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WORKING WITH BEAVERS

Alberta Beaver Beneficial Management Practices

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Acknowledgements

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Watershed Resiliency and Restoration Program

Alberta Beaver Beneficial Management Practices

The work of beavers supports watershed and ecological health across the landscape. Many of the benefits beavers provide directly benefit humans: attenuate flood peaks [1], store water during droughts [2], create fire breaks and refugia [3], support later season release of flows [4] and dramatically improve water quality and quantity by slowing water and trapping sediment [5,6]. For landowners, industry, municipalities and governments, beavers are one way to achieve environmental outcomes such as enhanced biodiversity, wetland habitat, riparian health, water quality, etc. Despite these benefits, beavers can also pose challenges at the human-beaver interface such as flooding of roads or property, cutting of trees, and damage to infrastructure. Even with these challenges, in the recent decade there has been a growing interest from municipalities and other land managers to coexist with beavers. This signaled to the *Working with Beavers* collaborative a need for sharing information on how best to coexist with beavers leading to the creation of the *Alberta Beaver Beneficial Management Practices (BMPs)* guide.

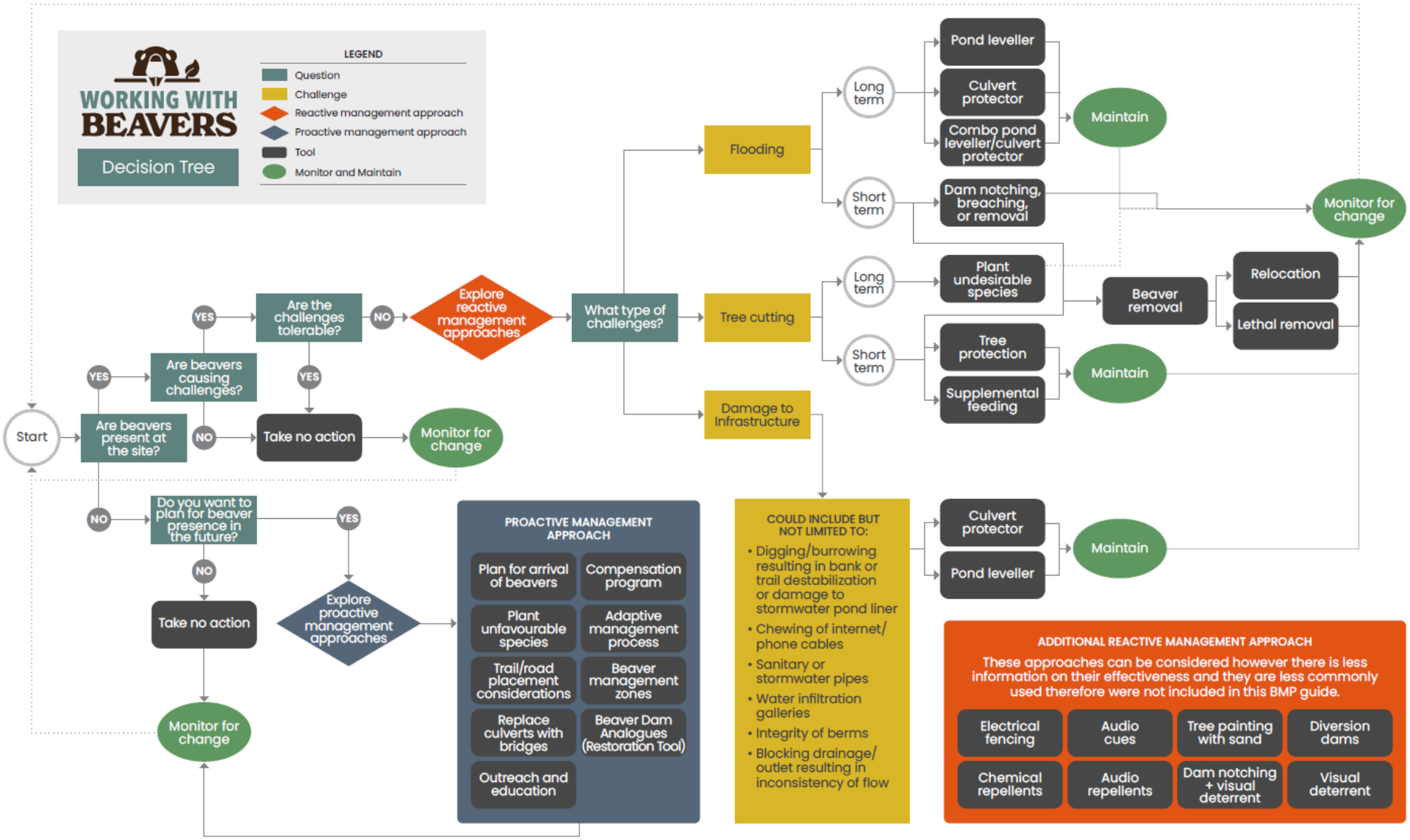
Beaver BMPs are practices that reduce or remove risks or human-beaver conflicts associated with the management of beavers, while supporting or promoting the benefits that beavers provide. Often a combination of strategies may be beneficial to address a particular issue or concern. The purpose of the *Alberta Beaver BMPs* is to provide information about available beaver management tools with the goal of improving implementation of beaver coexistence tools in Alberta. By improving human-beaver coexistence, challenges can be mitigated while still maintaining beavers on the landscape, supporting watershed and ecological health and the ecosystem services they provide.

A decision tree was created to accompany the BMPs to aid the decision-making process for how best to address the beaver issue at hand. The tree prompts yes/no answers to a series of questions that guides the user to consider both ***reactive*** and ***proactive*** management approaches that include coexistence tool options. Clicking on the coexistence tool of choice will take you to the corresponding section of the BMPs that includes the following:

- Description of the tool
- Advantages of using the tool
    - Environmental
    - Social
- Disadvantages of using the tool
    - Environmental
    - Social
- Beneficial Management Practices
- Summary of Alberta Regulatory considerations
- Resources

The primary audience for the BMPs are municipalities, provincial and federal agencies, First Nations', and industry; however, they can also be used by private landowners as well.

Throughout the BMPs, we focus on a reactionary management approach as this is currently the highest need for land managers in Alberta. However, the BMPs can be used as a building block in the development of proactive management approaches including a beaver management plan specific to a community. Beaver management plans and other proactive management approaches are described briefly in the "Proactive Management Approaches" section.


WORKING WITH BEAVERS
Decision Tree
LEGEND
Question
Challenge
Reactive management approach
Proactive management approach
Tool
Monitor and Maintain
Start
Are beavers present at the site?
YES
NO
Are beavers causing challenges?
YES
NO
Are the challenges tolerable?
YES
NO
Take no action
Monitor for change
Explore reactive management approaches
What type of challenges?
Flooding
Long term
Pond leveller
Culvert protector
Combo pond leveller/culvert protector
Maintain
Short term
Dam notching, breaching, or removal
Monitor for change
Tree cutting
Long term
Plant undesirable species
Beaver removal
Relocation
Lethal removal
Short term
Tree protection
Supplemental feeding
Maintain
Damage to Infrastructure
COULD INCLUDE BUT NOT LIMITED TO:
• Digging/burrowing resulting in bank or trail destabilization or damage to stormwater pond liner
• Chewing of internet/ phone cables
• Sanitary or stormwater pipes
• Water infiltration galleries
• Integrity of berms
• Blocking drainage/ outlet resulting in inconsistency of flow
Culvert protector
Pond leveller
Maintain
Do you want to plan for beaver presence in the future?
YES
NO
Take no action
Monitor for change
Explore proactive management approaches
PROACTIVE MANAGEMENT APPROACH
Plan for arrival of beavers
Compensation program
Plant unfavourable species
Adaptive management process
Trail/road placement considerations
Beaver management zones
Replace culverts with bridges
Beaver Dam Analogues (Restoration Tool)
Outreach and education
ADDITIONAL REACTIVE MANAGEMENT APPROACH
These approaches can be considered however there is less information on their effectiveness and they are less commonly used therefore were not included in this BMP guide.
Electrical fencing
Audio cues
Tree painting with sand
Diversion dams
Chemical repellents
Audio repellents
Dam notching + visual deterrent
Visual deterrent

The challenges related to beaver management and the implementation of coexistence tools are not unique to Alberta. Jurisdictions and researchers in other Canadian provinces and across the United States and United Kingdom have developed beaver management plans or beneficial management practices, which were reviewed during the creation of this beaver BMPs guide. The following resources are exemplary beaver management plans and decision trees that were referred to during the creation of the above decision tree:

- The *Beaver Management Plan For The* ***City of Port Moody***
- The *Beaver Management Plan 2.0 from the* ***City of Portland***
- The *Recommendations for an Adaptive Beaver Management Plan: For* ***Park City Municipal Corporation***

RESOURCES

Development of the BMPs for each tool came from a variety of sources including materials developed and owned by the authors of this report. The materials listed below include the broad body of knowledge drawn on for the development of the BMPs.

Working with Beaver Website – Positive Impacts of Beavers

Beaver Our Watershed Partner booklet

An Agricultural Decision Matrix Tool for Beaver Management

Virtual Tour: Beavers in our Landscape webinar

Working with Beaver Website – Positive Impacts of Beavers

Beaver Coexistence Tools fact sheet

In the case of materials coming from external sources, appropriate references are included.

Reactive Management Approach

When considering BMPs for beavers, there are both proactive and reactive approaches (JBL Environmental Services Ltd., 2019; J. M. Wheaton, 2013). Proactive approaches are taken in anticipation of an issue occurring whereas reactive approaches are taken due to an issue already occurring (i.e., crisis management). In the case of beaver management, the more traditional approaches are reactive, i.e., 'what can I do when a beaver dam is flooding my road.' In this beaver BMPs guide, we focus on reactive approaches since this is currently the highest need for municipalities in Alberta. Our hope is that Albertans can move towards more proactive approaches to beaver management in the future. This section outlines the tools available to land managers in reaction to issues that have arisen. Advantages and disadvantages of these tools are outlined along with the beneficial management practices suggested for each tool.

