Let’s Talk Water – Alluvial Basins

By Dr. Mike Strobel

In earlier discussions of the hydrogeology of eastern Nevada in “Let’s Talk Water” articles, we have greatly simplified the conditions. For the most part, the hydrogeology was broken into bedrock, which consists of either carbonate rocks (such as limestone) or volcanic rocks, and alluvial deposits that occupy the basins between mountain ranges. The reality is that the alluvial deposits are complex and can greatly affect ground-water movement.

Alluvial deposits, also referred to as alluvium, are sediments such as gravel, sand, silt, and clay, which have been transported by water flowing off of the mountains. When the basin and range originally formed, some rock blocks were uplifted, forming the mountain ranges, whereas other blocks were down dropped, forming the basins. Earlier “Let’s Talk Water” articles explain the geology of eastern Nevada in greater detail.

Following the formation of the mountains and basins, erosion began to affect the rocks. Geologists refer to erosion as weathering and it consists of breaking up of rock by various processes, such as frost wedging (where water gets into cracks in the rocks and then freezes, which makes the water expand and break up the rock), water erosion from rain and snowmelt, wind erosion, landslides and debris flows, plant roots growing into cracks in the rocks and causing spreading of the openings, and many other processes.

Once the rock has been weathered, then gravity and runoff of rainfall and snow melt carry the rock debris downslope to valleys and canyons. Larger streams in these valleys then can carry the rock debris down the mountains and out onto the basins. When the streams are confined by the steep walls of the mountain valleys, the water moves quickly and can carry a lot of sediment. Once the streams flow out onto the basins, then they spread out and lose their energy, resulting in the sediment loads being deposited. This is why we tend to find the larger sediments, such as boulders and gravels, near the mouths of the valleys and canyons, and the finer sediments further out on the basin floor. As the energy in the streams decrease, the ability to transport heavier sediments also decreases.

Because the streams are confined in these valleys while flowing out of the mountains and then spread out as they flow onto the basins, the sediments get deposited in a triangular fashion with the top of the triangle at the mouth of the valley and the base of the triangle onto the basin. This is referred to as an alluvial fan, because it has the shape of a fan. In a similar manner, if the fan occurred into a water body, such as a lake or ocean, instead of the basin floor, then it would be called a delta. If you look at the Mississippi or Nile Deltas, you will see these also have a similar triangular shape.

Many of the basins in Nevada are covered in numerous and overlapping alluvial fans. Over time, these fans have filled the basins with sediments transported from the mountains. And because the fans tend to have coarser sediments near where the streams enter the valleys and finer further away, many basins have finer sediments near the centers of the basins and coarser sediments near the margins. As one can imagine, the difference in sediment sizes can affect the ability of water to move through the basins. Larger sediments tend to have higher hydraulic conductivities whereas finer sediments tend to have smaller hydraulic conductivities. The ability of the sediments to store water also is affected by the grain size (porosity).

This all seems simple enough, but we also need to consider that most streamflow from the mountains to the basins is not continuous and generally occurs following rainfall and snowmelt. Therefore, the transport of sediments to the basins occurs in pulses. Plus, each rainfall and snowmelt event is different in magnitude and sometimes the streamflow is small and other times there are “gully-washers” or significant floods. Because of this, the size and distance sediments are transported on the basin floor is different with each event.

The result of the different depositional events onto the basin floor is a layering of the alluvial deposits, where coarse and fine sediments may alternate in a series of horizontal beds. This really can alter how ground water moves vertically through the alluvium.

During the times between alluvial deposition, wind action can transport and deposit fine-grained sediments around the basins. Wind-deposited sediments are referred to as eolian deposits (such as sand dunes). Soils also can form on the basin floors. Alluvial deposits interbedded with eolian deposits and soils can make vertical ground-water movement complex.

Lakes that form in some basins during wetter and cooler times can deposit layers of clay and silt (and salt when the water evaporates) in the basins. Lake deposits are referred to as lacustrine sediments. These clay and silt deposits act as local confining units to the alluvial sediments and can greatly restrict ground-water movement. During the Pleistocene Epoch (the last ice age ending around 8-9 thousand years ago) many of the basins in Nevada were covered by huge lakes. This is why many archeological sites focused on early humans in Nevada are found around the edges of basins…they lived along the shores of the lakes. These huge lakes left thick clay and silt deposits in many basins, causing complex conditions for the hydrogeology of the basin sediments.

Rivers that flow across many basins also can remove, transport, and deposit sediments. These are referred to as fluvial deposits. Meandering rivers can incise channels across the basins. As these rivers continue to meander and change course, the abandoned channels can become filled with sediments. These “cut and fill” features can cause localized variations in ground-water flow conditions. In some places, filled channels, if filled with gravel, can be considered good local aquifers. In other areas, if the channels are filled with fine sediments, these can inhibit ground water movement.

There are many other geologic conditions that can affect the hydrogeology of alluvial basins, but it is clear from just these examples that basins in Nevada are typically quite complex. Hydrogeologists use various tools, such as drilling into the sediments and collecting cores, geophysical techniques such as ground-penetrating radar and seismic profiles, and geologic mapping to try and identify where these variations in the alluvium occur. It's important to understand the conditions in the alluvial basins in order to better evaluate the overall hydrogeology of the basin and range system.

If you have any question about alluvial basins or any other water topic, please write to me in care of the Ely Times or at mstrobel@usgs.gov. Next week, we will discuss evapotranspiration.