Swimming with the Bugs: Health Risks due to Recreation along the Wissahickon, Cobbs and Tacony Creeks

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Recreation in natural waterways comes with health risks due to exposure to microbial pathogens.
Background - Burden of Disease

In 2001 the US EPA estimated 1.8 to 3.5 million people become sick annually due to recreational contact with waters contaminated by sewer overflows.²

²US EPA. Notice of proposed rulemaking, National pollutant discharge elimination system (NPDES), permit requirements for municipal sanitary sewer collection systems, municipal satellite collection systems, and sanitary sewer overflows. (2001).
In 2018, the US EPA estimated that 90 million illnesses across the US are attributable to recreation in surface waters, which costs and estimated $2.2-$3.7 billion annually.

DeFlorio-Barker et al. Environmental Health (2018) 17:3
DOI 10.1186/s12940-017-0347-9

Estimate of incidence and cost of recreational waterborne illness on United States surface waters

Stephanie DeFlorio-Barker¹, Coady Wing², Rachael M. Jones¹ and Samuel Dorevitch¹³
Defining Illness

Acute Gastrointestinal Illness (AGI):

**Definition**: three or more loose stools in 24 hours or any vomiting excluding those with chronic conditions or concurrent symptoms of coughing, sneezing, sore throat or runny nose.
Defining Recreation

Primary Recreation

**Definition:** Direct contact with water where immersion and ingestion are likely
Summary of Recreational Waterborne Disease Studies

**Courtesy of Henry Ngo, University of Guelph**
How can we measure/estimate health risks?

1. Epidemiological Studies
   - Randomized controlled trials
   - Prospective Cohort studies

2. Quantitative Microbial Risk Assessment (QMRA)
Randomized Controlled Trials (RCTs)

- The “gold standard” of epidemiological studies
  - Comparison of illness rates between two randomly chosen groups:
    - Control participants don’t swim
    - Intervention participants swim
- Participants are randomly assigned the intervention
- 2 RCTs have been conducted to date in recreational setting (Florida, UK)
- RCT are challenging to use in this context
Prospective Cohort Studies

- Executed in a similar way as the RCT
- Participants recruited at the beach
- Participants followed no matter what their exposure (not assigned to swimming or not swimming)
- Participants called 8-14 days after beach exposure
- 11 studies from US, Canada, UK, Spain
- Both RCTs and Cohort studies are costly and time consuming

Enrolled → Exposure survey → 8-14 days later Illness survey
Quantitative Microbial Risk Assessment (QMRA)

• Determines the likelihood and extent of human health effects following an exposure to microbial pathogens
• Pathogen specific
• Result is a risk of illness or infection
  • Acceptable risk is ~36 in 1000 exposures (3.6%)
• Recreation along waters impacted by combined sewer overflows (CSOs) in Philadelphia can represent a health risk
• Research is lacking around the potential health risks due to recreation along the Wissahickon

Combined Sewer Overflow, 2017, Philadelphia Water Department
http://www.phillywatersheds.org/watershed_issues/stormwater_management/combined_sewer_system
Sources of Fecal Pollution in Study Area
Research Questions

1. What is the risk of illness due to recreational activities observed at sites along the Wissahickon Creek?

2. How does this compare to the risk calculated due to recreation along CSO-impacted sites in Philadelphia?

1. Fecal indicator organism (FIO) data from grab samples at sites along Wissahickon, Cobbs and Tacony Creeks

2. Pathogen data collected through ultrafiltration (UF) and analyzed by qPCR

3. QMRA models for selected pathogens to estimate health risks of recreating in these waterways
Sampling Sites

- Valley Green Inn
- Margaree Dam
- Rope Swing
- Devil’s Pool
- Kitchens Lane
- Cobb’s Creek
- Tacony Creek

Surface Water Sampling Sites, 2016 - 2020
2020 Sampling Sites

- W – Valley Green Inn (VG)
- W – Rope Swing (RS)
- W – Margaree Dam (MD)
- W – Kitchens Lane (KL)
2020 Sampling Sites

W – Devil’s Pool (DP)
2020 Sampling Sites

Cobb’s Creek (CB)

Tacony Creek (TC)
Sample Collected

- Samples (N=70) were collected May 2020-September 2020:

