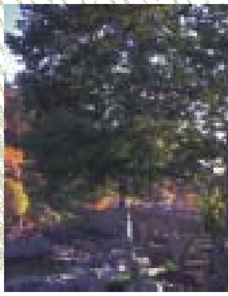
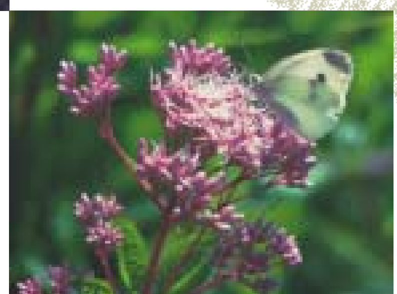
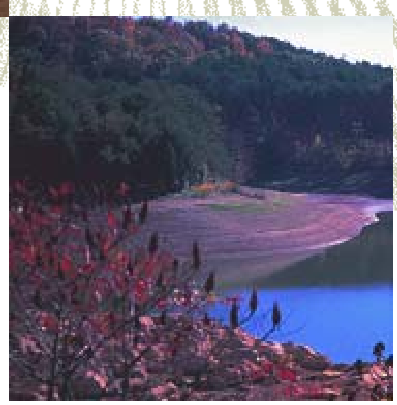
Massachusetts

Erosion and Sediment Control Guidelines for Urban and Suburban Areas







A Guide for Planners, Designers, and Municipal Officials

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MASSACHUSETTS EROSION AND SEDIMENT CONTROL GUIDELINES FOR URBAN AND SUBURBAN AREAS

A Guide for
Planners,
Designers and
Municipal Officials

Original Print: March 1997
Reprint: May 2003

originally prepared for:

Massachusetts Executive Office of Environmental Affairs

State Commission for Conservation of Soil,
Water and Related Resources
Massachusetts Department of Environmental Protection
Bureau of Resource Protection

U.S. Environmental Protection Agency
Region 1

Natural Resources Conservation Service
United States Department of Agriculture

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This project has been financed partially with Federal funds from the Environmental Protection Agency (EPA) to the Massachusetts Department of Environmental Protection (DEP) under a 319 Nonpoint Source Competitive Grant. The contents do not necessarily reflect the views and policies of EPA or of DEP, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

Preface

In 1975, the Soil Conservation Service, USDA, in Massachusetts published the first edition of the ***Guidelines for Soil and Water Conservation in Urbanizing Areas of Massachusetts***. This was a 300+ page book dealing with a wide variety of conservation-related urban problems and situations encountered throughout the state of Massachusetts.

After the third printing and in 1982, the Soil Conservation Service began an update and revision to bring this volume up to date. At the same time, the format was changed from a single volume to a series of ***"Massachusetts Conservation Guides"*** - each keyed to a specific subject area. Only the first two of the proposed five guides were published: ***Volume I - Erosion & Sediment Control in Site Development and Volume II - Vegetative Practices in Site Development.***

In late 1993, realizing the need for a complete, up-to-date volume for persons undertaking to plan, install or review urban developments in the state, the State Commission for Conservation of Soil, Water and Related Resources took the lead to prepare a complete and comprehensive revision of this handbook. The Commission enlisted the aid of the Executive Office of Environmental Affairs, the Massachusetts Department of Environmental Protection, and the Natural Resources Conservation Services (formerly the Soil Conservation Service) of the U. S. Department of Agriculture. This group, working through the Franklin, Hampden, Hampshire Conservation Districts-Division V, undertook to update the original document and this volume is the culmination of their efforts.

There are numerous excellent references available to the general public covering the fields of erosion and sediment control, pollution control, and stormwater management. This guide draws upon many of those documents. It is meant to provide the lay person who is involved in projects which affect the land and water resources in Massachusetts with background information. Further details may be found in other documents, which are referenced as sources of information.

This guide deals primarily with conservation measures and conservation practices. These practices are generally referred to as ***"Best Management Practices"*** or ***"BMPs"*** and is intended to be a companion handbook with the recently prepared ***"Mega-Manual"*** prepared by the Massachusetts Department of Environmental Protection.

Only limited detail is included about the soils, engineering, hydrology, plant materials and other knowledge that is needed to plan and design a potential project. It is intended only as a guide and should be used as such. A professional planner should be engaged to prepare the proposal and a professional engineer for the detailed erosion and sediment control plan and designs, drawings, and specifications.

The contents of this guide are based on material almost entirely in the public domain, published by federal or state agencies or public educational institutions. It should not be interpreted as necessarily representing the policies or recommendations of other referenced agencies or organizations nor of the agencies who sponsored this revision. The mention of trade names, products, companies or publications does not constitute an endorsement, but are used for clarification.

In the fall of 1994, the USDA Soil Conservation Service was renamed the Natural Resources Conservation Service. Numerous references used herein were published as Soil Conservation Service documents and have not been renamed or revised at this date.

Acknowledgements

The following individuals were instrumental in guiding the development of this guide:

Thomas Anderson of the State Commission for Conservation of Soil, Water and Related Resources for his assistance in obtaining funds and coordinating the review of the draft documents with other state agencies.

William P. Annable, P. E., for collecting materials and related information, revising and updating the previously prepared editions of the handbook and updating and preparing this version of the Guidelines.

John Bennett of the Franklin Conservation District for his assistance in reviewing and commenting on the draft documents.

Russell Cohen of the Massachusetts Riverways Program for his assistance in reviewing and commenting on the draft documents.

Richard DeVergilio of the Natural Resources Conservation Service, USDA for his assistance in collecting, editing and preparing plant materials information for the various sections of the handbook.

Carl Gustafson of the Natural Resources Conservation Service, USDA for his assistance in collecting available information, coordinating the inputs of other personnel from the NRCS, and reviewing and commenting on the draft documents.

Gene Mills of the Franklin, Hampden, Hampshire Conservation Districts-Division V for his work in preparing contract documents, handling the contracting procedures, arranging meetings and document reviews and guiding this project to completion.

Leslie O'Shea of the Office of Watershed Management, Massachusetts Department of Environmental Protection for her assistance in guiding the preparation of the guide through the 319 process and providing comments on the draft documents.

Kathy Ruhf of the Franklin, Hampden, Hampshire Conservation Districts-Division V for her assistance in reviewing and commenting on the draft documents.

Arthur Screpetis of the Office of Watershed Management, Massachusetts Department of Environmental Protection for his assistance in completing the contract and publishing the document.

Jan Smith of the Massachusetts Coastal Zone Management program for his assistance in reviewing and commenting on the draft document.

Gerry Suriner of the Franklin, Hampden, Hampshire Conservation Districts-Division V Office for her work in preparing copies, making mailings, typing and filing contract materials and preparing and distributing materials and drafts.

Kenneth Taylor of the Hampden Conservation District for his assistance in reviewing and commenting on the draft documents.

Michael Whalen of the Berkshire Resource and Conservation Development Project for his assistance in preparing the grant proposal.

The preparation of this guide was financed by the Massachusetts State Commission for Conservation of Soil, Water and Related Resources; the Massachusetts Executive Office of Environmental Affairs; the Massachusetts Department of Environmental Protection through funds from the United States Environmental Protection Agency under the section 319 Nonpoint Source Competitive Grant Program; the United States Department of Agriculture, Natural Resources Conservation Service; and the Franklin, Hampden, Hampshire Conservation Districts-Division V.

This guide was published with financial assistance from the Massachusetts Department of Environmental Protection through funds from the United States Environmental Protection Agency under the section 319 Nonpoint Source Competitive Grant Program and the United States Department of Agriculture, Natural Resources Conservation Service.

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Principles for Site Development

Developing an Erosion and Sediment Control Plan

Erosion and Sedimentation

As undeveloped areas are converted to urban uses, the natural vegetation is removed, land slopes may be excavated or filled, ground surfaces are paved over, and stream channels are modified. The result is an increase in runoff and a reduction in the ability of the land to provide natural treatment to the runoff.

Land is disturbed and exposed to erosion by wind and water during this period of conversion. Soil displaced by erosion contributes to both onsite and offsite damages. A portion of the soil reaches the state's streams, lakes, and coastal waters as sediment.

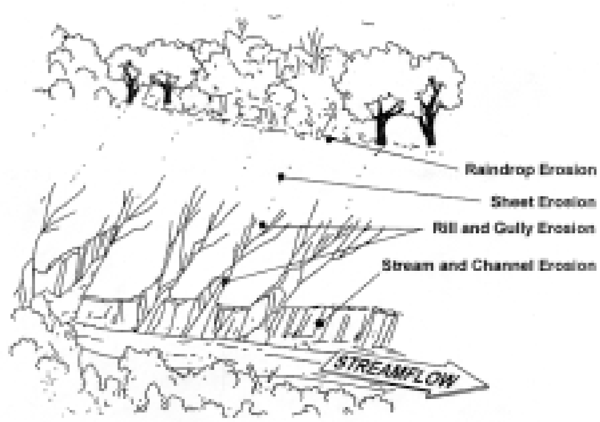
Erosion

Erosion is the wearing away of the land surface by running water, wind, ice, or other causes. Soil erosion is usually caused by the force of water falling as raindrops and by the force of water flowing in rills and streams. Raindrops falling on bare or sparsely vegetated soil detach soil particles. Water running along the surface of the ground picks up these particles and carries them along as it flows downhill towards a stream system.

As the runoff gains in velocity and concentration, it detaches more soil particles, cuts rills and gullies into the surface of the soil and adds to its sediment load. The merging rivulets produce larger channels which have a larger volume and usually higher velocity, and a greater capacity to remove sediment and transport it downstream.

The greater the distance the water runs uncontrolled, the greater its erosive force and the greater the resultant damage. Moreover, control becomes more difficult as the distance and volume increases.

Soil erosion is also caused by the force of wind blowing across unprotected ground. Open gravel pits and construction sites that have been stripped of vegetation are especially vulnerable to wind erosion. The wind-borne sediments land in streams, roads, and neighboring lots. Blowing dust is a nuisance, and can be a hazard on especially windy days. Wind erosion in areas undergoing development can be controlled best by keeping disturbed areas small and by stabilizing and protecting them as soon as possible.

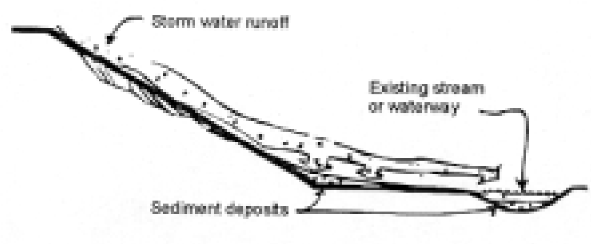


Types of Water Erosion

Sedimentation

Sedimentation is the deposition of soil particles that have been transported by water and wind. The quantity and size of the material transported increases with the velocity. Sedimentation occurs when the medium, air or water, in which the soil particles are carried is sufficiently slowed long enough to allow particles to settle out. Heavier particles, such as gravel and sand, settle out sooner than do finer particles, such as clay.

The length of time a particle stays in suspension increases as the particle size decreases. The coarsest, heaviest particles (gravel) are transported only a short distance, while water flow is at its maximum. Smaller, lighter particles (sand) move by rolling or bouncing along the surface, or stay in suspension over short distances while the water velocity is fairly high. Because of their slow settling rate, fine silt particles generally remain for several hours in suspension in the storm runoff that originally moved them. The still finer colloidal clays stay in suspension for very long periods and contribute significantly to water turbidity.



THE PROBLEM

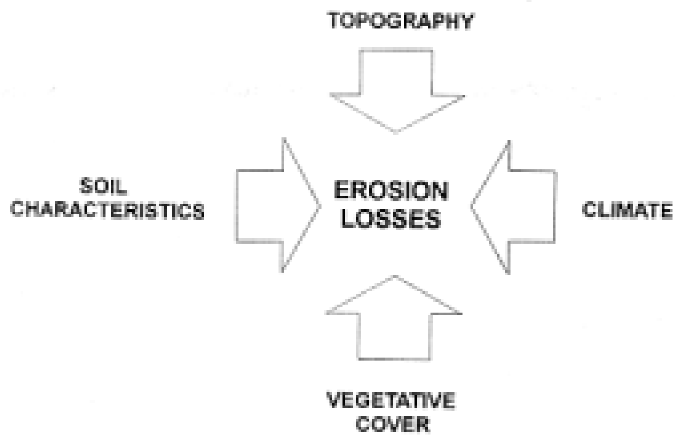
Factors that Influence Erosion

There are four principal factors that influence the potential for erosion: soils, surface cover, topography, and climate. These factors are interrelated in their effect on erosion potential.

Variability in terrain, soils, and vegetation makes erosion control unique to each development. Erosion and resulting sedimentation generally occur in Massachusetts only when the soil is disturbed. The seriousness of the problem is a function of the topography and size of the area disturbed, the characteristics of the soils, the climate, and the vegetative cover.

As a rule of thumb:

- The more fine-grained material there is in a soil, the greater the amount of material that will be picked up by water flowing across its surface;
- The steeper the slope, the faster the water will move, thus being able to carry more soil; and,
- The larger the unprotected surface, the larger the potential for problems.



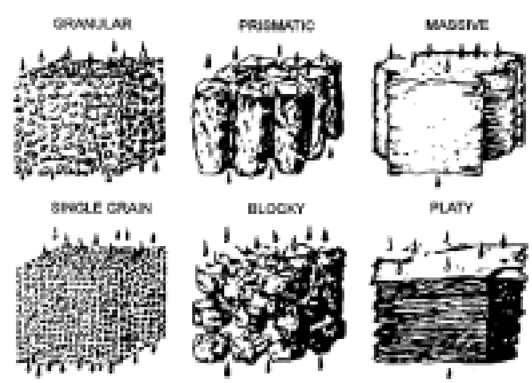
Soils

The vulnerability of a soil to erosion is known as its erodibility. Key factors that influence erodibility are:

- Soil texture (proportions of sand, silt, and clay)
- Organic matter content
- Soil structure (arrangement of soil particles)
- Soil permeability (the ease by which water passes through the soil)

Soil texture is described by the proportions of sand, silt, and clay in the soil. High sand content gives a coarse texture, which allows water to infiltrate readily, reducing runoff. A relatively high infiltration rate coupled with resistance to transport by runoff results in a low erosion potential. Soils containing high proportions of silt and very fine sand are most erodible. Clay particles and organic matter in the soil tend to bind it together into aggregates, thereby reducing erodibility. When clay erodes, however, the particles settle out very slowly.

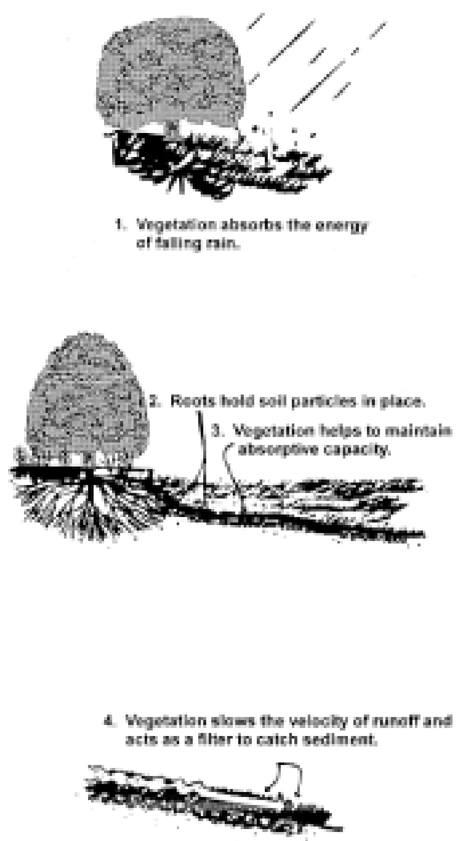
Organic matter, such as plant material, humus, or manure, improves soil structure, increases water-holding capacity, and may increase the infiltration rate. It reduces erodibility and the amount of runoff.



