Using Ecosystem Models to Predict Habitat Changes for Multi-Species Restoration

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Summary

Predicting the outcomes of habitat restoration actions in the lower Columbia River and estuary has largely been based on qualitative or quantitative models which tend to be limited spatially and temporally. Current restoration site planning and design efforts have largely relied on the experience of the practitioner, generalized peer reviewed metrics to anticipate post-restoration conditions, and models focused on determining hydraulic conditions. In the lower Columbia River and estuary, these approaches have been utilized for single species restoration at project sites. To assess how restoration actions could effect multiple species and physical conditions at a proposed restoration site, the Estuary Partnership used the Hydrologic Engineering Center Ecosystem Functions Model (HEC-EFM, USACE). We coupled a hydrodynamic model with vegetation and hydrology data from reference sites, fish suitability, and wildlife habitat suitability data to the ecological model to answer questions about the timing and frequency of inundation through different seasons using three different restoration scenarios. The ecological model was able to quantify and predict available acres for ESA listed salmonids, dabbling ducks, Columbia River white tailed deer and native vegetation under restored conditions. Based on modeled results, the spatial and temporal changes to habitat were mapped at the project site to inform design and feasibility questions.

Introduction

Off-channel and wetlands habitats in the lower Columbia River have been negatively impacted over the last 100 years. The 800-acre Shillapoo Wildlife Area South Unit/Buckmire Slough Restoration (Figure 1) represents an important opportunity to reconnect the Columbia River to wetlands and off-channel areas. The objective of the ecological modeling is to quantify potential benefits to Endangered Species Act (ESA) listed salmonids, waterfowl and other important species. This assessment will allow managers to evaluate restoration actions in light of current management objectives, which includes overwintering and nesting opportunities for dabbling ducks and controlling invasive plants. We used the ecological model to evaluate three restoration alternatives (Table 1), which included mainstem Columbia River levee breaches and other connections to the river, removal and relocation of water control structures, creation of beaver analogue structures and grading.

