Skagit Delta alternatives analysis: using output from the Salish Sea hydrodynamic model to quantify benefits and impacts of restoration project concepts

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Farms, Fish and Flood Initiative
Skagit Hydrodynamic Model Project
A Multi-Benefit Alternatives Assessment

Salish Sea Conference
April 4, 2018

SHDM Co-Leads
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Jenna Friebel Wa. Dept. Fish and Wildlife
Polly Hicks NOAA Restoration Center
Skagit Hydrodynamic Model Project

“Using an alternatives analysis, develop a suite of projects that are well supported to achieve the long-term viability of Chinook salmon tidal delta habitat and community flood risk reduction in a manner that protects and enhances agriculture and drainage.”

This is a tool developed through the 3FI process that provides transparency about the benefits and impacts from estuary restoration concepts.
Selecting the right tools to inform analyses of objectives and indicators

Models
- 3-D Hydrodynamic Modeling (PNNL)
- Channel Development Model (Greg Hood)
- Chinook Model (Eric Beamer)

Non-Model Analysis
- GIS
- Change in Channel Cross-section Analysis
- Vegetation community predictions
## PNNL SHDM Model Output and Indicators Supported

<table>
<thead>
<tr>
<th>Output description</th>
<th>Objectives/indicators supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area subject to tidal &amp; riverine processes (high tide/low flow or Q2/low tide)</td>
<td>Restore tidal and riverine processes (Fish)</td>
</tr>
<tr>
<td></td>
<td>Support regulatory agreements (Farm)</td>
</tr>
<tr>
<td>Depths of inundation within a project concept (May Mean Flow and Spring High Tide)</td>
<td>Restore diverse habitat types (Fish)</td>
</tr>
<tr>
<td>Duration of WSE over a 3 month period</td>
<td>Increase suitable channel habitat (Fish)</td>
</tr>
<tr>
<td>Changes in WSE during flood events</td>
<td>Reduce floodwater elevations (Flood)</td>
</tr>
<tr>
<td>Changes in flow balance between forks</td>
<td>Minimize loss of existing habitat (Fish)</td>
</tr>
<tr>
<td>Climate Change</td>
<td>Not used in alternatives analysis, but provided as additional information for consideration in future phases</td>
</tr>
<tr>
<td>Changes in salinity</td>
<td></td>
</tr>
</tbody>
</table>
Model Domain and Grid

Skagit Delta

Existing Skagit Bay Model
19,576 elements

Updated Grid
127,184 elements
Available Monitoring Data

- X Tide Gages (4)
- NOAA Met. Station (1)
- Dept. of Ecology Buoys (4)
- USGS Stream Gage (1)
- TNC WSE Gages (5)
- SRSC WSE Gages (7)
May 22, 2018

WDFW – Water Level Loggers
Model Setup and Validation – 11/14 – 6/15

Model sites calibrated within 1.4%, 1.0%, 2.8%, 9.6% and 2.3% relative error, respectively.
Animation: Velocity
Grouped Project Runs

- **Simulation 1: Small Projects**
- **Simulation 6: Moderate Influence #1**
- **Simulation 7: Moderate Influence #2**
- **Simulations 8 & 10: Selected Projects**

- Blue polygons are projects
- Simulations 1-7 isolate project effects
- Simulation 8 shows cumulative effect
- Simulations 9-10 show effects of climate change
Full model simulation from **Nov 1, 2014 – May 22, 2015** using historic hydrographs and tide charts

Two-week design runs to isolate effects of riverine, tidal, flood, etc.

- **Tidal**: Low flow (12,000 cfs) and high Spring tide (10.8 ft NAVD88)
- **Riverine**: Q2 flow (62,000 cfs) and low Spring tide (-3.3 ft NAVD88)
- **Flood**: Qflood (93,200 cfs) and high Spring tide (10.4 ft NAVD88)
- Mean May flow (20,400 cfs) and high Spring tide (10.8 ft NAVD88)
- Feb. to May Juvenile Outmigration
Fish Objective: Increased area subject to tidal & riverine processes

Analysis Method:

1. Determine if project was tidal, riverine or a combination of the two
2. Calculate within project concept footprint with wetted area increase

For tidal sites use high tide scenario, for riverine Q2.
For tidal and riverine, sum the areas accounting for overlap.

