ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF WATER PROGRAMS

CONTROL OF EROSION AND SEDIMENT DEPOSITION FROM CONSTRUCTION OF HIGHWAYS AND LAND DEVELOPMENT

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CONTROL OF SEDIMENTS RESULTING FROM HIGHWAY CONSTRUCTION AND LAND DEVELOPMENT

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FOREWORD

Soils, with their attendant pesticides and nutrients, become a liability to water resources management and to the water-using society, and a significant loss to the landowner when stolen from the lands by uncontrolled runoff.

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Cover Photograph: Eight Feet of Sediment Deposited in Debris Basin in One Month. Tyson's Corner, Fairfax County, Virginia.

INTRODUCTION

Sedimentation involves three basic processes--erosion, transportation and deposition. They are natural geologic phenomena that have been in continuous operation for millions of years. Through these processes rock particles, dissolved minerals, and other matter are derived from topographically higher areas and transported downslope into river, ponds, lakes, and oceans where they are deposited and provide the essentials for maintaining life.

Continuity of natural sedimentation processes is essential to maintain the normal regimen of river systems and coastal areas and to support the life cycle of organisms living in them. To upset the equilibrium is to cause undesirable readjustments of the system as a whole and possible damage to the existing environment. Man's land development activities have initiated these severe and highly undesirable readjustments in the natural sedimentation cycle, particularly in local areas, by drastically accelerating the erosion process. As a result of the greatly increased erosion, deposition of excess quantities of transported sediments occurs in downstream areas.

The Problem

Costs of correcting erosion and sediment deposition problems resulting from highway construction and land development activities often are unjustifiable transferred to the taxpayer. They result when consequences of the construction operations on downstream areas are not properly considered. Costs of remedial measures to rectify the damages incurred are borne by others than those benefitting from the development.

Although accelerated erosion and excess deposition of sediments resulting from construction activities have caused pollution of water bodies in many parts of the country, damaged homes and drainage systems, made treatment of water supplies more costly, and adversely affected aquatic life, very few localities have organized and implemented effective control measures (1). It appears that technical capability is not the governing factor but how this capability is applied, financed, and administered.

Objectives and Scope

The objectives of this study were to: (1) obtain an understanding of the effects of man's land development activities on natural erosion processes, (2) determine measures that will effectively control erosion at construction sites, and (3) estimate costs of achieving effective control.

The scope involved a review of existing published and unpublished literature on sedimentation problem areas; control measures used and proposed by concerned agencies, and the administrative approaches to control. Because of time limitations, much of the data, particularly regarding cost estimates, were obtained by telephone from various Federal, State and local agencies, as well as from private developers and consulting engineers.

Land development, for the purposed of this report, includes principally single-family and multiple-housing developments and the accompanying shopping-center complexes. Little effort was directed toward obtaining data on sedimentation resulting from construction of dams, canals, thermal or atomic power plants, transmission lines, railroads, or bridges.

Acknowledgments

Special acknowledgments are given to: Mr. R. C. Barnes of the Soil Conservation Service who freely submitted data and advice; Mr. Herbert Kelly, also of SCS, who released photographs of areas affected by erosion and sediment deposition and of control structures; Mr. O. C. (Bill) Leaf of the California Division of Soil Conservation who provided reports on erosion and sediment deposition and photographs and sketches of control structures; Mr. Richard Howell, California Highway Research Laboratory, who gave information on slope stabilization experiments and provided contacts for additional data; and Mr. W. L. Hottenstein, from the Federal Highway Administration, who submitted references and data on highway construction activities. Drafting of erosion control structure sketches was done by Messrs Robert Eggleston and James Ingram.

Editing was done by Messrs K. M. Mackenthun and W. C. Shilling who also provided technical advice and comments.

SUMMARY AND CONCLUSIONS

1. Man's land development activities have drastically upset the natural and necessary geologic process of sedimentation by greatly accelerating erosion. Deposition of excess quantities of sediments pollutes down stream waters and damages lands.

2. The cost of correcting the erosion and sediment problems resulting from land development often is unjustifiably transferred to the taxpayer rather than to those benefitting from the development.

3. The technical capability of controlling erosion and sediment deposition is available. It involves protection of disturbed soil from the energy of falling rain and flowing runoff water by installing protective covers, controlling runoff, and trapping sediments in transport.

4. The cost of effective erosion and sediment control probably is minimal.

5. The principal problem lies in achieving effective administrative control and enforcement by concerned agencies of erosion and sediment control programs.

CAUSES OF ACCELERATED EROSION

The principal influence land development activities have on the natural erosion process results from the exposure of disturbed soils to precipitation and storm runoff water. Shaping of land for construction purposes alters the soil cover in many ways, often detrimentally affecting the drainage, runoff, and stream-flow. Protective vegetative cover is removed, excavations are made and the removed material stockpiled without cover, slopes are modified by making steep cuts and fills, and the physical properties of the soil are changed (See Figure 1).

Figure No. 1. Accelerated erosion and excessive sediment deposition resulting from exposure of soils to falling and running water. Largo, Md.

The energy responsible for erosion is provided by falling rain and flowing runoff water. One inch of precipitation falling on one acre of exposed soil weighs 110 tons. In the lower portion of the Potomac River Basin, where the average annual rainfall is about 40 inches, approximately 4,500 tons of rain fall on each acre of land during the year. This falling rain and flowing runoff provide the energy required to erode large quantities of soil from areas under development and transport it farther downstream. Fortunately, the precipitation in this area is well distributed through the year (2).

If natural vegetation is left upon land being developed, the kinetic energy of the falling rain is dissipated. If it is removed, the bare and disturbed soil receives the full force of the energy. Raindrops strike the ground with a velocity of about 19 miles per hour, like miniature bombs. They knock individual soil particles loose and compact the exposed soil surface. Runoff increases as the compacted soil becomes less permeable; and the soil particles loosened by rain drops are carried down the slopes by overland flow. The impact of rain falling for a period of from one to four minutes is known to decrease infiltration to such an extent, even in sandy soils, that up to 98 percent of the rainfall runs off (2). Runoff moves as sheet flow or becomes concentrated in rills and gulleys (Figures 2, 3). It is dynamic in that it has energy to erode and transport soil particles. If the available energy is greater than the sediment load being carried, the moving water will erode to obtain the additional sediment. If the load is greater, deposition of transported material will occur.

Normally, runoff builds up rapidly to a peak and then diminishes. Excess quantities of sediment are derived by erosion principally during higher flows (Figure 4). During lower flows, as runoff velocities decrease, the transported materials are deposited to be picked up by later high flows (Figures 5, 6). In this way, sediments are carried downstream intermittently from the source area. A study of sedimentation due to highway construction and land development in the Scotts Run area of Virginia showed that 99 percent of the sediment discharged occurred during periods of high flow which took place during only 3 percent of the period of measurement (3).

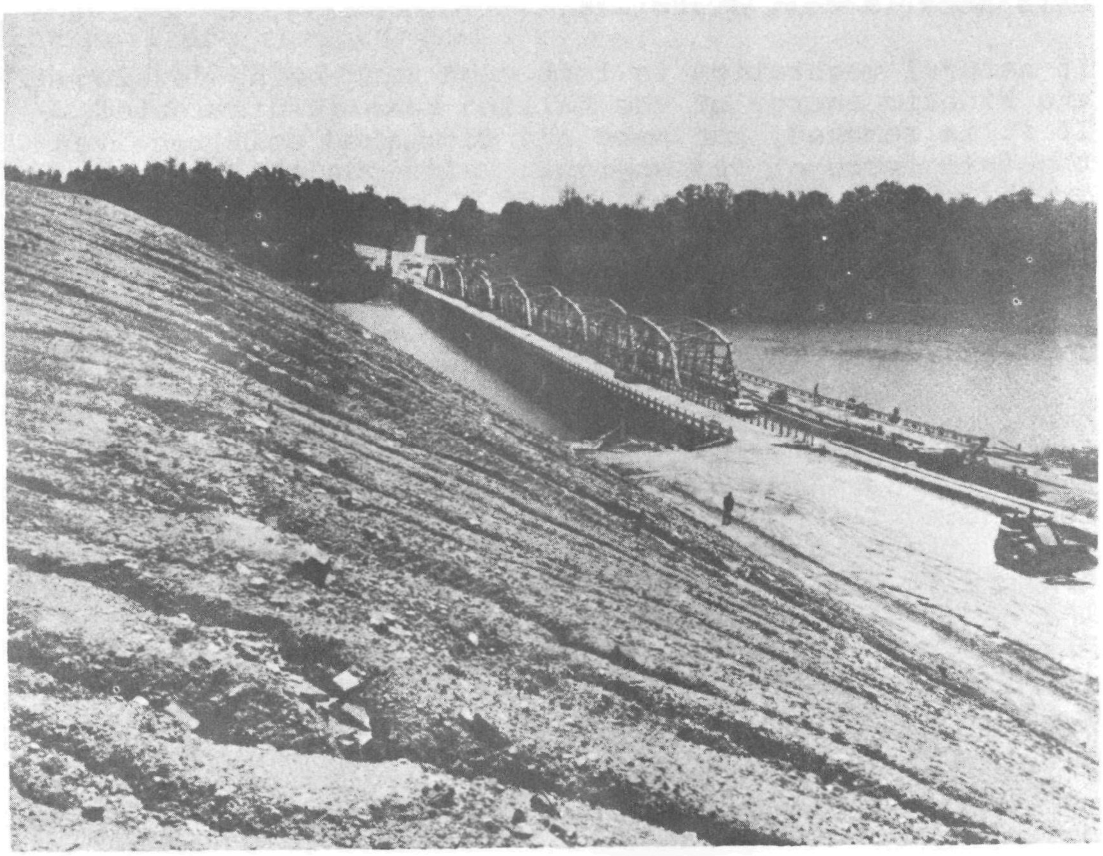

Figure No. 2. Rills developed on newly-constructed highway embankment. Alex City, Alabama.

Figure No. 3. Gulleys developed in ground exposed to runoff over the winter. Scale shows depth in feet. Vancouver, Washington.

