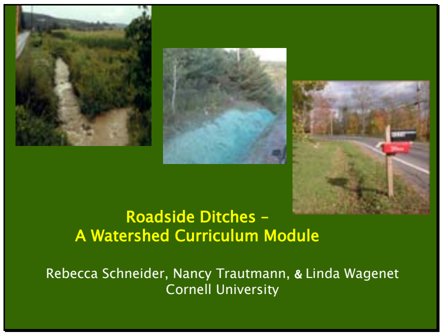
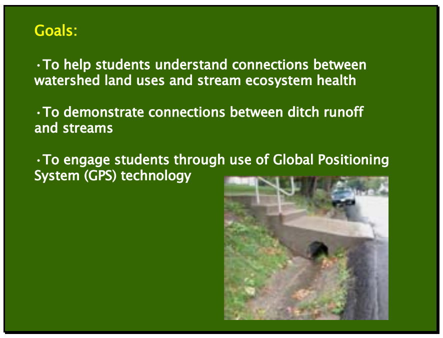
Slide 1




This PowerPoint presentation can be downloaded from http://ei.cornell.edu/watersheds/ditches/Ditch_10.asp.

Slide 2




Slide 3

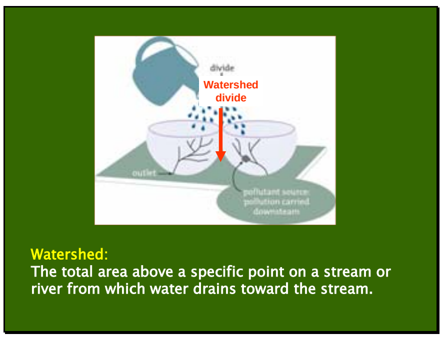

Problems associated with water resource quality and quantity, including both flooding and limited freshwater availability, are gaining prominence throughout the U.S. There is a growing recognition that land use and activities within watersheds, and particularly the extent of development, are directly linked to the quantity and quality of water in downstream surface waters.

In the U.S. and throughout the world, fresh water resources are becoming increasingly scarce, due in part to mismanagement. Water often is managed simultaneously for public water supply, flood control, irrigation supply, hydroelectric power generation, and wastewater disposal, without considering cumulative impacts on its quantity and quality at any one time and location.

We need a different approach to managing our water resources, based on comprehensive strategies to protect the quantity and quality of water as it cycles through the environment. Here, we'll look at stormwater runoff management as one vital piece of this larger task.

.

Slide 4



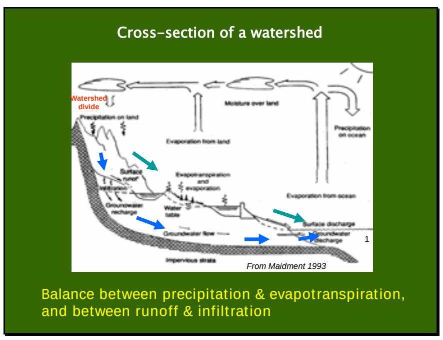

The first key step to successful water protection is identifying the proper spatial scale for management. Historically, water has been managed based on political boundaries by towns, states, or countries. However, water flow doesn't follow political boundaries, so watershed boundaries provide a better framework for comprehensive management.

A ***watershed*** is the region of land draining into a stream, river, pond, lake, or other body of water. One way to think of a watershed is to imagine a bowl. A lake or other body of water is at the bottom of the bowl. The sides of the bowl represent the land draining into the lake, and the top edge is the divide between this watershed and the next.

Slide 5


Every land area, regardless its location, is part of a watershed. As you might imagine, watersheds vary widely. Some are hilly, and others are relatively flat. Some are forested, and others contain cities. Some cover vast areas of land, and others are much smaller. The headwaters of a small stream near the top of a mountain may have a watershed the size of several football fields. In contrast, the watershed of the Mississippi River covers about 40% of the lower 48 states!

Slide 6

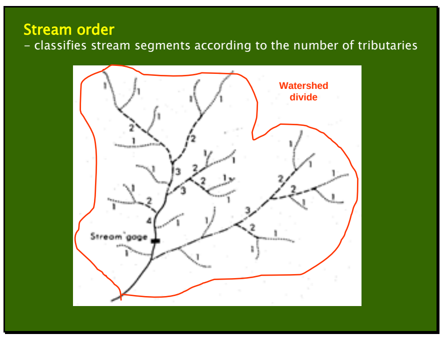



Water on Earth cycles between water vapor in the atmosphere and rain, snow, or other forms of precipitation. Some of the rainfall hitting land percolates into the soil, and some runs off into surface water bodies. Water vapor returns to the atmosphere through evaporation from land and water surfaces, along with evapotranspiration from plants. The watershed concept allows us to follow the flow of rain water as it moves through the watershed, and to understand what processes control the quantity and quality of water along the way.

