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GROUND WATER IN THE WINDOW ROCK-LUKACHUKAI AREA, NAVAJO INDIAN RESERVATION, ARIZONA AND NEW MEXICO[1]

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INTRODUCTION

The area along Navajo Route 12 from Window Rock to Lukachukai has a more abundant surface-water supply than most areas in the Navajo Indian Reservation (fig. 1). Streams, such as Tsaile, Wheatfields, and Whiskey Creek, flow perennially in reaches extending several miles west of the Chuska Mountains. Precipitation is about 22 inches per year in the Chuska Mountains and at the higher altitudes along the Defiance Plateau. Generally, ground water is available, but most wells produce only a few gallons per minute from depths ranging from less than 100 to more than 1,500 feet.

The Chuska Mountains are capped by the Chuska Sandstone—the principal aquifer in the mountains. Springs issue from the base of the Chuska Sandstone and furnish perennial flow to the streams along the west side of the mountains. No wells have been drilled into the Chuska Sandstone because the surface water in the mountains supplies the present demand.

In most of the Defiance Plateau, the principal aquifer is a combination of the De Chelly Sandstone and the Shinarump Member of the Chinle Formation. The Supai Formation is tapped by a few wells along the crest of the plateau where the De Chelly and Shinarump have been removed by erosion.

In the valley of Black Creek, between the Chuska Mountains and the Defiance Plateau, the principal aquifer is the alluvium. The alluvium combines with tuff to form the major aquifer in Buell Park on the west side of the valley. The De Chelly-Shinarump aquifer dips eastward beneath the valley and is penetrated at depths of as much as 750 feet by wells that produce as much as 50 gpm (gallons per minute). The Sonsela Sandstone Bed of the Petrified Forest Member of the Chinle Formation is tapped by a few wells that produce less than 10 gpm.

South of the Chuska Mountains and east of the valley of Black Creek, the two chief aquifers are the Gallup Sandstone and a combination of the Westwater Canyon Member of the Morrison Formation and the Dakota Sandstone. Artesian conditions prevail in these aquifers, which are penetrated at depths of from 500 to more than 2,000 feet below the land surface. The Crevasse Canyon and the Menefee Formations overlie the Gallup Sandstone and supply water to windmill wells for stock and domestic use. The water-bearing Entrada and Cow Springs Sandstones underlie the Westwater Canyon-Dakota aquifer, but these formations have not been developed.

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WATER-BEARING UNITS IN THE WINDOW ROCK-LUKACHUKAI AREA

Supai Formation.

The Supai Formation of Permian and Pennsylvanian age consists of brownish-orange, very fine to fine-grained, silty sandstone interbedded with red siltstone and mudstone (Read and Wanek, 1961, p. 3-4). The Supai crops out in an oval-shaped area on the crest of the Defiance Plateau and overlies the Precambrian rocks (Cooley and others, 1967).

The Supai Formation generally has a low permeability and yields water slowly, although the permeability may increase locally in fractured zones. Wells that penetrate the Supai in the Defiance Plateau yield as much as 5 to 8 gpm. The Supai Formation is recharged directly by precipitation and runoff in its area of outcrop. Ground water moves outward from the crest of the plateau. Natural discharge occurs from springs that yield from less than 1 gpm to more than 300 gpm, and perhaps by slow upward leakage into the De Chelly Sandstone. Water from the Supai Formation in the Defiance Plateau is of good chemical quality and generally has a dissolved-solids concentration of less than 500 ppm (parts per million).

De Chelly-Shinarump aquifer

The De Chelly Sandstone of Permian age and the Shinarump Member of the Chinle Formation of Triassic age are hydraulically connected and form a single aquifer in the Window Rock-Lukachukai area. The Moenkopi Formation, an aquiclude separating the De Chelly and Shinarump to the south and west, is absent in the Window Rock-Lukachukai area.

