

January  
2024

BEAVER HANDBOOK  
*FINAL PERFORMANCE REPORT*

The purpose of this Agreement is to reimburse the Grantee for update of the Beaver Restoration Guidebook – an open-source guide to the best available science, restoration techniques, and management practices for partnering with beavers in stream restoration.



Our objective was to complete the following project tasks:

1. Establish a transparent, periodic process for BRG revision, and the collection and solicitation of academic and practitioner input.
2. Complete a chapter on beaver habitat, outlining the current state of knowledge and providing a conceptual framework for the application of that knowledge in the real world.
3. Clarify the regulatory framework for beaver management and beaver-based restoration in the Mountain West.
4. Generate Best Management Practices (BMPs) in the form of detailed site evaluation, design options and considerations, and construction details for two forms of beaver/human conflict mitigation devices: pond levelers and culvert protection. Work with ODFW and federal agencies to evaluate concerns and workshop design alternatives. Publish BMPs standards with support from ODFW, NOAA, and USFWS.
5. Update specific topics, including developing new content where necessary, to explain what is known about the relationship between beaver and wildfire resilience.
6. Update the BRG library of references to include new literature with in-text citations, as applicable.
7. Publish revision 3.0 online as a downloadable pdf, and purchasable as a print-to-order physical document.
8. Facilitate an expedited permitting process in Oregon, in collaboration with state and federal agencies.



Oregon Conservation and Recreation Fund  
Agreement #: **OCRF 2022-44**

Reporting Period:  
**July 15, 2022 – January 02, 2024**

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## Overview:

This was a bold proposal to work across multiple agencies on multiple fronts; BMPs for beaver coexistence flow devices, a regulatory framework, and revising the Beaver Restoration Guidebook. We succeeded fully on the effort to publish the BMPs, while we assisted partnering agency staff on the latter two objectives up and to the point where our involvement was no-longer needed.

## Where we made progress:

### *Objective 4. Publish a set of best management practices for beaver coexistence flow devices*

We published “[Best Management Practices for Pond Levelers and Culvert Protection Systems: A guide for using flow devices to coexist with beavers.](#)” After the years of collaboration with both ODFW, NOAA and USFWS staff and beaver coexistence practitioners around the nation, it was an honor to present this publication. We decided to publish these BMPs as a stand-alone living document, which will be revised as practitioners see fit.

This document is intended to empower the landowners, organizations, municipalities, and wildlife professionals who are interested in finding solutions to ongoing conflicts between human infrastructure and beaver habitat while still retaining the beavers and their benefits. It is being utilized to facilitate beaver coexistence projects throughout Oregon, the USA and the Northern Hemisphere.

Project Beaver will be administering this living document into the future, with technical input on revisions from members of the Beaver Institute’s Beaver Management National Beaver Working Group.

### *Objectives 1 and 2. Establish a process for BRG revision and draft a chapter*

We hired [Fuse Consulting](#) to assist in planning the BRG revision process. They produced both a sample chapter (Chapter 9 – Beaver Coexistence) and a project roadmap (both attached). These documents were the product of a series of facilitated meetings, which we then presented to the original authors and project partners at USFWS, NOAA and ODFW. We chose to produce a chapter that leveraged our BMPs work rather than the originally proposed sample chapter on beaver habitat, as we felt a revised Chapter 9 was most likely to demonstrate our vision for this revision.

At that point, we were unable to secure agreement from the various stakeholders about a path forwards. While the original primary author was interested in proceeding with the revision as proposed, a couple of the other original authors and staff from USFWS decided that they would like to keep the Beaver Restoration Guidebook as an in-house publication of the USFWS (rather than continuing the partnership with Project Beaver).

USFWS’s Oregon Fish and Wildlife Office is responsible for any further progress on the BRG revision.

***Objectives 3 and 8. Clarify the regulatory framework and facilitate an expedited process***

We hired Rob Walton Consulting to complete an initial review of the regulations that relate to beaver management and beaver-based coexistence, and Fuse Consulting to assist in assembling those notes into a report entitled “*Beaver Flow Devices in Oregon: Navigating policies, statutes, administrative rules and guidelines*” (attached). We shared this draft report with collaborating staff at USFWS, NOAA and ODFW, and offered to assist this effort further by putting together and administering a multi-agency working group.

To quote a response from USFWS, “As each agency has its own unique process to determine the ecological impacts and regulatory and permitting requirements prior to utilizing these coexistence devices, individually developing a map of the regulatory process within each agency may be a more effective path forward than a facilitated multi-agency working group, at least initially.” At this point in the process, there was nothing further we could do to assess the respective agencies in their own respective processes for considering an expedited permitting process to support beaver coexistence and beaver-based restoration practices.

The respective agencies (ODFW, USFWS, NOAA, Army Corps, DSL) are responsible for any further progress on this effort.

**Where we were unable to make progress:**

***Objectives 5 - 7. Publishing a revision of the BRG***

As discussed above, staff from USFWS and a couple of the original authors decided that they would like to keep the Beaver Restoration Guidebook as an in-house publication of the USFWS, rather than continuing the partnership with Project Beaver.

USFWS’s Oregon Fish and Wildlife Office is responsible for any further progress on the BRG revision.

**Certification:**

I certify to the best of my knowledge and belief that this report is correct and complete for performance of activities for the purposes set forth in the award documents.

Jakob Shockey, Executive Director

\_\_\_\_\_  
*Printed Name & Title of Person Completing Report*

  
\_\_\_\_\_  
*Signature*

January 16, 2024

\_\_\_\_\_  
*Date Submitted*



# COEXISTING WITH BEAVERS IN OREGON:

Navigating policies, statutes, administrative rules and guidelines

Shelagh Pyper and Jakob Shockey

May 2023



## Introduction

The following report attempts to outline the current regulatory landscape for beaver-based restoration, including beaver dam analogs, pond levelers and culvert protectors in Oregon.

State and federal plans for the conservation and recovery of salmon and steelhead species listed in the *Endangered Species Act* (ESA) describe how beaver and beaver dams can create high-quality rearing habitat for juvenile salmon and steelhead. For example, the federal recovery plan for Oregon Coast coho salmon specifically recommends beavers, beaver dams, and beaver dam analogs (BDAs) to support beaver-based restoration, and implementation of the Beaver Restoration Guidebook, to support recovery of this threatened species. In arid areas of Oregon, generally east of the Cascade mountains, beaver-based restoration is being recommended and implemented by agencies and landowners to help restore groundwater and increase water security. Unfortunately, the federal and state laws that protect Oregon's rivers, salmon and fish and wildlife habitat make it difficult, if not impossible, to get permits for beaver-based restoration and coexistence projects, despite the fact that they can protect ecosystem health and contribute to species resilience and recovery.



Figure 1. This report consolidates information from government agencies for those implementing beaver-based restoration.



This report includes the following sections:

- [Government Context and Contacts](#)
- [Planning requirements for Beaver Coexistence Devices](#)
- [Looking forward: Permitting Pathway for Beaver Coexistence Devices](#)
- [Oregon Statutes Relevant to Beaver-based Restoration](#)
- [Relevant Oregon Administrative Rules \(OAR\)](#)

## Government Context and Contacts

Many regulatory bodies at the federal and state levels have mandates that intersect with beaver dams and any structure installed in a natural waterway (Figure 2). We list these agencies, their potential role key contacts in the table below (Table 1).

### STAKEHOLDER MAP

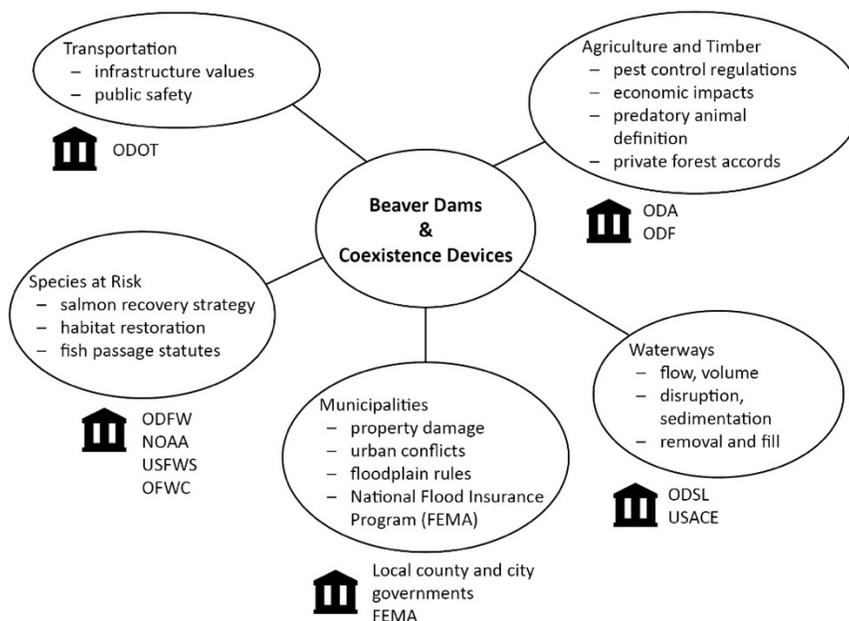


Figure 2: Five key areas that have relevant regulations, definitions, guidelines and administrative rules



