Lessons learned from decadal-scale evaluations of river restoration projects

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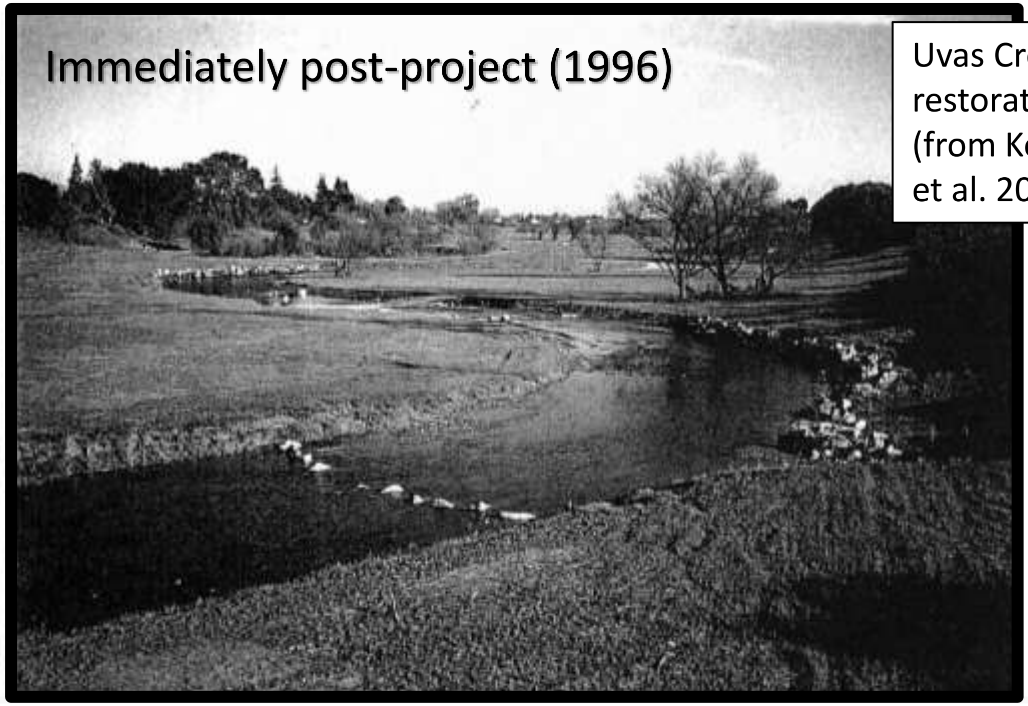
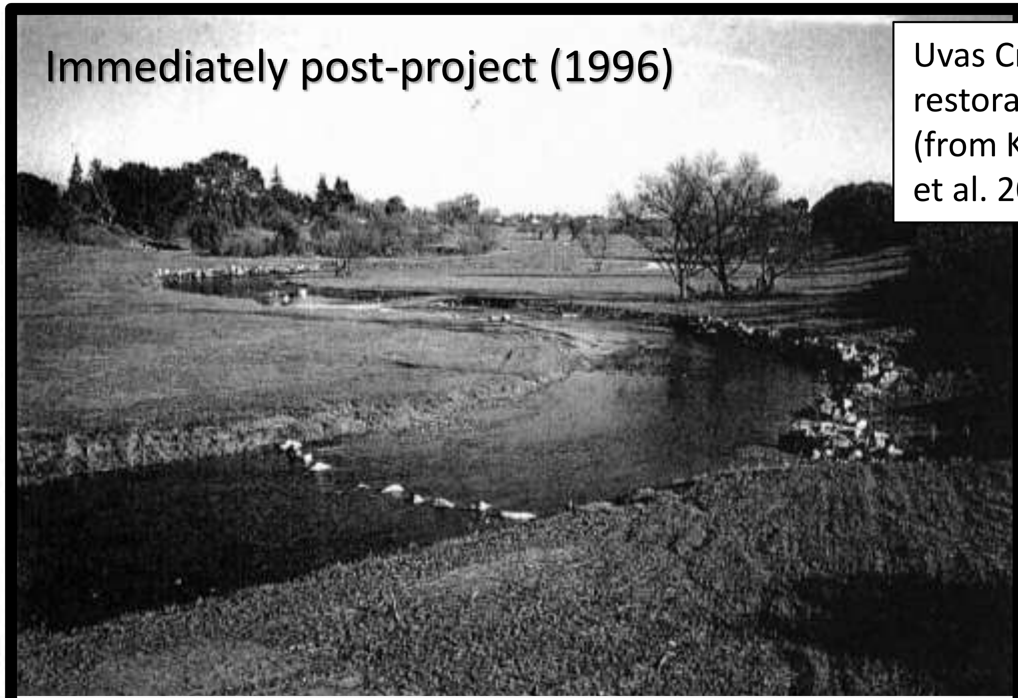
Stream Restoration Webinar Series: The Evolution of Stream Restoration June 4, 2024



Uvas Creek restoration (from Kondolf et al. 2001)

San Clemente Dam removal (2016)

Uvas Creek restoration (from Kondolf et al. 2001)



San Clemente Dam removal (2016)

LITERATURE REVIEW:

Synthesis of 316 publications world-wide, 1983-2019

Journal of Environmental Management 264 (2020) 110417

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: http://www.elsevier.com/locate/jenvman

ELSEVIER

Research article

Over forty years of lowland stream restoration: Lessons learned?

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"Stream restoration efforts have increased, but **the success rate is still rather low**…Measures are still mainly focused on hydromorphological techniques, while biological goals remain underexposed and therefore need to be better targeted. Moreover, restoration practices occur mainly on small scales, **despite the widely recognized relevance of tackling multiple stressors acting over large scales** for stream ecosystem recovery."

91 European projects, monitored for 1-12 years

Ecological Indicators 58 (2015) 311–321

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Review

The effect of river restoration on fish, macroinvertebrates and aquatic macrophytes: A meta-analysis

Jochem Kail[a,*], Karel Brabec[b], Michaela Poppe[c], Kathrin Januschke[a]

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"Results indicated significant effects of restoration on all three organism groups, especially of widening projects on macrophyte richness/diversity, instream measures on fish and macroinvertebrates, and higher effects on abundance/biomass compared to richness/diversity…Project age was the most important factor but had non-linear and even negative effects on outcomes, indicating that **restoration effects may vanish over time**."

