HYDROGEOLOGIC CHARACTERIZATION, SURFACE WATER–GROUND WATER INTERACTION, AND WATER QUALITY IN THE SOUTHERN SAN LUIS BASIN IN THE VICINITY OF TAOS, NM, by Paul Drakos and Jay Lazarus,

Glorieta Geoscience, Inc., P.O Box 5727, Santa Fe, NM 87502

Paul Drakos is Senior Geologist at Glorieta Geoscience, Inc. He received a B.S. in geology from the University of Oregon in 1982 and a M.S. in Geology from the University of New Mexico in 1989. His principal areas of expertise are in hydrogeologic testing, characterization, and basin analysis, and in geomorphic mapping and analysis of sediment transport. He has supervised drilling, well design, completion, and testing of numerous shallow and deep wells in the Taos Valley. Mr. Drakos is currently conducting detailed geomorphic mapping of several canyons on the Pajarito Plateau for Los Alamos National Laboratory. Jay Lazarus is Sr. Geohydrologist at Glorieta Geoscience, Inc. He received a B.A. in history for the University of Illinois in 1972, and a B.S. in Geology from the University of Arizona in 1975. His principal areas of expertise include fracture flow characterization, ground water exploration and development, surface water/ground water interactions and water rights analyses and development.

ABSTRACT

The Town of Taos, located in the southern San Luis basin in northern New Mexico, has historically relied on shallow ground water produced from depths of less than 500 feet for its municipal water supply. Shallow ground water sources are in communication with surface water, which has been diverted for agricultural purposes through acequias by Taos Pueblo, Spanish settlers and their descendents, and other non-Indian irrigators. Due to the on-going basin-wide water rights adjudication lawsuit, the Town is negotiating with the other parties to minimize its effects on surface water and shallow ground water by moving its pumping centers to deeper portions of the currently undeveloped aquifer. Pumping from deeper wells with poorer water quality at locations further away from the Town's existing water supply system will result in increased distribution and treatment costs. Additional operating and maintenance costs will be partially offset by lower litigation costs and better cooperation between water users in the Taos Valley.

In the vicinity of Taos, potential productive aquifers may be located at depth in basin fill sediments of the Tesuque Formation. Geological, geophysical, water quality, and aquifer testing data from 13 shallow (less than 500 ft total depth) and 8 deep (between 800 and 2000 ft total depth) wells, piezometer nests, or exploratory borings have been used to describe aquifer characteristics of alluvial/fluvial and eolian hydrostratigraphic units within the Plio-Pleistocene-age Lama Formation, and underlying Miocene-age Chamita and Tesuque Formation basin fill sediments. The shallow (<400 ft deep) Agua Azul aquifer is in direct hydrologic communication with surface water in the Rio Pueblo de Taos basin. Vertical hydraulic conductivity (k') through the upper Servilleta Basalt and interbedded clay which overlies the Agua Azul aquifer is 0.02 ft/day. Water quality data indicate that pH, temperature, and concentrations of some metals, increase with depth in basin fill aquifers underlying the Agua Azul aquifer. Agua Azul water quality is good. However, the deep Ojo Caliente and Chama-El Rito aquifers may be high in iron and fluoride, are moderately alkaline, and produce relatively warm water (20-25^0 C). Preliminary data indicate that, with some water quality treatment, deep ground water production shows potential for a future water supply for the Town of Taos and other water users in the basin.

