4. WATER DISTRIBUTION SYSTEM

4.1 Lower Pressure Plane

Plate 1 shows the primary water distribution system network for the City of San Angelo. The City's water distribution system is divided into two pressure planes with all of the City except the far west and southwestern areas in the lower plane. The lower plane is currently serving the majority of the City. The lower plane is supplied water from six high service pumps at the City of San Angelo's water treatment plant. These six pumps include 1-10 MGD pump, 1-12 MGD pump, 1-7 MGD pump, and 3-15 MGD pumps. The total rated capacity of these pumps is 74 MGD. The firm pumping capacity, which is the capacity with the largest pump out of service, is 59 MGD. The pumps deliver water to one elevated storage tank, the 1.0 million gallon loop elevated tank as well as a number of booster pump stations and ground storage tanks. The loop tank has on overflow elevation of 2,052 ft.

4.2 Upper Pressure Plane

The upper pressure plane currently has two supply points from the lower pressure plane. One of the delivery points is the Southwest Pump Station, and the other is the Abilene Pump Station. These pump stations pump to both the upper and lower pressure planes. The Southwest Pump Station has a 9.4 million gallon ground storage tank. The upper pressure plane side of the Southwest Pump Station consists of 2-900 gpm pumps and 1-2,000 gpm pump used as a fire pump. The Abilene Pump Station has a 3.5 million gallon ground storage tank. The upper pressure plane side of the Abilene Pump Station consists of 2-1,000 gpm pumps. The firm

pumping capacity of the upper pressure plane is 3,800 gpm. These two pump stations deliver water to the 0.1 million gallon Mercedes elevated tank. The overflow elevation of the Mercedes elevated tank is 2,104 ft. A summary of the existing water distribution facilities is shown in Table 4.1. A summary of the Existing pumping facilities is shown in Table 4.2. Various pumps in the City are shown in Photos 1-6.

Table 4.1
City of San Angelo
Existing Pumping and Storage Facilities

Pumping Facilities			Storage Facilities		
Name	Firm Capacity	Rated Capacity	Name	Volume	Overflow Elevation
WTP High Service P.S.	59.0 MGD	74.0 MGD	WTP Clearwell	6.0 MG	1830 ft.
Southwest Lower Plane P.S.	11.5 MGD	17.3 MGD	Southwest Ground Tank	9.4 MG	1970 ft.
Southwest Upper Plane P.S.	2.6 MGD	5.5 MGD	Abilene Ground Tank	3.5 MG	1995 ft.
Abilene Lower Plane P.S.	4.6 MGD	9.2 MGD	Lakeview Ground Tank	5.0 MG	1949 ft.
Abilene Upper Plane P.S.	1.4 MGD	2.9 MGD	Delmar Ground Tank	3.27 MG	1937 ft.
Lakeview P.S.	3.0 MGD	6.0 MGD	Loop Elevated Tank	1.0 MG	2052 ft.
Delmar P.S.	0.0 MGD	15.0 MGD	Mercedes Elevated Tank	0.1 MG	2104 ft.

Table 4.2
City of San Angelo
Existing Pumping Facilities

RAW WATER PUMPING FACILITIES	Flow	Head	H.P.
WTP High Service Pump Station			
RW #1	4,200 GPM / 6.0 MGD		
RW #2	4,200 GPM / 6.0 MGD		
RW #3	4,200 GPM / 6.0 MGD		
RW #4	4,900 GPM / 7.0 MGD		
RW #5	8,300 GPM / 12.0 MGD		
RW #6	13,900 GPM / 20.0 MGD		
RW #7	8,700 GPM / 12.5 MGD		
RW #8	8,700 GPM / 12.5 MGD		
LOWER PLANE PUMPING FACILITIES			
WTP High Service Pump Station			
HS #1	6,000 GPM / 8.6 MGD	255'	600 H.P.
HS #2	9,000 GPM / 13.0 MGD	275'	700 H.P.
HS #3	5,000 GPM / 7.2 MGD	255'	400 H.P.
HS #4	10,500 GPM / 15.0 MGD	255'	800 H.P.
HS #5	10,500 GPM / 15.0 MGD	255'	800 H.P.
HS #6	10,500 GPM / 15.0 MGD	255'	800 H.P.
Southwest Lower Plane Pump Station			
#1	4,000 GPM / 5.8 MGD	175'	210 H.P.
#2	4,000 GPM / 5.8 MGD	175'	210 H.P.
#3	4,000 GPM / 5.8 MGD	175'	210 H.P.
Abilene Lower Plane Pump Station			
#1	3,200 GPM / 4.6 MGD	125'	125 H.P.
#2	3,200 GPM / 4.6 MGD	125'	100 H.P.
Delmar Pump Station			
#1	10,500 GPM / 15.0 MGD	215'	700 H.P.
Lakeview Pump Station			
#1	3,500 GPM / 5.0 MGD	100'	105 H.P.
#2	3,500 GPM / 5.0 MGD	100'	105 H.P.
UPPER PLANE PUMPING FACILITIES			
Southwest Upper Plane Pump Station			
#1	2,000 GPM / 2.9 MGD	130'	130 H.P.
#2	900 GPM / 1.3 MGD	200'	68 H.P.
#3	900 GPM / 1.3 MGD	200'	68 H.P.
Abilene Upper Plane Pump Station			
#1	600 GPM / 0.9 MGD	180'	40 H.P.
#2	600 GPM / 0.9 MGD	180'	40 H.P.