Informed by review of 813 European projects

CHAPTER ELEVEN

Effective River Restoration in the 21st Century: From Trial and Error to Novel Evidence-Based Approaches

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"We conclude that river restorations conducted up until now have had highly variable effects with, **on balance, more positives than negatives**. This modest success rate can partly be attributed to the fact that the catchment filter is largely ignored; large-scale pressures related to catchment land use or the lack of source populations for the recolonization of the restored habitats are inadequately considered. The key reason for this shortfall is a lack of clear objective setting and planning processes. Furthermore, we suggest that there has been **a focus on form rather than processes and functioning in river restoration**, which has truncated the evolution of geomorphic features and any dynamic interaction with biota."

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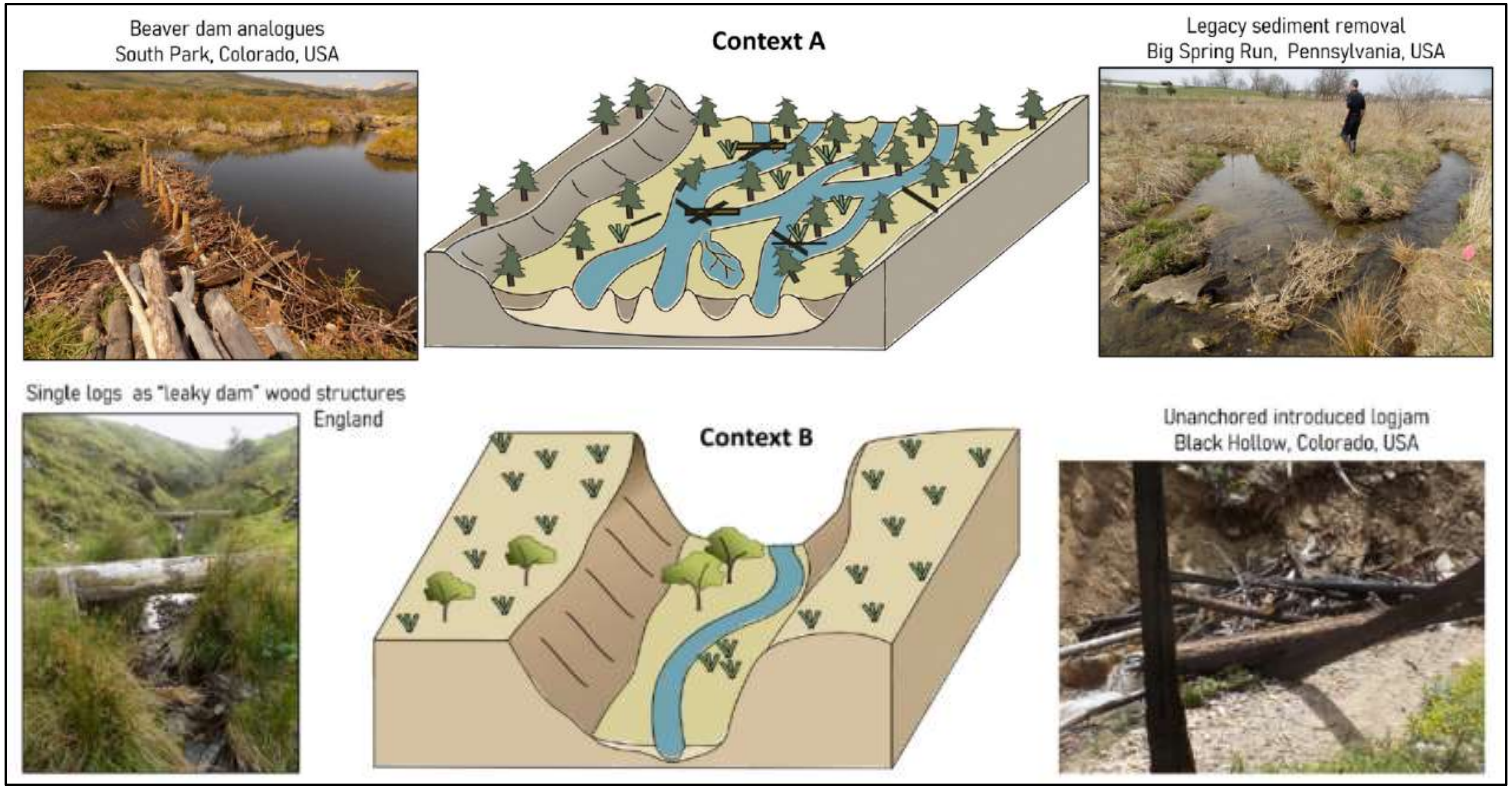
DOI: 10.1002/rra.4236

RESEARCH ARTICLE

WILEY

Geomorphic context in process-based river restoration

Ellen Wohl[1] | Sara Rathburn[1] | Sarah Dunn[1] | Emily Iskin[1,2] | Aaron Katz[1] | Anna Marshall[1] | Mickey Means-Brous[1] | Julianne Scamardo[1,3] | Shayla Triantafillou[1] | Hiromi Uno[1]



