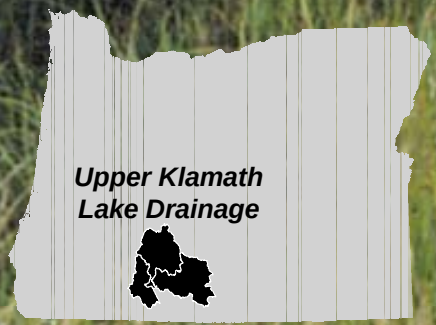
Temperature TMDL Analysis

Land Cover, Hydrology and Morphology

Presented by Matthew Boyd
Oregon DEQ

DEQ
State of Oregon Department of Environmental Quality



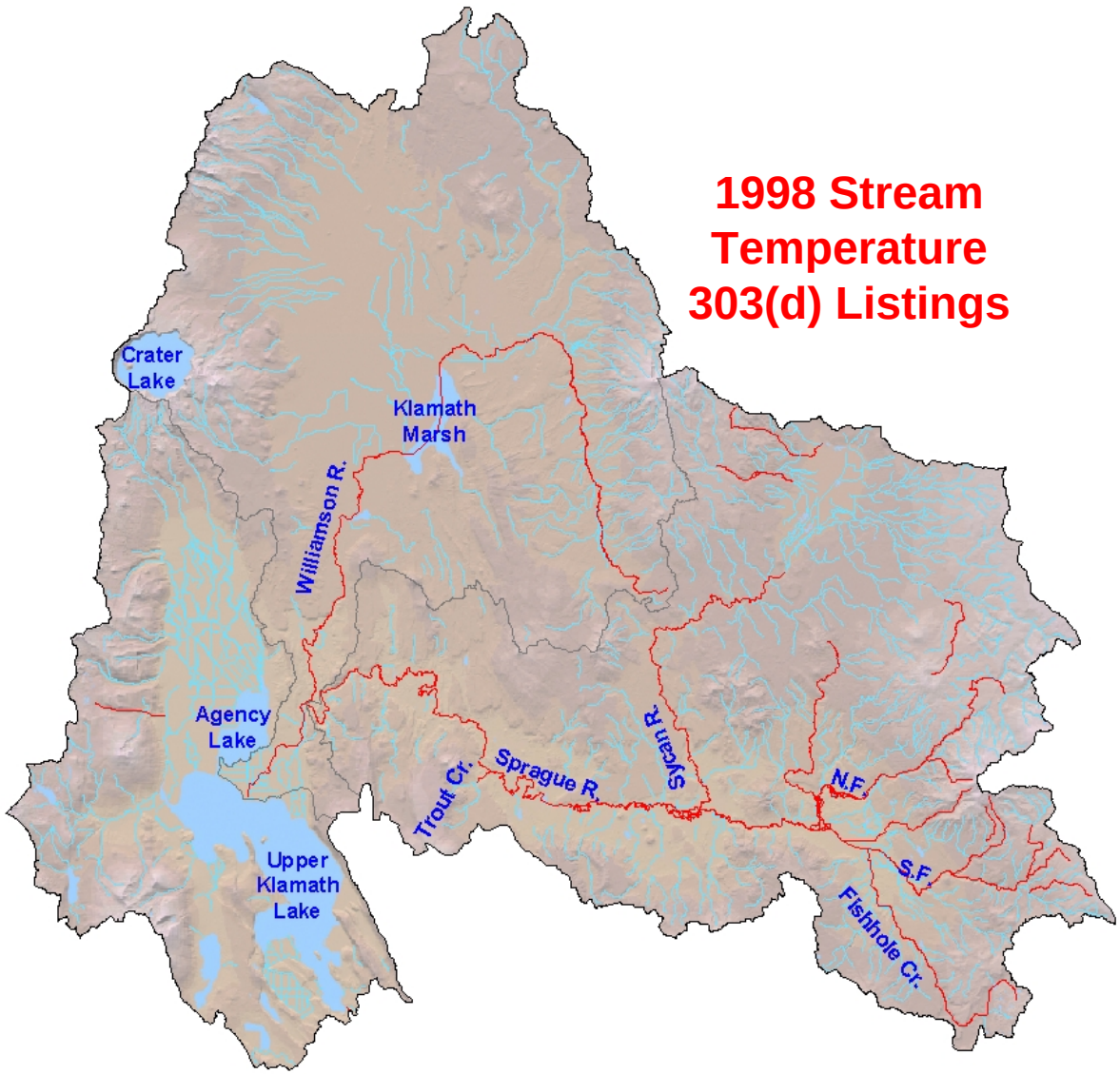
North Fork Sprague River

Temperature Limited Water Bodies

Upper Klamath Lake Drainage

Drainage Area = 3,800 mi^2

Perennial Stream Miles = 3,008 mi

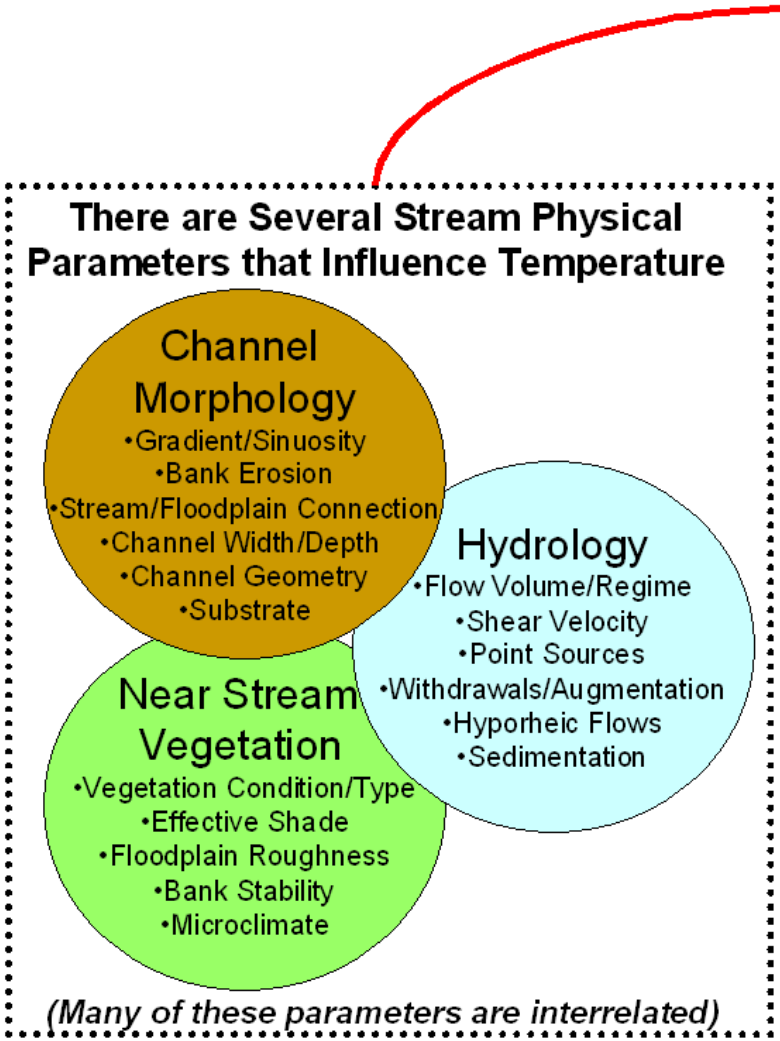


Oregon's Stream Temperature Standard

- The intent is to minimize human sources of stream warming.
- Numeric triggers based on salmonid sub-lethal temperatures are used to invoke the standard.
- Narrative triggers can also invoke the standard
- TMDL development is scaled to a drainage

Stream Temperature Analysis

Channel Morphology, Near Stream Land Cover and Hydrology Parameters are Considered in the Analytical Methodology



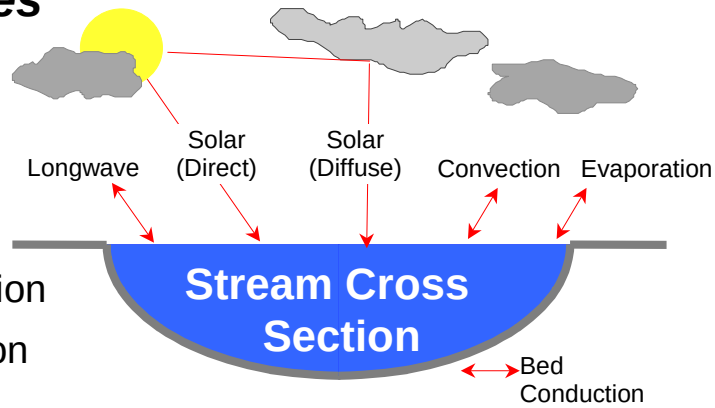
Important Stream Parameters Often Affected by Human Activities

Effective shade and stream flow are highly sensitive to human activities and significantly affect the stream temperature regime.

