Brazos River Authority

Investigation of an Expansion of the Surface Water Advanced Treatment System to Provide Treated Surface Water

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TO
PROVIDE TREATED SURFACE WATER

EXECUTIVE SUMMARY

The Brazos River Authority operates a Surface Water Advanced Treatment Plant and Distribution System (SWATS) to provide treated surface water to four wholesale customers (existing participants) in Johnson and Hood Counties. Growth in the region indicates that the SWATS may need to be expanded. The Brazos River Authority (BRA), with a matching grant from the Texas Water Development Board (TWDB), retained Alan Plummer Associates, Inc., to develop a plan for the SWATS to meet the 20-year demands for both existing participants and possible other potential customers in Hood, Johnson, and Somervell counties.

Public participation in the study was solicited during three public meetings in Johnson County and three public meetings in Hood County. Input from the public meetings and the existing participants indicated that potential additional customers that could be served directly by the SWATS included the cities of Cleburne, Keene, and Alvarado; the Bethany Water Supply Corporation; and Aqua Source, a private water supply company. Other individuals and small water systems could be served, if desired, by one of the existing participants.

Future population was projected using the approximate growth rates predicted by the TWDB and supplementing that with an estimate of a portion of the population presently on well systems that would need an alternate surface water supply in the 20-year time frame. The projected water demand was based on a per connection use, equivalent to the minimum Texas Natural Resource Conservation Commission (TNRCC) standard for small water system capacity, with corrections for water conservation savings.

Expanded service to the existing participants and up to five additional participants was considered in six different options. The evaluation of each option pointed to the need for immediate expansion followed by periodic additional expansions for the water treatment plant. Each option also includes improvements and expansion of the existing distribution system.

The conclusions of the report are as follows:

1. The SWATS participants and potential new customers should make commitments immediately for near future water service based on their peak demand.

2. The SWATS water treatment plant should be expanded to treat 15 MGD as soon as possible

3. Additional expansions will be required over the next 20 years.

4. A chart should be developed based on actual peak daily water production to predict the time to start additional expansions.

5. A Hood County pipeline to serve the City of Granbury and a portion of AMUD should be constructed as soon as possible.

6. BRA should undertake a sampling and testing program to gather information relative to the utilization of reverse osmosis (RO) or electrodialysis reversal (EDR) for future plant expansions.

7. BRA should continue communication with potential new customers of SWATS regarding regulations, raw water demand, treated water demands, and water supply issues.

8. The existing participants and BRA should review existing contracts to explore possibilities of changes to encourage the use of treated surface water for base loading demands and supplementing with groundwater to meet peak demands.

9. The SWATS participants and potential new customers should provide input to the Senate Bill 1 Regional Water Planning Committee regarding raw and treated water needs for the planning area.

10. The SWATS participants and potential new customers should execute agreements with the BRA to secure long-term rights to raw water needed to meet future demands.

11. BRA should review the existing brine discharge permit to ensure that increased brine flow and increased salt content in the brine flow will not exceed existing permit limits.

The projected probable estimate of unit costs for treated water from the expanded system are shown in Appendix F and will depend on the option selected. The average unit cost varies between $2.75 and $3.85 per 1000 gallons. Unit costs for each option are totally dependent on the ratio of the annual usage to the system design capacity.

INVESTIGATION OF AN EXPANSION
OF THE
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BACKGROUND

The Brazos River Authority (BRA) operates an advanced surface water treatment plant and distribution system (SWATS) near Lake Granbury to serve two wholesale customers in Johnson County and two wholesale customers in Hood County. These customers are Johnson County Fresh Water Supply District (JCFWSD), Johnson County Rural Water Supply Corporation (JCRWSC), Acton Municipal Utility District (AMUD), and the City of Granbury (Granbury). For the purposes of this report, the existing wholesale customers will be called Participants.

The water treatment plant includes a conventional water treatment process followed by an electrodialysis reversal (EDR) process for total dissolved solids (TDS) and chloride removal. The plant was originally designed with a rated capacity of 5.0 MGD for its conventional treatment portion and 3.5 MGD for its EDR portion. The EDR portion of the plant and the raw water lift station has been expanded to allow for the treatment of 5.0 MGD through the EDR portion of the plant. The conventional treatment side has been uprated to 7.0 MGD.

The agreements between BRA and the Participants require the finished water to have a chloride content less than 300 mg/L. Historically, the water treatment plant has produced about 78 percent of the raw water as finished water. The remaining 22 percent, which has elevated total dissolved solids (brine), is returned to the lake under an existing discharge permit. It is anticipated that Lake Granbury water will continue to include chloride at levels which will require removal to comply with the current agreements and secondary drinking water requirements.

The peak demand water requirements by the Participants are currently about equal or greater than the amounts specified in the agreements. Therefore, there is an immediate need to develop a plan to provide capacity to meet the increasing peak daily demands from each of the Participants.

The Brazos River Authority retained Alan Plummer Associates, Inc., to develop a plan for the BRA SWATS to meet the future demands (20 years) for the Participants and possible other potential customers throughout Hood and Johnson counties. Additionally, the planning scope included consideration of portions of Somervell County.

PUBLIC MEETINGS

Of major interest to BRA for this project was obtaining input from the general public and potential water customers. Obtaining this input was achieved through workshops with Participants, public meetings, and questionnaires requesting water-related information that BRA sent to entities. Public meetings were held on March 16, 1998, in both Johnson and Hood Counties to discuss the purpose and scope of the project. The meeting agenda, meeting notes, and an attendee list are included in Appendix A.

A second set of public meetings was held in Johnson and Hood Counties on July 21, 1998, to discuss the preliminary findings of the project and some of the potential projects developed as a result of those findings. The meeting agenda, meeting notes, and an attendee list are also included in Appendix A.

A third set of public meetings was held in both Johnson and Hood counties on December 4, 1998, to review the findings and recommendations with the public and to obtain any final public input. The meeting agenda, meeting notes, and an attendee list are included in Appendix A.

POTENTIAL NEW CUSTOMERS IN HOOD, JOHNSON, AND SOMERVELL COUNTY AREAS

Potential new customers in the three counties have been divided into two distinct classes.

New Wholesale Customers Served Directly by SWATS

One class of customer is a water system that would become a Participant under a contract arrangement with BRA. Water systems that fall into that category include the City of Keene, Bethany Water Supply Corporation, the City of Cleburne, and the City of Alvarado in Johnson County; the Somervell Water Supply District (SWSD) in Somervell County; and Aqua Source, a private corporation presently serving more than 5,000 people in Hood and Johnson counties.

The water systems in Johnson County (Keene, Bethany, Cleburne, and Alvarado) could be served by an extension of the pipeline that now serves Johnson County Fresh Water Supply District and Johnson County Rural Water Supply Corporation. Service to Aqua Source would be by a branch pipeline from the Hood County Pipeline. Service to SWSD would be by a new pipeline. Potential service to SWSD is being studied by separate engineering contract. A study was recently completed for the City of Stephenville in Erath County. The study included groundwater and three surface water sources, including Lake Granbury. The study concluded that the City of Stephenville pursue the acquisition of water from Lake Proctor. According to the study, Lake Granbury water was considerably more expensive than the other options considered, because of the length of the pipeline. Therefore, service to the City of Stephenville will not be considered further in this report.

New Retail Customers Served Indirectly by SWATS

The other class of customer is water systems that could be incorporated into a Participant's system or that could contract with a Participant to provide service. These customers include all of the other privately owned water systems in Johnson, Hood, and Somervell Counties. However, several small individual private water systems that are remotely located from any of the Participant's distribution systems cannot be economically served and will need to continue to rely on wells in the near term This includes subdivisions in Somervell County, subdivisions in northern and western Hood County, the cities of Lipan and Tolar, subdivisions in southwestern Johnson County, and subdivisions in southern Parker County. Representatives of the Rio Brazos WSC in Parker County attended one of the public meetings and specifically requested consideration. Unfortunately, their area of service is too remote from any existing distribution system for service from the SWATS plant to be economically feasible at this time.

WATER NEEDS OF PARTICIPANTS

The water needs and relevant issues of each of the Participants were discussed during workshops with each Participant. These needs and issues are discussed below.

Johnson County Rural Water Supply Corporation

Workshop No. 1 was conducted with the JCRWSC on April 22, 1998. The primary topics included existing facilities, existing system operations, population projections, future water needs, and potential new customers in the Johnson County area.

The Johnson County Rural Water Supply Corporation (JCRWSC) is the largest water supplier in Johnson County. They serve customers in rural areas over most of the county. Their service area extends slightly across three other county lines. Like most Rural Water Supply Corporations, most of their customers are residential. JCRWSC is in a rapidly expanding growth mode.

- The following significant issues were discussed. The JCRWSC has experienced a recent growth rate of 6.6 percent per year and presently are ten years ahead of the projections made just four years ago. A significant amount of new water will need to be identified to keep up with growth. Surface water delivery to the east side of the JCRWSC system would be a plus. JCRWSC is presently base loading off of the groundwater system and is using the SWATS water to satisfy their peak demands, because groundwater is significantly cheaper. The workshop participants concluded that Keene, Bethany, and Cleburne were potential new Participants for the SWATS plant. Other smaller private operators could be more efficiently served through one of the existing Participants.

Technical Memorandum No. 1 is a summary of the items discussed in the workshop and is included in Appendix B1.

Johnson County Fresh Water Supply District Workshop

Workshop No. 2 was conducted with the JCFWSD on April 22, 1998. The primary topics included existing facilities, existing system operations, population projections, future water needs, and potential new customers in the Johnson County area.

The Johnson County Fresh Water Supply District #1 (District) serves the residential and commercial customers located in the City of Joshua. The District has approximately 1600 connections and presently experiences a peak demand of approximately 500 gallons per day per connection, which is significantly lower than the TNRCC capacity guideline of 864 gallons per day per connection (0.6 gpm per connection).

During the workshop, the following significant issues were discussed.

- JCFWSD has been cited by TNRCC for not having the 0.6 gpm per connection capacity.
- JCFWSD could use an additional 250,000 gallon elevated storage tank.
- JCFWSD currently has a shortage of water and has asked BRA for more.
- JCFWSD is presently base loading from SWATS water and is using its wells for peaking.
- JCFWSD is concerned about the inability of BRA to keep the TST elevation greater than 40 feet during peak demand times. This requires JCFWSD to run pumps to transfer water to their elevated storage tank. JCFWSD believes that the current project may not help them, because their understanding is that it only lifts into the JCRWSC system.

Technical Memorandum No. 2 is a summary of the items discussed in the workshop and is included in Appendix B2.

Acton Municipal Utility District.

Workshop No. 3 was conducted with the AMUD on April 28, 1998. The primary topics included existing facilities, existing system operations, population projections, future water needs, and potential new customers in the Hood County area.

The Acton Municipal Utility District (AMUD) is the largest water supply agency in Hood County serving several large residential developments in the vicinity of Lake Granbury. AMUD's customers are about 98 percent residential and include Pecan Plantation, Decordova Bend, and Indian Harbor.

The following significant issues were discussed during the workshop.

- The AMUD has projected their additional surface water needs out to the year 2050 to be about 15,000 ac-ft/yr.
- The growth in new connections has been about five percent per year for the last five years.
- There is significant growth potential within the major developments already served, and new developments being planned within reach of the service area.
- The workshop participants concluded that there were no other large private customers that could be logically served by the SWATS plant. All of the private operators could be more efficiently served through one of the Participants.

Technical Memorandum No. 3 is a summary of the items discussed in the workshop and is included in Appendix B3.

City of Granbury.

Workshop No. 4 was conducted with the City of Granbury on April 28, 1998. The primary topics included existing facilities, existing system operations, population projections, future water needs, and potential new customers in the Hood County area.

The City of Granbury provides water for the residential and commercial customers in the City and in portions of the extraterritorial jurisdiction not served by other private water companies. Granbury has a treatment plant with a limited capacity. However, they only use it now when they need it for peaking, usually only 2 or 3 months out of the year. They also have several wells. They presently receive water from SWATS through the distribution system of AMUD at a rate of about 0.5 MGD. AMUD's distribution system is a limiting factor on the amount of delivery. Granbury is presently constructing a line along 377 which will connect to the AMUD distribution system and give them a second and more favorable point for water delivery.

During the workshop, the following significant issues were discussed.

- Granbury's wells are declining in total yield.
- They are committed to obtaining more surface water to meet their growing demands.
- The growth in Hood County has been more than seven percent since 1980.
- Granbury expects the growth to be about six percent for the next several years. Several large developments are under construction and expected to be substantially built out within the next ten years.
- Granbury has projected a raw water need of 12,500 acre feet per year.

Technical Memorandum No. 4 is a summary of the items discussed in the workshop and is included in Appendix B4.

FUTURE POPULATION AND WATER DEMANDS

Growth in water demand for an area with a relatively small industrial base is directly proportional to population growth. There has been little emphasis on predicting growth in Hood, Johnson, and Somervell Counties by the North Central Texas Council of Governments (NCTCOG); therefore, most projections indicate a nominal growth of approximately 2.0 percent for the three counties. This growth projection seems appropriate for those areas more remotely located from the DFW metroplex area. However, based on historical growth patterns, the attractiveness of Lake Granbury for developments, and the relative close proximity to Fort Worth, it is expected that growth rates will be significantly greater than 2.0 percent for the Granbury service area. As discussed below, based on information relevant to each of these areas, most likely growth rates and high growth rates have been projected. The projected population for these entities are summarized in Table 1 and presented in more detail in Appendix C. Table 1 also presents a population summary of the options considered. The options are presented in more detail in Appendix C.

Population Projection Summary
Most Likely Series (MGD)
Individual Utilities

Utility	Population 2000	2005	2010	2015	2020
Granbury	8,281	11,316	14,808	18,865	23,618
Acton MUD	13,833	15,886	18,098	20,486	23,070
JCRWSD	4,936	5,653	6,474	7,415	8,492
JCRWSC NW	15,445	18,226	21,190	24,357	27,750
JCRWSC NE	6,229	7,123	8,090	9,139	10,279
Keene	5,582	6,163	6,804	7,512	8,294
Alvarado	3,168	3,498	3,862	4,264	4,708
Bethany WSC	3,402	3,773	4,184	4,639	5,145
Cleburne*	0	2,200	6,800	10,800	17,133

* Population Served by SWATS

Population Projection Summary
Most Likely Series (MGD)
Options Considered

Options	Year 2000	2005	2010	2015	2020
Base	42,494	51,080	60,570	71,122	82,929
Option 1	48,076	57,243	67,374	78,635	91,224
Option 2	51,478	61,015	71,557	83,274	96,369
Option 3	57,707	68,138	79,647	92,413	106,648
Option 4	60,875	71,636	83,509	96,677	111,355
Option 5	42,494	53,280	67,370	81,922	100,062

Hood County

Since 1990, by the most conservative (TWDB) 1998 population estimate, Hood County has grown an average of 3.38 percent per year. Discussions with the county commissioners indicate that they believe the TWDB population estimate for the county for 1998 is too low. They cite more than 35,000 vehicle registrations in the county in 1997. Also, the U.S. Postal Service, using their own techniques, estimated the 1997 population in Hood County to be 55,284 which represents a growth rate of more than 9.5 percent per year between 1990 and 1997. Based on recent history, it is believed that the county is experiencing a growth wave due to migration from the Metroplex. The county is expected to continue growing at a much faster than normal pace during the next several years. In addition to expected population growth, treated surface water demands are expected to increase during the next 20 years due to several of the private water systems, now on wells, converting part or all of their service to treated surface water. The existing SWATS Surface Water Treatment Plant is the logical choice to provide for these additional treated surface water demands.

Granbury. The City of Granbury has grown an average of more than 5 percent per year between 1990 and 1998 based on TWDB estimates. However, there is a discrepancy between the TWDB existing population (6,050) and the population reported by the Granbury Chamber of Commerce (7,281). The Granbury Chamber of Commerce numbers show a growth rate since 1990 of over 7.5 percent per year.

The TWDB annual growth projection for the City of Granbury of 1.9 percent is considered to be a very low rate, but includes only the city and not the entire service area. A 7.5 percent growth rate is included as a maximum expected growth rate over the 20-year period. The most likely growth rate over the next 20 years for the Granbury service area is 4.31 percent per year. This total system growth rate is a combination of population growth within the city and expansion of the system to serve an expanding geographical area presently on groundwater. Granbury projections are included on page C-1.

AMUD. The AMUD has grown from 3163 connections in 1990 to 4320 connections in 1997, for an average growth rate over that 7 year period of 4.55 percent per year. The AMUD has provided an estimate of system growth to be 150 connections per year over the next 50 years which reflects a 3 to 4 percent per year increase during the initial years. This growth rate is highly probable, but higher than can be supported by existing projections. Therefore, this report uses the low rate of 2.06 percent per year for the AMUD which reflects the TWDB's county growth rate. It is likely that over the next 20 years, the AMUD will be asked to take over additional groundwater systems that cannot keep up with the increasing water demand due to decreasing groundwater availability. An additional 0.5 percent growth rate has been added to account for the addition of existing groundwater systems. A sustained high growth rate of 5.7 percent per year is possible, particularly for short periods of time. A 5.7 percent growth rate is included as a maximum expected growth rate over the 20 year period. AMUD projections are included on page C-2.

Other Potential Customers. There are a large number of private water supply systems throughout the county which provide water to Hood County residents that may convert to groundwater beyond the time frame for this planning effort. The time frame for these areas to be served by surface water could be shortened due to more stringent regulation requirements and/or faster than the expected diminishing groundwater resources. Two such communities are Lipan and Tolar, which due to their relatively small water demands and remoteness from existing surface water system, cannot be economically served at this time. However, if a major pipeline is installed in a westerly direction from Granbury to serve Stephenville or an expanded Granbury service areas, water supply service to these communities should be further considered.

Summary of Hood County. The population figures summarized above and presented in Appendix C combine the expected growth for both the existing service areas and the expansion to include systems now on wells. The projections indicate that the total population served by the SWATS plant in Hood County in 2020 is 46,688, which is about 87 percent of the total population predicted by TWDB. This appears to be a reasonable number since the SWATS plant is anticipated to be the only major surface water treatment plant in Hood County. Potential population from Aqua Source owned systems are included in the expansions of the Granbury and AMUD systems.

Johnson County.

According to the TWDB, since 1990 Johnson County as a whole has grown an average of 1.88 percent per year. However, it is probable that Johnson County will experience an increased growth wave that has started because of the proximity to the Metroplex. Construction of the planned major thoroughfare from Fort Worth to Cleburne will contribute to the increased growth rate.

Joshua. The City of Joshua, served by the JCFWSD, is likely to continue the modest growth rate of about 2.75, predicted by the TWDB. We consider this to be both the low growth rate and the most likely growth rate. The high growth rate of 6 percent is possible, particularly for short periods of time. It is included as the maximum expected growth rate. JCFWSD projections are included on page C-3.

Johnson County Rural Water Supply Corporation. Johnson County Rural Water Supply Corporation has grown an average of 3.2 percent per year since 1990, from 6,765 connections in 1990 to 8,485 connections at the end of 1997. The growth rate has been 5.86 percent per year since 1994. That growth rate for JCRWSC is expected to continue in the near term as more people convert from private wells to a more reliable source and as people continue to move from the Metroplex to more rural subdivisions. The TWDB projections of 2.09 percent have been used as the most likely growth rate. An additional one growth rate of about 1 percent was added to account for existing well systems. The low rate of 2.09 percent per year reflects the TWDB's county growth rate. The high growth rate of 6 percent per year is possible, particularly for short periods of time. It is included to as an upper limit of expected growth rates. JCRWSC projections for their northwest section are included on page C-4. JCRWSC projections for their northeast section are included on page C-5.

Other Potential Customers. With the addition of a reliable surface water source, the Cities of Keene and Alvarado are expected to grow at a rate comparable to the City of Joshua. The TWDB projections of 0.78 percent growth rate have been used for the City of Keene, but it is probable that the growth rate will be much higher if the city decides to join the SWATS system to receive treated surface water. A growth rate of 2.0 percent has been used for the City of Alvarado. This reflects the average Johnson County growth, but could be expected to be higher with the addition of a reliable treated water supply. The low rate of 2.01 percent per year reflects the TWDB's county growth rate. The high growth rate of 6 percent per year is possible, particularly for short periods of time. It is included as an upper bound for expected growth rates. Projections for Keene and Alvarado are included on pages C-6 and C-7 respectively.

The Bethany WSC is expected to grow at a higher rate than the general county rate, because they have an established water system that will likely expand to fill a need. Bethany is projecting a most likely growth rate of 3.0 percent per year which we believe is appropriate for their CCN. The low rate of 2.01 percent per year reflects the TWDB's county growth rate. The high growth rate of 6 percent per year is possible, particularly for short periods of time. It is included as an upper bound for expected growth rates. Bethany WSC projections are included on page C-8.

Summary of Johnson County. During the next 20 years, it is anticipated that several of the private water systems, now on wells, will be converting part or all of their service to treated surface water. Many of those systems could be served by the JCRWSC. Others will be served by other systems in the county with other sources of water such as the Cities of Cleburne, Burleson, and Mansfield, and private water supply corporations such as Bethesda and Bethany.

TWDB's total population projection for Johnson County is 172,168 for the year 2020. Cities that have other sources of treated water include Briar Oaks, Burleson, Cleburne, Grand View, Mansfield, and Rio Vista. The remaining projected population within Johnson county in 2020 is 106,183. This report projects the population in Johnson County to be served, or partially served, by the SWATS is 62,739. The remaining population of more than 40,000 would be served by private well systems, the Bethesda Water Supply Corporation with their wells, and treated surface water from the City of Fort Worth.

Water Demand

The water demands have been based on the most likely growth rates and consideration of the expected diminishing dependence upon groundwater. The projected peak surface water demands for these entities are summarized in Table 2 and presented in detail in Appendix C. Table 2 also presents a demand summary of the options considered. Because the two counties are largely residential with very few large industrial users, the water demands for these counties will be approximately proportional to the population growth. Existing average demand varies between 84 and 183 gpcd depending on location. It is believed that water conservation programs will reduce the per capita demands. Table 3 is a summary of the projected per capita average demand with conservation savings for several entities in Hood and Johnson County. Table 3 was derived from the Texas Water Development Board Regional Population Projections in Texas last updated on November 16, 1998. For the purpose of estimating average rates, the study assumes that the

Peak Surface Water Demand Summary
Most Likely Series (MGD)
Individual Utilities

Utility	2000	2005	2010	2015	2020
Granbury	2.43	3.24	4.26	5.53	7.08
Acton MUD	2.52	3.35	4.24	5.19	6.21
JCRWSD	0.77	1.14	1.53	1.95	2.40
JCRWSC NW	2.34	3.39	4.54	5.80	7.18
JCRWSC NE	0.68	1.03	1.45	1.93	2.48
Keene	0.30	0.79	1.30	1.81	2.35
Alvarado	0.19	0.46	0.74	1.03	1.32
Bethany WSC	0.32	0.50	0.69	0.89	1.10
Cleburne*	0.00	0.56	1.71	2.74	4.37

* Population Served by SWATS

Peak Surface Water Demand Summary
Most Likely Series (MGD)
Options Considered

Options	2000	2005	2010	2015	2020
Base	8.07	11.11	14.57	18.47	22.87
Option 1	8.37	11.91	15.86	20.28	25.22
Option 2	8.69	12.40	16.55	21.17	26.32
Option 3	9.37	13.43	18.00	23.10	28.80
Option 4	9.56	13.90	18.74	24.13	30.12
Option 5	8.07	11.67	16.28	21.21	27.24

REGIONAL MUNICIPAL WATER USE PROJECTIONS WITH CONSERVATION SAVINGS IN TEXAS

Average GPCD

REG	COUNTY	CITY	P1990	P2000	P2010	P2020	P2030	P2040	P2050
G	HOOD	GRANBURY	187.8	183.0	173.0	164.0	162.0	160.0	159.0
G	HOOD	TOLAR	97.3	87.3	81.5	74.9	71.2	66.3	66.3
G	HOOD	COUNTY-OTHER	106.7	105.5	95.8	88.3	84.9	82.8	82.7
G	JOHNSON		112.8	125.9	116.0	106.2	103.1	100.9	100.2
G	JOHNSON	ALVARADO	94.8	92.1	84.0	78.0	74.9	73.0	72.0
G	JOHNSON	BRIAR OAKS	106.8	112.2	105.9	98.9	94.8	91.5	89.8
G	JOHNSON	BURLESON (P)	111.0	107.0	98.0	82.0	81.0	80.0	79.0
G	JOHNSON	GRAND VIEW	126.2	118.2	110.9	103.9	101.2	98.1	97.2
G	JOHNSON	JOSHUA	80.9	78.0	69.0	63.0	60.0	58.0	58.0
G	JOHNSON	KEENE	103.5	130.2	121.9	115.0	111.0	108.0	107.1
G	JOHNSON	MANSFIELD (P)	118.7	142.5	132.9	113.1	112.0	110.8	109.8
G	JOHNSON	RIO VISTA	94.1	95.0	88.6	82.6	78.1	74.7	73.5
G	JOHNSON	COUNTY-OTHER	105.5	124.2	115.1	107.1	104.1	102.1	102.1

Table derived from the TWDB Regional Population Projections in Texas, last Updated on 11/16/98 By Joelle Labrosse average per capita demand will be as shown in Table 3 which includes a reduction for conservation.

Review comments from the Texas Water Development Board are included as Attachment 1. The comments indicate that the population projections appear reasonable for facility planning purposes, but requested that the water demand projections address the implementation of municipal water conservation. Average per capita water demand projections have been changed to include the potential savings from conservation.

Existing peak demand varies between 250 and 350 gpcd depending on location. For purposes of planning system size, the year 2000 peak demand has been calculated based on the assumption that each household connection should have available 0.6 gpm. At 2.9 persons per household, this computes to a per capita demand of 298 gpcd. The projected peak demand gpcd was reduced by the same amount as the average gpcd shown in Table 3.

It should be noted that the timing for the construction of new facilities indicated in this report is based on the population and water demand projections used. If either is higher, the facilities will be required sooner. The following are possible reasons why the population growth and the water demand could be higher than projected in this report:

1. Present economic activity in the both Hood County and Johnson County indicates that the population may be growing at a much higher rate over the near term than the rate predicted by the present official projections.

2. The existing per capita water demand comes from a population composed of a large number of rural developments in Johnson County, and a large number of lakeside cottages and weekend retreats in Hood County. Much of the new development in both counties is more surburban in nature with larger houses, more bathrooms, and larger landscaping demands, which historically have a higher water demand. Even with new water saving appliances and other savings attributed to water conservation, it is possible that the average per capita demands may increase rather than decrease.

WATER DELIVERY SYSTEM IMPROVEMENTS

Description of Improvements

The future water delivery system for the SWATS will be, at a minimum, a parallel pipeline to Johnson County to serve JCFWSD and JCRWSC (Johnson County Parallel Pipeline), and one or two pipelines to the City of Granbury to serve both Granbury and AMUD (Hood County Pipeline). In addition, depending on the option or options chosen, one or more of the following pipelines will be required:

1. An extension of the Johnson County Pipeline to Keene (Option 1)
2. An extension of the Johnson County Pipeline to Keene and Bethany (Option 2),
3. An extension of the Johnson County Pipeline to the east side of JCRWSC (Option 3)

4. An extension of the Johnson County Pipeline to Alvarado (Option 4)
5. An extension of the Johnson County Pipeline to Cleburne (Option 5).

Also, the Hood County pipeline could be extended to serve Aqua Source in the vicinity of the Bentwater Addition, if Aqua Source elects to contract for service. The extension of a line to serve Aqua Source would be a relatively minor addition to the Hood County Pipeline. Since there has been no commitment from Aqua Source to contract for water, a pipeline to serve them has not been included in any of the calculations. The Baseline Option and each of the additional options are discussed below. Appendix C, Pages C-9 through C-13 show the population trends and the most likely peak demand for each of the options.

Johnson County Parallel Pipeline. The existing pipeline to Johnson County has a capacity of about 7.0 MGD considering the existing constraints. Additional capacity can be obtained relatively inexpensively up to about 11 MGD, by the installation of an in line booster pump station. At about 11 MGD, it will be necessary to construct a parallel line from the SWATS to JCRWSC Water Plant #12. The larger line and the expected amount of water taken at Water Plant #12 will allow operation of the existing line from there to the TST until the flow reaches about 14 MGD. At that time, an additional in line booster pump station to serve the western portion of Johnson County will extend the life to beyond the year 2020 for all of the options considered. The size of the parallel pipeline is proposed to be 36 inches in diameter. The timing of each improvement depends on the option that is selected. The high service pump station at the plant would need to be upgraded during each incremental expansion. Appendix D, page D-1 shows the principal capital improvements required and their probable estimated project cost in 1999 dollars, for the baseline condition that includes only the existing Participants. Figure 1 shows the Johnson County pipeline to be paralleled in the future.

Hood County Pipeline. The City of Granbury (Granbury) receives water from the SWATS plant through an AMUD pipeline. The pipeline does not have adequate capacity to provide all the water needed for Granbury and also to meet the needs of AMUD's customers. Granbury has recently built a 12- inch pipeline along SH377 that will provide service to customers along SH377 and provide an additional connection to the AMUD system. However, that pipeline and

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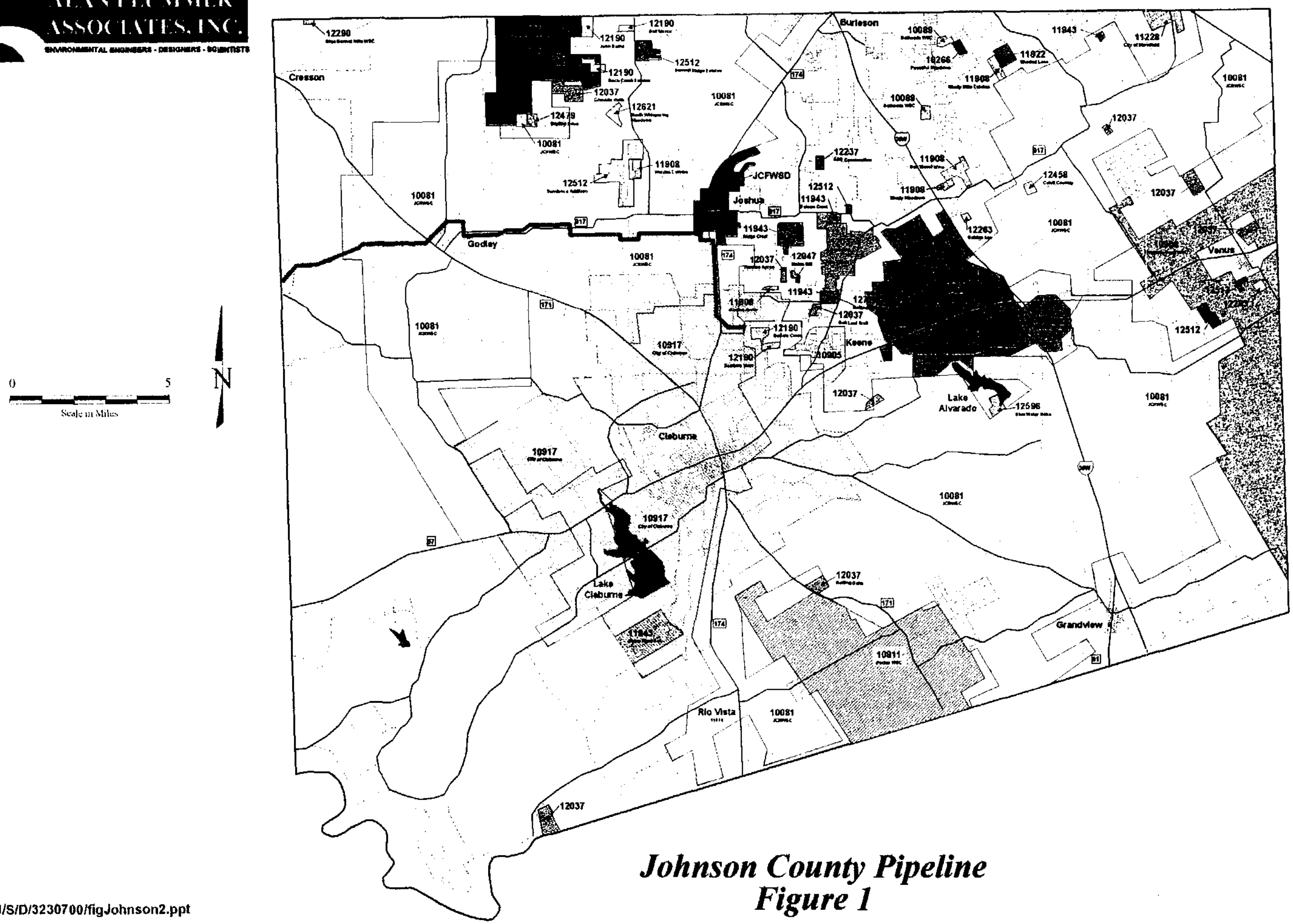

Johnson County Pipeline
Figure 1

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the AMUD pipeline will not provide sufficient capacity to meet the projected Granbury needs. It is recommended that a new pump station and pipeline be constructed from the SWATS plant to Granbury that could be used by both Granbury and AMUD to provide the capacity needed for immediate and future growth. Figure 2 shows the a proposed general route for the Hood County pipeline. The pipeline should be sized to provide for a minimum of a 20 year projected growth. AMUD could tap the line at various places to provide for their continuing growth, and if Aqua Source became a member of the system, a branch line could be provided for service to several of their subdivisions including Bentwater, Mallard Point, Quail Ridge, Nolan Creek, Country Meadows, North Fork Creek, Plaza East, and Eastwood Village. It is anticipated that a separate pump station would be constructed with suction from the SWATS Clearwell. It would need to be expanded with each increase in demand from AMUD and Granbury. An alternative would be to increase the high service pump capacity, presently owned and operated by AMUD, but that would require more coordination, since AMUD also uses that pump station for their well system. Appendix D, page D-2 shows the principal capital improvements required and their probable estimated project cost in 1999 dollars.

Extend Johnson County Pipeline to Keene or Bethany (Option 1 or 2). If only Keene, or Keene and Bethany opt to become Participants of the SWATS, then an extension of the Johnson County Pipeline from Water Plant # 17 is the appropriate expansion. The line should be constructed for at least a 20 year capacity life. The effect of adding these two Participants would be a 25-35 percent increase in the peak flow of the Johnson County Pipeline. It would also be a 10-15 percent increase in plant production. Appendix D, page D-3 shows the principal capital improvements required and their probable estimated project cost in 1999 dollars for Option 1. Appendix D, page D-4 shows the principal capital improvements required and their probable estimated project cost in 1999 dollars for Option 2. Figure 3 shows the extension for Keene (Option 1). Figure 4 shows the extension to Keene and Bethany (Option 2).

Extend Johnson County Pipeline to Alvarado (Option 3 or 4). If JCRWSC opts to participate in a line to the eastern portion of the county, then Keene, Bethany, and Alvarado could be served by that pipeline. The line would extend from the existing Johnson County Pipeline along a utility easement to a point east of IH35W. The effect of adding all of these Participants (Option 4) would be a 75 percent increase in the peak flow of the Johnson County Pipeline. It would also be a 35 percent increase in plant production. Construction of Option 3 or Option 4 would be in lieu of Option 1 or Option 2. Appendix D, page D-5 shows the principal capital improvements required and their probable estimated project cost in 1999 dollars for Option 3. Appendix D, page D-6 shows the principal capital improvements required and their probable estimated project cost in 1999 dollars for Option 4. Figure 5 shows the extension to east of I-35 (Option 3). Figure 6 shows the extension to Alvarado (Option 4).

