Managing Nuisance Beavers Along Roadsides

A Guide for Highway Departments

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Introduction

Damage to roads by beavers is a serious problem for many highway departments across the country. Beavers plug culvert pipes and create dams that impound water against roadbeds, which may flood or wash out roads (Fig. 1). Damage also occurs when a roadbed becomes saturated with water and settles. The overall stability of the road decreases as the pavement becomes stressed and potholes form. In New York State, town highway departments allocate approximately 19 workdays of effort and $2,500 in repair costs annually for each beaver-obstructed culvert. Several northeastern states currently have beaver management concerns or will soon experience problems.

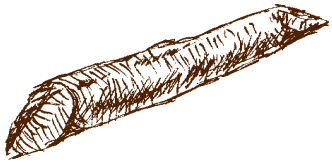
Highway departments have used grates, pitchfork guards, deep-water fences, and water level control devices to deter beavers from plugging culverts (Fig. 2). In general, these methods have solved the problems only for a short time; in addition, water level control devices can be applied in only a limited number of situations (3 percent of sites in New York State in 1993) and require proper installation and continued maintenance.

Figure 1. Plugged culvert pipe. Beavers typically use mud, sticks, and other debris to plug culverts. Culvert plugging activity is usually highest during the spring and fall.

Figure 2. Water level control device. These devices are likely to fail if they are not regularly inspected and maintained and may be prone to vandalism. When installed correctly, these devices are placed through the beaver dam.

Management of beaver populations and damage is usually the responsibility of the state wildlife management agency and it involves balancing the positive effects that beavers have on the environment with the damage that they cause. Currently, trapping is the most common means used nationwide to accomplish population and damage control objectives. In the near future, beaver populations are likely to increase if interest in trapping declines and abandoned farmland reverts back to forest. As beaver populations increase, nuisance problems are also likely to increase. Because of these changes it is imperative that highway departments develop and implement long-term plans for managing beaver problems along roadsides.

Recognizing this need, the NYSDEC Bureau of Wildlife, in conjunction with the Department of Natural Resources at Cornell University, initiated a research project in 1997 to explore alternative options for managing nuisance beavers along roadways. Publications available to highway departments on road design and culvert pipe selection have inadequately addressed issues of beaver damage, largely because of lack of information. This publication seeks to fill that gap.



Summary of NYSDEC–Cornell University Study

The objectives of this study were to determine (a) what factors cause beavers to plug culverts, (b) what factors influence the presence of beavers along roadsides, and (c) regional differences, if any, in these factors occur within New York State. To accomplish these objectives, several habitat (stream, vegetation, and topography) and culvert variables were measured at roadside sites in southern and northern New York. Important findings of the study are summarized below.

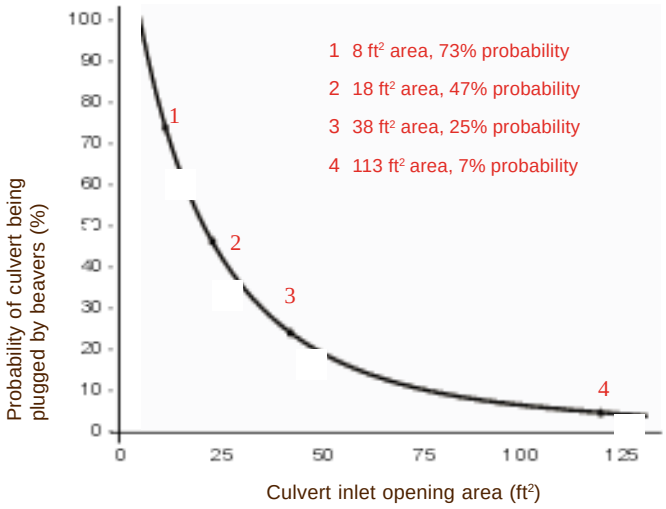


Figure 3. Probability of culvert being plugged by beavers as a function of the area of its inlet opening. Points (1)–(4) on the graph are discussed in detail in Table 2.

In this publication, a culvert is defined as a water crossing structure with a span of less than 20 feet as measured along the road centerline.

