Virginia City Highlands Property Owners Association

Road Management Guidelines

&

Road Maintenance Plan

Version 1.0 July, 2006

Table of Contents

1.0 Introduction

The VCHPOA unpaved roads carry local traffic between rural lands, and provide connecting links between paved collector roads. More than 83 % of the VCHPOA roads have an unpaved surface. Most of these roadways consist of graveled surfaces, while the remainder consists of natural material (clay soils and rock) with perhaps some gravel placed at some time in the past. These roadway surfaces and ditches are subject to erosion and degradation which lead to sedimentation within ditches themselves, watercourses, and private property.

This document is the first working draft of the Virginia City Highlands Property Owners Association (VCHPOA) Road Management Plan. In order to maintain and manage our road system we must first apply the proper road maintenance procedures. The following information contained in this document has been taken from   This document should be updated on a yearly basis or as often as needed when on the ground conditions change.

The cost involved in the maintenance of the unpaved roads is one of the most significant items in the budget of the VCHPOA. Erosion and deterioration of the unpaved roads and drainage system is the single most significant factor affecting maintenance needs and costs involved with the roadway system. The costs to the VCHPOA is not limited to direct costs associated with keeping these unpaved roads passable, but also includes additional costs due to increased flooding, impaired drainage, loss of wildlife habitat and other riparian zone natural resources, adverse effects on the natural food chain, and loss of aesthetics which can have profound effects on property values. Most of the latter-mentioned effects are considered in today's social climate to be *environmental* issues, and they are; but rest assured, they are very real economic concerns as well.

The goal of the VCHPOA Road Management plan is to improve all roads by using sound and well established road maintenance and management practices. A particular road is only one of many in our road system. A road management plan is a common sense, step-by-step approach to scheduling and budgeting for all road maintenance work. The plan will consist of surveying the mileage and condition of all roads in the system, establishing short-term and long-term maintenance goals and tasks and prioritizing road projects according to budget constraints. The road management plan will help and allow the Board of the VCHPOA to develop a road budget. Through proper roadway management, the VCHPOA can determine the most cost-effective, long-term treatments for roads, control road maintenance costs, and spend dollars more wisely. If the VCHPOA sticks with the plan outlined herein we will all be rewarded with roads that are easier and less costly to maintain on a yearly basis. Pertinent information about all roads will be readily available for years to come instead of scattered among files or tucked away in someone's head.

The Board of the VCHPOA recognizes that a commitment to effective road management is an attitude. It is a matter of making sure that association members' money is well spent. It does not mean paving our roads with gold but it does mean using the best materials available. It does not mean taking short cuts resulting in a shoddy work but it does mean using correct construction techniques and quality control. A commitment to effective management means planning for 5 or even 10 years instead of putting a band-aid on today's problem. It means taking the time to do things right the first time and constructing projects to last. The horse and buggy days are over. We are in an age of travelers' demands, increasing traffic; declining revenues and taxpayer revolts. We are expected to do more with less. Building roads to last requires an attitude of excellence. Such an attitude helps to make better decisions, saves money in the long run, and results in a better overall road system.

1.1 Standards

The road maintenance and management outlined herein are the standards that will be implemented throughout our road system. Written standards in the areas of design, construction and maintenance will define the level of service we hope to achieve and provide. Without written standards there is no common understanding about what we are striving for in road design, construction and maintenance. Maintenance standards address the need for planned periodic maintenance. A good maintenance plan protects our roads, which represents many dollars of investment. It also is an excellent aid when it comes time to create a budget. Considerations include: How often shall new gravel be applied to the roads? Some roads require it more often than others do. How often are roads to be graded? How often and in what locations should road stabilizers be applied? What is our plan for installing and checking road signs? Because of legal liability, a missing sign can be very costly if not installed or replaced when needed. What is our plan for ditching and shouldering? The list goes on.

In order to maintain adopted standards the VCHPOA recognizes that limiting vehicle speed on our road system is vital for both community safety and for minimizing road maintenance costs. Because our road system does not included sidewalks many people in our community use our road system for walking, riding horses and riding bikes. Obviously since both pedestrians and motor vehicles use our road system safety is an issue and a concern. Safety is even more of an issue on our road system because of the limited traction that comes with driving on gravel roads. Therefore, in order to address this safety issue a maximum speed limit of 20 mph has been adopted for all unpaved roads. Should lower maximum speeds be necessary on certain roads or sections of roads they will be posted accordingly. As mentioned earlier, by setting the maximum speed limit at 20 mph our dirt road system will suffer less wear and tear resulting in lower yearly maintenance costs. Another benefit not mentioned in setting a maximum speed limit of 20 mph and perhaps not realized by the community is the reduction in particulate matter (aka "airborne dust").

1.2 Implementation and Prioritization

The full implementation of this road management plan will be accomplished when all necessary road system information is collected and incorporated into the second working draft of this document. Collection of this information is the first step in implementing this plan. Information such as road inventory and condition, current roadway widths and surveying of roadway easements, drainage and ditch conditions needs to be collected in order to determine and schedule priority work for each year. Collecting this vital information will be done in a systematic approach using the following guidance documents:

Gravel Roads Maintenance and Design Manual, South Dakota Local Transportation Assistance Program November 2000

Unimproved Roads PASER Manual, Transportation Information Center University of Wisconsin-Madison 2001

Recommended Practices Manual, A Guideline for Maintenance and Service of Unpaved Roads (Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority, February 2000)

2.0 Gravel Road Basics and Current Inventory

Everyone involved in gravel road maintenance must understand the correct shape of the entire area within the road's right-of-way. Figure 3-1 shows a typical cross section of a gravel road.

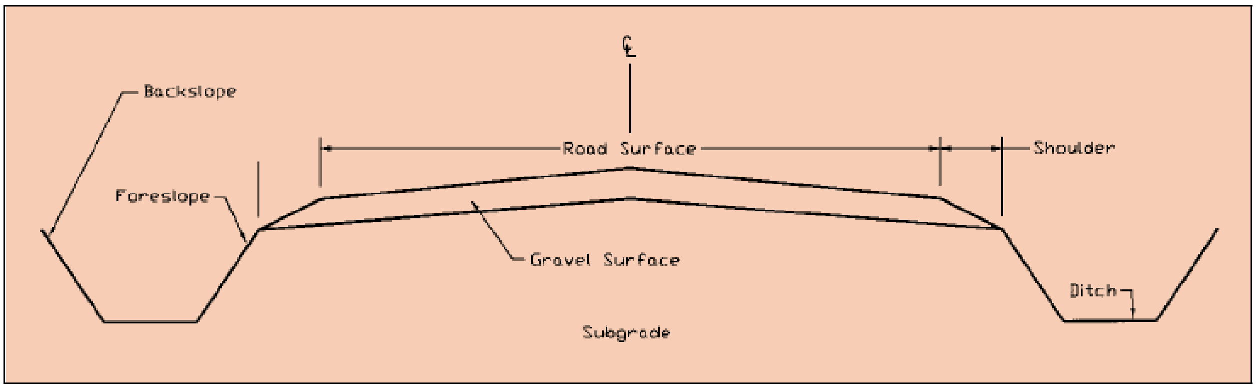


Figure 3-1: Road cross section (from Gravel Roads and Maintenance and Design, SD LTAP Nov. 2000)

In order to maintain a gravel road properly, there needs to be an understanding of three basic road components: (1) a crowned driving surface, (2) a shoulder area that slopes directly away from the edge of the driving surface, and (3) a ditch. The shoulder area and the ditch of many of the VCHPOA gravel roads are minimal to nonexistent. Regardless of where the road is located it must have the basic shape of the cross section in Figure 3-1 or it will not perform well, even under very low traffic. Most paved roads are usually designed and then constructed with careful consideration given to correct shape of the cross section. Once paving is finished, the roadway keeps its shape for an indefinite period of time. Gravel roads are quite different. Unfortunately in our case, many of our gravel roads were not constructed well initially and subsequent road maintenance has not been performed correctly either.

2.1 Road System Evaluation

A determination of inspected VCHPOA gravel roads revealed that a majority, if not all, of our roads do not meet the minimum recommended design criteria outlined above. A majority of our gravel roads lacked both a crown and shoulder, and in some cases had no effective ditch system to take water away from the roads. Most collector roads (major) also have inconsistent widths along their entire distance. The inspection also revealed that some private driveway entrances impact the VCHPOA gravel roads causing damage during the wettest periods of the year. Some private driveways lack culverts, some have improperly sized culverts, and some have improperly installed culverts.

