WATER FOR TEXAS - TODAY AND TOMORROW

A 1996 CONSENSUS-BASED UPDATE

TO THE TEXAS WATER PLAN

Volume III

Water Use Planning Data Appendix

Prepared by

Water Demand/Drought Management
Technical Advisory Committee
of the
Consensus-Based State Water Plan

Supported by the Staffs of
Texas Water Development Board
Texas Natural Resource Conservation Commission
Texas Parks and Wildlife Department

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The planning data presented in this Volume III was developed first and is needed to complete further Water Plan assessments to be published in late 1996 in

Volume I - Executive Summary
and
Volume II - Technical Planning Appendix

Although the planning data in this Volume III has been adopted for use in the consensus planning process, the forecasts related to irrigation will likely be slightly adjusted in late 1996 to account for better determination of surface water diversion losses.

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1.0 PLANNING OVERVIEW

Assessing the current and future water needs at the state, regional, and local levels is a detailed and complex process that requires substantial investment of time and resources to achieve planning objectives. Although some water demand and supply management measures can be implemented in a short time frame to address current or future water needs, the development of new water supplies can entail planning, design, permitting, and construction activity that can typically span from ten to 30 years. This planning effort is a formidable task, especially at the local level. State water planners face the additional challenge of considering regional and interregional effects of how one or more entities' water use can affect the water supplies of neighboring areas and the environment. The effectiveness of government policy and programs to adequately respond to these challenges is equally critical.

For these reasons, and to satisfy certain financing requirements in the Texas Constitution, the State Water Plan starts at the local level, then builds to a regional, multi-regional, and statewide perspective covering a 50-year planning horizon. The inherent difficulties in developing such a long-range perspective for a large, diverse state such as Texas necessarily relegates these study efforts to one of "reconnaissance-level" planning that guides government leaders and water managers toward courses of action. The specific details that adequately define the feasibility of certain recommended actions of the Plan remain to be fully determined.

The ten to 20-year forecast, drawing on more reliable and specific information, has a greater likelihood of occurrence, and the Plan's recommendations for this time frame should be seriously and expeditiously investigated by the affected parties for any near-term needed action. With forecasting uncertainty increasing over time, the 30-to 50-year time frame of the Plan should serve to orient decisionmakers and the public on broad courses of action. It should also help evaluate the compatibility of potential near-term actions with long-term needs. Another aspect of prudent long-range planning is presenting alternative future development scenarios and assessing how population and water use forecasts respond to changes in the underlying assumptions. Thus, a range of forecasts has been developed to anticipate possible future conditions.

A key element in assessing these complex, interrelated, long-range water issues is to reasonably forecast prospective water uses. However, there is considerable debate among various water interest groups over methods to define or describe the need for water. Terminology such as water uses, demands, requirements, needs, basic needs, etc. are typically ill-defined and used interchangeably, thereby causing confusion over what is intended.

For purposes of the consensus Water Plan forecasts, the term "water use" embodies the concepts of

* *the amount of water needed to be supplied, under alternative weather or conservation assumptions, to satisfy a particular type of water application, and*

* *the maintenance of current, everyday lifestyles through increasingly efficient, but not severely restricted, water use methods.*

In other words, the projected water uses are not supply-limited and include more than just the limited quantity of water for minimum basic human health and safety purposes. The forecasts also include allowances for reasonable, efficient water use for various indoor and outdoor activities (e.g. laundry, lawn watering, car washing, swimming pools, etc.) and allow for the anticipated water use associated with the growth and development of industrial, commercial, and agricultural enterprises that provide jobs to the associated population base.

Texas state water planners feel it is important to specify the water use forecasts in this manner to provide clear information to state, regional, and local leaders that these types and levels of anticipated water uses either can or cannot be adequately met. To do otherwise would be unresponsive to the planning directives in Chapter 16 of the Texas Water Code and would mask important policy information from the decisionmakers in defining and/or implementing timely avenues for response.

1.1 ORGANIZATION OF THE WATER USE PLANNING DATA APPENDIX

The purpose of this data appendix is to present the recommended "most likely" population and water use forecasts and various alternative scenarios that will provide the planning bases of the 1996 Texas Water Plan update, and to describe the background, methods, assumptions, data sources, and limitations of the analyses that underlie these forecasts. The full update of the Texas Water Plan is targeted for adoption and publication in late 1996.

The first portion of this appendix provides a narrative, tabular, and graphical explanation of the data, procedures, and process by which the forecasts were developed. Section 3.0 of this document provides a tabular and graphical overview of the scenarios that were recommended to be carried forward into the Water Plan. Section 4.0 presents the actual numerical forecasts, summarized by statewide, basin, and planning region totals, and shows in detail the most likely forecasts listed alphabetically by county. Population and water use data for individual Texas cities and towns and other types of water uses are listed within their respective counties. The alternative projection scenarios, which provide upper and lower bounds to the most likely forecast, are subsequently presented in summary totals.

In addition to this document, consensus planning staff is developing an electronic version of this narrative and numerical information, which will be made available on diskette or through Internet access. The electronic form should be available to the public by the fall of 1995.

1.2 CONSENSUS-BASED PLANNING APPROACH

In November 1992, the Texas Water Development Board (TWDB) began a process of substantially broadening the basis of participation in the development of information for use in the Texas Water Plan. Better consensus of opinion regarding the planning and policy assumptions used in the development of the Plan and acceptance of the Plan's recommendations was desired by the TWDB, the Texas Natural Resource Conservation Commission (TNRCC), the Texas Parks and Wildlife Department (TPWD), various other water interests, and the general public.

As stated in the operating agreement among the three state water resource agencies, the primary goal of the consensus planning process is the following:

"To promote coordinated policy, planning, regulation, management, and wise use of the State's water resources and to minimize or avoid any needless and unproductive conflict in the management of such resources, the State water agencies shall develop and implement an ongoing consensus planning and policy process to provide for the preservation, conservation, management, and development of the State's water resources. These recommended policies and management processes should avoid fragmentary, uncoordinated water resources management by applicable federal, state, regional, and local agencies in order to provide timely and responsible solutions to water resources problems...."

More specifically as it relates to the topic of this planning document, the staffs of the three state water resource agencies were charged to

"Provide Texas water planners, managers, and regulators with consensus-based population and water demand forecasts which consider water conservation and other demand management practices..."

The consensus planning effort is expected to be a continuing process in which the issues evolve over time. Success is likely to be measured by the degree to which differences are resolved, rather than by an expectation of total consensus on every water issue. The intensive near-term activities of these consensus efforts are expected to occur during 1992-96. During the first phase from 1992-94, four committees were formed to address key water issues that will provide planning and policy guidance for subsequent study efforts in the 1994-96 time frame.

Water Quality, Water Demand/Drought Management, and Ecological Water Needs Committees chaired by the TNRCC, TWDB, and TPWD, respectively, are the three Technical Advisory Committees (TACs) formed to guide the Phase I efforts. In addition to the chairs from the three State agencies, these TACs included outside participants representing key interest groups and the general public. A fourth committee, the Coordination Committee managed the overall efforts, ensured consistency among the TACs, and supervised the reporting and coordination.

Each of these Phase I committee efforts has produced information useful not only to the later Phase II consensus study efforts and general water planning, but also to planning data and/or policy recommendations for near-term agency and legislative use or action in 1995 that could improve state water management and regulation. The publication of this appendix is the *culmination of one of the major Phase I activities. Phase II efforts, scheduled for 1995-1996, will focus on water supply availability, allocation of supplies to various water uses, potential needs and management options, and various water policy issues. These efforts are currently under way and are expected to culminate in a full update of the Water Plan by the end of 1996.*

1.2.1 Public Coordination of Consensus Forecasts

Substantial coordination with outside parties occurred throughout the development of the forecasts. As previously discussed, the overall effort of the Water Demand/Drought Management Committee was guided by a Technical Advisory Committee composed of representatives of other government agencies, the state demographer, river authorities, ground-water districts, municipalities, industry, agriculture, academia, and public interest and environmental groups. During the development of the forecasts, agency staff also coordinated with other outside water entities, and municipal, industrial, agricultural, and trade association groups.

In the spring of 1994, the consensus draft population and water use projections were distributed to more than 300 recipients. Each of the 24 Texas Councils of Government (COGs) was provided with copies of the draft projections for review by its member governments. A series of formal public meetings were held in five major cities around the state in the summer of 1994 to discuss the issues being debated by the TACs and to review the draft forecasts. Where significant debate arose over the forecasts, TWDB staff conducted several subsequent coordination meetings around the state. All comments were reviewed by staffs of the three state water agencies. Based on the public comments and additional information, the staffs of the three agencies incorporated relevant changes into the projections to more closely reflect the public's view of population changes and water needs in various areas of the state.

1.2.2 Use of Forecasts in the Planning and Regulatory Process

In October 1994, the Technical Advisory Committee for the Water Demand/Drought Management Committee approved a recommended most likely series of population and water demand forecasts for use as the primary basis for developing the 1996 Water Plan and for use in state planning and regulatory processes. In addition, two other scenarios were also recommended by the TAC as alternative scenarios to provide upper and lower bounds to the recommended most likely series. In January 1995, the six Members of the Texas Water Development Board formally approved these projections.

In order to meet the goals of the consensus process to reduce unnecessary conflict among the agencies and to provide greater certainty and direction to affected parties on the methods of the state decisionmaking process, it was agreed by the three state water resource agencies that the adopted most likely case forecasts would serve, to the maximum extent possible, as a consistent basis for the planning and regulatory actions of the three agencies. The three agencies acknowledge that (1) any forecasts have inherent limitations and are subject to redefinition with better information, and (2) the ultimate permitting process must allow the best information possible to be the basis of the regulatory decisionmaking. The most likely forecasts were agreed to by the three agencies on a "rebuttable presumption" basis. In other words, the three state agencies have agreed to use the recommended most likely scenario as the primary basis for planning

regulatory evaluation. However, this agreement does not preclude a party to a permit hearing from offering additional information for consideration by the TNRCC.

