TEXAS
WATER DEVELOPMENT
BOARD

Data-Collection Programs of the Hydrologic Monitoring Section for Fiscal Years 1994 and 1995

LP-215

September 1996

Texas Water Development Board
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INTRODUCTION

The Hydrologic Monitoring Section (HyMon) of the Texas Water Development Board operates data-collection programs to provide and maintain several comprehensive databases on the occurrence and use of the state's ground- and surface-water resources. These databases contain information about ground-water quality, ground-water levels, surface-water quality, surface-water quantity, evaporation rates, and elevations of lake bottom surfaces collected during hydrographic surveys.

The United States Geological Survey (USGS) has collected surface-water quality and quantity data in Texas since 1915 and has maintained these databases. The USGS is the recognized data collecting authority for this resource; the TWDB has only participated in identifying locations and providing funds. Surface water, a very visible resource, has always been a priority of the federal government and has enjoyed a higher profile with the public. Recently, however, issues underscoring the importance of ground water and matters of its control have brought this natural resource in its less visible occurrence to the public's attention. The TWDB is the primary data collecting authority for this resource.

Ground water comprises a significant part of the total water resource of the state of Texas--accounting for approximately 56 percent of the entire consumptive use of water in the state in 1990, the last year for which complete statewide water-use data are available. The TWDB is the only public or private agency that maintains a statewide database containing water-level and ambient (or background) water-quality information. To best plan for use of this resource, maintenance of this database is essential.

One issue of concern for any state experiencing or anticipating increased water demands is the availability of water. As ground water provides Texans with more than half their water, conscientious and consistent monitoring of ground-water availability is a necessity. Although best-management practices encouraged by water conservation districts have finally begun to slow the rate at which water levels are dropping, particularly in west Texas, principal aquifers continue to be developed at rates far exceeding natural recharge. Their depletion is causing adverse regional economic impact in these locations:

The El Paso Area

Surface flows of the Rio Grande have been fully allocated, mostly to agricultural users, and ground water is used to satisfy most of the consumptive needs of rapidly developing municipalities and expanding industries along the El Paso/Juarez corridor. The ground-water resources in the region, principally within the transboundary Hueco Bolson aquifer, are being depleted due to aquifer overdrafts, and saline water continues to encroach upon the fresh ground water remaining in storage. Economic development associated with the North American Free Trade Agreement (NAFTA) may exacerbate the problem.

Despite existing and expected water-supply problems in the area, little attention has been focused on binational management of the Hueco Bolson aquifer, and data and information on water-supply wells and aquifer properties is scattered in the files of numerous federal, state, and local entities. To help remedy these problems, hydrogeologists and engineers in the Board's Water Supplies Section began working jointly with New Mexican and Mexican scientists and engineers to compile existing binational data and information into a single GIS package. This binational product will serve as a tool for planners, administrators, and scientists to use for sensible evaluation of the transboundary aquifers of the region.

The Lower Rio Grande Valley and Immediate Brownsville Area

The availability of good quality surface water is insufficient to meet the area's current and anticipated water-use demands; in addition, isolated occurrences of fresh to slightly saline ground water are insufficient to supplement the surface-water supply during extended droughts such as the one currently being experienced. In late 1994, the Ground-Water Unit of the Hydrologic Monitoring Section completed a ground-water quality study after sampling approximately 150 wells in a total of thirteen counties bordering the Rio Grande. Amounts of dissolved solids, chloride, and sulfate appear to have increased since the 60's in ground water of the Gulf Coast aquifer in the Lower Rio Grande Valley and Brownsville area.

The High Plains

The Ogallala aquifer, the major source of municipal and irrigation water in the Texas Panhandle, is being overdrafted in several areas. Underground water conservation districts continue to encourage efficient irrigation and agricultural practices which slowed the rate at which water levels declined for a couple of years; however, over the last two years there has been little rise and an increased rate of decline due to the drought. Ground water continues to become more difficult and expensive to obtain.

The Dallas-Fort Worth Metroplex and Waco Areas

Severely lowered water levels in the Trinity aquifer have created large regional cones of depression and the potential for quality deterioration of the ground water remaining in storage. In comparison to the High Plains region, however, little organized activity at local or statewide levels has occurred to slow these depletions; instead, activity has been directed at obtaining surface-water supplies.

The San Antonio Area and Irrigated Areas West of the City

Overdrafts placed upon the Edwards (BFZ) aquifer have caused water shortages periodically resulting in reduced flows at Comal and San Marcos Springs, as well as reduced baseflows of the rivers downstream. The threat of federal intervention resulted in state legislation enacted to restrict its development and maintain springflow needed to meet the ecological needs of springs' endangered species.

The Houston Area

Extensive historical ground-water pumpage has caused widespread land subsidence, changes to the aquifer's hydraulic characteristics, damage to structural surface developments, and some saltwater encroachment. As in north-central Texas, more surface water is being used than in the past, although ground-water levels have not recovered to pre-development levels.

The continued use of the state's ground-water resources to satisfy the numerous beneficial purposes they serve depends on their availability and planned development. Such planning can only be accomplished if sufficient good-quality data needed to make these determinations are assimilated.

The TWDB is charged with long-range planning to ensure that the state's water resources are known and developed in a prudent and efficient manner. The Board relies heavily on data-collection activities and studies to provide the data needed to make the proper decisions concerning the state's water resources. Most data collection involves ground-water monitoring conducted by Board personnel. Additional information is obtained through cooperative agreements with the USGS, the City of El Paso, and numerous underground water conservation districts. Surface-water resource information is obtained through cooperative agreements with the USGS.

The purpose of this report is to describe the ground- and surface-water data-collection programs conducted or funded by the Board's HyMon staff during Fiscal Years 1994 and 1995.

GROUND-WATER PROGRAMS

In order to assess the ground-water resources of the state's aquifers and to provide a ground-water database to the public, data must be continuously collected and analyzed. These data are used to describe the occurrence and quality of ground water which now, or, may in the future, supply the needs of water users in Texas. The objective of data-collection activities is to provide information needed to determine the availability and mode of occurrence of ground water and the storage capacity of the aquifers. Information concerning the geologic and hydrologic properties of underground water-bearing formations must be accurate to support rational planning, development, and management of these resources in conjunction with surface-water supplies. Current ground-water information is essential to properly evaluate the impact that development and related public or private activities will have on our environment.

Data-collection activities such as those conducted by the Board's HyMon staff--monitoring changes in water-levels, monitoring water-quality, and monitoring well development programs--are essential in obtaining accurate information. Other Section activities in support of data collection include well-report processing, data entry, public and interagency assistance, core-drilling, materials testing, and geophysical logging.

Water-Level Monitoring

The Board maintains a network of water-level observation wells. Data from the network reflect changes in the amount of water in underground storage, the depth to water, and the direction and rate of water movement. Water levels are measured annually in each network well at a time of year when levels have recovered from the effects of pumping during the season of peak water demands. Excessive water-level declines may result in decreased well yields, increased pumping costs, abandonment of wells, land surface subsidence, and encroachment of poor quality ground water.

The Board's water-level observation well network currently consists of just over 7,000 wells measured annually by staff and cooperators. Typically, TWDB ground-water staff measure more than 3,000 observation wells, whereas underground water conservation districts, the USGS, and other cooperators measure the remainder. Cooperators measure observation wells within their areas, which may include counties or parts of counties within their jurisdiction. Upon completion, all measurements from cooperators and the Board are incorporated into the ground-water database which permits rapid retrieval for use by staff, all cooperators, other governmental entities, and the public.

In FY '95, HyMon staff evaluated the current observation network to determine if a "minimum adequate" number of wells were monitored in each county. To maintain an "ideal" network, the number of water-level network wells would constantly change in response to the specific needs of different projects. For example, construction of ground-water flow models covering several counties requires a different amount of water-level measurements than does the construction of a one county-wide water-level map. Although such limitations must be considered when prescribing the number and location of wells in an ideal water-level network, a minimum number of wells can be considered adequate in order to determine basic trends. That number of wells which HyMon considers an adequate amount in each county varies depending on annual ground-water pumpage. For example, in counties such as Andrews in the High Plains, where more than 100,000 acre-feet of ground water is pumped annually (for irrigation, municipal, and/or industrial purposes), adequate network coverage is one monitored well per 25 square miles. At the other extreme, in a county such as Maverick in South Texas where there is little change in levels and little ground-water use, adequate coverage is one well per 150 square miles.

According to the definition of adequacy of the water-level network using criteria based on pumpage and water-level change, the number of wells measured historically in many counties is more than adequate while the number of historically measured wells in several counties is less than adequate. Typically underground water conservation districts and the USGS measure a larger number of wells than deemed adequate by the Board's criteria. These are areas such as the High Plains and Harris and El Paso Counties where declining water levels are of concern. Presently cooperators in 55 counties monitor all or the majority of wells in their areas. The Board has no control over these monitoring programs and the adequacy of their networks, and districts continue to take over water-level measuring duties that were formerly the responsibility of the Board.

In counties where the number of wells has been determined to be smaller than adequate, HyMon is attempting to increase the number of water-level monitoring wells through inventory of new wells. However, wells are not always available precisely in areas that most need monitoring; in north-central Texas for example, wells are not available for yearly measuring as many of the municipalities have switched to surface water.

