Snohomish County Watershed-Scale Stormwater Management Planning for Little Bear Creek - Analysis of Factors Affecting BIBI

Frank Leonetti and Arthur Lee
Snohomish County Public Works
Surface Water Management
Everett, WA

SAME
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Plan Objective

To identify stormwater strategies that will meet water quality standards that support use of Little Bear Creek for people and aquatic life

1. NPDES Phase 1 requirement
2. Performance targets
3. ID Strategies/costs

2004 watershed evaluation for salmon recovery planning suggested Little Bear Creek was most “at risk”
## Benthic Index of Biological Integrity

- **10 metrics comprise**
- **10-50 point scale**
- **500 minimum bug count**
- **LBC 20-54 species** (39-81 is excellent range)
- **Responds to gradient of disturbance**

<table>
<thead>
<tr>
<th>Biological Condition</th>
<th>Description</th>
<th>B-IBI&lt;sub&gt;10-50&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>Comparable to least disturbed reference condition; overall high taxa diversity, particularly of Ephemeroptera (mayfly), Plecoptera (stonefly), Trichoptera (caddisfly), long-lived, clinger, and intolerant taxa. Relative abundance of predators high.</td>
<td>[46, 50]</td>
</tr>
<tr>
<td>Good</td>
<td>Slightly divergent from least disturbed condition; absence of some long-lived and intolerant taxa; slight decline in richness of Ephemeroptera, Plecoptera, and Trichoptera; proportion of tolerant individuals increases.</td>
<td>[38, 44]</td>
</tr>
<tr>
<td>Fair</td>
<td>Total taxa richness reduced – particularly intolerant, long-lived, Plecoptera, and clinger taxa; relative abundance of predators declines; proportion of tolerant individuals continues to increase.</td>
<td>[28, 36]</td>
</tr>
<tr>
<td>Poor</td>
<td>Overall taxa diversity depressed; proportion of predators greatly reduced as is long-lived taxa richness; few Plecoptera or intolerant taxa present; dominance by three most abundant taxa often very high.</td>
<td>[18, 26]</td>
</tr>
<tr>
<td>Very Poor</td>
<td>Overall taxa diversity very low and dominated by a few highly tolerant taxa; Ephemeroptera, Plecoptera, caddisfly, clinger, long-lived, and intolerant taxa largely absent; relative abundance of predators very low.</td>
<td>[10, 16]</td>
</tr>
</tbody>
</table>

From King County 2014
### BIBI - Lines of Evidence – 25+ Years

Based on subbasin-scale analyses across urban-forest gradient

<table>
<thead>
<tr>
<th>Lines of Evidence</th>
<th>Indicators/Metrics</th>
<th>Investigators (published/unpublished)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land cover (i.e., Total Impervious Area, Forest)</td>
<td>% Impervious/Forest Cover or Combination</td>
<td>Alberti, Booth, May, Morley, Horner, WRIA 8, Leonetti</td>
</tr>
<tr>
<td>Riparian Buffers</td>
<td>Buffer Land cover as above</td>
<td>Morley, May, Horner, McBride, WRIA 8</td>
</tr>
<tr>
<td>Hydrology</td>
<td>8-9 Flow Metrics by site, year, and averages (WY or CY)</td>
<td>Konrad and Booth, DeGasperi et al., Cassin et al., WRIA 8 study, Others</td>
</tr>
<tr>
<td>Sediment/Substrate</td>
<td>Fine sediment/ D50</td>
<td>ODEQ, Plotnikoff, Dorfmeir,</td>
</tr>
<tr>
<td>Hydraulics</td>
<td>Bed Shear Stress, HPC2, HPD2, theta</td>
<td>Morley, Examples from Hartley</td>
</tr>
<tr>
<td>Channel/Habitat</td>
<td>Combination - HQI, PSCI, EAI</td>
<td>May, McBride, King County 1999, WRIA 8 study</td>
</tr>
</tbody>
</table>

Factors/Influence for “At-A-Site” management are largely unknown
• 13.6 m²
• Impervious area ≈10-40%
• Avg Bankfull width ≈1.6-10m
• 17.5 miles mainstem
• 303D listed for Bioassessment
• 41 inches precip

