

Water Runs Downhill: Managing Runoff on Steep Slopes



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Southern Tier Central Regional Planning & Development Board**

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Why Are Steep Slopes Important?

Green hills with steep slopes contribute to the natural beauty of the Finger Lakes region. However, when intense rain falls on these hills, water rushes down the slopes and causes flash flooding, washouts, and water pollution. Although some amount of flooding and erosion is natural, there are ways to reduce the costly damage to property and roads.

When rain falls on natural slopes covered by healthy vegetation, the plants and soil absorb and slow down some of this water. However, development on steep slopes often disrupts these natural functions and results in more runoff, faster runoff, and less protection for the soil. Concentrated high energy flow causes erosion, washouts, and landslides. Increased peak flows cause flood damage to homes and property. In most cases, homeowners insurance policies do not cover damage due to flooding, landslides, or other “earth movement events.” The quality of streams and lakes is impaired by the soil and debris that washes off the hillsides. Damage to roads is costly for the entire community.

Development on slopes with a grade of 15% or greater should be avoided, if possible, to limit soil loss, erosion, excessive stormwater runoff and the degradation of surface water. On slopes greater than 25%, no development, re-grading, or stripping of vegetation should even be considered.

(Source: New York State Stormwater Management Design Manual, January 2015;

<https://www.dec.ny.gov/chemical/29072.html>.)

No Adverse Impact is the principle that it is not ok to make changes to your land that adversely impact others by causing erosion, flooding, or water quality impairment.

Developing on steep slopes can cause a myriad of issues. As slopes become steeper, runoff becomes more erosive and stabilizing a slope becomes more challenging. This guide outlines strategies for managing the energy of rain and snow melt and thus reducing the potential for damage. The objective of these techniques can be summarized as: Slow it down. Spread it out. Soak it in.

Steep slopes present challenges because of the difficulties of stabilizing steep soils and safely managing runoff.



USDA Natural Resources Conservation Service



Sustainable Keuka Lake Municipal Handbook



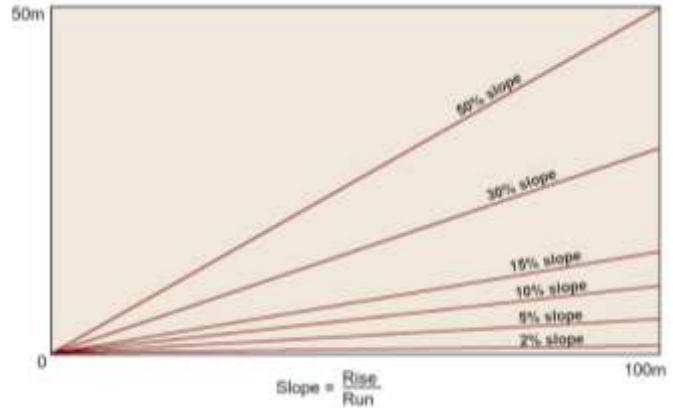
Mecklenburg Fire Department

Good Practices for Managing Slopes

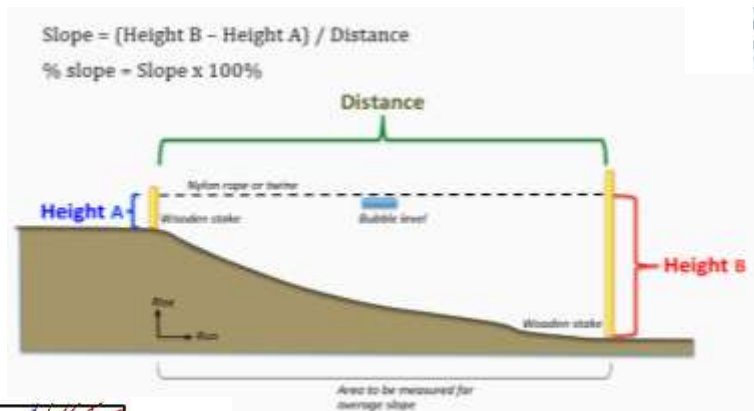
Plan the Project: Evaluate the Site

Because steep slopes are prone to drainage and erosion problems, land use activities should be designed to fit the landscape and protect natural features. The first step is to evaluate the existing conditions.