Extend Johnson County Pipeline to Cleburne (Option 5). If Cleburne opts to become a member of SWATS, then an extension of the Johnson County Pipeline from Water Plant #17 is the appropriate expansion. The line should be constructed for at least a 20 year capacity life. The effect of adding Cleburne to the system would be a 45 percent increase in the peak flow of the Johnson County Pipeline. It would also be an 20 percent increase in plant production. Appendix D, page D-7 shows the principal capital improvements required and their probable

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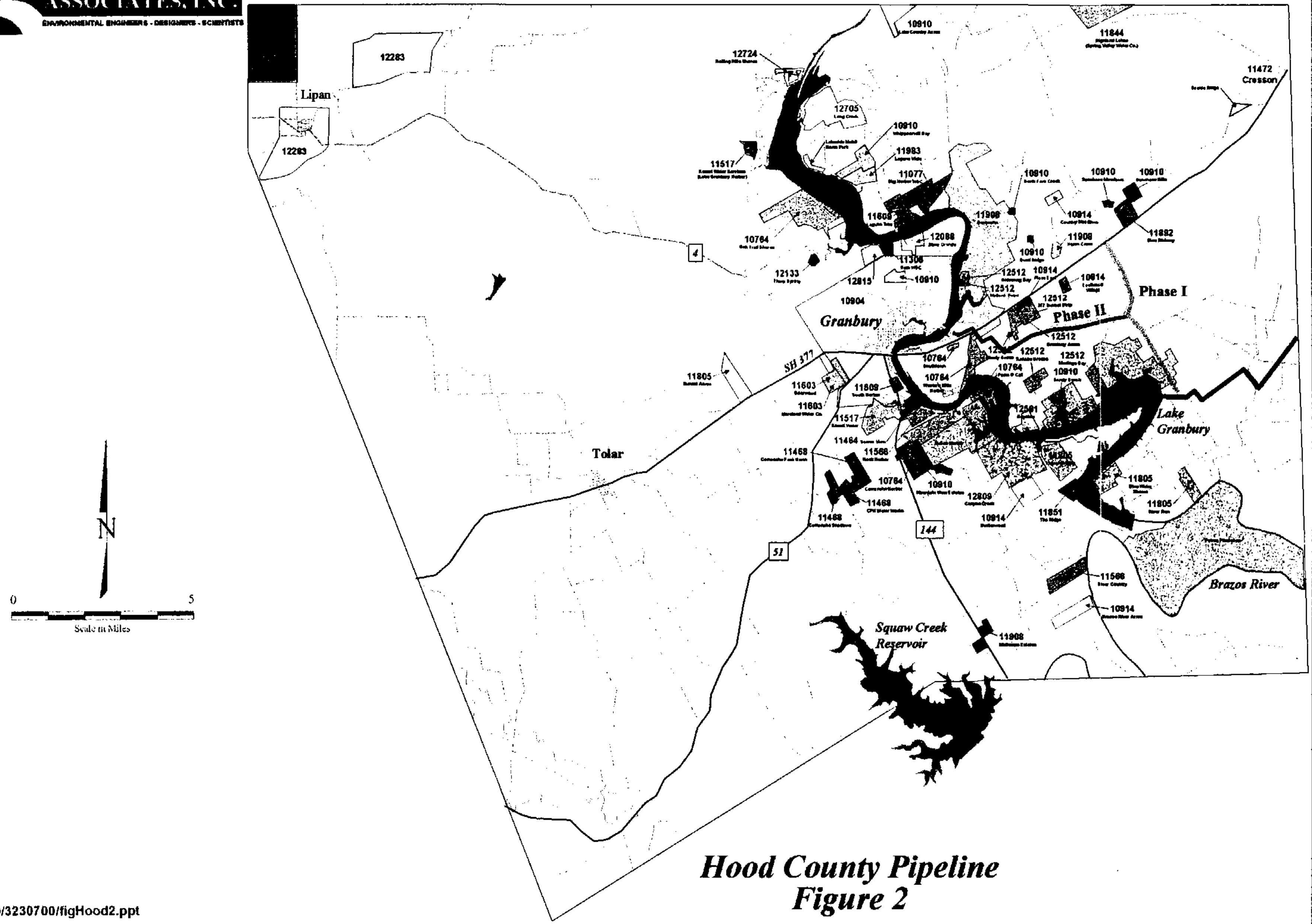

Hood County Pipeline
Figure 2

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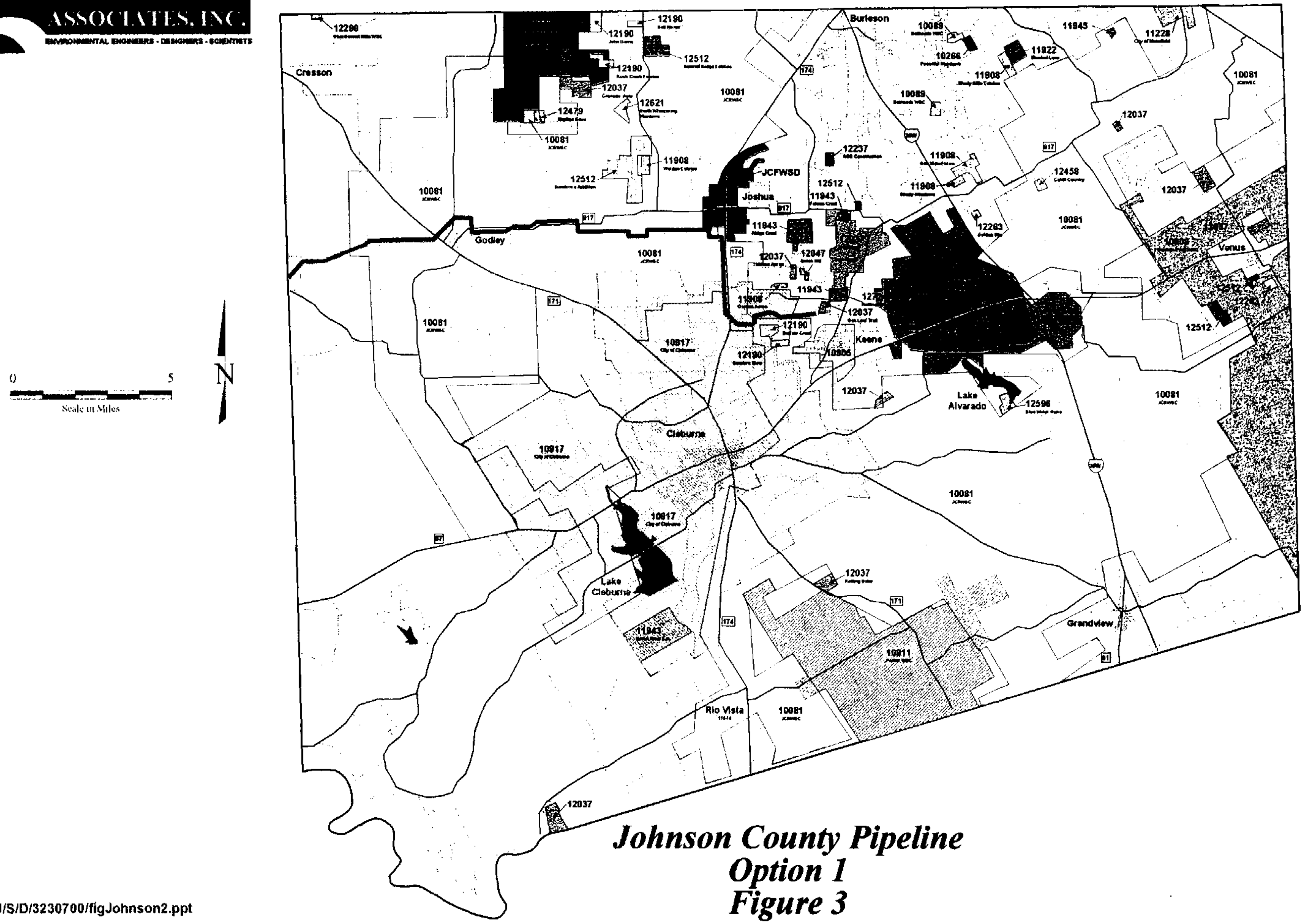

Johnson County Pipeline
Option 1
Figure 3

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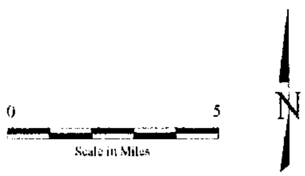

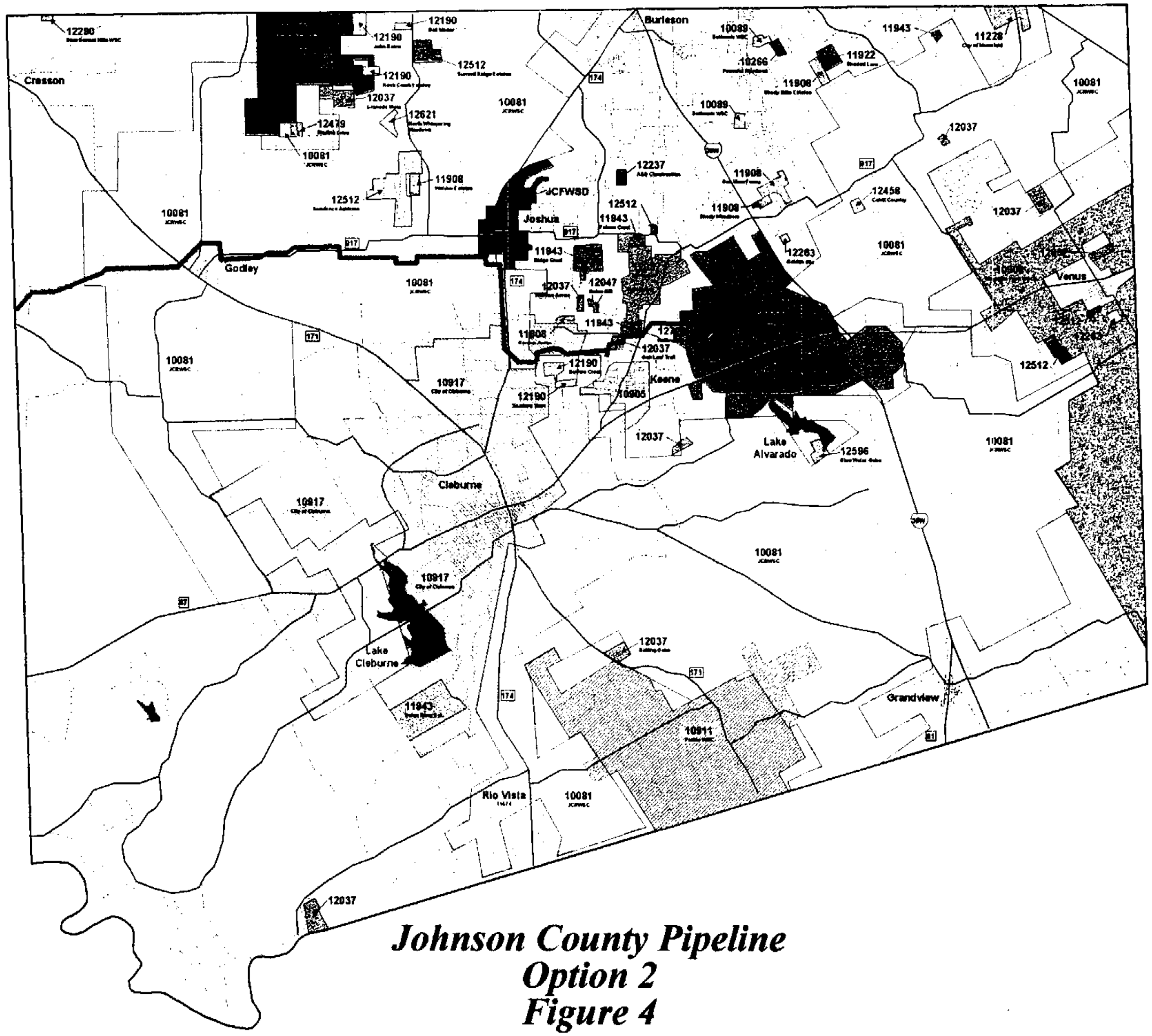

Johnson County Pipeline
Option 2
Figure 4

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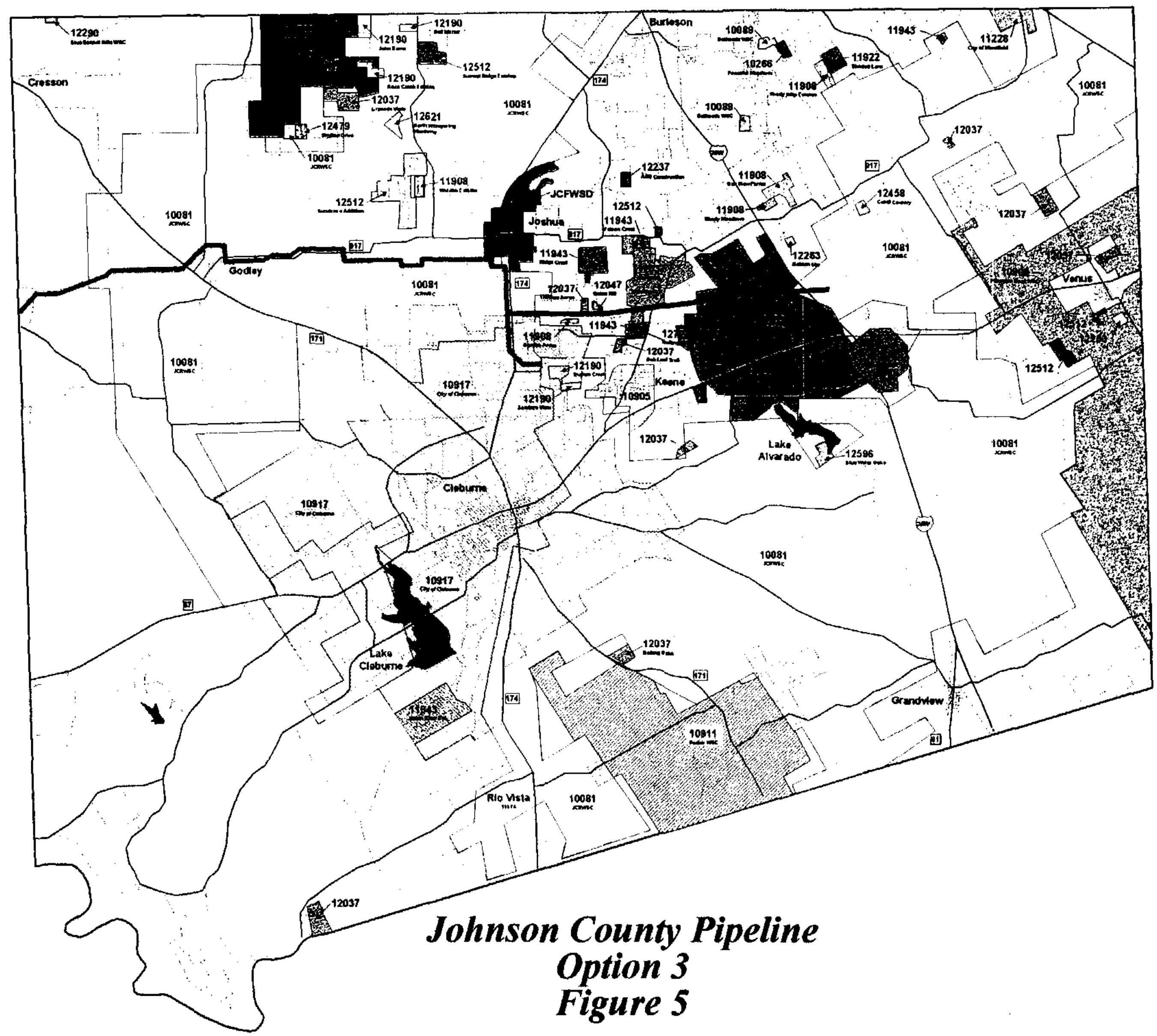

Johnson County Pipeline
Option 3
Figure 5

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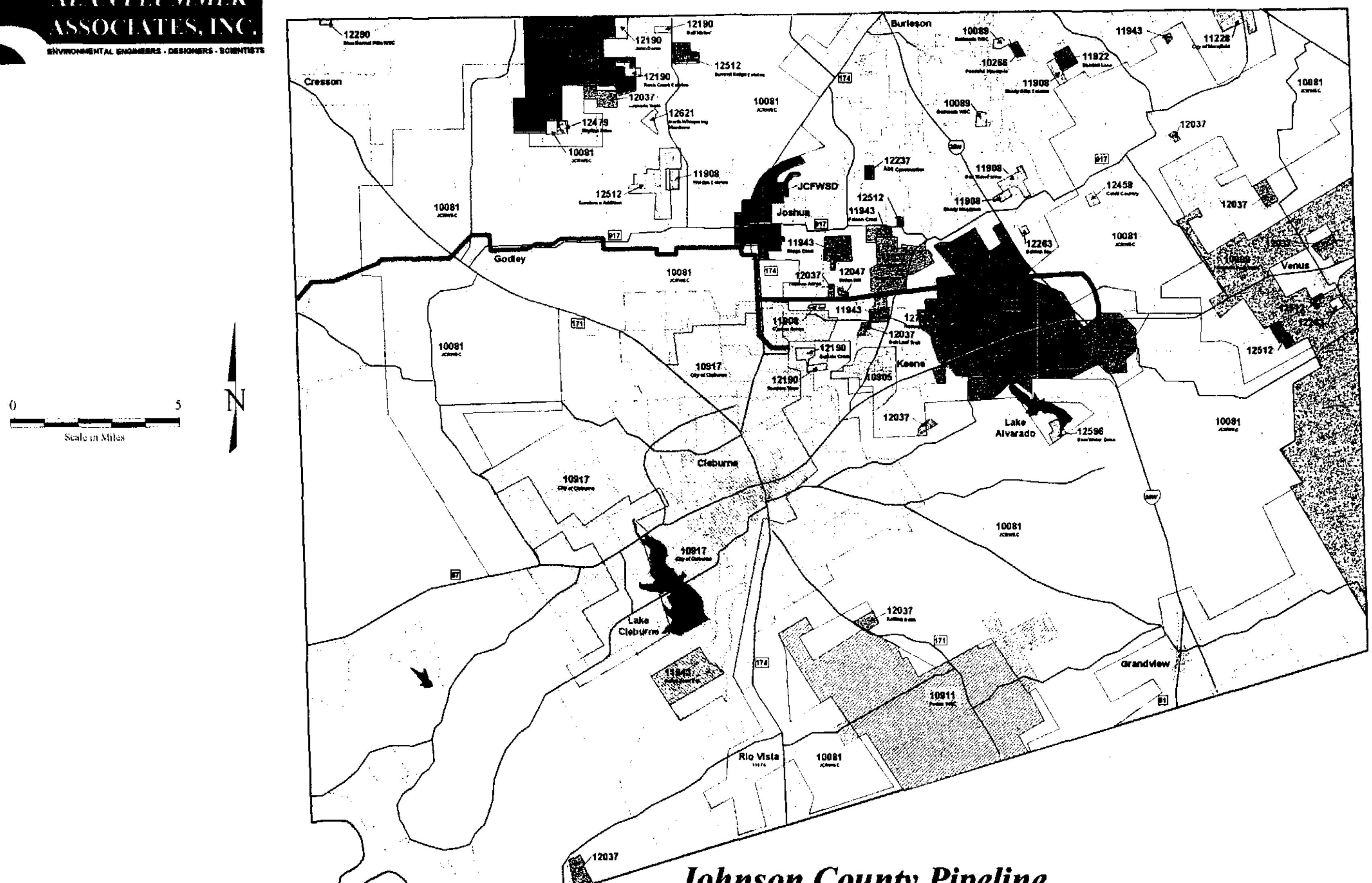

Johnson County Pipeline
Option 4
Figure 6

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estimated project cost in 1999 dollars for Option 5. Figure 7 shows the extension to Cleburne. Please note that options 1, 2, 3, and 4 are mutually exclusive, but Option 5 could be constructed with any of the other options. It is shown added to the base option only, for simplicity.

DISTRIBUTION SYSTEM PHASED IMPLEMENTATION

The distribution system to be constructed will largely depend on what Participants and new Participants are willing to contract and pay for, and whether SRF State Participation Funds are available for the future capacity. However, even if there are no new Participants willing to contract for water, the system needs to be expanded for the four existing Participants. The expansion should be structured so that it can be extended, or enlarged if new Participants are willing to join the system. Table 4 is a table of the demand flows in the existing Johnson County pipeline. The graph at the bottom of Table 4 shows the peak flow the pipeline would be expected to carry for each of the options considered. The expansion concept is to size pipelines to accommodate projected flow for at least 20 years, and to size pump stations to accommodate projected demands for about 5 years. The distribution system should be expanded in phases.

The following water delivery system improvements should be implemented in phases to serve the projected needs of the current Participants.

Phase 1

Phase 1 should be implemented immediately. It consists of the following:

1. Construct the Hood County pipeline from the SWATS Treatment Plant to SH 377. It consists of 9600 lineal feet of 24-inch pipeline and 13,000 lineal feet of 16-inch pipeline, and the addition of high service pumps to handle 5.0 MGD of flow. See (Figure 2). There is an immediate need to increase the pipeline size from the SWATS plant to Granbury to meet the needs of both Granbury and AMUD. A 24-inch pipeline is recommended to Acton to accommodate the 20 year demand. The addition of Aqua Source would require some minor rerouting of the pipeline, some additional pipeline and a possible up sizing of the high service pump station. This project needs to be done as soon as possible. The timing is not dependent on which option is selected. Table 5 shows the peak demand flow for the proposed Hood County Pipeline.

2. Construct additional pumping capability for Hood County. The recommended alternative is to construct a new joint pump station to serve Granbury's and AMUD's customers to the north. This would allow AMUD to maintain the existing pump station to serve their customers to the south. A second alternative is to increase the pump station capacity belonging to AMUD. It could continue to be owned and operated by AMUD, or it could be converted to a SWATS pump station and operated like the one that serves Johnson County. The Hood County High Service Pump Station would be sized for a projected 5 year growth. The capacity would be increased when needed and sized for a projected 5 year growth at that time. (Refer to Appendix Page D-2.)

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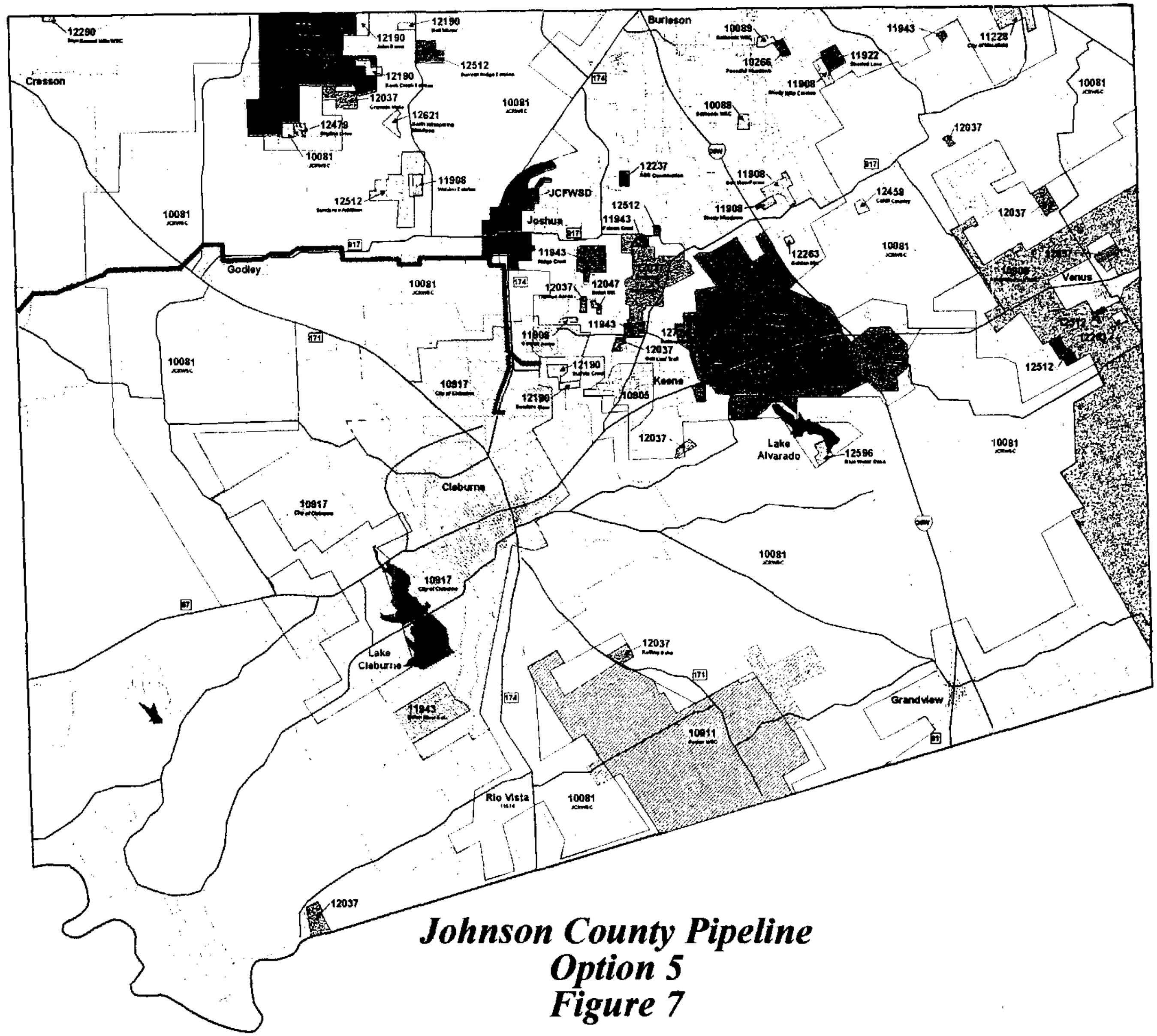

Johnson County Pipeline Option 5 Figure 7

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Expansion Summary

Johnson County Pipeline

Option	2000	2005	2010	2015	2020
Base	3.11	4.53	6.07	7.75	9.58
1	3.42	5.32	7.37	9.57	11.93
2	3.73	5.82	8.05	10.45	13.02
3	4.41	6.85	9.50	12.38	15.50
4	4.60	7.31	10.24	13.41	16.83
5	3.11	5.08	7.78	10.49	13.95

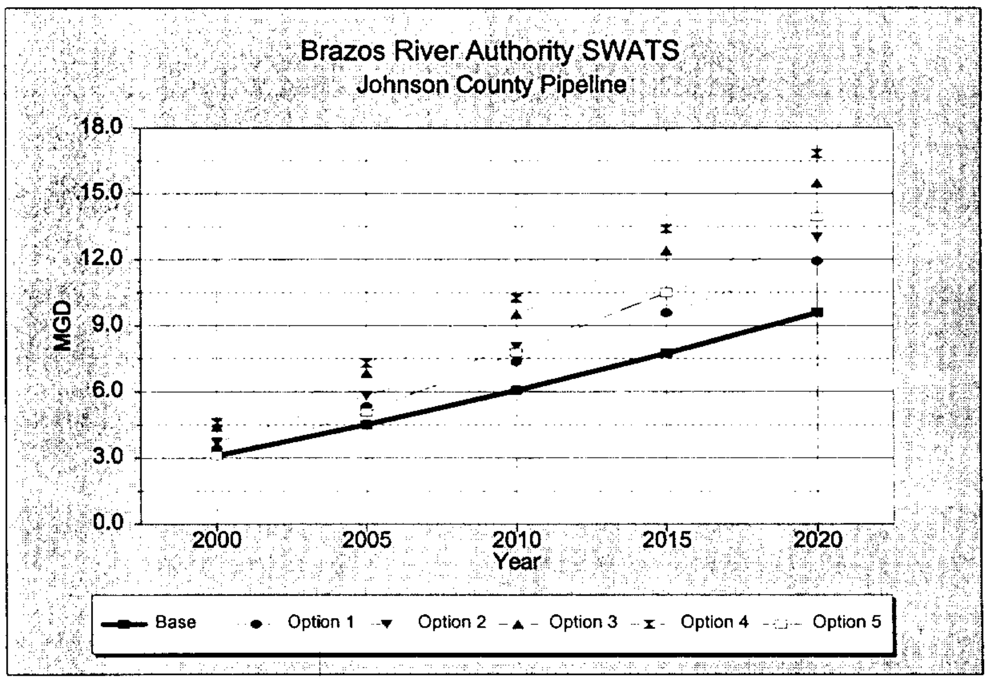


Table - 4

Expansion Summary

Hood County Pipeline

Option	2000	2005	2010	2015	2020
A	4.20	5.58	7.22	9.16	11.43

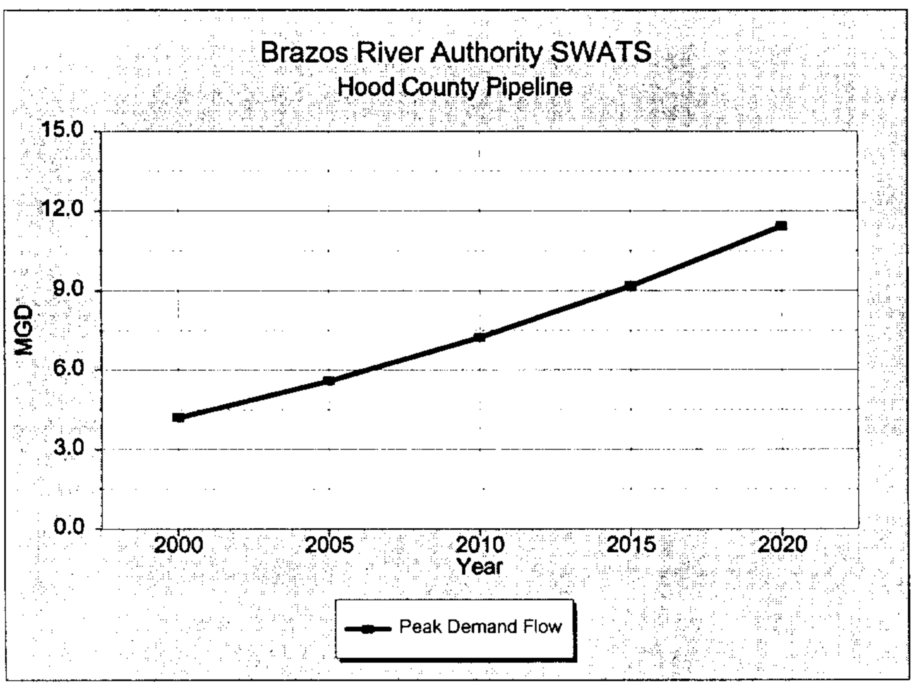


Table - 5

3. Install additional capacity in the Johnson County High Service Pump Station. The amount of additional capacity would depend on the additional subscribed amount of treated surface water. This project needs to be done immediately, and sized for a projected 5-year growth. The capacity would be increased when needed and sized for a projected 5-year growth at that time. (Refer to Appendix page D-1.)

4. Install an extension to the Johnson County Pipeline to serve additional Participants in the system.

Phase 2

Implement Phase 2 when the flow in the Hood County Pipeline reaches 5.0 MGD. This is estimated to be year 2003.

1. Install a second line to Granbury generally following Acton Road. It would consist of about 21,200 lineal feet of 20-inch pipeline and 8,700 lineal feet of 16-inch pipeline.

2. Install additional capacity in the Hood County High Service Pump Station. Additional incremental increases in pump station capacity would be added as needed.

Phase 3

Implement Phase 3 when the flow in the Johnson County Pipeline reaches 7.0 MGD. The estimated time of this event varies from 2004 to 2012 depending on the number of participants.

1. Install an in line booster pump station in the Johnson County Pipeline. This is a relatively inexpensive addition to get additional capacity from the existping pipeline, allowing the delay of a much more expensive parallel by at least 5 years.

2. Install additional capacity in the Johnson County High Service Pump Station.

Phase 4

Implement Phase 4 when the peak demand in the Johnson County Pipeline reaches 11.0 MGD. The estimated time of this event varies from 2011 to after 2020 depending on the number of participants

1. Construct a parallel line from the SWATS Treatment Plant to Water Plant #12. This project would be required exceeded 11.0 MGD.

2. Install additional capacity in the Johnson County High Service Pump Station.

Phase 5

Implement Phase 5 for Options 1- 4 when the flow in the pipeline causes the pressure at the Keene delivery point to drop below 25 psi. Phase 5 will be concurrent with Phase 4 for Options 3 and 4. It will be needed until after the year 2020 for Options 1 and 2.

1. Install an in line booster pump station in the line that serves the City of Keene.

2. Install additional capacity in the Johnson County High Service Pump Station.

PLAN FOR WATER TREATMENT PLANT IMPROVEMENTS

Raw Water Quality

The raw water for SWATS is diverted from Lake Granbury. Lake Granbury, which is impounded by Decordova Bend Dam, was constructed by the Brazos River Authority for water conservation, water supply, and water-based recreation. The lake provides 136,823 acre-feet of storage capacity.

The quality of the water in Lake Granbury is dependent upon the quality of the upstream Brazos River and the rainfall runoff from adjacent watersheds. In general, the water in Lake Granbury is a good quality suitable for a potable water supply. The water does exhibit the occurrence of eutrophication which is a normal condition for most Texas reservoirs. The occurrence of eutrophication results from nutrients, primarily nitrogen and phosphorus, being introduced into the lake water. The potential effect of eutrophication includes contributing to taste and odor conditions and can increase the levels of THM precursors. Each of these effects can be properly treated by the water treatment plant. The Authority's environmental and water quality program should continue to monitor the eutrophication conditions as well as nutrient loads being introduced into the lake.

A summary of water quality data for other selected parameters is shown in Table 6. As indicated in the table, the levels of TDS and chloride have been measured to be as high as 1730 mg/L and 710 mg/L, respectively. A major objective of the water treatment by the SWATS plant is to reduce the chloride to 250 mg/L or less. The reduction of chloride to 250 mg/L can be achieved by several treatment processes including the currently used Electrodialysis Reversal (EDR). The EDR units have proven to be very effective in achieving the levels of treatment required. Reverse osmosis is also considered a leading candidate to accomplish the treatment.

A particular constituent that effects the type of treatment process selected to reduce chloride and TDS is barium. Current Authority and other water quality sampling and testing programs do not test for barium in the water. The data available for Lake Granbury water, which is only two test results, reflects a barium concentration 0.14 to 0.3 mg/L. Although sufficient water data is not available for barium in Lake Granbury, studies that have examined sources of minerals being introduced into the Brazos River upstream of Lake Granbury above Possum Kingdom Reservoir have determined the presence of barium. Three tests of the Lake Granbury sediment indicate an

LAKE GRANBURY WATER QUALITY DATA

Parameter	Units	Minimum	Maximum	Mean	Number of Samples	Reference
Total Dissolved Solids	mg/l	191	1,730	1,080	102	1
Conductivity	umhos/cm	691	3,260	2,240	463	2
Chloride	mg/l	108	710	447	48	2
Sulfate	mg/l	56	485	268	48	2
pH	SU	7.1	8.7	8.0	394	2
Temperature	F	41	85	66	151	2
Alkalinity	mg/l $CaCO_3$	81	146	108	48	2
Calcium	mg/l	33	350	100	102	1
Magnesium	mg/l	5.8	50.0	29.4	102	1
Silica	mg/l	0.8	12.0	6.6	102	1

References

1 USGS Data 1992-1997

2 TNRCC Data 1981-1992

average concentration of barium of 190 mg/kg. The significance of barium with respect to water treatment is discussed below. In order to further evaluate treatment alternatives, it is important that the Authority gather additional barium data in the future.

Safe Drinking Water Act Issues

Public health and aesthetic concerns are the motivation for water treatment. The first paragraph of the American Water Works Association (AWWA) Water Quality and Treatment Handbook states, "In order to be used for human consumption, water must be free from organisms that are capable of causing disease and from minerals and organic substances that could produce adverse physiological effects. Drinking (or potable) water should be aesthetically acceptable; it should be free from apparent turbidity, color, and odor and from any objectionable taste."

The guidelines used to determine how to meet these goals come from federal and state legislation and the science and medical communities. BRA can anticipate mounting pressures to provide an adequate quantity of safe water while the public's definition of safe becomes more stringent. The guidelines for safe water are expected to narrow due to the following factors:

- Public reluctance to accept any health risks associated with public water supplies;
- Globalization and rapid transportation that will increase the transfer of pathogens around the world;
- The increasing ability to identify and measure health impacts; and
- The increased number of sensitive individuals due to advances in medical technology.

