Enhancing Cold Water Refuges at Small Tributaries in the Lower Columbia River

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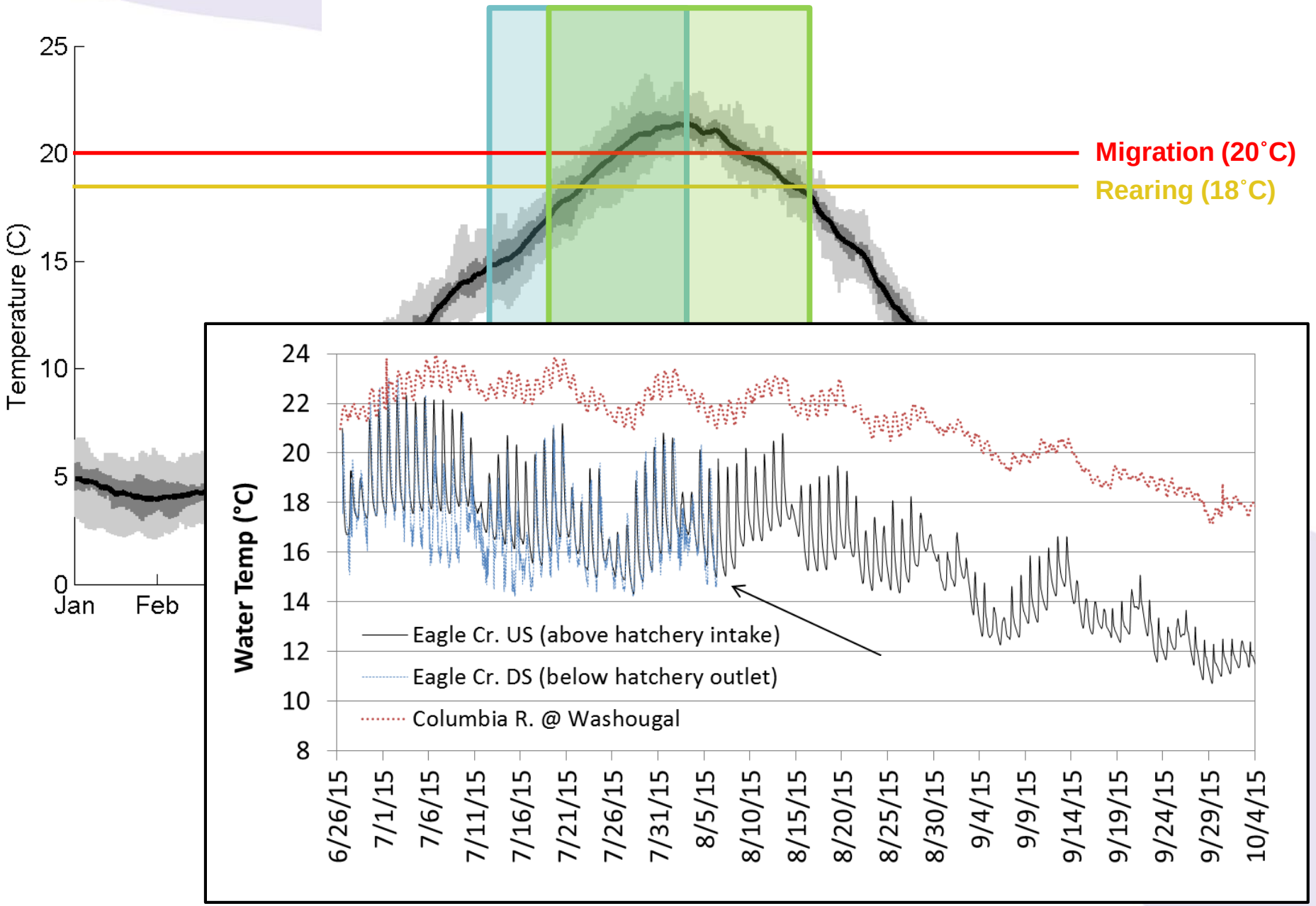
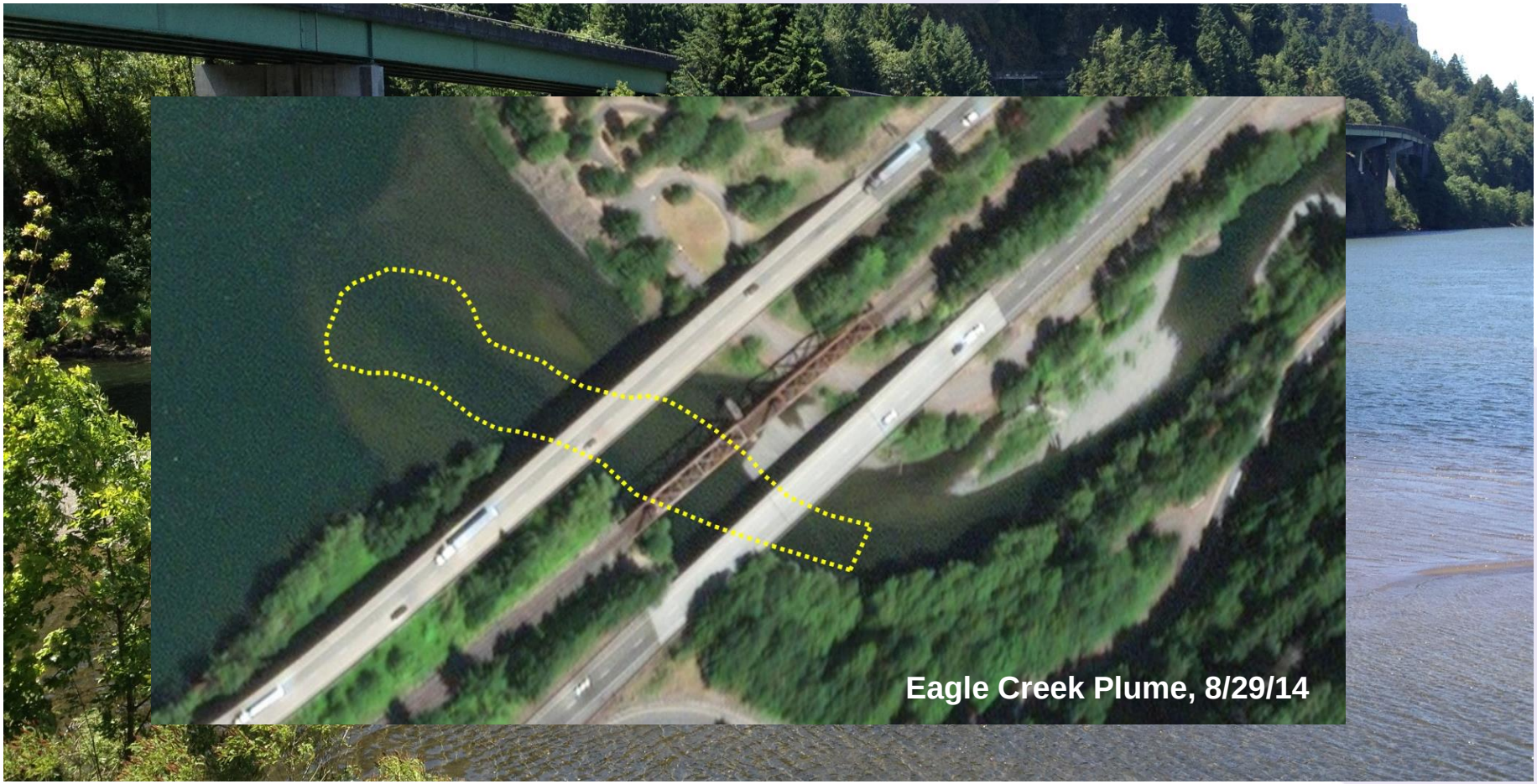
Lower Columbia Estuary Partnership

