RIVER RESTORATION NORTHWEST

DIGITAL BINDER

22nd Annual River Restoration Symposium

February 5-9, 2024

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River Restoration Northwest is a nonprofit scientific and educational organization. Our mission is to advance the science and standards of river restoration practice through an interdisciplinary approach.

RIVER RESTORATION NORTHWEST

WELCOME TO THE 22ND ANNUAL RIVER RESTORATION NORTHWEST SYMPOSIUM!

Dear River Restoration Northwest Community,

I am thrilled to welcome each of you to the 22nd Annual Symposium of River Restoration Northwest. The interest and excitement this year from presenters, attendees, and sponsors has been wonderful to be a part of. We sold out registration before the New Year, which is an RRNW record. This year we are excited to host a full schedule of three distinguished keynote speakers, a full suite of presentation and posters, diverse continuing education short course offerings on Monday, and a Friday field trip to a completed project.

Our time together includes opportunities to think big, and to get into technical details. Perhaps even more importantly, it offers several ways to connect with one another and share ideas in support of our audacious goal to care for our region's water ways. New this year we have a professional mentorship program. For members, please remember to join us for a members meeting on Wednesday at lunch where we will provide organizational updates and vote on three new board members.

We look forward to sharing in many lively conversations this week. On behalf of River Restoration Northwest's board of directors and volunteers, welcome!

Caitlin Alcott
RRNW Board President

2023-2024 River Restoration Northwest Board of Directors

RRNW EVENT ORGANIZERS

The 22nd Annual River Restoration Northwest Symposium and non-symposium events including Short Courses and the Film Event, were organized by the RRNW Board of Directors with help from the following individuals - thank you!!

RRNW Board of Directors

Caitlin Alcott, Oregon, President
Tessa Artruc (Interim), Washington
Reid Camp, Idaho
Katie Jagt, Colorado
Nick Legg, Oregon
Ellen McClure, Oregon, Treasurer
Jared Mckee, Oregon
Judi Radloff, Washington, VP of Programs
Lisa Remlinger, Washington
Dominique Shore, Utah
Annika Sullivan, Oregon, Secretary/
Incoming President
Mark Wilcox, Oregon

Short Course Instructors

Dr. Rocko Brown
Janine Castro
Maggie Chumbley
Dr. Derron Coles
Serina Fast Horse
Dr. Yong Lai
Dr. Joseph Merz
Toby Query

Session Conveners

Eleanor Bartolomeo
Eric Berntsen
Paul Cereghino
Kevin Coulton
Garrett Jackson
Lauran McMullen
Amy Puls

Symposium Interns

Ariana Arellano
Ciana David
Landen Matechuk
Caroline Slagle

Super Volunteers

Kelsey Alsheimer - Program Support
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Glen Leverich - Invited Speaker Coordinator
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Contracted Support

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Shauna Stevenson, Internship Coordinator
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Cameo Management Solutions

RRNW MEMBERSHIP

•Support the vision and mission of the organization
•Priority registration for the annual symposium, short courses and other events
•A voice in development and direction of the organization and future symposia
•Attendance, voting privileges and promotional items at the annual members meeting
•Members-only prize drawing at the symposium

https://www.rrnw.org/join/

PETER C. KLINGEMAN SCHOLARSHIP FUND

The Scholarship Fund bears the name of the founding father of RRNW, Dr. Peter C. Klingeman. It was Pete who pulled together the other four founding members following a national stream conference in Reno; it was Pete who was confident that those founding members could organize a regional conference with only a few short months of planning; and it was Pete who took the gamble and secured Skamania Lodge on his personal credit card. That is how RRNW started, and it was because of Pete's dedication and unwavering belief in RRNW that we are still here today. Pete Klingeman worked at Oregon State University where he taught within the Civil Engineering Department. Pete's courses drew in students from a wide swath of natural resource disciplines because Pete knew rivers, and for those interested in studying rivers, his classes were not to be missed. While technically a hydraulic engineer, Pete was a bit of a renaissance man – including geomorphology, biology, fisheries, and water quality in his courses. During an email exchange in the early years of River Restoration Northwest, there was a very fitting typo: the RRNW Board accidentally referred to Pete as "the Treasure" — and while he was indeed an excellent Treasurer for many years, he was, and will always be The RRNW Treasure.

The Peter C. Klingeman Scholarship Fund is supported by the following efforts – THANK YOU!

•Direct Contributions during annual Symposium, Short Courses & Membership Registration
•Direct Contributions via www.rrnw.org
•RRNW would like to thank Nancy Klingeman once again for her significant financial support of the Peter C. Klingeman Scholarship Fund

Information and applications are provided during the Symposium Early Registration each year.

PCK Scholarship Funds (formerly referred to as Professional Stipends) are available to those working for watershed councils, conservation districts, environmental education organizations, regional fisheries enhancement groups, Native American Tribes and First Nations, and non-profit organizations involved in stream, riparian and watershed restoration. Scholarship applications are ranked by a multidisciplinary committee, and awards are distributed geographically and among professional disciplines.

RRNW 2024 Symposium At-A-Glance

Monday February 5

8:00am- 5:00pm	Short Courses (full and half-day)

Tuesday February 6

7:30am	Registration & Continental Breakfast: Cascade Locks Ballroom
8:30am	Welcome Address: Caitlin Alcott, President RRNW Board of Directors
8:40am	***Invited Speaker:*** Rukaiyah Adams | CEO 1803 Fund – *Regard the Water, Regard Ourselves*
9:30 am	***Session 1*** | *Urban River Restoration*
10:30am	30 min. Break
11:00am	***Session 2*** | *Restoring Puget Sound Estuaries: Insights from Monitoring and Lessons Learned from Construction*
12:00pm	Lunch and Mentorship Program Kick-off Lunch
1:30pm	***Session 3*** | *Learning from Our Past: Lessons on Monitoring from Tribal Restoration Programs Now and in the Future*
2:30pm	Poster Lightning Talks
3:00pm	40 min. Break
3:40pm	***Session 4*** | *Restoring Riverscapes as Complex Habitats that Include Humans*
5:00pm	Hosted Reception: Cascade Locks Ballroom
6:30pm	Group Buffet Dinner: Stevenson Ballroom
7:30pm	Trivia Night

Wednesday February 7

7:30am	Continental Breakfast: Cascade Locks Ballroom
8:30am	***Invited Speaker***: Daniel Schindler | University of Washington - *Habitat mosaics: the space and time scales where important ecological dynamics are expressed in salmon rivers of western Alaska*
9:20am	***Session 5*** | *Doing More with Less for the Love of Monitoring*
10:20am	40 min. Break
11:00am	***Session 6*** | Poster Session
12:00pm	Lunch and Annual Members Meeting & Elections
1:30pm	***Session 7*** | *Key Results from Intensively Monitored Watersheds: Incorporating Lessons into Restoration Programs and Project Design*
2:50pm	30 min. Break
3:20pm	***Session 8*** | *Towards Effective Enhancement of Cold-Water Refuges*
5:00pm	No-host Reception with live music by Bigfoot Mojo
6:30pm	Group Buffet Dinner: Stevenson Ballroom
8:00pm	Film Event: Adams Room, *Covenant of the Salmon People*, Nez Perce Tribe

Thursday February 8

7:30am	Continental Breakfast: Cascade Locks Ballroom
8:30am	***Invited Speaker***: Jack Schmidt | Utah State University – *The Future of the Colorado River: how we got here and what the water crisis means for river ecosystems*
9:20am	***Session 9*** | *Different Dam Problems with Different Dam Solutions*
10:20am	Poster Lightning Talks - *Moving from "Street Cred" to "Stream Cred" - updates from WSDOT*
10:40am	40 min. Break
11:20am	***Session 10*** | *Big Scale Hydrology - Redefining Stream Power*
12:00pm	Lunch
1:00pm	***Session 11*** | *Restoring Habitat for Overlooked Aquatic Organisms*
2:40pm	Closing Comments: Annika Sullivan, Incoming President RRNW Board of Directors

Friday February 9

8:00am- 1:00pm	***Field Trip*** | *Restoring Splash-Dammed, Scoured-to-Bedrock, Confined River Reaches of the Washougal River, Washington (2015-2023), led by Brice Crayne/Lower Columbia Fish Enhancement Group*

2024 INVITED SPEAKERS

Rukaiyah Adams, CEO
1803 Fund

Since January 2023, Rukaiyah Adams has served as the Chief Executive Officer of the 1803 Fund. The 1803 Fund seeks to grow shared prosperity, through the alignment of financial investments and investments in community-based organizations. It is not a conventional investment firm, and it is not traditional philanthropy—the work of the 1803 Fund includes aspects of both. The professionals that work with Rukaiyah describe the work as 'investing for the people'.

Through August 2022, Ms. Adams was the Chief Investment Officer at Meyer Memorial Trust (Meyer), one of the largest charitable trusts in the Pacific Northwest. She was responsible for leading all investment activities to ensure the long-term financial strength of the organization. Throughout her tenure as CIO, Ms. Adams consistently delivered top-quartile performance. Under her leadership, Meyer increased assets managed by diverse managers by more than 3x, and assets managed by women managers increased by 10x, proving that hiring diverse managers is not a concessionary practice.

Ms. Adams' team has been at the forefront of socially responsible investing, including crafting language to describe the nascent practice. She devised and wrote the field-leading concepts for social responsibility in the "affirmative covenant" investment framework and for diversity, equity, and inclusion in the "people, products, and shared prosperity" framework. Before joining Meyer, Ms. Adams ran the $6.5 billion capital markets fund at The Standard, then a publicly traded company. At The Standard, she oversaw trading desks that included bond strategies, preferred equities, derivatives, and other risk mitigation strategies.

From 2017-2020 Ms. Adams was chair of the prestigious Oregon Investment Council, the board that manages approximately $100 billion of public pension and other assets for the State of Oregon. During her tenure as chair, the Oregon state pension fund was among the top-performing public pension funds in the United States. The top-of-class performance was made possible by a series of strategic changes overseen by Ms. Adams that boosted returns and decreased risk.

Ms. Adams serves on the boards of the Albina Vision Trust, the Self Enhancement, Inc. Foundation, Oregon Health and Science University Foundation, and Oregon Public Broadcasting, where she is also the current chair. She also serves on the Oregon Higher Education Coordinating Commission. She has engaged in pro bono legal work on behalf of the Lawyers Committee for Civil Rights, the Homeless Prenatal Program in San Francisco, and the Children's Defense Fund. She has given two TED Talks. Her 2016 TED Talk — A Homegirl's Guide to Being Powerful — details her path to becoming a more thoughtful investor and the role of investment capital in achieving social justice. This TED Talk has more than 14,000 views.

Ms. Adams holds a Bachelor of Arts with academic distinction from Carleton College, a Juris Doctor from Stanford Law School, where she was on the Law and Policy Review and the Co-President of the Law Student Association, and a Master of Business Administration from the Stanford Graduate School of Business.

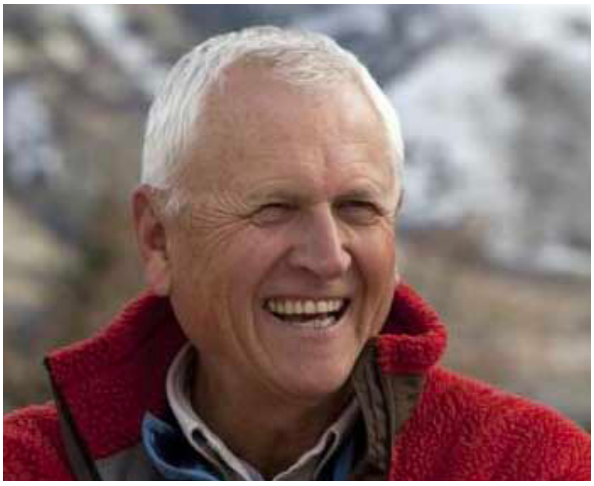
Daniel Schindler, Professor

School of Aquatic and Fishery Sciences,
University of Washington

Daniel Schindler is a Professor in the School of Aquatic and Fishery Sciences at the University of Washington (UW). He is a principal investigator of the UW Alaska Salmon Program which has studied the ecology of salmon and their watersheds in western Alaska since 1946.

His research is focused on freshwater ecosystems and their watersheds, addressing questions ranging from understanding basic ecological and evolutionary processes to the effects of climate change, watershed development, and fisheries on ecosystem dynamics and natural resources.

He is a previous recipient of the Frank Rigler Award from the Society of Canadian Limnologists, the Carl R. Sullivan Fishery Conservation Award from the American Fisheries Society, and the G.E. Hutchinson Award from the Association for the Science of Limnology and Oceanography. He was elected to the Washington State Academy of Sciences in 2018 and recognized as a Fellow of the American Fisheries Society in 2021.



Jack Schmidt, Director

Center for Colorado River Studies and Emeritus Janet Quinney Lawson Chair in Colorado River Studies

Jack Schmidt is the Director of the Center for Colorado River Studies and Emeritus Janet Quinney Lawson Chair in Colorado River Studies. His research career at Utah State University has focused on understanding how water resource development affects river ecosystems and how adverse environmental impacts can be mitigated.

Between 2011 and 2014, he served as Chief of the US Geological Survey Grand Canyon Monitoring and Research Center.

FILM NIGHT

Wednesday Film Night
8:00 pm in the Adams Room

Covenant of the Salmon People, Nez Perce Tribe

COVENANT OF THE SALMON PEOPLE is a 60-minute documentary portrait of the Nez Perce Tribe as they continue to carry out their ancient promise to protect Chinook salmon, cornerstone species and first food their people have subsisted on for tens of thousands of years. As a dammed river system and climate impacts threaten the extinction of Chinook salmon, a cornerstone of their culture and ancestral diet, they continue to do their part to uphold this relationship–but will it be enough to save wild salmon from extinction?
The covenant with salmon is woven into their culture, history, and now their modern-day species restoration work. The Nez Perce people are the oldest documented civilization in North America, with archaeological sites along Idaho's Salmon River dating back 16,500 years.

Today the tribe is facing the extirpation of their most prized salmon species despite decades of recovery efforts, and the widespread construction of dams across their traditional lands has challenged recovery. The only option for the tribe to uphold their ancient deal with salmon and save the species from extinction is the breaching of four dams on the lower Snake River–will the Federal Government take charge of the situation or sit idly while this iconic species vanishes from their home waters?

SHUTTLE SCHEDULE

Tuesday, February 6th

From Best Western & Carson Hot Springs:

7:30 AM

To Best Western & Carson Hot Springs:

7:30 pm

8:30 pm

9:30 pm

Wednesday, February 7th

From Best Western & Carson Hot Springs:

7:30 am

To Best Western & Carson Hot Springs:

7:30 pm

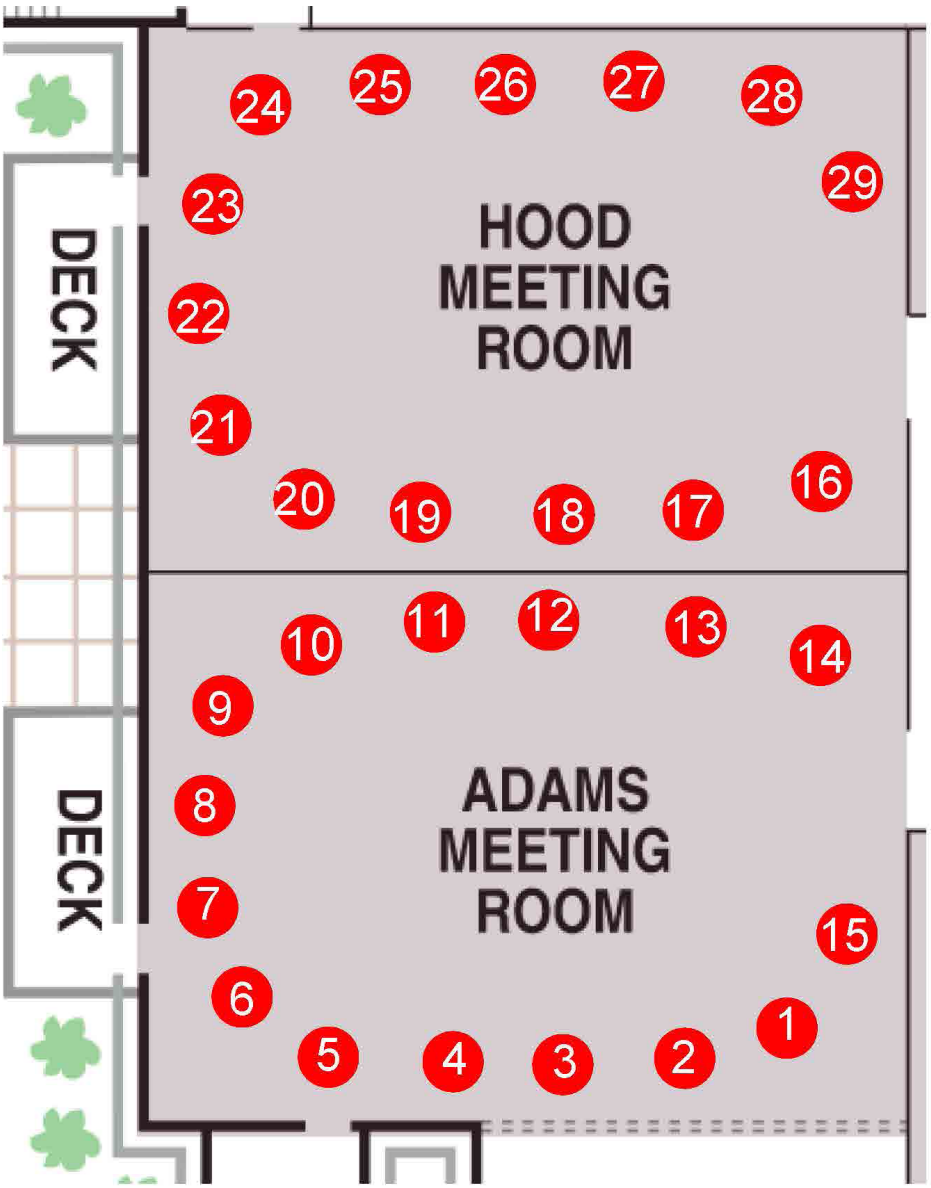
8:30 pm

9:30 pm

POSTER SESSION

Space	Presentation Title	First Name	Last Name
1	WSDOT Adaptive Restoration for Successful Riparian Establishment	Ryan	Leigh
2	Assessing Beaver Habitat Suitability in British Columbia Using Machine Learning	Landen	Matechuk
3	Restoring Mill Creek: An Adaptive Design Approach in Response to the Keystone Pipeline Spill	James	Ellis
4	Planting The Seed for Beaver Success	Jefferson	Jacobs
5	Riparian Vegetation Enhancement and Monitoring in Mine Tailings Restoration	Lauren	Osborne
6	Applied Lessons Learned within the Middle Fork John Day River Intensively Monitored Watershed	Kasey	Bliesner
7	When are Juvenile Coho Moving through Tide Gates?	Julie	Huff
8	Salmon Recovery and Bank Stabilization on the Pend Oreille River	Kayla	Kassa
9	Functions and guidelines of unanchored wood in stream restoration	Ryan	DeKnikker
10	Considering Geomorphic Processes in the Effective Restoration of Mountain Streams	Sarah	Davidson
11	Working with the river: how to restore geomorphic process and protect infrastructure in gravel bed streams	Lucy	MacKenzie
12	An Unprecedented Opportunity: NOAA Restoration Center Funding under the Bipartisan Infrastructure Law and Inflation Reduction Act	Larissa	Lee
13	Incorporating Terrestrial Connectivity into Fish Barrier Removal Projects	Marc	Hershfield
14	Wildfire and River Restoration: Case Studies from the Methow River Watershed	Zachary	Sudman
15	Geomorphic Risk Analyses in River Restoration Design Projects: Large Wood Risk and Avulsion Risk Analyses	Cameron	Reister
16	Planting Eelgrass for Wild Salmon	Dan	Wadhams
17	Building a foundation for restoration of the Lower Big Quilcene River: Quantifying historic changes in channel planform, sediment transport, incision and sediment budget	Tim	Abbe
18	Proposed Bypass Flow Program for Coastal Low-Flow/Seasonal Streams	Sheldon	Leiker
19	Hydrogeomorphic response to flooding in Yellowstone National Park: Comparing landscape controls and threshold hydraulics	Zack	DeLuca
20	Planting for success: Riparian restoration to facilitate beaver habitat expansion	Maureen	Thompson
21	Stream Bed Design for Future Compatibility	Henry	Hu
22	Innovative Approaches to Stream Restoration and Fish Passage: Learning from Nature's Playbook	Tammy	Schmidt
23	Organic Material in Simulated Streambed Designs: A Flume Study Investigating Meander Bars Design Guidelines With Organic Material	Tyler	Fouty
24	Climbing the Geomorphic Ladder: Envisioning a Holistic Approach to Step-Pool Design	Jeff	Kamps
25	Regenerative Land Management for Water Security and Riparian Habitat Enhancement	Kieran	Sikdar
26	Rewilding a Floodplain in Carmel, California	Joseph	Zhang
27	Where Olympic Mudminnow and Salmon Habitat Restoration Meet	Sierra	Hemmig
28	Understanding how sediment supply variability in small watersheds can impact restoration and fish passage design	Darrell	Sofield
29	Creating a new estuary for Pacific salmon in Bellingham Bay, WA	Sara Brooke	Benjamin

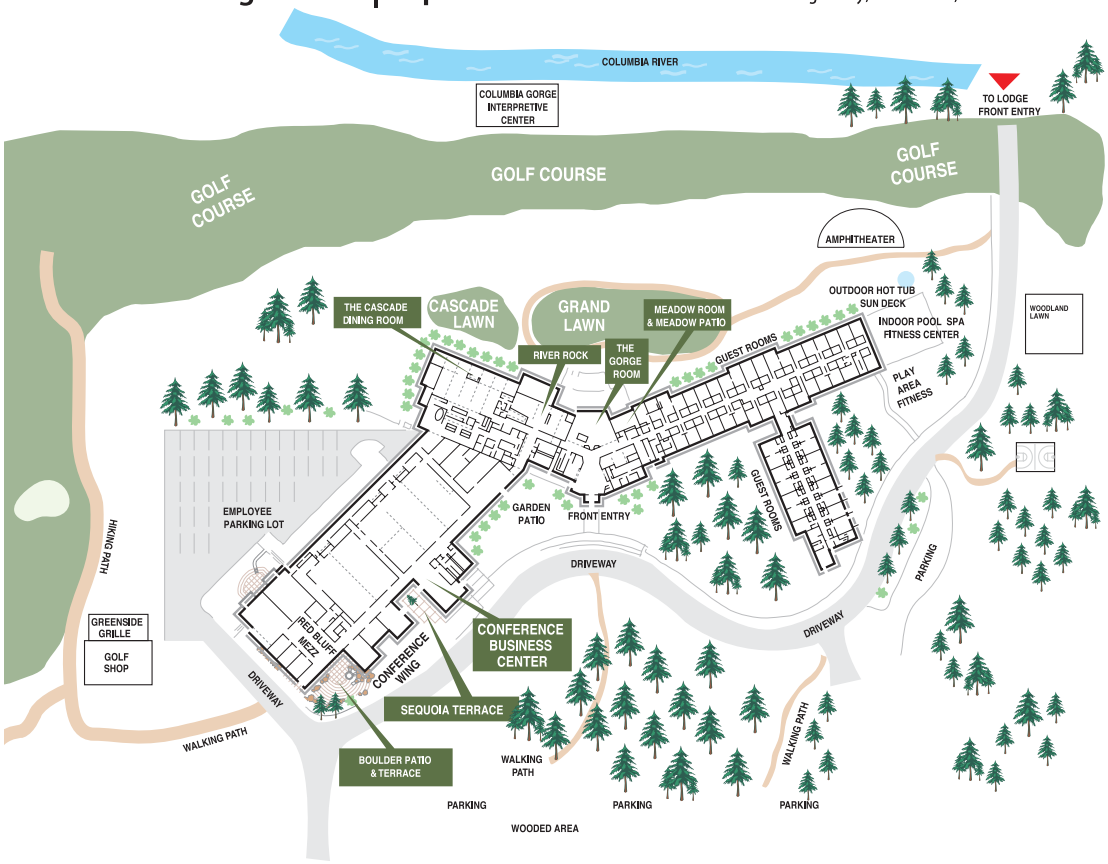
POSTER LOCATIONS



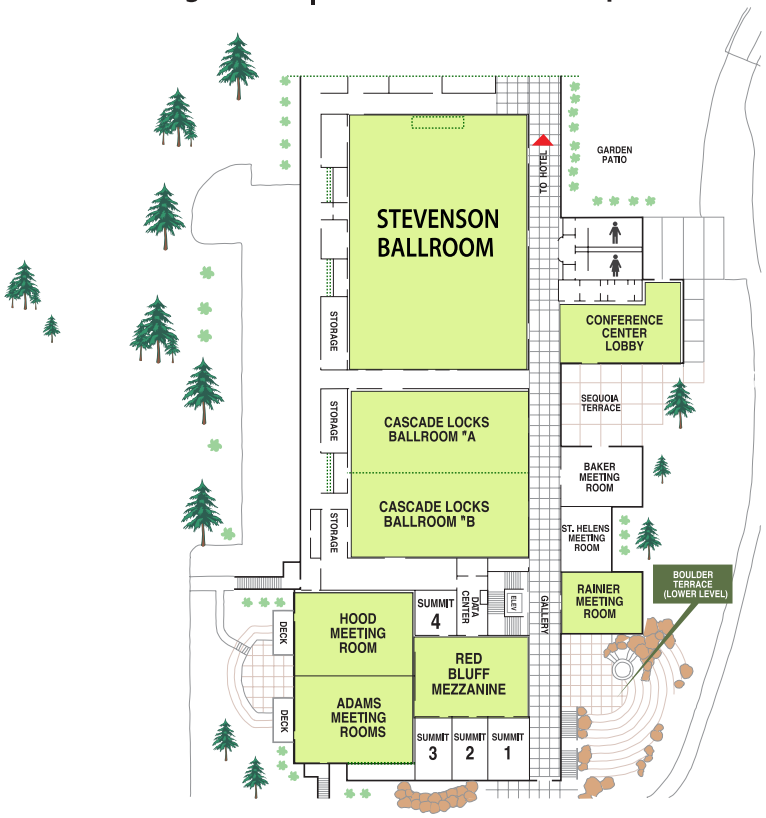
1	Ryan Leigh
2	Landen Matechuk
3	James Ellis
4	Jefferson Jacobs
5	Lauren Osborne
6	Kasey Bliesner
7	Julie Huff
8	Kayla Kassa
9	Ryan DeKnikker
10	Sarah Davidson
11	Lucy MacKenzie
12	Larissa Lee
13	Marc Hershfield
14	Zachary Sudman
15	Cameron Reister
16	Dan Wadhams
17	Tim Abbe
18	Sheldon Leiker
19	Zack DeLuca
20	Maureen Thompson
21	Henry Hu
22	Tammy Schmidt
23	Tyler Fouty
24	Jeff Kamps
25	Kieran Sikdar
26	Joseph Zhang
27	Sierra Hemmig
28	Darrell Sofield
29	Sara Brooke Benjamin

FLOOR PLANS

Skamania Lodge Resort | Properties Overview • 1131 SW Skamania Lodge Way, Stevenson, WA 98648



Skamania Lodge Resort | Main Level Conference Floorplan • 1131 SW Skamania Lodge Way, Stevenson, WA 98648



PROFESSIONAL DEVELOPMENT HOURS

River Restoration Northwest

22nd Annual Symposium

Feb. 5 – Feb. 8, 2024 Skamania Lodge, Stevenson, Washington

Professional Development Hours & Continuing Education Units

Professional Development Hours (PDH) These are nationally recognized units of record in non-credit professional development programs. The basis for award is: 1 PDH = 1 contact hour (nominal) of instruction or presentation, rounded down to the nearest 0.5 hour (Source: ASCE). PDHs may be earned at this symposium by registering and attending sessions. Actual times are shown below for each event and exclude all planned breaks.