2.2 Road Inventory

The following is a list of the VCHPOA roadways and their approximate lengths:

Table 1: Main Paved Roads	
Name	**Length (ft)**
Cartwright	13,300
Total	**13,300**

Table 2: Main Gravel Roads	
Name	**Length (ft)**
Empire[1]	8,000
Sazarac	4,700
Clemons	2,200
Panhandle[1]	300
Agate	900
Adobe[1]	3,200
Dortort	3,300
Crestview	3,200
Total	**25,800 ft**

Table 4: Secondary Gravel Roads			
Name	**Length (ft)**	**Name**	**Length (ft)**
Grizzley	1,800	Alpine	900
Appaloosa	900	Hermit	900
Adobe (remaining length)	900	Mustang	1,100
Adobe Spur	700	Conestoga	600
Sullivan	800	Delta	3,500
Morgan	1,400	Colt	800
Harte	1,900	Sutro	600
Panhandle (remaining length)	900	Goodman	300
Clemons (remaining length)	2,400	Graves	2,000
Prospect	400	Bowie	900
Nugget	1,300	Enterprise	2,500
Bonanza	5,400	Empire (remaining length)	500
Highland VCHPOA	2,300	Diablo	600
Highland Spur	300	Bulette	800
Saddleback	2,900	Calavaras VCHPOA	1,100
Applegate	1,500	Silverado	2,800
Pine Crest	400	Stallion	400
Flint Ridge	400	Palamino	500
Total		**47,400 ft**	

The VCHPOA is responsible for maintaining approximately 73,200 linear feet of dirt roads and 13,300 feet of paved surface. This equates to 13.9 miles of gravel roads and 2.5 miles of paved road, totaling 16.4 miles of roadway.

2.3 Culverts

Table 5: Culvert Inventory

Name	Number of Culverts	Name	Number of Culverts
Cartwright		Mustang	
Empire		Highland Spur	
Sazarac		Conestoga	
Clemons		Applegate	
Panhandle		Pine Crest	
Agate		Flint Ridge	
Adobe		Silverado	
Enterprise		Stallion	
Dortort		Delta	
Saddleback		Colt	
Grizzley		Sutro	
Appaloosa		Goodman	
Palamino		Livery	
Adobe Spur		Remington	
Sullivan		Fey	
Morgan		Graves	
Harte		Bowie	
Alpine		Diablo	
Hermit		Bulette	
Prospect		Crestview	
Nugget		Calavaras	
Bonanza		Highland	

2.4 Ditch Inventory

Table 5: Ditch Inventory			
Name	**Number**	**Name**	**Number**
Cartwright		Mustang	
Empire		Highland Spur	
Sazarac		Conestoga	
Clemons		Applegate	
Panhandle		Pine Crest	
Agate		Flint Ridge	
Adobe		Silverado	
Enterprise		Stallion	
Dortort		Delta	
Saddleback		Colt	
Grizzley		Sutro	
Appaloosa		Goodman	
Palamino		Livery	
Adobe Spur		Remington	
Sullivan		Fey	
Morgan		Graves	
Harte		Bowie	
Alpine		Diablo	
Hermit		Bulette	
Prospect		Crestview	
Nugget		Calavaras	
Bonanza		Highland	
		Total	

2.5 Road Signage Inventory

No signs except Road Name signs. Will need to install proper road signs (speed, dips, curve, yield, others) to address and satisfy liability.

2.6 PASER Ratings

Table 5: Gravel Roads			
Name	**Rating**	**Name**	**Rating**
Cartwright	N/A	Mustang	
Empire		Highland Spur	
Sazarac		Conestoga	
Clemons		Applegate	
Panhandle		Pine Crest	
Agate		Flint Ridge	
Adobe		Silverado	

Enterprise		Stallion	
Dortort		Delta	
Saddleback		Colt	
Grizzley		Sutro	
Appaloosa		Goodman	
Palamino		Livery	
Adobe Spur		Remington	
Sullivan		Fey	
Morgan		Graves	
Harte		Bowie	
Alpine		Diablo	
Hermit		Bulette	
Prospect		Crestview	
Nugget		Calavaras	
Bonanza		Highland	

The PASER Manual for Gravel Roads will be used to rate gravel roads.

3.0 Maintenance and Management Practices

3.1 Maintenance Implementation

3.1.1 Road Grading

Do not disturb roadway sections which *do not* need maintenance while repairing, blading, or grading those sections which do. When routine maintenance is being performed, the amount of disturbed areas will be limited to that which can be re-established to the desired final shape by the end of the work day. To minimize opportunity for degradation of the roadway, it is best not to blade, grade, or drag if rain or freezing temperatures are favorable within the 48 hour forecast. As much as possible, avoid non-essential or non-emergency work near streams or stream crossings during the "wet" months of the year. Save this work for drier seasons. It is best to limit roadway blading to times when there is enough moisture content to allow for immediate re-compaction. Often, an optimum time for this is soon after a rain while the surface materials are still moist but not too wet. Blading with little moisture content in the soil is futile, and is more often a causative factor in road surface degradation such as "washboarding" and other problems associated with loss of fines.

Proper crowning and compacting of the road surface quickens the removal of runoff, thus protecting the road surface from degradation.

Performance
Blading and Dragging Blading and dragging is a smoothing operation which pulls loose material from the side of the road or spreads wind-rowed aggregate to fill surface irregularities and restore the road crown. It is performed with the moldboard tilted forward with light down pressure on the motor grader blade as shown in Figure 3-1. The angle of the moldboard is adjusted to between 30 and 45 degrees, and in most cases, the front wheels are tilted slightly 10 to 15 degrees toward the direction the aggregate should roll. It is a challenge to recover loose aggregate from the shoulder of the roadway without spilling material around the leading edge (toe) of the moldboard. Operating the moldboard without enough angle is a primary cause of this spilling.

Moldboard Angle and Pitch
Along with correct angle, it is important to understand proper pitch or "tilt" of a moldboard. If the moldboard is pitched back too far, the material will tend to build up in front of the moldboard and will not fall forward and move along to the discharge end of the blade. This also causes excess material loss from the toe of the moldboard. It also reduces the mixing action that is desirable when recovering material from the shoulder and moving it across the roadway, leveling and smoothing it in the process. This mixing action is part of routine maintenance. Traffic tends to loosen material from the road surface and displace it to the shoulder area as well as between the wheel tracks. The stone will tend to separate from the sand and the fine sized material. At the same time, small potholes and an uneven surface will develop. It is the job of the maintenance operator to recover the material, mix it again as it rolls along the face of the moldboard and restore good surface shape.

Grader Stability
It can sometimes be hard to keep a machine stable, especially while carrying a light load of material. Counteracting machine bounce or "loping" requires experience in knowing the cause and then finding a solution. If a motorgrader begins to rock from side to side - often called "duck walking" in the field - it is usually caused by blade angle that closely matches the angle from corner to corner of the tires on the rear tandems. The solution is generally to stop, change angle slightly on the moldboard and slowly resume blading. Simply reducing speed will often eliminate the loping effect of a machine. Experimenting with different tire inflation pressures can also help stabilize a machine as well as leaning the front wheels in the direction that material is being moved. Filling tires with liquid ballast to about 70% capacity is sometimes done to increase traction, weight and stability of the grader. The ballast often used is a solution of calcium chloride and water. Stability problems that are constant and severe should be brought to the attention of your equipment dealer and/or tire supplier.

Articulation
Virtually all modern motorgraders are equipped with frame articulation. It can be an advantage to slightly articulate the machine to stabilize it even in a common maintenance operation.

Crown
Establishing proper crown in the gravel surface probably generates more controversy than any other aspect of good maintenance. How much crown is enough? Can one get too much? What is a recommended crown? First of all, problems develop quickly when a gravel road has no crown. Water will quickly collect on the road surface during a rain and will soften the crust. This will lead to rutting which can become severe if the subgrade also begins to soften. Even if the subgrade remains firm, traffic will quickly pound out smaller depressions in the road where water collects and the road will develop potholes. A properly drained gravel road should have crown. Yet an operator can also build too much crown into the road surface. This can lead to an unsafe condition in which the driving public does not feel comfortable staying "in their lane" or simply staying on the right side of the road. Because of the excessive crown, drivers begin to feel a slight loss of control of the vehicle as it wants to slide towards the shoulder. There is additional risk driving on gravel roads with excessive crown in regions that experience snow and ice cover. For these reasons drivers will tend to drive right down the middle of the road regardless of how wide it is.

What then is recommended crown? Recommendations from supervisors and skilled operators across the country indicate that at least 1/2 inch of crown per foot (approximately 4%) on the cross slope is ideal. It is also recognized that it is virtually impossible for any operator to maintain an absolutely uniform crown. However, try to deviate as little as possible. There are crown gauges available which can be used to determine existing crown. There are also very sophisticated electronic slope controls available for graders. These are found more often in construction operations than in maintenance, but certainly can be used for maintenance.

There is one further problem with crown that needs to be discussed. The ideal shape is a straight line from the shoulder up to the centerline of the road. This gives the road the same shape as the roof of a house, often referred to as a flat "A" shape. However, this shape can sometimes become rounded. The engineering term for this is "parabolic crown." This is virtually always a problem. The middle portion of the road will have considerably less crown than the outer edges. Water will not drain from the middle and potholes and ruts will form. The greatest cause of parabolic crown is excess wear at the center of the cutting edge. This is normal wear and will vary with types of gravel, width of road, wheel path location and other factors. A good operator will make an effort to avoid the parabolic shape on a roadway by keeping the cutting edge straight.

A simple method is to use a cutting torch and straighten the cutting edge whenever 1/2 to 3/4 inch or more of center wear exists. Another method is to use a thicker, harder section of cutting edge in the middle of the moldboard to resist wear. This will retard excess center wear, but generally will not eliminate it. Another option is to use the modern carbide-tipped bits on the cutting edge. These are extremely wear resistant and dramatically reduce center wear. There are also carbide insert or carbide-faced cutting edges that are very wear-resistant.

In summary, the recommended crown is a straight line from the shoulder to the centerline that rises approximately 1/2 inch per foot (or approximately 4%).