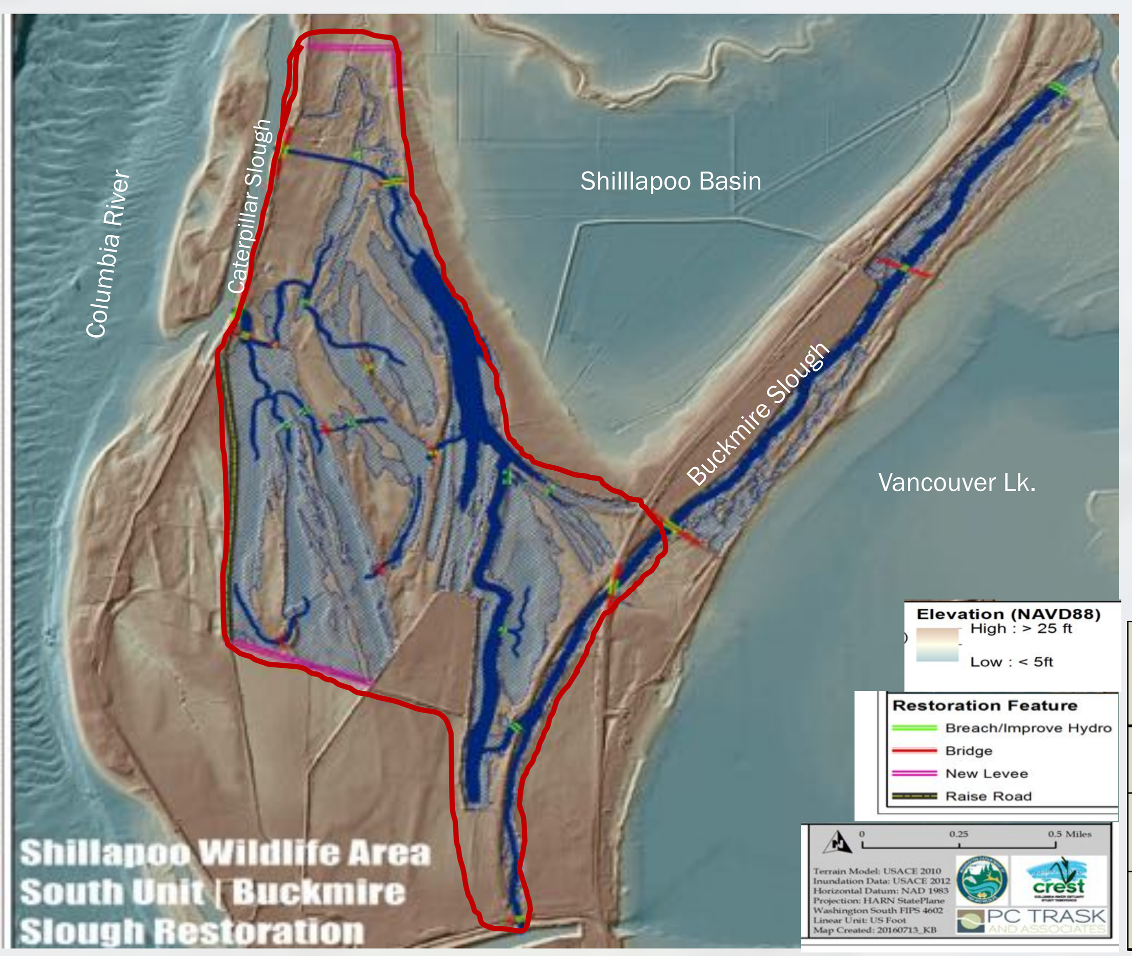

Figure 1. Site Map. The red border line show the 800 acre project extent. The sough to the east represents an additional restoration site that would be connected.

The ecological model allowed us to quantify changes to habitat and vegetation over time and space under different restoration alternatives. We modeled the winter season (December-January) and spring-summer (February - June) to answer questions about available juvenile salmonid rearing habitat. We modeled overwintering (December-January) and nesting season (February - April) to determine dabbling duck habitat. We modeled (February - July) to look at potential native vegetation communities during the growing season. We modeled these three periods for all three restoration alternatives.

Table 1. Restoration Alternatives and restoration actions.

Restoration Scenario	Levee breach (number/location)	Remove internal water control structures	Channel excavation (y/n)	Beaver analouge structures (y/n) & potential effected acres	Scrape down (y/n) & acres	Hydrualic model time period/season
Alternative 1	2 breaches (Caterpillar Slough)	y	y	n	n	February -July 2009
Alternative 2	4 breaches (3 on Caterpillar Slough & 1 to the flushing channel/Vancouver Lk.)	y	y	n	n	February -July 2009
Alternative 3	3 breaches (2 on Caterpillar Slough & 1 to the flushing channel/Vancouver Lk.)	y	y	y (30-40 acres)	y (5 acres)	December 2008 -July 2009

Results

Figures 7-9 below show the results from restoration Alternative 2 using 0.1-7 ft. depth criteria. There were three restoration alternatives that were modeled to asses potential habitat benefits to salmonids, waterfowl and for native plant establishment.

Figure 7. Shows extent, percent time inundated and acres inundated for waterfowl (dabbling ducks) during nesting season (February-April).
Figure 8. Shows extent, percent time inundated and acres inundated for salmonids during juvenile rearing (February-June).
Figure 9. Shows extent, percent time inundated and acres inundated for native vegetation establishment.