Continuing Education Units (CEU) These units are customarily used for continuing education courses. The basis for award is: 1 CEU = 10 contact hours of instruction (therefore 1 CEU = 10 PDHs) in a qualifying continuing education activity (Source: ASCE). Symposium sessions and presentations have been evaluated for instructional content to identify CEUs.

Instructions for Use of this Form Circle the units for sessions that you attended and calculate the total. Keep this form with your professional records.

Presentation	Qualifying PDHs	Qualifying CEUs
Monday, February 5		
Optional Full-Day Short Course	8.00	0.80
Optional Half-day Short Course	4.00	0.45
SUB-TOTAL: _____ (8.0 max)		_____
Tuesday, February 6		
Keynote Speaker	1.00	0.10
Session 1 presentations	1.00	0.10
Session 2 presentations	1.00	0.10
Session 3 presentations	1.00	0.10
Lightning Poster session 1	0.50	0.05
Session 4 presentations	1.50	0.15
Wednesday, February 7		
Invited Speaker	1.00	0.10
Session 5 presentations	1.00	0.10
Session 6 presentations	1.00	0.10
Session 7 presentations	1.50	0.15
Session 8 presentations	1.50	0.15
Thursday, February 8		
Invited Speaker	1.00	0.10
Session 9 presentations	1.00	0.10
Poster Lightning session 2	0.50	0.05
Session 10 presentations	0.50	0.05
Session 11 presentations	1.50	0.15
ROUNDED SUB-TOTAL: _____ (16.5 max)		_____
COMBINED TOTAL: _____		_____

PROGRAM SCHEDULE

Monday, February 5

Short Courses

Speaking of Science – Delivering Inspired Presentations
Janine Castro

- 9:00 AM-12:00 PM, Mount Baker Room

Facilitating in the Wild – Working with Complexity and Diversity
Maggie Chumbley

- 8:00 AM-5:00 PM, Rainier Room

Ecohydraulics
Dr. Rocko Brown and Dr. Joe Merz

- 8:00 AM-5:00 PM, Adams Room

Diverting Bias
Dr. Derron Coles

- 8:00 AM-12:00 PM, Hood Room

Indigenizing Restoration
Serina Fast Horse and Toby Query

- 1:00 PM-5:00 PM, Hood Room

SRH-2D – Erosion, Aggradation, and Sediment Transport Modeling
Dr. Yong Lai

- 8:00 AM-5:00 PM, Jefferson Room

Tuesday, February 6

8:30 AM-8:40 AM
Welcome Address: Caitlin Alcott, President RRNW Board of Directors

8:40 AM-9:30 AM
Keynote Speaker: Rukaiyah Adams

- 8:40 AM: Regard The Water, Regard Ourselves - Rukaiyah Adams

9:30 AM-10:30 AM
Session 1: Urban River Restoration

- 9:30 AM: Best Practices Nationwide of Aquatic Organism Passage – aopMAP and the FHWA National Culvert Removal, Replacement & Restoration Grant Program - Casey Kramer

- 9:50 AM: Urban Stream Restoration - Where Managing Stream Power Improves Habitat and Builds Infrastructure Resilience - Nora Boylan

- 10:10 AM: Chinook Wind - Creating an Intertidal Wetland in an Urban Landscape - Mason Bowles

11:00 AM-12:00 PM
Session 2: Restoring Puget Sound Estuaries: Insights from Monitoring Efforts and Lessons Learned from Construction

- 11:00 AM: Successful Stillaguamish River Estuary Restoration - Dan Elefant

- 11:20 AM: Restoration of Puget Sound and Columbia River Estuaries: Lessons Learned/Challenges/Opportunities - Sky Miller

- 11:40 AM: Using Biogenetics and Landscape Connectivity to Plan Effective Tidal Delta Restoration Projects for Chinook Salmon - Emily Howe

1:30 PM-2:30 PM
Session 3: Learning from Our Past: Lessons on Monitoring from Tribal Restoration Programs Now and in the Future

- 1:30 PM: Remote sensing applications to support tribal efforts in riverine and floodplain assessment and monitoring: - Mischa Hey

- 1:50 PM: Learning from repeat green LiDAR surveys to monitor/plan floodplain restoration in the Tucannon River, WA - Kris Fischer

- 2:10 PM: Skokomish Estuary Restoration Monitoring - Lisa Belleveau

2:30 PM-3:00 PM
Lightning Session: Poster Lightning Talks

- Salmon Recovery and Bank Stabilization on the Pend Oreille River - Kayla Kassa

- Applied Lessons Learned within the Middle Fork John Day River Intensively Monitored Watershed - Kasey Bliesner

- Planting The Seed for Beaver Success - Jefferson Jacobs

- An Unprecedented Opportunity: NOAA Restoration Center Funding under the Bipartisan Infrastructure Law and Inflation Reduction Act - Larissa Lee

- Riparian Vegetation Enhancement and Monitoring in Mine Tailings Restoration - Lauren Osborne

- Wildfire and River Restoration: Case Studies from the Methow River Watershed - Zachary Sudman

- Assessing Beaver Habitat Suitability in British Columbia Using Machine Learning - Landen Matechuk

- Regenerative Land Management for Water Security and Riparian Habitat Enhancement - Kieran Sikdar

3:40 PM-5:00 PM
Session 4: Restoring Riverscapes As Complex Habitats That Include Humans

- 3:40 PM: Getting to Yes – Finding Synergies to Boost Project Viability - Wayne Gullstad

- 4:00 PM: Experiments with Biocultural Restoration in North Puget Sound - Jared Busen

- 4:20 PM: Traditional Harvesting is Land Tending: Traditional Indigenous Land Management Practices & Biocultural Restoration - Lindsey Crofoot

- 4:40 PM: Forest Farming and Riparian Restoration - Patrick Shults

Wednesday, February 7

8:30 AM-9:20 AM
Invited Speaker: Daniel Schindler

- 8:30 AM: Habitat mosaics: the space and time scales where important ecological dynamics are expressed in salmon rivers of western Alaska - Daniel Schindler

9:20 AM-10:20 AM
Session 5: Doing more with less for the love of monitoring

- 9:20 AM: Evaluating large floodplain restoration projects using a combination of remote sensing and supplemental field surveys: A case study on the Middle Entiat - Phil Roni

- 9:40 AM: Locating Cold Water Sources within the Entiat River Watershed: Opportunities for Habitat Restoration - Mark Ingman

- 10:00 AM: Understanding the past to guide the future: 82 years of change in Hiłsyaqƛis (Tranquil Creek), British Columbia - Daphnee Tuzlak

11:00 AM-12:00 PM
Session 6: Posters

- Innovative Approaches to Stream Restoration and Fish Passage: Learning from Nature's Playbook - Tammy Schmidt
- Climbing the Geomorphic Ladder: Envisioning a Holistic Approach to Step-Pool Design - Jeff Kamps
- Organic Material in Simulated Streambed Designs: A Flume Study Investigating Meander Bars Design Guidelines with Organic Material - Tyler Fouty
- Stream Bed Design for Future Compatibility - Henry Hu
- Where Olympic Mudminnow and Salmon Habitat Restoration Meet - Sierra Hemmig
- Planting The Seed for Beaver Success - Jefferson Jacobs
- Building a foundation for restoration of the Lower Big Quilcene River: Quantifying historic changes in channel planform, sediment transport, incision, and sediment budget - Tim Abbe
- Restoring Mill Creek: An Adaptive Design Approach in Response to the Keystone Pipeline Spill - James Ellis
- Hydrogeomorphic response to flooding in Yellowstone National Park: Comparing landscape controls and threshold hydraulics - Zack DeLuca
- Wildfire and River Restoration: Case Studies from the Methow River Watershed - Zachary Sudman
- Riparian Vegetation Enhancement and Monitoring in Mine Tailings Restoration - Lauren Osborne
- Applied Lessons Learned within the Middle Fork John Day River Intensively Monitored Watershed - Kasey Bliesner
- Salmon Recovery and Bank Stabilization on the Pend Oreille River - Kayla Kassa
- Assessing Beaver Habitat Suitability in British Columbia Using Machine Learning - Landen Matechuk
- Functions and guidelines of unanchored wood in stream restoration - Ryan DeKnikker

- Planting Eelgrass for Wild Salmon - Daniel Wadhams
- Rewilding a Floodplain in Carmel, California - Joseph Zhang
- Incorporating Terrestrial Connectivity into Fish Barrier Removal Projects - Marc Hershfield
- An Unprecedented Opportunity: NOAA Restoration Center Funding under the Bipartisan Infrastructure Law and Inflation Reduction Act - Larissa Lee
- Geomorphic Risk Analyses in River Restoration Design Projects: Large Wood Risk and Avulsion Risk Analyses - Cameron Reister
- Proposed Bypass Flow Program for Coastal Low-Flow/Seasonal Streams - Jonathan Martin
- Considering Geomorphic Processes in the Effective Restoration of Mountain Streams - Sarah Davidson
- Working with the river: how to restore geomorphic process and protect infrastructure in gravel bed streams - Lucy MacKenzie
- Understanding how sediment supply variability in small watersheds can impact restoration and fish passage design - Darrell Sofield
- Regenerative Land Management for Water Security and Riparian Habitat Enhancement - Kieran Sikdar
- When are Juvenile Coho Moving through Tide Gates? - Julie Huff
- WSDOT Adaptive Restoration for Successful Riparian Establishment - Ryan Leigh
- Planting for success: Riparian restoration to facilitate beaver habitat expansion - Maureen Thompson
- Creating a new estuary for Pacific salmon in Bellingham Bay, WA - Sara Brooke Benjamin

1:30 PM-2:50 PM
Session 7: Key Results from Intensively Monitored Watersheds: Incorporating Lessons Learned into Restoration Programs and Project Design

- 1:30 PM: Review of Results from Pacific Northwest Intensively Monitored Watersheds and Implications for Habitat Restoration Programs - Robert Bilby

- 1:50 PM: Designing and Implementing Successful In-Stream Wood Projects: Lessons Learned from Intensively Monitored Watersheds - Eli Asher

- 2:10 PM: Low-tech process-based restoration: how maintenance, adjustments to restoration actions, and time led to increased juvenile steelhead production - Stephen Bennett

- 2:30 PM: Detecting a response to restoration in low abundance salmon populations - Joseph Anderson

3:20 PM-5:00 PM
Session 8: Towards effective enhancement and management of cold-water refuges for threatened and endangered aquatic species: global practices and regional case studies

- 3:20 PM: Closing the gap between science and management of cold-water refuges in rivers and streams - Francine Mejia

- 3:40 PM: Physical Modeling of the Lower Yakima Cold Water Refuge Project at RM 2.5 - Jaron Brown

- 4:00 PM: Understanding flow and temperature relationships on dam-influenced cold-water refuges - Eric Berntsen

- 4:20 PM: Design and construction of cold-water refugia for Bull Trout and Westslope Cutthroat Trout on the Pend Oreille River - Jeremy Payne

- 4:40 PM: Post-construction monitoring of cold-water refuge restoration projects for native fish - Andy Johnsen

Thursday, February 8

8:30 AM-9:20 AM
Invited Speaker: Jack Schmidt

- 8:30 AM: The Future of the Colorado River: how we got here and what the water crisis means for river ecosystems - Jack Schmidt

9:20 AM-10:20 AM
Session 9: Different dam problems with different solutions

- 9:20 AM: A Bypass River as Floodplain Restoration Measure: It's Not About Just Letting the Water Flow - Bernd Cyffka

- 9:40 AM: Water Releases from Dams as a Restoration Tool: Use of River Pools on the Trinity River - Yong Lai

- 10:00 AM: Water quality and river health in the Klamath River during dam removal based on multiple ways of knowing - Desiree Tullos

10:20 AM-10:40 AM
Lightning Session: From Street Cred to Stream Cred (Dedicated Poster Lightning Session)

- 10:20 AM: Innovative Approaches to Stream Restoration and Fish Passage: Learning from Nature's Playbook - Tammy Schmidt

- 10:25 AM: Climbing the Geomorphic Ladder: Envisioning a Holistic Approach to Step-Pool Design - Jeff Kamps

- 10:30 AM: Organic Material in Simulated Streambed Designs: A Flume Study Investigating Meander Bars Design Guidelines with Organic Material - Tyler Fouty

- 10:35 AM: Stream Bed Design for Future Compatibility - Henry Hu

11:20 AM-12:00 PM
Session 10: Big Scale Hydrology - Redefining Stream Power!

- 11:20 AM: Watershed-Scale Effects of Floodplain and Stage 0 Restoration on Hydrologic Attenuation - Erich Hester

- 11:40 AM: Focusing on hydrology and collaboration to restore a large Idaho river - John McLaren

1:00 PM-2:40 PM
Session 11: Restoring Habitat for Overlooked Aquatic Organisms

- 1:00 PM: Floodplain forest regeneration and fluvial processes: Cottonwood ecology and riparian forest restoration - Katrina Strathmann

- 1:20 PM: The Castor Conundrum: Implications for beaver related restoration - Vanessa Petro

- 1:40 PM: Management of heterogeneous forest headwater ecosystems for amphibian habitat restoration, conservation, and risk mitigation in the US Pacific Northwest. - Deanna (Dede) Olson

- 2:00 PM: Salmonid-focused restoration is destructive... - Alexa Maine

- 2:20 PM: Beyond ‘do no harm’: Restoration Needs of Freshwater Mussels - Laura McMullen

2:40 PM
Closing Comments: Annika Sullivan, Incoming President RRNW Board of Directors

Friday, February 9

8:00 AM-1:00 PM

Field Trip: Restoring Splash-Dammed, Scoured-to-Bedrock, Confined River Reaches of the Washougal River, Washington (2015-2023)

Led by Brice Crayne, Lower Columbia Fish Enhancement Group

Plenary Session Abstracts

Tuesday – February 6

#3948 - Best Practices Nationwide of Aquatic Organism Passage – aopMAP and the FHWA National Culvert Removal, Replacement & Restoration Grant Program

Casey Kramer, PE[1], Jim Neighorn, PE[2], Justin Lennon, PE[3], Steve Morrow[2], Sven Leon, PE[2], Jennifer Mora[2]

[1]Natural Waters, LLC, Olympia, WA, [2]FHWA - Western Federal Lands, Vancouver, WA, [3]WSP, Baltimore, MD

AOP (Aquatic Organism Passage) water crossing design is an evolving field that combines the built environment with the natural world to produce resilient infrastructure while also providing environmental benefits, specifically related to the passage of fish and other aquatic organisms. The design and construction of AOP water crossings is gaining popularity across the US, as environmental agencies, tribal entities, and infrastructure owners seek improved approaches to road-stream crossing designs. Providing effective AOP at water crossings represents a significant investment and management priority for various agencies across the country. In support of AOP implementation, the FHWA National Culvert Removal, Replacement & Restoration Grant Program (Culvert AOP Program) was set as a new competitive grant program focused on the improvement of passage for anadromous fish. The grant program places an emphasis on restoring access to aquatic habitat and on monitoring the success of the funded fish passage projects.

This presentation will provide a discussion of both the Culvert AOP Grant Program and of aopMAP (aquatic organism passage Monitoring & Assessment Protocol), a standardized AOP monitoring protocol that has been developed by FHWA Western Federal Lands with the support of WSP and Natural Waters. Data collection has been underway with aopMAP on over 100 sites from Alaska to Maine. As billions of additional dollars are made available to replace aging infrastructure, monitoring the effectiveness and sustainability of water crossings over time becomes increasingly more important in ensuring passage goals are achieved and maintained. With design approaches varying across the world, a consistent protocol for monitoring and assessment of performance data becomes essential in helping environmental agencies, infrastructure owners, and tribal entities understand failures and successes. We will discuss the new technologies being implemented in monitoring, lessons learned, and observations on design and construction best practices from early adopter sites. The presentation will conclude with discussions on next steps, including integration of biological assessment protocols, long-term research goals, and opportunities for partner agencies to become involved in the project. The project team envisions the results of the research study to be utilized nationwide for improving AOP water crossing design and sharing best practices.

#3977 - Urban Stream Restoration - Where Managing Stream Power Improves Habitat and Builds Infrastructure Resilience

Nora Boylan, PG[1], Luke Russell, GIT[1], Nick Legg, PG[2]

[1]Wolf Water Resources, Portland, OR, [2]Lichen Land and Water, Portland, OR

Hydromodification, the change in flow regime due to land development, increases erosivity of streamflows and degrades streams. Stream degradation, in turn, diminishes habitat and exposes critical infrastructure that requires exorbitant costs to repair. Connecting these impacts to changes in erosivity is a critical linkage in understanding the problems and potential management solutions. To make this connection, we employ the concept of excess specific stream power, a measure of potential erosivity in units of kilowatt-hours – the same as your electricity bill! This "stream energy meter" integrates the magnitude and frequency of erosive events relative to established erosion thresholds. Understanding the flow events that do the most erosion, and how land use and/or climate change are changing the frequency of these events, is a crucial part of any successful urban watershed program. As in forest environments, unit stream power provides a user-friendly erosion measure because it can easily be adjusted to reflect various management and restoration regimes. Furthermore, established erosion thresholds allow us to assess potential stream degradation in varying stream environments. Using Tryon Creek, a small, urbanized tributary in Portland, Oregon, we find that stream restoration and floodplain reconnection are essential for managing the excess energy. Our analysis shows that a simple doubling of the active channel width can reduce the excess energy of the stream by up to 80 percent. These results highlight integrated benefits of stream restoration at improving habitats, reducing risk to infrastructure, and generally offsetting the impacts of urbanization.

#3967 - Chinook Wind - Creating an Intertidal Wetland in an Urban Landscape

Mason Bowles, PWS

King County Water and Land Resources, Seattle, WA

The Chinook Wind project created 4 acres of new estuarine wetland, aquatic, and riparian habitat area to provide transitional off-channel rearing habitat for juvenile Chinook on the Duwamish River in Tukwila, WA. Over 97% of the wetlands on the Duwamish River have been converted to urban land uses, and the creation of Chinook Wind is a rare example of adding wetland area with off-channel intertidal mud flat habitat, as well as low and high marsh. Transitional habitat is one of the limiting factors to Chinook salmon survival which have <1% smolt: adult survival in the Lower Green and Duwamish Rivers. After property acquisition and seven years of planning, design and permitting, construction involved the demolition of a derelict hotel, asbestos abatement, and site decontamination. Site grading required the excavation of 80,000 cy of soil over a two-year period to create a spiral design with a breakwater and quiescent backwater. The establishment of new plant soil horizons was critical to establishing a new biotic community. Field assessments of reference and relic soils, lab analysis, and bench testing were performed to develop construction specifications. These included requirements for decompacting the site and blending mature composts with on-site soils, followed by repeated application of humic acids and mycorrhizal amendments during the planting phase. Over 70 species of plants, including native trees, shrubs, groundcovers and wetland grasses were installed to create intertidal marsh, seasonal pollinator habitat and a riparian buffer. Intertidal marsh habitat was creating using both wetland sod and seeds. The custom-grown wetland sod included four species of native wetland sedges that include species both rare and extirpated from the Duwamish River. Wetland grass and forb seeds were planted after being collected from wild stands over a two-year period and germinated using both natural and artificial stratification. A key element to the successful establishment of the intertidal marsh grasses was developing an integrated approach to managing and excluding Canada geese. This included the installation of barrier fencing, and the use of

"goosebuster" system consisting of solar-powered loudspeaker system that randomly broadcast recorded goose distress calls. Lessons learned include the importance of supporting construction inspectors through weekly or even daily site visits to inspect, demonstrate, and correct construction and installation errors and omissions.

#3986 - Successful Stillaguamish River Estuary Restoration

Dan Elefant, PE

Environmental Science Associates, Seattle, WA

Island biogeography and conservation biology support the necessity for larger and more connected habitat restoration. Based on over 10 years of experience in engineering designing and constructing estuary restorations in the Puget Sound, the presenter will focus on key design and analysis elements that led to successful construction implementation that set a trajectory for mature marsh evolution in the Stillaguamish Estuary. 2019 salmonid usage data, vegetation assessments, and onsite geomorphic evaluation from the Stillaguamish Tribe's zis a ba Phase 1 estuary restoration was used to inform design of this year's 2023 estuary restoration construction with The Nature Conservancy. Recent monitoring data (drone elevation and fish sampling) confirms that TNC's site is now on a restoration trajectory as compared to analysis from 2014 that suggested the site was not performing to support rearing salmonids. Restoration recovery data from both zis a ba Phase 1 and TNC's Port Susan Bay site will be presented with a focus on its incorporation into the Tribe's next 2 phases of restoration with the goal of 700 acres of connected habitat.

#3987 - Restoration of Puget Sound and Columbia River Estuaries: Lessons Learned/Challenges/Opportunities

Sky Miller, PE

Environmental Science Associates, Seattle, WA

All of our large estuary restoration projects are intended to maximize salmon habitat restoration. However, each project has neighbors or stakeholders with unique concerns and needs to be addressed. I'll describe twelve estuary projects that have been designed and constructed, and how we addressed these concerns and lessons learned. For example, the Nookachamps Mitigation Bank project constructed the City of Mount Vernon a new dike to keep a major arterial open during floods and constructed a passive recreational trail for the Parks Department, in exchange for 40 acres of City owned land. The zis a ba (1) project included design and construction of a $400,000 one-way flood gate structure to drain 4000 acres of agricultural land during large floods, providing much needed flood relief for neighboring farms. On the Port Susan Bay estuary project, Construction crews use innovative low ground pressure equipment ("floating excavators") to allow construction in soft soils and construction to continue after breaches allow tides into the construction site. At the Blue Heron Slough Conservation Bank, we used an innovative public-private partnership between the Port of Everett and a private investment firm to develop and finance the project. All of these and more lessons learned will be discussed in this presentation.

#3985 - Using Biogenetics and Landscape Connectivity to Plan Effective Tidal Delta Restoration Projects for Chinook Salmon

Emily Howe, PhD[1], Mike LeMoine, PhD[2], Anne Beaudreau, PhD[3]

[1]The Nature Conservancy, Seattle, WA, [2]Skagit River System Cooperative, Burlington, WA, [3]University of Washington, seattle, WA

Connected and resilient landscapes are beneficial for Chinook salmon recovery, yet we lack a framework for assessing the potential effectiveness of estuarine restoration designs over broad temporal and spatial scales. As a result, it is difficult to accurately assess the return-on-investment tradeoffs when comparing alternative designs. To address this issue, we developed an analytical framework using hydraulic, landscape connectivity-abundance, and bioenergetic models to compare the abundance and growth potential of juvenile Chinook salmon across a suite of restoration and climate scenarios. The framework stems from two hypotheses: H1) Well placed restoration projects support increased juvenile Chinook salmon use beyond the intended project area by increasing connectivity among sites or by creating or promoting areas with high growth potential; and H2) Warming water temperatures driven by climate change counteract restoration efforts by increasing the metabolic demand of juvenile Chinook salmon feeding in estuarine deltas, which may be further impacted by poor project placement. To develop the comparative framework, we leveraged restoration design plans and monitoring data for projects in the Stillaguamish delta in Washington State, where over 900 acres of estuarine wetlands are on track for restoration through a series of past, current, and future restoration projects. We used design plans, abundance estimates, and growth potential results to evaluate which juvenile Chinook salmon recovery actions provide cumulative, broad-scale restoration benefits and remain resilient to future climate change. This work thus examines the extent to which salmon recovery planning requires looking beyond project boundaries to include consideration of project placement within the estuarine landscape mosaic.