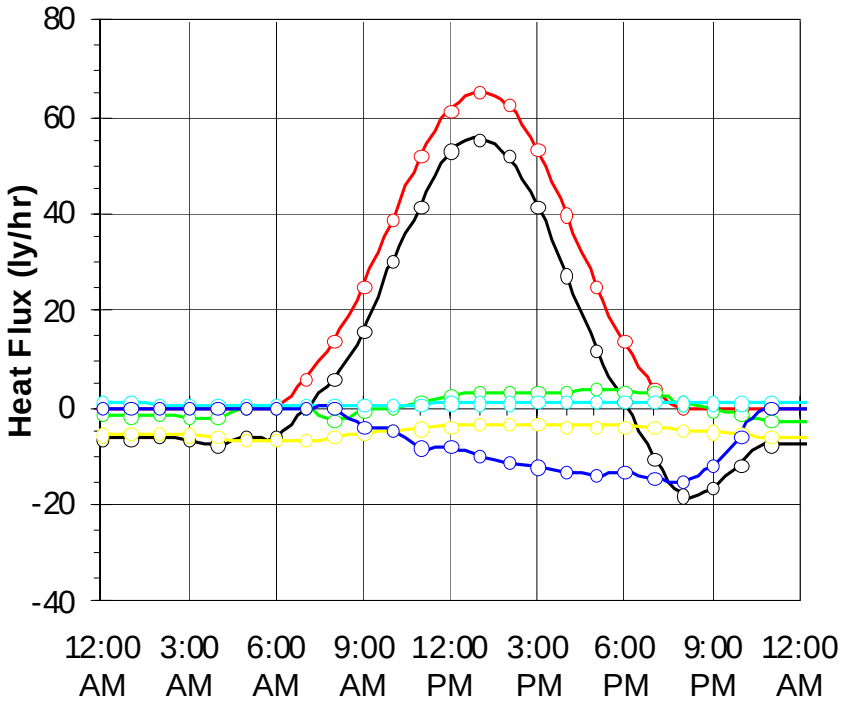
- **Effective Shade** is controlled by near stream vegetation and channel width
- **Stream Flow** is controlled by withdrawals, augmentation and discharge from point sources

Stream Temperature Simulation Methodology

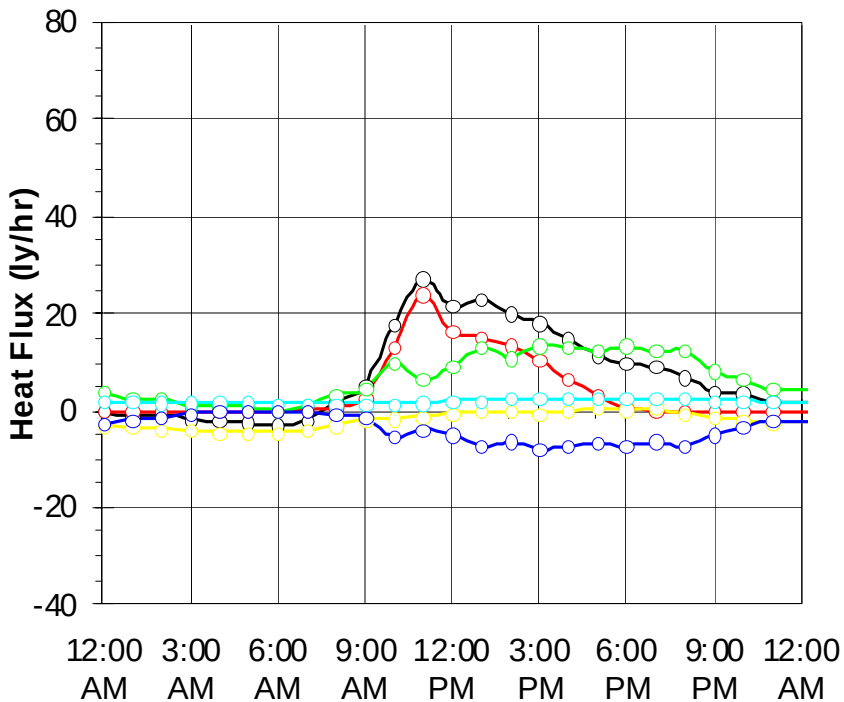
Heat Transfer Processes



Total Energy Budget
Solar Radiation
Longwave Radiation
Air Convection
Bed Conduction
Evaporation



