Greater Lake Washington

Human Health Risk Assessment
Objectives

- Tier 1: Which parameters deserve additional inquiry?
- Tier 2:
  - Based on site specific exposure which chemicals pose carcinogenic, non-carcinogenic or pathogenic risks?
  - **Which exposure routes and locations pose the greatest risks?**
The bottom line objective...

- Are we monitoring the “right” things in the right places to ensure that significant human health threats are not slipping under the radar?
- What are we missing?
Environmental Data Sources

- **Water**
  - Ambient program
  - USGS/WA DOE/KC special studies
    - Sammamish River
    - Small Streams Toxicity
    - DOE pesticide monitoring
- **Sediment**
  - Ambient program
  - Major Lakes Capital
- **Tissue**
  - D. Houck samples
  - J. McIntyre (MS student funded by KC)
# Exposure Scenarios

<table>
<thead>
<tr>
<th>HHRA Tier</th>
<th>Domestic water supply + sediment</th>
<th>Swimming</th>
<th>Wading</th>
<th>Fish consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 1</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Tier 2</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Evaluated by WA Dept. of Health</td>
</tr>
</tbody>
</table>

Evaluated by WA Dept. of Health
## Tier 1 Pathways

<table>
<thead>
<tr>
<th>Media</th>
<th>Ingestion</th>
<th>Inhalation</th>
<th>Dermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Sediment</td>
<td>Yes</td>
<td>No</td>
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<tr>
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<td>Yes</td>
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</table>
Exposure pathways

**Sediment**
- Incidental Ingestion
- Pica
- Dermal Contact

**Water**
- Incidental Ingestion
- Dermal Contact

**Fish**
- Recreational Consumption
- Tribal Consumption

**Uplands - outside of SWAMP assessment area**
- High Water Mark
- Undocumented domestic water withdrawal

**Groundwater - outside of SWAMP assessment area**
- Shoreline Use/Wading
- Swimming & Recreational Water Sports
- Fishing
Tier 1 approach

- Conservative screening values derived from EPA CERCLA program
  - $10^{-6}$ cancer risk
  - 0.1 HQ for noncarcinogens (accounting for multiple contaminants)
- Drinking water
- Inhalation of volatiles from showering
- Eating sediment as if it were residential soil
- Higher end fish consumption
- “Max” concentrations
## Tier 1 results

<table>
<thead>
<tr>
<th>Number of Chemicals</th>
<th>Water</th>
<th>Sediment</th>
<th>Fish Tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of unique chemicals for which data were available</td>
<td>382</td>
<td>141</td>
<td>119</td>
</tr>
<tr>
<td>Number of detected chemicals</td>
<td>115</td>
<td>74</td>
<td>21</td>
</tr>
<tr>
<td>Number of chemicals retained for Tier 2 evaluation</td>
<td>50 (13%)</td>
<td>47 (33%)</td>
<td>42 (35%)</td>
</tr>
</tbody>
</table>
Tier 1 uncertainties

- 187 chemicals had no toxicity information with which to evaluate them for further investigation
- 41 had inadequate detection limits
- Pathways skipped (e.g. dermal)
- Whole body fish (vs. fillets)
Tier 2
Chemical assessment

- More robust consideration of chemicals ‘passing’ Tier 1
- Use watershed specific exposure assumptions
- Location specific data
- Dermal assessment
- TEFs for PAHs without chemical specific data
- Exposure point concentrations
  - >10 detects = 95% UCL of arithmetic mean
  - <10 detects = max detected concentration used
Chemical assessment con’t

- Sum of intakes across all pathways and all media \times CSF = cancer risk
  - Additive across all carcinogens
  - A lifetime (or exposure duration) risk

- Sum of intakes across all pathways and all media / RfD = noncancer risks
  - A daily average risk
## Tier 2 pathways

<table>
<thead>
<tr>
<th>Media</th>
<th>Ingestion</th>
<th>Inhalation</th>
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</tr>
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<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Tissue</td>
<td>No</td>
<td>No</td>
<td>No</td>
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</table>
Tier 2 Bacteria (*E. coli*)

- Seasonal screen (6/1 to 9/15)
  - Most beaches provide lifeguards 6/15 to Labor Day
- Holding time exceedances included
- Estimated values included
- Location specific maxima <126cfu/mL (EPA beach criteria) screened out
- N<20 screened out due to insufficient data
Study design issues (bacteria)

- Best example of why “monitoring” cannot serve all needs
- Non-random sampling on Tuesdays with Thursday follow-ups
- Biased design to protect weekend users
  - Technically cannot be used to answer the question:
  - What is the probability of getting sick from swimming?
Bacteria approach