## AGENCIES

State and Federal Agencies	References <sup>1</sup>	Role/Duties
<b>Oregon State Agencies</b>		
Oregon Fish and Wildlife Commission (OFWC)	ORS 497,498	<ul style="list-style-type: none"> <li>- "... make decisions affecting the wildlife resources of the state..."</li> <li>- Prescribe and administer trapper education</li> <li>- Open/close areas to trapping</li> </ul>
	<b>Key Contact(s):</b>	<b>Oregon Fish and Wildlife Commission, Chair</b> <i>Current contact person: Mary Wahl</i>
Oregon Dept. of Fish and Wildlife (ODFW)	ORS 496.004 OAR 635-050-0050 ORS 509.580 OAR 141-085	Implement furbearer rules on public land  Implement fish passage statute and regulations including task force
	<b>Key Contact(s):</b>	<b>Oregon Department of Fish and Wildlife, Director</b> <i>Current contact person: Curt Melcher</i>
	<b>Fish passage</b>	<b>Statewide Fish Passage Program, Program Leader</b> <i>Current contact person: Greg Apke,</i> <i>Email: <a href="mailto:Greg.D.Apke@state.or.us">Greg.D.Apke@state.or.us</a></i> <i>Phone: 503-931-4361</i>
	<b>Beaver policy (public land)</b>	<b>Interdivision Beaver Coordinator</b> <i>Current contact person: Adrienne Averett</i> <i>Email: <a href="mailto:Adrienne.W.AVERETT@odfw.oregon.gov">Adrienne.W.AVERETT@odfw.oregon.gov</a></i> <i>Phone: 971-808-8799</i> <b>Carnivore-Furbearer Coordinator</b> <i>Current contact person: Derek Broman</i> <i>Email: <a href="mailto:Derek.j.broman@state.or.us">Derek.j.broman@state.or.us</a></i> <i>Phone: 503-947-6095</i>
Oregon Dept. of Agriculture (ODA)	ORS 610.002	Implement predatory animal rules on private land
	<b>Beaver policy (private land)</b>	<b><i>We did not identify a contact role or person</i></b>
Oregon Dept. of State Lands (ODSL)	ORS 196.668 OAR 141-085-506	Implement wetland removal/fill rules
	<b>Key Contact(s):</b>	<b>Removal-Fill Specialist</b> <i>Current contact person: Bethany Harrington</i> <i>Email: <a href="mailto:Bethany.Harrington@dsl.oregon.gov">Bethany.Harrington@dsl.oregon.gov</a></i> <i>Phone: 541-325-6171</i>
Oregon Dept. of Environmental Quality (ODEQ)	Section 401 of the Clean Water Act	Implement water quality rules
	<b>Key Contact(s):</b>	<b><i>We did not identify a contact role or person</i></b>
Dept. of Transportation (ODOT)	Limit 10(i) under section 4(d) of the Endangered Species Act (ESA), final rule (65 FR 42422)	Maintain road/highway culverts using BMPs to protect and conserve salmon and steelhead that are listed as threatened within Oregon's waters, as depicted in the ODOT Routine Road Maintenance Water Quality and Habitat Guide Best Management Practices (Blue Book)
	<b>Key Contact(s):</b>	<b><i>We did not identify a contact role or person</i></b>



State and Federal Agencies	References <sup>1</sup>	Role/Duties
Oregon Dept. of Forestry (ODF)	ORS 527.710	Operators must submit a plan prior to removal of beaver dams.
	2022 Private Timber Accord	A 2022 agreement, includes the prioritizing beaver conflict resolution with non-lethal methods
<b>Key Contact(s):</b> <i>We did not identify a contact role or person</i>		
<b>Federal Agencies</b>		
National Oceanic and Atmospheric Administration (NOAA) Fisheries	Endangered Species Act	Protect listed commercial fish species (salmon/steelhead)
	<b>Key Contact(s):</b>	<b>Senior Policy Advisor (Portland)</b> Current contact person: Irma Lagomarsino, Email: <a href="mailto:irma.lagomarsino@noaa.gov">irma.lagomarsino@noaa.gov</a> Phone: 707 496-1679
US Fish and Wildlife Service (USFWS)	Endangered Species Act	Protect listed species (including non-commercial fish species like bull trout, lamprey, etc)
	<b>Key Contact(s):</b>	<b>Aquatic Resources Division Manager Oregon Fish &amp; Wildlife Office</b> Current contact person: Chris Allen, Email: <a href="mailto:Chris.Allen@fws.gov">Chris.Allen@fws.gov</a> Phone: 503-231-6906 <b>Aquatic Ecologist, Oregon Fish &amp; Wildlife Office</b> Current contact person: Brian Bangs Email: <a href="mailto:brian_bangs@fws.gov">brian_bangs@fws.gov</a> Phone: 541-908-1538
United States Army Corps of Engineers (USACE)	§ 401 of Clean Water Act	Require permits to discharge into navigable waters
	<b>Key Contact(s):</b>	<b>Portland Permits Section Chief</b> Current contact person: Melody White Email: <a href="mailto:Melody.J.White@usace.army.mil">Melody.J.White@usace.army.mil</a> Phone: 503-201-0797
Federal Emergency Management Agency (FEMA)	Floodplain development	National Flood Insurance Program
	<b>Key Contact(s):</b>	<i>We did not identify a contact role or person</i>

Table 1: Agencies that may have regulations relevant to coexistence device projects.

<sup>1</sup> Legislation, statutes, regulations, etc. Acronyms: Oregon Revised Statute (ORS), Oregon Administrative Rule (OAR).



## Planning Requirements for Beaver Coexistence Devices

Beaver coexistence devices are a unique construction project that defy conventional permitting pathways. The habitat benefits and ecological goods and services provided by beaver-managed flood plains are well understood. However, the Best Management Practices for coexistence solutions have only recently been assembled (Shockey 2023) and there is yet no straightforward permitting pathway through the regulatory framework.

Beaver dam analogs (BDAs) and Post Assisted Log Structures (PALS) are similar projects to culvert protectors and pond levelers. Unlike culvert protectors and pond levelers, there are now clear regulatory requirements for BDAs and similar beaver-based restoration techniques. These requirements are provided in the table below (Table 2), followed by a space where we outline the similar requirements that have yet to be determined for culvert protectors and pond levelers. Subsequent updates to this report will include planning requirements for these coexistence devices as they become available; until then, these gaps in guidance are indicated with red text.

Subject	Requirement/Guidance	Relevant statute or regulation
<b>Beaver Dam Analog (BDA)</b>		
	Fish passage (ODFW) <ul style="list-style-type: none"> <li>Approval is not needed if there are no migratory fish or if BDAs/VPSs meet criteria</li> <li>Expedited ODFW approvals if consistent with BRG and LtPBR Manual</li> <li>BDAs and PALS that don't conform must submit standard application</li> </ul>	ORS 509.580-910 <a href="#">State of Oregon Fish Passage Approvals for Instream Habitat Restoration Actions</a> “The primary goal of this new policy guidance bulletin (see below) is to streamline and expedite the state’s fish passage review and approval procedures for instream habitat restoration projects designed and implemented to specifically mimic natural habitat features created by beaver and beaver dams.”
	General Authorization (ODSL)	ORS 196 OAR 141-085,089,090,093 Fill/removal rules
	401 (ODEQ)	Clean Water Act § 401 permitting Water quality rules
	Regulatory Compliance (USACE)	Applied for as joint part of General Authorization permitting (ODSL)
	ESA Compliance (NOAA and USFWS)	Triggered through other permits
	NEPA Compliance (USFS or BLM)	Only applicable if on public land
	Archeologic compliance (Oregon State Historic Preservation Office)	Requirement triggered through other permits (via ODSL and USACE)



Subject	Requirement/Guidance	Relevant statute or regulation
	Local government permitting	FEMA Flood insurance requirements of local planning departments to insure “no-rise” for floodplain development projects. Currently requires an engineer certification of no-rise. This could result in a requirement to submit a Conditional Letter of Map Revision to FEMA
Materials/construction guideline	BDA is “comprised of organic materials and with a porous organic material weave between untreated wood posts”	ODFW BDA Guidance
Work window	In-water work windows shall be implemented, unless otherwise negotiated by ODFW	Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife Resources [ <a href="https://fs.usda.gov">link</a> , fs.usda.gov]
Monitoring/adaptive management	Monitoring report required policy guidance by Dec. 31 annually for 3 years	ODFW BDA Guidance
<b>Pond Levelers</b>		
	Fish passage (ODFW) <ul style="list-style-type: none"> <li>• If no large-bodied fish are present, no approval needed if constructed with no less than 6” by 6” size mesh.</li> <li>• If large-bodied fish are present, case-by-case approval required</li> </ul>	ORS 509.580-910  ODFW Division 412 Fish Passage Administrative Rules 635-412-0035 Fish Passage Criteria (3)(C) i-iv (lines 725-732)
	<b>Guidance Needed</b> General Authorization (ODSL)	<b>Unknown applicability</b> ORS 196 OAR 141-085,089,090,093 Flow devices would seem to fall under the 50 Cubic foot exception, except when working in Essential Salmon Habitat
Materials/construction guideline	Minimize adverse impacts to habitat, cage and hide the intake 30’ – 60’ upstream, adequately sized and vented pipe, durable materials and no pressure treated wood, modify for stream width, depth and other features as described in BMP document. Construct with hand tools only.	<b>No agency guidance</b> <i>Best Management Practices for Pond Levelers and Culvert Protection Systems (Shockey 2023)</i>
Work window	In-water work windows shall be implemented, unless otherwise negotiated by ODFW	Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife Resources [ <a href="https://fs.usda.gov">link</a> , fs.usda.gov]



Subject	Requirement/Guidance	Relevant statute or regulation
Monitoring/adaptive management	Maintenance visits a minimum of once a year.	<b>No agency guidance</b> <i>Best Management Practices for Pond Levelers and Culvert Protection Systems (Shockey 2023)</i>
<b>Culvert Protection</b>		
	Fish passage (ODFW) <ul style="list-style-type: none"> <li>• If no large-bodied fish are present, no approval needed if constructed with no less than 6” by 6” size mesh.</li> <li>• If large-bodied fish are present, case-by-case approval required</li> </ul>	ORS 509.580-910  ODFW Division 412 Fish Passage Administrative Rules 635-412-0035 Fish Passage Criteria (3)(C) i-iv (lines 725-732)
	<b>Guidance Needed</b> General Authorization (ODSL)	<b>Unknown applicability</b> ORS 196 OAR 141-085,089,090,093 Flow devices would seem to fall under the 50 Cubic foot exception, except when working in Essential Salmon Habitat
Materials/construction guidelines	Minimize adverse impacts to habitat, facilitate wildlife passage, durable materials and no pressure treated wood, modify for site specific features as described in BMP document. Construct with hand tools only.	<b>No agency guidance</b> <i>Best Management Practices for Pond Levelers and Culvert Protection Systems (Shockey 2023)</i>
Work window	In-water work windows shall be implemented, unless otherwise negotiated by ODFW	Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife Resources [ <a href="https://fs.usda.gov">link</a> , fs.usda.gov]
Monitoring/adaptive management	Maintenance visits a minimum of once a year.	<b>No agency guidance</b> <i>Best Management Practices for Pond Levelers and Culvert Protection Systems (Shockey 2023)</i>

Table 2: Potential planning requirements and relevant statutes, regulations or other documents for BDAs, pond levelers and culvert protection.



