# Incorporating Climate Change into Stream Simulation Culvert Design

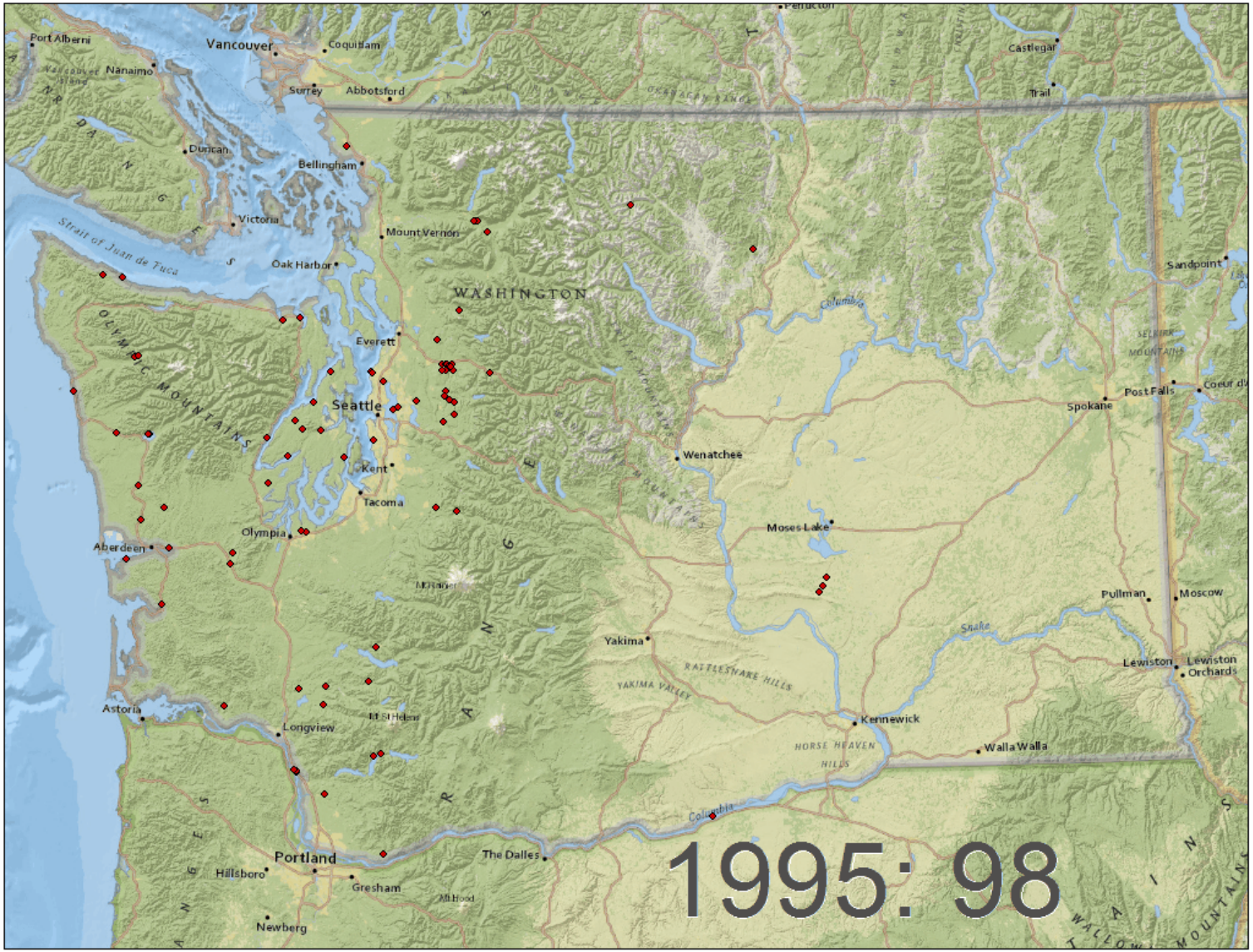
Jane Atha, WA Dept. of Fish and Wildlife

# Historical Perspective: 1943

<u>Title 35, §5734-1, Construction of hydraulic projects</u>

"[projects] . . . shall secure the written approval of the [Departments] as to the adequacy of the means outlined for the protection of fish life . . ."