#3857 - Remote sensing applications to support tribal efforts in riverine and floodplain assessment and monitoring:

Mischa Hey

100 NE Circle Blvd UNIT 126, Corvallis, OR

As tribes continue to adopt and leverage remote sensing to guide and inform riverine monitoring and assessment, there may be additional value in the data that is not being fully exploited. Remote sensing and spatial analytics have substantial utility to support riverine and floodplain assessment and monitoring at extents not feasible with traditional field surveys. This presentation will provide an overview of relevant technologies such as topobathymetric lidar, sonar, and multiple imagery types, as well as processes for integrating and analyzing these data. Broad-scale, objective, and reproducible analytics allow for geographic and temporal comparison across entire river systems to aid in inundation modeling, restoration prioritization, efficacy monitoring, and more. Quantification and mapping of geomorphic features, thermal refugia, floodplain connectivity, instream structure, riparian vegetation, solar exposure, and water quality are some of the applications we will review. The goal of this presentation is to provide tribal entities and their partners information on how to leverage the concept of digital

twins in natural systems through remote sensing technologies, data fusion, and analytics to get the most out of their data.

#3892 - "Learning from repeat green LiDAR surveys to monitor/plan floodplain restoration in the Tucannon River, WA"

Kris Fischer

46411 Timine Way, Pendleton, OR

Restoration work in the Tucannon River started in the mid-90's with the listing of spring Chinook. Over the past 30 years various restoration project intensities have been completed by the restoration partners, with the question always being "how much is enough"? With the second edition of the Tucannon restoration plan completed in 2021, we refocused our efforts on reducing stream power using natural stream processes to increase channel complexity, and floodplain connectivity. To monitor success, the Tucannon monitoring plan was developed using a combination of on the ground rapid habitat surveys and large-scale remote geomorphic change detection surveys using repeat red/green LiDAR to measure geomorphic change. The red/green LiDAR was collected in the Tucannon during 2017 and again in 2020 after a 25-year event caused significant flooding. This presentation will introduce you to the significant findings of the Tucannon Monitoring Plan and show you what 60 miles of red/green LiDAR can teach you about your work.

#3918 - Skokomish Estuary Restoration Monitoring

Lisa Belleveau, MES

Skokomish Indian Tribe, Skokomish, WA

The purpose of this presentation is to share the results from monitoring the Skokomish Estuary Restoration Project and highlight some watershed-wide actions to continue to restore and enhance salmon habitat throughout the Skokomish River.

In 2007 the Skokomish Tribe broke ground with a phased estuary restoration project. Since then, almost 1,000 acres have been reintroduced to tidal inundation. One of the main objectives of this project was to restore salmon habitat to help revive the existing salmon populations and also support the introduction of new populations, like sockeye. A monitoring plan was created in order to measure the success of the project. With funds provided by the Environmental Protection Agency the Tribe has been conducting estuary monitoring since 2011. Monitoring includes vegetation surveys paired with pore-water salinity, elevation and sediment changes; tidal channel depth, temperature and salinity; as well as fish presence, timing and abundance.

Our monitoring results show that native saltmarsh plants are dominate in the restoration area; salmon are utilizing the habitat; sediment is accreting (which could help offset the impacts of sea level rise); and even though we have seen six of the top ten Skokomish River crests over the last two years the impacts of the flooding to the surrounding community have been greatly reduced. One important lesson here is that monitoring is essential in order to understand the efficacy of such projects.

In addition to the large estuary restoration project there are many ongoing and planned projects throughout the watershed. These projects will complement the estuary restoration and are

intended to promote natural sediment distribution and increase floodplain connectivity. The increase in off-channel habitat connectivity will provide both refugia for threatened species and more floodwater dispersion.

#3909 - Salmon Recovery and Bank Stabilization on the Pend Oreille River

Kayla Kassa, PE[1], Mike Zarecor, PE[2]

[1]Osborn Consulting, Spokane, WA, [2]Osborn Consulting, Vancouver, WA

The Pend Oreille River, a significant tributary of the Columbia River with a 1,300 square miles watershed in Northeast Washington. It flows from Lake Pend Oreille in Sandpoint, ID, through Newport, WA, into Canada where it feeds into the Columbia River. The Pend Oreille River watershed provides habitat to numerous threatened and priority species, including fish species such as the bull trout, westslope cutthroat trout, and the mountain whitefish. The watershed not only provides habitat and clean water for innumerable species, but it is also a recreation destination area. Many landowners purchase vacation property along the Pend Oreille River, but due to significant water level fluctuation, wave action, vegetation loss, and development, significant amounts of sediment are lost annually through erosion processes. This not only has negative effects on the Pend Oreille River, but on the entire Columbia River Basin. Additionally, increased sedimentation and loss of vegetation has contributed to increased water temperatures in the Pend Oreille River. This has resulted in threatened fish species that require cold water and clean gravel to not only spawn but to survive. Osborn Consulting worked with the Pend Oreille Conservation District (POCD) to improve water quality and riparian habitat for salmonids, as well as provide bank stabilization for local landowners by addressing these issues with a combination of traditional bank stabilization techniques, such as riprap, along with advanced bioengineered techniques, such as large woody material, coir logs, coir matting, and native plants, to stabilize the banks along the project areas for a total of approximately 8,713 LF of stabilization and just under 13 AC of total restoration at 71 different properties.

#3905 - Applied Lessons Learned within the Middle Fork John Day River Intensively Monitored Watershed

Kasey Bliesner[1], Ken Fetcho[2]

[1]Oregon Department of Fish and Wildlife, La Grande, OR, [2]Oregon Watershed Enhancement Board, Salem, OR

The Middle Fork John Day River (MFJDR) Intensively Monitored Watershed (MFIMW) was established in 2008 to 1) evaluate the overall benefit of restoration actions to spring Chinook Salmon and summer steelhead in the MFJDR, and 2) understand how specific restoration actions impact instream habitat, temperature, and salmonid metrics at multiple scales. To date, 149 restoration projects have been implemented along the upper mainstem MFJDR and in the tributaries, including 73 miles of instream habitat treated, removal of barriers that improved access to 135 miles of habitat, instream water leases that provided over 6cfs of flow, and riparian planting and protection along 39 stream miles. Many of these restoration projects were multi-faceted, designed to address multiple limiting factors, including increased water temperature (the primary limiting factor for MFJDR salmonids), degraded floodplain function and connectivity, reduced habitat quantity and diversity, and altered hydrology. MFIMW partners produced a

summary report in 2016, and another in 2023 after 15-years of intensive monitoring, restoration, and collaboration. In the 15-year Summary Report monitoring experts and restoration practitioners provided results of monitoring and reflected on past lessons learned to offer new recommendations to guide restoration in an adaptive management approach. An adaptive management assessment found that from 2017 to 2023 partners incorporated approximately 50% of the recommendations provided during the 10-year summary into the ongoing planning, restoration, and monitoring efforts in the MFIMW. Adaptions included scheduling recurring meetings to increase communication amongst the restoration practitioners and monitoring experts, focusing on reach/project scale juvenile salmonid movement in and out of restored reaches, investigating fry and parr usage of floodplains, and implementing a coordinated water temperature monitoring strategy. Recommendations adopted by restoration practitioners included protecting riparian plantings to ungulate browse, prioritizing, and increasing riparian plantings, better coordination of restoration projects amongst partners, and increasing floodplain inundation by incorporating numerous process-based restoration actions. While changes to overall watershed-scale fish population abundance and productivity have not yet been detected, monitoring results summarized from MFIMW partners refined our understanding of the impacts of restoration actions in the MFJDR. Long-term habitat trend monitoring in collaboration with Oregon State University and the University of Oregon found that sites encompassing both passive and active restoration exhibited deeper residual pool depths, narrower channel widths, more habitat units per kilometer (i.e., increased complexity), and higher large wood densities than any other treatment type. While average redd count and spawner abundance of Spring Chinook salmon has remained static, redd distribution has shifted downstream to the restored Oxbow Conservation Area reaches – indicating a preferential selection of restored habitat for spawning activity. Juvenile salmonid movement monitoring shows the importance of access to cold-water tributaries during years of higher-than-average water temperatures. Water temperature monitoring and analysis improved with coordination and trend analysis shows improvements in select reaches. Utilizing an adaptive management approach, MFIMW partners are using long-term monitoring results to understand how habitat and fish populations respond to restoration actions. This has led to a refined process to prioritize restoration practices to address limiting factors and improve habitat conditions.

#3819 - Planting The Seed for Beaver Success

Jefferson Jacobs, M.S.

Oregon Natural Desert Association, Bend, OR

The Oregon Natural Desert Association (ONDA) has been utilizing volunteer labor to implement riparian planting projects in eastern Oregon's high desert for nearly two decades. Over the past decade, ONDA's riparian restoration strategy has developed to focus specifically on removing the factors limiting beavers' management of floodplains, utilizing an in-house conceptual model referred to as "BeaverHOODS". This beaver-based prioritization strategy was adopted in part because of the remote locations of restoration projects, and objectives requiring inherent ecological resilience achievable only from nature-based solutions. The aim of the Strategy is to explicitly support the recovery of beavers' management of floodplains, thereby furthering processes that restore and dynamically manage creeks: rather than relying on anthropogenic controls and actions. By prioritizing beavers' requirements, these beaver-based solutions to improving riparian health have proven exceptionally successful on timeframes and scales

skeptics previously thought unlikely. Within this framework, a frequent limiting factor preventing the management of floodplains by beavers is a lack of woody riparian vegetation with proper diversity, abundance and size suitable for beaver food and construction materials. Because the BeaverHOOD Strategy encourages riparian woody abundance metrics of up to 18,000 mature stems per half-mile reach, ONDA was incentivized to improve and evolve planting techniques into an intentional and repeatable approach which could meet these goals over short timelines; all while utilizing volunteer labor. This presentation represents the current culmination of our learning processes and describes how we incorporate a specifically targeted suite of easily reproducible and common-sense approaches which complement and support each other including: Site planning and scouting, creating and tracking hydrological changes, alignment of appropriate planting techniques with site characteristics and needs, browse control, and weed management. By sharing this information, we hope to provide accessible and immediately implementable strategies and techniques that can be put to use improving the success of riparian plantings, as well as more effectively include and prioritize riparian vegetation plans into a bigger overall watershed restoration vision.

#3946 - An Unprecedented Opportunity: NOAA Restoration Center Funding under the Bipartisan Infrastructure Law and Inflation Reduction Act

Larissa Lee[1], Lauren Senkyr[2], Regina Southworth[3]

[1]NOAA, Seattle, WA, [2]NOAA Restoration Center, Portland, OR, [3]National Oceanic and Atmospheric Administration, Corvallis, OR

The Bipartisan Infrastructure Law (BIL) and the Inflation Reduction Act (IRA) present a once-in-a-generation opportunity for NOAA and partners to continue making an impact for fisheries, threatened and endangered species, and coastal communities. The BIL provides $891 Million over 5 years, with $491 Million for habitat restoration and $400 Million reserved for fish passage. The IRA provided an additional $484 Million of funding for these restoration, conservation, and resilience efforts. This funding is being made available through competitive grant opportunities managed by the Office of Habitat Conservation (OHC) in NOAA Fisheries. In 2022, the first year that these funds were available, OHC held four competitions: National Fish Passage, Tribal Fish Passage, Transformational Habitat Restoration and Resilience, and Habitat Restoration for Tribes and Underserved Communities. Nationally, this resulted in $482 M allocated through 109 awards. In this poster, we present the resulting selected projects in Oregon, Washington, and Idaho that were funded through all four funding opportunities, in order to inform applicants and restoration practitioners about the types of projects and applications that may be most competitive through future funding opportunities. We will examine various factors in these applications, such as the range of fund amounts that were allocated per award, the location of projects, and the type of organization that received funding, among other factors. We will also examine how these locations overlap with Evolutionarily Significant Units (ESU) for NOAA's ESA-listed salmon. In 2023, OHC announced the same 4 funding opportunities, with longer application periods, larger caps on projects, and a greater emphasis on Tribes. One more round of competitive funding opportunities using these funding sources is expected, and this information is presented to spark conversations about how to implement projects through NOAA's funding opportunities in the Northwest Region that are most impactful to species recovery. An understanding of these opportunities and the projects selected in round one, and

how funding opportunities changed in round two, will help the River Restoration community compete more effectively and creatively for future restoration funding.

#3898 - Riparian Vegetation Enhancement and Monitoring in Mine Tailings Restoration

Lauren Osborne

Confederated Tribes of the Warm Springs Reservation of Oregon, John Day, OR

Riparian plantings are a ubiquitous feature of river restoration projects; despite significant investments made towards riparian rehabilitation, little precision monitoring has been performed to assess planting survival. General plant density counts are completed regularly; however, assessments of survival and recruitment of specific plants is rarely pursued. The Confederated Tribes of the Warm Springs Reservation of Oregon (CTWSRO) completed two separate planting efficacy studies on the Oxbow Conservation Area (OCA) located on the Middle Fork of the John Day within a historically dredged reach of stream. The OCA received a 5-phase restoration effort between 2011-2016 intended to mitigate the impacts of historic dredge mining, with major restoration components including channel consolidation, construction of natural channel morphology, large woody debris placement, and riparian protection/enhancement. The two studies were similar in location, but differed drastically in monitoring efforts. The original 2012 study counted all woody stems in established cross-sections along the riparian, which included recently installed plantings and existing woody stems, while the subsequent 2021 study used real-time kinematic positioning equipment to electronically tag 330 installed plants along the riparian to track survival of only installed plants. The first study showed variation in survival and additional recruitment in monitoring plots, whereas the 2021 study showed little survival in installed plants, with almost a fifth of the plants installed being lethally browsed by small rodents within the first-year post-installment. Through both monitoring efforts key lessons were learned for future planting efforts within the OCA. The two that are potentially easiest and most impactful to address are 1) established plants will successfully recruit new plants in the area; therefore, protecting these plants may lead to quicker revegetation of the stream than intentional plantings and 2) fine-meshed rodent exclusionary fencing may be a necessary addition to the currently installed eight-foot ungulate exclusionary fences to protect newly installed plants from small-animal browse, especially when plants are sparse and immature. By addressing these and additional lessons learned, we may see more success in the revegetation of riparian areas along dredge mined streams.

#3891 - Wildfire and River Restoration: Case Studies from the Methow River Watershed

Zachary Sudman, Tim Hanrahan

Rio Applied Science and Engineering, Boise, ID

Under current climate change trends, wildfire frequency, extent, and severity are all projected to increase throughout western North America. As investments in salmonid habitat restoration in the Pacific Northwest continue, the compounding threat of wildfire creates an impetus for more rigorous consideration of wildfire impacts in the context of stream restoration design.

Case studies from the Methow River Basin provided observations of direct fire impacts to fish habitat restoration projects and indirect secondary post-fire impacts to restoration projects in the

Chewuch River and Beaver Creek. Additionally, observations of fire impacts were made on Wolf Creek, a designated wilderness-area watershed relatively free of anthropogenic disturbances. The Chewuch River case study included fifteen restoration sites along seven river miles. As a result of the Cub Creek 2 fire in 2021, eight restoration sites along the Chewuch River experienced direct fire impacts, mostly in the form of burning of constructed large wood structures. Three post-fire debris flows occurred in summer 2022, with one debris flow reaching the Chewuch River and depositing large volumes of fine sediment at multiple restoration sites. The Beaver Creek case study included twelve restoration sites along one river mile, as well as observations along six river miles upstream and downstream of the restoration sites. The Carlton Complex fire in 2014 directly burned constructed log jams at eight of the restoration sites in Beaver Creek. Large magnitude precipitation events in 2014 and 2017 resulted in numerous debris flows and flooding in Beaver Creek, accompanied by inputs of sediment and woody material which resulted in substantial channel migration and avulsion. The Wolf Creek case study included hillslope, floodplain, and river observations along four miles of valley within the Okanogan National Forest. The Cedar Creek fire in 2021 directly burned approximately 50% of the case study area and 80% of the contributing watershed. Areas of high and moderate burn severity resulted in fire consumption of most existing large wood jams, along with overstory and understory vegetation on the valley bottom and hillslopes. Increased erosion processes in the first year after the fire produced and transported fine sediment to the stream channel, while minimal changes to channel morphology were observed throughout the case study area.

The lessons learned from the case studies provide information for river restoration practitioners and stakeholders to understand and consider the risks wildfires pose to restoration projects, and suggestions for mitigating those risks. Through more rigorous consideration of observed and projected climate and wildfire trends, stream restoration actions can become more resilient to the effects of wildfire and habitat restoration projects can more effectively buffer some of the negative impacts of wildfire, thereby contributing to proactive management strategies aimed at climate change adaptation and mitigation.

#3911 - Assessing Beaver Habitat Suitability in British Columbia Using Machine Learning

Landen Matechuk, MSc. Student

University of British Columbia, Vancouver, BC, Canada

Beavers, renowned as ecosystem engineers, profoundly influence hydrological, biological, and geomorphological processes within freshwater ecosystems. Historically, fur trapping reduced North American beaver populations from an estimated 100-400 million to mere hundreds of thousands (Naiman et al., 1988). This decline removed a natural control from stream systems across the continent. Though beaver numbers have since rebounded to an estimated 15–30 million, contemporary challenges such as land development, agriculture, and climate change further reduce potential habitats (Müller-Schwarze & Sun, 2003). Given their pivotal role, a renewed emphasis has been placed on beaver conservation and habitat restoration.

For effective beaver reintroduction, understanding and identifying suitable habitats is paramount. Yet, this often involves a complex and time-consuming analytical process. Our study seeks to streamline this by employing a random forest machine learning model. Trained on beaver habitat data from British Columbia's Nechako watershed, the model combines topographic, biologic,

and hydrologic data, identifying their correlation with existing beaver habitats. Validated against field surveys, the model's output delineates habitat suitability, with potential applications throughout British Columbia. This research underpins data-driven decisions, crucial for the success of beaver reintroduction and broader freshwater ecosystem restoration.

#3982 - Regenerative Land Management for Water Security and Riparian Habitat Enhancement

Kieran Sikdar, CFM[1], Ricardo Aguirre, PE, D.WRE, CFM, AP[2], Brian Wahlin, Ph.D., PE, D.WRE[3]

[1]WEST Consultants, Salem, OR, [2]WEST Consultants, Inc., Red Rock, AZ, [3]WEST Consultants, Inc., Tempe, AZ

Water security is an escalating challenge across the United States, affecting municipalities, producers, and riparian and aquatic habitats. This presentation reviews two active projects located in the arid Southwest and explores the potential of regenerative land management as a robust strategy to ensure water security while simultaneously combating desertification threats to riparian habitats.

This presentation will explore the implementation of holistic land management techniques in lieu of conventional infrastructure-based engineering solutions. This approach yields both ecological and economic advantages, and Mr. Aguirre's work through WEST continues to examine the potential enduring benefits of managed livestock and holistic planned grazing as precision tools for storm water infiltration, flood mitigation, water quality enhancement, and erosion prevention.

Through the lens of two active projects—the "3 Canyons Land Management Project" in Cochise County and the "WEST Demonstration Site," developed in collaboration with the Drylands Alliance for Addressing Water Needs (DAAWN) 501c3 nonprofit, Red Rock, AZ—this presentation illustrates how holistic planned grazing effectively mitigates flooding and preserves water quality, especially in arid and/or desertifying regions, thus safeguarding riparian habitats and bolstering water security. Furthermore, the discussion emphasizes the pivotal role of soil health in flood reduction, and how planned grazing can repair the nutrient cycle to promote soil health.

This presentation will also explore methodologies of establishing collaborative relationships with agricultural producers, private landowners, and other local, state, and federal land management agencies designed to lay out a strategic framework that incorporates individuals' holistic objectives for planning, implementation, and comprehensive monitoring for ongoing project success.

#3965 - Getting to Yes – Finding Synergies to Boost Project Viability

Wayne Gullstad

King County Drainage District No. 7, Duvall, WA; Cherry Creek Farm, Duvall, WA

Cherry Creek was transformed into a ditch in the 1930s with the intent of improving the conveyance of water post-flood. It supports runs of three types of salmon plus steelhead and sea-run cutthroat trout. It is regarded by Wild Fish Conservancy, Sound Salmon Solutions, and Washington Dept. of Fish & Wildlife as a very important target for fish-enhancement restoration.

King County Drainage District No. 7 (DD7) lies adjacent to Cherry Creek. The Drainage District manages a levee and pump station that protects Cherry Valley from flooding during certain times of the year. The levee, also built in the 1930s, is of suboptimal design and in need of repair.

The Cherry Creek restoration project and the DD7 levee restoration project are both critical to their constituents. However, neither project was considered viable...until they sought to collaborate.

The Cherry Creek and DD7 teams could not be more different in their objectives. In fact, those constituencies typically find themselves on opposing sides of fish- or drainage-related projects. In this case, they found synergies between the projects that not only made both viable, but created a pathway to further projects that will benefit both fish and drainage. The result of the collaboration is a successful project. The current phase of the Cherry Creek Project (about 1/3 complete) includes restoration along 3,000 feet of creek and a rebuild of 1,800 feet of levee. The restoration work involves reshaping banks to increase the aquatic zone, addition of large woody debris, removal of invasive plants species, and establishment of a vegetated buffer. Subsequent work will restore another 4,000 feet of Cherry Creek and rebuild an equivalent amount of levee.

The Cherry Creek Project serves as an example of finding creative synergies in salmon enhancement projects. Finding ways to provide benefits to erstwhile opponents simply means your project has a greater chance of being accepted.

#3956 - Experiments with Biocultural Restoration in North Puget Sound

Paul Cereghino[1], Jared Busen[2]

[1]NOAA Fisheries, Olympia, WA, [2]Snohomish Conservation District, Lake Stevens, WA

Within the colonial cultural structure of riparian restoration there is no institutional structure for multigenerational stewardship of the land. Without this structure riparian restoration projects are typically set up as a one time planting occurring at the same time as site preparation, with maintenance only funded to occur once or twice a year for 3-5 years depending on grants. This leads to riparian restoration sites that are not maintained at the level they need to achieve broad-based ecological functions such as reduction in invasive species, appropriate width and density of the riparian ecosystems and habitat creation for a range of aquatic and terrestrial species. The standard colonial cultural structure strives to remove humans from the restoration site. How do we develop a culture that values long-term stewardship of restored habitat to ensure success with a framework that is designed to keep people out, from having the opportunity to develop a connection with the land? This presentation will discuss three examples and their efforts towards establishing a culture of stewardship, developing connections with the land.

1) Raising Cane Ranch, an established agroforestry riparian buffer integrated with a working cider orchard.

2) Snohomish Waterfront Park, an agroforestry riparian buffer in development along the Snohomish River for use by the public.

3) Skykomish Field Station, an effort to develop self-replicating and culturally-driven community events, rather than the institutionally-driven volunteer events typical in the restoration industry.

#3963 - Traditional Harvesting is Land Tending: Traditional Indigenous Land Management Practices & Biocultural Restoration

Lindsey Crofoot

Northwest Indian College, Bellingham, WA

For countless generations the Indigenous peoples of the Pacific Northwest have practiced biocultural land management that shaped their traditional lands to meet the needs of the people and promoted healthy resilient ecosystems. Traditional harvesters have long played a role in tending the landscape to produce a diversity of forest and forest related products. They are inherent land managers and were historically agro-foresters, silviculturists, wetland ecologists, prairie and shrub-step specialists, habitat managers, wildlife biologists and more. Traditional Native inter-generational and community land management centered in place has been shown to produce an extremely accurate historical data set that informs management practices that are highly adaptable, meet the needs of the people, and are sustainable. Traditional Native land management practices and values of reciprocity recognize that people are an ingrained part of the biodiversity and structure of the native ecosystems and when people can fulfill their traditional roles in the landscape there is a direct positive impact on the functioning and resilience of the ecosystem. With this knowledge modern land management practices can be supported and enhanced through the thoughtful and deliberate inclusion of traditional Native land management practices and TEK. A small-scale biocultural restoration project planted in Spring of 2022 provides a model for the integration of TEK within restoration, monitoring, and long-term management plans that has the potential to be scaled and implemented across a diversity of ecological landscapes. The urban forest restoration project located in Bothell, WA aims to restore the natural structure and function a highly invaded pasture in the lower reaches of the Sammamish River watershed while creating a forest garden composed of native vegetation that will provide produce and forest products intergenerationally for members of the co-housing community that live surrounding the restoration site. Being the first NRCS Cultural Planting Enhancement (E612E) through the Conservation Stewardship Program in Washington State, this enhancement required that native vegetation be selected for both their cultural importance and adaptability to site conditions. Stakeholders including the landowners, community members, University of Washington Bothell Restoration Ecology professor and interns, and Northwest Indian College Natural Resources professor and intern. Together this group developed restoration goals and plans that were inclusive of TEK and Native land management values and techniques. Long term project management goals that are rooted in TEK include harvesting and traditional land tending as a means of controlling aggressive or invasive species, increasing native plant diversity, limiting competitive coexistence, and increasing facilitation, which is expected to increase soil health, increase water quality coming from the site, restore the natural function of the ecosystem, and promote resilience and resistance to climate change. While small, this model of biocultural restoration has the potential to make significant impacts on how ecological restoration is approached as culture and a people's role within the ecosystem become a larger part of restoration efforts and projects.

