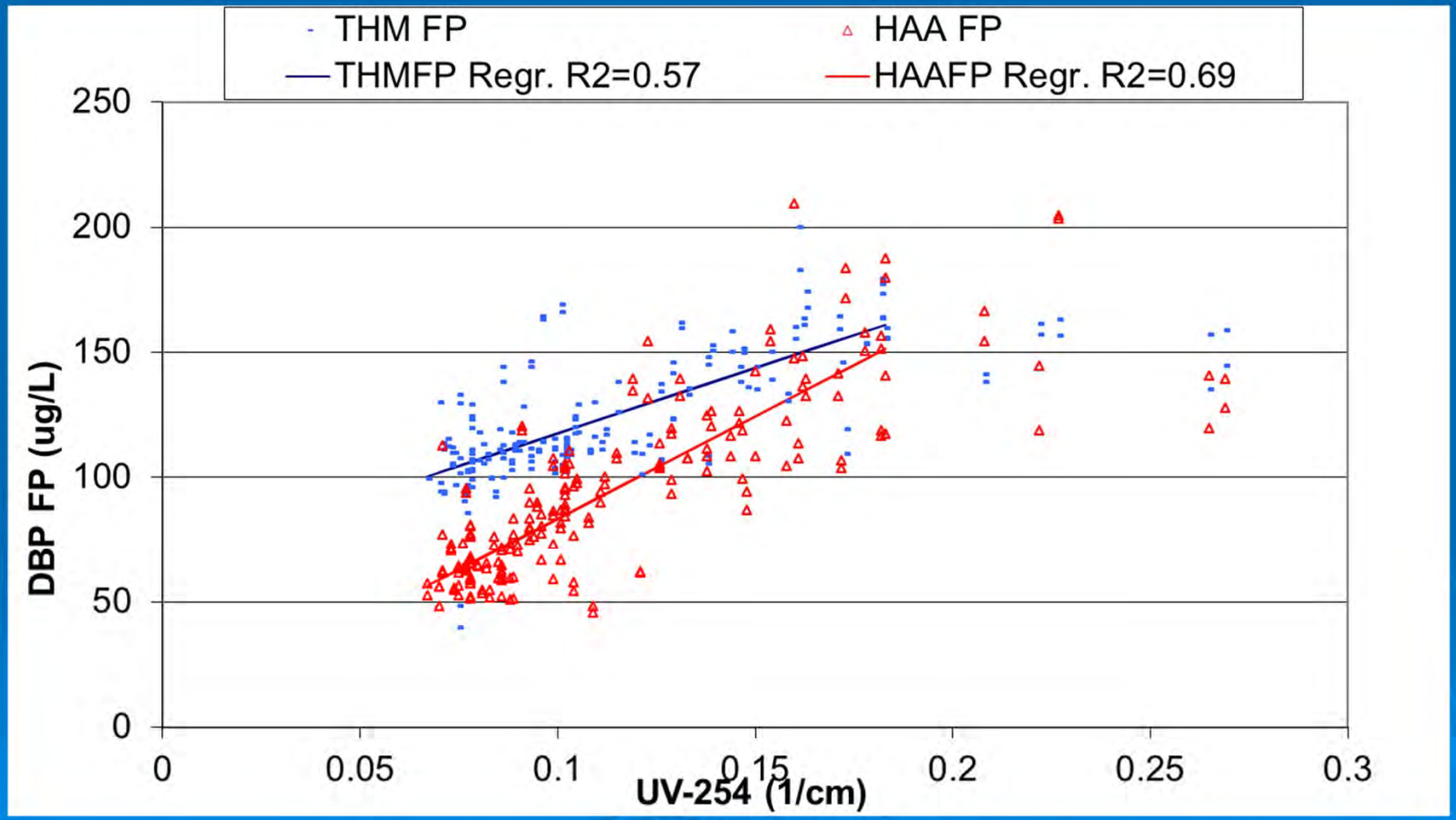
Formation Potential Results Cont'd

UV-TOC relationship demonstrated high correlation.



