PEATT Pilot Project
PFAS Testing
in the
Warrington, Warminster and Horsham areas
Pennsylvania Department of Health

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Director, Bureau of Epidemiology
State Epidemiologist

December 19th, 2018
What is PFAS?

- Perfluoroalkyl and Polyfluoroalkyl Substances
  - Human-made chemicals
  - Used in protective surfaces and things that have water-repellant coatings
What is PFAS?

- To be classified as a Perfluoroalkyl or Polyfluoroalkyl Substance...
- Must have carbon-fluorine bonds - very strong

- The longer the “chain” the stronger the compound
- More resistant to environmental breakdown
What is PFAS?

- **Perfluoroalkyl** Substances have all C-F bonds (completely fluorinated)
  - Perfluorooctanoic acid (PFOA)
  - Perfluorooctane sulfonic acid (PFOS)
  - Perfluorohexanesulfonic acid (PFHxS) and
  - Perfluorononanoic acid (PFNA)
  
  are all “Pers”
What is PFAS?

- **Poly**fluoroalkyl Substances have some C-F bonds and some Hydrogen bonds (*partially* fluorinated)
  - Weak spots in chain
  - Eventually degrade to “pers”
What is PFAS?

- PFOS and PFOA are two long-chain compounds
- Being phased out of commercial production in U.S. and Europe
  - Still in some imported goods
- Being replaced by shorter-chain “replacement” or “substitute” compounds in manufacturing and industrial processes (e.g. GenX compounds)
PFAS Exposure in Southeastern PA

- Military and firefighter training
  - PFAS in the foam

- Former Naval Air Station Joint Reserve Base
  Willow Grove and Horsham Air Guard Station (HAGS)
  - 2014: Found contamination in 2 public water systems
  - 5 public wells taken out of service
  - 2016 additional wells removed, private well owners given bottled water
Former Naval Air Warfare Center (NAWC) Warminster

- 2013: Detected PFAS contamination in groundwater and public water systems
- 2014: Removed 3 public wells from service; private well owners given bottled water
- 2015: PFAS found in 93 out of 100 private wells within 1-3 mile radius
- July 2016 all contaminated wells removed from service (in compliance with new EPA health advisory levels)
Prior to May 2016 - Provisional Health Advisory Levels (PHAL)

• 0.2 microgram per liter (ug/L) for PFOS and 0.4 ug/L for PFOA (200 and 400 parts per trillion, respectively)

May 2016 - Lifetime Health Advisory Level (LHAL)

• 70 parts per trillion or 0.07 ug/L for PFOS and PFOA combined.
• Affected area = population of 84,184 (2010 census)
• 32,595 households in water service area
PFAS Exposure in Community

• PFAS levels in community drinking water

• 1,440 ppt - about 21 times higher than the LHAL (70 ppt) found in a municipal well in Warminster Municipal Authority (WMA) area

• Assumed to have been exposed for a long time - nearly 50 years

• Wide range of exposure:
  - Some municipal wells had no levels of PFAS
  - Some municipal wells much higher than national guideline
  - Found PFAS in 93 private wells near NAWC.
• Received competitive grant funds from the Association of State and Territorial Health Officials (ASTHO) along with New York state

• Testing the PFAS Exposure Assessment Technical Toolkit for the CDC/ATSDR

• May 2018 - Sent eligibility forms and letters to 600 randomly chosen households in Warminster, Horsham, Warrington area zip codes served by public water systems contaminated with PFAS

• 276 households returned forms - 584 potential participants

• 305 individuals returned their paperwork to DOH - questionnaires and signed consent forms
• Initial Eligibility Letters-
  - Response rate of 46% (276/600 households)

• 235 participants who completed paperwork AND gave blood samples-
  - Response rate of 40% (235/584 participants)
  - Participants represented 118 households out of the 276 who responded
• Weekly clinics in Bucks and Montgomery Counties to draw the blood samples

• From May through September 2018

• 235 samples obtained and sent to Wadsworth Laboratory in the New York State Health Department