#3922 - Forest Farming and Riparian Restoration

Patrick Shults, MS[1], Wayne Gullstad[2,3]

[1]WSU Extension Forestry, Olympia, WA, [2]King County Drainage District No. 7, Duvall, WA, [3]Cherry Creek Farm, Duvall, WA

Riparian buffers have well-documented success at protecting waterways but also traditionally remove productive land from agricultural production. With already slim profit margins, the resulting decrease in production and income can put significant stress on farm operations. Moreover, buffers are expensive and difficult to install and maintain. This makes it extremely difficult for farmers and landowners to adopt a "no-touch" conservation-only riparian buffer, even with the help of financial incentives and technical assistance. Going forward, solutions and systems that address landowner financial and social needs are paramount. The most effective way to meet objectives like salmon restoration is to work with farmers on developing economically and environmentally viable forms of riparian land management.

Agroforestry is the intentional integration of forestry and agricultural practices to develop economically viable agroecological systems that also provide environmental and cultural benefits. Forest farming, which involves the intentional management of non-timber forest products in woodlots, is an agroforestry practice that is highly compatible with stream and wetland restoration. It can be used to develop "working" riparian buffers that maintain agricultural production in that space while protecting streams and providing habitat. Forests in the Pacific Northwest are ripe with opportunity for forest-grown specialty crops, including log-grown mushrooms, bigleaf maple syrup, Oregon grape, huckleberry, and more. Washington State University Extension and partners in the region are exploring these forest farming crops for both upland and riparian applications. The results of these efforts are being developed into demonstration-based educational opportunities and toolkits to support landowner adoption.

Pairing incentive-based riparian restoration efforts with research, market development, and resources for growing forest farmed crops may encourage adoption of riparian buffers on agricultural lands. In this presentation, you will learn about what's been done in this field and where forest farming could be headed in the Pacific Northwest.

Plenary Session Abstracts

Wednesday – February 7

#3972 - Evaluating large floodplain restoration projects using a combination of remote sensing and supplemental field surveys: A case study on the Middle Entiat

Phil Roni, PhD

Cramer Fish Sciences, Issaquah, WA

River restoration efforts continue to grow in size and complexity and several large projects covering 5 km, 10 km, or longer channel lengths have been implemented or are currently in the planning stages. However, monitoring protocols and programs have not been designed to monitor restoration effectiveness at this broad scale. The Middle Entiat Project implemented in 2019 and 2020 represented a unique opportunity to monitor physical and biological responses to a large restoration project (about 8 km) and test new and efficient effectiveness monitoring techniques. In 2018, we implemented a monitoring program to answer the following questions:

1. Did the restoration in the Middle Entiat increase habitat complexity, pool frequency, wood cover, side channel area and length, channel morphology, and floodplain connectivity?
2. What are the seasonal patterns of fish habitat use, and have juvenile and adult fish capacity increased following restoration?
3. How has the total area of suitable habitat for juvenile Chinook salmon *Oncorhynchus tshawytscha* and steelhead *O. mykiss* changed following restoration?
4. Did specific restoration design elements meet their objectives?

The trigger for post-restoration monitoring hitting a flow target (bankfull flow of 24 hours or more), which occurred in 2022. We collected pre- (2018) and post-restoration (2022) data including: 1) detailed geo-referenced fish-habitat surveys, 2) channel and floodplain geomorphic assessment based on bathymetric LiDAR, 3) quantification of large wood (LW) using satellite imagery, 4) census of summer low-flow juvenile fish abundance, and 5) as-built surveys to quantify changes in topography and morphology from restoration rather than construction.

Comparison of fish habitat survey data before and after restoration demonstrated that most pool and habitat metrics improved from 20% to 40%. Floodplain and geomorphic metrics calculated primarily from remotely sensed data and hydraulic model outputs also showed that bankfull area (84%), bankfull width (31%), floodprone width and area (10%), sinuosity (21%), river complexity index (47%), and length and area of side channels at high flows (79% and 40%) all increased following restoration. Total juvenile Chinook and steelhead abundance increased from 573 to 2782 and 80 to 544 fish before and after restoration, respectively. Total juvenile Chinook and steelhead capacity based on the 90th percentile of fish densities suggest that reach capacity increased 32% and 26% for juvenile Chinook and steelhead, respectively. Habitat suitability modeling based on showed that total weighted usable area increased for juvenile and spawning Chinook and steelhead at base flows (130 cfs), two-year flows (2,680 cfs), and spawning flows (130 cfs and 660 cfs).

Our evaluation of design objectives indicates that most bar and apex jams are meeting two or more of their design objectives. The constructed perennial side channel and some seasonal side channels were meeting their design objectives at high flows but many were disconnected or dry at low flows. The Middle Entiat case study demonstrated that simple before and after monitoring using remotely sensed data coupled with targeted field data collection can be used to evaluate not only the physical and biological success of large floodplain projects but also individual design elements.

#3988 - Locating Cold Water Sources within the Entiat River Watershed: Opportunities for Habitat Restoration

Mark Ingman[1], Mousa Diabat, Ph.D[2]

[1]Cascadia Conservation District, Wenatchee, WA, [2]NV5 Geospatial, Corvallis, OR

The Entiat River watershed in central Washington supports populations of chinook salmon, steelhead trout, bull trout, and lamprey. Among a number of factors, stream temperature impacts abovementioned species in the Entiat River. The Entiat River and its tributaries are projected to warm in the coming decades due to increased atmospheric temperature and decreased snowpack across the watershed. During the summer and early fall baseflow, water temperatures in rivers may exceed the thermal tolerances of salmonids. The objectives of this project are to analyze the summer thermal behavior and to locate cold-water inflows to the main channel of Entiat River and Mad River, and to identify opportunities for restoration projects that aim to enhance summer refugia and rearing habitats for salmonids. To achieve these objectives, during the summer of 2023 we collected high-resolution airborne thermal infrared (TIR) and true color imagery of 60 kilometers of the Entiat River, Mad River, and main tributaries. The TIR imagery was collected using an advanced cooled-technology sensor (FLIR SC6000, longwave TIR 8-9.2um) mounted to a helicopter's floor which was flown at 400 m above ground level to achieve spatial resolution of 50 cm and temperature resolution was at a 0.1 ºC. Imagery was collected in the afternoon during summer when the thermal contrast is maximized between water in the channel and sources of cold-water inflow such as springs and hyporheic zones. The TIR data assisted in identifying several sites of cold-water sources and potential thermal refuges across the watershed. For each tributary, a longitudinal temperature profile was generated, which showed the thermal gradient of downstream cooling and warming that can be attributed to inflow from springs and tributaries (both cold and warm), riparian vegetation, and various environmental parameters. These data allowed us to identify the locations and hydrologic processes, such as groundwater discharge, that contribute to the maintenance of cold-water features within the drainage network that may function as refuges for salmonids and other cold-water fish. This project's analysis is added to the already on-going effort of mapping the watershed using a variety of technologies, such as topobathymetric lidar, and true color imagery, giving habitat-restoration planners to consider both the location of thermally suitable habitat and the physical processes contributing to it to and design future habitat restoration in the Entiat River watershed. Lastly, these data that constitute over 95% of the anadromous range for the Entiat watershed for cold water species will be made available for project managers in the Upper Columbia via the UCSRB data portal. The overarching goal is to encourage future restoration projects that are more strongly aligned with enhancing cold water habitat conditions.

#4141 - Designing and Implementing Successful In-Stream Wood Projects: Lessons Learned from Intensively Monitored Watersheds

Eli Asher

Governor's Salmon Recovery Office, Olympia, WA

Twenty years of before-after/control-impact data from Intensively Monitored Watersheds across the Pacific Coast has shown decidedly mixed results from placing large wood in streams with the aim of restoring or enhancing salmon and steelhead habitat. In watersheds where wood placement has resulted in positive fish population responses, treatments tend to have commonalities: they target limiting habitat factors, they cover a broad geographic extent, and they are intensive. The combination of extensive, intensive treatments, however, is infeasible or unaffordable for all watersheds. This talk highlights the importance of appropriately targeted, large scale, comprehensive treatments to achieve positive population responses and argues that watersheds that cannot support this level of treatment—even if habitat is the primary limiting factor—may not be good candidates for restoration.

#3949 - Low-tech Process-based Restoration: insights from 15 Years of Monitoring and Implementation

Stephen Bennett, Biologist[1], Scott Shahverdian, Fluvial Geomorphlogist[1], Nick Weber, Fish Ecologist[1], Gus Wathen[1], Joe Wheaton, PhD[2], Nick Bouwes[1]

[1]Anabranch Solutions, Providence, UT, [2]Utah State University, Logan, UT

The rediscovery and further development of beaver dam analogs (BDAs) and other low-tech process-based stream restoration (LTPBR) approaches over the last 15 years has led to an explosion of interest and implementation of these techniques across North America and Europe. At their core, these approaches rely on stream flow and structure (beaver dams and large woody debris) to “do the work” of restoring key natural processes of erosion, deposition, and floodplain connection. We provide insights on use of beaver, BDAs, and post-assisted log structures (PALS) to restore riverscape health using monitoring from two Intensively Monitored Watersheds and case studies, and provide guidance on assessment, design, implementation, and expectation management. We present our findings in the context of an adaptive management plan and understanding that the local flow, sediment, and wood regimes, and beaver population dynamics constrain what is possible from restoration actions, and dictate how long-term maintenance and adjustments may be required to restore sustainable stream processes.

#3975 - Detecting a response to restoration in low abundance salmon populations

Joseph Anderson[1], James Lamperth[2], Clayton Kinsel[1], Marisa Litz[1]

[1]WDFW, Olympia, WA, [2]WDFW, Kelso, WA

Streams with few salmon often are targeted for restoration, but do low spawner counts limit the potential benefits of stream restoration? Using abundance estimates of coho adults, parr, and smolts from the Hood Canal and Lower Columbia Intensively Monitored Watersheds, we used a series of models to evaluate the influence of adult salmon abundance on the potential population response to stream restoration. We found strong support for density dependent capacity limits on coho salmon abundance, but the strength of density dependence exhibited considerable variation

across streams and through time. Higher salmon abundances that tested the capacity limits of freshwater habitats to support salmon provided the strongest evidence for increases in population abundance following restoration. In rivers with consistently low adult abundance, restoration techniques that improve density *independent* survival (rather than increasing spawning or rearing capacity) likely offer the best opportunity to benefit salmon populations. When planning stream restoration, we suggest practitioners consider recent patterns of salmon abundance and whether the project is intended to increase habitat capacity to support salmon, increase freshwater survival irrespective of total abundance or both.

#3935 - Review of Results from Pacific Northwest Intensively Monitored Watersheds and Implications for Habitat Restoration Programs

Robert Bilby, Ph.D.

Salmon Recovery Funding Board Monitoring PanelRFBPanel, North Bend, WA

Intensively Monitored Watershed (IMW) programs have been active across the Pacific Northwest for over twenty years. These studies were established to determine the contribution habitat restoration can make to salmon recovery and to improve the effectiveness of habitat restoration programs. IMWs couple multiple restoration actions concentrated in a single watershed with intensive monitoring of habitat and fish populations. Recently, two efforts to review the results of regional IMWs and identify management implications have been completed. The Pacific Northwest Aquatic Monitoring Partnership (PNAMP) released a report in 2022 that reviewed results from 13 IMWs in Washington, Oregon, Idaho, and California. This review concluded that certain types of restoration actions, like barrier removal, were consistently associated with positive fish response but some, frequently employed, restoration actions, including wood placement, produced inconsistent fish response. The PNAMP review also concluded that limiting factors often were not accurately identified, limiting the effectiveness of restoration actions and that adaptive management processes were poorly developed in some regions, making it difficult to implement findings from IMWs or other monitoring programs.

Following the PNAMP review, a synthesis of the results from the 5 IMWs funded by the Washington Salmon Recovery Funding Board (SRFB) was initiated. This review was intended to summarize results from each IMW and investigate some of the uncertainties identified in the PNAMP review. As with the PNAMP review, the SRFB IMWs demonstrated consistent, positive fish response to barrier removal, and inconsistent response to wood placement. The IMW data related to wood projects suggests that successful projects require very intensive treatment at a site and often requires multiple treatment applications. The review also found that fish response to restoration was affected by the number of juvenile fish available to utilize habitat created through restoration. In systems with strong density dependence, fish populations should respond favorably to increased habitat. In contrast, in systems with weak density dependence increasing habitat area may not generate a positive fish response; there already is enough habitat to accommodate the juvenile fish. Therefore, restoration actions should couple efforts to increase escapement with restoration treatments that address density-independent mortality factors (e.g., predation). This presentation will explore the most significant results of these two reviews with a focus on implications for restoration practitioners.

#3958 - Closing the gap between science and management of cold-water refuges in rivers and streams

Francine Mejia, PhD[1], Valerie Ouellet, PhD[2]

[1]USGS, Seattle, WA, [2]Integrated Statistics, Inc, Orono, ME

Human activities and climate change threaten coldwater organisms in freshwater ecosystems by causing rivers and streams to warm, increasing the intensity and frequency of warm temperature events, and reducing thermal heterogeneity. Cold-water refuges are discrete patches of relatively cool water that are used by coldwater organisms for thermal relief and short-term survival. Globally, cohesive management approaches are needed that consider interlinked physical, biological, and social factors of cold-water refuges. We review current understanding of cold-water refuges, identify gaps between science and management, and evaluate policies aimed at protecting thermally sensitive species. Existing policies include designating cold-water habitats, restricting fishing during warm periods, and implementing threshold temperature standards or guidelines. However, these policies are rare and uncoordinated across spatial scales and often do not consider input from Indigenous peoples. We propose that cold-water refuges be managed as distinct operational landscape units, which provide a social and ecological context that is relevant at the watershed scale. These operational landscape units provide the foundation for an integrated framework that links science and management by (1) mapping and characterizing cold-water refuges to prioritize management and conservation actions, (2) leveraging existing and new policies, (3) improving coordination across jurisdictions, and (4) implementing adaptive management practices across scales. Our findings show that while there are many opportunities for scientific advancement, the current state of the sciences is sufficient to inform policy and management. Our proposed framework provides a path forward for managing and protecting cold-water refuges using existing and new policies to protect coldwater organisms in the face of global change.

#3936 - Physical Modeling of the Lower Yakima Cold Water Refuge Project at RM 2.5

Jaron Brown, P.E., Vaughn Collins, PE, CFM

Northwest Hydraulic Consultants, Tukwila, WA

Benton Conservation District (BCD) has identified the mouth of Amon Creek, a tributary to the Yakima River near Richland Washington, as a cold-water refuge location for adult salmonids. The site is characterized by unusual hydrology: Amon Creek is primarily fed by irrigation return water, and river levels are decoupled from Yakima River flows and are rather driven by Columbia River hydropower operations. A project to maximize thermal refugia at the site is now entering the final design stage.

Early analysis in the project considered river geomorphology, tributary location, flood hazard regulations, and construction considerations. A variety of analyses were performed to support an alternatives analysis including thermal-hydrodynamic numerical modeling. A key feature of the design is a flow deflector berm in the mainstem channel. The berm is designed to prevent warm and cold water mixing during summertime low flows within the migration window, but then be overtopped in winter high flows to induce scour in the habitat pool and self-maintain design depths. Preliminary analysis including numerical modeling gave confidence in project performance related to thermal refugia, but questions remained around sediment transport processes, scour and sustainability.

A small-scale physical model was constructed to assess these uncertainties and refine the project design. The physical model was designed using Froude scaling at a distorted scale of 1 to 72 horizontally and 1 to 36 vertically. An acrylic grit with a low specific gravity was used to simulate the prototype sediment and mobilizes at the scaled shear stress threshold. The model was useful in rapidly refining design elements including berm elevations, grading and large wood structures elements to maximize project objectives related to cold water distribution, sediment transport, and scour. The model proved to be a cost-effective way to gain confidence in a novel design and allow stakeholders a more intuitive understanding of project performance than traditional numerical modeling outputs.

#3973 - Understanding flow and temperature relationships on dam-influenced cold-water refuges

Eric Berntsen, PH, CFM[1], Francine Mejia, PhD[2], Christian Torgersen[2], Andy Johnsen[1], Joseph Maroney[1]

[1]Kalispel Tribe Natural Resources Department, Usk, WA, [2]USGS, Seattle, WA

Dam operations can affect mixing of the water column, thereby influencing cold-water refuge persistence and spacing. We examined associations between streamflow and water temperature among cold-water refuges in two dam-influenced rivers in inland northwestern USA in the summer months. To describe thermal and hydrologic patterns, we used in-situ thermographs and flow data from USGS gages. To determine whether tributary confluences could potentially be used as cold-water refuges by adult salmonids, we defined thermal refuges when bottom water temperatures in the confluences were at least two degrees cooler than the mainstem. We analyzed associations between streamflow, percent number of days when thermal refuges were stratified, and distance between cold-water refuges at different flows. We then developed flow thresholds for informing thermal refuge enhancement and management. Preliminary findings suggest that this approach can help identify the extent to which surface-release flows influence the persistence, spacing, and magnitude of cold-water refuges in rivers.

#3947 - Design and construction of cold-water refugia for Bull Trout and Westslope Cutthroat Trout on the Pend Oreille River

Jeremy Payne, P.E.

Northwest Hydraulic Consultants, Inc., Seattle, WA

The Pend Oreille River is a large, impounded river with epilimnetic releases from Albeni Falls Dam (Mejia et al. 2020), resulting in water temperatures which exceed the upper tolerances of adult Bull Trout (*Salvelinus confluentus*) and Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*). The US Geological Survey examined thermal heterogeneity across space and time in the Pend Oreille River and identified potential cold-water refuges for adult salmonids that were consistently below their physiological threshold (18°C) during low-flow summer conditions. Two locations along the Pend Oreille River (Indian Creek and Duncan Springs) near Usk, WA were identified as good candidates for cold-water habitat restoration due to high potential for increasing thermal habitat area, quality, and diversity.

This presentation will describe the analyses, design and construction of the two projects. Geomorphic analyses of the project sites and adjacent reaches of the Pend Oreille River were

performed to identify channel planform patterns and geomorphic features that could be incorporated into the design. Existing and proposed temperature models using TELEMAC-3D were developed to better understand how the proposed design features impacted thermoregulation at the project areas. The geomorphic analysis and numerical modeling were used to develop a wood-based restoration design that mimicked natural geomorphic features and included structures intended to provide both aquatic habitat and refugia for native species, as well as retain cold water inputs to the maximum extent possible. Furthermore, the location, orientation, and depth of the proposed wood structures were designed to maximize habitat creation and functionality at all life stages of the target trout species.

The project was successfully constructed in September 2022. On-site design modifications were performed during construction to adapt the proposed habitat structures to changing field conditions and to ensure that the framework for desired habitat and geomorphic processes and functions were achieved. A companion talk will describe post-construction monitoring of the project.

#3980 - Post-construction monitoring of cold-water refuge restoration projects for native fish

Andy Johnsen[1], Francine Mejia, PhD[2], Christian Torgersen[2], Eric Berntsen, PH, CFM[1], Joseph Maroney[1]

[1]Kalispel Tribe Natural Resources Department, Usk, WA, [2]USGS, Seattle, WA

The Kalispel Tribe of Indians and the U.S. Geological Survey are monitoring two cold-water refuge restoration sites at tributary confluences in an impounded portion of the Pend Oreille River, Washington for five years. The objective is to quantify changes in area and volume of cold water less than 18°C resulting from the placement of instream structures and modification of channel morphology at tributary confluence sites. We deployed high-resolution arrays of temperature loggers in a grid pattern at the restoration sites, conducted weekly flights with a drone equipped with a digital camera and thermal infrared imager, and mapped changes in water depth in the restoration sites. Variable flows from hydropower operations influenced the spatial and temporal dynamics of water temperature in an around the restoration sites. Thermal stratification was strongly associated with higher reservoir flows both before and after the restoration project was initiated. Cold-water patch surface area at locations greater than 50 cm deep increased compared to pre-restoration conditions but was highly variable. These preliminary findings suggest that year-to-year variability in summer reservoir flow may affect the spatial and temporal dynamics of cold-water refuges after restoration.

Plenary Session Abstracts

Thursday – February 8

#3893 - A Bypass River as Floodplain Restoration Measure: It's Not About Just Letting the Water Flow

Bernd Cyffka

CU Eichstaett-Ingolstadt, Floodplain Institute, Neuburg/Danube (Germany/Bavaria)

In Europe, the Water Framework Directive (WFD) is a legally binding instrument to restore water bodies to good status. One aspect of the WFD is that all transverse structures, small or large, must be passable for migratory species. This has often led to purely technical measures, such as fish ladders. In some cases, however, where space and money were available, longer bypass watercourses were also built. This presentation deals with the restoration measure called "Dynamisation of the Danube floodplains between Neuburg and Ingolstadt/Bavaria". The centrepiece of this measure is an approximately 5-mile-long watercourse that bypasses the Bergheim hydropower station through a riparian forest of about 4.6 sq. mi. and thus makes it possible for species to migrate upstream.

However, this bypass, which today is existing for more than twelve years and has thus developed accordingly, not only serves the migration of species, of course mainly fish. It has meanwhile developed into a habitat where adult fish spawn, young fish grow up and certain species live permanently. This success story has become known and recognised beyond the region. But is it that simple, do you just have to let the water flow?

At the beginning, there were fears that the water body in the predominant alluvial clay would very quickly colmate and develop into a clayey-sandy habitat. This would not do justice to the overall habitat conditions, because the restoration area lies in front of the Alps and the creatures in the water bodies depend on clean, fast-flowing water that flows over a generally gravelly streambed. There were two measures that prevented this: a) the creation of gravel depots during the construction of the watercourse and b) so-called controlled floodings, which provides hydrological dynamics about twice a year with five times more water than usual and continually changes the streambed and the river banks through erosion and aggradation. This has led to the fact that even in formerly clayey sections of the river, gravel banks can now be found inhabited by Red List species.

This presentation shows selected examples of changes in the riverbed over the years and describes monitoring measures such as profile surveying, laser scanning and photogrammetry.

#3880 - WATER RELEASES FROM DAMS AS A RESTORATION TOOL: USE OF RIVER POOLS ON THE TRINITY RIVER

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Flow releases from dams are often used to mitigate downstream effects on a stream's biology. The releases in summer are normally higher than pre-dam flows to provide colder water temperatures. For example, the flow release in July-September from Lewiston Dam on the Trinity River, California is maintained at or above 450 ft^3/s (12.7 m^3/s) with temperatures in the range of 9 to 11 ^oC to provide cold water for spring Chinook holding. In contrast, the unregulated mean flow before Lewiston Dam was about 191 ft^3/s (5.4 m^3/s) with the mean temperature of 20 ^oC. The higher flow and colder water provide holding habitat for spring Chinook, but might be detrimental to the river biome by causing spatial uniformity in cold temperatures. This can render formerly suitable habitats unusable or sub-optimal for organisms that compose the stream food base, which can hinder juvenile salmonid growth and survival to adult.

This research explores the hypothesis that water releases from dams may be adaptively lowered, even during Summer, and used as a river restoration tool to provide greater environmental benefits than the existing practice. In particular, we propose that flow releases from Lewiston Dam may be lowered in Summer so that river pools may maintain temperature stratification to provide habitat for spring Chinook holding while also achieving other biotic and water resource benefits.

We developed a three-dimensional (3D), computational fluid dynamics (CFD) model and conducted a modeling study on two pools on the Trinity River to prove the feasibility of the hypothesis. In specific, the release rate that is required to maintain thermal stratification in the pools is quantified along with important thermal processes identified. The study is further strengthened by field measurements. We show that the CFD model results closely agree with the measured data, providing validation that the model may be used in other pools on the Trinity River. In such applications, the model can be used to determine the critical flow under which pool stratification is formed and maintained, evaluate the potential for temperature stratification, and develop flow schedules on regulated streams that maintain cold water in pools and temperature diversity in other areas without depleting reservoir storage.

With the hypothesis confirmed, we are currently applying the CFD model to a dozen pools of the Trinity River to understand how pool bathymetry influences the formation and persistence of thermal stratification under variable flows and water temperatures. This knowledge will be used to expand the results to all 36 pools in a 64 km reach below Lewiston Dam. From this, rating curves will be developed to relate discharge to the volume of pool habitat that provides springers the temperature, velocity and depths. Flow releases that meet these goals will then be evaluated for their influence on indicator species.

Take home message: pool temperature stratification may be explored to increase reservoir summer water releases for the benefits of both adult salmon and other species.

#3869 - Water quality and river health in the Klamath River during dam removal based on multiple ways of knowing

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Water quality is an often-underappreciated aspect of river health. In northern California's Klamath River, the world's largest dam removal is expected to improve water quality, but how

the dam removal will affect current high rates of primary production is less clear. The removal of four hydroelectric dams is somewhat unique due to the scale of the project and anticipated impacts on water quality: The project will release 13M cy of mostly fine mineral and organic sediments and re-establish longitudinal transport of sediment and nutrients. The dam removal will eliminate reservoir-derived cyanobacterial blooms, but the interacting changes to nutrients, turbidity, and winter scour make predicting changes to production challenging. Primary production in the Klamath River contributes to sags in dissolved oxygen and pH that impact ESA-listed salmon, and algal proliferations clog boat motors and tribal fishing nets, and decline perceived aesthetics and recreational access.

The broad goals of this research are to document seasonal progression of primary producer assemblages and habitat associations and to compare changes to primary production dynamics before, during, and after dam removal. This research is part of a larger project examining the ecological and socio-cultural dimensions of water quality, primary production, and river health in the Klamath Basin throughout dam removal. The project includes partnership across multiple institutions, including the Yurok Tribe, with a core emphasis on exploring multiple ways of knowing in making decisions about water quality management.

