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CUYAHOGA S.W.C.D.
28080 Chardon Road
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OIL AND GAS WELL SITE RESTORATION HANDBOOK



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**OHIO FEDERATION
OF
SOIL AND WATER
CONSERVATION DISTRICTS**



**OHIO GUIDELINES FOR OIL
AND GAS WELL SITE RESTORATION**

**OHIO DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WILDLIFE**

WILDLIFE DISTRICT OFFICES

ACKNOWLEDGEMENTS:

These guidelines were written by Joe Hoerst, District Technician of the Washington Soil and Water Conservation District Marietta, Ohio. This product was developed during an inter-divisional ODNR pilot program when the Division of Oil and Gas contracted with seven local soil and water conservation districts to provide advisory services on well site restoration. This six month program with local districts and the respective county Division of Oil and Gas inspectors provided a milestone of new partnerships between the divisions of Oil and Gas and Soil and Water Conservation. Assistance from USDA Soil Conservation Service also was realized primarily from the technical training standpoint. Background material was supplied by the West Virginia Division of Oil and Gas. Funding for this publication was provided by the Ohio Department of Natural Resources and the Ohio Environmental Protection Agency.

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FOREWORD

Drilling for oil and gas reserves began in Ohio well over a hundred years ago. In recent years drilling activities have greatly accelerated. The petroleum industry today provides employment and business to suppliers and Ohio petroleum to the nation. In many parts of the state the oil and gas drilling activity is an important part of the local economy.

However, with the increase in drilling have come disturbances to the land. Due to the rough topography in the eastern half of Ohio where drilling is concentrated, the potential for excessive erosion is tremendous. Drilling activity may also disturb important drainage patterns or create drainage problems. In addition, water quality of surface waters and groundwater aquifers may be affected by sediment and waste brine at wells and storage sites, access roads or from waste disposal activities. In any case, it is clear that to protect water quality and reduce soil loss, it is necessary to properly plan, construct and restore well sites, access roads and other disturbed land.

This handbook has been developed to provide the oil and gas industry and other related contractors with a concise source of site restoration information. The handbook provides general guidelines which will cover most situations. It may be necessary, however, to contact your county soil and water conservation district (SWCD) for additional assistance. The information within should help reduce soil loss due to oil and gas production activities and limit water quality degradation due to sediment delivery to streams and lakes.

The Importance of Planning Well Sites

It has often been said, "An ounce of prevention is worth a pound of cure." When topsoil is stockpiled, access roads properly located and conservation practices installed as the site is developed, restoration is quicker, simpler and less expensive. Planning the site according to an erosion control and water management plan and controlling construction on the site can be very cost effective.

Considerations for Planning

Topography: The relief of the land plays an important role in laying out of access roads to prevent erosion. Whenever possible, construct roads along the contour of the hillside. Avoid going directly up the slope or exceeding slopes of 15% (15 feet vertical rise in 100 feet horizontal distance). Any road going across the slope acts as a large diversion ditch. It collects the runoff from above and channels it down the hill. Unless properly spaced and sized waterbars and/or culverts are installed, erosion problems will occur. This means more bulldozer time to repair the road along with increased wear and tear on pumper trucks. When roads are properly planned and constructed many expensive maintenance problems can be eliminated.

Soil Type: Consider the inherent properties and characteristics of soils in the design of roads and well sites. The first priority is to stockpile the topsoil. When topsoil is saved and spread during restoration, seeding has a much greater chance of becoming established. Slip prone, unstable or wet soils should be avoided due to the many problems they cause. In the event these soils cannot be avoided, special precautions taken before and during site construction will help reduce problems in the future.

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These soils can be identified prior to site development by obtaining soil maps and soil information from any SWCD office. There is an SWCD office in every county. Many have published soil surveys of their entire county and information concerning every soil type.

Limiting Factors Concerning Vegetation

The stockpiling and use of topsoil may be the best method of improving your success in reseeding. The topsoil, however thin the layer may be, contains nutrients, organic material and other elements which favor germination and growth of grass and legumes. The sub-soil, which normally remains after site construction, is usually more acid and contains fewer nutrients to help the vegetation get established.

Follow these six important steps for successful seeding: 1) stockpile topsoil; 2) replace and grade topsoil; 3) prepare seedbed; 4) spread and incorporate lime and fertilizer; 5) seed proper species and 6) apply a mulch. Remember to follow every step; skipping any step may adversely affect your results.

EROSION AND SEDIMENTATION CONTROL MEASURES

General Information

This following chapter covers commonly used erosion and sediment control measures and their general guidelines for installation.

The erosion and sedimentation control measures described in this handbook offer an effective means of reducing erosion and preventing damage to both the construction area, off site properties, streams and lakes.

However, these measures, as well as the site and other involved areas, must be well vegetated to operate properly.

The recommendations herein are minimum guidelines and have been prepared for average conditions in Ohio. For site conditions which exceed average conditions or have severe limiting factors, contact your local soil and water conservation district office.

Although the use of any practice or combination of practices will effectively control runoff and prevent erosion, there is no substitute for properly planning road placement and site location. Planning may help avoid the expense and trouble of installing some practices and repairing erosion or water quality problems.

Access Roads

Recent studies have indicated the greatest amount of erosion attributed to oil and gas well drilling activity occurs on access roads. Roads may act as diversions, collecting and directing runoff as it crosses the slope. Without methods of properly managing storm runoff, tremendous soil losses may occur.

Planning, design and proper construction of access roads is imperative due to the heavy loads and amount of use they must withstand. Water control structures such as water bars and culverts may help control erosion, but they are no substitute for proper location and construction of the access road.

A. Description

A roadway constructed to provide access to the well site.

B. Purpose

To provide a route for travel for moving equipment and materials used for drilling, operating and maintaining well sites.