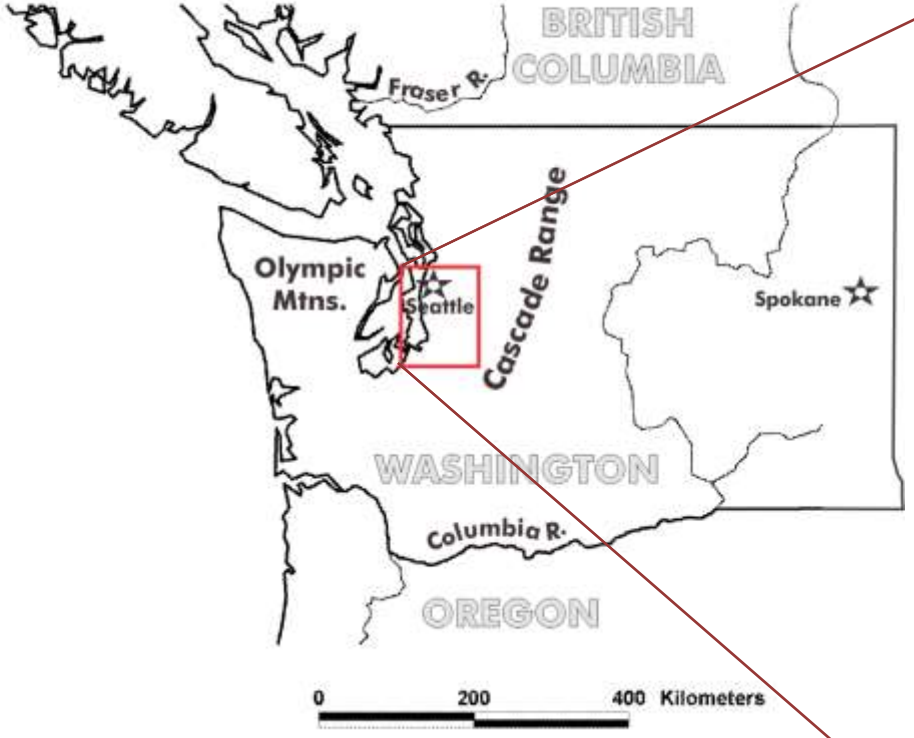
"Process-based restoration can fail to produce the desired results if geomorphic context is not effectively incorporated into restoration design…an understanding of geomorphic context can be used to select a restoration approach, and we provide examples of how **restoration can fail to achieve desired outcomes when geomorphic context is not considered**."

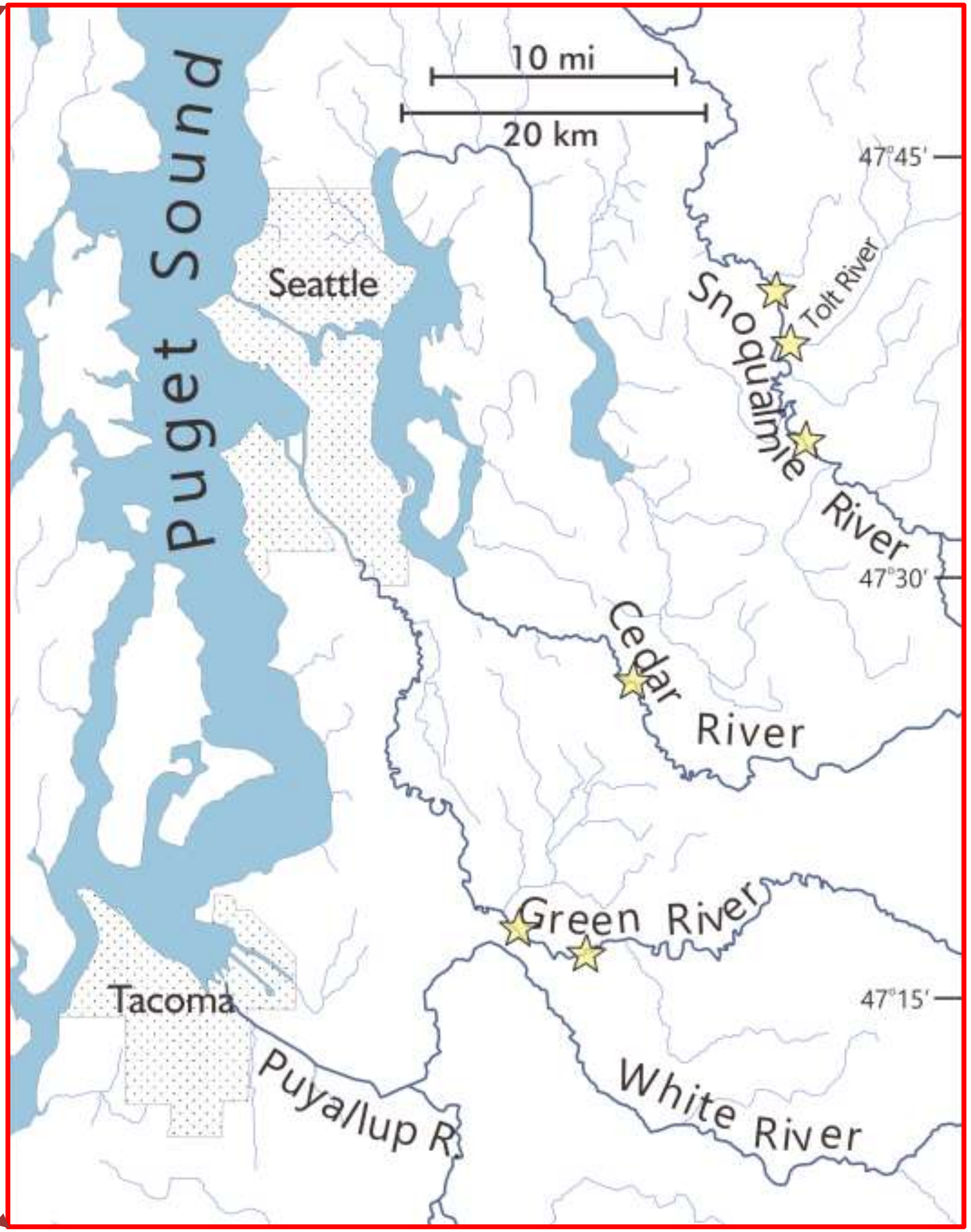
A summary of these reviews:

- Restoration “works,” although results are typically modest at best.
- Documented *physical* improvements are more widespread than biological ones.
- Most restoration projects do not address the root cause(s) of impaired processes, or act at the necessary scale to correct those underlying causes.