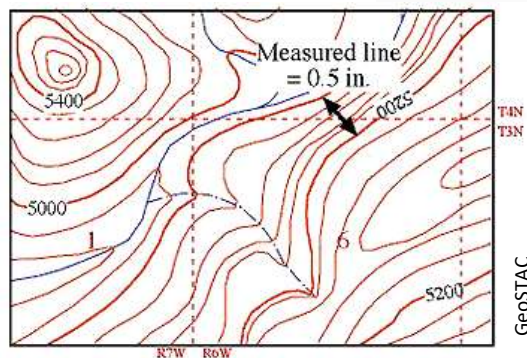
- Measure the slope.** How steep is the slope? Are there less steep areas that are more suitable for development? A standard way to describe the steepness of a slope is as the percent of the vertical change relative to horizontal change. This can be measured in the field or on a topographic map. A slope with 1-foot vertical change for each horizontal foot is a 100% grade. For development, a 15% grade is considered steep and requires extra attention to slope stability and drainage issues (if the elevation change is more than 1 ½ feet over a 10-foot horizontal distance). A 25% grade is challenging and should be left undisturbed if possible.



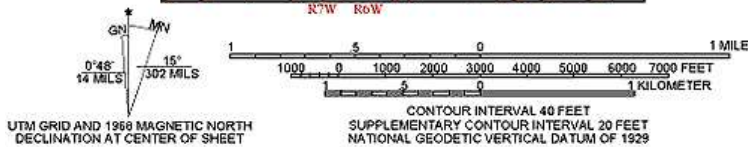
Saskatchewan, CA



University of Tennessee Extension



GeoSTAC



Determining hillslope from a topographic map

Length of measured line = 0.5 in, $0.5 \text{ in} \times \frac{2000 \text{ ft}}{1 \text{ in}} = 1000 \text{ ft} (.19 \text{ mi}) = \text{horizontal distance}$

Elevation change = 200 ft. (read off of contour lines)

Percent slope = $\frac{200 \text{ ft}}{1000 \text{ ft}} \times 100 = 20\% \text{ slope}$

If the elevation changes 14 inches over the length of an 8-foot board, the grade is 15%. A 2-foot elevation change over 8 feet is a 25% grade.

On a topographic map, the contour lines are closer together in steep areas and farther apart on gentler slopes. If the horizontal distance between 10-foot contour lines is less than 65 feet, the slope is greater than 15% and is considered steep. 40 feet between 10-foot contour lines indicates a 25% grade, which should be protected.

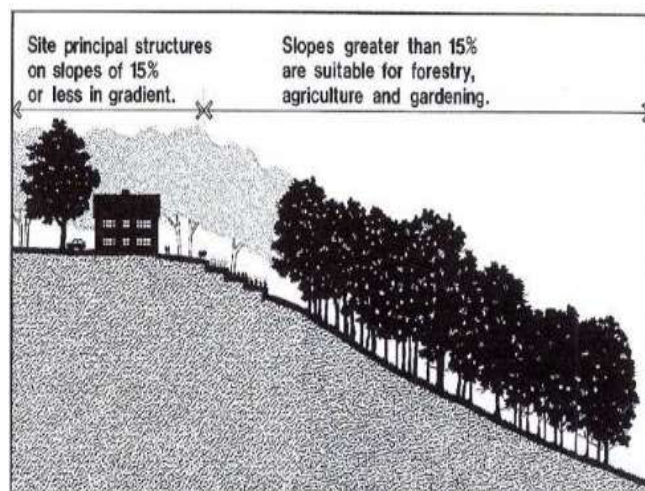
- Determine soil characteristics. Soil survey maps contain a wealth of information about soil characteristics and can be accessed on the Web Soil Survey online application (<https://websoilsurvey.sc.egov.usda.gov>). This can assist with selecting plant species and designing erosion protection techniques.
- Observe Drainage Patterns. Valuable information can be obtained by observing the slope under heavy rainfall events or persistently wet conditions. Note the direction and speed of runoff. How slowly or quickly does water soak into the soil? Are there springs or seeps? Is drainage concentrated into channels or rivulets that increase the potential for erosion and washouts? Are there catch basins, ditches, or other practices intended to manage runoff? Look for opportunities to slow down or disperse concentrated flow.
- Identify Existing Vegetation. What types of plants are growing on the site? Is the vegetation healthy? Is the plant diversity and density sufficient to protect the soil?
- Characterize any erosion problems. Identify any areas where exposed soil is vulnerable to erosion. Are there gullies, rills, or other signs of soil erosion? If so, is the eroded sediment captured before it washes off the site? If there is a stream or drainage ditch, are the banks stable?
- Identify special features. A hillside often offers vistas, wildlife habitat, or other features that contribute to its charm. Identify those special places or characteristics that you want to protect or enhance.
- Prepare a map of existing conditions. Document the existing water bodies and natural features on a site map. Also show any existing structures, access roads, or other development.