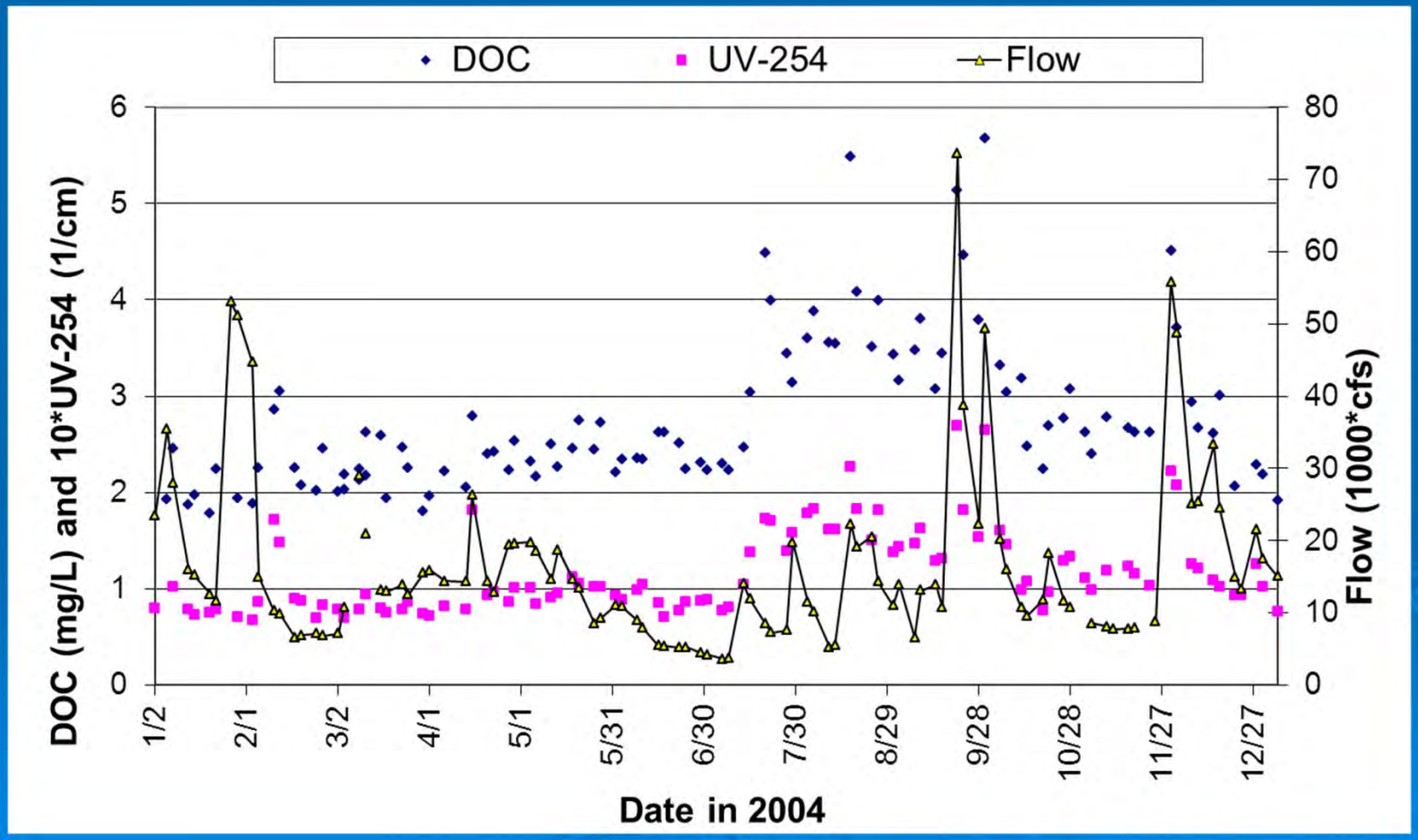
Formation Potential Results Cont'd

DBP FP also correlated well with UV254.



