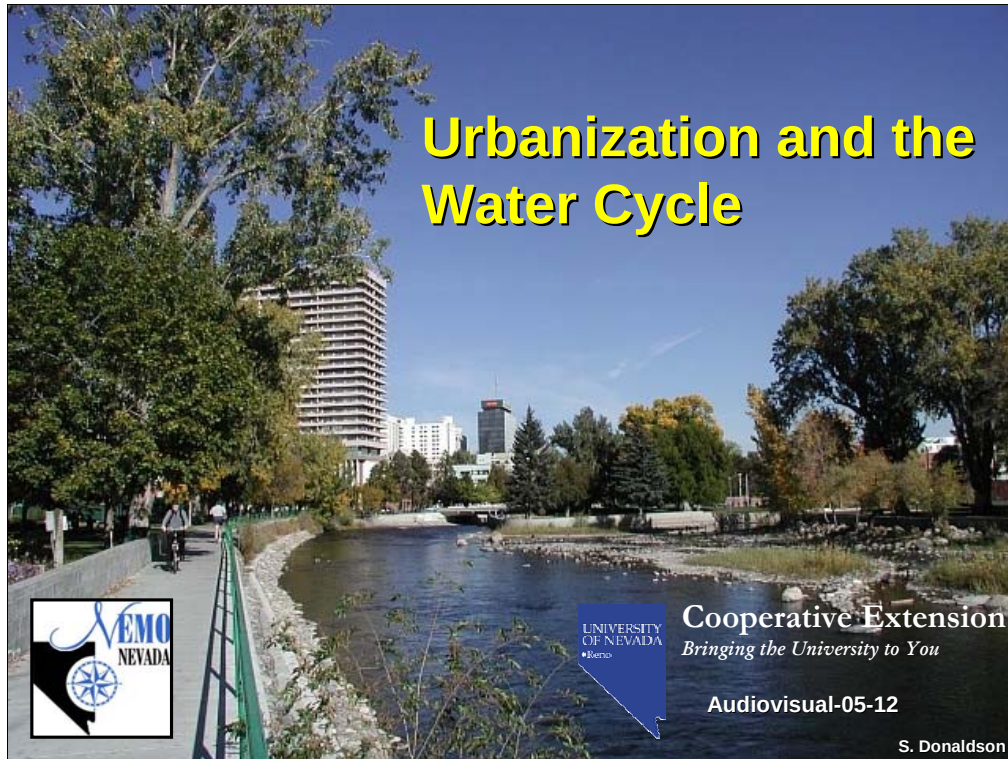




Urbanization and the Water Cycle

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University of Nevada Cooperative Extension Audiovisual-05-12

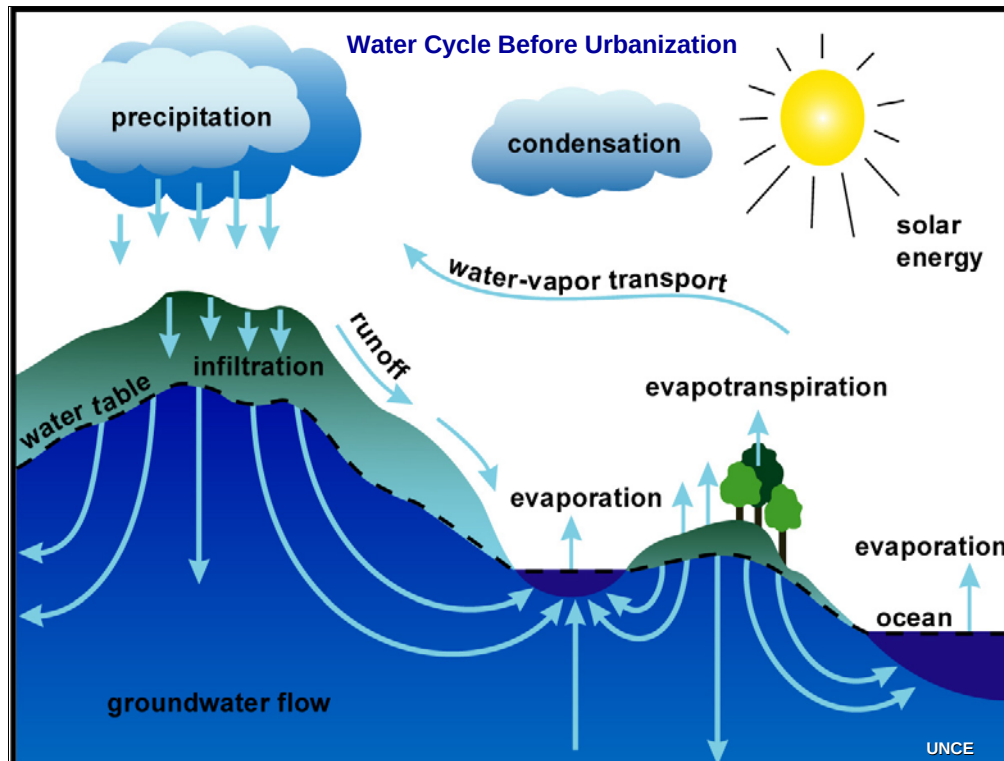
Portions of this presentation were adapted from Linking Land Use to Water Quality, NEMO Project, University of Connecticut Cooperative Extension System and Why Watersheds, Center for Watershed Protection, 1999.



