



Lower Columbia

Estuary
Partnership

2014-2015 Columbia Gorge Tributaries Temperature Monitoring Results

Estuary Partnership
Science Work Group
March 2015

Thermal Refugia Study Objectives

Year 1 (2014 – 2015)

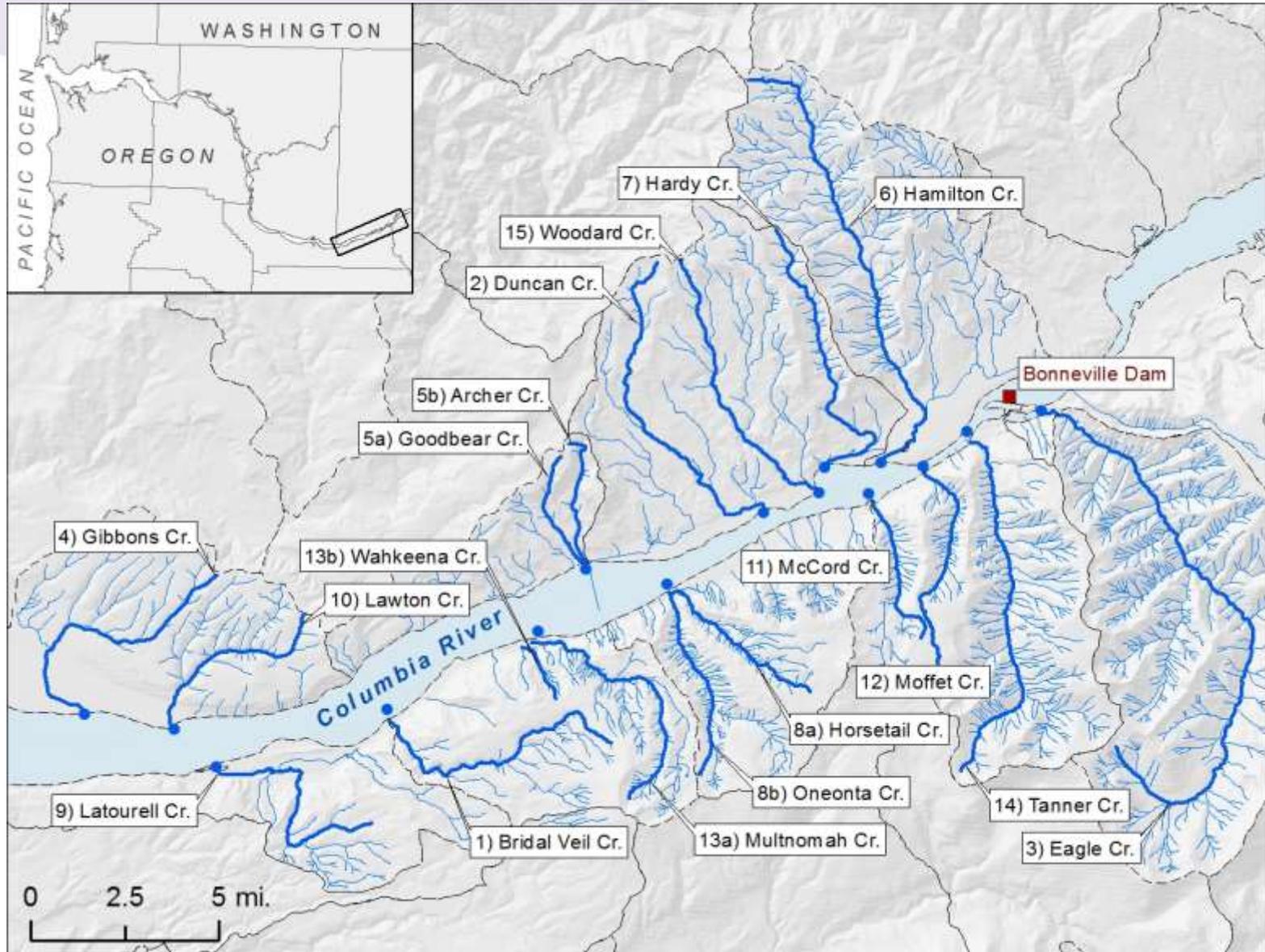
Document summertime stream conditions for 15 lower Columbia Gorge tributaries at and near their Columbia R. confluence zones:

- Stream temperatures
- Confluence temperatures (cold water plume formation)
- Stream discharge
- Topography
- Fish presence (qualitative)

Future Phases

- Document additional cold water sources downstream
- Implications for restoration/protection

Study Area



Preliminary Assessment

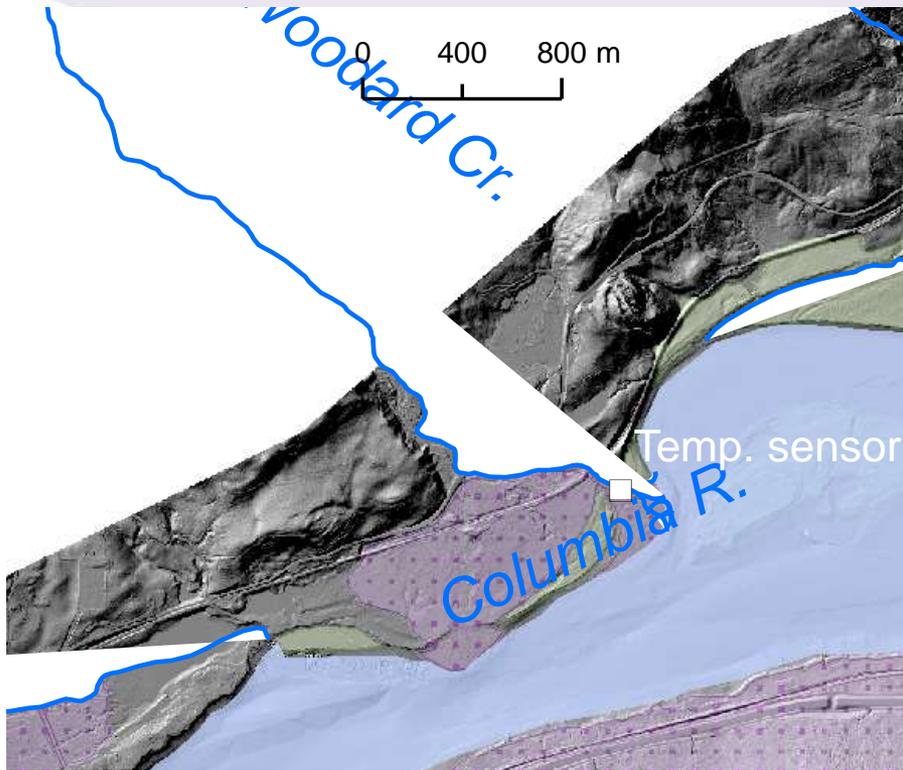
Stream Geomorphology

- Typical Gorge tributary is an alluvial fan system with:
 - No floodplain component: Single stream temperature sensor.
 - Floodplain component. Multiple stream temperature sensors to capture heating effects.

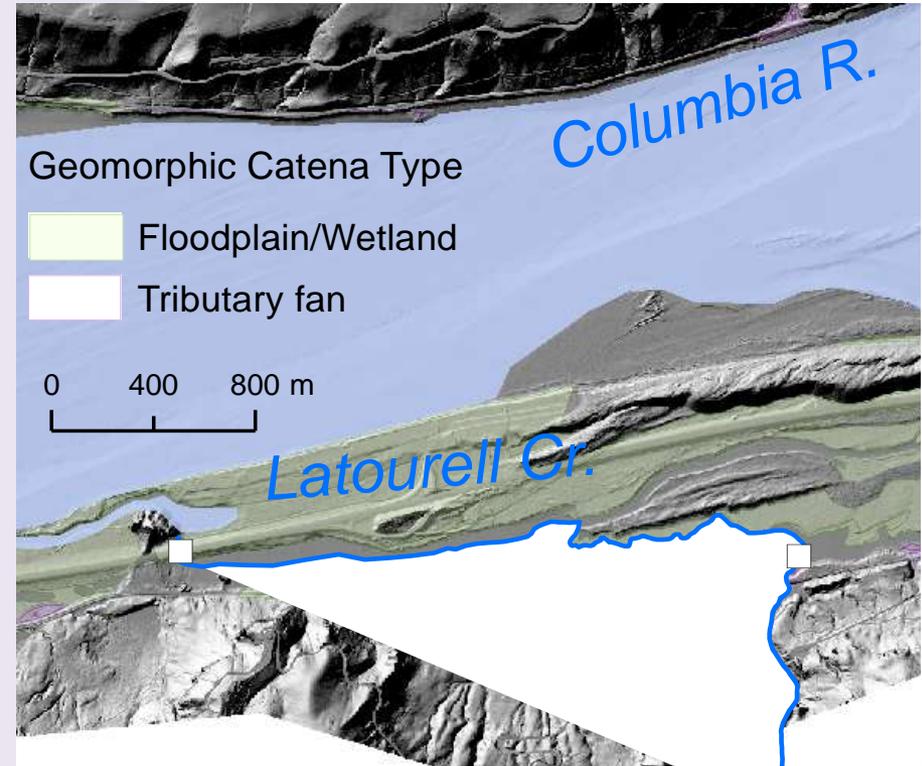
Potential Plume Formation at Confluence Zones

