Module 2:

Fundamentals of Erosion and Runoff

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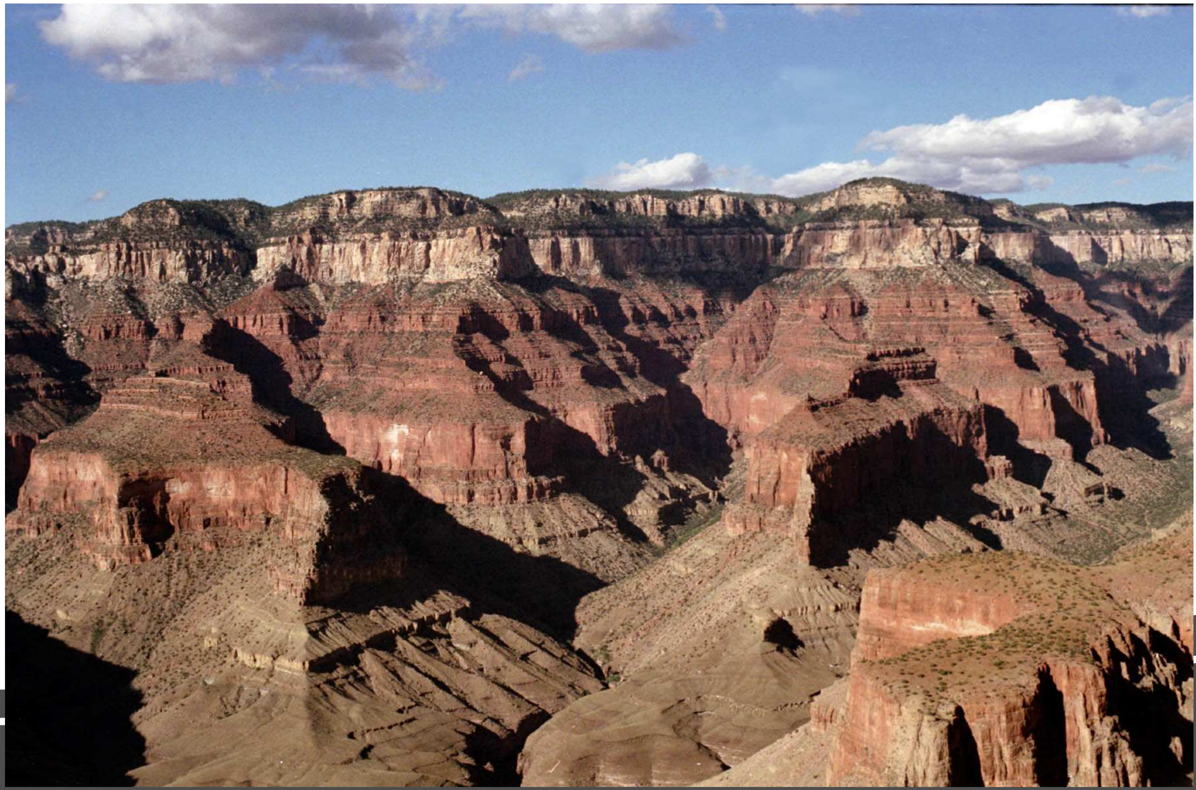
Module 2a

Goal

Once we can better understand the forces which cause erosion and runoff, only then can we begin to minimize the negative results.



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Module 2b.

