# Beavers in Neskowin

## A Collaborative Beaver Plan for Hawk Creek

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**Funded by:**

Oregon Watershed Enhancement Board

The Nature Conservancy

Nestucca, Neskowin, the Sand Lakes Watershed Council

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**Suggested citation:**

Shockey, J. (2023). Beavers in Neskowin, A Collaborative Beaver Plan for Hawk Creek. Project Beaver, Jacksonville OR. 52 pp .


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# How to Use This Plan

This document attempts to do two things: It provides a set of recommendations for coexisting with beavers and a how-to plan for building aquatic habitat resiliency through partnering with beavers. The recommendations in this plan are based on feedback during meetings and field trips conducted in 2021 and 2022. These recommendations are in the "A Snapshot in Time" section and the suggested project plan appendices.

The rest of this plan lays out a toolkit and approach that is more stable over time—a roadmap towards partnership between beavers and humans in Neskowin.

# Introduction

For millions of years, the North American Beaver has actively shaped the form and function of aquatic ecosystems in North America. Perhaps even more than glaciers or plate tectonics, beavers have shaped our landscape. These large rodents make a key biotic contribution to alluvial floodplain processes that slow water flow and increase sediment retention. Through their persistent construction of dams, ponds, channels, and burrows, beavers slow the transport of water and sediment, allowing it to spread out, building the valley floors that we—and myriad other species—call home.

Beavers are the quintessential "keystone species" for the landscape of the Northern Hemisphere. They provide a stable habitat niche within which the rest of our aquatic ecosystems have evolved, forming the riverscape on which our fish and wildlife resources depend. Beaver-managed riverscapes are prime salmon, trout, and lamprey habitat. Beavers create the complexity and diversity these fish need at every stage of their life cycle: clean gravels for spawning; slower water along the edges of streams and in side channels for babies; warmer nutrient-rich patches to grow bugs for fish food; and clean, cold, deep water in the main stem for traveling adults. On Oregon's coast, in particular, beavers are critical in creating and maintaining the nursery habitat needed by juvenile Oregon Coast coho salmon, an Evolutionarily Significant Unit (ESU). This nursery habitat is critical for the recovery of Oregon Coast coho populations, as it is the place where juveniles grow and strengthen before they head out to sea.

As we face foreboding impacts from climate change, it's important to note these benefits beaver provide for climate resilience and adaptation. Beaver ponds and wetlands are sinks for carbon and processing domains for nitrogen and phosphorus. High in a watershed, beaver slow the runoff of melting snow-pack, allowing it to sink into the ground like a sponge for slow release later in the season. Beaver-managed floodplains cool water, store water, reduce the force of floods, and create resilience amidst wildfire. Within our lifetimes, we have become acclimated to riverscapes without this pervasive engineering influence of beavers. The streams and rivers we are familiar with, those that curve through a valley bottom as a single channel with dry banks on either side, are a recent product of human tinkering. Our baseline for what is a normal and healthy riverscape has shifted from what these systems actually looked like before the large-scale historic removal of beavers.

## History

In most areas of the North American West, our watersheds house just a fraction of the beaver populations they once supported, and their absence is felt like a ghost across the landscape. It shouldn't be surprising then, that with drastically reduced populations of the ecosystem engineer who built and maintained these systems, the structure and complexity of our streams, rivers, wetlands, and floodplains has declined. Without beavers, streams incise,

In 1794, the explorer David Thompson penned in his journal when reviewing the North America of his day:

> *"it may be said to have been in possession of two distinct races of Beings, Man and the Beavers... [sic] except the Great Lakes, the waves of which are too turbulent, [beavers] occupied all the waters of the northern part of the Continent. Every River where the current was moderate and sufficiently deep, the banks at the water edge were occupied by their houses. To every small Lake, and all the Ponds they builded Dams, and enlarged and deepened them to the height of the dams. Even to grounds occasionally overflowed, by heavy rains, they also made dams, and made permanent Ponds, and as they heightened the dams [beavers] increased the extent and added to the depth of the water; Thus all the low lands were in the possession of Beavers, and all the hollows of the higher grounds."*

This is the past context of a beavers-managed landscape from which our baseline of "normal" riverine ecology has shifted.

down-cutting lower and lower until locked into a trench, disconnecting from their floodplains, and simplifying into single-threaded channels. Sediment and carbon are exported from long-term storage, water warms and loses its oxygen, becoming eutrophic, and the landscape dries out. The impact is felt well beyond the banks of streams and rivers, as the water table drops and entire forests are stressed. Forest fires grow into megafires, burning for miles across a uniform expanse of fuel. Across North America, but especially in the West, our watersheds and ecosystems are impoverished by the loss of old complex natural processes (like beavers), and the species of fish and wildlife that depend upon this waterway habitat are struggling.

In 1794, explorer David Thompson describes a North America vastly different from the one we see today, now degraded beyond recognition in just 200 years. The North American Beaver was trapped to near extinction in the heyday of fur trapping to feed a fashion market, which sustained the first Euro-American colonies and drove western expansion. On the west coast, no company was more associated with this extraction of beaver pelts from the landscape than the Hudson Bay Company.

Sometime in the early or mid 1800s, a Hudson Bay Company ship wrecked off the Oregon coast near the present-day community of Neskowin. At the time of this wreck, the Nestucca people lived in this area. A significant number of timbers from this ship washed ashore, and some of the Nestucca were able to salvage these heavy slab planks to construct a solid cabin. This structure was later claimed for $30.00 by settler Chris Christensen. The nearby stream, reportedly first called Neschesne, was renamed Slab Creek by the arriving European immigrants and pioneers, after the number of lumber slabs still lying around. And so the wreck of that vessel from the fur trade era left its mark.

Today, the vibrant human community of Neskowin inhabits this area, as does a thriving community of beavers, which have slowly returned to this landscape. In the center of this community, a parcel of public land under the stewardship of the U.S. Fish and Wildlife Service has dramatically changed since the establishment of the Nestucca Bay National Wildlife Refuge. In just two decades, beavers have resumed managing the hydrology, building dams and fully reconnecting the floodplain in many areas—creating acres of highly functional habitat. This, in turn, has led to an increase in young beavers dispersing out from the wildlife refuge onto adjacent private lands and businesses. Given that the land-use objectives of beavers and humans are often different, this increase in beaver activity directly conflicts with certain areas of human infrastructure and land use. To mitigate the increased flooding due to beaver dams, and with no other options apparent, notching down dams and trapping the beavers has seemed to be the only answer. Yet at the same time, there are areas where beavers and their habitat-building would be welcome—such as in the upper reaches of the Hawk Creek watershed, where a history of clear-cut logging has degraded the quality of the stream ecosystem. And so, today, we find ourselves in a predicament.

### A collaborative approach

Much of the upper Neskowin watershed is accessible to beavers, and there is occasional evidence of them moving through. However, having suffered degradation over time, the natural processes that create habitat and diversify an ecosystem have been constrained and simplified, resulting in stream conditions that don't offer beavers enough of what they need to survive. Instead of moving upstream, young, dispersing beavers are choosing to remain in the low-gradient areas, nearer to the coast and closer to people. The subsequent impacts on human infrastructure, homes, and businesses have frustrated the local community. No matter the benefit beaver can provide coho, when they're flooding a septic field or a golf course, or clogging a culvert under a major highway, those conflicts must be resolved. A comprehensive management plan and restoration strategy is needed to remedy these problems of frustration, damage, and the resulting beaver "population sink" in key areas of repeated lethal trapping, which also addressing the need for climate adaptation, water security, and salmon recovery. To that end, the Neskowin Beaver Collaborative group came to be. Comprised of community members, landowners, business owners, non-profit organizations, and state and federal land managers, the Collaborative seeks to find solutions that are acceptable and, in the greater picture, beneficial to all..



## Understanding beavers

Beavers are herbivores, eating primarily the cambium (the layer just below bark) from trees and shrubs. Species like willow, cottonwood, and ash have co-evolved with this activity, and can re-sprout after repeated browsing by beavers. Aspen actually depends upon disturbance to spur growth. In addition to trees and shrubs, beavers eat aquatic vegetation, grasses, rushes, sedges, and forbs.

A beaver family typically consists of a breeding pair (beaver often mate for life), their two to four newborn kits from the current year, and their two to four yearling kits from the previous year. The juveniles generally disperse towards the end of summer in their second year of life. The geographic area of a beaver family's territory and home range seems to vary depending upon food availability. As such, the visible impact and intensity of beaver activity also varies as they move around their territory, foraging on various plant species at different times of year.

Beaver dams are their telltale sign on the landscape. Beavers build their dams out of sticks, mud, grass, and even rocks, in a variety of types of bodies of water: wetlands, marshes, the outflow of ponds

and lakes, river side channels, and small to medium-sized streams. Generally speaking, beavers may build dams anywhere they sense the flow of moving water to slow that flow and create a pond to deepen the water. This keeps them safe from predation, both around their lodge or den and across the range of their active territory. Most important to the whole family's safety, they will maintain the water depth around the underwater entrance to their lodge or den, concealing the entrance and protecting it, by building what we refer to as their "primary dam" just downstream. Because of its importance, they are most attentive to any leaks or potential damage to this dam—often repairing any breach within just one night. Beaver also build dams to facilitate safe movement throughout their territory, increasing the water depth just enough to dig out canals—little water slide highways—that allow them to move about far more quickly than if they were waddling on land. These dams can be thought of as secondary, or auxiliary dams. Beaver are often less invested in these structures and may be slower to repair them if they are breached or removed.

## Habitat

Beavers, like people, tend to prefer fertile low-gradient valley bottoms over steeper mountain streams, for these valley bottoms typically boast sufficient water, plants for forage and building materials. In areas where there is an existing abundance of deep water, such as in large streams and rivers or lakes, beavers don't need to build dams to create protection from predators. In such habitat, they will dig out bank dens—secure in the dry riverbank. These living quarters are subterranean air pockets, accessible only through underwater tunnel entrances, and often positioned under the roots of a large tree to help protect against predators that may attempt to dig in on them from above.

Beavers exhibit different behaviors and strategies for survival across a wide range of habitat conditions. In areas with high, disconnected banks and deep water, they almost invisibly live in bank dens, felling trees only if they need to access upper limbs and leaves for food. In areas with limited water or shallow water, they build dams to facilitate more deep-water habitat for safety and improved mobility. Where the floodplain and expanse of water extend across a valley from slope to slope, beaver build free-standing lodges to raise their living quarters up out of the water. European trappers and explorers, when traversing the landscape of North America prior to large-scale beaver trapping, noted that in expansive wetlands covering entire valley bottoms, there were always beaver lodges poking up like small islands—frequently crowned by the nests of Trumpeter Swans.

## Population dynamics

Because beaver populations are not at carrying capacity—the limit at which an ecosystem cannot support more of any given species—dispersing beavers have a wide geography with a lot of options to explore when they are choosing where to live. This is important to note when contemplating beaver through the lens of a desired restoration action. We often see beaver preferring to fill the habitat of valley bottoms first, but our restoration preference is generally to have them reestablish high in the watershed, where we most need their engineering expertise. When beavers do target higher elevation sites, or those with steeper gradients, it is thus essential that we do what we can to sustain these families in place. These populations are especially vulnerable to both natural predation and recreational trapping as they grow from just one pair of animals—who have a lot of work to do to build the water depth and shelter they need to stay safe. As the first breeding pair in a new area, they represent a frontier for beaver dispersal deeper into the watershed, and all future ecosystem benefits hinge on their establishment and continued reproductive success.

In areas where we don't see beavers living in what appears to be suitable habitat, it is often the case that there is even better unoccupied habitat nearby. In a system that has not returned to its carrying capacity since the fur trade era, if dispersing beavers continue to choose an area of habitat and are repeatedly removed from that habitat by humans, that area can be thought of as a "population sink." Dispersing beavers arrive and are killed, arrive and are killed, and the spot becomes a "black hole" for the population, functionally stalling any further dispersal past that spot into the habitat beyond. We see this across the Pacific Northwest, both at sites where recreational and market trapping is frequently practiced, and in areas where beavers are regularly removed due to conflicts with human infrastructure.

