Ditch Elimination

1. Description

Ditch elimination involves eliminating a roadside ditch to: reduce or eliminate flow volumes introduced into the streams, reduce or eliminate sediment runoff to the stream, and disconnect the road network from the stream network (Penn State, 2005a). This is accomplished by raising the road profile, removing berms, and out-sloping the road to move water to areas where there is high infiltration capacity and native vegetation, which can trap sediment and restore natural drainage patterns. Ditch elimination can also be accomplished and supported through the use of cross-pipes to move water from upslope sides of the road to the downslope side of the road.

Out-sloping

- Out-sloped road surfaces drain water from the entire width of the road toward the fill-bank or down-slope side. The road is shaped to avoid collection or concentration of water in a ditch. Minor overland sheet flow can flow across the road. Out-sloping is useful on roads where concerns about winter icing are minimal or side-slopes are gentle (Penn State, 2005b).

Cross-pipe

- Cross-pipes are culverts used to carry only road drainage under the roadway. Cross-pipes must be outletted to natural vegetation where water can settle out sediment and infiltrate (Penn State, 2006). Cross-pipes must occur a minimum of every 500 feet; however, increasing road slopes required more cross pipes to ensure less water in the upslope road ditch and less water flowing out of each individual downslope pipe outlet. Additional guidance on cross-pipe design considerations can be found in USDA Forest Service document 9777 1812-SDTDC, *Relief Culverts* (Johnson et.al, 1997).

Ditch elimination is a unique roadside ditch management practice because it involves removal of the ditch, therefore management and maintenance of the ditch in the future is eliminated however, the road surface condition, slope, and crown become the focus of maintenance inspections and activities. These new maintenance activities typically involve using road grading and compacting equipment to maintain the road surface and shape as opposed to back-hoe, grade-all, or other excavation equipment used to “clean-out” or reshape a ditch. Ditch elimination results in water sheet flowing into the surrounding landscape and therefore some maintenance activities may include using large leaf blowers to blow organic debris and loose soil away from the road preventing it from building up and creating a barrier to sheet flow.

2. Practice Feasibility

Ditch elimination can be applied on most soils and topography since runoff is simply directed to infiltrate into the surrounding landscape. Key constraints of ditch elimination vary and include the following:

Current Conditions

- The road must be a dirt or gravel road that is incised on one or more sides with concentrated runoff flowing down the road bed or in ditches adjacent to the road.

Available Space

- The design elevation of the road surface must allow sheet flow runoff into the surrounding landscape; therefore, additional space on one or both sides of the road is generally needed. These adjacent pervious areas receiving sheet flow must be a suitable distance from the stream network, based on slope, to ensure sheet flow runoff is infiltrated.

Topography

- Pervious areas adjacent to the road receiving road runoff must have a shallow stable slope to allow for safe sheet flow that will not concentrate and form down gradient gullies or ditches.

Slope

- In order to achieve sediment load reductions, the road must be sufficient to generate sediment movement (≥ 3%), but no greater than 12% where achieving sheet flow discharge is not feasible.

Soil Condition

- Soil conditions generally do not constrain the use of this practice; however, impermeable soils in Hydrologic Soil Group (HSG) C or D require additional disconnection area to insure infiltration and restoration of natural drainage patterns.

Material Availability

- Raising the road profile generally requires large amounts of low-cost, nearby fill material. Suitable fill material includes:
    - Native shale/rock
    - Concrete waste
    - Mining spoils

3. Elimination Methods

This practice generally requires little formal design elements to construct. Design details for construction of this type of project includes a map showing start and end points of ditch elimination, locations and amounts of road fill, locations and sizes of cross pipes and other drainage features, water features (streams, wetlands, etc.), topography or flow directions, and intersecting roads and driveways. Figure 1 shows a detailed example plan for ditch elimination, simpler designs (aerial photo with notes, GIS, etc.) may be allowed as long as they provide the required information.