The following will be adhered to when blading:

a. Avoid blading during extended dry periods to minimize the loss of fine aggregates and minimize “washboarding”. If blading cannot be avoided during dry periods then a water truck and a compactor will be used in conjunction with the blading effort.

b. Blading/dragging speed depends on the operator’s skill, type and condition of machine (grader), tire pressure, and road surface condition. Normally, **three miles per hour in second gear is advised**.

c. Periodically blade the road surface against traffic flow to prevent aggregate from drifting onto ends of bridges, culverts, intersections, and railroad crossings. This is commonly referred to as “back dragging”.

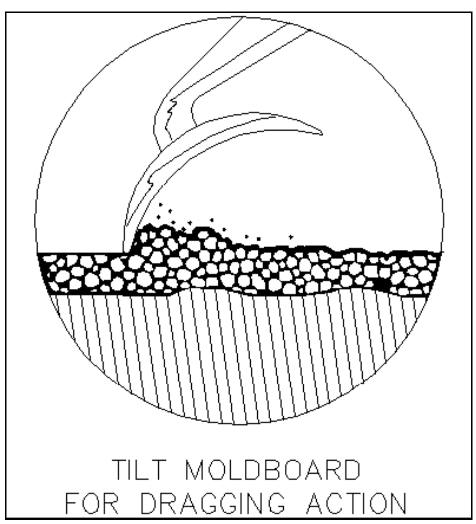
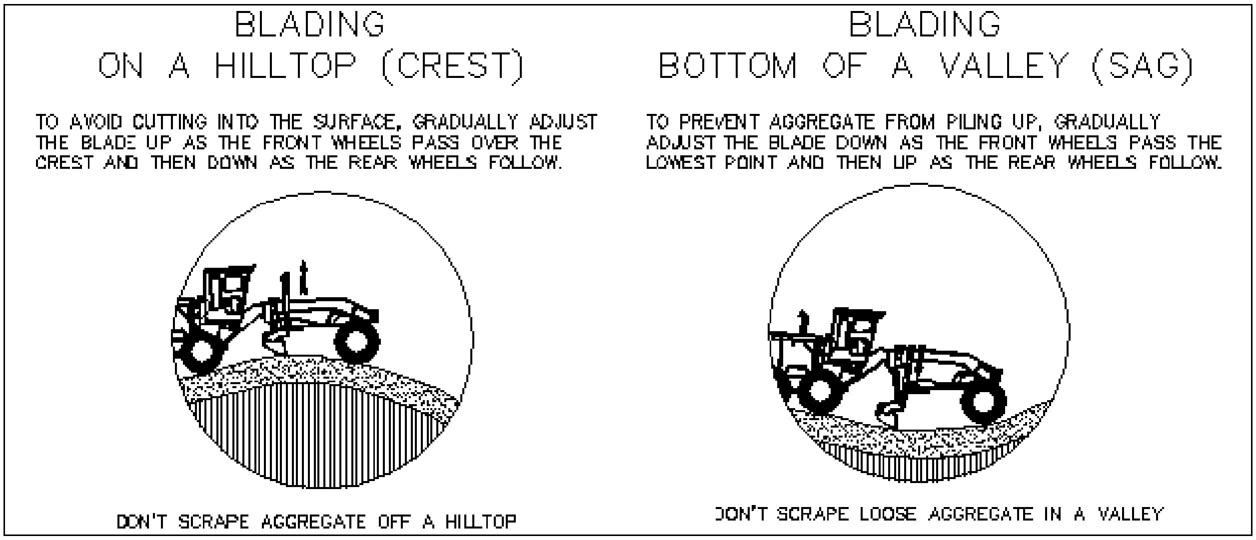


Figure 3-1. Blading (from Recommended Practices Manual, A Guideline for Maintenance and Service of Unpaved Roads, February 2000)

d. On hill crests, avoid cutting into the road surface, gradually adjusting the blade up as the front wheels pass over the crest and then down as the rear wheels follow (figure 1- 3a).

e. In valleys or swags, gradually adjust the blade down as the front wheels pass the lowest point and then adjust the blade up as the rear wheels follow. This will prevent loose, easily erodible materials from piling up where runoff and concentrated flows frequently occur, thus preventing loss of valuable road fill, and preventing massive sedimentation to local streams and waterways (figure 1-3b).



(a) (b)

Figure 1-3. Blading on Hill Crests and in Valleys or Swags (from Recommended Practices Manual, A Guideline for Maintenance and Service of Unpaved Roads, February 2000)

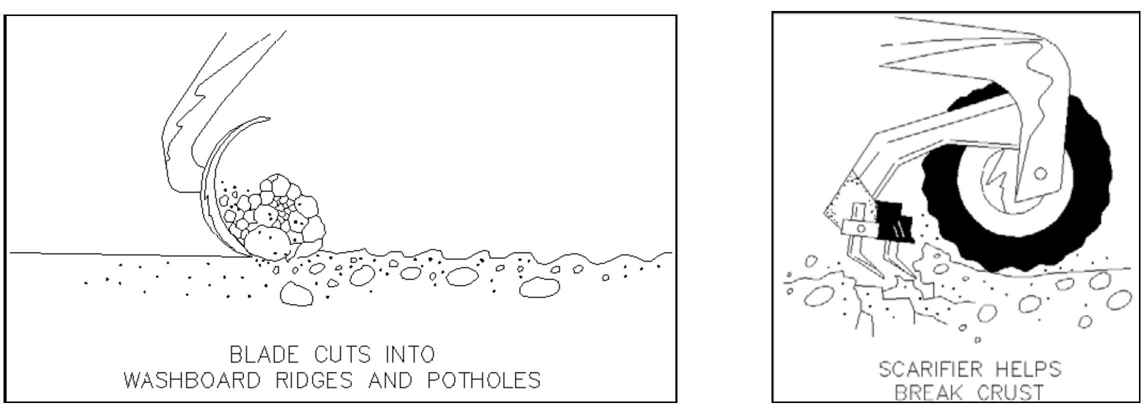
Gravel roads are generally maintained by routine blading and adding gravel as needed either by “spot graveling” or regraveling entire sections. However, almost any gravel road will gradually begin to show distress that requires more than routine maintenance to correct. The most common problems that develop are “berms” or secondary ditches that build up along the shoulder line and the shifting of material from the surface to the shoulder area and even onto the inslope of the grade. This comes from gravel being displaced by traffic, winter plowing operations, erosion of material during heavy rain and sometimes from poor routine blading techniques. This often causes major problems with drainage. At certain intervals, virtually every gravel road requires some major rehabilitation.

Reshaping Surface and Shoulder

These can usually be corrected with the motorgrader alone. Spring is the best time for this as there is minimal vegetative growth and moisture is present. The reshaping of the driving surface and the road shoulder can be done by cutting material with the motorgrader and relaying it to the proper shape and crown. If possible, the use of a roller for compaction will greatly improve the finished surface. This will leave a denser, stronger, smoother surface that will be easier to maintain.

Reshaping Entire Cross Section
Severe rutting, loss of crown, gravel loss and deep secondary ditches — a combination of any two or more of these calls for a major reshaping. This requires a much greater effort. It often occurs after a gravel road has been subjected to an unusually heavy haul. This will be worse if a heavy haul occurs during wet weather. Major reshaping often has to be done on the entire cross section and it may have to be done immediately regardless of the vegetative growth. Motorgraders, disks, pulverizers/mixers and rollers are often needed. These are not always available, but certainly make the job easier. The field supervisor's knowledge and the operator's skill in knowing how to rebuild the cross section becomes very important. These projects seldom have the benefit of much planning or technical assistance. There is seldom any surveying or staking done. But it is very important to rebuild a uniform cross section and pay attention to restoring good drainage. Only after this is done — and done correctly — should good surface gravel be replaced.

Reconstructive Grading
Reconstructive grading consists of cutting through, redistributing, and re-compacting the road surface crust, and/or adding new road fill material to obtain the desired roadway shape and profile. This method is used when reshaping the roadway or when the correction of major surface defects such as deep ruts, soft spots, severe erosion, etc. is necessary. Figure 1-4a shows motor grader cutting operations performed with the moldboard tilted backward with sufficient down pressure on the blade to produce a cutting action. Breaking the crust with a scarifying rake may be required before moldboard work can be performed (see figure 1-4b).



(a) (b)

Figure 1-4. Grading Tools (from Recommended Practices Manual, A Guideline for Maintenance and Service of Unpaved Roads, February 2000)

The following should be adhered to when grading:

a. Perform grading cutting operations with the outer edge of the moldboard at the road surface's edge.

b. If the road ditch is not to be re-worked along with road grading operations, keep a minimum of one foot from the ditch line so that vegetation or rock stabilization is not disturbed. In this case, grading work must always bring the road surface back up to and slightly above the ditch line elevation to allow road surface runoff to flow into the ditch and not create a *false ditch* down the roadway (figure 1-5).