The total number of water-level measurements obtained during Fiscal Years 1994 and 1995 by county is shown in Figures 1 and 2. Cooperators are listed below, and their areas of influence are illustrated in Figure 3:

High Plains Underground Water
Conservation District No. 1
(Lubbock)

North Plains Groundwater
Conservation District No. 2
(Dumas)

Panhandle Ground Water
Conservation District No. 3
(White Deer)

Sandy Land Underground
Water Conservation District
(Plains)

Permian Basin Underground
Water Conservation District
(Stanton)

Glasscock County Underground
Water District
(Garden City)

Edwards Underground
Water District
(San Antonio)

U.S. Geological Survey
(El Paso and Houston)

Barton Springs/Edwards Aquifer
Conservation District
(Austin)

Hickory Underground Water
Conservation District No. 1
(Brady)

Santa Rita Underground Water
Conservation District
(Big Lake)

Springhills Water
Management District
(Bandera)

Sterling County Underground
Water Conservation District
(Sterling City)

Irion County Underground
Water Conservation District
(Sterling City)

Mesa Underground Water
Conservation District
(Lamesa)

Hill Country Underground
Water Conservation District
(Fredericksburg)

Evergreen Underground
Water Conservation District
(Jourdanton)

El Paso Water Utilities
(El Paso)

Emerald Underground Water
Conservation District
(Ozona)

South Plains Underground
Water Conservation District
(Brownfield)

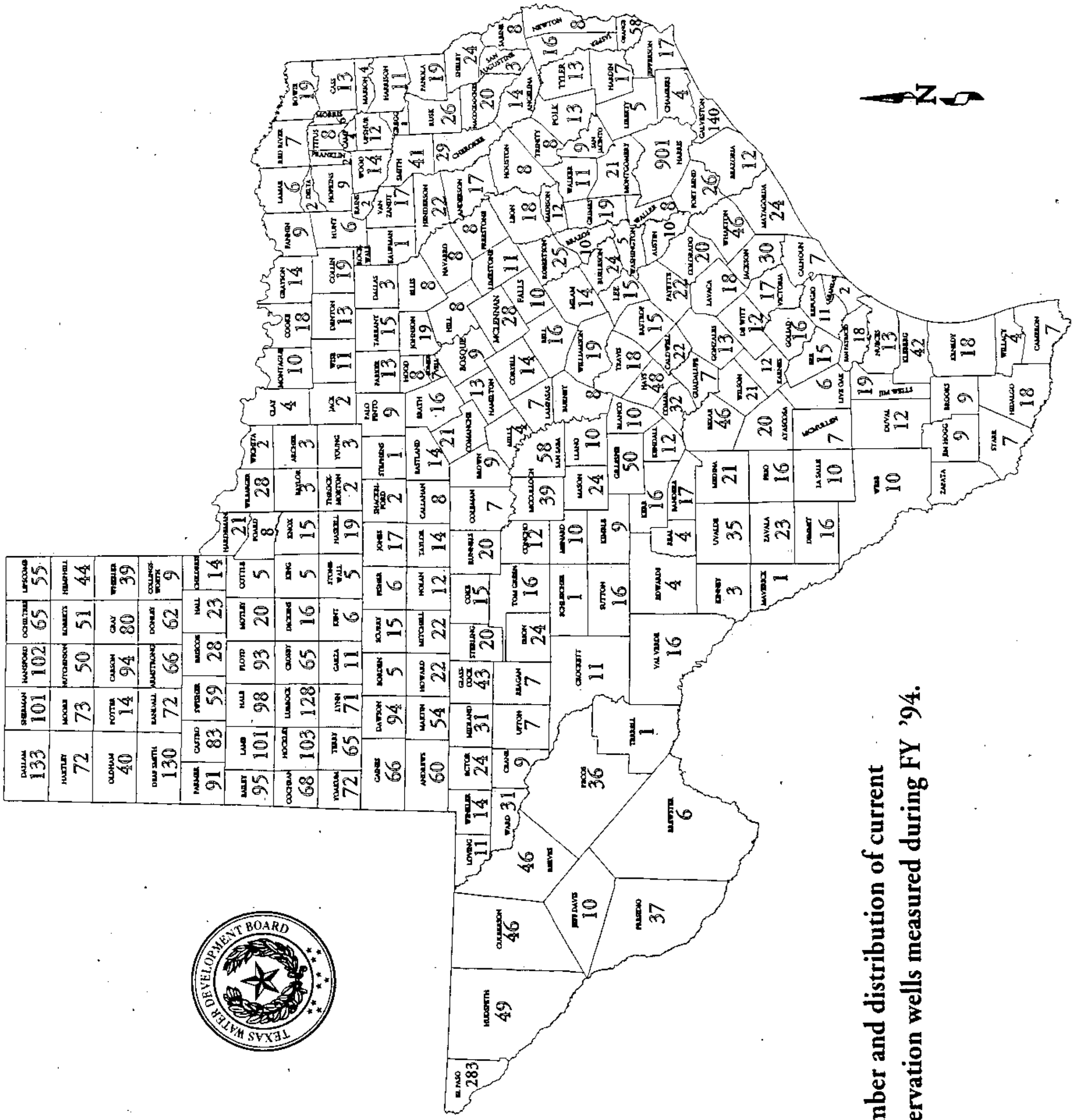


Figure 1. Number and distribution of current observation wells measured during FY '94.

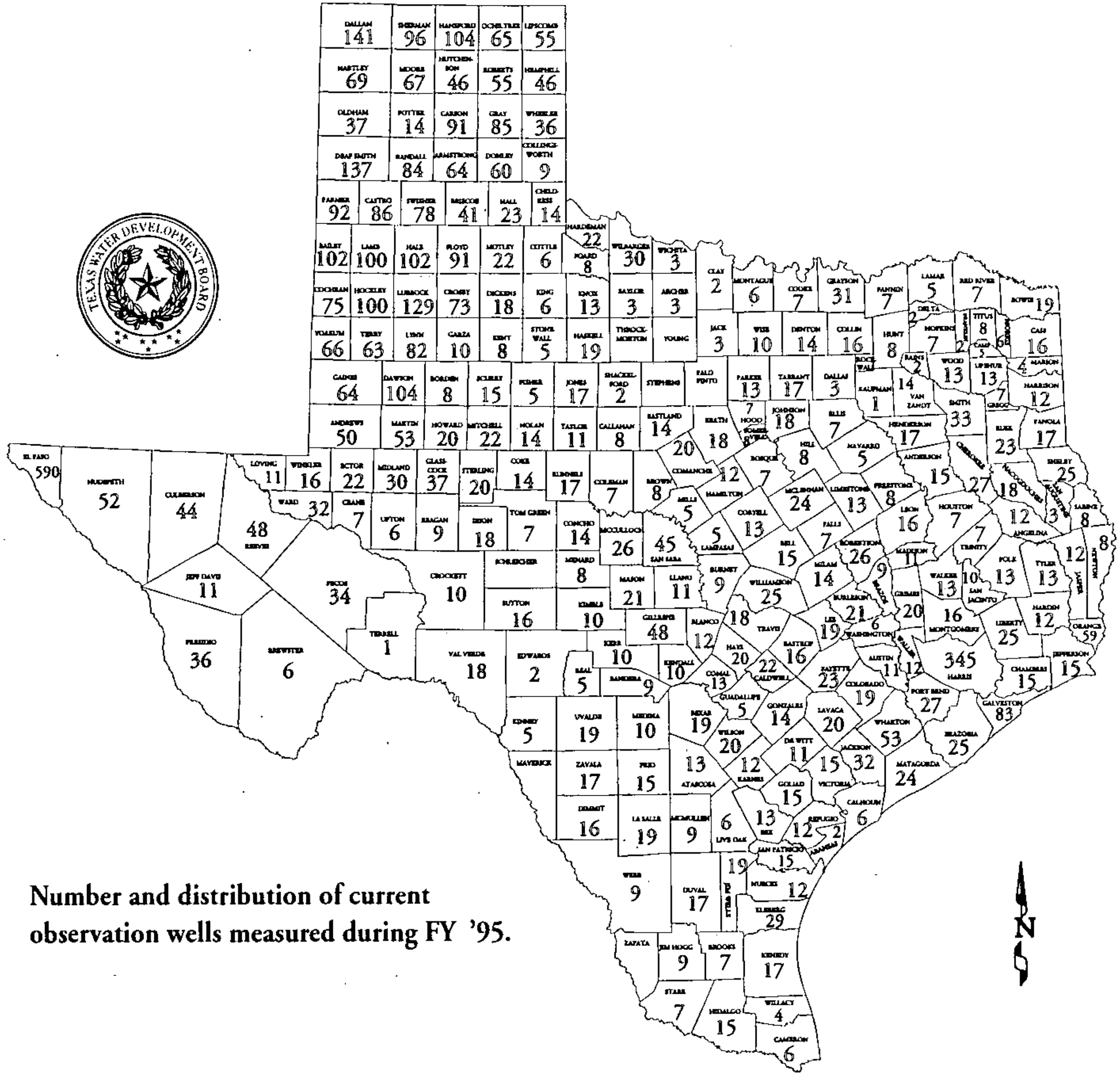


Figure 2. Number and distribution of current observation wells measured during FY '95.

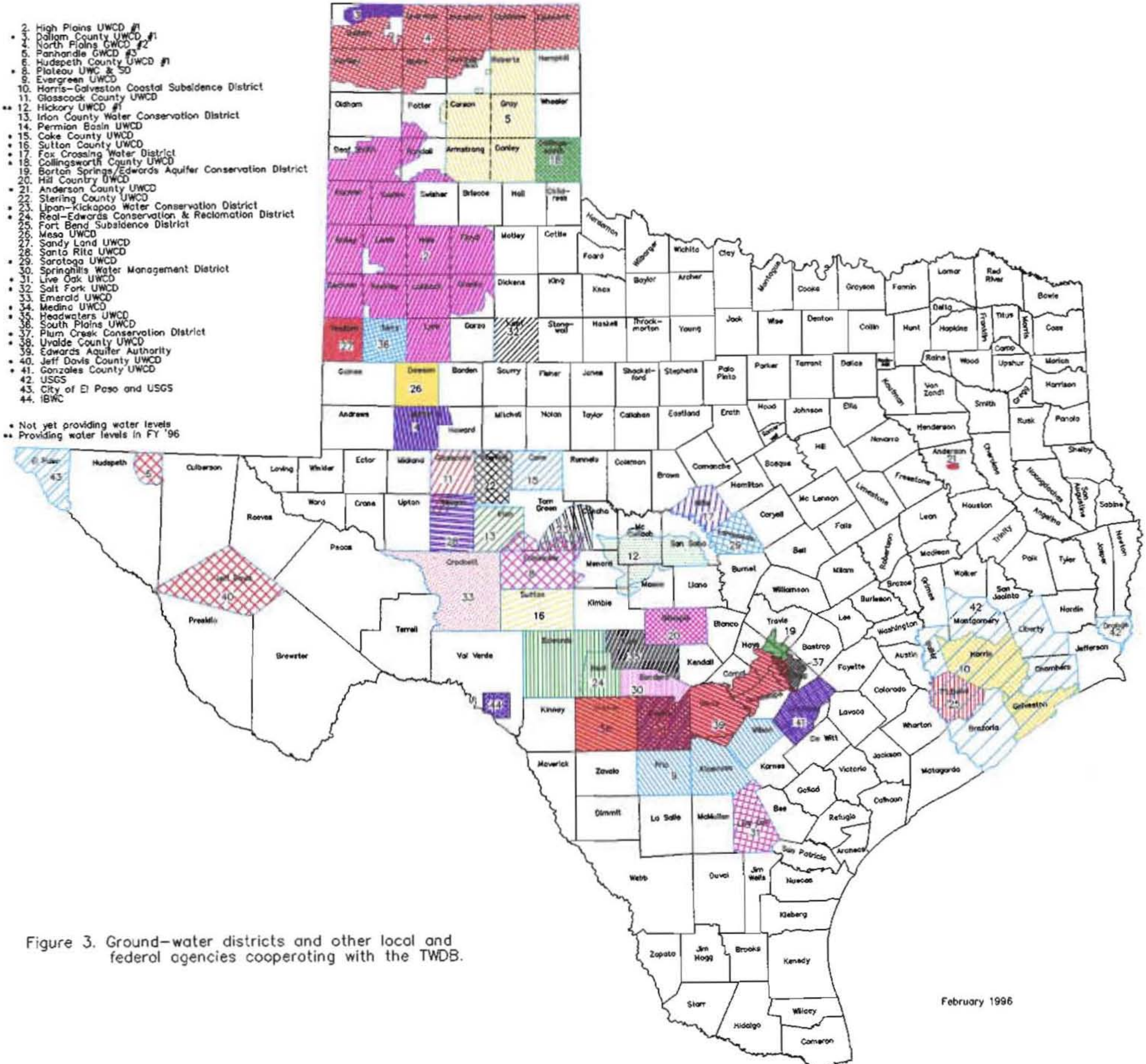


Figure 3. Ground-water districts and other local and federal agencies cooperating with the TWDB.