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C. Design Guidelines

- 1) Minimum roadbed width should be 14 feet for a single lane and 20 feet for a double lane.
- 2) Side slopes for excavated cuts should in no case exceed 2:1.
- 3) Earthen fill slopes should be no steeper than 2:1.
- 4) Install side ditches on road sections where surface runoff endangers fill areas.
- 5) Install adequate culverts under the road and in natural drainageways unless a bridge is needed for larger drainage areas.
- 6) Place culverts across roadways to handle flows from the side ditch when permissible velocity is exceeded in the ditch. For spacing requirement, see table No. 1, page
- 7) Provide headwalls or drop inlets if erosion of the inlet is a problem.
- 8) Headwalls can be constructed of rock rip-rap, logs or concrete.
- 9) Grades normally should not exceed 15% except for short lengths but maximum grades of 20% may be used if necessary for special purposes.
- 10) Do not locate roads near water courses, whenever possible.
- 11) Areas having soils that are slide prone should be avoided. If these areas cannot be avoided, the access road should be located in a manner that would minimize cuts and fills.
- 12) Reseed, mulch, etc., roadbanks, roadbeds and all other disturbances promptly and in accordance with the recommended rates.

D. Construction Guidelines

The area to be excavated or occupied by a fill should be cleared and grubbed of all trees, stumps, large roots, boulders and debris. All such material should be disposed of by burning, burying or removal from sites.

Water Bars

Water bars (also known as water breaks, cross drains) are the most commonly used conservation practices. They can be constructed during or immediately following drilling and fracturing of the well. A bulldozer or tractor with blade can easily construct water bars. To work effectively the structures must be adequately spaced and sized.

Water Bars for Access Roads

A. Description

A channel or open ditch constructed diagonally across roads to carry surface runoff.

B Purpose

To prevent accumulation of large volumes of water by diverting surface runoff from road surface at designed intervals. Erosion in the form of gullies may be prevented by construction of water bars.

C. Construction Material

Compacted soil.

D. Design Guidelines

- 1) Minimum height - 8 inches
- 2) Minimum top width - 2 feet (6 feet including downhill toe)

LITERATURE CITED

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Illustrations on page 14 by David N. Allan, Soil Conservation Service, Durham, NH.

Inoculate: Introduction of bacterium to legume seed to ensure adequate numbers of specific bacteria are present to assist in nitrogen fixation.

Odd lot: A small, unmanaged, irregularly shaped area, such as a fence corner, that may be used to produce wildlife habitat.

Parabolic: A concave curve with gently sloping sides and a nearly flattened bottom.

Slope: The degree of deviation from horizontal measured as a numerical ratio, a percentage or degrees.

To calculate **Ratio** - The horizontal distance (run) divided by vertical distance (rise)

- example: 2' run in a 1' rise: = 2:1 slope

To calculate **Percentage** - The vertical distance (rise) divided by horizontal distance (run) x 100

- example: 4' rise in 50' run

$(4 \text{ divided by } 50) \times 100 = 8\%$

To calculate **Degree** - The angle of the slope from a horizontal plane, and a 1:1 or 100 % slope being 45°.

<u>Grade</u>	<u>Slope Equivalents</u> <u>Degrees</u>	<u>Percent</u>
1:1	45	100
2:1	27	50
3:1	18.5	33
4:1	14	25
10:1	5.1	10

- 3) Water bars should be at a 30 degree angle to the road at an outslope of 2-4%
- 4) Cross section should be parabolic (see figure 1).
- 5) Provide a safe outlet to prevent erosion caused by water discharge. Material for an outlet may be rock, concrete, etc. of sufficient composition and quantity to prevent soil detachment.

E. Construction Guidelines

Construct water bars to a specified line and grade. The soil should be well graded and ready for seeding.

- 1) **Location** - Place water bars at the head of any slope (or edge of a well site) and then spaced appropriately down the slope.
- 2) **Spacing** - Water bars are only effective when spaced at recommended distances. For spacing recommendations see table 1.

F. Maintenance

- 1) Where access roads will be used frequently when soil conditions are wet, the roadway will require frequent grading unless a crushed rock surface is installed. Water bars should be reshaped after each grading operation.

Broad Based Dips

Broad based dips can be used where no intermittent or permanent streams cross the road. They are particularly effective when constructed on an access road that

intersects small swales or drainage patterns. Because of the construction techniques this type of dip should not be used on roads exceeding 10% grade. Dips should be lined with crushed rock or gravel. They do not increase wear on vehicles or reduce hauling speed when properly installed.

Broad based dips are often made too small. The following formula is used to compute dip spacing.

$$\text{Spacing (ft.)} = \frac{400}{\text{slope (\%)}} + 100$$

Use table 2 to calculate proper spacing.

Protect the discharge area from erosion. The outlet may require stone or a good grass sod.

- A. Description
A constructed dip or swale across a road surface with the dip sloped to the outslope for drainage. See figure 2.
- B. Purpose
To provide cross drainage on roads during and after well development to prevent excessive build-up of surface runoff.
- C. Design/Construction Guidelines
 - 1) Maximum road grade on which dips can be constructed is 10%.
 - 2) Minimum width should be 20 feet.
 - 3) Construct a 3% reverse grade in an existing roadbed by cutting upgrade of the dip location.
 - 4) Spacing - See table 2.

GLOSSARY

Arch pipe: An elliptically curved pipe which provides increased flow without need for increased height.

Cfs: Cubic feet per second.

Contour: An imaginary or measured line that is kept at the same elevation (level) for its entire length, usually in reference to tillage or terracing at right angles to the direction of the slope.

Design criteria: Information and calculations used to determine dimensions, grades, etc. in engineering plans.

Discharge rate of flow: A volume of fluid passing a point per unit of time, commonly expressed as cubic feet per second.

Drop inlet: A structure for safely dropping water to a lower level and into a pipe conduit.

Erosion: The wearing away of land surface by running water, wind, ice or other geological agents. Specific forms of erosion commonly expressed include: gross, gully, natural, rill and sheet.

Excessive erosion: The rate of erosion exceeding a limit where the productivity level can be maintained. Expressed in ton per acre per year. Most soils in Ohio have a permissible soil loss between 1 - 5 ton/acres/year.

Fill: An area upon which earth has been placed to raise elevation.

Grade: See slope.

Habitat: A geographical area that can provide for the needs of wildlife.