- Fit data to distribution
- Apply distribution to swimmer illness/concentration relationship
  - Illness per 1,000 = 11.74 + 9.397 (log E. coli)
- Rank by illnesses per 1,000 swimmers
- Ranks used to describe relative magnitude of bacteria problems and prioritize locations
Chemical Data Confidence

- Widely varied data density
  - Some locations N=50
  - Some locations 1 or 2 detections in similar number of sampling events
- 95%UCL (i.e. >10 results) = high confidence
- High FOD% (>50%) = high confidence
- <10 detections, <50% FOD = low confidence
- Frequent blank qualifications = low confidence (e.g. phthalates)
Data confidence bottom line

- Metals and bacteria = high
- Organic chemicals = low
- About 13 locations with higher confidence PAH data
Risk additivity and management thresholds

- Different programs have different ‘allowable’ risk thresholds
  - Drinking water (MCLs), CERCLA, FDA medications, FDA food, CWA, MTCA, etc.
- Unknown ‘background’ risk
  - E.g. geologic sources
  - No definitions on regional or global ‘background’ contaminants
- KC has no defined risk thresholds
For discussion here…

- Excess cancer = $> 10^{-6}$
- HQ >1 when non-carcinogenic risks are summed by target organ*
- Why these levels?
  - Common usage in other environmental risk assessments (as opposed to product or FDA pharmaceutical assessments)
  - Typical starting “points of departure” for CERCLA and MTCA assessments
*Non-cancer endpoint/target organs*

<table>
<thead>
<tr>
<th>Endpoint</th>
<th># Tier2 chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancer only</td>
<td>11</td>
</tr>
<tr>
<td>Liver</td>
<td>9</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
</tr>
<tr>
<td>Blood</td>
<td>4</td>
</tr>
<tr>
<td>Kidney</td>
<td>4</td>
</tr>
<tr>
<td>CNS</td>
<td>3</td>
</tr>
<tr>
<td>Eyes</td>
<td>2</td>
</tr>
<tr>
<td>Methemoglobinemia</td>
<td>2</td>
</tr>
<tr>
<td>Body weight</td>
<td>1</td>
</tr>
<tr>
<td>Hair</td>
<td>1</td>
</tr>
<tr>
<td>Heart</td>
<td>1</td>
</tr>
<tr>
<td>Lung</td>
<td>1</td>
</tr>
<tr>
<td>Skin</td>
<td>1</td>
</tr>
</tbody>
</table>
Legend

**Cancer Probability**
- △ 1E-6 to 1E-5 - Lowest Probability
- △ 1E-5 to 1E-4
- △ 1E-4 to 1E-3
- △ 1E-3 to 1E-2
- △ 1E-2 to 1E-1
- △ 1E-1 to 0.99 - Highest Probability

**E. coli Illness Rank**
- ◆ 1 - Highest E. coli Illness Rank
- ◆ 2
- ◆ 3
- ◆ 4
- ◆ 5 - Lowest E. coli Illness Rank

**Maximum Non-Cancer Hazard Quotient**
- ◇ 1.1 - 3.0 - Lowest Risk
- ◇ 3.1 - 5.0
- ◇ 5.1 - 15.0
- ◇ 15.1 - 100.0
- ◇ 100.1 - 300.0 - Highest Risk

**Population Density (per sq. mile)**
- 2 - 1389
- 1389 - 3316
- 3316 - 5056
- 5056 - 6592
- 6592 - 9169
- 9169 - 87809
Drink + wade when accessible
**Legend**

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Legend

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- ◈ 4
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- ◁ 9169 - 87809
Swim, water only
Top risk drivers (locations)

- Arsenic (100+)
- HPAHs like Benzo(a)pyrene (13-22)
- Chyrsene (11)
- Pentachlorophenol (17)
- Bis (2-ethylhexyl) phthalate (39)
- Location frequency data skewed to uneven sampling
Are these chemicals unusual?

IM data from WA
Urban Counties

Y Data

10^-6
10^-5
10^-4
10^-3
10^-2
10^-1
10^0
10^1
10^2
10^3
Where do the risks line up?