Plugged versus Nonplugged Culvert Pipes

- At 81 percent of the sites measured (168 out of 208), culvert size (area of inlet opening) was the major determinant of whether the pipe would be plugged by beavers (Fig. 3).
- Pipe-arch culverts, which may retain the natural stream width, were less prone to being plugged by beavers (Fig. 4). Round culverts may (a) channel the water and reduce the natural stream width, (b) alter stream flow rates, and (c) generate noise that may attract beavers. On average, the width of the stream at plugged culverts was twice that of the culvert inlet opening.
- Culvert pipe material and installation features (e.g., smooth versus corrugated pipe, flush versus projecting pipe inlet) did not differ between plugged and nonplugged pipes.
- The number of pipes installed at a site did not differ between plugged and nonplugged culverts.

Figure 4. A pipe-arch culvert. These structures may be less prone than round culverts to being plugged by beavers, most likely because they maintain the natural stream width. Additionally, pipe-arch culverts are generally large culverts.

Presence versus Absence of Beavers Along Roadsides

- Stream width was greater at sites where beavers were absent.
- Stream gradient was greater at sites where beavers were absent.
- Woody vegetation (trees and shrubs) was more abundant at sites where beavers were present.
- In areas of the state with flat topography, the presence of beavers along roadways is primarily related to the total amount of woody vegetation adjacent to the road (Fig. 5.) "Percent open area" is the amount of land adjacent to a road that is devoid of woody vegetation. A value of 0 percent could represent wetlands with shrub or forest cover, mature forest, or abandoned farmland that is reverting back to forest. A value of 100 percent means that no woody vegetation is present by the roadside, such as in agricultural or residential areas. (See form on page 13 for guidelines on assessing percent open area.)
- In hilly or mountainous regions of the state, beavers selectively occupy streams of low gradient (Table 1, Fig. 6). Low-gradient streams with less than 50 percent open area that do not currently support beavers should be targeted for proactive management.

In most situations the above information can be used to identify roadside areas that have the potential to support beavers. With this information, highway managers can develop and prioritize culvert replacement plans. Incorporating assessment of beaver habitat into road construction plans will also reduce future conflicts.

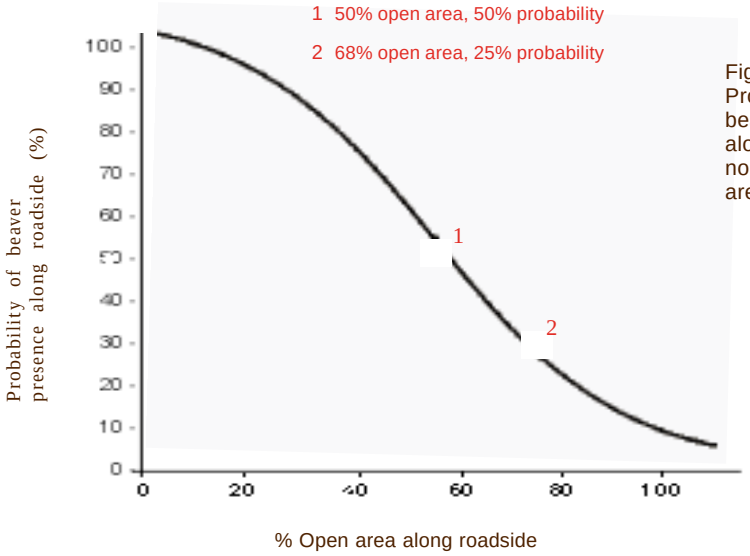


Figure 5. Probability of beaver presence along roadsides in nonmountainous areas.

Table 1. Probability of beaver presence along roadsides in hilly or mountainous regions

Percent Open Area	0	50	100
Stream Gradient			
Low (0%)	99%	96%	61%
Medium (2%)	94%	52%	7%
High (4%)	43%	5%	1%

Figure 6. Roadside area with a high-gradient stream. In many areas of New York State, beavers do not typically inhabit streams with a gradient of more than 3 percent. In this situation stream gradient, rather than available vegetation, is limiting beaver presence.

Economic Considerations

Economic analyses of current and proposed techniques for managing nuisance beavers along roads will be useful for deciding which management option is most suitable for different highway department budgets (Tables 2 and 3). Long-term versus short-term expenditures should be considered when preparing annual budgets.

