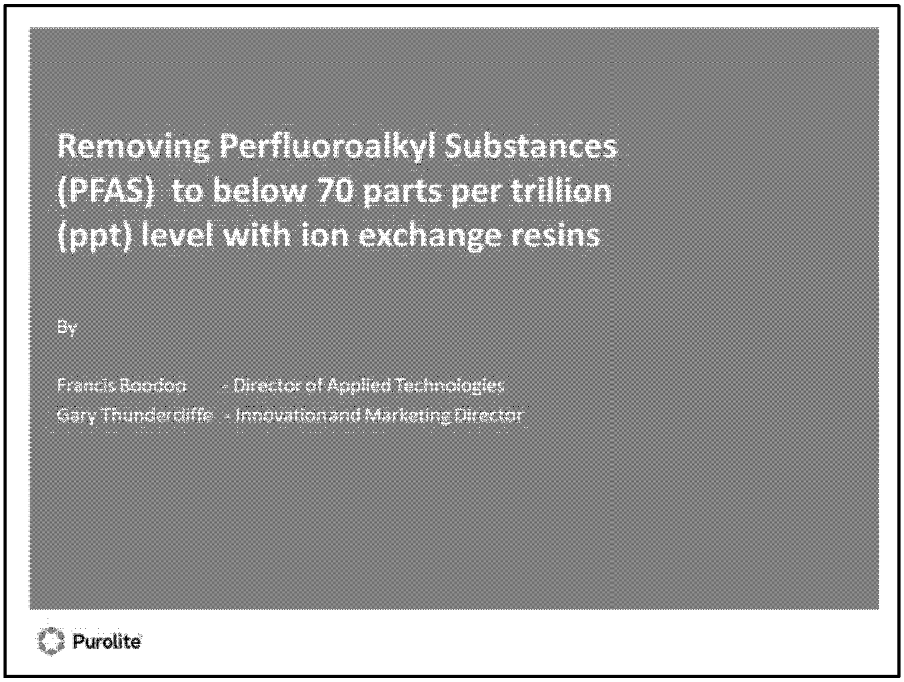

Welcome everyone. My name is Francis Boodoo and I will be making this presentation in conjunction with my colleague Gary Thundercliffe.

Our presentation today is “Removing Perfluoralkyl Substances (PFAS) to below 70 parts per trillion with ion exchange resins”.

We are hoping to complete the presentation within 45 minutes which will leave us with about 15 minutes for discussion and questions.

Take-aways from this Webinar (Page 1)

- Consider Ion Exchange resin (IX) as a viable alternative to GAC.
- Special high capacity IX now available for PFC removal.
- Such resins can effectively reduce both short and long chained perfluoroalkyl substances (PFAS or PFCs) (such as PFOA, PFOS, PFBS and PFBA) to below 70 parts per trillion (ppt) levels
- Current focus on long chained PFCs (e.g. PFOS, PFOA) will soon change to focus also on short chain PFCS as these are persistent. IX shows better performance than GAC.
- PFCs are generally ionized at pH range typical of drinking water. IX removes PFCs by a combined mechanism of ion exchange and adsorption. IX yields superior results since GAC removes PFCs mainly by adsorption.

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Before we begin the presentation I always like to list some points that I hope you will take away from the presentation.
Here they are:

(1) – You should consider ion exchange as a viable alternative to GAC for specific jobs which we will get into.
(2) We now have special high selectivity high capacity resins available for PFC removal. Note that I will be using the term PFC instead of PFAS during the presentation as it is easier to say and for some reason the commercial part of the industry seems to like saying PFC.
(3) These high capacity resins can effectively reduce both short and long chained PFCs to below 70 ppt which– the latest Health advisory from US EPA for PFOS and PFOA. Examples of short chained PFCs are PFBS and PFBA.
(4) We think the industry will soon start focusing on short as well as long chained PFCs since short chained PFCs are persistent in the environment. Ion exchange shows significantly better performance on short chained PFCs.
(5) Another point of interest is that PFCs are generally ionized at typical pH for drinking water. This is what makes ion exchange better than GAC as ion exchange can remove PFCs by a combination the ion exchange and the adsorption mechanisms.

Take-aways from this Webinar (Page 2)

- Single use application of higher capacity resins is practical e.g. Purolite A632E
- Regenerable resins available can reduce operating cost vs GAC.
- Consider resins also for polishing effluent from GAC to reduce PFCs to lower levels
- CAPEX reduction is possible – IX can operate at higher velocities
- Choose between resins and GAC:
    - (a) CAPEX, (b) OPEX, (c) consistent reduction of PFCs to acceptable levels
- Are resins applicable for POE / POU devices? - being evaluated now

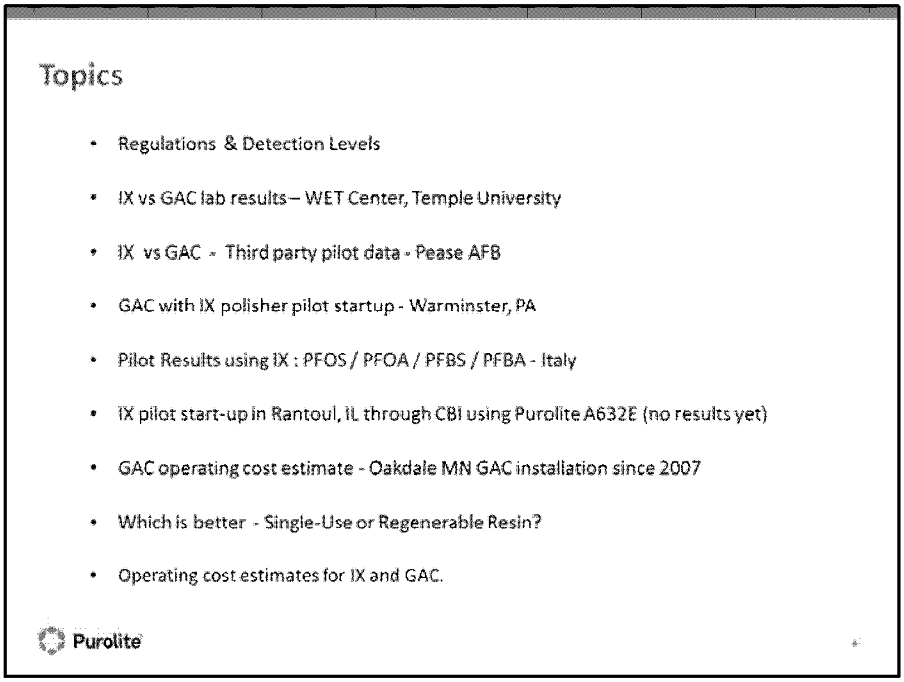
Purolite

(6) It is possible to use high capacity resins on a single use basis s for example our Purolite A632E.

(7) We are also working on regeneration methods that allow reuse of the regenerant and there reduced operating cost vs GAC

(8) I suggest you also consider ion exchange as a polisher downstream of existing GAC systems as a way to reduce the PFC concentration to even lower levels.

(9) Since ion exchange resin can generally be operated at high linear velocities than GAC, there is the potential to reduce capital cost with smaller ion exchange systems.
(10) You should choose between ion exchange and GAC based on (a) CAPEX, (b) OPEX and © ability to consistently reduce PFCs to below health advisory levels, and
(11) I thought I would mention POE/POU application for resins since we are getting more and more inquiries. The short answer is that are now evaluating this at present and we are hopeful.



So here are individual topics we will be discussing:

Regulations
IX vs GAC at Wet Center
IX vs GAC third part data
IX as a polisher to GAC
A really interesting study in Italy
Just a note that we are starting a pilot with A632E at Rantoul, IL – no results as yet
We will look at GAC at Oakdale MN operating since 2007
Then we will look at Single use vs regenerable resins
And finish with operating cost estimates for IX and GAC

Health Advisories for PFCs in parts per trillion (or ng/L)

		US EPA	NJ	MN	NC	Italy	UK	Germany
PFOA	perfluorooctanoic acid	70	40	300	2000	500	300	
PFOS	perfluorooctanesulfonic acid	70		300		30	300	
PFBA	perfluorobutanoic acid			700				
PFBS	perfluorobutanesulfonic acid			700				
PFNA	perfluorononanoic acid		10					
PFOA + PFOS		70				500		100

Detection Levels for PFCs in parts per trillion (or ng/L)

		ASTM D7968-14	EPA 537-2009	Test America	Shimadzu
PFOA	perfluorooctanoic acid	6.24	1.7	4 - 20	15.6
PFOS	perfluorooctanesulfonic acid	18.83	1.4	4 - 20	10.3
PFBA	perfluorobutanoic acid	22.01		4 - 20	
PFBS	perfluorobutanesulfonic acid	6.49	3.1	4 - 20	
PFNA	perfluorononanoic acid	2.82	0.7		12.3

