Flood Protection and Salmon Habitat Enhancement in Urban Areas on the Green River, Washington

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King County Water and Land Resources
Presentation Overview

• King County Integrated River and Floodplain Management
• Green River System Wide Improvement Framework (SWIF)
• Project Area + Vision/Goals
• Advisory Structure
• Technical Studies
• Deficiencies Action Plan
• Flood Protection Goal Setting
• Alternatives Analysis
• Capital Project Development
Takeaway Points

• Multi-objective planning and project implementation promote more comprehensive and cost-effective solutions; break down the silos

• Grounded in best available science and knowledge to tee up policy options and inform decision making

• Decisions on level of protection (LOP) from flooding should be determined based on risk tolerance and expected annual damages; Define LOP by flow containment (cfs) rather than recurrence interval or % annual chance flood

• Implement a collective vision shared by diverse project partners, constituents and interest groups
Integrated River and Floodplain Management

King County does integrated river and floodplain management to evaluate, plan for, and balance multiple objectives, including:

- Flood protection (flood risk reduction)
- Economic resiliency (regional, local)
- Community resiliency (tribes, cities, equity and social justice)
- Ecological resiliency (aquatic, riparian, and floodplain habitat)
- Recreation (trails, access, safety, connection to the river)
- Agriculture (productivity, drainage)
What is a System Wide Improvement Framework (SWIF)?

USACE SWIF policy, November 2011:

“A plan prepared by levee sponsors and approved by the USACE to implement system-wide improvements to a levee system (or multiple levee systems w/in a watershed) ...”

“... solutions will satisfy the multiple requirements that apply to levee systems (ESA, Tribal Treaty Rights, etc.) while allowing levee sponsors to remain eligible for PL84-99 funding while addressing deficiencies.”
Project Area: Green-Duwamish River

- Watershed Area = 475 mi²
- Population = 370,000
- 10 cities
- Residential, commercial, industrial and agriculture
- Green River: 36 miles of levees and revetments
- Howard Hanson Dam (constructed 1962 at RM 64.5)
- All species of salmon present
Lower Green River: Context

Socio-Economic
- $7.3 billion in floodplain structures and contents
- 100,000+ jobs
- 100 million sf warehouse + distribution space (2<sup>nd</sup> largest on West Coast)
- Comprises 1/8<sup>th</sup> of the GDP for WA State
- Annual taxable revenue of $8 billion
- Boeing, REI HQ, Starbucks roasting plant
Lower Green River: Context

Salmon Populations & Habitat

- All species of salmon present, including ESA-listed Chinook salmon
  - Historical pop. approx. 38,000
  - 40-year average = 5,000
  - Low of 800 adults in 2009
  - 25-65% hatchery origin

- Limited spawning in Lower Green (above RM 24)

- Lethal water temperatures (> 23°C) have occurred in Green River mainstem (July 2006); TMDL water quality standard is 16°C

- Tribal fishing rights
# Green River Flood Facility Deficiencies

<table>
<thead>
<tr>
<th>Location</th>
<th>Levees (#/miles)</th>
<th>Revetments (#/miles)</th>
<th>Total Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duwamish (RM 5.5-11)</td>
<td>3 (0.6 miles)</td>
<td>22 (3.3 miles)</td>
<td>3.9</td>
</tr>
<tr>
<td>Lower Green (RM 11-32)</td>
<td>41 (17.7 miles)</td>
<td>45 (9.8 miles)</td>
<td>27.5</td>
</tr>
<tr>
<td>Middle Green (RM 32-44)</td>
<td>12 (1.9 miles)</td>
<td>13 (2.9 miles)</td>
<td>4.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>56 (20.2 miles)</td>
<td>80 (16.0 miles)</td>
<td>36.2</td>
</tr>
<tr>
<td>PL 84-99 levees (RM 12.4-30.8)</td>
<td>12 (16 miles)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Aging system of levees** – built to protect agricultural land uses, not regionally significant urban areas
- **Slope stability and toe scour issues**
- **Other deficiencies** – vegetation, encroachments, animal burrows, etc.
- **Current containment** = 12,000 cfs with variable freeboard
- **Certification and Accreditation** of Levees; FEMA mapping
What is the Green River SWIF?

