WATER AND SANITATION
FOR HEALTH PROJECT

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WATER SUPPLY TECHNICAL ASSISTANCE

COLONIA FELIPE ANGELES

CIUDAD JUAREZ, CHIHUAHUA, MEXICO

WASH FIELD REPORT NO. 188

JULY 1986

Prepared for
the USAID Representative to Mexico
WASH Activity No. 231

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Prepared for the USAID Representative to Mexico
under WASH Activity No. 231

by

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EXECUTIVE SUMMARY

At the request of the USAID representative in Mexico City and authorized by USAID's Office of Health, the Water and Sanitation for Health (WASH) Project sent a two-person team to Ciudad Juarez, Chihuahua, in March 1986 to develop a groundwater exploration program and study alternative water supply schemes for Colonia Felipe Angeles, located northwest of downtown Juarez. The community presently has a population of approximately 40,000 inhabitants and is not served by the city of Juarez's water system. The colonia's northern and eastern border is the Rio Grande River with El Paso, Texas as its immediate U.S. neighbor.

The following is a summary of the consultants' findings, conclusions, and recommendations.

Findings:

1. The State of Chihuahua has established an organization called Fondo de Inversiones Financieras Para Obras de Agua Potable y Alcantarillado (FIFAPA) to use a loan from the Inter-American Development Bank for improvement and expansion of the existing water and sewer system. Their funds, however, have been limited and have not been able to supply marginal areas with water. The loan term expires December 1986 and unless extended this activity will terminate.

2. The Junta Municipal de Aguas y Saneamiento is the government agency charged with the operation and maintenance of the water and sewer systems, planning of future expansions, collection of service fees, quality control, flood control, and the aspects of sanitation covering wastewater disposal. At present, FIFAPA assists the Junta Municipal de Aguas in its improvement and expansion activities.

3. For several years, residents of the community have sought a local water source to supply their needs. These efforts have included the drilling of a well in 1983. Thus far, these efforts have been unsuccessful.

4. The topography of the study area is very irregular--making the construction of a water supply system difficult and expensive.

5. The Junta Municipal de Aguas and FIFAPA are planning to conduct water exploration west of the Juarez Mountains. The time for this activity, however, has not been established.

6. The community of Felipe Angeles is well organized and has very active leaders.

Conclusions:

1. Water use for Colonia Felipe Angeles based upon a per capita consumption of 20 litres per person is approximately 212,000 gallons per day or approximately 150 U.S. gallons per minute on a continuous basis.

2. Groundwater in the Colonia Anapra area flows to the northeast toward the Rio Grande.

3. The quality of the nearby Bagby Ranch water is good.

4. The Mexican Government has plans to drill a test well in the near future in the vicinity of Colonia Anapra, but there is no indication it would be used to supply water to Colonia Anapra or Colonia Felipe Angeles.

5. Groundwater is likely to occur beneath the West Mesa area between the Juarez Mountains and the igneous body of rock on which Colonia Felipe Angeles is situated.

6. The quality of water beneath the West Mesa area is unknown but is likely to be better close to the Juarez Mountains.

7. The depth to groundwater beneath the West Mesa area location is not known but is almost certainly greater than 200 feet.

8. Drilling costs will probably be in the range of $40 to $60 U.S. per foot for a 10-inch cased and gravel packed well.

9. The cost of additional geophysical work will be approximately $25,000 U.S. per location provided high production drilling rigs are used.

10. It is likely that wells can be sited within several hundred feet of each other. Proper well spacing can only be determined following completion of the first well and an aquifer performance test.

11. Ciudad Juarez has the required infrastructure for implementing complex water and sewer systems.

12. The Junta Municipal de Aguas y Saneamiento and FIFAPA have been planning strategies for solving the water supply problem of the marginal areas.

13. Economic resources are limited.

14. The topography of Colonia Felipe Angeles is very irregular and the design of a water supply and distribution system requires careful planning and detailed studies.

15. Water resources information in the study area is not readily available and careful groundwater exploration is needed.

16. Connection to the existing water supply system is feasible.

17. Transmission of water from the Anapra area requires detailed studies to select an optimum pipeline route.

18. Transmission of water from the West Mesa area would not require as much topographic survey effort since the topography between this area and Colonia Felipe Angeles is relatively constant.

19. Water vending would need to be expanded (through financing) by the Junta Municipal de Aguas since existing private water purification companies do not have the required equipment to deliver water in tank trucks nor the capital for such investment.

20. The community is well organized and the existing "Pro-Water Committee" is willing to assist in every way possible in the implementation of a water program.

21. Government representation in the "Pro-Water Committee" is needed to inform the community of the government water supply plans for their colonia.

22. Health education needs to be implemented.

23. Excreta disposal facilities need to be improved.

Recommendations:

1. A well field could be located in the vicinity of Colonia Anapra. The depth to water should be approximately 100 feet, and the wells will likely yield in excess of 200 U.S. gallons per minute.

2. An alternative location for a proposed well field has been selected approximately one to two miles east of Colonia Felipe Angeles.

3. Any test well should be drilled with cable tool or air rotary methods so that the depth to water, water quality, potential well yield, and aquifer composition can be determined as the well is drilled. A mud rotary rig could also be used to achieve faster production rates but would require the use of electric logging methods and drillers experienced in this technique. Another means to increase production rates and lower project costs would be to use a 6-inch slim hole rotary rig (if available). The other advantage of using rotary equipment is that a jetting nozzle can be used during well development to increase the yield of the well.

4. In either location, geophysical studies may lead to better well site selection. If no geophysical studies are undertaken, optimal well sites would be close to arroyos where fresh water recharges the groundwater system.

5. At least two wells--each with adequate capacity to serve Colonia Felipe Angeles--should be constructed for water supply. This will allow for system redundancy in the event of the failure of a pump. It will also permit alternating operation of wells such that natural groundwater flow may resupply the area of influence of each well with fresh water should water quality deteriorate with time.

6. Communication between the community and the local water supply authorities should be improved through government representation in the Colonia Felipe Angeles "Pro-Water Committee."

7. The "Pro-Water Committee" should work with the Junta Municipal de Aguas and FIFAPA to develop ideas for the investigation of the alternatives for

providing water to the colonia--raising funds within the community or through international assistance.

8. The community should discuss with the Junta Municipal de Aguas and FIFAPA the way in which the community can assist in accomplishing the alternatives that are the most feasible.

9. A latrine committee should be formed to begin working with local authorities in the design of a latrine program that would also meet the goals and plans of government agencies.

Chapter 1

INTRODUCTION

At the request of the USAID representative in Mexico City, the Water and Sanitation for Health (WASH) Project initiated Activity No. 231 on March 3, 1986, to provide technical assistance to Colonia Felipe Angeles in Juarez, through the Presbyterian Church's Project Verdad. The technical assistance was provided with the understanding that USAID was not making a commitment for additional technical assistance nor for the funding of any improvements that were recommended. The scope of work for the assistance was as follows:

1. Meet with Project Verdad and Ciudad Juarez government officials to discuss water supply for the marginal areas of Juarez.

2. Review existing information and provide assistance in locating a groundwater supply source.

3. Recommend a groundwater exploration program.

4. Develop a water supply plan that will consider alternative supply sources (i.e., groundwater, water vending, or connection to the system) and outline a program to provide the unserved areas with water.

5. Define the project elements that are required, including financing, management, community participation, health education, and operation and maintenance.

6. Explore possibilities for financing the project, including the use of private voluntary organization (PVO) funds and/or loans or grants from the Mexican government or the Inter-American Development Bank (which has ongoing projects in Juarez).

7. Prepare a draft report to be left with Project Verdad at the end of the assignment.

Drs. Henry Van and William M. Turner were assigned to carry out the study and prepare recommendations. They arrived in Ciudad Juarez on March 8, 1986; completed their assignment; and prepared the draft report below in English and Spanish on April 30, 1986. The report was subsequently reviewed with Mexican Government officials and submitted to WASH in June 1986.

The report is based on the study of background documents, field surveys, and discussions with government officials, drillers, water vendors, and community members (see Appendix A for officials contacted). Conclusions and recommendations are presented in Chapter 5 for each aspect of the project--in the same order as the topics were presented in each chapter.

The list of the activities of the consultants is included in Appendix B.

Chapter 2

EXISTING CONDITIONS

2.1 Project Area and Population

Ciudad Juarez is located approximately 250 miles from the state capital of Chihuahua City. Its northern boundary is the Rio Grande; and across the river is the U.S. city of El Paso, Texas. The terrain is desert with the Franklin Mountains to the north on the U.S. side and the Juarez Mountains to the south on the Mexico side.

The weather is characterized by high temperatures which reach approximately 44 degrees centigrade in the summer. Rainfall is generally low. The predominant wind direction is from the northeast with speed as high as 60 miles per hour during January, February, March, and part of April.

In general, most of the Ciudad Juarez area is flat except toward the southwest where the Juarez Mountains are located. Colonia Felipe Angeles, however, is situated in an area with a very irregular topography.

The community of Colonia Felipe Angeles is situated northwest of downtown Ciudad Juarez (Juarez) in Chihuahua, Mexico. The community presently has a population of approximately 40,000 inhabitants, and it is steadily increasing. The colonia's northern and eastern border is the Rio Grande; and to the west and south are the Juarez Mountains and downtown Juarez, respectively.

2.2 Water Supply

The Colonia Felipe Angeles does not have piped water supply. Water is supplied to the colonia inhabitants by means of tank trucks on a periodic basis. There is no set schedule for delivering the water. Community members have stated that they have been without water for as long as one month because the water supply trucks do not show up. Also, frequently the water trucks deliver water only to those people living near the better roads. The water trucks charge $0.50 U.S. for approximately 55 gallons.

Upon delivery of the water to the users, the water is stored in different types of containers--such as 55 gallon drums, concrete tanks, or plastic containers. Most water-storing containers are open to the atmosphere. The colonia has unpaved streets; and dust accumulation can be substantial during heavy traffic or simply under high winds, a condition which is typical of the Juarez/El Paso area.

According to some members of the colonia, the average number of people per household is approximately 10 and many live in only two rooms.

2.3 Health and Sanitation

The result of inadequate water supplies is poor sanitation practices, human suffering, and a high incidence of disease. The burden is greatest on

children. Enteric bacterial infections, such as paratyphoid fever, bacillary dysentery, and skin diseases, are common. Although time did not allow for gathering statistics regarding the incidence of the above diseases resulting from the lack of adequate domestic water supplies, from previous conversations held with two local physicians, the team learned that the situation is critical and becomes more alarming as these areas become more populated. The majority of infant mortality results from a combination of malnutrition and infectious diseases. The disease most common to this colonia is diarrhea caused by a lack of clean water, sanitation, and personal hygiene. In El Paso, diarrhea is considered a minor disease. In the poor areas of Juarez, however, this disease is combined with malnutrition to produce fatal results.