NEMO stands for "Nonpoint Education for Municipal Officials."

What we'll be covering:

- The water cycle
- Infiltration and filtration
- Watersheds
- Naturally-occurring challenges
 - Closed basins
 - Desert soils
 - Precipitation patterns
- Alteration of the water cycle by development
- Impervious surfaces



The Water Cycle Before Urbanization

The hydrologic or water cycle transports water between earth's land, atmosphere, and oceans. The major processes moving water are evaporation, transpiration, condensation, and precipitation. Evaporation occurs when the sun's energy turns liquid water on the earth's surface into water vapor, which enters the atmosphere. Water vapor leaves plants in a process called transpiration. Together, these two processes are called evapotranspiration.

The water vapor in the atmosphere cools to form clouds (condensation). Through precipitation in the form of rain or snow, the water returns to earth.

Precipitation in the form of snow accumulates in the mountains, providing storage in the form of a snowpack that will slowly melt and release water in the spring and summer months.

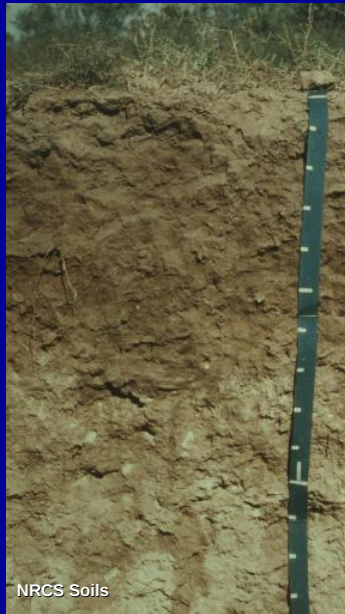
Some of the precipitation in the form of rain runs off land surfaces into rivers or lakes. While it's hard to believe, rivers contain only about 0.0001 percent and fresh water lakes only about 0.009 percent of all water on earth!

Rain also soaks into the ground (infiltrates) and replenishes the water stored in the soil. We call the subsurface water supply in the saturated zone below the water table groundwater, and it provides flow to rivers and oceans. Aquifers are formations containing groundwater in sufficient quantities to provide water to wells.

Groundwater accounts for about 0.61 percent of the earth's water, while the oceans contain most of the earth's water, or about 97.2 percent. Of the fresh water supply on earth, 78 percent is tied up in polar ice caps and snow, leaving only a minute fraction available for use by people. Of the available fresh water, 98 percent is in the form of groundwater, while the remaining 2 percent is in the form of surface water. Because our usable water supply is so limited, it's vitally important to protect its quality.

There is no "new" water ever produced on the earth. The water we use today has been in existence for billions of years, and may once have provided a drink for a dinosaur. The hydrologic cycle continually renews and refreshes our finite water supplies.

Infiltration and water filtration



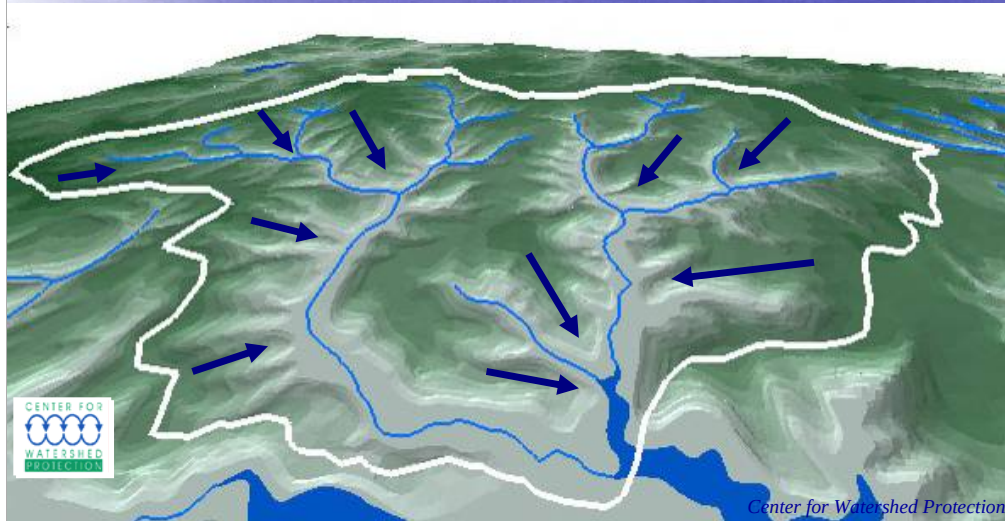
Infiltration is the downward movement of water from the land surface into the subsoil. Water filtration occurs during infiltration. This process is an essential component in the natural processing of water.