FIGURE 1: TYPICAL PLAN FOR DITCH ELIMINATION

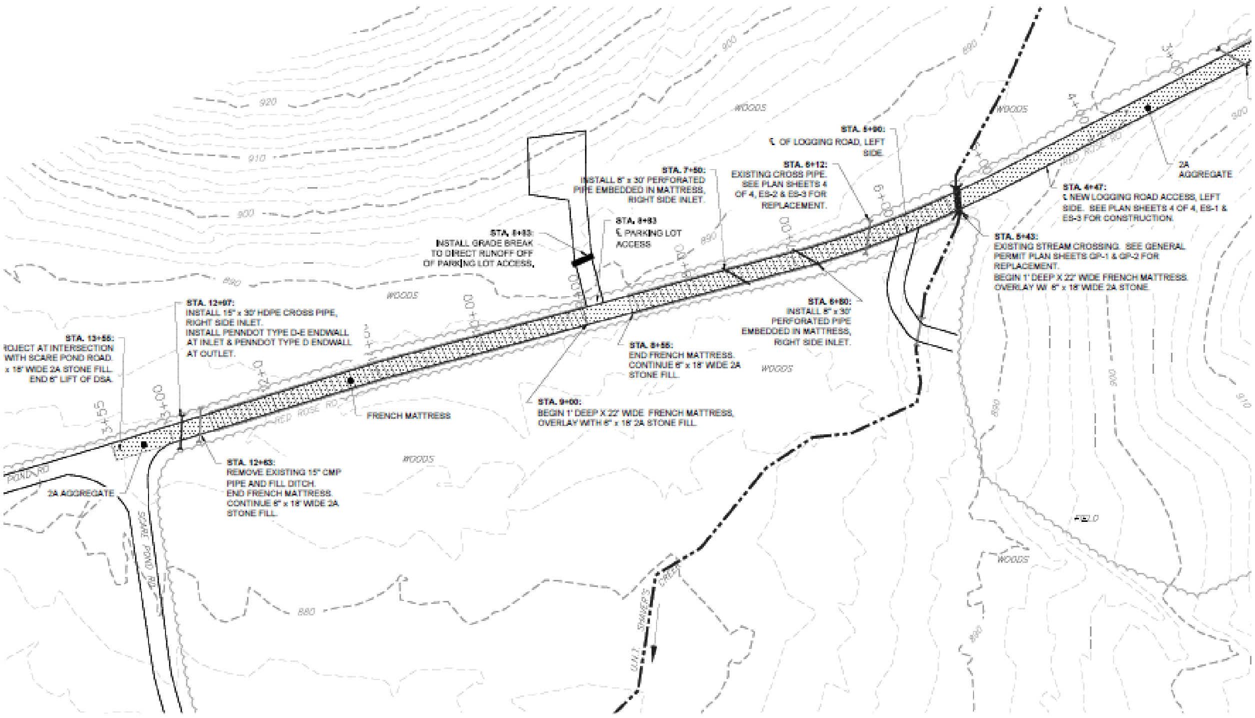
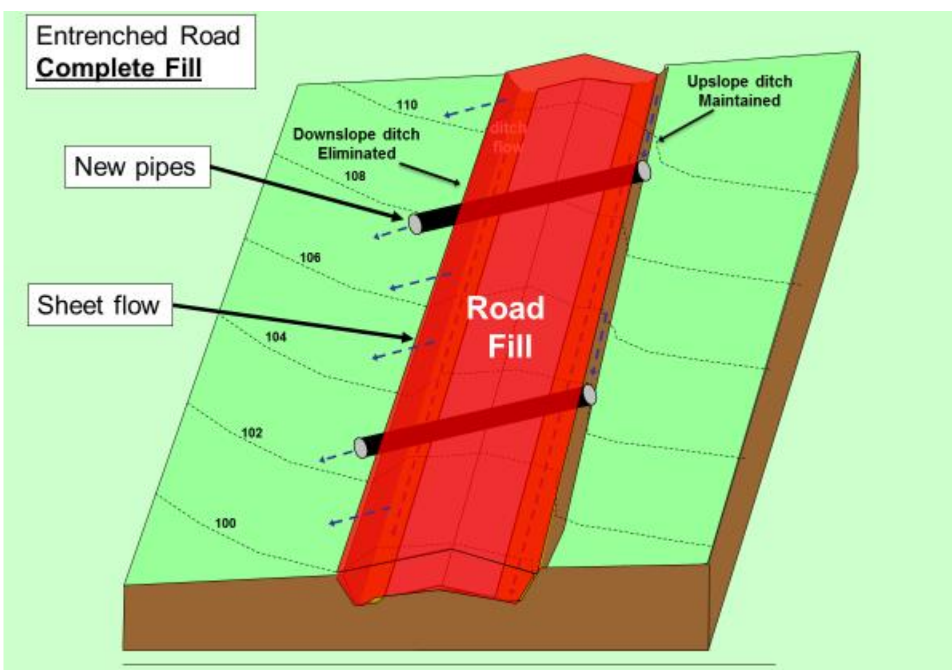


FIGURE 2: CENTER FOR DIRT AND GRAVEL ROAD STUDIES EXAMPLE DIAGRAM



3.1 Construction Sequence

The following identifies the critical stages of construction where an intermediate inspection is recommended and represents important elements for ensuring the success of the ditch elimination (Penn State, 2005c).