Wells in the observation network provide data needed to prepare water-level (potentiometric) maps and water-level change maps illustrating the effects of long-term ground-water withdrawals. Declines can result in greater pumping costs and water-quality deterioration as undesirable water is drawn toward pumping centers. Water-level, and water-level change maps and models in combination with other information enable determination of total volumes of water presently in storage and projections of future aquifer storage.

Continuous water-level recorders are operated in representative wells in areas where uninterrupted records of water-level changes are needed. During the past year, the Board maintained 39 automatic water-level recorders in 37 counties (Fig. 4). The installation of datapods on 37 of these has resulted in reduced travel, and, to a lesser extent, reduced data entry costs associated with maintenance and data retrieval. Several water districts listed below help Board staff "service" the datapods.

Panhandle GCD#3
High Plains UWCD #1 (5 recorders)
Permian Basin UWCD
Glasscock County UWCD
Lipan-Kickapoo UWCD
Plateau UWCD
Hickory County UWCD (3 recorders)
Hill Country UWCD
North Plains GCD#2 (3 recorders)
Mesa UWCD

HyMon staff are evaluating observation wells in which additional recorders should be located to ensure that the best data possible are being collected. Other recorders maintained by the USGS and certain underground water conservation districts provide the TWDB with additional data. Hydrographs indicate that, for the most part, long-term water-level declines are occurring in many of the state's aquifers.

Water-Quality Monitoring

The Board maintains a water-quality monitoring network consisting of wells and springs in major and minor aquifers. Water samples for chemical analysis are periodically collected throughout the state from selected sites in order to monitor changes which may occur in ground-water quality naturally or as a result of human activities. Board personnel evaluate results of analyses to determine the frequency of re-sampling, to point out ground-water quality problem areas, and to provide a basis for determining where additional detailed ground-water quality studies are needed. Ambient water-quality data are used for planning purposes, comparison of water quality over time, and determination of baseline water quality. HyMon analyzes water-quality data collected from the network as part of the overall aquifer study and publishes these results. Many other agencies use network data in their regulatory functions and nonpoint source programs.

Records of chemical analyses are stored in the Board's database. Computer programs are used to facilitate retrieval of chemical quality data for a particular well, aquifer, or geographical area, and to identify any significant changes or trends in water quality. Historically, the Texas Department of Health analyzed the water samples under an interagency contract, with other laboratories being used as needed. Prior to the Federal Safe Water Drinking Act, water samples were analyzed only for major anion and cation content. Since passage of the act, samples are still routinely analyzed for these dissolved constituents as before, but now include other constituents such as nitrogen compounds, trace metals, and radionuclide content. Occasionally, samples are also analyzed for certain organic compounds. This has resulted in dramatic increases in analysis costs.

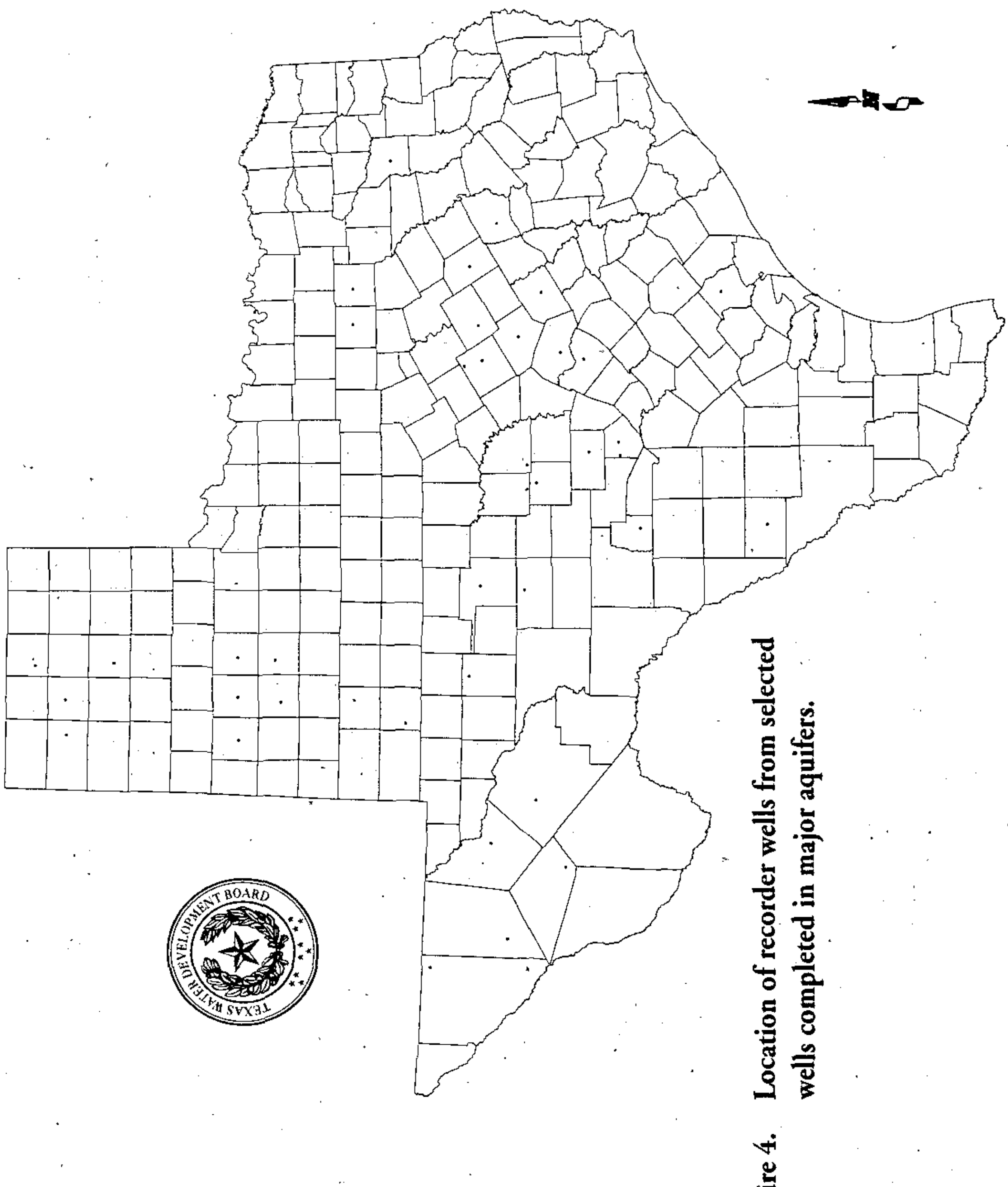


Figure 4. Location of recorder wells from selected wells completed in major aquifers.

In FY '95, HyMon staff evaluated the water-quality monitoring network to determine if an adequate number of wells are sampled to cover each aquifer by county. The water-quality network is based on the sampling of wells (and springs) completed in major or minor aquifers with a density of one site per 50 square miles in areas of large ground-water use. However, aquifer evaluations need sufficient data to determine future ground-water use. In order to provide sufficient network density in areas where there is small ground-water use and where major or minor aquifers exist, HyMon will sample available sites to attain a density of one well per 125 square miles. While a county may have adequate water-quality data within its boundary for one aquifer, it may be deficient in another. Adjustments, if any, to minimum requirements will be made at the conclusion of each major or minor aquifer sampling.

These procedures were initiated in FY 1989. While sufficient numbers of wells were sampled prior to this period, wells were concentrated either in aquifer segments or in aquifers not yet scheduled for sampling. The cycle target is a six-year period based on approximately 590 samples per year for a total of 3,545 sites. Additional samples of ground water will be collected from aquifers above the required quantity when HyMon identifies wells or springs meeting sampling criteria and from areas where Water Supplies Section studies are in progress. HyMon will sample annually a total of 700 sites if funding continues, while outside sources will continue to contribute approximately 300 ground-water analyses per fiscal year.

Currently, there are 83,905 analyses of water samples from 47,760 sites in the Board's ground-water database. The number and distribution of wells the Board sampled for water-quality analysis during the biennium are shown in Figures 5 and 6.

During the biennium, the objective of ground-water sampling in Texas was to determine the baseline water-quality characteristics and changes, if any, in the quality of ground water from selected aquifers. Possible changes in water quality resulting from the impacts of water-level decline, ground-water recharge, saltwater encroachment, irrigation return flow, oil production activity, mining, leachate from feedlots, dairies, landfills, and industrial/agricultural activity were considered in determining water-quality parameters to be sampled. Figure 7 shows the water-quality monitoring projects conducted during the biennium; Tables 1 and 2 list the number of tests conducted in FY '94 and FY '95 for selected constituents and the number of concentrations determined to be greater than EPA's Maximum Contaminant Levels.

Well Data

To maintain a current inventory of high capacity (public supply, industrial, and irrigation) well-development in the state, HyMon personnel review driller's reports submitted by licensed water-well drillers. During the biennium, 52,070 reports were received. Approximately half were for shallow monitor wells. Copies were made of the high-capacity well reports of the remaining half to assist the staff in locating and inventorying these wells in the field. This allows the Board to remain abreast of significant well development and ground-water use throughout Texas to determine the areas and extent of development for long-range water planning purposes. Areas experiencing significant development must be closely monitored to determine if ground-water availability is sufficient to meet anticipated water requirements.

Data from inventoried wells are processed, entered into the ground-water database, and filed. These data are then available for use by agency staff, other governmental entities, and the public. Processing consists of accurately locating the wells on topographic sheets and assigning to each the correct coordinates of latitude and longitude to spatially position the well in the TWDB database. Each well is also assigned a unique state well number before filing.