2.0 PLANNING METHODOLOGIES, ASSUMPTIONS, AND SCENARIOS

2.1 GENERAL PLANNING ASSUMPTIONS

2.1.1 Planning Horizon

The planning period for this amended water plan is 1990 through the year 2050, with all data and projections of population and water uses tabulated and listed by decade. All previously adopted state water plans included the 50-year planning period in order to comply with Section 16.052 of the Texas Water Code. This provision of the Texas Water Code states:

"The executive administrator [of the Board] shall not prepare or formulate a plan which contemplates or results in the removal of surface water from the river basin of origin if the water supply involved will be required for reasonably foreseeable water supply requirements within the river basin of origin during the next ensuing 50-year period, except on a temporary, interim basis."

Although the Legislature dropped this planning provision from the Water Code in 1993, it is still required by the state constitution as a test for allowing State financial participation in funding interbasin transfers.

2.1.2 Geographical Level of Analysis

There are 15 river basins and eight coastal basins that traverse the state of Texas (see Figure 4-1). Each basin is designated as a separate planning area for the purposes of calculating in-basin water supplies and for projecting long-term in-basin water uses. In addition to the supply and demand analyses for the river and coastal basins, the water plan provides similar analyses and data for addressing potential water problems at the regional and local level. More specifically, the TWDB has designated 15 regions within the state as water resource planning regions (see Figure 4-2). Each region was defined on the basis of regional economic and commerce centers, major population centers, and location of water resources in relation to the major sources of water (ground water and surface water) used within each region.

Water use is projected at the county level for manufacturing, irrigation, steam-electric power, and other uses such as mining and livestock. Projections of municipal water uses are developed at *the city level using city-specific water use characteristics and future estimates of population. The county population projections provide the overall control totals for all city-specific and county rural population projections. By developing projections of population and water uses at the county level, county projections can be aggregated and delineated to river and coastal basins, water resource planning regions, metropolitan statistical areas, or any other desired regional aggregations.*

2.1.3 Consumptive and Non-Consumptive Water Uses

As a natural resource, water is unique in that it has both consumptive and nonconsumptive uses. Consumptive uses, such as municipal and industrial uses, steam-electric power generation, and agricultural irrigation, reduce the total quantity of water available, either through evaporation, chemical alteration, or physical consumption. Some portion of the water used for such purposes is lost and not returned to the hydrologic cycle.

By contrast, non-consumptive uses, such as navigation, water recreation, and hydroelectric power generation, do not noticeably reduce the total quantity of water, and can have multiple uses simultaneously. For instance, the main artery of waterborne commerce in Texas, the Intercoastal Waterway, provides transportation of commodities through ports along the Texas Gulf Coast but also provides for water-related recreation such as fishing, swimming, boating, and skiing. In Texas, water for recreation is typically provided for indirectly in that no substantial water rights are reserved specifically for that purpose. Water used for commercial navigation in Texas is primarily provided for by sea water for which no water right is needed. Water used for hydroelectric power generation differs somewhat in that no noticeable water is consumed, but it is typically provided for through a water right, which limits the direct availability of this water for other consumptive uses. Projections of water needs for navigation, water-related recreation, and hydroelectric generation were not developed for this report.

2.1.4 Environmental Water Needs

Environmental water needs to support instream flows and fresh water inflows to bays and estuaries deserve special mention to highlight how this use will be considered in the Water Plan, to give due reference to the quantity of water that may be needed for these purposes, and to note the potential direct effect this water need may have in reducing the availability of water for other purposes.

This subject is being given full consideration in ongoing professional studies and debates among the TWDB, TNRCC, TPWD, and technical advisory committees. It is the intent of the state agencies' staffs to have these environmental needs considered as constraints on any additional water supply availability identified in the planning process. For planning purposes, the environmental needs will be met prior to the identification of any remaining new supplies for other

purposes. A final identification of instream flows needs remains to be determined, with more detailed, field-oriented studies developed at the time of project permitting. Cooperative bay and estuary studies by the TWDB, TNRCC, and TPWD are also ongoing as mandated by the 69th Texas Legislature.

2.2 POPULATION

The latest population estimates published by the U.S. Bureau of the Census indicate that Texas currently ranks as the second most-populated state in the nation, with a population of more than 18.3 million. A large and increasing population will continue to place pressure on the state's water resources to provide sufficient quantities of water to meet local and regional municipal water needs. Because population is a causal factor associated with municipal water use, the TWDB develops population projections for use in assessing potential future municipal water needs. The methodology, assumptions, scenarios, and data sources used in the development of the consensus population projections are presented below.

2.2.1 Forecasting Methodology and Key Planning Assumptions

The technique for projecting population is a cohort-component procedure, which uses the separate cohorts (age/sex/race/ethnic groups) and components of cohort change (fertility rates, survival rates, and migration rates) to calculate future populations. Projections of each cohort are then summed to the total population. Cohorts used in the projection process are defined as single-year-of-age (0 to 75) cohorts by sex and race/ethnic groups, which include Anglo, Black, Hispanic, and Other. Anglos are defined as persons of white non-Spanish origin; Blacks are defined as persons of Black non-Spanish origin; Hispanics are defined as persons of Spanish origin of all racial and ethnic groups; and Other is defined as those persons of other race/ethnic groups of non-Spanish or non-Black origin.

Many counties in Texas have special populations generally referred to as "institutional" populations. These groups of people are assumed not to participate in the same demographic processes as the base population and generally tend to move in and out of these institutional arrangements in fixed intervals. More specifically, these groups are defined as college/university populations, military populations, prison populations, and populations in other institutional arrangements. Institutional populations are removed from the base population for computing future cohort populations, but are added back into the total projected base cohort population at the end of each projection interval.

The components of cohort change include fertility rates, survival rates, and migration rates. Fertility rates for each female cohort are incorporated into the projection procedure for calculating the number of births anticipated to occur between each projection interval. Survival rates for each cohort are used to compute the change in the number of cohorts relating to the number of deaths anticipated to occur between each projection interval. Net migration rates for each cohort are used to compute the change in each cohort due to immigration or emigration in a specific locale.

Key assumptions used in developing the population projections are associated with the *demographic components of change for each cohort and are described below:*

1) Fertility rates for Anglo females are trended downward through the year 2010 and held constant at the 2010 rate through the year 2050; and fertility rates for Black, Hispanic, and Other females are trended downward through the year 2030 and held constant at the 2030 rate through the year 2050.

2) State survival rates by age, sex and race/ethnicity are assumed to follow national trends over the projection period, and are applied to all counties in the State. The reason to subtitute State survival rates to county level is because that the number of deaths by single years of age for most of the counties are so small that total mortality levels are almost similar among the counties.

3) Migration rates for State and county by age, sex and race-ethnicity are derived from the 1980-1990 populations using residual migration method. Three migration scenarios are assumed and applied to the same set of fertility and mortality rates to produce projected populations.

The projected county population is allocated to each city of 500 or more population based on each city's historic share of the county population. The rural or "county-other" population is calculated as the residual of the sum of the cities' projected population and the projected county population.

2.2.2 Forecasting Scenarios

Three population projection scenarios, based on varying the 1980-1990 migration rates, were selected to project a range of alternative future populations. The three population projection scenarios are presented below:

1) 0.0 Migration: Zero net migration over the projection period. Only the natural increase or decrease in population is assumed.

2) 0.5 Migration: One-half of the 1980-1990 migration rate is assumed to occur over the projection period.

3) 1.0 Migration: The 1980-1990 migration rate is assumed to occur over the projection period.

From this range of population projections, consensus planning staff and the Water Demand/Drought Management TAC approved a "most likely" growth scenario for each of the 254 counties, based on recent and prospective growth trends and their combined professional opinions.

2.2.3 Data Sources

The development of the population forecasts incorporated a number of data sources and information files based on the 1990 Census data obtained from Dr. Steve Murdock, Chief Demographer for the Texas State Data Center at Texas A&M University. These data sources included the following:

1) 1990 Population by Cohort (Age, Sex, and Race/Ethnic Groups) Modified for Age and Race/Ethnicity.

2) 1990 Institutional Populations (Prison Populations, College Populations, Military Populations, and Other Populations in Institutional Arrangements).

3) Projected Fertility Rates by Age and Race/Ethnic Groups.

4) Projected Survival Rates by Single Years of Age, Sex, and Race/Ethnic Groups.

5) 1980-1990 Migration Rates by Single-Year Estimates and Cohort.

2.2.4 Limitations of the Analysis

One noticeable limitation in making projections is the quality of the underlying data on which the projections are based. The accuracy of the 1990 census count may have some serious limitations on the accuracy of the consensus population projections and analyses. The U.S. Bureau of the Census has acknowledged that it may have under-counted the state population by as many as 500,000 people. Because the consensus population projections are based on the federally adopted 1990 census count information, the alleged undercount could result in conservatively lower projections for some areas of the state.

Because the Water Plan projections start at the local level and builds to higher regional aggregations, one of the more conspicuous limitations of such micro-level forecasting is that discrete, nontrend-type changes, such as the unexpected opening or closing of a large factory, can sometimes have a significant, unanticipated effect on the population and water use projections. Any unforeseen changes in the factors affecting the migration rates, fertility rates, or mortality rates can result in an under- or over-projection of the state's population. Therefore, it is incumbent on TWDB staff to continually monitor current trends and update the population projections to more accurately reflect such changes and occurrences.