Take No Action

DESCRIPTION OF TOOL

If beavers are present, and not causing a conflict with human managed systems or needs, or the conflict is tolerable, then the best response is to take no action, leaving beavers to take their natural place in the ecosystem. If there is potential for conflict to occur in the future, monitor the site so proactive or mitigative actions can be taken.

ADVANTAGES OF USING THIS TOOL

Environmental

- By taking no action, beavers are allowed to persist in the landscape and natural ecosystem processes and functions will occur:
  - Water storage: beaver dams act as speed bumps, slowing water allowing it to recharge groundwater and store surface water.
  - Water filtration: slowing water allows time for sediments and contaminant to sink to the bottom of the pond. The riparian vegetation further filters the water producing enhanced water quality downstream of the beaver pond.
  - Habitat creation for other species including waterfowl, deer, moose, elk, bobcats, fish, amphibians, etc.
  - For more information on environmental benefits of beavers please visit Working with Beaver Website – Positive Impacts of Beavers.

Social

- Beaver activities allow ecosystem process and functions to occur resulting in ecosystem services provided to humans:
  - Flood mitigation: beaver dams act as speed bumps, slowing water and allowing it to filter into the groundwater. The wetlands created behind the dams also store water, further reducing flood risk. Research has proven that beaver dam sequences are able to withstand extreme rainfall events and delayed the flood peak in the stream [1].
  - Drought mitigation: as stated above, beaver dams slow water down which allows it to filter into the groundwater. This cool groundwater is then released downstream of the wetland, which is especially important during the hot, dry conditions of late summer in Alberta.

  - Enhanced water quality: as beaver wetlands are created and water filters into the groundwater, the filtration process improves water quality. The slowing of water by beaver dams allows sediments and contaminants to settle at the bottom of the wetland, improving the water quality of the wetland and waters that flow downstream which reduces water treatment costs for downstream water users.
  - Fire risk reduction: beaver activity increases wetness and vegetation in the riparian area (area directly adjacent to streams). Streams with beavers have increased wetness, including increased riparian vegetation, which has been proven as a fire break and refugia for the many species compared to streams without beavers [3].
  - Aesthetic viewing opportunities: humans enjoy viewing wildlife, which beaver wetlands are teeming with. These recreational opportunities provide enhanced human well-being.
  - For more information on environmental benefits of beavers please visit Working with Beaver Website – Positive Impacts of Beavers.

- With the growing recognition of the importance of beavers and their positive ecological impact there is an increasing social acceptance to 'take no action' compared to the alternative which includes lethal removal, relocation or deterrence. Coexisting with beavers aligns with public interest in many areas, especially in the urban environment.

DISADVANTAGES OF USING THIS TOOL

Environmental

- No environmental considerations of taking no action.

Social

- Beavers and the natural ecosystem processes they facilitate may expand into areas where there is less tolerance for the activity (e.g., flooding of a nearby road). If this occurs, explore proactive management approaches or return to the decision tree to explore reactive management approaches to address the challenge.
- Social disapproval of the presence of beavers, especially where there have been human-beaver conflicts in the past, or residents have past experience with conflicts with beavers (cutting of prized trees, flooding of roads, etc.).

BENEFICIAL MANAGEMENT PRACTICES

Allow beavers to remain active at the site, allowing natural processes and functions to take place uninterrupted. Monitor the site for change, as depicted in the decision tree.

SUMMARY OF ALBERTA REGULATORY CONSIDERATIONS

No approvals needed for beavers to remain in place.

RESOURCES OR DETAILED BMPS

Working with Beaver Website – Positive Impacts of Beavers

Reintegrating the North American beaver (Castor canadensis) in the urban landscape [7]

Beavers Northwest

Beaver Institute

Dam Notching, Breaching, or Removal

Figure 1: Practitioners creating a notch in a beaver dam prior to installing a pond leveller (Location: Parkland County, Alberta)

Figure 2: A second example of practitioners creating a notch in a beaver dam prior to installing a pond leveller (Location: Lac Ste. Anne County, Alberta).

DESCRIPTION OF TOOL

Dam notching, breaching, or removal are traditional management tools used to completely or partially drain a beaver pond to alleviate flooding; each is defined as:

- Dam Notching: removal of a small portion of the top of the dam in one spot with the intent to partially drain the pond to a manageable level but not to drain the pond.
- Dam breaching: removal of a portion of the dam with the intent to drain the pond partially or completely.
- Dam removal: complete removal of the dam from bank to bank to drain the pond completely.

There are a variety of methods used to breach or remove a dam including but not limited to: hand tools, heavy equipment such as backhoes, and explosives. Each method comes with its own risks and benefits. If a pond leveller cannot be installed at the site, dam breaching, notching or removal may be the next best option, however, beavers are likely to repair the dam shortly after breaching or removal [8,9].

ADVANTAGES OF USING THIS TOOL

Environmental

- A small notch or partial breach could allow beavers to remain in place, providing environmental benefits, however they are likely to repair the dam so it would have to be repeated.
- Partially draining a wetland (partial dam breach or notching) has less impact on water storage, downstream flooding and habitat disruption than completely draining a wetland (dam removal).

Social

- Immediate flood mitigation (could be used in emergency situations).
- Could be used to coexist with beavers while managing flooding, an approach that is viewed by many, as more socially acceptable over removal of the beavers.

DISADVANTAGES OF USING THIS TOOL

Environmental

- Partially or completely draining a wetland can cause significant negative environmental impacts not only for beavers but also amphibians, waterfowl, invertebrates, and vegetation. Some of these species may be federally or provincially protected species at risk which would trigger additional regulations before using this tool. Partial removal could result in the dam failing and draining of the entire, or much more of the wetland, than intended.
- Exposed soil from rapid loss of water creates opportunity for invasive plants and other undesirable plant species to become established, particularly in areas where native plant competition may be limited.
- If a beaver lodge is present in the wetland created by the dam, breaching or dam removal could result in exposure of the lodge and subsequently, the beavers, to predators.
- Depending on time of year, breaching or dam removal could also put beavers at risk of losing their winter food cache, causing them to starve over the winter.

Social

- Complete or partial removal of a dam and drainage of the wetland can cause significant negative social implications, especially in populated areas where the wetland and beaver dam provide recreational opportunities.
- Endangering the welfare of beavers or other wildlife often will be noticed by the public and there may be pushback.
- Safety risks exist to personnel undertaking the dam removal or breaching - working in moving water and around debris.
- Population control may be a necessary step along with dam management to promote longer term success of using this approach for dealing with flooding issues. If new beavers inhabit the area, it would need to be repeated.
- Dam removal and lethal control are more costly to taxpayers than a pond leveller or culvert protector [10].

BENEFICIAL MANAGEMENT PRACTICES

Beneficial management practices for this tool are to remove the least amount of dam possible to achieve the desired pond level. The more the dam is disturbed, the higher the risk for social and environmental negative impacts.

- Partial removal such as notching or partially breaching the dam is preferred over complete dam removal.
- The use of hand tools is recommended over heavy equipment, both of which are recommended over the use of explosives.
- The below is a list of dam breaching procedures using hand tools, created by Mike Callahan of the Beaver Institute [11]:
    1. The tools (potato or clam rake) are hand carried to the site.
    2. No heavy equipment will be used at any time. No significant damage is expected to any grassy, upland, wetland or other areas as a result of this manual work.
    3. First, stand on the downstream side of the dam to remove sticks from the area to be breached. These sticks are piled on the top or side of the dam.
    4. Once the loose sticks are removed, mud from the dam is manually dug out of the area to be breached with a potato rake and piled on top of the dam away from the moving water to reduce downstream siltation.
    5. The width and depth of the breach are limited by the size of the stream channel and any downstream road culverts. At no time should a breach be made so large enough that water flows over the banks of the stream. All released water should remain in the channel and not exceed the volume of runoff from a large storm.
    6. If beavers are living in the area to be drained, they will almost always repair the dam breach at night. If this occurs, breaching on successive days may be needed to reach the water level goal. Note, unless the beavers are removed from the area, dam breaching is almost always a short-term solution.
    7. If the beaver dam is very old or very large, breach slowly, constantly assessing the dam integrity throughout the breaching process.
    8. In cold climates, to prevent freezing deaths of beavers or hibernating turtles and other amphibians, ask the advice of a regional government wildlife biologist.
- Dam notching or breaching will be more successful with inactive beaver dams as beavers will seek to repair active dams as quickly as possible [8,9].
- Pairing dam notching with a visual deterrent is an untested tool that has shown some potential to deter the beaver from repairing a notch by using a white sheet or jugs

suspended directly above the dam notch [12]. This deterrent is relatively low cost so could be experimented with to determine if it's effective at a site [9].

SUMMARY OF ALBERTA REGULATORY CONSIDERATIONS

Regulations that may apply to this tool include:

- Provincial
    - Public Lands Act
    - Water Act
- Federal
    - Fisheries Act
    - Migratory Bird Act
    - Species at Risk Act
- Additional regulations may apply depending on the location of the site or the methods used. For example, if explosives are being used to remove or partially breach a dam, there are additional regulations and safety measures (not discussed in this document, please check with your local municipality). If heavy machinery is used there will be additional safety measures and regulations that apply.

For further regulatory details, please review the section on "Regulations Related to Beaver Management."

RESOURCES

Self-Help Information - Pond lever, Beaver Institute, Inc. (Page 5 focuses on dam removal procedures)

The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains. Version 2.01

Beaver Management Technical Paper #1: Beaver Management Tools Literature Review and Guidance

Code of Practice: Beaver dam breaching and removal, Fisheries and Oceans Canada

An Agricultural Decision Matrix Tool for Beaver Management

Flow Device: Pond Leveller

Figure 3: Constructed pond leveller being placed into the dam and wetland. The wire cage (intake end) will be lowered and secured with weights to be kept at the bottom of the pond. The outlet end will be secured in the dam (Location: Lac Ste. Anne County, Alberta).

Figure 4: View of the outlet end of the pond leveller after being secured in the dam (Location: Lac Ste. Anne County, Alberta).