<table>
<thead>
<tr>
<th>Site</th>
<th>Wet (n =)</th>
<th>Dry (n =)</th>
<th>Total (n =)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Devil’s Pool (W-DP)</td>
<td>3</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Rope Swing (W-RS)</td>
<td>3</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Kitchens Lane (W-KL)</td>
<td>3</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Valley Green Inn (W-VG)</td>
<td>3</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Margaree Dam (W-MD)</td>
<td>3</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Cobbs Creek (CB)*</td>
<td>2</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Tacony Creek (TC)*</td>
<td>3</td>
<td>7</td>
<td>10</td>
</tr>
</tbody>
</table>

* 10 samples for CB (5) & TC (5) were pulled from archived samples from 2018 & 2019

- 1L grab samples for *E. coli*, total coliforms, fecal enterococci, and fecal (thermotolerant) coliforms
- ~ 50L were filtered using dead-end ultrafiltration to measure for human sewage markers and enteric pathogens
- Wet/dry samples collected
Fecal Indicator Organisms: Methods
What are fecal indicator organisms?

• Indicators of fecal contamination in water

• Commonly used indicators are **bacteria:**
  - Total Coliforms (TC)
  - Thermotolerant/ Fecal Coliforms (FC)
  - *E.coli*
  - *Enterococci*

• Recreational water guidelines are based on these indicators
PA also uses a GM of 200 cfu/100mL for fecal coliforms

*Note: We did not sample per EPA guidelines, we are using these as a frame of reference*
Methods: FIOs

Membrane Filtration

![Diagram of membrane filtration process]

**METHOD OF MEMBRANE FILTRATION**

- Filtering of water through membrane filter
- Place membrane filter on appropriate nutrient medium
- Incubate for 24-48 hours
- Growth of typical colonies
Indicators Results
Wissahickon Results: FIOs

- Values shown in **red** indicate a geometric mean/ STV higher than the EPA/PA guidelines

<table>
<thead>
<tr>
<th>Site</th>
<th>n</th>
<th>Total Coliforms</th>
<th>E. coli</th>
<th>Enterococci</th>
<th>Fecal Coliforms</th>
<th>E.coli</th>
<th>Enterococci</th>
<th>Fecal Coliforms</th>
</tr>
</thead>
<tbody>
<tr>
<td>W-RS</td>
<td>10</td>
<td>120,103</td>
<td>614</td>
<td>37</td>
<td>779</td>
<td>40%</td>
<td>30%</td>
<td>70%</td>
</tr>
<tr>
<td>W-DP</td>
<td>10</td>
<td>50,354</td>
<td>30</td>
<td>11</td>
<td>158</td>
<td>20%</td>
<td>10%</td>
<td>30%</td>
</tr>
<tr>
<td>W-KL</td>
<td>10</td>
<td>75,814</td>
<td>357</td>
<td>32</td>
<td>1071</td>
<td>40%</td>
<td>10%</td>
<td>80%</td>
</tr>
<tr>
<td>W-MD</td>
<td>10</td>
<td>64,356</td>
<td>258</td>
<td>10</td>
<td>359</td>
<td>20%</td>
<td>10%</td>
<td>40%</td>
</tr>
<tr>
<td>W-VG</td>
<td>10</td>
<td>78,531</td>
<td>355</td>
<td>25</td>
<td>455</td>
<td>40%</td>
<td>20%</td>
<td>60%</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>74,644</td>
<td>227</td>
<td>20</td>
<td>464</td>
<td>32%</td>
<td>16%</td>
<td>56%</td>
</tr>
</tbody>
</table>

US EPA's guidelines for primary recreation:
- *E. coli GM* (126 cfu/100 mL); STV (410 cfu/100mL)
- *Enterococci* (35 cfu/100 mL); STV (130 cfu/100mL)

PA guidelines for primary recreation
- Fecal Coliforms (200 cfu/ 100mL) STV (400/100mL)
Wissahickon Results: FIOs

- Values shown in red indicate statistically significantly higher geometric mean of the indicator in the rain sample.