One concept that has developed due to these increasing pressures is a multiple barrier approach for protection against waterborne diseases. These barriers are: protection of source water, water treatment, and protection of the distribution system.

The United States Environmental Protection Agency (USEPA) has and will continue to develop various regulations concerning the production of potable water as required by the Safe Drinking Water Act and its amendments. The rules apply to potential pathogenic and chemical contaminants in the water supply.

Turbidity, disinfection contact time and residual concentrations, and fecal coliform presence are used to determine the level of pathogenic inactivation in the finished water supply.

Turbidity is due to suspended particulate matter in the range of colloidal particles, with diameters from 1 micron down to 0.001 micron. Turbidity is removed in the water treatment process for aesthetic reasons, but the measure of turbidity throughout the treatment process is used to approximate the level of removal of many other constituents including the following: color, metals, pathogens, synthetic organic compounds (SOCs), and taste and odor constituents. The combined processes of coagulation, flocculation, sedimentation, and filtration are responsible for the removal of turbidity and associated constituents.

The established correlation between turbidity removal and crypto sporidium removal has lead to more stringent turbidity removal goals. Cryptosporidium has been identified as a potential contaminant of municipal drinking water supplies. A few outbreaks of *Cryptosporidiosis* have been linked to contaminated drinking water supplies, most notably in Milwaukee a few years ago. Field tests have shown that, if the turbidity in filtered water consistently reaches an optimum level of 0.1 nephelometric turbidity units (NTU), the risk of cryptosporidium can be minimized.

Disinfection contact time (the product of the disinfectant concentration and the effective contact time) is used to ensure appropriate pathogen inactivation after the coagulation, flocculation, sedimentation, and filtration processes, creating multiple barriers for contaminants within the treatment plant. Fecal coliform presence is used to further ensure that pathogen inactivation has effectively taken place and disinfectant residual is to ensure recontamination does not take place within the distribution system.

Chemical contamination is controlled through maximum contaminant levels (MCLs) for various organic and inorganic compounds. The disinfection process used for pathogen inactivation can form certain byproducts with organic compounds that may be harmful over long periods of exposure. These disinfection-byproducts (DBPs) have generally been grouped into total trihalomethanes (THM) and haloacidic acids (HAA) for the purposes of regulation. In addition, total organic compounds (TOC), the precursors for DBPs are also regulated.

There are two primary regulations being developed that will have a significant impact on water treatment: the Enhanced Surface Water Treatment Rule (ESWTR) and the Disinfectant/ Disinfection-Byproduct Rule (D/DBPR). These together are referred to as the Microbial/Disinfection-Byproduct cluster.

The current Surface Water Treatment Rule (SWTR) requires the 99.9 percent removal of Giardia (3.0 log) and the 99.99 percent removal of viruses (4.0 log). Giardia is a particularly resistant bacteria that is easily identified and is used to determine the overall removal of bacteria from the treated water. The conventional treatment processes for the SWATS plant have the capacity to provide 2.5 log reduction of Giardia and 2 log reduction of viruses. The selected Disinfection then through sufficient disinfectant contact time will meet the remaining requirement for 0.5 log reduction of giardia and 2.0 log reduction of viruses.

Filtration is required at all surface water treatment plants in Texas by the Texas Natural Resource Conservation Commission (TNRCC). The first two barriers (sedimentation and filtration) within the plant are primarily responsible for turbidity removal. The importance of turbidity removal in water treatment is due to the associated removal of bacteria, viruses, and other potentially harmful constituents. In addition, there has been an established correlation between turbidity removal and crypto sporidium removal.

Crypto sporidium has been identified as a potential contaminant of municipal drinking water supplies. This protozoan parasite, first identified in 1976 as a human pathogen, is now recognized as a common cause of abdominal related illnesses including diarrhea, abdominal cramping, and vomiting. Cryptosporidium ocysts are very small (2-6 um) and have shown to be somewhat resistant to chlorine disinfection. Therefore, maintaining optimum finished water turbidities of 0.1 NTU or below is necessary to reduce the risk of cryptosporidium contamination. Disinfection is the final barrier in the treatment process and is required by the SWTR.

The ESWTR and the D/DBPR are scheduled to be issued (promulgated) in November 1998. Surface water systems serving 10,000 people or more are to be in compliance by November 2001. The long-term 1 ESWTR and the Groundwater Disinfection Rule are scheduled to be promulgated in November 2000 and be in effect by November 2003.

The ESWTR will require that finished water turbidities be less than 0.3 NTU 95 percent of the time, that individual filter turbidities not exceed 0.5 NTU, and that turbidity spikes after back washing be essentially eliminated. Filter particle counters may be required in the subsequent LTI or LT2 ESWTRs.

The LTI ESWTR will include the Filter Backwash Rule that will require treatment of spent backwash water returned to the plant and will limit the rate of return of spent backwash water.

The D/DBPR will reduce the MCL for THMs to 0.08 mg/L, will establish an MCL for five HAAs of 0.06 mg/L, will require an overall reduction of TOC prior to disinfection, and will limit the maximum disinfection concentrations.

The use of chlorine for disinfection of surface water will be subject to the D/DBP Rule. This may require monitoring and lowering the raw water TOC concentrations if the raw water TOC concentrations exceed the 2.0 mg/L limit established by the D/DBP Rule to require specific TOC reductions. Since TOC is used as a surrogate for DBP precursors, the D/DBP Rule may, in the future, require its concentration to be reduced prior to the addition of chlorine when raw water TOC concentrations exceed 2.0 mg/L, unless (1) the treated water TOC concentrations are below 2.0 mg/L or (2) the raw water TOC concentrations are below 4.0 mg/L, the alkalinity is greater than 60 mg/L, and finished water THM and HAA concentrations are below 0.04 mg/L and 0.03 mg/L, respectively. The treatment technique specified in the Rule which will be used to reduce the TOC concentrations is called enhanced coagulation. For raw water TOC concentrations between 2.0 and 4.0 mg/L with an alkalinity greater than 120 mg/L, a 20 percent TOC reduction will be required.

To optimize coagulation for the removal of turbidity and TOC may require chemical addition for pH adjustment. Optimum pH levels for TOC removal are normally between 5 and 6, and optimum pH levels for turbidity removal are normally between 6 and 7. Jar testing may be required to determine the range of pH that is effective for the removal of both TOC and turbidity.

The Ground Water Disinfection Rule is expected to require all groundwater to meet the same disinfection contact time (CT) requirements as surface waters and to increase the testing of groundwater required.

Conventional Treatment

The SWATS conventional water treatment plant has recently been uprated in capacity from 5 MGD to approximately 7 MGD. The plant generally consists of three raw water pumps, approximately 4,000 LF of 24-inch raw water line, two 60-foot diameter solids contact clarifiers, four 392 square foot dual media (sand/anthracite) filters, a 750,000 gallon clearwell, transfer pumps, and 5 MGD of EDR treatment units, a 1 million gallon finished tank, and two high service pumps.

Chlorine dioxide is used for disinfection and taste, odor, and algae control. Chloramines are used for disinfection in the finished water.

At a 7 MGD treatment rate the surface loading rate on the solids contact clarifiers is 0.86 gpm/SF and filter loading rate is 3.1 gpm/SF with all four filters in operation and 4.1 gpm/SF with one filter out-of-service for back washing. The loading rates are well within accepted criteria for solids contact clarifiers and dual media filters.

In order to fully optimize treatment performance and reduce the risk of microbial contamination, the treatment plant should be operated at as near a constant rate as possible each day with flow "spikes" eliminated or greatly reduced. Pulsing the water through the plant can contribute to particle breakthroughs every time the flow rate is significantly changed (such as turning on or off a raw water pump). The variable frequency drive at the raw water pump station should be used to gradually adjust the raw water flow into the plant. The addition of more treated water storage will enable the plant to operate on a consistent basis throughout the day and not have to adjust the treatment rate in response to hourly demands.

In order to improve both turbidity and TOC removal through the clarifiers, tube settlers are recommended. With optimized chemical coagulation, settled water turbidities of 0.5 NTU or less have frequently been obtained on a consistent, long-term basis using tube settler with solids contact clarification. Additionally, it may be possible to uprate the clarifier capacity as much as 50 percent using tube settlers. This would require either pilot testing, or full scale testing on one clarifier to obtain the data necessary to prove the performance of the renovated clarifiers and develop the data necessary to request the uprating approval from the TNRCC.

In order to reduce the possibility of turbidity or particle breakthroughs, it is recommended that an additional 24-inches of anthracite be added to each filter. In order to increase the media depth, it may be necessary to replace the existing filter bottoms and/or raise the backwash troughs in each filter. A settled water and filtered water particle counter are recommended.

It will be necessary to pretreat any backwash water prior to returning it to the plant. While the exact requirements to be included in the filter backwash rule have not yet been determined, TNRCC is requiring all spent backwash water to be at a minimum settled and decanted prior to being returned to the plant. In addition, the return flows must be pumped back to the plant over as long a period as possible to reduce the impact on the overall raw water quality (and chemical dosing requirements). The chemical feed equipment must be paced from the combined flow (raw plus return) into the plant.

Advanced Treatment (Desalting)

Because of the brackish water in Lake Granbury, any expansion of the existing treatment plant will need to provide for salt removal capabilities in addition to conventional treatment. This project has examined both EDR units and RO units to provide the desalting required for the expansion. This examination determined that neither process has a definitive cost advantage. It is noted that the RO process provides the ability to remove some of the pathogens and other organics that could be beneficial. Because of a lack of adequate information on certain quality parameters in the raw water supply, and because the RO process is very sensitive to those parameters, we believe that a series of sampling, testing, and pilot scale testing would be necessary before we could recommend the RO process. It is recommended that BRA begin an immediate sampling and testing program to gather information required to further evaluate the reverse osmosis process. See Figure 8 for a suggested testing program. If adequate data is not gathered prior to initiating the design of the water treatment plant expansion, the EDR process should be selected for the immediate term expansion. Collecting the appropriate data and performing further evaluations could result in the reverse osmosis process being the leading candidate for future expansions.

Energy Conservation

Presently, pumping operations are cut back between 5:00 p.m. and 9:00 p.m. during the summer and 6:00 a.m. to 10:00 a.m. in the winter, to save on demand charges. This operation saves on the total electrical cost, but severely restricts the ability of the plant to maintain the versatility it needs for the most efficient water production.

One solution would be the installation of an electric generator to power one or more of the high service pumps. Besides being used for "electric peak-shaving," the generator would also provide standby service in case of a plant power outage.

A second possibility is a renegotiation with the power company. With the possibility of deregulation of the electrical power industry, it is likely that peak electrical demand charges may be substantially modified and reduced, especially for major power users such as the SWATS plant. BRA may be in a good position to renegotiate the electric rates at the plant to eliminate or reduce the current peak electrical demand charges.

A third possibility would be the installation of additional ground storage at the plant. This would allow the plant to lower the level in the ground storage tank just prior to the peak time and then continue producing water at a uniform rate through the peak time. Additional ground storage is recommended even if other provisions can be made for energy conservation, because it will give the plant operating staff some versatility that they do not presently have.

Suggested sampling and testing procedure
for
Determining the suitability of the RO Process

Barium:

- Sample once a week on a Monday or Tuesday and send to the lab to get results back the same week.
- Continue this once-per-week testing program for about two months, if there are no drastic changes. However, if there is a heavy rainfall upstream; or there are other reasons to think there might be a significant change in Barium concentration, resume once-per-week testing until changes are quantified.
- Record the conductivity (and the TDS if possible) at the time of the Barium sample. This may provide a correlation between Barium and Conductivity/TDS. Such a correlation, if any, would be a considerable benefit in setting dosage rates for antiscalant addition later on, if the RO option were to be installed.

Silt Density Index (SDI):

- Test for the 15-minute SDI once or twice per week for two months, then once every two weeks, for the remainder of a year. However, it will be beneficial to test more often if there is heavy rainfall, or the raw water turbidity is otherwise high, or there is an upset in solids contact reactors.
- The SDI should generally be taken downstream of the cartridge filters, but it should be checked upstream of the cartridge filters once every two weeks, until a correlation is established.
- The main objective for the SDI testing is to show that the SDI going to the desalting units can be maintained at less than 5.0 most of the time.

Figure - 8

Plant Expansion

An analysis of the units required for treatment and the size of the existing units indicate that the optimum expansion of the SWATS treatment plant would be in 5.0 MGD finished water increments. That would mean that the conventional side of the plant would have a comparable incremental expansion from 6.25 MGD to 7.1 MGD (70 to 80 percent recovery). Table 7 shows the major components that would be expanded for each 5.0 MGD increment. Figure 9 shows each stage expansion in a different color. Note that, although the plant expansions are shown in 5-MGD increments, the first expansion is recommended to be 10 MGD because it is projected that a 10-MGD capacity will be exceeded by the year 2003. The plant site as planned will accommodate a treatment capacity of 35MGD. Also, it is important to note that when the plant capacity exceeds 20 MGD, it will be necessary to construct the remaining desalting units in a separate area of the plant. The decision to us RO in lieu of EDR at some later date will not substantially affect the layout. The foot print for an RO facility is slightly smaller than the same capacity EDR facility.

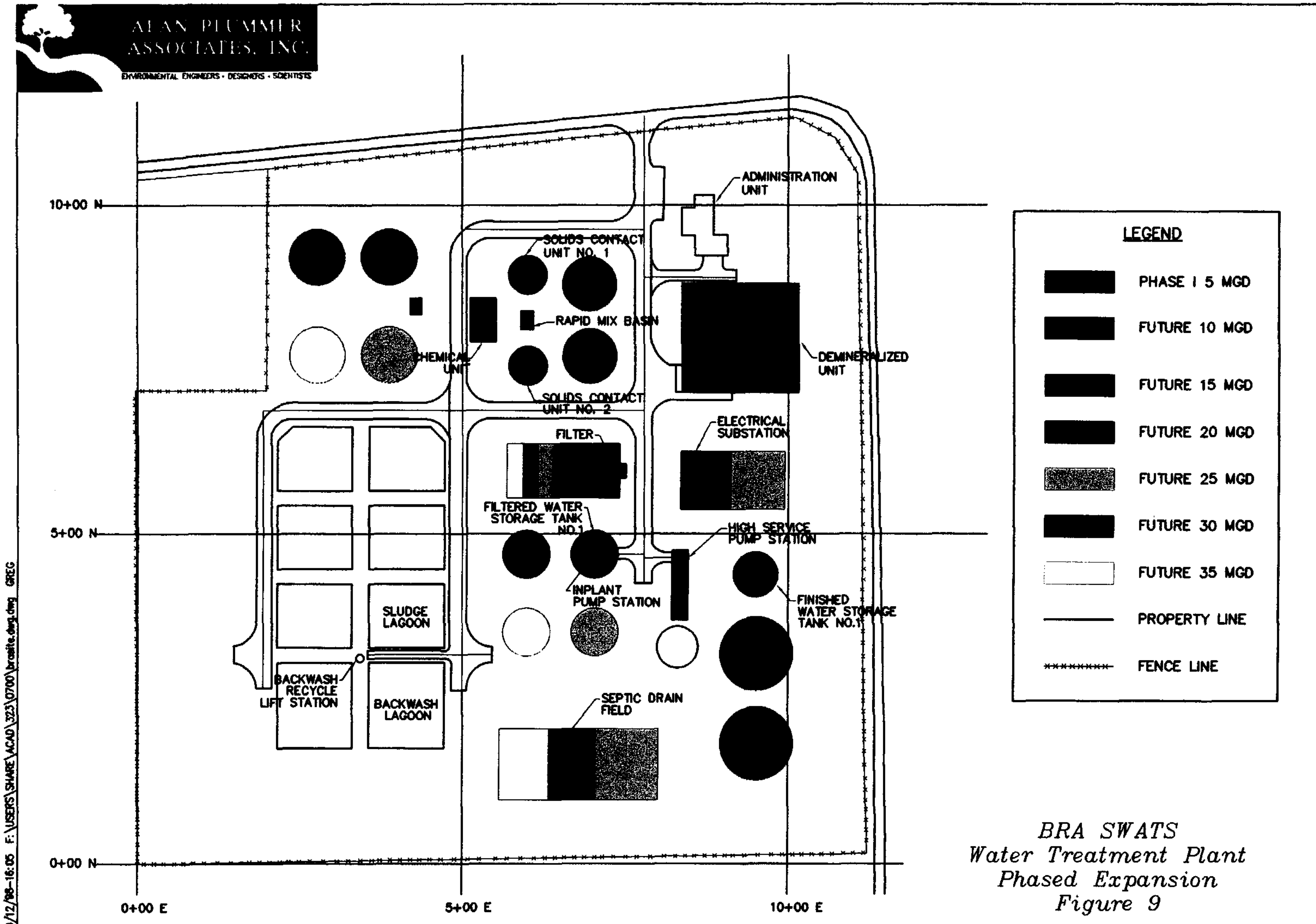
Table 8 shows the Opinion of Probable Project Costs for a 5.0 MGD expansion of the existing treatment plant. Note that each 5.0 MGD incremental expansion has an estimate of probable project cost of $14,700,000. Table 9 shows the various treatment plant demands for each of the different options evaluated. An immediate 10.0 MGD initial expansion is recommended for all options, because a 5.0 MGD expansion would be a capacity in less than three years for every option. It is estimated that a 10 MGD expansion could be designed and constructed at a savings of about 15 percent over the cost of two projects of 5.0 MGD each.

It should be noted that the basic plan for plant expansion assumes a conventional treatment process similar to the one that exists at the SWATS Treatment Plant. With the advances in various membrane technologies, it is important during the preliminary design stage of the treatment plant expansion that those technologies be considered as a replacement to the conventional treatment process. Some of the advantages of membrane technology include reduction in the use of chemicals, possible reduction in by products formation, more consistent treated water as influent to the advanced treatment system. Some of the possible disadvantages are cost, limit of membrane production technology, and limited data on the long term operation of membrane plants. A recommendation should be part of the preparation of the preliminary design.

Plant Expansion Options

Uprated SWATS Plant

Plant Capacity		**10.0**			**15.0**			**20.0**			**25.0**			**30.0**			**35.0**	
Conventional Flow		**8,681** **12.5**			**13,021** **18.8**			**17,361** **25.0**			**21,701** **31.3**			**26,042** **37.5**			**30,382** **43.8**	
Demineralized Flow Efficiency		**6,944** **10.0**			**10,417** **15.0**			**13,889** **20.0**			**17,361** **25.0**			**20,833** **30.0**			**24,306** **35.0**	
Unit Processes	Size Req'd	Total No. of Units	Add	Size Req'd	Total No. of Units	Add	Size Req'd	Total No. of Units	Add	Size Req'd	Total No. of Units	Add	Size Req'd	Total No. of Units	Add	Size Req'd	Total No. of Units	Add
Raw Water Pumps	8,681	4	1	13,021	5	1	17,361	6	1	21,701	8	2	26,042	9	1	30,382	10	1
Rapid Mix	1,160	1	0	1,741	1	0	2,321	2		2,901	2	0	3,481	2	0	4,061	2	0
Flocculation	34,810	5	2	52,216	8	3	69,621	10	2	87,026	13	3	104,431	15	2	121,836	18	3
Sedimentation	139,242	4	2	208,862	6	2	278,483	8	2	348,104	10	2	417,725	12	2	487,346	14	2
	10,851	**4**		**16,276**	**6**		**21,701**	**8**		**27,127**	**10**		**32,552**	**12**		**37,977**	**14**	**2**
Filters	**1,669**	**6**		**2,504**	**8**		**3,339**	**10**		**4,173**	**12**		**5,008**	**14**		**5,843**	**16**	**2**
Backwash Pumps	22	0	0	22	0	0	22	0	0	22	0	0	22	0	0	22	0	0
Filtered Water Storage	781,250	1	0	1,171,875	2		1,562,500	2	0	1,953,125	3		2,343,750	4	1	2,734,375	4	**0**
Demineralizer Feed Pumps	9,931	5	2	14,896	7	2	19,861	9	2	24,826	11	2	29,792	13	2	34,757	15	2
Blend Pumps	6,944	4	1	10,417	6	2	13,889	7	1	17,361	9	2	20,833	10	1	24,306	11	1
Demineralizer	**6,944**	**6**		**10,417**	**9**		**13,889**	**12**		**17,361**	**15**		**20,833**	**18**		**24,306**	**21**	**3**
Finished Water Storage	2.50	3		3.75	4	**1**	5.00	5		6.25	7	**2**	7.50	8	**1**	8.75	9	**1**



BRA SWATS
Water Treatment Plant
Phased Expansion
Figure 9

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Lake Granbury Surface Water and Treatment System

Preliminary Opinion of Probable Construction Cost

5.0 MGD Advanced Water Treatment Plant Expansion

Raw Water Pump Station		$132,000
Rapid Mix Basin		$144,000
Clarifiers		$996,000
Effluent Filtration		$726,000
Other Plant Improvements		$1,356,000
Site Work and Yard Piping		$240,000
Miscellaneous		$726,000
Conventional 7.0 MGD WTP Modification	Subtotal	**$4,320,000**
5.0 MGD EDR Train		$3,600,000
Installation		$1,800,000
Building		$900,000
5.0 MGD EDR Demineralization	Subtotal	**$6,300,000**
5.0 MGD WTP Expansion Opinion of Probable Construction Cost		**$10,620,000**
Engineering and Survey	14%	$1,486,800
Construction Admin	6%	$637,200
Financial	15%	$1,911,600
5.0 MGD WTP Expansion Opinion of Probable Project cost		**$14,700,000**

Expansion Summary

SWATS Treatment Plant

Option	2000	2005	2010	2015	2020
Base	8.07	11.11	14.57	18.47	22.87
1	8.37	11.91	15.86	20.28	25.22
2	8.69	12.40	16.55	21.17	26.32
3	9.37	13.43	18.00	23.10	28.80
4	9.56	13.90	18.74	24.13	30.12
5	8.07	11.66	16.28	21.21	27.24

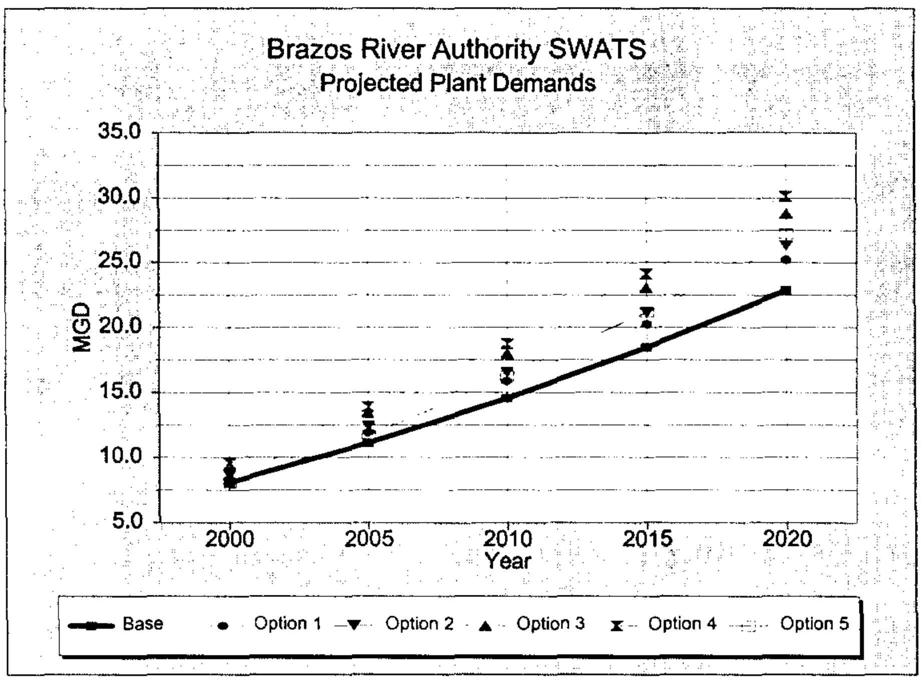

Table - 9

BUDGET CONSIDERATIONS

Introduction

The financial considerations for the SWATS Treatment Plant and Distribution system is complex due to the large number of factors that effect the costs of treated water. To standardize the estimated project budget for each of the different options studied, the following assumptions were made:

1. The existing budget was broken down for each participant for the following:
   a. Annual capital cost for the WTP
   b. Annual capital cost for the distribution system
   c. Annual operating budget fixed costs. This is not presently a contractual requirement. It was assumed to be personnel costs which are largely independent of the amount of water treated.
   d. Annual operating budget variable costs. These include power, chemicals, and other remaining budget items that are generally proportional to the amount of water treated.
   e. Discrete variable costs, which are contractual requirement for services provided for each specific Participant.

2. New Participants were assumed to have similar contracts as the existing Participants

3. The projected budgets were prepared on an annual basis, with increases each time a capital improvement was made.

4. Capital expansions were added to the existing debt service payments and prorated to the appropriate Participants, based on their peak demand during that year.

5. The variable annual operating budget was increased proportional to the increase in average flow.

6. The fixed annual operating budget was increased proportional to the square root of the increase in average flow.

7. The average cost per 1000 gallons was based on the estimated annual usage for that year. **Please note: The unit cost of water is totally dependent on the amount of water actually used.**

Projected Unit Costs

This project has evaluated the probable unit costs associated with required improvements and/or expansions of the water treatment plant and distribution system to serve the Participants and other entities that would be served by various options described above. The capital expenditures associated with the various options are presented in Appendix F.

Appendix F, pages F-1 to F-12 shows the average estimated annual costs and costs per 1000 gallons for base option and each of the five other options over the twenty year period. The average unit cost for Lake Granbury surface water treated and delivered varies between $2.75 and $3.85 per 1000 gallons.

Note for all tables in Appendix F that unit cost figures depend on the assumed treated water usage. They will not be the same for all entities. Unit costs for each entity also depend on the following:

1. the ratio of the annual water usage to the contract amount
2. the apportionment of required capital investment
3. system equity buy in to be determined by BRA.

CONCLUSIONS AND RECOMMENDATIONS

1. The SWATS Participants and potential new customers should make commitments within the immediate time frame for future water service based on their peak demand.

2. The SWATS water treatment plant should be expanded to treat 15 MGD as soon as possible.

3. By the year 2020 the SWATS water treatment plant should be expanded to produce up to 30 MGD.

4. A chart should be developed based on actual peak daily water production, to predict the need to begin the process for the next expansion. When the peak daily production is within 2 to 3 MGD of the plant design capacity, design should begin on the next expansion. Figure 10 is a chart analyzing the base option demand as projected in this report. The chart should be modified annually when actual numbers are obtained.

5. The water distribution system to serve the City of Granbury and portion of AMUD should be expanded by construction of the Hood County pipeline as soon as possible.

6. BRA should undertake a sampling and testing program to gather information relative to further examination of the utilization of RO or EDR for future plant expansions.

7. BRA should continue communication with potential new customers of SWATS regarding regulations, raw water demand, treated water demands, and water supply issues.

SWATS Plant Expansion
Base Option

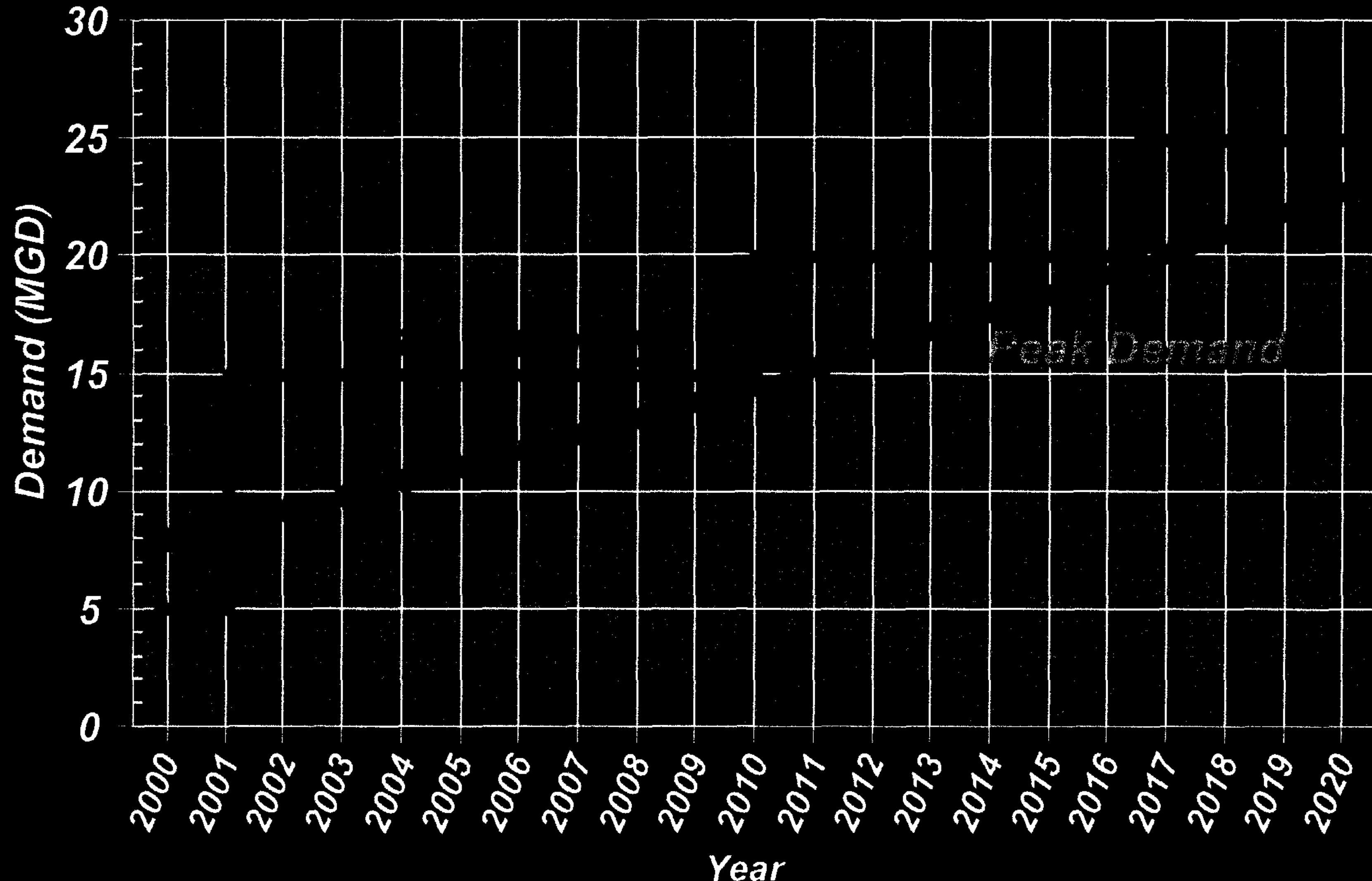

Figure 10

8. Review the existing contracts with the existing Participants to explore possibilities to change them to encourage base loading from surface water and satisfying peak demands with ground water. One possible change would be to redefine fixed cost to include those annual budget items that are constant regardless of flow (i.e., personnel costs). It is believed that with that modification, the variable cost would be on the order of $1.08 per 1000 gallons, and would then compare more favorably with the total cost of providing well water. The average fixed costs would be between $398,000 and $432,000 per MGD of contracted flow, depending on which option is selected.

9. The SWATS Participants and potential new customers should provide input to the Senate Bill 1 Regional Water Planning Committee regarding raw and treated water needs for the planning area.

10. The SWATS Participants and potential new customers should execute agreements with the Brazos River Authority to secure long-term rights to raw water needed to meet future demands. **The cost of this raw water is not considered in this report**.

11. Review the existing brine discharge permit to insure that increased brine flow and increased salt content in the brine flow will not exceed existing permit limits.

ATTACHMENT 1

TEXAS WATER DEVELOPMENT BOARD
REVIEW COMMENTS

Brazos River Authority
Lake Granbury Surface Water Treatment System
Expansion Feasibility Study

Long Range Potable Water Needs
For Customers in Hood County.

Hood County Annex #1

March 16, 1998 1:00 PM

Agenda

1.	Opening Remarks:	
2.	Purpose of the Project:	Tom Clark/Dennis Qualls
3.	Brazos River Authority Overview:	Tom Clark/Dennis Qualls
4.	SWATS Overview:	Jay Emami
5.	Project Review:	Jim Altstaetter
6.	Project Specific Discussion for Hood County:	Jim Altstaetter
7.	Questions:	

Notes:

Presenters:
Mr. Tom Clark, Water Treatment Division Manager, Brazos River Authority
Mr. Dennis Qualls, Water Resources Planner, Brazos River Authority
Mr. Jay Emami, Technical Development Manager, Brazos River Authority
Mr. James Altstaetter, Principal, Alan Plummer Associates, Inc.

Brazos River Authority
Lake Granbury Surface Water Treatment System
Expansion Feasibility Study

Long Range Potable Water Needs
For Customers in Hood County.

Hood County Annex #1

March 16, 1998 1:00 PM

Meeting Minutes

Mr. Tom Clark opened the meeting by welcoming everyone and indicating that this was the first of three meetings being held to explain the project to the public and to seek public input.

Mr. Tom Clark explained that the purpose of the project was to complete a study covering a 20 year period for the expansion of the BRA Surface Water Advanced Treatment System (SWATS). The study would be focusing primarily on the needs of utilities in Johnson County and Hood County. The report would address the needs of all persons in the county, but the recommended expansion would address only customers to be served by the SWATS.

Mr. Denis Qualls discussed the BRA organization. He also explained that the project was funded by a 50 percent grant from the Texas Water Development Board, with the other 50 percent coming from the local entities such as the county and the four existing participants of the SWATS.

Mr. Jay Emami explained the SWATS treatment plant indicating that it was an advanced treatment plant utilizing Electrodialysis Reversal as a process to remove salt content from the water. The plant is located in Hood County near Lake Granbury, and serves the Acton Municipal Utility District, the City of Granbury, the Johnson County Fresh Water District (JCFWSD), and the Johnson County Rural Water Supply Corporation (JCRWSC). In addition to the treatment plant, the BRA operates the raw water intake structure and raw water pipeline from Lake Granbury; and a high service pump station, force main, and delivery points to participants in Johnson County.

Mr. Jim Altstaetter outlined the scope of the project which was primarily the following:

- Determine potential new customers
- Identify water needs of the existing participants.
- Define future population and water demands
- Develop several alternative plans to meet the identified future needs.
- Develop opinions of probable cost for the alternative plans
- Develop a plan and opinion of probable cost for the water treatment plant expansions.

Mr. Altstaetter noted that this would be an iterative process. Potential plans would be developed and discussed with the potential customers. These discussions would lead to modifications to those plans and further discussions. The final report would include alternatives that would be usable and could be implemented if approved

Mr. Jim Altstaetter indicated that the BRA SWATS Treatment Plant served the existing participants in Hood County, the City of Granbury and AMUD, through a connection to AMUD located at the SWATS Treatment Plant. The City of Granbury gets SWATS water from the AMUD distribution system. Both entities would be questioned to determine their expansion needs as well as the potential for other utilities and subdivisions in the county to become participants in the SWATS.

A representative from the Rio Brazos Water Supply Corporation in southern Parker County expressed interest in a pipeline extending north to their subdivision.

A representative from Southwest Water Services Inc., expressed his interest in the timing of the expansion project. Southwest Water presently operates a demineralization plant for Oak Trail Shores. Timely SWATS expansion could remove the need to expand the existing treatment plant.

A representative from H2M Water Company expressed an interest in the project, from the standpoint of providing them an alternative source of supply.

The meeting adjourned at 2:00 AM.

Presenters:
Mr. Tom Clark, Water Treatment Division Manager, Brazos River Authority
Mr. Dennis Qualls, Water Resources Planner, Brazos River Authority
Mr. Jay Emami, Technical Development Manager, Brazos River Authority
Mr. James Altstaetter, Principal, Alan Plummer Associates, Inc.