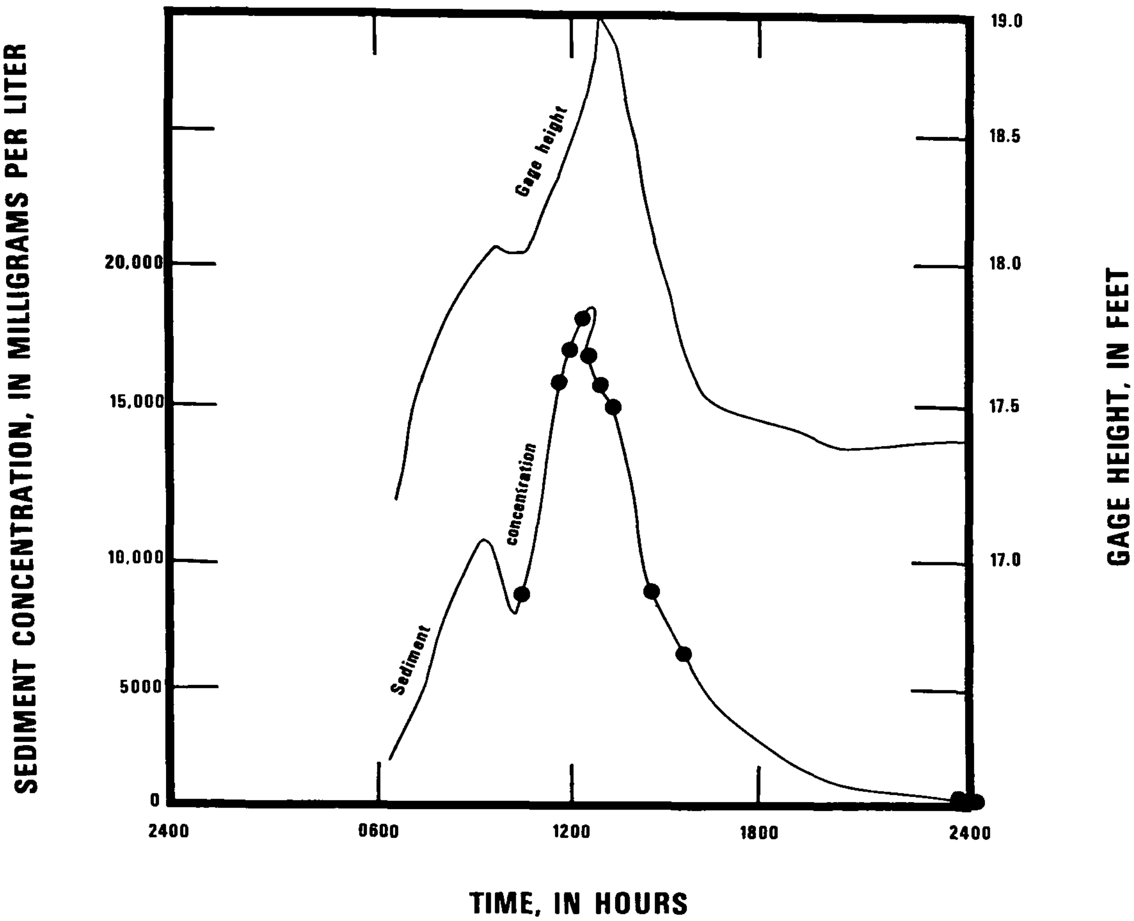

Figure No. 4. Variation in sediment concentration and stream stage for a typical storm-runoff period; Scotts Run Basin, Va. (From USGS Water Supply Paper 1591-E).

Figure No. 5. Excessive sediment deposition from unprotected fill slope during highway construction. Maryland, US40 and US 29.

Figure No. 6. Excessive sediment deposition at industrial site due to accelerated erosion farther upstream. Ardmore, Md.

EFFECTS OF EXCESSIVE SEDIMENT LOADS

Over one billion tons of sediment reach the rivers of our country each year. Approximately 10 percent of this quantity is contributed by erosion from lands undergoing highway construction or land development (4). Although the quantities may be small compared to the total, they could represent over one-half of the sediment loads carried by streams draining small watersheds under development.

Sediment yields in streams flowing from urbanized drainage basins vary from approximately 200 to 500 tons per square mile each year. In contrast, the urbanizing areas have a yield of from 1,000 to 100,000 tons (5). It is easy to realize the tremendous quantities of sediments annually reaching our streams and rivers since an estimated 4,000 acres of land are undergoing development each day for housing, highway construction, and industrial sites (4). For very small areas, where construction activities have altered the soil mantle and vegetative cover, sediment derived from one acre of land may exceed 20,000 to 40,000 times that obtained from adjacent farm or undeveloped woodlands in an equivalent period of time.

Wherever the velocity of streams carrying sediment decreases, deposition occurs. The excessive quantities of sediment cause costly damage to water areas and to public and private lands (Figure 7). Obstruction of stream channels by masses of deposited materials reduces their hydraulic capacity which, in turn, causes an increase in flood heights and a consequent increase in damages (Figure 8). Sediments often fill drain ditches along roads and railroads, and plug culverts and storm sewers (Figure 9, 10, 11). Municipal water supply reservoirs lose storage capacity, and the cost of filtering the muddy water becomes excessive. The added expense of water purification amounts to millions of dollars each year. The aesthetic attraction of many lakes and reservoirs used for swimming, boating, fishing, and other water-related activities is reduced greatly (Figure 12). Some published reports indicated that over 600 miles of streams in the State of Virginia alone have been affected by excessive quantities of sediment (4). To remove these deposits and repair damage involved will be costly (Figure 13). Estimates of the cost of engineering, surveying, reconstruction, and removal of deposited materials reach approximately $4,000,000.

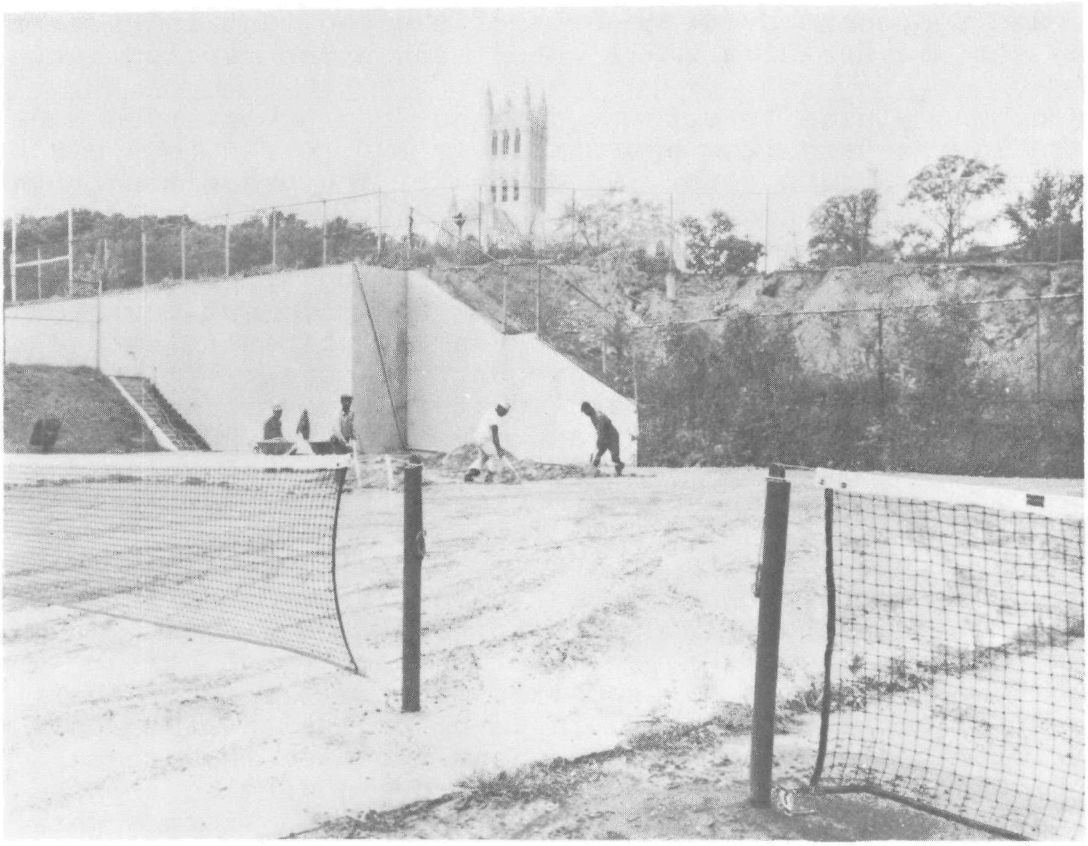

Figure No. 7. Deposition of sediments from erosion of newly-constructed athletic field farther upslope. Washington, D. C.

Figure No. 8. Sediment-choked stream channel. Oxford, Massachusetts.

Figure No. 9. Sediment deposited in energy dissipator due to road construction. Lake Tahoe, Calif.

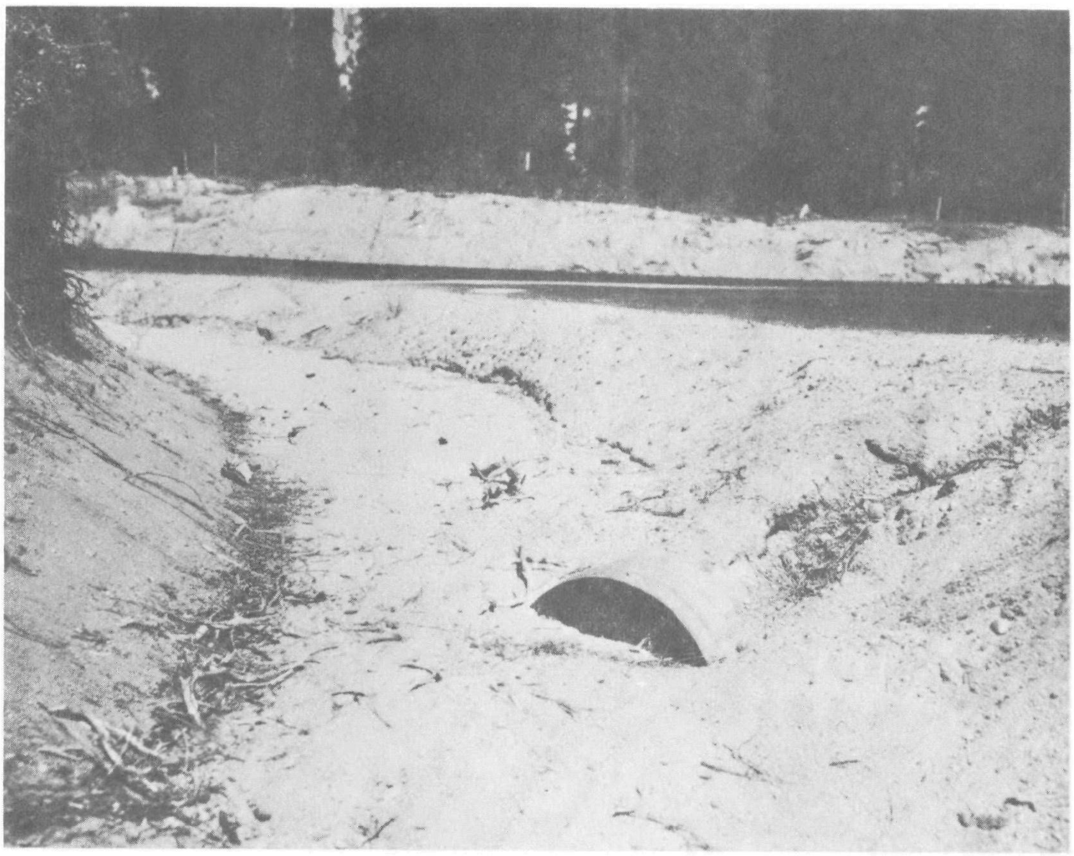

Figure No. 10. Sediment from subdivision under development plugging culvert. Lake Tahoe, Calif.

Figure No. 11. Erosion and deposition of sediment from soils exposed to rainfall and runoff. Bowie, Md.

Figure No. 12. Excess deposition of sediments in lake due to accelerated erosion activity in watershed. Lake Barcroft, Va.

Figure No. 13. Erosion caused by runoff during construction of new school. Pontiac, Michigan.

The general effect of fine-grained sediments such as silts and fine sands in an aquatic environment is to reduce drastically both the kinds of organisms present and their total number. The sediments alter the existing environment by screening out sunlight and changing the heat radiation. As particles settle to the bottom, they form a blanket which creates an undesirable environment for organisms which normally occur (Figure 8). It often smothers developing eggs of fish and also other organisms. Coarser-grained materials also blanket bottom areas to suppress bottom life. Where currents become strong, the abrasive action of these materials has a severe effect upon the benthos.

Other adverse effects of excessive sediment deposition on the stream systems or on downstream receiving waters can result from nutrients or pollutants which may be adsorbed on fine-grained soil particles (6). Nutrients such as phosphorus and nitrogen in generous amounts can cause accelerated eutrophication (enrichment) of waters with the accompanying increases in algal vascular plant nuisances, foul odors, and water treatment problems. Organic matter such as fatty acids, higher-order alcohols, and products of plant life also may be adsorbed to soil particles to contribute to displeasing taste and odor in water supplies.

