Beaver management at the Penobscot Indian Nation, USA: Using flow devices to protect properties and create wetlands

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Abstract

Beaver (*Castor canadensis*) management in North America is largely an exercise in protecting properties. The primary defense used by most wildlife agencies is population management: controlling overall populations and extirpating beavers from „sensitive" areas. However, this strategy can be ecologically harmful and, with properties unprotected in any physical way, is often only a temporary solution. At the Penobscot Indian Nation (Maine, USA), we have taken a different approach. Because of their great ecological value, we welcome beavers wherever habitat can support them. To make this possible, we protect all vulnerable properties (mostly road culverts) with „flow devices," which control damming behavior. With 18 high-quality devices, we have eliminated beaver-related road maintenance costs on our 52,610 hectares (ha) for 5 years. Flow devices are an effective solution that, by allowing beavers to occupy more of the landscape, indirectly protect or produce wetlands. Using a Global Positioning System we found that the wetlands created by beavers near six flow devices totaled 45 ha. Flow device concepts, as well as two models that we have designed, are discussed.

Key words: *beavers, conflicts, flow devices, wetlands.*

Introduction

Beavers (*Castor canadensis*) have made an impressive recovery in North America during the past half-century. Nearly extinct following the Fur Trade (ca. 1600–1900), they now occupy much of their former, continental range. Beaver-human conflicts are also widespread due primarily to the threat of flooding to roads. Road culverts are ubiquitous, easy to plug, difficult to unplug, and when clogged can quickly turn a road into a spillway.

Population management—removing beavers from vulnerable areas and subduing overall populations—is often perceived as the best solution to this problem. However, with this strategy, culverts typically remain naked and consequently conflicts are recurrent. Furthermore, on a continent dominated by people, „vulnerable areas" are everywhere. Therefore, a reliance on lethal solutions requires that beavers, an important keystone species, are extirpated from a large segment of the landscape.

At the Penobscot Nation (Maine, USA), we have taken a different approach. We have protected all of the threatened properties (18 culvert sites) on our 52,610 hectares (ha) with high-quality „flow devices." As a result, beaver-related road maintenance costs, formerly an expensive problem, have been eliminated. This is a 5-year record achieved despite the constant

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presence of beavers near the devices and in the general absence of trapping. (Trapping is legal, but apparently because of low pelt prices the motivation to do so is lacking). This strategy has freed us from the endless cycle of population monitoring and control and allowed us to allow beaver populations to grow and occupy areas where they would otherwise be unwelcome. As a result, we have indirectly created or preserved numerous wetlands both near conflict points and in more remote parts of the landscape. To sample this relationship we used a Global Positioning System (GPS) to map the beaver-created wetlands, or flowages, near 6 flow device sites. I will return to that study following a discussion on flow devices.

Flow devices

Flow devices control damming behavior by reducing or eliminating damming stimuli. In addition to visual cues, beavers are stimulated to construct dams by the sound and feel of running water.

Flow device systems have two basic components. First, they have an „escapeway" where water is inaccessible for effective damming activity as it passes from the upstream side of a dam or road to the downstream side. Escapeways are either added as pipes, or are represented by preexisting culverts (including small bridge underpasses) or overflows. (For simplicity, culverts and overflows are collectively called „outlets.") Second, flow device systems have a „filter" that bars beavers from directly plugging the escapeway while also diffusing incoming water over a large area so its loss is imperceptible. I have invented two types of filters: the „Beaver Deceiver" (BD), a wooden-frame fence, and the „Round Fence" (RF), a self-supporting vertical cylinder (Figs. 1 and 2).