Mainstem thermal regime during migration



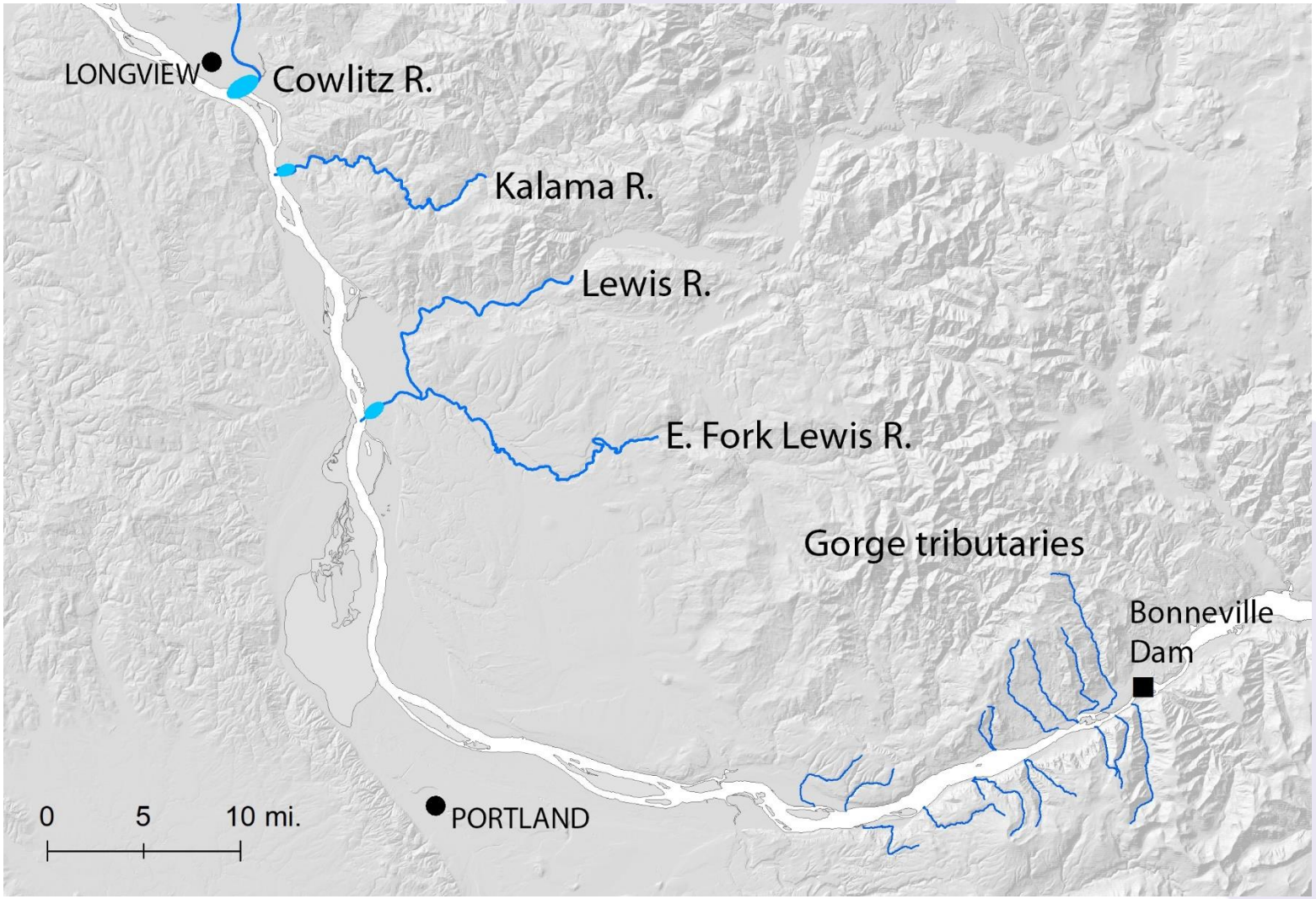
Cold water refuge – *initial thoughts and questions*

- **Question 1 – What are the characteristics of CWR?**
  - **Temperature:** > 2°C colder than mainstem Columbia (Keefer et al. 2011)
  - **Water depth:** juveniles > 0.5m water depth (Bottom et al. 2005)
    adults > 2m water depth (Johnson et al. 2010)
  - **Surface area:** ~1 acre (smallest plume reported above Bonneville Dam)