Brazos River Authority
Lake Granbury Surface Water Treatment System
Expansion Feasibility Study

Attendee List

Hood County

03/16/98

Printed Name	Representing	Phone No.	Fax No.
Tony Emami	Brazos River Authority	254-776-1441	254-772-5780
JEFF STAMPS	H2M WATER COMPANY	817/654-1702	817/457-7554
DENIS QUALLS	BRAZOS RIVER AUTHORITY	254 776 1441	254 772-7435
Tom Starr	AMUD	817-326-2361	817-326-5031
Ron Collins	Hood Co. Com. Pct 3	817-573-3300	
ALAN BROWN	RIO BRAZOS WSC	817-573-4131	817-279-1238
GREG REYNOLDS	CITY OF GRANBURY	817-573-7030	817 573 5591
John Chisholm	AMUD	817-326-4720	817-326-5031
Danny Miles	BRA	817-326-3484	817-326-3716

Brazos River Authority
Lake Granbury Surface Water Treatment System
Expansion Feasibility Study

Attendee List

Hood County

03/16/98

Printed Name	Representing	Phone No.	Fax No.
J K MASSIE	Rio Brazos Water Sup.	1-817-573-4131	
CLIFF Moody	Commissioner Pct 2 Hood Co.	1-817-579-3300	
[illegible]	Southwest [illegible]	214/36[illegible]	214/36[illegible]

Brazos River Authority
Lake Granbury Surface Water Treatment System
Expansion Feasibility Study

Long Range Potable Water Needs
For Customers in Johnson County.

City of Cleburne Civic Center

July 21, 1998 10:00 AM

Agenda

1.	Opening Remarks:	Jay Emami
2.	Population Projections.	Jim Altstaetter
3.	Candidates for Treated Surface Water	Jim Altstaetter
4.	Project Specific Discussion for Johnson County:	Jim Altstaetter
5.	Questions:	

Notes:

Presenters:
Mr. Jay Emami, Technical Development Manager, Brazos River Authority
Mr. James Altstaetter, Principal, Alan Plummer Associates, Inc.

Brazos River Authority
Lake Granbury Surface Water Treatment System
Expansion Feasibility Study

Long Range Potable Water Needs
For Customers in Johnson County.

City of Cleburne Civic Center

July 21, 1998 10:00 AM

Meeting Minutes

Mr. Jay Emami welcomed everyone to the meeting on behalf of BRA and indicated that the purpose was to update the public on the progress of the project to date.

Mr. Jim Altstaetter explained that the population projections from the TWDB and the NCTCOG were indicating a percent growth that was much lower than what he believed to be the actual. Mr Altstaetter indicated that a more realistic number for Johnson County would be between 3 and 4, and would try to develop the rationale that would support that growth projection to be approved by the TWDB.

Mr Jim Altstaetter showed an overhead map that identified the most likely distribution projects to serve Candidates for Treated Surface Water. He indicated that he had identified Keene, Alvarado, and Bethany WSC as potential new participants for the SWATS in Johnson County. Also, there were several utilities that could be served by the existing participants. Particularly, all subdivisions that are located in close proximity to the existing distribution systems of the JCRWSC.

Mr Altstaetter showed 6 different charts that indicated potential alternatives for expansion of the distribution system into Johnson County. Options 1 and 2 showed a method of extending the pipeline to serve Keene and Bethany WSC. Options 3 and 4 showed a method of extending the pipeline to serve Keene, Bethany WSC, Alvarado, and JCRWSC on the east side. Option 5 showed that the existing pipeline would need to be improved in the future just to serve the existing participants, even if no new participants were added. Option 6 showed the extension of the pipeline to serve the City of Cleburne. .

The Bethany WSC and the City of Keene were both represented at the meeting. Both indicated their continued interest an expansion project, and both were very interested in what the project would cost, in terms of dollars per 1000 gallons of water purchased. Mr. Altstaetter indicated that it was necessary to further define the potential projects, including requirements for plant expansion before the costs could be determined.

The meeting adjourned at 11:00 AM.

Presenters:
Mr. Jay Emami, Technical Development Manager, Brazos River Authority
Mr. James Altstaetter, Principal, Alan Plummer Associates, Inc.

ALAN PLUMMER ASSOCIATES, INC.

ENVIRONMENTAL ENGINEERS • DESIGNERS • SCIENTISTS

JOB NAME

JOB NO. PAGE OF

CALCULATED BY DATE

VERIFIED BY DATE 7/21/98

PUBLIC MEETING, CLEBURNE CIVIC CENTER
JULY 21, 1998 10 AM

NAME	TITLE	ORGANIZATION	PHONE NUMBER
JIM ALTSTAETTER		ALAN PLUMMER ASSOC.	817-284-272
BRIAN McDONALD	ENGINEER	ALAN PLUMMER ASSOC.	817-461-14
Rick Voorhies	City Administrator	City of Keene	817-641-73
John Haley	~~Bet~~ Gen. Manager	Bethany WSC	817-790-25
Charles D. Yarbrough	Pres.	J C Rural Water Supply	817-645-664
W J Dickens III	Director	"	"
Terry Kelley	General Manager	Johnson County Rural WSC	
SHELLEE HUBBARD	CHEMIST/ACTING SUPT.	BRAZOS RIVER AUTH. LGSWATS	817-326-348
Jay Emami	Technical Development Director	Brazos River Authority	
Roger Harmon	County Judge	Johnson County	817-556-636
CURTIS E. JOHNSON	TWDB		512/463-806

Brazos River Authority
Lake Granbury Surface Water Treatment System
Expansion Feasibility Study

Long Range Potable Water Needs
For Customers in Hood County.

Hood County Annex #1

July 21, 1998 1:30 PM

Agenda

1.	Opening Remarks:	Jay Emami
2.	Population Projections.	Jim Altstaetter
3.	Candidates for Treated Surface Water	Jim Altstaetter
4.	Project Specific Discussion for Hood County:	Jim Altstaetter
5.	Questions:	

Notes:

Presenters:
Mr. Jay Emami, Technical Development Manager, Brazos River Authority
Mr. James Altstaetter, Principal, Alan Plummer Associates, Inc.

Brazos River Authority
Lake Granbury Surface Water Treatment System
Expansion Feasibility Study

Long Range Potable Water Needs
For Customers in Hood County.

Hood County Annex #1

July 21, 1998 1:30 PM

Meeting Minutes

Mr. Jay Emami welcomed everyone to the meeting on behalf of BRA and indicated that the purpose was to update the public on the progress of the project to date.

Mr. Jim Altstaetter explained that the population projections from the TWDB and the NCTCOG were indicating a percent growth that was much lower than what he believed to be the actual. Mr Altstaetter indicated that a more realistic number would be in excess of 4 percent, and would try to develop the rationale that would support that growth projection to be approved by the TWDB.

Mr Jim Altstaetter showed an overhead map that identified the most likely distribution project to serve Candidates for Treated Surface Water. He indicated that he had not identified any obvious new participants for the SWATS in Hood County. However, there were several obvious utilities that could be served by the existing participants. Particularly, all subdivisions that are located in close proximity to the existing distribution systems of either AMUD or Granbury could become indirect customers of the SWATS.

Mr. Altstaetter indicated that there was one primary alternative to serve Hood County and that was a pipeline from the SWATS Treatment Plant to the City of Granbury that would serve both Granbury and AMUD. The line would be sized to provide capacity for the 20 year projected water demand. Branches from that line, could be constructed to serve other independent subdivisions along the route, but so far, no one had expressed much interest.

No one representing the general public was present. The meeting was adjourned at 1:45PM

Presenters:
Mr. Jay Emami, Technical Development Manager, Brazos River Authority
Mr. James Altstaetter, Principal, Alan Plummer Associates, Inc.

ALAN PLUMMER ASSOCIATES, INC.
ENVIRONMENTAL ENGINEERS • DESIGNERS • SCIENTISTS

JOB NAME ______
JOB NO. ______ PAGE ______ OF ______
CALCULATED BY ______ DATE ______
VERIFIED BY ______ DATE 7/21/98

Public Meeting, Hood County Annex #1

July 21, 1998,

Name	Title	Organization	Phone Number
Jim Altstaetter	Principal	Alan Plummer Assoc	817-284-2729
BRIAN McDONALD	ENGINEER	ALAN PLUMMER ASSOC	817-461-1491
John Chisholm	General Manager	HMWD	817-326-4720
CURTIS F. JOHNSON		TWDB	(512) 463-8060
SHELLEE HUBBARD		BRAZOS RIVER AUTH. LGSWATS	817.326.3484
Jay Emami		Brazos River Authority	254-776-144

Brazos River Authority
Lake Granbury Surface Water Treatment System
Expansion Feasibility Study

Long Range Potable Water Needs
For Customers in Johnson County.

City of Cleburne Civic Center

December 4, 1998 10:00 AM

Meeting Minutes

Mr. Jay Emami welcomed everyone to the meeting on behalf of BRA and indicated that the purpose was to review the final draft of the report. Representatives from the City of Keene, Bethany WSC and Johnson County Rural Water Supply Corporation, as well as BRA and the TWDB attended the meeting.

Mr. Jim Altstaetter used an overhead presentation to explain the contents of the report. The essence of the report is that the system needs to be expanded whether or not any new customers joined, and that Keene, Bethany WSC, Alvarado, Cleburne, and Aqua Source would be potential new wholesale customers, if they chose to be.

Mr Jim Altstaetter reviewed the six potential alternatives to include the existing participants plus a combination of new participants. He indicated that areas remote to the existing distribution system or an existing participant's distribution system could not be economically served at this time. Predicted average units costs were provided based on the projections made. It was noted that unit costs were dependent on the amount of water used.

The meeting adjourned at 11:00 AM.

Presenters:
Mr. Jay Emami, Technical Development Manager, Brazos River Authority
Mr. James Altstaetter, Principal, Alan Plummer Associates, Inc.

COMMUNICATION PLANNER

Name: [illegible]		**Subject:**	
Company: Cleburne		File:	
Position:		Circulate:	
Address:		Delegate to:	
		Return to:	

Bus.: | Fax: | Res.: | Car:

Typ	Date/ Note	Time/ Seq.	Subject		Response	Follow-up Date
			NAME	Entity	PHONE	
			DENIS [illegible]	BRAZOS R[illegible]	[illegible]	
			[illegible]	[illegible]	[illegible]	
			John Hokey	Bethany WSC	817-790-[illegible]516	
			[illegible]	[illegible] WSC	[illegible]	
			[illegible]	[illegible]	[illegible]	
			Mike [illegible]		[illegible]	
			CURTIS E. JOHNSON	TWDB	512-463-8060	
			Jay Emami	BRA	(254)-776-1441	
			Jim Altstaetter	APAI	817-234-2724	
			JOHN PERCIFIELD	BETHANY WSC	817-790-2295	
			Terry Kelley	Johnson Co. Rural WSC	817-645-6646	

Over

Brazos River Authority
Lake Granbury Surface Water Treatment System
Expansion Feasibility Study

Long Range Potable Water Needs
For Customers in Hood County.

Hood County Annex #1

December 4, 1998 1:30 PM

Meeting Minutes

Mr. Jay Emami welcomed everyone to the meeting on behalf of BRA and indicated that the purpose was to review the final draft of the report. Representatives from the City of Granbury and AMUD, as well as BRA and the TWDB attended the meeting. There were no outside parties at the meeting.

Mr. Jim Altstaetter used an overhead presentation to explain the contents of the report. The essence of the report is that the system needs to be expanded whether or not any new customers joined, and that Keene, Bethany WSC, Alvarado, Cleburne, and Aqua Source would be potential new wholesale customers, if they chose to be.

Mr Jim Altstaetter reviewed the six potential alternatives to include the existing participants plus a combination of new participants. He indicated that areas remote to the existing distribution system or an existing participant's distribution system could not be economically served at this time. Predicted average units costs were provided based on the projections made. It was noted that unit costs were dependent on the amount of water used.

Mr. Curtis Johnson indicated that the projected population would need to correspond to the projections by the TWDB. He also indicated that TWDB would need to see a final draft after incorporating the comments from the four existing customers.

The meeting adjourned at 11:00 AM.

Presenters:
Mr. Jay Emami, Technical Development Manager, Brazos River Authority
Mr. James Altstaetter, Principal, Alan Plummer Associates, Inc.

COMMUNICATION PLANNER

Name: HOOD COUNTY MEETING

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			NAME	ENTITY	PHONE	
			[illegible]	[illegible]	[illegible]	
			Curtis E. Johnson	TWDB	(512) 463-8060	
			Jay Emami		(254)-776-1441	
			GREG Reynolds		817-573-7030	
			Richard English		(817)-573-7030	
			John Chisholm		817-326-5920	
			[illegible]		817-326-3484	

Over

Type: O = Outgoing Call I = Incoming Call M = Meeting C = Correspondence F = Facsimile

APPENDIX B

PARTICIPANT WORKSHOPS

CUSTOMER WORKSHOP
JOHNSON COUNTY RURAL WATER SUPPLY CORPORATION

Project: 323-0700

Date: June 22, 1998

Prepared for: Brazos River Authority

Prepared by: James L. Altstaetter/Brian K. McDonald

INTRODUCTION

This technical memorandum describes the items discussed in the SWATS Customer Workshop Number 2, with Johnson County Rural Water Supply Corporation (JCRWSC) on April 22, 1998. In addition, population and water demand projections are presented.

PROJECT GOALS

The goals of the project are following:

- To plan for future phased expansion of the Brazos River Authority (BRA) Surface Water and Treatment System (SWATS) plant.
- To identify potential new customers for the SWATS plant.
- To identify potential new customers for the customers of the SWATS plant.
- To develop a concept to use the SWATS surface water to base load for all customers and use the existing well systems to provide for peak demand.

EXISTING FACILITIES

Alan Plummer Associates, Inc. (APAI) was provided with a map and other data showing plant locations and system layout. The system consists of 27 wells with a capacity of approximately 6.75 MGD. The current allocation of surface from the SWATS plant is 1.625 MGD, and will be increased to 2.321 MGD at the completion of the 1.5 MGD SWATS plant expansion.

There is no source of treated surface water for the east side of the Johnson County Rural Water Supply Corporation (Corporation) system. The Corporation is currently negotiating to obtain additional water from the City of Mansfield for the eastern portion of the Corporation system.

The Corporation's biggest need is the need for additional capacity in its distribution system in order stay ahead of demand. A pipeline to the east side of Johnson County would be particularly helpful to their distribution system.

EXISTING SYSTEM OPERATIONS

No significant water quality issues were noted. It was indicated that during the initial startup of the SWATS system, some scaling was observed. Apparently, since the SWATS plant has adjusted the pH of the finished water, no significant scaling exists.

The Corporation provided information regarding the amount of well water and surface water used and the number of connections for the past several years. The data is included in Table 1.

The Corporation uses surface water as a supplement to meet peak demand, because groundwater is cheaper than surface water.

FUTURE WATER NEEDS

A copy of the 1995 Master Plan performed by Kimley-Horn Associates was provided. The 1998 current conditions are approximately the same as the plan predicted to happen between year 2008 and year 2012. Because the growth rate has been much higher than predicted, the Corporation must take some significant and immediate steps to ensure a sufficient water supply for its customers. A recent Corporation newsletter says that the population growth of Johnson County is 3% per year but that the growth in Corporation water connections is 6.6% per year. It was pointed out that the water usage rate may be even higher if the per capita water usage rate increases as new residents move from urban areas into previously rural areas.

The Corporation needs to make surface water available to the east side of its system. A pipeline which would have connected the east side of the Corporation system to the SWATS water supply was previously proposed but never built.

The Corporation is charged with operating at the lowest possible cost. Currently, this means using groundwater as much as possible, because it is cheaper than using surface water.

BRA would prefer not to deal with a large number of small customers but instead would prefer that these small companies become customers of the Corporation or be absorbed by the Corporation. The best way to add the smaller, scattered water companies and subdivisions to the system appears to be for these companies to become customers of the Corporation, because the Corporation already has a distribution system in place near most of the rural subdivisions. The Corporation should plan to provide water to independent water suppliers, whose existing wells can not keep with the increasing demand. The addition of new direct customers to the SWATS plant will be considered only if the customers are comparable in size to one of the existing customers.

The amount of surface water required by the Corporation is the number of connections in the system times 0.6 gpm per connection minus the total well production capacity.

APAI has performed a 20 year population and water demand projection for two portions of the Corporation water system: the northwest portion currently served by SWATS (plants 12, 13, 20, 23, 6, 7, 8, 17, 1, and 19) and the northeast portion which could be connected by the previously proposed pipeline (plants 14, 15, and 16). The results are shown in Tables 2 through 7. Projections were made using low, medium, and high growth rates for each portion. Using the medium growth rate of 4.36 percent per year, APAI estimates peak surface water demand for the northwest portion in the year 2000 to be 2.55 MGD, increasing to 10.41 MGD in the year 2020. Again using the medium growth rate of 4.36 percent per year, APAI estimates peak surface water demand for the northeast portion in the year 2000 to be 0.76 MGD, increasing to 3.96 MGD in the year 2020.

COORDINATED USE OF SWATS TREATED SURFACE WATER AND JCRWSC GROUNDWATER

As stated above, the Corporation uses surface water as a supplement to meet peak demand, because groundwater is cheaper than surface water. The current cost to the Corporation for surface water is $2.50 or more per 1000 gallons. The current cost of groundwater is between $0.60 and $0.70 per 1000 gallons. APAI indicated that if each customer would use surface water as the base supply and use well water as a supplement to meet peak demand, the unit cost of treated surface water would be reduced. This would result in a slightly higher total treated water cost, but would also greatly improve the prospect of a sufficient future water supply. A further discussion of this topic is included in the section on Management Issues.

DISCUSSIONS OF POTENTIAL SWAT CUSTOMERS

A project which extends a pipeline to the City of Keene and possibly to the Bethany Water Supply Corporation appears to be a feasible way to add new customers for the SWATS plant. The City of Keene has preliminary interest in receiving water from the SWATS plant and would like to see a cost estimate. The Corporation would be more interested in a pipeline to the eastern portion of the Corporation system if the City of Keene participated.

Bethany Water Supply Corporation currently has an agreement with Bethesda Water Supply Corporation for additional water. Bethesda receives water from the City of Fort Worth. It is questionable whether Bethany would be interested in participating in a pipeline project.

The City of Cleburne is another potential new customer. The City of Cleburne currently plans to extend a pipeline south to Aquilla Lake. City officials are willing to listen to alternate proposals but are not pursuing alternatives.

MANAGEMENT ISSUES

As mentioned above, a pipeline which would have connected the east side of the Corporation system to the SWATS water supply was previously proposed but never built. A cooperative venture between BRA and the Corporation may be an appropriate way to build the pipeline, however allocation of the costs of such a project are complicated. Such costs include the construction cost of the pipeline, the present value of transmission lines, debt service on the SWATS plant, "equity buy-in," and the cost of excess capacity for future expansion.

The current method of cost distribution provides a disincentive for the Corporation to use surface water. If one customer doesn't use its full allocation, then the costs rise for the other customers. To resolve this problem, it may be necessary for BRA and the customers to redefine which costs are fixed costs which must be paid regardless of the usage amount and which costs are variable and depend on usage.

CUSTOMER WORKSHOP
JOHNSON COUNTY FRESH WATER SUPPLY DISTRICT

Project:	323-0700
Date:	June 22, 1998
Prepared for:	Brazos River Authority
Prepared by:	James L. Altstaetter/Brian K. McDonald

INTRODUCTION

This technical memorandum describes the items discussed in the SWATS Customer Workshop Number 3, with Johnson County Fresh Water Supply District (JCFWSD) on April 22, 1998. In addition, population and water demand projections are presented.

PROJECT GOALS

The goals of the project are following:

- To plan for future phased expansion of the Brazos River Authority (BRA) Surface Water and Treatment System (SWATS) plant.
- To identify potential new customers for the SWATS plant.
- To identify potential new customers for the customers of the SWATS plant.
- To develop a concept to use the SWATS surface water to base load for all customers and use the existing well systems to provide for peak demand.

1. EXISTING FACILITIES

The JCFWSD will provide APAI with the 1986 Master Plan for the District.

The City of Joshua has obtained a planning grant which they intend to use to map the water and sewer systems operated by the District. When this is completed, JCFWSD hopes to have better data on both their water and wastewater systems. JCFWSD has some water lines which are outside the city limits of Joshua. They are trying to locate an aerial photograph/map of the system which shows coliform sampling sites.

JCFWSD's wells extend into both the Trinity and Paluxy aquifers. The water is disinfected with chlorine.

2. EXISTING SYSTEM OPERATIONS

JCFWSD receives water from the SWATS plant at TST Plant 4. JCFWSD's current allocation is 0.375 MGD, and JCFWSD's portion of the pending plant expansion will be 0.165 MGD. JCFWSD has five wells with a total capacity of approximately 475 gpm or 0.700 MGD. They have one 250,000 gallon elevated storage tank.

A typical water bill for a residential JCFWSD customer is approximately $42 per month, $6.96 for the first 1000 gallons and $5.75 per 1000 gallons thereafter. The average residential customer uses approximately 7000 gallons per month. The large majority of District customers are residential. There are no industrial customers and only a small number of light commercial customers.

In general, BRA treats SWATS water with chlorine dioxide and chloramine. In January, BRA uses free chlorine as a precaution to destroy growth in the water lines.

3. FUTURE WATER NEEDS

JCFWSD has been cited by the TNRCC for having a capacity less than 0.6 gpm per connection. JCFWSD should consider obtaining a variance from this requirement from TNRCC, while at the same time, should work to develop firm water supply to meet the 0.6 gpm per connection.

JCFWSD was cited by the TNRCC for having a high iron concentration in its water. The TNRCC reported a sample with 3.17 mg/L of iron, compared to the maximum allowable concentration of 0.3 mg/L. It is not clear where this sample was obtained and whether it is characteristic of the system. JCFWSD should press the TNRCC for this information and consider collecting additional samples.

JCFWSD could use an additional 250,000 gallon elevated storage tank.

JCFWSD is not presently able to get enough flow volume in the new Mountain Valley subdivision. They anticipate that the problem will be solved with installation of looped water lines in the area. However, it needs to be evaluated after the installation. Rapid growth in the area could dictate the need for an upsizing of the existing line that will form part of the loop.

There is a new 290 acre tract under development south of Joshua which will be served by JCFWSD. There are approximately 50 lots ranging in size from 5 to 10 acres each. JCFWSD also expects significant development to the east/southeast of Joshua along FM 917. FM 803 is the boundary between Bethesda Water Supply Corporation and JCFWSD in this region.

JCFWSD currently has a shortage of water and asked if the various expansions of the SWATS plant will be designed to stay ahead of demand or to catch up to demand. The planning effort will consist of recommendations that typically may be to expand the plant every five years. There must be a balance between imposing the costs of excess capacity on existing customers and meeting future demand. Because of easement requirements, the pipelines normally would be sized to handle the anticipated flow for at least 20 years.

The present SWATS plant is overloaded during the peak summer months. In at least one previous year, BRA was able to treat 4.2 MGD using the existing 3.5 MGD system. However, the amount depends on the quality of the water entering the plant. The existing EDR units are rated for 3.5 MGD. Treated water in excess for 3.5 MGD is available only if the quality of the raw water coming into the plant is low enough in salts to allow blending of the EDR treated water with conventional treated water. The conventional portion of the treatment plant is rated a 5.0 MGD. The current SWATS plant expansion will increase the EDR plant treatment capacity from 3.5 MGD to 5 MGD.

APAI has performed a 20 year population and water demand projection for the JCFWSD water system. The results are shown in Tables 1 through 3. Projections were made using low, medium, and high growth rates. Using the medium growth rate of 4.36 percent per year, APAI estimates peak surface water demand in the year 2000 to be 0.84 MGD, increasing to 3.35 MGD in the year 2020.

COORDINATED USE OF SWATS TREATED SURFACE WATER AND JCFWSD GROUNDWATER

JCFWSD's operating policy has been to use surface water and to supplement this with groundwater to meet peak demand. In the winter, this policy has meant shutting down the wells. In the future, JCFWSD intends to continue using surface water, but to keep the wells operating at a minimal level to help prevent maintenance and startup problems. JCFWSD prefers to use surface water because of the "take-or-pay" nature of the contract with BRA.

JCFWSD has no pumping costs when the wells are not in use because there is enough pressure in the elevated storage tank. This issue will be discussed further in the section on Management Issues.

5. DISCUSSIONS OF POTENTIAL SWAT CUSTOMERS

One potential project would be the extension of the line that presently serves the Johnson County Rural Water Supply Corporation (JCRWSC) which would allow BRA to supply water to the City of Keene, and possibly Alvarado and Bethany.

JCFWSD indicated that the City of Alvarado is already a customer of the Corporation, receiving approximately 1.5 million gallons per month. Alvarado also has an intake structure on Lake Alvarado. However, the costs of using Lake Alvarado as a source may be prohibitive, and Lake

Alvarado will not yield a large amount of water. Cost would be the biggest factor in determinin g if the City of Alvarado would be willing to be a direct customer of the SWATS plant.

The JCFWSD indicated that the manager of the Bethany system has worked out an agreement with Bethesda (which receives water from the City of Fort Worth) and would probably not be interested in receiving water from the SWATS plant.

The group discussed the fact that the Town of Godley has its own distribution system.

6. MANAGEMENT ISSUES

The issue of the operating policy for the TST was discussed. The BRA SWATS plant decreases pumping, or EDR treatment during peak electrical demand times, which results in a significant electrical savings. The peak time is between the hours of 5AM and 9 AM in the summer and between the hours of 5 PM and 10 PM in the winter. Historically, the SWATS plant has endeavored to maintain the TST elevation at 70 feet or greater to allow the water to flow directly into the JCRWSC's system. This operating condition also served the JCFWSD well because it allowed them to take the water from the TST into their elevated tank because they only needed the elevation in the TST to be 40 feet or greater. However, this operating condition placed a great deal of stress on the SWATS plant because it required an all out effort to fill the TST prior to the peak electrical demand time when they would turn their high service pumps off. There is a current project being constructed that will provide for the lifting of water from the TST into the JCRWSC system. The plan is to stay above 40 feet so that the District does not need to pump. During peak periods, the District can pump if needed to draw the tank below 40 feet to more effectively use TST storage capacity.

The issue of fixed and variable cost allocation of the SWATS plant and the distribution system was not an issue with the JCFWSD because they use all of the water allocated to them at the present time.

CUSTOMER WORKSHOP
ACTON MUNICIPAL UTILITY DISTRICT

Project:	323-0700
Date:	June 22, 1998
Prepared for:	Brazos River Authority
Prepared by:	James L. Altstaetter/Brian K. McDonald

INTRODUCTION

This technical memorandum describes the items discussed in the SWATS Customer Workshop Number 2, with the Acton Municipal Utility District (AMUD) on April 28, 1998. In addition, population and water demand projections are presented.

PROJECT GOALS

The goals of the project are following:

- To plan for future phased expansion of the Brazos River Authority (BRA) Surface Water and Treatment System (SWATS) plant.
- To identify potential new customers for the SWATS plant.
- To identify potential new customers for the customers of the SWATS plant.
- To develop a concept to use the SWATS surface water to base load for all customers and use the existing well systems to provide for peak demand.

1. EXISTING FACILITIES

The Acton Municipal Utility District (AMUD) serves the subdivisions of Enchanted Village, Indian Harbor, Holiday Estates, Port Ridglea, Wildwood Estates, Nassau Bay, The Trees, The Bluffs, DeCordova Hills, DeCordova Bend Estates, Stewart Oaks, Grand Tera, Grande Cove, Walnut Creek, Thistle Ridge, Secluded Oaks, and Pecan Plantation with wells and SWATS water.

The AMUD water line running across Lake Granbury to Indian Harbor is a 10 inch diameter ductile iron line. Originally it was lying on the lake bottom, but it has been silted over with about 3 feet of sediment. AMUD also has a 6 inch steel line which crosses the lake, but this line has significant leakage and is not in service. AMUD does not anticipate using this line in the future.

There are no customers tapped into the 10 inch line along Acton Road. There is a 6 inch line across the road which supplies customers. The 10 inch line serves both Indian Harbor and the City of Granbury.

Pecan Plantation is served primarily by wells located on the development. However, there is a 6 inch line along Fall Creek Highway.

There is a mix in the AMUD service area of full-time and weekend residents. Indian Harbor has mostly weekend residents, while other subdivisions have full-time residents.

The majority of the AMUD wells are screened in the Trinity aquifer; there are two wells screened in the Paluxy aquifer.

2. EXISTING SYSTEM OPERATIONS

AMUD delivers water to Granbury at system pressure. Granbury has a storage tank near the Western Hills Harbor subdivision. Granbury would prefer that AMUD maintain a pressure of 35 psi in the line at this location. AMUD actually maintains a pressure of 20-25 psi.

The City of Granbury has indicated that the amount of water available from the 10-inch line along Acton road is insufficient and that they would prefer a service line from the 10-inch line near the AMUD storage tank at the intersection of Acton Road and State Highway 377.

AMUD provided Alan Plummer Associates, Inc. (APAI) with a historical list of water connections broken down by major service area.

The City of Granbury allotment from SWATS, which is delivered through the AMUD system, is 0.5 MGD. The amount that Granbury actually receives has peaked at 0.685 MGD before. AMUD believes that Granbury uses their entire allotment of surface water from the SWATS plant.

3. FUTURE WATER NEEDS

BRA asked AMUD to project their additional raw water needs out to the year 2050. AMUD estimated that the additional 2050 surface water demand will be 12-15,000 ac-ft/yr on top of the current 3,000 ac-ft/yr, assuming that they would use only surface water and no groundwater. BRA performed its own analysis and projected that AMUD would need only an additional 7,800 ac-ft/yr. AMUD provided APAI with a copy of BRA's letter on this subject.

APAI is looking at a 20-year horizon for this planning project. APAI projects that, for various reasons, many of the smaller water companies in the area will eventually go out of business or be served by AMUD.

There are committees sponsored by the Chamber of Commerce who are planning how to attract industry to Hood County. They are a possible source of population projection information.

The growth in connections in the AMUD service area in the last five years has been approximately 5% per year.

There is currently a cap of 3,000 lots at Pecan Plantation. If the developer meets certain contingencies, this number can be expanded. There are still approximately 2,500 undeveloped acres in Pecan Plantation. The older lots have approximately 0.25 acres; there are some lots containing 3 to 5 acres.

Indian Harbor is less than 50% developed. DeCordova Bend is 86% developed. Pecan Plantation is approximately 33% developed. AMUD does not know the intentions of the Pecan Plantation developer with regard to lot size.

There is a new development requiring 140 connections which will be located west of Montego Bay Estates. There is also a new development on a larger property to the north in the planning stages.

AMUD projects that water companies in Hood County will be forced to rely on surface water in the future due to depleted aquifers. There is some concern that smaller water companies in the area are not planning for the future. It is difficult to include these small water companies in plans for AMUD's future, because AMUD customers would have to pay now for capacity to address future demand from these subdivisions.

AMUD believes that the TNRCC will not intervene unless a subdivision is out of water. The AMUD board is not interested in speculative investment.

AMUD believes it is probable that the smaller water companies will probably be acquired or served by larger entities in the future. AMUD is wary of supplying existing smaller water systems because they may not pay their bills. AMUD is generally wary of taking over operation of an existing system for many reasons: the system may be in disrepair, the distribution lines in the system may be too small, the system may not have fire hydrants, etc.

Home insurance costs in subdivisions without fire hydrants are significantly higher than in subdivisions with adequate fire hydrants. The potential savings on home insurance may go a long way toward paying for water system upgrades.

The cost of laying a line with extra capacity (10 or 12 inches instead of 8 inches) is not prohibitive once the decision has been made to install a line. However, it may be difficult to get board permission to extend AMUD's service area.

APAI envisions a report which will recommend a series of plant expansions, with each expansion meeting an additional five years of demand. The recommended plant expansions will be based on the population projections. Population projections are difficult to accurately forecast, so the recommended expansions may satisfy demand for 4 years or 6 years instead of 5 years. Even if the actual population growth rate differs from the projected growth rate, the report will tell BRA and the four customers how to expand the SWATS plant to meet demand.

APAI has performed a 20 year population and water demand projection for the AMUD water system. The results are shown in Tables 1 through 3. Projections were made using low, medium, and high growth rates. Using the medium growth rate of 4.34 percent per year, APAI estimates peak surface water demand in the year 2000 to be 2.51 MGD, increasing to 9.19 MGD in the year 2020.

4. COORDINATED USE OF SWATS TREATED SURFACE WATER AND AMUD GROUNDWATER

AMUD uses groundwater to meet its base demand and supplements with surface water to meet peak demand.

Currently the SWATS plant capacity is 3.5 MGD, and the customer allotments are 1.625 MGD for the Johnson County Rural Water Supply Corporation, 1.0 MGD for AMUD, 0.5 MGD for Granbury, and 0.375 for the Johnson County Fresh Water Supply District. When the current plant expansion is complete, the plant capacity will be 5.0 MGD, and the customer allotments will increase proportionately.

The current contract between AMUD and BRA requires that AMUD pay "variable costs" for a minimum of 10% of the contracted allotment.

5. DISCUSSIONS OF POTENTIAL SWAT CUSTOMERS

After discussion of potential new customers for AMUD, there was general agreement that there are no new pipeline projects for AMUD that would bring in direct SWATS customers. The best source of new customers, besides growth in the AMUD service area, appears to be taking over/supplying existing systems that are adjoining the AMUD service area. It will be difficult to obtain board approval to take over an existing system. AMUD has never taken over an existing system.

6. MANAGEMENT ISSUES

The issue of coordinated usage of groundwater and surface water was discussed. The current contracts between BRA and the four major customers can actually discourage usage of the full customer allotment. The source of this disincentive appears to be that the contracts treat the entire operation and maintenance budget as a variable cost, when in fact, a large portion of the O&M budget is fixed regardless of the amount of water treated.

AMUD believes that BRA used wastewater contracts as a model for the water contracts. The difference between the two models is that the flow into wastewater treatment plants is uncontrolled, but the flow from the water plant can be controlled by the customers because they are able to use groundwater to make up the difference. The disincentive was not foreseen by BRA or its customers.

BRA suggested getting public involvement with water resources planning. If people are made aware that they are facing a potentially serious water supply problem in subdivisions served by smaller water companies, they can exert public pressure to make sure that their needs are being planned for. APAI suggested that the county commissioners may be interested in this subject.

CUSTOMER WORKSHOP
CITY OF GRANBURY

Project:	323-0700
Date:	June 22, 1998
Prepared for:	Brazos River Authority
Prepared by:	James L. Altstaetter/Brian K. McDonald

INTRODUCTION

This technical memorandum describes the items discussed in the SWATS Customer Workshop Number 2, with the City of Granbury on April 28, 1998. In addition, population and water demand projections are presented.

PROJECT GOALS

The goals of the project are following:

- To plan for future phased expansion of the Brazos River Authority (BRA) Surface Water and Treatment System (SWATS) plant.
- To identify potential new customers for the SWATS plant.
- To identify potential new customers for the customers of the SWATS plant.
- To develop a concept to use the SWATS surface water to base load for all customers and use the existing well systems to provide for peak demand.

EXISTING FACILITIES

Granbury recently installed two additional water supply wells. These wells yielded 40 to 50 gpm each. The groundwater yield is declining. These wells were installed just to maintain existing groundwater flow capacity. It costs approximately $100,000 to install a new water supply well. The declining yields are making this not cost effective.

Granbury has let a contract to install a 12 inch pipeline extending eastward along State Highway 377. In the short term, this 12 inch pipeline will tie into an AMUD 10 inch line. In the long term, Granbury expects to install a 16 to 24 inch pipeline from the SWATS plant to the Granbury service area. Granbury pays approximately $100,000 per year to AMUD for transmission of water. In the future, this money can be used to pay for a new pipeline to the SWATS plant.

EXISTING SYSTEM OPERATIONS

Granbury currently has contracts for 2,400 ac-ft/yr of raw water. Part of this is treated at the BRA SWATS plant, and part is treated at the City of Granbury plant.

Presently, Granbury uses 1.2 MGD on average (1.9 MGD peak). Granbury receives approximately 0.5 MGD from the SWATS plant. The remainder is generally made up by groundwater. The average daily usage is 150 gal/cap/day. Doubling the number of connections (see discussion of Future Water Needs) will increase the surface water demand by a factor of 3 to 4.