2.3 MUNICIPAL WATER USE

The quantity of water used for municipal purposes in Texas is heavily dependent on population growth, climatic conditions, and water conservation measures. For planning purposes, municipal water use comprises both residential and commercial water uses. Commercial water use includes business establishments, public offices, and institutions, but does not include industrial water use. Residential and commercial uses are categorized together because they are similar types of uses, i.e., they both use water primarily for drinking, cleaning, sanitation, air conditioning, and landscape watering.

2.3.1 Forecasting Methodology and Key Planning Assumptions

The methodology for forecasting municipal water use relies on three primary components:

1) population forecasts of the state, counties, cities, towns, and rural areas of counties;

2) per capita (per person) municipal water use forecasts of cities, towns, and rural areas of counties; and

3) improved water use efficiency due to the implementation of conservation measures.

Population as a Component of Municipal Water Use Projections

The population projection=s methodology and procedures used in the consensus planning process provides for the estimation of alternative future populations for each specific municipality and rural area of Texas (see detailed discussion in previous section).

Per Capita Water Use and Weather Influences

The quantity of water used for municipal purposes is reported to the Texas Water Development Board on an annual basis by cities and other water suppliers such as rural water supply corporations, municipal utility districts, fresh water supply districts, and other types of water suppliers. The types of information reported include ground water and/or surface water use, source of the water (aquifer, river, reservoir, or stream), water sales and water purchases to other municipalities and end-users, number of service connections, estimated population served, and other pertinent information. This information provides for the identification of the water use and water supply network for each geographical area of Texas.

In calculating the per capita water use for a specific entity, all water sales to other municipalities, industries, or other utilities are removed from the reported total water produced (pumpage or diversions) in order to arrive at the quantity of water used for municipal purposes by that specific entity. Annual per capita water use, typically stated in gallons per capita daily (gpcd), is then calculated by dividing the adjusted reported annual water use for a specific entity by its estimated annual population. Annual population estimates developed by the State Data Center's Population Estimation Program are used for calculating city per capita water use.

The diversity of the state with respect to climatic conditions, population density, and the availability of water is indicative of the wide range of per capita water use estimates by geographical area across the state, as well as the varying quantities of water used on annual basis. From a climatological perspective, rainfall conditions play a major role in the quantity of water used for municipal purposes, particularly for outdoor purposes. During below-normal rainfall conditions, people tend to use more water than during normal or average weather conditions. To portray this weather-related phenomenon, two types of per capita water use estimates were calculated for use in the consensus water planning efforts. One estimate assumes below-normal rainfall conditions; the other assumes normal weather conditions. These two estimates were incorporated into two separate scenarios of municipal water use forecasts.

To better represent current-day water use plumbing, appliances, and conservation technology, the assumed normal weather per capita water use is based on the average per capita water use over the last five years of record (1987-1991) for each entity. The assumed below-normal rainfall condition per capita water use is based on the highest per capita water use recorded by an entity over the last ten years of record (1982-1991). For planning purposes, the assumed below-normal rainfall per capita water use variable is constrained to an upper limit of 25 percent above the calculated (five year average) normal condition per capita water use variable. This constraint was used as an adjustment for water conservation practices put in place after 1985.

Municipal Water Conservation

Municipal water conservation is increasingly recognized by water utilities as a cost-effective approach for extending water supplies. In addition, many conservation strategies are simply good management alternatives. Staffs of the three agencies have estimated a likely range of water conservation savings that could be attained over the 1990-2050 planning period. These are included in alternative municipal water use forecast scenarios. These potential savings are based on assumptions regarding the rate of implementation of indoor plumbing conservation measures as well as the rates of implementation of conservation measures in seasonal, dry-year irrigation, and other municipal water uses. These four municipal use sub-categories and associated potential savings assumptions are presented in Table 2-1.

A primary assumption associated with the definition of the "expected" municipal water conservation case is that these levels of savings are likely to occur from both market forces and regulatory requirements. The typical plumbing fixtures and appliances available for purchase are noticeably more water-efficient than those sold in earlier decades. The availability of water-efficient landscaping in the marketplace and improved landscaping practices are changing outdoor water uses. Better public education on efficient indoor and outdoor water uses and pricing "signals" from the marketplace are also changing consumer behavior.

In addition to the market-type forces, a driving force underlying the expected municipal water conservation savings is the likely effect produced by the State Water-Efficient Plumbing Act passed in 1991. Not only are these potential water savings from the implementation of the Act substantial, but they are also economically sound from a cost-saving perspective, do not require day-to-day behavior changes by the consumer, affect the larger year-round base water use, and will occur with a relatively high degree of predictability.

The primary difference between the expected and advanced conservation savings scenarios is one of timing. The majority of the additional savings reflected in the advanced conservation case arises from accelerating the effect of the plumbing bill with municipal utilities engaging in active water-efficient plumbing retro-fit programs. Some additional savings arise from slightly more aggressive assumptions on seasonal, dry-year urban irrigation, and other municipal uses. The advanced conservation scenario represents the maximum technical potential for water conservation savings. The expected scenario represents feasible strategies for water conservation savings that are economically sound.

Unique water conservation savings patterns were projected for each individual municipality and rural area *considered in the forecasts, as well as for the state as a whole. These projected savings estimated by the consensus planning staff are provided as guidelines for regional and local water planners and managers. Although staffs of the three agencies feel the identified array of conservation measures embodied in the projections are reasonable and feasible, the selection of specific water conservation goals and implementation of strategies to achieve those goals is the primary responsibility of the utility manager and local government.*

Each entity's projected municipal water conservation savings (measured in gallons) are subtracted from the estimated value of the per capita water use scenario for the assumed below-normal rainfall conditions and the assumed normal weather conditions. In most instances, this calculation results in declining per capita water use for each city and community. An example of how the expected and advanced conservation cases affect the two per capita water use scenarios is presented in Table 2-2.

Calculation of Municipal Water Use

Estimates of future municipal water use are computed by multiplying the projected population of an entity by the entity's projected per capita water use, adjusted for conservation savings. The projected municipal water use is then converted to an annual acre-foot measure.

2.3.2 Forecasting Scenarios

A wide array of municipal water use scenarios were developed for all 254 counties and each city with a population of 1,000 or more. These scenarios are combinations of the three alternative population forecasts, the two per capita water use forecasts, and the three water conservation measures. Table 2-3 lists all of the multiple scenarios for the municipal water use projections.

From this array of scenarios, the Technical Advisory Committee and the consensus planning staff selected a "most likely" municipal water use scenario for water supply planning. This "most likely" municipal water use scenario assumes below-normal rainfall per capita water use, adjusted for expected conservation savings, and the "most likely" population forecast for all cities of 1,000 or more population.

Table 2-3

Description of Municipal Water Use Scenarios

0.0 Migration Rate	0.5 Migration Rate
Below-Normal Rainfall	Below-Normal Rainfall
Expected Water Conservation Advanced Water Conservation Plumbing Code Only	Expected Water Conservation Advanced Water Conservation Plumbing Code Only
Normal Weather Conditions	Normal Weather Conditions

Expected Water Conservation	Expected Water Conservation
Advanced Water Conservation	Advanced Water Conservation
Plumbing Code Only	Plumbing Code Only
1.0 Migration Rate	Most Likely Case
Below-Normal Rainfall	Below-Normal Rainfall
Expected Water Conservation	** Expected Water Conservation
Advanced Water Conservation	Advanced Water Conservation
Plumbing Code Only	Plumbing Code Only
Normal Weather Conditions	Normal Weather Conditions
Expected Water Conservation	Expected Water Conservation
Advanced Water Conservation	Advanced Water Conservation
Plumbing Code Only	Plumbing Code Only

***The "most likely" municipal water use planning scenario.*

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2.3.3 Data Sources

Data sources used in developing the municipal water use projections are presented below.

1) Texas Water Development Board, Annual Municipal Water Use Summaries for Cities and Counties, Water Uses Section, 1980-1991.

2) Texas Water Development Board, Annual Per Capita Water Use; Annual Municipal Water Use Summaries for Cities and Counties, Water Uses Section, 1980-1991.

3) Texas Water Development Board and Texas Natural Resource Conservation Commission, Municipal Water Conservation Savings, Staff Files, 1993.

4) Texas Water Development Board, 1994 Consensus Population Projections for Cities and Counties, Water Uses Section, 1994.

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2.3.4 Limitations of the Analysis

As previously mentioned, climatic conditions play a major role in the quantity of water used for municipal purposes. Even though the assumed below-normal rainfall per capita water use estimate reflects a short-term dry condition, it is not a per capita water use estimate associated with an extended period of drought. Consequently, these projections could result in seriously underestimating municipal water demand associated with an extended drought. Demand, defined here, is the quantity of water that a city would be willing to purchase or use if sufficient quantities of water were available.

The implementation of the 1991 State Water-Efficient Plumbing Act and other conservation measures included in the municipal water use projections will certainly save water. However, not all areas of Texas will experience gains from conservation at the same rate. For example, rural areas in Texas tend to use less water for municipal purposes than urban areas and may not fully incorporate the "expected" conservation measures and realize the anticipated water savings as soon as most urban areas.

In addition, the potential water conservation savings associated with the municipal water use projections do not encompass voluntary or mandatory restrictions such as rationing of water use during prolonged dry periods. During the past few years, some municipalities in Texas have implemented water use restrictions due to insufficient treatment capacities or lack of available water supplies during extended dry periods. As used in these planning forecasts, conservation is an improvement in water use efficiencies and applies to everyday water use, regardless of weather conditions. Temporary restrictions of water use may be imposed during water supply shortages associated with drought or system delivery problems. However, these types of restrictive practices are not incorporated into the municipal water use forecasts.

2.4 MANUFACTURING WATER USE

The importance of water for the production of goods for domestic and foreign markets varies widely among manufacturing industries in Texas. Manufactured products in Texas range from food and clothing to refined chemical and petroleum products to computers and automobiles. Some processes require direct consumption of water as part of the products being manufactured; others require very little water consumption, but may require large volumes of water for cooling or cleaning purposes. In some manner or another, water is passed through the manufacturing facility and used either as a component of the product or as a transporter of waste heat and materials.