TABLE 14

General Guidelines for Lime and Fertilizer Rates

pH	Reaction	Soils	Liming Rates in Tons Per Acre
8.5	Alkali	All	0
8.0	Alkaline	Soils	0
7.0	Neutral		0
6.5	Neutral		0
6.0	Slightly Acid	Sandy Loams, Clay	2 2
5.5	Medium Acid	Sandy Loams, Clay	3 4
5.0	Strongly Acid	Sandy Loams, Clay	4 5
4.5	Strongly Acid	Sandy Loams, Clay	5 6
4.0	Very Strongly Acid +	Sandy Loams, Clay	6 7

NOTE:

Apply 500 pounds of type 12-12-12 or equivalent fertilizer per acre. One ton per acre is approximately equal to 5 Lbs. per 100 sq. ft.

Lime type: ground agricultural lime.

TABLE 1

Spacing of Water Bars*

<u>Road Grade (%)</u>	<u>Distance Between Bars (ft.)</u>
1	400
2	245
5	125
10	78
15	58
20	47

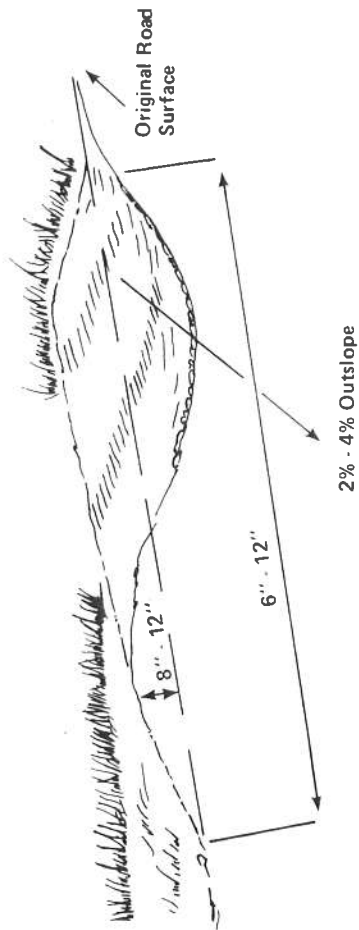
* US Forest Service

TABLE 2

Spacing of Broad Based Dips

<u>Road Grade (%)</u>	<u>Distance Between Dips (ft.)</u>
2	300
3	235
4	200
5	180
6	165
7	155
8	150
9	145
10	140

FIGURE 1
Water Bars



Lime and Fertilizer

Lime and fertilizer should be applied to assure an adequate stand. When lime and fertilizer are not used, re-seeding and resurfacing are often necessary the following year. The importance of these items cannot be over emphasized. Well sites are often located in soils which are strongly acid and of low productivity. Some of these soils are shaley and may have a very low available water capacity. To successfully establish a vegetative cover in adverse conditions such as these, generous applications of lime and fertilizer are necessary.

Guidelines

Application

- A. When possible, a soil sample should be taken and tested to determine specific needs. In lieu of a test, use table 14. For information concerning soil testing, contact the Cooperative Extension Service.
- B. Determine the type of soil on the project site and the acid content of the soil. Once these facts are known, select the amount of lime and fertilizer from table 14 which best meet the use and performance required.
- C. Lime and fertilizer should be incorporated to a depth of three to six inches during the seedbed preparation process.

**TABLE 13
Mulch Anchoring Guide**

Anchoring Method and Material	Kind of Mulch to be Anchored	How to Apply
<p>I. Manual</p> <p>A. Peg and Twine</p>	Hay or Straw	After mulching, divide areas into blocks approximately 1 sq. yd. in size. Drive 4-5 pegs per block to within 2" to 3" of soil surface. Secure mulch to soil surface by stretching twine between pegs in a crisscross pattern on each block. Secure twine around each peg with two or more turns, drive pegs flush with soil where mowing and maintenance is planned.
<p>B. Mulch Netting</p>	Hay or Straw	Staple light weight paper, jute, wood fiber, or plastic netting to soil surface according to manufacturer's recommendations.
<p>2. Mechanical</p> <p>Mulch Anchoring Tool or Crimping</p>	Hay or Straw	Apply mulch and pull a mulch anchoring tool over mulch. When a disk is used, set in the straight position and pull across the slope with suitable power equipment. Mulch material should be "tucked" into the soil surface about 3 inches.

Pipe Culverts for Access Roads

Pipe culverts are usually installed on permanent roads at the time of construction. They are commonly used where vehicle traffic will be relatively heavy following drilling activity or where access roads cross significant drainage patterns. Pipe structures are the most expensive type of cross drain but are quite effective in controlling water. Because of the additional cost, it is important to properly install and maintain the culvert.

- A. Description

Pipe buried under the road to carry surface water from the road ditches and natural drainageways.
- B. Purpose

Pipe culverts are primarily used to channel uphill drainage water under roadways. They also can be used to divert water collected in road side ditches. Pipe culverts are necessary where desired road gradient is higher than natural channel.
- C. Materials
 - 1) Steel
 - 2) Concrete
 - 3) Cast iron
 - 4) Aluminum
 - 5) Plastic (heavy wall)
- D. Design Guidelines
 - 1) For pipe culverts used to divert road side ditch water, use same spacing requirement as water bars. See table 1.
 - 2) For culverts located below sizable watersheds (between 10-500 ac.) see table 3.
 - 3) Minimum suggested culvert size is a 15 inch diameter.

- 4) Position culverts at approximately 30° down-grade. See figure 3.
- 5) Culvert grade should be less than ½ inch per foot of pipe (4.0%).
- 6) Use at least 12 inches of earth cover or ½ of the diameter of the pipe, whichever is greater, to cover the pipe. See figure 4. Culverts should extend to lower edge of fill.
- 7) Provide adequate materials to prevent erosion at pipe discharge. See figure 5.
- 8) Pipes should have headwalls at their inlet when collecting water from road side ditches. See figure 4.

