Executive Summary

The Middle Rio Grande Basin covers approximately 3,060 square miles in central New Mexico, encompassing parts of Santa Fe, Sandoval, Bernalillo, Valencia, Socorro, Torrance, and Cibola Counties. In this report, "Middle Rio Grande Basin" refers to the geologic basin defined by the extent of deposits of Cenozoic age along the Rio Grande from about Cochiti Dam to about San Acacia. In 2000, the population of the Middle Rio Grande Basin was about 690,000, or about 38 percent of the population of New Mexico (U.S. Census Bureau, 2001a, 2001b).

In 1995, the New Mexico Office of the State Engineer declared the Middle Rio Grande Basin a "critical basin"; that is, a ground-water basin faced with rapid economic and population growth for which there is less than adequate technical information about the available water supply. Though the basin had been intensively studied for a number of years, important gaps remained in the understanding of the water resources of the basin. In an effort to fill some of these gaps, the U.S. Geological Survey (USGS) and other Federal, State, and local agencies began the Middle Rio Grande Basin Study, a 6-year effort to improve the understanding of the hydrology, geology, and land-surface characteristics of the basin.

Characteristics of the Middle Rio Grande Basin

Much of the Middle Rio Grande Basin is classified as desert, with mean annual precipitation ranging from 7.6 inches at Belen to 12.7 inches at Cochiti Dam. Mean annual temperatures range from 54.0° F at Corrales to 56.5° F at Albuquerque and Belen (National Weather Service, 2002).

Scurlock (1998) listed eight main plant communities in the present-day Middle Rio Grande Basin and bordering mountains. They are, in a progression from near the Rio Grande to the mountaintops: riparian, desert grassland, plains-mesa grassland, scrublands, juniper savanna, pinyon-juniper woodlands, ponderosa pine, and subalpine and mixed coniferous forest. The vegetation of the riparian woodland (or bosque) has evolved significantly since the introduction of exotic species prior to 1900 and the construction of flood-control and bank-stabilization projects. During the last 60 to 70 years, the bosque has developed in an area that was formerly semibarren flood plain.

The Albuquerque area began to grow significantly during and after the Second World War. Postwar growth expanded the economic base of the area and led to a population increase in Albuquerque from about 35,000 to about 200,000 people between 1940 and 1960 (Reeve, 1961). This population growth led to increased pumping of ground water.

Geology

The Middle Rio Grande Basin lies in the Rio Grande rift valley, a zone of faults and basins that stretches from Mexico north to approximately Leadville, Colorado (about 150 miles north of the New Mexico border)—the modern Rio Grande follows this rift valley. The rift formed more than 25 million years ago and initially consisted of a succession of topographically closed basins. These closed basins filled with sediment from the adjacent mountain ranges, dune deposits from windblown sand, and volcanic deposits from local volcanic areas such as the Jemez Mountains. Flowing southward into and through the successive basins in the rift, the Rio Grande deposited river-borne sediment and established the through-flowing river seen today. About 3 million years ago the Rio Grande began to erode into sediment that it had deposited previously, suggesting that the river drained all the way to the Gulf of Mexico. Basin-fill deposits derived from all these sources (deposited in both open- and closed-basin conditions) are known as the Santa Fe Group and range from about 1,400 feet thick at the basin margins to approximately 14,000 feet in the deepest parts of the Middle Rio Grande Basin. The Santa Fe Group, in addition to younger alluvial deposits along the Rio Grande, makes up the Santa Fe Group aquifer system.

Each of the different settings in which sediment was deposited in the Middle Rio Grande Basin (such as mountain-front alluvial fans, rivers and streams, or sand dunes) resulted in a unique type of sedimentary deposit. These deposits are a complex mixture of different sediment types and grain sizes that change rapidly in the vertical and horizontal directions. Some of these deposits make better aquifer material than others, resulting in variations in the quantity and quality of water produced from wells installed in different locations.

Faults throughout the basin further increase the complexity of the aquifer system. Ground-water flow can be restricted across faults by offsetting units of different permeability or enhanced along faults by the presence of fractured rock. Over time, such fractures may become barriers to flow because of the precipitation of chemical cements in the fractures.

Surface, airborne, and borehole-geophysical techniques have been used to improve the understanding of the geologic framework of the Santa Fe Group aquifer system. Such properties as magnetism, gravity, electrical properties, and natural radioactivity have allowed scientists to better define the boundaries of the aquifer system, faults, and areas underlain by a more permeable aquifer material.

Geologic information collected for the Middle Rio Grande Basin Study has been incorporated into a new conceptualization of the composition of the aquifer system. This improved understanding has been formalized into a three-dimensional geologic model that is the basis for a new ground-water-flow model of the basin.

Surface Water

In the Middle Rio Grande Basin, the surface- and ground-water systems are intimately linked through a series of complex interactions. These interactions can make it difficult to recognize the boundary between the two systems, and changes in one often affect the other. The most prominent hydrologic feature in the basin is the Rio Grande, which flows through the entire length of the basin, generally from north to south. The fifth longest river in North America, its headwaters are in the mountains of southern Colorado. Flow in the Rio Grande is currently (2002) regulated by a series of dams and storage reservoirs. The greatest flows occur in late spring as a result of snowmelt and for shorter periods during the summer in response to rainfall. Historically, the Rio Grande has flowed year-round through much of the basin, except during severe drought. Within the basin, tributary steams, wastewater-treatment plants, flood-diversion channels from urban areas, and a large number of arroyos and washes contribute flow to the river.