Culvert Replacement

An economic analysis of several culvert replacement scenarios yielded the following results (Table 2):

- Costs for installing box culverts will always be greater in the short term than those for round or pipe-arch culverts of equal size because box culverts cost more per linear foot than the other designs.
- Box culverts have approximately twice the service life of round or pipe-arch culverts (80 versus 40 years). This difference sometimes makes box culverts the most cost-effective alternative in the long term.
- Large box culverts (38 ft.^{2} or greater) are more economical than round and pipe-arch culverts where the road profile is low. In these situations, fill requirements (raising the roadbed) for round and pipe-arch culverts of equal size outweigh their lower expense (per linear foot).
- Where the road profile is medium or high, box culverts cost about the same to install as pipe arches (on an annualized basis).
- When installing box culverts where the road profile is medium or high, it is better to install a structure with a higher rise dimension than a low-profile box. This will reduce some of the costs of backfilling.

Table 2. Estimated cost of several culvert replacement scenarios

	Cost ($) per site[a]: Initial/Annualized			
Culvert Inlet Opening Area (ft.^{2})[b]:	8	18	38	113
Culvert Type and Roadbed Profile[c]				
Round (low)	$7,341 / $470	$8,902 / $514	$13,311 / $669	$41,751 / $1,717
Round (medium)	$12,417 / $817	$14,215 / $850	$17,611 / $895	$37,304 / $1,141
Round (high)	$17,493 / $1,165	$19,750 / $1,200	$24,070 / $1,247	$46,741 / $1,374
Pipe-Arch (low)	$7,560 / $481	$8,956 / $519	$12,703 / $633	$33,478 / $1,218
Pipe-Arch (medium)	$12,678 / $830	$14,526 / $870	$18,247 / $928	$36,444 / $1,062
Pipe-Arch (high)	$17,795 / $1,178	$20,096 / $1,220	$24,798 / $1,283	$48,127 / $1,414
Box (low)	$16,036 / $482	$20,201 / $524	$27,298 / $599	$46,865 / $881
Box (medium)	$25,015 / $825	$30,875 / $870	$40,849 / $948	$64,546 / $1,009
Box (high)	$33,994 / $1,168	$41,548 / $1,215	$54,400 / $1,298	$85,108 / $1,349

[a]Costs include fill, backfill, pavement, and culvert. Annualized cost is the total cost per year based on culvert service life and interest rate (assumed to be 5 percent).

[b]Size classes for culvert inlet opening area correspond with a 73, 47, 25, and 7 percent probability of being plugged by beavers, respectively. As a management strategy total costs for a culvert replacement assume that beavers will not obstruct the culvert pipes; however, the validity of this assumption is directly influenced by the given size of the culvert pipe.

[c]The existing roadbed will influence the fill and backfill requirements for a specific size culvert pipe. For example, a low-profile road will have high fill requirements when a large culvert pipe is installed. Similarly, backfill costs will differ with the road profile and culvert type. These features of the existing road will greatly influence total costs. Low-, medium-, and high-profile roads are defined as 5, 10, and 15 feet above the adjacent ground, respectively.

- If the high initial costs of installing a box culvert preclude it as an option, install large pipe arches instead. When the road profile is low, it is more economical to install pipe arches than round culverts primarily because of lower fill costs.

Water Level Control Devices and Pitchfork Guards

The majority of the expense for water level control devices and pitchfork guards/grates is annual maintenance and inspection (Table 3), which may exceed the annualized costs of many culvert replacement options.

Trapping

When removal of beavers is desired, trapping may be the most cost-effective short-term solution to roadside problems. A recent survey of licensed nuisance wildlife control operators indicated that the average fee charged per beaver removed was $35 (range = $25–$50). Respondents indicated that it was often necessary to trap every year. None of the trappers surveyed charged a fee during the regular trapping season and they encouraged highway departments to wait until the season opened if possible.

Table 3. Estimated cost of some common management options for dealing with nuisance beavers along roadsides

	Cost ($) per site	
	Clemson Beaver Pond Leveler[a]	Pitchfork Guard/Grate
Materials	$400	$50
Installation[b]	$275	$138
Annual Maintenance/Inspection[c]	$867	$3,500
Initial cost (year 1)	$1,542	$3,688

[a]Estimates provided by NYSDEC.

[b]Assuming two staff days (leveler) and one staff day (pitchfork guard) at $125.00 per staff day plus vehicle use (50 miles per day at $0.25 per mile). Installation includes construction time.