• Wadsworth returned all results so far to DOH, and all 235 participants have been notified of their individual results as well as a preliminary comparison to the overall community group
Study Demographics

Mostly adults 20+ years old

- Average age – 49 years
- 66% had college education or higher
- 12% were ever employed on a military base

More females than males

- 55.70% Male
- 44.30% Female
Study Demographics

Most are long-term residents (>10 years)

- 67% less than 10 yrs
- 17.60% 10-39 yrs
- 14.60% 40+ yrs

Estimated Tap Water Consumed Daily

- 20.40% < 4 cups
- 23.80% 4-7 cups
- 18.70% 8+ cups
- 37% unknown

- 82% used public water
Reading Individual Results (first letter)

For an ADULT age 20 or older (unit: microgram/L)

<table>
<thead>
<tr>
<th>PFAS chemicals measured in your blood</th>
<th>Concentration found in your blood</th>
<th>3-11 years</th>
<th>12-19 years</th>
<th>20 plus years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Geometric mean</td>
<td>95th percentile</td>
<td>Geometric mean</td>
<td>95th percentile</td>
</tr>
<tr>
<td>Perfluorooctanoic acid (PFOA)</td>
<td>3.52</td>
<td>1.92</td>
<td>4.19</td>
<td>1.66</td>
</tr>
<tr>
<td>Perfluorooctanesulfonic acid (PFOS)</td>
<td>9.60</td>
<td>3.88</td>
<td>11.00</td>
<td>3.54</td>
</tr>
<tr>
<td>Perfluorohexane sulfonic acid (PFHxS)</td>
<td><strong>8.37</strong></td>
<td>0.84</td>
<td>3.12</td>
<td>1.27</td>
</tr>
<tr>
<td>Perfluorononanoic acid (PFNA)</td>
<td>0.80</td>
<td>0.79</td>
<td>3.26</td>
<td>0.60</td>
</tr>
<tr>
<td>Perfluorobutanesulfonic acid (PFBuS)</td>
<td>ND</td>
<td>*</td>
<td>&lt;0.10**</td>
<td>*</td>
</tr>
<tr>
<td>Perfluorodecanoic acid (PFDeA)</td>
<td>ND</td>
<td>*</td>
<td>0.37</td>
<td>0.14</td>
</tr>
<tr>
<td>Perfluorodecanoic acid (PFDoA)</td>
<td>ND</td>
<td>*</td>
<td>&lt;0.10**</td>
<td>*</td>
</tr>
<tr>
<td>Perfluoroheptanoic acid (PFHpA)</td>
<td>ND</td>
<td>*</td>
<td>0.21</td>
<td>*</td>
</tr>
<tr>
<td>Perfluorocarbonate sulfonamide (PFOSA)</td>
<td>ND</td>
<td>*</td>
<td>&lt;0.10**</td>
<td>*</td>
</tr>
<tr>
<td>2-(N-Methyl-perfluorooctane sulfonamido) acetic acid (MeFOSAA)</td>
<td>ND</td>
<td>*</td>
<td>1.02</td>
<td>*</td>
</tr>
<tr>
<td>Perfluoroundecanoic acid (PFUA)</td>
<td><strong>0.95</strong></td>
<td>*</td>
<td>0.28</td>
<td>*</td>
</tr>
</tbody>
</table>

This is the NHANES average. 95% of population is below this number.

ND or * means “non detect”-levels are so tiny they cannot be detected (<0.01).

Match the colored columns.

Your number was in italicized bold if it exceeded the 95th percentile.