## Looking Forward—Permitting Pathway for Beaver Coexistence Devices

At the time of this report, a broader conversation is supporting a collaborative process to develop an expedited permit pathway for installing coexistence devices like pond levelers and culvert protectors in Oregon. [Project Beaver](#) is one of many non-governmental organizations working to promote coexistence strategies that empower landowners with better tools to "live with beavers." These efforts align with state and federal strategies and public communication around living with beavers, accelerating the pace of landscape-scale beaver-based restoration, fish recovery and water issues. Staff at ODFW have voiced a commitment to working with federal agencies and others to prepare a permitting pathway for beaver coexistence flow devices that are in accordance with the BMPs—similar to the 2020 ODFW permitting pathway that was established to support the implementation of BDAs in Oregon

The following diagram represents the two key groups navigating question of responsible beaver management, The Beaver Coalition (dba Project Beaver) and other NGOs and relevant State and Federal Agencies. By identifying areas of shared interest and motivation, and working collaboratively toward common goals, it is hoped that a clear framework for beaver coexistence projects will be achieved.

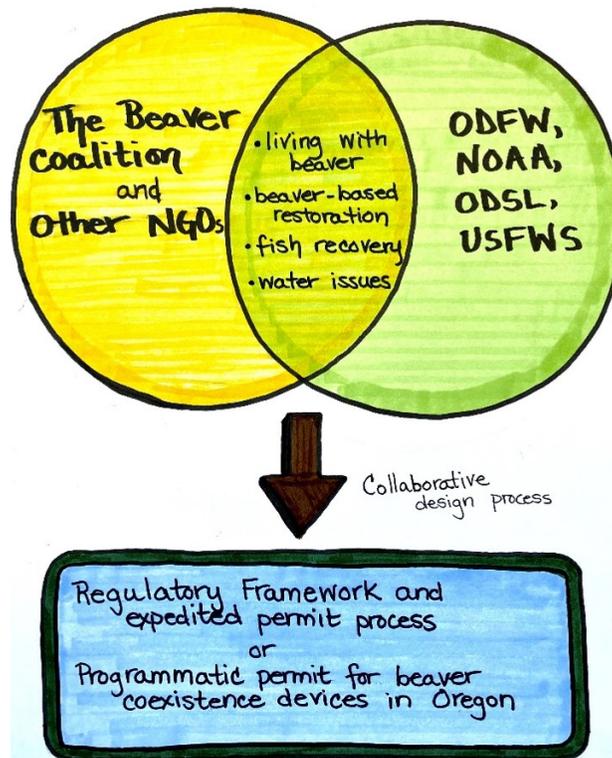


Figure 3: Two key groups navigating question of responsible beaver management



A complication to beaver-based restoration is the implementation of fish passage statutes and regulations by the ODFW. In practice, these regulations greatly restricted the implementation of coexistence solutions to beaver/human conflicts in Oregon in 2019 and into 2020, as well as BDAs for few years before that. Recognizing this, in 2020 ODFW developed an expedited permitting pathway for those BDAs that are implemented in accordance with the best management practices (BMPs) outlined in the Beaver Restoration Guidebook (Pollock et. al. 2017) and the Low-tech Process-based Restoration of Riverscapes Design Manual (Wheaten et. al. 2019).

During 2021 and 2022, a working group was convened by Project Beaver with Fuse Consulting that included staff from ODFW, NOAA Fisheries, and the USFWS. This group provided guidance on the development of the *Best Management Practices for Pond Levelers and Culvert Protection Systems*, which was published in December 2022. Also in late 2022, ODFW approved their new Division 412 Fish Passage Administrative Rules, which established guidance for flow devices in accordance with this new Best Management Practices (BMP) document for streams without large-bodied fish. These new rules also established that flow devices will be approved for fish passage on a case-by-case basis in streams with large bodied fish. In May 2023, Project Beaver has issued a revised BMP document (version 1.2) that was responsive to final ODFW comments (Shockey 2023). Staff at ODFW have voiced a commitment to working with federal agencies and others to prepare a permitting pathway for beaver coexistence flow devices that are in accordance with the BMPs—similar to the 2020 ODFW permitting pathway that was established to support the implementation of BDAs in Oregon. Likewise, staff at NOAA Fisheries, USFWS and USACE have voiced a commitment to better defining a straightforward process to ensure compliance for beaver coexistence flow devices with the ESA and other federal laws.



## Oregon Statutes Relevant to Beaver-based Restoration

The following table lists Oregon Revised Statutes and definitions that may have bearing on characterization of pond levelers and culvert protectors. As these devices retain beaver managed floodplains and slow the flow of runoff, they present a net benefit for fish species. They have some “artificial” components but are not designed to be “obstructions.” Naturally occurring beaver dams remain on site and would continue to be the main obstruction in the waterway – an obstruction that is both porous and passable by fish, who have evolved to navigate and benefit from these habitat features. This list and the summaries are not exhaustive. Please review any relevant statutes in full before beginning any project.

In addition to these statutes, the following state policy serves to protect beaver dams:

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*Attention Coastal Beaver Trappers: ODFW requests your continued cooperation in protecting beaver dams in coastal areas important to Coho salmon rearing. If you are not familiar with this program, which was initiated in 1998, please contact your local ODFW biologist. – 2022 Oregon Furbearer Hunting and Trapping Regulations*

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Oregon Revised Statute (ORS)	Subject	Summary
ORS 509.580	Definitions for: - ORS 509.580-590 - ORS 509.600-645 - ORS 509.910	“Artificial obstruction” means any dam, diversion, culvert or other human-made device placed in the waters of this state that precludes or prevents the migration of native migratory fish[...] “Net benefit” means an increase in the overall, in-proximity habitat quality or quantity that is biologically likely to lead to an increased number of native migratory fish after [...] measures have been completed.
ORS 509.585	Fish passage required for artificial obstructions	(1) It is the policy of the State of Oregon to provide for upstream and downstream passage for native migratory fish. (6) The department shall submit a proposed determination of the required fish passage or alternatives to fish passage to the commission for approval.
	Statewide inventory	(1) ODFW shall complete and maintain a statewide inventory of artificial obstructions in order to prioritize enforcement actions based on the needs of native migratory fish.



Oregon Revised Statute (ORS)	Subject	Summary
	Waiver of requirement by commission	(7)(a) The commission shall waive the requirement for fish passage if the commission determines that the alternatives to fish passage proposed by the person owning or operating the artificial obstruction provide a net benefit to native migratory fish. [See the full ORS for determining net benefit]
	Rules and Exemptions	(7)(c) ODFW Director shall develop rules establishing general criteria for determining the adequacy of fish passage and of alternatives to fish passage. [See the full ORS for a list of criteria]
ORS 509.625	Power of department to inspect artificial obstructions and have fish passage constructed or remove obstruction	(1) The State Department of Fish and Wildlife may determine or ascertain by inspection of any artificial obstruction whether it would be advisable to construct fish passage [...]
ORS 509.645	<ul style="list-style-type: none"> <li>- Filing protest with commission</li> <li>- Review and determination by commission</li> <li>- Alternative dispute resolution</li> </ul>	(1) A person owning or operating an artificial obstruction may request alternative dispute resolution... A person owning or operating an artificial obstruction may file a protest with the State Fish and Wildlife Commission within 30 days from the receipt of the State Department of Fish and Wildlife determinations under ORS 509.585. The person shall identify the grounds for protesting the department's determinations.

Table 3: Oregon Statutes relevant to beaver-based restoration



## Relevant Oregon Administrative Rules (OAR)

There are also administrative rules that govern projects in waterways in Oregon. The following table lists OARs relevant to the ODSL and ODFW (Table 4). The removal/fill exemption under the ODSL may apply to flow devices, and may mean that no involvement or permit is required from the ODSL. It is included here to help clarify whether removal/fill rules apply to these restoration projects. Note: This list and the summaries are not exhaustive. Please review any relevant rules in full before beginning any project.

Subject	OAR	Summary
<b>Department of State Lands</b>		
Remove/fill exemptions	141-085-0530	These exemptions apply in all waters of this state except State Scenic Waterways.... (7) Fish Passage and Fish Screening Structures in Essential Indigenous Anadromous Salmonid Habitat (ESH). Less than 50 cubic yards of removal-fill for construction or maintenance of fish passage and fish screening structures that are constructed, operated or maintained under ORS 498.306, 498.316, 498.326 or 509.600 to 509.645. This exemption includes removal of material that inhibits fish passage or prevents fish screens from functioning properly.
Waterway Habitat Restoration	141-089-0790	(1) Fish and Wildlife Passage. This activity includes installation or replacement of fish passage structures including, but not limited to vertical slot fishways, nature-like fishways and lamprey ramps to aid fish and/or wildlife passage. (5) Porous Weir. This activity includes the construction of a self-sustaining, low profile, structure. A porous weir delays but does not store water. It is used to redirect flow toward the center of the channel, provide energy dissipation and promote increased sedimentation along banks while allowing fish passage through a porous design. This activity includes, but is not limited to cross vanes and artificial riffles.
<b>Department of Fish and Wildlife</b>		
Survival guidelines for listed species	635-100-0135	(A) Fish passage statutes ORS 498.351 and 509.605. These statutes require adequate upstream and downstream fish passage at dams or artificial obstructions.
Fish passage task force	635-412-0010	(1) The Director shall appoint nine members to constitute the Fish Passage Task Force, [which will] serve as the public advisory committee and advise the Director and Commission regarding rulemaking to implement the fish passage and waiver requirements; ODFW shall establish a list of priority “artificial obstructions” defined as “any dam, diversion, dike, berm, levee, tide or flood gate, road, culvert or other human-made device placed in the waters of this state that precludes or prevents the migration of native migratory fish...”
Fish passage approval	635-412-0020	If ODFW determines that native migratory fish are or were present, ... prior to construction of artificial obstruction... approved fish passage plan is required [see full OAR for conditions for approval]
Fish passage waivers and exemptions	635-412-0025	(4) The Commission (or Department as applicable) may grant exemptions from fish passage requirements at an artificial obstruction if it is determined that... [see full OAR for conditions for exemptions]



Subject	OAR	Summary
Fish passage criteria	635-412-0035	<p>(d) If native migratory fish- or site-specific circumstances warrant it, the Department may provide an exception to any specific fish passage criterion if the Department determines in writing that fish passage shall still be provided;</p> <p>(e) All fish passage structures shall be designed to take into consideration their upstream and downstream connection and prevent undesirable impacts to fish passage [see OAR for list of mitigation examples and required information]</p> <p>(4) Requirements for fish passage at artificial obstructions in estuaries, and above which a stream is present, are:</p> <p>(a) Fish passage shall be provided at all current and historic channels;</p> <p>(b) Fish passage structures shall meet the criteria of OAR 635-412-0035(2) or (3), except fish passage structures shall be sized according to the cumulative flows or active channel widths, respectively, of all streams entering the estuary above the artificial obstruction; and</p> <p>(c) Tide gates and associated fish passage structures shall be a minimum of 4 feet wide and shall meet the requirements of OAR 635-412-0035(2) within the design streamflow range and for an average of at least 51% of tidal cycles, excluding periods when the channel is not passable under natural conditions.</p> <p>(5) Requirements for fish passage at artificial obstructions in estuaries, floodplains, and wetlands, and above which no stream is present, are:</p> <p>(a) Downstream Fish Passage: (A) Downstream fish passage shall be provided after inflow which may contain native migratory fish;</p> <p>(B) Downstream fish passage shall be provided until water has drained from the estuary, floodplain, or wetland, or through the period determined by the Department.</p>

Table 4: Summary of relevant Oregon Administrative Rules (OARs).



