Technical Information Sheets

Technical Information Sheet Environmentally Sensitive Maintenance Practices (ESMPs)

Practice: *ESMP #01 Insloping*

Category: Practices Relating to Road Profile

Refer to: Manual Chapter 5, Section 5.3.1.1

Description: Insloping is applied when the road has been constructed along a steep bank, with a steep uphill bank on one side and a steep downhill bank on the other side, ending at the edge of a stream. Insloping means the entire surface of the road slopes toward the uphill embankment side to eliminate drainage over the steep downhill embankment into the adjacent stream, as shown in Figure 1.

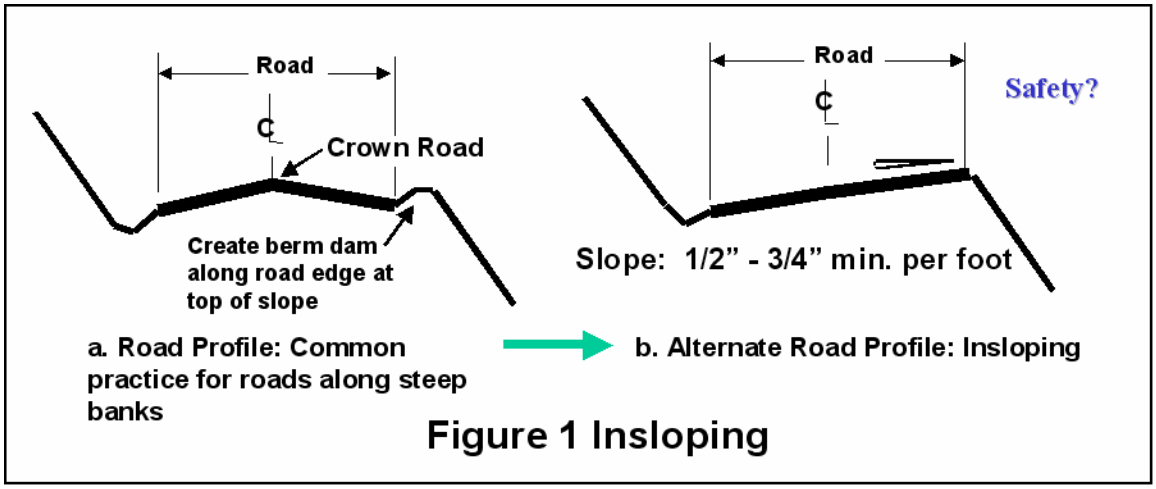
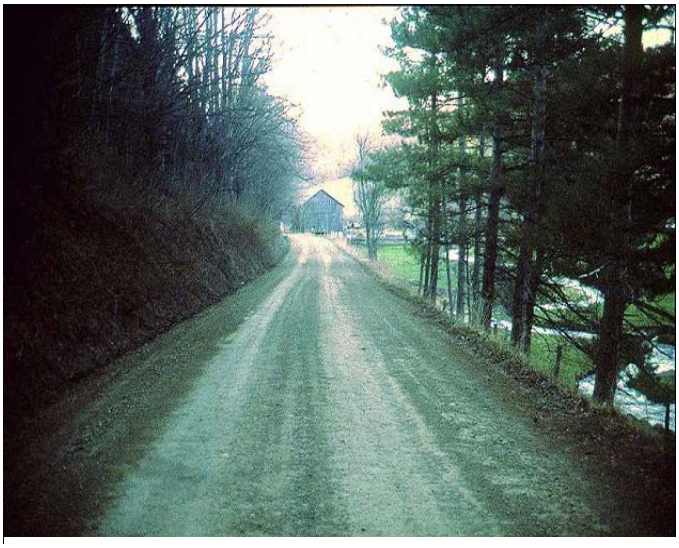


Figure 1 Insloping

Common Practice and Associated Problems: With a steep uphill bank on one side and a steep downhill bank on the other, common practice is to install a normal road crown. This practice concentrates drainage from half of the road toward the downhill side, causing erosion or severe washouts down over the bank, resulting in sediment into the stream. Sometimes a berm dam is installed along this edge of the road at the top of the slope. The berm dam creates a secondary ditch, building up water volume and flow that will result in a washout over the embankment and again into the stream. The photo shows a prime candidate for insloping.

Installation: The road is sloped entirely toward the uphill side using a normal cross slope (1/2" per foot). A roadside ditch collects the water and carries it to a strategically located cross culvert with proper outlet protection. Pipe flows should be directed to a vegetative filter strip. A berm barrier can be constructed along the road at the top of the downhill embankment, if desired, for vehicle safety. Multiple crosspipes will lessen the amount of water to be handled by each pipe, keeping ditch and pipe sizes to a minimum along with minimizing the erosion potential at the pipe outfall.



ESMP#01-01 Road candidate for insloping. Crosspipes can be strategically placed to outlet into the vegetative areas between the stream meanders.

Advantages:

- Eliminates flow over the downhill embankment
- Eliminates erosion on bank and sediment flow into stream
- Adds only one half of road surface runoff to ditch along uphill bank, eliminating need to increase size of ditch or cross pipes
- Allows all road drainage to strategically place cross pipes outletting to vegetative filter strips, filtering out sediment and attached pollutants
- Additional crosspipes minimize volume and velocity of water, minimizing ditch and pipe size, adding to roadside safety

Safety Considerations: Vehicle safety has to be considered. This practice should be used on a low volume road with a minimum cross slope. A higher berm along the downhill side creates an additional safety factor. Attempting to keep shallow ditches on the uphill side with flattened foreslopes and additional crosspipes will add to safety regarding vehicles sliding on winter ice.

Related Practices:

ESMP #02 Outsloping
ESMP #11 Stream Saver System

Technical Information Sheet Environmentally Sensitive Maintenance Practices (ESMPs)

Practice: *ESMP#02 Outsloping*

Category: Practices Relating to Road Profile

Refer to: Manual Chapter 5, Section 5.3.1.2

Description: Outsloping is applied when the road crosses a gentle sloping terrain. Outsloping means the entire surface of the road slopes toward the downhill side with a normal cross slope. Outsloping is similar to superelevation or banking of a curve, but on a straight section of road and with no ditching. The outsloped road blends into the gentle slope of the terrain with no ditching or cross pipes, allowing the natural sheet flow conditions to prevail, as shown in Figure 1. This technique should be used with *gentle sloping terrain and low overland flow conditions.*

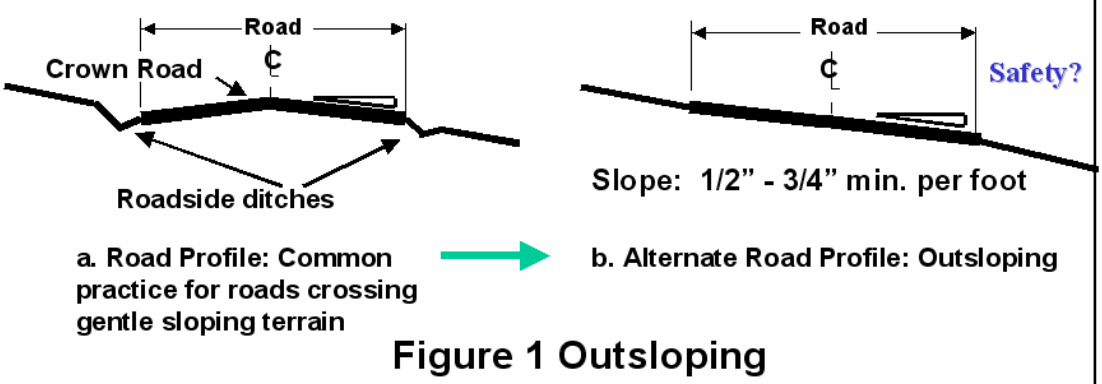


Figure 1 Outsloping

Common Practice and Associated Problems: Common practice dictates a road with a normal crown and side ditches. This configuration creates a dam and concentrates the overland sheet flow, causing potential erosion of ditches and ditch outlets. This profile also requires cross pipes to outlet the uphill side ditch with the potential clogging and flooding concerns. The volume of water to be handled can become substantial.

Installation: The road is sloped entirely toward the downhill side using a normal cross slope (1/2" per foot). The outsloped road profile blends into the sloping terrain and there are no ditches or cross pipes. The uphill natural sheet flow continues down across the road and through lower vegetative filtering areas (vegetative filter strip).
The photo depicts outsloping of a road. The wooded area on the uphill side results in low surface runoff . This runoff continues to sheet flow across the road and into the vegetative area on the other side. No ditches and no ditch maintenance required.

ESMP#2-01 Outsloped road showing no ditches and vegetative filtering areas for overland sheet flows.

Advantages:

- Eliminates concentrating the natural overland sheet flow. Eliminates erosion on bank and sediment flow into stream
- Eliminates ditches and cross pipes, eliminating erosion potential and maintenance
- Allows all road drainage to blend into the natural drainage system
- Has been successfully used for driveways crossing gentle sloping terrain, eliminating driveway ditch flows onto the main gravel road and ditches

Safety Considerations: Vehicle safety should be considered. Although the use of a normal cross slope helps in safety, the road surface condition, amount of flows and temperatures may cause icing of the road surface. Although this has not been the case on actual sites where outsloping has been constructed, conditions should be monitored closely during the winter months. In addition, a heavy storm may require road maintenance afterward if flows are substantial enough to cause road surface degradation. Again, this practice should be used on a low volume road crossing gentle sloping terrain with low overland flow conditions.

Related Practices:

ESMP #01 Insloping
ESMP #11 Stream saver system

Technical Information Sheet Environmentally Sensitive Maintenance Practices (ESMPs)

Practice: *ESMP #03 Ditch Turnouts and Vegetative Filter Strips*

Category: Practices Relating to Roadside Ditches

Refer to: Manual Chapter 5, Section 5.3.2.8

ESMP#3-01 Standing water can only lead to problems!

Description: All roadside ditches should be outletted to carry the water away from the road. Otherwise, the water will pond in the ditch, seeping back into the road structure, reducing its structural capacity and leading to road degradation. Terminology varies from region to region with various descriptive terms used for outletting ditches. Ditch outlets, ditch turnouts, tail ditches, and bleeders are all commonly used terms. Whatever you call it, the ditch turnout carries the ditch flow from the ditch, away from the road, and into a vegetative filter strip. The vegetative filter strip is an area of vegetation that filters out the sediment laden ditch water, increases water infiltration into the ground, and permits only clean runoff into a nearby stream. Ditch turnouts and vegetative filter strips should automatically go together.

Common Practice and Associated Problems: Do not outlet ditches directly to streams! Ditches carry surface runoff from the road and from the surrounding terrain along with any sediment and any contaminants attached to the sediment. Outletting directly to the stream is common since the stream is usually at the low point of the road. But this allows sediment and pollution to go directly into the stream, adversely affecting the stream ecology. Road personnel should turn ditches out prior to that low point into a vegetative filtering area to prevent stream pollution.

Installation: Turnouts can be installed during ditch cleaning operations. Turnouts should be skewed in the direction of water flow into a vegetative area. There are no exact spacing or size requirements for turnouts. Available charts do not take into consideration the many variables of specific sites, but may be used as guidelines. Road personnel need to consider the volume of water and ditch slope and the off right-of-way conditions and ownership. The volume of water can vary considerably depending on the terrain. The ditch may just drain the road surface or it may drain the road surface plus a major hillside area adjacent to the road. Road personnel should use their knowledge and experience when locating and constructing turnouts.