Granbury's water customers pay approximately $5 per 1000 gallons. Granbury pays more than $3 per 1000 gallons for water treatment and something less than $1 per 1000 gallons for transmission through the Acton Municipal Utility District (AMUD) system.

The population within the Granbury service area doubles during school hours because a large number of children are bused from outside the service area to schools inside the service area.

Last year, 14% of water transmitted from the SWATS plant did not go through the EDR treatment. Of the water that was treated with EDR, 26.9% was wasted as brine from the EDR. Therefore, some of Granbury's allotment of raw water is wasted during treatment.

It is not feasible for Granbury to deliver water to subdivisions on the lake south of the city due to physical barriers (lake crossing).

FUTURE WATER NEEDS

Granbury estimates that, over the next 20 years, the city will become fully reliant on surface water due to the economics of declining well yields.

Granbury cannot justify using part of its allocation to supply subdivisions outside of Granbury's current service area. If these subdivisions/smaller water companies had raw water allotments of their own, Granbury would consider using its lines to supply this water to the subdivisions/smaller water companies.

Granbury expects Western Hills Harbor to be one of the first subdivisions to approach the city for surface water, because they are already experiencing water shortages during peak demand and declining well yields.

There is a proposed road extending from State Highway 377 on the west side of Granbury to State Highway 51 on the north side of Granbury. This project, combined with a water main crossing Lake Granbury on the State Highway 51 bridge, would open up a large area for new development.

The City of Granbury has annexed property along State Highway 377 as far east as the Plaza East subdivision. Granbury has plans to annex more property the east, as far as the Joy Paris realty office. In this corridor, Granbury has annexed property within 500' of State Highway 377. Property in this corridor within a mile of State Highway 377 falls into Granbury's extraterritorial jurisdiction (ETJ).

Knox Ranch, a new development with more than 1,500 lots, is planned to the west of Granbury on the south side of State Highway 377. This project, plus others also in progress, will double the number of connections in the Granbury water system. Knox Ranch will have sewer service from Granbury. Granbury expects Knox Ranch, Mallard Pointe, and Bentwater to approach buildout in the next 10 years.

BRA asked Granbury to project their water needs to the year 2050. Granbury's projection was 12,500 ac-ft/yr. BRA made the same projection and determined that Granbury needed 11,300 ac-ft/yr. Granbury believes that amount may last until 2010. Granbury's current raw water allotment is 2,400 ac-ft/yr.

A 1989 Water Master Plan was completed for the city. According to this plan, the population in Granbury increased 7.8% per year from 1980-88. This growth period was followed by a couple years of no growth or population decline. The U.S. Postal Service (USPS) has estimated that population growth in Hood County has been more than 7.5% per year from 1990-97. Granbury provided Alan Plummer Associates, Inc. (APAI) with a letter from the USPS addressing this issue.

Granbury uses 2.9 people per household as a planning number. Granbury expects 6% per year population growth in the near future.

Granbury uses a maximum daily demand of 350 gal/cap/day for planning purposes. Cleburne uses approximately 376 gal/cap/day, and Stephenville uses approximately 330 gal/cap/day.

Housing starts might be a good way to estimate the growth in connections to the Granbury water system.

APAI envisions a report which will recommend a series of plant expansions, with each expansion meeting an additional five years of demand. The recommended plant expansions will be based on the population projections. Population projections are difficult to accurately forecast, so the recommended expansions may satisfy demand for 4 years or 6 years instead of 5 years. Even if the actual population growth rate differs from the projected growth rate, the report will tell BRA and the four customers how to expand the SWATS plant to meet demand.

APAI has performed a 20 year population and water demand projection for the Granbury water system. The results are shown in Tables 1 through 3. Projections were made using low, medium, and high growth rates. Using the medium growth rate of 4.34 percent per year, APAI estimates peak surface water demand in the year 2000 to be 2.43 MGD, increasing to 10.20 MGD in the year 2020.

COORDINATED USE OF SWATS TREATED SURFACE WATER AND GRANBURY GROUNDWATER

Current contracts between BRA and the four major customers can actually discourage usage of the full customer allotment. The source of this disincentive appears to be a misallocation of fixed and variable costs paid by the customers. Granbury's contract with BRA fully "take-or-pay;" Granbury pays both fixed and variable costs for its allotment regardless of the usage amount.

DISCUSSIONS OF POTENTIAL SWAT CUSTOMERS

It appears that the only new customer for BRA in the area may be H2M Water Services, the company that will supply Mallard Pointe and Bentwater. It may be feasible for H2M to connect to Granbury's new 12 inch line, which will run east along State Highway 377.

MANAGEMENT ISSUES

Fixed and variable cost allocation of the SWATS plant and the distribution system was not an issue with the City of Granbury because they use all of the water allocated to them at the present time.

APPENDIX C

POPULATION PROJECTIONS

Projected Population and Water Demand
Granbury

Most Likely Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	4.3	4.3	4.3	4.3	4.3
Population	8,281	11,316	14,808	18,865	23,618
Average Annual	1.52	2.01	2.56	3.18	3.87
Peak Daily	2.90	3.91	5.04	6.33	7.82
Well Capacity	0.46	0.67	0.79	0.81	0.74
Surface Water (Peak)	2.43	3.24	4.26	5.53	7.08

High Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	7.5	7.5	7.5	7.5	7.5
Population	9,064	13,012	18,681	26,819	38,502
Average Annual	1.66	2.32	3.23	4.52	6.31
Peak Daily	3.17	4.49	6.36	9.00	12.74
Well Capacity	0.46	0.67	0.79	0.81	0.74
Surface Water (Peak)	2.71	3.82	5.58	8.20	12.01

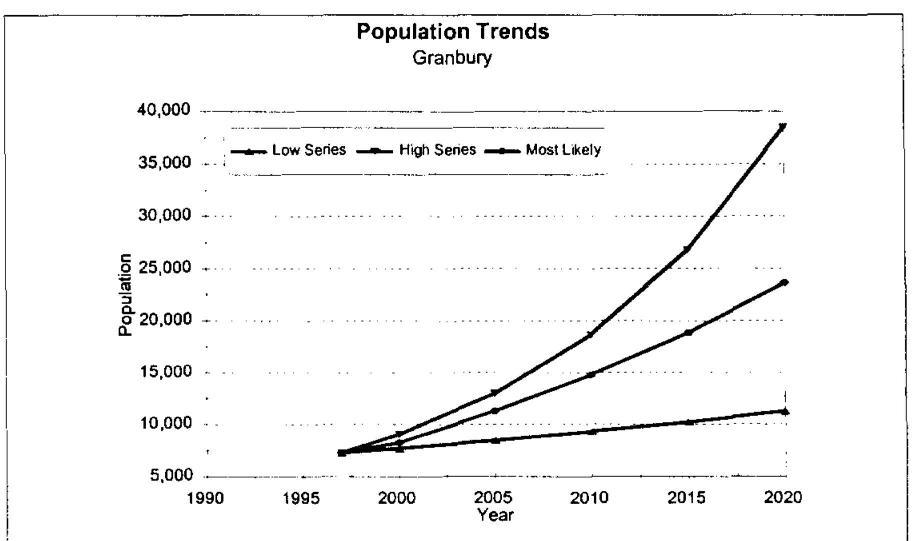
Low Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	1.9	1.9	1.9	1.9	1.9
Population	7,720	8,482	9,319	10,238	11,248
Average Annual Useage	1.41	1.51	1.61	1.73	1.84
Peak Daily Demand	2.70	2.93	3.17	3.44	3.72
Well Capacity	0.46	0.67	0.79	0.81	0.74
Surface Water Needs (Peak)	2.24	2.26	2.39	2.63	2.99

Flows in MGD

Assumptions

Average Water Demand	183	178	173	168.5	164

Parameter	Value	Units	Source
peak water demand	350	gal/cap/day	City of Granbury
2020 Conservation Savings	5.43%		TWDB
average number of people per connection	2.9	cap/conn	City of Granbury
1997 City of Granbury service area population	7296	population	City of Granbury
Granbury well capacity decline over 20 years	100	%	engineering estimate
2000 well capacity	0.464	MGD	City of Granbury
Shading indicates demand exceeds well capacity			



Projected Population and Water Demand
Acton Municipal Utility District

Most Likely Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	2.1	2.1	2.1	2.1	2.1
Population	13,833	15,886	18,098	20,486	23,070
Average Annual	1.46	1.60	1.73	1.89	2.04
Peak Daily	4.12	4.67	5.24	5.84	6.48
Well Capacity	1.60	1.32	1.00	0.65	0.26
Surface Water (Peak)	2.52	3.35	4.24	5.19	6.21

High Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	5.7	5.7	5.7	5.7	5.7
Population	14,136	18,607	24,491	32,238	42,434
Average Annual	1.49	1.87	2.35	2.97	3.75
Peak Daily	4.21	5.46	7.09	9.19	11.92
Well Capacity	1.60	1.32	1.00	0.65	0.26
Surface Water (Peak)	2.61	4.15	6.09	8.54	11.65

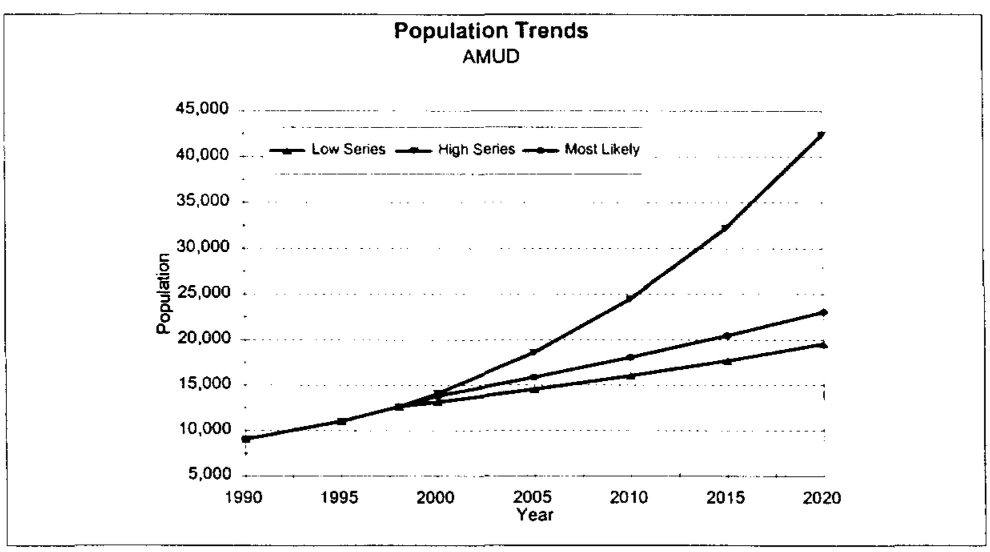
Low Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	2.0	2.0	2.0	2.0	2.0
Population	13,176	14,547	16,061	17,733	19,579
Average Annual Useage	1.39	1.46	1.54	1.63	1.73
Peak Daily Demand	3.93	4.27	4.65	5.06	5.50
Well Capacity	1.60	1.32	1.00	0.65	0.26
Surface Water Needs (Peak)	2.33	2.96	3.65	4.41	5.23

Flows in MGD

Assumptions

Average Water Demand	105.5	100.65	95.8	92.05	88.3

Parameter	Value	Units	Source
peak water demand	298	gal/cap/day	0.6 gpm/connection
2020 Conservation Savings	5.77%		TWDB
average number of people per connection	2.9	cap/conn	engineering estimate
1998 AMUD system connections	4367	-	AMUD
well capacity decline over 20 years	100	%	engineering estimate
2000 well capacity	1.6	MGD	AMUD December 1997 well capac
Shading indicates demand exceeds well capacity			



Projected Population and Water Demand
Johnson County Fresh Water Supply District

Most Likely Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	2.8	2.8	2.8	2.8	2.8
Population	4,936	5,653	6,474	7,415	8,492
Average Annual	0.38	0.42	0.45	0.49	0.53
Peak Daily	1.47	1.66	1.88	2.13	2.40
Well Capacity	0.70	0.53	0.35	0.18	0.00
Surface Water (Peak)	0.77	1.14	1.53	1.95	2.40

High Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	6.0	6.0	6.0	6.0	6.0
Population	5,419	7,252	9,705	12,987	17,380
Average Annual	0.42	0.53	0.67	0.86	1.09
Peak Daily	1.61	2.13	2.82	3.72	4.92
Well Capacity	0.70	0.53	0.35	0.18	0.00
Surface Water (Peak)	0.91	1.61	2.47	3.55	4.92

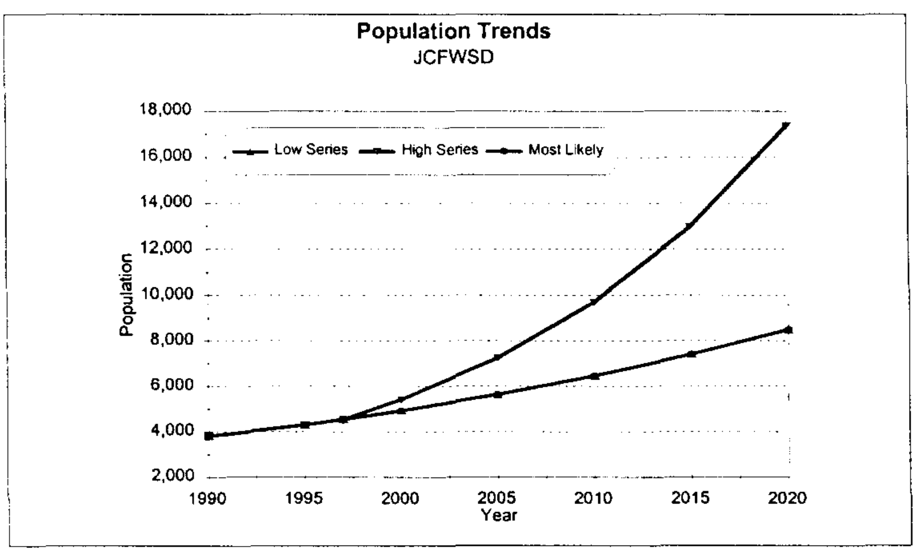
Low Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	2.8	2.8	2.8	2.8	2.8
Population	4,936	5,653	6,474	7,415	8,492
Average Annual Useage	0.38	0.42	0.45	0.49	0.53
Peak Daily Demand	1.47	1.66	1.88	2.13	2.40
Well Capacity	0.70	0.53	0.35	0.18	0.00
Surface Water Needs (Peak)	0.77	1.14	1.53	1.95	2.40

Flows in MGD

Assumptions

Average Water Demand	78	73.5	69	66	63

Parameter	Value	Units	Source
peak water demand	298	gal/cap/day	0.6 gpm/connection
2020 Conservation Savings	5.03%		TWDB
average number of people per connection	2.9	cap/conn	engineering estimate
1997 City of Joshua population	4550	people	NCTCOG
well capacity decline over 20 years	100	%	engineering estimate
2000 well capacity	0.7	MGD	District
Shading indicates demand exceeds well capacity			



Projected Population and Water Demand
Johnson County Rural Water Supply Corporation NW

Most Likely Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	2.1	2.1	2.1	2.1	2.1
Population	15,445	18,226	21,190	24,357	27,750
Average Annual	1.92	2.18	2.44	2.71	2.97
Peak Daily	4.60	5.35	6.13	6.95	7.79
Well Capacity	2.26	1.97	1.59	1.14	0.62
Surface Water (Peak)	2.34	3.39	4.54	5.80	7.18

High Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	6.0	6.0	6.0	6.0	6.0
Population	16,651	22,282	29,819	39,904	53,401
Average Annual	2.07	2.67	3.43	4.43	5.72
Peak Daily	4.96	6.54	8.63	11.38	15.00
Well Capacity	2.26	1.97	1.59	1.14	0.62
Surface Water (Peak)	2.70	4.58	7.04	10.23	14.38

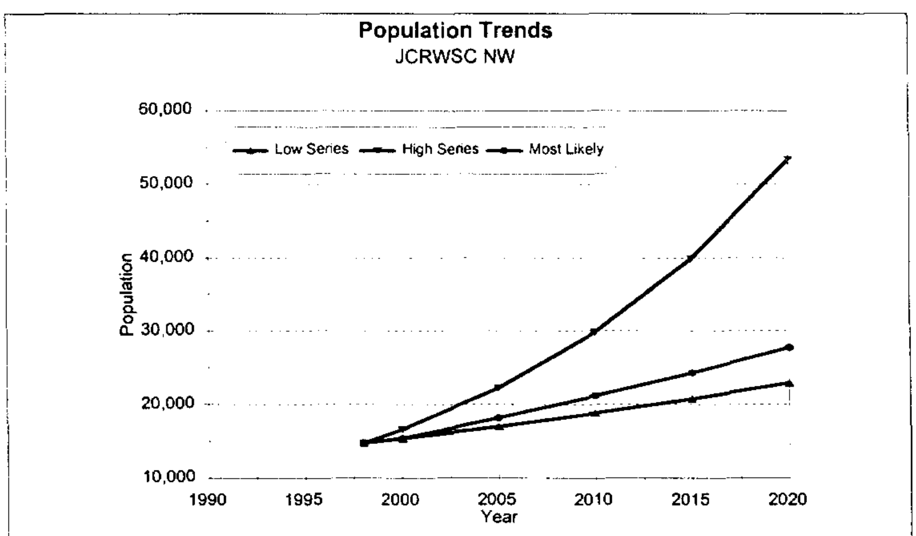
Low Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	2.0	2.0	2.0	2.0	2.0
Population	15,421	17,034	18,816	20,785	22,959
Average Annual Useage	1.92	2.04	2.17	2.31	2.46
Peak Daily Demand	4.60	5.00	5.45	5.93	6.45
Well Capacity	2.26	1.97	1.59	1.14	0.62
Surface Water Needs (Peak)	2.34	3.04	3.85	4.78	5.83

Flows in MGD

Assumptions

Average Water Demand	124.2	119.65	115.1	111.1	107.1

Parameter	Value	Units	Source
peak water demand	298	gal/cap/day	0.6 gpm/connection
2020 Conservation Savings	5.74%		TWDB
average number of people per connection	2.9	cap/conn	engineering estimate
1998 Corporation system connections	5110	-	Corporation
well capacity decline over 20 years	100	%	engineering estimate
2000 well capacity	2.26	MGD	1995 Master Plan;12,13,20,23,6,7
Shading indicates demand exceeds well capacity			



Projected Population and Water Demand
Johnson County Rural Water Supply Corporation NE

Most Likely Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	2.1	2.1	2.1	2.1	2.1
Population	6,229	7,123	8,090	9,139	10,279
Average Annual	0.77	0.85	0.93	1.02	1.10
Peak Daily	1.86	2.09	2.34	2.61	2.89
Well Capacity	1.18	1.06	0.89	0.68	0.41
Surface Water (Peak)	0.68	1.03	1.45	1.93	2.48

High Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	6.0	6.0	6.0	6.0	6.0
Population	6,716	8,987	12,027	16,094	21,538
Average Annual	0.83	1.08	1.38	1.79	2.31
Peak Daily	2.00	2.64	3.48	4.59	6.05
Well Capacity	1.18	1.06	0.89	0.68	0.41
Surface Water (Peak)	0.82	1.58	2.59	3.91	5.64

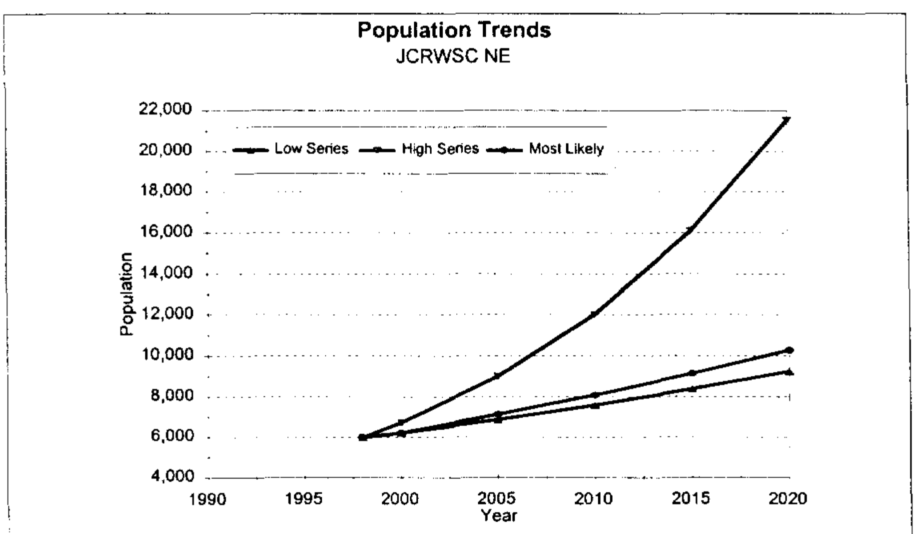
Low Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	2.0	2.0	2.0	2.0	2.0
Population	6,220	6,870	7,589	8,383	9,260
Average Annual Useage	0.77	0.82	0.87	0.93	0.99
Peak Daily Demand	1.85	2.02	2.20	2.39	2.60
Well Capacity	1.18	1.06	0.89	0.68	0.41
Surface Water Needs (Peak)	0.67	0.96	1.30	1.72	2.20

Flows in MGD

Assumptions

Average Water Demand	124.2	119.65	115.1	111.1	107.1

Parameter	Value	Units	Source
peak water demand	298	gal/cap/day	0.6 gpm/connection
2020 Conservation Savings	5.74%		TWDB
average number of people per connection	2.9	cap/conn	engineering estimate
1998 Corporation system connections	2061	-	Corporation
well capacity decline over 20 years	100	%	engineering estimate
2000 well capacity	1.18	MGD	1995 JCRWSC Master Plan; 14,1
Shading indicates demand exceeds well capacity			



Projected Population and Water Demand
Keene

Most Likely Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	2.0	2.0	2.0	2.0	2.0
Population	5,582	6,163	6,804	7,512	8,294
Average Annual	0.73	0.78	0.83	0.89	0.95
Peak Daily	1.66	1.81	1.98	2.15	2.35
Well Capacity	1.36	1.02	0.68	0.34	0.00
Surface Water (Peak)	0.30	0.79	1.30	1.81	2.35

High Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	6.0	6.0	6.0	6.0	6.0
Population	6,028	8,067	10,795	14,447	19,333
Average Annual	0.78	1.02	1.32	1.71	2.22
Peak Daily	1.80	2.37	3.13	4.14	5.47
Well Capacity	1.36	1.02	0.68	0.34	0.00
Surface Water (Peak)	0.44	1.35	2.45	3.80	5.47

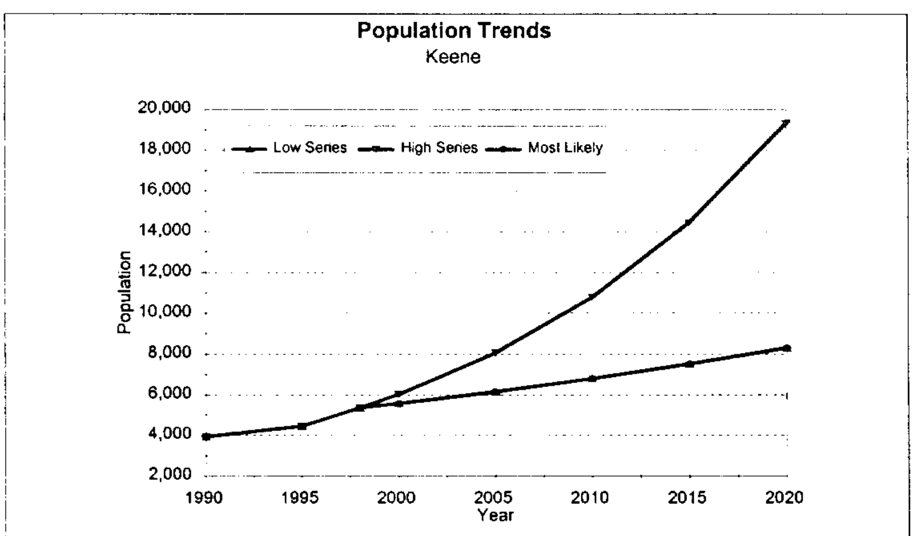
Low Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	2.0	2.0	2.0	2.0	2.0
Population	5,583	6,167	6,812	7,525	8,312
Average Annual Useage	0.73	0.78	0.83	0.89	0.96
Peak Daily Demand	1.66	1.81	1.98	2.16	2.35
Well Capacity	1.36	1.02	0.68	0.34	0.00
Surface Water Needs (Peak)	0.30	0.79	1.30	1.82	2.35

Flows in MGD

Assumptions

Average Water Demand	130.2	126.05	121.9	118.45	115

Parameter	Value	Units	Source
peak water demand	298	gal/cap/day	0.6 gpm/connection
2020 Conservation Savings	5.10%		TWDB
average number of people per connection	2.9	cap/conn	engineering estimate
1998 Keene system connections	1850	-	City of Keene
well capacity decline over 20 years	100	%	engineering estimate
2000 well capacity	1.36	MGD	City of Keene
Shading indicates demand exceeds well capacity			



Projected Population and Water Demand
Alvarado

Most Likely Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	2.0	2.0	2.0	2.0	2.0
Population	3,168	3,498	3,862	4,264	4,708
Average Annual	0.39	0.42	0.44	0.47	0.50
Peak Daily	0.94	1.03	1.12	1.22	1.32
Well Capacity	0.75	0.56	0.38	0.19	0.00
Surface Water (Peak)	0.19	0.46	0.74	1.03	1.32

High Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	6.0	6.0	6.0	6.0	6.0
Population	3,421	4,579	6,127	8,199	10,973
Average Annual	0.42	0.55	0.71	0.91	1.18
Peak Daily	1.02	1.34	1.77	2.34	3.08
Well Capacity	0.75	0.56	0.38	0.19	0.00
Surface Water (Peak)	0.27	0.78	1.40	2.15	3.08

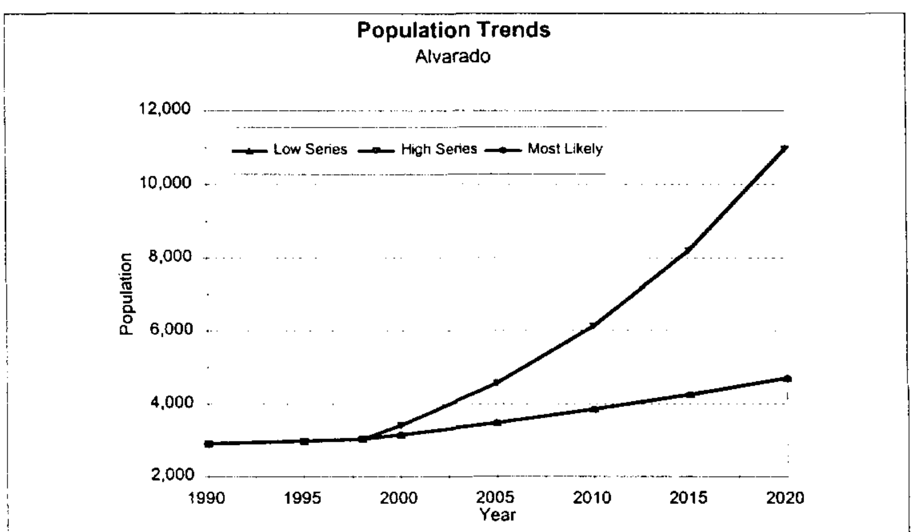
Low Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	2.0	2.0	2.0	2.0	2.0
Population	3,169	3,500	3,866	4,271	4,718
Average Annual Useage	0.39	0.42	0.45	0.47	0.51
Peak Daily Demand	0.94	1.03	1.12	1.22	1.33
Well Capacity	0.75	0.56	0.38	0.19	0.00
Surface Water Needs (Peak)	0.19	0.47	0.74	1.03	1.33

Flows in MGD

Assumptions

Average Water Demand	124.2	119.65	115.1	111.1	107.1

Parameter	Value	Units	Source
peak water demand	298	gal/cap/day	0.6 gpm/connection
2020 Conservation Savings	5.74%		TWDB
average number of people per connection	2.9	cap/conn	engineering estimate
1998 Alvarado system connections	1050	-	TNRCC
well capacity decline over 20 years	100	%	engineering estimate
2000 well capacity	0.75	MGD	TNRCC
Shading indicates demand exceeds well capacity			



Projected Population and Water Demand

Bethany WSC

Most Likely Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	2.1	2.1	2.1	2.1	2.1
Population	3,402	3,773	4,184	4,639	5,145
Average Annual	0.42	0.45	0.48	0.52	0.55
Peak Daily	1.01	1.11	1.21	1.32	1.45
Well Capacity	0.70	0.61	0.52	0.44	0.35
Surface Water (Peak)	0.32	0.50	0.69	0.89	1.10

High Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	6.0	6.0	6.0	6.0	6.0
Population	3,667	4,908	6,568	8,789	11,762
Average Annual	0.46	0.59	0.76	0.98	1.26
Peak Daily	1.09	1.44	1.90	2.51	3.30
Well Capacity	0.70	0.61	0.52	0.44	0.35
Surface Water (Peak)	0.39	0.83	1.38	2.07	2.95

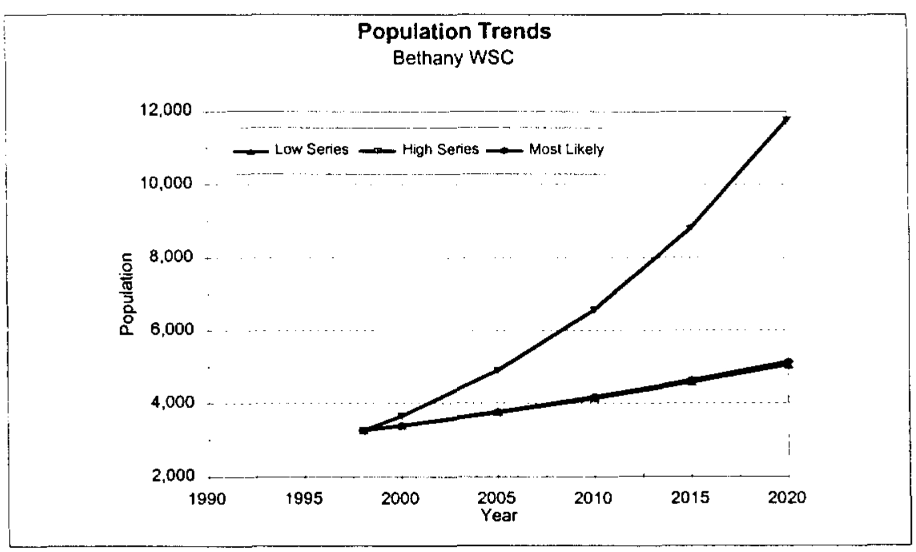
Low Series	2000	2005	2010	2015	2020
Growth Rate (%/yr)	2.0	2.0	2.0	2.0	2.0
Population	3,397	3,752	4,144	4,578	5,057
Average Annual Useage	0.42	0.45	0.48	0.51	0.54
Peak Daily Demand	1.01	1.10	1.20	1.31	1.42
Well Capacity	0.70	0.61	0.52	0.44	0.35
Surface Water Needs (Peak)	0.31	0.49	0.68	0.87	1.07

Flows in MGD

Assumptions

Average Water Demand	124.2	119.65	115.1	111.1	107.1

Parameter	Value	Units	Source
peak water demand	298	gal/cap/day	Bethany WSC
2020 Conservation Savings	5.74%		TWDB
average number of people per connection	3	cap/conn	Bethany WSC Survey
1998 Bethany system connections	1088	-	Bethany WSC
well capacity decline over 20 years	50	%	engineering estimate
2000 well capacity	0.698	MGD	Bethany WSC
Shading indicates demand exceeds well capacity			

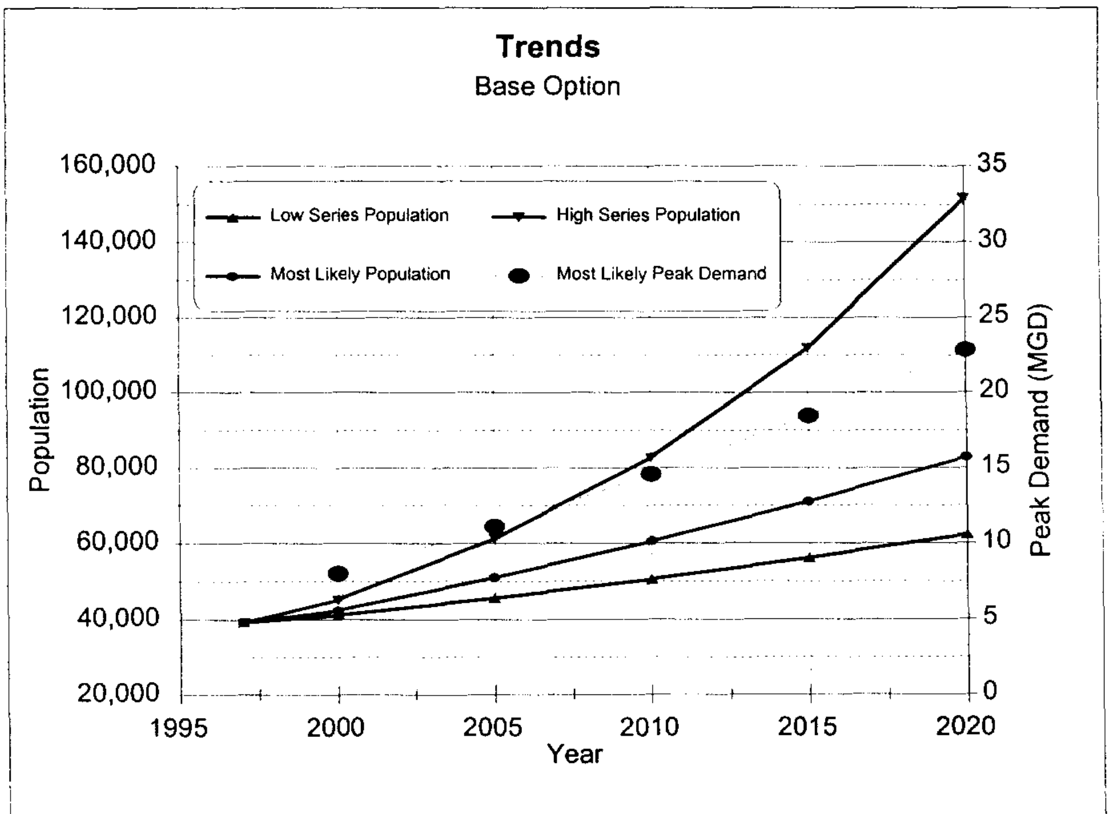


Projected Population and Water Demand
Base Option with Conservation

Most Likely Series	2000	2005	2010	2015	2020
Population	42,494	51,080	60,570	71,122	82,929
Average Annual	5.28	6.21	7.18	8.26	9.42
Peak Daily	13.09	15.59	18.29	21.25	24.49
Well Capacity	5.02	4.48	3.73	2.77	1.62
Surface Water (Peak)	8.07	11.11	14.57	18.47	22.87

High Series	2000	2005	2010	2015	2020
Population	45,269	61,153	82,696	111,948	151,716
Average Annual	5.64	7.39	9.68	12.78	16.88
Peak Daily	13.96	18.64	24.90	33.30	44.58
Well Capacity	5.02	4.48	3.73	2.77	1.62
Surface Water (Peak)	8.94	14.16	21.17	30.52	42.96

Low Series	2000	2005	2010	2015	2020
Population	41,252	45,716	50,670	56,171	62,278
Average Annual Useage	5.10	5.43	5.76	6.16	6.57
Peak Daily Demand	12.69	13.87	15.15	16.55	18.07
Well Capacity	5.02	4.48	3.73	2.77	1.62
Surface Water Needs (Peak)	7.67	9.39	11.42	13.77	16.45