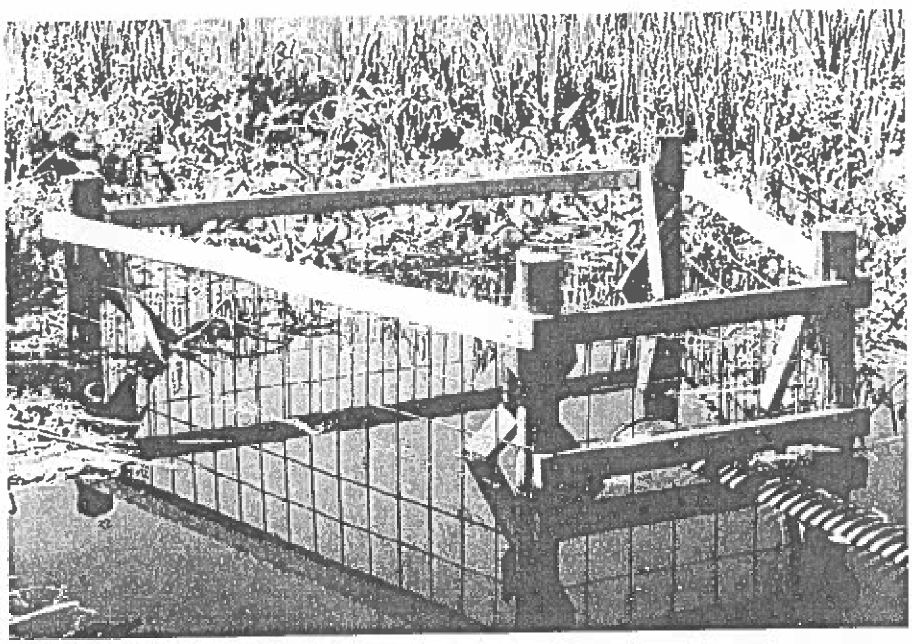

Fig. 1. Beaver Deceivers act as a filter to diffuse the flow of water over a broad area as it enters a pipe or outlet. A common size used on pipe systems, the sides of this model are 3m and the front is 2.4m.

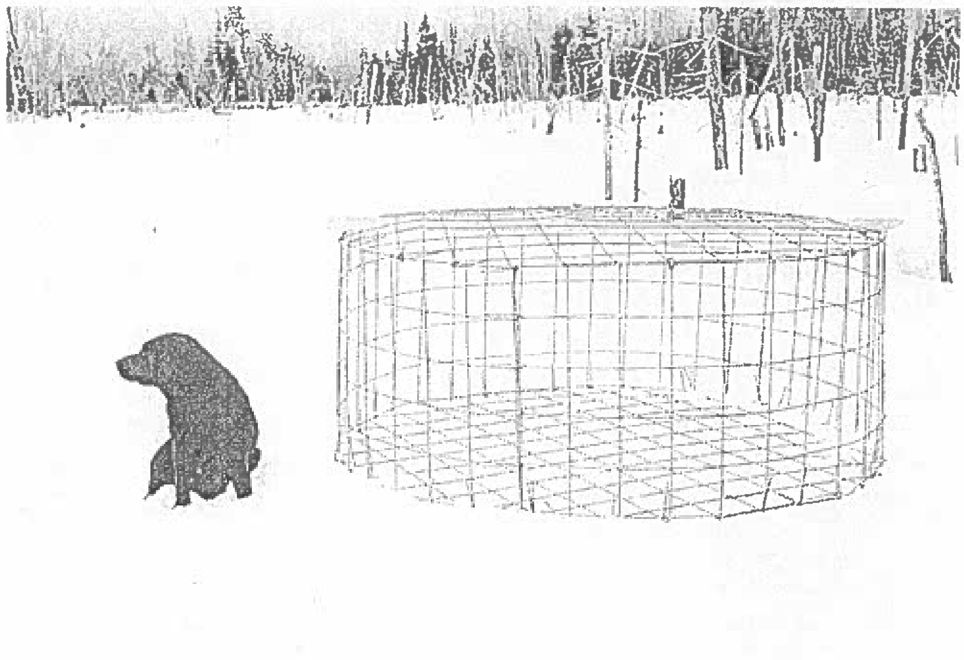

Fig. 2. Round Fences are a simple filter that can be capped on both ends and used beneath the surface at deepwater sites.