1. Identify suitable nearby fill material.
    - *Note: If using a recycled or industrial by-product, ensure the material does not pose any danger or require special handling.*
2. Prepare the existing road base by ensuring it has the proper crown or outslope.
    - *Optional: Install Geotextile to ensure solid road base.*
3. Fill material should be placed in 8-inch maximum lifts.
4. Compact each lift and ensure the final lift has proper crown or outslope of ½-inch to ¾-inch per foot.
5. Place cross-pipes if needed to drain upslope ditch; be sure to place pipes as low as possible.
    - *Note: Cross pipes should have a minimum of 1-foot of cover and 2% slope.*
6. Fill road section to ensure connection with surrounding landscape.
    - *Note: For outsloped roads ensure the highest point on the road cross section is on the uphill side of the road*
7. Place and compact final driving surface, ensuring proper crown or outslope.

3.2 Construction Inspection

Inspections during and immediately after construction are needed to ensure that the ditch elimination project is in accordance with the standard design and implementation procedures. Use a detailed inspection checklist that requires sign-offs by qualified individuals and critical stages of construction to ensure that the contractor's or roadcrew's interpretation of the plan is consistent with standard practice requirements. A construction inspection checklist should:

- Check the condition of the existing road base to confirm it meets specifications and has the appropriate slope or crown
- Check the fill material to ensure that it is confirms with the project specifications and is free of any unwanted foreign or contaminated material
- Verify the proper depth and coverage of fill material
- Verify that each lift has been properly compacted
- Check all cross pipes have been installed at the proper locations, using appropriate pipe material, and have suitable coverage
- Verify adequate coverage of vegetation where sheet flow from the road is directed
- Verify that new surface aggregate meets specifications
- Check driving surface for compaction, slope, and crown

The project should also be inspected after the first major rain event. The post-storm inspection should focus on whether the desired sheet flow off the road is occurring and the project objectives are still being met.

3.3 Procedures for Acceptance

Project acceptance is a visual inspection that takes place after the first major rain event after the construction phase is over to make sure the road surface and infiltration areas are functioning as intended. If so, the practice is accepted by the local roads department and should be reported to the proper stormwater management authority. Post-construction acceptance should also include as-built drawings showing:

- Start and end of the ditch elimination project
- Locations and lengths of road fill sections with fill depths
- Locations of geo-separation fabric, cells, and/or grids
- Locations, types, and sizes cross pipes showing inlet and outlets
- Locations, types, and sizes of stream culvert pipes
- Locations of diversion swales
- Locations of other drainage improvements
- Direction of sheet flow

The local approval authority should keep detailed inspection reports describing any needed maintenance. If any issues are found, identify a timeframe for repair and conduct a subsequent inspection to ensure completion of repairs.

A written inspection report is part of every inspection and should include:

- The date of inspection
- Name of Inspector
- The condition of:
    - Road surface condition
    - Road crown
    - Road slope
    - Adjacent pervious areas
    - Cross-pipes
    - Any other item that could affect the proper function of the ditch elimination practice
- Description of needed maintenance

4. Sediment and Nutrient Crediting Protocol

4.1 Credit Calculations

The sediment load produced by gravel roads is based on the area of road being managed multiplied by the appropriate Road LandClass.

Total Road Area (acres)= Length of Road (feet) * **16 (default road width)** /43560
or for crowned roads with cross pipes
Total Road Area (acres)= Length of Road (feet) * **8 (half the default road width)** /43560

Total Road TSS Load (tons/year) = (Total Road Area * TSS Load for Road LandClass)

The Total Road TSS Load is multiplied by the load reduction values in Table 1 or 2 to determine the tons of sediment removed.

It is suggested that a simplified default loading rate based on Bay-wide average loads (Chesapeake Bay Program, 2018) and the assumption that the gravel road averages 16 feet wide be made available to simplify reporting requirements. Default Bay-wide average loading reduction rates for Non-regulated Road, MS4 Road, and CSS Road are shown in Table 1.