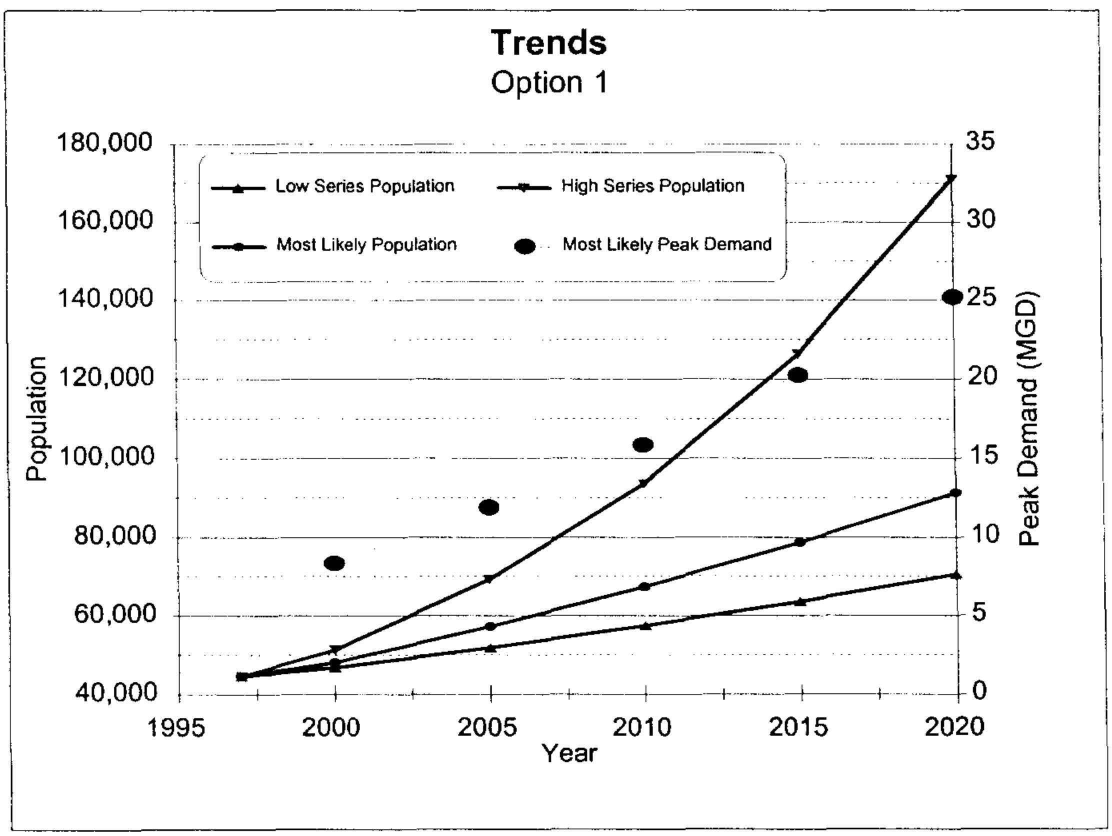


Projected Population and Water Demand
Option 1 - Base plus Keene, with Conservation

Most Likely Series	2000	2005	2010	2015	2020
Population	48,076	57,243	67,374	78,635	91,224
Average Annual	6.00	6.99	8.01	9.15	10.37
Peak Daily	14.76	17.40	20.27	23.40	26.84
Well Capacity	6.38	5.50	4.41	3.11	1.62
Surface Water (Peak)	8.37	11.91	15.86	20.28	25.22

High Series	2000	2005	2010	2015	2020
Population	51,297	69,220	93,491	126,394	171,049
Average Annual	6.43	8.40	11.00	14.49	19.10
Peak Daily	15.76	21.01	28.03	37.44	50.05
Well Capacity	6.38	5.50	4.41	3.11	1.62
Surface Water (Peak)	9.37	15.51	23.63	34.32	48.43

Low Series	2000	2005	2010	2015	2020
Population	46,835	51,883	57,482	63,695	70,590
Average Annual Useage	5.83	6.20	6.59	7.05	7.52
Peak Daily Demand	14.36	15.68	17.13	18.70	20.42
Well Capacity	6.38	5.50	4.41	3.11	1.62
Surface Water Needs (Peak)	7.97	10.19	12.72	15.59	18.80

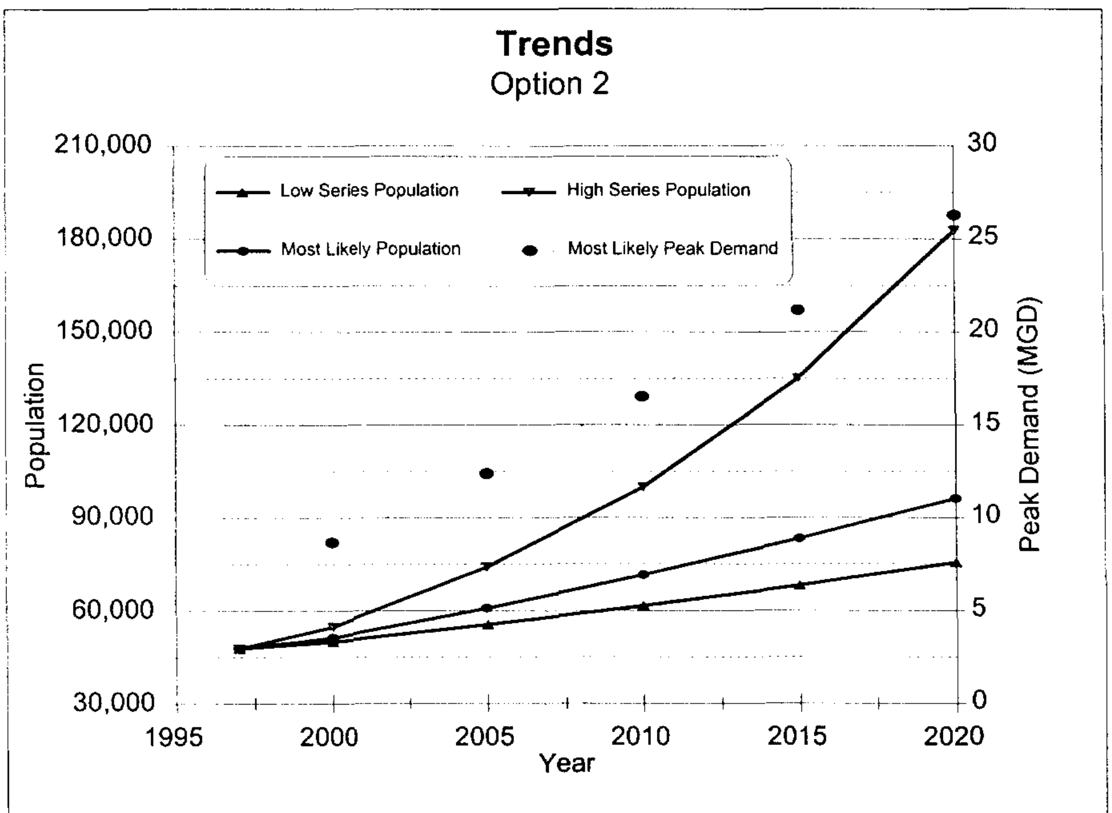


Projected Population and Water Demand
Option 2: Option 1 plus Bethany, with Conservation

Most Likely Series	2000	2005	2010	2015	2020
Population	51,478	61,015	71,557	83,274	96,369
Average Annual	6.43	7.44	8.49	9.67	10.92
Peak Daily	15.77	18.51	21.48	24.72	28.28
Well Capacity	7.08	6.11	4.93	3.55	1.97
Surface Water (Peak)	8.69	12.40	16.55	21.17	26.32

High Series	2000	2005	2010	2015	2020
Population	54,965	74,128	100,059	135,184	182,811
Average Annual	6.88	8.99	11.75	15.46	20.36
Peak Daily	16.85	22.45	29.93	39.95	53.35
Well Capacity	7.08	6.11	4.93	3.55	1.97
Surface Water (Peak)	9.77	16.34	25.00	36.39	51.38

Low Series	2000	2005	2010	2015	2020
Population	50,232	55,635	61,627	68,273	75,647
Average Annual Useage	6.25	6.65	7.07	7.56	8.06
Peak Daily Demand	15.37	16.78	18.33	20.01	21.84
Well Capacity	7.08	6.11	4.93	3.55	1.97
Surface Water Needs (Peak)	8.29	10.68	13.40	16.46	19.88

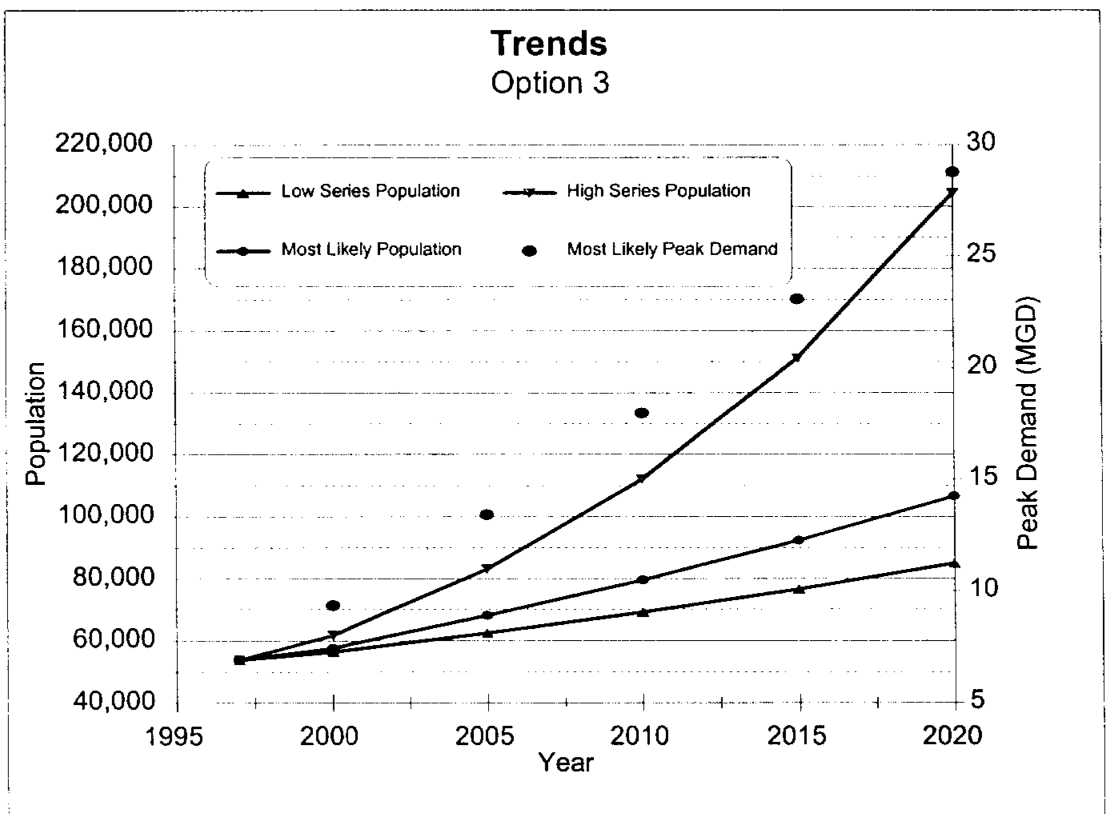


Projected Population and Water Demand
Option 3 - Base plus Keene, Bethany, and Johnson County Northeast, with Conservation

Most Likely Series	2000	2005	2010	2015	2020
Population	57,707	68,138	79,647	92,413	106,648
Average Annual	7.20	8.29	9.42	10.68	12.02
Peak Daily	17.63	20.60	23.82	27.33	31.17
Well Capacity	8.26	7.17	5.82	4.23	2.37
Surface Water (Peak)	9.37	13.43	18.00	23.10	28.80

High Series	2000	2005	2010	2015	2020
Population	61,681	83,115	112,086	151,278	204,349
Average Annual	7.72	10.07	13.14	17.25	22.67
Peak Daily	18.85	25.09	33.42	44.54	59.40
Well Capacity	8.26	7.17	5.82	4.23	2.37
Surface Water (Peak)	10.59	17.92	27.59	40.31	57.03

Low Series	2000	2005	2010	2015	2020
Population	56,451	62,505	69,216	76,656	84,907
Average Annual Useage	7.02	7.48	7.94	8.49	9.06
Peak Daily Demand	17.22	18.80	20.52	22.40	24.45
Well Capacity	8.26	7.17	5.82	4.23	2.37
Surface Water Needs (Peak)	8.96	11.63	14.70	18.17	22.07

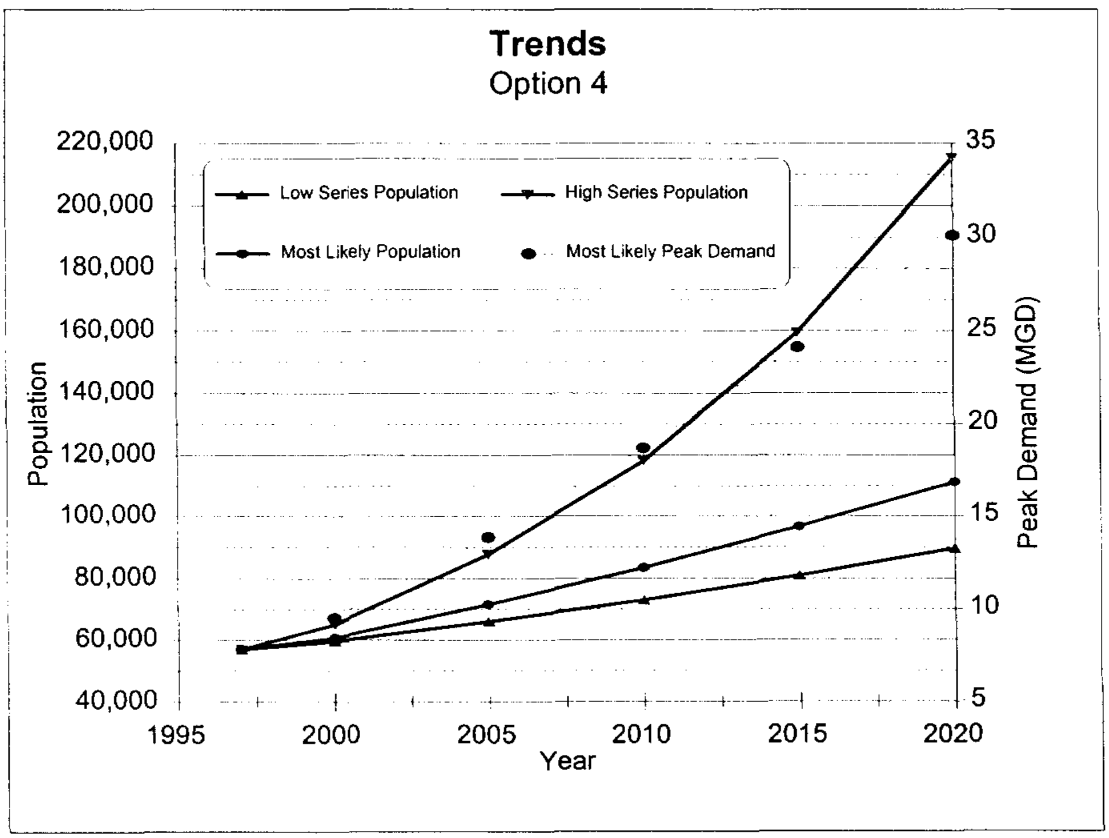


Projected Population and Water Demand
Option 4 - Option 3 plus Alvarado with Conservation

Most Likely Series	2000	2005	2010	2015	2020
Population	60,875	71,636	83,509	96,677	111,355
Average Annual	7.59	8.71	9.87	11.15	12.53
Peak Daily	18.57	21.63	24.94	28.54	32.49
Well Capacity	9.01	7.73	6.20	4.41	2.37
Surface Water (Peak)	9.56	13.90	18.74	24.13	30.12

High Series	2000	2005	2010	2015	2020
Population	65,102	87,694	118,213	159,478	215,322
Average Annual	8.14	10.62	13.84	18.16	23.84
Peak Daily	19.87	26.44	35.19	46.87	62.48
Well Capacity	9.01	7.73	6.20	4.41	2.37
Surface Water (Peak)	10.86	18.70	28.99	42.46	60.11

Low Series	2000	2005	2010	2015	2020
Population	59,620	66,005	73,082	80,927	89,625
Average Annual Useage	7.42	7.89	8.39	8.96	9.56
Peak Daily Demand	18.17	19.83	21.64	23.62	25.77
Well Capacity	9.01	7.73	6.20	4.41	2.37
Surface Water Needs (Peak)	9.16	12.10	15.44	19.20	23.40



Flows in MGD

APPENDIX D

PIPELINE EXPANSION OPTIONS

OPINION OF PROBABLE COSTS

Johnson County Parallel Pipeline, Base Option
Financial Recap

Period (Years)	20
Percentage	6.00%

Improvements for Year 2000 to Meet Requirements of Year 2012 (7 MGD)

Facilities	Description	Quantity	Units	Peak Flow	Cost	Annual Fixed Cost	Annual Per Peak MGD	Accum/Peak MGD
High Service Pump Addition	403 ft head	300	HP	7.00	$258,750	$22,559	$3,223	$3,223

Improvements for Year 2012 to Meet Requirements of Year 2025 (12 MGD)

In Line Booster Pump Station		1200	HP	12.00	$1,811,250	$157,913	$13,159	$15,039
High Service Pump Addition	380 ft head	300	HP					

Improvements for Year 2025 to Meet Requirements of Year 2032 (16 MGD)

Parallel SWATS to #12	36 in diam	75200	LF	16.00	$12,373,425	$1,078,772	$67,423	$77,293
High Service Pump Addition	355 ft head	300	HP					

Hood County Pipeline
Financial Recap

Period (Years)	20
Percentage	6.00%

Improvements for Year 2000 to Meet Requirements of Year 2003 (5 MGD)

Facilities	Description	Quantity	Units	Peak Flow	Cost	Annual Fixed Cost	Annual Per Peak MGD	Accum/Peak MGD
From AMUD Ground Storage Tank	24 in diam	5200	LF	5.00	$3,460,350	$301,689	$60,338	$60,338
From Decordova to NB&IH&Granbury Diversion	24 in diam	4400	LF					
To SH377 Storage Tank	16 in diam	13000	LF					
High Service Pumps	270 ft head	600	HP					

Improvements for Year 2003 to Meet Requirements of Year 2024 (14 MGD)

Facilities	Description	Quantity	Units	Peak Flow	Cost	Annual Fixed Cost	Annual Per Peak MGD	Accum/Peak MGD
To Nausau Bay	20 in diam	4400	LF	14.00	$3,481,050	$303,494	$21,678	$43,227
To Indian Harbor	20 in diam	16800	LF					
To Granbury	16 in diam	8700	LF					
High Service Pumps	300 ft head	600	HP					

Johnson County Parallel Pipeline, Option #1
Financial Recap

Period (Years)	20
Percentage	6.00%

Improvements for Year 2000 to Meet Requirements of Year 2009 (7 MGD)

Facilities	Description	Quantity	Units	Peak Flow	Cost	Annual Fixed Cost	Annual Per Peak MGD	Accum/Peak MGD
#17 to Keene	16 in diam	10,600	LF	7.00	$1,124,700	$98,056	$14,008	$14,008
High Service Pump Addition	403 ft head	300	HP					

Improvements for Year 2009 to Meet Requirements of Year 2018 (11 MGD)

In-Line Booster Pump Station	250 ft head	1200	HP	11.00	$1,811,250	$157,913	$14,356	$23,270
High Service Pump Addition	384 ft head	300	HP					

Improvements for Year 2018 to Meet Requirements of Year 2024 (14.4 MGD)

SWATS to #12	36 in diam	75200	LF	14.40	$12,373,425	$1,078,772	$74,915	$92,690
High Service Pump Addition	392 ft head	300	HP					

Johnson County Parallel Pipeline, Option #2
Financial Recap

Period (Years)	20
Percentage	6.00%

Improvements for Year 2000 to Meet Requirements of Year 2007 (6.9 MGD)

Facilities	Description	Quantity	Units	Peak Flow	Cost	Annual Fixed Cost	Annual Per Peak MGD	Accum/Peak MGD
#17 to Keene	16 in diam	10600	LF	6.90	$2,019,113	$176,035	$25,512	$25,512
Keene to Bethany	10 in diam	15900	LF					
High Service Pump Addition	408 ft head	300	HP					

Improvements for Year 2007 to Meet Requirements of Year 2016 (11 MGD)

In-Line Booster Pump Station	247 ft head	1200	HP	11.00	$1,811,250	$157,913	$14,356	$30,359
High Service Pump Addition	384 ft head	300	HP					

Improvements for Year 2016 to Meet Requirements of Year 2022 (14.2 MGD)

SWATS to #12	42 in diam	75200	LF	14.20	$14,319,225	$1,248,415	$87,917	$111,434
High Service Pump Addition	398 ft head	300	HP					
In-Line Booster Pump Station	0 ft head	0	HP					

Improvements for Year 2022 to Meet Requirements of Year 2028 (19 MGD)

	0 in diam	0	LF	19.00	$948,750	$82,716	$4,353	$78,371
High Service Pump Addition	368 ft head	300	HP					
In-Line Booster Pump	122 ft head	200	HP					

Johnson County Parallel Pipeline, Option #3
Financial Recap

Period (Years)	20
Percentage	6.00%

Improvements for Year 2000 to Meet Requirements of Year 2005 (6.9 MGD)

Facilities	Description	Quantity	Units	Peak Flow	Cost	Annual Fixed Cost	Annual Per Peak MGD	Accum/Peak MGD
Line B (From Line A to Line E)	24 in diam	14700	LF	6.90	$6,473,063	$564,351	$81,790	$81,790
Line B (From Line E to Line F)	18 in diam	13700	LF					
Line B (From Line F to Line D)	16 in diam	20800	LF					
Line E	16 in diam	9400	LF					
Line F	10 in diam	10400	LF					
Line D	16 in diam	600	LF					
High Service Pump Addition	408 ft head	300	HP					

Improvements for Year 2005 to Meet Requirements of Year 2012 (11 MGD)

High Service Pump Addition	384 ft head	300	HP	11.00	$1,811,250	$157,913	$14,356	$65,660
In-Line Booster Pump Station	254 ft head	1200	HP					

Improvements for Year 2012 to Meet Requirements of Year 2020 (16 MGD)

Line A (From SWATS to TST)	36 in diam	75200	LF	16.00	$12,977,175	$1,131,409	$70,713	$115,855
High Service Pump Addition	368 ft head	300	HP					
In-Line Booster Pump Station	0 ft head	100	HP					

Improvements for Year 2020 to Meet Requirements of Year 2024 (19 MGD)

		0	LF	19.00	$345,000	$30,079	$1,583	$99,145
High Service Pump Addition	368 ft head	300	HP					

Johnson County Parallel Pipeline, Option #4
Financial Recap

Period (Years)	20
Percentage	6.00%

Improvements for Year 2000 to Meet Requirements of Year 2004 (7 MGD)

Facilities	Description	Quantity	Units	Peak Flow	Cost	Annual Fixed Cost	Annual Per Peak MGD	Accum/Peak MGD
Line B (From Line A to Line E)	24 in diam	14700	LF	6.90	$7,905,675	$689,253	$99,892	$99,892
Line B (From Line E to Line F)	20 in diam	13700	LF					
Line B (From Line F to Line D)	20 in diam	20800	LF					
Line B (From Line D to Alvarado)	12 in diam	13200	LF					
Line E	16 in diam	9400	LF					
Line F	10 in diam	10400	LF					
Line D	16 in diam	600	LF					
High Service Pump Addition	408 ft head	300	HP					

Improvements for Year 2004 to Meet Requirements of Year 2011 (11 MGD)

High Service Pump Addition	384 ft head	300	HP	11.00	$1,811,250	$157,913	$14,356	$77,015
In-Line Booster Pump Station	251 ft head	1200	HP					

Improvements for Year 2011 to Meet Requirements of Year 2018 (16 MGD)

SWATS to TST	36 in diam	75200	LF	16.00	$12,977,175	$1,131,409	$70,713	$123,661
High Service Pump Addition	342 ft head	300	HP					
In-Line Booster Pump Station	0 ft head	5	HP					

Improvements for Year 2018 to Meet Requirements of Year 2022 (19 MGD)

			LF	19.00	$345,000	$30,079	$1,583	$105,719
High Service Pump Addition	352 ft head	300	HP					
In-Line Booster Pump Addition	114 ft head	200	HP					

Johnson County Parallel Pipeline, Option #5
Financial Recap

Period (Years)	20
Percentage	6.00%

Improvements for Year 2000 to Meet Requirements of Year 2008 (7 MGD)

Facilities	Description	Quantity	Units	Peak Flow	Cost	Annual Fixed Cost	Annual Per Peak MGD	Accum/Peak MGD
Line to Cleburne	20 in diam	12000	LF	7.00	$1,423,125	$124,075	$17,725	$17,725
High Service Pump Addition	403 ft head	300	HP					

Improvements for Year 2008 to Meet Requirements of Year 2016 (11.5 MGD)

High Service Pump	364 ft head	300	HP	11.50	$1,811,250	$157,913	$13,732	$24,521
Inline Booster Pump Station	302 ft head	1200	HP					

Improvements for Year 2016 to Meet Requirements of Year 2022 (16 MGD)

Line A (SWATS to #12)	42 in diam	75200	LF	16.00	$14,034,600	$1,223,600	$76,475	$94,099

APPENDIX E

EVALUATION OF DESALTING ALTERNATIVES

BRAZOS RIVER AUTHORITY
LAKE GRANBURY WATER TREATMENT PLANT

Draft Report

October 1998

CAROLLO ENGINEERS

ALAN PLUMMER ASSOCIATES, INC.
EVALUATION OF DESALTING ALTERNATIVES

BRAZOS RIVER AUTHORITY
LAKE GRANBURY WATER TREATMENT PLANT

October 1998

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1.0 INTRODUCTION AND BACKGROUND

The Lake Granbury Surface Water and Treatment System (SWATS) has been operating for approximately 10 years. This facility treats water from Lake Granbury conventionally before feeding it to an electrodialysis reversal (EDR) system that removes a significant portion of the total dissolved solids (TDS). The EDR process is necessary because the water from Lake Granbury does not normally meet U.S. Environmental Protection Agency primary drinking water standards. In the worst-case, the TDS can exceed 1,700 mg/L, which is in excess of the 1,000 mg/L regulatory limit.

The existing SWATS plant is capable of treating up to 7.0 million gallons per day (mgd) through the conventional process. After some intermediate storage, this flow is fed to the EDR process where the recovery is approximately 75 percent. Hence, a product water flow of 5.0 mgd is available for distribution and 2.0 mgd of high-TDS reject water is returned to the lake. The product water generally attains the plant treatment goals of 250 mg/L of chloride ion concentration and 900 mg/L of TDS.

The SWATS plant is being considered for expansion to meet the growing demand in the Hood and Johnson County area. The intent of this report is to evaluate the different desalting methods that could be utilized for the plant expansion. The candidate processes include additional EDR equipment, reverse osmosis (RO) equipment and nanofiltration equipment. The latter two processes are membrane-based and have been refined significantly within the last ten years. during the period that the existing EDR system has been in service. Hence, an updated evaluation between these membranes processes and the EDR process is merited. This technical memo will present this evaluation and make a recommendation for the SWATS plant expansion.

2.0 DESIGN CRITERIA

As part of this evaluation several assumptions will be made related to the raw water quality, design criteria for the desalting equipment, the costs of utilities and raw materials and economic criteria. The intent of this section is to establish some of these assumptions.

The following values for raw water quality (Table 2.1) are based on data obtained from a database from the Lake Granbury WTP.

Table 2.1 Raw and Desalting Feed Water Quality Brazos River Authority - Lake Granbury Water Treatment Plant

Parameter	Value	Units
Maximum Total Dissolved Solids (TDS)[1]	1750	mg/L
Average TDS[1]	1090	mg/L
Maximum Chloride Ion Concentration[1]	660	mg/L
Average Chloride Ion Concentration[1]	400	mg/L
Maximum Sulfate Ion Concentration[1]	380	mg/L
Average Sulfate Ion Concentration[1]	200	mg/L
Maximum Filtered Water Turbidity[1]	0.50	NTU
Average Filtered Water Turbidity[1]	0.10	NTU
pH Range[1]	7.3 - 8.0	pH units
Average pH[1]	7.7	pH units
Temperature Range[2]	45 - 90	degrees F
Average Temperature[2]	68	degrees F
Maximum Alkalinity[2]	146	mg/L $CaCO_3$
Average Alkalinity[2]	106	mg/L $CaCO_3$
Maximum Calcium Ion Concentration[3]	136	mg/L
Maximum Magnesium Ion Concentration[3]	46	mg/L
Maximum Strontium Ion Concentration[3]	2.00	mg/L
Maximum Barium Ion Concentration[3]	0.30	mg/L
Maximum Silica[4]	15.0	mg/L

[1] Value determined from plant data over the period January 1997 through August 1998. TDS values calculated from conductivity data using a factor of 0.59.
[2] Value determined from Paradox database provided by the SWATS plant.
[3] Value obtained from Ionics data based on their maintenance assistance at the plant.
[4] General assumption - data not available.

There are two additional raw water and filtered water parameters that would be useful for our analysis. Those are the **Silt Density Index (SDI)** and the **barium ion concentration.** We realize that this data may not be available now, but it may be desirable to begin sampling for these prior to final design.

The following design and operational flow criteria (Table 2.2) were developed based on other work associated with this project. These values will be used in the evaluation of the various alternatives for this project. In general, the design or maximum conditions will be used to size the facilities, while the average conditions will be used to determine annual costs.

Table 2.2 Lake Granbury WTP Design and Operational Flow Criteria
Brazos River Authority - Lake Granbury Water Treatment Plant

Parameter	Value	Units
Existing Conventional Plant Design Flow Rate	7.0	mgd
Existing Desal Plant Design Flow Rate	5.0	mgd
Next Phase Expansion, Conventional Plant Desal Flow Rate-EDR	7.0	mgd
Next Phase Expansion, Conventional Plant Desal Flow Rate-RO	8.5	mgd
Expanded Desal Plant Product Design Flow Rate	10.0	mgd
Modular EDR Plant Product Expansion Design Flow Rate[5]	1.6	mgd
Modular RO Plant Product Design Flow Rate[6]	1.1	mgd
Maximum Finished Chloride Ion Concentration	250	mg/L
Maximum Finished TDS Concentration	900	mg/L

[5] This maximum flow rate is based on the largest EDR unit train available and we will compare this to the cost of an equal size RO unit train.
[6] The modular RO product flow rates are designed to permit shop fabrication of the RO modules.

The above flow rate values assume an EDR system water recovery rate of 75 to 80 percent in the desalting units. An RO system water recovery rate of 50 percent is also assumed. It should be noted, however, that the recovery of the RO alternative might be improved significantly if sampling and testing is done to verify that the barium concentration of the raw water is actually lower than the value shown in Table 2.1.

In addition, it will be assumed that the water produced will meet all primary standards of the USEPA.

The following economic and utility evaluation criteria (Table 2.3) will be used to calculate the capital and annual operating costs of the alternatives developed within the project.

Table 2.3 Economic and Utility Evaluation Criteria Brazos River Authority - Lake Granbury Water Treatment Plant		
Parameter	**Value**	**Units**
Equipment Life (Evaluation Period)	20	years
Net Interest Rate*	5	%/year
Base Year for Economic Analysis	1999	---
Installation Cost of Desalting Equipment	50	percent adder
Building Cost	100	$/square foot
General Contractor Mark-Up on Desal Equipment	25	percent adder
Current Power Cost	0.076	$/kWh
Brazos River Authority Labor Rate	25	$/hour
* The net interest rate is defined as the real interest rate less the inflation rate. As an example, if the real interest rate is 8 percent per year and the inflation rate is 3 percent per year, the net interest rate would be 5 percent per year, as indicated above.		

Other assumptions will be necessary during the course of our evaluation. For example, we will assume that the desalting equipment will operate continuously during the course of a year at the average annual WTP plant flow rate instead of assuming that it will operate intermittently.

3.0 MEMBRANE TECHNOLOGY FOR WATER TREATMENT AND TDS REDUCTION

The three technologies to be evaluated for this project are EDR, RO and Nano-Filtration (NF). The latter is a modification of the RO technology. NF membranes are specially treated RO membranes to cause them to pass a large percentage of monovalent ions (sodium, chloride, etc.) and still to retain (or reject) the majority of the divalent ions in water (calcium, magnesium, sulfate, etc.). As such, NF membranes are used primarily for water softening. In addition, since NF membranes retain much of the ability of RO membranes to reject THM precursors, they are also used for that purpose - often in combination with water softening. For these applications - water softening and THM precursor removal - the advantage of NF over RO is that NF equipment can be operated at a significantly lower pressure than RO equipment. The main reasons for this are (1)the osmotic pressure of the water being treated remains low because a substantial portion of the monovalent ions is passed by the NF membrane; (2) the NF membrane has inherently greater "flux" characteristics (passes more water for a given pressure) than the RO membrane.

RO membranes are designed to reject monovalent ions almost as much as divalent ions, and therefore, are used for desalting applications; that is, for applications where TDS, and sodium and chloride reduction, are the primary objectives. Since TDS and chloride reduction are the main objectives for the Lake Granbury Water Treatment Plant, the obvious conclusion must be that RO would be the proper process for this application, and should be selected rather than NF. Accordingly, NF will be eliminated from further consideration and the subsequent evaluations will be centered on comparisons between the EDR and RO processes.

4.0 GENERAL COMPARISON OF ELECTRODIALYSIS REVERSAL (EDR) WITH REVERSE OSMOSIS (RO) TECHNOLOGY

The Electrodialysis (ED) and Electrodialysis Reversal (EDR) technology has been developed, and patented in the USA and elsewhere, by Ionics. Incorporated over the past 50 years. Asahi in Japan is the only other company with a significant presence in ED. However, Asahi has not been very active in municipal water treatment. but instead has worked primarily on using ED for concentrating seawater for salt production.

A detailed explanation and discussion of EDR technology is beyond the scope of services for this project, and reference is made to the technical literature and to catalogue data readily available from Ionics.

The primary use of EDR is the desalting of brackish water in municipal and industrial applications. The source water may be either well water or surface water. In many industrial applications, tap water is desalted for boiler feed water. for ultra pure water for semi-conductor manufacturing, and for pharmaceutical manufacturing.

The primary advantages of the EDR process over the RO process are as follows:

- High tolerance of feed waters containing high concentrations of scaling constituents (calcium sulfate, barium sulfate, etc.); and high concentrations of organic substances (humic acid, fulvic acid, etc.), which tend to "foul" the membranes, and thus reduce production.

- For moderately brackish waters - TDS up to about 2.000 mg/L - electric power consumption for EDR is somewhat less than for RO.

- For most natural waters, dosing rates for treatment chemicals (acid. anti-scalant, etc.) are somewhat less than for RO.

- The EDR membrane stacks can be taken apart so that the membranes and spacers can be cleaned with brushes and detergents on-site. Hollow fine fiber RO membrane elements, once plugged with scale and/or foulants, must be discarded. For spiral wound RO membrane elements, there are several firms which offer off-site cleaning services. There are a few firms which offer "reconditioning services", involving unrolling the spiral wound elements, cleaning the active membrane surface, installing new spacers, and re-rolling the elements. Needless to say, this is a very time consuming and, therefore, costly operation.

The reverse osmosis (RO) technology got its start in the early fifties at UCLA. Today, there are 5 or 6 major manufacturers of spiral wound RO membrane elements, and 2 or 3 manufacturers of hollow fine fiber RO membrane elements. Initially, RO membranes were only capable of desalting brackish waters in a single pass. But RO salt rejection has been improved to more than 99 percent, suitable for single pass seawater desalination.

The main advantages of the RO process, over the EDR process, are as follows:

- For feed waters having a TDS of more than 2,000 mg/L, electric power consumption is less than for EDR than for RO. However, for a feed water TDS greater than 4,000 to 5,000 mg/L, EDR salt reduction is too low to produce an acceptable product and RO is the better choice.

- Generally, the RO process equipment is somewhat less complex and less costly than EDR equipment.