- Hydrodynamic Simulations

Stream Geomorphology



**Alluvial Fan system, no
floodplain**



**Alluvial Fan system with
floodplain**

Stream Classification Source:

Columbia River Estuary Ecosystem Classification (CREEC)

Stream Geomorphology

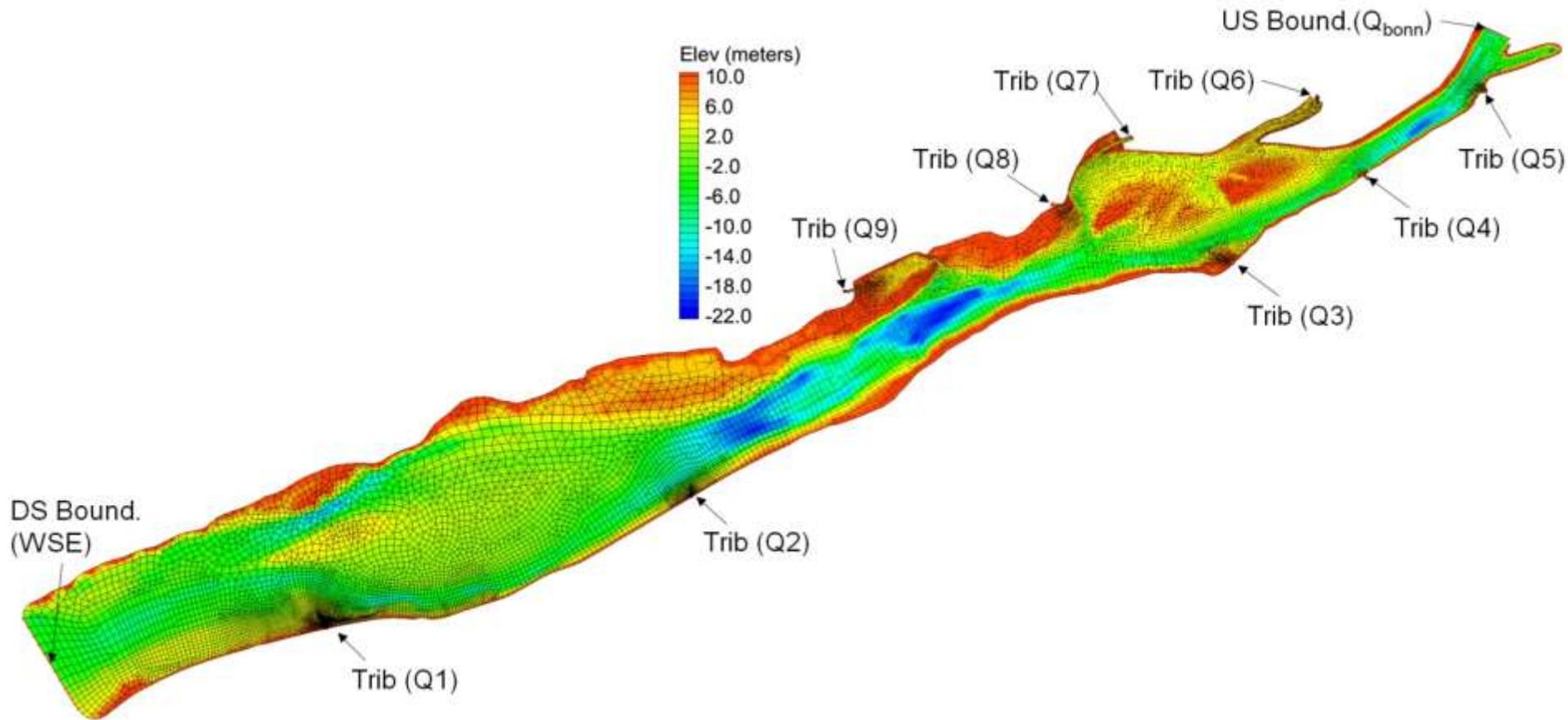


**McCord Creek
confluence**



**McCord Creek
confluence
looking upstream**

Potential Cold Water Plume Formation



Hydrodynamic and Water Quality Model
(Tuflow FV)

Potential Cold Water Plume Formation

The likelihood of a plume to form at a tributary confluence is influenced by:

- Discharge (tributary and mainstem Columbia R.)
- Water temperature (tributary and mainstem Columbia R.)
- Bathymetric profile (eddy formation)
- Atmospheric effects (solar radiation, wind)

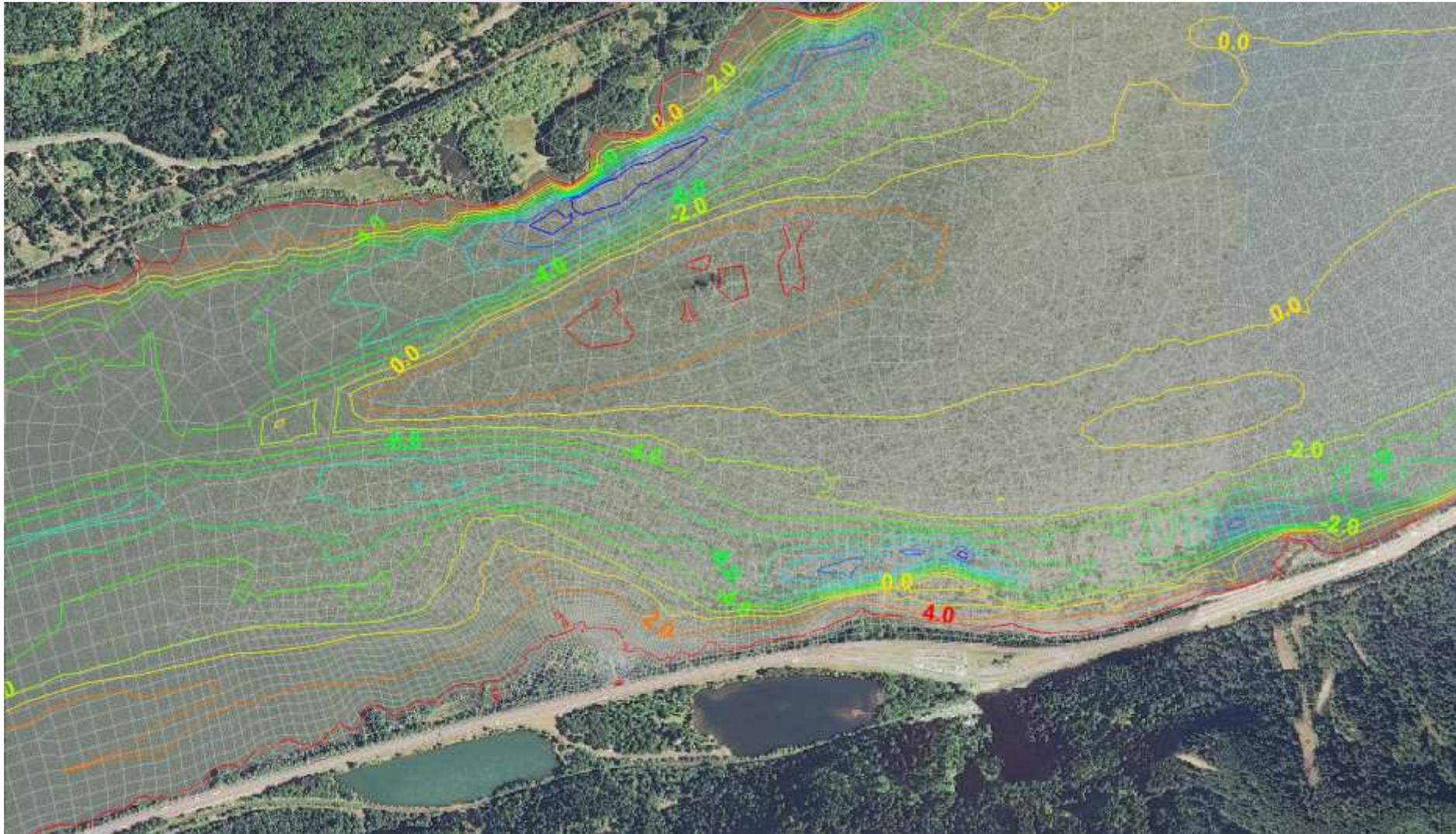
Typical Columbia R. summer discharge: 100,000 – 150,000 cfs

