Groundwater-Surface Water Interactions
Along the Truckee and Carson Rivers
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Introduction
In Nevada, our water supply comes from two main sources: groundwater aquifers, and surface water from streams and rivers. These two sources provide vital water for communities, natural ecosystems, agriculture and wildlife.

These two water sources often seem to be separate, and they are usually managed separately. However, ground and surface water are really two interconnected parts of the same freshwater resource. Water can actually pass back and forth between surface and groundwater over space and time.

Through the process known as the hydrologic cycle, rain and melting snow infiltrate into the soil and move downward to replenish or recharge groundwater in an aquifer (a body of permeable rock or sediment that stores and transmits water). The seepage of groundwater into a stream or its emergence from a spring is known as discharge. When all of the pores in an unconfined aquifer are filled or saturated with water, the upper level of this saturated zone is called the water table.

If you excavate a hole and dig beneath the water table, the hole will fill with water to the level of the water table. If the water table intersects the ground surface on a slope, water may also seep out of the ground and become surface water. Such groundwater discharge is easy to see in springs. Groundwater discharge is somewhat harder to see when it occurs in the channels of streams and rivers. In fact, in the headwaters of many rivers, most stream flow during dry seasons comes from groundwater discharge; this is known as the stream's baseflow. Portions of the stream where inflow from groundwater occurs are also known as gaining or upwelling reaches.

On the other hand, if the level of the water table adjacent to a stream is lower than the surface of the stream, water can leak out of the stream and recharge the groundwater. This occurs on losing reaches of the stream, where the water down-
wells into the bed. On many streams and rivers, losing and gaining reaches may alternate as the stream meanders or goes over slight drops or riffles. In these areas, water can flow down through the streambed sediments, only to return as upwelling to the bottom of the channel further downstream. The area of the stream bed and stream banks where this interaction between surface and groundwater occurs is known as the hyporheic zone. Downwelling and upwelling areas of the stream can occur at various spatial scales, such as locally on a river’s bend, or on the broader scale of a river valley as it enters a canyon or cuts across floodplain features (Stanford and Ward 1993).

Because water resources are so precious, it is important for planners and government officials to understand the interactions of groundwater and surface water. Each water source can replenish the other, and sustained depletion of one resource can result in depletion of the other. Surface water containing pollutants can easily pass into the groundwater - and vice versa - in the hyporheic zone. The linkages between groundwater and surface water are important to the quality and quantity of our water supply, the integrity of our aquatic and riparian (streamside) habitats, and the ability of our river banks to store water during high flows to prevent or reduce flooding of our communities.

Implications for Water Quantity

It is generally agreed that human consumption should not use more groundwater each year than is replenished by the recharge to aquifers by annual rainfall and snowmelt (Dunne and Leopold, 1978). At the same time, the total amount of water available from surface water each year varies greatly with annual changes in total precipitation. In drought years, total river flow and recharge to groundwater are both diminished.

Some communities such as Reno and Carson City use both surface and groundwater for their municipal and industrial water uses. As communities grow, it becomes critically important for water managers to know how much surface and groundwater is available and how much is lost to evaporation or consumptive use. In order to characterize the total water supply, hydrologists estimate a water budget for the watershed.

A simple water budget for a portion of a watershed can be generalized as follows, using the Carson Valley as an example. Water enters the valley as rain and snow and from surrounding mountains as both stream flow and groundwater flow. Municipal and household water comes from groundwater wells throughout the valley. Irrigation water is diverted or pumped directly from the Carson River or from agricultural wells. Water exits the valley either as surface water passing over Mexican Dam or as water evaporated to the atmosphere (Maurer and Berger 2007).

If we assume that the amount of groundwater stored in valley aquifers remains constant (a management goal), then the amount withdrawn from wells each year should not exceed annual groundwater recharge by precipitation. To determine the water budget, water managers must determine how much groundwater contributes to streamflow. Water-supply engineers must be able to estimate how much water can be pumped from wells without causing significant
changes to water-table depth or groundwater discharge to the Carson River. The water budget can become complex, because it also requires information regarding the agricultural use (diversions, returns and consumption) and the amount of evaporation and evapotranspiration.