The De Chelly is a pale-orange, very fine to medium-grained, well-sorted, generally firmly cemented, quartz sandstone. It is 450 feet thick in a well at Window Rock (Cooley and others, 1964, p. 59), and 750 feet thick in Canyon del Muerto on the west side of the Defiance Plateau (Read and Wanek, 1961, pl. 2). The De Chelly crops out on most of the south and west sides of the Defiance Plateau, in a narrow belt on the east side, and in Canyon de Chelly and its tributaries.

The Shinarump Member of the Chinle Formation is composed of light-gray, fine to very coarse grained, poorly sorted sandstone and conglomerate. The grain size and permeability of the Shinarump vary locally. The thickness of the Shinarump is also variable, but it is generally from about 50 to 250 feet thick. It crops out in most of the

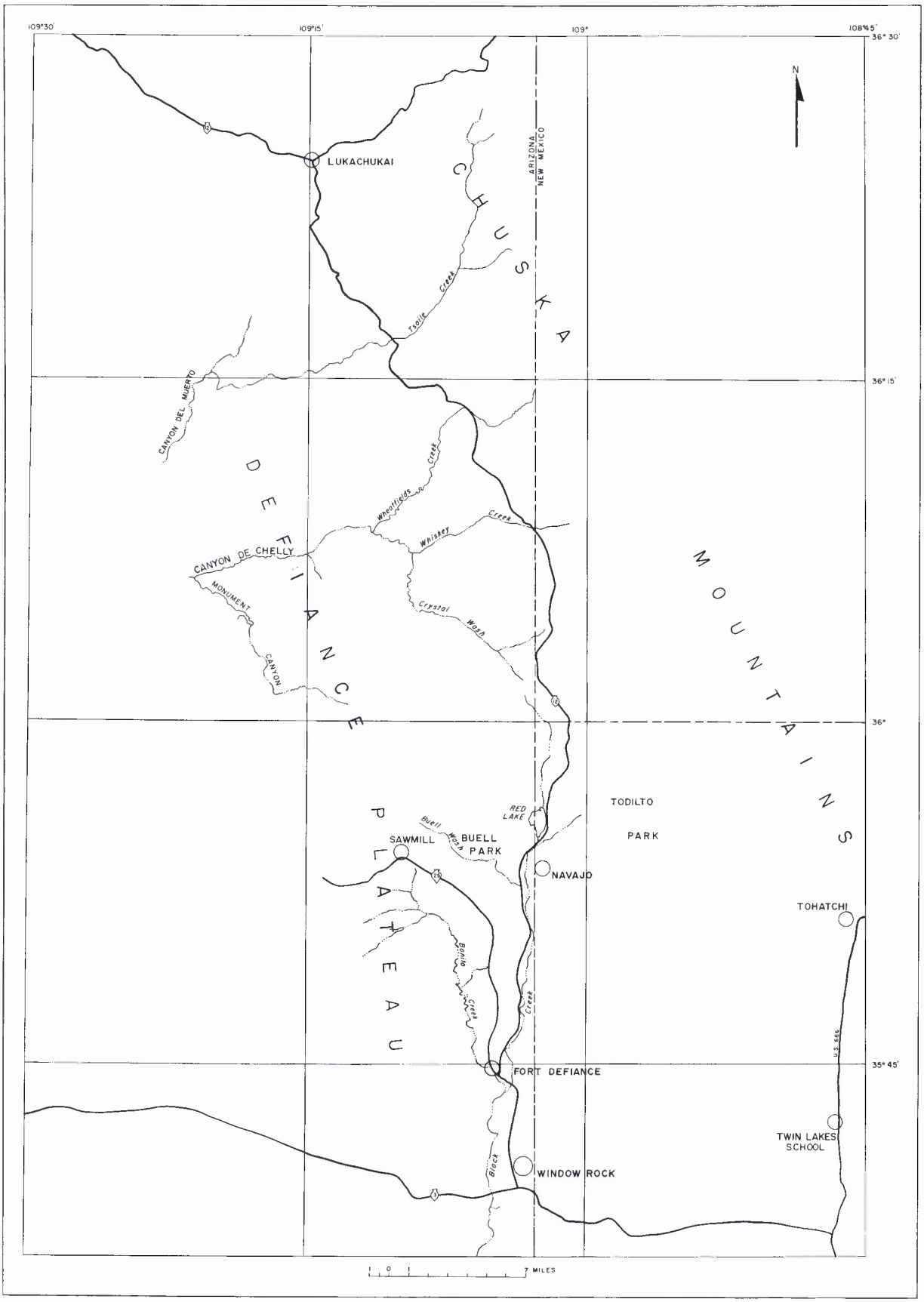

FIGURE 1.