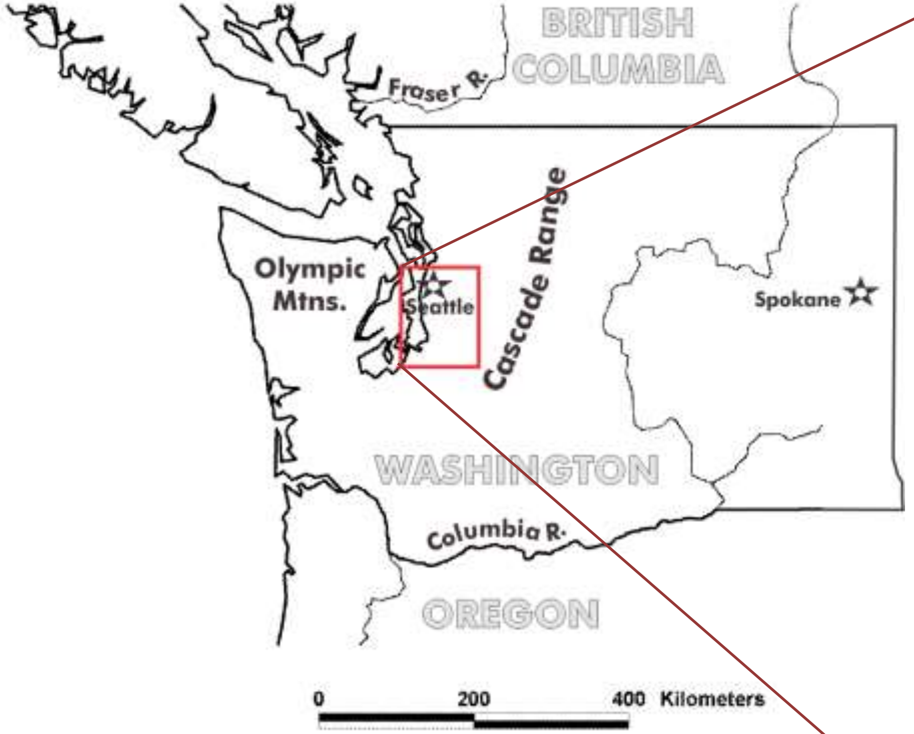
What can we learn from recent project examples?

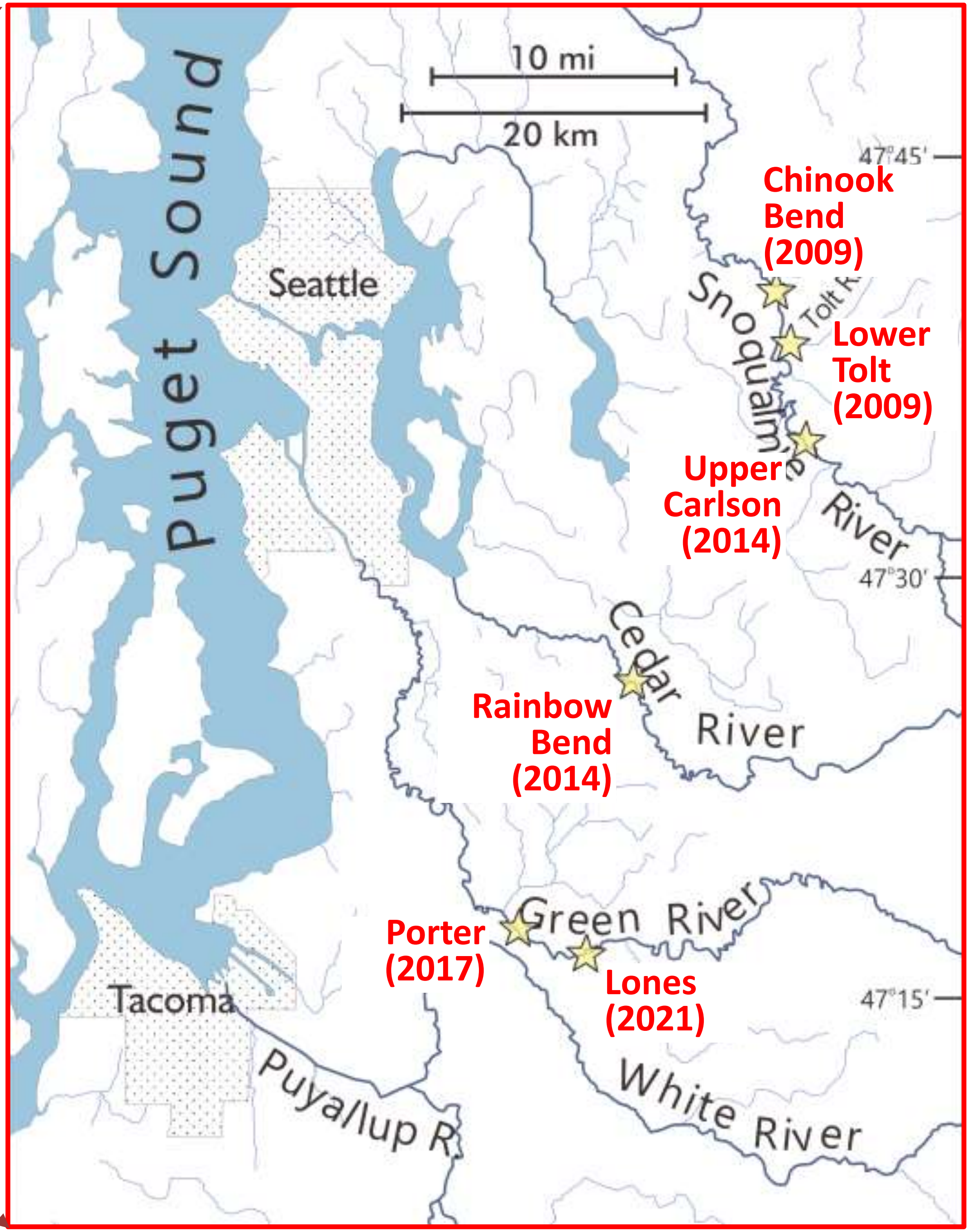
PROJECT EXAMPLES FROM WESTERN WASHINGTON