Sprague River
River Crest Road - River Mile 50.9

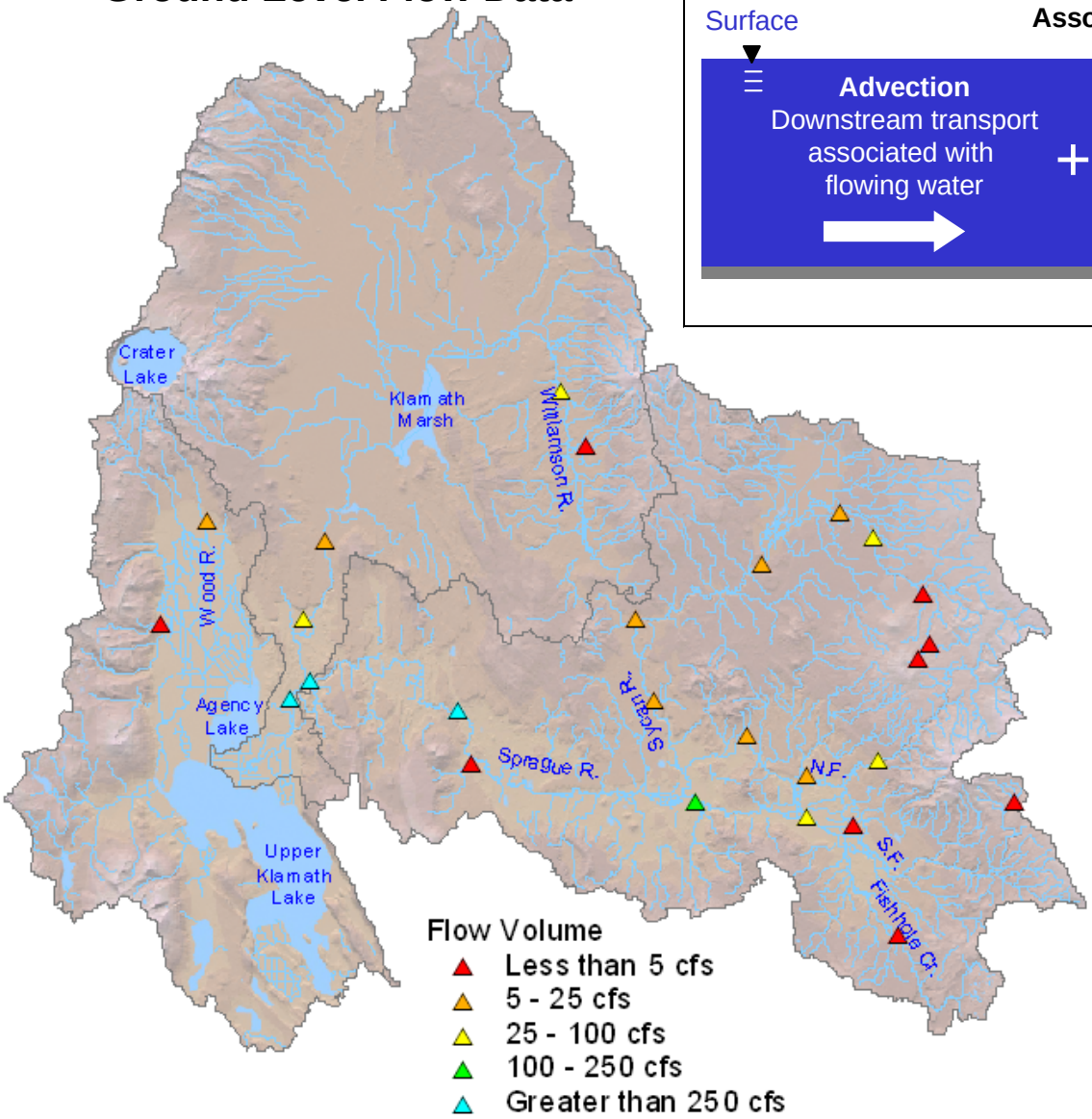


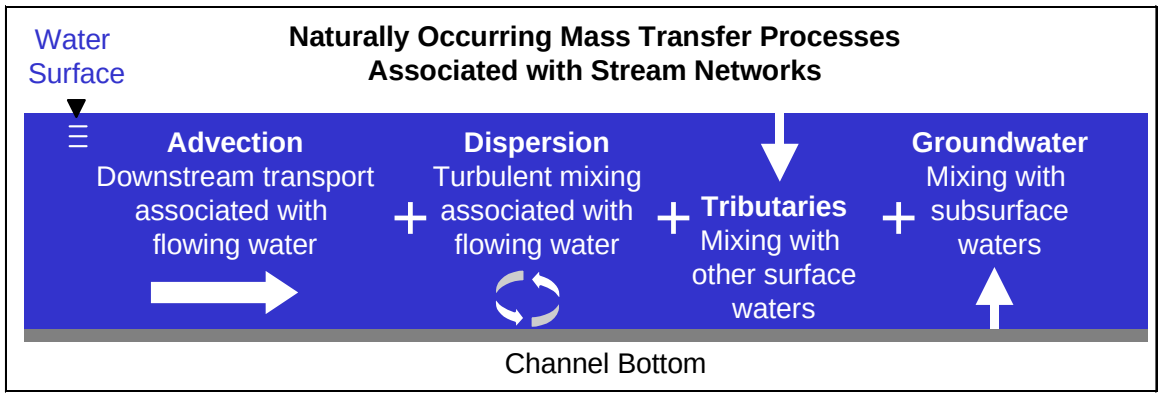
North Fork Sprague River
Upstream Lee Thomas Campground

Stream Temperature Simulation Methodology

Mass Transfer Processes

Ground Level Flow Data





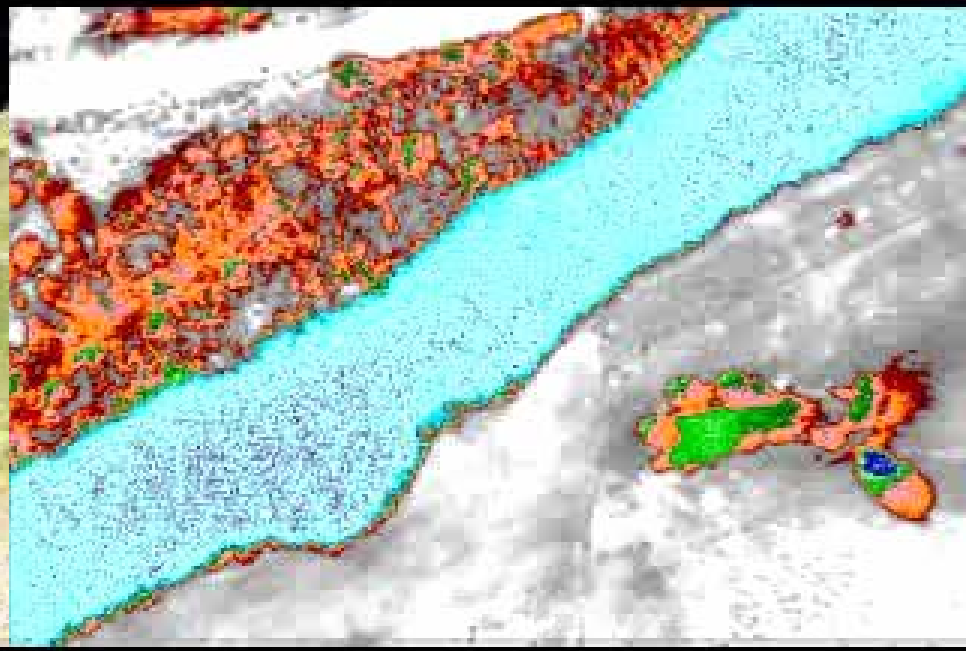
Williamson River Calibrated Video

(River Miles 11.8 to 19.8)

Click on Image to Play

Digital Day Video

FLIR



FLIR Temperature Scale (± 0.4 °F)

<50	50	52	54	55	57	59	61	63	64	66	68	70	72	73	75	81	83	85 →

Stream Temperature Analysis - *Analytical Methods*

1. Collect and summarize data
Ground level, Remote Sensing & GIS Data

2. Derive spatial data sets
Channel Morphology, Land Cover & Hydrology

3. Simulate Current Conditions
- Heat & Mass Transfer
- Statistically Validate Methodology

4. Develop Potential Conditions
Channel Morphology, Land Cover & Hydrology

5. Simulate Potential Conditions
- Run Multiple Scenarios
- Perform Sensitivity Analysis

6. Develop Management Targets - Surrogate Measures

Winema National Forest staff performing stream survey on Fishhole Creek, a tributary to the Sprague River, as part of a coordinated long-term monitoring plan. Data of this type is instrumental to the landscape scaled water quality analysis that is developed in TMDLs.

Stream Temperature Analysis - *Analytical Methods*

1. Collect and summarize data

Ground level, Remote Sensing & GIS Data

2. Derive spatial data sets

Channel Morphology, Land Cover & Hydrology

3. Simulate Current Conditions

- Heat & Mass Transfer
- Statistically Validate Methodology

4. Develop Potential Conditions

Channel Morphology, Land Cover & Hydrology

5. Simulate Potential Conditions

- Run Multiple Scenarios
- Perform Sensitivity Analysis

6. Develop Management Targets - Surrogate Measures

Color aerial photos used to digitize stream data nodes and digitized land cover polygons

Stream Temperature Analysis - *Analytical Methods*

1. Collect and summarize data

Ground level, Remote Sensing & GIS Data

2. Derive spatial data sets

Channel Morphology, Land Cover & Hydrology

3. Simulate Current Conditions

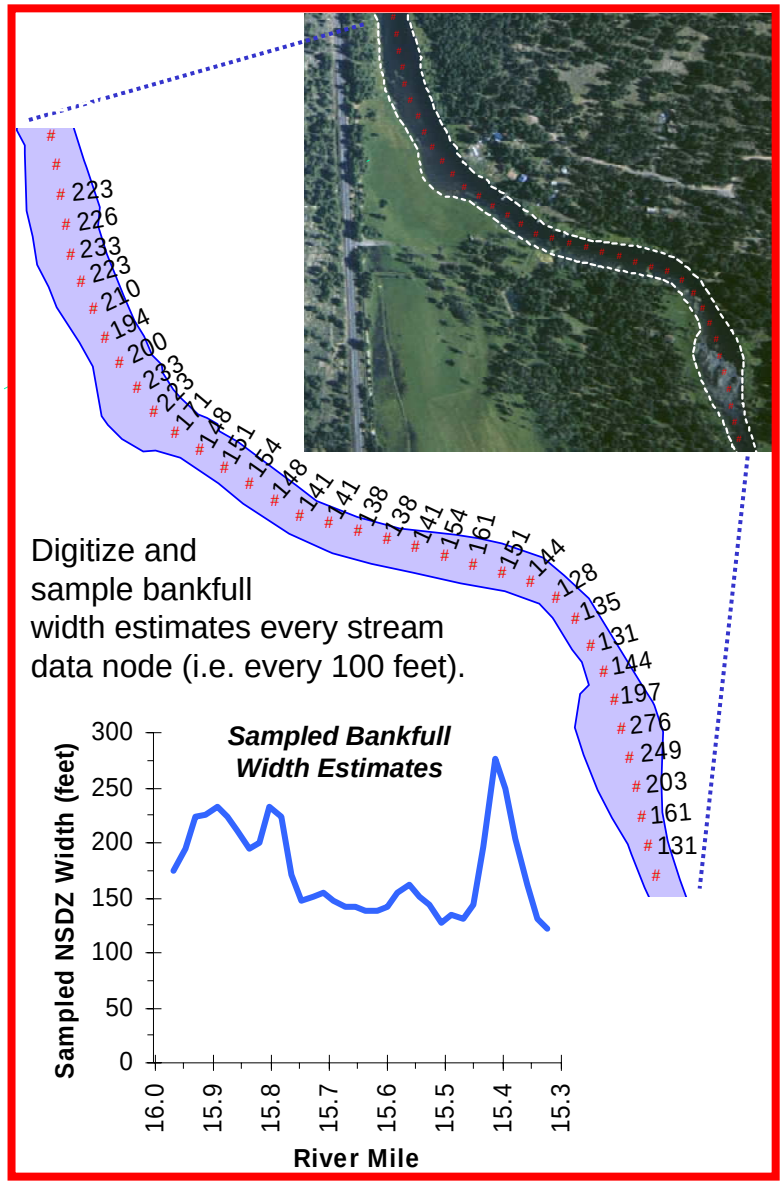
- Heat & Mass Transfer
- Statistically Validate Methodology