I place flow devices in two categories: „pipe systems," where you add your own pipe(s), and „fence systems," which are built directly on outlets without adding pipes. In the former systems I typically use one 6m-long pipe; interior diameter 25–30 cm. (Generally, pipes with smaller diameters than this are avoided because they are considerably less hydrodynamically efficient). The pipe „begins" on the backside of a beaver dam or fence and goes out into the stream or wetland to a filter. The pipe ends a short ways inside the downstream end of the filter. Pipe systems are used at all beaver dams as well as many outlets. At the latter sites, a small „receiver fence" is also built in front of the outlet to prevent beavers from clogging it, and to „receive" the pipe.

Beavers expect leaks to occur *at* the dam. Therefore, with the filter separated from the dam, pipe systems have the advantage of „physical incongruity." Fence systems, by contrast, are attached directly to the dam, which is usually a road embankment. Because of their added vulnerability, fence systems are typically used at low-risk sites such as quiet culverts with little water flow. They are also used at sites where there is insufficient room for a pipe system.

We prefer polyethylene pipes. They are lightweight and easy to work with, can be connected together to increase „separation," and accept elbow joints. In this country, these black, corrugated pipes come in a flexible, single-walled model and a rigid, two-walled version. In most instances, we use the heavier variety. Usually installed horizontally, they are visible at the water's surface. By contrast, flexible pipes are placed underwater, except where they

„hump" over the dam. The hump controls the water level and ensures that the pipe intake remains below the surface, and silent. With the ability to place the pipes at any level, both methods represent a great opportunity to create wetlands in areas where there are no vulnerable properties.

If possible, filters should always be silent; if the sound of running water is present, even a large, well-made filter is likely to be circum-dammed. On a horizontal pipe this can be done by putting a downward pointing, 90° elbow-joint on the upstream end that, as with humps, prevents noise from escaping. Road culverts often tip downhill and gurgle incessantly. If a fence system is used, the culvert should be quieted. Sometimes this can be done with a small, downstream debris dam (manmade) that raises the water level enough to eliminate riffles inside the culvert. If it accomplishes this goal, even a crude dam of a few stones is just as important as an elaborate filter. Beaver dams may serve the same purpose, with less work. If the culvert cannot be quieted, the fence should be made larger, or a pipe system should be used.

In most cases, trapezoids are the ideal filter shape. Funnel-shaped, their downstream end is the approximate width of the escapeway. The sides, or legs, and the front of a BD are typically close to being equilateral. A small BD that has become fairly standard on pipe systems has 4 posts, legs that are 3m-long, and a front that is 2.4–3m-long. If there is any stream flow at all, this shape ensures that most of the water enters through the front of the structure, over a large area, and well away from the escapeway. This distance factor is important because water velocity, an important damming stimulus, increases as it nears the intake. Because beaver dams are roughly perpendicular to stream flow, the sides of a trapezoid also present a more unnatural direction for a dam than do triangles or squares. Furthermore, of any quadrilateral figure that begins on either side of the escapeway and is of equal front-to-back length, trapezoids have the longest perimeter (largest filter) and the one that diffuses incoming water most evenly. Finally, being simple, four-sided figures trapezoids are stable yet easy to build.

Beaver deceivers should never block the stream channel. If they do, they will likely become a beaver dam. Conversely, if beavers can swim freely around the device, damming efforts, if they occur at all, will be concentrated in the corner nearest the intake and be futile and short-lived. At sites that are too narrow for a trapezoid, thin rectangles and pentagons are used.

Beaver Deceivers have a rugged frame of pressure-treated wood, cedar, or some other rot-resistant species. The posts, which have a diameter of ≈11–12cm and are usually spaced 2.4–3m apart, each have two diagonal braces placed inside the fencing. Posts and braces are driven into the substrate with a sledgehammer. Posts are also attached to each other with a horizontal „stringer" near the top of the fence. All connections are made with large nails driven into pre-drilled holes. The fencing is stapled to the outside of the posts and to the bottom of the stringer. With a wooden frame, beavers cannot be allowed inside BDs. The sides of the fence must be high enough to prevent them from going over the top and the escapeway and floor should be fenced. In our experience this is the lightest frame structure that will still survive the forces of ice.