Natural processing involves:

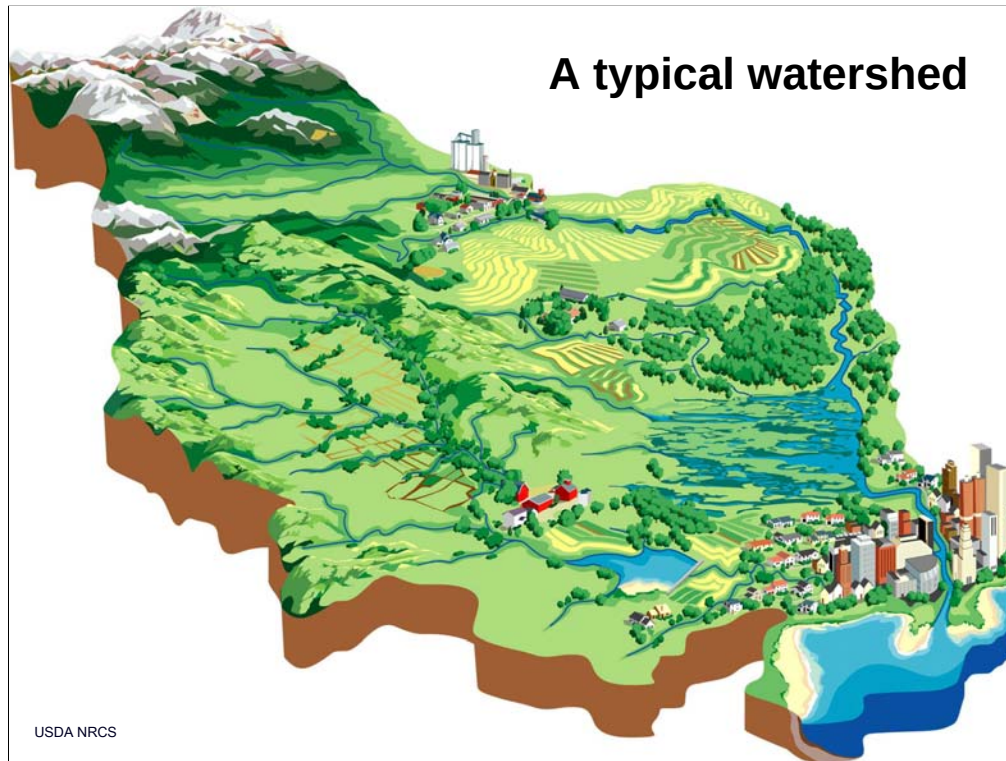
- Filtering of sediment and debris
- Adsorption and/or uptake of nutrients, pathogens and some toxic chemicals by plants and soil microbes

What is a watershed?

A watershed is the area of land that drains to a particular point along a stream



A watershed can be defined as the area of land that drains to a particular point along a stream. Each stream has its own watershed. Topography is the key element affecting this area of land. The boundary of a watershed is defined by the highest elevations surrounding the stream. A drop of water falling outside of the boundary will drain to a different watershed.



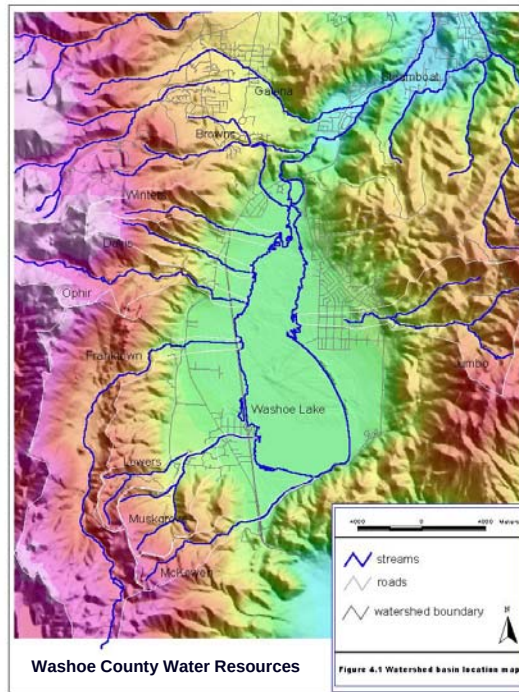
The hydrologic cycle replenishes the water in watersheds.

Homes, farms, ranches, forests, small towns, big cities and more can make up watersheds. Some watersheds cross county, state, and even international borders. Some are millions of square miles, others are just a few acres. Just as creeks drain into rivers, watersheds are nearly always part of a larger watershed. This graphic shows a typical watershed, in which snow falls in the mountains and is stored during the winter, similar to what happens in the Sierra.