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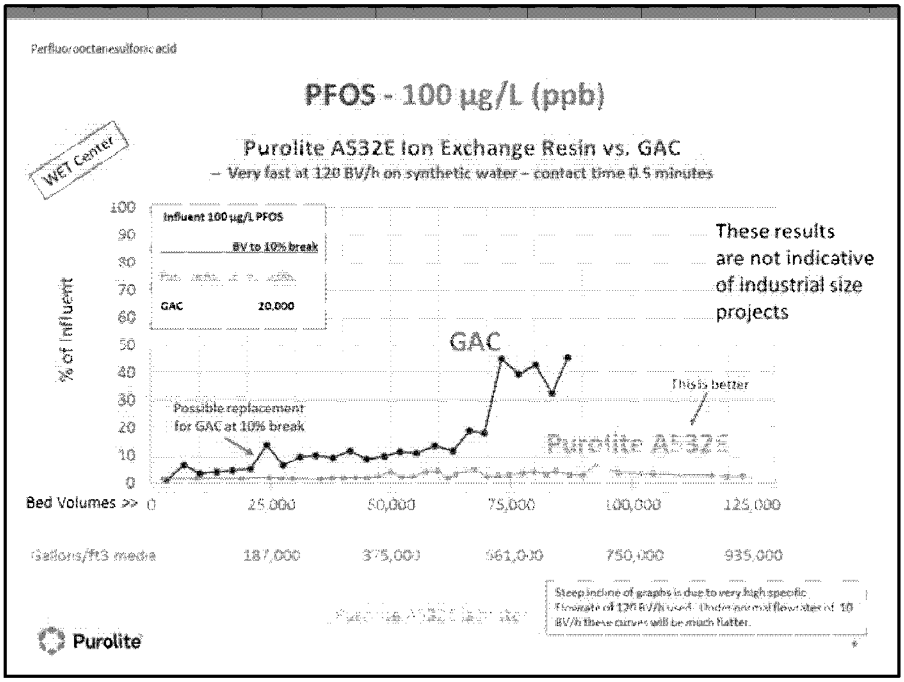
DLs are partly driving HAs

So here I compare regulations with detection levels from various labs.
In the top table we see that health advisories from the EPA, NJ, MN, NC, Italy, the UK and Germany. You can see that there is a lot of variance in the regulations from as low as 30 ppt in Italy to as high 2000 ppt in NC.

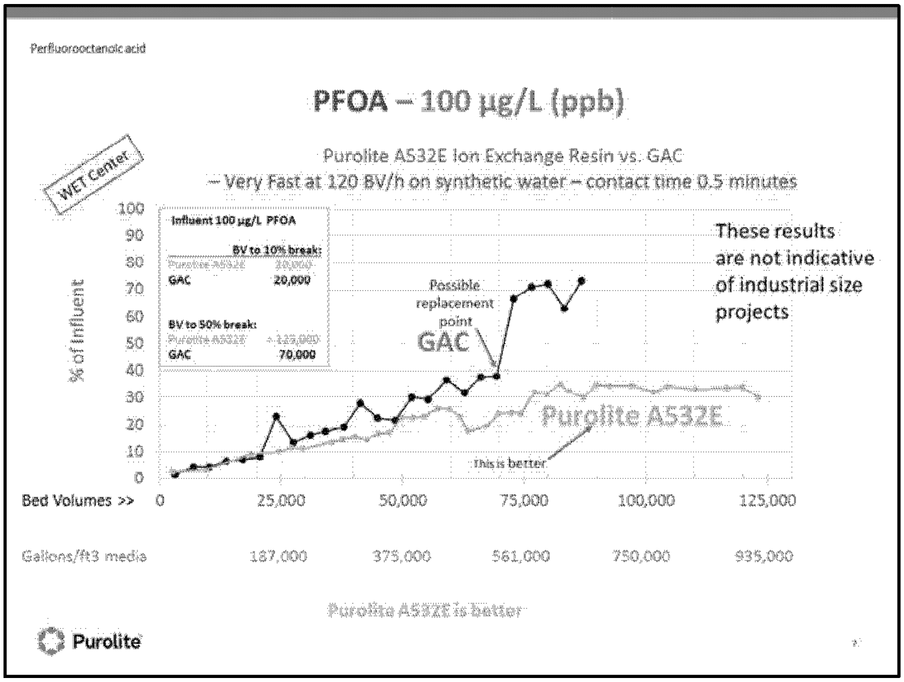
Take a look at the bottom table showing information I was able to find from various labs and various standard methods like ASTM and US EPA 537-2009.
The detection levels are what I either got from the methods, or from specific labs. As you can see everybody is trying to get down to single digit levels. In effect what I see here is that detection levels are partly driving the regulations – I have seen this movie before with perchlorate about 15 years ago and more recently with NDMA.



Here is some information that was generated by the WET center at Temple University which our company partially funded. These graphs are for PFOS with an influent level of 100 ppb.

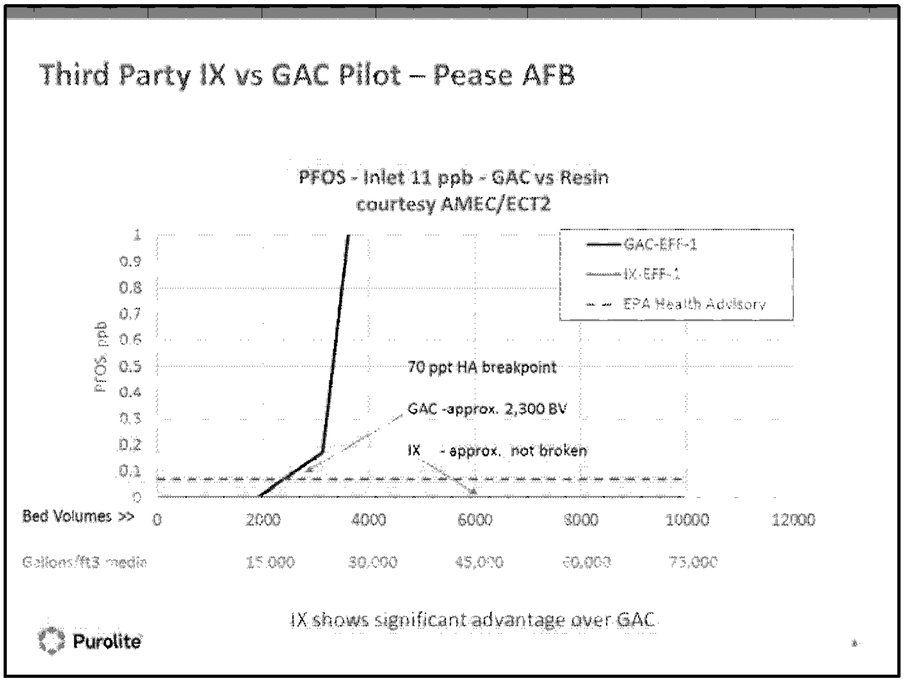
Column studies were run comparing GAC to resin – Purolite A532E in this case. What you should note in particular is that these studies were done at very fast specific flowrate of 120 bed volumes per hour or about ½ minute contact time. So these results are not meant for design of industrial systems but were really run this fast in order to finish the capacity study in a reasonably short time. So at these fast rates, the results may be more indicative of how these media would behave in the tiny cartridges that people install under their sinks.

But what we see here, at least for PFOS, the capacity pf A532E, even under these very fast conditions, is quite good at about 125,000 bed volumes without a break or about 1,000,000 gallons of water treated per cubic foot of resin. It also shows that this resin holds on to the contaminant much better than GAC.



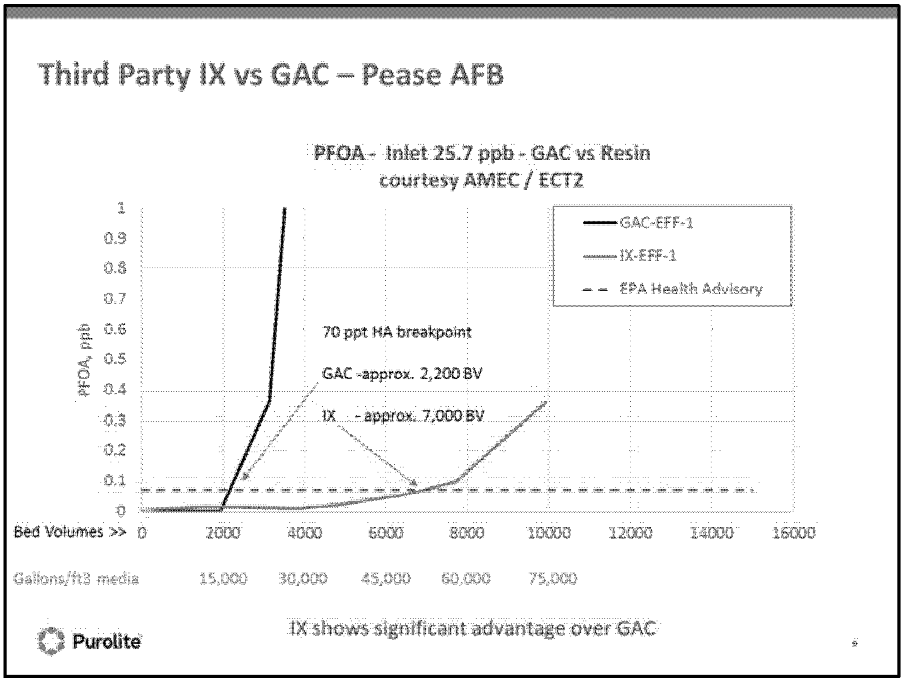
Here is a similar comparison of A532E and GAC under the same flow conditions as the previous slide.