To compensate for the lack of separation, BDs are typically about twice as large on fence systems as they are on pipe systems. If they are built on culverts that cannot be silenced, they should be even larger. Every site is different, but generally a BD takes two skilled workers about 4 hours to build (remember, it is often only one part of the system).

Round Fences are smaller, but much quicker to build than BDs. They can be made by one person in less than an hour by bending a long, thin sheet of fencing (6m x .9m) into a circle. Typically used below the surface with flexible pipes, they need a floor and a roof. When used above the water line at shallow sites, the top can be left open.

For both types of flow devices I prefer to use heavy-duty sheets of fencing with a grid pattern just small enough to exclude adult beavers (≈15cm x 15cm). Sheets are easier to work with than rolled fencing and the large grid reduces the chances of the filter being clogged by small, non-beaver-related debris. As with larger filters, a wide grid lowers cleaning costs and failure rates. This mesh size also allows all stream-traveling animals, with the exception of beavers and large turtles, to pass through.

Steel dissolves quickly in acidic waters and is thus the weak point in these systems. Therefore, the wire should be heavy gauge (≥6ml) and galvanized (≈lifespan 15–20 years). In the U.S., the product that meets all these criteria is called „utility fence." Sold for fencing domestic animals, it has the added advantage of being very long (6m). I prefer the widest of the 3 available widths: 1.8m. When these panels are cut in half the short way, 3m-long sheets are produced that are a convenient size for building BDs. Cut in half the long way, the walls of two RFs are created. The 6m-length forms a respectably sized circle (diameter: 1.8m), making the uncut fencing perfect for capping the cylinder.

On busy roads, or very high roads, fence systems and receiver fences should not prevent beavers and large turtles from using the culvert. In these instances, a small opening, or „turtle door," is left in the fence (usually next to the escapeway). To this we often attach a short section of fence, or „wing," that roughly parallels the road. The idea is to create a narrow passageway with at least one sharp turn that accommodates the animals, but not if they are hauling woody debris inside.

So which type of filter should you use? Security increases and cleaning costs decrease as filters become larger. Trapezoids are also a more favorable shape than circles. To prevent beavers from detecting escaping water, there needs to be an appropriate ratio between filter size and pipe or outlet size. Built „in-place," BDs can be as big as necessary, which makes them preferable at high-flow sites where multiple, or larger-than-normal pipes are needed. Overall, BDs provide greater insurance and require less maintenance than Round Fences. Round Fences, however, have the advantage in initial speed and economy and are particularly useful at deep sites where it is difficult to build a fence or at sites where a hidden system is desired.

In terms of filter size, I believe RFs and small BDs are at the bottom limit of what is effective and economical over the long-term. Consequently, I rarely use filters that are smaller than RFs. This would include „perforated pipe" systems, which combine filter and pipe. The filter, which is represented by the total surface area of the perforations, is typically quite little by comparison. Perforations along the length of a pipe also defeat the concept of separation—they can actually serve to guide damming efforts from the dam out along the pipe.

Study area

The 6 flowages we measured are located just west of the Penobscot River in a rural area between Bangor and Millinocket, Maine. It is a region heavily forested with broad-leafed and coniferous trees and with little topographical relief. Average annual precipitation is 112 cm and the average number of frost-free days is 135.