Figure 5: View of the intake end of the pond leveller after being constructed on land, prior to installation in the pond.

Figure 6: Multi-intake combination device (Location: Calgary, Alberta).

DESCRIPTION OF TOOL

Pond levellers, or flow devices, are intended to manage water levels in the pond at a point that minimizes problems of flooding of the human interface and still maintains suitable beaver habitat created by a beaver dam. Some of these devices use widely available, flexible and durable drainage pipe. The materials are assembled on land and then the structure is positioned in the pond [13].

ADVANTAGES OF USING THIS TOOL

Environmental

- By using this tool, the many environmental benefits of the beaver dam and pond behind the dam are provided, or still partially provided, including maintained water levels, recharge and feed groundwater aquifers, and provide habitat for a variety of species. Beaver families will continue to grow and disperse to other parts of the watershed, spreading the benefits to a wider area.
- This tool creates a more stable situation so new beavers are not moving in repeatedly and starting over, which can result in more extensive cutting of woody plants.
- Strong materials included in these designs can withstand freeze - thaw cycles.
- Design stays in place unless beaver dam completely washes away and does not require the same type of repeated human disturbance of the area as mechanical or explosive efforts. Maintenance is generally minor, two times a year.

Social

- Reduced efforts of population control and dam removal or breaching by explosives will often be appreciated by neighbours, as well as the public that does not support such removal approaches.
- Continues flow of water downstream to height of pipe, providing water to downstream neighbours and communities.
- Provides options for people or organizations who are not able or do not want to remove dams by using explosives.
- Regarding human safety, this is a low-tech, hand-built tool may have less risks than traditional management (e.g., dam removal with explosives).
- Once there is a trained/experienced project lead, installation can be done as a volunteer/community effort once necessary approvals are in place, potentially saving money by not needing to hire a contractor or trapper; and encouraging community involvement and volunteerism.
- Mitigation devices such as pond levellers and culvert protectors can substantially reduce the cost of problem beaver management. Cost savings, in terms of reduced maintenance, road repairs and beaver population control, range from 44 to 90% [10,14–17].
- A pond leveller or culvert protector is less costly to taxpayers than dam removal and lethal control [10].
- Being able to support land managers with cost-sharing of materials and/or labour can be helpful for those considering coexisting with beavers with some of the tools discussed in this guide or who might be on the fence. There are a variety of grant opportunities available to individuals and groups that could help provide this support.

DISADVANTAGES OF USING THIS TOOL

Environmental

- Non-natural materials in waterway that could potentially get washed out and become undesirable litter elsewhere or pose entanglement concerns.
- Beaver families grow and disperse to other parts of the watershed, which may be undesirable in some nearby areas.
- Beavers may figure it out and move downstream or upstream or somewhere else entirely, resulting in new or additional conflict areas.
- Beavers may bury the outlet end if not protected, or bury the intake end, if not deep enough, preventing the device from working, increasing the water held behind the dam. This is why careful attention to site design considerations and on-going monitoring/maintenance are needed to help promote success.
- Exposed soil from rapid loss of water creates opportunity for invasive plants and other undesirable plant species to become established, particularly in areas where native plant competition may be limited.

Social

- Not intended to stop flooding in high water years or at specific and certain times of the year, so it cannot address all flooding concerns entirely.
- Requires financial investment although it is lower than conventional methods [10].
- Can be difficult to remove if there is still water in the pipe or if some or all of the device becomes buried. Beavers are expected and needed to help secure the dam end of the pipe, though they can sometimes widen the dam upstream along the pipe which adds more material that needs to be moved if the device is going to be taken out, but this should not be a deterrent to installation.
- Streams are dynamic systems and sometimes the main channel moves after significant flood events leaving the initial installation site as a side channel or more of a depositional area.
- Documentation of the device's location is required to maintain it. The site can become buried or infill over time. The pipe and intake cage are generally completely underwater and not visible and sometimes the outlet end becomes overgrown or covered by mud and sticks as beavers continue to maintain the dam. Also, future land managers, wildlife conflict staff, or other department staff may not know the device is present, resulting in it not being maintained and then becoming non-functioning, leading to skepticism of the effectiveness of the device.

BENEFICIAL MANAGEMENT PRACTICES

- To be used when some flooding can be tolerated but the desired water level is lowered to reduce conflict with human property or other infrastructure.
- Only lower the water level enough to mitigate the conflict with human needs. The pond leveller pipe is not intended to carry the highest flows or drain the pond. The intent is to keep water moving to the desired pond height that addresses the flooding issue once high flows have subsided and maintains beaver habitat [18].
- The height of the bottom of the outlet end of the pipe dictates the pond level. This can be adjusted if the desired height of the pond changes over time but can take some effort [18].
- Use at sites with active beavers because a pond leveller in a free-standing dam requires beavers to maintain the dam. Pond levellers can also be used proactively if beavers aren't active at the site but are expected to return in the future (Mike Callahan, personal communication, 2023).

- By moving the intake upstream and under water the sound and feel of running water is relocated, thus minimizing the trigger that alerts beavers to plug the leak [18]. Silent leaks are not detected or repaired; beaver may react more to the noisy ones.
- Pond levellers have flexible applications because they can be used in free standing dams or can be combined with culvert exclusion fence to create fence and pipe design [11]. In the fence and pipe combination design the pipe acts as a pond leveller would in a free-standing dam. A combination device does not require as large of an exclusion fence at the culvert as a standalone culvert exclusion fence. Refer to "Flow Device: Culvert Protector" section for more information on the fence element of the combination device.
- Works best when pond depth is 1 meter or greater so the intake end of the pipe can be fully submerged [11]. Maintaining a minimum 1m depth of water is also important because this is the amount of water required for beavers to survive the winter and escape predation [13].
- Should be installed during the ice-free period, after peak flows in the spring (for human safety reasons and so the device can be placed properly without the dam or the device being washed away) and before beavers begin to cache their food in the fall for the winter. Installation needs to be in accordance with regulatory restrictions related to fish activity windows, if applicable.
- If a pond leveller device is intended but the water levels needs to be initially dropped by more than 30 cm (1 ft), a round of trapping or hunting may be beneficial for the success of the leveller as any new beavers moving in could adapt to the lower level, whereas the previous population may feel threatened with the dramatic water loss [19].

Design Considerations for Flexible Pond Leveller™:

Like many beaver management strategies, there are a variety of ways to achieve the same goal. The Flexible pond leveller is an example of a strategy that practitioners use for beaver coexistence now based on lessons learned from early attempts that did not work as well. The strategies and principles for flow devices continue to evolve but the following are some design considerations that are showing success today.

- Pipe diameter/capacity rule of thumb size ~30% of downstream conduit (e.g. culvert, bridge) (Adrian Nelson, personal communication, 2016). One site may need several pipes if the watershed is large.
- 30-40 feet of pipe length allows for moving the intake end far enough upstream to effectively reduce the risk of them being able to block the intake end [18].
- Protect the intake end of the pipe with a wire mesh cage big enough to provide 1-2 feet of gap between the pipe and the edges to reduce the chance of beavers blocking the intake end (Mike Callahan, personal communication; Adrian Nelson, personal communication, 2018).
- Notch the underside of the intake end of the pipe to increase the surface area water has to move into the pipe. This reduces suction so beavers are less likely to detect the movement of water and reduces the chance of them blocking the intake end (Mike Callahan, personal communication, Adrian Nelson, personal communication, 2018).
- Minimal overhang on the downstream side of the dam helps reduce sound of running water (Adrian Nelson, personal communication, 2018).
- Protection of the pipe outlet with a wire mesh panel may be beneficial to reduce risk of beaver plugging up the discharge end of the pipe. This can be added after installation, if beavers start showing signs of plugging the discharge, and are most effective when placed at an angle away from the pipe (Adrian Nelson, personal communication, 2018).

- Wire mesh for the intake cage and outlet panel needs to be small enough that beavers cannot move sticks through the mesh but large enough to not accumulate debris that could reduce water movement, attract beavers or restrict fish and small mammal movement (Mike Callahan, personal communication). Mesh sizes ranging from 4”x4” to 6”x8” have been used with success in many jurisdictions. On occasion, fences using the larger mesh sizes (e.g. 6"x8") have had young beaver get inside the fence and plug the culvert with mud and small sticks.
- Use cinder blocks attached to the pipe at strategic locations along the pipe (towards center and intake cage end) to help keep the pipe submerged. T-posts are also used to secure the pipe outlet at the dam and along the length to support it if water levels change or there is fast moving water [18].
- High Density Polyethylene (HDPE) pipe is recommended as it's relatively easy to use and can generally be moved manually. A double wall pipe is most recommended for Alberta though there may be circumstances where single wall is useful (Adrian Nelson, personal communication, 2021).
    - Double wall pipe (Figure 7) is corrugated on the outside but smooth on the inside which reduces the sound of water running through the pipe reducing the risk that beavers will chew through it. It does bend but is less flexible than single wall pipe and holds up well to freeze and thaw cycles and ice movement.

Figure 7: Double wall pipe

    - Single wall pipe (Figure 8) is corrugated on the inside and outside (more similar to a metal culvert) which amplifies the sound of running water through the pipe increasing the risk that beavers will chew through it. To reduce this risk, it is best used in situations where the pipe can be completely submerged at all times when water is flowing through it. Single wall pipe is more flexible so can be used for situations where there isn't room for a straighter pipe or a multi-intake approach will not work, if it can remain submerged or buried.