# Identified Fish Passage Barrier Culverts



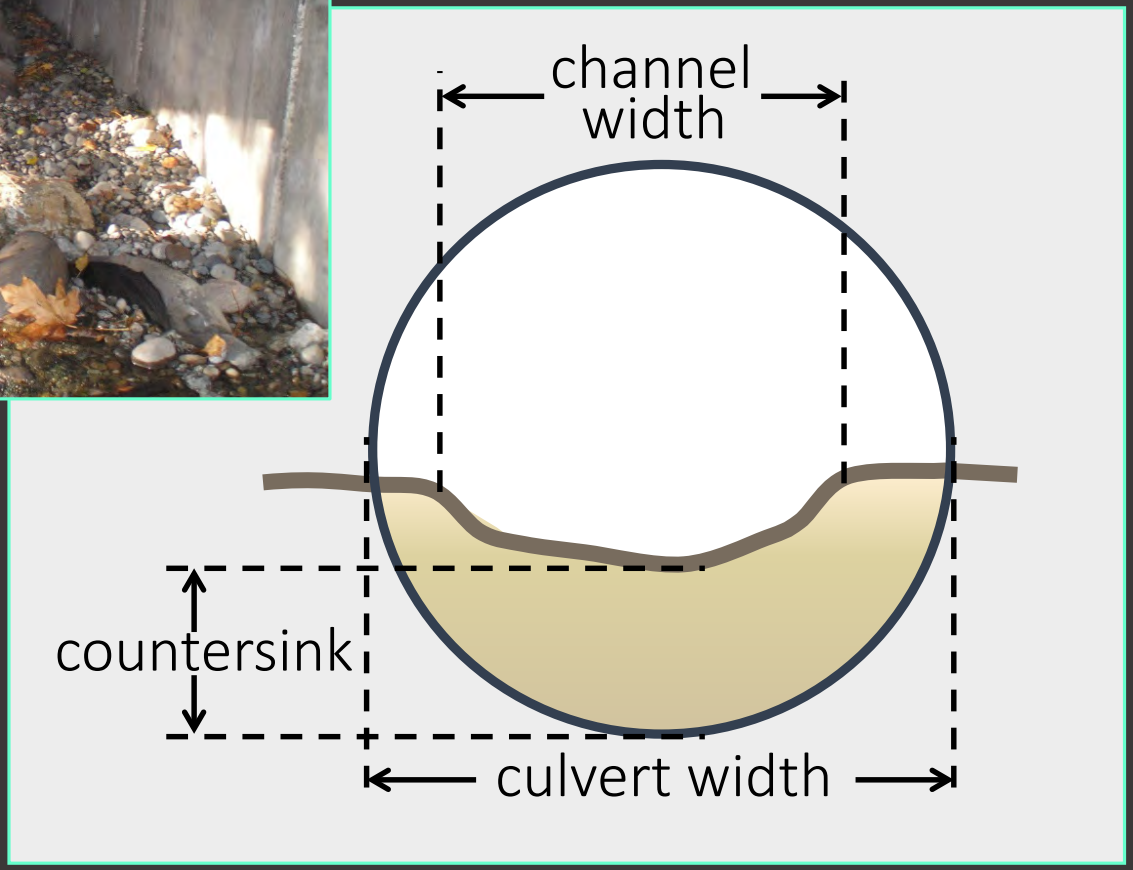
# Evolution in Culvert Design

Stream Simulation culvert

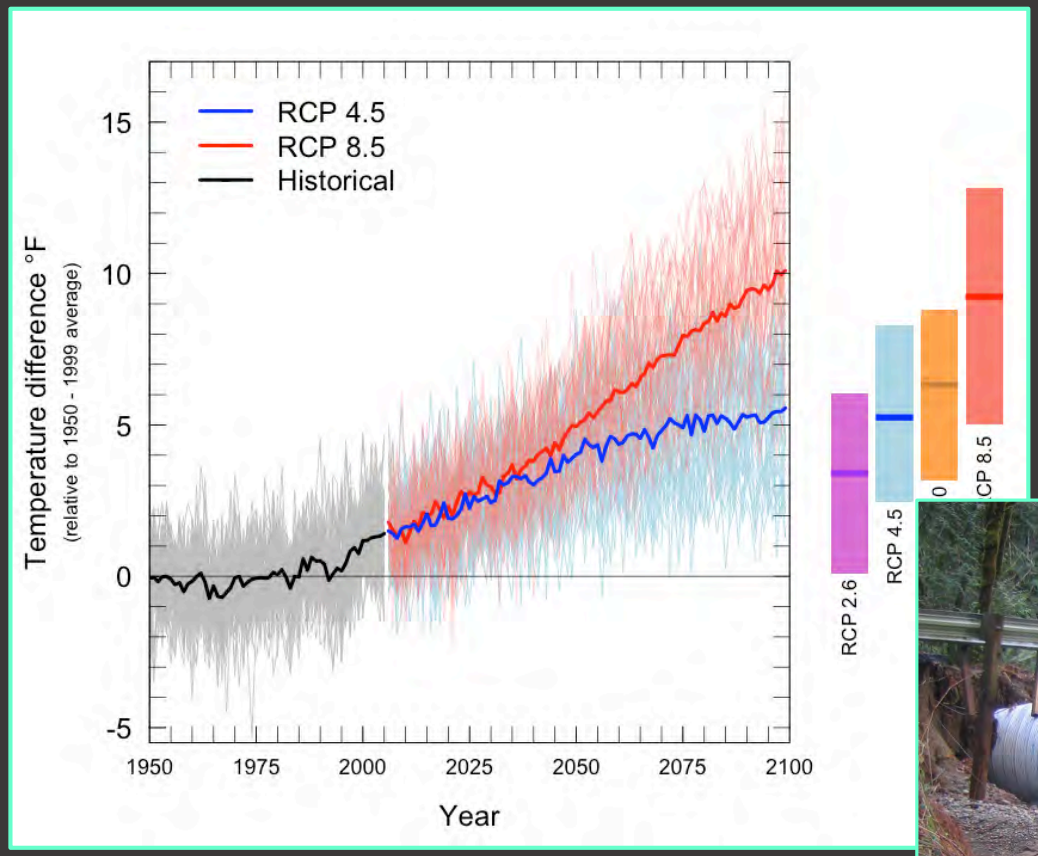
- Passes flood flows and debris
- Allows passage of nearly all fish and aquatic organisms
- Allows many stream processes (including banks)

