Application Name: Coho Response to Beaver Dam Analogues

By: Upper Nehalem WC

Offering Type: Open Solicitation

Application Type: Monitoring

OWEB Region: North Coast
County: Washington
Coordinates: 45.748167,-123.32522

Applicant:
Maggie Peyton
1201 Texas Avenue Ste A
Vernonia OR 97064-1447
(503) 429-0869
maggie@nehalem.org

Payee:
Susan Spicer Pond
1201 Texas Avenue Ste A
Vernonia OR 97064
503.429.0869
susan@nehalem.org

Project Manager:
Maggie Peyton
1201 Texas Ave., Suite A
Vernoinia Or 97064
(503) 396-2046
maggie@nehalem.org

Budget Summary:
OWEB Amount Requested: $91,278
Total Project Amount: $115,678

Administrative Information

Abstract

Provide an abstract statement for the project. Include the following information: 1) Identify the project location; 2) Briefly state the project need; 3) Describe the proposed work; 4) Identify project partners.

1) The Pilot Beaver Dam Analog Pilot Study project is located in the upper Nehalem watershed on public lands managed by the Oregon Department of Forestry and private lands managed by OSU Blogett Tract and Olympic Resource Management. See attached Maps depicting BDA locations.

2) The project needs to gain funding support to continue long-term landscape scale effectiveness monitoring of the BDA Pilot Study project to determine their effectiveness in creating critical over-winter rearing habitat for ESA-listed OC Coho Salmon on the Oregon Coast. The BDAs have been implemented and 3 years of monitoring have been completed, funding is needed for 7 additional years to complete the study.

3) The field work includes biological survey by RBA summer / winter snorkel surveys for juvenile presence to compare changes in over winter retention rates at each site (27) and physical attribute survey to measure effects of BDA design on beaver response and channel form at each site (57).

4) Project partners WSC, NOAA, ODF, ODFW, UNWC, Olympic Resource Management, OSU Blodget Tract, and Trask Consulting

Location Information

What is the ownership of the project site(s)?

✓ *Public land (any lands owned by the Federal government, the State of Oregon, a city, county, district or municipal or public corporation in Oregon)*

What agency(ies) are involved?

Oregon Department of Forestry

✓ *Private (land owned by non-governmental entities)*

Please select one of the following Landowner Contact Certification statements:

● I certify that I have informed all participating private landowners involved in the project of the existence of the application, and I have advised all of them that all monitoring information obtained on their property is public record.

❍ I certify that contact with all participating private landowners was not possible at the time of application for the following reasons: Furthermore, I understand that should this project be awarded, I will be required by the terms of the OWEB grant agreement to secure cooperative landowner agreements with all participating private landowners prior to expending Board funds on a property.

Please include a complete list of participating private landowners

Olympic Resource Management
OSU Blodget Tract - School of Forestry

❑ *Not applicable to this project*

✓ *This grant will take place in more than one county.*

List the counties affected:

Washington, Columbia and Clatsop County

Permits

Other than the land-use form, do you need a permit, license or other regulatory approval of any of the proposed project activities?

❍ Yes

● No

Racial and Ethnic Impact Statement

Racial and Ethnic Impact Statement

❍ The proposed grant project policies or programs could have a disproportionate or unique POSITIVE impact on the following minority persons. (indicate all that apply)

❍ The proposed grant project policies or programs could have a disproportionate or unique NEGATIVE impact on the following minority persons. (indicate all that apply)

● The proposed grant project policies or programs WILL HAVE NO disproportionate or unique impact on minority persons.

Insurance Information

If applicable, select all the activities that are part of your project - These require a risk assessment tool unless otherwise noted (check all that apply).

❑ *Working with hazardous materials (not including materials used in the normal operation of equipment such as hydraulic fluid)*

❑ *Earth moving work around the footprint of a drinking water well*

❑ *Removal or alteration of structures that hold back water on land or instream including dams, levees, dikes, tidegates and other water control devices (this does not include temporary diversion dams used solely to divert water for irrigation)*

❑ *Applicant’s staff or volunteers are working with kids related to this project (DAS Risk assessment tool not required, additional insurance is required)*

❑ *Applicant’s staff are applying herbicides or pesticides (DAS Risk assessment tool not required, additional insurance is required)*

✓ *Insurance not applicable to this project*

Additional Information

❑*This project affects Sage-Grouse.*

Problem Statement

Issue

Provide an overview of the present situation, specific problem, and/or watershed issue that this monitoring is intended to inform.

Oregon Coast (OC) Coho Salmon are listed as threatened under the federal Endangered Species Act (ESA). The type of habitat most limiting the recovery of the OC Coho evolutionarily significant unit (ESU), and the Nehalem OC Coho Salmon population, is high quality over-winter rearing habitat (NMFS Recovery Plan for Oregon Coast Coho, 2016; ODFW Oregon Coast Coho Conservation Plan, 2007). High quality over-wintering habitat for juvenile coho is usually recognizable by one or more of the following features: large wood, a lot of wood, pools, connected off-channel alcoves, beaver ponds, lakes, connected floodplains and wetlands. Because high quality over-winter rearing habitat can take many forms, the term stream complexity is used to define this limiting factor. The recent 12-year assessment of the ODFW Oregon Coast Coho Conservation Plan (Draft, 2021) finds the North Coast stratum (which includes the Nehalem River population) has a decreasing trend in winter parr capacity, which likely reflects a decreasing trend in off-channel, alcove, and beaver pool habitats.

Beaver are a key component of hydrologic, geomorphic, and biotic processes within the stream systems, and their dams alter stream and riparian structure and function to the benefit of many aquatic and terrestrial species. Structures designed to mimic the function of beaver dams are increasingly being used as effective and cost-efficient stream and riparian restoration approaches. The use of beaver dam analogues (BDAs) in eastern Oregon have been documented (Bouwes et. al., 2016; Weber et. al., 2017) to successfully support ESA-listed salmon and steelhead by creating and providing much needed critical habitat attributes at a very affordable implementation cost. Subsequently, restoration practitioners were eager to implement BDAs on the Oregon coast as a cost-effective restoration tool to support ESA-listed salmonids. However, no studies had yet determined their effectiveness in western Oregon.

This BDA Pilot Study is applicable coast wide, and a critical outcome is a data-driven advancement of an exportable BDA design and construction methodology for the entire coastal region. Accordingly, this project focuses heavily on assessment and evaluation, specifically reviewing the project design and implementation strategies, location selection, monitoring metrics, cost profiles and biological outcomes that result from implementation. This study will provide valuable information on the use of BDAs as a restoration tool to support ESA-listed salmonids coast-wide in the future.

The first 3 years of monitoring documented that exponential change is occurring as the BDA structures mature and their utility as a foundation for beaver colonization continues to improve. Ensuring that there is no lapse in monitoring will result in a very comprehensive picture of BDA’s as a potentially very effective restoration tool. Therefore, funding is needed to continue the monitoring for an additional 7 years.

Strategies

Select all activities that apply.

✓ *The proposed monitoring or data need is identified as an essential or needed action in a LOCAL assessment or plan at the proposed location.*

Provide the name of local plan, Watershed assessment or other locally relevant document.

Locally developed watershed assessments, analysis and action plans:
Nehalem River Watershed Assessment (01);
Nehalem Winter Habitat Assessment (05-07);
Nehalem Data Synthesis (08);
Rock Creek Limiting Factors Analysis (11);
Nehalem Conservation Action Plan (12);
Nehalem BDA Pilot Study Project (18-21); and
Nehalem Strategic Action Plan (21);

The above plans all center on restoring degraded freshwater habitats and the ecosystem processes and functions that affect those habitats as a strategy to enact in partnership with state and federal agencies, stakeholders and landowners concerned. Beaver are considered a viable partner in the effort and key to achieving long term measurable positive ecological outcomes across the landscape. .

✓ *The project will develop a monitoring plan, quality assurance documents or monitoring protocols as part of the monitoring activities you are proposing.*

Provide the name of the document that will be developed and a description of its scope and extent.

Nehalem Beaver Dam Analogue Pilot Study Project. This project is an important pilot study to advance our corporate knowledge of the use of beaver dam analogues (BDAs) as a dam building foundation for the provision of winter persistent ponds that are known to provide the highest quality winter rearing habitat for juvenile salmonids. The key question of the study is can we encourage native bank dwelling beaver to adopt constructed BDAs to increase the quality, quantity, and longevity of dammed rearing habitat that is critical to the recovery of 3 ESA-listed salmon species in Oregon. High quality over-winter rearing habitat for juvenile Oregon Coast (OC) Coho is the primary limiting factor for most
populations in the OC Coho evolutionarily significant unit (ESU), including the Nehalem population.

The project contains an extensive 10-year effectiveness monitoring component designed to quantify salmonid response and profile the attributes of both successful and unsuccessful BDAs for use by future restoration technicians interested in facilitating the recovery of functional beaver dams on the landscape in western Oregon.

The post project monitoring protocol has been established in years 1-3 already completed. A description is included in the Year 2 final report document included as an attachment to this proposal. In addition, the monitoring metrics are archived in an Excel spreadsheet and are available upon request.

❑ *None of these activities.*

Is this project a part of a comprehensive monitoring strategy/program?

❍ Yes
● No

Are other organizations/entities cooperating with this monitoring project by concurrently conducting field work that are not being funded out of this grant?

❍ Yes
● No

Project History

Continuation - Are you requesting funds to continue work on a monitoring project previously funded by OWEB?

❍ Yes
● No

Resubmit - Have you submitted, but were not awarded an OWEB application for this project before?

❍ Yes
● No

Phased - Is proposed work in this application a phase of a comprehensive monitoring plan or project?

● Yes
❍ No

If your monitoring project will be implemented in a phased manner, list the phases of your project.

Phase	Brief Description	Project Number
Phase i	Pre and post BDA implementation monitoring	
Phase II	Long term BDA effectiveness monitoring	

Plans and Salmon

Will this project benefit salmon or steelhead?

● Yes
❍ No

✓Oregon Coast - Steelhead
✓Oregon Coast - Coho Salmon

How will the resulting monitoring project benefit salmon or steelhead or their habitat?

Beaver colony eco-structure expansion with-in active and off channel stream habitat increasing the quality and quantity in the aquatic habitat available to salmonids seeking critical rearing and velocity refuge opportunities in salmon bearing stream reaches. Thereby contributing a priority habitat attribute needed for the recovery of OC Coho Salmon by addressing the primary limiting factor for the Nehalem OC Coho population.

Does the project address either a problem or data need identified in a REGIONAL assessment or recovery plan at the proposed location?

● Yes
❍ No

Regional Assessments or Recovery Plans
Recovery Plan for Oregon Coast Coho Salmon Evolutionarily Significant Unit
Comprehensive Conservation and Management Plan for Tillamook Bay, Oregon
Oregon Coast Coho Conservation Plan for the State of Oregon

Proposed Solution

Monitoring Activity

What are you proposing to do? Choose only one.

❍ *Status and Trend Monitoring*
❍ *Effectiveness Monitoring of a Restoration Project(s)*
● *Landscape Scale Effectiveness Monitoring -- Details will follow.*
❍ *Rapid Bioassessment Monitoring*

Goal, Objectives, and Activities

State your project goal. A goal statement should articulate desired outcomes (the vision for desired future conditions) and the watershed benefit.

Seek a low cost restoration tactic (BDA's) that enhances natural beaver colonization either directly or indirectly. Expand the surface area of interactive floodplain habitats that provide ample juvenile salmonid rearing and low velocity winter rearing habitat to address the identified seasonal habitat limitation. In addition, evaluate the efficacy of the method (BDA's) over a long enough period of time (10 years proposed) to be able to develop a sense of the true cost / benefit relationship before going full scale across the coastal landscape. It is also desirable to discover what confounding factors exist in the general application of the technique. What materials are appropriate and facilitate longevity, what are the vectors of structure degradation, can beaver colonization be encouraged with parallel riparian planting treatments, does colonization even have to occur at a BDA site for it to provide the desired objective of floodplain inundation.

List specific and measurable objectives. Objectives support and refine the goal by breaking it down to steps for achieving the goal. (NOTE: If you quantify your objectives, ensure all numbers match the metrics listed in your selected habitat types.) Provide up to 7 objectives.

Objective #1

Describe your objective and state the monitoring question(s) you intend to answer for each objective.

Increase Beaver Dam abundance / Quantify changes in beaver dam abundance on the reach scale.

Describe the project activities. Activities explain how the objective will be implemented.

Beaver dams are counted and measured at low winter flows in March each spring to only count those dams that were retained throughout the entire winter and therefore providing the low velocity coho rearing habitat contiguously.

Objective #2

Describe your objective and state the monitoring question(s) you intend to answer for each objective.

Aggrade incised channels to increase frequency of floodplain connectivity / Quantify changes in measurable aggradation associated with BDA installations.

Describe the project activities. Activities explain how the objective will be implemented.

Aggradation is measured with a laser level above each BDA installation to quantify the value of BDA's for restoring floodplain connectivity with or without colonization.

Objective #3

Describe your objective and state the monitoring question(s) you intend to answer for each objective.

Directly or indirectly Increase reach scale pool surface areas with treatments / Quantify changes in pool surface area associated with beaver dam construction (with or without BDA).

Describe the project activities. Activities explain how the objective will be implemented.

Measure pool surface area of all beaver dams (natural and BDA's) during March at winter low flows to estimate potential carrying capacity for coho at full seeding.

Objective #4

Describe your objective and state the monitoring question(s) you intend to answer for each objective.

Document the modeled relationship between pool surface area and smolt production / Quantify modeled change in smolt production potential at full seeding as a result of changes in pool surface area

Describe the project activities. Activities explain how the objective will be implemented.

Utilize the Nickelson Seasonal Habitat Limiting Factors Model formulas for projecting changes in potential coho production as a result of changes in pool surface area.

Objective #5

Describe your objective and state the monitoring question(s) you intend to answer for each objective.

Evaluate reach scale over winter retention of coho juveniles pre and post project 3,6,9 year interval / Quantify actual changes in juvenile coho retention in the project reach between summer and winter to calculate % over winter retention

Describe the project activities. Activities explain how the objective will be implemented.

Conduct 2 additional paired RBA inventories at the 6 and 9 year interval to quantify changes in actual over winter retention rates over time (Both the Pre and the 3 yr post have already been completed, see attachments). This involves a complete reach scale snorkel inventory during September and then again in March just prior to smolting. The winter inventory must be conducted nocturnally and therefore you will notice differential rates between the summer and winter inventories.

Objective #6

Describe your objective and state the monitoring question(s) you intend to answer for each objective.

Evaluate a suite of different design concepts for BDA construction / Quantify success rates associated with each design alteration to build a case for the preferred BDA design in highly erodible Tyee sandstone geologies.

Describe the project activities. Activities explain how the objective will be implemented.

Several different design attributes were utilized in the original Pilot Study Project so that the details of construction success or failure could be evaluated. Each of these design approaches has multiple replicates and many individual variables are monitored to evaluate their success (Potential for underscour, durability, aggradation, weave height, weave material, etc.).

Objective #7

Describe your objective and state the monitoring question(s) you intend to answer for each objective.

Evaluate the potential benefit for beaver of riparian manipulation to recreate early seral / Quantify changes in vegetative recovery associated with alder removal and document the relationship between these altered sites and beaver dam abundance.

Describe the project activities. Activities explain how the objective will be implemented.

Several large sections of riparian alder were felled in concert with BDA installations. These areas may respond in a differential manner because the creation of early seral conditions may increase utilization by beaver because of a developing food source, the plethora of complex cover from predators, the adjacent availability of building material, etc.

List the major activities of the monitoring project and time schedule you will use to complete the monitoring. Schedule should relate to budget.

Element	Description	Start Date	End Date
Physical attribute survey - year 4	Beaver dams, pools surface, aggradation, limiting factors, riparian - report	3/2022	4/2022
Physical attribute survey - year 5	Beaver dams, pools surface, aggradation, limiting factors, riparian - report	3/2023	4/2023
Physical attribute survey - year 6	Beaver dams, pools surface, aggradation, limiting factors, riparian - report	3/2024	4/2024
Physical attribute survey – year 7	Beaver dams, pools surface, aggradation, limiting factors, riparian - report	3/2025	4/2025
Physical attribute survey – year 8	Beaver dams, pools surface, aggradation, limiting factors, riparian - report (repeat in 2027 and 2028)	3/2026	4/2026
RBA Survey	Summer (repeat in summer 2027)	9/2023	9/2023
RBA Survey	Winter (repeat in winter 2028)	3/2024	3/2024
BDA practitioner workshop	Year 6 UNWC to host a practitioner workshop (UNWC will also host annual fall project tours for interested parties)	5/2024	5/2024

Element	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023	Q2 2023	Q3 2023	Q4 2023	Q1 2024	Q2 2024	Q3 2024	Q4 2024	Q1 2025	Q2 2025	Q3 2025	Q4 2025	Q1 2026	Q2 2026
Physical attribute survey - year 4																		
Physical attribute survey - year 5																		
Physical attribute survey - year 6																		
Physical attribute survey – year 7																		
Physical attribute survey – year 8																		
RBA Survey																		
RBA Survey																		
BDA practitioner workshop																		

Habitat Types

What habitat type(s) are you proposing to work in?