The presentation will include a summary of methods and results from 2023 field observations of biomass and % cover of periphyton, filamentous algae, and macrophytes, along with their water quality and habitat correlates (turbidity, PAR, substrate, nutrient concentrations). In addition, this presentation will include summaries of Tribal perspectives and knowledge on water quality and algae, documented during interviews with elders and leaders within the Yurok Tribe. Collectively, these results translate to conceptual models and hypotheses based on multiple ways of knowing, which will be presented, regarding expected changes for the river following drawdown and removal of the largest dams, set to begin in January 2024.

#3928 - Innovative Approaches to Stream Restoration and Fish Passage: Learning from Nature's Playbook

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The Washington State Department of Transportation (WSDOT) stands at the crossroads of transportation efficiency and ecological stewardship. The challenge lies in harmonizing safe and efficient movement of both people and fish. This presentation delves into WSDOT's dynamic journey of redefining fish passage and stream restoration practices, guided by lessons from nature, past experiences, and biomimicry techniques.

Harnessing insights from nature and capitalizing on past successes and failures, WSDOT has embarked on a transformative mission to reimagine fish passage within transportation systems. Through the lens of biomimicry, the agency is constructing in-water features and channel complexities that mimic natural processes and geomorphic characteristics. This sweet dance between engineering and biology is akin to the serendipitous fusion of chocolate and peanut butter yielding the sublime peanut butter cup – a synergy that transcends the sum of its parts.

Exploring new techniques like deformable grade controls, meander bars, large woody material, and the art of incorporating small woody material and slash, this presentation unearths how the collaboration of biology and engineering can produce peanut butter cup-like marvels. Just as

chocolate and peanut butter complement each other, so do disciplines like biology and engineering in WSDOT's pursuit of stream restoration excellence. Striking this balance requires meticulous monitoring, assessment, redesign, innovation, research, and implementation.

This evolution is characterized by a forward-looking mindset, wherein WSDOT designs for the future life of streams. We try to anticipate channel responses, account for future flow patterns, and forward compatibility with future barrier corrections beyond the highway. From humble beginnings, where errors were made and triumphs celebrated, WSDOT has learned through monitoring, research, and adaptability to create new tools and techniques for maintaining fish passage at highway crossing for the design life of the project. Join us as we explore this captivating journey, bridging the gap between biology and engineering, and celebrating nature's wisdom.

#3930 - Climbing the Geomorphic Ladder: Envisioning a Holistic Approach to Step-Pool Design

Jeff Kamps

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Fish passage and restoration projects can occur in streams with a gradient between 3 and 10 percent, typically with a step-pool morphology. Designs for these stream types have tended toward using factors of safety that do not mimic natural fluvial conditions, creating homogenous designs typically with the goal of step stability and certainty. However, in natural systems, morphology readily adjusts based on sediment supply, transport capacity, complexity features, and recent flow events. Process-based restoration requires an interdisciplinary team that can create solutions with the goals of mimicking natural functions and processes, ensuring fish passage, and accounting for the built infrastructure throughout the life of the project.

Research has helped better understand the driving forces or factors behind the inherent stability and chaos of the step-pool morphology. In general, each study has focused on specific parameters and the interplay between several parameters that govern step-pool systems, such as channel geometry, grain size, scour, hydraulics, or hydrology. Understanding step-pool systems provides significant value but does not yield the ability to design a full complement of step-pools that may span several hundred feet and thus attain the stated goals while addressing the risks. The additional complexity of constructing these features within a road crossing, where vegetation cannot grow and provide the root mass common to forested streambanks, exacerbates the problem.

Near-term design and construction consistency is needed in step-pool design. Designing systems that mimic the existing stream in equilibrium and provide similar habitats through the crossing can be challenging. Integrating woody material into step designs is not well understood or studied, creating higher risk for this technique. With the substantial, ongoing investment in fish passage projects, the efficacy, understanding, and consistency of step-pool designs must be improved significantly to maximize the return on investment without impacting ecological integrity. Utilizing a consistent approach to measure these systems will provide one facet to understanding them more fully. Additionally, a consistent approach will provide a database of information from which comparisons can be made and improve our understanding of how to integrate woody material with boulders into designs.

A recently developed step-pool design validation spreadsheet provides a holistic tool that calculates and accounts for most of the parameters associated with step-pool morphologies and focuses on each step within a complete sequence of steps to ensure that each parameter is accounted for. By teaming step-pool measurement processes with the step-pool design validation tool, we hope to implement a robust data collection process for designing step-pool systems that can mimic natural environments and can validate a chosen stability level prior to construction. Compiling a wealth of existing conditions data and subsequent design data will provide the foundation for monitoring data that will act as a feedback loop to inform future designs and fine-tune the tools. Our intent of this abstract is to invite multidisciplinary voices into this opportunity to guide the design of step-pool systems for steep fish passage and restoration projects, share our research and findings, and build on these lessons learned to raise the bar.

#3940 - Organic Material in Simulated Streambed Designs: A Flume Study Investigating Meander Bars Design Guidelines With Organic Material

Tyler Fouty, Ph.D.

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Fish populations in the Pacific Northwest over the last century have seen consistent declines, a major contributor is the reduction of spawning grounds due to water crossings being barriers to fish movement. The leading barrier type are culverts that are undersized for the site which leads to sediment being washed out and the outlet being perched or being clogged with sediment or organic material. In the past three decades Washington State has implemented the stream simulation design (SSD) methodology to design fish barrier corrections. Currently there are 2,057 known fish barriers across the state. One challenge with SSD is that there is no guidance on the construction of streambed designs that incorporates organic material to increase bed stability and maintain a low flow channel. This flume study investigated the following streambed designs: 1.) meander bars, and 2.) organic streambed mixture. The first design involved the addition of root wads and slash between meander bars, and 2.) three different volume ratios of sediment and organic material mixtures. Designs were subjected to three flood frequency events 10-, 25- and 50-year and the change in channel morphology was used to evaluate channel stability. Channel morphology was collected by using a novel technique of a high-resolution handheld scanner, EinScan-H. Twenty configurations were tested relative to a plane streambed (no organic material). The results show the addition of organic material will increase channel stability. Meander bars will increase stability by 10-67 percent. Organic streambed mixture under a 1:1 ratio will increase stability by 18-63 percent. The increase in channel stability will increase the design's lifespan, reduce maintenance, and provide fish habitat in the water crossing.

#3961 - Stream Bed Design for Future Compatibility

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Under WSDOT's Fish Passage Program, the principal objective of fish passage and stream restoration design is to provide access to quality spawning and rearing habitat for anadromous salmonids at all life stages. Under this guidance, WSDOT has accumulated a wealth

of experience in stream bed design that considers channel complexity, stream geomorphic characteristics and responses and is also aimed to be compatible for a variety of future conditions. Much of the experience has been positive and successful. Yet, there are still unknowns and challenges that may threaten the success of many current and future projects.

While an obvious but not an emergent issue, hydrology remains a challenging engineering aspect. Streams and creeks with existing fish passage barriers are mostly small. Nearly all of these creeks do not have any flow records or stream gauges. Moreover, many of them are located within urban areas. These characteristics create challenges in determining flood discharges for hydraulic design. Engineers often take a conservative approach due to these unknowns. However, we find that high design discharges may result in stream bed design that is not supported by stream geomorphic characteristics. To address the issue, WSDOT has developed methodologies to evaluate applicability of hydrology data from different sources and whether proposed flood discharges represent stream characteristics observed in field.

Many of the WSDOT fish passage barriers are located in the transition zones between upper steep terrain and lower shallow and floodplain of a larger receiving waterbody. In the vicinity of the sites, there may be nearby infrastructures that potentially affect the project sites hydrologically, hydraulically, and geomorphologically, such as undersized culverts, dams, and utility lines. WSDOT has taken a future forward approach to ensure that the restored streams meet changing conditions during the design life of fish passage structures. For example, how does the design consider the interaction between a tributary and a mainstem river? How does the scour analysis consider future channel responses if nearly infrastructure is altered or under a climate change condition?

In addition to design for future compatibility, WSDOT also recognizes that wood and in-stream vegetation play a vital role in shaping stream characteristics. A stream with quality fish habitat exhibits a geomorphic balance between flow, sediment, and wood. In the first several years after construction and within structures, any imbalance among wood, flow, sediment and wood/vegetation poses a risk for fish passage. For example, a plane bed stream type without adequate water depth and flow complexity may create a velocity or water depth barrier. WSDOT has made significant progress in designing and implementing features that mimic the natural stream functions and processes. They are designed to address the issues that have led to less than successful restoration efforts in the past. WSDOT has applied these channel complexity features to several projects constructed recently, such as partially spanning complex wood steps. In this presentation, WSDOT will share design principles and observations learned on construction and applications of these features.

#3925 - Watershed-Scale Effects of Floodplain and Stage 0 Restoration on Hydrologic Attenuation

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Increased peak flows and associated flood risk, as well as decreased baseflow and associated impacts to floodplains and aquatic ecosystems, are common effects of human land use (e.g., urbanization, agricultural development, and certain forestry practices) that can be exacerbated by

climate change. Enhancing floodplain capacity through river restoration to increase surface and groundwater storage along river networks has potential to mitigate such impacts. Yet this potential has been poorly quantified at the watershed scale. We simulated the effect of varying the amount and location of floodplain and Stage 0 restoration on surface water storage in a series of watersheds using the U. S. Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS). First, we modeled a synthetic 4th-order watershed using average stream geometry and hydrology for the Virginia Piedmont with storms ranging in size from the 2-year down to monthly discharges. Model results indicate that Stage 0 techniques (simulated as low banks/shallow channel) were more effective at inducing floodplain exchange and flood wave attenuation than restoring bankfull floodplains (simulated as higher banks/deeper channel). The incremental effect of an individual restoration project varied depending on where it was in the 4th-order channel network, and on the amount of previous restoration that had already occurred in the watershed, with tradeoffs between enhancing flood attenuation and enhancing floodplain exchange. As expected, flood attenuation and floodplain exchange both increased with percent of channel network restored, yet Stage 0 approaches exhibited substantial flood attenuation potential even when implemented in relatively small portions of channel networks. Second, we simulated the cumulative effect of Stage 0 restoration (simulated as multiple/shallow channels, fully connected floodplain) along Meadow Creek, a tributary to the Grande Ronde River in the Columbia River Basin, similarly focusing on storm hydrographs. We again found Stage 0 restoration reduced peak flows at multiple scales, with potential to mitigate effects of land use change and climate change. Important future directions include extending this analysis to a) additional processes such as groundwater exchange to evaluate effects of restoration on baseflow between storms, and b) annual timeframes to assess effects on seasonal low flows and potential to mitigate climate impacts on such flows. Overall, our results indicate that floodplain and Stage 0 restoration approaches have substantial potential to reduce peak flows, increase floodplain storage, and increase system resilience to climate change. We emphasize the importance of viewing watersheds as a whole to understand the potential impacts of restoration projects, and watershed level planning to prioritize which stream reaches have the greatest benefit in supporting improved hydrologic response.

#3992 - Focusing on hydrology and collaboration to restore a large Idaho river

John McLaren, Ph.D., Robert Van Kirk, Ph.D., Christina Morrisett, Ph.D., Melissa Muradian, Daniel Wilcox

Henry's Fork Foundation, Ashton, ID

Restoration action often seeks to remove anthropogenic alterations to the physical or hydrological structure of a stream ecosystem. However, aggressive restoration actions are often unrealistic in larger waterways given ongoing human reliance on waterways for critical infrastructure, including irrigation, power generation, and municipal use, and the legal and administrative structures that prioritize such uses. In the Henry's Fork of the Snake River in eastern Idaho, the benefits of a functioning ecosystem are subservient to the needs and legal requirements of irrigated agriculture. To produce measurable ecological benefits, conservation organizations such as the Henry's Fork Foundation must work within existing legal and physical infrastructure. The Henry's Fork Foundation accomplishes restoration through intensive monitoring which guides collaborative action. The Henry's Fork Foundation identified key hydrological drivers of fish and invertebrate populations, targeted management flexibilities that

could affect those drivers, then worked with irrigation districts, individual irrigators, and state and federal agencies to achieve conservation objectives. For example, improving precision in water management and incentivizing reduced irrigation consumption has reduced the use of water in a storage reservoir by almost 50% relative to water supply. The savings increased annual winter flow, decreased annual summer flow, and allowed a managed springtime freshet in three of the last five years despite long-term drought conditions. These actions have improved water quality, macroinvertebrate indices, and increased fish populations up to 150%. Reductions in water consumption are just the beginning; ongoing monitoring indicates the possibility to use irrigation water for intentional and incidental managed aquifer recharge. Managed aquifer recharge would improve water quality and fish and macroinvertebrate populations on both the local and watershed scale. The experience and successes of the Henry's Fork Foundation may prove useful for other large "working" river systems across the western U.S.

#3818 - Floodplain forest regeneration and fluvial processes: Cottonwood ecology and riparian forest restoration

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Cottonwood forests are a foundational species in lowland alluvial floodplain and channel systems in the arid west. Cottonwood forest provide shade, floodplain roughness, food-web nutrient input, and a source of large wood critical to maintaining channel morphology and in-channel habitat complexity for anadromous fish, including salmon, steelhead, and lamprey. On the Yakima River, land use activities have eliminated riparian forests, levees and roads have restricted the river's migration zone where riparian forests are created, and river regulation attenuates annual flood patterns that are required for cottonwood establishment. Supportive flow conditions for cottonwood recruitment are naturally restrictive, and cottonwood recruitment under unregulated flow conditions occurs at intervals typically resulting in a riparian forest mosaic of many single-aged stands. Lack of riparian forest regeneration on regulated rivers has been identified as a key problem in stream systems throughout the west. Without successful recruitment, cottonwood stands will die out as older trees senesce without replacement. The presentation will report results of assessments of cottonwood regeneration in Yakima River basin, and outline strategies to improve cottonwood recruitment and survival and to restore cottonwood forests.

#3953 - The Castor Conundrum: Implications for beaver related restoration

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Beaver-related restoration has quickly gained popularity in the past decade because it is often described as a novel and cost-effective strategy for promoting aquatic habitat restoration for listed salmonid species, and more recently, mitigating the effects of climate change. Despite growing support to integrate beaver into conservation planning, data regarding their population ecology is limited and the implementation of using beaver as a management tool is far outpacing research. A common misconception in promoting beaver populations is that an increase in beaver

abundance leads to an increase in beaver dams, with concomitant ecological benefits. However, not all beaver build dams because dam construction is a facultative response that can vary due to several factors. Taken in combination, these challenges can lead to misdirected management actions that result in a greater likelihood of not meeting expected restoration outcomes. This presentation will cover some of the common misconceptions, inconvenient truths, and unforeseen consequences that need to be considered when pursuing measures intended to bolster beaver activity in dynamic aquatic systems. Providing this crucial context will allow managers to decide on the appropriate actions to best manage watersheds that include beaver while maximizing their potential benefits.

#3903 - Management of heterogeneous forest headwater ecosystems for amphibian habitat restoration, conservation, and risk mitigation in the US Pacific Northwest.

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Moist coniferous forest ecosystems in the US Pacific Northwest are managed for multiple aims including wood production, restoration and conservation of late-successional and old-growth (LSOG) forest species and habitats, and mitigations to reduce adverse effects of natural disturbances. Management approaches for aquatic-riparian ecosystems within these forests have focused on retention of water quality and quantity while maintaining habitats for aquatic species. Headwater basins in these forests are a transitional zone between uppermost fish distributions and reaches dominated by stream-associated amphibians. The Density Management and Riparian Buffer Study of Western Oregon is a Before/After/Control/Impact experiment characterizing headwater aquatic-vertebrate assemblages and habitats in managed forests and assessing effects on them of alternative streamside buffer widths with upland thinning for forest restoration. After 30 years of implementation, results provide insights for application of riparian buffer widths for system restoration, conservation, and risk mitigation.

We examined aquatic-vertebrate densities and habitats at 43 stream reaches across 8 study sites with data from pretreatment surveys and surveys in years 1, 2, 5, and 10 after a first thinning treatment, followed by years 1, 5, and 11-12 after a second thinning treatment, along with unthinned controls. Streamside buffer-width treatments included the one site-potential tree-height buffer of the federal Northwest Forest Plan (~70 m; 1-tree), and two narrower buffers – a streamside retention buffer (6 m) and a variable-width buffer (minimum width 15 m). Composite animal and habitat characterization separated two unique headwater ecosystems within these forests: distinct low- and high-flow systems and associated fauna which may warrant discrete management consideration for conservation. No significant buffer-width effects on were detected overall, yet selected sites showed increased coastal giant salamander densities and down wood inputs in reaches with 1-tree buffers. With the value of 1-tree buffers apparent in some cases for both LSOG animals and habitats, a mixed-width buffer approach warrants consideration in heterogeneous headwater ecosystems for both restoration and conservation aims, and as a trade-off with both episodic winter-storm treefall events and summer-wildfire risk, as increased down wood in 1-tree buffers was tied to a single-year winter storm event over the 30-year study and is a fuels consideration for subsequent summer fire risk.

#3993 - Salmonid-focused restoration is destructive...

Alexa Maine

Confederated Tribes of the Umatilla Indian Reservation, Walla Walla, WA

Salmonid-focused restoration can be destructive...to long-lived organisms like freshwater mussels...when they are not properly and carefully planned for. Freshwater mussels are a First Food for Columbia Basin Tribes like the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), and harvest of mussels remains a reserved treaty right for tribal members. Populations of freshwater mussels are declining rapidly and harvest of mussels is not currently possible. Mussels can form dense beds that provide invaluable ecosystem services on which salmonids and other aquatic life rely. Nutrient cycling, removal of toxins and pollutants, substrate bioturbation, water quality improvement, sediment stabilization, and other services are provided by mussels, but these are seldom considered as benefits to the ecological community when mussels are present in areas in need of habitat restoration. Salmonid-focused restoration practices can result in long term suitable habitat for mussels. However, in the short term, restoration actions can be destructive and damaging to mussels. Mussels are not often considered in planning phases of restoration projects and, even when planned for, are frequently killed by actions like instream construction, dewatering, sedimentation, channel fill, or wood and boulder placement. Because mussels are long-lived (some species 80-100 years), sessile, and reliant on microhabitat characteristics that are not well understood, relocation of mussels outside of a project area to avoid damage during instream work in many cases results in 50-90% mortality and should be used only a last resort. Alternatives to relocation exist, and resources are available to help habitat restoration professionals avoid moving or damaging mussels during restoration work. Given the current rate of mussel abundance and richness decline throughout the western US, habitat restoration projects should consider designs that protect and enhance mussels short term and long term. Especially for areas with dense, reproductive beds of mussels, significantly more effort needs to be taken to minimize disturbance and focus project design to restore rivers in a holistic manner. Single species restoration is destructive to often overlooked but highly valuable organisms like mussels, and their benefit to the river ecosystem should be considered in project planning. Mussels provide significant services to their river community, but they need help from the restoration community to persist and survive. Restoration work is important...so are mussels. Let’s work together to protect, restore, and enhance mussel populations for the good of the entire river community!

#3981 - Beyond ‘do no harm’: Restoration Needs of Freshwater Mussels

Laura McMullen, PhD[1], Zee Searles Mazzacano, PhD[1], Travis Williams[2], Kevin MacKay[1]

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Freshwater mussels in the Pacific Northwest have distinct habitat preferences and needs that vary by species. Restoration actions in western watersheds could include design elements to improve and enhance habitat specifically for freshwater mussels. While no northwestern freshwater mussels are federally protected, one species (Gonidea angulata, the Western ridged mussel) has been petitioned for federal listing. Our western species have documented declines in many watersheds; they face a number of environmental threats and are designated as sensitive species in many states. Restoration actions in rivers can harm mussel populations if care is not taken to

survey for mussels prior to project planning and implementation, and if best practices to protect mussels from construction effects are not followed. Here we present a synthesis of information from published literature as well as our own observations in the Willamette River watershed demonstrating the habitat preferences and needs of our native freshwater mussels. Channelization, bank hardening, changes in river flow and temperature regimes, changes in sediment regimes, and poor water quality all degrade potential habitat for freshwater mussels. Restoration projects are often designed with needs of native salmonids in mind, and while many habitat characteristics may benefit both salmonids and mussels, such as cooler water temperatures, mussels also have specific needs including water depths, flows, and substrate composition and stability. We relate native salmonid habitat and restoration needs to freshwater mussel habitat and restoration needs, and make recommendations for restoration actions that can directly benefit freshwater mussels. We also present a conceptual framework for identifying locations in watersheds that could benefit from restoration or protection for freshwater mussels, and determining restoration actions that might most support their populations. This framework can provide watershed managers, restoration practitioners, landowners, and partners a tool to ensure freshwater mussel habitat and populations needs are incorporated in the planning phase.

Poster Presentation Abstracts

#3990 - 1 WSDOT Adaptive Restoration for Successful Riparian Establishment

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WSDOT's fish passage program is a statewide response to help protect and restore fish populations by removing barriers between downstream and upstream channel habitats. Riparian restoration planting is an essential component of fish passage design as it can serve as habitat for fish and wildlife, provide stabilization to the bank slope, and help achieve the desired hydraulic and sediment transport conditions. This presentation discusses the programmatic and restoration challenges of constructing a natural system, the importance of flexibility in design implementation during construction, and methods used to overcome natural site changes to achieve successful riparian restoration.

There are many programmatic challenges associated with fish passage riparian restoration. Projects involve several agencies, co-managers, support groups, the project office, and the construction office. Communication, coordination between groups, and contract execution can be difficult and complex. WSDOT has utilized several tools to achieve successful restoration. These tools include regular interdisciplinary coordination during construction, the use of hold points in the contract to approve critical elements of the design, force account bid items for restoration adjustments, scheduled site visits during the warranty period, specific requirements for turnover from contractor to WSDOT, and the implementation of an internal Plant Establishment crew to maintain sites after warranty conclusion until permit closeout.

Restoration challenges include stream bank erosion and high flow events during the early years of plant establishment caused by steep slopes, winter precipitation, and the lack of established roots. To address these challenges, project teams develop adaptive strategies combining different bioengineering techniques and site-specific native plant species mixes. Bioengineering methods such as live fascines and trench plantings can be used along the stream channel and the stream bank to provide faster growing plant species that reinforce soil and reduce erosion. Plant species used near water are selected to increase channel complexity and provide shade for aquatic wildlife once established. Bioengineering can also be used in upland areas to control stormwater runoff and groundwater seepage.

In conclusion, successful riparian restoration depends not only on the integration of multiple technical and programmatic factors but more importantly the ability to be flexible and adapt implementation methods after design. Achieving this goal takes established relationships and open communication with several groups during the design and construction phases. This includes understanding and identifying site-specific limitations, employing correct restoration techniques and plant species, and coordinating between interdisciplinary design and construction teams.

#3911 - 2 Assessing Beaver Habitat Suitability in British Columbia Using Machine Learning

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Beavers, renowned as ecosystem engineers, profoundly influence hydrological, biological, and geomorphological processes within freshwater ecosystems. Historically, fur trapping reduced North American beaver populations from an estimated 100-400 million to mere hundreds of thousands (Naiman et al., 1988). This decline removed a natural control from stream systems across the continent. Though beaver numbers have since rebounded to an estimated 15–30 million, contemporary challenges such as land development, agriculture, and climate change further reduce potential habitats (Müller-Schwarze & Sun, 2003). Given their pivotal role, a renewed emphasis has been placed on beaver conservation and habitat restoration.

For effective beaver reintroduction, understanding and identifying suitable habitats is paramount. Yet, this often involves a complex and time-consuming analytical process. Our study seeks to streamline this by employing a random forest machine learning model. Trained on beaver habitat data from British Columbia's Nechako watershed, the model combines topographic, biologic, and hydrologic data, identifying their correlation with existing beaver habitats. Validated against field surveys, the model's output delineates habitat suitability, with potential applications throughout British Columbia. This research underpins data-driven decisions, crucial for the success of beaver reintroduction and broader freshwater ecosystem restoration.

#3864 - 3 Restoring Mill Creek: An Adaptive Design Approach in Response to the Keystone Pipeline Spill

Scott Stoneman, PE[1], James Ellis, PE[2], Michelle Bonfanti[1], Andrew Toman, PE[3]

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Restoration design projects often hinge on extensive data collection, feasibility studies, and coordination with multiple stakeholders. However, unforeseen circumstances sometimes demand immediate action. In December 2022, TC Energy reported a crude oil leak from the Keystone Pipeline in northern Kansas, with the spill located on the banks of Mill Creek, the largest tributary to the Little Blue River. In response to the incident, TC Energy along with Federal and State agencies promptly mobilized crews to contain the contamination, which had migrated 4 miles downstream. Three months later, as cleanup efforts were underway, TC Energy contracted WSP to provide design and environmental permitting of restoration measures for the impacted area.

WSP assembled a multidisciplinary team from across the country to provide a rapid response to the incident. The team was faced with limited historical data, requiring a variety of creative solutions to establish baseline conditions. Throughout the project, an adaptive design approach was adopted, with the design team continuously refining their plans based on evolving site conditions and improved baseline knowledge. Following consultation with USACE and Federal/State agencies the design was authorized to follow a phased approach and construction began on the first phase of the restoration design almost immediately, providing the opportunity for each phase of design to be refined using lessons learned from the previous phases and

allowing the creek to be restored as cleanup efforts progressed downstream. Dedicated staff from the design team were deployed on-site full time for six months, allowing for real-time adjustments and optimization, and close coordination with the project owner, contractors, and stakeholders.