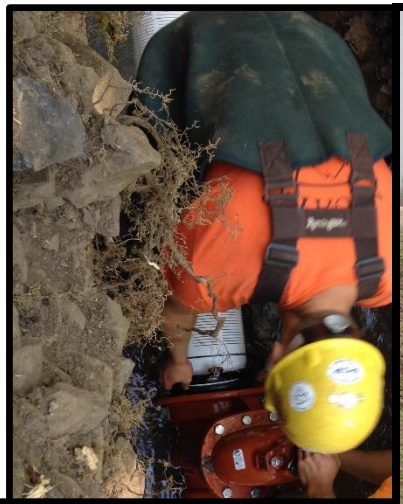
Cold water refuge – *initial thoughts and questions*

- **Question 2 – Where is CWR currently available in lower Columbia?**
  - No mainstem CWR (that meets study criteria) available between the Lewis River and Bonneville Dam (57 river miles)



Cold water refuge – *initial thoughts and questions*

- **Question 3 – What factors influence the formation of CWR plumes in the mainstem?**
  1. Water temperature: both in the tributary and mainstem
  2. Discharge: both in the tributary and mainstem Columbia River



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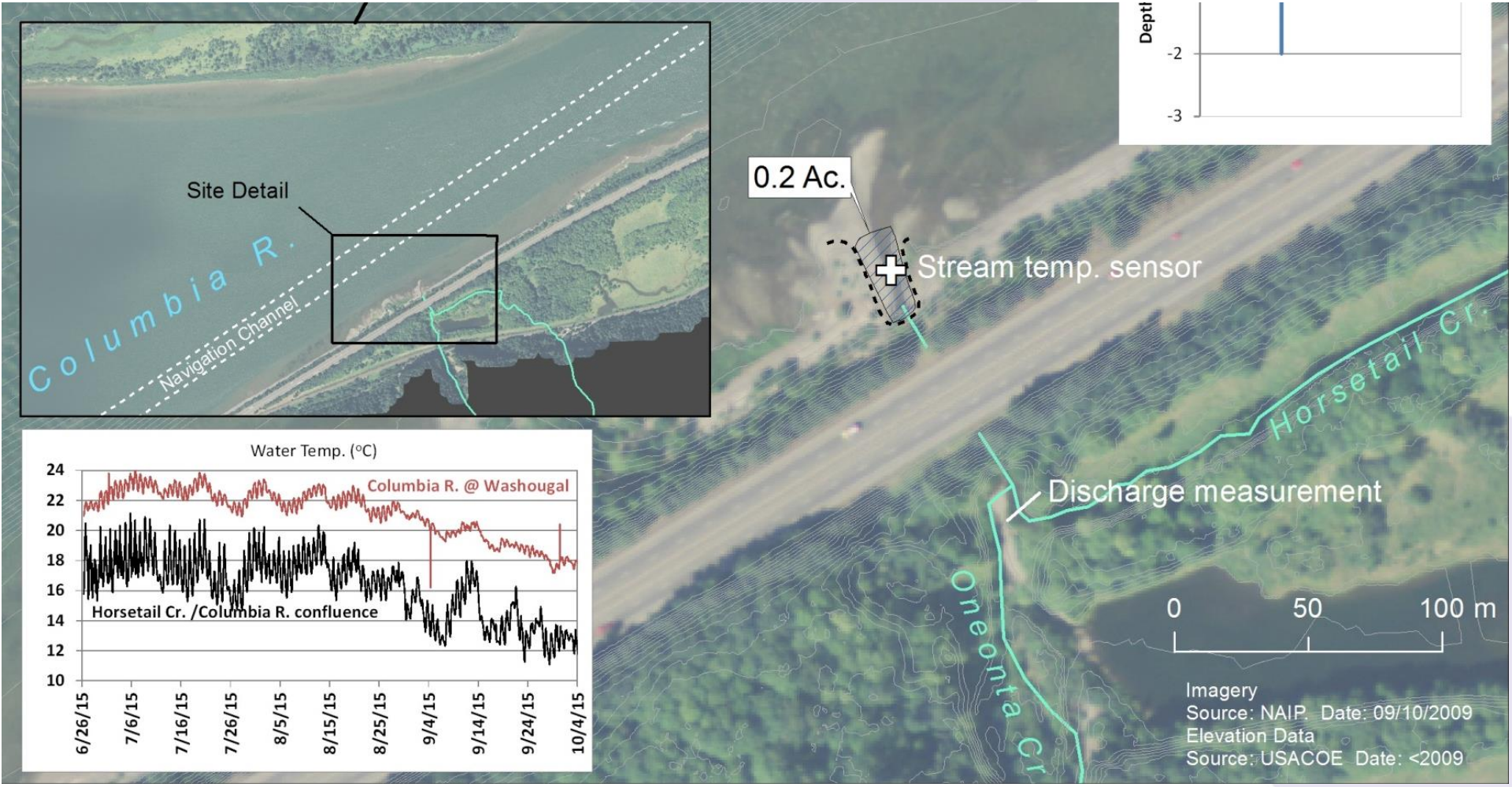
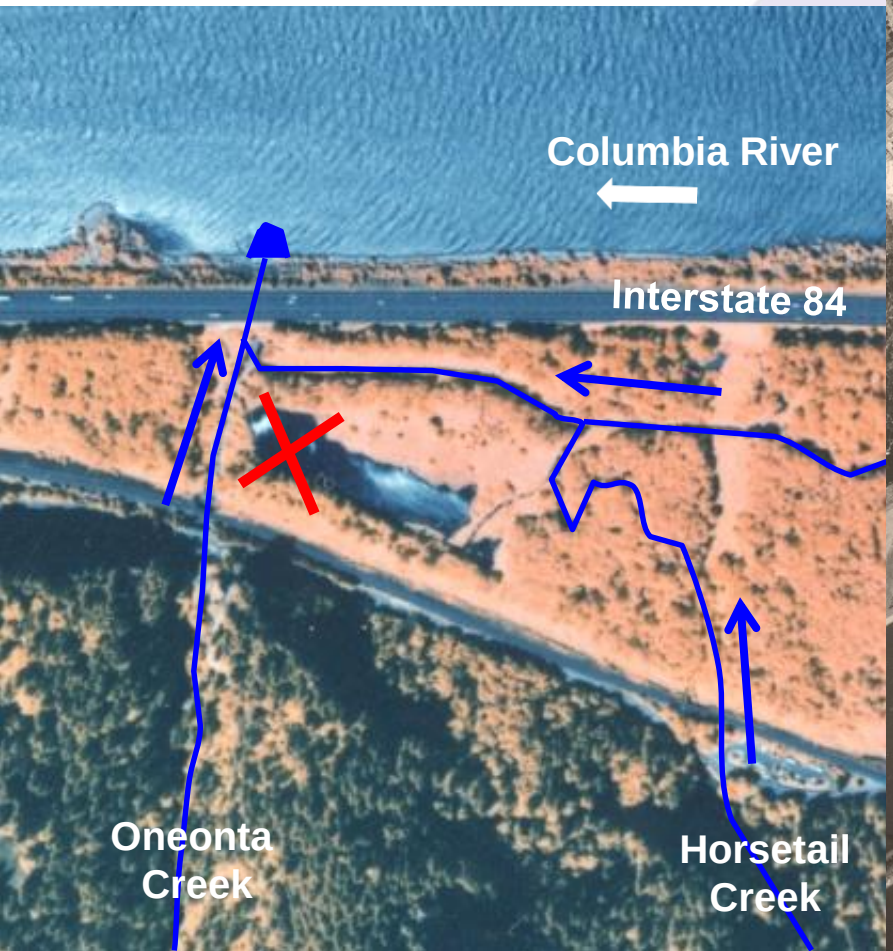