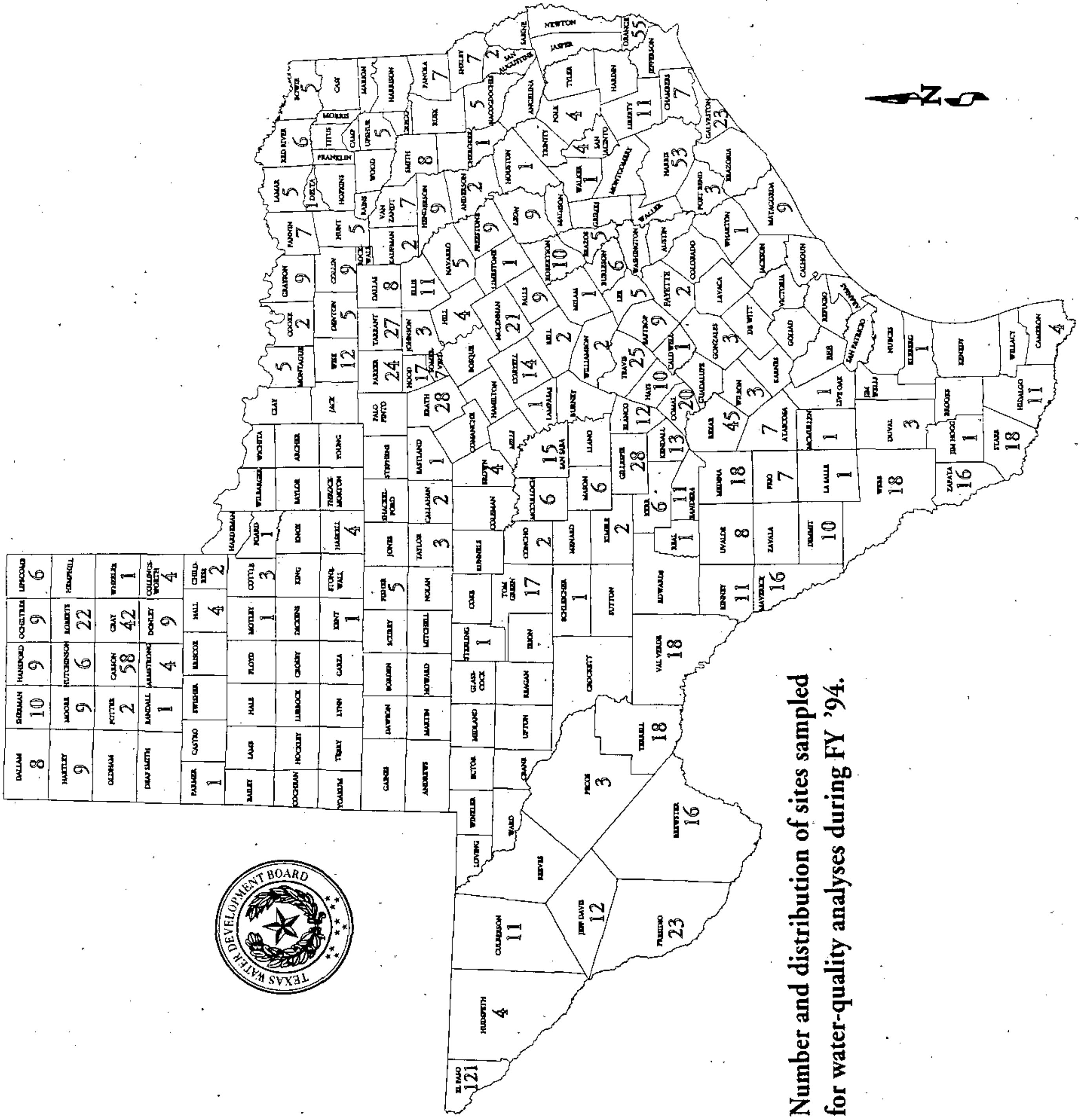


Figure 5. Number and distribution of sites sampled for water-quality analyses during FY '94.

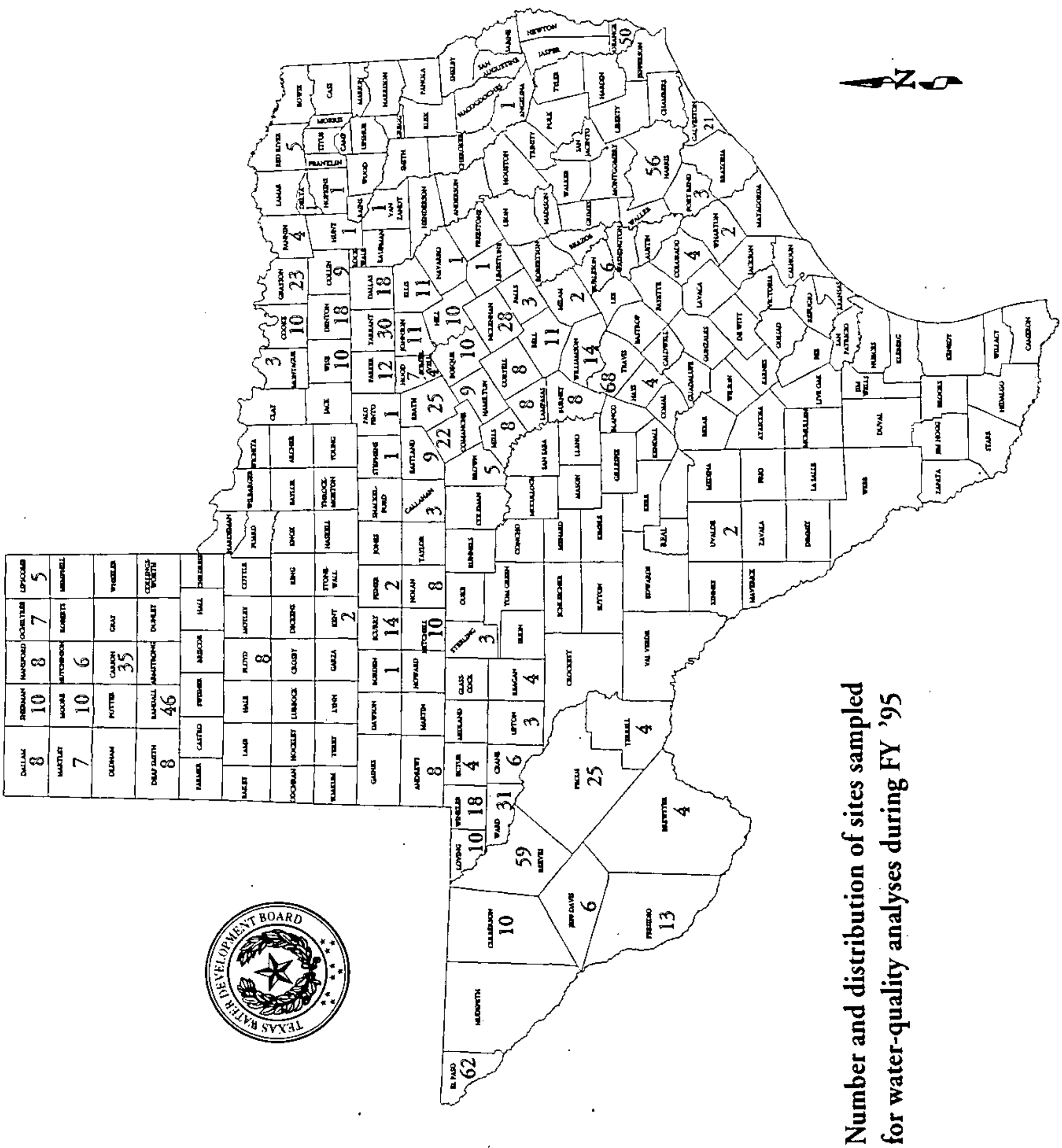


Figure 6. Number and distribution of sites sampled for water-quality analyses during FY '95

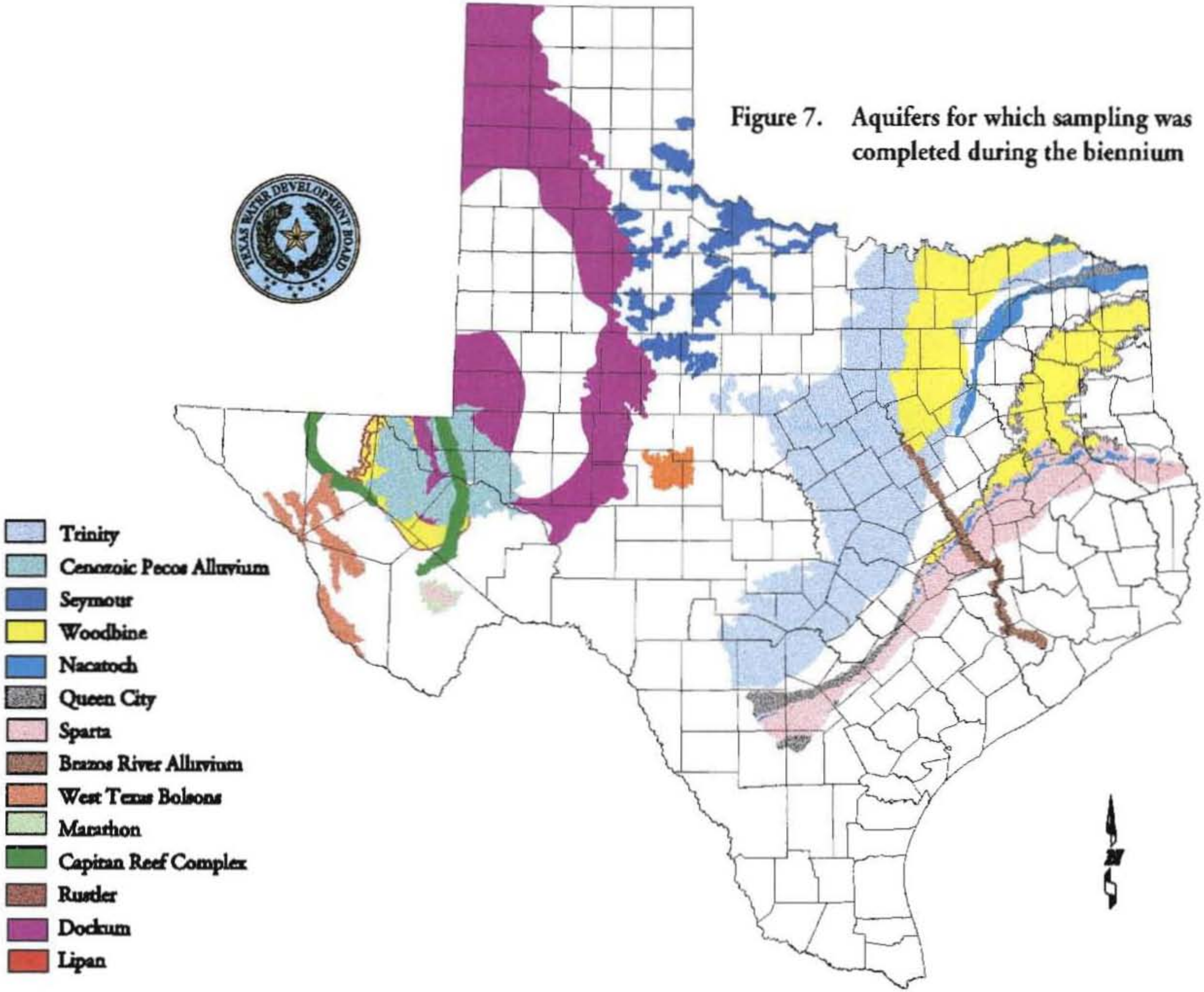


Figure 7. Aquifers for which sampling was completed during the biennium

Category	Constituent	MCL	Number of tests 1,385	Number greater than MCL
Primary	Arsenic	50 µG/L	701	0
	Barium	2 MG/L	718	0
	Cadmium	5 µG/L	703	4
	Chromium	100 µG/L	702	0
	Fluoride	4 MG/L	1080	13
	Mercury	2 µG/L	614	0
	Nitrate (N)	10 MG/L	1040	4
	Selenium	50 µG/L	710	0
Secondary	Chloride	300 MG/L	1367	158
	Copper	1 MG/L	703	0
	Fluoride	2 MG/L	1080	105
	Iron	0.3 MG/L	717	95
	Manganese	50 µG/L	730	94
	pH	≥ 7.0	1328	$198 < 7.0$
	Silver	100 µG/L	690	0
	Sulfate	300 MG/L	1233	165
	Dissolved Solids	1,000 MG/L	960	221
	Zinc	5 MG/L	710	0
Radioactivity	Gross Alpha	15 pCi/L	575	65
	Gross Beta	50 pCi/L	576	4
	Radium	5 pCi/L	71	16

Table 1. Number of tests conducted in FY '94 for selected constituents and the number of concentrations greater than the Maximum Contaminant Level (MCL).