## Benefits to the ecosystem

The remnants of those once vast, pre-fur trade beaver populations now live in a dramatically altered and impoverished hydrologic world. In addition to the degradation caused by the removal of beavers, human activities over the last 150 years have drastically impacted the landscape; road building, mining, overgrazing, wetland removal, channelization for irrigation, and development have all encroached on ecosystem function. We place a significant emphasis on the value of beaver dams, but incised streams with the force of a fire hose will blow out all but the strongest dam-building effort. This doesn't mean we ought to write off beaver restoration as a lost cause, but rather quite the opposite. It means we ought to double down on our efforts to employ restoration actions to kickstart the systems back towards health, so that able beavers can again resume a management role in our waterways. Furthermore, in addition to dams, beaver presence itself brings a whole host of desirable impacts. Through their foraging and tree-felling, beavers move literal tons of vegetation from the riparian forests into the aquatic habitat. This allochthonous input of trees, branches, twigs, leaves—and even beaver scat—contributes nutrients to the aquatic food-web. Floating collections of beaver sticks will aggregate in pools, becoming tangles of habitat that biologists have called "river reefs" for the reef-like diversity of life they support. Jumbles of larger branches and logs provide structural complexity and diversified habitat. Even the dug-out entrance to a bank den and the canals beavers excavate to move materials throughout the landscape play a role, serving as some of the best rearing and escapement habitat for young fish. In conclusion, even if we don't see beavers currently building and behaving in the classic manner they historically did, they are valuable—essential even--to our watershed systems. We ought to use all of the tools that we can—for infrastructure protection, coexistence, and restoration—to help them reestablish where we so desperately need them.

# A Snapshot in Time

This assessment and its accompanying recommendations are rooted in the site visits and collaborative process that unfolded across late 2021 and early 2022. Our focus is on the area around Neskowin, including Hawk Creek and Kiwanda Creek. We did not assess Neskowin Creek ( formally Slab Creek) or Butte Creek.

## Current assessment

For ease of communication, the following overview map shows designated specific geographic areas with generic numeric names (see Figure 1). The points in this map correspond with those in the following table (see Table 1), which highlights the observations of stakeholders on current beaver activity, regular high-water, areas of concern, restoration potential, and other seasonal notes. This list is not an exhaustive survey of all beaver-related activity—it is snapshot of observations that emerged during this collaborative project.


Figure 1. Overview map showing zones and points of interest.

**Table 1: Observations of current beaver activity**

| Point | Observations |
|---|---|
| **Zone A** | There have been occasional dams within this zone along the east side of Highway 101, where some flow from Hawk Creek moves south before crossing under 101 in an old culvert at point #17. Dams in this area can back water up into the main channel of Hawk Creek, and upstream. Someone installed a pond-leveler within the Oregon Department of Transportation (ODOT) right of way, but this flow device was poorly constructed, undersized, and wasn't maintained. It seems to have become silted in and is no longer operable. |
| 20 | Big primary dam with active beaver lodge just upstream. Dam causing flooding at Schlictings (point #21). Recently blew out in winter flood so not currently a problem. |
| 21 | Flooding from dam in refuge (point #20) impacting human infrastructure. |
| 17 | Small culvert near Summit Road that ODOT should replace, beavers could easily dam in the future. |
| **Zone B** | There has been seasonal beaver activity within this private land zone, with damming often occurring near point #23. These beavers are likely to be dispersing young beavers from the wildlife refuge area, and those that have attempted to set up territories in this area have been lethally trapped out due to concerns around floodplain reconnection. |
| 23 | Site of repeated lethal trapping in past. |
| 25 | Barn nearly flooded in last storm (2021). |
| **Zone C** | Beavers are not actively maintaining territories within this zone, and forage availability is likely a limiting factor—especially in the upper half within the footprint of recent clear-cutting. In this upper reach a tangle of windfall alders has contributed to instream complexity, pools, and sediment retention that is reconnecting the floodplain. The lower half of this zone does not have this element of instream complexity, but is instead primarily a long riffle of cobble with little large woody debris or other complexity. While the riparian conditions in the upper and lower areas of this zone differ, there aren't suitable forage species like willow, red-osier dogwood, and ash within either reach. |
| 22 | Beaver activity could be encouraged upstream. |

| Point | Observations |
|---|---|
| **Zone D** | Within this zone, beavers are not actively maintaining territories and this is probably because there is very little forage available within the footprint of the golf course. This lack of riparian vegetation like willows is likely to be the main limiting factor keeping beavers from inhabiting the area. To the west of Highway 101, occasional beaver dams within the channel at point #13 will flood the golf course at the ninth green. These dams are routinely removed by hand. No beaver are trapped. |
| 13 | Beavers occasionally build dams in channel that cause flooding to the north. |
| 14 | Ninth green on golf course gets flooded from dams in channel to the south. |
| 18 | Always wet as vegetation shows. |
| 19 | Site needs to be dry in the summer (especially August) as that is peak period for golf course. |
| 7 | East side of golf course is lower than west. |
| 24 | The seventh green that is prone to being flooded from dams in Butte Creek downstream of point #11 in Zone H. |
| **Zone E** | The habitat value for beavers within this area of the Nestucca Bay National Wildlife Refuge is extremely high, given the low gradient, abundant water, and forage availability. This zone is the area in which any beaver dams will influence flooding at the Tsunami Trail. |
| 4 | Tsunami Trail. Major escape trail. Foot traffic recommended. Building emergency supply sheds on hill that will be accessed by the community via this route. Water bureau has line under the trail. Trail designed to be dry 75% of the time. Not statistically significant difference in water level north and south of the trail according to an analysis performed by the US Fish and Wildlife Service. |
| 5 | Beavers build a dam here that causes flooding of the Tsunami evacuation trail, and is likely to be serving as a primary dam. The resulting beaver pond can also flood Hawk Street. Beaver activity can increase in late winter, sometimes seasonally abandoned. In spring the golf course would like a constant flow out of the dam so they can dry out the course. |
| 8 | Previous pond leveler. Worked for a while but ultimately was undersized, not maintained, and failed. |



| Point | Observations |
|---|---|
| **Zone F** | The habitat value for beavers within this area of the Nestucca Bay National Wildlife Refuge is extremely high, given the low gradient, abundant water, and forage availability. There is currently at least one family group of beavers maintaining a territory in the southern area of this zone, as evidenced by signs like cuttings, damming, skid trails, and canals. |
| 2 | Homes with sewer system concerns/failures. Mandatory hook-up vs ultraviolet self-contained package. |
| 3 | Lots of beaver activity, reconnecting floodplain out from straightened ditch that ran through cranberry bogs. |
| 6 | The #5 dam might cause sewer concerns in this neighborhood. |
| **Zone G** | The habitat value for beavers within this area of the Nestucca Bay National Wildlife Refuge is extremely high, given the low gradient, abundant water, and forage availability. There is currently at least one family group of beavers maintaining a territory in this zone, as evidenced by signs like cuttings, damming, skid trails, and canals. |
| 15 | Active beavers and large beaver dam. Influences the Fay property. |
| 16 | New box culvert, water now drains out of Hawk Creek here. Dam to south pushes water south. |
| **Zone H** | While currently inactive, there has been regular beaver activity within this area. The dams within this area have been routinely removed by the golf course to prevent flooding on the seventh green. |
| 9 | ODOT culvert (on list to be replaced). Beaver dam at 90º turn in Butte Creek in the area of upstream culvert mouth. History of upstream beaver damming activity and supportive landowner. |
| 10 & 11 | Multiple old dams between these points #10 and #11. |
| 12 | Regular dam breaching and removal in the past throughout Butte Creek between here and Highway 101 to manage flooding at the seventh green. Quality fish and wildlife habitat. Concern is around flooding that moves south-southwest onto the course. |

# Recommendations


Aside from these project areas, there will be areas where the habitat created by beavers is not desired (currently zones B and D). In the case of these two zones, the intrinsic habitat value for beavers is very high, and it will take active human intervention to maintain the incised conditions with poor forage availability that currently limit beaver activity. If more native trees and shrubs establish along these reaches, the value of the beaver habitat will increase and more activity can be expected. If beavers do establish a territory within either of these floodplain zones, pond levelers may be used to minimize the footprint of the impoundment behind the beaver dam, but only if enough deep-water habitat can be tolerated to facilitate a functional pond leveler installation.

These zones are both low gradient and wide, as evidenced particularly well by LiDAR imagery (see Figure 2 for imagery of Zone B). If land use in either of these zones were to allow for more beaver ponds, beavers would create functional habitat quickly, with little or no human restoration effort required. Planting willow cuttings would hasten that process.

These recommendations represent this snapshot in time. There will be other, future needs for this plan's toolkit—whether it be habitat modification to restrict the habitat footprint near human infrastructure, businesses, or homes, or habitat restoration within another area (like Butte Creek east of Highway 101).



Table 2 summarizes the potential projects that are recommended at the time of this writing. The corresponding sections that follow include the recommended project details, such as goal, strategy and success metrics, project background, current conditions, objectives and technical approach, permitting, and dependencies.

## Table 2: Potential projects

| | |
|---|---|
| 1 | **Monitor beaver activity** |
| 2 | **Conduct Habitat Restoration in Upper Hawk Creek** |
| 3 | **Install Pond leveler at Highway 101 and Hawk Creek** |
| 4 | **Install Pond leveler at Tsunami Trail and Kiwanda Creek** |
| 5 | **Address Flooding at seventh and ninth greens at golf course** |

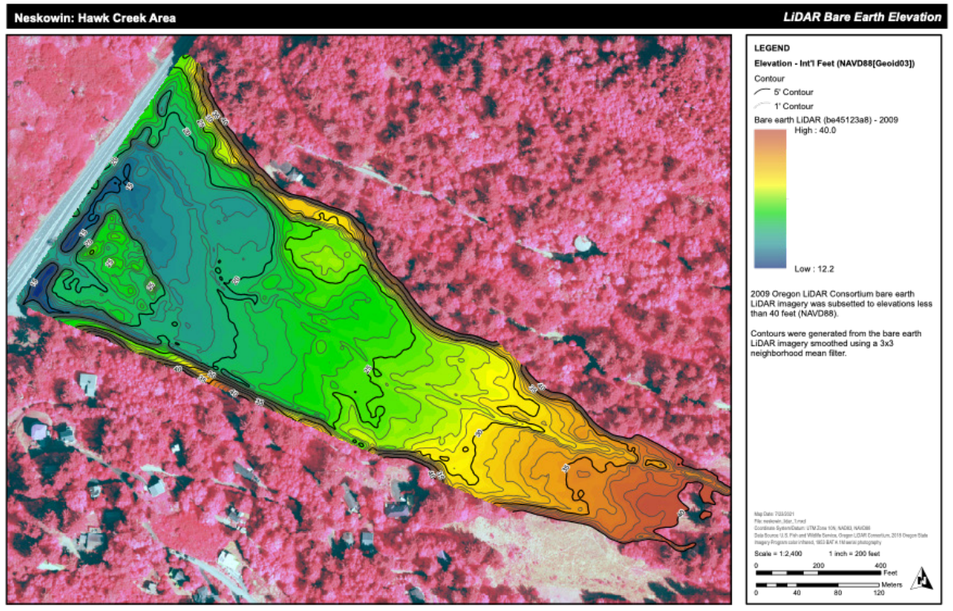



Figure 2. LiDAR imagery of Zone B.

# Monitor Beaver Activity

## Project Background

As outlined in the plan, beaver activity should be monitored in areas where there is the potential for negative impacts to human infrastructure, homes and businesses, or important trees, in order to remedy future conflict before it becomes critical. Beaver activity should also be monitored in areas where increased beaver activity is desired and promoted through restoration.

| | |
|---|---|
| **Stream** | Hawk Creek and Butte Creek |
| **Area** | Private land, ODOT right-of-way |
| **Goal** | Track beaver presence and activity over space and time to inform future decision making |
| **Strategy** | Conduct rapid walking assessments to survey for changes in beaver presence and activity, and point assessments for an area of specific concern |
| **Tools** | Monitoring |
| **Success** | Informed collaborative and adaptive problem solving for the community of Neskowin into the future |



## Objectives

- Track beaver activity at areas where there is the potential for negative impacts to human infrastructure, homes and businesses, or important trees.
- Track beaver presence and activity in areas where increased beaver activity is desired and promoted through restoration.
- Record only the data that is needed and useful—avoid overly complicated monitoring that could be confusing or generate too much irrelevant data.


