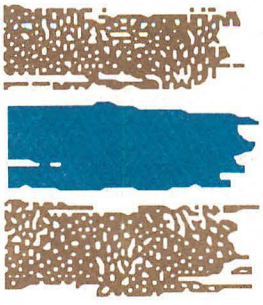

EDWARDS UNDERGROUND
WATER DISTRICT

Report 92-02

Investigation of the Fresh/Saline-Water Interface in the Edwards Aquifer in New Braunfels and San Marcos, Texas

Executive Summary

INTRODUCTION

The purpose of this investigation was to develop site-specific information at selected sites along the fresh/saline-water interface and to establish a long term monitoring system. The report discusses the drilling, construction, and testing of a series of monitoring wells located in New Braunfels and San Marcos, Texas. Data collected as a result of this study will continue to provide information needed to determine whether encroachment of poor quality water presents a serious problem to maximum use of the aquifer as natural and man-made stresses on the aquifer system occur.

HISTORICAL PERSPECTIVE

In a west to northeast direction, the porous and faulted limestones of the Edwards Aquifer arc across south central Texas from Kinney County through Uvalde, Medina, Bexar, Comal, and Hays Counties. The 180-mile expanse of the Edwards Aquifer is hydrogeologically bounded by: 1) ground-water divides in Kinney County to the west and in Hays County to the northeast; 2) the faulted outcrop of the aquifer, known as the recharge zone, to the north and northwest, and 3) the interface between the fresh water and saline water to the south and southeast. Stratigraphically, the aquifer is bounded by the older Glen Rose Formation below, and the younger Del Rio Formation above (see Figure No. 1-1). The arbitrary boundary between the fresh-water and saline-water zones is defined by a 1000 mg/l dissolved solids concentration contour. This contour is sometimes referred to as the "bad-water line", or more accurately, the fresh/saline-water interface or saline zone boundary.

Recharge enters the aquifer from the north and west, and the flow in the aquifer is generally from the west to east and northeast. In Comal and Hays Counties, major discharge points from the fresh-water zone occur at Comal Springs and San Marcos Springs, respectively.

The fresh-water zone of the Edwards Aquifer is highly productive, and over a million people depend on it as their sole source of drinking water. The aquifer is also an important source of water for agriculture and commercial users. As population increases, pumpage demands increase, and as periodic drought conditions occur, recharge amounts decrease. Over time, the overall effect on the artesian reservoir from these phenomena is a decrease in hydraulic pressure in the fresh-water zone. As a result, many believe that pressure in the saline zone could become greater than in the fresh, and a reversal of the hydraulic gradients could occur. If this reversal were to happen in the vicinity of large capacity supply wells, intrusion of saline water into the fresh zone could threaten the quality and quantity of the water used for public supply. Recognizing this concern, the EUWD, the City Water Board/City of San Antonio (with technical support from William F. Guyton and Associates, Inc.), the United States Geological Survey (USGS), and the Texas Department of Water Resources (TDWR), began drilling a transect of monitoring wells in San Antonio near the City Water Board's Artesia Well Field in March of 1985. Seven test wells were completed to study site specific information across the fresh/saline-water interface and to provide a means for identifying changes in water quality that may occur in the aquifer with time as a result of hydrologic stresses that are imposed on the aquifer system in the area.

