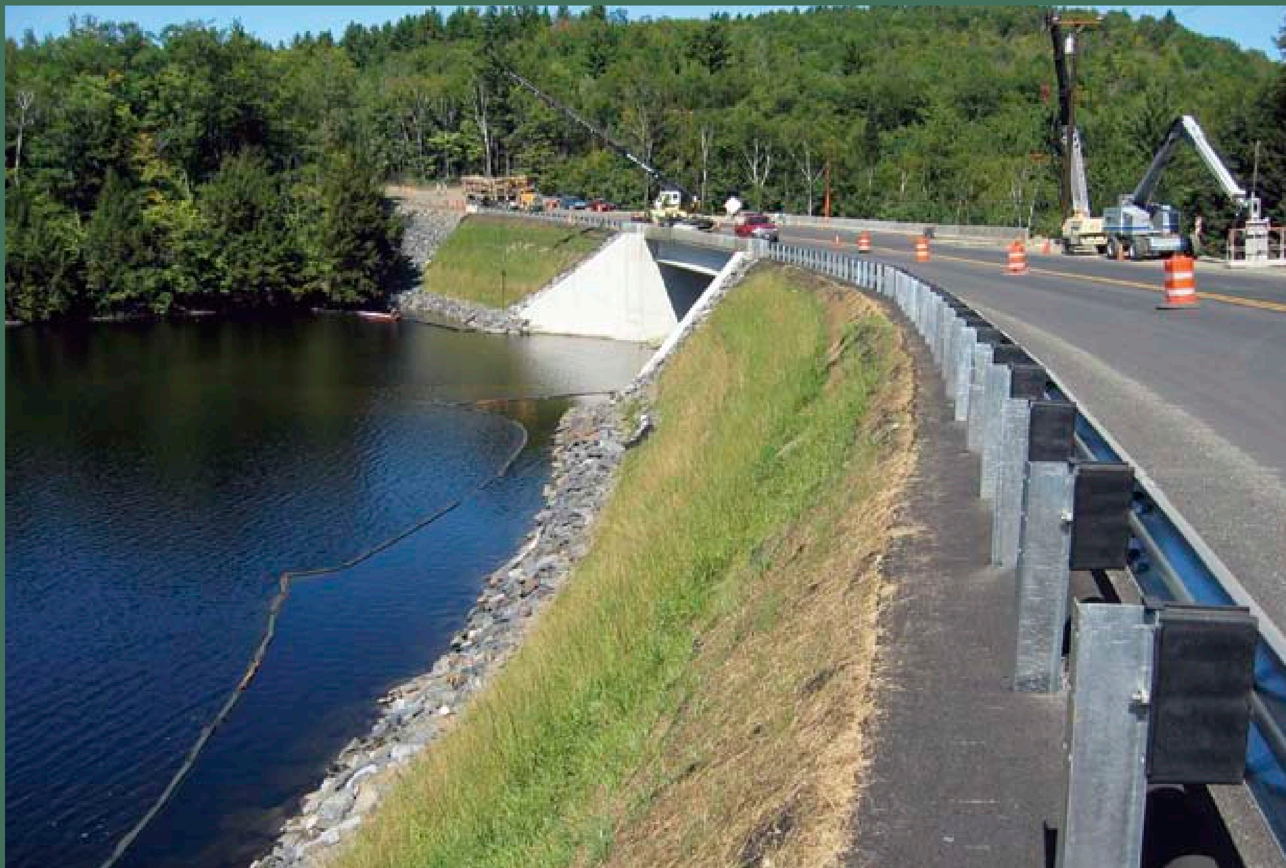

I. Introduction

A. WHY THIS MANUAL

Connecting Maine is the State's integrated, long range, multimodal transportation plan for the next 20 years. Maine's Statewide Transportation Vision is to provide a transportation system that is safe, supports a healthy economy, promotes family and community connections and protects and enhances Maine's natural and cultural environment. As such, minimizing impacts to water quality is not only important to Maine people but is an integral part of the Maine Department of Transportation's (MaineDOT's) work.

Maine lakes generate significant revenues from taxes and tourism, and the citizens of Maine have already invested millions of dollars towards restoring and improving water quality. The state's cold water fisheries are a major tourism draw as well as a source of recreation for residents. The loss of shellfish harvest areas has been estimated to have cost the state millions of dollars in revenues. MaineDOT's mandate, at the state and federal level, is to make public investment decisions that are consistent with public policy directives. Those directives include supporting Maine's economy and protecting its environmental resources. A strong economy at the expense of environmental quality is not an option in Maine.

The objective of this manual is to provide guidance for incorporating erosion and sedimentation control Best Management Practices (BMPs) into design, construction and maintenance activities. This is the second major revision to this manual. It was developed after careful review of the previous MaineDOT BMP Manual, BMP Manuals from other states, standard practices from other agencies and municipalities, and the field experience of the authors. This manual provides a compilation of structural and non-structural BMPs that have been found to work when properly selected, designed and installed.