Cold water refuge – *initial thoughts a*

- **Question 3 – What factors influence the**
  1. Water temperature: both in th
  2. Discharge: both in the tributar
  3. Atmospheric conditions: solar
  4. Physical setting: topography im



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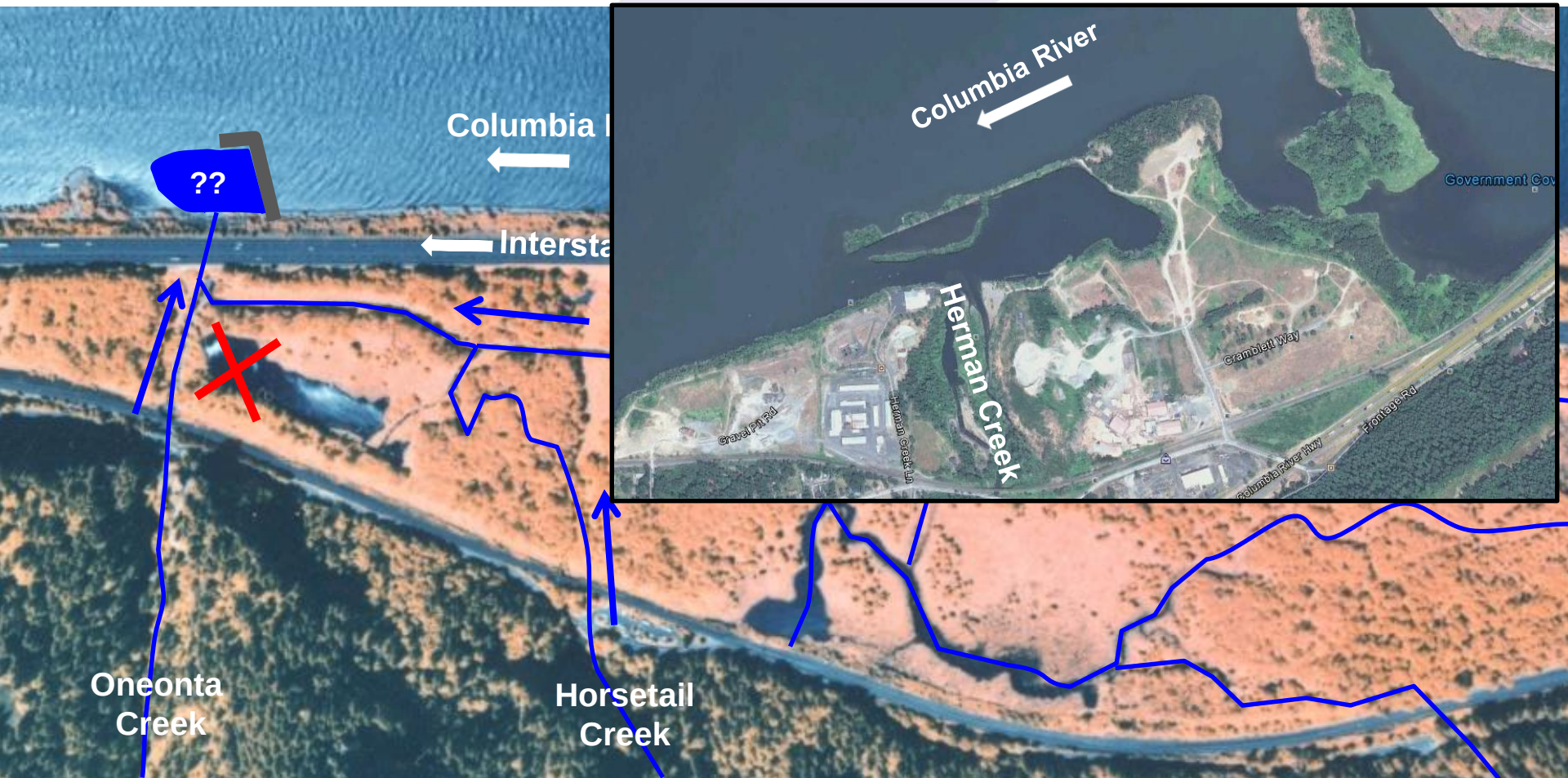
- **Question 3 – What factors influence the formation of CWR plumes in the mainstem?**
  1. Water temperature: both in the tributary and mainstem
  2. Discharge: both in the tributary and mainstem Columbia River
  3. Atmospheric conditions: solar radiation, wind
  4. Physical setting: bathymetry immediately within and surrounding confluence