# MOVING THE BEAVER RESTORATION GUIDEBOOK FORWARD

A Roadmap for conventions, revisions and  
stewardship

Fuse Consulting Ltd.

[www.fuseconsulting.ca](http://www.fuseconsulting.ca)

July 2023

DRAFT

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*The Fuse Consulting Ltd. main office is located on Treaty 6 territory, the ancestral and traditional territory of the Cree, Denesuliné, Blackfoot, Saulteaux, Mohawk, and Nakota Sioux. We commit to living in harmony with the traditional peoples of these lands, learning from them, respecting their knowledge, lifting them up and growing towards a just and sustainable future.*

## About the Beaver Restoration Guidebook (BRG)

The Beaver Restoration Guidebook (BRG) began with a proposal in 2013, outlining the two primary goals of (1) synthesizing the current state of science backing beaver restoration work and (2) disseminating this knowledge through a series of workshops. The researchers and experts behind this project understood that the prevalent myths, preconceptions, human/beaver conflicts, and vague regulations surrounding beaver-based restoration work were impeding the high ecological value that this knowledge could bring. As is common with rapidly expanding scientific subjects, much of the most up to date information on this topic remained buried in gray literature and within the individual experiences of practitioners. The BRG was created by compiling an immense variety of resources — websites, reports, legislation, presentations, personal experiences, etc. — that was then anchored within and supported by more than 1400 references from scientific journals. It provides users with the necessary fundamental background in beaver ecology before diving into the more technical aspects of stream restoration and coexistence.

Despite being mainly focused on beaver restoration in the western United States, the BRG has been accessed by thousands of people and practitioners well beyond its initial geographical scope. The number of workshops initially scheduled needed to be expanded to meet demands of attendees. The overwhelming success of the BRG and its initial workshops was a testament to the necessity of this work. Since its initial proposal, the BRG has always been intended as a “living document” that will continue to undergo regular updates. Beaver based restoration science is still developing rapidly, and the success of the BRG is tied into its ability to find, compile, and synthesise the frontiers of this discipline while also referencing and relying on the foundational knowledge that has already become widely accepted. This roadmap is intended to help move the BRG forwards as science progresses so that it can continue to build on the legacy it is creating.

## A roadmap to secure the BRG as the go-to resource for restoration practitioners

The current BRG is known to be the most comprehensive document on beaver-based restoration in the western United States. This document has been a work in progress since 2013 and released its first published version in 2015. It has resulted in a centralized resource of comprehensive technical information on beaver restoration for a variety of practitioners.

The individuals and organizations currently working on beaver-based restoration in the United States could benefit from a BRG that is more accessible to a wider variety of audiences. To improve the usability of the BRG, The Beaver Coalition (dba Project Beaver) has hired Fuse Consulting, a science communications consulting firm. The science communications experts at Fuse recommend the following steps to achieve the goal of a more usable BRG:

- Synthesize the current information in the BRG to pull out key messaging, thereby creating a less information dense product, thereby making it easier to navigate

- Write the document in less technical language so that the document is accessible to a variety of practitioner audiences
- Identify where the background science is stable, vs. where is it in the process of evolving (encouraging the reader to stay-tuned for updates)
- Ensure that the BRG has a consistent writing style throughout
- Organize the BRG into relevant sections, allowing the reader to easily access the sections that are of most interest

It is also important that the group bringing the BRG forward devise a clear process for updating the evolving science related to beaver conservation and management. Having a distinct process and predetermined time-frame for updates will allow clarity and consistency for all those involved, and will also allow individuals accessing the document to know when to look for BRG updates.

Following these recommendations will help secure the long-term credibility of the BRG and ensure the information is used more broadly and more often by those that require it.

The roadmap below outlines more specific ideas on how to create a BRG that is an accessible and credible go-to resource for all restoration practitioners.

The recommendations in this roadmap for securing the BRG as a go-to resource are not prescriptive in nature, they are ideas for consideration. The use of the recommendations below remains at the discretion of the individuals and groups involved in moving the BRG forward.

Here we outline a vision for making the BRG easier to use as well as ideas for creating a credible and consistent pathway for new information to be added/ revised. We envision an accessible, user-friendly document for all types of restoration practitioners with information that is organized in a way that allows for easy navigation to help practitioners solve specific challenges they may be facing with beavers. We also see a process to ensure the BRG is trusted as being a credible up-to-date resource, and that users can easily find and download it in full, or access specific chapters, knowing when to expect science updates.

There are three components to the roadmap to realize this vision:

1. Revising and updating the current BRG document
2. Setting up trusted stewardship and a credible review process
3. Creating a hosting platform

More details on each of these components can be found in the following sections.

## **1. Revising and updating the current BRG document**

The current BRG is a highly technical and lengthy document (over 200 pages). To find content on specific topics, the reader needs to navigate the whole document. The content is valuable, and could be accessed more easily if:

- The language was less technical
- The content was more visually appealing
- Distinct chapters on specific topics could be accessed and shared as stand-alone content
- Information summary sheets were created to synthesize topics, outline key messages and provide valuable resources

To demonstrate what these changes could look like, Fuse Consulting re-worked Chapter 9 of the BRG. This chapter covered Non-lethal Options for Mitigating the Unwanted Effects of Beaver.

Chapter contents were re-ordered into the proposed repeated chapter outline and the resulting updated Chapter contents are as follows:

- 1-page Summary information sheet (a newly developed infographic)
- Why Choose Non-Lethal Options?
- Strategies & Tools
  - Strategies & Tools for Managing Tree Cutting Behaviors
    - Wire Mesh Cages
    - Sand Painting
    - Emerging Practices and Ongoing Research
    - Proactive Planting
  - Strategies & Tools for Managing Dam-building Behaviors
    - Pond Levelers
    - Culvert Protection Systems
    - Emerging Practices and Ongoing Research
    - Proactive Culvert Sizing
- Fish Passage Considerations
- Case Studies
  - Lessons on Cost Savings
  - Urban Beaver in Martinez California – Cohabitating with Beaver in an Urban Setting
- Resources

Content was also summarized, translated into less technical language and written in a consistent voice and tone.

An information summary sheet was not part of the scope for the re-working of Chapter 9; however, a key recommendation would be to create these short 1-page visual summaries for each chapter of the BRG. Fuse Consulting has found through previous experiences that offering summaries on key topics ensures that key messages can be accessed in a very succinct manner. Information sheets can be a way to draw in readership by communicating the most useful information within the main document for specific key audiences. They can also include links to other key resources and further reading.

## **2. Setting up trusted stewardship and a credible review process**

While the BRG was intended to be a “living document” there was no funding or established process for facilitating its future revisions after the latest version published in 2017. In 2020, the authors agreed that The Beaver Coalition (now called Project Beaver) would seek funding to start planning future

revisions after drafting an agreement with the original authors. It is important to address these challenges to move forward with the BRG and ensure its longevity, accuracy, and relevancy.

The original developers of the BRG identified that managing the scope of the information; particularly, distilling the immense amount of information available into a format that was both usable and accessible for its intended audience was greatest challenge in the creation of the document. Bringing in a technical editor was identified as a lesson learned that could have helped guide the development of the document. With these learnings in mind, Fuse Consulting sees two key roles that need to be fulfilled to bring the vision forward:

- A publisher
- A technical committee

Agreed upon guidelines and conventions for how these roles operate would also be essential for ongoing success.

Fuse Consulting is recommending that one organization is made responsible for the stewardship of the BRG moving forward, and that the organization chosen is given the role of Publisher. The Publisher in this case would be responsible for coordinating and following through on these tasks:

- Hosting the most current version of the BRG and ensuring access to all who wish to have it
- Ensuring that edits and updates to the BRG are made in a timely manner according to the guidelines and conventions
- Releasing addendums

At this time, Project Beaver could occupy the role of the Publisher.

To ensure that scientific information in the BRG remains accurate and up to date, a Technical Subcommittee could be created. The idea behind this sub-committee would be to meet annually or bi-annually and review specific sections of the BRG that could be in need of updates in the form of new scientific research findings, or replacement of old methodology. This Sub-committee could be comprised of scientists that have contributed to the current BRG, or new researchers in the field (including students).

The changes brought forward for the Publisher to implement would need to be in accordance with the above-mentioned guidelines/conventions agreement.

The guidelines and conventions would play an essential role for the BRG. They would provide a clear structure for content and will help ensure consistency even if members of the Sub-Committee and/or Publisher change. They would also be intended to streamline the process of updating the BRG, by concentrating the more rapidly evolving science in the “Emerging Practices and Ongoing Research” section. This provides an area of greater focus for the Sub-Committee to review, compared to the more evergreen content of the rest of each chapter.

These guidelines and conventions would be created early in the process and would provide structure to the processes that would allow for changes and publishing to occur. A facilitated process would be an ideal way to form the guidelines and conventions and could help the network of BRG project participants determine important factors such as:

- *What is the vision and mandate of the BRG?*
- *Who should sit on the Technical Sub-committee?*
- *How many Technical Sub-committee members should there be?*
- *What is the decision-making model for the Technical Sub-committee?*
- *Who chairs the Technical Sub-committee and how long can one individual hold that position?*
- *How often are edits made on the BRG and when are they released?*
- *Where does the budget from the BRG come from and who manages it?*
- *What happens if there is inadequate funding?*
- *What are the responsibilities of the Publisher and who ensures they are following through on those responsibilities?*
- *What is the process for getting scientific edits to the Publisher?*
- *Etc.*

These guidelines and conventions would serve as the main document for how all individuals and organizations operate for all business and outreach associated with the BRG.