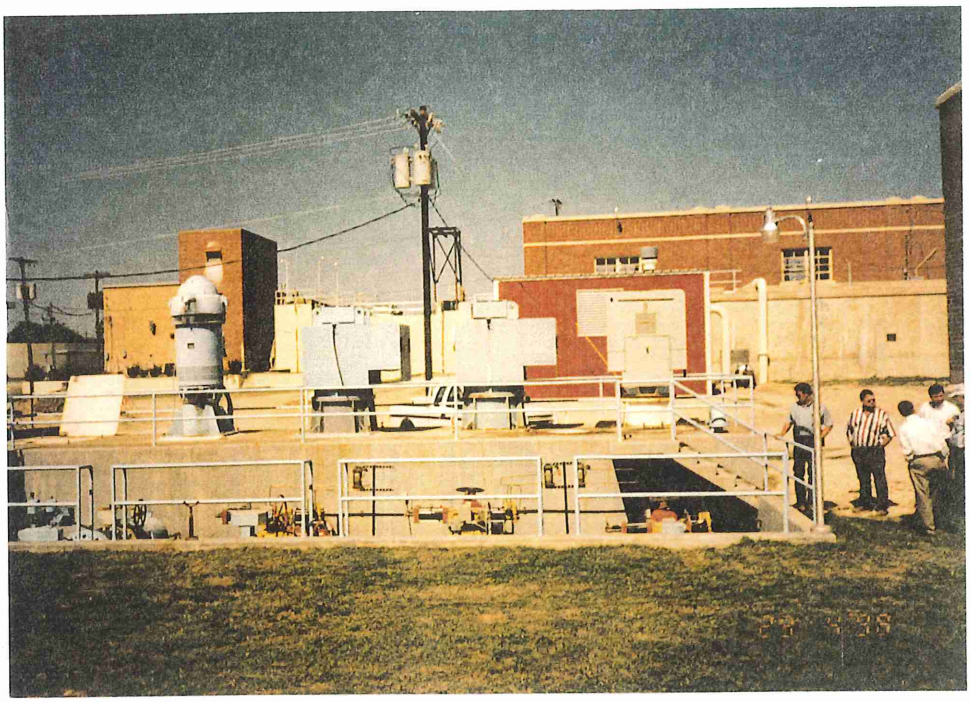


Photo No. 1 W.T.P. Pump Station. Pump No. 3, Pump No. 4, Pump No. 5, Pump No. 6 (from right to left).

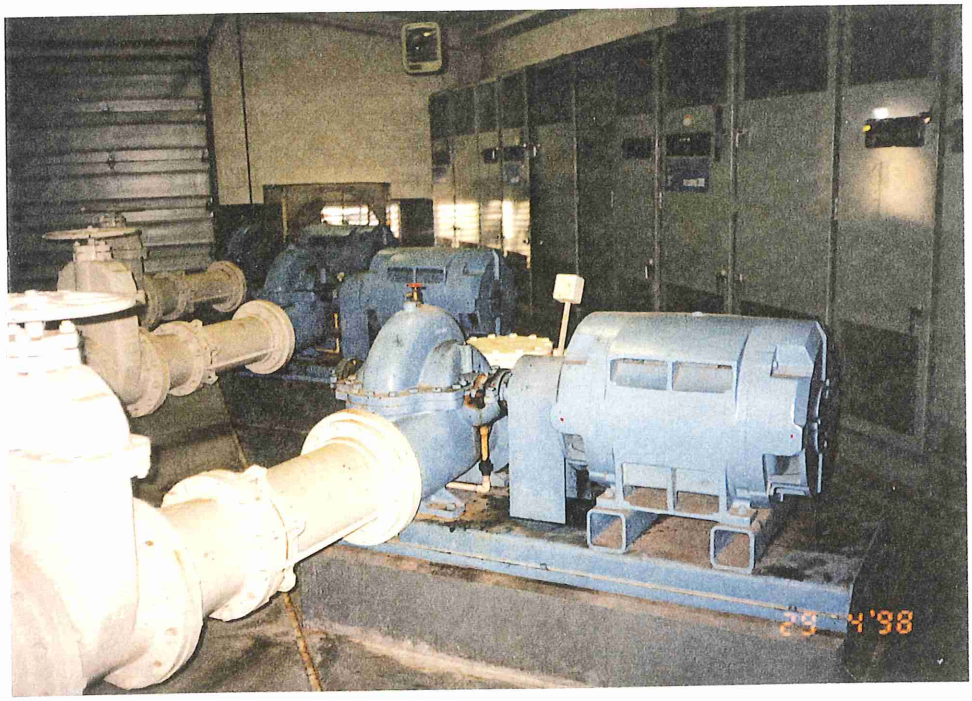


Photo No. 2 Southwest Pump Station. Lower Plane Pumps.