This project highlights the challenges and opportunities encountered in employing an adaptive design strategy in responding to environmental disturbance within river systems. By presenting the valuable lessons learned from the restoration of Mill Creek, the presentation aims to provide a model for future efforts in response to sudden disturbances to river systems.

#3819 - 4 Planting The Seed for Beaver Success

Jefferson Jacobs, M.S.

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The Oregon Natural Desert Association (ONDA) has been utilizing volunteer labor to implement riparian planting projects in eastern Oregon's high desert for nearly two decades. Over the past decade, ONDA's riparian restoration strategy has developed to focus specifically on removing the factors limiting beavers' management of floodplains, utilizing an in-house conceptual model referred to as "BeaverHOODS". This beaver-based prioritization strategy was adopted in part because of the remote locations of restoration projects, and objectives requiring inherent ecological resilience achievable only from nature-based solutions. The aim of the Strategy is to explicitly support the recovery of beavers' management of floodplains, thereby furthering processes that restore and dynamically manage creeks: rather than relying on anthropogenic controls and actions. By prioritizing beavers' requirements, these beaver-based solutions to improving riparian health have proven exceptionally successful on timeframes and scales skeptics previously thought unlikely. Within this framework, a frequent limiting factor preventing the management of floodplains by beavers is a lack of woody riparian vegetation with proper diversity, abundance and size suitable for beaver food and construction materials. Because the BeaverHOOD Strategy encourages riparian woody abundance metrics of up to 18,000 mature stems per half-mile reach, ONDA was incentivized to improve and evolve planting techniques into an intentional and repeatable approach which could meet these goals over short timelines; all while utilizing volunteer labor. This presentation represents the current culmination of our learning processes and describes how we incorporate a specifically targeted suite of easily reproducible and common-sense approaches which complement and support each other including: Site planning and scouting, creating and tracking hydrological changes, alignment of appropriate planting techniques with site characteristics and needs, browse control, and weed management. By sharing this information, we hope to provide accessible and immediately implementable strategies and techniques that can be put to use improving the success of riparian plantings, as well as more effectively include and prioritize riparian vegetation plans into a bigger overall watershed restoration vision.

#3898 - 5 Riparian Vegetation Enhancement and Monitoring in Mine Tailings Restoration

Lauren Osborne

Confederated Tribes of the Warm Springs Reservation of Oregon, John Day, OR

Riparian plantings are a ubiquitous feature of river restoration projects; despite significant investments made towards riparian rehabilitation, little precision monitoring has been performed to assess planting survival. General plant density counts are completed regularly; however, assessments of survival and recruitment of specific plants is rarely pursued. The Confederated Tribes of the Warm Springs Reservation of Oregon (CTWSRO) completed two separate planting efficacy studies on the Oxbow Conservation Area (OCA) located on the Middle Fork of the John Day within a historically dredged reach of stream. The OCA received a 5-phase restoration effort between 2011-2016 intended to mitigate the impacts of historic dredge mining, with major restoration components including channel consolidation, construction of natural channel morphology, large woody debris placement, and riparian protection/enhancement. The two studies were similar in location, but differed drastically in monitoring efforts. The original 2012 study counted all woody stems in established cross-sections along the riparian, which included recently installed plantings and existing woody stems, while the subsequent 2021 study used real-time kinematic positioning equipment to electronically tag 330 installed plants along the riparian to track survival of only installed plants. The first study showed variation in survival and additional recruitment in monitoring plots, whereas the 2021 study showed little survival in installed plants, with almost a fifth of the plants installed being lethally browsed by small rodents within the first-year post-installment. Through both monitoring efforts key lessons were learned for future planting efforts within the OCA. The two that are potentially easiest and most impactful to address are 1) established plants will successfully recruit new plants in the area; therefore, protecting these plants may lead to quicker revegetation of the stream than intentional plantings and 2) fine-meshed rodent exclusionary fencing may be a necessary addition to the currently installed eight-foot ungulate exclusionary fences to protect newly installed plants from small-animal browse, especially when plants are sparse and immature. By addressing these and additional lessons learned, we may see more success in the revegetation of riparian areas along dredge mined streams.

#3905 - 6 Applied Lessons Learned within the Middle Fork John Day River Intensively Monitored Watershed

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The Middle Fork John Day River (MFJDR) Intensively Monitored Watershed (MFIMW) was established in 2008 to 1) evaluate the overall benefit of restoration actions to spring Chinook Salmon and summer steelhead in the MFJDR, and 2) understand how specific restoration actions impact instream habitat, temperature, and salmonid metrics at multiple scales. To date, 149 restoration projects have been implemented along the upper mainstem MFJDR and in the tributaries, including 73 miles of instream habitat treated, removal of barriers that improved access to 135 miles of habitat, instream water leases that provided over 6cfs of flow, and riparian planting and protection along 39 stream miles. Many of these restoration projects were multi-faceted, designed to address multiple limiting factors, including increased water temperature (the primary limiting factor for MFJDR salmonids), degraded floodplain function and connectivity, reduced habitat quantity and diversity, and altered hydrology. MFIMW partners produced a summary report in 2016, and another in 2023 after 15-years of intensive monitoring, restoration, and collaboration. In the 15-year Summary Report monitoring experts and restoration

practitioners provided results of monitoring and reflected on past lessons learned to offer new recommendations to guide restoration in an adaptive management approach. An adaptive management assessment found that from 2017 to 2023 partners incorporated approximately 50% of the recommendations provided during the 10-year summary into the ongoing planning, restoration, and monitoring efforts in the MFIMW. Adaptions included scheduling recurring meetings to increase communication amongst the restoration practitioners and monitoring experts, focusing on reach/project scale juvenile salmonid movement in and out of restored reaches, investigating fry and parr usage of floodplains, and implementing a coordinated water temperature monitoring strategy. Recommendations adopted by restoration practitioners included protecting riparian plantings to ungulate browse, prioritizing, and increasing riparian plantings, better coordination of restoration projects amongst partners, and increasing floodplain inundation by incorporating numerous process-based restoration actions. While changes to overall watershed-scale fish population abundance and productivity have not yet been detected, monitoring results summarized from MFIMW partners refined our understanding of the impacts of restoration actions in the MFJDR. Long-term habitat trend monitoring in collaboration with Oregon State University and the University of Oregon found that sites encompassing both passive and active restoration exhibited deeper residual pool depths, narrower channel widths, more habitat units per kilometer (i.e., increased complexity), and higher large wood densities than any other treatment type. While average redd count and spawner abundance of Spring Chinook salmon has remained static, redd distribution has shifted downstream to the restored Oxbow Conservation Area reaches – indicating a preferential selection of restored habitat for spawning activity. Juvenile salmonid movement monitoring shows the importance of access to cold-water tributaries during years of higher-than-average water temperatures. Water temperature monitoring and analysis improved with coordination and trend analysis shows improvements in select reaches. Utilizing an adaptive management approach, MFIMW partners are using long-term monitoring results to understand how habitat and fish populations respond to restoration actions. This has led to a refined process to prioritize restoration practices to address limiting factors and improve habitat conditions.

#3983 - 7 When are Juvenile Coho Moving through Tide Gates?

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There are over three thousand tide gates in the estuaries along the Oregon Coast that keep tidal waters off of low-lying lands to protect community buildings and agricultural lands. Many are aging and near the end of their useful life. Therefore, the coastal restoration community has focused efforts to upgrade old tide gates to side-hinge, self-regulating style tide gates which are credited to be fish-friendly. The 41-mile Coquille estuary has four upgraded tide gates. The Lower Coquille Tide Gate and Fish Passage Monitoring program examines coho fish passage with respect to tide gates at three of these tide gate upgrade sites. The Winter Lake project houses the largest upgraded tide gate complex along the Oregon Coast and is comprised of 7 electronically operated slide gates which service 3 hydrologically separate units within the 1700-acre Beaver Slough Drainage District. The 135-acre Seestrom Tidelands project is comprised of a single 8’x8’ muted-tidal regulator (MTR) gate while the smallest project, Cochran, is a 6’ diameter MTR gate that services 28 acres.

Passive Integrated Technology (PIT) tags and antenna arrays are the foundation of the monitoring program as they allow tracking of individual coho through the tide gates and allow analysis of site conditions at the time of passage. Here, we examine six different site conditions (hour of day, velocity, upstream (landward) water level, rate of change in landward water level, tidal bin, and hydraulic head) of coho entering and exiting the project sites. Furthermore, we look into passage differences with water temperature and river stage. These results grant us insight into how coho access tide gated systems and provide dialogue on how tide gate management can be modified to improve passage.

#3909 - 8 Salmon Recovery and Bank Stabilization on the Pend Oreille River

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The Pend Oreille River, a significant tributary of the Columbia River with a 1,300 square miles watershed in Northeast Washington. It flows from Lake Pend Oreille in Sandpoint, ID, through Newport, WA, into Canada where it feeds into the Columbia River. The Pend Oreille River watershed provides habitat to numerous threatened and priority species, including fish species such as the bull trout, westslope cutthroat trout, and the mountain whitefish. The watershed not only provides habitat and clean water for innumerable species, but it is also a recreation destination area. Many landowners purchase vacation property along the Pend Oreille River, but due to significant water level fluctuation, wave action, vegetation loss, and development, significant amounts of sediment are lost annually through erosion processes. This not only has negative effects on the Pend Oreille River, but on the entire Columbia River Basin. Additionally, increased sedimentation and loss of vegetation has contributed to increased water temperatures in the Pend Oreille River. This has resulted in threatened fish species that require cold water and clean gravel to not only spawn but to survive. Osborn Consulting worked with the Pend Oreille Conservation District (POCD) to improve water quality and riparian habitat for salmonids, as well as provide bank stabilization for local landowners by addressing these issues with a combination of traditional bank stabilization techniques, such as riprap, along with advanced bioengineered techniques, such as large woody material, coir logs, coir matting, and native plants, to stabilize the banks along the project areas for a total of approximately 8,713 LF of stabilization and just under 13 AC of total restoration at 71 different properties.

#3912 - 9 Functions and guidelines of unanchored wood in stream restoration

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It is widely accepted that wood material plays an important role in restoring stream and floodplain habitat, but there remain misunderstandings of wood attributes and functions, and agreement on how wood should be re-introduced is lacking. Our poster focuses on a topic of such confusion and disagreement: the placement of “unanchored” wood. We define “unanchored” as wood that has no mechanical or geotechnical stabilization, simply the placement of a piece of wood by itself or entangled with other pieces. Wood creates habitat by altering hydraulics, sediment transport and the channel to create unique types of aquatic habitat. For wood to do this it must be stable, either where placed or where wood is deposited by the

stream. We argue that basic science and engineering still applies for unanchored wood placements to be successful. If wood placements fail to achieve restoration objectives, they can be a waste of valuable restoration dollars. While this leads to wood stabilization in many restoration designs, there are geomorphic settings where stabilization isn't necessary for wood to function. Unanchored wood can be a more affordable and effective strategy if particular criteria are met with respect to the size and shape of the wood, along with specific conditions of the stream reach such as flows, bed material, sediment supply, channel morphology and riparian vegetation. An obvious example would be a piece of wood that is stable in a small 2nd order channel is not stable in a larger 4th order channel. We present definitions and guidelines on the use of unanchored wood throughout a drainage network, along with situations where anchoring is appropriate in achieving goals. We emphasize a process-based approach and caution with regards to establishing prohibitions on anchoring options. For example, if large rock is placed to increase morphologic drag and increase sediment retention, it will increase the probability of natural wood retention which sets up a positive feedback benefiting restoration. We include examples of applying our guidelines for unanchored wood placements in different regions of Washington State.

#3964 - 10 Considering Geomorphic Processes in the Effective Restoration of Mountain Streams

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The type and intensity of geomorphic processes govern the morphology, bed stability, and in-stream habitat availability in mountain streams. In systems subject to debris flows and debris floods, large-scale episodic destabilization of the riverbed reorganizes riverine habitats, while sediment delivery may cause aggradation and build fans. Human activity over the past century or more has increased the sediment supply to many mountain streams through modification of surrounding hillslopes, changing the frequency and magnitude of debris floods and debris flows. For example, logging and associated road construction concentrate runoff on steep slopes while wildfires reduce slope stability and create hydrophobicity. As a result, many streams have experienced substantial aggradation leading to an overall reduction in habitat quality and connectivity due to a reduction in surface flow during low flow periods, side channel disconnection, and fish stranding in isolated pools.

Restoration projects in mountain streams should consider the watershed conditions and dominant hydrogeomorphic process type within the system. This requires developing an understanding of the watershed physiography, historical changes within the watershed, and the present-day process regime. In this presentation we use several project examples to illustrate potential methods for identifying hydrogeomorphic processes such as debris flows and debris floods, quantifying the frequency-magnitude relationships of these events, and accounting for their effects in hydraulic models. We also use the project examples to explore several design options that consider hydrogeomorphic processes to support the long-term success of restoration measures in three mountain streams. This work highlights the need to shift our expectations regarding channel stability in dynamic, aggrading systems, and adjust restoration approaches accordingly.

#3966 - 11 Working with the river: how to restore geomorphic process and protect infrastructure in gravel bed streams

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In many urban stream restoration projects, there is a desire to balance protecting adjacent infrastructure and enhancing in-stream habitat. However, these two goals often stand in opposition to each other. Traditional bank stabilization solutions (such as riprap) provide robust protection for infrastructure but can reduce habitat quality in streams. Conversely, dynamic streams may produce heterogeneous channel morphologies and diverse flow characteristics that support high quality habitat niches, but their movement can pose a hazard to infrastructure. We present a novel bank stabilization approach, Geomorphological River Engineering (GeoRivEng), that offers a compromise between these two end-members: the approach supports the maintenance of dynamic and heterogeneous channels whilst slowing channel migration toward infrastructure during small to moderate floods.

GeoRivEng builds on experimental research demonstrating that larger-than-average grains (e.g., D_{84}) disproportionately affect channel stability in gravel bed channels; significant bank erosion will only occur when this material is fully mobilized. Laboratory experiments conducted on a stream table demonstrated that placing larger-than-average grains atop the floodplain introduced a negative feedback, whereby the introduction of coarse material to the channel via bank erosion acted to reduce further erosion. Here we present a series of follow-up experiments that explore how the technique may be practically deployed in a prototype river system, the Coquihalla River in British Columbia, Canada. The results provide a to inform future restoration activities on the Coquihalla River, and elsewhere in the Pacific Northwest.

#3946 - 12 An Unprecedented Opportunity: NOAA Restoration Center Funding under the Bipartisan Infrastructure Law and Inflation Reduction Act

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The Bipartisan Infrastructure Law (BIL) and the Inflation Reduction Act (IRA) present a once-in-a-generation opportunity for NOAA and partners to continue making an impact for fisheries, threatened and endangered species, and coastal communities. The BIL provides $891 Million over 5 years, with $491 Million for habitat restoration and $400 Million reserved for fish passage. The IRA provided an additional $484 Million of funding for these restoration, conservation, and resilience efforts. This funding is being made available through competitive grant opportunities managed by the Office of Habitat Conservation (OHC) in NOAA Fisheries. In 2022, the first year that these funds were available, OHC held four competitions: National Fish Passage, Tribal Fish Passage, Transformational Habitat Restoration and Resilience, and Habitat Restoration for Tribes and Underserved Communities. Nationally, this resulted in $482 M allocated through 109 awards. In this poster, we present the resulting selected projects in Oregon, Washington, and Idaho that were funded through all four funding opportunities, in order to inform applicants and restoration practitioners about the types of projects and applications that

may be most competitive through future funding opportunities. We will examine various factors in these applications, such as the range of fund amounts that were allocated per award, the location of projects, and the type of organization that received funding, among other factors. We will also examine how these locations overlap with Evolutionarily Significant Units (ESU) for NOAA's ESA-listed salmon. In 2023, OHC announced the same 4 funding opportunities, with longer application periods, larger caps on projects, and a greater emphasis on Tribes. One more round of competitive funding opportunities using these funding sources is expected, and this information is presented to spark conversations about how to implement projects through NOAA's funding opportunities in the Northwest Region that are most impactful to species recovery. An understanding of these opportunities and the projects selected in round one, and how funding opportunities changed in round two, will help the River Restoration community compete more effectively and creatively for future restoration funding.

#3943 - 13 Incorporating Terrestrial Connectivity into Fish Barrier Removal Projects

Marc Hershfield

WSDOT, Olympia, WA

The concepts of fish passage and terrestrial wildlife habitat connectivity are inextricably linked. Riparian corridors, where aquatic and terrestrial environments meet, comprise small portions of the landscape but provide disproportionately important ecosystem functions. These areas are commonly utilized by wildlife to travel between patches of suitable habitat, and in highly fragmented urban landscapes, represent some of the last remaining travel routes available.

WSDOT's Fish Barrier Removal work aimed at providing access to upstream fish habitat presents an opportunity to simultaneously provide habitat connectivity for other species which also suffer from highway-imposed habitat fragmentation. Improving conditions for wildlife movements past our highway system is an important goal articulated in WSDOT's Executive Order 1031.02, Protections and Connections for High Quality Natural Habitats. A key section of the Executive Order refers to WSDOT's intention to develop criteria and guidance for the construction of wildlife passage structures.

WSDOT currently relies on a highway prioritization tool called the Habitat Connectivity Investment Priorities (HCIP) to locate specific opportunities to restore habitat connectivity already adversely impacted by human transportation corridors. The HCIP rank the approximately 7,000 mile highway system using one-mile-long segments, which are intended to be the focus of efforts to reduce wildlife-vehicle collisions and improve connectivity. For example, we determine which fish barrier removal projects fall within high priority locations regarding terrestrial wildlife connectivity using the HCIP, thus triggering a memo that includes recommendations to enhance the subsequent structure for terrestrial wildlife species.

The size and shape of a structure are the most permanent attributes affecting structure use and therefore should be considered early. Structure dimensions should be based on site-specific species presence, and the openness index (O.I.), which is calculated by multiplying the width (span) by the height (vertical clearance) of the structure and dividing the product by the length. Based on camera monitoring and previous studies, WSDOT has determined minimum sizing and openness recommendations for various species. Examples of recently constructed bridges, including before and after photos, will be in the poster, including dimensions and habitat enhancement features.

When terrestrial wildlife features are incorporated into fish barrier removal projects, those crossings are monitored to determine effectiveness of enhancements, including reductions in wildlife-vehicle collisions and increases in safe passage for animals. Preliminary results indicate there are major benefits when incorporating habitat connectivity features within fish barrier removal projects.

Addressing terrestrial wildlife habitat connectivity at the same time as fish barrier removal work leads to engineering efficiencies, and ultimately cost savings, associated with performing planning and construction tasks at a single point in time. Proactively addressing terrestrial wildlife and fish connectivity needs simultaneously will protect valued wildlife resources for future generations and enable a holistic wildlife corridor planning process that incorporates the efforts of partners and co-managers.

#3891 - 14 Wildfire and River Restoration: Case Studies from the Methow River Watershed

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Under current climate change trends, wildfire frequency, extent, and severity are all projected to increase throughout western North America. As investments in salmonid habitat restoration in the Pacific Northwest continue, the compounding threat of wildfire creates an impetus for more rigorous consideration of wildfire impacts in the context of stream restoration design.

Case studies from the Methow River Basin provided observations of direct fire impacts to fish habitat restoration projects and indirect secondary post-fire impacts to restoration projects in the Chewuch River and Beaver Creek. Additionally, observations of fire impacts were made on Wolf Creek, a designated wilderness-area watershed relatively free of anthropogenic disturbances. The Chewuch River case study included fifteen restoration sites along seven river miles. As a result of the Cub Creek 2 fire in 2021, eight restoration sites along the Chewuch River experienced direct fire impacts, mostly in the form of burning of constructed large wood structures. Three post-fire debris flows occurred in summer 2022, with one debris flow reaching the Chewuch River and depositing large volumes of fine sediment at multiple restoration sites. The Beaver Creek case study included twelve restoration sites along one river mile, as well as observations along six river miles upstream and downstream of the restoration sites. The Carlton Complex fire in 2014 directly burned constructed log jams at eight of the restoration sites in Beaver Creek. Large magnitude precipitation events in 2014 and 2017 resulted in numerous debris flows and flooding in Beaver Creek, accompanied by inputs of sediment and woody material which resulted in substantial channel migration and avulsion. The Wolf Creek case study included hillslope, floodplain, and river observations along four miles of valley within the Okanogan National Forest. The Cedar Creek fire in 2021 directly burned approximately 50% of the case study area and 80% of the contributing watershed. Areas of high and moderate burn severity resulted in fire consumption of most existing large wood jams, along with overstory and understory vegetation on the valley bottom and hillslopes. Increased erosion processes in the first year after the fire produced and transported fine sediment to the stream channel, while minimal changes to channel morphology were observed throughout the case study area.

The lessons learned from the case studies provide information for river restoration practitioners and stakeholders to understand and consider the risks wildfires pose to restoration projects, and

suggestions for mitigating those risks. Through more rigorous consideration of observed and projected climate and wildfire trends, stream restoration actions can become more resilient to the effects of wildfire and habitat restoration projects can more effectively buffer some of the negative impacts of wildfire, thereby contributing to proactive management strategies aimed at climate change adaptation and mitigation.

#3950 - 15 Geomorphic Risk Analyses in River Restoration Design Projects: Large Wood Risk and Avulsion Risk Analyses

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Risks, or undesirable outcomes, are inherent to any stream restoration design project. Incorporating risk analyses for large wood structure placement and avulsion potential into the design process allows for better planning and development of criteria that can improve the resilience of stream restoration design projects. In this poster, two geomorphic risk analysis methods are presented that can be used in stream restoration design to characterize, quantify, and communicate these risks. The first method, large wood risk analysis, evaluates and documents potential property damage and public safety concerns associated with large wood structure placement. Property damage risk identifies risk to infrastructure located within and downstream of the project area from failure of the large wood structure. Public safety risk identifies the potential risk to public users of the project area from encountering or interacting with the large wood structures. The second method, avulsion risk analysis, evaluates and documents the probability associated with increased inundation, channel reoccupation, and channel cutoffs due to the stream restoration design. The evaluation considers the geometry of the stream channel, sediment transport contributions, and presence of either natural or human-made constraints on channel movement. Utilizing these valuations, the potential risk associated with channel avulsion posed to adjacent and downstream infrastructure is identified. This poster presents these methodologies and examples of the analyses that can be used by restoration design teams to better characterize, quantify, and communicate uncertainties associated with stream restoration design projects.

#3929 - 16 Planting Eelgrass for Wild Salmon

Daniel Wadhams, Field Crew Lead

Broughton Aquaculture Transition Initiative, Alert Bay, BC

Estuaries in the priority watersheds of the Broughton Aquaculture Transition Initiative have been strongly impacted by industrial activities, especially logging, resulting in loss of critical nearshore habitats such as eelgrass (Zostera marina). The latter provides both shelter and prey for juvenile out-migrating Pacific salmon (Oncorhynchus spp.), which in turn is a substantial food source for the local First Nations and for many wild species inhabiting the coast. In order to provide a healthier habitat for salmon, we propose a methodology of eelgrass planting in these estuaries using an anchoring system with virtually no environmental impact. We then present the results obtained a year after planting 1,600 eelgrass shoots in the Lull Creek estuary. In addition, we describe a recent planting project during which a total of 4,800 shoots were harvested from two nearby locations and planted in three estuaries. Although the success of eelgrass planting is

dependant on many biotic and abiotic factors (e.g. hydrological currents, sediment type, water quality, avian grazing), the preliminary results portend a favourable outcome for larger scale similar projects in the Broughton Archipelago area, northern Vancouver Island, BC.

#3861 - 17 Building a foundation for restoration of the Lower Big Quilcene River: Quantifying historic changes in channel planform, sediment transport, incision and sediment budget

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The Lower Big Quilcene River offers an example of how quantitative interpretation of historic landscape alterations can provide valuable information for restoration design. The river drains 173 square km of the eastern slope of the Olympic Mountains and flows into Quilcene Bay along the Hood Canal in northwest Washington State. The Lower 6.6 km of the river was historically an unconfined pool-riffle channel. The focus of this project is a 57 hectare, 1.6 km segment of the river valley known as the Moon Valley Reach located immediately downstream (east) of the U.S. 101 highway. Most of the lower Quilcene underwent significant changes in the twentieth century such as channel straightening, clearing, dredging and removal of floodplain forests that severely impacted salmonid habitat. Historic maps and imagery, together with 4.3 m deep test pits show that the river occupied large parts of the valley bottom as recently as 1939, prior to being confined to a narrow straight path along the southside of the valley. The river's sinuosity has diminished from about 3.0 in 1877 to 2.08 in 1940 to 1.04 presently. These impacts resulted in a more than 10-fold increase in unit stream power and in a period of about 80 years the river incised up to 2.8 m in the upstream portion of Moon Valley Reach. This has transformed the upstream portion of the reach from a gravel bedded pool-riffle channel to a boulder plane bed channel. Gradual development of an inset floodplain has occurred, being most pronounced in downstream half of the reach but has been limited throughout the reach by bank armoring. We estimate that about 244,000 cubic meters of alluvium has been exported from the Moon Valley Reach. This corresponds to historic progradation of the river's delta into Hood Canal. Quantifying historic changes provided the foundation for a process-based restoration design that is focused on raising the river channel and groundwater table, increasing floodplain connectivity, restoring a meandering anabranching channel complex and placing large quantities of wood throughout the restoration corridor to dissipate energy and sustain the restored channel complexity.