2.4 Institutions

The institution responsible for providing adequate water supply to Juarez is the Junta Municipal de Aguas. This agency has conducted some hydrogeologic studies of the marginal areas of Juarez, including Colonia Felipe Angeles. Their studies indicate that good groundwater in the area is not readily available (1).

Another institution is the Fondo de Inversiones Financieras Para Obras de Agua Potable y Alcantarillado (FIFAPA) which assists the Junta Municipal de Aguas in the construction of water and sewer systems funded by a loan from the Inter-American Development Bank. These agencies receive technical assistance for water exploration from a national agency called Secretaria de Agricultura y Recursos Hidraulicos (SARH) which is in the Secretariat of Agriculture and Water Resources.

Chapter 3

WATER RESOURCES

3.1 Introduction

For several years, residents of the community have sought a local water source to supply their water needs. These efforts have included the drilling of a well in 1983. Thus far, these efforts have been unsuccessful. Recently, through the interest and assistance of Project Verdad, a program funded by the Presbyterian Church, renewed community efforts are underway. The present WASH activity is in response to a request from the community of Colonia Felipe Angeles and Project Verdad to locate satisfactory water supplies and to develop preliminary plans for bringing the water to the community.

3.2 Hydrogeologic Setting

In the arid northern part of the State of Chihuahua, reliable drinking water supplies are obtained from groundwater sources. Ciudad Juarez itself obtains all of its potable water from deep wells drilled in alluvial sand and gravel deposits south of the present channel of the Rio Grande. The initial effort in Colonia Felipe Angeles was also to drill a test well south of the Rio Grande in the community itself in the hope of finding water in alluvial materials. This effort met with failure.

While there is a paucity of hydrogeologic information in the vicinity of Colonia Felipe Angeles, there is a great wealth of hydrogeologic information immediately to the north of the international border in New Mexico and Texas. The data base of compiled information has been greatly increased in recent years because of the law suits between the City of El Paso and the State of New Mexico. These lawsuits deal with the legal rights of El Paso to withdraw groundwater from the Mesilla Bolson of southern New Mexico.

In addition to the available data from New Mexico and Texas, the geology of the Colonia Felipe Angeles area and the border area immediately south of the international boundary was dealt with in very general terms by Lloyd and Marston (2). The geology of the area has also been field checked for similarity to and continuation of the geologic trends on the United States side of the border. The results of the field studies indicate that the geologic information from the United States side of the border can be easily extended far enough south of the international boundary to be used reliably in the present study. Also the general comments of Lloyd and Marston are helpful. Figure 1 is a large scale physiographic map of the transborder region extending approximately 100 miles in all directions from Las Cruces, New Mexico. The figure includes the El Paso and Ciudad Juarez areas.

Figure 2 covers the same area as Figure 1 and depicts early and middle quaternary paleodrainage patterns which existed in the vicinity of El Paso and Ciudad Juarez. It is of considerable interest that the Rio Grande in early and middle quaternary time flowed somewhat to the west of its present course at Ciudad Juarez.

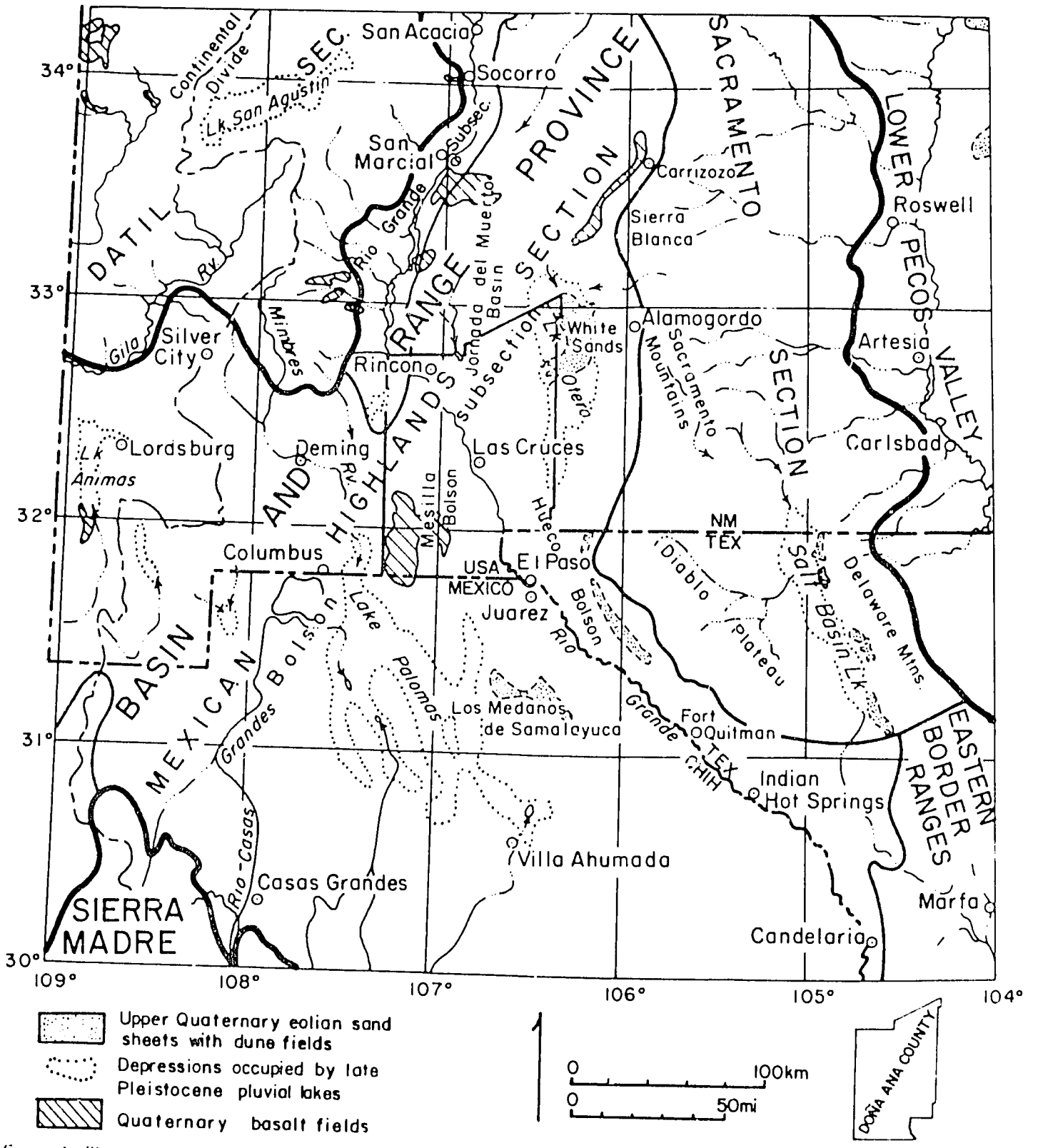

Figure 1. Physiographic subdivisions, major stream systems, pluvial lake basins, and dune and basalt fields in south central New Mexico region.

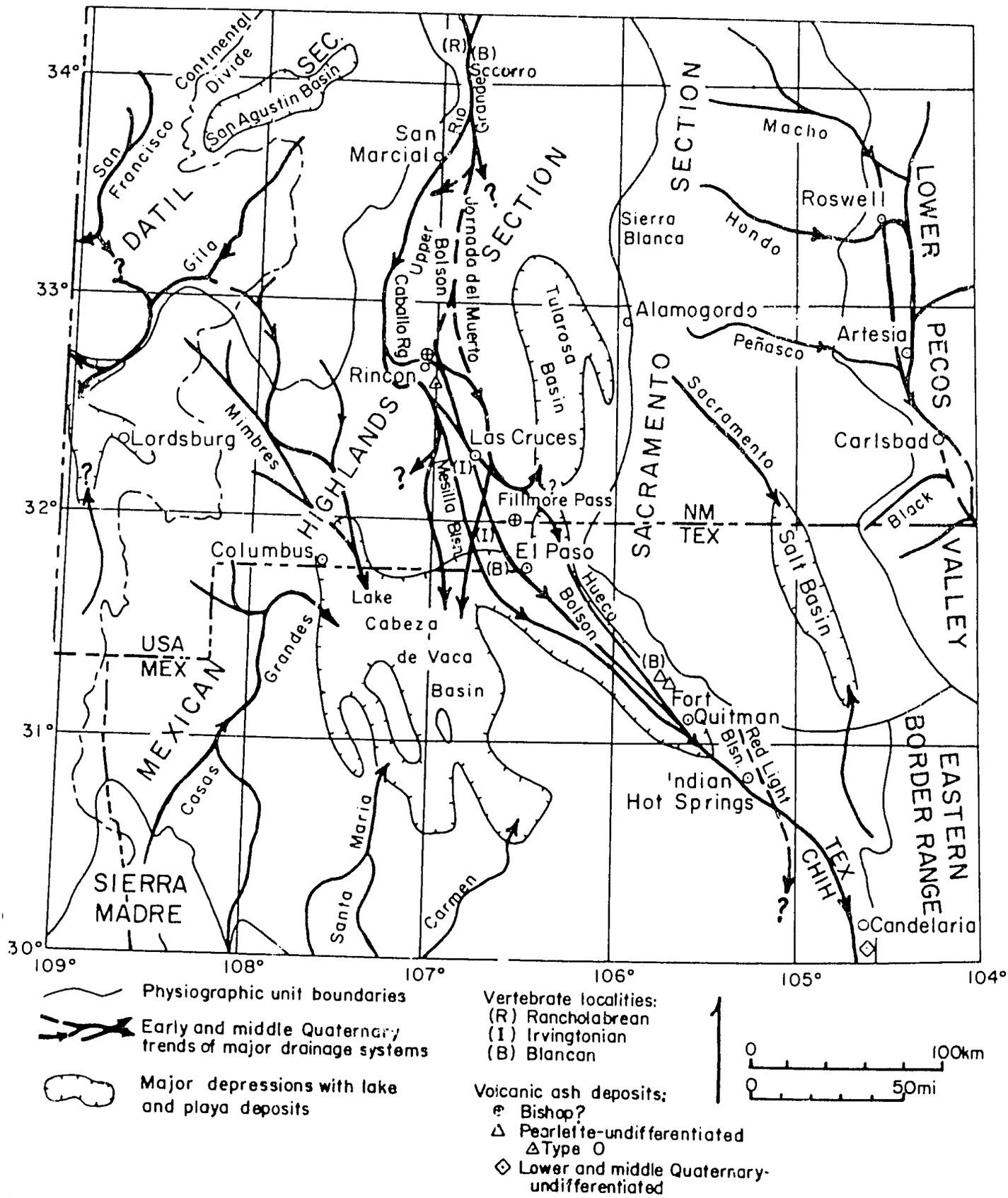

Figure 2. Early and middle Quaternary paleodrainage, undrained depressions, volcanic ash, and vertebrate faunal localities, and major physiographic subdivisions in south-central New Mexico region.