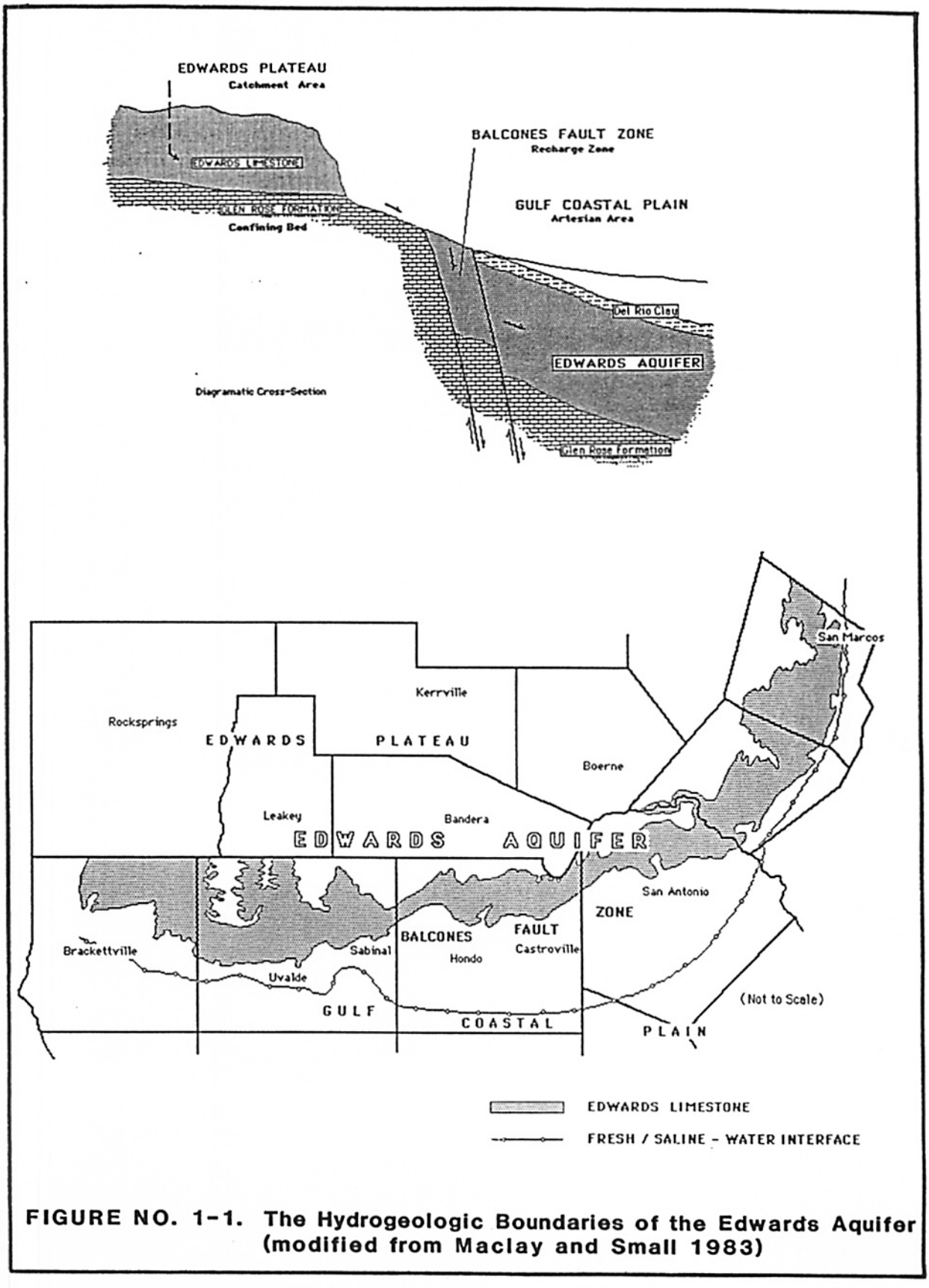

FIGURE NO. 1-1. The Hydrogeologic Boundaries of the Edwards Aquifer (modified from Maclay and Small 1983)

Additional monitoring well transects were considered for areas near Uvalde, D'Hanis, New Braunfels and San Marcos. The New Braunfels and San Marcos areas were considered the most critical locations for additional study because of the narrowing of the Edwards Aquifer fresh-water artesian zone through these communities, and the close proximity of public supply wells and springs to the saline zone. These sites were also selected because they represented areas of hydrologic stress on the aquifer and could be located on public property, allowing for access for long term monitoring at minimal cost.

OBJECTIVES

The EUWD began a monitoring program to study the fresh/saline-water interface in New Braunfels and San Marcos. The drilling of monitoring wells for the New Braunfels transect began in August, 1989 and for the San Marcos transect, began in June, 1990.

The study had three major objectives. The first was to delineate the interface between the fresh-water and saline-water zones. The second objective was to characterize this interface by describing and analyzing the hydrogeological and chemical data collected during the drilling of each monitoring well. The last objective was to predict, if possible, using the data collected during the drilling, the potential of the saline water to intrude upon the fresh water of the Edwards Aquifer, particularly near the springs and public supply wells in New Braunfels and San Marcos, Texas.

SITE LOCATIONS AND GEOLOGY

The transects for the monitoring wells are located in the townships of New Braunfels and San Marcos, Texas (see Figure No. 1-2).

NEW BRAUNFELS TRANSECT

The four wells which make up the New Braunfels transect are located near Landa Park and are identified as well numbers A-1, B-1, B-2, and C-1 (see Figure No. 2-1).

A major fault, the Comal Springs Fault, lies approximately 680 feet to the west of the sites, trending in a northeast direction with approximately 800 feet of displacement. On the west side of the fault, the limestones of the Edwards Group crop out, whereas on the east side, the Edwards has been completely displaced, lying approximately 460 feet below the surface. Emerging from the fault are the Comal Springs, the origin of the Comal River.

After the wells were drilled and geophysically logged, displacements of the geologic units were noted and compared to a well owned by the Lower Colorado River Authority (LCRA). The displacements were determined to be: 40 feet between wells A-1 and B-1, 25 feet between B-1 and C-1, and 120 feet between the LCRA well and well C-1. Based on the evidence, faults were identified between each EUWD well and the LCRA well.

A plan view and cross section of the sites are presented in Figure Nos. 2-1 and 2-2, respectively. In both of these figures, the boundary between the fresh and