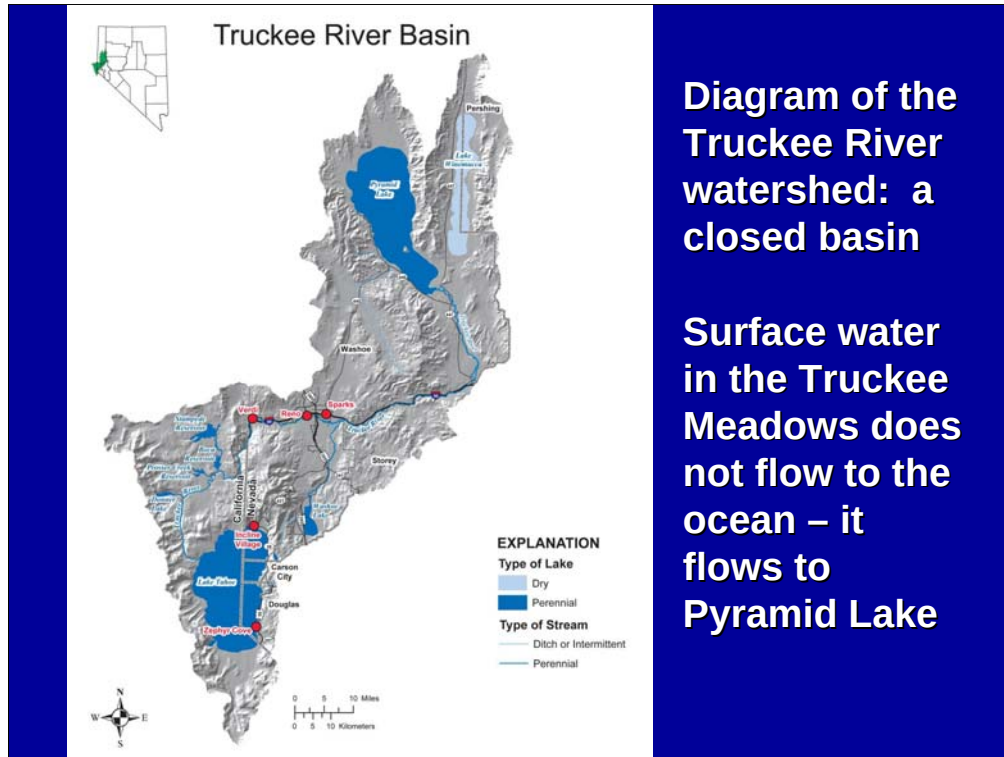
In this graphic, you can imagine the snowmelt flowing into the Truckee River past the skyscrapers of Truckee (!), through forested areas, past agricultural fields, and through Reno and Sparks on its way to Pyramid Lake. Large watersheds such as the Truckee River watershed contain many subwatersheds which drain to tributaries such as Steamboat Creek.

Naturally occurring challenges

- Closed basins
- Precipitation
- Soils



Because we live in the semi-arid environment of the Great Basin, we face a number of natural challenges that can impact our water quality, including pollutant retention within the closed basins, infrequent precipitation events, and soils that often repel moisture.

