APPENDIX TO

LONG-RANGE WATER SUPPLY PLAN 1990 - 2050

TO THE CITY OF DALLAS, TEXAS
DALLAS WATER UTILITIES

JOB NO. 45 - 88007 - 031

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Introduction

This "Appendix to the Long Range Water Supply Plan for Years 1990 to 2050" has been prepared and compiled by Turner Collie & Braden Inc. to substantiate the information provided in the main report. The information presented in this appendix should be used to support and compliment the data, investigations, findings and recommendations furnished in the main report and not used as a separate report for a long range water supply study.

Appendix A
Population Projections, Per Capita Water Usage Projections, and Water Demand Projections

POPULATION

1. GENERAL

The population projections summarized in Table 5-1 were derived using the publications or studies presented in Section XI of the main text. Also, each entity was requested to review and comment on the proposed projections. Final projections were then established taking those comments into consideration. The resulting population projections (listed in Table 5-1), are depicted graphically in Exhibits A-1 through A-32. Each exhibit's legend indicates comparisons with projections from other studies. Note that not all combinations are available for each city.

2. NOTES ON POPULATION PROJECTIONS

Addison:

The population has decreased over the past two years; however, the historic long-term growth rate has been rapid. The 1976 report on "Water and Wastewater System Improvements", presented an ultimate population of approximately 21,000 based on forecasted land-use and zoning. The updated projection shows the city approaching its ultimate population in 2050. Growth rates for the revised projection nearly parallels those developed by the North Central Texas Council of Governments (NCTCOG) and the Texas Water Development Board (TWDB).

Argyle:

The population of this small city has increased steadily. The updated projection reflects limited historical data and considers information received in a letter from the City Secretary, February 1989, and growth trends developed by the TWDB.

Dallas County WCID No. 6 (Balch Springs):

The city's growth has increased steadily although not as great as others in the study area. The updated projection incorporates the historic growth rate trends and recognizes that the city is landlocked. Balch Springs is estimated to have a saturation population of about 35,000. This population is expected to be reached soon after 2050. The updated projection lies between projections made by NCTCOG and TWDB (1982) and is nearly identical to the draft Low series projections developed by TWDB in 1988.

Carrollton:

This favorably located city's population has nearly doubled in the last eight years and there is plenty of land for additional growth. The updated projection indicates steady growth with a leveling trend appearing as the saturation population of 262,250 (developed in the 1977 report, "A Plan for Water Works & Sanitary Sewerage") is approached, but not reached, by 2050. Growth rates for the updated projection closely parallel those developed by TWDB (1988) and NCTCOG (1986).

Cedar Hill:

The city's population has increased 250 percent in the last eight years, and an adequate amount of land is available for continued growth. The updated projection closely parallels the rates projected by NCTCOG through 2010.

Cockrell Hill:

The city is landlocked and fully developed. The updated projection is based on the 1988 NCTCOG population estimate through 2050.

Collin County (Those areas within the Elm Fork Watershed):

Only limited historical data is available, but the region appears to be growing steadily. Adopted population projections for 1990 through 2020 were coordinated with projections made for the Collin County Water Supply Study. Growth rates after 2020 were adjusted to closely parallel those developed by TWDB (1988).

Combine Water Supply Corporation:

The corporation serves a small but growing population. The updated populations are projected to follow growth rates experienced in recent years.

Coppell:

The city's population has nearly quadrupled in the last eight years. The updated projection shows continued rapid growth with a leveling trend in later years because the city is landlocked. Growth rates for the updated projection are very similar to those projected by NCTCOG (1986).

Corinth:

The city's small population has nearly tripled in the last eight years. The updated projections are based on historic growth, the town's recent land-use and thoroughfare plans, an ultimate population of 40,000, and growth trends developed by TWDB (1988) after 2000.

Dallas:

The revised projection closely approximates estimates from projections made by, CH_2M Hill (1984), TWDB (1988), NCTCOG (1986). It is based on a continuation of the growth pattern exhibited in recent years.

Denton:

The city's steady population growth has increased more rapidly in recent years. Population projections are based on historic growth and NCTCOG's forecasts. These projections parallel the City's utility forecast through 2010. After 2010 a growth trend of 1.8 percent per year was used. This rate is consistent with the City of Denton's development plans.

Denton County (All county area east of Denton Creek currently not under contract to DWU):

The region has experienced increasing growth rates in recent decades. The updated projection indicates an "S" shaped growth pattern and future growth rates will begin to decrease. Although decreasing, the growth rates are expected to remain relatively steep and closely follow the projection developed by Espey Huston & Associates, "Denton County Water Study, 1988" through year 2010. After 2010, the projection parallels the growth rates developed for TWDB's 1988 High series projections.

DeSoto:

Growth has been rapid for several years. The updated projection reflects a long-term historic growth trend and closely follows projections made by NCTCOG (1986).

Duncanville:

The city has experienced a steady and rapid population growth for several years. The updated projection reveals a flattened growth trend as the saturation population of 50,000 (estimated in 1980 study) is approached. The updated projection is nearly identical to projections developed by CH_2M Hill (1984) and NCTCOG (1986).

Farmers Branch:

For various reasons, population growth in the city has been nonexistent for nearly 20 years. NCTCOG sources suggest that build-out has occurred for residential development and the declining population is a result of smaller households. The updated projection is based on recent comprehensive planning studies by the City and considers redevelopment of the oldest parts of the City. Projections also consider the development of higher density housing along the west side of the City until the saturation population of 34,686 is reached near the year 2015. Projections after 2015 are held at the saturation population.

Flower Mound:

The town has experienced increasing growth rates in the past two decades and has more than tripled in population during the last eight years. The updated projection assumes an "S" shaped growth curve and future years will experience decreasing, although relatively steep, growth rates. The updated projection shows growth rates nearly identical to rates projected by TWDB (1988) and also approximately follows projections made by CH_2M Hill (1984) and NCTCOG (1986).

Glenn Heights:

The city's small population has increased 450 percent in the past eight years. The updated projection reflects a continued strong growth trend and shows growth rates nearly identical to those projected by CH_2M Hill (1984).

Grand Prairie:

The city's population has increased steadily for many years. The updated projection continues this steady growth trend and closely parallels projections made by CH_2M Hill (1984), TWDB (1988), NCTCOG (1986), and city estimates.

Highland Park:

The town is landlocked and fully developed. The updated projection assumes a constant population at the 1988 NCTCOG estimate through 2050.

Highland Village:

The city's small population has nearly doubled in the past eight years. In light of residential development now occurring along Lake Lewisville, this growth is expected to continue. The updated projection reveals a leveling trend in later years as the saturation population of 21,570 (1986 study) is reached within the period of study. The updated projection is based on the City of Highland Village's 1986 "Water Distribution System Study", prepared by Freese and Nichols, Inc.

Hutchins:

Population growth has been stagnant in recent years and the updated projection does not show any significant future increases. The updated projection very closely follows projections made by CH_2M Hill (1984) and NCTCOG (1986).

Irving:

The city's growth rate has increased the last eight years, adding over 50,000 persons. The updated projection assumes continued growth but at a flatter rate as the saturation population is approached soon after 2050. The saturation population has been estimated at 200,000 to 300,000 with 250,000 used for this study. The updated projection closely follows projections made by the city's consultant through 2000.

Lake Cities M.U.A.:

The population has decreased slightly in recent years. However, the long-term historic trend has been one of steady growth. The updated projection forecasts growth at a rate slower than in the past but steady because of close proximity to Denton, Lewisville, and Lake Lewisville.

Lancaster:

The city's growth has been steady. The updated projection continues this growth and closely follows projections made by CH_2M Hill (1984) through 2030 and NCTCOG (1986) projections through 2000.

Lewisville:

The city's growth rate has been increasing in recent years. The updated projection forecasts continued growth with leveling occurring in the future as the saturation population of 110,000 (1987 study) is reached within the period of study. The updated projection closely follows forecasts made by TWDB (1982) through 2010.

Ovilla:

The updated projection continues the historic growth trend of this city's small population and very nearly follows the High Series populations developed by TWDB (1988).

Seagoville:

The city's growth rate has increased in recent years. The updated projection continues the growth identified by City planners through 2010. After 2010, a flatter growth rate is assumed until a population of 30,000 is reached by 2050.

The Colony:

The updated projection indicates growth that closely follows projections made by TWDB (1982) and growth rates that parallel those projected by NCTCOG (1986) and TWDB (1988).

University Park:

The city is landlocked and fully developed. The updated projection assumes a constant population at the 1988 NCTCOG estimate through 2050.

Wilmer:

The updated projection forecasts growth at a rate nearly parallel to rates projected by CH_2M Hill (1984), TWDB (1982), and city's consultant. Preliminary projections were nearly identical to the proposed projections made for the "Ellis County Water Supply Study" (1988) prepared by Espey Huston & Associates. The updated population projections have been adjusted to agree with that study for consistency.

PER CAPITA WATER USAGE AND WATER DEMANDS

1. GENERAL

Section VII of the main report discussed the various average-day and peak-day water demand projections for DWU's recommended Planning Area. They were derived from population projections, per capita water usage projections, various drought and peak-day use factors, and in some cases, from projections of historic water use patterns.

This Appendix presents the development of per capita water use, peaking factors, and water demand projections for the City of Dallas' planning area for the period 1990 - 2050. Also included is a discussion of each customer city's alternate water supply sources, if any, and a tabulation of historic demands.

2. PER CAPITA WATER USAGE

Per capita water usage projections were developed using historical municipal water demands, historical population estimates, and various engineering and planning studies for each entity within the planning area. Rather than use a single system-wide factor for projecting planning area water demands, separate per capita factors were developed considering only residential, commercial, and light industrial uses for each entity. To determine representative factors, historical municipal water demands for each entity was divided by its historical population. Entities experiencing similar growth patterns were grouped together to aid in evaluating per capita projections.

Review of the historical per capita information (see Table 3-4 of the main report) indicated an unexpected increase in system per capita consumption for 1984. This increase continued for each of the calendar years 1985-1987, the last years with complete data. Partial data for 1988 indicated the trend was continuing. The magnitude of these increases appeared to be representative of increases observed during drought periods. However, these years experienced near normal rainfall.

Discussions with the U. S. National Weather Service (NWS) in Fort Worth were conducted in an attempt to explain these increases. Several theories have been presented that explain various current or potential climatological changes. One theory is a possible "Green House Effect" caused by changes in the ozone layer. Another theory is a climatological cycle of higher than normal temperatures which could be followed by cooler or near normal temperatures, which could then repeat itself. Because specific local climatological changes cannot be substantiated currently, the NWS has not established an official position until specific trends are identified. Therefore, because of the uncertainty, both a high and low case per capita projection was developed to aid in projecting future water demands.

Low case per capita projections were developed for each entity which considered only historical per capita increases before 1984. Existing and expected growth patterns and trends were considered in making these projections. For high case per capita projections, the highest per capita usage during the calendar years 1984-1987 was assumed as a base, and subsequent increases were assumed to parallel the historic growth trends identified for the low case projections. Long-term historic growth trends were used to develop per capita projections for all entities, except for the cities of Cedar Hill and The Colony.

Cedar Hill:

The city has experienced a significant increase in per capita usage the last four years that is difficult to explain. It is believed the city's population increases, which have nearly doubled in five years, produced a more urban community. This urbanization would cause an increased per capita water usage. It was assumed that higher per capita usage for city is now normal and the projection of low and high case per capita factors were based on the past four years of data only.

The Colony:

The city's historic data shows a downward trend of per capita water usage until 1981, and then an upward trend which is projected to continue. The downward trend is likely explained by early commercial development with very little population which caused a high per capita usage. As population grew, per capita usage declined to "normal" levels and has since increased as the population became more urbanized. Low and high case per capita projections are based on the most recent historic information representing the increased residential development.

Table 3-4 presented historic per capita data for the period 1975-1988 for each entity. Tables A-1 and A-2 present the low case and high case projections for the City of Dallas, current treated water customers, current raw water customers, and potential customers. As a typical illustration of the per capita projection methodology, data for the City of Dallas is presented on Figure A-1.

Rather than use a range of per capita projections to develop water demands, it was decided that a specific per capita projection be used for each city or entity. A 75 percent trend observed for the City of Dallas for calendar years 1984-1987 was used to select a reasonable per capita value based on the uncertainty of recent higher per capita factors.

Per capita water usage projections for all entities were established consistent with this trend between low and high case projections. To test the accuracy of these projections, each was compared to preliminary 1988 per capita factors. In every case except two, the preliminary 1988 data fell between the low and high case projections. The majority were within four percent of the proposed per capita projection. The two exceptions were the Town of Addison and the City of Farmers Branch. Both of these cities have large commercial and industrial developments which have not stabilized in relation to the residential population. These cities exhibited higher per capita factors than those calculated from the 1984-1987 data. New high case per capita factors were adopted for these cities consistent with this new information. Table A-3 presents per capita projections determined using this methodology. These projections do not consider reductions for water conservation measures. Adjustments to show the impacts due to water conservation measures are discussed in item eight of this appendix.

3. PEAKING FACTORS

Historical peaking factors (peak-day/average-day ratios) were developed for each entity. These factors were based on historic average-day and peak-day water demands obtained from DWU Consumption Records and if available each entity's statement of annual water consumption for the period 1972-1987. For entities with a shorter historic record, an average ratio of 1.856 was used, or the peaking factor was established from available data. These peaking factors were compared with available city master plans or distribution studies and specific adjustments were made if major differences were noted. Tables A-4 through A-21 present specific peak-day water usage, average-day water usage and peaking ratios determined for each entity. The final peaking factors adopted for this study are presented in Table A-22. Note that the City of Denton's peaking ratio was taken from the 1988 Denton County study and that the City of Lewisville's peaking ratio was taken from its 1987 "Water Distribution Report".

4. AVERAGE-DAY WATER DEMANDS

As presented in Section III of the main report, the City of Dallas currently provides direct water service to twenty (20) treated water customers and two (2) raw water customers. In addition to supplying these customers, the City also sells water directly to Dallas Power & Light (DP&L) and to small irrigation/domestic users around its water supply sources. Development of water demand projections for the twenty two (22) treated and raw water customers is based on multiplication of population projections by per capita water use projections, except for D/FW Airport where direct water demand projections were made from historic usage. Water demand projections for DP&L and irrigation/domestic customers are also based on historic use patterns as follows:

Dallas Power & Light, a division of TU Electric, obtains water from the Elm Fork of the Trinity River (to be stored at North Lake) and also uses water directly from Lake Ray Hubbard.

The current raw water contract with DWU for diversion of water to the North Lake facility expires in October 1997. It indicates that DP&L could take as much as 9,550 acre-feet annually (8.53 mgd). DWU "Annual Surface Water Reports" indicate that DP&L generally draws less than the maximum amount. No specific yearly trend could be determined for the water drawn for the North Lake facility. However, further evaluation of the historic information and discussions with DP&L personnel indicated that DP&L attempts to draw a specific amount of water over a two to three year period for their cooling needs. No expansion is currently planned and indications are that DP&L will not change their current diversion operations. Therefore, the average annual diversion rate of 2,933 acre-feet (2.62 mgd) was used because the DP&L peak years for maximum intake were consistently classified as off-peak years for DWU. A tabulation of the historic diversion information for this facility is presented in Table A-23.

It should be noted that DP&L makes full use of flood waters released from DWU's upstream reservoirs to meet its needs for this North Lake facility thus reducing demands on the system's conservation storage. The contract further indicates that in times of general water shortages or prolonged droughts, DWU may restrict releases of water to DP&L's North Lake facility. It is indicated that these restrictions be reasonable in relation to the City's water supply and requirements. The restrictions should also consider the importance of a power supply to the City, citizens, and industry to prevent an unnecessary curtailment of DP&L's ability to supply power. In the event that such curtailment is necessary, once water supply is replenished, DP&L is allowed to draw in excess of its contracted amount (9,550 acre-feet per year) until it has received the amount of curtailment or 16,000 acre-feet, whichever is less. Based on this information, the use of an average annual diversion rate appears reasonable.

Dallas Power & Light also holds Contractual Permit No. 43, issued by the Texas Water Commission, issued October 26, 1967, to use public waters from Lake Ray Hubbard for cooling. The permit allows a maximum diversion of 3,000 acre-feet annually (2.68 mgd) until expiration of DP&L's contract with DWU in January 2020. Over the 10-year period from 1978 to 1987, DP&L has drawn water at an average annual diversion rate of 2,360 acre-feet (2.11 mgd). During this time, annual diversions varied from a low of 1,959 acre-feet (1.75 mgd) in 1982 to a high of 2,857 acre-feet (2.55 mgd) in 1985. Considering this information, the permitted maximum diversion rate was used throughout the study. A tabulation of the historic diversion information from Lake Ray Hubbard is presented in Table A-23. DP&L's Lake Ray Hubbard contract also has a curtailment clause similar to the North Lake contract, except DP&L is not allowed to withdraw more than the contracted amount to make-up curtailment.

DWU's, "Annual Surface Water Reports" were used to evaluate small irrigation and domestic requirements. This information indicated that consumption for these users is much less than the quantities drawn by DP&L for cooling. Irrigation usage appears to be increasing with a peak demand of 522,665 thousand gallons (0.45 percent of total system usage) observed in 1986.

The volume of small domestic uses is increasing, but is fairly consistent at 0.04 percent of the total planning area's usage. These percentages were assumed to continue into the future. Table A-23 presents the historic information for these users. Table A-24 presents the projections for these customers and Table A-25 presents the average-day water demand projections for the planning area without water conservation measures.

As indicated, the average-day water demands for the planing area are projected to double by 2050, increasing from about 427 million gallons per day (mgd) in 1990 to about 828 mgd by 2050 without the implementation of enhanced conservation measures. The majority of this increase will occur within the City of Dallas' customer entities. These customers will increase their average-day water usage by a factor of 2.6, from 170 mgd to 442 mgd during the study period. The City of Dallas is projected to increase average-day water usage by a factor of 1.5, from 257 mgd to 387 mgd during the period. Of the customers entities total demand, Dallas will supply 131 mgd of the 170 mgd requirement in 1990 and 357 mgd of the 442 mgd requirement by 2005. Presumably, the customer entities will use their alternate supply sources to meet their additional requirements. These sources include existing wells and existing and future surface water supplies. Table A-26 presents the average-day water demand projections for the system including these alternate supply sources without water conservation measures.

5. ALTERNATE SOURCES OF SUPPLY

The information regarding alternate supply sources were obtained from various historic city planning reports and verified for accuracy by the individual cities. Where necessary, revisions were made to agree with current plans. The quantity of the alternate supplies was subtracted from the total planning area demands to produce water demand projections to be supplied by DWU.

Addison:
No other supply sources were considered.

Balch Springs:
No other supply sources were considered.

Carrollton:
The City of Carrollton has a single Trinity Well to augment flow requirements in times of peak water demand. This well has a rated capacity of approximately 2 mgd, but the city forecasts that only 121,000,000 gallons per year (0.33 mgd) can be obtained from this source. Depleting groundwater supplies are assumed to prevent the use of this well after 1999. Therefore, 0.33 mgd was established as the average-day alternate supply through year 1999. For peak-day demands, it was assumed that this well could supply water consistent with the city's historic peaking factor of 1.817. Therefore, 0.60 mgd was established as the peak-day alternate supply through 1999.

Cedar Hill:

The city has water rights to 6.48 mgd in Joe Pool Lake. Because diversion and treatment facilities have not been designed or constructed, it has been assumed that this supply will not be available until 1995. Therefore, an average-day alternate supply of 6.48 mgd was established beginning in 1995. For peak-day demands it was assumed that this supply could be drawn consistent with the city's historic peaking factor of 2.14. Therefore, 13.87 mgd was established as the peak-day alternate supply beginning in 1995. The City's 1983 Water Distribution Study indicated an approximate maximum rate of 14.0 mgd from this source.

Cockrell Hill:

No other supply sources were considered.

Coppell:

No other supply sources were considered.

Dallas/Fort Worth International Airport:

DFW has historically received about 60 percent of its supply from DWU and about 40 percent from Fort Worth. Indications from DFW officials are that these sources and percentages will continue into the future.

City of Denton:

The city has rights to 4.8 percent of the firm yield of Lewisville Lake (4.3 mgd) and to 26 percent of the firm yield of Lake Ray Roberts (19.76 mgd). Because Lake Ray Roberts is currently filling, its firm yield can not be fully counted. Therefore, an alternate supply of 23.07 mgd has been assumed for 1990. This 23.07 mgd includes all the alternate supply in Lewisville Lake and 95 percent of the yield in Lake Ray Roberts. After 1990, the full dependable yield (24.06 mgd) of these two sources is utilized to meet average-day demands.

Denton County:

No other supply sources were considered.

De Soto:

No other supply sources were considered.

Duncanville:

The city has rights to 1.06 mgd in Joe Pool Lake. Because diversion and treatment facilities have not been designed or constructed, it is assumed that this supply will not be available until 1995. Therefore, an average-day alternate supply of 1.06 mgd was established beginning in 1995. For peak-day demands it was assumed that this supply could be drawn consistent with the city's historic peaking factor of 1.867. Therefore, 1.98 mgd was established as the peak-day alternate supply beginning in 1995.

Farmers Branch:

No other supply sources were considered.

Flower Mound:

No other supply sources were considered.

Glenn Heights:

No other supply sources were considered.

Grand Prairie:

The City of Grand Prairie currently obtains water supplies from two alternate sources and additionally, has water rights in Joe Pool Lake. Their current alternate sources include a contract with the Trinity River Authority for the delivery of 1.0 mgd through 1998. This contract has been temporarily amended to allow the city to take up to 2.5 mgd through 1990. The other alternate source is from groundwater wells drawing water from the Twin Mountains formation in the Trinity Group aquifer. The city's Long-Range Water Supply Plan, prepared by Freese and Nichols in 1988, indicates that the well's average-day supply will decrease from 3.5 mgd in 1990 to 2.0 mgd in 2010 and remain constant thereafter. The city has rights to 1.58 mgd in Joe Pool Lake. It has been assumed that this supply will not be available to the city until 1995. The following tabulation shows average-day and peak-day alternate supplies for the study period.

YEAR	AVERAGE-DAY (mgd)				PEAK-DAY (mgd)				
	TRA	Wells	Joe Pool	TOTAL	TRA	Wells	Joe Pool	Storage	TOTAL
1990	1.4	3.5	0	4.90	2.5	8.6	0	2.0	13.10
2000	1.0	2.7	1.58	5.28	1.0	6.8	6.32	2.0	16.12
2010	1.0	2.0	1.58	4.58	1.0	5.0	6.32	2.0	14.32
2020	1.0	2.0	1.58	4.58	1.0	5.0	6.32	2.0	14.32
2030	1.0	2.0	1.58	4.58	1.0	5.0	6.32	2.0	14.32
2040	1.0	2.0	1.58	4.58	1.0	5.0	6.32	2.0	14.32
2050	1.0	2.0	1.58	4.58	1.0	5.0	6.32	2.0	14.32

These supplies are consistent with the recommendation presented in the city's long-range plan.

Highland Park/University Park (Park Cities):

The Dallas County Park Cities Municipal Utility District has water rights to a dependable yield of 6.04 mgd as their share of Grapevine Reservoir. The supply has been assumed as the District's average-day alternate supply. For peak-day demands, it was assumed that this supply could be drawn consistent with the system average peaking factor of 1.856. Therefore, 11.21 mgd was assumed as the peak-day alternate supply.

Highland Village:

No other supply sources were considered.

Hutchins:

No other supply sources were considered.

Irving:

Presently, Irving's four wells can produce a total of 1.25 mgd for average-day conditions and can be operated to produce a total of 5.0 mgd for peak-day conditions. The City indicates that this yield can be relied on through 1990. The city also has water rights to 39.5 mgd in Cooper Reservoir. Through a preliminary agreement with DWU, Irving will pump this Cooper Reservoir water to Lewisville Lake for storage. For the purposes of this study it has been assumed that up to 79.0 mgd will be released and treated at DWU's Elm Fork Treatment Plant to be delivered to Irving. Therefore, based on the agreement between DWU and Irving, the peak-day supply from Cooper Reservoir (79.0 mgd) will be included in the systems requirements in the planning of treatment and facility needs only. It is anticipated that these supplies will be available by the year 2000.

Lancaster:

No other supply sources were considered.

Levisville:

No other supply sources were considered.

Seagoville:

No other supply sources were considered.

The Colony:

No other supply sources were considered.

Wilmer:

No other supply sources were considered.

6. PEAK-DAY WATER DEMANDS

Peak-day demands are the basis for planning and design of treatment and distribution systems. Peak-day projections for the study period were determined by applying individual peaking factors (peak-day/average-day ratios) for each entity to the average-day water demand projections for that entity.

Peaking factors for the various entities ranged from approximately 1.6 to approximately 2.3 with an average of approximately 1.9 (see Table A-22). Peak-day water demand projections and associated peaking factors are presented in Table A-27 for the planning area without water conservation measures.

As indicated, total peak-day water demand for the planning area is projected to increase from approximately 774 mgd in 1990 to approximately 1535 mgd by 2050 without the implementation of enhanced conservation measures. Table A-28 presents peak-day water demand projections including the customer cities' alternate supply sources without water conservation measures. Peak-day water demand supplied by DWU will likely increase from approximately 666 mgd in 1990 to approximately 1163 mgd by 2050. Of this, the City of Dallas peak-day water usage is expected to increase from approximately 456 mgd in 1990 to approximately 685 mgd by 2050. Demands from existing and potential customer entities are projected to increase from approximately 211 mgd in 1990 to approximately 478 mgd by 2050.

7. DROUGHT WEATHER DEMANDS

The previously presented average-day and peak-day demands, without water conservation measures, are for normal weather conditions. However, to continue the commitment made following the 1950's drought of assuring adequate water supplies during droughts, water demands must also be projected which simulate consumption during various drought conditions. These various drought weather water demands are used to plan and size future supply sources, treatment and distribution facilities. Both an extended drought and a one-year peak drought are used in planning.

The extended drought of record for the Dallas area is considered to the seven-year drought of the 1950's. An extended drought factor is used to project water demands that could occur assuming that the hydrologic conditions observed during the 1950's. Dallas Water Utilities has assumed that this factor was approximately 1.04. However, because usage patterns have drastically changed within the planning area since the 1950's, a factor of 1.06 is used to simulate this extended drought period. This 1.06 factor was established by comparing current usage patterns to the patterns observed during the 1950's drought period and is applied to average-day water demand projections to estimate water demands that must be met during extended drought periods. The resulting extended drought demands are used to plan future supply sources and design raw water transmission lines. Table A-29 presents the average-day water demand projections for the system during an extended drought condition without water conservation measures. These demands increase from approximately 411 mgd in 1990 to approximately 787 mgd by 2050.

One-year peak drought factors were established for each entity to simulate the recent 1980 peak drought year. These factors were derived from a comparison of predicted normal weather water demands for 1980 with actual water demands experienced. Drought factors ranged from 1.08 to 1.35. For entities with insufficient historical records, an average system drought factor (1.17) was used. These factors are applied to peak-day water demand to plan future treatment capacity needs. For the Dallas/Fort Worth International Airport the historic drought factor of 1.35 was only used for 1990 projections. A factor of 1.17 was used after 1990 to simulate the reuse of water to meet drought weather irrigation demands by the airport. Table A-30 presents the peak-day water demand for the system for a one-year peak drought condition without water conservation measures. Specific drought weather factors for each entity are also presented in this table. This table assumes that the City of Irving's share of Cooper Reservoir will be delivered to Lewisville Lake and 79.0 mgd will be treated at DWU's Elm Fork Treatment Plant for delivery to Irving. A one-year peak-day drought weather system demand of approximately 782 mgd is expected for 1990 that could increase to approximately 1462 mgd by 2050.

8. EFFECT OF WATER CONSERVATION/DEMAND LEVEL PLANNING ON WATER DEMAND PROJECTIONS

Section VI of the main report shows how implementation of increased water conservation measures and demand level planning will lead to reduced water usage in the future. Average-day and peak-day demand projections used in developing alternative supply plans were adjusted to reflect the effect of increased water conservation measures and demand level planning. Reductions used to adjust each years average-day demand due to water conservation follow:

1990	2000	2010	2020	2030	2040	2050
0%	7%	6.5%	6.5%	6.5%	6.25%	6.25%

Figure 7-1, of the main report, illustrates the impact of these reductions on projected per capita usage. For restrictions due to demand level planning, a 10 percent reduction was used to adjust each years peak-day demand.

Tables A-25 through A-28 presented average-day and peak-day demands during normal weather conditions without water conservation measures. Tables A-31 through A-34 present these normal weather demands considering adjustments due to water conservation measures. Table 7-1 of the main report indicates the reductions in the extended drought demand used in planning future supply sources and designing raw water transmission lines. These demands reflect adjustments to Table A-29 for water conservation measures and are expected to be reduced to approximately 432 mgd by year 2000 and to approximately 738 mgd by year 2050 as a result. Table 7-2 of the main report indicates the Demand Planning reductions to the one-year peak drought demand which are used in planning for future treatment capacity needs. These one-year peak-day drought demands reflect adjustments to Table A-30 for demand level planning and are expected to be reduced to approximately 704 mgd for 1990 and to approximately 1316 mgd by 2050 as a result.

Table A-1
Per Capita Water Usage Projections (gpcd)
Average Day Use Under Normal Weather Conditions
Low Case

City	1990	2000	2010	2020	2030	2040	2050
Dallas	245	260	275	280	285	290	290
Treated Water Customers							
Addison	350	350	350	345	340	335	330
Dallas County WCID #6 (Balch Springs)	110	115	120	125	130	135	140
Carrollton	205	210	215	220	225	230	235
Cedar Hill	180	185	190	195	200	205	210
Cockrell Hill	125	135	145	150	155	160	160
Combine WSC	*City of Seagoville Customer, Demand Included with City of Seagoville*						
Coppell	150	160	170	180	190	195	200
D/FW Airport	---	---	---	---	---	---	---
Desoto	165	170	175	180	185	190	190
Duncanville	165	170	175	180	185	190	195
Farmers Branch	320	325	330	335	340	345	350
Flower Mound	110	120	130	140	150	160	170
Glenn Heights	130	140	150	160	165	170	175
Grand Prairie	160	165	170	175	180	185	185
Hutchins	160	175	180	185	190	195	200
Irving	195	215	225	230	235	240	245
Lancaster	140	150	160	165	170	175	180
Lewisville	*Included under Raw Water Customers*						
Mesquite	---	---	---	---	---	---	---
Ovilla	*City of Cedar Hill Customer, Demand Included with City of Cedar Hill*						
Seagoville	120	125	130	135	140	145	150
The Colony	135	155	165	175	185	195	200
Weighted Subtotal:	181	189	195	200	204	209	212
Raw Water Customers							
Argyle	*City of Denton Customer, Demand Included with City of Denton*						
Corinth	*City of Denton Customer, Demand Included with City of Denton*						
DP&L	---	---	---	---	---	---	---
Denton	160	170	175	180	185	190	195
Irrigation/Domestic Users	---	---	---	---	---	---	---
Highland Village	150	180	200	210	215	220	225
Lake Cities	*City of Denton Customer, Demand Included with City of Denton*						
Lewisville	160	165	170	175	180	185	190
Weighted Subtotal:	159	169	175	180	185	190	195
Potential Customers							
Collin County (Raw Water)	150	154	158	162	162	162	162
Denton County (Raw Water)	115	130	140	145	150	155	160
Park Cities MUD (Treated Water)							
Highland Park	360	360	360	360	360	360	360
University Park	230	245	250	250	250	250	250
Wilmer (Treated Water)	105	110	115	120	125	130	135
Weighted Subtotal:	168	170	171	170	171	172	174
WEIGHTED TOTAL:	**213**	**220**	**227**	**230**	**233**	**236**	**237**

Table A-2
Per Capita Water Usage Projections (gpcd)
Average Day Use Under Normal Weather Conditions
High Case

City	1990	2000	2010	2020	2030	2040	2050
Dallas	270	285	300	305	310	315	315
Treated Water Customers							
Addison	400	400	400	395	390	385	380
Dallas County WCID #6 (Balch Springs)	125	130	135	140	145	150	155
Carrollton	220	225	230	235	240	245	250
Cedar Hill	210	215	220	225	230	235	240
Cockrell Hill	140	150	160	165	170	175	175
Combine WSC	*City of Seagoville Customer, Demand Included with the City of Seagoville*						
Coppell	175	185	195	205	215	220	225
D/FW Airport	---	---	---	---	---	---	---
Desoto	180	185	190	195	200	205	205
Duncanville	175	180	185	190	195	200	205
Farmers Branch	370	375	380	385	390	395	400
Flower Mound	130	140	150	160	170	180	190
Glenn Heights	130	140	150	160	165	170	175
Grand Prairie	180	185	190	195	200	205	205
Hutchins	210	225	230	235	240	245	250
Irving	215	235	245	250	255	260	265
Lancaster	150	160	170	175	180	185	190
Lewisville	*Included under Raw Water Customers*						
Mesquite	---	---	---	---	---	---	---
Ovilla	*City of Cedar Hill Customer, Demand Included with the City of Cedar Hill*						
Seagoville	145	150	155	160	165	170	175
The Colony	150	170	180	190	200	210	215
Weighted Subtotal:	201	209	214	219	224	228	231
Raw Water Customers							
Argyle	*City of Denton Customer, Demand Included with City of Denton*						
Corinth	*City of Denton Customer, Demand Included with City of Denton*						
Denton	180	190	195	200	205	210	215
DP&L	---	---	---	---	---	---	---
Highland Village	165	195	215	225	230	235	240
Irrigation/Domestic Users	---	---	---	---	---	---	---
Lake Cities	*City of Denton Customer, Demand Included with City of Denton*						
Lewisville	185	190	195	200	205	210	215
Weighted Subtotal:	181	190	197	202	207	211	216
Potential Customers							
Collin County (Raw Water)	150	154	158	162	162	162	162
Denton County (Raw Water)	115	130	140	145	150	155	160
Park Cities MUD (Treated Water)							
Highland Park	370	370	370	370	370	370	370
University Park	250	265	270	270	270	270	270
Wilmer (Treated Water)	105	110	115	120	125	130	135
Weighted Subtotal:	174	174	174	173	174	175	176
WEIGHTED TOTAL:	**235**	**242**	**248**	**251**	**254**	**257**	**258**

Table A-3
Per Capita Water Usage Projections (gpcd)
Average Day Use Under Normal Weather Conditions
Recommended Estimate

City	1990	2000	2010	2020	2030	2040	2050
Dallas	264	279	294	299	304	309	309
Treated Water Customers							
Addison	388	388	388	383	378	373	368
Dallas County WCID #6 (Balch Springs)	121	126	131	136	141	146	151
Carrollton	216	221	226	231	236	241	246
Cedar Hill	203	208	213	218	223	228	233
Cockrell Hill	136	146	156	161	166	171	171
Combine WSC	*City of Seagoville Customer, Demand Included with City of Seagoville*						
Coppell	169	179	189	199	209	214	219
D/FW Airport	---	---	---	---	---	---	---
Desoto	176	181	186	191	196	201	201
Duncanville	173	178	183	188	193	198	203
Farmers Branch	358	363	368	373	378	383	388
Flower Mound	125	135	145	155	165	175	185
Glenn Heights	130	140	150	160	165	170	175
Grand Prairie	175	180	185	190	195	200	200
Hutchins	198	213	218	223	228	233	238
Irving	210	230	240	245	250	255	260
Lancaster	148	158	168	173	178	183	188
Lewisville	*Included under Raw Water Customers*						
Mesquite	---	---	---	---	---	---	---
Ovilla	*City of Cedar Hill Customer, Demand Included with City of Cedar Hill*						
Seagoville	139	144	149	154	159	164	169
The Colony	146	166	176	186	196	206	211
Weighted Subtotal:	196	204	209	215	219	223	226
Raw Water Customers							
Argyle	*City of Denton Customer, Demand Included with City of Denton*						
Corinth	*City of Denton Customer, Demand Included with City of Denton*						
Denton	175	185	190	195	200	205	210
DP&L	---	---	---	---	---	---	---
Highland Village	161	191	211	221	226	231	236
Irrigation/Domestic Users	---	---	---	---	---	---	---
Lake Cities	*City of Denton Customer, Demand Included with City of Denton*						
Lewisville	179	184	189	194	199	204	209
Weighted Subtotal:	175	185	191	196	201	206	211
Potential Customers							
Collin County (Raw Water)	150	154	158	162	162	162	162
Denton County (Raw Water)	115	130	140	145	150	155	160
Park Cities MUD (Treated Water)							
Highland Park	368	368	368	368	368	368	368
University Park	245	260	265	265	265	265	265
Wilmer (Treated Water)	105	110	115	120	125	130	135
Weighted Subtotal:	173	173	173	173	173	174	176
WEIGHTED TOTAL:	**230**	**236**	**243**	**246**	**249**	**252**	**253**

Table A-4
Town of Addison
Historic Peaking Factors

Year	Average-Day Demand (mgd)	Peak-Day Demand (mgd)	Peaking Factor
1972	0.224	0.400	1.786
1973	0.318	0.474	1.491
1974	0.393	0.740	1.883
1975	0.458	0.739	1.614
1976	0.542	1.104	2.037
1977	0.724	1.188	1.641
1978	0.945	1.228	1.299
1979	1.169	2.186	1.870
1980	1.545	2.350	1.521
1981	1.905	2.827	1.484
1982	2.074	3.535	1.704
1983	2.638	3.790	1.437
1984	3.136	3.832	1.222
1985	3.224	5.582	1.731
1986	3.198	4.865	1.521
1987	3.535	5.281	1.494
		Average	1.608

Table A-5
City of Balch Springs
Historic Peaking Factors

Year	Average-Day Demand (mgd)	Peak-Day Demand (mgd)	Peaking Factor
1972	0.870	1.186	1.363
1973	0.837	1.313	1.569
1974	0.900	1.500	1.667
1975	1.147	2.086	1.819
1976	1.080	1.620	1.500
1977	1.338	2.257	1.687
1978	1.367	2.375	1.737
1979	1.203	2.315	1.924
1980	1.465	2.300	1.570
1981	1.310	2.206	1.684
1982	1.331	2.292	1.722
1983	1.401	2.044	1.459
1984	1.643	2.280	1.388
1985	1.738	2.711	1.560
1986	1.840	2.972	1.615
1987	1.952	2.687	1.377
		Average	1.603

Table A-6
City of Carrollton
Historic Peaking Factors

Year	Average-Day Demand (mgd)	Peak-Day Demand (mgd)	Peaking Factor
1972	2.901	5.146	1.774
1973	3.463	6.192	1.788
1974	3.732	8.535	2.287
1975	3.394	5.598	1.649
1976	2.528	6.685	2.644
1977	4.091	7.873	1.924
1978	5.837	11.700	2.004
1979	7.098	---	---
1980	9.506	14.918	1.569
1981	8.904	14.627	1.643
1982	9.359	16.534	1.767
1983	10.475	17.266	1.648
1984	12.657	19.189	1.516
1985	15.709	23.770	1.513
1986	13.352	24.378	1.826
1987	14.815	25.197	1.701
		Average	1.817

Table A-7
City of Cedar Hill
Historic Peaking Factors

Year	Average-Day Demand (mgd)	Peak-Day Demand (mgd)	Peaking Factor
1972	---	---	---
1973	---	---	---
1974	0.026	0.141	5.423
1975	0.144	0.474	3.292
1976	0.047	0.237	5.043
1977	0.230	0.538	2.339
1978	0.453	0.743	1.640
1979	0.463	0.585	1.263
1980	0.787	1.308	1.662
1981	0.726	1.125	1.550
1982	0.940	1.375	1.463
1983	1.022	1.484	1.452
1984	1.013	2.100	2.073
1985	1.542	3.300	2.140
1986	2.040	3.937	1.930
1987	2.367	3.478	1.469
		Average	

A peaking factor of 2.140 was established for use consistent with the recommendations of the City's consultants, Shimek, Jacobs, & Finklea, to project peak-day demands.

Table A-8
City of Cockrell Hill
Historic Peaking Factors

Year	Average-Day Demand (mgd)	Peak-Day Demand (mgd)	Peaking Factor
1972	0.339	0.600	1.770
1973	0.302	0.312	1.033
1974	0.321	1.920	5.981
1975	0.306	0.723	2.363
1976	0.287	0.552	1.923
1977	0.321	0.477	1.486
1978	0.347	0.567	1.634
1979	0.314	0.325	1.035
1980	0.391	1.040	2.660
1981	0.352	0.556	1.580
1982	0.374	0.530	1.417
1983	0.382	0.590	1.545
1984	0.402	0.686	1.706
1985	0.451	0.706	1.565
1986	0.392	0.496	1.265
1987	0.392	0.513	1.309
		Average	1.619

Data from 1974 was not used because of the unusually high ratio compared to other years.

Table A-9
City of Coppell
Historic Peaking Factors

Year	Average-Day Demand (mgd)	Peak-Day Demand (mgd)	Peaking Factor
1972	---	---	---
1973	---	---	---
1974	0.105	0.365	3.476
1975	0.134	0.227	1.694
1976	0.155	0.420	2.710
1977	0.187	0.352	1.882
1978	0.193	0.594	3.078
1979	0.190	0.249	1.311
1980	0.451	1.274	2.825
1981	0.593	1.230	2.074
1982	0.715	0.992	1.387
1983	0.726	1.532	2.110
1984	1.211	2.230	1.841
1985	1.567	3.235	2.064
1986	1.731	4.537	2.621
1987	2.189	4.748	2.169
		Average	2.232

Table A-10
City of Dallas
Historic Peaking Factors

Year	Average-Day Demand (mgd)	Peak-Day Demand (mgd)	Peaking Factor
1972	168	320	1.905
1973	149	258	1.732
1974	160	348	2.175
1975	161	282	1.752
1976	163	285	1.748
1977	181	310	1.713
1978	195	363	1.862
1979	186	305	1.640
1980	220	404	1.836
1981	196	335	1.709
1982	199	341	1.714
1983	211	352	1.668
1984	236	395	1.674
1985	242	400	1.653
1986	239	438	1.833
1987	241	418	1.734
		Average	1.773

Table A-11
Dallas/Fort Worth International Airport
Historic Peaking Factors

Year	Average-Day Demand (mgd)	Peak-Day Demand (mgd)	Peaking Factor
1972	---	---	---
1973	---	---	---
1974	1.221	2.000	1.638
1975	0.997	1.416	1.420
1976	1.019	2.400	2.355
1977	1.272	2.400	1.887
1978	1.143	2.596	2.271
1979	1.623	2.459	1.515
1980	1.775	2.758	1.554
1981	1.710	2.872	1.680
1982	1.499	3.600	2.402
1983	1.560	3.515	2.253
1984	2.015	3.601	1.787
1985	1.618	2.365	1.462
1986	1.658	2.458	1.483
1987	1.764	2.482	1.407
		Average	1.794

Table A-12
City of DeSoto
Historic Peaking Factors

Year	Average-Day Demand (mgd)	Peak-Day Demand (mgd)	Peaking Factor
1972	0.005	---	---
1973	0.042	---	---
1974	0.176	0.990	5.625
1975	0.261	0.700	2.682
1976	0.629	2.310	3.672
1977	0.704	2.959	4.203
1978	1.386	3.220	2.323
1979	1.395	2.888	2.070
1980	1.787	4.584	2.565
1981	1.926	4.660	2.420
1982	2.493	5.011	2.010
1983	2.540	4.504	1.773
1984	3.255	5.655	1.737
1985	3.770	7.000	1.857
1986	4.044	7.259	1.795
1987	4.622	8.209	1.776
		Average	2.033

Because of the inconsistent data observed before 1978, only data after 1978 were used to determine the average.

Table A-13
City of Duncanville
Historic Peaking Factors

Year	Average-Day Demand (mgd)	Peak-Day Demand (mgd)	Peaking Factor
1972	1.861	3.595	1.932
1973	1.978	3.480	1.759
1974	2.256	4.947	2.193
1975	2.449	3.675	1.501
1976	2.638	4.312	1.635
1977	3.232	6.111	1.891
1978	3.683	7.383	2.005
1979	3.790	6.676	1.761
1980	4.966	9.333	1.879
1981	4.307	8.348	1.938
1982	4.354	7.893	1.813
1983	4.355	8.424	1.934
1984	5.231	9.006	1.722
1985	5.866	11.617	1.980
1986	5.634	11.529	2.046
1987	6.230	11.714	1.880
		Average	1.867

Table A-14
City of Farmers Branch
Historic Peaking Factors

Year	Average-Day Demand (mgd)	Peak-Day Demand (mgd)	Peaking Factor
1972	4.299	8.500	1.977
1973	4.374	9.000	2.058
1974	4.492	9.450	2.104
1975	3.564	7.761	2.178
1976	4.469	9.221	2.063
1977	5.245	10.261	1.956
1978	5.541	12.434	2.244
1979	5.152	10.226	1.985
1980	6.746	13.654	2.024
1981	5.819	11.171	1.920
1982	5.702	11.880	2.083
1983	6.368	12.256	1.925
1984	7.679	---	---
1985	7.807	11.278	1.445
1986	7.854	15.611	1.988
1987	8.630	16.364	1.896
		Average	1.990

Table A-15
Town of Flower Mound
Historic Peaking Factors

Year	Average-Day Demand (mgd)	Peak-Day Demand (mgd)	Peaking Factor
1972	---	---	---
1973	---	---	---
1974	0.003	---	---
1975	0.042	0.083	1.976
1976	0.059	---	---
1977	0.095	0.196	2.063
1978	0.260	0.800	3.077
1979	0.317	0.853	2.691
1980	0.468	0.845	1.806
1981	0.449	1.082	2.410
1982	0.558	1.282	2.297
1983	0.728	1.397	1.919
1984	1.089	1.994	1.831
1985	1.309	2.630	2.009
1986	1.340	3.200	2.388
1987	1.480	4.850	3.277
		Average	2.312

Table A-16
City of Grand Prarie
Historic Peaking Factors

Year	Average-Day Demand (mgd)	Peak-Day Demand (mgd)	Peaking Factor
1972	2.410	---	---
1973	2.588	---	---
1974	4.538	---	---
1975	1.863	---	---
1976	0.970	---	---
1977	1.838	---	---
1978	2.549	---	---
1979	2.787	---	---
1980	3.441	20.681	6.010
1981	3.036	11.583	3.815
1982	1.873	13.791	7.363
1983	4.105	11.695	2.849
1984	7.454	16.041	2.152
1985	7.761	14.836	1.912
1986	6.352	15.539	2.446
1987	7.853	11.998	1.528
		Average	

A peaking factor of 1.960 was established for use consistent with Grand Prarie's recent Long-Range Water Supply Plan - 1988.

Table A-17
City of Hutchins
Historic Peaking Factors

Year	Average-Day Demand (mgd)	Peak-Day Demand (mgd)	Peaking Factor
1972	0.128	0.400	3.125
1973	0.023	0.045	1.957
1974	0.040	0.250	6.250
1975	0.042	0.106	2.542
1976	0.056	0.057	1.018
1977	0.040	0.092	2.300
1978	0.070	0.139	1.986
1979	0.051	---	---
1980	0.192	0.546	2.844
1981	0.091	0.114	1.253
1982	0.144	0.373	2.590
1983	0.190	0.362	1.905
1984	0.308	0.415	1.347
1985	0.488	0.531	1.088
1986	0.570	0.927	1.626
1987	0.664	0.845	1.273
		Average	1.741

Because of the small usage before 1980, only the data from 1980–1987 was used to determine the average peaking factor.

Table A-18
City of Irving
Historic Peaking Factors

Year	Average-Day Demand (mgd)	Peak-Day Demand (mgd)	Peaking Factor
1972	12.166	---	---
1973	8.050	---	---
1974	8.697	---	---
1975	8.320	---	---
1976	9.493	---	---
1977	12.796	---	---
1978	12.893	---	---
1979	11.974	---	---
1980	16.818	24.017	1.428
1981	14.221	31.505	2.215
1982	18.841	33.714	1.789
1983	15.384	30.216	1.964
1984	20.682	35.313	1.707
1985	23.114	40.780	1.764
1986	24.403	52.271	2.142
1987	27.196	52.928	1.946
		Average	1.869

Table A-19
City of Lancaster
Historic Peaking Factors

Year	Average-Day Demand (mgd)	Peak-Day Demand (mgd)	Peaking Factor
1972	0.516	1.500	2.907
1973	0.465	0.859	1.847
1974	0.049	0.859	17.531
1975	0.064	0.202	3.156
1976	0.134	0.537	4.007
1977	0.187	0.879	4.701
1978	0.385	1.372	3.564
1979	0.324	1.052	3.247
1980	0.721	1.798	2.494
1981	0.504	-----	------
1982	0.971	-----	------
1983	0.601	0.824	1.371
1984	0.585	1.792	3.063
1985	0.620	3.800	6.129
1986	2.063	2.799	1.357
1987	2.727	3.311	1.214
		Average	

Because of the large variances observed in the City of Lancaster's data, and small volumes taken before 1986, the system average peaking factor (1.856) was used.

Table A-20
City of Seagoville
Historic Peaking Factors

Year	Average-Day Demand (mgd)	Peak-Day Demand (mgd)	Peaking Factor
1972	0.602	0.943	1.566
1973	0.526	0.929	1.766
1974	0.603	1.153	1.912
1975	0.664	1.155	1.739
1976	0.622	1.117	1.796
1977	0.761	1.386	1.821
1978	0.826	1.600	1.937
1979	0.844	0.886	1.050
1980	1.021	1.798	1.761
1981	0.878	1.576	1.795
1982	0.960	1.652	1.721
1983	1.080	1.723	1.595
1984	1.205	2.000	1.660
1985	1.196	2.274	1.901
1986	1.240	1.944	1.568
1987	1.314	1.961	1.492
		Average	1.693

Table A-21
City of The Colony
Historic Peaking Factors

Year	Average-Day Demand (mgd)	Peak-Day Demand (mgd)	Peaking Factor
1972	---	---	---
1973	---	---	---
1974	---	---	---
1975	---	---	---
1976	---	---	---
1977	---	---	---
1978	---	---	---
1979	---	---	---
1980	---	---	---
1981	---	---	---
1982	---	---	---
1983	---	---	---
1984	---	---	---
1985	1.524	1.732	1.136
1986	1.795	2.487	1.386
1987	1.871	2.504	1.338
		Average	

Because of the small sample size, the system average peaking factor (1.856) was used.

Table A-22
Summary of Peaking Factors

Entity	Peaking Factor
Dallas	1.773
<u>Treated Water Customers</u>	
Addison	1.608
Balch Springs	1.603
Carrollton	1.817
Cedar Hill	2.140
Cockrell Hill	1.619
Combine WSC (1)	City of Seagoville Customer
Coppell	2.232
D/FW Airport	1.794
Desoto	2.033
Duncanville	1.867
Farmers Branch	1.990
Flower Mound	2.312
Glenn Heights	1.856
Grand Prairie	1.960
Hutchins	1.741
Irving	1.869
Lancaster	1.856
Lewisville	1.970
Ovilla (1)	City of Cedar Hill Customer
Seagoville	1.693
The Colony	1.856
<u>Raw Water Customers</u>	
Argyle (1)	City of Denton Customer
Corinth (1)	City of Denton Customer
Denton	2.100
Highland Village (1)	City of Lewisville Customer
Lake Cities (1)	City of Denton Customer
Lewisville	1.970
<u>Potential Customers</u>	
Collin County	1.856
Denton County	1.856
Highland Park	1.856
University Park	1.856
Wilmer	1.856

(1) Peaking factor included with supplying City.

Table A-23
Historic Cooling/Irrigation/Domestic Demands

Historic Water Demand (Thousands of Gallons)

Year	Municipal Usage (1)	North Lake DP&L (2) (Elm Fork)	DP&L (2) Hubbard	Irrigation (2)	Domestic (2)	Total System Usage
1979	78,019,692	1,547,792	926,069	128,385	31,282	80,653,220
1979	73,632,134	1,572,557	807,133	74,620	38,125	76,124,569
1980	96,395,248	684,287	828,639	195,931	35,192	98,139,297
1981	81,719,053	261	692,108	100,036	30,956	82,542,414
1982	89,844,699	1,985,084	638,342	32,585	25,416	92,526,126
1983	90,292,709	273,389	692,108	86,676	29,815	91,374,697
1984	113,415,877	1,252,669	716,220	89,609	26,883	115,501,258
1985	115,135,415	552,611	931,021	321,615	27,046	116,967,708
1986	113,144,439	1,575,815	836,394	522,665	43,664	116,122,977
1987	125,832,912	1,114,085	919,649	491,351	46,597	128,404,594

(1) From DWU Consumption Records.
(2) From DWU Annual Surface Water Reports

Table A-24
Other System Water Demands

Purpose	Average Day Water Demand Projections (mgd)						
	1990	2000	2010	2020	2030	2040	2050
Cooling (DP&L)							
North Lake (Elm Fork	2.62	2.62	2.62	2.62	2.62	2.62	2.62
Hubbard	2.68	2.68	2.68	2.68	2.68	2.68	2.68
Sub-Total	5.30	5.30	5.30	5.30	5.30	5.30	5.30
Irrigation	1.89	2.30	2.69	2.98	3.23	3.48	3.68
Domestic	0.17	0.20	0.24	0.26	0.29	0.31	0.33
Total	7.36	7.80	8.23	8.54	8.82	9.09	9.31

Table A-25
Projections of Average-Day Demands for DWU Recommended Planning Area (mgd)
Normal Weather Conditions Without Water Conservation Measures

City	1990	2000	2010	2020	2030	2040	2050
Dallas	256.94	288.79	320.37	340.21	358.81	376.29	386.50
Treated Water Customers							
Addison	3.64	4.75	5.59	6.14	6.52	6.78	6.94
Dallas County WCID #6 (Balch Springs)	2.22	2.77	3.25	3.67	4.05	4.40	4.71
Carrollton	18.11	26.22	33.14	39.09	44.22	48.68	52.59
Cedar Hill	4.32	7.01	9.63	12.18	14.66	17.08	19.42
Cockrell Hill	0.42	0.45	0.48	0.50	0.52	0.53	0.53
Combine WSC	*City of Seagoville Customer, Demand Included with City of Seagoville*						
Coppell	3.04	5.28	7.35	9.26	11.02	12.37	13.56
D/FW Airport	2.88	3.69	4.51	5.33	6.15	6.98	7.80
Desoto	5.62	8.21	10.49	12.51	14.31	15.91	16.92
Duncanville	6.53	7.70	8.46	9.00	9.42	9.76	10.06
Farmers Branch	8.77	9.60	10.51	12.92	13.09	13.27	13.44
Flower Mound	2.05	3.62	5.22	6.82	8.42	10.00	11.56
Glenn Heights	0.70	1.33	2.00	2.71	3.35	3.99	4.63
Grand Prairie	17.92	23.31	28.34	33.05	37.46	41.60	44.39
Hutchins	0.56	0.66	0.70	0.75	0.80	0.84	0.89
Irving	35.81	47.13	53.86	57.69	60.44	62.56	64.31
Lancaster	3.47	4.94	6.43	7.70	8.93	10.11	11.24
Lewisville	1.00	4.57	4.57	4.57	4.57	4.57	4.57
Mesquite	0.30	---	---	---	---	---	---
Ovilla	*City of Cedar Hill Customer, Demand Included with City of Cedar Hill*						
Seagoville	1.63	2.63	4.02	4.48	4.96	5.48	6.03
The Colony	2.94	4.47	5.78	7.08	8.35	9.60	10.58
Subtotal:	121.95	168.34	204.35	235.46	261.25	284.50	304.17
Raw Water Customers							
Argyle	*City of Denton Customer, Demand Included with City of Denton*						
Corinth	*City of Denton Customer, Demand Included with City of Denton*						
Denton	14.98	21.58	27.38	34.13	41.74	50.53	60.98
DP&L	5.30	5.30	5.30	5.30	5.30	5.30	5.30
Highland Village	*City of Lewisville Customer, Demand Included with City of Lewisville*						
Irrigation/Domestic Users	2.06	2.5	2.94	3.24	3.52	3.79	4.01
Lake Cities	*City of Denton Customer, Demand Included with City of Denton*						
Lewisville	9.39	12.69	20.00	21.51	22.17	22.83	23.49
Subtotal:	31.73	42.07	55.62	64.18	72.73	82.45	93.78
Potential Customers							
Collin County (Raw Water)	1.49	2.13	2.92	3.84	4.51	5.17	5.81
Denton County (Raw Water)	5.62	9.20	12.91	16.40	20.03	23.79	27.67
Park Cities MUD (Treated Water)							
Highland Park	3.23	3.23	3.23	3.23	3.23	3.23	3.23
University Park	5.32	5.64	5.75	5.75	5.75	5.75	5.75
Wilmer (Treated Water)	0.37	0.51	0.65	0.78	0.90	1.06	1.22
Subtotal:	16.03	20.73	25.46	30.01	34.42	39.00	43.68
TOTAL:	**426.6**	**519.9**	**605.8**	**669.9**	**727.2**	**782.2**	**828.1**

Table A-26
Projections of Average-Day Demands to be Supplied to Recommended Planning Area by DWU (mgd)
Normal Weather Conditions Without Water Conservation Measures

City	1990	2000	2010	2020	2030	2040	2050
Dallas	256.94	288.79	320.37	340.21	358.81	376.29	386.50
Treated Water Customers							
Addison	3.64	4.75	5.59	6.14	6.52	6.78	6.94
Dallas County WCID #6 (Balch Springs)	2.22	2.77	3.25	3.67	4.05	4.40	4.71
Carrollton	17.78	26.22	33.14	39.09	44.22	48.68	52.59
Cedar Hill	4.32	0.53	3.15	5.70	8.18	10.60	12.94
Cockrell Hill	0.42	0.45	0.48	0.50	0.52	0.53	0.53
Combine WSC	*City of Seagoville Customer, Demand Included with City of Seagoville*						
Coppell	3.04	5.28	7.35	9.26	11.02	12.37	13.56
D/FW Airport	1.73	2.21	2.71	3.20	3.69	4.19	4.68
Desoto	5.62	8.21	10.49	12.51	14.31	15.91	16.92
Duncanville	6.53	6.64	7.40	7.94	8.36	8.70	9.00
Farmers Branch	8.77	9.60	10.51	12.92	13.09	13.27	13.44
Flower Mound	2.05	3.62	5.22	6.82	8.42	10.00	11.56
Glenn Heights	0.70	1.33	2.00	2.71	3.35	3.99	4.63
Grand Prairie	13.02	18.03	23.76	28.47	32.88	37.02	39.81
Hutchins	0.56	0.66	0.70	0.75	0.80	0.84	0.89
Irving	34.56	7.63	14.36	18.19	20.94	23.06	24.81
Lancaster	3.47	4.94	6.43	7.70	8.93	10.11	11.24
Lewisville	1.00	4.57	4.57	4.57	4.57	4.57	4.57
Mesquite	0.30	---	---	---	---	---	---
Ovilla	*City of Cedar Hill Customer, Demand Included with City of Cedar Hill*						
Seagoville	1.63	2.63	4.02	4.48	4.96	5.48	6.03
The Colony	2.94	4.47	5.78	7.08	8.35	9.60	10.58
Subtotal:	114.31	114.55	150.92	181.71	207.17	230.09	249.43
Raw Water Customers							
Argyle	*City of Denton Customer, Demand Included with City of Denton*						
Corinth	*City of Denton Customer, Demand Included with City of Denton*						
Denton	0.00	0.00	3.32	10.07	17.68	26.47	36.92
DP&L	5.30	5.30	5.30	5.30	5.30	5.30	5.30
Highland Village	*City of Lewisville Customer, Demand Included with City of Lewisville*						
Irrigation/Domestic Users	2.06	2.50	2.94	3.24	3.52	3.79	4.01
Lake Cities	*City of Denton Customer, Demand Included with City of Denton*						
Lewisville	9.39	12.69	20.00	21.51	22.17	22.83	23.49
Subtotal:	16.75	20.49	31.56	40.12	48.67	58.39	69.72
Potential Customers							
Collin County (Raw Water)	0.00	2.13	2.92	3.84	4.51	5.17	5.81
Denton County (Raw Water)	0.00	9.20	12.91	16.40	20.03	23.79	27.67
Park Cities MUD (Treated Water)							
Highland Park	0.00	0.21	0.21	0.21	0.21	0.21	0.21
University Park	0.00	2.62	2.73	2.73	2.73	2.73	2.73
Wilmer (Treated Water)	0.00	0.51	0.65	0.78	0.90	1.06	1.22
Subtotal:	0.00	14.69	19.42	23.97	28.38	32.96	37.64
TOTAL:	**388.0**	**438.5**	**522.3**	**586.0**	**643.0**	**697.7**	**743.3**

Assumes full use of each customer entity's alternate supply sources.