#3952 - 18 Proposed Bypass Flow Program for Coastal Low-Flow/Seasonal Streams

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In 2016, the California Department of Fish and Wildlife identified nine historical raw water diversions in the Santa Cruz Mountains that had been operating since the early 1900s without having had environmental flow studies characterizing necessary bypass flows for maintaining

downstream aquatic habitat. A multi-year (2019-2022 water years) Raw Water Intake Bypass Flow Study (RWIBFS) was conducted to develop long-term seasonal bypass flows for each of the nine diversions, which are mostly situated along coastal low-flow/seasonal streams. The main components of the RWIBFS included:

- Biological and hydrological surveys identifying the presence of potential habitat for any life stage of the following focal species: California red-legged frog, foothill yellow-legged frog, western pond turtle, California giant salamander, and rainbow trout.
- Installation of permanent stream gages downstream each diversion.
- Installation of temporary stream gages in Habitat Monitoring Stations.
- Development/calibration of a 20-year hourly time-step hydrology model evaluating inter and intra-seasonal variability in streamflow.

Data collected from this study was used to develop long-term bypass flows that could be adjusted in real time. Real-time adjustments were pursued over monthly/seasonal bypass flows in order to adapt to the wide fluctuations in streamflow associated with the inherent uncertainties of **when** and **how** precipitation is distributed in these watersheds and between water years. With a number of climate models predicting increasing droughts interrupted by periods of intense rainfall (e.g., atmospheric rivers), incorporating adaptable bypass-flow programs for systems managing multiple beneficial uses may improve our ability to manage ecological and municipal flows through changing hydrological conditions.

#3876 - 19 Hydrogeomorphic response to flooding in Yellowstone National Park: Comparing landscape controls and threshold hydraulics

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Flood-induced geomorphic change has been linked with metrics representing fluvial forces or energy, such as stream power (the product of the specific weight of water, slope, and discharge,) gradients and unit stream power (/channel width) magnitude. Ideally metrics used to explain geomorphic change would account for not only peak-flow magnitude, but also flood duration and channel bed-material caliber. To evaluate the effects of the June 2022 flooding in northern Yellowstone National Park (YNP), we calculated cumulative flood impulse, a metric that incorporates flow duration exceeding the channel bed-surface incipient-motion threshold based on critical Shields stress, grain size, slope, and hydraulic radius. The June 2022 flood, which had an annual exceedance probability on the order of 0.002, was driven by an atmospheric river, rain-on-snow event that resulted in extensive valley-bottom geomorphic change and damage to roads that connect northern YNP to nearby population centers. We evaluate the hydrogeomorphic response of the Gardner River and Soda Butte Creek and assess whether cumulative flood impulse predicts geomorphic change of riverscapes subjected to an historic flood. We quantify topographic change using digital elevation models of difference (DoDs) created from pre-flood (fall 2020) and post-flood (fall 2022) lidar. Further, we calculate flood impulse using HEC-RAS modeling, supported by post-flood channel surveys to measure bathymetry, grain size, and high-water surface elevations. Hydraulic modeling shows that the threshold of bed mobility was exceeded for 23 days during the June 2022 flood, with variability between confined and unconfined reaches. Impulse was highest in straight, confined reaches between bends upstream

of areas with significant geomorphic change. DoDs show that in confined bends up to 8 m of lateral erosion in banks with more than 10 m of total relief occurred; in unconfined valley reaches, more than 1 m of vertical aggradation occurred in avulsed, single-thread channels; and some reaches experienced little net change. Results indicate that the cumulative impulse framework may be a useful tool for investigations of geomorphic change resulting from floods. Our work applies impulse to large-scale geomorphic change and informs understanding of riverscape response to floods. Examining floods is important to understanding evolving hydroclimatic extremes and the resulting impact on natural and built environments. Flood duration has proven to be a critical element in the effectiveness of flood events and may be overlooked if only peak metrics (stream power, shear stress) are considered. The cumulative dimensionless impulse framework provides restoration professionals with a tool to incorporate variability in flood duration and bed material caliber into a single data product to evaluate the impact of floods on riverscapes.

#3938 - 20 Planting for success: Riparian restoration to facilitate beaver habitat expansion

Maureen Thompson, PhD

Think Wild, Bend, OR

Central and Eastern Oregon riparian landscapes are beset by environmental issues: wildfires, drought, rising water temperatures, invasive species, and a history of harmful land use practices, which threaten habitat for not only fish and wildlife, but also for humans. Research supports that the presence of beavers, and their activity in stream ecosystems, lead to improved habitat for fish, wildlife, and native plants, as well as increased drought, flood, and fire tolerance. However, a variety of factors limit beaver populations' success in Oregon, including suitable habitat, resource availability, drought, and public perception. The relationship between loss of riparian habitat and beaver habitat use is iterative. Since many riparian areas are impaired due to anthropogenic stressors, they no longer support the conditions beaver need to survive. Often the places where people would like beaver can't sustain them, and the places where beaver are attracted they are unwelcome. Beaver Works Oregon is a program under Think Wild dedicated to supporting beaver success on Oregon's high desert landscape. To address the factors limiting their success in tandem, Beaver Works Oregon has been engaged in efforts to create the habitat conditions and human tolerance necessary to support beaver populations through 1) riparian habitat restoration, 2) outreach, and 3) conflict mitigation. Our project works to establish BeaverHOODs, stream reaches with adequate food, water, sediment, and construction building materials, as well as human tolerance for beavers to establish and thrive. To achieve this, we collaborate with local watershed councils, agencies, and landholders to identify, consult on, and plan habitat restoration projects. We then take volunteer groups out to the worksites to implement and monitor the projects by spending a weekend - planting, camping, and learning about beaver habitat, healthy ecosystems, and working lands. We have completed 13 volunteer-led wildlife habitat projects throughout the Deschutes and John Day River Basins. We planted more than 3,000 trees and built 9 Beaver Dam Analogs (BDAs) to support beaver habitat along riparian waterways on private and public lands in Deschutes and Crook Counties. Because approximately 51% of riparian stream miles exist on private lands, and public support is key to beaver success, our project also includes accessible education, outreach, and support services to rural youth, adults, and agencies about coexistence solutions and benefits of beavers in Central and Eastern Oregon watersheds. We also provide non-lethal solutions to landowners

experiencing problems with beavers. In this way, Beaver Works is a useful dual case study for public engagement in riparian habitat restoration efforts while simultaneously addressing issues along the human-wildlife conflict tolerance spectrum. In this session, we detail how a three-prong strategy works to amplify restoration outcomes. We discuss pinch points influencing project success, our efforts to refine riparian revegetation management actions, and establish metrics comparable across other riparian restoration projects. Our aim is to share lessons learned, proof of concept, and point to areas needing further research. In doing so, we intend to inform current and future efforts in the beaver riparian habitat restoration and co-existence realm.

#3961 - 21 Stream Bed Design for Future Compatibility

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Under WSDOT's Fish Passage Program, the principal objective of fish passage and stream restoration design is to provide access to quality spawning and rearing habitat for anadromous salmonids at all life stages. Under this guidance, WSDOT has accumulated a wealth of experience in stream bed design that considers channel complexity, stream geomorphic characteristics and responses and is also aimed to be compatible for a variety of future conditions. Much of the experience has been positive and successful. Yet, there are still unknowns and challenges that may threaten the success of many current and future projects.

While an obvious but not an emergent issue, hydrology remains a challenging engineering aspect. Streams and creeks with existing fish passage barriers are mostly small. Nearly all of these creeks do not have any flow records or stream gauges. Moreover, many of them are located within urban areas. These characteristics create challenges in determining flood discharges for hydraulic design. Engineers often take a conservative approach due to these unknowns. However, we find that high design discharges may result in stream bed design that is not supported by stream geomorphic characteristics. To address the issue, WSDOT has developed methodologies to evaluate applicability of hydrology data from different sources and whether proposed flood discharges represent stream characteristics observed in field.

Many of the WSDOT fish passage barriers are located in the transition zones between upper steep terrain and lower shallow and floodplain of a larger receiving waterbody. In the vicinity of the sites, there may be nearby infrastructures that potentially affect the project sites hydrologically, hydraulically, and geomorphologically, such as undersized culverts, dams, and utility lines. WSDOT has taken a future forward approach to ensure that the restored streams meet changing conditions during the design life of fish passage structures. For example, how does the design consider the interaction between a tributary and a mainstem river? How does the scour analysis consider future channel responses if nearly infrastructure is altered or under a climate change condition?

In addition to design for future compatibility, WSDOT also recognizes that wood and in-stream vegetation play a vital role in shaping stream characteristics. A stream with quality fish habitat exhibits a geomorphic balance between flow, sediment, and wood. In the first several years after construction and within structures, any imbalance among wood, flow, sediment and wood/vegetation poses a risk for fish passage. For example, a plane bed stream type without

adequate water depth and flow complexity may create a velocity or water depth barrier. WSDOT has made significant progress in designing and implementing features that mimic the natural stream functions and processes. They are designed to address the issues that have led to less than successful restoration efforts in the past. WSDOT has applied these channel complexity features to several projects constructed recently, such as partially spanning complex wood steps. In this presentation, WSDOT will share design principles and observations learned on construction and applications of these features.

#3928 - 22 Innovative Approaches to Stream Restoration and Fish Passage: Learning from Nature's Playbook

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The Washington State Department of Transportation (WSDOT) stands at the crossroads of transportation efficiency and ecological stewardship. The challenge lies in harmonizing safe and efficient movement of both people and fish. This presentation delves into WSDOT's dynamic journey of redefining fish passage and stream restoration practices, guided by lessons from nature, past experiences, and biomimicry techniques.

Harnessing insights from nature and capitalizing on past successes and failures, WSDOT has embarked on a transformative mission to reimagine fish passage within transportation systems. Through the lens of biomimicry, the agency is constructing in-water features and channel complexities that mimic natural processes and geomorphic characteristics. This sweet dance between engineering and biology is akin to the serendipitous fusion of chocolate and peanut butter yielding the sublime peanut butter cup – a synergy that transcends the sum of its parts.

Exploring new techniques like deformable grade controls, meander bars, large woody material, and the art of incorporating small woody material and slash, this presentation unearths how the collaboration of biology and engineering can produce peanut butter cup-like marvels. Just as chocolate and peanut butter complement each other, so do disciplines like biology and engineering in WSDOT's pursuit of stream restoration excellence. Striking this balance requires meticulous monitoring, assessment, redesign, innovation, research, and implementation.

This evolution is characterized by a forward-looking mindset, wherein WSDOT designs for the future life of streams. We try to anticipate channel responses, account for future flow patterns, and forward compatibility with future barrier corrections beyond the highway. From humble beginnings, where errors were made and triumphs celebrated, WSDOT has learned through monitoring, research, and adaptability to create new tools and techniques for maintaining fish passage at highway crossing for the design life of the project. Join us as we explore this captivating journey, bridging the gap between biology and engineering, and celebrating nature's wisdom.

#3940 - 23 Organic Material in Simulated Streambed Designs: A Flume Study Investigating Meander Bars Design Guidelines With Organic Material

Tyler Fouty, Ph.D.

Washington State University, Pullman, WA; Jacobs, Bellevue, WA

Fish populations in the Pacific Northwest over the last century have seen consistent declines, a major contributor is the reduction of spawning grounds due to water crossings being barriers to fish movement. The leading barrier type are culverts that are undersized for the site which leads to sediment being washed out and the outlet being perched or being clogged with sediment or organic material. In the past three decades Washington State has implemented the stream simulation design (SSD) methodology to design fish barrier corrections. Currently there are 2,057 known fish barriers across the state. One challenge with SSD is that there is no guidance on the construction of streambed designs that incorporates organic material to increase bed stability and maintain a low flow channel. This flume study investigated the following streambed designs: 1.) meander bars, and 2.) organic streambed mixture. The first design involved the addition of root wads and slash between meander bars, and 2.) three different volume ratios of sediment and organic material mixtures. Designs were subjected to three flood frequency events 10-, 25- and 50-year and the change in channel morphology was used to evaluate channel stability. Channel morphology was collected by using a novel technique of a high-resolution handheld scanner, EinScan-H. Twenty configurations were tested relative to a plane streambed (no organic material). The results show the addition of organic material will increase channel stability. Meander bars will increase stability by 10-67 percent. Organic streambed mixture under a 1:1 ratio will increase stability by 18-63 percent. The increase in channel stability will increase the design's lifespan, reduce maintenance, and provide fish habitat in the water crossing.

#3930 - 24 Climbing the Geomorphic Ladder: Envisioning a Holistic Approach to Step-Pool Design

Jeff Kamps

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Fish passage and restoration projects can occur in streams with a gradient between 3 and 10 percent, typically with a step-pool morphology. Designs for these stream types have tended toward using factors of safety that do not mimic natural fluvial conditions, creating homogenous designs typically with the goal of step stability and certainty. However, in natural systems, morphology readily adjusts based on sediment supply, transport capacity, complexity features, and recent flow events. Process-based restoration requires an interdisciplinary team that can create solutions with the goals of mimicking natural functions and processes, ensuring fish passage, and accounting for the built infrastructure throughout the life of the project.

Research has helped better understand the driving forces or factors behind the inherent stability and chaos of the step-pool morphology. In general, each study has focused on specific parameters and the interplay between several parameters that govern step-pool systems, such as channel geometry, grain size, scour, hydraulics, or hydrology. Understanding step-pool systems provides significant value but does not yield the ability to design a full complement of step-pools that may span several hundred feet and thus attain the stated goals while addressing the risks. The additional complexity of constructing these features within a road crossing, where vegetation cannot grow and provide the root mass common to forested streambanks, exacerbates the problem.

Near-term design and construction consistency is needed in step-pool design. Designing systems that mimic the existing stream in equilibrium and provide similar habitats through the crossing can be challenging. Integrating woody material into step designs is not well understood or

studied, creating higher risk for this technique. With the substantial, ongoing investment in fish passage projects, the efficacy, understanding, and consistency of step-pool designs must be improved significantly to maximize the return on investment without impacting ecological integrity. Utilizing a consistent approach to measure these systems will provide one facet to understanding them more fully. Additionally, a consistent approach will provide a database of information from which comparisons can be made and improve our understanding of how to integrate woody material with boulders into designs.

A recently developed step-pool design validation spreadsheet provides a holistic tool that calculates and accounts for most of the parameters associated with step-pool morphologies and focuses on each step within a complete sequence of steps to ensure that each parameter is accounted for. By teaming step-pool measurement processes with the step-pool design validation tool, we hope to implement a robust data collection process for designing step-pool systems that can mimic natural environments and can validate a chosen stability level prior to construction. Compiling a wealth of existing conditions data and subsequent design data will provide the foundation for monitoring data that will act as a feedback loop to inform future designs and fine-tune the tools. Our intent of this abstract is to invite multidisciplinary voices into this opportunity to guide the design of step-pool systems for steep fish passage and restoration projects, share our research and findings, and build on these lessons learned to raise the bar.

#3982 - 25 Regenerative Land Management for Water Security and Riparian Habitat Enhancement

Kieran Sikdar, CFM[1], Ricardo Aguirre, PE, D.WRE, CFM, AP[2], Brian Wahlin, Ph.D., PE, D.WRE[3]

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Water security is an escalating challenge across the United States, affecting municipalities, producers, and riparian and aquatic habitats. This presentation reviews two active projects located in the arid Southwest and explores the potential of regenerative land management as a robust strategy to ensure water security while simultaneously combating desertification threats to riparian habitats.

This presentation will explore the implementation of holistic land management techniques in lieu of conventional infrastructure-based engineering solutions. This approach yields both ecological and economic advantages, and Mr. Aguirre's work through WEST continues to examine the potential enduring benefits of managed livestock and holistic planned grazing as precision tools for storm water infiltration, flood mitigation, water quality enhancement, and erosion prevention.

Through the lens of two active projects—the "3 Canyons Land Management Project" in Cochise County and the "WEST Demonstration Site," developed in collaboration with the Drylands Alliance for Addressing Water Needs (DAAWN) 501c3 nonprofit, Red Rock, AZ—this presentation illustrates how holistic planned grazing effectively mitigates flooding and preserves water quality, especially in arid and/or desertifying regions, thus safeguarding riparian habitats and bolstering water security. Furthermore, the discussion emphasizes the pivotal role of soil health in flood reduction, and how planned grazing can repair the nutrient cycle to promote soil health.

This presentation will also explore methodologies of establishing collaborative relationships with agricultural producers, private landowners, and other local, state, and federal land management agencies designed to lay out a strategic framework that incorporates individuals' holistic objectives for planning, implementation, and comprehensive monitoring for ongoing project success.

#3939 - 26 Rewilding a Floodplain in Carmel, California

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McBain Associates and SWCA Environmental Consultants performed restoration design and hydraulic modeling on the Rancho Cañada Floodplain Restoration Project on the Carmel River, located at the Palo Corona Regional Park, California. Goals of this project include rewilding a former golf course to a fully functional river ecosystem with greatly increased floodplain connectivity and improving riparian and salmonid habitat. The existing Carmel River is approximately 15 feet below adjacent floodplain surfaces. A process-based restoration approach was adopted for the design, which will allow for future channel and floodplain dynamism. The project will create roughly 25 acres of winter and spring juvenile salmonid rearing habitat, and will reconnect nearly 40 acres of floodplain to the Carmel River. Our presentation will provide an overview of the design approach and engineering analyses, as well as provide insight into the stakeholder engagement process.

#3979 - 27 Where Olympic Mudminnow and Salmon Habitat Restoration Meet

Sierra Hemmig[1], Lauren Kuehne, MS[2], Noelle Nordstrom[3], Garrett Rasmussen[1], Caroline Walls, MS[1]

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Freshwater restoration in the Pacific Northwest tends to focus almost exclusively on salmon (*Oncorhynchus* spp). As a result, the existence and habitat needs of non-commercial aquatic species, such as the Olympic mudminnow (*Novumbra hubbsi*), are often overlooked. But when Olympic Mudminnow and salmon habitat overlap, resource managers can work restore ecosystem function to the benefit of both species.

Quileute Natural Resources (QNR) is actively engaged in restoration on the Quillayute River to protect Treaty fishing rights and Quillayute salmon. In the lower Quillayute River, an off-channel wetland, known as James Pond, provides high-quality rearing habitat for Chinook and coho salmon. But the channel connecting the river to James Pond is partially blocked by an undersized culvert, preventing full utilization of the habitat. Efforts by QNR to engage the landowner to correct the barrier have yielded two critical considerations for restoration planning: (1) James Pond is home to one of only a few north coast Olympic mudminnow populations, and (2) low-flow water levels in James Pond have been declining in recent decades, threatening the quality of the habitat for both salmon and mudminnow.

Olympic mudminnow are endemic to the Olympic Peninsula and are identified as a Species of Greatest Conservation Need by the Washington State. Within their limited native range, Olympic mudminnow occupy select, and often disconnected, wetlands and ponds. Populations are highly fragmented compared to other regions, most likely due to reduced connectivity and availability of suitable habitat. Olympic mudminnow do not readily disperse into new areas, leaving them particularly vulnerable to habitat degradation. Prolonged low flows in 2022 left thousands of mudminnow stranded and dead in the James Pond wetland, as the puddles in which they took refuge dried. Genetic evidence indicates that the James Pond population has suffered historical bottlenecks, possibly due to extreme drying events in the past. For these reasons, resource managers are interested in preserving and protecting the James Pond mudminnow population, and understanding the population's sensitivity to changes that may result from restoration actions targeting salmon.

While climate change cannot be ruled out as contributing factors for declining water in James Pond, resource managers believe a significant driver is a logging road that bisects the uppermost extent of the wetland complex, altering the hydrology and preventing full flows from reaching James Pond. Historic aerial photographs clearly show that as the surface area of James Pond declined, novel ponding above the logging road emerged. The road will be pulled back in 2025 to restore uninterrupted flow between the upper wetland and James Pond.

Complicating matters, however, is the discovery that a subset of the James Pond mudminnow population is now thriving in the newly created pond above the logging road. Removing the hydrologic barrier will benefit fish in James Pond, but how will it impact the mudminnow population above the road? QNR and partners are working to develop a plan that restores James Pond without sacrificing the upper wetland, which will likely include beaver dam analogs and post assisted log structures along the flow path.

#3968 - 28 Understanding how sediment supply variability in small watersheds can impact restoration and fish passage design

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Underlying soil conditions and basin configurations can have an outsized role in governing sediment delivery and supply . Washington State Department of Transportation (WSDOT) is designing, constructing, and monitoring hundreds of new stream crossings along existing highways. These new crossings are designed to allow for fish passage and not impede natural channel processes.

These culvert replacements are focused on low-order streams reaches with small basins (less than 1.5 square miles), with a range of gradients , wide variety of subsurface soil conditions and sediment supply variability. These projects allow scientists and engineers to observe how a subset of these reaches experience more scour than conventional Scour Calculations (FHWA's HEC 18) and methods of determining long-term degradation generally predict. The existing methods are based off measurements and study area rivers/streams with alluvial (sand or cobble bedded streams) with moderate gradients (less than 6 percent) and larger basins. Observed sediment transport (volume and D-max) in some cases were greater than expected, which resulted in subpar instream habitat conditions

We have found that lack of understanding in the sediment supply, or the properties of the underlying soil conditions, are the most common factors for why channel degradation can be greater than anticipated. Not accounting for a) the potential sediment supply variability or b) potential for significant changes in sediment supply over time can a play heavy role in the success of projects to provide fish passage and improve habitat. We draw from several investigations that highlight problematic soils that impact the local sediment supply. We provide a framework for screening these potentially dynamic reaches using field indicators We will share our experience with the limitations of current calculation and modeling methods. If time allows, we will share existing and design solutions that can account for the added risks.

#3989 - 29 Creating a new estuary for Pacific salmon in Bellingham Bay, WA

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A new estuary was designed and constructed at the Little Squalicum Estuary in northern Bellingham Bay in Washington State. This project was estuary creation and not restoration, in order to compensate for the loss of almost all natural estuary area in the bay. Over the past 150 years, Bellingham Bay has lost an estimated 282 acres of aquatic land as the result of historical dredging, filling, and shoreline modifications, drastically reducing rearing habitat necessary for local salmonid populations. The new estuary is 2.2 miles east of the mouth of the Nooksack River, in an urban area where estuaries within 5 miles of river mouths have been shown to be essential for the survival and health of juvenile Chinook (*Oncorhynchus tshawytscha*) and other species of Pacific salmon. The WRIA 1 Nearshore and Estuarine Assessment and Restoration Plan identified Little Squalicum as one of the last remaining locations for estuary habitat expansion in Whatcom County.

Many factors had to align to allow for the large estuary habitat creation project to occur within a new City Park on the fringes of a past superfund cleanup project site. Key steps to initiating the project included an initial restoration feasibility study with funding provided by the innovative Bellingham Bay Demonstration Pilot project, a partnership of 14 different federal, state, local, and tribal agencies working together to improve nearshore habitats in Bellingham Bay. Through the City's park master planning process, a diverse group of stakeholders incorporated the estuary creation concept into the park master plan. The project required extensive collaboration as the work was within a high-use park, with multiple public meetings. Persistence by environmental staff within Bellingham Public Works was required over almost 15 years, along with coordination and extensive testing and reporting regarding both potential contaminants, remediation, and permit issues.

The estuary was created in the Little Squalicum Creek valley that was developed into a gravel pit in the mid-1900s. The estuary basin is 2.4 acres in area with elevations extending from 1 to 18 FT NAVD88. Excavation of over 32,000 CY occurred with 10,000 CY moved to the down-drift beach to enhance surf smelt (*Hypomesus pretiosus*) spawning habitat on the upper intertidal beach. A new inlet through the beach was designed using several empirical relationships along with a reference inlet database developed to design inlet sizing and elevations. The inlet runs under an elevated BNSF railroad trestle constructed in the 1920s. BNSF was engaged multiple times, which caused some delays, and steel sheet pile walls were installed to protect trestle

abutments from scour. The project was designed to be self-sustaining with sea level rise. Detailed design was initiated in 2015, and upon receiving full funding from multiple state and foundation sources, was constructed in 2022–23. The majority of the funding was acquired through demonstrating quantified benefits to nearshore habitat for salmon. The project sponsor was Bellingham Public Works, with Bellingham Parks as landowner and partner. The project was designed by Coastal Geologic Services, now part of Natural Systems Design in Bellingham, WA.

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Founded in 1984, **Inter-Fluve** has been a pioneer in the field of science-based river restoration design and engineering. Over the last 39 years, we have developed an unparalleled approach to restoration that utilizes natural river processes to create projects that not only achieve their design criteria, but persist through time. To date, our portfolio includes over 2,500 projects, completed on four continents and spanning all corners of the US. Critical to our success is our ability to understand the necessary interface of modern rivers with essential infrastructure, and to work collaboratively with stakeholder groups to develop consensus solutions to river management challenges. Inter-Fluve's team of over 50 scientists and engineers maintain expertise in fish passage, large wood placements, hydraulic modeling, geomorphic assessment, bio-engineering, topographic and bathymetric surveying, stream simulation, as well as planning and implementation management. Known for our in-house, interdisciplinary approach, our engineers understand the complexities of working within dynamic natural environments and our scientists understand the importance of sound engineering design.

We deliver impactful global solutions to create a more connected, sustainable world — from intelligence to infrastructure, cybersecurity to space exploration. Our more than 60,000 employees across 50 countries work every day, challenging the expectations of today to reinvent the way we'll all live tomorrow. At **Jacobs**, we make the world smarter, more connected and more sustainable. Challenging today is our response to the increasing complexity our world is experiencing. It calls on us to join forces, putting our knowledge and imagination together to reinvent the way we solve problems and shape the next generation of innovative solutions. Reinventing tomorrow is our promise and an invitation to raise the bar in everything we do. From the brilliant solutions we create with our clients, to the open and inclusive culture we create for our people. From the positive difference we make in our communities, to the added value we deliver to our shareholders.