Figure 8: Single wall pipe, chewed through by beavers

- Not maintenance free. Requires minor maintenance and monitoring.
- The lifespan of a pond leveller is typically 10 years.
- A multi-Intake design modification to the flexible pond leveller can be used when a channel is narrow or water is too shallow or there isn't sufficient length of straight channel for a standard flexible pond leveller and a bend in the pipe is needed when using double walled pipe. The multi-intake system involves minimum two intake cages and two lengths of pipe. The idea is that two lengths of pipe of standard flexible pond leveller are not directly coupled together so the outlet end of one pipe and the intake end of another are open but are joined (or protected) by a cage between them. With this design, water flows into the pipe at minimum two (but could be more) points so it is easier to hide the flow from the beavers [20].
- Modifications can be made to the flexible pond leveller design where human conflict over fish and beaver cannot be resolved. The idea with a 'fish lift' is a series of boxes are installed to create a cascade of 'pools' up the face of the dam so fish can rest on their way up or down the beaver dam. This design modification has been used with success in areas of salmon migration in British Columbia and Washington. There has yet to be a demonstration of a similar concept for fish species in Alberta.
    - The 'Fish Lyft' system has been used with success in Port Moody, BC and is a "series of boxes, through which an outflow passes, and a large pipe that connects the system to the pool of water. As the system's boxes are filled with the leveller's outflow, the fish move through it into the outflow pipe and then pass into pools by way of the outflowing water." For more about the Fish Lyft System by Humane Solutions refer to their website [21].
    - The 'Snohomish Pond Leveler' is an innovative fish-friendly flow management device prototype designed to allow adult Coho salmon to easily migrate upstream past two beaver dams. It was developed in 2013 by Mike Callahan and a team from Snohomish County in Washington, USA. For more information about the Snohomish Pond Leveler by Beaver Solutions and Snohomish County refer to their website. [22].
    - According to Wheaton et al, "Beaver dams can act as a barrier (typically temporarily or seasonally) to upstream and downstream movement of fish. Too often, this is assumed to always be detrimental. However, for many native fish that co-evolved with beaver dam activity in the systems, beaver dams are passable and not a problem. Moreover, the fact that beaver dams tend to lead to the creation of both more, and more diverse aquatic habitat tends to offset negative impacts for many native fish. For many fish who pass upstream of beaver dams with ease, this tends to correspond with when they spawn and that migration tied to higher flows" [23].

SUMMARY OF ALBERTA REGULATORY CONSIDERATIONS

Regulations that may apply to this tool include:

- Provincial
    - Public Lands Act
    - Water Act
- Federal
    - Fisheries Act
    - Migratory Bird Act
    - Species at Risk Act
- Additional Regulations

For further regulatory details, please review the section on "Regulations Related to Beaver Management Tools."

RESOURCES

Best Management Practices for Pond Levelers and Culvert Protection Systems: A guide for using flow devices to coexist with beavers, The Beaver Coalition

Self-Help Information - Pond lever, Beaver Institute, Inc.

Pond Leveler Pipe Instructions - YouTube

Code of Practice: Beaver dam breaching and removal, Fisheries and Oceans Canada

Working with Beavers - Pond Leveller

Beaver Coexistence Tools - Materials & Suppliers list

Cost-Benefit Analysis of Beaver Coexistence Tools fact sheet

Flow Device: Culvert Protector

Figure 9: Culvert protector installed an a 6' culvert (Location: County of Barrhead, Alberta).

DESCRIPTION OF TOOL

Culvert protection is a form of barrier to keep beavers away from culverts where problems have or could happen as a result of plugging a culvert. Culvert protection involves restricting a beaver's access to the culvert using materials such as wire mesh or specially designed culvert extensions [13].

ADVANTAGES OF USING THIS TOOL

Environmental

- Rather than removing beavers, this tool creates a more stable situation so there are not new beavers moving in repeatedly and starting over, which can result in more extensive cutting of woody plants and repeat plugging of culverts.
- Beaver families grow and disperse to other parts of the watershed, spreading the benefits to a wider area.
- Strong materials are used in these designs and can withstand freeze - thaw cycles.
- Design stays in place unless the culvert completely washes away.
- Wildlife passage can be added to culvert protector design to allow for continued movement of wildlife species through the culvert while excluding beavers from entering with sticks and debris needed for them to plug the culvert. Adult and young beavers can still pass through when not carrying building materials [24].

Social

- Maintains a clear culvert even though beaver may dam on the fence.
- Continues flow downstream.
- Provides options for people or organizations who are not able or don't want to clear culverts or do population control.
- Regarding human safety, this is a low-tech, hand-built tool may have less risks than traditional management (e.g., dam removal with explosives).
- Once there is a trained/experienced project lead, installation can be done as a volunteer/community effort once necessary approvals are in place, potentially saving money by not needing to hire a contractor or trapper, while also encouraging community involvement and volunteerism.
- Mitigation devices such as pond levellers and culvert protectors can substantially reduce the cost of problem beaver management. Cost savings, in terms of reduced maintenance, road repairs and beaver population control, range from 44 to 90% [10,14–17].
- A pond leveller or culvert protector is less costly to taxpayers than dam removal and lethal control[10].
- Being able to support land managers with cost-sharing of materials and/or labour can be helpful for those considering coexisting with beavers with some of the tools discussed in this guide or who might be on the fence. There are a variety of grant opportunities available to individuals and groups that could help provide this support.

DISADVANTAGES OF USING THIS TOOL

Environmental

- Non-natural materials in waterway that could potentially get washed out and become undesirable litter elsewhere or pose entanglement concerns.
- Beaver families grow and disperse to other parts of the watershed, which may be undesirable in some nearby areas.
- Beavers may figure the restriction out and dam around it. This is not a cause for concern if some flooding can be tolerated and they don't dam high enough to get over the top.
- Beavers may move upstream or downstream or somewhere else entirely.
- Water levels may be lowered to culvert height which can result in loss of the ponding effect and can decrease the environmental benefits provided by beavers.

Social

- The wire mesh culvert exclusion can look like a cage or trap so communication is helpful to inform the public, in particular that the culvert protector is not an animal trap.
- Requires financial investment although lower than conventional methods [10].

BENEFICIAL MANAGEMENT PRACTICES

- Culvert protectors can be used for any sized culvert as long as stream channel conditions are suitable and budget allows for more materials that would be needed for larger culverts. In Alberta, the exclusion fence, and fence and pipe designs have been used on 2-6' diameter culverts, to date.

- Culvert protection can include multiple culverts with one fencing structure or multiple beaver-proof add on structures.

Design Considerations for the Keystone Fence™

- There are a variety of designs but the Keystone Fence™ [25], which is a trapezoid shape, has proved highly effective in other jurisdictions. Below is a list of considerations for this design.
    - 60 cm (2 ft) open water between fence and both banks to use as a stand-alone tool.
    - Create length and odd shape to make it difficult for beaver to dam around.
    - The fence upstream side is well away from the stimulus of moving water at the culvert.
    - Has a floor to prevent beaver from digging underneath to get to the culvert opening.
    - Wood header adds stability to the structure as well as covers any potentially sharp edges of the wire mesh left during construction. In highly visible areas, also provides a clean look to the device.
    - Can have a top if there is concern that people or pets may get into the structure, or if cannot keep up with maintenance and beaver may get in.
    - The height of the fence should be 1-1.5ft taller than expected highest water to reduce risk of beaver going over and getting to the culvert during high water flow periods.
    - Wildlife passage can be added to allow for continued movement of wildlife species through the culvert while excluding beavers from entering with sticks and debris needed for them to plug the culvert. The beaver itself can still pass through [24].
    - 4-6" x 4-8" wire mesh allows for water, fish and small mammal movement. On occasion, fences using the larger mesh sizes (e.g. 6"x8") have had young beaver get inside the fence and plug the culvert with mud and small sticks.
    - Metal or steel grates are not required if the culvert is protected with an exclusion fence. So if the culvert to be protected had those tools before they can be removed once the fence is in place. If there is concern about the effectiveness of the exclusion fence, they can be left in place but they do amplify the sound of running water and may create more aggressive damming behavior on the fence.
    - Requires minor maintenance and monitoring. Checking at minimum in the spring and fall to remove any debris buildup is important for keeping the device functional.
    - Lifespan typically 10 years.

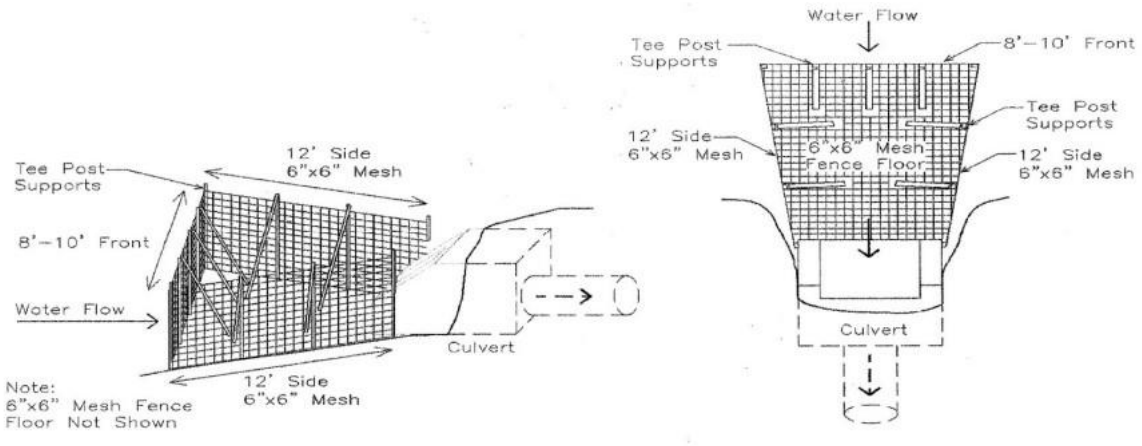


Figure 10: Keystone Fence™ trapezoidal culvert protector design [25]

Design Considerations for the Beaver-Proof Add On

- Another culvert protection design that has been successful in Alberta is the Beaver-Proof Add On, which can be added to existing culverts of a wide variety of sizes or can be added during new culvert installation (Figure 11). The extensions can be galvanized or plastic and claim to be maintenance free [26].

Figure 11: Beaver-Proof Culvert Add-on installed while doing a routine replacement of old culverts at this road crossing. The road had been experiencing flooding resulting from beaver plugged culverts. The installation happened in 2012 and cost $35,000 and has not required any further maintenance. Installed costs recouped, now saving the county $5,000-10,000 annually (Location: Foothills County, Alberta) [17].