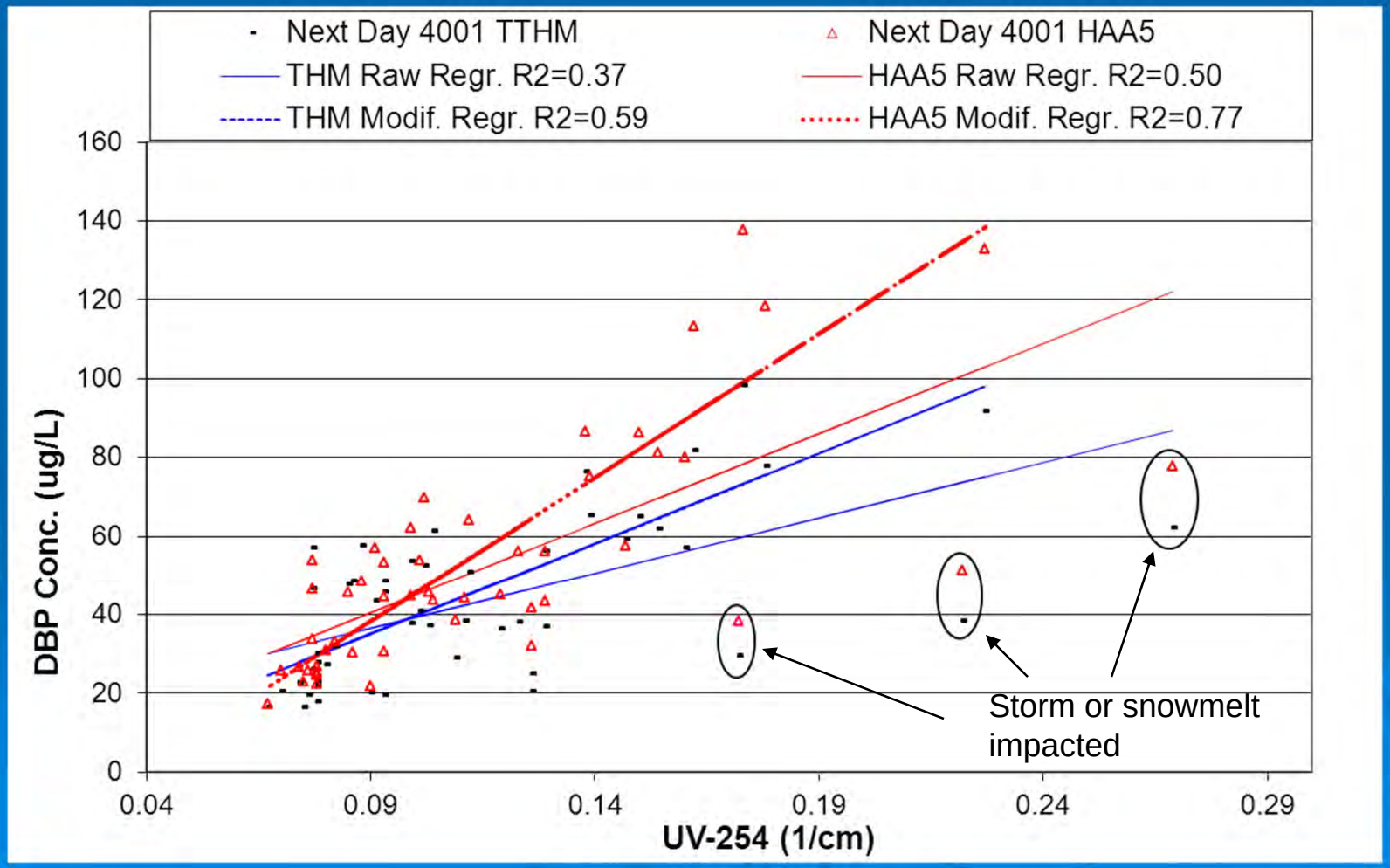
Formation Potential Results Cont'd

Increases in UV254 predicted river events well.



Formation Potential Results Cont'd

WTP Effluent DBPs exhibited good correlation to river UV254.



Formation Potential Results Summary

TOC was a good predictor of DBP FP, but it is not a convenient parameter to use.

UV was also a good predictor of DBP FP because it correlated well with TOC and DOC. UV254 also had good correlation with WTP effluent DBPs.

Increases in UV254 predicted river events well. UV254 was adopted as the convenient parameter to anticipate elevated DBPs. UV254 analysis is a rapid test and can be done at the plant site.

Formation Potential Results Summary cont'd

Routine UV254 monitoring has shown that coagulant demands increase with UV increases.

UV increases can precede turbidity increases during weather events.