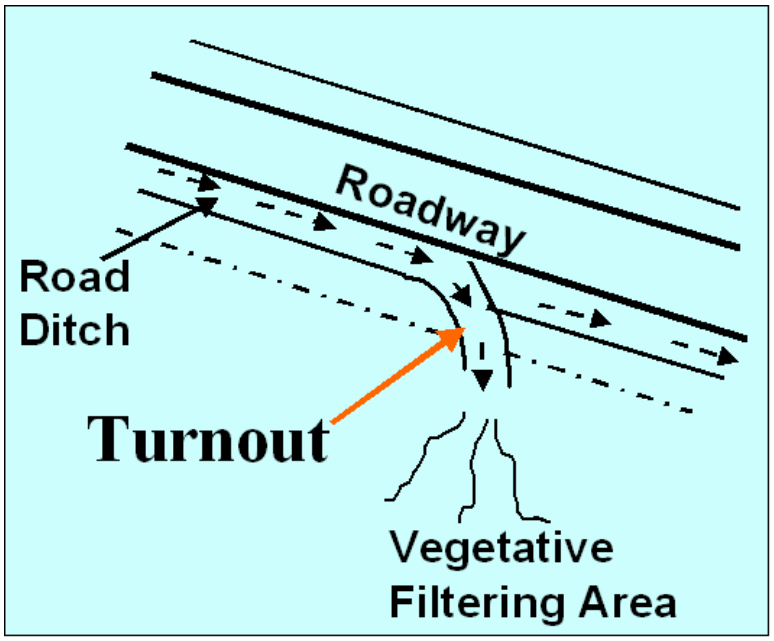


Figure 1: Ditch turnout into vegetative filter strip.

It is important to note that installing more turnouts limits the length of the ditch to each individual turnout. This in turn reduces the amount of water and flow within the ditch reducing water velocity and erosion potential and keeping the size of both the ditch and the turnout nominal. Limiting the amount of water that has to be handled should always be a consideration in any drainage situation. Refer to *ESMP#10 Through Drains*, for reducing water volume in ditches stemming from natural roadside springs.

Ditch turnouts should be strategically located to direct flows to vegetative areas. Vegetative filters strips will spread the water flow, slow velocity, decrease energy, and

ESMP#3-02 Multiple small turnouts mean nominal size ditches with less water, less velocity, less erosion potential, although large sized turnouts may be the only option on certain sites.

filter out the sediment. Other pollutants that may have attached to the sediment will also be contained and may be broken down physically or chemically by the soil or plants (refer to Manual, Chapter 4).

Advantages: The combination of ditch turnouts and vegetative filter strips:

- Carries the water away from the road and keeps streams clean
- Multiple turnouts decrease the volume and velocity of the water that the turnout handles, thereby decreasing the energy and erosion potential and keeping a nominal size on ditch and turnout
- Vegetative filter strips slow the water, dissipate energy, and filter out sediment and other attached pollutants

Safety Considerations: Ditch turnouts and vegetative filter strips carry the water away from the road providing effective road drainage to prevent flooding and road structural deterioration.

Related Practices:

ESMP #04 Broad Based Dips
ESMP #05 Grade Breaks
ESMP #10 Through Drains
Manual Chapter 5, Section 5.3.2, Practices Relating to Roadside Ditches

Technical Information Sheet Environmentally Sensitive Maintenance Practices (ESMPs)

Practice: *ESMP #04 Broad Based Dips*

Category: Practices Relating to Ditches and Road Profile

Refer to: Manual Chapter 5, Section 5.3.3.1

Description: Broad based dips are shallow, gradual dips skewed across the road in the direction of water flow, as depicted in Figure 1. This practice is used where there is a high embankment on one side of the road with a downhill grade. The high embankment does not allow for ditch turnouts and requires a cross pipe to carry the water to the other side and then to an outlet. Broad based dips allow the ditch water to flow to the other side joining that ditch flow to a joint outlet or turnout to a vegetative filter strip. The "dip" channel is skewed in the direction of water flow, and the crown of the road is eliminated within this area.

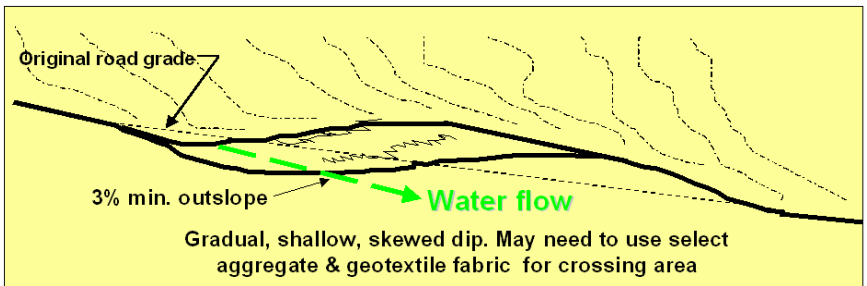


Figure 1: Broad Based Dip

Broad based dips present an alternative to installing and maintaining cross pipes on very low traffic volume roads. Broad based dips should be used only for ditch flows and not for perennial streams with permanent or intermittent flows.

ESMP#3-01 Broad based dips can be used in lieu of cross-pipes.

Common Practice and Associated Problems: Many roads have long downhill sections with a steep embankment on the uphill side, requiring ditches to be outletted through cross pipes or run from the top of the grade all the way to the bottom before they are outletted. Water volume and velocity continually increase as the flows run downhill, necessitating larger ditches and cross pipes to outlet the flow. Increased volume and velocity results in increased

erosion potential and flooding. In addition, water runs down the road surface, again picking up volume and velocity, and causes erosion gullies and rutting to occur. All of these factors lead to ever-increasing road maintenance and the associated increased costs.

Installation: Broad based dips can be graded into the road rather easily with the existing road materials. The bottom of the dip has to pick up the ditch flow, carry it across the road, and outlet to a vegetative filter strip. Broad based dips eliminate the road crown within the dip area. Water volume must be contained in the channel with no overtopping, and longitudinal slopes must be gradual to prevent vehicles from dragging. Proper transitions must be constructed to blend to and from the road crown. Test the dip by driving the road after installation.

ESMP#3-02 Broad based dip reinforced with large aggregate.

There are no exact formulas for spacing or size for broad based dips. These factors will depend upon many variables, such as road grade, traffic, volume of water, terrain, etc. The use of multiple broad based dips on a long downhill stretch of road also allows a smaller ditch size to carry the limited water volume from a shorter section or road. This limited volume of water should not have substantial flow or velocity to do any damage to the road surface crossing. Steeper road grades require placing more broad based dips closer together to limit water volume and velocity. Broad based dips can be easily constructed with a grader or small dozer within a short time period using the existing road materials.

Select larger sized aggregate to fill the dip. Geotextile separation fabric may be required to reinforced and stabilize the dip, since we have traffic and water crossing perpendicular to one another. The need to reinforce the dip depends on water volume and velocity and the type of road material. (See Manual Chapter 7 and ESMP #15for using geotextile separation fabrics.)

Road grader operators have to be aware of the broad based dip installations so that they do not think they are washouts or problem areas and reshape the road back to a normal crown. In addition, winter plow operators should be aware of these installations for proper and safe plowing operations.

Advantages:

- Breaks road into smaller sections for better drainage, handling less water with less velocity
- Allows the ditch to outlet across the road without a cross pipe
- Multiple broad based dips allow use of smaller sized ditches
- Reduces road surface water flows, eliminating damaging erosion gullies and ruts

- Outlets smaller volumes of water into vegetative filtering areas, providing for less erosion and greater sediment control

Safety Considerations: Broad based dips have a calming effect on traffic speed. Broad based dips also break the downhill momentum of vehicles, reducing the operator's chance of losing control.

Related Practices:

ESMP #05 Grade Breaks
ESMP #03 Ditch Turnouts and Vegetative Filter Strips
ESMP #15 Road Separation Fabrics

Technical Information Sheet Environmentally Sensitive Maintenance Practices (ESMPs)

Practice: *ESMP #05 Grade Breaks*

Category: Practices Relating to Ditches and Road Profile

Refer to: Manual Chapter 5, Section 5.3.3.2
(Adapted from the Pennsylvania Dirt and Gravel Roads Program, Technical Bulletin, 2/21/04)

Description: Grade breaks are long gradual breaks in the longitudinal grade of a road on a downhill slope, as depicted in Figure 1, breaking the road into shorter lengths for more efficient drainage. Grade breaks retain the road crown and require appropriately placed cross pipes.

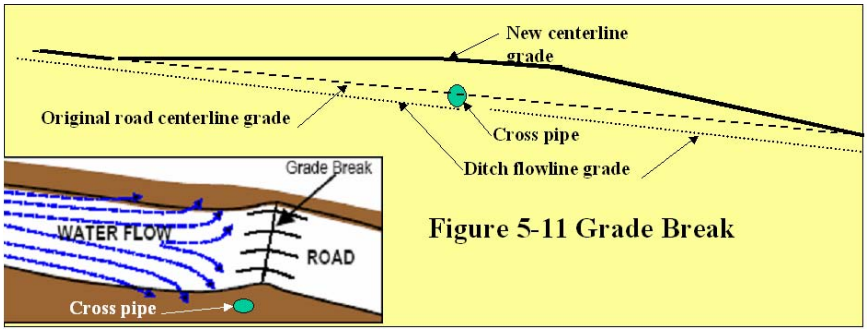
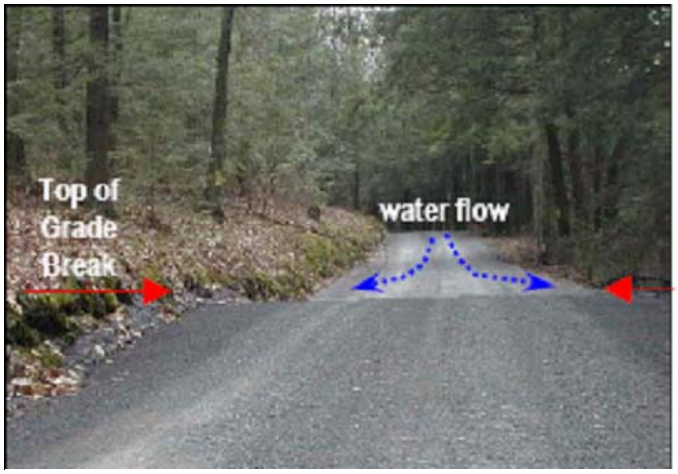


Figure 5-11 Grade Break

Grade breaks limit water flow by limiting the road section area to be drained. A shorter section of road decreases concentration and velocity, resulting in a smaller ditch cross pipe size. This reduction in water volume and flow in turn helps alleviate problems at the pipe outlet. Grade breaks also limit the length of flow and thus velocity down the road surface, eliminating potential surface erosion gullies and rutting.

Common Practice and Associated Problems: Many roads have long downhill sections where the ditches run from the top of the grade all the way to the bottom before they are outletted. Water volume and velocity continually increase as the flows run downhill, necessitating larger ditches and cross pipes to outlet the flow. Increased volume and velocity results in increased erosion potential and flooding. Erosion can be combated with additional ditch armoring, but that is very costly. Large flows through large pipes cause potential problems at the pipe outlet to dissipate the flow energy. In addition, water runs down the road surface, again picking up volume and velocity, and causes erosion gullies and rutting to occur. All of these factors lead to ever-increasing road maintenance and the associated increased costs.

Installation: There are no exact formulas for spacing or size for grade breaks. These factors will depend upon many variables, such as road grade, traffic, volume of water, terrain, etc. Multiple grade breaks keep the road sections shorter for effective drainage and less erosion potential. Steeper road grades require placing more grade breaks closer together to limit water volume and velocity. Grade breaks can be constructed with a grader or dozer. It is important to gradually taper the grade break back into the road grade. Testing the longitudinal slopes by driving through the break at a reasonable speed will indicate whether additional work is needed. The grade break also needs to accommodate snow plowing without road surface damage.



ESMP#5-01

As shown in the above figure, a grade break can be installed at the location of the cross pipe. This allows the cross pipe to effectively meet the ditch gradient with the road being built up and over the pipe to create the grade break. This eliminates the need to install the cross pipe at a much deeper elevation than the road ditch, resulting in additional potential for pipe blockage and road flooding. Pipe outlet areas need continual monitoring and erosion protection established as needed.