Figure 3. Map of recommended point and rapid walking assessments.

## Technical Approach

Follow the protocol as outlined in this plan. We recommend setting up the following assessments (see figure 3).

***Walking surveys:***

- **Survey #1:** A walking assessment of the incised channel of Hawk Creek in the floodplain east of Highway 101 on private lands.
- **Survey #2:** A walking assessment of Hawk Creek upstream of the valley bottom through private lands.

*Point assessments:*

- **Point assessment #1;** The water level impacting infrastructure east of Highway 101 on private land.
- **Point assessment #2:** The water level impacting the Tsunami Trail on the wildlife refuge.
- **Point assessment #3:** The water level impacting golf course from damming south in Hawk Creek.
- **Point assessment #4:** The water level impacting golf course from damming north in Butte Creek.
- **Point assessment #5:** Damming within undersized culvert under Highway 101 near Summit Road.

## Permitting

There are no standard permits required for this activity; however, permission must be granted to whomever will be collecting the observations for access to these points by the applicable landowner.

## Dependencies

- A lead entity must be established (like the Nestucca, Neskowin, and Sand Lakes Watershed Council) to coordinate and administer this project as recommended in the plan.
- We recommend installing staff gauges (like the existing one near the Tsunami Trail) at point assessment sites where water levels are explicitly of concern (such as assessments #1, #3, and #4).



# Upper Hawk Creek Habitat Restoration

## Project Background

Much of upper Hawk Creek within Zone C could benefit from beaver activity, but beavers are currently not choosing to set up territories there. This lack of activity is probably due to two factors: limited forage and instream complexity in Zone C, and a population sink in Zone B around the willows at Point #23 (see Figure 1 in plan). Dispersing beavers have found the area around this point to be higher quality unoccupied habitat than that within Zone C. Those young beavers that settle in Zone B have been trapped out, leaving this area un-occupied for the next dispersers to find, and given the quality of habitat around Point #23, we can expect this treadmill to continue unless we create a different approach.

This population sink has important ramifications to the beavers' use of habitat throughout the rest of Hawk Creek. Even though beavers occasionally move through Zone C, as evidenced by occasional signs of foraging, they are choosing to settle in the lower areas first. However, through a restoration effort within this upper reach, we can increase the habitat value for beavers so they may choose to occupy it. This restoration could be a low-tech, process-based effort to address both the lack of in-stream complexity (where applicable) and forage availability. If this restoration is successful in addressing the limiting factors for beavers, and young dispersing beavers choose to occupy this upper reach, this would lead to improved water quality and quantity in late summer and reduced risk from flooding in the winter. Functional beaver-managed habitat would also increase wildfire resiliency and fish and wildlife habitat, particularly for Oregon Coastal coho.

Within this reach of Hawk Creek there is also an old off-channel reservoir. Due to a breach in the berm that separates this large pond from Hawk Creek at its most upstream point, this site now presents a significant entrapment risk for native fish. The landowner is open to modifying this reservoir to address the entrapment concerns and increase the habitat value in that area.

| | |
|---|---|
| **Stream** | Hawk Creek |
| **Area** | Private land |
| **Goal** | Improve the quality of aquatic and riparian habitat in upper Hawk Creek |
| **Strategy** | Restore natural processes to address the limiting factors for beaver habitat within this reach |
| **Tools** | Low-tech process-based restoration and riparian planting |
| **Success** | An increase in aquatic habitat complexity and beaver activity and presence |

## Objectives

- Increase instream habitat structure and complexity .
- Increase riparian habitat complexity to include native species preferred by beavers .
- Increase beaver activity and presence .
- Reduce entrapment risk at the old off-channel reservoir.

## Current Conditions

| | |
|---|---|
| Date(s) Surveyed | September 29, 2021 |
| Start Coordinates | 45.103308, -123.968023° |
| Stop Coordinates | 45.105312, -123.952784° |
| Observer(s): K. Moroney, B. Schlicting, J. Shockey, S. Koenigsberg, G. Amidi-Abraham | |

**Beaver activity**

Occasional sign of beaver foraging (loose chewed sticks) within the last year. No other activity.

**Riparian habitat**

Riparian habitat is dominated by even-aged stand of alder with some fir in the lower reach. Understory is primarily Stink Currant with none of the species preferred by beavers for forage. Within the footprint of recent clear-cutting in the upper reach, much of the riparian buffer trees have blown over and there is little riparian habitat left.

**Instream habitat**

A tangle of windfall alders in the upper reach (within the footprint of clear-cutting) has contributed to instream complexity, pools, and sediment retention that is reconnecting the floodplain. The lower half of this zone does not have this element of instream complexity, but rather is primarily a long riffle of cobble with very little large woody debris or other complexity.

**Limiting factors**

Appropriate riparian forage is limiting throughout, as is instream complexity and structure in the lower area downstream of the recent clear-cutting.

**General notes**

Old off-channel reservoir presents a significant entrapment risk to native fish.

## Recommendations

Low-tech process-based restoration in the lower reach downstream of the recent clear-cutting. Riparian planting of willow and red osier dogwood stakes throughout. Modify old off-channel reservoir to alleviate entrapment risk to native fish.

## Technical Approach

The following actions are recommended in order:

- Plant live stakes of willow and red-osier dogwood when dormant (during wintertime) within the upper reach where clear-cutting has recently occurred. Plant an average of two stakes per linear foot in accordance with the guidance in this plan. This reach is roughly 2,000 feet long, so an initial planting could target 4,000 stakes.
- Conduct low-tech, process-based restoration (ltPBR) in accordance with the guidance in this plan and the Low-Tech Process Based Restoration of Riverscapes: Design Manual, which can be found for free at http://lowtechpbr.restoration. While this restoration can be implemented in one entry, it is most successful if implemented over 2-3 years (or longer). This reach is roughly 3,500' long, so we recommend contracting with a competent ltPBR crew of at least four individuals with a full kit (trailer, hydraulic post pounder, grip hoist, chainsaws, safety gear and hand tools) for one week per year, for three years in a row. This crew should be able to install 15 PALS or 10 BDAs in a day, for a rough total of 30 PALS and 20 BDAs throughout this reach within a week. Structures should utilize wood debris material sourced from within, or nearby, the designated work area including utilizing grip hoists to source live trees on-site (ideally these would include some conifers). This practice will also open spotty light gaps in the dense riparian canopy to facilitate early serial habitat for willow and red-osier dogwood plantings.
- Plant live stakes of willow and red-osier dogwood when dormant (during wintertime) within the lower reach after low-tech, process-based restoration has occurred. Plant an average of two stakes per linear foot in accordance with the guidance in this plan. This reach is roughly 3,500 feet long, so an initial planting could target 7,000 stakes. We suggest planting this quantity in the winter after every year of ltPBR implementation. Prioritize areas with recent sediment recruitment.
- Design and implement a modification for old off-channel reservoir to alleviate entrapment risk to native fish.

## Permitting

To the best of our knowledge, the following permitting activities should be conducted prior to each activity:

- **Riparian Planting.** We don't know of any permitting that is required for planting native riparian vegetation. Landowner permission via a voluntary landowner agreement is recommended if this work is facilitated by an organization like the watershed council.
- **Low-tech process-based restoration.** Prior to implementation, the organization facilitating this work should;
  - collaborate with the US Forest Service (USFS) to apply for an Army Corps/DSL Fill Removal permit via the Wyden Authority process (this process may require a cultural survey component for the State Historic Preservation Office (SHPO)),
  - collaborate with the Oregon Department of Fish and Wildlife (ODFW) for Expedited Fish Passage Plan Application for Instream Habitat Restoration Actions,
  - plan implementation for the applicable in-water work period, or collaborate with the regional fish biologist at ODFW to submit request to work outside that in-water work window, and
  - check with Tillamook County planning and secure any required floodplain development permitting.

- **Reservoir modification.** This design should be developed with stakeholders including staff with the USFS, ODFW, and the National Marine Fisheries Service (NMFS). If possible, include this project within the permitting materials for the ltPBR. Otherwise, the organization facilitating this work should;
    - collaborate with the USFS to apply for an Army Corps/DSL Fill Removal permit via the Wyden Authority process (this process may require a cultural survey component for the SHPO),
    - collaborate with the ODFW to insure the design meets fish passage criteria,
    - plan implementation for the applicable in-water work period, or collaborate with the regional fish biologist at ODFW to submit request to work outside that in-water work window, and
    - check with Tillamook County planning and secure any required floodplain development permitting,

## Dependencies

In addition to permitting requirements, due diligence should be done to preserve any associated water-rights (if applicable) in collaboration with the Oregon Water Resources Department (OWRD, perhaps through such tools as an in-water lease agreement.



# Pond leveler at Highway 101 and Hawk Creek

## Project Background

There is an active primary beaver dam within the Nestucca Bay National Wildlife Refuge at 45.105103°, -123.979890°, which is impounding water upstream on private land and causing flooding concerns for human safety and infrastructure. These concerns are due to flooding both the driveway near the Hawk Creek Gallery and an adjacent sewer leach field.

| | |
|---|---|
| **Stream** | Lower Hawk Creek |
| **Area** | Nestucca Bay National Wildlife Refuge |
| **Goal** | Minimize the height of a beaver dam to reduce flooding on upstream private land to protect infrastructure |
| **Strategy** | Install a pond leveler at the beaver dam just west of the Highway 101 crossing over Hawk Creek |
| **Tools** | Habitat Modification |
| **Success** | Stabilizing a maximum height to the water impoundment behind the beaver dam at a level that doesn't threaten adjacent private land infrastructure |

## Objective

- Reduce the threat to private infrastructure by setting a minimum height to the beaver dam.

## Current Conditions

| | |
|---|---|
| Date(s) Surveyed | September 29, 2021 |
| Start Coordinates | 45.104627°, -123.978834° |
| Stop Coordinates | 45.105103°, -123.979890° |
| Observer(s): K. Moroney, B. Schlicting, J. Shockey, S. Koenigsberg, G. Amidi-Abraham | |

**Beaver activity**
Fresh beaver sign. Active primary dam and lodge.

**Riparian habitat**
Functional beaver-managed wetland habitat within wildlife refuge with lots of native vegetation. Reduced riparian vegetation upstream of Highway 101.

**Instream habitat**
Complex aquatic habitat within wildlife refuge. Simplified, incised channel with limited pools upstream of Highway 101. Lots of sediment moving!

**Limiting factors**
N/A in wildlife refuge. Riparian forage is limiting in upstream reach.

**General notes**
Impoundment is backing up water onto private land. If the dam grows too high, water impacts both a driveway and septic leach field. Sediment recruitment behind this dam is significant and will present a maintenance challenge for the pond leveler in the long run.

## Recommendations

Install a pond leveler within dam to limit height of beaver dam.

## Technical Approach

The following actions are recommended in order:

- Install a staff gauge in Hawk Creek just east of the Highway 101 culvert to monitor water level on private land where infrastructure concerns exist. Identify a level that is mutually acceptable to the landowners and US Fish and Wildlife (USFWS) refuge staff.
- Set up a monitoring point at this location per the recommendations of this plan.
- Reach out to ODOT to coordinate removal of defunct pond leveler from the east side of the highway.
- Lower the dam crest to mutually agreed level and install a pond leveler during the in-water work period and in accordance with any specific fish passage guidance from ODFW.
- Maintain this pond leveler to ensure that the intake remains unobstructed by debris and sediment.
- Monitor this device in accordance with any specific fish passage guidance from ODFW.
- Remove flow device if regular maintenance and monitoring is ceased.



## Permitting

To the best of our knowledge, the following permitting activities should be conducted prior to each activity:

- Pond levelers may pose unknown risks to the natural fish passage at beaver dams, and the ODFW and NMFS must be coordinated with to ensure that any pond leveler installation within the range of a threated species (Oregon Coast coho salmon) is conducted in accordance to the best available standards and in a manner consistent with fish passage regulations. This coordination should take place with both the ODFW regional office and fish passage program. There is no official permitting process in place for flow devices and this potential project represents an opportunity to pilot and closely monitor the use of these coexistence solutions in a salmon bearing stream.
- Plan installation for the applicable in-water work period, or collaborate with the regional fish biologist at ODFW to submit request to work outside that in-water work window.
- Joint Permit for fill/ removal through the Army Corps and Department of State Lands. Because this site is within Essential Salmon Habitat, this pond leveler installation may trigger this permit.
- Coordinate any needs for staging within the highway right-of-way with ODOT.