# Stream Simulation Culvert Design

Photo courtesy of Corey Morss



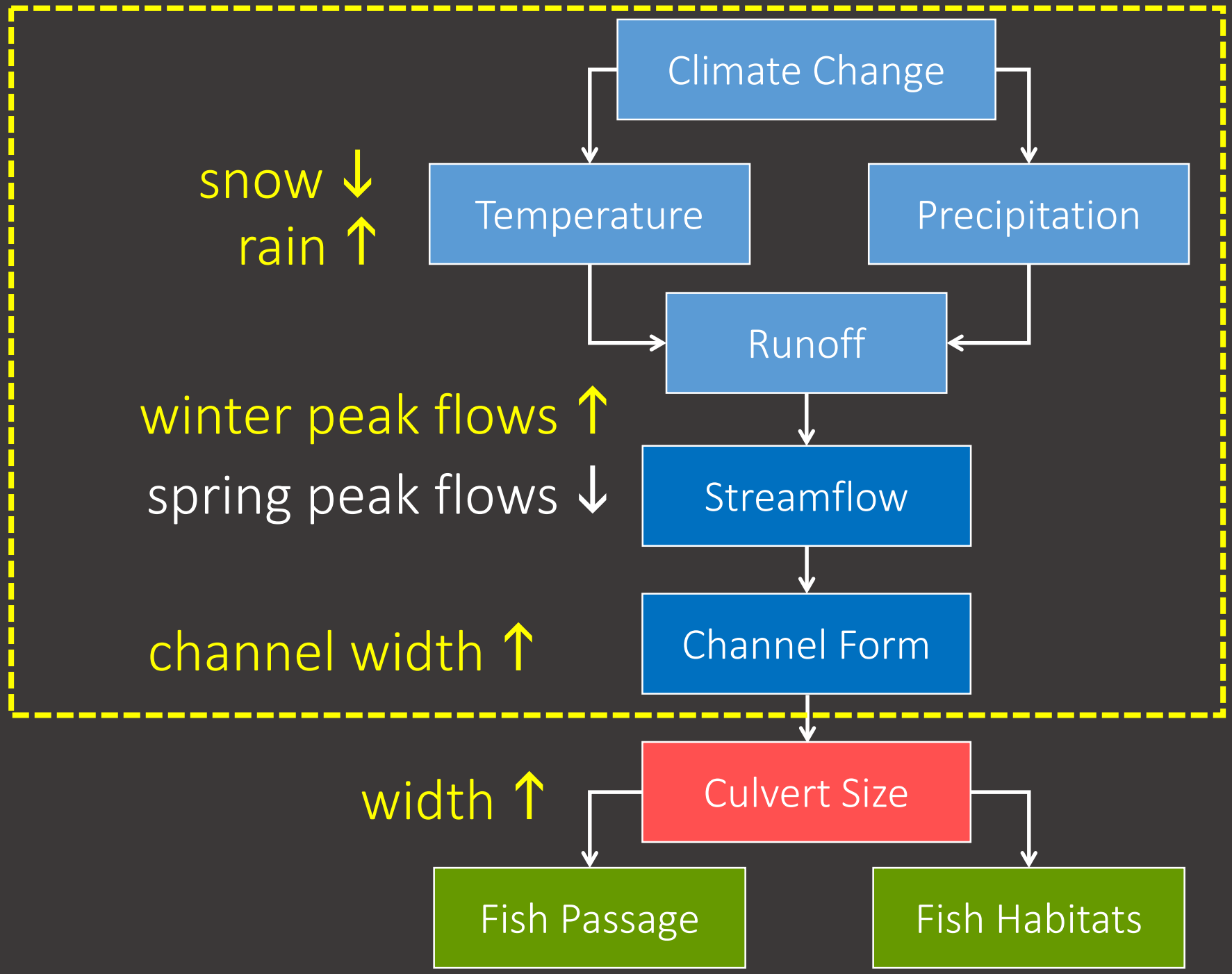
# Considering Future Conditions




Data source: Abatzoglou et al. 2013

# Three parts:

1. Estimating construction costs
2. Internet-based, interactive map for aid in climate-adapted culvert structure design
3. Modeling culvert performance under projected peak stream flows


Climate Change
snow ↓
rain ↑
Temperature
Precipitation
Runoff
winter peak flows ↑
spring peak flows ↓
Streamflow
channel width ↑
Channel Form
width ↑
Culvert Size
Fish Passage
Fish Habitats

# Modelling Process

UW

Global Climate Models
future projections: temp. and precip.