Road maintenance personnel, specifically the grader operator, must be aware of grade breaks and their purpose. An uninformed operator may see the grade break as a road surface deviation or consider the grade break as a source of extra road material to use elsewhere.

Advantages:

- Breaks road into smaller sections for better drainage, handling less water with less velocity
- Allows use of smaller sized ditches and cross pipes
- Smaller cross pipes decreases pipe outlet problems
- Eliminates damaging road surface water flows, eliminating gullies and ruts
- Outlets smaller volumes of water into vegetative filtering areas, providing for less erosion and greater sediment control

Safety Considerations: Grade breaks can actually have a calming effect on traffic speed. Grade breaks also break the downhill momentum of vehicles, reducing the operator's chance of losing control.

Related Practices:

ESMP #04 Broad Based Dips
ESMP #03 Ditch Turnouts and Vegetative Filter Strips

Technical Information Sheet Environmentally Sensitive Maintenance Practices (ESMPs)

Practice: *ESMP#06 Driveways*

Category: Practices Relating to Driveways

Refer to: Manual Chapter 5, Section 5.3.4

Description: Driveways pose several problems or concerns not only for the road user, but also for road maintenance personnel. Safety for the road user and the property owner served by the driveway should be a priority. Safe ingress and egress with minimal interference with other traffic should be a goal in driveway construction. Many states have regulations regarding driveways entering the state road system. These regulations are good resources for local governments, since the only way to insure effective driveway construction and rehabilitation is through the adoption and enforcement of policies and regulations, necessitating a driveway permit system. This provides the needed control allowing the road manager to review the site and determine what needs to be done for proper drainage to protect the road and the environment and provide safe access for the property owner and a safe road for other drivers. With that said, this technical information sheet will deal with the one specific problem for road maintenance personnel that also affects road safety and the environment – ***Drainage***.

ESMP#6-01 Improperly constructed driveways not only cause road drainage and road safety hazards, but also cause degradation of the environment through erosion and sediment.

Common Practice and Associated Problems: If property owners are under no regulations and do not need to obtain a permit or notify the governing entity, the end result of driveway construction will most likely cause continual drainage problems and road safety hazards. Roadside ditches will be filled in, and driveways sloping down to the road will continue on a down slope right to the road edge. This condition will drain the driveway onto the road, creating hydroplaning in the summer and icing in the winter. Blocked drainage ditches, likewise, will flood the road and again cause these unsafe situations. Water ponding on the roadway and in the roadside ditch will seep into the road structure and began the degradation that will plague the road crew and shorten the life of the road.

Installation: Driveway installation must follow a few rules – the first of which is maintaining proper road and shoulder and ditch profile. Ditch flow has to be maintained. For driveways sloping down toward the road, the low point should be over the ditch line, allowing both the road and driveway to drain into the ditch off either side of the driveway, as shown in Figure 1. For driveways with deep ditches, a pipe under the driveway continues to carry the ditch flow. These driveway drainage pipes may have nominal cover and have to be strong enough to support the vehicle loads. Refer to ESMP#09 for alternatives in shallow culvert installations.

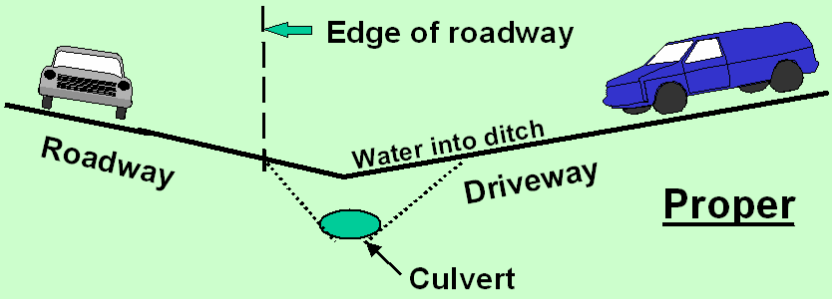


Figure 1 Proper driveway construction with deep ditch

For driveways with medium depth ditches, an open-top culvert or a box with an open grate may suffice, as shown in Figure 2. These units can be prefabricated or homemade. The photo insert in the figure pictures two types of prefabricated units, one all-plastic and one of a combination of plastic and metal. This system should only be employed for paved driveways, which will only drain clean surface runoff into the channel without clogging the grate.

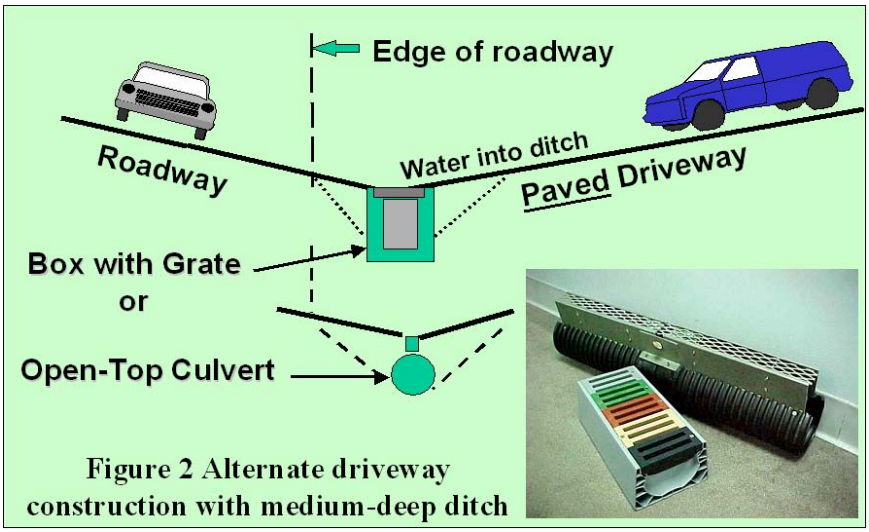


Figure 2 Alternate driveway construction with medium-deep ditch

In many instances, the roadside ditch will be shallow with nominal flows. In this case the ditch may continue across the driveway, as shown in Figure 3. Vehicles should not have any problem traversing a shallow ditch carrying only ditch flows during storm events. This area may require stabilization and reinforcement through the use of larger aggregate and/or a geotextile separation fabric. The need to reinforce the crossing depends on water volume and velocity and the type of driveway material. Geotextile separation fabrics are discussed in the Manual, Chapter 7 and ESMP #15.

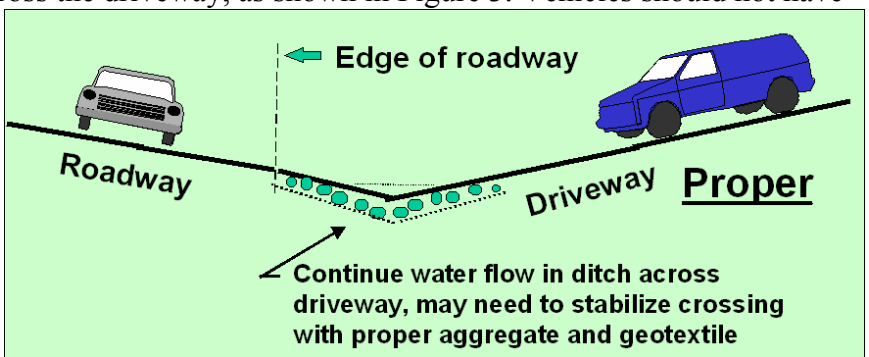


Figure 3 Driveway construction with shallow ditch

Advantages:

- Regulations and driveway permits give the road manager the authority to enforce proper conditions at the driveway site to meet drainage and safety requirements
- Properly constructed driveways:
  - Maintain roadside ditch flows, preventing blockage and flooding
  - Maintain proper road surface drainage off of the road
  - Eliminate water on the road surface which could cause hydroplaning or icing
  - Maintain road structural adequacy by keeping water out of the road structure.
  - Eliminate erosion and sediment from block ditches or road surface ponding, thereby protecting the environment.

Safety Considerations: These practices maintain proper drainage off, out of and away from the road, keeping the road safe, eliminating the potential hydroplaning and icy conditions. The driveway will also be safer due to proper drainage and less degradation.

One safety factor to keep in mind: if a box with grate facility is homemade, use appropriately sized openings in the grate that will not be a safety hazard to animals or bicycles.

Related Practices:

ESMP #07 Culvert End Structures
ESMP #08 Aprons at Culvert Outlets
ESMP #09 Shallow Culvert Installations
ESMP #15 Road Separation Fabrics

Technical Information Sheet Environmentally Sensitive Maintenance Practices (ESMPs)

Practice: *ESMP #07 Culvert End Structures*

Category: Practices Relating to Culverts

Refer to: Manual Chapter 5, Section 5.3.5.3

Description: A culvert end structure is simply a structure built at a pipe opening, either at the pipe's entrance or outlet end. The terms headwall and endwall are also used interchangeably, again referring to end structures for the drainage pipes or culverts.

Common Practice and Associated Problems: Many pipes are installed without any consideration for end structures. The end areas of roadway cross pipes transporting ditch water from side of the road to the other are prime targets for erosion and sediment. The pipe redirects the water flow, turning it through the pipe and across the road. This redirection of flow causes turbulence resulting in erosion around the pipe opening. Where there are close roadside embankments, gouging out the bank to install the crosspipe enhances the erosion potential if bare soil remains, as shown in the photo.

ESMP#7-01 Typical process of gouging out the roadside bank to install a cross pipe for ditch flow with no end structure leads to continual erosion and maintenance.

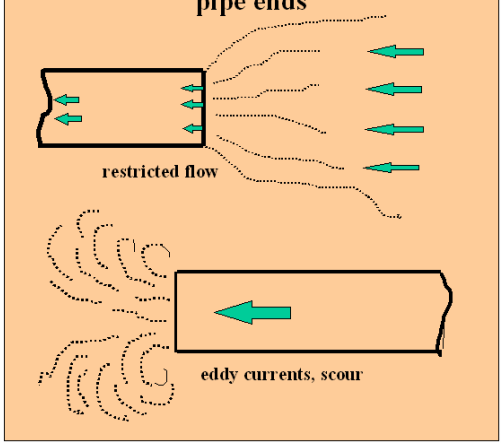
Even when water flows directly into and out of a pipe, these straight transitions are prone to erosion. Water flow into the pipe is usually restricted by the pipe opening, causing turbulence and possible erosion around the pipe entrance. Since the pipe restricts flow, the water travels faster through the pipe and out the other end. As the flow emerges from the pipe, eddy currents cause swirling flows on each side, leading to erosion around the pipe, as depicted in Figure 1. End structures can solve the erosion problem and provide other benefits as well, as described below.

Installation: Materials vary from concrete, flagstone or native stone to gabions or prefabricated units. Consequently, the cost of installation can vary as much as the material being used. Native stone not only becomes cost effective since it may be available on site, but it is also environmentally aesthetic, blending into the natural conditions. Several factors may influence the choice of materials, including local availability, skill and time required for construction, durability, cost, and volume and velocity of water to be handled. The photos show different types of end structures, including a geosynthetic, prefabricated unit.

ESMP#7-02

The shape of the end structure is important to direct water flow, protect the road and embankments, and improve drainage. The end structure should funnel the water into the pipe while protecting the surrounding area from erosion. On the inlet side, end structures direct the flow into the pipe, reducing turbulence and maximizing the flow capacity of the pipe. Outlet structures prevent erosive back eddy currents from undermining the pipe and road structure.

Figure 1 Flow characteristics at pipe ends



Cross pipes should be installed on an angle (skewed – not perpendicular) across the road in the direction of water flow for smoother flow transitions into and out of the pipe to further reduce erosion potential.

Culvert end structures may not be enough to protect against erosion at the pipe outlet. Further erosion protection may be needed in this "apron" area past the structure. Culvert aprons including the use of flared end sections are covered in Technical Information Sheet ESMP#08 referenced below.