[c]For leveler, assumes one inspection per week for four months per year; one-third staff day per inspection. Fifty miles per inspection at $0.25 per mile. For pitchfork guard, assumes one inspection per day from April to May, one inspection every two weeks from June to mid-September and one inspection per day from mid-September to October; one-fourth staff day per inspection. Fifty miles per inspection at $0.25 per mile. Costs are based on a single pitchfork guard or grate. Total maintenance and inspection costs per site would decrease if guards or grates were being used at multiple sites within a jurisdiction.

Management Recommendations

Management actions recommended in this section are based on the synthesis of the NYSDEC-Cornell study and the economic analyses. Although these recommendations are based on research conducted in New York State, they may be applicable to other regions as well. Note that increasing the size of the culvert at problem sites will decrease the probability of plugging by beavers. Thus the intensity or scale of management actions will dictate the degree to which this probability is reduced. The intensity of management by highway departments will depend on the history of the site, the level of tolerance for a given type or level of damage, and, ultimately, economic considerations.

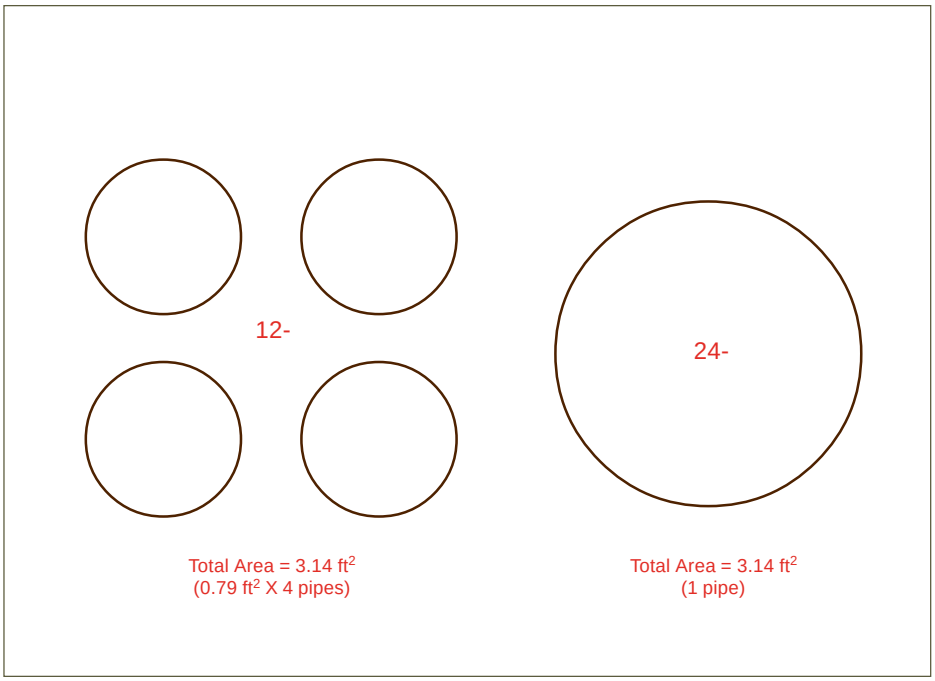
- Replace existing smaller culvert pipes with oversized ones where possible.
- Use box or pipe-arch culverts with a *minimum* inlet opening area of 18 ft.^{2} (47 percent probability of being plugged). If possible, increase this area to 38 ft.^{2} (25 percent probability of being plugged) or larger. If a culvert cannot be oversized to at least an 18-ft.^{2} area, money and time will be wasted.
- Determine to what extent the culvert can be oversized based on economic considerations. Calculate fill and backfill requirements for the replacement culvert type and road profile. Hydrological requirements must be met first.
- When oversizing, ensure that the width of the culvert inlet is equal to or greater than that of the stream. This will reduce the potential for altering the flow of the stream into the culvert and will decrease noise.
- Use low-profile box culverts if possible (Fig. 7). They may be the most economically feasible option for roads that require substantial increases in fill to accommodate large culverts (e.g., roads that bisect or run parallel to wetlands). Although these structures may be more expensive than others in the short term, their long life expectancy and low cover requirements may offset short-term expenditures.

No management action is 100 percent effective at reducing beaver problems.