### US EPA's guidelines for primary recreation:
- **E. coli GM** (126 cfu/100 mL); STV (410 cfu/100mL)
- **Enterococci** (35 cfu/100 mL); STV (130 cfu/100mL)

### PA guidelines for primary recreation
- **Fecal Coliforms** (200 cfu/100mL)
- **STV** (400/100mL)

<table>
<thead>
<tr>
<th>Site</th>
<th>Dry</th>
<th>Rain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Total Coliforms</strong> (cfu/100mL)</td>
<td><strong>E. coli</strong> (cfu/100mL)</td>
</tr>
<tr>
<td>W-DP</td>
<td>41,217</td>
<td>8</td>
</tr>
<tr>
<td>W-RS</td>
<td>56,838</td>
<td><strong>217</strong></td>
</tr>
<tr>
<td>W-VG</td>
<td>66,062</td>
<td><strong>375</strong></td>
</tr>
<tr>
<td>W-MD</td>
<td>55,374</td>
<td><strong>190</strong></td>
</tr>
<tr>
<td>W-KL</td>
<td>74,178</td>
<td><strong>239</strong></td>
</tr>
</tbody>
</table>

US EPA's guidelines for primary recreation:
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- **Enterococci** (35 cfu/100 mL); STV (130 cfu/100mL)

PA guidelines for primary recreation
- **Fecal Coliforms** (200 cfu/100mL)
- **STV** (400/100mL)
Takeaways from FIO Results: Wissahickon

- Dry samples exceeded guidelines for *E. coli* at most sites

- Wet samples exceeded guidelines for nearly all sites and FIOs

- In dry conditions, *enterococci* guideline less likely to be exceeded

- **Devil’s Pool** and **Rope Swing** showed the greatest increases in FIO markers after rainfall events.

- Recreation within 24 hours of rainfall could be riskier than during dry conditions

CSO Results: FIO Markers

- Values shown in red indicate a geometric mean/ STV higher than the EPA/PA guidelines

<table>
<thead>
<tr>
<th>Site</th>
<th>n</th>
<th>Total Coliforms</th>
<th>E. coli</th>
<th>Enterococci</th>
<th>Fecal Coliforms</th>
<th>E. coli</th>
<th>Enterococci</th>
<th>Fecal Coliforms</th>
</tr>
</thead>
<tbody>
<tr>
<td>CB</td>
<td>10</td>
<td>158,671</td>
<td>4,462</td>
<td>144</td>
<td>4,257</td>
<td>70%</td>
<td>20%</td>
<td>100%</td>
</tr>
<tr>
<td>TC</td>
<td>10</td>
<td>282,908</td>
<td>11,269</td>
<td>1016</td>
<td>38,558</td>
<td>100%</td>
<td>60%</td>
<td>100%</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>222,962</td>
<td>7,695</td>
<td>382</td>
<td>12,812</td>
<td>88%</td>
<td>40%</td>
<td>100%</td>
</tr>
</tbody>
</table>

US EPA's guidelines for primary recreation:
- *E. coli GM* (126 cfu/100 mL); STV (410 cfu/100mL)
- *Enterococci* (35 cfu/100 mL); STV (130 cfu/100mL)

PA guidelines for primary recreation
- Fecal Coliforms (200 cfu/ 100mL); STV (400/100mL)
### CSO Results: FIO Markers

- Values shown in red indicate statistically significantly higher geometric mean of the indicator in the rain sample.

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<tr>
<th>Site</th>
<th>Dry</th>
<th>Rain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Coliforms (cfu/100mL)</td>
<td>E. coli (cfu/100mL)</td>
</tr>
<tr>
<td>TC</td>
<td>232,211</td>
<td>15,730</td>
</tr>
<tr>
<td>CB</td>
<td>125,469</td>
<td>3,354</td>
</tr>
</tbody>
</table>

US EPA's guidelines for primary recreation:
- *E. coli* GM (126 cfu/100 mL); STV (410 cfu/100mL)
- *Enterococci* (35 cfu/100 mL); STV (130 cfu/100mL)

PA guidelines for primary recreation
- Fecal Coliforms (200 cfu/ 100mL)

**Please Note:**
- Data was aggregated from Summer 2018 – Summer 2020 (5 out of 10 samples came from 2020, the rest from Summer 2018 and 2019)
- *Enterococci* and Fecal Coliforms were only tested for in Summer 2020
  - No wet samples were collected in 2020 at TC
Takeaways from FIO Results: CSOs

- 5/6 wet samples had greater FIO geometric means dry samples.
- Even without rain, all FIOs were above recreational guidelines.
- Recreation following rain may be riskier than during dry conditions.
Pathogens: Methods
What pathogens are found in surface water?

**Viruses**
- norovirus
  - Extremely small
  - Infectious
  - Often move like chemicals

**Bacteria**
- *Salmonella, Campylobacter*
  - Microscopic (smaller than algae)
  - *E.coli* / coliforms are bacteria

**Protozoa**
- *Cryptosporidium, Giardia*
  - Size of algae
  - Produce egg like cysts
  - Resistant to chlorine
Routes of Infection?

