CHAPTER 10. GULLY TREATMENT

1. GENERAL

DEFINITION

Gully treatment is the stabilization of active gullies by vegetative or structural measures or a combination thereof.

INTRODUCTION

Gullies can be prevented by such measures as increasing the absorptive capacity of the soil, protecting the land surface and natural drainageways from erosion, and by conducting surface runoff water from fields at a non-erosive velocity through properly prepared and maintained waterways.

Besides ruining fertile land, gullies interfere with farm operations, undermine farm improvements, encroach on public highways, endanger livestock, and often mar the beauty and lower the market value of a farm. Materials eroded from gullies reduce the capacity of reservoirs, natural streams, and drainage channels, and cover bottom lands with deposits of infertile soil.

CAUSES

Gullies are caused by runoff water cutting, or collecting in, surface depressions and flowing at a velocity sufficient to detach and carry away soil particles. The power to erode increases as the stream increases in size, velocity, and duration. If the depression or drainageway is not protected from erosion a gully will form and be enlarged by each flow through it. Many large gullies have formed because simple steps were not taken to stop them in the beginning.

Drainageways which collect runoff water may be natural or may have been caused by:

1. Improperly located farm roads, field and access roads, and trails.
2. Livestock trails.
3. Up-and-down slope cultivation.
4. Unprotected terrace outlets and waterways.
5. Unrepaired breaks in terraces and diversions.
6. Excavated drainage or diversion channels without needed vegetative or structural protection.

7. Rilling on bare slopes.

8. Improperly designed and placed road drainage structures.

9. Built-up fence rows or property boundaries.

10. Improper land use.

11. Toxic wastes that destroy vegetation.

It is important that the technician be acquainted with those practices and conditions that are likely to start gullying. This will enable him to assist the landowner in selecting land use changes and cultural measures which will prevent further erosion and help to control existing gullies.

2. PLANNING

Gully control can best be attained through a plan that takes into account the treatment of the watershed draining into the gully, as well as treatment of the gully itself. A conservation plan for, or the conservation treatment of, any piece of land should consider all needed and feasible gully stabilization work. The plan may include such practices as critical area plantings, grassed waterways or outlets, grade stabilization structures, diversions, and debris basins. These may be used singly or in combination with other practices to accomplish the following:

1. Interception of runoff water above the gullied area with a diversion or terraces.

2. Retention of runoff water on the drainage area by tillage practices, vegetation and structures.

3. Elimination of the gully by filling and shaping the drainageway with earth-moving equipment for critical area planting or grassed waterway development.

4. Revegetation, either by natural processes or by critical area planting and grassed waterway development.

5. Construction of grade stabilization structures to control the grade of the gully and detain or impound water.

6. Complete exclusion of livestock.

7. Control of sediment from active gullies with debris basins.

8. Drainage of seep areas where gully banks are unstable.

GULLY TREATMENT BY VEGETATIVE MEANS

The objective of most gully control work is to stabilize the gully surfaces by vegetative means. All other measures should lead to that objective, except in areas where rainfall is too low to support a good grass cover.

Any gully, regardless of its size or condition, usually will regain a cover of natural vegetation if it is properly protected and is in an area where vegetation will grow readily. Diversion or retention of the water which causes the gully, protection from grazing or trampling by livestock, protection from fire, and the removal of other causes of disturbance usually result in growth of natural vegetation which will, in time, cover the gully and heal the erosion scars. (See Figure 10-1.)

Nearly all structural measures used, particularly in grassland areas, depend upon vegetation to support them and to stabilize the soil exposed to excessive runoff. Of first importance in revegetation is the exclusion of livestock or mechanical disturbance from the gullied area.

Most gullied areas or gully banks are not in good condition for vegetative growth since the fertile topsoil has been washed away, slopes are steep, and the battering of raindrops on the unprotected soil has produced conditions adverse to plant survival. Bank sloping may be necessary before vegetation can be expected to do an adequate job of gully stabilization.