Water supplies for Ciudad Juarez, El Paso, and the New Mexico communities as far north as Las Cruces are derived from groundwater pumping. All of the groundwater occurs within the Hueco Bolson on the east side of the Franklin and Juarez Mountains and the Mesilla Bolson on their western side.

The Hueco and Mesilla Bolsons are broad intermontane structural basins. In the vicinity of Colonia Felipe Angeles, the eastern edge of the Mesilla Bolson and the Hueco Bolson deposits become coextensive. Figure 3 is a generalized physiographic map of Ciudad Juarez and vicinity. Figure 4 is a generalized west to east cross section from the Juarez Mountains on the west to the Rio Grande on the east. In the vicinity of Ciudad Juarez, the Hueco Bolson is estimated by gravity survey work in the area as more than 1,000 meters thick.

The Mesilla and Hueco Bolsons are filled with unconsolidated clastic sediments known collectively as the upper Santa Fe Group.

Hawley, et al., (3) divides the upper Santa Fe Group into two formations: the lower Fort Hancock Formation of Pliocene age and the younger Camp Rice Formation.

The Fort Hancock Formation is relatively fine-grained sediments with interbedded and disseminated gypsum in places. These sediments are regarded as deltaic and lacustrine deposits. Water in the Fort Hancock Formation is likely of poor quality and unuseable for domestic water supply. Of greater importance for potable water is the Camp Rice Formation which overlies the Fort Hancock Formation and is comprised largely of fluvial sediment deposited by the through-flowing Rio Grande system. Alluvial fan deposits interfinger with the Fort Hancock and Camp Rice Formations around the edge of the depositional basin.

The fluvial facies of the Sante Fe Group clastic sediments and the bolson deposits contain the largest amount of fresh water in the area of interest. The water-bearing sediments are primarily sand with layers of gravel, silt, clay, and sandy clay. Horizontal permeability greatly exceeds vertical permeability, usually by several orders of magnitude, because of clay layers ranging in thickness from a few inches to some tens of feet. Figure 5 is a geologic map of Ciudad Juarez area extending as far north as the international boundary.

The southern end of the Mesilla Valley, known locally as the narrows, is a bedrock high covered with a thin alluvial veneer. The narrows are caused by a north-south trending intrusive body of igneous rock of tertiary which intruded a sequence of black marine shales and thin-bedded sandstone of cretaceous age. The intrusive contact between the two rocks is easily seen in arroyos which have incised channels into the igneous body west of Colonia Felipe Angeles. The north-south igneous body continues south into Mexico from near Anapra and together with the Juarez Mountains separates the Rio Grande Valley from the early and middle Quaternary Lake Cabeza de Vaca Basin south of the international boundary. The Lake Cabeza de Vaca Basin is shown in Figure 2. The igneous intrusive passes beneath the land surface southeast of Colonia Felipe Angeles.

Colonia Felipe Angeles is located on the eastern flank of this north-south trending body of igneous rock, and it was into this body of igneous rock that

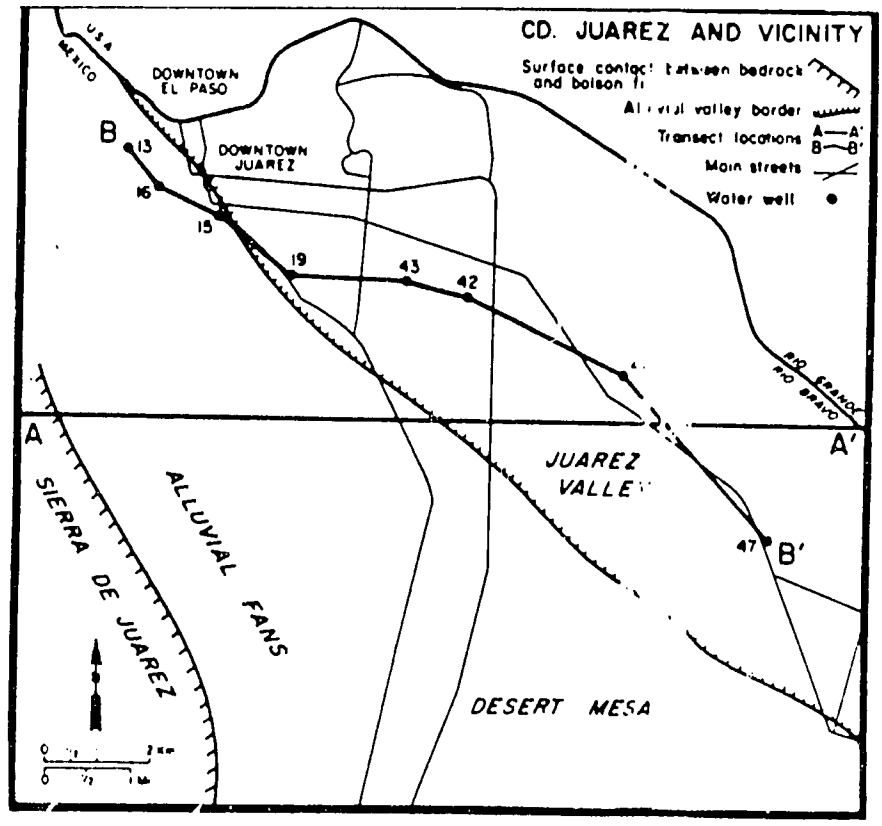

Figure 3. Study area including line of geologic section. Geologic cross section is shown in Figure 4.

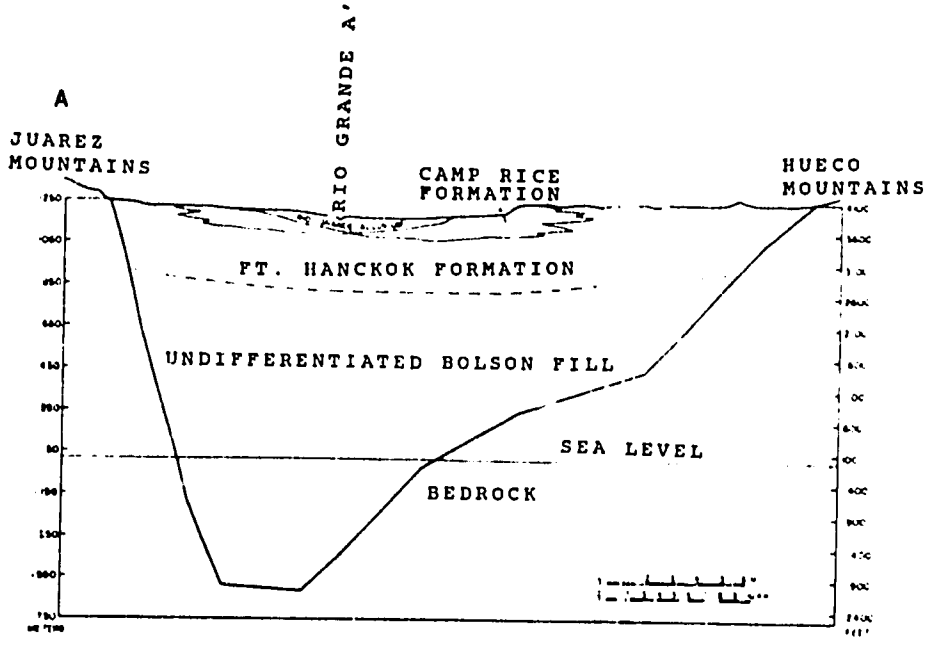

Figure 4. Generalized west to east geologic cross section of the Hueco Bolson. See Figure 3 for location.

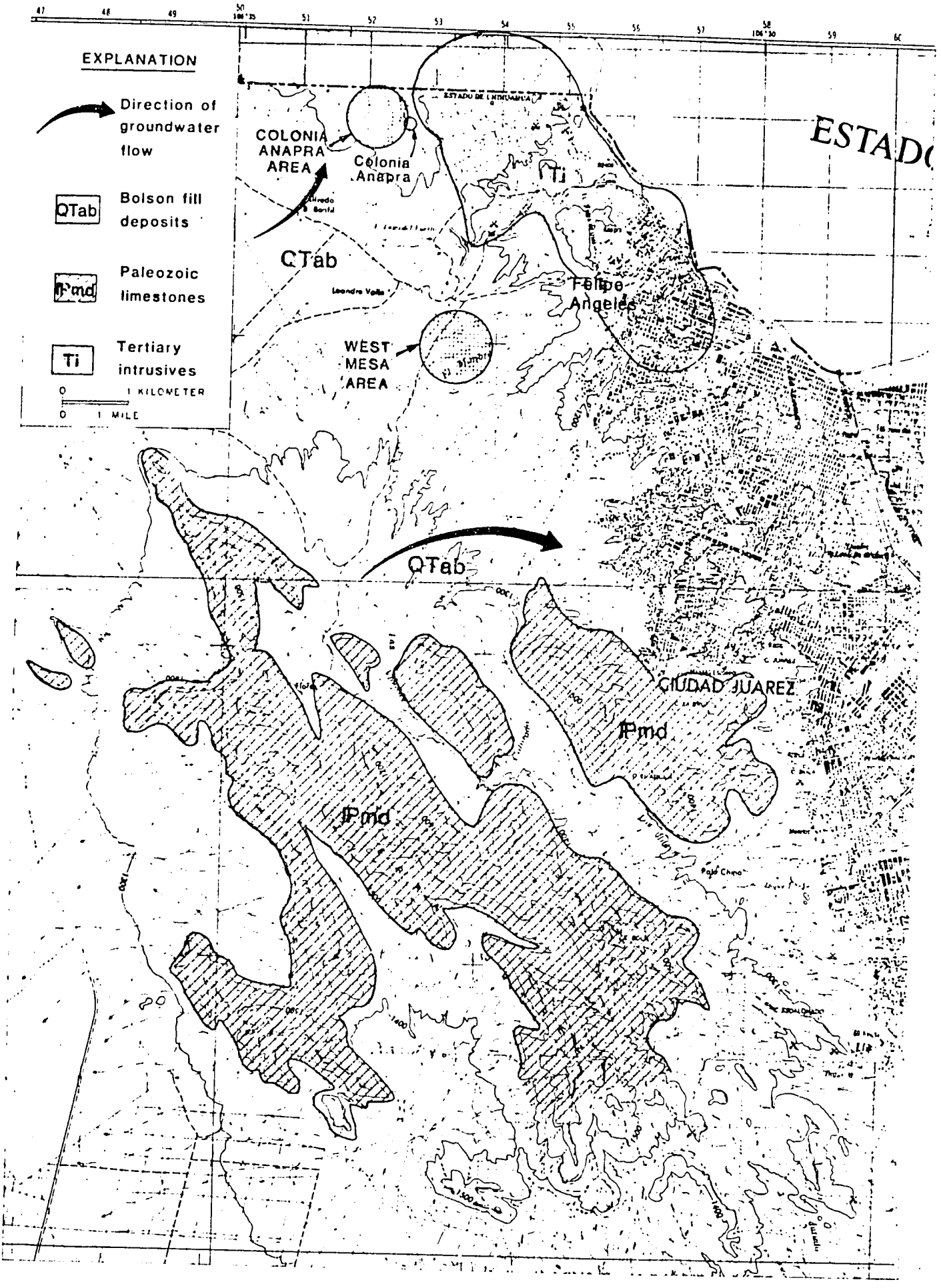

FIGURE 5--GENERALIZED HYDROGEOLOGY OF THE JUAREZ - COLONIA ANAPRA AREA

the earlier test well was drilled. West of the north-south range of tertiary igneous rock, the thick deposits of Sante Fe Group covered are really extensive.