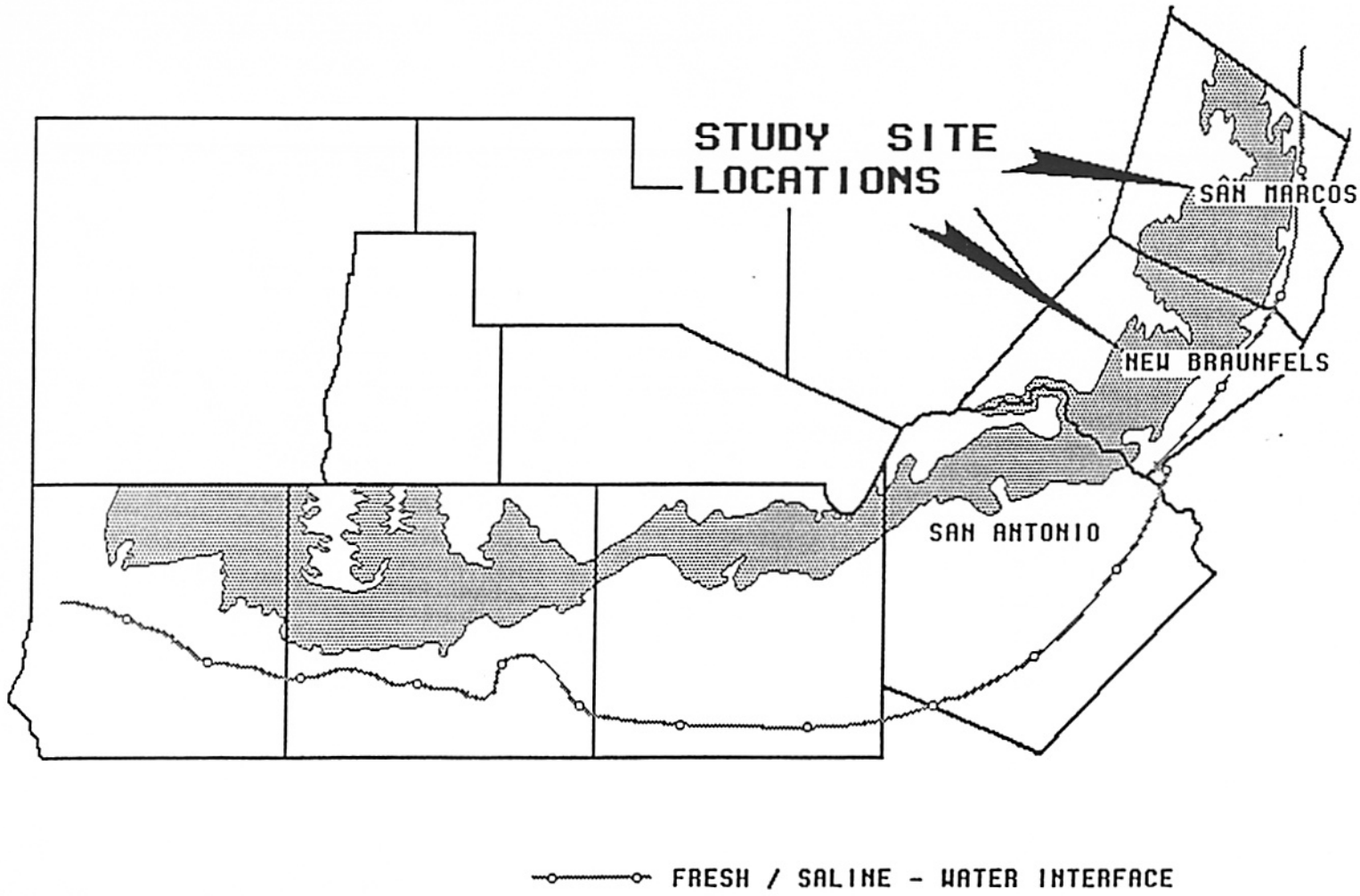

FIGURE NO. 1-2. Study Site Locations.