E. Construction Guidelines *

Install culverts to a specified line and grade. The ditch should be excavated to a depth and grade to insure adequate cover for the pipe. A minimum of one foot of cover or half the diameter of earth cover, whichever is greater, is considered adequate. If adequate cover cannot be achieved, install an arch pipe or two smaller pipes.

A firm foundation is needed to support the pipe. The soil should be well compacted along the pipe and free of rock, roots and clumps. A back hoe is recommended for pipe culvert installation.

* Plastic pipe may require special installation techniques. Follow manufacturers recommendations.

TABLE 12
Guide to Mulch Materials
(Rates and Use)

Mulch Material	Quality Standards	Application Rates lbs./100/sq.ft.	Application Rates lbs./ac.	Depth of Application
Hay or straw	Air-dried free from coarse materials	100 lbs. 2-3 bales	2 tons 80-100 bales	Lightly cover 75-90% of surface

Remarks: Use straw where mulch effect is to be maintained for more than three months. Straw is subject to wind blowing unless kept moist, tied down, or crimped. It is the most common and widely used mulching material and is good for erosion control in critical areas.

General Note: All mulches will provide some degree of 1) erosion control, 2) moisture conservation, 3) weed control, and 4) reduction of soil crusting.

For dormant seedings mulching rates will be increased 50%.

Mulching

Mulch can be used alone or in conjunction with other structural or vegetative erosion control measures. Mulch is applied on any disturbed area which is subject to erosion to protect bare soil or newly seeded areas. The recommended rates of mulch are seldom achieved. Many producers don't recognize the value of adequately covering the seeding. Hand spreading mulch is very labor intensive. However, all the time and money invested in seeding may be wasted if only a half-hearted attempt is made. A 90% cover should be your goal. Mechanical straw blowers do a fine job of distributing mulch even in hard to reach places. They are easy to use and are highly recommended.

Guidelines

Application

- A. Select the type of mulch and application rate from table 12 which will best meet the the use and performance requirements.
- B. Determine anchoring requirements if needed and select a method of anchoring from table 13 which best meet the specific job requirements.
- C. Spread immediately after seeding to prevent excessive moisture loss and possible damage to newly sprouted seedlings.

FIGURE 2
Broad Based Dip

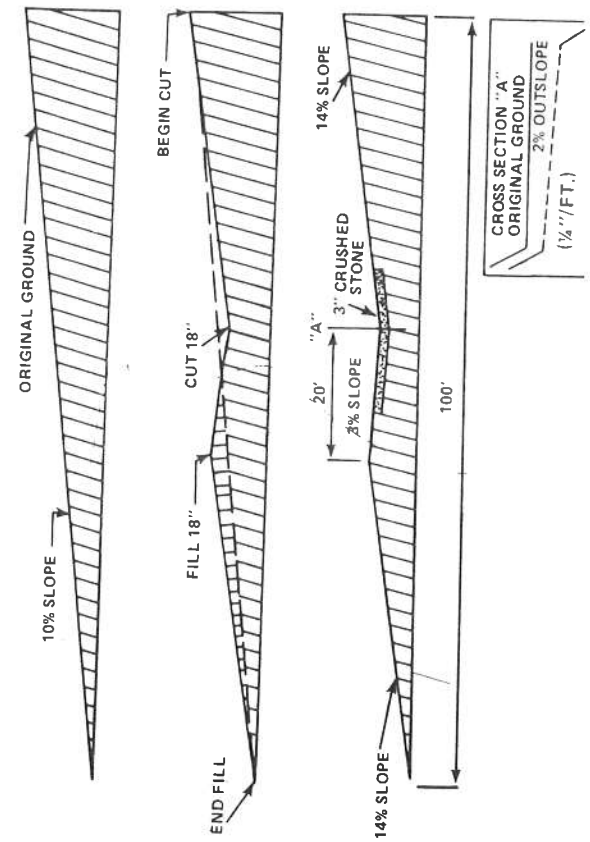


TABLE 3*

Pipe Sizes for Culverts Across Road

Drainage Area (Ac.)	Pipe Diameter (In.)	Pipe Capacity (C.f.s.)
10	15	5
20	18	9
30	21	12
50	24	18
80	27	24
100	30	29
230	36	50
400	42	72

*From Soil Conservation Service Engineering Field Manual Chapter 2 and 3 using corrugated metal pipe. For other types of pipe or unusual circumstances contact your local soil and water conservation district office.

B. Other Areas

1. To determine acreage and pounds of seed needed for other areas such as loading decks, turnouts, tank batteries, etc. use the following formula:

$$\text{Avg. length} \times \text{avg. width} = \text{sq. ft.}$$

$$\text{Sq. ft.} \times .000023$$

Multiply the answer times the pounds per acre as recommended in seed mixture tables to determine amount of seed.

2. To determine fertilizer and mulch needs use the above procedures.

Example:

An access road is 12' wide and 500' long. The well site is 200' wide and 250' long. What is the total area?

Area of Road (From Chart) 0.14 ac.

Area of Well Site 1.15 ac.

1.29 ac. total

Use 1.29 x recommended seeding rates/acre to determine quantities needed.

TABLE 11

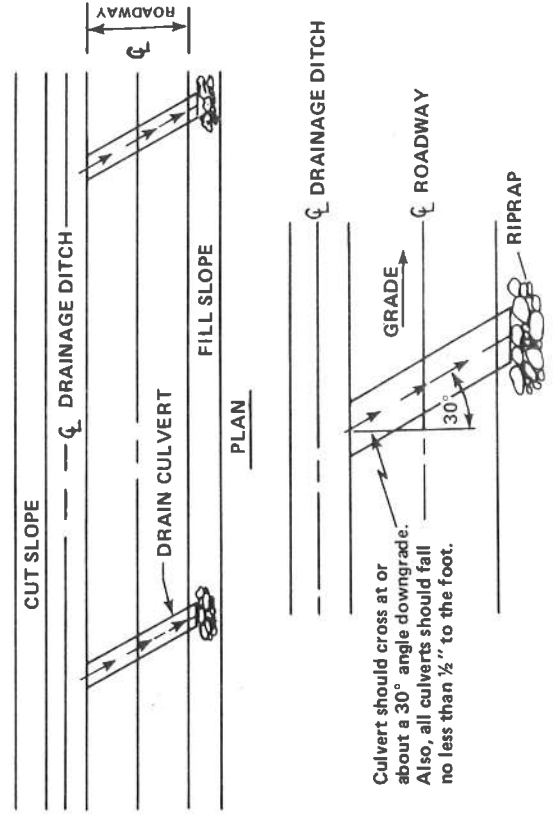
How to Calculate Seed and Fertilizer Needs for Roads and Disturbed Areas