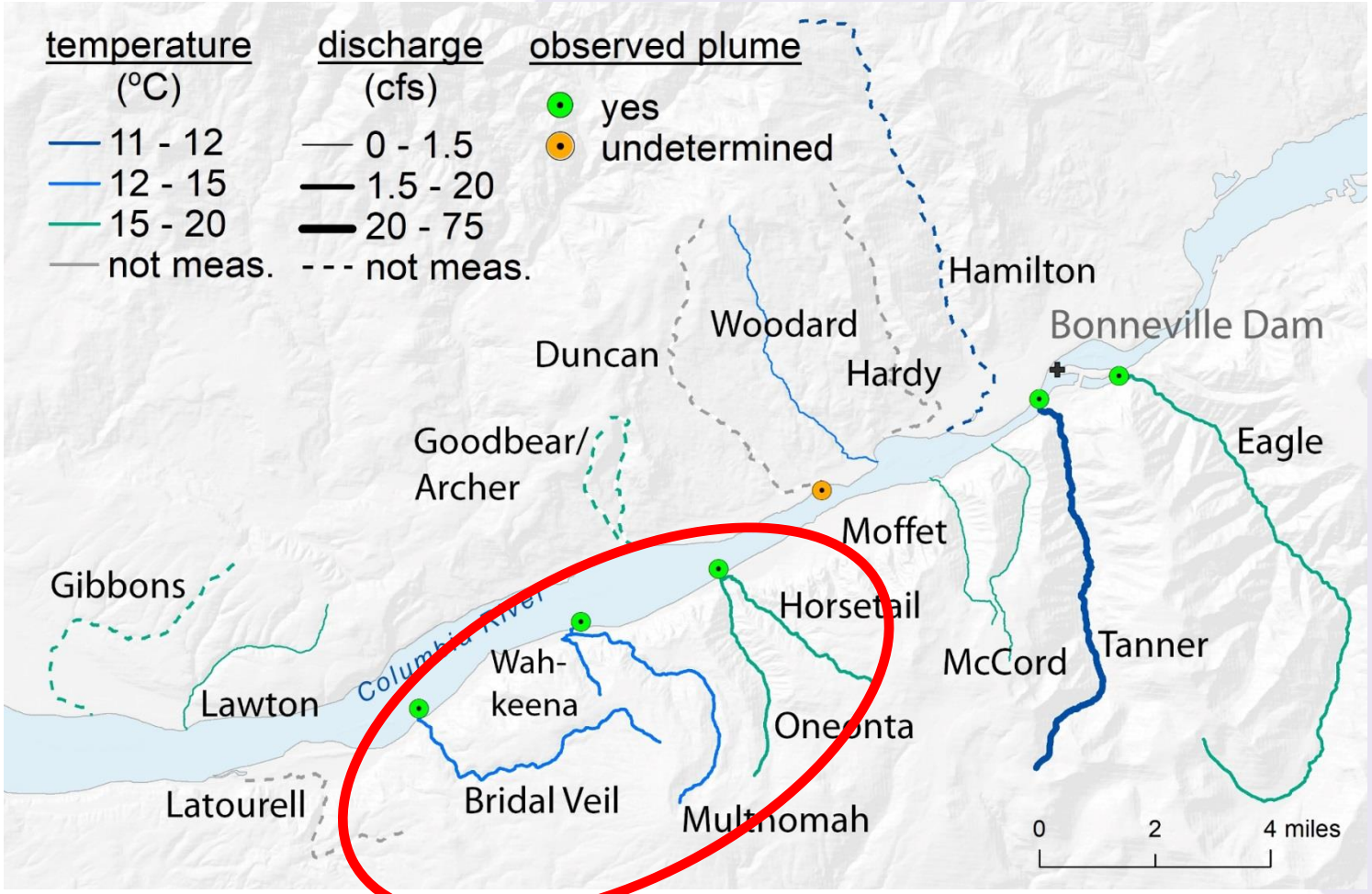
Cold water refuge – *Feasibility Study (Phase I)*

Purpose: **Assess feasibility of expanding cold water plumes in the mainstem Columbia River by manipulating nearshore topography.**

Approach:

- ❑ **Step 1: Select study sites**

  Selection criteria: discharge, temperature, location



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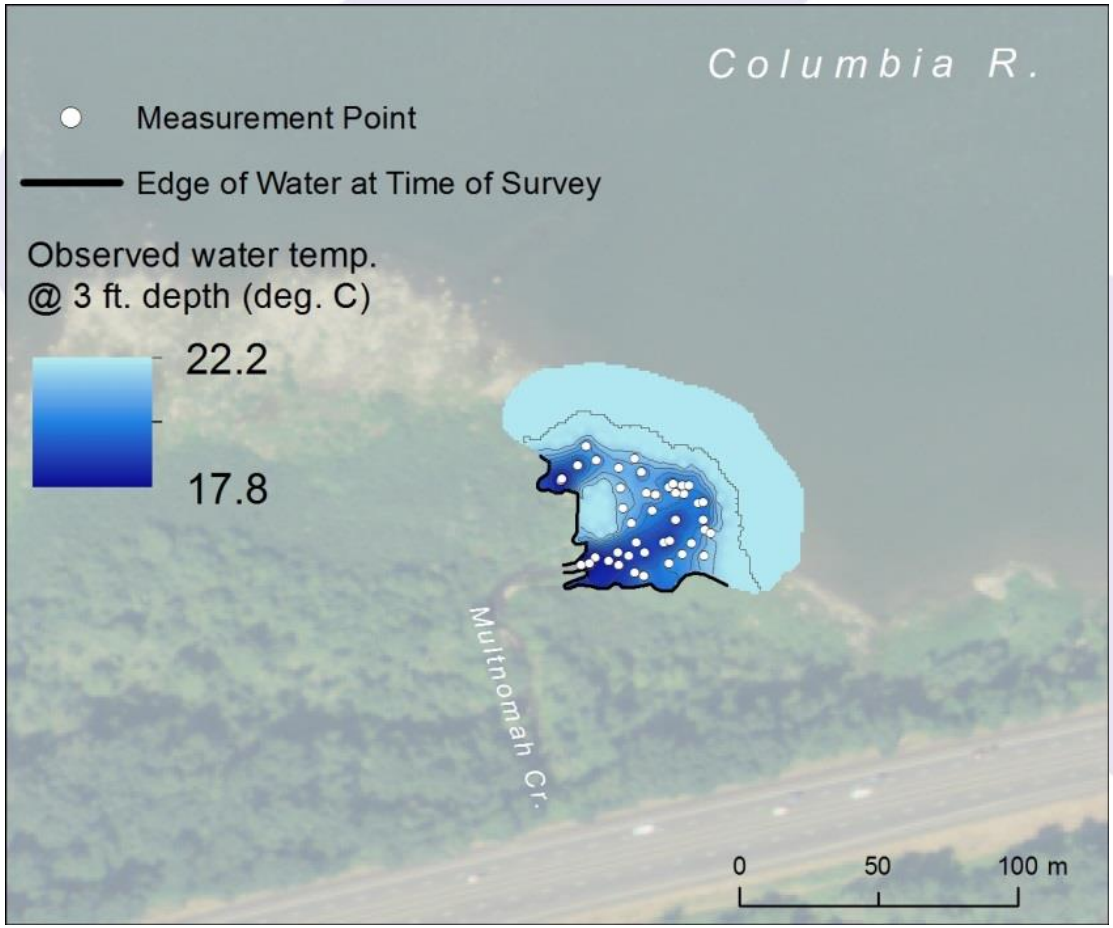
- ❑ **Step 1: Select study sites**
- ❑ **Step 2: Plume mapping (existing conditions)**