TABLE 1: PROPOSED DEFAULT LOADING RATES FOR DITCH ELIMINATION

<table>
<tr><th>LandClass</th><th>Bay-wide average load TSS Load (tons/acre)</th><th>Road Length (feet)</th><th>Road Area (acres)[1]</th><th>Load (tons/year)</th><th>Lbs/ft</th></tr>
<tr><td>Non-regulated Road</td><td>1.49</td><td rowspan="3">1</td><td rowspan="3">0.00036731</td><td>0.00055</td><td>1.095</td></tr>
<tr><td>MS4 Road</td><td>0.94</td><td>0.00035</td><td>0.691</td></tr>
<tr><td>CSS Road</td><td>1.08</td><td>0.00040</td><td>0.793</td></tr>
<tr><td colspan="6">[1] Road area based on 16-foot road width identified in Simpson Et. Al.</td></tr>
</table>

The credit is calculated by applying the removal efficiencies provided in Table 2 and Table 3 (adjusted based on road slope) to the TSS loads produced by the Road LandClass provided in Table 1 multiplied by the area of road impacted.

The credit outlined in Table 2 would be applied to the portion or section of road where the ditch is eliminated by raising the road profile and sheet flow discharge is achieved.

Table 2: Ditch Pollutant Removal Efficiencies for Complete Ditch Elimination

Ditch Elimination/Raising Road Profile				
Pollutant		**Sediment**	**Total N****	**Total P****
	Slope (%)			
Removal Rate*	3	29%	0%	0%
	4	43%	0%	0%
	5-6	56%	0%	0%
	6+	63%	0%	0%
*Sediment removal rates based on UMD/MAWP recommendations found in Simpson et.al. and adjusted using WEPP model runs by the Center for Dirt and Gravel Road Studies and grouped using Jenks Natural Breaks Optimization.				
**No nutrient removal is expected for ditch elimination since the road is not fertilized.				

The credit outlined in Table 3 would be applied when—due to site constraints—the ditch is only eliminated on one side and cross-pipes are used to convey water to the downslope side of the road. The credit applies the portion or section of road draining to side of the road where cross-pipes are needed to covey water to adjacent natural vegetation/cover.

Table 3: Ditch Pollutant Removal Efficiencies for Ditch Elimination with Cross-pipes

Ditch Elimination/Cross-Pipe Installation				
Pollutant		**Sediment**	**Total N****	**Total P****
	Slope (%)			
Removal Rate*	3	19%	0%	0%
	4-6	24%	0%	0%
	7-9	27%	0%	0%
	10+	30%	0%	0%
*Sediment removal rates based on WEPP model runs by the Center for Dirt and Gravel Road Studies and grouped using Jenks Natural Breaks Optimization.				
**No nutrient removal is expected for cross-pipe installation since the road is not fertilized.				

4.2 Credit Example

Table 4 is an example of a 3,000-foot road with some variation in slope. In this example, fill material was added and a new driving surface installed which grade matches the adjacent landscape and provides complete sheet flow runoff from the road surface into vegetation with sufficient area to infiltrate.

TABLE 4: EXAMPLE #1 CREDIT CALCULATION USING DEFAULT RATES

Total Road Center Line Length (feet)	Road Width (feet)*	Slope (%)	Land Class	TSS Load Reduction Efficiency	Load Reduction (lbs./yr.)
800	16	4	Non-regulated Road (1.09 lbs./ft)	43%	376.54
2200	16	5		56%	1348.53
		Total Load Reduction from Ditch elimination			**1725.06**
3000				***Pounds/ft.***	***0.58***
** Assumes default road width of 16 feet.*					

Table 5 is an example of a 3,000-foot road with some variation in slope. In this example, due to topography half the new driving surface grade matches the adjacent landscape and provides sheet flow runoff from the road surface into vegetation. The other half of the road drains to upslope side of the road, which is drained using cross-pipes to covey water under the road to the adjacent landscape for infiltration.