<table>
<thead>
<tr>
<th>High Tide/ Low Flow</th>
<th>Pleasant Ridge South</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>0.0</td>
</tr>
<tr>
<td>Small Projects</td>
<td>22.3</td>
</tr>
<tr>
<td>Increase in Area</td>
<td><strong>22.3</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q2 Flow/ Low Tide</th>
<th>Pleasant Ridge South</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>0.4</td>
</tr>
<tr>
<td>Small projects</td>
<td>27.8</td>
</tr>
<tr>
<td>Increase in Area</td>
<td><strong>27.4</strong></td>
</tr>
</tbody>
</table>

Low Flow (12,000 cfs)  
High Spring Tide (10.8 ft)

Q2 Flow (62,000 cfs)  
Low Spring Tide (-3.3 ft)
Fish Objective: minimize impacts to offsite habitat

Effect of change in flow and WSE between forks on existing habitat

- Examined for areas outside of project footprints that are inundated during Q2 Baseline and not during Q2 with selected project run (see red circled areas)

<table>
<thead>
<tr>
<th>Project Concept</th>
<th>Net Off-site Loss (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avon-Swinomish By-pass</td>
<td>336.4</td>
</tr>
<tr>
<td>NF Levee Setback A</td>
<td>132.5</td>
</tr>
<tr>
<td>NF Levee Setback B</td>
<td>68.3</td>
</tr>
</tbody>
</table>

Q2 Flow (62,000 cfs)/Low Spring Tide (-3.3 ft)
Fish Objective: Increase Area of Tidal and Riverine Channels Suitable To Chinook Rearing Fry

Indicator: Total number of acre-hour suitable habitat predicted

Method:

\[ \sum_{elevation x} \left( \text{hours inundated} \left( x \text{ to } x + 6 \text{ft} \right) \right) \times \text{areax} \]

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Hrs water depths suitable for smolts</th>
<th>Acres at elevation</th>
<th>Acre*hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3</td>
<td>0</td>
<td>4.8</td>
<td>0</td>
</tr>
<tr>
<td>-2</td>
<td>728</td>
<td>7.8</td>
<td>5,666</td>
</tr>
<tr>
<td>-1</td>
<td>996</td>
<td>8.7</td>
<td>8,655</td>
</tr>
<tr>
<td>0</td>
<td>1,351</td>
<td>14.7</td>
<td>19,915</td>
</tr>
<tr>
<td>1</td>
<td>1,680</td>
<td>48.4</td>
<td>81,422</td>
</tr>
<tr>
<td>2</td>
<td>1,936</td>
<td>87.0</td>
<td>168,438</td>
</tr>
<tr>
<td>3</td>
<td>1,977</td>
<td>92.8</td>
<td>183,426</td>
</tr>
<tr>
<td>4</td>
<td>1,248</td>
<td>190.5</td>
<td>237,851</td>
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<tr>
<td>5</td>
<td>980</td>
<td>306.4</td>
<td>300,383</td>
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<tr>
<td>6</td>
<td>625</td>
<td>167.9</td>
<td>105,018</td>
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<tr>
<td>7</td>
<td>296</td>
<td>37.1</td>
<td>10,982</td>
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<tr>
<td>8</td>
<td>40</td>
<td>18.0</td>
<td>727</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>15.9</td>
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<tr>
<td>10</td>
<td>0</td>
<td>15.5</td>
<td>0</td>
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<tr>
<td>11</td>
<td>0</td>
<td>13.7</td>
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<tr>
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<td>0</td>
<td>8.1</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>0</td>
<td>4.3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Total acre*hours</td>
<td></td>
<td>1,122,486</td>
</tr>
</tbody>
</table>

Total acre*hours: 1,122,486
SHDM Logic Framework

Scores for each indicator were normalized and weighted

- **Farm**
  - **IMPACT - 40 PTS**
    - Minimize farmland loss
    - Avoid preserved farmland
  - **BENEFIT - 60 PTS**
    - Maximize fish/acre farmland
    - Support regulatory agreements
    - Prioritize public lands

- **Fish**
  - **IMPACT - 15 PTS**
    - Minimize loss of existing habitat
  - **BENEFIT - 85 PTS**
    - Restore tidal and riverine processes
    - Increase suitable channel habitat
    - Increase number of smolts
    - Increase connectivity
    - Restore diverse habitat types

- **Flood**
  - **IMPACT - 25 PTS**
    - Minimize new levees systems where none existed
  - **BENEFIT - 75 PTS**
    - Reduce flood water elevations
    - Reduce risk of levee failure
    - Improve drainage

**Total Score**
- **TOTAL IMPACT SCORE - 80 PTS**
- **TOTAL BENEFIT SCORE - 220 PTS**
SHDM Multiple Interest Score

- Total Benefit and Impact Scores for each project concept were plotted

- The plotted scores were then used to identify distinct groups of project concepts
Current 3Fl Partners
Dike District #17/Dike District Partnership
NOAA Restoration Center
Skagitonians to Preserve Farmland

HDM Working Group
Dike District #3
Dike District #17/Dike District Partnership
Dike & Drainage District #22
NOAA Restoration Center
Seattle City Light
Skagit Conservation District
Skagitonians to Preserve Farmland

Technical Analyses
Pacific Northwest National Laboratory
Skagit River System Cooperative
The Nature Conservancy
US Geological Survey

Funding Organizations
EPA/National Estuary Program
NOAA Restoration Center
Private Donors
SRFB/RCO/Skagit Watershed Council

WA Dept. of Agriculture
WA Dept. of Fish and Wildlife
Western WA Agricultural Association
Skagit Watershed Council
The Nature Conservancy
Upper Skagit Tribe
US Geological Survey
WA Dept. of Fish and Wildlife
Western WA Agricultural Association