• Kleindl 1994
• May 1996/1997
• King County 2001
• Morley 2000
• McBride 2001
• King County 2005
• Alberti & Shandas 2009
• Snohomish County 2016
9 subbasins – mixed land uses – forest & impervious
What we did for Little Bear Creek analyses

- Described BIBI scores for 15 sites, over time (2002-2015)
  - Snohomish County and King County data
- Described land cover/ stream buffer conditions from BIBI sites (2013 NAIP Land cover classification)
- Calculated Gaged (2) and HSPF modeled flow metrics (2002-2015)
- Described substrate, bed stability, channel conditions and changes between 2014-2015
- Exploratory analyses of factors x BIBI scores
  - By Site
  - By Year
  - Least-squares regression
B-IBI Sites

7 long-term mainstem sites;

10 total mainstem sites;

4 tributaries
Site scores (‘02-’15)

• Are there trends?
• Do site scores increase/decrease similarly over time?
• Do sites change condition categories (poor, fair, good, etc)?
• Are avg. site scores correlated with upstream landcover?
• Are avg. site scores correlated with buffer condition?
  – Does residual buffer condition (to basin landcover) correlate with BIBI
• Are avg. site scores correlated with averaged hydrologic metrics?
• Are annual scores correlated with annual flow metrics?
• Are annual score changes (+/- BIBI points) correlated with annual difference in flow metrics (by site and by site averages)?
• Are 2014/2015 scores correlated with sediment (<2mm) quantity?
• Are annual score changes (+/- BIBI points) correlated with annual differences in sediment?
Site scores (‘02-’15)

- 1 site-pair (2602/2692) was correlated out of 21 site-pairs
- Thought 1 site (2585) positive/ 1 site (2781) neg trend
- Added 2016 and site 2603 is positive at $\alpha=0.05$
- Site 2692 changes most from year-year
Landcover (2013 NAIP w/ 1-ft 2011 Impervious Mapping)

• Mainstem Little Bear Creek locations
Does better/worse buffer explain residual BIBI relative to Land Cover? (LCI = %Forest - %TIA)
Hydrologic metrics – magnitude, duration, timing, frequency, variability

- High Pulse Count
- High Pulse Duration
- High Pulse Range
- Low Pulse Count
- Low Pulse Duration
- Low Pulse Range
- TQmean
- R-B Flashiness Index (RBI)
- Fall/Rise Rates
- Flow Reversals

• DeGasperi et al. 2009 (Juanita)
• King County 2015 (WRIA 8 study)
• Horner 2013
• King County 2012
• King County 2005
Comparing LBC Flow-BIBI to regional regressions

2002-2015 Long-term average BIBI at 10 LBC Mainstem sites

Next, Also compared to WRIA 8 Study (2010-2013 data) – King County 2015
Long-term (5-12 years) BIBI Average at 10 mainstem LBC sites
Time series (2002-2015)
Shows change in HPC – HSPF model
Time series (2002-2015)
Shows change in HPC (HSPF) and B-IBI for 5 long term sites

- Some inverse relationship evident

Avg HPC 5 Sites
\[ y = 0.489x - 970.64 \]
\[ R^2 = 0.2436; p=0.07 \]

Avg BIBI 5 sites
\[ y = -0.0604x + 151.99 \]
\[ R^2 = 0.0155; NS \]
Influence of annually persistent flow values – 2.8 BIBI pts

\[
y = -0.4746x + 36.122 \\
R^2 = 0.604
\]
Flow metric Year-Year Change and BIBI Change

![Graph showing Year-Year Change and BIBI Change](image)
Fine sediment

Sediment at BIBI quadrats, BIBI riffles, Survey-wide transects.