Table A-27
Projections of Peak-Day Demands for DWU Recommended Planning Area (mgd)
Normal Weather Conditions Without Water Conservation Measures

City	1990	2000	2010	2020	2030	2040	2050
Dallas	455.55	512.03	568.01	603.19	636.16	667.16	685.27
Treated Water Customers							
Addison	5.85	7.64	8.99	9.87	10.49	10.90	11.17
Dallas County WCID #6 (Balch Springs)	3.56	4.44	5.21	5.89	6.50	7.05	7.54
Carrollton	32.91	47.64	60.22	71.03	80.35	88.46	95.56
Cedar Hill	9.25	15.01	20.61	26.07	31.38	36.54	41.57
Cockrell Hill	0.68	0.73	0.78	0.81	0.83	0.86	0.86
Combine WSC	*City of Seagoville Customer, Demand Included with City of Seagoville*						
Coppell	6.78	11.79	16.41	20.67	24.60	27.61	30.27
D/FW Airport	5.17	6.62	8.09	9.56	11.03	12.52	13.99
Desoto	11.42	16.69	21.33	25.44	29.08	32.34	34.40
Duncanville	12.19	14.37	15.80	16.81	17.58	18.22	18.78
Farmers Branch	17.46	19.11	20.92	25.71	26.06	26.40	26.75
Flower Mound	4.73	8.38	12.07	15.77	19.46	23.12	26.74
Glenn Heights	1.30	2.47	3.71	5.03	6.22	7.40	8.58
Grand Prairie	35.13	45.69	55.56	64.78	73.43	81.54	86.99
Hutchins	0.98	1.15	1.21	1.30	1.39	1.46	1.55
Irving	66.93	88.09	100.67	107.83	112.97	116.92	120.20
Lancaster	6.44	9.16	11.92	14.30	16.58	18.76	20.87
Lewisville	1.97	9.00	9.00	9.00	9.00	9.00	9.00
Mesquite	0.30	---	---	---	---	---	---
Ovilla	*City of Cedar Hill Customer, Demand Included with City of Cedar Hill*						
Seagoville	2.77	4.45	6.81	7.58	8.40	9.28	10.20
The Colony	5.46	8.29	10.73	13.14	15.50	17.82	19.63
Subtotal:	231.28	320.71	390.04	450.58	500.85	546.21	584.65
Raw Water Customers							
Argyle	*City of Denton Customer, Demand Included with City of Denton*						
Corinth	*City of Denton Customer, Demand Included with City of Denton*						
Denton	31.46	45.33	57.50	71.68	87.65	106.12	128.05
DP&L	5.30	5.30	5.30	5.30	5.30	5.30	5.30
Highland Village	*City of Lewisville Customer, Demand Included with City of Lewisville*						
Irrigation/Domestic Users	2.06	2.50	2.94	3.24	3.52	3.79	4.01
Lake Cities	*City of Denton Customer, Demand Included with City of Denton*						
Lewisville	18.69	25.45	39.98	43.01	44.32	45.62	46.94
Subtotal:	57.51	78.58	105.72	123.23	140.79	160.83	184.30
Potential Customers							
Collin County (Raw Water)	2.76	3.96	5.42	7.13	8.37	9.59	10.78
Denton County (Raw Water)	10.44	17.08	23.96	30.44	37.17	44.15	51.36
Park Cities MUD (Treated Water)							
Highland Park	6.00	6.00	6.00	6.00	6.00	6.00	6.00
University Park	9.87	10.47	10.67	10.67	10.67	10.67	10.67
Wilmer (Treated Water)	0.68	0.95	1.21	1.45	1.68	1.97	2.27
Subtotal:	29.75	38.47	47.26	55.69	63.89	72.38	81.08
TOTAL:	**774.1**	**949.8**	**1111.0**	**1232.7**	**1341.7**	**1446.6**	**1535.3**

Table A-28
Projections of Peak-Day Demands to be Supplied to Recommended Planning Area by DWU (mgd)
Normal Weather Conditions Without Water Conservation Measures (1)

City	1990	2000	2010	2020	2030	2040	2050
Dallas	455.55	512.03	568.01	603.19	636.16	667.16	685.27
Treated Water Customers							
Addison	5.85	7.64	8.99	9.87	10.49	10.90	11.17
Dallas County WCID #6 (Balch Springs)	3.56	4.44	5.21	5.89	6.50	7.05	7.54
Carrollton	32.31	47.64	60.22	71.03	80.35	88.46	95.56
Cedar Hill	9.25	1.14	6.75	12.20	17.51	22.67	27.70
Cockrell Hill	0.68	0.73	0.78	0.81	0.83	0.86	0.86
Combine WSC	*City of Seagoville Customer, Demand included with City of Seagoville*						
Coppell	6.78	11.79	16.41	20.67	24.60	27.61	30.27
D/FW Airport	3.10	3.97	4.85	5.74	6.62	7.51	8.40
Desoto	11.42	16.69	21.33	25.44	29.08	32.34	34.40
Duncanville	12.19	12.39	13.82	14.83	15.60	16.24	16.80
Farmers Branch	17.46	19.11	20.92	25.71	26.06	26.40	26.75
Flower Mound	4.73	8.38	12.07	15.77	19.46	23.12	26.74
Glenn Heights	1.30	2.47	3.71	5.03	6.22	7.40	8.58
Grand Prairie	22.03	29.57	41.24	50.46	59.11	67.22	72.67
Hutchins	0.98	1.15	1.21	1.30	1.39	1.46	1.55
Irving (2)	61.93	88.09	100.67	107.83	112.97	116.92	120.20
Lancaster	6.44	9.16	11.92	14.30	16.58	18.76	20.87
Lewisville	1.97	9.00	9.00	9.00	9.00	9.00	9.00
Mesquite	0.30	---	---	---	---	---	---
Ovilla	*City of Cedar Hill Customer, Demand Included with City of Cedar Hill*						
Seagoville	2.77	4.45	6.81	7.58	8.40	9.28	10.20
The Colony	5.46	8.29	10.73	13.14	15.50	17.82	19.63
Subtotal:	210.52	286.10	356.64	416.59	466.27	511.03	548.89
Raw Water Customers							
Argyle	*City of Denton Customer, Demand Included with City of Denton*						
Corinth	*City of Denton Customer, Demand Included with City of Denton*						
Denton	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DP&L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Highland Village	*City of Lewisville Customer, Demand Included with City of Lewisville*						
Irrigation/Domestic Users	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lake Cities	*City of Denton Customer, Demand Included with City of Denton*						
Lewisville	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subtotal:	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potential Customers							
Collin County (Raw Water)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denton County (Raw Water)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Park Cities MUD (Treated Water)							
Highland Park	0.00	0.40	0.40	0.40	0.40	0.40	0.40
University Park	0.00	4.87	5.07	5.07	5.07	5.07	5.07
Wilmer (Treated Water)	0.00	0.95	1.21	1.45	1.68	1.97	2.27
Subtotal:	0.00	6.22	6.67	6.92	7.14	7.43	7.73
TOTAL:	**666.1**	**804.3**	**931.3**	**1026.7**	**1109.6**	**1185.6**	**1241.9**

(1) Assumes full use of each customer entity's alternate supply sources.
(2) Includes 79.0 mgd peak supply from Cooper Reservoir.

Table A-29
Projections of Average-Day Demands to be Supplied to Recommended Planning Area by DWU
Extended Drought Weather Conditions Without Water Conservation Measures

City	1990	2000	2010	2020	2030	2040	2050
Dallas	272.36	306.12	339.59	360.62	380.34	398.87	409.69
Treated Water Customers							
Addison	3.85	5.04	5.93	6.51	6.91	7.19	7.36
Dallas County WCID #6 (Balch Springs)	2.36	2.93	3.44	3.89	4.30	4.66	4.99
Carrollton	18.85	27.79	35.13	41.43	46.88	51.61	55.75
Cedar Hill	4.58	0.57	3.34	6.04	8.67	11.23	13.72
Cockrell Hill	0.45	0.48	0.51	0.53	0.55	0.56	0.56
Combine WSC	*City of Seagoville Customer, Demand Included with City of Seagoville*						
Coppell	3.22	5.60	7.79	9.81	11.68	13.11	14.37
D/FW Airport	1.83	2.35	2.87	3.39	3.91	4.44	4.96
Desoto	5.95	8.70	11.12	13.26	15.16	16.86	17.94
Duncanville	6.92	7.04	7.85	8.42	8.86	9.22	9.54
Farmers Branch	9.30	10.18	11.14	13.70	13.88	14.06	14.25
Flower Mound	2.17	3.84	5.53	7.23	8.92	10.60	12.26
Glenn Heights	0.74	1.41	2.12	2.87	3.55	4.23	4.90
Grand Prairie	13.80	19.11	25.19	30.18	34.86	39.24	42.19
Hutchins	0.60	0.70	0.74	0.79	0.84	0.89	0.94
Irving	36.64	8.09	15.22	19.29	22.20	24.44	26.30
Lancaster	3.68	5.23	6.81	8.17	9.47	10.72	11.92
Lewisville	1.06	4.84	4.84	4.84	4.84	4.84	4.84
Mesquite	0.30	---	---	---	---	---	---
Ovilla	*City of Cedar Hill Customer, Demand Included with City of Cedar Hill*						
Seagoville	1.73	2.79	4.26	4.75	5.26	5.81	6.39
The Colony	3.12	4.74	6.13	7.50	8.85	10.18	11.21
Subtotal:	121.15	121.42	159.98	192.61	219.60	243.89	264.40
Raw Water Customers							
Argyle	*City of Denton Customer, Demand Included with City of Denton*						
Corinth	*City of Denton Customer, Demand Included with City of Denton*						
Denton	0.00	0.00	3.52	10.68	18.74	28.06	39.13
DP&L	5.30	5.30	5.30	5.30	5.30	5.30	5.30
Highland Village	*City of Lewisville Customer, Demand Included with City of Lewisville*						
Irrigation/Domestic Users	2.06	2.50	2.94	3.24	3.52	3.79	4.01
Lake Cities	*City of Denton Customer, Demand Included with City of Denton*						
Lewisville	9.95	13.45	21.20	22.81	23.50	24.21	24.90
Subtotal:	17.31	21.25	32.96	42.03	51.06	61.36	73.34
Potential Customers							
Collin County (Raw Water)	0.00	2.26	3.10	4.07	4.78	5.48	6.16
Denton County (Raw Water)	0.00	9.76	13.68	17.38	21.23	25.21	29.33
Park Cities MUD (Treated Water)							
Highland Park	0.00	0.23	0.23	0.23	0.23	0.23	0.23
University Park	0.00	2.78	2.89	2.89	2.89	2.89	2.89
Wilmer (Treated Water)	0.00	0.54	0.69	0.83	0.96	1.12	1.29
Subtotal:	0.00	15.57	20.59	25.40	30.09	34.93	39.90
TOTAL:	**410.8**	**464.4**	**553.1**	**620.7**	**681.1**	**739.1**	**787.3**

Assumes full use of each customer entity's alternate supply sources.
Extended Drought Weather Conditions are expected to result in 6% higher demand than under Normal Weather Conditions.

Table A-30
Projections of Peak-Day Demands to be Supplied to Recommended Planning Area by DWU
One Year Maximum Drought Weather Conditions Without Water Conservation Measures (1)

City	Drought Factor	1990	2000	2010	2020	2030	2040	2050
Dallas	1.15	522.97	587.81	652.07	692.46	730.32	765.90	786.69
<u>Treated Water Customers</u>								
Addison	1.11	6.49	8.48	9.98	10.96	11.64	12.10	12.39
Dallas County WCID #6 (2)	1.17	4.17	5.19	6.09	6.89	7.60	8.24	8.83
Carrollton	1.27	41.03	60.50	76.48	90.20	102.05	112.34	121.36
Cedar Hill	1.28	11.85	1.46	8.63	15.62	22.41	29.02	35.46
Cockrell Hill	1.13	0.77	0.83	0.89	0.91	0.94	0.97	0.97
Combine WSC	*City of Seagoville Customer, Demand Included with City of Seagoville*							
Coppell	1.15	7.80	13.56	18.87	23.77	28.29	31.75	34.81
D/FW Airport	1.35	4.19	5.36	6.55	7.75	8.94	10.14	11.33
Desoto	1.13	12.90	18.86	24.11	28.74	32.86	36.54	38.88
Duncanville	1.25	15.24	15.49	17.28	18.54	19.50	20.30	21.00
Farmers Branch	1.25	21.82	23.89	26.15	32.14	32.57	33.00	33.43
Flower Mound	1.21	5.72	10.13	14.60	19.08	23.55	27.97	32.35
Glenn Heights	1.17	1.52	2.89	4.34	5.88	7.28	8.66	10.04
Grand Prairie	1.14	25.11	33.71	47.01	57.53	67.38	76.63	82.85
Hutchins	1.17	1.15	1.34	1.42	1.52	1.62	1.70	1.81
Irving (3)	1.28	80.12	112.76	128.86	138.02	144.60	149.66	153.86
Lancaster	1.11	7.15	10.17	13.24	15.87	18.40	20.83	23.16
Lewisville		2.30	9.00	9.00	9.00	9.00	9.00	9.00
Mesquite	1.17	0.30	---	---	---	---	---	---
Ovilla	*City of Cedar Hill Customer, Demand Included with City of Cedar Hill*							
Seagoville	1.17	3.24	5.21	7.96	8.87	9.83	10.85	11.94
The Colony	1.17	6.39	9.70	12.56	15.37	18.14	20.85	22.96
Subtotal:		259.26	348.53	434.02	506.66	566.61	620.59	666.45
<u>Raw Water Customers</u>								
Argyle	*City of Denton Customer, Demand Included with City of Denton*							
Corinth	*City of Denton Customer, Demand Included with City of Denton*							
Denton	1.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DP&L		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Highland Village	*City of Lewisville Customer, Demand Included with City of Lewisville*							
Irrigation/Domestic Users		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lake Cities	*City of Denton Customer, Demand Included with City of Denton*							
Lewisville	1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subtotal:		0.00	0.00	0.00	0.00	0.00	0.00	0.00
<u>Potential Customers</u>								
Collin County (Raw Water)	1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denton County (Raw Water)	1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Park Cities MUD (Treated Water)								
Highland Park	1.11	0.00	0.44	0.44	0.44	0.44	0.44	0.44
University Park	1.08	0.00	5.26	5.47	5.47	5.47	5.47	5.47
Wilmer (Treated Water)	1.17	0.00	1.12	1.41	1.70	1.96	2.30	2.65
Subtotal:		0.00	6.81	7.33	7.61	7.88	8.21	8.56
TOTAL:		**782.2**	**943.2**	**1093.4**	**1206.7**	**1304.8**	**1394.7**	**1461.7**

(1) Assumes full use of each customer entity's alternate supply sources.
(2) Balch Springs
(3) Includes 79.0 mgd peak supply from Cooper Reservoir.

Table A-31
Projections of Average-Day Demands for DWU Recommended Planning Area (mgd)
Normal Weather Conditions With Water Conservation Measures

City	1990	2000	2010	2020	2030	2040	2050
Dallas	256.94	268.58	299.54	318.09	335.48	352.77	362.35
Treated Water Customers							
Addison	3.64	4.42	5.23	5.74	6.10	6.36	6.51
Dallas County WCID #6 (Balch Springs)	2.22	2.57	3.04	3.43	3.79	4.12	4.41
Carrollton	18.11	24.38	30.99	36.55	41.35	45.64	49.31
Cedar Hill	4.32	6.52	9.01	11.39	13.71	16.01	18.21
Cockrell Hill	0.42	0.42	0.45	0.47	0.48	0.50	0.50
Combine WSC	*City of Seagoville Customer, Demand Included with City of Seagoville*						
Coppell	3.04	4.91	6.87	8.66	10.31	11.60	12.71
D/FW Airport	2.88	3.43	4.22	4.98	5.75	6.54	7.31
Desoto	5.62	7.63	9.81	11.70	13.38	14.91	15.87
Duncanville	6.53	7.16	7.91	8.42	8.80	9.15	9.43
Farmers Branch	8.77	8.93	9.83	12.08	12.24	12.44	12.60
Flower Mound	2.05	3.37	4.88	6.38	7.87	9.37	10.84
Glenn Heights	0.70	1.24	1.87	2.53	3.13	3.74	4.34
Grand Prairie	17.92	21.68	26.50	30.90	35.03	39.00	41.61
Hutchins	0.56	0.61	0.65	0.70	0.74	0.78	0.83
Irving	35.81	43.83	50.36	53.94	56.51	58.65	60.29
Lancaster	3.47	4.59	6.01	7.20	8.35	9.48	10.54
Lewisville	1.00	4.25	4.27	4.27	4.27	4.28	4.28
Mesquite	0.30	---	---	---	---	---	---
Ovilla	*City of Cedar Hill Customer, Demand Included with City of Cedar Hill*						
Seagoville	1.63	2.44	3.76	4.19	4.64	5.14	5.65
The Colony	2.94	4.16	5.41	6.62	7.81	9.00	9.91
Subtotal:	121.95	156.56	191.07	220.16	244.27	266.72	285.16
Raw Water Customers							
Argyle	*City of Denton Customer, Demand Included with City of Denton*						
Corinth	*City of Denton Customer, Demand Included with City of Denton*						
Denton	14.98	20.07	25.60	31.91	39.03	47.37	57.17
DP&L	5.30	5.30	5.30	5.30	5.30	5.30	5.30
Highland Village	*City of Lewisville Customer, Demand Included with City of Lewisville*						
Irrigation/Domestic Users	2.06	2.33	2.75	3.03	3.29	3.55	3.76
Lake Cities	*City of Denton Customer, Demand Included with City of Denton*						
Lewisville	9.39	11.80	18.70	20.11	20.73	21.40	22.02
Subtotal:	31.73	39.50	52.35	60.36	68.35	77.63	88.25
Potential Customers							
Collin County (Raw Water)	1.49	1.98	2.73	3.59	4.22	4.84	5.44
Denton County (Raw Water)	5.62	8.56	12.07	15.33	18.72	22.30	25.94
Park Cities MUD (Treated Water)							
Highland Park	3.23	3.01	3.02	3.02	3.02	3.03	3.03
University Park	5.32	5.25	5.38	5.38	5.38	5.39	5.39
Wilmer (Treated Water)	0.37	0.48	0.61	0.73	0.84	0.99	1.14
Subtotal:	16.03	19.28	23.81	28.06	32.19	36.56	40.95
TOTAL:	**426.6**	**483.9**	**566.8**	**626.7**	**680.3**	**733.7**	**776.7**

Table A-32
Projections of Average-Day Demands to be Supplied to Recommended Planning Area by DWU (mgd)
Normal Weather Conditions With Water Conservation Measures

City	1990	2000	2010	2020	2030	2040	2050
Dallas	256.94	268.58	299.54	318.09	335.48	352.77	362.35
Treated Water Customers							
Addison	3.64	4.42	5.23	5.74	6.10	6.36	6.51
Dallas County WCID #6 (Balch Springs)	2.22	2.57	3.04	3.43	3.79	4.12	4.41
Carrollton	17.78	24.38	30.99	36.55	41.35	45.64	49.31
Cedar Hill	4.32	0.50	2.95	5.33	7.65	9.93	12.13
Cockrell Hill	0.42	0.42	0.45	0.47	0.48	0.50	0.50
Combine WSC	*City of Seagoville Customer, Demand Included with City of Seagoville*						
Coppell	3.04	4.91	6.87	8.66	10.31	11.60	12.71
D/FW Airport	1.73	2.06	2.53	2.99	3.45	3.93	4.39
Desoto	5.62	7.63	9.81	11.70	13.38	14.91	15.87
Duncanville	6.53	6.17	6.92	7.43	7.81	8.15	8.44
Farmers Branch	8.77	8.93	9.83	12.08	12.24	12.44	12.60
Flower Mound	2.05	3.37	4.88	6.38	7.87	9.37	10.84
Glenn Heights	0.70	1.24	1.87	2.53	3.13	3.74	4.34
Grand Prairie	13.02	16.77	22.22	26.62	30.75	34.71	37.32
Hutchins	0.56	0.61	0.65	0.70	0.74	0.78	0.83
Irving	34.56	7.10	13.43	17.01	19.58	21.62	23.26
Lancaster	3.47	4.59	6.01	7.20	8.35	9.48	10.54
Lewisville	1.00	4.25	4.27	4.27	4.27	4.28	4.28
Mesquite	0.30	---	---	---	---	---	---
Ovilla	*City of Cedar Hill Customer, Demand Included with City of Seagoville*						
Seagoville	1.63	2.44	3.76	4.19	4.64	5.14	5.65
The Colony	2.94	4.16	5.41	6.62	7.81	9.00	9.91
Subtotal:	114.31	106.53	141.11	169.90	193.71	215.71	233.84
Raw Water Customers							
Argyle	*City of Denton Customer, Demand Included with City of Denton*						
Corinth	*City of Denton Customer, Demand Included with City of Denton*						
Denton	0.00	0.00	3.10	9.42	16.53	24.82	34.61
DP&L	5.30	5.30	5.30	5.30	5.30	5.30	5.30
Highland Village	*City of Lewisville Customer, Demand Included with City of Lewisville*						
Irrigation/Domestic Users	2.06	2.33	2.75	3.03	3.29	3.55	3.76
Lake Cities	*City of Denton Customer, Demand Included with City of Denton*						
Lewisville	9.39	11.80	18.70	20.11	20.73	21.40	22.02
Subtotal:	16.75	19.43	29.85	37.86	45.85	55.07	65.69
Potential Customers							
Collin County (Raw Water)	0.00	1.98	2.73	3.59	4.22	4.84	5.44
Denton County (Raw Water)	0.00	8.56	12.07	15.33	18.72	22.30	25.94
Park Cities MUD (Treated Water)							
Highland Park	0.00	0.20	0.20	0.20	0.20	0.20	0.20
University Park	0.00	2.44	2.55	2.55	2.55	2.56	2.56
Wilmer (Treated Water)	0.00	0.48	0.61	0.73	0.84	0.99	1.14
Subtotal:	0.00	13.66	18.16	22.41	26.54	30.90	35.29
TOTAL:	**388.0**	**408.2**	**488.7**	**548.3**	**601.6**	**654.4**	**697.2**

Assumes full use of each customer entity's alternate supply sources.

Table A-34
Projections of Peak-Day Demands to be Supplied to Recommended Planning Area by DWU (mgd)
Normal Weather Conditions With Water Conservation Measures (1)

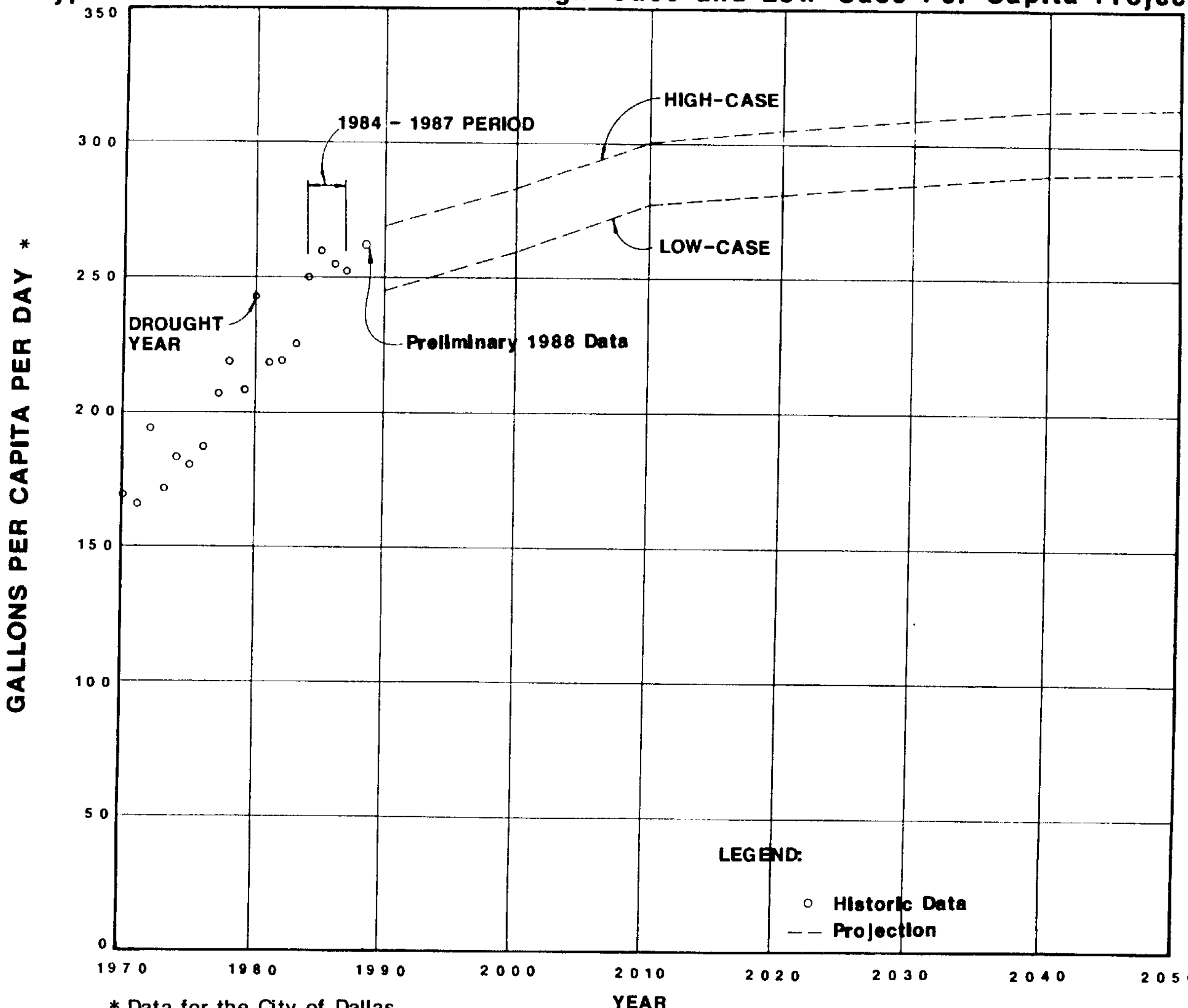
City	1990	2000	2010	2020	2030	2040	2050
Dallas	455.55	476.19	531.09	563.98	594.81	625.46	642.44
Treated Water Customers							
Addison	5.85	7.10	8.40	9.23	9.81	10.22	10.47
Dallas County WCID #6 (Balch Sprin	3.56	4.13	4.87	5.50	6.07	6.61	7.07
Carrollton	32.31	44.31	56.31	66.41	75.13	82.93	89.59
Cedar Hill	9.25	1.06	6.31	11.41	16.37	21.26	25.97
Cockrell Hill	0.68	0.68	0.73	0.76	0.78	0.81	0.81
Combine WSC	*City of Seagoville Customer, Demand Included with City of Seagoville*						
Coppell	6.78	10.96	15.34	19.32	23.00	25.88	28.37
D/FW Airport	3.10	3.69	4.54	5.36	6.19	7.04	7.87
Desoto	11.42	15.52	19.95	23.78	27.19	30.32	32.25
Duncanville	12.19	11.52	12.92	13.87	14.59	15.22	15.75
Farmers Branch	17.46	17.77	19.56	24.04	24.36	24.75	25.08
Flower Mound	4.73	7.79	11.28	14.74	18.19	21.67	25.06
Glenn Heights	1.30	2.29	3.47	4.70	5.81	6.94	8.05
Grand Prairie	22.03	27.50	38.55	47.18	55.27	63.02	68.13
Hutchins	0.98	1.07	1.13	1.21	1.30	1.37	1.45
Irving (2)	61.93	76.19	88.00	94.27	98.75	102.76	105.64
Lancaster	6.44	8.52	11.15	13.37	15.50	17.59	19.56
Lewisville	1.97	8.37	8.42	8.42	8.42	8.44	8.44
Mesquite	0.30	---	---	---	---	---	---
Ovilla	*City of Cedar Hill Customer, Demand Included with City of Cedar Hill*						
Seagoville	2.77	4.14	6.36	7.09	7.86	8.70	9.56
The Colony	5.46	7.71	10.03	12.28	14.49	16.71	18.40
Subtotal:	210.52	260.34	327.33	382.95	429.09	472.24	507.54
Raw Water Customers							
Argyle	*City of Denton Customer, Demand Included with City of Denton*						
Corinth	*City of Denton Customer, Demand Included with City of Denton*						
Denton	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DP&L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Highland Village	*City of Lewisville Customer, Demand Included with City of Lewisville*						
Irrigation/Domestic Users	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lake Cities	*City of Denton Customer, Demand Included with City of Denton*						
Lewisville	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subtotal:	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potential Customers							
Collin County (Raw Treated)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denton County (Raw Water)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Park Cities MUD (Treated Water)							
Highland Park	0.00	0.37	0.37	0.37	0.37	0.37	0.37
University Park	0.00	4.53	4.74	4.74	4.74	4.75	4.75
Wilmer (Treated Water)	0.00	0.89	1.13	1.36	1.57	1.84	2.12
Subtotal:	0.00	5.78	6.24	6.47	6.68	6.97	7.25
TOTAL:	**666.1**	**742.3**	**864.6**	**953.4**	**1030.6**	**1104.7**	**1157.2**

(1) Assumes full use of each customer entity's alternate supply sources.

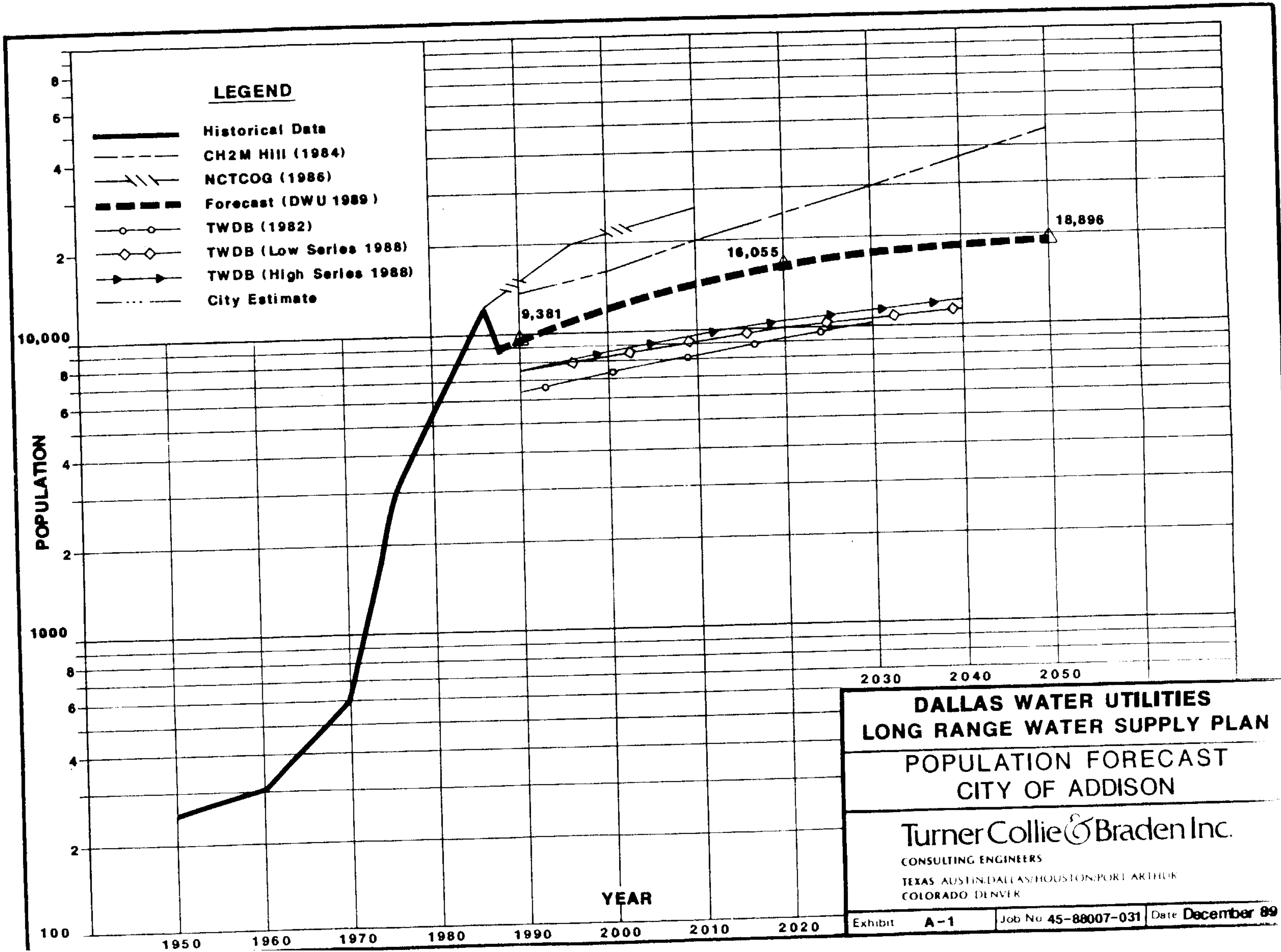
(2) Includes 79.0 mgd peak supply from Cooper Reservoir.

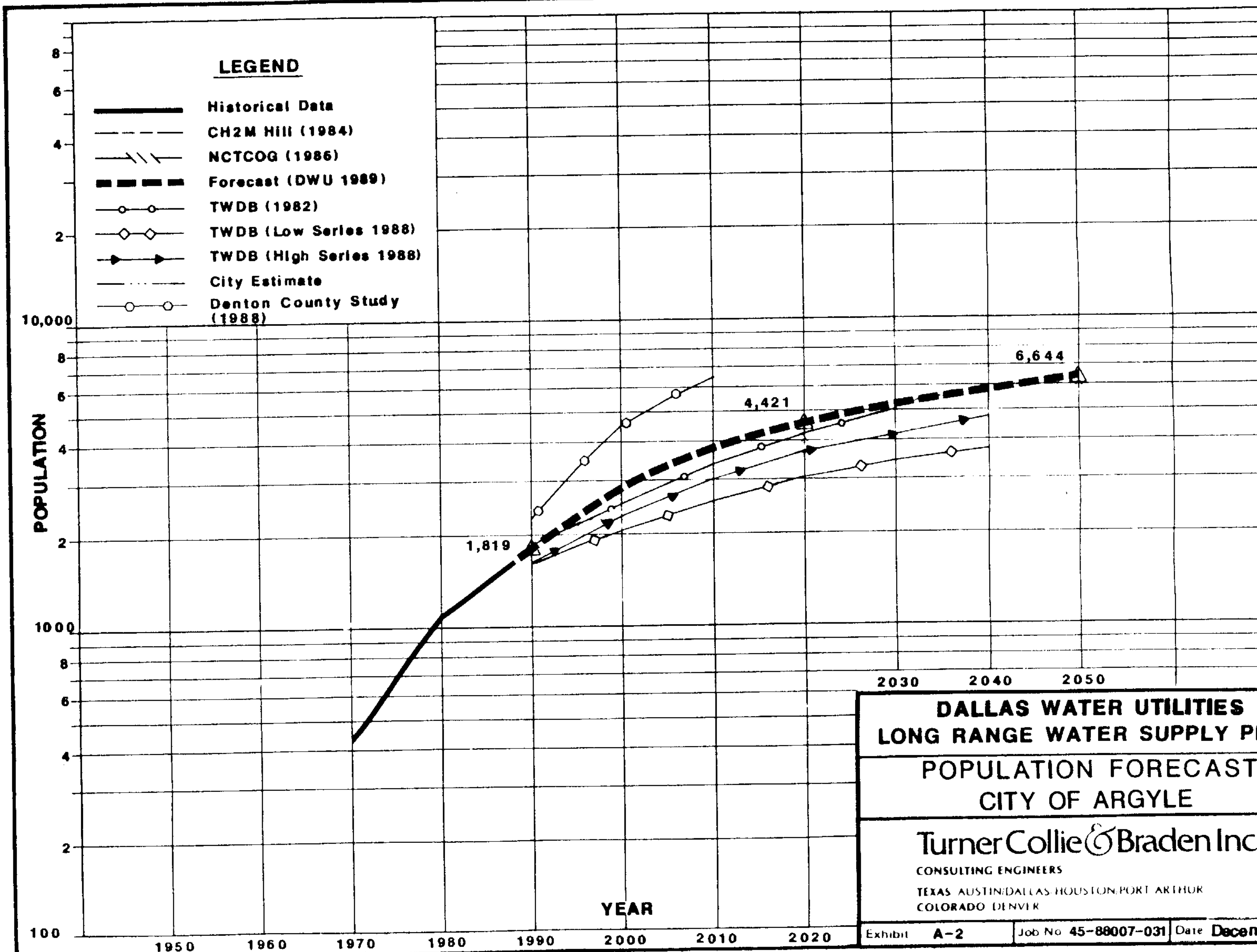
Figure A-1

Typical Illustration of Basis for High-Case and Low-Case Per Capita Projections



* Data for the City of Dallas


LEGEND
Historical Data
CH2M Hill (1984)
NCTCOG (1986)
Forecast (DWU 1989)
TWDB (1982)
TWDB (Low Series 1988)
TWDB (High Series 1988)
City Estimate
9,381
16,055
18,896
POPULATION
10,000
1000
100
YEAR
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN
POPULATION FORECAST
CITY OF ADDISON
Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER
Exhibit A-1
Job No 45-88007-031
Date December 89

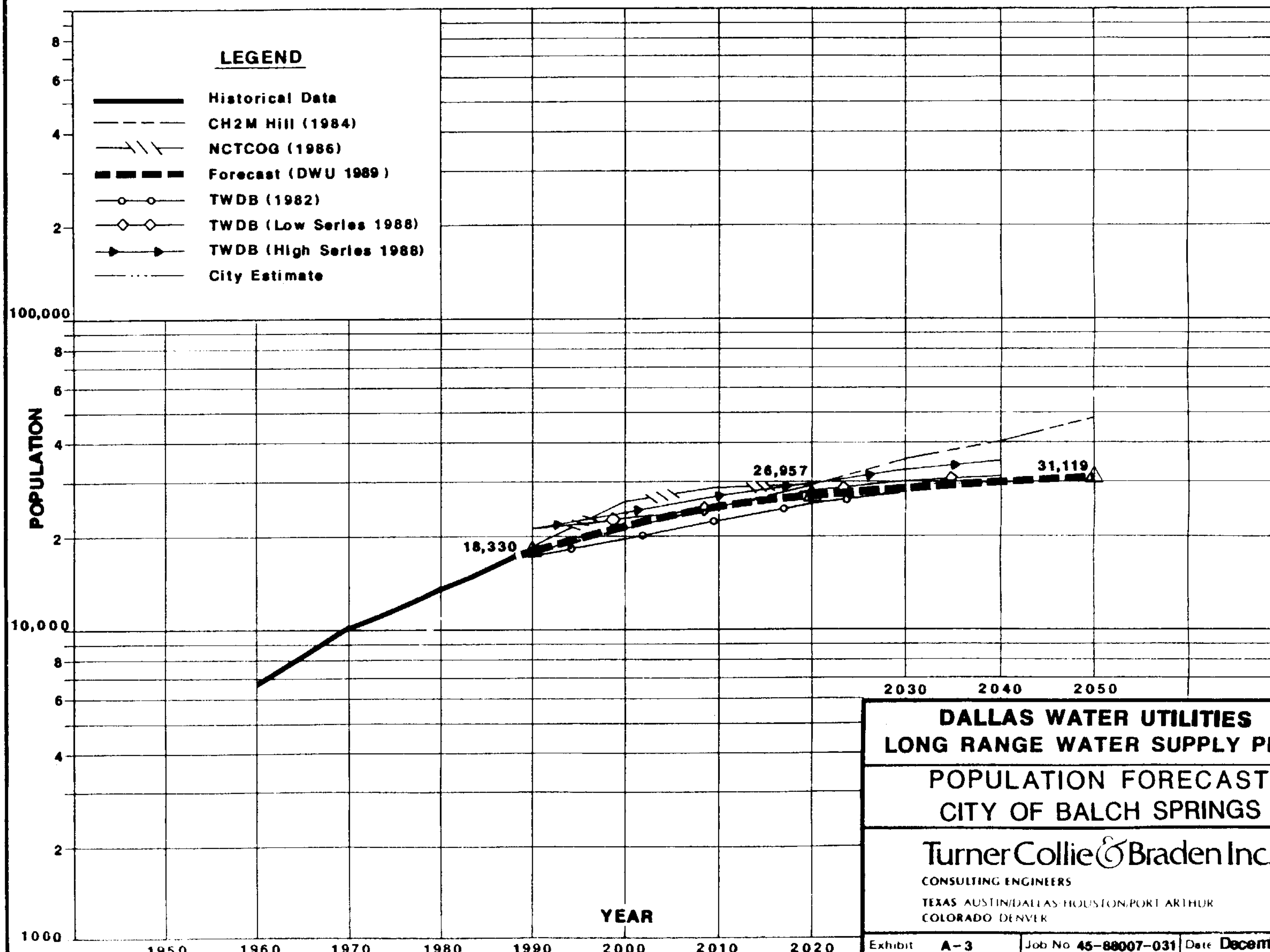


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF ARGYLE

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-2	Job No 45-88007-031	Date December 89

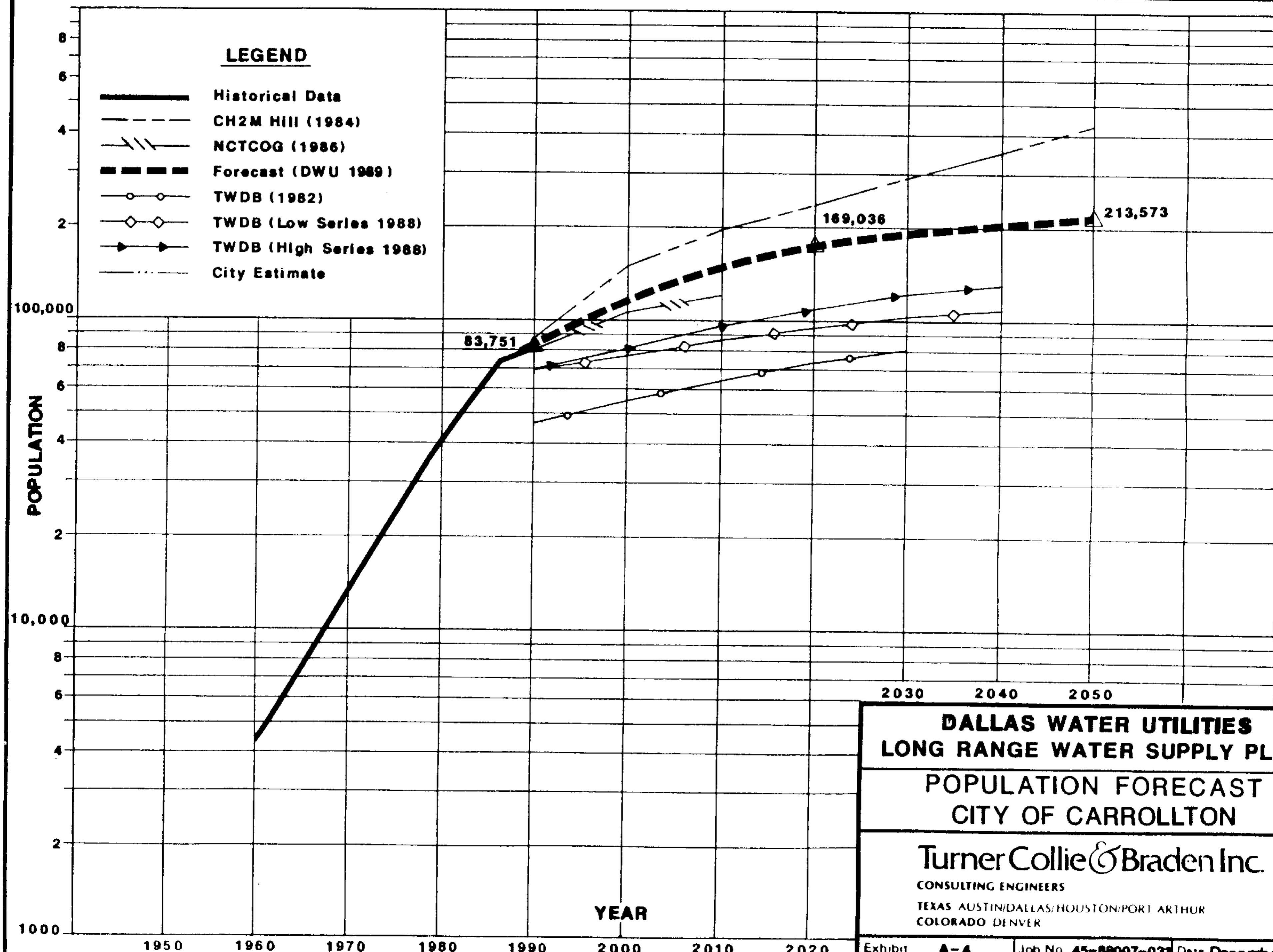


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF BALCH SPRINGS

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-3	Job No 45-88007-031	Date December 89

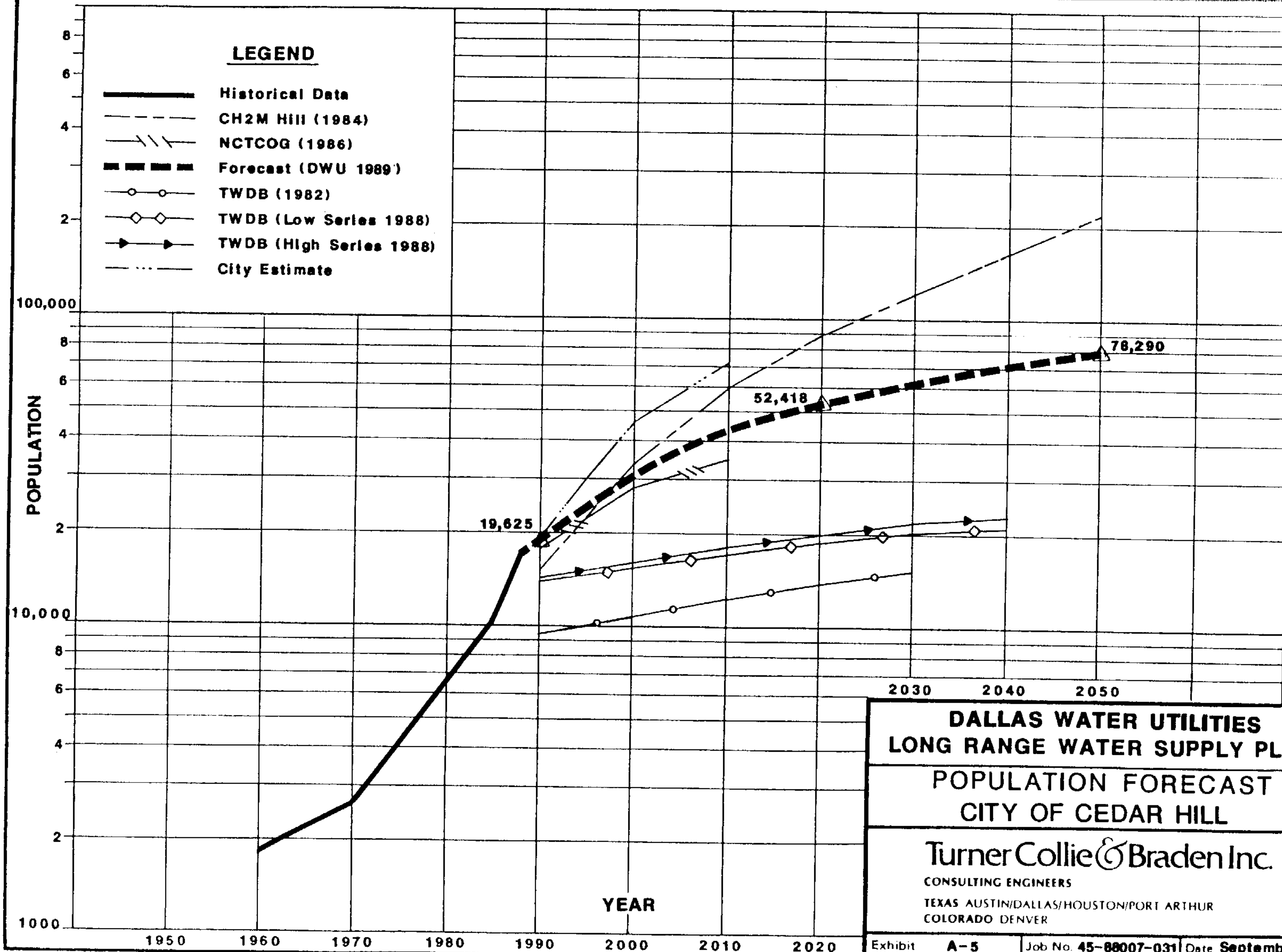


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF CARROLLTON

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-4	Job No. 45-88007-031	Date December 89

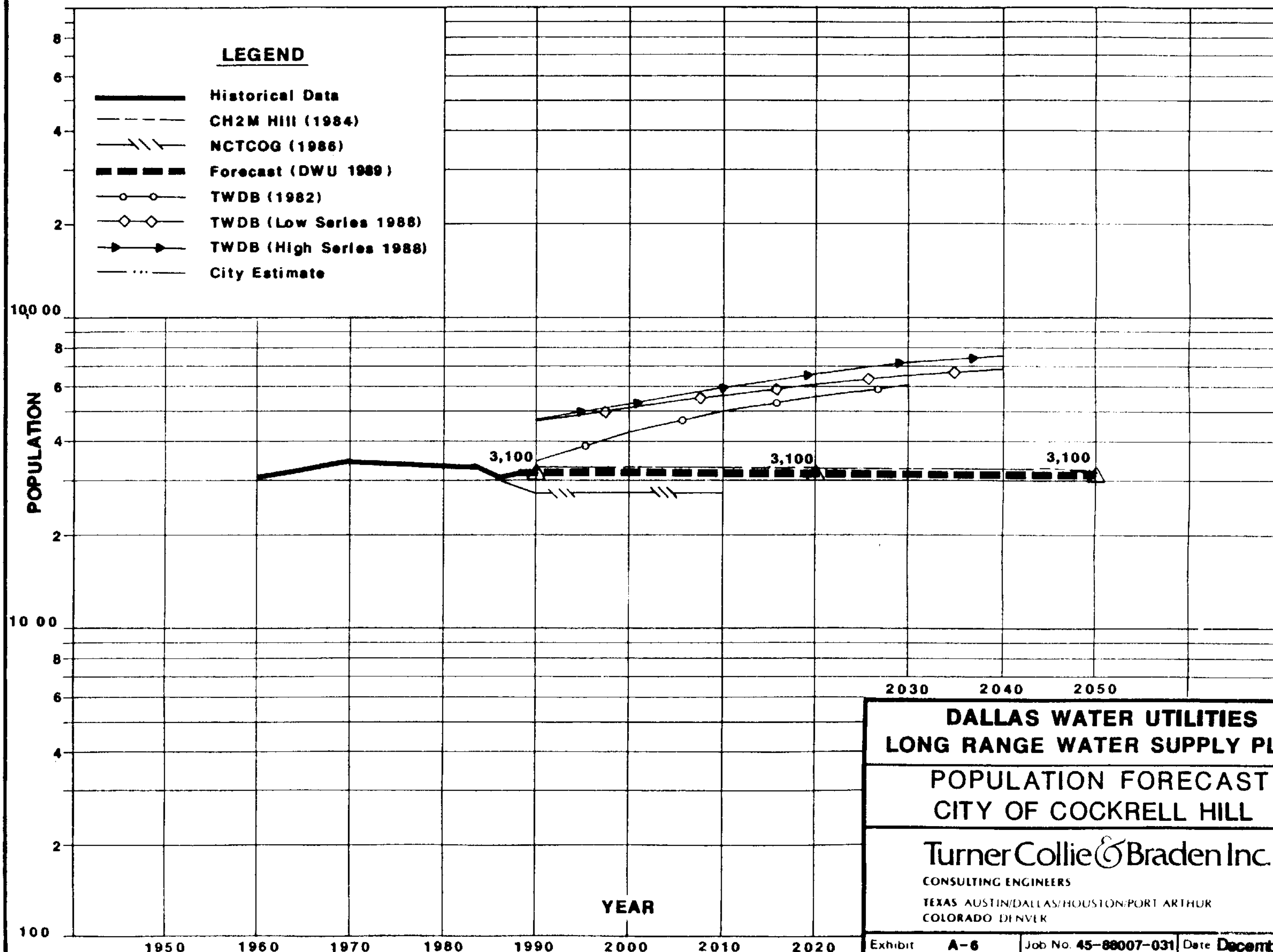


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF CEDAR HILL

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit **A-5**	Job No. **45-88007-031**	Date **September 89**

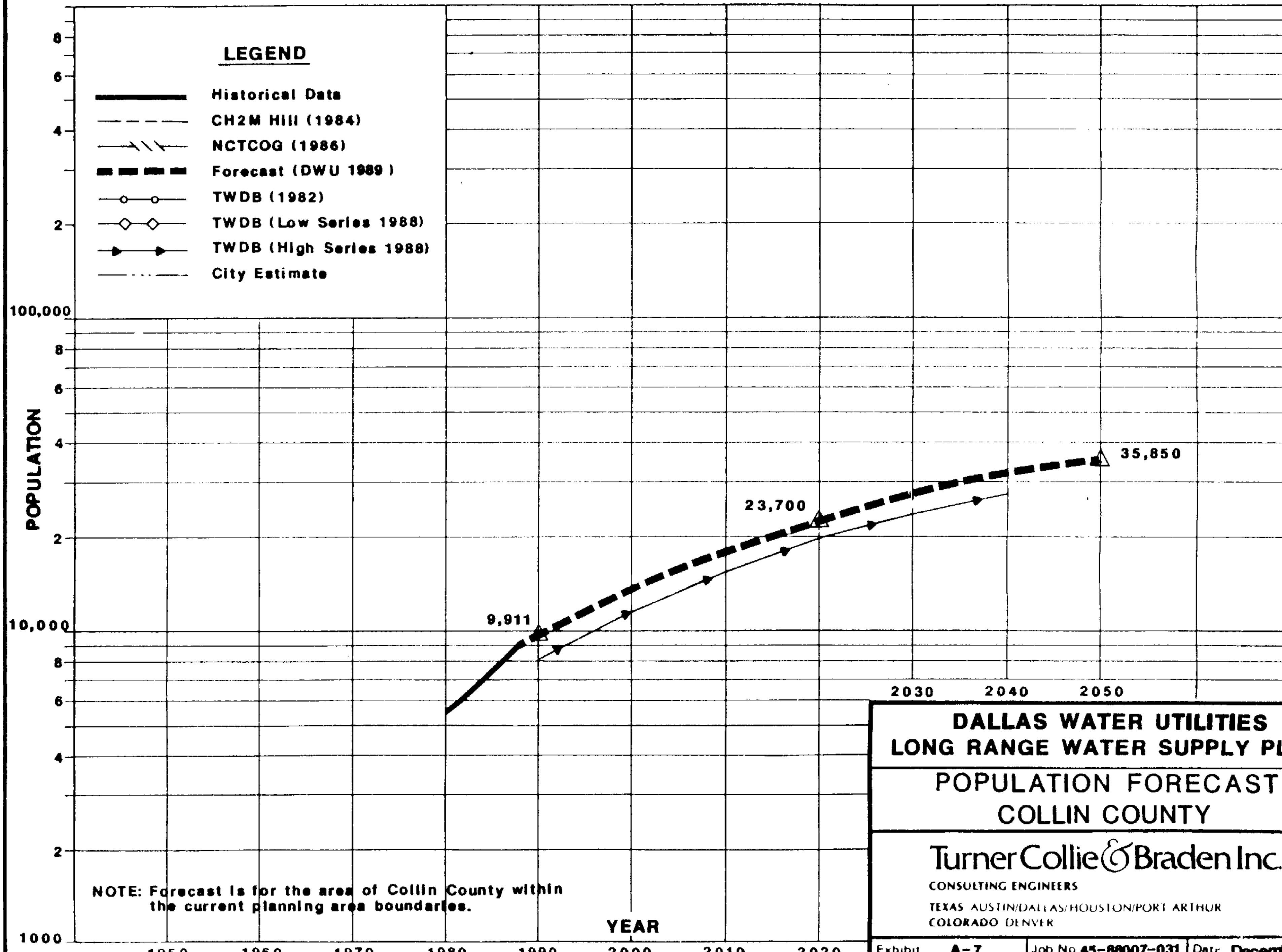


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF COCKRELL HILL

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit	A-6	Job No. 45-88007-031	Date December 89