Again you can see that both GAC and A532E are trending up with GAC eventually breaking away at about 70,000 BV while A532E continues on. But of course in both case leakage is higher than desired unless of course one were to install another column downstream and then operate the system as a lead-lag pair of columns.



I got permission from AMEC to show this pilot study at Pease AFB comparing GAC and IX (this was not our resin). Inlet PFOS was 11 ppb and you can see that the GAC curve in black breaks much earlier than the ion exchange curve in blue.

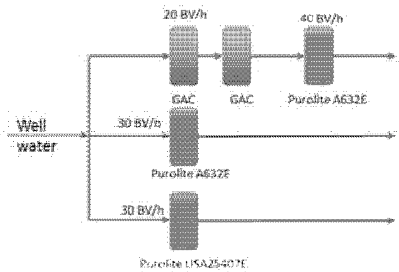
If using the new health advisory level of 70 ppt as the breakpoint, then GAC would have done about 2300 bed volumes or about 17,000 gallons per cubic foot
For the resin you can see the capacity had not broken at the end of the study.
So this study emphasizes the difference in performance of GAC vs IX under these particular set of conditions.



Here are the graphs for PFOA for the same study. In this case PFOA inlet concentration was 25.7 ppb and again you can see an early break from GAC at about 2200 BV or 16,000 gals/ft3 while the resin did break in this case at about 7,000 BV or about 52,000 gal/ft3

Warminster - GAC Pilot; IX added a few weeks ago

- Concern with GAC consistently reaching latest Health Advisory 70 ppt when using Lead - Lag vessels of GAC
- Resin polisher pilot now in operation as shown in order to achieve non-detect



GAC Effluent - parts per trillion (ppt)

PFC:		Analytical Lab. Detection Limit	Raw Inlet	Lead GAC #1	Lag GAC #2
Perfluorooctanoic acid	PFOA	1	270	190	100
Perfluorononanoic acid	PFNA	1	20	20	20
Perfluoroheptanoic acid	PFHpA	1	50	40	30
Perfluorobutanesulfonic acid	PFBS	4	90	90	90
Perfluorohexanesulfonic acid	PFHxS	4	290	190	90
Perfluoroctanesulfonic acid	PFOS	5	720	350	150

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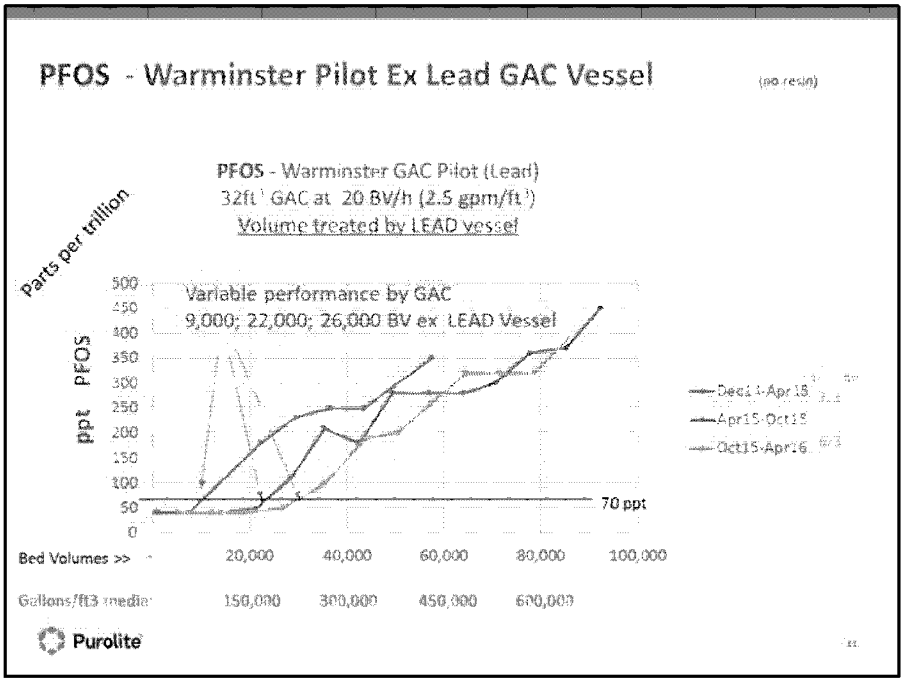
Here is the Warminster PA study. The system operates with two blue GAC vessels in series or lead-lag fashion and the GAC operates at a specific flowrate of 20 BV/h or about 2.5 gpm/ft3 – a bit faster than I would expect but in this case the customer changes out the GAC charge in both the lead and lag vessels. So in effect the combine specific flowrate is about 10 BV/h or about 1.25 gpm/ft3 which is more typical.

The customer wanted to evaluate whether ion exchange would be able to reduce the effluent concentrations of PFCs from the GAC to levels lower than the recently published health advisory level of 70 ppt. So in June we installed our A632E downstream of the GAC as well as in a bypass stream to evaluate how the resin alone will perform. We have also installed another of our resin which we are hopeful will be easier to regenerate if we choose to go that way. So this study is an important one for the industry as I am not sure if there are any other pilots running like this at present. We are just starting to get results, so I am sure everyone will be anxious to learn how it performs.

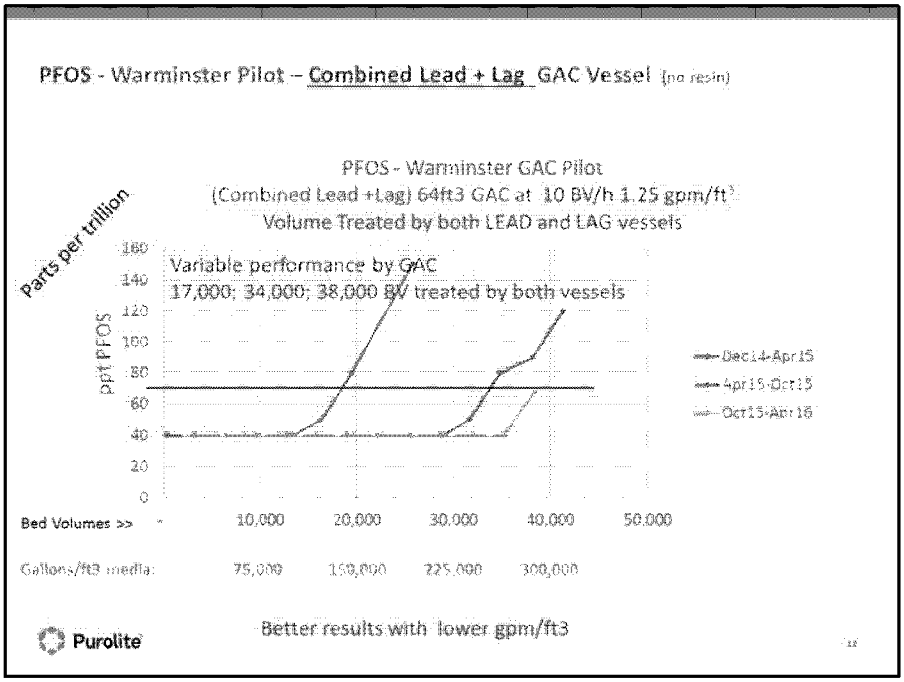
In this case, you can see in the table the results before the IX was installed and you can see that the GAC was reducing PFOS, PDOA and PFHxS by maybe about a ½ through the lead vessel and then half again through the lag vessel. These numbers are higher than the current health advisory levels.



Let's take a closer look at what happens with PFOS as it exits the lead vessel – we will look at the lag vessel in the next slide.

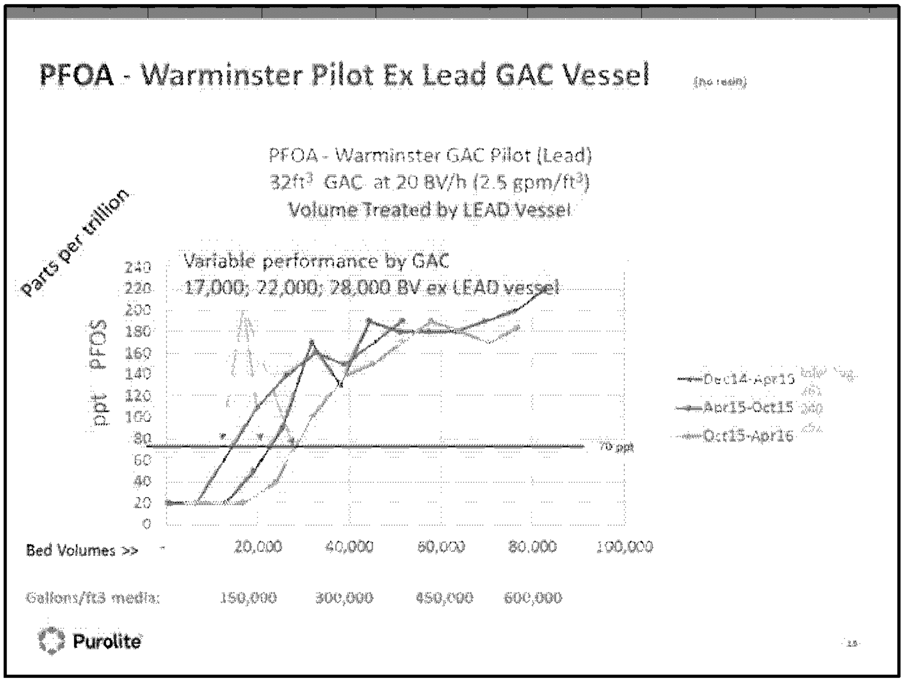
You can see that the y-axis is showing ppt levels of PFOS, the GAC volume per vessel is 32ft3 and the flowrate is 2.5 gpm/ft3.