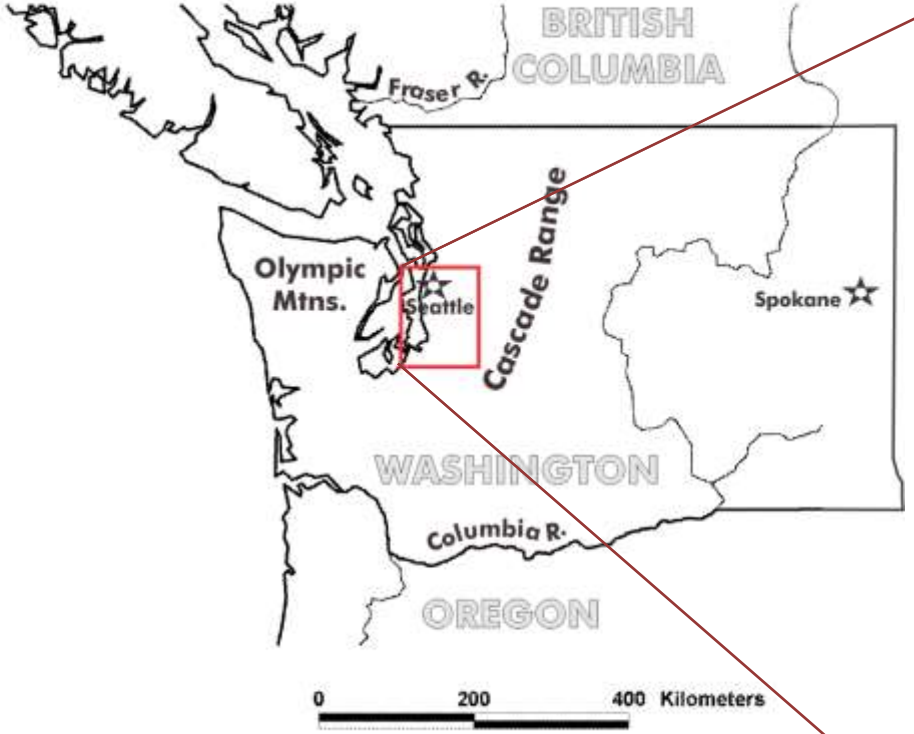


6 project along three major rivers of western WA, constructed 2009-2021





6 project along three major rivers of western WA, constructed 2009-2021


BRITISH COLUMBIA
Fraser R.
Olympic Mtns.
Seattle