Soil structure is determined by the shape and arrangement of soil particle. A stable, sharp, granular structure absorbs water, readily, resists erosion by surface flow, and promotes plant growth. Clay soils or compacted soils have slow infiltration capacities that increase runoff rate and create severe erosion problems.

Soil permeability refers to a soil's ability to transmit air and water. Soils that are least subject to erosion from rainfall and shallow surface runoff are those with high permeability rates, such as well-graded gravels and gravel-sand mixtures. Loose, granular soils reduce runoff by absorbing water and by providing a favorable environment for plant growth. "Well-graded" soils are those which contain a wide range of particle sizes. Well-drained and well-graded gravels and gravels and mixtures with little or no silt have low erodibility to sheet flow, but wash easily under concentrated flow. Coarse, granular soils also have high permeabilities and a sufficiently good infiltration capacity to prevent or delay runoff.

Surface Cover



Vegetative cover is extremely important in controlling erosion. It performs these functions:

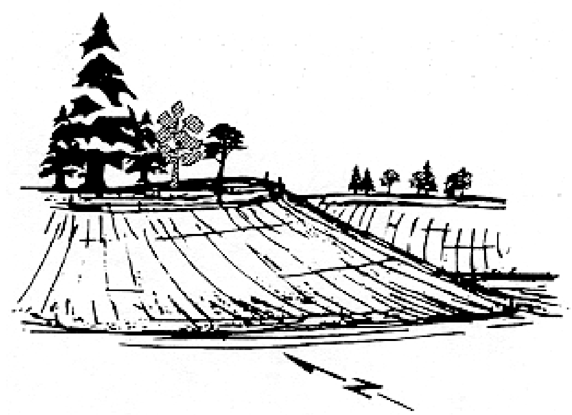
- Shields the soil surface from the impact of falling rain,
- Holds soil particles in place,
- Helps to maintain the soil's capacity to absorb water,
- Slows the velocity of runoff.

Soil erosion and sedimentation can be significantly reduced by scheduling construction activities to minimize the area of exposed soil and the time of exposure. Special consideration should be given to the maintenance of existing vegetative cover on areas of high erosion potential such as erodible soils, steep slopes, drainageways, and banks of streams.

Vegetation slows runoff velocity, disperses flow, and promotes infiltration and deposition of sediment. Plants remove water from the soil, increasing the capacity to absorb water. Plant roots help maintain soil structure.

The type and condition of ground cover influence the rate and volume of runoff. Impervious surfaces protect the area covered, but prevent infiltration and decrease the "time of concentration" for runoff, thereby increasing high peak flow and potential for stream and channel erosion. Covers such as mulches, paving, and stone aggregates also protect soils from erosion.

Topography



Topographic features distinctly influence erosion potential. Watershed size and shape, for example, affect runoff rates and volumes. Slope length and steepness are key elements in determining the volume and velocity of runoff and erosion risks. As both slope length and gradient increase, the rate of runoff increases and the potential for erosion is magnified. Swales and channels concentrate surface flow, which results in higher velocities. Exposed south-facing soils are hotter and drier, which makes vegetation more difficult to establish.

Climate

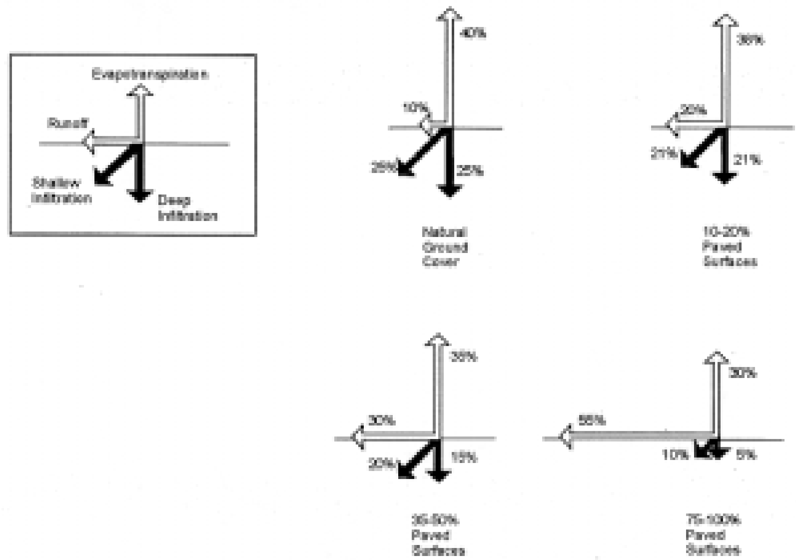
Where storms are frequent, intense, or of long duration, erosion risks increase. The high erosion risk period of the year results from seasonal changes in temperature, as well as variations in rainfall. When precipitation falls as snow, no erosion will take place immediately. In the spring, however, the hazards will be high. Most plants are still dormant. The existing vegetative cover is less able to buffer the raindrops. The ground is still partially frozen, or else saturated from melting snow, and its absorptive capacity is reduced.

Exposed areas should be well stabilized in the fall, before the period of high erosion risk in the spring.

The frequency, intensity, timing, and duration of rainfall are fundamental factors in determining the amounts of runoff produced. The ability of runoff to detach and transport soil particles also increases as both the volume and the velocity of runoff increase. Development should be scheduled to take place during the periods of low precipitation and low runoff.

In Massachusetts, soil erosion is caused primarily by runoff water from rainfall and snowmelt. Wind erosion is a problem for farmers on the broad plains adjoining the Connecticut River, and can be a problem for exposed soils at construction sites also.

Areas where the soil has been disturbed and left bare by construction activities should be revegetated early enough in the Fall so that a good cover is established before cold weather comes and growth stops until the spring. A good cover is defined as vegetation covering 75 percent or more of the ground surface. October is too late to seed and obtain a good cover for the winter. Where good cover has not been established, structural stabilization methods, such as hay bales, silt fences or anchored mulch, must be used.



Typical changes in runoff with increasing areas of impermeable surfaces such as roofs, paved surfaces:

Effects of Urbanization

Before colonial times, most of Massachusetts was forested. The forest system provided protection by intercepting rainfall in the tree canopy, reducing the possibility of erosion and the deposition of sediment in waterways. The trees and the forest duff layer absorbed large amounts of runoff, releasing it slowly to the streams by percolation through the soil.

As settlement occurred and the population grew, land was cleared for buildings, fields, pastures and roads. Low spots, often wetlands, were filled. Today, as areas are converted to urban uses, the natural vegetation is removed, land slopes are modified, areas are paved over.

After vegetated terrain is cleared, the additional area of compacted and impervious surfaces changes the hydrologic characteristics. Volume of surface runoff and the rate of flow increases. Ground water recharge decreases. Runoff that was previously slowly released to streams by filtering through the soil now runs quickly off the surface directly into the streams. This increases velocity and quantity of flow causing streambank erosion and general habitat destruction. Sediment from eroded and unstable streambanks and cleared areas is deposited downstream; filling ponds, streambeds and stormwater facilities. Summer base flows are reduced.

In addition to the increase in impervious surfaces, urbanization creates a significant amount of ground surface modification. Natural drainage patterns are modified and runoff is transported via road ditches, storm sewers, drainage swales, and constructed channels. These modifications increase the velocity of the runoff which in effect decreases the time that it takes for runoff to travel through the watershed. This decreased time creates higher peak discharges.

Vegetative cover on an undisturbed site protects the ground surface. Removal of that cover increases the site's susceptibility to erosion. Disturbed land may have an erosion rate 1,000 times greater than the pre-construction rate. Proper planning and use of control measures can reduce the impact of man-induced accelerated erosion.

The major problem associated with erosion on a construction site is the movement of soil off the site and its impact on water quality. Millions of tons of sediment are generated annually by construction activities in the United States. The rate of erosion on a construction site varies with site conditions and soil types but is typically 100 to 200 tons per acre and may be as high as 500 tons per acre.

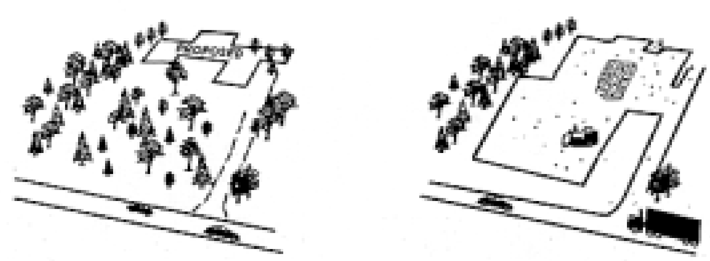
Under natural conditions, stream channels will normally handle, at bankfull, capacity the peak discharge from a storm that could be expected once every two years. The increased discharge caused by urbanization will cause out-of-bank flooding more frequently. The stream channel begins to widen and deepen to accommodate the increased flow and to change grade to handle the increased velocity. Eventually the increased sediment transport can lead to problems downstream.

Urbanization can be a significant cause of pollution problems due to sediment loads, with both short-term and long-term impacts. Short-term changes in water quality can restrict recreational activities, stress aquatic organisms, and damage shellfish beds. Long-term accumulation of pollutants into receiving waters can create particularly difficult to correct problems such as eutrophication, polluted groundwater, and contaminated sediments.

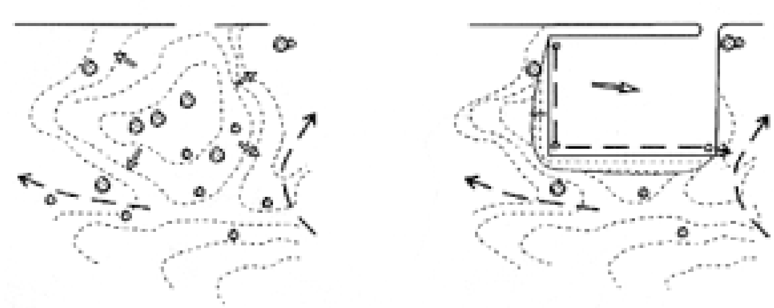
Erosion and Sediment Hazards Associated with Site Development

Hazards associated with site development include increased water runoff, soil movement, sediment accumulation, and higher peak flows caused by:

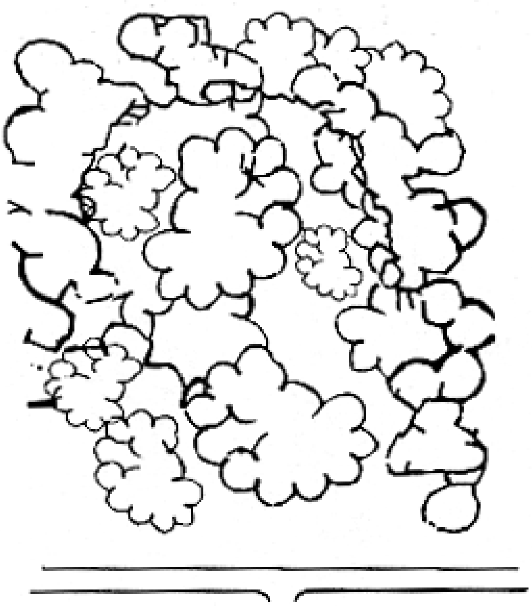
- **Removal of plant cover and a large increase of soil exposed to erosion by wind and water.**

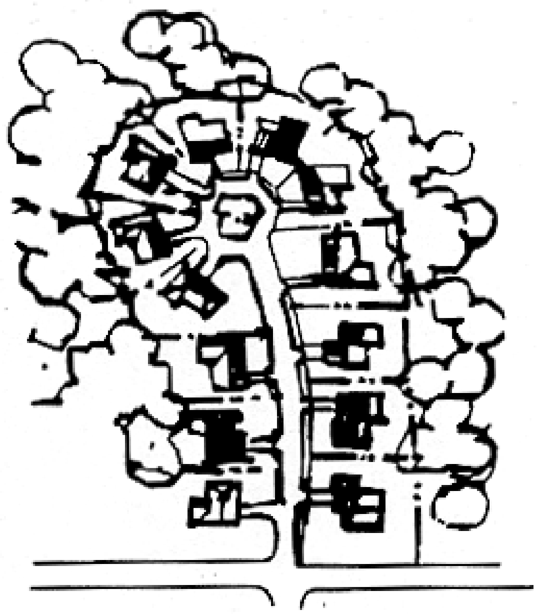


- **Changes in drainage areas caused by regrading the terrain, diversions, or road construction.**

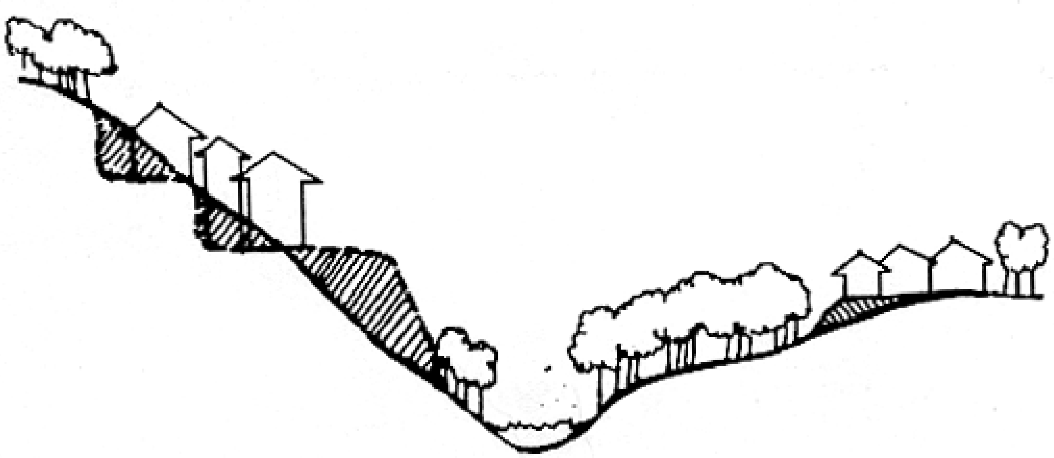


- A decrease in the area of soil which can absorb water because of construction of streets, buildings, sidewalks, or parking lots.

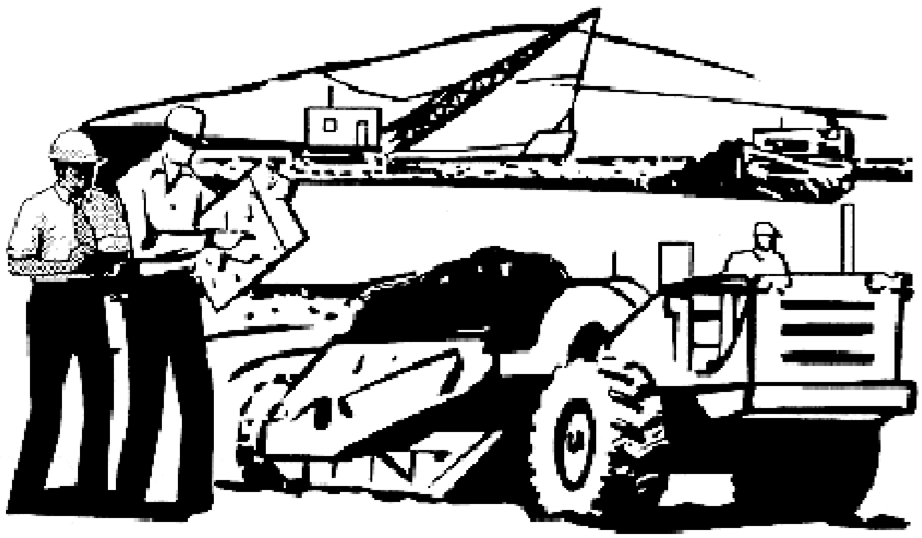




- Changes in volume and duration of water concentrations caused by altering steepness, distance and surface roughness.