- ✓ *Instream Habitat*
- ✓ *Riparian Habitat*
- ❑ *Upland Habitat*
- ❑ *Wetland and/or Estuary Habitat*

Landscape Effectiveness

Select all of the activities you will be implementing for the effectiveness monitoring of restoration projects proposed in this application.

- ✓ *Habitat Surveys*
- ✓ *Instream surveys*
- ✓ *Vegetation*
  - ❑ *Canopy cover*
  - ❑ *Percent cover*
  - ✓ *Plant survival*
  - ❑ *Percent shade*
  - ❑ *Stem density*
  - ❑ *Species diversity*
- ❑ *Macroinvertebrates*
- ✓ *Juvenile Fish*
  - ✓ *Presence*
  - ❑ *Absence*
  - ✓ *Abundance*
  - ❑ *Distribution*
  - ❑ *Genetic sampling*
- ❑ *Adult Fish*
- ❑ *Other Biological Monitoring*
- ❑ *Invasive Species*
- ❑ *Soil Surveys*
- ✓ *Water Quantity*
  - ✓ *Surface Water*
  - ✓ *Ground Water*
- ❑ *Water Quality*

Methods and Design

Describe the study design used to choose sampling locations, parameters, and frequency. Explain how this design will address the project's monitoring questions.

Site selection for BDA installation began with a review of the existing RBA (Rapid Bio-Assessment) database to identify reaches exhibiting a legacy of beaver presence. An attempt was made in the fall of 2017 to utilize NetMap to identify High IP reaches for beaver dam construction but this effort was unrefined and unground truthed at the time. The results of this effort did not deliver the level of refinement necessary for narrowing the field of potential locations for ground truthing. Subsequent modeling runs have been developed that have been more successful at utilizing the LIDAR based NetMaps program for identifying High Beaver IP that overlaps with coho distribution. This tool is currently being ground truthed in the Nehalem basin.

Potential sites were then ground truthed by field crews from Trask Consulting. The sites had to meet specific criteria to qualify for implementation:
>Target tributary must be 4th order or less and in general exhibit a bankfull >channel less than 24 ft
>Must exhibit low interactive terraces (approx. 2ft)
>Must not exhibit exposed bedrock (no exceptions)
>Must exhibit beaver presence (active dens, feed stations, scent mounds, fresh chewing’s)
>Must be accessible to track machinery

Once a potential reach had been identified that met the above criteria, we began establishing specific site locations for each BDA. The final site selection was in general driven by 3 primary morphological criteria:
>The existence of confining hillslopes to tie a full floodplain spanning post row into the adjacent toe slopes
>Evidence of a historical beaver pond (uniform terrace heights left and right, depositional soils)
>Appropriate distance from the last BDA site so that impoundment doesn’t influence the next upstream BDA (minimum lineal distance for spacing between BDA’s calculated using stream gradient and proposed post height to estimate extent of inundation at full pool)

The selected reaches were reviewed by NOAA Fisheries scientist Dr. Michael Pollock who commented favorably on the sites as having features conducive to attracting beaver. Project design was based on the Beaver Restoration Guidebook (Pollock et al 2015/17), lessons learned from BDA projects in eastern Oregon and elsewhere, and local knowledge of the sites, beaver behavior and what constitutes high quality Coho salmon rearing habitat. Development and implementation of long-term effectiveness monitoring protocol was a collaboration with UNWC, NOAA, ODFW, ODF and the Primary Consultant (Bio-Surveys, LLC.).

Monitoring Questions:
1) Does the BDA achieve aggradation and how far upstream are the impacts of aggradation detectible (the goal is to increase the frequency of floodplain linkage to achieve low velocity for winter rearing salmonids).
2) What are the differences in aggradation between a successful and an unsuccessful BDA?
3) Do specific BDA’s designs promote or avoid avulsion? Where avulsion occurs has it resulted in significant channel lengthening?
4) Has a vegetative treatment (willow) increased the beaver occupancy rates of constructed BDA’s over time?
5) How does the inner riparian girdling of existing alder influence both occupancy rates and willow growth rates?
6) Is there a relationship between the number of bank dwelling beaver dens/mile and the final occupancy of BDA’s by native beaver?
7) Can a BDA be constructed (includes willow weave) in a reach with no evidence of beaver and have that site still provide the functionality that benefits juvenile salmonids during winter flow regimes? Is this then a viable channel restoration technique even without beaver utilization of the BDA?

8) How does augmentation of the simple post line design with a willow weave influence the following: occupancy, aggradation, avulsion, longevity, cost, etc.?
9) How does BDA clustering influence the following: occupancy, longevity, cost, etc.
9) How does the treatment of a reach impact the over winter retention rates of juvenile salmonids in that reach (the goal is that BDA's will be adopted and maintained by beaver to provide a long term quantifiable change in the winter retention of juvenile salmonids on the reach scale).

Attributes to be evaluated:

Reach Selection:
MORPHOLOGY
>Avg Gradient
>Avg Terrace height
>Avg bankfull width
>Avg Floodplain width
>Designated Net Maps Coho Anchor (Yes/ No)

Site Selection:
MORPHOLOGICAL CONDITION
>Actual Floodplain Width above BDA (potential)
>Actual dominant terrace height at implementation site
>Tributary confluence (yes / no / what stream order)
>Gradient at implementation site
>Legacy of beaver pond channel matrix (Yes / No)
>Lineal distance to any existing beaver dam
>Watershed Area

ECOLOGICAL CONDITION
>Beaver sign present at the site of implementation (yes / no / describe – bank dens, dams , feeding stations)
> Willow, vine maple available at site (yes / no) Quantify
> LWD for denning, hiding cover (Present / Absent / Provided) Quantify

CONSTRUCTION DESIGN
>Post height
>Post spacing
>Post material (harvested green / imported cured, etc)
>Post installation method (cost/BDA)
>BDA design (posts only, posts w/ willow weave, posts w/ willow weave and substrate backfill)
>Variable post spacing on floodplain periphery at BDA installation site (What's enough / What's over kill)
>Girdling to increase solar radiation at implementation site to accelerate willow plantings

BDA FREQUENCY
>How many / mile / reach
>Is clustering (back to back) beneficial (emulates the distribution of dams observed in natural colonies)
>Should clustering wait for a successful dam to be constructed prior to augmentation in yr 2 (cost effective)

CURRENT BEAVER ABUNDANCE
>Existing bank dens / mile
>Existing feeding stations / mile

FINAL SUCCESS METRICS
>How many BDA’s utilized by beaver / mile / reach
>Height of successful BDA’s (initial post height and final dam height)
>Quantify riparian vegetation community (document and describe beaver food resources before / after)
>Final Post depth achieved
>Quantify and describe scour associated with post installation (does branch seeding influence scour)
>Describe final passage condition on successful BDA’s for juvenile and adult salmonid
>How many BDAs survive winter flows, how many years
>Was there a difference in the BDA design response

Because the RBA protocol was designed to conduct basin scale inventories of salmonid distribution and abundance it utilizes a 20 percent sampling frequency to achieve significant linear distances. For the RBA being conducted for BDA monitoring we have increased the sampling frequency to 100% of all beaver pond habitat types and maintained the 20 percent sampling frequency for all other habitat types. This guarantees that sampling for the target habitat type is very high resolution with lower variance associated with the final estimate of abundance. The RBA inventory is conducted once in the late summer to produce an estimate of abundance just prior to winter. The identical inventory is conducted a second time in late February / early March just prior to smolting for an estimate of abundance post winter. The goal is to calculate a reach scale over winter retention estimate for juvenile coho both prior to the installation of the BDA’s and then 3, 6, and 9 years after BDA installation.

Describe in detail the monitoring methods that will be followed and provide the citation for the protocols that will be used.

Physical Attribute Monitoring: The physical attribute monitoring is conducted with a stationary laser level. These are simple measurements of gradient, pool surface areas, terrace heights, dam heights, post height, weave height, aggradation heights, channel heights, scour depths, etc. that are all attributes that can either be manipulated by design or altered by hydrology. Because there is limited precedent in the literature for establishing monitoring protocols for BDA installations, this project has relied most significantly on the foundational processes discussed in the “Beaver Restoration Guidebook” BRG. (Pollock, M.M., G. Lewallen, K. Woodruff, C.E. Jordan and J.M. Castro (Editors) 2015. The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains. Version 1.0. United States Fish and Wildlife Service, Portland, Oregon. 189 pp.).

Most importantly the guidelines for Assessing Habitat Quality for Beaver (pg. 51-53) assisted in the initial location of suitable reaches for implementing BDA’s. Many of the attributes that were chosen for long term monitoring were also documented in the BRG Chapter 6 – BDA’s.

Biological Monitoring: The biological monitoring conducted to quantify the change in coho over winter retention before project implementation and 33 years post project is a snorkel inventory classified as a modified Rapid Bio Assessment (RBA). The RBA methodology was developed by Bio-Surveys, LLC (Steve Trask), the Mid-Coast Watershed Council (Wayne Hoffman) and ODFW (Bob Buckman) in 1998. The method is described in the methods section of “Upper Nehalem Rapid Bio-Assessment 2009”.

Comparing over winter retention inter-annually removes the variability associated with the differential adult escapement between years if you were to focus directly on changes in productivity. Quantifying the change between pre and post project over winter occupancy of coho utilizing the RBA protocol has been used successfully as a long-term monitoring strategy on many other project locations within the OC Coho ESU to evaluate the impacts of large wood treatments. These inter-annual comparisons have been conducted annually over 10-year periods and changes have been so dramatic between pre and post project occupancy that differential winter flow regimes have been relatively minor background noise.

Information and Engagement

Will the monitoring activites proposed in this application consist of gathering baseline data prior to restoration projects being implemented?

- ● Yes
- ❍ No

Provide a description of the future restoration projects you are proposing to monitor.

So far there have been 2 separate implementation years (2018 and 2019). 3 years of monitoring has already occurred on 3 stream reaches and 27 BDA structures. In 2019 an additional 30 BDA's were implemented on 3 additional stream segments. So far we have collected 2 years of post project monitoring on this second group of installations. This suggests (as noted in the budget) that an additional 7 years of fiscal support is being requested to complete a decade of monitoring. There is an opportunity to initiate additional BDA reaches as we move forward with this monitoring proposal. Currently there is a BDA augmentation project scheduled for Bear Cr in the summer of 2021. If the funding were in place we would be able to conduct a pre implementation inventory on this reach as well. In addition, there is an OWEB funded BDA project scheduled for implementation on Crawford Cr in 2021 in the Upper Nehalem where a pre-project evaluation could also be conducted. Estimates for additional pre-project evaluations have been included in the proposed budget.

Baseline data was gathered prior to BDA project implementation on 3 independent stream reaches (Lousignont, Bear and Rock). This encompassed 27 BDA installations. There were both physical and biological metrics collected. In addition, there is a 1st, 2nd and 3rd year report of findings available from the UNWC. This monitoring was developed to establish a set of metrics to track over time that we believed would assist in evaluating the success of the project in achieving stated goals and objectives. Some of these metrics included the following:
>Number of existing beaver dams in the reach
>Gradient
>FPH above active channel (terrace height)
>Bank Full Height
>Floodplain width
>Food availability (Beaver)
>Cover from predation
>Beaver sign present
>Number of Bank dens between BDA sites
>Estimates of pre project pool surface area for rearing
>Standing count of coho parr during summer flow regimes
>Standing count of coho pre-smolts in March just prior to smolting

These are the bare bones attributes that were quantified prior to a reach scale BDA installation. Most other post project attributes were focused on measuring the changes associated with the installation of BDA's and were not part of the pre project inventory.

Will the monitoring activities proposed in this application gather data about several restoration projects of the same type (e.g., all fish passage barrier removal) that are proposed this cycle, in progress, and/or previously implemented?

● Yes
❍ No

Identify the OWEB grant number(s).

na

Provide a description of the restoration project(s) to be monitored.

The BDAs were implemented in 2018 and 2019. None of these implementations utilized OWEB funding but depended on Pilot Study support from NOAA and NFWF. 3 years of monitoring was funded by these sources that have already been completed. This proposal seeks support for the remaining 7 years of monitoring suggested in the original design. All 3 of the streams included in the existing monitoring have only had BDA treatments, no other restoration treatment method is being evaluated.

Year project(s) was implemented.

The BDAs were implemented in 2018 (27) and 2019 (30).

Will the monitoring activities proposed in this application gather data about several different types of restoration projects and/or other actions that are proposed this cycle, in progress, and/or previously implemented?

❍ Yes
● No

Are you monitoring a non-OWEB project?

❍ Yes
● No

How does this project complement relevant existing data and current or planned monitoring efforts?

The use of BDAs have been documented in eastern Oregon (Bouwes et. al., 2016; Weber et. al., 2017) to successfully support ESA-listed salmon and steelhead by creating and providing needed critical habitat attributes. This BDA Pilot Study is applicable coast wide, and a critical outcome is a data-driven advancement of an exportable BDA design and construction methodology for the entire coastal region. Accordingly, this project focuses heavily on assessment and evaluation, specifically reviewing the project design and implementation strategies, location selection, monitoring metrics, cost profiles and biological outcomes that result from implementation. This study will provide valuable information on the use of BDAs as a restoration tool to support ESA-listed salmonids coast-wide in the future.

Effectiveness monitoring is a primary goal of this project because of the need for documenting lessons learned for the restoration community in Western Oregon. If successful, the winter-persistent ponds will provide a quantifiable increase in high quality summer and winter rearing habitat (measured in the number and surface area of ponds created) and even more important, provide valuable on-the-ground experience with BDAs in western Oregon to jump-start other projects that may increase the distribution of beaver ponds in the coast range– perhaps the single most cost effective restoration action for the recovery of OC Coho.
Numerous other ecological benefits will be realized by the successful location and colonization by beaver of analogue sites.
These include:
>Increased floodplain connectivity
>Trapping and storage of nutrient rich sediments for macroinvertebrate
production and gravels for spawning

>Increased capture and storage of run off in floodplain terraces in fall/winter high flow periods for slow release during spring/summer low flow periods (addresses primary limiting factor for salmonids of summer temperature limitation)
>Creation and expansion of stream adjacent wetlands
>Increase wildlife and amphibian habitats (cavity nesting)
>Initiates heterogeneity in riparian vegetative communities by resetting early seral conditions

A successful Beaver dam analogue project would result in beaver utilizing the analogue site for the development of a maintained dam that is winter persistent. This addresses the observed seasonal habitat limitation for OC Coho of the lack of low velocity winter refugia. In addition, a winter stable impoundment attenuates the impacts of peak flow events on the remainder of the watershed downstream (providing lower peaks and a less flashy flood profile temporally).

Describe how the appropriate technical experts and community stakeholders are engaged.

This project sought assistance from multiple agencies for the final sampling design and fiscal support required for a long range monitoring effort. Development and implementation of long-term effectiveness monitoring protocol was developed through collaboration with NOAA, ODFW, ODF, and the Primary Consultant (Bio-Surveys, LLC). These partners also participated in the collaboration and review of the site specific final design metrics.

Wrap-Up

Outcomes

Report the total number of stream miles that will be monitored under this application.

8.4

Report the total number of acres that will be monitored under this application.

70

Provide a brief description explaining how you calculated totals for stream miles or total acres monitored.

Physical habitat monitoring is occurring for 57 BDAs installed in 7 unique streams that encompass a total of 8.4 contiguous stream miles (these are stream miles defined as the cumulative lineal distances for each of the 7 stream reaches that begin and end with a BDA).

For the Biological monitoring (RBA), there are 17 BDAs being monitored in 3 unique stream reaches. The RBA inventory covers 4.0 stream miles and begins at the lowest BDA in each reach and extends above the last BDA to the end of coho distribution. These additional headwater habitats (above the last BDA) are included in the inventory because winter occupancy within the BDA reach is influenced by summer parr that are being transported through the structure reach with every high winter flow event. We are measuring the change in coho retention within the structure reach before and after BDA installation that has produced large quantities of off channel impounded winter habitat.

Quality Control/Assurance

If necessary, do you have an EPA or ODEQ approved Quality Assurance Project Plan or Sampling and Analysis Plan?

- ❍ Yes
- ❍ No
- ● N/A

How do you plan to incorporate quality assurance/quality control measures into your monitoring and data management approach and practices?

The project intends to utilize the same biological contractors that have conducted the first 3 years of inventory and analysis (Trask Consulting, Inc. and Bio-Surveys, LLC.). This lends an important level of continuity to a long term study plan. Part of what has occurred in the first 3 years of monitoring has required a significant level of adaptive management to the study design. It is relevant to discuss this concept as a quality assurance metric because it is not always clear how biological systems will respond to treatment and adaptation is required to generate the most valuable data from the study sites regardless of preconceived expectations of performance. An example of the need for adaptation occurred in the 1st year of sampling. The original monitoring protocol was designed to follow just BDA placements and the attributes relevant to their success or failure. After year 1, it became increasingly clear that the injection of a BDA was significantly altering stream hydrology and allowing beaver to build their own winter stable dams in concert with the BDA but not on the BDA. As it turned out, additional attributes needed to be added to the sampling equation to account for the indirect benefits of reach scale BDA treatments.