Five manufacturing industries account for approximately 90 percent of the 1.56 million acre-feet of water currently used by all manufacturing industries in Texas. These five water-intensive industries are chemical products, petroleum refining, pulp and paper, food and kindred products, and primary metals. The chemical and petroleum refining industries account for nearly 60 percent of the state's annual manufacturing water use.

Ten counties account for approximately 77 percent of the state's total manufacturing water use. These counties are Harris, Brazoria, Jefferson, Morris, Cass, Harrison, Galveston, Jasper, Tarrant, and Orange.

Because of the importance of the state's manufacturing sector in terms of income and employment to local and regional economies, analyses of future water use and availability of water for these industries are necessary to ensure the continued economic vitality of many regional economies. The methodology, assumptions, data sources, and projection scenarios used to develop the consensus manufacturing water use projections are briefly presented in the following text.

2.4.1 Forecasting Methodology and Key Planning Assumptions

Future manufacturing water use is largely dependent on technological changes in the production process, on improvements in water-efficient technology, and on the economic climate (expansion/contraction) of the market place. Technological changes in production affect how water is used in the production process, while improvements in water-efficient technology affect how much water is used in the production process. As older production facilities and accompanying production processes are modernized or retooled, the new production processes are anticipated to be more resource efficient.

The manufacturing water use projections are based on three specific assumptions regarding industry growth:

1) Industry growth assumes future expansions of existing capacity within an industry as well as new manufacturing facility locations within the state.

2) Historical interactions of oil price changes and industry activity are assumed to continue over the projection period.

3) The types of industries that comprised a county's current manufacturing base are assumed to comprise the county's manufacturing base in the future.

Because of the need to develop manufacturing water use projections at the county level, and because of the absence of pertinent, and often confidential industry production information at the local level, a "top-down" approach was used for developing projections of potential industry growth.

State Level Control

Long-term projections of manufacturing output by two-digit Standard Industrial Classification (SIC) for the state, developed by Perryman Consultants, Inc., were used as the overall state "control-totals" for anticipated future manufacturing growth for all two-digit SIC industries in Texas. This projection series encompasses numerous indicators of overall business activity, such as output, employment, sales, inflation, and productivity. Due to the problematic situation of future timber supplies, TWDB staff developed independent projections for the pulp and paper industry to reflect the anticipated slowing of timber harvesting in Texas.

Regional Level Control

Regional shares of industry output were developed for each Metropolitan Statistical Area (MSA) and non-MSA area in Texas using the U.S. Bureau of Economic Analysis (BEA) state and regional long-term projections of economic activity for the various manufacturing sectors. Based on the geographic distribution of BEA regional manufacturing growth, regional shares of the state manufacturing activity were calculated for each decade of the planning period. Projected state manufacturing output was then distributed to each regional manufacturing sector according to estimated future regional shares.

County Level Control

The Texas Employment Commission's (TEC) quarterly earnings and employment data for all manufacturing facilities in Texas provided the necessary information for distributing the base year regional output to each county. All counties were grouped by their designated MSA or non-MSA for calculating each county's base-year (1990) output share of the regional total. County industry output was projected by applying the corresponding state industry-specific growth rate to the corresponding county industry base-year output. After each projection interval (decade), all county industry outputs were adjusted to sum to their regional manufacturing output control totals.

Water Use/Production Output Coefficients

The quantity of ground water pumpage and surface water use for manufacturing purposes is reported to the Texas Water Development Board on an annual basis by major manufacturing firms or by water suppliers that sell water to manufacturing firms. The types of information reported to the TWDB include the source of water supplies (aquifer, stream, river, or reservoir) and the quantity of self-supplied and purchased ground water, surface water, saline water, and treated effluent. Additional information is provided concerning water transfers or sales to other users; internal water supply networks for cooling, condensing, refrigeration, processing and wash down, boiler feed, air conditioning, sanitation, and drinking; and other uses such as fire protection and landscape maintenance. Based on the TWDB's records of reported water use by industry and county, an industry-specific, base-year water use coefficient, defined as acre-feet per unit of output, was calculated for each industry within a county.

Manufacturing Water Use Efficiencies

In order to update previous information on potential manufacturing water use efficiencies, the Texas Water Development Board in 1993 commissioned research on the industrial water use characteristics of the principle water using industries in Texas. This research produced time-dependent estimates of potential changes in manufacturing water use patterns that could be expected to occur (Pequod Associates, 1993). A survey was conducted by the contractor to obtain information on water costs, conservation practices, investment requirements, technology, and other water-related information from individual manufacturing facilities in Texas. From this information and previous research performed by the contractor, industry-specific water use efficiency estimates were developed and used in the consensus manufacturing water use projections. Specifically, each county’s industry-specific water use coefficient was reduced over time by applying the corresponding industry’s water use efficiency expressed as a percentage reduction in that industry’s water requirement.

Industrial water use efficiency estimates listed below are expected to be attained over the 1990-2030 period. The scheduling is primarily dependent on the expansion of new plant or significant rehabilitation of older plant processes. These industries' water use efficiency estimates are expressed as a percentage reduction in an industry’s water use per unit of output, as outlined below.

** Food and Kindred Products (SIC 20): 4% reduction by the year 2000; 8% reduction by the year 2010; 12.5% reduction by the year 2020; 17% reduction by the year 2030; the 2030* efficiency is held constant through the year 2050.

* Chemical and Allied Products (SIC 28): 4% reduction by the year 2000; 8% reduction by the year 2010; 12.5% reduction by the year 2020; 17% reduction by the year 2030; the 2030 efficiency is held constant through the year 2050.

* Pulp and Paper Products (SIC 26): 6.8% reduction by the year 2000; 14% reduction by the year 2010; 22% reduction by the year 2020; 30% reduction by the year 2030; the 2030 efficiency is held constant through the year 2050.

* Semiconductors (SIC 36): 8.8% reduction by the year 2000; 18% reduction by the year 2010; 29% reduction by the year 2020; 40% reduction by the year 2030; the 2030 efficiency is held constant through the year 2050.

* Petroleum Refining (SIC 29): 4% reduction by the year 2000; 8% reduction by the year 2010; 12.5% reduction by the year 2020; 17% reduction by the year 2030; the 2030 efficiency is held constant through the year 2050.

Calculation of Manufacturing Water Use

County manufacturing water use was projected over time by applying each industry's water use coefficient, adjusted for water use efficiency, to the industry's projected output. Projections of county-specific industry water use were then summed to obtain projections of total county manufacturing water use.

2.4.2 Forecasting Scenarios

Four scenarios were developed and incorporated into the manufacturing water use projections. Three of these scenarios were based on oil prices, which correspond to the independent manufacturing growth projections for the state prepared by Perryman Consultants, Incorporated. An additional scenario was developed assuming no additional growth in the manufacturing sector. The four scenarios and underlying key assumptions are presented below.

1) Low Oil Price Scenario: Oil prices would remain stable in the $13-$17 per barrel range for West Texas Intermediate Crude.

2) Baseline Oil Price Scenario: Oil prices would remain stable in the $18-$23 per barrel range for West Texas Intermediate Crude.

3) High Oil Price Scenario: Oil prices would remain stable in the mid-to high $20s per barrel range for West Texas Intermediate Crude.

4) No Growth Scenario: There will be no expansion in an industry above its current capacity and no new facility location in Texas over the projection period.

The Technical Advisory Committee and consensus planning staff selected three of the four scenarios for inclusion in the consensus water resources planning efforts: the No-Growth Scenario as the low-range forecast, the Baseline Oil Price Scenario, and the Low Oil Price Scenario as the upper-range forecast. Staffs of the three agencies and the Technical Advisory Committee selected the Baseline Oil Price Scenario as the "most likely" projection series to be used for the consensus water supply planning efforts.

It should be noted that an individual oil price scenario can stimulate one industrial sector while simultaneously having a depressing effect on another. For example, some industries, such as oil field equipment and metal fabricating, typically respond negatively to low oil prices. Other industries, such as petroleum refining, typically receive positive stimulus to their production levels from low price levels. Because only one oil price level can conceivably exist statewide at one particular time, and most Texas counties have a mix of industrial sectors, a single oil price scenario can cause one county's overall manufacturing activity and corresponding water use to increase while simultaneously causing another county's manufacturing activity and water use to decrease.

2.4.3 Data Sources

The following data sources were used in the development of the manufacturing water use projections:

1) Texas Water Development Board, County Manufacturing Water Use Summaries By Ground Water and Surface Water Use; Water Uses Section, 1980-1991.

2) Texas Economic Forecast, Long-Term Projections of Texas Manufacturing Output By Two-Digit Standard Industrial Classification; Perryman and Consultants, Incorporated, 1993.

3) BEA Regional Projections, U.S. Bureau of Economic Analysis, U.S. Department of Commerce, Volume 2, Metropolitan Statistical Area Projections, 1990.

4) Texas Employment Commission, Reported Employment and Earnings by Manufacturing Facility, Quarterly Employment and Earnings Data Tapes, 1990.

5) Texas Industrial Water Use Efficiency Study, Pequod and Associates, Incorporated, Irvine, California, Prepared for the Texas Water Development Board, 1993.

2.4.4 Limitations of the Analysis

With respect to growth of the manufacturing sector, the potential impact of NAFTA is not specifically incorporated into the forecasts. The staff has reviewed the numerous research publications on the potential effects of the trade agreement relating to specific industries. Those industries identified as potential rapid-growth industries compare reasonably well with those industries identified as faster-growing industries in the consensus forecasts. Slow-growth industries compare favorably as well. Identification of specific geographical areas in Texas where potential impacts of NAFTA could occur and how they could affect local economies are particular concerns to the consensus planning staff. Consequently, should NAFTA have a highly significant effect on manufacturing growth beyond that already allowed for, future growth of Texas' localized manufacturing sectors might exceed the projected growth and water use anticipated in the consensus projections.