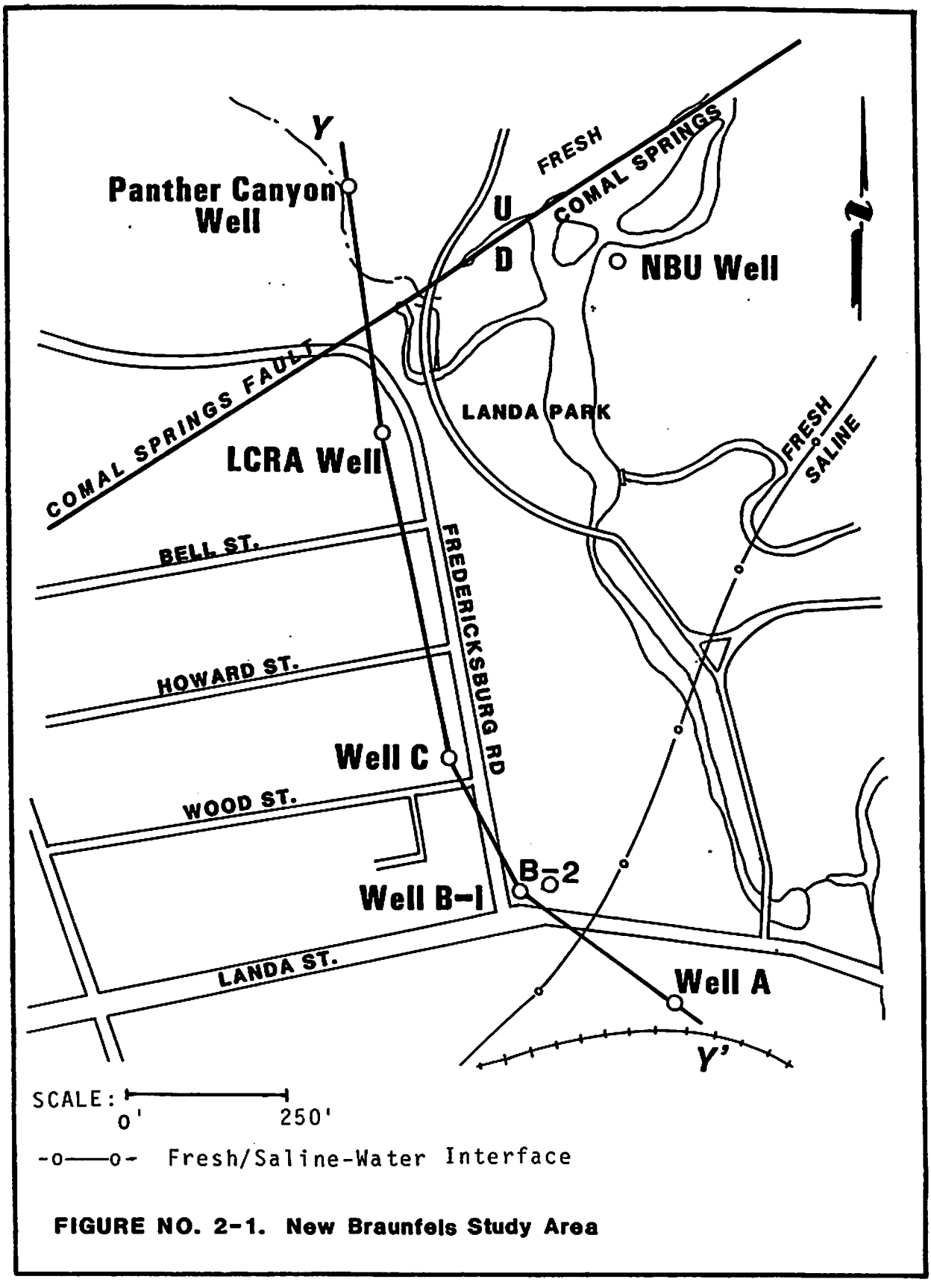

FIGURE NO. 2-1. New Braunfels Study Area

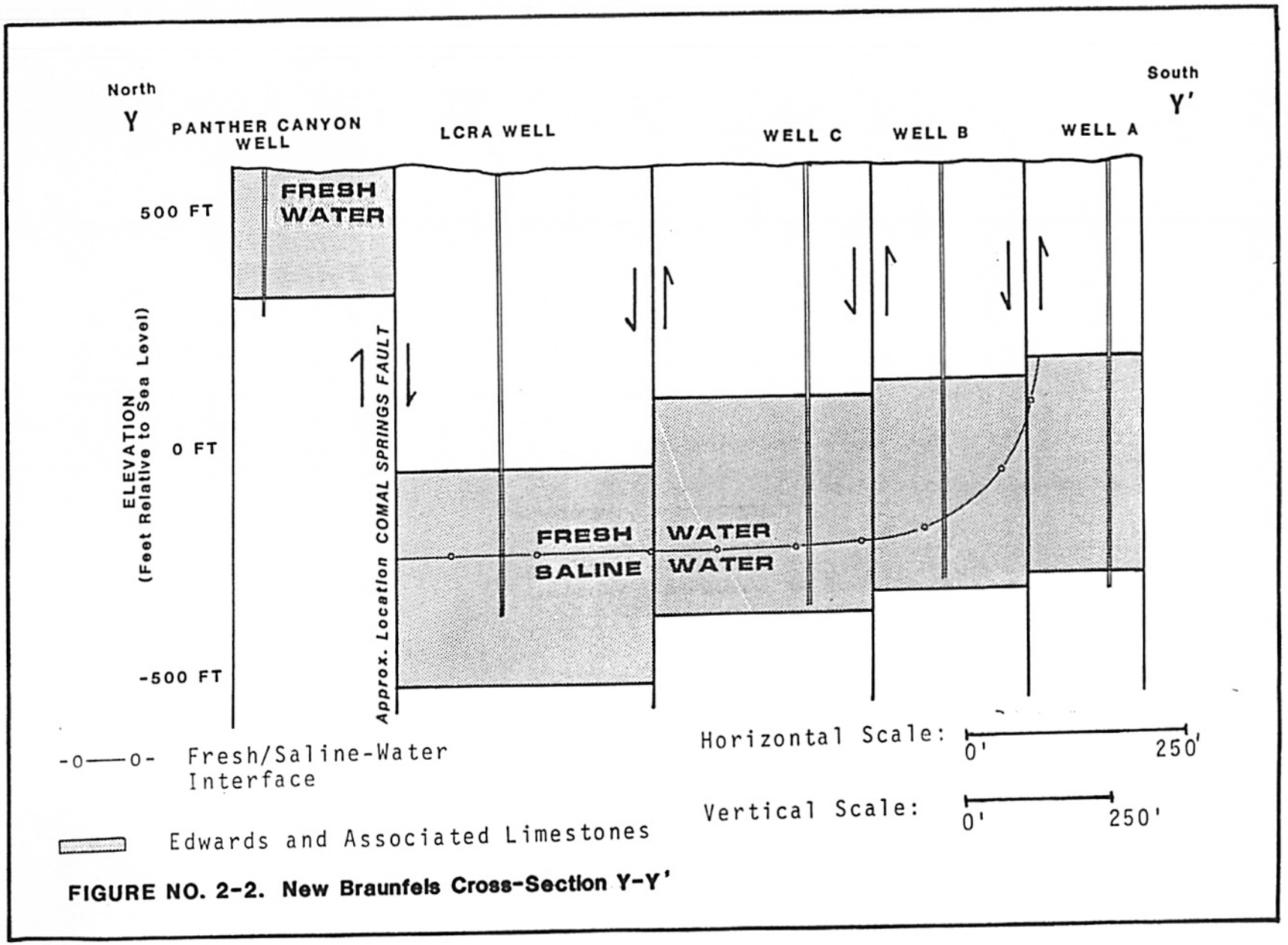

FIGURE NO. 2-2. New Braunfels Cross-Section Y-Y'

saline zones have been drawn within the Edwards Group based on the geophysical well logs and water quality data collected from each well in the transect. The boundary represents a change in water quality that ranges between 500 to 1000 µS/cm and between 1000 to over 3000 µS/cm (1500 microsiemens per centimeter is approximately equivalent to 1000 milligrams per litre of total dissolved solids).

SAN MARCOS TRANSECT

The two wells which make up the in San Marcos transect are located near Spring Lake and are identified as well numbers B and C (see Figure No. 2-3).