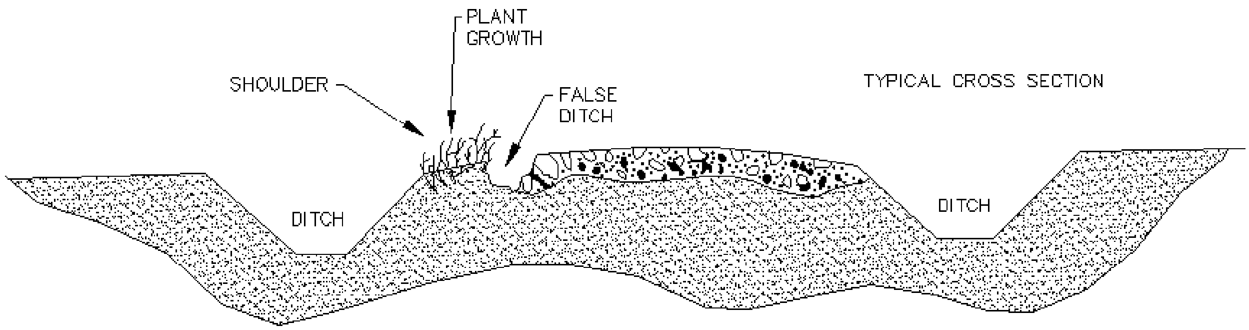


Figure 1-5. False Ditch (from Recommended Practices Manual, A Guideline for Maintenance and Service of Unpaved Roads, February 2000)

c. Lightly scarify the existing road surface before adding new material. This blends the soils and improves cohesion.

d. Adding new material should be done by running the dump truck down the center of the roadway and dumping as it travels. The new material should then be blended with the scarified old material using a grader, and compacted.

e. To reduce potential roadway degradation, the entire width of the roadway disturbed by grading should be compacted by the end of the day.

f. Positive drainage to road ditches or other outlets must be established throughout the entire finished road surface.

Erosion Control

Having discussed the importance of reshaping a gravel road, there is another issue that must be addressed. When major reshaping is done outside of the traveled way, vegetation and ground cover will obviously be disturbed. This can lead to erosion of soil. The problem will vary depending on the region. In arid and semi-arid areas, the problem is small or nonexistent. Areas which receive frequent rains, have rolling or rugged terrain, and have highly erodible soils, are particularly vulnerable. When vegetative cover is disturbed,there are problems that can arise. While trying to eliminate problems, new ones can be created such as clogged culverts and blocked ditches, pollution of streams and lakes, and eroded slopes which can shorten the life of improvements. You may be found in violation of state and federal regulations. Damage claims and lawsuits may be filed. The solution to this issue is not to cancel plans for gravel road improvement, but to plan your work carefully and use methods of reducing or eliminating erosion. Here are some things to consider: • Some regions have certain times in the year when frequent and heavy rainfall can be expected. Try to avoid major reshape work during those periods of time.

- Keep disturbed areas small. The more earth you disturb, the greater will be the risk of soil erosion. Set work boundaries and don’t let work crews get outside of them.

- Consider stabilization of disturbed areas. Silt fences, mulching, erosion control blankets and other means should be considered.

- Keep water velocity low. Removing vegetative cover and topsoil generally increases the amount and speed of runoff. Keep slopes as shallow or gentle as possible. Keep ditch slope as gentle as possible. Shorten drainage runs and work to get vegetative cover reestablished as soon as possible after work is finished.

- Keep sediment within work boundaries. Sediment can be retained by filtering water as it flows (as through a silt fence), and ditch checks will retain dirty runoff water for a period of time until the soil particles settle out.

- Inspect recent work. This is vital to make sure channels haven't formed in ditch bottoms or on slopes, or around and under controls that were used. Be particularly vigilant after heavy rains.

Distress Conditions

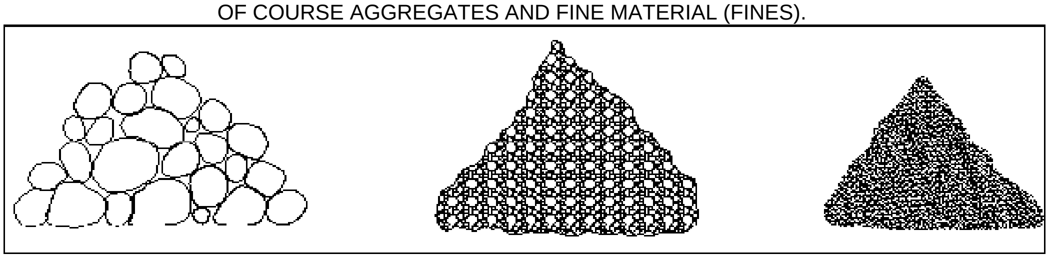


Figure 1-6. Aggregate Comparison (from Recommended Practices Manual, A Guideline for Maintenance and Service of Unpaved Roads, February 2000)

Surface Deteriorations
Dust

Dust in the air is a loss of fine, binder aggregates from road surfaces. Loss of these fines leads to other types of road distresses such as loss of cohesion and compaction of the road fill material, and reduced capacity to maintain moisture in the road fill. These deficiencies also tend to feed on themselves, compounding the problems - especially the lack of moisture within the road fill. Mechanically adding water to the road surface for dust control is a very short-term, expensive, and infeasible solution. In some cases, dust can be reduced by applying chemical additives which draw moisture from the air to improve fine aggregate cohesion, however, this also can be an expensive solution and may be feasible only in the most severe cases.

Raveling

Raveling is the loss of coarser aggregates. This is brought about when the coarser aggregates are worn away by traffic after fine, binder aggregates have been lost due to dust or erosion. Correct by grading or blading with the addition of fines or other binder to improve surface gradation and composition.

Slipperiness

Slipperiness is caused when the road surface contains excessive fine aggregates in proportion to coarser aggregates, especially within the crust. Traffic wear can reduce coarse aggregates to finer aggregates, thus disproportioning the original road fill aggregate mix. During wet weather, the road surface becomes slippery and may become impassible. This problem can be corrected by mixing the surface fines with coarser aggregate by grading and/or blading the road surface and compacting back in place. Occasionally, coarser aggregate will need to be hauled in and added to the roadway.

Surface Deformations

Surface deformation problems are almost solely the end result of excessive moisture in the road fill and thus can be reduced with proper road surface and road ditch maintenance.

Rutting

Ruts are longitudinal depressions in the wheel paths caused by high moisture content in the subsurface soil or base, inadequate surface course thickness, and /or heavy traffic loads. Rutting can be corrected by adding suitable material, grading, crowning, and rolling the road surface. Do not simply fill ruts with stone or soil. Filing ruts with stone can lead to new ruts being generated beside the original ones and thus would be an expensive and temporary "fix" which can also interfere with grading. The surface must be re-mixed and properly bladed or graded in more severe cases. Areas of sustained and repeated rutting may require more severe measures. An elaborate drain system and/or geotextile fabric foundation with a crushed stone road fill may be used to correct severe rutting problems.

Corrugating/"Washboarding"

Corrugating/"washboarding" is a series of ridges and depressions across the road surface caused by the lack of surface cohesion. This lack of cohesion is a result of the loss of fines in the road surface which, in turn, is usually a result of very dry conditions within the road surface. These conditions are aggravated and enhanced by excessive vehicle speeds and high traffic volumes. Where surface fines are segregated from coarser aggregates, blading with sufficient moisture content can repair the road surface. When the causative problem is of loss of fines, blading alone is not recommended. The problem will only recur shortly thereafter. The problem is best corrected by scarifying the road surface while damp, thereby re-mixing the road surface with a good percentage of fines, regrading, re-establishing the crown, and compacting the surface.

The two causes just mentioned are completely out of the control of gravel maintenance operators and managers. The third primary cause - the quality of the gravel - is the cause we need to concentrate on. Good quality surface gravel is thoroughly discussed in Section 3.1.5. Simply put, good gravel must have the right blend of stone, sand, and fines. The stone should be fractured and the fine-sized particles should have a binding characteristic, technically called "plasticity." This type of gravel resists washboarding; however, the maintenance operators also must do their part.

Virtually any gravel will develop some washboard areas under traffic. The key for the maintenance operator is to strive to keep the material blended. In dry conditions, the operator can only smooth the road temporarily. When moisture is present, it pays to quickly get out and rework these areas. The material should be cut to a depth of one inch or more below the depressions, mixed and relayed to the proper shape. If time allows, using the machine to apply wheel compaction to material will help reform the crust. If possible, use of a roller will improve the compaction.

With the best of maintenance, washboarding can never be completely eliminated. However, the key to reducing it is to work hard at obtaining quality gravel with a good binding characteristic. The operator can then reshape trouble spots when moisture is present and most roads will perform quite well.

If a motorgrader causes washboarding, it is almost always the result of running it at too great of a speed. The ridges and depressions will be spaced further apart. The solution to the problem is simple - reduce grading speed! Another problem can be improper tire inflation pressure or defective tires. This will cause a motorgrader to bounce or otherwise operate in an unstable manner.

Intersections
There is one important thing to understand in knowing how to shape a gravel intersection: is it a controlled or uncontrolled intersection? This means: does traffic have to stop or yield from side roads? If so, it is a controlled intersection. The primary road on which traffic passes through should retain its crown and the intersecting roads should have its crown gradually eliminated beginning approximately 100 feet before the intersection. At the point of intersection, the side roads are virtually flat to match the primary road. When the intersection is uncontrolled the roads should all have the crown gradually eliminated beginning approximately 100 feet from the intersection. The intersection itself becomes virtually flat, allowing vehicles to pass through without feeling a noticeable hump or dip from any direction.