Look at how variable the results are. If using the new 70 ppt health advisory level for a breakpoint, then you will see in Dec2014 to Apr 2015, capacity was 9000 BV, for Apr15 to Oct15 it was 22,000 BV and the last change out showed about 26,000 BV capacity – so quite variable results.

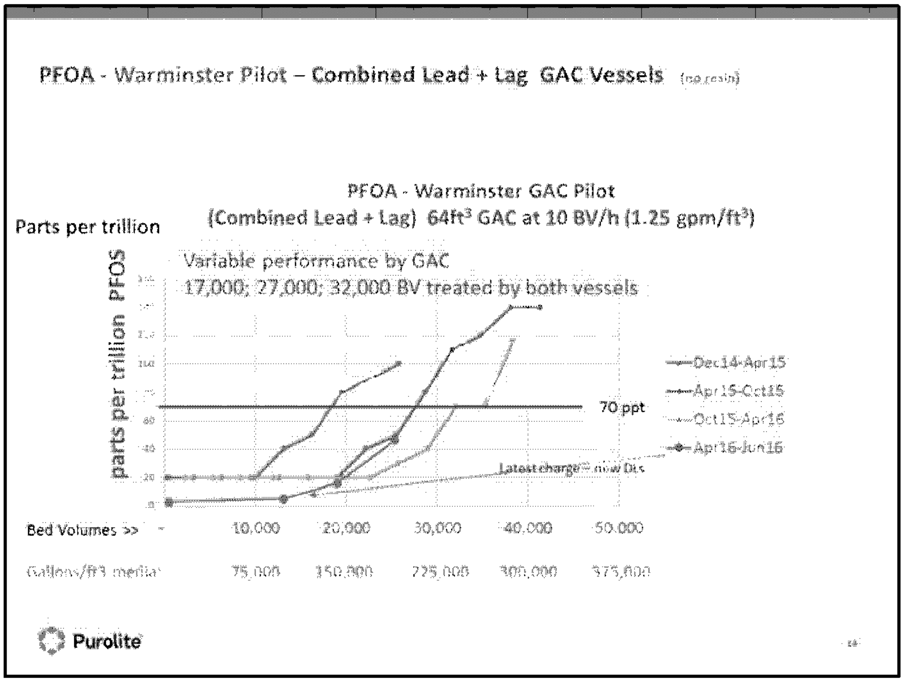


Now look at the results ex the lag vessel – you see the same type of variability. In this case I shows the breakpoint capacity related to the total volume of GAC in both vessels, since both are changed out at the same time.

Again the capacity varies quite a bit from 17,000 BV to 38,000 BV – so this would be difficult to predict on an on-going basis.



The same kind of results are obtained for PFOA ex the lead vessel – you can see capacity varies from 17,000 to 28,000 BV in this case.



And the same type of variability for the results out of the LAG vessel, with capacities from 17,000 to 32,000 BV.

Here is the latest charge just recently installed with the purple color. They plan to change out the GAC soon base don 70 ppt break.

As you can see they also just switched to a new test method with a lower detection level.

Warminster Pilot – 1st Set of Analyses on IX pilots – ppt (ng/L)*

	Detection Levels	Raw Water	Ex GAC LAG	Ex A632E Polisher		Ex Standalone A632E		Ex Standalone USA25407E	
Bed Volumes	>>>		15000	4090	6078	1920	5040	1920	5342
PFOA	1	230	100	ND	ND	ND	3	ND	ND
PFNA	1	12	3	ND	ND	ND	2	ND	1
PFHpA	1	68	35	ND	ND	ND	4	ND	2
PFBS	4	24	18	ND	ND	ND	ND	ND	ND
PFHxS	4	190	78	ND	ND	ND	ND	ND	ND
PFOS	5	700	22	ND	ND	ND	ND	ND	ND

GAC changed after 2 months service.
A632E polisher is doing its job so far at 6078 bed volumes.
Data for resins looks good so far – need more data before any conclusions !

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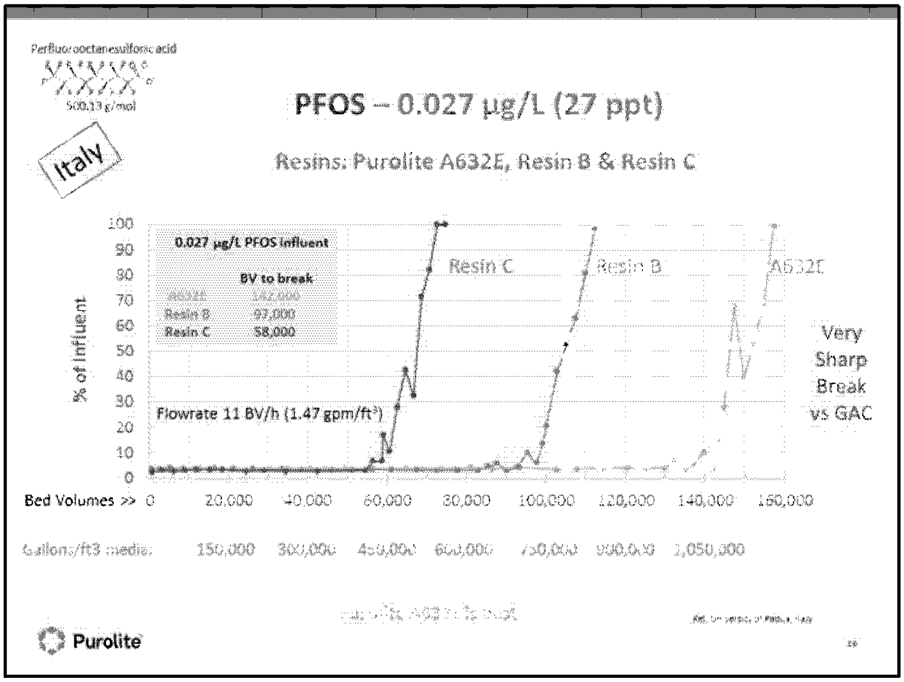
* Eurofins Lancaster Labs

Really impressive results for A632E in polisher to GAC position and in standalone position. But these are just a few data points – so no need to get too excited about them. We have to wait for more data point to detect a trend since the values are close to the already low detection levels.



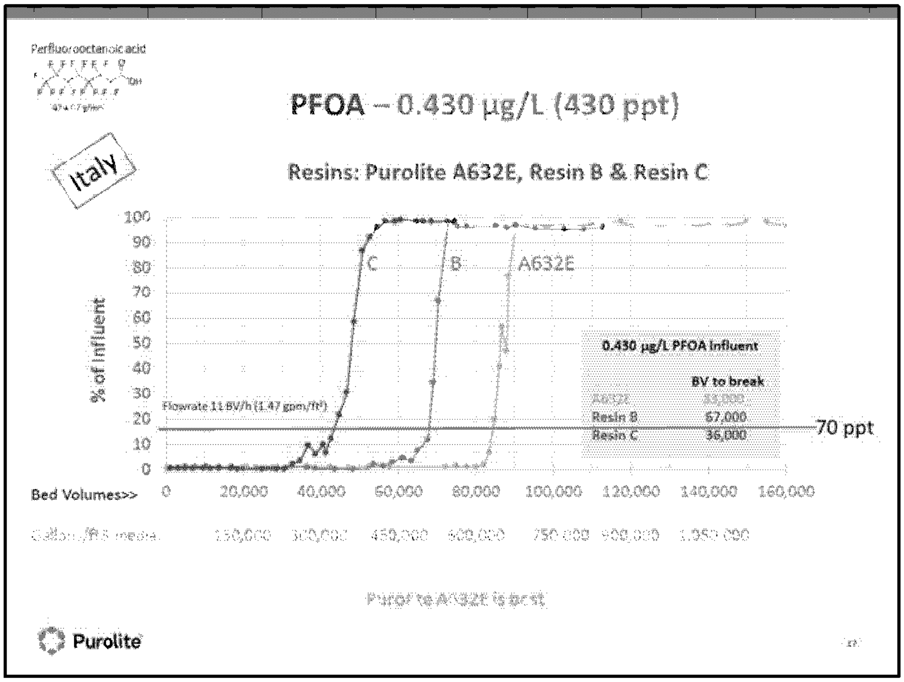
Now lets look at this interesting study done in Italy with our resins. The plan here was to evaluate the regenerability of the resins, no side by side pilot was run with GAC.

As you can see the PFOS influent level was quite low at 27 ppt and what is very noticeable here are the very flat curves obtained for all three resins.

The y-axis in this case is percent of influent while the x-axis is the usual bed volumes or gallons treated per ft3 of resin.