Adapted grasses, trees, shrubs, or vines provide good protection to gullied areas planned for critical area planting. The possible uses of the area after stabilization will determine the type of vegetation to be established.

A stabilized gully may be used as a grassed waterway for terrace outlets, a wildlife habitat, a woodland area or pasture. It should not be cultivated, burned, or used in a way that will weaken or destroy the reestablished vegetation. The best possible use should be selected after considering the size of the gully, its location with respect to other land uses on the farm, the control measures needed, and the type of maintenance required.

If it is to be used for a grassed waterway, the gully should be shaped to proper size and proportion. Erosion-resistance grasses should be well established before any terraces are constructed to empty into the channel. Trees, vines and shrubs ordinarily are not used in waterways unless the amounts of water flowing through the channel are relatively small and of infrequent occurrence.

Critical area planting of a gullied area in pastureland will be affected by the intensity of grazing on the area. Limited grazing of a grass vegetation during the establishment stage is often beneficial in controlling competitive weeds and shrubs. Overgrazing will seriously hinder establishment. Gullied areas in pastures might be better protected permanently from all grazing and retained for wildlife use after planting with grasses, shrubs, vines or trees suitable for wildlife habitat. In wooded or gullied areas adjacent to woods, it is desirable to plant trees of an adapted species and use the area as protected woodland.

In gullied areas where erosion is less critical, the slowest but cheapest method of gully control is protection from disturbance. Good results may be obtained and heavy expense avoided by the simple process of fencing the area to exclude grazing or cultivation.



Gully caused by concentrated runoff in overgrazed pasture



Figure 10-1 Gully treated by diversion of water, shaping and fencing to exclude grazing

GULLY TREATMENT BY FILLING AND SHAPING

Elimination of the gully or critically gullied area by filling and shaping may be the most practical or feasible means of treatment in preparation for critical area planting or grassed waterway development (see Figures 10-2 and 10-3). When this method of treatment is used, the gully or gullied area is shaped and smoothed so that the area can be established to vegetation and maintained with regular farm equipment. Where practical, the gully should be reshaped to provide stable velocities and other desirable hydraulic characteristics. See Chapter 7 of this manual.

During the filling process, the soil worked into the gully should be compacted since uncompacted material offers little resistance to erosion. It is best to fill field gullies during the time of year that a close-growing crop may be seeded immediately on the disturbed area to protect it from washing. Piecemeal filling or shaping should be discouraged since the partial blocking of the waterway often causes overfalls and increased gully erosion, and more land and soil may be lost than if the gully were untreated.

GULLY TREATMENT BY WATER DIVERSION OR RETENTION

Reduction of the runoff which flows through a gully is one of the most effective control measures. This may be accomplised by diverting all or most of the runoff to a protected outlet or by holding excess rainfall on the land in the drainage area. Where these methods are feasible, they should be installed before other needed control measures are attempted within the gully.

Water Diversion

Care should be given to the disposal of the diverted water. Where it is not possible to empty a diversion onto a smooth, well-vegetated area or into a protected outlet, the water should not be diverted; otherwise, the diverted runoff may cause gullying in the disposal area. It may be possible to divert water from a number of gully heads to a common location and install a single, more economical stabilizing structure.

Diversions usually are constructed from the upper side in order to provide a wide channel section and easier construction. Diversions constructed adjacent to a gully or at the head of a gully overfall should be located away from the edge of the gully a distance equal to at least three times the depth of the gully. This will provide space for the gully banks to slough and stabilize, or to be shaped, without endangering the diversion.