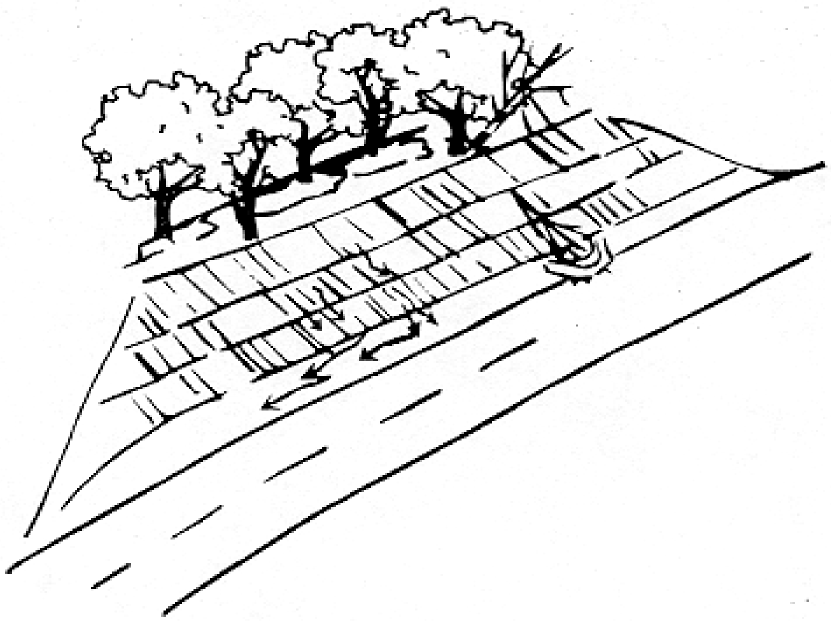


• Soil compaction by heavy equipment, which can reduce water intake of soils to 1/20 or less of the original rate.

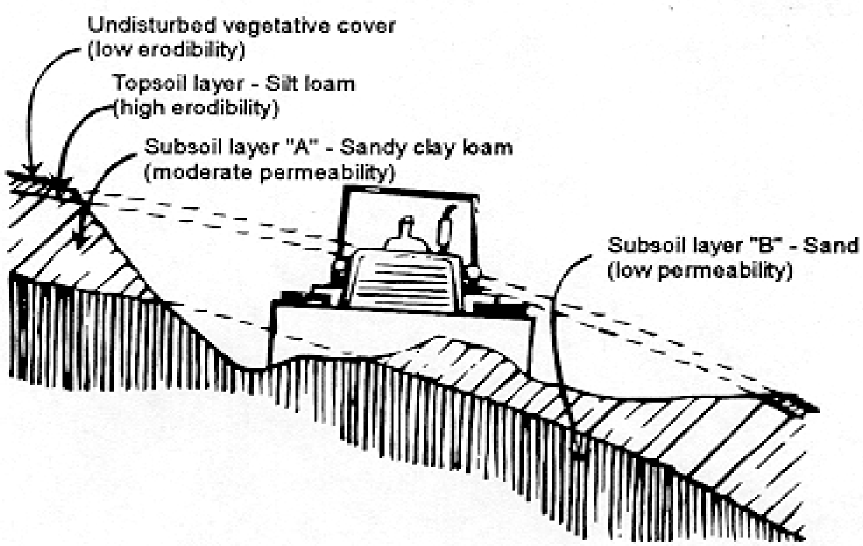


• Prolonged exposure of unprotected sites and service areas to poor weather conditions.

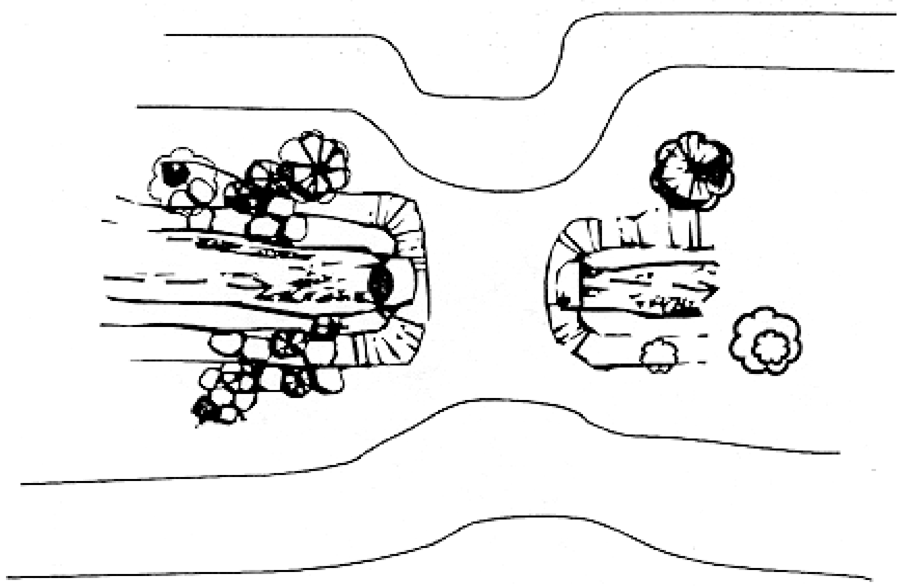
- Altering the groundwater regime may adversely affect drainage systems, slope stability, survival of existing vegetation, and establishment of new plants.



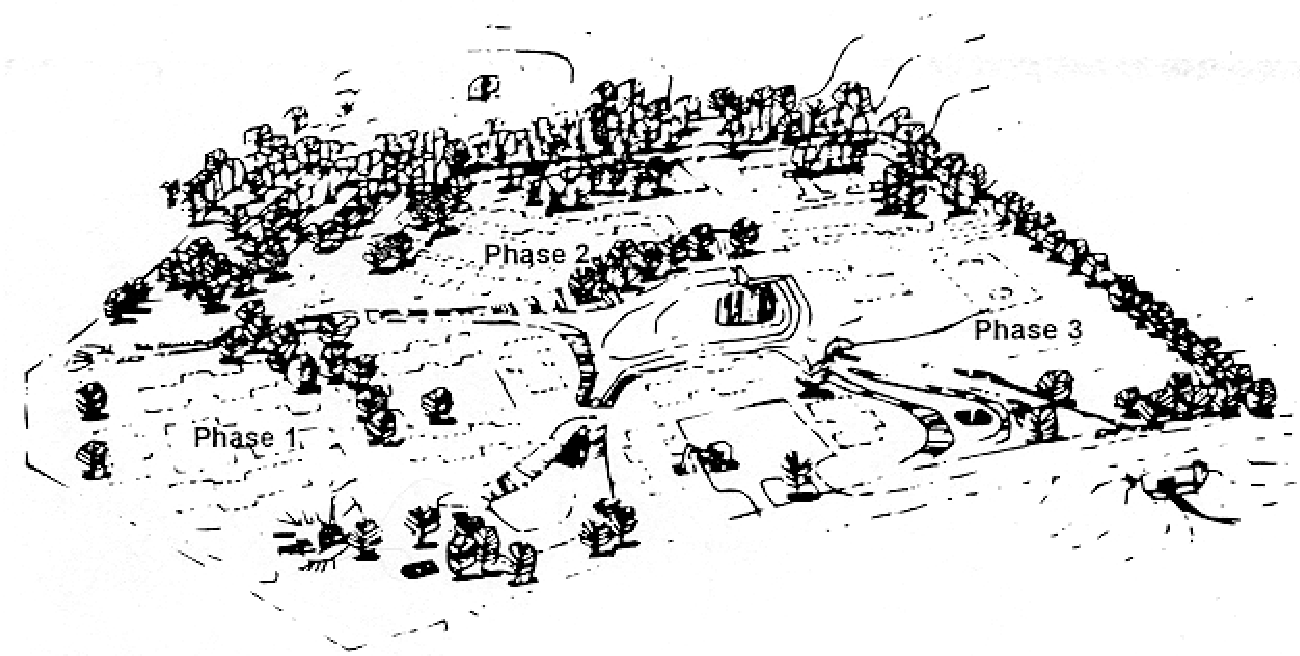
- Exposing subsurface materials that are too rocky, too acid, or otherwise unfavorable for establishing plants.



• Obstructing streamflow by new buildings, dikes, and landfills.



• Inappropriate timing and sequence of construction and development activities.

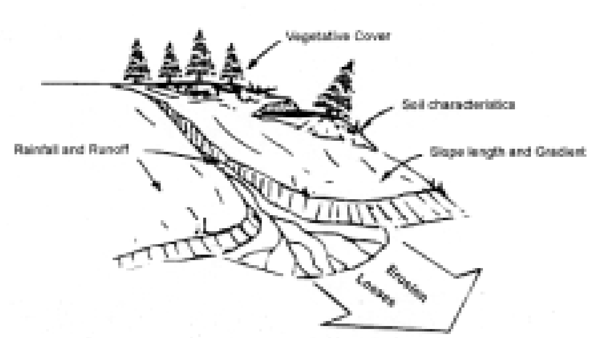


- **Abandonment of sites before construction is completed.**

Analyzing the Project Site

Most soil and water management problems encountered during land use change are caused by one or more of the following:

- Soil Limitations,
- Sloping Land,
- Drainage Problems
- Exposed Soil.



Soil Characteristics and Limitations

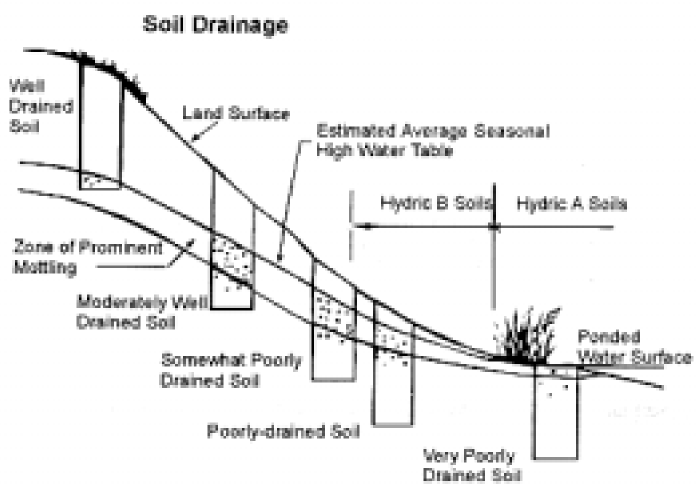
Soil characteristics have a major influence on how a proposed development site can best be utilized. Characteristics such as texture, permeability, and structure affect a soil’s erodibility. Other characteristics that affect the potential, and the limitations, of a site include natural drainage, depth to seasonal water table, depth to bedrock, flood hazard potential, natural fertility, and engineering, physical, and chemical properties.

Significant differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are shallow to bedrock. Some are too unstable to be used as a foundation for buildings or roads. Finer-textured or wet soils have severe limitations for use as septic tank absorption fields. A site with a high water table is poorly suited to basements or underground installations. Depth to bedrock or to a cemented pan (cemented or hardened subsurface layers), large stones, slope, and the hazard of cutbanks caving affect the stability of ditch banks and the ability of construction equipment to perform excavation or grading work. Knowledge of the soil properties is of great value in deciding how to utilize the project site.

Drainage

Drainage is the removal of excess surface and subsurface water from the soil. How easily and effectively the soil is drained depends on the depth to bedrock, to a cemented pan, or to other layers that affect the rate of water movement; permeability; depth to water table (depth to standing water if the soil is subject to ponding): slope; susceptibility to flooding; subsidence of organic layers; and potential frost action.

Some soils are so wet that it would be difficult to use them for development. Two examples are the Scarboro soil series ("mucky fine sandy loam"), found on outwash plains and terraces; and the Whitman soil series (fine sandy loam) found in some upland areas. Poorly-drained soils such as Ridgebury and Walpole have severe limitations for houses, small commercial buildings, or lawns. Even moderately-well-drained soils such as the Woodbridge, Sudbury, or Deerfield series would present moderate to severe limitations for some development purposes.



Depth to seasonal high water table

Areas with a high water table should either be avoided or steps taken to control the condition. A high water table can cause malfunctioning septic systems, damp basements, and uneven foundation settlement.

Depth to bedrock

If the rock is soft or fractured, excavations can be made with trenching machines, backhoes, or small rippers. If the rock is hard or massive, blasting or special equipment generally is needed for excavation.

Flood hazard potential

Flooding, the temporary covering of the soil surface by flowing water, is caused by overflowing streams, by runoff from adjacent slopes, or by inflow from high tides.

Ability to support vegetation

"Tilth" (physical condition of the soil related to ease of tillage, fitness as a seedbed, and impedance to seedling emergence and root penetration) is important to the germination of seeds and the infiltration of water into the soil. Soils that have good tilth are generally granular and porous.

Fertility tends to be low for soils in their natural state. Most soils in the Northeast are acid. They require applications of lime to lower acidity sufficiently for lawns and other vegetation to do well. There are some exceptions; for example some shrubs prefer acid soils.

Soil Survey Reports

Soil survey reports offer detailed information on the soil characteristics. These reports contain soil maps, soil descriptions, and soil interpretation tables. They have been published for most areas of Massachusetts. Copies are available for review at the local Conservation District office.

Soil surveys maps are aerial photographs on which soil scientists have drawn boundaries of natural soil bodies, identifying each as a specific map unit. A map unit delineation on a soil map represents an area dominated by one major kind of soil or an area dominated by several kinds of soil, on the basis of soil series and soil phase. Map unit descriptions and accompanying tables provide detailed information on each, as well as interpretations on their use for numerous purposes.

Examples of two tables are shown in the accompanying figures.

A soil series is made up of soils that have horizons (soil layers) similar in arrangement and characteristics. Soils of one series can differ in texture, underlying material, slope, stoniness, wetness, etc. On the basis of such differences, a soil series is divided into soil phases. The smallest map unit that is practical to identify is three to five acres.

Every map unit generally has some soils that belong to other taxonomic classes. These soils are known as inclusions. The inclusion may be similar to the dominant soil and therefore may not affect the use or management of the soil. On the other hand, the inclusion may be contrasting and therefore require different management and may affect the potential use of the soil mapping unit. Inclusions could affect the site specific use of an area but may have little or no effect on broader land use determinations.

Soil survey reports are very useful to planners, contractors, engineers, and local officials. Planners can evaluate the effects of specific land uses in an area. Contractors can identify potential sources of sand and gravel, topsoil, and roadfill. They can use the survey to determine the areas where high water table, restrictive layers or bedrock may hinder excavation. Engineers and local officials may also use the survey to plan for waste disposal and site development.

The reports contain descriptions for each soil series, with information on the composition of each layer of the soil profile; to a depth of at least 60 inches. There are tables evaluating the limitations for use of each soil series. Other tables contain engineering, physical, and chemical properties.