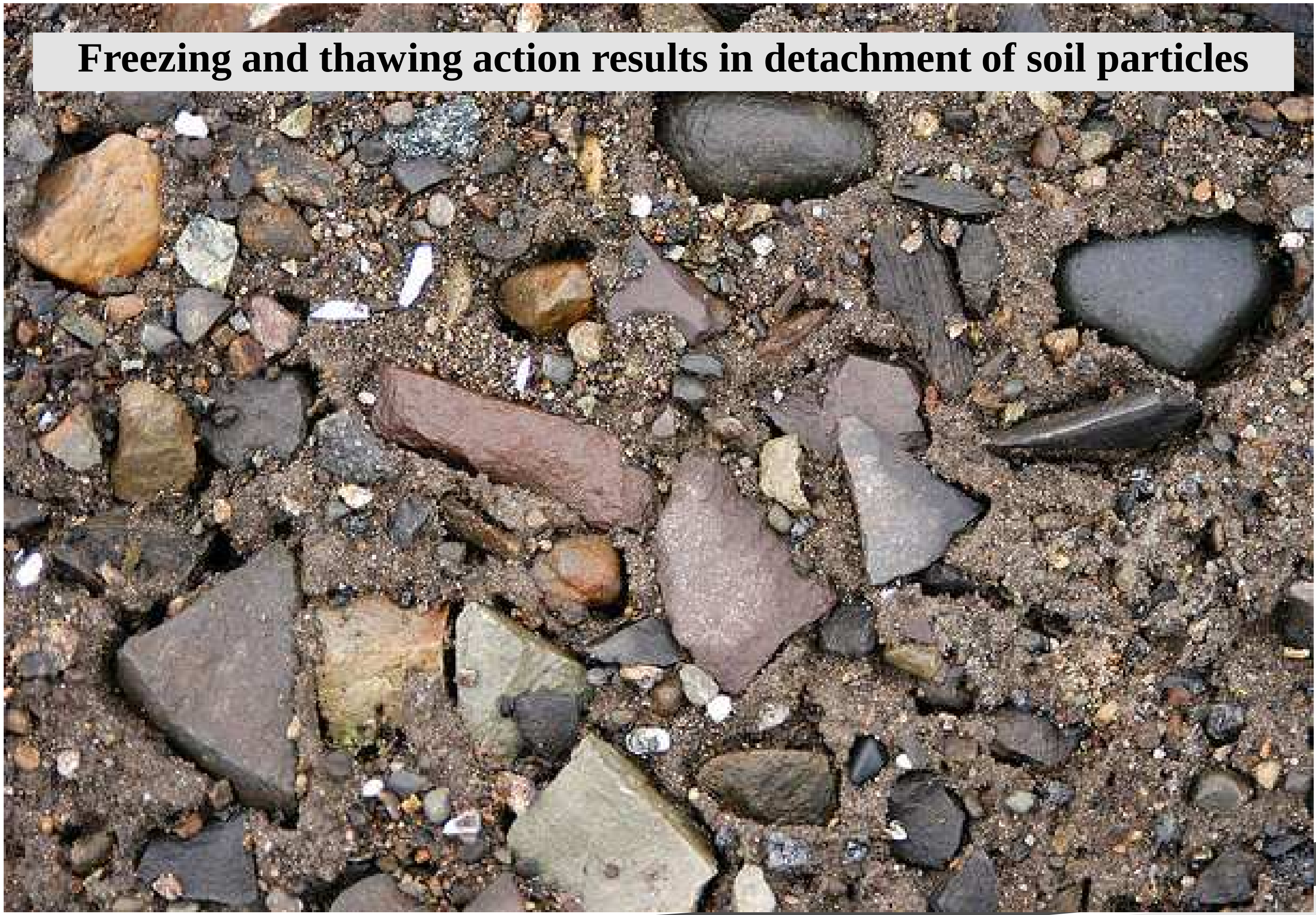
Erosion Defined

Soil erosion is defined as the removal of the land surface by erosive forces such as …

……….water,

…….wind,

……. ice,


Freezing and thawing action results in detachment of soil particles

and by gravity.

…or a combination of all the forces that cause erosion

As we discussed in Module 1, the mount of sediment that leaves a construction is much higher than other types of land disturbing activities largely due to the mature of the construction process and methods used on a typical construction site

When a site is stripped of vegetative ground cover the soil is susceptible to erosion in several ways

Five stages of erosion-Raindrop Impact

- First effect on soil
- Dislodges soil particles
- Splashes
- Becomes sheet erosion

Raindrop Impact

- Raindrops hit the exposed soil like tiny bombs
- Larger raindrops strike the soil surface harder

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Raindrop Impact

- **The magnitude of this energy is dependent on the amount and intensity of rainfall, raindrop diameter, and raindrop velocity**