Technical planning, analyses and participatory process to achieve:

1. Desired level of protection from flooding
2. Reach agreement on a prioritized list of capital projects to provide flood protection while improving habitat, and other goals (e.g., recreation, agriculture)
3. Vegetation management plans to address ESA, CWA, and PL 84-99 stds
4. Develop and implement Deficiencies Action Plan
Green SWIF Vision and Goals

**Vision:**
Improve flood protection, for current and future generations, in a way that builds economic, ecological and community resiliency.

**Goals:**
- Integrated River and Floodplain Management
- Flood Protection
- Vegetation Management
- Ecological Resiliency
- Economic Resiliency
- Community Resiliency
Green SWIF: Who is Involved?

- King County Flood Control District, lead agency
- King County
- Green River Cities
- Muckleshoot Tribe
- USACE, FEMA, NOAA
- WRIA 9
- PSP, Ecology, WDFW
- Business community
- Environmental organizations
- Citizens
Technical Studies:

**Flood Risk Assessment**

- **Geomorphic Assessment** – channel patterns and gradient, stream incision, and damages to levees and revetments
- **Geotechnical Assessment** – levee stability, vulnerability, and potential breach locations
- **Hydraulic Assessment** – flooding patterns, channel capacity, and floodplain inundation (for flood flows of 12,000 to 26,800 cfs)
- **Economic Analysis** – Expected annual damages and economic impacts

**Aquatic, Floodplain, and Riparian Habitat**

- Riparian vegetation – trees, shrubs, invasive species
- Aquatic Habitat – pools, large wood, edge habitat
Risk Assessment – Key Findings

Geomorphology

• Channel incision between 1986 and 2011 was a minimum of 1-2 feet everywhere, with maximum incision of 7-10.5 feet at channel bends in all four reaches of Lower Green
• Most damaged levees and revetments are located around channel bends
• Channel locations with >5 feet of incision represent a substantial risk of future damage to levees and revetments
Risk Assessment – Key Findings

Geotechnical

• Most levees constructed in 1960s used river alluvium (sand/gravel), and dragline methods without compaction
• Levee stability analyses → shallow failure surfaces that would not result in significant reduction of levee prism
  – Considered a maintenance issue, with a low probability of causing a levee breach, but must be repaired
Current Conditions Report: Geotechnical Assessment

15 Potential Breach Locations

<table>
<thead>
<tr>
<th>Potential Breach</th>
<th>Levee Reach</th>
<th>River Bank</th>
<th>River Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dykstra</td>
<td>Left</td>
<td>30.69</td>
</tr>
<tr>
<td>2</td>
<td>Tukwila 205</td>
<td>Left</td>
<td>14.83</td>
</tr>
<tr>
<td>3</td>
<td>Horseshoe Bend</td>
<td>Right</td>
<td>25.50</td>
</tr>
<tr>
<td>4</td>
<td>Meyer’s Golf</td>
<td>Right</td>
<td>21.80</td>
</tr>
<tr>
<td>5</td>
<td>Lower Russell Road</td>
<td>Right</td>
<td>18.60</td>
</tr>
<tr>
<td>6</td>
<td>Briscoe-Desimone</td>
<td>Right</td>
<td>16.62</td>
</tr>
</tbody>
</table>
Current Conditions Report: **Hydraulic Assessment**

**Discharge vs. flood frequency at Auburn**  
(unregulated and regulated at HHD)

<table>
<thead>
<tr>
<th>Flood Event</th>
<th>Flow at Auburn Gage (cfs)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-yr 5% C.L.</td>
<td>9,900</td>
<td>2-yr events very similar, well below levee system crest</td>
</tr>
<tr>
<td>10-yr 95% C.L.</td>
<td>11,900</td>
<td>Lowest volume 12,000 cfs range peak event</td>
</tr>
<tr>
<td>200-yr Median</td>
<td>12,600</td>
<td>Highest volume 12,000 cfs range peak event</td>
</tr>
<tr>
<td>100-yr 5% C.L.</td>
<td>15,100</td>
<td>--</td>
</tr>
<tr>
<td>500-yr Median</td>
<td>18,800</td>
<td>Also used for the very similar 200-yr 5% event</td>
</tr>
<tr>
<td>500-yr 5% C.L.</td>
<td>26,800</td>
<td>--</td>
</tr>
</tbody>
</table>
Current Conditions Report: **Hydraulic Assessment (Inundation)**