Category	Constituent	MCL	Number of tests 1,048	Number greater than MCL
Primary	Arsenic	50 µG/L	505	1
	Barium	2 MG/L	505	0
	Cadmium	5 µG/L	505	2
	Chromium	100 µG/L	495	0
	Fluoride	4 MG/L	889	14
	Mercury	2 µG/L	482	0
	Nitrate (N)	10 MG/L	852	36
	Selenium	50 µG/L	502	2
Secondary	Chloride	300 MG/L	1,032	155
	Copper	1 MG/L	497	0
	Fluoride	2 MG/L	889	159
	Iron	0.3 MG/L	510	41
	Manganese	50 µG/L	505	25
	pH	≥ 7.0	923	177 < 7.0
	Silver	100 µG/L	497	1
	Sulfate	300 MG/L	901	166
	Dissolved Solids	1,000 MG/L	860	207
	Zinc	5 MG/L	498	0
Radioactivity	Gross Alpha	15 pCi/L	566	79
	Gross Beta	50 pCi/L	569	23
	Radium	5 pCi/L	71	19

Table 2. Number of tests conducted in FY '95 for selected constituents and the number of concentrations greater than the Maximum Contaminant Level (MCL).

State Well Numbering

The Board devised a statewide well-numbering system to avoid duplication of records and to afford a means of convenient identification for wells, oil tests, test holes, and springs. Personnel chose the system for its suitability for computer processing of the well data. This numbering system is a necessary basis of identification which allows easier retrieval of data and cross-reference to publications by the Board, USGS, and others.

The system is based on divisions of the state into numbered quadrangles formed by lines of latitude and longitude (1-degree) and by repeated subdivision of these into smaller quadrangles (7 1/2-minute and 2 1/2-minute) that are also numbered. Thus every well is assigned a unique seven digit number indicating its approximate location. The Board maintains most state well numbers, and the USGS maintains those well numbers in the Houston and El Paso areas. Historically, wells had been located on county-highway maps, but they are now maintained on more accurate topographic base maps. Permanent numbers are assigned to all wells that are field located and inventoried in connection with TWDB data-collection and study activities. During the biennium, state well numbers were assigned to 2,762 newly inventoried wells.

Drillers' Report Processing

Water well drillers in Texas are required to be licensed and to file a water well report with the state covering the drilling of all water wells and related testholes. Reports are also required for dewatering, monitoring, and injection wells. These reports contain information such as depth, location of cased and screened intervals, lithology encountered, water level, water quality, and other pertinent information.

The Board is currently constructing maps similar to the county highway maps produced by the Texas Department of Transportation (TxDOT). These computer-generated maps show the same cultural features as the TxDOT maps but will also display the Board's 2 1/2 minute grid for each county. The maps are being produced for and in cooperation with the Texas Natural Resource Conservation Commission (TNRCC) for sale to all licensed water-well drillers in the state. The purpose is to assist the drillers in identifying and assigning the appropriate five-digit number to reports submitted to the TNRCC on water wells they drill.

Board personnel process reports submitted to the state by licensed water well drillers. This processing consists of separating the reports by county and reviewing the reports for completeness of information needed to identify and locate the wells. Staff make copies of high-capacity well reports in order to locate and inventory these wells in the field. More than 450,000 reports on file provide a valuable fundamental tool for use in detailed ground-water studies. They also serve as a useful reference to well owners when a water well needs to be drilled and to well-service personnel when equipping, reworking, or servicing wells.

Data Entry

The Board recognized the need to incorporate large quantities of hand or typewritten ground-water records collected over the years into a computer-compatible format allowing easy storage and retrieval of these data. To accomplish this, Board personnel designed a program and entered records into the newly created ground-water database. Initial entry, involving input of data readily accessible from published reports, has been completed for the entire state. Additional information must be added continually to the records from agency files and field notes. Ultimately, staff members are assigned to verify the accuracy of the data. Personnel added tens of thousands of ground-water records to the database during the biennium. The data are used by Board personnel to monitor and study ground-water activities and to respond to inquiries from the public and other governmental entities.

The Board began investigating means to modernize the data/mapping system program. To accomplish this, (a) a new unit was created to handle all inquiries for ground-water data and to collect, maintain, and disseminate information related to the located well-data files; (b) a database was developed to track public inquiries; (c) gridded well-location maps of all Texas counties were prepared for the TNRCC to distribute to all water-well drillers to assist them in locating wells they drill; (d) the state well number control program was developed to replace the previous card file system was used to evaluate discrepancies in wells already numbered and entered in the database, resulting in the correction of numerous well numbers; and (e) document image processing (DIP) was initiated in July of 1994 by the agency.

Imaging

DIP is used to store large volumes of paper on high capacity optical disks for compact storage, easy retrieval, and preservation. DIP enables paper to be replaced with electronic digitized images by scanning document images on high capacity optical disk devices. The documents can then be transmitted paperlessly to their points of use via networks or facsimile and printed if paper copies are required. Records stored occupy only about 5% of the space taken by equivalent paper files and seldom are lost or damaged. The initial project consisted of scanning the located well files, files in high demand and in danger of deteriorating, being lost, or destroyed. These files consist of approximately 500,000 pages of data on 115,000 wells. During FY'95, approximately 37,134 pages had been imaged comprising 10,044 wells in 21 counties.

In the near future, HyMon plans to establish a computer station suitable for handling ArcView; to train staff in the use of ArcView to assist in responding to inquiries for information; and to continue to check files, identify and correct errors in the database, and digitize located wells from topographic maps using AutoCAD. The use of ArcInfo to plot well locations on topographic maps will eliminate the tedious task of manually transferring the well locations from the old highway based maps. The addition of another scanner would help reduce the time required to complete the imaging of the well files, however, this would also mean additional help is needed to help expedite the process.

Public & Interagency Assistance

HyMon personnel respond to thousands of inquiries received annually from sources such as consultants, water-well drillers needing pertinent information prior to drilling, municipalities needing additional water due to increased population growth, and private individuals seeking to obtain domestic water supplies. The inquiries may be for basic ground-water data or for expertise concerning the availability, quantity, and quality of ground water for specific sites throughout the state. Some inquiries may require only a few minutes to complete whereas others may require several hours or days. During the biennium, almost 8,000 such requests were answered.

The Board's Water Resources Planning staff is charged with evaluating the water resources of the state for long-range planning purposes. To accomplish this goal, HyMon staff provide information on the occurrence, availability, quantity, and quality of ground water to meet specified planning periods. HyMon staff assist underground water conservation districts by providing (1) current and historical well data, (2) water-level and water-quality data, (3) geohydrologic expertise, and (4) personnel to conduct studies and/or test-hole drilling operations. In addition, staff assists managers of newly formed districts by providing all pertinent well data the Board has on file for the area within each district.

Geotechnical Services

Core-Drill Rig

Despite the extensive network of water-level and water-quality observation wells maintained by the TWDB, staff often find they lack sufficient information to adequately determine ground-water conditions within specific areas of the state. Often this means research and field work is required to collect, compile, and assess the additional needed data. In areas lacking data, the Board has the capability to drill test holes to provide the necessary information. Since 1969, the Board has operated a rig to obtain subsurface data by coring and drilling. The rig is used extensively to assist ground-water personnel conduct studies in areas where reliable data are lacking or supplemental data are needed. When not involved in these activities, the rig is available for use at other projects seeking financing from the Board's Development Fund. The rig is also used to assist other governmental entities under appropriate agreements when their programs will provide information that is mutually beneficial.

The Board's rig has been involved in 75 projects since the inception of the drilling-rig program. During the biennium, the rig has assisted in two major projects: "Valentine," where 4 wells were pump-tested for the USGS in Culberson County; and Stephenville (Erath County), where four holes were drilled ranging from 355 to 500 feet in total depth. Historically, the hole depths drilled/cored by the rig have ranged from 30 to 1,585 feet, and the number of holes drilled during each project has varied from 1 to 44 holes.

Materials Testing Laboratory

The Board maintains a laboratory to perform a wide variety of tests for evaluating construction materials and basic research. The equipment, personnel, and procedures have been inspected and approved by the National Bureau of Standards. Laboratory personnel conduct tests to determine permeabilities, concrete batch design, and properties of soil cement and soil samples. They also perform consolidation tests, rock soundness tests, Atterberg limits (plasticity) tests, organic impurities tests, grain-size analyses, and other appropriate tests.

The laboratory is used to perform tests of cores and materials obtained from holes drilled for ground-water personnel conducting studies in areas where additional data is needed. Moreover, laboratory personnel may secure samples and perform field testing on Board funded projects; they may evaluate results from consultant laboratories to assure compliance with project plans and specifications; and personnel may test materials for other state and federal agencies under appropriate agreements. During drilling for the Stephenville project, core samples were collected and tested for permeability, porosity, moisture content and sieve analysis. Water samples were also collected, water levels were measured, and each well was pump-tested.

Geophysical Logging

Since 1968, the Board has operated a mobile geophysical logging unit to obtain subsurface stratigraphic data. Recorded responses indicate the physical properties and structure of geological formations below land surface and presence of and depth to water. Staff use this information to conduct studies in areas where reliable data are lacking, where supplemental data are needed, and in projects involving the Board's core drill rig.

When not involved in these activities, the logging unit is available for use in evaluating the geological conditions of other projects seeking financing from the Board's Development Fund. The logging unit may also be utilized to assist other governmental entities under appropriate agreements if their programs will provide information that is mutually beneficial. During this biennium, however, no wells were logged.