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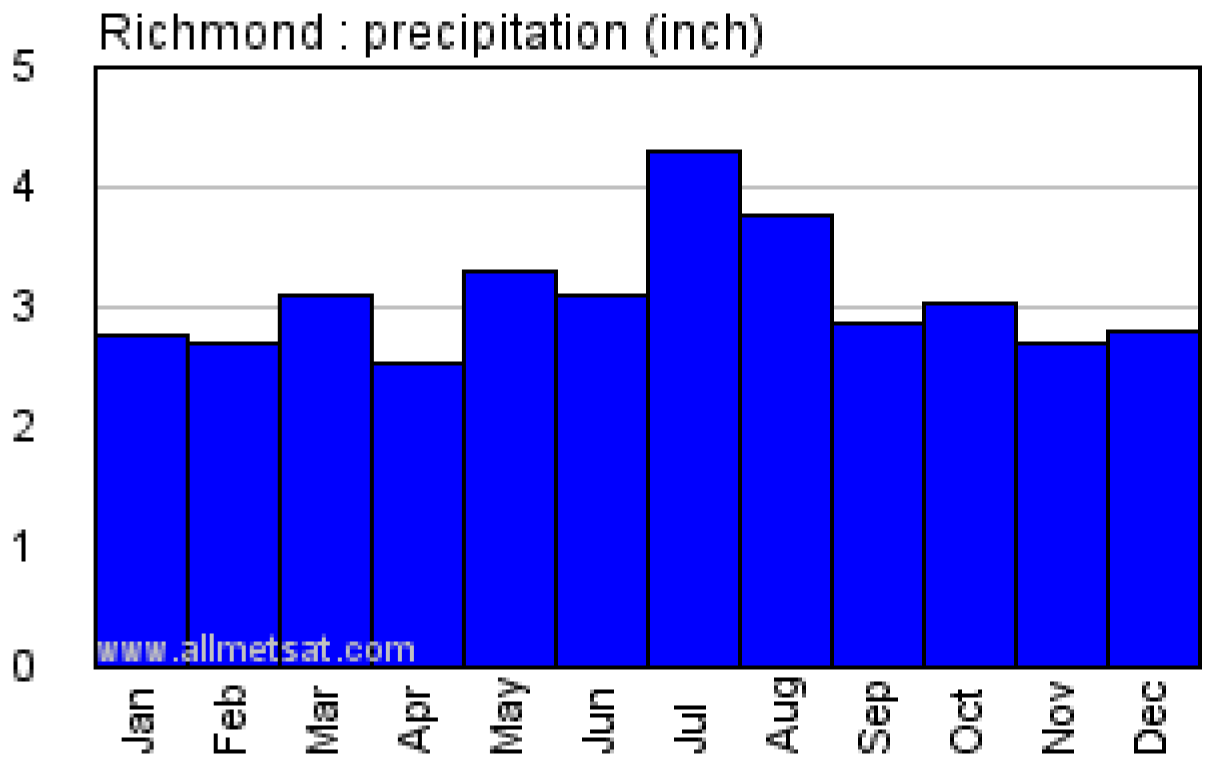
Rainfall Distribution

- **Rainfall is not evenly distributed throughout the year**
- **Most erosive rainfall is during the months of June – Sept.**



Another damaging effect of raindrop impact is the compacting, puddling, and sealing of the soil surface. Repeated strikes churn the surface into a slurry, which seals the pore spaces in the soil preventing water infiltration

Sheet Erosion

- Shallow sheets of water run across the surface
- Seldom detaches soil particles but…
- Transports detached soil
- Sheet flow moves only a short distance before it concentrates or diminishes

Rill Erosion

- Shallow water collects in low spots
- Deeper flow means more concentrated quantity of water
- Velocity of water becomes greater
- Creates tiny channels down the slope
- Usually easily repaired

Gully Erosion

- **Volume and velocity increases**
- **Creates larger channels or cuts**
- **Too large to be easily repaired**
- **May Require Heavy Equipment to repair**

Channel Erosion

Greater volume & velocity of water.

Causes movement of materials within the stream bed & banks.

In summary, there are five stages of erosion:

Five Stages

- Raindrop (90%)
- Sheet
- Rill
- Gully
- Channel

Four Factors Influencing Erosion

Four Factors Influencing Erosion

Climate

- Precipitation
- Frost
- Wind

Groundcover

Soil

- Structure
- K-factor
- Particle size distribution

Topography

- Steepness
- Length
- Configuration

Four Factors Influencing Erodibility

Climate

- Precipitation
- Freeze-thaw-drought effects
- Wind

- Precipitation:
  - Type
  - Intensity
  - Raindrop size
- Temperature extremes
- Wind

Four Factors Influencing Erodibility

Groundcover

- **Most important** factor from the standpoint of controlling erosion.
- Amount of erosion is directly proportionate to the amount of bare soil exposed to raindrop impact
- Dramatic reductions in soil loss can be obtained simply by covering the soil surface to protect it from raindrop impact

EFFECTIVENESS OF VARIOUS GROUND COVERS IN PREVENTING SOIL EROSION

(this table compares fully established stands of groundcover with bare soil)

Type of Ground Cover	Percent Reduction
Permanent grass	99
Perennial ryegrass	95
Annual ryegrass	90
Small grains	95
Millet	95
Field bromegrass	97
Grass sod	99
Hay or straw (@2 tons/acre)	98

Four Factors Influencing Erodibility

Soil

- Structure
- K-factor
- Particle size distribution

Soil properties influencing erodibility:

1. Structure
2. Texture
3. Bulk Density
4. Organic matter
5. Infiltration and permeability rates

Erodibility of Soil (K-factor)