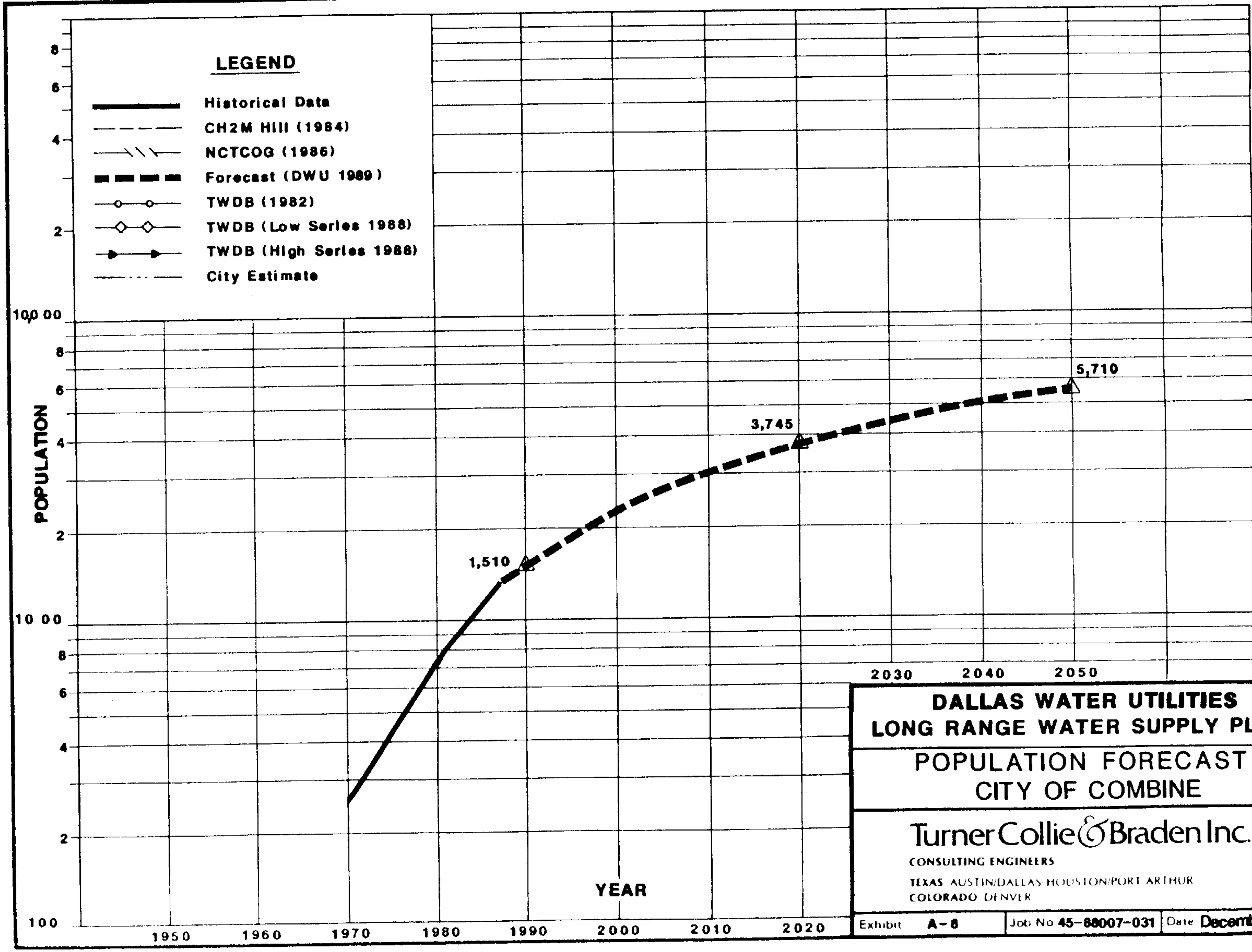


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
COLLIN COUNTY

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-7	Job No 45-88007-031	Date December 89

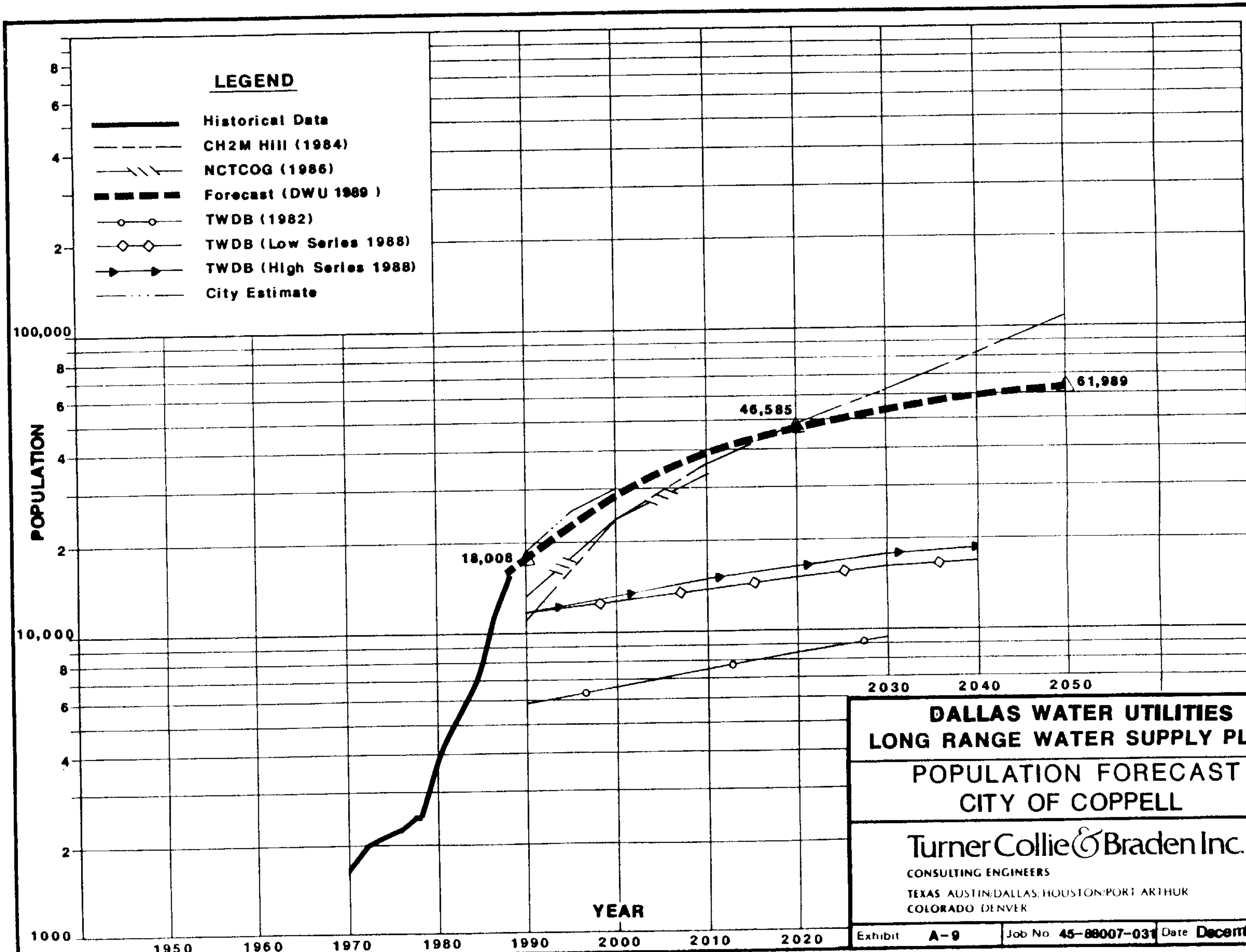


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF COMBINE

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-8	Job No 45-88007-031	Date December 89

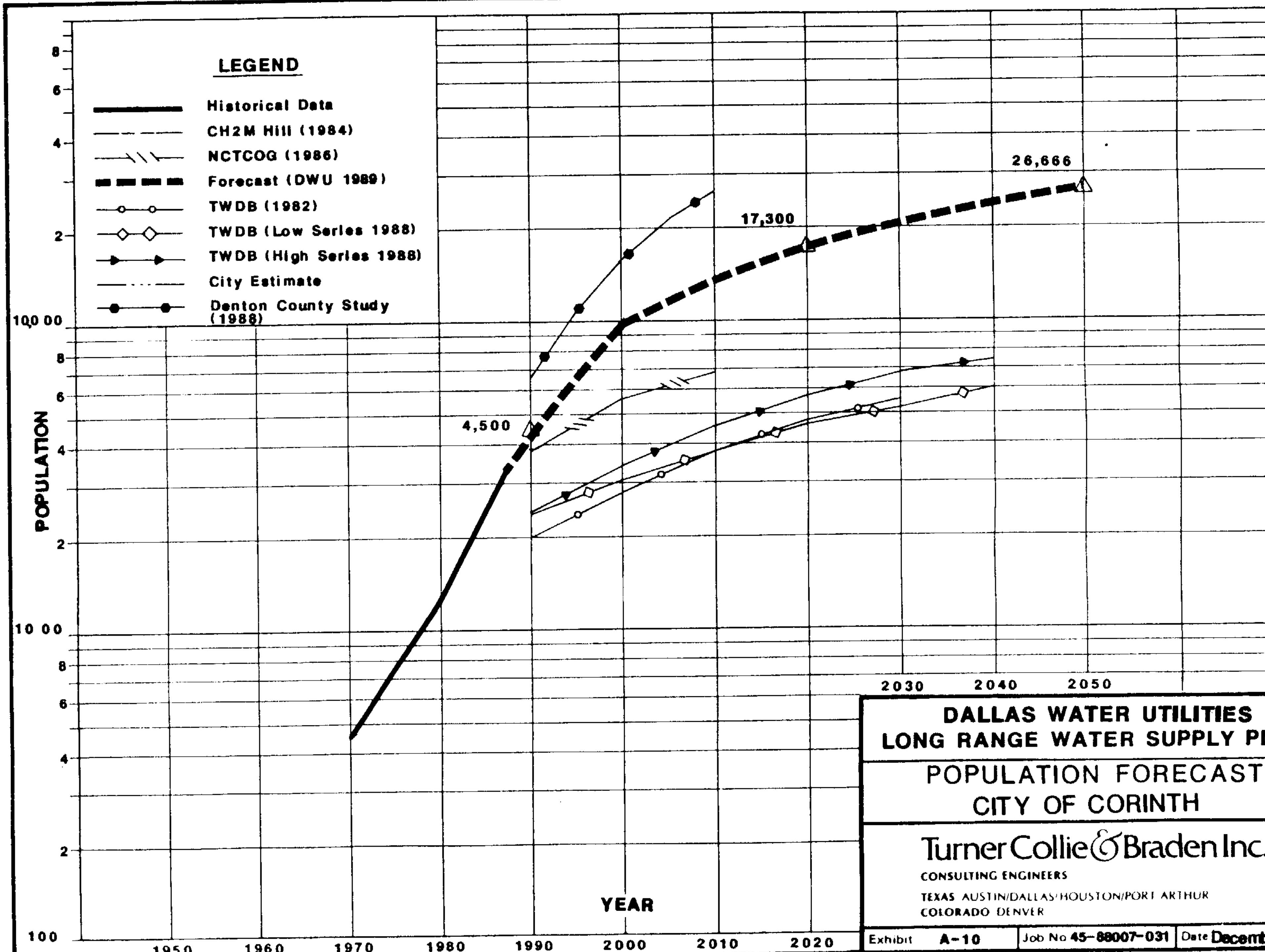


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF COPPELL

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-9	Job No. 45-88007-031	Date December 89

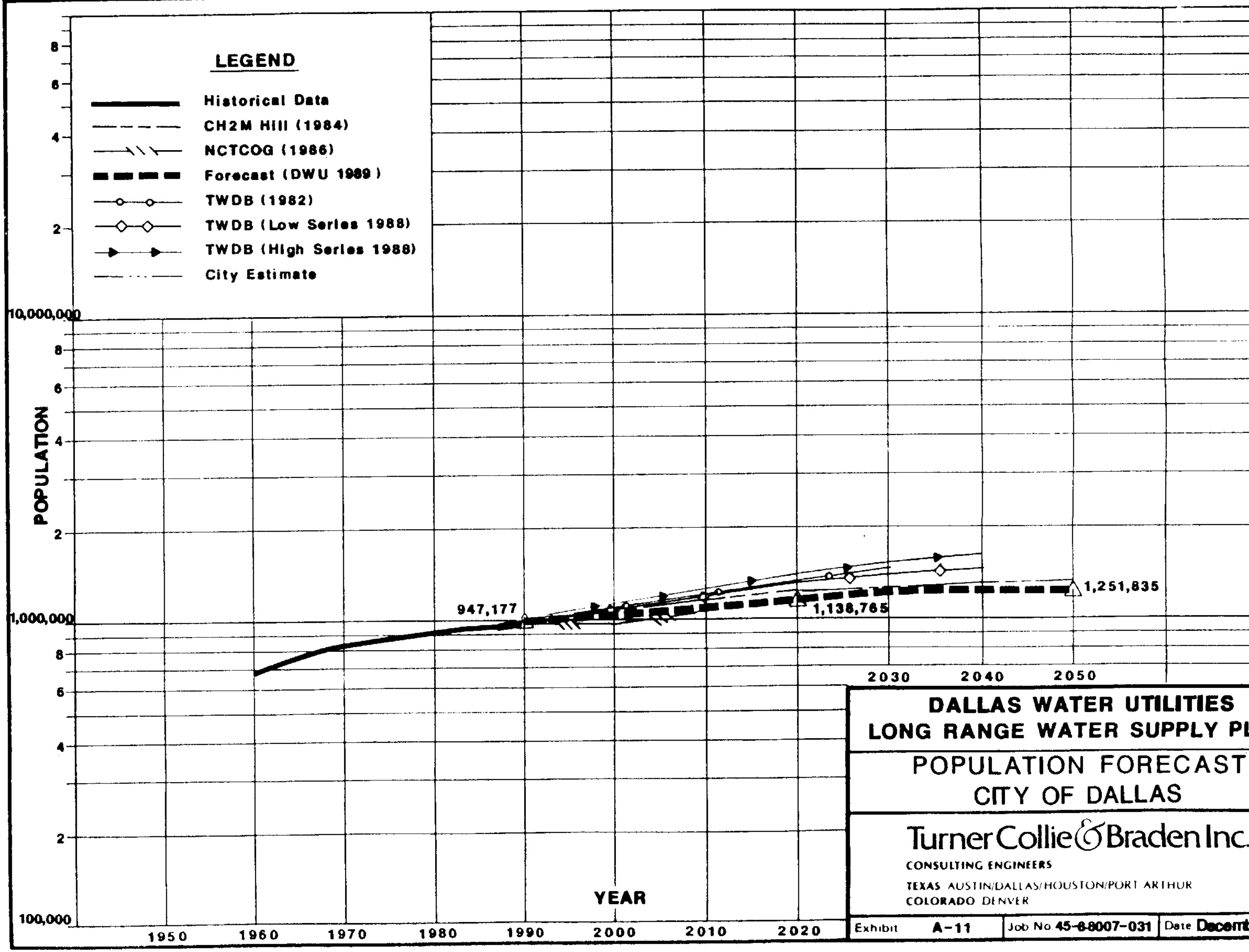


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF CORINTH

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-10	Job No 45-88007-031	Date December 89

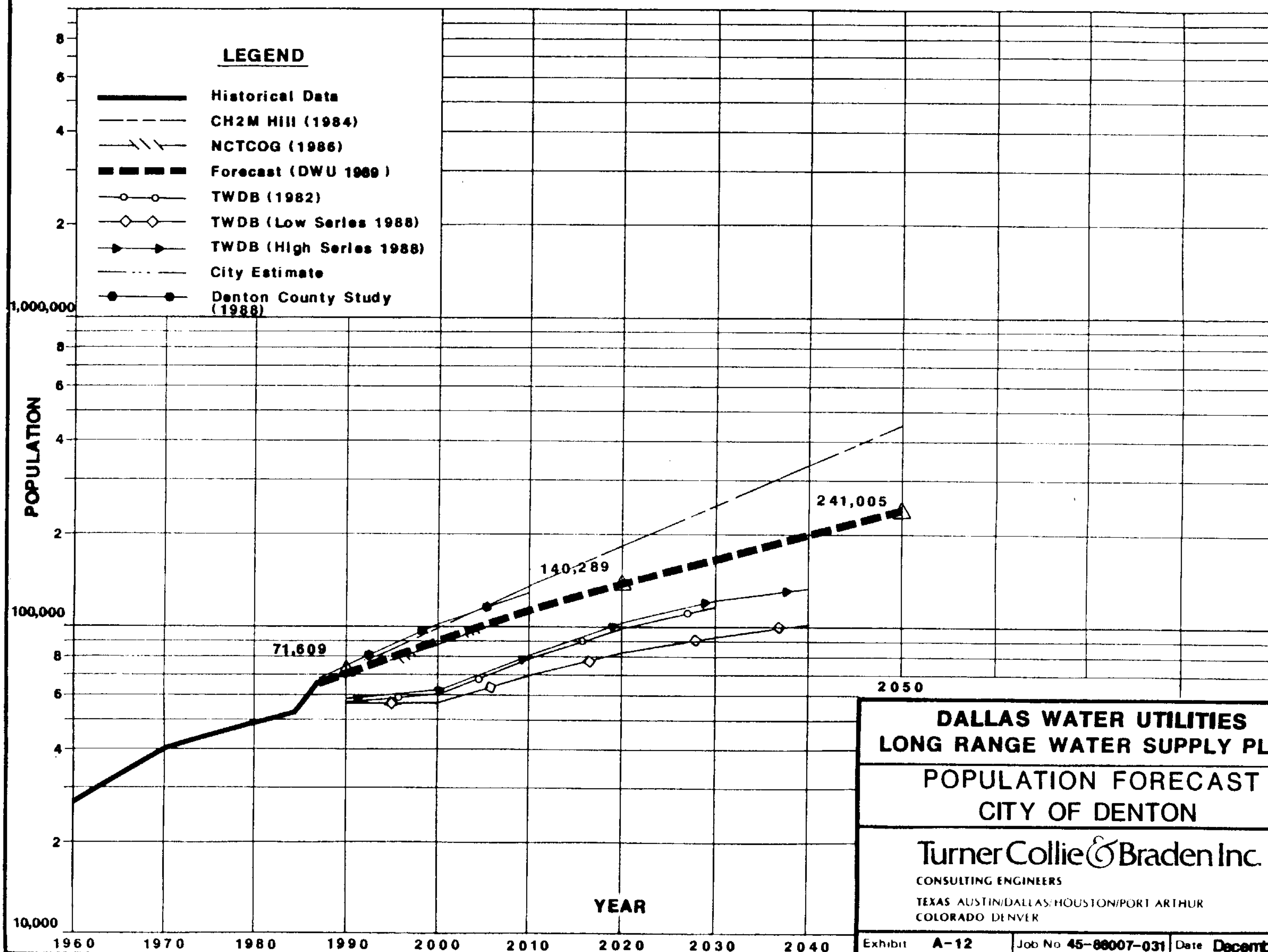


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF DALLAS

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-11	Job No. 45-6-8007-031	Date December 89

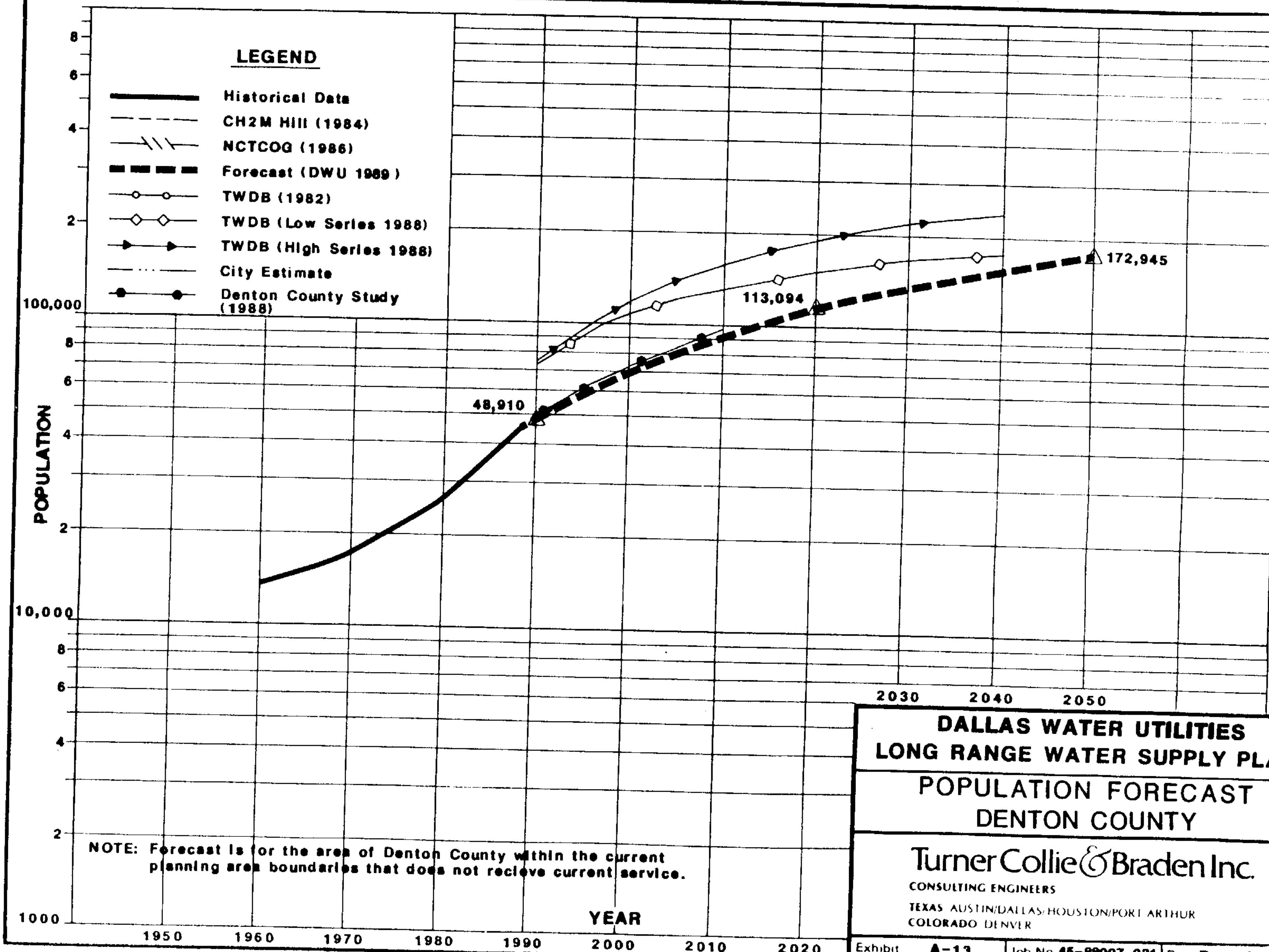


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF DENTON

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-12	Job No 45-88007-031	Date December 89

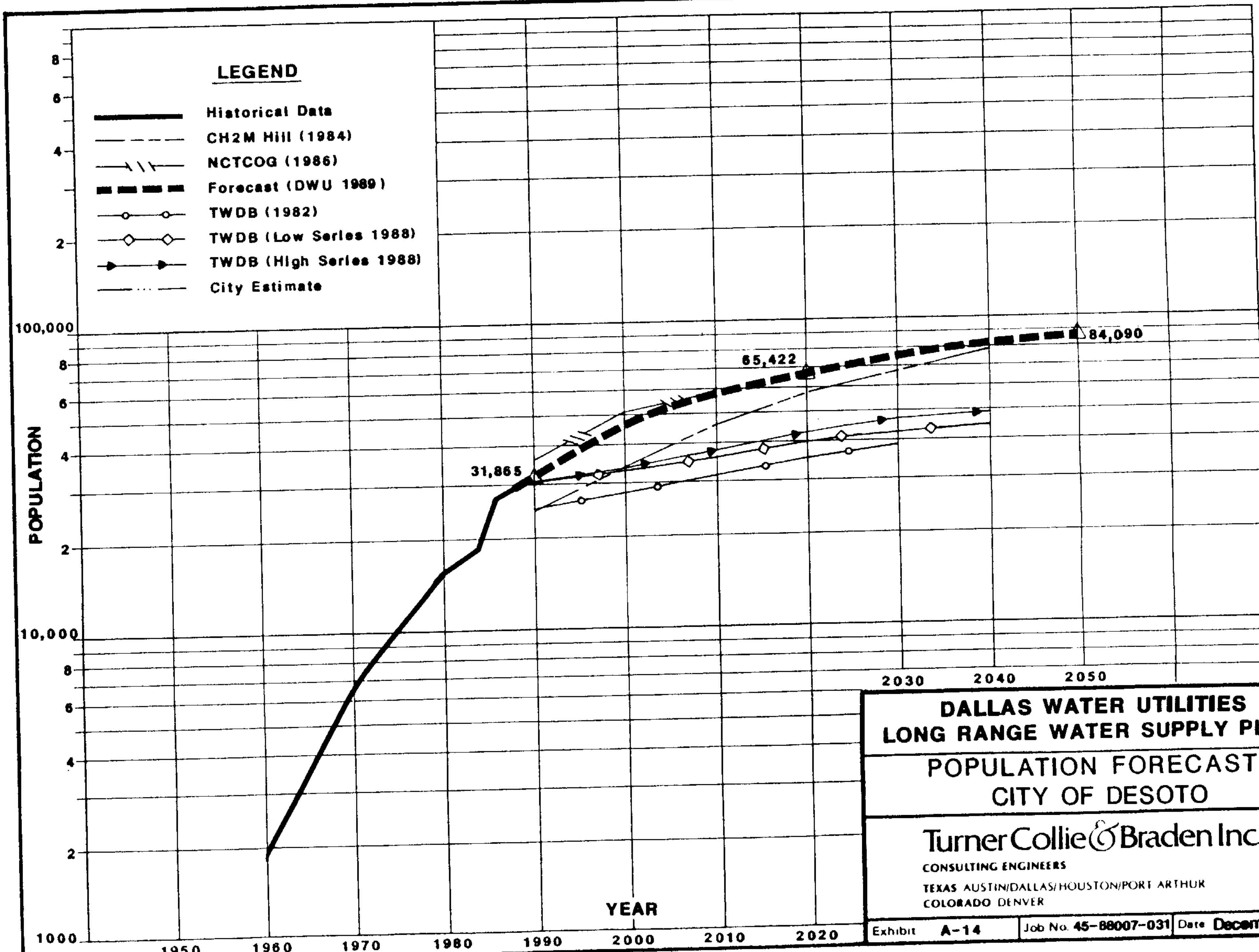


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
DENTON COUNTY

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-13 | Job No 45-88007-031 | Date December 89

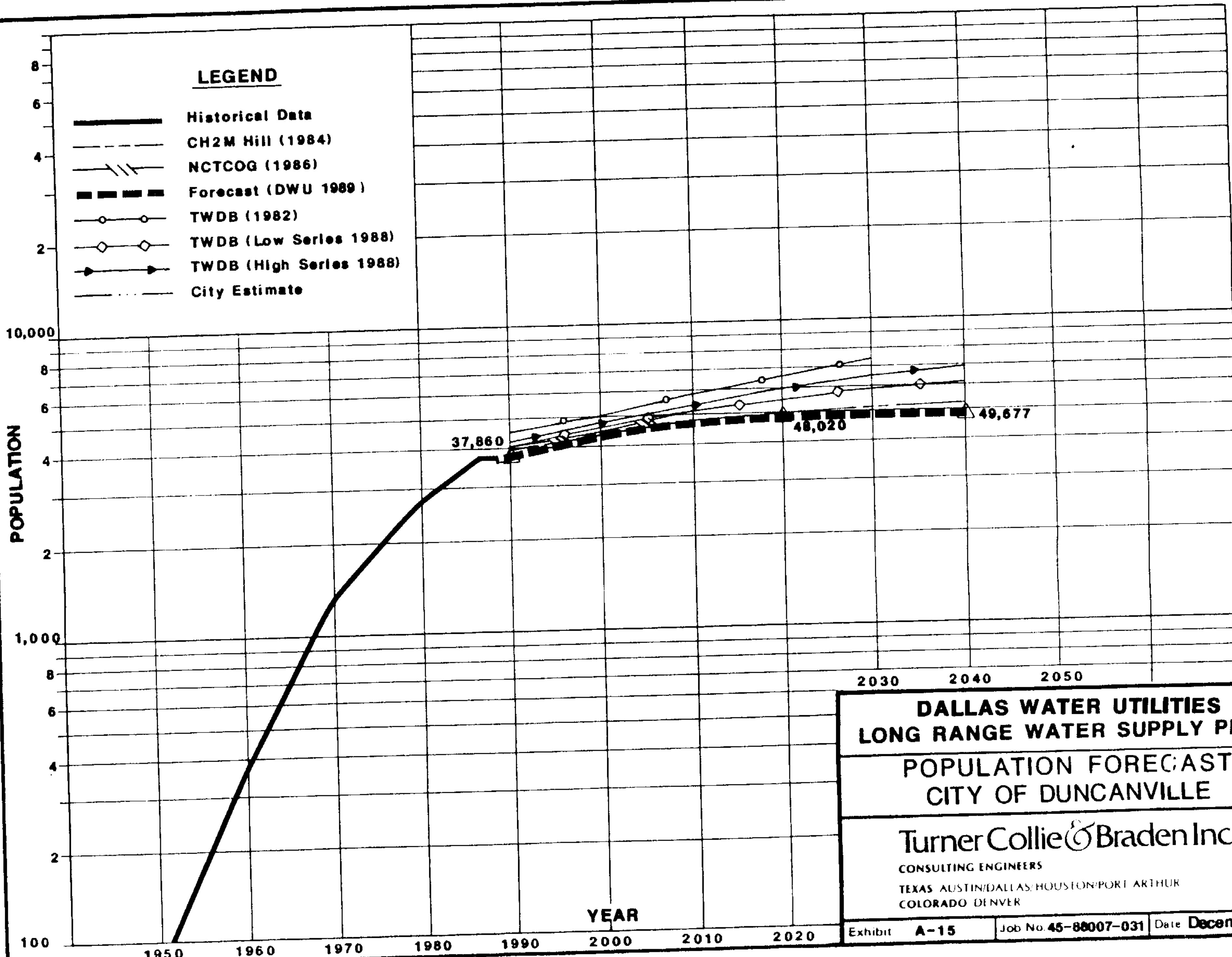


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF DESOTO

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-14	Job No. 45-88007-031	Date December 89

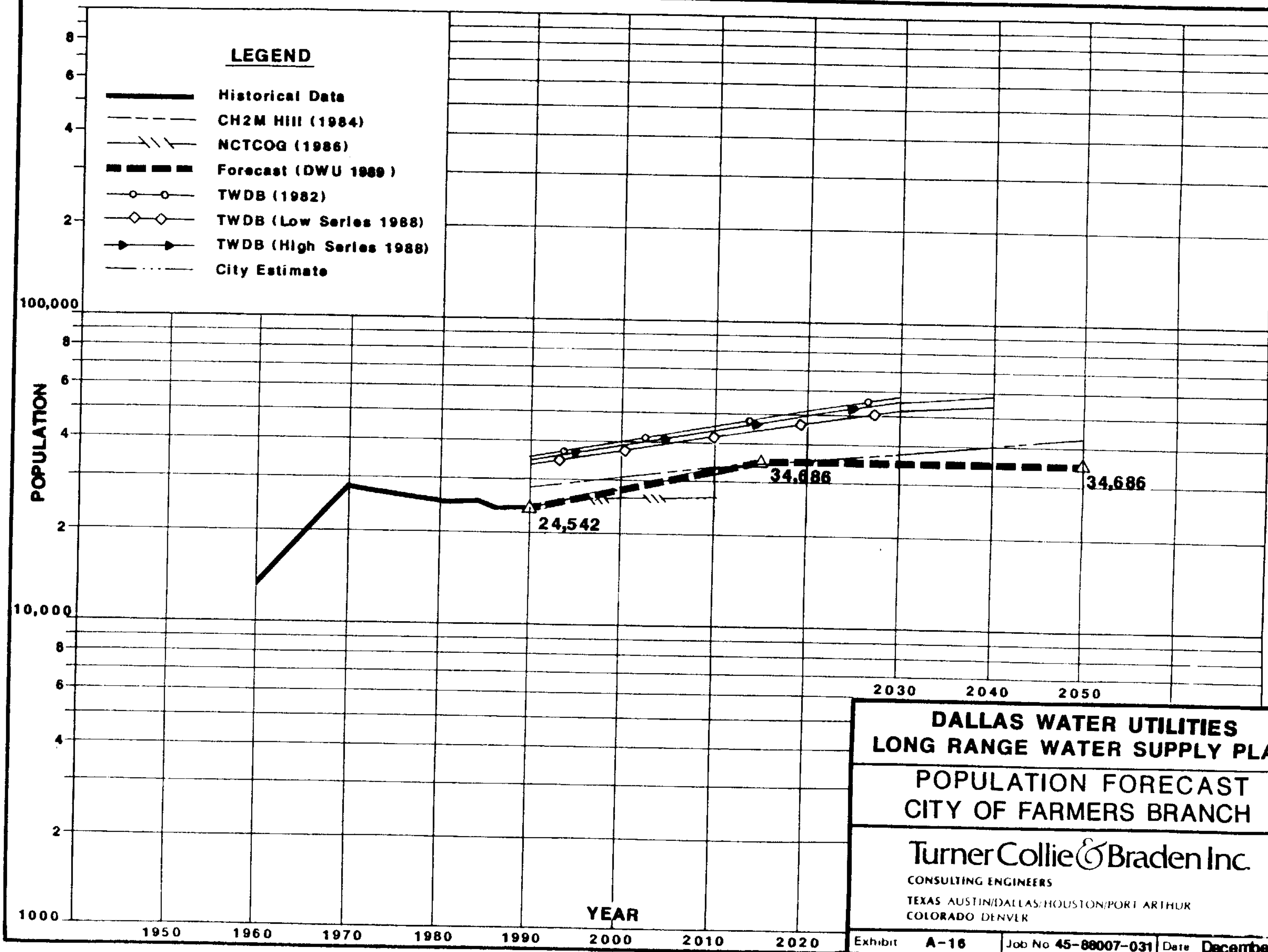


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF DUNCANVILLE

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-15	Job No. 45-88007-031	Date December 89

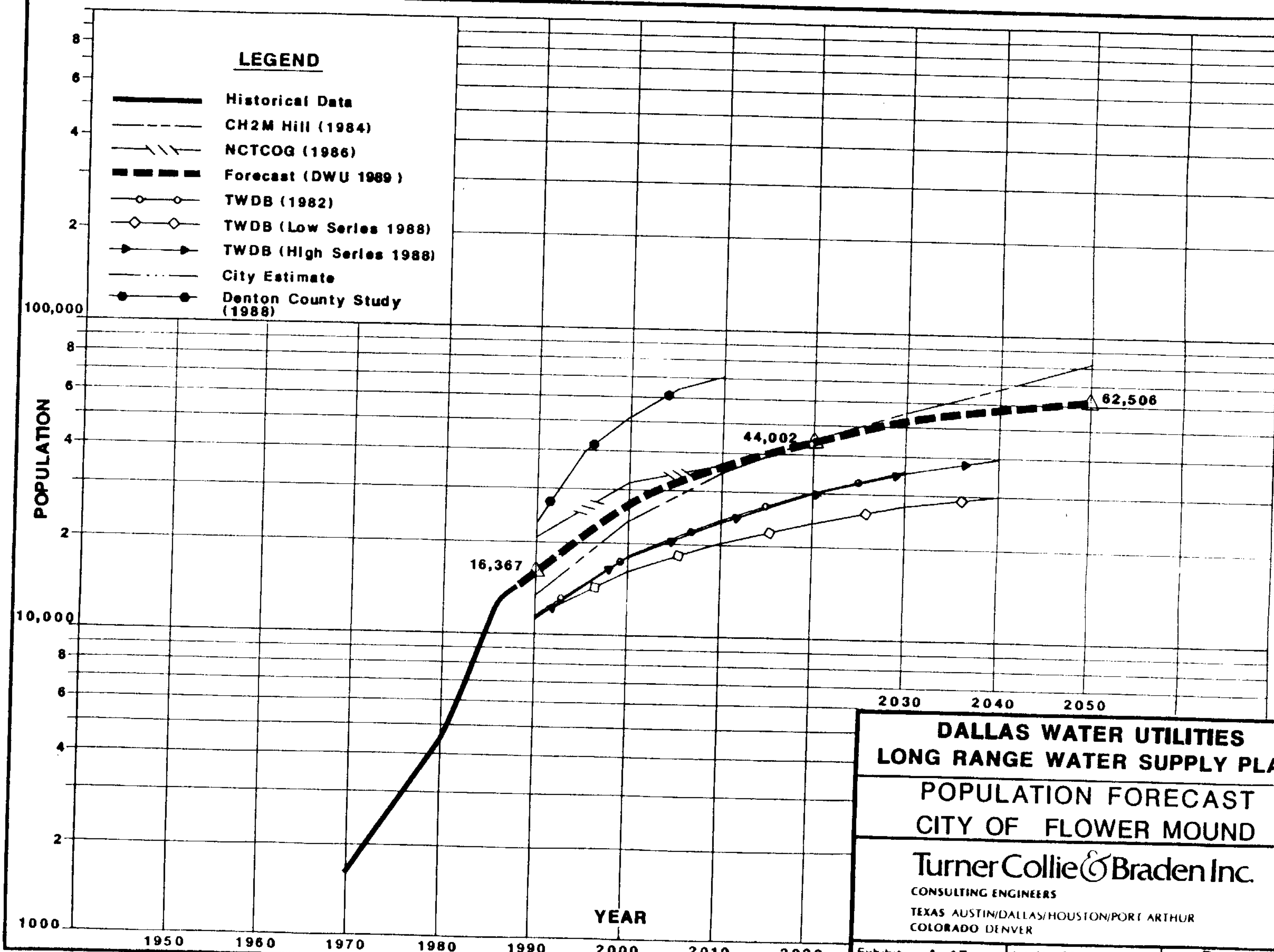


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF FARMERS BRANCH

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-16	Job No 45-88007-031	Date December 89

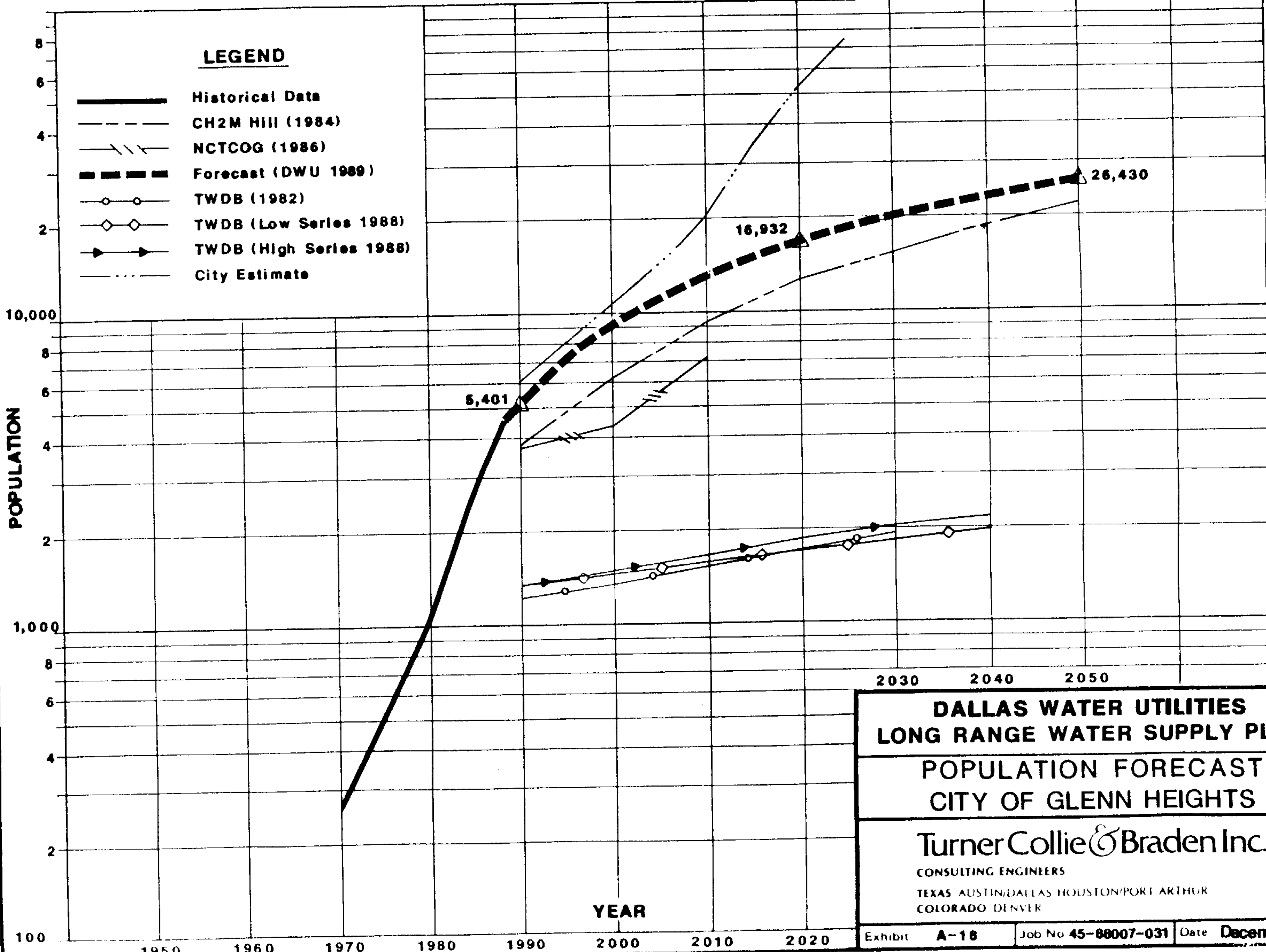


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF FLOWER MOUND

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-17	Job No. 45-88007-031	Date December 89

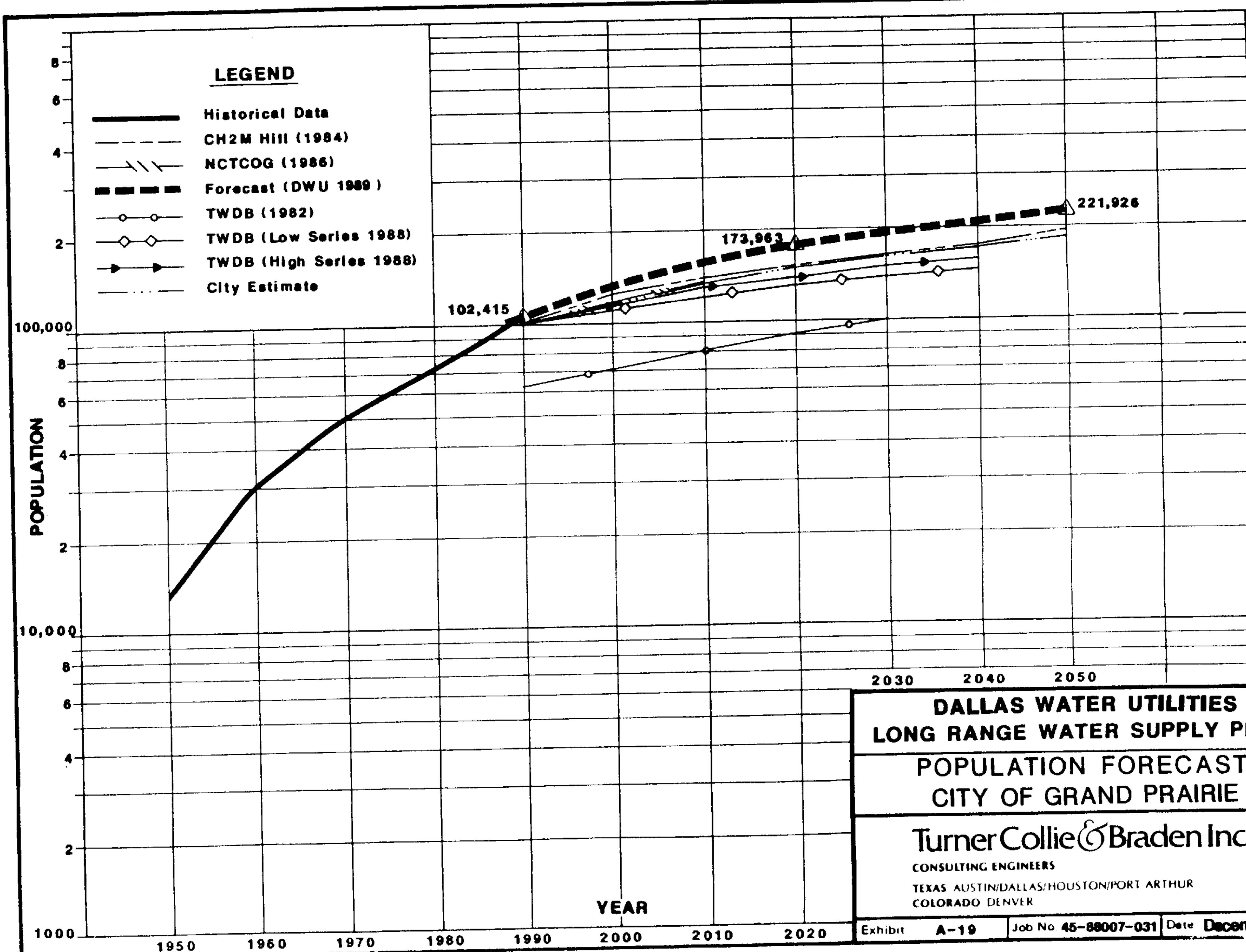


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF GLENN HEIGHTS

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-18	Job No 45-88007-031	Date December 89

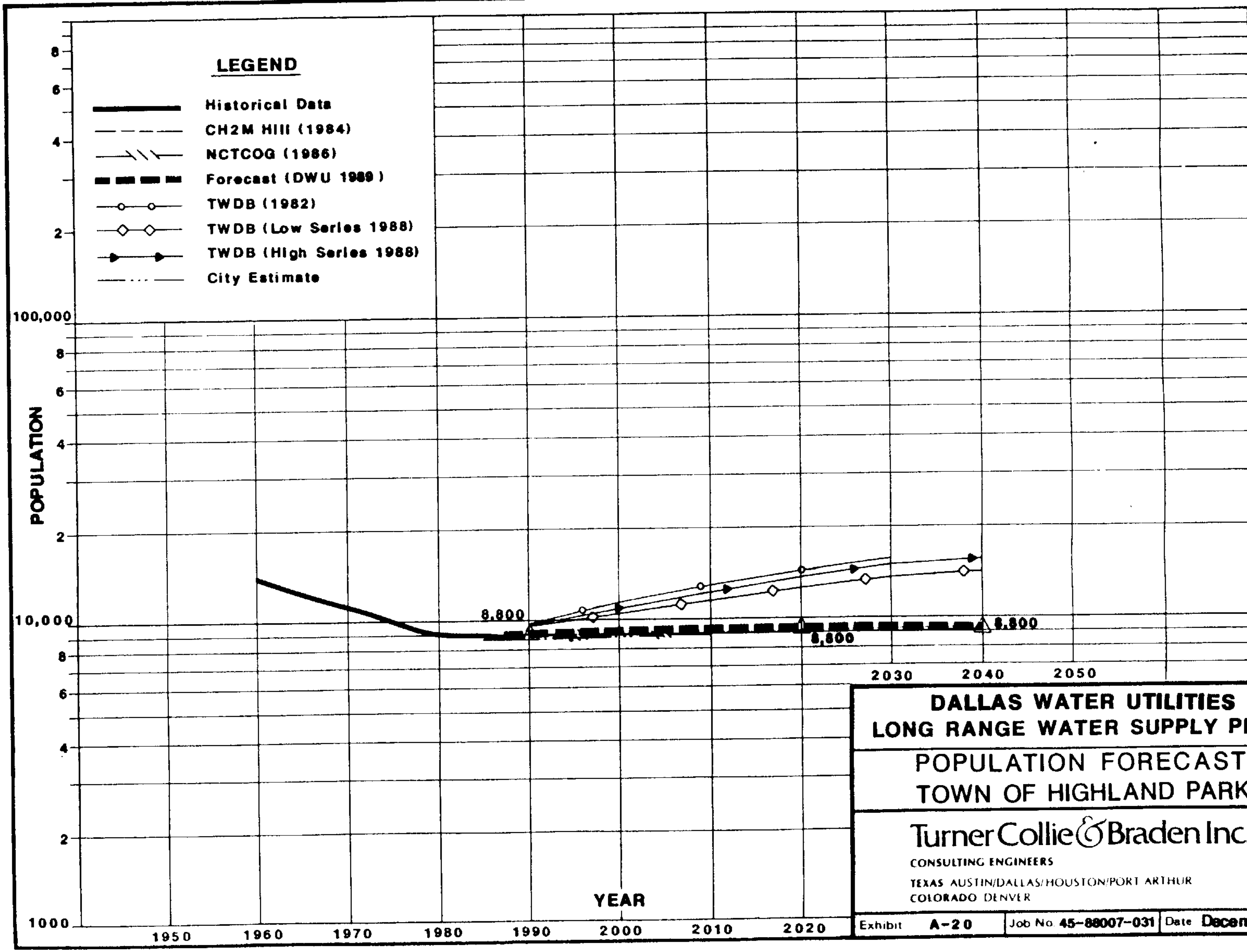


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF GRAND PRAIRIE

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-19	Job No. 45-88007-031	Date December 89

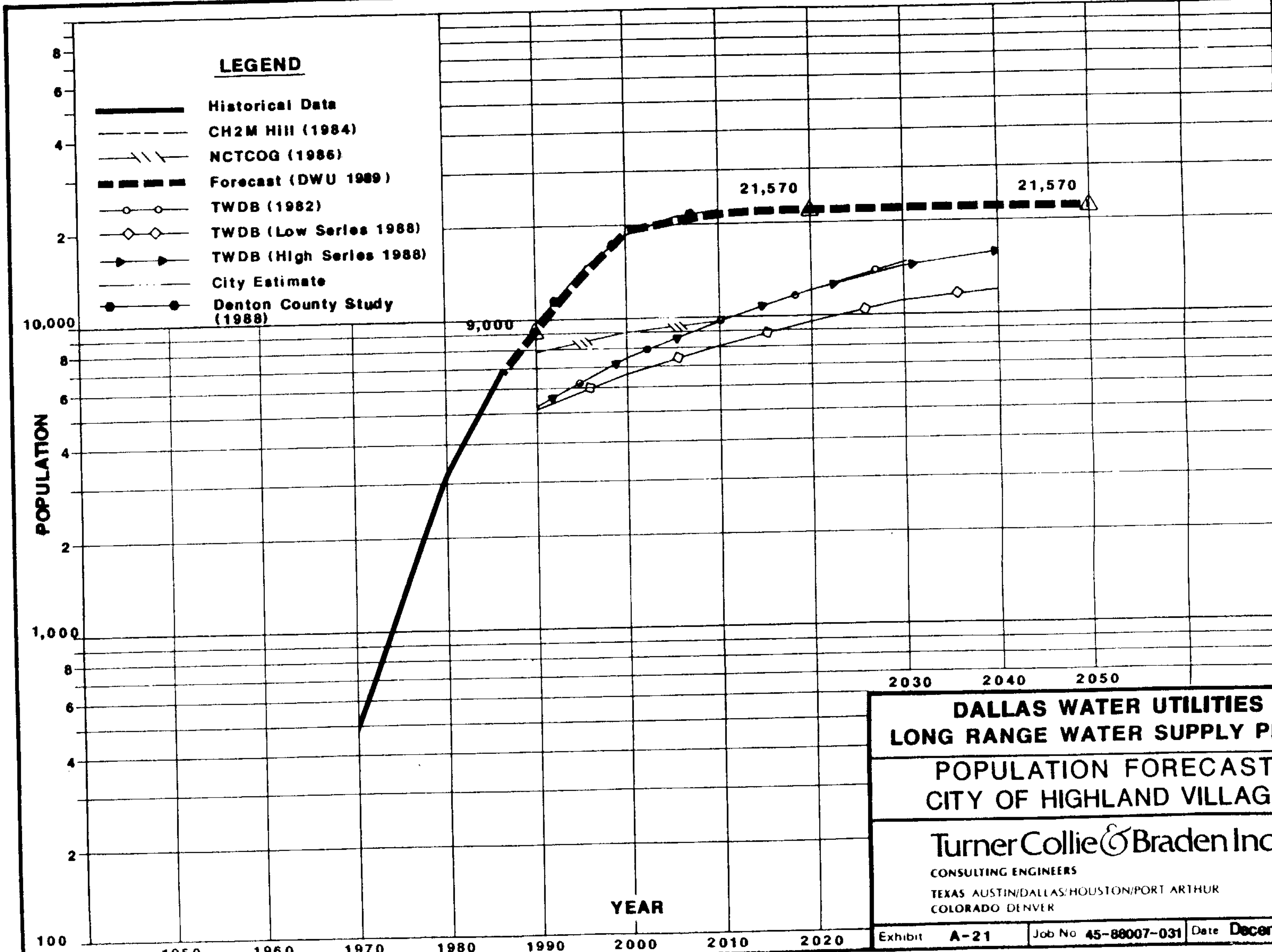


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
TOWN OF HIGHLAND PARK

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-20	Job No. 45-88007-031	Date December 89

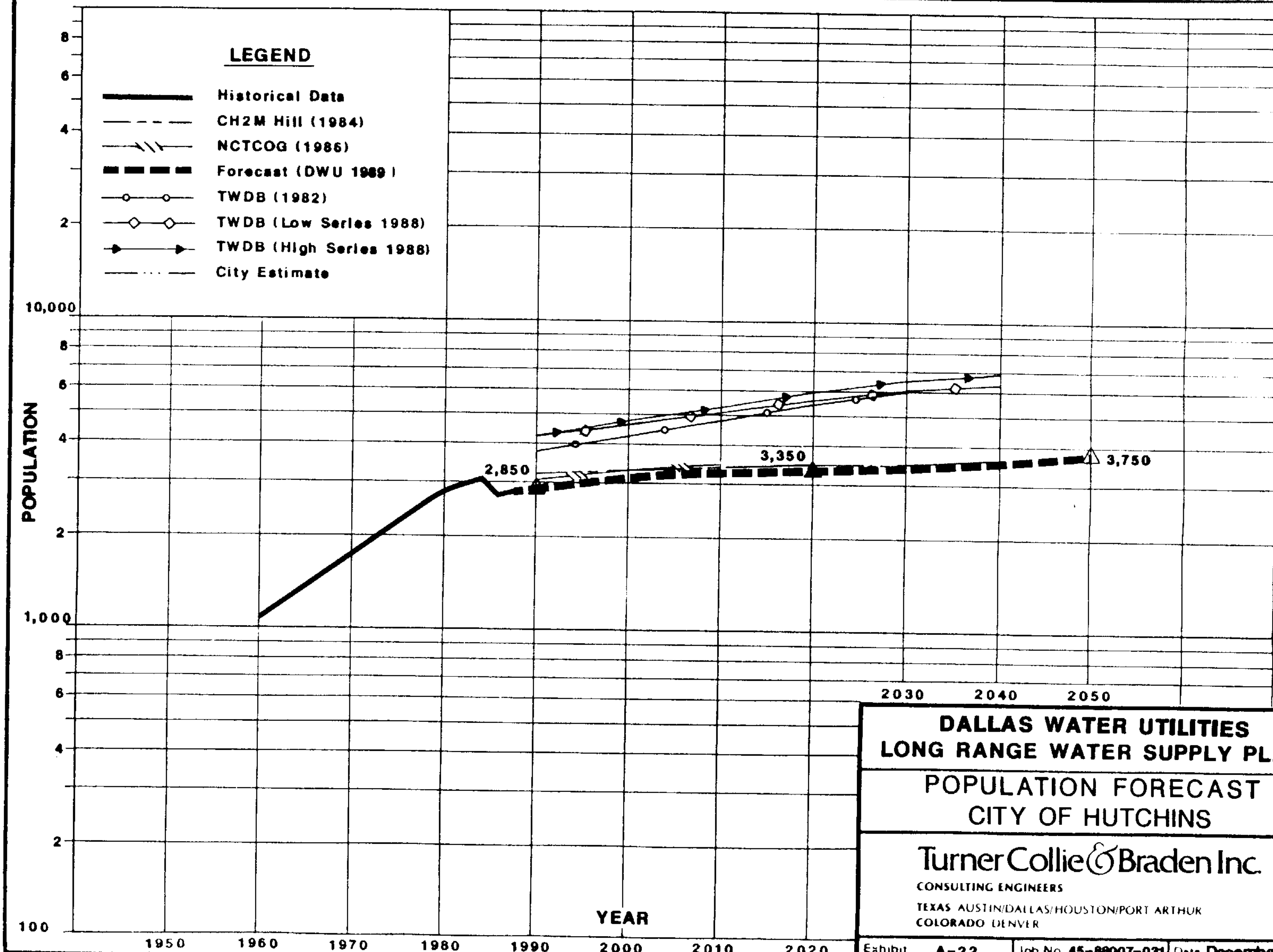


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF HIGHLAND VILLAGE

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-21	Job No 45-88007-031	Date December 89