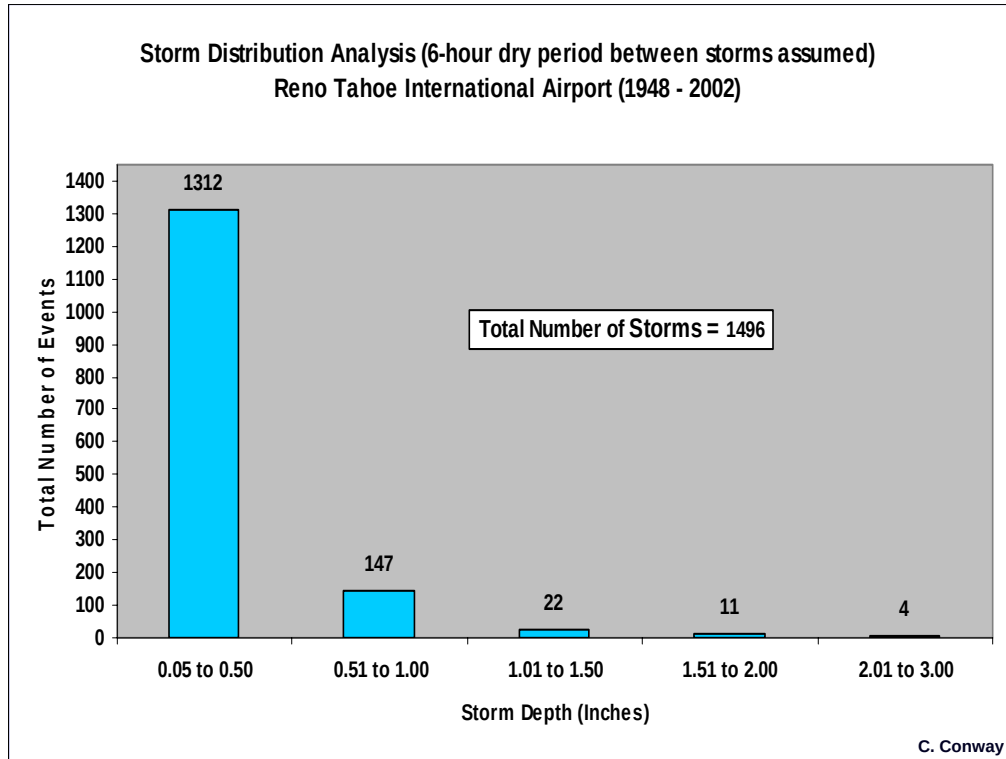


The Truckee River begins at Lake Tahoe and flows through Reno and Sparks as it travels to Pyramid Lake. Water also enters the river from streams and agricultural ditches. The largest point source to the Truckee River, the Truckee Meadows Water Reclamation Facility (TMWRF), returns treated wastewater to the Truckee River via Steamboat Creek. Water from the Truckee River does not flow to the ocean, since the Truckee River watershed is a closed basin.

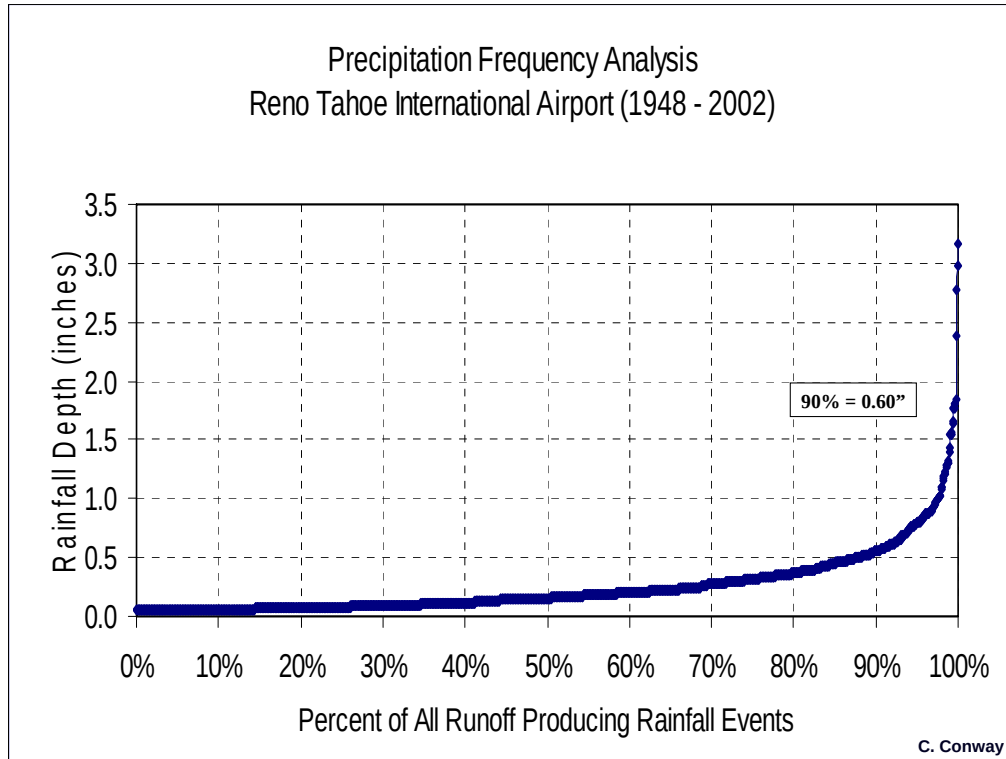
What does “closed basin” mean?

The Great Basin is a unique watershed, in that all water remains within the basin rather than eventually draining to an ocean. Water leaves Lake Tahoe via the Truckee River and flows into Pyramid Lake, staying entirely within the basin. There are many smaller closed subbasins within the Truckee Meadows, including Lemmon Valley, Spanish Springs, and Cold Springs. **The pollution entering a closed basin stays within the closed basin.** Our actions affect downstream users as well as our own communities.