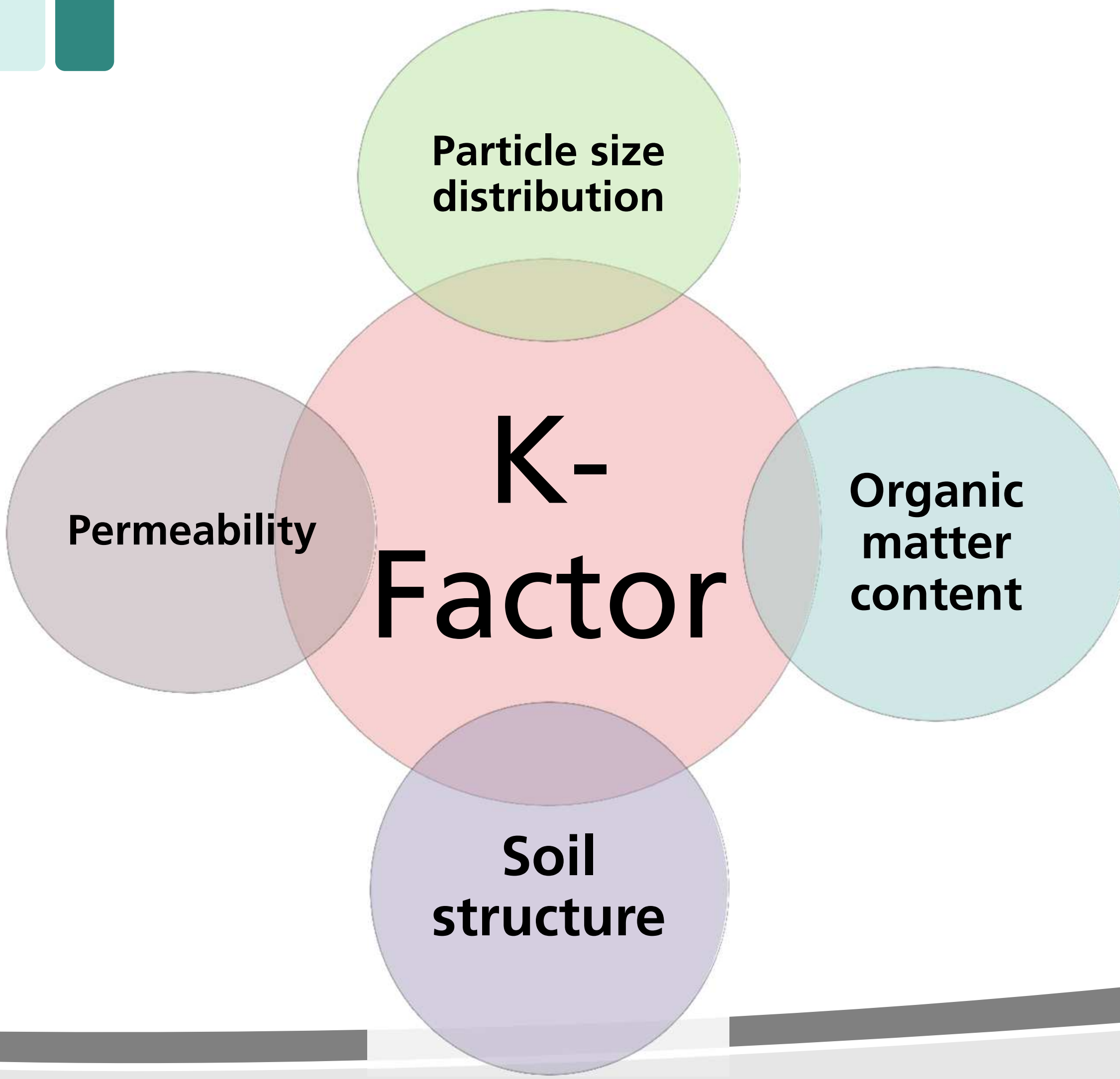
Different soils will erode at different rates

➔ The K-factor

The K-factor assists us to determine how erodible a soil is.

Erodibility is the vulnerability of a material to erode

Erodibility of Soil (K-factor)



Erodibility of Soil (K-factor)

K - factors

X < 0.23	*→ low erodibility*
0.24-0.36	*→ moderate erodibility*
X > 0.37	*→ high erodibility*

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Soil Compaction

During construction, the subsoil is compacted by construction vehicles, increasing the bulk density of the soil close to that of concrete

Common Bulk Density Measurements

Land Surface/Use	Bulk Density
Undisturbed Lands Forest & Woodlands	1.03 g/cc
Residential Neighborhoods	1.69 to 1.97 g/cc
Golf Courses - Parks Athletic Fields	1.69 to 1.97 g/cc
Concrete	2.2 g/cc

Four Factors Influencing Erodibility

Topography

- Steepness
- Length
- Shape

Energy = Volume X Speed

The energy of runoff is a function of slope angle, slope length, and volume of the runoff.