TEMPORARY EROSION AND SEDIMENT CONTROL MEASURES

Temporary erosion and sediment control measures should be used to correct detrimental conditions: that develop during construction operations; that were not predicted during project design; that are needed temporarily to control erosion or sediments that become problems during construction but are not associated with permanent control (7).

Planning

To be most effective, temporary controls must be initiated during the design stages of development projects (Figure 14, 15). Special provisions should be made to require that operation of construction equipment does not create sedimentation problems. Fording of streams should be minimized, and if certain crossings are used consistently, temporary bridges should be required. Tracks of wheeled vehicles should not be left to initiate erosion activity.

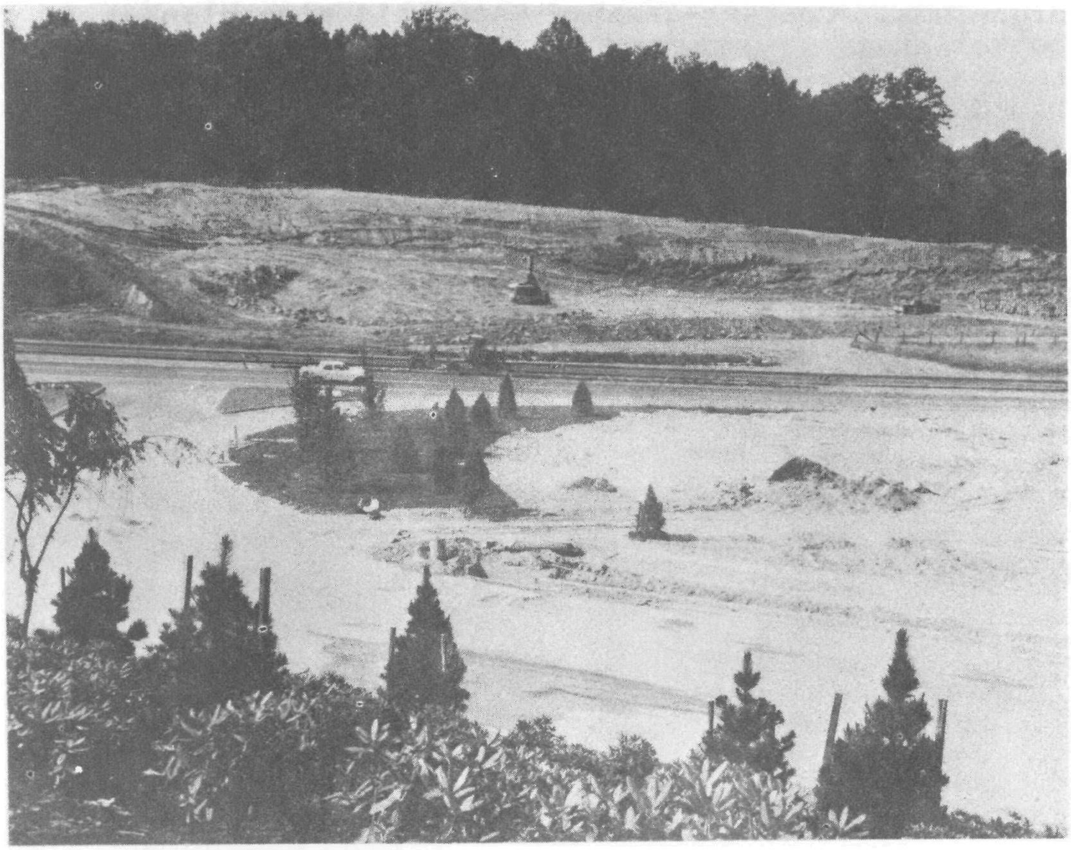

Figure No. 14. Erosion prevention and beautification work being done concurrently with construction. Tysons Corner Shopping Center, Va.

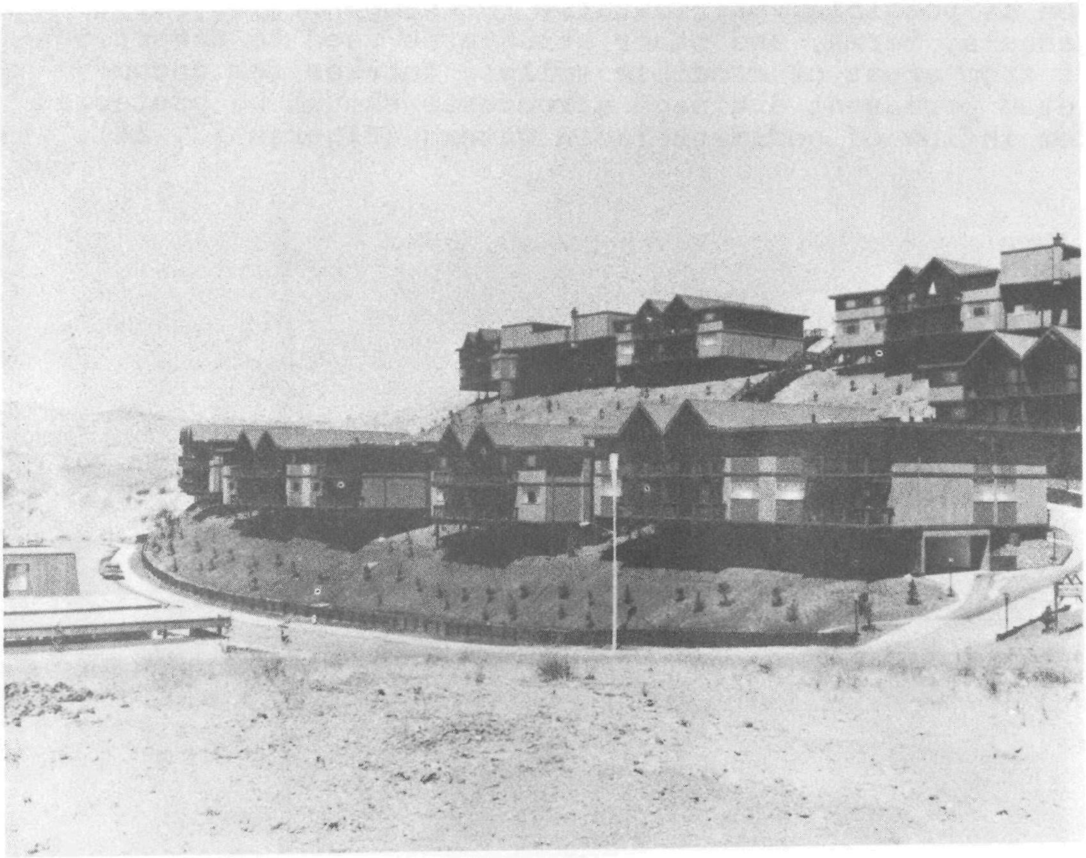

Figure No. 15. Hillside development planned to reduce danger of erosion or landsliding. Contra Costa County, Calif.

Special efforts must be made to minimize the areal extent of exposed soils at construction sites and the steepness and length of cut and fill slopes. Also, some means must be devised to prevent runoff water from concentrating or flowing at erosive velocities (Figure 16). Construction schedules should be programmed to permit installation of permanent sediment and erosion control structures as soon as possible, particularly intercept drains, diversion channels, berms, and other structures used to divert run-off from areas of erodible soils. Intakes for incompleted permanent drainage structures should be protected from inflow of sediment-laden waters (Figures 17, 18).

Figure No. 16. Disturbed soils left exposed for period of 2 years incurred severe erosion with subsequent deposition of sediments in downstream areas. Highway construction, McLean, Va.

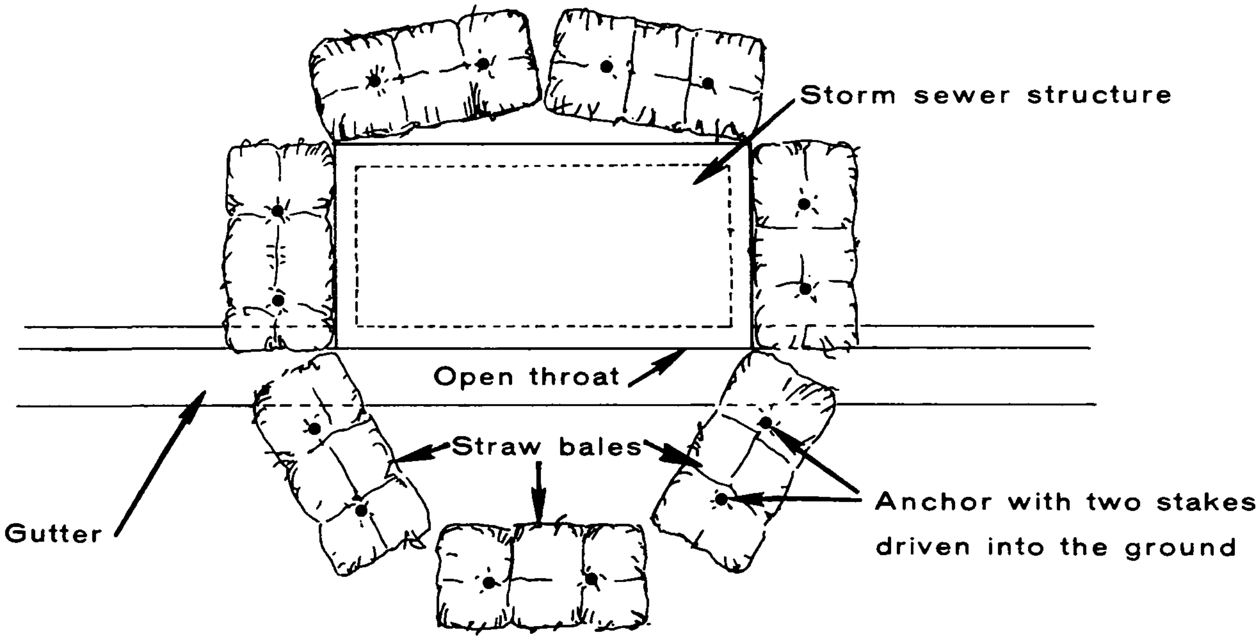

Figure No. 17. Temporary barrier of hay bales to prevent sediment-laden water from entering incomplete storm sewer system. (Revised from Reference No. 11).