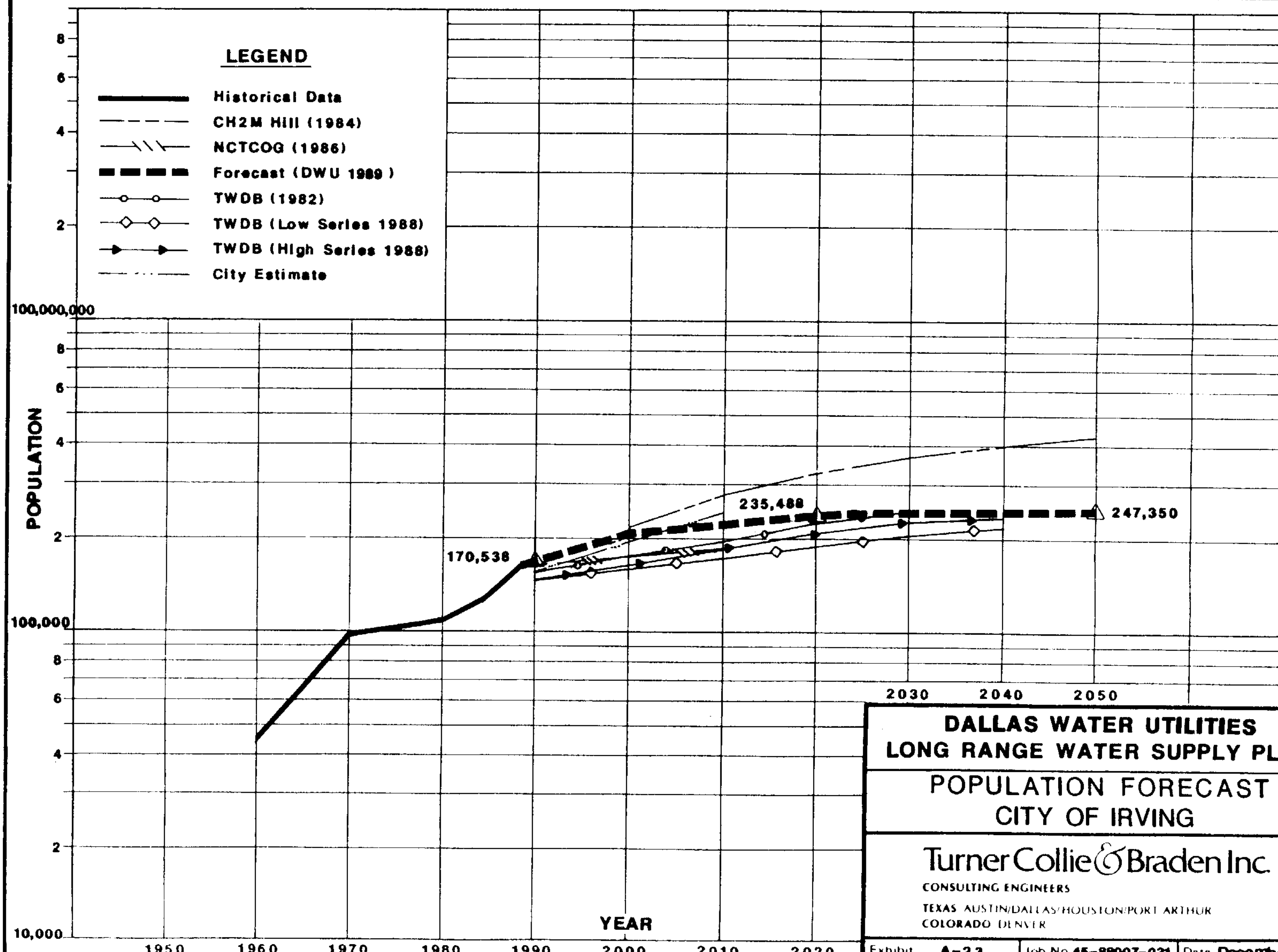


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF HUTCHINS

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-22	Job No 45-88007-031	Date December 89

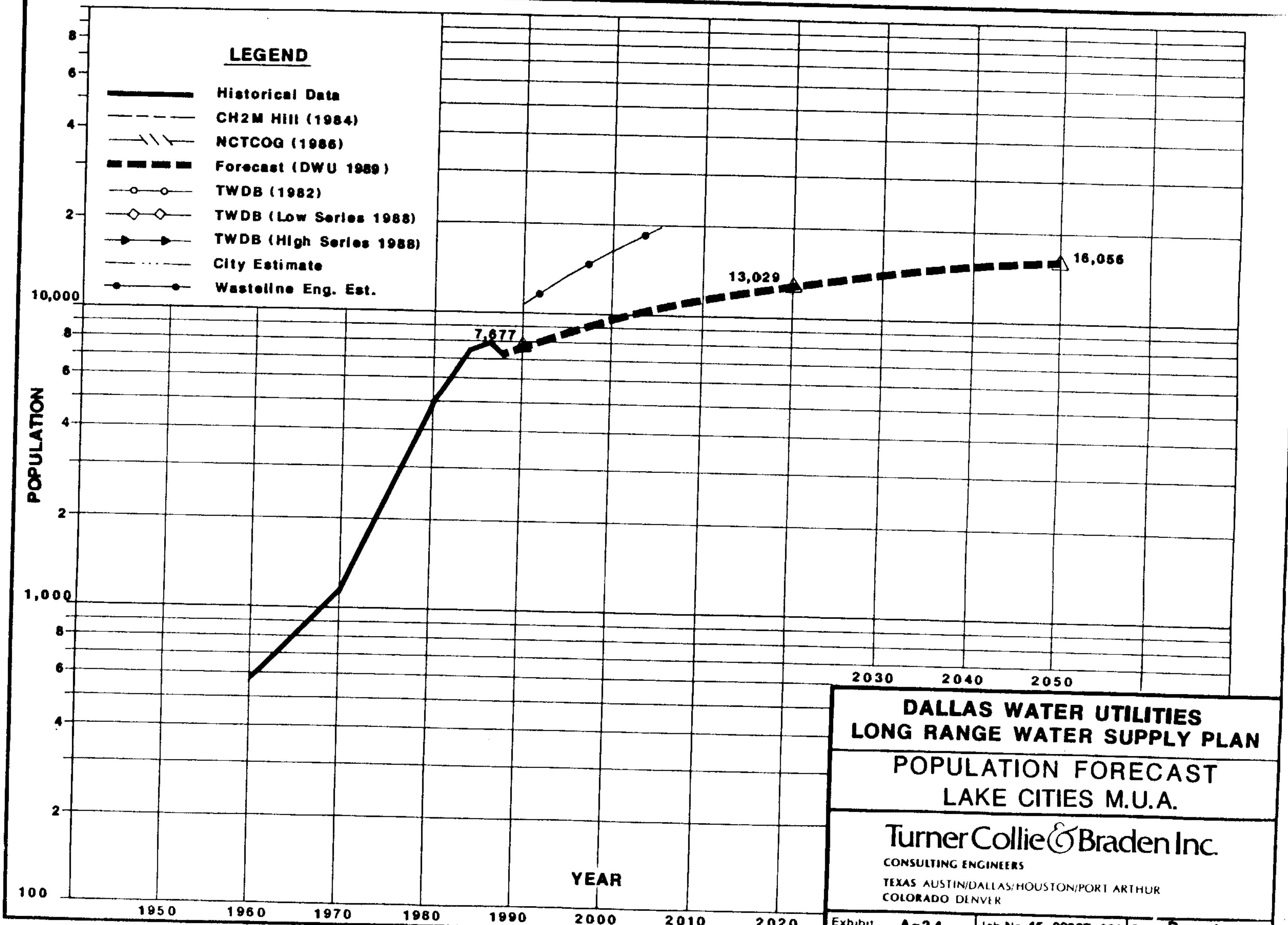


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF IRVING

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-23	Job No. 45-88007-031	Date December 89

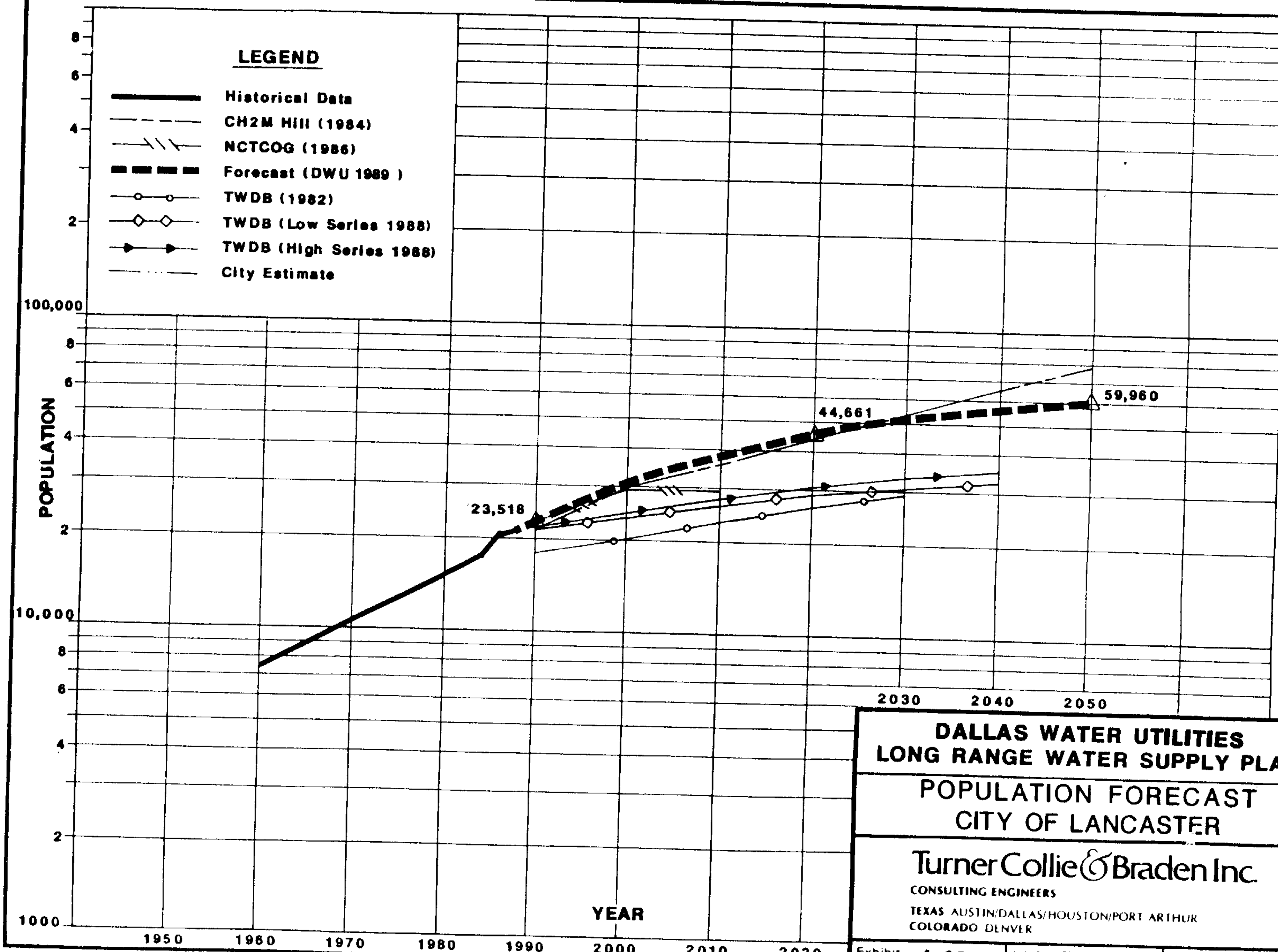


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
LAKE CITIES M.U.A.

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-24 | Job No 45-88007-031 | Date December 89

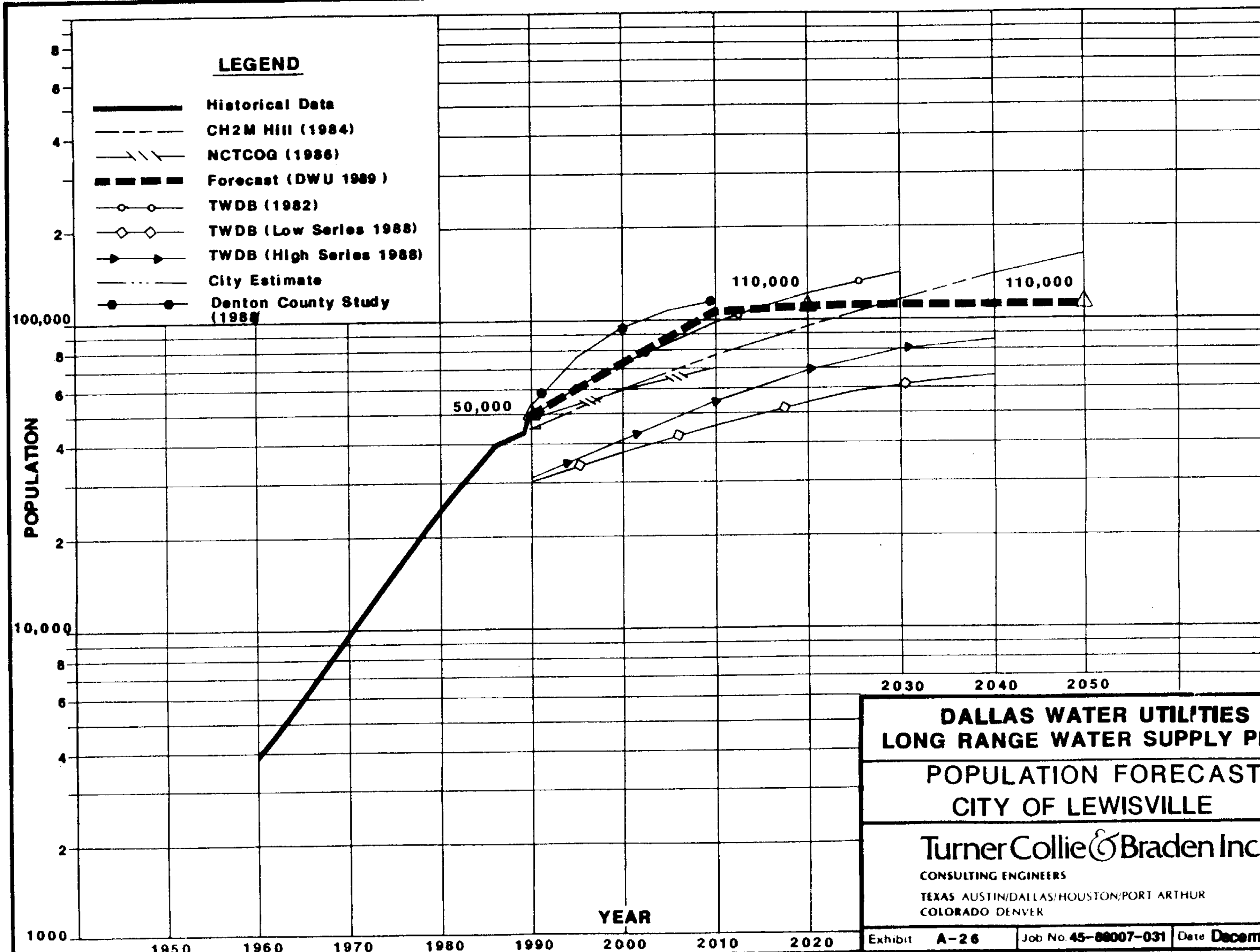


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF LANCASTER

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-25	Job No. 45-88007-031	Date December 89

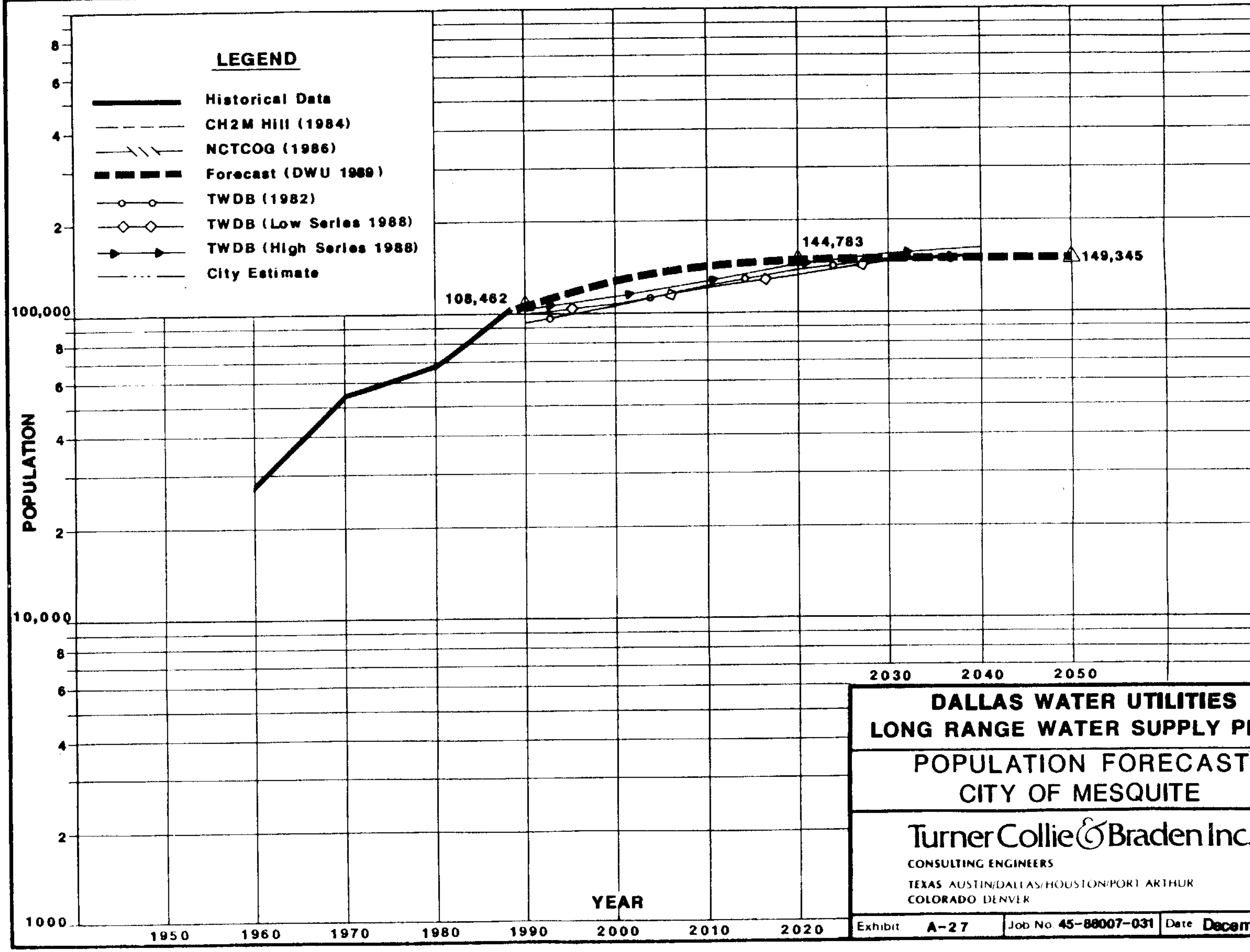


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF LEWISVILLE

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-26	Job No. 45-88007-031	Date December 89

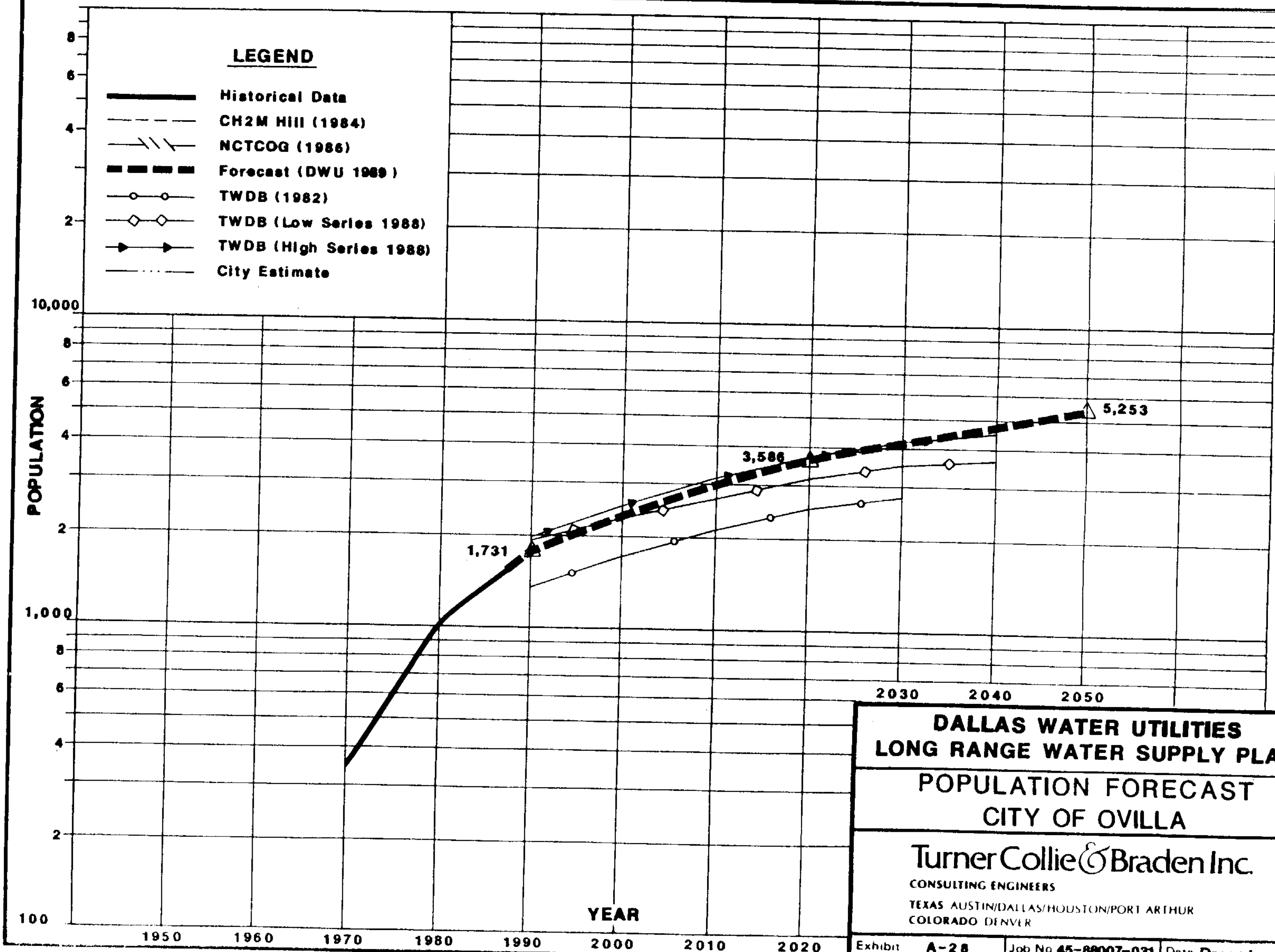


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF MESQUITE

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-27	Job No. 45-88007-031	Date December 89

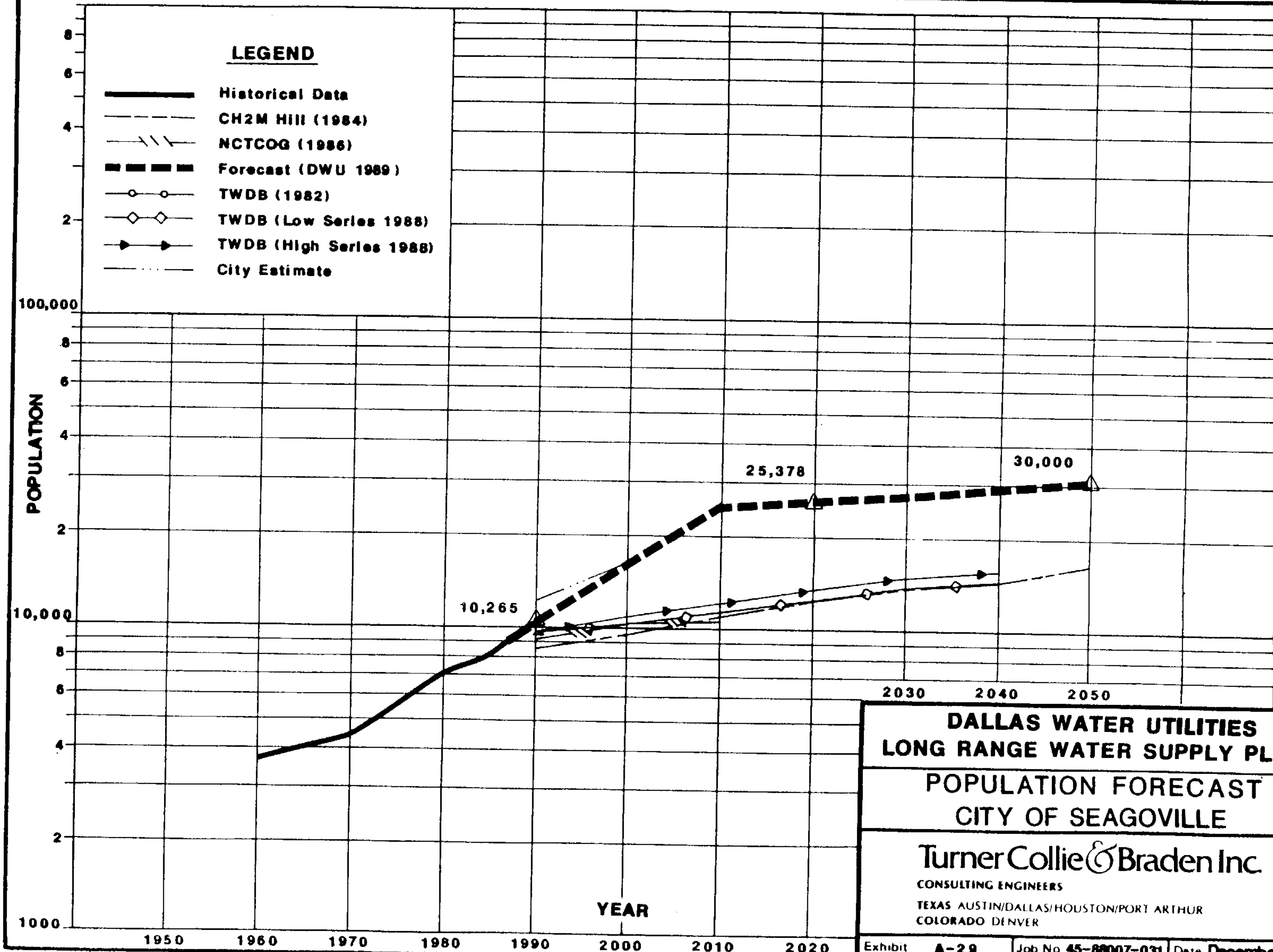


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF OVILLA

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-28	Job No. 45-88007-031	Date December 89

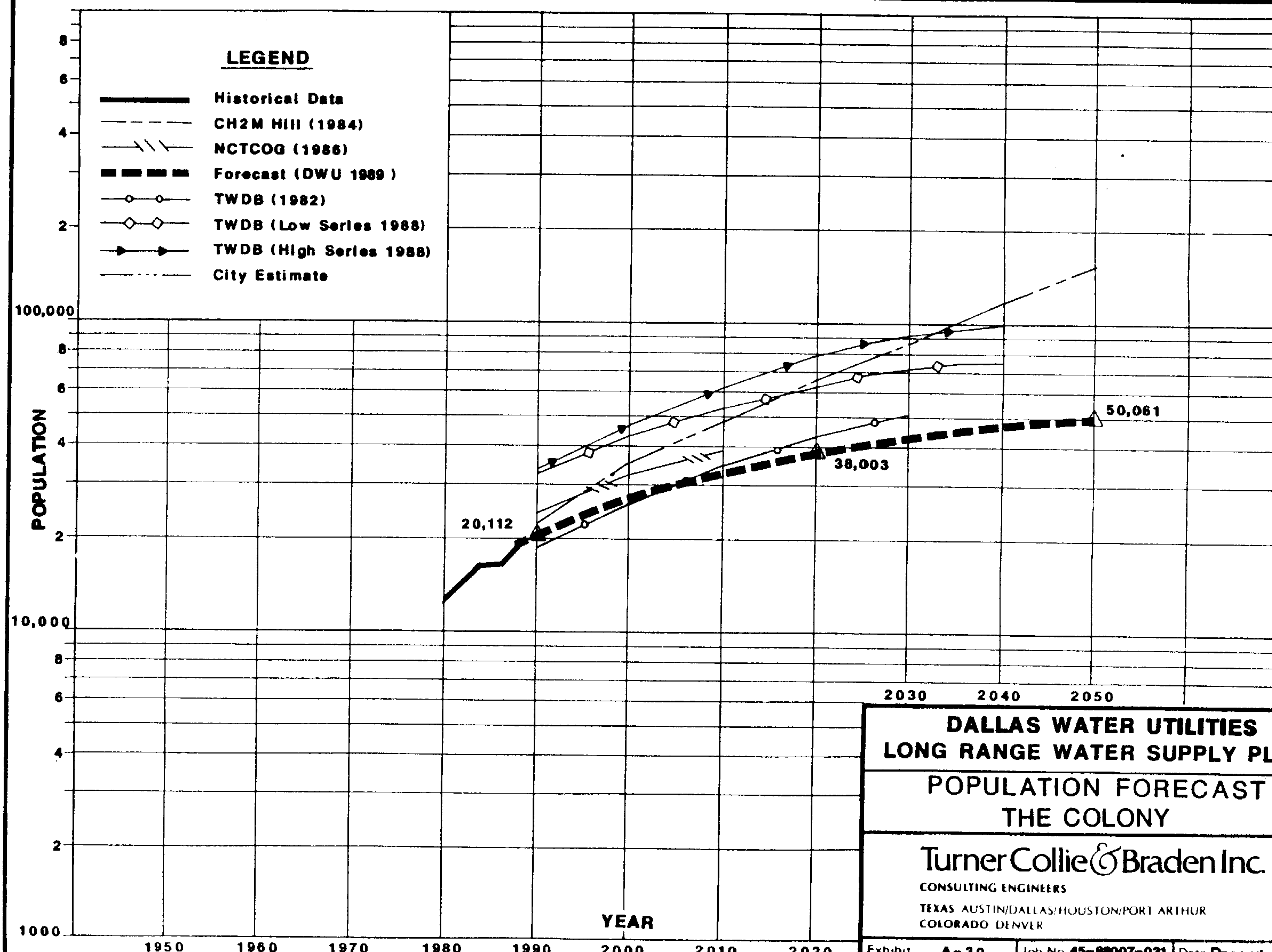


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF SEAGOVILLE

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-29	Job No 45-88007-031	Date December 89

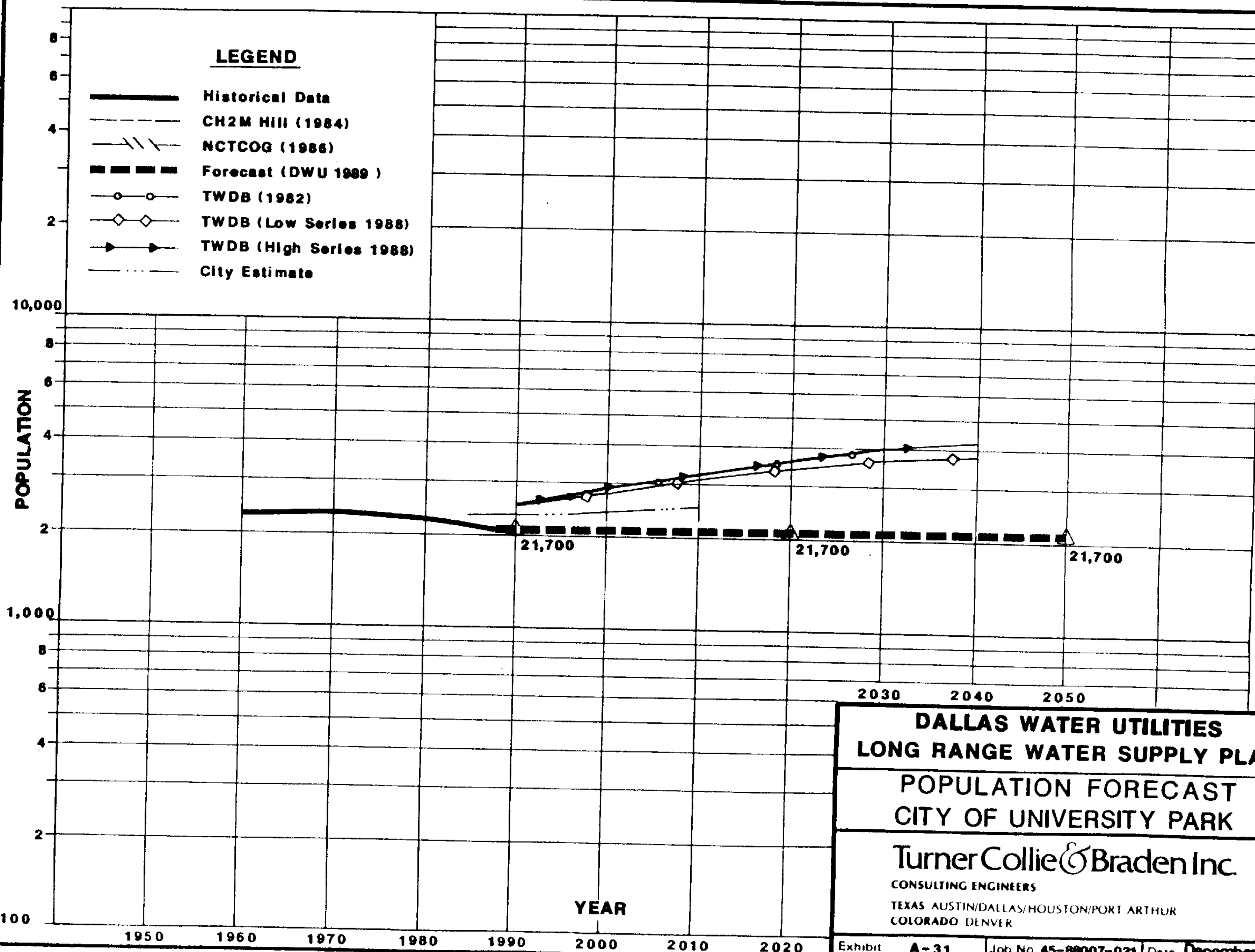


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
THE COLONY

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-30	Job No. 45-88007-031	Date December 89

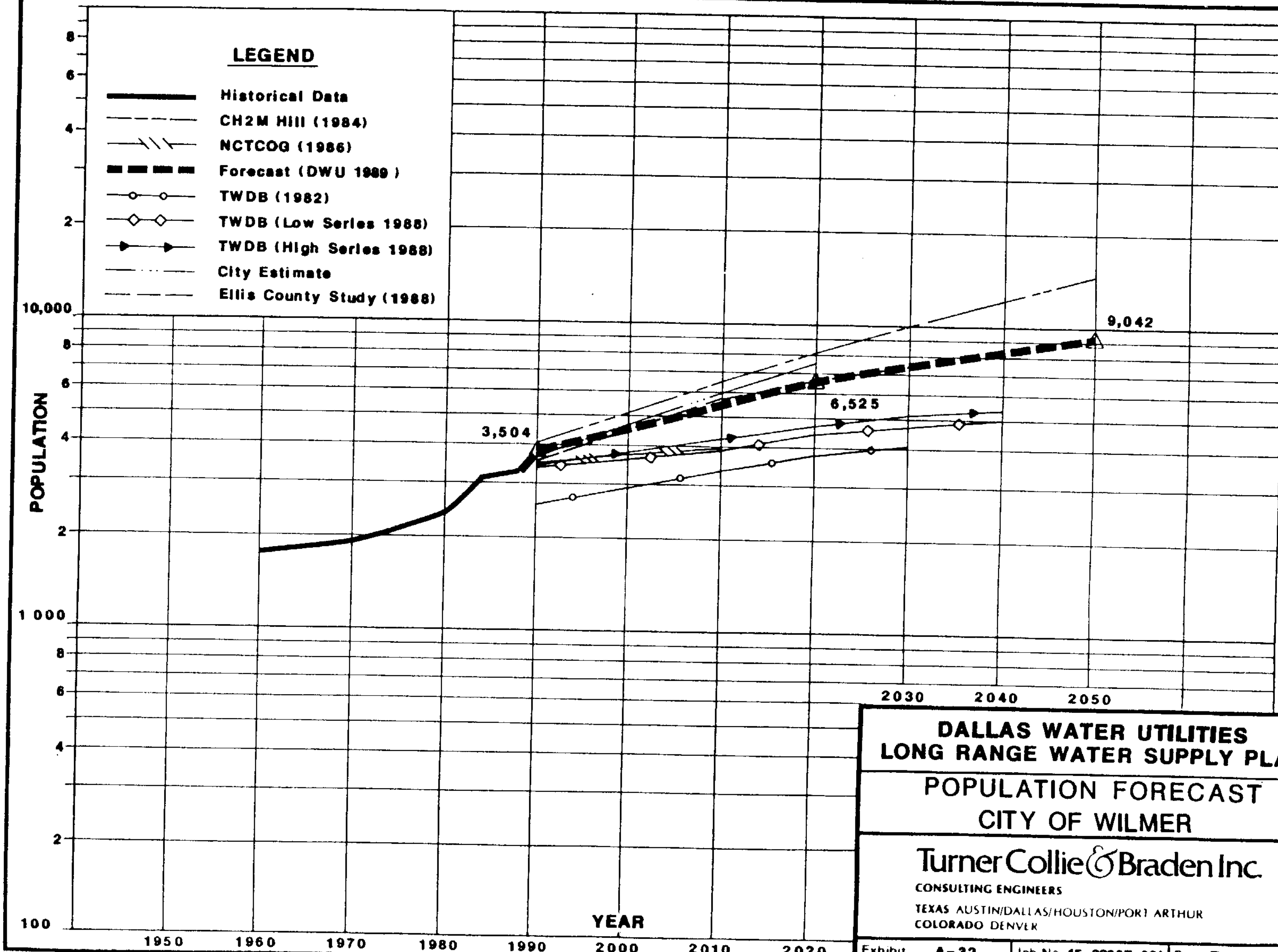


DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF UNIVERSITY PARK

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-31	Job No. 45-88007-031	Date December 89



DALLAS WATER UTILITIES
LONG RANGE WATER SUPPLY PLAN

POPULATION FORECAST
CITY OF WILMER

Turner Collie & Braden Inc.
CONSULTING ENGINEERS
TEXAS AUSTIN/DALLAS/HOUSTON/PORT ARTHUR
COLORADO DENVER

Exhibit A-32	Job No. 45-88007-031	Date December 89

Appendix B
Reservoir Data and Area–Capacity Data

1. RESERVOIR DATA

Appendix B discusses each existing water supply reservoir, included in Section III of the main report. Also, pertinent data for each reservoir, including potential reservoirs, are presented in Tables B-1 through B-26.

Lewisville Lake

Lewisville Lake, formerly Garza-Little Elm Reservoir was completed in August 1955. It is a U.S. Army Corps of Engineers (COE) multiple-purpose project used for flood control, water conservation, and recreation. Lewisville Dam, which controls runoff from a drainage area of 1,660 square miles (including the 692-square mile Ray Roberts Lake watershed), is located in Denton County on the Elm Fork of the Trinity River near the City of Lewisville, Texas. It is downstream from the old Lake Dallas Dam which was breached in October, 1957, incorporating Lake Dallas into Garza-Little Elm Reservoir. The name of the lake was changed from Garza-Little Elm to Lewisville Lake in 1972.

The top of the water conservation pool was raised seven feet to 522.0 feet in November 1988 as part of the Ray Roberts Lake Construction/Lewisville Lake Modification Project. This project increased the capacity of Lewisville Lake to 1.8 billion acre-feet. The City of Dallas' portion of the yield from Lewisville Lake flows by gravity down the Elm Fork of the Trinity River to diversion points at Carrollton Dam and Frazier Dam. At these points, the water is routed to the Elm Fork and Bachman WTPs, respectively. The dependable yield to the City of Dallas for the Ray Roberts Lake/Lewisville Lake system is estimated to be 144.8 mgd in 1990. [Data obtained from the Fort Worth District, U.S. Army COE and from Dallas Water Utilities (DWU).]

Ray Roberts Lake

Ray Roberts Lake, formerly Aubrey Lake, is a U.S. Army COE project authorized for flood control, water supply, water-quality control, recreation, and fish and wildlife enhancement. The dam is approximately 30 miles upstream from Lewisville Dam and impounds the Elm Fork of the Trinity River. The dam was completed in 1987 and the reservoir was at 80 percent of conservation storage after the heavy rains in the spring of 1989. The project will provide 260,000 acre-feet of flood control storage and 749,200 acre-feet of conservation storage.

The cities of Dallas and Denton were joint local sponsors of the Ray Roberts Lake/Lewisville Lake modification project. Under an agreement between the two cities dated November 19, 1962, Denton financed 26 percent of the construction cost and Dallas financed the remaining 74 percent. The dependable yield to the City of Dallas of the Ray Roberts Lake/Lewisville Lake system is estimated to be 144.8 mgd in 1990. (Data obtained from the Fort Worth District, U.S. Army COE and from DWU.)

Lake Palestine

Lake Palestine is located about 90 miles southeast of Dallas in the Upper Neches River watershed on the Neches River in Anderson, Cherokee, Henderson, and Smith Counties. The lake is used for water supply purposes and is owned and operated by the Upper Neches River Municipal Water Authority (UNRMWA). Blackburn Crossing Dam, which impounds and controls the runoff from the 839-square-mile contributing drainage area, was constructed in three phases, the last of which was completed in 1971.

Transfer of 114,337 acre-feet of water per year (102.0 mgd) is recognized under Contractual Permit No. CP 173, held by the City of Dallas, to divert water to the Trinity River Basin for municipal and industrial use. The present yield of the lake is 193.6 mgd (1990) and is expected to decrease to 187.6 mgd by the year 2050 due to sedimentation. Dallas' share in the year 2050 will decrease to approximately 100.7 mgd.

A preliminary study completed by Dannenbaum Engineering Corporation in 1989 recommends that an 84-inch raw water transmission line be installed with an intermediate booster pump station from Lake Palestine to the proposed Southeast WTP. This study proposes the pump station be designed to pump a peak rate of 120 mgd, the maximum permitted diversion rate. (Data obtained from the UNRMWA's "Hydrology Report on Lake Palestine and Neches River Channel Dam and Reservoir," 1984.)

Lake Fork

Lake Fork, located in the Sabine River watershed, is a SRA water supply reservoir that was completed in 1980. The Lake Fork Dam impounds Lake Fork Creek, a tributary to the Sabine River, approximately five miles west of Quitman, Texas. The reservoir is located in Wood, Rains, and Hopkins Counties and has a contributing drainage area of 493 square miles. Lake Fork is the only reservoir to be constructed in the planned Tri-Lakes Project, which was discussed in the 1975 DWU Long-Range Water Supply Plan. This lake was initially planned and constructed as a water supply and surface cooling reservoir for steam electric power generation.

The City of Dallas entered into a three-way contract with SRA and Texas Utilities Generating Company (TUGCO) on October 1, 1981, to allow the City of Dallas to use previously permitted water rights held by TUGCO in Lake Fork. The contract entered into by the City of Dallas, SRA, and TUGCO provided Dallas with 74 percent of the dependable yield of Lake Fork with a 120,000 acre-feet/year (107.12 mgd) diversion limitation. (Data obtained from DWU and the SRA's "Report on Update of the Master Plan for the Sabine River and Tributaries in Texas," March 1985).

2. AREA-CAPACITY DATA

Revised area-capacity data for Lewisville Lake, Lake Ray Hubbard, and Lake Palestine are presented in Tables B-27 through B-33. As indicated in Section VIII of the main report, area-capacity data for Lakes Ray Hubbard and Palestine for 2050 were not used for development of yields.

TABLE B-1

PERTINENT DATA

LEWISVILLE LAKE

RIVER MILE	30.0 ELM FORK OF THE TRINITY RIVER
DRAINAGE AREA	1660 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	579,200 CFS
VOLUME	2,114,100 AC-FT
VOLUME	23.91 INCHES
OUTFLOW PEAK	157,100 CFS
SPILLWAY	
TYPE	UNCONTROLLED OGEE
LENGTH	560 FT. NET AT CREST
CREST ELEVATION	532.0 FT. MSL
OUTLET WORKS	
CONDUIT SIZE	16 FT. DIA.
CONTROL	3-6.5'X13' BROOME-TYPE GATES
ELEVATION AT INVERT	448.0 FT. MSL

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY* (AC.-FT.)
TOP OF DAM	560.0	---	---
DESIGN WATER SURFACE	549.2	60,700	1,804,000
TOP OF CONSERVATION POOL	522.0	28,980	618,400
SEDIMENT ALLOWANCE	---	---	73,800
STREAMBED	435.0	---	---

* STORAGE CAPACITY INCLUDES 73,800 AC-FT OF STORAGE FOR ESTIMATED SEDIMENT DEPOSITION BY YEAR 2085, WITH 63,400 AC-FT BELOW ELEVATION 522.0 AND 10,400 AC-FT BETWEEN 522.0 AND 532.0 FT MSL.

TABLE B-2

PERTINENT DATA

RAY ROBERTS LAKE

RIVER MILE	60.0 ELM FORK OF THE TRINITY RIVER
DRAINAGE AREA	692 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	494,200 CFS
VOLUME	933,000 AC-FT
VOLUME	25.28 INCHES
OUTFLOW PEAK	22,500 CFS
SPILLWAY	
TYPE	UNCONTROLLED BROADCRESTED
LENGTH	100 FT.
CREST ELEVATION	645.5 FT. MSL
OUTLET WORKS	
CONDUIT SIZE	13 FT. DIA.
CONTROL	2-6'X13' SERVICE GATES
ELEVATION AT INVERT	545.0 FT. MSL

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY* (AC.-FT.)
TOP OF DAM	665.0	68,500	---
DESIGN WATER SURFACE	658.8	59,620	1,931,900
TOP OF CONSERVATION POOL	632.5	29,350	799,600
SEDIMENT ALLOWANCE	---	---	54,600
STREAMBED	524.0	0	0

* INCLUDES 54,600 AC-FT OF STORAGE FOR ESTIMATED 50-YEAR SEDIMENT DEPOSITION WITH 50,400 AC-FT BELOW ELEVATION 632.5 AND 4,200 AC-FT BETWEEN ELEVATIONS 632.5 AND 640.5 FT MSL.

TABLE B-3

PERTINENT DATA

GRAPEVINE LAKE

RIVER MILE	11.7 DENTON CREEK
DRAINAGE AREA	695 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	319,400 CFS
VOLUME	797,800 AC-FT
VOLUME	21.52 INCHES
OUTFLOW PEAK	182,500 CFS
SPILLWAY	
TYPE	UNGATED OGEE
LENGTH	500 FT.
CREST ELEVATION	560.0 FT. MSL
OUTLET WORKS	
CONDUIT SIZE	13 FT. DIA.
CONTROL	2-6.5'X13' BROOME-TYPE GATES
ELEVATION AT INVERT	475.0

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY* (AC.-FT.)
TOP OF DAM	588.0	---	---
DESIGN WATER SURFACE	581.0	---	---
TOP OF CONSERVATION POOL	535.0	7384	181,100
SEDIMENT ALLOWANCE	---	---	58,111
STREAMBED	470.0	0	0

* ELEVATION-AREA-CAPACITY DATA ARE THOSE TAKEN FROM RESERVOIR RESURVEY OF 1966. STORAGE CAPACITY INCLUDES 58,111 AC-FT OF STORAGE FOR ESTIMATED SEDIMENT DEPOSITION BY YEAR 2050, WITH 41,881 AC-FT BELOW ELEVATION 535.0 AND 16,230 AC-FT BETWEEN ELEVATION 535.0 AND 560.0.

TABLE B-4

PERTINENT DATA

LAKE RAY HUBBARD

RIVER MILE	31.8 EAST FORK OF THE TRINITY RIVE
DRAINAGE AREA	1071 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	445,000 CFS
VOLUME	1,287,250 AC-FT
VOLUME	22.4 INCHES
OUTFLOW PEAK	375,000 CFS
SPILLWAY	
TYPE	GATED - 14 - 40' X 28'
LENGTH	560 FT.(NET)
CREST ELEVATION	409.5 FT. MSL
OUTLET WORKS	
CONDUIT SIZE	3-4.5'X6.75' SLUICES
CONTROL	3-4' X 6'; 3-2' X 3-1-1/2 X 2'
ELEVATION AT INVERT	388.0 ; 409.0 ; 409.0

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY* (AC.-FT.)
TOP OF DAM	450.0	---	---
DESIGN WATER SURFACE	440.5	25,820	611,500
TOP OF CONSERVATION POOL	435.5	22,745	490,000
SEDIMENT ALLOWANCE	---	---	24,956
STREAMBED	382.0	0	0

* STORAGE CAPACITY INCLUDES 24,956 AC-FT OF STORAGE FOR ESTIMATED SEDIMENT DEPOSITION BY YEAR 2050, ALL OF WHICH LIES BELOW ELEVATION 435.5 FT MSL.

TABLE B-5

PERTINENT DATA

LAKE TAWAKONI

RIVER MILE	514.5 SABINE RIVER
DRAINAGE AREA	756 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	210,000 CFS
VOLUME	733,912 AC-FT
VOLUME	18.3 INCHES
OUTFLOW PEAK	50,000 CFS
SPILLWAY	
TYPE	UNCONTROLLED OGEE
LENGTH	480 FT.
CREST ELEVATION	437.5
OUTLET WORKS	
CONDUIT SIZE	2 – 4' X 6'
CONTROL	GATED
ELEVATION AT INVERT	378.0

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY* (AC.-FT.)
TOP OF DAM	454.0	54,722	1,660,023
DESIGN WATER SURFACE	446.2	43,560	1,290,000
TOP OF CONSERVATION POOL	437.5	36,153	936,244
SEDIMENT ALLOWANCE	---	---	64,788
STREAMBED	374.0	0	0

* STORAGE CAPACITY INCLUDES 64,788 AC-FT OF STORAGE FOR ESTIMATED SEDI SEDIMENT DEPOSITION BY YEAR 2050, WITH 62,482 AC-FT BELOW ELEVATION 437.5 AND 2,306 AC-FT BETWEEN ELEVATIONS 437.5 AND 442.0 FT MSL.

TABLE B-6

PERTINENT DATA

LAKE PALESTINE

RIVER MILE	354.0 NECHES RIVER
DRAINAGE AREA	839 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	137,300 CFS
VOLUME	591,800 AC-FT
VOLUME	13.1 INCHES
OUTFLOW PEAK	60,400 CFS
SPILLWAY	
TYPE	UNCONTROLLED OGEE
LENGTH	500 FT.
CREST ELEVATION	345.0 FT. MSL
OUTLET WORKS	
CONDUIT SIZE	8.5 FT. DIA.
CONTROL	2 - 5' X 7' SLUICE GATES
ELEVATION AT INVERT	298.0 FT. MSL

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY* (AC.-FT.)
TOP OF DAM	364.0	43,750	1,070,140
DESIGN WATER SURFACE	355.3	35,395	726,036
TOP OF CONSERVATION POOL	345.0	25,562	411,839
SEDIMENT ALLOWANCE	---	---	19,352
STREAMBED	295.0	0	0

* STORAGE CAPACITY INCLUDES 19,352 AC-FT OF STORAGE FOR ESTIMATED SEDIMENT DEPOSITION BY YEAR 2050, WITH 18,265 AC-FT BELOW ELEVATION 345.0 AND 1,087 AC-FT BETWEEN ELEVATIONS 345.0 AND 350.0 FT MSL

TABLE B-7

PERTINENT DATA

LAKE FORK RESERVOIR

RIVER MILE	31.0 LAKE FORK CREEK
DRAINAGE AREA	493 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	178,500 CFS
VOLUME	393,000 AC-FT
VOLUME	14.94 INCHES
SPILLWAY	
TYPE	GATED OGEE -5 -40'X20' TAINTER
LENGTH	200 FT (NET)
CREST ELEVATION	385.0 FT MSL
OUTLET WORKS	
CONDUIT SIZE	2 - 5' X 8'
ELEVATION AT INVERT	360.0 FT MSL

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY (AC.-FT.)
TOP OF DAM	419.5	---	---
DESIGN WATER SURFACE	407.9	32,066	821,945
TOP OF CONSERVATION POOL	403.0	27,690	675,819
SEDIMENT ALLOWANCE	360.0	4,840	40,624
STREAMBED	335.0	---	---

TABLE B–8

PERTINENT DATA

JOE POOL LAKE

RIVER MILE	11.2 MOUNTAIN CREEK
DRAINAGE AREA	232 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	342,200 CFS
VOLUME	360,700 AC–FT
VOLUME	29.15 INCHES
OUTFLOW PEAK	30,300 CFS
SPILLWAY	
TYPE	BROADCRESTED
LENGTH	50 FT. NET AT CREST
CREST ELEVATION	541.0 FT.MSL
OUTLET WORKS	
CONDUIT SIZE	10.5 FT. DIA.
CONTROL	2 – 4.75' X 10.5' SLUICE GATES
ELEVATION AT INVERT	466.0 FT. MSL

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY* (AC.–FT.)
TOP OF DAM	564.5	---	---
DESIGN WATER SURFACE	559.5	18,600	642,400
TOP OF CONSERVATION POOL	536.0	10,940	304,000
SEDIMENT ALLOWANCE	---	---	38,000
STREAMBED	456.0	0	0

* INCLUDES 38,000 AC–FT OF STORAGE FOR ESTIMATED 100–YEAR SEDIMENTATION IN PROPOSED RESERVOIR WITH 34,000 AC–FT BELOW ELEVATION 522.0 AND 4,000 AC–FT BETWEEN ELEVATIONS 522.0 AND 536.0 FT MSL

TABLE B-9

PERTINENT DATA

COOPER RESERVOIR

RIVER MILE	23.2 SOUTH SULPHUR RIVER
DRAINAGE AREA	476 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	234,790 CFS
VOLUME	741,250 AC-FT
VOLUME	29.21 INCHES
OUTFLOW PEAK	167,000 CFS
SPILLWAY	
TYPE	GATED OGEE 5 - 40' X 20' GATES
LENGTH	200' (NET) AT CREST
CREST ELEVATION	426.2 FT. MSL
OUTLET WORKS	
CONDUIT SIZE	2 - 13 FT. DIA.
CONTROL	SLIDES GATES
ELEVATION AT INVERT	398.0

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY (AC.-FT.)
TOP OF DAM	458.5	---	---
DESIGN WATER SURFACE	452.8	26,563	603,670
TOP OF CONSERVATION POOL	440.0	19,276	310,000
SEDIMENT ALLOWANCE	415.5	5,084	37,000
STREAMBED	386.0	0	0

TABLE B-10

PERTINENT DATA

WRIGHT PATMAN LAKE

RIVER MILE	44.5 SULPHUR RIVER
DRAINAGE AREA	3,400 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	451,000 CFS
VOLUME	3,645,000 AC-FT
VOLUME	20.1 INCHES
OUTFLOW PEAK	478,600 CFS
SPILLWAY	
TYPE	UNCONTROLLED OGEE
LENGTH	200 FT.
CREST ELEVATION	259.5 FT. MSL
OUTLET WORKS	
CONDUIT SIZE	20.0 FT. DIA.
CONTROL	4 - 10' X 20' HYDRAULIC SLIDE GA
ELEVATION AT INVERT	200.0 FT. MSL

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY (AC.-FT.)
TOP OF DAM	286.0	234,100	---
DESIGN WATER SURFACE	278.9	200,600	5,730,500
TOP OF CONSERVATION POOL	220.6	20,300	158,000
SEDIMENT ALLOWANCE	---	---	68,000
STREAMBED	180.0	0	0

TABLE B-11

PERTINENT DATA

LAKE O' THE PINES

RIVER MILE	81.2 CYPRESS CREEK
DRAINAGE AREA	850 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	367,100 CFS
VOLUME	1,320,300 AC-FT
VOLUME	29.1 INCHES
OUTFLOW PEAK	74,600 CFS
SPILLWAY	
TYPE	UNCONTROLLED OGEE
LENGTH	200 FT.
CREST ELEVATION	249.5 FT. MSL
OUTLET WORKS	
CONDUIT SIZE	2 - 10' DIA.
CONTROL	2 - 8' X 12.5' GATES
ELEVATION AT INVERT	199.0 FT. MSL

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY (AC.-FT.)
TOP OF DAM	277.0	---	---
DESIGN WATER SURFACE	269.9	63,200	1,856,000
TOP OF CONSERVATION POOL	228.5	18,700	254,900
SEDIMENT ALLOWANCE	---	---	2,150
STREAMBED	180.0	0	0

TABLE B-12

PERTINENT DATA

RICHLAND CHAMBERS RESERVOIR

RIVER MILE	5.4 RICHLAND CREEK
DRAINAGE AREA	1,957 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	727,456 CFS
VOLUME	--------
VOLUME	--------
OUTFLOW PEAK	597,565 CFS
SPILLWAY	
TYPE	24 – 40' X 29.4' GATES
LENGTH	1155 FT.
CREST ELEVATION	290.0 FT. MSL
OUTLET WORKS	
CONDUIT SIZE	2 – 3' X 5'
CONTROL	3' X 5' GATES
ELEVATION AT INVERT	266.0 FT. MSL

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY (AC.-FT.)
TOP OF DAM	SW 330 ; NE 326	---	1,419,273
DESIGN WATER SURFACE	320.0	---	---
TOP OF CONSERVATION POOL	315.0	---	1,181,886
SEDIMENT ALLOWANCE	---	---	80,000
STREAMBED	230.0	0	0

TABLE B-13

PERTINENT DATA

TOLEDO BEND RESERVOIR

RIVER MILE	156.5 SABINE RIVER
DRAINAGE AREA	7,178 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	-----
VOLUME	-----
VOLUME	-----
OUTFLOW PEAK	-----
SPILLWAY	
TYPE	CONTROLLED OGEE
LENGTH	440.0 FT. (NET)
CREST ELEVATION	145.0 FT. MSL
OUTLET WORKS	
CONDUIT SIZE	8.3' X 12'
CONTROL	8.3' X 12' GATE
ELEVATION AT INVERT	100.0 FT. MSL

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY (AC.-FT.)
TOP OF DAM	185.0	---	---
DESIGN WATER SURFACE	175.3	197,600	5,102,000
TOP OF CONSERVATION POOL	172.0	181,600	4,477,000
SEDIMENT ALLOWANCE	---	---	---
STREAMBED	73.0	0	0

TABLE B-14

PERTINENT DATA

LAKE TEXOMA

RIVER MILE	725.9 RED RIVER
DRAINAGE AREA	39,719 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	1,350,000 CFS
VOLUME	9,190,0000 AC-FT
VOLUME	-------------
OUTFLOW PEAK	750,000 CFS
SPILLWAY	
TYPE	OGEE
LENGTH	2,000 FT.
CREST ELEVATION	640.0 FT. MSL
OUTLET WORKS	
CONDUIT SIZE	20 FT. DIA.
CONTROL	8 - CONDUITS
ELEVATION AT INVERT	523.0 FT. MSL

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY (AC.-FT.)
TOP OF DAM	670.0	---	---
DESIGN WATER SURFACE	640.0	143,300	5,382,000
TOP OF POWER POOL	617.0	89,000	2,722,000
BOTTOM OF POWER POOL	590.0	44,100	1,049,000
STREAMBED	534.0	---	---

* LAKE TEXOMA WAS ORIGINALLY ALLOCATED FOR FLOOD CONTROL AND THE GENERATION OF HYDROELECTRIC POWER, THE CORPS OF ENGINEERS HAS INDICATED THAT AS MUCH AS 150,000 AC-FT OF WATER COULD BE RE-ALLOCATED FOR MUNICIPAL USE FROM THE POWER POOL.