All of the existing physical metric data has been compiled in an Excel spreadsheet that is appended with each years new data. All of the juvenile salmonid inventory data has been archived in both an Access data base and then converted to an Excel spreadsheet for analysis. The raw data is entered and then reentered for identifying any potential input error.

Project Management

List the key individuals, their roles, and qualifications relevant for monitoring implementation.

Role	Name	Affiliation	Qualifications	Email	Phone
Project Manager	Steve Trask	Trask Consulting, Inc.	The field work, analysis and reporting will be conducted by Steve Trask of Trask Consulting. Steve has been conducting field inventories in the Oregon Coast Range specializing in coastal coho for 42 years.		
UNWC Project Manager	Maggie Peyton	Upper Nehalem Watershed Council Executive Director and Project Manager since 1996.	25 years experience developing, managing and monitoring restoration projects and conducting assessment projects in the Nehalem watershed.	maggie@nehalem.org	(503) 396-2046 Ext._____

Data

Describe the experience of the technical staff and/or contractors who will be directly conducting the monitoring. Include experience successfully applying monitoring approaches and collecting and analyzing data as it relates to the proposed monitoring work.

The field work, analysis and reporting will be conducted by Steve Trask of Trask Consulting, Inc. and Jeremy Lees of Bio-Surveys, LLC. Steve has been conducting field inventories in the Oregon Coast Range specializing in coastal coho for 42 years. The first 10 years of that effort was while employed by the ODFW Research section on the development of the Coastal Coho Seasonal Habitat Limiting Factors Model (Nickelson , et.al.). The remaining time was accumulated while the owner and senior fish biologist for Bio-Surveys, LLC. Bio-Surveys has conducted over 13,000 miles of snorkel inventories for salmonid species that has included most of the Coastal coho ESU and portions of the Willamette basin. Jeremy Lees, the current owner and lead biologist for Bio-Surveys has been with the company for 14 years. Both biologists have archived, analized, and reported on the data collected for many aquatic systems across the state of Oregon.

Describe how the resulting data will be managed, analyzed, and interpreted. Explain the steps and software tools used to manage and analyze the data to answer the monitoring questions posed in the application.

The physical data will be collected in March (post winter) of each of 7 subsequent years on 57 BDA locations. This data is archived in an Excel spreadsheet (attached). All of the data manipulation is conducted in Excel and inter annual trends in attributes are summarized and compared with previous years. The goal here is to watch the development of the BDA's over time to determine longevity, quantify changes in their productive capacity, quantify their utility for encouraging reach scale beaver use, evaluate the efficacy of different design criteria and quantify changes in available pool surface area for winter and summer rearing.

The biological data will be collected in September of 2023 / March 2024 and then again in September 2026 / March 2027. This involves the RBA snorkel inventories to quantify over winter retention of juvenile coho in the project reach. Both a summer and a post winter inventory are conducted for comparison. All of the RBA data is archived in the Nehalem Basin Access database that includes hundreds of historical miles of baseline inventory and all of the summer / winter comparison data. The monitoring reach data is then filtered out of this larger database and analyzed in Excel for changes in juvenile coho abundance specific to changes in BDA installations. Because we can not control for interannual differences in seeding levels (Adult escapement to the project reach), we are utilizing the percent of the summer population still present in the reach post winter just prior to smolting. This over winter retention (OWR) is the surrogate utilized for quantifying changes in smolt production in the project reach as it relates to increases in pool surface area and increased floodplain connectivity. So there are 2 separate numbers being generated in the monitoring review for coho productivity, 1) the modeled potential based on fully seeded winter density rates for beaver pond habitat (Nickelson, et, al.) and 2) the actual number of smolts retained in the reach from RBA snorkel inventories. These numbers are generally less than the modeled abundance because these high quality habitats have contemporarily not been seeded to capacity by adequate adult escapement.

Describe how the data will be stored, reported and made available to natural resource professionals and the public.

UNWC will store the project data on their inhouse data server, and make it available to the public via www.nehalem.org and by request. Project reports will be shared with all partners involved, especially ODFW, NOAA and ODF. Reports will also be shared with all private timberland managers, including Weyehaeuser Co. and Stimson Lumber Co., and Small Woodland Owners association, and Columbia, Clatsop and Tillamook SWCDs, and TEP and the Lower Nehalem Watershed Council.

How will this data be applied to inform future planning, implementation, or adaptive management of restoration or acquisition projects?

UNWC foresees BDA installation expanding across the coastal temperate rainforest landscape as a matter of restoration routine in response to the growing need to build climate change resilience, increase carbon storage capacity and restore native coho freshwater abundance. Lessons learned in the initial 3 years of the pilot study were incorporated in the adaption of the BDA design and method of installation within the pilot study area and in BDA projects currently in development in the upper Nehalem watershed.

Budget

Item	Unit Type	Unit Number	Unit Cost	OWEB Funds	External Cash	External In-Kind	Total Costs
Salaries, Wages and Benefits							
Project and Outreach Manager	Hours	770	$40.00	$22,400	$8,400	$0	$30,800
			Category Sub-total	**$22,400**	$8,400	$0	$30,800
Contracted Services							
Trask Consulting, LLC	Years	7	$8,000.00	$40,000	$16,000	$0	$56,000
BioSurveys, LLC	Each	2	$10,000.00	$20,000	$0	$0	$20,000
			Category Sub-total	**$60,000**	$16,000	$0	$76,000
Travel and Training							
UNWC staff	Miles	1000	$0.58	$580	$0	$0	$580
			Category Sub-total	**$580**	$0	$0	$580
Materials and Supplies							
			$0	$0	$0	$0	$0
			Category Sub-total	**$0**	$0	$0	$0
Equipment							
			$0	$0	$0	$0	$0
			Category Sub-total	**$0**	$0	$0	$0
Other							
			$0	$0	$0	$0	$0
			Category Sub-total	**$0**	$0	$0	$0
			Modified Total Direct Cost Amounts	**$82,980**	$24,400	$0	$107,380
Indirect Costs							
Federally Accepted 'de minimis' Indirect Cost Rate (up to 10%)	10%			$8,298	$0		$8,298
			Total	**$91,278**	$24,400	$0	$115,678

* = OWEB funds excluded from indirect.

Provide context and justification for how your budget was developed. Explain how project costs and/or rates were determined.

Contracted Services Trask Consulting: the cost of the field surveys/reports of 57 BDA's is $8,000 /year for 7 years (total of $56,000) for contracted services (as per quote).

Contracted Services for BioSurveys: we had NOAA funding in place to conduct pre – post project RBA inventory of original BDA Pilot Study site to quantify changes in the over winter retention of juvenile coho within the project reach of 3 target streams (Lousignont, Bear and Rock). The post project portion of this inventory was completed in July 2020 and March 2021. We have an estimate of the impacts on coho production after 3 winters (time enough for reach level changes to be significant enough to measure). This full summer / winter comparison of abundance will be replicated within the scope of this 10 year monitoring proposal 2 more times (winter 2024 and winter 2027). The cost (as per quote) of each of these summer / winter comparisons is $10,000 (total for the 2 replicates = $20,000).

UNWC project and outreach manager at $40/hour for 770 hours (110/yr) over the cours of the study will coordinate activities, distribute annual reports, host annual tours and develop and host a practitioner workshop at year 6.

Does the budget identify a contingency amount for specific line item(s) within the Contracted Services and/or Material and Supplies budget category?

❍Yes
●No

Funding and Match

Fund Sources and Amounts

Organization Type	Name	Source Note	Contribution Type	Amount	Description	Status
Federal	NOAA Restoration grant	State, federal and private partners are interested in seeking cost share to support this monitoring project.	Cash	$24,400	Cost share for effectiveness monitoring and project management	Pending
Fund Source Cash Total			$24,400	**Fund Source In-Kind Total**		$0

Match

Contribution Source-Type: Description	Amount
NOAA Restoration grant-Cash: Cost share for effectiveness monitoring and project management	$24,400
Match Total	$24,400

Do match funding sources have any restrictions on how funds are used, timelines or other limitations that would impact the portion of the project proposed for OWEB funding?

❍ Yes

● No

Do you need state OWEB dollars (not Federal) to match the requirements of any other federal funding you will be using to complete this project?

❍ Yes

● No

Does the non-OWEB cash funding include Pacific Coast Salmon Recovery Funds?

❍ Yes

● No

Uploads

Reports: BDA Yr 2 Monitoring Report.pdf - BDA Year 2 Monitoring Report by Trask Consulting

Project Design: Nehalem Basin BDA Pilot Design Plan.pdf - Nehalem BDA Design Plan

Reports: Nehalem BDA Project Effectiveness Monitoring + 2021 .pdf - Pre/Post RBA survey of BDA pilot study project sites

Map: BDA Monitoring Study App Maps.pdf - BDA Study Area Maps (2018, 2019, 2021 sites)

Permit Page

No Permits have been identified for this application.

April 2, 2020 Prepared by: Steve Trask

Trask Consulting, Inc.

Upper Nehalem BDA Pilot Project 2018/2019

Year 2 Post Implementation Monitoring

Introduction

The Upper Nehalem Watershed Council installed 27 BDA (Beaver Dam Analogue) structures in August of 2018. An additional 30 BDA's were installed in August of 2019. 7 unique headwater tributaries of the Nehalem River were selected for implementation to intentionally broaden the range of variability associated with the underlying geology, hydrology and channel morphology. Because this project was conceived as a BDA pilot for Oregon Coast Range coho recovery, we also made an attempt to vary many of the design attributes of the BDA's with the hopes that design variability would reveal the strengths and weaknesses of the design criteria moving forward. This report documents the results of the post project monitoring that occurred in the last week of March in both 2019 and 2020. Our desire was to quantify success and failure metrics at the end of winter. This approach guarantees that surface area calculations and potential smolt production estimates remained viable through all winter flow events to the time of smolting for OCN coho.

This document includes the results of the year 1 inventory reported in April of 2019 and a replicate of that inventory conducted for year 2 on the first 27 BDA's installed in the summer of 2018. In addition, this document contains the results of the year 1 monitoring inventory conducted on an additional 30 BDA's installed during the summer of 2019. Additional monitoring efforts are scheduled for April 2021 to assist in developing a working understanding of BDA's in the Oregon Coast Range as an ecosystem recovery tool.

Target Questions

- If beaver are present in the reach, will they colonize BDA sites without a trap and transplant strategy?
- Do any of the variable design elements listed below influence BDA colonization rates?
- Can BDA's be installed in depositional floodplains (high sediment load) without scouring out?
- Do the BDA's provide winter habitat for salmonids without colonization by beaver?
- How does the availability of winter habitat change with variable winter flows?

- Does the installation of BDA’s influence over winter survival rates for coho on the reach scale?
- What is the longevity of the BDA’s installed and are there design characteristics that influence longevity?

Methodology

Site selection for BDA installation began with a review of the existing RBA (Rapid Bio-Assessment) database to identify reaches exhibiting a legacy of beaver presence. An attempt was made in the fall of 2017 to utilize Net Maps to identify High IP reaches for beaver dam construction but this effort was unrefined and unground truthed at the time. The results of this effort did not deliver the level of refinement necessary for narrowing the field of potential locations for ground truthing. Subsequent modeling runs have been developed that have been more successful at utilizing the LIDAR based NetMaps program for identifying High Beaver IP that overlaps with coho distribution. This tool is currently being ground truthed in the Nehalem basin.

Potential sites were then ground truthed by Field crews from Trask Consulting. The sites had to meet specific criteria to qualify for implementation;

- Must be located on ODF lands (Early adopting Nehalem basin partner with 39% ownership in the basin)
- Target tributary must be 4th order or less and in general exhibit a bankfull channel less than 24 ft
- Must exhibit low interactive terraces (approx. 2ft)
- Must not exhibit exposed bedrock (no exceptions)
- Must exhibit beaver presence (active dens, feed stations, scent mounds, fresh chewing’s)
- Must be accessible to track machinery

Once a potential reach had been identified that met the above criteria, we began establishing specific site locations for each BDA. The final site selection was in general driven by 3 primary morphological criteria:

- The existence of confining hillslopes to tie a full floodplain spanning post row into the adjacent toe slopes
- Evidence of a historical beaver pond (uniform terrace heights left and right, depositional soils)
- Appropriate distance from the last BDA site so that impoundment doesn’t influence the next upstream BDA (minimum lineal distance for spacing between BDA’s calculated using stream gradient and proposed post height to estimate extent of inundation at full pool)

Basic design criteria that remained constant between all 27 sites;

- All post rows were full spanning toe slope to toe slope (reduces the risk of a lateral end run of the stream channel and maximizes floodplain impoundment on successful BDA's)
- All posts were suppressed Douglas fir harvested on site from the adjacent understory in 60 yr old stands (high ring count to resist rot and extend longevity)
- All posts were cut to 9ft and pounded to depths below the stream bed that ranged from 4-6 ft (any bedrock in the reach compromises this design feature)
- All post rows were installed level across the entire floodplain (prevents focusing winter flow vectors that could under scour the post row)
- All post rows were pounded with a 314 series excavator (30,000 lbs.)
- All sites without native willow were willow staked in the winter before or after construction (photo 1 below).

Photo 1

Basic design criteria that was altered and usually replicated to look for strengths and weaknesses;

- Post spacing ranged from 18 – 36 inches on center
- Post heights ranged from 28 - 62 inches above the existing stream bed
- Post diameters ranged from 5 – 12 inches (photo 2 below).

Photo 2

- Some post lines were woven, some were not (photo 3 below)

Photo 3

- Weaving materials utilized were Vine Maple or Douglas Fir limbs
- Food (willow / vine maple) caches were left adjacent and upstream of some BDA locations
- Artificial Beaver Dens were constructed at some sites to provide cover and denning opportunities (photo 4 below).

Photo 4

- Some sites riparian alder were girdled to provide sunlight to willow plantings

- Some sites riparian alder were fellen to provide sunlight to willow plantings and complex cover for beaver (photo 5 below)

Photo 5

- Some constructed BDA's utilized a double back to back design to reduce lift heights (photo 6 below)

Photo 6

- Some BDA’s were constructed on existing natural beaver dams, these were not included as successful colonization sites in the monitoring review unless they were eventually supplemented by beaver (photo 7 below).

Photo 7

Summary of Post Implementation Results year 1

- 26 of the 27 sites installed remained intact after the first winter. The single failed site still remains partially functional but 5 of the posts in the center of the row tipped out and reduced the BDA's potential for full floodplain inundation (photo 8 below).

Photo 8

- 3 of the 27 sites installed were colonized by beaver in the 1st winter (11% success rate)
- 2 of the 3 successful BDA's colonized by beaver also contained the placement of a food cache just above the BDA site
- The resulting increase in impounded pool surface area as a result of beaver colonization (measured at low base winter flow) was 8,570 Sq. ft
- The increase in impounded pool surface area results in a modeled increase in potential coho smolt production of 1,274 (utilizes full seeding value of 1.6 fish/sqm for post winter Beaver Ponds from Nicholson, 1998)

- 5 of the remaining 24 BDA's retained impounded pool surface areas at low winter base flows without beaver colonization (21% success rate, photo 9 below).

Photo 9

- The resulting <u>increase</u> in impounded pool surface area as a result of 5 BDA's with successful post weaves without beaver colonization (measured at low base winter flow) was 12,325 Sqft
- The <u>increase</u> in impounded pool surface area at BDA's even without beaver use resulted in a modeled increase in potential coho smolt production of 1,832 (utilizes full seeding value of 1.6 fish/sqm for post winter Beaver Ponds from Nicholson, 1998)
- The combined total <u>increase</u> in the potential for coho smolt production for the 27 BDA's after 1st winter was 3,106. This results in a modeled increase in adult escapement of 114 adult coho (assumes an avg. smolt / adult marine survival rate of 6.2%, Avg. marine survival rate based on ODFW life cycle monitoring sites between 2001 – 2010, Nicholson, 2012).

- 3 of the 27 BDA's were woven with green Douglas fir limbs, all 3 of these BDA's successfully impounded base winter flows (100% success rate). 19 of the 27 BDA's were woven with Vine Maple, only 2 of these BDA's impounded base winter flows (11% success rate)
- 7 of the 7 sites that developed impoundments (with or without beaver) exhibited quantifiable lifts in channel aggradation (avg. channel lift post winter = 0.88 ft)
- 6 of the 24 BDA sites not colonized by beaver had a new beaver dam built above the BDA post line. The distance above ranged from 15 – 175 ft and averaged 93 ft (Photo 10 below).