Design Considerations for a Combination Device

- An exclusion fence style culvert protector can be combined with a pond leveller to create fence and pipe design if beavers continue to dam on the fence and ponding cannot be tolerated even if culvert is clear or there isn't enough free water space to build a large enough fence to effectively deter beavers from damming. The fence and

pipe combination design does not require as large of an exclusion fence as a typical culvert protector and the pipe acts as a pond leveller maintaining water level at a certain height that can be tolerated (Figure 12 & Figure 13). Refer to the "Flow Device: Pond Leveller" section for more information.

Figure 12: A second example of a combination device (pond leveller and culvert protector) (Location: Lamont County, Alberta).

Figure 13: Double pipe combination device for higher capacity (Location: Cooking Lake Blackfoot Provincial Recreation Area, Alberta)

Design Considerations for a Diversion Dam Fence™

- Another culvert protection tool is a Diversion Dam Fence™ (Figure 14). A Beaver Diversion Fence™ (BDF) inexpensively protects road culverts from beaver damming by diverting the beaver from damming inside the culvert to damming immediately

upstream of the culvert instead. It helps control where beavers dam and is ideal if ponding upstream of the road is tolerable [27]. For more information on diversion dams, please see Beaver Solutions – Beaver Diversion Fence™ fact sheet.

- The diversion dam fence concept has also been used on trail bridges. Figure 15 shows an example of a modification of the diversion dam fence used on a bridge. The height of the fence is taller than a standard diversion dam to limit damming at this location.

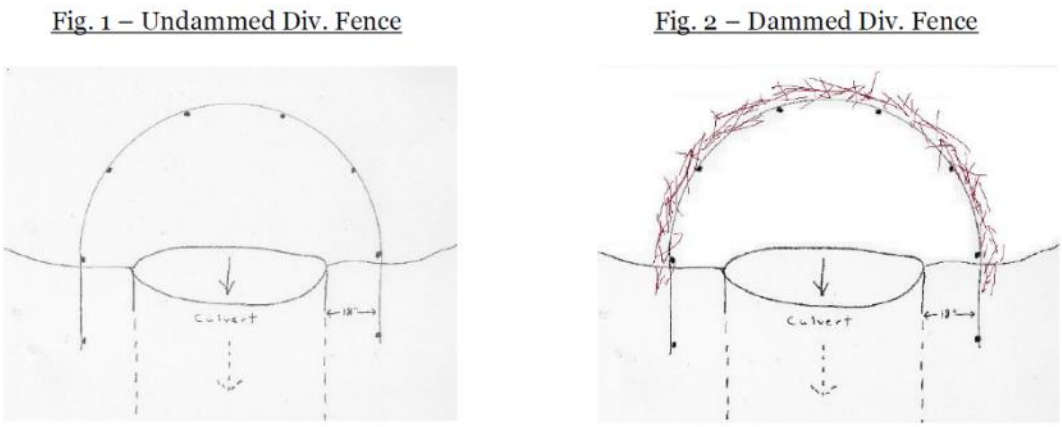


Figure 14: Diversion Dam Fence™ [27].

Figure 15: Modification of the diversion dam fence concept used on a bridge (Location: Cooking Lake Blackfoot Provincial Recreation Area, Alberta)

SUMMARY OF ALBERTA REGULATORY CONSIDERATIONS

Regulations that may apply to this tool include:

- Provincial
  - Public Lands Act
  - Water Act

- Federal
    - Fisheries Act
    - Migratory Bird Act
    - Species at Risk Act
- Additional Regulations

For further regulatory details, please review the section on "Regulations Related to Beaver Management Tools."

RESOURCES

Best Management Practices for Pond Levelers and Culvert Protection Systems: A guide for using flow devices to coexist with beavers, The Beaver Coalition

Beaver Proof Add On

Blocked Road Culverts and Drains, The Beaver Institute, Inc.

Self Help Information – Culverts, Drains, The Beaver Institute Inc.

Road Culvert Fence Instructions - YouTube

Code of Practice: Beaver dam breaching and removal, Fisheries and Oceans Canada

Working with Beavers - Culvert Protector

Beaver Coexistence Tools - Materials & Suppliers list

Cost-Benefit Analysis of Beaver Coexistence Tools fact sheet

Supplemental Feeding and Dam Building Woody Material

DESCRIPTION OF TOOL

A short-term or labour-intensive long-term solution to protect valued trees is to provide an alternate source of food and dam-making materials. Beaver can be supplied with cut woody material and this diverts attention away from areas where problems might occur [13]. Providing a live wood supply from nearby or off-site minimizes local cutting of trees and shrubs by beaver but has high costs in time for the person(s) providing the supplemental woody material [13].

ADVANTAGES OF USING THIS TOOL

Environmental

- Providing substitute food sources minimizes impacts on riparian and nearby upland trees and shrubs in areas where beavers are living and seeking food, which if there are limited woody plants available, will enable those plants to be sustained and support riparian health at the site [28].
- Provides an alternative use for suitable species of trees and shrubs removed from road ditches or other projects and developments where woody plants are removed, rather than landfilling or chipping them for mulch.

Social

- Reduces the amount of standing trees and shrubs beavers need to take on site because they have a more easily accessible source.
- Provides an alternative use for suitable species of trees and shrubs removed from road ditches or other projects that results in more integrated use of cut materials, which may also save costs in landfilling.
- In situations where community members or volunteers are involved, it provides a practical way for community members to support co-existence efforts, including integrating and building partnerships or connections to potentially unrelated activities, expanding the awareness of the tool. When used at conservation or public outreach focused sites, such as nature centers, it can be a positive way to reach and engage a wider public audience.

DISADVANTAGES OF USING THIS TOOL

Environmental

- Alternate supply of woody plants is required so consider location in terms of distance from destination site as well as impact to source location.
- Need disease free supply so not transferring diseases from one place to another.
- May need trailer, off-highway vehicle or truck to haul which contributes to costs and environmental impact.
- If there is no other food source for the beavers and there is a problem securing or providing food even for a few days, this is a risky approach for the beavers.

Social

- Can be a high investment in time and money and commitment from staff or volunteers.
- Short term, stop-gap measure while beavers and/or their food supply gets established or another solution is reached, but not generally suited to long term use because of the amount of work required and ongoing woody materials needed.
- Using this tool long term may give the impression that it is a viable option for all or many beaver feeding needs or beaver conflict tree cutting sites, which is unrealistic.

BENEFICIAL MANAGEMENT PRACTICES

- Use live and fresh cut tree and shrub species preferred by beaver (e.g. aspen, willow, poplar) and place close to water's edge for ease of access.
- Use sizes of branches or trunks that can be easily moved by beaver or chewed through to make smaller. Using smaller sizes also helps with transportation space and costs.

SUMMARY OF ALBERTA REGULATORY CONSIDERATIONS

No approvals needed for supplemental feeding or dam building woody material for beavers if the material is cut from your own private land. It is recommended that if using woody material from roadside ditches or other municipal lands that discussions happen first with those authorities, which may need to provide consent. To harvest from public (Crown) lands, you must be within a certain designated Forest Area and a tree cutting permit is required[29].

RESOURCES

Beaver Our Watershed Partner booklet

An Agricultural Decision Matrix Tool for Beaver Management

Tree Protection

DESCRIPTION OF TOOL

Tree protection using wire or other means is a way of creating a barrier between beavers and vegetation to protect it from being used by beavers for food or dam building. Barriers, to keep beaver away from places where problems will happen, are low to moderate in cost, with reasonable effectiveness, but do require periodic maintenance.

Figure 16: Tree wiring or exclusion is one method of tree protection (Location: Calgary, Alberta)

ADVANTAGES OF USING THIS TOOL

Environmental

- Protects trees and shrubs at small and larger scale for their habitat and other environmental, aesthetic, cultural or agricultural benefits.
- Maintains trees on the landscape which are important for soil stability, streambank stability, providing shade and habitat for some other animals.

Social

- Allows beavers to be active in an area but protects trees.
- Builds tolerance for beaver activity without the risk to trees.
- Relatively low-cost effort with long term results when wiring trees.
- If using electric fencing, protection can be temporary and moveable, during high priority or high-risk periods, which is beneficial, as the fencing is not permanent.
- Saves important, specific or small groves of trees.

- Being able to support land managers with cost-sharing of materials and/or labour can be helpful for those considering coexisting with beavers with some of the tools discussed in this guide or who might be on the fence. There are a variety of grant opportunities available to individuals and groups that could help provide this support.

DISADVANTAGES OF USING THIS TOOL

Environmental

- If beavers don't have other food supply, can cause them to move to a different area.
- Girdling of trees or shrubs if not wrapped wide enough initially or modified to allow growth of trees over time.
- Doesn't protect all age classes of trees.

Social

- Wire may be unsightly.
- Large areas of trees and shrubs makes it more difficult to protect them all so may not achieve the goal of tree protection in the minds of some.
- Labor intensive initially but savings are realized over time when trees are wired. If electric fencing is used, costs may be ongoing, or short term, and less predictable. Also when using electric fencing.

BENEFICIAL MANAGEMENT PRACTICES

- Use durable materials that are not prone to chewing or being pulled down.
- If using wire, low gauge (thicker) wire is better (e.g. stucco wire vs chicken wire).
- Small wire mesh size reduces the chance of beavers reaching through.
- Ensure no gaps between ground and bottom wire. Extending the mesh into ground can reduce the risk of beaver digging underneath.
- Can wire individual plants or groups of plants.
- Provide adequate space between the tree and the wire to allow the tree to grow without girdling. As years go by and the tree grows, the wire may need to be widened.
- To reduce cutting likelihood, follow Pollock et al. (2018) protocols of ensuring the wire is 30 cm larger diameter than the tree and the wire is 1 m above the anticipated snowline. Westbrook and England (2022) found that following these core installation protocols regardless of wire type reduces likelihood of beaver cutting.
- Some wire sizes and configurations are more effective than others: wire fencing that is 50 mm x 50 mm square mesh size or 100 mm x 150 mm rectangular elk wire fencing is less likely to be cut than chain link fencing (50 mm x 50 mm diamond mesh) or chicken wire poultry netting (25 mm hexagon mesh) [30].
- Electric fencing single trees or stands of trees is an option in areas with very limited amounts of tall herbaceous material that might interfere with the conduction of the electrical current. Varying heights and techniques can work; some sources suggest a height of 3-4 inches (7-10 cm) as an effective height [31], but this will not work if vegetation taller than this is present. Using electric fencing would require electric fencing unit including grounding, fence posts, power supply and wire for this purpose.