The very flat curves is really important since GAC tends to have a more gradual break at closer to a 45 degree climb while the water is treated. In this case the breaks are very sharp - almost at ninety degrees to the horizontal – this is almost ideal as if operating in lead-lag fashion the lead vessel will remove virtually all the PFC and leakage ex the lag vessel will be extremely low – that is exactly what you want..

You can see that A632E is really giving outstanding capacity for PFOS at about 1,000,000 gallons of water treated per cubic foot of resin where as the other resins (which are also Purolite resins) are not doing as well.

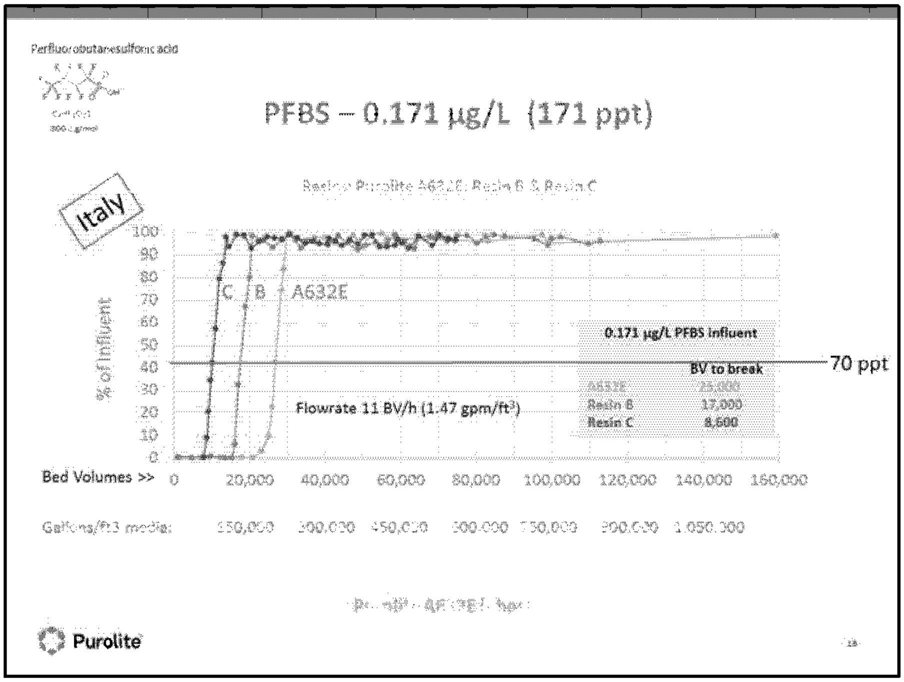


So again the same study from Italy but this time for PFOA.

You can see the same shapes for the curves – very flat and then a ninety degree break.

In this case capacity for PFOS is about 83,000 bed volumes our about 600,000 gals/ft3.. Here the influent PFOA is 430 ppt.

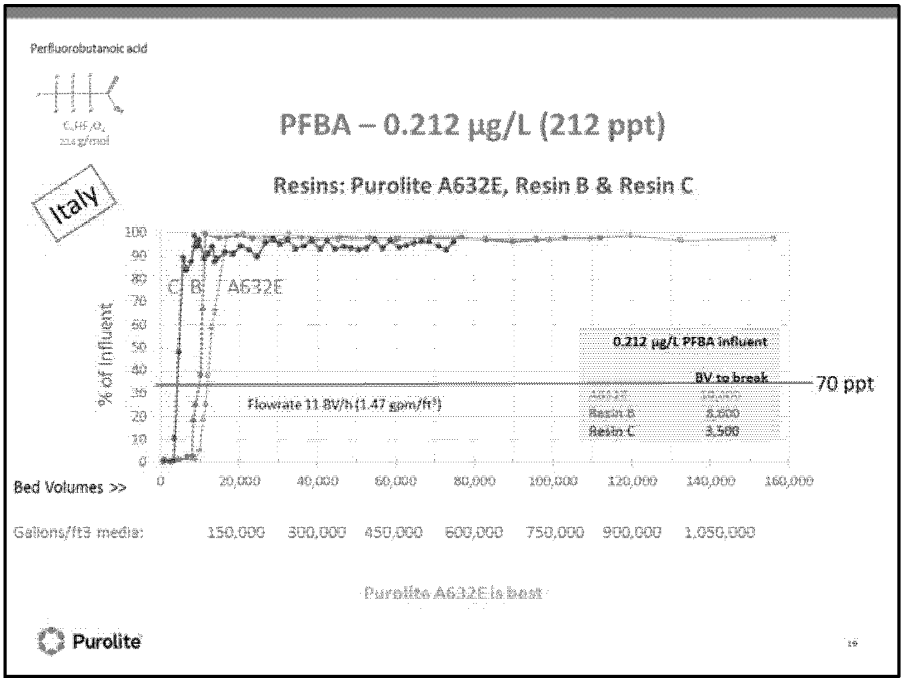
US00003392



Here is how the resins behaved for the short chained compound – PFBS – perfluorobutanesulfonic acid.

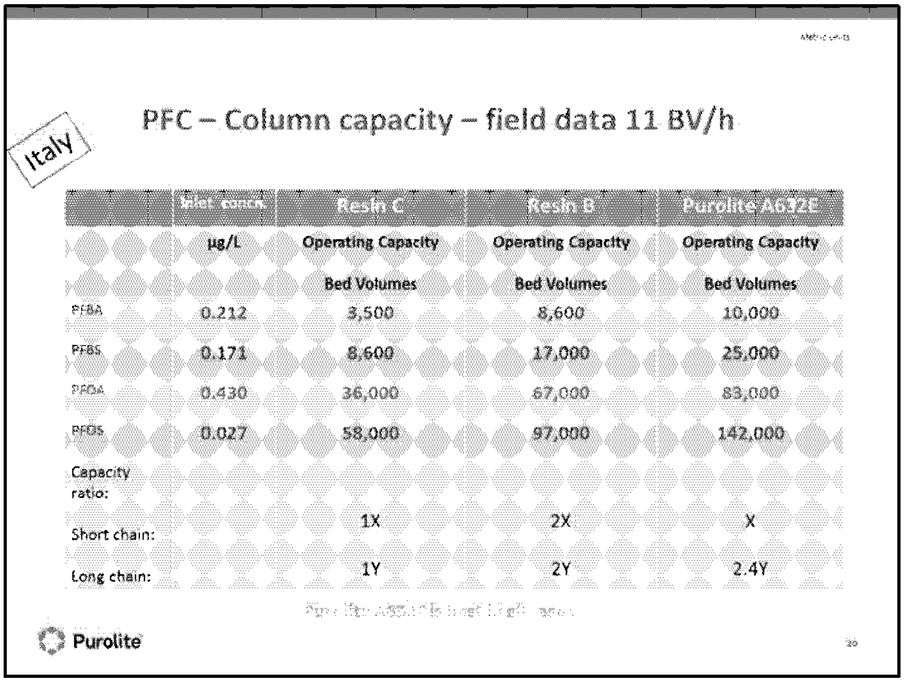
Inlet level was 171 ppt you can see that capacity for PFBS by all three resins was much less than for PFOS and PFOA, but still the capacity of A632E is still decent at about 25,000 BV or about 187,000 gallons/ft3.

And as I said, we are evaluating various regenerants right now –so hopefully we will have something definite in the near future.



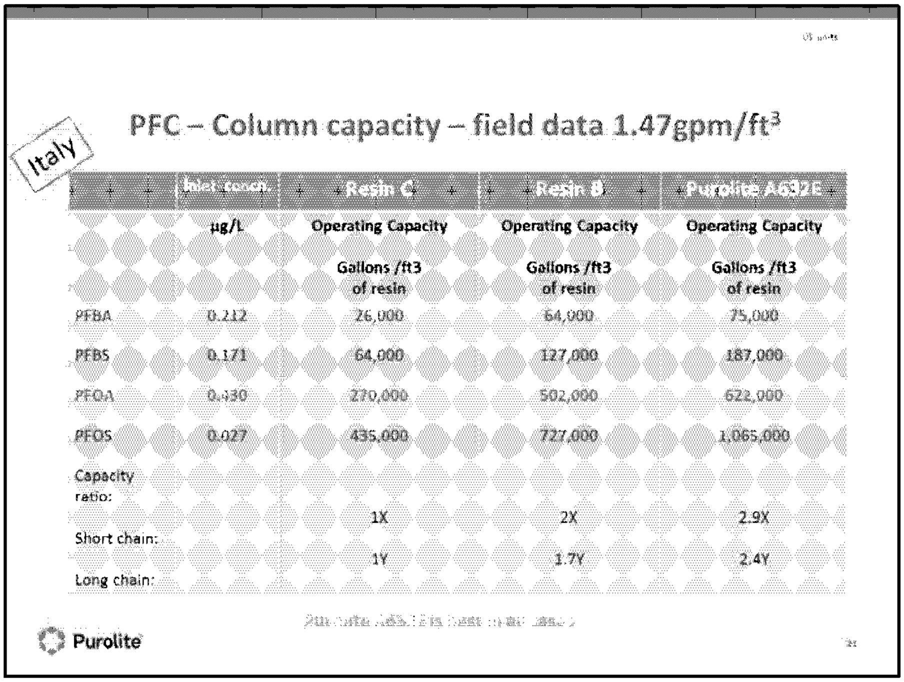
Here is the capacity for the shortest PFC studied - PFBA. Inlet level is 212 ppt and again you can see the capacity of A632E is about 10,000 BV or about 75,000 gallons/ft3.