Photo 10

Year 1 Discussion

BDA colonization and other new dam building

3 of the 27 constructed BDA's were colonized by beaver in the first 7 months post construction. We expect additional BDA sites to be utilized as we progress into a more active period of dam construction (spring / summer). As we have reported in the results

section, significant increases in both summer and winter rearing surface areas for salmonids have been provided by at least 7 of 27 constructed BDA's. One of the most interesting phenomenon occurring in year 1 has been the frequency of natural beaver dams (6 of 24) built in close proximity (avg. 93 ft) above an installed BDA (photo 10). The occurrence of this was frequent enough (25% of the time) to suggest that a significant relationship exists between the BDA installation and the natural dam construction. It is observable that the BDA reduces the speed and hydraulic power of stream channels during high winter flows for a quantifiable distance upstream that is related to the height of the BDA posts and the background gradient of the channel. Essentially the BDA post rows that are woven or colonized by beaver impound winter flows. This may be affording naturally constructed beaver dams additional stability and longevity if they are within the range of impoundment associated with the BDA installation. If this relationship persists in out year monitoring inventories, we will be suggesting that very significant additional benefits exist to the installation of BDA's for salmonids that are at first glance not directly related to BDA construction. It is also significant to note that there were no natural beaver dams in any of the 4 stream reaches prior to treatment.

BDA weaving

Because willow was only present on 1 or 4 stream reaches, there was none available for weaving. On the 1 stream where willow was available, it was deemed more important to leave it as a potential beaver food resource. Therefore the project utilized the most abundant and accessible understory vegetation available (Vine Maple). In the results we compared the success rate of BDA's woven with Douglas Fir limbs with those woven with Vine Maple (100% VS. 11%). Douglas fir limbs contained fine branching with needles attached which facilitated the capture of even mobile sediments. In addition, fir limbs created a broader base to the weave because of the secondary branching that over lapped the layer below it (more effectively emulating the footprint of a natural beaver dam). This rapid sealing of the BDA prevented degradation of the stream bed directly upstream of the structure from high flow vectors deflected down and under the structure (photo 4 below). This type of vertical deflection was commonly observed in Lousignont Cr (4 of 7 BDA's) where all of the structures were woven with vine maple and lacked a broad foot print at the transition from the weave to the stream bed.

Photo 11

Willow planting

Because willow was present in some adjacent 4th order stream reaches that shared a common ridge line with the target streams, willow staking occurred on 3 of the 4 stream reaches because of the absence of this valuable food resource for beaver. Willow stakes were planted in February, 6 months before construction of the BDA's in August and kept a minimum of 12 ft from the edge of the stream to provide them with an opportunity to sprout before detection by wandering beaver. Each stake was doused in Plant Skid (a mammal deterrent) after planting. Initial willow sprouting and growth rates were high. Because all of the BDA sites were accessed by machinery in August, there were well developed access corridors to each of the implementation sites. It seemed like these corridors funneled bands of elk through the riparian and great losses occurred to the establishing willow stakes from ungulate grazing in every location post construction. The damage was to the tender young sprouting vegetation and not the stake. During the post winter inventory we have observed that a significant percentage of these stakes are developing buds and there may be hope that some survival is still possible. Supplemental staking has occurred at some sites where the damage was most severe. In addition, we added more willow volume to riparian areas that received an Alder felling treatment that expanded the potential for sunlight. Consider securing an extended maintenance budget for BDA project sites where planting a beaver forage species is a necessity for success

Fish Passage
Passage for adults was clearly unimpeded throughout the migration window in 20 of 27 BDA sites. For the 7 sites that were either colonized by beaver or sealed naturally from weaving, adult passage was always provided episodically during high flow events laterally around the structure (photo 12 below).

Photo 12

For the 7 sites that were either colonized by beaver or naturally sealed with weaving, upstream juvenile passage during summer low flow regimes may be compromised by the resultant channel lift. This is a natural process in small head water streams of the Oregon Coast Range where a) upstream temperature dependent migrations of juvenile salmonids are not occurring because temperatures do not exceed critical thermal thresholds and b) beaver dams have historically existed that also would have naturally terminated low flow summer passage upstream. This suggests that BDA's are most appropriate for locations that are at least ½ mile from stream corridors exhibiting elevated summer temperatures that exceed 64 deg. The ½ mile buffer for cold water tributaries that enter a temperature elevated larger stream order has been establish with thousands of miles of RBA snorkel inventories as the normal full extent of upstream temperature dependent migrations for juvenile salmonids in the Oregon coast range.

Changes in juvenile Coho production

The project includes a pre and post evaluation of changes in the over winter retention rates of juvenile coho associated with BDA construction. This is accomplished by conducting both a summer population inventory and a winter population inventory utilizing the RBA snorkel protocol to generate an over winter survival rate. The pre project summer and winter inventory was completed and we are still waiting to conduct the post project suite of surveys. Because OCN coho escapement was extremely low in 2018, we will be advocating for an extension of the post project inventory to the summer of 2020 and the winter of 2021. OCN coho escapement is predicted to increase in the fall of 2019 with improvement in ocean conditions already evident.

The commentary above summarizes year 1 of a multi-year monitoring project to review the Oregon Coast Range BDA Pilot Project. The results of the year 2 inventory have been appended to this report below. This portion of the document includes a year 2 review for the 27 BDA's installed in 2018 and the year 1 review of 30 BDA's installed in 2019.

Monitoring results from March 2020

Implementation of 30 additional BDA's occurred in 3 unique tributaries of the Nehalem (Walker Cr, Fish Hawk Cr and Deer Cr) in August of 2019. Some significant design elements were altered in 2019 as a result of observations and lessons learned from the 1st post winter monitoring effort for those BDA's installed in 2018. A review of these changes and the rationale associated with the design modifications is discussed below.

Alterations in design

- Post rows were only woven to a level 1ft above the existing stream bed (regardless of the final post height. This was because post rows woven to the top of the final post elevation during year 1 were not colonized by beaver. Even though these fully woven post rows were highly successful in impounding winter flows without beaver, they did not effectively achieve the stated goal of beaver colonization. The hope with this first design alteration was that beaver would recognize the 1 ft lift as a potential starter dam and not as a finished product, encouraging colonization of the BDA. The reasons for the lack of colonization of a fully woven post row are unclear but it appeared that several things were happening. 1) The full weave created a finished product so to speak, beaver could be observed utilizing the impoundment but exerting no effort to maintain the artificial dam. Instead it was more likely that the beaver would initiate their own dam construction just above the constructed post row (ranging in distance from 12-195 ft). This was likely due to a significant reduction in peak flow hydraulic potential just above the post row where impounded flows reduced background velocities and allowed beaver to anchor their own dam resistant to winter flows. 2) The fully woven post row created a powerful downward scour vector that often undermined the weave and created a hole beneath the structure (Photo 11) that was difficult for beaver to repair with floating wood. This is a uniquely challenging condition in the Oregon Coast Range because almost all of the 57 BDA's installed to date in the Nehalem have been located in historical beaver flats that exhibit deep accumulations of highly erodible fine sediments. By default, most of the viable sites have lacked a scour resistant mix of gravel / cobble substrates. These deep sediments have allowed for the deep penetration (5 ft) of a driven post that has provided a stable footing for maximizing the longevity of the BDA. 57 total BDA's installed with only 2 exhibiting significant post failure after year 1 from under scour.
- Conifer limbs were used almost exclusively for weaving in year 2 because beaver did not eat them out of the structure as they had done with the vine maple weave in year 1. In addition, green conifer limbs (needles intact) presented a much tighter seal against the stream bed to help thwart under scour.
- Conifer limb weaving was also modified from exclusively a horizontal weave in year 1 to a combination of parallel and horizontal weaves in year 2 that provided for a much wider woven footprint against the stream bed that assisted in diffracting erosive flow vectors created by either a vertical weave diffracting down and under above the structure or plunge scour below the structure. This combination of weaves began with a horizontal weave tight against the stream bed followed by a weave parallel with the thalweg. This combination initiates the shape of the BDA that is meant to emulate a natural beaver dam that is wider at its base than at its finished top (bread loaf shaped in crossection).

- Because the default condition for locating a BDA in the Coast Range starts with choosing a location with no visible evidence of exposed bedrock, viable sites are often sediment dominated with low aggregate loading (Tyee sandstone underlying geology). This predisposes the post row to rapid erosion during winter flow events. It is for this reason that we have recommended floodplain spanning post rows (Photo 3). Lateral erosion is a given in legacy beaver flats (deposition plains) if any vertical height is designed into the BDA through vegetative weaving. The result of this lateral erosion is an immediate end run of the active stream channel around the structure (photo 13) unless a complete set of posts exists across the floodplain.

Photo 13

- Considerable inter agency discussion in the technical review of design parameters continually returns to the concept of clustering BDA's to emulate the dam spacing observed in natural colonies. The results from the first 2 years the Nehalem BDA Pilot Project suggest that this approach is unnecessary and results in a lower net gain in the expansion of impounded pool surface area (the stated objective). BDA spacing that is less than the designed impoundment wedge results in BDA's that are backwatered by the lower BDA and unutilized by beaver because there is no water spilling over the weave and providing an audible attraction to build or repair. Year 2 results indicate that if BDA spacing is greater than the designed impoundment wedge (i.e., If design parameters = final weave height 2ft, background stream gradient 1.5% then an inundation wedge extends 133.3 ft upstream) then each BDA site has an equal chance of being colonized even if the BDA below was colonized. Establishing a larger lineal buffer between BDA sites is recommended to address the situation where beaver may build above the design height of the post row. Additionally, a larger lineal buffer between BDA's provides for an opportunity for spawning gravels to continue to sort out near the top of the inundation wedge as background gradients are revealed in the active channel.

Numerical Results

27 BDA's implemented 2018	**Year 1**	**Year 2**	**Inter annual trend**
BDA sites colonized by beaver	3	7	↑
Avg final height of successful BDA	2.17 ft	1.8 ft	NA
Avg pool lift of successful BDA	2.25 ft	1.9 ft	NA
Change in pool surface area of successful BDA	8,570 sqft	17,427 sqft	↑
Change in coho smolt potential at full seeding for successful BDA's	1,273	2,569	↑
Impounded surface area as a result of uncolonized full vertical post weaves	12,325 sqft	1,200 sqft	↓
Change in coho smolt potential at full seeding for BDA's w/ full weave but no beaver	1,832	178	↓
Natural dams constructed between BDA's	6	19	↑
Change in pool surface area for natural beaver dams constructed directly above BDA sites	Unquantified	47,237 sqft	↑
Change in coho smolt potential at full seeding for natural beaver dams above BDA's	Unquantified	7,022	↑

Avg distance to 1st natural dam above BDA	93 ft	80 ft	NA
BDA's that did not survive winter	1	0	↓
30 BDA's implemented 2019		**Year 1**	**Inter annual trend**
BDA sites colonized by beaver		5	NA
Avg final height of successful BDA		1.7 ft	NA
Avg pool lift of successful BDA		1.01 ft	NA
Change in pool surface area of successful BDA		3,220 sqft	NA
Change in coho smolt potential at full seeding for successful BDA's		501	NA
Impounded surface area as a result of uncolonized full vertical post weaves		0	NA
Change in coho smolt potential at full seeding for BDA's w/ full weave but no beaver		0	NA
Natural dams constructed between BDA's		11	NA
Avg distance to 1st natural dam above BDA		95 ft	NA
Change in pool surface area for natural beaver dams constructed directly above BDA sites		12,228 sqft	NA
Change in coho smolt potential at full seeding for natural beaver dams above BDA's		1,818	NA
BDA's that did not survive winter		2	NA
Total increase in coho smolt potential at full seeding (57 BDA's)		12,088	NA
Total increase in potential adult coho escapement		749	NA

with full freshwater seeding and 10 yr avg ocean survival (57 BDA's)			

* All of the physical metrics were gathered in March at base winter flow. This suggests that all quantities represent post winter conditions (just prior to smolting). In addition, the metrics gathered at base flows do not over estimate minimum rearing surface areas that remained durable throughout the winter.

Year 2 Discussion of Numerical results

Trend analysis for those BDA's in place for 2 years exhibit significant 2nd year increases in both impounded surface areas and potential smolt production (+ 84%) as the structures mature and beaver continue to be recruited to the treated reach. This increasing trend suggests that the investment in BDA's as a restoration tool continues to not only produce the desired outcome (impounded floodplain habitat) but that the potential for coho production continues to increase with time. We would like to recommend that monitoring continue on these reaches to quantify the actual longevity of this treatment on the reach scale and it's efficacy for boosting coho smolt production.

The only significant downward trend observed in the inter annual comparison of physical metrics was the decline in the abundance of pool surface area impounded by BDA weaves that were uncolonized by beaver. This metric declined for 2 reasons; 1) 4 additional BDA sites were colonized in year 2 that were uncolonized in Year 1. This reduced the size of the population of BDA's woven but uncolonized. 2) There was also an increase in the magnitude of under scour after year 2 that resulted in the woven structures impounding less pool surface area at base winter flows in year 2. This suggests that the concept of creating full post weaves (attaining bank full inundation with the weave) for the provision of impounded rearing surface area without beaver is a very short lived positive attribute (1 winter) and should not be considered a viable long term design component for BDA's sited in deposition plains exhibiting a Tyee sandstone underlying geology.

The year 1 monitoring revealed an interesting phenomenon (initial Discussion on page 13 above) where natural beaver dams were being constructed 12-195 ft directly above a BDA installation (avg distance 95 ft). We initially hypothesized that these natural dams were being located by beaver as a result of the radical change in winter hydrology created by the installed post row (change in background stream gradient from 1-2.5% to 0% gradient). In year 1 there were 6 of these natural dams linked to a BDA installation. In year 2 there were 19 natural dams in the same treated reach all linked to a BDA installation. The rearing surface area and potential smolt production resulting from these natural dams increased by 217% between years and was responsible for 42% of all additional coho production in year 1 increasing to 72% of all additional coho production in year 2. This phenomenon appears to constitute an actual cause and effect relationship between the BDA installation and the construction of winter persistent natural beaver dams and strengthens our initial hypothesis. There were no natural beaver dams in any of the original 4 stream reaches where 2 years of monitoring data has been completed. For the supplemental 30 BDA's installed in 2019 there were already 11 new natural beaver dams associated with BDA's after the first winter inventory. It is because of this clear response that we are suggesting that very significant additional benefits exist to the installation of BDA's for salmonids that are at first glance not directly related to BDA construction.

Colonization rates increased slightly in year 2 (11% – 17%) when comparing vertical weave parameters that were altered from a full bankfull weave in 2018 to a just a 1ft vertical weave in 2019. In 2018 there were just 3/27 BDA's colonized the first winter. In 2019 there were 5/30 BDA's colonized by beaver during the first winter. Colonization refers to a single BDA site and consists of a visual observation that beaver have been adding building material to a post row. It does not include post rows that have just accumulated the occasional beaver stick as drift.

In 2018, the riparian felling of alder was utilized to increase solar penetration to the forest floor above some BDA installations to encourage the growth and survival of willow planted for beaver forage (photo 5). This felling was done randomly with little concern for the final location of the fellen tree. This resulted in many trees laying full spanning over the stream corridor. This section of very high wood complexity was observed in year 2 as performing uniquely from other BDA locations. The high in channel wood complexity has completely terminated the beaver's ability to push dam building material through the wetted channel to the location of the post row. It is likely that this type of felling treatment will guarantee that the BDA installation will never be colonized by beaver. The area under the fellen wood however is being highly utilized by beaver with multiple feeding stations and mini dams observed tucked within the matrix of alder logs. It appears that the very high wood complexity has been a significant attraction to beaver because of its capacity to provide impenetrable cover from predators. The log matrix has also resulted in the highest survival rates for planted willow stakes because elk can't access stakes driven within the log matrix. For BDA's installed in 2019, we altered the felling prescription to specifically address the observed inability of beaver to push building material to the BDA site. This resulted in alder being fellen only away from the active stream channel so that there were no logs spanning the stream (photo 14).

Photo 14

For BDA projects that are designed to treat a continuous stream reach with multiple BDA installations, a dedicated riparian release site that drops trees across the active channel near the middle of the treated reach might be a very effective ancillary tool for the provision of complex cover for both protecting beaver and for protecting a vegetative seed source from ungulate deprivation. It would be recommended that no BDA be located below the release site within the reach of the designed inundation wedge.

Girdling was also utilized in year 1 as a riparian management tool that could benefit the growth of willow as a future beaver food source. The willow stakes under the girdled canopy have not indicated a significant differential growth or survival response when compared to willow staked under a full alder canopy after 2 growing seasons. Both have resulted in slow growth and continual exposure to ungulate depredation. It appears that the slow burn associated with a girdling treatment has limited potential for generating a rapid plant response. We would recommend investing in a falling strategy that gets immediate solar results and can provide interstitial complexity to the planting that boosts survival from depredation.

Five artificial Beaver Dens were constructed for the 27 BDA's installed in 2018. After the second year of monitoring, only 1 of 5 constructed dens is being utilized. Only 1 of 5 sites where dens were constructed was also successfully colonized by beaver. We would expect a higher utilization rate as BDA's mature and as colonization rates increase in out years.

Supporting data

All of the monitoring data collected for this review is contained in an Excel Spreadsheet that should accompany your utilization of this final report document. A list of physical attributes are listed that are being tracked over time and may be of interest to restoration biologists and technicians considering the implementation of BDA's in the Oregon Coast Range to enhance beaver recovery.