It appears likely that a paleo-channel of the Rio Grande extended into Mexico from the international boundary in the vicinity of the Bagby Land and Cattle Company feedlot and onward between the Juarez Mountains and the narrow igneous intrusive and that the paleo-channel actually passed through what is now Ciudad Juarez. If a paleo-channel of the Rio Grande did exist in this area, it will be of importance because the river at that time may have formed stream channel deposits of higher than normal permeability. Wells drilled into these buried paleo-channel deposits will normally produce greater volumes of water and water of better chemical quality.

3.2.1 Groundwater Occurrence

Groundwater in the area of interest occurs below the mesa area of the Hueco Bolson south of the international boundary and west of Colonia Felipe Angeles between the Juarez Mountains and the narrow zone of cretaceous igneous intrusives. At the international boundary, in the vicinity of Colonia Anapra, the depth to water is known to be approximately 100 feet. On the mesa surface west of Ciudad Juarez, the depth to groundwater is not known but is almost certainly in excess of 200 feet.

3.2.2 Direction of Groundwater Flow

From data compiled by the United States Geological Survey, immediately north of the international boundary, groundwater in the vicinity of Colonia Anapra flows from Mexico into the United States and ultimately discharges into the Rio Grande. The groundwater is forced to the surface by the narrows described above which has only a thin alluvial cover. The north-south trending tertiary igneous rock acts as an effective barrier to eastward groundwater flow in Mexico toward the Rio Grande.

South and southwest of Colonia Felipe Angeles, normal groundwater flow will be to the northeast toward the Rio Grande and toward the east where Ciudad Juarez has a widely distributed well field.

The gradient to the groundwater table in the vicinity of Colonia Anapra is approximately 20 feet per mile to the northwest.

Lloyd and Marston estimate that the rate of groundwater flow toward Ciudad Juarez from the Juarez Mountains is approximately 2.4 cubic meters per day per meter width of aquifer.

3.2.3 Well Yield

Based on wells drilled adjacent to the international boundary in the United States, the U.S. Geological Survey estimates the yield of wells in the area to be from 100 to 1,000 gallons per minute (gpm). There are no drilled wells in the vicinity of Colonia Anapra; however, it is likely that high yield wells will be possible in the Colonia Anapra area and in general throughout the mesa area west of Ciudad Juarez.

3.2.4 Groundwater Recharge

Recharge to the groundwater system in the area of interest takes place either as mountain-front recharge along the eastern side of the Juarez Mountains or as line source recharge through infiltration of storm runoff through the beds of the arroyos.

At Colonia Anapra there is a small pit approximately two feet deep which reportedly contains water following runoff events. The pit dries up as the water infiltrates below the bottom of the pit into the ground. This high rate of infiltration is typical of the area.

3.2.5 Water Quality

The quality of water in the Mesilla Bolson near Anapra is somewhat variable. It is known that the water quality decreases with depth. The thickness of the fresh water zone in the vicinity of Anapra is probably about 200 feet. Below this depth, the quality of the water deteriorates. Data compiled by the U.S. Geological Survey from north of Anapra indicates that the fresh water aquifer generally contains water which has less than 1,000 milligrams per liter (mg/l) of total dissolved solids. Water of this quality is deemed satisfactory for drinking water purposes.

The quality of groundwater in the mesa area east of Juarez Mountains may be similar to the water by the mountain front. This is the case in the Hueco Bolson east of the Franklin Mountains (Figure 2) where a paleo-channel of the Rio Grande passes through Filmore Pass in the El Paso area. This paleochannel created more permeable deposits through which groundwater recharge along the east side of the Franklin Mountains moves more rapidly. Water within this narrow aquifer zone is of significantly better quality--even at a distance of 10 miles from the mountain front--than surrounding groundwater (4).

It also is likely that if coarse-grained clastics are associated with the paleo-channel which passed between the igneous intrusive and the Juarez Mountains, this area may also contain better quality groundwater than elsewhere.

3.3 Bagby - Colonia Anapra Cooperative Program

In 1983, the community of Colonia Anapra approached the Bagby Land and Cattle Company (located along the international boundary and about one-half mile from Colonia Anapra) for water. The Bagby Land and Cattle Company has two wells which are approximately 200 feet deep. The Bagby Land and Cattle Company agreed to provide Colonia Anapra with water from their wells. While the employees of the Bagby Land and Cattle Company prefer to drink bottled water, the water was sampled by the team and found to be acceptable and potable. The Anapra community has been drinking the water for some time and has not reported any problems with this water supply.

Interviews with residents of Colonia Anapra indicate that there is a population of approximately 400 persons in Colonia Anapra. Each family paid approximately $5 U.S. toward materials for the main water transmission line

and approximately $15 U.S. for materials to bring the water from the main line to homes. All labor was supplied by members of the community.

This example of international cooperation is reported in a front page article in the El Paso Herald-Post dated March 7, 1986 (see Appendix C).

It appears, therefore, that there is water available at the international boundary for a water supply to Colonia Anapra and possibly to Colonia Felipe Angeles.

3.4 Government Groundwater Exploration Program

Discussion with Ing. Soria of the Secretaria de Agricultura y Recursos Hidraulicos (SARH) in Juarez revealed that the SARH has plans to drill an exploration well in the vicinity of Colonia Anapra in the near future. The permit for the well was approved by the SARH in November or December of 1985. The exploration program is intended to determine the existence of potable groundwater in the West Mesa area. The WASH team understands that the government well will be drilled as a test well and not necessarily completed as production well to supply water to the residents of Colonia Anapra.

3.5 Well Location

3.5.1 Colonia Anapra Area

Interviews with residents of Colonia Anapra indicate that much of the land in the area is privately owned, and there would be no difficulty in securing a piece of property for one or more wells. Because of the apparent variability of groundwater quality in the Colonia Anapra area, further studies should be carried out to locate optimal well sites. These well sites will likely be associated with paleodrainage channels which passed through the Colonia Anapra area in early to middle quaternary time. High permeability sediments associated with these buried channels will continue to be conduits for rapid groundwater flow. In addition to increasing the available yield, rapidly flowing groundwater is generally of the best chemical quality because this groundwater has had the shortest residence time in the aquifer and has had less opportunity to either dissolve constituents in the aquifer or to suffer increasing salt concentration through evaporation from the water table.

Other optimal well sites may be associated with present day drainage channels (arroyos) as these channels serve as line sources of recharge. That is, surface runoff which occurs in these channels infiltrates through the sandy beds of the channels and percolates to the groundwater system. If water quality is a problem in the area, better quality groundwater will also be in close proximity to these surface arroyos.

Additionally, continued pumping from wells which encounter increasingly poorer quality water with depth will cause an upconing of poor quality into the shallower, better quality water. The extent of this problem will depend upon the vertical permeability of the sediments. Should there be abundant clay beds with depth encountered by a well, the upconing effect will be minimized. Without this knowledge prior to drilling a well, it is desirable to locate a

well in an area where either fresh water is continually replenishing the shallow water table or where fresh groundwater will sweep past a well at high groundwater flow rates so that the effect of water of poor quality can be swept away.

For these reasons, a thermonic survey of the Colonia Anapra area may be helpful to determine optimal well sites.

Thermonics is based upon the fact that moving groundwater redistributes rising geothermal heat. In general, soils in recharge zones will have cooler temperatures than soils elsewhere.

In the absence of further studies, it is recommended that the wells be located close to major arroyos. The area for consideration is depicted in Figure 5.

3.5.2 West Mesa Area

Colonia Felipe Angeles is approximately three miles from the proposed Colonia Anapra well field. The terrain between Colonia Anapra and Colonia Felipe Angeles is very irregular. It may be more feasible to locate a well field on the West Mesa area from one to two miles southwest of the igneous intrusive and approximately a mile south of the Lago del Puerto. This location is shown in Figure 5. There are presently no wells in the West Mesa area, and depths to groundwater and the water quality in the area are unknown.

3.6 Number of Wells

Because of the possible poor quality of the water and the possibility of upconing of poor quality water, it is recommended that up to three wells be considered for water supply. Each well should have a capacity of at least 200 gpm. If water quality is determined to be deteriorating from any particular well, the well would be shut off and water taken from another well. This will allow time for the groundwater to sweep past the well with the degraded water quality and to replenish the area affected by the well with a new supply of better quality water. Furthermore, because wells invariably have problems at one time or another, it will be necessary for redundancy to be built into the water supply system such that if the pump on a well fails, another well can be used to supply water.

3.7 Suggested Well Field Parameters

Wells in the well fields must be properly spaced to minimize the drawdown effects caused by one well upon the other. In the Mesilla Bolson, the assumption that the aquifer is really extensive and homogeneous is more or less valid and the well known Theis relationship may be used to calculate well spacings. The Theis equation is:

$$s = 114.6\ Q\ W\ (\ u\ )\ /\ T$$

where:

s = the drawdown, feet
Q = pumping rate, gallons per minute
W(u) = well function with argument "u," dimensionless
u = $1.86r^2S/Tt$
T = aquifer transmissivity, gallons per day per foot
r = distance from pumping well, feet
t = length of pumping period, days
S = aquifer specific yield, dimensionless

Although there is no pump test data, it is generally known that the wells in the Anapra, New Mexico area are of high yield. The hydraulic parameters of transmissivity and the storage coefficient may reasonably be estimated as 200,000 gallons per day per foot (gpd/ft.) and 0.20, respectively. These are values used by the U.S. Geological Survey in the Albuquerque, New Mexico area for similar aquifer materials. The length of the planning horizon will be 40 years, and the design pumping rate should be approximately 500 gallons per minute. The table below gives the expected drawdown in a pumping well caused by another pumping located at various distances from the first pumping well.

Distance (feet)	Drawdown (feet)
100	3.72
200	3.32
500	2.79

It is concluded that if the aquifer has a transmissivity of 200,000 gpd/ft. and a specific yield of 0.20, the drawdown caused by a pumping well is slight; and additional wells may be added at almost any distance from another pumping well. The effects of wells upon each other are cumulative. In the example above, if there were two production wells located 100 feet from a third production well, the drawdown in the third well caused by the other two would be 7.44 feet instead of 3.72.