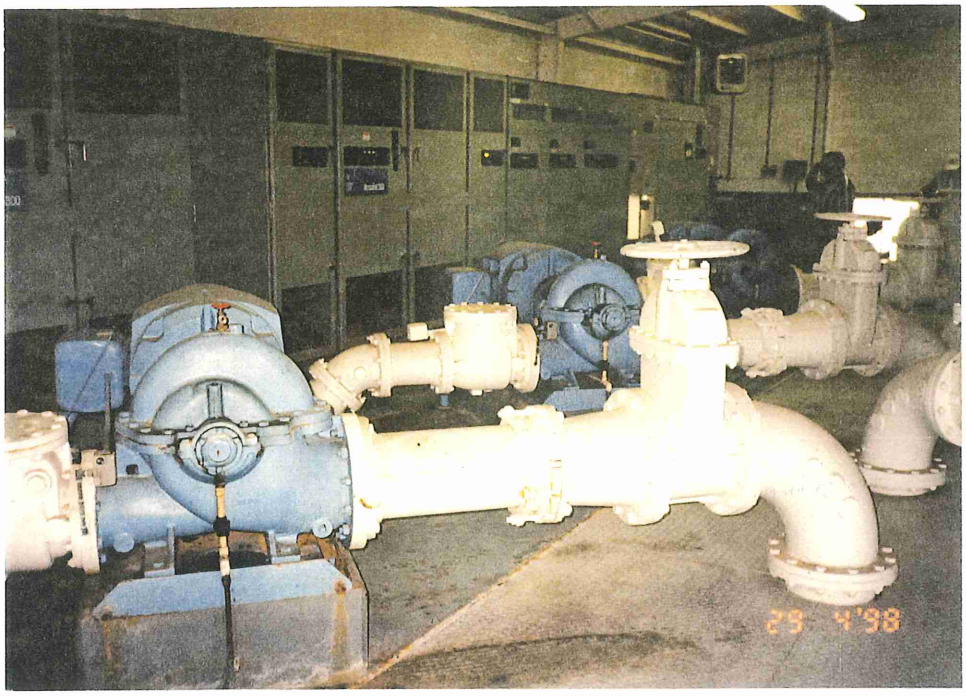


Photo No. 3 Southwest Pump Station.
Upper Plane Pumps.

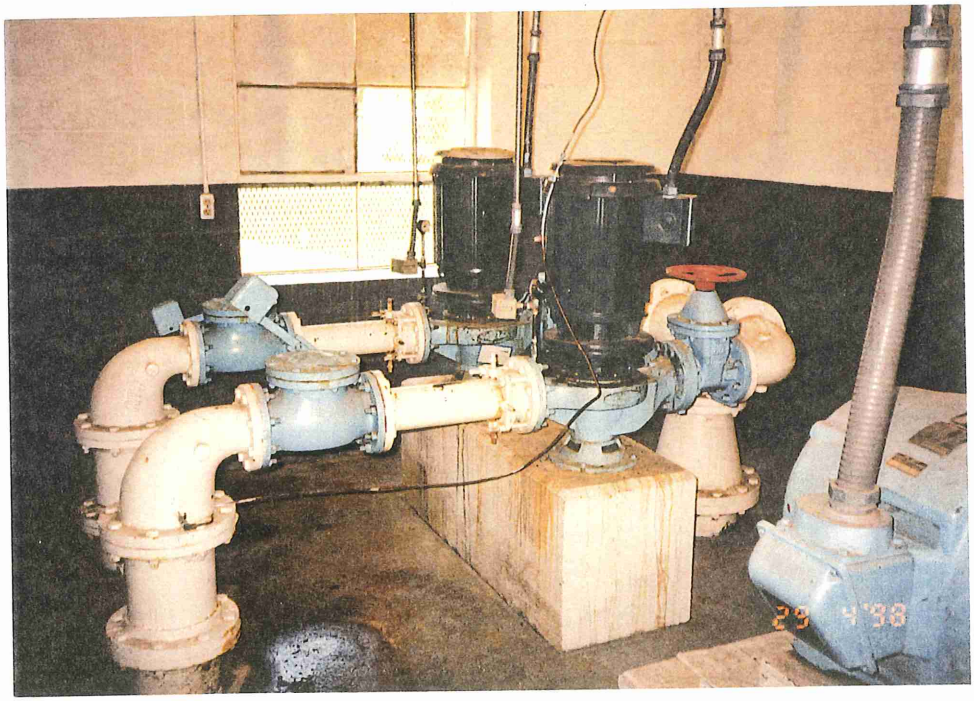


Photo No. 4 Abilene Pump Station.
Upper Plane Pumps.

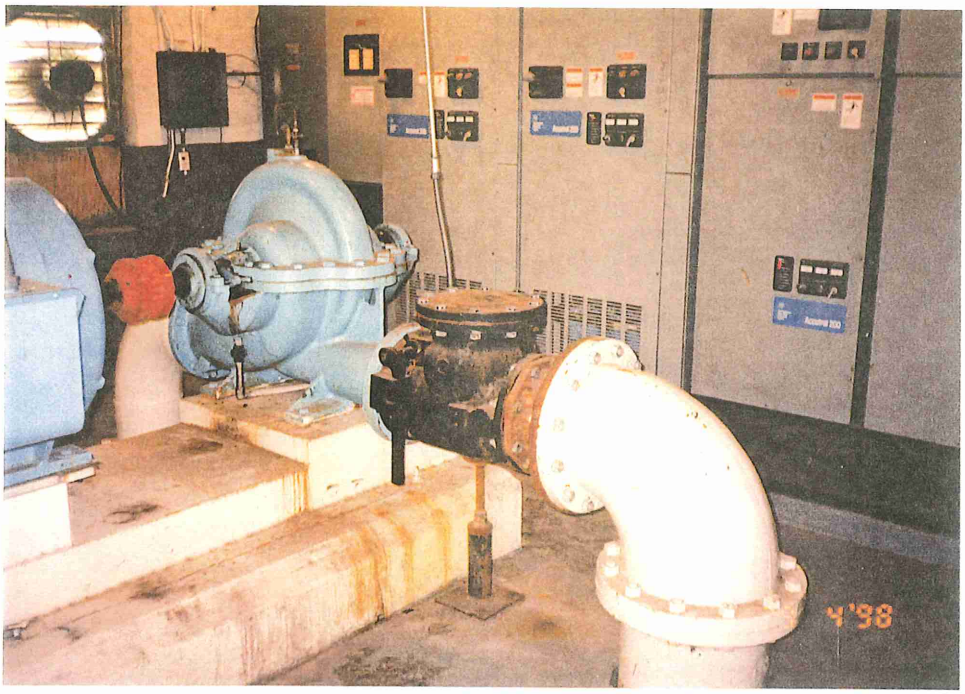


Photo No. 5 Abilene Pump Station.
Lower Plane Pump (100 h.p.).