So as we go from PFOS, to PFOA to PFBS to PFBA, the capacity continues to decrease.



	Inlet conc.	Resin C	Resin B	Purolite A632E
	µg/L	Operating Capacity	Operating Capacity	Operating Capacity
		Bed Volumes	Bed Volumes	Bed Volumes
PFBA	0.212	3,500	8,600	10,000
PFBS	0.171	8,600	17,000	25,000
PFOA	0.430	36,000	67,000	83,000
PFOS	0.027	58,000	97,000	142,000
Capacity ratio:				
Short chain:		1X	2X	X
Long chain:		1Y	2Y	2.4Y

So here is a summary of the results for all four PFCs – in metric units and we can turn to the next slide .....



PFC – Column capacity – field data 1.47gpm/ft³

Italy

	Inlet conc.	Resin C	Resin B	Purolite A632E
	µg/L	Operating Capacity Gallons /ft3 of resin	Operating Capacity Gallons /ft3 of resin	Operating Capacity Gallons /ft3 of resin
PFBA	0.212	26,000	64,000	75,000
PFBS	0.171	64,000	127,000	187,000
PFOA	0.430	270,000	502,000	622,000
PFOS	0.027	435,000	727,000	1,065,000
Capacity ratio:				
Short chain:		1X	2X	2.9X
Long chain:		1Y	1.7Y	2.4Y

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Here is the summary in US units.

Look at the relative operating capacities for Resin C, Resin B and Resin A632E –

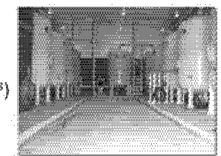
For short chained PFCs we have 1X for resin C, 2X for resin B and about 3X for resin A632E

For long chained PFCs, we have 1Y, 1.7 Y and 2.4 Y.

So in all cases you can see that A632E is the best for all 4 PFCs.

GAC at Oakdale MN – Estimated Operating Cost to 300 ppt break

http://www.health.state.mn.us/divs/eh/water/com/waterline/featurestories/oakdale.html



- System Details: 2500 gpm flowrate
- Calgon Carbon GAC – 10 Vessels, 100,000 lbs GAC total (approx. 3333 ft^3)
- Lead – Lag vessels operating at approx. 1.5 gpm/ft^3
- When lead vessel reaches breakthrough the GAC in the lead is replaced
- Then the Lag vessel is switched to the Lead position. The freshly charged vessel is switched to the Lag position.

	Days to breakthrough	Calculated BV	Calculated Gals/ft3	Estimate Inlet concentration - ppt
PFBA	42	12,000	90,000	230
PFOA	286	82,000	615,000	490
PFOS	550	158,000	1,200,000	710

GAC changed based on PFOS breakthrough

Treated 1.9 billion gals; 5 GAC changes (total 50,000 lbs GAC), for a cost of $0.12 per 1000 gallons. Estimated equivalent price for GAC = $4.75 /lb (or approx. $142/ft3) which likely includes all charges for installation, new media, labor, incineration, transportation, etc.

Minnesota Health Advisories are currently 300 ppt for PFOS and PFOA.
Operating cost will rise in future if operating to current Health Advisory set by EPA of 70 ppt.

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Here is a study of an old GAC system at Oakdale MN operating since 2007. I got this online from the depart of health in MN as shown in the link...

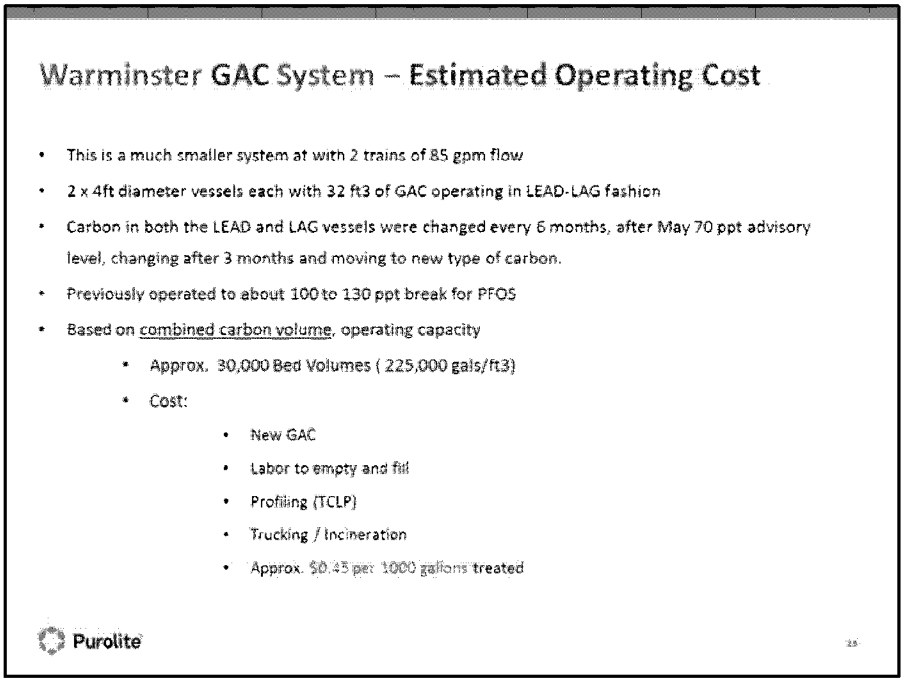
This a 2500 gpm system, 10 vessels of GAC with five trains of GAC in lead-lag mode.

The leads vessel is replaced when breakthrough occurs while the lag is moved into the lead position and the freshly re-charged vessel is put into the lag position.

You can see from the table that the system is run to a PFOS break which means PFBA and PFOA have already broken. MN operates to 300 ppt break for PFOS.

The cost is stated to be $0.12 per 1000 gallons of water treated. And this apparently includes all associated costs – new GAC, labor, transportation, incineration, etc.

I expect operating cost will go up significantly once they start using the new EPA health advisory level of 70 ppt. In fact with both PFOS and PFOA present, EPA recommends a combined HA of 70 ppt - so yes cost will go up.



We tried to get an estimated operating cost for Warminster with GAC if operating to 70 ppt HA level.

Looks like they may change out in 2 to 3 months with the old carbon installed in April. The last charge is now bituminous coal rather than coconut shell as the former is considered to be superior.

If we consider all costs – new GAC, labor, transportation, profiling, incineration we estimate an operating cost of about $0.45 per 1000 gallons of water treated.

Which is Better – Single Use or Regenerable Resin

- Capacities range from 10,000 to 140,000 Bed Volumes capacity depending on PFC type
- Short chained PFCs - capacity closer to 10,000 to 20,000 BV (75,000 – 150,000 gals/ft^3)
- Long chained PFCs – capacity closer to 70,000 to 140,000 BV (500,000 - 1,000,000 gals/ft^3)
- Which is better depends on relative OPEX and CAPEX and ability to meet new HA levels
- Single use + Incineration – simple system; use resins with very high capacities for PFCs
- Regenerable – must allow for operator input and extra regeneration equipment
  - Must consider disposal cost for spent regenerant
  - Now testing multiple reuse of regenerant (up to 10 times) with high capacity A632E
  - Expect reduction in OPEX, especially on medium to large systems

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Now lets take a look at whether to use single-use resin or regenerable resin – what are the pros and cons?

First capacities range from 10,000 to 140,000 bed volumes (75,000 to 1.000.000 gals/ft3)

Short chained capacity varies from 10,000 to 20,000 BV

Long chained capacity varies from 70,000 to 140,000 BV

So which is better depends on relative OPEX, CAPEX and the ability of the resin or GAC to consistently meet the new HA levels

Single use + incineration is simple; so you may want to consider this with resins with very high capacities.

Regenerable – must allow for operator input, extra equipment for regen, disposal of spent regenerant.

We are now testing multiple reuse of regenerants up to 10 times, so we expect reduction on OPEX

Regenerable Resins

Advantages

- Lower OPEX vs single use IX or GAC
- Regenerant recovery / reuse methods
- Minimum impact on environment

Disadvantages

- Alcohol/chemical regenerants
- Recover /reuse regenerant by evaporation /distillation
- Spent regenerant must still be disposed of eventually
- Requires trained operator skills
- Process must be properly designed

Purolite is working on new regenerant methods capable of regenerating the highest capacity resin such as Purolite A632E. More on this at a later date.