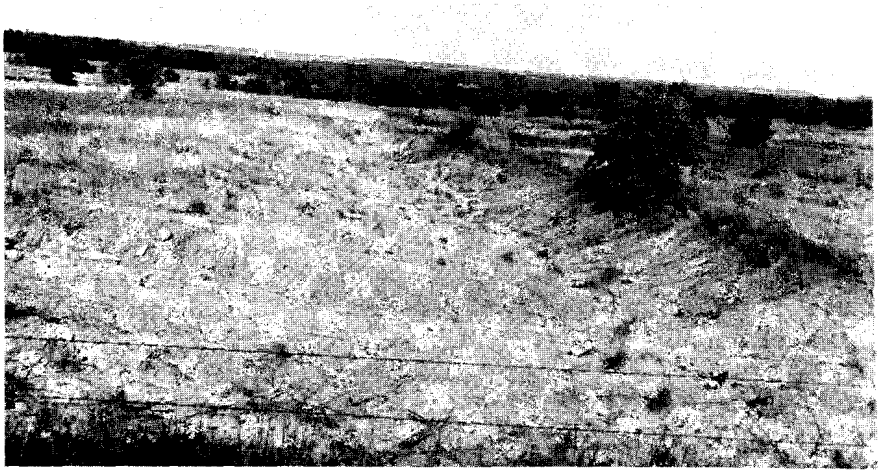
Where a small gully has started on an area of thin vegetation in pastureland, it is often possible to stop head cutting by constructing an eyebrow-shaped ridge above the gully head with the ends of the ridge leading slightly downslope onto good grass cover. This is a temporary measure and requires considerable skill and care in the selection of outlet areas. Prompt application of revegetative measures in the gully should follow this practice.



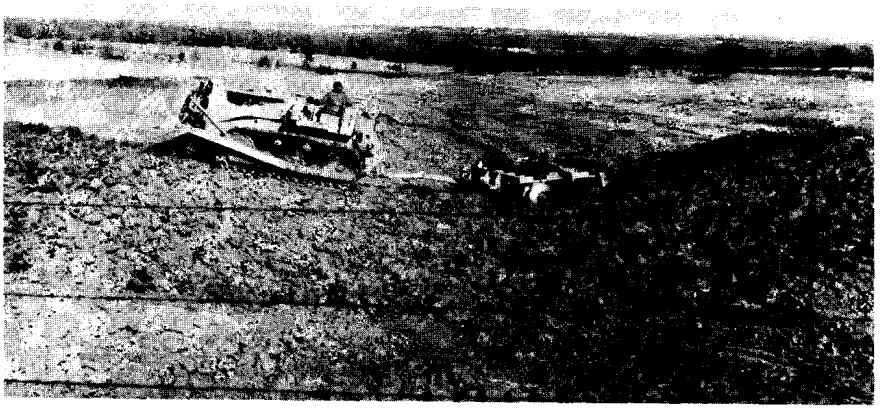
Gully caused by emptying terraces into an unprotected outlet



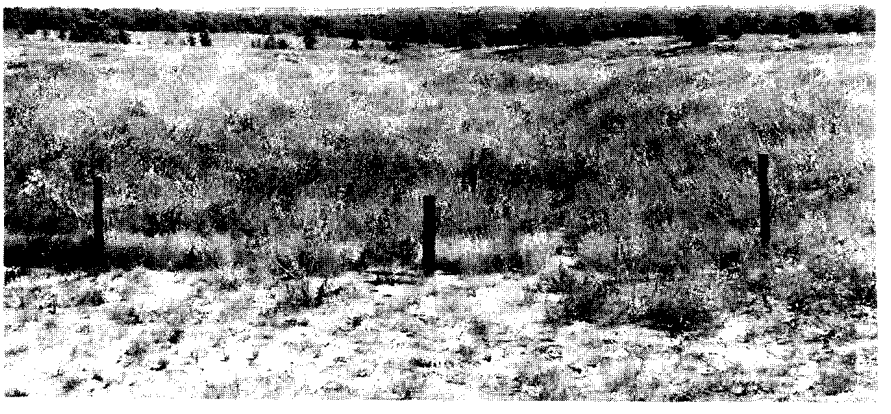
Figure 10-2 Same gully treated by filling, shaping and planting to grass



Gullied area



Reshaped and plowed before seeding native grasses



Fenced to exclude or control grazing

Figure 10-3 Critical area planting

Water Retention

Proper land use and conservation cropping and tillage practices are the first steps in holding water on the drainage area of a gully. These can be supplemented, as necessary and feasible, by other water-holding measures to further reduce the runoff into the gully. Some of these measures are discussed in the following paragraphs.