4. Develop Potential Conditions

Channel Morphology, Land Cover & Hydrology

5. Simulate Potential Conditions

- Run Multiple Scenarios
- Perform Sensitivity Analysis



6. Develop Management Targets - Surrogate Measures

Stream Temperature Analysis - *Analytical Methods*

1. Collect and summarize data

Ground level, Remote Sensing & GIS Data

2. Derive spatial data sets

Channel Morphology, Land Cover & Hydrology

3. Simulate Current Conditions

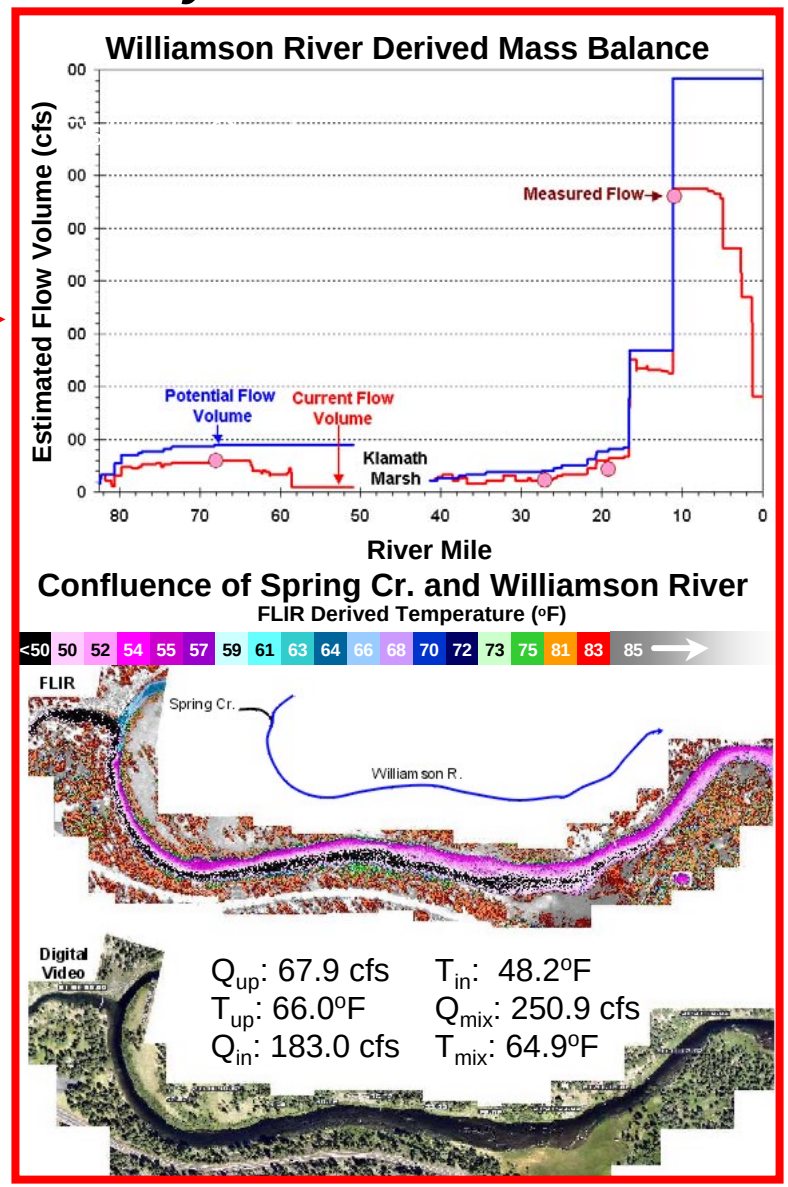
- Heat & Mass Transfer
- Statistically Validate Methodology

4. Develop Potential Conditions

Channel Morphology, Land Cover & Hydrology

5. Simulate Potential Conditions

- Run Multiple Scenarios
- Perform Sensitivity Analysis



6. Develop Management Targets - Surrogate Measures

Stream Temperature Analysis - *Analytical Methods*

1. Collect and summarize data

Ground level, Remote Sensing & GIS Data

2. Derive spatial data sets

Channel Morphology, Land Cover & Hydrology

3. Simulate Current Conditions

- Heat & Mass Transfer
- Statistically Validate Methodology

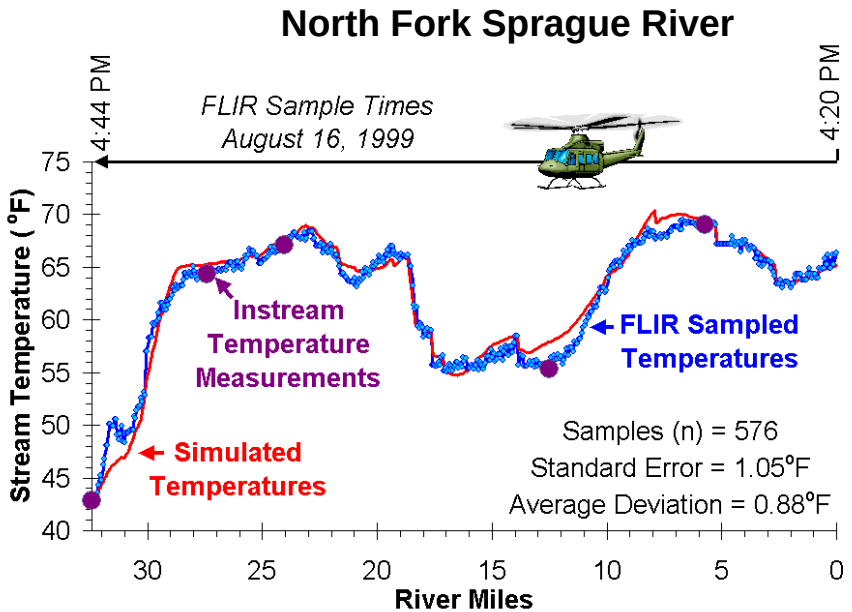
4. Develop Potential Conditions

Channel Morphology, Land Cover & Hydrology

5. Simulate Potential Conditions

- Run Multiple Scenarios
- Perform Sensitivity Analysis

6. Develop Management Targets - Surrogate Measures



North Fork Sprague River current condition simulation. Validated with FLIR data and instream continuous data. Statistical limitations indicate that the model is valid to roughly ± 1.0°F.