This illustration shows a cross-section of a watershed. On the left is the lip of the bowl, or the watershed divide. After rainfall, runoff flows over land into streams, lakes, and other water bodies. Where the ground is permeable, some water infiltrates into the soil and moves deeper underground until it hits a hard layer such as bedrock. Groundwater forms where the pores in rock and soil fill up with water. It seeps in a downhill direction, eventually discharging into springs, streams, lakes, and other water bodies.

In each watershed, water hitting the land surface is divided into surface runoff and infiltration. The more water runs off, the less is available to recharge the groundwater.

Slide 7




Various systems exist for classifying stream segments. In the Strahler ordering system, the smallest segments of a stream that are visible and permanent (i.e. year-round -- denoted by a solid blue line on the U.S.G.S. 1:24,000 topographic quadrangles) are called 1st order. First-order streams have no tributaries; typically they are short and drain small areas at the high points of watersheds. Although first-order streams are small, collectively they make up about 75% of the total stream and river mileage in the U.S.

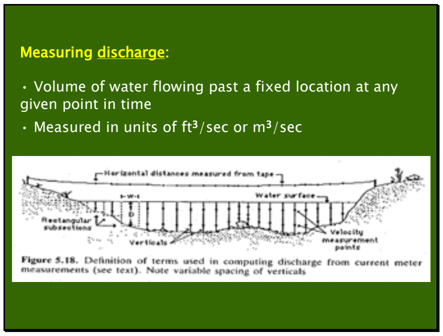
When two 1st order streams come together, they form a 2nd order stream. It is not until two 2nd order streams combine that they form a 3rd order stream (regardless of how many additional 1st order streams join along the way). And the confluence of two 3rd order streams form a 4th order stream.

Slide 8


Why does this matter? Knowing the order of a stream segment provides some useful information about its physical and ecological properties. 1st and 2nd order streams tend to be narrow and shallow. Typically they are heavily shaded by trees, keeping the water cool. With little light, growth of algae is limited. The aquatic food web is based instead on leaf litter from surrounding trees. These leaves provide food for a diverse and abundant range of aquatic invertebrates, which in turn become food for many fish and birds. First-order streams are more likely than downstream reaches to dry up during summer months. They tend to have steeper slopes, faster currents, and channels lined with boulders, rocks, and gravel. Unfortunately, few federal regulations protect our headwater stream systems, and people frequently replace the trees along the stream banks with lawns, crops, or pavement.

Farther downstream in higher order streams, the wider, deeper waters receive more sunlight. Phytoplankton and macrophytic plants grow well and provide habitat and food for aquatic organisms that are adapted to life in slower, warmer waters. These higher order stream reaches are likely to have flatter slopes, slower flows, and channels lined with sandy or silty sediments.

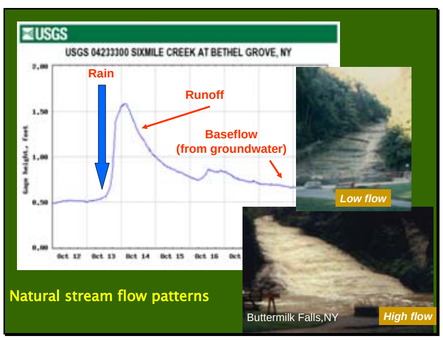
Slide 9




The volume of water flowing past a certain point over a designated period of time is called ***streamflow*** or ***discharge***. In metric units, it is reported in terms of cubic meters per second (m3/sec). In small mountain streams, the rate of flow may be under 1 m3/sec, compared with 17,000 m3/sec for the Mississippi River. The world's largest river, the Amazon River in Brazil, averages just over 200,000 m3/sec.

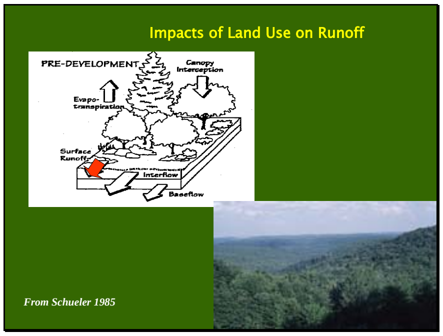
Streamflow can be determined by measuring water depth and flow velocity. By taking depth measurements at regular intervals across the stream, you will be able to calculate the cross-sectional area of the stream at that particular time. Once you measure the velocity of the flow, you will be able to multiple the area (m2) times the velocity (m/sec), to calculate the discharge (m3/sec).