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Read the slide

Example Operating Cost – Single Use Resin or GAC – 400 gpm

	Unit cost $	Resin Qty	Resin $	GAC Qty	GAC $
Resin @ 4 gpm/ft3	250 $/ft3	100 ft3	25,000		
GAC @ 1.5 gpm/ft3	60 $/ft3			267	16,000
Labor -hours –extract/refill	$60/hr	1.5 hr /30ft3	300	1.5 hr/30ft3	801
Trucking	$ 6 to $20/ft3	100 ft3	Avg 900	267 ft3	2403
TCLP	$750 /test	1	750	1	750
Incineration (non-haz)	$225/supersack (35ft3)	100 ft3 (3 s/sacks)	675	267	1716
Taxes and Overhead			5500		4334
Total			$33000		$26000
EXAMPLE (ONLY):					
Est. Capacity - Bed Volumes		80,100		30,000	
Est. Capacity - gals/ft3		600,750		225,000	
Est. Capacity – gals/charge		60,000,000	$0.43/Kgal	60,000,000	$0.43/Kgal

In this example, single-use resin must have about 2.6 X more capacity.
So economics depends on which PFCs are targeted

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Read the slide

Regenerable Resin - Example Only

Assumptions:	Resin life	– 5 years;
	Regeneration frequency	– every 3 months
	Regenerant reuse	– 10 times

	$ / regeneration /ft3 resin	$ /1000 gals of water treated
Resin Cost (amortized over 5 years)	$20	
Regeneration Cost – assume regen. every 3 months	$10	
Labor Cost	$10	
Eventual Disposal (all costs)	$30 (as haz waste)	
Total	$70	
Assume 75,000 gals/ft3 resin (10000 BV)		0.93
Assume 225,000 gals/ft3 resin (30,000 BV)		0.31
Assume 600,000 gals/ft3 resin (80,000 BV)		0.12

Note- above estimates are hypothetical – technology still under evaluation

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Read the slide

Take-aways from this Webinar (Page 1)

- Consider Ion Exchange resin (IX) as a viable alternative to GAC.
- Special high capacity IX now available for PFC removal.
- Such resins can effectively reduce both short and long chained perfluoroalkyl substances (PFAS or PFCs) (such as PFOA, PFOS, PFBS and PFBA) to below 70 parts per trillion (ppt) levels
- Current focus on long chained PFCs (e.g. PFOS, PFOA) will soon change to focus also on short chain PFCS as these are persistent. IX shows better performance than GAC.
- PFCs generally ionized at pH range typical of drinking water. IX removes PFCs by a combined mechanism of ion exchange and adsorption. IX yields superior results since GAC removes PFCs mainly by adsorption.

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Take-aways from this Webinar (Page 2)

- Single use application of higher capacity resins is practical e.g. Purolite A632E
- Regenerable resins available can reduce operating cost vs GAC.
- Consider resins also for polishing effluent from GAC to reduce PFCs to lower levels
- CAPEX reduction is possible – IX can operate at higher velocities
- Choose between resins and GAC:
  - (a) CAPEX, (b) OPEX, (c) consistent reduction of PFCs to acceptable levels
- Are resins applicable for POE / POU devices? - being evaluated now

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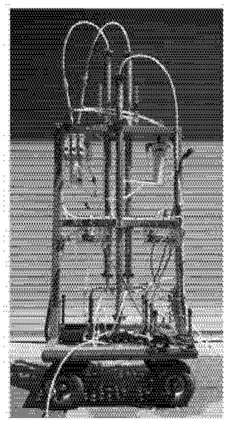
Piloting, Modeling Evaluation

- Complete Modeling Capability
- Custom engineered pilots
- Ion Exchange Resins / Adsorbents
- Skid mounted / shippable
- Operations manual
- Flow control & totalizer
- Sample ports
- Sampling protocol / sample log
- On-site technical support
- Remediation expertise

- Option: regeneration as needed



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Summary

- Experienced ground and potable water remediation specialists
- Modeling capability of select contaminants
- Special Resins/ adsorbents for emerging contaminants (PFCs, chrome-6, etc.)
- Piloting services /Technical support
- Joint Turnkey solutions with partners

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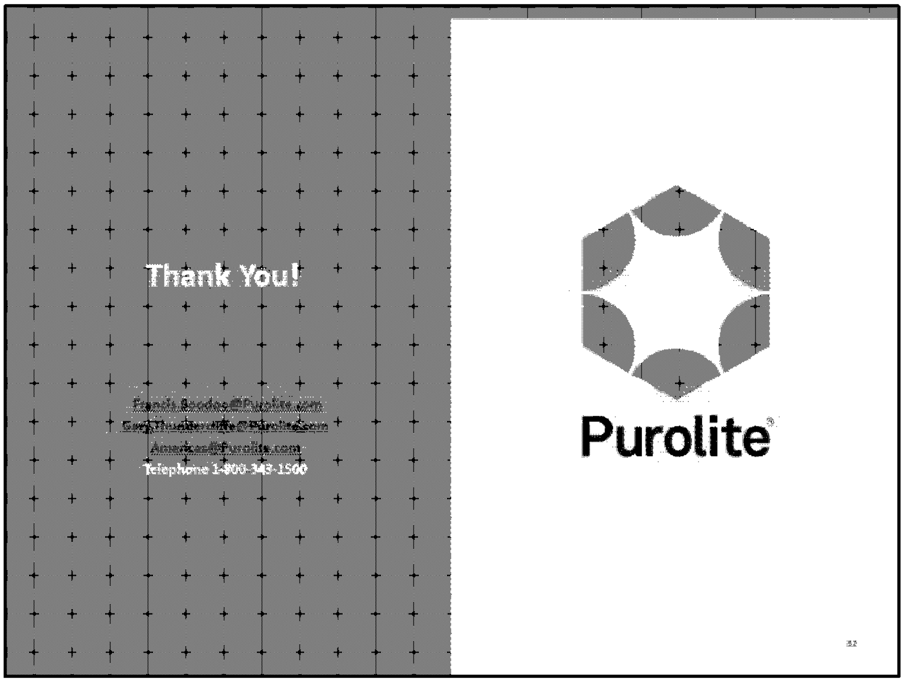
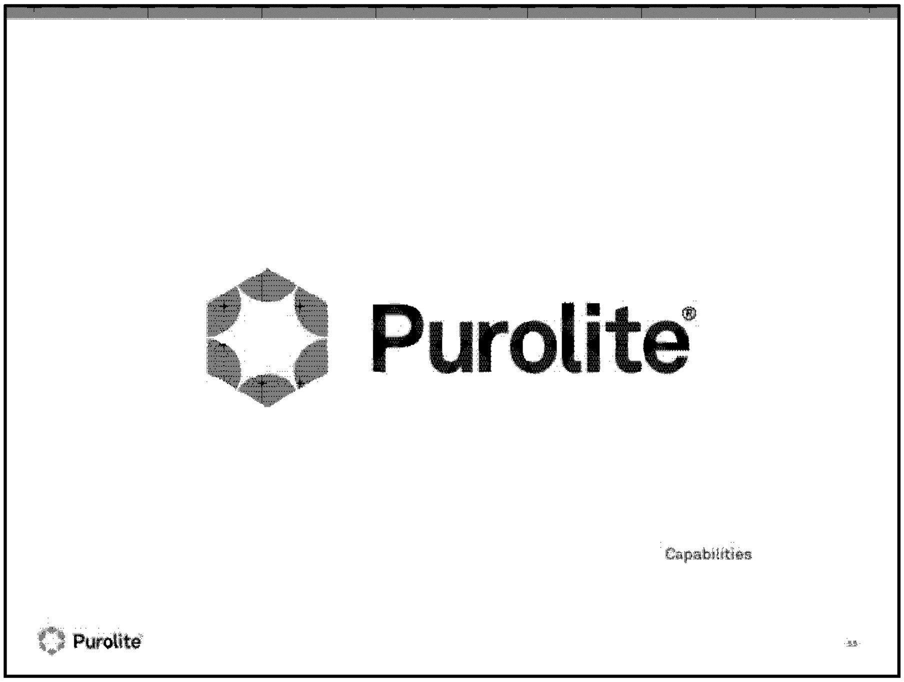
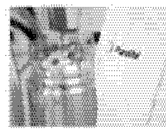

Thank You!
Americas@Purolite.com
Telephone 1-800-343-1500
Purolite
32

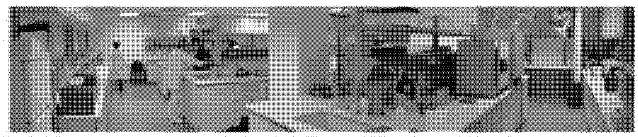


"Good Morning/Afternoon. My name is Jeffrey Frain and I am the Global Marketing Director at Purolite. Thank you for giving me the opportunity to talk to you today. I want to take about 10 minutes to introduce you to the capabilities and characteristics of our company"

Purolite — Global Reach



- World's 2nd largest supplier of ion exchange resins
- 40+ sales offices throughout the world
- Privately held
- Founded in 1981
- 1200 employees
- 4 global manufacturing sites
- 5 global R&D sites



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Purolite's Values

Heritage

35 years of heritage, knowledge, customer-focus and expertise in the resin industry, coupled with our proven quality, manufacturing and regulatory experience.

Innovation

Family of engineers and scientists dedicated to listening to the challenges our customers face. Through innovative R&D we meet the needs of tomorrow, before they arrive.

Regulatory

25 year track record of regulatory expertise - food contact, potable and groundwater and FDA-inspected plant.

Quality

Continually exceeding quality and consistency is the cornerstone of all our activities.

Future

Through forward-thinking investments we are committed to exceeding demands for outstanding quality and reliability for our customers.