Stream Temperature Analysis - *Analytical Methods*

1. Collect and summarize data

Ground level, Remote Sensing & GIS Data

2. Derive spatial data sets

Channel Morphology, Land Cover & Hydrology

3. Simulate Current Conditions

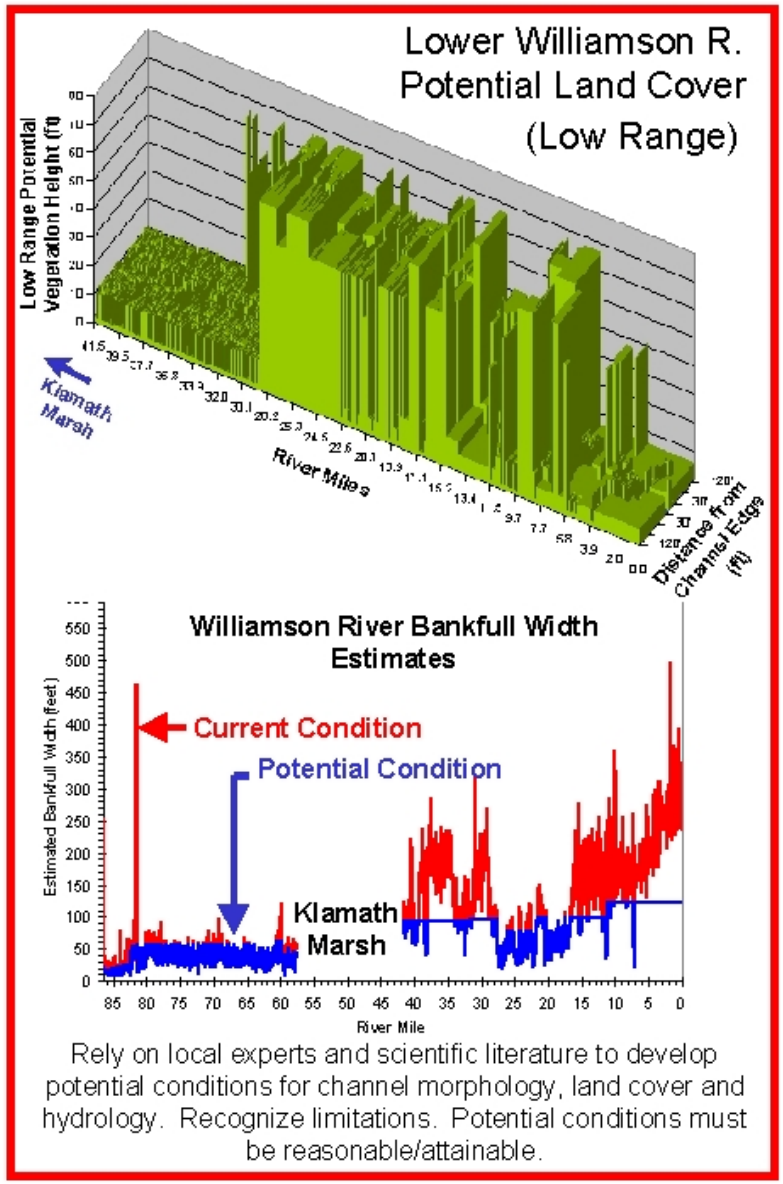
- Heat & Mass Transfer
- Statistically Validate Methodology

4. Develop Potential Conditions →

Channel Morphology, Land Cover & Hydrology

5. Simulate Potential Conditions

- Run Multiple Scenarios
- Perform Sensitivity Analysis



Rely on local experts and scientific literature to develop potential conditions for channel morphology, land cover and hydrology. Recognize limitations. Potential conditions must be reasonable/attainable.

6. Develop Management Targets - Surrogate Measures

Stream Temperature Analysis - *Analytical Methods*

1. Collect and summarize data

Ground level, Remote Sensing & GIS Data

2. Derive spatial data sets

Channel Morphology, Land Cover & Hydrology

3. Simulate Current Conditions

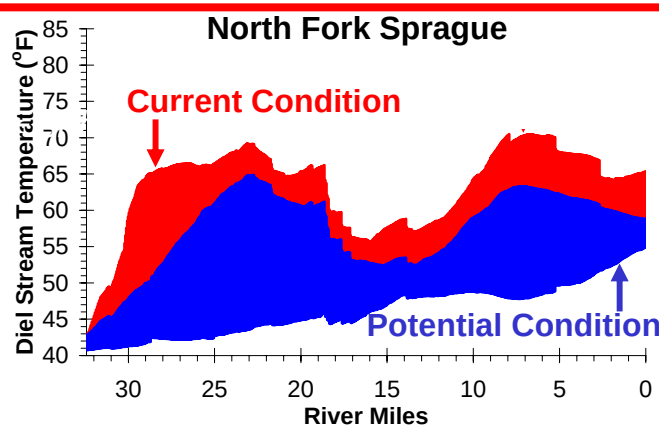
- Heat & Mass Transfer
- Statistically Validate Methodology

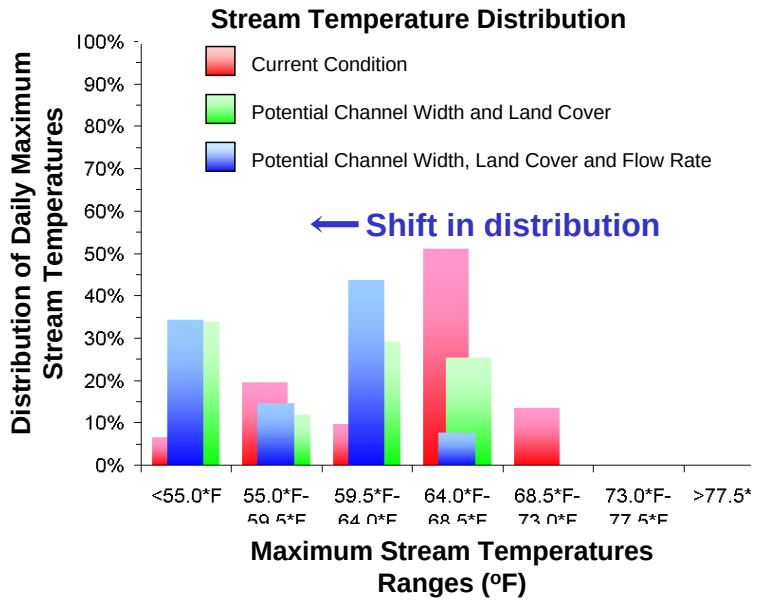
4. Develop Potential Conditions

Channel Morphology, Land Cover & Hydrology

5. Simulate Potential Conditions

- Run Multiple Scenarios
- Perform Sensitivity Analysis





Temperature distributions are a good way to examine changes to the temperature regime, while recognizing spatial scaled variability

6. Develop Management Targets - Surrogate Measures

Stream Temperature Analysis - *Analytical Methods*

1. Collect and summarize data

Ground level, Remote Sensing & GIS Data

2. Derive spatial data sets

Channel Morphology, Land Cover & Hydrology

3. Simulate Current Conditions

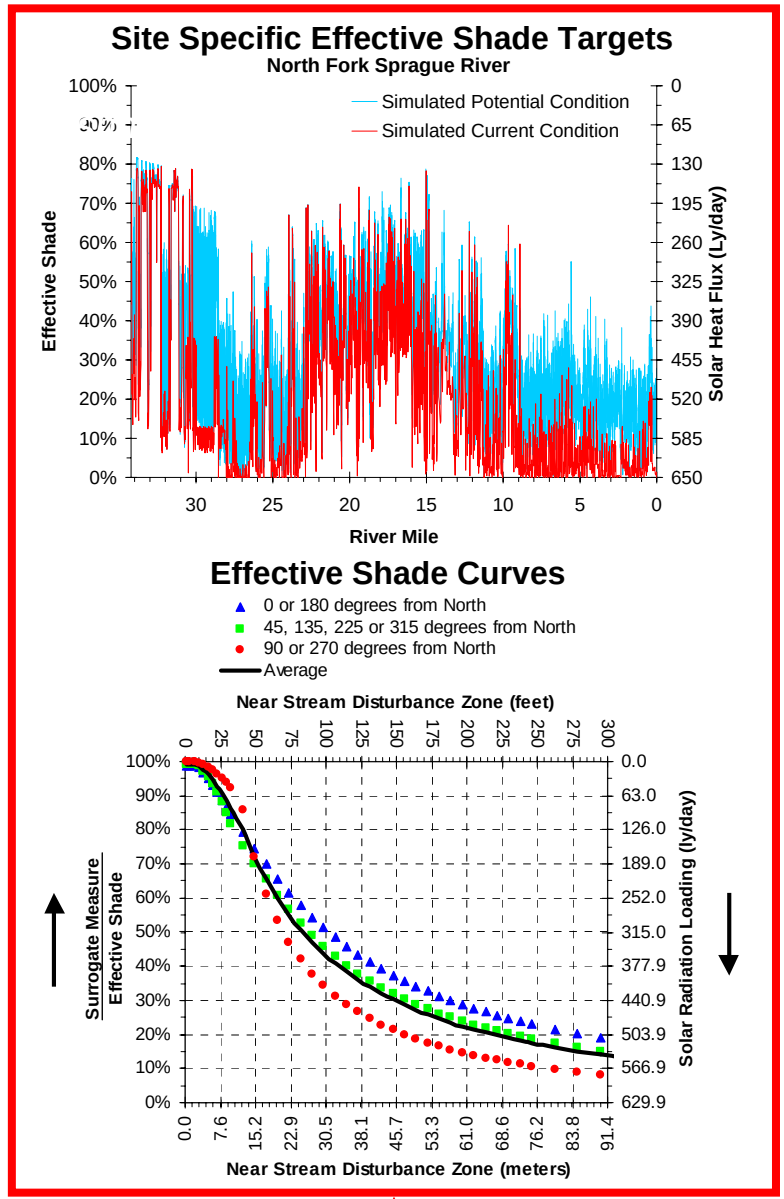
- Heat & Mass Transfer
- Statistically Validate Methodology