The drawdown in the pumping well caused by its own pumping will be 6.3 feet for the example presented.

3.8 Suggested Well Parameters

To pump from 150 to 400 gallons per minute from a well, the casing needs to be 10 inches in diameter. It is recommended that a 14-inch surface casing be cemented to a depth of six meters in a 20-inch hole. The well should be drilled to a maximum depth of 500 feet in the Colonia Anapra area and to 1,000

feet in the West Mesa area. When, during the drilling, it is determined that the well will likely produce 500 gpm, drilling may be terminated.

The ultimate design of the well may change from that envisioned here because of new information and the capabilities of the various types of equipment operated by drillers.

3.9 Pumping Test

Subsequent to the development of the well, a standard step-drawdown type of aquifer performance test should be conducted for a period of at least 96 hours followed by a recovery period of at least eight days. During the entire period of the test, water level measurements are made frequently in the test well. The results of the aquifer performance test will enable the determination of the optimal pumping rate for the well and determination of the aquifer transmissivity which is necessary to properly space wells in a well field.

3.10 Permits

Prior to drilling and constructing a well in either the Colonia Anapra or the West Mesa area, it will be necessary to obtain a permit from the Secretariat of Agriculture and Water Resources.

3.11 Drilling Methods

Because no exploration drilling has been carried out in these areas and there is no information as to groundwater quality, it will be necessary to use cable tool or air rotary drilling methods to drill the test wells. These methods do not require the use of drilling mud which prevents the recognition of the water table when it is reached and which does not allow collection of water samples for analysis as the well is deepened (because of the unconsolidated character of the material). As the well is deepened using either the cable tool or air rotary method, rock cuttings will be sampled and a grain-size analysis carried out on the coarser clastic deposits beneath the water table. Water samples can be taken from various depths and analyzed for chemical quality.

Use of the cable tool or air rotary method will also enable the determination of probable well yield as the borehole is deepened.

When the borehole has been drilled to an optimal depth, determined by using information from grain size and water quality analyses, the production string will be designed. The production string consists of 10-inch casing and 10-inch well screen. If the screen and blank casing are assembled in such a way as to place the screen opposite the coarsest clastic material beneath the water table, the screened zones should also produce the best quality water.

Upon placing the production string in the well, the casing which was driven during the drilling process will be pulled back thereby exposing the production string to the water-bearing clastic sediment. This method of drilling is commonly called the "pull back method."

Development of the well will require surging the well followed by bailing for a period of some hours. The surging causes fine sand that might otherwise damage the impellers of an electrosubmersible pump to be pumped out of the aquifer near the casing. The bailing removes the fine sand grains. Development should continue until the bailed water is clear and nearly sand free.

It is unlikely that bailing will be able to extract up to 500 gpm from the well. And, unless up to 500 gpm is extracted from the well, simple surging and bailing may not completely develop the well. The test pump used for the pumping test should be set and the well subjected to "overpumping" to further develop the well.

3.12 Well Construction Costs

Cost estimates provided by Perforacion de Pozos Profundos for the test well which was drilled in Colonia Felipe Angeles and a verbal estimate by Talleres Industriales de Santiago, S.A. in Ciudad Juarez were used to estimate well costs.

Perforacion de Pozos Profundos based its cost estimate on a well cased to 495 feet with 14-inch casing and cased from 495 feet to 820 feet with 8-inch casing. The total estimated cost was approximately $48,130 U.S. or approximately $58.69 U.S. per foot and was dated September 4, 1979. The rate of exchange at that time was 25 pesos to one U.S. dollar.

The verbal estimate from Tallerers Industriales de Santiago, S.A. was based on an 8-inch cased well to 500 feet and was approximately $2,400 per meter or approximately $40 U.S. per foot. The lower per foot cost can be attributed to the smaller diameter of the well. The above costs are based on an exchange rate of $450 pesos to one U.S. dollar.

For cost estimation purposes, a price of $60 U.S./foot could be reasonably used in 1986. This should be sufficient for payment of any necessary consulting services as well. The cost for the test wells completed as production wells in the Colonia Anapra area will be a maximum of $30,000 U.S. and in the West Mesa area, $60,000 U.S. If insufficient water is encountered while drilling the wells, they may be abandoned without spending the full amount budgeted for the particular well. The contract documents must contain provisions for partial completion and partial payment of the work. A proposed tender document is contained in Appendix D.

3.13 Thermonic Groundwater Exploration Program

A thermonic groundwater exploration program entails the drilling of many small diameter holes to a depth of approximately 20 feet in a direction perpendicular to the direction of groundwater flow. In the Colonia Anapra area, the lines would be oriented approximately north-south.

Initially holes are drilled about 200 feet apart. Based upon temperatures measured in these shallow holes, additional shallow holes may be required to zero in on the zones of high groundwater flow rate.

In the Anapra area, a reconnaissance thermonic survey would precede the drilling of any shallow wells to determine the relationship between water temperature and well yield in the general area.

The thermonic geophysical methods are known to the Mexican Government which, some 15 years ago, contracted for two thermonic studies: one in Leon, Guanajuato, and the other in the alluvial basins south and southwest of Hermosillo, Sonora. This work was carried out by one of the WASH team members at the direction of Eng. Heinz Lesser-Jones and Eng. Robles Linares of the SARH head office in Mexico City.

3.14 Cost Estimate for Thermonic Program

A budget estimate for a thermonic survey in the study area is given below.

Reconnaissance thermonic survey of Anapra, New Mexico Area	3 days	$ 3,000 U.S.
Install 20 shallow temperature observation holes in both the Colonia Anapar and the West Mesa area to a depth of 20 feet	1 week	$ 8,000 U.S.
Supervision of drilling and casing activity and logging temperatures		$ 7,000 U.S.
Data interpretation and report preparation	1 week	$ 4,000 U.S.
Contingency		$ 3,000 U.S.
	TOTAL	$25,000 U.S.

3.15 Aquifer Performance Test and Pumping Test Cost Estimate

The test wells must be adequately tested to determine specifications for electrosubmersible pumps. An indication of well capacity will have been determined during the drilling and development of the well. A pump sufficiently large to produce the amount estimated by the driller and if possible up to 500 gpm will be installed in the well.

A professional hydrogeologist or similar Mexican engineer should record data from the well during a pumping period of 96 hours and a recovery period of eight days. The costs estimated for this activity are given below.

Test Set Up	16 hours at $35 U.S./hr.		$ 560
Test	96 hours at $35 U.S./hr.		$3,360
Recovery	8 days at $200 U.S./day		$1,600
Data Analysis	2 days at $400 U.S./day		$ 800
Travel and Subsistence			$1,500
		TOTAL	$7,820

These costs compare well with actual United States costs for similar work. Appendix E shows a list of well contractors in Mexico and the United States.

Chapter 4

WATER SUPPLY PLAN

4.1 Introduction

As mentioned in previous chapters, for several years members of Colonia Felipe Angeles have sought a local water supply source to satisfy their domestic needs. Their efforts, however, have been unsuccessful; but as a result of the assistance of Project Verdad, renewed efforts have gotten underway.

Based on the conclusions and recommendations made as a result of the preliminary geologic and hydrogeologic study described in Chapter 3, a preliminary field reconnaissance was conducted to assess the engineering requirements to implement a domestic water supply program. Although detailed engineering information to design a complete water supply program has not been gathered, this chapter outlines the basis for the planning, implementation, and management of such a program. Opinions of local Mexican officials, information from publications, conversations with community members, and observations from visits to the study area were used in preparing this report.

Chapter 4 outlines the various factors required to implement a water supply program in Colonia Felipe Angeles. Information is given about the water supply problem in Ciudad Juarez and its impact on Colonia Felipe Angeles, the various alternatives for implementing a water supply program including financial possibilities, and the steps to follow for implementing such a program.

4.2 Current Water Supply Program

Ciudad Juarez has had an active water supply program which has been able to increase household connections by a rate of about an average of 7 percent per year and the volume of water produced by an average of approximately 3 percent per year. The city of Ciudad Juarez has had a population growth of 4.3 percent per year during the years of 1930 to 1980 (5).

Based on 1979 estimates, only 44 percent of the inhabitants of Ciudad Juarez were born in the city and the other 56 percent come from other parts of Mexico--showing that there is a substantial inflow of immigrants. From 1940 to 1970, the city's growth rate was 7.32 percent while the state's was 3.22 percent per year; and the population of Juarez in 1985 has been estimated to be approximately 990,600 inhabitants. From these figures one can see that the water supply demand is substantial. But, in spite of this demand, local authorities have been able to serve approximately 74 percent of the population (5).

The marginal areas of Juarez have not been provided with water because of their location in relation to the rest of the existing water supply system. These marginal areas are located in the southern side of the city toward the Juarez Mountains and also north from the valley. The terrain is not very favorable, and it takes detailed planning and time to install a water supply system. At present, the central urban area of Juarez has 68 wells which yield 47,556 gpm or 3,000 liters per second (l/sec.). The southwest portion of the

water supply system has two transmission lines. These lines are fed from 15 water wells which yield approximately 12,682 gpm (800 liters per second (l/sec.). These two lines are close to the Colonia Felipe Angeles. The existing system has been designed and continues to be designed in such fashion that each zone has its own battery of water wells and pumping stations.

In 1981, the state government obtained a loan from the Inter-American Development Bank for 600,000,000 pesos ($23,076,923 U.S.) for improvement and expansion of the Ciudad Juarez water supply system. The original loan period was from 1981 through 1984. The loan, however, was extended to 1986. This program has already completed improvements for approximately 400 kilometers (248 miles) of the proposed 500 kilometers (310 miles) of water distribution piping. Local authorities hope that by the first part of 1987, the state government can extend this loan to continue expanding the water supply and sewer systems in Ciudad Juarez.

4.3 Local Government Water Supply Agencies

There is one agency in Ciudad Juarez responsible for providing water to the city. This is the Junta Municipal de Aguas y Saneamiento.

4.3.1 Junta Municipal de Aguas y Saneamiento

The responsibilities of this municipal agency include the operation and management of the water and sewer systems, planning for future expansion, collection of service fees, quality control, flood control, and that part of sanitation which covers wastewater disposal. Since 1981, the Junta Municipal de Aguas has been assisted by a project called Fondo de Inversiones Financieras Para Obras de Agua Potable y Alcantarillado (FIFAPA).

4.3.2 FIFAPA

This agency was created to design and construct the improvements and expansion programmed under the Inter-American Development Bank loan of 1981. If this loan is not extended in the last part of 1986, this agency will be closed.

4.4 Water Supply Alternatives for Colonia Felipe Angeles

Water supply planning can be hazardous; because if not done carefully, failures may occur that have far-reaching consequences. In particular, the development of groundwater resources is not an exact science, and poorly conceived plans can have serious impacts by failing to provide the infrastructure that must be available to cope with development. With this in mind, the following alternatives are presented.