Advantages:

- Prevents erosion from occurring around the pipe opening
- Provides a low-cost, long lasting solution to erosion problems at pipe openings
- Reduces continual maintenance needed to address the erosion and sediment and clogging of the pipe
- Provides structural support for the road

- Anchors the culvert providing structural support and preventing crushing of the pipe end by heavy vehicles

Safety Considerations: Culvert end structures increase safety by providing structural support to the roadway and to the culvert. There are also many designs to enhance roadside safety as to errant vehicles, as well as providing the other benefits described above. One such design is depicted in Figure 2.

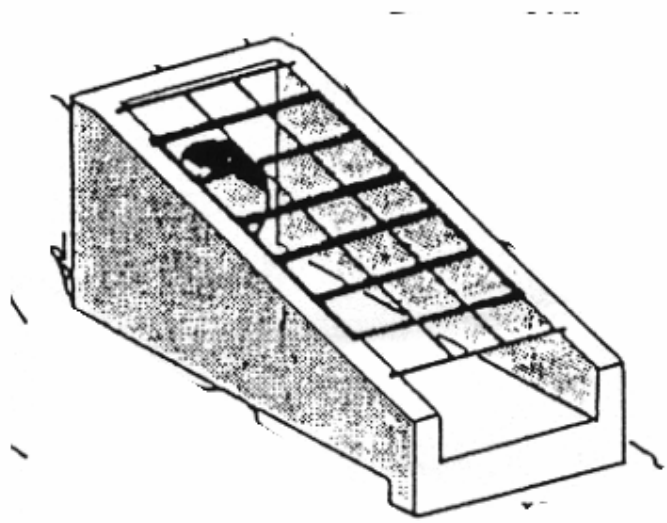


Figure 2: Vehicle safe end structure for roadside embankment

Related Practices:

ESMP #08 Aprons at Culvert Outlets
ESMP #09 Shallow Culvert Installations

Technical Information Sheet Environmentally Sensitive Maintenance Practices (ESMPs)

Practice: *ESMP #08 Aprons at Culvert Outlets*

Category: Practices Relating to Culverts

Refer to: Manual Chapter 5, Section 5.3.5.4

Description: Aprons at culvert outlets refer to the immediate area at a pipe outlet. Culvert outlets, even with an end structure, may still pose a problem with the flow discharge energy. A conveyance channel may need to be created to a stable discharge point. A simple flared end section may suffice as an apron to spread the water flow and dissipate the erosive energy. Other materials, however, can be used as culvert aprons, or used in conjunction with flared end sections to extend the stabilizing apron area.

Common Practice and Associated Problems: Many pipes are installed without any consideration for erosive energy potential of the exiting water. Since flow is usually restricted by a pipe, the water travels faster through the pipe and out the other end. As the flow emerges from the pipe, dissipation of the flow energy is often needed to prevent erosion. This apron area is often neglected and can lead to severe erosion and maintenance headaches, as shown in the photo.

ESMP#8-01 Severe erosion at a pipe outlet.

Installation: This is one area where rock riprap can be very effective. The rip-rap will spread the water flow, slowing it down and dissipating energy. Native stone becomes the cost effective aesthetic material choice, but, depending on location, even brush and tree stumps can be effective. The size of rock and the dimensions of the apron depend on many variables such as pipe size, soil type, the discharge volume and velocity,

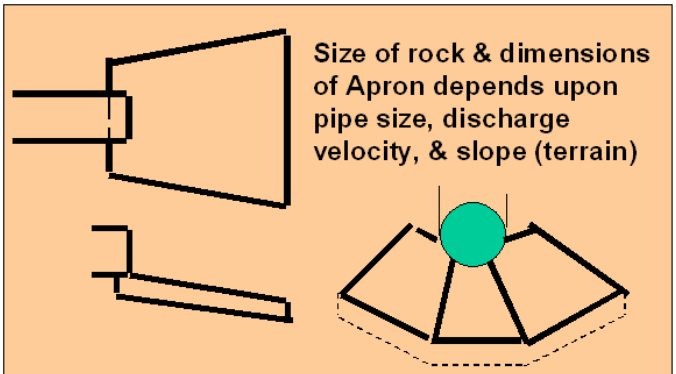


Figure 1 Aprons at Culvert Outlets

and the slope of the outlet channel or terrain. Although there are charts available that can be used as guidelines, apron installation should not be technically challenging. Experienced road personnel know the amount of water flow and the potential problems at a specific site. They can size the apron based on their past experience. Then, they need to follow up with field inspections during and after the next several rainstorms. If erosion is evident past the riprap limits, expand the apron and inspect again.

ESMP#8-02 Rock riprap makes an effective apron to dissipate energy and prevent erosion at the pipe outlet.

Flared end sections can be metal, concrete or plastic. As mentioned, these pre-fabricated sections may be enough to transition the flow to a stable discharge, or may be used in conjunction with other materials, such as riprap. The flared end section initiates spreading the flow and protects against those swirling eddy currents on each side of the pipe opening, while the riprap further spreads the flow and dissipates the flow energy eliminating the erosion potential. Typical flared end sections are shown in the photo.

Advantages:

- Prevents erosion from occurring around the pipe opening, reducing maintenance
- Provides a low-cost, long lasting solution to erosion problems at pipe openings
- Helps anchors the culvert, providing structural support

Safety Considerations: Culvert aprons prevent erosion of outlet ditches, eliminating the vehicle drop-off potential in roadside ditches.

Related Practices:

ESMP #07 Culvert End Structures

ESMP #09 Shallow Culvert Installations

ESMP#8-03 Typical Flared End Sections.

Technical Information Sheet Environmentally Sensitive Maintenance Practices (ESMPs)

Practice: *ESMP #09 Shallow Culvert Installations*

Category: Practices Relating to Culverts

Refer to: Manual Chapter 5, Section 5.3.5.1

Description: Roadway cross pipes are subjected to a variety of forces and loads. The weight of the backfill material above the pipe is a concern in deep installations. Many drainage cross pipes, however, are placed at a shallow depth to better accommodate the flow of water from roadside ditches. Vehicle loading due to the weight and movement of the vehicle is significant in these shallow installations. (See Manual Chapter 5, Section 5.3.5 for a discussion on traffic load distribution.) Road managers should consider various alternatives in those installations where proper cover cannot be maintained. This technical information sheet addresses several alternatives for shallow pipe culvert installations.

Common Practice and Associated Problems: Because of site conditions, depth of drainage ditches, water flow, etc., many cross pipes are installed without sufficient cover and with no consideration of the traffic loading. These shallow installations are subject to failure under traffic loads. In particular, flexible type pipe tends to deflect under traffic

ESMP#9-01 Shallow pipe installations can cause continual road deterioration.

loads, causing road materials to shift resulting in road surface degradation and possible pipe failure. The more shallow the pipe, the greater the direct force from vehicles, and the greater the deflection and resulting damage. A minimum of 12 inches of cover material over the pipe and below the road material minimizes or dissipates the traffic loads. Pipes larger than 24-inch diameter may need additional cover. The required cover, however, cannot always be met in many situations, and the pipe becomes a shallow installation. In

addition, the road surface area directly above the pipe becomes a maintenance headache with continual surface degradation.

Installation: There are several alternatives to improve shallow installations:

Rigid Pipe: A rigid pipe (concrete, cast iron, steel) has the strength to resist deflection under the traffic loads to the detriment of the road.

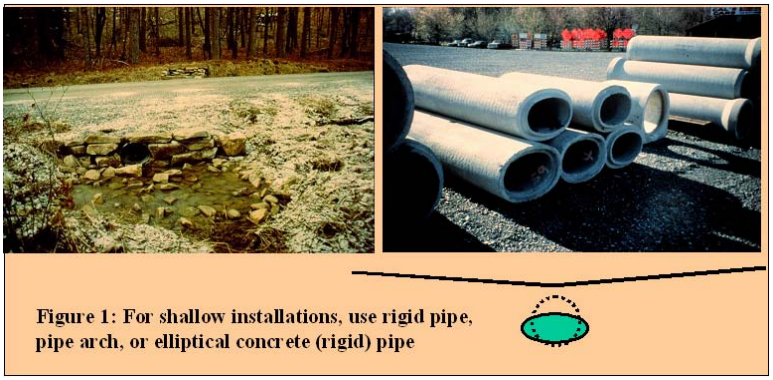


Figure 1: For shallow installations, use rigid pipe, pipe arch, or elliptical concrete (rigid) pipe

Elliptical Pipe or Pipe Arch ("Squash Pipe"): Pipe arch not only allows proper flow capacity but also allows additional cover. An equivalent 18-inch diameter corrugated metal pipe arch is only 15 inches in height. That extra three inches of additional cover is significant in further distribution (reduction) of traffic loads. Rigid pipe also comes in an elliptical shape allowing extra cover in addition to the extra strength factor of the pipe itself. See Figure 1 with accompanying photos.

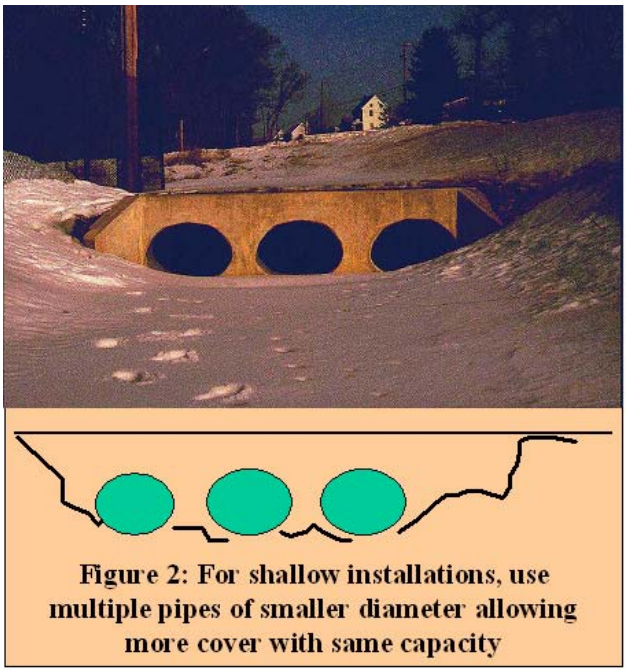


Figure 2: For shallow installations, use multiple pipes of smaller diameter allowing more cover with same capacity

Multiple Pipes: Multiples pipes are another alternative. Multiple pipes of smaller diameter allow more cover but still provides adequate flow capacity (see Figure 2). To use multiple pipes, however, road mangers must keep a few rules in mind. Flow capacity is directed related to the area of the pipe opening. This means that two 12-inch diameter pipes do not equal the flow capacity of one 24-inch diameter pipe. The area of a circle (the opening of the pipe) is πr^2 or 3.14 times the radius squared. A 24-inch diameter pipe has 452 square inches of opening (3.14 x 12 x12). A 12-inch pipe has 113 square inches, or two 12-inch pipes have a total of 226 square inches of opening. It would take four 12-inch pipes to equal the flow of one 24-inch pipe (4 x 113 = 452 square inches). Using three 15-inch pipes or two 18-inch pipes would give additional flow capacity and still maintain greater cover over the pipes.

Another rule for multiple pipes is to make sure they are installed far enough apart to allow adequate backfill compaction between the pipes for the compaction equipment being used.

One of the concerns voiced in multiple pipe use is clogging. Any pipe can clog. One of the simpler solutions for metal or plastic pipes is cutting the inlet end of the pipe on a slant or bevel. Any debris flowing toward the pipe will tend to ride up the slant, which will allow water to continue through the pipe. For multiple pipes, staggering the inlet ends so that they are not parallel in one line perpendicular to flow will lessen the probability of clogging. Each pipe inlet end is extended a little further (offset) from the pipe beside it. When large debris, such as tree limbs or logs, come downstream, they will either block only one pipe or be forced to an angle, skewing across the pipe entrances, but allowing water to continue to flow through the pipes (see Figure 3).