A major fault, the San Marcos Springs Fault, lies approximately 650 feet to the west of the sites trending in a southwest to northeast direction with approximately 430 feet of displacement. On the west side of the fault, the top of the Edwards Group crops out, whereas on the east side, the top of the Edwards Group lies approximately 420 feet below the surface. Emerging from the fault are the San Marcos Springs, the origin of the San Marcos River.

Based upon the information collected, no significant displacements of formations exist between wells B and C.

A plan view and cross section of the sites are presented in Figure Nos. 2-3 and 2-4, respectively. In both of these figures, the boundary between the fresh and saline zone within the Edwards Group near the EUWD transect is believed to follow the fault plane of the San Marcos Springs Fault. This boundary is based on the geophysical well logs and water quality data collected from the two

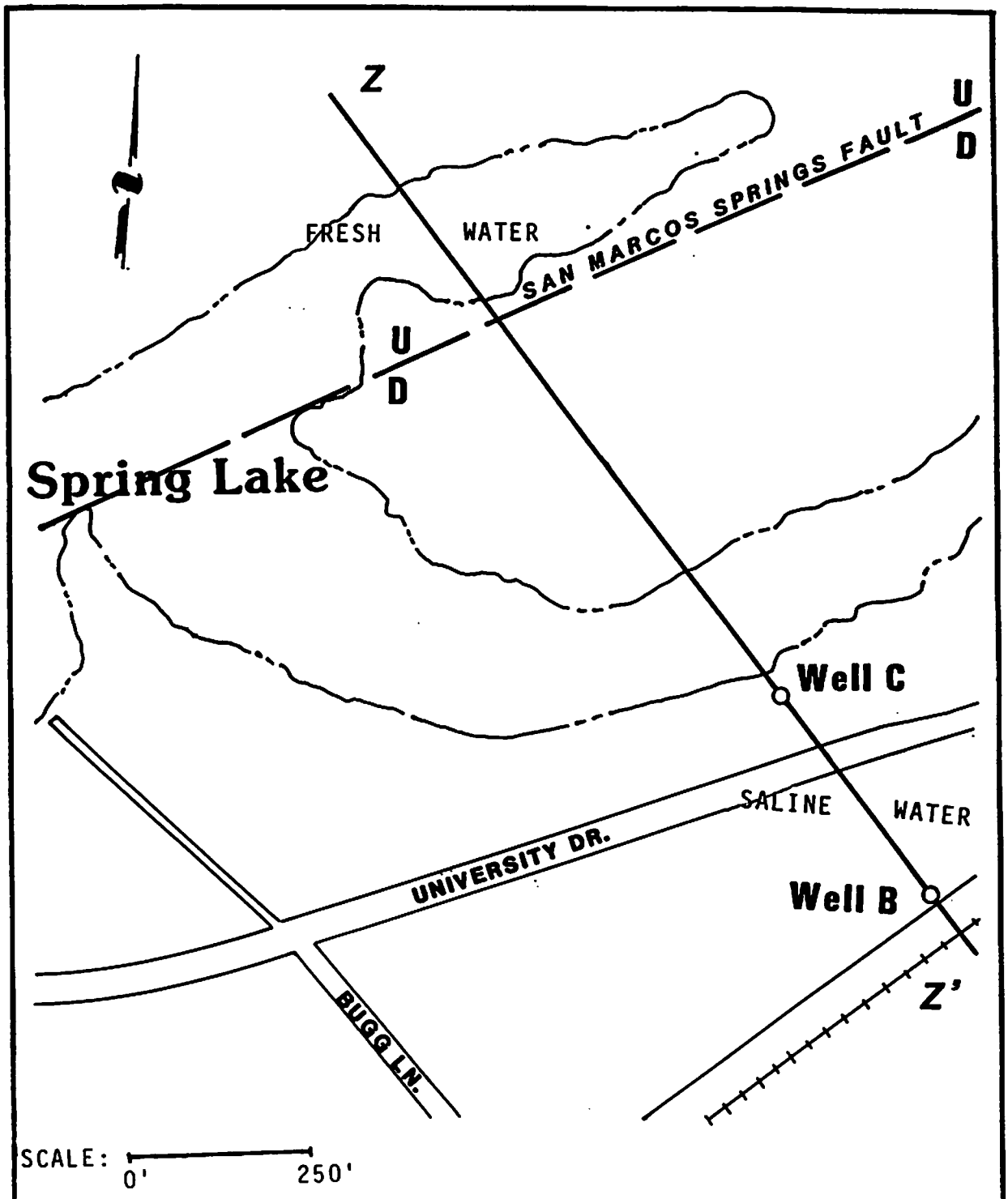

FIGURE NO. 2-3. San Marcos Study Area

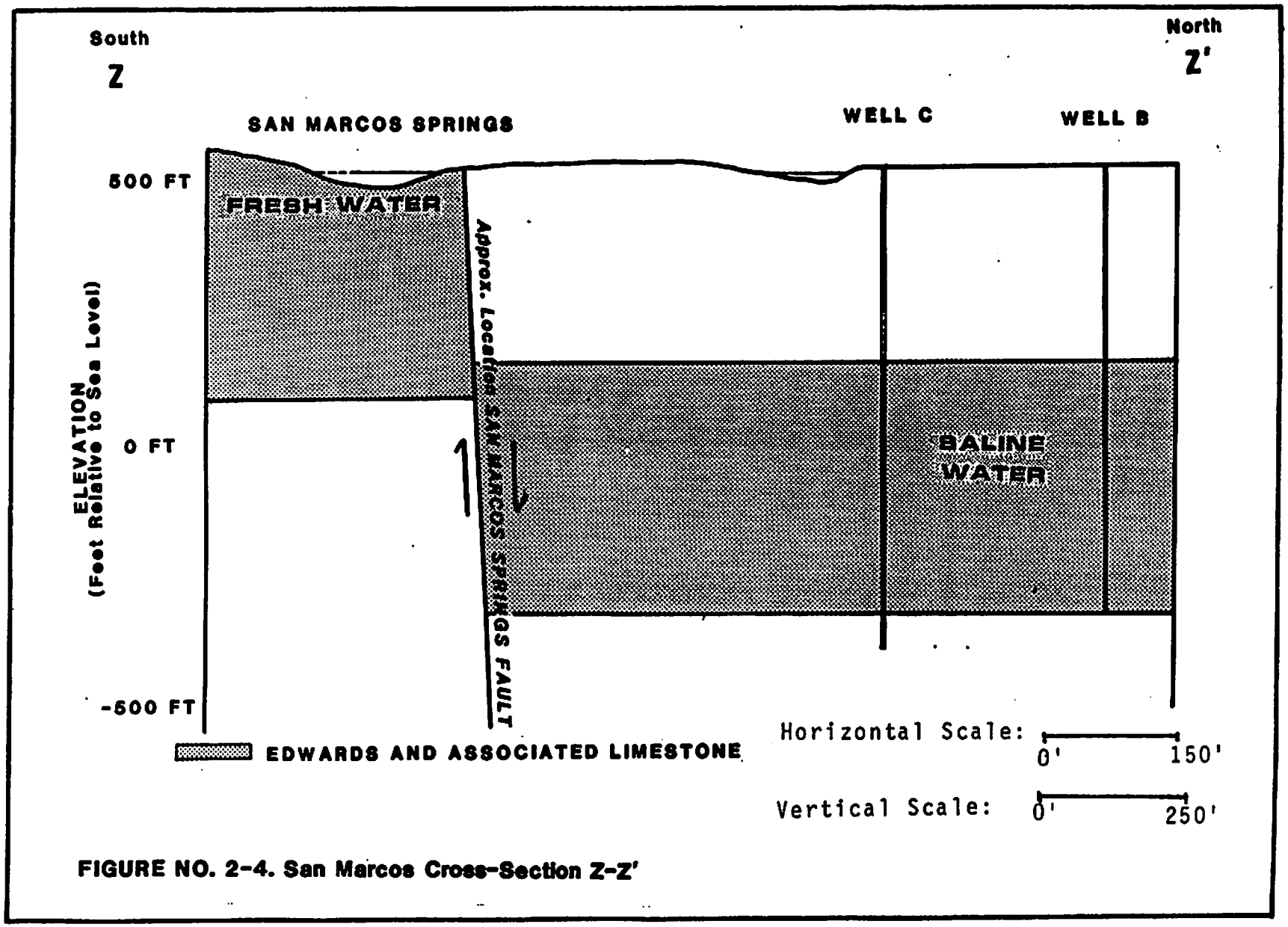

FIGURE NO. 2-4. San Marcos Cross-Section Z-Z'

wells drilled in this transect and a third well just recently drilled by the EUWD. The boundary between the two zones represents a change in water quality from approximately 500 to over 12,000 µS/cm.

DATA COLLECTION

The limestones of the Edwards Aquifer lie approximately 400 to 800 feet beneath the surface at both the New Braunfels and San Marcos sites. During the drilling process, the cuttings were collected at 10-foot intervals and a written documentation of the lithologic descriptions was made. The cuttings were bagged and marked for each 10-foot interval within the Edwards Group. The cutting descriptions were later reviewed with a binocular scope and thin sections were made of representative samples from each bag for petrographic (microscopic) examination.