TABLE B-15

PERTINENT DATA

ROANOKE RESERVOIR

RIVER MILE	32.0 DENTON CREEK
DRAINAGE AREA	604 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	325,600 CFS
VOLUME	780,000 AC-FT
VOLUME	24.21 INCHES
OUTFLOW PEAK	297,000 CFS
SPILLWAY	
TYPE	OGEE
LENGTH	280 FT. NET AT CREST
CREST ELEVATION	584.0 FT. MSL
OUTLET WORKS	
CONDUIT SIZE	15 FT. DIA.
CONTROL	3 – 4.5' X 15' POWER SLIDE GATES
ELEVATION AT INVERT	560.0 FT. MSL

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY (AC.-FT.)
TOP OF DAM	631.0	---	---
DESIGN WATER SURFACE	625.7	11,420	320,600
TOP OF CONSERVATION POOL	---	---	---
SEDIMENT ALLOWANCE	---	---	26,200
STREAMBED	534.0	0	0

TABLE B-16

PERTINENT DATA

GEORGE PARKHOUSE RESERVOIR
STAGE I

RIVER MILE	3.6 SOUTH SULPHER RIVER
DRAINAGE AREA	645 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	-----
VOLUME	-----
VOLUME	-----
OUTFLOW PEAK	-----
SPILLWAY	
TYPE	GATED CONCRETE OGEE
LENGTH	240.0 FT.
CREST ELEVATION	375.0 FT. MSL
OUTLET WORKS	
CONTROL	4 - 4' X 6'
ELEVATION AT INVERT	353.0 FT. MSL

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY (AC.-FT.)
TOP OF DAM	412.0	---	---
DESIGN WATER SURFACE	406.0	33,800	157,460
TOP OF CONSERVATION POOL	401.0	29,200	635,393
SEDIMENT ALLOWANCE	---	---	---

TABLE B-17

PERTINENT DATA

GEORGE PARKHOUSE RESERVOIR
STAGE II

RIVER MILE	5.5 NORTH SULPHUR RIVER
DRAINAGE AREA	381 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	-----
VOLUME	-----
VOLUME	-----
OUTFLOW PEAK	-----
SPILLWAY	
TYPE	GATED OGEE (10 – 40' X 28')
LENGTH	240.0 FT.
CREST ELEVATION	375.0 FT. MSL
OUTLET WORKS	
CONTROL	4 – 4' X 6'
ELEVATION AT INVERT	353.0 FT. MSL

FEATURE	ELEVATION (FEET)	AREA* (ACRES)	CAPACITY (AC.-FT.)
TOP OF DAM	412.0	---	---
DESIGN WATER SURFACE	406.0	44,650	1,060,435
TOP OF CONSERVATION POOL	401.0	40,700	846,960
SEDIMENT ALLOWANCE	---	---	25,600
STREAMBED	335.0	---	---

* ULTIMATE AREAS AND CAPACITIES ARE STAGE I PLUS STAGE II

TABLE B-18

PERTINENT DATA

MARVIN C. NICHOLS RESERVOIR

RIVER MILE	15.1 SULPHER RIVER
DRAINAGE AREA	2656 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	-----
VOLUME	-----
VOLUME	-----
OUTFLOW PEAK	-----
SPILLWAY	
TYPE	GATED CONCRETE OGEE
LENGTH	400.0 FT. (10 – 40' X 28')
CREST ELEVATION	290.0 FT.MSL
OUTLET WORKS	
CONDUIT SIZE	7 FT. DIA.
CONTROL	4 – 4' X 6'
ELEVATION AT INVERT	268.0 FT. MSL

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY (AC.-FT.)
TOP OF DAM	330.0	---	---
DESIGN WATER SURFACE	322.5	142,450	3,770,825
TOP OF CONSERVATION POOL	312.0	127,400	2,220,011
SEDIMENT ALLOWANCE	---	---	56,350
STREAMBED	239.0	---	---

TABLE B-19

PERTINENT DATA

CARL L. ESTES LAKE

RIVER MILE	479.7 SABINE RIVER
DRAINAGE AREA	1,128 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	367,500 CFS
VOLUME	1,650,200 AC-FT
VOLUME	27.43 INCHES
OUTFLOW PEAK	55,200 CFS
SPILLWAY	
TYPE	OGEE
LENGTH	200 FT. NET AT CREST
CREST ELEVATION	403.0 FT. MSL
OUTLET WORKS	
CONDUIT SIZE	15 FT. DIA.
CONTROL	2 - 7' X 15' SLIDE GATES
ELEVATION AT INVERT	399.0 FT. MSL

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY* (AC.-FT.)
TOP OF DAM	428.5	---	---
DESIGN WATER SURFACE	420.4	66,500	2,151,300
TOP OF CONSERVATION POOL	379.0	24,900	393,000
SEDIMENT ALLOWANCE	---	---	20,400
STREAMBED	320.0	0	0

* ESTIMATED 100 YEARS OF SEDIMENT STORAGE DISTRIBUTED AS FOLLOWS:
3,700 AC-FT BETWEEN ELEV. 403.0 AND 379.0 FT. MSL
16,700 AC-FT BELOW ELEV. 379.0 FT. MSL

TABLE B-20

PERTINENT DATA

BIG SANDY RESERVOIR

RIVER MILE	10.6 BIG SANDY CREEK
DRAINAGE AREA	233 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	266,700 CFS
VOLUME	341,600 AC-FT
VOLUME	32.68 INCHES
OUTFLOW PEAK	17,800 CFS
SPILLWAY	
TYPE	BROADCRESTED
LENGTH	100.0 FT.
CREST ELEVATION	325.0 FT. MSL
OUTLET WORKS	
CONDUIT SIZE	5 FT. DIA.
CONTROL	2 - 4.25' X 9' SLIDE GATES
ELEVATION AT INVERT	300.0 FT. MSL

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY (AC.-FT.)
TOP OF DAM	367.5	---	---
DESIGN WATER SURFACE	362.5	12,810	272,762
TOP OF CONSERVATION POOL	340.0	4,950	76,179
SEDIMENT ALLOWANCE	---	---	6,900
STREAMBED	294.5	0	0

TABLE B-21

PERTINENT DATA

WATERS BLUFF RESERVOIR

DRAINAGE AREA	1,489 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	309,865 CFS
VOLUME	1,929,500 AC-FT
OUTFLOW PEAK	218,350 CFS
SPILLWAY	
TYPE	CONTROLLED OGEE
LENGTH	440.0 FT.
CREST ELEVATION	276.0 FT. MSL
OUTLET WORKS	
CONDUIT SIZE	-----
CONTROL	-----
ELEVATION AT INVERT	253.0 FT. MSL

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY (AC.-FT.)
TOP OF DAM	320.0	---	---
DESIGN WATER SURFACE	314.7	49,519	998,490
TOP OF CONSERVATION POOL	303.0	36,396	525,163
STREAMBED	246.0	0	0

TABLE B-22

PERTINENT DATA

PECAN BAYOU LAKE

RIVER MILE	100.8 PECAN BAYOU
DRAINAGE AREA	316 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	317,500 CFS
VOLUME	406,100 AC-FT
VOLUME	24.10 INCHES
OUTFLOW PEAK	184,200 CFS
SPILLWAY	
TYPE	BROADCRESTED
LENGTH	800 FT.
CREST ELEVATION	1653.0 FT. MSL
OUTLET WORKS	
CONDUIT SIZE	16 FT. DIA.
CONTROL	3 - 5' X 16' SLUICE GATES
ELEVATION AT INVERT	1588.0 FT. MSL

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY* (AC.-FT.)
TOP OF DAM	1676.0	---	---
DESIGN WATER SURFACE	1670.4	12,010	379,700
TOP OF CONSERVATION POOL	1637.0	5,150	102,000
SEDIMENT ALLOWANCE	---	---	10,100
STREAMBED	1569.0	0	0

* ESTIMATED 50 YEARS OF SEDIMENT STORAGE DISTRIBUTED AS FOLLOWS:
1,600 AC-FT BETWEEN ELEV. 1653.0 AND 1637.0 FT. MSL
8,500 AC-FT BELOW ELEV. 1637.0 FT. MSL

TABLE B-23

PERTINENT DATA

BLACK CYPRESS LAKE

RIVER MILE	17.0 BLACK CYPRESS BAYOU
DRAINAGE AREA	335.0 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	-----
VOLUME	-----
VOLUME	-----
OUTFLOW PEAK	-----
SPILLWAY	
TYPE	HIGH CREST OGEE OVERFLOW
LENGTH	600.0 FT.
CREST ELEVATION	262.0 FT. MSL
OUTLET WORKS	
CONDUIT SIZE	1 GATE - CONTROLLED 10' COND
CONTROL	2 - 4.5' X 10' GATES
ELEVATION AT INVERT	-----

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY (AC.-FT.)
TOP OF DAM	274.59	---	---
DESIGN WATER SURFACE	270.90	---	---
TOP OF CONSERVATION POOL	253.00	21,951	447,262
SEDIMENT ALLOWANCE	---	---	---
STREAMBED	---	0	0

TABLE B-24

PERTINENT DATA

LITTLE CYPRESS LAKE

RIVER MILE	19.7 LITTLE CYPRESS BAYOU
DRAINAGE AREA	619.0 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	302,600 cfs
VOLUME	1,043,600 acre-feet
VOLUME	31.61 inches
OUTFLOW PEAK	170,700 cfs
SPILLWAY	
TYPE	GATED OGEE CREST
LENGTH	280.0 FT.
CREST ELEVATION	210.0 FT. MSL
OUTLET WORKS	
CONDUIT SIZE	2- 30" DIAMETER CONDUIT
CONTROL	OGEE CREST
ELEVATION AT INVERT	205.0' and 220.0'

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY (AC.-FT.)
TOP OF DAM	250.0	---	---
DESIGN WATER SURFACE	245.0	22,520	461,735
TOP OF CONSERVATION POOL	230.0	13,760	193,485
SEDIMENT ALLOWANCE	---	---	7,768
STREAMBED	186.0	0	0

TABLE B-25

PERTINENT DATA

TENNESSEE COLONY LAKE

RIVER MILE	341.7 TRINITY RIVER
DRAINAGE AREA	12,302 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	1,370.700 CFS
VOLUME	12,257,600 AC-FT
VOLUME	18.68 INCHES
OUTFLOW PEAK	620,700 CFS
SPILLWAY	
TYPE	OGEE
LENGTH	400.0 FT. AT CREST
CREST ELEVATION	257.0 FT. MSL
OUTLET WORKS	
CONDUIT SIZE	10' X 20'
CONTROL	8 - 10' X 20' SLUICE GATES
ELEVATION AT INVERT	224.0 FT. MSL

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY* (AC.-FT.)
TOP OF DAM	318.0	212,500	---
DESIGN WATER SURFACE	308.1	188,800	6,749,700
TOP OF CONSERVATION POOL	275.0	97,960	2,020,100
SEDIMENT ALLOWANCE	---	---	246,400
STREAMBED	195.0	0	0

* ESTIMATED 100 YEARS OF SEDIMENT DISTRIBUTED AS FOLLOWS:
67,800 AC-FT BETWEEN ELEV. 292.0 AND 275.0 FT. MSL
178,600 AC-FT BELOW ELEV. 275.0 FT. MSL

TABLE B-26

PERTINENT DATA

TEHUACANA RESERVOIR

RIVER MILE	11.2 TEHUACANA CREEK
DRAINAGE AREA	336 SQUARE MILES
SPILLWAY DESIGN FLOOD	
PEAK INFLOW	266,100 CFS
VOLUME	558,200 AC-FT
VOLUME	31.1 INCHES
OUTFLOW PEAK	178,800 CFS
SPILLWAY	
TYPE	GATED OGEE WIER
LENGTH	160.0 FT.
CREST ELEVATION	-----
OUTLET WORKS	
CONDUIT SIZE	3' X 6'
CONTROL	-----
ELEVATION AT INVERT	-----

FEATURE	ELEVATION (FEET)	AREA (ACRES)	CAPACITY* (AC.-FT.)
TOP OF DAM	320.0	20,750	474,850
DESIGN WATER SURFACE	315.0	17,875	378,437
TOP OF CONSERVATION POOL	310.0	15,200	295,850
SEDIMENT ALLOWANCE	---	---	7,536
STREAMBED	265.0	0	0

Table B-27
Area-Capacity Calculations
Lake Lewisville
Surveyed in 1989

ELEVATION (feet)	CAPACITY AREA 0	CAPACITY AREA 1	CAPACITY AREA 2	CAPACITY AREA 3	CAPACITY AREA 4	CAPACITY AREA 5	CAPACITY AREA 6	CAPACITY AREA 7	CAPACITY AREA 8	CAPACITY AREA 9
450	0 0	0 0	0 0	0 0	0 0	4 8	21 25	54 41	103 58	169 74
460	252 91	352 109	470 127	606 146	761 164	934 182	1135 219	1372 256	1646 292	1957 329
470	2304 366	2804 633	3570 900	4604 1168	5906 1435	7474 1702	9466 2282	12039 2863	15192 3443	18925 4024
480	23239 4604	27938 4793	32825 4982	37902 5172	43169 5361	48624 5550	54309 5819	60263 6089	66486 6358	72979 6628
490	79742 6897	86742 7103	93947 7308	101358 7514	108975 7719	116797 7925	125005 8492	133781 9059	143123 9625	153031 10192
500	163507 10759	174432 11092	185690 11424	197281 11757	209204 12089	221459 12422	234150 12959	247377 13496	261141 14032	275442 14569
510	290279 15106	306170 16676	323631 18246	342662 19816	363263 21386	385434 22956	408950 24075	433584 25194	459338 26314	486212 27433
520	514204 28552	542911 28861	571926 29170	601250 29478	630883 29787	660824 30096	691167 30589	722002 31082	753330 31574	785151 32067
530	817464 32560	851061 34634	886732 36708	924478 38783	964298 40857	1006192 42931	1049664 44013	1094218 45095	1139854 46177	1186572 47259
540	1234372 48341									

Capacities given in acre-feet and areas in acres.

Average End Area Method of Calculation

Table B-28
Area-Capacity Calculations
Lake Ray Hubbard
Surveyed in 1989

ELEVATION (feet)	CAPACITY AREA 0	CAPACITY AREA 1	CAPACITY AREA 2	CAPACITY AREA 3	CAPACITY AREA 4	CAPACITY AREA 5	CAPACITY AREA 6	CAPACITY AREA 7	CAPACITY AREA 8	CAPACITY AREA 9
390	0	160	640	1440	2559	3998	5789	7963	10521	13463
	0	320	640	959	1279	1599	1983	2366	2750	3133
400	16788	20496	24586	29057	33910	39145	44698	50504	56563	62876
	3517	3899	4281	4662	5044	5426	5679	5933	6186	6440
410	69443	76434	84021	92204	100983	110358	120272	130670	141550	152914
	6693	7289	7885	8481	9077	9673	10156	10639	11122	11605
420	164760	177038	189697	202736	216155	229955	244239	259109	274567	290611
	12088	12468	12849	13229	13610	13990	14577	15164	15751	16338
430	307243	324600	342823	361912	381866	402685	424368	446913	470319	494586
	16925	17790	18656	19521	20387	21252	22114	22975	23837	24698
440	519715	545530	571855	598690	626035	653890	682198	710902	740002	769498
	25560	26070	26580	27090	27600	28110	28506	28902	29298	29694

Capacities given in acre-feet and area in acres.

Table B-29
Area–Capacity Calculations
Lake Palestine
Surveyed in 1989

ELEVATION (feet)	CAPACITY AREA 0	CAPACITY AREA 1	CAPACITY AREA 2	CAPACITY AREA 3	CAPACITY AREA 4	CAPACITY AREA 5	CAPACITY AREA 6	CAPACITY AREA 7	CAPACITY AREA 8	CAPACITY AREA 9
290	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0
300	32	104	195	305	433	579	796	1133	1592	2173
	63	82	100	119	137	156	277	398	520	641
310	2874	3776	4956	6414	8151	10167	12652	15797	19603	24070
	762	1041	1319	1598	1876	2155	2815	3476	4136	4797
320	29197	34901	41099	47791	54977	62657	70930	79897	89558	99912
	5457	5951	6445	6939	7433	7927	8620	9314	10007	10701
330	110959	122621	134818	147550	160818	174622	189105	204413	220546	237503
	11394	11929	12465	13000	13536	14071	14896	15720	16545	17369
340	255284	274104	294176	315499	338073	361590				
	18194	19446	20697	21949	23200	23833				

Capacities given in acre-feet and areas in acres.

Average End Area Method of Calculation

Table B-30
Area-Capacity Projections
Lake Lewisville
For the Year 2000

ELEVATION (feet)	CAPACITY AREA 0	CAPACITY AREA 1	CAPACITY AREA 2	CAPACITY AREA 3	CAPACITY AREA 4	CAPACITY AREA 5	CAPACITY AREA 6	CAPACITY AREA 7	CAPACITY AREA 8	CAPACITY AREA 9
450	0 0	0 0	0 0	0 0	0 0	0 0	9 17	35 36	78 49	134 64
460	205 78	290 91	387 103	495 113	614 125	747 141	902 169	1093 213	1339 279	1664 372
470	2103 505	2697 683	3495 914	4549 1193	5909 1527	7624 1903	9735 2320	12271 2752	15241 3187	18635 3602
480	22433 3994	26600 4340	31097 4653	35887 4927	40941 5181	46239 5415	51768 5644	57523 5865	63502 6093	69705 6313
490	76131 6539	82785 6770	89680 7019	96834 7289	104275 7593	112037 7931	120159 8313	128676 8722	137614 9153	146983 9586
500	156786 10020	167017 10442	177668 10859	188731 11267	200205 11682	212111 12130	224500 12648	237451 13253	251064 13974	265462 14822
510	280779 15811	297155 16941	314716 18181	333552 19491	353718 20842	375229 22179	398048 23459	422099 24644	447141 25440	472858 25993
520	499576 27443	527348 28101	555725 28653	584615 29127	613954 29551	643718 29977	673939 30466	704703 31062	736143 31817	768429 32756
530	801754 33894	836318 35233	872295 36722	909805 38298	948911 39913	989621 41508	1031894 43037	1075610 44396	1120369 45121	1166418 46978
540	1211334 47460									

Capacities given in acre-feet and areas in acres.

Average End Area Method of Calculation

Table B-31
Area-Capacity Projections
Lake Ray Hubbard
For the Year 2000

ELEVATION (feet)	CAPACITY AREA 0	CAPACITY AREA 1	CAPACITY AREA 2	CAPACITY AREA 3	CAPACITY AREA 4	CAPACITY AREA 5	CAPACITY AREA 6	CAPACITY AREA 7	CAPACITY AREA 8	CAPACITY AREA 9
390	0 0	0 0	92 183	534 702	1435 1099	2623 1277	4172 1822	6181 2195	8542 2528	11234 2856
400	14253 3182	17592 3496	21241 3802	25187 4090	29416 4368	33916 4632	38682 4899	43717 5171	49036 5468	54666 5791
410	60640 6157	67001 6565	73791 7016	81047 7495	88795 8001	97051 8511	105817 9022	115088 9519	124848 10001	135078 10460
420	145762 10907	156885 11340	168443 11775	180437 12213	192879 12671	205796 13163	219219 13684	233194 14266	247771 14887	263002 15576
430	278943 16306	295650 17108	313166 17923	331539 18823	350800 19700	370970 20639	392052 21525	414036 22443	436897 23279	460603 24134
440	485105 24869	510344 25610	536262 26226	562804 26857	589949 27434	617629 27926	645784 28384	674297 28642	703045 28853	732335 29727

Capacities given in acre-feet and area in acres.

Table B-32
Area-Capacity Projections
Lake Palestine
For the Year 2000

ELEVATION (feet)	CAPACITY AREA 0	CAPACITY AREA 1	CAPACITY AREA 2	CAPACITY AREA 3	CAPACITY AREA 4	CAPACITY AREA 5	CAPACITY AREA 6	CAPACITY AREA 7	CAPACITY AREA 8	CAPACITY AREA 9
290	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0
300	0	0	0	0	0	0	0	0	29	109
	0	0	0	0	0	0	0	0	57	103
310	254	697	1542	2719	4296	6317	8817	11843	15425	19580
	188	697	994	1359	1795	2247	2753	3299	3866	4443
320	24312	29618	35492	41925	48914	56461	64574	73258	82518	92350
	5021	5592	6155	6711	7267	7828	8397	8972	9547	10117
330	102747	113702	125211	137275	149909	163142	177025	191623	207011	223260
	10678	11232	11785	12344	12923	13543	14223	14974	15801	16697
340	240450	258656	277884	298047	319147	341076				
	17684	18727	19729	20598	21601	22257				

Capacities given in acre-feet and areas in acres.

Table B-33
Area-Capacity Projections
Lake Lewisville
For the Year 2050

ELEVATION (feet)	CAPACITY AREA 0	CAPACITY AREA 1	CAPACITY AREA 2	CAPACITY AREA 3	CAPACITY AREA 4	CAPACITY AREA 5	CAPACITY AREA 6	CAPACITY AREA 7	CAPACITY AREA 8	CAPACITY AREA 9
450	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0
460	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0
470	0	114	397	830	1531	2467	3731	5452	7555	10058
	0	227	340	526	876	996	1532	1909	2297	2710
480	12951	16194	19752	23592	27682	31992	36499	41185	46038	51048
	3076	3409	3707	3974	4206	4414	4599	4773	4933	5088
490	56209	61518	66981	72612	78435	84481	90785	97384	104311	111586
	5234	5384	5541	5721	5926	6166	6442	6756	7097	7453
500	119220	127216	135574	144295	153387	162873	172811	183289	194423	206352
	7815	8177	8539	8904	9279	9694	10182	10774	11494	12363
510	219227	233206	248436	265039	283096	302641	323652	346055	369736	394548
	13388	14569	15891	17315	18800	20290	21731	23075	24288	25335
520	420319	446874	474039	501668	529653	557939	586534	615509	644989	675153
	26208	26901	27429	27829	28142	28430	28760	29189	29772	30556
530	706212	738390	771906	807011	843893	882612	923177	965546	1009288	1054753
	31561	32795	34237	35974	37790	39647	41483	43255	44230	46699
540	1117745									
	47994									

Capacities given in acre-feet and areas in acres.

Average End Area Method of Calculation

Appendix C
Guidelines for Municipal Water Conservation and Drought Contingency Planning and Program Development
Texas Water Development Board Guidelines
April 1986

GUIDELINES FOR MUNICIPAL WATER CONSERVATION AND DROUGHT CONTINGENCY PLANNING AND PROGRAM DEVELOPMENT

Texas Water Development Board
April 1986

Guidelines for Municipal Water Conservation and Drought Contingency Planning and Program Development

Texas Water Development Board
April 1986

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A water conservation plan and a drought contingency plan are required as a part of an application submitted by a political subdivision to the Texas Water Development Board for financial assistance from the Development Fund or the Water Loan Assistance Fund. Furthermore, a successful applicant is required to have a program in place before loan funds can be released. The origin of these requirements is action taken by the 69th Texas Legislature in 1985. The conservation requirements were established by House Bill (HB) 2 and House Joint Resolution (HJR) 6. On November 5, 1985, Texas voters approved an amendment to the Texas Constitution that provided for the implementation of HB 2.

The Texas Water Development Board has promulgated Financial Assistance Rules which specify water conservation planning requirements. This document provides the guidelines for developing conservation and drought contingency plans and programs that will meet the regulatory requirements of the Texas Water Development Board.

Included in these guidelines are the required elements of the **water conservation plan** that must accompany an application. The implemented plan is anticipated to become the required **water conservation program.** Included with these guidelines are three tables (Tables 1, 2, and 3) that present examples of methods, structural techniques, and behavioral changes that can be used in designing and implementing a water conservation plan. Tables 4, 5, and 6, which list water conserving devices for retrofit and new construction and the expected energy savings associated with various water conserving devices, are also provided. A **Sample Review Checklist**, which provides a convenient method of insuring that all components important in developing a water conservation plan have been considered, has also been included as an appendix.

The rules and, therefore, these guidelines apply to eligible applicants who sell water or provide wastewater service directly to individual customers and to those utilities that sell water or provide wastewater service to other political subdivisions of the state. In the latter case, the requirements of the Board for water conservation and drought contingency planning and program implementation will need to be met through contractual agreements between the selling political subdivision and the purchasing political subdivision.

Guidelines for Water Conservation and Drought Contingency Plan Development

I. INTRODUCTION

Water used in the residential and commercial sector involves the day-to-day activities of all citizens of the state and includes water used for drinking, bathing, cooking, toilet flushing, fire protection, lawn watering, swimming pools, laundry, dish washing, car washing, and sanitation. Since the early 1960s, per capita water use in the state has increased about four gallons per person per decade. More important, per capita water use during droughts is usually about one-third greater than during periods of average precipitation.

The objective of a conservation program is to reduce the quantity required for each water using activity, insofar as is practical, through the implementation of efficient water use practices. A drought contingency program provides procedures for voluntary and mandatory actions to be put into effect to temporarily reduce the demand placed upon a water supply system during a water shortage emergency. Drought contingency procedures include conservation but may also include prohibition of certain uses. Both programs are tools that water purveyors should have available to operate effectively in all situations.

Many communities throughout the United States have used conservation measures to successfully cope with various water and wastewater problems. Reductions in water use of as much as 25 percent or more have been achieved, but the normal range is from 5 percent to 15 percent. As a result of reduced water use, wastewater flows have also been reduced by 5 percent to 10 percent.

A drought contingency program includes those measures that a city or utility can use to cause a significant, but temporary, reduction in water use. These measures usually involve either voluntary use reductions, the restriction or elimination of certain types of water use, water rationing, or the temporary use of water from sources other than the established supplies. Communities that have used drought contingency programs have achieved short-term water use reductions in excess of 50 percent during drought emergency situations. Because the onset of emergency conditions is often rapid, it is important that a city or utility be prepared in advance. Further, the citizen or customer must know that certain measures not used in an ongoing conservation program may be necessary if drought or other emergency conditions occur.

II. WATER CONSERVATION PLAN

A water conservation plan and a drought contingency plan specify and explain the actions a specific city or utility will take to implement a water conservation program. The implementation of the water conservation plan is considered to be the water conservation program. The Texas Water Development Board will carefully review each applicant's plan to insure that the specific methods and actions described in the plan will accomplish water conservation. The nine principal water conservation methods to be examined and considered in preparing a water conservation plan that will meet the Board's regulations are as follows:

1. **Education and Information;**
2. **Plumbing Codes** or ordinances for water conserving devices in new construction;
3. **Retrofit Programs** to improve water use efficiency in existing buildings;

4. Conservation-oriented **Water Rate Structures**;
5. **Universal Metering** and meter repair and replacement;
6. **Water Conserving Landscaping;**
7. **Leak Detection** and repair;
8. **Recycling and Reuse**; and
9. Means of **Implementation and Enforcement**.

The applicant's water conservation plan will include one or more of these methods, or equivalent methods, as appropriate, in order to reduce per capita water use so that total water use and sewage flow rates are reduced. The water conservation methods are described and illustrated below.

Education and Information: The most readily available and lowest cost method of promoting water conservation is to inform water users about ways to save water inside homes and other buildings, in landscaping and lawn uses, and in recreational uses. In-home water use accounts for an average of 65 percent of total residential use, while the remaining 35 percent is used for exterior residential purposes such as lawn watering and car washing. Average residential in-home water use data indicate that about 40 percent is used for toilet flushing, 35 percent for bathing, 11 percent for kitchen uses, and 14 percent for clothes washing. Water saving methods that can be practiced by the individual water user are listed below.

In the Bathroom, Customers Should be Encouraged to:

- Take a shower instead of filling the tub and taking a bath. Showers usually use less water than tub baths.
- Install a low-flow shower head which restricts the quantity of flow at 60 psi to no more than 3.0 gallons per minute.
- Take short showers and install a cutoff valve or turn the water off while soaping and back on again only to rinse.

- Not use hot water when cold will do. Water and energy can be saved by washing hands with soap and cold water; hot water should only be added when hands are especially dirty.
- Reduce the level of the water being used in a bath tub by one or two inches if a shower is not available.
- Turn water off when brushing teeth until it is time to rinse.
- Not let the water run when washing hands. Instead, hands should be wet, and water should be turned off while soaping and scrubbing and turned on again to rinse. A cutoff valve may also be installed on the faucet.
- Shampoo hair in the shower. Shampooing in the shower takes only a little more water than is used to shampoo hair during a bath and much less than shampooing and bathing separately.
- Hold hot water in the basin when shaving instead of letting the faucet continue to run.
- Test toilets for leaks. To test for a leak, a few drops of food coloring can be added to the water in the tank. The toilet should not be flushed. The customer can then watch to see if the coloring appears in the bowl within a few minutes. If it does, the fixture needs adjustment or repair.
- Use a toilet tank displacement device. A one-gallon plastic milk bottle can be filled with stones or with water, recapped, and placed in the toilet tank. This will reduce the amount of water in the tank but still provide enough for flushing. (Bricks which some people use for this purpose are not recommended since they crumble eventually and could damage the working mechanism, necessitating a call to the

plumber). Displacement devices should never be used with new low-volume flush toilets.

- Install faucet aerators to reduce water consumption.
- Never use the toilet to dispose of cleansing tissues, cigarette butts, or other trash. This can waste a great deal of water and also places an unnecessary load on the sewage treatment plant or septic tank.
- Install a new low-volume flush toilet that uses 3.5 gallons or less per flush when building a new home or remodeling a bathroom.

In the Kitchen, Customers Should be Encouraged to:

- Use a pan of water (or place a stopper in the sink) for rinsing pots and pans and cooking implements when cooking rather than turning on the water faucet each time a rinse is needed.
- Never run the dishwasher without a full load. In addition to saving water, expensive detergent will last longer and a significant energy saving will appear on the utility bill.
- Use the sink disposal sparingly, and never use it for just a few scraps.
- Keep a container of drinking water in the refrigerator. Running water from the tap until it is cool is wasteful. Better still, both water and energy can be saved by keeping cold water in a picnic jug on a kitchen counter to avoid opening the refrigerator door frequently.
- Use a small pan of cold water when cleaning vegetables rather than letting the faucet run.
- Use only a little water in the pot and put a lid on it for cooking most food. Not only does this method save water, but food is more nutritious since vitamins and minerals are not poured down the drain with the extra cooking water.

- Use a pan of water for rinsing when hand washing dishes rather than a running faucet.
- Always keep water conservation in mind, and think of other ways to save in the kitchen. Small kitchen savings from not making too much coffee or letting ice cubes melt in a sink can add up in a year's time.

In the Laundry, Customers Should be Encouraged to:

- Wash only a full load when using an automatic washing machine (32 to 59 gallons are required per load).
- Use the lowest water level setting on the washing machine for light loads whenever possible.
- Use cold water as often as possible to save energy and to conserve the hot water for uses which cold water cannot serve. (This is also better for clothing made of today's synthetic fabrics.)

For Appliances and Plumbing, the Customer Should be Encouraged to:

- Check water requirements of various models and brands when considering purchasing any new appliance that uses water. Some use less water than others.
- Check all water line connections and faucets for leaks. If the cost of water is $1.00 per 1,000 gallons, one could be paying a large bill for water that simply goes down the drain because of leakage. A slow drip can waste as much as 170 gallons of water EACH DAY, or 5,000 gallons per month, and can add as much as $5.00 per month to the water bill.
- Learn to replace faucet washers so that drips can be corrected promptly. It is easy to do, costs very little, and can represent a substantial amount saved in plumbing and water bills.

- Check for water leakage that the customer may be entirely unaware of, such as a leak between the water meter and the house. To check, all indoor and outdoor faucets should be turned off, and the water meter should be checked. If it continues to run or turn, a leak probably exists and needs to be located.
- Insulate all hot water pipes to avoid the delays (and wasted water) experienced while waiting for the water to "run hot."
- Be sure the hot water heater thermostat is not set too high. Extremely hot settings waste water and energy because the water often has to be cooled with cold water before it can be used.
- Use a moisture meter to determine when house plants need water. More plants die from over-watering than from being on the dry side.

For Out-of-Door Use, Customers Should be Encouraged to:

- Water lawns early in the morning during the hotter summer months. Much of the water used on the lawn can simply evaporate between the sprinkler and the grass.
- Use a sprinkler that produces large drops of water, rather than a fine mist, to avoid evaporation.
- Turn soaker hoses so the holes are on the bottom to avoid evaporation.
- Water slowly for better absorption, and never water on windy days.
- Forget about watering the streets or walks or driveways. They will never grow a thing.
- Condition the soil with compost before planting grass or flower beds so that water will soak in rather than run off.
- Fertilize lawns at least twice a year for root stimulation. Grass with a good root system makes better use of less water.
- Learn to know when grass needs watering. If it has turned a dull grey-green or if footprints remain visible, it is time to water.

- Not water too frequently. Too much water can overload the soil so that air cannot get to the roots and can encourage plant diseases.
- Not over-water. Soil can absorb only so much moisture and the rest simply runs off. A timer will help, and either a kitchen timer or an alarm clock will do. An inch and one-half of water applied once a week will keep most Texas grasses alive and healthy.
- Operate automatic sprinkler systems only when the demand on the town's water supply is lowest. Set the system to operate between four and six a.m.
- Not scalp lawns when mowing during hot weather. Taller grass holds moisture better. Rather, grass should be cut fairly often, so that only 1/2 to 3/4 inch is trimmed off. A better looking lawn will result.
- Use a watering can or hand water with the hose in small areas of the lawn that need more frequent watering (those near walks or driveways or in especially hot, sunny spots).
- Learn what types of grass, shrubbery, and plants do best in the area and in which parts of the lawn, and then plant accordingly. If one has a heavily shaded yard, no amount of water will make roses bloom. In especially dry sections of the state, attractive arrangements of plants that are adapted to arid or semi-arid climates should be chosen.
- Consider decorating areas of the lawn with rocks, gravel, wood chips, or other materials now available that require no water at all.
- Not "sweep" walks and driveways with the hose. Use a broom or rake instead.
- Use a bucket of soapy water and use the hose only for rinsing when washing the car.

The water conservation plan will need to contain ways to communicate water saving practices, such as those listed above, to the public. Among the methods for public education about water conservation are television, radio, and newspaper announcements and advertisements; posters and public displays; fairs, contests, and school programs; bill stuffers, flyers and newsletters; and sales events. The appropriate combination of educational materials and the methods used to communicate with residential users will depend on the location of the applicant, the type of media available, and other factors unique to the applicant's conditions.

Plumbing Codes: Cities of 5,000 population or more and utilities and cities with general plumbing codes will need to adopt water saving plumbing codes for new construction and for replacement of plumbing in existing structures. The standards for residential and commercial fixtures should be:

Tank-type toilets	- No more than 3.5 gallons per flush
Flush valve toilets	- No more than 3.0 gallons per flush
Tank-type urinals	- No more than 3.0 gallons per flush
Flush valve urinals	- No more than 1.0 gallons per flush
Shower heads	- No more than 3.0 gallons per minute
Lavatory and kitchen faucets	- No more than 2.75 gallons per minute
All hot water lines	- Insulated
Swimming pools	- New pools must have recirculating filtration equipment

These standards are recommended because they represent readily available products and technology and do not involve additional costs when compared to "standard" fixtures. For example, conventional toilets using 1.0, 1.5, 2.5, and 3.5 gallons per flush are available at list prices that range from about $50 to $150 each. Insulated hot water lines decrease water wasted by reducing the amount of time it takes to receive hot water at the tap. Water lines can be insulated for about $0.50 per linear foot. In addition, new swimming pools should contain recirculating filtration and disinfection equipment to eliminate the need to fill and drain the pool daily.

Utilities and cities that do not have a plumbing code will need to adopt a water saving plumbing code or distribute information to their customers and builders to guide them in purchasing and installing water saving plumbing devices.

Retrofit Programs: A city or utility should make information available through its education program for plumbers and customers to use when purchasing and installing plumbing fixtures, lawn watering equipment, or water using appliances. Information regarding retrofit devices such as low-flow shower heads or toilet dams that reduce water use by replacing or modifying existing fixtures or appliances should also be provided. A city or utility may wish to provide certain devices (toilet dams, low-flow shower heads, faucet aerators, etc.) free or at a reduced cost to the customer.

Water Rate Structures: A city or utility should adopt a conservation-oriented water rate structure. Such a rate structure usually takes the form of an increasing block rate, although continuously increasing rate structures, peak or seasonal load rates, excess use fees, and other rate forms can be used. The increasing block rate structure is the most commonly used water conservation rate structure. Under this structure, the price per unit of water increases in steps or blocks as certain customer use levels are reached. For example, the first 5,000 gallons a month may have a base rate of $5.00, the next 3,000 gallons a month may cost $1.50 per thousand gallons, and all use above 8,000 gallons a month may cost $2.00 per thousand gallons. Generally, when using a block rate structure, the first block accounts for minimal residential water requirements and normally is 5,000 gallons per month or less. The next block accommodates all but the larger residential customers, and blocks beyond the second tier are set high enough to discourage the use of large quantities of water. Under no circumstance, however, should the price for the first block or base level be established below the actual cost of providing the service. In the event that increased prices for the base level place an excessive burden on the poor, life-line rates may need to be established. In addition, separate rate structures will probably be needed for commercial, institutional, and industrial customers.

Universal Metering: All water users, including the utility, city, and other public facilities, should be metered. In addition, the utility should have a master meter. For new multi-family dwellings that are easily metered individually (such as duplexes and fourplexes) or apartments with more than five living units or apartments, each living unit should be metered separately. A regularly scheduled maintenance program of meter repair and replacement will need to be established in accordance with the following time intervals:

1. Production (master) meters - test once a year;
2. Meters larger than 1" - test once a year; and
3. Meters 1" or smaller - test every 10 years.

Most important, metering can provide an accurate accounting of water uses throughout the system when both the utility and customers are metered. In addition, utilities may be able to identify and bill previously unbilled users and, thereby, generate additional revenues. Metering and meter repair and replacement, coupled with an annual water accounting or auditing, can be used in conjunction with other programs such as leak detection and repair and, thereby, save significant quantities of water.

Water Conserving Landscaping: As stated previously, annual in-home water use accounts for an average of 65 percent of total residential use, while the remaining 35 percent is used for exterior residential purposes, such as lawn watering and car washing. However, during the summer months, as much as 50 percent of the water used in urban areas is applied to lawns and gardens and adds greatly to the peak demands experienced by most water utilities. In order to reduce the demands placed on a water system by landscape watering, the city or utility should consider methods that either encourage, by education and information, or require, by code or ordinance, water conserving landscaping by residential customers and commercial establishments engaged in the sale or installation of landscape plants or watering equipment. Some methods that should be considered include the following:

1. Establishing platting regulations for new subdivisions that require developers, contractors, or homeowners to use only adapted, low water using plants and grasses for landscaping new homes;
2. Initiating a Xeriscape or Texscape program that demonstrates the use of adapted, low water using plants and grasses;
3. Encouraging or requiring landscape architects to use adapted, low water using plants and grasses and efficient irrigation systems in preparing all site and facility plans;
4. Encouraging or requiring licensed irrigation contractors to always use drip irrigation systems when possible and to design all irrigation systems with water conservation features, such as sprinklers that emit large drops rather than a fine mist and a sprinkler layout that accomodates prevailing wind direction;
5. Encouraging or requiring commercial establishments to use drip irrigation for landscape watering when possible and to install only ornamental fountains that recycle and use the minimum amount of water; and

6. Encouraging or requiring nurseries and local businesses to offer adapted, low water using plants and grasses and efficient landscape watering devices, such as drip irrigation systems.

Leak Detection and Repair: A continuous leak detection, location, and repair program can be an important part of a water conservation plan. An annual water accounting or audit should be part of the program. Sources of unaccounted for water include defective hydrants, abandoned services, unmetered water used for fire fighting or other municipal uses, inaccurate or leaking meters, illegal hook-ups, unauthorized use of fire hydrants, and leaks in mains and services. Once located, corrective repairs or actions need to be undertaken. An effective leak detection, location, and repair program will generally pay for itself, especially in many older systems. For example, a utility that produces an average of one million gallons per day at an average water rate of $0.95 per one thousand gallons will lose approximately $35,000 in revenue each year when system losses amount to 10 percent.

Recycling and Reuse: A city or utility should evaluate the potential of recycling and reuse because these methods may be used to increase water supplies in the applicant's service area. Reuse can be especially important where the use of treated effluent from an industry or a municipal system or agricultural return flows replace an existing use that currently requires fresh water from a city's or utility's supply. Recycling of in-plant process or cooling water can reduce the amount of fresh water required by many industrial operations.

As an example, several cities in Texas now provide treated municipal effluent to industries and irrigation projects in their areas. In industry, the use of treated wastewater for cooling purposes has a long and very successful history. The same is true for irrigation. One farm near Lubbock has been irrigated with treated wastewater from Lubbock since the 1930s. The City of El Paso has in operation a major aquifer recharge project through which up to 10 million gallons per day of highly treated municipal wastewater will be injected into the aquifer from which the City obtains its water supply.

Implementation and Enforcement: Each city or utility that adopts a water conservation program must have the authority and means to implement and enforce the provisions of the program if the goal of conserving water is to be achieved. Enforcement may be provided by utility personnel, local police, or special employees hired to administer and enforce the program. The applicant's water conservation plan will need to include a description of the means to implement and enforce a program, and to annually report on program effectiveness.

III. DROUGHT CONTINGENCY PLAN

Drought or a number of other uncontrollable circumstances can disrupt the normal availability of community or utility water supplies. Even though a city may have an adequate water supply, the supply could become contaminated, or a disaster could destroy the supply. During drought periods, consumer demand is often significantly higher than normal. Some older systems, or systems serving rapidly growing areas, may not have the capacity to meet higher than average demands without system failure or other unwanted consequences. System treatment, storage, or distribution failures can also present a city or utility with an emergency demand management situation.

The following guidelines pertain to the preparation of drought contingency plans. It is important to distinguish drought contingency planning from water conservation planning. While water conservation involves implementing permanent water use efficiency or reuse practices, drought contingency plans establish temporary methods or techniques designed to be used only as long as an emergency exists.

An effective drought contingency plan will need to include the following six elements:

1. **Trigger Conditions** signaling the start of an emergency period;
2. **Drought Contingency Measures**;
3. **Information and Education**;
4. **Initiation Procedures**;
5. **Termination Notification** actions; and
6. **Means of Implementation**.

Trigger Conditions: The city or utility will need to establish a set of trigger or threshold conditions, such as lake or well levels or peak use volumes, that will indicate when drought contingency measures need to be put into effect. Since each city and utility has different circumstances, trigger conditions will be unique for each system. In most cases, several trigger levels will be needed to distinguish among mild, moderate, or severe drought conditions. For example, mild conditions may include the following situations:

1. Water demand is approaching the safe capacity of the system;
2. Lake levels are still high enough to provide an adequate supply, but the levels are low enough to disrupt some other beneficial activity, such as recreation; and
3. The water supply is still adequate, but the water levels or reservoir capacities are low enough that there is a real possibility that the supply situation may become critical if the drought or emergency continues. (An example is a reservoir that has an 18-month supply in storage, if no more rains occur).

Moderate conditions may include the following situations:

1. Water levels are still adequate, but they are declining at such a rapid rate that a more serious problem will result in the very near future if some type of formal action is not taken;
2. Water demand occasionally reaches what has been determined to be the safe limit of the system, beyond which the failure of a pump or some other piece of equipment could cause a serious disruption of service to part or all of the system; and
3. Reservoir levels, well levels, or river flows are low enough to disrupt some major economic activity or cause unacceptable damage to a vital ecosystem.

Severe conditions could include a number of situations ranging from the inability to provide certain services to the impairment of health and safety. Some examples include:

1. The imminent or actual failure of a major component of the system which would cause an immediate health or safety hazard;
2. Lake, river, or well levels are so low that diversion or pumping equipment will not function properly;
3. Water levels are low enough in the distribution system storage reservoirs to hinder adequate fire protection; and
4. Water demand is exceeding the system's capacity on a regular basis, thus presenting the real danger of a major system failure.

Trigger conditions for the phase-out or a downgrade of the condition's severity should also be considered. Further, unforeseen events can occur so as to require the initiation of an emergency demand management response program for which no trigger condition has been established.

Drought Contingency Measures: The city or utility will need to establish a list of emergency measures and a plan for their implementation when preselected trigger conditions are reached. The types of measures will depend on local conditions, but in most cases there should be different types of measures that apply to the various levels of severity (i.e., mild, moderate, severe) for drought or emergency conditions. Specific measures could include the following:

1. Imposing restrictions or bans on non-essential uses such as lawn watering, car washing, and pool filling;
2. Communicating methods to reduce the quantity of water needed for the essential purposes of drinking, cooking, bathing, and clothes washing;

3. Implementing rationing plans;

4. Establishing pricing structures that incorporate surcharges and penalties or fines for non-compliance;

5. Locating and assessing additional sources including wells, ponds, or reservoirs; reactivating abandoned wells or dams; purchasing water from others on an emergency basis; building emergency facilities; and considering temporary reuse of wastewater for non-potable uses; and

6. Designing means of enforcement.

The measures for each level of severity should include continued implementation of relevant requirements and actions imposed under the preceding level. Examples of some of the measures that could be employed for mild, moderate, and severe conditions include:

1. **Mild Condition Measures**

   (a) Inform public by mail and through the news media that a trigger condition has been reached, and that water users should look for ways to reduce water.

   (b) Activate an information center and discuss the situation in the news media.

   (c) Advise the public of the trigger condition situation daily.

   (d) Advertise a voluntary daily lawn watering schedule.

2. **Moderate Condition Measures**

   (a) Mandatory lawn watering schedule.

   (b) Fine water wasters.

   (c) Institute an excessive use fee, special pricing structure, or surcharge.

(d) Prohibit certain uses such as ornamental water fountains or other non-essential water uses.

(e) Request industries or other non-municipal water users to stop certain uses, find additional sources, increase recycling, or modify production processes where possible.

3. **Severe Condition Measures**

(a) Prohibit all outdoor water use.

(b) Limit the amount of water each customer can use and establish legal penalities for those who fail to comply.

(c) Require industrial or commercial water users to stop operations so that remaining water is available for essential health and safety related uses.

Information and Education: Once trigger conditions and emergency measures have been established, the public should be informed of what will be expected during a drought or emergency situation. The material should describe trigger conditions and emergency measures and the need to implement the measures. Possible methods of educating and informing the public include:

1. Radio and television public service announcements and news stories;
2. Newspaper stories; and
3. Letters, bill stuffers, and brochures to water customers.

Initiation Procedures: The city or utility should have written procedures that contain adequate methods of informing customers, other utilities, and government entities as far in advance as possible that a trigger condition is being approached or that it has been reached, and that a certain phase of the drought contingency plan must be implemented.

These written procedures may include:

1. Automatic regulatory implementation provisions;
2. Prearranged media notification or press release procedures;
3. Direct notification procedures including mail or, if needed, telephone notification systems;
4. Prearranged contract procedures to obtain emergency water supplies from other sources if needed; and
5. Checklists or operating procedures as necessary.

Termination Notification: The city or utility should have a written procedure to inform the customers and other directly affected parties that the emergency has passed. The establishment of termination triggers and the decision to terminate must be based on sound judgment by proper city or utility authorities.

Implementation: The primary reason for developing a plan is to have a guide for implementing a drought contingency program if the need occurs. It is the full intention of the Texas Water Development Board that the city or utility develop a workable plan that customers understand and which can be used in the event it is needed. In order to accomplish this, each city or utility will need to develop and adopt legal and regulatory documents or instruments that are appropriate.

Legal and **regulatory components** that may be necessary for implementation are listed below.

1. Ordinances, bylaws, or other implementing legal documents.
2. Changes in plumbing codes.
3. New or revised contracts with potential water suppliers.
4. Conditions in contracts with industries or commercial water users who may have water supplies cut off or curtailed.
5. Changes or conditions to water rights permits or contracts with current water suppliers.

Table 1. Examples of Methods Used to Implement Water Use Efficiency Practices

Education and Information	Economic and Price	Regulatory
1.Setting a good public example.	1.Providing low interest loans or grants to install water saving irrigation equipment.	1.Instituting plumbing codes requiring that water saving fixtures be used.
2.Using radio and TV public service announcements.	2.Sending out free shower heads and toilet dams to customers.	2.Passing laws which fine or penalize water wasters.
3.Teaching about water resources in public schools.	3.Providing coupons for discounts on water saving devices.	3.Requiring industries and irrigators to use water efficient equipment.
4.Using TV, newspaper, and radio to disseminate information.	4. Giving tax breaks to those who modify agricultural or industrial practices.	4.Restricting the sale of equipment that wastes water.
5.Providing bill "stuffers" and brochures.	5.Giving breaks on water rates for those who save.	5.Requiring the use of certain water saving plants or grasses or restrict the sale of water wasting plants by nurseries.
6.Conducting public meetings and seminars.	6.Using increasing block rate structures.	
7.Setting up an information "hot line."	7.Assessing tax or price increases on those who fail to save.	
8.Inviting public input.	8.Assessing fines.	
9.Providing information on water saving appliances and plumbing fixtures.	9.Providing free customer assistance and conservation device installation.	
10.Setting up demonstration projects.		

Table 2. Examples of Structural Techniques that Increase Water Use Efficiency

Municipal and Commercial	Industrial	Agricultural
1.Repairing water distribution leaks and meters.	1.Employing recirculation of water in the plant.	1.Lining canals and repairing transmission systems.
2.Retrofitting toilets, faucets, and showers with dams, (or similar devices), aerators, and low flow shower heads, respectively.	2.Using air cooling.	2.Controlling phreatophytes.
3.Installing low-flush or dual-flush toilets.	3.Modifying the plant's production process.	3.Installing water control structures.
4.Insulating hot water pipes.	4.Repairing leaks.	4.Using furrow dikes.
5.Repairing leaks.	5.Repairing steam traps.	5.Using drip or improved LEPA irrigation systems.
6.Using water efficient appliances.	6.Practicing energy conservation.	6.Recovering tailwater.
7.Installing drip or efficient lawn watering equipment.	7.Replacing high water use processes with new process technologies that use less water.	7.Installing moisture measuring devices.
8.Using low water using and drought resistance plants and grass.	8.Using low water use fixtures in office facilities.	8.Contouring land or using levees.
9.Using moisture sensing controls to determine the need to water the lawn.	9.Using drip or water efficient landscape watering equipment.	9.Consolidating canal systems.
10.Using pressure reduction.	10.Using low water using and drought resistant plants and grass.	10.Applying watershed management.
11.Practicing water harvesting.	11.Installing moisture sensing controls.	
12.Installing water meters.		

Table 3. Examples of Behavioral Changes that Increase Water Use Efficiency

Municipal and Commercial	Industrial	Agricultural
1.Taking shorter showers.	1.Minimizing the use of hosedown practices for the work area.	1.Practicing irrigation scheduling.
2.Turning off water when brushing teeth.	2.Instructing employees on water saving practices.	2.Practicing improved tillage.
3.Washing only full loads in dish and clothes washers.	3.Employing the same practices as commercial operations in the office area.	3.Practicing periodic deep plowing.
4.Using a broom to clean driveway instead of waterhose.	4.Setting good community examples and aiding in water resource information dissemination.	4.Mulching.
5.Using lawn watering equipment carefully.		5.Employing system efficiency evaluation.
6.Maintaining a high level of water conservation awareness.		6.Maintaining irrigation equipment.
7.Scheduling lawn watering.		
8.Washing the car with a bucket and hose with a shutoff valve.		
9.Demanding good conservation practices by utility and governmental authorities.		

Table 4. Water Conserving Retrofit Devices

Application	Device	Function	Water Savings	Estimated Unit Water Savings gpcd	Estimated Cost $	Service Life Years
Toilet	Two displacement bottles	Reduces flush volume	0.5 gal/flush	2.3	0-0.20	5
Toilet	Water closet dam	Reduces flush volume	1.0 gal/flush	4.5	1.50-3.00	5
Toilet	Dual-flush	Variable-flush volume	3.5 gal/flush	15.7	15.00	15
Shower	Flow restrictor	Limits flow to 3 gpm	1.5 gpm	6.7	0.50	5
Shower	Reduce-flow shower head	Limits flow to 3 gpm	1.5 gpm	6.7	3.00-20.00	15
Shower	Reduce-flow shower head with cutoff valve	Limits flow to 2.5 gpm	2 gpm	8.0	5.00-20.00	15
Shower	Cutoff valve	Facilitates "navy" shower"	-	-	2.50-5.00	15
Faucets	Aerator	Reduces splashing, enhances flow aesthetics, creates appearance of greater flow	-	0.5	0.50-2.00	15
Hot water pipes	Insulation	Reduces warm-up time	-	0.5	0.50/ft	25
Water hook-up	Pressure-reducing valve	Reduces available water pressure at fixtures and, hence, flow rate	-	3.0	85.00	25

gpcd = gallons per capita per day; gpm = gallons per minute

Table 5. Water Conserving Devices for New Construction

Application	Device	Function	Water Savings	Estimated Unit Water Savings gpcd	Estimated Additional Cost $	Service Life Years
Toilet	Low-flush, 3.5 gal/flush	Reduced flush volume	1.5 gal/flush	7.5	0	25
Toilet	Low-flush, 2.5 gal/flush	Reduced flush volume	2.5 gal/flush	12.5	0	25
Toilet	Low-flush, 1.0 gal/flush	Reduced flush volume	4.0 gal/flush	20.0	*	25
Shower	Reduced-flow shower head	Reduces shower flow rate to 3.0 gpm	1.5 gpm	6.7	0	15
Shower	Reduced-flow shower head with cutoff valve	Reduces shower flow rate to 2.5 gpm	2.0 gpm	8.0	0	15
Shower	Cutoff valve	Facilitates "navy shower"	-	-	2.50-5.00	15
Faucet	Aerator	Reduces splashing, enhances flow aesthetics, creates appearance of greater flow	-	0.5	0.50-2.00	15
Water hook-up	Pressure-reducing valve	Reduces available water pressure at fixtures and, hence, flow rate	-	3.0	45.00	25
Appliances	Water-efficient dish-washing appliances	Reduced water requirement	6-gal/cycle	2.0	0	15
Appliances	Water-efficient clothes-washing machine	Reduced water requirement	14-gal/cycle	3.5-7.0	70.00	15

*Some are expensive, but others are available at costs comparable to 3.5 gallon per flush models.

Table 6. Estimated Energy Savings Associated with Residential Water Conservation

Device	Hot Water Saved[a]	Amount of Energy Saved		Value of Energy Saved	
		Gas Water Heaters[c]	Electric Water[e]	Gas[f]	Electric[g]
	(Gal/day/D.U.)[b]	(Therms/year/D.U.)[d]	(Kw-hr/year/D.U.)	(Dollars/year/D.U.)	
Showerhead, 3.0 gpm	8.0	22.9	541	12.6	32.4
Water saving dishwashers	4.7	13.6	320	7.5	19.2
Water saving clothes-washing machines	2.4	6.8	160	3.7	9.6
Subtotal	15.1	43.3	1,021	23.8	61.2
Insulation of hot water pipes	4.7	13.6	320	7.5	19.2
Total	19.8	56.9	1,341	31.3	80.4

a/ 140° F water saved as follows: shower 3.4 gallons per capita per day (gpcd); dishwasher 2.0 gpcd; washing machines 1.0 gpcd; thermal pipe insulation 2.0 gpcd.
b/ D.U.= dwelling units; 2.37 persons per dwelling unit.
c/ 79 percent efficiency. Source: The California Appliance Efficiency Program - Revised Staff Rept. California Energy Resources Conservation & Devel. Comm. Conservation Div. (Nov. 1977).
d/ One Therm = 100,000 BTU.
e/ 98 percent efficiency. Source: ibid.
f/ $0.55/therm.
g/ $0.06/kw-hr.

SAMPLE REVIEW CHECKLIST

for Water Conservation and Drought Contingency Plan Development

The following checklist provides a convenient method to insure that the most important items that are needed for the development of a conservation and a drought contingency program are considered.

1. Utility Evaluation Data

   A. Population of Service Area ________________ (Number)

   B. Area of Service Area ________________ (Sq. mi.)

   C. Number and Type of Equivalent 5/8" Meter Connections in Service Area ______(Res.) ______(Comm.) ____(Ind.)

   D. Net Rate of New Connection Additions per year (New Connections less disconnects) _____(Res.) _____(Comm.) ____(Ind.)

   E. Water Use Information

   (1) Water Production for the Last Year ________________ (gal./yr.)

   (2) Average Water Production for Last 2 Years ________________ (gal./yr.)

   (3) Average Monthly Water Production for Last 2 Years ________________ (gal./mo.)

   (4) Estimated Monthly Water Sales by User Category (1000 gal.) (Use latest typical year)

	Residential	Commercial-Institutional	Industrial	Total
January	________	________	________	________
February	________	________	________	________
March	________	________	________	________
April	________	________	________	________
May	________	________	________	________
June	________	________	________	________
July	________	________	________	________
August	________	________	________	________
September	________	________	________	________
October	________	________	________	________
November	________	________	________	________
December	________	________	________	________
Total	________	________	________	________

   (5) Average Daily Water Use ________________ (gpd)

   (6) Peak Daily Use ________________ (gpd)

   (7) Peak to Average Use Ratio (average daily summer use divided by annual average daily use) ________

   (8) Unaccounted for Water (% of Water Production)

F. Wastewater Information

(1) Percent of your potable water customers sewered by your wastewater treatment system _____.

(2) Percent of potable water customers who have septic tanks or other privately operated sewage disposal systems __________%.

(3) Percent of potable water customers sewered by another wastewater treatment utility _________%.

(4) Percent of total potable water sales to the three categories described in F(1), F(2), and F(3).

(a) Percent of total sales to customers you serve ________%.

(b) Percent of total sales to customers who are on septic tanks or private disposal systems ________%.

(c) Percent of total sales to customers who are on other wastewater treatment systems _________%.

(5) Average daily volume of wastewater treated ____________ (gal)

(6) Peak daily wastewater volumes ______________________ (gal).