SUMMARY OF ALBERTA REGULATORY CONSIDERATIONS

No approvals needed for wiring trees.

RESOURCES

Tree Damage, The Beaver Institute, Inc.

Working with Beavers – Tree Wrapping

Population Control: Relocation

DESCRIPTION OF TOOL

Live trapping and moving beaver from one location to another is a technique being used in some jurisdictions to address issues caused by beaver without killing or lethally trapping them. It reduces the population in one area and has the potential to increase it in another. In Alberta, currently a province-wide framework for live relocation of beavers does not exist but may be allowed under special permit.

ADVANTAGES OF USING THIS TOOL

Environmental

- Acts as predator control in one area where natural predation is missing and is not providing natural balance needed in population.
- Beaver families are dispersed to other parts of the watershed where space and habitat are suitable, enabling quicker establishment of beaver colonies.
- Brings beneficial beaver activity into new or different areas including enhanced wildlife habitat, reconnects floodplains with channels, and extends seasonal flows because increasing surface water behind dams can then lengthen stream flow periods.

Social

- Many people and groups are against lethal trapping, so this provides an alternative that is acceptable to those that do not want the animals killed.
- A short-term solution to an immediate problem where a conflict arises and can be addressed quickly.
- Brings beneficial beaver activity into new or different areas where desired and acceptable.
- Provides research opportunities to better understand beaver movement, behavior and responses to relocation.

DISADVANTAGES OF USING THIS TOOL

Environmental

- Without beavers at a site, dams become weak and fail, reducing ponding and creating a flush of water and sediment downstream.
- Once beavers are removed, but suitable habitat remains, then unoccupied habitat creates new opportunities for other beavers to move in and they start over with dam and lodge building which can mean more felling of trees in the short term, and new conflicts.
- New beavers that move in may not select the same damming or lodge site, potentially changing the location of an issue like flooding or tree felling, creating new conflicts.
- Can bring beaver activity to a new area where it is not appreciated and conflict has to be addressed in a new location.
- Habitat where beavers will be relocated to needs to be suitable to support their establishment. If not, the relocation may not be successful and beavers may perish.
- Could introduce disease into new areas. Appropriate understanding of disease presence and transmission is needed.

- Beavers move so they may not stay where they are initially relocated, including creating new issues or putting the beavers at risk of predation, disease or human-caused mortality they otherwise would not have faced.

Social

- Can bring beaver activity to a new area so communication about what it can mean to have beaver on the landscape is integral to success and needs to be part of the plan, increasing costs and time.
- Tolerance and education is needed so people understand what it means to have beavers in their area, and the timeframe to achieve this may not match the relocation timeframe.
- Short term, since nature abhors a vacuum, new beavers occupy newly available territory and start over, which can perpetuate the issue, extending costs and length of coexistence challenges.
- Appropriate understanding of where to release new beavers with the right conditions (e.g. habitat, open territory, etc.) is important and may take some time to determine and may not match the timeframe needed to address the source location concerns (e.g., flooding).
- Appropriate understanding of disease presence and transmission is needed which may take some time or expertise that is unavailable.

BENEFICIAL MANAGEMENT PRACTICES

- Relocation is generally prohibited in Alberta without special permitting.
- If relocation is allowed:
    - Follow all regulatory requirements or permit conditions, if applicable.
    - Transfer using humane practices so stress on the animals is minimal.
    - Keep family units together, particularly kits and parents, if possible.
    - If there are no kits, move the adult pair together if possible after yearlings have dispersed.
    - Relocate to an area where tolerance for beaver presence by landowners and neighbours is acceptable.
    - Relocate to an area not already occupied by beaver as their territorial nature may threaten the success of establishing in the release area.
    - Consider predators in the area and if the risk of death to the relocated beaver is high, look elsewhere.
    - Suitable habitat is needed for success so being prepared to help with supplemental feeding (e.g. trimmings to get started), and shelter provision can be beneficial.

SUMMARY OF ALBERTA REGULATORY CONSIDERATIONS

In Alberta, guidance exists on regulatory requirements needed for relocation. It is generally prohibited without a special permit from the Government of Alberta under the Wildlife Act.

Regulations that apply to this tool include:

- Provincial
    - Wildlife Act

For further regulatory details, please review the section on "Regulations Related to Beaver Management Tools."

RESOURCES

Training and Workshops for Restoration Professionals, Methow Beaver Project

The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains. Version 2.01

Guidelines for Reintroductions and Other Conservation Translocations, IUCN

Population Control: Lethal Removal

DESCRIPTION OF TOOL

Lethal removal includes hunting and trapping with the intent of immediately killing beavers to reduce the population in an area. Lethal removal is often done before conflicts with human activities arise but also as result of conflict. If conditions, situational circumstances, or human tolerances do not allow for coexistence with beavers, then lethal removal may be the necessary tool.

ADVANTAGES OF USING THIS TOOL

Environmental

- Acts as predator control where natural predation is missing.
- Can be used to manage disease if that is an issue identified in a population.

Social

- It's a well-used technique so those in the business of beaver removal understand how it's done and there is a comfort level there by those doing it, and those asking for it to be done.
- There are well defined regulations for lethal trapping and hunting in Alberta.
- A short-term solution to an immediate problem.
- Hunting and lethal trapping is a skill. Selling pelts can be a source of income.
- Trapping can be adjusted to allow for live animal relocation, where circumstances allow under regulations and if suitable conditions for release are available.
- May be an acceptable option if there is "a 'no tolerance zone' for beavers where human health, property or safety would occur with any beaver damming" [19].
- May be an acceptable option if "topography or development of an area presents so many potential conflicts if beavers are permitted to stay, it would be cost-prohibitive to "beaver-proof" with flow devices" [19].

DISADVANTAGES OF USING THIS TOOL

Environmental

- Without beavers, dams become weak and can fail, reducing ponding and creating a flush of water and sediment downstream.
- Open space (territory) creates new opportunities for other beavers to move in and they start over with dam and lodge building which can mean more felling of trees in the short term.
- New beavers that move in may not select the same damming or lodge site, potentially changing the location of an issue like flooding or tree felling.
- Proper carcass disposal is needed to avoid attracting other wildlife, which otherwise may cause other issues.

Social

- Many people/groups against killing of animals which can create conflict with lethal removal policies.
- High input time and expenses, on-going.
- Selling pelts can be a source of income but current pelt prices offer little return on investment.

- Appropriate skills are required by the person doing the lethal removal to humanely end the animal's life.
- Proper carcass disposal is needed to avoid attracting other wildlife which may cause other human safety or aesthetic issues. If use of the hide or preservation of the animal's body is desired (e.g., taxidermy) a permit is required.
- Not appropriate to use in populated or recreational areas where there are people and pets without dedicated supervision.

Trapping

According to the Alberta Wildlife Act, trapping means to "capture, injure or kill animals of any kind or attempt to do so by means of the use of a trap." A trap is defined as "a device, other than a weapon, designed and commonly used to capture, injure or kill animals of any kind" [32].

BENEFICIAL MANAGEMENT PRACTICES

- Follow trapping regulations and guidelines.
- Beavers are most active at dawn and dusk and in spring and fall so these times can increase rate of success of getting the animal.
- Beavers make trails and spend time at their dams so those can be good trapping locations.
- Being skilled with trap setting provides a better chance of humanely trapping the animal.
- Dispose of carcass appropriately. Check with your local jurisdiction for procedures.
- Use approved traps for your area.
- Carefully consider use of traps in areas of human recreation or pets where there is risk of unintended injury.
- Consider working with an experienced contractor/trapper as appropriate skills are required to ensure lethal removal is conducted in a humane manner as required by Alberta Trapping Regulations.

Hunting

DESCRIPTION OF TOOL

According to the Cambridge Dictionary, hunting is "the activity or sport of chasing or searching for wild animals or birds with the intention of killing or catching them." In Alberta, the Wildlife Act further defines hunt to mean "shoot, harass, or worry; chase, pursue, follow after or on the trail of, search for, flush, stalk or lie in wait for; capture or willfully injure or kill; [and/or] attempt to capture, injure or kill" [32].

BENEFICIAL MANAGEMENT PRACTICES

- Follow hunting regulations and guidelines.
- Beavers are most active at dawn and dusk and in spring and fall so these times can increase rate of success of getting the animal.
- Beavers make trails and spend time at their dams so those can be good hunting locations.
- Being skilled with hunting weapon provides a better chance of humanely killing the animal with a clear shot and intent to shoot to kill and not maim.
- Dispose of carcass appropriately. Check with your local jurisdiction for procedures.

- If needed, work with an experienced contractor as appropriate skills are required to ensure lethal removal is conducted in a humane manner.

SUMMARY OF ALBERTA REGULATORY CONSIDERATIONS

The government of Alberta Website states the following [33]:

- "Beavers may be hunted and trapped, without a licence and during all seasons, on privately owned land by the owner or occupant of the land, or by a resident with written permission from the owner or occupant of the land."
- "Additionally, beavers may be trapped under a Fur Management Licence during an open season or by someone who holds a Damage Control Licence (this can be issued from any Fish and Wildlife Office). A Damage Control Licence authorizes the removal of beavers outside of normal trapping seasons."
- "It is against the law to disturb or remove a den or lodge without a Damage Control Licence."

Regulations that may apply to this tool include:

- Provincial
    - Wildlife Act
        - Alberta Hunting Regulations
        - Alberta Trapping Regulations

For further regulatory details, please review the section on "Regulations Related to Beaver Management Tools."