NV5 Geospatial is a leading professional services firm specializing in spatial data generation, integration, enablement and analytics, serving the needs of clients worldwide. NV5 Geospatial goal is to improve your operations and decision making in areas such as Natural Resources, Government, Infrastructure, Energy, and Public Safety by utilizing the power of geospatial data and insight through our unique cloud-based delivery infrastructure. In an age when we are immersed in near infinite spatial data, the new challenge is not just capturing and processing geospatial data but finding what it means to you and your business. Our next generation solutions unleash the power of spatial insight and will help you make better decisions and increase your spatial IQ.

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Tetra Tech is a leading, global provider of consulting and engineering services. We differentiate ourselves by Leading with Science® to provide innovative technical solutions to our clients. With more than 21,000 associates worldwide, Tetra Tech provides clear solutions to complex problems. Throughout the Pacific Northwest, Tetra Tech has localized experience in river processes and restoration design. We believe in a holistic approach to ecosystem restoration and have the capabilities to perform every aspect of a restoration project, from initial feasibility assessment through post-construction monitoring and outreach efforts. We have successfully completed numerous challenging and innovative ecosystem restoration projects by leveraging our broad understanding of physical and ecological river processes into detailed engineering and restoration designs. We use our deep knowledge of hydrologic, hydraulic, and sediment transport processes, often in conjunction with various models, to understand the specific needs and challenges of each project. Combined with our fisheries, wildlife, ecological, wetlands, and permitting expertise, we focus on developing holistic restoration approaches and plans that restore natural ecosystem functions and processes while seeking to benefit all of a river's stakeholders.

WEST Consultants, Inc (WEST) are a team of water resources engineers and scientists with combined academic, technical, and real-world expertise and experience in a diverse range of water resource disciplines. Our team includes more than 60 professionals and leaders in the industry, that make significant contributions to the development of state-of-the-art hydrologic and hydraulic and fluvial geomorphic technical methods, assessment and design approaches, and modeling technologies.

From the Chehalis basin in Washington to the Mississippi River through the Midwest to the Gyeong-In Ara Waterway in the Republic of Korea, WEST offer technical services locally, nationally and internationally in water related engineering, including: riverine dynamics, sediment transport, surface and groundwater hydrologic modeling, wetland hydrology, bridge hydraulics, floodplain hydraulic modeling, erosion and scour assessment and mitigation, hydrotechnical engineering and hazards assessments, , fluvial geomorphic assessments and mitigation, riverine measurements, environmental engineering, water quality and contaminate transport modeling, coastal and estuarine modeling, hydro-software sales, hydro-related computer programming, and related training.

WEST staff are teachers to the industry through HEC-RAS, riverine dynamics and fluvial geomorphology training offered nationwide through the American Society of Civile Engineers (ASCE) and through a number of state and regional floodplain management associations and agencies. We have targeted and local experience and expertise working locally in Washington on riverine and floodplain systems; focused on leading the industry on fish passage, stream and restoration projects, and related hydrotechnical engineering projects.

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Our engineers, surveyors, and environmental design service experts lay the groundwork for infrastructure, energy, and building projects, and our approach to development forms wildlife habitats, restores wetlands, and builds active communities. We can help you with nature-based solutions, carbon capture, and other sustainability-focused goals.

We lead the industry with our innovative approach, balancing technological innovation with environmental, regulatory, and economic needs. We deliver award-winning, integrated design and engineering with every solution—getting water to where it's needed, at the best value for our clients and their communities.

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We are an award-winning stream and wetland restoration contractor with over 25 years' experience building complex wetland projects in the northwest.

We strive to be on the forefront of innovation, including assisting the pioneering of stage zero construction techniques on valley wide restoration projects and amphibious excavators designed and fabricated for Pacific Northwest wetlands and tidal environments.

Amphibious excavation	**Stage Zero/Valley Restoration**
Engineered log jams	Value engineering
Compressed work windows	Stakeholder collaboration
Design build partnering	Safety and affordability

ESA

Environmental Science Associates (ESA) is a multidisciplinary environmental consulting firm with extensive experience designing and permitting habitat restoration projects on rivers of all sizes, including some of the largest in Oregon and western Washington. ESA's staff includes scientists and engineers focused on site analysis and engineering, primarily in support of salmon recovery efforts. Our team includes regional experts in engineering, geomorphology, geology, hydrology, fish ecology, and permitting. We have extensive experience on restoration projects from initial feasibility studies through design, permitting, and funding, and ultimately to construction. We apply this experience in delivering highest quality designs informed by technical analysis to support landowner and stakeholder discussions, as well as clients' decisions regarding preferred alternatives to advance to design

HNTB Corporation is an employee-owned infrastructure firm serving public and private owners and contractors. Celebrating more than a century of service, HNTB understands the life cycle of infrastructure and addresses clients' most complex technical, financial and operational challenges. Professionals nationwide deliver a full range of infrastructure-related services, including award-winning planning, design, program management and construction management. Under a general engineering consultant (GEC) contract, Washington State Department of Transportation (WSDOT) selected HNTB to support fish passage delivery in its Northwest Region. HNTB is the prime consultant under the GEC, working with a diverse array of subconsultants to meet WSDOT's needs. GEC team members provide a variety of roles — geomorphologists; stream design and environmental engineers; fishery biologists; project and procurement managers; project control staff; roadway, drainage, geotechnic and structural engineers; utility engineers and landscape architects — who rise each morning to meet the challenges of this work. Foundational elements, including stream hydraulics, geomorphology, design and project advertising, are underway. For more information, visit https://www.hntb.com/expertise/environmental-planning/.

Natural Systems Design + Coastal Geologic Services (NSD + CGS) is a Pacific Northwest environmental engineering firm that specializes in the restoration of rivers, shorelines, and wetlands. Founded in 2003, the firm's design approach adheres to the philosophy that clean water and functional natural processes are critical to sustaining a healthy aquatic ecosystem.

Through combining ecology, geomorphology, hydrology, hydraulics, and engineering services, we design rivers, streams and wetlands that look and perform as functional ecosystems. NSD + CGS scientists and engineers work to restore aquatic and ecosystem processes to self-sustaining conditions. Whether through design of innovative flow regimes to restore hyporheic zones, enhancement of habitat complexity using large wood and log jam structures (ELJs), or design of riparian zones and instream spawning and rearing habitat, the firm works along urban streams, large rivers and their tributaries, in estuaries, and along shorelines to restore watershed processes.

NSD + CGS offers unparalleled regional expertise in littoral drift and coastal dynamics, slope stability assessment, armor removal, soft shore protection/nature-based solutions design, nearshore restoration design, sea level rise/climate change assessments and adaptation, and outreach. We have mapped bluffs and beaches throughout the region and have developed design guidelines for nearshore construction and restoration. Our project design process integrates our cumulative experience, practicality, and awareness of the variability of regional nearshore conditions. This results in project designs that function successfully, are resilient, and require little maintenance.

Founded in 1972, **NHC** is an independent, employee-owned company with a horizontal structure. Our sole focus is to design and implement location-specific solutions to resolve both legacy and emerging water resource issues in rapidly changing geographies. Many of our early employees are still with us today; their long tenure is testament to our commitment to our people, our clients, and the projects we are entrusted to support. As we continue to grow and evolve, we remain committed to the independent culture that has shaped our consulting practice over the past 50 years. Today, NHC offers more than 260 dedicated employees based out of 16 offices in Canada, the US, Asia, and South America. Our physical hydraulic modelling operations are the largest in western North America and remain instrumental in our ability to test and refine location-specific approaches to every solution we design.

Otak is known for delivering innovative solutions that maximize natural form and function for restoration projects in riverine, estuarine, and wetland environments. Our approach is based on a strong technical foundation provided by our in-house team of fish biologists, geomorphologists, ecologists, floodplain managers, and water resources engineers. We understand the complexities in these sensitive environments and our multidisciplinary team regularly supports our clients with aquatic habitat restoration design including:

- Ecological Design
- Hydrologic modeling
- Complex hydraulic modeling (1-D and 2-D)
- Bioengineered streambanks
- Fish passage improvements
- Large woody material design
- Floodplain reconnection and storage
- Riparian vegetation improvements
- Wetland mitigation
- Hydrological budgeting and monitoring
- Environmental baseline assessments and permitting
- Field-fit construction observation and inspection

Otak recognizes the practice of ecological restoration is still evolving, and we are committed to supporting professional organizations that promote collaborative learning such as River Restoration Northwest. As a part of this support, Gary Wolff serves as an instructor in the River Restoration Professional Certificate Program through Portland State University where he shares his passion, knowledge, and experiences with the restoration community. You'll frequently find Otak staff cleaning out stormwater planters, planting native vegetation with our local watershed councils, or participating in community science efforts in their spare time!

Parametrix Whether it's resilient infrastructure, livable communities, or habitat restoration, we partner with clients to create vibrant, sustainable communities and restore the health of the planet for generations to come.

From offices across the Western United States, our team of engineers, planners, scientists, landscape architects, surveyors, project managers, and construction managers are helping our clients imagine what's possible and create tomorrow, together.

As a 100-percent employee-owned firm, our people have a vested interest in strong performance and exceptional client service. Individually and as a team, we are committed to providing high-quality, cost-effective solutions that enable our clients to make informed decisions.

As the nation's largest nature-based solutions company, **RES (Resource Environmental Solutions)** is restoring a resilient earth for a modern world, project by project. RES creates durable, resilient natural infrastructure for communities through solutions for environmental mitigation, stormwater and water quality, and climate and flooding resilience.

RES has a unique operating model for delivering ecological mitigation and restoration projects, based on science-led design, full delivery, and long-term performance. From headwaters to coastal shores, RES designs, builds, and sustains sites that preserve the environmental balance, lifting impaired ecosystems to restored health and ultimately, self-sufficiency. These projects restore sensitive wetland, prairie, and species habitats as well as floodplains, streams, river valleys, and coastal and tidal systems. The result is nature-based systems that cleanse water, shelter wildlife, buffer storms, and sequester carbon from the atmosphere.

Connected by a passion to make our natural systems more resilient, **Wolf Water Resources (W2r)** is an active partner to the Pacific Northwest's salmon recovery organizations. We are a watershed science and engineering firm specializing in the restoration of riverine and floodplain habitats. Our staff consists of multiple licensed engineers along with a variety of scientists in the fields of geomorphology, hydrology, biology, aquatic science, river science, and landscape ecology. These team members work shoulder to shoulder from project initiation to final design, and because it is at our core to work in an integrated manner, that is how we engage with clients: by listening, learning from each other's perspectives, and finding an approach that works for the entire stakeholder team.

WSP is a globally-recognized professional services firm employing approximately 68,000 people.

WSP is one of the world's leading professional services firms. WSP provides technical expertise and strategic advice to clients in the

Transportation & Infrastructure, Property & Buildings, Environment, Industry, Resources (including Mining and Oil & Gas) and Energy sectors, as well as offering project and program delivery and advisory services. Its experts include engineers, advisors, technicians, scientists, architects, planners, surveyors and environmental specialists, as well as other design, program and construction management professionals.

Dedicated to serving local communities, we are engineers, planners, technical experts, strategic advisors and construction management professionals. WSP designs lasting solutions in the buildings, transportation, energy, water and environment markets. With more than 14,000 employees in 300 offices across the U.S., we partner with our clients to help communities prosper.

Silver Sponsors

Alta Science & Engineering, Inc. (Alta) is a HUBZone small business with more than three decades' experience in successfully supporting the project goals of our local, state, federal, tribal, and private clients. Alta specializes in the restoration of streams, rivers, wetlands and lakes, and supports our clients at each level of project planning, design and implementation to create lasting solutions for complex challenges. With more than 40 employees working across offices in Idaho and Washington, our professional staff includes engineers, scientists, geologists, ecologists, drafters, construction managers, technicians, database architects, and support personnel. Our services include:
Hydrogeology, including Groundwater Monitoring | Groundwater Characterization | Contaminant Fate & Transport | Groundwater Remediation Systems | Dewatering System Design | Evaluation of Groundwater & Surface Water Interaction | Development of Groundwater Supply Solutions |Water Quality, including TMDL Technical Support | Groundwater Monitoring | Surface Water Monitoring | Modeling & Analysis | Lake & Reservoir Monitoring & Assessment | Permitting Design & Submission | Watershed Advisory Group (WAG) Planning, Team Participation & Facilitation

Anchor QEA's energetic and talented team of scientists, planners, engineers, and landscape architects work collaboratively with our clients to achieve common goals on habitat restoration and water resources projects. We provide a full range of science and engineering services, including hydrologic and hydraulic modeling, geomorphology, fish and wildlife biology, wetland science, habitat design, dam and levee removal, permitting, civil and geotechnical engineering, landscape architecture, and construction management. We are also skilled in project management, facilitation, and stakeholder involvement, which helps us deliver successful projects to our clients and the community.

The strength Anchor QEA brings to every project reflects our core values of technological leadership, integrity, superior product quality, and client satisfaction. We have earned a reputation with our clients for our proactive and unique approach to projects, technical expertise, quality of work, and commitment to meeting schedules and budgets. You can learn more on our website about the Planning and Restoration services we offer, or by contacting RRNW attendees Merri Martz or Tracy Drury to explore the ways our team can help you achieve success with your projects.

Biohabitats
CONSTRUCTION

We inspire communities to rediscover a sense of place through preserving indigenous ecosystems, restoring biological diversity, and embracing ecological stewardship.
Behind all of our work is an intention to respect Earth's ecological limit, heal damaged ecological processes, and catalyze mutually beneficial relationships among the land and all forms of life. Our five core values and three drivers embody the spirit of our culture: revere wild nature, heal compassionately, practice wholeness, act with uncompromising integrity, and evolve to be the best. They serve as the foundation for how we do what we do. Science forms the core of our practice and provides us with facts. But stories provide the patterns, connections, relationships, and context that enable us to see challenges from a whole-systems perspective.

COMPASS
ECOSPATIAL

Compass Ecospatial, LLC (Compass) is a Washington-based woman-owned and managed small business with staff in western and eastern Washington, Idaho, and Oregon. Compass is an environmental consulting firm specializing in ecological and geospatial services. We cross-pollinate our expertise and diverse experience to provide our clients with pragmatic, applied science-based solutions that are backed up by high-resolution, data-driven analyses tailored to meet their unique needs and requirements.

Compass is run and staffed by local people with nationally recognized expertise; we believe in the power of curiosity, passion, scientific inquiry, and innovation to drive positive change. We are a triple bottom-line company – balancing the needs and benefits for people, places, and profit. We are committed to using a practical, science-based approach informed by deep expertise to provide quality services and workable solutions to our clients' most pressing natural resource and environmental regulatory challenges. We seek solutions that provide multiple benefits – increasing transparency and predictability and improving timelines in environmental permitting and regulatory compliance processes, that also improve and conserve nature and promote biodiversity across the spectrum of habitats on land and in waters, to help solve some of the most confounding issues for our clients.

We are currently working on restoration and compensatory mitigation projects in Washington, Oregon, Idaho, California and Hawaii. Come work with us!

At **Cramer Fish Sciences**, we help clients in California, Oregon, Idaho, Washington, Montana and Alaska find reliable and practical solutions to challenges with fish populations and riparian and aquatic ecology.

We use science to help solve issues with salmon and trout populations along the entire West Coast.

Cramer Fish Sciences is built around a core group of senior scientists with distinguished careers in fish, aquatic ecology, genetics, biostatistics, and population modeling, mixed with upcoming scientists that have outstanding scholastic achievement and fresh training in leading-edge methods and technologies. Support, field research, and population monitoring is provided by teams of well-rounded full-time and seasonal technical and field staff.

Founded in 1980, **Dudek** is a 100% employee-owned environmental, planning, and engineering firm. Our 700+ employees nationwide help clients plan, design, and build projects that improve communities' built and natural infrastructure. We are creative, pragmatic problem-solvers working at the intersection of science, engineering, regulations, and multiple stakeholders' interest to help clients achieve project goals. With offices in 6 states, projects in all 50, and staff nationwide, we're poised to quickly mobilize for any project need.

Since 1996, **Ecological Land Services (ELS)** has provided high quality environmental permitting and documentation services specializing in land, water, and shoreline projects involving resources such as wetlands, streams, rivers, wildlife habitat, and sensitive, threatened, and endangered wildlife and plant species. We are staffed with 23 highly skilled biologists, several of whom specialize in a specific discipline, 3 hardworking field crew members, 4 talented AutoCAD drafters that provide technical support, and 5 administrative support personnel who are always happy to help. We have offices in Bellingham, Bremerton, Longview, Washougal, and Sunnyside and we provide our services all over the beautiful Pacific Northwest and Alaska. We are dedicated to providing our clients with efficient, cost-effective, and creative environmental solutions, and products.

Fain Environmental LLC (dba NW Fish Passage) provides environmental consulting services for projects related to fish passage, ecosystem restoration, geomorphic assessment, water resources, and floodplain management. We work collaboratively on multidisciplinary teams with tribes, federal, state, county, city, and private stakeholder clients. We have managed and provided technical guidance for projects on sites that range from San Francisco Bay to the Salish Sea. We provide analysis and solutions for projects with a diverse range of type, scale and complexity. Our firm specializes in hydrologic and geologic services for streams, rivers, floodplains, lakes, estuaries, and coasts. We provide cost-effective design and permit services to enable "shovel ready" projects.

We believe that the way we work can add meaning and value to the world. That ideas inspire positive change. That coloring outside the lines can illuminate fresh perspectives. And that small details yield important realizations. Above all, we believe that collaboration is the best way forward.
We specialize in engineering, architecture, environmental and construction services. While we are most well-known for adding beauty and structure to communities through high-performance buildings and smart infrastructure, we provide much more than that. We create an unshakable foundation for progress because our multidisciplinary teams also include scientists, economists, builders, analysts and artists.
Our employees, working in more than 200 locations around the world, push open the doors to what's possible each and every day.

We provide practical solutions for complex renewable energy, water, and environmental projects.

For more than 55 years, Kleinschmidt has provided engineering, regulatory, and environmental consulting services to energy companies and government agencies across North America. We provide practical solutions to complex renewable energy, water and environmental projects. We are a mid-sized, employee-owned, environmental engineering consulting firm offering technical expertise and the skills required to work on large, complex projects. We have 11 offices strategically located throughout North America that enable us to provide personal attention and be responsive to our clients.

Who We Work For:

- Power utilities
- Independent power and energy developers
- Government and NGO's
- Water utilities

What We Do:

- Hydropower Engineering
- Dam Safety and Water Infrastructure Engineering
- Licensing and Permitting
- Environmental Services
- Fisheries Engineering
- Water Resource Engineering and Habitat Restoration
- GIS, Statistics, and Modeling

Mead & Hunt is an engineering and architecture firm with 700+ employees and approximately 40 professionals in the Pacific Northwest. Our technical skills and industry knowledge allow us to serve diverse markets so you can accomplish your goals with a single, full-service firm. Mead & Hunt provides an innovative, collaborative approach to water resources management emphasizing personal relationships. Our robust and precise analytical capabilities and strong communication skills allow us to illustrate clear project options so you can confidently select the right option. Funding and permitting knowledge are the added ingredients necessary to meet your future water needs.

Since 1996, **OEI** has provided a broad range of hydrologic and geomorphic consulting services for a variety of public and private sector clients in the Pacific Northwest and northern California. OEI specializes in combining numerical modeling, GIS analyses, and field investigations to evaluate streams, aquifers, and watersheds for habitat enhancement, sediment transport, flood hazard mitigation, and water resource investigations. Our habitat enhancement work ranges from developing regional prioritizations to guide programmatic restoration efforts to performing site specific design work in both tidal and fluvial settings. Streamflow enhancement has become an increasing focus over the past decade and OEI staff have specialized expertise in modeling surface water/groundwater interactions, streamflow depletion, and forest management and climate change impacts on water budgets and streamflows. Over the years, OEI has intentionally remained a small company comprised of highly experienced staff to ensure a level of project dedication, communication, and technical excellence that sets us apart from our larger competitors.

Olson Environmental, LLC - A Division of MacKay Sposito (Olson Environmental) offers a full range of wetland and wildlife services. Since 1991, Olson Environmental has completed more than 3,000 natural resource-based projects in the Pacific Northwest, including residential, commercial, and retail development, as well as public works and transportation projects for local counties and cities.

In addition, Stormwater Facility Maintenance is a growing service within Olson Environmental. Protecting the land and your investment, and preventing fines, means hiring certified wetland management professionals to manage your stormwater facility. Key factors include the type of vegetation and growth – some trees cannot be removed, while invasive species are required for removal. Through our extensive knowledge, we are able to operate and manage the facility most efficiently, resulting in lower fees than most landscape companies, who may put your facility at risk. We

have decades of experience and manage dozens of residential, commercial, and industrial developments.

Wetland and wildlife services offered by Olson Environmental include wetland delineation, habitat assessments, mitigation monitoring, mitigation planning, stormwater facility maintenance, technical writing, biological assessments, SEPA, JARPA, ESA compliance, and wetland/habitat mitigation planting & maintenance. Olson Environmental has prepared or assisted in the preparation of critical areas ordinances for the Cities of Washougal, La Center, Yacolt, and Winlock and environmental documents for Urban Growth Boundary expansion for La Center and Washougal. Additional services include GIS Analysis, GPS mapping, and landscaping.

PARR excellence

Parr Excellence was created in 2018 by Bill Norris and Rich Phaneuf, restoration professionals who have worked together for over 30 years. Parr is a State of Washington Micro Business Enterprise, HUBZone Certified Business and SBE of eight restoration professionals located in Bingen, Washington. Parr staff have been successfully performing reach assessments, topographic and bathymetric data collection, hydraulic modeling, and design of habitat restoration projects that consistently meet stakeholder values for nearly three decades.

RDG RIVER DESIGN GROUP

River Design Group's (RDG) reputation is built upon the quality of our deliverables, the professionalism of our staff and our passion for rivers. RDG has established a record of working collaboratively with watershed groups, tribes, private landowners, conservation organizations, local governments, and public agencies to complete innovative projects that include assessment, planning, design, implementation and monitoring throughout the Western US. RDG maintains a team of highly skilled preprofessional staff of 30 members with backgrounds in water resources, engineering, fisheries, geomorphology, wetlands, hydrographic survey, and geographic information systems located at offices within in Oregon, Montana, and Idaho.

SWCA® ENVIRONMENTAL CONSULTANTS

SWCA has served as a valued environmental and cultural resources partner to private and public clients in a range of geographies for more than 40 years. Our dedicated ecosystem restoration and engineering team designs, permits, and builds environmental restoration projects. We have the expertise and the relationships necessary to seamlessly guide clients' projects from inception to completion. With a strong record of project delivery, our team will help you achieve your project goals through sound science, creative solutions, and technical excellence.

Our interdisciplinary team of restoration professionals includes engineers, landscape architects, restoration ecologists, fluvial geomorphologists, fisheries and wildlife biologists, botanists, and permitting specialists. We bring together all the necessary disciplines for our restoration projects to ensure we efficiently design, permit, and implement effective and lasting projects. This collaboration allows us to holistically evaluate the landscape setting, watershed conditions, historical ecology, past and current land use, site constraints, and potential changes from climate change to develop a customized restoration approach for each project that achieves the desired ecological outcomes. As the science and practice of ecological restoration develops, we are also incorporating new techniques, research, and tools.

Our approach to ecological restoration centers on restoring processes to maintain functional and resilient ecosystems. Restoring processes such as sediment transport, natural inundation regimes, wood and native vegetation recruitment, groundwater recharge, and nutrient cycling is important in sustaining restored ecosystems over time without the need for extensive future interventions. While restoring ecological processes is key to our restoration approach across all landscapes, we are experienced in balancing other objectives such as flood control and infrastructure protection for multi-benefit projects.

Our team of restoration experts have decades of experience working in a variety of ecosystems across the Western U.S. including coastal rivers and estuaries, streams, riparian woodlands, tidal marshes, vernal pool complexes, oak woodlands, coastal sage scrub, wet meadows, and dry washes. We understand the unique ecology of each of these environments and the species that depend on them. Our biologists also have specialized knowledge in many special-status species and their habitat needs throughout their life history including coho and Chinook salmon, steelhead, Delta smelt, Ridgway's rail, salt marsh harvest mouse, giant garter snake, California tiger salamander, California red-legged frog,

Bronze Sponsors

The Environmental Professional Program (EPP) at Portland State University offers practical, state-of-the-science training to graduate students and professionals.

Our classes are offered in a short-course format and focused on the skills and knowledge required to implement a wide-range of environmental projects including: physical processes, ecology, analytical methods, field techniques, regulations and project management. EPP Courses can be taken for CEU and PDH credit. EPP courses cannot be used for academic credit.

Waterfall Engineering was founded in 2007 by owner Pat Powers. The company specializes in water resources, hydraulics, hydrology, and fisheries engineering. Design expertise includes stream restoration, streambank protection, fish passage, off-channel spawning and rearing habitat, fish screens, river engineering, watershed assessments, construction management and hydraulic modeling. Mr. Powers has 28 years of experience in project assessment, development, design and construction management. He offers a unique skill to help clients strategize difficult project solutions.

RIVER RESTORATION NORTHWEST

THANK YOU!

We appreciate your consistent support and enthusiasm as we collaboratively learn, grow, and create a positive influence on our collective mission.