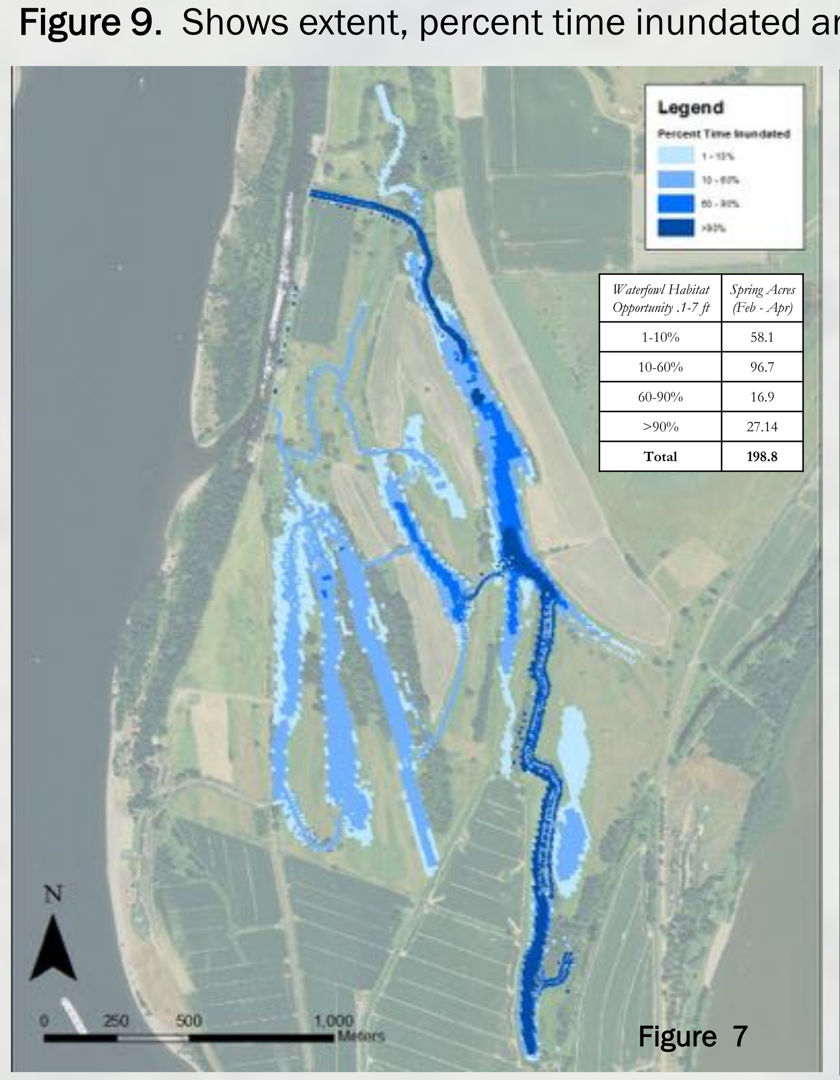

Figure 7

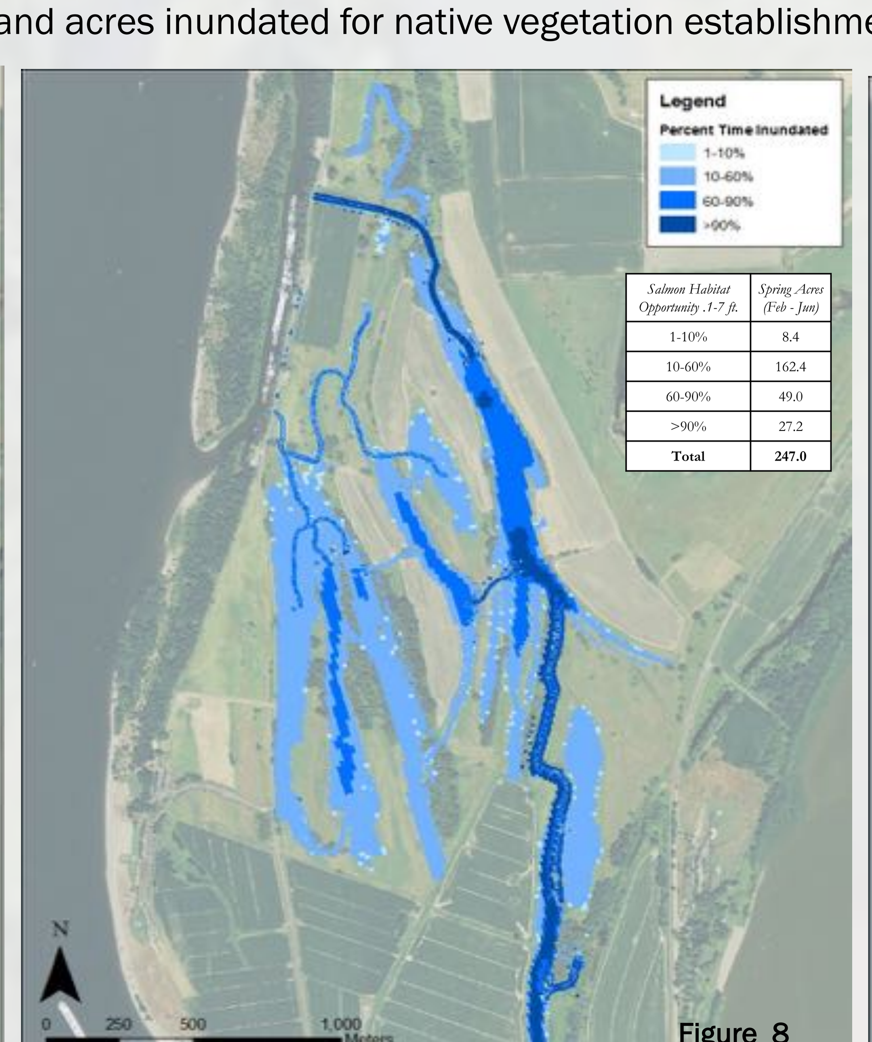

Figure 8

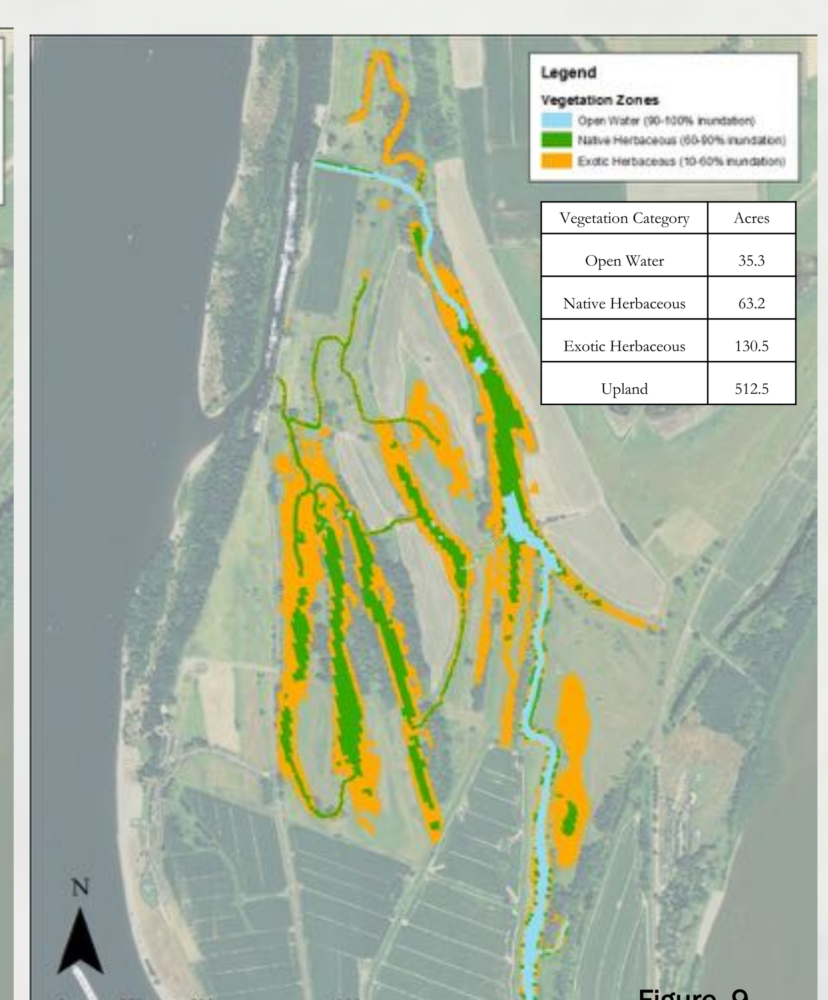

Figure 9

Methods

1. Develop Ecological Zone Concept. We developed a zonal approach that identifies unique physical and biological characteristics within the project site including plant communities and terrestrial and aquatic species of interests. The zonal approach allowed us to group species into five zones including : 1) open water/mud flat; 2) emergent; 3) riparian; 4) shrub-scrub and 5) upland.

2. Analyze Reference Site Data. We evaluated continuous surface water stage data and plant survey data from 2009-2014 during the growing season (Feb.-July) using two reference sites. The plant surveys used transects established along an elevation gradient from the low point in the wetlands into riparian and upland areas. Individual plant species were identified and keyed along with a corresponding elevation using an RTK. Based on frequency of occurrence the top 10 plants were selected and assigned a minimum, average and maximum elevation for each year (Table 2). The plants for each zone were averaged across all years. Average daily water surface elevations were also evaluated using the Hydrologic Engineering Center HEC-DSS and HEC-EFM software. Based on this approach 2009, 2010 & 2013 were identified as average water years (Figure 2).