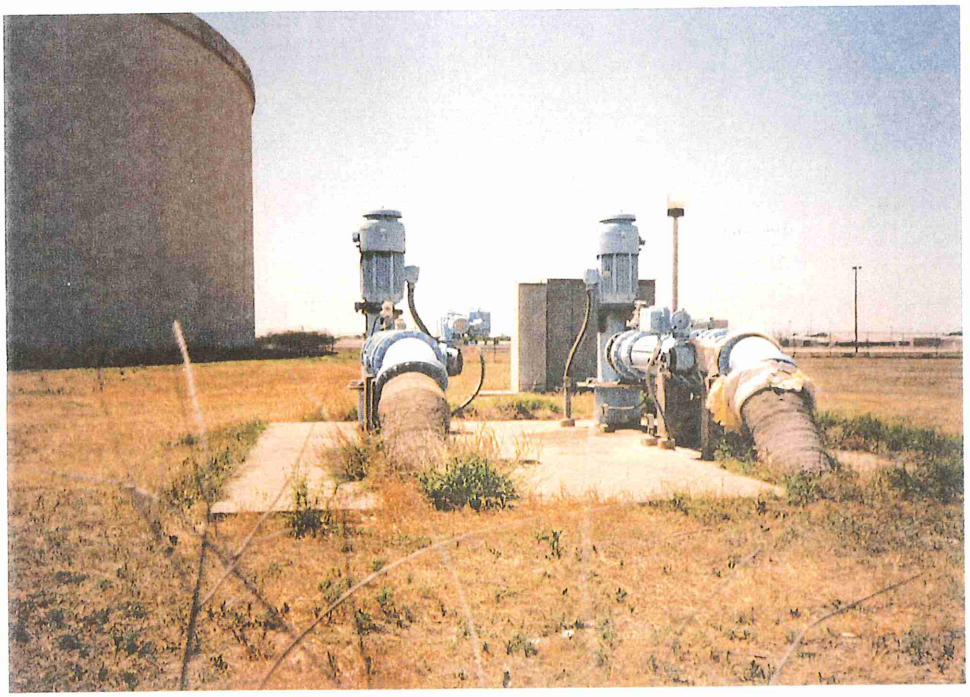


Photo No. 6 Lakeview Pump Station.
Pumps.

5. DESIGN CRITERIA

The water distribution system was analyzed for four operating conditions: maximum day demands, maximum hour demands, tank filling demands and maximum day demand with fire flows. By examining the water system under these various operating conditions, it is possible to determine if low or high water pressures exist, if elevated storage tanks are operating properly, and if the pumping facilities are meeting the required demands at acceptable pressures. The four operating conditions were examined for the existing 1998 condition, and future 2005 and 2020 operating conditions.

5.1 Water System Analysis Software

A model of the City of San Angelo's water distribution system was developed using the CYBERNET computer model. The CYBERNET program is an AutoCAD based software package that graphically models a water distribution system utilizing an AutoCAD drawing file. The CYBERNET model is used to simulate the operation of the piping system, elevated tanks and pumping facilities in a water distribution system. The computer model was also used to simulate how the existing water distribution system will perform if new areas of the City are added to the existing water distribution system. Information on the existing distribution system for input to the computer model was obtained from computerized mapping provided by the City of San Angelo.

5.2 Hydraulic Analysis Criteria

The Hazen-Williams Equation was used to determine the friction losses in the distribution

pipelines. Based upon the pipeline materials used in the City of San Angelo's water system, it is recommended that a Hazen-Williams roughness coefficient of 130 be used to represent the roughness of the distribution lines. This represents the roughness of a moderately aged water distribution line.

The criteria used to determine the size of new water lines for proposed improvements included: 1) allowing adequate minimum and maximum pressures throughout the proposed distribution system, 2) maintaining a flow velocity at or below 7 ft/sec, 3) using 12-inch water lines as a minimum size for connecting major sections of the city and 4) connecting new pipelines to the existing distribution system in a looped arrangement where possible. Looped pipelines allow water to reach any given point in the system from at least two directions.

The criteria used to determine adequate storage facilities included: 1) allowing enough ground and elevated storage to meet regulatory requirements, and 2) providing enough elevated storage to meet peak hourly demands and to provide adequate fire protection.

The criteria used to evaluate the adequacy of the pumping facilities included: 1) maintaining a firm pumping capacity to meet maximum day demands, and 2) providing enough pumping capacity to adequately accomplish tank refilling during night time conditions. During maximum hour demand conditions, it is typical for the system demand to exceed the pumping capacity of the pump stations. During these peak times, the elevated storage tanks provide the balance of the required system demands. Typically it is desirable that the pump stations supply approximately 70% of the maximum hour demands. In no case should the pump stations supply less than 60% of the maximum hour demand. If the pump stations are supplying less than 60% of the total demand, it

is difficult to accomplish tank refilling during night time conditions. Pumping at greater rates than 80% of the maximum hour demand does not permit the full utilization of the elevated tanks, which can result in poor water quality conditions.

5.3 Regulatory Requirements

Two State regulatory agencies, the Texas Natural Resources Conservation Commission (TNRCC) and Texas State Board of Insurance, publish minimum water design standards for municipal water distribution systems. Listed below are a number of these minimum regulatory standards that apply to the City of San Angelo's Water Distribution System.

1. The distribution system shall be designed to maintain a minimum operating pressure of 35 psi at a flow rate of 1.5 gallons per minute per connection.

2. If the distribution system is intended for fire protection, the system must be designed to maintain a minimum pressure of 20 psi under combined fire and drinking water flow conditions representing maximum day consumption demands.

3. A distribution system with more than 250 connections shall maintain a minimum total storage capacity of 200 gallons per connection.

4. A distribution system with more than 2,500 connections shall maintain a minimum elevated storage capacity of 100 gallons per connection.