SURFACE-WATER PROGRAMS

Surface-Water Quantity Monitoring

The Board cooperates with the USGS in a data-collection program operated by the USGS. This program collects data consisting of daily streamflow measurements, daily reservoir levels, periodic springflow measurements, and peak discharges. Gages are located throughout the state, typically in areas which are historically most impacted by demographics. All current and/or historical water-resource information is archived in Texas Natural Resource Information Services (TNRIS) data files for public and private use or analysis.

Tables 3 and 4 list the eight river and 15 coastal basins analyzed and gages necessary to comprise an "ideal" network in which one gage is required for every 500 square miles, based on a minimum of one gage per coastal basin. The Board funded only 20 percent of the gaging network in FY '94 and FY '95. Historically, funded gages have been ranked by importance and need when analyzing the network. No efforts to improve the network have been attempted recently. All efforts have been directed towards optimizing a shrinking program and towards maintaining current funding levels.

Surface-Water Quality Monitoring

TWDB programs and projects require information about background water quality and changes in water quality. Since the TWDB is not responsible for statewide water-quality monitoring, these data are derived from daily and periodic water-quality measurements collected by the USGS with funds provided by the TWDB.

Evaporation

Climatic data, consisting of daily high and low temperatures, daily rainfall, daily wind speed, and daily evaporation rates, are processed annually to determine statewide lake-surface evaporation estimates. Files of raw and empirical data are maintained by TNRIS for multiple users' needs in relation to water-resource analyses.

The Board funded and maintained 47 stations in FY '94 and FY '95, as illustrated in Figure 8. These stations are located in 38 of the 87 one-degree quadrangles that compose the state. Forty-six additional stations operated by other entities add 11 more quadrangles of coverage. This totals to 49 out of 87 quadrangles that are adequately covered by the existing network; an "ideal" data-collection network would consist of one station in each quadrangle.

Hydrographic Surveying

In 1991, the Board authorized HyMon staff to initiate a new data-collection program to determine the current storage capacities of the State's major reservoirs and to determine changes caused by sedimentation. Staff researched and identified Global Positioning System (GPS) technology as the most efficient method of determining the horizontal position of a vessel during a survey. In 1992, a reservoir survey program was developed around this technology and specialized equipment was obtained. Staff then proceeded to test, train, and develop procedures for conducting surveys which became known as the Hydrographic Survey Program.

River Basin	Drainage area (sq. miles)	Gages to meet standard	Board-funded gages	All current gages
Canadian	12,700	25.4	3	5
Red	24,463	48.9	13	37
Sulphur	3,558	7.1	0	7
Cypress	2,812	5.6	3	8
Sabine	9,756	19.5	5	21
Neches	10,011	20	3	19
Trinity	17,969	36	9	77
San Jacinto	5,600	11.2	2	58
Brazos	43,000	86	16	85
Colorado	38,893	79.8	12	65
Lavaca	2,309	4.6	4	5
Guadalupe	6,070	12.1	9	40
San Antonio	4,180	8.4	3	22
Nueces	16,950	33.9	14	30
Rio Grande	48,259	96.5	2	87
Total	**247,530**	**495**	**98**	**531**

Coastal Basins	Board-funded Gages	All current gages
Neches/Trinity	0	2
Trinity/San Jacinto	0	1
San Jacinto/Brazos	0	4
Brazos/Colorado	0	1
Colorado/Lavaca	1	1
Lavaca/Guadalupe	2	2
San Antonio/Nueces	3	4
Nueces/Rio Grande	1	1

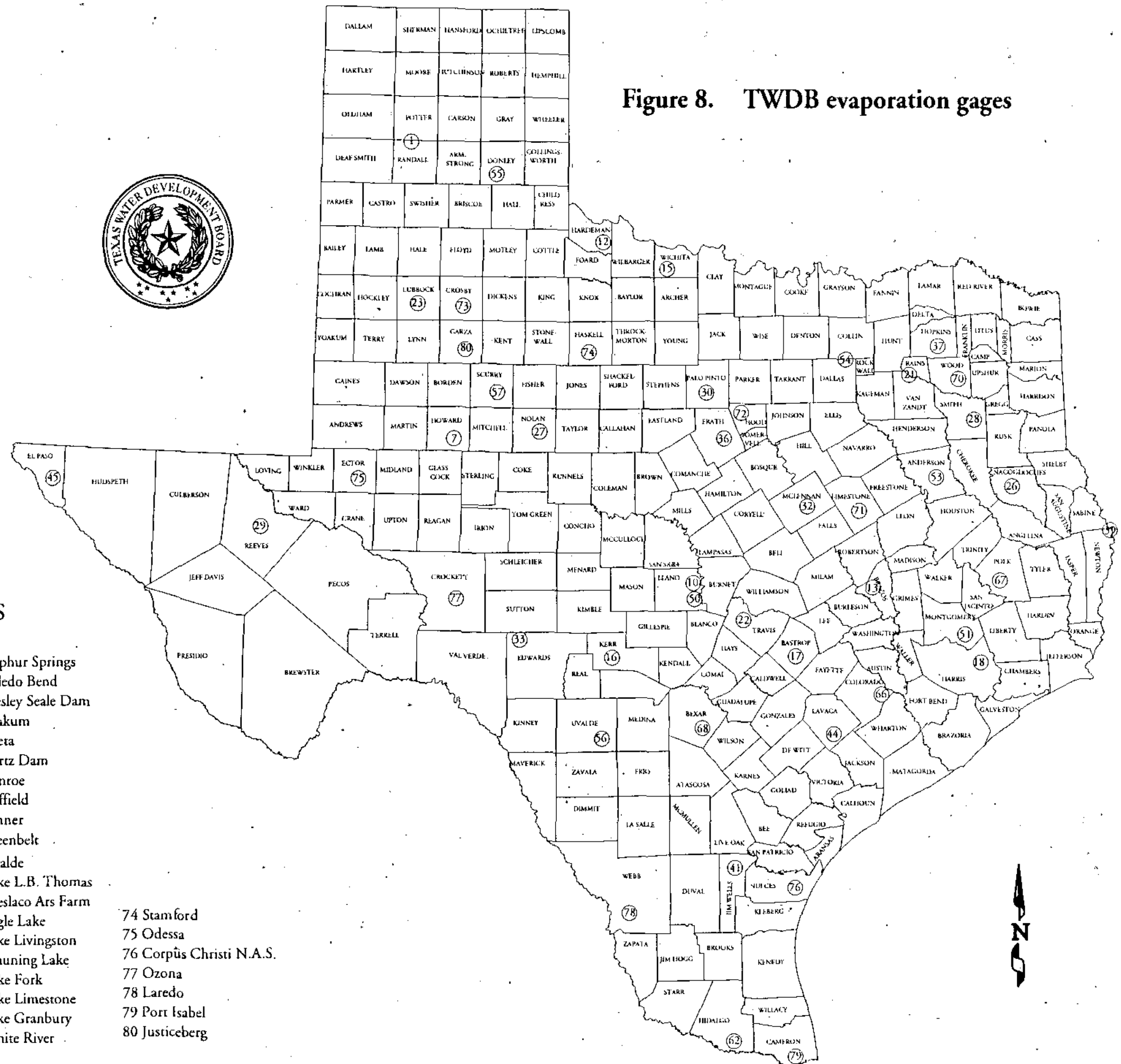
Table 3. Number and location of adequate surface-water quantity gages in FY '94.

River Basin	Drainage area (sq. miles)	Gages to meet standard	Board-funded gages	All current gages
Canadian	12,700	25.4	3	5
Red	24,463	48.9	13	35
Sulphur	3,558	7.1	0	8
Cypress	2,812	5.6	3	8
Sabine	9,756	19.5	5	20
Neches	10,011	20	3	14
Trinity	17,969	36	9	70
San Jacinto	5,600	11.2	2	45
Brazos	43,000	86	14	72
Colorado	38,893	79.8	12	50
Lavaca	2,309	4.6	4	5
Guadalupe	6,070	12.1	8	31
San Antonio	4,180	8.4	3	17
Nueces	16,950	33.9	14	28
Rio Grande	48,259	96.5	2	87
Total	**247,530**	**495**	**95**	**495**

Coastal Basins	Board-funded gages	All current gages
Neches/Trinity	0	2
Trinity/San Jacinto	0	1
San Jacinto/Brazos	0	4
Brazos/Colorado	0	1
Colorado/Lavaca	1	1
Lavaca/Guadalupe	2	2
San Antonio/Nueces	3	3
Nueces/Rio Grande	1	1

Table 4. Number and location of adequate surface-water quantity gages in FY '95.

Figure 8. TWDB evaporation gages



LOCATIONS

01 Bushland
07 Big Spring
10 Buchanan Dam
12 Chillicothe
13 College Station
15 Iowa Park
16 Ingram
17 Lake Bastrop
18 Lake Houston
21 Lake Tawakoni
22 Lake Travis
23 Lubbock
26 Nacogdoches
27 Oak Creek
28 Overton
29 Pecos
30 Possum Kingdom
32 Riesel
33 Sonora
36 Stephenville
37 Sulphur Springs
39 Toledo Bend
41 Wesley Seale Dam
44 Yoakum
45 Ysleta
50 Wirtz Dam
51 Conroe
53 Coffield
54 Renner
55 Greenbelt
56 Uvalde
57 Lake L.B. Thomas
62 Weslaco Ars Farm
66 Eagle Lake
67 Lake Livingston
68 Brauning Lake
70 Lake Fork
71 Lake Limestone
72 Lake Granbury
73 White River
74 Stamford
75 Odessa
76 Corpus Christi N.A.S.
77 Ozona
78 Laredo
79 Port Isabel
80 Justiceberg

The program's goal is to survey each of the State's 77 "major" reservoirs once during the next decade. These reservoirs are estimated to represent 98 percent of the conservation storage in the state's reservoirs larger than 5,000 acre-feet. During the biennium, seventeen reservoirs (shown in Fig. 9) had been surveyed. Staff estimates that 70 percent of the identified reservoirs could be surveyed in the next seven years. The Board allocated funds to implement the new data-collection program, but stipulated that a fee would be charged for services performed. Staff develops a rate schedule, solicits surveys, and monitors expenses to ensure full cost-recovery. At least every two years, staff must present to the Board a revised rate schedule, and summary of expenses and revenues for the previous period.

After a client expresses an interest in a survey, staff preplans the survey and submits the details to the client in a contract. The surface acreage of the lake at the normal pool level as depicted on USGS 7 1/2-minute topographic maps is the basis for the design. A survey line pattern is determined for a standard survey based on 500-foot transects. Depending on the hazards to navigation present such as submerged vegetation, and depending on special requirements of the client, a contract amount is agreed upon, a date to perform the survey is set, and contracts are signed. Staff prepares survey setup files that will guide the boat during the survey, checks the available satellite survey time periods, and gathers information on local first-order surveying benchmarks.