Slide 10



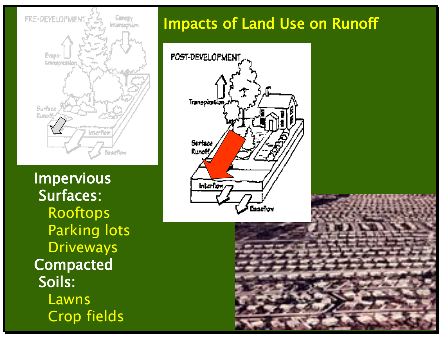

This is a ***hydrograph*** showing water level in Six Mile Creek, the stream that feeds the drinking water reservoir for the City of Ithaca. You see that water level rose from 0.5 ft to a peak of 1.55 feet following a rain event. What maintains streamflow between storms? Sometimes water will continue to flow in creeks and streams for days, weeks, or even months between rain events. This baseflow comes from groundwater that continually seeps out of the ground and into the stream. It is estimated that on average in the U.S., 52% of all the water flowing in our streams is contributed by groundwater.

Slide 11



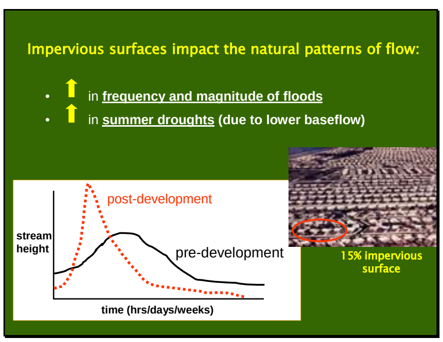

Imagine a stream flowing through a forest. As rain falls, much of the water that reaches the forest floor seeps into the ground and the rest trickles overland and drains into a stream. Gradually the streamflow increases, reaches a peak, and then drops back down to baseflow over the next few days.

Slide 12




Now imagine the same stream running through an area covered with parking lots, buildings, and roads. Given the same amount of rainfall, more water would drain immediately into the stream and less would percolate downward through the soil to become groundwater.

Slide 13




Land development results in soil compaction and increase in impervious surfaces including rooftops, parking lots, and roads. As a result, more of the water moves as surface runoff and less seeps into groundwater. As a result, there is an increase in the magnitude and frequency of flood events. Streamflow reaches a higher peak after storms, indicating higher flood levels, and floods occur more frequently because more water runs off after each storm rather than soaking into the ground.

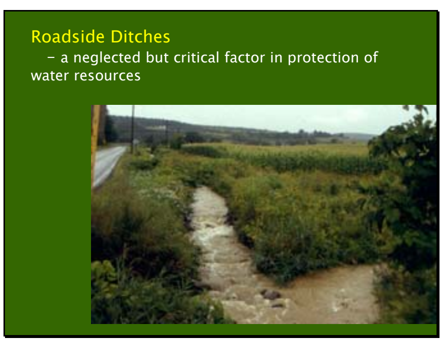
Another consequence of less water seeping into the ground is reduced recharge of groundwater supplies. This leads to an increase in summer droughts, with stream dry-outs and wells that run dry.

Studies indicate that such changes will begin to occur when there is as little as 15% impervious surface in a watershed.

Slide 14


Increased impervious surface area not only leads to larger and more frequent floods but also causes more erosion from stream banks, ditches, and any unprotected soils that the runoff flows across. Sedimentation destroys habitat for organisms that require rocky stream bottoms. In addition, lower baseflow levels result in degradation or elimination of stream habitat during dry periods.

Slide 15




Connecting impervious surfaces with natural streams, roadside ditches influence the sediment loads, hydrologic regime, and quality of surface runoff. However, the extent and types of ditches have not been mapped in most watersheds.

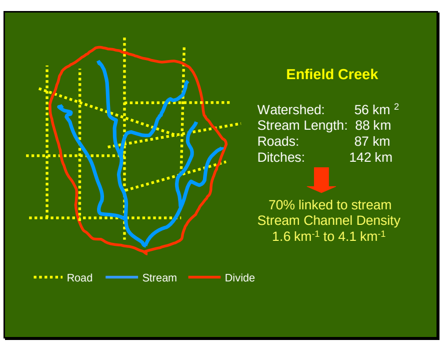
Slide 16


The people in charge of ditch construction and maintenance typically are town and county highway staff who are charged with keeping the roads clear and in good shape to maintain the flow of traffic. They are busy filling potholes, removing snow, and cleaning out ditches and rarely are included in discussions of water resource protection.

Slide 17


Problematically, ditches that most quickly remove runoff also produce the largest impacts on streams or other receiving waters.