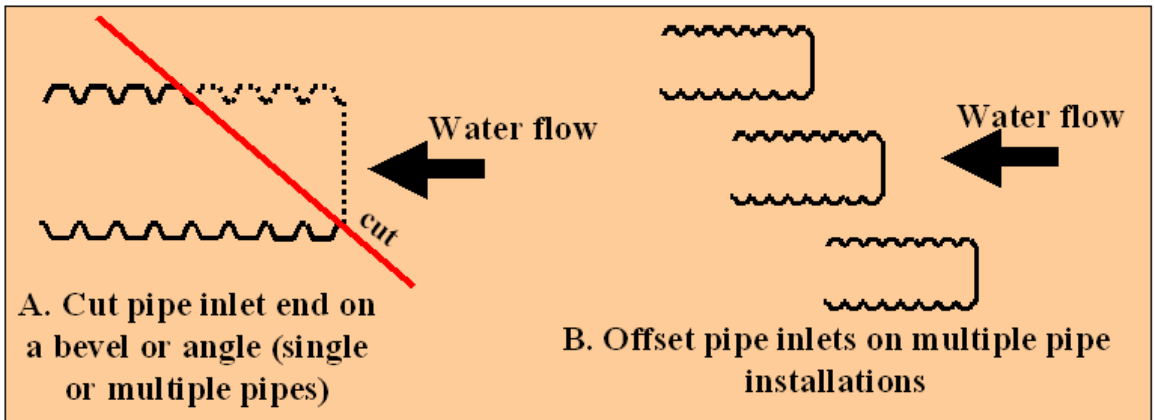


Figure 3 Recommendations to Help Eliminate Pipe Clogs

Advantages:

- The use of rigid pipe diminishes the potential of pipe failure and road surface degradation.
- Elliptical or pipe arches allow adequate cover over cross pipes to protect the pipe and the road.
- Multiple pipes allow adequate cover over cross pipes to protect the pipe and the road.
- Cutting pipe inlet ends on a slant and offsetting multiple pipes reduces potential clogging and the resulting flooding of the road and environment.

Safety Considerations: Shallow culvert alternatives will keep the road and cross pipe(s) in good condition, eliminating the safety factors surrounding road degradation or pipe failures.

Related Practices:

ESMP #07 Culvert End Structures
ESMP #08 Aprons at Culvert Outlets

Technical Information Sheet Environmentally Sensitive Maintenance Practices (ESMPs)

Practice: *ESMP #10 Through Drains*

Category: Practices Relating to Culverts (and Roadside Ditches)

Refer to: Manual Chapter 5, Section 5.3.5.5

Description: Through drains are cross culverts that are strategically placed to handle natural springs or spring seeps flowing perpendicular to the road and carry them under (through) the road to the other side to continue in the original channel prior to the road's existence. Many roads intercept native ground water flows in this manner. The through drain allows this natural flow to continue without entering the road ditch or interfering with road drainage, as shown in Figure 1.

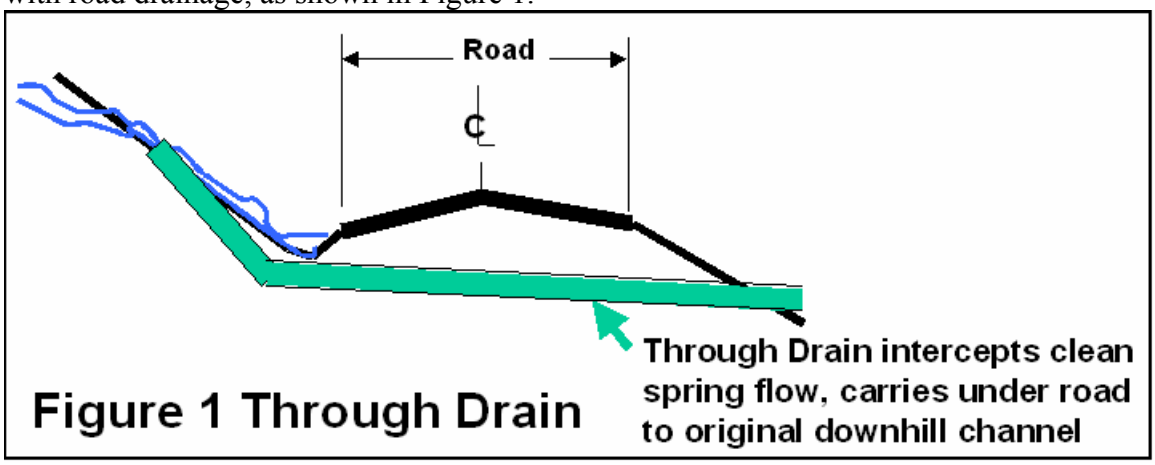
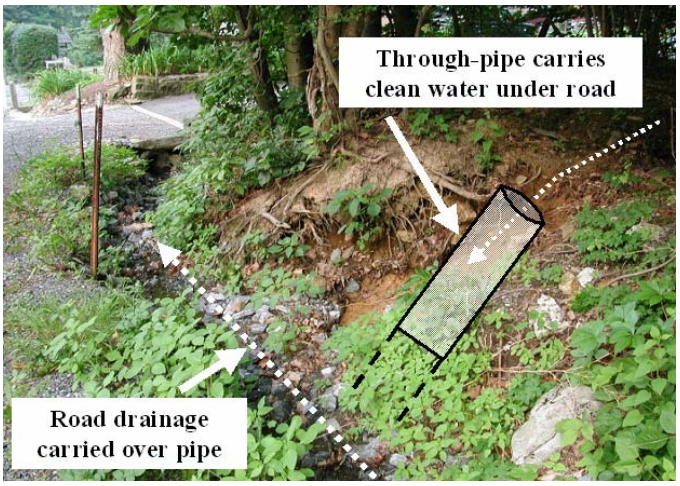


Figure 1 Through Drain

Common Practice and Associated Problems: Common practice allows natural springs of clean water to flow into the road ditch, mix with often sediment-laden ditch flows, and then flow directly to a stream. The additional flows can be substantial during certain periods of the year, such as during the spring rains, causing flooding of the road ditch and road degradation. Even if flooding does not occur, this added volume has to be handled by oversized ditches, increasing the erosion and sediment potential of the combined ditch and spring flows. In addition, substantial flows diverted into streams could adversely affect the stream ecology.

Installation: Through drains should be installed wherever natural spring flows are intercepted by the road and are carried by the roadside ditch and the surrounding terrain and off right-of-way conditions allow installation. The through drain pipes are placed to pick up the natural spring waters and carry them under the road, outletting on the other side into the original downhill flow channel. This eliminates the usually clean water from entering the road ditch, thus keeping the water clean as it continues in its original path prior to the road's existence. The photo depicts typical placement of a through drain.



ESMP#10-01 Through Drains keep springs and spring seeps out of road drainage facilities.

The through drain outlet has to be stabilized as to flow volume and energy. If the natural spring waters have been flowing into the ditch for a number of years, the natural channel on the downhill side may be nonexistent. This channel may have to be reestablished, providing proper erosion prevention until the channel is stabilized.

Advantages:

- Maintains clean natural spring waters as clean water
- Eliminates handling of this water volume via the road ditch, reducing ditch size
- Reduces ditch flow reduces erosion potential and resulting sediment

Safety Considerations: Through drains will decrease ditch size and reduce the flooding and road degradation potential, keeping the road and roadside safer for vehicles.

Related Practices:

ESMP #07 Culvert End Structures
ESMP #08 Culvert Aprons

Technical Information Sheet Environmentally Sensitive Maintenance Practices (ESMPs)

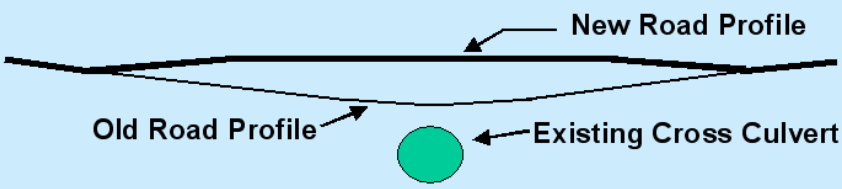
Practice: *ESMP #11 Stream Saver System*

Category: Combination Practices

Refer to: Manual Chapter 5, Section 5.3.6.1

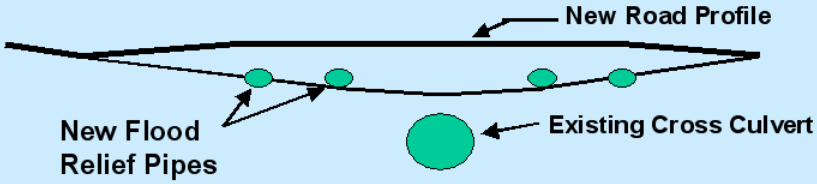
Description: The Stream Saver System raises the road profile over the low-point stream crossing; the road surface remains level for an extended area away from the stream on both sides, as shown in Figure 1. If the cross pipe cannot handle the flow, this level road allows sheet flow across the road during flooding conditions with less erosion potential. Using broad based dips and turnouts into vegetative filtering areas for the road and ditch drainage on each approach as conditions warrant avoids direct discharge into the stream and alleviates some flood flow. If pipe capacity is severely limited, a flood relief crossing can be established away from the stream depending on the existing terrain and land use. This crossing should be a stabilized low water crossing (refer to Chapter 7, Section 7.4.3.8.3 for a description of a stabilized low water road crossing using geosynthetics).

Figure 1 Stream Saver System



> Raise the road over the stream crossing.
> Keep road grade level over stream area for sheet flow during flooding conditions
> Use broad based dips and turnouts to vegetative filter strips for road and ditch flows on each approach

Figure 2 Stream Saver System with Flood Relief Pipes



Use smaller diameter pipes at higher elevations for flood relief flow

In raising the road, additional pipes installed at higher elevations allow for flood flow relief, as shown in Figure 2. Depending on the depth of material used to create the new road profile, the additional flood

relief pipes can be laid with minimal or no excavation. During major storms, these flood relief pipes handle the extra flow, minimizing overtopping the road thus preventing road deterioration.

Common Practice and Associated Problems: Common practices followed the traditional topographical site conditions where the road's low point was directly over the stream. This condition seemed to be the most practical way of draining the road. Roadside ditches could be carried to the low point and outletted directly to the stream with a cross culvert carrying the steam under the road. In analyzing the existing problems at these sites, however, this procedure was not the best for the road and definitely not the best for the environment. When all surface and ditch flows drain directly into the stream, they carry all of the road's sediment and pollutants with them. When major storms hit, creating flows beyond the culvert's capacity, the low point of the road became the v-shaped channel, narrowing the overflow across the road, increasing the flow energy and causing erosion of the road surface, again directly into the stream.

Installation: Every site will have different requirements. The installation basics, however, are the same. Add enough road material to raise the road over the stream with a level grade extended in each direction for 50 to 100 feet. Use ditch turnouts into vegetative filter strips for roadside ditches on each approach. Use broad based dips, grade breaks, or additional cross culverts as needed on each approach to break up the surface runoff from the road and surrounding terrain and handle effectively prior to the stream. Refer to the individual technical information sheets on these additional techniques for more detailed information.

ESMP#11-01 Stream Saver System – raised level road with ditch turnouts to vegetative filters.

Advantages:

- Eliminates surface drainage and any sediment from the road and roadside ditches directly into the stream, protecting the stream and the environment
- Raises the road to reduce flooding and surface erosion, establishing a level surface for lower energy sheet flow, with much less road deterioration
- Provides additional flow capacity for flood flows as needed (by installation of additional flood relief pipes)

Safety Considerations: Stream Saver Systems protects the structural stability of the road, keeping the road safer. Road deterioration from flooding and surface erosion will be minimal.

Related Practices:

ESMP #03 Ditch Turnouts and Vegetative Filter Strips
ESMP #04 Broad Based Dips
ESMP #05 Grade Breaks
ESMP #07 Culvert End Structures
ESMP #08 Culvert Aprons
ESMP #12 Raising the Entrenched Road

Many other practices can be used in conjunction with the Stream Saver System as the site conditions may warrant.