The General Agreement on Tariffs and Trade (GATT) is another U.S. trade agreement that could have positive or negative impacts on Texas manufacturing. Again, this trade agreement was not specifically incorporated into the consensus projections. Should such significant and positive impacts occur under this trade agreement, manufacturing growth in Texas might exceed the consensus manufacturing growth and corresponding water use projections.

An industry's desire and ability to invest in more water use-efficient production processes is directly related to the cost of water relative to other production inputs, anticipated economic climate (expansion or contraction), each facility’s fiscal and management strategy as to the timing of modernizing or retooling of the facility, and in some cases, the political or regulatory climate facing the producer. The basic question facing plant managers is typically, "Does the economic return on investing substantial amounts of money in new manufacturing processes, primarily to reduce water use, make financial sense when the cost of water is insignificant relative to other production costs?" Therefore, the actual scheduling of the water use efficiencies for a particular industry may not coincide with that of the many facilities that comprise the overall industrial sector. This scheduling problem could result in a potential overestimation or underestimation of an industry’s future water use, particularly at a more local level of analysis. However, the time-dependent estimates of potential changes in water use efficiency patterns are the best available information at this time.

The increasing interaction of regional, state, national, and foreign markets in the production and sale of manufactured products will continue to be a major factor in the growth of the Texas manufacturing sector. Any occurrences such as future federal trade policy decisions, foreign military conflicts that could disrupt or accelerate the anticipated flow of goods and services, or any catastrophic event that could cause significant changes from the assumptions and scenarios on which the manufacturing water use projections are based could result in a deviation from the consensus projections. Therefore, it is incumbent on consensus staff to continually monitor the trends in manufacturing growth and water use in relation to the causal factors of these trends, and update the forecasts to include changes in these factors.

2.5 AGRICULTURAL IRRIGATION

Irrigated agriculture accounts for almost 65 percent of the total water used in the state. Currently, approximately 10 million acre-feet of water is used to grow a variety of crops ranging from food and feed grains to fruits and vegetables to cotton. Of this 10 million acre-feet, groundwater resources provide approximately 70 percent of the water used for irrigation purposes, with surface water supplies accounting for the remaining 30 percent. Irrigation enables farmers to produce a more dependable supply of food and fiber commodities with less dependence on variable rainfall. Although irrigated agriculture accounts for only 30 percent of all harvested cropland acres in Texas, the value of irrigated crops account for more than 50 percent of the total value of crop production in the State.

Irrigated acreage development peaked in Texas in 1974 with 8.6 million acres of irrigated cropland. Since that time, irrigated acreage has declined by more than 2.5 million acres, with a corresponding decline in on-farm water use of more than 3.0 million acre-feet. There are a number of factors associated with this declining trend, including more acreage being set aside for compliance with federal farm programs, poor economic conditions in the agricultural sector during the last ten years, a decline in the number and size of farms, technological advancements in crop production, advancement and implementation of more water efficient irrigation systems, and better irrigation management practices.

The importance of irrigated agriculture, in terms of food and fiber production and the direct and indirect effects on income and employment to the state, local, and regional economies, necessitates analyses of potential future water needs and available water supplies for the Texas irrigated agriculture sector.

2.5.1 Forecasting Methodology and Key Planning Assumptions

Forecasting Model

The Texas Water Development Board, with technical assistance from the staff of Texas A&M University, developed a linear programming model for use in evaluating the many factors affecting irrigation water demand for the Texas agricultural sector. Linear programming models are based on mathematical techniques for systematically determining solutions for maximizing or minimizing values of linear functions under various variable (resource) constraints. For the development of the irrigation water demand projections, the objective function of the model was structured to solve for the maximization of farm income based on the profitability of specific crops grown in Texas using the resources necessary for the production of these crops. To simplify the modeling process, the TWDB used the Texas A&M University delineation of major agricultural production regions in the State.

Several types of variables are used in the modeling procedure to determine future irrigation water demands by geographical location. These variables include crop prices, yields, production costs, water costs, and six types of irrigation delivery systems. These data are crop-specific and reflect the major crops grown in Texas, which include cotton, grain sorghum, wheat, corn, rice, peanuts, alfalfa hay, fruits, vegetables, and nuts. As part of the revenue stream, federal farm deficiency payments for specific crops and land set-aside requirements for compliance with federal farm programs are included in the model. Crop enterprise budgets, developed by Texas A&M University, provided crop-specific information such as current crop prices, variable production costs, fixed production costs, yields, deficiency payments, irrigation water applications, land restrictions for participation in federal programs, and irrigation delivery systems. Because the Texas A&M University crop enterprise *budgets are planning budgets, variable costs for the crops were, in some instances, adjusted (increased or decreased) in the modeling procedure to calibrate the water demand calculated by the model to the actual published water use for each of the 14 agricultural regions. The variable costs were adjusted because these costs were the basic unknown variables in contrast to published crop prices, yields, harvested and planted acres per crop, and water use.*

Irrigation Equipment and Water Use Efficiencies

Furrow, surge, side roll, low pressure center pivot, high pressure center pivot, and low energy precision application (LEPA) are the six types of irrigation delivery systems used in the model. Information was provided by irrigation specialists regarding the type of soils and topography suitable for each type of system, capital and other costs, potential adoption rates for new, more efficient irrigation systems, along with the relative water-use efficiency of the various delivery systems. The efficiency of each delivery system varies depending on factors such as topography, types of soils, and climatic conditions. To the extent possible, regional irrigation specialists provided information to adjust the efficiency for each system to reflect prevailing soil and climatic conditions in each of the agricultural production regions.

Water Supply and Irrigation Costs

To account for the cost of groundwater pumpage associated with different groundwater depths, three lift zones in each major groundwater use region were identified along with the irrigated acreage associated with each of the three lift zones. Irrigated acreage maps were overlain with maps identifying the various well depths by geographical area. This information was used in the modeling procedure to calculate future water costs (pumping costs) by applying projected energy prices to the varying lifts and costs per foot of lift capacity.

For areas depending on surface water supplies, irrigation costs measured in cost per acre-foot were obtained from many of the irrigation districts throughout the state. While these districts have a variety of pricing schedules, most charge a fixed price for a given volume of water, with either a declining or increasing unit price for additional volumes of water.

Land and Acreage Constraints

In addition to the variables used in the analyses that have been previously mentioned, specific resource constraints were included to reflect historical trends in acreage, cropping patterns, and water use. Dryland and irrigated acreage were constrained to the largest amount of annual acreage in production during the period 1974-1990. Also, an irrigated land constraint was incorporated to limit the acreage that can be converted to more efficient irrigation delivery systems. Due to the differences in soil type and topography, not all areas can be converted to more efficient irrigation systems, such as LEPA. This constraint prevents the model from converting irrigated acreage to a specific irrigation delivery system that is not suitable for that type of soil or topography even though the cost-effectiveness of such a conversion would be encouraged by the model without the constraint.

To ensure a reasonable mix of crops that resembles historical cropping patterns, an acreage constraint was placed on each crop within a geographical area based on annual crop acreage during 1985-1990. Finally, a water constraint for each geographical area was incorporated into the model. This constraint restricts the amount of water available for irrigation to the largest quantity of annual water used for irrigation purposes during the period 1974-1990.

Once the most profitable combination of irrigated and dryland crop production was estimated, along with the quantities of water required for that level of production, the regional projections were distributed to the county level by apportioning a county’s share of the regional acreage and water use for that county. The county shares were calculated by estimating the county's historical crop acreage as a percent of total regional crop acreage.

Summary of Modeling Assumptions

The irrigation water demand projections are based on specific assumptions regarding crop prices, yields, agricultural policy, and technological advances. The various key assumptions used in the development of the irrigation water demand forecasts are presented below.

1) Profitability Variables: Farm production expenses, crop prices, energy prices, and crop yields are assumed to change over time. The direction and magnitude of those changes are based on forecasts prepared by the Food and Agriculture Policy Research Institute (FAPRI). Energy forecasts were developed by the Department of Energy. The rates of growth or decline of these variables over time were applied to the prices received and paid by Texas farmers so as to capture the adjustments between national and regional prices.

2) Federal Farm Policy: Current federal farm programs and payments are assumed to remain constant over time. In some cases, depending on the projection scenario, deficiency payments and mandatory land set-aside provisions are reduced by one-half.

3) Improved water use efficiencies for surface water irrigation are assumed to be realized by more efficient canal delivery systems. Improved water use efficiencies for ground water irrigation are assumed to be realized through implementation of more efficient on-farm irrigation systems.

Surface Water Conveyance Losses

Conveyance loss, also referred to as diversion loss, is the amount of water lost during the delivery of surface water from the point of diversion on the river or stream to the point of use on the farm. Surface water is typically conveyed by an open canal system, which exposes the water supply to possible loss from seepage, breaks, evaporation, and uptake by riparian vegetation. Surface water irrigation comprises about 31 percent of the total agricultural irrigation water use in Texas and occurs primarily along the upper and middle Texas Gulf Coast, along the Rio Grande, and in some areas of the Texas Hill Country. For areas of the state using surface water for irrigation, the water use estimates in 1990 and projections from 2000 to 2050 include conveyance losses. For areas of the state using ground water for irrigation, water use estimates and projections do not include conveyance losses because ground water is generally pumped on or near the point of use.