Typical Columbia Gorge tributary discharge: 1 – 50 cfs

- At these relative flows, cold water plumes are not likely to form at most confluence zones

Potential Cold Water Plume Formation

Bathymetric Effects



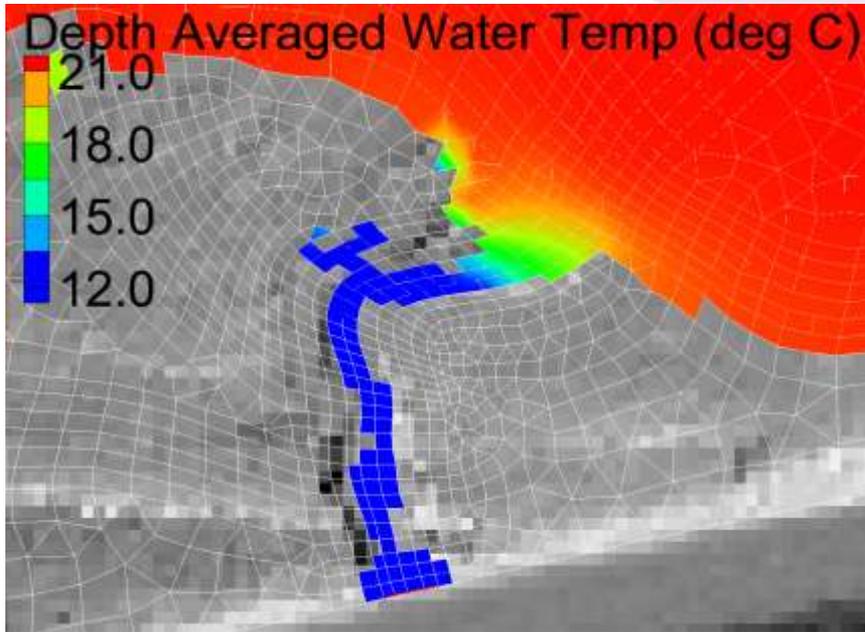
Potential Cold Water Plume Formation

Bathymetric Effects

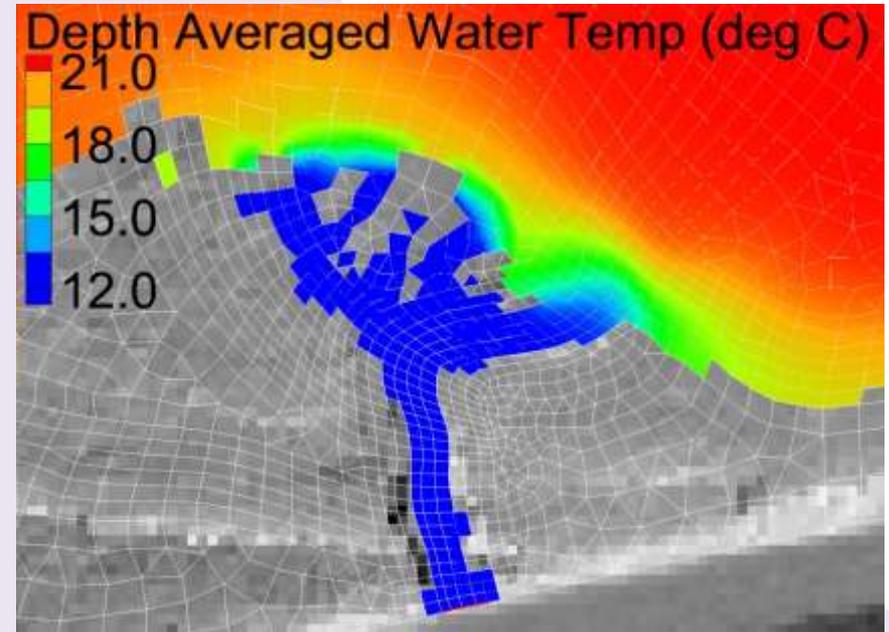


Potential Cold Water Plume Formation

Tributary Discharge Effects



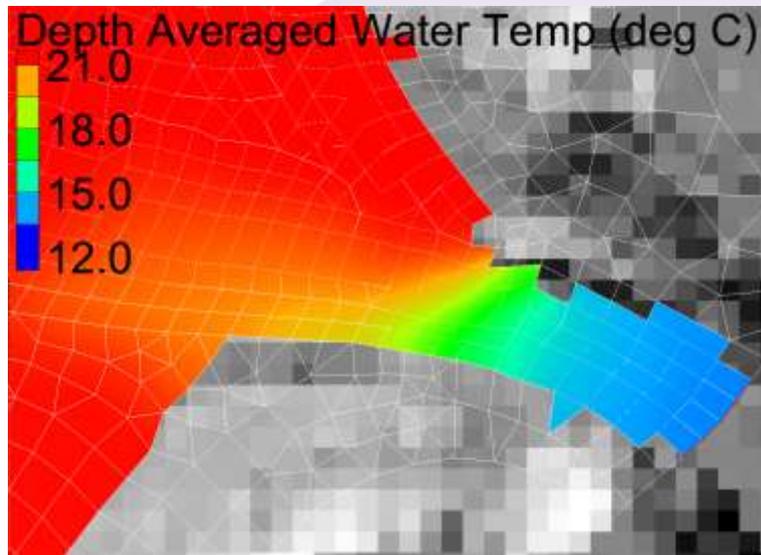
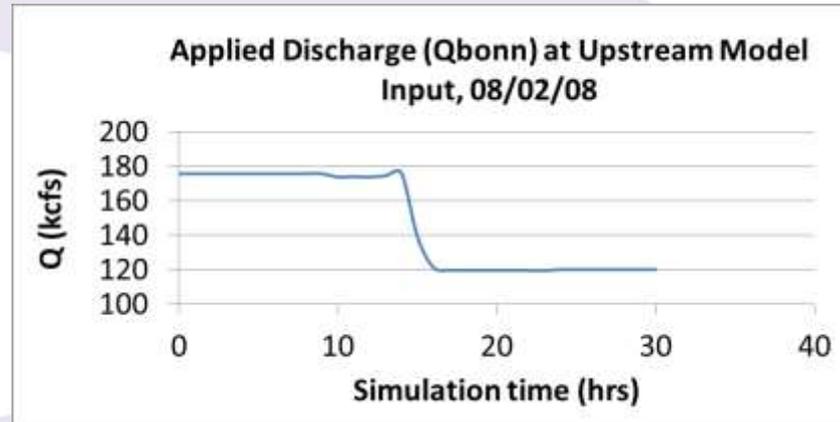
$$Q_{\text{TRIB}} = 10 \text{ cfs}$$