The greater the energy of the runoff and/or the greater the turbulence of water is, the more erosive it is.

More Energy Means Higher Erodibilty

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Slope Steepness

The steepness of a slope causes velocity (speed) of the runoff to increase.

Less chance for water to infiltrate on a steep slope ➔ More runoff

Energy=Volume x Speed

Three categories of erodibility (Table 2.3):

Slope gradient	Erosion hazard
0-7%	Low
7-15%	Moderate
15% & over	High

Slope Length

The longer the slope

- the greater the depth of runoff
- the greater the velocity (speed of the runoff)

Energy=Volume x Speed

TABLE 2.4.
SLOPE GRADIENT AND LENGTH COMBINATIONS AT WHICH THE EROSION HAZARD WILL BECOME CRITICAL

Slope gradient	Slope length
0-7%	300 feet (100 meters)
7-15%	150 feet (50 meters)
15% & over	75 feet (25 meters)

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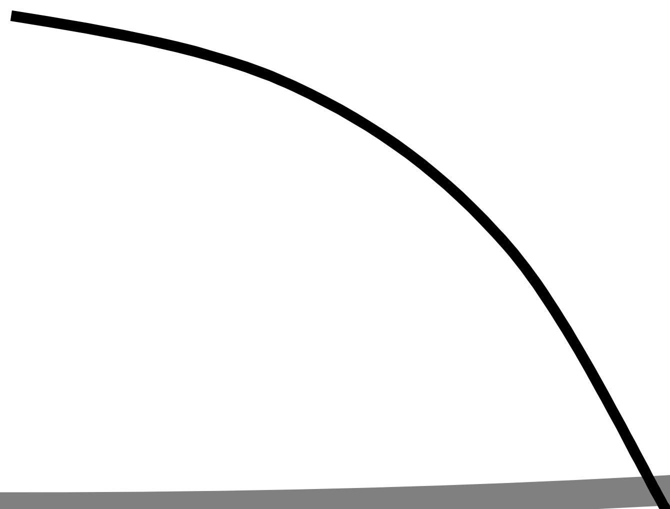
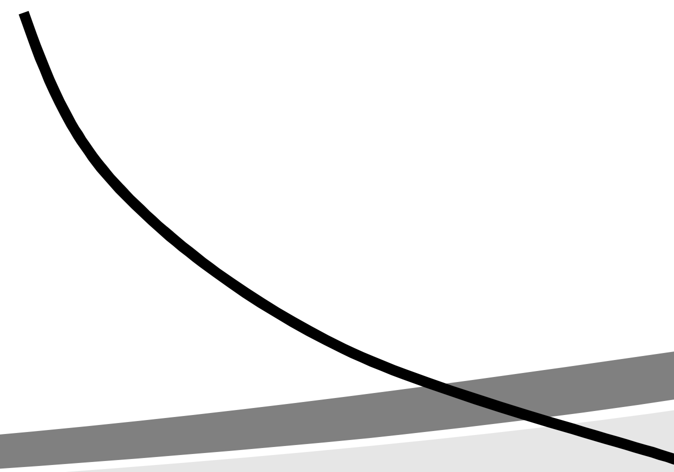
Slope Shape

Convex slopes (steeper at the lower end) have more erosion potential



Concave slopes (steeper at the top or upper end & flatter at the lower end) have less potential for erosion



2c. Runoff

Runoff

- **Runoff occurs when the rate of rainfall exceeds the infiltration capacity of the soil.**
- **Runoff on unprotected soil begins a few minutes after the start of rainfall.**
- **Water on the soil surface gains energy as it begins to run down slopes as runoff**

Runoff

- Runoff starts as sheet flow, which is a major agent in transporting soil particles
- Generally shallow and has very little velocity
- Usually does not detach soil particles but will transport particles detached by raindrop impact

Concentrated Flow

- **As the depth of sheet flow moves down-hill, it begins to concentrate in low spots**
- **Beginning of concentrated flow**
- **As the runoff concentrates, it gains force & momentum to detach other soil particles**
- **A "chain reaction" occurs where depth & velocity of runoff increase**

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Concentrated Flow

- The detachment of soil by flowing water is confined to the areas of concentrated flow (rills, gullies, channels)
- The soil is detached by rolling, lifting and abrasive actions (the force is horizontal)
- As velocity increases, vertical currents (eddies) occur to lift particles
- This is called “turbulence”