These flowages, as well as most others in North America, have a dynamic history. In all likelihood, beavers were common in most of the continent's wetlands and waterways for thousands of years prior to the arrival of Europeans. Flowage sites, which are predictably located in low-gradient basins along small streams, were invariably occupied intermittently or permanently, flooded, and kept „open." From high above a wooded region like Maine, flowages would have appeared as small, distinct patches in the forested matrix. However, when beavers were extirpated from most of their range for tens or hundreds of years during the Fur Trade (ca. 1600–1900), dams decayed, flowages drained, trees invaded, and the patches slowly faded away. Flowage sites were largely invisible on aerial photographs from 1939 (S. Lisle, unpubl.). With the return of beavers, this anomalous successional trend is being reversed.

Recently reoccupied, our study flowages are shallow reservoirs containing a mixture of shrubs and floating-leafed and emergent-herbaceous vegetation. Standing dead trees are also common, a dramatic reminder of the profound, long-term effect of the Fur Trade (Fig. 3). Presently, upland forage is plentiful; because of heavy timber harvesting, early-successional hardwoods (broad-leafed, deciduous trees) like aspen (*Populus tremuloides*) and birch (*Betula* spp.) are common.

Fig. 3. A vestige of the Fur Trade, standing dead trees are common in beaver-created wetlands in North America.

Methods and results

We used a backpack-mounted, Trimble Pro XL GPS to delineate the wetland borders, dams, lodges, stream channels, and roads near the flow devices (Fig. 4). The mapping was done in winter on cross-country skis. The border we scribed around the flowages was basically the edge between open wetland and forest (it is probably also close to the average annual water line). The total wetland area at the six sites was 45 ha. The average distance from the closest lodges to the culverts was 320m.

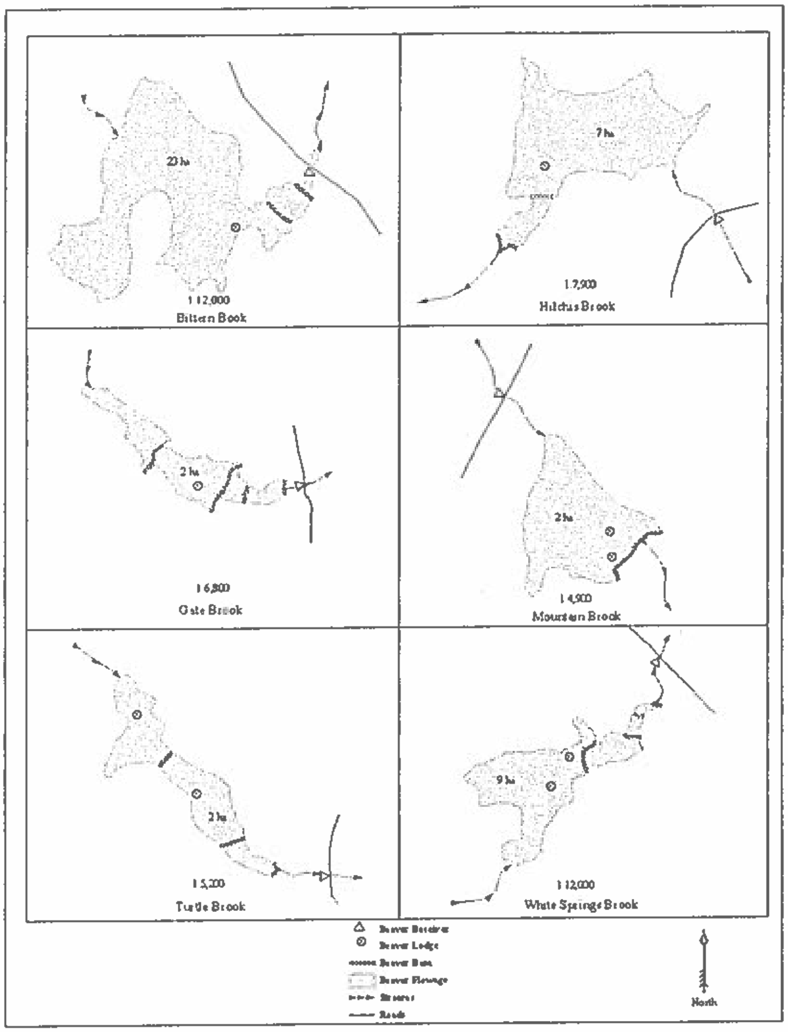

Fig. 4. The beaver-created wetlands, or flowages, near six flow device sites. Without flow devices to protect the roads, beavers could not be allowed to occupy these areas.