Cascade Range
Spokane
WASHINGTON
Columbia R.
OREGON
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200
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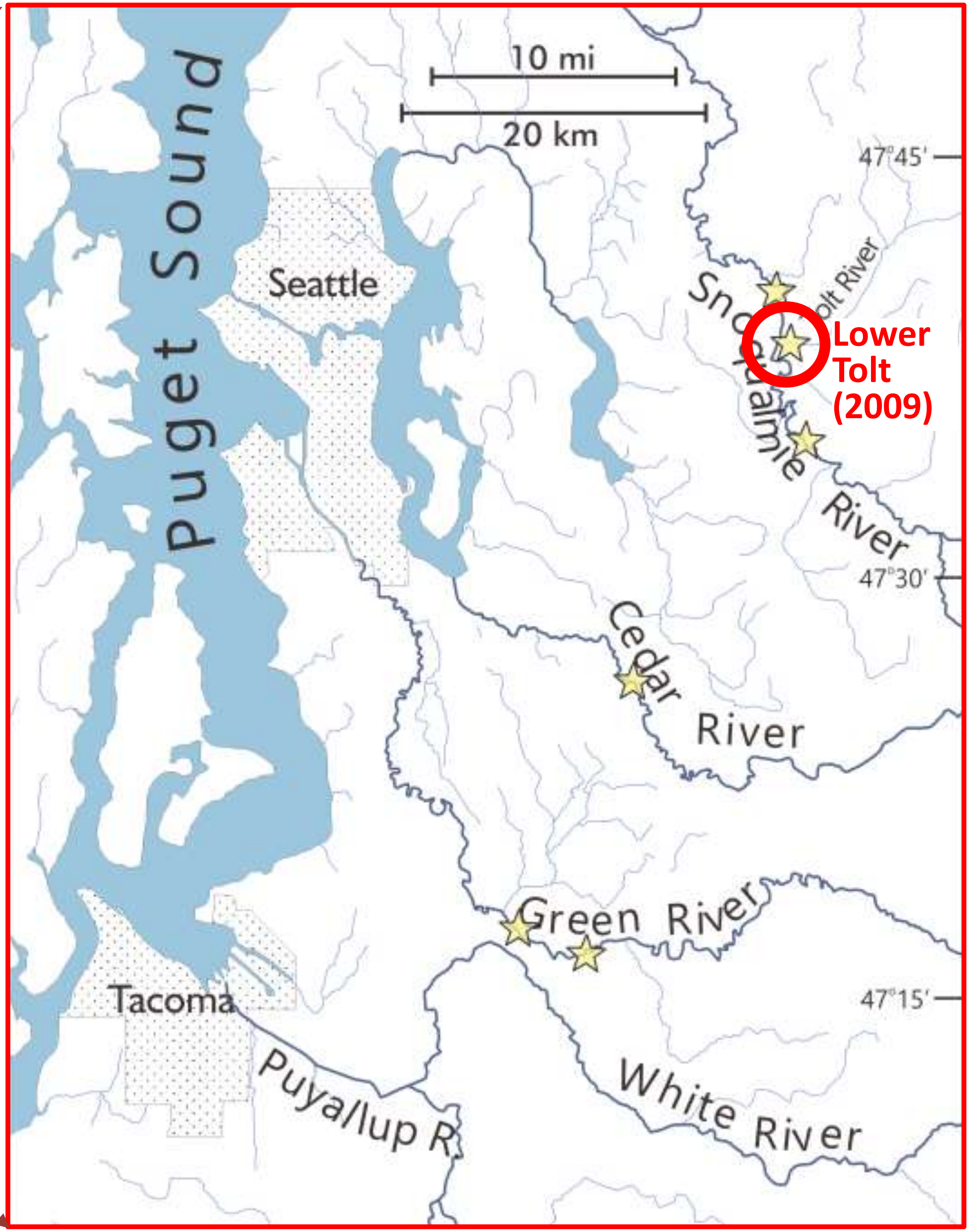
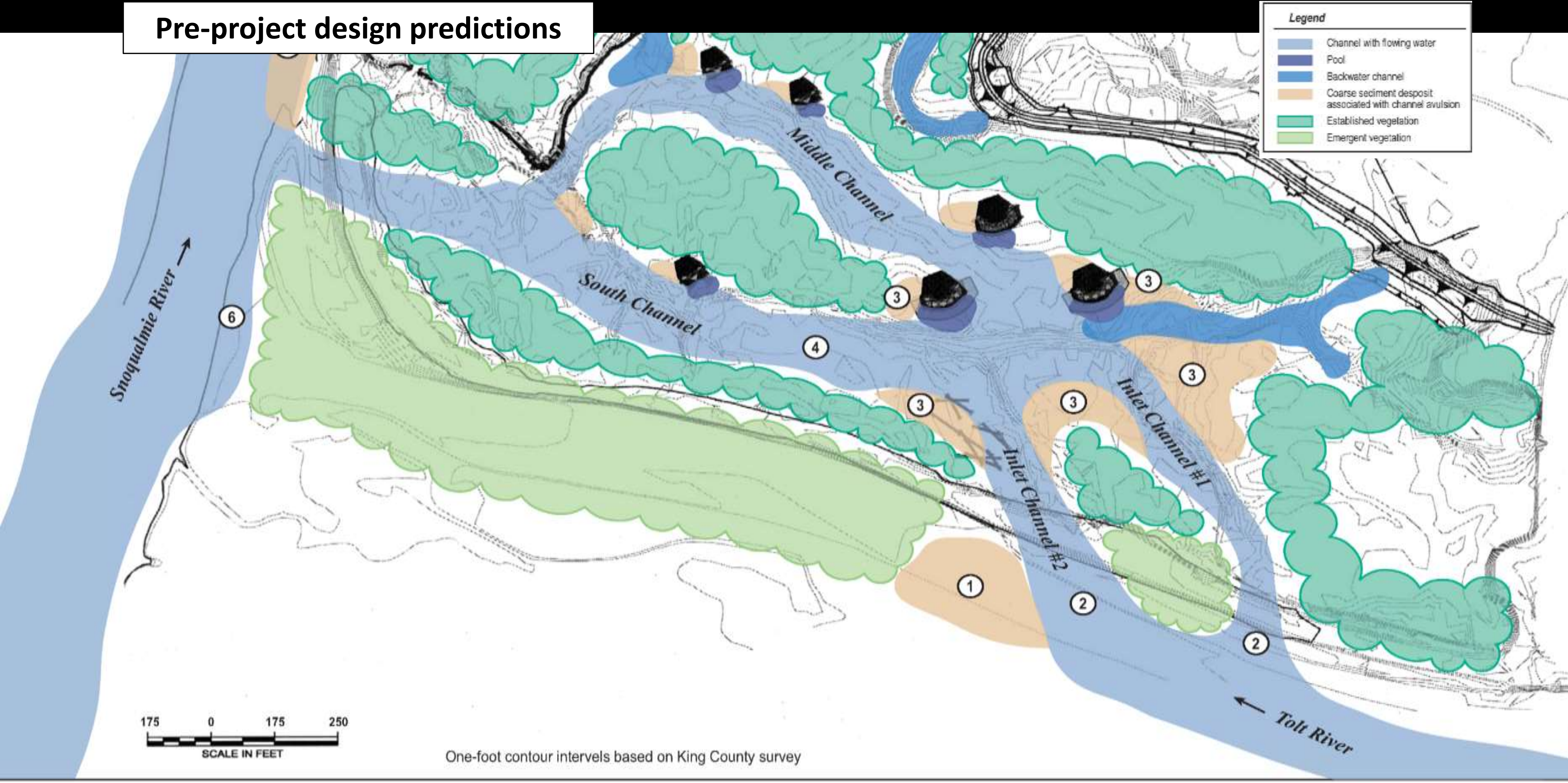