Although surface water irrigation represents a relatively small portion of irrigated agriculture, the loss of water through conveyance can be considerable. Estimates of loss can range between ten and 55 percent of the total amount of water diverted. The TWDB estimates conveyance loss by examining data from surface water diversions reported to the TNRCC; estimates of on-farm water use from a joint study effort of the Soil Conservation Service (U.S. Department of Agriculture), Texas Soil and Water Conservation Board, TWDB, and other parties; and communications with river authorities, water districts, and irrigation companies. Based on this information, historical conveyance loss estimates were calculated and used as a basis for the conveyance loss factors used in the consensus projections.

Some surface water supply entities have tried to reduce water losses by making improvements to their conveyance systems. Such improvements can include repairing weaknesses in the canals, controlling vegetation, and lining the canals. These improvements can be expensive, and not all entities have the necessary capital for investment.

Because funding for capital improvement varies between entities or is uncertain in the future, the consensus planning staff developed two scenarios that attempt to capture changes in canal conveyance efficiency. The most likely scenario assumes that no improvements requiring capital investment will be made. It does assume conveyance loss will decline slightly as management practices improve. A second scenario assumes water supply entities will make capital investments to improve the efficiency of the canal system. For this scenario, conveyance loss declines more precipitously. The most likely scenario was used in conjunction with scenario 1 and scenario 2 of the irrigation water use projections, which are the least aggressive conservation case and the most likely case respectively. The second scenario, which included capital improvement in the conveyance system, was used in conjunction with scenario 3, the most aggressive conservation case.

The consensus planning staff first estimated on-farm irrigation water use. AOn-farm@ water use refers to the amount of irrigation water used at the field, excluding conveyance loss. For the base year, 1990, county irrigation estimates were obtained from the Soil Conservation Service estimates of on-farm water use. For areas of the state that use surface water, the water lost by conveyance was added after the on-farm estimates were derived to determine total irrigation water demand.

The relative proportions of ground and surface water supplies for irrigated agriculture are determined by a water supply allocation process, which requires irrigation water demand estimates as an input. Consequently, the initial estimates of conveyance losses contained within this report were developed using water supply allocations from the 1990 Water Plan. From these initial estimates of overall irrigation water use, the water supply allocations will be updated. This supply allocations process may, in turn, result in some further adjustments to the quantity of conveyance loss.

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2.5.2 Forecasting Scenarios

Six forecast scenarios were developed to encompass a range of possible economic conditions affecting irrigation water demands. The consensus planning staff, with approval from the Technical Advisory Committee, selected three of the scenarios for use in the Water Plan. The selected scenarios are presented below.

1) Scenario I: Crop yields, crop prices, and production costs are assumed to change over time. Federal farm payments are held constant at current levels during the projection period. There will be no further adoption of advanced irrigation technology during the period 1990-2050.

2) Scenario II: Crop yields, crop prices, and production costs are assumed to change over time. Federal farm payments are held constant at current levels over the projection period. The expected level of advanced irrigation technology is adopted.

3) Scenario III: Crop yields, crop prices, and production costs are assumed to change over time. Federal farm program payments are reduced by one-half from current payment levels. An aggressive level of advanced irrigation technology is adopted.

The consensus planning staff and the Technical Advisory Committee selected Scenario II as the "most likely" case for use in water supply planning efforts.

2.5.3 Data Sources

Numerous data sources were used to develop the consensus irrigation water demand projections, consisting of the following:

1) Texas A&M University Crop Enterprise Budgets, Texas Agricultural Extension Service, Texas A&M University, 1992.

2) Texas Crop Statistics, Texas Agricultural Statistics Service, Cooperative Program of the United States Department of Agriculture and the Texas Department of Agriculture, 1985, 1989.

3) 1993 U.S. Agricultural Outlook, Food and Agricultural Policy Research Institute, Iowa State University and the University of Missouri-Columbia, Staff Report #1-93, April, 1993.

4) Surveys of Irrigation in Texas, Texas Water Development Board, Report 329, 1958-1989, Cooperative Program of the Texas Water Development Board, Soil Conservation Service-U.S. Department of Agriculture, and the Texas State Soil and Water Conservation Board, January, 1991.

5) New, Leon L., ACenter Pivot Irrigation Systems," Texas Agricultural Extension Service, Mimeograph #L-2219.

6) Report of the Texas Rice Task Force, AThe Future of the Texas Rice Industry@, Texas A&M University,

September, 1993.

7) Taylor, Earl L., Rister, M. Edward, Goodwin, H.L., and Waller, Mark L., AThe Economic Impact of the Texas Rice Industry," Department of Agricultural Economics, Texas A&M University, Faculty Paper Series F-93-6, June, 1993.

8) Thompson, Troy N., Rister, M. Edward, Grant, Warren R., Schubert, Christine R., Bordelon, Dan, ATexas Ratoon Crop Rice Production: 1988 Survey Results," and Department of Agricultural Economics, Texas A&M University, Faculty Paper Series F-93-7, July, 1993.

9) Amosson, Stephen, AThe Economics of Efficient Irrigation Systems," Extension-Economist Management, Texas A&M University.

10) Ellis, John, Lacewell, Ronald D., and Renueau, Duane R., AEstimated Economic Impact from Adoption of Water-Related Agricultural Technology,@ Western Agricultural Economics, December, 1985.

11) Henggler, Joseph C., Sweeten, John M., and Keese, C. Wayne, ASurge Flow Irrigation," Texas Agricultural Extension Service, Mimeograph #2220.

12) Pena, Jose G., and Jenson, Robert, AIrrigation Water Use, Conservation Potential and the Economic Implications of Adopting More Efficient Irrigation Technology: The Case In Uvalde County," Texas Agricultural Extension Service, Texas A&M University.

13) ASurge Values Help Furrow Irrigators Improve Application Efficiencies," The Cross Section, High Plains Underground Water Conservation District No.1, June, 1994.

14) Feng, Yinjie, AOptimal Intertemporal Allocation of Ground Water for Irrigation in the Texas High Plains," Dissertation in Agricultural Economics, Texas Tech University, August, 1992.

2.5.4 Limitations of the Analysis

Federal farm programs and policies play a major role in the actions of individual farmers and the decisions that are made in relation to food and fiber production. Substantial reductions or elimination of federal farm payments and programs could severely impact some crop production activities in Texas. Changes in farm program payments, set-aside requirements, quotas, and other policies could undermine the underlying assumptions of the consensus irrigation water demand projections. The Farm Bill is scheduled for reauthorization in 1995. The TWDB staff will monitor changes from the previous authorization and make any necessary changes to the forecast assumptions in order to maintain an up-to-date recommended forecast.

As with the other series of consensus forecasts, any significant impacts of the North American Free Trade Agreement (NAFTA) and the General Agreement on Tariffs and Trade (GATT) are not considered in the consensus irrigation water demand projections. Again, should significant impacts be realized as a result of these trade agreements, the irrigation water demand projections could result in overestimating or underestimating future water use in the Texas irrigated agriculture sector.

From a technical perspective, the modeling procedure assumes that production inputs are used in fixed proportions and does not allow for the substitution of inputs as the relative prices of those inputs change. Consequently, rational decisions by farmers relating to potential savings associated with possible future substitution of production resources and the corresponding profitability of a specific crop production activity may not be fully realized by this modeling constraint.

2.6 STEAM-ELECTRIC POWER PRODUCTION

Although Texas is the second most-populated state in the United States, it is the largest generator and consumer of electricity. It is also the largest user of coal-generated power. Power production in Texas is concentrated primarily in ten privately owned utilities, which account for 85 percent of production. Nine percent is both publicly and privately held, while only six percent is publicly owned. The industry has faced and will continue to face significant changes in the structure of power generation. These changes range from new generation technology, to federal regulations on the Amarketing@ of electricity, to the impacts of energy conservation on future power demand. These changes will not only have an impact on how and where power will be generated, but also on how water will be used in the process.

In determining current and future water use for steam-electric power generation, the TWDB relied on several types of information. Current water use for the base year 1990 was obtained from the TWDB's water use survey, which contains reported use by plant. Future water use was estimated using a combination of available information including published material on planned additions to existing plants, existing water rights permits, specific company information, lignite resource ownership, and other related data sources. Individual plant design, thermodynamic operating characteristics, energy conservation strategies, and technological improvements were also evaluated to determine how water use will change.

2.6.1 Forecasting Methodology and Key Planning Assumptions

Water use projections for steam power generation have two major components: power generation capacity and water use for that projected capacity. Power generation projections were based on current per capita electric power demand for the reported residential, commercial, governmental, and Aother@ sectors on a utility-specific basis. Similarly, industrial power demand was based on each utility's reported sales by Standard Industrial Classification (SIC). A composite growth factor was estimated for the remaining unaccounted sales.

For existing plants, future water use was assumed to remain constant at the average of 1988-1991 historical water use patterns, unless information indicated that plants were scheduled for closure. For planned plants and facilities, water use permits and/or plant design data was used to determine future water needs. If permit or plant design information was unavailable, it was assumed that additional generation would use water at the same gallons-per-kilowatt-hour rate as the current average use for that utility. Upper and lower case scenarios were developed to reflect different conservation and technology assumptions. The lower case uses a lower estimate of gallons-per-kilowatt-hour than the upper case.

Historical water use was estimated by aggregating water use data from several sources. For plants that use ground water or diverted surface water, the TWDB's survey of water use provided actual reported withdrawals. For plants that use cooling ponds or other water impoundments, water use was calculated by adding reported ground water use for boiler feed and sanitary uses to net natural evaporation and forced evaporation estimates. Net natural evaporation is the gross evaporation minus the total unadjusted precipitation. Forced evaporation, due to the heat load, is a function of the plant's thermodynamics and electric power generation.

In developing steam electric power generation projections, the following assumptions were made:

1) Power generation demands will grow in direct proportion to population growth for residential, commercial, governmental, and Aother@ sectors. The power generation demands are based on the most likely population growth scenario.