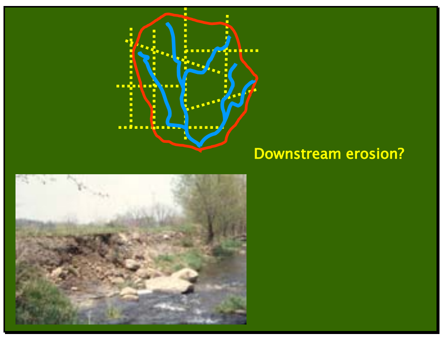
Slide 18




Cornell University scientists decided to investigate roadside ditches to determine their contributions of water, sediment, and other contaminants into our waterways. In 2005, they initiated research in three small watersheds, located in Enfield Creek, Six Mile Creek, (both draining into Cayuga Lake) and Doolittle Creek, which drains south into the Susquehanna River system.

Here are the results of the mapping of the Enfield Creek system. Ditches are a major extension to the natural stream channel system, and largely are connected in the 1st order, 2nd order streams and the ephemeral streams (e.g. those that dry out frequently) even further up in the watershed.

Slide 19

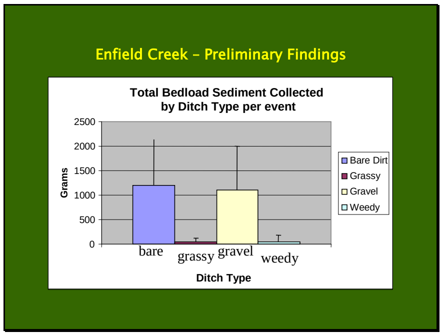



Since stream shape and stream profile are controlled naturally by the amount of water that flows in the stream and the amount of sediment that it carries, we predict that ditch inputs may be contributing to streambank erosion downstream. However we don't yet have enough data to answer this part.

Slide 20

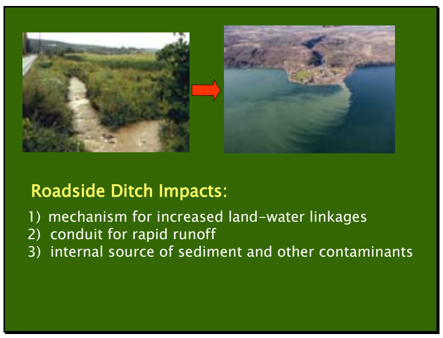

In-depth monitoring is quantifying the amounts of water, suspended sediment, dissolved chemicals, and bedload sediment that ditches are contributing to Doolittle Creek, near Candor, NY. Bedload pitfall traps capture the pebbles and gravel that are too heavy to move suspended in the water, but instead bounce and roll along the bottom.

Slide 21




This pilot research indicates that suspended sediment and bedload are significantly higher from ditches that have been scraped and left exposed than from vegetated ditches.

Slide 22




The pilot ditch research is showing that roadside ditches impact water resources in 3 major ways.

Slide 23


Based on our findings so far, we have begun outreach to town highway staff and town planners statewide. We have a set of recommendations that aim to reduce stormwater runoff and increase groundwater recharge.

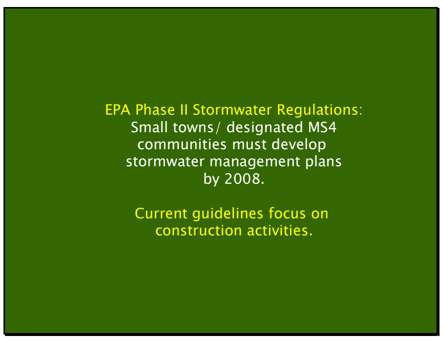
A primary recommendation is that town highway staff discontinue the practice of scraping ditches and leaving them exposed to erode during storm events. If ditches must be scraped, they should be hydroseeded with grass seed immediately afterwards to promote the growth of vegetation to hold the soil in place.

Slide 24


Another recommendation is to replace impervious surfaces with more porous ones wherever possible, for example by installing porous rather than impervious surfaces for parking lots.

Where impervious surfaces are necessary, it is not always necessary to have them drain into ditches. For example, when parking lots are built, drainage can be directed into infiltration basins or detention ponds so that the rainwater stays on-site and recharges the groundwater. Similarly, homeowners can direct the downspouts from house rooftops into rain gardens or low-lying depressions rather than having them drain into ditches.

Slide 25




In 2003 the federal government recognized the importance of trying to reduce stormwater runoff and enacted the Phase II Stormwater Regulations. These rules requires that small towns (population <100,000) by 2008 develop and implement stormwater management programs that include public education, monitoring, and construction site control. However, management and planning are largely directed towards control of construction activities and strategies to reduce or mitigate the extent of impervious surfaces, e.g. through the use of gravel driveways and permeable parking lots.

Improved ditch management is of particular importance now as thousands of towns nationwide are posed with the issue of developing programs to meet these Phase II EPA regulations. Understanding the contribution of roadside ditch systems to stream water quantity and quality is critical for successful control of stormwater runoff and improvement of the nation's waterways.