Concentrated Flow

- **Detachment & transport is determined by the water volume and velocity**

- **The erosive capacity of flowing water depends on velocity, turbulence, amount & type of abrasive material flow, the roughness of the channel and slope gradient and length**

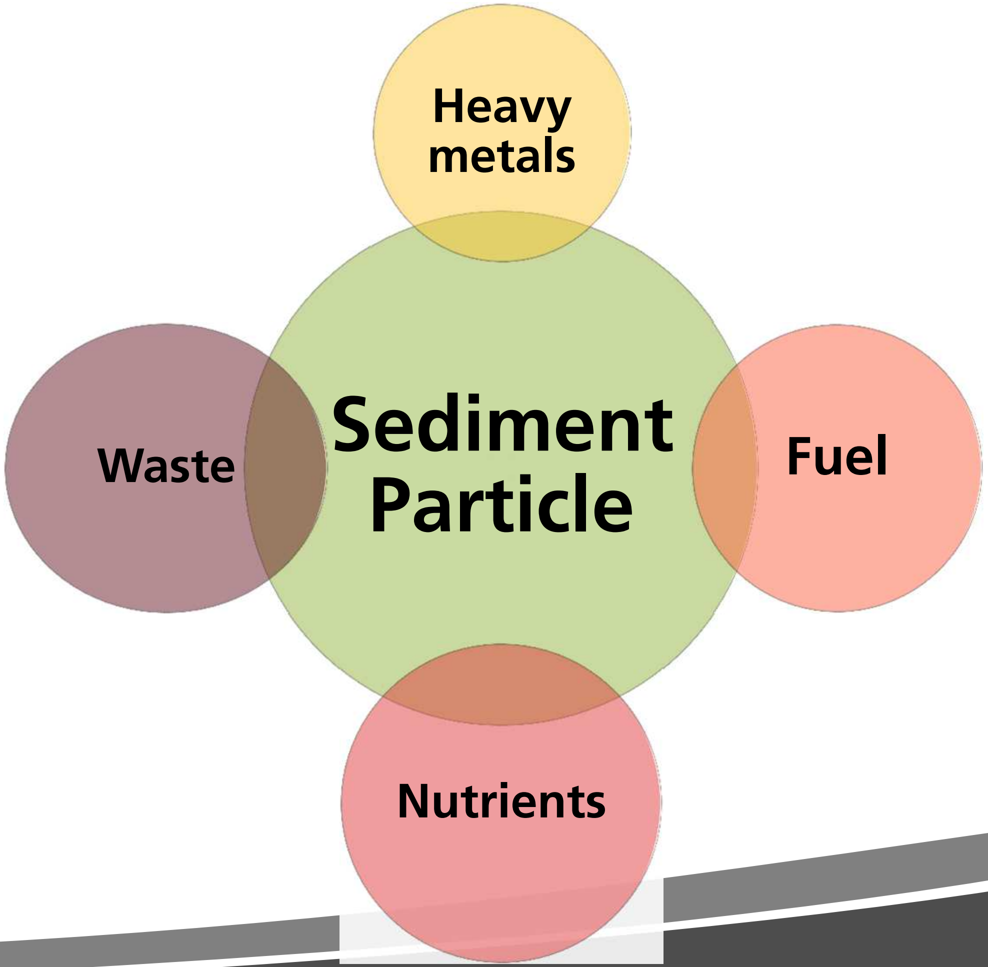



The energy of runoff is a function of: slope gradient; slope length; and runoff volume.

The greater the energy of the runoff and/or the greater the turbulence of water, the more erosive it is.

It's more than just a little dirt we're dealing with.

Construction Sites & Water Quality



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Nutrients

Algal Bloom- James River

Nutrients attached to sediment in stormwater runoff are a major source of degradation to many of Virginia's water bodies (including Chesapeake Bay)