Window Rock–Lukachukai Area, Arizona and New Mexico.

northern part of Defiance Plateau and caps a ridge along the west side of the valley of Black Creek.

Wells drilled into the De Chelly-Shinarump aquifer in the Window Rock-Lukachukai area generally produce from less than 5 gpm to about 50 gpm. The De Chelly is water-bearing in all of the area, but the Shinarump is dry in most of the northern part of the defiance Plateau. The Shinarump is more permeable than the De Chellly; where the Shinarump is saturated, it probably contributes more water to wells than the De Chelly.

In the northern part of the Defiance Plateau, ground water occurs under water-table conditions at depths of from 200 to 500 feet in the De Chelly Sandstone. Wells that penetrate the De Chelly in this area generally produce less than 10 gpm. On the east side of the Defiance Plateau, water occurs under artesian conditions, because the De Chelly-Shinarump aquifer is confined by overlying impermeable beds of the Chinle Formation.

The De Chelly-Shinarump aquifer is recharged by precipitation and runoff in its area of outcrop. Ground water moves outward from the recharge area. Natural discharge from the De Chelly-Shinarump aquifer is to springs, to the tuff-alluvium aquifer in Buell Park, and probably to alluvium along the valley of Black Creek.

Water from the De Chelly-Shinarump aquifer in the Window Rock-Lukachukai area is generally of good chemical quality. The principal dissolved solids are calcium and bicarbonate. The dissolved-solids concentration is generally less than 700 ppm, although a well at the Fort Defiance Consolidated School produced water from the Shinarump having a dissolved-solids concentration of 2,840 ppm (Kister and Hatchett, 1963, p. 56).

SONSELA SANDSTONE BED

The Sonsela Sandstone Bed of the Petrified Forest Member of the Chinle Formation of Triassic age consists of gray, very fine to coarse-grained sandstone and conglomeratic sandstone. The bedding is lenticular, and the unit is from about 30 to 100 feet thick in the Window Rock-Lukachukai area. The Sonsela caps an eastward-dipping cuesta on the east side of the Defiance Plateau and mesas at the western foot of the Chuska Mountains. It is deeply buried to the east of the valley of Black Creek, where it is overlain by more productive aquifers.

Few wells have been drilled into the Sonsela Sandstone Bed in the Window Rock-Lukachukai area, but it produces enough water to supply windmill wells on the northwest side of the Defiance Plateau. Wells obtaining water from the Sonsela probably will not produce more than 20 or 30 gpm in the Window Rock-Lukachukai area; however, potential production may be somewhat larger where the Sonsela is very thick or coarse-grained and conglomeratic.

The Sonsela Sandstone Bed is recharged by precipitation and runoff in its areas of outcrop in the valley of Black Creek and on the west side of the Chuska Mountains, and probably by ground water from alluvium in the valley of Black Creek. The direction of ground-water movement has not been determined. Natural discharge issues from small springs on the west side of the Chuska Mountains.

The chemical quality of water in the Sonsela Sandstone Bed is variable in the Window Rock-Lukachukai area, but the water is probably suitable for stock, at least in places near the outcrops. Chemical analyses of water from the Sonsela indicate that the dissolved-solids concentration is generally less than 2,500 ppm; water from some springs has a dissolved-solids concentration of less than 1,000 ppm. Sodium, bicarbonate, and sulfate are the principal ions in solution.

ENTRADA-COW SPRINGS AQUIFER

The Cow Springs Sandstone and the underlying upper sandy member of the Entrada Sandstone of Jurassic age are combined as a single aquifer in this report, although they are separated by the Todilto Limestone and the Summerville Formation in the northern part of the Window Rock-Lukachukai area and may be hydraulically connected to the Westwater Canyon Member of the Morrison Formation of Jurassic age in the southern part of the area.