Plan the Project: Develop a Site Plan

Some sites are too steep to be developed safely. Other steep slopes present development challenges that can be managed with careful site planning and project design. The site planning process involves balancing the existing features and limitations of a site with the desired use. The objective is to design a project that fits the landscape—building on its assets and avoiding problems. Natural features and drainage patterns should be retained to the extent possible. Plan the development to fit the site.

The objective of site planning is to anticipate and avoid problems.

- Protect existing natural features. Whenever possible preserve and maintain healthy vegetation, existing drainage patterns, and natural features, such as streams and wetlands, as well as vegetated buffers along all waterbodies. If a sloped area is currently stable and well vegetated, the best management strategy is usually to protect the existing vegetation and not disturb the soil. Use the existing topography wherever possible to minimize grading.



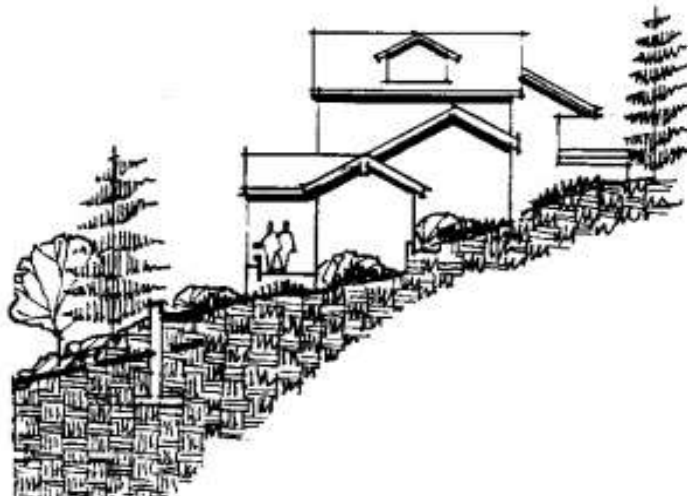
Keuka Lake Scenic Viewshed Protection Plan

- Correct existing problems. If the site has drainage or erosion problems, additional effort will be needed to stabilize the slope. If gullies or washouts have occurred, it may be necessary to re-grade the severely eroded areas, add topsoil, and install erosion control practices to prevent additional erosion.
- Locate development away from steep areas. Whenever possible locate buildings, driveways, walkways, utilities, and other development on gentler slopes and away from the top or the toe of steep areas. Use steep parts of the site as natural areas and wildlife habitat.
- Minimize disturbance of vegetation and soil. Planning for both the final site design and construction activities should strive to retain the benefits of existing soils and vegetation. Avoid removal of or damage to plants whenever possible. Minimize cutting, filling, and grading, as well as removal or compaction of topsoil.
- Minimize hard surfaces that shed water. Rain that falls on buildings, pavement, and compacted soil runs off quickly and is unable to soak into the ground, increasing the amount of runoff that needs to be managed.
- Determine proposed drainage patterns. Water flow paths must allow safe conveyance down the slope without causing gullies or washouts. Moderate flows can be directed onto soils with stable vegetation. Concentrated flows should not be allowed to rush straight down the hillside and may require professionally designed management practices. Retain or restore natural drainage patterns wherever possible.



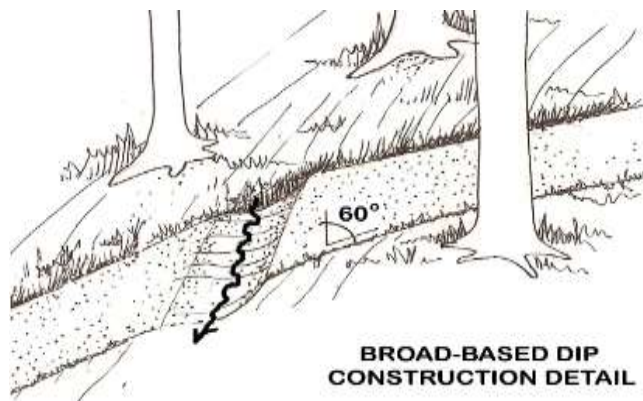
Sustainable Keuka Lake Municipal Handbook

Cluster subdivision design enables protection of steep slopes or other sensitive areas by allowing denser development in less sensitive areas without changing the number of developable sites.