Study 2: PAC Testing

Study Design

1) River water collected weekly

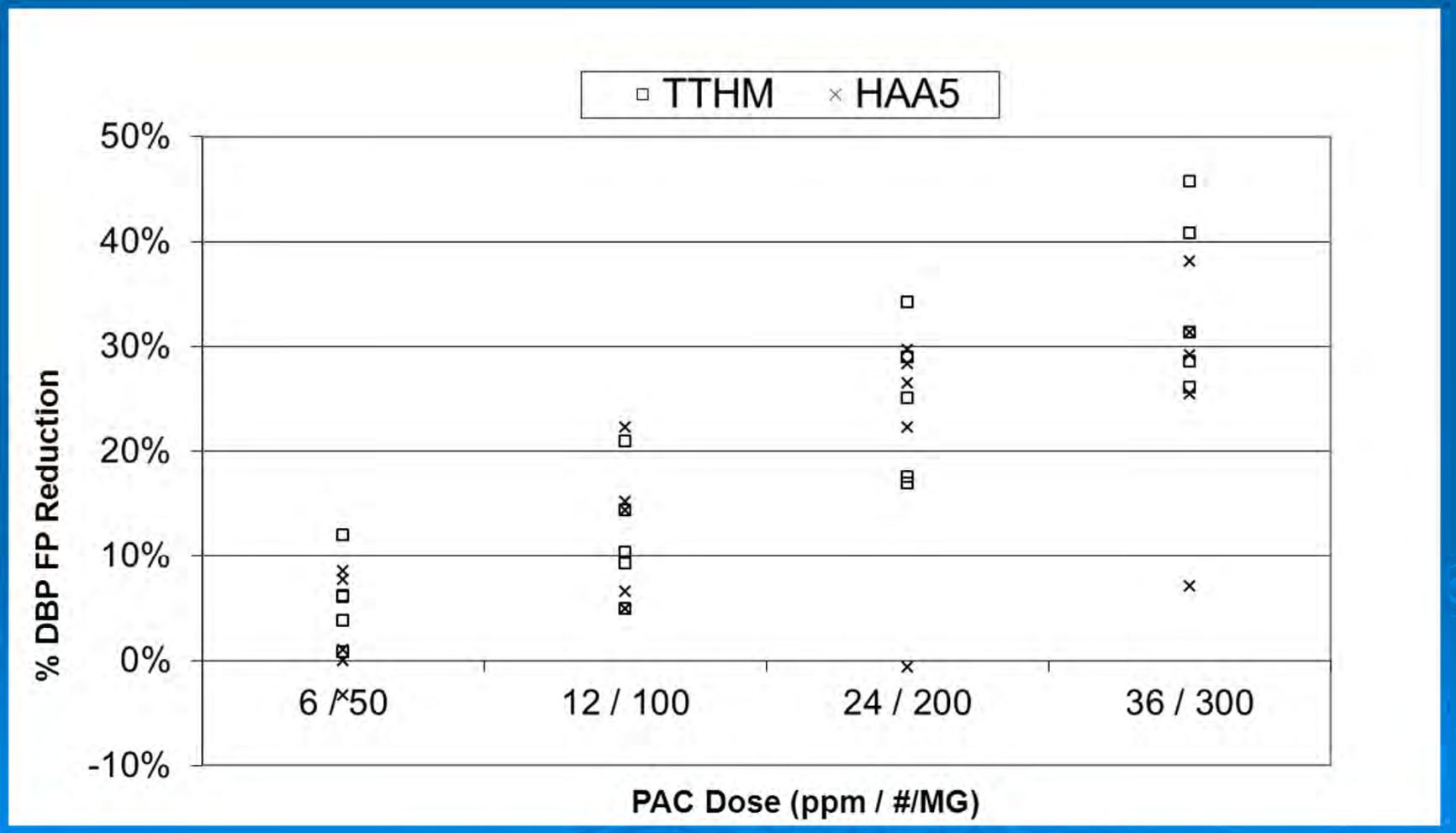
2) Six 1-liter aliquots jar-tested with different PAC doses (including blank and duplicate)

3) After 1 hour of mixing and 10 min of settling, PAC removed with 1-μm filter

Aliquots of water before and after filtering were measured for TOC, DOC, and UV254. PAC was lignite-based and had been in regular use for T&O control.