How Groundwater Affects Stream Water Quality

Exchange between surface and groundwater systems provides benefits for overall water quality. During Nevada’s hot, dry summers, the river water is warmed by the sun as it flows out of watersheds originating in the Sierra. Since water is also diverted from rivers into canals for agricultural use, valley rivers often have very little water in their channels during summer and fall. This results in longer residence times for the water at shallower depths in bright sunlight, thereby increasing water temperatures in summer. Groundwater inflow can augment stream flow and moderate stream water temperature by providing water at nearly constant temperatures. Groundwater is often cooler than surface water, and cooler water can hold more dissolved oxygen, which is needed by trout and other fish.

Water quality can be improved by chemical and biological filtering of organic and inorganic pollutants in the hyporheic zone. Nutrients discharged into the stream water can be consumed by microbes in the stream bed, and these microbes become food for subsurface aquatic insects (benthic macroinvertebrates). Similarly, stream contaminants such as metals may enter the food chain. Dissolved minerals and metals may also precipitate out of stream water within the hyporheic zone, and can be biodegraded by the diverse bacteria and animal life living there.

The Aquatic Habitat within the Hyporheic Zone

The hyporheic zone provides a diverse habitat for many different types of aquatic organisms and is an important contributor to biological communities in the food web. Microbes, bacteria, algae, macroinvertebrates and fish all contribute to the biodiversity of a river. In a natural balance, aquatic communities provide important ecosystem services and can be used as stress indicators. If organisms become stressed to the point where conditions are uninhabitable, stream biodiversity decreases. Conversely, maintaining a river channel that is well-connected with its flood plain and hyporheic zone typically enhances aquatic diversity. Because of its aesthetic value and fish and wildlife habitat, such a channel can also promote high property values for adjoining landowners.

The hyporheic zone is highly controlled by the conditions in the river. When oxygenated river water flows into the hyporheic zone, it transports dissolved oxygen needed by the macroinvertebrates and other creatures living in stream gravels. These small creatures, especially caddis flies, stoneflies, mayflies and dragonflies, provide food for trout and water birds. Hyporheic flow can also flush or clean stream gravels of mucky sediment and decaying matter, making the substrate suitable for deposition of fish eggs and growth of the embryos of trout. If a river is affected by erosion and nutrients, the streambed can be covered with fine sediment or dense algae, thus negatively impacting the aquatic communities that typically dwell there.

Functions of the Hyporheic Zone during Flood Conditions

Every few years, a large Sierra storm or the rapid melting of snow causes a sudden increase in the volume of flow to valley streams and rivers. If the river level rises higher than the adjacent groundwater table, river water will enter the river banks as bank storage. This bank storage lowers the amount of water in the river, and can
reduce the risk of flooding of nearby communities.

If the river rises over its banks and spreads across a natural undeveloped floodplain, the flood water will recharge groundwater throughout the flooded area. This allows the infiltrating water to be stored for later use by riparian vegetation. In time, when the flows in the channel decrease, the water can be released from bank storage back into the river.

**Hyporheic Research on the Truckee and Carson Rivers**

Scientists from University of Nevada, Reno, (UNR) and the Desert Research Institute (DRI) are conducting research on groundwater-surface water exchange on the Truckee and Carson rivers. The goal of the research is to better understand the influences of hyporheic exchanges on conditions in the river bed and the adjacent floodplain. The researchers have collected aerial images using heat-sensing cameras to help identify locations of groundwater influence. They are also using variations in water level and temperature as a tool to track the movement of water through the rivers and the floodplain. The scientists are evaluating the extent to which the distribution of aquatic life (such as plants, insects and fish) may be influenced by these exchanges between ground and surface water. Findings from the scientific studies will contribute to a better understanding of how the river ecosystems function, which will in turn allow them to be managed more effectively to sustain the aquatic habitat, biodiversity and flow volume.
removing meanders can have negative consequences, including downcutting of the channel and reduction of the amount of water exchange between riparian areas and the hyporheic zone. These changes can affect the river’s ability to reduce nutrient concentrations and to moderate flooding downstream.

Rivers are dynamic. They are in a constant state of change that varies from season to season and from year to year. By understanding the importance of natural river processes and hyporheic exchange, river managers can protect and use the hyporheic zone to maintain a healthy ecosystem while still meeting the water needs of human users.

References

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