Technical Information Sheet
Environmentally Sensitive Maintenance Practices (ESMPs)

Practice: *ESMP #12 Raising the Entrenched Road*
Category: Major Reconstruction
Refer to: Manual Chapter 5, Section 5.3.7

Description: Raising an entrenched road involves major filling of the road cross section between high banks, bringing the road surface back up to the original road surface elevation. When you look at the photo, you see a typical entrenched road in a forested area. Usually entrenchment results from years of traditional road maintenance involving road grading, shoulder cutting, ditch cleaning and widening. As the road profile drops, or becomes entrenched, water draining to the road is trapped and the road begins to function as a channel. Restoring the road to its original surface elevation eliminates a multitude of problems and maintenance headaches.

ESMP12-01 A typical entrenched road.

Common Practice and Associated Problems: Although common road maintenance practices naturally lead to an entrenched condition, we continue year after year making the situation worse. (Refer to chapter 5, Section 5.3.7, for a detailed description and photo sequence of road entrenchment over the road's life.) An entrenched road becomes the stream channel, even as ditch size continues to increase in an attempt to handle the entrenched flows. Flooding and surface deterioration along with a saturated road structure create ongoing maintenance to keep the road usable. Snow removal becomes an increasing problem with the plowed snow piling up against the high banks, adding to the water problem. As the above photo depicts, these roads have severe drainage, erosion and sedimentation problems requiring continual maintenance. All these problems can be eliminated by bringing the road surface back up to the original elevation.

Installation: Installation involves substantial fill and a major work effort. Fill material is expensive, but obtaining free fill material and using in-house equipment and operators can offset costs. Various types of fill material can be used. A new road with good road material can then be built on top of the fill material. The road surface is built back up to its original elevation, eliminating the banks on both sides and providing for excellent road drainage conditions with much less erosion and sediment pollution. Figure 1 shows the typical entrenched roadway before and after filling, completely eliminating the bank on one side and reducing the bank height on the other side. Drainage can then sheet flow off the road without a ditch on the one side. The road will no longer be a drainage channel, experiencing far less road surface deterioration. Snow removal becomes easier, and the removed snow will not be a future source of water back into the road.

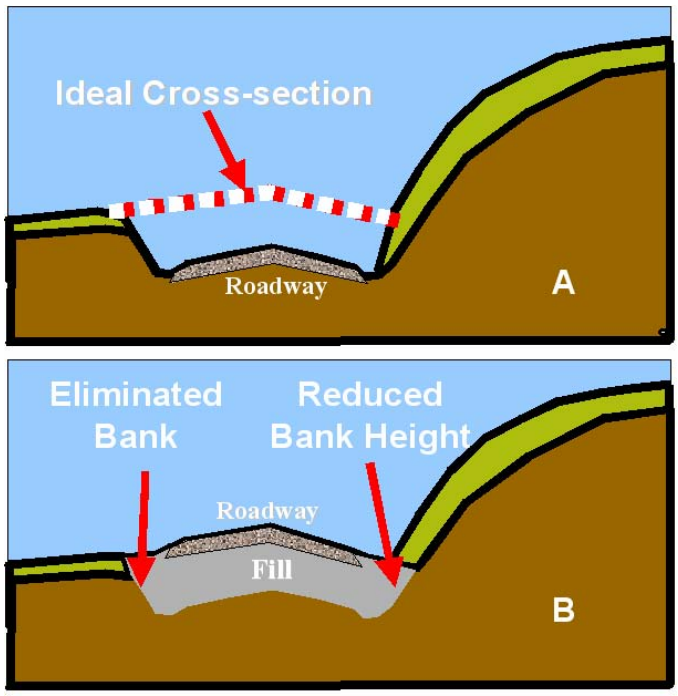


Figure 1: Raising the Road

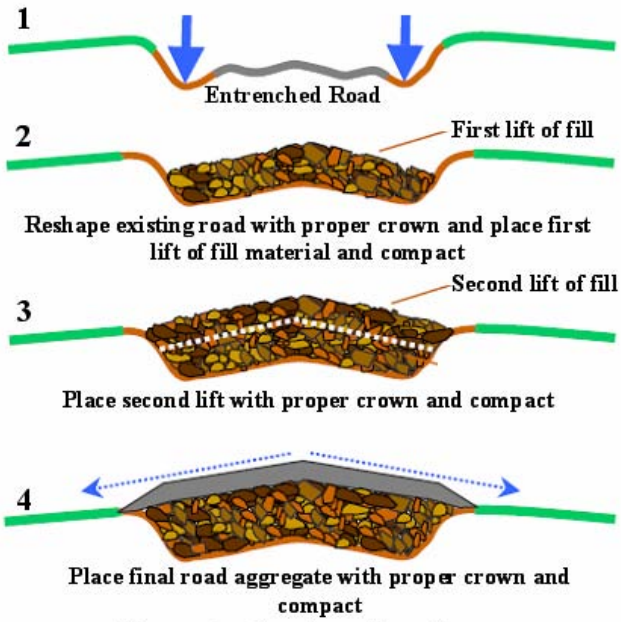


Figure 2: Construction Sequence

Figure 2 shows the construction sequence, beginning at the top with an entrenched road cross section. The entrenched road traps road drainage on the road and in the parallel ditches. To prepare for raising the road, proper crown is needed on the existing road. Then each lift of material is placed in uniform 8- to 12-inch lifts with proper crown of ½-inch to ¾-inch per foot and compacted. Compaction is critical. A large static roller, vibratory roller or sheep's foot roller should be used to thoroughly compact each lift of fill material. Geotextile separation fabrics or geogrids between lifts will add strength to the road base. (See Chapter 7, Section 7.4.4.6 and ESMP #15 for using separation fabrics and Section 7.4.4.8 for geogrids.) The road is then reconstructed on top of the fill using good road aggregates.

The road material is placed with the proper crown and compacted the same as the fill material.

The photos show an entrenched road project from the start of the filling operation to the final road surface being compacted.

ESMP12-02 Raising the entrenched road—step-by-step.

When the road is immediately next to a stream, the procedure is slightly different. In this example, the road has a high embankment on one side and falls steeply off directly into the stream on the other side. The road is entrenched with side ditches, as shown in Figure 3. As also depicted in the figure, the road is raised upslope away from the stream, eliminating the entrenchment on the stream side. This allows for sheet flow across additional vegetated area. The high embankment on the other side is reduced with better stability and drainage control. Depending on site conditions, the implementation of insloping would provide additional benefits.

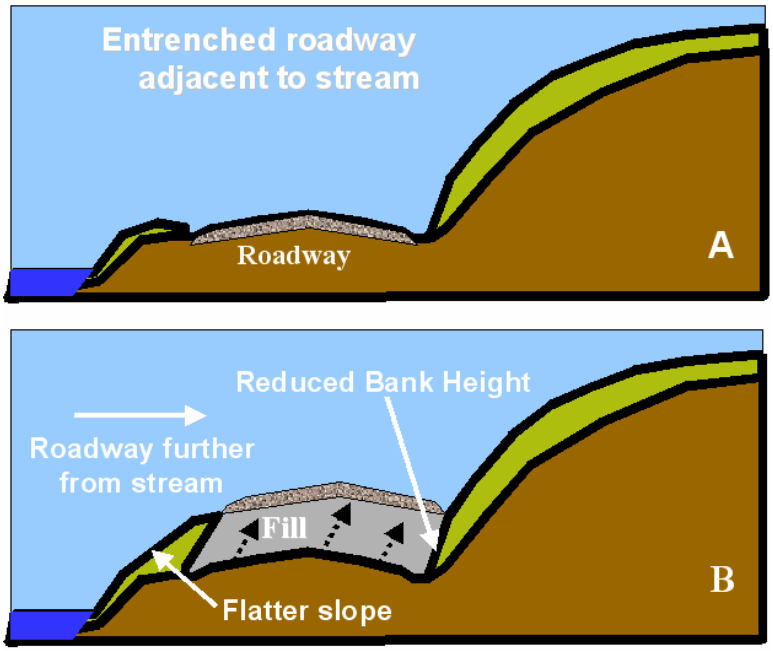


Figure 3: Raising the Road & moving away from the stream

Advantages:

- Allows road surface drainage to sheet flow off the road through vegetated areas reducing erosion and the resultant sediment pollution
- Eliminates ditches and ditch maintenance in terrain where sheet flow can be established
- Eliminates concentration of water trapped in an entrenchment, prolonging the life of the road with less maintenance
- Allows for more efficient snow plowing, removing the snow away from the road and eliminating snow melt back into the road structure

Safety Considerations: Raising the entrenched road helps maintain the road in a safe condition with no flooding and far less surface erosion and rutting.

Related Practices:

ESMP #11 Stream Saver System
ESMP #15 Road Separation Fabrics
Manual Chapter 7, Section 7.4.4 Geosynthetic Applications in Road Maintenance

Many other practices can be used in conjunction with raising the Entrenched Road as the site conditions may warrant.

Technical Information Sheet Environmentally Sensitive Maintenance Practices (ESMPs)

Practice: *ESMP #13 Slope Geometry, Benching, and Diversion Swales*

Category: Practices Related to Road and Stream Banks

Refer to: Manual Chapter 6, Sections 6.4.2.1, 6.4.2.2, 6.4.2.3

Description: Slope geometry, benching, and diversion swales are all related to bank stability. Whether the bank requires stabilization and what practice or practices will be the most appropriate remedy can only be ascertained from a initial site visit that includes a thorough review and analysis of conditions. To determine the stability of a bank, we

ESMP#13-01 Eroded roadside banks are common sights, but add up to a large erosion and sediment pollution problem effecting both roads and the environment. Site investigation and corrective actions are essential.

must consider the site's topography along with the soils, drainage conditions, and vegetation (Chapter 6, Section 6.4.1). Based on this site investigation, the selected practices can be effectively implemented. Diversion swales are used where a vast area drains down toward the road, adding significant surface drainage flows down over the road embankment to the roadside ditch. The diversion swale will divert the upslope surface flow away from the road and roadside ditch. Slope geometry has to do with the degree or steepness of the bank itself and the bank's surface condition. Flattening slopes and roughening or grooving the bank surface are practices that alter the slope geometry for greater stability. Benching is the establishment of a bench or step or multiples steps across a steep bank to aid in stability. Each practice is described in detail below.

Common Practice and Associated Problems: Common road maintenance practices tend toward cutting the toe of slopes (bank gouging), cutting or cleaning banks for better sight distance, and smoothing the surface until it "shines,", all of which can lead to bank instability, resulting in erosion and sediment pollution, and eventually to road deterioration as ditches fill and flood. Cutting the toe of slope leaves a certain-to-erode vertical surface, unable to withstand gravity's relentless force as the bank attempts to re-stabilize itself. In most maintenance work involving bank cleaning or cutting for whatever reasons, the work ends with bare soil remaining, subject to erosion from the impact of raindrops and surface flows, carrying the sediment into the roadside ditches or downhill into the adjacent stream. Reestablishing vegetation is a necessary part of this work and should not be overlooked. Bank cutting often results in a smooth bank surface. The equipment operator's expertise used to be defined by how well the operator could "shine" the bank surface. Then, if we did try to seed and mulch this extra smooth sloped surface, the results were much less than desired.

