# Clean and Healthy Rivers: Critical Resources for a Sustainable Water Supply

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In developing our water resources, we often forget the importance of maintaining the natural systems that provide us with our water. By doing so, we can lose or degrade the most efficient and cost effective water management tool available to us to maintain a sustainable water supply. To protect the surface water resources in New Mexico for future use, it is necessary to understand the functions and services provided by the healthy river and how the loss of function in the impaired river leads to a subsequent loss in services. By examining threats to our rivers from poor management, we can provide the context to develop approaches to maintain and restore our rivers in the future.

All healthy rivers have several basic functions. Rivers transport water and sediment, mitigate flooding, and recharge aquifers. While rivers take a variety of forms, there are common geomorphological characteristics. With minor differences, all natural rivers have either a meandering pattern or step-pool form, a floodplain, a riparian corridor, and an associated hyporheic zone. The hyporheic zone is the least understood of these characteristics and relates to subsurface flow under and adjacent to the river. Depending on the hydraulic head differences between surface and subsurface flows, water may flow into the hyporheic zone or back into the river. The exchange of water between surface and subsurface flows is critical for nutrient and oxygen exchange, maintaining base flow, and maintaining the shallow groundwater table.

In the healthy river, these common geomorphological characteristics provide a host of services. These include: mitigating flooding; storing water by maintaining the shallow groundwater table; providing abundant natural primary production in the riparian area; mitigating pollution; providing water for recreational, municipal, industrial and agricultural use; and providing aquatic and terrestrial habitat. Overbank flooding is the driver for many of these services. When a river reaches flood stage, water overflows the banks onto the floodplain mitigating the impacts from flooding by dissipating energy from floodwaters and reducing flood volume downstream. Floodwaters also irrigate the floodplain and infiltrate into the ground recharging the shallow groundwater table. The riparian corridor provides structure and stabilizes the channel and adjacent floodplain reducing erosion. Riparian vegetation also helps mitigate the impacts from flooding by slowing floodwaters and further dissipating flood energy. In-stream biogeochemical processes provide some pollutant mitigation. Further pollutant mitigation occurs during overbank flooding by filtering pollutants as floodwaters infiltrate into the floodplain. Figure 1 shows Jaramillo Creek as it flows through a wet meadow in the Valle Caldera National Preserve. The creek maintains the ability to mitigate the impacts from flooding, store water and filter pollutants on the adjacent floodplain, maintain base flow, maintain productive grasslands, provide aquatic and terrestrial habitat, and provide excellent fishing opportunities. Riparian areas are also one of the most highly productive areas on the landscape providing forage and habitat for both livestock and wildlife. The combined effects of these services provide healthy and clean water for recreational, municipal, industrial, and agricultural use. Dr. Paul Bauer, Associate Director of the New Mexico Bureau of Geology and Mineral Resources at New Mexico Tech, summed it up well in his book entitled The Rio Grande: A River Guide to the Geology and Landscapes of Northern New Mexico (Bauer 2011):

> *Rivers are essential to life and lifestyle. They are critical habitat for the vast biodiversity of the planet. They recharge aquifers, nourish floodplains and farmland, create swamps, drain swamps, dilute natural and human pollution, and transport sediments and nutrients into bays estuaries, deltas, and oceans. Rivers provide us with drinking water, crop irrigation, navigation, food, hydroelectric power, spiritual fulfillment, and many other uses – including of course, recreation.*

The river with geomorphological impairment can lose one or more functions of the healthy river. For purposes of this discussion, the relevant impairments are all related to sediment transport (sediment regime) by one or all of the following: aggradation, degradation, bank destabilization, or the loss of floodplain, and associated incision. Aggradation can occur from a change in sediment supply that leads to a depositional sediment regime as a result of events such as increased runoff and subsequent upland erosion following wildfire, increased in-stream erosion upstream of the aggradation area, and increased erosion in tributary watersheds. The result is seen in the formation of side bars, mid-channel bars, channel widening, lateral migration, and in extreme cases, channel avulsion. Aggradation also occurs behind both large and small retention structures that result from decreased flow velocities and the subsequent decreased capacity to transport sediment. Degradation can arise from a change in sediment supply to an erosional regime for a variety of reasons that include denuding of stream banks, channel modification including straightening, poorly designed in-stream structures, levees, hardened bank stabilization, and floodplain narrowing related to urban or agricultural encroachment or transportation and utility development. Most degradation is associated with some form of bank instability. In extreme cases this leads to channel incision and a disconnected floodplain.

Figure 1. Jaramillo Creek provides all the services of a healthy river including flood mitigation, groundwater recharge, pollutant mitigation, aquatic and terrestrial habitat and recreation opportunities.

With the onset of incision and the loss of floodplain comes a commensurate loss in services. The most significant of these are the loss of floodplain water storage capacity, reduced base flow and severely reduced floodplain forage quality and quantity. With incision also comes increased erosion, reduced flood and pollutant mitigation capacity, and the loss of both aquatic and terrestrial habitat. The combined effect of this is to reduce the amount of water available for recreational, municipal, industrial, and agricultural use and to increase the risks of flooding. Figure 2 shows degradation in the form of incision along Magado Creek in the Sacramento Mountains. The incision has resulted in a disconnected floodplain and a loss of flood and pollutant mitigation. There is also a subsequent decrease in water storage, base flow, productivity of the adjacent grasslands and both aquatic and terrestrial habitat.

Threats to rivers often result in geomorphic changes. Confining the river from urban encroachment, installation of levees in the floodplain, and insufficiently designed utility and transportation crossings can result in narrowing the river and destabilization of the bed and banks (Fig. 3). Poor watershed management can result in increased surface runoff and erosion leading to an increase in sediment supply. Dams and other channel modifications can drastically alter stream geomorphology. These impacts are often accompanied by channel adjustment that can then lead to other problems as mentioned above such as bank destabilization and incision.

Figure 2. An incised reach of Magado Creek no longer provides water to the floodplain reducing flood mitigation, shallow groundwater recharge, pollutant mitigation, aquatic and terrestrial habitat, and forage quality and quantity.

Figure 3. Following multiple attempts at bank stabilization to protect encroaching urban infrastructure, the Rio Ruidoso has been reduced to a concrete canal with loss of all natural function except water transport.

To protect our future surface waters from poor management it is necessary to adopt meaningful solutions. These include: protecting healthy rivers from degradation (including the associated floodplain); direct restoration funding toward those areas with the greatest potential for restoration and future protection exists; conduct sound watershed management and upland restoration; promote healthy watersheds; and stop new development on floodplains. These decisions are not complicated, but they are difficult and require viewing our rivers as a resource with multiple services. The path that is chosen will decide the fate of our future surface water supply and the health of our rivers. A quote from Luna Leopold, past Chief Hydrologist of the USGS, sums it up best:

> *"Water is the most critical resource issue of our lifetime and our children's lifetime. The health of our waters is the principal measure of how we live on the land."*