Level impounding terraces provide storage and can be farmed where cropland is involved in the drainage area of the gully. The ends may be left partially open, if necessary to drain part of the water from the terrace channel to prevent drowning out of crops or pasture vegetation. If level terraces are to retain all of the runoff, they should be constructed only on permeable soils and mild slopes.

Runoff water often can be prevented from entering or flowing through relatively large gullies by the use of carefully located earthen dams.

Selection of the damsite and elevation of the spillway are very important. The dam should be located near enough below the gully head that the channel gradient will be lowered to a slope that will stop the headward extension of the gully. The site should provide enough natural storage so that the emergency spillway will not flow often. Generally, a principal spillway or trickle tube is needed to reduce frequency and duration of emergency spillway flow.

In many areas where gullies are formed by runoff from small drainage areas, small earth dams are used to stop headward cutting and to furnish temporary stock water after periods of rainfall. Such structures, however, give better protection if equipped with a drop inlet that will slowly release the impounded runoff water and provide storage space for runoff from succeeding rains. Since there will be only occasional spillway discharge, vegetative practices and natural reproduction of native vegetation below the fill will have an opportunity to control the gully at little cost.

The two types of earth dam structures described above usually are designed as grade stabilization structures which are discussed later in this chapter.

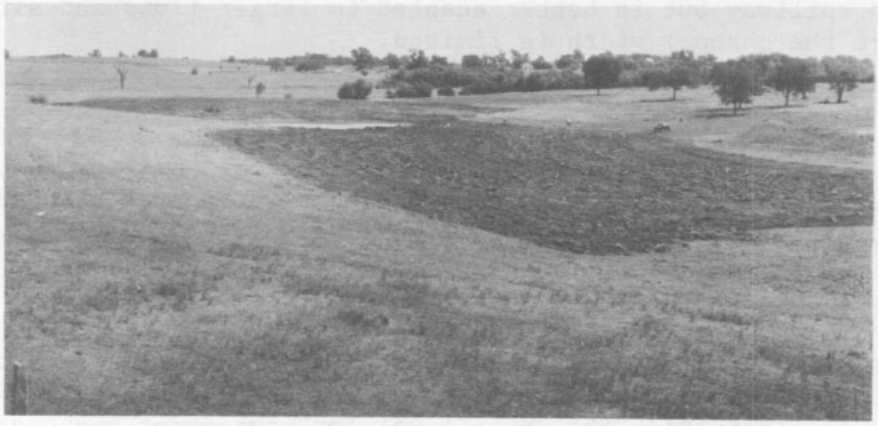
GULLY TREATMENT BY GRADE STABILIZATION STRUCTURES

It is not always possible to keep runoff water out of gullies by retaining or diverting it, and the runoff must flow through the gully channel. To do this safely may require that both vegetation and structures (see Figure 10-4) be planned and established in the gully at critical points.

Planning gully treatment under these conditions may require that the gradient of the channel be reduced so that water will travel at a non-erosive velocity. Some type of structure may be required at overfalls, abrupt changes in gradient, entrances of branch gullies or at other critical points to supplement vegetation in stabilizing the channel gradient.



Original gullied area



After installing drop inlet structure for grade control, and shaping



After critical area planting

Figure 10-4 Gullied area treated by using drop inlet structure along with shaping and critical area planting

Structural Measures

Structural measures should be used for gully control only when other measures are not applicable or adequate. The following types of structural measures are used in gully control work. (See Chapter 6 of this manual for technical information and design requirements.)

1. Straight drop spillway

   This type of structure is generally used in the lower reaches of water disposal systems, such as terraces, diversions, outlets, and waterways; for large overfalls adjacent to streams; or for drainage.

2. Box inlet drop spillway

   This type of structure has the same general usage as the straight drop spillway but is better adapted to larger flows and sites where the channel width is limited.

3. Hood inlet spillway

   This structure uses a straight-pipe principal spillway, usually on a steep slope, in an earth embankment to control head cutting or to safely drop water to a lower level.