10 mi
20 km
47°45′
47°30′
47°15′
Puget Sound
Seattle
Tacoma
Snoqualmie River
Tolt River
Lower Tolt (2009)
Cedar River
Green River
White River
Puyallup R.

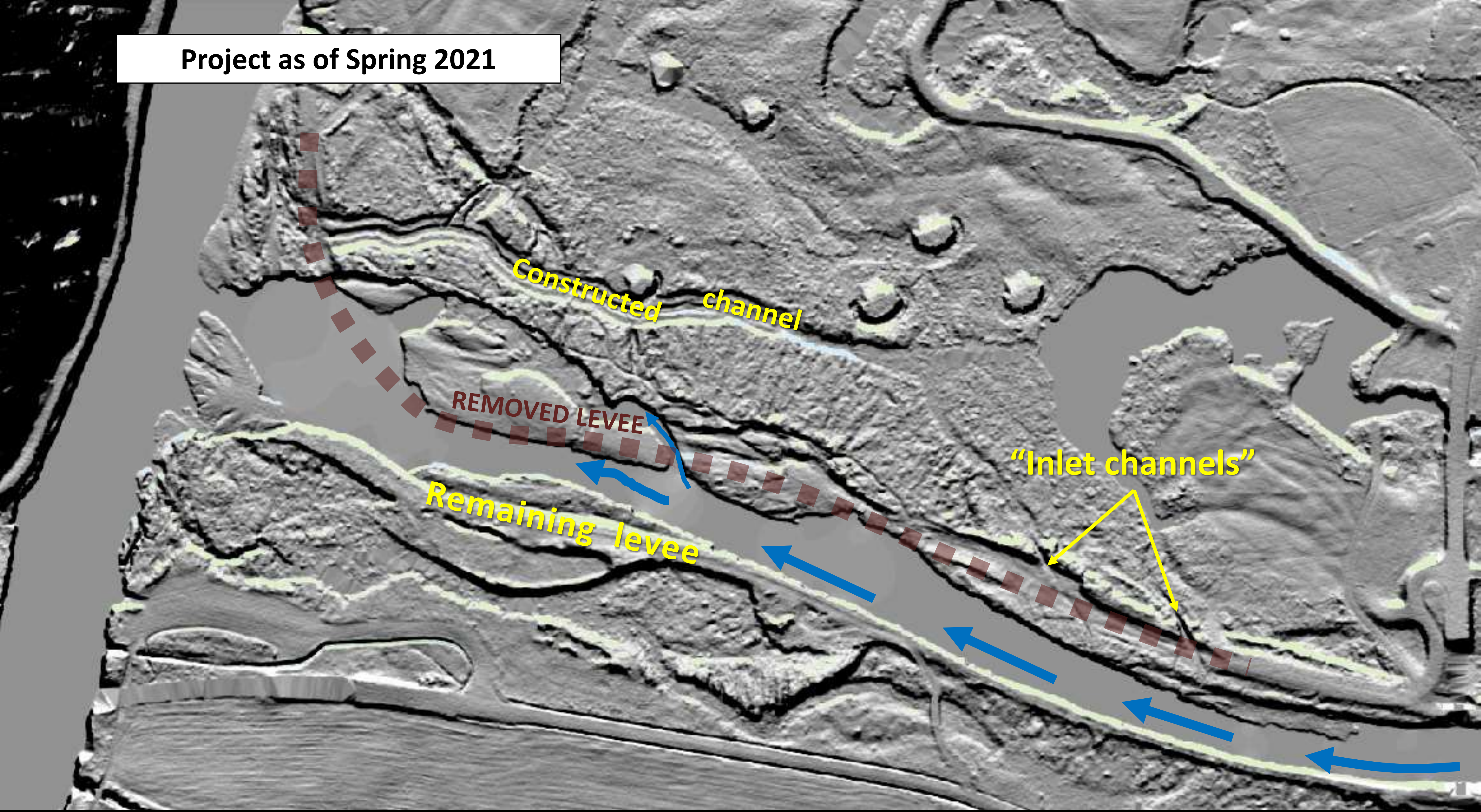
Pre-project (2007) conditions

Pre-project design predictions



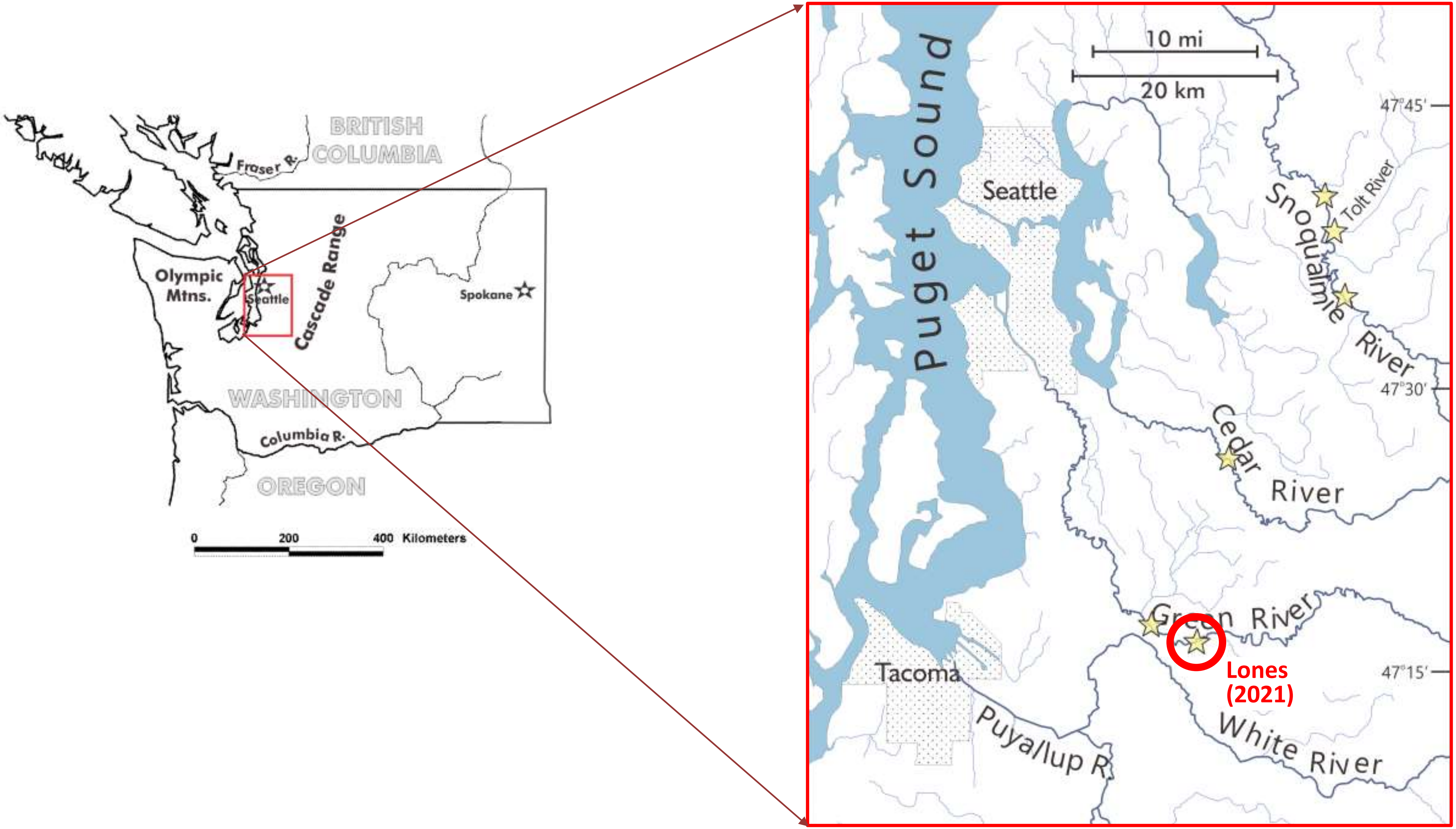
nticipated channel and floodplain evolution of the lower Tolt River floodplain approximately 10 years following a complete avulsion of the Tolt River to the reconnected floodpla
oodplain reconnection project.