(7) Estimated percent of wastewater flows to your treatment plant that originate from the following categories:

Residential ________%
Industrial and Manufacturing ________%
Commerical/Institutional ________%
Stormwater ________%
Other - Explain ________%

G. Safe Annual Yield of Water Supply __________________ (gal.)

H. Peak Daily Design Capacity of Water System __________________ (gpd)

I. Major High-Volume Customers (List) ______________________________
____
____

J. Population and Water Use or Wastewater Volume Projections (List) ______________________________
____

K. Percent of Water Supply Connections in System Metered ______(Res). ______(Comm.) ______(Ind.)

L. Water or Wastewater Rate Structure (Uniform, Increasing Block, etc.) ______________________________
____

M. Average Annual Revenues from Water or Wastewater Rates ______________ (Dollars)

N. Average Annual Revenue from Non-Rate Derived Sources ______________ (Dollars)

O. Average Annual Fixed Costs of Operation ______________ (Dollars)

P. Average Annual Variable Costs of Operation ______________ (Dollars)

Q. Average Annual Water or Wastewater Revenues for Other Purposes (if applicable) ______________ (Dollars)

R. Copies of Applicable Local Regulations (List) ______________

____

S. Copies of Applicable State, Federal or Other Regulations (List) ______________

T. Special Information (List) ______________

2. Public Involvement in Planning Process

A. Public at Large (List) ______________

B. Special Interest Groups (List) ______________

____

____

3. Conservation Plan Procedure. A checklist of items to be considered and, as appropriate, incorporated in the plan.

	Considered	Incorporated/Addressed Yes	Incorporated/Addressed No
A. Step 1 - Identify Need(s) and Establish Goals			
(1) System audit			
(a) Establish current average, seasonal, and peak use patterns	☐	☐	☐
(b) Determine unaccounted water volumes and likely causes	☐	☐	☐
(c) Determine adequacy of treatment, storage, and distribution systems	☐	☐	☐
(d) Define limits of existing supply and identify potential new sources	☐	☐	☐

	Considered	Incorporated/Addressed Yes	No
(e) Determine capacity of wastewater collection and treatment system	☐	☐	☐
(2) Define problems from audit			
(a) Peak use problem	☐	☐	☐
(b) Average use problem	☐	☐	☐
(3) Establish goal as percentage of reduction to achieve	☐	☐	☐
B. Step 2 - Assess Supply and Demand Management Potentials			
(1) Supply management methods			
(a) Metering and meter repair	☐	☐	☐
(b) Leak detection and repair	☐	☐	☐
(c) Pressure regulation	☐	☐	☐
(d) Watershed management	☐	☐	☐
(e) Evaporation suppression	☐	☐	☐
(f) Reuse	☐	☐	☐
(2) Demand management methods			
(a) Pricing	☐	☐	☐
(b) Regulation	☐	☐	☐
(c) Education	☐	☐	☐
C. Step 3 - Analyze the Cost Effectiveness and Impacts of the Management Program			
(1) Supply management methods			
(a) Metering and meter repair	☐	☐	☐
(b) Leak detection and repair	☐	☐	☐
(c) Pressure regulation	☐	☐	☐
(d) Watershed management	☐	☐	☐
(e) Evaporation Suppression	☐	☐	☐
(f) Reuse	☐	☐	☐

	Considered	Incorporated/Addressed Yes	No
(2) Demand management methods			
(a) Pricing	☐	☐	☐
(b) Regulation	☐	☐	☐
(c) Education	☐	☐	☐
D. Step 4 - Identify the Actions to Minimize Adverse Impacts			
(1) Supply management programs			
(a) Costs of program result in operating deficit	☐	☐	☐
(b) Costs of program not covered by revenue	☐	☐	☐
(c) Lack of cooperation from local government or board	☐	☐	☐
(d) Community opposition	☐	☐	☐
(2) Demand management programs			
(a) Revenue decrease	☐	☐	☐
(b) Additional expenditures needed to pay for program	☐	☐	☐
(c) User expenditures required for retrofit devices	☐	☐	☐
(d) Users water bill increases	☐	☐	☐
(e) Large volume user problems	☐	☐	☐
(f) Public and political opposition	☐	☐	☐
(g) Equity of program	☐	☐	☐
(h) Lack of cooperation of community departments	☐	☐	☐

	Considered	Incorporated/Addressed Yes	No
E. Step 5 - Choose Management Program(s) and Design the Specifics of Each			
(1) Supply management programs			
(a) Metering and meter repair	☐	☐	☐
(b) Leak detection and repair	☐	☐	☐
(c) Pressure regulation	☐	☐	☐
(d) Watershed management	☐	☐	☐
(e) Evaporation suppression	☐	☐	☐
(f) Reuse	☐	☐	☐
(2) Demand management programs			
(a) Pricing	☐	☐	☐
(b) Regulation	☐	☐	☐
(c) Education	☐	☐	☐
F. Step 6 - Evaluate and Select the Needed Hardware and Software			
(1) Supply management programs			
(a) Metering and meter repair	☐	☐	☐
(b) Leak detection and repair	☐	☐	☐
(c) Pressure regulation	☐	☐	☐
(d) Watershed management	☐	☐	☐
(e) Evaporation suppression	☐	☐	☐
(f) Reuse	☐	☐	☐
(2) Demand management programs			
(a) Water-saving fixtures	☐	☐	☐
(b) Reuse and recycle systems	☐	☐	☐
(c) User habit changes	☐	☐	☐

	Considered	Incorporated/Addressed Yes	No
G. Step 7 - Summarize the Conservation Plan			
(1) Conservation Goal	☐	☐	☐
(2) Supply management program	☐	☐	☐
(3) Demand management program	☐	☐	☐
(4) Public involvement	☐	☐	☐

4. Drought Contingency Plan Procedure

	Considered	Incorporated/Addressed Yes	No
A. Step 1 - Identify System Constraints			
(1) Source-related problems			
(a) Aquifer and well yield	☐	☐	☐
yield	☐	☐	☐
level	☐	☐	☐
well capacity	☐	☐	☐
(b) Reservoirs (specific)	☐	☐	☐
yield	☐	☐	☐
level	☐	☐	☐
special concerns	☐	☐	☐
(c) Surface water diversion (general)	☐	☐	☐
flow variation	☐	☐	☐
levels	☐	☐	☐
water rights	☐	☐	☐
environmental	☐	☐	☐
recreational	☐	☐	☐
water quality impacts	☐	☐	☐
(2) System-related problems			
(a) Peak or high demands	☐	☐	☐
(b) System limits	☐	☐	☐
(c) Public health & safety	☐	☐	☐
(d) Storage capacity	☐	☐	☐

	Considered	Incorporated/Addressed Yes	No
B. Step 2 - Locate and Assess Alternate Sources			
(1) Existing wells, ponds, or reservoirs	☐	☐	☐
(2) Reactivate abandoned wells or dams	☐	☐	☐
(3) Purchase water from others on emergency basis	☐	☐	☐
(4) Build emergency facilities	☐	☐	☐
(5) Reuse wastewater	☐	☐	☐
C. Step 3 - Assess System Management and Rank Severity of Impacts			
(1) Determine impacts drought or emergency conditions would have	☐	☐	☐
(2) Rank impacts by order of severity	☐	☐	☐
(3) Group causal condition by order of impact severity	☐	☐	☐
(4) Set "Trigger Conditions"	☐	☐	☐
D. Step 4 - Design Emergency Management Program			
(1) Evaluate measures			
(a) Information	☐	☐	☐
(b) Media programs	☐	☐	☐
(c) Economic incentives	☐	☐	☐
(d) Fines	☐	☐	☐
(e) Limits on amounts (Rationing)	☐	☐	☐
(f) Prohibition of certain uses	☐	☐	☐
(g) Legal penalties	☐	☐	☐
(2) Rank measures by order of severity of conditions determined in Step 3	☐	☐	☐

	Considered	Incorporated/Addressed Yes	No
E. Step 5 - Evaluate Procedure and Regulations and Implement Plan			
(1) Procedural considerations to address in the plan			
(a) Notification procedure	☐	☐	☐
(b) Public information on "Trigger Conditions"	☐	☐	☐
(c) Method to update plan	☐	☐	☐
(d) Utility guidebook or check list	☐	☐	☐
(2) Legal or regulatory considerations			
(a) Utility ordinances or bylaws	☐	☐	☐
(b) Changes to plumbing codes	☐	☐	☐
(c) Revised or alternate contracts with suppliers	☐	☐	☐
(d) Amended contracts with major customers to provide for cut-off procedures	☐	☐	☐
(e) Changes to water rights or other contracts	☐	☐	☐

Appendix D
Water Conservation and Drought Contingency Plans

Included in this appendix are components of the current and recommended Water Conservation and Draft Drought Contingency Plan as follows:

1. Current Water Conservation Plan
2. Recommended Water Conservation Plan
3. DWU Rate Structure
4. Draft Drought Contingency Plan
5. City of Dallas Emergency Authority, Section 49-20

The current City of Dallas Water Conservation and Draft Drought Contingency Plans fully meet all requirements of the TWDB, but further evaluation of the existing plan identified some areas that could be enhanced to more effectively meet the specific needs of the City of Dallas and its customers.

The City of Dallas has developed these plans to promote water conservation and improve efficiency within its water system. Included are voluntary actions designed to encourage reductions in water usage by the City and its customers and mandatory actions to be imposed during extended droughts or other emergency situations. The goal of the voluntary actions of the water conservation plan is to produce a 7 percent reduction in consumption of per capita water usage, over that which would occur without these conservation efforts, within the system by year 2000. Supplemental and background information used in developing this plan can be found in the "Long Range Water Supply Plan" (1989). This conservation plan is an integral part and necessary element of the long range water supply plan.

These plans were established both to meet the needs of the City of Dallas Water Utilities Department and to fulfill the requirements of the Texas Water Development Board (TWDB) as defined in the April 1986, "Guidelines For Municipal Water Conservation and Drought Contingency Planning and Program Development". The TWDB guidelines outline nine components of a water conservation and six components of a drought contingency plan. These components follow:

- **<u>Water Conservation Plan</u>**
  - Education and information
  - Plumbing codes or ordinances for water conserving devices in new construction
  - Retrofit programs to improve water use efficiency in existing buildings
  - Conservation-oriented water rate structures
  - Universal metering and meter repair and replacement
  - Water conserving landscaping
  - Leak detection and repair
  - Recycling and reuse
  - Means of implementation and enforcement

- **<u>Drought Contingency Plan</u>**
  - Trigger conditions signaling the start of an emergency period
  - Drought contingency measures
  - Information and education
  - Initiation procedure
  - Termination notification actions
  - Means of implementation

Current Water Conservation Plan

DALLAS WATER UTILITIES

CONSERVATION PROGRAM

I. Public Education

A. School Program

1. Conservation poster contest for grades 1-8
2. Bookcovers to all DISD schools
3. Curriculum aids
4. Science Fair awards
5. Classroom speakers (4,000 children in 1987)
6. Tours

B. Literature Distribution

1. Bill inserts on conservation three or four times a year
2. Brochures available on subjects such as:
   a. Saving water outdoors
   b. Native and drought-tolerant plants
   c. Wildflowers
   d. Low-flow showerheads
   e. Reducing toilets' water use

C. Speaking Engagements

1. Environmental groups
2. Garden clubs
3. Senior citizens centers
4. Youth groups
5. Civic groups

D. Special Events and Promotions

1. State Fair exhibit
2. Home and Garden Show
3. Mall exhibits

4. Water-only-upon-request promotion with restaurants

5. Proclamations

E. Public Service Announcements on TV

F. Co-sponsorship of Xeriscape Seminars, Demonstration Gardens

II. Metering

A. Ordinance requiring all connections to be metered

B. Ordinance requiring all fire lines to be metered or be closed systems with alarms.

III. Rate Structure

A. Inclining block (rate per unit higher as usage increases)

B. Summer rates

1. Effective May through October

2. Usage over 15,000 gallons/month charged at a higher rate

a. Residential customers' rates per 1000 gallons are 36% higher

b. General Service customers' rates per 1000 gallons are 15% higher

IV. Plumbing Codes

A. Plumbing Code passed in 1981 included measures to conserve water

B. Plumbing fixtures installed or replaced must meet the criteria in Appendix L of the Uniform Plumbing Code

V. Main Replacement

A. To reduce lost water due to leaks and main breaks.

B. $1.5 million allocated each year

VI. Retrofit

A. Brochures on why and how to retrofit

1. Focus on low-flow showerheads, water-saving devices in toilet

2. Low-flow showerheads and toilet dams given away during conservation speeches

3. Shower flow gauge bags given away at State Fair and other public contact opportunities

B. Pilot residential retrofit program in summer of 1987

1. DWU installer went door-to-door to 2560 homes giving away low-flow showerheads and toilet dams

   a. Offered to install devices free-of-charge

   b. Devices were installed or left for installation at 2025 homes

2. Follow-up telephone surveys indicated lower than expected satisfaction with devices

VII. Emergency

A. Chapter 49 Section 20 of the Dallas City Code establishes the city's policy and procedures in the event of a water emergency

B. Emergency Water Management Plan developed

1. Outlines the conditions when a particular level of conservation is required

2. Defines the stages of an emergency

3. Provides for specific events for each stage which could trigger an emergency

Recommended Water Conservation Plan

RECOMMENDED WATER CONSERVATION PLAN

EDUCATION AND INFORMATION

The ultimate success of any water conservation program is dependent on an informed public. The customers must have an awareness of the benefits and needs for water conservation. They must also have the knowledge of how to contribute to the plan. The public education program is designed to provide information to as many of the users as possible. The elements of the education program are described below.

An Informative School Program which provides book covers that promote water conservation to students. This element of the program also includes a poster contest typically receiving 500 entries, classroom presentations including curriculum aids and materials, teacher workshops, science fair awards, and tours of DWU facilities.

A Literature Program which provides conservation brochures as bill inserts to all customers. The brochures cover topics such as saving water outdoors and indoors, use of native plants and wildflowers, low-flow showerheads, and the use of displacement devices to reduce water consumption by toilets.

Speaking Engagements and Programs that annually promote water conservation ideas to environmental groups, garden clubs, senior citizens centers, youth groups, and civic groups. Low-flow showerheads and toilet dams are generally distributed free at these events.

Special Events and Promotions are also part of the program. Such events promote water conservation by demonstrating native and drought-tolerant plants or by providing computer games that estimate personal water usage. These events are presented annually at the State Fair, Home and Garden Show, and at area shopping malls. Dallas Water Utilities has also promoted "water-only-upon-request" at area restaurants, and the City has made various proclamations promoting the benefits of water conservation.

Public Service Announcements promoting the importance of conservation are placed on radio and television during the high water using seasons of spring and summer.

Comprehensive Television Campaign informing the public of the needs and benefits of water conservation. This campaign is continuous throughout the year to develop an overall awareness at all times and is intended to enhance the Public Service Announcements described above.

Regional Coordination and cost sharing with other water suppliers to benefit all authorities in promoting water conservation within the local medias' coverage area and to provide a coordinated effort at an overall reduced cost.

PLUMBING CODE

The City of Dallas plumbing code passed in 1981 requires low-water use toilets, showers and other fixtures in all new construction and for all renovation involving improvements of over 50 percent to a structure. To further promote this code, the City will use the education and information program to provide information about benefits to the individual customer in adhering to the code. The City is also working with local plumbing suppliers to insure an adequate supply of fixtures.

RETROFIT PROGRAM

In the summer of 1987, DWU initiated a pilot residential retrofit program to install low-flow showerheads and toilet dams in census tract 127 (bounded by Gus Thomasson Road to the south, Shiloh Road to the east, and the Atchison, Topeka, and Santa Fe Railroad to the northwest). During a three-week period DWU installed or distributed devices at 2,025 homes (79 percent) of the 2,560 homes visited, at no charge. Information is being developed to assess the effectiveness of this program. Upon completing the evaluation, the City will make this information available through its education program for plumbers and customers to use when purchasing and installing plumbing fixtures. The City is also evaluating promotion of retrofitting by offering free or at cost household water-use audits and retrofit kits if it is found that the pilot retrofit program was beneficial.

WATER RATE STRUCTURE

The City of Dallas has adopted a conservation-oriented rate structure for customers within the City of Dallas. This rate structure consists of a combination meter service charge, increasing block rates, and seasonal rates. Ninety-seven percent of wholesale treated water sales are charged at a two-part demand and volume rate. The remaining three percent is charged at a flat volume rate. Untreated wholesale water customers are charged either a non-interruptible rate or an interruptible rate. Included in current wholesale customer contracts are clauses which state that if a customer withdraws more than the agreed demand, the customer must remain liable for that demand for five years. These clauses were implemented as a conservation measure to defer high one-year water use by customers. The current rate structure is attached to this plan. The City is currently evaluating an exterior (outdoor) rate structure component to promote an incentive to reduce heavy exterior watering during the summer. If adopted, this program will be promoted for commercial/ industrial and residential customers.

UNIVERSAL METERING

A current City Ordinance requires all connections, except closed fire systems with alarms, to be metered. Individual metering is required at all single-family residential locations. Multi-family residential locations (apartments and condominiums) and businesses can be combined through a single meter per complex. As part of this program residential meters are replaced at 15 year intervals and repairs to larger general service meters are made at 5 year intervals.

WATER CONSERVING LANDSCAPING

As a demand management tool, the City of Dallas encourages water conservation landscaping by promoting use of native and drought tolerant plants by residential and commercial customers. Dallas Water Utilities sponsors xeriscape seminars and demonstration gardens to promote information on water conserving landscaping. The Dallas Public Works Department has developed a list of low maintenance plants for use in landscaping at city fire stations to promote the program and save on irrigation demands. To better promote this program, the City intends to adopt a policy of using native and drought tolerant plants at all new City facilities. The City is evaluating the cost and benefits of providing customer rebates for purchase of native or drought-tolerant plants.

LEAK DETECTION AND REPAIR

The City has a leak repair program to reduce loss of water due to leaks and main breaks. Currently, $1.5 million is allocated to the water main repair program. The City intends to establish a continuous leak detection program utilizing electronic leak detection equipment during the coming years.

RECYCLING AND REUSE

To promote non-potable water reuse, the City of Dallas allows sale of wastewater treatment plant effluent to customers for 50 percent of the untreated water rate. The City intends to continue monitoring ongoing health studies concerning potable water reuse while using the education and information program to promote the reuse concept to the public. The City's Long Range Water Supply Plan includes several alternatives which utilize reclaimed discharges as a supply source in lieu of new reservoirs. Implementation of these alternatives will depend on public acceptance and public health considerations.

IMPLEMENTATION AND ENFORCEMENT

The Dallas Water Utilities and the Department of Public Works administer and implement the various components of the City's program. The Dallas Water Utilities is responsible for the following elements:

- Evaluation and recommendation of rate structures for adoption by City Council
- Evaluation and recommendation of plumbing code modification (as the code relates to metering and rates) for adoption by the City Council
- Maintenance and replacement of meters
- Public education and information
- Leak detection and repair
- Evaluation and implementation of recycling and reuse
- Evaluation and documentation of program success.
- Enforcement of ordinances relating to the water use.

The Department of Public Works is responsible for enforcement of the plumbing code.

DWU Rate Structure

DALLAS WATER UTILITIES
MONTHLY STANDARD RATES
EFFECTIVE OCTOBER 1, 1989

1) CUSTOMER CHARGE

RESIDENTIAL	WATER	SEWER	COMBINED
⅝ Inch Meter	$ 1.36	$ 1.74	$ 3.10
¾ Inch Meter	2.24	1.74	3.98
1 Inch Meter	2.99	1.74	4.73
1½ Inch Meter	5.98	1.74	7.72
2 Inch Meter	10.18	1.74	11.92
GENERAL SERVICE			
⅝ Inch Meter	1.62	1.74	3.36
¾ Inch Meter	2.24	1.74	3.98
1 Inch Meter	2.99	1.74	4.73
1½ Inch Meter	5.98	1.74	7.72
2 Inch Meter	10.18	1.74	11.92
3 Inch Meter	33.93	1.74	35.67
4 Inch Meter	114.74	1.74	116.48
6 Inch Meter	166.96	1.74	168.70
8 Inch Meter	247.28	1.74	249.02
10 Inch Meter	323.49	1.74	325.23

2) USAGE CHARGE PER 1,000 GALLONS

RESIDENTIAL	WATER	SEWER
Up to 4,000 Gallons	1.02	**2.20
4,001 to 10,000 Gallons	1.35	2.20
Above 10,000 Gallons		
Winter	1.35	2.20
*Summer	1.93	2.20
GENERAL SERVICE		
Up to 10,000 Gallons	0.79	1.33
Above 10,000 Gallons		
Winter	0.79	1.33
*Summer	0.93	1.33
OPTIONAL GENERAL SERVICE		
1st Million Gallons or Less ($730.00 Minimum)	0.73	1.33
Above 1 Million Gallons	0.73	1.33
SEWER METERED SEPARATELY		1.47
UNTREATED WATER	0.4656	

Standard Rates are approximately 5% greater than Prompt Payment Rates and apply if payment is received after the due date shown on the bill.

*Summer Rate applies to water billed in May, June, July, August, September, and October.

**Sewer charges for residential accounts are calculated on an average of the water billed in December, January, February, and March (40,000 gallons maximum).

Industrial wastewater discharges containing concentrations of BOD and/or Total Suspended Solids greater than 250 milligrams per liter are assessed sewer surcharges. Certain commercial users such as restaurants, car washes, and small food processors are assessed standard surcharges. These surcharges are included as part of the monthly bill.

DALLAS WATER UTILITIES
MONTHLY PROMPT PAYMENT RATES
EFFECTIVE OCTOBER 1, 1989

1) CUSTOMER CHARGE

RESIDENTIAL	WATER	SEWER	COMBINED
5/8 Inch Meter	$ 1.29	$ 1.65	$ 2.94
3/4 Inch Meter	2.13	1.65	3.78
1 Inch Meter	2.84	1.65	4.49
1 1/2 Inch Meter	5.68	1.65	7.33
2 Inch Meter	9.67	1.65	11.32
GENERAL SERVICE			
5/8 Inch Meter	1.54	1.65	3.19
3/4 Inch Meter	2.13	1.65	3.78
1 Inch Meter	2.84	1.65	4.49
1 1/2 Inch Meter	5.68	1.65	7.33
2 Inch Meter	9.67	1.65	11.32
3 Inch Meter	32.23	1.65	33.88
4 Inch Meter	109.00	1.65	110.65
6 Inch Meter	158.61	1.65	160.26
8 Inch Meter	234.92	1.65	236.57
10 Inch Meter	307.32	1.65	308.97

2) USAGE CHARGE PER 1,000 GALLONS

RESIDENTIAL	WATER	SEWER
Up to 4,000 Gallons	0.97	**2.09
4,001 to 10,000 Gallons	1.28	2.09
Above 10,000 Gallons		
Winter	1.28	2.09
*Summer	1.83	2.09
GENERAL SERVICE		
Up to 10,000 Gallons	0.75	1.26
Above 10,000 Gallons		
Winter	0.75	1.26
*Summer	0.88	1.26
OPTIONAL GENERAL SERVICE		
1st Million Gallons or Less ($690.00 minimum)	0.69	1.26
Above 1 Million Gallons	0.69	1.26
SEWER METERED SEPARATELY		1.40
UNTREATED WATER	0.4423	

The above Prompt Payment Rates apply if payment is received on or before the due date shown on the bill. These represent a 5% discount from the Standard Rates.

*Summer Rate applies to water billed in May, June, July, August, September, and October.

**Sewer Charges for residential accounts are calculated on an average of the water billed in December, January, February, and March (40,000 gallons maximum).

Industrial wastewater discharges containing concentrations of BOD and/or Total Suspended Solids greater than 250 milligrams per liter are assessed sewer surcharges. Certain commercial users such as restaurants, car washes, and small food processors are assessed standard surcharges. These surcharges are included as part of the monthly bill.

Wholesale Water and Wastewater Rates
Effective October 1, 1987

Treated Water

1. Two-Part Rate

Demand:	$94,589	per mgd
Volume:	$0.2806	per 1000 gallons

2. Flat Rate

Volume Only:	$0.9120	per 1000 gallons

Untreated Water

1. Non-interruptible Rate:	$0.3813	per 1000 gallons
2. Interruptible Rate:	$0.2497	per 1000 gallons

Wastewater

$0.7750 per 1000 gallons plus I/I adjustment for unmetered customers

Draft Drought Contingency Plan

DRAFT

EMERGENCY WATER MANAGEMENT PLAN

STAGE 1 WATER WATCH

Triggering Criteria

Total raw water supply in connected lakes drops below 55% of total conservation storage, demand exceeds 90% of deliverable capacity for three consecutive days, or short term deficiencies in distribution system limit supply capability.

Actions Available (applied locally or to all customers, as necessary)

-The City Manager or his designee requests voluntary reductions in water use.

-Accelerate public information efforts to teach and encourage reduced water use.

-Staff will begin a review of the problems which initiated the Stage 1 actions.

-Notify major water users and work with them to achieve voluntary water use reduction.

-Prohibit city government use of water for street washing, vehicle washing, operation of ornamental fountains and all other non-essential use.

-Request a reduction in landscape watering by city government.

-Determine effect on wholesale customers and notify them of impact. Advise wholesale customers of actions being taken within Dallas and solicit implementation of like procedures in wholesale customer cities.

Termination Criteria

-All initiated actions will remain in effect until the condition which triggered STAGE 1 has been alleviated. If STAGE 1 is initiated because of excessive demands, all initiated actions will remain in effect through September 30 of the year in which they were triggered, or until the director determines that these measures are no longer required.

DRAFT

EMERGENCY WATER MANAGEMENT PLAN

STAGE 2 WATER WARNING

Triggering Criteria

Total raw water supply in connected lakes drops below 50% of total conservation storage or demand exceeds 95% of deliverable capacity for two consecutive days. STAGE 2 actions will not ordinarily be taken until STAGE 1 actions have first been implemented.

Actions Available (applied locally or to all customers, as necessary)

-Initiate engineering studies to evaluate alternatives should conditions worsen.

-Continue public information efforts regarding water supply conditions and conservation efforts.

Begin mandatory water use restrictions as follows:

Prohibit hosing off of paved areas, buildings or windows; operation of ornamental fountains, swimming pool draining followed by refilling; washing or rinsing vehicles by hose; using water in such a manner as to allow runoff or other water wastes.

Exceptions: Vehicles may be washed or rinsed with a hose at commercial car washes; vehicles may be washed at any location with a bucket or other container.

Limit landscape watering at each service address to once every five days based on the last digit of the address per the schedule below. Foundations may be watered with a hand-held or soaker hose on any day for up to two hours. Golf courses may water courses on even numbered days between the hours of 9:00 p.m. and 9:00 a.m. the following day. Nurseries may water plant stock only without restrictions.

Last Digit of Address	Allowed Water Dates
0 and 5	5th, 10th, 15th, 20th, 25th, 30th
1 and 6	1st, 6th, 11th, 16th, 21st, 26th
2 and 7	2nd, 7th, 12th, 17th, 22nd, 27th
3 and 8	3rd, 8th, 13th, 18th, 23rd, 28th
4 and 9	4th, 9th, 14th, 19th, 24th, 29th

No watering will be allowed on the 31st. Apartments, office building complexes or other property containing multiple addresses will be identified by the lowest address number. Where there are no numbers, a number will be assigned by the director. These restrictions also apply to city government facilities.

-Advise wholesale customers of actions being taken within Dallas and solicit enforcement of like procedures in wholesale customer cities. Wholesale customer cities shall either impose water use restrictions equivalent to those imposed on Dallas' retail customers or, where applicable, may reduce rate-of-flow controller settings by 5%.

Enforcement

-Violations of restrictions will result in a warning, and then a citation may be issued with a fine not to exceed $1,000 per incident.

Termination Criteria

-All initiated actions will remain in effect until the conditions which triggered STAGE 2 have been alleviated. If STAGE 2 is initiated because of excessive demands, all initiated actions will remain in effect through September 30 of the year in which they were triggered or until the director determines that conditions exist which will allow removal of STAGE 2 actions.

DRAFT

EMERGENCY WATER MANAGEMENT PLAN

STATE 3 WATER EMERGENCY

Triggering Criteria

Total raw water supply in connected lakes drop below 35% of total conservation storage or demand exceeds 95% of deliverable capacity for five consecutive days. STAGE 3 actions will not ordinarily be taken until STAGE 2 actions have first been implemented.

Actions Available (applied locally or to all customers, as necessary):

-Implement recommended engineering alternatives.

-Continue implementation of all restrictions from previous stages.

-Prohibit residential or commercial lawn watering and car washing between the hours of 9 a.m. and 9 p.m. on scheduled days.

-Foundations, shrubs, trees may be watered with soaker or hand-held hose on the same five-day rotational basis as landscapes for up to two hours.

-Golf courses using treated water for grounds watering must adhere to the five-day rotational watering schedule listed in Stage 2 based on their addresses.

-Nurseries may water plant stock only between the hours of 9 p.m. and 9 a.m.

-Advise wholesale customers of actions being taken within Dallas and solicit enforcement of like procedures in wholesale customer cities. Wholesale customer cities shall either impose water use restrictions equivalent to those imposed on Dallas' retail customers or, where applicable, may reduce their rate-of-flow controller settings by an additional 5%.

-All rates for retail water usage in excess of 4,000 gallons per month shall be increased by 10%.

Enforcement

-Violations of restrictions will result in a warning, and then a citation may be issued with a fine not to exceed $1,000 per incident.

Termination Criteria

-All initiated actions will remain in effect until the conditions which triggered STAGE 3 have been alleviated. If STAGE 3 is initiated because of excessive demands, all initiated actions will remain in effect through September 30 of the year in which they were triggered or until the director determines that conditions exist which will allow removal of STAGE 3 actions.

DRAFT

EMERGENCY WATER MANAGEMENT PLAN

STAGE 4 WATER CRISIS

Triggering Criteria

Total raw water supply in connected lakes drop below 20% of total conservation storage or demand exceeds 100% of deliverable capacity for two consecutive days. STAGE 4 actions will not ordinarily be taken until STAGE 3 actions have first been implemented.

Actions Available (applied locally or to all customers, as necessary:)

-Continue implementation of all restrictions from previous stages.

-Prohibit all commercial and residential landscape watering including golf courses. Nurseries' plant stock watering will be limited to once every five days based on the last digit of the address per the schedule in Stage 2.

-Foundations may be watered for a two hour period with soaker or hand-held hose on the five-day rotational basis prescribed for landscape watering in stage 2. Watering is allowed only between the hours of 9:00 p.m. and 9:00 a.m.

-Any and all washing of vehicles is prohibited.

-All commercial water users may be required to reduce water consumption by a percentage determined by the director.

-Advise wholesale customers of actions being taken within Dallas and solicit enforcement of like procedures in wholesale customer cities. Wholesale customer cities shall either impose water use restrictions equivalent to those imposed on Dallas' retail customers or, where applicable, may reduce their rate-of-flow controller settings by a percentage determined by the director. This percentage reduction shall be equivalent to the reduction in consumption imposed on Dallas retail customers.

-All rates for retail water usage in excess of 4000 gallons per month shall be increased by an additonal 10%.

Enforcement

-Violations of restrictions will result in a warning, and then a citation may be issued with a fine not to exceed $1,000 per incident.

Termination Criteria

-All initiated actions will remain in effect until the conditions which triggered STAGE 4 have been alleviated. If STAGE 4 is initiated because of excessive demands, all initiated actions will remain in effect through September 30 of the year in which they were triggered or until the director determines that conditions exist which will allow removal of STAGE 4 actions.

City of Dallas Emergency Authority
Section 49-20

EMERGENCY AUTHORITY

Sec. 49-20

(a) Purpose and scope. The purpose of this section is to establish the city's policy and procedures in the event of shortages or delivery limitations in the city's water supply. This section applies to:

(1) all persons and premises within the city using water from the water system or untreated water,

(2) all retail customers who live in unincorporated areas within the city's extraterritorial jurisdiction and are served by the water system; and

(3) all wholesale service customers outside the city to the extent provided by subsection (i).

(b) Emergency water management plan. The director must promulgate and submit an emergency water management plan to the city council for approval including:

(1) the conditions when a particular level of conservation is required,

(2) defined stages of emergency; and

(3) a provision for specific events for each stage which could trigger an emergency.

(c) Authority. The city manager is authorized to implement measures prescribed when called for in the emergency water management plan. The director is authorized to enforce the measures implemented and to promulgate regulations, not in conflict with this section or state and federal laws, in aid of enforcement.

(d) Implementation of emergency. The director, upon determination that the conditions of a water emergency exist, must advise the city manager. The city manager must then order that the appropriate stage of emergency response, as detailed in the emergency water management plan, be implemented. To be effective, the order must be:

(1) made by public announcement; and

(2) published in a newspaper of general circulation in the city within twenty-four (24) hours after said public announcement, which order then becomes immediately effective upon publication.

(e) Duration of the order; Change and extention. The order can be made effective for up to, but not more than 60 days from the date of publication. Upon recommendation of the director, the city manager may upgrade or downgrade the stage of emergency when the conditions triggering that stage occur. Any change in the stage of the order must be made in the same manner prescribed in subsection (d) for implementing orders. The city council may, upon the recommendation of the city manager and the director, extend the duration of the emergency order for additional time periods not to exceed 120 days each. The city manager may terminate the order in the manner prescribed in subsection (d) when the director determines that the conditions creating the emergency no longer exist.

(f) Violation of section; fines. A person commits an offense if he or she knowingly makes, causes or permits a use of water contrary to the measure implemented by the city manager as prescribed in the emergency water management plan. For purposes of this subsection, it is presumed that a person has knowingly made, caused or permitted a use of water contrary to the measures implemented if:

(1) the measures have been formally ordered consistent with the terms of subsection (d); and

(2) the manner of use has been prohibited by the emergency water management plan; or

(3) the amount of water used exceeds that allowed by the emergency water management plan; or

(4) the manner or amount used violates the terms and conditions of a compliance agreement made pursuant to a variance granted by the director under subsection (g).

Any person violating any provision of the emergency water management plan shall be deemed guilty of a misdemeanor and upon conviction fined an amount not greater than $1000.

(g) Variances. During the times the emergency water management plans are operative, the director may grant variances in special cases after evaluation of hardship, need or customer efforts to conserve water. The director can grant variances only under the following circumstances and conditions:

(1) the applicant must sign a compliance agreement on forms provided by the director, and approved by the city attorney, agreeing to use the water only in the amount and manner permitted by variance;

(2) granting of variance must not cause an immediate significant reduction in the city's water supply;

(3) the applicant must demonstrate extreme hardship or need relating to their health, safety or welfare, or show evidence of substantial water conservation efforts.

(4) the health, safety and welfare of other persons must not be adversely affected by granting of the variance.

(h) Revocation of variances. The director may revoke a variance granted when he or she determines:

(1) that the conditions of subsection (g) are no longer being met;

(2) the terms of the compliance agreement are violated; or

(3) the health and safety of other persons requires revocation.

(i) Wholesale service to customers outside the city. The director shall advise governmental entities receiving wholesale water service from the city of actions taken under the emergency water management plan. The director may restrict service to wholesale service customers outside the city as permitted under the contract and state law.

(j) Authority Under Other Laws. Nothing in this section shall be construed to limit the authority of the mayor, the city council or the city manager to seek emergency relief under the provisions of any state or federal disaster relief act.

Appendix E
Return Flow and Water Reuse Data

1. RETURN FLOW DATA

Return flows are discharged treated wastewater into watershed streams and lakes. Table E-1 presents specific information on the projected quantity of flow discharged into water sources which the City of Dallas uses for supply. Table E-2 presents the return flow which has been included as dependable supply for the City of Dallas.

2. WATER REUSE DATA

Attachments E-1 through E-5 describe various symposiums, prototypes, or requirements, referenced in Section VII of the main report, concerning water reuse.

Table E-1
Total Return Flows (mgd)

Return Flows to Elm Fork of the Trinity River

Return Flows to Ray Roberts Lake	1990	2000	2010	2020	2030	2040	2050
Grayson and Cooke Counties (1)	1.73	1.88	2.03	2.17	2.32	2.52	2.73

Return Flows to Grapevine Lake	1990	2000	2010	2020	2030	2040	2050
Grapevine	1.21	1.74	2.15	2.46	2.71	2.91	3.07

Return Flows to Lewisville Lake	1990	2000	2010	2020	2030	2040	2050
Flower Mound	1.30	2.14	3.10	4.06	5.01	5.96	6.89
The Colony	1.87	2.64	3.44	4.21	4.96	5.73	6.31
Argyle *(With Denton)*	----	----	----	----	----	----	----
Corinth *(With Denton)*	----	----	----	----	----	----	----
Denton	9.53	12.76	16.28	20.30	24.82	30.13	36.36
Highland Village *(With Lewisville)*	----	----	----	----	----	----	----
Denton County (2)	3.57	5.44	7.68	9.75	11.91	14.18	16.50
Lake Lewisville Total	16.27	22.98	30.50	38.32	46.70	56.00	66.06

Return Flows to the Elm Fork of the Trinity River	1990	2000	2010	2020	2030	2040	2050
Lewisville	7.03	12.91	17.56	18.52	18.94	19.36	19.78
Total Elm Fork Return Flows	**26.24**	**39.51**	**52.24**	**61.47**	**70.67**	**80.79**	**91.64**

Return Flows to Lake Ray Hubbard	1990	2000	2010	2020	2030	2040	2050
Garland (3)	15.00	0.00	0.00	0.00	0.00	0.00	0.00
Heath	0.20	0.28	0.36	0.44	0.51	0.58	0.65
Murphy	0.18	0.24	0.31	0.37	0.43	0.49	0.55
Plano	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Richardson	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Rockwall	0.83	1.13	1.39	1.70	1.95	2.25	2.49
Rowlett	2.13	3.26	4.16	4.87	5.44	5.90	6.26
Sachse	0.62	0.97	1.22	1.41	1.54	1.64	1.72
Wylie	0.94	1.48	1.93	2.31	2.63	2.89	3.12
Total Return Flows to Lake Ray Hubbard	**31.90**	**19.36**	**21.37**	**23.10**	**24.50**	**25.75**	**26.79**

Return Flows to Lake Tawakoni	1990	2000	2010	2020	2030	2040	2050
Greenville	3.61	5.26	6.58	8.56	10.21	11.86	13.51

Return Flows to Lake Palestine	1990	2000	2010	2020	2030	2040	2050
Tyler	7.40	7.70	7.90	8.10	8.30	8.50	8.70

Return Flows to Lake Fork	1990	2000	2010	2020	2030	2040	2050
No Significant Sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	1990	2000	2010	2020	2030	2040	2050
Total Return Flows	**69.15**	**71.83**	**88.09**	**101.23**	**113.68**	**126.90**	**140.64**

Table E-2
Return Flows Included as Dependable Supply for the City of Dallas (mgd)

Return Flows to Elm Fork of the Trinity River

Return Flows to Ray Roberts Lake (Limited by Contract)

	1990	2000	2010	2020	2030	2040	2050
Grayson and Cooke Counties (1)	1.51	1.63	1.78	1.91	2.05	2.24	2.45

Return Flows to Grapevine Lake (Limited by Permit)

	1990	2000	2010	2020	2030	2040	2050
Grapevine	0.64	0.92	1.13	1.30	1.43	1.53	1.62

Return Flows to Lewisville Lake (Limited by Contract)

	1990	2000	2010	2020	2030	2040	2050
Flower Mound	1.24	2.04	2.95	3.86	4.77	5.67	6.56
The Colony	1.78	2.51	3.27	4.01	4.72	5.45	5.83
Argyle *(With Denton)*	----	----	----	----	----	----	----
Corinth *(With Denton)*	----	----	----	----	----	----	----
Denton	9.07	12.15	15.50	19.32	23.62	28.68	34.61
Highland Village *(With Lewisville)*	----	----	----	----	----	----	----
Denton County (2)	3.40	5.18	7.31	9.28	11.34	13.50	15.71
Lake Lewisville Total	15.49	21.88	29.03	36.47	44.45	53.30	62.71

Return Flows to the Elm Fork of the Trinity River (Limited by Permit)

	1990	2000	2010	2020	2030	2040	2050
Lewisville	7.03	8.00	8.00	8.00	8.00	8.00	8.00
Total Elm Fork Return Flows	24.67	32.43	39.94	47.68	55.93	65.07	74.78

Return Flows to Lake Ray Hubbard (Limited by Permit)

	1990	2000	2010	2020	2030	2040	2050
Garland (3)	15.00	0.00	0.00	0.00	0.00	0.00	0.00
Heath	0.20	0.28	0.36	0.44	0.51	0.58	0.65
Murphy	0.18	0.24	0.31	0.37	0.43	0.49	0.55
Plano	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Richardson	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Rockwall	0.83	1.13	1.39	1.70	1.95	2.25	2.49
Rowlett	2.13	3.26	4.16	4.87	5.44	5.90	6.26
Sachse	0.62	0.97	1.22	1.41	1.54	1.64	1.72
Wylie	0.94	1.48	1.93	2.31	2.63	2.89	3.12
Total Return Flows to Lake Ray Hubbard	28.30	19.36	21.37	23.10	24.50	25.75	26.79

Return Flows to Lake Tawakoni

	1990	2000	2010	2020	2030	2040	2050
Greenville	3.61	5.26	6.32	6.48	6.64	6.80	6.96

	1990	2000	2010	2020	2030	2040	2050
Total Return Flows	56.58	57.05	67.63	77.26	87.07	97.62	108.53

(1) Includes Gainesville, Muenster, Valley View, Collinsville, Tioga, and Gunter.
(2) Does not include current customer entities.
(3) City of Garland shall divert all return flows out of Lake Ray Hubbard prior to the year 2000.

Attachment E-1
How Water Professionals Look at Conservation

ATTACHMENT E-1

HOW WATER PROFESSIONALS LOOK AT CONSERVATION
A Preliminary Report

Loretta C. Lohman*

In recent years issues of water conservation in domestic, industrial and agricultural settings have been a major topic of debate and concern throughout the country. In Colorado, especially, water conservation for urban domestic use has been a key element in discussions about various water projects, particularly in the permitting conditions for Two Forks. Beyond this there has been a growing interest in the literature about water conservation means and methods and about the public acceptability of various measures. Some states, such as California and Massachusetts, have gone so far as to require use of low flow plumbing fixtures in all new and retrofit construction. Other states have proposed incentives for implementation of water conservation projects, including water reuse.

Despite this interest and not withstanding demonstrable benefits, adoption of the wide variety of water conservation measures and practices available has been sporadic and often short-lived throughout the nation. Most often this has been attributed to consumer reluctance to make changes in daily practice or the reluctance of utilities to charge for the full cost of the water sold. However, public opinion surveys consistently show support by the domestic water user for such practices as every third day watering or restriction of outside and indoor water use when the need is presented to them. The fact that such support for conservation measures has not become a "way of life" thus may not be entirely due to consumer attitudes. It may be that consumers are receiving mixed messages from their water utilities and from the professionals who are responsible for most of the decisions about water supply and water quality.

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BACKGROUND

From 1981 through 1985 the author was deeply involved in public attitude surveys relating to the specific issue of water reuse--one way of conserving available water supplies.[1] In the course of the study she closely reviewed all available public opinion surveys that in any way related to the topic[2]. One of the surveys [Stone] studied the opinions of professionals in the water industry, policy makers, and utility managers as well as the general public. The findings of that study indicated that professionals and utility managers lagged somewhat behind the general public and the policy makers [politicians] in their acceptance of a wide variety of reclaimed water uses.

At the 1987 Water Reuse Symposium IV the author took a spontaneous survey of the audience--an audience of water utility managers, technicians, engineers and researchers in the various areas of water quality. They were asked two questions which were identical to those twice asked of the citizens of Denver, and which had been addressed in slightly different form to citizens all around the country. The audience of water professionals were significantly <u>more</u> reluctant to accept high contact or potable water reuse than was the general public [Table 1].[3] This exercise was repeated at professional meetings in California, Toronto, and Denver.

During the same conference Bruvold presented a paper in which he began to re-analyze the data from seven studies which he previously had interpreted as indicating fairly broad public support <u>against</u> most water reuses. In reviewing the data <u>and</u> the methods of interpretation he presented some early analysis that essentially reversed earlier interpretations. Instead he found an acceptance for reuses was based on "salient" factors such as pollution control, cost, or conservation. Bruvold concluded that "favorability is <u>not</u> inversely related to degree of contact..."[4]

Finally, participation on the Board of Directors of Metro Water Conservation, Inc., discussions with some members of the Fort Collins Water Board, and conversations with various Denver metropolitan area water providers and utility personnel around the country, led to formulation of a hypothesis about water conservation [of which water reuse is part]. That is:

> *Solutions to many water resource problems, which could be non-structural, are inhibited by varying degrees of resistance on the part of the involved water professionals. As a part of this, such reluctance is masked by attribution of personal belief to the feelings of the general "public."*

To quote Norm Evans [who was paraphrasing Pogo]: "We have met the enemy and he is us."

OTHER RESEARCH

At about the same time this hypothesis was formulated the AWWA Research Foundation sent a questionnaire to those who had participated in the latest Reuse Symposium or who had indicated interest in water reuse to the Foundation. That survey was geared to identifying research needs in the area of water reuse. The results will not be fully available until March of 1988. However, preliminary compilation indicates support for the existence of a professional bias <u>against</u> implementation of water reuse that is partially couched in terms of concern about public acceptance.

Despite the broad literature indicating general public support and despite the increasing number of reuse projects in successful operation around the country, the AWWARF respondents selected research into public attitudes about water reuse as a primary research need. In a table entitled "Obstacles to Implementation of Reuse" general public attitude against reuse was rated the number one obstacle to both direct potable reuse and indirect potable reuse. Out of 12 possible obstacles listed it was also rated the number one obstacle to domestic reuse, and the fifth highest to urban irrigation, agricultural reuse and industrial reuse.

Public attitudes/opinions and educational techniques were the highest ranking areas requiring further research, second only to quality standards and regulations. Water conservation was the area considered by these professionals to require the least research.

There have been a number of studies following conservation measures imposed for localized droughts or shortages which show broad public willingness to accept suggested or even required reductions in water use. However such changes in water use usually end when the shortage ends, perhaps because the water provider fails to encourage continued conservation as a means of reducing further crises or avoiding further capital outlays.

THE WATER PROFESSIONALS SURVEY

Since the general public has been well surveyed on the entire gamut of water issues in the last 15 years it became clear that it was the water industry attitudes that needed exploration. To this end the author, with the assistance of some printing funds from the CWRRI and MWCI,[5] developed a "soup to nuts" questionnaire about broadly defined water conservation that was distributed to attendees at a series of professional meetings held around the country between June and November, 1988.

Because no such survey had been attempted before, and because the topic of water conservation is such a vast topic, the questionnaire was not tightly focused or drawn. Since this was an unfunded research project, dependent upon the good will of meeting organizers and the voluntary effort of conference participants, the sample was likewise unscientific. Responses came from an American Society of Civil Engineers conference, a National Water Supply Improvement Association conference, a regional American Water Works Association conference, and two American Water Resources Association conferences.[6] Completed questionnaires from the AWWA National Conference were lost in the conference clean-up.

However, the respondents from five conferences do represent self-identified water industry professionals. And while the questionnaire received many justified criticisms, it did elicit a great deal of information that at least <u>indicates</u> what might be the general state of mind of water professionals. The first thing, of course, that such an informal effort indicates is the high degree of interest on the part of those who did take the time to fill out a complicated questionnaire during a busy conference schedule. In fact, about 25 percent of the respondents took the form home with them and mailed it directly to the author.

Even with the completed questionnaires that were lost after the AWWA National Conference the response rate was 27 percent.[7] This return is comparable to that expected for a mailed questionnaire. It represents a sufficient response to enable drawing of some conclusions adequate for a "white paper" type of presentation which will hopefully stimulate sufficient interest in the area to generate more completely funded research.

Preliminary Demographics

One hundred and sixty-one responses were received from 37 states, and from South Africa and Canada. The Western U.S. was home to 27.3 percent, with the remainder of the respondents fairly evenly divided among the climatological regions of the country. Only the Midwest and Pacific Northwest were somewhat poorly represented in the total distribution of responses.

Respondents included a full gamut of water-related professions, including system managers, consulting engineers, hydrologists, government water program managers [at Federal, State and local levels], planners, policy makers, biologists, chemists, geologists, economists, and lawyers. No single occupation dominated the respondents, although engineers, utility and other management personnel and hydrologists were especially well represented.

General Water Conservation

The very first question elicited the respondent's opinion whether mandatory conservation was ever necessary. Nearly 17 percent felt that there was never a reason to enforce mandatory water conservation. The 77 percent of respondents who felt there were occasions that required mandatory water conservation offered two primary reasons for such a step: (1) 38.5 percent felt that mandatory steps were required in situations of drought and water emergency; (2) an additional 38.5 percent felt that conservation should be required when demand exceeded supply or shortages were imminent. A respectable 7.3 percent felt conservation should always be mandatory, while 6.0 percent felt it a proper response to contamination problems in the water supply. The remaining reasons supporting mandatory conservation included public safety, salt water barriers and protection of fish and wildlife.

In terms of the respondents' personal habits concerning water, just over half have low-flow shower heads but fewer than a third have either faucet aerators or low water-using toilets in their homes. But nearly all maintain their water using appliances "most of the time" according to manufacturer instructions. Over half have taken part in water conservation programs as consumers, but fewer than one third have participated in the design or administration of a conservation program.

While just under 40 percent felt they pay a great deal of attention to how much water they use outside, most also felt they used a moderate amount of water in total. They also felt that about 47 percent of the general public will voluntarily restrict outdoor water use when asked by their utility. **[Past experience around the country indicates a cooperation rate in excess of 80 percent for such programs.[8]]**

The respondents, although generally in favor of conservation under specific circumstances, had some difficulty in defining methods which could be used to encourage general conservation. The only method broadly favored was the use of public education, with some support for alternate day irrigation systems. Evapotranspiration programs to guide the amounts of irrigation required, along with restriction of turf areas and regulations restricting or requiring recirculation for hot tubs and swamp coolers, were not considered appropriate. There was some luke-warm support for utility sponsored water audits.

Methods that might be used to <u>enforce</u> water conservation were also difficult to define. There was fairly broad support for universal metering. Methods that "may be" appropriate include, in descending order of selection: building and plumbing code amendments regarding fixtures, inverted or uniform pricing structures, required recycling of certain waters, and, perhaps, some site planning with an eye to water conservation. Unacceptable methods of enforcing water conservation include dual distribution systems, restrictions on commercial/industrial water uses, restrictions on cooling systems or ornamental lakes and fountains, or water tap fees.

Despite this, more than 95 percent felt they could strongly support revisions in the commercial and industrial rate structure to encourage conservation. More than 93 percent proffered the same support for residential rates as a means to encourage conservation.

While this group of respondents found that a supply shortage was a good reason to conserve water there were only two other moderately strong reasons for conservation: (1) conservation could alleviate the need for new capital investment in development of water resources; and (2) it is essentially not right to <u>waste</u> a resource. There was support from about half the respondents for the statement that conservation might reduce sewage treatment costs and that it might save money for the consumer. But there was little support for the concept that conservation might alleviate some types of pollution problems or that conserved water would allow more growth or greater river water recreation. The respondents did <u>not</u> support conservation as a means of satisfying citizen demands or other requirements upon which new development projects might be conditional or conservation as a means of preserving agriculture.

<u>Conservation Through Water Reuse</u>

Very few of the respondents have had any experience with a water reuse or recycling program--either as consumers or professionals. However 86 percent thought non-potable reuse was generally a good idea. Over 90 percent thought it could be used for cooling water and for park, greenbelt and golf course irrigation. Support for non-food process water, construction dust control, and use in ornamental lakes and fountains was almost as strong--just over 80 percent. Boiler feed water was considered a good use by 73 percent, while only 63 percent felt that commercial laundries should engage in non-potable recycling.

Over 93 percent of the respondents felt the technology for water treatment is advanced enough to allow non-contact reuses. At the same time more than 75 percent supported a rate structure revision to encourage general use of recycled water.

However respondent support for specific reuses lagged behind the general public, ranging from 89.4 percent for lawn irrigation to 15.5 percent for drinking water [see Table 1]. The professionals came closer to public opinion when given a three way choice about drinking reclaimed water. Over 67 percent said they personally would "mind a little bit" or "not at all." At the same time, 77.5 percent of the respondents felt that the general public would "mind drinking reused water a lot." This contravenes the results of the survey conducted in Denver,[Table 2][9] and of other surveys conducted throughout the country which have been well discussed by Bruvold.[10]

Table 2 compares the responses of this group of professionals to those at Reuse Symposium IV and to the responses of the citizens of Denver. Clearly the perception of the water professional about what the "public" feels [that the public would mind reuse a lot] lags far behind what the public actually does feel. This <u>perception</u> about public attitude, expressed in this survey and in the AWWARF study, appears to be a far greater obstacle to reuse than does the actual public opinion.

CONCLUSION

As indicated at the outset, this is a preliminary report of survey results. Further analysis should reveal whether attitudes about conservation in general and reuse in specific are tied to a region, a profession, education, experience, or etc. Even without a further and better controlled study it will be possible to draw some inferences from more thorough examination of the responses to this survey that lead to general conclusions about implications in terms of future research and policy analysis. It also may be possible to produce some analysis across surveys of the general public that will either contradict or support some of the perceptions seemingly expressed by the respondents in this survey about general public attitudes and willingness to cooperate in conservation programs.

TABLE 1

COMPARISON OF PROFESSIONAL/PUBLIC APPROVAL OF REUSES

Reuse	1988 Professional Approval %	1987 Professional Approval %	Public Approval%
watering the lawn	89.4		95.8
flushing toilets	88.1	100.0	95.8
washing cars	79.4		95.3
watering the garden	81.3	100.0	90.3
doing laundry	43.5	29.0	68.0
bathing	26.9		60.0
cooking food	16.1	13.0	39.2
drinking water	15.5		29.8

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TABLE 2

COMPARISON OF PROFESSIONAL/PUBLIC RESPONSE TO DRINKING RECLAIMED WATER

Opinion Group	1988 Professional %	1987 Professional %	Public %
Minds a lot	30.6	58.0	23.8
Minds a little bit	40.0	31.0	45.0
Doesn't mind at all	27.5	11.0	27.0
Doesn't know	1.9		4.2

REFERENCES

1. Lohman and Milliken, Informational/Educational Approaches to Public Attitudes on Potable Reuse of Wastewater, OWR, 1985.

2. A partial list includes: Bruvold, 1972, 1976, 1979; Gallup, 1973, Carley, 1972; Baumann, 1974; and Stone, 1974.

3. Lohman, "Potable Wastewater Reuse Can Win Public Support," Proceedings, AWWA, 1988, 1039.

4. Bruvold, "Public Evaluation of Salient Water Reuse Options," Proceedings, AWWA, 1988, 1021.

5. The Colorado Water Resources Research Institute and Metropolitan Water Conservation, Inc. generously provided funds for questionnaire printing and suggestions for questions. However full responsibility for the questionnaire and analysis of the results is the author's.

6. Special credit should be given to Ken Reid, Executive Director of AWRA for his enthusiastic help during two conferences. Others who assisted were Steve Ballard-ASCE, Bill Brinker-HDR, and Bill Lauer-DWD.

7. The generally acceptable response for an aggressively conducted mail survey is in the range of 25 percent. Mailed surveys that where contacts are not followed up by letter and telephone tend to have a response rate of about five percent. This survey distributed 600 questionnaires to the six conferences, five of which had returns.

8. Records from Denver Water Department and write-ups on the Marin County response to drought support this number. Surveys conducted in the Denver area by Metropolitan State College and the University of Denver School of Business in the last eight years indicate general support for outdoor conservation and support nearing 90 percent for alternate day watering.

9. Lohman, et. al, Educational Informational Approaches.

10. See note 2.

Attachment E-2
Florida Cities Adopt Dual Distribution Systems

ATTACHMENT E-2

FLORIDA CITIES ADOPT DUAL-DISTRIBUTION SYSTEMS

In the early 1970s, St. Petersburg had a water supply and a wastewater problem. To meet revised discharge standards to Tampa Bay, the city had to either upgrade its four WWTPs to advanced waste treatment, including nitrogen removal, or cease discharging into the bay, then one of the most polluted water bodies in the nation. Concurrently, groundwater supplies were being severely strained and the city had to find a way to reduce potable demand. The city council solved both problems at once when it authorized a project to reclaim wastewater from the four plants for urban irrigation, including schools, golf courses, parks, and commercial and residential areas.

Between 1977 and 1987, the city spent over $100 million expanding and upgrading the four plants advanced secondary treatment (without nitrogen removal) and constructing 200 miles of pipes in a looped network which connects the plants in series directly to customers. Recently, the system, whose water is also used for supplemental fire protection, was expanded to encompass "water critical" residential areas. In 1987, the average daily flow of 20 million gallons a day reached over 5,000 customers. When the project is fully complete by the year 2000, the system will have a 42-mgd capacity with the potential to serve 17,000 customers, while irrigating nearly 9,000 acres.

Residents pay a flat monthly fee of $10.30 for unlimited use and commercial customers pay a fee based on acreage. The system, whose color-coded lines and valve boxes distinguish it from the potable water system, meets the controversial state reclaimed water standards (currently being revised) for public access use of 90% BOD removal, less than or equal to 5 mg/L of total suspended solids, and no detectable fecal coliforms. Thanks to the system, city water demand has leveled out.

Located 10 miles from Orlando, Altamonte Springs has an equally ambitious project called "APRICOT". The name, standing for "A Prototype Realistic Innovative Community of Today", is a variation of the futuristic motif of Disney World's EPCOT Center. Impetus for the project is a 1982 city ordinance that requires dual distribution systems for all newly developed areas of the city, which is in the throes of a "real water crunch", according to Alison Marcous, information liaison in the Department of Public Works. Marcous said planners will eventually propose to install the system in commercial buildings and factories to be used for toilet flushing, sprinkler systems, and for such other outside uses as car washing. The goal is to provide reclaimed water to every property in the city, she said.

The reclaimed water meeting state potable water standards will be processed by the city's WWTP, which was recently upgraded to tertiary treatment and which will be expanded to include dual media filtration with a 12-mgd capacity. The identical filter process was used in a pilot study of the Epidemiology Research Center of Florida yielding an effluent that achieves low turbidity levels, zero fecal coliforms, and viruses below detectable limits, Marcous said.

The project is expected to go on line in 1993. Total cost is estimated at $32 million, to be financed through a combination of developer and new connection fees and a bond issue. "There is no federal money", Marcous said, "because the city wanted total control over the project." To spur maximum usage, residents electing not to use the system will be charged an availability fee. The reclaimed water will be unmetered and will be available to users for a flat rate, to be set at half the potable rate.