The Cow Springs Sandstone consists of greenish-gray, very fine to fine-grained, well-sorted sandstone. The Cow Springs intertongues with and grades into the Summerville and Morrison Formations northward from Fort Defiance (Harshbarger and others, 1957, p. 39, 50). The combined thickness of the Summerville and Cow Springs tongues included in the Summerville at Fort Defiance is 339 feet (Cooley and others, 1964, p. 150).

The upper sandy member of the Entrada Sandstone is an orange-pink, very fine to fine-grained, well-sorted sandstone. It thins northward from 224 feet at Fort Defiance (Cooley and others, 1964, p. 150) to 178 feet at Todilto Park (Harshbarger and others, 1957, p. 37).

The Cow Springs and Entrada Sandstones crop out in a narrow band running northward from Window Rock to the foot of the Chuska Mountains. The Entrada Sandstone also crops out on the west side of the Chuska Mountains northeast of Lukachukai. Both formations have been removed by erosion in the Defiance Plateau.

No wells have been drilled in the Window Rock-Lukachukai area that obtain water from these formations, although they produce sufficient water for windmill wells elsewhere in the Navajo Indian Reservation. The Entrada-Cow Springs aquifer probably contains water under artesian pressure east of Fort Defiance and may contribute water to the overlying Westwater Canyon-Dakota aquifer by upward seepage.

The chemical quality of the water from the Entrada-Cow Springs aquifer is unknown in the Window Rock-Lukachukai area. Elsewhere in the Navajo Indian Reservation, however, the quality of water from the Cow Springs Sandstone varies from place to place, but the dissolved-solids concentration is generally less than 1,500 ppm and in many places is less than 1,000 ppm. Water from the Entrada Sandstone generally has a dissolved-solids concentration of more than 2,000 ppm, particularly northwest of the Window Rock-Lukachukai area.

Westwater Canyon-Dakota aquifer

The Westwater Canyon Member of the Morrison Formation of Jurassic age and the Dakota Sandstone of Cretaceous age form a single water-bearing unit in most of the Window Rock-Lukachukai area. The Westwater Canyon Member consists of grayish-red to grayish-green and yellow medium to very coarse grained sandstone and conglomeratic sandstone. The member thins from north to south in the Window Rock-Lukachukai area. It is 277 feet thick at Todilto Park and 67 feet thick about 4 miles southwest of Window Rock (Cooley and others, 1964, p. 137, 149). The Dakota Sandstone consists primarily of light-gray to buff very fine to coarse-grained sandstone with some interbedded siltstone and coal. The thickness of the Dakota varies irregularly but probably is from 75 to 200 feet in the area.

The Dakota Sandstone and the Westwater Canyon Member crop out in a narrow belt northward from Window Rock to the Chuska Mountains (Cooley and others, 1967). The Dakota caps a prominent eastward-dipping cuesta east of Window Rock, and the Westwater Canyon Member forms a cliff or steep slope on the west side of the cuesta. The Dakota is 1,425 feet below the land surface 2 miles southeast of Window Rock (McGavock and others, 1966, p. 52), owing to the eastward dip.

A few wells produce water from the Westwater Canyon-Dakota aquifer between Window Rock and U.S. Highway 666. These wells, however, also produce water from the Gallup Sandstone and other units, and the contribution of the Westwater Canyon-Dakota aquifer has not been determined separately.

The aquifer is recharged by precipitation and runoff along its narrow outcrop east of Window Rock and Fort Defiance, by seepage from the overlying Chuska Sandstone in the Chuska Mountains, and possibly by water from the Entrada-Cow Springs aquifer east of the outcrop. The direction of ground-water movement has not been determined. No points of natural discharge are known to exist for the Westwater Canyon-Dakota aquifer in the Window Rock-Lukachukai area.

The chemical quality of the water from the Westwater Canyon-Dakota aquifer has not been determined in the Window Rock-Lukachukai area. Wells that furnish the water supply for Window Rock, however, produce water from the Gallup Sandstone and the Westwater Canyon-Dakota aquifer; the water is of good chemical quality, having a dissolved-solids concentration of less than 500 ppm.