Intersections with Paved Roads
The rule for shaping these intersections is always the same. Begin to eliminate crown on the gravel road approximately 100 feet from the edge of the pavement. At the intersecting point, the gravel should match the paved surface. This requires continual attention since potholes can easily develop at the edge of pavement. However, be careful not to push gravel out onto the pavement since this causes a dangerous loss of skid resistance on the pavement. The technique of "back-dragging" is useful in these operations. In order to fill a pothole at the edge of pavement, extra material may spill onto the pavement. Simply pick up the moldboard and set it down in front of the material, then back up and spread the excess back on the gravel road.

Superelevation at Curves
This is one of the biggest challenges in gravel road maintenance and a situation that is not understood very well by many operators. This is sometimes called "banking a curve" in the

field. The outer edge of the roadway is higher than the inside edge and the road surface is shaped straight from the upper to the lower edge. Once again, as the operator approaches a curve, adjustments should be made with the blade to take out the normal crown and begin to transition into a straight, superelevated surface. This shape should be maintained uniformly throughout the curve. A gentle transition is then made at the other end back to a normal crowned road surface when you are once again on a straight section of road. This requires constant attention during each maintenance pass over the road. Traffic will tend to displace the gravel towards the upper end of the road and the inside of the curve will become lower. Curves can very easily go out of proper shape.

The correct amount of slope or "banking" of a curve can only be determined by engineering analysis. There is also a device available for determining the safe speed of a curve called a ball bank indicator.

Driveways

The public road should always retain its normal crowned shape while passing driveways. Too often the gravel builds up on the road at a driveway entrance. This changes the shape of the roadway itself, which can cause loss of control of vehicles. The driveway entrance should always match the edge of the public road. Water runoff should be shed off the driveway and away from the roadway into ditches and not onto the roadway itself.

Depressions

Depressions are localized low areas one or more inches below the surrounding road surfaces caused by settlement, excessive moisture content, and improper drainage. These are larger areas not to be confused with potholes. Depressions should be corrected by filling them with a well-graded aggregate, then grading the effected road surface, and compacting. Underdrains or cross drains may be necessary to improve drainage and prevent recurrence.

Potholes

Potholes are small depressions or voids in the road surface one or more inches deep which are caused by excessive moisture content, poor drainage, poorly graded aggregate, or a combination of these factors. Potholes may be corrected by patching with well-graded materials and compacting, and/or spot grading. Large areas of potholed road surface indicate a poor road fill condition over an extended section of roadway, and thus may require the re-grading, re-crowning, and re-compacting of the affected roadway section to mix aggregates into a well-graded road fill and improve road surface drainage. Underdrains may also be necessary in these areas to drain the sub-grade.

Soft spots

Soft spots are areas of the road surface and/or sub-grade made weak by poor drainage. These areas depress under vehicular weight and almost always develop one or more of the other types of surface deformations. These areas can be corrected by improving drainage conditions or replacing the soft spot with more drainable materials. Depending on the cost effectiveness and feasibility of each, the following methods may be used to correct soft spots:

a. Improving the drainage of the road fill and/or sub-grade with underdrain. This method is outlet dependent.

b. Improving the drainage of the road fill and/or sub-grade by grading road ditches low enough to remove water from beneath the problem area. This may involve piping to move water from one side of the road to the other. This method is outlet dependent.

c. Patching the soft spot area with a suitable material such as well-graded stone or gravel.

d. A combination of the above.

Road Shoulder

The road shoulder serves several essential functions. It is there to support the edge of the traveled portion of the roadway. But another important function is to provide a safety area for drivers to regain control of vehicles if forced to leave the road surface. Yet another important function is to carry water further away from the road surface to the foreslope and ditch.

In order for the shoulder to perform all of these functions, its shape is critical. First of all, the shoulder should meet the edge of the roadway at the same elevation. In other words, the shoulder should be no higher or no lower than the edge of the roadway. By maintaining this shape, the low shoulder or drop-off is eliminated which is a safety hazard and also reduces roadway edge support. But the other extreme, which is a high shoulder, should also be avoided. This will be discussed later.

It is also recognized that gravel roads in some regions, particularly those with very narrow right-of-ways, have very little shoulder area. In some cases, the edge of the roadway is actually the beginning of the foreslope down to the ditch. But here again, it is important that there is not a steep drop-off or a ridge of soil to block drainage. Maintaining shoulders is a critical part of gravel road maintenance.

High Shoulders (Secondary Ditches)

This problem can be seen along gravel roads almost anywhere people travel. There are many slang terms used in the field such as “berms” or “curbs.” The engineering term for this condition is “secondary ditch” and it is a good description of the condition. When a gravel road develops a high shoulder, it destroys the drainage of water directly from the surface to the real ditch. This causes several problems. In relatively level terrain, the water collects here and seeps into the subgrade, often causing the whole roadway to soften. In rolling and rugged terrain, the water quickly flows downhill along the secondary ditch, often eroding away a large amount of gravel and even eroding into the subgrade. This also creates a serious safety hazard. There are many reasons to work hard to eliminate secondary ditches.

Causes of High Shoulders

What causes secondary ditches to form? There are several causes. They can develop from improper maintenance such as losing material from the toe of a grader’s moldboard, which builds up a high shoulder, or from cutting too deep at the shoulder line with the toe of the moldboard. This is a particular problem when the cutting edge is not kept reasonably straight.

But there are other causes, such as excessive “whip-off” of loose material from fast traffic, which tends to build up along the shoulder line. Also, heavy loads on gravel roads with weak subgrades can cause this problem as well. When heavy vehicles have to travel near the shoulder while meeting other vehicles, the roadway can rut while the shoulder area shoves upward. Yet another cause is the buildup of sand in northern regions where winter ice/snow control requires some winter sanding operations on gravel roads. An expert in the field once made this statement: “It is difficult to completely eliminate secondary ditches, but it pays to work hard to keep them to an absolute minimum.” This is excellent advice. The time spent in dealing with a high shoulder (secondary ditch) will result in a road that is easier to maintain afterwards. But the real challenge is getting the job done.

Pulling Shoulders and Covering

The material from a high shoulder is not always suitable to be reused on the roadway. It may be best to cut the material loose, pull it onto the roadway and then load and remove it. However, this can be very expensive. It is sometimes acceptable to pull the material and cover it. A method called “sweeping it under the carpet” may be used in this case.

Make sure that the soils are suitable to be used as base material under the edge of the roadway and shoulder before doing this. If you’re not absolutely sure, try this on a test section of 1000 ft. or less to see how it performs. This method works best when there is a lot of sandy soil both in the subgrade of the roadway and also in the material recovered from the high shoulder. The sand will be unsuitable to recover and spread onto the roadway, but will be reasonably easy to cut and place under the gravel that will be placed back over it. If the road is scheduled to be regraveled, it is an excellent time to do shoulder work to get the roadway back into good shape.

Again, this is much more than routine maintenance and signs should be placed to warn motorists of roadwork being done. A better option would be to close the section of road being worked on if possible.

3.1.2 Ditches

Ditches are constructed to convey water from storm runoff to an adequate outlet. A good ditch is shaped and lined using the appropriate vegetative or structural material and does not cause flooding, erosion, or sedimentation. Energy dissipating structures to reduce velocity, to dissipate turbulence, or to flatten flow grades in ditches are often necessary.

Efficient disposal of runoff from the road will help preserve the road bed and banks. Well vegetated ditches slow, control, and filter runoff providing an opportunity for sediments to be removed from the runoff water before it enters surface waters. In addition, a stable ditch will not become an erosion problem itself. Ideally, “turn-outs” (intermittent discharge points also called “tail ditches”) will help maintain a stable velocity and the proper flow capacity within the road ditches by timely outleting water from them. This will help alleviate roadway flooding, reduce erosion, and thus reduce maintenance problems. In addition, properly placed “turn-outs” help distribute roadway runoff and sediments over a larger vegetative filtering area, helping to reduce the amount of road ditch maintenance required to remove caught-up sediment.

Ditch Profile and Grading
Roadway ditch location, profile, shape, lining and outlets effect how efficiently water will be removed from the roadway. Ideally ditches should resist erosion, be self cleaning, and discharge onto nearly level vegetated areas, thus maximizing the length of time between regrading, thereby reducing maintenance costs. As shown in figure 2-1, ditches should be located on the uphill side of the roadway to prevent runoff water from flowing onto and over the road surface.