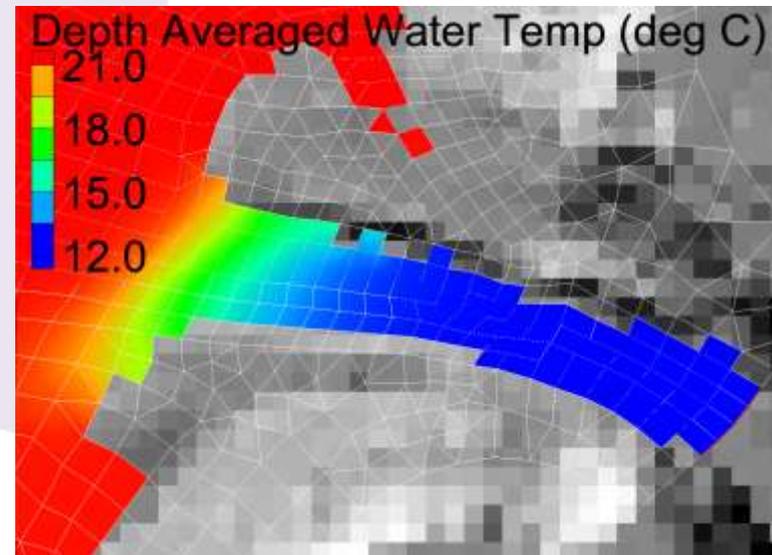
$$Q_{\text{TRIB}} = 50 \text{ cfs}$$

Potential Cold Water Plume Formation

Mainstem Discharge Effects



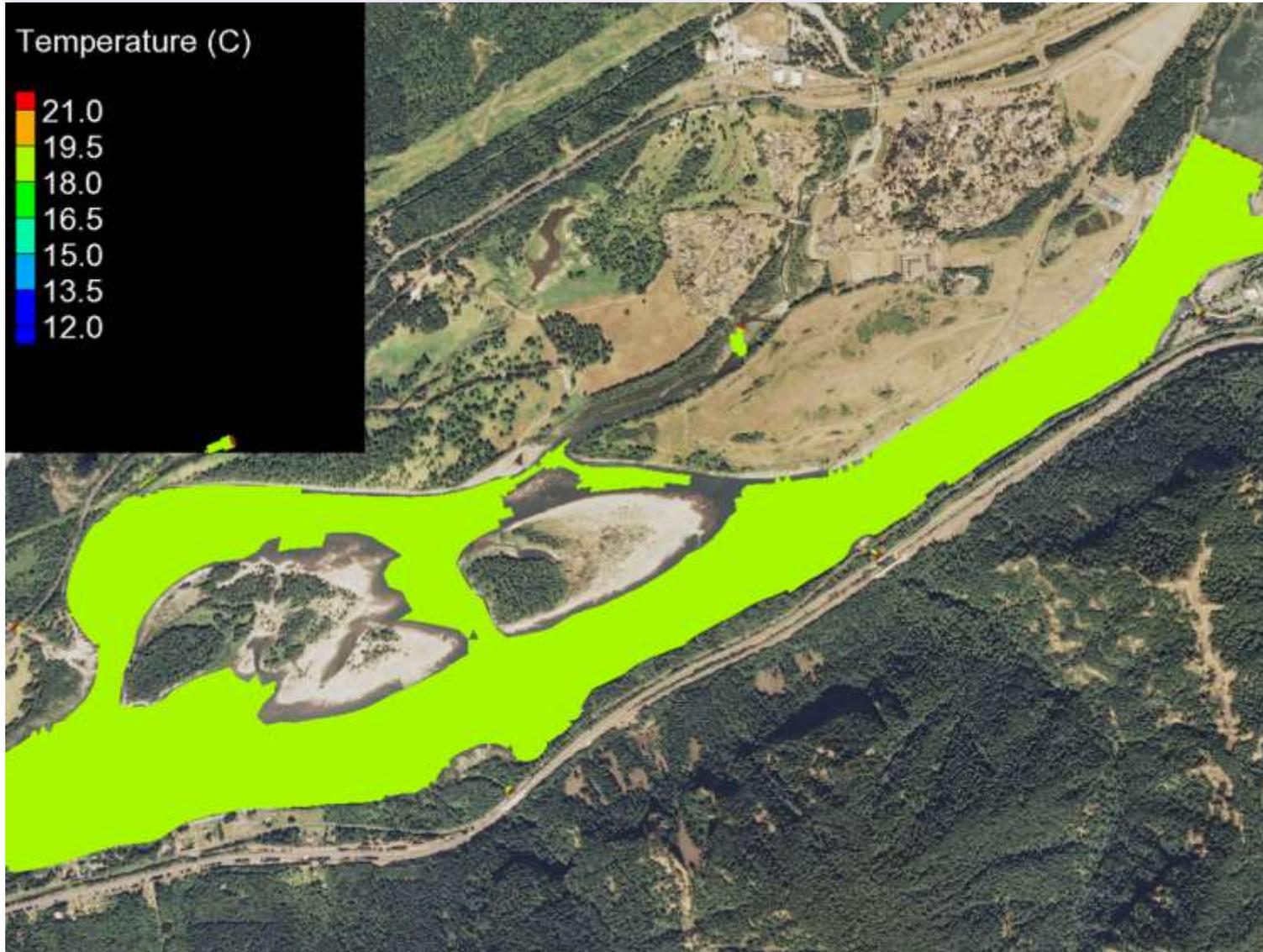
$Q_{\text{BONN}} = 175,000$ cfs



$Q_{\text{BONN}} = 120,000$ cfs

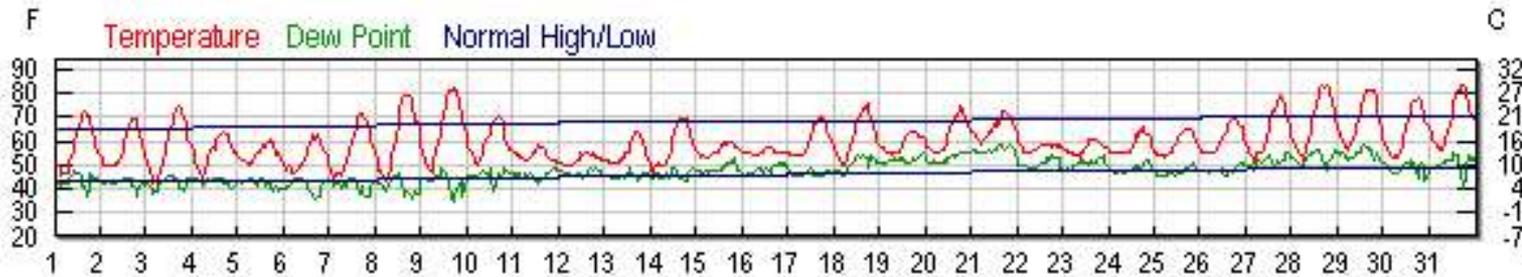
Potential Cold Water Plume Formation

Model Predictions



2015 Monitoring Conditions

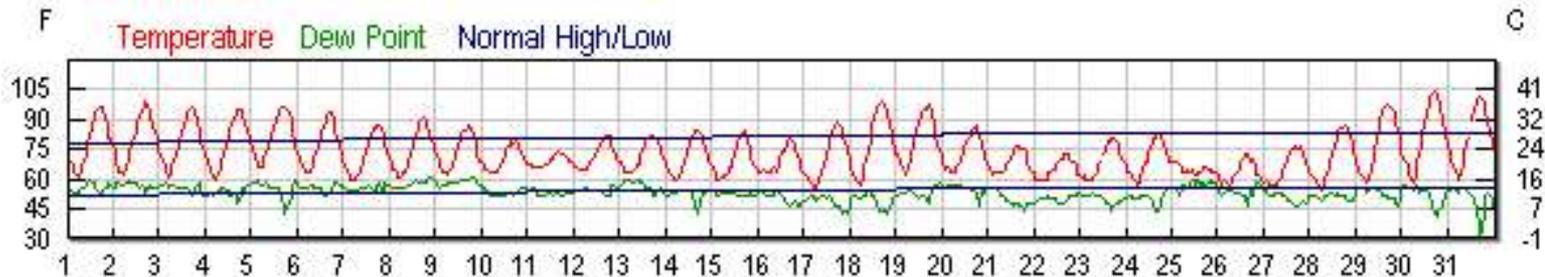
Above average temperatures



May



June



July

Source/Location: Weather Underground/Troutdale, OR

2015 Monitoring Conditions

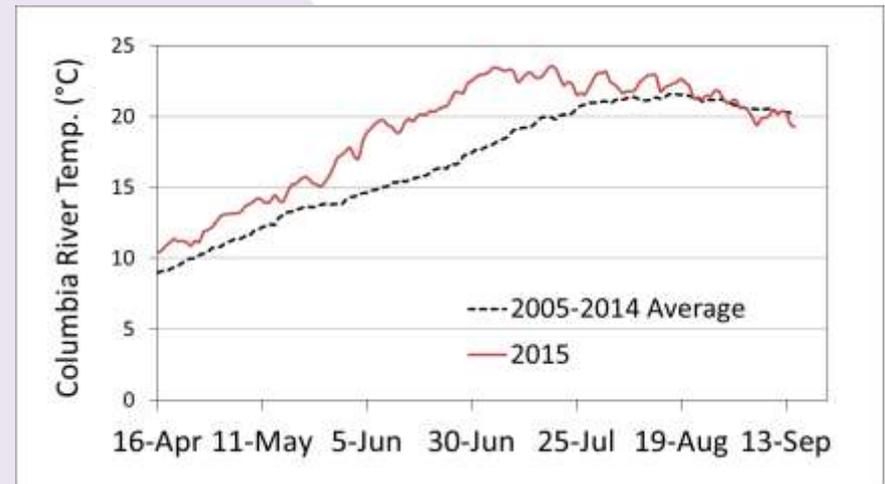
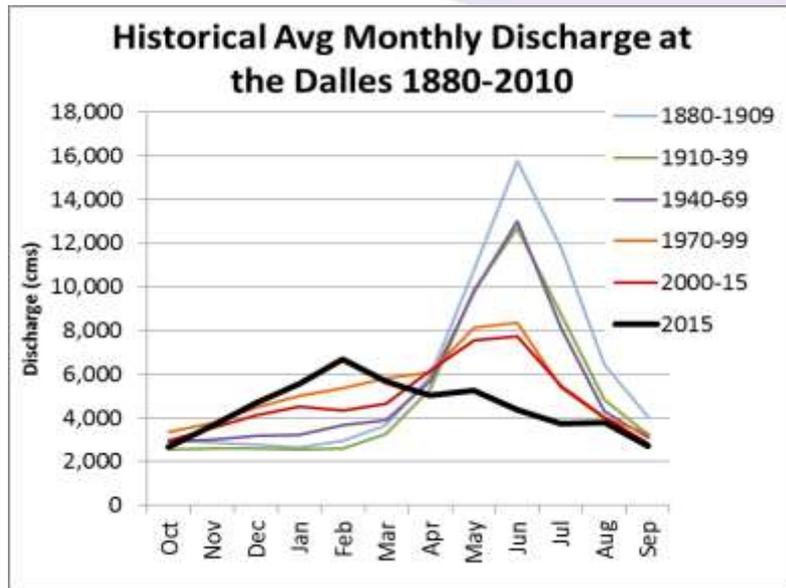
Below average precipitation:

Month	Average precipitation (inches)	2015 Monthly precipitation (inches)	2015 % of average precipitation