- Only 3 chemicals exceeded drinking water regulatory standards (DEHP, Pb, Tl)
- (does not include bioaccumulatives)

<table>
<thead>
<tr>
<th>Scenario/Model</th>
<th>Carcinogenic Risk Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Puget Sound lifetime risk (NCI, 2005)</td>
<td>3.4E-1</td>
</tr>
<tr>
<td>Domestic water supply with backyard wading use (most conservative scenario in this study)</td>
<td>1.4E-2</td>
</tr>
<tr>
<td>Lung cancer risk in a 75 year old smoker who smoked 1 pack/day for 40 years (Bach et al. 2003)</td>
<td>8.0E-2</td>
</tr>
<tr>
<td>Lung cancer risk in a 75 year old smoker who smoked 2 packs/day for 50 years (Bach et al. 2003)</td>
<td>1.5E-1</td>
</tr>
<tr>
<td>Backyard or beach wading use alone</td>
<td>2.0E-4</td>
</tr>
</tbody>
</table>
Bacteria (E. coli) results

- Distributions fitted (e.g.)

- Apply dose – illness response relationship
- Categorize relative to swimming standard in WQS
# E. coli illness frequency and rank

<table>
<thead>
<tr>
<th>Frequency of illness</th>
<th>Number of locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greatest</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>24</td>
</tr>
<tr>
<td>Least</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Waterbody</th>
<th>Illness Rates % ile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25th</td>
</tr>
<tr>
<td>Thornton Creek</td>
<td>11.85</td>
</tr>
<tr>
<td>Tributary to Thornton Creek</td>
<td>11.81</td>
</tr>
<tr>
<td>Juanita Creek</td>
<td>10.17</td>
</tr>
<tr>
<td>Juanita Creek</td>
<td>10.17</td>
</tr>
<tr>
<td>McAleer Creek</td>
<td>9.23</td>
</tr>
<tr>
<td>Idylwood Creek</td>
<td>9.11</td>
</tr>
<tr>
<td>Lyon Creek</td>
<td>9.10</td>
</tr>
<tr>
<td>Mercer Slough</td>
<td>8.70</td>
</tr>
<tr>
<td>Piper’s Creek</td>
<td>8.40</td>
</tr>
</tbody>
</table>

EPA recommended WQ standard = 8 illnesses/1,000 swimmers
Sensitivity, what’s driving the bus?

- **Exposure duration**
  - 78 yrs is high compared to other assessments
    - Less than an order of magnitude shift for both 15 and 30 year periods = moderate influence

- **Hours of swimming and number so swimming days**
  - 240 min 95th%ile vs. 60 min median
  - 58 days/yr 95th%ile vs. 8 days median
  - Average cancer probability RPD minus 180%
  - Only 3 highest (of 18) locations with non-cancer HIs >1 remain of concern
Sensitivity, con’t

- Plus-minus 50% of raw data has no influence on number of locations with a carcinogen EPC of concern
- Due to the frequent use of maxima as EPCs
- Soil ingestion and soil ingestion rate not a significant source of risk
  - Pica child risks very similar to normal child due to the preponderance of the risks coming via water.
Uncertainties

- **Scope**
  - Almost 11,000 parcels in the watershed abut a waterbody
  - Non-random data collection limitations
  - 95% of location had water or sediment samples but not both
    - Limited ability to integrate risks across pathways
  - Assumed central range of exposures
    - No contaminated sites
    - No definition of “background”
Uncertainties, con’t

● **Analytical**
  - Analyte list variable (spatially+temporally)
    - Aldicarb N=4
    - Dibenzo(a,h)anthracene N=863
  - Total arsenic vs. speciated
  - PCBs
    - No confirmation via congeners
    - Whole fish not fillets
    - Spotty sediment coverage
  - CDDFs (none at all)
  - Phthalates
    - Lots of blank contamination
Uncertainties, con’t

- Exposure
  - 1.4 million people
  - Almost 600,000 parcels
  - ~11,000 waterfront parcels
  - Wide spread in days of use
  - Hours of contact per event
  - Years of use
  - Need more targeted population of users and distinct risk questions
Uncertainties, con’t

- **Methods**
  - Temporal changes in exposure unaccounted for
    - 8yrs data extrapolated to 70+
  - Upper bound of risk to sensitive groups vs. typical population-wide risks
  - Lead, widespread but challenging to evaluate via pharmokinetic model
    - Air and dust are likely major factors, water/sediment are uncertain
  - Do real exposures match the scenarios evaluated?
    - All pathways simultaneously for the durations/frequency considered?
    - How common?
      - Can you be a 95%ile user in multiple areas simultaneously?
  - By sensitive subpopulations?
Conclusions

- Urban nearshore lake and stream waters pose the highest risks
  - PAHs + bacteria
    - As background vs. area-wide?
  - Mid-lake WA or Sammamish have few risks
- Monitoring should focus on
  - Tracking changes in risk drivers
    - May-October for bacteria
    - Year round for PAHs and PCBs
  - Identifying sources
  - Documenting source reduction (post control)