This manual is a guide to the Best Management Practices for erosion and sedimentation control. It is a dynamic document that changes as new practices, laws, and technologies are developed. This manual is not a stormwater design guide for permanent structural measures although some practices are common to both. The technologies and regulatory requirements in this field are constantly growing and as they do, new practices will be included.

It is MaineDOT's goal to keep this document current by reviewing and incorporating new ideas. You, the user, are part of that process. We believe strongly in practical field experience and innovation. As you apply practices presented in this manual, we encourage you to share your experiences when you have found ways to accomplish the intended goals in a more efficient and effective manner. Please feel free to contact the Department's Surface Water Quality Unit.

B. IMPACT FROM DEVELOPMENT

As Maine's natural landscape is converted to commercial, industrial, residential and other uses, both the quantity and quality of surface water runoff changes. These land use changes increase the quantity and rate of runoff and decrease the quality of the runoff. Unless adequately managed, these changes are a threat to the water resources of the state.

The change in quantity occurs as a result of changes in land use surface cover. As the surface cover of the land changes from trees and grass that soak up rainfall to impervious surfaces (buildings, parking lots, roads) the ability of the land to absorb rainfall decreases and the amount of runoff increases. These developed areas typically channelize stormwater runoff to get rid of it quickly, increasing the rate of flow even more. These increases in runoff volume and runoff rate can cause flooding and erosion in streams and rivers. Additionally, shallow ground water drains slowly to streams, maintaining a base flow in the streams during dry summer important for stream aquatic life. When the water runs off quickly, it does not have a chance to soak into the ground and therefore is not available to maintain base flow.

The quality of runoff can also seriously impact Maine's water resources. Contaminants such as heavy metals, and nutrients such as phosphorus, are attached to eroded soil particles. These pollutants can severely degrade the quality of surface water resources. High concentrations of phosphorus in lakes and ponds are responsible for algae blooms which reduce the recreational value of the resource and decrease available oxygen for all aquatic life. In streams and rivers, sediment in spawning areas can suffocate fish eggs and permanently damage spawning habitat. Estuaries can become polluted resulting in the loss of shellfish habitat. It can eliminate some fisheries within just a couple of years.

Because of the prevalence of lakes and other water resources in Maine, MaineDOT's construction sites are either right on top of a water resource (bridges) or connected to a water resource through drainage systems. We take seriously our responsibility for protecting the state's water resources; it's a matter of stewardship. We look forward to working together with all our partners in government and in the private sector to deliver sound investments that are sensitive to Maine's valuable resources.

C. EROSION AND SEDIMENTATION

Contractors know how to move dirt; and they do it as efficiently as possible with the goal of completing the project in a cost effective way. They also know how to control water in order to move dirt. In 'the old days' controlling water meant getting it off the construction site as fast as possible and it didn't matter whether the water was clean or dirty. But today, the quality of water, where it goes, and how it gets there are important. The need to incorporate erosion and sedimentation (E&S) controls into the construction process is relatively new to the industry. The federal Clean Water Act of 1972 set the ground work, and slowly technology has developed and expanded. Now contractors are exposed to advertisements, trade magazines, tradeshows, and manuals - all promoting the installation of erosion and sedimentation control BMPs. Unfortunately, they are seldom told what these BMPs are actually doing. When BMPs are installed incorrectly or in the wrong place, it may result in a discharge from the site, costing money, time, and reputation.

In order to plan for and use BMPs correctly it is important to have a basic understanding of erosion and sedimentation and how they happen.

Erosion - Erosion is the detachment and movement of soil particles by the action of water, ice, gravity, or wind. Natural erosion always occurs but the rate is slow enough that the environment can adjust. When humans began to manipulate the landscape we accelerated the process by exposing soil to the forces of water and wind.

Sedimentation - Sedimentation is the deposition of soil particles that were detached and transported by the erosion process. Sedimentation occurs when the velocity of the wind or water becomes insufficient to keep the soil particles in suspension. Particles can be transported great distances and deposited in environmentally sensitive areas such as rivers, lakes, and wetlands. It is sedimentation that can severely alter water quality, damage an aquatic ecosystem, and destroy a wetland.

1. THE PRINCIPLES AND FACTORS

This section will explain the major factors and principles, and give you some tips to consider when working E&S controls into your project plan and schedule. Then, using these principles, it will describe how to use this manual for your site conditions.

Soil

On most construction projects the first thing the contractor will do is clear and grub the site, removing all organic matter and topsoil. This allows them to shape the landscape to the project design grade. After the topsoil is grubbed off, what remains is called the subsoil. Subsoil types can vary widely across the state of Maine as well as within a project site. Since the subsoil is usually what is exposed to forces of erosion during construction, it is important to understand how various soil properties are affected by the forces of erosion and sedimentation during this phase of construction.

Soil Texture

Subsoil is comprised of many small mineral particles compacted together, but it is not solid. Between these particles are pore spaces. How the subsoil erodes and is suspended in water depends on the size and shape of the individual particles and how well they are compacted in place. We describe these soil particles by their size, referred to as soil texture. There are three different categories of soil texture – sand, silt, and clay. Each soil texture exhibits different characteristics with respect to how water flows through it, how water erodes it, and how it settles out as sediment.