Soil survey reports should be supplemented with onsite soil investigation for a specific land use.

TABLE 11.--BUILDING SITE DEVELOPMENT

(Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
BoB---------------- Brookfield	Slight---------	Slight---------	Slight---------	Moderate: slope.	Moderate: frost action.	Moderate: large stones.
BoC---------------- Brookfield	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: large stones, slope.
BoD---------------- Brookfield	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
BrC*:						
Brookfield--------	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: large stone, slope.
Brimfield---------	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock.	Severe: thin layer.

TABLE 15.--ENGINEERING INDEX PROPERTIES

(The symbol < means less than; > means more than. Absence of an entry indicates that data were not estimated)

Soil name and map symbol	Depth	USDA texture	Classification		Frag-ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas-ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
BoB, BoC, BoD---- Brookfield	0-2	Fine sandy loam	SM, ML, GM	A-2, A-4	15-30	65-100	60-95	40-80	25-65	<25	NP-5
	2-65	Gravelly sandy loam, gravelly fine sandy loam, fine sandy loam.	SM, GM	A-2, A-4	0-15	65-100	60-95	40-70	25-85	---	NP
BrC*, BrE*:											
Brookfield------	0-2	Fine sandy loam	SM, ML, GM	A-2, A-4	15-30	65-100	60-95	40-80	25-65	<25	NP-5
	2-65	Gravelly sandy loam, gravelly fine sandy loam, fine sandy loam.	SM, GM	A-2, A-4	0-15	65-100	60-95	40-70	25-45	---	NP
Brimfield-------	0-2	Fine sandy loam	SM, ML, GM	A-2, A-4	15-30	65-100	60-95	40-85	20-65	<25	NP-5
	2-15	Gravelly fine sandy loam, sandy loam, loam.	SM, ML, GM	A-2, A-4	0-15	65-100	60-95	40-80	20-65	<25	NP-5
	15	Unweathered bedrock.	---	---	---	---	---	---	---	---	---

Excerpts from tables in typical Soil Survey report.

Status of Soil Survey Reports in Massachusetts, as of January 1996.

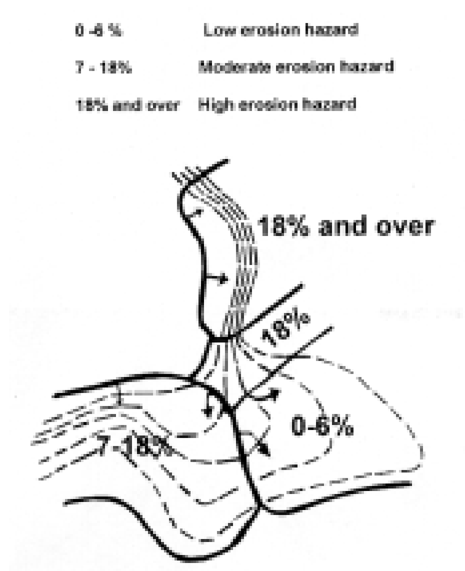
Berkshire County	Published
Franklin County	Report being updated
Hampden and Hampshire Counties, Western	Published
Hampshire County, Central	Published
Hampden County, Central	Published
Hampden and Hampshire Counties, Eastern	Published
Worcester County, Northwestern	Awaiting publication
Worcester County, Northeastern	Published
Worcester County, Southern	Awaiting publication
Middlesex County	Awaiting publication
Essex County, Northern	Published
Essex County, Southern	Published
Norfolk and Suffolk Counties	Published
Plymouth County	Report being updated
Bristol County, Northern	Published
Bristol County, Southern	Published
Barnstable County	Published
Dukes County	Published
Nantucket County	Published

Slopes

Runoff velocity increases as slope length and gradient increase. As the velocity increases, so does its capacity to detach and transport soil particles. In general, the flatter and shorter a slope, the slower the runoff velocity and the greater the infiltration rate on that slope.

Removal of existing vegetative cover from slopes increases the vulnerability of the slopes to erosion. Vegetation retards runoff velocity and root systems hold soil particles in place. Vegetation maintains the soils' capacity to absorb precipitation.

Soils are most vulnerable to erosion where highly erodible soils and steep or long slopes appear in combination, and where surface soils are low in fertility and ability to support vegetation.

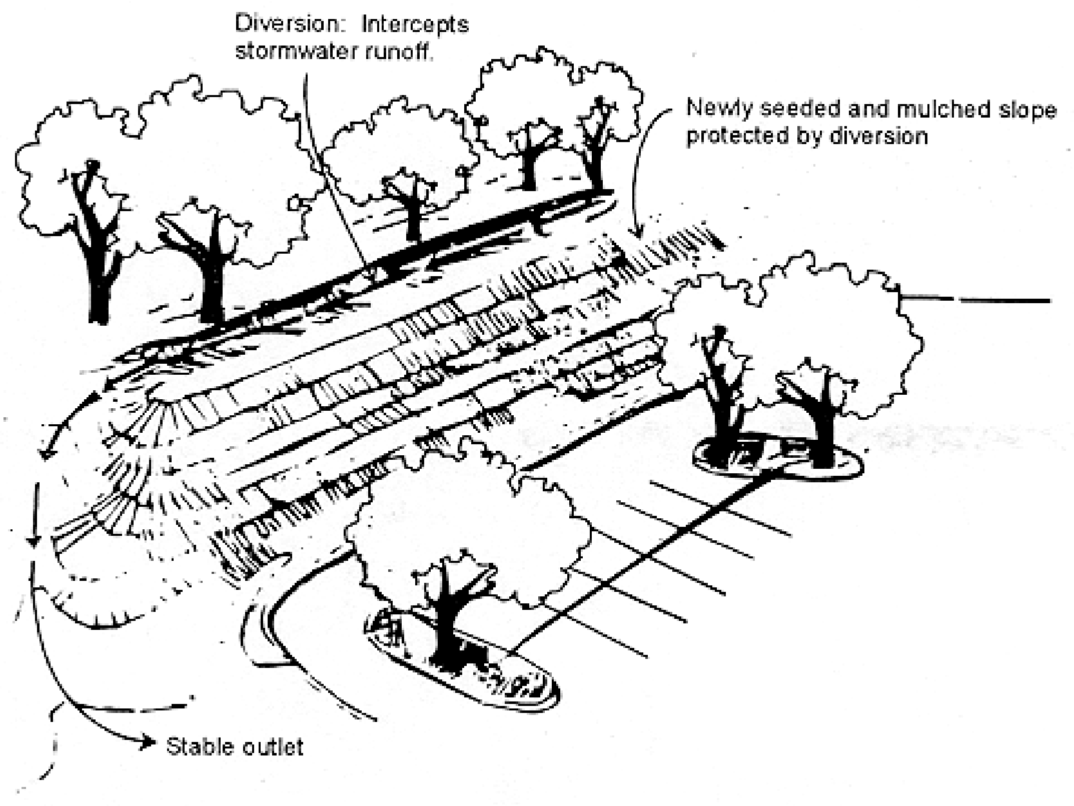


Practices to Divert Runoff

Runoff can be diverted from slopes that are exposed during development by using diversions to intercept runoff and keep it away from the slope face. A diversion extends across a slope, usually a combination of dike and ditch. Diversions can be used at intervals across the slope face to reduce slope length. Diversions are also used to collect runoff from a construction site and divert it to a sediment retention trap or pond.

Diversions can be bare channels, vegetatively stabilized channels, or lined channels (paving, erosion control fabric, etc.). Temporary diversions must remain in place until slopes have been permanently restabilized.

Diversions concentrate the volume of surface runoff. As a result, they also increase its erosive force. It is important to plan in advance for the disposal of runoff collected by diversions. Runoff must be released onto a stabilized area to reduce its erosion potential. In some cases this can be simply achieved by gradually reducing the gradient of the diversion channel.



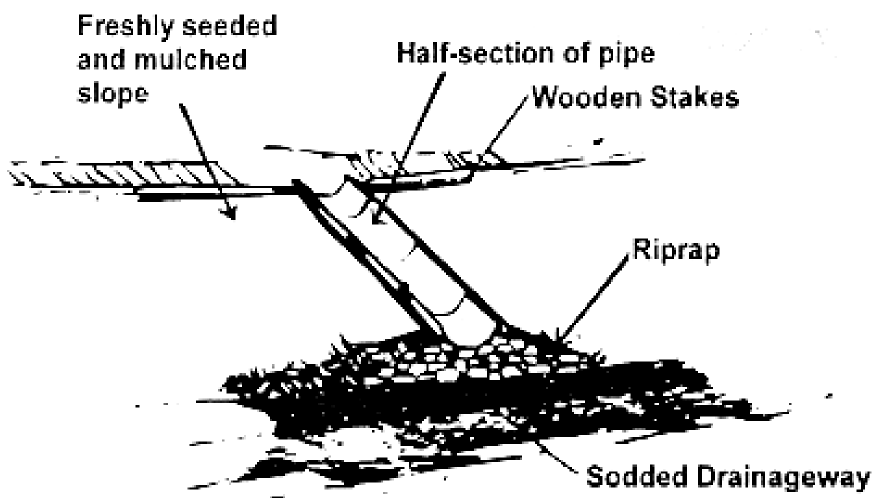
Slope Drains

If runoff cannot be satisfactorily disposed of by conveying across a slope, it can be drained over the face of the slope itself. Slope drains can run down the surface of the slope as a sectional downdrain, paved chute, or a pipe placed beneath the surface of the slope.

On-surface sectional downdrains are usually corrugated metal, or plastic pipe. These slope drains are temporary. For permanent installations; paved chutes with a surface of concrete or bituminous material, or subsurface pipes are used.

Compact the soil carefully at the mouth of the slope drain and anchor it adequately. Otherwise, undercutting can occur at the lip of the slope drain and under the drain.

At the slope drain outlet, energy dissipators are frequently necessary. Failure to utilize an “energy dissipater,” such as rock riprap, can result in serious erosion problems at the outflow end of the slope drain. An energy dissipater breaks up the flow of water and reduces velocity to a non-erosive level.

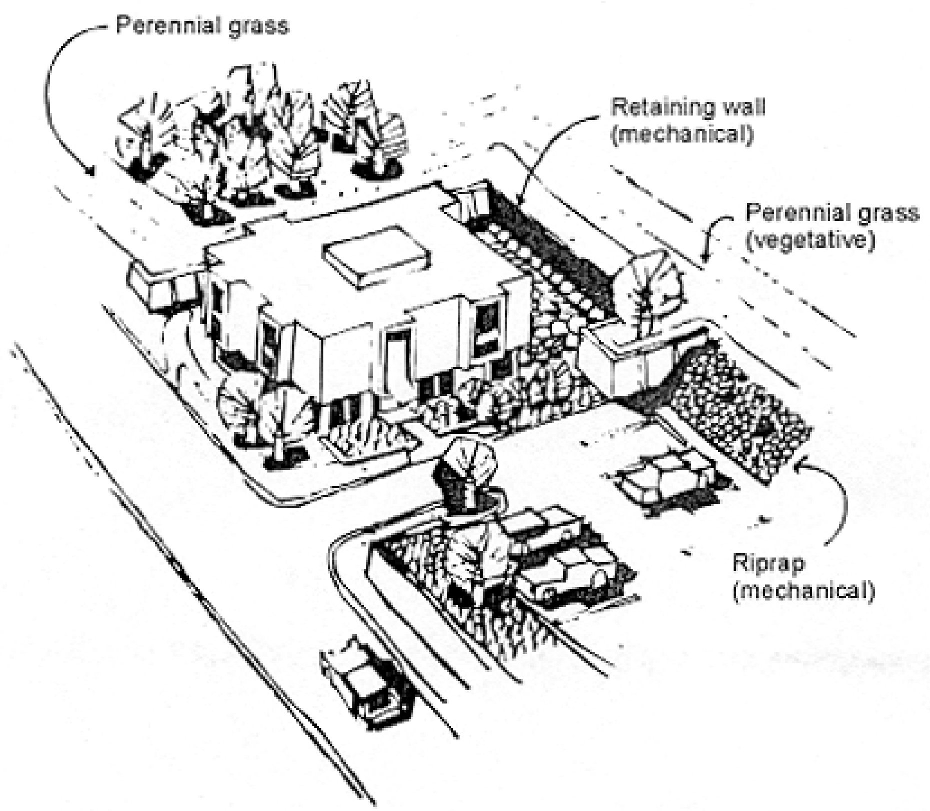


SECTIONAL DOWNDRAIN

Retaining Walls, Slope Protection

Retaining walls may be used to reduce extreme slope gradients, dividing a slope into a series of shorter, flatter segments and structural vertical walls. Retaining walls can be used in a situation where the builder is trying to keep existing mature vegetation. The cost of building retaining walls is often justified because of the maintenance costs that are saved on areas that would be difficult or impossible to stabilize otherwise.

Slope paving (e.g. asphalt or concrete paving, rock lining) may also be used to protect steep slopes that cannot be vegetated. If possible, use permeable materials.



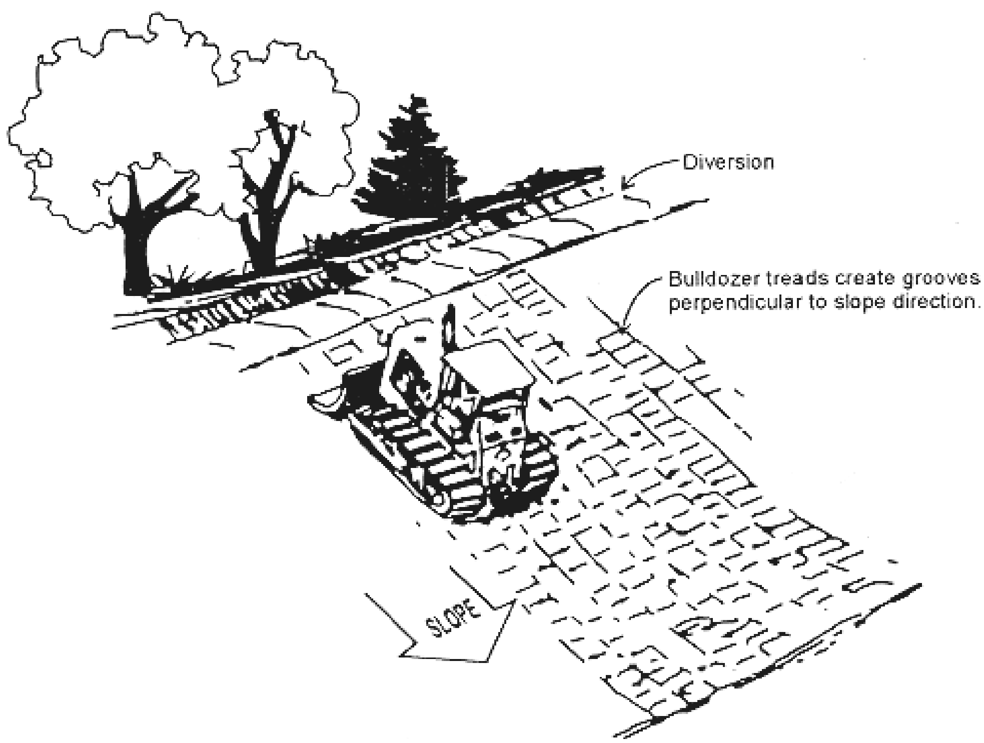
Examples of Vegetative and Mechanical Control Measures

Slope Stabilization Measures

Another way to stabilize slopes is to reduce their steepness. The selection of the appropriate grade for cut and fill slopes should be based on several considerations. The stability of the soil, its drainage characteristics, and its erodibility should be considered first.