Air-lift pump tests were performed at 50-foot intervals. Submersible pump tests with expandable packers were also performed at three separate settings in the openhole section of the Edwards. The packer tests were performed on different production zones of the aquifer: one in the Person Formation, above the Regional Dense Member, and two in the Kainer Formation. Once total depth had been reached, but before completion of the holes as monitoring wells, a 9-hour pump test at New Braunfels and a 7-hour pump test at San Marcos were performed using submersible pumps.

Water quality samples for common ion analysis were collected after every pump test. Conductivity and temperature readings were made during all pump tests and additional water quality samples collected for analysis.

Water samples collected were filtered, titrated for alkalinity, measured for pH, and acidized at the site. The samples were analyzed by the USGS and the TWDB laboratories.

Various wireline geophysical logs were run by the EUWD and a private logging company.

CONCLUSIONS

By drilling the well transects at their respective locations in New Braunfels and San Marcos, the regional hydrology in each area can be better understood. In both instances, the saline zone was found to be much closer to the city supply wells and springs than previously believed (see Figure Nos. 7-1 and 7-2).

By studying the hydrogeologic and chemical data, the fresh/saline-water interface can be characterized from the well transects. In New Braunfels, all of the monitoring wells drilled for this study, as well as the LCRA well, contained saline water in the lower portion of the Edwards Group. Thus, in the study area, a transition zone exists between the Comal Springs Fault and the Saline Zone Boundary. However, in San Marcos, the well transect indicates only a zone of high salinity; no transition zone was observed at this location.