Above results from NHANES 2013-2014, except PFOSA which is from 2011-2012.
Reading Community Results (second letter)

For an ADULT age 20 or older (unit: microgram/L)

- **This is the national average**
- **This is the community average**

Your number was in *italicized bold* if you exceeded the 95th percentile

<table>
<thead>
<tr>
<th>PFAS chemicals measured</th>
<th>Your Results</th>
<th>U.S. Population Results by Age Group</th>
<th>Warminster, Warrington, and Horsham Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perfluorooctanoic acid (PFOA)</td>
<td>2.96</td>
<td>1.98</td>
<td>3.32</td>
</tr>
<tr>
<td>Perfluorooctanesulfonic acid (PFOS)</td>
<td>11.4</td>
<td>5.22</td>
<td>11.50</td>
</tr>
<tr>
<td>Perfluorohexane sulfonic acid (PFHxS)</td>
<td><strong>7.44</strong></td>
<td>1.36</td>
<td>7.63</td>
</tr>
<tr>
<td>Perfluorononanoic acid (PFNA)</td>
<td>0.79</td>
<td>0.69</td>
<td>0.78</td>
</tr>
<tr>
<td>Perfluorodecanoic acid (PFDeA)</td>
<td>ND</td>
<td>0.19</td>
<td>0.36</td>
</tr>
<tr>
<td>Perfluorohexanoic acid (PFHpA)</td>
<td>ND</td>
<td>*</td>
<td>0.35</td>
</tr>
<tr>
<td>2-(N-Methyl-perfluoroctane sulfonamido) acetic acid (MeFOSAA)</td>
<td>ND</td>
<td>*</td>
<td>0.35</td>
</tr>
<tr>
<td>Perfluoroundecanoic acid (PFUA)</td>
<td>ND</td>
<td>*</td>
<td>0.35</td>
</tr>
</tbody>
</table>

Above results from NHANES 2013-2014

ND or * means “non detect”-levels are so tiny they cannot be detected (<0.01)
Results

- Tested for 11 PFAS compounds (all perfluorinated)
  - 4 compounds were commonly detected
    - PFOS (100%)
    - PFHxS (99.0%)
    - PFOA (98.7%)
    - PFNA (78.1%)
  - All four detected in 79% of participants

Note: PFOS, PFOA and PFHxS are main components found in Aqueous Film Forming Foams (AFFF)
- PFHxS has longer half-life in the body
- PFOA used in non-stick surface coatings and water and stain resistant coatings
- PFNA levels on the rise, biodegradation product during polyvinyl fluoride production/application
Results

Of the remaining 7 compounds:
- PFDeA was found in 14 participants
- MeFOSAA was found in 9 participants
- PFUA in 8 participants
- PFHpA in 1 participant
Results Overall

• PFAS levels in the community and at national level

Average blood levels were higher compared to NHANES’s average levels
- 94% had higher levels of PFHxS
- 81% had higher levels of PFOS
- 75% had higher levels of PFOA
- 59% had higher levels of PFNA

This is consistent with other studies on PFAS exposure through drinking water
Results Overall

- Four most commonly found PFAS

<table>
<thead>
<tr>
<th>PFAS Compound</th>
<th>Community Results</th>
<th>NHANES Results (2013-2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>95% Confidence Interval</td>
</tr>
<tr>
<td>PFOA</td>
<td>3.13</td>
<td>2.81-3.50</td>
</tr>
<tr>
<td>PFOS</td>
<td>10.24</td>
<td>8.86-11.83</td>
</tr>
<tr>
<td>PFHxS</td>
<td>6.64</td>
<td>5.51-7.99</td>
</tr>
<tr>
<td>PFNA</td>
<td>0.74</td>
<td>0.67-0.80</td>
</tr>
</tbody>
</table>

Results shown in ug/L. Range excludes <LOD
Distribution of serum PFAS levels

- **PFOA (µg/L)**: Detected in 232 Participants
  - 90th Percentile: 7.38
  - Average: 3.13

- **PFOS (µg/L)**: Detected in 235 Participants
  - 90th Percentile: 29.35
  - Average: 10.24

- **PFHxS (µg/L)**: Detected in 233 Participants
  - 90th Percentile: 23.70
  - Average: 6.64