Oversizing refers to the use of culverts that have an inlet opening that exceeds the hydrological requirements for a given site (expected runoff in a design storm).

Figure 7. Low-profile box culvert.

One possible outcome of oversizing a culvert pipe is that beavers may shift their dam-building activity to an upstream or downstream site that may cause problems.



Adapted from D. P. Orr, *Roadway and Roadside Drainage*, Cornell Local Roads Program, Cornell University, 1997.

Figure 8. Diameter versus area for culvert pipes. A 24-inch pipe has four times the capacity of a single 12-inch pipe.

- When installing culverts, avoid creating a depression at the inlet. A depression that creates a "pond" at the culvert inlet may encourage beavers to expand that pond.
- Installing multiple culvert pipes is not an acceptable alternative to installing larger pipes (Fig. 8). Smaller pipes have a much greater probability of being plugged (Fig. 3), and this probability is not reduced with multiple pipes. In addition, debris collects and is trapped between multiple pipes, which may encourage beavers to expand on this debris and plug the culverts.
- After a culvert has been oversized, do not place a grate or guard in front of the culvert. This will only encourage beavers to plug the culvert's inlet. Once a culvert has been oversized it should be observed periodically for signs of beaver plugging. If beavers attempt to plug an oversized culvert, consider integrating other techniques such as trapping, deep-water fencing, or water level control devices.
- Altering stream characteristics is generally unrealistic for discouraging beaver presence along roadsides. Large-scale removal of vegetation may be a viable option in a limited number of situations such as where rights-of-way (ROW) are large enough (state or interstate highways), but caution must be exercised when removing streamside vegetation because of possible detrimental effects to other wildlife species and the possibility that stream erosion may occur. In addition, vegetation must be removed regularly to prevent preferred trees and shrubs from regenerating.

- At all times work cooperatively with landowners when resolving beaver damage problems. Trapping is a win-win situation when the trapper can obtain a saleable pelt while providing a service to the local highway department. Outside of the trapping season, highway departments must be prepared to pay private nuisance trappers for their services. When working with landowners to secure permission for a trapper, however, the objectives for removing the beaver from the roadside area must be made very clear to the trapper.
- Trapping is usually the most effective management action at sites where beavers have a history of plugging very large culverts (inlet opening area >38 ft.^{2}) or when oversizing is not an option.
- Previous culvert plugging by beavers *may* alter the effectiveness of oversizing a culvert. Trapping may be necessary at these sites for one or two years to remove established family groups of beavers that may have this experience.

Beaver Impoundments against the Roadbed

- In situations where a water level control device can be installed (and is desired), a commitment to continual maintenance must be made.
- Regulated trapping is usually the most efficient and cost-effective solution when impounded water from an upstream or downstream beaver dam is damaging a road.

Proactive Strategies for Roadside Nuisance Beaver Management

- At sites where beavers are present in the stream or watershed but have not obstructed the culvert pipe, measure its size and evaluate its probability of being plugged (see sample form, page 13). Just because beavers have not plugged a pipe in the past does not mean they will not do so in the future. Catalog these sites for future culvert replacement plans. At sites where beavers are not present in the roadside area, measure and catalog current habitat conditions at each stream crossing. This process can be done over several years.
- Document the size of the culvert inlet, stream gradient, and percent open area (see sample form, page 13). If money is allocated for proactive replacement of culvert pipes, rank sites based on the probability of beaver presence.
- When planning and designing roads, evaluate site conditions to assess potential beaver habitat. If beavers may be present in the area, consider road (height of base) and culvert (type, size) characteristics that will minimize potential beaver problems in the future.

At all times observe state wildlife agency regulations concerning beaver trapping, installation of water level control devices, and beaver dam removal. Contact state wildlife offices for questions concerning conservation law.

Culvert Replacement Planning

Before replacing a culvert, highway personnel must evaluate and document current conditions at each stream crossing within their jurisdiction (see sample form, page 13). The outline at right is intended to serve as a working decision model that highway departments can use to classify stream crossings in relation to beaver presence and nuisance activity. This model can be used to rank culvert replacement plans and implement strategies for reducing beaver interference with culverts.

I. High Priority

A. Plugged culvert pipes

1. Rank sites based on previous history and actual or potential level of damage to the road.

2. Give higher priority to sites where road damage (actual or potential) is severe or to chronic problem sites.

B. Impounded water from a beaver dam(s) is damaging the road.

1. Rank sites as above.

II. Medium Priority

A. Beavers (or beaver sign) are present in the roadside area, but no problems are associated with the culvert pipe or road.