4. Drop inlet spillway

   This type of structure has the same general usage as the hood inlet and has the added advantages of permitting drainage of the pond or fluctuating the water level for management purposes.

5. Chute spillways

   This structure is sometimes used where the head or drop to be controlled and spillway capacities are relatively small. Formless chutes are limited to areas where temperature variations are moderate and conditions are favorable for building the shape of the structure in the soil.

Earthfill Structures with Vegetated Spillway Only

These may be used as grade stabilization structures and to impound sediment or water for gully treatment. They may also provide temporary livestock water or be used as debris basins. This type has limited use since a vegetated spillway stable enough to withstand frequent flows through it can seldom be found in the right location in gullied areas. Vegetated spillways occasionally can be developed prior to construction of the earthfill. Requirements for design and installation are the same as those for Ponds and Reservoirs. See Chapter 11 of this manual.

SEDIMENT CONTROL WITH DEBRIS BASINS

Debris basins are used where physical conditions or landownership prevent the treatment of the sediment source by the installation of gully control measures.

This type of structure is a dam, usually equipped with a pipe principal spillway, constructed across a waterway or at some other suitable location to form a sediment storage basin. A debris basin is used to preserve the capacity of reservoirs, ditches, canals, diversions, waterways or streams and to prevent undesirable deposition on bottom lands. This is done by storing a high percentage of the sediment and other debris moving from the drainage area.

The capacity of a debris basin is governed by the volume of sediment expected to be trapped at the site during the planned useful life of the structure or the improvements it is designed to protect. Where it is assured that periodic removal of debris will take place, the design capacity may be reduced accordingly.

Usually, the design, layout and construction principles for debris basins are identical to those for principal spillway-type grade stabilization structures or farm ponds. Only the primary purpose of the structure may differ. Therefore, previous discussions in this chapter or in Chapter 11 of this manual will apply, depending upon type of debris basin being considered.

For further guidance on construction and construction materials, see Chapter 17 of this manual.

3. SURVEYS

Surveys should be adequate to determine the gradient and cross sections of gullies to be treated with vegetation alone or in combination with filling and shaping. In many cases hand level data will be satisfactory.

A thorough field survey of site locations should be made for grade stabilization structures so that the most economical type of structure can be designed. Profile and cross-section surveys are needed to show the characteristics of the watercourse above and below the planned structure location. The structure may affect the flow of water for quite a distance above and below its proposed site, or have an effect on other structures. Topographic and soils information as well as a geologic investigation may be needed on the structure site itself for detailed designing. Decisions on these surveys should be made in the field based on the type of structure being considered.

Earthfill structures and some of the drop spillways or chutes may need additional field surveys for an emergency spillway. Profile and cross-section surveys of the proposed spillway sites may be needed for a design that provides adequate capacities at nonerosive velocities.

Field surveys should also record the location, pertinent elevations, and sizes of any bridges, culverts, fence lines, buildings, etc., which might influence the design of the structure. Determinations must be made as to the size and shape of the watershed and all other factors that influence runoff and the design of the structure. (See Figure 10-5, Gully survey example.)

4. DESIGN GUIDELINES

Guidance in the design of gully treatment measures will be found in Chapter 6 - Structures, Chapter 7 - Waterways, Chapter 8 - Terraces, Chapter 9 - Diversions, and Chapter 11 - Ponds and Reservoirs.

A permanent grade stabilization structure must have a stable downstream grade with no degrading after the protective measures are established. Any excess grade should be compensated for in the structure design by lowering the apron floor or adding other structures in the channel below. If topography permits, the drop inlet is more suitable than an overfall structure where there is excess grade below the structure location.

The type of structure and the site selection will be influenced to some extent by the availability of materials. For example, if a drop inlet structure is being considered, suitable core and fill material should be readily available. Available rock suitable for a rubble masonry structure may be the deciding factor on the type of drop spillway to construct.