City of Durango, CO

If you must build on a sloped site, minimize the amount of cutting and filling by stepping the foundation and the building with the slope.



Southern Tier Central Regional Planning & Development Board

Driveways should not funnel water down the hill. A recommended solution is to create a series of shallow channels across the drive to intercept runoff and disperse water into established vegetation.

- Use best management practices for timber harvesting. If trees are removed from steep areas, either as part of a logging operation or to develop a site, this should be done during dry weather (when the soils are dry) or when the ground is frozen and covered with snow. Winch logs off steep slopes, where possible. If logging roads and skid trails are needed, hire a consulting forester to ensure that the project is properly planned and executed.



Chemung County Soil and Water Conservation District

Roads and driveways should follow the natural grade whenever possible.

- Anticipate future changes. If additional utilities or access routes may be desired in the future, include this in the initial site plan. Consider the full-grown size of plants so that they don't block the view or interfere with other activities.
- Develop an implementation plan. Plan for phased construction that minimizes the amount of soil or vegetation that is disturbed at any time. Stabilize one area before disturbing the next. Use temporary seeding or mulching if permanent stabilization must be delayed.

It is recommended that an Erosion and Sediment Control Plan be developed for any site with a slope greater than 15%.

Get professional assistance. If development must be located on areas with slopes greater than 15%, it is recommended that you obtain professional assistance with project planning, particularly if there are existing drainage or erosion problems. An erosion and sediment control specialist or professional engineer can help with selecting and designing management practices for erosion control and runoff management.

Cultivate Healthy Soil

Good soil structure reduces its susceptibility to erosion and supports healthy vegetation, which provides additional erosion protection. The soil should be loose enough to absorb and store water, but not so soft that it erodes easily. A deep, well-drained soil that's rich in organic matter is able to absorb rainwater (which helps prevent flooding and soil erosion), filters out water pollutants, and also promotes vigorous plant growth that will require less irrigation, pesticides, and fertilizer.

- Preserve existing soil. Healthy soils have taken years to develop. Protect this resource by avoiding grading, shaping, and topsoil removal whenever possible.

***Soil preparation (topsoil, tilling, raking, and amendment)
is critical for establishing healthy vegetation.***

- **Restore topsoil.** It may be necessary to replace the topsoil if it has been washed away by erosion or stripped during construction (leaving an infertile, compacted soil surface). Loosen the subsoil to a depth of at least 12 inches and then apply topsoil to provide a good growth medium for vegetation. Fresh topsoil should be compacted to avoid erosion and slippage, preferably with hand-held tools.
- **Avoid over-compaction of soil.** Although topsoil should not be too soft, the use of heavy equipment can cause severe compaction, which limits the ability of soil to absorb water and to support vegetation. If soil compaction cannot be avoided, it can be loosened or de-compacted before planting using a tiller or other equipment.
- **Add compost.** Compost enriches the soil and enables it to hold more moisture. Compost can be tilled into the subsoil, incorporated into topsoil, or applied to the surface as a blanket.
- **Fertilize.** Fertilizer can be incorporated into the top two to four inches of topsoil. The fertilizer mix and application rates should meet the nutritional needs of the specific site, as determined by a soil test. Do not over-fertilize, as the unused nutrients can pollute nearby waterbodies. (All application of fertilizer must be in accordance with the New York State Nutrient Runoff Law – ECL Article 17, Title 21.)
- **Roughen the surface of exposed soil.** Prepare bare soil for seeding or planting by creating horizontal grooves or steps across the slope. This can be accomplished with stair-step grading, tracking (driving equipment with cleats up and down the slope), or other techniques. These irregularities in the soil surface catch rain, reduce erosion, and help to establish seeds.