April	3.85	2.20	57
May	2.94	0.82	28
June	2.42	0.63	26

Source/Location: Weather Underground/Troutdale, OR

2015 Monitoring Conditions

Columbia River Impacts: low flows, high temperatures

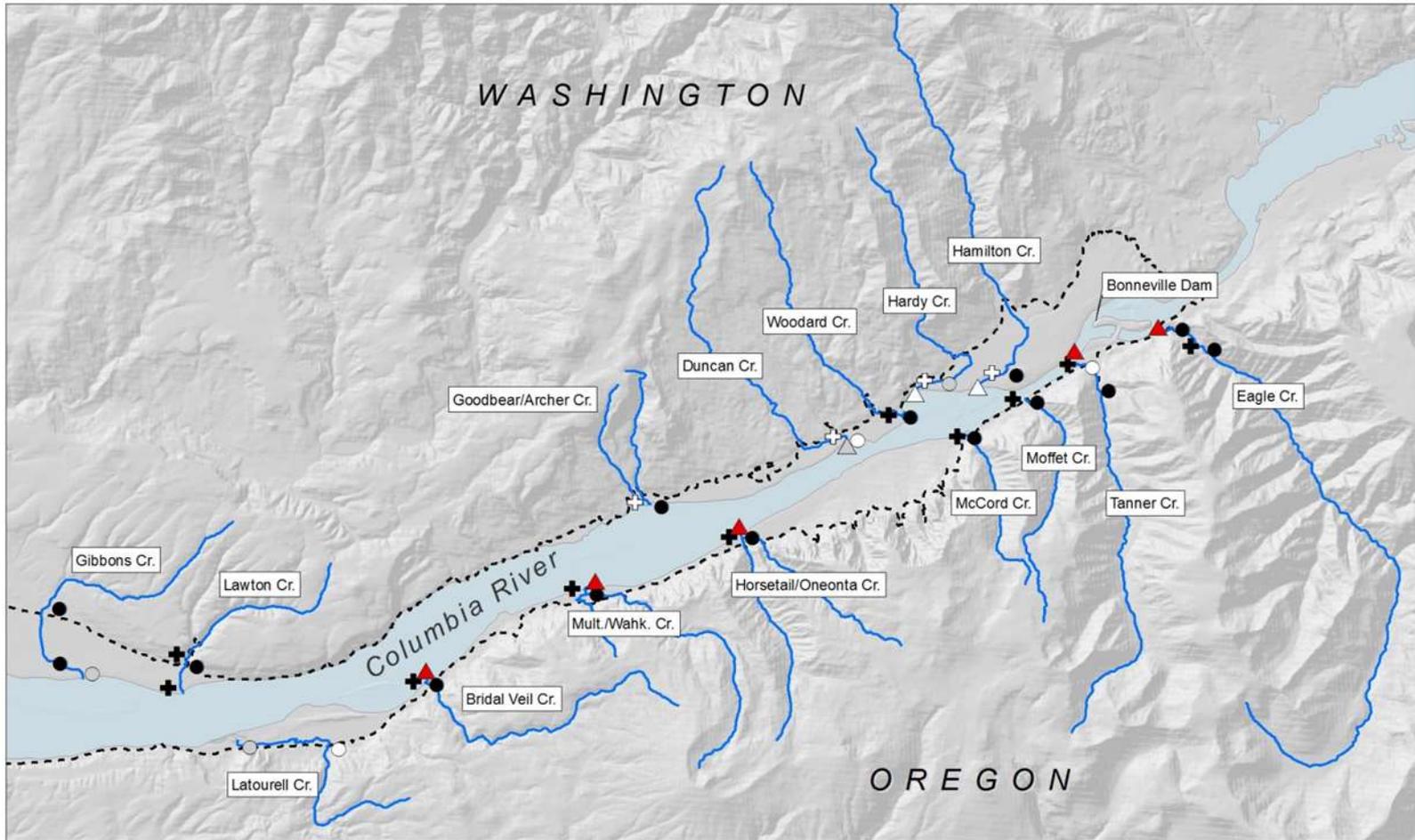


Columbia River DART (@ Washougal)

LCEP Ecosystem Monitoring (Amy Borde)

Monitoring Concerns: No flow in smaller tributaries
No connection @ confluences

Data Collection Summary



Lower Columbia River Gorge Thermal Refugia Assessment: 2014 - 2015 Data Collection Summary

Plume Mapping

- ▲ Plume observed, mapped
- △ Plume observed, not mapped
- △ Planned, not measured

Stream Discharge

- ⊕ Measured
- ⊕ Planned, not measured

Continuous Stream Temperature

- Full or partial record
- Data available, not downloaded
- Sensor lost, no record