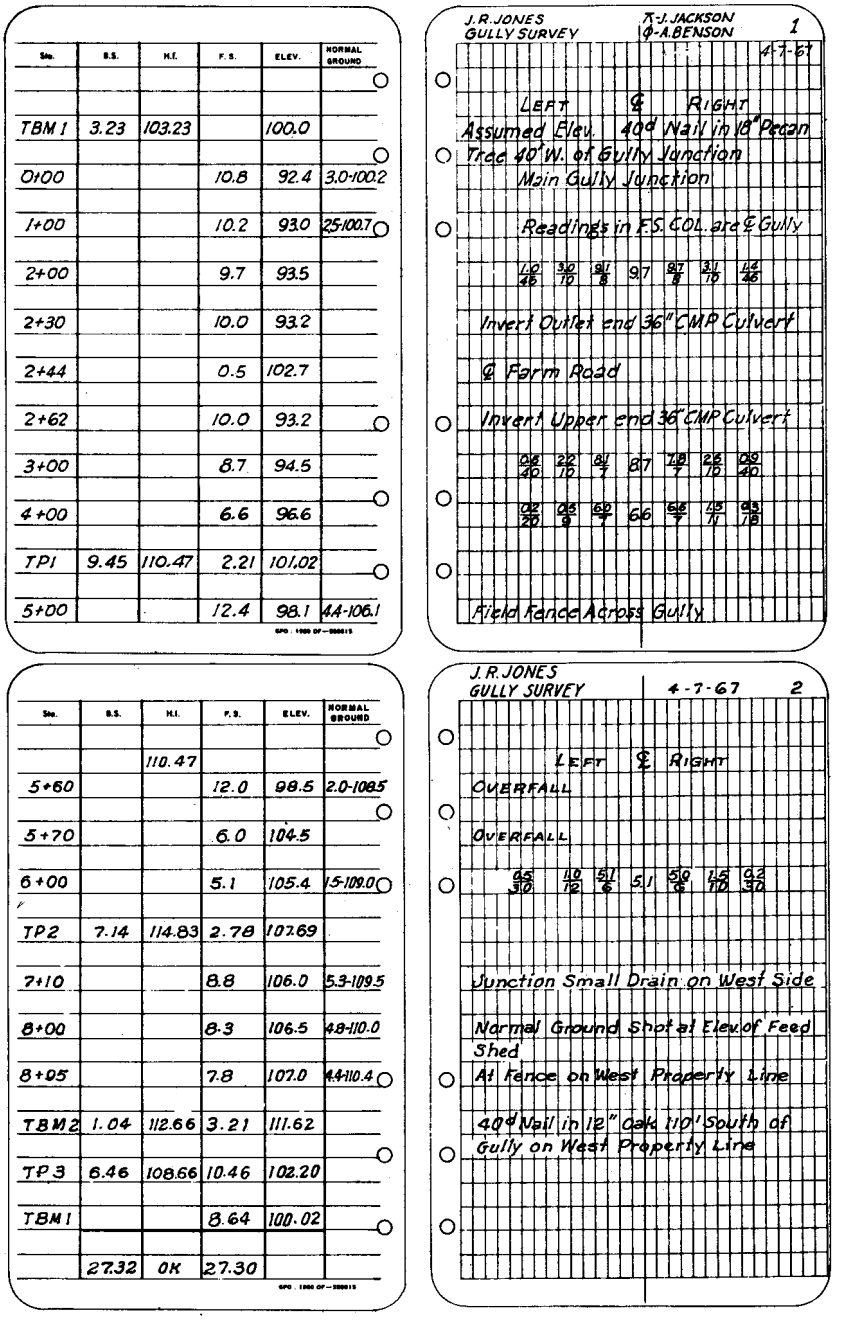
The type of foundation for any proposed site may determine the type and size of structure to be constructed. Wet, seepy foundations are not suitable for large concrete structures unless the design includes expensive corrective measures. This may be the place where a drop inlet structure is needed. Dry, unstratified foundations are suitable for almost any type of structure. Where there are wet areas on the structure site, drop spillways or chutes can be constructed in a drier area and the waterflow diverted to them.