### **3. Creating a hosting platform**

In order for readers to know where to access the BRG, a consistent online platform to host the BRG is a necessity.

Considering that many users of the BRG arrive at the document in need of answers for one specific beaver management question, we recommend breaking the document into independent chapter pdfs. This modular format not only directs users to the content they are looking for — it also allows more flexibility in revising and distributing chapters one at a time. The informational summary sheets that have been proposed as the first page of each chapter would also be very valuable as stand-alone pieces.

## **Next Steps**

We suggest prioritizing the creation of the guidelines and conventions document that outlines both how the Publisher, and review committee work together as well as document conventions, publishing rules and processes for revision and release of the BRG. This document will form the basis for the rules on how to move forward together.

The drafted ‘Proposed Interim Agreement’ is a good starting point for the development of this guidance document. Other questions to consider are:

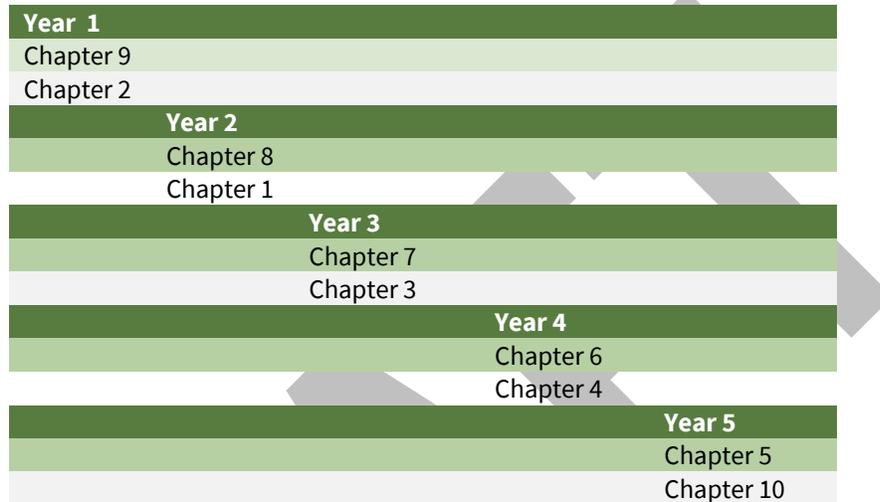
- How many chapters are reviewed each year? (see below for one potential schedule)
- What kind of creative commons license does the Publisher hold? For example, if the Publisher is not an exclusive host and doesn’t own the content, this provides a back-up plan for hosting and distribution in case the Publisher dissolves.

### **Proposed Option for Chapter Review/Update**

1. **An annual calendar milestone** or natural deadline (such as a conference, deadline, publication date) is selected for review committee members to propose/**nominate 2 chapters**

**for review that year.** Their selections could be motivated by new research, changes on the landscape, permitting updates or other relevant events/developments.

2. **Committee chair circulates those chapters for review/comment** providing a deadline for reviewers to return suggested updates.
3. **Committee** (or a contractor acting on their behalf) **consolidates updates and sends updated text to the Publisher.**
4. **Publisher** (or a contractor acting on their behalf) **develops, issues and releases the updated chapter,** hosts/distributes the new version, and takes steps to pull down the previous version.



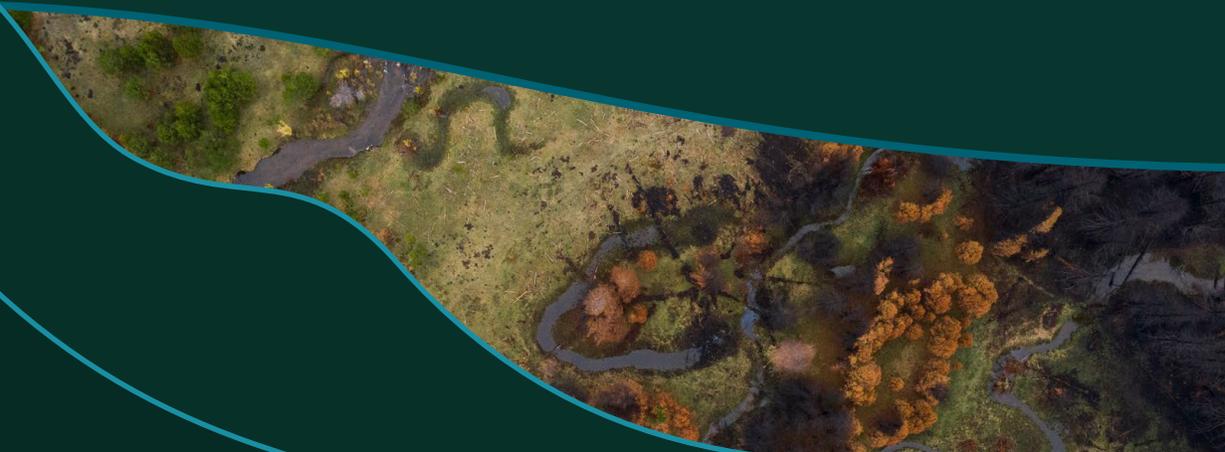
Using this system, the entire BRG will have been reviewed and updated within approximately 5 years, after which the cycle begins again with the original two chapters.



# The Beaver Restoration Guidebook

Working with Beaver to Restore Streams,  
Wetlands, and Floodplains

Version \_\_, 2023



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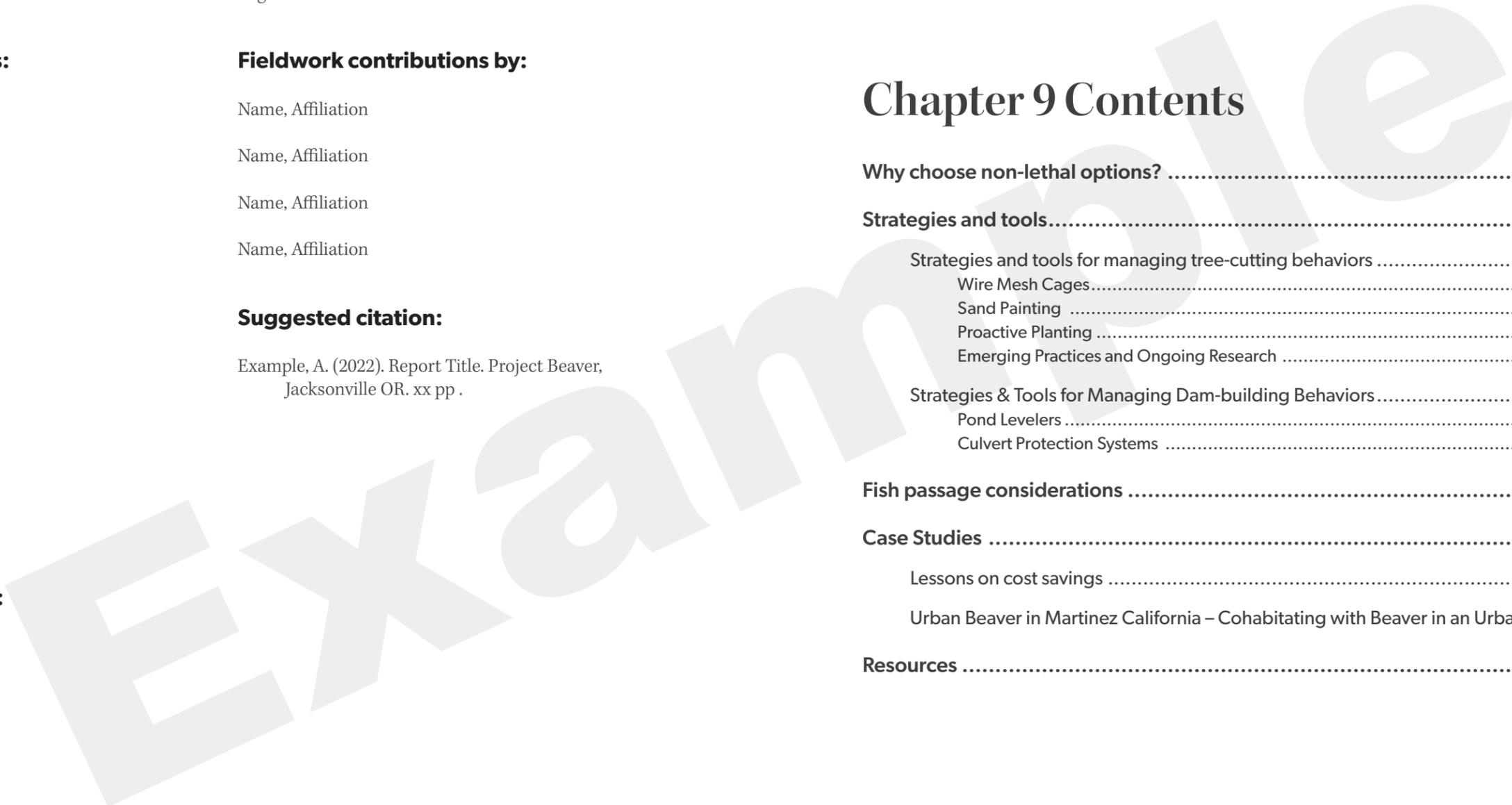
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# Non-lethal Options for Mitigating the Unwanted Effects of Beaver

## Chapter 9 Contents

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\* PLACEHOLDER FOR 1-PAGE SUMMARY INFORMATION SHEET\*

## Why choose non-lethal options?

Beavers have been building dams for millions of years in North America, and many other plants and animals have evolved alongside them to benefit from their ecosystem engineering. The long history of beavers managing water across the landscape means that beaver-modified floodplains have a profoundly positive impact on the habitats of other species. However, beaver dams and tree-cutting behaviors can also negatively impact human infrastructure and land use.

Lethal removal of beavers has historically been the preferred method for solving beaver/human conflicts in many states and provinces throughout North America. However, interest in non-lethal approaches has been growing. Since beavers are territorial, they quickly recognize and make themselves at home in newly available habitat. Using lethal options to remove a family of beavers from an area only frees it up for a new beaver family to move in. Trapping can become a frustrating cycle of reactive management that depletes the local beaver population and degrades habitat.