Used to validate model results and assess effectiveness of proposed alternatives.



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- ❑ **Step 1: Select study sites**
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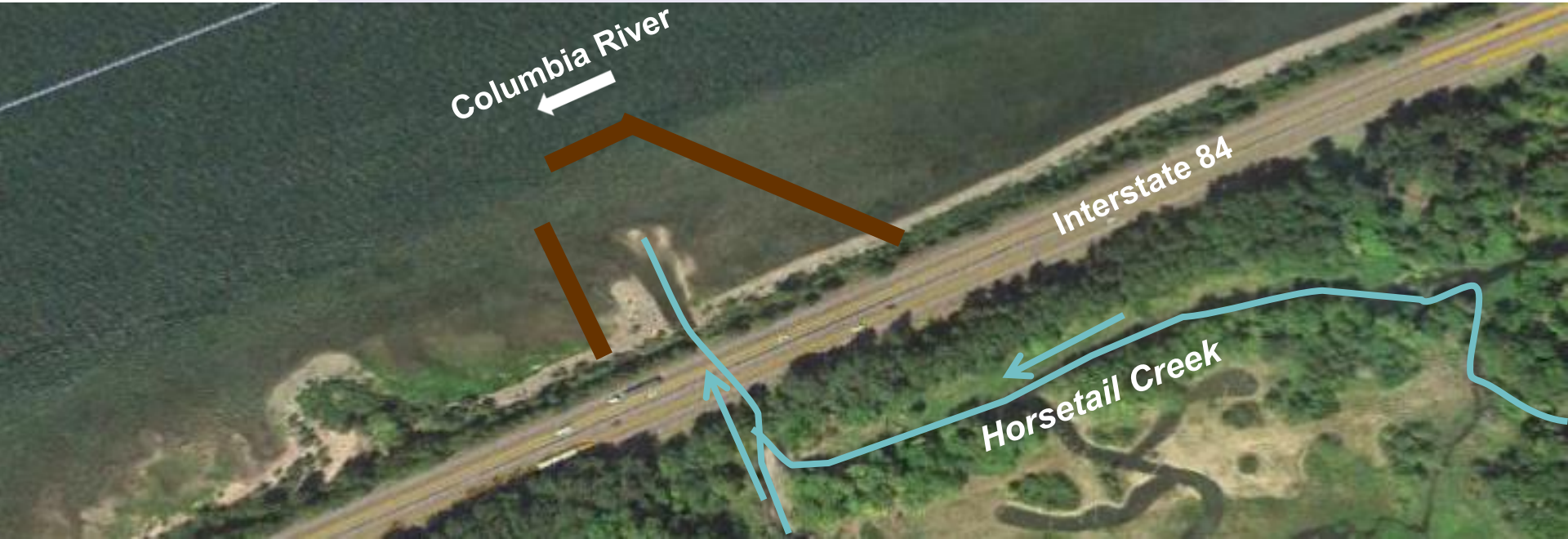
- ❑ **Step 3: Develop basic structure concepts**
  - A. Upstream diversion
  - B. Upstream diversion with downstream extension
  - C. Paired upstream and downstream structures



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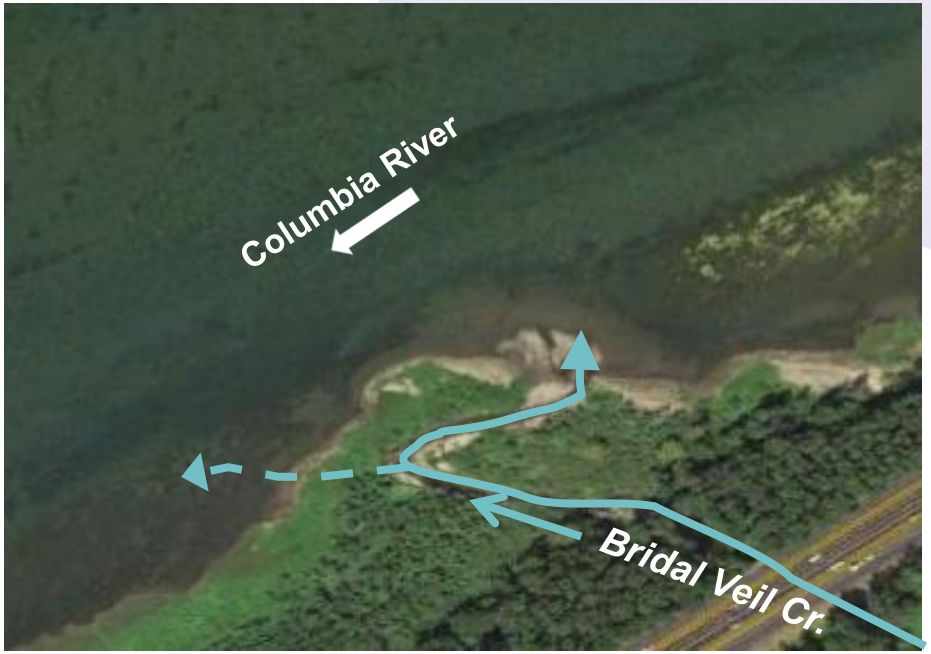
  - A. Upstream diversion
  - B. Upstream diversion with downstream extension
  - C. Paired upstream and downstream diversion structures
  - D. Re-route stream to downstream side of alluvial fan
  - E. Various combinations of above