## Dependencies

In addition to permitting requirements, the staff gauge and monitoring points must be set up before installation of the pond leveler.

# Pond leveler at Tsunami Trail and Kiwanda Creek

## Project Background

There is an active primary beaver dam within the Nestucca Bay National Wildlife Refuge at 45.112339°, -123.977600°, which impounds water on the tsunami trail that runs through the refuge, connecting the community along the Neskowin beach with the high ground on the hills where emergency provisions will be housed. The elevation of this evacuation route was set so that it would be dry 75% of the year, but beaver activity has been causing consistent flooding of the trail. Community volunteers have worked with US Fish and Wildlife Refuge staff to regularly breach the beaver dam due to the concerns for human safety and this infrastructure. Breaching this dam also results in regularly flooding the golf course downstream.

| | |
|---|---|
| **Stream** | Kiwanda Creek |
| **Area** | Nestucca Bay National Wildlife Refuge |
| **Goal** | Minimize the height of a beaver dam to reduce flooding on the tsunami trail |

| | |
|---|---|
| **Strategy** | Install a pond leveler at the beaver dam downstream of the tsunami trail on Kiwanda Creek |
| **Tools** | Habitat Modification |
| **Success** | Stabilizing a maximum height to the water impoundment behind the beaver dam at a level that doesn't threaten adjacent trail |

## Objectives

- Reduce the standing water on the tsunami trail to 25% of the year, as designed.
- Reduce flooding on golf course due to beaver dam breaching.

## Current Conditions

| | |
|---|---|
| **Date(s) Surveyed** | December 8, 2021 |
| **Start Coordinates** | 45.112542, -123.977708° |
| **Stop Coordinates** | 45.112227, -123.977676° |

**Observer(s): J. Shockey, S. Koenigsberg, R. Wicklund, and D. Shively**

| | |
|---|---|
| **Beaver activity** | Fresh beaver sign. Active damming, assumed to be primary although lodge was not located. |
| **Riparian habitat** | Functional beaver-managed wetland habitat within wildlife refuge with lots of native vegetation. |
| **Instream habitat** | Historically, Kiwanda Creek was a ditch through cranberry bogs. Beavers are now facilitating an increase in complex aquatic habitat within wildlife refuge. |
| **Limiting factors** | N/A in wildlife refuge. |
| **General notes** | Beaver dam flooding the tsunami trail, regular human breaching and beaver maintenance. |

## Recommendations

Install a pond leveler within dam to limit height of beaver dam.

## Technical Approach

The following actions are recommended in order:

- Set up a monitoring point at this location per the recommendations of this plan.
- Lower the dam crest to mutually agreed level, as measured on the staff gauge installed on site, and install a pond leveler during the in-water work period and in accordance with any specific fish passage guidance from ODFW.
- Maintain this pond leveler to ensure that the intake remains unobstructed by debris and sediment.
- Monitor this device in accordance with any specific fish passage guidance from ODFW.
- Remove flow device if regular maintenance and monitoring is ceased.

## Permitting

To the best of our knowledge the following permitting activities should be conducted prior to each activity:

- Pond levelers may pose unknown risks to the natural fish passage at beaver dams, and the ODFW and NMFS must be coordinated with to ensure that any pond leveler installation within the range of a threated species (Oregon Coast coho salmon) is conducted in accordance to the best available standards and in a manner consistent with fish passage regulations. This coordination should take place with both the ODFW regional office and fish passage program. This potential project represents an opportunity to pilot and closely monitor the use of these coexistence solutions in a salmon bearing stream.
- Plan installation for the applicable in-water work period, or collaborate with the regional fish biologist at ODFW to submit request to work outside that in-water work window.
- Joint Permit for fill/ removal through the Army Corps and Department of State Lands. Because this site is within Essential Salmon Habitat, this pond leveler installation may trigger this permit.
- Coordinate any needs for staging within the highway right-of-way with ODOT.

## Dependencies

In addition to permitting requirements, the monitoring points must be set up before installing the pond leveler.



# Flooding at 7th and 9th greens at Neskowin Beach Golf Course

## Project Background

Water levels are impacting the golf course from damming south in Hawk Creek near the ninth green, and north in Butte Creek near the seventh green. Dams have been regularly breached by the representatives from the golf course at both of these locations.

| | |
|---|---|
| **Stream** | Varies |
| **Area** | Neskowin Beach Golf Course |
| **Goal** | Reduce flooding on golf course during summer season |

| | |
|---|---|
| **Strategy** | Dam breaching on Hawk Creek and potentially extending a berm to protect the seventh green to facilitate more beaver habitat in Butte Creek |
| **Tools** | Habitat Modification |
| **Success** | Maintain a dry golf course over the summer (especially August) |

## Objectives

- Facilitate more dry summer days on the course while reducing the ongoing need to breach beaver dams.
- Allow for more beaver dams and aquatic habitat in Butte Creek.

## Current Conditions at Butte Creek and the 7th green

| | |
|---|---|
| **Date(s) Surveyed** | September 29, 2021 |
| **Start Coordinates** | 45.108405, -123.977575° |
| **Stop Coordinates** | 45.109832, -123.974845° |

Observer(s): B. Schlicting, J. Shockey, S. Koenigsberg, G. Amidi-Abraham

**Beaver activity**
Recent, but no active beaver sign. Evidence of beaver dams throughout site, but all were currently removed. Extensive canal building, and foraging on willow.

**Riparian habitat**
Lots of willow and other forage species preferred by beaver.

**Instream habitat**
Simplified, incised channel with limited pools upstream with the beaver dams gone. Evidence of floodplain connection and complexity to the north when beaver dams are within this stretch.

**Limiting factors**
N/A

**General notes**
Any damming upstream of the cart bridge near the seventh green results in surface flow to the north, then east, where it crosses through a gap in a historic berm adjacent to the cart path and onto the gold course.

### Recommendations

Short-term: continue to lower beaver dams by hand within this section. Long-term: consider extending the existing berm so that water no longer flows onto the course if beaver are actively damming in Butte Creek. This project could facilitate roughly 4.5 acres of high quality aquatic habitat.



## Current Conditions at Hawk Creek and the 9th green

| | |
|---|---|
| **Date(s) Surveyed** | December 8, 2021 |
| **Start Coordinates** | 45.105655, -123.981370° |
| **Stop Coordinates** | 45.105612, -123.980041° |

Observer(s): K. Moroney, B. Schlicting, J. Shockey, S. Koenigsberg, R. Wicklund, D. Shively

**Beaver activity**
Recent beaver sign, and recently removed secondary dams.

**Riparian habitat**
Functional beaver-managed wetland habitat to the south with lots of native vegetation.

**Instream habitat**
Shallow and narrow channel running along the edge of the golf course, with complex aquatic habitat to the south.

**Limiting factors**
N/A in wildlife refuge.

**General notes**
Any damming upstream of the cart bridge near the seventh green results in surface flow to the north, then east, where it crosses through a gap in a historic berm adjacent to the cart path and onto the gold course.

### Recommendations

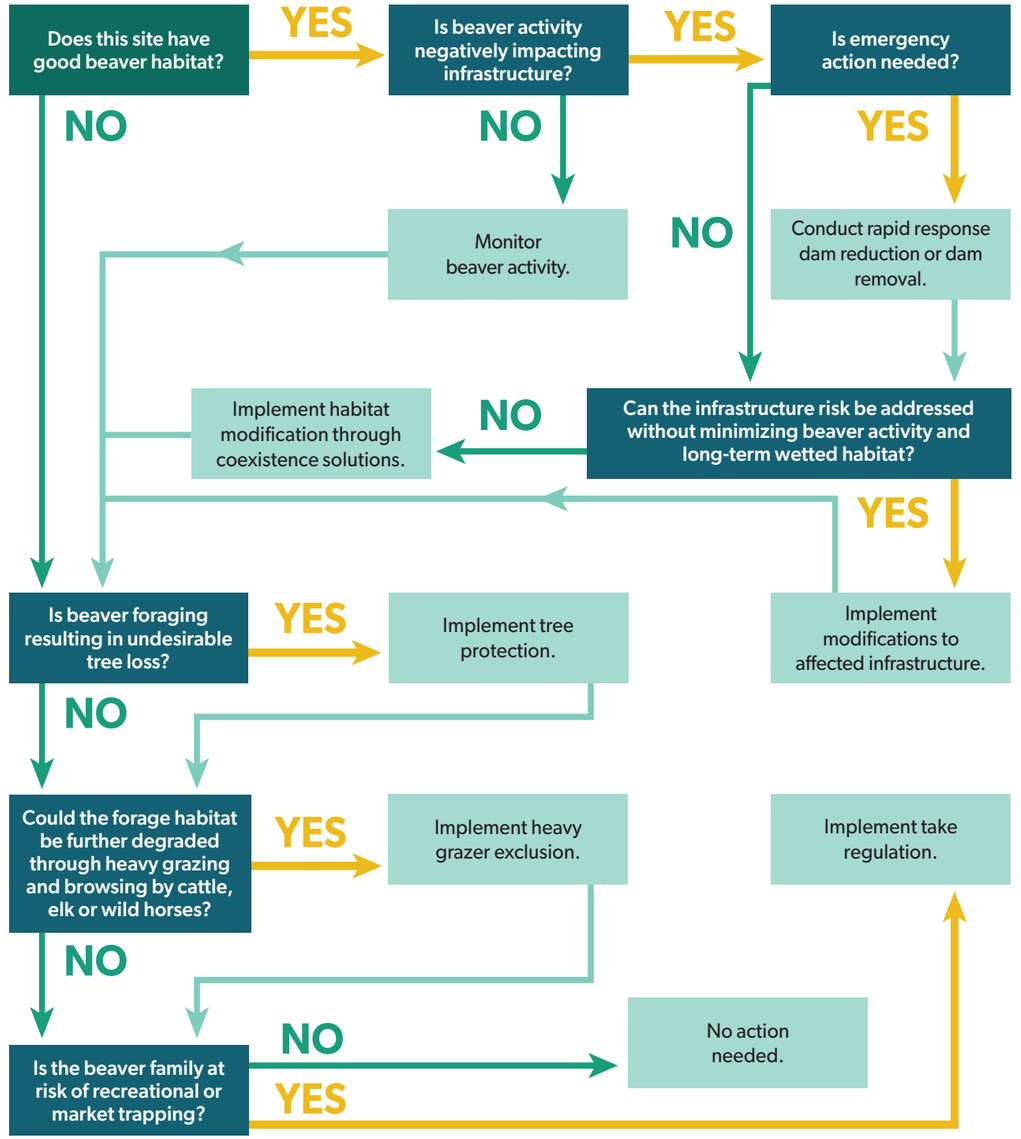
Continue to lower beaver dams by hand within this section.

# Toolkit for Partnering with Beavers

Within each of the following sections, we present the action-based toolkit for project implementation and provide the reasoning behind these activities. These tools are outlined in three iterative sections: 1) help beavers stay, 2) help beavers find it, and 3) help beavers fix it, and should be prioritized in the sequence they are presented. These recommendations represent the best currently available guidance. The thinking on coexistence solutions and beaver-based restoration will evolve, and it will be important to check in with contemporary beaver-based restoration techniques over time. We recommend The Beaver Restoration Guidebook for a compendium of the best available thinking, and will be updating this guidance in the future. This can be found at www.projectbeaver.org/guidebook.



## Help Beavers Stay



## No Action

No action is needed in areas with no adverse effects from beaver activity to human infrastructure, homes and businesses, and important trees. However, beaver activity should be monitored (see monitoring section) if resources allow.

## Monitor Activity

Beaver activity should be monitored in areas where there is the potential for negative impacts to human infrastructure, homes and businesses, or important trees, in order to remedy a future conflict before it becomes critical. Beaver activity should also be monitored in areas where increased beaver activity is desired and promoted through restoration. Simple, observational monitoring of beaver activity over time will be the foundation for collaborative and adaptive problem solving for the community of Neskowin.