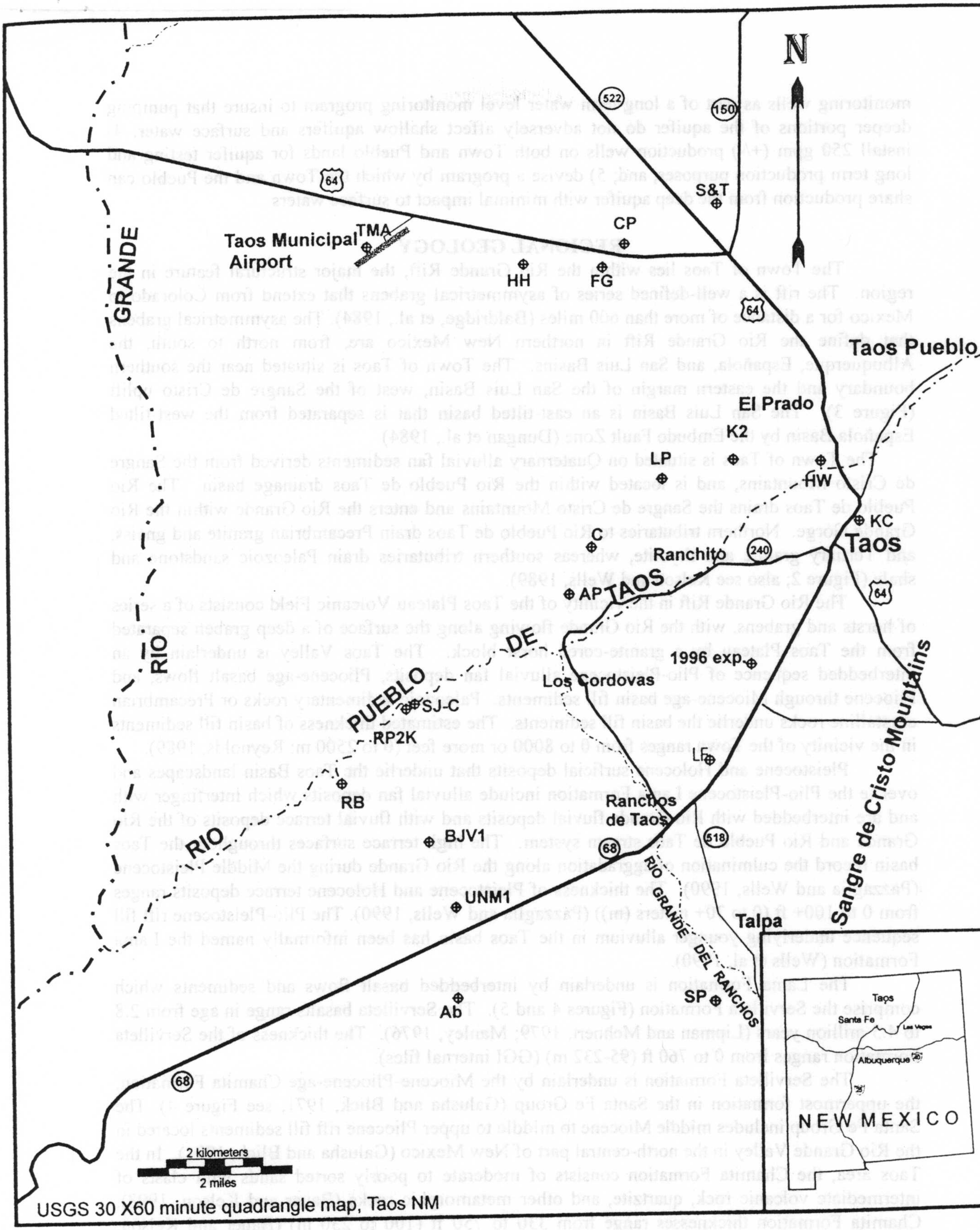

Figure 1. Location of wells in the Taos area. Explanation: 1996 exp = 1996 Town Yard exploratory boring (Town of Taos), AB= Abraham, AP= Arroyo Park, BJV1= Taos Golf Course, C= Valle Vista, CP= Colonias Point, FG= Faustine Gonzales, HH= Habitat for Humanity, HW= Howell Well, K2= Karavas Tract K-2, KC= Kit Carson Park, LF= La Fontana School, LP= La Percha, RB= Riverbend, RP2K= Rio Pueblo 2000, S&T= Quail Ridge, SJ-C= San Juan-Chama, SP= Saxe/Patterson, TMA= Taos Municipal Airport, UNM1= UNM-Taos.