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- **Step 1: Select study sites**
- **Step 2: Plume mapping (existing conditions)**
- **Step 3: Develop basic structure concepts**
- **Step 4: 3-D modeling to assess potential of each concept design at each of three sites**
  - Quantify plume size using depth and temperature criteria

Bridal Veil Creek

Cold water refuge – *Feasibility Study (Phase I)*

Model Results: Temperature Variability (ΔT vs. time, where $\Delta T = T_{max.\,enclosure} - T_{existing\ condition}$)

Variations are due to:

- mainstem flow
- atmospheric heating/cooling
- wind strength

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- **Step 4: 3-D modeling to assess potential of each concept design at each of three sites**
  - Quantify plume size using depth and temperature criteria
- **Step 5: Alternatives assessment**
  - Are we having an effect? (compare sizes of existing and modeled plumes)
  - Does modeled plume meet CWR criteria for juveniles and adults?
  - Which is most cost-effective? (ratio of structure length to plume size)
- **Step 6: Select and develop alternatives** (two per site, including concept designs)

Bridal Veil Creek

Cold water refuge – *Feasibility Study (Phase I)*

Step 6: **Concept designs**

- **Primary goal: force local hydraulics to create CWR plumes**
- **Secondary goals: cover, food web, hydraulic refugia, atmospheric conditions, etc.**
- **Structure intensity: *LWD Jam* → *Landform***

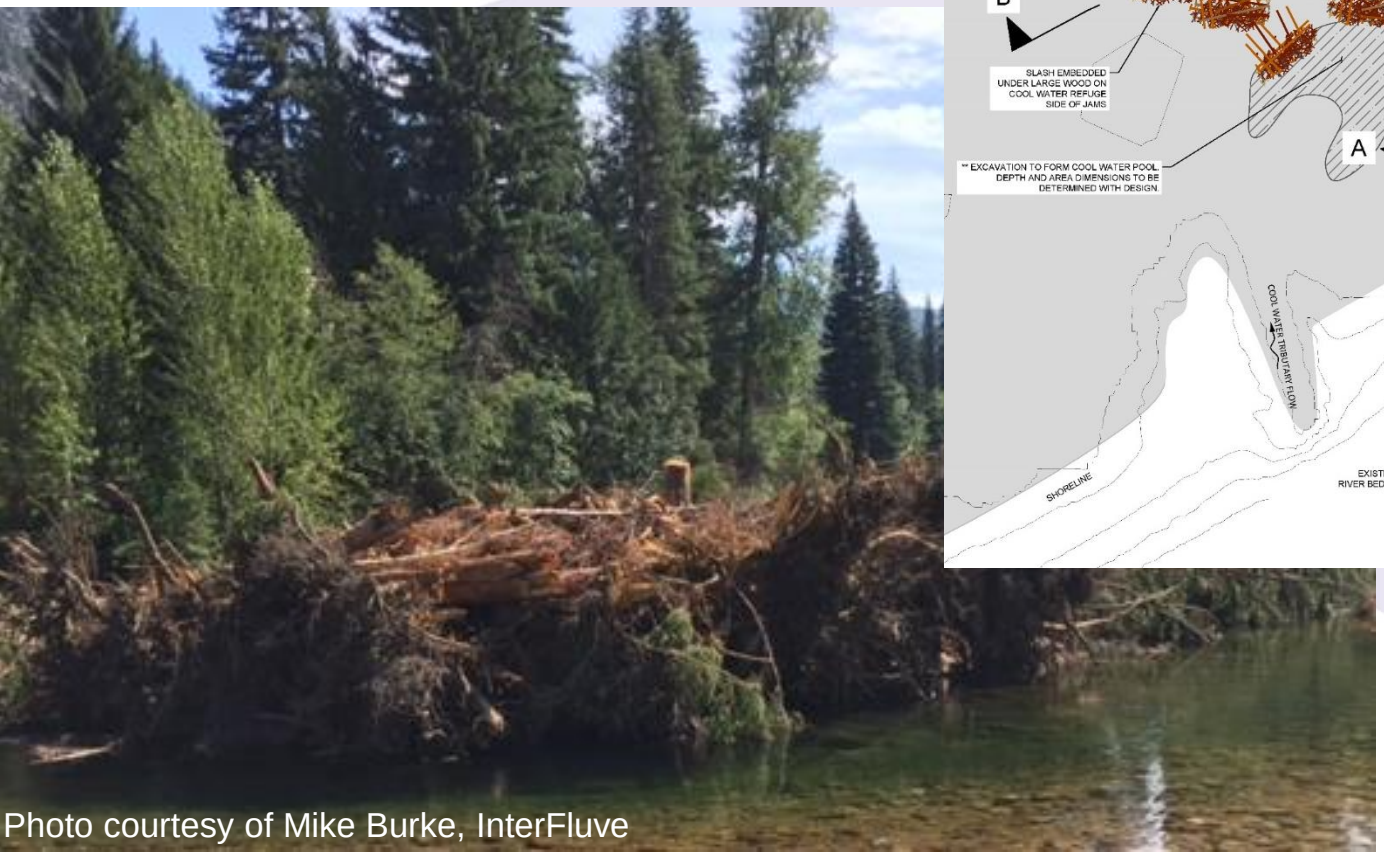
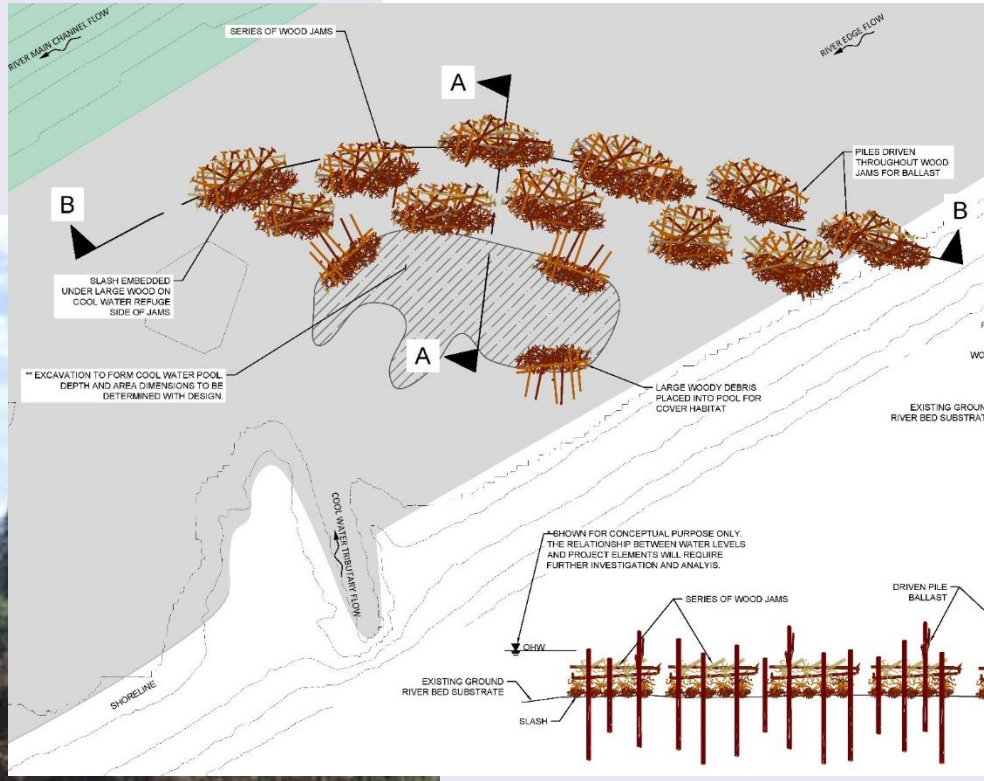