The field survey begins with staff obtaining coordinates for a shore control point near the reservoir. The GPS units monitor the first-order benchmark and desired control point for two hours. The data are processed that evening, and the first-order coordinates are established for the control point. A shore radio station is set up to broadcast differential corrections from the GPS receiver located at the control point to the GPS receiver on the boat. The information received allows the boat to determine its location within three meters every second during the survey. A depth sounder also collects vertical information of the lake's submerged bottom every second. The collected data are stored on a PC for processing after the survey. A guidance system directs the boat crew to the starting location of each line that was predetermined when making the survey setup files, and provides information during the actual run of the survey line by comparing the GPS location information received with the survey setup file data. Data are collected every second, no matter whether the boat is located on the survey line or not. As long as contact is maintained with the shore radio station, the boat can independently collect hydrographic information. Staff can also pause the automatic program to enter additional data manually when the vegetation or water depth prohibits vessel access or operation of the depth-sounding equipment.

Personnel process information in the office and construct a contour map of the lake bottom. An area-elevation-capacity table and chart are also determined. The surveyed true capacity of the reservoir is compared with the previously determined capacity and the results are summarized in a survey report prepared for the client. After delivery of the report, the contract is considered fulfilled.

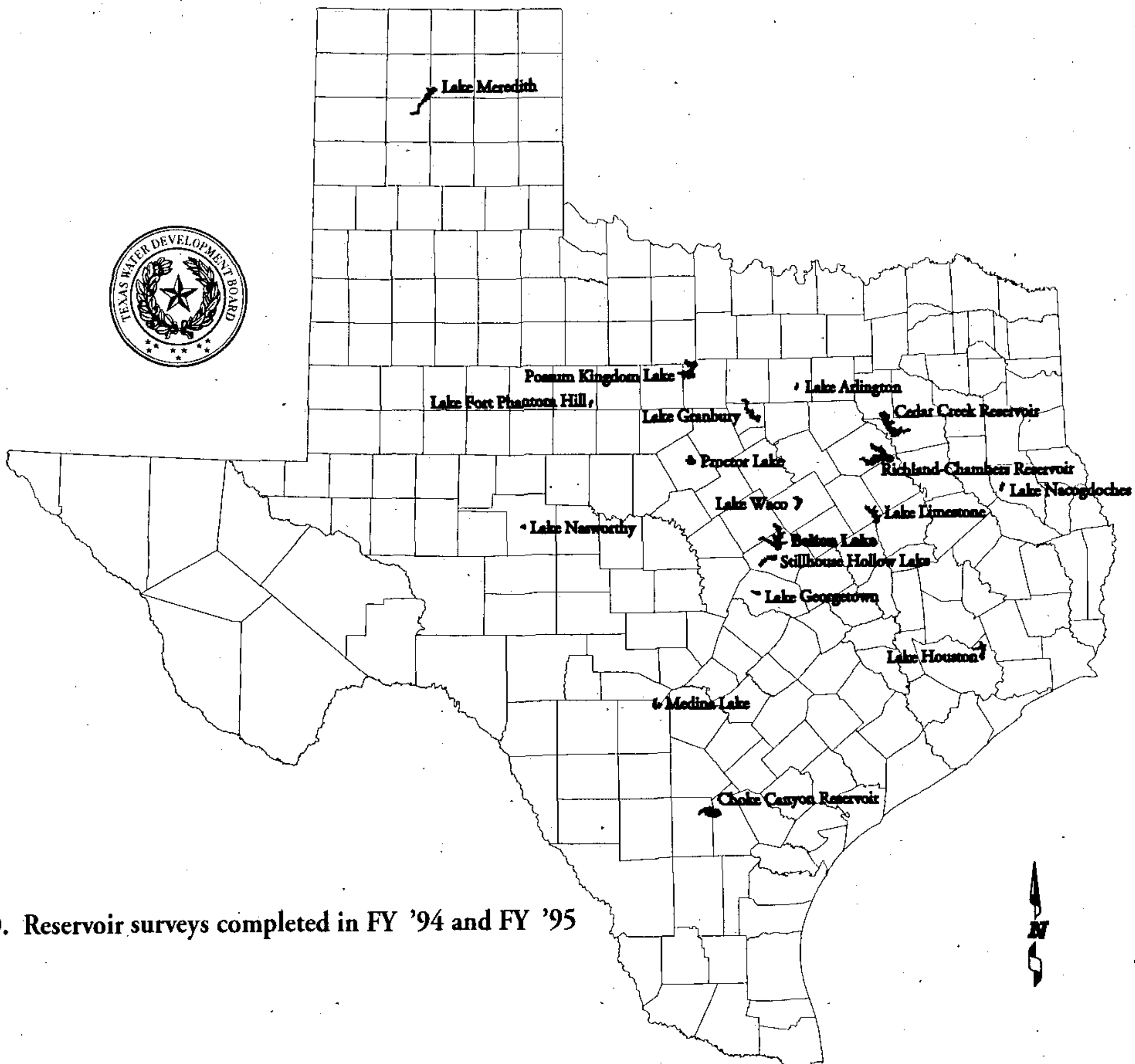


Figure 9. Reservoir surveys completed in FY '94 and FY '95

CONCLUSIONS AND RECOMMENDATIONS

Ground-water monitoring networks and studies are essential to accurately assess the resources of the state's aquifers. It is imperative that these activities be maintained to ensure that the state's valuable ground-water resources are developed in a prudent and efficient manner, thereby securing the state's continued economic growth and the general welfare of its citizens.

Data-Collection Activities

If monitoring networks are to provide the most reliable information possible, they must be continuously reviewed to determine if adequate coverage is being maintained. This can only be accomplished if funding to cover staff and travel expenses is continued and expanded. Funding for chemical analysis, the most costly portion of this activity, must be continued and even increased to cover any additional analysis costs. The baseline quality of ground water present must be established; any long-term deterioration or short-term pronounced changes resulting from contamination must be monitored, described, and quantified.

Another important function of data collection is to obtain information on the occurrence and use of water in the state. This information, collected by staff of the TWDB Water Use & Projections Section, includes ground- and surface-water use for (1) municipal and manufacturing, (2) mining and steam-electric generation, and (3) agricultural purposes. These data are utilized by TWDB staff and others to evaluate current resources and to develop future water-supply requirements. Table 5 shows population from 1950 and the total historical water use for several years since 1974 through 1990, the last year for which statewide water-use data completely broken down by specific use are available. In 1990, 15,718,804 acre-feet of water was used in Texas with 56 percent (8,917,770 acre-feet) being supplied from ground-water sources and 44 percent (6,801,834 acre-feet) from surface-water sources. Figures 10 and 11 show the total ground- and surface-water use, respectively, by county in 1990.

Legislation

During the past legislative session, two bills were passed that will directly or indirectly influence the activities of the Board's staff. HB 2294, sponsored by Senator Kenneth Armbrister and Representative Gerald Yost, reorganizes existing law and separates Chapter 52 of the Texas Water Code into two new chapters. New Chapter 35 governs duties of state agencies, including the TNRCC and the TWDB, regarding designation of ground-water management areas and critical areas. New Chapter 36 governs the creation, administration, operation, and duties of ground-water conservation districts. This legislation does not affect current administrative or financial requirements of the TWDB on ground-water issues.

HB 1989, sponsored, by Senator Frank Madla and Representative Ciro Rodriquez, establishes guidelines and authority for the TNRCC and TWDB to investigate the feasibility of aquifer storage and recovery (ASR) projects. It authorizes pilot projects in certain counties and makes them eligible for research and planning funds from the TWDB. It requires the TWDB, in conjunction with the TNRCC, to report findings to the Legislature prior to each session.

YEAR	SOURCE	POPULATION	MUNICIPAL (1)	MANUFACTURING	POWER (2)	IRRIGATION (3)	MINING	LIVESTOCK	TOTAL
1950		7,711,194							
1960		9,579,677							
1970		11,196,730							
1974	GROUND		967,061	486,337	52,884	10,404,522	178,880	127,408	12,217,092
	SURFACE		964,374	1,112,631	148,212	2,680,553	48,156	168,210	5,122,136
	TOTAL	**12,285,613**	**1,931,435**	**1,598,968**	**201,096**	**13,085,075**	**227,036**	**295,618**	**17,339,228**
1977	GROUND		1,138,526	396,874	45,046	9,156,391	198,821	124,524	11,060,182
	SURFACE		1,252,984	1,223,098	222,252	2,283,393	62,134	141,380	5,185,241
	TOTAL	**13,205,698**	**2,391,510**	**1,619,972**	**267,298**	**11,439,784**	**260,955**	**265,904**	**16,245,423**
1980	GROUND		1,290,271	248,640	53,000	8,956,971	178,369	119,311	10,846,562
	SURFACE		1,522,970	1,271,352	251,172	3,749,377	60,707	124,698	6,980,276
	TOTAL	**14,229,191**	**2,813,241**	**1,519,992**	**304,172**	**12,706,348**	**239,076**	**244,009**	**17,826,838**
1984	GROUND		1,412,910	238,249	54,324	6,899,829	115,736	124,298	8,845,346
	SURFACE		1,659,358	1,178,572	309,747	3,032,022	61,568	168,130	6,409,397
	TOTAL	**16,082,723**	**3,072,268**	**1,416,821**	**364,071**	**9,931,851**	**177,304**	**292,428**	**15,254,743**
1985	GROUND		1,387,915	223,014	58,456	6,073,910	99,608	129,312	7,972,215
	SURFACE		1,694,444	1,204,724	300,564	2,686,597	77,771	163,387	6,127,487
	TOTAL	**16,369,582**	**3,082,359**	**1,427,738**	**359,020**	**8,760,507**	**177,379**	**292,699**	**14,099,702**
1986	GROUND		1,387,594	217,415	50,707	5,288,367	80,644	118,853	7,143,580
	SURFACE		1,670,961	1,130,867	290,010	2,609,617	79,034	162,060	5,942,549
	TOTAL	**16,685,000**	**3,058,555**	**1,348,282**	**340,717**	**7,897,984**	**159,678**	**280,913**	**13,086,129**
1987	GROUND		1,363,615	195,092	50,636	4,597,530	105,680	122,383	6,434,936
	SURFACE		1,678,704	1,171,417	300,744	2,657,073	51,016	155,515	6,014,469
	TOTAL	**16,785,097**	**3,042,319**	**1,366,509**	**351,380**	**7,254,603**	**156,696**	**277,898**	**12,449,405**
1988	GROUND		1,426,842	204,592	49,592	5,065,515	103,616	100,138	6,950,295
	SURFACE		1,778,065	1,304,715	396,087	3,365,091	49,575	153,816	7,047,349
	TOTAL	**16,838,200**	**3,204,907**	**1,509,307**	**445,679**	**8,430,606**	**153,191**	**253,954**	**13,997,644**
1989	GROUND		1,411,505	242,237	52,720	6,262,209	86,562	100,450	8,155,683
	SURFACE		1,734,538	1,294,841	354,523	3,277,429	62,277	152,859	6,876,467
	TOTAL	**16,672,262**	**3,146,043**	**1,537,078**	**407,243**	**9,539,638**	**148,839**	**253,309**	**15,032,150**
1990	GROUND		1,386,850	237,768	58,540	7,038,202	86,562	109,848	8,917,770
	SURFACE		1,791,548	1,322,279	375,576	3,085,133	62,277	164,221	6,801,034
	TOTAL	**16,986,510**	**3,178,398**	**1,560,047**	**434,116**	**10,123,335**	**148,839** (4)	**274,069**	**15,718,804**
1991	GROUND		1,305,539	228,734	49,365	6,143,211	130,410	112,288	7,969,547
	SURFACE		1,762,503	1,328,554	SEE(5)BELOW	2,817,558	67,446	167,054	6,143,115
	TOTAL	**17,349,000**	**3,068,042**	**1,557,288**	**49,365**	**8,960,769**	**197,856**	**279,342**	**14,112,662**
1992	GROUND		1,284,040	263,126	47,790	5,707,516	135,386	142,876	7,580,734
	SURFACE		1,818,345	1,256,909	SEE(5)BELOW	2,580,075	72,693	187,429	5,915,451
	TOTAL	**17,655,650**	**3,102,385**	**1,520,035**	**47,790**	**8,287,591**	**208,079**	**330,305**	**13,496,185**
1993	GROUND		1,333,396	245,268		7,629,009		149,727	9,357,400
	SURFACE		1,953,432	1,342,552	SEE(5)BELOW	2,713,430		193,858	6,203,272
	TOTAL	**18,031,484**	**3,286,828**	**1,587,820**	**0**	**10,342,439**	**0**	**343,585**	**15,560,672**
1994	GROUND					7,402,371		149,643	7,552,014
	SURFACE				SEE(5)BELOW	3,381,996		193,723	3,575,719
	TOTAL	**18,378,185**	**0**	**0**	**0**	**10,784,367**	**0**	**343,366**	**11,127,733**