NYS Dept. of Environmental Conservation

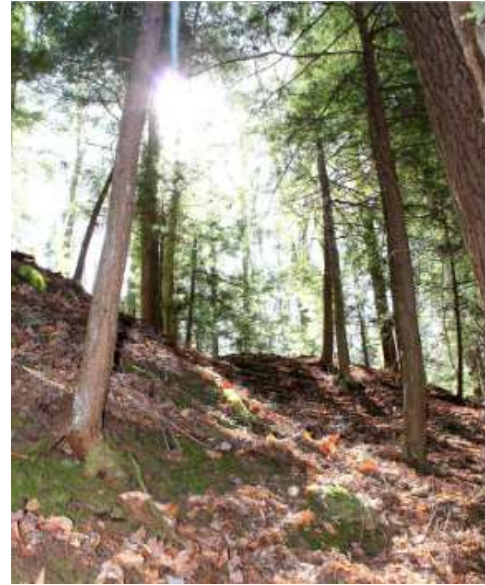
Cutting furrows along the contour helps to prevent erosion before vegetation is established. After the slope is roughened, it should be seeded and mulched as soon as possible.

Protect and Restore Vegetation

Healthy vegetation is the best practice for both managing runoff and preventing erosion on steep slopes. Plants draw water out of the soil and return it to the atmosphere. The foliage intercepts rain and shields the soil surface from raindrop impacts, which would otherwise strike the surface at 25-30 feet per second and cause splash erosion of soil particles. Root systems add structure to the soil and increase its strength (like woody rebar). Overland flow is slowed and dispersed by the stems and leaf litter, reducing the concentrated energy that can scour out soil.

***Establishing and maintaining vegetation are the most
important factors for protecting steep slopes.***

- Protect existing vegetation. Because exposed soil is vulnerable to erosion, care is needed to minimize damage to existing protective vegetation. Physically mark the limits of land disturbance on the site.
- Establish permanent vegetative cover. The site should be stabilized with permanent vegetation as soon as possible. If this is not possible, protect the soil surface with temporary seeding or mulching.
- Select a suitable mixture of plants. A mixture of trees, shrubs, vines, and ground cover can provide deep and complex root structures for holding the soil in place. Select plant species that are suited to the local site conditions, including soil type, drainage, and degree of shading.
- Plant native species. Native species are more likely to thrive and require less maintenance.
- Mulch. Use mulch to protect exposed soil and conserve moisture while vegetation is becoming established. This is a temporary practice. Long-term protection is provided by vegetative cover.
- Irrigate. Water may be essential to establish new plants.
- Use biotechnical soil stabilization practices if needed. A variety of practices integrate plants with woody material, mats, or other products to stabilize the soil and give plants time to become established.



Chemung County Soil and Water Conservation District

Minimize disturbance of existing forest cover on steep slopes.



USDA Natural Resources Conservation Service

Mulch bare soils with plant residues.

Growing plants on a steep slope is not just landscaping. The plants are intended to prevent erosion, so technical assistance may be needed to select suitable species and get them established.

Divert or Slow Down Water

The erosive force of water increases with velocity and steep slopes encourage faster runoff. Managing water flow paths can reduce the potential for erosion, washouts, and flash flood damage. The most feasible practices for use on steep slopes are generally those that replicate natural systems (called green infrastructure).

- Divert flow away from steep areas. A swale or berm along the top of a slope or diagonally across a slope can be used to divert runoff to a more stable area and prevent erosive flow down the slope.
- Slow it down. Fast-moving water erodes soil and quickly finds its way into rivers and streams, with much of this water arriving at the same time and contributing to high peak flows. Vegetation, low spots, uneven surfaces, and gentle (less steep) flow paths can slow down and hold back water.



Acton Wakefield Watersheds Alliance

A series of water bars can be constructed diagonally across a trail or other slope to deflect water into a stable vegetated area. The water bar can be an earthen ridge at a 30-degree angle across the slope. Or it can be made by placing a log, rocks, or other material in a trench and backfilled on the downhill side.

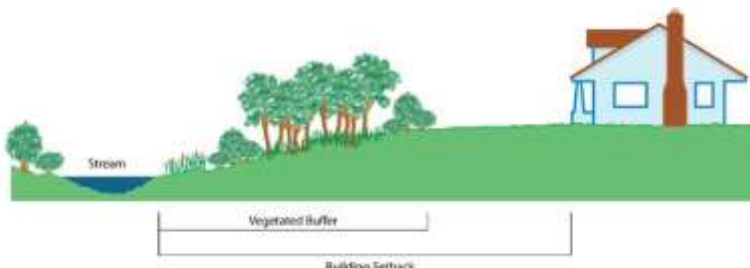
- Spread it out. Allowing runoff to spread out, rather than concentrating flows in ditches or channels, slows the water and absorbs its energy. This reduces erosion and peak flows.
- Soak it in. Water that soaks into the soil is water that does not contribute to washouts or flooding.