The inner valley of the Rio Grande contains a complex network of irrigation canals, ditches, and drains. During irrigation season, water is diverted from the river at four locations in the basin and flows through the Rio Grande inner valley in a series of irrigation canals and smaller ditches for application to fields. This water recharges ground water, is lost to evaporation, is transpired by plants, or is intercepted by interior drains and returned to the river. Besides the Rio Grande, the inner-valley surface-water system also contains a system of riverside drains, which are deep canals that parallel the river immediately outside the levees. The drains are designed to intercept lateral ground-water flow from the river, thus preventing waterlogged conditions in the inner valley. The drains then carry this ground water back to the Rio Grande.

Estimated and measured annual surface-water inflow into the Middle Rio Grande Basin is about 1,330,000 acre-feet (for water years 1974–2000) and measured annual surface-water outflow is about 1,050,000 acre-feet (for water years 1974–2000). Currently (2002), the primary consumptive use by humans of surface water in the Middle Rio Grande Basin is irrigation in the inner valley of the Rio Grande. Other water is consumed by reservoir evaporation, recharge to ground water, and evapotranspiration by riparian vegetation. Other nonconsumptive uses include recreation, esthetics, and ceremonial use by Native Americans.

Ground Water

The Santa Fe Group aquifer system is divided into three parts: the upper (from less than 1,000 to 1,500 feet thick), middle (from 250 to 9,000 feet thick), and lower (from less than 1,000 to 3,500 feet thick). In places, the upper part and(or) the middle part of the aquifer has eroded away. Much of the lower part may have low permeability and poor water chemistry; thus, ground water is mostly withdrawn from the upper and middle parts of the aquifer. Only about the upper 2,000 feet of the aquifer is typically used for ground-water withdrawal. Ground water from the Santa Fe Group aquifer system is currently the sole source of water for municipal supply, domestic, commercial, and industrial use in the Middle Rio Grande Basin.

The depth to water in the Santa Fe Group aquifer system varies widely, ranging from less than 2 feet near the Rio Grande to about 1,180 feet in an area west of the river beneath the West Mesa. Effects of ground-water pumping are not evident on the earliest ground-water-level maps of the Middle Rio Grande Basin (1936 conditions). However, a ground-water-level map showing more recent conditions (winter 1994–95) shows well-defined cones of depression in the Albuquerque and Rio Rancho areas and marked distortion of water-level contours across the Albuquerque area. Water levels in a network of 255 wells are being measured to monitor further water-level changes.

Water enters the Santa Fe Group aquifer system in four main settings: mountain fronts and tributaries to the Rio Grande, the inner valley of the Rio Grande, the Rio Grande, and subsurface basin margins. Water entering the aquifer in the first three settings is usually termed recharge, whereas water entering the basin in the subsurface is typically termed underflow.

Ground water discharges from the Santa Fe Group aquifer system in several ways: pumpage from wells, seepage into the Rio Grande and riverside drains, springs, evapotranspiration, and subsurface outflow to the Socorro Basin. If ground-water pumpage from an aquifer exceeds recharge, water levels in the aquifer decline, as has been observed in the Middle Rio Grande Basin. These declining water levels can have adverse effects that influence the long-term use of the aquifer, including deterioration of water quality, water-well problems, and land subsidence.

Ground-Water Chemistry

A useful approach to characterizing ground-water chemistry in the Middle Rio Grande Basin is to divide the basin into 13 zones, or regions, of different water-chemistry characteristics. The median concentrations of two constituents (chloride and sulfate) exceed the U.S. Environmental Protection Agency (USEPA) secondary standards for drinking water in several zones. Arsenic concentrations in ground water exceeded the USEPA primary standard (finalized in 2001) of 0.010 milligram per liter (mg/L) of arsenic in one zone.

Most of the ground water in the basin is not very susceptible to contamination because the depth to water in most areas is greater than 100 feet. Deposits in the inner valley of the Rio Grande, however, are more susceptible to contamination because the depth to water is generally less than 30 feet. There are four Superfund sites, three RCRA (Resource Conservation and Recovery Act of 1976) sites, and about 700 former and present leaking underground-storage-tank sites in the Middle Rio Grande Basin.

Ground-Water-Flow Modeling

Several ground-water-flow models of the Middle Rio Grande Basin have been developed. The most recent (2002) is a USGS model that incorporates new hydrogeologic data collected since 1995 (McAda and Barroll, 2002). The model encompasses the entire thickness of the Santa Fe Group in order to simulate probable flow paths in the lower part of the aquifer. Model simulations show that (1) prior to installation of the riverside drains along the Rio Grande, the river was losing flow, though currently (2002) the drains intercept much of this flow and divert it back into the river; (2) the Rio Grande and riverside drains are so closely related, especially during the nonirrigation season, that they function as one system; (3) the hydrologic connection between the Rio Grande and underlying Santa Fe Group aquifer system is variable and changes with the lithology of a particular river reach; (4) in much of the Santa Fe Group aquifer system throughout the basin, water removed from storage is partially replaced during the nonirrigation season; and (5) mountain-front recharge to the Santa Fe Group aquifer system is less than amounts estimated by previous models.

The McAda and Barroll (2002) ground-water-flow model of the Middle Rio Grande Basin does not make any projections of future conditions, though it could be modified to do so. However, it does provide water-resource managers a more accurate and powerful tool than previous models to evaluate the potential effects of management decisions.