(1) Municipal use excludes reported industrial sales.
(2) Electric power cooling water is consumptive use.
(3) Irrigation surface-water use for 1974, 1977, on-farm use. Surface-water diversion loss estimates are included after 1977.
(4) 1989 Mining data is subsitituted for 1990.
(5) 1991 thru 1994 surface-water use data for Power is not available.

Table 5. Historical Water-Use Summary in Acre-Feet

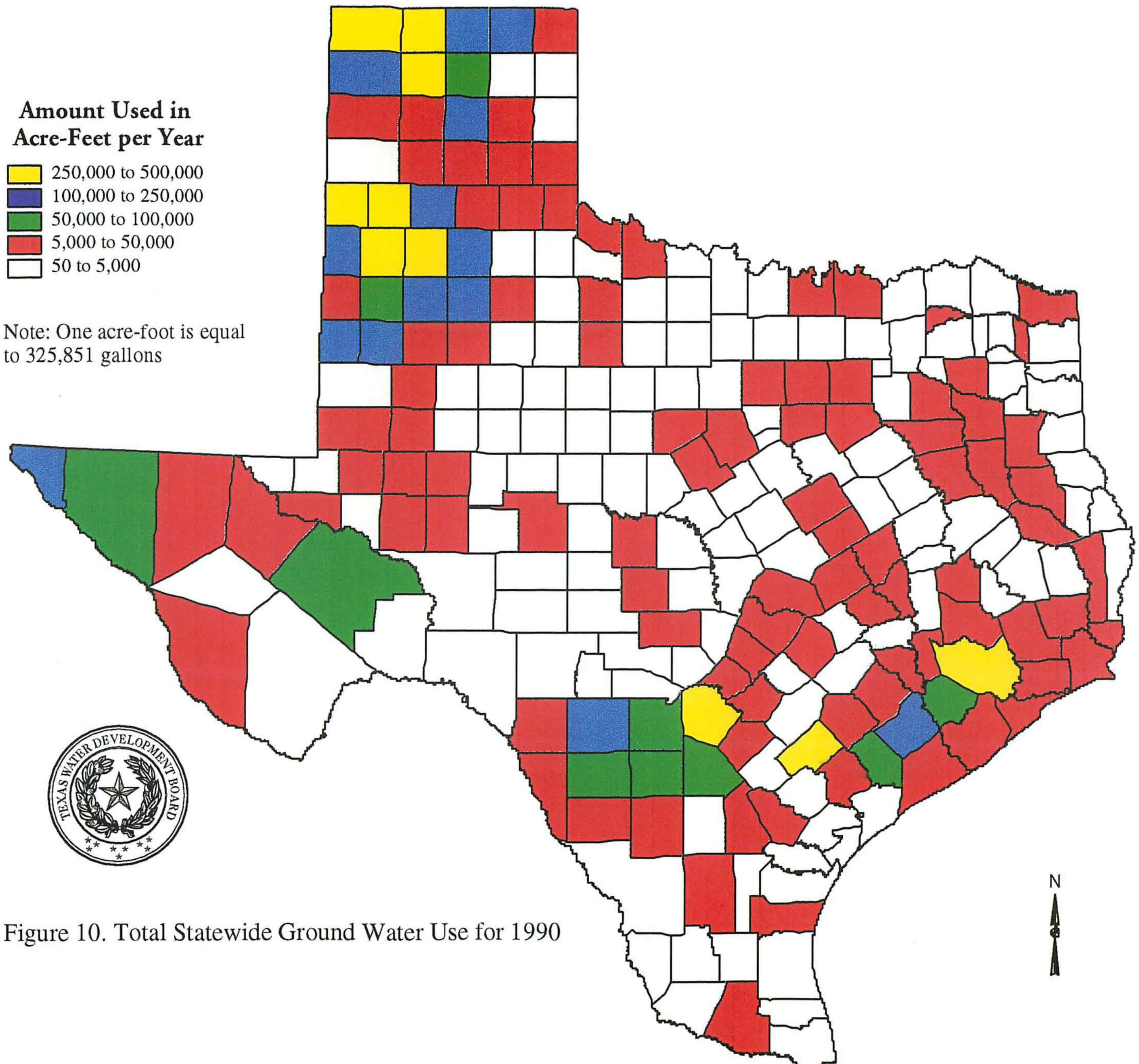


Figure 10. Total Statewide Ground Water Use for 1990

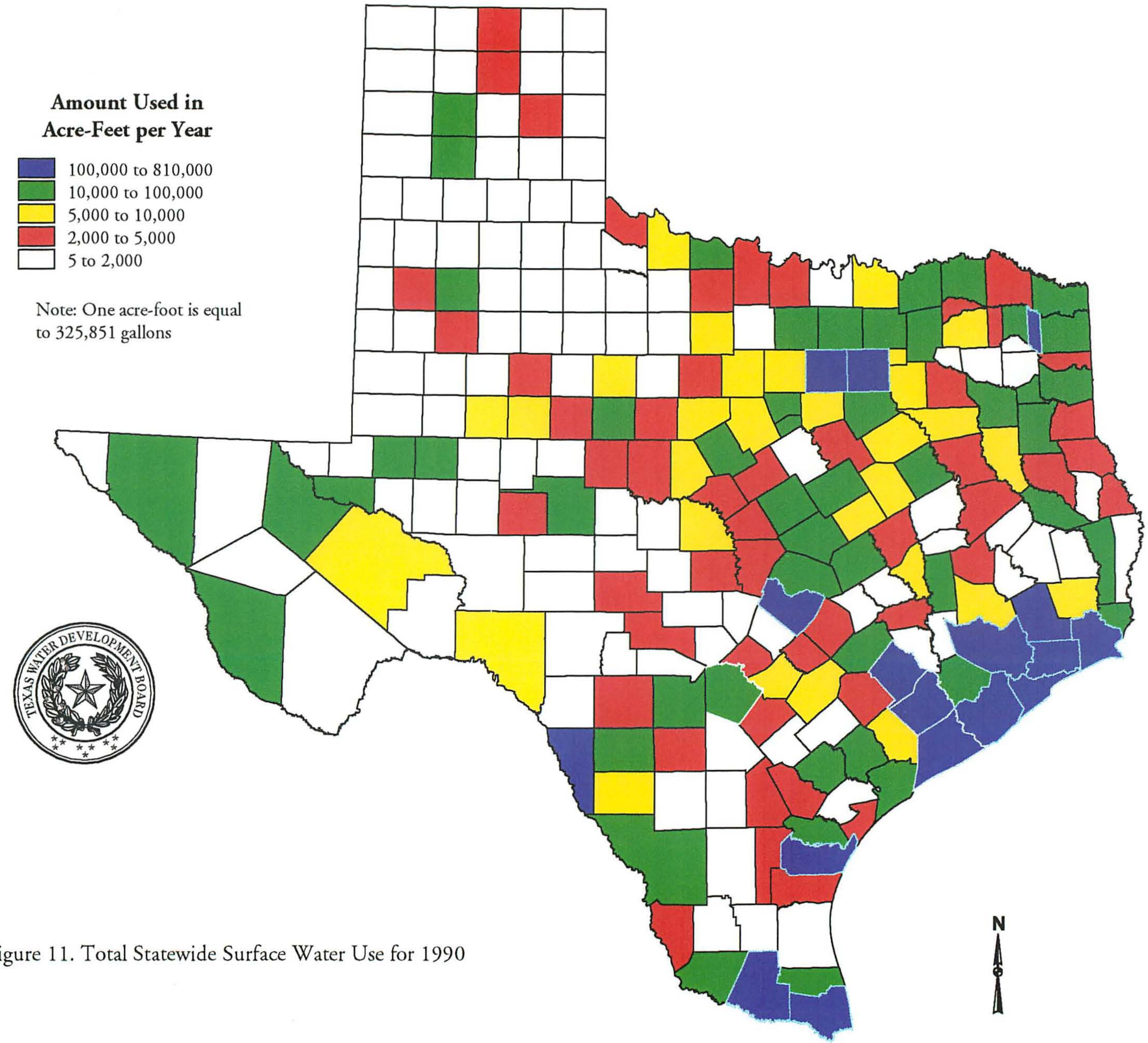


Figure 11. Total Statewide Surface Water Use for 1990

In summary, if the Board is to continue its role as the state's water-planning agency, it must respond to whatever challenges the future holds and staff must work hard to demonstrate to the legislature the importance of this role; the legislature must be convinced that the funds necessary to maintain data-collection activities, special studies, and water and wastewater projects are essential. Only then can Texas continue to be a leader in water-resource planning, development, and management.