5. A distribution system with more than 250 connections shall maintain at each pump station a minimum total pumping capacity of 1,000 gallons per minute and the ability to meet peak hourly demands with the largest pump out of service.

6. The pump stations shall have a firm pumping capacity that meets or exceeds the maximum day demand of the system.

5.4 Selection of Line Sizes and Locations

The analysis of a water distribution system, the size of the City of San Angelo's is normally limited to the primary network. If the principal waterlines are capable of delivering an adequate supply of water at a suitable pressure to all sections of the City, then adequately sized smaller waterlines can deliver the water to the customer.

The principal waterlines are normally 12 inches in diameter or larger and are located at intervals of ½ to 1 mile. They should be connected to the system in "loops"; that is, they should connect to the network at both ends, so water can reach any given point from at least two directions. Waterlines 16 inches in diameter and larger are designed to deliver water from a large supply to a large demand area. It is desirable to avoid connecting individual services to these principal transmission lines when they are constructed through an existing service area.

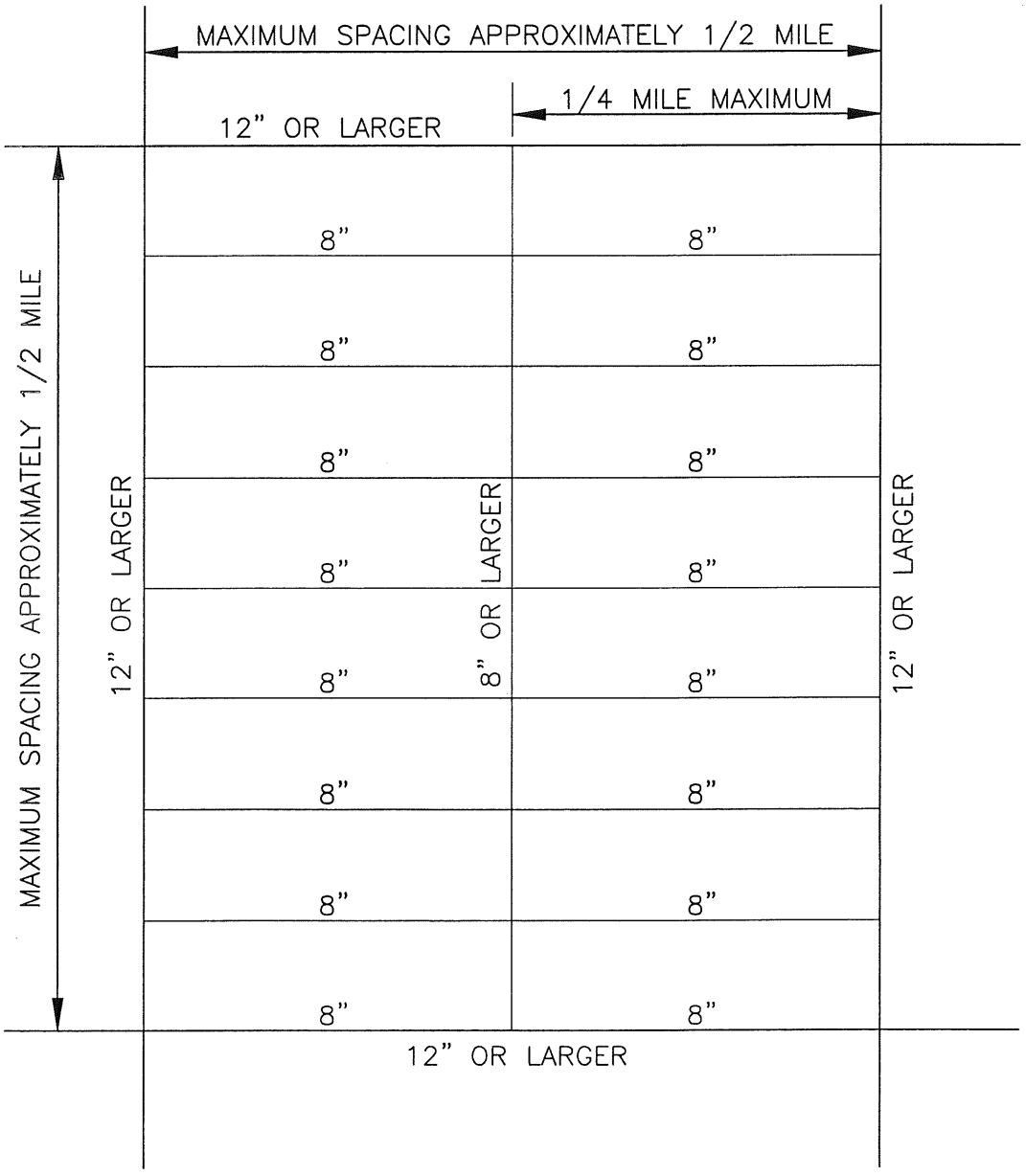
If the water distribution network is to function properly, it is important to establish certain standards in the design and construction of the smaller distribution lines. Observing the following rules should provide satisfactory service.

1. The minimum size line for a house should be 1 inch.

2. The minimum distribution system waterline that should be installed, if the line is less than one quarter mile long, is a 8-inch waterline. If two or more fire hydrants are required, the minimum size should be an 10-inch waterline. At intervals of about one half mile, the 8-inch waterline should cross and be connected to waterlines at least 12 inches in diameter. (Figure 5.1)

3. In a cul-de-sac, a 6-inch waterline can be used if a fire hydrant is not required and if no more than six customers are to be served. The minimum diameter that should be used in a cul-de-sac where a fire hydrant is required is 8 inches. If the distance from the connecting street is 300 feet or less, the fire hydrant should be located at the intersection with the connecting street.