- 25 grid points x 8 quadrats = 200 potential fine sed pts.
  - (#grid pts/ 200)*100 = % surface fines in quadrat
- 25 pebble count per riffle x 8 riffles = 200 pebbles
  - (#pebbles-sand or finer / 200) *100 = % riffle fines
2014, 2015
54 sediment metrics – mainstem and tribs

Fine Sediment in BIBI quadrats and sampled riffles 2014, 2015
Tributaries had higher HPC and flashiness.
Roughness and Relative Bed Stability (EPA-EMAP)

- Simple description
  - Observed Gravel Size/ Erodible Gravel Size

- Data included are slope, avg. channel depth, substrate size (pebble count)

- Mainstem and Tribs
  - Tribs have highest values!

\[
y = 5.9842x + 31.125 \\
R^2 = 0.2919
\]

\[
y = 9.5319x + 30.35 \\
R^2 = 0.309
\]
Channel Roughness (Morley 2000) – D84/BankFullDepth or D50/BankFullDepth
Summary of LBC Analyses

• Basin and Buffer Land Cover quality is supportive of BIBI scores

• Established within-basin correlation of flow and BIBI for mainstem sites (better fit than LC alone)

• WRIA 8 Flow-BIBI dataset was better fit to long-term mainstem sites

• Correlation with HPC/HPR/RBI was best and regionally consistent

• Annual flow changes correlate w/BIBI changes, which may also respond to changes in sediment

• Tribs - Higher flow/flashiness, less sand/fines, greater D50, better buffer quality, smaller X-sectional area may not produce same disturbance effect on streambed OR may mask/mitigate effect?

• Next Steps – Develop site- or catchment-scale narrative for protection/restoration – Flow, Buffer, Sediment, Roughness
BMP* Implications

• Protect and Restore buffer quality

• Implement SW flow control retrofits to reduce high pulses and flashiness metrics

• Reduce sources and limit fine sediment supply/transport

• Protect and improve channel roughness

*Best Management Practice
Cost of Modeled Strategies

1. **HSPF**
   - Baseline flow, shading benefit (riparian planting)  
     $ 5 M

2. **SUSTAIN**
   - Optimize BMP** suite for flow control (B-IBI)  
     $ 229 M
   - Reduce fecal coliform, temperature

3. **HSPF**
   - Routing
   - Optimize for temperature using bioretention  
     $ 6 M
   - Optimize for fecal coliform using biofiltration  
     $ 49 M

**Projected Cost**

$ 289 M

*Figures are rounded*
## Other Strategies

<table>
<thead>
<tr>
<th>Structural</th>
<th>Non-Structural</th>
<th>Instream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Strips*</td>
<td>Development Code Change*</td>
<td>Riparian Planting</td>
</tr>
<tr>
<td>Raingardens*</td>
<td>Supplemental Treatment*</td>
<td>Buffer Enhancement*</td>
</tr>
<tr>
<td>Bioretention*</td>
<td>Street Sweeping</td>
<td>Stream Restoration</td>
</tr>
<tr>
<td>Downspout Disconnection</td>
<td>Water Quality Outreach</td>
<td>Wetland Restoration</td>
</tr>
<tr>
<td>Detention/Retention*</td>
<td>Bacteria Source Tracking</td>
<td>Bank Stabilization</td>
</tr>
<tr>
<td>Permeable Pavement*</td>
<td>Property Acquisition</td>
<td>Ditch Modifications*</td>
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<tr>
<td>Amended Soils*</td>
<td></td>
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<tr>
<td>Cisterns</td>
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<tr>
<td>Flow Augmentation</td>
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</table>

* Modeled strategy
### Existing and Projected WQ Conditions

<table>
<thead>
<tr>
<th>STANDARD / TARGET</th>
<th>EXISTING</th>
<th>FUTURE BUILD-OUT</th>
<th>FUTURE BUILD-OUT WITH PLAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Zinc</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Dissolved Copper</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Temperature</td>
<td>🟥</td>
<td>🟥</td>
<td>🟥</td>
</tr>
<tr>
<td>Fecal Coliform</td>
<td>🟥</td>
<td>🟥</td>
<td>🟥</td>
</tr>
<tr>
<td>B-IBI (aquatic health)</td>
<td>🟥</td>
<td>🟥</td>
<td>🟥</td>
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