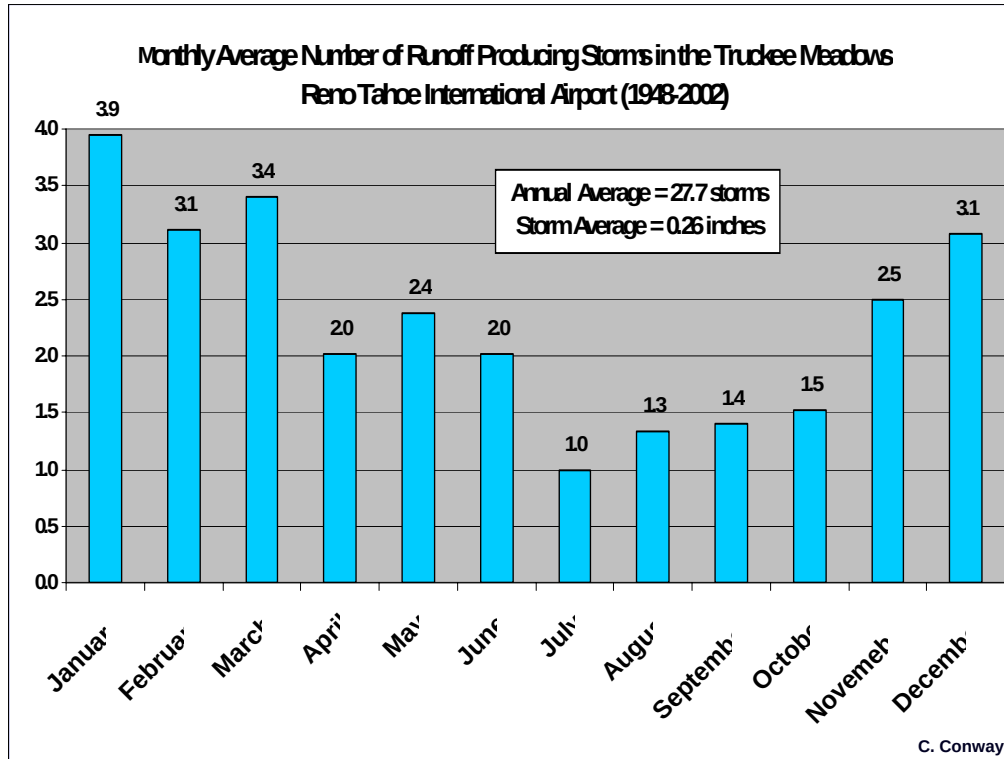
Truckee River tributary water quality historically has been good, with a few exceptions. As growth proceeds into upper watershed areas along tributaries, however, road and development construction affects tributary form and function. Buffer areas along streams that improve water quality are impaired by construction activities. Streams become confined and no longer function naturally, interfering with their ability to protect water quality. Flows decrease as water is diverted to meet the needs of growth, and remaining in-stream flows become a source of concentrated pollutants to receiving waters. Watershed planning is essential to protect these critical elements of our community water system.



This is a bar graph, showing the number of storms in the Truckee Meadows between 1948 and 2002 versus the measured precipitation of the storm. As you can see, the bulk of the storms in the Truckee Meadows produce less than one-half inch of precipitation.



Here is another graph showing the same data – 90 percent of the rainfall events in the Truckee Meadows produce less than 0.60 inches of precipitation.



While the storms are not normally very large in size, the time between storms can be very significant. This graph shows the average number of storm water runoff-producing storms in the Truckee Meadows for each month of the year. There are few storms during the summer months. It is not uncommon for a lag time of 1 to 4 months between storms to occur. During this time, pollutants are accumulating. The first storm water runoff event after a long dry spell can have quite high concentrations of pollutants!

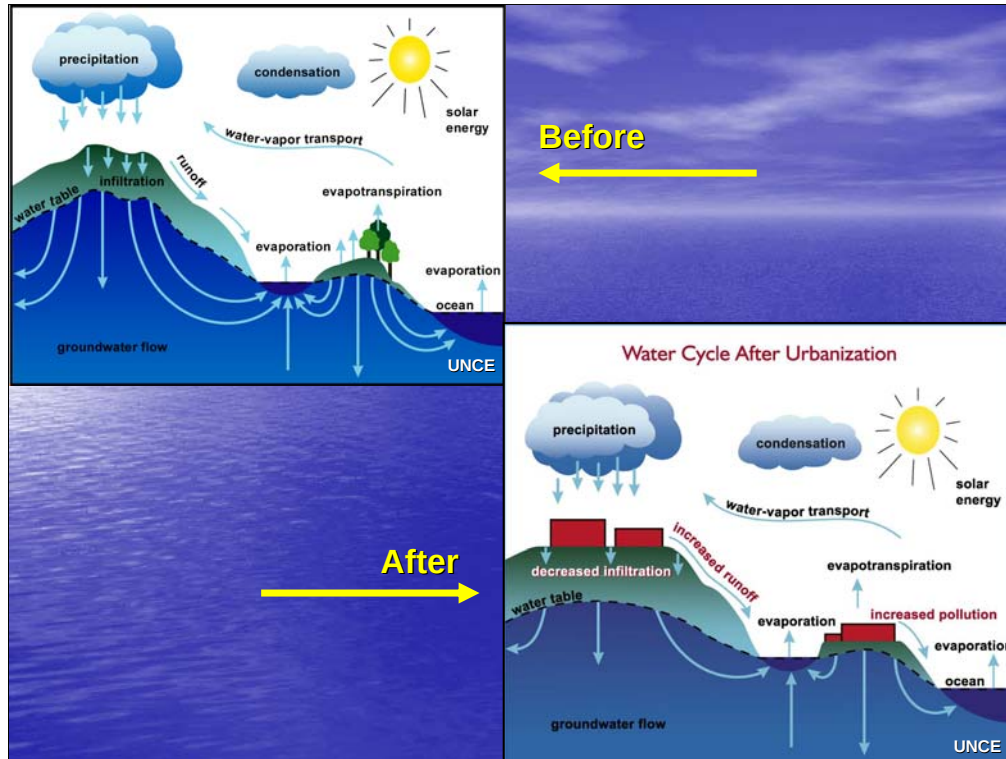


In addition to closed basins and infrequent precipitation, our soils also present us with some unique challenges. Many desert soils are somewhat impermeable or resistant to water infiltration. When they are very dry, they may even behave hydrophobically – that is, they almost seem to repel water. Although it seems unlikely, surface runoff of storm water may actually increase in these dry soils. As the water is shed across the soil surface, there is little opportunity for natural pollutant uptake and decontamination by the soil. The effect increases when there is a lack of vegetative cover. Additionally, the storm water runoff may remove some of the soil and carry it, and any attached pollutants, to the nearest water body.