2) Industrial power generation demands will grow in direct proportion to industrial and manufacturing growth projections for each of the major electric power use Standard Industrial Classifications (SICs).

3) For the upper case, no change in electric power generation capacity is assumed. In addition, a constant water use rate, equal to the average of water use between 1988 and 1991, is assumed for the water use projections.

4) For the lower case, a combination of technological advances, conservation measures, and other factors are assumed to reduce total water use by five percent by 2000, ten percent by 2010, and 15 percent from 2020 to 2050.

2.6.2 Forecasting Scenarios

Technological advances in new steam-electric power plants could have significant impacts on water use. One such advancement is the use of gas-fired combined cycle plants, which have a higher over-all thermodynamic efficiency than conventional Rankine cycle plants because they employ both a combustion turbine and a waste heat boiler. Because these plants can generate up to two-thirds of their power in combustion turbine generators, which eliminates water use for that process, water use per kilowatt hour is reduced by half or more. Another important development in the power industry is the promotion of advanced energy conservation methods promoted by the Public Utility Commission of Texas. Advances in distributed generation, co-generation, and advancements in coal processing and conversion for use in combined cycle plants was also examined. These important water-saving concepts were incorporated into water saving factors for the lower case scenario.

Two sets of projections were developed to reflect these changes in the power industry. An upper range scenario, selected as the "most likely" case for planning purposes, incorporates the use of existing technology as needed to meet projected demand based on population and industrial activity. A lower range scenario incorporates new technology and conservation by assuming a water use reduction of five percent by the year 2000, ten percent by the year 2010, and 15 percent from 2020 to 2050.

2.6.3 Data Sources

A number of sources were used in developing the water use projections for steam electric power production for the 1994 Consensus Water Plan. These sources include:

1) The Texas Water Development Board, Survey of Annual Water Use, 1980-1991.

2) 1996 Consensus Water Plan, Projections of Population, Industrial, and Agricultural Activities, 1994.

3) The Public Utility Commission of Texas projections of additions and removals of power generation to the year 2005; generation, fuel use, and thermodynamics of existing plants; co-generation statistics; long-range projections of power needs; and the impact of technology on power generation in Texas.

4) Texas Natural Resource Conservation Commission, water rights permit information.

5) The Electric Power Research Institute, research on new technologies and related information.

6) The U.S. Department of Energy, various universities, and other sources for a variety of background information.

2.6.4 Limitations of the Analysis

Only the unfolding of future events will determine whether or not the assumptions underlying the steam-electric power cooling water forecasts will hold. The methodology assumes that power generation will occur in locations that have historically had power generation or where power companies have announced new locations, owned significant lignite resources, or obtained water rights or other types of permits, but where future plants will be located is unknown. Furthermore, unforeseen technological advances, market forces, and conservation efforts could also affect both power plant location and water use.

In addition to methodological limitations, changes in federal regulations could have an important effect on steam-electric power production and water use. Provisions of the Clean Air Act, for example, could restrict the location of future plants, while causing existing plants to close. New legislation may also affect how the power industry is structured, which may, in turn, affect power demand and water use. In the past, power generation has been vertically integrated, each firm owning most aspects of the production process from the natural resources to the distribution of power through utility lines. However, pending legislation would decouple generation and power distribution, making it easier for new producers to use existing lines to carry their electricity to markets. This legislation could also affect the number and location of steam-electric power producers.

2.7 LIVESTOCK

Texas is the nation's leading livestock producer, accounting for approximately 11 percent of the total United States production. Livestock production was valued at approximately $8 billion in 1993 and represented more than half of the total value derived from all agricultural operations in Texas. Cattle and calf operations dominate Texas livestock production, making up more than 75 percent of the livestock value. In 1993 there were approximately 14 million head of cattle and calves, 20 million chickens, 1.7 million head of sheep and lambs, and 0.5 million hogs and pigs. Although livestock production is an important component of the Texas economy, the industry consumes a relatively small amount of water. In 1990, total livestock production consumed approximately 274,000 acre-feet of water in Texas, representing less than two percent of the total water use.

2.7.1 Forecasting Methodology and Key Planning Assumptions

Estimating livestock water consumption is a straightforward procedure that consists of estimating water consumption for a livestock unit and the total number of livestock. Texas A&M University Agricultural Extension Service provided information on water use rates, estimated in gallons per day per head, for each type of livestock: cattle, poultry, sheep and lambs, and hogs and pigs. The Texas Agricultural Statistics provided current and historical numbers of livestock by livestock type and county. Water use rates were then multiplied by the number of livestock for each livestock type for each county. In counties where the number of head of livestock was unavailable, historical livestock distribution patterns were assumed. County livestock water use was then aggregated to the state level to estimate total water consumption by livestock type. The United States Department of Agriculture, Soil Conservation Service provided information on the source of water supply for range livestock. Water supply for confined livestock operations, such as poultry, hogs, dairy and feedlots, are assumed to be supplied by groundwater sources. Because water used for livestock

represents such a minor use, livestock production is assumed to remain constant after the year 2000.

2.7.2 Forecasting Scenarios

Because water used in raising livestock represents less than two percent of the total water use, only one scenario was developed to project livestock water use.

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2.7.3 Data Sources

Four primary information sources were used in calculating livestock water use estimates:

1) Texas Livestock Statistics, Texas Agricultural Statistics Service.

2) 1993 Texas Agricultural Cash Receipts and Price Statistics, Texas Agricultural Statistics Service.

3) United States Department of Agriculture, Soil Conservation Service.

4) Texas A&M Agricultural Extension Service.

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2.7.4 Limitations of the Analysis

The accuracy of the water use projections for livestock is limited by the simplicity of the projection methodology. Although it is not likely that the water use rate for livestock will change dramatically in the future, the number of livestock may change depending on future economic conditions facing the industry. Changes in public policy, such as NAFTA and GATT trade agreements or authorization of the 1995 Farm Bill, could affect livestock prices as well as production costs. Significant changes in prices paid and received by livestock producers would surely affect production in Texas. Regardless of such effects, however, water used by livestock would most likely remain a small percentage of total water use.

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2.8 MINING

Although the Texas mineral industry is foremost in the production of crude petroleum and natural gas in the United States, it also produces a wide variety of important nonfuel minerals. Texas is the only state to produce native asphalt and is the leading producer nationally of Frasch-mined sulfur. It is also one of the leading states in the production of clay, gypsum, lime, salt, stone, and aggregate. In all instances, water is required in the mining of these minerals either for processing, leaching to extract certain ores, controlling dust at the plant site, or for reclamation.

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2.8.1 Forecasting Methodology and Key Planning Assumptions

Projections of fresh water use for mineral production in Texas were developed for the categories of fuels and nonfuels. Consumptive use of fresh water in mining includes data on actual water use in 1990 as well as estimates of water needs in ten-year intervals to the year 2050. Derived from an examination of recent and historical data, trends in production, estimated total mineral reserves currently accessible, and rates of water use, these projections are tabulated by county, river or coastal basin, and climatic zones within basins. They represent the sum of estimated mining water use for the two categories of mineral products: fuels and nonfuels.

Projections of water use were based on projected future production levels for each mineral commodity. This future production was derived from both state and national historic rates, which was constrained by the accessible mineral reserves in the region. Water use projections were based on these projected production levels and historic rates of water use of each mineral or mineral group, moderated by the water requirements of the technological processes used in mining and rates of consumption.

In 1990, mining water use was almost evenly divided between fuels and nonfuels. From less than one percent of the state's total water use in 1990, mining water use is estimated to increase to approximately 293,800 acre-feet by 2050 and will represent less than two percent of the state's total water use.

For each category of mineral products, the requirements for mining water was determined as a function of production. Estimates of future production were calculated by analyzing both recent data, and state and national production trends. A water use coefficient, computed from data collected by the Texas Water Development Board's 1990 Water Use Survey, which reports the quantity of water used in the production of each increment of output, was applied to estimated mineral production levels. A rate of water consumption derived from U.S. Bureau of Mines data was then applied to the total water use for each mineral industry. In short, tabulations of water use for each basin, zone, and county represent the sum of estimated water use for the production of fuels and nonfuels where historically this mineral production has occurred, and where the estimated mineral reserves are sufficient to meet the demand.

Because projections indicated petroleum production would decline rapidly after the year 2000, estimates of water use in oil production also declined sharply. This decline is overshadowed by the increase in water use for synthetic fuels. Estimates of lignite production for synthetic fuels were distinct from lignite used as fuel in electric utilities. Because different synthetic fuel processes have different water needs, a water use coefficient was derived for those processes anticipated for estimated projects in Texas. The distribution of estimated water use was determined on the basis of concentration and distribution of mineral reserves. These water demands were added into the fuels category starting in 2020.

The estimates of water use for mining require two basic assumptions. First, it was assumed that the location of mines within the basin zone would remain constant. Second, it was assumed that each region would retain its share of state production. For example, if the Canadian Basin produced five percent of the state's production of petroleum in 1990, it was assumed that it would produce five percent of state's output through the year 2050.

2.8.2 Forecasting Scenarios

Although mining is an important industry in Texas, water for mining represents less than one percent of the total water use in Texas. In 1990, the entire industry used less than 150,000 acre-feet of water. Due to the relatively small quantity of water consumed, only one scenario was developed for mining.

2.8.3 Data Sources

Several data sources were used to develop water use estimates and projections for mining. These sources are the following:

1) U.S. Bureau of Mines, Published Reports and Information.

2) Bureau of Economic Geology, Published Reports and Data.

3) Texas Railroad Commission, Annual Reports.

4) Texas Comptroller of Public Accounts, Mineral Tax Reports.

5) Texas Water Development Board, Water Use Survey, 1990.