Discussion

Flow devices make the existence of these rich, non-forested „marshes"—these beaver flowages—possible. Before the devices were installed, the culverts were clogged routinely by beavers living in the same lodges we mapped. The road maintenance costs were unacceptable. The only other way to effectively protect the roads would have been to permanently remove all of the beavers. As history has shown, without beavers to maintain dams, flowages drain and forest succession begins.

Reliance on lethal solutions affects more than just the immediate area around culverts. On average, the lodges were roughly in the middle of the habitat areas we measured. At each site, the beavers were also using the streams above and below the flowages, and on the opposite side of the road. It would be a conservative estimate, therefore, to say that a lethal solution would extirpate beavers from at least 640 m of the stream ecosystem (lodge-culvert distance x 2). This is a combined distance of 3.84 km. If this average were to hold for our other 12 flow device sites, this native, keystone species would be forever removed from 11.52 stream kilometers. In the state of Maine alone, there are hundreds of such sites.

The wetlands directly protected by flow devices are only a sample of our total wetland gains. With the threat to our properties eliminated, we have been able to allow overall beaver populations to grow. This has resulted in many additional wetlands in more remote areas.

But are these wetland gains real? Without trapping, won't beavers become over-populated, destroy their food resources, and abandon the wetlands anyway? Not necessarily. Unlike most herbivores, beavers have a built-in population check: territorial behavior. Beaver families, or colonies, rarely exceed 10 members and they defend relatively large areas (e.g., each of the six wetlands we measured represents the approximate territorial boundary of one colony). Beavers also have a broad diet. With a diversity of vegetation many of these wetlands, particularly the large ones, will support a colony indefinitely. In addition, we have designed a forest management program that promotes cautious, erosion-sensitive timber harvesting around the edges of flowages in an effort to encourage early-successional hardwoods.

In general, the key to flow device success is large, silent filters, durable, wide-mesh fencing, big pipes, and rugged, well-planned construction. Physical incongruity also helps, but is not always necessary. Considering that every problem site is different, a flexible approach, combined with the experience to know what type of device to use and how to use it, is also extremely important. We have found that good flow devices, and a good flow device strategy, can succeed at almost any site regardless of the presence of beavers.

Although we have the advantage of a relatively small jurisdiction, we believe that much larger areas could also be beaver-proofed. The problem is of manageable proportions because beavers are restricted to a small percentage of the landscape by topography and an aquatic lifestyle. In the rolling hills of central Maine, for instance, flowages only represented 1.5% of the landscape (S. Lisle, unpubl.). Consequently, the number of potential problem sites is also limited. Despite high beaver populations and hundreds of kilometers of roads, our relatively small number of conflict points reinforces this conclusion.

Marshes are generally the most productive wildlife habitats on the landscape. In a pattern that may mimic Europe, approximately half of these ecosystems have been lost to development in North America. In an attempt to compensate for this, the federal government spends millions of dollars each year building a few hectares of manmade, „mitigation" wetlands.

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The resurgence of beavers is the greatest wetland restoration event we will ever experience. While reclaiming their ancient haunts, beavers have converted thousands of forested wetlands back to their original condition as marshes (in fairness, this does not represent a „loss" of timber). If beavers were not so frequently viewed as pests to be eradicated, if humans were to take responsibility for protecting—in a reasonable, lasting manner—the structures they have placed everywhere on the landscape, then the return of beavers, as shown by our experience, would represent an even greater opportunity.