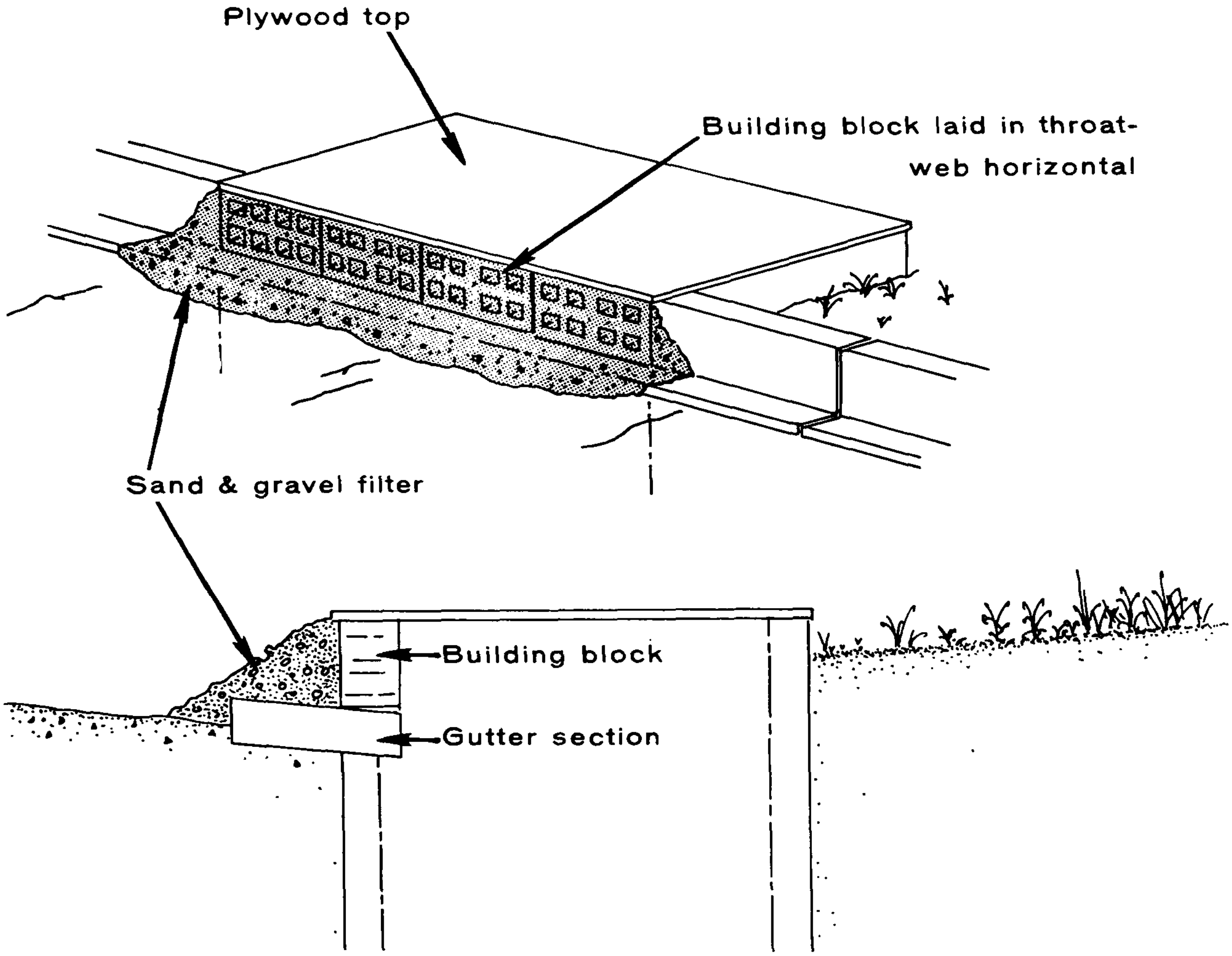

Figure No. 18. Sand and gravel filter protecting intake area of incomplete storm sewer system. (Revised from Reference No. 11).

The type, size, extent, and distribution of temporary control meausures required at a site will depend principally upon the distribution and intensity of precipitation; the erodibility of the soils; and the topographic relief, size, and geometric configuration of the site area. In the western U. S. where the rainfall is seasonal and intense, larger and more elaborate control structures may be needed than in eastern areas where precipitation is more evenly distributed throughout the year (Figure 19). In Los Angeles, for example, adequate temporary sediment and erosion control is required to be provided, and maintained in good working order, at construction sites between November 1 and April 15 of each year (8). Earlier removal is permitted only upon approval by the County. In eastern areas, where rainfall is distributed more uniformly throughout the year, temporary control structures are less elaborate but must be provided periodically as storms occur. Seeding and revegetating activities are very useful in the eastern areas; but in the arid west they may provide fewer protective benefits for soils, particularly for temporary control.

There probably is little agreement on the meaning of "adequate" erosion and sediment control. Temporary measures used during construction activities do not prevent sedimentation processes from occuring, they only control them. As the energy responsible for sedimentation processes is provided by falling and flowing water, it is essential that control measures effectively dissipate this energy. Exposed soils must be protected from the impact of rainfall. Runoff must be diverted from erodible areas and its velocity reduced. Sediments being transported by water should be trapped in sediment basins located in the construction site area.

The following paragraphs provide information on physical structures and practices which are useful in providing economical and effective control of erosion and sediment deposition. Most of these control measures have been required on various construction projects, or have been suggested for use, by the various organizations concerned with control.

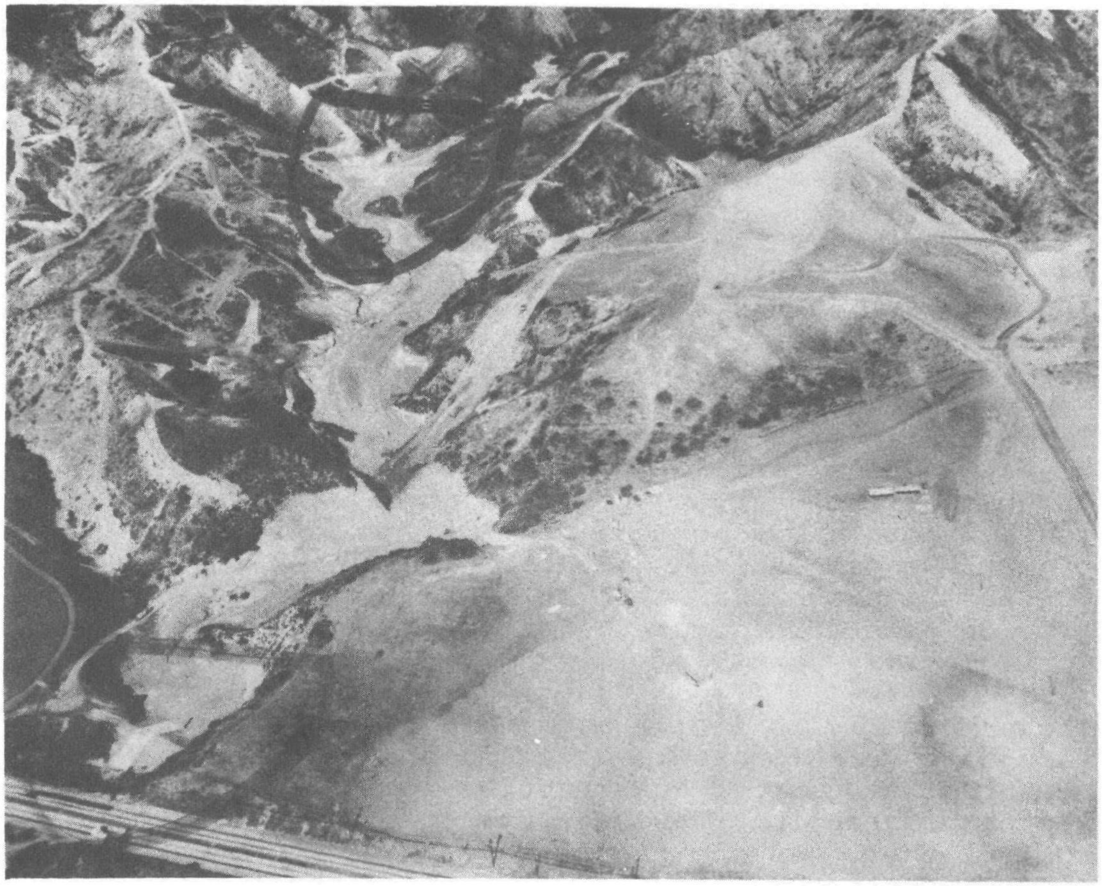

Figure No. 19. Large, well-designed sediment basins in construction site area for the Malibu Campus of Pepperdine University, California. (Courtesy of Los Angeles County Engineers Office).

Surface Protection of Exposed Soils

Exposed soil surfaces can be protected from the impact of falling rain and the energy of runoff water by installing coverings formed from mulch; sheets of plastic; burlap, or jute netting; temporary growths of fastgrowing grasses; or sod blankets.

Mulch consists of hay, straw, wood chips, corn stalks, bark, or any other suitable protective material. It can be anchored to slopes with liquid asphalt, stakes, covered with netting, or worked into the soil with various types of equipment to provide additional slope stability and to decrease erosion from runoff water (Figure 20, 21, 22). Often sheeps-foot rollers are used to embed mulch in the soil and to further compact the surface layers.

Figure No. 20. Hydroseeder applying seed, fertilizer and mulch on cutslope adjacent to newly-constructed road. Spalding County, Georgia

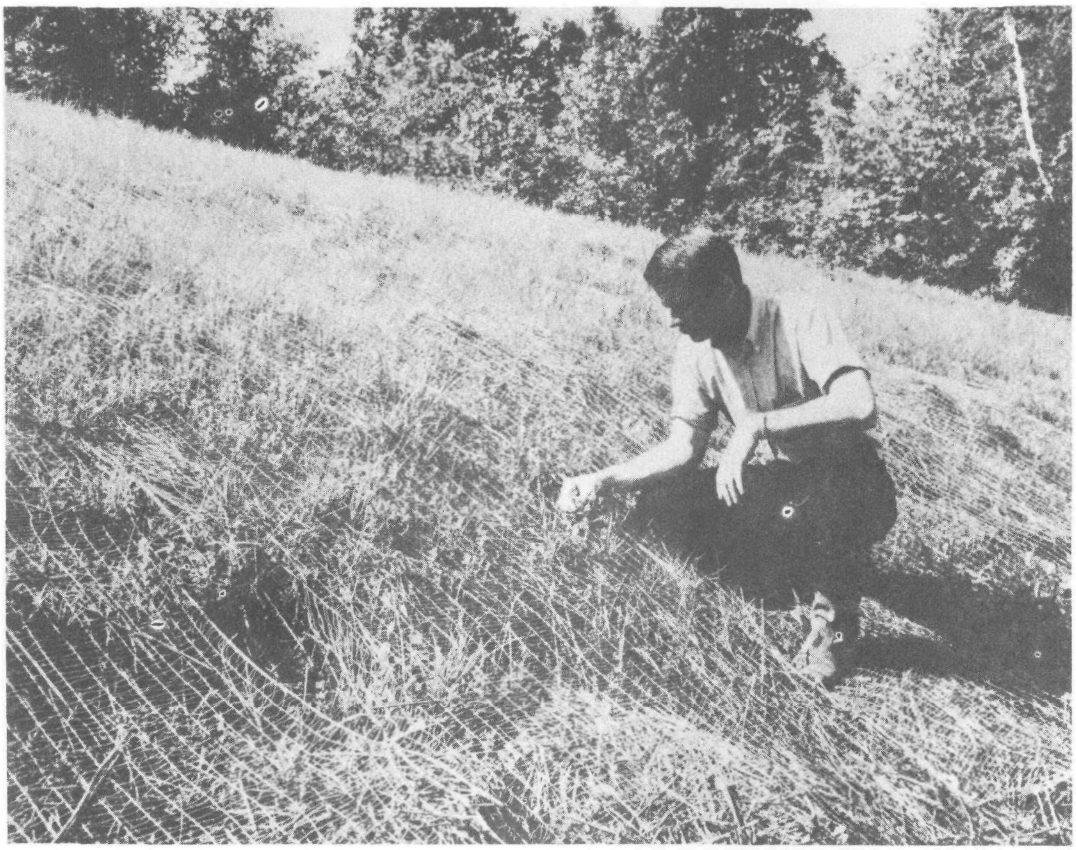

Figure No. 21. After seeding and fertilizing, the slope was mulched and covered with netting. Cereal Springs, Illinois.