Nehalem Basin BDA Pilot Design Plan

Rationale for BDA construction and location

BDA's are intended to jump-start the creation, extend the durability and sustain the colonization of beaver dams to provide high quality rearing habitat and store water on the landscape. An increase in functional beaver dams is essential for increasing the survival and spatial distribution of ESA-listed Coho salmon. In addition, the capacity of a successful BDA to initiate the following:

- Trap and store nutrient rich sediments and spawning gravels
- Store winter rains in floodplain terraces for slow release during spring / summer
- Create stream adjacent wetlands
- Increase salmonid, wildlife and amphibian rearing habitat
- Initiate heterogeneity in riparian vegetative communities by resetting early seral conditions

results in powerful outcomes for the restoration of system process. The key question of the project is "Can we encourage native bank dwelling beaver to adopt constructed BDA's to increase the quality, quantity and longevity of dammed rearing habitat that is critical to the recovery of three listed salmon species in Oregon".

All of the target reaches selected for the Nehalem Pilot demonstrate a legacy of historical beaver use, appropriate deposition plains for maximizing inundation, functional (<2ft) interactive floodplain terraces, the presence of the target listed species, OCN (Oregon Coast Natural) Coho, reasonable access to the site for implementation and are contained within the boundaries of Oregon State ownership.

Responsible Party

All of the project designs, implementation and proposed adaptive management strategies will be developed and conducted by a senior Fish Biologist from Bio-Surveys, LLC (Steve Trask). Steve was involved in the development of the NSAP for the Nehalem Basin and has been the project lead since inception. Bio-Surveys is working under contract for the Nehalem Watershed Council and all project management will be conducted by Maggie Peyton (UNWC). Agency supervision and liaison responsibility will be provided by Troy Laws (ODFW).

BDA Design Elements

Because this has been developed as a pilot for western Oregon Watersheds, we have incorporated some additional design features into the project to facilitate a comparative analysis of beaver colonization rates, BDA function and longevity. Besides the foundation of each BDA being constructed of live Douglas Fir posts harvested from the adjacent RMA we have incorporated a suite of additional design features that include:

- Girdling riparian alder to emulate early seral conditions and increase plant access to solar
- Plant desired food species for beaver in locations where they are lacking (Willow)
- Fall riparian alder to provide hiding cover and a deterrent to beaver predators
- Willow weave within the existing channel (variable heights)

- Willow weave beyond the channel prism to accelerate the development of full floodplain inundation
- No weave to quantify the time required for just a post installation to function as a dam pool (with or without beaver colonization)
- Create stream adjacent denning houses with rootwad clusters for the provision of cover
- None of the sites will be back filled with bedload to maintain porosity for juvenile migrants

Rationale for BDA spacing and general goals

Longitudinal profiles have been provided for each of the 4 selected stream reaches that establish the spacing and gradient between proposed BDA sites. Initial site selection for each BDA was driven by the combined morphological features of floodplain width and channel form. Broad floodplains were required to maximize inundation and stream channels with low interactive terraces were required to present dam building beaver with the best case scenario for achieving success (sites with channel incision over 3 ft were not included). Final spacing was a random outcome with some sites creating inundation to the base of the next upstream BDA site and some sites leaving riffle habitat between BDA sites for food production and spawning. Final lineal inundation estimates were based on the assumption that BDA's would be constructed to the final design height by either the construction crew or beaver. The goal is to provide adequate variation in the BDA design criteria that the nuances of beaver selecting and colonizing manmade BDA sites may be revealed in follow-up effectiveness monitoring.

Literature cited

Project design and BDA site selection was based on the Beaver Restoration Guidebook (Pollock et al 2015, revised 2017), lessons learned from BDA projects in eastern Oregon and elsewhere, and local knowledge of the sites, beaver behavior and what constitutes high quality Coho salmon rearing habitat.

Monitoring Plan Structure

Collect Pre implementation metrics

The physical metrics that describe the selected BDA site are included in table 1 below:

Table 1

BDA Design and Monitoring Metrics

Trib D Buster Cr

Post height above thalweg	BFW	BFH above thalweg	FPW	FPH above thalweg	Gradient	Distance to next BDA	Terrace Height above thalweg	# of posts	Design Elements
4.02	14	1.18	42	3.02	1.60%	225	3.02	21	willow weave
4.38	14.5	2.3	78	3.38	1.20%	366	3.38	25	willow weave
3.24	13.4	1.06	74	2.24	0.70%	525	2.24	23	willow weave

4.44	13	1.32	96	3.44	1.60%	201	3.44	7	willow weave
3.64	10	1.9	40	2.64	1.10%	279	2.64	20	willow weave
3.03	13	1.04	130	2.03	1.10%	549	2.03	56	willow weave
3.49	14.5	1.37	85	2.49	0.30%	300	2.49	28	willow weave
4.16	12	2.52	102	3.16	0.80%	330	3.16	23	willow weave
5.56	10	2.54	60	4.46	NA	NA	4.46	25	willow weave

Bear Cr

Post height above thalweg	BFW	BFH above thalweg	FPW	FPH above thalweg	Gradient	Distance to next BDA	Terrace Height above thalweg	# of posts	Design Elements
3.23	24	1.28	163	2.23	1.58%	300	2.23	45	willow weave
2.4	30	0.88	153	1.4	2.00%	336	1.4	60	willow weave, Gir
2.79	18	0.83	105	1.79	1.79%	3,432	1.79	45	No Weave
2.46	19	1.12	56	1.46	1.10%	310	1.46	23	willow weave
2.4	12	1.07	60	1.4	1.29%	615	1.4	30	willow weave, fall
2.14	25	0.64	108	1.14	1.29%	145	1.14	54	willow weave, Gir
2.9	10	0.93	110	1.9	NA	NA	1.9	55	Weave full floodp

Rock Cr

Post height above thalweg	BFW	BFH above thalweg	FPW	FPH above thalweg	Gradient	Distance to next BDA	Terrace Height above thalweg	# of posts	Design Elements
2.6	11.5	0.7	92	1.6	1.16%	375	1.6	45	willow weave
1.48	10	0.42	111	0.48	0.48%	351	0.48	55	willow weave
2.93	11	0.75	123	1.93	NA	NA	1.93	20	willow weave

NF Louisignont Cr

Post height above thalweg	BFW	BFH above thalweg	FPW	FPH above thalweg	Gradient	Distance to next BDA	Terrace Height above thalweg	# of posts	Design Elements
2.9	17.5	0.49	82	1.9	0.84%	375	1.9	40	willow weave
2.93	14	1.32	76	1.93	0.93%	225	1.93	36	willow weave
3.23	14	0.98	96	2.23	1.10%	300	2.23	18	willow weave
2.79	15	0.56	91	1.79	1.47%	195	1.79	45	willow weave
4.31	15	0.57	85	3.31	1.17%	735	3.31	42	willow weave
3.93	6	0.7	193	2.93	1.97%	138	2.93	60	willow weave
4.55	7	1.07	150	3.55	NA	NA	3.55	75	willow weave

Final Success Metrics

The project contains an extensive monitoring component (10 years) designed to quantify salmonid response and profile the attributes of both successful and unsuccessful BDA's for use by future restoration technicians interested in facilitating the recovery of functional beaver dams on the landscape in western Oregon.

1) Changes in over-winter retention rates pre and post project for OCN Coho.
2) The number and area of new beaver ponds created with the use of BDA construction.
3) Number of BDAs utilized by beaver/mile/reach
4) Height of successful BDAs (initial post height and final dam height)
5) Riparian vegetation community present (document and describe beaver food resources before/after)
6) Final post depth achieved
7) Scour associated with post installation (quantify and describe how willow weaving influences scour)
8) Final passage condition on successful BDAs for juvenile and adult salmonids
9) Presence/absence of BDAs after winter flows (longevity)
10) Difference in responses to variable BDA designs

Collection methodologies for the metrics listed above

1) RBA snorkel inventory to estimate over winter retention of coho parr in treated reaches. This involves developing a summer and winter population estimate both pre project and then 2 year post project.
2) Quantify number of BDA sites that have been colonized by beaver and the changes in pool surface area related to the inundation created by damming. Increases in surface area will also be calculated for BDA that have not been colonized by still function to create impounded habitats.
3) BDA success rates by category. With willow weave, without willow weave, with willow planting, without willow planting, willow planting with falling and girdling, willow planting without modification to the overstory, juxtaposition of successful sites within a reach, etc.
4) Compare designed post height to final step height of both occupied and unoccupied BDA's.
5) Quantify vegetative community adjacent to BDA sites pre and post project. Are there changes in vegetative communities associated with inundation? Have vegetative prescriptions led to higher colonization rates of BDA's over time.
6) What did we learn about soil Oregon Coast Range soil lenses and the ability to drive green Douglas fir posts as BDA construction members. How deep, best diameter, best method, what was too high above the thalweg for longterm stability, etc.
7) Quantify and photo document scour response in active channel below BDA installation sites. Was there a method of willow weave (compaction, density, style) that reduced or truncated midchannel scour that would weaken and cause structure failure.
8) Photo document passage conditions at BDA sites. Quantify vertical step metrics post project.

9) Quantify structure failure rates longterm (10 year). How long can this design be expected to provide a viable platform for beaver colonization?
10) What design elements stood out as critical for achieving success? What combination of variables describes the perfect final condition?

Adaptive Management

It is the projects intent to have an adaptive management strategy in place for successful BDA's. In the summer of 2019 or 2020 the construction team may install more BDA's in areas adjacent to where resident Beaver responded positively to initial BDA installation (actively using specific analogue sites for dam construction). The construction of these additional analogues is designed to mimic the natural distribution of dams within a natural colony where additional dams are subsequently constructed back to back. This augmentation strategy is specifically designed to add value to successful BDA's that were stand alone single installations and not colonial clusters.

There is also the potential that additional vegetative treatments may be required post project to insure that a longterm robust beaver food source is available at successful BDA sites.

Project Effectiveness Monitoring
Pre and Post Project Over Winter Retention (OWR) of Juvenile Coho Between Summer and Winter

Conducted by
Bio-Surveys, LLC
For the Upper Nehalem Watershed Council

Introduction

Monitoring in the form of summer/winter comparisons of juvenile salmonid production has been conducted for two years (2017/18 and 2020/21) on three tributaries of the Upper Nehalem basin: Bear Cr, Rock Cr, and North Fork Lousignont. These surveys are classified as pre-treatment and 3 yr post-treatment indexes of the winter retention rates for juvenile salmonids.

The intent of this monitoring is to quantify the changes in the over winter retention (OWR) of juvenile salmonids as it relates to instream beaver dam analog (BDA) treatments designed to encourage beaver occupation and improve the abundance of over wintering habitats (channel complexity, low velocity micro habitats, floodplain connectivity, etc.). The 3 stream reaches selected exhibited high potential for eliciting a response to BDA installations.

The targeted tributaries of the Nehalem (Bear, Rock, and NF Lousignont) have been documented as historical spawning destinations for large numbers of adult coho. Boosting the headwater retention of winter parr to the smolt stage enhances a life history strategy (headwater rearing) that has been in rapid decline as system function has deteriorated from the lack of natural wood recruitment that historically maintained floodplain connectivity. Maintaining a broad array of life histories has been considered a valuable restoration and recovery goal by strategic action plans throughout the range of the coastal coho ESU for the retention of life history diversity. Successful life history strategies become genetic attributes (run timing, nomadic fry migration, temperature dependent upstream migrations, etc.) as a result of natural selection.

Study Reach Overview

Bear Creek

Bear Creek defines the optimal anchor habitat for coho with broad interactive floodplains, high wood complexity, sorted spawning gravels, consistent summer flow volumes, cool summer temperature regimes, and a low gradient profile. Average gradient throughout the sampled reach was 1.9%. This gradient profile is within the optimum range for coho spawning and rearing. Lower Bear Cr has an old LWD treatment reach.

The Bear Creek survey extended 1.8 miles upstream from the confluence with South Fork Rock to where canyon confinement and increased gradient limit further anadromous spawning and rearing potential. The snorkel inventory extended to the end of coho distribution during both the pre and post project inventories.

A legacy of high beaver occupation was documented during 2009, 2010, and 2011 RBA inventories with an average of 34 beaver dams observed. In 2015 only 15 dams were observed and during our 2017 pre-project inventory only 3 beaver dams remained with very little fresh activity noted.

Rock Creek

The Rock Creek survey extended 1.1 miles upstream from the start point to the end of coho distribution where increased gradient and canyon confinement limit further anadromous spawning and rearing potential. This is the uppermost segment of Rock Creek starting approximately 26.4 miles river miles upstream of its confluence with the mainstem Nehalem.

Rock Creek portrays less of the natural geomorphic potential for floodplain interaction because of hillslope confinement but contains three isolated flats that exhibit wide floodplains and low terrace heights. The inventoried reach was characterized by mature coniferous riparian, high wood complexity, sorted spawning gravels, consistent summer flow volumes, cool summer temperature regimes, and average gradient of 2.9%.

Beaver occupation throughout the project reach was low during our 2009, 2010, 2011, and 2017 RBA inventories with an average of 2 beaver dams observed.

North Fork Lousignont

The NF Lousignont Creek survey extended 1.3 miles upstream from the start point to the end of coho distribution where increased gradient and canyon confinement limit further anadromous spawning and rearing potential. This is the uppermost segment of the NF Lousignont Creek starting approximately 1.2 river miles upstream of its confluence with the mainstem Lousignont.

North Fork Lousignont exhibited sinuous channel meander, high wood complexity, average gradient of 2.3%, abundance of fine substrate, forested riparian, and a series of legacy beaver flats with abundant willow available for forage.

Beaver occupation was sporadic throughout the project reach during our 2009, 2010, 2011, and 2017 RBA inventories with an average of 4 beaver dams observed. High beaver usage was observed immediately downstream of the project reach.

Methodology

A 20 percent snorkel survey of pool habitats (no riffle or rapid habitats) and 100% sample of beaver dams and BDA structures was conducted during summer flow regimes in the target streams and then repeated at the end of winter (March) just prior to smolt migrations to determine if there was a difference in the over winter retention rates of summer parr to the smolt stage before and after BDA treatments. Assumptions were made that smoltification had not occurred by the inventory date. In addition, the entire reach was inventoried to the end of coho distribution both pre and post because coho are known to drop out of headwater habitats to occupy higher quality winter refugia that might exist within the reach (our hypothesis was that this would be provided by the colonized BDA's).

All of the winter sampling occurred at night. Nocturnal calibration factors developed by ODFW research were utilized to expand the observed numbers of coho to an actual estimate of abundance. These calibration factors were variable based on the complexity of the cover associated with the pool. These calibration factors are included in Table 1.

Table 1

Calibration factors

N x 1.20 for summer estimates of all habitat complexities

N x 1.23 for winter nocturnal estimates in low and medium complexity habitats

N x 1.89 for winter nocturnal estimates in high complexity habitats

The intent was to quantify and compare over winter retention rates on the reach scale in identical reaches both prior to a BDA treatment and 3 years after a BDA treatment. The assumption is made that the BDA structures placed within the treated reaches will aid in restoring beaver to the reach. It is also assumed that with increased beaver occupation, over winter retention rates will continue to improve as floodplain connectivity increases associated with the structures capacity to create grade controls that reduce gradient, lower velocities, and impound backwater habitats on the floodplain. The current hypothesis is that the additional low velocity habitats created by increased floodplain connectivity (occurring upstream of an occupied well seated structure) boosts the abundance of winter refugia within a stream reach and slows the progression of juveniles through the reach as they are pulsed in and out of micro-habitats as a result of alterations in flow associated with cyclical rain events. This process retains more juvenile salmonids near incubation sites to the smolt stage.

The abundance of all salmonid species was collected but because only pools were sampled, the data is most applicable to coho that are known to be primarily pool rearing. In addition, both winter and summer inventories extend to the end of coho distribution so that winter estimates of abundance are capable of representing members of the population that drop out of head water stream segments to winter rear in optimum segments of the surveyed reach with lower gradients and / or higher wood densities.

Results

Bear Creek

For Bear Creek the pre-project OWR rate for 2017/18 was 24.04%. When compared with the OWR for the post project inventory (2020/21) there was a 79.4% increase in abundance to 43.13% of the summer population estimate. This was a significant increase which was accompanied by an increase in beaver activity throughout the upper portion of the treatment reach.

Active full spanning beaver dams documented during the pre and post project summer inventories (2017-2020) increased from 3 to 14. A majority of the beaver dams observed in summer 2020 did not survive winter flows through 2021, but the remaining dams provided high complexity pool habitats that substantially increased winter refuge and rearing potential. Pre and post project winter inventories observed 3 (2018) and 5 (2021) full spanning beaver dams that resisted avulsion.

During the pre-project sample (2017/18) beaver pools were rearing 2.7% of the summer and 7.5% of the winter coho population estimates. In the post project sample (2020/21) the combined BDA and natural beaver pond totals were rearing 28% of the summer population and 39.2% of the winter coho population.