If the slope gradient is flattened, the overall length of the slope increases, and this increases the amount of surface area subject to erosion. It is easier, however, to establish vegetation on a flatter slope.

Slope surfaces can be roughened by running wheeled construction equipment across the slopes, or tracked equipment up and down the slope face. This reduces the velocity of water flowing down the slope and increase infiltration rates. The rough surface holds water, seed, and mulch better than a smooth slope. The grooves created by the construction equipment should run across the slope horizontally, and not up and down the slope. Slopes can also be scarified (loosened with a harrow) to produce desired surface roughness.



Drainage

Protecting streams and waterways on or near sites undergoing development and protecting areas downstream from development involves three goals:

- The increased sediment loads carried by surface runoff from areas under construction must not be allowed to enter streams.
- Streambanks must be protected from erosion hazards caused by increases in runoff volume and velocity.
- The rates of release of increased volumes of runoff into streams and waterways and the velocity of flow in stream channels must be controlled.

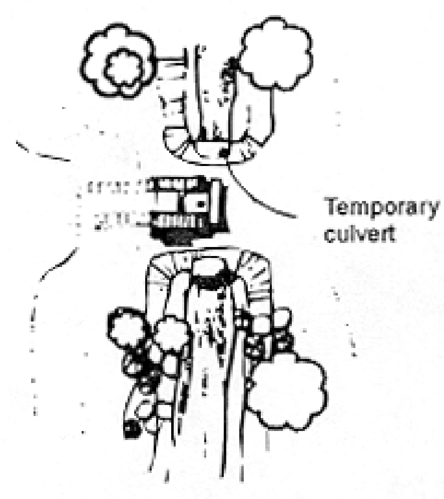
Contact the local Conservation Commission regarding any stream crossing or other work conducted in a wetland resource area. The Massachusetts Wetland Protection Act requires that the proponent file a "Request for Determination of Applicability" or "Notice of Intent."

There are several identifying characteristics for streams that are particularly vulnerable to erosion. Streams which have a small channel capacity and steep banks are very susceptible to erosion. Streams which flow through areas of erodible soil, and streams with sharp meanders or bends in the channel alignment are also prone to erosion.

Streambank Stabilization Measures

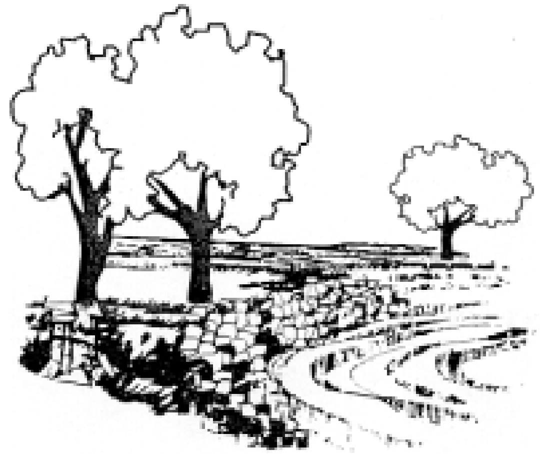
Maintain existing vegetation on streambanks. Streambank vegetation helps stabilize the soil, slows runoff and dissipates its erosive energy, and filters sediment from runoff.

To prevent the destruction of streambank vegetation, stream crossing and construction traffic along the banks must be controlled. Culverts and temporary bridges should be constructed only as a last alternative.



Control Stream Crossing Points

Vegetative Measures



RIPRAPPED STREAMBANK

When streambanks must be disturbed, or where existing vegetative cover is inadequate, grass or grass-legume mixtures may be established. Vegetative restabilization should be done immediately after streambank grading has been completed. Grass and legume vegetation is recommended for the protection of streambanks. Woody vegetation (shrubs) may be used if ice damage is a potential problem.

As soon as planting or seeding has been completed, banks should be mulched and the mulch securely anchored. Straw with a plastic-emulsion tacking agent, excelsior blanket, a netting over straw, or similar materials may be used. In recent years manufacturers have developed many new products for soil stabilization.

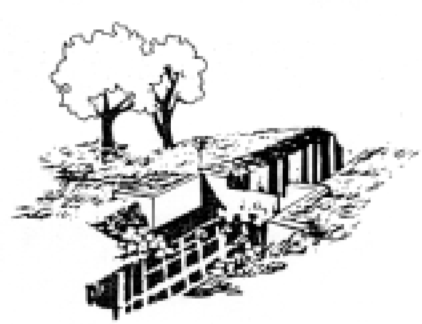
It is important to check periodically and repair areas where vegetation has failed.

Structural Measures

Streambanks can be protected from erosion by structural as well as vegetative measures. If vegetation will not provide sufficient protection, banks can be protected with revetments and deflectors.

Where sharp bends occur or where there are constrictions in the stream channel (such as culverts, bridges, or grade control structures), structural treatment may be necessary. Riprap, gabions, and concrete paving are often used to protect and reinforce a stream bank. Deflectors, consisting of jetties or pilings that angle outward from the bank in a downstream direction, may also be used to keep erosive currents away from vulnerable bank areas.

Grade Control Structures

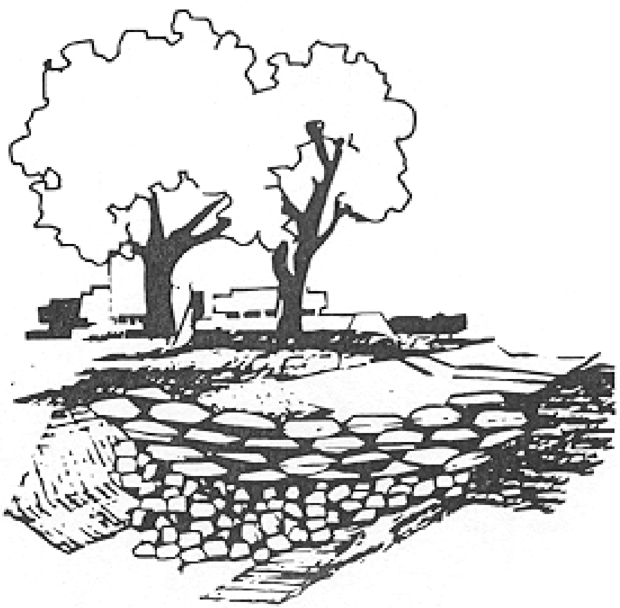


Grade control structures can be used to reduce the channel gradient, thereby reducing the velocity of flow in a channel. Check dams, weirs, and drop spillways, made of a variety of materials, both temporary and permanent, reduce channel grade and dissipate the energy of flowing water. These structures concentrate the volume of water and increase velocity of flow, therefore, special care must be taken to prevent undercutting at the toe of the structure and erosion of the banks.

Sediment Traps or Basins

The first step in preventing sediment from entering streams and waterways is to control erosion on construction sites. The second is to trap sediment transported by runoff before it reaches streams and waterways or leaves the construction site. Runoff must be detained for a sufficient period of time to allow the suspended soil particles to settle.

Vegetative filter strips between streams and development areas can slow runoff and filter out sediment.



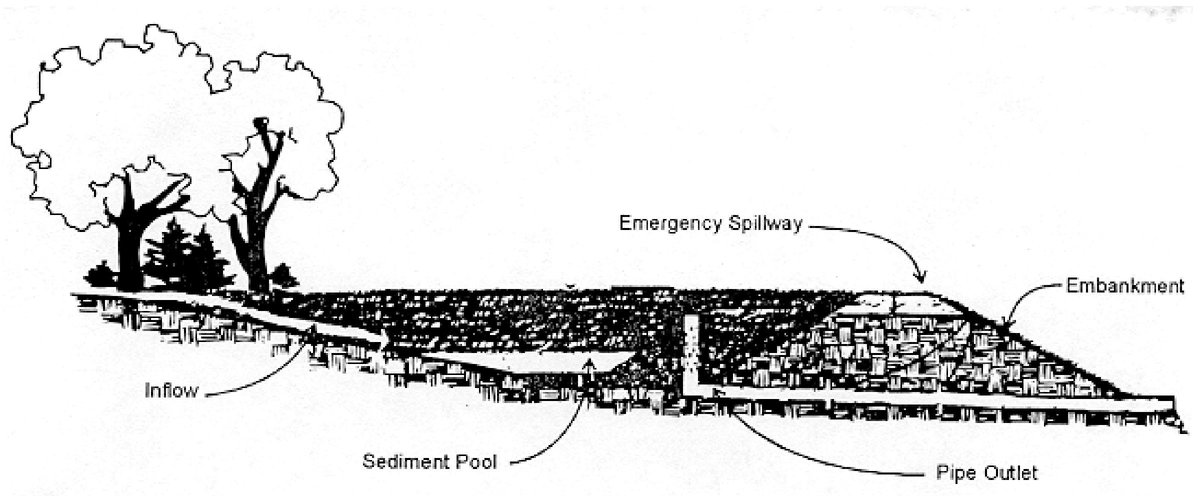
Sediment traps can be constructed in drainageways. Sandbags, straw bale barriers, and excavated sediment traps, placed at regular intervals within a drainage channel, are easy and economical to construct. Sandbag barrier sediment traps are constructed of bags filled with sand or crushed rock and stacked in an interlocking manner designed to trap sediment and reduce velocity of flow.

Straw bale barrier sediment traps are constructed of bales of hay or straw stacked and staked in place. Tying the bales to stakes with wire provides additional stability. Soil excavated from the drainage channel should be compacted along the upstream face of the barrier. Piping, or undercutting, can be reduced by setting the bales at least six inches into the bottom of the drainway and compacting excavated soil along the upstream side. Sediment traps require cleaning out periodically; and they should be checked after heavy rains to repair any damage and remove accumulated sediment.

Streams may also be protected from increased sediment loads by trapping runoff in sediment basins before it is released into stream channels. In addition to trapping sediment, these basins are designed to release runoff at nonerosive rates. Sediment basins usually consist of an earthen dam, a spillway to carry normal water flow, and an emergency spillway for storm flows. Construct sediment basins before clearing and grading of the main site begins. They are generally located at or near the low point of the site. Sediment basin outlets must be stabilized.

Surface runoff, and runoff intercepted by erosion control measures such as diversions, should be conveyed in erosion-resistant drainageways and released to stabilized areas, storm sewers, or sediment basins. The drainageways should be designed to insure that runoff is transported without risk of erosion or flooding.

The development should be planned to maintain and utilize the existing drainageways. Increases in runoff volume and velocity because of changes in soil and surface conditions during and after construction must be anticipated. Where the capacity of the natural site drainage channels is exceeded, additional capacity, stabilizing vegetation, or structural measures will be needed.



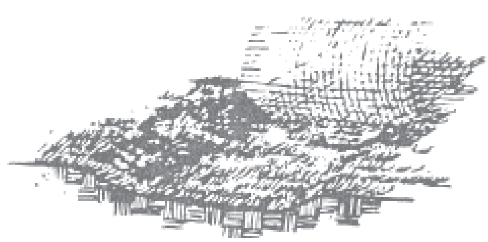
Bare Channels

Bare channels should be used with caution, and only in areas where the channel slope is quite flat. In areas where the soils have moderate to high erosion potential, stabilization techniques will need to be a part of the design.

Grassed Waterways

Waterways are designed to transport excess surface water from diversions or natural concentrations of flow in a stable channel. Grassed waterways are vegetatively stabilized channels. Jute netting, paper twine fabric, excelsior blankets, and various other mulching techniques are frequently used to protect channels until vegetation becomes well established. In some vegetatively lined channels, bank protection may also be necessary. Riprap is a commonly used material.

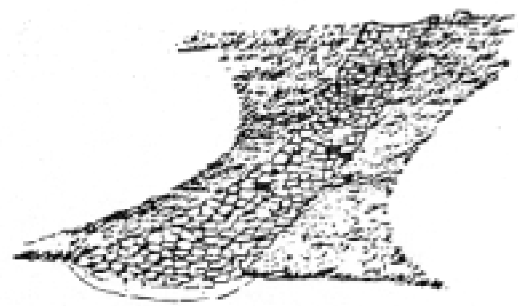
GRASSED WATERWAY



GRASSED WATERWAY WITH NETTING

Lined Channels

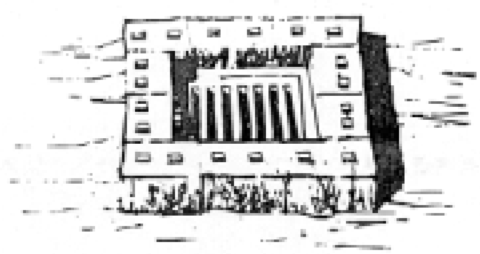
Linings are necessary in drainageways where: vegetation cannot be established because flow is of long duration in the channel, runoff velocities or concentrations are high, erodible soils exist or slopes are very steep. Concrete paving and riprap are commonly used channel linings. In general, vegetative stabilization and the use of permeable channel linings, such as riprap, are preferred to the use of impermeable linings, such as concrete or grouted riprap.



RIPRAP LINED DRAINAGEWAY

Inlet Protection

The capacity of the storm sewer system can be severely impaired by sediment deposits. Sediment should be prevented from entering an enclosed storm sewer by temporary sediment traps and filters at system inlets. Filters made of crushed rock, sod, or straw bales can be placed at inlets where sediment traps cannot be constructed. It is essential to check traps and filters regularly and remove accumulated sediment.



STRAW BALE DRAIN INLET SEDIMENT BARRIER

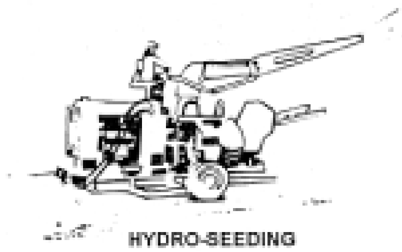
Enclosed Drainage

The capacity of vegetated drainage channels may be exceeded by the increases in runoff caused by earthchanging activities. As a result, vegetatively lined channels may scour and erode. If storm sewers will be needed, install them before major construction begins.

Ground Cover

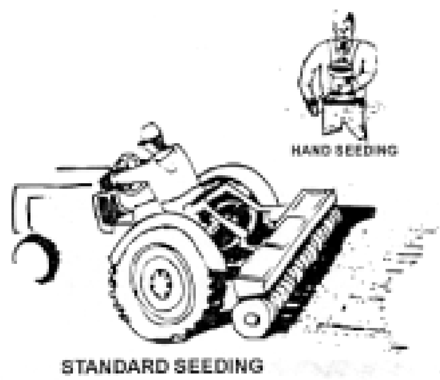
Vegetative Stabilization Techniques

Grass and legumes are the most commonly used plant materials for stabilizing slopes. Vegetation is usually established in one of three ways.



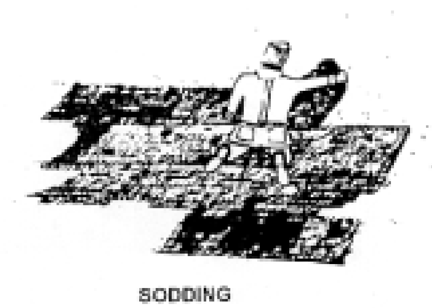
Hydroseeding

A mixture of seeds, fertilizer, and water is sprayed on the slope. A mulch and a mulch tacking agent should also be applied. Hydroseeding is effective on large areas.