A. Road Area (Acres)

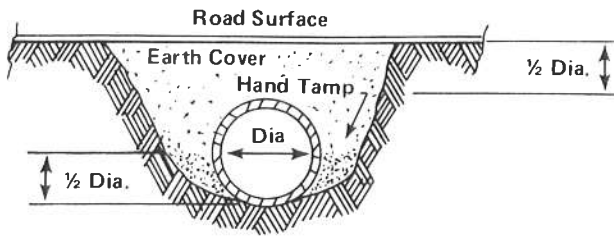
Road Length Feet	Road Width - Feet					
	8'	10'	12'	14'	18'	20'
50	.01	.01	.01	.02	.02	.02
100	.022	.02	.03	.03	.04	.05
250	.05	.06	.07	.08	.10	.11
500	.09	.12	.14	.16	.21	.23
750	.144	.17	.21	.24	.31	.34
1000	.18	.24	.28	.32	.41	.46
1500	.28	.34	.41	.48	.62	.69
2000	.36	.48	.56	.64	.83	.92
5000	.92	1.15	1.38	1.61	2.07	2.30
5280	.97	1.21	1.45	1.70	2.18	2.43

2. Multiply the appropriate table figure times the pounds per acre that is recommended for seed mixtures in tables 7, 8, or 9.

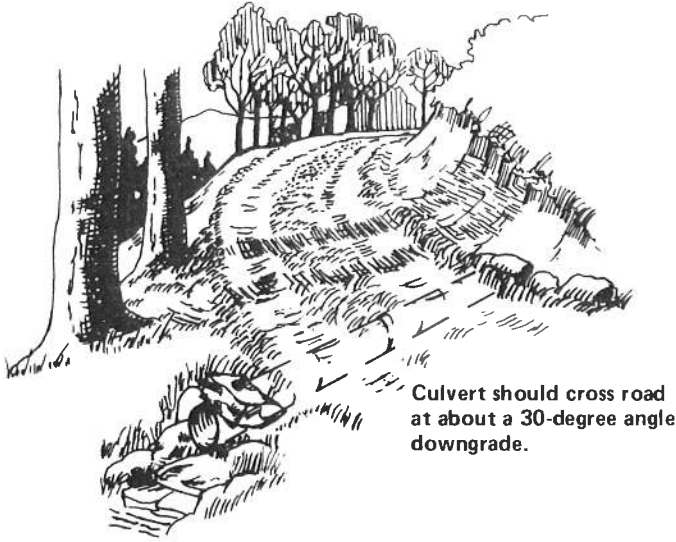
FIGURE 3
Culvert Detail



**FIGURE 4
Culvert Installation**



**FIGURE 5
Culvert Placement**



life habitat. Mixtures with high rates of legumes are most suitable. Tall Fescue is not considered an acceptable nesting cover. Tall Fescue should be used for seeding the critical areas.

The level well site also lends itself to establishing food plots for wildlife. A food plot of ¼ acre or less, seeded with appropriate amounts of soybeans, corn, dwarf sorghum, millet, sunflowers, buckwheat and lespedeza will provide a quality winter food source. The Ohio Department of Natural Resources, Division of Wildlife, often has a limited number of food plot seeding material available for distribution.

Brush and trees cleared from the site can be used to construct brush piles. (A landowner waiver may be necessary.) Rows of evergreens can also be planted along the site to promote wildlife cover. These trees, once mature, can also be used as a visual barrier. Tree packets are available at minimal cost from local soil and water conservation districts.

For additional information contact the Division of Wildlife, Ohio Department of Natural Resources, or your local soil and water conservation district.

TABLE 10

Seeding Periods for Permanent Hayland and Pasture Plantings

Seeding Period		
Southern Ohio	Northern Ohio	Species
Spring Seedings		
Mar. 1 to April 15	Mar. 10 to June 10	Alfalfa, Red Clover, Birdsfoot Trefoil, Bromegrass, Orchardgrass, Tall Fescue, Timothy
Summer Seedings		
Mar. 1 to Sept. 15	Mar. 1 to Sept 1	Alfalfa, Bromegrass, Orchardgrass, Timothy, Tall Fescue

Alternative Seedings For Wildlife

A correctly restored well site can provide important wildlife cover. In a forested area the site may be beneficial as a "wildlife opening." A site located near cropland may also act as an odd lot. In either setting, the change in habitat and the "edge effect" created can be effective in providing nesting, resting, loafing and feeding areas. The lush vegetation will be readily utilized by nearly all game and non-game animals.

Most grass-legume mixtures provide excellent wild-

Access Road Entrance

Erosion often occurs where an access road joins an established roadway. Steep slopes and concentrated runoff may cause severe gully erosion and result in sedimentation on the roadway and/or in the ditch.

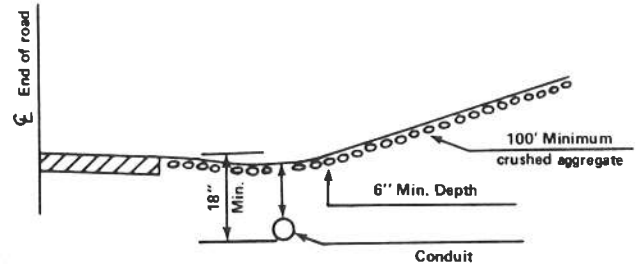
Most local governments have restrictions and standards for entrances. Generally, requirements include culvert pipes and a stone roadbed for a specific distance. Producers should check with officials for local regulations.