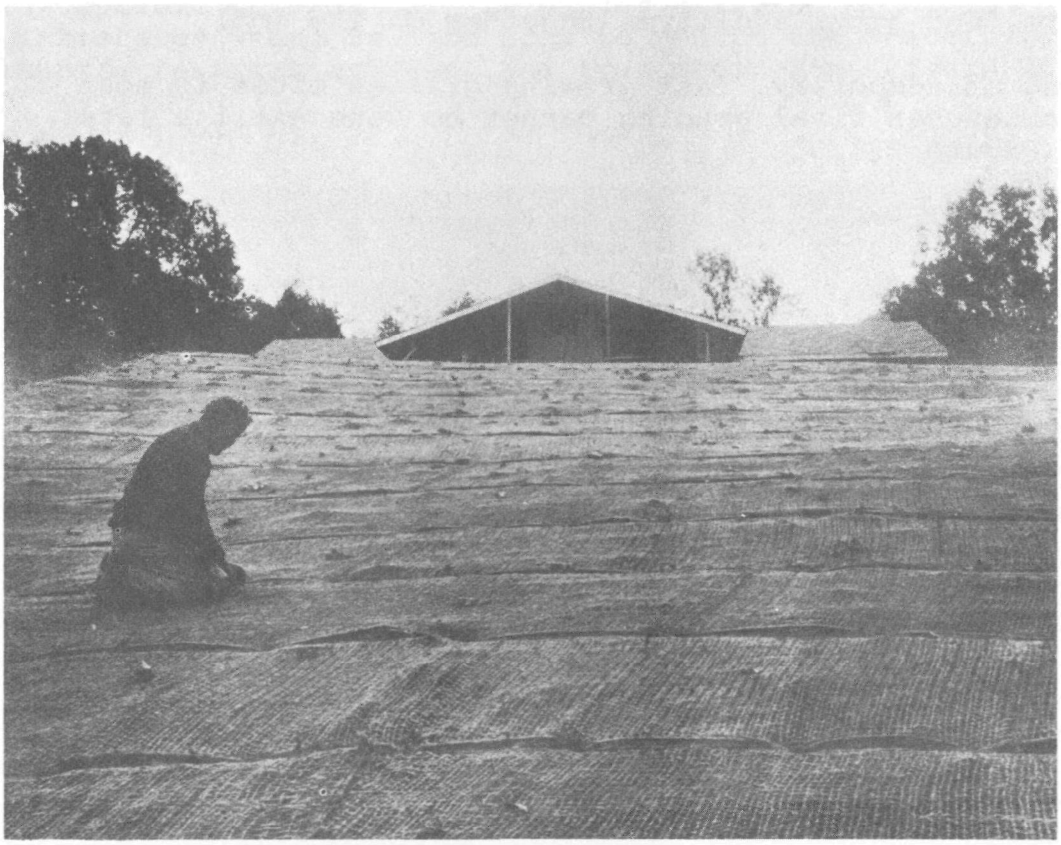

Figure No. 22. Fiber netting staked to slope to prevent erosion. Edgewater, Maryland.

Plastic sheeting, covers formed by plastic sprays, or asphalt linings also are useful in protecting erosion-susceptible soils. Liquid plastic sprays are in the developmental stages, particularly in areas of seasonal rainfall. They may be found to be useful in these areas as seeding can be done during, or prior to, installation with the finished cover protecting and supporting the seeds for later germination. In areas of sterile soils where establishment of vegetation is difficult, plastic spray covers may be extremely useful to hold seed, fertilizers, and other additives together on the soil.

Seeding of temporary, fast growing grasses often is most desirable when final grading cannot be done until a later date (Figure 23).

Figure No. 23. Newly-seeded, fast-growing vegetation on bank adjacent to industrial park site. Springfield, Va.

Seed beds should be prepared carefully by working fertilizer and required additives into the soil surface. Cultivation should be along the contours. Seeds tend to gravitate to lower portions of small rills where erosion may start. Here they germinate, protect the soil, and decrease the velocity of runoff water (Figure 24). Sod often is used as a covering in critical areas susceptible to erosion. It can be anchored to slopes with stakes where it also acts to reduce the velocity of runoff, restrict erosion, and trap sediments (Figure 25).

Figure No. 24. Contrast between vegetated and bare slope adjacent to newly-constructed highway. North Carolina

Figure No. 25. Vegetated and rip-rapped channel. Sod is staked to anchor it. Bethesda, Maryland.

Vegetation and mechanical control measures should be used concurrently. Areas requiring protection involve any bare erodible soils, but particular emphasis should be placed upon protecting long, steep slopes and areas where runoff water can concentrate. All slopes of 2:1 and steeper should be mulched to protect them from precipitation as soon as they are roughly graded.

Control of Runoff Water

Control of runoff can be accomplished by the installation of temporary diversions, berms, slope drains, flow barriers, or other types of structures which will prevent concentration of runoff in areas of erodible soils or decrease its velocity.

Diversion structures consisting of temporary compacted earth embankment, bales of straw, ditches, and furrows that can quickly be constructed can be used to intercept runoff before it reaches erodible areas.

They decrease the velocity of the runoff and channel the water toward erosion-resistant natural or artificial drainage ways that can carry it out of the construction site (Figure 25, 26). Generally diversion structures are constructed across a slope approximately along the countours. They can be lined with impervious, erosion-resistant material or, if the gradient if low enough, unlined. The number of diversions, their spacing, and extent depends on the area of the site, the volume of runoff, the erodibility of the soil, density of drainage channels, the topographic relief, and other factors. Particularly critical areas for the installation of diversions is at the crests of cut and fill slopes where they can prevent runoff from gaining access to the slope.

Berms are broad benches, sloping inward, placed at intervals along a slope. They decrease the length of the slope and divert runoff into slope drains where it can be discharged into nonerodible, or protected areas.

Slope drains often are used to carry water from diversion structures and the upper part of slopes to topographically lower areas or into channels where the energy can be dissipated. Very portable and lightweight flexible neoprene tubes are reported to be excellent for temporary

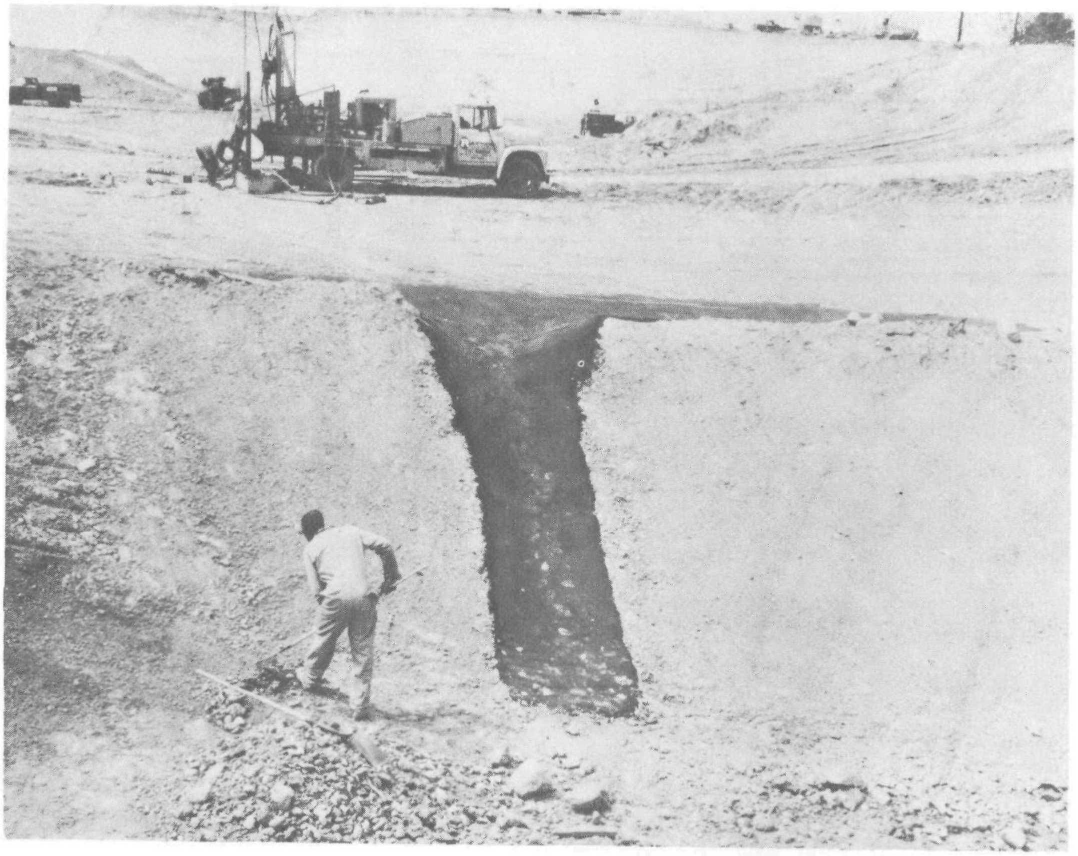

Figure No. 26. Temporary asphalt-paved apron and drop chute to prevent erosion. Maryland.

use as they can be installed quickly and by a few men (Figure 27). Because of their light weight, flaps with grommets are attached so that the tubes can be anchored to the slopes with stakes. Being flexible, they can easily be curved and fitted with extensions to enable them to discharge into erosion-resistant areas. The efficacy of slope drains should not be negated by permitting the discharge to initiate erosion. In many areas, energy dissipating structures or sediment traps may be required to complement the operation of a drain or other structure (Figure 28, 29).

Trapping of Sediments

Sediments carried by flowing water can be trapped behind small temporary barriers or in large sediment basins which decrease the velocity of flow below that necessary for transportation. Barriers used may be impervious enough to stop completely the flow of water or may consist of semi-pervious materials such as sand, gravel, or even bales of hay (Figures 30, 31, 32). In the latter cases, the barriers also act as a filter which allows the movement of water but retains most of the sediment load.

The size and cost of structures to trap sediments probably vary more widely than any others used for sediment purposes. Barriers range from small temporary dikes several feet in height, constructed of bales of hay or quickly compacted soils, to large well-designed earth dams which are engineered to specified requirements. Large imprevious barriers for sediment basins generally are constructed with uncontrolled outlet pipes extending under, or through, them. After the water has deposited its sediment load in the reservior it can escape through the riser pipe which extends above the sediment storage level (Figure 33, 34, 35, 36). Very large barriers and sediment basins are used in the west where rainfall is seasonal and construction is detained for long periods of time (Figure 19). Semi-pervious barriers may consist of a dike, formed of bales of hay staked to the ground, and a low spillway-embankment section of sand and gravel that permits slow movement of water through it (Figure 31). These types of barriers generally are small and quickly constructed in areas where rainfall is more uniform and storm periods fairly short.

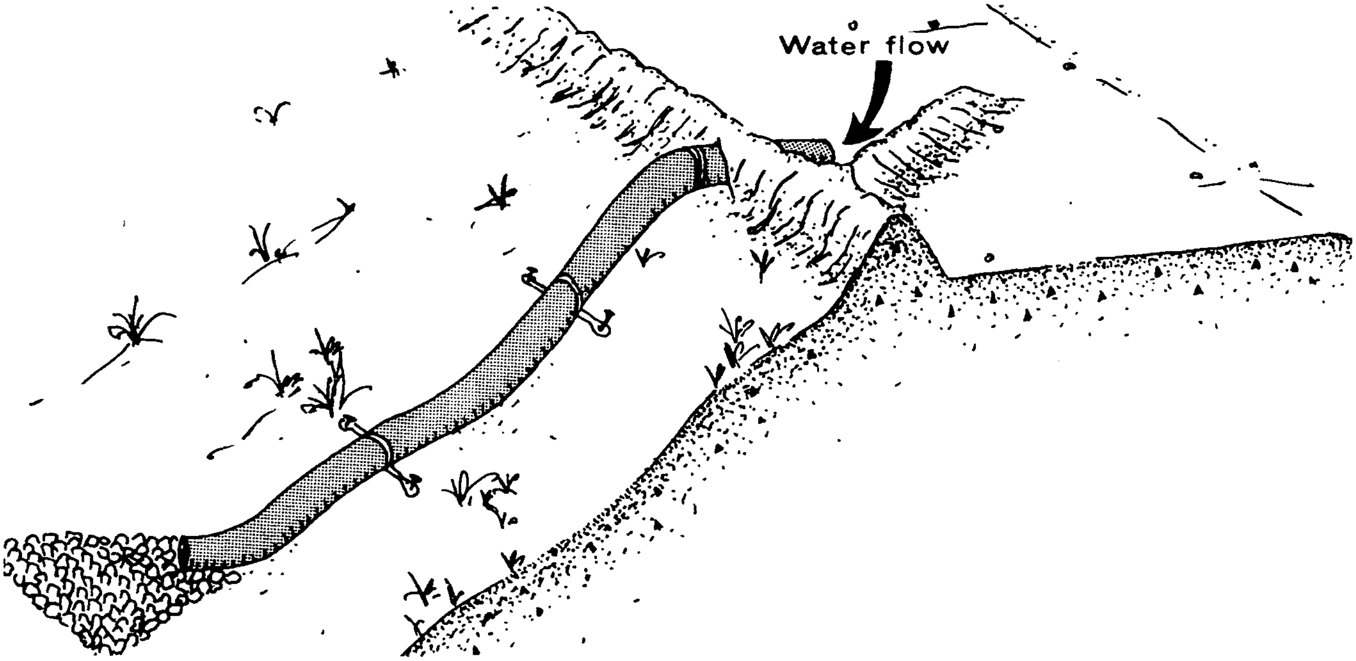

Figure No. 27. Temporary, flexible slope drain. Discharges on gravel energy dissipator to prevent erosion at discharge end.