Purolite

Industries Served

- Semiconductor
- Petrochemical and Refining
- Mining and Metals Finishing
- Nuclear Power
- Chemical Processing
- Life Sciences
- Pharmaceutical
- Potable Water
- Ground Water Remediation
- Food and Beverage

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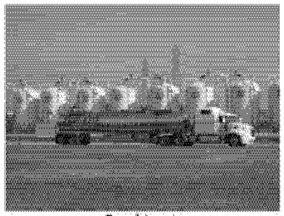
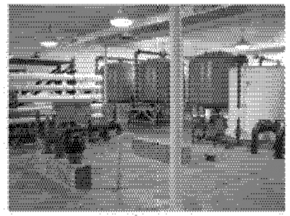
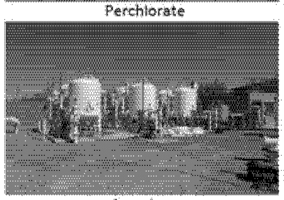
Some groundwater projects



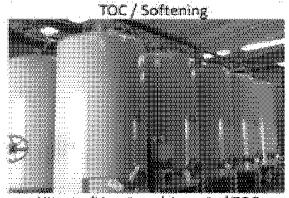
Perchlorate



TOC / Softening



Arsenic



Nitrate / Uranium / Arsenic / TOC

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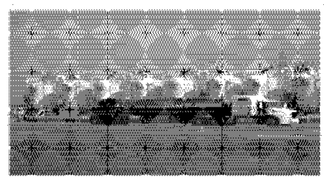
Perchlorate and Pertechnetate



- Oak Ridge National Laboratory – license BiQuat resin
- Hanford, WA.; Paducah Kentucky - Pertechnetate
- Aberdeen Proving Ground; ATK Thiokol – Perchlorate
- Patented Weak Base regenerable process - piloted at Redstone Arsenal via ARA
- Currently Treating 60 MGD of water - 30,000 ft3 of resin installed – in USA, France
- Israel - Consulting on large perchlorate/RDX/Chrome-6/nitrate project
- 16 years experience - 35% market share
- Modeling capability +/-15% accuracy

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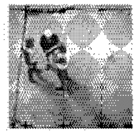
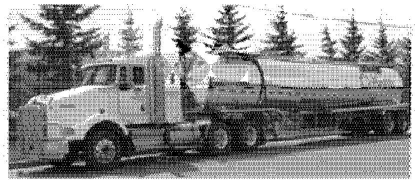
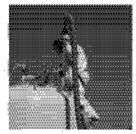
Complete Turnkey Services







- On-Site change out of ion exchange resins and adsorbents
- Competitive pricing with guaranteed performance
- System design, simulation and installation
- Full range of specialty ion exchange resins and adsorbents

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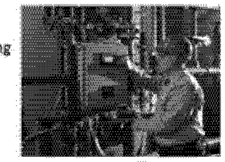
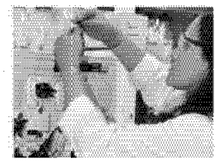
Services: Technical Engineering Support



Field support engineers:
- ~200 technical sales person in the field
- On and offsite system analysis and troubleshooting
- Technical resources/consulting

Technical Support Services:
- **PureDesign™** System modeling
- Pilot systems
- System design/operation
- Resin analysis
- Column performance evaluation/audits
- Technical training



Customized Solutions:
- Create unique solutions based on customer needs.
- Dedicated applications laboratories

Multiple packaging and delivery options

Application references and case histories

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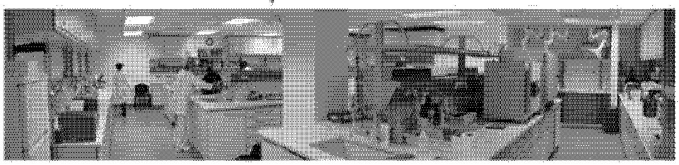
Research & Development



Purolite is committed to driving the future of resin technology

- all facilities ISO 9001 certified; UK and Romania ISO 18000 certified
- Vitality Index >11% and growing

- R&D Center of Excellence Research Facilities in Llantrisant Wales, UK.
  - Recently completed laboratory upgrade and expansion
- R&D, Q/C and Applications Research Centre in China
- New Philadelphia Applications and Q/C Laboratories
- New Romanian Q/C, Pharmaceutical and Customer Applications Laboratory
- Moscow specialty synthesis research laboratory

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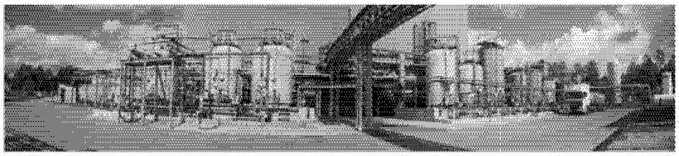
Manufacturing – Quality leadership



Purolite is continually expanding and improving manufacturing

- all facilities ISO 9001 certified

- Purolite China Co. Ltd – China – Adsorbents, specialty copolymers, chelating resins
- Purolite Corp – USA – Specialty, UltraClean and nuclear grade resins
- Purolite S.R.L – Romania – Uniform Particle Size resins, Active Pharmaceutical Ingredients. (FDA inspected, cGMP)
- Purolite Ltd – UK – Enzyme Carriers, Immobilized Enzymes, Chromatographic resins - synthetic and agarose media

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What we provide our customers

Premier Products

The quality and consistency of our products is fundamental to our performance. Throughout all Purolite plants, production is carefully controlled to ensure that our products meet the most stringent criteria, regardless of where they are produced.

Reliable Service

We are technical experts and problem solvers. Reliable and well trained, we understand the urgency required to keep businesses operating smoothly. Purolite employs the largest technical sales organization in the industry.

Innovative Solutions

Our continued investment in research & development means we are always perfecting and discovering innovative uses for ion exchange resins and adsorbents. We strive to make the impossible possible.

Purolite

Purolite is more than a resin company.
It's a solutions company.

Purolite

Thank You!

Francis.Boodoo@Purolite.com
Gary.Thundercliffe@Purolite.com

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Back-up slides

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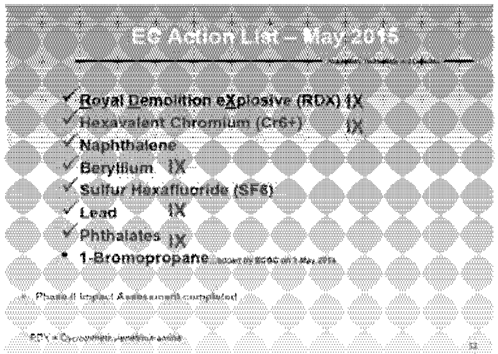
Department of Defense



IX = treatable by ion exchange

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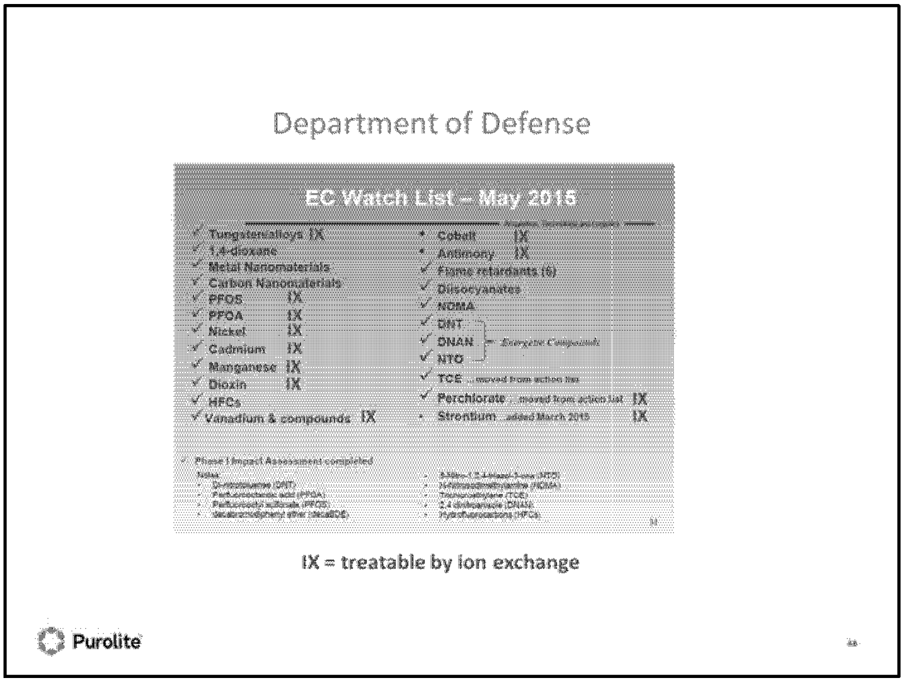

Department of Defense
EC Watch List – May 2015
Tungsten alloys IX
1,4-dioxane
Metal Nanomaterials
Carbon Nanomaterials
PFOS IX
PFOA IX
Nickel IX
Cadmium IX
Manganese IX
Dioxin IX
HFCs
Vanadium & compounds IX
Cobalt IX
Antimony IX
Flame retardants (6)
Diisocyanates
NDMA
DNT
DNAN
NTO
Energetic Compounds
TCE ... moved from action list
Perchlorate ... moved from action list IX
Strontium ... added March 2015 IX
Phase I Impact Assessment completed
IX = treatable by ion exchange
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