4. Develop Potential Conditions

Channel Morphology, Land Cover & Hydrology

5. Simulate Potential Conditions

- Run Multiple Scenarios
- Perform Sensitivity Analysis



6. Develop Management Targets - Surrogate Measures

Stream Temperature Analysis - *Analytical Methods*

1. Collect and summarize data

Ground level, Remote Sensing & GIS Data

2. Derive spatial data sets

Channel Morphology, Land Cover & Hydrology

3. Simulate Current Conditions

- Heat & Mass Transfer
- Statistically Validate Methodology

4. Develop Potential Conditions

Channel Morphology, Land Cover & Hydrology

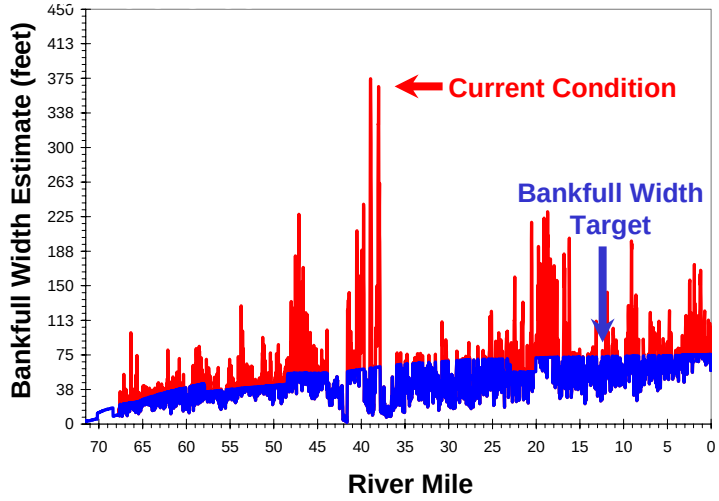
5. Simulate Potential Conditions

- Run Multiple Scenarios
- Perform Sensitivity Analysis

6. Develop Management Targets - Surrogate Measures

Site Specific Bankfull Width Targets

Sycan River



W:D as a Function of Channel Type

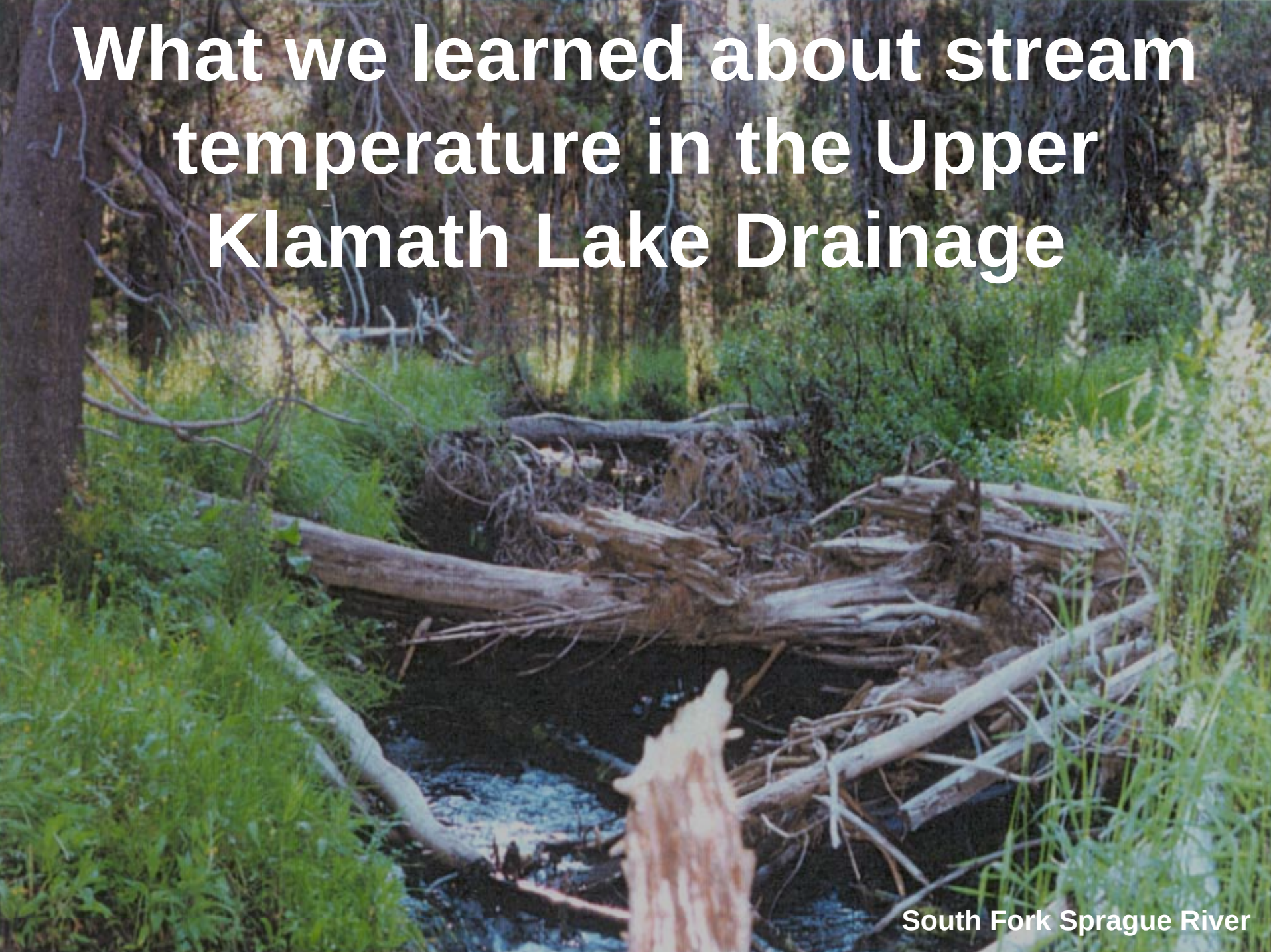
Level I Stream Type	Width to Depth
A	7.9
B	18.6
C	29.8
D	N/A
E	7.1
F	27.6
G	8.0

Rosgen level I stream type targets and width to depth targets.