Project as of Spring 2021

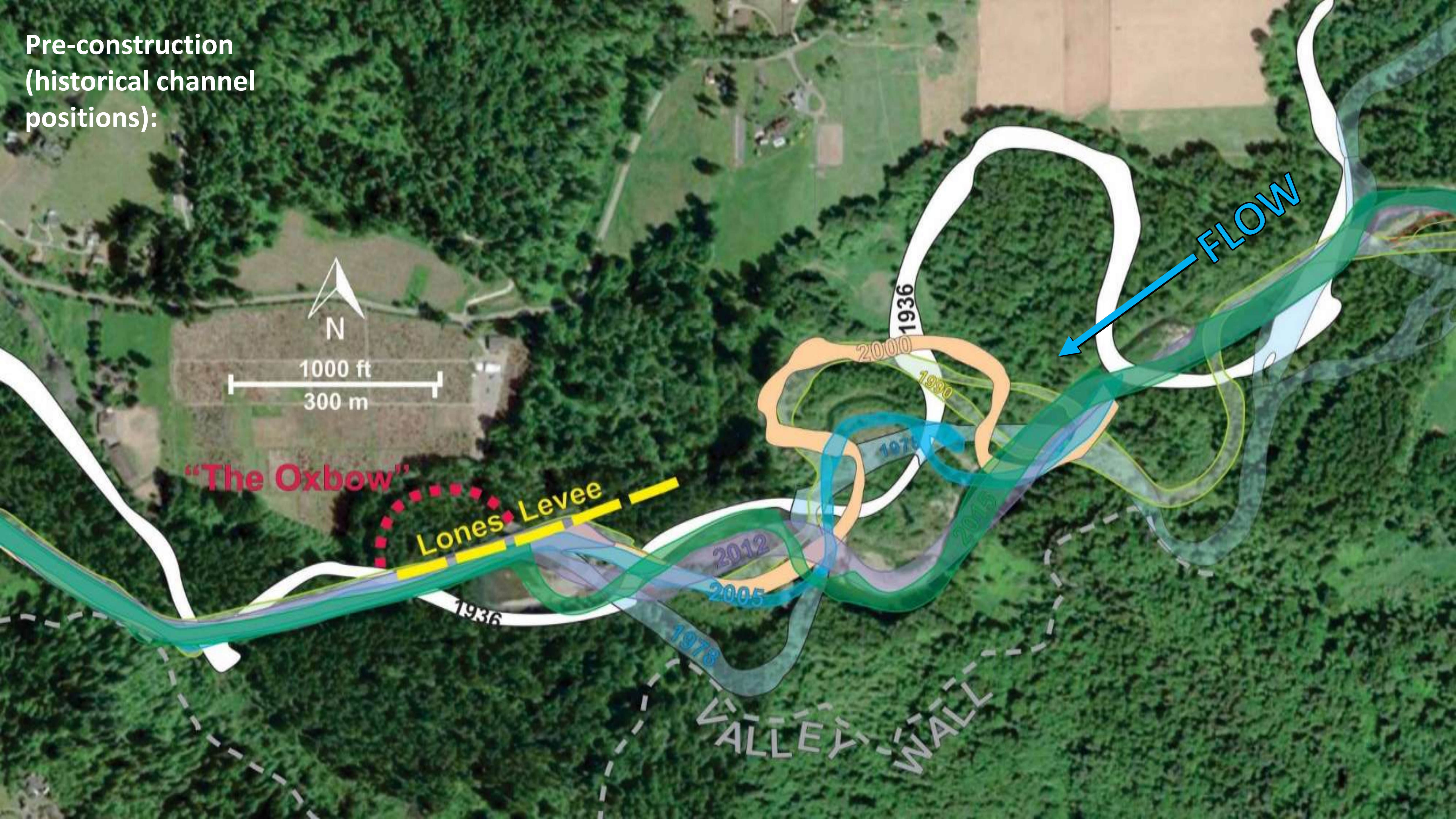


Design lessons from this project:

- The dominant (but not necessarily immediate) response to levee removal is localized channel widening and shallowing.
- Initiating channel avulsions to achieve greater habitat complexity may require more than simply allowing access.
- Remaining levees, revetments, or otherwise armored banks tend to “pin” the thalweg along their margins.


BRITISH COLUMBIA
Fraser R.
Olympic Mtns.
Seattle
Cascade Range
Spokane
WASHINGTON
Columbia R.
OREGON
0
200
400 Kilometers
10 mi
20 km
47°45′
47°30′
47°15′
Puget Sound
Seattle
Snoqualmie River
Tolt River
Cedar River
Green River
Lones (2021)
Tacoma
Puyallup R.
White River

Pre-construction (historical channel positions):



Project actions:

- **Remove 1600-foot-long levee**
- **Open and/or create side channels through prior levee footprint**
- **Construct multiple engineered log jams to encourage flow splitting and limit future channel migration beyond project limits**


2 months post-construction
(photo from November 2021):
Lones Levee removal
Side-channel
excavations
and adjacent
ELJ construction
FLOW

5 months post-construction (February 2022):


8 months post-construction
(May 2022):
The Oxbow
Original trace of levee


19 months post-construction
(April 2023):
The Oxbow
Original trace of levee
Bar growth
No
change
Google Earth

Design lessons applied from prior projects:

- Take advantage of preexisting floodplain topography
- Aggressively grade to create/expand side channels
- Introduce large engineered log jams to encourage flow splitting

Design lessons from *this* project? None, to date—but perhaps:

- Flow split reduces energy for channel migration (and thus may limit new floodplain creation)
- Valley gradient & flow regulation may reduce longevity of multiple channels—not every river, in every setting, can support multiple channels indefinitely

The take-home messages, from literature and project examples

For policy and management:

1. Restoration is generally beneficial and worth pursuing—but outcomes are not guaranteed.
2. Protect, reconnect, and restore…in that order (not the other way around).
3. Distinguish “process-based” from “form-based” restorative actions. Systemic impairments *require* the former; localize, discrete impacts may (or may not) see benefit from the latter.
4. *Time* is needed to express physical and (particularly) biological restoration results. In the interim, maintenance, adjustment, and enhancement may be needed (along with any required funding).

The take-home messages, from literature and project examples

For engineering design:

1. The only near-certain response to levee removal is widening and shallowing. More widespread floodplain reengagement may not occur without additional design elements.
2. Remaining levees or revetments may compromise otherwise well-designed outcomes intended for the opposite bank of the river.
3. Channel avulsion and side-channel development to achieve greater habitat complexity may require more than simply allowing access.
4. The lithologic and topographic “templates” of the watershed and river will determine the channel form(s) that can be supported. Ignore them at your peril!