- **PFNA (µg/L)**: Detected in 185 Participants
  - 90th Percentile: 1.48
  - Average: 0.74
<table>
<thead>
<tr>
<th>Location/Study</th>
<th>Mean PFOA Levels in Blood (ug/L) with drinking water exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>C8, Ohio River Valley (2005-2006)</td>
<td>33</td>
</tr>
<tr>
<td>Hoosick Falls, NY (2016)</td>
<td>24</td>
</tr>
<tr>
<td>E. Metro, MN (2008-2009)</td>
<td>15</td>
</tr>
<tr>
<td>Bennington, VT (2016)</td>
<td>10</td>
</tr>
<tr>
<td>Australia Firefighters (2015)</td>
<td>5</td>
</tr>
<tr>
<td>U.S. Population (2005-2006)</td>
<td>4</td>
</tr>
<tr>
<td>Pease Tradeport, NH (2015)</td>
<td>3</td>
</tr>
<tr>
<td>U.S. Population (2013-2014)</td>
<td>2</td>
</tr>
<tr>
<td>Uppsala, Sweden (Women, 2008-2011)</td>
<td>2</td>
</tr>
</tbody>
</table>

Notes: Industrial contamination source & Military Base contamination source & NHANES

References: Holzer et al. 2008, Rotander et al. 2015, Gyllenhammar et al. 2015, Daly et al. 2018
Mean PFOS Levels in Blood (ug/L) with drinking water exposure

- **Australia Firefighters (2015)**: 74 ug/L
- **E. Metro, MN (2008-2009)**: 36 ug/L
- **C8, Ohio River Valley (2005-2006)**: 19 ug/L
- **U.S. Population (2005-2006)**: 17 ug/L
- **Warminster, Warrington, Horsham (2018)**: 10.24 ug/L
- **Pease Tradeport, NH (2015)**: 9 ug/L
- **Uppsala, Sweden (Women, 2008-2011)**: 7 ug/L
- **U.S. Population (2013-2014)**: 5 ug/L

*Industrial contamination source*

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Holzer et al. 2008, Rotander et al. 2015, Gyllenhammar et al. 2015, Daly et al. 2018
Mean PFHxS Levels in Blood (ug/L) with drinking water exposure

- Australia Firefighters (2015) 33
- E. Metro, MN (2008-2009) 8
- Warminster, Warrington, Horsham, PA (2018) 6.64
- Decatur, AL (2009) 6
- Uppsala, Sweden (Women 2008-2011) 5
- Pease Tradeport, NH (2015) 4
- U.S. Population (2005-2006) 2
- Arnsberg, Germany (2008) 2
- U.S. Population (2013-2014) 1

Industrial contamination source ▢ Military Base contamination source & NHANES

Holzer et al. 2008, Rotander et al. 2015, Gyllenhammar et al. 2015, Daly et al. 2018
Results by Age Category

• In general PFOA, PFOS, PFHxS and PFNA levels increased with age (statistically significant between age groups)

• In most age groups, community results exceeded NHANES levels for each compound

• Exception- lower PFNA in 3-11 and 12-19 age groups
Community Results compared to National (NHANES 2013-2014) Results

Results shown in ug/L
# Results by Age Category

Community Results compared to National (NHANES) Results

<table>
<thead>
<tr>
<th>PFAS Compound</th>
<th>Community Results</th>
<th>NHANES Results (2013-2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3-11 years</td>
<td>12-19 years</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>95% C.I.</td>
</tr>
<tr>
<td>PFOA</td>
<td>2.02</td>
<td>1.66-2.45</td>
</tr>
<tr>
<td>PFOS</td>
<td>3.91</td>
<td>3.02-5.07</td>
</tr>
<tr>
<td>PFHxS</td>
<td>2.00</td>
<td>1.24-3.23</td>
</tr>
<tr>
<td>PFNA</td>
<td>0.39</td>
<td>0.35-0.43</td>
</tr>
</tbody>
</table>

Results shown in ug/L
Results by Gender

- Males had higher PFAS levels than females
  - (Not statistically significant)
- Exception – PFNA
- Consistent with other studies
- Attributed to female elimination routes
  - Breast feeding
  - Transfer to fetus during pregnancy
  - Menstruation
Results by Gender

PFAS Levels by Gender (Community vs NHANES 2013-2014)

Difference between male and female participants not statistically significant (P>0.05 for all four compounds)
Results by Length of Residence

- Longer residence time correlated with higher PFAS blood concentrations (Statistically significant between categories)

- Only measured by current residence, not total time (former addresses) in the area
Results by Length of Residence

PFAS Levels by Length of Current Address

Note: Unadjusted results
There was some correlation between the estimated quantity of tap water consumed and PFAS levels.