Possible Change in Channel Types

Current Condition	Potential Condition
A	A
B	B
C	C or E
D	C, D or E
E	E
F	C or E

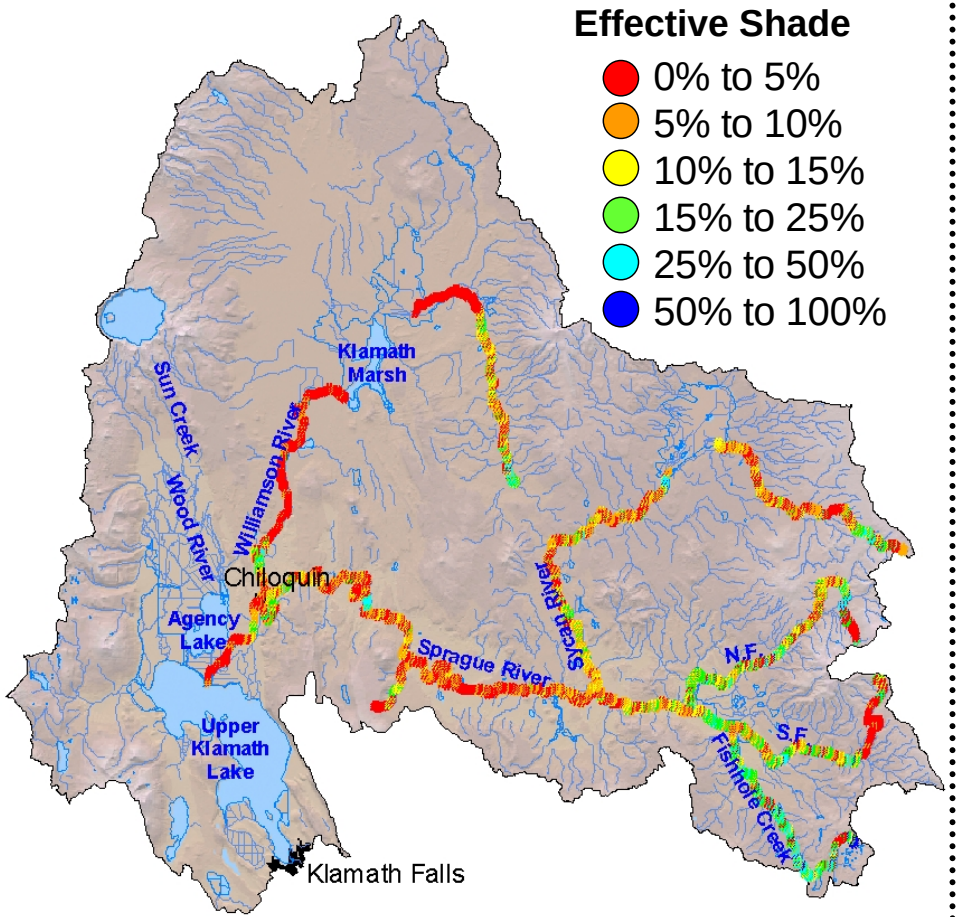
What we learned about stream temperature in the Upper Klamath Lake Drainage



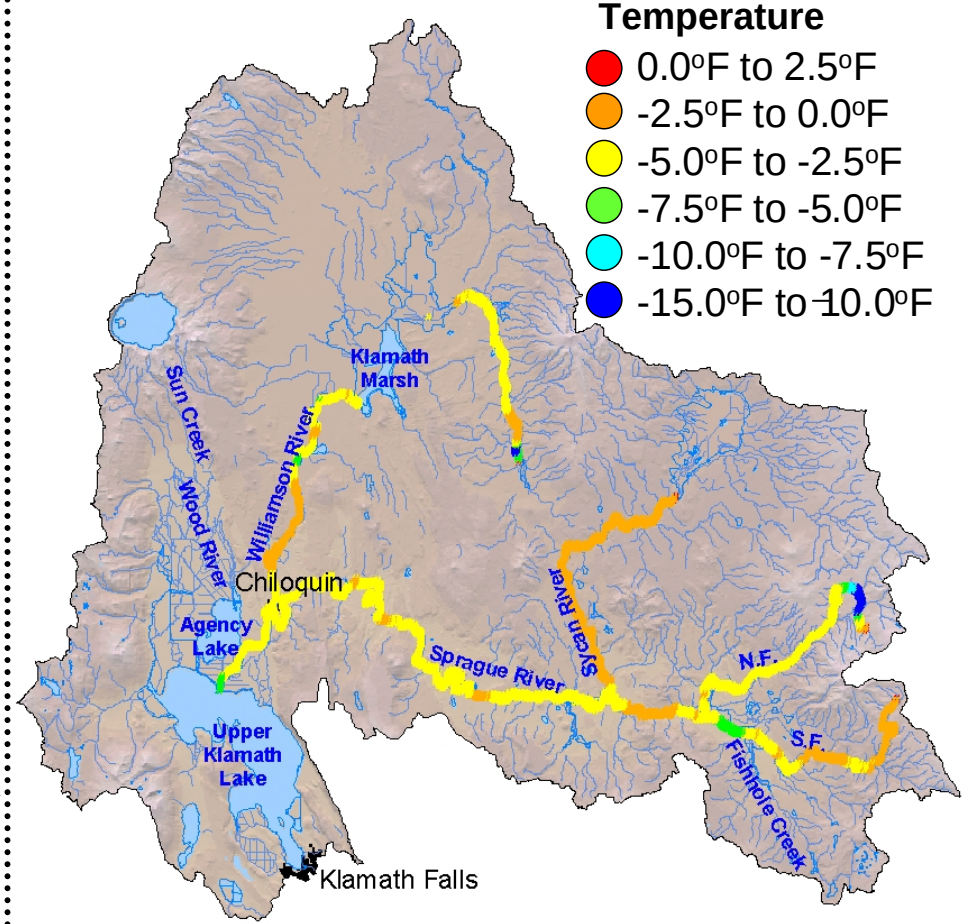
South Fork Sprague River

Conclusion #1 - Modest increases in effective shade produce thermally significant cooling.