- In addition to inorganic constituents (dissolved ions), the RO membrane retains/rejects most dissolved organic compounds (herbicides, pesticides, TOC, THM precursors, etc.), as well as protozoa, bacteria, and most viruses. Thus, RO can often be used to disinfect water, in addition to desalting it. This is not possible with EDR, as the raw water feed stream in EDR becomes the diluted product water stream.

Disadvantages of RO are:

- It is more sensitive to feed water quality than EDR. RO membrane manufacturers require that the Silt Density Index (SDI) of the feed water be less than 5, and preferably less than 3 - in fact, the lower the SDI the better. All RO membrane manufacturers base their warranties on the SDI value of the feed water. If the maximum allowable SDI value is exceeded, the warranty may be void. The SDI concept is explained in Section 9.0 of this Report.

- As mentioned earlier in the RO process discussion, it is very critical that sparingly soluble salts (scaling compounds) are kept in solution as the feed water is concentrated to the level of the reject brine. Six key sparingly soluble salts which occur in natural waters are as follows:

- Calcium carbonate ($CaCO_3$)
- Calcium sulfate ($CaSO_4$)
- Barium sulfate ($BaSO_4$)
- Strontium sulfate ($SrSO_4$)
- Calcium fluoride (CaF_2)
- Silica (SiO_2)

Calcium carbonate generally is controlled by dosing the feed water with acid (usually sulfuric, but sometimes hydrochloric). The other compounds, except silica, are usually controlled to a certain extent with anti-scalants (scale inhibitors). If silica concentrations are high, the product water recovery rate must be kept low enough to keep the silica in solution. The effectiveness of anti-scalants is limited and recovery must be reduced - even with anti-scalant dosing - if the concentration of sparingly soluble salts is very high.

- Another problem that occasionally happens with RO is carry-over of chemicals from the pretreatment process, that is: coagulation and filtration where alum and polymers are used. The aluminum concentration of RO feed water should not exceed 0.35 mg/L. Thus, incomplete removal of alum in the filtration process may cause precipitation of aluminum on the RO membrane.

  In addition, there have been cases where traces of cationic polymer, carried over into the RO feed water, have combined with anti-scalant compounds to form a precipitate on the RO membrane.

From the above discussion, it is to be concluded that RO, being more sensitive to feed water quality than EDR, must be watched more closely and/or must be equipped with a higher degree of fail safe protection than EDR. For example, failure of the anti-scalant dosing system may have catastrophic consequences for RO: completely scaled up membrane elements may have to be thrown away. For EDR, on the other hand, the membrane stacks can be taken apart for cleaning. However, having said this, it should be realized that many RO plants requiring anti-scalant dosing have been operated successfully for many years. In other words, RO can usually be made to work; even for a feed water having high concentrations of sparingly soluble salts. But it may not be the best process, taking into account operational and reliability considerations; and other risk factors.

5.0 THE EDR ALTERNATIVE

A Block Flow Diagram of this alternative is shown on Figure 01. The unit treatment processes used are essentially the same as those in the existing plant. The new "third generation" EDR units are envisioned for the plant expansion, using the largest EDR train size available. Accordingly, not counting on any bypass flow, three (3) EDR units at a capacity of 1.6 to 1.67 mgd would be needed to make up the required next phase finished water capacity of 5.0 mgd. Assuming a water recovery of 75 to 80 percent in the EDR units, the coagulation/filtration capacity required will be 7.0 mgd, similar to the existing configuration.

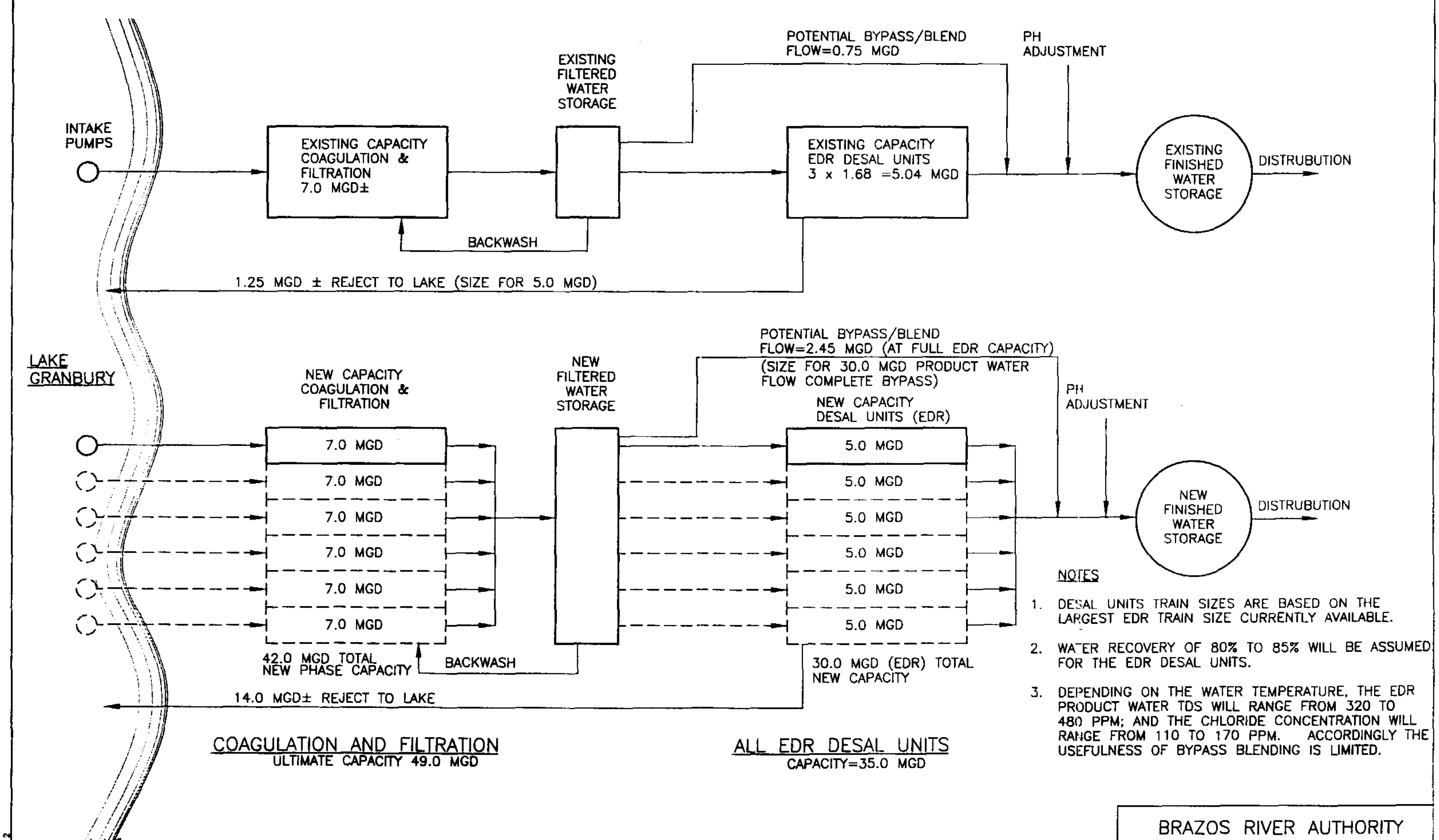
As noted on Figure 01, the TDS and chloride concentrations of the EDR product water are projected to range from 320 to 480 mg/L (TDS) and from 110 to 170 mg/L (chloride), depending on the water temperature. Since these values are less than the 900 mg/L (TDS) and 250 mg/L (chloride) limits for the finished water, some bypass and blending operation could be done at certain times of the year.

As shown in Figure 01, additional capacities of 5.0 mgd (EDR) and 7.0 mgd (conventional) would be added in the future to reach the ultimate projected capacity of 35.0 mgd of finished water.

6.0 THE RO ALTERNATIVE

A Block Flow Diagram for the RO alternative is shown on Figure 02. Since the RO process inherently produces a very low TDS water - typically in the range of 30 to 70 mg/L - it makes sense to utilize blending of RO product water with bypassed filtered water. As shown in Figure 02, a nominal RO desalting capacity of about 3.3 mgd with a nominal bypass flow of 1.7 mgd is envisioned to produce the required flow of 5.0 mgd for the next phase of plant expansion. For RO, a nominal capacity of 1.0 to 1.1 mgd for one train is a frequently used and convenient capacity. However, since RO capacity is inherently very modular, it is very easy in this case to match RO train capacity to pretreatment capacity.

The nominal water recovery for the RO alternative is only 50 percent, due to the high barium concentration that often may occur in the raw feed water. As discussed above, barium sulfate is one of the group of sparingly soluble salts that can cause problems in desalting plants. In checking with one of the anti-scalant vendors, it was found that the recovery might be pushed up to 65 percent - with a very high anti-scalant dosing rate of nearly 9 mg/L in the RO feed water. However, due to the large uncertainty of the barium concentration (only one data point), it is considered prudent to figure on a more conservative recovery of 50 percent for this preliminary design and process evaluation.



NOTES

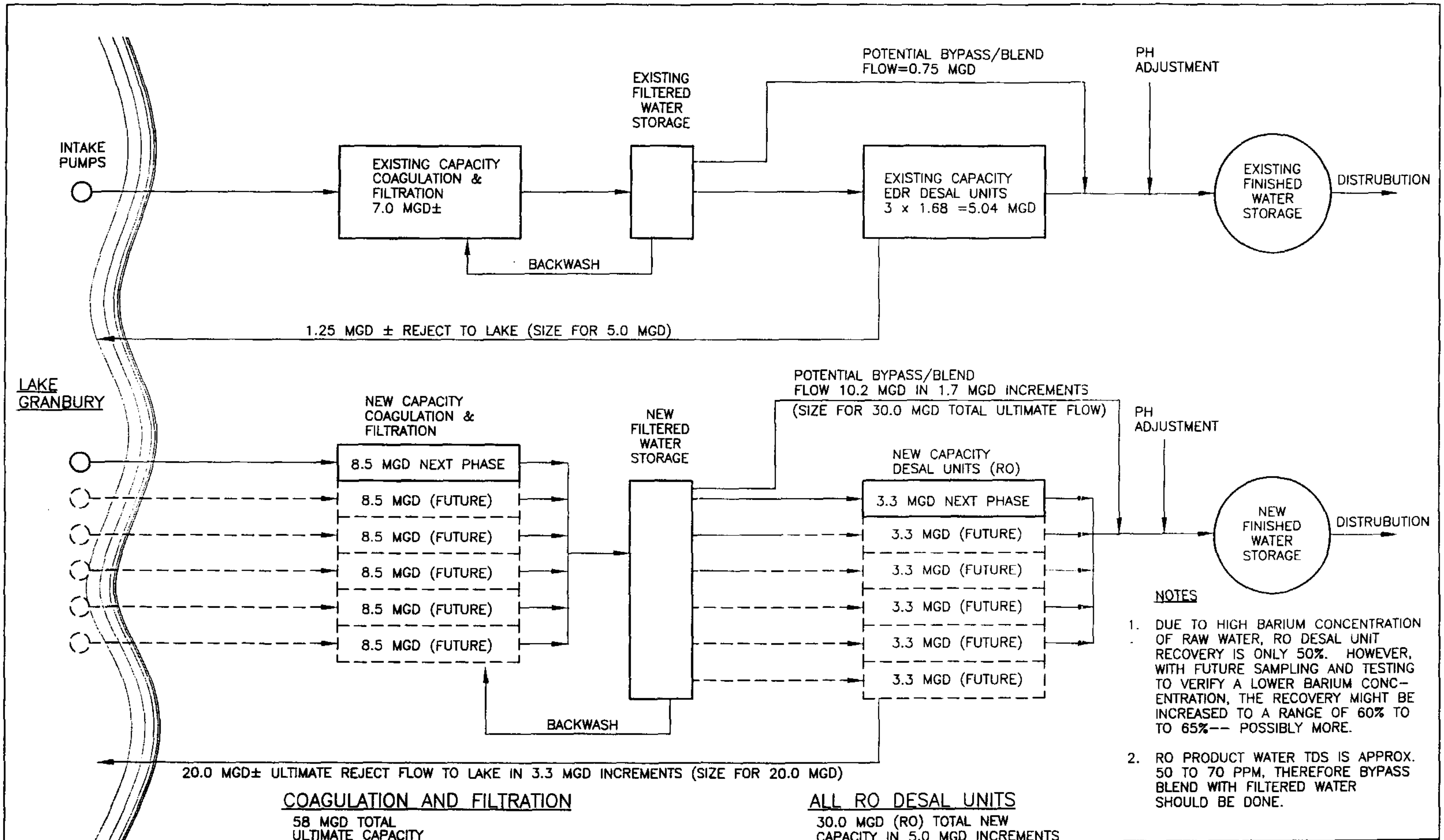
1. DESAL UNITS TRAIN SIZES ARE BASED ON THE LARGEST EDR TRAIN SIZE CURRENTLY AVAILABLE.
2. WATER RECOVERY OF 80% TO 85% WILL BE ASSUMED FOR THE EDR DESAL UNITS.
3. DEPENDING ON THE WATER TEMPERATURE, THE EDR PRODUCT WATER TDS WILL RANGE FROM 320 TO 480 PPM; AND THE CHLORIDE CONCENTRATION WILL RANGE FROM 110 TO 170 PPM. ACCORDINGLY THE USEFULNESS OF BYPASS BLENDING IS LIMITED.

OCT - 3

BRAZOS RIVER AUTHORITY
WACO, TEXAS
LAKE GRANBURY WTP EXPANSION
BLOCK FLOW DIAGRAM—EDR OPTION

FIGURE 01

EXHIBIT 2



BRAZOS RIVER AUTHORITY
WACO, TEXAS
LAKE GRANBURY WTP EXPANSION
BLOCK FLOW DIAGRAM–RO OPTION
FIGURE 02

Nevertheless, with future sampling and testing to verify a lower barium concentration, the RO recovery ratio might be increased to a range of 60 percent to 65 percent - possibly more.

In summary, for the RO alternative, the conventional (coagulation/filtration) capacity required for the next phase of plant expansion will be about 8.3 to 8.5 mgd. This is calculated as follows: feed water to the RO units is 6.6 mgd (at 50 percent recovery), plus 1.7 mgd bypass/blend flow, plus 0.2 mgd allowance for filter backwash and safety margin, equals 8.5 mgd.

A further refinement of the RO design may be considered once a decision has been made to utilize the RO process. In addition to the uncertainty with the barium concentration, another risk in using RO is that there are no data on the Silt Density Index (SDI) of the effluent from the conventional plant (see discussion above and in Section 9.0).

It is recommended, therefore, that a sampling and testing program be instituted to develop a seasonal history of SDI and barium concentration data.

7.0 BUDGET COST ESTIMATES

The following cost estimates are rough-order-of-magnitude (ROM) based on the preliminary design criteria and assumptions discussed above.

Since these ROM cost estimates are to be used primarily for comparing the EDR and RO alternatives, certain costs considered approximately equal for both are not included.

For example, it is assumed that additional labor required for the expanded desalting capacity is the same for both options. Likewise, chemical costs for membrane cleaning and pH adjustment of finished water are assumed to be equal and are not included. However, the cost of chemicals dosed to the main treatment process is included for each process.

Table 7.1 Estimated ROM Capital Cost for the EDR Alternative Brazos River Authority/Lake Granbury Water Treatment Plant		
Parameter		**Cost**
• Three (3) EDR trains of 1.6 mgd ± capacity each at $\$1.2 \times 10^6$ each (including 25% contractor mark-up)	$	3,600,000
• Installation allowance, including interconnecting piping in process room and chemical room, electrical, instrumentation, etc., start-up and operator training, etc., at 50% of equipment cost	$	1,800,000
• Building cost; 9,000 square feet at $100.00 per square foot	$	900,000
• EDR plant cost, including building	$	6,300,000
• Annual debt service, crf (20 years, 5%) = 0.08024 x 6,300,000	$	505,500
• Daily debt service (nominal) = 505,500 ÷ 365 =	$	1,390
• Cost of debt service per 1,000 gallons of finished water produced = $1,390 ÷ 5,000 =	$	0.28/K gal

Table 7.2 Estimated ROM Capital Cost for the RO Alternative Brazos River Authority/Lake Granbury Water Treatment Plant		
Parameter		**Cost**
• Three (3) RO trains of 1.1 mgd ± capacity each at $1,000,000 each (including 25% contractor mark-up)	$	3,000,000
• Installation allowance, including interconnecting piping in process room and chemical room, electrical, instrumentation, etc., start-up and operator training, etc., at 50% of equipment cost	$	1,500,000
• Bypass pumping equipment and piping, including electrical, instrumentation, etc., for 1.7 mgd capacity	$	600,000
• Building cost; 70 feet x 80 feet = 5,600 square feet at $100.00 per square foot =	$	560,000
• RO plant cost, including building	$	5,660,000
• Annual debt service, crf (20 years, 5%) = 0.08024 x 5,660,000 =	$	455,000
• Daily debt service (nominal) = 455,000 ÷ 365 =	$	1,245
• Cost of debt service per 1,000 gallons of finished water produced = $1,245 ÷ 5,000 =	$	0.25/K gal

Table 7.3 Major Operating Costs for the EDR Alternative Brazos River Authority/Lake Granbury Water Treatment Plant	
Parameter	**Cost**
• Electric power cost, main process at 4.2 kwh per 1,000 gallons of finished water produced = 4.2 x 0.076	S 0.32/K gal
• Allowance for miscellaneous power; A/C, lights, instrumentation, chemical pumps, losses; at 30% of main process power = 0.3 x 4.2 x 0.076	S 0.10/K gal
• Process chemicals, dosing 2 mg/L anti-scalant into brine make-up stream, quantity = 2 x 0.25 mgd x 8.34 = 4.2 lbs/day at $1.00/lb = $4.20/day/train = S4.20 x 3 = $13.00/day. Process chemical cost = $13.00 ÷ 5,000	S 0.01/K gal
• Hydrochloric acid dose to electrode feed stream - allowance	S 0.01/K gal
• Other operating cost components assumed approximately equal to RO	S xx.xx
• Major operating costs (excluding labor and miscellaneous costs)	S 0.44/K gal (plus "other" costs)

Table 7.4 Major Operating Costs for the RO Alternative Brazos River Authority/Lake Granbury Water Treatment Plant	
Parameter	**Cost**
• Electric power cost, main process at 3.6 kwh per 1,000 gallons of finished water produced. averaging RO power and bypass power requirements = 3.6 x 0.076	S 0.28/K gal
• Allowance for miscellaneous power at 30% = 0.3 x 3.6 x 0.076	S 0.08/K gal
• Process chemicals, dosing 6.6 mg/L anti-scalant into RO feed stream, daily requirement = 6.6 x 6.6 mgd x 8.34 = 363 lbs/day cost at $1.00/lb = 363 ÷ 5,000 =	S 0.07/K gal
• Other operating cost components assumed approximately equal to EDR	S xx.xx
• Major operating costs (excluding labor and miscellaneous costs)	S 0.43/K gal (plus "other" costs)

Table 7.5 Overall Cost Comparison Summary Between EDR and RO Brazos River Authority/Lake Granbury Water Treatment Plant

Parameter	EDR	RO	Comments
• Main process power	0.32	0.28	
• Miscellaneous power (allowance)	0.10	0.08	
• Main process chemicals	0.02	0.07	High for RO due to high barium concentration in raw water
• Miscellaneous chemicals, membrane cleaning, pH adjustment of finished water, allowance	0.01	0.01	Estimate derived from other projects
• Membrane replacement (including electrode replacement for EDR)	0.12	0.12	Estimate derived from other projects
• Labor, four persons at $25.00/hour	0.11	0.11	Assume same labor requirements for EDR and RO
• Cartridge filter replacement	0.02	0.02	Estimate derived from other project
• Miscellaneous maintenance, at 4% of capital cost	0.13	0.12	
• Debt service	0.28	0.25	
Total finished water cost attributable to the desalting process - only; in $ per 1,000 gallons of finished water	$1.11	$1.06	Cost per K gal

Note: All cost tables will be revised (for the final draft) after cost information is received from OEMs.

8.0 CONCLUSIONS AND RECOMMENDATIONS

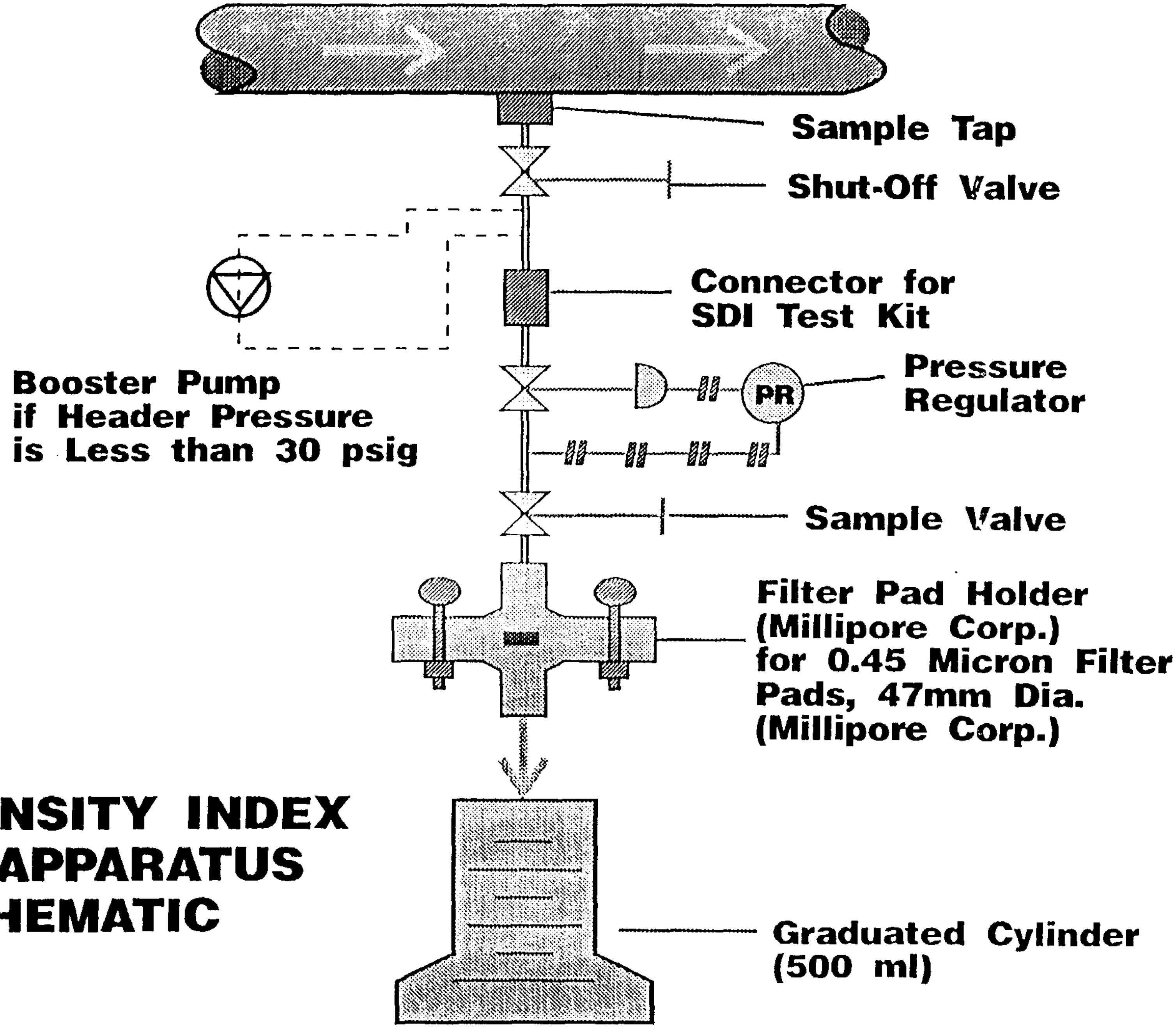
The water cost attributable to the desalting unit process of the Lake Granbury WTP is $1.11 for EDR, and $1.06 for RO, respectively, per 1,000 gallons of finished water: based on a nominal production of 5.0 mgd for each process. These ROM cost figures are so close that they are well within the accuracy of the overall estimate.

Accordingly, the decision as to which process to use may better be based on other considerations; such as previous experience with EDR and the lack of data on barium concentration and Silt Density Index (SDI) of the desal plant feed water.

Considering the risk factors involved with RO due to the lack of certain key data, and the fact that operating personnel is familiar with EDR but not RO, it may be better to continue with EDR for the next plant expansion. However, as mentioned earlier, RO can be made to work. In any case, a concerted effort should be made to gather the critical data (over a period of one year or more) needed to properly design an RO plant and to minimize the risk factors associated with it. Once seasonal data on SDI and barium concentration are in hand, future phases of plant expansion might be done with RO instead of EDR.

9.0 SILT DENSITY INDEX (SDI), TEST APPARATUS SCHEMATIC AND MEASUREMENT PROCEDURE

The following pages give an explanation of the Silt Density Index (SDI) concept, the test equipment needed, and the measurement procedure.



SILT DENSITY INDEX TEST APPARATUS SCHEMATIC

PLUGGING FACTOR AND SILT DENSITY INDEX

$$PF = \left(1 - \frac{T_i}{T_f}\right) 100 = \text{Plugging Factor}$$

$$SDI = \frac{\left(1 - \frac{T_i}{T_f}\right) 100}{T_{test}} = \text{Silt Density Index}$$

Where:

T_i = Time in seconds to collect the initial fixed volume (usually 500 ml).

T_f = Time in seconds to collect the same fixed volume at the end of the test period.

T_{test} = Time in minutes between the beginning of the first timing and the beginning of the second (usually 15 minutes).

B. SILT DENSITY INDEX

The concentration of the colloids (n) is determined by the Silt Density Index (*SDI*). The *SDI* is derived from the rate of plugging of a 0.45 micron Millipore® filter at 207 kPa (30 psig) applied pressure. Although the *SDI* measurement is not absolute, it is by far the best method that has been found to determine colloidal concentration. Excellent correlation has been obtained between the *SDI* and the rate of colloidal deposits in permeators. Other methods (turbidity and particle counts) that measure colloidal concentration are unacceptable. Particle counters do not give accurate results in the sub-micron range. Turbidity is a function of particle size and shape as well as concentration. Thus, no correlation exists between turbidity and colloidal fouling from one site to another.

Well waters usually have an *SDI* of approximately 1.0 and generally do not require any pretreatment for colloidal fouling. If a well water has an *SDI* in excess of about 1.0, possible causes are:

- Shallow well with surface water intrusion.
- Iron corrosion products present.
- Biological contamination present.
- Colloidal sulfur present.

Surface waters (lakes, rivers, oceans, bays, or reservoirs) contain large amounts of colloidal matter and have *SDI* values in the 10-175 range.

Equipment for measuring the *SDI* is shown in Figure 1.

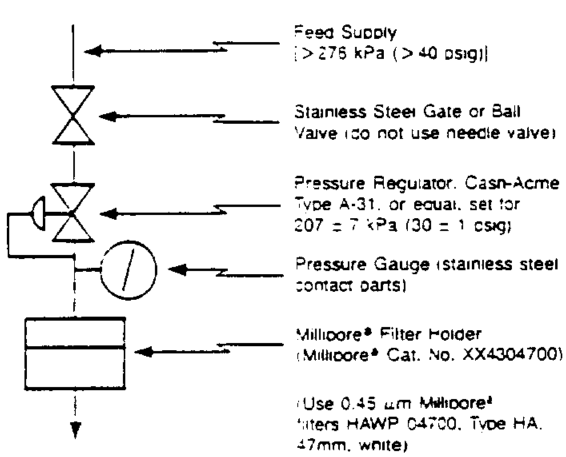


Figure 1. Silt Density Index Apparatus

The procedure for measuring *SDI* is as follows:

1. Assemble the apparatus as shown in Figure 1 and set the pressure regulator at 207 kPa (30 psi).
2. Before installing the Millipore® filter, flush the water to be tested through the apparatus to remove entrained contaminants.
3. Measure the water temperature.
4. Open the membrane filter holder and place a 0.45 µm Millipore® filter (47 mm in diameter) on the support plate of the holder. Handle membrane filter only with dull tweezers to avoid puncturing. Avoid touching the membrane filter with fingers.
5. Make sure the O-ring is in good condition and properly placed. Replace the top half of the filter holder and close loosely.
6. Bleed out trapped air by cracking the ball valve. Close valve and tighten filter holder.
7. Open ball valve. Simultaneously, using a stopwatch, begin measuring the time required for the flow of 500 ml. Record time (t_i). Leave the valve open for continued flow.
8. Measure and record time to collect a 500 ml volume after 5, 10, and 15 minutes of total elapsed flow time. Note: Pressure must remain at 207 ± 7 kPa (30 ± 1 psig) throughout the test.
9. Measure the water temperature. Note: Water temperature must remain constant (± 1 degree C) throughout test.
10. After completion of the test, the membrane filter may be retained for future reference. The *SDI* is calculated using Equation 2.

$$SDI = \frac{\% P_{30}}{t_t} = \frac{100\left(1 - \frac{t_i}{t_f}\right)}{t_t} \qquad (2)$$

Where:

P_{30} = plugging at 207 kPa (30 psig) feed pressure. For accurate *SDI* measurements, P_{30} should not exceed 75 percent. If P_{30} exceeds this value, re-run test and obtain T_f at a shorter time, (t_t).

t_t = total less time in minutes (usually 15, but may be less if 75 percent plugging occurs in less than 15 minutes)

t_i = initial time (seconds) required to collect 500 ml sample

t_f = time (seconds) required to collect 500 ml sample after test time t_t (usually 15 minutes)

APPENDIX F

SWATS EXPANSION OPTIONS

OPINION OF PROBABLE COSTS

Cost Accounting for Proposed SWATS Expansion
Base Option

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SWAT Peak Demand	8.68	9.29	9.90	10.50	11.11	11.80	12.49	13.18	13.88	14.57
SWAT Average Demand	5.46	5.65	5.84	6.02	6.21	6.40	6.60	6.79	6.99	7.18
Estimated Expansion Cost	$24,990,000									$14,700,000
New Annual Capital Cost	$2,178,742	$0	$0	$0	$0	$0	$0	$0	$0	$1,281,613
Existing Annual Capital Cost	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229
Treatment Plant Capital Cost	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$4,668,584
Johnson County Pipeline Cost	$258,750									
New Annual Capital Cost	$22,559	$0	$0	$0	$0	$0	$0	$0	$0	$0
Existing Annual Capital Cost	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229
Johnson Pipeline Capital Cost	$570,788	$570,788	$570,788	$570,788	$570,788	$570,788	$570,788	$570,788	$570,788	$570,788
Hood County Pipeline Amount	$3,460,350		$3,481,050							
New Annual Capital Cost	$301,689	$0	$303,494	$0	$0	$0	$0	$0	$0	$0
Existing Annual Capital Cost										
Hood Pipeline Capital Cost	$301,689	$301,689	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183
Annual Budget										$3,471,665
Fixed Costs	$739,245	$764,723	$789,378	$813,286	$836,512	$862,123	$886,995	$911,189	$934,756	$957,744
Variable Costs	$1,856,859	$1,920,155	$1,983,451	$2,046,747	$2,110,043	$2,176,097	$2,242,151	$2,308,205	$2,374,259	$2,440,313
Discrete Variable Costs	$299,168	$309,366	$319,563	$329,761	$339,959	$350,602	$361,244	$371,886	$382,529	$393,171
Total Fixed Cost	$4,998,693	$5,024,170	$5,352,320	$5,376,228	$5,399,453	$5,425,065	$5,449,937	$5,474,130	$5,497,698	$6,802,299
Fixed Cost per MGD	$575,993	$540,997	$540,891	$511,833	$485,896	$459,626	$436,201	$415,180	$396,207	$466,976
Total Variable Cost	$2,156,026	$2,229,520	$2,303,014	$2,376,508	$2,450,002	$2,526,699	$2,603,395	$2,680,091	$2,756,788	$2,833,484
Variable Cost per 1000 Gallons	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08
Total Cost per 1000 Gallons	$3.59	$3.52	$3.59	$3.53	$3.46	$3.40	$3.34	$3.29	$3.24	$3.68
Net Present Value	$2.44									

Member Peak Flow	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
JCRWSC (NW)	2.55	2.76	2.97	3.18	3.39	3.62	3.85	4.08	4.31	4.54
JCFWSD	0.84	0.92	0.99	1.06	1.14	1.22	1.30	1.37	1.45	1.53
AMUD	2.69	2.85	3.02	3.18	3.35	3.53	3.71	3.88	4.06	4.24
Granbury	2.59	2.75	2.92	3.08	3.24	3.44	3.64	3.85	4.05	4.26
Johnson County Line Peak	3.40	3.68	3.96	4.24	4.53	4.83	5.14	5.45	5.76	6.07
Hood County Line Peak *	4.48	4.75	5.03	5.30	5.58	5.91	6.24	6.57	6.90	7.22

Cost Accounting for Proposed SWATS Expansion
Base Option

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
SWAT Peak Demand	15.35	16.13	16.91	17.69	18.47	19.35	20.23	21.11	21.99	22.87
SWAT Average Demand	7.40	7.61	7.83	8.04	8.26	8.49	8.72	8.95	9.19	9.42
Estimated Expansion Cost						$14,700,000				
New Annual Capital Cost	$0	$0	$0	$0	$0	$1,281,613	$0	$0	$0	$0
Existing Annual Capital Cost										
Treatment Plant Capital Cost	$3,460,355	$3,460,355	$3,460,355	$3,460,355	$3,460,355	$4,741,968	$4,741,968	$4,741,968	$4,741,968	$4,741,968
Johnson County Pipeline Cost		$1,811,250								
New Annual Capital Cost	$0	$157,913	$0	$0	$0	$0	$0	$0	$0	$0
Existing Annual Capital Cost										
Johnson Pipeline Capital Cost	$22,559	$180,472	$180,472	$180,472	$180,472	$180,472	$180,472	$180,472	$180,472	$180,472
Hood County Pipeline Amount										
New Annual Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Existing Annual Capital Cost										
Hood Pipeline Capital Cost	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183
Annual Budget										
Fixed Costs	$983,084	$1,007,788	$1,031,900	$1,055,461	$1,078,508	$1,103,910	$1,128,740	$1,153,036	$1,176,830	$1,200,153
Variable Costs	$2,513,623	$2,586,932	$2,660,242	$2,733,551	$2,806,860	$2,885,530	$2,964,201	$3,042,871	$3,121,541	$3,200,211
Discrete Variable Costs	$404,982	$416,793	$428,605	$440,416	$452,227	$464,902	$477,577	$490,252	$502,927	$515,602
Total Fixed Cost	$5,071,181	$5,253,798	$5,277,910	$5,301,471	$5,324,518	$6,631,533	$6,656,363	$6,680,659	$6,704,453	$6,727,776
Fixed Cost per MGD	$330,419	$325,742	$312,122	$299,675	$288,252	$342,677	$328,993	$316,426	$304,841	$294,128
Total Variable Cost	$2,918,605	$3,003,725	$3,088,846	$3,173,967	$3,259,087	$3,350,432	$3,441,777	$3,533,122	$3,624,467	$3,715,812
Variable Cost per 1000 Gallons	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**
Total Cost per 1000 Gallons	**$2.96**	**$2.97**	**$2.93**	**$2.89**	**$2.85**	**$3.22**	**$3.17**	**$3.13**	**$3.08**	**$3.04**
Net Present Value										

Member Peak Flow	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
JCRWSC (NW)	4.79	5.04	5.30	5.55	5.80	6.08	6.35	6.63	6.90	7.18
JCFWSD	1.61	1.70	1.78	1.87	1.95	2.04	2.13	2.22	2.31	2.40
AMUD	4.43	4.62	4.81	5.00	5.19	5.40	5.60	5.81	6.01	6.21
Granbury	4.51	4.76	5.02	5.27	5.53	5.84	6.15	6.46	6.77	7.08
Johnson County Line Peak	6.41	6.74	7.08	7.42	7.75	8.12	8.48	8.85	9.21	9.58
Hood County Line Peak *	7.61	8.00	8.39	8.77	9.16	9.62	10.07	10.52	10.98	11.43