For summer rearing comparisons, this increase is clearly the result of higher beaver occupation. For winter rearing, this is an impressive increase considering 9 of the 14 dams observed in the post project summer inventory were avulsed by the time of the winter inventory. For the dams observed during the winter inventories of the pre and post project reaches, there was a 67% increase from 3 (2018) to 5 (2021) dams, but a 423% increase in the percentage of population rearing within those beaver pools. This was a result of the increased size of the post project year impoundments and their associated floodplain habitats. This increase in post project dam size may be related to the BDA's effect on stream hydraulics in reducing the kinetic energy associated with high winter flow events and the aggradation of mobile bedload that increased the frequency of floodplain connectivity.

Rock Creek

For Rock Creek the pre-project 2017/18 OWR rate was 25.06%. When comparing this OWR to the post-project OWR there was a 102.7% increase to 50.8% of the summer population retained in 2020/21. This was the highest OWR rate increase and was accompanied by a significant increase in beaver activity and full colonization of BDA's throughout the treatment reach.

Active full spanning beaver dams documented during the pre and post project summer inventories (2017-2020) increased from 2 to 8. All BDA's were colonized by beaver with strong substantial dams. Most of the observed beaver activity consisted of dams that were either built into BDA's or built within the treatment reach. Utilizing the BDA's as a foundation increased dam strength and its ability to sustain the force of high flow events. As a result, the two most substantial dams endured through the winter providing an abundance of complex high quality rearing habitat. During the post project summer of 2021, increased beaver occupation was also observed upstream of the treatment reach with an expansive complex that contained the highest summer coho counts documented in the inventory. This complex was completely avulsed by high flows over the course of the winter but the lower BDA provided abundant high flow refugia that truncated their winter movement out of the reach.

During the pre-project years (2017/18) beaver pools were rearing 6.1% of the summer and 15.9% of the winter coho population estimates. In the post project years (2020/21) the combined BDA and beaver pool totals were rearing 53.4% of the summer and 58.2% of the winter coho population estimates.

These post project increases in OWR rates and percentages of the population rearing in beaver pools are interrelated and a result of the significant post project expansions of pool habitat provided by the colonized BDA's and the subsequent increases in both summer and winter rearing potential.

NF Lousignont Creek

For Lousignont Creek the pre-project OWR rate for 2017/18 was the lowest of the sample reaches at 17.8%. When comparing the OWR for the pre-project there was a marginal 38% increase, to 24.56%, observed post project (2020/21). This was no significant increase in beaver occupation documented throughout the treatment reach.

Active full spanning beaver dams documented during the pre and post project summer inventories (2017-2020) increased from 1 to 3. One BDA was colonized by beaver. This dam was partially breached by winter flows but retained structure with the BDA as a foundation and continued to provide the highest quality rearing habitat within the sample reach.

During the pre-project years (2017/18) beaver pools were rearing 2.8% of the summer and 19.6% of the winter coho population estimates. In the post project years (2020/21) the combined BDA and beaver pool totals were rearing 8% of the summer and 24% of the winter coho population estimates.

The post project increase in OWR was likely due to two factors: the fortification of the first pool in the reach by the beaver colonized BDA which endured winter flows unlike the pre-project years; and the increase in winter velocity refuge provided by the uncolonized BDA’s that were located within pool habitats on peak flow events.

Pre and Post Project Seasonal Coho Abundance Comparison and Overwinter Retention Rates (OWR)

Table 2

	PRE 2017 Summer	PRE 2018 Winter	3 YR POST 2020 Summer	3 YR POST 2021 Winter	OWR % Increase
Bear					
Random 20%	8,580	1,962	3,462	1,262	
BDA (Uncolonized) 100%			29	155	
BDA (Colonized) 100%	240	159			
Beaver Pool (No BDA) 100%			1,318	657	
Total	8,820	2,121	4,809	2,074	
Total # of Beaver Dams	3	3	14	5	
OWR		**24.04%**		**43.13%**	**79.40%**
Rock					
Random 20%	2,574	578	876	399	
BDA (Uncolonized) 100%				4	
BDA (Colonized) 100%	167	109	171	536	
Beaver Pool (No BDA) 100%			833	16	
Total	2,741	687	1,880	955	
Total # of Beaver Dams	2	2	8	4	
OWR		**25.06%**		**50.80%**	**102.70%**
NF Lousignont					
Random 20%	3,253	480	2,514	510	
BDA (Uncolonized) 100%				44	
BDA (Colonized) 100%			102	84	
Beaver Pool (No BDA) 100%	94	117	116	33	
Total	3,347	597	2,732	671	
Total # of Beaver Dams	1	2	3	2	
OWR		**17.80%**		**24.56%**	**38%**

*All fish numbers are expanded and include visual bias.

Discussion

The intention of this project was to create inundation with full spanning structures that facilitates an expansion of low velocity edge habitat on an adjacent floodplain with rising flows (site selection here is everything). Increasing the availability of stable low velocity habitats within a stream segment like those provided by beaver pools moderates and reduces non volitional downstream migrations.

A significant uncontrolled variable in a multi-year monitoring effort is the variability associated with differences in winter flow patterns between years. Because juvenile salmonids are faced with extreme flow variation during the winter, a steady attrition from headwater habitats to lower basin habitats is naturally observed. As flows rise, many low velocity micro habitats that existed during low flows are overwhelmed by current. This forces juveniles out of familiar habitat and toward the floodplain that is developing new low velocity edges and backwaters with every inch of rise.

Every rise, however, is followed by a subsequent decrease in flow that empties backwater habitats and concentrates low velocity edges back toward the dominant flow in the main channel prism. With each rise and fall cycle, juveniles are reshuffled in a downstream vector (some losing their footing each cycle). This knowledge that non-volitional downstream migrations are progressive suggests that an increase in the number of oscillations from high to low events results in a decrease in OWR rates on the reach scale.

Based on snorkel observations of fish abundance, *sites which provide the highest quality winter habitat occur where* <u>*continuous*</u> *low velocity habitat exists through all winter flow levels (beaver ponds or large dam pool habitats created by well seated log jams or boulder complexes).* This occurs when site-specific channel and floodplain interactions complement each other to provide low velocity shelter at different flow levels. This is the primary feature that distinguishes highly functional winter habitat units from most other potential winter habitats. These sites are rare within a stream reach and tend to hold juvenile salmonids at a disproportionately higher density.

It is important for the reviewer to recognize that BDA's injected within a stream reach have the capacity to alter the streams hydrology whether they are colonized by beaver or not. Many new beaver dams in the 3 study reaches were constructed just upstream of a constructed BDA because the post row reduced stream power sufficiently enough to allow a natural beaver dam to be built that was winter stable. This response to BDA construction is discussed in detail in the full BDA Monitoring Report.

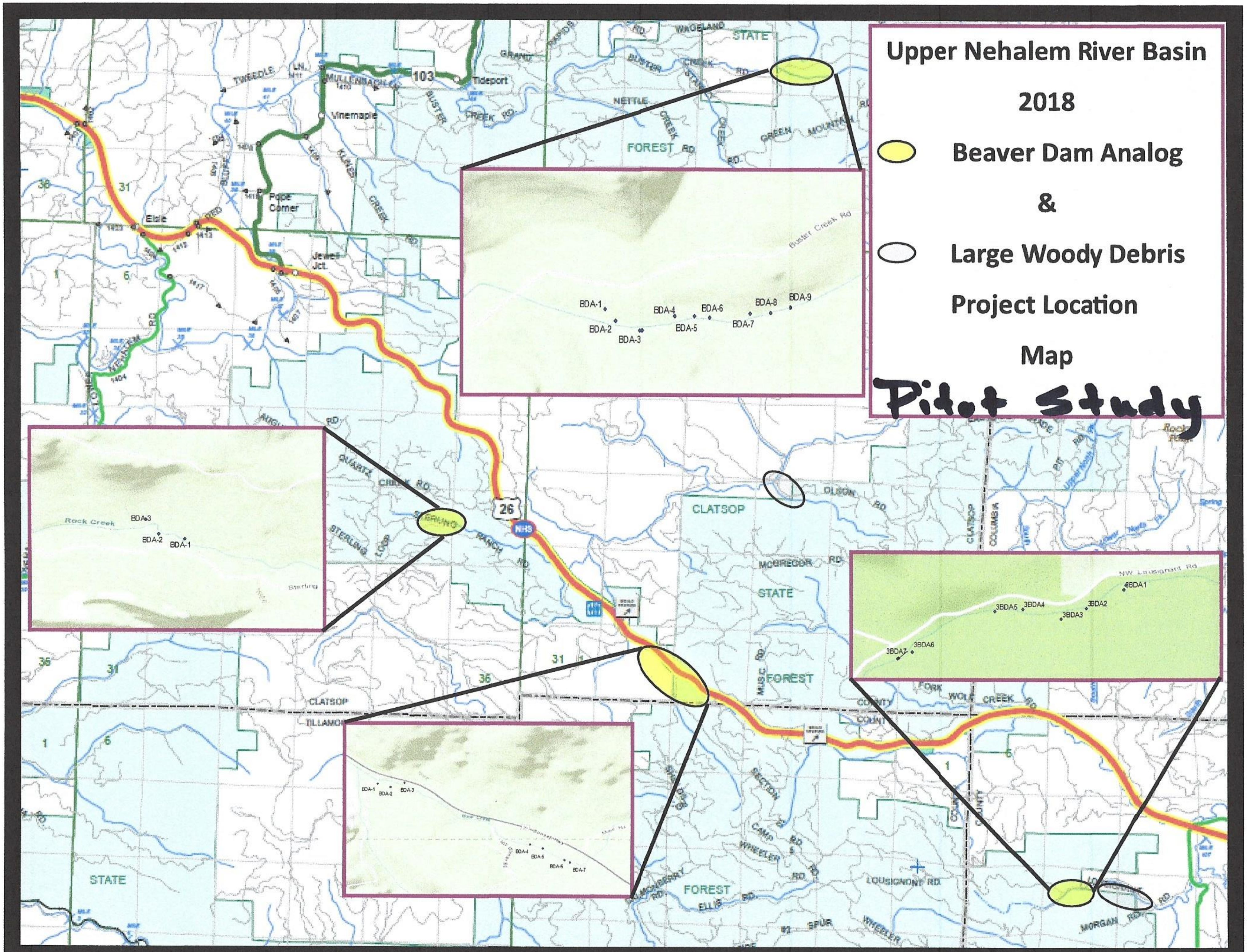
Understanding that the increased presence of beaver in a stream reach adds significant benefit for multiple system processes suggests that additional effort should be expended to both protect and sustain the relationship. Considering the food requirements of beaver (Willow, Vine Maple) in the riparian planting plan is important for extending the longevity of beaver within the reach. Local outreach and education could also be important so that the beaver/salmon linkage is understood more broadly by rural residents on the landscape that might be trapping or removing beaver because of the notion that they are a nuisance.

BDA Design and Monitoring Metrics

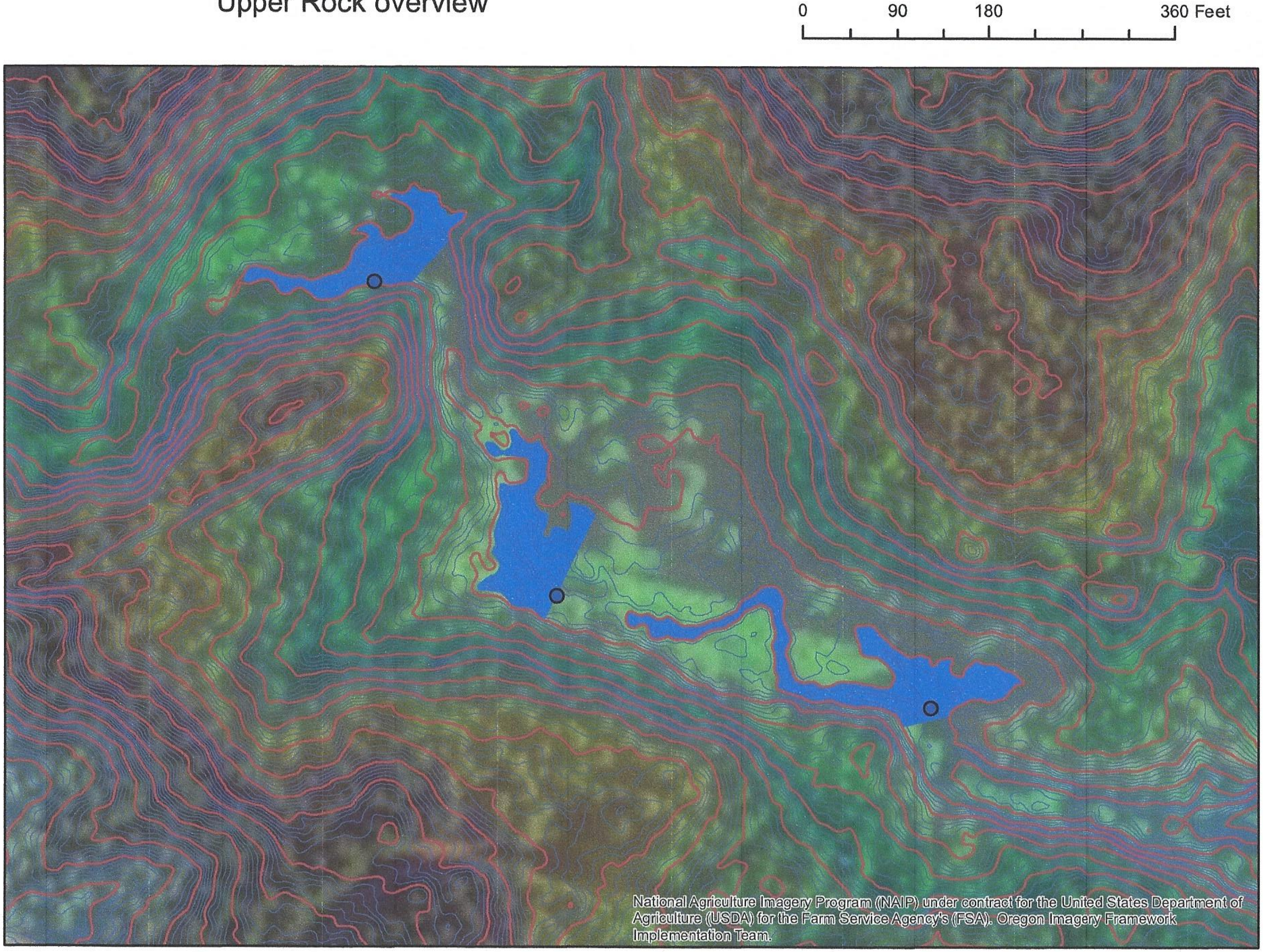
August 2018 Implementation / March 2019 Post Winter Monitoring Review

Stream	Structure #	Post height above thalweg (Inches)	Post Spacing (Inches on Center)	BFW (Ft)	BFH above thalweg (Ft)	FPW (Ft)	FPH above thalweg (Ft)	Gradient %	Distance to next BDA (Ft)	Terrace Height above thalweg (Ft)	# of posts
BUSTER	1	36	24	14	1.18	42	3.02	1.60%	225	3.02	21
BUSTER	2	42	18	14.5	2.3	78	3.38	1.20%	366	3.38	25
BUSTER	3	48	30	13.4	1.06	74	2.24	0.70%	525	2.24	23
BUSTER	4	50	24	13	1.32	96	3.44	1.60%	201	3.44	7
BUSTER	5	54	24	10	1.9	40	2.64	1.10%	279	2.64	20
BUSTER	6	50	24	13	1.04	130	2.03	1.10%	549	2.03	56
BUSTER	7	52	24	14.5	1.37	85	2.49	0.30%	300	2.49	28
BUSTER	8	56	24	12	2.52	102	3.16	0.80%	330	3.16	23
BUSTER	9	57	36	10	2.5	120	4.5	1.20%	315	4.5	8
BUSTER	10	62	36	10	2.54	60	4.46	1.20%	0	4.46	25
BEAR	1	36	30	24	1.28	163	2.23	1.58%	300	2.23	45
BEAR	2	42	24	30	0.88	153	1.4	2.00%	336	1.4	60
BEAR	3	42	32	18	0.83	105	1.79	1.79%	3,432	1.79	45
BEAR	4	36	30	19	1.12	56	1.46	1.10%	310	1.46	23
BEAR	5	38	30	12	1.07	60	1.4	1.29%	615	1.4	30
BEAR	6	48	24	25	0.64	108	1.14	1.29%	145	1.14	54
BEAR	7	28	24	10	0.93	110	1.9	NA	0	1.9	55
ROCK	1	48	16	11.5	0.7	92	1.6	1.16%	375	1.6	45
ROCK	2	42	24	10	0.42	111	0.48	0.48%	351	0.48	55
ROCK	3	38	24	11	0.75	123	1.93	NA	0	1.93	20
LOUSIGNONT	1	34	30	17.5	0.49	82	1.9	0.84%	375	1.9	40
LOUSIGNONT	2	32	24	14	1.32	76	1.93	0.93%	225	1.93	36
LOUSIGNONT	3	36	24	14	0.98	96	2.23	1.10%	300	2.23	18
LOUSIGNONT	4	30	24	15	0.56	91	1.79	1.47%	195	1.79	45
LOUSIGNONT	5	53	30	15	0.57	85	3.31	1.17%	735	3.31	42
LOUSIGNONT	6	56	30	6	0.7	193	2.93	1.97%	138	2.93	60
LOUSIGNONT	7	32	24	7	1.07	150	3.55	NA	0	3.55	75
BUSTER	1										
BUSTER	2										
BUSTER	3										