4.4.1 Connection to the Existing Water Supply System

Based on the information obtained during personal interviews with the directors of the Junta Municipal de Aguas y Saneamiento and FIFAPA, engineers

Manuel Ortega and Horacio Almazan suggested that connecting Colonia Felipe Angeles to the existing water supply system is a very viable alternative; but because of the irregular topography of the study area, careful planning is recommended. They mentioned that there is a possibility of installing a pumping station at a water storage tank called "Postal" and pumping to Colonia Felipe Angeles. This possibility would require an engineering feasibility study and requires funding from a financial institution or donor. The feasibility study would involve topographic survey and selection of the best water piping route for Colonia Felipe Angeles. This is an alternative that would certainly be compatible with the existing system, provided that the feasibility study assesses the most adequate manner to allocate the water without jeopardizing other zones which are now being served from the same zone (Postal).

4.4.2 Transmission and Distribution

4.4.2.1 Anapra Area

In Chapter 3, Anapra was indicated as a possible site for locating groundwater, provided that further studies are carried out to locate optimal well sites. FIFAPA, however, conducted preliminary geophysical studies in the Anapra area. We understand that the study showed that there is an area with water resources. Although the study stated that there may not be sufficient water for large production wells, the details of the geophysical methods used are not known. Generally, earth resistivity and seismic methods (the two most widely used geophysical methods) are not able to evaluate the production capability of aquifers and this is particularly true in the geological setting of the Ciudad Juarez area. Further information on the geophysical methods used is required before a conclusion can be drawn about the study's conclusions.

Assuming that required water resources are available in the Anapra area, there are engineering problems that need to be overcome.

This area was visited by the study team several times, making detailed observations about the existing topography between the Anapra area and the Colonia Felipe Angeles. The distance between these two areas is approximately five miles. The topography is very irregular with a large number of high and low spots. The difference in elevation between Anapra and the lowest portion of Colonia Felipe Angeles could be as much as 100 to 130 feet. The design of a water transmission line between the above two areas would require a detailed route selection study to select the economic location of the pipeline. Also, due to the extremely irregular topography of Colonia Felipe Angeles, the configuration of the distribution system will have to be studied carefully. Figure 5 shows the relationship between the Anapra area and the Colonia Felipe Angeles. In this figure, the rough terrain and the irregular topography which prevails between these two areas can be seen. The area north of Anapra is the Bagby Ranch from which Anapra is now being provided water across the United States and Mexico border (see Chapter 3).

After confirmation of the availability of reliable water resources in the Anapra area, field studies and investigations, as mentioned above, need to be conducted to develop the necessary design data. Also, most important is the

continuous coordination with the Junta Municipal de Aguas and FIFAPA to stimulate strong interest for the proposed project.

The Colonia Felipe Angeles "Pro-Water Committee" and members of the community showed high interest and willingness to contribute in the construction of the water supply system in any way local authorities see appropriate and in a manner acceptable to both parties. This community has very competent leaders and the organization of community participation would be feasible. The community expressed understanding of the economic problems Mexico is undergoing and feels that to accomplish a project of this magnitude, solidarity and cooperation will play an important role. The "Pro-Water Committee" will have a big task in explaining to community members that a thorough and conscientious field investigation for a water supply system is usually time consuming and expensive but is one of the most important phases of the whole undertaking. An error at this stage can plague the operation of the project. On the other hand, it is in this phase that, by careful work, great savings can be effected, not only in original cost but also in future operation and maintenance of the system. Too often valuable support is lost because adequate coordination with local authorities is not obtained. This must be avoided so as not to delay the project. The attempt at close community/government coordination can be counterproductive, however, if local authorities do not respond to the communities or if promises are not fulfilled (7).

The quality of the water now used in the Anapra area is good. Table 1 shows the results from the chemical analysis of a sample taken from a house tap. The analysis was conducted by a local engineering consulting firm. The water is from the Bagby Ranch. It was sampled by the team and found to have acceptable taste.

4.4.2.2 West Mesa Area

Because the topography between the Anapra and Colonia Felipe Angeles is so irregular, the study team looked for an alternate water resources area in West Mesa. As mentioned in Chapter 3, this area is approximately three miles southwest of Colonia Felipe Angeles. The topography is more homogeneous and slopes down toward the colonia. Colonia Felipe Angeles could be approximately 100 to 130 feet lower from the West Mesa area. This makes the installation of a gravity system (from the wellhead) feasible.

In 1973, a well was drilled approximately three miles southwest of the West Mesa area. FIFAPA stated that the yield of the well was approximately 100 gpm --which was considered to be inadequate for the population of the area. At this time the study team felt that the adequacy of the well cannot be evaluated because there are too many unknown factors such as the depth of the well, the method of well construction, the method of well development, and the pumping equipment used. Furthermore, the site that was drilled is probably located farther south than what may have been the location of the paleodrainage channel of the Rio Grande. At present FIFAPA has plans to conduct water exploration on the other side of the Juarez Mountains. If water is found, this area would supply the marginal areas located west and southwest of the city.

Table 1

Chemical Analysis of the Anapra Area Groundwater

PARAMETER	CONCENTRATION
Total Hardness	520 mg/l
Total Alkalinity	50 mg/l
Chloride (as ion)	265 mg/l
Chloride (as sodium chloride)	9 mg/l
Turbidity	0 units
Color	12 units
pH	7.5
Conductivity	2000 ohms
Total Dissolved Solids	1300 mg/l

Assuming that adequate water supplies are found in the West Mesa area, the transmission line would require a pumping station on the west side of the colonia to pump the water to the elevated areas.

The installation of a water transmission line in this area would require less investment because the engineering required would be less demanding than transporting the water from the Anapra area. This is true simply because the distance required to transport the water would be less, and the topography is not as irregular as that found at the area between the Colonia Felipe Angeles and Anapra.

4.4.3 Transmission and Vending

In the event that the construction of the transmission line is possible but that a distribution system is too expensive, the colonia could be supplied with water by means of water vending. This alternative would require the construction of water storage tanks at the end of the water transmission line, from either Anapra or West Mesa. The water vending could be supplied by the

government through an extension of the existing service. Currently, the government has 60 water tank trucks which take water to the marginal areas. With these trucks 12,000 families in the marginal areas of the city are served with water. This number of trucks, however, may not be sufficient to adequately serve Colonia Felipe Angeles. Conversations with community members revealed that the water vending program is not able to provide a regular service. Often water trucks take as long as one month to return to the colonia. Also, the community members say that the trucks tend to serve only the very accessible areas leaving many families without water.

The possibility of using private companies for water vending was investigated and found that local water purification companies would not be interested in serving the marginal areas. Three of the four water purification companies were visited and asked if they would be interested in providing this kind of service. The owners responded by saying that they did not have the required equipment to sell water to the marginal areas. This activity requires tank trucks, and they did not have them because they sell only bottled water. They said that for them to provide this service, it would require the purchase of the tank trucks. They see this type of service as being only temporary because as soon as the government installs a water supply system, the water vending would not be required; and perhaps they would not be able to recuperate their investment. Water vending to the marginal areas is viewed as a temporary business, and it is not attractive to them (8).

4.5 Project Elements

Based on observations made during this preliminary study, local water supply authorities and community leaders have identified project elements relevant to the water supply program for the Colonia Felipe Angeles. These are:

1. coordination with local water supply and health authorities
2. planning
3. community participation
4. financing
5. management
6. operation and maintenance
7. health education
8. sewer system.

These project elements are discussed below.

4.5.1 Coordination with Local Water Supply and Health Authorities

In previous sections, the importance of coordinating with local water supply authorities was expressed--clearly defined objectives and concepts must be established before the project is implemented. Experience in successful water supply projects throughout the world indicates clearly the need for good coordination on the part of both the authorities and the community. Often, the parties involved do not share the same set of priorities or understanding of the problems that either party faces.

To date, local water supply authorities have had limited economic resources to finance water supply projects. It was not until 1981, when the FIFAPA program was funded by the Inter-American Development Bank, that the water supply system in the city began to be improved and expanded. The works that the city has accomplished are complex and coordination would facilitate understanding of the goals that the Junta Municipal de Aguas and FIFAPA have established. Also, it would inform the community about the complex procedure required for planning a water supply system. Both time and economic resources will be required to conduct field investigations to determine the best source of water, conduct topographical surveys of the project area, and complete engineering designs and financing plans. If coordination has been carried out, the community will be more understanding and more willing to help and even assist in the development of alternatives, if required.

4.5.2 Planning

Proper planning is an essential element of any successful water supply program and cannot be overemphasized. A fundamental objective should be to supply safe water, distributed as widely as possible for the least initial cost and through a system that requires a minimum of maintenance. The community should be informed that the local water supply authorities, which are involved in the design and construction of the necessary installations, need to carry out extensive preliminary water resources exploration that will also complement the existing water supply system and future expansion plans.

Based on conversations with the Junta Municipal de Aguas and FIFAPA, plans are being considered to serve the marginal areas of Ciudad Juarez. It appears that some of these plans have been slowed due to limited economic resources. These two water supply authorities have expressed interest in carrying on more intense water exploration programs. Due to the economic situation of Mexico, however, these plans have not been implemented as fast as they would like. However, the Colonia Felipe Angeles should continue to work with these authorities to develop the required water supply system in phases. These phases could be implemented as funds become available.

The planning of a water supply program must consider the political realities of the area. Variations depend on the extent that the community is willing to work with the local authorities. The approach, however, that is most likely to result in an efficient and successful program is a step-by-step process that involves effective coordination and involves the community extensively at every stage of project planning and implementation.

4.5.3 Community Participation

The community has an important role to play in the development of the water supply program. The community should form a committee to be comprised of:

- representatives of the local government
- community leaders
- religious leaders
- members of the community.

Colonia Felipe Angeles has had a committee that has looked after the interests of the community in matters of water supply. This committee is called "Pro-Water Committee." Although it has most of the representation required, it has lacked continuous government representation. From time to time, government officials are visited by members of the committee to express their desire for water supply; but government officials have not been permanent members of this committee. This leads to a lack of continuity of the efforts and loss of knowledge of the problems the government is facing.

In the case of the water supply program, the task of obtaining the necessary local cooperation and participation in the development of the project should be assigned to an interested and responsible party, preferably someone that understands some aspects of the technical requirements of a water supply program. This person should be brought into the planning of the project as early as possible.

The community must be given some understanding, through their representatives, of the project and the problems that a project of this type may be facing, as well as the procedures that must be followed to implement such a project.

4.5.4 Financing

Currently the State of Chihuahua has a loan from the Inter-American Development Bank for improvement and expansion of the water and sewer system in Ciudad Juarez. This loan is being implemented by a program called FIFAPA. This program will terminate at the end of 1986. If an extension is not negotiated by the state government, this project will come to an end. There may be a possibility of funding some work between now and the end of 1986 for Colonia Felipe Angeles, but it is not certain.