Cost Accounting for Proposed SWATS Expansion
Option 1

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SWAT Peak Demand	9.08	9.79	10.49	11.20	11.91	12.70	13.49	14.28	15.07	15.86
SWAT Average Demand	5.86	6.14	6.42	6.71	6.99	7.19	7.40	7.60	7.81	8.01
Estimated Expansion Cost	$24,990,000								$14,700,000	
New Annual Capital Cost	$2,178,742	$0	$0	$0	$0	$0	$0	$0	$1,281,613	$0
Existing Annual Capital Cost	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229
Treatment Plant Capital Cost	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$4,668,584	$4,668,584
Johnson County Pipeline Cost	$1,124,700								$1,811,250	
New Annual Capital Cost	$98,056	$0	$0	$0	$0	$0	$0	$0	$157,913	$0
Existing Annual Capital Cost	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229
Johnson Pipeline Capital Cost	$646,285	$646,285	$646,285	$646,285	$646,285	$646,285	$646,285	$646,285	$804,198	$804,198
Hood County Pipeline Amount	$3,460,350		$3,481,050							
New Annual Capital Cost	$301,689	$0	$303,494	$0	$0	$0	$0	$0	$0	$0
Existing Annual Capital Cost										
Hood Pipeline Capital Cost	$301,689	$301,689	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183
Annual Budget										$3,808,463
Fixed Costs	$756,144	$785,008	$812,849	$839,766	$865,847	$894,164	$921,611	$948,264	$974,187	$999,439
Variable Costs	$1,992,124	$2,087,597	$2,183,071	$2,278,544	$2,374,018	$2,443,648	$2,513,278	$2,582,907	$2,652,537	$2,722,167
Discrete Variable Costs	$320,961	$336,343	$351,725	$367,107	$382,490	$393,708	$404,926	$416,145	$427,363	$438,582
Total Fixed Cost	$5,091,089	$5,119,954	$5,451,287	$5,478,205	$5,504,286	$5,532,603	$5,560,050	$5,586,702	$7,052,152	$7,077,404
Fixed Cost per MGD	$560,712	$523,185	$519,539	$489,170	$462,334	$435,746	$412,213	$391,233	$467,923	$446,169
Total Variable Cost	$2,313,084	$2,423,940	$2,534,796	$2,645,652	$2,756,507	$2,837,356	$2,918,204	$2,999,052	$3,079,901	$3,160,749
Variable Cost per 1000 Gallons	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**
Total Cost per 1000 Gallons	**$3.46**	**$3.36**	**$3.41**	**$3.32**	**$3.24**	**$3.19**	**$3.14**	**$3.09**	**$3.56**	**$3.50**
Net Present Value	$2.40									

Member Peak Flow	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
JCRWSC (NW)	2.55	2.76	2.97	3.18	3.39	3.62	3.85	4.08	4.31	4.54
JCFWSD	0.84	0.92	0.99	1.06	1.14	1.22	1.30	1.37	1.45	1.53
AMUD	2.69	2.85	3.02	3.18	3.35	3.53	3.71	3.88	4.06	4.24
Granbury	2.59	2.75	2.92	3.08	3.24	3.44	3.64	3.85	4.05	4.26
Keene	0.40	0.50	0.60	0.70	0.79	0.89	0.99	1.09	1.20	1.30
Bethany										
JCRWSC (NE)										
Cleburne										
Alvarado										
Johnson County Line Peak	3.80	4.18	4.56	4.94	5.32	5.73	6.14	6.55	6.96	7.37
Hood County Line Peak *	4.48	4.75	5.03	5.30	5.58	5.91	6.24	6.57	6.90	7.22

Cost Accounting for Proposed SWATS Expansion
Option 1

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
SWAT Peak Demand	16.75	17.63	18.52	19.40	20.28	21.27	22.26	23.25	24.23	25.22
SWAT Average Demand	8.24	8.47	8.69	8.92	9.15	9.39	9.64	9.88	10.13	10.37
Estimated Expansion Cost				$14,700,000					$14,700,000	
New Annual Capital Cost	$0	$0	$0	$1,281,613	$0	$0	$0	$0	$1,281,613	$0
Existing Annual Capital Cost										
Treatment Plant Capital Cost	$3,460,355	$3,460,355	$3,460,355	$4,741,968	$4,741,968	$4,741,968	$4,741,968	$4,741,968	$6,023,581	$6,023,581
Johnson County Pipeline Cost								$12,373,425		
New Annual Capital Cost	$0	$0	$0	$0	$0	$0	$0	$1,078,772	$0	$0
Existing Annual Capital Cost										
Johnson Pipeline Capital Cost	$255,970	$255,970	$255,970	$255,970	$255,970	$255,970	$255,970	$1,334,741	$1,334,741	$1,334,741
Hood County Pipeline Amount										
New Annual Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Existing Annual Capital Cost										
Hood Pipeline Capital Cost	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183
Annual Budget										
Fixed Costs	$1,026,924	$1,053,691	$1,079,796	$1,105,284	$1,130,197	$1,157,364	$1,183,907	$1,209,868	$1,235,284	$1,260,187
Variable Costs	$2,799,582	$2,876,997	$2,954,412	$3,031,828	$3,109,243	$3,192,262	$3,275,282	$3,358,302	$3,441,321	$3,524,341
Discrete Variable Costs	$451,054	$463,527	$476,000	$488,473	$500,945	$514,321	$527,697	$541,072	$554,448	$567,824
Total Fixed Cost	$5,348,431	$5,375,199	$5,401,303	$6,708,404	$6,733,318	$6,760,484	$6,787,028	$7,891,760	$9,198,789	$9,223,692
Fixed Cost per MGD	$319,366	$304,864	$291,711	$345,788	$331,939	$317,816	$304,917	$339,497	$379,608	$365,740
Total Variable Cost	$3,250,637	$3,340,524	$3,430,412	$3,520,300	$3,610,188	$3,706,583	$3,802,979	$3,899,374	$3,995,769	$4,092,165
Variable Cost per 1000 Gallons	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08
Total Cost per 1000 Gallons	$2.86	$2.82	$2.78	$3.14	$3.10	$3.05	$3.01	$3.27	$3.57	$3.52
Net Present Value										

Member Peak Flow	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
JCRWSC (NW)	4.79	5.04	5.30	5.55	5.80	6.08	6.35	6.63	6.90	7.18
JCFWSD	1.61	1.70	1.78	1.87	1.95	2.04	2.13	2.22	2.31	2.40
AMUD	4.43	4.62	4.81	5.00	5.19	5.40	5.60	5.81	6.01	6.21
Granbury	4.51	4.76	5.02	5.27	5.53	5.84	6.15	6.46	6.77	7.08
Keene	1.40	1.50	1.61	1.71	1.81	1.92	2.03	2.13	2.24	2.35
Bethany										
JCRWSC (NE)										
Cleburne										
Alvarado										
Johnson County Line Peak	7.81	8.25	8.69	9.13	9.57	10.04	10.51	10.98	11.45	11.93
Hood County Line Peak *	7.61	8.00	8.39	8.77	9.16	9.62	10.07	10.52	10.98	11.43

Cost Accounting for Proposed SWATS Expansion
Option 2

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SWAT Peak Demand	9.43	10.17	10.92	11.66	12.40	13.23	14.06	14.89	15.72	16.55
SWAT Average Demand	6.21	6.51	6.82	7.13	7.44	7.65	7.86	8.07	8.28	8.49
Estimated Expansion Cost	$24,990,000							$14,700,000		
New Annual Capital Cost	$2,178,742	$0	$0	$0	$0	$0	$0	$1,281,613	$0	$0
Existing Annual Capital Cost	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229
Treatment Plant Capital Cost	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$4,668,584	$4,668,584	$4,668,584
Johnson County Pipeline Cost	$2,019,113						$1,811,250			
New Annual Capital Cost	$176,035	$0	$0	$0	$0	$0	$157,913	$0	$0	$0
Existing Annual Capital Cost	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229
Johnson Pipeline Capital Cost	$724,264	$724,264	$724,264	$724,264	$724,264	$724,264	$882,177	$882,177	$882,177	$882,177
Hood County Pipeline Amount	$3,460,350		$3,481,050							
New Annual Capital Cost	$301,689	$0	$303,494	$0	$0	$0	$0	$0	$0	$0
Existing Annual Capital Cost										
Hood Pipeline Capital Cost	$301,689	$301,689	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183
Annual Budget										
Fixed Costs	$770,665	$800,434	$829,136	$856,877	$883,747	$912,820	$940,995	$968,351	$994,955	$1,020,866
Variable Costs	$2,108,641	$2,213,332	$2,318,024	$2,422,715	$2,527,407	$2,599,085	$2,670,764	$2,742,443	$2,814,122	$2,885,801
Discrete Variable Costs	$339,733	$356,601	$373,468	$390,335	$407,203	$418,751	$430,300	$441,848	$453,397	$464,945
Total Fixed Cost	$5,183,589	$5,213,359	$5,545,554	$5,573,295	$5,600,165	$5,629,238	$5,815,326	$7,124,295	$7,150,899	$7,176,810
Fixed Cost per MGD	$549,589	$512,394	$507,962	$477,984	$451,526	$425,419	$413,559	$478,425	$454,875	$433,643
Total Variable Cost	$2,448,375	$2,569,933	$2,691,492	$2,813,051	$2,934,609	$3,017,837	$3,101,064	$3,184,291	$3,267,519	$3,350,746
Variable Cost per 1000 Gallons	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08
Total Cost per 1000 Gallons	$3.37	$3.27	$3.31	$3.22	$3.14	$3.10	$3.11	$3.50	$3.45	$3.40
Net Present Value	$2.41									

Member Peak Flow	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
JCRWSC (NW)	2.55	2.76	2.97	3.18	3.39	3.62	3.85	4.08	4.31	4.54
JCFWSD	0.84	0.92	0.99	1.06	1.14	1.22	1.30	1.37	1.45	1.53
AMUD	2.69	2.85	3.02	3.18	3.35	3.53	3.71	3.88	4.06	4.24
Granbury	2.59	2.75	2.92	3.08	3.24	3.44	3.64	3.85	4.05	4.26
Keene	0.40	0.50	0.60	0.70	0.79	0.89	0.99	1.09	1.20	1.30
Bethany	0.35	0.39	0.42	0.46	0.50	0.54	0.57	0.61	0.65	0.69
JCRWSC (NE)										
Cleburne										
Alvarado										
Johnson County Line Peak	4.15	4.57	4.98	5.40	5.82	6.26	6.71	7.16	7.61	8.05
Hood County Line Peak *	4.48	4.75	5.03	5.30	5.58	5.91	6.24	6.57	6.90	7.22

Cost Accounting for Proposed SWATS Expansion

Option 2

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
SWAT Peak Demand	17.47	18.40	19.32	20.25	21.17	22.20	23.23	24.26	25.29	26.32
SWAT Average Demand	8.73	8.96	9.20	9.43	9.67	9.92	10.17	10.42	10.67	10.92
Estimated Expansion Cost			$14,700,000					$14,700,000		
New Annual Capital Cost	$0	$0	$1,281,613	$0	$0	$0	$0	$1,281,613	$0	$0
Existing Annual Capital Cost										
Treatment Plant Capital Cost	$3,460,355	$3,460,355	$4,741,968	$4,741,968	$4,741,968	$4,741,968	$4,741,968	$6,023,581	$6,023,581	$6,023,581
Johnson County Pipeline Cost						$14,319,225				
New Annual Capital Cost	$0	$0	$0	$0	$0	$1,248,415	$0	$0	$0	$0
Existing Annual Capital Cost										
Johnson Pipeline Capital Cost	$333,948	$333,948	$333,948	$333,948	$333,948	$1,582,364	$1,582,364	$1,582,364	$1,582,364	$1,582,364
Hood County Pipeline Amount										
New Annual Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Existing Annual Capital Cost										
Hood Pipeline Capital Cost	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183
Annual Budget										
Fixed Costs	$1,048,986	$1,076,371	$1,103,077	$1,129,152	$1,154,638	$1,182,358	$1,209,443	$1,235,935	$1,261,871	$1,287,284
Variable Costs	$2,965,520	$3,045,240	$3,124,960	$3,204,680	$3,284,399	$3,369,838	$3,455,276	$3,540,714	$3,626,152	$3,711,590
Discrete Variable Costs	$477,789	$490,634	$503,478	$516,322	$529,166	$542,931	$556,696	$570,462	$584,227	$597,992
Total Fixed Cost	$5,448,472	$5,475,858	$6,784,177	$6,810,251	$6,835,737	$8,111,873	$8,138,958	$9,447,063	$9,472,998	$9,498,412
Fixed Cost per MGD	$311,798	$297,623	$351,094	$336,354	$322,873	$365,394	$350,377	$389,443	$374,624	$360,944
Total Variable Cost	$3,443,310	$3,535,874	$3,628,438	$3,721,001	$3,813,565	$3,912,768	$4,011,972	$4,111,175	$4,210,379	$4,309,582
Variable Cost per 1000 Gallons	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08
Total Cost per 1000 Gallons	$2.79	$2.76	$3.10	$3.06	$3.02	$3.32	$3.27	$3.57	$3.51	$3.46
Net Present Value										

Member Peak Flow	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
JCRWSC (NW)	4.79	5.04	5.30	5.55	5.80	6.08	6.35	6.63	6.90	7.18
JCFWSD	1.61	1.70	1.78	1.87	1.95	2.04	2.13	2.22	2.31	2.40
AMUD	4.43	4.62	4.81	5.00	5.19	5.40	5.60	5.81	6.01	6.21
Granbury	4.51	4.76	5.02	5.27	5.53	5.84	6.15	6.46	6.77	7.08
Keene	1.40	1.50	1.61	1.71	1.81	1.92	2.03	2.13	2.24	2.35
Bethany	0.73	0.77	0.81	0.85	0.89	0.93	0.97	1.01	1.05	1.10
JCRWSC (NE)										
Cleburne										
Alvarado										
Johnson County Line Peak	8.53	9.01	9.49	9.97	10.45	10.97	11.48	11.99	12.51	13.02
Hood County Line Peak *	7.61	8.00	8.39	8.77	9.16	9.62	10.07	10.52	10.98	11.43

Cost Accounting for Proposed SWATS Expansion
Option 3

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SWAT Peak Demand	10.18	10.99	11.81	12.62	13.43	14.35	15.26	16.17	17.08	18.00
SWAT Average Demand	6.92	7.26	7.60	7.95	8.29	8.52	8.74	8.97	9.20	9.42
Estimated Expansion Cost	$24,990,000					$14,700,000				
New Annual Capital Cost	$2,178,742	$0	$0	$0	$0	$1,281,613	$0	$0	$0	$0
Existing Annual Capital Cost	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229
Treatment Plant Capital Cost	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$4,668,584	$4,668,584	$4,668,584	$4,668,584	$4,668,584
Johnson County Pipeline Cost	$6,473,063				$1,811,250					
New Annual Capital Cost	$564,351	$0	$0	$0	$157,913	$0	$0	$0	$0	$0
Existing Annual Capital Cost	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229
Johnson Pipeline Capital Cost	$1,112,580	$1,112,580	$1,112,580	$1,112,580	$1,270,493	$1,270,493	$1,270,493	$1,270,493	$1,270,493	$1,270,493
Hood County Pipeline Amount	$3,460,350		$3,481,050							
New Annual Capital Cost	$301,689	$0	$303,494	$0	$0	$0	$0	$0	$0	$0
Existing Annual Capital Cost										
Hood Pipeline Capital Cost	$301,689	$301,689	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183
Annual Budget										$4,366,442
Fixed Costs	$800,602	$831,977	$862,210	$891,419	$919,700	$950,443	$980,222	$1,009,123	$1,037,218	$1,064,573
Variable Costs	$2,350,429	$2,467,074	$2,583,718	$2,700,363	$2,817,007	$2,894,050	$2,971,092	$3,048,134	$3,125,177	$3,202,219
Discrete Variable Costs	$378,689	$397,482	$416,275	$435,069	$453,862	$466,274	$478,687	$491,100	$503,513	$515,925
Total Fixed Cost	$5,601,842	$5,633,216	$5,966,944	$5,996,152	$6,182,347	$7,494,703	$7,524,482	$7,553,382	$7,581,478	$7,608,832
Fixed Cost per MGD	$550,345	$512,474	$505,433	$475,168	$460,255	$522,444	$493,135	$467,080	$443,763	$422,771
Total Variable Cost	$2,729,119	$2,864,556	$2,999,994	$3,135,431	$3,270,869	$3,360,324	$3,449,779	$3,539,234	$3,628,689	$3,718,144
Variable Cost per 1000 Gallons	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**
Total Cost per 1000 Gallons	**$3.30**	**$3.21**	**$3.23**	**$3.15**	**$3.12**	**$3.49**	**$3.44**	**$3.39**	**$3.34**	**$3.29**
Net Present Value	$2.45									

Member Peak Flow	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
JCRWSC (NW)	2.55	2.76	2.97	3.18	3.39	3.62	3.85	4.08	4.31	4.54
JCFWSD	0.84	0.92	0.99	1.06	1.14	1.22	1.30	1.37	1.45	1.53
AMUD	2.69	2.85	3.02	3.18	3.35	3.53	3.71	3.88	4.06	4.24
Granbury	2.59	2.75	2.92	3.08	3.24	3.44	3.64	3.85	4.05	4.26
Keene	0.40	0.50	0.60	0.70	0.79	0.89	0.99	1.09	1.20	1.30
Bethany	0.35	0.39	0.42	0.46	0.50	0.54	0.57	0.61	0.65	0.69
JCRWSC (NE)	0.75	0.82	0.89	0.96	1.03	1.11	1.20	1.28	1.36	1.45
Cleburne										
Alvarado										
Johnson County Line Peak	4.90	5.38	5.87	6.36	6.85	7.38	7.91	8.44	8.97	9.50
Hood County Line Peak *	4.48	4.75	5.03	5.30	5.58	5.91	6.24	6.57	6.90	7.22

Cost Accounting for Proposed SWATS Expansion
Option 3

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
SWAT Peak Demand	19.02	20.04	21.06	22.08	23.10	24.24	25.38	26.52	27.66	28.80
SWAT Average Demand	9.67	9.93	10.18	10.43	10.68	10.95	11.22	11.49	11.75	12.02
Estimated Expansion Cost		$14,700,000				$14,700,000				
New Annual Capital Cost	$0	$1,281,613	$0	$0	$0	$1,281,613	$0	$0	$0	$0
Existing Annual Capital Cost										
Treatment Plant Capital Cost	$3,460,355	$4,741,968	$4,741,968	$4,741,968	$4,741,968	$6,023,581	$6,023,581	$6,023,581	$6,023,581	$6,023,581
Johnson County Pipeline Cost		$12,977,175								$345,000
New Annual Capital Cost	$0	$1,131,409	$0	$0	$0	$0	$0	$0	$0	$30,079
Existing Annual Capital Cost										
Johnson Pipeline Capital Cost	$722,264	$1,853,673	$1,853,673	$1,853,673	$1,853,673	$1,853,673	$1,853,673	$1,853,673	$1,853,673	$1,883,752
Hood County Pipeline Amount										
New Annual Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Existing Annual Capital Cost										
Hood Pipeline Capital Cost	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183
Annual Budget										
Fixed Costs	$1,094,354	$1,123,345	$1,151,607	$1,179,192	$1,206,146	$1,235,520	$1,264,211	$1,292,265	$1,319,723	$1,346,621
Variable Costs	$3,287,662	$3,373,105	$3,458,548	$3,543,991	$3,629,434	$3,720,687	$3,811,940	$3,903,192	$3,994,445	$4,085,698
Discrete Variable Costs	$529,691	$543,457	$557,224	$570,990	$584,756	$599,458	$614,160	$628,862	$643,565	$658,267
Total Fixed Cost	$5,882,156	$8,324,170	$8,352,432	$8,380,017	$8,406,971	$9,717,957	$9,746,648	$9,774,702	$9,802,160	$9,859,137
Fixed Cost per MGD	$309,285	$415,386	$396,590	$379,502	$363,896	$400,879	$384,020	$368,586	$354,400	$342,362
Total Variable Cost	$3,817,354	$3,916,563	$4,015,772	$4,114,981	$4,214,190	$4,320,145	$4,426,100	$4,532,055	$4,638,010	$4,743,965
Variable Cost per 1000 Gallons	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08
Total Cost per 1000 Gallons	$2.75	$3.38	$3.33	$3.28	$3.24	$3.51	$3.46	$3.41	$3.37	$3.33
Net Present Value										

Member Peak Flow	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
JCRWSC (NW)	4.79	5.04	5.30	5.55	5.80	6.08	6.35	6.63	6.90	7.18
JCFWSD	1.61	1.70	1.78	1.87	1.95	2.04	2.13	2.22	2.31	2.40
AMUD	4.43	4.62	4.81	5.00	5.19	5.40	5.60	5.81	6.01	6.21
Granbury	4.51	4.76	5.02	5.27	5.53	5.84	6.15	6.46	6.77	7.08
Keene	1.40	1.50	1.61	1.71	1.81	1.92	2.03	2.13	2.24	2.35
Bethany	0.73	0.77	0.81	0.85	0.89	0.93	0.97	1.01	1.05	1.10
JCRWSC (NE)	1.54	1.64	1.74	1.83	1.93	2.04	2.15	2.26	2.37	2.48
Cleburne										
Alvarado										
Johnson County Line Peak	10.08	10.65	11.23	11.81	12.38	13.01	13.63	14.26	14.88	15.50
Hood County Line Peak *	7.61	8.00	8.39	8.77	9.16	9.62	10.07	10.52	10.98	11.43

Cost Accounting for Proposed SWATS Expansion
Option 4

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SWAT Peak Demand	10.43	11.29	12.16	13.03	13.90	14.87	15.83	16.80	17.77	18.74
SWAT Average Demand	7.16	7.54	7.93	8.32	8.71	8.94	9.17	9.40	9.64	9.87
Estimated Expansion Cost	$24,990,000					$14,700,000				
New Annual Capital Cost	$2,178,742	$0	$0	$0	$0	$1,281,613	$0	$0	$0	$0
Existing Annual Capital Cost	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229
Treatment Plant Capital Cost	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$4,668,584	$4,668,584	$4,668,584	$4,668,584	$4,668,584
Johnson County Pipeline Cost	$7,905,675			$1,811,250						
New Annual Capital Cost	$689,253	$0	$0	$157,913	$0	$0	$0	$0	$0	$0
Existing Annual Capital Cost	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229
Johnson Pipeline Capital Cost	$1,237,482	$1,237,482	$1,237,482	$1,395,395	$1,395,395	$1,395,395	$1,395,395	$1,395,395	$1,395,395	$1,395,395
Hood County Pipeline Amount	$3,460,350		$3,481,050							
New Annual Capital Cost	$301,689	$0	$303,494	$0	$0	$0	$0	$0	$0	$0
Existing Annual Capital Cost										
Hood Pipeline Capital Cost	$301,689	$301,689	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183
Annual Budget										$4,545,573
Fixed Costs	$810,305	$843,343	$875,134	$905,809	$935,480	$967,531	$998,554	$1,028,641	$1,057,873	$1,086,319
Variable Costs	$2,431,632	$2,563,530	$2,695,428	$2,827,326	$2,959,224	$3,038,032	$3,116,841	$3,195,649	$3,274,458	$3,353,267
Discrete Variable Costs	$391,772	$413,023	$434,274	$455,524	$476,775	$489,472	$502,169	$514,867	$527,564	$540,261
Total Fixed Cost	$5,736,447	$5,769,484	$6,104,769	$6,293,358	$6,323,028	$7,636,692	$7,667,715	$7,697,802	$7,727,035	$7,755,480
Fixed Cost per MGD	$550,153	$510,819	$501,948	$483,000	$454,982	$513,705	$484,241	$458,118	$434,794	$413,839
Total Variable Cost	$2,823,404	$2,976,552	$3,129,701	$3,282,850	$3,435,999	$3,527,504	$3,619,010	$3,710,516	$3,802,022	$3,893,528
Variable Cost per 1000 Gallons	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08
Total Cost per 1000 Gallons	$3.28	$3.18	$3.19	$3.15	$3.07	$3.42	$3.37	$3.32	$3.28	$3.23
Net Present Value	$2.45									

Member Peak Flow	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
JCRWSC (NW)	2.55	2.76	2.97	3.18	3.39	3.62	3.85	4.08	4.31	4.54
JCFWSD	0.84	0.92	0.99	1.06	1.14	1.22	1.30	1.37	1.45	1.53
AMUD	2.69	2.85	3.02	3.18	3.35	3.53	3.71	3.88	4.06	4.24
Granbury	2.59	2.75	2.92	3.08	3.24	3.44	3.64	3.85	4.05	4.26
Keene	0.40	0.50	0.60	0.70	0.79	0.89	0.99	1.09	1.20	1.30
Bethany	0.35	0.39	0.42	0.46	0.50	0.54	0.57	0.61	0.65	0.69
JCRWSC (NE)	0.75	0.82	0.89	0.96	1.03	1.11	1.20	1.28	1.36	1.45
Cleburne										
Alvarado	0.25	0.30	0.36	0.41	0.46	0.52	0.58	0.63	0.69	0.74
Johnson County Line Peak	5.14	5.69	6.23	6.77	7.31	7.90	8.48	9.07	9.66	10.24
Hood County Line Peak *	4.48	4.75	5.03	5.30	5.58	5.91	6.24	6.57	6.90	7.22

Cost Accounting for Proposed SWATS Expansion
Option 4

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
SWAT Peak Demand	19.82	20.90	21.97	23.05	24.13	25.33	26.53	27.72	28.92	30.12
SWAT Average Demand	10.13	10.38	10.64	10.90	11.15	11.43	11.70	11.98	12.25	12.53
Estimated Expansion Cost	$14,700,000				$14,700,000					$14,700,000
New Annual Capital Cost	$1,281,613	$0	$0	$0	$1,281,613	$0	$0	$0	$0	$1,281,613
Existing Annual Capital Cost										
Treatment Plant Capital Cost	$4,741,968	$4,741,968	$4,741,968	$4,741,968	$6,023,581	$6,023,581	$6,023,581	$6,023,581	$6,023,581	$7,305,194
Johnson County Pipeline Cost	$12,977,175							$345,000		
New Annual Capital Cost	$1,131,409	$0	$0	$0	$0	$0	$0	$30,079	$0	$0
Existing Annual Capital Cost										
Johnson Pipeline Capital Cost	$1,978,575	$1,978,575	$1,978,575	$1,978,575	$1,978,575	$1,978,575	$1,978,575	$2,008,654	$2,008,654	$2,008,654
Hood County Pipeline Amount										
New Annual Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Existing Annual Capital Cost										
Hood Pipeline Capital Cost	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183
Annual Budget										
Fixed Costs	$1,117,131	$1,147,115	$1,176,335	$1,204,847	$1,232,700	$1,262,921	$1,292,437	$1,321,292	$1,349,532	$1,377,192
Variable Costs	$3,440,695	$3,528,123	$3,615,551	$3,702,979	$3,790,407	$3,883,731	$3,977,055	$4,070,378	$4,163,702	$4,257,026
Discrete Variable Costs	$554,347	$568,433	$582,519	$596,605	$610,691	$625,727	$640,763	$655,799	$670,834	$685,870
Total Fixed Cost	$8,442,857	$8,472,841	$8,502,061	$8,530,573	$9,840,039	$9,870,260	$9,899,775	$9,958,710	$9,986,949	$11,296,222
Fixed Cost per MGD	$426,010	$405,465	$386,901	$370,043	$407,775	$389,685	$373,203	$359,206	$345,306	$375,044
Total Variable Cost	$3,995,042	$4,096,556	$4,198,070	$4,299,584	$4,401,098	$4,509,458	$4,617,817	$4,726,177	$4,834,537	$4,942,897
Variable Cost per 1000 Gallons	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08
Total Cost per 1000 Gallons	$3.37	$3.32	$3.27	$3.23	$3.50	$3.45	$3.40	$3.36	$3.31	$3.55
Net Present Value										

Member Peak Flow	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
JCRWSC (NW)	4.79	5.04	5.30	5.55	5.80	6.08	6.35	6.63	6.90	7.18
JCFWSD	1.61	1.70	1.78	1.87	1.95	2.04	2.13	2.22	2.31	2.40
AMUD	4.43	4.62	4.81	5.00	5.19	5.40	5.60	5.81	6.01	6.21
Granbury	4.51	4.76	5.02	5.27	5.53	5.84	6.15	6.46	6.77	7.08
Keene	1.40	1.50	1.61	1.71	1.81	1.92	2.03	2.13	2.24	2.35
Bethany	0.73	0.77	0.81	0.85	0.89	0.93	0.97	1.01	1.05	1.10
JCRWSC (NE)	1.54	1.64	1.74	1.83	1.93	2.04	2.15	2.26	2.37	2.48
Cleburne										
Alvarado	0.80	0.86	0.91	0.97	1.03	1.09	1.15	1.20	1.26	1.32
Johnson County Line Peak	10.88	11.51	12.14	12.78	13.41	14.09	14.78	15.46	16.14	16.83
Hood County Line Peak *	7.61	8.00	8.39	8.77	9.16	9.62	10.07	10.52	10.98	11.43

Cost Accounting for Proposed SWATS Expansion
Option 5

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SWAT Peak Demand	8.79	9.51	10.23	10.94	11.66	12.59	13.51	14.43	15.35	16.28
SWAT Average Demand	5.53	5.78	6.03	6.29	6.54	6.87	7.20	7.54	7.87	8.20
Estimated Expansion Cost	$24,990,000							$14,700,000		
New Annual Capital Cost	$2,178,742	$0	$0	$0	$0	$0	$0	$1,281,613	$0	$0
Existing Annual Capital Cost	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229	$1,208,229
Treatment Plant Capital Cost	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$3,386,971	$4,668,584	$4,668,584	$4,668,584
Johnson County Pipeline Cost	$1,423,125							$1,811,250		
New Annual Capital Cost	$124,075	$0	$0	$0	$0	$0	$0	$157,913	$0	$0
Existing Annual Capital Cost	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229	$548,229
Johnson Pipeline Capital Cost	$672,303	$672,303	$672,303	$672,303	$672,303	$672,303	$672,303	$830,216	$830,216	$830,216
Hood County Pipeline Amount	$3,460,350		$3,481,050							
New Annual Capital Cost	$301,689	$0	$303,494	$0	$0	$0	$0	$0	$0	$0
Existing Annual Capital Cost										
Hood Pipeline Capital Cost	$301,689	$301,689	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183
Annual Budget										$3,917,941
Fixed Costs	$743,916	$773,727	$802,433	$830,146	$856,963	$890,224	$922,287	$953,271	$983,280	$1,012,400
Variable Costs	$1,879,287	$1,965,011	$2,050,735	$2,136,459	$2,222,184	$2,335,133	$2,448,082	$2,561,031	$2,673,980	$2,786,929
Discrete Variable Costs	$302,781	$316,593	$330,404	$344,215	$358,027	$376,225	$394,422	$412,620	$430,818	$449,016
Total Fixed Cost	$5,104,879	$5,134,691	$5,466,890	$5,494,603	$5,521,420	$5,554,681	$5,586,744	$7,057,254	$7,087,263	$7,116,383
Fixed Cost per MGD	$580,866	$540,103	$534,640	$502,072	$473,440	$441,365	$413,585	$489,036	$461,596	$437,213
Total Variable Cost	$2,182,068	$2,281,603	$2,381,139	$2,480,675	$2,580,210	$2,711,357	$2,842,504	$2,973,651	$3,104,798	$3,235,945
Variable Cost per 1000 Gallons	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08	$1.08
Total Cost per 1000 Gallons	$3.61	$3.51	$3.56	$3.48	$3.39	$3.30	$3.21	$3.65	$3.55	$3.46
Net Present Value	$2.46									

Member Peak Flow	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
JCRWSC (NW)	2.55	2.76	2.97	3.18	3.39	3.62	3.85	4.08	4.31	4.54
JCFWSD	0.84	0.92	0.99	1.06	1.14	1.22	1.30	1.37	1.45	1.53
AMUD	2.69	2.85	3.02	3.18	3.35	3.53	3.71	3.88	4.06	4.24
Granbury	2.59	2.75	2.92	3.08	3.24	3.44	3.64	3.85	4.05	4.26
Keene										
Bethany										
JCRWSC (NE)										
Cleburne	0.11	0.22	0.33	0.44	0.55	0.78	1.01	1.25	1.48	1.71
Alvarado										
Johnson County Line Peak	3.51	3.90	4.29	4.68	5.08	5.62	6.16	6.70	7.24	7.78
Hood County Line Peak *	4.48	4.75	5.03	5.30	5.58	5.91	6.24	6.57	6.90	7.22

Cost Accounting for Proposed SWATS Expansion
Option 5

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
SWAT Peak Demand	17.26	18.25	19.24	20.22	21.21	22.42	23.62	24.83	26.04	27.24
SWAT Average Demand	8.54	8.87	9.21	9.54	9.88	10.30	10.72	11.14	11.57	11.99
Estimated Expansion Cost			$14,700,000					$14,700,000		
New Annual Capital Cost	$0	$0	$1,281,613	$0	$0	$0	$0	$1,281,613	$0	$0
Existing Annual Capital Cost										
Treatment Plant Capital Cost	$3,460,355	$3,460,355	$4,741,968	$4,741,968	$4,741,968	$4,741,968	$4,741,968	$6,023,581	$6,023,581	$6,023,581
Johnson County Pipeline Cost						$14,034,600				
New Annual Capital Cost	$0	$0	$0	$0	$0	$1,223,600	$0	$0	$0	$0
Existing Annual Capital Cost										
Johnson Pipeline Capital Cost	$281,988	$281,988	$281,988	$281,988	$281,988	$1,505,588	$1,505,588	$1,505,588	$1,505,588	$1,505,588
Hood County Pipeline Amount										
New Annual Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Existing Annual Capital Cost										
Hood Pipeline Capital Cost	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183	$605,183
Annual Budget										
Fixed Costs	$1,042,631	$1,072,009	$1,100,604	$1,128,475	$1,155,673	$1,188,097	$1,219,659	$1,250,424	$1,280,451	$1,309,790
Variable Costs	$2,901,017	$3,015,105	$3,129,193	$3,243,280	$3,357,368	$3,500,604	$3,643,840	$3,787,075	$3,930,311	$4,073,547
Discrete Variable Costs	$467,397	$485,778	$504,160	$522,541	$540,922	$563,999	$587,077	$610,154	$633,232	$656,309
Total Fixed Cost	$5,390,156	$5,419,535	$6,729,743	$6,757,613	$6,784,811	$8,040,836	$8,072,398	$9,384,776	$9,414,803	$9,444,141
Fixed Cost per MGD	$312,233	$296,963	$349,844	$334,155	$319,894	$358,703	$341,715	$377,961	$361,596	$346,655
Total Variable Cost	$3,368,414	$3,500,883	$3,633,352	$3,765,821	$3,898,290	$4,064,603	$4,230,917	$4,397,230	$4,563,543	$4,729,856
Variable Cost per 1000 Gallons	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**	**$1.08**
Total Cost per 1000 Gallons	**$2.81**	**$2.75**	**$3.08**	**$3.02**	**$2.96**	**$3.22**	**$3.14**	**$3.39**	**$3.31**	**$3.24**

Net Present Value

Member Peak Flow	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
JCRWSC (NW)	4.79	5.04	5.30	5.55	5.80	6.08	6.35	6.63	6.90	7.18
JCFWSD	1.61	1.70	1.78	1.87	1.95	2.04	2.13	2.22	2.31	2.40
AMUD	4.43	4.62	4.81	5.00	5.19	5.40	5.60	5.81	6.01	6.21
Granbury	4.51	4.76	5.02	5.27	5.53	5.84	6.15	6.46	6.77	7.08
Keene										
Bethany										
JCRWSC (NE)										
Cleburne	1.92	2.12	2.33	2.53	2.74	3.06	3.39	3.72	4.04	4.37
Alvarado										
Johnson County Line Peak	8.32	8.86	9.41	9.95	10.49	11.18	11.87	12.57	13.26	13.95
Hood County Line Peak *	7.61	8.00	8.39	8.77	9.16	9.62	10.07	10.52	10.98	11.43