3. Synthesize and Pair Reference Site Data with Ecological Zones. The result was that the ecological zones were expressed as a function of percent time inundated/inundation frequency. We developed synthesized curves for three average water years, including 2009, 2010 and 2013 (Figure 3). We evaluated the ecological zones within these years and established four categories of daily inundation: 1-10%, 10-60%, 60-90%, >90%. This approach was the foundation for interpreting ecological modeling results including quantifying vegetation, waterfowl and salmon habitat as well as other species of concern within each ecological zone (Figure 4).

4. Hydraulic Modeling. The Hydrologic Engineering Center's HEC-RAS (2D model was used) to power the ecological model HEC-EFM. We utilized water depth results across the project site which was represented by 24,000 cells. Modeling occurred from Dec.-July 2009 to inform ecological modeling. Figure 5 shows an example of a portion of the model and the combined 1D and 2D (black area & inset) approach utilized.

5. Ecological Modeling. We utilized HEC-EFM to answer spatial and temporal questions related to habitat and to predict vegetation communities. Model inputs included: HEC-RAS hydraulic results, habitat requirements for waterfowl and salmonids, and duration, seasonal, time series and statistical criteria (Figure 6). Habitat requirements included water depths for juvenile salmonids and dabbling ducks; two depth ranges were chosen, including preferred depths (.1- 3ft.) and habitat opportunity depths (.1-7 ft.) Model outputs represented the percentage of time a portion of the site (cell) is inundated within a given time period. The data has unique spatial identifiers, which are associated with specific georeferenced cells within the hydraulic model. The information was also exported to ARC-GIS in order to further evaluate results and to produce maps. Relationships developed within the ecological zonal approach were used to designate four categories of inundation: 1-10%, 10-60%, 60-90% and >90%. The acreage of each inundation category was summed to determine differences in area of inundation (expressed as acres) for each restoration alternative (Figures7-9).

Table 2. Reference Site Vegetation Characterization by Zone (elevations in NAVD 88).