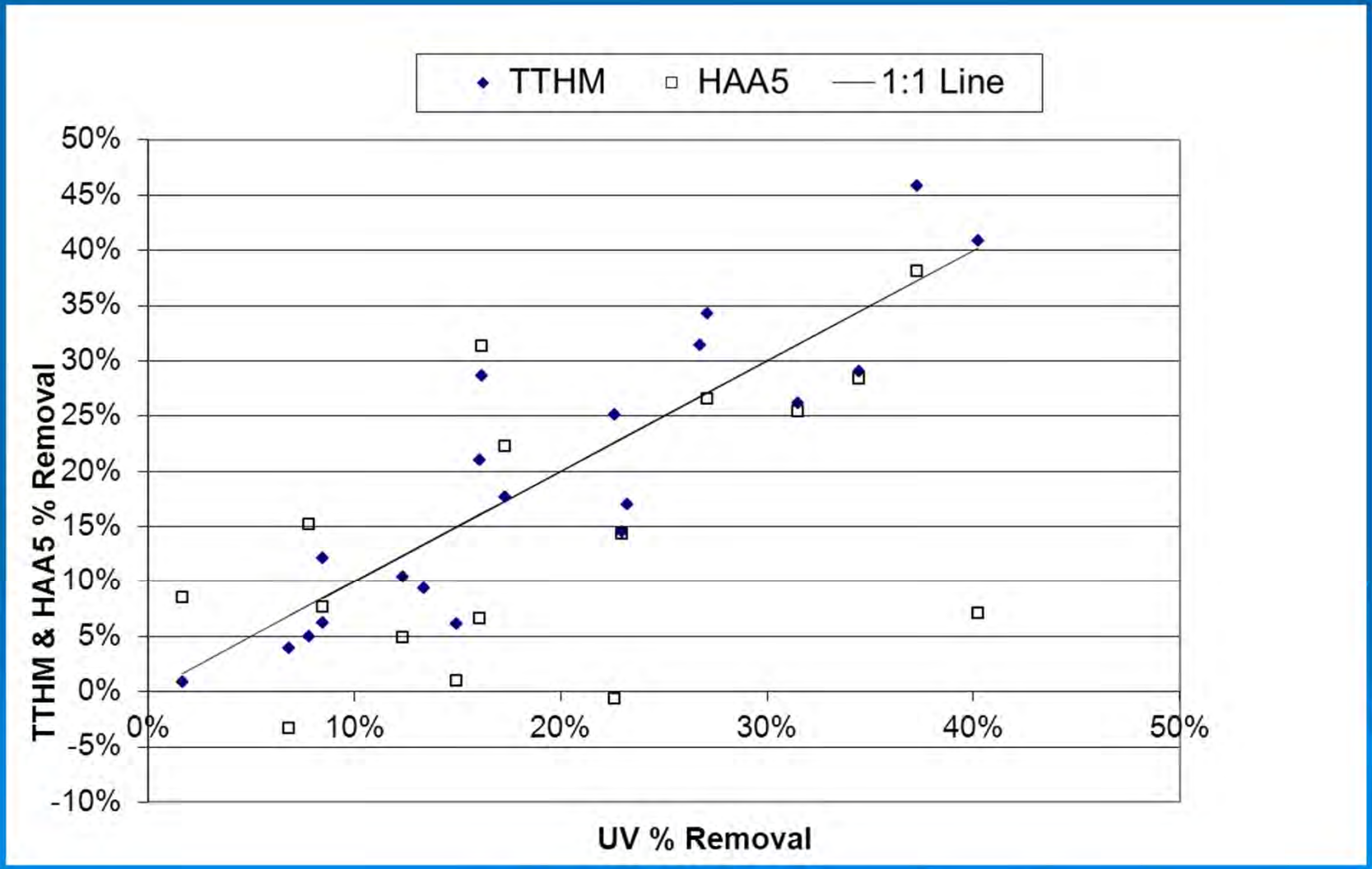
PAC Testing Results

DBP FP reduction versus PAC dose:



PAC Testing Results cont'd

DBP FP reduction versus UV254 reduction:



Development of Algorithm

An effluent HAA result of 45 μg/L (comfort level of 75% of MCL) approximately correlated to UV254 = 0.10 cm^{-1} – a suitable UV254 level to start PAC dosing.

Experience with the algorithm through the seasons lead to adjustments to avoid wasting PAC at lower temperatures.

Development of Algorithm cont'd

Current PAC Algorithm for Different Water Temps (ºF)
(May change on short notice in response to spills and T&O events.)