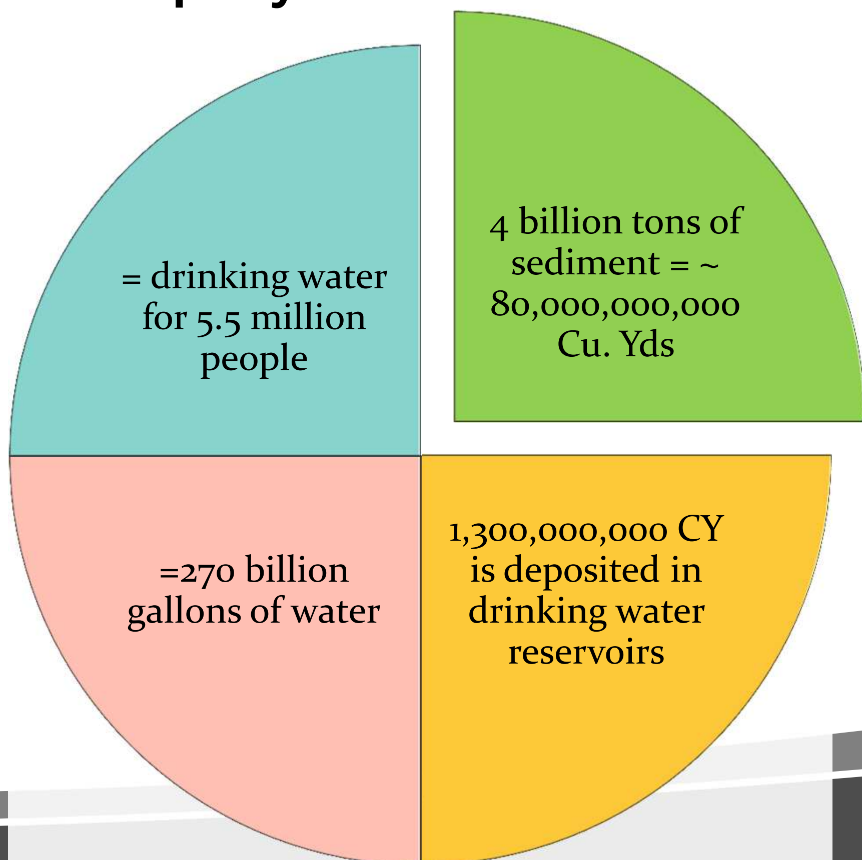
When sediment and associated/attached contaminants and nutrients (Phosphorus and Nitrogen) enter waterways a cascade of issues can occur:

- **(Sediment shades the bottom of the waterway and weakens or kills the aquatic vegetation, which oxygenate the water and serve as cover for young fish and other aquatic organisms;**

(Nutrients stimulate algae to grow resulting in algal blooms. This algal growth shades native aquatic vegetation and decaying algae and native vegetation depletes oxygen in the water;
(Sediment and contaminants in the water plugs gills of fish and other aquatic organisms thus weakening and/or killing them;
(Sediment settles in waterways and smothers spawning beds, oyster reefs, crab habitat, etc;
(Stocks of fish, oysters and crabs decline and reduce the income of commercial watermen and sports fishermen, , thereby hurting the economy of the region; and
(Shipping lanes, reservoirs, harbors, marinas, and other waterways may require dredging, at considerable cost (Tables 2.6 and 2.7).

Quantifying Erosion and Sediment Control

It has been estimated that the total sediment production in the U.S. is 4 billion (4,000,000,000) tons per year. The average annual sewage load in the U.S. is 8,000,000 tons per year