It is always more efficient and cost-effective to prevent erosion than it is to repair damage after the fact.

Protect Waterbodies

Streams and lakes are dynamic systems that naturally overflow their banks during periods of high water. Streams adapt to changing conditions by adjust their shape or location. Streambanks and the shorelines of lakes are often threatened by erosion. Allowing space for these natural processes protects the natural systems and keeps vulnerable development away from high-risk areas.

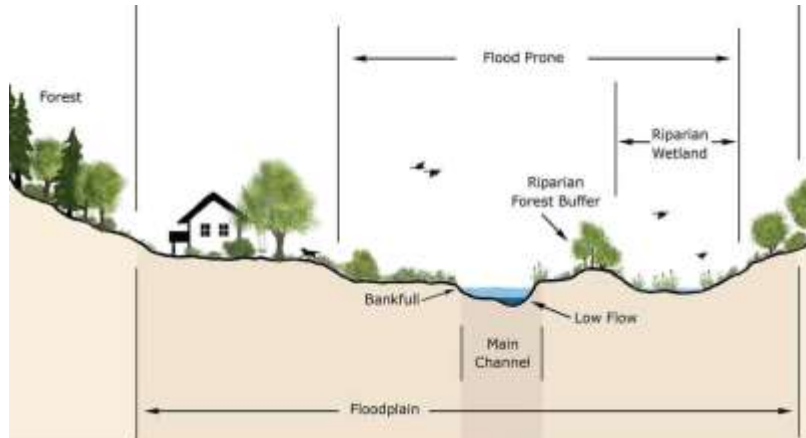
- Locate development a safe distance from waterbodies. To protect both development and natural systems, buildings and other intense uses should be set back 50 or 100 feet from the banks of most streams, rivers, wetlands, and lakeshores.



Keuka Lake Land Use Leadership Alliance

If buildings and development that are setback from potentially eroding banks, a vegetated buffer can provide bank stability, protect water quality, and enhance habitat.

- Allow floodplains to flood. The floodplain is an important part of a stream system because it provides a place for water to spread out and slow down during floods. This temporary storage reduces downstream flooding. In addition, the slower moving water has less energy for eroding streambanks. Berms, levees, or high banks can disconnect a stream from its floodplain and cause downstream problems.



Whenever possible, buildings and other development should be located outside of mapped floodplains and any unmapped areas that are prone to flooding. Any development within the floodplain should be protected from flood damage.

- Maintain a vegetated buffer along streams and lakeshores. Whenever possible, preserve natural vegetation near a stream or lake. The root systems hold the soil in place—preventing bank erosion. In addition, the plants also slow down water, both surface runoff flowing down the bank and out-of-bank flows during a flood—reducing the potential for erosion and flooding. Avoid mowing near the bank because grass generally lacks adequate root systems to stabilize the soil. A mixture of trees, shrubs, and groundcover generally provides the best erosion protection and habitat along streams and lakeshores.
- Do not disturb the channel or banks of a stream. Leaves, branches, and even logs are a natural part of healthy stream systems, providing nutrients and improving in-stream habitat. However, if the stream contains manmade debris or if diverted flow threatens development it can be removed—but this should be done in a way that avoids altering the stream channel or banks, including vegetation. The channel and banks should not be altered without assistance from a stream professional.



Stream crossing structures should be located and constructed to minimize disturbance of the banks and bottoms of streams.

Retaining or restoring a variety of plants along the bank of a stream or lake is the easiest and most effective way to protect the bank, while also providing habitat and protecting water quality.

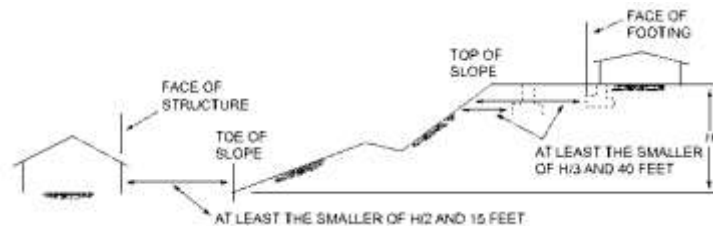
Monitor and Maintain the Site

Maintenance may be needed to ensure that vegetation is established, remains healthy, and continues to stabilize the slope. Water and fertilize plants as needed. If erosion problems develop, the site should be repaired in a timely manner—preferably before the next major storm event.