When the structure is to control a gully head or overfall, the site selection should be carefully made. The crest of any erosion control structure should be set at an elevation which anticipates the upstream movement of the gully head during the healing period.

The location for a suitable emergency spillway is another important factor in selecting a site for any erosion control or detention dam where part of the flow is carried through the dam by a principal spillway. In some cases, drop spillways will need an emergency spillway to help carry the less frequent peak flows around the end of the embankment. Therefore, site selection and design should include full consideration of this important feature.

Scour at the outlet is one of the important factors leading to failure of an overfall structure. Scour may be controlled by giving proper consideration in the design to the:

1. Stability of the grade below the structure.



Sta.	B.S.	H.I.	F.S.	ELEV.	NORMAL GROUND
TBM 1	3.23	103.23		100.0	
0+00			10.8	92.4	3.0-100.2
1+00			10.2	93.0	25-100.7
2+00			9.7	93.5	
2+30			10.0	93.2	
2+44			0.5	102.7	
2+62			10.0	93.2	
3+00			8.7	94.5	
4+00			6.6	96.6	
TP1	9.45	110.47	2.21	101.02	
5+00			12.4	98.1	4.4-106.1

J.R. JONES
GULLY SURVEY

T-J. JACKSON
Φ-A. BENSON

1

4-7-67

℄ LEFT ℄ RIGHT

Assumed Elev. 40d Nail in 18" Pecan Tree 40' W. of Gully Junction

Main Gully Junction

Readings in F.S. COL. are ℄ Gully

1.0/4.6 3.0/1.0 8.1/8 9.7 8.7/8 3.1/1.5 1.4/4.6

Invert Outlet end 36" CMP Culvert

℄ Farm Road

Invert Upper end 36" CMP Culvert

0.6/4.0 2.2/1.0 8.4/7 8.7 7.8/7 2.6/1.5 0.9/4.0

0.2/2.0 0.8/9 6.2/7 6.6 6.6/7 1.5/1.1 0.3/1.8

Field Fence Across Gully

Sta.	B.S.	H.I.	F.S.	ELEV.	NORMAL GROUND
		110.47			
5+60			12.0	98.5	2.0-108.5
5+70			6.0	104.5	
6+00			5.1	105.4	1.5-109.0
TP2	7.14	114.83	2.78	107.69	
7+10			8.8	106.0	5.3-109.5
8+00			8.3	106.5	4.8-110.0
8+05			7.8	107.0	4.4-110.4
TBM 2	1.04	112.66	3.21	111.62	
TP 3	6.46	108.66	10.46	102.20	
TBM 1			8.64	100.02	
	27.32	OK	27.30		

J.R. JONES
GULLY SURVEY

4-7-67

2

℄ LEFT ℄ RIGHT

OVERFALL

OVERFALL

6.5/3.0 1.0/1.2 5.1/6 5.1 5.0/6 1.5/1.0 0.2/3.0

Junction Small Drain on West Side

Normal Ground Shot at Elev. of Feed Shed

At Fence on West Property Line

40d Nail in 12" Oak 110' South of Gully on West Property Line

Figure 10-5 Gully survey example

(See cover sheet and sketch map example in Chapter 1 of this manual.)

2. Velocities occurring in the downstream channel.

3. Tailwater elevations for different flow stages.

4. Dissipation of water energy in the outlet.

Scour below drop spillways or chutes usually is reduced as the tailwater elevation is increased. Scour at the outlet end of drop inlets is reduced by having the pipe section extend beyond the toe of the fill and cantilevered on a pipe support, or otherwise protecting against undercutting of the pipe.

The peak and volume of runoff are almost directly proportional to the length and size of the watershed. The site chosen for a structure may be adapted to a drop spillway, but the drainage area and runoff may be too large for this type of stabilizing structure. For large runoff volumes or high peak flows, temporary storage may be required to provide an economical discharge. The technician should consider the need for temporary storage at the time the preliminary site selection is made.