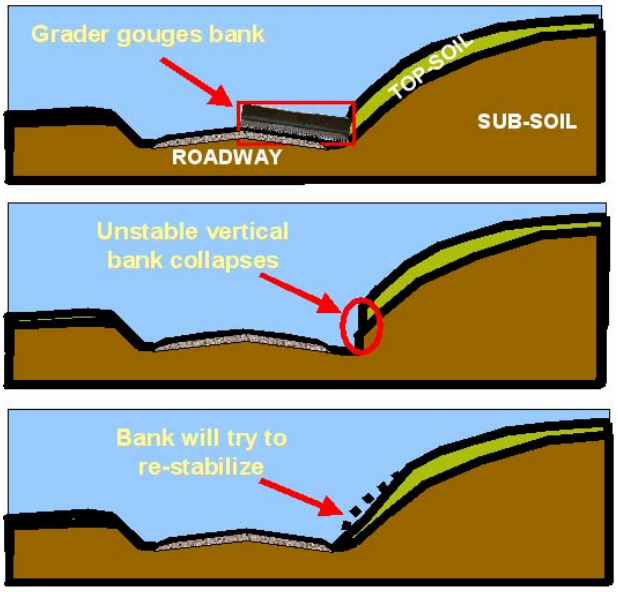


Figure 1: Bank Gouging

Installation: Diversion swales divert upslope surface water before it washes over the top of the road bank and into the road's drainage ditch. Diversion swale profiles can vary, but are normally wide with gradual side slopes. Swales must contain the overland flow and not be overtopped. Diversion swales must be stable, with a level longitudinal grade for infiltration back into the soil or sloped to an adequate discharge area. Diversion swales effectively drain, low, gradual vegetative slopes. The surface runoff from the entire upward slope drains into a swale at the top of the road embankment. The road bank would then be protected against erosion gullies. The volume of water to be handled by the road ditch decreases along with the size of the road ditch and potential flooding and erosion problems. Diversion swales are usually outside the right-of-way but need not interfere with agriculture. Wider and more gradual, the sideslopes and longitudinal slope will result in more infiltration and less flow accumulation. By eliminating washouts and

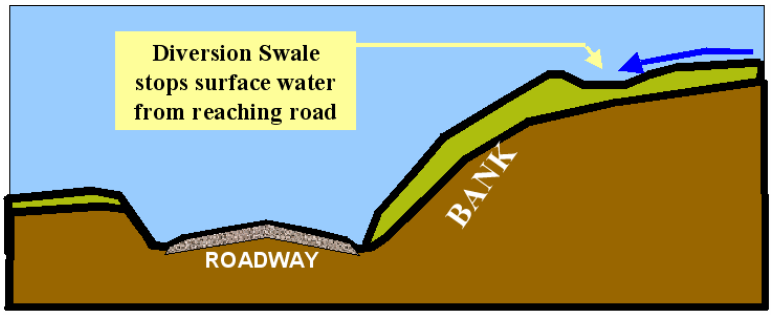


Figure 2: Diversion Swale

erosion gullies that form down over the road bank and start to "eat" back into the hillside, the swale can actually improve drainage of the landowner's property.

ESMP#13-02 Diversion Swale: Wider swales and gradual slopes result in more infiltration and less water volume to handle.

Begin by examining the slope. Flattening a steep slope and roughening or grooving the surface slows the water flow down the surface and with properly re-established vegetation can eliminate the erosion potential. On the uphill side, flattening the slope will move the top of the bank further away from the road and possibly beyond the right-of-way limits. The same may hold for flattening the slope on the downhill side as we add material and extend the toe of the embankment further away from the road. Right-of-way limits, land use, and property owner expectations all need to be considered.

Roughening, grooving, or tracking slopes are simply methods to simulate natural conditions. We need to think in terms of existing natural banks. Natural banks are not regular or consistent as to surface and slope and they are not polished and shiny. These techniques require light equipment in order to prevent packing the soil to the detriment of plant growth. Track equipment should be used up and down the slope, not across, so the grooves catch water and hold seeds and mulch. Roughening, grooving, or tracking of slopes catch rainwater, slow surface water flow, reduce erosion, increase infiltration, and trap sediment. In addition, by holding water, seeds, and nutrients, the rough surface enhances vegetative growth.

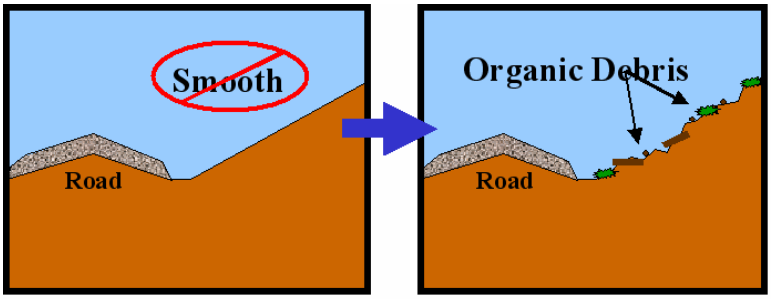


Figure 3: Roughening, grooving, or tracking slopes have many advantages in stabilizing banks

ESMP#13-03 Tracking newly constructed banks.

Benching is commonly used effectively on long, steep slopes with the same benefits of holding soil, water, seed, and mulch for enhanced vegetation growth, as listed above for roughening the sloped surface. The top of the bank may have to be moved back and may be off the right-of-way. A

good working relationship with property owners is again required.

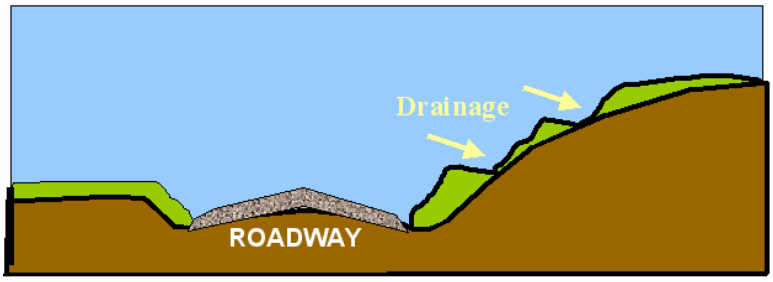


Figure 4: Benching is commonly used on steep slopes

The bench needs to collect water. The outside edge needs to be higher than the inner edge to prevent over the bank flow, as shown in Figure 4. The bench then should have a gradient to drain the bench to a proper outlet. Some benches can be gradually run out to the road ditch grade, for drainage. Do not overlook the use of smaller multiple benches or steps, and keeping some irregularity for a more natural appearance, if appropriate for the site.

ESMP#13-04 Newly constructed low-gradient bank bench.

Advantages: All of these practices result in improved bank stability, tending to do all of the following:

- Catching rain water
- Slowing surface water flow
- Reducing erosion
- Increasing filtration
- Trapping sediment
- Holding water, seeds and mulch for enhanced vegetative growth.

Whether diversion swales, flattened slopes, rough surfaces, or benches, there will be less erosion, less sediment, and less maintenance.

Safety Considerations: Bank stability results in better roadside conditions and less road deterioration, resulting in safer roads.

Related Practices:

Manual Chapter 6, Section 6.4.1 Initial Site Visit
Manual Chapter 6, Section 6.4.2.4 Seeding and Mulching
Manual Chapter 6, Section 6.4.3 Bioengineering Techniques

Technical Information Sheet Environmentally Sensitive Maintenance Practices (ESMPs)

Practice: *ESMP #14 Roadside Trees – Using the Forest System to Reduce Maintenance*

Category: Practices Related to Roadsides

Refer to: Manual Chapter 6, Sections 6.3

Description: By taking advantage of natural principles when managing roadside trees, it is possible to provide safe clearances, enough shade to control dust and invasive species and eliminate the rapid re-growth of colonizer species and frequent mowing cycles. Roads that look like they are in harmony with nature, require less money to maintain, pollute less, and offer the additional benefit of being beautiful. We need to develop a strategy following some basic guidelines to **use the forest system to reduce maintenance.**

ESMP#14-01 Following some guiding natural principles, we can use the forest system to reduce maintenance.

Tree trimming and removal, brushing, brush cutting, and right-of-way clearing are all terms for roadside vegetation management. These activities are common, and road managers may need to perform these activities for a variety of reasons. We need to look at these common practices and reasons, however, and determine what is best for our roads and the environment.

Common Practice and Associated Problems: The normal methods used to trim trees and remove brush along roadsides include manual methods ranging from chainsaws to hand pruners; mechanical methods using mowers and brush cutters; and chemical methods with chemical application equipment and herbicides. All of these methods and equipment have their place in an integrated vegetation management program and can be used effectively. There are some cautions, however, that should be noted.

In an environmentally sensitive maintenance program, chemical methods using herbicides are certainly a concern. Due to the many hazards associated with herbicides, federal and state governments have adopted various laws and regulations governing their use. These regulations require local government applicators to become certified through

testing. Environmentally sensitive maintenance does not promote the use of herbicides. If you do use herbicides, you must become familiar with the laws and follow all the requirements and regulations associated with herbicides use.

Boom mowers bring up an additional caution. Boom mowers, when properly used, can be labor saving. One only has to travel, however, down a road on which a boom mower was used, destroying the roadside vegetation and leaving a hurricane-aftermath look, to realize that the use of this equipment can get out of hand. Damage to large tree limbs can eventually kill the total tree. Refer back to the discussion in Chapter 4 on understanding your trees and the effects of wounds. In addition, boom mower operators are frequently instructed to cut "everything you can reach and everything small enough that you can cut." This direction and practice will ultimately have, as its consequence, roadsides vegetated only by large trees. Some of the most beautiful, slow-growing, strong, wildlife-friendly trees along the roads are being systematically removed because they have the misfortune of being small. Planners frequently choose trees such as dogwood and serviceberry as roadside trees. Yet they are often removed by boom mower operations just because of their size. Would it not have been better to remove the big old damaged or dead trees and save those small dogwoods? The dogwood makes an excellent roadside tree with the added value of blossoms to beautify the roadside in the spring.

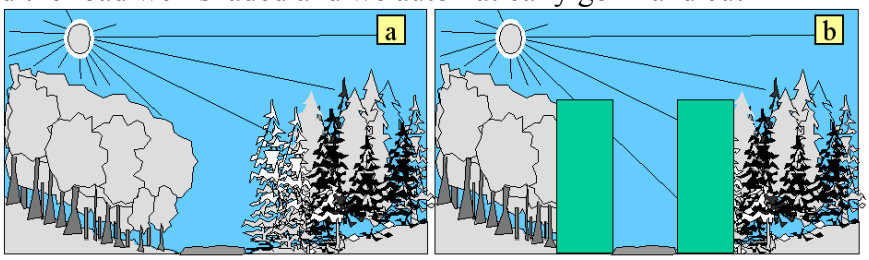
ESMP#14-02 Dogwoods are a good roadside tree with the added value of aesthetics.

A third caution is the common practice of traditional right-of-way clearing and its use for dirt and gravel roads. Traditional clearing practices may have their place on the interstate and superhighways, but they can cause continually more maintenance work when used on our gravel roads in forested areas. Common accepted reasons for clearing the roadside of trees and bushes are to eliminate shade, improve visibility, establish a safety clear zone and reduce routine tree trimming. Although all of these reasons have some merit and may apply for some roads, we need to look closely at the conditions created and the need for future maintenance.

Although shading is viewed as negative, it also has advantages. Shading retains road moisture, cutting dust. Shading reduces the growth of unwanted colonizer trees and encourages desirable plant growth. A limited amount of shading may be more effective and efficient for our unpaved road maintenance and the environment.

Regarding visibility, one of the greatest safety hazards results from an abrupt transition from bright sunlight to dense shade or vice versa. This extreme change in light can have a devastating effect on the motorists' visibility and be a direct cause of accidents. This type of extreme change in light conditions should be avoided.

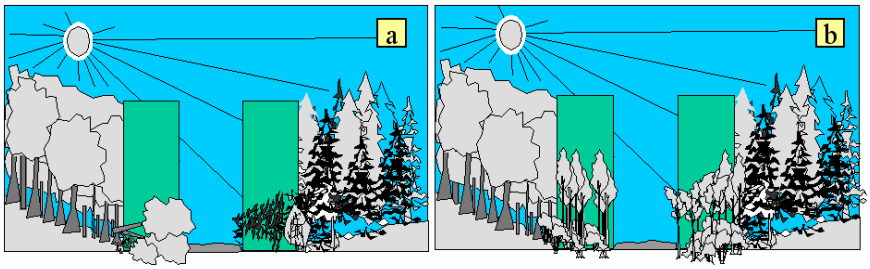
Traditional clearing techniques involve total removal of brush and vegetation along the roadside from right-of-way line to right-of-way line, typically resulting in vastly increased sunlight along the edge of the road. Looking at the sequence of events in a traditional cleared roadside, however, this may not be what is desired. If the roadside is wooded or forested and the road well shaded and we automatically go in and cut everything down, as shown in Figure 1a to 1b, on each side of the road for whatever distance we consider necessary, the results may lead to increased maintenance.