Ingestion/Inhalation
(e.g. drinking water, bathing, recreation, hand to mouth, food)

Viruses
norovirus

Bacteria
Salmonella, Campylobacter

Protozoa
Cryptosporidium, Giardia
Differences between **pathogens** and **indicator organisms**

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Pathogens</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Mostly bacteria</td>
<td>- Viruses, bacteria, protozoa</td>
</tr>
<tr>
<td>- Present in larger quantities in feces and/or the environment</td>
<td>- Present in lower quantities</td>
</tr>
<tr>
<td>- Easier to detect/ measure</td>
<td>- Challenging to measure</td>
</tr>
<tr>
<td>- Less costly to monitor</td>
<td>- More costly to monitor</td>
</tr>
<tr>
<td>- <strong>Indirectly can suggest a health risk</strong></td>
<td>- <strong>Can be directly linked to health risk</strong></td>
</tr>
</tbody>
</table>

Total coliforms, fecal coliforms and *E.coli* belong to the bacteria group and don’t behave like viruses or protozoa
Methods: Pathogens

Ultrafiltration
Methods: Pathogens

- Ultrafilters sent to USDA/USGS lab, for qPCR or RT-qPCR:

  ![Diagram of DNA/RNA Extraction Process]

  1. Ultrafilters
  2. Spin
  3. Wash
  4. Elute
  5. Spin
  6. DNA/RNA Extraction
Methods: Pathogens

Human pathogens:

• **Viruses**
  • adenovirus, enterovirus, norovirus GI & GII, SARS-CoV-2, Hepatitis A, rotavirus

• **Bacteria**
  • Campylobacter, enterohemorrhagic E. coli, Salmonella, Shigella

• **Protozoa**
  • Giardia, Cryptosporidium
Methods: Human Sewage Markers

• Genetic markers of human sewage
  • Human *Bacteroides* (HF183)
  • Pepper mild mottle virus
  • Human polyomavirus
Pathogen Results
Virus Results: Wissahickon

- adenovirus- detected in **13%** of samples (9/70)
- enterovirus- not detected
- SARS-CoV-2- not detected
- norovirus (GI,GII)- detected in **1.4%** samples (1/70)
- Hepatitis A- not detected
- rotavirus- detected in **67%** of samples (47/70 samples)
Bacteria & Protozoa Results: Wissahickon

**Campylobacter** - detected in 1.4% of samples (1/70)

**Salmonella spp.** - detected in 5.7% of samples (4/70)

**Enterohemorrhagic and Shiga-toxin producing E.coli and Shigella**-detected in 7.1% of samples (5/70)

**Cryptosporidium spp.**- detected in 40% of samples (28/70)

**Giardia**- detected in 1.4% of samples (1/70)
Wissahickon Results: Pathogens

70% of samples tested positive for 1 pathogen

40% of samples tested positive for 1-2 pathogens
Wissahickon Results: Pathogens

80% of samples tested positive for 1-3 pathogens

80% of samples tested positive for 1-2 pathogens
Wissahickon Results: Pathogens

90% of samples tested positive for 1-2 pathogens
Virus Results: CSOs

- adenovirus- detected in 55% of samples (11/20)
- enterovirus- detected in 15% of samples (3/20)
- SARS-CoV-2- not detected
- norovirus (GI,GII)- detected in 30% samples ( 6/20)
- Hepatitis A- not detected
- rotavirus- detected in 80% of samples (16/ 20 samples)
Bacteria & Protozoa Results: CSOs

- **Campylobacter** - detected in 15% of samples (3/20)
- **Salmonella spp.** - detected in 30% of samples (6/20)

Enterohemorrhagic and Shiga-toxin producing *E.coli* and *Shigella*- detected in 50% of samples (10/20)

- **Cryptosporidium spp.** - detected in 65% of samples (13/20)
- **Giardia** - detected in 20% of samples (4/20)

Between 1-4 pathogens detected in all samples collected on the CSO sites
CSO Results: Pathogens

Cobb’s Creek (CB)

100% of samples tested positive for 1-4 pathogens

Tacony Creek (TC)

100% of samples tested positive for 1-6 pathogens
Human specific fecal markers were detected at all sites nearly 100% of the time.