If not removing the beavers, why not simply dismantle their dam? Flooding issues can be temporarily improved by manually notching or removing the beaver dam, but beavers are able to fix most dam breaches within a few days. More extreme measures, such as the use of heavy equipment or dynamite to remove problem beaver dams, have produced mixed results (Dyer and Rowell 1985) and are short-lived solutions. Enthusiasm for extreme dam removal approaches is declining because of the negative impacts to fish, wildlife, and water resources.

Non-lethal and pro-coexistence approaches have gained popularity for a number of reasons, including:

- Non-lethal management is more effective and less costly than lethal removal (Lisle 2003, Callahan 2005, Simon 2006, Boyles and Savitzky 2008, Hood et al. 2017).
- The public is increasingly dissatisfied with lethal removal. Trapping, drowning, and bludgeoning are increasingly considered inhumane (IAFWA 1997, AVMA 2000, Hadidian 2003).
- There is growing demand for live beavers. Organizations and agencies are interested in reintroducing beavers to locations where they can provide environmental benefits (Apple 1985, Olsen and Hubert 1994, McKinstry et al. 2001, Boyle and Owens 2007, Pollock 2012).
- The benefits of beavers are now better understood and more accessible. Beaver-modified floodplains improve water quantity and quality, carbon sequestration and vegetative evapotranspiration, and reduce severity from floods, drought, and wildfire.

## Strategies and tools

Beaver activities that conflict with human interests generally fall into two categories: (1) tree cutting and (2) dam building. Dam building can be further divided into beaver dams that block culverts or irrigation canals and dams that do not. This distinction is important because it affects which mitigation options are appropriate for the situation. The list below summarizes the strategies and tools available for mitigating beaver behaviors.

1. Managing tree-cutting behaviors:

- Tree protection techniques
  - » Wire mesh cages
  - » Sand painting
  - » Fencing
- Preventive mitigation strategies
  - » Proactive planting

2. Managing dam-building behaviors:

- Flow devices
  - » Pond levelers
  - » Culvert protection systems (for dams that block culverts or irrigation canals)
- Preventive mitigation strategies
  - » Culvert sizing

Whenever possible, create a long-term plan 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.

## Strategies and tools for managing tree-cutting behaviors

Managing tree-cutting behaviors requires understanding what beavers eat and how far they are willing to travel to obtain food. Beavers can travel up to 328 feet (100 meters) from a water body to cut and harvest trees, but they are much less likely to harvest trees the farther they get from water (Rutherford 1955, Allen 1983, Gallant et al. 2004). Although beavers generally prefer species in the genera *Populus* or *Salix* (cottonwood, aspen, and willow), they will harvest a wide range of trees and shrubs (reviewed in Boyle and Olsen 2007 and Baker and Hill 2003). Beavers also use the base of large trees as gnawing stations, whether or not it is a species they like to eat. Beaver teeth grow continuously and need to be frequently worn down by gnawing on wood to stay healthy. Gnawing stations are not always used as a food source or as dam building material—even when gnawing leads to the death of the tree. This can frustrate landowners if the gnawed trees are viewed as being ‘wasted’ by the beavers.

### Wire Mesh Cages

Wire mesh cage specifications can vary slightly but all involve installing a heavy gauge wire around mature trees to prevent beavers from accessing the trunk.

### Objectives and Risks

The goal of installing wire mesh cages is to block beaver access to specific mature trees that are desired along the watercourse. The goal is not to prevent beavers from taking any trees at all. Wrapping too many trees can deprive beavers of enough food to survive the winter, resulting in death, abandonment of the site, or more persistent attempts to get past the cages.

### How to:

## WIRE MESH CAGES

**Expertise level needed:** LOW | Easy to learn

**Cost:** \$\$\$

**Effectiveness:** ✓✓✓

#### Planning

When choosing which trees to protect, consider protecting only ornamental, fruit or special native trees, while leaving most of the riparian vegetation for beaver habitat.

#### Installation Considerations

- Use a heavy gauge wire mesh (e.g., 6 gauge) to prevent beavers from chewing through it. Chicken wire is not recommended.
- Mesh size should be 6 x 6 inches or smaller.
- The cage diameter should be 1–2 feet larger than the tree trunk.
- The cage should extend 3–4 feet above the ground or, in colder climates, above the anticipated snow line.
- One piece of wire mesh can be used to encircle multiple trees.
- Consider staking the mesh to the ground if it can be easily lifted. Beavers can use their bodies to push on the wire mesh and test its stability.
- Prioritize which trees are wrapped. Leaving a sufficient food supply for beavers can help reduce attempts to bypass the mesh cages.

#### Maintenance and Monitoring

- Wire mesh cages need to be maintained over time to continue to function properly. Cage inspection every 1–2 years is recommended.
- Monitor the cages for rust and movement out of place.
- If a wire mesh cage is too small, it can girdle and kill the tree over time as it grows. Monitor tree growth and increase cage size when necessary.

#### Solution Effectiveness

There are few sources of peer-reviewed literature on non-lethal methods for preventing beavers from cutting trees (Westbrook

and England 2022). An extensive review of technical information from various government and private organization websites suggests that surrounding trees with a cylindrical wire mesh cage is the simplest, most effective means of preventing a beaver from cutting down a tree (beaversolutions.com, APNM.org, beaversww.org, martinezbeavers.org, www.kingcounty.gov/environment/animalsAndPlants/beavers). The effectiveness of tree wrapping depends on both the gauge of wire used and the installation method (height, diameter, etc.). To increase effectiveness, adhere to height and diameter guidelines and consider secureness of the wire wrapping. Staking the cages to the ground helps prevent beavers from lifting them from below or pushing them flush against the tree for better access (Westbrook and England 2022).

Several websites and bulletins suggest that paint mixed with sand can be effective with repeated applications. Although wire mesh cages are presumably a more effective solution, they can also impede naturalistic views and affect public perception of natural spaces, particularly in parks. Sand painting may be preferred in cases where maintaining a natural-looking view and area is more important than ensuring the safety of certain trees. Unlike wire mesh cages, failing to maintain sand painting will not result in eventual tree death from girdling. An ongoing joint research project between the Miistakis Institute and Cows and Fish (2020) has shown that sand painting can effectively reduce tree harvest compared to unpainted trees. Since this method works by deterring beaver from harvesting trees instead of physically preventing them, it is better suited to areas where some level of harvest is acceptable.

## Sand Painting

### Objectives and Risks

The goal of sand painting is to deter beavers from chewing certain trees while maintaining a more natural look compared to wire mesh cages. The finished result is a sandpaper-like coating that beavers do not like to chew. Some concerns have been raised that the paint and sand combination may affect the health of beavers that consume it. Therefore, it is important to mix enough sand into the paint to properly deter beavers and prevent them from consuming large quantities of paint.

### How to:

<b>SAND PAINTING</b>	Expertise level needed: <b>LOW   Easy to learn</b>
	Cost: <b>\$\$\$</b>
	Effectiveness: <b>✓ ✓ ✓</b>

#### Planning

When choosing what type of paint to use, consider its environmental toxicity, breathability for the tree, and durability over time.

#### Installation Considerations

- Beaversww.org recommends a mixture of 8 ounces (227 grams) of fine sand (30-mil, 70-mil, or masonry sand) mixed with 1 quart (0.94 liter) of oil or latex paint.
- Match the color of the paint to the tree trunk to preserve the natural look of the area.
- Paint from the base of the tree to 4 feet above the ground.

#### Maintenance and Monitoring

Sand paint is not permanent and will need to be reapplied as it is worn off by the elements and as trees grow.

#### Solution Effectiveness

## Proactive Planting

Land-use planners can reduce future conflicts by anticipating that beavers will need to harvest trees. Municipalities that are planting trees should take into consideration which species are preferred by beavers and how they respond to being cut. Planting many native species that are well-adapted to beavers helps ensure that riparian vegetation will grow back. Woody species preferred by beavers are aspen and cottonwood (Populus) and willow (Salix). These trees grow fast, sprout rapidly, and have soft wood that is easy to chew through and peel (Müller-Schwarze and Sun 2003). Planting ornamental trees can result in higher conflict as many do not recover well from damage. Once these trees are felled by beavers, they will be gone from the area.

Although beavers prefer certain tree species, planting only 'unpalatable' species does not guarantee they will be protected. Beaver diets vary depending on what is available. If beavers have lived at a site long enough to deplete their preferred food source, they will resort to less preferred species. They may also take unpalatable species to use for dam building or gnawing.

### FAQ: What do beavers eat?

*As herbivores, beavers consume a wide variety of plant species. They eat the leaves, twigs, and inner bark of most types of woody plants that grow near the water (Jenkins and Busher 1979). They also eat many kinds of herbaceous plants, including grasses, sedges, and aquatic species.*

*Beaver diets change seasonally. During the summer months, beavers favor herbaceous vegetation which is more nutritious. During fall and winter when herbaceous plants become unavailable, beavers consume more inner bark (i.e., cambium) of woody shrubs and trees (Chabreck 1958, Jenkins 1975).*

## Emerging Practices and Ongoing Research

- Chemical deterrent techniques are considered marginally effective because they work for a few months at most and need repeat applications (Nolte et al. 2003).
- Noise and flashing lights appear to deter beavers for a few days at most (Kimball and Perry 2008).

- One of this guidebook’s authors (Pollock) has noted the effectiveness of enclosure cages at various field sites using the same specifications recommended for wire mesh cages. Not all cages were 100 percent effective. In some cases, beavers managed to harvest trees inside of enclosures, presumably by climbing the cages.
- Placement of 3- to 4-foot-high fences between streams and the trees that need protecting has also been suggested, presuming that beavers will not travel long distances on the upland side of the fence because they are exposed to predators. Electric fences strung 4–6 inches above the ground have also been suggested. We could find no data assessing the effectiveness of these approaches.

## Strategies & Tools for Managing Dam-building Behaviors

Habitat modification techniques, such as pond levelers and culvert protection systems, can be used to facilitate coexistence with dam-building beavers living near human infrastructure and have been repeatedly shown to be less expensive than trapping over time. These techniques are often called flow devices and work by either limiting the area flooded by existing dams or by modifying the ability of beavers to construct dams. Flow devices are key tools for minimizing both the damage to human-occupied land and the degradation of riparian and wetland ecosystems that can occur if beavers are removed completely. Proper design and installation, paired with frequent monitoring and maintenance, are necessary to ensure flow device operation minimizes instream environmental impacts to important native fish, wildlife species, and their habitats. Flow devices are best used as an interim solution while planning for a long-term fix like culvert replacement or land-use changes.