FIGURE 5.1
CITY OF SAN ANGELO
RECOMMENDED CRITERIA FOR SPACING OF SMALLER PIPELINES



4. All waterlines, beside those in cul-de-sacs, should be connected to the other distribution system waterlines at both ends. Where it is not practical to connect a waterline to the water distribution system at both ends, such dead end waterlines should be at least 8 inches in diameter.

Some portions of the existing system do not conform to the design criteria listed above. There is approximately 350,000 feet of 2-inch waterlines in the City. Most of these waterlines were constructed between 1940 and 1960. These waterlines will not be capable of carrying the projected future water demands and fire flows. It is recommended that these 2-inch waterlines be replaced with 8-inch and 12-inch waterlines that meet the design criteria above over the next seven to ten years.

6. WATER DISTRIBUTION ANALYSIS

6.1 Water System Improvements for 1998 Demands

A.) Lower Pressure Plane

The water distribution system was examined under four operating conditions for the existing 1998 condition. The first step in this analysis process is to calibrate the hydraulic model with the existing operation. Pressure readings under peak operating conditions were obtained by the City at various locations as shown in Plate 1. The pressure readings and corresponding modeled pressures are shown on table 6.1

The 1998 population of the City is estimated at 94,066, and there are approximately 31,200 connections in the water system. The ratio of people to connections is approximately 3.0. The Texas Natural Resource Conservation Commission (TNRCC) requires that municipal water systems similar to San Angelo's to provide approximately 100 gallons of elevated storage for each water system connection. This quantity of elevated storage typically provides equalization storage as well as emergency storage for fire protection. Currently the lower plane has 1.0 MG of elevated storage. If the pressure plane delineation is not changed, then the lower plane will need approximately 3.0 MG to satisfy the minimum regulatory requirements set by TNRCC. The City of San Angelo's water distribution system is deficient in elevated storage. It is recommended to construct a new 1.25 million gallon elevated storage tank on the northern part of the City as shown in Plate 5 to provide additional system reliability and fire protection. It is also recommended that a standby generator be added at the Southwest pump station to improve system reliability. It is recommended that the standby diesel generator be sized to operate two pumps for both the lower

Table 6.1
Comparison of Field Pressures & Computer Model Pressures
City of San Angelo

Location #	Location	Field Measured Pressure During Peak Usage (psi)	Peak Hour Model Pressure (psi)
1	Lakeview P.S.	53	49
2	Ballinger Hwy. & Pruitt Rd.	67	63
3	Water Treatment Plant	102	106
4	Ruby Lee Ln. S. of Hwy. 1223	39	40
5	Abilene P.S.-Upper P.P.	60	69
6	Abilene P.S.-Lower P.P.	45	48
7	Southwest P.S.-Upper P.P.	71	76
8	Southwest P.S.-Lower P.P.	46	57
9	Mathis Field	62	59

and upper pressure planes. It is recommended that the standby diesel generator be sized at 1,000 kW, which will be able to operate two future 4,500 gpm (350 H.P.) pumps on the upper side as well as two existing 4,000 gpm (250 H.P.) pumps on the lower side of the Southwest pump station. This standby generator sizing is based upon reduced voltage starting and starting one pump at a time.

There is a need for greater transmission capacity to the upper pressure plane due to its increased water demand. A new 30-inch waterline will need to be constructed from the existing 27-inch at the Sante Fe R.R. to the existing 36-inch waterline at the intersection of Loop 306 and College Hills Boulevard. This will increase the transmission capacity to the upper plane to an acceptable level for this time period.

B.) Upper Pressure Plane

The Standby diesel generator will add system reliability to the upper pressure plane. In Highland Range Estates in the far northwestern part of the upper pressure plane, the available fire flow is less than a 1,000 gpm. It is recommended to connect the 8-inch waterline on Loch Lomond Road to the 16-inch waterline on F.M. 2288. This will increase the available fire flow for this area to an acceptable level.

C.) Chlorine Degradation Study

The purpose of the chlorine residual degradation study was to identify the chlorine content of the water entering the distribution system and how quickly the content decays to a point below

regulatory standards. Chlorine in the form of chloramine is added to the water by the City for disinfection at the water treatment plant.

Previous studies have shown that there are two primary mechanisms at work that cause chlorine residuals to decay within a distribution system. The first mechanism is bulk decay. Bulk decay represents the chlorine decay that occurs when the chlorine reacts with organic or inorganic chemicals within the water. The second mechanism is wall reaction decay. Wall reaction decay represents the chlorine decay that occurs when the chlorine reacts with corrosion within water lines and storage tanks or with biofilms attached to the distribution lines.

The first step in the analysis was to determine which decay mechanism is predominant within the City of San Angelo's water distribution system. The bulk decay rate of the water being delivered to the distribution system was determined by taking a 5 gallon container of water from the downstream side of the water treatment plant and measuring chlorine concentration within the 5 gallon container over a 3 week time period. The results shown in Figure 6.1 indicate that the initial chlorine concentration was approximately 2.2 mg/l. After one week, the chlorine residual decayed to 1.2 mg/l. After two weeks, the chlorine residual decayed to approximately 0.9 mg/l. Although significant, these residuals levels are well above the minimum chlorine residual standard of 0.5 mg/l as set forth by the TNRCC. The resulting bulk chlorine decay coefficient was calculated at 0.066 as shown in Figure 6.2. Therefore, it appears that bulk chlorine decay does not pose a significant problem within the City of San Angelo's water distribution system.