Photo courtesy of Mike Burke, InterFluve



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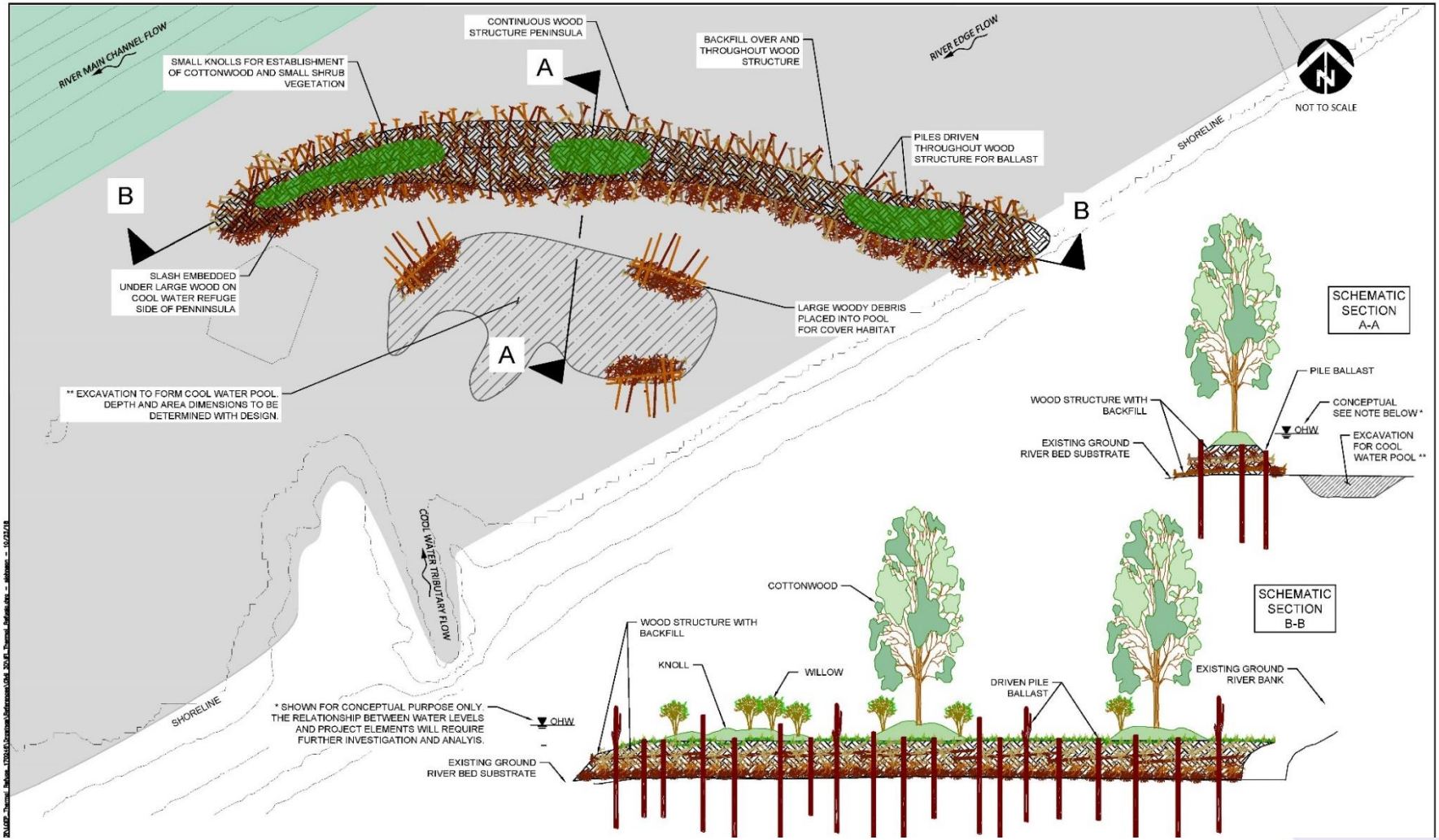

Cold water refuge – *Feasibility Study (Phase I)*

Caveats: **Initial assessment, which ignores Phase II questions, such as….**

- **Geomorphic processes (tributary sediment load, Col. River sediment transport)**
- **Impacts to existing alluvial fan processes/habitats**
- **Design specifics (porosity, materials, etc.)**
- **Public safety**
- **Life span of structures**
- **Required maintenance**
- **Etc….**

Horsetail Creek

Acknowledgements…. EPA
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