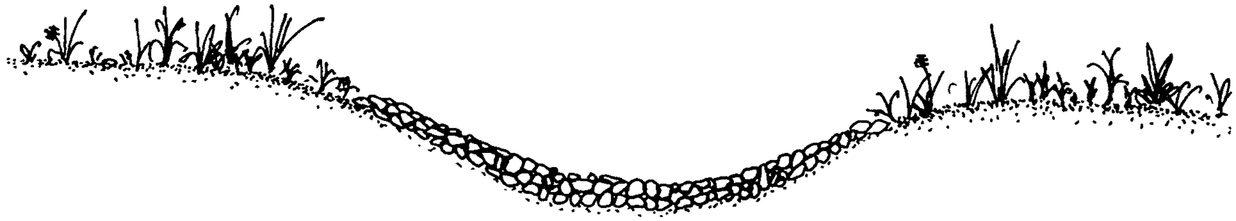

Figure No. 28. Diversion channel lined with gravel to prevent erosion. (From California Division of Soil Conservation).

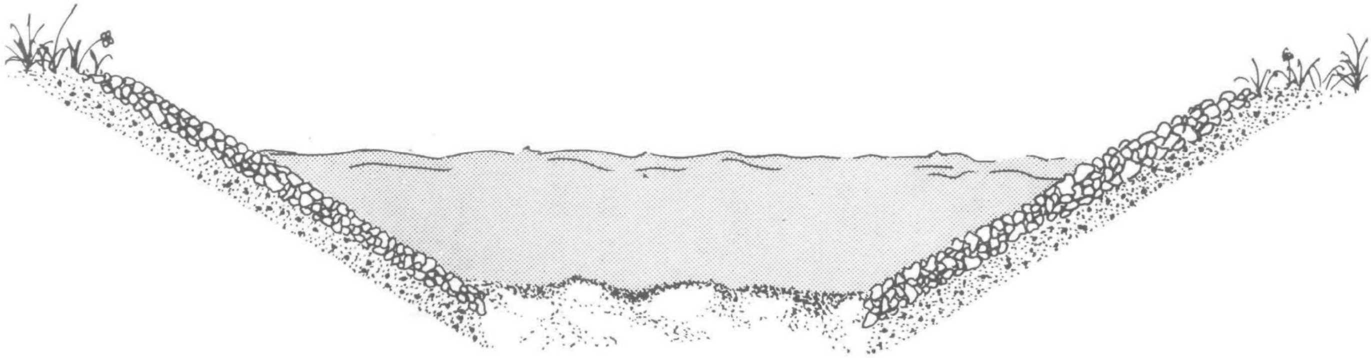

Figure No. 29. Gravels placed on banks of diversion channels to prevent erosion. (From California Division of Soil Conservation).

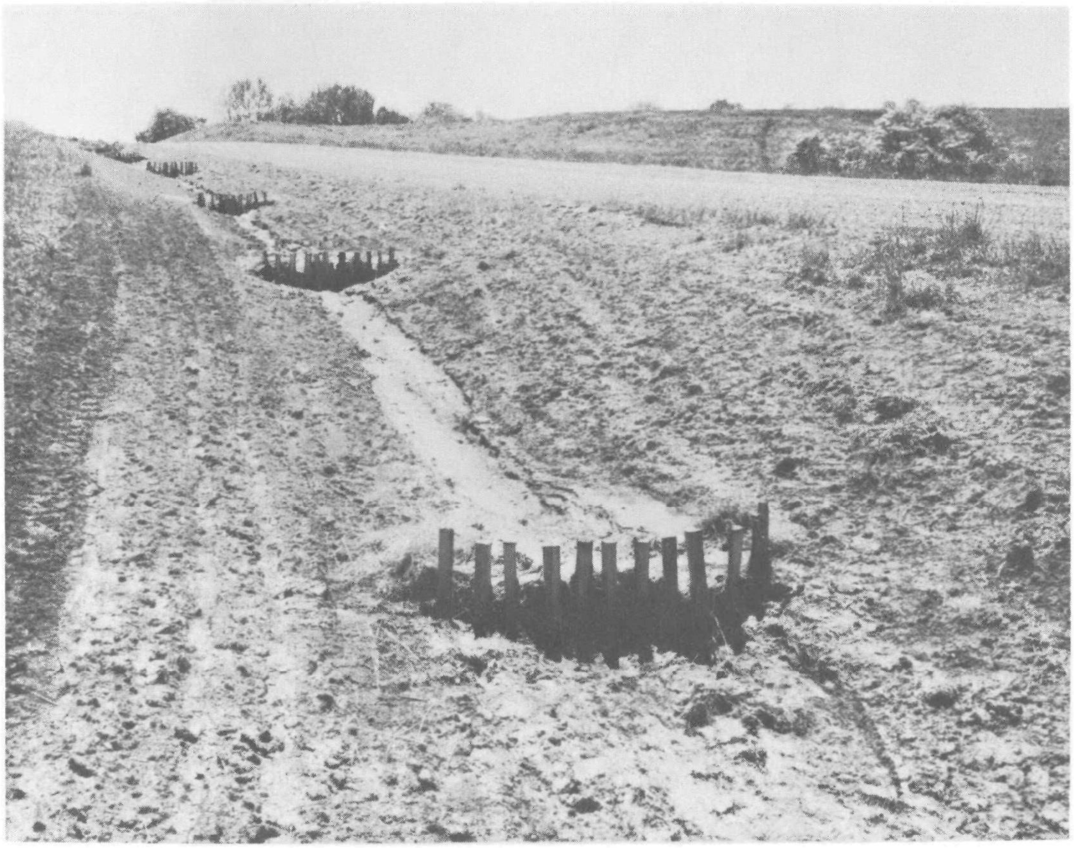

Figure No. 30. Temporary semi-pervious barriers. Straw is placed behind stakes to decrease velocity of water and trap sediments. Goreville, Illinois.

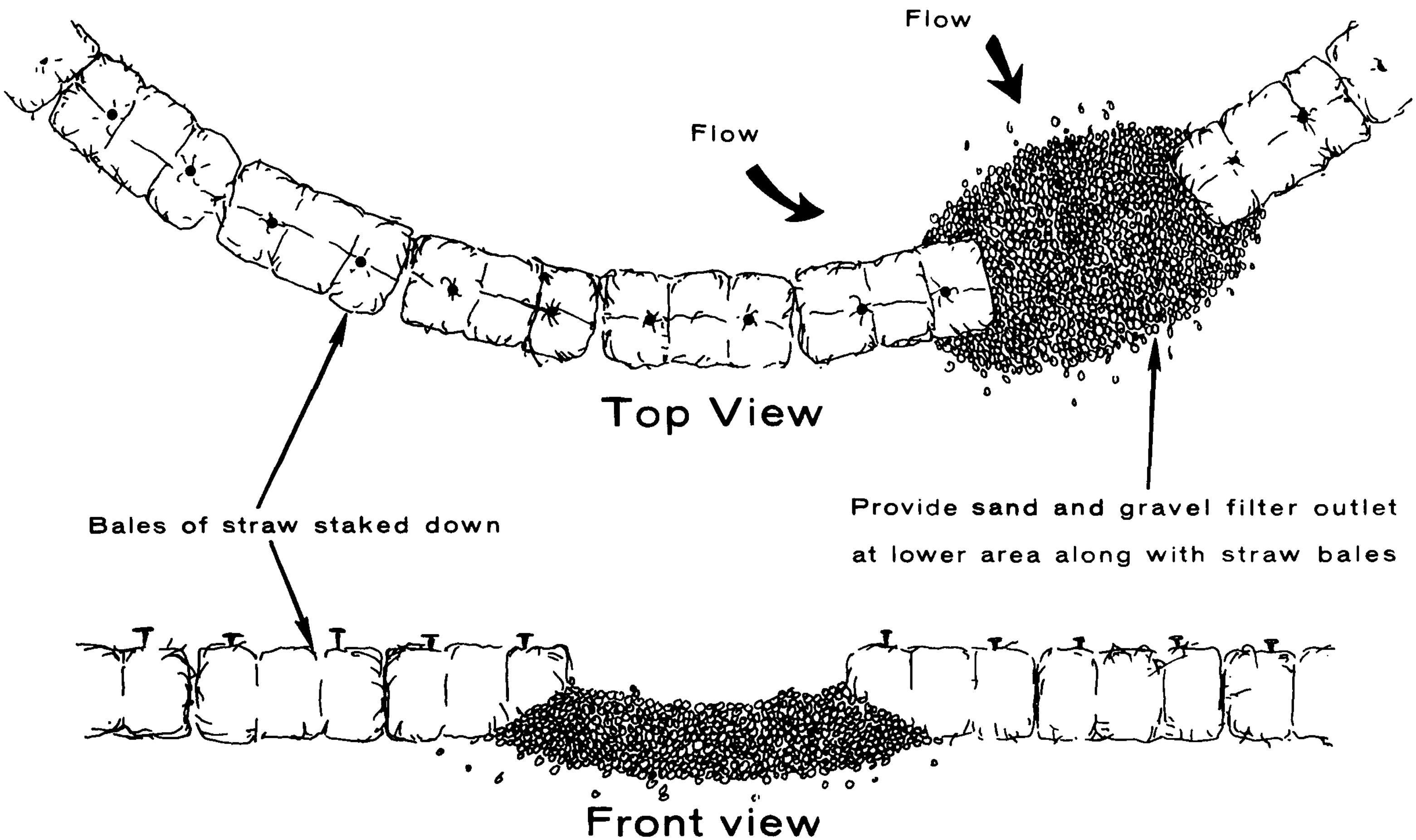

Figure No. 31. Semi-pervious barrier of hay bales with more pervious embankment of sand and gravel for spillway. (Revised from Reference No. 11).