Regulations, Standards, and Guidance

Development on slopes—as in other locations—is subject to various building, environmental, and land use regulations. Even if no permit is required, the design standards developed by New York State provide valuable guidance for designing and implementing good practices on steep slopes. The following resources can help with stabilizing and safely using steep land.

- New York State Uniform Code. The state Building and Residential Codes require that foundation drains and surface runoff from a building site be discharged to a drainage system approved by the building official.¹ Buildings must be set back from both the top and the toe of slopes steeper than one unit vertical in three units horizontal (33.3% slope).²



- New York State Stormwater Construction Permit. A state permit is required for construction activity that disturbs one or more acres. This permit requires development of a Stormwater Pollution Prevention Plan (SWPPP) that addresses erosion and sediment control during construction. For some projects, the SWPPP must also address the long-term impacts on water quantity and water quality. Construction activities must minimize the disturbance of steep slopes that are greater than 25% (based on the soil type). If the steep slope drains to a drinking water source (including Seneca and Keuka Lakes), the construction project may be ineligible for coverage under the general permit (and therefore requires an individual permit with a more stringent design and review process).³
- New York State Design Standards for Erosion and Sediment Control. The “Blue Book” provides minimum design standards and specifications for the selection, design, and implementation of erosion and sediment control practices. It includes detailed guidance for (1) the site planning process, (2) runoff control, (3) soil stabilization, and (4) sediment control. This manual recommends that an Erosion

¹ 2020 Residential Code of New York State, Sections R401.3 and R405; 2020 Building Code of New York State, Section 1805.4.3; and 2020 Plumbing Code of NYS, Section 1101.2.

² 2020 Residential Code of New York State, Section R403.1.7; 2020 Building Code of New York State, Section 1808.7.

³ New York State Department of Environmental Conservation, SPDES General Permit for Stormwater Discharges from Construction Activity, Permit No. GP-0-20-001, Effective Date: January 29, 2020; <https://www.dec.ny.gov/chemical/43133.html>.

and Sediment Control Plan be prepared for all land development and construction activities on slopes that exceed 15% (regardless of regulatory requirements).⁴

- New York State Stormwater Design Manual. The peak flows from a site should not be any greater after development than they were before it was developed. To achieve this, the design manual spells out a 6-step process for site planning and practice selection. It recommends that steep slopes be kept in an undisturbed natural condition to limit soil loss, erosion, excessive stormwater runoff, and the degradation of surface water. Development on slopes with a grade of 15% or greater should be avoided, if possible. On slopes greater than 25%, no development, re-grading, or stripping of vegetation should be considered.⁵
- Municipal land use management. Some local governments use their land use authorities to regulate development on steep slopes and to assist with developing a site plan that fits the site and protects the natural features. Although local requirements vary, the objective is generally to encourage development on flatter sites, limit or prohibit development on steep slopes, and minimize risks from activities that do occur on steep slopes. Working with local officials early in the development process helps to ensure compliance with these local regulations and may improve the overall outcomes for the completed project.
- Best Management Practices During Timber Harvesting Operations. Timber harvesting on steep slopes can result in the rapid development of gullies and should be avoided where possible. When slopes are logged, water that collects on forest roads and skid trails must be controlled and dispersed. Guidance for forest management and BMP implementation has been developed by the Chemung County Soil and Water Conservation District.⁶
- Critical Area Treatment Handbook. Healthy plants are critical for stabilizing steep slopes. To assist with site planning, selecting appropriate plant materials, and techniques for seeding and planting, USDA Natural Resources Conservation Service has developed a handbook for conservation plantings in the northeast.⁷

BE A GOOD NEIGHBOR

The small steps that you take to manage runoff from your property will combine with the efforts of your neighbors to reduce flooding and erosion damage in your community.



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⁴ New York State Standards and Specifications for Erosion and Sediment Control, November 2016; <https://www.dec.ny.gov/chemical/29066.html>.

⁵ New York State Stormwater Design Manual, January 2015; <https://www.dec.ny.gov/chemical/29072.html>.

⁶ Best Management Practices during Timber Harvesting Operations, 2020, Chemung County Soil and Water Conservation District; <http://www.u-s-c.org/forestrybmps.pdf>.

⁷ A Guide to Conservation Plantings on Critical Areas for the Northeast, 1991, USDA Natural Resources Conservation Service; https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/nypmspu11417.pdf.