Levee overtopping that exceeds design protection will result in floodplain inundation of <1 to 10+ feet.
Risk Assessment – Key Findings

Economics

• HEC-FDA (Flood Damages Assessment) modeling estimated system-wide estimated annual damages of $47.1 million
  – National and Regional Economic Development (NED, RED) effects
• Present value damages (based on 50 years and 3.5% discount rate) is $1.1 billion
  – Analysis assumes all businesses remain and re-open following downtime caused by flood
  – There are 5,371 residential structures in planning area
Shoreline/Riparian Vegetation Mapping

Reach 3 Riparian Vegetation Cover Types

- Agriculture
- Bare Earth
- Grass
- Impervious
- Ornamental
- Other
- Shrub
- Trees

Data Sources: King County, 2014; USDA, 2014
Lower Green River Aquatic Habitat

Findings

- Low diversity, quality and substantially modified from historical conditions
- Habitat dominated by glides
- Riffles and pools limited downstream of RM 24
- Temperature impaired water body (TMDL), with lethal conditions for salmonids in some years

<table>
<thead>
<tr>
<th>Habitat Unit</th>
<th>Acres</th>
<th>Percent of Total Area in Reach 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pools</td>
<td>4.13</td>
<td>2.0%</td>
</tr>
<tr>
<td>Spawning Gravel</td>
<td>18.51</td>
<td>2.80%</td>
</tr>
<tr>
<td>Total Area</td>
<td>22.64</td>
<td>4.79%</td>
</tr>
</tbody>
</table>

There are 5 log jams present in Reach 3

- Pool
- Riffle
- Run
- Glide
- Log Jams
- River Mile
Habitat Resources: Riparian/Shoreline Shade

Potential Shade GIS Model

- Tool to evaluate ‘potential shade’ to the river cast from existing trees within a 150’ shoreline zone
- Tool can be used to model the effects of future conditions
# Levee Deficiencies (PL84-99)

## Horseshoe Bend Levee System example

<table>
<thead>
<tr>
<th>Category (item)</th>
<th>Unacceptable</th>
<th>Min. Acceptable</th>
<th>Acceptable</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encroachments</td>
<td>1</td>
<td>28</td>
<td>7</td>
<td>36</td>
</tr>
<tr>
<td>Unwanted Veg. Growth</td>
<td>22</td>
<td>6</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>Slope Stability</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Depressions/Rutting</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Excavation</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Debris</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Erosion/Bank Caving</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>9</td>
<td>0</td>
<td>10</td>
<td>19</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>34</strong></td>
<td><strong>45</strong></td>
<td><strong>19</strong></td>
<td><strong>98</strong></td>
</tr>
</tbody>
</table>

**Deficiencies Action Plan**

Near-term actions: encroachments, animal burrows, debris, depressions, brushing

Mid-term actions: vegetation

Long-term actions: slope stability (and toe scour)
Level of Protection Goal Options

Three LOP goal options to be applied to shoreline:
A. Maintain current condition or Level of Protection (LOP)
B. Increase LOP
C. Achieve maximum LOP of $X$ cubic feet per second (cfs), (Provisional $X = 18,800$ cfs)
Green River SWIF Next Steps

Alternatives Analysis to achieve LOP goals and other multiple objectives:
- Alternatives vary in terms of project types (flood walls, in-place replacement levees, setback levees) and extent of habitat restoration

Capital Project Development/Prioritization to achieve selected alternatives
- 10-12 conceptual project designs and planning level cost estimates

Submittal of SWIF to USACE – Feb 2015

Implementation/Funding – 2015 and beyond
Capital Project Options

Flood Wall and Levee Layback
➢ Build wall at the toe of existing levee toe and lay back the levee embankment to stable slope

In-place Replacement Levee
➢ Replace levee with same river-ward toe, but build new levee geometry (3:1 H:V)

Setback Levee
➢ Set back the levee from the river’s edge (e.g., 50-300+ feet) with new levee geometry
Questions?

Project website:
Google “Green River System Wide Improvement Framework”

Email: lorin.reinelt@kingcounty.gov