Levels reached concentrations that can be found in dilute sewage.
BREAK
Risk Assessment

Translating pathogen and sewage marker data into recreational risk assessment
Quantitative Microbial Risk Assessment (QMRA)

- Modeling approach to estimate the risk of illness (or infection) after exposure to microorganisms in the environment
Hazard Identification

Two modelling approaches employed:

1. Used measured human sewage marker (HF183) data to calculate illness risk

2. Used measured pathogen data to calculate illness risk

Pathogens: norovirus, adenovirus, enterovirus, Giardia, Cryptosporidium, *E.coli* O157:H7, Salmonella, Campylobacter
HF183 to estimate pathogens

- **What is HF183?** Human *Bacteroides*- bacteria specific to the human gut and therefore representative of human fecal material
- **Author measured pathogens and HF183 markers at 54 US locations**
- We used their work to estimate pathogens in our samples from our HF183 measurements
Model 1 - HF183 Model

Pathogens in sewage × HF183 in samples = Pathogens in samples (per L)
HF183 in sewage

Model 2- Pathogen Model

Concentrations of pathogens were included in the model as follows:

1. We looked at how many samples were positive for that given pathogen and calculated the likelihood that the pathogen was present

2. If a sample was positive, probability distributions using the raw data were used to estimate pathogen concentration.

Yes No

Pathogen= 0

Yes No
Quantitative Microbial Risk Assessment (QMRA)

Hazard Identification  Exposure Assessment  Dose Response  Risk Characterization  Risk Management
Exposure Assessment

Exposure Pathways
Exposure Assessment

**Volume of water ingested =**  
Ingestion rate per activity (mL/hr) x duration of activity (hr)

**Dosage of pathogens ingested =**  
Volume of water ingested (mL) x concentration of pathogens (organisms/mL)
Quantitative Microbial Risk Assessment (QMRA)
Dose-Response

- Curves from feeding studies, outbreak data
- Selection was on:
  - Study methods
  - Sample size
  - Use in previous QMRAs
- For norovirus and Campylobacter, used 2 curves
Dose-Response

• Four risk models developed per exposure:
  • norovirus Model 1; Campylobacter Model 1
  • norovirus Model 1; Campylobacter Model 2
  • norovirus Model 2; Campylobacter Model 1
  • norovirus Model 2; Campylobacter Model 2

• Results presented for two models: the most and least cautious combinations
Quantitative Microbial Risk Assessment (QMRA)
Results: Wissahickon Sites

Comparison to Indicator GM/STV:
- **E. coli** - 376 cfu/100mL; 35% exceed STV
- **Enterococci** - 23 cfu/100mL; 17.5% exceed STV
- **Fecal Coliform** - 607 cfu/100mL; 62.5% exceed STV

US EPA’s guidelines for primary recreation:
- **E. coli GM** (126 cfu/100 mL); STV (410 cfu/100mL)
- **Enterococci** (35 cfu/100 mL); STV (130 cfu/100mL)

PA guidelines for primary recreation
- **Fecal Coliforms** (200 cfu/100mL); STV (400/100mL)

U.S. EPA acceptable illness rate of 36 illnesses per 1,000
Results: Devil’s Pool

Comparison to Indicator
GM/STV:
E. coli - 30 cfu/100mL; 20% exceed STV
Enterococci - 11 cfu/100mL; 10% exceed STV
Fecal Coliform - 158 cfu/100mL; 30% exceed STV

U.S. EPA acceptable illness rate of 36 illnesses per 1,000

US EPA’s guidelines for primary recreation:
- E. coli GM (126 cfu/100 mL); STV (410 cfu/100mL)
- Enterococci (35 cfu/100 mL); STV (130 cfu/100mL)

PA guidelines for primary recreation
- Fecal Coliforms (200 cfu/100mL); STV (400/100mL)
Results: CSO sites

Comparison to Indicator GM/STV:
- E. coli- 7,695 cfu/100mL; 88% exceed STV
- Enterococci- 382 cfu/100mL; 40% exceed STV
- Fecal Coliform- 12,812 cfu/100mL; 100% exceed STV

U.S. EPA acceptable illness rate of 36 illnesses per 1,000

US EPA’s guidelines for primary recreation:
- E. coli GM (126 cfu/100 mL); STV (410 cfu/100mL)
- Enterococci (35 cfu/100 mL); STV (130 cfu/100mL)