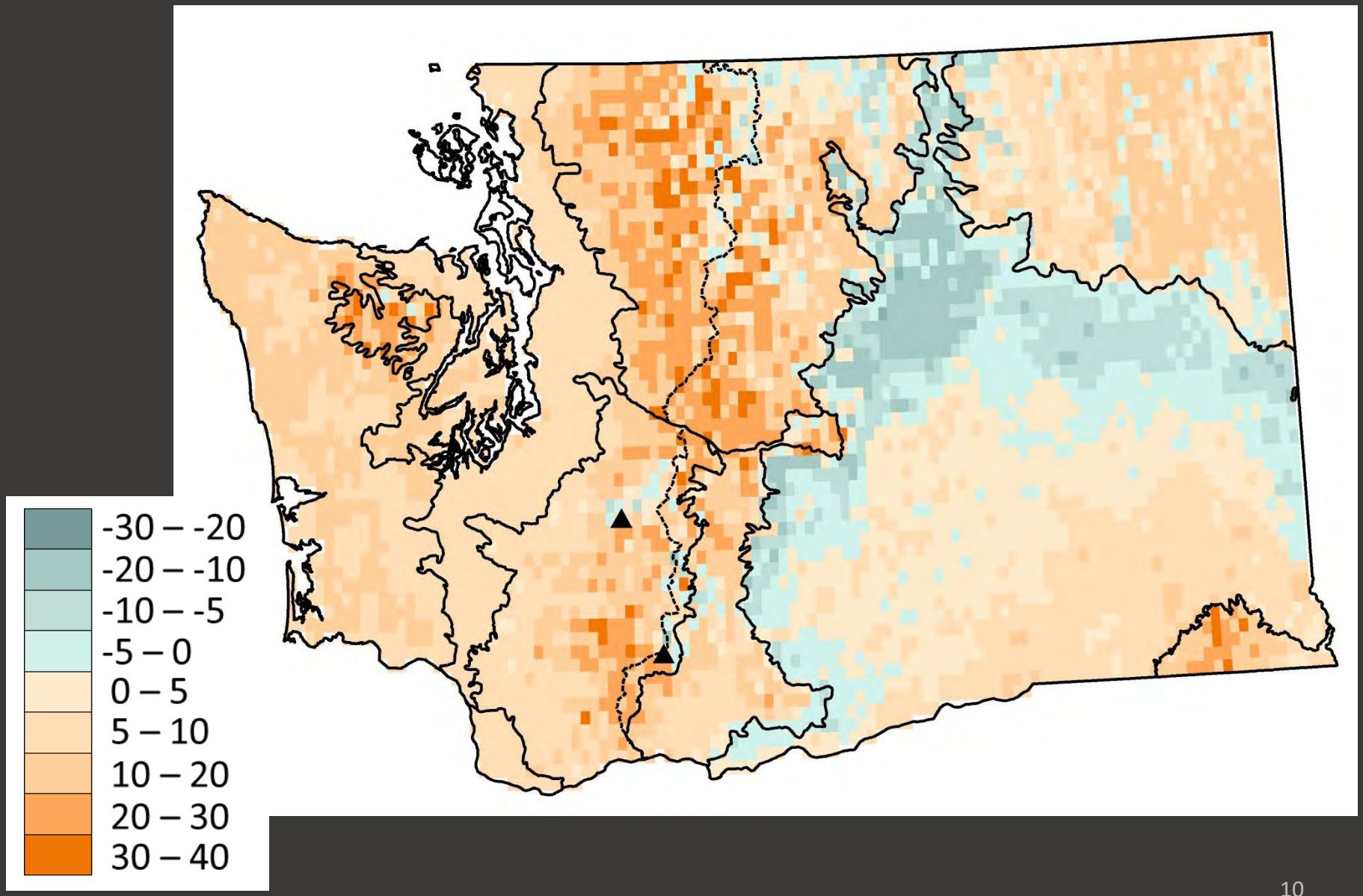
Hydrologic model projects runoff

WDFW

Estimate bankfull flow

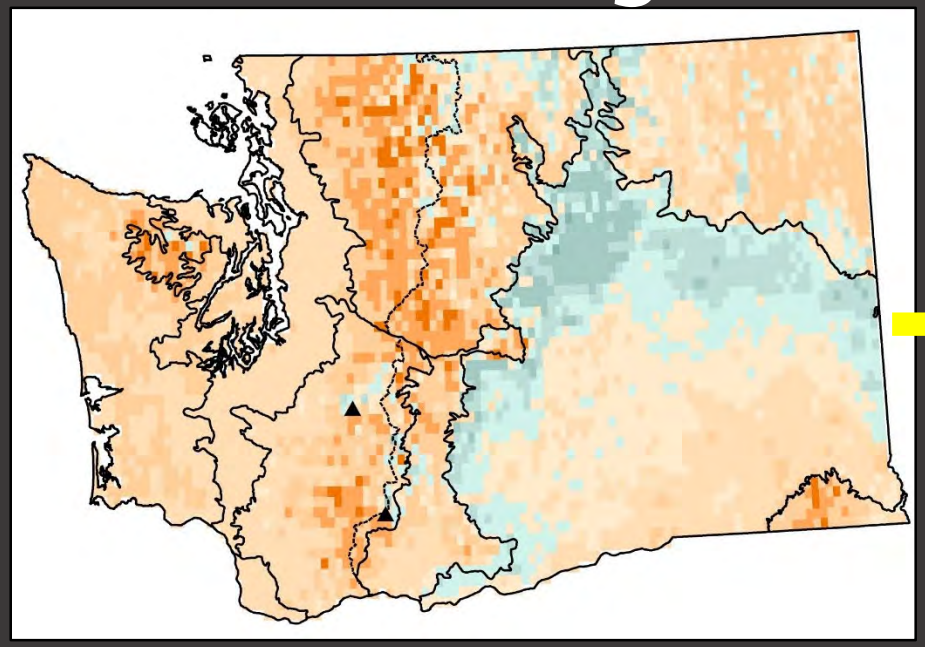
Predict bankfull width