Permeability is the soil's ability to allow water to flow through it. Permeability depends on the size of the pores between the soil particles and whether the pores are connected to each other. The term "pervious" is commonly used to mean the same thing. Sands are pervious; they have very large pores that are connected to each other which allow water to move quickly through them. Silts and clays have such smaller pores between the soil particles that water moves much slower through them even when the pores are connected.

Cohesion, the physical attraction of one soil particle to another that gives soils a sticky or 'plastic' characteristic, is also dependent on the particle size and shape. The smaller the particle and the more plate-like in shape the more cohesion there is in the soil.

General characteristics of these textures are:

- Sand
  - Size – 1/508th to 1/13th of an inch (USDA) (can see particles with naked eye)
  - Shape – rounded and blocky
  - High permeability (well drained)
  - No cohesion - will not hold together when wet
  - Low erosion potential (for coarse and medium sands) to medium erosion potential (for very fine sands)
- Silt
  - Size – 1/12,700th to 1/508th of an inch (cannot see individual particles with the naked eye)
  - Shape – all different shapes
  - Medium to low permeability (holds moisture well and drains slowly),
  - Little cohesion - Buttery feel when wet, "talcum powder" when dry.
  - High erosion potential because of small particle size and little cohesion
- Clay
  - Less than 1/12,700th of an inch (need electron microscope for smaller sizes)
  - Shape – plate-like
  - Low to very low permeability (holds moisture extremely well, drains extremely slowly),
  - High cohesion - sticky feel when wet, very hard when dry (plates stick together like wet panes of glass, fuse together when dry)
  - Medium erosion potential because cohesion holds clays together, but once eroded, very difficult to settle out because of the small size and plate-like shape.

Soils are seldom composed of a single texture. Most soils are a mixture of the three and therefore will erode and settle differently. For example, Table 1 shows the five of the twelve different U.S Department of Agriculture (USDA) soil texture classes based on their percentage of sand, silt and clay.

Soil Texture Class	Percent Sand	Percent Silt	Percent Clay
Sand	85 – 100	0 – 15	0 -10
Sandy Loam	45 – 85	0 – 50	0 – 20
Loam	23 – 53	27 – 50	7 – 28
Silt Loam	0 – 50	50 -85	0 – 28
Silty Clay	0 – 20	40 -72	28 – 40

Table 1

Note that sandy loam can have up to 50 percent silt in it. So, although the sand particles may not easily erode, the silt may. This means for every ton of sand, one thousand pounds of silt could erode away.

Topsoil

Topsoil is the soil on the top. On an undisturbed site, topsoil is a mixture of roots, decomposed plants and animals, and mineral soil. This high organic content is a great source of nutrients for plant growth. Undisturbed topsoil does not erode because it is protected by vegetation and held in place by roots. When disturbed, it stays in clods and is difficult to grade with equipment. It is usually hauled off site or may be used onsite as waste fill. When hauled off it can be used to make processed loam. After final grading is completed on a construction site, processed loam is usually brought in and spread on the surface to form new topsoil. Processed loam is a mixture of fine-textured sand and organic matter that is very light weight and very erodible. Nutrients in the organic matter have a high potential for polluting surface waters.

Soil Formation

Most of the soils across Maine were formed about 12,000 years ago when the last glaciers covered the state. These glaciers were over a mile thick. For thousands of years they moved across the land like a bulldozer scraping, crushing, and mixing rocks and soil. As the glaciers moved, this loose material was picked up and transported along with the moving ice sheet. When the glaciers began to melt and recede, most of the dirt and rock settled in place. They formed soils called **glacial till** that are a mixture of all the different textures of soil along with cobbles and boulders.

Other soils were formed as the glaciers melted and rivers of water and soil and gravel flowed out of them. This process sorted the various particles by weight and size. The larger particles dropped out first, forming large deltas and plains of well sorted, coarse-texture soils. These are called **outwash** and can be from a few feet to hundreds of feet thick.

The weight of the glaciers pushing down on the land left large sections of the coastal and southern part of the state under the sea after the glaciers melted. Over thousands of years fine-textured sediment settled out on the bottom of sea. Gradually, the land rose back up, and the sea receded, exposing the fine silts and clays left on the surface. These are called **marine sediments** and are found throughout southern and coastal Maine and up into the major river valleys (see Figure 1.)

How and when the soils were deposited by the glaciers and melting water determines the layers of the soil, called soil horizons. There can be marine sediments on top of tills, outwash on top of marine sediments, or just a thin layer of topsoil over bedrock. There are a wide variety of these deposit combinations and thicknesses as well as different soil textures throughout the state. Each county Soil and Water Conservation District (see Appendix A) has information about their soils provided by USDA Natural Resources Conservation Service. For most MaineDOT projects there will be a Geotechnical Report that will provide job specific soils information.