Traditional clearing practice for a shaded road would be from right-of-way line to right-of-way line.

Figure 1

When a section of trees is cut down, the remaining trees along the cut edge are open to storms and wind and may not be structurally strong enough to withstand these conditions. Wind damage, broken branches, and even uprooting can result, as shown in Figure 2a. Other problems include the rapid regrowth of the removed trees through stump sprouts, which are structurally weak and can become a continual maintenance problem. In addition, exposing low growing, broad-leafed, shade-tolerant plants to full sunlight typically kills them, with the potential of soil erosion.



Common reaction of previously protected trees exposed by clear cutting - broken stems, wind damage, uprooting.

Dense weak colonizer growth, which can threaten roadway & recreate shade, appears surprisingly fast.

Figure 2

When the roadsides, previously shaded, receive full sunlight, nature produces vigorous growth, as depicted in Figure 2b. This vigorous growth is due to the invasion of colonizer species that are most attracted to this environment, but are the worst possible roadside plants. Colonizer species, which we described in Chapter 4, Section 4.5.4 on succession, are fast-growing, weak growth types. Colonizer trees can threaten the roadway safety and recreate shade. These colonizer trees then become extremely high maintenance roadside plants. In many cases the plants we most want to remove are the plants most encouraged by our efforts. This creates the need to mow and trim in increasingly frequent cycles.

ESMP#14-03 You do not need fast-growing, weak-structured colonizer-type roadside trees!

So in this scenario, the mowing/removal of trees and brush in the interest of safety and visibility, have the opposite effect, starting an endless cycle of cutting and re-cutting of this colonizer growth.

ESMP#14-04 Remove dead, diseased, unstable, or dying trees first.

Alternative Practices: The solution is to **use the forest system to reduce maintenance.** Be selective! When doing roadside trimming and tree removal, remember to remove the dead, dying, unstable or damaged trees first. Trees that have been damaged by previous maintenance activities, automobile accidents, etc. will eventually die and become hazards.

The second priority is to remove the existing colonizer trees. These trees, even if they are healthy, are not good roadside trees. They are very rapid growers, have weak structures and short lives. They commonly fall onto the road or drop limbs, which create maintenance and hazards.

After removing the damaged trees and the colonizers, it is advisable to look the situation over and evaluate the rest of the trees. Maintaining strong, slow-growing, deep-rooted climax species should be an objective (refer to chapter 4, Section 4.5.4). Avoid straight-line cutting, however, favoring instead an irregular edge. Traffic will tend to travel more slowly on a road with an irregular edge. Speed has always been a major safety problem for our dirt and gravel roads. Clearing the roadside completely or cutting back on a straight line parallel to the road gives the motorist the safe illusion to increase speed.

Maintaining a uniform level of shading is best. One of the greatest dangers from shading comes from winter conditions where pockets of deep shade create irregular icing conditions. Thinning of the canopy to achieve the desired shade density should be the objective. Remember, deciduous trees will lose all their leaves in the winter, letting more sunlight penetrate to the road. Sometimes it is necessary to thin back off the edge of the right-of-way, as the desired sunlight may only be available from the side, not from above. Obviously it is necessary to discuss your plans and objectives with property owners to receive permission to work off the right-of-way.

Advantages: In a situation where a dirt and gravel road is heavily lined with trees or passes through forested areas, a program of vegetation management that seeks to use the forest system and take advantage of natural principles can save time and money in several ways.

ESMP#14-05 A before and after look at selective tree trimming during a road project – using the forest system to reduce maintenance.

1. Allowing a level of shading helps to retain moisture. Moisture is nature's stabilizing agent. Allowing enough shade to remain to hold some moisture on dirt and gravel roads helps to hold the surface together and reduce dust. Although few road managers would readily identify moisture retainage as a benefit of shaded roads, they will almost always tell you they use less dust control in shaded areas.

2. Maintaining shade along our roads reduces the establishment of colonizer species (aspen, birch, poplar, sumac, striped maple, etc.). These rapid growing, weak-wooded trees are the ones which create the biggest maintenance problems, especially during winter maintenance operations when they lean out into the road laden with heavy wet snow.

3. The trees that are removed are less likely to return as stump sprouts. All of us have witnessed the rapid return of vegetation under new power line cuts. This is usually a combination of stump sprouts and colonizer species, resulting in increased mowing cycles. This scenario can be avoided by simply allowing the road to remain partially shaded.

A well-maintained roadside forest system also adds to the aesthetics, which in turn enhances tourism.

Safety Considerations: Safety factors were discussed throughout the above. Well-managed roadsides with structurally strong, deep-rooted, long-lived trees will be safe roads. These roads will also be easier to keep clear and safe through the winter snows. And irregular edges have a tendency to reduce traffic speeds for additional safety.

Related Practices:

Manual Chapter 6, Section 6.3.3.7 Tree Leaves
Manual Chapter 6, Section 6.3.4 Using Other Plants for the Roadside

Technical Information Sheet Environmentally Sensitive Maintenance Practices (ESMPs)

Practice: *ESMP #15 Road Separation Fabrics*

Category: Practices Using Geosynthetics

Refer to: Manual Chapter 7, Sections 7.4.4.6

Description: Road separation fabrics are geosynthetic fabrics that separate the subsoil from the road aggregate, providing improved road stability and reinforcement, improved drainage, prevention of subgrade pumping of fines, and thereby dust reduction.

How They Work: When roads are built, the subsoil or subgrade is prepared with a crown, then a specified thickness of aggregate is laid down and compacted ***(Figure 1a).*** Over time, however, depending on conditions (water and traffic), the aggregate gets pushed down into the soils and the soils pump up through the aggregate ***(Figure 1b).*** We end up with a transition zone not as strong as the aggregate, and the road can no longer support the traffic loads with deterioration as the result.

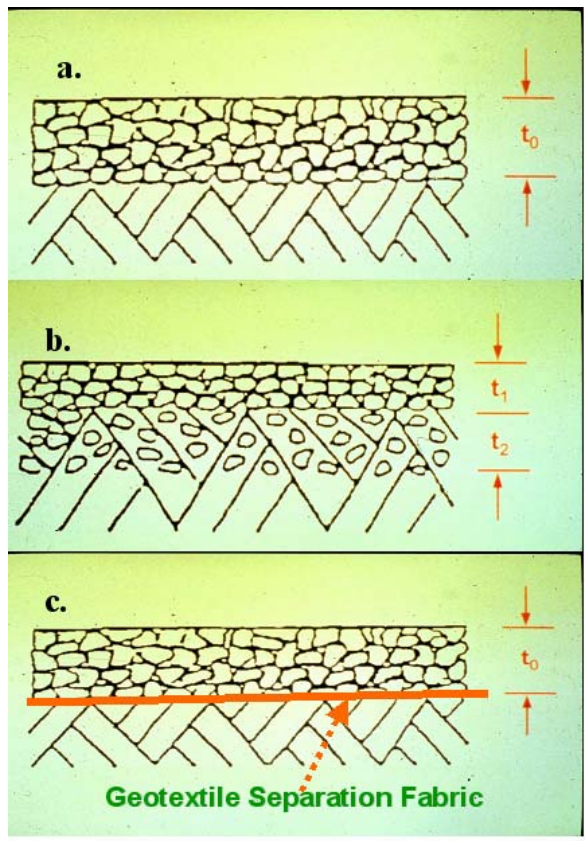


Figure 1: The value of Separation Fabrics

With the separation fabrics, we prepare the subgrade, roll out the fabric, and build the road on top of the fabric ***(Figure 1c).*** The aggregate cannot be pushed into the soil, and the soil cannot pump up into the aggregate. Everything stays in place, and the road remains strong enough as designed for the traffic loads. Water can travel either way, but if it gets into the road, it can drain downward or out laterally due to the crown into side ditches or subdrains. The prevention of soil fines from pumping up through the aggregate to the road surface eliminates the mud in wet weather and the dust in dry weather.

Installation: Fabrics come in woven or non-woven types for this application. The existing road conditions, particularly the aggregate, rock outcrops, water and saturated subsoils, are considered in selection of the fabric type. Transverse joints should be overlapped a minimum of 18 inches in the direction of traffic. Fabric rolls come in standard 12-, 15-, and 18-foot widths (or customized to any width), eliminating the need for longitudinal joints.

ESMP#15-01 Separation fabrics keep the soil and road aggregate in place.

Installation steps include surface preparation with an established crown, rolling out the fabric, placing the road aggregate, and compacting. Aggregate should be backdumped from the truck to a minimum depth of 6 inches, preferably 8 inches. Grading and re-establishing the crown followed by compaction of the aggregate completes the project, as depicted in the series of photos. On this project, sections of the road received additional

Rolls of fabric waiting for installation | **Rolling out the fabric** | **Backdumping the aggregate**

Spreading the aggregate | **Compacting the aggregate** | **Final grading**

ESMP#15-02 Installation of a separation fabric.

shale material to raise the road elevation (refer to Tech Sheet #ESMP 12, Raising the Entrenched Road).

If the fabric gets damaged during placement, simply patch with another piece of fabric making sure that an 18” overlap on all sides is maintained. Tears can happen, as shown in the photo, where the blade of the dozer caught the fabric by accident.

ESMP#15-03 If damaged, use a fabric patch with 18" overlap on all sides.

Advantages: The use of separation fabrics provides us with a number of advantages:

- Stabilization
- Prevention subgrade pumping
- Drainage improvement
- Rutting and pothole reduction
- Dust reduction
- Reduced maintenance and costs
- Longer road life

Fabrics also help to distribute traffic loads over a greater area, making them advantageous to use over soft, saturated soil conditions. Figure 2 shows this load distribution effect of the fabric. (Traffic load distribution was discussed in Chapter 5, Section 5.3.5, Practices Related to Culverts in regards to culvert installations.)

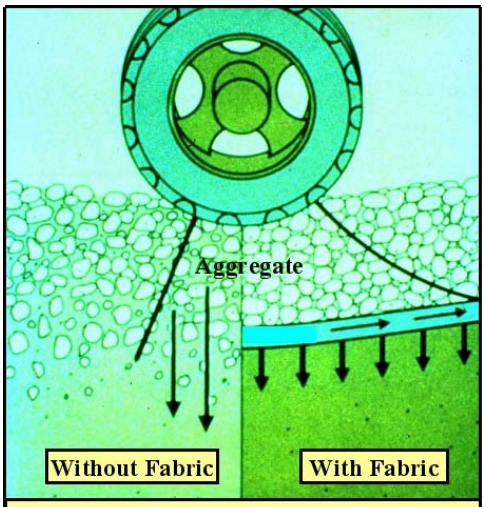


Figure 2
Fabrics Separate & Distribute the Load

ESMP#15-04 Separation fabrics have proven to be effective.

Separation fabric applications prove effective to substantially reduce road deterioration, resulting in reduction of road maintenance.

The use of fabrics for stabilizing water-crossing areas in conjunction with broad based dips and driveways was mentioned in Chapter 5. In these applications, they perform a reinforcement function and a separation function to strengthen and keep these areas intact.

Safety Considerations: Structurally strong roads that remain in place with minor maintenance will be safer roads.

Related Practices:

ESMP #04 Broad Based Dips
ESMP #06 Driveways
ESMP #12 Raising the Entrenched Road
ESMP #11 Stream Saver System
Manual Chapter 7, Section 7.4.4 Geosynthetic Applications in Road Maintenance