TABLE 5: EXAMPLE #2 CREDIT CALCULATION USING DEFAULT RATES

Total Road Center Line Length	**Road Width***	**Slope (%)**	**Land Class**	**TSS Load Reduction Efficiency**	**Load Reduction (lbs/year)**
3000	8	5	Non-regulated Road (1.09 lbs/ft)	56%	919.45
3000	8	5		24%	248.60
		Total Load Reduction from Ditch elimination			**1168.04**
3000				***Pounds/ft.***	***0.39***
** Assumes default width crowned-road with half the road surface draining to downslope side and half draining upslope side of the road with cross pipes installed following guidance found in Relief Culverts (Johnson et.al, 1997).*					

1. Maintenance and Visual Indicators

Routine maintenance checkups occur annually as part of regular maintenance visits and are used to immediately correct minor maintenance problems. The checkups are also used to provide quality control on maintenance activities and to determine whether the road crew needs to schedule a follow up visit to repair moderate maintenance problems.

TABLE 6: DEFINING NUMERIC TRIGGERS TO CLASSIFY DITCH ELIMINATION MAINTENANCE CONDITIONS

#	INDICATOR	Pass	Minor	Moderate	Severe
1	Driving Surface	No change to driving surface.	Erosion occurring to less than 10% of the surface	Erosion occurring to less than 25% of the road	Erosion occurring to 25% or greater of the surface
2	Flow Distribution	100% of flow leaving road surface is sheet flow	75% of flow leaving road surface is sheet flow	Less than 50% of runoff leaving the road is sheet flow	Less than 25% of the runoff leaving the road is sheet flow
3	Sediment/Aggregate Movement	No movement of aggregate or sediment buildup	Few isolated areas of deposition and aggregate movement	Windrows and/or wheel tracks divert flow parallel to road gully's less than 1" inches deep	Gully erosion greater that 1" deep occurring to or adjacent to road surface.
4	Crown/Outslope Integrity	No change to slope	Crown/ outslope deviates by 5%	Crown/outslope deviates by 10%	Crown/outslope deviates by 15%
5	Adjacent Vegetative Cover	Dense vegetation (90%) or undisturbed forest floor	Isolated bare spots	Vegetation cover of 75% or more (not forest)	Vegetation cover less than 75% (not forest)
6	Road Drainage	Road drainage features functioning as designed	Isolated location of maintenance recommended, functioning	Road drainage elements not conforming to standards maintenance; required	Road drainage elements not functioning as designed, restoration required

5.1 Typical Maintenance Procedures

Shoulder Maintenance/Berm Removal

- The objective is to keep the surface smooth so that moving vehicles can leave the main roadway safely, and also to assure that water from the road will move across the shoulder and into the ditch or landscape. It is particularly important to remove the accumulated winter maintenance abrasives or lose road material from the shoulders to prevent water from being trapped on the road surface.

Blading

- Remove potholes, corrugations, and other surface defects, rendering the surface smoother and safer to travel on. Blading is usually preceded by scarification to a depth slightly deeper than the deepest surface defects. Blading should be used to establish a cross-slope of 4%–6% (½ to ¾ inch per foot) for good drainage and to reduce the development of potholes in the aggregate surface.

Re-graveling

- The addition of aggregate materials to re-establish the crown and grade of the road, needed periodically to make up for materials that have been lost due to traffic, water erosion, dusting, and blading losses.

2. Verification Procedures

Inspection of this practice is needed to verify that the ditch has been eliminated and runoff water is infiltrating into the surrounding landscape and therefore can continue to earn its pollutant reduction credits, in the context of either a local or Bay-wide TMDL. The inspection should occur a minimum of **once every 3 years** and include comparison to the as-builts and field assessments. Verification uses a subset of the list of visual indicators that assess the hydrologic function and pollutant removal capability of the RDM practice, by answering three simple questions:

1. Does it still physically exist? i.e., can you find it and are the road surface conditions and cover in the adjacent pervious area still functioning?
2. Is water exiting the road and infiltrating into the landscape as it was originally designed?
3. Is the maintenance condition sufficient to still support its pollutant reduction functions?

TABLE 7: PERFORMANCE VERIFICATION INDICATORS

	Visual Indicator	Task/Investigation
Pass	Road surface is connected to surround landscape, water can sheet flow off road	None
Minor	Some concentrated flow along or down road surface; most runoff exits road as sheet flow; no impact to stream network	Make note and check on next maintenance
Moderate	Moderate concentrated flow along or down road resulting in road surface erosion	Maintain shoulder, crown and outslope
Severe	Road incision is occurring and or ditch is emerging; concentrated runoff has little access to surrounding landscape and is discharging to the stream network	Re-establish road surface connection to surrounding landscape; use geotextile if chronic problem; check for and eliminate run-on from offsite water sources (lanes, trails, etc.)

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