Properly designed access road entrances should permit a clear view of the highway. They should be constructed so water or stone will not run on to the road pavement. Whenever possible, avoid making excessive cuts when constructing the access road entrance. Figure 6 shows a typical road entrance.

Road matting works effectively in supporting and preventing stone from incorporating into the soil. Road matting may greatly extend the lifetime of the stone roadbed.

FIGURE 6

Typical Road Entrance



DIVERSION DITCH

Diversion ditches are an important element in protecting the site from erosion and surface water problems. They should be constructed while the site is being prepared. Diversions, when constructed at the top of the cut slope and at the base of the site, will effectively reduce erosion and drainage problems.

A. Description

A channel or ridge constructed across a slope for diverting surface runoff.

B. Purpose

To intercept surface water before it enters an erodible area and to channel the runoff to a safe outlet.

C. Design Guidelines

- 1) For drainage area less than 2 acres see figure 7.
 - a) Minimum depth of 18 inches
 - b) Minimum top width - 8 feet
 - c) Maximum ditch grade - 2%
 - d) Minimum ditch grade - 0.5%
- 2) For drainage area greater than 2 acres and when the area being protected is of high value:
 - a) Capacity of the ditch should handle a 10-year frequency storm for a 24-hour duration. For further design information, contact the local soil and water conservation district office.

Red Clover /2 and Alsike or Ladino and Timothy /1 or Bromegrass or Orchardgrass	6 2 ¼ 2-4 6 4
Reed Canarygrass /3	10
Korean Lespedeza /4 (Southern Ohio)	8

* These are general seeding rates applicable for soils ranging from well drained to imperfectly drained and high to moderate productivity. For more information refer to the Agronomy Guide (OSU Coop Extension Service Bulletin 472) or contact your local soil and water conservation district office.

- /1 Timothy rates should be 4 lb/ac. for summer seedings.
- /2 For poorly drained soils with low to moderate productivity.
- /3 For poorly drained soil with low to moderate productivity. (May have high water table and subject to overflow.)
- /4 For excessively drained soil with low to medium productivity.

	Tall Fescue	½	20
	Korean Lespedeza (South-Ohio) /2	¼	8
Year Around	Tall Fescue	1	40

/2 Inoculate legume seeds using four times the normal when hydro-seeding.

TABLE 9
Permanent Hayland and Pasture Plantings*

Species	Rate lb/ac.
Alfalfa	10-12
Alfalfa	10
Red Clover and Timothy /1/ or Bromegrass or Orchardgrass	2 2-4 6 4
Birdsfoot Trefoil Timothy /1 (optional)	6 2-4
Bromegrass Ladino	10 1-1½
Tall Fescue Ladino	10-15 1-1½
Kentucky Bluegrass Ladino	10 1-1½

SURFACE DRAINS

Surface drains may be needed where drilling activity intercepts or blocks natural drainage patterns, or where excavation may trap runoff. Surface drains are used in flat areas with low grades, usually less than 2% and small drainage areas. When properly designed, a drained site may dramatically improve working conditions and reduce maintenance costs and restoration problems.

A. Description

An open drainage ditch constructed to a specific size and grade.

B. Purpose

To drain surface depressions, to collect and convey surface water. This does not apply to major drainageways and open ditches.

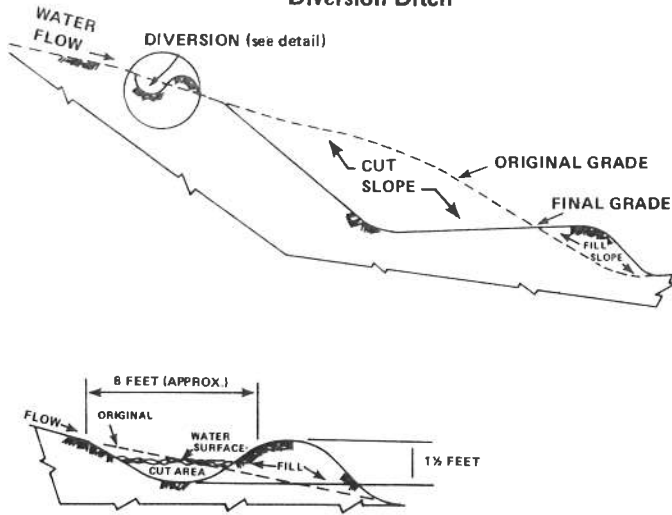
C. Design Guidelines

- 1) Ditch side slopes should not be steeper than 3:1 when excavated in soil.
- 2) Base capacity of ditch on handling 0.1 cfs per acre of drainage. Minimum depth should be 1.5 foot with 3:1 side slopes and should not exceed 2.0% grade.
- 3) Cross section of the ditch should be V-shaped for ditches 1% or less. Ditches over 1% should be flat bottomed or parabolically shaped.
- 4) Ditches should be seeded, lined or paved with stone, riprap, etc. to prevent erosion.

D. Construction Guidelines

- 1) Cut the ditch to a designated line and grade. The spoil should be spread and leveled, so that surface water can flow into the ditch.
- 2) Excavated surfaces should be reasonably uniform and smooth. Areas to be excavated should be cleared of trees and brush and should be disposed of by burning, burying or removal.

FIGURE 7
Diversion Ditch



	Tall Fescue	1	40
	Creeping Red Fescue	1/2	20
	Tall Fescue	1/2	20
	Tall Fescue	1/2	15
	Reed Canary-grass	1/4	8
For critical areas in pastures of 8% slope or less use any of the above or -			
	Orchardgrass	1/2	16
	Red Clover	1/4	8
	Tall Fescue	1/2	20
	Red Clover	1/4	8

For Special Areas (Steep Banks or Cuts, Ditch Bank and Reclaimed land)			
March 1 to June 15	Crownvetch /2	1/4	10
	Tall Fescue	1/2	20
	Deer Tongue	1/2	15
	Tall Fescue	1/2	15
	Deer Tongue	1/2	20
	Birdsfoot Trefoil /2	1/2	10
	Creeping Red Fescue	1/2	20
	Flatpea /2	1/2	20

June 15 to Aug. 15	Oats and Sundangrass	2 2	64 80
	Perennial Ryegrass	1	40
Aug. 16 to Nov. 1	Rye Wheat	3 3	112 120
	Perennial Ryegrass	1	40

/1 "Critical Areas" are highly erodible or critically eroding sites. These areas usually cannot be stabilized by ordinary conservation treatment and management and if left untreated can cause severe erosion or sediment damage. Examples of critical areas are cuts, fills, denuded or gullied areas, steep slopes and areas of concentrated flows of water (diversions, waterbars, etc.).