Soils that have been burned during a wildfire are often hydrophobic for a year or longer after the fire.



We also face a number of other naturally occurring challenges, including drought, catastrophic fires that leave major areas of the land denuded and primed for erosion during thunderstorms, and steep slopes that are particularly unstable when vegetation is removed. During major storm events, excessive soil erosion may occur. Storm water runoff carrying soil particles along with accumulated surface pollutants causes an influx of water high in sediment, nutrients, and other pollutants into local water bodies. This can be especially challenging for water treatment plants.



In addition to naturally-occurring challenges, our current rapid rate of growth and development also contributes to water pollution. How does urbanization affect the water cycle? When we develop within a watershed the increase in impervious surfaces, including rooftops and pavement (roads, driveways, and parking lots), decreases the amount of water that soaks into the ground, or infiltrates, and increases the amount of runoff. The impervious surfaces collect and accumulate pollutants leaked from vehicles, or deposited from the atmosphere. The runoff water carries pollutants directly into water bodies. Because there is less infiltration, storm water peak flows are larger and arrive earlier, increasing the magnitude of urban flood events.

Alteration of the water cycle by development results in:

- Increased volume and velocity of runoff
- Increased frequency and severity of flooding
- Peak storm flow many times greater than in undeveloped basins
- Decreased natural runoff storage capacity in vegetation, wetlands, and soils
- Loss of habitat
- Decreased water quality in tributary streams resulting in reduced dilution in receiving waters
- Increased thermal stress or temperature pollution



Effects on the water cycle are not limited to surface water. Paving may alter the location of recharge, or replenishment of groundwater supplies, restricting it to unpaved areas. If infiltration is decreased sufficiently, groundwater levels may decline, affecting streamflows during dry weather periods. There are concerns that increases in impervious cover may also contribute to dropping of water tables and subsequent well failures.

Impervious surfaces

Materials such as concrete, asphalt, roofing, and compacted soil that prevent percolation of runoff into the ground

Center for Watershed Protection

It's common to think of impervious surfaces in terms of construction, including pavement, roofs, parking lots, etc. Don't forget that compacted soils can also act as impervious surfaces.

Impervious surfaces:

- Indicate intensive land uses that cause pollution
- Inhibit recharge of groundwater
- Prevent natural processing of pollutants by soil and plants
- Provide a surface for accumulation of pollutants
- Provide an express route for pollutants to waterways

S. Donaldson

The impervious surface is not necessarily a pollutant itself, but it transports pollutants, impedes infiltration, increases the volume of runoff generated, transfers heat to the runoff, and indicates more intensive and polluting land uses.

There are many forms of impervious cover in the urban landscape



Impervious cover is any surface in an urban watershed that does not allow water to soak into the ground. Forms of impervious cover include roads, parking lots, buildings, sidewalks, and driveways.

Stream quality is related to impervious cover



This slide illustrates how stream quality, as measured by bank stability, water quality and available habitat, deteriorates when impervious cover increases in a watershed.

Watersheds with less than 5% impervious cover have stable stream banks, good water quality and provide a variety of habitat.

The second picture shows a stream that has about 10% impervious cover in its watershed. While relatively stable, the stream shows some signs of erosion.

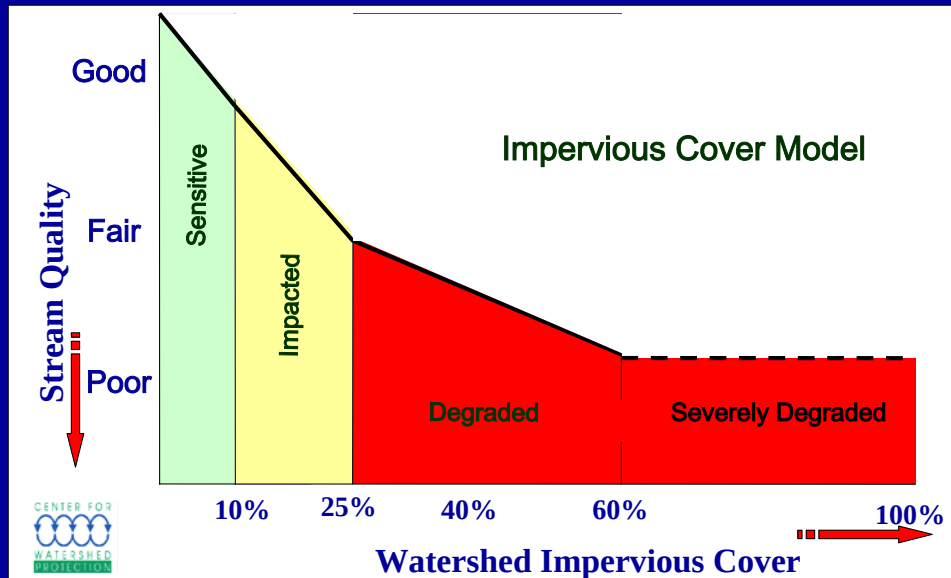
The third stream has about 20% impervious cover in its watershed. Stream erosion has become serious. Note that the amount of erosion has been so great that the drain pipe that once rested on the stream bottom and within the stream bank is now 2 feet above the water and protrudes nearly 6 feet from the stream bank.