Gallup Sandstone

The Gallup Sandstone of Cretaceous age consists of light-gray to buff fine to very coarse grained sandstone with some interbedded gray siltstone and mudstone and minor amounts of coal. The Gallup crops out as an eastward-dipping cuesta east of Fort Defiance and Window Rock. It is 725 feet below the land surface 2 miles southeast of Window Rock and 1,425 feet below the land surface at Twin Lakes (McGavock and others, 1966, p. 52, 42). The formation is from about 75 to more than 400 feet thick east of Window Rock.

Wells east of Window Rock and Fort Defiance produce as much as 50 to 100 gpm from the Gallup Sandstone. Water in the Gallup is under artesian pressure, but this pressure is not high enough to cause wells to flow in the area immediately east of Window Rock; however, flowing wells have been completed in the Gallup at Twin Lakes (Davis and others, 1963, p. 118).

The Gallup is recharged from precipitation and runoff along its narrow outcrop and perhaps by seepage from the Chuska Sandstone in the Chuska Mountains. The direction of ground-water movement in the Gallup Sandstone has not been determined east of Window Rock. No points of natural discharge are known to exist for the Gallup Sandstone in the Window Rock-Lukachukai area.

The chemical quality of the water from wells tapping the Gallup Sandstone between Window Rock and U.S. Highway 666 is generally good. The dissolved-solids concentration is less than 800 ppm, although it increases slightly with distance from the recharge area.

Crevasse Canyon and Menefee Formations

The Menefee Formation and the underlying Crevasse Canyon Formation of Cretaceous age are considered as a single water-bearing unit in this report. The formations consist of interbedded, lenticular, tan to light-gray, fine-grained sandstone; gray siltstone and mudstone, and some coal. Individual sandstone beds may be 40 feet or more thick, but most of the beds are from 5 to 20 feet thick.

The Crevasse Canyon and Menefee Formations crop out in most of the area between Window Rock and U.S. Highway 666. The combined thickness of these two formations increases northeastward from the edge of the outcrop about 1 mile east of Window Rock to 1,425 feet at Twin Lakes (McGavock and others, 1966, p. 42).

Wells that penetrate the Menefee and Crevasse Canyon Formations generally produce sufficient water from the sandstone beds to provide stock and small domestic supplies. The water in many of the sandstone beds is under artesian pressure, but the pressure is not high enough to cause the wells to flow. These formations are recharged directly from precipitation and runoff in the area of outcrop. The direction of ground-water movement has not been determined, but the lenticularity and discontinuity of the sandstone beds probably retard regional movement.

The chemical quality of the water in the Crevasse Canyon and Menefee Formations varies from place to place and may vary from one sandstone bed to another in the same location. The dissolved-solids concentration ranges from less than 700 ppm to more than 3,000 ppm. The principal dissolved constituents are sodium, calcium, bicarbonate, and sulfate. The fluoride concentration in water from wells in the Menefee Formation is variable and generally ranges from 0.5 to 3 ppm, although it is more than 5 ppm in water from some wells.

CHUSKA SANDSTONE

The Chuska Sandstone of Pliocene(?) age consists of light-gray to white, fine- to coarse-grained, weakly to moderately cemented sandstone. The Chuska is confined to the higher altitudes in the Chuska Mountains and to a few outliers, where it unconformably overlies rocks ranging from Triassic through Late Cretaceous age. The Chuska is about 1,000 feet thick in the mountains, and its base slopes gently southwest (Harshbarger and Repenning, 1954, p. 6).

No wells have been drilled into the Chuska Sandstone, and its water-bearing characteristics, which probably are good compared to the other formations in the area, have not been tested. The Chuska Sandstone is recharged by precipitation and runoff in most of its area of outcrop, which receives from 20 to 25 inches of precipitation annually.