	Season/Zone		Open Water to Emergent Elevations			Emergent to Shrub Scrub Elevations			Shrub Scrub to Riparian Elevations			Riparian to Upland Elevations		
Year	Start	End	Min (ft.)	Av. (ft.)	Max (ft.)	Min (ft.)	Av. (ft.)	Max (ft.)	Min (ft.)	Av. (ft.)	Max (ft.)	Min (ft.)	Av. (ft.)	Max (ft.)
2009	Feb	July	2.6	2.8	3.0	2.9	3.2	3.5	3.6	3.9	4.1	no data	no data	no data
2010	Feb	July	2.5	2.7	2.9	2.8	3.0	3.4	3.8	3.9	4.0	no data	no data	no data
2011	Feb	July	2.5	2.7	3.1	2.7	2.9	3.1	3.4	3.4	3.4	no data	no data	no data
2012	Feb	July	2.6	2.7	3.0	2.8	3.1	3.5	3.6	3.6	3.6	no data	no data	no data
2013	Feb	July	2.5	2.7	2.9	3.1	3.2	3.3	3.6	3.8	4.0	4.0	4.0	4.0
2014	Feb	July	2.5	3.2	4.6	3.1	4.0	4.5	4.5	4.8	5.0	no data	no data	no data

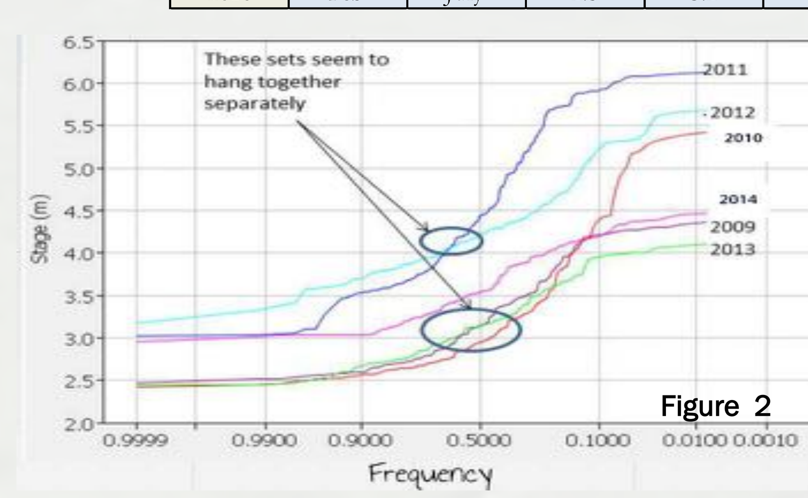

Figure 2

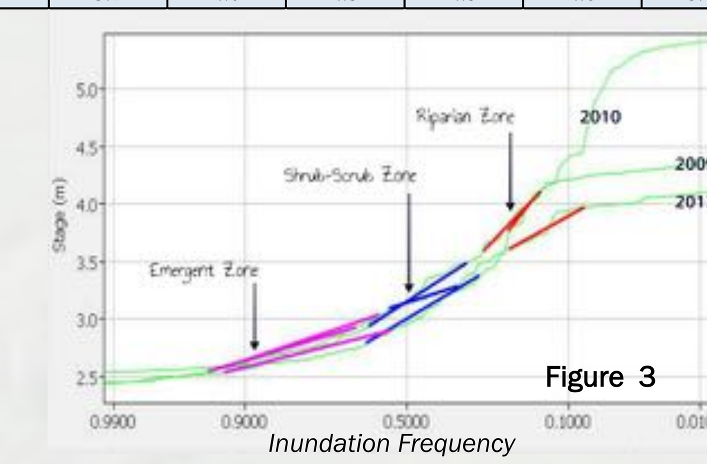

Figure 3

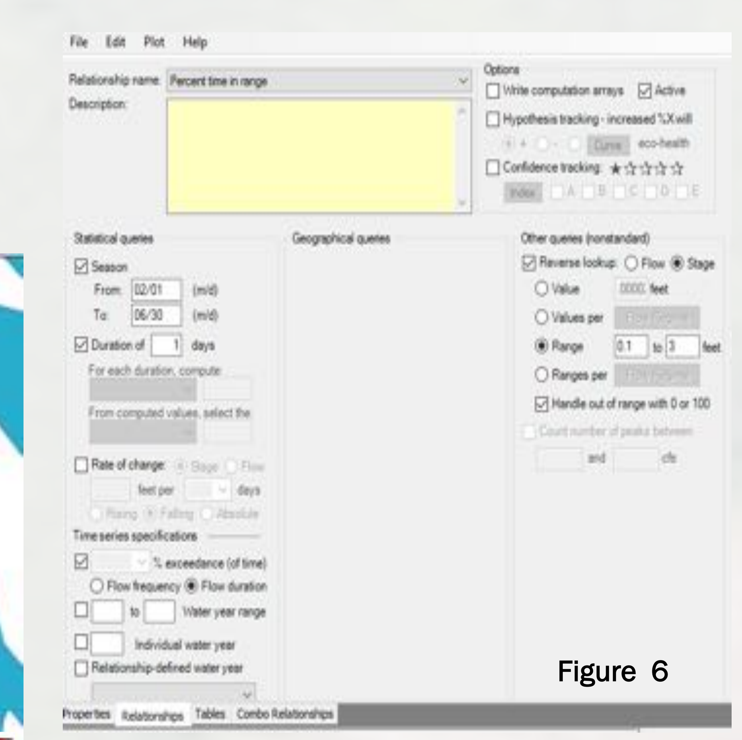

Figure 6

Figure 4

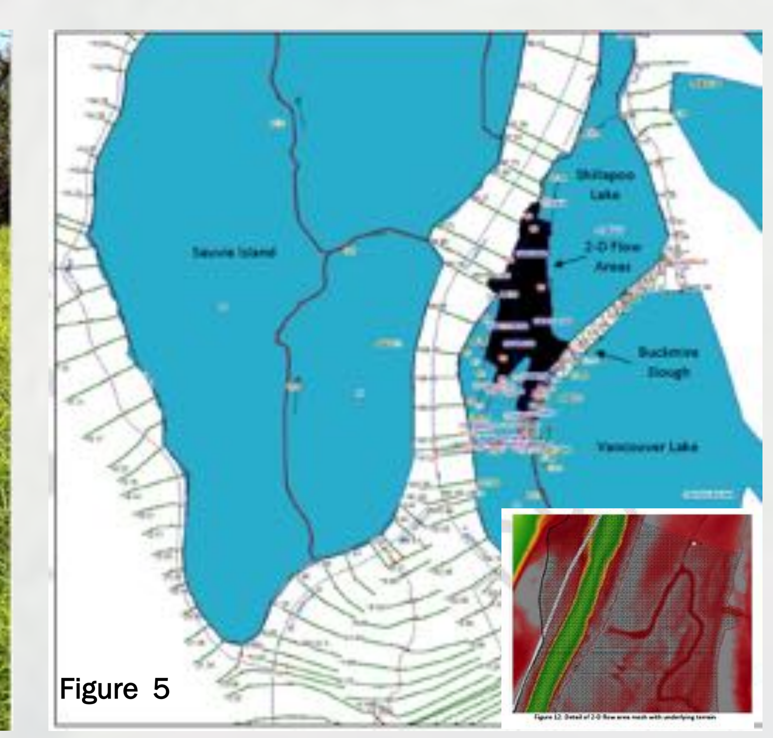

Figure 5

Conclusions

- Ecological modeling was used to assist managers and the technical team in selecting the preferred restoration alternative.
- Ecological modeling allowed us to quantify habitat benefits and to predict spatial extent of habitat, including juvenile salmonid rearing habitat and overwintering /nesting habitat for waterfowl during different seasons
- Coupling a hydraulic model with an ecological model allowed us to evaluate physical and ecological conditions in tandem.