The fourth picture shows a stream with about 30% impervious cover. The stream channel has “blown out” and is about five times wider than it was before development. The water quality is poor and there is very little suitable habitat for aquatic life.

The last picture shows a stream that has 65% impervious cover in its watershed. Stream erosion has become such a problem that the stream was channelized with concrete. The concrete provides no habitat to support aquatic life.

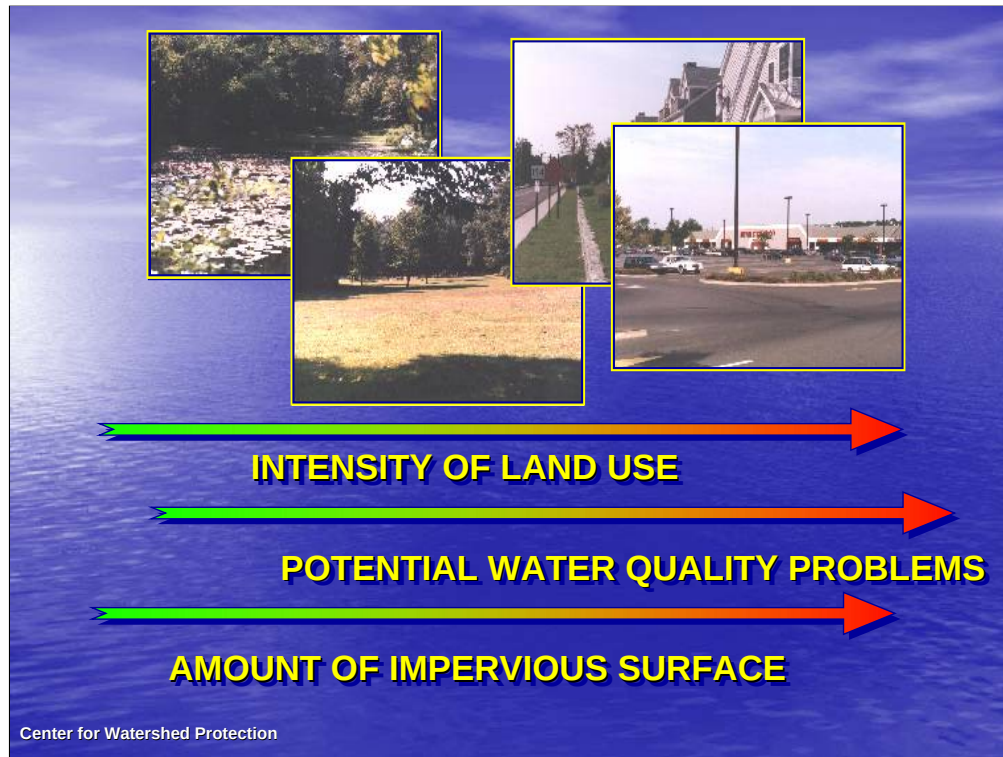
It is important to note that these impacts generally apply to headwater streams, which are composed of first- and second-order streams. Since these small headwater streams comprise about 75% of all the river and stream mileage in the contiguous U.S., their proper management and protection is essential to the protection of our larger lakes, rivers, and estuaries.

Relationship between impervious cover and stream quality



As mentioned in the previous section, water that can not soak into the ground flows over the land surface, eventually ending up in a waterway. The amount of impervious surface in a watershed directly affects the amount of runoff, influencing the stream quality.

This graph shows that as the percentage of impervious cover increases, the stream quality decreases. A stream receiving runoff from a watershed that is composed of less than 10% impervious cover is considered to be "sensitive." This stream is in good shape. At 10% impervious cover, stream quality really begins to decline. Between 10 and 25%, streams are categorized as "impacted." At levels between 25% and 60% streams are considered "damaged," and at more than 60% impervious cover, streams are considered "severely damaged."



As we move to more intense land use, potential water quality problems increase. The common thread throughout is the increasing amount of impervious cover in the watershed. By making wise choices during the development process, the impacts can be minimized and our future water supply protected.