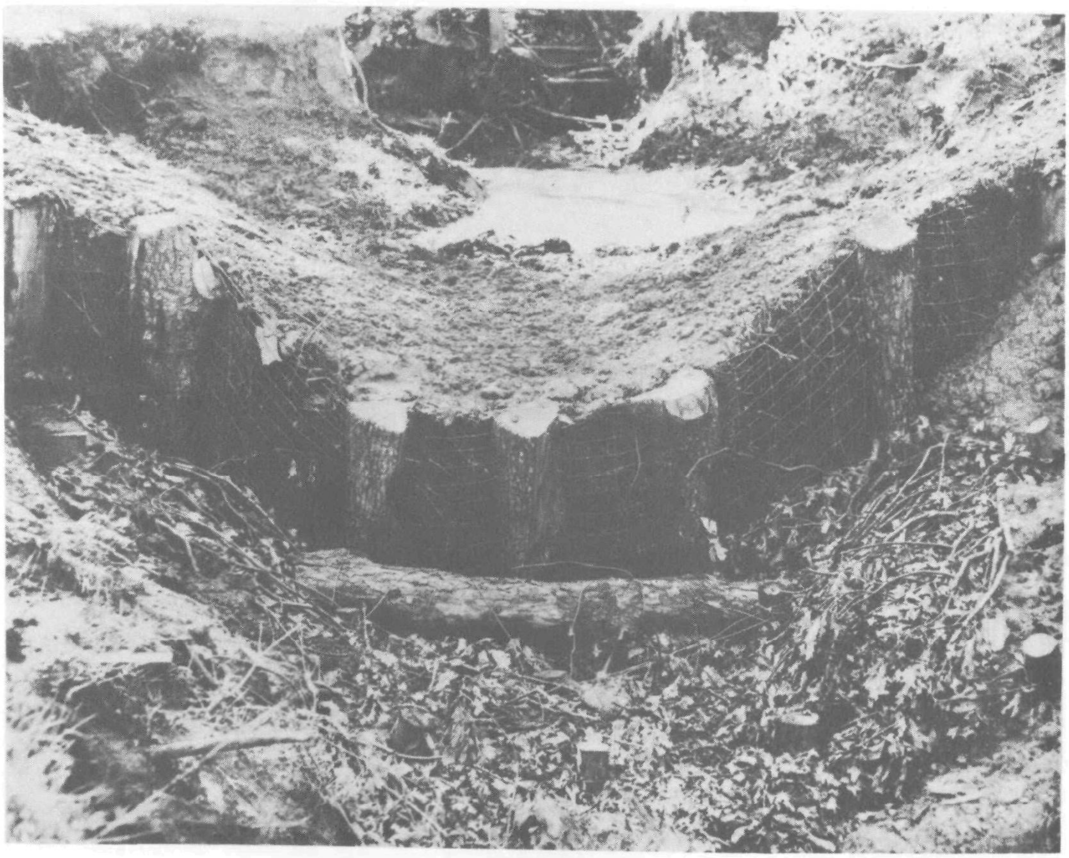

Figure No. 32. Semi-pervious barrier of brush and wire fencing. Can be easily adapted for land-development sediment control. Missouri

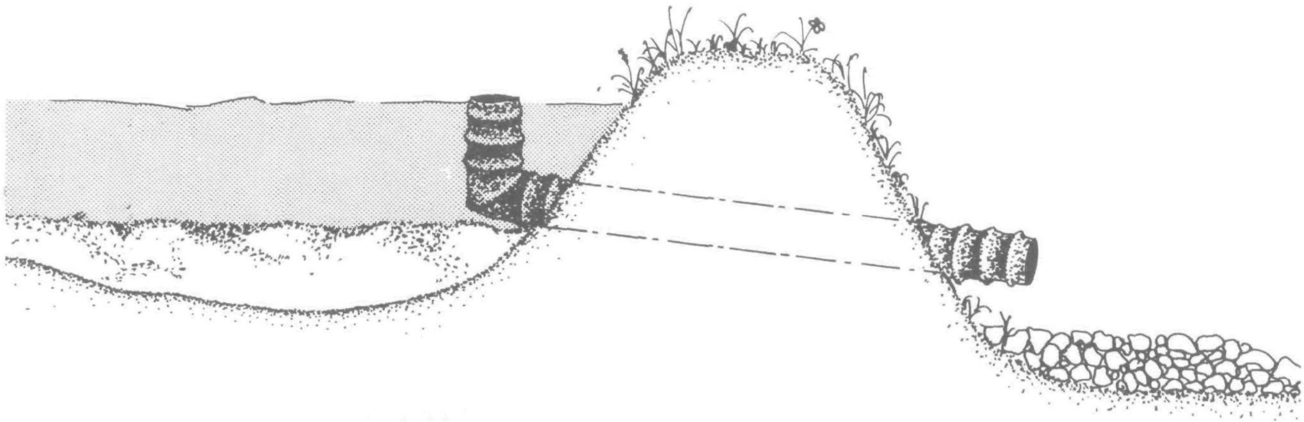

Figure No. 33. Small sediment basin with outlet pipe discharging on energy dissipator to prevent erosion at discharge end. (Revised from Calif. Division of Soil Conservation).

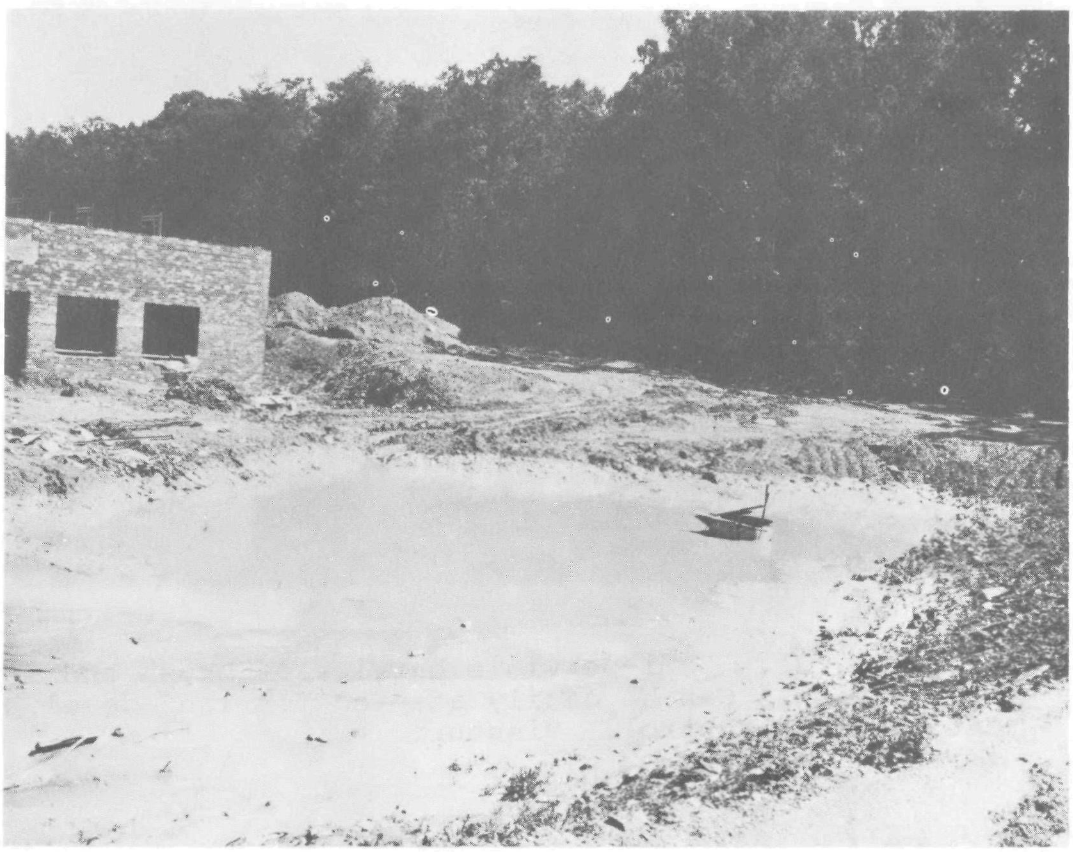

Figure No. 34. Small sediment basin ready for removal of trapped materials. Note large outlet and high-water line. Gaithersburg, Maryland.

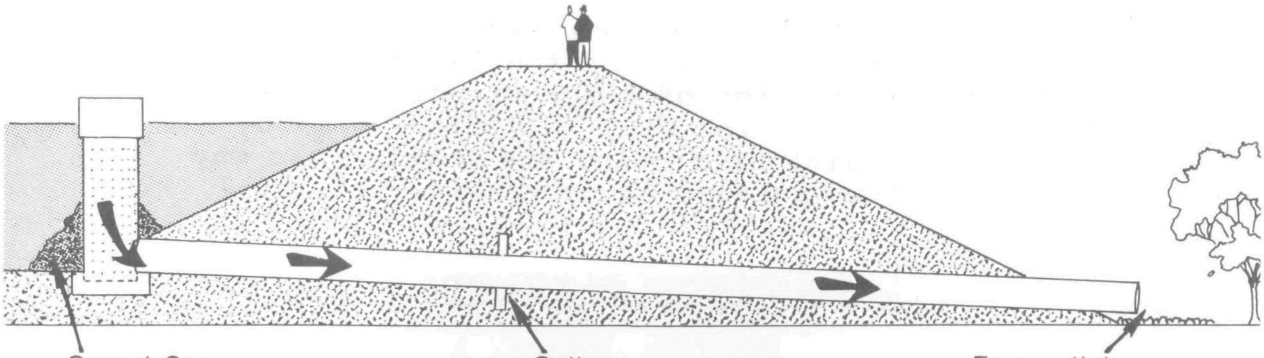

Figure No. 35. Large, well-engineered sediment basin dam. Note outlet pipe with riser, gravel core filter, and seepage-path cut-off collars on outlet. (Revised from Ref. No. 11)

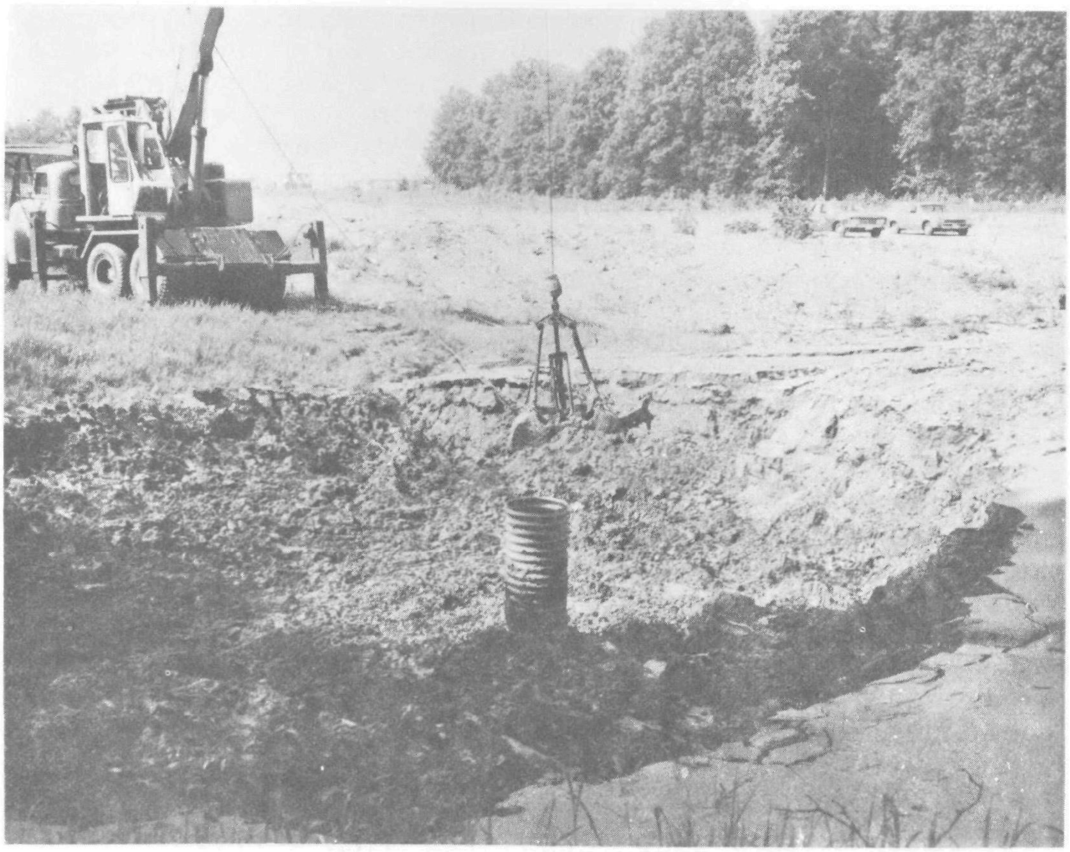

Figure No. 36. Accumulated sediment being removed from small basin in Maryland.