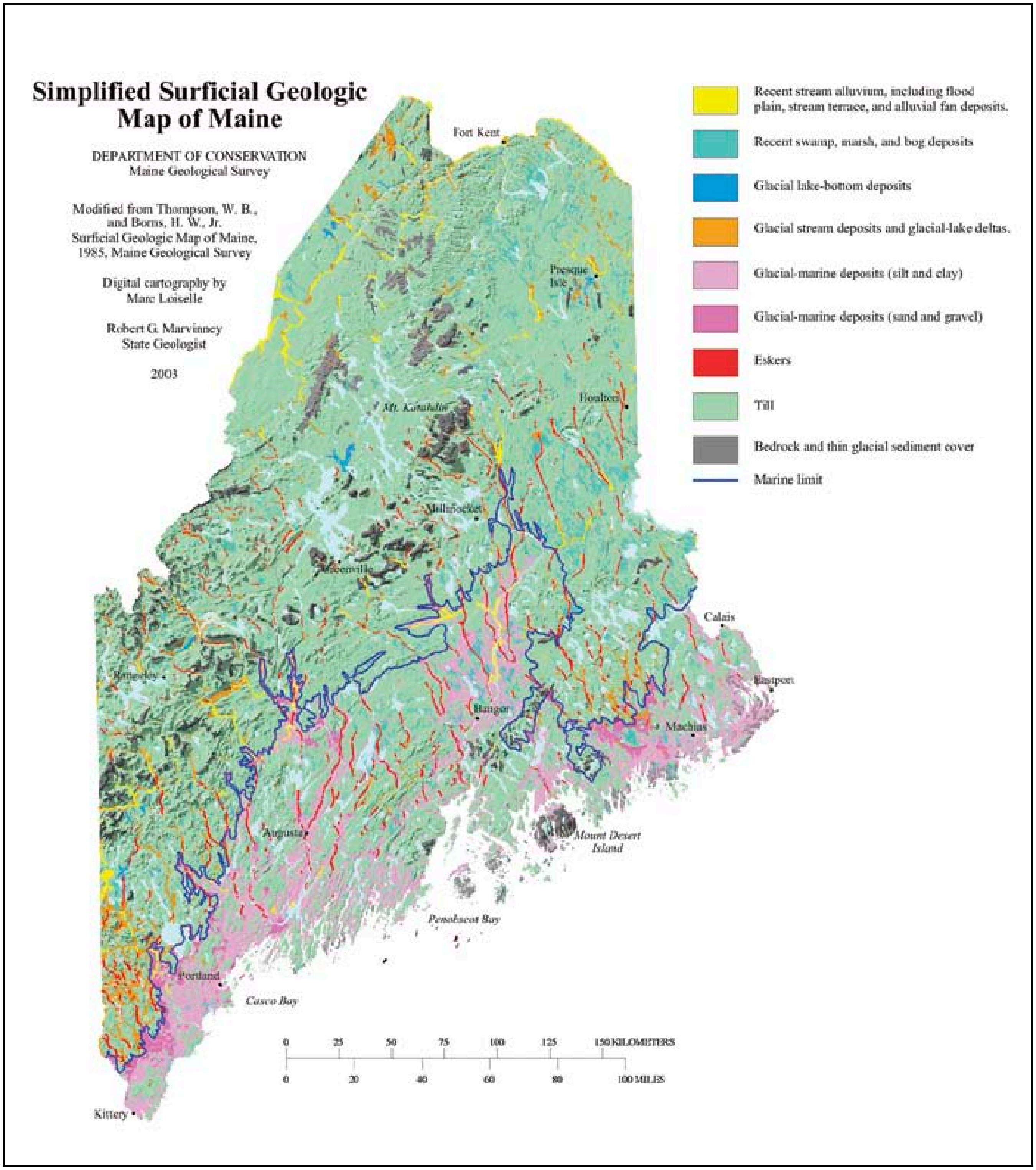

Figure 1

Water

The unending circulation of the earth's water supply is called the hydrologic cycle (Figure 2). The cycle is powered by energy from the sun and is characterized by continuous exchanges of water among the oceans, the atmosphere, and the continents. Two hydrologic processes that affect erosion and sedimentation are precipitation (rainfall) and surface runoff.