--- Columbia R. floodplain boundary



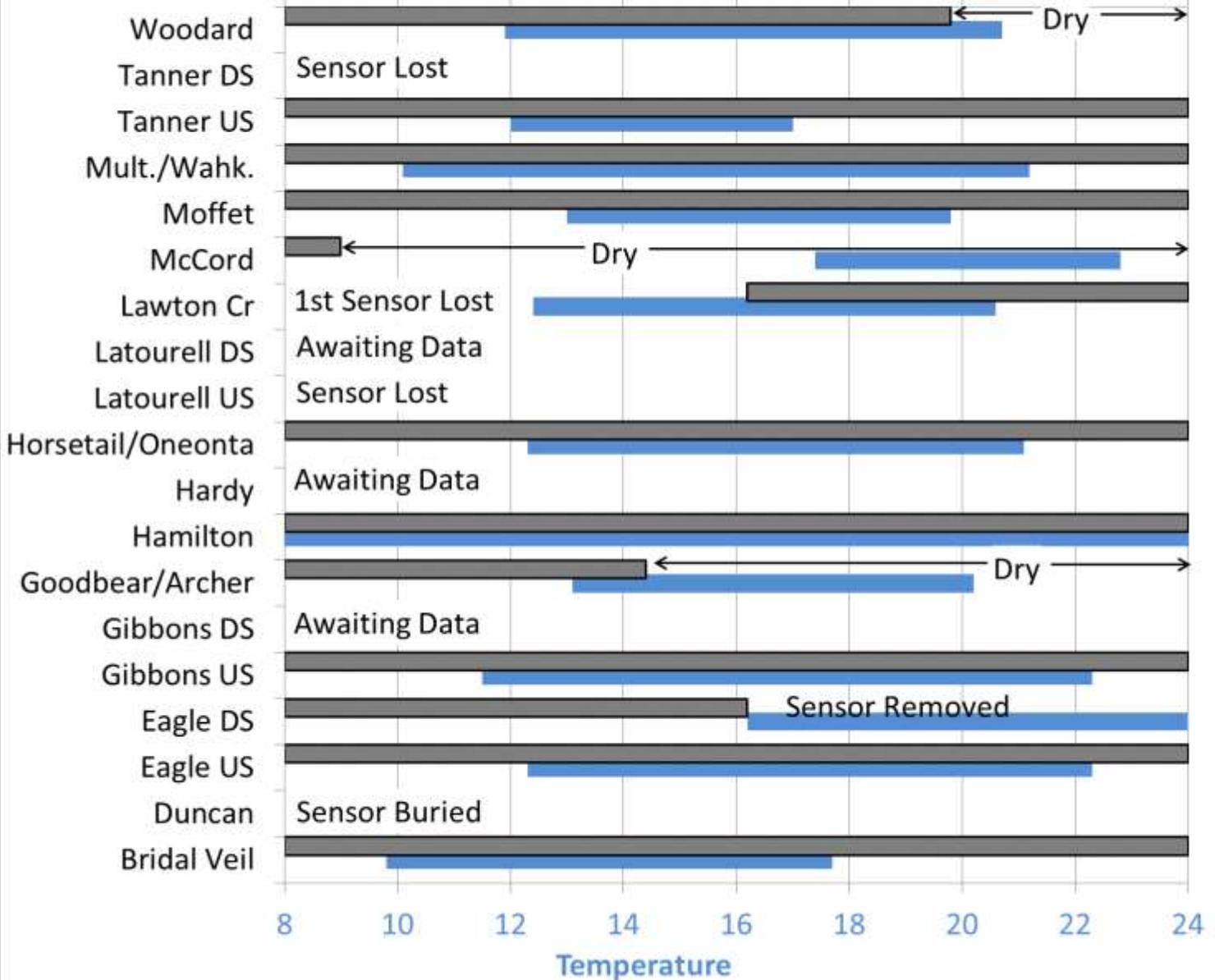
Stream Temperature Results

- Deployed 19 temperature sensors:
 - 4 lost or stolen
 - 3 awaiting data collection
 - 12 full or partial rRecords from 6/26/2015 – 9/14/2015
- 3 showed loss of surface flow intermittently or for the duration of period
(Goodbear/Archer, McCord, Woodard Creeks)



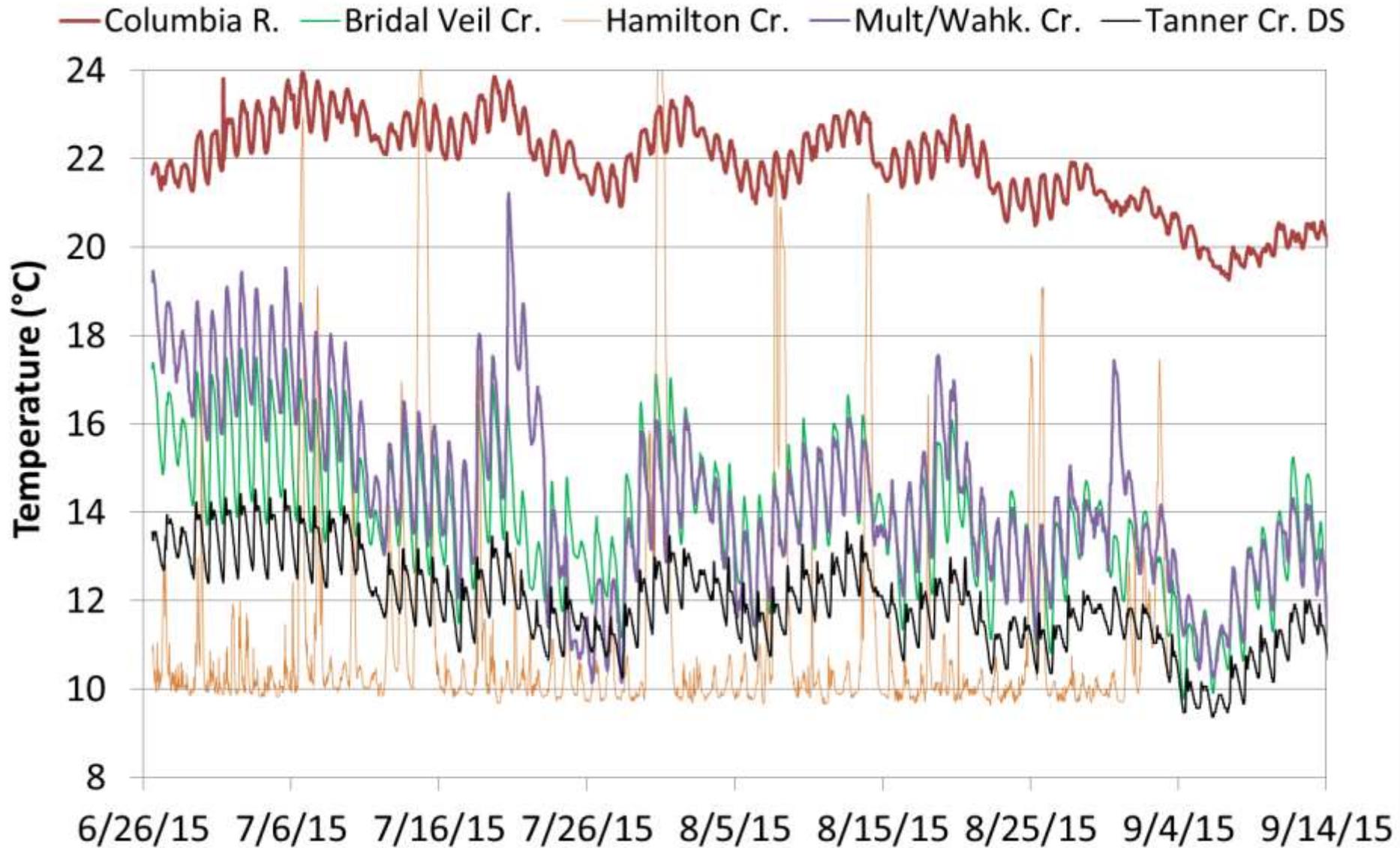
Monitoring Period (Day of Year Range)