# Mean % Change BFW in 2080s

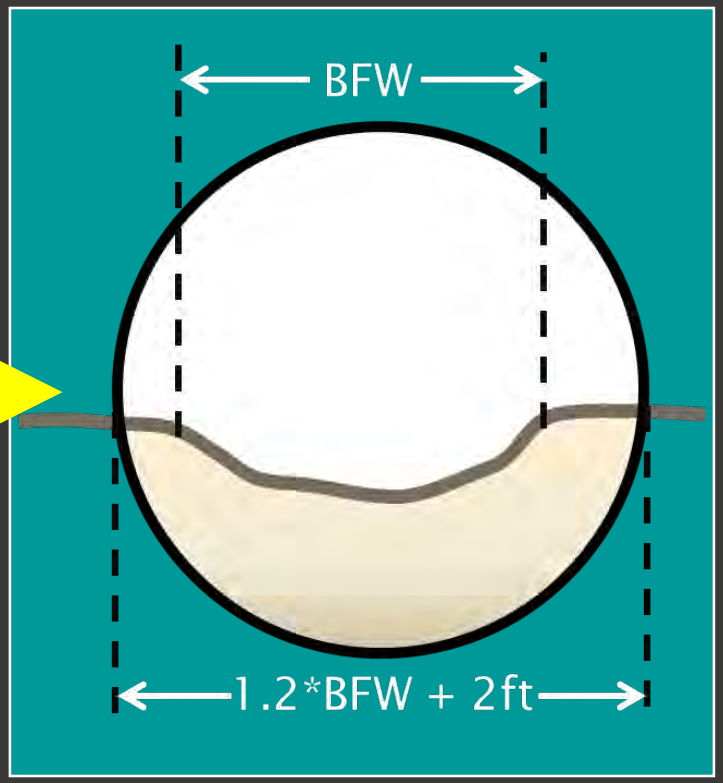


# Info for Climate-Adapted Culverts

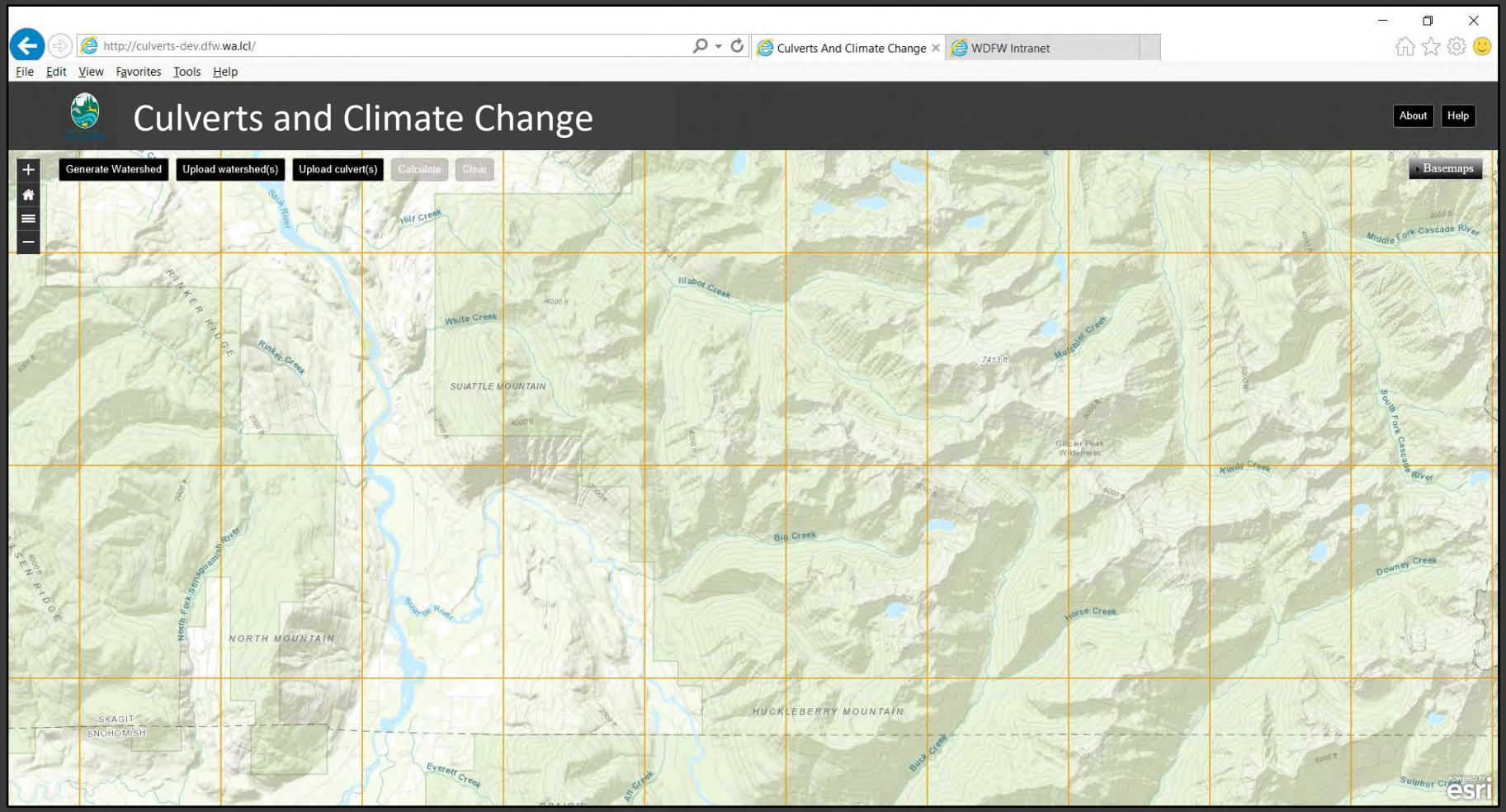
## Mean % Change BFW



?