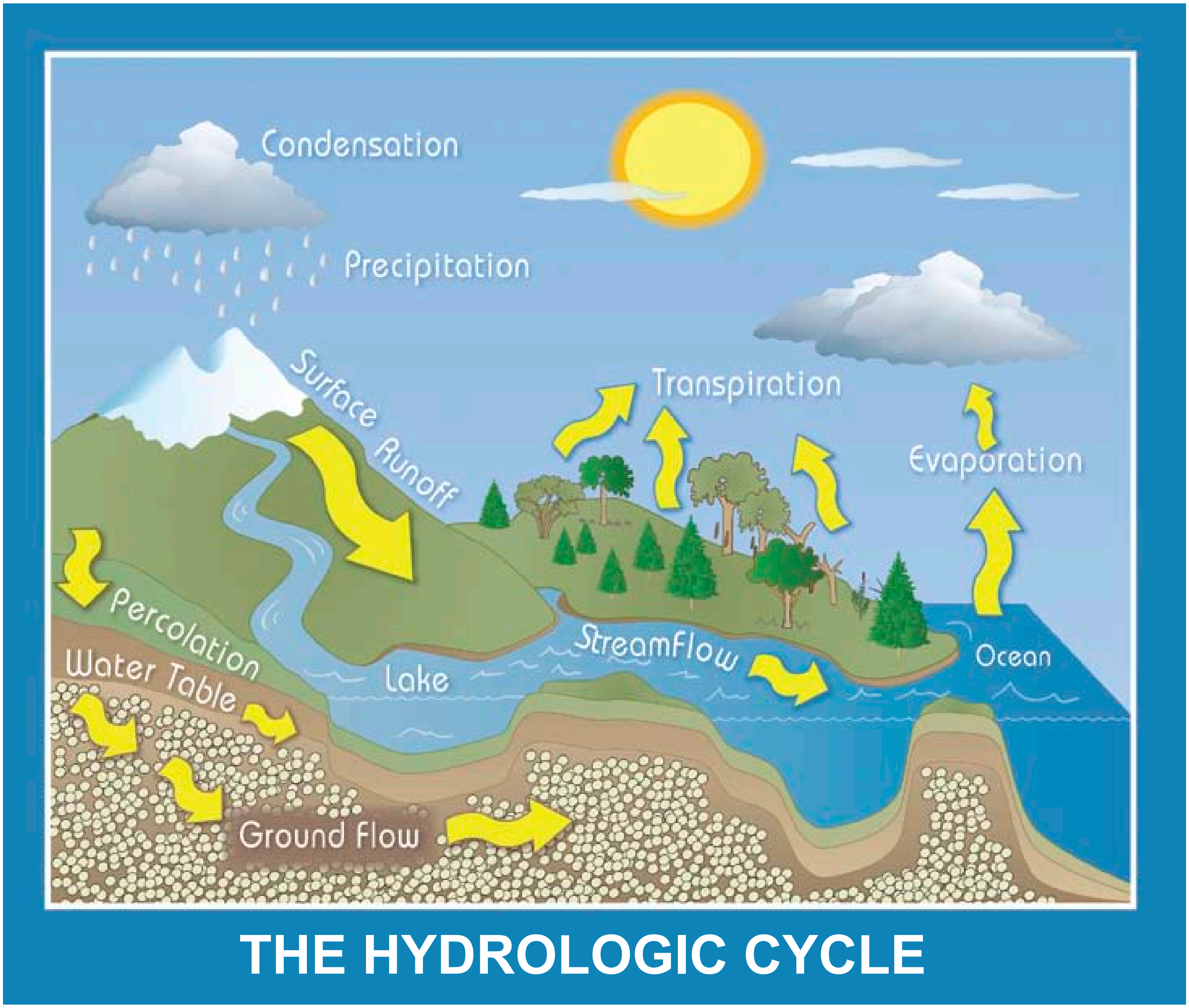

Figure 2

Rainfall

Maine receives approximately 42 inches of precipitation a year. It falls as either rain or snow. Unfortunately, it is the one factor that the contractor has no control over. Sometimes it doesn't rain for days on end and sometimes it seems like it'll never stop.

Rainfall varies in **intensity** (how big the drops are and how fast they fall), **duration** (how long the storm lasts), and **frequency** (how often does a storm occur). In a normal year in Maine, statistics show that we will get at least one rain event that will produce about 2.5 inches in a day. This same frequency storm can come in some of the following ways:

- short duration (quick) and high intensity (raining buckets),
- long duration (many hours) and low intensity (light but steady), or typically,
- a combination of the two, with some short downpours mixed in with periods of steady light rains.

As you will see in the next section, all three of these storms may produce the same volume of rain, but they will produce different amounts of runoff. In general, high intensity downpours generate more runoff than low intensity light rain.

Runoff Factors

Runoff is the surface water that flows over the land, through and off a construction site. It begins when rainfall has no place else to go - when soil and vegetation can no longer absorb and store rainwater it ponds on the ground, and if there is any slope to the land, runoff begins.

How runoff occurs on a job site depends on five factors:

- Soil type
- Surface cover and roughness
- Watershed size
- Slope of land
- Length of slope

Soil Type

We have already discussed soil texture and permeability - sands are pervious (well-drained), silts are moderately pervious, and clays are impervious. Permeability has a great bearing on how much runoff is produced by a rainfall event. The movement of water into the soil is called **infiltration** and a common way of measuring permeability – the movement of water through the soil is called **percolation**. If, during a storm event the rainfall intensity is less than or equal to the infiltration rate and percolation rate, there will be no runoff - all the rain infiltrates and percolates through the soil. If however, the rainfall intensity exceeds the infiltration and percolation rates, the rain will pond on the surface and begin to run off.

Sand has a high permeability rate because it is composed of large particles that pass water easily between the particles. Clays have essentially no permeability because the soil particles are flat, “plate-like.” It is very difficult for water to move through them. Silts are a mixture of the two, but because of the small particle size they react more like clays than sands. Organic matter greatly increases the permeability of soils because it allows water to run into and through the soil along root paths.