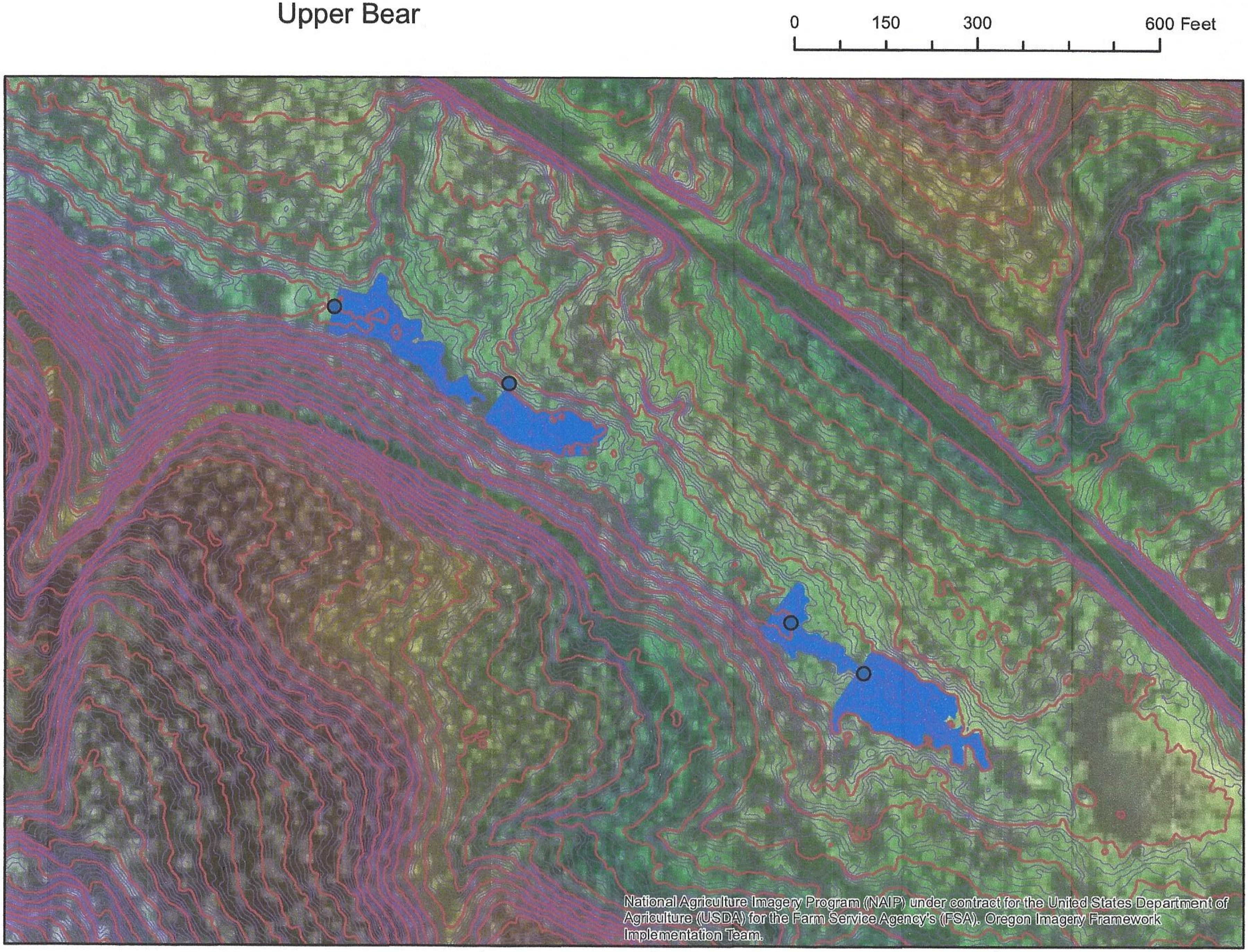
Stream	Structure #	Plant Willow	Vine Maple weave	Fir Limb Weave	Girdle	Fall	No Weave	Den Constructed	Constructed Den Utilized	Support existing BD	Food cache	Beaver Use Post Consruction	Dam Height (Ft)	Aggradation	Under Scour	Lateral Scour	Plunge Scour	Impounds @ low flow w/o Beaver	Pool Lift (Ft)	Legacy Beaver Pond site	Pre/Post Change in Surface Area for BDA only (Sq Ft)	Additional coho smolt capacity BDA only (1.6 smolts / sqm or 6,475 smolts / acre)	Pre/Post Change in Surface Area for all natural dams above BDA (Sq Ft)	Additional coho smolt capacity for all natural dams above BDA (1.6 smolts / sqm or 6,475 smolts / acre)	BDA survived 1st winter	BDA survived 2nd winter	BDA survived 3rd winter
BUSTER	1	Y	Y																	y					Y		
BUSTER	2	Y	Y																	y					Y		
BUSTER	3	Y	Y					y	y		y									y					Y		
BUSTER	4	Y	Y								y									y					Y		
BUSTER	5	Y	Y								y									y					Y		
BUSTER	6	Y	Y																	y					Y		
BUSTER	7	Y	Y								y	y	2.00	y		y				y					Y		
BUSTER	8	Y	Y																	y					Y		
BUSTER	9	Y					y			Y										y					Y		
BUSTER	10	Y					y			Y										y					Y		
BEAR	1	Y	Y							Y	Y		2.00	1.00				Y	2	Y	2070	308			Y		
BEAR	2	Y	Y			Y		Y												Y					Y		
BEAR	3	Y					Y							0.33					0.3	Y					Y		
BEAR	4	Y	Y		Y			Y												Y					Y		
BEAR	5	Y	Y			Y		Y												Y					Y		
BEAR	6	Y	Y					Y												Y					Y		
BEAR	7	Y	Y								Y									Y					Y		
ROCK	1	y		Y									4.00	1				y	4	Y	6150	914			Y		
ROCK	2	y		Y								y	3.50	1					3.5	Y	8500	1263			Y		
ROCK	3	y		Y									1.00		y			y	1	Y	3535	525					
LOUSIGNONT	1		Y											1	y					Y					Y Y Y Y		
LOUSIGNONT	2		Y								y				y	y				Y					Y Y		
LOUSIGNONT	3		Y												y					Y					y		
LOUSIGNONT	4		Y												y					Y							
LOUSIGNONT	5		Y											0.83				y		Y	480	71					
LOUSIGNONT	6		Y													y				Y	90	13					
LOUSIGNONT	7						Y				Y	Y	1.00	1				Y	1		70	10					
BUSTER	1														y								blown		y	y	
BUSTER	2														y								3918	582 y	y 1320 y	196 y	
BUSTER	3														y												


Upper Nehalem River Basin
2018
Beaver Dam Analog
&
Large Woody Debris
Project Location
Map
Pilot Study
BDA-1
BDA-2
BDA-3
BDA-4
BDA-5
BDA-6
BDA-7
BDA-8
BDA-9
Buster Creek Rd
Rock Creek
Sterling
3BDA1
3BDA2
3BDA3
3BDA4
3BDA5
3BDA6
3BDA7
NW Lousignont Rd
Elsie
Jewell Jct.
Pope Corner
Vinemaple
Tideport
103
26
CLATSOP
TILLAMOOK
COLUMBIA
STATE
FOREST
CLATSOP STATE FOREST
FOREST RD
NETTLE CREEK RD
GREEN MOUNTAIN RD
BUSTER CREEK RD
KLINES CREEK RD
QUARTZ CREEK RD
STERLING LOOP
RANCH RD
OLSON RD
MCGREGOR RD
WOLF CREEK RD
LOUSIGNONT RD
MORGAN RD
ELLIS RD
SPUR
WHEELER
CAMP RD
TWEEDLE LN.
MULLENBACH LN.

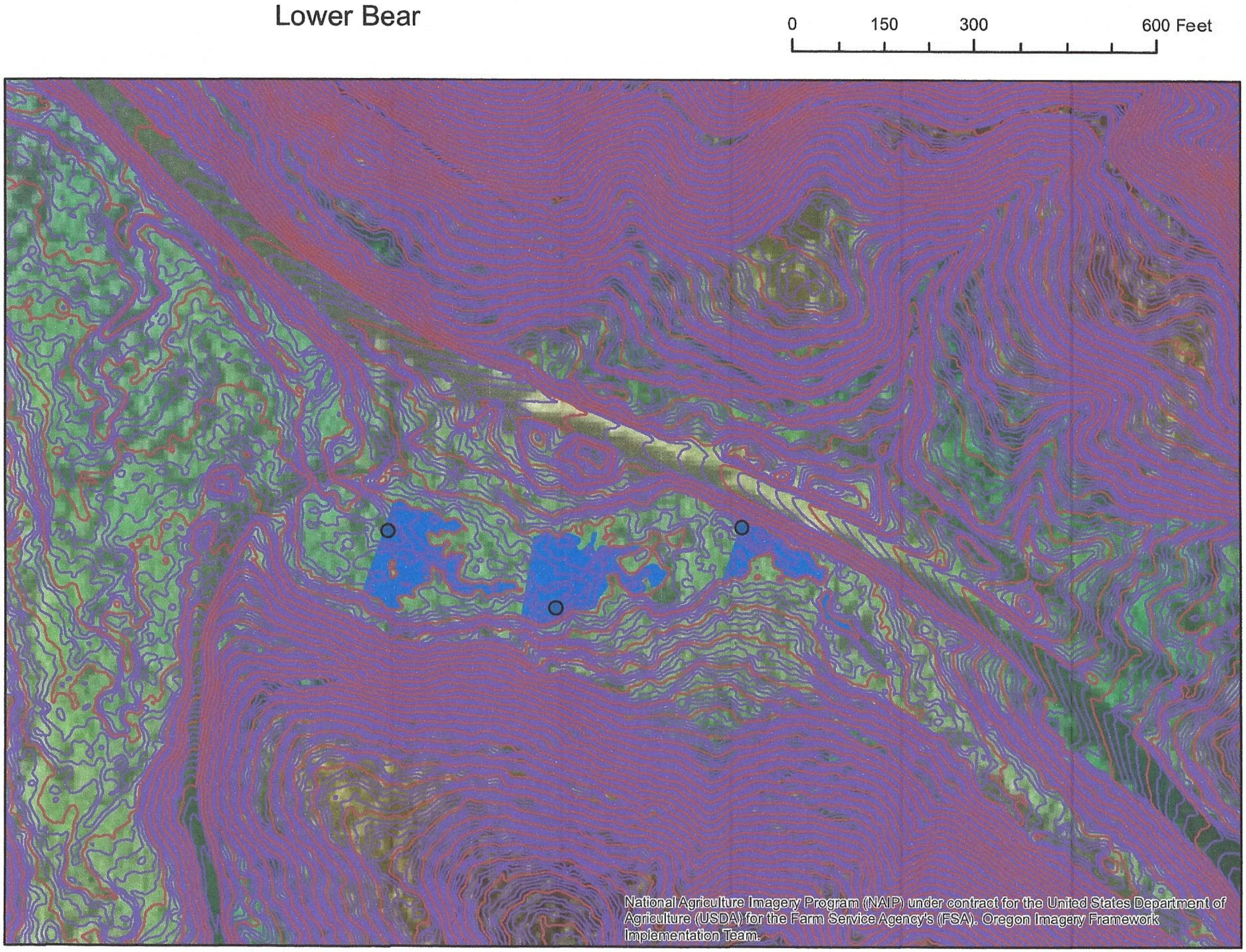
Upper Rock overview



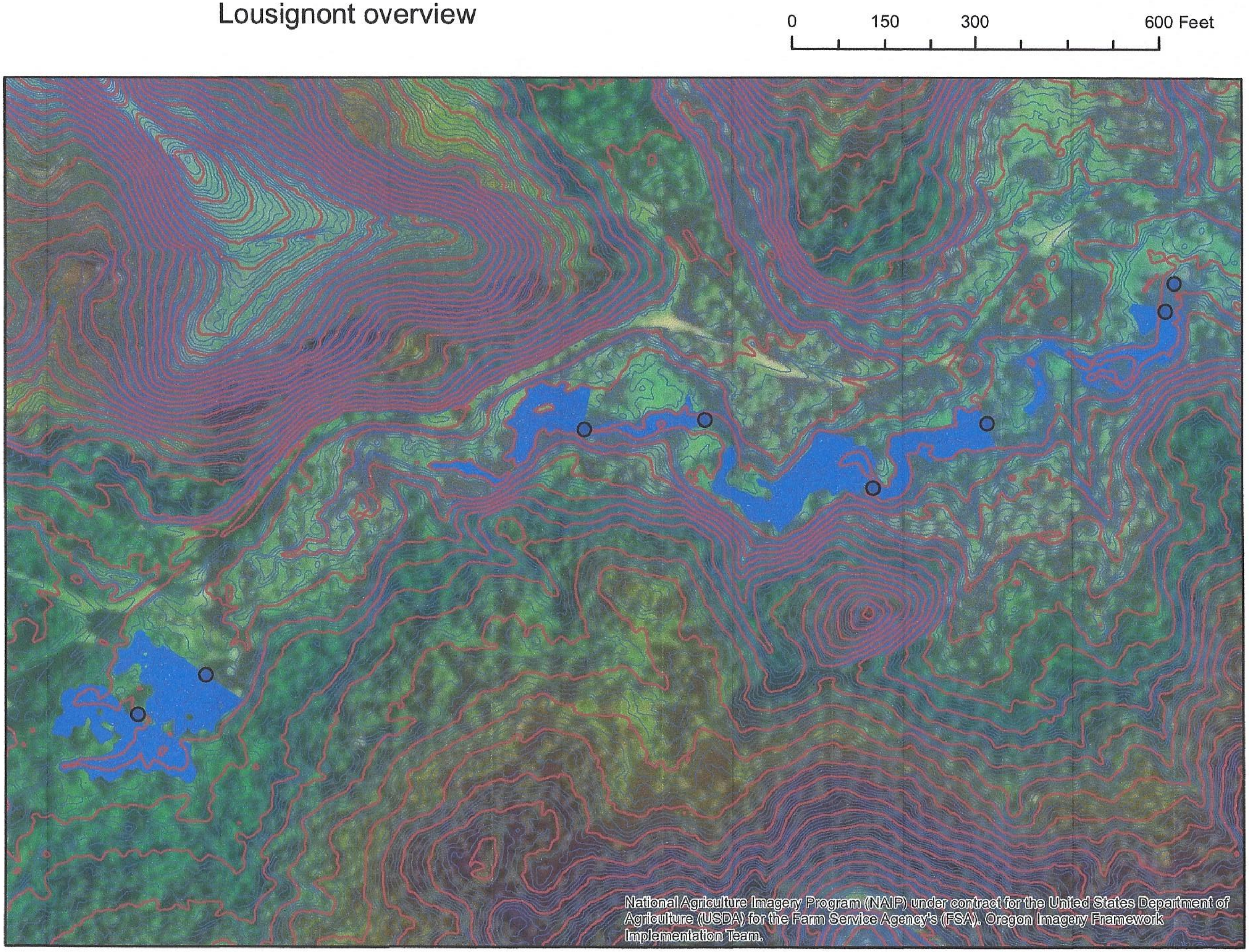
Upper Bear


0
150
300
600 Feet
National Agriculture Imagery Program (NAIP) under contract for the United States Department of Agriculture (USDA) for the Farm Service Agency's (FSA). Oregon Imagery Framework Implementation Team.