177 187 197 207 217 227 237 247 257

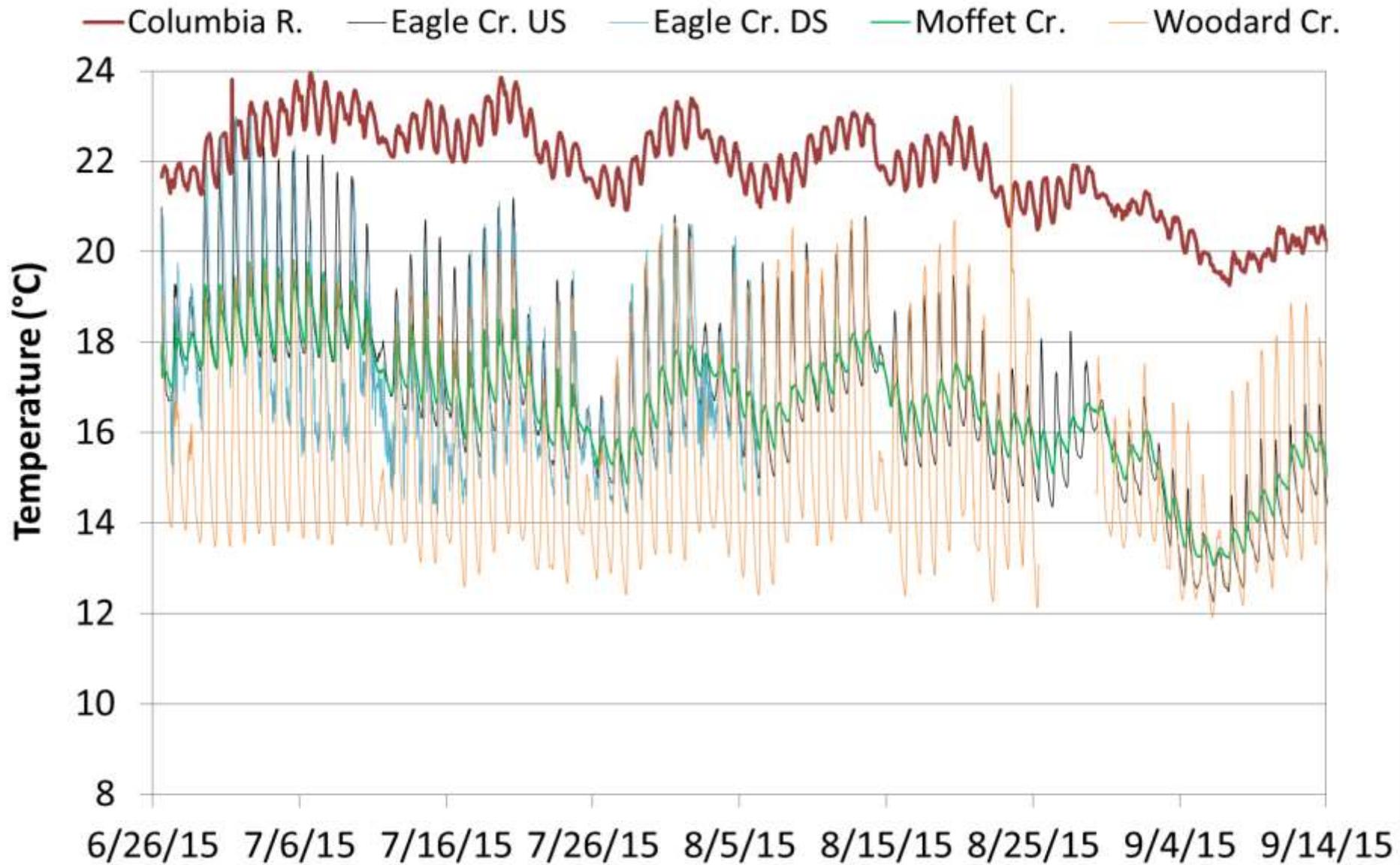


Day of Year:
177: Jun 26
257: Sep 14

Stream Temperature Results



Stream Temperature Results



Discharge Results

Measured above 9 of 15 tributary confluences

Tributary	Date Time	Q (cfs)	Date Time	Q (cfs)
Tanner Cr. DS	8/10/15 13:00	53		
Eagle Cr. US	8/11/15 10:30	13.9		
Bridal Veil Cr.	8/5/15 10:30	7.1		
Multnomah/ Wahkeena Cr.	7/29/14 10:00	6.5		
Horsetail/ Oneonta Cr.	8/11/15 14:30	1.8	8/14/14 13:00	3.9
Lawton Cr.	8/6/15 10:00	1.5		
McCord Cr.	8/10/15 11:30	1.1		
Moffet Cr.	8/11/15 11:00	0.4		
Woodard Cr.	8/6/15 11:00	< 0.5		

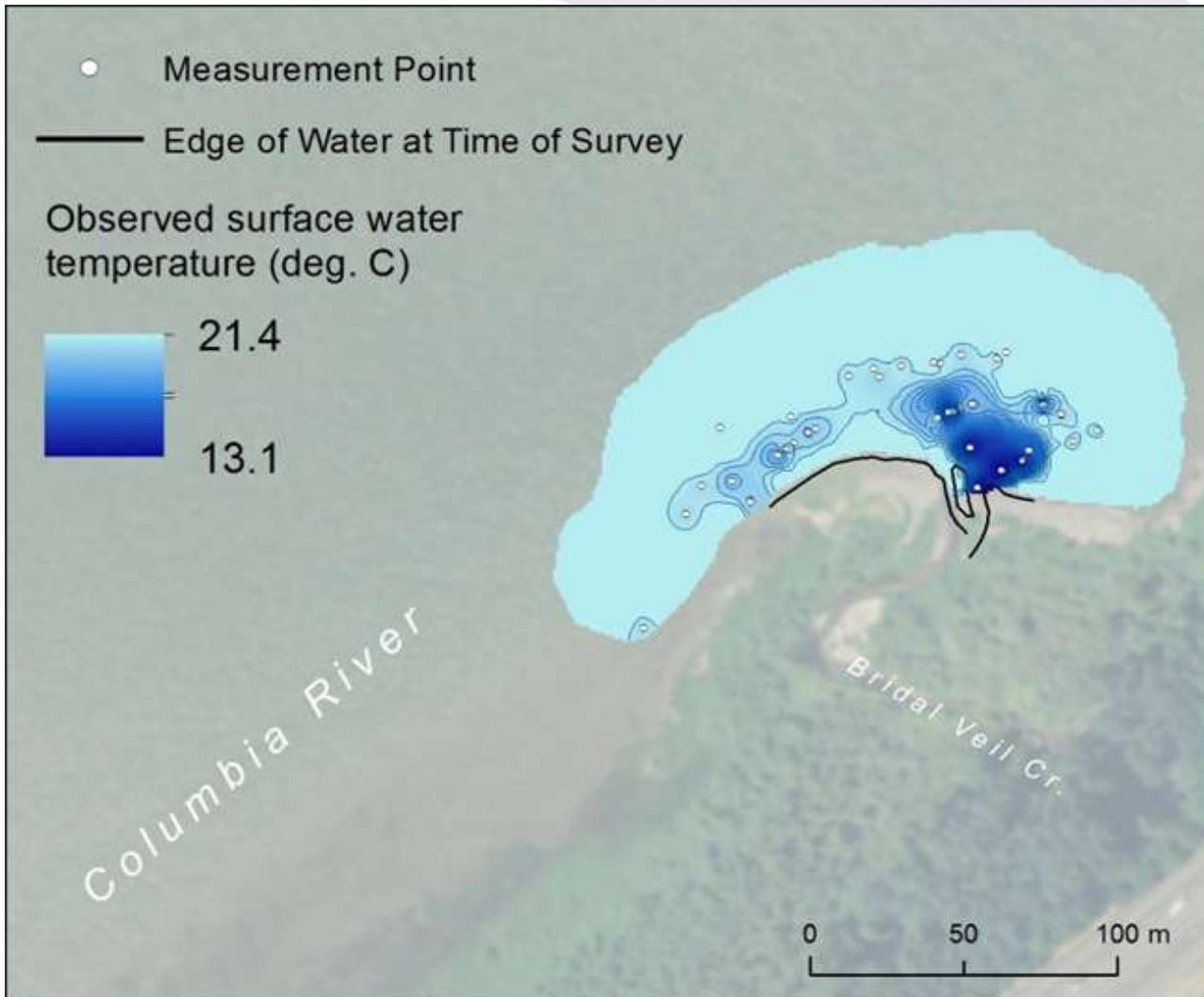
Cold Water Plume Observations

- Plume formation observed at 5 of 15 tributary complexes:
Bridal Veil, Multnomah, Horsetail, Tanner, Eagle Creeks
- All had discharges > 6 cfs
- Plumes were dynamic, varying with time and water depth
- Adult salmonids observed using Tanner, Eagle Creeks (hatchery tributaries)
- Adults also observed at Lawton Cr. confluence, where a significant plume was not detected.
- Potential for cold water formation at Duncan Creek confluence.

Cold Water Plume Observations

Bridal Veil Creek Confluence.