On bare soil intense rainfall can decrease the infiltration rate by physically beating the soil surface and compacting the soil particles. After an intense rain, this can be seen as a crust on the surface. Compaction by equipment also affects the infiltration rate. The more compacted the soil surface is, the lower the infiltration rate. The soil may have a high percolation rate, but it won’t matter if the water can’t get into the soil.

The depth of soil and height of water table will also influence when runoff occurs. Shallow soils and high water tables limit the volume of water that the soil can store. If the soil is already saturated, even if the water could get in it has no place to go and all additional rainfall will produce runoff. That is one reason why flooding occurs in the spring or after many days of rain.

Surface Cover and Roughness

Surface cover intercepts rainfall and protects the soil’s infiltration rate by preventing compaction of the soil. In most instances it is vegetation that is always preferred for soil stabilization, but as you will see in this manual other materials can be used. To simplify the explanation in this section we will only discuss vegetation.

Vegetation intercepts the impact of a raindrop. The leaves, stems, and branches of vegetation capture and hold raindrops. Roots of the plants loosen the soil, creating more pore spaces, increasing the infiltration rate, and increasing the storage capacity of the soil. All these characteristics will reduce the amount of runoff. The roughness of the natural ground surface produces many small pockets where rainfall can pond providing storage on the surface and giving the rainfall more time to either infiltrate or evaporate. This roughness can also be accomplished by grading.

When runoff does begin, the amount of vegetation and the roughness of the ground will effect how fast the runoff flows. The same amount of runoff flowing over bare, smooth ground will flow faster and shallower than water flowing through vegetated, rough soil.

Watershed

A watershed is the area (acres or square feet) that captures rainfall and, once runoff begins, directs it to a common point of concern. For example, the watershed of your roof gutter is the area of roof that drains to it. The rainwater that falls on the other side of the roof is in a separate watershed. But if both downspouts flow into the same driveway ditch then they form a larger watershed consisting of your whole roof and any other structures or land that drains into that ditch. If the driveway ditch empties into a road ditch, then the watershed for the road ditch includes your home and property as well as all the other properties that are uphill from that point. Each time small watersheds combine the watershed becomes larger and the volumes of runoff water increase.

On construction sites the watershed may be the area above a cross-culvert or it may be a point where the contractor wants to install a particular BMP. Because construction typically involves removal of the vegetation and compaction of soils, even small watersheds can generate a large amount of runoff.

Slope

Any child with a toboggan understands how steepness of a slope affects speed. The same can be said for runoff; the steeper the slope, the faster the runoff flows.

Length of Slope

As the slope length increases, the size of the watershed above the base of the slope increases, therefore so does the amount of runoff.

Types of Runoff

At the top of the watershed, runoff will usually begin to flow as a broad shallow film over the surface. This is called **sheet flow.** Sheet flow usually occurs for only fifty to one hundred feet before it concentrates. As it begins to gain speed and increase in depth it will begin to form small channels; this is called concentrated flow. There are two types of concentrated flow: **shallow concentrated** flow and **channelized flow**. Shallow concentrated flow forms small channels of water, from several inches to a foot in width. As these small rills of water come together, they form streams and eventually rivers; this is channelized flow. In the forest it may be difficult to see shallow concentrated flow (rills) because the ground is rough and the small rills may dry up after the rain. Streams and rivers are permanent channels that have actually eroded into the soil over many years. The size and slope of the watershed, and the permeability and depth of the soil will determine if the streams will flow year round or just intermittently. If the watershed stays undisturbed, the amount of runoff from the watershed stays relatively constant and these stream channels will change very slowly over time. But on construction sites there are changes to the landforms, slopes, slope lengths and the vegetative cover. Construction changes flow paths. Controlling the factors that effect runoff is the key to good water management and good erosion and sedimentation control. It is all about controlling the power of water.

The Power of Water

A falling raindrop, sheet flow, and concentrated flow all have energy. That energy working over a period of time can be very powerful. The power of falling and flowing water increases with an increase in the velocity and weight of water.

Consider standing in a shallow stream. The flowing water pushes against you, but because the depth is shallow you are able to stand up. Now imagine what would happen if the water was moving at the same speed but was as deep as your shoulders. The weight (depth) of water would increase the power and push you downstream. What if the water was up to your shoulders but not moving? As in the shallow stream you would not move. Velocity and weight create power, but velocity has a much greater impact on the amount of power produced than the weight. It doesn't take much change in velocity to produce a lot more power. These same principles that apply to you standing in a stream, affect a soil particle and cause erosion and sedimentation.

For a given volume of runoff, the depth of runoff is determined by the velocity. The slower water flows, the deeper the depth; the faster water flows, the shallower the depth. Once runoff begins, the power of the runoff increases as the depth (volume) and velocity increase. This will occur until they reach a maximum amount for a given storm. Whether runoff flows as sheet flow or channel flow, the speed of the flow will be dependent on the slope and the surface cover or roughness that it is flowing over. The thicker the vegetation or rougher the rock lining, and flatter the slope - the slower it flows. When water, regardless of its depth, stops moving then sediment suspended in the water will begin to settle to the bottom, with the heavier particles settling faster than lighter particles.

