Improving the Evaluation and Design Process For Fish Passage Restoration Projects Through Application of Two-Dimensional Numerical Models

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Fish passage improvement projects are a critical component in meeting the larger goals of river restoration.
Design teams are required to demonstrate the functionality of their proposed restoration project.
1D Model Representation:
HEC RAS Modeling Software

Redwood Creek Proposed Plan: Plan 12 7/21/2011
Flow: Redwood Creek Main Channel

Legend
EG 9% 2-year
WS 9% 2-year
Crit 9% 2-year
Ground

Station (ft)
Elevation (ft)
2D Model Representation:
MIKE 21 Modeling Software

(DHI, 2008)
Most restoration design goals are to increase channel complexity

(BAI, 2011)
A 2D model can serve as both a design check AND as an iterative design development tool
Porter Creek at Calistoga Road
2D Model Development

Model inputs
- Topography (1ft Gridscale)
- Roughness
- Boundary Conditions
- Design Flows
## Design Criteria

### Fish Passage Design Flows

<table>
<thead>
<tr>
<th>Life Stage</th>
<th>Low Flow</th>
<th>High Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juvenile</td>
<td>1 cfs</td>
<td>27 cfs</td>
</tr>
<tr>
<td>Adult</td>
<td>3 cfs</td>
<td>171 cfs</td>
</tr>
</tbody>
</table>

### Fish Passage Criteria

<table>
<thead>
<tr>
<th>Life Stage</th>
<th>Low Flow (depth)</th>
<th>High Flow (velocity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juvenile</td>
<td>0.5 ft</td>
<td>1 fps</td>
</tr>
<tr>
<td>Adult</td>
<td>1.0 ft</td>
<td>4 fps in Culvert</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 fps outside Culvert</td>
</tr>
</tbody>
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2D Model development: An iterative design approach

Initial Ramp
thalweg follows low flow notches

Revised Ramp
thalweg follows sinuous low flow channel

Increasing the effective low flow channel length and reducing the effective slope
2D model was able to demonstrate functionality

Results are displayed as an intuitive map
Depth comparison:
Adult low flow 3 CFS

Note Vertical Exaggeration

Culvert Outlet

Resting Pool
Preferential swim path to overcome velocity
Adult high design flow 171 cfs
Velocity comparison: profiles and cross sections
Adult high flow 171 CFS

[Graph showing velocity comparison between 1D and 2D models with distance along preferred swim path (feet) on the x-axis and velocity (FPS) on the y-axis.]

[Graph showing elevation and velocity profiles with distance (feet) on the x-axis and elevation (feet) and velocity (FPS) on the y-axis.]
## Conclusions

<table>
<thead>
<tr>
<th></th>
<th><strong>1D</strong></th>
<th><strong>2D</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Familiarity</strong></td>
<td>Widespread</td>
<td>Still building</td>
</tr>
<tr>
<td><strong>Time/Cost</strong></td>
<td>Requires More Conceptualization and Interpretation of Results</td>
<td>Requires More Data Collection and Troubleshooting</td>
</tr>
<tr>
<td><strong>Accuracy and Utility</strong></td>
<td>Lacks Details General Design Check Greater Uncertainty = Potential Missed Opportunities or Overdesign</td>
<td>Very Detailed Iterative Design Tool Less Uncertainty = Greater Chance for Success and Potential Cost Savings</td>
</tr>
</tbody>
</table>
Thank you