We suggest monitoring activities for both stream reaches and points of interest. This approach prioritizes simplicity, recording only the data that is needed and useful. Monitoring needs may change over time as beaver activity and habitat changes, so these surveys may also need to be adapted in the future. We suggest any future amendments to these efforts consider the same priorities—avoid overly complicated monitoring that could be confusing or generate too much irrelevant data.

### Protocol for rapid walking assessment

This protocol is for surveying for changes in beaver presence and activity over time. Use this protocol for areas with little or no beaver activity where the stream remains confined within a clear incised channel. The goal is to assess beaver presence and activity in a broad sense, either to note potential negative impacts to human infrastructure, homes and businesses, or important trees, or to note successes from restoration actions.

- **Set-up:** Choose a stretch of stream for your survey. Record the downstream location (starting place) and upstream location (ending place) in coordinates with the decimal degrees format. You can do this with a simple GPS, or even a mapping app on a cell phone. Give this survey reach a name.

- **Monitoring:** Walk this survey reach twice a year at a minimum, prioritizing early summer (after juvenile dispersal) and late fall (prior to heavy fall rains). Avoid walking in the spring so you don't step on salmon eggs hidden in the gravel of the stream bed. Starting at your downstream point, walk up the stream channel looking for sign of beavers. Go slowly, looking for signs of foraging such as cut vegetation and chewed sticks, as well as more pronounced use such as slides, scent mounds (rare), channels, dams, and dens. When you find a beaver sign, note the location (coordinates with the decimal degrees format), the type of activity, and take a picture. Make sure all of the important details are clear in the picture and try to include a sense of scale. You may also note how recent the sign appears to be.

- **Recording the data:** Create a blank document in a word processor like Word in Microsoft or Pages in Mac. Label this file "Beaver Monitoring_[SURVEY REACH NAME]_[DATE]." Within your document record your name, the starting and ending coordinates of your survey reach, and an overall description of what you noticed. If you noted beaver activity, then create a table within this document that is only one cell wide. Within the table, insert your first photo. In the cell directly below this photo, type out the coordinates in decimal degrees format. Follow this format for as many photos as you have. Send an email with this document to the organization or individual who is cataloging these monitoring data, titled "Beaver monitoring at [SURVEY REACH NAME] on [DATE]."

- **Data curation:** The organization or individual who is cataloging these monitoring data will maintain a file of these walking assessments.

### Protocol for point assessments

Use this protocol for areas where there is a specific concern for human infrastructure, homes and businesses, or important trees.

- **Set-up:** Pick a specific location, or set of locations, from which to take a take a photo. Choose a place and angle that clearly shows the area of concern and that will also show changes over time due to beaver activity. Consider a location that can be accessed during varied stream flows. Include a static element in your photo, like a fence-post, road bed, etc. This unchanging element in your photo will be important for ensuring subsequent photos maintain the same frame of reference as the habitat and seasons change. Note the location's coordinates in decimal degrees format and give this photo-point a name. See Appendix B for an example.

- **Monitoring:** At a minimum, take periodic photo-points twice a year—early summer (post juvenile dispersal), and late fall (prior to heavy fall rains). If possible, visit these points and take photos throughout the year, especially during periods that might help explain the beaver activity, like during and after high-water events. Record any observations that could be relevant, like fresh beaver sign, recent precipitation events, changed water level, or any other changes in the habitat since your last visit.

- **Recording the data:** Send an email to the organization or individual who is cataloging these monitoring data, titled "Beaver monitoring at [PHOTO-POINT NAME] on [DATE]" If you are tracking multiple photo-points, send separate emails. Within the body of the email, include any observations you made and attach your photo.

- **Data curation:** The organization or individual who is cataloging these monitoring data will maintain a database of point assessments. This can be a simple as a table in a word processor like Word in Microsoft or Pages in Mac. Each entry should include the photo-point name, location (coordinates in decimal degrees format), observer, photo, and any noted observations.

## Tree Protection

Signs of beavers foraging on native trees and shrubs is little cause for alarm. Native streamside and wetland vegetation has coevolved with this beaver activity and has evolved adaptations in response, such as resprouting (called coppicing) from the roots or directly out of the stumps. Through their activities, beavers move vegetative matter into the water, and this material contributes to both habitat and food for fish and other wildlife that live in the aquatic environment. These allochthonous inputs to the aquatic system support both instream productivity and complexity.

There may be instances when tree protection from beavers is warranted, such as: when there is a threat to safety from falling trees in highly trafficked area; when there is threat to a structure from a falling tree; or when we wish to protect important trees like non-native ornamental and fruit trees near homes, businesses, or parks. Temporary tree protection can also be useful when establishing new vegetation on stream banks or floodplains during restoration projects.

Trees and other vegetation are best protected from beaver foraging in two ways: exclusionary fencing or a sand and paint mixture applied to the bark. These techniques are effective but come with both an initial implementation and a maintenance cost.

***Things to consider:***

- Beavers can also cause tree mortality through flooding. If beavers successfully reconnect a floodplain that has been disconnected for some time, the trees and shrubs that have grown up in the meantime may not be tolerant of wet roots. However, there is also a benefit here, for as trees die and become snags they will contribute valuable habitat to a myriad of species. If there is a strong concern around tree mortality through flooding, pond levelers can be used to lower the water level (see Habitat Modification section).

## Wire Mesh Cages

In locations where trees or shrubs should be protected from gnawing or felling by beavers, wire mesh cages can be installed around the trunk of a single tree or wire fencing around multiple trees/shrubs. This method requires material, labor, and periodic monitoring, maintenance, and re-installation as trees grow. A typical tree cage consists of welded wire with 2 inches by 4 inches mesh, 4 feet in height with 2-3 steel T-posts holding it in place. An effective mesh cage consists of the following:

- The gauge should be reasonably heavy (e.g., 6 gauge) to prevent beavers from chewing through and be flexible enough for this application.
- Mesh size should be 6x6 inches or smaller (2x4 inches is ideal).
- The cage should be 1 to 2 feet in diameter larger than the tree trunk.
- Cages should extend 3 to 4 feet above the ground.
- Wire fencing can be used to encircle multiple trees.

***Things to consider:***

- Beavers can be heavy, so build your tree cage from a material that can withstand a 60-pound animal putting its front legs up on it (i.e., not chicken-wire).
- Leave adequate room between fencing and tree bark for trees to grow.
- Inspect caged trees on a regular (annual) schedule to adjust cages as needed.



## Sand/Paint Mixture

In areas where trees should be protected from gnawing or felling, but where investment in the higher costs for material and labor is not worth the effort, abrasive paint may be used. This method requires minimal material and labor and annual monitoring and repainting. This method might be useful for volunteer events where skill in manual labor is not critical to success. This method does not work on saplings; use only on stems approximately 6-inches in diameter or larger. Abrasive paint should consist of a mixture of:

- Mix 8 ounces of fine dry sand (30-mil, 70-mil, or masonry sand).
- Add mixture to 1 quart of latex paint, matched to the color of the tree trunk.
- Once combined, paint the mixture on the tree to 4 feet above the ground.

***Things to consider:***

- This method is not recommended for any tree with a stem less than 6-inches in diameter.
- Check latex paint for environmental safety. Some exterior latex paints contain heavy metals to protect color from fading. For this reason, sometimes interior paint is better for this application near streams.
- As the protected tree grows in diameter, areas of unprotected bark will emerge. Inspect painted trees on a regular (annual) schedule to add additional paint as needed.

## Electric Fencing

In areas where beavers need to be temporarily excluded from a large area of riparian habitat, such as a new restoration project, plantings can be protected with electrical fencing. This fence should consist of:

- Two aluminum wires, positioned at 6 inches and 12 inches from the ground
- Wire should be affixed to short steel T-posts with plastic insulators
- Fence can be powered by solar fence charger or a grid-tied charger if power is available

***Things to consider:***

- Vegetation must be maintained under fence to keep the fence from grounding out, and to mitigate for the potential for fire hazard.

# Habitat Modification

Beavers construct dams from mud and sticks on small and medium-sized streams to create safety from predation and facilitate habitat for themselves. This activity also creates functional riparian and wetland ecosystems. Beavers are prone to constructing dams at undersized culverts, spillways, and other in-channel human infrastructure that inadvertently facilitate dam building. By concentrating flow and partially constricting the stream channel, poorly designed infrastructure components attract dam-building activity. Beavers cue off the sound of running or trickling water when damming and make use of existing in-channel and on-channel edge objects, such as logs and boulders, so human structures present a noisy, attractive construction location.

Culverts, spillways, and similar human infrastructure can be protected from beavers' damming while preserving their function through a combination of beaver exclusion and diminishing the environmental cues to a dam in that location. The use of culvert protection as a long-term, cost-effective solution for human and beaver coexistence is key to minimizing damage on two fronts: damage from beavers-caused flooding on human infrastructure, and damage to riparian and wetland ecosystems if beavers are trapped out.

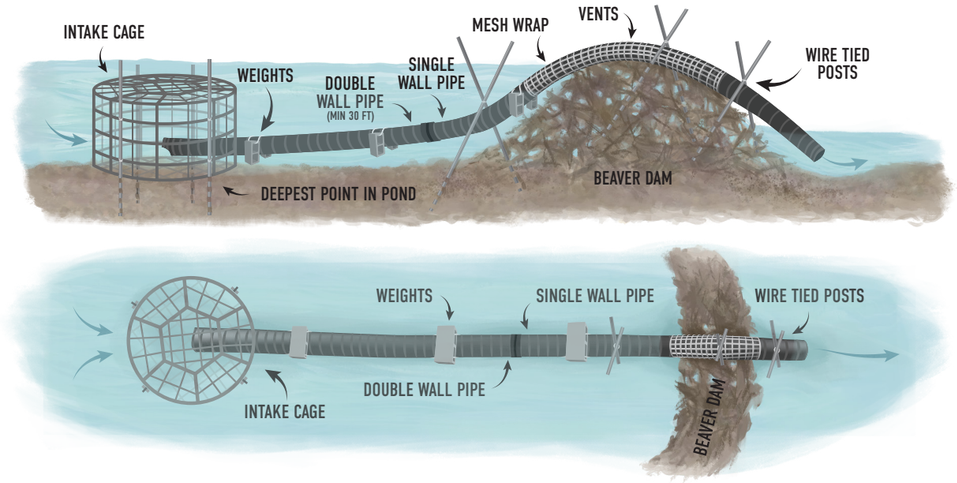
Habitat modification allows us to coexist with beavers near human infrastructure by altering their structures to artificially restrict the habitat footprint by modifying the ability for beavers to dam at constriction points (such as under-sized culverts) or flood adjacent infrastructure. These coexistence techniques for habitat modification include rapidly breaching or removing dams and installing pond levelers and culvert protection systems. When correctly implemented, these strategies can offer long-term, cost-effective coexistence solutions.

When using any of these methods in streams with native migratory fish (NMF), it is important that regulatory guidelines for migratory fish passage are followed; currently, direct communication with an ODFW fish biologist is required on a case-by-case basis. The applicability of existing stream restoration permits and/or need for additional permitting or NEPA will also be case-by-case. Additional regulations regarding removal or fill of material within regulated waters are discussed below.

## Pond Levelers

In areas where freestanding dams are not located at a culvert, but still present a threat to human infrastructure if the pond level should rise above a certain elevation, pond levelers have proven highly effective. The goal of a pond leveler is to minimize the disruption to the beaver family and their habitat, so they do not abandon the site, while establishing a maximum water height and footprint which protects the landowner's assets. Pond levelers set the water surface elevation of a beaver pond by using a plastic culvert pipe to create a leak over the crest of the dam that beavers cannot repair. The intake for the leak is hidden upstream within the beaver pond and is enclosed within a cage to keep beavers from swimming near enough to sense the flowing water. Similar to an overflow drain on a bathtub which limits the water depth, a pond leveler leaks water over the crest of the beaver dam at a desired water surface height during the low flows when beavers might otherwise increase the height of the dam (Figure 2). The outlet of this pond leveler is placed downstream of the dam.