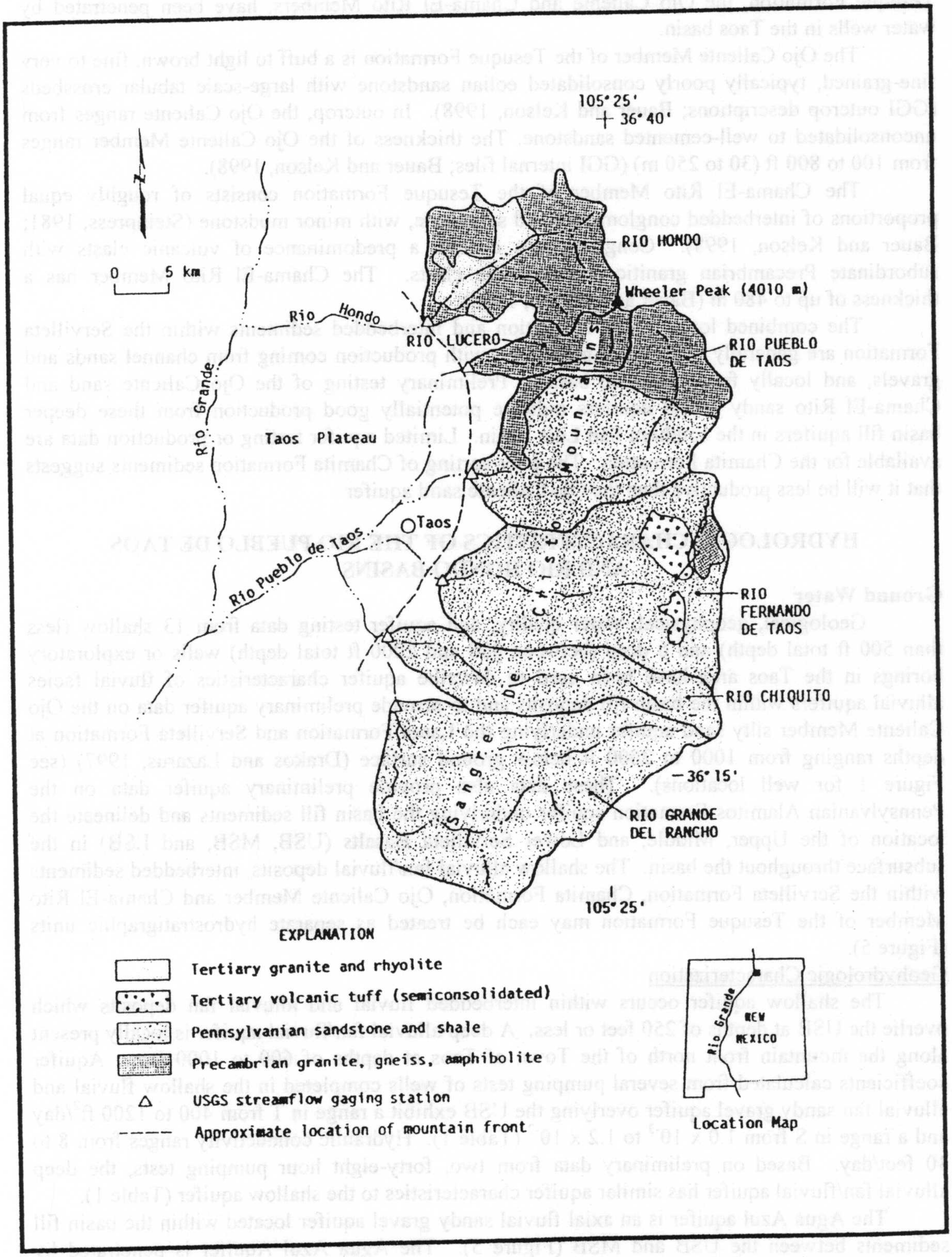

Figure 2. Simplified geologic map of the Taos, NM area (Kelson and Wells, 1989)

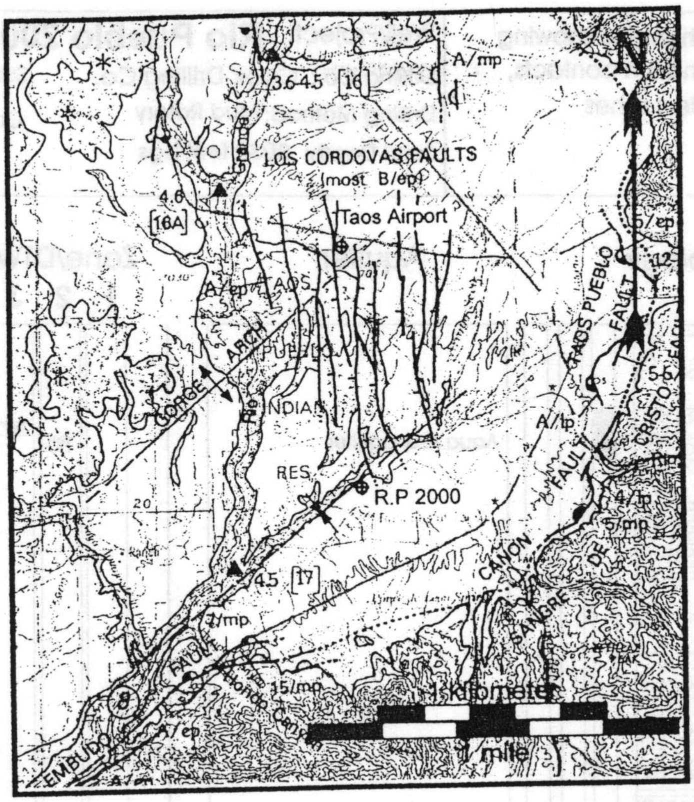

Figure 3 . Tectonic map of the Taos area showing well locations relative to known faults. (Machette and Personius, 1984)