While simultaneously eliminating beaver-related road maintenance expenses, we have preserved or created dozens, or perhaps hundreds, of hectares of vibrant, natural, wetlands at no cost. Aided by relatively flat terrain, good habitat, little trapping, and a lack of houses and agriculture, our wetland gains have been exceptional. Although this kind of return cannot be expected everywhere, it hints at the tremendous potential of beaver management, and more specifically, flow devices.

Glossary

Beaver Deceiver. A *filter* with a very specific, wooden frame structure. Built „in-place," it can be any size or shape, but is usually funnel-shaped, or trapezoidal. When viewed from the dam, trapezoidal beaver deceivers often look like upside-down equilateral triangles. Although the front is sometimes a little shorter than the sides, or *legs*, it is almost always much wider than the back, which is usually about the width of the *pipe* or *outlet*. The *legs* are generally the same length.

Culvert. A tube or passageway usually made of steel, plastic, or concrete, which is used to move water beneath or through dams, roads, and other barriers. Included in this category are the underpasses of small bridges and *downspouts*.

Debris dam. A small, downstream, manmade dam designed to quiet a culvert by raising the water level enough to eliminate riffles inside t

Escapeway. A *pipe*, *culvert*, or *overflow* where water passes from the upstream side of a *dam* to the downstream side. Combined with most *flow devices*, it is inaccessible for effective damming activity; with some *diversion dams*, it is accessible, but unattractive.

Fence system. A *fence*, or *filter*, build directly on an *outlet* without added pipes. Structures that silence the *outlet* are part of the system.

Filter. A device that disperses the flow of water over a large area as it enters an *escapeway*. It is meant to reduce the damming stimulus associated with moving water while shielding the *escapeway* from being directly plugged.

Flowage. A beaver-created wetland.

Flow device. A device designed to control water levels—despite the presence of beavers—by reducing, directing, or eliminating damming behavior.

Hump. The upward benć is a flexible pipe as it passes through or over a dam. It controls the water level and silences the filter.

Intake. The opening at the upstream end of a pipe or culvert.

Keystone species. A species that has an ecological value greatly disproportionate to the biomass it represents in an ecosystem.

Mitigation wetland. A manmade wetland meant to replace the values lost when a natural wetland is destroyed by development.

Outlet. A *culvert* or *overflow*.

Overflow. An *escapeway* on the top of a manmade dam.

Physical incongruity. The condition created when dam-leaks occur away from the dam. An increase in *separation* increases physical incongruity.

Pipe. The *escapeway* added to *pipe systems*.

Pipe system. A *flow device* where you add your own pipe(s).

Receiver fence. On *pipe systems*, a fence built just in front of the *outlet* to protect it from being clogged and to „receive" the *pipe*.

Round Fence. A *filter* in the form of an upright cylinder of fencing. Typically .9m high with a diameter of 1.8m, it has a floor, and, depending on the depth of water where it is used, a roof.

Separation. The distance between the *dam* and the *filter*.

Silencer. A mechanism that reduces or eliminates the sound of running water near the *filter*. On straight pipes, silencers are downward pointing elbow joints on the upstream end. On flexible pipes, they are „humps" that keep the intake below the water line. Both systems are meant to prevent sound from escaping at the upstream end of the pipe. At *culverts*, silencers can be downstream *debris dams* or beaver dams. Here, they are meant to eliminate sound by eliminating riffles inside the *culvert*. At *overflows* and high *culverts* that produce waterfalls, flumes can be used to reduce the sound by lowering the water more gradually.

Stringer. The wooden, horizontal framing member at the top of *Beaver Deceivers*. Usually about 3.3cm x 8.9cm and pressure-treated, they connect the posts and support the fencing.

Turtle door. A small opening in a *fence system*, or *receiver fence*, that allows beavers and large turtles to travel through the outlet. Used most typically at busy roads and high roads, they are usually placed next to the *outlet*. Often combined with a *wing*, they are meant to accommodate the animals, but not if they are hauling woody debris.

Wing. Part of a turtle door, it is a section of fence that roughly parallels the road and creates a narrow passageway with at least one sharp turn.