PA guidelines for primary recreation
- Fecal Coliforms (200 cfu/100mL) STV (400/100mL)
Pathogen Estimates vs. HF183 Estimates

Cautious Pathogen Estimate

Least Cautious Pathogen Estimate

Cautious HF183 Estimate

Least Cautious HF183 Estimate

Average Illness Per 1,000 Events

CSO Wissahickon Devil's Pool

Swimming (30 min)  Wading (30 min)  Fishing (60 min)
Results

Pathogen model

• Illness **risk higher than EPA acceptable risk** in CSO impacted waterways for all activities

• Not the case for Devil’s Pool or Wissahickon
Results

HF183 model

- All sites showed higher mean illness than EPA acceptable risk in CSO impacted waterways and Devil’s Pool for all activities (Swimming, Wading, & Fishing)
Results

• HF183 model more appropriate for waterways with CSOs or known human sewage

• **FIOs guidelines** for primary recreation **did not align with pathogen risk estimates**
  • Thermotolerant coliforms (fecal coliforms) and *E.coli* results suggest that you should not swim in the Wissahickon or Devil’s pool

• **Pathogen risk model** suggest mean risk is between:
  • 0.5-1.5 cases/ 1000 swimmers for Wissahickon
  • 1.5 cases/ 1000 swimmers for Devil’s Pool
# Study Strengths & Limitations

<table>
<thead>
<tr>
<th>STRENGTHS</th>
<th>LIMITATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Study sites representative of recreational activities</td>
<td>• No culture data</td>
</tr>
<tr>
<td>• Many sites</td>
<td>• Only 1 summer pathogen data</td>
</tr>
<tr>
<td>• Analyzed for many pathogens</td>
<td>• Recreational behaviours may have been affected by COVID</td>
</tr>
<tr>
<td>• Collected 10 samples per site over swimming season</td>
<td>• Few rain events</td>
</tr>
<tr>
<td>• Multiple models (dose response &amp; exposure assessment)</td>
<td>• Rotavirus not included</td>
</tr>
<tr>
<td></td>
<td>• Combined Tacony and Cobbs data as well as wet and dry weather data due to limited samples</td>
</tr>
</tbody>
</table>
Quantitative Microbial Risk Assessment (QMRA)

Hazard Identification

Exposure Assessment

Dose Response

Risk Characterization

Risk Management
Take home messages

1. Wet weather may be riskier than dry weather
2. Indicator organisms do not correlate with pathogen presence (and certain indicators may overestimate the health risk)
   - Enterococci seems to be a better indicator
3. HF183 QMRA model can be used to estimate illness risk in sewage impacted waters; not appropriate for non-impacted
4. Even though risk was low, there were still pathogens found in the Wissahickon
5. Human recreators likely contributing to contamination in Wissahickon (rotavirus & HF183 results)
Should we swim, wade or fish?

Tacony & Cobbs Creeks

- All recreation is risky
- No swimming, wading
- Fishing only if appropriate hand hygiene is promoted
Should we swim, wade or fish?

Wissahickon

• Wading and fishing low risk
• Swimming poses higher risk (although on average lower than EPA acceptable risk)
Should we swim, wade or fish?

Devil’s Pool

- Wading and fishing low risk
- Swimming poses higher risk than Wissahickon (although on average lower than EPA acceptable risk)
Future Work—Recommendations

- Microbial source tracking for the Wissahickon
- Identify pathogen sources, particularly for dry weather
- Investigation of sources of pollution (leaking septic or stormwater drains)
- Investigate upstream influences

Future Work- Recommendations

- Increase sampling FIB in accordance with the EPA/PA guidelines to better characterize water quality
  - Focus on enterococci
- Develop individual site and specific event risk estimates (ie. weather conditions, months, temperatures)
Recommendations- Public Health

• Recreation should not occur in CSO waters
• Risk is likely higher for children, elderly and immunocompromised
• Messaging about the risks need to be more clearly communicated/ strategies developed
• Trash and bathroom facilities needed to avoid human fecal contamination
So now what?

How can we help you and other stakeholders utilize these results?
Acknowledgements

- Temple Undergraduate Merit Scholars and Student Workers
- Shannon McGinnis
- Philadelphia Water Department
- William Penn Foundation
- Drexel’s Academy of Natural Sciences
- USGS-USDA Wisconsin- Laboratory for Infectious Diseases (Mark Borchardt, Tucker Burch, Aaron Firnsthahl, Joel Stodyk, Sue Spencer)
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