TABLE 8

Permanent Seeding for Critical Areas/ 1

Recommended Seeding Period	Species or Mixture	Seeding Rates Pounds per 1000	
		sq.ft.	lb/ac.
Year Around	Creeping Red Fescue	½	20
	Perennial Ryegrass	¼	10
	Bluegrass	¼	10

TABLE 4

Permissible Velocites

Soil Texture	Maximum Velocity ft./sec.
Sand and sandy loam (noncolloidal)	2.5
Silt loam (also high lime clay)	3.0
Sandy clay loam	3.5
Clay loam	4.0
Stiff clay, fine gravel, graded loam to gravel	5.0
Graded silt to cobbles (colloidal)	5.5
Shale, hardpan and coarse gravel	6.0

TABLE 5

**Recommended Widths for Vegetation Strips
Between Earthmoving Activities and Streams**

Slope Between Disturbed Sur- face and Stream (%)	Width of Filter Strip	
	In Forested Area (ft.)	In Municipal Watersheds And Critical Areas (ft.)
0	25	50
10	45	90
20	65	130
30	85	170
40	105	210
50	125	250
70+	165+	330+

Filter Strips

Filter strips are the last line of defense to stop sediment from reaching streams. They help maintain water quality by trapping erosion sediments between the disturbed area and the stream system. By leaving essentially undisturbed buffer strips of vegetation between the streams, access roads, well sites and other disturbed areas, the existing vegetation will help trap sediment and prevent it from reaching the stream. Filter strips, however, are no substitute for protecting the disturbed area and cannot be expected to protect water quality alone.

A. Description

An undisturbed natural vegetative strip left between the disturbed area and a water course.

B. Purpose

The filter strip acts as a buffer area to catch sediment before it enters the water course.

C. Design Guidelines

- 1) Roads and other disturbed areas located above a stream course need a filter strip. The width of the filter strip depends on the slope of the land between the disturbed area and the water course. See table 5 for spacing requirements.
- 2) In areas where a filter strip may have to be constructed, follow the critical area treatment procedures. See table 8.

D. Construction Guidelines

The filter strip areas should not be disturbed. No equipment operation that will expose the soil should be allowed in this area.

Not all seedings made in the resoration of well sites necessitate "Critical Area" treatment. Many sites may be located in pasture or cropland. The ground may be nearly level or have gentle slopes which remain as part of the farm. However, care should be taken in these areas to protect the topsoil. The landowner has invested a good deal of time and money in lime, fertilizer and chemicals to maintain productivity levels.

The present or planned use of the site should be considered. In a pasture or hayland situation, a grass-legume mixture is usually needed. The exact mixture will depend on the soil suitability, the type of farming operation and the landowners preference. Often times it may be advantageous to have the farmer perform the seedbed preparation, fertilizer application, seeding, etc. Most farm operators are better equipped and have more expertise in these matters than oil and gas producers.

For general seeding recommendations see table 9. Table 10 contains recommended seeding periods. To determine necessary quantities use table 11.

TABLE 7
Temporary Seeding for Critical Areas

Recommended Seeding Period	Species or Mixture	Seeding Rates in Pounds per 1000	
		sq.ft.	lb/ac.
March 1 to June 15	Oats	3	128
	Perennial Ryegrass	1	40

Guidelines

Site Preparation

Strip and stockpile topsoil before the site is excavated. If the site will be leveled from a hillside, store topsoil beyond the area under construction.

- A. Install needed surface water control measures.
- B. Seedbed should be prepared to a depth of 2 to 3 inches by disking or using other suitable equipment with adequate amounts of lime and fertilizer being incorporated during seedbed preparation.
- C. Perform all planting and tillage operations at right angles to slopes.

Establishment

- A. Select species from table 9.
- B. Apply seed by broadcasting, drilling or hydraulic application according to rates indicated in table 9. All seed should be covered by ¼ inch of topsoil.
- C. Mulch netting may also be necessary on steep slopes.

Management and Maintenance

- A. Delay mowing for one year. Remove heavy residue after mowing to prevent smothering.
- B. Mow as needed to control weeds, improve appearance or to maintain a stand of desired vegetation. As much as possible, mowing should be done after August 15 to prevent destroying wildlife nests.

Sediment Barriers

Sediment barriers should be used in areas where excessive soil loss or sediment loads to a water course could cause serious problems. They should be used when activity above the barrier leaves bare soil even for a short period.

A. Description

A temporary restriction or barrier across a slope or at the toe of a slope.

Types of Barriers:

- 1) Hay or straw bales. See figure 8
- 2) Silt fences. See figure 9

B. Purpose

To trap sediment from a disturbed area by retarding and filtering storm water runoff.

C. Design Guidelines

- 1) Place straw bale dikes and silt fence on contour.
- 2) Spacing is governed by slope. Use the following guideline.

Percent Slope	Distance between barriers - feet
2-8	110-92
8-12	92-75
12-18	80-60
18-24	60-52

D. Construction Guidelines

- 1) Place hay or straw bales in a row along the contour with adjacent bales securely tied with either wire or nylon string. Anchor each bale with two metal or wood stakes. Wooden stakes should be at least 2" x 2" and driven in the ground a minimum of 1½ feet. Bales should be placed in the ground at least four inches.
- 2) Place silt fences on the contour. Space fence posts not more than 10 feet apart. If woven wire fence is used, fasten it securely on the upstream side of the fence posts.

GUIDELINES

Site Preparation

- A. Install needed surface water control measures.
- B. Seedbed should be prepared by disking or using other suitable equipment on the contour. The seedbed should be firm and have been worked at a depth of two to three inches.
- C. Perform all tillage and planting operations at right angles to slopes.