Carbon Dose @ Intake - #/MG				
uv 254	<40	>40 <55	>55 <66	>66
0.050	0	0	45	55
0.085	0	0	50	70
0.090	0	0	60	80
0.099	0	0	70	100
0.109	0	45	85	115
0.120	0	60	95	130
0.129	0	75	110	150
0.140	0	90	125	165
0.160	50	110	140	185
0.180	75	125	160	210
0.200	100	145	180	225

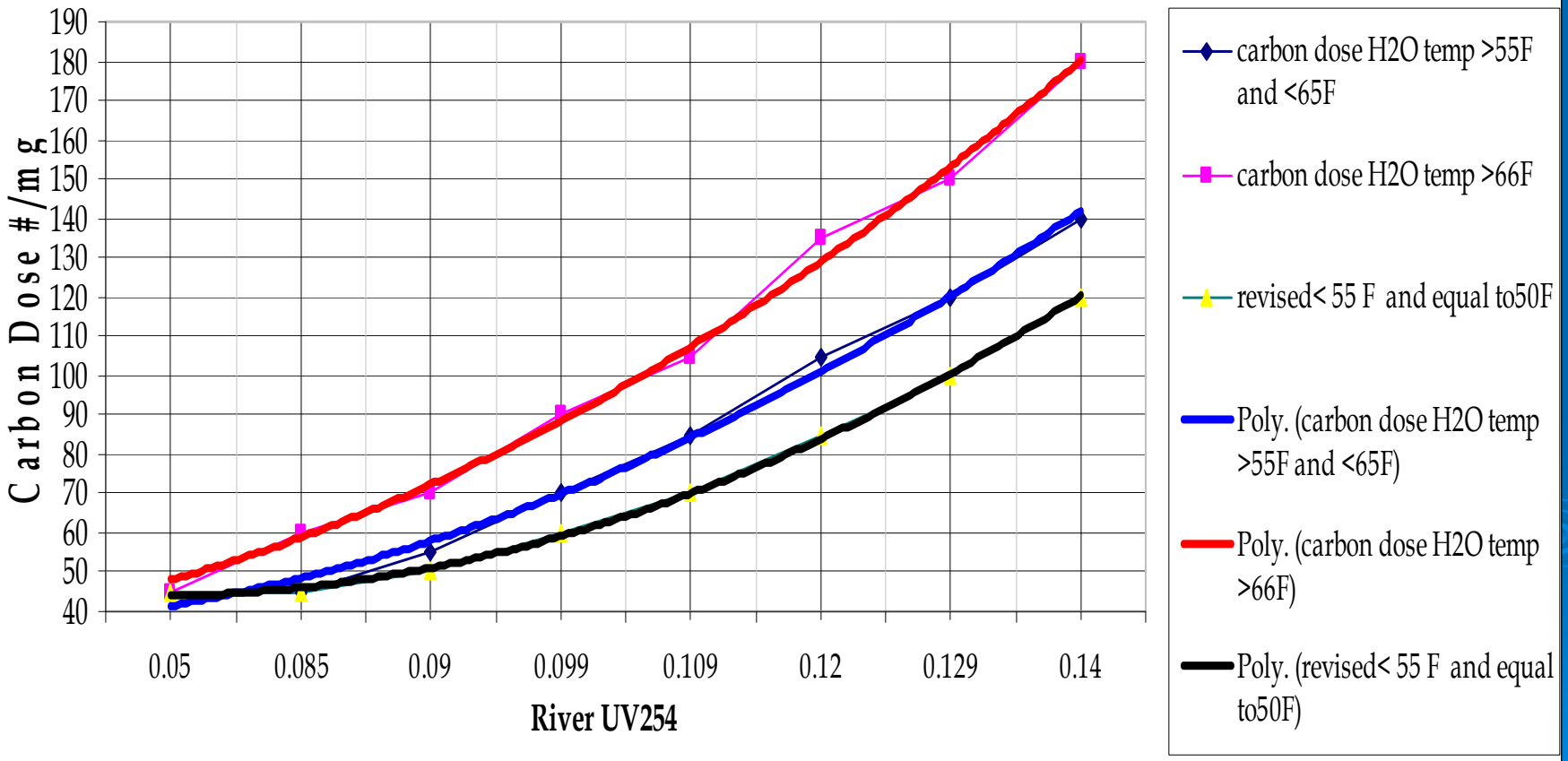
FULL SCALE TREATMENT

- Dosing Carbon Slurry at Influent Channels to the Tidal Raw Water Basin; 12- 18 hour DT

BAXTER WTP CARBON DOSING GUIDE- *November 2008*

Amended 10/15/13 :

no routine dosing water temp < 50F unless UV254 river >0.110/cm or spill or T&O



How have things been since algorithm developed?