# Habitat Program Internet Site




Projections of future % change in

BFW and 100-year flood discharge

# Internet Site Output

project location

drainage area

bankfull flow

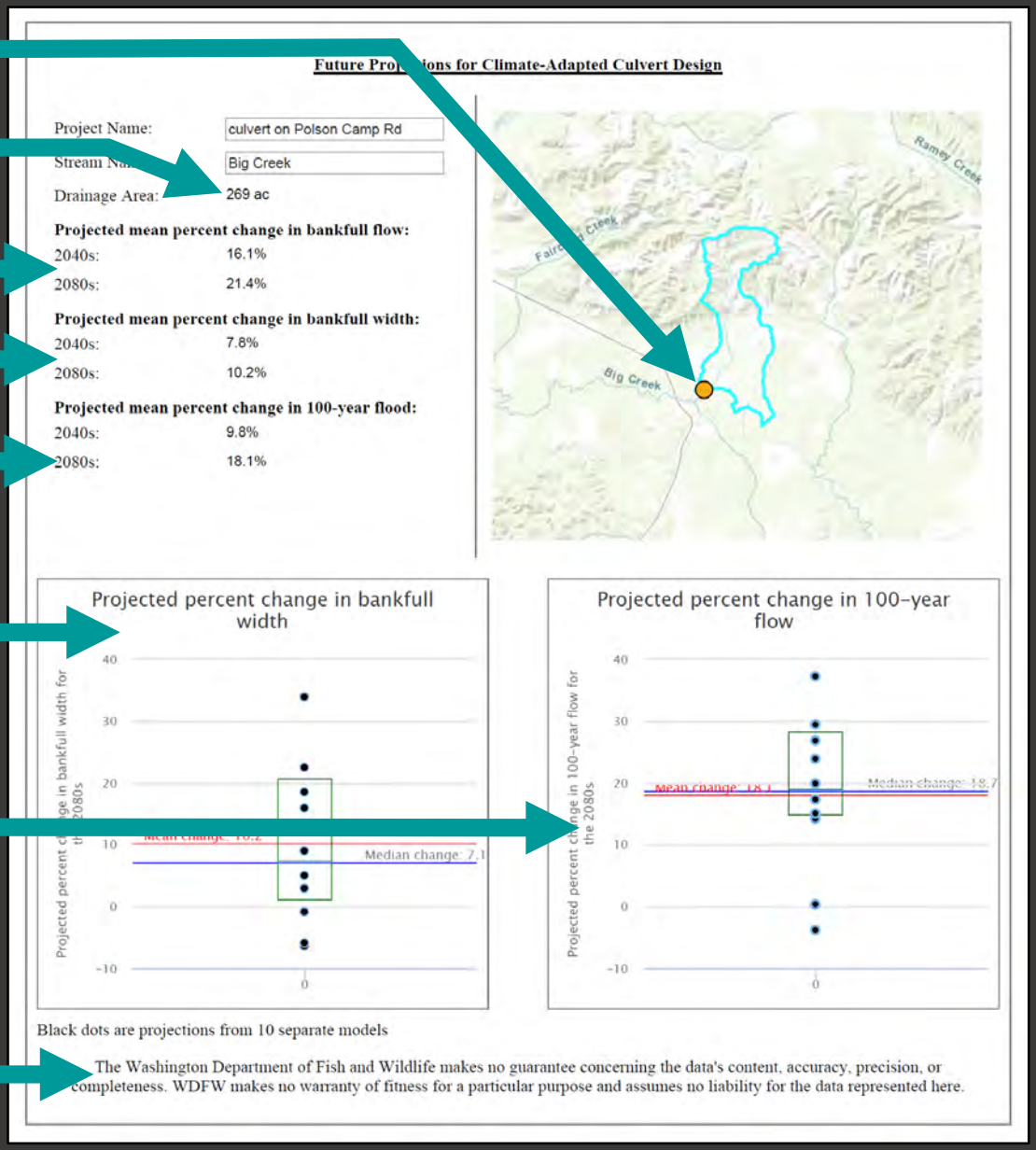
bankfull width

100-year flood

bankfull width

100-year flood

disclaimer



**Future Projections for Climate-Adapted Culvert Design**

Project Name: culvert on Polson Camp Rd

Stream Name: Big Creek

Drainage Area: 269 ac

**Projected mean percent change in bankfull flow:**

2040s: 16.1%

2080s: 21.4%

**Projected mean percent change in bankfull width:**

2040s: 7.8%

2080s: 10.2%

**Projected mean percent change in 100-year flood:**

2040s: 9.8%

2080s: 18.1%



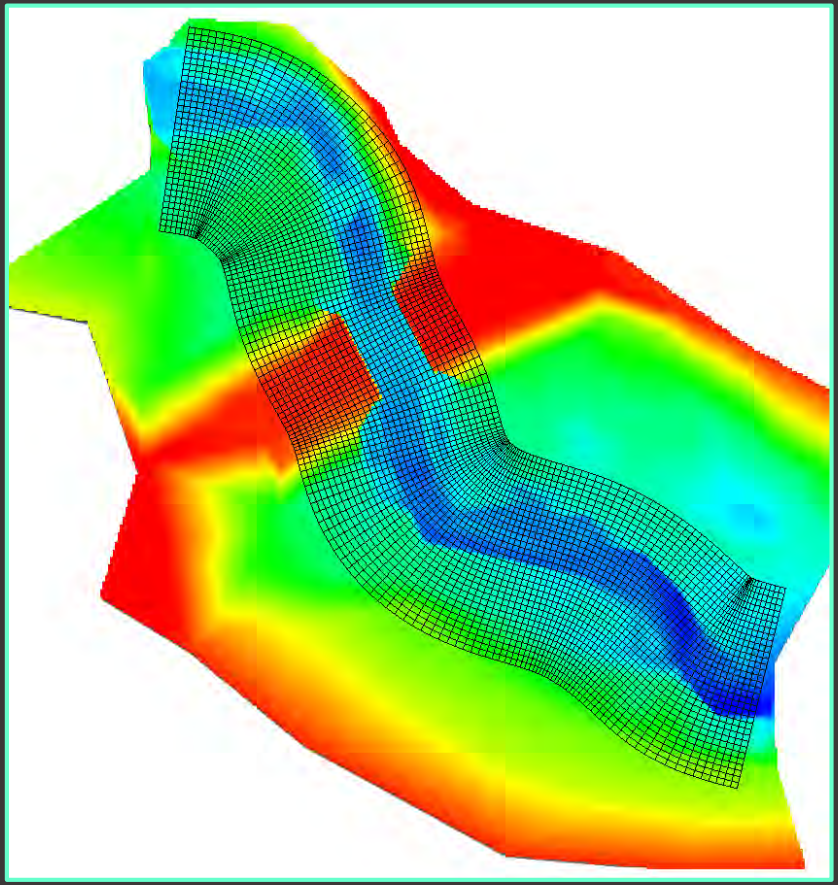
Black dots are projections from 10 separate models