If properly constructed, installed and maintained, the use of pond levelers limits the extent of beaver ponds, minimizing flooding and potential nuisance or damage. Pond levelers permit coexistence with beavers, and the many ecosystem benefits they provide, in areas where a human tolerance for beaver-facilitated habitat is limited. Flow devices can be cost-effective solutions for controlling the height of a beaver dam and the resulting footprint of the beaver pond. They can last 5-10 years or longer if properly maintained.

The following guidance is in accordance with the Best Management Practices (BMPs) for pond leveler construction, installation and maintenance (Shockey 2023). However, each pond leveler will need to be field fit for specific site conditions and the techniques for using flow devices to coexist with beavers are ever evolving, so check for future revisions to these BMPs when designing project specifics.

Essential design components of this system include:

- **Minimize adverse impacts to habitat:** The installation of a pond leveler will decrease habitat for beavers and other native fish and wildlife. In order to minimize adverse impacts to habitat:
    - Maximize the footprint of the beaver pond by lowering the dam crest elevation only as much as is required to alleviate human flooding concerns. Maintaining maximum water depth over the openings to the beaver den or lodge is vital to prevent abandonment and/or the construction of new dams upstream or downstream of the flow devices.
    - Minimize fish and wildlife interaction with the pond-leveling system, particularly regarding impairing or preventing fish passage and the entrapment of other species such as turtles, waterfowl, or even larger mammals. Sharp edges that fish and wildlife could come into contact with should be smoothed, beveled, or tucked away and there should be no artificial

protrusions into the flow path of the pond leveler. Pond levelers should not dewater the stream or otherwise artificially restrict instream flows. Fish passage design components may be required for the device. Reference the Appendices for state-specific criteria.

  - » Consider the long-term plan for the site. Infrastructure changes like upgrading culverts or moving critical infrastructure away to give the aquatic and riparian ecosystems more room are the best long-term coexistence solutions.

- **An upstream intake:** While beavers will quickly fix any leak in the upstream surface of their dam, hiding the intake of the pond leveler 30' to 60' upstream removes it from the proximity of the dam where beavers tend to search for the leak.

- **A caged intake:** The intake must be caged to prevent beavers from swimming close enough to the pipe to feel or hear running water. If this exclusionary cage is too small and beavers sense the leak, they will mobilize enough debris to encapsulate the entire intake cage in days. The cage must have openings small enough that a beaver cannot fit through. The size of the cage must correspond with the size of the pipe used, so that when fully flowing there is no discernible flow through the fence.

- **Eliminated "trickling" sound and feel:** Beavers can detect leaks by hearing and feeling them. It is essential to eliminate the sensations of flowing water within the pond leveling system upstream of the beaver dam. Beavers are adapted to cascading water on the downstream side of their dam and will generally not attempt to repair leaks from this side. This outlet can be further protected with a domed lattice of sticks or mesh.

- **Dispersed intake flow:** The uniform, circular lip of the intake pipe must be disrupted to prevent the intake flow coupling with the pond surface (a whirlpool) if the intake cage is positioned in less than 4' of water. One effective method is to cut a half-circle of pipe material out of the bottom lip of this opening (Figure 2).

- **Stabilized flow device:** Staking the intake cage is only necessary where the intake cage is subjected to discernible flows. At these sites, firmly stabilize the intake cage and pipe to keep beavers from moving it and to minimize the need for adjustment after high-flow events. The pipe can be held in place at the dam using steel posts, and the intake cage and pipe can be held in place with either steel posts or weights (Figure 1).

- **Vented pipe:** Small vent holes or slits must be cut into the top surface of the submerged pipe to release gas trapped in the pipe or within the pipe wall. These holes are essential to minimize air entrapment and keep the pipe from floating. The size of holes must be kept to a minimum to avoid attracting the attention of a beaver and to avoid potentially trapping fish, amphibians, or other wildlife.

- **Rugged construction:** It is important to construct a pond leveling system with high quality materials that can withstand normal environmental forces over time. For the pipe, use High Density Polyethylene, which is often called HDPE, and henceforth "plastic culvert pipe" in this guide. This pipe is available as single wall or double wall construction. Double wall is more robust and its smooth interior is quieter, but it lacks flexibility. Single wall is flexible, but not as quiet. Metal products like wire mesh, tie wire, screws and steel posts should all be heavy duty products that will last for a reasonably long period while being exposed to the elements.



- **Appropriately sized pipe:** Determining the appropriate pipe size for your site can be tricky, and requires considering the size of the watershed, its land use, the percentage of impervious surface, and the permeability of the beaver dam itself. The porosity of the beaver dam depends on the materials used in the dam and can fluctuate seasonally, or even daily, as beaver add fresh mud and other materials to maintain the dam. Except where there are concerns with fish passage, use a pipe size that will carry the majority of flows moving over the beaver dam. Pipe size, material and gradient will change how much water (usually measured in cubic feet per second) can flow through your pond leveler. Look up the flow calculations for your pipe (usually available from the manufacturer) and estimate based on a 1% gradient. For reference, at 1% slope a 12" double wall pipe will move 3.8 cubic feet per second (CFS), while a 12" single wall pipe will move 2.7 CFS. A 15" double wall pipe will move 7.0 CFS, while a 15" single wall pipe will move 4.2 CFS.

***Things to consider:***

- Reduce the dam height to only the minimum needed. The more the beavers' dam and pond are reduced, the more likely you are to destabilize the situation by causing the beavers to build another dam. The amount of water over the beavers' underwater den entrance will determine how far down you can bring the beavers impoundment before destabilizing the situation and causing the beavers to build a new dam. A minimum of six inches of water over the top of the den entrance should be maintained.

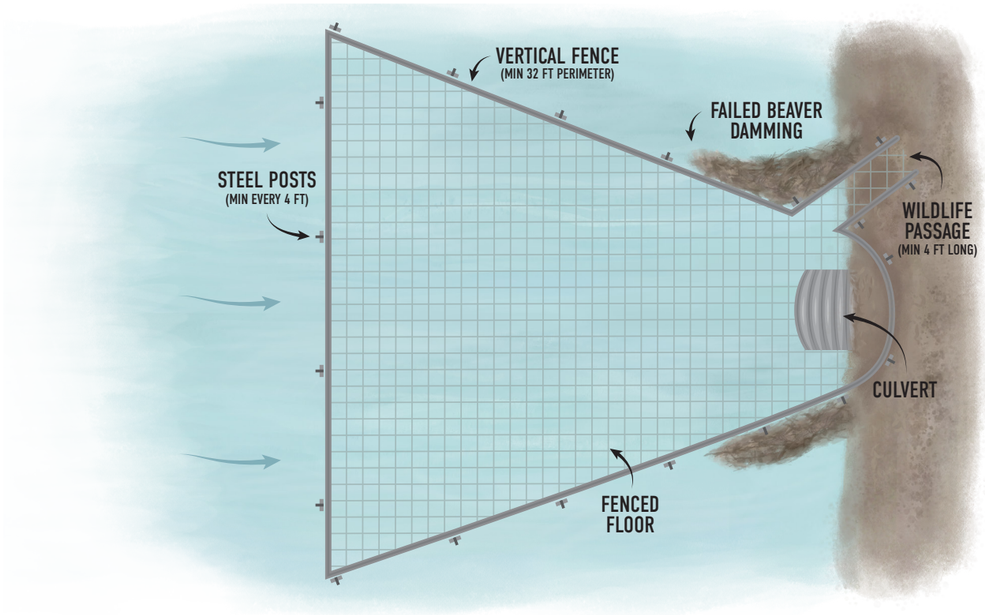
- This method requires an investment of time and materials, plus monitoring and maintenance to ensure the intake cage and pipe remain in good condition. Quarterly/seasonal cleaning, such as February, May, August, and November, may be necessary to clear the cage of obstructions (i.e., woody debris). These flow devices should be removed from the stream as soon as they are not needed.

- The ODFW fish passage program is concerned that since pond levelers change flow rates and distribution over the crest of the beavers dam during low flow conditions, this could impact juvenile fish movement. This hypothesis is untested. Consult with ODFW fish passage biologist as needed.

## Culvert Protection Systems

Culverts, spillways and similar human infrastructure can be protected from beaver damming while preserving their function. Many of the culverts where beaver damming occurs are undersized and may present fish passage issues. If possible, replace the culvert with a structure that is properly sized and designed.

If financial, logistical, and time critical responses prevent immediate culvert replacement, a properly constructed, installed and maintained culvert protection system can provide a cost-effective solution that can last 5-10 years, or longer if properly maintained. A culvert protection system is designed to protect infrastructure while allowing beavers to remain in their habitat. It is vital that the addition of a culvert protection system does not further impact the passage of target fish species or life stages of concern.




A **trapezoidal culvert fence** (Figure 3) protects the culvert by physically excluding beavers from the area around the culvert inlet using wire fencing. The shape of the fence also alters the physical and auditory cues that promote dam building. Beavers will often start to construct a dam along the two sides of the fence exclosure nearest to the culvert, but generally abandon the dam building as the angle of the fencing pushes them out into still water where they no longer detect the sensations of flowing water. As a result, a majority of the fence remains unobstructed.

An **anchor fence** directly protects the culvert's mouth with a semi-circle of fencing. Beaver damming activity is still allowed at the culvert mouth, but the location of the dam is controlled by the fence structure. By relocating the damming activity upstream, flow through the culvert is unimpeded. This design can be modified to accommodate a pond leveler through the anchor fence if the elevation or extent of the upstream beaver pond must be limited. The modification of adding a pond leveler to an anchor fence is often called a **pipe and fence** culvert protector.

An **anchor dam** is a similar strategy used to protect culverts at sites where fencing should not be used in the stream. This tactic includes construction of a Beaver Dam Analog (BDA) reinforced with steel posts—just upstream of the culvert mouth. While this tactic does not exclude the beavers from the infrastructure, it can divert them into investing and improving upon the reinforced BDA as their new dam, leaving the culvert open. This design can be modified to accommodate a pond leveler through the reinforced BDA if the extent of the upstream beaver pond must be limited. The modification of adding a pond leveler to an anchor dam is often called a **pipe and dam** culvert protector.

Create a long-term plan for site that includes infrastructure changes such as upgrading culverts or moving critical infrastructure away from riparian habitat. The best long-term coexistence solution for beaver-human conflicts is to give the aquatic and riparian ecosystems more room to facilitate natural processes and build ecosystem resilience.



The following guidance represents the Best Management Practices (BMPs) for culvert protection system construction, installation and maintenance (Shockey 2023). However, each culvert protection system will need field fit for specific site conditions and the techniques for using flow devices to coexist with beavers are ever evolving, so check for future revisions to these BMPs when designing project specifics.

Essential design components of this system include:

- Excude beavers exclusion from the culvert: Unless constructing an anchor dam or pipe and dam, exclude beavers from the area around the culvert using heavy gauge wire that is small enough that both adult and sub-adult beaver cannot pass through.

- Provide fish passage: It is essential that designs minimize passage obstruction or delay of fish species and life stages of concern. When passage of fish species is a concern, mesh openings or migration pathways within the structure must be large enough to accommodate passage of the target species and life stages.

- Start with a clean culvert: During the appropriate time of year, remove all the aggregated damming materials from within the culvert and upstream area of work. Take appropriate safety precautions when removing dams that are retaining large quantities of water. This activity can be quite dangerous since the force behind the flowing water increases exponentially as the dam is lowered, the risk of a sudden dam collapse increases, and a person could be swept into the culvert and drowned.

- Stabilize flow device in place: It is important to stabilize the anchor fence in place with steel posts and/or untreated cedar lumber (as needed), to minimize the need for major readjustment after high flows.

- Use rugged construction: It is important to construct the culvert protection system with high quality materials that can withstand the forces of nature in a streambed. Metal products like wire mesh, tie wire, screws, and steel posts should all be of quality construction that will hold up over time and exposure.

- Facilitate wildlife passage: Leave an opening in the exclusionary fence that runs up onto dry land to provide an exit for other wildlife that may use the culvert to move up and down the stream (Figure 3).

- Minimize adverse impacts to habitat by:

    - » Minimize sediment mobilization and turbidity when removing damming material from the culvert and during installation and maintenance.