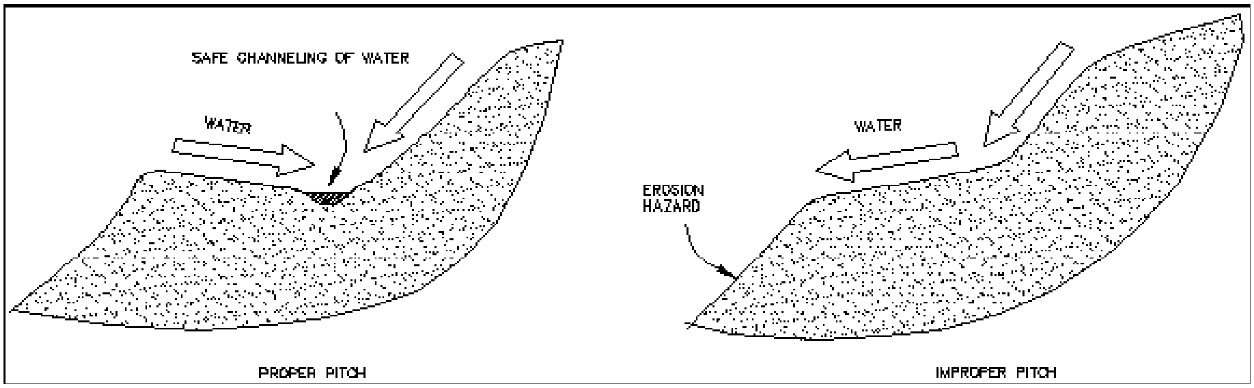


Figure 2-1. Hillside Pitch of Roadway and Proper Ditch Location (from Recommended Practices Manual, A Guideline for Maintenance and Service of Unpaved Roads, February 2000)

Excavate roadway ditches at a bottom elevation 1 to 2 feet below the road base. The ditch bottom should be rounded-V shaped (preferred), parabolic, or flat, as shown in figure 2-2, and at least 2 feet wide to disperse the flow and slow the velocity. Do not construct U-shaped ditches. U-shaped ditches actually have up to 30 percent less drainage capacity than other shapes and they tend to look messy. Their steep sides make maintenance difficult and the sides tend to cave in, compounding maintenance problems and adding to erosion and sedimentation.

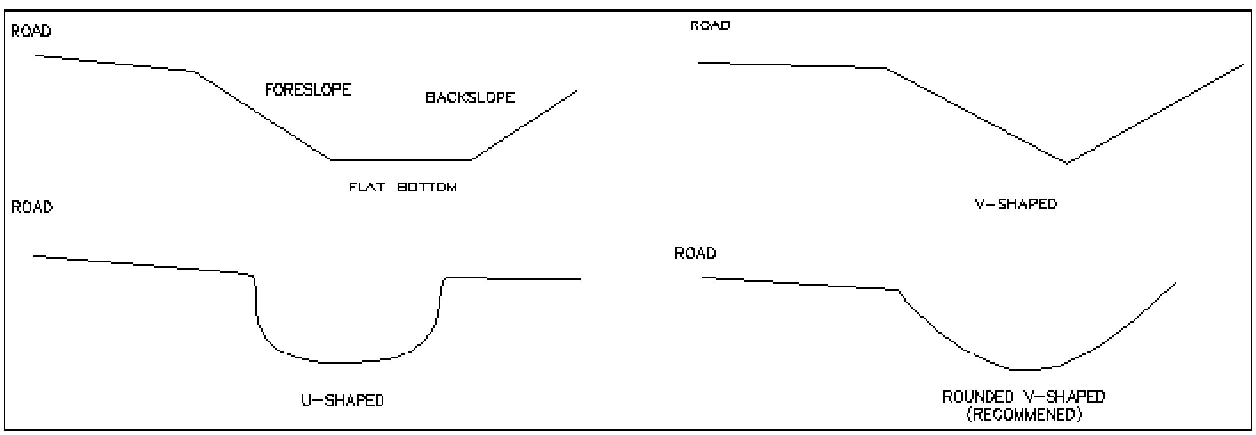


Figure 2-2. Common Ditch Shapes (from Recommended Practices Manual, A Guideline for Maintenance and Service of Unpaved Roads, February 2000)

Where possible, install "turn-outs" ("tail-ditches") to help maintain a stable velocity and the proper flow capacity within the road ditches by timely outleting water from them. See Figure 2-3 below. These structures are critical elements in establishing and maintaining a stable unpaved roadway drainage system. It is imperative that landowners adjacent to these roadways allow water to be discharged in this manner at crucial points. Correspondingly, these turn-out points must be stabilized to prevent creating worse erosion problems such as gullies. In many cases, the discharged runoff can be spread to reduce the erosive energy of concentrated flows.

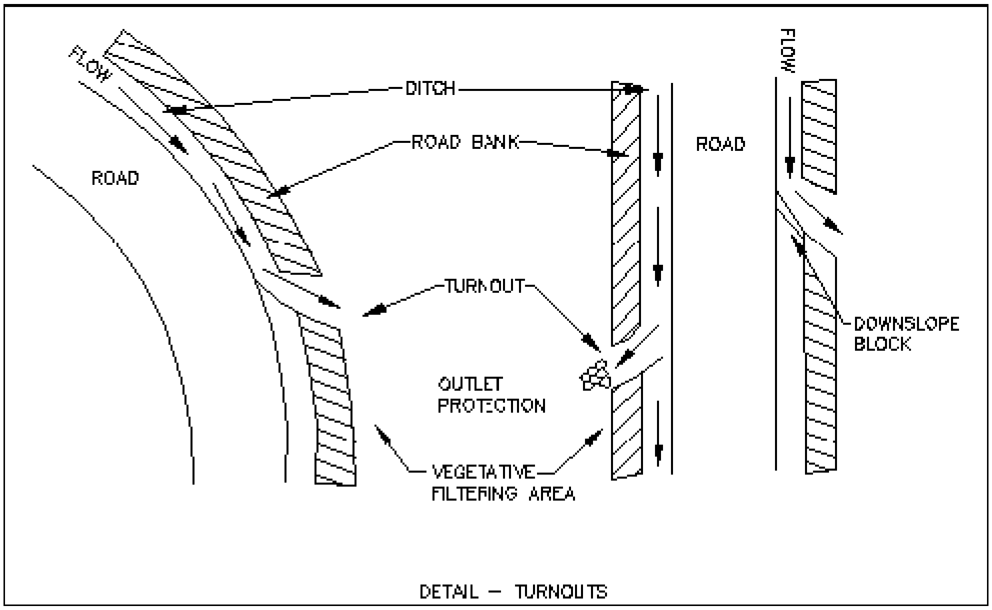


Figure 2-3. Typical Locations for "Turnouts" ("Tail Ditches") (from Recommended Practices Manual, A Guideline for Maintenance and Service of Unpaved Roads, February 2000)

Line ditches which have a channel slope less than 5% with grass, and line those which have a 5% or greater channel slope with geo-fabric or aggregate filter underlain riprap or other material. Line ditches as soon as possible to prevent erosion and to maintain the ditch profile. Whenever possible, excavate ditch only as far as lining can catch up before the next expected or potential rainfall event.

All ditches should have appropriate outlets which allow water to completely drain from them. Standing water in ditches against road fill weakens the roadway. The preferred equipment for creating ditches is a rubber-tired excavator with an articulated bucket. A well designed and constructed road ditch can be cleaned with a grader or excavator making maintenance quicker, easier, and less costly.

Other Applications
Diversion ditches and berms may be used as structures to intercept, consolidate, and direct or redirect runoff at the top of a slope to prevent gullies and rills on slopes, or across the slope to break up the slope length or redirect water flow. These ditches and berms should be located where the outlet will empty onto a stable disposal area. Ditches and berms may be used in combination where runoff is significant and/or hard to control.

Cleaning & Maintenance
Check all ditches, including "tail-ditches" and "turn-outs", after major storm events, as the storms may have caused obstructions, erosion, or bank collapse. Have a post-storm plan for checking for damage and determining maintenance needs.

Clean out ditches, when they become clogged with sediments or debris, to prevent ponding, bank overflows, and road washouts. Re-grade ditches only when absolutely necessary and line with vegetation or stone as necessary. Re-grading of ditches should be limited to late spring or summer, after spring rains have diminished and drier weather has set in, and when vegetation can re-establish itself. Other times may be suitable depending on weather patterns, work to be performed, and exigency of work to be done. The main concern is to limit disturbance to the ditches during times of high erosion potential.

3.1.3 Culverts and Drains

A culvert is a closed conduit used to convey water from one area to another, usually from one side of a road to the other side. Culverts preserve the road base by draining water from ditches along the road, keeping the sub-base dry.

Disposal of runoff from roadway ditches help preserves the road bed, ditches, and banks. Strategically placed culverts, along with road ditch turn-outs, help maintain a stable velocity and the proper flow capacity for the road ditches by timely "outleting" water from them. This helps alleviate roadway flooding, reduces erosion, and thus reduces maintenance problems. In addition, strategically placed culverts help distribute roadway runoff over a larger filtering area.

Culvert Profile
Culverts can be divided into two functional types: *Stream Crossing* and *Runoff Management*. The first culvert type, *stream crossing culvert*, is self defining. A culvert is required where the roadway crosses a stream channel to allow water to pass downstream. The second type culvert, *runoff management culvert*, is one which is strategically placed to manage and route roadway runoff along, under, and away from the roadway. Many times these culverts are used to transport upland runoff, accumulated in road ditches on the upland side of the roadway, to the lower side for disposal. These culverts are commonly called *cross-drains*. Installation, modification, and improvements of culverts should be done when stream flows and expectancy of rain are low. Ideally, the entire installation process, from beginning to end, should be completed before the next rain event. All existing and/or reasonable potential stream flows should be diverted while the culvert is being installed. This will help reduce or avoid sedimentation below the installation site.