Standard seeding

Seed is drilled or broadcast either mechanically or by hand. A cultipacker or similar tool is used after seeding to compact the seedbed and cover the seed. The proper timing of seeding, mulching, and watering is important for areas seeded in this manner.



Sodding

Sod strips are laid on the slope and in this way instant cover is provided. Sod should be placed on a prepared bed and pegged on steep slopes. Water and fertilizer are important. This method is effective and is often used on steep slopes and waterway channels.

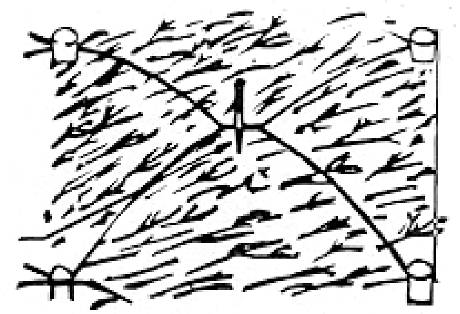
Suitable soil, good seedbed preparation, and adequate water, lime, and fertilizer are “musts” for all these methods.

Immediately after rough grading is completed, exposed slopes should be temporarily stabilized. If final grading will be delayed, temporary seeding and mulching may be used for short period of protection.

As soon as slopes are brought to final grade, permanent vegetation should be planted.

Maintenance will consist primarily of mowing, fertilizing, liming, and watering. It should be scheduled on a regular basis. Reseed bare areas as necessary.

Mulches

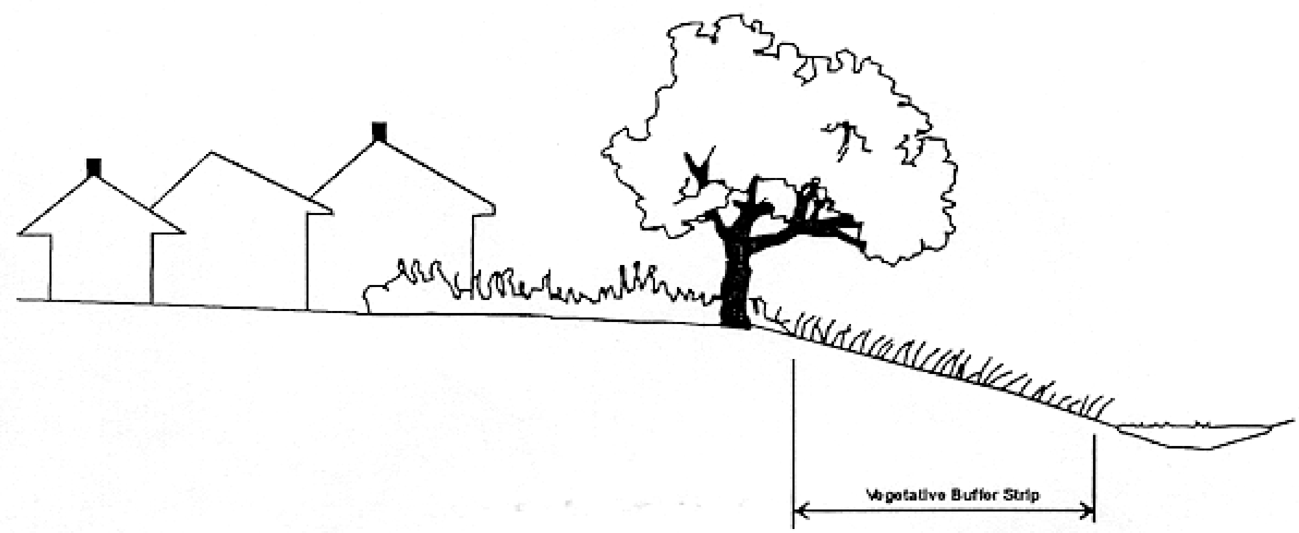


Mulch is usually used after permanent seeding, but may be used before seeding to protect exposed areas for short periods. Mulches protect the soil from the impact of falling rain, slow the velocity of runoff, and increase the capacity of the soil to absorb water. Mulches hold seed in place, preserve soil moisture, and insulate germinating seeds from the extremes of heat and cold.

Many types of mulch are available; such as straw, woodchips, and excelsior mats. Most mulches must be anchored, using plastic emulsions or jute, fiberglass, or plastic netting.

Vegetative Buffer Strips

Sediment can be reduced by maintaining a natural vegetative buffer or filter strip at the base of a slope and by placing sod strips at intervals across the face of the slope. These measures help to slow runoff and trap sediment.



Potential Problems

Some of the problems that arise when a site is developed are high watertable, flood-prone areas, seepage, or adverse soil conditions. If such problem areas are recognized early, site plans can be developed to accommodate, not aggravate, them.

Flood Plains

Is the proposed development located in a flood plain? A Soil Survey report can be used to locate areas subject to flooding by stream overflow. For example, soils such as those in the Hadley or Podunk series would be described as "subject to flooding." The maps in soil survey reports show the location of such soils.

If a Flood Hazard Analysis has been performed for the town, it may be used to locate flood hazard areas.

If neither of the above are available, a rough identification of flood hazard areas may be accomplished by interviewing local residents, checking town records. Field checks of vegetative cover types, soil moisture, or vertical distance above stream level help point out susceptible areas.

Effect of Development on Surface Runoff

Development usually results in the increase of hard-surfaced, impervious areas, which can increase flooding downstream. These effects may be reduced through:

Minimum lot sizes

For example, the runoff from a subdivision of one-quarter acre lots for a two-year frequency storm can be 50% greater than that from the same subdivision with one-acre lots.

Preservation of the natural drainage pattern

Development may disrupt drainage paths that have developed over hundreds of years. The existing, natural drainageways usually have sufficient capacity for the runoff from all except major, infrequent storm events; unless there has been significant change in the cover conditions upstream.

Stormwater Retarding Structures

Often it is not feasible to preserve enough of the natural drainage and vegetative cover to prevent an increase in runoff. A properly designed retarding structure temporarily stores runoff from a developed area and releases the water over a period of time, at a rate within the capacity of the channel downstream

Adverse Soil Conditions

Large Rocks and Ledge

If these are encountered, development costs rise significantly. Plan the development around these conditions and leave rocks and ledge undisturbed if possible.

Settlement Potential

Fills placed on soft organic soils or located in wet areas tend to settle unless care is taken to see that they are properly constructed. Foundations for larger buildings are usually designed by a soils or foundations engineer, but plans for houses, parking lots, driveways may not have been developed with sufficient concern for possible foundation settlement.

Water Table

Areas with a high water table should either be avoided or steps taken to drain or otherwise control the condition. High water table can cause malfunctioning septic systems, damp basements, uneven foundation settlement.

Seepage

Seepage may be encountered at the base of a hill (where the ground surface flattens out); or on a slope, where a roadside cut or an excavation for a foundation is made. Houses, driveways, roads, parking lots, etc., located in such areas usually require drainage measures.

Cuts and Fills

Constructed cuts and fills tend to change site characteristics (drainage, soil materials, stability, etc.). The earth-moving involved raises development costs. A comparison should be made of the cost of doing such work, and the subsequent drainage measures required vs. working with the natural ground contours to minimize cuts and fills. The comparison may show the latter to be more economical; as well as more pleasing to the eye.

Stabilization Principles for Site Development

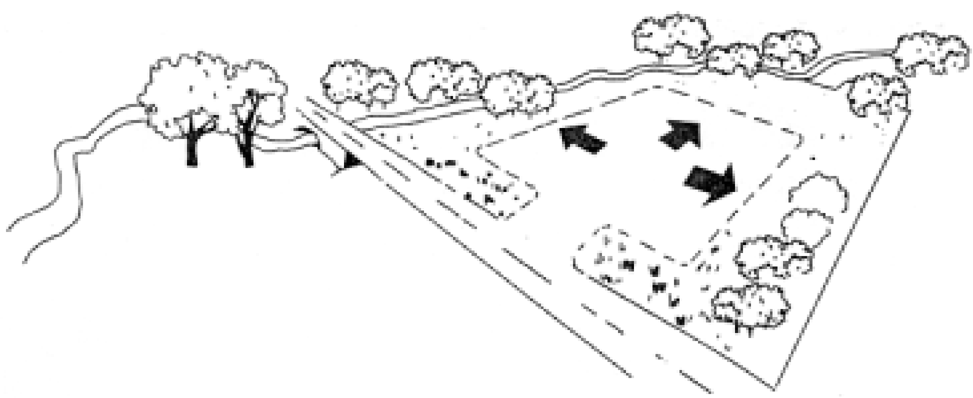
Review and consider all existing conditions in the initial site selection for the project. Select a site that is suitable rather than force the terrain to conform to development needs. Ensure that development features follow natural contours. Steep slopes, areas subject to flooding, and highly erodible soils severely limit a site's use, while level, well-drained areas offer few restrictions. Control seepage and high water table conditions. Any modification of a site's drainage features or topography requires protection from erosion and sedimentation.

Keep Disturbed Areas Small

Careful site selection will help on this point. The site, or corridor, should be able to accommodate the development with a minimum of grading.

The development plan should fit its topographic, soil, and vegetative characteristics with a minimum of clearing and grading. Natural cover should be retained and protected wherever possible. Critically erodible soil, steep slopes, streambanks, and drainageways should be identified. The development can then be planned to disturb these vulnerable areas as little as possible.

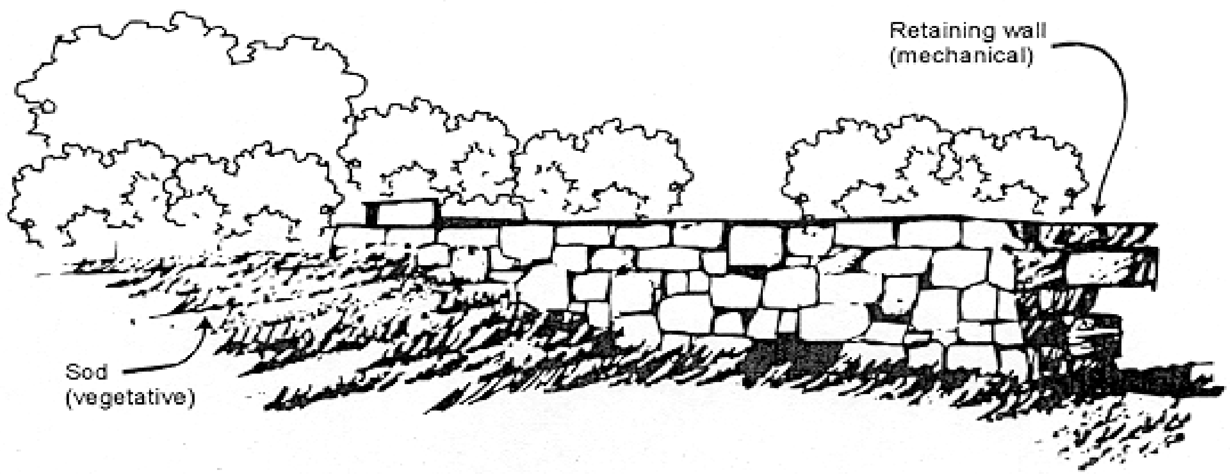
Where earth change and removal of vegetation are necessary, keep the area and duration of exposure to a minimum. Plan the phases of development so that only areas which are actively being developed are



exposed. All other areas should have a good cover of vegetation or mulch.

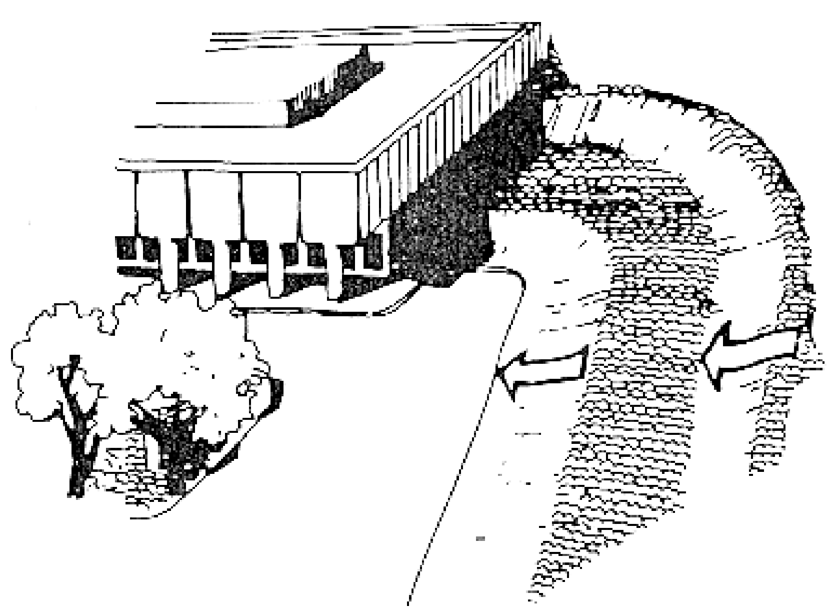
Stabilize and Protect Disturbed Areas as Soon as Possible

Two methods are available for stabilizing disturbed areas: mechanical (or structural) methods and vegetative methods. In some cases, both are combined in order to retard erosion.

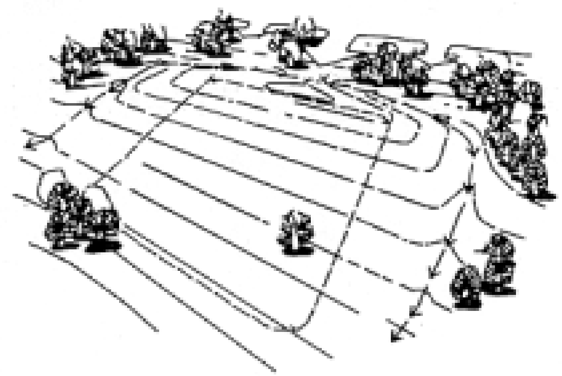


Keep Stormwater Runoff Velocities Low

The removal of existing vegetative cover during development and the resulting increase in impermeable surface area after development will increase both the volume and velocity of runoff. These increases must be taken into account when providing for erosion control.



Protect Disturbed Areas from Stormwater Runoff



Best management practices can be utilized to prevent water from entering and running over the disturbed area. Diversions and other control practices intercept runoff from higher watershed areas, store or divert it away from vulnerable areas, and direct it toward stabilized outlets.

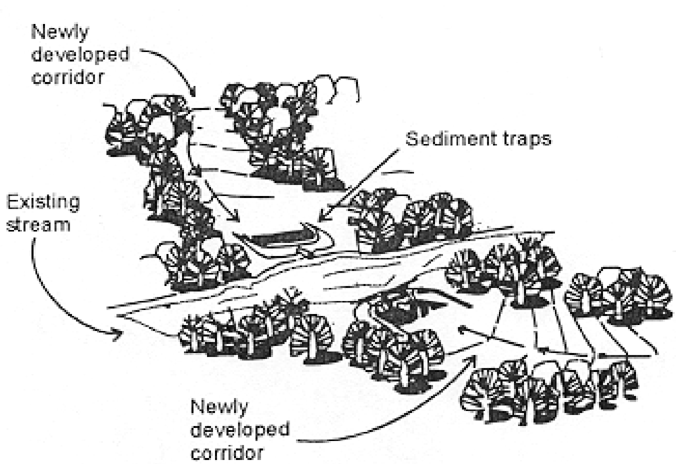
Retain Sediment within the Corridor or Site Area

Sediment can be retained by two methods: filtering runoff as it flows and detaining sediment-laden runoff for a period of time so that the soil particles settle out. The best way to control sediment, however, is to prevent erosion.