Another source of funds may be through the Junta Municipal de Aguas. This institution, however, mainly operates and maintains the system. It collects revenues through water supply fees for operation and maintenance of the system and has very limited funds for expansion of projects.

Project Verdad of the Presbyterian Church has expressed the interest in helping the community to obtain funds to do groundwater exploration and install a well.

Another alternative would be for the community to raise funds through some community activities. This would be a slow process but could raise enough funds to get the initial phases started.

4.5.5 Management

Based on the conversations held with the directors of the Junta Municipal de Aguas and FIFAPA, the necessary infrastructure to carry the administration, operation, and maintenance is established with the required technical staff and experience. Once the water supply system for Colonia Felipe Angeles is constructed, the Junta Municipal would take charge of the system management. For this reason, not much discussion is given in this section since there is no reason to organize the community to manage the water system--except for the

continuing involvement of the "Pro-Water Committee" of Colonia Felipe Angeles in looking out for the interests of the community.

4.5.6 Operation and Maintenance

It was mentioned above that the Junta Municipal de Aguas would be the agency to operate the water system. Also, this agency has been conducting the operation and maintenance of the existing system and would most likely need only the additional manpower (and operating funds) to serve the additional installations.

4.5.7 Health Education

A health education program is needed in Colonia Felipe Angeles with the objective of educating the community to assist in the prevention of communicable diseases. A survey to identify the specific elements of a health education program is advisable. Once these data have been developed, a program could be designed to fit the needs of the community and the goals of the local authorities. A health education program could be developed and implemented with the technical assistance of health educators and the Project Verdad staff.

Active community participation could also be used to provide health education --which includes giving the people the information and understanding they need to make decisions concerning the selection and use of sanitation and water supply facilities. Women and children are particularly important to reach in a health education program because of their traditional roles. It is usually the women who promote health practices in a community.

4.5.8 Sewer System

At present, Colonia Felipe Angeles does not have a sewer system. Once piped water is brought to the community, however, the need for wastewater disposal will become more evident. This is a matter that the Junta Municipal de Aguas and FIFAPA are planning very carefully in their water supply system expansion plans. Because the design and construction of a sewer system would require additional time and funds, the community, as either a temporary or a permanent measure, could implement a latrine program. This program could be implemented with the assistance of local health authorities.

At present, Project Verdad has initiated the planning of a health education program which will include the use of latrines. Staff of this project, however, recognize the need for additional training in the construction and installation of latrines. This could be accomplished by means of short workshops to train representative groups so they can, in turn, train other community members and direct the construction of latrines in their areas.

Each family could contribute a certain amount of cash or labor to pay for its latrine. Additional funds to build the latrines could come from individual payments, funds raised through community activities, government grants, or international donations.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations given below will address two main areas, namely, water resources and water supply plan. The present study deals with the determination of potential groundwater sources and discussion of the project elements. Under each area, conclusions have been formulated and recommendations are listed.

5.1 Water Resources

5.1.1 Conclusions

The conclusions drawn from the information gathered during this study are the following:

1. Water use for Colonia Felipe Angeles based upon a per capita consumption of 20 litres per person per day (an amount that would be provided from public standpipes) is approximately 212,000 gallons per day or approximately 150 U.S. gallons per minute on a continuous basis.

2. Groundwater in the Colonia Anapra area flows to the northeast toward the Rio Grande.

3. The quality of the Bagby water is good.

4. The Mexican Government has plans to drill a test well in the near future in the vicinity of Colonia Anapra, but there is no indication it would be used to supply water to Colonia Anapra or Colonia Felipe Angeles.

5. Groundwater also is likely to occur beneath the West Mesa area between the Juarez Mountains and the igneous body of rock on which Colonia Felipe Angeles is situated.

6. The quality of water beneath the West Mesa area is unknown but is likely to be better close to the Juarez Mountains.

7. The depth to groundwater beneath the West Mesa area location is not known but is almost certainly greater than 200 feet.

8. Drilling costs will probably be in the range of $40 to $60 per foot of a 10-inch cased and naturally gravel packed well.

9. The cost for additional geophysical work will be approximately $25,000 U.S. per location provided high production drilling rigs are used.

10. It is likely that wells can be sited within several hundred feet of each other. Proper well spacing, however, can only be determined following completion of the first well and the performance of an aquifer performance test using the test well.

5.1.2 Recommendations

The following are recommendations based on the conclusions drawn:

1. A well field could be located in the vicinity of Colonia Anapra. The depth to water should be approximately 100 feet, and the wells will most likely yield in excess of 200 U.S. gallons per minute.

2. A location for a proposed well field has been selected approximately one to two miles west of Colonia Felipe Angeles.

3. Any test well should be drilled with cable tool or air rotary methods so that the depth to water, water quality, potential well yield, and aquifer composition can be determined as the well is drilled. This information will be necessary to the final design of the completed well. A mud rotary rig could also be used to achieve faster production rates but would require the use of electric logging methods and drillers experienced in this technique. Another means to increase production rates and lower project costs would be to use a 6-inch slim hole rotary rig (if available). The other advantage of using rotary equipment is that a jetting nozzle can be used during well development to increase the yield of the well.

4. In either location, geophysical studies may lead to better well site selection. If no geophysical studies are undertaken, optimal well sites will be in close proximity to arroyos where fresh water recharges the groundwater system.

5. At least two wells, each with adequate capacity to serve Colonia Felipe Angeles, should be constructed for water supply. This will allow for system redundancy in the event of the failure of a pump. It will also permit alternating operation of wells such that natural groundwater flow may resupply the area of influence of each well with fresh water should water quality deteriorate with time (from upconing of salt water).

5.2 Water Supply Plan

5.2.1 Conclusions

The conclusions drawn from the information gathered during this study are the following:

1. Ciudad Juarez has the required infrastructure for implementing complex water and sewer systems.

2. The Junta Municipal de Aguas y Saneamiento and FIFAPA have been planning strategies for solving the water supply problem of the marginal areas.

3. Economic resources have been limited.

4. The topography of Colonia Felipe Angeles is very irregular, and the design of a water supply and distribution system requires careful planning and detailed studies.

5. Water resources in the study area are not readily available, and careful water exploration is needed.

6. Connection to the existing water supply system is feasible.

7. Transmission of water from the Anapra area requires detailed studies to select an optimum pipeline route. The reason for this is the irregular topography between Anapra and Colonia Felipe Angeles.

8. Transmission of water from the West Mesa area would not require as much topographic survey effort since the topography between this area and Colonia Felipe Angeles is relatively homogeneous.

9. Water vending would need to be expanded by the Junta Municipal de Aguas since existing private water purification companies do not have the required equipment to deliver water in tank trucks nor the capital for such investment.

10. The community is well organized and the existing "Pro-Water Committee" is willing to assist in every way possible in the implementation of the program.

11. Government representation on the "Pro-Water Committee" is needed to inform the community of the government water supply plans for their colonia. In this way, members of the community would know the problems which the water supply agencies are facing.

12. Health education needs to be implemented.

13. Excreta disposal facilities need to be improved.

5.2.2 Recommendations

The following are recommendations based on the above conclusions:

1. Communication between the community and the local water supply authorities should be improved through government representation on the Colonia Felipe Angeles "Pro-Water Committee."

2. The "Pro-Water Committee" should work with the Junta Municipal de Aguas and FIFAPA to develop ideas for the investigation of the alternatives. For example, if these agencies feel that connection to the existing water supply system is a more immediately feasible alternative but economic resources are limited, the community and the agencies should work together to see in what way the funds could be raised to begin investigating this alternative. Perhaps the community could raise funds to conduct the connection feasibility study.

   On the other hand, if these agencies feel that at present it is best to expand their water exploration program and the community can raise some funds to assist the agencies in implementing this activity, then both groups should work together to develop ways to accomplish this goal. The Junta Municipal de Aguas and FIFAPA have valuable technical resources to help the community.

3. The community should discuss with the Junta Municipal de Aguas and FIFAPA the way in which the community can assist in accomplishing the alternatives they see as more feasible.

4. A latrine committee should be formed to begin working with local authorities in the design of a latrine program that would meet the goals and plans of the government.

References

1. Personal conversation with Ing. Manuel Ortega of the Junta Municipal de Aguas y Saneamiento, April 2, 1986.

2. Lloyd, J., William and Marston, A. Richard, "Municipal and Industrial Water Supply in Ciudad Juarez, Mexico," Water Resources Bulletin, American Water Resources Association, Vol. 21 No. 5, October 1985.

3. Hawley, John W., 1985, Quarternary History of Dona Ana County Region, South-Central New Mexico, New Mexico Geological Society Guidebook, Las Cruces Country pp. 139-150.

4. Wilson, Clyde A; White, Robert R.; Orr Brennon R.; and Royball R. Gray, 1981, Water Resources of the Rincon and Mesilla Valleys and adjacent areas, New Mexico State Engineer Technical Report No. 43.

5. Junta Municipal de Aguas y Saneamiento de Ciudad Juarez, Chihuahua, 1985 Records.

6. Personal conversation with Ing. Horacio Almazan, Fondo de Inversiones Para Obras de Agua Potable y Alcantarillado, Ciudad Juarez, Chihuahua, April 2, 1986.

7. National Demonstration Water Project, "Safe Water and Waste Disposal for Rural Health: A Program Guide," USAID Contract No. AID/DSAN-C-0063, Washington, D.C.

8. Personal conversations with local water purification companies in Ciudad Juarez, Chihuahua, March 1986.

APPENDIX A

Persons Contacted

Persons Contacted

Rev. William D. Schlesinger
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Project Verdad
10160 Sumatra
El Paso, Texas 79925
Tel.: 915-592-8818

Mr. Jose Luis de Santiago
Talleres Industriales de Santiago
18 de Marzo #1251
Ciudad Juarez, Chihuahua
Tel.: 2-21-13, 2-85-08

Ing. Luis Soria Espino
Geological Engineer
Presidente de Administracion de Usos del Agua
Secretaria de Agricultura y Recursos Hidraulicos
Zona Valle de Juarez
Calle 2 de Abril y Venezuela
Tel.: 4-66-09, 2-33-02

Mr. Carlos Marin
Civil Engineer
International Boundary and Water Commission, U.S. Section
4171 N. Mesa Street
El Paso, Texas 79902
Tel.: 915-541-7301

Ing. Manuel Ortega
Director
Junta Municipal de Aguas y Saneamiento
Calles 16 de Septiembre y Mariscal
Ciudad Juarez, Chihuahua
Tel.: 2-33-09, 2-33-10, 2-33-11, 2-76-83

Ing. Horacio Almazan
Fondo de Inversiones Financieras Para Obras de Agua Potable y Alcantarillado (FIFAPA)
Calles Colombia y Jose Borunda
Ciudad Juarez, Chihuahua
Tel.: 5-11-18, 4-47-71

Dr. Rene Franco Barreno
Avenida Las Americas #765
Ciudad Juarez, Chihuahua
Tel.: 6-57-49

Sr. Mario Rodriguez
Purificadora Juarez
Calle Insurgentes #781 Sur
Ciudad Juarez, Chihuahua
Tel.: 4-21-03, 3-46-38

Sr. Saul G. Urquidi
Calle Zaragoza #3218
Ciudad Juarez, Chihuahua
Tel.: 3-41-22

Sr. Fernando Martinez
Purificadora de Agua Joo-Mar
Calle 20 de Noviembre #2276
Ciudad Juarez, Chihuahua
Tel.: 6-74-28

APPENDIX B

Activities of the Consultants

ACTIVITIES OF CONSULTANTS

DR. WILLIAM M. TURNER'S DAILY LOG

March 6, 1986 — Visit New Mexico State Engineer's Office and obtained State Engineer publications on the Mesilla Bolson. Report contains abundant data relevant to the present project. Reviewed published literature on geology and hydrogeology of study area.