The Washington Department of Fish and Wildlife makes no guarantee concerning the data's content, accuracy, precision, or completeness. WDFW makes no warranty of fitness for a particular purpose and assumes no liability for the data represented here.

# PART 2: 2-dimensional culvert modeling

# 2-Dimensional Culvert Modeling

- Culvert performance metrics
- Chehalis Basin study sites
- 2D hydrodynamic modeling
- 2D mobile bed modeling



# Case Studies

# Climate Change Projected Impacts

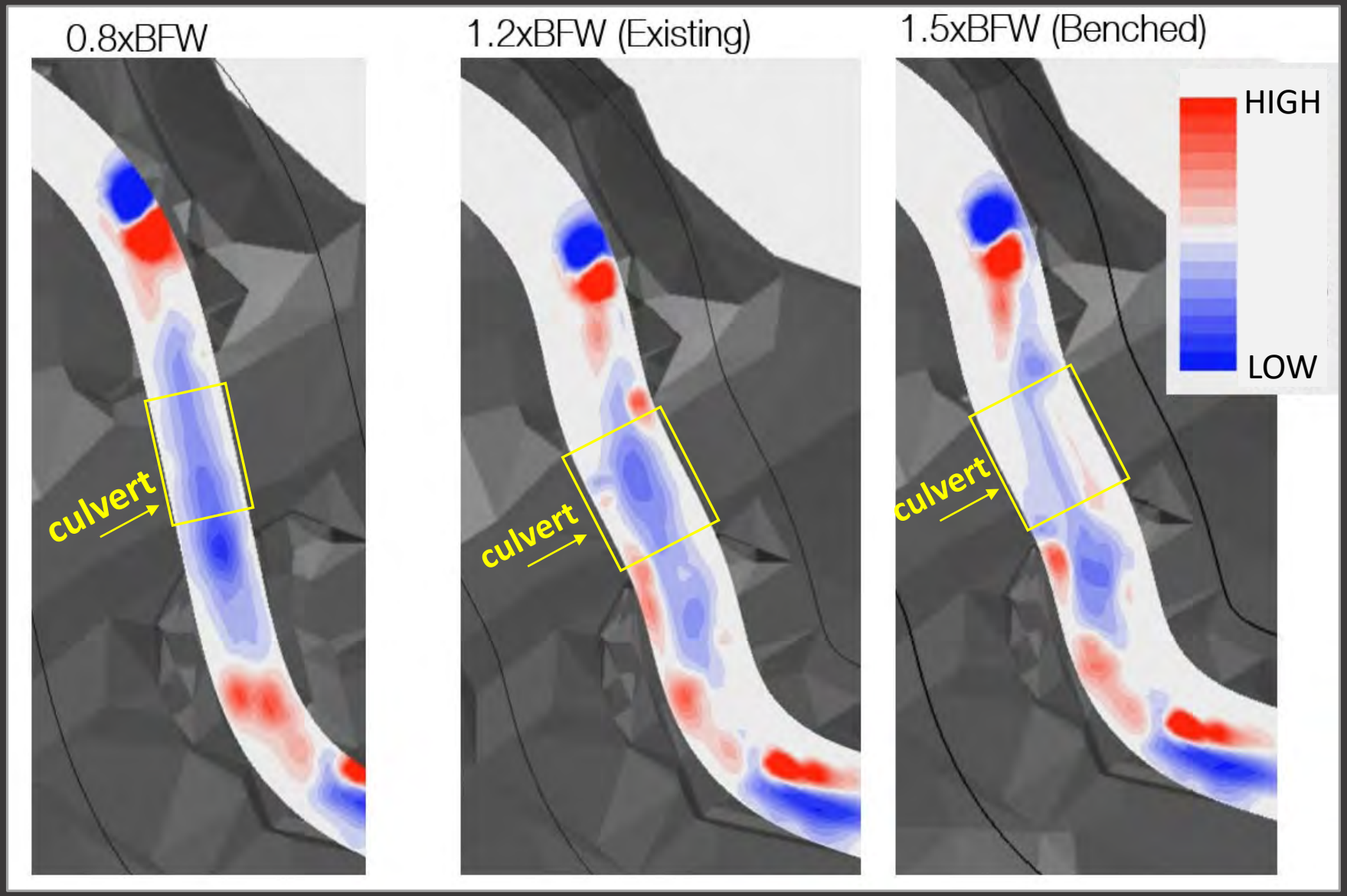
| Study Site name | 2080s % Change in Q bf | 2080s % Change in Q 100 |
|---|---|---|
| Big Creek | 21.4 | 18.1 |
| Comfort Creek | 19.8 | 25 |
| Boyer Road | 20.1 | 31.1 |
| Taylor Creek | 19.1 | 24 |
| Lost Creek | 17.1 | 36.8 |