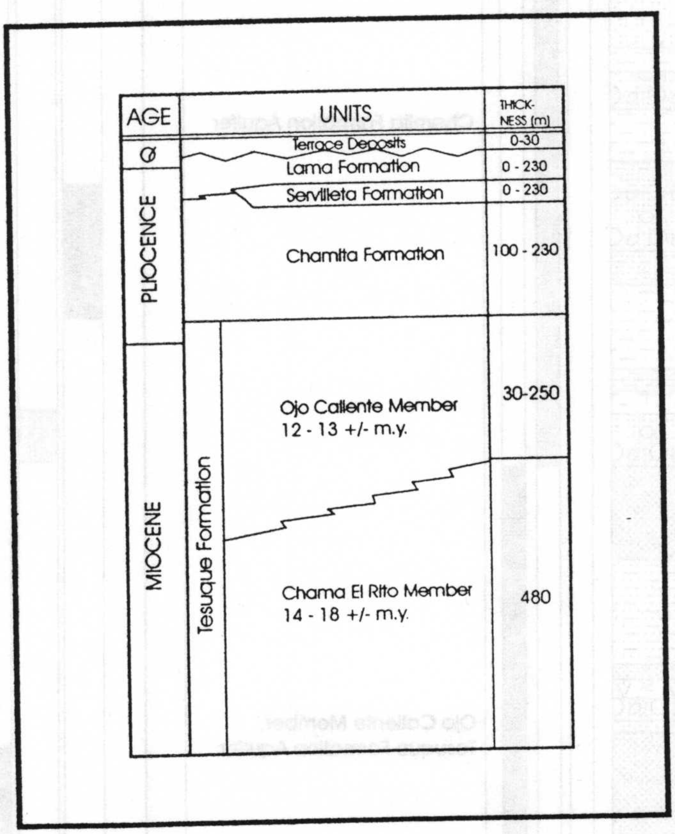

Figure 4. Late Cenozoic stratigraphy exposed in the Southern San Luis Basin. Q - Quaternary. Complied from Galuche and Blick, 1971; Dungan et al., 1984 ; Bauer and Kelson, 1998; and GGI internal files.

hydraulic conductivity (k') through USB and interbedded clay was calculated from a single pumping test as 0.02 ft/day (Glorieta Geoscience, Inc., 1995).

Preliminary testing of deeper aquifers in the basin indicates that productive aquifers are present at depths below 800 to 1000 feet, but that some deeper aquifers may be alkaline (high pH), and high in fluoride and iron. Preliminary testing of the Ojo Caliente Member silty sand aquifer between 1000 and 1200 ft suggest that k is lower than in the shallow aquifers (e.g. less than 1 ft to a few ft/day). Due to the greater aquifer thickness of the Ojo Caliente relative to the Agua Azul aquifer, the two aquifers have similar values for T (Table 1).

Water level measurements indicate that an upward gradient exists in deep aquifers whereas shallow aquifers exhibit a downward gradient and discharge to the Rio Grande (Sorrell and Banet, 1993). This upward gradient is observed in the Ojo Caliente and Chamita Formation aquifers in a deep piezometer nest currently undergoing testing by GGI. These data suggest that the shallow basin fill ground water system above approximately 1000 feet below ground surface is an interconnected system which receives recharge from the Sangre de Cristos and tributaries of the Rio Grande and discharges to the Rio Grande whereas ground water present below 1000 feet may be part of a regional San Luis Basin ground water system flowing southward from Colorado and discharging to the Española Basin along the Embudo Fault zone.

Table 1. Aquifer data summary for Taos Valley aquifers.

Aquifer	Formation	Well Depth (ft)*	T (ft^2/day)	k (ft/day)	Storage	Water Quality			
						pH	Temp. ^{0}C	Hard-ness (mg/kg)	Comments
Shallow fluvial/ alluvial fan	Quaternary Alluvium/ Lama Fm.	100-150	400-1200	8-30	1.2×10^{-2} - 1.0×10^{-3}	7.4–7.6	12	140-230	Constituents within EPA standards
Deep alluvial fan/ fluvial	Lama Fm.	600-800	500-1100	5-10	n.a.	7.4-7.5	n.a.	130-150	Constituents within EPA standards
Agua Azul	Fluvial/ axial R. Grande above MSB	200-400	280-1600	8-40	8×10^{-3} 5×10^{-4}	7.8-8.5	12	60-80	Constituents within EPA standards
Chamita silty sand	Chamita Fm	1100-1400			n.a.	9.4	19	20-	High F
Ojo Caliente Sand	Ojo Caliente	1200-2000	110-700	0.4-5	n.a.	8.1-9.1	20-25	30-50	High F, Fe in approx. 50% of samples
Paleozoic Sed.	Alamitos Fm.	1000	400	3	n.a.	8.0-8.4	16	30	High F, Fe