After construction is completed, inspection and maintenance are vital to the performance of erosion and sedimentation control measures. If not properly maintained, some practices may cause more damage than they prevent.

When considering which control measure to use, always evaluate the consequences of a measure failing. Failure of a practice may be hazardous or damaging to both people and property. For example, a large sediment basin failure can have disastrous results; low points in dikes can allow them to overflow and cause major gullies a fill slope.

It is essential to inspect all practices to determine that they are working properly and to ensure that problems are corrected as soon as they develop. Provide some means to see that routine checks of operating erosion and sedimentation control practices are carried out after construction is over.



Developing An Erosion and Sediment Control Plan

An erosion and sedimentation control plan should serve as a blueprint for the location, installation, and maintenance of practices to control all anticipated erosion, and prevent sediment from leaving the site.

Tracts of land vary in suitability for development. Knowledge of the soil type, topography, natural landscape values, drainage patterns, flooding potential, and other pertinent data helps identify both beneficial features and potential problems of a site. Developers and builders can minimize erosion, sedimentation, and other construction problems by selecting areas appropriate for the intended use.

The erosion and sedimentation control plan should be a part of the general construction contract. It should show location, design, and construction schedule for all erosion and sedimentation control practices. Also, developers and builders must abide by the local town bylaws.

Contents

An erosion and sedimentation control plan must contain sufficient information to describe the site development and the system intended to control erosion and prevent off-site damage from sedimentation. At a minimum, the plan should contain the following items:

- Brief narrative,
- Vicinity map,
- Site topography map,
- Site development plan,
- Erosion and sedimentation control plan drawing,
- Detail drawings and specifications,
- Vegetation plan,
- Supporting calculations,
- Construction sequence,
- Maintenance plan.

The narrative will clarify details of the plan as an aid for the inspector and the contractor. The narrative should be concise, but should describe:

- Nature and purpose of the proposed development,
- Pertinent conditions of the site and adjacent areas, and
- Proposed erosion and sedimentation control measures.

The narrative should also include how the developer has incorporated applicable regulations (e.g. filed wetlands NOI, applied for an NPDES Storm Water Permit, etc.)

The designer should assume that the plan reviewer has not seen the site and is unfamiliar with the project. Map scales and drawings should be appropriate for clear interpretation.

There is an example erosion and sedimentation control plan in Part 4.

Data Collection and Preliminary Analysis

The base map for the erosion control plan is prepared from a detailed topographic map. A soils map may be obtained from the local Conservation District office. Transferring soil survey information to the topographic map is helpful for site evaluation. Inspect the site to verify the base map with respect to natural drainage patterns, drainage areas, general soil characteristics, and off-site factors.

The base map should reflect such characteristics as:

- Soil type and existing contours,
- Natural drainage patterns,
- Unstable stream reaches and flood marks,
- Watershed areas,
- Existing vegetation,
- Critical areas such as steep slopes, eroding areas, rock out croppings, and seepage zones,
- Unique or noteworthy landscape values to protect,
- Adjacent land uses; especially areas sensitive to sedimentation or flooding, Critical or highly erodible soils that should be left undisturbed.

Base map should include:

Scale
North arrow
Benchmark
Property boundaries
Lot lines

Use the base map to locate:

- Buffer zones,
- Suitable stream crossing areas,
- Access routes for construction and maintenance of sedimentation control devices,
- Borrow and waste disposal areas, and
- The most practical sites for control practices.

Analysis of the topography, soils, vegetation, and hydrology will help the planners and designers to recognize the limitations of the site, and identify locations suitable for development.

Preparing the Plan

The erosion and sedimentation control plan should seek to protect the soil surface from erosion, control the amount and velocity of runoff, and capture sediment on-site during each phase of the construction project:

Schedule activities

Coordinate installation of erosion and sediment control practices with construction activities.

Sediment control practices should precede grading activities.

Protect the soil surface

Limit the extent of disturbance. Stabilize the soil surface immediately. Once the surface has been disturbed, it is vulnerable to erosion and should be protected with appropriate cover, such as mulch or vegetation.

Control surface runoff

Divert water from undisturbed areas to avoid disturbed areas. Break up long slopes with temporary diversions to reduce the velocity of runoff. Divert sediment-laden water to sediment impoundments. Make all outlets and channels stable for the intended flow.

Capture sediment on-site

Divert runoff that transports sediment to an adequate sediment-trapping device to capture sediment on the site.

Preparing the Plan - Step by Step

Runoff-Erosion Analysis

Landscape

Evaluate proposed changes in the landscape to determine their effect on runoff and erosion. Make a note of all physical barriers to surface runoff, such as roads, buildings, and berms. Check slope grades and lengths for potential erosion problems. Designate intended collection points for concentrated flow and specify controls to dissipate energy or stabilize the surface. Designate areas to be protected or used as buffer zones in this phase.

Runoff yield

Evaluate surface runoff for the entire contributing drainage area, both on-site and off-site. Delineate small subwatersheds on-site and estimate peak runoff rates and volumes at selected collection points. Base runoff determinations on site conditions during and after development, not preconstruction conditions.

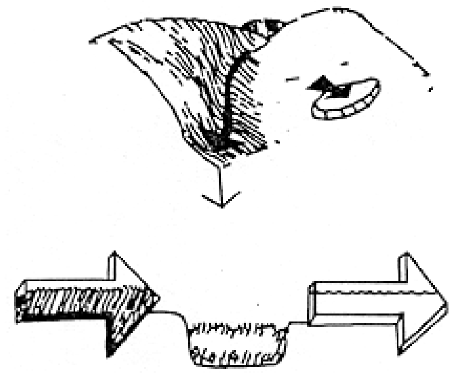
Sediment yield

Estimate sediment yield by subwatersheds. This aids in identifying preferred locations for sediment traps and barriers and can be used to estimate the expected cleanout frequency. An area that is subject to excessive erosion may need extra storage capacity in traps or additional precautions during construction.

Sediment Control

Erosion control practices reduce the amount of sediment generated, but they do not eliminate the need for sediment control devices such as barriers and traps. Sediment control practices operate by reducing flow velocity and creating shallow pools that reduce the carrying capacity of runoff. Thus sedimentation occurs on-site rather than off-site. Sediment is generally not controlled by filtering, but by deposition. The designer should locate all traps and barriers recognizing that they represent deposition points where access for maintenance will be necessary.

Sediment basins and traps

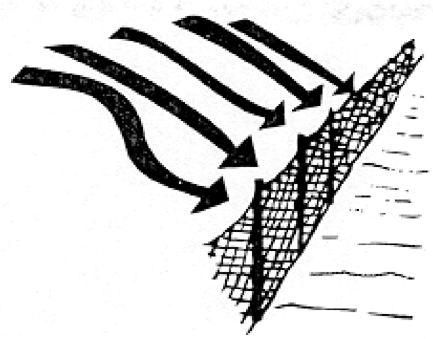


Select sites and install sediment basins and traps before other construction activities are started. Also, consider locations for diversions, open channels, and storm drains at this time so that all sediment-laden runoff can be directed to an impoundment structure before leaving the construction site.

Divert sediment-free water away from sediment basins and release it through stable outlets. This reduces construction costs and improves basin efficiency.

The plan should show access points for cleanout of all traps and basins and indicate sediment disposal areas. Maintenance of storage capacity is essential throughout the construction period.

Sediment fences



Sediment fences provide effective control of sediment carried in sheet flow. They are particularly useful where there is limited space to work such as near property lines, among trees, or near sidewalks or streets. Sediment fences should never be used across streams, ditches, channels, or gullies.

A sediment fence operates by reducing flow velocity and causing a shallow pool to form. If filtering action is required, the designer should assume that the barrier will clog rapidly so that all runoff must be retained behind the fence or released through a designated outlet. Any outlet points must be reinforced and stabilized and should be designated in the plan.

Place sediment fences on relatively flat ground with sufficient area for a pool to develop without putting unnecessary strain on the fence. If a level area is not available at the fence location, excavate a trench directly upslope from the fence.

Show sediment fences on the plan and indicate deposition areas and needed overflow or bypass outlet points. Also show access routes for maintenance.

Inlet protection

Inlet protection devices for storm sewers, conduits, slope drains, or other structures make effective, low-cost deposition areas for trapping and holding sediment. A shallow excavation in conjunction with a sediment barrier can be effective at many locations. Show where these measures will be located, what type of device will be used, and how these devices will be constructed and maintained.

Protection of Disturbed Areas

Once an area is disturbed, it is subject to accelerated erosion. In the plan, show how erosion will be controlled on these disturbed areas. Erosion control can be achieved by:

- Limiting the size of clearing and time of exposure by proper scheduling,
- Reducing the amount of runoff over the disturbed surface,
- Limiting grades and lengths of slopes, and
- Reestablishing protective cover immediately after land-disturbing activities are completed or when construction activities are delayed for 30 or more working days.

Cut-and-fill slopes

Steep cut or fill slopes are particularly vulnerable to erosion. Protect by installing temporary or permanent diversions just above the proposed slope before it is disturbed. Provide a stable channel, flume, or slope drain, where it is necessary to carry water down a slope. Flow channels may be either vegetated, lined with stone, or paved, or a combination - depending on slope and soil conditions.

Shorten long slopes by installing temporary diversions across the slope to reduce flow velocity and erosion potential. Install permanent diversions with slope drains and protected outlets on long steep slopes (over 20%) as the slopes are constructed.

Finish final slope grades without delay and apply surface stabilization measures as soon as possible. Roughen slope surfaces to improve the success of vegetative stabilization. Consider both the stabilization measures and how they will be maintained before planning the steepness of the finish slope. For example, if the finished slope is to have grass cover that will be mowed, it should be constructed on a grade of 3:1 or flatter.

Surface covers

Riprap, gravel, straw and other cover materials can provide immediate surface protection to disturbed soil areas. Riprap is especially useful where concentrated runoff occurs over steep slopes. Riprap should be installed on a gravel or filter fabric bed.

Construction traffic

Construction roads, parking areas, and construction access routes need to be carefully planned. Ensure that traffic patterns follow site contours and limit the length of routes up steeper slopes. Generally, road grades should not exceed 12%.

Controlling surface runoff is necessary to prevent serious roadside erosion. Proper grading of the road surface, stable channel design, and use of water bars, other diversions, and culverts help prevent erosive flows.

Where water tables are high, subsurface drainage may be needed to stabilize the subgrade. Storm drains should be considered for water disposal where channel grade exceeds 5%. Plans should show all stabilization measures needed to control surface runoff from all roads.

Borrow areas and disposal areas

Clear only as needed, and protect from surface runoff. Maintain berms as fill slopes are constructed to reduce slope length and control runoff. Slope all areas to provide positive drainage, and stabilize bare soil surfaces with permanent vegetation or mulch as soon as final grades are prepared. Direct all runoff that contains sediment to a sediment-trapping device. In large borrow and disposal sites, shape and deepen the lower end to form an in-place sediment trap, if site conditions warrant it.

Utilities

Use the spoil from utility trench excavations to divert flow from upslope areas (but use care in spoil placement to avoid blocking natural surface outlets). Diversions and water bars can reduce erosion when properly spaced across utility rights-of-way.

When utilities are located near a stream, maintain an undisturbed buffer zone wherever possible. If site dewatering is necessary, pump or divert muddy water to sediment traps or sump pits before discharging it to the stream. If streams must be crossed, make sure all necessary materials and equipment are on-site before construction begins, and complete work quickly. Finish all disturbed surfaces to design grade and immediately stabilize them with permanent vegetation or other suitable means. Where utilities cross the stream, specify measures to prevent sedimentation.

Perimeter protection

Consider diversion dikes for perimeter protection for all proposed developments and install them where appropriate before clearing the site. Exercise care not to create flooding or erosion by blocking the natural drainage pattern. Be sure to provide an adequate outlet.

Dust control

Exposed soil surfaces that are nearly level have little potential for runoff erosion but may be subject to severe wind erosion. Keeping the disturbed surface moist during windy periods is an effective control measure, especially for construction haul roads.

Preserving vegetation

Preserve existing vegetation on the site as long as possible as a cost-effective way to prevent on-site erosion and off-site sedimentation.

Runoff Conveyance

The safe conveyance of runoff water from a construction site is achieved by: utilizing and supplementing existing stable watercourses, designing and constructing stable open channels, or installing storm drains with stable outlets. The plan should indicate locations and designs for these facilities. Complete and stabilize outlets for channels, diversions, slope drains, or other structures before installing the conveyance measure.

Contact the local Conservation Commission regarding any stream crossing or other work conducted in a wetland resource area. The Massachusetts Wetland Protection Act requires that the proponent file a "Request for Determination of Applicability" or "Notice of Intent."

Existing watercourses

When using existing watercourses, either show that flow velocities are acceptable for increased runoff conditions or indicate how necessary stabilization will be achieved.

Excavated channels

When channels are to be excavated, the design should be prepared by a professional engineer. Include calculations in the plan documentation.

Wide, shallow channels with established grass linings are usually stable on slopes up to 5%. These channels must be protected with temporary liners until grass is established. If channel gradients are too steep to use vegetation, riprap or concrete linings may be required. In some instances grade stabilization structures may be needed.

Storm drains

Where the site plan calls for a system of storm drains, the drains may be used effectively in the erosion and sedimentation control plan. Build junction boxes or inlets early in the construction sequence, and grade the adjacent area to drain toward the inlet. Install an inlet protection device at all open pipe inlets and excavate a shallow basin in the approach to the inlet for sediment storage.

The storm drain flow from the protected inlets may be diverted to a sediment basin for additional sediment control. Restrict the drainage area for inlets to less than one acre. Inspect inlet protection devices frequently for needed maintenance.

Stream Protection

Streambanks, streambeds, and adjoining areas are susceptible to severe erosion if not protected. Include sufficient detail to show that streams are stable for the increased velocities expected from the development activity. At a minimum, all streams should be stable for flows from the peak runoff from the 10-year storm.

Contact the local Conservation Commission regarding any stream crossing or other work conducted in a wetland resource area. The Massachusetts Wetland Protection Act requires that the proponent file a "Request for Determination of Applicability" or "Notice of Intent."