This same idea of power applies to rainfall. The power of a raindrop depends on its size and the speed that it falls. As we discussed earlier, this is the intensity. As the intensity increases so does the power. Controlling the power of water as it flows over soil is the basis for the majority of E&S control BMPs.

To complete this discussion of power, we must not forget wind. Wind is just air and has very little weight, but it certainly can have the velocity and that is what generates power.

2. THE EROSION PROCESS

We began this discussion on page 3 with a definition of erosion as the detachment and movement of soil particles by wind or water. In our discussion of soils, runoff, and the power of water and wind we presented the factors involved in the erosion process. Understanding this process is critical to determining how to control it. There are five different types of erosion that we are concerned about - four of them are forms of erosion by water, and one of them is by wind. They are raindrop erosion, sheet erosion, rill erosion, gully erosion, and wind erosion.

Raindrop Erosion

Raindrop erosion occurs when rain drops collide with bare soil. The force of this impact dislodges soil particles and splashes them into the air. How much this occurs depends on the intensity of the rain (velocity and size of drops) and the texture of the soil (how much sand, silt, or clay). The harder the rain and the finer the soil texture, the more raindrop erosion will occur. Consider that a large raindrop will fall at a rate of 30 feet/second and may be up to 250 times larger than a silt particle. That silt particle doesn't have a chance! Sand on the other-hand may be the same or up to twice the size of that raindrop and therefore has a better chance of absorbing raindrop impact and staying in place.

As soon as water begins to pond on the ground surface, runoff begins. But it isn't just water. All of the soil particles that have been dislodged by the raindrops are now suspended in the water. If the land has even the slightest slope, the fine-textured soils will stay in suspension and begin to move with the runoff. At this point the second type of erosion occurs - Sheet Erosion.

Sheet Erosion

Sheet erosion occurs on unprotected soil when sheet flow runoff begins. The depth of water during sheet runoff is typically no more than ¼ of an inch, but that can be six to six thousand times deeper than the soil particles it is flowing over – and depth and velocity is power. This relative tidal wave of water easily picks up soil particles and carries them away. How fast and far this sheet of water flows depends on the surface cover and roughness, and the slope of the land.

Sheet erosion usually moves the GREATEST AMOUNT of soil from an unprotected job site. For instance, the loss of just 1/8 of an inch of soil off one acre of land will fill a 10 wheel dump truck (15 cu.yds. or 25 tons). On steep, unvegetated highway backslopes sheet erosion may only occur for twenty feet before it develops into the next form of erosion - Rill Erosion.

Rill Erosion

Rill erosion occurs when the sheet erosion gains enough power (velocity and depth) to concentrate and cut very small channels into the soil. As more water flows into these small channels, the water depth and power increases and they cut deeper into the soil. These small channels are called rills. They are no more than an inch wide and one to two inches deep.

Keep in mind that between these rills, raindrop and sheet erosion is still occurring. This water will also flow down the slope parallel to the rills, combine with the rills and form the most destructive form of erosion - Gully Erosion.

Gully Erosion

Gully erosion occurs when water is concentrated and flows with enough power (velocity and depth) to cut into the soil to a depth of over one foot. It will occur as a result of rills coming together on an unprotected slope. On road projects, gullies form near the base of long slopes, in the bottom of an unprotected ditch, or as water flows off of a road surface, parking lot or other flat grade onto a steep unprotected slope.

Interestingly, gullies form from the bottom of the slope and progress uphill. The flowing water reaches a critical level that a small waterfall forms and the power of the water falling over the edge (increased velocity) erodes the soil at that point and this erosion proceeds upstream. This small waterfall that moves upstream is called a head cut and leaves steep banks downstream. The steep banks will begin to collapse under their own weight, that soil will also wash away, and the gully widens further.

Gullies can form anywhere the power of water is strong enough to begin to scour the soil and begin this head cutting process. If left untreated, the head cut will continue to move up the slope until the watershed decreases in size, which decreases the volume of runoff, which decreases the depth of water, which decreases the power enough that the soil can resist it and not erode. At the lower reaches of the gully it will continue to cut down and widen out to the point that the slope may actually flatten out, slow the velocity and decrease power enough that the erosion rate may slow down enough for sedimentation to occur in the gully.

It was stated above that sheet erosion erodes the greatest amount of soil because it covers a larger area, but gully erosion is the most dramatic. Which 'costs' the most? Gully erosion is the most expensive for the developer or contractor to repair but sheet erosion usually costs our water resources the most.

On transportation projects, the length of back slopes and size of watersheds are usually small enough that gullies do not form as described above. But they do form in constructed channels (ditches) or where water flowing off the road surface is concentrated on the shoulder by a grader berm, constructed curb, or a winter sand berm then allowed to spill onto an unprotected inslope.

In reading this section about water erosion you can see that the types of erosion are determined by the types of runoff.

Wind Erosion

Wind erosion occurs when the wind dislodges, picks up, and transports the soils. As with water, the texture of the soil moved depends on the power of the eroding force. Wind can cause dust clouds or sand storms. It occurs when the soil is dry, loses or has no cohesion, and is unprotected from the power of the wind. Dust is a major form of non-point source pollution.