    - » Reduce the footprint of the beaver pond only as much as is necessary to address human concerns.

***Things to consider:***

- Beavers damming at a culvert is a signal that it is undersized. Determine the feasibility of replacing it with a more appropriate-sized culvert before installing a culvert protection system is recommended.

- Fish and wildlife passage considerations are essential in designing a site-appropriate culvert protection system.

- Avoid galvanized metal to limit the leaching of zinc and other pollutants into the environment.

- Culvert protection systems should have a maintenance plan and be checked quarterly, such as in February, May, August, and November. These flow devices should be removed from the stream as soon as they are not needed.

- Consult with ODFW regarding the potential for both fish and wildlife passage issues at the culvert, or that could result from any culvert protection system.

### Rapid Response Dam Reduction or Removal

Dam breaching should be considered if there is an acute flooding risk due to the dam. Because beavers will often rapidly repair a breached dam, breaching should be considered a short-term, emergency approach for safety purposes and to relieve dangers to infrastructure. Dams may be reduced to the extent that they might still provide benefits associated with beaver dams, while still protecting infrastructure.

Full dam removal is a more significant effort and will typically drain the entire beavers' pond. This exposes submerged den and burrow entrances, allowing access by terrestrial predators. If beavers are present, it is best to avoid dam removal during the kit season from April to June to protect beaver kits that may not be fully mobile and more vulnerable to predation.

There are two recommended ways to breach or remove a beavers' dam, depending on the size of the dam:

- Breaching or removing a dam by hand: Remove material from the dam slowly by hand and/or using hand tools such as four-pronged pitch forks, long-handled cultivator rakes (potato hooks), shovels and chain saws to dislodge and remove material.

- Power excavating: Remove material slowly using a backhoe or excavator to breach or remove large dams. The machinery should be stationed at the top of the bank, road, or bridge where practicable. Remove the dam from the top down in layers, scraping off six inches to one foot of material to reduce the potential for flooding or stream scouring. Wait for the water levels to stabilize and flow to clear before removing the next layer. Remove material to the desired depth or substrate or to the natural substrate-level if needed. To maintain compliance with the Oregon DSL large wood exemption, ponds should only be lowered to the level necessary to eliminate risk and no further (https://www.oregon.gov/dsl/WW/Documents/Removal_Fill_Guide.pdf ).The specific reason for dam breaching or full removal should be documented to demonstrate compliance with DSL removal and fill regulations and exemptions.

***Things to consider:***

- Reduce the dam height to only the minimum needed. The more the beavers' dam and pond are reduced, the more likely you are to destabilize the situation. The amount of water over the beavers' underwater den entrance will determine how far down you can bring the beavers' impoundment before destabilizing the situation and causing the beavers to build a new dam.



- Breaching or removal of dams could result in increased tree/shrub damage as beavers seek new vegetation to patch or rebuild dam.

- Use appropriate best practices for controlling sediment plumes as needed.

- Time the work in accordance with the ODFW in-water work periods (June 15 - October 15) or coordinate with the regional fish biologist if outside this period.

- Obtain a DSL Removal-Fill Permit. This permit is required if removing >50 cu yds. of material under standard DSL rules or if removing more material than necessary to eliminate risk under large wood exemption (see section 5.1 for details).

## Heavy-Grazer Exclusion

Riparian habitat where beavers are living could be protected by exclosures where it is prone to degradation through heavy grazing and browsing by large ungulates like cattle, elk, or wild horses. Exclosures should be built to the best available wildlife-friendly standards, which could include drop wires in migration corridors, barbless or buck and rail fencing. The National Resource Conservation Service has posted a number of excellent guidebooks for reference, including the "Landowners Guide to Wildlife Friendly Fences" from Montana Fish, Wildlife & Parks (Paige, 2012).

Prioritize a core of riparian habitat for protection from heavy ungulate pressure if the whole area cannot be protected. Focus on the areas that beavers are currently actively occupying, including any ponded areas and preferred food species like willow, red-osier dogwood, cottonwood, ash, and aspen. This exclosure will give the beavers more stability in forage availability to establish a stable territory. Without this fencing, beavers are often forced to move out of their aquatic habitat as it becomes severely degraded under prolonged heavy ungulate pressure, especially over the summer months.

***Things to consider:***

- Exclosures require regular inspection and fencing maintenance, especially in the dry summer months when pressure from cattle and other ungulates to access lush riparian vegetation may be persistent. Even a few days of cattle in an exclosure can lead to severe degradation. As such, exclosure fencing is a short- and mid-term strategy.

- Rotational grazing plans and range riders can also help keep cattle from denuding and dwelling in riparian areas.

- Long-term strategies should also be considered and planned. For cattle, these could include the retirement of grazing allotments. With heavy pressure from native ungulates like elk, wolf reintroduction has been successful in alleviating browse pressure so that beavers can return (Marshall, 2013).

## Take Regulation

Active beaver families within the higher gradient systems in public lands should be protected, as they are relatively rare, difficult to reestablish, and vital to dispersing juvenile beavers into the surrounding area.

On public land under the stewardship of US Forest Service, the Regional Forester or Forest Supervisor has the authority to issue a closure order to limit the lethal removal of beaver by the public in two ways: through generally closing an area to entry to protect a "[s]pecial biological communit[y]" under 36 C.F.R. § 261.53(b), or separately by prohibiting "[p]ossessing, storing, or transporting" a beaver in specified areas and/or generally prohibiting "hunting" in those areas under 36 C.F.R. § 261.58(s) & (v). See the appendix "Beavers and Federal Land Closures" for more detail.

If we are to achieve our goal of increasing the function and resiliency of aquatic habitat by a strategy of "more beavers on the landscape, with the ability to positively impact the hydrology, biology, and biodiversity of the ecosystem" than the ability to close an area to killing beavers is a vital tactic. Regulating the recreational and market trapping of beavers on public land can be tricky, given political sensitivities around trapping closures. However, without first reducing this anthropogenic predation pressure, much of our remaining beaver-based restoration toolkit is less effective. For example, in 2005, a large stream restoration project was conducted by the Siuslaw National Forest with a goal of increasing habitat complexity and processes so that beavers would take over. The project was successful, and within the first year beavers had occupied the project, building 22 dams by the third year and starting the cascade of beneficial habitat processes that the USFS staff had hoped and designed the project to achieve. The beavers subsequently disappeared from the project area and the entire sub-watershed seven years after this project began. A private trapper later informed USFS staff that a local private timber company had paid them to trap out the entire sub-basin — both the private land (as a "predator" species) and the federally managed public lands (as a recreational fur-taker) (pers. comm. K. Ellingson, 2022).

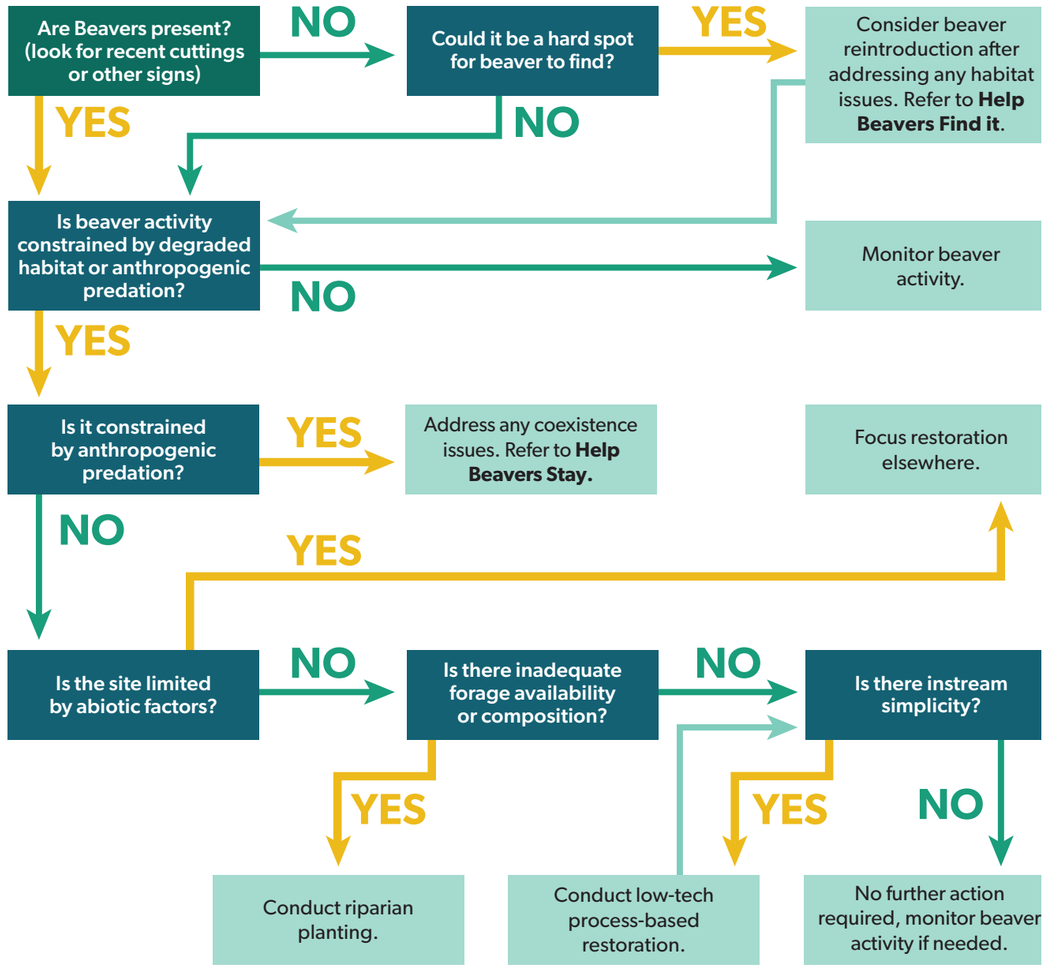
This does not mean there should be no beavers trapping, only that we shouldn't actively remove them from the systems where we are trying to encourage them, especially during reproductive periods when it maximally impacts the population. Strategic closures should be utilized at the watershed or sub-basin level, or across a specific management region of public land. ODFW also has the authority to close an area to the recreational removal of beavers by the public.

***Things to consider:***

- ODFW also has the authority to close an area to the recreational removal of beavers by the public.
- In 2021-2022, the ODFW Commission appointed a working group to consider the closure of all federally managed public lands in Oregon to beavers' recreational trapping. A house bill was also introduced during the 2020 legislative session to that effect.



# Help Beavers Fix It



# Low-tech, Process-based Restoration

The best available guidance for the low-tech, process-based restoration toolkit is within the Low-Tech Process Based Restoration of Riverscapes: Design Manual. We will not get into the planning, design and implementation toolkit here, as those are clearly and carefully laid out in this manual. In that spirit of deference to this best available information, the following introduction is largely quoted from various passages in this open-source manual.

Structural starvation of wood and beaver dams in riverscapes is one of the most common impairments affecting a riverscape's health. At a basic level, a riverscape starved of structure drains too quickly and efficiently, lacks connectivity with its floodplain, and has simpler, more homogeneous habitat. By contrast, a riverscape system with an appropriate amount of structure provides obstructions to flow. What follows in the wake of structurally forced hydraulic diversity are more complicated geomorphic processes that result in far more diverse habitat, resilience, and a rich suite of associated ecosystem services.

There  is a subset of low-tech tools—namely post-assisted log structures (PALS) and beaver dam analogues (BDAs)—for initiating process-based restoration in structurally starved riverscapes. While the concept of process-based restoration in riverscapes has been advocated for at least two decades, details and specific examples on how to implement it remain sparse. Here, we describe "Low-tech process-based restoration" as using simple, low unit-cost, structural additions (e.g., wood and beavers dams) to riverscapes to mimic functions and initiate specific processes. This technique is increasingly recognized as a low-tech tool for initiating process-based restoration in structurally starved riverscapes —namely post-assisted log structures (PALS) and beaver dam analogues (BDAs).

Hallmarks of this approach include:

- An explicit focus on the processes a low-tech restoration intervention aims to promote.
- A conscious effort to use cost-effective, low-tech treatments (e.g., hand-built, natural materials, nonengineered, short-term design life-spans),
- "Letting the system do the work," which defers critical decision making to riverscapes and nature's ecosystem engineers.