Daily Routine UV254 analysis of raw water & RWB effluent continues

- data used to trigger dosage changes and track carbon product effectiveness

Refined the Dosing Curves based on full scale experience

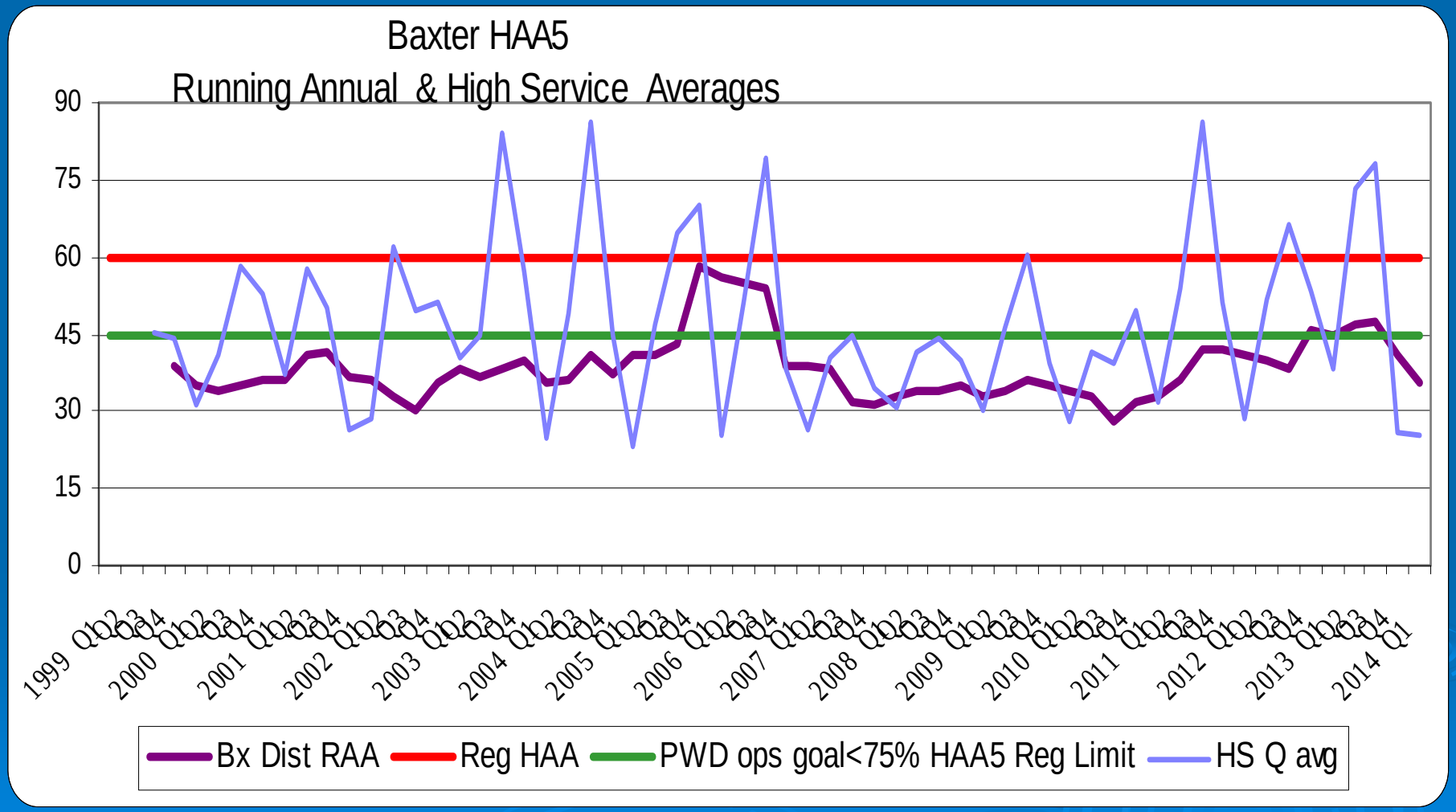
-jar test results underpredict full scale UV254 % removal across the large 176 MG Raw Water Basin with 12- 18 hour detention time