The petrographic data for all the wells was consistent at both sites and indicates that the formations now containing saline water may have been exposed to a fresh-water environment at one time in geologic history. Overall, the greatest physical and chemical changes were observed in the New Braunfels transect, as supported by the

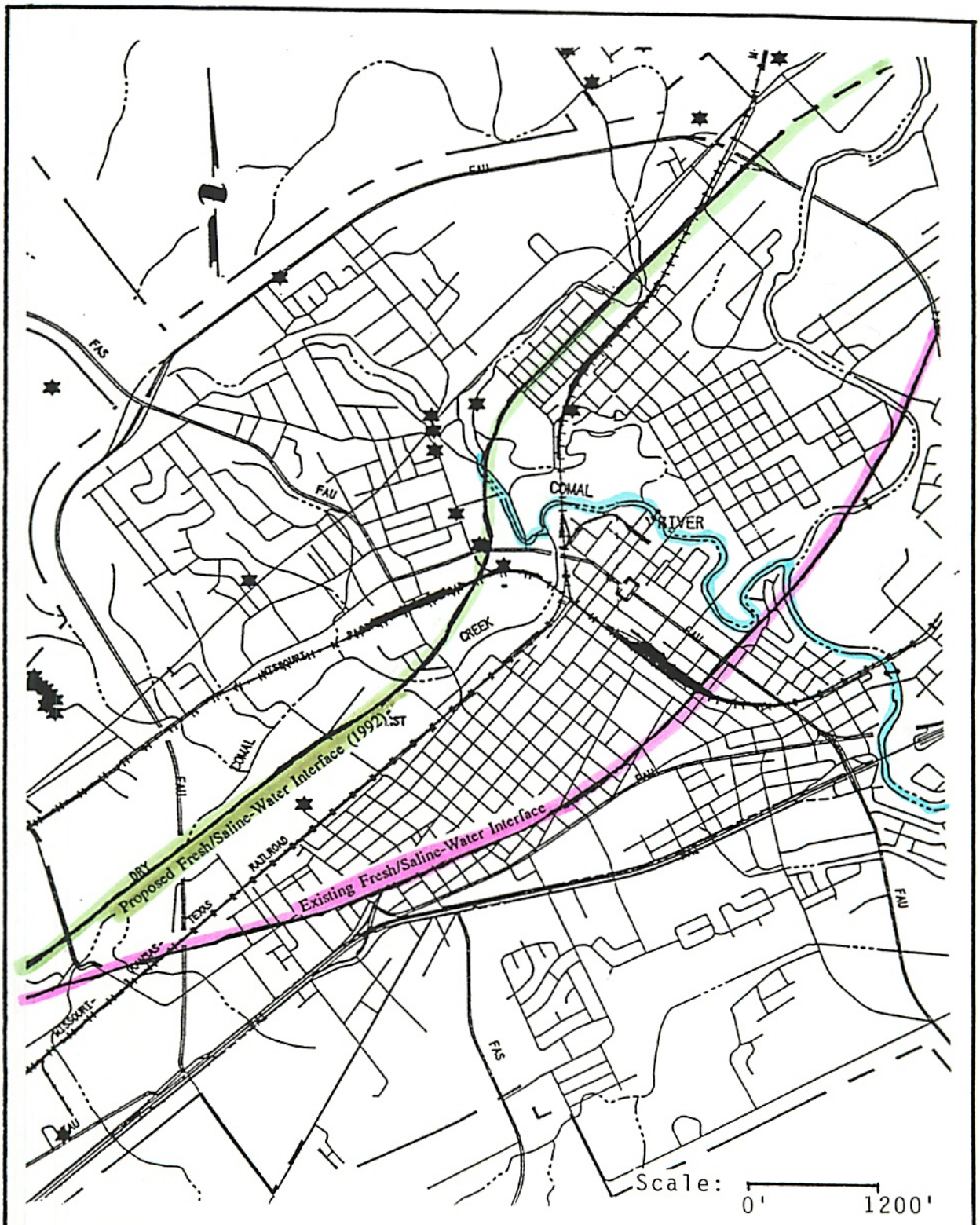

FIGURE NO. 7-1 New Braunfels proposed Fresh/Saline-Water Interface based on study results.