Culverts for Stream Crossings
When installing culverts (and bridges) for stream crossings, seek to maintain the original and natural full bank capacity (cross-sectional area) of the channel. Constrictions at these points are contributing factors in costly bridge and culvert "blow-outs" which generate a large volume of sediment deposited directly into the stream. Align and center the culvert with the existing stream channel whenever possible. As a minimum, align the culvert with the center of the channel immediately downstream of the outlet. If channel excavation is required to help align the culvert, it is frequently best to excavate the upstream channel to fit the culvert entrance and align the outlet with the existing natural channel. Minimal disturbance of the channel at the culvert outlet should be the priority consideration. Inasmuch as possible, the grade of culverts should be determined by the grade of the existing channel, but usually not less than 0.5% nor more than 1%. The outlet should discharge at the existing channel bottom. A professional engineer,

experienced in hydrology and culvert hydraulics, should be consulted for determination of actual culvert grades when dealing with peculiar alignment or laying conditions, and upon any deviation from normal and usual installation procedures. Keep disturbance of the channel bottom, sides, adjacent land, and surrounding natural landscape to a minimum during installation. Install energy dissipating structures and/or armor at the outlet where scour and erosion are likely to occur from high exit velocities due to steep culvert installation, near proximity to channel banks, drops at the end of the culvert, etc. (see Section 3.1.4). Establish and maintain at least one foot of road bed cover over all culverts. Two feet or more cover is the desired optimum.

Culverts for Runoff Management

Where cross-drains are needed in conjunction with "turn-outs", it is ideal to place culverts no more than 500 feet apart along the roadway to control the volume and velocity of flow within road ditches. Steeper road slopes may require closer spacing to discharge accumulated runoff in excess of ditch capacity and/or to keep velocities down. Inasmuch as possible in non-stream crossing locations, a "turn-out" ("tail-ditch") should coincide with the outlet location of a cross-drain culvert to "dump" transported and accumulated water from the receiving ditch. Where private roads and driveways intersect public roadways, install culverts to maintain continuity of flow within the ditch while allowing access across the ditch. In cases of no head wall, install culverts long enough to extend out at each end at least 2 feet past the toes of the road bank slopes. Install energy dissipating structures and/or armor at the outlet where scour and erosion are likely to occur from high exit velocities due to steep culvert installation, near proximity to ditch banks, drops at the end of the culvert, etc. (see Section 3.1.4). Establish and maintain at least one foot of road bed cover over all culverts. Two feet or more cover is the desired optimum.

Culvert Installation/Replacement

In live (flowing) streams install sandbags, silt fences, earthen dikes, or other appropriate measures to inhibit flow when possible. Use a pump to convey water around the excavation/work site. Discharge pumped water onto a stable outlet to prevent scour. With live stream flows which cannot be impounded, divert the flow to one side of the culvert alignment. Enough room should be allowed to properly excavate the entire pipe trench and bed the entire culvert.

Minimize disturbance of the surrounding soil and vegetation. Excavate trench side slopes on a safe grade to prevent caving. Inasmuch as possible, the bottom of the trench should be at least twice the width of the culvert to be installed and graded as near to designed culvert grade as possible.

One method of properly installing a culvert is to start at the outlet end, lay the culvert up-slope, properly bedding each joint as installation proceeds. The first section or "joint" is critical, and special attention should be given to proper installation, grade, and alignment to reduce the potential for scour and erosion from water discharge, and, to ensure the whole culvert is aligned properly. Pipe joints should be wrapped 1-1/2 times around with geotextile filter fabric. The fabric should extend at least two feet either side of the joint or edges of the connecting band if one is used. This is especially true with concrete or other types of pipes which may not have rubber or mastic seals at the connecting joints. Once the culvert is installed and secured in place, divert the flow through the culvert and commence filling the by-pass channel, if any, and complete the backfilling around the culvert. Backfill around and over the culvert should be placed evenly and level in maximum 12" loose lifts and thoroughly compacted before adding successive lifts. Scarify (roughen) the top two inches of compacted surfaces which have a slick, smooth, or glossy finish after compaction. Six (6) inch loose lifts should be used below the midpoint of the culvert. Do not use or operate machinery closer than two feet of the culvert.

Mulch and vegetate all disturbed areas. Use silt fences or other appropriate erosion control measures to prevent or reduce erosion and sedimentation until stabilizing vegetation is established.

Head Walls (Headers)
Head walls may be used when hydraulic capacity needs to be increased, and/or when installing a head wall will be more efficient than culvert replacement. Head walls should be flush with the end of the culvert. Head wall “wings” (extensions) help mold and direct channel flow into the culvert and protect the area around the inlet from scour. Head walls may be of poured concrete, bagged concrete, concrete blocks, bricks, logs, cut wood, or may be shaped loose rock riprap, etc.

Cleaning and Maintenance
One method to account for all culverts is to maintain an inventory of culverts and under-drains and use a checklist from this inventory to account for culverts during inspections. Inspect culverts often, especially in the spring and autumn, and after storm events, checking them for signs of corrosion, joint separation, bottom sag, pipe blockage, piping, fill settling, cavitation of fill (sinkhole), sediment buildup within the culvert, effectiveness of the present inlet/outlet inverts, etc. Check inlet and outlet channels for signs of scour, degradation, aggradation, debris, channel blockage, diversion of flow, bank and other erosion, flooding, etc.

Practice preventive maintenance to avoid clogging of pipes and other situations which may damage the culvert or diminish its design function. If a culvert is plugged with sediment, flush it from the outlet end with a high pressure water hose. Take measures to reduce downstream sedimentation and clean debris and sediment from the outlet ditch afterwards.

When replacing damaged culverts which handle the flow adequately, use the same size, shape, and type of pipe. Changing any of these criteria may adversely effect the established stability of the ditch, stream, and/or roadway.

3.1.4 Outlet Structures

Outlet structures are used to reduce and/or control energy from ditch or culvert discharge, and release the discharge downstream under controlled, stable conditions.

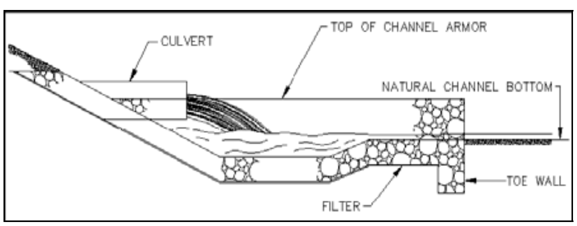
Outlet structures reduce the velocity of water carried by road ditches and culverts, therefore helping to control sedimentation. Water should outlet to areas with moderate slopes and vegetative filter strips or riparian areas before entering surface waters. This type of outlet, often referred to as day-lighting, will allow for most of the sediments to be removed before runoff enters surface waters.

Location
Outlet structures should be located where concentrated, turbulent, and/or high velocity flows are discharged onto areas which can be erosive, or where the discharged water requires filtration or settling of sediments. This can be outlets for swales and road ditches, flumes, runoff management culverts within the road ditch system, or culverts used at stream crossings.

Structures

Splash/Stilling/Plunge Basin
Basins (usually rock- lined) which are water-filled, or will fill with water during runoff events, located at high-energy outlets of conveyance structures such as steep flumes, and more usually, cantilevered pipe outlets.

The purpose is to use the pooled water to dissipate the energy of the flowing water discharged by the conveyance structure. Basins are usually constructed as a depression below the outlet channel elevation as shown in Figure 4-1, but can be constructed with the basin bottom at the outlet channel elevation and the basin formed by constructing a weir (riprap, gabion, etc.) across the outlet channel as shown in Figure 4-2. The basin is usually wider than the outlet channel by design and tapers to fit the existing channel at the basin exit point. The basins must always be lined with a properly sized and/or classified, non-erosive lining such as riprap, concrete mats, gabions, etc. underlain with filter fabric or a graded aggregate filter. These structures require the design services of a professional engineer.



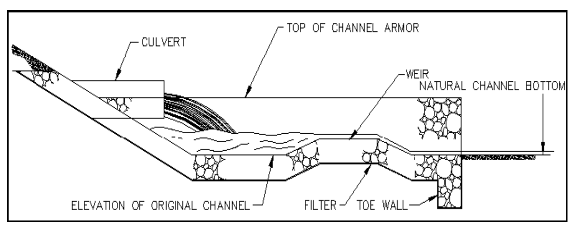


Figure 4-1. Depressed Type Plunge Basin Figure 4-2. Weir-formed Plunge Basin (from Recommended Practices Manual, A Guideline for Maintenance and Service of Unpaved Roads, February 2000)

Splash Apron
A widened, flat, armored area, level to slightly sloping, located at the low-energy discharge point of conveyance structures and/or splash/plunge basins. Flow exiting this structure should enter a stream or vegetated outlet.

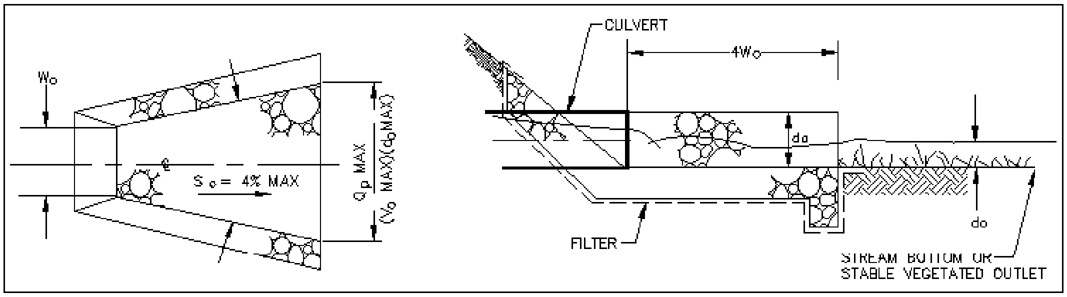


Figure 4-3. Splash Apron (from Recommended Practices Manual, A Guideline for Maintenance and Service of Unpaved Roads, February 2000)

As shown in Figure 4-3, the structure's bottom dimensions taper from a narrow width at the conveyance structure discharge point to a wider dimension at the outlet some distance downstream. This spreads the water in a fanning action over the rough, armored surface reducing the velocity, and promoting sheet flow as the water exits into streams or onto vegetated areas. Armored side slopes are often necessary to prevent scour and erosion along the edge of the structure. The armor usually extends above and around pipe structures and blends into other conveyance structures to prevent scour and undermining at the discharge point. Toe walls may also be necessary where the structure outlets onto earthen surfaces. Armor material should be sized and/or classified to withstand the maximum design discharge velocities.