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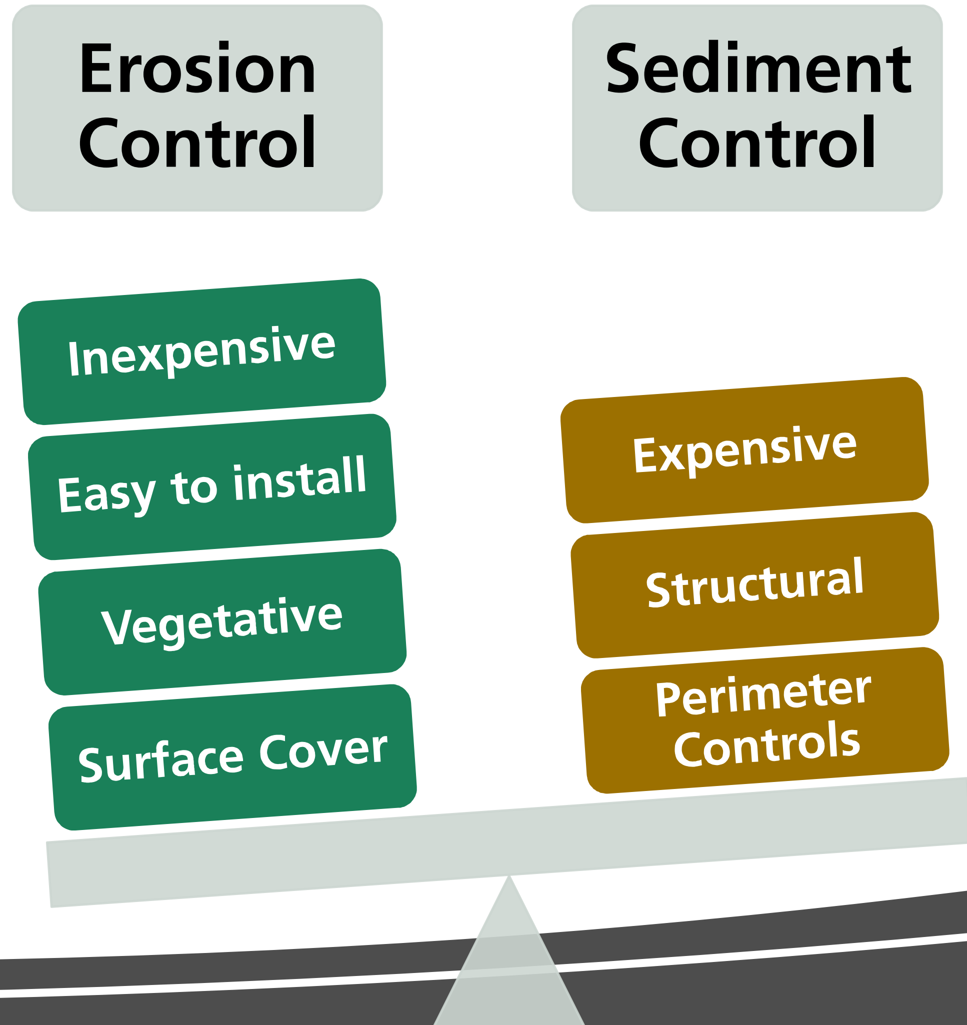
In addition to filling up reservoirs, sediment will also block shipping channels. Considering that 46% of our imported goods come via the water ways, we can see that sediment accumulation in our shipping channels is costly to remove and maintain as well as create safety hazards to the vessels and the public.

Principles of Erosion & Sediment Control

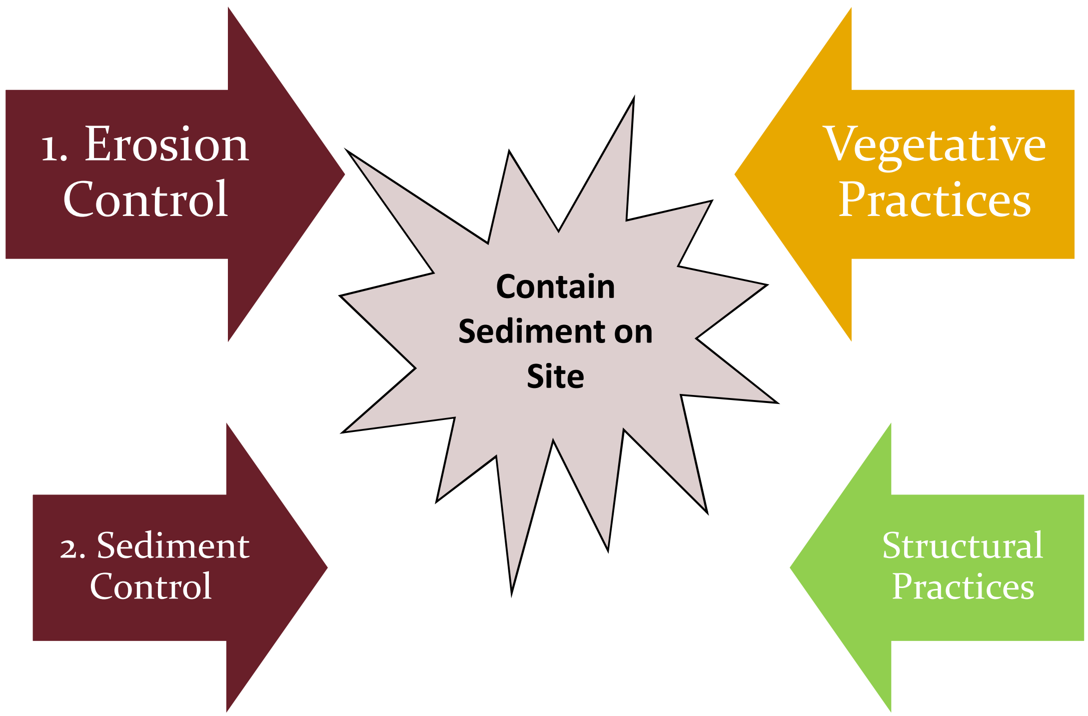
If we can control erosion we can effectively control sediment

If there is no erosion…there is no sediment

Principles of Erosion & Sediment Control



The two Principles of ESC come together



END OF MODULE 2

QUESTIONS?