2.8.4 Limitations of the Analysis

As explained above, water use in mining is a function of production and technology. These projections assume production and technology will remain relatively constant throughout the projection period. Although it is unlikely that this assumption will hold as production costs and market prices change, the quantity of water used by the industry is so small that making such an assumption is acceptable for planning purposes.

3.0 SUMMARY OF POPULATION AND WATER USE FORECASTS

The graphical and tabular data shown in the following section provides a summary of the recommended "most likely" case and alternative scenario forecasts to be used in state water planning. Table 3-1 provides a brief explanation of the scenario descriptions for these forecasts. Figures 3-1 through 3-10 illustrate the alternative projected population and water uses for municipal per capita, total municipal, manufacturing, steam-electric power cooling, irrigation, livestock, and mining from 1990 through the year 2050.

Figure 3-1 shows the projected population of the state under alternative growth scenarios.

The "most likely" case forecast has Texas growing from its 1990 level of approximately 17.0 million to about 36.0 million by the year 2050, a 111.8 percent increase or an approximate doubling of population during the planning period. Although the state's population and economy are anticipated to grow steadily over the projection period, the "most likely" case forecast for overall statewide water use (shown in Figure 3-2) shows only a gradual increase during this period. Overall statewide water use is projected to grow marginally from the state's current use of about 15.8 million acre-feet per year (MAF) to only 18.6 MAF by 2050, a 17.7 percent increase. The relative composition of state water use will change as well, with irrigation falling from its current share of 66.1 percent of total use to only 45.7 percent by the year 2050 (see Figure 3-3). Municipal and industrial uses will increase their shares from 20.2 and 13.6 percent of total use to 33.9 and 20.4 percent, respectively.

Two primary factors account for the disparity between population and economic growth and much slower growth in total water use. First, urban (municipal, manufacturing, and steam-electric) water uses are anticipated to increase over time, while water use for irrigated agriculture is projected to decline. For the first time in Texas history, urban water uses are projected to exceed agricultural uses by the decade of 2040 (see Figure 3-4). Second, the amount of water to meet the needs associated with the anticipated population and economic growth are buffered somewhat by increasingly more efficient water use.

This first phenomenon should be interpreted very carefully. Statewide totals are of little practical use except for conceptual educational purposes. Given the vast geographic breadth of Texas, useful information in planning for future water needs becomes of much greater value when specified at the regional and local levels. Large water availabilities at one end of the state typically have little practical meaning to another region 500 miles away. Also, simply because water use is declining in one sector does not necessarily imply that the water is available for use elsewhere or for another purpose. Unused ground-water supplies that result from the decline in irrigated agriculture may not necessarily be economically available for urban uses. This decline in agricultural water needs may simply extend the useful life of the ground-water supply for local longer-term irrigation use and may not be available for more distant urban areas.

Table 3-1

Description of Population and Water Use Scenarios
for the Consensus Water Plan

Population Scenarios:

Three population scenarios, based on varying migration rates, were developed to project a range of alternative future populations. Migration rates, developed from the 1980 and 1990 US Census are incorporated into the scenarios by making the following migration assumptions:

Migration Rate 0.0 Assumes zero net migration for any county

Migration Rate 0.5 Assumes 50% of the 1980-1990 net migration rate (positive or negative) for each county.

Migration Rate 1.0 Assumes 100% of the 1980-1990 net migration rate (positive or negative) for each county.

The Most Likely Series: The most likely population scenario was selected by the consensus planning staffs of the Texas Water Development Board, the Texas Natural Resources Conservation Commission, and the Texas Parks and Wildlife Department as the growth pattern most likely to occur. The most likely population scenario for a given county may be any of the three migration scenarios described above. In a few cases, the most likely population scenario is not one of the three scenarios above; these were adjusted to reflect public input.

Municipal Water Use Scenarios:

Several municipal water use scenarios, based on varying population forecasts, per capita municipal water use estimates and conservation factors, were developed to provide an extensive array of alternative municipal water use scenarios. The individual elements that comprise the various scenarios are described below:

Population Scenarios:

Migration Rate 0.0

Migration Rate 0.5

Migration Rate 1.0

Most Likely Population Series

Per Capita Water Use Estimates:

Normal weather conditions:

Per capita water use projections were developed using an average of per capita water use data from 1987 to 1991 for each community and entity in Texas. This time period is assumed to reflect normal weather conditions.

Below-normal rainfall conditions:

Per capita water use projections were developed using the highest recorded per capita water use from 1982 to 1991 for each community and entity in Texas. The highest water use from this period is assumed to reflect below-normal rainfall conditions. An upper limit of 25 percent above the normal weather per capita water use estimate was applied to account for water conservation practices put in place after 1985.

Conservation Factors:

Expected conservation:

Expected conservation assumes levels of water savings that are likely to occur from both market forces and regulatory requirements. It assumes households will use more efficient plumbing fixtures and appliances already on the market, as well as employ more water efficient outdoor irrigation and landscape practices. In addition, expected conservation assumes that plumbing fixture standards required under the 1991 State Water Efficient Plumbing Act will be in place. The Act requires improved water-use efficiency in toilets, shower heads, urinals, faucets and drinking fountains. The expected conservation represents feasible strategies for water conservation savings that are economically sound.

Advanced conservation:

> Advanced conservation assumes the same improvements in water conservation as listed under expected conservation. The primary difference between the expected and advanced cases is one of timing. The advanced case assumes that municipal utilities and individuals engage in water conservation activities at an accelerated rate. The advanced conservation represents the maximum technical potential for water conservation savings.

Conservation from the Plumbing Code only:

These scenarios incorporate improvements in water-use efficiency due solely from the 1991 State Water Efficient Plumbing Act. It includes improvement in water use efficiency in toilets, shower heads, urinals, faucets and drinking fountains, but does not include conservation resulting from using more water efficient appliances or employing improved outdoor watering and landscape practices.

The Most Likely Series: The most likely municipal water use scenario incorporates the most likely population projection, with the per capita water use estimated that reflects below normal rainfall conditions, and the expected level of conservation. This scenario was selected by the consensus staffs of the three agencies and approved by the Technical Advisory Committee as the water supply planning scenario.

Manufacturing Water Use Scenarios:

The manufacturing water use scenarios were developed to capture a range of outcomes resulting from various oil prices and associated manufacturing growth, and water conservation. The components of the manufacturing scenarios are described below:

Oil Price:

> Base Oil Prices: Assumes oil prices remain stable in the $18-$23 per barrel range for West Texas Intermediate Crude.
>
> High Oil Prices: Assumes oil prices remain stable in the mid to high $20 per barrel range for West Texas Intermediate Crude.
>
> Low Oil Prices: Assumes oil prices remain stable in the $13-$17 per barrel range for West Texas Intermediate Crude.

Conservation:

With Conservation: Assumes improved water-use efficiency in selected manufacturing industries in Texas.

W/O Conservation: Assumes no improvement in water-use efficiency in manufacturing industries.

No Growth:

No mfg growth. Assumes no expansion in an industry above current capacity, or construction of new facilities in Texas over the projection period.

The Most Likely Series: The most likely manufacturing water use scenario assumes baseline oil prices, with water use efficiencies. This scenario was selected by the consensus planning staffs of the three agencies and approved by the Technical Advisroy Committee as the most likely growth scenario for water supply planning.

Irrigation Water Use Scenarios:

Three irrigation scenarios, based on various assumptions pertaining to profitablilty, federal farm program payments, and adoption of water-efficient irrigation technology were developed to project a range of alternative future projections. These assumptions are described below:

series 1: Assumes crop yields, crop prices and production costs change over time. Assumes federal farm payment are held constant at current levels, and no change in water-efficient irrigation technology.

series 2: Assumes crop yields, crop prices, and production costs change over time. Assumes federal farm payments are held constant at current levels, and the expected level of water-efficient irrigation technology is adopted.

series 3: Assumes crop yields, crop prices, and production costs change over time. Assumes federal farm program payment are reduced by one-half from current levels, and a more advanced level of water-efficient irrigation technology is adopted.

The Most Likely Series: Series 2 is the most likely irrigation water use scenario, and assumes federal farm payments are held constant, and the expected level of water-efficient irrigation technology is adopted. This scenario was selected by the consensus planning staffs and approved by the Technical Advisory Committee as the most likely scenario for water supply planning.

Steam Electric Power Water Use Scenarios:

Two sets of projections, based on various assumptions regarding conservation technology were developed.

Upper Series: Assumes existing technology and conservation patterns to meet demands.

Lower Series: Assumes adoption of new technology and conservation patterns to produce water use savings.

The Most Likely Series: The high series is the most likely steam electric power water use scenario, and assumes existing technology and conservation patterns.

Mining Water Use Scenario:

Mining: One set of mining water use projections was developed. These projections were based on projected production of mineral commodities, and historic rates of water use, moderated by water requirements of technological processes used in mining.

Livestock Water Use Scenario:

Livestock: One set of livestock projections was developed. This series was based on historical water consumption for livestock and a projected number of livestock.

FIGURE 3.1

Projected Statewide Population
Alternative Growth Scenarios

SCENARIOS DEFINITION

0.0. Migration Zero net migration over the projection period. Only the natural increase or decrease in population is assumed.

0.5 Migration One-half of the 1980-1990 migration rates are assumed to occur over the projection period.

1.0 Migration The 1980-1990 migration rates are assumed to occur over the projection period.

Most Likely Future population growth selected from the various migration scenarios to represent the most likely growth pattern for each geographical area.

It should be noted that the 1.0 migration scenario is not always the highest growth pattern for a geographical area and the 0.0 migration scenario is not always the lowest growth pattern for a geographical area. For those areas which have experienced net out-migration over the last decade, the 0.0 migration scenario is generally the highest population growth projection for that area. For those areas which have experienced net in-migration over the last decade, the 1.0 migration scenario is generally the highest population growth projection for that area.

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