RESOURCES

Alberta Trapping Regulations

Alberta Hunting Regulations

Regulations Related to Beaver Management

The nature and history of beavers, which are semi-aquatic fur-bearing mammals, complicates the regulatory process for the use of beaver coexistence tools because they require involvement of multiple pieces of legislation and thus multiple government departments. In Alberta, there is currently no overarching provincial guidance, such as a Beaver Management Plan seen in other jurisdictions (e.g., Utah Beaver Management Plan, Beaver Management Plan for The City of Port Moody, etc.). This has created complexity among departments, regions, and staff within the Alberta Government in how requests for approvals are interpreted, conditions applied, and decisions made. This complexity is a barrier for the effective use of beaver coexistence tools by land managers.

However, with increased use of coexistence tools we now have a better collective understanding of the approvals commonly required. Beaver management tools can require provincial, federal, and/or local authorizations prior to installation or implementation, which are summarized below and in Table 1. This information is based on first-hand experience and a cursory review of relevant legislation concerning beavers and beaver management in Alberta and does not represent a legal interpretation or opinion. For legal purposes, the reader must seek legal counsel and/or the official legislation before starting a project. Always check with your local regulatory approvals staff before using any of the following reactive management tools: Dam Notching, Breaching, or Removal; Flow Device: Pond Leveller; Flow Device: Culvert Protector; Population Control: Relocation; Population Control: Lethal Removal (Trapping or Shooting).

There are regulatory considerations for proactive beaver management approaches as well, however, they are not outlined in this document due to the focus on reactive management approaches as this is currently the highest need for land managers in Alberta.

Provincial

Public Lands Act

Applies to:

- Dam Notching, Breaching, or Removal
- Flow Device: Pond Leveller
- Flow Device: Culvert Protector

According to the Public Lands Act, in Alberta, the province holds the title to the bed and shore around naturally occurring lakes, streams, and rivers, and the bed and shore of all waterbodies, if they are naturally occurring and permanent [34]. In the Surveys Act [35], bed and shore is defined as: “the land covered so long by water as to wrest it from vegetation or as to mark a distinct character on the vegetation where it extends into the water or on the soil itself” (section 17). Given this definition, if breaching or removal of a dam, or use of a coexistence device, such as pond leveller or culvert protector, will impact bed and shore, a public lands authorization may be required. A Departmental License of Occupation (DLO) may also be required for any long-term infrastructure occupying public land.

Water Act

Applies to:

- Dam Notching, Breaching, or Removal
- Flow Device: Pond Leveller
- Flow Device: Culvert Protector

Alberta's Water Act [36] requires that an approval and/or licence be obtained before undertaking a construction activity in a water body or before diverting and using water (surface water and groundwater).

Any disturbance of wetland areas requires Water Act approval and triggers requirements under the Alberta Wetland Policy [37].

The removal of beaver dams is considered an exempt activity under Schedule 1 (2) (h) of the Water Act (Ministerial) Regulations if the exemption parameters can be met:

"(h) removal of a beaver dam from a water body if the person removing the beaver dam owns or occupies the land adjacent to the water body where the beaver dam is located, or has been authorized to remove the beaver dam under section 95 of the Act;"

Section 95 of the Act is enacted only by the Director to manage situations that are causing interference with water rights or property damage.

There is an Accepted Practice for Beaver Dam removal on Crown Land which is in place to help govern these activities as an approval is not necessary for streams that are non-fish-bearing. Contact your local Water Act approvals officer for more information.

Culvert maintenance is covered under the Code of Practice for Watercourse Crossings [38], and is therefore exempt from requiring a Water Act permit. The Code outlines the required practices for the construction, maintenance, replacement or removal of permanent and temporary watercourse crossings, such as bridges and culverts (including addition, maintenance and removal of culvert protectors). The Code also stipulates reporting requirements where necessary.

There is an Accepted Practice for installation of Beaver dam drain pipe to help govern this activity as an approval is not necessary for streams that are non-fish-bearing. Contact your local Water Act approvals officer for more information.

The Government of Alberta website advises that you should consult your local municipal, provincial and federal government policies and procedures [33]. It is best to assume removal of dams also includes partially breaching or notching as they could use similar approaches and result in similar impacts as complete removal.

Wildlife Act

Applies to:

- Population Control: Relocation
- Population Control: Lethal Removal (Trapping or Shooting)

In Alberta, the Wildlife Act regulates both lethal removal, including hunting and trapping, and relocation.

Lethal Removal (Trapping and Hunting)
In Alberta, hunting and trapping regulations are outlined in the Wildlife Act and create the Alberta Hunting Regulations and Alberta Trapping Regulations [32]. According to the Alberta Government "Human-wildlife conflict-Beavers" site, "Beavers may be hunted and trapped, without a license and during all seasons, on privately owned land by the owner or occupant of the land, or by a resident with written permission from the owner or occupant" [33]. Beaver may also be trapped by a person employed by a municipality under a contract of service whose duties include the control of animals [33]. Trapping of beavers can also be done with Fur Management License during an open season, issued from any Fish and Wildlife Office [33].

According to the Wildlife Act, section 36, it is illegal to disturb or remove a den or a lodge without authorization, such as a Damage Control License [32]. A Damage Control License authorizes beaver removal outside normal trapping seasons. To remove a beaver dam, it is recommended to consult with local municipal, provincial and federal government.

Damage control licences and permits, Alberta.ca

Relocation
In Alberta, relocation of beavers is generally prohibited without a special permit from the Government of Alberta [32]. Contact the local Environment and Protected Areas office for further information.

Federal

Fisheries Act

Applies to:

- Dam Notching, Breaching, or Removal
- Flow Device: Pond Leveller
- Flow Device: Culvert Protector

Fisheries and Oceans Canada has a Code of Practice (COP) for Beaver dam breaching and removal which provides "national best practices for the breaching or removal of beaver dams that impound water, change water flows and have the potential to cause damage to nearby infrastructure and property."[39] This code of practice describes "the conditions under which the code can be applied to your project and the measures you are required to implement in order to prevent harmful impacts to fish and fish habitat and avoid contravention of the Fisheries Act and the Species at Risk Act". [39]

Consult the Code of Practice for Beaver dam breaching and removal to determine whether you are able to meet the conditions of the code. According to the Government of Canada website [39] the COP can be used if you determine:[39]

- "If there are no aquatic species at risk within the affected area by consulting DFO's aquatic species at risk map;
- the dam is not located at the outlet of a lake;
- the work does not include realigning the watercourse, dredging, grading, excavating or placing fill on the bed or banks of the watercourse;
- the work does not involve the use of explosives;
- and measures are implemented to protect fish and fish habitat when carrying out the works, undertakings and activities."

As a condition of using this code of practice, a notification form must be submitted to your regional DFO office 10 working days before starting work. If your project does not meet all the conditions or you are unsure whether or not you can meet all the requirements, submit a request for review through The Fish and Fish Habitat Protection Program.

Migratory Bird Conventions Act

Applies to:

- Dam Notching, Breaching, or Removal
- Flow Device: Pond Leveller
- Flow Device: Culvert Protector

The Migratory Brid Conventions Act [40] provides for the protection of migratory birds through the Migratory Birds Regulations and the Migratory Birds Sanctuary Regulations. Draining a beaver pond or altering the water level of a beaver pond could impact migratory bird habitat. Demonstrating due diligence means that the proponent should know if migratory birds, and their nests and eggs may be in the area; that the activity that the proponent wants to undertake would likely impact those migratory birds, nests and eggs; and that the proponent attempted to avoid or reduce such impact[41].

According to Environment and Climate Change Canada's Guidelines to Avoid Harm to Migratory Birds [41], "to avoid damaging migratory birds, nests and eggs, it is recommended to:

- understand how migratory birds and their nests are legally protected.
- consult the nesting calendars when planning your activities.
- plan your activity ahead of time, evaluate if the activity may cause harm to migratory birds, and determine what measures can be taken to avoid causing this harm.
- develop and implement preventive and mitigation measures, such as beneficial management practices."

When altering water levels, the Government of Canada recommends determining "if birds are or will likely be nesting in or near the beaver pond and avoid any adjustments to water levels that could result in flooding or drying out nests until birds have raised their young. It is also important to identify nests of species listed under Schedule 1 of the Species at Risk Act and take care not to damage or destroy them at any time of the year" [41].

Species at Risk Act

Applies to:

- Dam Notching, Breaching, or Removal
- Flow Device: Pond Leveller
- Flow Device: Culvert Protector

The Species at Risk Act covers at-risk amphibians, birds, invertebrates, and vegetation, and provides legal protection to prevent species from becoming extinct and secures the necessary actions for their recovery [42]. The Species at Risk Act also protects the habitat that is necessary for the survival or recovery of a species, referred to as critical habitat[42]. When planning activities or works that will impact beaver pond or a stream, the proponent must determine whether there are species at risk present, and if there are, according to section 73, a permit would be required [42].

Additional Regulations / Exemptions

Additional regulations may apply depending on the location of the site or the methods used. For example, if explosives or heavy machinery are being used to remove a dam, there are additional regulations and safety measures not discussed in this document, please check for additional regulations with your local, provincial, and federal authorities.

When working on First Nation Reserve Lands, the Nation's department responsible for land management will need to provide information about permissions required for use of a tool which could include adherence to water bylaws, Council approval, etc.

There may be relevant exemptions to some regulations, including road maintenance exemptions which may allow for flow devices such as culvert protectors or combination devices to be installed under certain conditions without the need to apply for additional regulatory approvals. For example, some National Parks have a standing Environment Impact Assessment for the installation of pond levellers and culvert protectors under certain conditions.

Additional Regulatory Resources

The resources listed below relate to the overarching legislation described above and may be necessary to applications for approval under an Act.

Listing of Historical Resources Overview

Listing of Historical Resources Web Map Application

Fish and Wildlife Management Information System (FWMIS)

Fish and Wildlife Internet Mapping Tool (FWMIT)

Damage control licences and permits, Alberta.ca

Regional Management Maps for Water Course Classification

Table 1: Summary of Alberta and Canadian Regulations that could apply when using Reactive Beaver Management Tools[+]

[+]We have excluded tools that do not require permitting or approvals (e.g., take no action, tree wiring/exclusion, etc.)