Ground water moves outward from the crest of the Chuska Mountains in all directions, but more water moves to the southwest side of the mountains as a result of the southwesterly dip of the base of the formation. Some water also may move downward from the Chuska Sandstone into some of the older aquifers. Natural discharge is to springs on all sides of the mountains. Water from springs issuing from the Chuska Sandstone is of good chemical quality, generally having a dissolved-solids concentration of less than 250 ppm.

TUFF-ALLUVIUM AQUIFER

Alluvium of Quaternary age and lapilli tuff and interbedded cinders of Tertiary age combine to form a single aquifer in Buell Park. The lapilli tuff and interbedded cinders form the floor of Buell Park, a nearly circular depression about 2½ miles in diameter. Alluvium locally overlies the tuff and cinders.

The water table in the tuff-alluvium aquifer is within 35 feet of the land surface where Buell Wash leaves Buell Park (Akers and others, 1962, p. 10). Pumping tests conducted on test wells drilled in Buell Park indicate that the amount of water that can be produced from this aquifer varies from place to place and may depend upon the saturated thickness of the more permeable cinders. One well was pumped at 625 gpm for 72 hours and had a total drawdown of 28 feet; other wells were test pumped at lower rates (Akers and others, 1962, p. 10).

The tuff-alluvium aquifer is recharged by precipitation and runoff in Buell Wash and its tributaries in Buell Park and probably by ground water from the Supai Formation and De Chelly Sandstone that surround the tuff. The direction of ground-water movement in this aquifer has not been determined but probably coincides with that in the Supai Formation and De Chelly Sandstone, which is generally to the east near Buell Park. Natural discharge from this aquifer is to the springs in Buell Park. Water from the test wells drilled into the tuff-alluvium aquifer in Buell Park is generally of good quality, having a dissolved-solids concentration of less than 450 ppm.

ALLUVIUM

Alluvium of Quaternary age is found along most of the stream channels in the Window Rock-Lukachukai area. The alluvium is composed of clay, silt, sand, and gravel. The thickness of the alluvium is variable, but locally it is more than 100 feet thick in the valley of Black Creek near Navajo and south of Window Rock.

Drilled and dug wells produce water from the alluvium for domestic supplies in the valley of Black Creek near Window Rock. Pumping tests conducted on wells drilled in the alluvium near Navajo indicate a coefficient of transmissibility of 22,000 gpd (gallons per day) per foot (Akers and others, 1962, p. 10). Wells in the alluvium at Navajo produce 60 gpm. Collection galleries constructed in the alluvium along Bonito Creek near Fort Defiance are reported to produce as much as 100 gpm (Davis and others, 1963, p. 146).

Water in the alluvium in the Window Rock-Lukachukai area is under water-table conditions. Recharge is primarily from flow in the stream channels, but some recharge also may occur from other aquifers. Ground water in the alluvium probably moves parallel to the direction of the surface drainage. Natural discharge occurs by evapotranspiration where the water table is near the surface, to a few springs, and probably to other aquifers.

Water from the alluvium near Red Lake and along Bonito Creek near Fort Defiance is of good chemical quality, having a dissolved-solids concentration of less than 450 ppm. South of Forth Defiance, the chemical quality is more variable, and the dissolved-solids concentration ranges from less than 1,000 ppm to more than 2,500 ppm. The principal ions is solution are calcium, bicarbonate, and sodium, although sulfate is an important constituent in water with a high dissolved-solids content.

WATER USE

The principal sites of ground-water withdrawal for public supply and industrial use in the Window Rock-Lukachukai area are Navajo, Fort Defiance, and Window Rock. At Navajo, the forest-products plant obtains its water supply from wells drilled into the alluvium south of Red Lake, and the community obtains its domestic supply from a well in Buell Park. Fort Defiance now obtains its water from collection galleries in the alluvium along Bonito Creek, but the supply will be increased by a new well drilled into the De Chelly-Shinarump aquifer. School wells at Fort Defiance also tap the De Chelly-Shinarump aquifer. Window Rock formerly obtained its water supply from wells drilled into the De Chelly-Shinarump aquifer, but this supply was inadequate and now is supplemented by water from wells penetrating the Gallup Sandstone and the Westwater Canyon-Dakota aquifer.

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