Increase in Effective Shade Resulting from Potential Channel Width & Land Cover

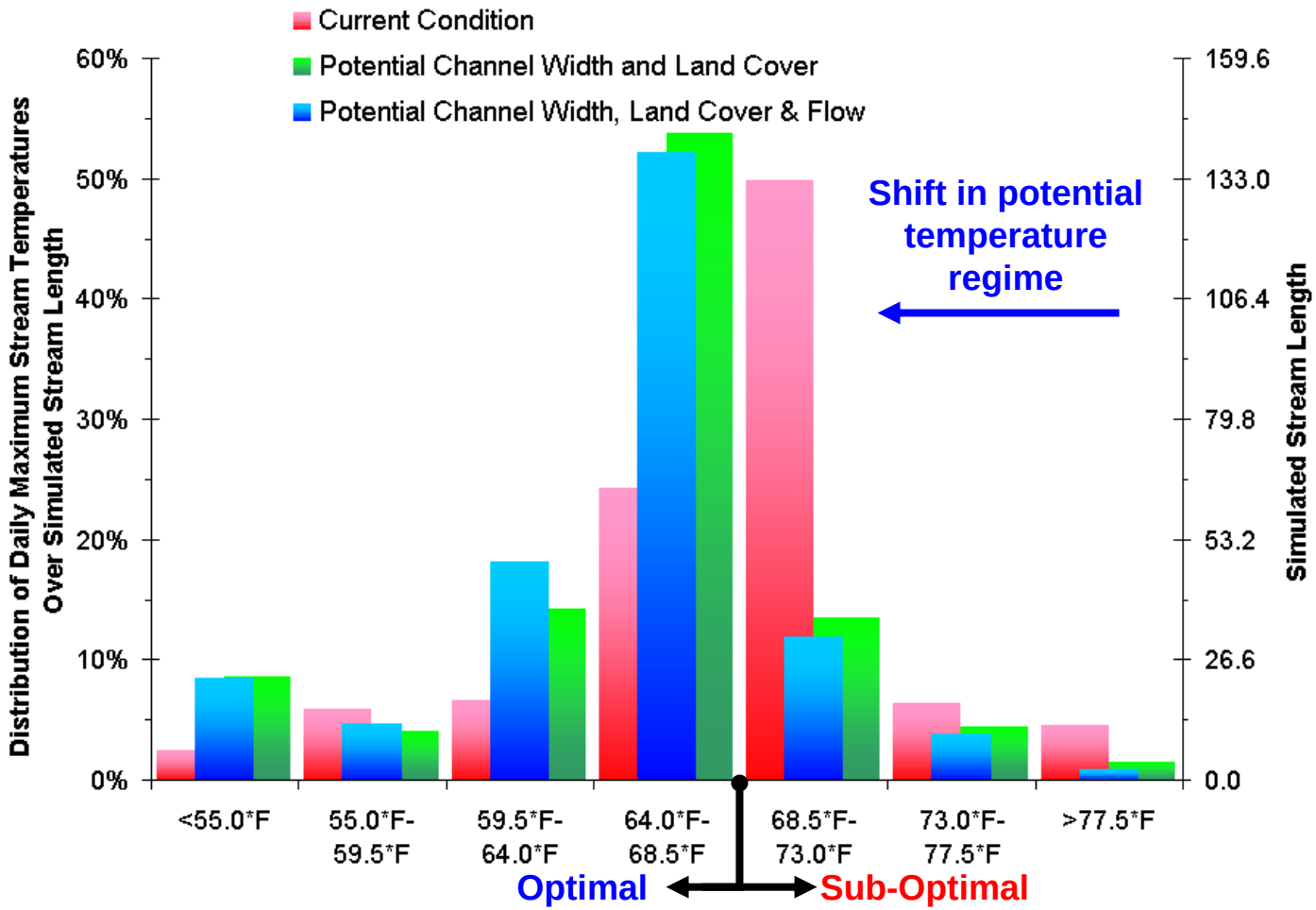


Temperature Difference Resulting from Potential Channel Width & Land Cover

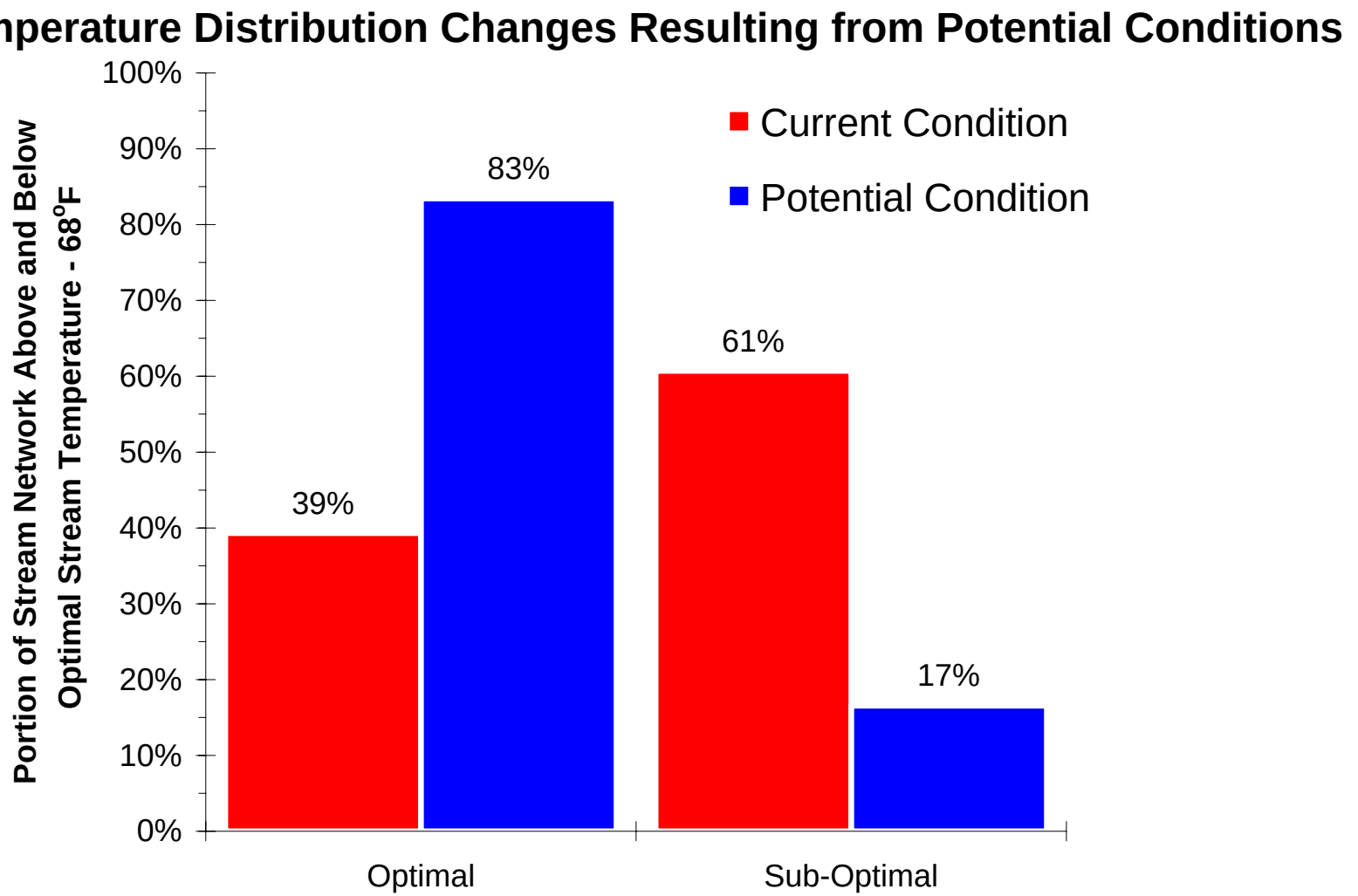


<u>Conclusion #2</u> - Thermal variability includes departures from biologically derived temperature threshold conditions (i.e. proposed new Redband Trout limit of 68ºF). This holds true even in the defined "potential conditions."

Simulated Potential Daily Maximum Stream Temperature Summaries

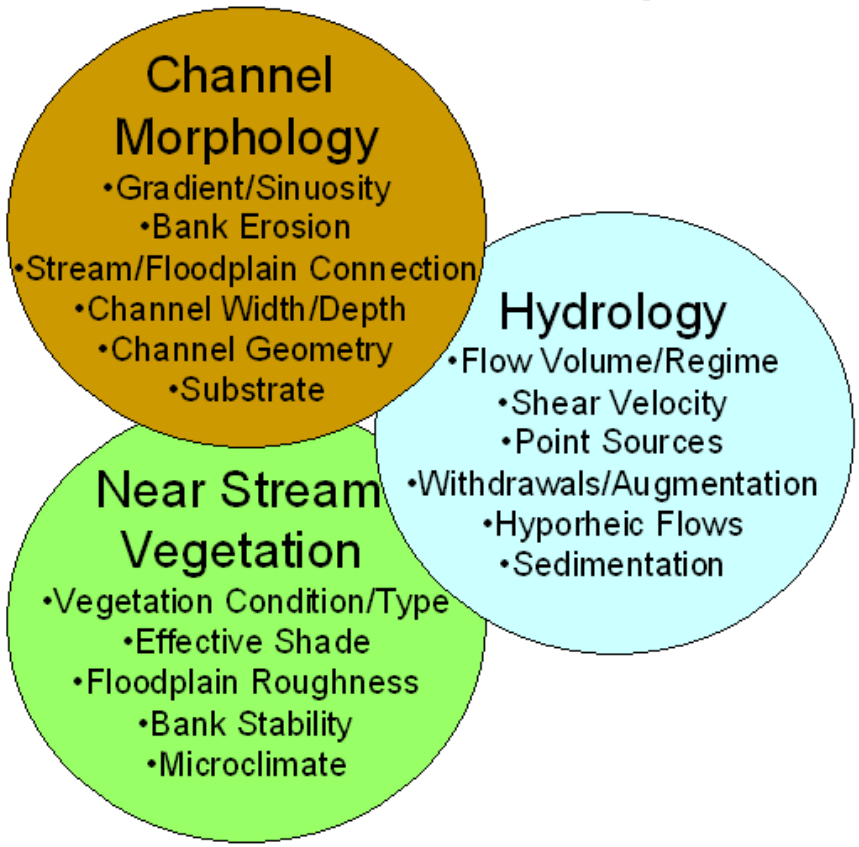


<u>Conclusion #3</u> - The shift in stream temperature distribution is favorable to fish. An additional 117 stream miles are expected to become optimal, making sub-optimal thermal exposure very limited in the potential condition.



<u>Conclusion #4</u> - Simple conceptual models that focus on a single stream, landscape or atmospheric parameter will fail to capture the interactions of a multitude of parameters that are interrelated. These parameters combine to have complex thermal effects.

There are Several Stream Physical Parameters that Influence Temperature



(Many of these parameters are interrelated)

<u>Conclusion #5</u> - A comprehensive restoration approach should be developed that focuses on the protection and recovery of near stream land cover and channel morphology, and increases instream flow volume.