*For more information on how to install flow devices access the Best Management Practices for Pond Levelers and Culvert Protection Systems document on the Project Beaver website: [projectbeaver.org](http://projectbeaver.org)*

### Pond Levelers

Pond levelers are immediate and cost-effective solutions that allow beavers to remain on-site while protecting human interests. The net benefit of these coexistence solutions makes them an important tool for facilitating more beaver-managed habitat in and around human infrastructure, homes, and crops. There are many different types and styles of pond levelers with varying degrees of effectiveness. Of the pond levelers studied so far, flexible pond levelers have the highest rate of effectiveness and fish passage and are therefore currently considered a best management practice.

#### Objectives and Risks

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 that protects human assets. Pond

leveling devices control the height of a beaver dam by creating a hidden leak in the dam. This is achieved using a plastic culvert pipe and a caged intake located upstream within the beaver pond. Beavers will be unable to raise the water height by adding height to the dam. Since they generally will not raise the dam’s height unless water is running over the top, the physical height of the dam will be constrained along with the water level.

Artificially constraining the extent of beaver-facilitated habitat can impact the fish and wildlife that rely on beaver-managed ecosystems. As such, pond levelers should only be installed after careful consideration and every effort is made to maintain the maximum possible extent of the beaver pond.

#### How to:

## POND LEVELERS

Expertise level needed: **HIGH** | Consult an expert

Cost: \$\$\$

Effectiveness: ✓✓✓

#### Planning

- Prepare and submit a project plan to the applicable local, state, and/or federal permitting authority.
- Plan to conduct the entire installation within a single day during an appropriate in-water work window.

#### Installation Considerations

Determine the new water height of the pond. If the pond contains a beaver den or lodge, find the elevation of the entrance tunnel. The water surface elevation of the pond must not drop below the top of the underwater entrance tunnel. This elevation marks the lowest possible pond elevation that can be used in the design. If the water level is lowered below the top of the burrow entrance, beavers may relocate to adjacent stream reaches, build a new dam (often downstream), or freeze to death in cold winter climates. If beavers abandon the dam, the investment in designing and installing a pond leveler is lost. If the target dam does not contain a lodge or den, it is still important to only lower the water height the minimum amount needed to meet the coexistence objectives.

- Select the upstream location for the intake cage. Prioritize maximum water depth, pond width, and the distance from the dam (in that order). Install the intake cage at the deepest point in the upstream pond as far from the beaver dam as the site allows. If possible, place in a sheltered area (like the inside bend of a stream channel slightly outside the thalweg) to minimize debris accumulation during high flow events.
- Incrementally remove material from the beaver dam to the desired height before installing the pipe through the dam at this elevation.
- Float the intake cage into place using pontoons. Simple pontoons can be made with 6-8’ lengths of capped 6” or 8” PVC pipe and temporarily fastened under the intake cage with rope and a quick-release knot. Orienting the pontoons perpendicular to the pipe will increase stability during installation.
- Stake the pipe and intake cage in place where possible with steel posts. Where the water is too deep or substrate is too hard (or soft), weigh the pipe and intake cage down with concrete blocks or steel weights.
- Wrap any exposed single wall pipe on the crest of the beaver dam with a wire mesh wrap, typically hardware cloth, to dissuade beavers from chewing into the pipe. Double wall pipe does not need to be wrapped.
- Cover the exposed pipe with woody debris and mud to help camouflage it, and to help prevent beavers from chewing on the

exposed pipe. Notch a small leak in the dam away from the pond leveler to give the beavers something to fix after the disruption of installation and lowering the water.

### Maintenance and Monitoring

Pond levelers can last 5–10 years or longer if properly maintained and adaptively managed for changing site conditions. To maximize the life of a pond leveler:

- Check the pond leveling system regularly (at least once a year) for any weather- or beaver-related damage. Before and after the typical peak-flow seasons are good periods to conduct maintenance. In many regions, these periods are in the fall before the winter precipitation and in spring after the last of the high flows.
- Use only hand tools for maintenance.
- Remove any accumulated debris from the intake cage.
- Monitor the water level over the entrance tunnel to the beavers' den and look for potential new damming activity upstream and downstream of the device.

### Solution Effectiveness

Callahan (2003) examined the effectiveness of 116 flexible pond levelers on free-standing dams that were causing conflicts with humans but that were not associated with human infrastructure such as culverts. He found that installation of flexible pond levelers resolved human-beaver conflicts 83 percent of the time.

In studied situations where conflict was not resolved, failure was most commonly (75% of the time) as result of beaver constructing dams downstream of the installation site. The remaining failures were due to vandalism or insufficient pipe capacity.

## Culvert Protection Systems

Considerable research has gone into the development of non-lethal solutions to the widespread problem of beavers damming culvert inlets and flooding roads. Many of the culverts where beaver damming occurs are undersized and already have fish passage issues. Whenever possible, replace the culvert with a structure that is properly sized and designed.

Financial, logistical, and time-critical responses sometimes prevent immediate culvert replacement, so several studies have evaluated a range of other options. These studies suggest that a highly cost-effective solution is to install heavy-duty (i.e., 2- to 6-gauge) cattle panel wire mesh fencing in a rectangular or trapezoidal configuration upstream of the culvert (Jensen et al. 1999, Jensen et al. 2001, Callahan 2003, Boyles 2006, Simon 2006, Boyles and Savitzky 2008). Other types of culvert protection systems, for example anchor fences and anchor dams, can be used in different situations. Culvert protection systems can also be paired with pond levelers to create pipe-and-fence culvert protectors or pipe-and-dam culvert protectors.

### Objectives and Risks

The goal of culvert protection systems is to preserve the function of culverts, spillways, and similar human infrastructure while allowing beavers to remain in the area. Culvert protection designs work by either physically excluding beavers from the culvert or spillway or by altering the cues that promote dam-building activity.

### How to:

## CULVERT PROTECTION SYSTEMS

Expertise level needed: **HIGH** | Consult an expert

Cost: \$\$\$

Effectiveness: ✓✓✓

### Planning

Contact your state fish and wildlife agency to determine if the site must consider passage of target fish species and life stages in the design. Discuss any concerns that the recommended 6 x 6 inch mesh spacing, distance between the culvert and anchor fencing, or distance between the culvert and anchor dam may obstruct fish passage.

### Installation Considerations

- Determine the footprint of the wetted stream channel upstream of the culvert or spillway during low flow in the absence of beaver damming. If there is a wide area of shallow water upstream of the culvert (without the influence of a beaver dam), consider a trapezoidal culvert fence. If there is not an adequate, shallow, upstream wetted area adjacent to the culvert's inlet, then consider an anchor fence or an anchor dam.
- Determine the human infrastructure tolerance for upstream impoundment. If the culvert capacity remains open, how high can a beaver dam be built? If the beavers can be allowed to naturally set the height of their dam, consider an anchor fence or anchor dam. If there is a maximum dam height that must be enforced, consider installing a pipe and fence or a pipe and dam flow device.

### Maintenance and Monitoring

A properly constructed, installed, and maintained culvert protection system can provide a cost-effective solution that can last 5–10 years or longer.

- Check the fence system regularly (at least once every three months) for weather- or beaver-related damage.
- Remove any accumulation of debris from the fencing of a trapezoidal culvert fence and from the intake cage for a pipe and fence flow device.

### Solution Effectiveness

Simon (2006) expanded upon Callahan's study, examining the effectiveness of various beaver management strategies at 482 sites. Simon found that culvert-protective fences, some of which included pond levelers, were effective 97 percent of the time (at 220 out of 227 sites). Pond levelers not associated with roads were successful 87 percent of the time, cylindrical fences attached to the inlet of culverts were successful 60 percent of the time, and lethal removal by trapping was successful just 16 percent of the time because other beavers quickly occupied the site. Simon found the 10-year annualized installation and maintenance costs of culvert fences, culvert fences with pond levelers, and pond levelers to be \$275, \$290, and \$200, respectively (in 2006 dollars).

### The best solution is an appropriately sized culvert

The correct sizing of culverts is another approach that has been suggested to reduce beaver/road conflicts. Many culverts are undersized or contain design elements that are attractive to beavers. Jensen and Curtis (1999) comprehensively examined factors associated with beavers damming culverts on streams in New York. On streams

with a 3 percent gradient or less, they found that beavers plugged larger culverts far less often. Culverts with an 8.6 square-foot inlet area (i.e., 3.3 feet in diameter) had a 73 percent chance of being plugged by beaver, whereas culverts with a 113 square-foot opening (i.e., 12 feet in diameter) had a 7 percent chance of being plugged.

Jensen and Curtis (1999) also found that pipe arch culverts that maintain the stream's width are less likely to be plugged by beavers than round culverts. They speculated that round culverts are more attractive to beavers in part because they channel water and reduce stream width. Jensen and Curtis found that, on average, the stream width at plugged culverts was twice that of the culvert inlet opening. Jensen and Curtis thought that round culverts may also generate flow noise that attracts beaver, but found that the frequency of plugging did not differ between smooth-walled and corrugated pipes. They further found that culverts that extended beyond the road prism were no more likely to be plugged than culverts that were flush with the road prism. Jensen and Curtis also examined the annualized costs of replacing small culverts with larger ones and found that various pipe arch and box culverts with 10.5 square-meter openings ranged from \$881 to \$1,717 (in 1999 dollars) — about three to six times the annualized costs estimated by Simon (2006) for culvert-protective fences with pond levelers. Although more expensive on average, there are other benefits to using large culverts with natural streambed bottoms that should be considered, including improved passage of fish, wildlife, sediment, and organic matter, as well as increased stream habitat.

### Emerging Practices and Ongoing Research

Another historically popular method of controlling beaver pond levels and preventing culvert plugging is known as a Clemson leveler. It consists of a perforated polyvinyl chloride (PVC) pipe whose upstream end is wrapped in wire mesh fencing. The pipe is then inserted horizontally through the dam. Reported success rates with the Clemson leveler are only about 50 percent (Nolte et al. 2000). Due to the lower success rate and potential fish passage issues, ongoing research is shifting away from the Clemson leveler and towards the flexible pipe leveler.