March 7,1986 — Traveled to El Paso

March 8,1986 — Field trip to Anapra and Sunland Park on U.S. side of the border. Located 2 wells owned by Bagby Land and Cattle Company. Traveled to south side of border to visit community of Colonia Anapra which receives water from Bagby wells. Sampled water which was of good potable quality. Talked with residents of Colonia Anapra on method of project construction and cost. Carried out geological reconaissance of Colonia Anapra and Colonia Felipe Angeles area.Located office of Talleres Industriales de Santiago a local water well construction company. Started work on report.

ACTIVITIES OF CONSULTANTS

March 9,1986 — Field trip with Henry Van and Bill Schlesinger to Colonia Anapra and to review geology of the Colonia Felipe Angeles area. Continued work on the report.

March 10,1986 — Visited office of Talleres Ind. de Santiago to ask for cost estimate for 500 foot 8-inch diameter well in Colonia Anapra area. Visited American Consulate to see if topographic maps had arrived from Mexico City. They had not. Called Sam Taylor's office again. Magda Sotomayor said she would get them and send them to Cd. Juarez. Took field trip west to the Sierra Juarez to view extent of surface catchment basins and recent runoff activity in major arroyos draining the area.

March 11,1986 — Returned to Talleres Ind. de Santiago for cost estimate. Was told that any well would required permit. Jose Luis de Santiago said he had called Ing. Soria with SARH. Visited with Ing. Soria who indicated that areas which I

had defined as potential groundwater sources had also been identified by the Mexican Government as potential groundwater sources. He showed me a permit issued in December 1985 for a groundwater exploration well to be drilled by the SARH in the colonia Anapra area. He also said there was little or no data on the hydrogeology of the area west and northwest of Cd. Juarez and that if any data did exist it would be at the SARH office in Chihuahua, Chih.

I returned to the Consulate and learned the maps had been hand carried to El Paso by a DEA employee . Map H13-A25 could not be found in Mexico City . I located a copy of this map at the International Boundary and Water Commission office and had the important part of it reproduced photographically in El Paso. The original was returned to the Commission. I picked up other maps from the DEA office in El Paso.

March 12, 1986 Continued work on section of report dealing with groundwater resources and well location . Had meeting in evening with Van

and Schlesinger to review findings. Left rough draft report with Van and Schlesinger.

DR. HENRY VAN'S DAILY LOG

February 8, 1986 Met with members of the Colonia Felipe Angeles and Project Verdad to discuss the study and obtain background information on well drilling in the community .

March 9, 1986 Field trip with Bill Turner and Bill Schlesinger to Colonia Anapra and Colonia Felipe Angeles to assess the topography, become familiar with the study area and coordinate activities with Turner and Schlesinger .

March 10, 1986 Met with Bill Turner to discuss his activities for that day.

March 11, 1986 Met with Bill Turner to discuss the outline of the report and items to talk with Mexican

officials .

March 12, 1986 — Met with Turner and Schlesinger to hear Turner's exit briefing where he submitted the draft geology and hydrogeology report .

March 14, 1986 — Began work on Chapters 1 and 2 of the report which deal with the introduction and existing conditions , respectively.

March 18, 1986 — Met with Dr. Rene Franco to discuss meetings with Mexican Government officials and a field trip to gather information about the topography of the study area and collect a water sample from Anapra .

March 22, 1986 — Conducted field trip to collect topographic information and water sample from Anapra. Also, talked with community member .

March 23, 1986 — Began to prepare Chapter 4" Water Supply Plan."

April 1, 1986 — Met with Ing. Horacio Almazan of FIFAPA to discuss the study and ask him his respective

ACTIVITIES OF CONSULTANTS

	views . Also, Met with the owner of the JO-MAR water purification company .
April 2, 1986	Meet with Ing. Manuel Ortega of the Junta Municipal de Aguas to discuss the study and ask his respective views .
April 3 - 4, 1986	Continue to work on Chapter 4 of the report.
April 5, 1986	Met with the owners of two water purification companies ; AGUASUR and PURIFICADORA DE JUAREZ . Telephoned Mrs. Socorro Membrila, community leader and discussed the status of the study . Prepared aerial photographs to tale pictures of the study area.Continued to work on Chapter 4.
April 19-20,1986	Continued to work on the report.
April 24, 1986	Met with members of Project Verdad and presented the the study's conclusions and recommendations.

ACTIVITIES OF CONSULTANTS

April 26, 1986	Met with Dr. Rene Franco to discuss the report and gave him a draft copy for his review. Took second set of pictures of the aerial photograph with the study area outlined.
May 3-4, 1986	Incorporated Dr. Franco's comments and assembled all chapters and appendices . Also, sent a final draft to Turner for his review.
May 9, 1986	Presented the final draft to Project Verdad and leaders of Colonia Felipe Angeles.
May 13, 1986	Submitted the final report to WASH Project, in English.
May 24,1986	Began to translate the English version of the report. Gave a presentation to the Presbyterian Church leaders ,leaders and members of the Colonia Felipe Angeles about the conclusions and recommendations of the report. Discussed strategies for a plan implementation.

ACTIVITIES OF CONSULTANTS

May 25, 1986	Continued to translate the English version of the report.
May 26,1986	Met with Ing. Manuel Ortega and Ing. Horacio to present conclusions and recommendations given in the report. Continued to translate the English version of the report.
May 31, 1986	Edited and assembled the Spanish version of the report.

APPENDIX C

Newspaper Article on the Bagby Ranch
Water Supply to Anapra

EL PASO HERALD-POST MARCH 7, 1986, C

Manuela Miramontes waters trees in her front yard in Colonia Anapra.

Herald Post photo by John Hopper

Cooperation flows with water

New Mexico cattleman, *colonia* scratch each other's back

By Terrence Poppa
El Paso Herald Post Juarez reporter

When residents of dusty Colonia Anapra turn on their taps, something more than water splashes out.

International cooperation also flows.

Bagby

The water for the isolated Juarez neighborhood is the gift of New Mexico cattleman Stewart Bagby, the owner of a cattle import company with corrals and stockyards only a dozen yards from the international border.

Only a half-mile away is Colonia Anapra, a squatter settlement of 100 families in a narrow valley in the shadow of Mount Cristo Rey.

The 57-year-old New Mexico cattleman began pumping water to the parched *colonia* four years ago — free of charge even though the electricity bill to operate the pumps comes to $500 a month, he said.

In exchange, the settlers keep thieves from slipping across the border to strip the corrals and stockyards of yards of boards, sheet metal and other supplies.

The Anapra residents have also served notice they will not allow illegals to try crossing to the United States on Bagby's land, nor tolerate drug smuggling.

"We're neighbors, we're friends, and that's what it boils down to," said Bagby.

The bilateral backscratching began four years ago when a group of men and women from the recently settled shantytown showed up at Bagby's office, offering to buy water from him if he would let them install pipes to his well.

Deliveries by a government water truck were irregular and not enough to use for making adobe bricks.

Bagby, a former Chihuahua rancher ended up refurbishing a well and installing two 100-gallon-a-minute pumps.

Some of the water goes to corrals to water livestock. But the majority flows over the hilly border to the homes of the settlers.

The *paracaidistas* — "parachutists" as squatters are called in Spanish — say the arrangement has made a big difference in their lives.

"Where there is water there is life," said Francisco Medrano, a 44-year-old carpenter and resident of Colonia Anapra, pointing to a line of fruit trees he planted in his dusty back yard.

He said the neighborhood suffers the same shortages as other *colonias* surrounding Juarez — no electricity, gas, sewers, paved roads and other conveniences.

But the steady supply of fresh water has allowed residents to make their own concrete blocks and bricks and build better homes. Each home has a tap outside.

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APPENDIX D

Tender Form

TENDER FORM

ITEM	DESCRIPTION	UNIT	QUANTITY	COST
	A) SEGURIDAD DE SANEAMIENTO			
1.	Perforacion a 6m con diam. de 14 pulgadas	M	6	
2.	Instalacion de tuberia de acero a 6m	M	6	
3.	Cementacion en espacio anular entre el tubo y el suelo	Lote		
	B) PERFORACION			
1.	Perforacion exploratoria diametro de 5 pulgadas	M	150	
2.	Registro electrico, resistividad ondas de gamma, potencial, y neutron-densidad de neutron			
3.	Ampliacion de perforacion a 12 pulgadas de diam.		150	
4.	Colocacion de tuberia de ademe. Tubo liso, Tubo Johnson y accesorios		150	
5.	Colocacion de filtro de Grava	Lote		
6.	Aforo con duracion de 48 horas necesario para desarrollar el pozo y determinar el gasto y nivel dinamico del mismo			
	C) MATERIALES			
1.	Tubo saneamiento, lamina 1/4 pulgadas y 14 pulgadas de diametro			
2.	Tubo tipo Johnson de 8 pulgadas de diam.			
3.	Centradores y aditamentos			
4.	Grava, para filtro del pozo approx. 15 metros cubicos			

APPENDIX E

Water Well Contractors

Water Well Contractors

Aqua Drilling Company
West Washington Avenue
Anthony, New Mexico
Tel.: 505-882-3602

Ballard Drilling Co. & Well Service
2208 Anthony Road
Anthony, New Mexico
Tel.: 505-882-3119

PERCHISA
Perforaciones de Chihuahua, S.A.
Chihuahua, Chih.
Tel.: 17-25-47, 17-25-35, 17-00-77

Perforaciones de Pozos Profundos
Calle 26, No. 1102 Esquina con Lisboa
Chihuahua, Chih.
Tel.: 5-20-55

Perforaciones y Aforos del Norte, S.A.
Calle 21 No. 711
Chihuahua, Chih.
Tel.: 13-58-50

POZOS
Independencia No. 4800
Chihuahua, Chih.
Tel.: 12-56-66, 12-41-81, 12-95-43

Perforaciones "El Indio"
Chihuahua, Chih.
Tel.: 5-46-46