(Significant difference for PFOA and PFNA compounds)
- Less than 4 cups/day category had lower levels than 4-7 cups/day category
- 4-7 cups/day had higher levels than 8 or more cups/day category
Overall, private well users had slightly higher levels of PFOA, PFOS, and PFNA than public water users, but not PFHxS.

Differences in levels not statistically significant (P>0.05 for all)
Results by Military Base Employment

- Participants who worked on a military base showed higher levels of PFOA, PFOS, and PFHxS, but not PFNA
  (Not statistically significant between categories)

- PFNA is not as predominant a compound as PFOS, PFOA, or PFHxS in firefighting foam (AFFF)
### Results by Military Base Employment

**Results shown in ug/L. Range excludes <LOD**

Differences in levels not statistically significant (P>0.05 for all)

<table>
<thead>
<tr>
<th>PFAS</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>95% CI</td>
</tr>
<tr>
<td>PFOA</td>
<td>3.52</td>
<td>2.69-4.61</td>
</tr>
<tr>
<td>PFOS</td>
<td>12.90</td>
<td>9.36-17.78</td>
</tr>
<tr>
<td>PFHxS</td>
<td>10.32</td>
<td>6.79-15.69</td>
</tr>
<tr>
<td>PFNA</td>
<td>0.77</td>
<td>0.62-0.94</td>
</tr>
</tbody>
</table>
PFAS Compounds Bioaccumulate

- PFAS not stored in fat, but binds to both plasma and liver proteins (main bioaccumulation reservoirs)

- Continued exposure to even low levels in drinking water can substantially increase total human exposure

- Chronic drinking water exposure may increase serum PFAS concentration by 100-times the concentration of PFAS in drinking water; more pronounced in children

Hoffman et al. 2011, Post et al. 2012, Guelfo et al. 2018
Health Effects Associated with PFAS

• Health studies:
  - Occupationally exposed populations
  - Populations exposed via contaminated drinking water

• Health effects include:
  - Altered thyroid function
  - Altered immune function
  - Cancers
  - Elevated cholesterol
  - Endocrine disruption

www.atsdr.cdc.gov/pfas/health-effects.html
C8 (PFAS) Science Panel (2005-2013)

C8 panel was a group of public health scientists established as part of a class action lawsuit settlement following PFOA contamination of the Ohio river by the DuPont company in Parkersburg, WV.

The Science Panel concluded that there was a probable link to C8 (PFAS) exposure for the following health conditions:

- Diagnosed high cholesterol
- Ulcerative colitis
- Thyroid disease
- Pregnancy-induced hypertension
- Testicular cancer, kidney cancer

C8 Project Panel Study 2012 www.c8sciencepanel.org/prob_link.html
US EPA classified PFOA as likely carcinogenic to humans

- Studies and incidence reports show mixed results and are inconclusive

  - Barry et al. found kidney and testicular cancers with increased blood levels of PFOA
  - Incidence report for Kent County, Michigan showed no consistent elevation in cancer incidence except for prostate cancer
  - DOH cancer data review showed no consistent pattern in cancer incidence

Altered Thyroid Function

- Association between clinical hypothyroidism and serum PFOA levels in children (C8)

- Positive association with increased PFOS serum levels and Thyroid Stimulating Hormone (TSH)
  - Higher levels of TSH generally indicates a lower thyroid hormone level

- Significant sex difference in the associations of TSH with PFNA and PFHxS

Blake et al. 2018
Other Concerns

• Dyslipidemia (altered cholesterol levels)
  - Reported in multiple studies
  - Generally higher or abnormal levels of total cholesterol in association with higher PFAS serum concentration