Drop Inlet/Box/Manhole

An enclosed structure, constructed or prefabricated from reinforced concrete, concrete blocks, bricks, plastic, or other sound structural material, which will receive the discharge end of a culvert, flume, ditch, etc., dissipate the energy, and safely release the discharged runoff at a lower elevation. See Figure 4-4 below.

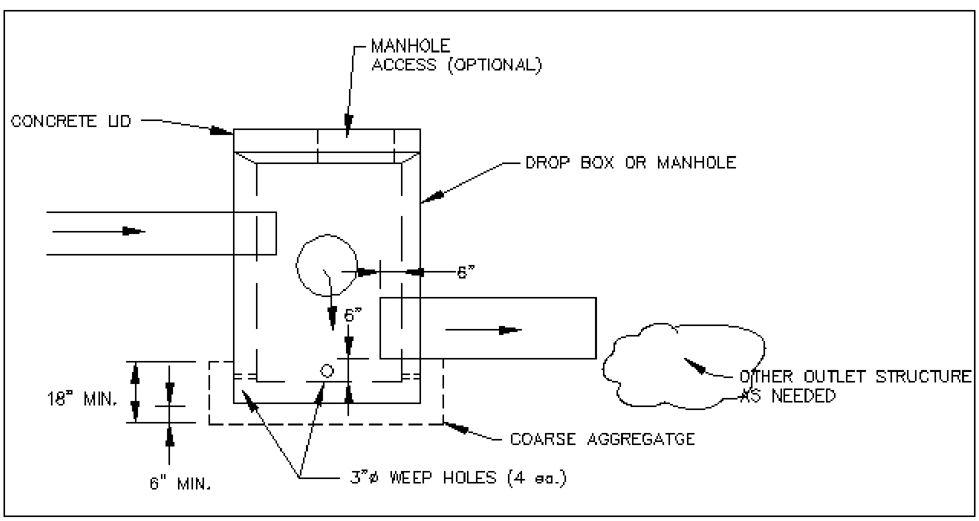


Figure 4-4. Drop Inlet/Box/Manhole Illustration (from Recommended Practices Manual, A Guideline for Maintenance and Service of Unpaved Roads, February 2000)

This structure works well where there is a severe cross-slope from one side of the road to the other and a cross-drain culvert is installed, or where there is a desire to reduce road ditch and flume slopes. This situation is often found where head cutting gullies have eroded up to the roadway. These structures require the design of a professional engineer.

Stilling Well

An enclosed structure, constructed or prefabricated from reinforced concrete, concrete blocks, bricks, plastic, or other sound structural material, which will receive the discharge end of a culvert or pipe, dissipate the energy, and safely release the discharged runoff at a higher level.

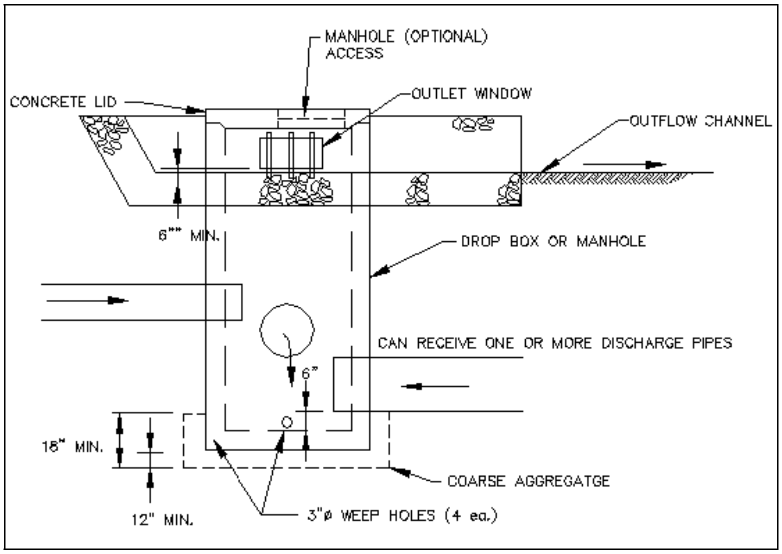


Figure 4-5. Stilling Well Illustration (from Recommended Practices Manual, A Guideline for Maintenance and Service of Unpaved Roads, February 2000)

a. To be used only at the singular outlet location of one or more pipes.

b. Use only when lowest pipe *inlet* invert will be higher than the outlet invert of the stilling well structure.

c. This structure works well in areas where energy dissipating structures are needed at the ends of pipes and there is limited space to install such structures. Also can be a cost-saving structure.

d. These structures require the design of a professional engineer.

3.1.5 Gravel

3.1.6 Road Markings, Postings and Designated Speeds

To be completed in 2006 - 2007

3.2 Equipment, Personnel and Labor

4.0 VCHPOA Road Improvement Plan

NOTE: The following road improvement plan presented below should only be used for long-term planning and as a general outline of the potential scope of work that should be completed each fiscal year. .

4.1 Responsibilities

4.1.1 Road Manager Responsibilities (if available)

The Road Manager will be responsible for preparing a list of annual road repair, restoration and improvements (LARRRI) that needs to be performed in accordance with this document during the upcoming fiscal year. The Road Manager will calculate material costs, labor and equipment, and other costs to complete the work. The Road Manager will submit this information (LARRRI) to the VCHPOA Board for review and approval. The Road Manager will oversee the work being completed and ensure the approved road budget is followed.

4.1.2 VCHPOA Board of Directors Responsibilities

The VCHPOA Board of Directors shall be responsible for oversight of the Road Manager and all activities involved with the repair, restoration and improvement of any dirt road within the administrative boundaries of the VCHPOA. In the event a road manager position has not been filled the President of the VCHPOA Executive Board shall appoint someone from the Executive Board to act as the Road Manager.

The VCHPOA Board of Directors shall present the list of annual repair, restoration and improvements (LARRRI) to the Annual Meeting of Association Members for discussion and then shall be approved by a vote of the Executive Board.

4.1.3 Association Employee and Contractor Responsibilities

Association employees and contractors will be responsible for adhering to the LARRRI and will be responsible for the actual completion of any and all repair, restoration and improvement activities associated with the dirt roads managed by the VCHPOA.

4.1.4 Association Member Responsibilities

All property owners within the VCHPOA have a responsibility to maintain the free flow of all drainage courses on their property. Property improvements including driveways must allow for the free flow of water through the ditches that line many of the roads. Owners may utilize culverts, swales or any other method that maintains the free flow of water. Culverts must be sized accordingly but as a general rule should not be less than 12 inches in diameter.

Drivers will be responsible for obeying all road speed limits and work signage. Drivers will also be expected to reduce their speed and use 4-wheel drive, if available, when dirt and aggregates are not in a compacted state.

2006 – 2007 LARRRI

Fall 2006 Projects

- **Repair, reshape and rip rap ditches as needed along length of Sazarac Rd**.
  - Labor – 2 people for eight 8hr days. Approx Cost: $3,200
  - Rip rap stone. Approx Cost: Free, donated.
  - Equipment – Loader. Approx Cost: Fuel Only $150
  - Equipment – Backhoe for 1 day. Approx Cost: $1000
- ***Total Budget + 20%: $4,350.00***
- **Install 6 Culverts to Improve Drainage.**
  - Labor – 2 people for three 8hr days. Approx Cost: $1,200
  - Equipment – Backhoe for 3 days. Approx Cost: $1,200
  - Material – 6-18" Culverts 20' long. Approx Cost: $3,000
- ***Total Budget + 20%: $6000.00***

Spring 2007

- **Spring Maintenance grading ****funding from operating budget**
  - Labor – 1 person for 15 days. Approx Cost $3000
  - Equipment
    - Motor Grader 15 day fuel only. Approx Cost $500
- ***Total Budget + 10%: $3,850.00***
- **Rebuild Empire Rd, Sazarac Rd, Agate Rd. and as much of Clemons* and Panhandle* , approximately 15,000 total linear feet.**
  - Labor – 2 people for thirteen 8hr days. Approx Cost: $4,400
  - Equipment
    - Compactor rental for 13 days. Approx Cost: $2400
    - Backhoe Rental. Approx Cost: $2400
    - Motor Grader 13 days fuel only: Approx Cost: $700
    - Water Truck 13 days fuel only: Approx Cost: $500
      - Material – 3/4" Road Base. Approx Cost $78,000
- ***Total Budget + 10%: $97,250.00***

Funding

- **Fall 2006: $15,350**
- **Spring 2007: $97,250**

Total for 2006-2007: $112,600

Adopted July 22, 2006 at the Annual Meeting of the owners.