Establishment

- A. Select a species from table 7.
- B. Apply the seed by broadcasting, drilling or hydraulic application according to the rate indicated in table 8. All seed should be covered by approximately ¼ inch of topsoil.

Permanent Vegetation

Permanent vegetative cover is needed on all disturbed areas when earthmoving activities have ceased. Vegetation will re-establish ground cover to control (in association with other conservation practices) water runoff and erosion. The seedbed for permanent vegetative cover should be prepared to a depth of 2-3 inches and lime and fertilizer incorporated. Mulch should be applied to conserve soil moisture and provide temporary erosion control.

Table 8 presents recommended seed species or mixtures, rates and seeding dates. For alternative rates or mixtures contact the local soil and water conservation district.

Often new seedings need protection from livestock grazing. It is mutually beneficial for the producer and landowner to work together to protect the seeded area until vegetation is well established.

TABLE 6

Six Steps To A Successful Seeding

1.	STOCKPILE TOPSOIL
2.	REPLACE AND GRADE TOPSOIL
3.	PREPARE SEEDBED
4.	SPREAD AND INCORPORATE LIME AND FERTILIZER
5.	SEED PROPER SPECIES
6.	SPREAD MULCH

Temporary Vegetative Cover Guidelines

Temporary vegetative cover is needed on disturbed areas where the earthmoving activities will be stopped for a period of more than two months, but less than six months. The vegetation will provide short term, rapid cover for the control of surface runoff and erosion until permanent vegetation can be established or earthmoving activities can resume. Temporary cover is especially important in protecting stockpiled topsoil.

Temporary seedings may require fertilizer, lime, mulch, etc. for quick plant growth. Individual sites should be evaluated to determine these needs. For ground cover other than listed here contact the local soil and water conservation district office.

**FIGURE 8
Straw Bale Dike**

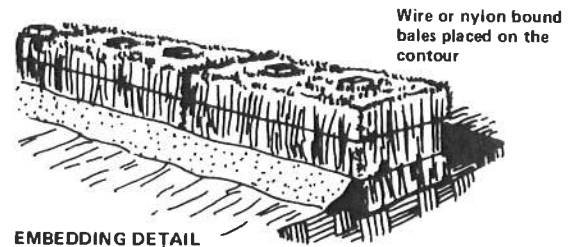
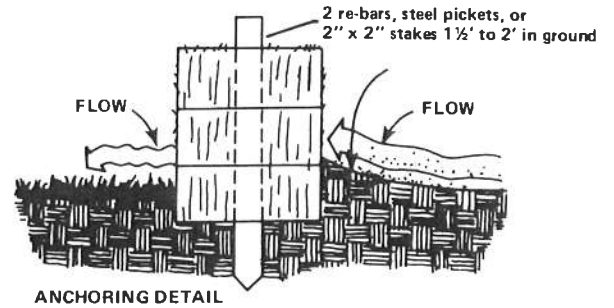
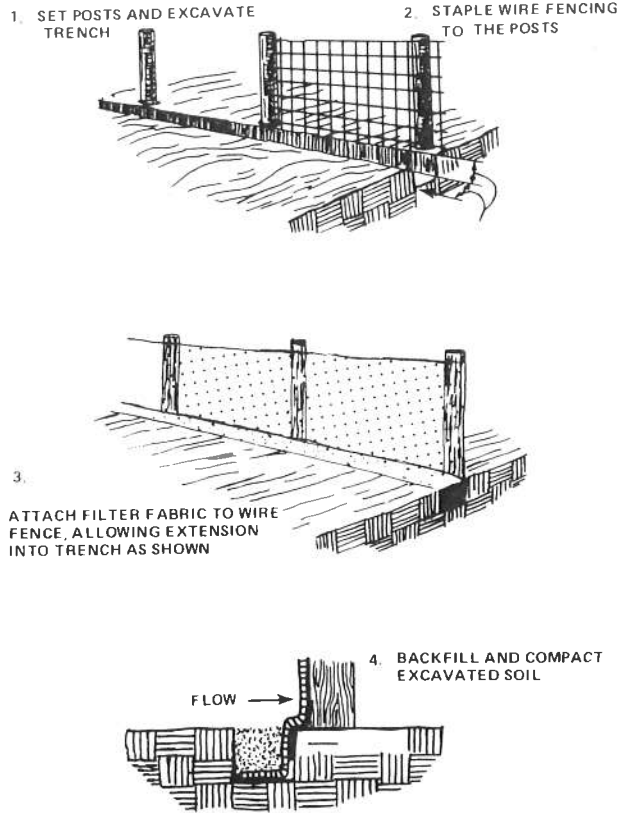


FIGURE 9
Building A Silt Fence



VEGETATIVE PRACTICES

General Information

The guidelines in this chapter have been developed as methods for minimizing soil erosion and sedimentation of surface water. These are guidelines for selecting, planning and designing erosion control measures and for obtaining quality restoration results. They should be adjusted and modified to meet individual site design requirements. Soil and water conservation district personnel may offer seeding recommendations which have been successful locally.

For best results the disturbed areas should be seeded and mulched as soon as possible after they are no longer necessary in the drilling or production of the well. Cut slopes and diversion ditches should be treated immediately after their construction. Remember, dormant seedings and other late seedings may require a "nurse" companion crop and increased mulch rates.

Inoculum should be added to legume seed. Inoculum is bacteria which assists the legume in nitrogen fixation. Inoculate the seed at the manufacturer's recommended rate.

Successful seeding requires following a planned course of action which is simplified into six easy steps. See table 6.

Neglecting any one of these steps greatly reduces your chance of producing an adequate vegetative cover. Every step is important, like a link in a chain; however, stockpiling topsoil is the one factor which increases the chances for a successful seeding. The layer of topsoil, no matter how thin, contains many nutrients and is high in organic matter. Topsoil is much more productive than the subsoil and is a perfect medium for establishing a grass and legume cover. Topsoil is too valuable to be discarded during well site construction.