1. Catalog which culverts have a high probability of being plugged in the future.

2. Rank culvert replacement sites based on the probability of the culvert being plugged.

III. Low Priority

A. Beavers (or beaver sign) are not currently present in the roadside area, but stream gradient and vegetation conditions suggest a high probability that they will be present in the future (this classification assumes the stream has a continuous flow of water throughout the year).

1. In hilly or mountainous areas, give highest priority to sites where stream gradient is 0–2 percent and open area is 50 percent or less (see Table 1).

2. In areas that have little or no topographic relief, rank sites based on the percent open area that is adjacent to the road (Fig. 5).

3. Rank culvert replacement sites based on the probability of beaver presence and the inlet opening area ($ft.^2$) of the culvert that is currently installed.

Conclusions

In a Cornell University study, only 1 of 126 highway superintendents surveyed indicated that a portion of their annual budget was allocated for beaver damage management. Highway departments should shift their perspective from "What do we need to do this year to prevent beavers from damaging roads?" to "What do we need to do over the next 5 to 10 years to reduce the occurrence of beaver-damaged roads?" This outlook challenges highway managers to develop proactive rather than reactive responses to managing nuisance beavers along roadways. *Oversizing culverts appears to be a promising technique for long-term management of beaver damage to roads.* Often the best approach will be to evaluate roadside problems on a site-specific basis and integrate two or more of the recommendations presented here.

Developing and implementing long-term plans is important because beaver populations are generally high in much of the Northeast. It is imperative that these plans be supported by allocations within annual budgets. In areas where beaver population densities are low, sites that currently do not support beavers may do so in the future. Highway departments should also establish or strengthen existing relationships with trappers. In many circumstances, trapping may be the most economical option, especially in areas where beaver population densities are low.

Beavers will remain and perhaps increase in abundance in much of the Northeast and other parts of the country, and they will continue to damage roads. We must acknowledge this fact and plan appropriately.

Selected References

Beaver Damage Control Techniques Manual, 1997. New York State Department of Environmental Conservation. Call or write your regional NYSDEC office.

The Beaver Handbook, A Guide to Understanding and Coping with Beaver Activity, NEST Field Guide FG-006, 1995. Write to Northeast Science and Technology, 60 Wilson Avenue, Timmins, Ontario P4N 2S7, CANADA.

Roadway and Roadside Drainage, CLRP Publication No. 97-5, 1997. Cornell Local Roads Program. Write to Cornell Local Roads Program, 416 Riley-Robb Hall, Cornell University, Ithaca, NY 14853.

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Olean, NY 14760-3632
(716) 372-0645

Guidelines for Completing the Culvert Inventory and Roadside Assessment of Beaver Habitat Form

Step	Action
1	At each stream crossing within your jurisdiction assess whether beavers are or ever were present in the roadside. In some cases this may be obvious and in others the stream may need to be surveyed to determine beaver presence. Work with landowners if a stream survey is necessary. Proceed to step 2.
2	If beavers (or beaver sign) are present in the roadside, determine the status and condition of the culvert. If the culvert is plugged proceed to step 3a. If the culvert is not plugged proceed to step 3b. If beavers (or beaver sign) are absent from the roadside, go to step 4.
3	a. Beavers Present: Culvert Plugged Give high priority to plugged culverts. Rank sites for management action according to the outline on page 10. i. Calculate the culvert inlet opening area (ft.^{2}) and the probability of the culvert being plugged by beavers (see Fig. 3). Determine if culvert oversizing is an option (based on what is currently installed and the road profile or height of road base). ii. If the calculated probability of beaver plugging for the current culvert is 50 percent or less (see Fig. 3) consider other techniques for managing damage (e.g., deep-water fencing combined with a water level control device, trapping). b. Beavers Present: Culvert Not Plugged If the culvert is not plugged and beaver sign is present in the roadside, an upstream or downstream dam is likely present. Give higher priority to sites where impounded water from a beaver dam is flooding or damaging the road. Rank sites according to the outline on page 10. i. Calculate the culvert inlet opening area (ft.^{2}) and determine the probability of beavers plugging the culvert in the future. ii. Give medium priority to sites where beavers are present but no problems exist. Follow guidelines under step 3a above and rank culvert replacements according to the outline on page 10. iii. At sites where culvert problems are not an issue, consider other techniques for managing water levels and/or trapping.
4	Beavers Absent If beavers (or beaver sign) are absent from the roadside, classify the stream gradient and/or percent open area (see example on bottom of form for instructions). Although these sites should be considered low priority for culvert replacement, this information can be used proactively to prevent beaver problems from occurring in the future. For percent open area calculate the average of the upstream and downstream values. Depending on topography use Figure 5 or Table 1 for calculating the probability of future beaver presence in the roadside area. Calculate the culvert inlet opening area (ft.^{2}) and the probability of the culvert being plugged by beavers as in step 3. Based on this value and the probability of beaver presence in the roadside, rank culvert replacements. For example, a site with a 50 percent or greater probability of beaver presence that had a culvert with a 50 percent or greater probability of plugging would receive a high culvert replacement ranking under this category.