University of Washington Climate Impacts Group estimates

# Geometries Used for Riverflow 2d

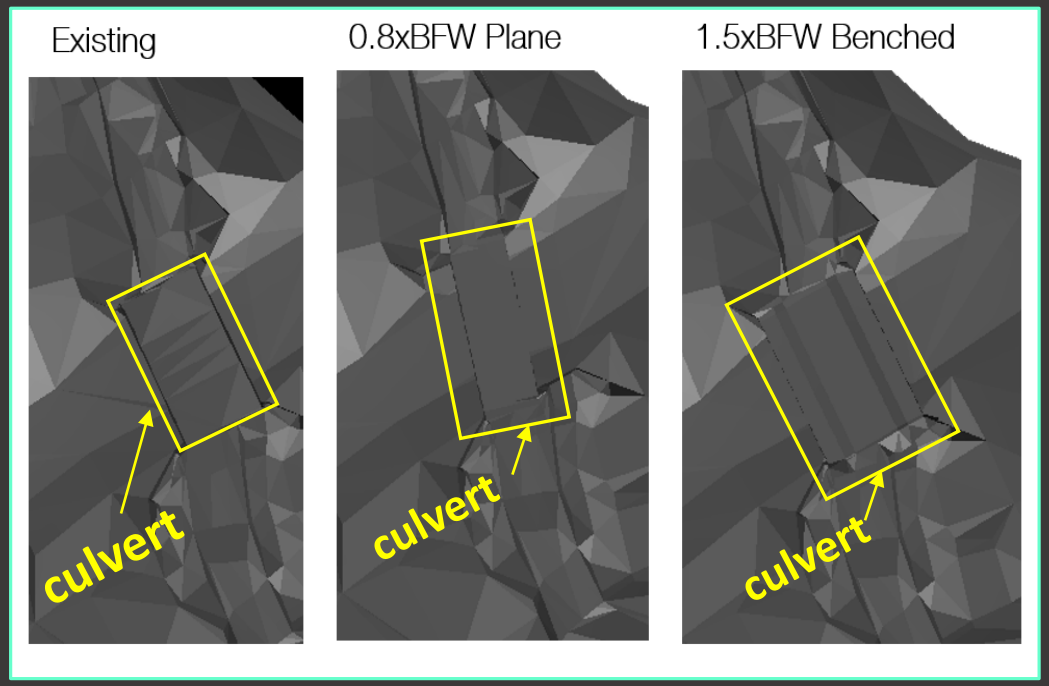
| | Scenario | | | | |
|---|---|---|---|---|---|
| Study Site name | 0.88 BFW with Plane Bed | Existing Conditions with Plane Bed | BFW with trapezoidal channel | 1.2BFW + 2 with benches | 1.5BFW with benches |
| Existing Hydrology | | | | | |
| Big Creek | | | | | |
| Comfort Creek | | | | | |
| Boyer Road | | | | | |
| Taylor Creek | | | | | |
| Lost Creek | | | | | |
| Future Hydrology | | | | | |
| Big Creek | | | | | |
| Comfort Creek | | | | | |
| Boyer Road | | | | | |
| Taylor Creek | | | | | |
| Lost Creek | | | | | |

# Initial Riverflow 2D Results




Graphic courtesy of Steve Winter, Natural Systems Design

# Initial Riverflow 2D Results




- Culvert width is critical:
  - Too narrow – bed shear excessive
  - Too wide – energy loss; bed shear insufficient
- Introduction of benches:
  - Improves continuity of flow and
  - Appears to improve sediment continuity

# Climate-Adapted Culverts Next Steps

1. Update climate change model input and land cover layers for web application.
2. Refine visualization and interface for web application.
3. Additional case studies and sediment studies for culvert modeling.
4. Refine recommendations for culvert design.
5. Quantify costs for constructing climate-adapted culverts.

Thank you!
for more information:
Jane.Atha@dfw.wa.gov