The second step in the chlorine degradation study is to determine if corrosion or biofilms within the piping and storage facilities is causing significant degradation of the chlorine residual

Figure 6.1
City of San Angelo
CHLORINE RESIDUAL BULK DECAY RATE

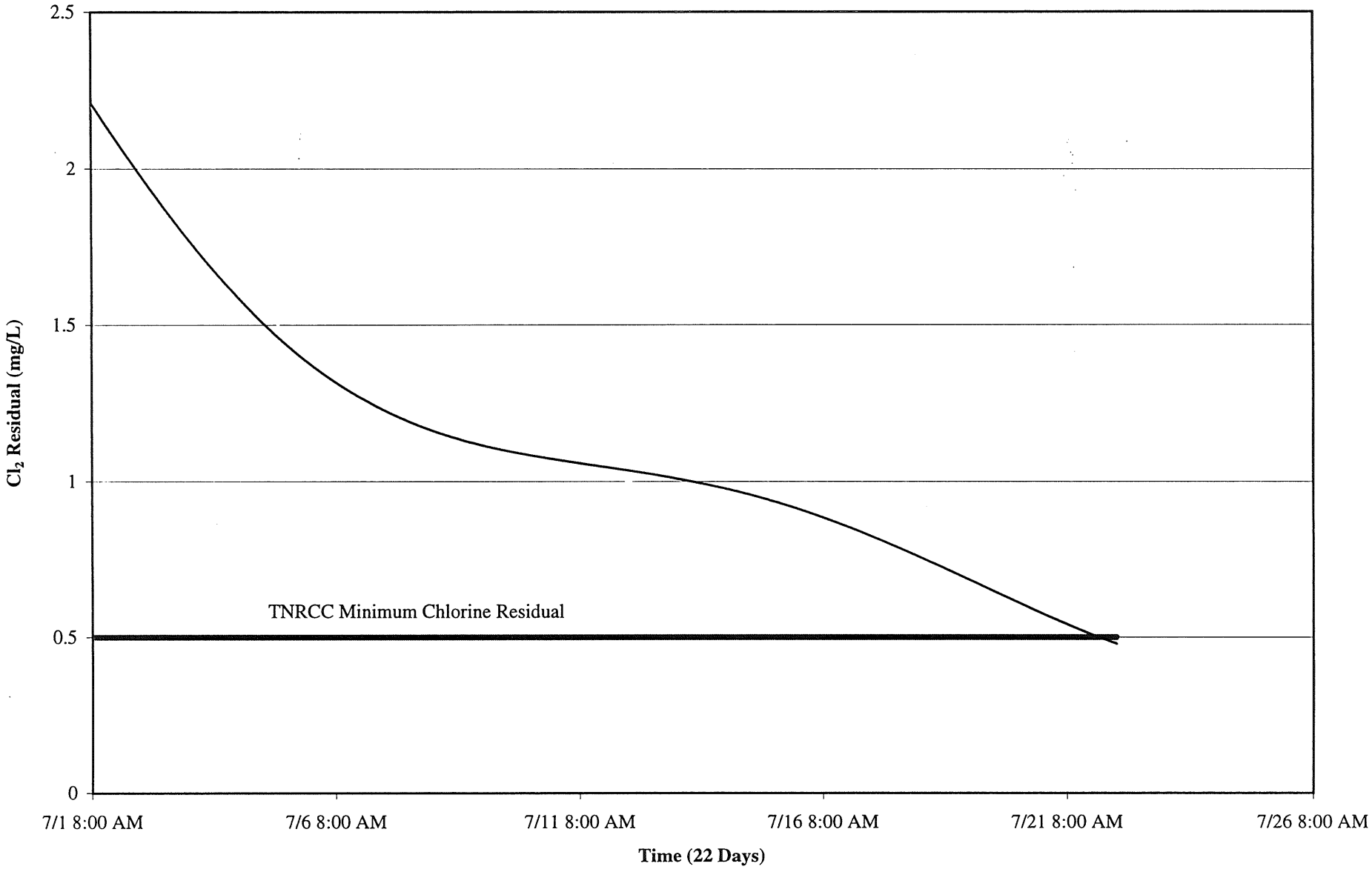
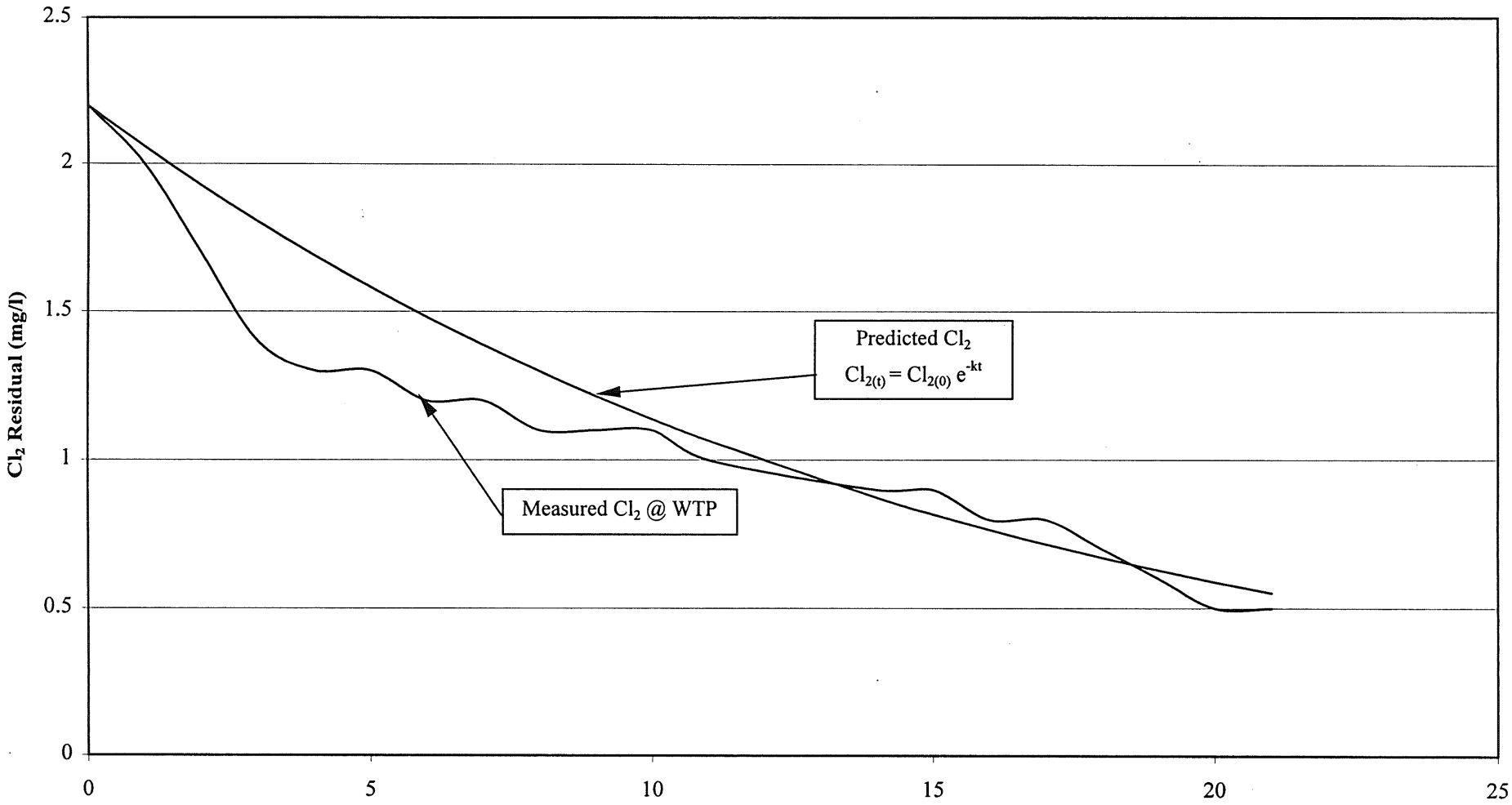