• Higher PFAS levels are associated with higher age at puberty

• Mixed results regarding weight or BMI in children

Post et al 2012, Rappazzo 2017, Blake et al 2018
PEATT Results by Health Condition

• Participant responses (149 out of 235)
  - Only 63 percent listed any health conditions

• Five main categories
  - Growth-related conditions
  - Women’s reproduction
  - Endocrine disruption
  - Cancer
  - Elevated cholesterol
Results by Health Condition*

- Elevated cholesterol most frequently reported
- Those reporting elevated cholesterol also had higher PFAS levels (all 4 compounds)
- Those reporting endocrine disruption had higher levels of PFOA and PFHxS
- Those with cancer had higher levels of PFOA and PFNA

* Unadjusted results
Results by Main Categories of Health Condition

Elevated Cholesterol: 49 cases
Endocrine Disruption: 26 cases
Cancers: 24 cases
Female Reproduction: 12 cases
Growth Related: 11 cases
- A subgroup of 25 out of the 235 participants
- These 25 at least two of the four PFAS compounds at levels higher than 90th percentile value of community

<table>
<thead>
<tr>
<th>PFAS Compound</th>
<th>90th Percentile Values (ug/L) for the community</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFOA</td>
<td>7.38</td>
</tr>
<tr>
<td>PFOS</td>
<td>29.35</td>
</tr>
<tr>
<td>PFHxS</td>
<td>23.20</td>
</tr>
<tr>
<td>PFNA</td>
<td>1.48</td>
</tr>
</tbody>
</table>
Average age = 61
Range (males 48-76, females 20-81)

22 individuals lived in community 18 years or more and used public water

5 individuals worked on a military base
Elimination Rate/Half-life

- PFOA = 2-4 years
- PFOS = 5-6 years
- PFHxS = 8-9 years

- General serum concentrations run higher in men than women
- Women excrete PFAS in breastmilk and during menstruation
- Children have higher PFAS concentrations due to maternal transfer and nursing, as well as environmental intake (dust, carpeting, consumer products)

Olsen et al. 2007, ATSDR, 2017, Blake et al. 2018
PFAS Levels in U.S. Population Over Time

Median concentration of selected per- and polyfluoroalkyl substances (PFAS) in blood serum (1999-2014) in the United States

Source: ATSDR, 2018
Our Partners

• Centers for Disease Control and Prevention (CDC)
• Association of State and Territorial Health Officials (ASTHO)
• Agency for Toxic Substances and Disease Registry (ATSDR)
• Bucks County Health Department
• Montgomery County Health Department
• New York State Health Department Laboratory
• Department of Environmental Protection (DEP)
Knowledge Gaps

- Key knowledge gaps in the following areas:
  - Toxicology
    - Need more longitudinal Epidemiological studies
  - Regulation – Need to develop MCLs
    - Primarily apply to PFOS/PFOA - need more research on complex mixtures & emerging contaminants
  - Protocols for environmental sampling and analysis
  - Need more research to understand fate and transport
Ongoing Work

- ATSDR is working to provide health-based guidelines on tolerable levels in water
- Department of Defense is funding 10-million dollar national study on PFAS exposure assessment and health assessment
- DOH attending webinars/continuing education on PFAS research and remediation
- National Toxicology Program (NTP) - actively funding research studies
  - Investigating PFC chain length and toxicity relationships
  - Doing invitro studies on
    - Brain neurotoxicity, immune effects, behavioral disorders, cellular toxicity
    - TOX21- testing for toxicity in human/animal cells through robotics screening facility
Contact Information

Should you have any questions or concerns, feel free to contact us at env.health.concern@pa.gov or by phone at 717-787-3350
PEATT Pilot Project Team

- Dr. Sharon Watkins
- Dr. Anil Nair
- Dr. Farhad Ahmed
- Dr. Marshal Ma
- Susan Schrack Wood