Existing roadway embankments with culverts can be converted temporarily into sediment traps by the installation of riser pipes. Alteration of other structures into temporary control facilities will be limited only by the ingenuity of individuals doing the work. This may provide additional advantages by decreasing the total cost of control.

ESTIMATED COST OF CONTROL

It is extremely difficult to obtain reliable information regarding the cost of temporary erosion and sediment control used only during construction, or during a temporary pause in construction. This is due to many factors the principal one probably being the bookkeeping procedures. Normally the costs are hidden in unit costs for excavation and compaction, pipe, or other equipment. It is difficult to define the temporary and the permanent portion of a facility. Many times a temporary control measure is a permanent one that has been installed earlier than prior scheduling had called for. In some cases continuity of grading operations may be interrupted for seeding. This creates an additional expense. It is difficult to determine the portion of this cost that should be considered due to temporary erosion and sediment control. Many large structures such as sediment basins act as temporary measures during construction and become permanent recreational features at a later date to enhance the value of the project (Figure 37). The proportion of these costs that may be designated as temporary control also is difficult to define. Control measures may provide a beneficial effect to the project in that they prevent erosion and deposition during construction which would normally require costly re-grading or cleaning out of storm sewers, ditches, or trenches for underground utilities. Climatic conditions vary drastically in different parts of the country, thus the type, size, and quantity of control measures required, and their costs will vary accordingly.

Estimated Cost of Temporary Control

Most of the estimated costs presented were obtained during telephone conversations with land developers, consulting engineers or geologists involved with development, and State highway departments. Many organizations were contacted but very few provided data.

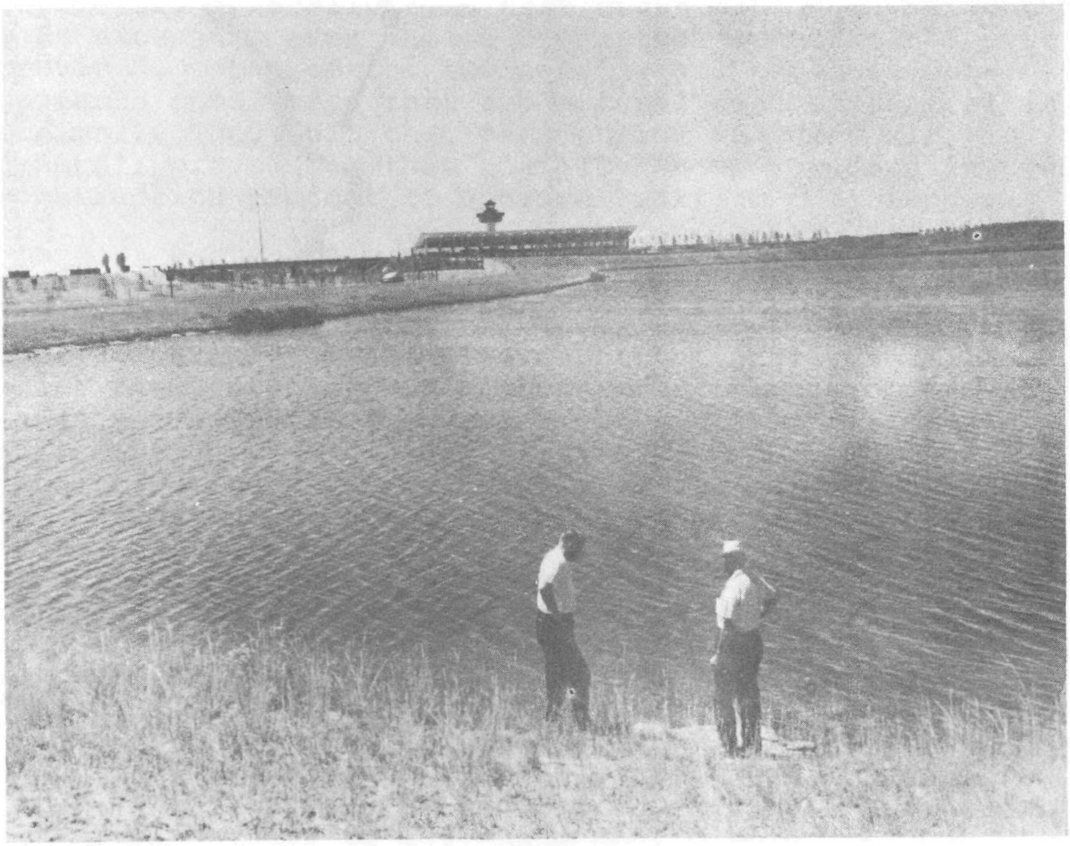

Figure No. 37. Sediment basin now used as permanent lake for irrigation purposes. Dulles Airport, Va.

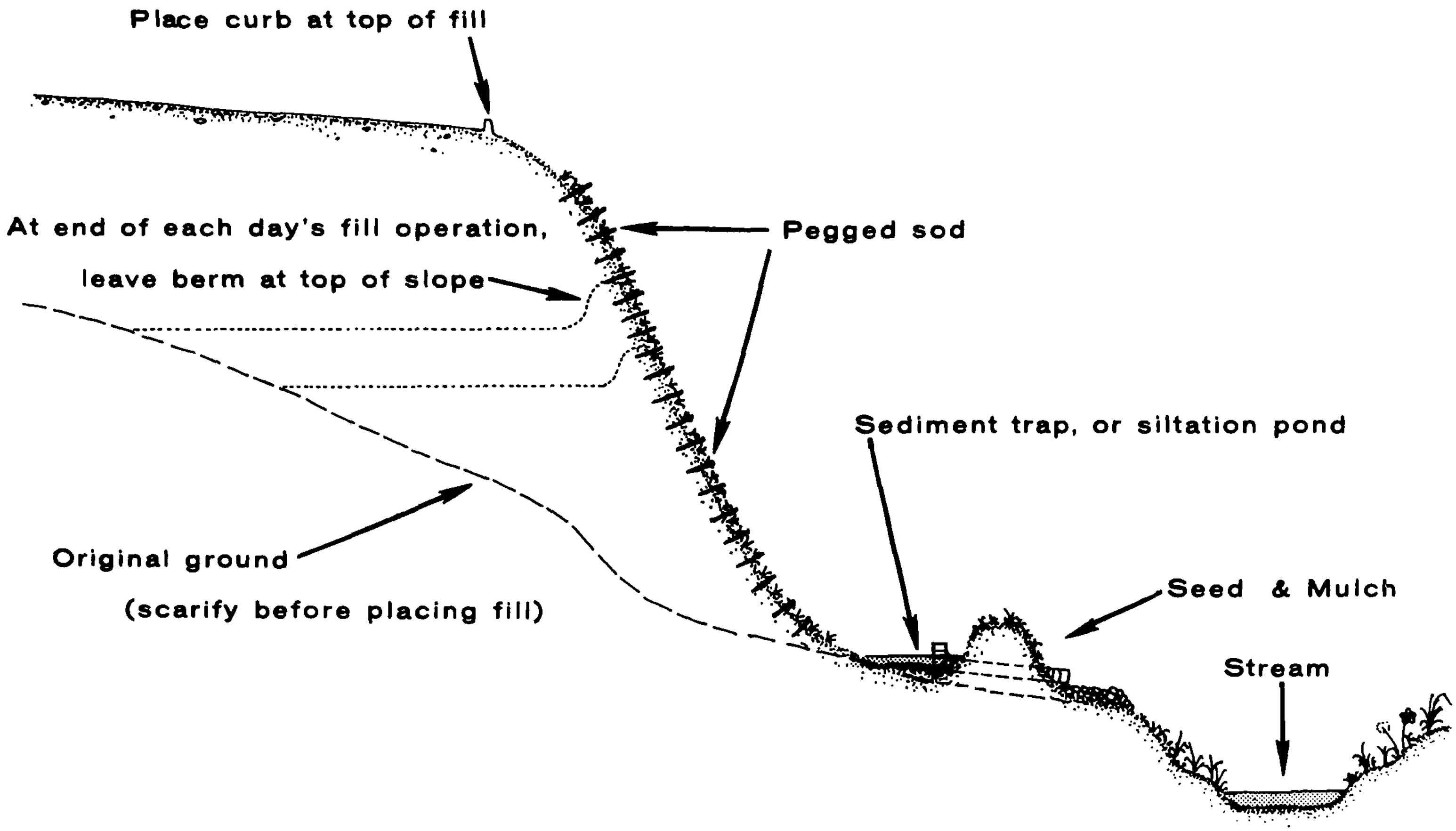

Figure No. 38. Idealized profile of construction area with many temporary erosion and sediment control measures installed. (Revised from Ref. No. 11).

The cost for erosion and sediment control on a highway with an average construction cost of $1,000,000 per mile was estimated to be between $10,000 and $15,000 per mile. The cost for control in housing developments was given as $40 per lot by engineering and geologic consultants and $100 per lot by developers.

Developers generally felt that costs of temporary control were excessive even though few actual cost figures were provided. Most of the engineering and geologic consultants considered that the actural cost of control is minimal. They felt that the control measures are, in general, procedures that normally should be done in every construction project to achieve maximum efficiency.

ADMINISTRATIVE APPROACH

Local governmental agencies constitutionally have the prime responsibility in planning for the use of private lands and controlling development within their area of jurisdiction. Most sedimentation problems, however, involve entire river systems, or drainage basins, which may extend across the boundaries of several counties or states and involve Federal or State-owned lands as well as private property. As a result, reciprocity between Federal agencies involved with construction and development on Federally-owned lands and the organizations representing State and local interests is necessary to obtain effective sedimentation control measures.

Many local organizations do not have the trained manpower, economic capability, or legal authority to undertake technical studies to determine controls required and how they should be implemented. Each local governmental entity has its own particular planning program, zoning policies, and drainage and flood control facilities. Erosion control efforts will have a severe effect on the operations of all organizations involved. To provide an integrated approach to erosion and sediment control, all Federal, State, and local organizations within a drainage basin must coordinate their control efforts. A basin-wide task force, which includes representatives from all concerned organizations within the basin, probably has the best chance of developing and carrying out a successful control program. Trained manpower can be made available by utilizing specific qualified personnel such as hydrologists, agronomists, engineers, planners, lawyers, and managers from the various participating groups within the task force. By using this reservoir of technical competence, an effective erosion and sediment control program can be developed, financed, and implemented. Development of poor control measures will lead to improper location of developments, poor construction practices, and increased runoff; and subsequently to severe erosion and sediment deposition problems.

The crucial element of a sedimentation control program is the enforcement of adopted standards. It is not sufficient for control agencies merely to initiate ordinances and adopt standards which make temporary erosion control measures mandatory during highway construction and land development activities. The measures must be properly carried out and adequately maintained. Firm, decision-making capability will be a requirement for the supervisory staff of the control agency. In addition, an adequate staff for inspection purposes must be available.

Information available indicates, that in some areas enforcement of standards is neglected. Often contractors doing the construction work have been delegated the responsibility for erosion control by agencies; and the resident engineers supervising work have no authority to direct work to be done, even if needed. The general feeling was indicated in the statement that "you cannot expect the contractor to assume responsibility when he is working under directives by the resident engineer." If this attitude, and similar ones, are prevalent among administrative agencies, the erosion and sediment control programs will not succeed. To adequately protect the quality of the nation's waters from pollution by sediments derived by erosion in areas undergoing development, it is essential that administrative agencies at all levels of government assume their appropriate share of the enforcement and control responsiblilties.

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