3. EROSION CONTROL

Controlling erosion is all about decreasing the power of the water or wind, and protecting the soil from it. The power is decreased by applying best management practices that influence the soil, surface cover, watershed size, slope, or slope length; or that decrease the volume or velocity of runoff. Decreasing the power is not always possible to do, but protecting the soil from the power of water and wind by covering it can always be done. Providing protection by applying mulch or other protections is usually the most practical method of preventing erosion.

The type of erosion control BMPs used are determined by the type of erosion that is occurring. The basic principles apply: protect the soil and/or reduce the power (velocity and depth) of the flowing water. To control wind erosion, controlling the velocity of the wind is done by using wind breaks and adsorbing or deflecting the power. This is not always practical, but we are able to protect the soil from the power of the wind in the same way as with the water – by covering it.

The erosion control BMPs in this manual are presented in three sections based on the type of runoff that generates it. Raindrop, sheet, and rill erosion occur over a broad area and will be called **Sheet and Rill** erosion. Gully erosion in channels will be called **Concentrated Flow**. Wind erosion is addressed as dust control in the **Miscellaneous** section.

4. THE SEDIMENTATION PROCESS

Sedimentation is the deposition of soil particles that have been eroded. Soil particles are deposited when the power (velocity and depth) of the water or wind that is carrying them is no longer strong enough to keep them suspended. Sediments are these soil particles once they settle out.

Sedimentation control is typically achieved by ponding water to slow it down. Stopping the water entirely and letting it infiltrate or evaporate would be ideal, but on construction sites that usually is not possible. Because soil particles have to have enough time to settle, it is critical to slow the velocity of the water as much as possible, have the ponded area basin be as shallow as possible, and have the distance the water flows through the basin as long as possible. The time it takes for a particle of soil to settle through the ponded water and settle on the bottom is called the residence time. The longer the residence time, the better. If the water speeds up again before the soil particles settle they will be re-suspended.

The size and shape of the particle has a great effect on the rate of sedimentation. Coarse texture soil particles (sand) will settle easily. They are heavy and blocky in shape. Clays are extremely small and are plate-like in shape. It is almost impossible to settle out clays, they float like feathers in the wind. Silts are not much better, they may be blocky in shape but they are very small in size. Because settling out silts and clays is so difficult, most sedimentation BMPs do not capture these particles well. Table 1 shows that a typical loam will have no more than 53% sand. If this soil erodes from a site almost half of it (silts and clays) will be very difficult, if not impossible, to settle out before leaving the site. There are methods to remove fine texture soils but they require expensive treatment methods and filtering. Therefore, it is much easier and less expensive to prevent erosion in the first place.

The key factors in the sedimentation process are the soil texture (particle size), the speed and depth of the water, and the distance the water flows through the BMP.

Filtration of sediment laden water through vegetation, pervious soils, or commercial structures is an alternative to settling in a ponded area.

5. SEDIMENTATION CONTROL

The type of sedimentation BMP used is governed by the type of runoff and erosion that is occurring. Sheet and Rill erosion have shallower depth, slower velocities, and occur over a broader area. The best sedimentation BMPs for this type of erosion are BMPs that are placed on the contour of the land and provide ponding at shallow depths, promote infiltration of the water (leaving the sediment on the surface), or provide filtration of the water.

Sediment laden water in concentrated flow may be from gully erosion or may have come from sheet and rill erosion that has been carried into a Concentrated Flow channel. This water is usually deep, fast, in a confined space, and over the duration of a rain event, involves a large volume of water. There are three approaches to removing sediment from concentrated flow: provide slow flow through a basin with a long residence time allowing soil to settle; convert concentrated flow back into sheet flow and utilize those sedimentation control BMPs; or use an engineered commercial devise to remove sediment through mechanical means.

The sedimentation control BMPs in this manual are presented in two sections based on the type of erosion that is occurring: sedimentation control BMPs for **Sheet and Rill** erosion and sedimentation control BMPs for **Concentrated Flow** erosion.

6. RULES OF THUMB

Before leaving this section, here are some general rules and observations about erosion and sedimentation:

- Erosion always happens before sedimentation. You can have erosion without sedimentation but you cannot have sedimentation without erosion.
- Erosion control is keeping the soil out of the water. Sedimentation control is removing the soil from the water. It is easier to keep it out than to remove it.
- Erosion control is protecting the soil from the power of water – the impact of the raindrop, and the velocity and depth of runoff and concentrated flow. Whenever possible you should:
    - decrease the amount of water on the project site by dividing watersheds and increasing infiltration,
    - slow the water down by flattening grades or roughening surfaces that the water flows over, and
    - cover the soil with something that can withstand the power of water.
- Sedimentation control is slowing the water velocity enough and for a long enough time for the soil to settle out. How much settles depends on soil texture.
- Construction being what it is, you can not always protect the soil from erosion; and sedimentation control is your safety net. Sedimentation control is the last line of defense but should be the first BMPs installed.