	Beaver Management Tool				
Legislation	**Dam Notching, Breaching, or Removal**	**Flow Device: Pond Leveller**	**Flow Device: Culvert Protector**	**Population Control: Relocation**	**Population Control: Lethal Removal (Trapping or Hunting)**
Provincial					
Public Lands Act	●	●	●		
Water Act*	●	●	●		
Wildlife Act				●	●
Federal					
Fisheries Act^	●	●	●		
Migratory Bird Act	●	●	●		
Species at Risk Act	●	●	●		

*Check for exemptions

^Check for Code of Practice

Proactive Management Approach

Proactive management approaches are taken in anticipation of an issue occurring whereas reactive approaches are taken due to an issue already occurring (i.e., crisis management). In the case of beaver management, the more traditional approaches are reactive, i.e., 'what can I do when a beaver dam is flooding my road.' In this beaver BMPs guide, we focus on reactive approaches since this is currently the highest need for land managers in Alberta. Our hope is that Albertans can move towards more proactive approaches to beaver management in the future. This section outlines several proactive management approaches and provides resources for further exploration. Many of these approaches could be combined to form a more robust beaver management plan for an area, which could incorporate proactive and reactive management approaches in various scenarios.

Proactive management includes anticipating the arrival of beavers in an unoccupied site, or managing existing beavers at a site where beaver activity is not causing conflict but could in the future.

There are regulatory considerations for proactive management approaches, however, they are not outlined in this document, because of the focus on reactive management approaches. The information in this section is to provide an introductory overview of proactive management approaches therefore the reader must explore these approaches further prior to implementation.

Plan for Arrival of Beavers

Planning for beavers means anticipating that in the future there may be beavers present at the site. If your site has good beaver habitat, or you are restoring an area and creating good beaver habitat, and there is a beaver population nearby, there is a chance beavers may occupy that site in the future. Including beavers as part of natural area can also result in positive recreational opportunities such as wildlife viewing through the creation of habitat [7]. Planning for beavers can include other proactive management approaches to reduce the risk of human-beaver conflict such as planting unfavourable species, trail placement considerations, public outreach, and others, as described in this section.

RESOURCES

Reintegrating the North American beaver (Castor canadensis) in the urban landscape [7]

Planning for Beavers Manual: Anticipating Beavers when Designing Restoration Projects

Plant Unfavourable Species

Beavers cut trees and shrubs for food, dam and lodge building, and occasionally to grind down their ever-growing incisors [43]. They can use almost anything to build a dam, so their preferences are variable and site specific depending on what's available to them at the site, including non-woody plants. In general, beavers tend to avoid coniferous trees [44–46], so these could be used to try to discourage beavers from harvesting more desirable and favourable species at a site. Common favourable woody plant species of beavers include aspen, willow, cottonwood, green ash, and poplar [13,43,45,46]. Maintaining diversity in the plant community is helpful for providing a variety of options and encouraging the longevity of forest and other treed areas.

RESOURCES

Planning for Beavers Manual: Anticipating Beavers when Designing Restoration Projects

Trail /Road Placement Considerations

Whether it is a new trail, maintenance of an old trail, or a redesign of trail systems, there are opportunities to consider beavers during trail planning, and a similar approach can be taken for road placement. Beavers will often be close to waterways, which is typically where most recreational trails are located due to the aesthetic of riparian areas. *The Planning for Beavers Manual: Anticipating Beavers when Designing Restoration Projects* [47] includes information on anticipating where beaver-induced flooding may occur. By anticipating where beavers may flood an area, the trail system can either be moved to avoid the pond or modified to use bridges or boardwalks which can allow for some ponding below the trail system without impeded trail access, as would occur with a gravel or dirt trail. Beavers and their activities are highly valued as a wildlife viewing experience. Ensuring appropriate trail access, while mitigating potential challenges can result in a positive user experience, especially in protected areas known for their recreational opportunities [7].

RESOURCES

Planning for Beavers Manual: Anticipating Beavers when Designing Restoration Projects

Replace Culverts with Bridges

To a beaver, a culvert is viewed as a partial dam created by a narrowing of the stream or valley around a stream, where all they need to do is plug the small opening. By opting to use open-span bridges instead of culverts, beavers are less likely to dam the stream because there is a larger opening [9]. This approach also benefits other terrestrial and aquatic wildlife such as bobcat and fish species.

If a bridge is not feasible, increasing the size of the culvert can greatly decrease the risk of plugging. Researchers in New York found that beavers plugged culverts with a 1m (3.3 ft) diameter 73% of the time, whereas ones with a 3.7m (12 ft) diameter were only plugged 7% of the time [9,48].

RESOURCES

The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains. Version 2.01

Outreach and Education

Public outreach is an important proactive beaver management approach as it can increase social tolerance of beaver challenges (willingness to coexist) and inform audiences of the benefits that beavers provide to the environment as well as human well-being by way of ecosystem services. Education also informs audiences of the variety of management options for landscapes that have or could have beavers. Finding beaver coexistence project champions and demonstration sites is another key component to increasing awareness and understanding of living with beavers on our landscape.

The *Alberta Beaver BMPs* was developed as part of a larger beaver focused program called *Working with Beavers*, which seeks to enhance coexistence with beavers to maintain or enhance watershed health and resiliency. *Working with Beavers* accomplishes this by incorporating outreach and education into its work with landowners, municipalities, industry, government agencies and other non-governmental organizations. This outreach increases knowledge and awareness to increase participation in activities that restore and sustain watershed functions while also educating on more operational management aspects, providing training for implementation of tools that enable coexistence with beavers. *Working with Beavers* provides presentations and workshops on beaver ecology, challenges, benefits, and coexistence solutions to all audiences. If you are interested in hosting a workshop or presentation for your community, please contact *Working with Beavers*.

Many different organizations across North America also offer education and outreach programs; some are listed below and it is recommended to search for one closest to you as they will have the most local experience.

RESOURCES

Working with Beavers

Beavers Northwest

Human-Beaver Coexistence Fund

Method Beaver Project

Beaver Institute

Compensation Program

Compensation to landowners for coexisting with beavers with resulting flooding or tree felling is a new concept, however, compensation programs have been used to mitigate other human wildlife conflict in Alberta with species such as grizzly bears, cougars, and wolves [49]. Alberta municipalities have access to ALUS (formerly Alternative Land Use Services), a charitable organization with an innovative community-developed and farmer-delivered program that produces, enhances and maintains ecosystem services on agricultural lands [50]. Some of the projects that ALUS supports compensate landowners for enhancing or creating pollinator habitat so it's possible there may be opportunity to create a project to support wetland habitat created by beavers, while compensating agricultural landowners for coexisting with beavers and allowing flooding of an area of their crop or pasture land. ALUS has supported riparian restoration projects, and some of the ALUS communities are exploring projects project like pond levellers to help balance the needs of the beavers with the needs of the county and the landowner.

Being able to support land managers with cost-sharing of materials and/or labour can be helpful for those considering coexisting with beavers with some of the tools discussed in this guide or who might be on the fence. There are a variety of grant opportunities available to individuals and groups that could help provide this support.

RESOURCES

ALUS: All Communities

Adaptive Management Process

One proactive approach that is beneficial for beaver management is the use of adaptive management processes [51,52] as shown by Joe Wheaton in the *Recommendations for an Adaptive Beaver Management Plan: For Park City Municipal Corporation* [53]. Wheaton's proposed Park City Municipal Corporation (PCMC) Beaver Adaptive Management Plan incorporates: evaluation and learning, adjustment, planning, and doing. Similar to Wheaton's evaluation of individual potential problem dams, the BMPs outlined in this guide would fit nicely into an adaptive management plan, which should be developed by land managers who seek to take a proactive approach to their beaver management.

RESOURCES

Recommendations for an Adaptive Beaver Management Plan: For Park City Municipal Corporation

Beaver Management Zones

A beaver management zone is the delineation of different areas that result in a different set of tools or actions based on certain thresholds related to current or potential beaver influences. Development of beaver management zones is often undertaken as part of development of a beaver management plan for a specific area and can incorporate factors such as beaver habitat, human infrastructure, social tolerance (willingness of the public/nearby land occupants to coexist with beavers), conservation desire, and others. Each management zone would have different beaver thresholds and resulting tools or actions. The development of management zones allows a community to strike a balance between coexisting in certain areas and exclude/removing beavers in others, creating a larger scale management plan as opposed to reactive management at individual sites.

RESOURCES

Recommendations for an Adaptive Beaver Management Plan: For Park City Municipal Corporation - classification of areas of potential management concern

Beaver Dam Analogues (Restoration Tool)

A beaver dam analogue (BDA) is a habitat management tool that mimics a naturally occurring beaver dam. It is simple, small and is often installed in series. This structure is often built instream using upright posts (natural or manufactured untreated wood fence posts), a natural weave material (typically willow, spruce, or other on-site vegetation), and at the base, gravel and mud. Depending on site location and available materials, some of these typical materials may be excluded. Posts can also be installed to support an existing beaver dam.

BDAs are a type of low-tech process-based restoration (LTPBR) used to restore degraded streams and riparian ecosystems. BDAs can be used specifically for beaver and fish habitat restoration, for general habitat restoration to the benefit of multiple species including species-at-risk, and/or to encourage natural beaver recolonization. They can also be used as a proactive management tool that guides beaver activity to places where culverts remain unobstructed, typically a few meters upstream of the culvert mouth.

RESOURCES

Low-Tech Process-Based Restoration of Riverscapes – design manual, resources, workshops

The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains. Version 2.01

References

All photos in this document are credited to *Working with Beavers* unless otherwise specified.

Development of the BMPs for each tool came from a variety of sources including materials developed and owned by the authors of this report. The materials listed below include the broad body of knowledge drawn on for the development of the BMPs.

Working with Beaver Website – Positive Impacts of Beavers

Beaver Our Watershed Partner booklet

An Agricultural Decision Matrix Tool for Beaver Management

Virtual Tour: Beavers in our Landscape webinar

Working with Beaver Website – Positive Impacts of Beavers

Beaver Coexistence Tools fact sheet

In the case of materials coming from external sources, appropriate references are included in-text with references listed below.

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