Culvert Inventory and Roadside Assessment of Beaver Habitat

Municipality: _____ Date of Inspection: _____

Road: _____ Inspected by: _____

Location Notes: _____

Step 1 ☐ Beavers (or beaver sign) Present in Roadside (fresh or old cuttings, lodge, or dam present within 330 ft. of road, upstream or downstream)

☐ Beavers (or beaver sign) Absent from Roadside (total lack of any of the above signs within 330 ft. of the road, upstream and downstream)

Beavers Present in Roadside (Culvert Evaluation)

Step 2 Culvert Type: _____ Current Status of Culvert: ☐Plugged ☐Not plugged

Culvert Condition: _____ Years of Service Remaining: _____

Step 3 Culvert Dimensions: _____ Culvert Inlet Opening Area (ft.^{2}): _____

Probability of culvert being plugged by beavers (see Figure 3 for calculating probabilities):_____

Priority for culvert replacement: ☐ Low ☐ Medium ☐ High

Ranking for culvert replacement: _____

Other management techniques: _____

Beavers Absent from Roadside (Habitat Evaluation)

Step 4 Estimate percent open area using the example at the bottom as a guide.

Percent Open Area (check one):

Upstream: ☐ 0% ☐ 50% ☐ 100%

Downstream: ☐ 0% ☐ 50% ☐ 100%

Average of Upstream and Downstream Percent Open Area: _____

Percent Stream Gradient (check one): ☐ Low (0–1%) ☐ Medium (2–3%) ☐ High (4% or greater)

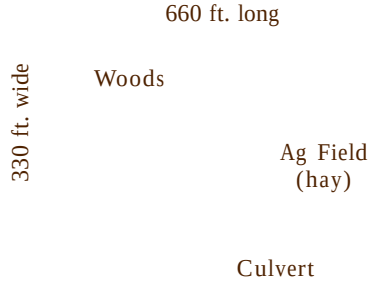
Probability of future beaver presence in roadside area (see Figure 5 or Table 1 for calculating probabilities): _____

How to Calculate Percent Open Area

Estimate percent open area upstream and downstream 330 ft. on each side of the culvert and extending 330 ft. off the road. This example is for one side of the road, but you should estimate on both sides (upstream and downstream).

Plot size is 660 ft. long (use culvert as center, 330 ft. on either side of culvert) and 330 ft. wide (extending off the road).

In this example the percent open area would be about 50% because open agricultural fields comprise almost half the plot size.



Beavers cause serious damage to roads across North America, primarily by plugging highway culverts. This can damage the road base and may cause roads to flood or wash out.

As beaver populations increase in many areas, new techniques for managing damage to roads are needed.

Managing Nuisance Beavers Along Roadsides: A Guide for Highway Departments contains specific information for highway agencies to use to make informed decisions. State and federal wildlife specialists, extension agents, and others will also find this useful.

The authors analyze the economic considerations of culvert replacements, water level control devices, pitchfork guards, and trapping.

Management recommendations include long-term, proactive strategies such as culvert selection and sizing as well as other techniques to manage beaver damage to roads.

A sample form is included to document the likelihood of beaver occupation along roadsides and catalog culverts and their susceptibility of being plugged by beavers. This process will help highway departments prioritize culvert replacements and make other long-range management plans.

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