Installing any type of flow device involves adding artificial materials to the stream. Ongoing research is investigating which materials are safest for long-term use in aquatic habitats.

- The use of pressure-treated wood is considered detrimental as it can leach chemicals into the water.
- Microplastics are considered an environmental contaminant and should be minimized by cutting any plastic materials in area where debris can be contained and properly disposed.
- Currently, the use of galvanized metal is being questioned but no conclusions have been made.

## Fish passage considerations

Numerous pond levelers and other devices have been designed to mitigate human-beaver conflicts (many are described in Gerich 2004). Some designs, such as beaver exclusion fencing with perforated pipes, array piping, pond drain pipes, and wire mesh culverts, appear impassable to fish whereas others — including several designs for various fencing and pond leveler combinations — appear to be passable by fish without issue. Fish passage issues appear to arise from two main design components: the use of small mesh sizes and the positioning of downstream pipes. Several pond leveler designs (particularly for Clemson-type levelers with a rigid pipe) have the pipe perched above the streambed on the downstream end. This presents a clear passage obstacle for fish. The location of flexible

leveler pipes can also present problems if the outlet is placed in a riffle rather than a pool, or if the outlet is too far downstream of the dam and migrating fish are unable to find the opening. Placing the outlet of a flexible leveler in a pool, with the outlet close to the face of the dam, minimizes fish passage problems.

Both mesh size and outlet placement can understandably impede the migration of large fish; however, little published research exists. The only study known to mention mesh size in the context of fish passage is Hall et al. (2005). This study on the Skagit River in Washington found that numerous chum salmon (*O. keta*) were able to willingly pass through a flexible horizontal pipe that had a vertical cylindrical wire cage with 10 x 15-centimeter meshing attached to the upper end. In Snohomish County, just north of Seattle, the Public Works Department built more than 50 flexible levelers using 10 x 15-centimeter mesh or 15 cm x 20-centimeter mesh, which they considered fish friendly. Although they did not do a formal study, repeated site visits during the fall adult salmon migration never revealed a fish blockage problem and spawning fish were observed upstream of many sites (Jake Jacobsen, Snohomish County Public Works, personal communication).

In the Pacific Northwest, some observations suggest that culvert-protective fencing alone accumulated enough debris during floods to raise concerns about adult salmon passage, although no data were collected (Jake Jacobsen, Snohomish County Public Works, personal communication). Therefore, pond levelers were installed at some culverts—in conjunction with fencing—to alleviate fish passage concerns.

The mesh size of Clemson levelers is typically too small for adult salmon to pass through. Mesh sizes ranging from 1 x 2 inches to 2 x 4 inches have been recommended (Wood et al. 1994, Langlois and Decker 1997, Brown 2001, MDNR 2001). Typical pipe diameters for Clemson-style levelers are 7.9–9.85 inches, and the levelers may be 20 feet long or longer. These diameters can obstruct the upstream movement of large fish such as adult salmon, particularly if the pipe is capped as is often suggested (Wood et al. 1994, Langlois and Decker 1997, Brown 2001, MDNR 2001). Close (2003) was able to modify a Clemson-style pond leveler on a stream in Minnesota to allow passage of 10 brook trout ranging in length from 6–8.6 inches, a size still much smaller than most adult salmon.

### Myth: Beaver dams block fish passage

Most recent research suggests that the increased complexity of habitat created by beaver dams is beneficial to many fish species (Collen and Gibson 2000, Schlosser and Kallemeyn 2000, Pollock et al. 2003, Pollock et al. 2004, Kemp et al. 2010, Kemp et al. 2012, Pollock et al. 2012; Bouwes et al. 2016). Dams might even provide a competitive advantage to certain native fish species relative to non-natives (Lokteff et al. 2013). This is reasonable because salmon, steelhead, and many other fish species are found throughout the range of the North American beaver and have lived in streams together with beavers since the last ice age. At times when low flows may temporarily inhibit non-native (e.g., bass) fish movement across beaver dams, native fish species, most notably salmonids, are able to jump high and far enough to clear the dams (Powers and Orsborn 1985).

Fish passage concerns for pond levelers often assume that fish must pass through the pipe to cross the dam. However, the claim that beaver dams block the movement of fish is largely unsupported by the literature, and under most circumstances fish can naturally pass beaver dams. The literature suggests that at most, beaver dams may act as temporary barriers to adult fish passage, typically during low-flow periods. As flows increase, dams become more easily passable by both juvenile and adult fish, with a diversity of flow paths over, through, under, and around these semi-permeable structures (Schlosser 1995, Pollock et al. 2014, Lokteff

et al. 2013). These flow paths continually change with beaver maintenance, construction, and abandonment and with fluctuations in discharge (Lokteff et al. 2013). Although not well-documented, observations suggest that rather than leaping over dams, juvenile and adult species of salmon (i.e., coho, sockeye, and steelhead) pass beaver dams by swimming around the dam, either accessing the numerous small, low-velocity flow paths that are present in most dams or swimming over the wet portions of the dam face and into the upstream pool. Such behavior can also be inferred from observations of migrating juvenile coho salmon into upstream overwintering ponds, the movement of juvenile coho salmon between beaver ponds and downstream tributary habitat, and the spawning of adult coho salmon and other salmonids in stream reaches above beaver dams (Bryant 1983, Everest et al. 1986, Murphy et al. 1989, Olsen and Hubert 1994, Solazzi et al. 2000, Roni et al. 2006, Rosenfeld et al. 2008). It is not understood how much the natural ability of fish to pass over dams is affected by artificially altering the water level in beaver ponds using a pond leveler.

## Case Studies

### Lessons on cost savings

In Virginia, Boyles (2006) compared the cost of installing and maintaining fencing upstream of culverts with the cost of removing beavers and conducting associated road maintenance and repairs. Boyles found that before fencing was installed, the average annual cost for 14 road maintenance sites with beaver activity was \$21,500, compared to \$3,200 after culvert fencing was installed.

Callahan (2003) extensively examined the effectiveness of culvert protection fences in New England. Out of 131 sites, 126 (96 percent) effectively prevented beavers from damming the culverts. Two sites failed because the entire fence was dammed by beavers, two others failed because proper maintenance was not performed, and another site was considered a failure because beavers constructed a new dam downstream. Callahan estimated that the average cost of the culvert-protective fences was \$654, with an expected lifespan of 10 years and an average maintenance time of 1 hour per year for an annualized cost of \$190 per year (in 2003 dollars).

Both studies included culverts with protective fences and pond levelers because of concerns that the fencing, if partially dammed, would provide insufficient flow capacity.

In Alberta, Hood et al (2017) conducted a cost-benefit analysis of installing pond levelers to counter beaver flooding. They determined that the installation of 12 pond levelers resulted in an overall net benefit of \$81,519 over 3 years and \$179,440 over 7 years (Canadian dollars). This study took into consideration installation and maintenance costs of the pond levelers, the budgeted costs for other beaver control methods, the maintenance costs of repairing damaged trails, and the potential income lost due to users not attending the park when trail systems are flooded by beaver. In parks where trail systems were the main attraction, park managers reported that on average, pond leveler installations mitigated trail repair expenses of \$2,803 per site per year.

## Urban Beaver in Martinez California – Cohabiting with Beaver in an Urban Setting

Like many towns and cities, Martinez (northern California) has a centralized creek that funnels runoff from the streets and gutters as it passes through the town. In Martinez, the combination of tidal influence and low elevation can easily trigger downtown flooding issues. In 2007, beavers built a dam in the creek. As a precaution against aggravating flooding issues, the city started the permitting process to have them lethally removed. However, many residents enjoyed watching the beavers and protested the planned removal.

Downtown business owners continued to push for removal while many other residents advocated for the beavers to stay. A hydrological assessment of the creek from a consulting firm increased fears of the business owners as they provided an assessment for a 5-foot-tall concrete weir under the inaccurate assumption that the resultant flooding would be equivalent to that of the beaver dam. The city pursued a special permit to relocate the beaver in hopes it would appease both sides. Finally, a large meeting was held in hopes of finding a solution. At the conclusion of 3 hours of public comment, the city council vote was a tie for both sides. The city proposed a subcommittee to study the issue further.

The subcommittee collectively researched beaver biology, management, benefits, risks, and options. The group was given 90 days to outline the pros and cons of trying to coexist with urban beavers in a city setting. The group consulted Skip Lisle, President and Chief Scientist, Beaver Deceivers, LLC to provide advice. After a field assessment, Mr. Lisle recommended the 'Castor Master' design (a type of pond leveler) he had used in similar situations to prevent vertical growth of the dam.

The dam was lowered, and the Castor Master was installed. Despite the success of the flow device, even though large storms, the downtown business owners continued to worry about flooding. A psychologist participating in the project realized that in addition to changing beaver behavior, human behavior and perception needed to change as well. The solution therefore needed to include two parts to address both the beavers and the residents.

For the beavers:

- The professional consultation and installation of the Castor Master (a cost of approximately \$10,500 in 2007)
- Wire wrapping or sand painting trees to prevent them from being cut (a cost of \$300 in 2007 with the use of volunteers for labor). The abrasive painting recipe on the Beaver Solutions Website was used and repeated every 18 months.

For the residents:

- Education in the form of town halls, outreach, and community lectures.
- Child education through fieldtrips, activities, and art projects.
- Media presence and education on radio and television news.
- Annual beaver festival to influence and educate.

- Citizen stewardship projects—such as tree planting—to encourage ownership.
- Constant public input in the form of cards and letters to city leaders.

Steps taken for the beavers were very successful and completed in about one month. The steps taken for the residents have been moderately effective and but have required constant reinforcement over the years.

Coexistence with beavers in Martinez has had a net positive effect. The dam and pond keep the creek from going dry every summer and as a result have increased local biodiversity. Several species that were only seen occasionally have now become regulars, including the western pond turtle, belted kingfisher, green heron, and otter. For the residents, the beavers have increased social cohesion, fostered a greater awareness of the watershed in general, and have increased ecological mindfulness for children and adults. The beaver festival has become one of the largest wildlife events in the state, increasing tourism for the town.

## Resources

Shockey, Jakob. (2023). Best Management Practices for Pond Levelers and Culvert Protection Systems version 1.2. Project Beaver, Jacksonville OR.

Example