Mapped on 8/5/2015 at 11:30 am. Columbia River temperature = 21.4 °C)



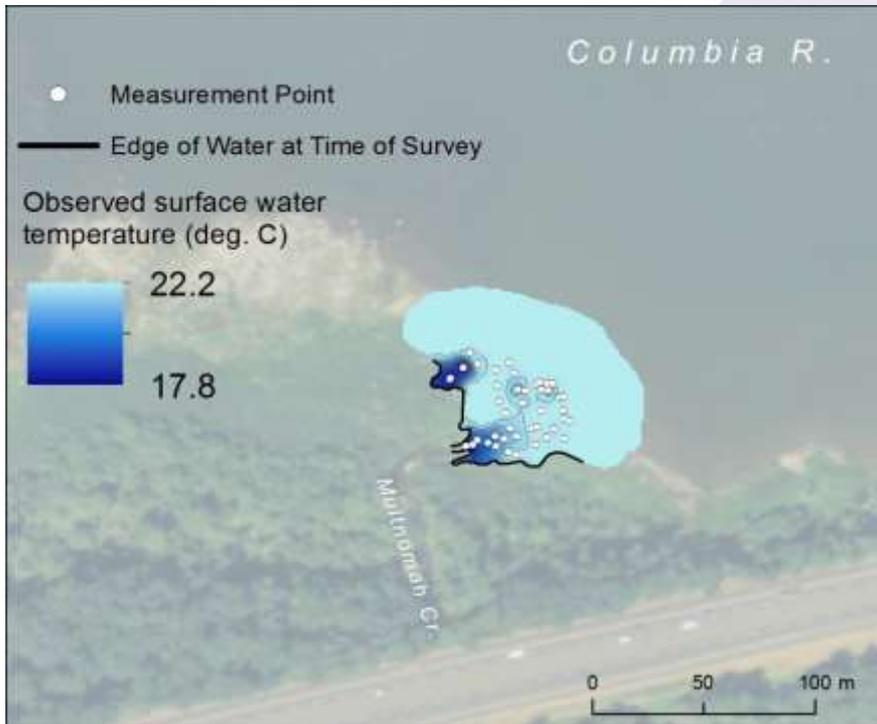
Surface Water Temperature (°C)	Acres
< 20	0.6
< 18	0.3
< 16	0.1

Cold Water Plume Observations

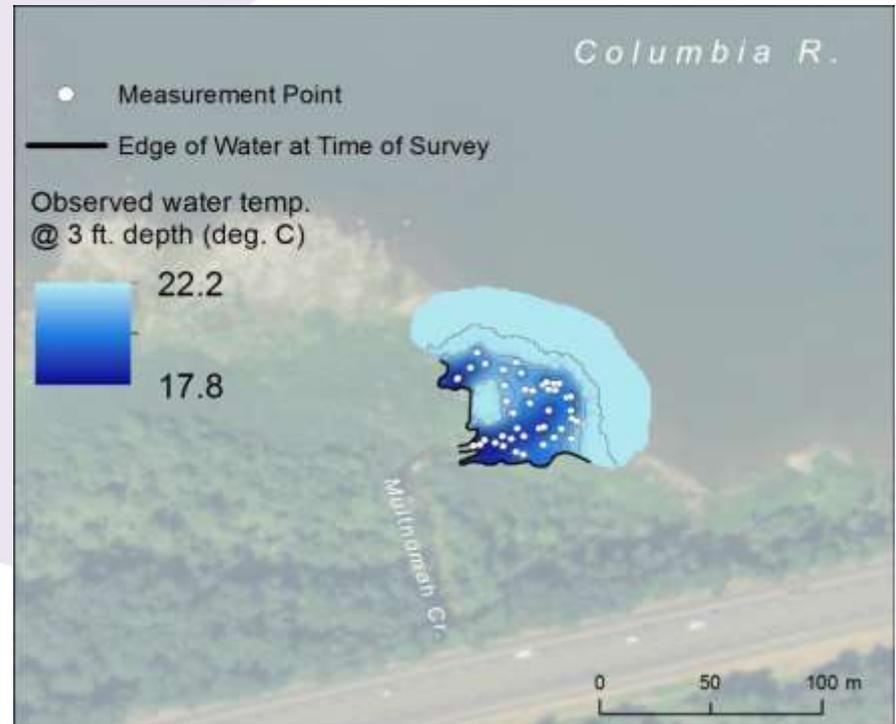
Multnomah/Wahkeena Creek Confluence.

Mapped on 7/29/2014 at 10:00 am. Columbia River temperature = 22.2 °C)

Surface Water (0-1 ft. depth)



3-4 ft. depth



Monitoring Results Summary (Temperature, Discharge, Plume)

Avg stream temp (deg C) Discharge (cfs) Observed Plume

11 - 12

0 - 1.5

yes

12 - 15

1.5 - 20

unk

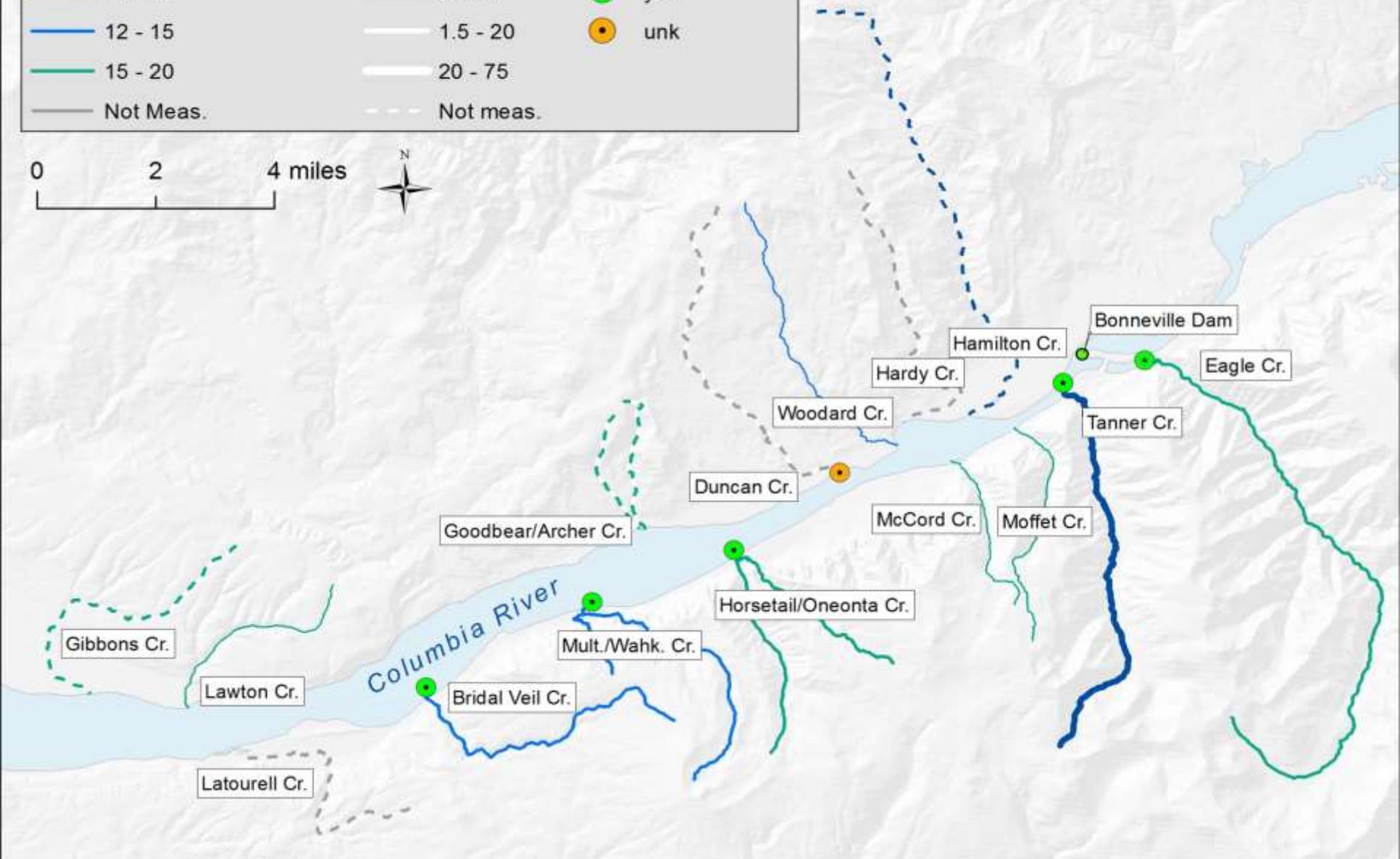
15 - 20

20 - 75

Not Meas.

Not meas.

0 2 4 miles



Final Observations

- *Average* temperatures for all tributaries monitored were 2 – 10 deg. C less than the Columbia R. for the period monitored.
- Lower flow tributaries that lost surface connection to the Columbia may have done so earlier in the 2015 summer compared to normal.
- Even at these streams, upstream reaches can still provide cold water refuge for juvenile salmonids (observed at McCord Creek).
- Still awaiting results for floodplain reach analysis.
- Cold water plumes were dynamic, varying with time and depth.
- Adult salmonids were observed to be using tributary confluences with and without cold water plumes.
- Further study planned in 2016.

A photograph of a small waterfall cascading into a stream. The water is clear and reflects the surrounding greenery. The stream is bordered by rocks and fallen leaves. The background is a dense forest with various shades of green.

Questions?

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