Consideration should be given to the land use at the proposed site or immediately adjacent to it. Drop spillways or chutes may be placed in cropland since they do not employ detention storage which would be lost by siltation. Improper land use above, adjacent to, or below the structure site may seriously reduce the effectiveness of the structure or stability of the downstream grade. Needed land treatment measures and proper land use should be applied to the watershed when excessive runoff or siltation would seriously affect the life and efficiency of the structure.

Gullies which produce large amounts of sediment may require an earth dam with a drop-inlet type debris basin. The sediment capacity should be designed to store the eroded soil rather than allow it to damage valuable land or structures below.

Extreme size should be avoided in structures. If the drainage area is too large, the width of spillway notch may greatly exceed the width of the channel, causing prohibitive construction costs and poor hydraulic conditions at the structure site. In such cases, it may be desirable to consider a box inlet drop spillway or attempt to control only the lateral gullies entering the main gully.

Final selection of the location, type and design of permanent structures, larger than those normally used in terrace outlet works, should be with the advice and consultation of technicians skilled in geology, hydrology, design and construction. Chapters 2, 3, 4 and 6 of this manual include additional criteria used in design.

5. INSTALLATION OF MEASURES

Chapter 17 of this manual describes surveys for setting line and grade stakes for construction of the various structures.

Careful clearing and excavation of the site is important since the ties between the structure and the sides and bottom of the gully are points of weakness. All backfill should be compacted.

Structures should be placed so that the discharge from the spillways will not cause embankment damage or side-cutting or undermining of the downstream banks.

Any overfall above an erosion control structures should be sloped to allow water to enter the pool area without additional erosion, even though the inlet crest may be equal to or higher than the gully head elevation.

Channel below the structures should be shaped as needed when the structure is built. Irregular banks below an entrenched structural spillway will not erode to the desired shape for the outlet channel, and the erosion will create undesirable silt bars downstream.

The following should be taken into account in the establishment of any type of vegetation.

1. The amount of runoff entering the gully should first be reduced to the extent practical.

2. Since gullied areas have had much of the topsoil washed away, it will be difficult to establish plants on the remaining subsoil.

3. Preparation of a good seedbed for sod, sprigs, seed, small plants, cuttings or vines, along with the application of fertilizer and soil amendments, is necessary to obtain a rapid vegetative growth.

4. If the gully banks are not too steep or do not receive large amounts of runoff, mulches of straw, hay, light brush or other organic materials are valuable in protecting newly planted vegetation from raindrop erosion. In some areas, it may be necessary to protect mulches from displacement by winds.

5. Protection from fire, heavy grazing and trampling is important for permanent control.

6. Plantings should be made during the season and under climatic conditions suitable for survival and rapid growth.

7. Maintenance of vegetative cover is as important as the original establishment of the cover.

8. A strip of grass of variable width around the gullied area should be included in the planting area to insure control of the area and to protect the more slowly established plantings in the severely damaged area. Where the gully lies in or adjacent to a cultivated field, a strip of vegetation at least 25 feet wide should be established and maintained next to the gully banks.

9. Areas that tend to remain wet may require tile drains to maintain favorable conditions for growth of vegetation.

6. MAINTENANCE

Periodic checks should be made of all gully control works. The following maintenance practices are important:

1. Protect all vegetative plantings from grazing until established and then allow only limited use.

2. Eliminate competition from undesirable weeds and grasses in vegetative plantings.

3. Protect all plantings from trampling and fire.

4. Make immediate repairs of breaks or low spots in terraces, diversions or structures.

5. Remove trash from drop inlets or weirs.

6. Sod or seed spot failures in vegetative plantings. Fertilize vegetation as required.

7. Mow or properly graze waterway areas.

8. Inspect sides, corners and wingwalls of all structures and repair cracks in earth caused by settling, rodent burrows, dry weather, etc., before the structure is weakened.

Considerable damage, as well as loss of structures may result from failure to protect and maintain the structures properly. Providing minor maintenance in a timely manner often saves costly repair jobs when an unusual storm occurs.