- change from lignite to wood-based carbon in FY09; better removal

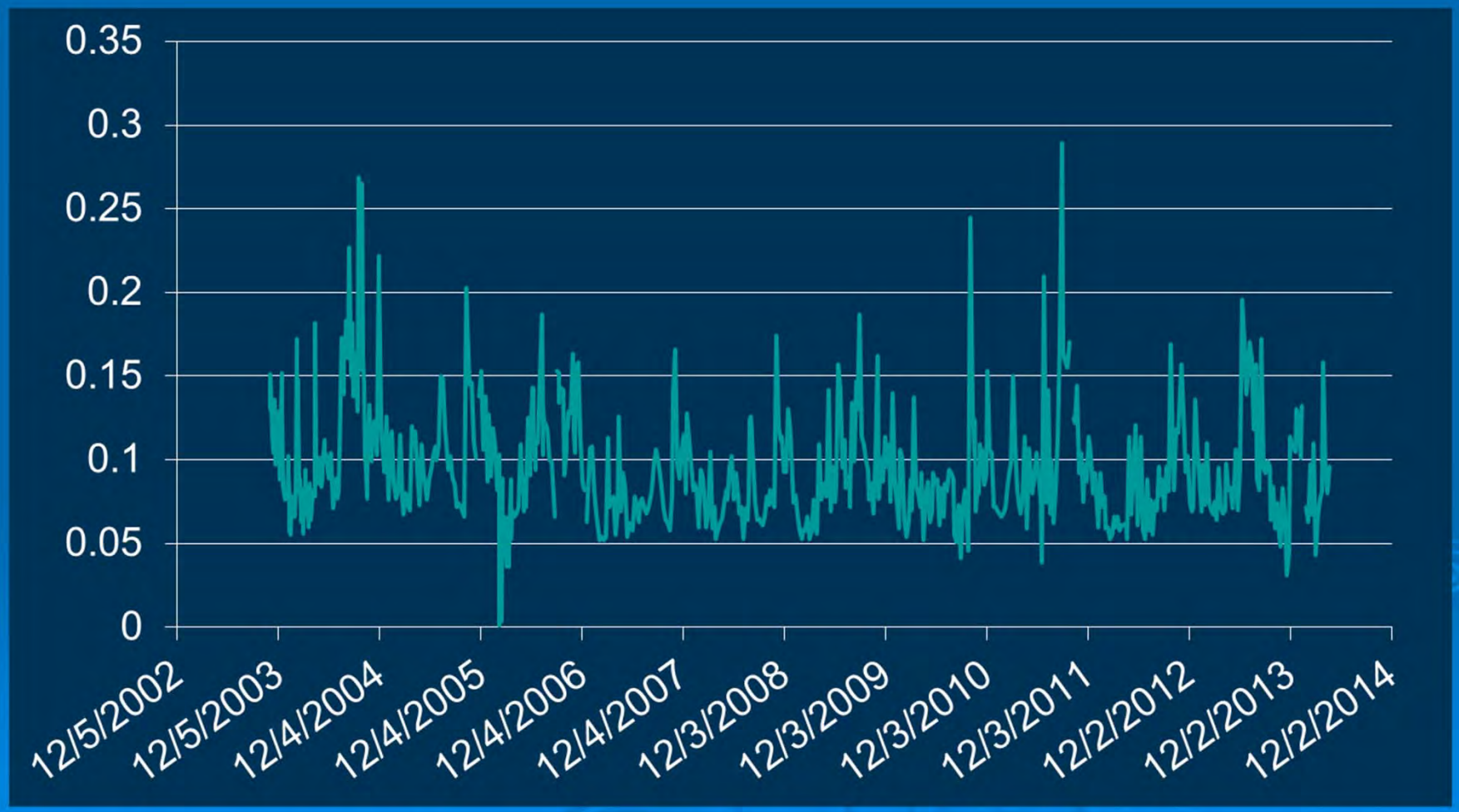
- change from wood to coconut product (good T&O removal); drop in effectiveness in NOM removal

-back to lignite product and refined 2008 Dosing Curves

Post-algorithm (2006) DBP results have been under better control…



…while UV-254 has been frequently exceeding 0.1 cm^{-1}.



Summary

- Formation potential study gave us a wealth of information over one year
- PAC study demonstrated the power of using PAC as a routine method for DBP control
- Development of algorithm and confirming UV254 as an effective trigger parameter gave us a valuable tool to make treatment process changes and meet DBP compliance

Acknowledgements

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John Muldowney, Bruce Aptowicz, Bill Wankoff, Rita Kopansky, Norm Jadczak, Joanne Utkus, Jerry Kuziw, Nicole Charlton, Donna Schwartz, Ramesh Shah

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Thank you.

Any questions?

Philadelphia PWD Water Department