Source: Journal WPCF, Volume 60, Number 11
November, 1988

Attachment E–3
Overhauling Health Effects Perspectives

ATTACHMENT E-3

OVERHAULING HEALTH EFFECTS PERSPECTIVES

Two factors, the absence of standards and the absence of regulations,[1] inhibit the development of water reuse projects. Because of insufficient information available to set standards or prepare regulations, this may continue to be an inhibiting problem for some time. Despite this reality, however, great progress is being made.

In every discussion about water reuse, the bottom line always comes down to the microbial purity of water and protection of the public health. Eventually, because of lack of information, it is recommended that the wastewater treatment used to produce recycled nonpotable water reliably produce water that is pathogen free and bacterologically equivalent to potable water. The gastroenteritis viruses that could be present in such water is of most concern. It is feared that these may contaminate the irrigated environment so that people exposed to the nonpotable water might get sick (usually with gastroenteritis).

The city of Colorado Springs reviewed these concerns with the Colorado Department of Health (CDH), when its discharge permit for the wastewater treatment facility expired on March 31, 1982. Establishment of an appropriate disinfection limit, based on indicator bacteria for the nonpotable water used to irrigate city parks, was a major unresolved issue.[2] The CDH was concerned about health effects on visitors active in parks that were irrigated with nonpotable water of wastewater origin. The CDH held that a standard of <2.2 total coliforms per 100mL for the nonpotable water was needed. The city held that the existing standard of <200 fecal coliforms per 100mL as a weekly geometric mean posed no greater health risk than the more stringent proposed standard; the more stringent standard would only result in an unnecessary financial burden on the community. About $1.6 million would be needed to modify the existing treatment train to meet the much more stringent proposed standard.[3] This conflict over the adoption of the proposed standard arose because there were insufficient data to provide guidance as to appropriate permit levels.

In the city's opinion, review of the scientific literature supported the effluent limit of 200 fecal coliforms per 100mL as the appropriate standard when applied to reclaimed wastewater used for landscape irrigation. This position did not reflect a support for relaxed water quality criteria. It represented the continuance of a long-standing state policy that had proven its effectiveness to protect the public health since 1977 - the bathing water standard that was developed by the Environmental Protection Agency in its 1976 Red Book.

Disease is rarely induced by a single bacterium - infective doses rage in the thousands of viable cells. Disinfection to 200 fecal coliforms per 100mL results in bacterial pathogen levels that are only fractions of an infective dose, at most. Thus, it was reasoned that a fecal coliform level below 200 per 100mL would yield no additional health protection from the standpoint of effective removal of bacterial pathogens.

The CDH, however, cited California standards specifically aimed at removing viral pathogens, and sought to adopt those standards. CDH perspective was that nonpotable water should be regulated with standards that would assure that there would not be a disease outbreak that might be caused from nonpotable water reuse. CDH was not willing to accept any risk that might produce a morbidity level above that which might be associated with potable water irrigation. This led to the proposal of the 2.2 total coliforms per 100 mL standard for nonpotable water used for park irrigation. Though CDH acknowledge that no empirical data existed to support this level of protection or the California rationale, it was included in the first draft of the renewed discharge permit.

This conflict was resolved only when the city offered to conduct an epidemiology study specifically designed to prove or disprove the hypothesis that gastrointestinal illness rates at parks irrigated with potable water were no different from gastrointestinal illness rates reported at parks irrigated with nonpotable water of wastewater origin. The hypothesis to be tested and around which the epidemiology study was designed was: "Attach rates over a 10-day period of self reported diarrheal illness will be no different in persons exposed to irrigation water in parks using treated wastewater for irrigation than for persons similarly exposed in parks using potable water for irrigation."[4] In addition, there were several supporting hypotheses which related to degree of exposure, coliform counts, and long incubating illness, like Hepatitis A, that could be water-borne. Some key findings from this report of the city of Colorado Springs Epidemiology Study may influence standard setting and regulatory thinking with regard to nonpotable water reuse.

Nonpotable water from the city of Colorado Springs is generated from a (10 mgd) $37850m^3/d$ tertiary treatment plant located at the Las Vegas Treatment Facility site. The secondary effluent from the activated sludge treatment facility is filtered through dual-media (sand and anthracite) gravity filters. The secondary effluent is chlorinated to about 2 mg/L of residual chlorine and the tertiary effluent is again chlorinated to about 5-8 mg/L before distribution to the irrigation system.

The city also uses nonpotable water of runoff origin (NPRO). This is a combination of urban mountain runoff water and local groundwater that it collected and stored in an on-site lake. This water was then pumped directly through sprinklerheads, without prior treatment, to irrigate one of the parks where visitors participated in the epidemiology study.

Bacteriologically, the nonpotable water of wastewater origin (NPWW) was different from that of NPRO. The fecal coliform and fecal streptococcus densities were usually <23/100 mL, as measured by the Most Probable Number (MPN) method, for NPWW. On the other hand, the NPRO densities were usually in the hundreds or thousands for the same microbes (Table 1).

Significant Study Findings

The 2-year prospective cohort epidemiology study, which consisted of 2642 subjects randomly selected and analyzed, used bivariate and multivariate statistical analysis techniques. The data supported the hypothesis. In other words, there was no difference in self-reported gastrointestinal illness rates between those park visitors in parks watered with potable water versus those watered with nonpotable water of either wastewater of runoff origin. This finding meant that the treatment level used in the past, which was designed to achieve a regulatory policy criterion of 200 fecal coliforms per 100mL, was adequate and did protect the public health. The nonpotable water used for irrigating public parks was as safe as potable water.

This finding was supported even after numerous statistical controls were applied: age, gender, household density, family income, park switching (visiting a park irrigated with a different type of water between initial and final telephone contact), degree of exposure to irrigation water, level of physical exertion, type of activity in the parks (golfing, soccer, softball, picnicking, and so on), weather conditions, and frequency of prior exposure to irrigation water. Also, the incubation time for self-reported gastroenteritis was unrelated to nonpotable water exposure. Thus, after exhaustive analysis, none of the data offered evidence that exposure to NPWW is a source of gastrointestinal illness. Furthermore, the many subjects interviewed produced a study of sufficient power so that a difference of only four cases out of 100 was required to detect a statistically significant difference (if there had been one) in illness rates between groups, with a 90% likelihood of being able to detect such a real difference.

Some other general observations were that common indicator bacterial groups below certain levels were only weakly related to illness rates and incubation time for gastrointestinal illness. This suggested that conventional indicator bacteria (fecal streptococci, fecal coliforms, total coliforms) are of limited value in assessing irrigation water safety with respect to gastrointestinal illness. However, statistically significant increases in gastrointestinal symptoms were associated with fecal coliforms and fecal streptococci levels above 500 per 100mL and with total coliform densities above 3000 per 100mL. Above the 500 per 100mL bacterial density level for both fecal streptococci and fecal coliforms, three out of four cases of self-reported gastrointestinal symptoms were predictable. This 75% predictive rate is quite significant and illustrates that bacterial indicator levels are good predictors of illness rates above certain levels rather than below such cut-off levels.

The bacterial pathogens Salmonella and Shigella were never recovered from NPWW, but Shigella was recovered twice from NPRO. Several findings including high bacterial densities, the presence of bacterial pathogens, and the incidence of symptom reports (it approached statistical significance) suggest that landscape irrigation with NPRO may be more likely to be a source of gastrointestinal illness than NPWW.

Disaggregated and analyzed data showed that "wet grass conditions" caused by irrigation with either potable or nonpotable water of either NPRO or NPWW origin was responsible for a statistically significant increase in self-reported gastrointestinal symptoms: stomach disorder plus at least any one of the following - diarrhea, vomiting, cramps, fever, weight loss, excessive gas, or blood in the stool. In other words, "wet grass" from any source was the one criterion linked to gastrointestinal illness reports across all park groups and categories investigated.

This information was not obvious from data that clearly showed that nonpotable water from wastewater or runoff origin was as safe as potable water. So, in order to make the discover, that wet grass, per se, from any water source caused an increase of self reporting of gastrointestinal illness, the following general analysis process were carried out: The park visitors who reported visiting the parks during wet grass conditions were compared to the rest of the subjects. A statistically significant increase in illness reporting was the result. Then the wet grass and dry grass populations were analyzed to see if there were differences in illness reporting rates within each group by comparing the subjects exposed to potable water with those exposed to nonpotable water of wastewater or runoff origin. No difference in illness reporting rates were found in those comparisons.

This meant that if there were no within group (wet grass and dry grass groups) differences in illness rate reports caused by water type, but there was a difference when the analysis was done across groups (wet grass versus dry grass), then the condition that caused this self reporting of gastrointestinal illness rate difference was on the grass and not in the water.

As the wet grass causal factor was more closely examined, it was found that a still stronger correlation existed when both wet grass conditions and fecal coliform or fecal streptococcus counts above 500 per mL coexisted. (This implicates NPRO more than any other type, because it was more likely to have such a high bacterial density. See Table 1.) Such a model produced the strongest statistically significant relationship with self-reported gastrointestinal symptoms.

Therefore, if water quality measures show nonpotable water has <500 fecal coliform or fecal streptococci, it will be just as safe to use as potable water. However, wet grass conditions resulting from any water was shown to be the only causal factor for increased self-reporting of gastrointestinal symptoms of park visitors. The wet grass findings was further strengthened when the fecal coliform density was <500/100 mL.

Data Discussion

The information from this epidemiology study challenges thinking with regard to NPRO and NPWW water used for irrigation purposes. On the one hand, the data clearly showed that wet grass conditions from potable or nonpotable water correlates with a statistically higher rate of gastrointestinal symptom reports. On the other hand, when nonpotable water of wastewater or runoff origin goes above the 500 per 100 mL density with indicator bacteria, an even stronger correlation is observed. Because nonpotable water of runoff origin was consistently more dense microbially, this may be of concern when such NPRO water is considered for irrigation purposes.

The question of interest is: What is the wet grass factor that may be causally associated with increased gastrointestinal illness reporting by park visitors during wet grass conditions? It may be something already on the grass that, when associated with any kind of water or moisture, can cause illness. It is an agent whose increasing activity correlates well, as Gram negative bacterial levels of the irrigation water go above 500/mL and as the fecal streptococcus density goes above 500/mL.

One hypothesis[5] might be that viruses with a high survival rate may be present on the grass.[5] Assuming they are not present in the potable water used for irrigation, they must be on the grass already if they are presumed to be the causal agents. Then, the argument might continue, as the bacterial count increases in the NPWW or NPRO these viruses (presumed present in great numbers now - remember this is pure conjecture) load the grass to a higher infective level. It would be interesting to know if these kinds of viruses are present on the grass or in the water when bacterial indicator levels are <500/mL. Their presence would mean that they can survive low humidity and sunny periods, which was the climate 80% of the time in Colorado Springs during this study. It would then also mean that these viruses would be present in nonpotable water because the bacterial count of that water is higher. Neither one of these suspicions seems reasonable.

For instance, even though laboratory findings indicate one plaque-forming virus unit[6,7] may cause gastrointestinal symptoms (this is disputable when one considers in the infective dose argument, non-immunological barriers, immunological response, and probabilistic factors[8]), reason would argue that they would have to be present in substantially large numbers on the grass surface to result in a high enough probability of exposure to park visitors to cause a statistically significant increase in illness rates. Furthermore, they would have to be present in large numbers in the water to effectively increase their numbers on the grass. This seems logical when one considers the fact that the irrigation shock of aerosolization may result in a half log loss of virus particles and that subsequent dieoff is about one log every 40 seconds.[9] While this virus proposition sounds enticing, it is not logical from a probability of contact with the virus context.

It seems unlikely that there are enough viruses present in the water[10] to cause a statistically significant increase in gastrointestinal illness when the bacterial density goes above 500 per 100mL in such water.

Because the weather in Colorado Springs is mostly sunny and dry for more than 80% of the time during which park visitations took place, (conditions unfavorable to viruses), it seems unlikely that the UV-filled viruses on the grass are so quickly replenished as to be available to infect individuals at statistically significant rates during the rare wet/cloudy conditions. Viruses, therefore, do not seem to be the operative causal factor.

It seems reasonable to assume that the causal factor for the increase in gastrointestinal illness rates, if it is already on the grass, survives sun and dryness and may even be dissolved in the moisture to make it more readily available to man. Pesticides, herbicides, and fertilizers were not used during the irrigation season during the epidemiology study; thus, toxic reactions to exposure to these products is ruled out. However, because increased bacterial loading further increases risk, there seems to be a clue here. Perhaps endotoxins from living or dead enterobacteriaceae are ubiquitous to the grass and may be further loaded on the grass during irrigation. This hypothesis fits the description of the model well, because it only takes microgram levels of endotoxin to cause gastrointestinal and pyrogenic symptoms. Endotoxins have been adequately documented as being responsible for such problems.[12-14]

Endotoxins are in potable water as well. Also, the Gram-negative bacteria do not have to be living because the endotoxin is the lipopolisaccharide from the cell membrane of the bacteria. Indeed, this model may make a great deal of sense; or both virus and endotoxins may be operating additively. Further studies, which include endotoxin and virus testing with the epidemiology study, are needed to test these hypotheses, as they relate to wet grass conditions regardless of the irrigation water source or type.

Policy Impact

Having found that the fecal coliform and or fecal streptococcus level must be above 500 per 100mL before one can detect an increase in gastrointestinal illness, the standards proposed by California seem unreasonably stringent for water to be used for irrigation purposes. Furthermore, it must be remembered that this wet grass finding/phenomenon, as a factor that was shown to be related to increased reports of gastrointestinal symptoms regardless of the water source and type used for irrigation, was only made when a criterion was deliberately searched for to determine if something could be found that was responsible for increased gastrointestinal symptoms. There was no evidence to even suppose that such an increase in gastrointestinal symptom reporting would be found from the initial analysis of the data. The study data showed very clearly that there were no increased gastrointestinal symptom reports from park visitors who visited parks irrigated with either potable water, NPRO, or NPWW. In the words, standard statistical analysis of the epidemiology data itself between the control group and the experimental group found that there was no difference between the self-reported gastrointestinal illness rates between these park visitors at parks irrigated with potable water and parks irrigated with NPRO and NPWW. Only when the data was dichotomized into wet grass and dry grass groups was the wet grass phenomenon discovered.

For purposes of standard setting and water reuse regulation, reuse, and policy formulation associated with such reuse, the Colorado Springs epidemiology study would suggest the following considerations. First, nonpotable water of runoff origin should be included in the standard setting/regulatory process. More of a health risk may be associated with this kind of water reuse than with reusing water originating from tertiary treated and chlorinated wastewater effluent. Second, it seems that NPRO and NPWW nonpotable water with a fecal coliform or fecal streptococcus density of <500 per 100mL is as safe to use for irrigation as potable water. Third, the type of park activity, be it golfing, picnicking, soccer, softball, or flag football, and so on, seems to make no difference in terms of bringing about a degree of exposure that would justify stricter standards for one kinds of activity as opposed to some other type.[15]

Because wet grass conditions regardless of water type is associated with increased gastroenteritis symptom reports, it may be wise to consider when irrigation should occur. Options might include irrigating at night when no one is in the park until sometime in the morning, after the sun has had a chance to evaporate the moisture; or, watering could take place during periods of peak sunshine, or watering after park activities as a rule rather than before park activities. It should also be kept in mind, as the fifth consideration that the potential for contacting gastroenteritis (which is the same in potable and nonpotable parks) may not even be significant enough to be of concern. Setting up a good management program may be adequate by itself. Furthermore, the high bacterial indicator limits found to be safe in this study suggest that even the bacterial standards need not be overly stringent. The 200 fecal coliform limit suggested in the EPA Red Book for bathing waters seems to provide adequate protection.

The final conclusion is that treated and chlorinated wastewater effluent is as safe to use to irrigate public parks used for all manner of activities from golfing to picnicking as is potable water. The quality of the NPWW or NPRO is of no health consequence as long as fecal coliforms or fecal streptococci are less than 500/mL.

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Attachment E-4
AWWA Guidelines

ATTACHMENT E-4

AWWA GUIDELINES

If water reuse is considered as a supply source several factors should be considered regarding policy by various agencies and associations. The American Water Works Association has issued a policy statement on water reuse with major goals as follows:

1. Identify the full range of contaminants possibly present in treated wastewaters.
2. Determine the degree to which these contaminants can be removed.
3. Determine the long-range physiological effects of continued use of reclaimed wastewaters.
4. Define parameters, processes, and test procedures required to produce uniform quality in treated wastewater.
5. Refine the treatment process to achieve greater capability and reliability.
6. Upgrade the capabilities of operational personnel.

These goals were implemented in the mid 1970's and some areas of improvement have been achieved since that date. Long range goals are continuing to determine the extended physiological effects of reclaimed waters.

Attachment E-5
Past Participant Cities For Water Reuse

ATTACHMENT E-5

PAST PARTICIPANT CITIES FOR WATER RE-USE

Reasons of nuisance, odors, plant relocation, management changes, and alternate sources of irrigation water were given for the following sites that were abandoned:

Baird, Texas - The wastewater from the Imhoff tank at Baird was used to irrigate a small garden area near the treatment plant until 1967. At that time a new trickling filter plant was built on the site of the garden. The City owns no more land in the area and discharges the 0.086 mgd of treated effluent, after chlorination, into a creek that is tributary to the Brazos River.

Breckenridge, Texas - The trickling filters built in 1922 have been upgraded to treat 0.3 mgd but need further enlargement. No information was received on when or why irrigation was abandoned.

Childress, Texas - Irrigation with Imhoff tank effluent began at Childress around 1925. The effluent would flow in an open ditch until it was pumped out for irrigation on 150 acres by a nearby farmer. When the farmer was not irrigating, the flow in the ditch continued downstream and served as a source of drinking water for cattle. This periodic withdrawal led to stagnant ponds in the ditch and numerous odor complaints. In 1952 the practice of discharging this dry channel was discontinued because of the odor complaints. Presently, the trickling filter effluent, amounting to 0.58 mgd, is discharged to Trosbecks Creek.

Georgetown, Texas - Irrigation of a pecan orchard near the city of Georgetown with primary effluent was discontinued in 1965. Reasons given for the abandonment were odor production and mosquito propagation. The loading rate at the time of abandonment was 7,000 gad. At present the 0.45 mgd is receiving activated sludge treatment with river discharge.

Mission, Texas - Mission is located in southern Texas about 4 miles from the Rio Grande. An Imhoff tank built in 1926 served as the treatment works with discharge to a floodway drainage ditch. In 1938 a farmer began pumping the effluent out of the ditch to irrigate small grain for cattle feed. After 2 years of operation a flood washed out the pump intake pool and created a new channel a considerable distance away. Because the effluent contained 600 to 700 mg/L of TDS, and there seemed to be abundance of irrigation water in the Rio Grande valley, the practice of sewage irrigation was never continued.

Plainview, Texas - The practice began in the early 1930's when Imhoff tank effluent was discharged down a dry channel. Farmers adjacent to the channel would pump the effluent and use it for irrigation on a voluntary basis. When no users pump out the water it travels 6 to 8 miles before it finally infiltrates into the ground. The practice was recently dropped although the plant now consists of trickling filters.

Robstown, Texas - Presently, Robstown discharges 0.7 mgd of activated sludge effluent to Ogo Creek. As recently as 1970 a portion of the effluent was used to irrigate turf grass. No reasons for abandonment were given.

San Marcos, Texas - Effluent from the treatment works at San Marcos has never been used for irrigation. The use referred to by Hutchins was a temporary application with liquid sludge for fertilizer. The sludge drying beds were overloaded, and the excess sludge was applied to the land until about 1950.

The effluent disposal system for 1.2 mgd from the larger of the two treatment plants is designed so that the effluent can be bypassed to irrigate adjacent property. Presently, the owner of the property feels that the flow is too small for him to consider converting his irrigation system.

Stamford, Texas - Effluent from the treatment works at Stamford was used to irrigate grain sorghum until 1945. The City Superintendent of Water and Sewers leased 15 acres from the City and operated the farm. When he retired in 1945 the practice was abandoned. Presently, an oxidation ditch is being constructed at Stamford, and the planned use of the effluent is for irrigation.

Stephenville, Texas - Presently, 0.5 mgd of stabilization pond effluent is being discharged to the Bosque River. No reasons for irrigation abandonment were given although abandonment probably occurred prior to 1950.

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Appendix F
Alternative Water Supply Plan Calculations

1. Section IX of the main report presents cost curves that were developed for primary raw water pump stations, booster pump stations, and water supply pipelines. Figure F-1 illustrates the change in the cost of water and power construction from 1973 to 1988. Figure F-2 shows the cost of living increase during the same time period. Figures F-3 and F-4 present estimated construction costs of installed raw water and booster pump stations, as a function of both design flow and total dynamic head (T.D.H.). The costs given in these figures include the costs of pumps, motors, electrical switchgear, flow measuring devices, all pump station piping and valves, trashracks, bulkheads, sluice gates, excavation of minor intake channel, and the pump station structure itself. These curves were developed by updating similar cost curves developed by URS/Forrest and Cotton, Inc. for the 1975 long-range study. Data used to update these curves was obtained from information contained in Graham Associates' March 1983 report, "Raw Water Transmission Facilities" from Lake Fork Reservoir to Lake Tawakoni; Dannenbaum Engineering's preliminary report, "Lake Palestine Utilization and Pipeline Alignment Study", and from cost information furnished by DWU personnel. All values were extrapolated up to 1989 prices using ENR Cost Indexes.

Figure F-5 presents the construction costs of pipelines as a function of pipeline diameter. The total cost per mile of installed pipeline includes the costs of A.W.W.A.(C301, Class 150 psi) pipe, fittings, excavation, laying, backfill, and right-of-way. This curve was developed by updating a similar curve from the 1975 "Long Range Water Supply Plan". Data used to update this curve was obtained from the following sources:

a) Discussion with suppliers
b) Dodge and Means costing data
c) Dannenbaum's Lake Palestine study

2. Tables F-1 through F-3 contain basic information on TU Electric's HV and MP rate structures (discussed in Section IX) and the cost analyses used to determine the most effective rate structure to use assuming a constant pumpage. The HV rate structure results in lower energy costs for planning purposes.

3. Table F-4 contains a summary of all pipeline alignments analyzed during the study. As discussed in Section IX, this information was used to determine the most economical routes for delivering water for the various schemes.

4. Tables F-5 through F-12 contain the detailed costs and net present values of the eight alternatives presented in Section IX.

5. Additional transmission facilities were analyzed for the four reuse schemes to supply additional mixing water to Lake Ray Hubbard. These facilities include pipelines and pumps to divert flow from the proposed diversion structure or from the existing Tawakoni pipeline near the same location, along the same alignment as the reuse pipeline, to near the outfall of the proposed reuse pipeline. Table F-13 presents the pipeline sizes and pumps analyzed along with the resulting additional costs for this mixing loop to develop an increased mixing ratio.

6. The following paragraphs discuss the analysis performed on the system's two unconnected reservoirs, Lake Palestine and Lake Fork, to determine which should be connected next.

LAKE FORK/LAKE PALESTINE COST COMPARISON

The City of Dallas currently holds certificates for raw water diversion to bring water to the Trinity River Basin from Lake Fork and Lake Palestine for municipal and industrial use. To use these supplies, it is necessary to construct transmission facilities to supply raw water for treatment and use. A comparison of the costs for connection of each reservoir was performed to determine which reservoir should be connected next.

For the purposes of this comparison, it was assumed that each supply would be delivered to the same treatment facility, the proposed Southeast WTP. For capital costs, pipelines and pumping facilities were designed to carry a maximum of 120 mgd. However, operation costs were based on 100 mgd. Results from two previous engineering studies submitted to the City of Dallas, which studied and made recommendations for transmission facilities needed to convey water from these two sources, were incorporated into this comparison in the development of capital costs for transmission facilities. Operation and maintenance costs were estimated in the manner indicated in Section IX of the text. The City of Dallas' original capital cost for the projects, $115,000,000 for Lake Fork, not including future renegotiation of the existing contract which is necessary in 2014, and $11,430,000 for Lake Palestine were disregarded in this analysis because they will be made regardless of which reservoir is connected next. A description of the previous engineering studies and a description of this analysis follows:

Lake Fork

In March, 1983, Graham Associates, Inc. was authorized by Dallas Water Utilities to provide an engineering study for conceptual planning to develop the Lake Fork Reservoir to supply the City of Dallas with raw water. The study recommended the construction of:

- A Raw Water Intake and Pump Station with a capacity of 107 mgd, with expansion capabilities to 214 mgd for the "maximum permitted delivery rate". The site chosen was large enough for an Operator's Residence, a Service Center and an Electrical Substation which are all required for operation and maintenance of the facility.

- Twenty-two miles of 84-inch diameter pipeline to deliver 107 mgd from Lake Fork to Lake Tawakoni.

- An outlet control structure near the west end of Iron Bridge Dam on Lake Tawakoni.

The study also presented conceptual plans for future facilities necessary to transmit water from Lake Tawakoni to the East Side Water Treatment Plant and south to a proposed Southeast Balancing Reservoir on the south side of Seagoville, Texas. Graham's study provided recommendations for the future facilities:

- Expand existing Iron Bridge Pump Station to 543.6 mgd.
- Construct approximately 32 miles of 108-inch diameter pipeline from Iron Bridge Pump Station to the East Side Treatment Plant.
- Construct a 200 to 400 mg capacity Balancing Reservoir adjacent to the existing facilities in the vicinity of Terrell, Texas.
- Construct a 96-inch pipeline to convey raw water from the 108-inch line south to the proposed Balancing Reservoir near Seagoville.

Graham's study also included provisions for a second parallel 84" pipeline from Lake Fork to Lake Tawakoni to carry a "peak day withdrawal" of 214 mgd.

Lake Palestine

Dannenbaum Engineering Corporation is currently under contract with Dallas Water Utilities to provide a conceptual design study titled, "Lake Palestine Utilization and Pipeline Alignment Study". To date, recommendations have been submitted to DWU to construct:

- A Raw Water Intake and Pump Station with an ultimate capacity of 120 mgd at Lake Palestine.
- Eighty-seven miles of 84-inch diameter pipeline to convey 120 mgd of raw water from Lake Palestine to the proposed Southeast Water Treatment Plant.
- An intermediate booster pump station with operator's residence.
- A 10 mg interim reservoir.
- A 475 mg terminal balancing reservoir.

These transmission facilities provide raw water from Lake Palestine to a recommended site for the proposed Southeast Water Treatment Plant.

COMPARATIVE COST ANALYSIS

This comparison re-analyzed the previously proposed facilities needed to transport supplies from each reservoir to the proposed Southeast WTP location recommended in Dannenbaum's report. No modifications to Dannenbaum's preliminary design were made. However, Graham's design of a 108" pipeline from Lake Tawakoni has been replaced with an 84" pipeline to reflect a pipeline sized to convey 120 mgd. This 84" pipeline conveys flow from Tawakoni through a proposed 100 MG balancing reservoir, located at an existing balancing reservoir site, to the location of the proposed Southeast Water Treatment Plant in Hutchins, Texas. This proposed alignment to the Southeast Plant is shown on Figure F-6.

To maintain a comparable basis for analyzing the two engineering studies, a unit price per foot was determined for the 84" transmission lines which are common to both alternatives. The engineering studies were used to determine the length of the recommended pipeline alignments. A permanent and temporary right-of-way width of 130 feet was used and costed for both routes with information for easement costs being provided by the City of Dallas' Property Management Department. The engineering studies were also utilized to compare capital costs for the pumping and interim facilities. The pumping facilities in the Lake Fork alternative were re-analyzed and costed for a 120 mgd capacity. Since Graham's initial estimates were made in 1983, the costs were updated using the Engineering News Record cost indexes. Cost for a proposed 100 mg balancing reservoir located at the site of the existing balancing reservoir near Terrell, Texas, was estimated by using price information provided by DWU. Dannenbaum's facility cost estimates were not altered. Table F-14 summarizes the estimated cost for the City of Dallas to construct either of the two pipelines to the proposed Southeast WTP. Detail computations follow this narrative discussion.

Based on the analysis, the cost per thousand gallons of water delivered to the proposed Southest WTP is esentially equal for the two reservoirs. Since a decision cannot be based on a cost differential, other factors should be considered.

First is the protection of long-term water rights to either of the two reservoirs. The City of Dallas has had contractual water rights to Lake Palestine since 1972 and to Lake Fork since 1981. Consideration of the difference in these dates quickly points to Lake Palestine as the next potential raw water supply source in order to protect the water rights. A delay in connecting Lake Fork could be easier to justify once Lake Palestine is connected and a plan for the connection of Lake Fork exists.

Another important consideration is the City of Dallas' existing contract with the Sabine River Authority (SRA). This contract must be renegotiated in the year 2014, for an additional 40 years, if future quantities of raw water are to be withdrawn. Based on the current cost of raw water, obtained from the SRA, and assuming a 5 percent inflation rate, renegotiation of this contract could cost the City of Dallas' approximately $14.5 million for the period 2014 through 2054.

LAKE FORK/LAKE PALESTINE COMPARISON COST ESTIMATES

Transmission Facilities

For this evaluation the pipeline costs were estimated on a direct comparable basis. Features of the transmission facilities were taken from the preliminary reports prepared by others. Costs from these reports for pump stations were updated up to 1989 prices.

Estimated Costs For Installed 84" Pipe (P.C.C.P.)

1) Graham's Study:

ES-1 - 22 miles @ $28,000,000. (1983 prices)
Cost per L.F. = $241/L.F.

- 5% inflation rate = $241 (1.3401) = $323/L.F.
- ENR Indexes: 1983-1988 = 166/156 = 1.0641
  = $241 (1.0641) = $256/L.F.

2) Dannenbaum's Study:

Table 5-6, page 5-18, Preliminary Report
Length of recommended alignment = 463,100 L.F.
Total pipeline cost (Table ES-1, page ES-4) = $109,661,000
Pipeline cost per linear foot = $239.80/L.F.
(Includes cost of $3.00/L.F. for R.O.W.)

Considering these costs, a unit price for 84" R.L.C.P. pipeline installed for study comparisons for Lake Fork/Lake Palestine is assumed to be:

R.O.W. Provided - $245/L.F.

Transmission Facilities

Estimated costs for R.O.W. acquisitions from City of Dallas Property Management Department.

- $6,000/acre (includes permanent and temporary)
- $220,000/year for labor costs
- $500/month for field office for Palestine alternative

Labor time for acquisitions:

- Lake Fork - 2 years
- Lake Palestine - 4 years

Unit Price For 84" Pipeline Requiring R.O.W. on Lake Fork Alternative

Assumed 130 ft. R.O.W. easement (Permanent and Temporary)
(130' x 1') ÷ 43560 sq. ft. = 0.00298 Ac./L.F.
0.00298 x $6,000 = $17.91/L.F.

Labor:
2 years x $220,000/year = $440,000
Length of pipeline from diversion structure to ESWTP
= 23.4 miles = 123,552 Ft.
$/L.F. = $440,000/123,552 Ft. = $ 3.56/L.F.
$17.91/L.F. + $3.56/L.F. = $21.47/L.F.

$245 + $21.47 = $266.47 say $266.50/L.F.

Unit Price For 84" Pipeline Requiring R.O.W. on Lake Palestine Alternative

Assumed 130 ft. R.O.W. easement
$17.91/L.F.

Labor:
4 years @ $220,000/year = $880,000

Field Office:
$500/month x 12 month/yr. x 4 years = $24,000

Transmission Facilities

Length of pipeline = 463,100/L.F.
$/L.F. = $904,000/463,100 L.F. = $1.95/L.F.
$17.91 + $1.95 = $19.86/L.F.

$245 + $19.86 = $264.86 say $265/L.F.

Pipeline Cost Summary

Lake Fork:

- w /R.O.W. = $245/L.F.
- w/o R.O.W. = $266.50/L.F.

Fork to Tawakoni: Length = 21.93 miles =	115,800 L.F.
(R.O.W. has already been acquired)	
$245/L.F. x 115,800 L.F. =	$28,371,000.
Tawakoni to Diversion Location:	
(R.O.W. has already been acquired)	
Length = 28.7 miles = 151,536 L.F.	
$245/L.F. x 151,536 L.F. =	$37,126,320
Diversion Location to SEWTP:	
(R.O.W. will need to be acquired)	
Length = 23.4 miles = 123,552 L.F.	
$266.50/L.F. x 123,552 L.F. =	$39,926.608
TOTAL:	$98,423,928

Lake Palestine:

- w/o R.O.W. = $265/L.F.

  Length = 87.71 miles = 463,100 L.F.
  $265/L.F. x 463,100 L.F. = $122,721,500.

Lake Fork Alternative:

Intake Pump Stations:

- Lake Fork Location: (Graham's Study - 1983 Table 1-1 and 1-2, page 1-7. Phase I Engineering Study)

  Graham's estimate for a 107 mgd pump station which includes:
  - Intake and Pump Station
  - Operator's Residence
  - Service Center
  - Electrical Substation
  - 21 Acres
  - 4 Pumping Units @ 700 HP each = 2800 HP Total

(Table 8-15, page 8-29)

$17,000,000

To provide an equal basis for comparison the pumping capacity was increased to 120 mgd.

Power required for a 120 mgd station would be approximately 3200 HP for 4 to 6 units.
Power and flow increase is 12.5%

Estimate separate costs for facilities and increase appropriate facilities by 12.5%.

	Facility	Cost	Increase	Cost Increase	New Cost
1)	Intake and Pump Station	$12,000,000	12.5%	1,500,000	13,500,000
2)	Residence	$ 180,000	--		180,000
3)	Service Center	$ 380,500	--		380,500
4)	Substation	$ 1,500,000	12.5%	187,500	1,687,500
5)	Acres and Improvements	$ 2,939,500	--		2,939,500
		$17,000,000			$18,687,500

Lake Fork Alternative:

Intake Pump Stations:
Lake Fork location continued:

Total estimated cost for 120 mgd pump station
(1983 price) = $18,687,500.

Using ENR cost indexes:
Pumping plants - 1983 to 1988

$$\text{factor} = \frac{168}{157} = 1.0980$$

$18,687,500. x 1.0980 = $20,518.875

say $20,500.000

Lake Tawakoni Location:
(Graham's Report - Table 1-2, page 1-7)

Estimated cost at $17,000,000 for a new 293.6 mgd Pumping Station. This capacity is incorrect and should be 107 mgd.

As requested, increase Iron Bridge expansion from 107 mgd to 120 mgd.

Assume same cost increases as at Lake Fork location:

Estimated cost of Lake Tawakoni (Iron Bridge) Intake and Pump Station

say $20,500,000

Booster Pump Station:

Provide cost estimate for a 120 mgd, 3500 HP booster pump station to be placed on 84" pipeline just west of the Trinity River, east of the proposed SEWTP. The pumps will pump 120 mgd at approximately 166 feet total head.

For comparison Dannenbaum's booster pump station is sized for 120 mgd and 3500 HP.

From Table 8-5 on page 8-5 of Dannenbaum's Report Volume I, the estimated cost is $5,000,000. This cost includes 18 acre site, booster pump station, electrical substation, operators residence, piping and valves.

The Lake Fork alternative would not cost as much for the following reasons:

1) Not as much land would be required because an interim balancing reservoir would not be needed. Estimate 8 acres would be needed for Lake Fork alternative. Estimate $7,500/AC for land and acquisition costs.
   Less Land Costs: 10 AC x $7,500/AC = $75,000

2) Operators residence would not be required because of close proximity to Dallas.
   Estimated cost of operators residence - $100,000

3) There should be a lesser construction cost for the facilities that would be built closer to the Dallas area in the Lake Fork alternative than the remote location costed in Dannenbaum's report.

   Estimate 2% less in construction costs
   $5,000,000 x .02 = $100,000

Estimated cost for Lake Fork alternatives booster pump station

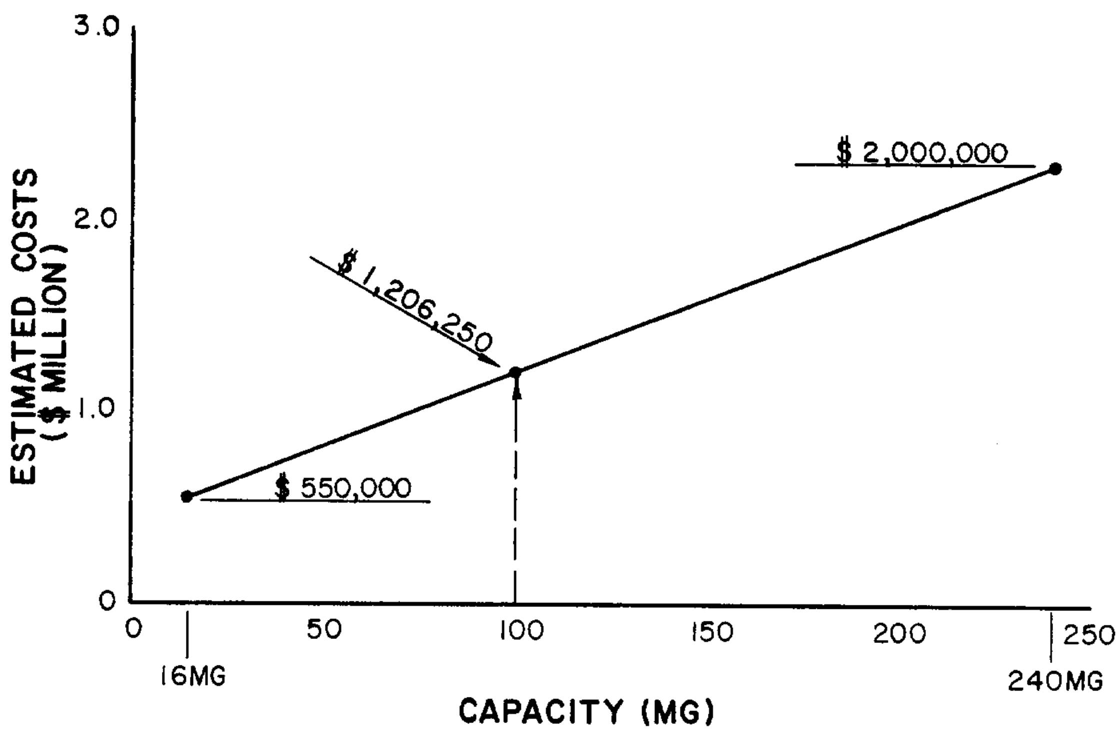
= $4,725,000

Interim Balancing Reservoir Capital Cost:

Cost out a 100 mg interim balancing reservoir with a 10' depth. Costs to include construction costs only. No land would have to be acquired at the current Lake Tawakoni to East Side WTP balancing reservoir site. Construction costs to include earthwork with impermeable clay liner and rip rap.

Utilized Dannenbaum's Preliminary Report Volume I, Table 2-7, page 2-23:

Plotting their estimated costs:



Estimated construction cost for a 100 mg interim balancing reservoir with 10' depth = $1,206,250.

Interim Balancing Reservoir Costs (Cont'd.)

- Additional cost estimate data provided by DWU:
  Construction cost of original 200 mg balancing reservoir at Terrell constructed in 1961 - $642,728.

- Using ENR cost indexes for 1961 to 1988
  Composite index shows an increase of 439%

- Estimated cost of 200 mg balancing reservoir in 1988 prices

  $642,728. x 4.39 = $2,821,576

  For this comparison, a 100 mg ballancing reservoir is assumed to cost $1.4 million.

- Compare to cost estimate using Dannenbaum's Report on page 7 of these calculations.

- Split difference for an estimated cost for a 100 mg interim balancing reservoir and an estimated cost of $1,308,500 is gained.

Outlet Control Structure No. 2:

(Graham's Report, page ES-1)

Raw Water Outlet Control Structure	-	$ 1,500,000

Using ENR cost indexes:

Composite indexes - 1983 to 1988

$$\text{factor} = \frac{168}{157} = 1.0980$$

$1,500,000 x 1.0980	=	$ 1,647,000

Total Facilities Cost for Lake Fork Alternative:

Intakes and Pump Stations: (Fork)	$20,500.000
(Tawakoni)	$20,500.000
Outlet Control Structure No. 2:	$ 1,647,000
Booster Pump Station:	$ 4,725,000
Balancing Reservoir:	$ 1,308,500
	$48,680,500

Lake Palestine Alternative: (Dannenbaum's Report)

Utilized conceptual cost estimates from Table ES-1, page ES-4, Volume 1

- Raw Water Intake and Pump Station: $ 21,289,000
- Booster Pump Station and Intermediate Reservoir: $ 5,600,000

Total: $ 26,889,000

Total Transmission Facility Costs:

Lake Fork Alternative:

$98,423,928 + $48,680,500 = $147,104,428

Lake Palestine Alternative:

$122,721,500 + $26,889,000 = $149,610,500

O&M: Transportation Facilities

Lake Fork:

Fork Intake Pump Station:	
2 operators @ $25,000 each	= $ 50,000
Equipment and Replacements	= $ 50,000
Tawakoni Intake Pump Station:	
2 operators @ $25,000 each	= $ 50,000
Equipment and Replacements	= $ 50,000
Booster Pump Station:	
Separate salaried operator would not be required. Location is close proximity to Dallas	
Equipment and Replacements (1/2 of intake pump station)	= $ 25,000
	$225,000

Lake Palestine:

Palestine Intake Pump Station:	
2 operators @ $25,000 each	= $ 50,000
Equipment and Replacements	= $ 50,000
Booster Pump Station:	
1 operator @ $25,000 each	= $ 25,000
Equipment and Replacements (1/2 of intake pump station)	= $ 25,000
TOTAL:	$150,000

Table F-1

Intake Fork to Tawakoni (107 mgd)

Net HP	Gross HP	Demand (kW)	Monthly Usage (kWh)	Annual Usage (kWh)
2610	3145	2345	1,711,786	20,541,430

	MP Rate	Limit	Monthly Cost	Annual Cost	HV Rate	Monthly Cost	Annual Cost
Meter	$10		$10	$120	$1,320	$1,320	$15,840
Demand	$1.260		$2,942	$35,304	$5.190	$12,170	$146,041
Energy	$0.032	2500	$79	$945	$0.005	$8,901	$106,815
	$0.025	400435	$10,011	$120,131			
	$0.014	Excess	$18,455	$221,458			
Fuel/Recovery	$0.024		$41,008	$492,090	$0.024	$41,008	$492,090
Total			$72,504	**$870,047**		$63,399	**$760,787**
Primary Service Credit			($469)	($5,634)			

BOOSTER 1

Net HP	Gross HP	mand (kW)	Monthly Usage (kWh)	Annual Usage (kWh)
0	0	0	0	0

	MP Rate	Limit	Monthly Cost	Annual Cost	HV Rate	Monthly Cost	Annual Cost
Meter	$10		$0	$0	$1,320	$0	$0
Demand	$1.260		$0	$0	$5.190	$0	$0
Energy	$0.032	2500	$0	$0	$0.005	$0	$0
	$0.025	1800	$0	$0			
	$0.014	Excess	$0	$0			
Fuel/Recovery	$0.024		$0	$0	$0.024	$0	$0
Total			$0	**$0**		$0	**$0**
Primary Service Credit			($1)	($6)			

BOOSTER 2

Net HP	Gross HP	mand (kW)	Monthly Usage (kWh)	Annual Usage (kWh)
0	0	0	0	0

	MP Rate	Limit	Monthly Cost	Annual Cost	HV Rate	Monthly Cost	Annual Cost
Meter	$10		$0	$0	$1,320	$0	$0
Demand	$1.260		$0	$0	$5.190	$0	$0
Energy	$0.032	2500	$0	$0	$0.005	$0	$0
	$0.025	1800	$0	$0			
	$0.014	Excess	$0	$0			
Fuel/Recovery	$0.024		$0	$0	$0.024	$0	$0
Total			$0	**$0**		$0	**$0**
Primary Service Credit			($1)	($6)			
Total for Pipeline			$72,504	**$870,047**		$63,399	**$760,787**
With Primary Service Credit			$72,033	$864,402			

Table F-2

Intake — Cooper to Ray Roberts (100 mgd)

Net HP	Gross HP	Demand (kW)	Monthly Usage (kWh)	Annual Usage (kWh)
5265	6343	4730	3,453,085	41,437,022

	MP Rate	Limit	Monthly Cost	Annual Cost	HV Rate	Monthly Cost	Annual Cost
Meter	$10		$10	$120	$1,320	$1,320	$15,840
Demand	$1.260		$5,948	$71,370	$5.190	$24,550	$294,600
Energy	$0.032	2500	$79	$945	$0.005	$17,956	$215,473
	$0.025	805943	$20,149	$241,783			
	$0.014	Excess	$37,289	$447,473			
Fuel/Recovery	$0.024		$82,722	$992,665	$0.024	$82,722	$992,665
Total			$146,196	**$1,754,357**		$126,548	**$1,518,578**
Primary Service Credit			($947)	($11,359)			

BOOSTER 1

Net HP	Gross HP	mand (kW)	Monthly Usage (kWh)	Annual Usage (kWh)
3200	3855	2875	2,098,741	25,184,894

	MP Rate	Limit	Monthly Cost	Annual Cost	HV Rate	Monthly Cost	Annual Cost
Meter	$10		$10	$120	$1,320	$120	$1,440
Demand	$1.260		$3,610	$43,319	$5.190	$14,921	$179,054
Energy	$0.032	2500	$79	$945	$0.005	$10,913	$130,961
	$0.025	490548	$12,264	$147,164			
	$0.014	Excess	$22,640	$271,683			
Fuel/Recovery	$0.024		$50,277	$603,329	$0.024	$50,277	$603,329
Total			$88,880	**$1,066,561**		$76,232	**$914,785**
Primary Service Credit			($575)	($6,906)			

BOOSTER 2

Net HP	Gross HP	mand (kW)	Monthly Usage (kWh)	Annual Usage (kWh)
3200	3855	2875	2,098,741	25,184,894

	MP Rate	Limit	Monthly Cost	Annual Cost	HV Rate	Monthly Cost	Annual Cost
Meter	$10		$10	$120	$1,320	$120	$1,440
Demand	$1.260		$3,610	$43,319	$5.190	$14,921	$179,054
Energy	$0.032	2500	$79	$945	$0.005	$10,913	$130,961
	$0.025	490548	$12,264	$147,164			
	$0.014	Excess	$22,640	$271,683			
Fuel/Recovery	$0.024		$50,277	$603,329	$0.024	$50,277	$603,329
Total			$88,880	**$1,066,561**		$76,232	**$914,785**
Primary Service Credit			($575)	($6,906)			
Total for Pipeline			$323,957	**$3,887,478**		$279,012	**$3,348,148**
With Primary Service Credit			$321,859	$3,862,308			

Table F-3

Intake — Hubbard to Southeast (90 mgd)

Net HP	Gross HP	Demand (kW)	Monthly Usage (kWh)	Annual Usage (kWh)
1150	1386	1033	754,235	9,050,821

	MP Rate	Limit	Monthly Cost	Annual Cost	HV Rate	Monthly Cost	Annual Cost
Meter	$10		$10	$120	$1,320	$1,320	$15,840
Demand	$1.260		$1,289	$15,471	$5.190	$5,362	$64,348
Energy	$0.032	2500	$79	$945	$0.005	$3,922	$47,064
	$0.025	177444	$4,436	$53,233			
	$0.014	Excess	$8,098	$97,170			
Fuel/Recovery	$0.024		$18,068	$216,821	$0.024	$18,068	$216,821
Total			$31,980	**$383,760**		$28,673	**$344,073**
Primary Service Credit			($207)	($2,486)			

BOOSTER 1

Net HP	Gross HP	mand (kW)	Monthly Usage (kWh)	Annual Usage (kWh)
2850	3434	2561	1,869,191	22,430,297

	MP Rate	Limit	Monthly Cost	Annual Cost	HV Rate	Monthly Cost	Annual Cost
Meter	$10		$10	$120	$1,320	$120	$1,440
Demand	$1.260		$3,214	$38,564	$5.190	$13,289	$159,470
Energy	$0.032	2500	$79	$945	$0.005	$9,720	$116,638
	$0.025	437091	$10,927	$131,127			
	$0.014	Excess	$20,157	$241,888			
Fuel/Recovery	$0.024		$44,778	$537,340	$0.024	$44,778	$537,340
Total			$79,165	**$949,985**		$67,907	**$814,888**
Primary Service Credit			($513)	($6,151)			

BOOSTER 2

Net HP	Gross HP	mand (kW)	Monthly Usage (kWh)	Annual Usage (kWh)
0	0	0	0	0

	MP Rate	Limit	Monthly Cost	Annual Cost	HV Rate	Monthly Cost	Annual Cost
Meter	$10		$0	$0	$1,320	$0	$0
Demand	$1.260		$0	$0	$5.190	$0	$0
Energy	$0.032	2500	$0	$0	$0.005	$0	$0
	$0.025	1800	$0	$0			
	$0.014	Excess	$0	$0			
Fuel/Recovery	$0.024		$0	$0	$0.024	$0	$0
Total			$0	**$0**		$0	**$0**
Primary Service Credit			($1)	($6)			
Total for Pipeline			$111,145	**$1,333,745**		$96,580	**$1,158,961**
With Primary Service Credit			$110,425	$1,325,103			

Table F-4
Trial Pipeline Designs for All Alternatives

Pipeline Route	Q (MGD)	Length (Miles)	Pipe Size (Inches)	Pump Station Size: Intake Net HP	Intake TDH	Booster Net HP	Booster TDH	Booster Net HP	Booster TDH	Capital Costs ($1,000,000): Intake	Booster1	Booster2	Pipeline	Constr. Interest	Engr & Contingencies	Total	Annual Expenses ($1,000,000): Debt Service	Energy Cost	O&M Cost	Cost ($) per 1000 gal
Central to Hubbard	100	34.0	78	4900	279					11.7			42.2	5.76	13.47	73.12	4.81	2.53	0.10	0.2038
Central to Hubbard	100	34.0	84	4100	234					11.1			47.6	6.27	14.67	79.61	5.23	2.12	0.10	0.2042
Central to Hubbard	100	34.0	90	3600	205					10.5			54.4	6.93	16.22	88.05	5.79	1.86	0.10	0.2124
Central to Hubbard	115	34.0	84	5350	265					13.3			47.6	6.50	15.22	82.59	5.43	2.76	0.10	0.1975
Central to Hubbard	115	34.0	90	4550	225					12.5			54.4	7.15	16.72	90.76	5.97	2.35	0.10	0.2005
Central to Hubbard	115	34.0	96	4000	198					11.9			60.5	7.73	18.10	98.23	6.46	2.07	0.10	0.2055
Central to Hubbard	115	34.0	102	3650	181					11.2			67.1	8.37	19.59	106.29	6.99	1.89	0.10	0.2139
Central to Hubbard	120	34.0	84	5800	275					13.9			47.6	6.57	15.37	83.41	5.48	2.99	0.10	0.1958
Central to Hubbard	120	34.0	90	4900	233					13.2			54.4	7.22	16.90	91.71	6.03	2.53	0.10	0.1977
Central to Hubbard	120	34.0	96	4300	204					12.5			60.5	7.80	18.25	99.05	6.51	2.22	0.10	0.2017
Central to Hubbard	120	34.0	102	3900	185					11.8			67.1	8.43	19.74	107.11	7.04	2.02	0.10	0.2091
Central to Hubbard	180	34.0	96	9450	299					21.4			60.5	8.75	20.47	111.12	7.30	4.87	0.10	0.1868
Central to Hubbard	180	34.0	102	7900	260					20.3			67.1	9.34	21.86	118.64	7.80	4.07	0.10	0.1822
Central to Hubbard	180	34.0	108	7000	222					19.3			74.0	9.96	23.32	126.54	8.32	3.61	0.10	0.1831
Cooper to Ray Roberts	60	80.6	60	3150	299	2600	247	2600	247	7.1	3.5	3.5	72.3	9.23	21.61	117.29	7.71	4.33	0.25	0.5614
Cooper to Ray Roberts	60	80.6	66	2800	266	1900	180	1900	180	7.1	3.4	3.4	80.0	10.03	23.48	127.41	8.38	3.44	0.25	0.5507
Cooper to Ray Roberts	60	80.6	72	2500	237	1600	152	1600	152	6.9	3.3	3.3	88.5	10.90	25.50	138.42	9.10	2.97	0.25	0.5627
Diversion Structure to Eastside	115	4.0	84		0					0.0			5.6	0.60	1.40	7.59	0.50	0.00	0.00	0.0119
Diversion Structure to Eastside	115	4.0	90		0					0.0			6.4	0.68	1.60	8.68	0.57	0.00	0.00	0.0136
Diversion Structure to SE WTP	80	23.4	66	0	0	2400	171			3.7			23.2	2.88	6.73	36.54	2.40	1.26	0.08	0.1281
Diversion Structure to SE WTP	80	23.4	72	0	0	1800	128			3.5			26.7	3.12	7.30	39.62	2.60	0.96	0.08	0.1245
Diversion Structure to SE WTP	80	23.4	78	0	0	1450	103			3.3			29.0	3.45	8.08	43.87	2.88	0.78	0.08	0.1279
Diversion Structure to SE WTP	80	23.4	84	0	0	1250	89			3.2			32.7	3.84	8.99	48.77	3.21	0.67	0.08	0.1354
Diversion Structure to SE WTP	180	23.4	90	0	0	5300	168			0.0	5.2		37.4	4.55	10.66	57.85	3.80	2.75	0.08	0.1009
Diversion Structure to SE WTP	180	23.4	96	0	0	4500	142			0.0	4.8		41.6	4.96	11.61	63.01	4.14	2.34	0.18	0.1013
Diversion Structure to SE WTP	180	23.4	102	0	0	3900	123			0.0	4.6		46.2	5.43	12.70	68.94	4.53	2.03	0.18	0.1026
Fork to Ray Roberts	120	106.9	90	6050	287	5400	256	5400	256	14.1	4.6	4.6	171.0	20.76	48.58	263.66	17.33	8.70	0.25	0.6000
Fork to Ray Roberts	120	106.9	96	5750	273	4700	223	4700	223	13.9	4.5	4.5	190.2	22.76	53.28	289.16	19.01	7.82	0.25	0.6183
Fork to Ray Roberts	120	106.9	102	5450	259	4250	202	4250	202	13.8	4.4	4.4	211.1	24.96	58.42	317.08	20.84	7.21	0.25	0.6462
Fork to Tawakoni	120	28.0	72	5800	275					13.9			30.8	4.77	11.17	60.64	3.99	2.99	0.10	0.1616
Fork to Tawakoni	120	28.0	78	4400	209					12.6			34.7	5.06	11.84	64.23	4.22	2.27	0.10	0.1506
Fork to Tawakoni	120	28.0	84	3400	161					10.9			39.2	5.35	12.52	67.95	4.47	1.76	0.10	0.1445
Fork to Tawakoni	120	28.0	90	2900	138					9.8			44.8	5.83	13.65	74.08	4.87	1.50	0.10	0.1478
Fork to Tawakoni	190	28.0	84	10000	300					22.6			39.2	6.60	15.44	83.82	5.51	5.15	0.10	0.1551
Fork to Tawakoni	190	28.0	90	7700	231					20.6			44.8	6.99	16.35	88.73	5.83	3.97	0.10	0.1428
Fork to Tawakoni	190	28.0	96	6200	186					18.4			49.8	7.29	17.06	92.56	6.09	3.20	0.10	0.1353
Fork to Tawakoni	190	28.0	102	5100	153					16.3			55.3	7.66	17.90	97.14	6.39	2.63	0.10	0.1315
Hubbard to Div. Str.	100	2.2	60	1000	57					5.5			2.0	0.80	1.87	10.14	0.67	0.53	0.10	0.0355
Hubbard to Div. Str.	100	2.2	66	900	51					5.3			2.2	0.80	1.87	10.15	0.67	0.48	0.10	0.0341
Hubbard to Div. Str.	100	2.2	72	800	46					6.3			2.4	0.82	1.93	10.47	0.69	0.43	0.10	0.0333
Hubbard to Div. Str.	215	2.2	90	2000	53					9.1			3.5	1.35	3.15	17.12	1.13	1.04	0.10	0.0289
Hubbard to Div. Str.	215	2.2	96	1800	48					9.1			3.9	1.39	3.25	17.66	1.16	0.94	0.10	0.0280
Hubbard to Div. Str.	215	2.2	102	1700	45					9.0			4.3	1.43	3.34	18.11	1.19	0.89	0.10	0.0278
Hubbard to ES WTP	115	3.2	72	2300	114					8.0			3.5	1.23	2.88	15.62	1.03	1.20	0.10	0.0554
Hubbard to ES WTP	115	3.2	78	2100	104					7.4			4.0	1.21	2.84	15.43	1.01	1.09	0.10	0.0526
Hubbard to ES WTP	115	3.2	84	2000	99					7.2			4.5	1.25	2.92	15.84	1.04	1.04	0.10	0.0520