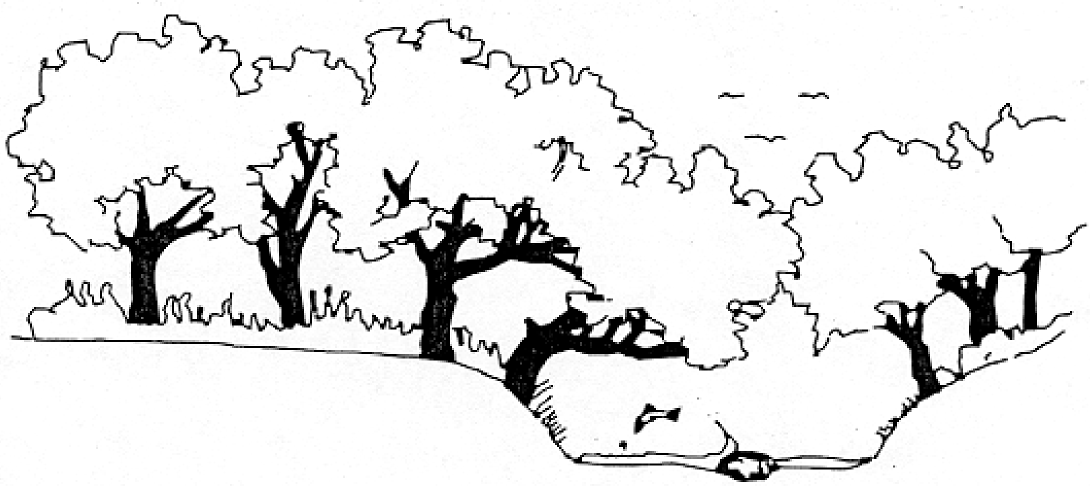
When stability analysis shows that the stream requires protection, vegetation is usually the preferred approach because it maintains the stream nearest to its natural state. When flow velocities approach 4-6 feet per second, or if frequent periods of bankful flows are expected; structural measures such as riprap lining or grade stabilization structures are usually necessary. In the plan, show where stream protection is needed and how it will be accomplished.

Runoff into stream

Only sediment-free runoff may be discharged from construction sites directly into streams. Ensure that all other flows enter from desilting pools formed by sediment traps or barriers.

Velocity control

Keep the velocity of flow discharged into a stream within acceptable limits for site conditions. Control velocity by installing an appropriate outlet structure.



Buffer zone

Areas adjoining streams should be left undisturbed as buffers. Existing vegetation, if dense and vigorous, will reduce flow velocities and trap sediment from sheet flow. However, the principal benefit of leaving natural buffer zones along streams is that they prevent excessive erosion in these sensitive areas. Maintaining stream canopies also protects fish and wildlife habitats; provides shade, windbreaks, and noise barriers, protects the bank from out-of-bank flood flows; and generally preserves natural site aesthetics.

Indicate stream buffer zones in plans that involve natural streams. The width is determined by site conditions but generally should not be less than 25 feet on each side of the stream. If natural buffers are not available, provide artificial buffers.

Off-site stream protection

Increased rate and volume of runoff from development activities may cause serious erosion at points some distance downstream. The developer should work with downstream property owners to stabilize sensitive downstream channel areas.

Stream crossing

Minimize the number of stream crossings. Construct crossings during dry periods. If necessary, divert water during construction. The plan should show the type of crossing to be used and the associated control measures to minimize erosion from surface runoff such as diversions, outlet structures, riprap stabilization, etc.

Construction Scheduling

Appropriate sequencing of construction activities is an effective means for controlling erosion and sedimentation. Use the construction schedule of the general contract as part of the erosion and sedimentation control plan. Install the primary erosion and sedimentation control practices for the site, i.e. sediment basins and traps, and a water conveyance system before undertaking major land-disturbing activities. Schedule work with an eye to the calendar, to minimize impacts due to seasonal changes.

Install sediment basins and primary sedimentation control practices as the first structural measures. Next install the overall water disposal outlet system for the site.

Stabilize all construction access routes, including construction entrances and exits, and the road drainage system, as the roads are constructed. Install storm drains early in the construction sequence and include them in the sedimentation control plan. Install inlet protection devices for efficient sediment control around the inlets. This allows early

Construction Scheduling - EPA Baseline General Permit Requirements for Site Stabilization:

Except as provided in the paragraphs below, stabilization measures shall be initiated as soon as practicable in portions of the site where construction activities have temporarily or permanently ceased, but in no case more than 14 days after the construction activity in that portion of the site has temporarily or permanently ceased.

(a) Where the initiation of stabilization measures by the 14^{th} day after construction activity temporary or permanently cease is precluded by snow cover, stabilization measures shall be initiated as soon as practicable.

(b) Where construction activity will resume on a portion of the site within 21 days from when activities ceased (e.g. the total time period that construction activity is temporarily ceased is less than 21 days), then stabilization measures do not have to be initiated on that portion of site by the 14^{th} day after construction activity temporarily ceased use of the inlets and the drain system.

Install diversions above areas to be disturbed and, where needed, along boundaries of areas to be graded before grading takes place.

After all principal erosion and sedimentation control measures are in place, perform the land clearing and rough grading. Clear areas only as needed and complete final grading and surface stabilization as soon as possible. Minimize the time of exposure and select temporary ground cover according to the location and season. Temporary surfaces should be stabilized as soon as active grading is suspended, regardless of the time of year. Disturbed areas should be revegetated early enough in the autumn that good cover is established before cold weather comes.

Inspection and Maintenance

In the erosion and sedimentation control plan, indicate who is responsible for maintenance and when it will be provided. The maintenance schedule should be based on site conditions, design safeguards, construction sequence and anticipated weather conditions. Specify the amount of allowable sediment accumulation, design cross-section, and, required freeboard for each practice and what will be done with the sediment removed. The plans should also state when temporary practices will be removed and how these areas and waste disposal areas will be stabilized.

Inspection Program

Essential parts of an inspection program include:

· Inspection during or immediately following initial installation of sediment controls.

· Inspection following severe rainstorms to check for damage to controls.

· Inspection prior to seeding deadlines, particularly in the fall.

· Final inspection of projects nearing completion to ensure that temporary controls have been removed, stabilization is complete, drainageways are in proper condition, and that the final contours agree with the proposed contours on the approved plan.

In addition, interim inspections should be made as manpower and workload permit, giving particular attention to the maintenance of installed controls.

All inspections should be documented by a written report or log. These reports should contain the date and time of inspections, dates when land-disturbing activities begin, comments concerning compliance or noncompliance and notes on any verbal communications concerning the project.

Before Construction

An on-site preconstruction meeting involving the owner, contractor, and erosion control personnel is recommended. This allows all parties to meet, review the plans and construction schedule, and agree on responsibility and degree of control expected. Discuss maintenance requirements, phasing of operations, and plan revisions. The preconstruction meeting is especially important for large, complex jobs or when the contractor and/or developer has had little experience in this type of work.

During Construction

The developer may be held responsible for off-site sediment damage resulting from construction activities even though an approved plan has been properly installed and maintained. Therefore, inspect the property boundary frequently for evidence of sedimentation.

It may be necessary to modify the erosion and sediment control plan during construction to account for unanticipated events or construction changes.

During Construction

In addition to the inspection and maintenance reports, the operator should keep records of the construction activity on the site, including:

· Dates when major grading activities occur in a particular area.
· Dates when construction activities cease in a particular area, temporarily or permanently.
· Dates when a particular area is stabilized, temporarily or permanently.

After Construction

Items to consider after construction is completed include permanent stabilization once activities have ceased, removal of temporary structural measures, final inspection, and maintenance of permanent structures.

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Best Management Practices (BMP) Selection

BMP Selection

Site Work

Clearing and Grading

Excavations, Stockpiles & Debris Disposal

Rill & Gully Erosion

Sediment Control

Storm Runoff

Streambank Protection and Stabilization

Stream Crossing

Building Construction, Utilities Installations

Special Site Problems

Final Site Stabilization

Best Management Practice Selection

On any construction site the objective in erosion and sediment control is to prevent off-site sedimentation damage. Four basic methods are used to control erosion on construction sites: planning, soil stabilization, runoff control and sediment control. Careful site analysis, planning and scheduling can reduce the need to utilize stabilization and control practices, and, thereby, reduce the cost of implementing these measures.

Identify Control Problem

Controlling erosion should be the first line of defense. Controlling erosion is very effective for small disturbed areas such as single lots or small areas of a development that do not drain to a sediment-trapping facility. Where soil properties and topography of the site make the design of sediment trapping facilities impractical, runoff control and soil stabilization should be used.

Sediment trapping facilities should be used on large developments where mass grading is planned, where it is impossible or impractical to control erosion, and where sediment particles are relatively large. A combination of erosion control and sedimentation control measures is usually the least expensive way to accomplish erosion and sediment control.

Identify Problem Areas

Areas where erosion is to be controlled usually involve slopes, graded areas or drainage ways. Slopes include graded rights-of-way, stockpile areas, and all cut or fill slopes. Graded areas include all stripped areas other than slopes. Drainage ways are areas where concentrations of water flow naturally or artificially. Problem areas that need sediment control can be either large or small.

Identify Required Strategy

Select the strategy to solve the problem. Strategies can utilize an individual practice or a combination of practices. For example, if there is a cut slope to be protected from erosion, the strategies may be to protect the ground surface, divert water from the slope or shorten it. Any combination of the above can be used. If no rainfall except that which falls on the slope has the potential to cause erosion, and if the slope is relatively short, protecting the soil surface may be all that is required to solve the problem.

Select Specific Control Measures

The tables on the following pages are guides for selecting erosion and sediment control practices. This material can be used by either designers and developers or by plan review agencies.

The practices chosen for a site will often vary from one individual to another, depending on individual judgement and preference, past experience with a conservation practice, and the practices' suitability for a particular site. Persons reviewing an erosion and sedimentation control plan should not expect to find one set of "predetermined practices" used. The reviewer can, however, refer to these tables: (a) as an aid in recognizing potential problem areas that may exist at a site, and (b) for guidance to see if the developer and designer have addressed the potential problems.

SITE WORK: On-site Roads, Controlling Road Runoff

ITEM	RECOMMENDED PRACTICES
Site Preparation	Preserving Natural Vegetation Construction Entrance Construction Road Stabilization Filter Berm
Surface Stabilization	Temporary Seeding Mulching Riprap
Runoff Control	Temporary Diversions Water Bars Sump Pit
Runoff Conveyance	Grassed Waterway (Slopes up to 5%) Lined Waterway Temporary Slope Drain Paved Flume Vegetated Swale Inlet Protection Outlet Protection and Stabilization
Other	Dust Control

(Note: The structural practices listed above are suitable for slopes of up to 12%, except as noted. Steeper slopes usually need special consideration.)

Clearing and Grading

ITEM	RECOMMENDED PRACTICES
Site Preparation	Preserving Natural Vegetation Construction Entrance Land Grading
Surface Stabilization	Surface roughening Terrace Topsoiling Temporary Seeding Permanent Seeding Mulching Riprap
Runoff Control	Temporary Diversion Permanent Diversion Terrace Water Bar Sump Pit
Outlet Protection	Outlet Protection and Stabilization Level Spreader
Runoff Conveyance	See Storm Runoff sheet
Sediment Traps and Barriers	See Sediment Control sheet
Other	Dust Control

Excavations, Stockpiles, & Debris Disposal

ITEM	RECOMMENDED PRACTICES
Surface Stabilization	Surface roughening Topsoiling Temporary Seeding Permanent Seeding Trees and Shrub Planting Mulching
Runoff Control	Temporary Diversion
Sediment Traps and Barriers	Sediment Trap Sediment Fence
Other	Dust Control

Rill and Gully Erosion

ITEM	RECOMMENDED PRACTICES
Runoff Control	Temporary Diversion Permanent Diversion Water Bar Buffer Zone
Runoff Conveyance	Riprap-lined Channel Lined Waterway Temporary Slope Drain Paved Flume
Outlet Protection	Outlet Protection and Stabilization Level Spreader
Surface Stabilization	Slope Stabilization Topsoiling Surface Roughening Temporary Seeding Permanent Seeding Mulching Riprap Tree and Shrub Planting

Sediment Control

(Measures should be installed before major land disturbance begins)

ITEM	RECOMMENDED PRACTICES
Disturbed areas of less than 2 acres	Sediment Trap Sediment Fence Filter Berm Brush Barrier (Drainage area up to ¼ acre) Filter Strip Straw or Hay Bale Barrier Silt Curtain
Disturbed areas, 2-5 acres	Sediment Trap Sediment Basin Filter Strip Rock Dam Silt curtain
Disturbed areas of more than 5 acres	Sediment Basin Rock Dam Silt Curtain
Other	Dust Control

Storm Runoff

ITEM	RECOMMENDED PRACTICES
Drainage area less than 20 acres	
Runoff Control	Temporary Diversion Permanent Diversion Water Bar
Runoff Conveyance	Grassed Waterway (Slopes up to 5%) Vegetated Swale Lined waterway Riprap-lined Channel Temporary Slope Drain Paved Flume Inlet Protection
Outlet Protection	Level Spreader (Drainage up to 5 acres) Outlet Protection and Stabilization

Drainage area more than 20 acres

Same as above, except in addition, the designer would normally perform hydrologic and hydraulic calculations showing that runoff, during and after construction of the project, would comply with permitting agency requirements.

Streambank Protection and Stabilization

ITEM	RECOMMENDED PRACTICES
Design velocity less than 6 feet per second	Vegetative Methods Soil Bioengineering Methods Structural Methods
Design velocity more than 6 feet per second	Soil Bioengineering Methods Structural Methods

(Note: Contact the local Conservation Commission regarding any work conducted in what may be a wetland resource area. The Massachusetts Wetland Protection Act requires that the proponent file a “Request for Determination of Applicability” or “Notice of Intent.”)

Stream Crossings

ITEM	RECOMMENDED PRACTICES
Temporary	
To move equipment	Stream Crossing, Temporary
Surface Stabilization	Temporary Seeding Mulching Riprap
Permanent	
Vehicular traffic,To move Equipment	Permanent Stream Crossing; e.g. Bridge or Culvert
Surface Stabilization	Permanent Seeding Mulching Riprap

(Note: Contact the local Conservation Commission regarding any work conducted in what may be a wetland resource area. The Massachusetts Wetland Protection Act requires that the proponent file a "Request for Determination of Applicability" or "Notice of Intent.")

Building Construction, Utilities Installations

ITEM	RECOMMENDED PRACTICES
Surface Stabilization	Surface Roughening Topsoiling Temporary Seeding Permanent Seeding Mulching Tree and Shrub Planting
Runoff Control	Temporary Diversion Water Bar Sump Pit
Sediment Control	Sediment Trap Sediment Fence Filter Strip
Other	Construction Road Stabilization Dust Control

Special Site Problems

ITEM	RECOMMENDED PRACTICES
Seepage areas or high water table	Subsurface Drainage Sump Pit
Unstable temporary channels	Check Dam Riprap-lined Channel
Unstable permanent channels	Riprap-lined Channel Lined Waterway Grade Stabilization Structure
Blowing dust or sand	Dust Control Sand Fence
Dune reinforcement and stabilization	Sand Dune and Sandblow Stabilization Sand Fence

(Note: Contact the local Conservation Commission regarding any work conducted in what may be a wetland resource area. The Massachusetts Wetland Protection Act requires that the proponent file a "Request for Determination of Applicability" or "Notice of Intent.")

Final Site Stabilization

ITEM	RECOMMENDED PRACTICES
Surface Stabilization	Surface roughening Terrace Topsoiling Permanent Seeding Sodding Trees and Shrub Planting Mulching Riprap
Runoff Control	Permanent Diversion
Runoff Conveyance	Grassed Waterway Vegetated Swale Lined Waterway Riprap-lined Channel Paved Flume
Outlet Protection	Level Spreader Outlet Protection and Stabilization
Inlet Protection	Sod Drop Inlet Protection, or permanent paving

References

Connecticut Council on Soil and Water Conservation, ***Connecticut Guidelines for Soil Erosion and Sediment Control***, Hartford, CT, January, 1985.

New York Guidelines for Urban Erosion and Sediment Control, March 1988.

North Carolina Sediment Control Commission, ***Erosion and Sediment Control Planning and Design Manual,*** Raleigh, NC, September, 1988.