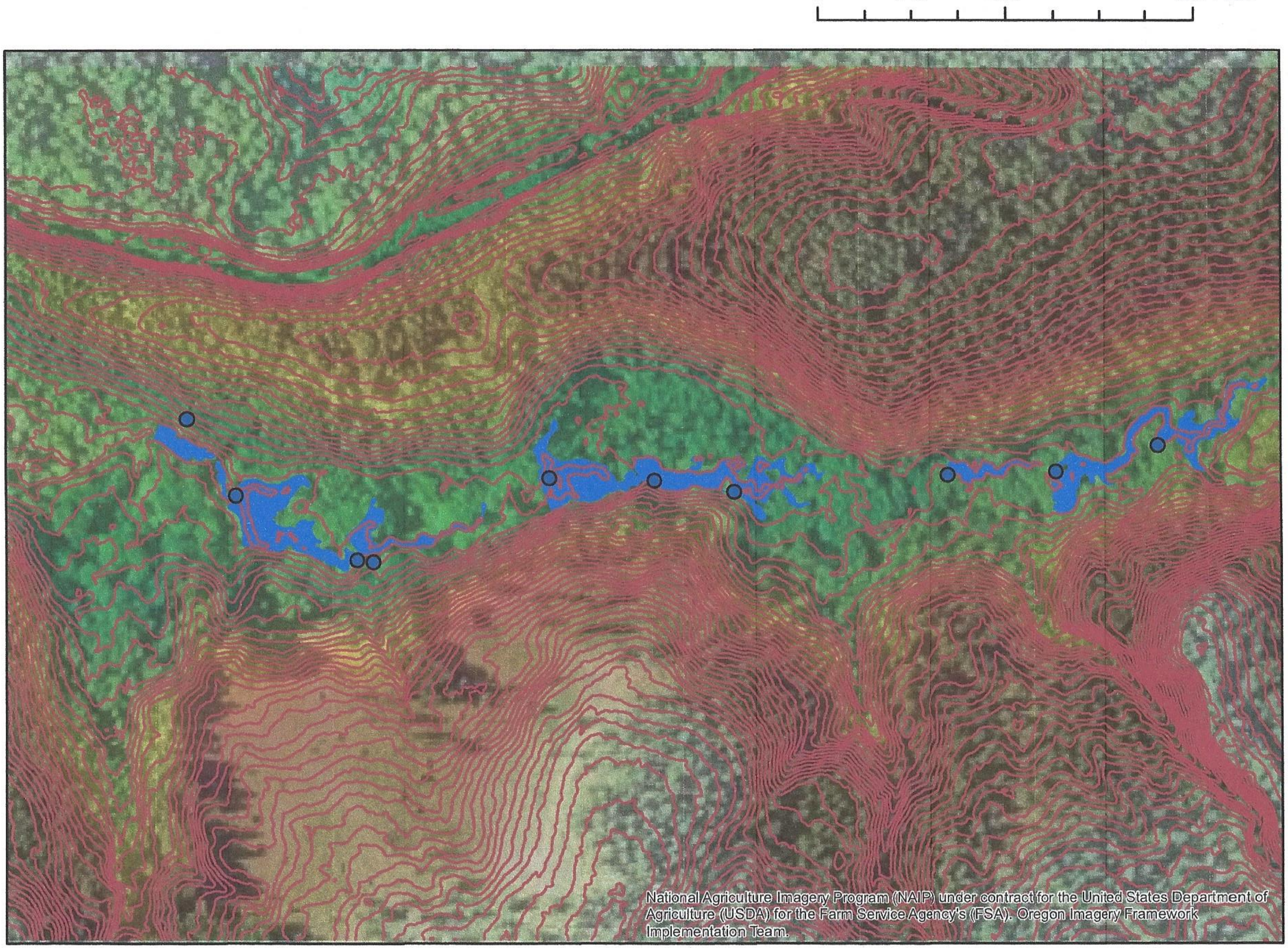
Lower Bear

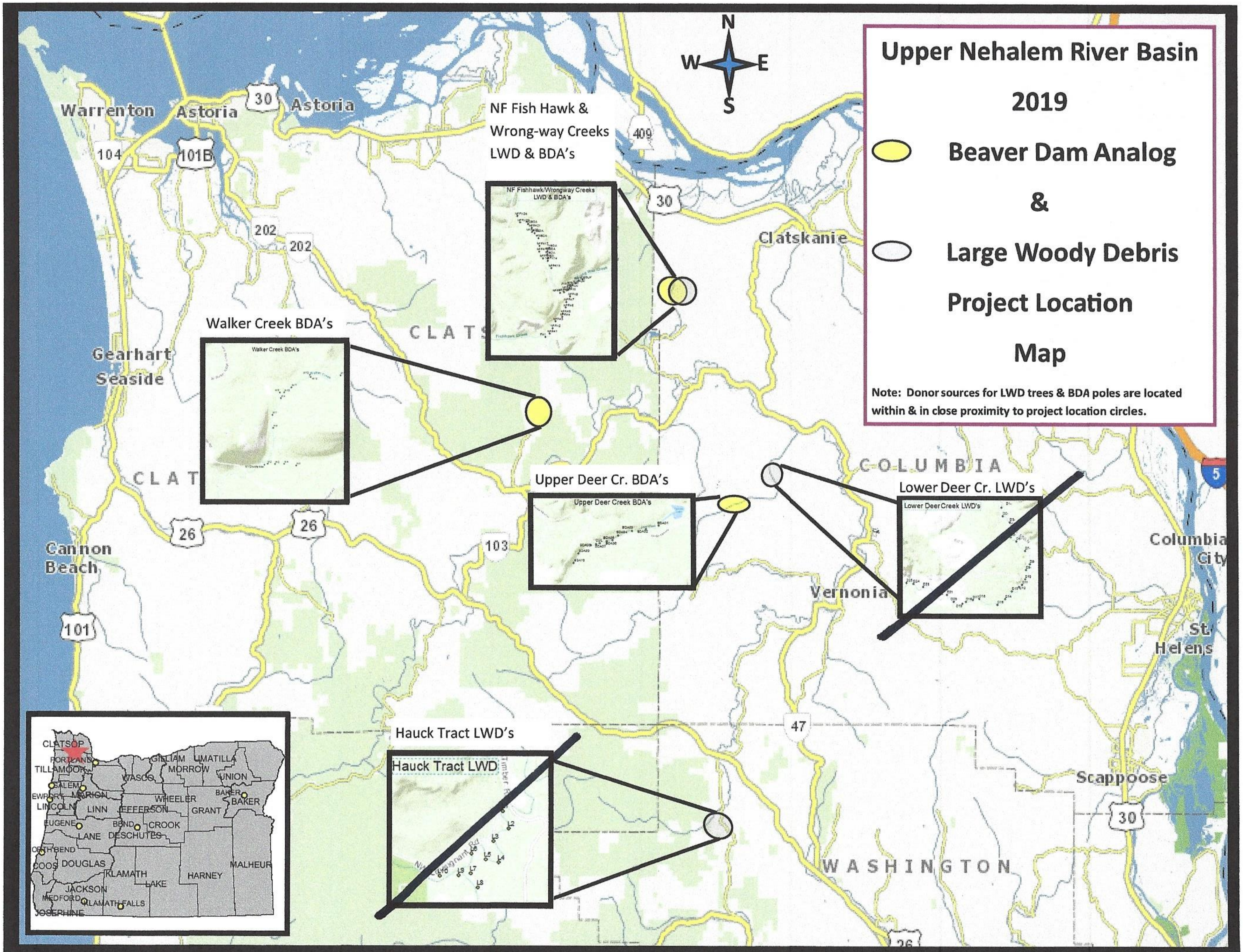

0
150
300
600 Feet
National Agriculture Imagery Program (NAIP) under contract for the United States Department of Agriculture (USDA) for the Farm Service Agency's (FSA). Oregon Imagery Framework Implementation Team.

Lousignont overview



Buster overview





Upper Nehalem River Basin
2019
Beaver Dam Analog
&
Large Woody Debris
Project Location
Map
Note: Donor sources for LWD trees & BDA poles are located within & in close proximity to project location circles.
NF Fish Hawk &
Wrong-way Creeks
LWD & BDA's
Walker Creek BDA's
Upper Deer Cr. BDA's
Lower Deer Cr. LWD's
Hauck Tract LWD's
Hauck Tract LWD
N
W
E
S
Warrenton
Astoria
Gearhart
Seaside
Cannon
Beach
Clatskanie
Vernonia
Columbia
City
St.
Helens
Scappoose
CLATS
CLAT
COLUMBIA
WASHINGTON
30
104
101B
202
409
26
103
101
47
5

Walker Creek - Upper Nehalem River Basin - 2019

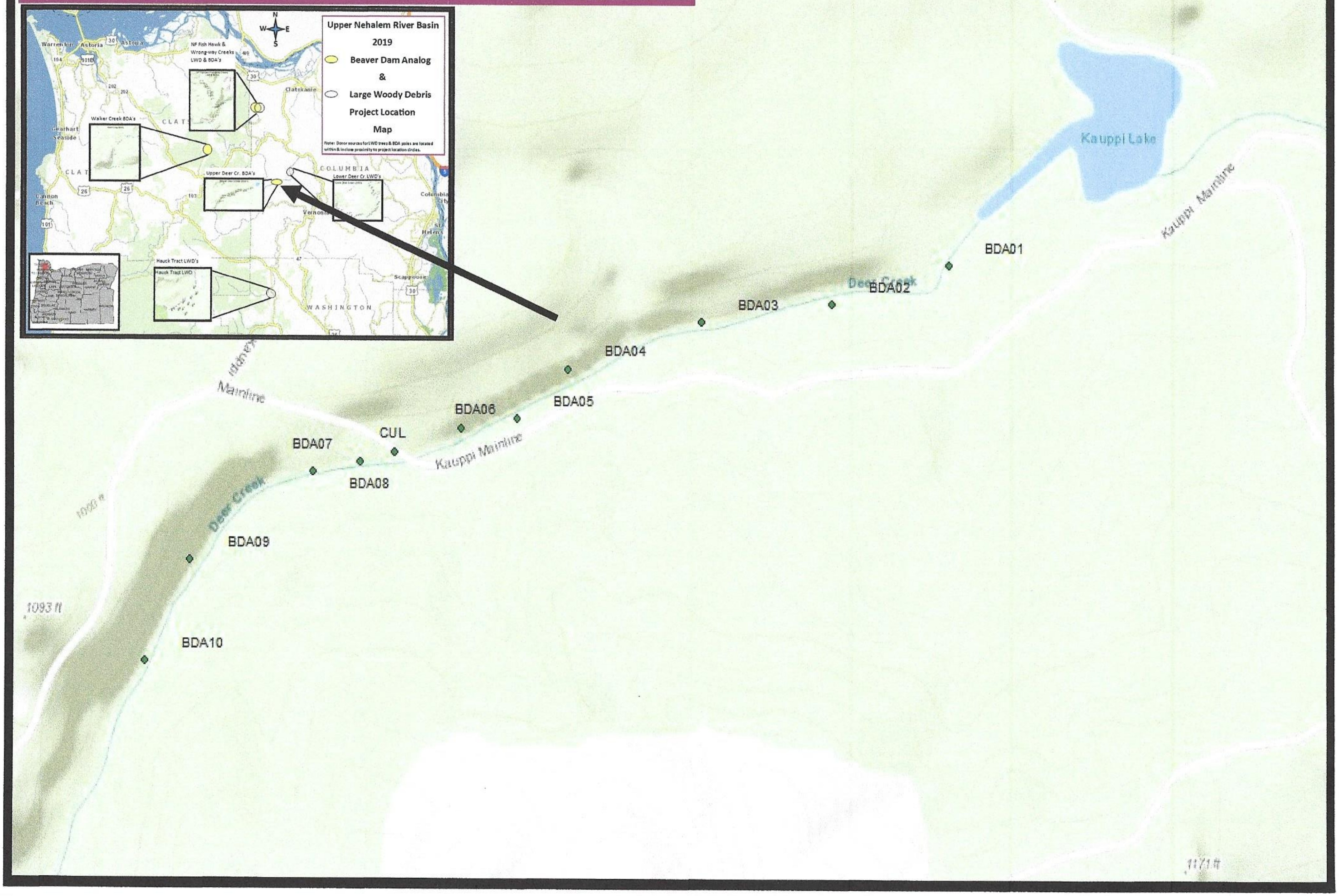
Beaver Dam Analog Location Map - Sites W1 through W14

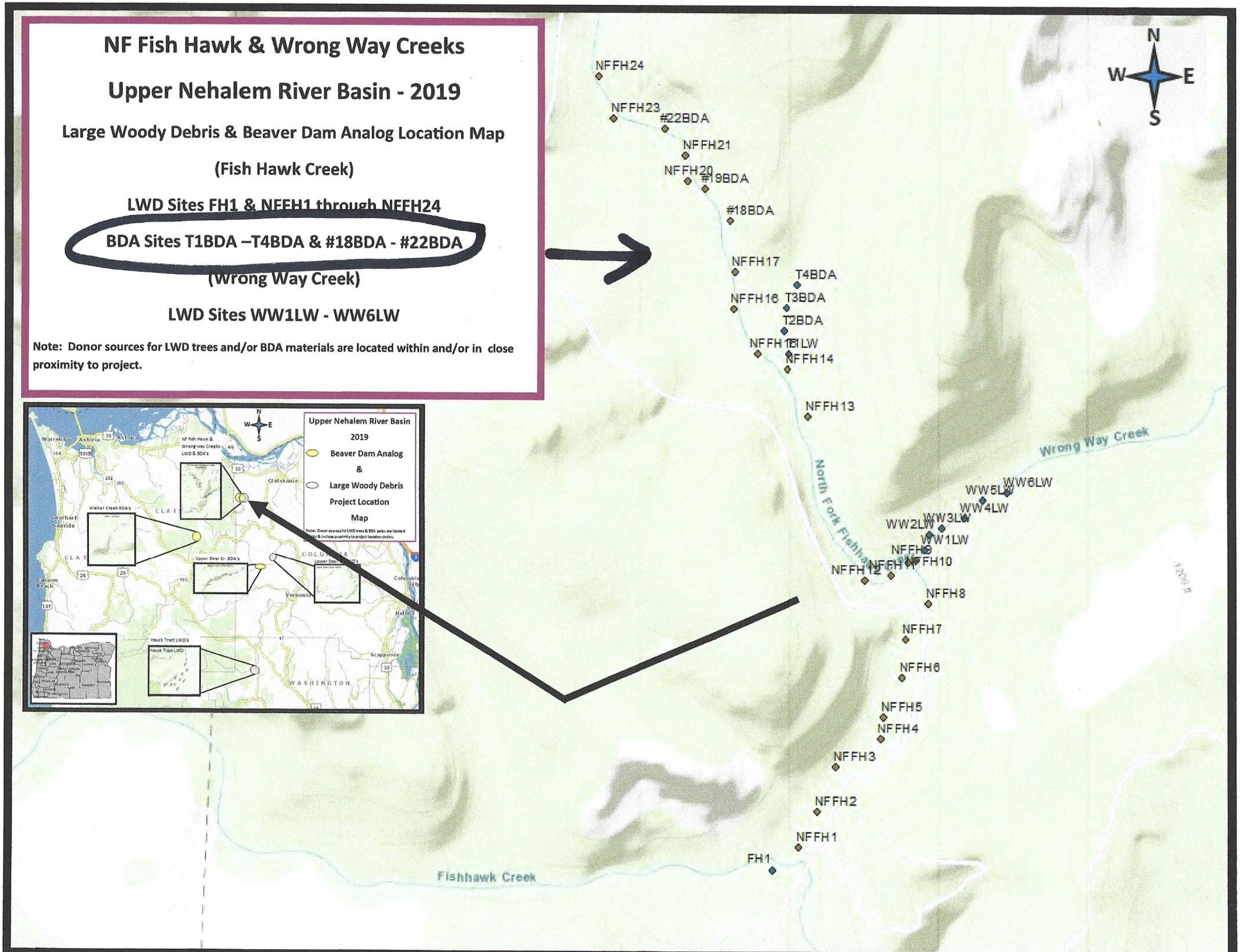
Note: Donor sources for LWD trees and/or BDA materials are located within and/or in close proximity to project.

Upper Deer Creek - Upper Nehalem River Basin - 2019

Beaver Dam Analog Location Map - Sites BDA01 through BDA10

Note: Donor sources for LWD trees and/or BDA materials are located within and/or in close proximity to project.





NF Fish Hawk & Wrong Way Creeks
Upper Nehalem River Basin - 2019
Large Woody Debris & Beaver Dam Analog Location Map
(Fish Hawk Creek)
LWD Sites FH1 & NFFH1 through NFFH24
BDA Sites T1BDA –T4BDA & #18BDA - #22BDA
(Wrong Way Creek)
LWD Sites WW1LW - WW6LW
Note: Donor sources for LWD trees and/or BDA materials are located within and/or in close proximity to project.
Upper Nehalem River Basin
2019
Beaver Dam Analog
&
Large Woody Debris
Project Location
Map
NF Fish Hawk & Wrong-way Creeks LWD & BDA's
Walker Creek BDA's
Upper Deer Cr. BDA's
Lower Deer Cr. BDA's
Hauck Tract LWD's
Warrenton
Astoria
Clatskanie
Gearhart
Seaside
Cannon Beach
Vernonia
Scappoose
Helens
Columbia
WASHINGTON
N
W
E
S
NFFH24
NFFH23
#22BDA
NFFH21
NFFH20
#19BDA
#18BDA
NFFH17
T4BDA
NFFH16
T3BDA
T2BDA
NFFH14
NFFH13
North Fork Fishhawk
Wrong Way Creek
WW6LW
WW5LW
WW4LW
WW3LW
WW2LW
WW1LW
NFFH9
NFFH10
NFFH11
NFFH12
NFFH8
NFFH7
NFFH6
NFFH5
NFFH4
NFFH3
NFFH2
NFFH1
FH1
Fishhawk Creek

Crawford Creek—Upper Nehalem River Basin - 2020

Beaver Dam Analog Location Map - Sites BD 1 through BD 8

Note: Donor sources for LWD trees and/or BDA materials are located within and/or in close proximity to project.