Table F-4
Trial Pipeline Designs for All Alternatives

Pipeline Route	Q (MGD)	Length (Miles)	Pipe Size (Inches)	Pump Station Size: Intake Net HP	Intake TDH	Booster Net HP	Booster TDH	Booster Net HP	Booster TDH	Capital Costs ($1,000,000): Intake	Booster1	Booster2	Pipeline	Constr. Interest	Engr & Contingencies	Total	Annual Expenses ($1,000,000): Debt Service	Energy Cost	O&M Cost	Cost ($) per 1000 gal	
Hubbard to SE WTP	100	25.5	78	5150	293					11.8			31.6	4.64	10.86	58.94	3.67	2.66	0.10	0.1817	*
Hubbard to SE WTP	100	25.5	84	4500	256					11.5			35.7	5.04	11.79	64.01	4.21	2.33	0.10	0.1817	*
Hubbard to SE WTP	100	25.5	90	4100	234					11.1			40.8	5.54	12.97	70.41	4.63	2.12	0.10	0.1876	
Hubbard to SE WTP	100	25.5	96	3800	217					10.7			45.4	5.99	14.02	76.08	5.00	1.97	0.10	0.1936	
Hubbard to SE WTP	180	25.5	102	8500	269					20.7			50.4	7.59	17.76	96.41	6.34	4.38	0.10	0.1646	*
Hubbard to SE WTP	180	25.5	108	7750	245					20.1			55.5	8.07	18.89	102.54	6.74	3.99	0.10	0.1649	
Hubbard to SE WTP	180	25.5	114	7200	228					19.5			60.6	8.55	20.02	108.66	7.14	3.71	0.10	0.1667	
Little Cyresss to Fork	60	63.2	66	2575	245	2550	242			7.0	3.5		62.7	7.82	18.31	99.37	6.53	2.66	0.18	0.4278	*
Little Cyresss to Fork	60	63.2	72	2250	214	2225	211			6.6	3.5		69.4	8.49	19.88	107.88	7.09	2.33	0.18	0.4381	
Palestine to Southeast WTP	120	86.8	84	8213	390	5050	240			15.7	4.6		121.5	15.14	35.44	192.33	12.64	6.84	0.18	0.4486	*
Parkhouse to Cooper	60	0.1	60	1200	114					4.4			0.1	0.48	1.12	6.09	0.40	0.63	0.10	0.0517	
Parkhouse to Cooper	60	0.1	66	1200	114					4.4			0.1	0.48	1.12	6.10	0.40	0.63	0.10	0.0517	*
Parkhouse to Cooper	60	0.1	72	1200	114					4.4			0.1	0.48	1.13	6.11	0.40	0.63	0.10	0.0518	
Southside to Hubbard	80	32.8	72	3900	278					9.4			36.0	4.85	11.36	61.63	4.05	2.02	0.10	0.2113	*
Southside to Hubbard	80	32.8	78	3250	231					8.9			40.7	5.30	12.40	67.30	4.42	1.68	0.10	0.2126	
Southside to Hubbard	100	32.8	78	5000	285					11.8			40.7	5.61	13.12	71.23	4.68	2.58	0.10	0.2018	
Southside to Hubbard	100	32.8	84	2850	162					9.2			45.9	5.88	13.77	74.75	4.91	1.48	0.10	0.1779	*
Southside to Hubbard	100	32.8	84	4200	239					11.2			45.9	6.10	14.27	77.47	5.09	2.17	0.10	0.2018	
Southside to Hubbard	100	32.8	90	3650	208					10.6			52.5	6.74	15.77	85.58	5.63	1.89	0.10	0.2086	
Southside to Hubbard	115	32.8	84	5400	268					13.3			45.9	6.32	14.80	80.32	5.28	2.79	0.10	0.1946	*
Southside to Hubbard	115	32.8	90	4700	233					12.7			52.5	6.96	16.29	88.43	5.81	2.43	0.10	0.1987	
Southside to Hubbard	115	32.8	96	4150	206					12.0			58.4	7.52	17.59	95.47	6.28	2.15	0.10	0.2030	
Tawakoni to Div. Str.	200	32.6	96	10500	299					23.8			58.0	8.74	20.45	111.00	7.30	5.41	0.10	0.1754	
Tawakoni to Div. Str.	200	32.6	102	9200	262					22.8			64.4	9.31	21.79	118.28	7.78	4.74	0.10	0.1728	*
Tawakoni to Div. Str.	200	32.6	108	8500	242					22.2			70.9	9.95	23.28	126.34	8.31	4.38	0.10	0.1751	
Tawakoni to Div. Str.	295	32.6	114	14500	280					34.2			77.5	11.93	27.91	151.50	9.96	7.46	0.10	0.1627	
Tawakoni to Div. Str.	295	32.6	120	13000	251					33.0			83.1	12.41	29.03	157.58	10.36	6.69	0.10	0.1593	*
Tawakoni to SE WTP	200	52.0	96	10530	300	5700	162			23.8	5.5		92.5	13.01	30.46	165.30	10.87	8.36	0.18	0.2658	
Tawakoni to SE WTP	200	52.0	102	9300	265	4500	128			22.9	4.8		102.7	13.93	32.60	176.91	11.63	7.11	0.18	0.2592	
Tawakoni to SE WTP	200	52.0	108	8600	245	3300	94			22.3	4.1		113.1	14.90	34.86	189.30	12.44	6.14	0.18	0.2570	*
Tawakoni to SE WTP	200	52.0	114	8000	228	2600	74			21.5	3.7		123.6	15.89	37.19	201.83	13.27	5.47	0.18	0.2591	
Texoma to Ray Roberts Tributary	60	16.7	66	3150	299					7.2			16.6	2.54	5.94	32.26	2.12	1.63	0.10	0.1760	*
Texoma to Ray Roberts Tributary	60	16.7	72	3025	287					7.1			18.3	2.72	6.36	34.52	2.27	1.57	0.10	0.1798	
Water's Bluff to Fork (AA)	60	33.3	60	3150	299	1100	104			7.1	3.1		29.9	4.28	10.02	54.39	3.58	2.21	0.18	0.2723	
Water's Bluff to Fork (AA)	60	33.3	66	2800	266	850	81			7.0	3.0		33.1	4.60	10.76	58.42	3.84	1.91	0.18	0.2703	*
Water's Bluff to Fork (AA)	60	33.3	72	2700	256	600	57			7.0	2.9		36.6	4.96	11.62	63.05	4.14	1.73	0.18	0.2760	

Table F–5
Net Present Value of Alternative 1

Interest Rate= *7.0%*

CAPITAL COSTS

Improvement	Capacity (mgd)	Year On-Line	Capital Cost	Years Until Expense Incurred	Factor	1989 Value
Pipeline - Palestine to SE WTP	120	2001	192,330,000	11	0.4751	91,374,598
WTP - Southeast Stage I	100	2001	103,540,800	11	0.4751	49,191,488
Pipeline - Fork to Tawakoni	120	2008	67,950,000	18	0.2959	20,103,953
Pipeline - Tawakoni to Diversion Structure	200	2008	119,916,640	18	0.2959	35,479,007
Pipeline - Diversion Structure to Eastside	115	2008	7,590,000	18	0.2959	2,245,607
WTP - Eastside Expansion	100	2008	101,760,000	18	0.2959	30,107,112
WTP - Eastside Expansion	50	2018	50,880,000	28	0.1504	7,652,465
Pipeline - Diversion Structure to Southeast	180	2023	57,850,000	33	0.1072	6,203,527
WTP - Southeast Stage II	100	2023	101,760,000	33	0.1072	10,912,203
Pipeline - Southside WWTP to Hubbard	100	2035	74,750,000	45	0.0476	3,559,108
Pipeline - Hubbard to Diversion Structure	100	2035	10,470,000	45	0.0476	498,513
WTP - Southeast Stage III	100	2035	101,760,000	45	0.0476	4,845,149
			990,557,440			$262,170,000

OPERATION AND MAINTENANCE COSTS TO THE YEAR 2050
(O&M expenses continue through 2050 for all facilities)

Improvement	Pipe Size	Capacity (mgd)	Year On-Line	Annual Cost	No. Years of O&M Expenses	Factor	Years Until Expense Incurred	Factor	1989 Value
Pipeline - Palestine to SE WTP	84	120	2001	7,020,000	49	13.7668	12	0.4751	45,914,358
WTP - Southeast Stage I	--	100	2001	2,364,000	49	13.7668	12	0.4751	15,461,758
Pipeline - Fork to Tawakoni	84	120	2008	1,860,000	42	13.4524	19	0.2959	7,402,975
Pipeline - Tawakoni to Diversion Structure	102	200	2008	4,840,000	42	13.4524	19	0.2959	19,263,656
Pipeline - Diversion Structure to Eastside	84	115	2008	20,000	42	13.4524	19	0.2959	79,602
WTP - Eastside Expansion	--	100	2008	2,364,000	42	13.4524	19	0.2959	9,408,943
WTP - Eastside Expansion	--	50	2018	1,182,000	32	12.6466	29	0.1504	2,248,247
Pipeline - Diversion Structure to Southeast	90	180	2023	2,830,000	27	11.9867	34	0.1072	3,637,657
WTP - Southeast Stage II	--	100	2023	2,364,000	27	11.9867	34	0.1072	3,038,665
Pipeline - Southside WWTP to Hubbard	84	100	2035	1,580,000	15	9.1079	46	0.0476	685,182
Pipeline - Hubbard to Diversion Structure	72	100	2035	530,000	15	9.1079	46	0.0476	229,840
WTP - Southeast Stage III	--	100	2035	2,364,000	15	9.1079	46	0.0476	1,025,171
				29,318,000					$108,400,000

TOTAL 1989 VALUE OF ALTERNATIVE 1 **$370,570,000**

Table F-6
Net Present Value of Alternative 2

Interest Rate= *7.0%*

CAPITAL COSTS

Improvement	Capacity (mgd)	Year On-Line	Capital Cost	Years Until Expense Incurred	Factor	1989 Value
Pipeline - Palestine to Southeast	120	2001	192,330,000	11	0.4751	91,374,598
WTP - Southeast Stage I	100	2001	103,540,800	11	0.4751	49,191,488
Pipeline - Hubbard to Eastside WTP	115	2008	15,840,000	18	0.2959	4,686,484
Pipeline - Southside WWTP to Hubbard	80	2008	61,630,000	18	0.2959	18,234,093
WTP - Eastside Expansion	100	2008	101,760,000	18	0.2959	30,107,112
WTP - Eastside Expansion	50	2018	50,880,000	28	0.1504	7,652,465
Pipeline - Central WWTP to Hubbard	120	2023	83,410,000	33	0.1072	8,944,446
Pipeline - Hubbard to SE WTP	180	2023	96,410,000	33	0.1072	10,338,497
WTP - Southeast Stage II	100	2023	101,760,000	33	0.1072	10,912,203
WTP - Southeast Stage III	100	2035	101,760,000	45	0.0476	4,845,149
			909,320,800			$236,290,000

OPERATION AND MAINTENANCE COSTS TO THE YEAR 2050
(O&M expenses continue through 2050 for all facilities)

Improvement	Pipe Size	Capacity (mgd)	Year On-Line	Annual Cost	No. Years of O&M Expenses	Factor	Years Until Expense Incurred	Factor	1989 Value
Pipeline - Palestine to Southeast	84	120	2001	7,020,000	49	13.7668	12	0.4751	45,914,358
WTP - Southeast Stage I	--	100	2001	2,364,000	49	13.7668	12	0.4751	15,461,758
Pipeline - Southside WWTP to Hubbard	72	80	2008	2,120,000	42	13.4524	19	0.2959	8,437,800
Pipeline - Hubbard to Eastside WTP	84	115	2008	1,140,000	42	13.4524	19	0.2959	4,537,307
WTP - Eastside Expansion	--	100	2008	2,364,000	42	13.4524	19	0.2959	9,408,943
WTP - Eastside Expansion	--	50	2018	1,182,000	32	12.6466	29	0.1504	2,248,247
Pipeline - Central WWTP to Hubbard	84	120	2023	3,090,000	27	11.9867	34	0.1072	3,971,859
Pipeline - Hubbard to SE WTP	102	180	2023	4,480,000	27	11.9867	34	0.1072	5,758,552
WTP - Southeast Stage II	--	100	2023	2,364,000	27	11.9867	34	0.1072	3,038,665
WTP - Southeast Stage III	--	100	2035	2,364,000	15	9.1079	46	0.0476	1,025,171
				28,488,000					$99,800,000

TOTAL 1989 VALUE OF ALTERNATIVE 2 **$336,090,000**

Table F-7
Net Present Value of Alternative 3

Interest Rate= *7.0%*

CAPITAL COSTS

Improvement	Capacity (mgd)	Year On-Line	Capital Cost	Years Until Expense Incurred	Factor	1989 Value
Pipeline - Fork to Tawakoni	120	2001	67,950,000	11	0.4751	32,282,556
Pipeline - Tawakoni to Southeast WTP	200	2001	190,936,000	11	0.4751	90,712,318
WTP - Southeast Stage I	100	2001	103,540,800	11	0.4751	49,191,488
Pipeline - Southside WWTP to Hubbard	115	2008	80,320,000	18	0.2959	23,763,790
Pipeline - Hubbard to Eastside WTP	115	2008	15,840,000	18	0.2959	4,686,484
WTP - Eastside Expansion	100	2008	101,760,000	18	0.2959	30,107,112
WTP - Eastside Expansion	50	2018	50,880,000	28	0.1504	7,652,465
Pipeline - Central WWTP to Hubbard	100	2023	73,120,000	33	0.1072	7,841,001
Pipeline - Hubbard to Southeast WTP	100	2023	58,940,000	33	0.1072	6,320,413
WTP - Southeast Stage II	100	2023	101,760,000	33	0.1072	10,912,203
WTP - Southeast Stage III	100	2035	101,760,000	45	0.0476	4,845,149
			946,806,800			$268,310,000

OPERATION AND MAINTENANCE COSTS TO THE YEAR 2050
(O&M expenses continue through 2050 for all facilities)

Improvement	Pipe Size	Capacity (mgd)	Year On-Line	Annual Cost	No. Years of O&M Expenses	Factor	Years Until Expense Incurred	Factor	1989 Value
Pipeline - Fork to Tawakoni	84	120	2001	1,860,000	49	13.7668	12	0.4751	12,165,343
Pipeline - Tawakoni to Southeast WTP	108	200	2001	6,320,000	49	13.7668	12	0.4751	41,336,003
WTP - Southeast Stage I	--	100	2001	2,364,000	49	13.7668	12	0.4751	15,461,758
Pipeline - Southside WWTP to Hubbard	84	115	2008	2,890,000	42	13.4524	19	0.2959	11,502,472
Pipeline - Hubbard to Eastside WTP	84	115	2008	1,140,000	42	13.4524	19	0.2959	4,537,307
WTP - Eastside Expansion	--	100	2008	2,364,000	42	13.4524	19	0.2959	9,408,943
WTP - Eastside Expansion	--	50	2018	1,182,000	32	12.6466	29	0.1504	2,248,247
Pipeline - Central WWTP to Hubbard	78	100	2023	2,630,000	27	11.9867	34	0.1072	3,380,579
Pipeline - Hubbard to Southeast WTP	78	100	2023	2,760,000	27	11.9867	34	0.1072	3,547,680
WTP - Southeast Stage II	--	100	2023	2,364,000	27	11.9867	34	0.1072	3,038,665
WTP - Southeast Stage III	--	100	2035	2,364,000	15	9.1079	46	0.0476	1,025,171
				28,238,000					$107,650,000

TOTAL 1989 VALUE OF ALTERNATIVE 3 $375,960,000

Table F-8
Net Present Value of Alternative 4

Interest Rate= *7.0%*

CAPITAL COSTS

Improvement	Capacity (mgd)	Year On-Line	Capital Cost	Years Until Expense Incurred	Factor	1989 Value
Pipeline - Palestine to Southeast WTP	120	2001	192,330,000	11	0.4751	91,374,598
WTP - Southeast Stage I	100	2001	103,540,800	11	0.4751	49,191,488
Pipeline - Fork to Ray Roberts	120	2008	263,660,000	18	0.2959	78,007,480
WTP - Elm Fork II	100	2008	104,744,000	18	0.2959	30,989,970
WTP - Elm Fork II Expansion	100	2018	101,760,000	28	0.1504	15,304,929
Pipeline - Southside WWTP to Hubbard	115	2029	80,320,000	39	0.0715	5,739,266
Pipeline - Hubbard to Eastside WTP	115	2029	15,840,000	39	0.0715	1,131,847
WTP - Eastside Expansion	50	2029	50,880,000	39	0.0715	3,635,631
WTP - Eastside Expansion	100	2035	101,760,000	45	0.0476	4,845,149
			1,014,834,800			$280,220,000

OPERATION AND MAINTENANCE COSTS TO THE YEAR 2050
(O&M expenses continue through 2050 for all facilities)

Improvement	Pipe Size	Capacity (mgd)	Year On-Line	Annual Cost	No. Years of O&M Expenses	Factor	Years Until Expense Incurred	Factor	1989 Value
Pipeline - Palestine to Southeast WTP	84	120	2001	7,020,000	49	13.7668	12	0.4751	45,914,358
WTP - Southeast Stage I	--	100	2001	2,364,000	49	13.7668	12	0.4751	15,461,758
Pipeline - Fork to Ray Roberts	90	120	2008	8,950,000	42	13.4524	19	0.2959	35,621,843
WTP - Elm Fork II	--	100	2008	2,364,000	42	13.4524	19	0.2959	9,408,943
WTP - Elm Fork II Expansion	--	100	2018	2,364,000	32	12.6466	29	0.1504	4,496,493
Pipeline - Southside WWTP to Hubbard	84	115	2029	1,140,000	21	10.8355	40	0.0715	882,648
Pipeline - Hubbard to Eastside WTP	84	115	2029	2,890,000	21	10.8355	40	0.0715	2,237,590
WTP - Eastside Expansion	--	50	2029	1,182,000	21	10.8355	40	0.0715	915,167
WTP - Eastside Expansion	--	100	2035	2,364,000	15	9.1079	46	0.0476	1,025,171
				30,638,000					$115,960,000

TOTAL 1989 VALUE OF ALTERNATIVE 4 **$396,180,000**

Table F-9
Net Present Value of Alternative 5

Interest Rate= ***7.0%***

CAPITAL COSTS

Improvement	Capacity (MGD)	Year On-Line	Capital Cost	Years Until Expense Incurred	Factor	1989 Value
Pipeline - Palestine to Southeast WTP	120	2001	192,330,000	11	0.4751	91,374,598
WTP - Southeast Stage I	100	2001	103,540,800	11	0.4751	49,191,488
Pipeline - Fork to Tawakoni	120	2008	67,950,000	18	0.2959	20,103,953
Pipeline - Tawakoni to Diversion Structure	200	2008	119,916,640	18	0.2959	35,479,007
Pipeline - Diversion Structure to Eastside WTP	115	2008	7,590,000	18	0.2959	2,245,607
WTP - Eastside Expansion	100	2008	101,760,000	18	0.2959	30,107,112
WTP - Eastside Expansion	50	2018	50,880,000	28	0.1504	7,652,465
Pipeline - Diversion Structure to Southeast WTP	80	2023	39,620,000	33	0.1072	4,248,639
WTP - Southeast Stage II	100	2023	101,760,000	33	0.1072	10,912,203
Pump Station - Parkhouse to Cooper	60	2035	6,100,000	45	0.0476	290,442
Pipeline - Cooper to Ray Roberts	60	2035	127,410,000	45	0.0476	6,066,435
Reservoir - Parkhouse	60	2035	71,434,000	41	0.0624	4,458,308
WTP - Elm Fork II	100	2035	104,744,000	45	0.0476	4,987,227
			1,095,035,440			$267,120,000

OPERATION AND MAINTENANCE COSTS TO THE YEAR 2050
(O&M expenses continue through 2050 for all facilities)

Improvement	Pipe Size	Capacity (MGD)	Year On-Line	Annual Cost	No. Years of O&M Expenses	Factor	Years Until Expense Incurred	Factor	1989 Value
Pipeline - Palestine to Southeast WTP	84	120	2001	7,020,000	49	13.7668	12	0.4751	45,914,358
WTP - Southeast Stage I	--	100	2001	2,364,000	49	13.7668	12	0.4751	15,461,758
Pipeline - Fork to Tawakoni	84	120	2008	1,860,000	42	13.4524	19	0.2959	7,402,975
Pipeline - Tawakoni to Diversion Structure	102	200	2008	4,840,000	42	13.4524	19	0.2959	19,263,656
Pipeline - Diversion Structure to Eastside WTP	84	115	2008	20,000	42	13.4524	19	0.2959	79,602
WTP - Eastside Expansion	--	100	2008	2,364,000	42	13.4524	19	0.2959	9,408,943
WTP - Eastside Expansion	--	50	2018	1,182,000	32	12.6466	29	0.1504	2,248,247
Pipeline - Diversion Structure to Southeast WTP	72	80	2023	1,040,000	27	11.9867	34	0.1072	1,336,807
WTP - Southeast Stage II	--	100	2023	2,364,000	27	11.9867	34	0.1072	3,038,665
Pump Station - Parkhouse to Cooper	66	60	2035	730,000	15	9.1079	46	0.0476	316,571
Pipeline - Cooper to Ray Roberts	66	60	2035	3,690,000	15	9.1079	46	0.0476	1,600,204
Reservoir - Parkhouse	--	60	2035	158,000	12	7.9427	46	0.0476	59,752
WTP - Elm Fork II	--	100	2035	2,364,000	15	9.1079	46	0.0476	1,025,171
				29,996,000					$107,160,000

TOTAL 1989 VALUE OF ALTERNATIVE 5 **$374,280,000**

Table F-10
Net Present Value of Alternative 6

Interest Rate= *7.0%*

CAPITAL COSTS

Improvement	Capacity (mgd)	Year On-Line	Capital Cost	Years Until Expense Incurred	Factor	1989 Value
Pipeline - Palestine to Southeast WTP	120	2001	192,330,000	11	0.4751	91,374,598
WTP - Southeast Stage I	100	2001	103,540,800	11	0.4751	49,191,488
Pipeline - Fork to Tawakoni	190	2008	97,140,000	18	0.2959	28,740,221
Pipeline - Tawakoni to Diversion Structure	295	2008	159,216,000	18	0.2959	47,106,269
Pipeline - Diversion Structure to Eastside WTP	115	2008	8,680,000	18	0.2959	2,568,099
WTP - Eastside Expansion	100	2008	101,760,000	18	0.2959	30,107,112
WTP - Eastside Expansion	50	2018	50,880,000	28	0.1504	7,652,465
Pipeline - Diversion Structure to Southeast WTP	180	2023	57,850,000	33	0.1072	6,203,527
WTP - Southeast Stage II	100	2023	101,760,000	33	0.1072	10,912,203
Pipeline - Waters Bluff to Fork	60	2035	58,420,000	45	0.0476	2,781,580
Reservoir - Waters Bluff	60	2035	31,295,000	45	0.0476	1,490,064
WTP - Southeast Stage III	100	2035	101,760,000	45	0.0476	4,845,149
			1,064,631,800			$282,970,000

OPERATION AND MAINTENANCE COSTS TO THE YEAR 2050
(O&M expenses continue through 2050 for all facilities)

Improvement	Pipe Size	Capacity (mgd)	Year On-Line	Annual Cost	No. Years of O&M Expenses	Factor	Years Until Expense Incurred	Factor	1989 Value
Pipeline - Palestine to Southeast WTP	84	120	2001	7,020,000	49	13.7668	12	0.4751	45,914,358
WTP - Southeast Stage I	--	100	2001	2,364,000	49	13.7668	12	0.4751	15,461,758
Pipeline - Fork to Tawakoni	102	190	2008	2,730,000	42	13.4524	19	0.2959	10,865,657
Pipeline - Tawakoni to Diversion Structure	120	295	2008	6,790,000	42	13.4524	19	0.2959	27,024,840
Pipeline - Diversion Structure to Eastside WTP	90	115	2008	20,000	45	13.6055	16	0.3624	98,625
WTP - Eastside Expansion	--	100	2008	2,364,000	42	13.4524	19	0.2959	9,408,943
WTP - Eastside Expansion	--	50	2018	1,182,000	32	12.6466	29	0.1504	2,248,247
Pipeline - Diversion Structure to Southeast WTP	90	180	2023	2,830,000	27	11.9867	34	0.1072	3,637,657
WTP - Southeast Stage II	--	100	2023	2,364,000	27	11.9867	34	0.1072	3,038,665
Pipeline - Waters Bluff to Fork	66	70	2035	2,090,000	15	9.1079	46	0.0476	906,348
Reservoir - Waters Bluff	--	70	2035	190,163	18	10.0591	43	0.0583	111,575
WTP - Southeast Stage III	--	100	2035	2,364,000	15	9.1079	46	0.0476	1,025,171
				32,308,163					$119,740,000

TOTAL 1989 VALUE OF ALTERNATIVE 6 **$402,710,000**

Table F-11
Net Present Value of Alternative 7

Interest Rate= *7.0%*

CAPITAL COSTS

Improvement	Capacity (mgd)	Year On-Line	Capital Cost	Years Until Expense Incurred	Factor	1989 Value
Pipeline - Palestine to Southeast WTP	120	2001	192,330,000	11	0.4751	91,374,598
WTP - Southeast Stage I	100	2001	103,540,800	11	0.4751	49,191,488
Pipeline - Fork to Tawakoni	190	2008	97,140,000	18	0.2959	28,740,221
Pipeline - Tawakoni to Diversion Structure	295	2008	159,216,000	18	0.2959	47,106,269
Pipeline - Diversion Structure to Eastside WTP	115	2008	8,680,000	18	0.2959	2,568,099
WTP - Eastside Expansion	100	2008	101,760,000	18	0.2959	30,107,112
WTP - Eastside Expansion	50	2018	50,880,000	28	0.1504	7,652,465
Pipeline - Diversion Structure to Southeast WTP	180	2023	57,850,000	33	0.1072	6,203,527
WTP - Southeast Stage II	100	2023	101,760,000	33	0.1072	10,912,203
Pipeline - Little Cypress to Fork	60	2035	99,370,000	45	0.0476	4,731,352
Reservoir - Little Cypress	60	2035	87,300,000	45	0.0476	4,156,658
WTP - Southeast Stage III	100	2035	101,760,000	45	0.0476	4,845,149
			1,161,586,800			$287,590,000

OPERATION AND MAINTENANCE COSTS TO THE YEAR 2050
(O&M expenses continue through 2050 for all facilities)

Improvement	Pipe Size	Capacity (mgd)	Year On-Line	Annual Cost	No. Years of O&M Expenses	Factor	Years Until Expense Incurred	Factor	1989 Value
Pipeline - Palestine to Southeast WTP	84	120	2001	7,020,000	49	13.7668	12	0.4751	45,914,358
WTP - Southeast Stage I	--	100	2001	2,364,000	49	13.7668	12	0.4751	15,461,758
Pipeline - Fork to Tawakoni	102	190	2008	2,730,000	42	13.4524	19	0.2959	10,865,657
Pipeline - Tawakoni to Diversion Structure	120	295	2008	6,790,000	42	13.4524	19	0.2959	27,024,840
Pipeline - Diversion Structure to Eastside WTP	90	115	2008	20,000	45	13.6055	16	0.3624	98,625
WTP - Eastside Expansion	--	100	2008	2,364,000	42	13.4524	19	0.2959	9,408,943
WTP - Eastside Expansion	--	50	2018	1,182,000	32	12.6466	29	0.1504	2,248,247
Pipeline - Diversion Structure to Southeast WTP	90	180	2023	2,830,000	27	11.9867	34	0.1072	3,637,657
WTP - Southeast Stage II	--	100	2023	2,364,000	27	11.9867	34	0.1072	3,038,665
Pipeline - Little Cypress to Fork	66	70	2035	2,840,000	15	9.1079	46	0.0476	1,231,593
Reservoir - Little Cypress	--	70	2035	467,853	18	10.0591	43	0.0583	274,504
WTP - Southeast Stage III	--	100	2035	2,364,000	15	9.1079	46	0.0476	1,025,171
				33,335,853					$120,230,000

TOTAL 1989 VALUE OF ALTERNATIVE 7 $407,820,000

Table F–12
Net Present Value of Alternative 8

Interest Rate= *7.0%*

CAPITAL COSTS

Improvement	Capacity (mgd)	Year On-Line	Capital Cost	Years Until Expense Incurred	Factor	1989 Value
Pipeline - Palestine to Southeast WTP	120	2001	192,330,000	11	0.4751	91,374,598
WTP - Southeast Stage I	100	2001	103,540,800	11	0.4751	49,191,488
Pipeline - Fork to Tawakoni	120	2008	67,950,000	18	0.2959	20,103,953
Pipeline - Tawakoni to Diversion Structure	200	2008	119,916,640	18	0.2959	35,479,007
Pipeline - Diversion Structure to Eastside WTP	115	2008	7,590,000	18	0.2959	2,245,607
WTP - Eastside Expansion	100	2008	101,760,000	18	0.2959	30,107,112
WTP - Eastside Expansion	50	2018	50,880,000	28	0.1504	7,652,465
Reservoir - Texoma	70	2023	78,400,000	29	0.1406	11,020,125
Texoma Desalinization Plant	70	2023	142,835,000	33	0.1072	15,316,868
Pipeline - Texoma to Ray Roberts	60	2023	32,260,000	33	0.1072	3,459,391
WTP - Elm Fork II	100	2023	104,744,000	33	0.1072	11,232,191
Pipeline - Diversion Structure to Southeast WTP	80	2035	39,620,000	45	0.0476	1,886,446
WTP - Southeast Stage II	100	2035	101,760,000	45	0.0476	4,845,149
			1,143,586,440			$283,910,000

OPERATION AND MAINTENANCE COSTS TO THE YEAR 2050

(O&M expenses continue through 2050 for all facilities)

Improvement	Pipe Size	Capacity (mgd)	Year On-Line	Annual Cost	No. Years of O&M Expenses	Factor	Years Until Expense Incurred	Factor	1989 Value
Pipeline - Palestine to Southeast WTP	84	120	2001	7,020,000	49	13.7668	12	0.4751	45,914,358
WTP - Southeast Stage I	--	100	2001	2,364,000	49	13.7668	12	0.4751	15,461,758
Pipeline - Fork to Tawakoni	84	120	2008	1,860,000	42	13.4524	19	0.2959	7,402,975
Pipeline - Tawakoni to Diversion Structure	102	200	2008	4,840,000	42	13.4524	19	0.2959	19,263,656
Pipeline - Diversion Structure to Eastside WTP	84	120	2008	0	42	13.4524	19	0.2959	0
WTP - Eastside Expansion	--	100	2008	2,364,000	42	13.4524	19	0.2959	9,408,943
WTP - Eastside Expansion	--	60	2018	1,182,000	32	12.6466	29	0.1504	2,248,247
Reservoir - Texoma	--	70	2023	334,000	30	12.4090	31	0.1314	544,467
Texoma Desalinization Plant	--	70	2023	11,600,000	27	11.9867	34	0.1072	14,910,537
Pipeline - Texoma to Ray Roberts	66	60	2023	1,730,000	27	11.9867	34	0.1072	2,223,727
WTP - Elm Fork II	--	100	2035	2,364,000	12	7.9427	46	0.0476	894,015
Pipeline - Diversion Structure to Southeast WTP	72	80	2035	1,040,000	15	9.1079	46	0.0476	451,006
WTP - Southeast Stage II	--	100	2035	2,364,000	15	9.1079	46	0.0476	$118,720,000
				39,062,000					$237,440,000

TOTAL 1989 VALUE OF ALTERNATIVE 8 **$521,350,000**

Table F-13
Pipeline Designs for Hubbard Reuse Loop

Pipeline Route	Q (MGD)	Length (Miles)	Pipe Size (inches)	Pump Station Size						Capital Costs ($1,000,000)							Annual Expenses ($1,000,000)			Cost ($) per 1000 gal
				Intake		Booster														
				Net HP	TDH	Net HP	TDH	Net HP	TDH	Intake	Booster1	Booster2	Pipeline	Constr. Interest	Engr & Contingencies	Total	Debt Service	Energy Cost	O&M Cost	
Div. Str. to Hubbard	135	15.0	72	6850	289					15.9			16.5	3.46	8.09	43.93	2.89	3.53	0.10	0.1323
Div. Str. to Hubbard	135	15.0	78	5450	230					15.3			18.6	3.62	8.48	46.01	3.02	2.81	0.10	0.1205
Div. Str. to Hubbard	135	15.0	84	4600	194					13.6			21.0	3.69	8.65	46.93	3.09	2.38	0.10	0.1129
Div. Str. to Hubbard	135	15.0	90	4000	169					12.5			24.0	3.90	9.12	49.52	3.26	2.07	0.10	0.1101
Div. Str. to Hubbard	165	15.0	78	8250	285					19.3			18.6	4.05	9.48	51.44	3.38	4.25	0.10	0.1284
Div. Str. to Hubbard	165	15.0	84	6700	231					18.0			21.0	4.16	9.75	52.90	3.48	3.45	0.10	0.1168
Div. Str. to Hubbard	165	15.0	90	5650	196					16.6			24.0	4.34	10.16	55.08	3.62	2.92	0.10	0.1102
Div. Str. to Hubbard	165	15.0	96	5000	173					15.5			26.7	4.51	10.56	57.24	3.76	2.58	0.10	0.1070
Div. Str. to Hubbard	272	15.0	96	12900	270					31.2			26.7	6.18	14.47	78.55	5.16	6.64	0.10	0.1199
Div. Str. to Hubbard	272	15.0	102	10900	228					29.0			29.6	6.26	14.66	79.54	5.23	5.61	0.10	0.1102
Div. Str. to Hubbard	272	15.0	108	9500	199					27.4			32.6	6.41	15.01	81.45	5.35	4.89	0.10	0.1042
Div. Str. to Hubbard	272	15.0	114	8500	178					25.1			35.6	6.49	15.19	82.41	5.42	4.38	0.10	0.0997
Div. Str. to Hubbard	272	15.0	120	7750	162					24.0			38.3	6.65	15.56	84.47	5.55	3.99	0.10	0.0972
Div. Str. to Hubbard	107	15.0	66	5635	300					12.7			14.9	2.95	6.90	37.43	2.46	2.91	0.10	0.1400
Div. Str. to Hubbard	107	15.0	72	4250	226					11.7			16.5	3.01	7.04	38.23	2.51	2.20	0.10	0.1232
Div. Str. to Hubbard	107	15.0	78	3500	186					10.8			18.6	3.14	7.35	39.91	2.62	1.81	0.10	0.1161
Div. Str. to Hubbard	107	15.0	84	3100	165					9.9			21.0	3.30	7.72	41.91	2.76	1.61	0.10	0.1142
Div. Str. to Hubbard	107	15.0	90	2750	146					9.5			24.0	3.58	8.37	45.45	2.99	1.43	0.10	0.1156
Hubbard to Div. Str.	179	2.2	60	3300	105					10.5			2.0	1.33	3.11	16.90	1.11	1.71	0.10	0.0447
Hubbard to Div. Str.	179	2.2	66	2000	64					10.2			2.2	1.32	3.09	16.76	1.10	1.04	0.10	0.0343

Cost to Install
Additional Dilution Loop

	Mixing Loop Capacity (mgd)	Raw Water Quantity (mgd)	Reuse Quantity (mgd)	Mixing Ratio (Raw:Reuse)	Capital Cost of Mixing Loop ($1,000,000)	Annual Energy and O&M Costs ($1,000,000)
Alternative 1	107/179	189.4	60	3.2 : 1	58.66	2.85
Alternative 2	165/179	247.2	180	1.4 : 1	74.00	3.82
Alternative 3	272/179	189.4	175	1.1 : 1	101.22	5.24
Alternative 4	165/179	247.2	60	2.7 : 1	74.00	3.82

Table F-14
Summary of Estimated Annual Charges and Cost of Water

	Lake Fork	Lake Palestine
Authorized Annual Basin Transfer (Ac-Ft/Yr)	120,000	114,337
1990 Dependable Yield Available to DWU for transfer (mgd)	107.0	101.7
Volume Utilized (mgd)	100	100
<u>Capital Costs</u>		
Transmission Facilities	147,104,428 (1)	149,610,500 (2)
<u>Annual Charges</u>		
Debt Service		
Transmission Facilities (3)	13,886,658	14,123,231
O & M		
Transmission Facilities (4)	225,000	150,000
Electric Power (5)	4,899,865	4,419,662
Total Annual Charges:	19,011,523	18,692,893
<u>Cost of Water</u>		
Per 1,000 Gallons	**$0.52**	**$0.51**

(1) Based on cost of two intake pump stations, outlet control structure, a 100 mg balancing reservoir, booster pump station, 84" pipelines, and R.O.W. aquisition from Lake Fork to Lake Tawakoni.

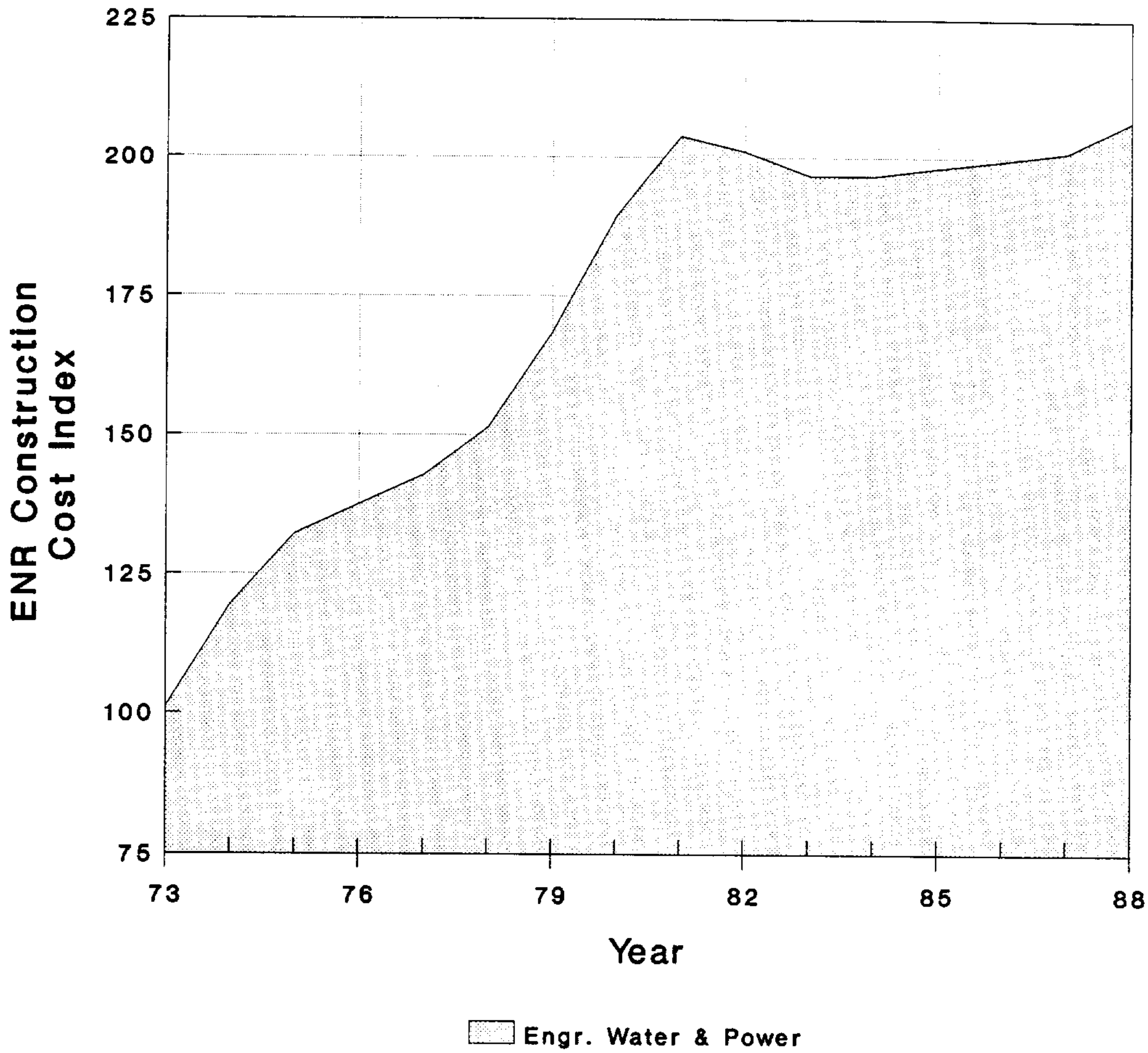
(2) Based on cost of raw water intake and pump station, a booster pump station and intermediate reservoir, 84" pipeline, and R.O.W. acquisition from Lake Palestine.

(3) Amortized over 20 years at 7 percent interest.

(4) Based on information provided by DWU Accounting Department.

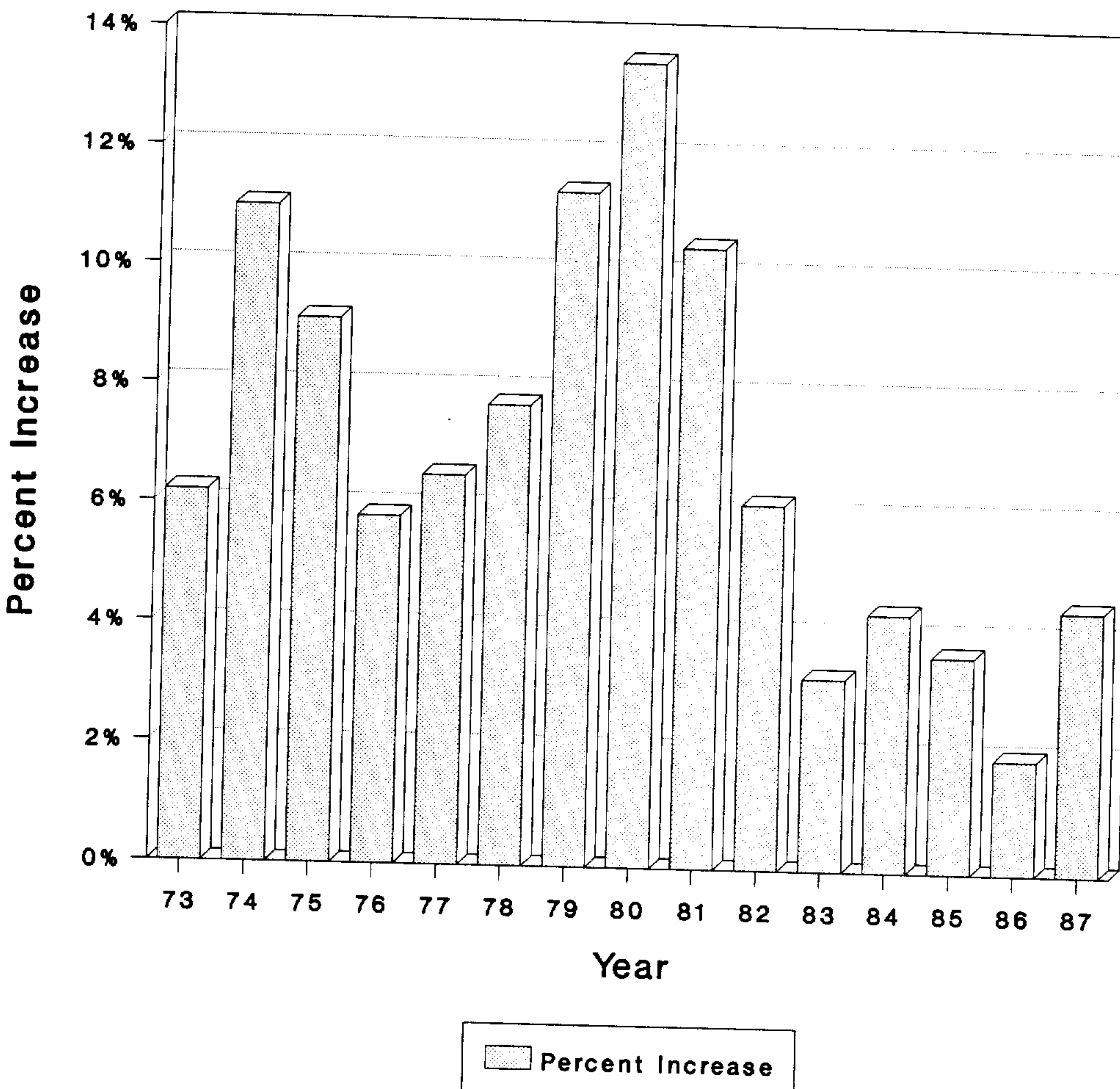
(5) Based on high volume rates.

Figure F-1
Cost Index for Water and Power Construction, 1973 - 1988



1972 = 100
Source: Engineering News Record

Figure F-2
Cost of Living Increase 1973 - 1988



Base Year: 1972
Source: US Bureau of Labor Statistics

Figure F-3
Intake Pump Station Construction Costs

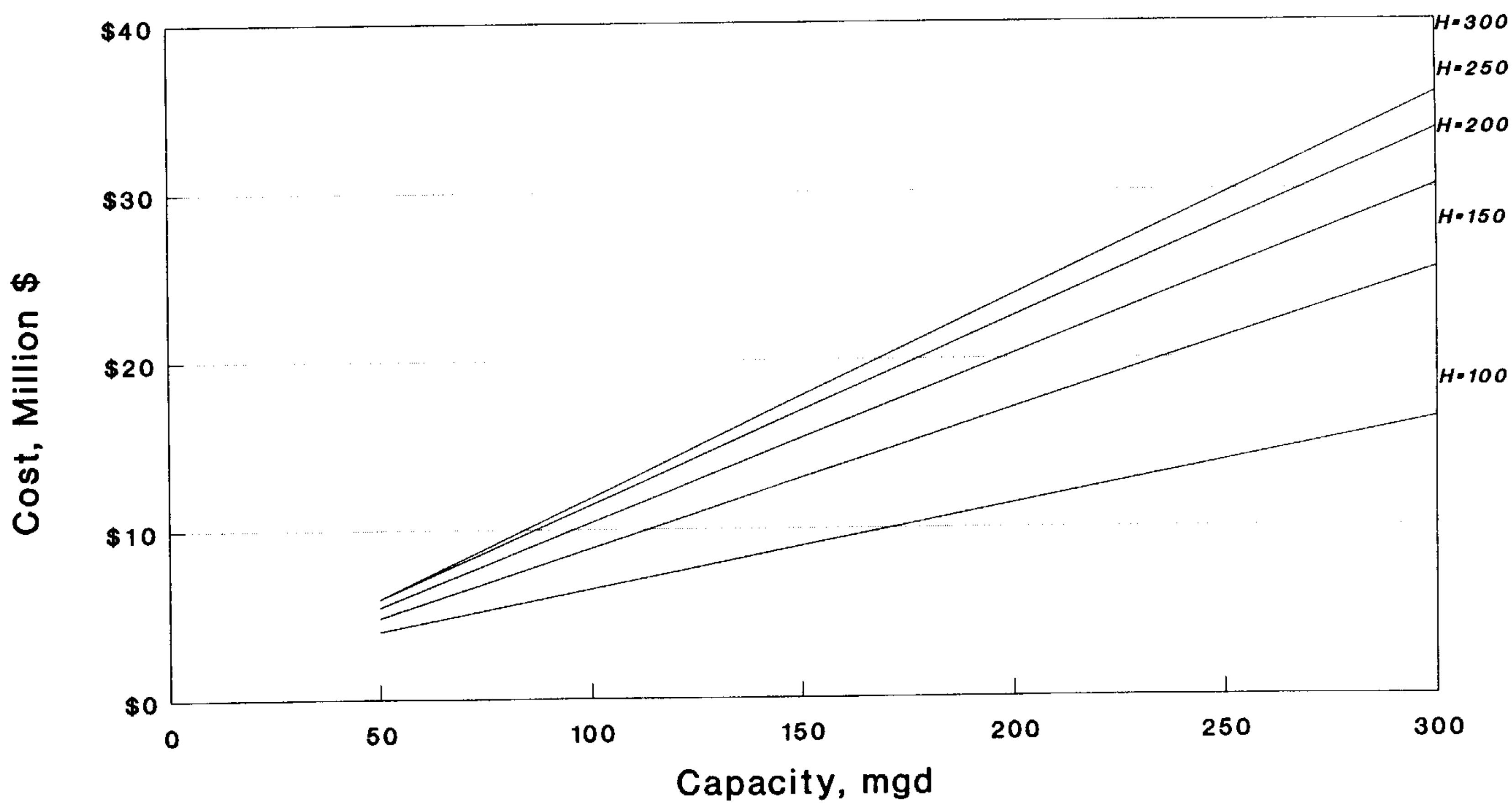


Figure F-4
Booster Pump Station Construction Costs

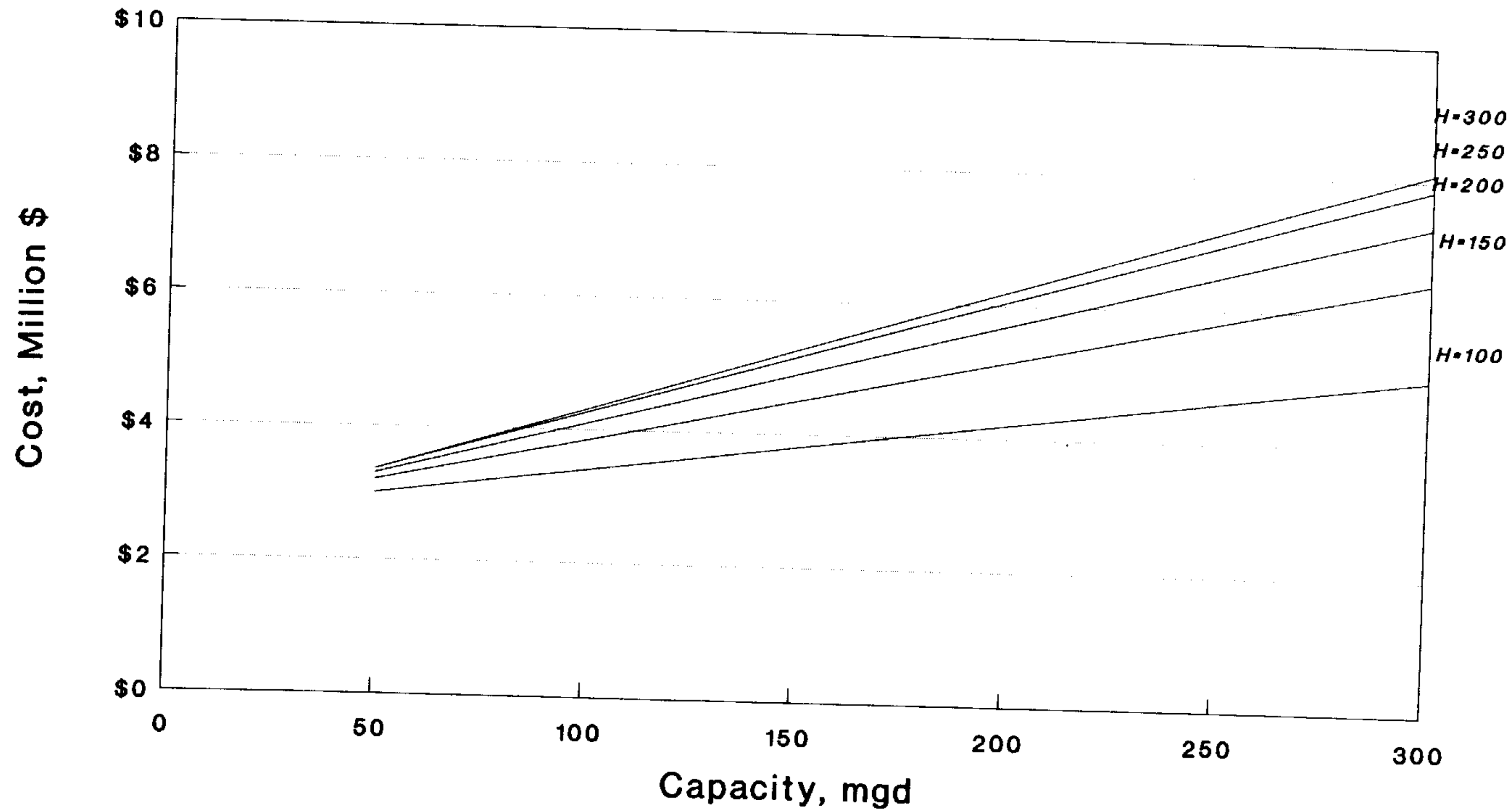
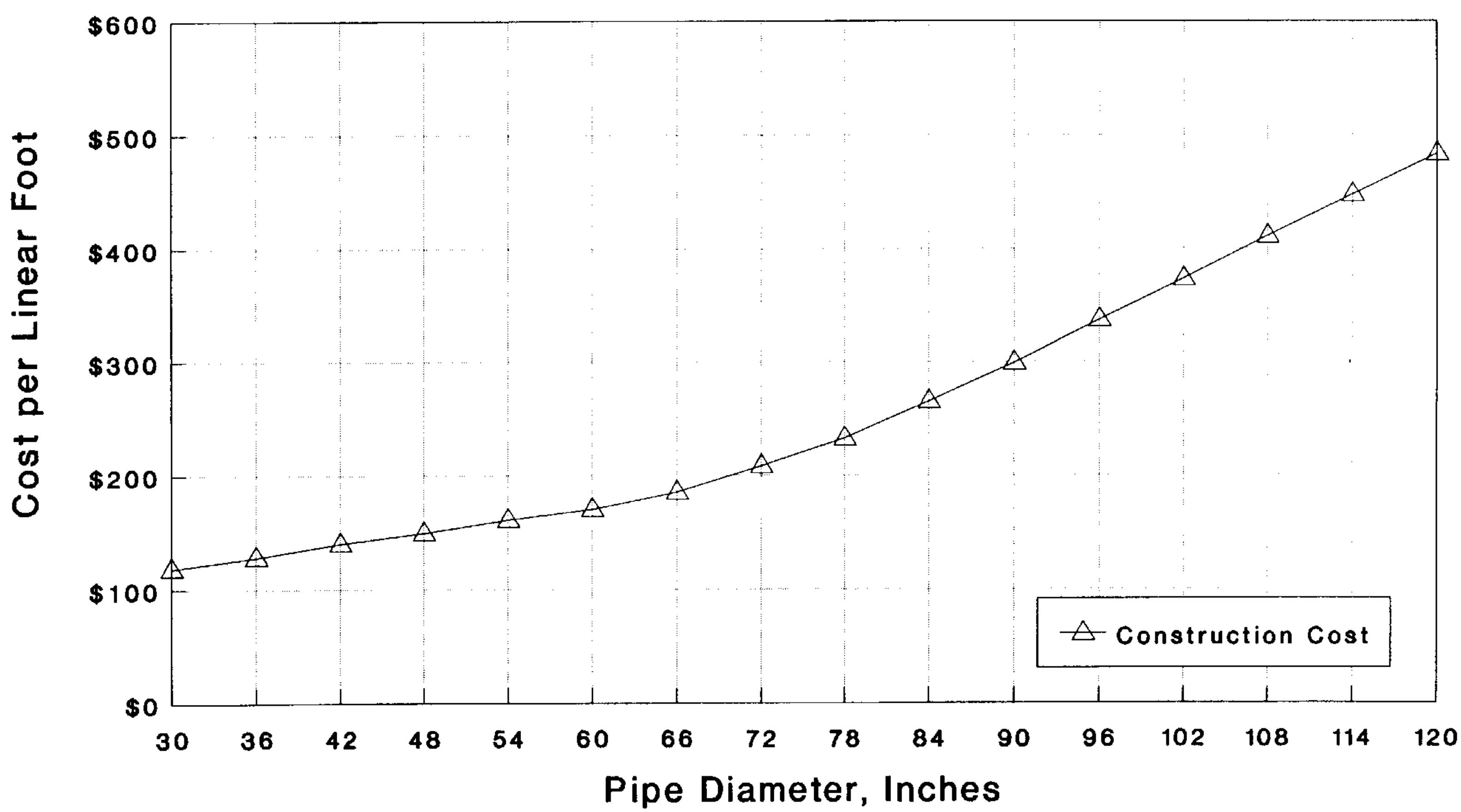


Figure F-5

Pipeline Construction Cost
Reinforced Concrete Cylinder Pipe



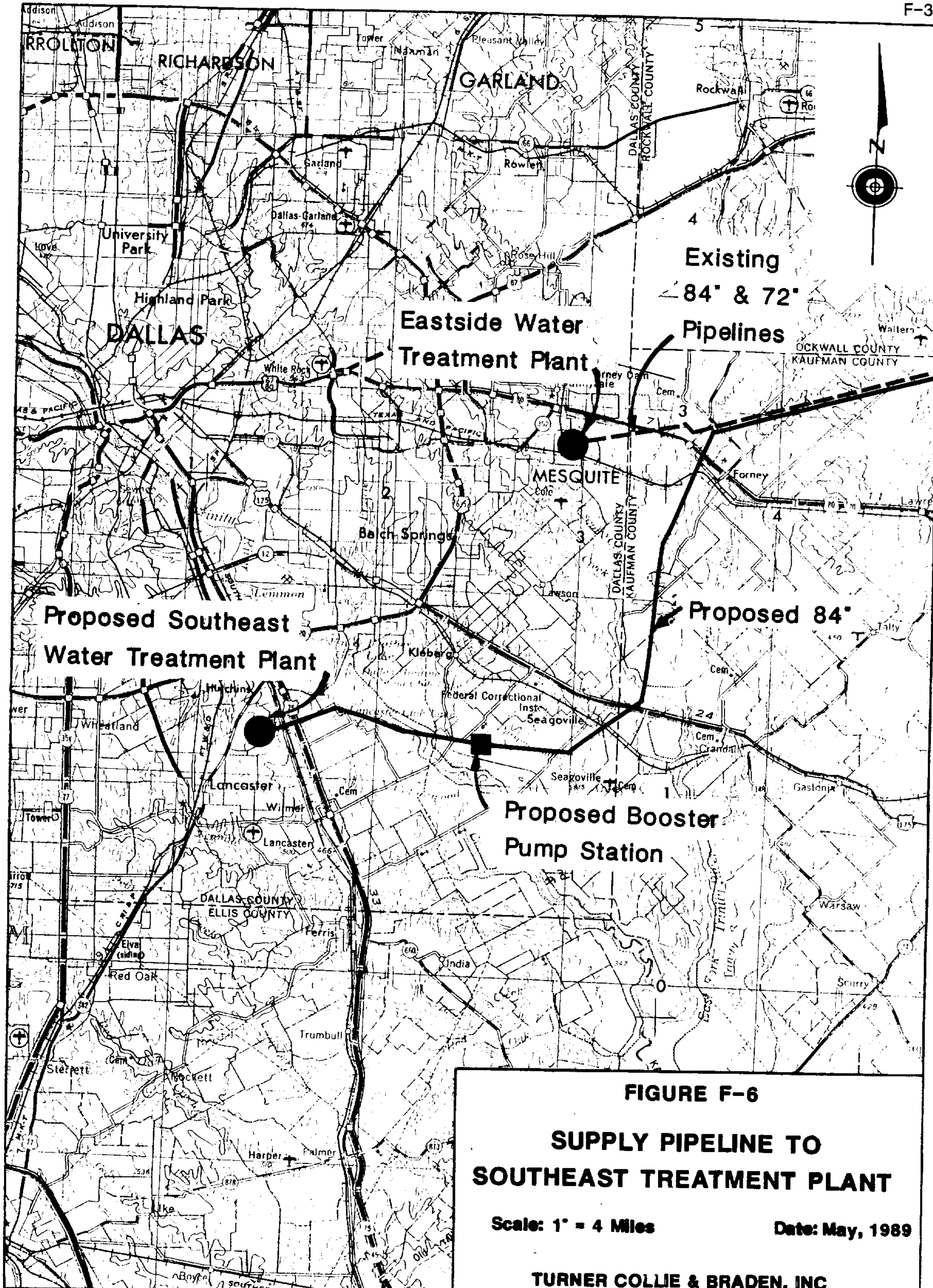


FIGURE F-6

SUPPLY PIPELINE TO SOUTHEAST TREATMENT PLANT

Scale: 1" = 4 Miles **Date: May, 1989**

TURNER COLLIE & BRADEN, INC