Notes:
* Typical well depths for a given aquifer
T= Transmissivity
k = hydraulic conductivity
n.a.= not available

<u>Los Cordovas Piezometer Nest</u>

A piezometer nest has been drilled to 2000 ft on Town of Taos property near Los Cordovas and is currently being tested by GGI. Water level data show an upward gradient between the Chamita Formation aquifer, screened from 1300 to 1380 feet with a water level of 170 ft below

Formation outcrop area, flow in contact with the alluvium, Servilleta basalt or the Tesuque Formation sediments until reaching the Rio Grande.

SURFACE WATER/GROUND WATER INTERACTION

Groundwater withdrawals from within the RPdTB may affect groundwater and stream discharge within and outside the RPdTB, and groundwater withdrawals from outside the RPdTB may affect the groundwater and stream discharge within the RPdTB. The stream systems other than the Rio Pueblo de Taos that may be affected by groundwater withdrawals within the RPdTB are the Rio Hondo and Rio Grande.

Within the Taos Valley, shallow ground water and surface water are in hydrologic communication. Examples of the direct hydrologic connection between the surface water and shallow ground water are located: 1) where the canyons of the Rio Pueblo de Taos and Rio Hondo cut down through the shallow sand alluvial and Agua Azul aquifers, resulting in increases in stream discharge; 2) at locations where springs discharge as a result of irrigation return flows throughout the Valley, and; 3) in leaky confined aquifers that receive recharge from the overlying shallow stream system. GGI (1995) measured a k'= 0.02 ft/day through the USB overlying the Agua Azul aquifer adjacent to the RPdT below Los Cordovas.

In order to increase municipal ground water diversions without adversely impacting surface water flows, deeper municipal and Pueblo wells will be drilled at locations downstream of most irrigation diversions. In order to determine effects on surface water caused by pumping deeper portions of the basin-fill aquifer, nested piezometers will be installed to monitor water levels during pumping tests on selected deep zones. These data will be used to calculate vertical hydraulic conductivity (k') through the shallow Servilleta basalts, interbedded Agua Azul sands and gravels, and through the deeper Chamita and Ojo Caliente aquifers. Field measurements of k' will be used to estimate effects on the shallow aquifer and interconnected surface waters caused by pumping deeper portions of the aquifer. It is hoped that pumping deeper portions of the aquifer will not result in increased stream depletions so future municipal ground water development will not require retirement of additional agricultural water rights and consequent adverse effects on the traditional agrarian lifestyle of the valley.

CONCLUSIONS

1. Wells completed in the Taos Valley are typically completed into basin fill sediments of the Rio Grande Rift. Wells completed within the Sangre de Cristo Mountains or along the mountain front penetrate alluvial fan deposits, Paleozoic sedimentary rocks, and Precambrian crystalline rocks, which are typically less productive aquifers than the basin fill deposits.
2. The Agua Azul aquifer is a productive axial fluvial sandy gravel aquifer with good water quality.
3. A shallow fluvial and alluvial fan sandy gravel aquifer overlying the USB and the Agua Azul aquifer is also a productive basin fill aquifer with good water quality
4. Preliminary testing of deeper aquifers in the basin indicates that productive aquifers are present at depths below 800 to 1000 feet. Deep aquifers ground water is soft, and some areas of deeper aquifers may be alkaline (high pH), and high in fluoride and iron.
5. Testing of the Paleozoic limestone and sandstone aquifer underling the basin fill sediments at the Town Yard location suggest that this aquifer has transmissivity values within the range of values obtained from testing of the productive basin fill aquifers. The Paleozoic limestone and sandstone aquifer underling the basins fill may also be high in fluoride and iron.
6. The shallow ground water system is in hydrologic communication with surface flows in the Rio Pueblo de Taos and Rio Hondo.
7. To increase municipal ground water diversions without adversely impacting surface water flows, deeper municipal and Indian wells will be drilled at locations downstream of most irrigation diversions. In order to determine effects on surface water caused by pumping deeper