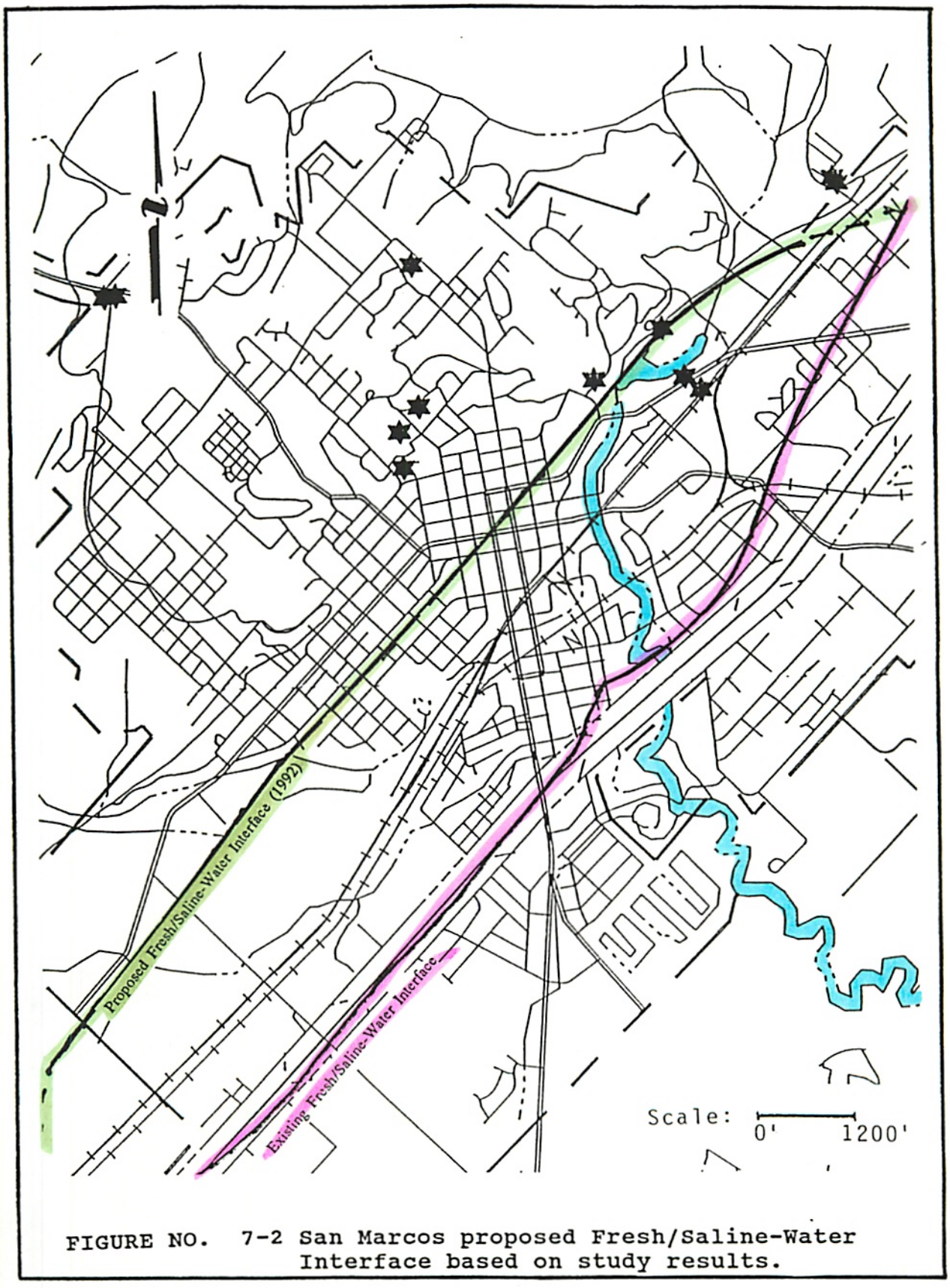

FIGURE NO. 7-2 San Marcos proposed Fresh/Saline-Water Interface based on study results.

petrophysical and water quality evidence.

All the wells in New Braunfels were observed to have large secondary porosity development, relatively medium transmissivity values, and relatively low to medium salinity. In San Marcos, secondary porosity was not as developed, the transmissivities were lower, and the salinity values were high. During the 9-hour pump test in New Braunfels, water levels did not drop significantly, and the quality of the water in the pumping well (B-1) increased in salinity from 1000 to 2000 µS/cm. It did not increase to the same salinity as the A-1 well, but it did increase in salinity compared to the fresh water in the C-1 well. The lower portion of the B-1 well produced a higher salinity value when packered off and pumped then what was observed in the openhole 9-hour pump test.

The conclusions to be drawn from this pump test are not definitive of saline water intrusion because the production well used was a transition well (containing both fresh and saline waters). However, an increase in salinity in the production well could indicate that the interface between the fresh/saline zones moved. This is supported by a low sloping cone of depression during the pump test combined with the ability of water to flow from the saline zone to this transitional well. However, the well must have also drawn fresh water to it, for the salinity values did not increase to the same values observed in the saline zone. Nevertheless, the data suggests that an element of caution should be considered during periods of increased hydrologic stress on the aquifer system in this area.

The USGS has shown that "flow patterns are controlled by the higher altitude of the recharge area and by barrier faults that locally disrupt the lateral continuity of the rocks forming the aquifer". In New Braunfels, the Edwards is completely displaced by the Comal Springs Fault. Thus, if the flow system in the lower block at the New Braunfels transect is not in direct communication with the flow system in the upper block, then saline water intrusion at Comal Springs is unlikely to occur.

In the area from San Antonio to New Braunfels, the water in the fresh zone diverges into two flow paths created by the Comal Springs Fault, and is believed to converge between New Braunfels and San Marcos. Thus, even if the blocks are not communicating at the Comal Springs Fault in New Braunfels, the upper and lower flow paths could combine at some point and the movement of the saline zone boundary could have an effect on the fresh water in San Marcos.

Long term monitoring of the potentiometric surfaces and water quality between the fault blocks and within each fault block, however, will help to determine the direction and mechanism for any movement along the saline zone boundary.

RECOMMENDATIONS

A recommendation was made and approved by the EUWD Board of Directors to drill a third well in San Marcos. The well was completed in March, 1992 and several significant discoveries were made: 1) No faults were found between Well C and the San Marcos Fault as has been indicated in several published technical reports; 2) Saline water exists (throughout the Edwards vertical section) on the

downthrown side of the San Marcos Fault within 300 feet of the San Marcos Springs; and 3) New data suggests that the San Marcos Springs Fault completely separates the Edwards Group. However, a possible connection between the upthrown block and downthrown block may exist along the San Marcos Springs Fault. Data analysis is still pending.

A fourth well on the upthrown side of the San Marcos Fault, up gradient from the springs, should be drilled to determine if saline water exists on that side of the fault. In addition, the wells drilled by the USGS at the Federal Fish Hatchery along McCarty Lane, and located between New Braunfels and San Marcos, could be used for further studying and testing. The location of another transect between San Antonio and New Braunfels, combined with the well at the Fish Hatchery, would further delineate the flow paths between San Antonio and San Marcos. The saline zone boundary has not been detailed in this area, and with information from an additional study, would likely change. In addition to studying the Edwards Aquifer from well transect data, tracer tests should increase our knowledge of the fresh-water flow regime and improve the delineation of the saline zone boundary.