It is important to remember that these instream structures themselves are not the solution but rather a means to initiate specific, desirable processes that will address the limiting factors for beavers to move back into an area. If we are successful, beavers will move in and take over our restoration project.

Ten guiding principles define the core basis for low-tech process-based restoration for structurally starved systems (Wheaton et al., 2019). These principles are broken into two categories: 1) Riverscapes and 2) Restoration. The 'Riverscapes Principles' inform planning and design through an understanding of what constitutes healthy, functioning riverscapes and, therefore, what are appropriate targets and analogues to aim for. By contrast, the 'Restoration Principles' relate to our specific restoration actions and give us clues as to how to develop designs to promote processes that lead to recovery and resilience.



## Riverscapes Principles

1. Streams need space. Healthy streams are dynamic, regularly shifting position within their valley bottom, reworking and interacting with their floodplain. Allowing streams to adjust, meander, and spread out laterally within their valley bottom is essential for maintaining functioning riverscapes.

2. Structure forces complexity and builds resilience. Structural elements, such as beaver's dams and large woody debris, force changes in flow patterns that produce physically diverse habitats. Physically diverse habitats are more resilient to disturbances than simplified, homogeneous habitats.

3. The importance of structure varies. The relative importance and abundance of structural elements vary based on reach type, valley setting, flow regime, and watershed context. Recognizing what type of stream you are dealing with (i.e., what other streams it is similar to) helps develop realistic expectations about how that stream should or could look ( form) and behave (process).

4. Inefficient conveyance of water is often healthy. Hydrologic inefficiency is the hallmark of a healthy system. More diverse residence times for water can attenuate potentially damaging floods, fill up valley bottom sponges, and slowly release that water later, elevating baseflow and producing critical ecosystem services.

## Restoration Principles

5. It's okay to be messy. When structure is added back to a stream, it is meant to mimic and promote the processes of wood accumulation and beavers' damming activity. Structures are fed to the system like a meal and should resemble natural structures (log jams, beaver dams, fallen trees) in naturally 'messy' systems. Structures do not have to be perfectly built to yield desirable outcomes. Focus less on the form and more on the processes the structures will promote.

6. There is strength in numbers. A large number of smaller structures working in concert with each other can achieve much more than a few isolated, over-built, highly secured structures. Using a lot of smaller structures provides redundancy and reduces the importance of any one structure. It generally takes many structures, designed in a complex, to promote the processes of wood accumulation and beavers' damming activity that lead to the desired outcomes.

7. Use natural building materials. Natural materials should be used because structures are simply intended to initiate process recovery and go away over time. Locally sourced materials are preferable because they simplify logistics and keep costs down.

8. Let the system do the work. Giving the riverscape and/or beavers the tools (structure) to promote natural processes to heal the system with stream power and ecosystem engineering, as opposed to diesel power, promotes efficiency that allows restoration to scale to the scope of degradation.

9. Defer decision-making to the system. Wherever possible, let the system make critical design decisions by simply providing the tools and space it needs to adjust. Deferring decision-making to the system downplays the significance of uncertainty due to limited knowledge.

10. Self-sustaining systems are the solution. Low-tech restoration actions in and of themselves are not the solution. Rather, they are intended to initiate processes and nudge the system towards the ultimate goal of building a resilient, self-sustaining riverscape.

***Things to consider:***

- Focus low-tech, process-based restoration work to 1) build strongholds, 2) start new strongholds, and 3) connect strongholds—as suggested at the beginning of this section.
- Some of the same objectives, for example, addressing a velocity barrier for beavers' habitat, can also be accomplished with traditional large woody debris projects, as long as these projects adhere to the Restoration Principles laid out above.

# Riparian Planting

Restoration planting in degraded riparian areas has been a primary tool for restoration practitioners for some time. At its best, a riparian planting can kick off cascading habitat processes. At its worse, people can spend endless time, money, and herbicides "doing battle" with non-native vegetation while limping the plants along on a life support system of water, fertilizers, mulch, and browse protection. Here we avoid this latter treadmill by focusing specifically on situations where beavers' habitat is limited by appropriate forage type, availability, or degradation. If these conditions are due to heavy ungulate browse, work to first exclude these animals (see "Heavy-Grazer Exclusion" on page 43).

## Willow staking

Live staking during the dormancy period (late fall-early spring) is both an effective and low-cost way to kick-start beavers' forage where it is limiting. Many species can be rooted from live stakes.

Two woody shrubs that are excellent for creating foraging habitat are willow (one of the native *Salix spp*) and Red-osier dogwood (*Cornus sericea*). Guidelines for live-staking include:

- When possible, harvest these plant materials at, or near, the restoration site and plant immediately.
- Insert the cuttings with as much plant material below ground as possible, and cut off the stem above ground, leaving two to four buds exposed.
- Make sure to insert cuttings "right side up." Avoid confusion by clipping a sharp point on bottom cut during harvest.
- A cutting must have access to water year-round at its base — plant where this is possible, such as in-stream or along the bank edges.
- Keep cuttings moist in cold storage if not used within a week after harvesting.



- Soak cuttings in water for 24 hours before planting, if possible.
- Dibbles or other hand tools can help open a hole for the cutting before planting.
- If the ground is too hard to press cutting into soil, larger cuttings (2-3" width) can be driven in with a power post driver. Wrap top of cutting with duct tape to keep from splaying apart in driver. Cut off the taped end after cutting is driven in.
- Waddles of finer willow material can also be dug and staked down for sprouting, as long as the area will stay perennially wet.

## Planting nursery stock

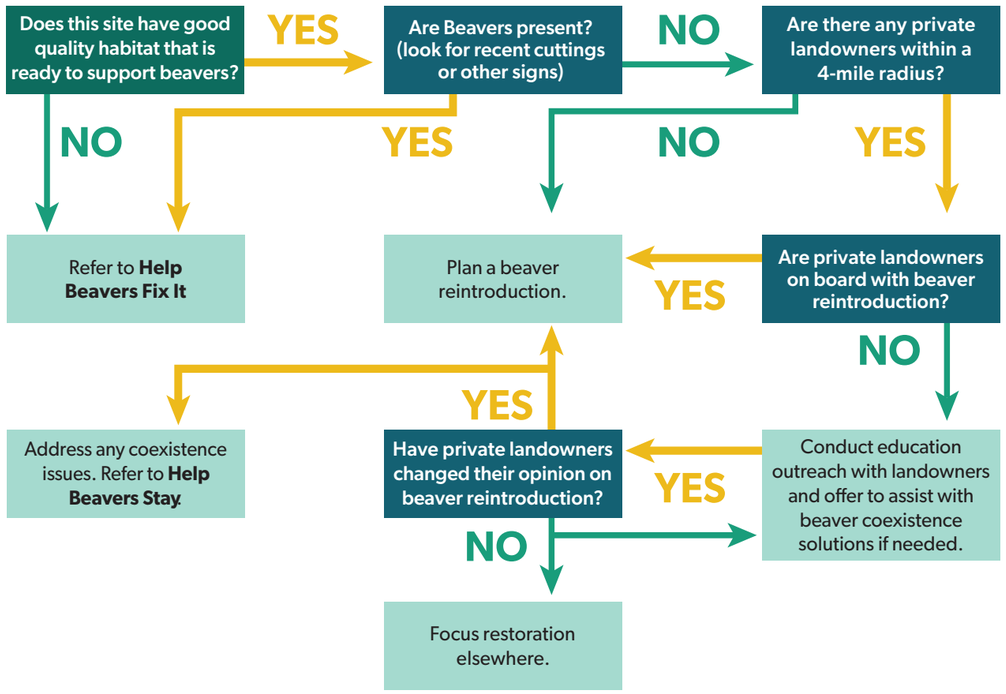
Planting rooted stock of native trees and shrubs also has a place in restoring beavers' forage in a riparian area. General guidelines for establishing these nursery-raised plantings include:

- Choose hardy, drought resistant species.
- Protect from browse (ungulate and beavers) for the planting's first few years until established.
- Mulch deeply, with biodegradable materials.
- Irrigate, if possible, throughout the summer as needed for the first few years until established.

***Things to consider:***

- Consider the conditions that led to a degraded riparian vegetative community. Address the underlying issues first. For example, if the stream's severely degraded hydrology has led to a lack of native riparian vegetation, those underlying hydrologic processes and functions should be restored before planting will be effective.
- Decide on either an r or K selection strategy for planting. An r selection strategy, like that employed by mice, invests a lot of young lives with only a little resource rationed to each. Alternatively, a K selection strategy, like that employed by elephants, invests in fewer offspring at once with a lot more resources. This analogy to the natural history of animals is applicable in considering whether to invest little in many, or to invest lots in few plantings. There are trade-offs to both strategies, so consider in the context of your site's resources, such as water availability, solar exposure, browse risk, etc.

# Help Beavers Find It




## Translocation

Translocation of beaver colonies is a strategy for establishing beaver in otherwise inaccessible habitat. This a restoration-focused tool for areas that have "beaver-ready" habitat with no identified limiting factors, yet beavers have been unable to find these places due to extirpation or habitat connectivity issues. In these areas, translocating animals can be an effective strategy for both recolonizing a specific site, as well as seeding a new population of beaver higher in the watershed from which juvenile beaver can disperse in years to come.

All of the habitat in the Neskowin watershed appears to be accessible to dispersing young beavers, and the preferential territory selection has been favoring unoccupied, low-gradient sites before those higher in the watershed. For example, given how small the Hawk Creek watershed is, it would not be pragmatic to translocate beaver into the upper watershed, because they'd be likely to waddle their way right back down into their preferred, low-gradient, water-rich habitat. If we want to encourage beavers to move into the upper watershed, we need to solve the population sink problem where the beavers are encountering conflict with human infrastructure, and we must lure them to expand of their own volition through ltPBR. There is, however, the potential to utilize live trapping as a mitigation to conflict in some areas of private land low in the watershed, and to deliver those young beaver pairs to the USFSas part of a translocation effort onto public land within the larger basin. Toward that end, we've included information on that process.

In order to translocate beavers, an appropriate, unoccupied location must be identified through a survey of 2,000 feet upstream and downstream (4,000 feet total) from the release site. The location must show no signs of beaver activity and be approved by a regional ODFW wildlife biologist. If private land is nearby, this action must be supported by the majority of property owners within a 2-mile radius of the new relocation site. A list of contacted landowners must be recorded, including their name, address, signature, and the support/opposition for the translocation. Relocations will be most successful if conducted between August 1 and October 31, a window when kits are old enough to withstand translocation and before winter so that the transplanted beavers have time to ready themselves for winter weather at their new site. Every attempt should be made to trap all members of the family (this could be anywhere between a recently dispersed pair to a family of 12). They should be held until all members of the family can be relocated together (within reasonable timeframes). Follow-up monitoring at release sites by project implementers and reporting to an ODFW agency wildlife biologist is essential to determine the success of reintroduction efforts. This monitoring includes at least two surveys, once 30 days after release and once the fall following release. A survey is to be conducted 2,000 feet upstream and downstream (4,000 feet total) from the release site.

The ODFW published relocation requirements for beavers in 2017, which are structured as a set of requirements and recommendations for successful relocation. As such, ODFW regional staff must be contacted and approve the release site and relocation process (ODFW 2017).

***Things to consider:***

- Beavers should be sourced from areas with human infrastructure conflict on private lands. However, remember that relocation is only a temporary solution for the party experiencing the infrastructure conflict. Moving the animals should be seen as providing a short-term reprieve until habitat/infrastructure modifications can be accomplished. Beavers are highly territorial, and if they have identified the area as good habitat, a new family will likely move into any territory that is opened up through the removal of beavers. In some areas, if coexistence solutions are not possible, then these could become established source locations for repopulating approved sites on federally managed public land.

- Ideally, capture and relocation sites will occur within the same sub-basin. Translocation beyond that threshold requires additional approval from ODFW staff at regional and statewide levels.

- Live capture traps can be dangerous for people, pets, and other wildlife and should be well signed. Any relocation trapping should be conducted by trained staff, project partner, or an ODFW licensed wildlife control officer (WCO).

- It is important to remember that these ODFW requirements prohibit releases into areas already occupied by beavers.


PROJECT
BEAVER