Figure 6.2
City of San Angelo
CHLORINE RESIDUAL BULK DECAY COEFFICIENT CALCULATIONS



Bulk Decay Coefficient (k) = 0.066

within the distribution system. Based on the age of the pipes and on previous studies, a wall reaction decay coefficient of 0.3 was chosen. The CYBERNET model was used to run a water quality model for the maximum day water demand condition for a 5 day period to allow water to be distributed throughout the entire system. The chlorine residual in the tanks and the nodes throughout the system were checked for the 5 day period, and all residual levels were above the required 0.5 mg/l minimum chlorine residual standard. The projected chlorine residuals throughout the City for a maximum day demand condition are shown in Plate 4.

6.2 Water System Improvements for 2005 Demands

A.) Lower Pressure Plane

Ground storage tanks are approximately 30% to 35% of the cost of elevated storage tanks. There exists high ground west of the City that would allow the construction of a ground storage tank that would act as elevated storage for a significant portion of the City where much of the future growth is expected. It is recommended that the City incorporate the western part of the lower pressure plane into the upper pressure plane. The change in the pressure plane delineation is shown in Plate 5. By incorporating part of the lower plane into the upper plane, the needed elevated storage can be achieved at a lower cost. The lower pressure plane would still have an estimated 1998 population of 59,974. With the change in pressure plane delineation, the lower pressure plane would need approximately 2.0 MG of elevated storage. There will be enough elevated storage with the construction of the new 1.25 million gallon elevated tank in the north part of the City.

Transmission capacity to the upper pressure plane will need to be added in order to serve 2005 water demands. Constructing a 36-inch/30-inch waterline from the water treatment plant to the existing 24-inch waterline along the Sante Fe R.R. will allow more water to be delivered to the Southwest Tank. A new 20-inch waterline constructed along Howard Street will increase the amount of water that can be delivered to the Abilene Tank.

The area south of GoodFellow Air Force Base suffers from both low pressures and inadequate fire protection. A 20-inch waterline constructed across the Concho River along Chadbourne Street would loop the water system, resulting in raised pressures, adequate fire protection, and added reliability for the water system.

The approximate 1998 maximum day demand is 42.9 MGD. The raw water pump station is able to pump this amount. However, the electrical switch gear for the older 6 MGD pumps needs to be replaced. This would allow the City to reliably maximize the use of the less expensive water from the Twin Buttes Reservoir.

B.) Upper Pressure Plane

The approximate 2005 population of the expanded upper pressure plane is 42,301. The upper pressure plane needs approximately 1.4 MG of elevated storage in order to come into regulatory compliance. It is projected that the year 2020 population in the upper pressure plane will be 52,500, requiring approximately 1.75 MG of elevated storage to come into regulatory compliance. The elevated storage for the upper pressure plane can be constructed at ground level at a substantially reduced cost. It is therefore recommended that the ground tank acting as elevated storage for the upper pressure plane be 3.0 MG in size. The 3.0 MG tank would allow

for up to 1.25 MG to be utilized as pump station supply for the Westside II pressure plane. Due to the space limitations, constructing another tank at the same site would be difficult. Even though it is not required, a larger 4.0 MG tank might be considered to take more advantage of the lower cost elevated storage. Alternate bids can be taken for a 4.0 MG and 5.0 MG tank to determine if the additional cost warrants the larger tank. It is recommended that the overflow elevation of the new 3.0 MG tank will be approximately 2,140 feet to increase the service area of the Westside I pressure plane. The Mercedes elevated tank has an overflow elevation of 2,104 feet and is incompatible with the new tank. It is recommended to abandon the Mercedes elevated tank after the new tank is in service.

Due to the increasing water demand of the upper pressure plane, the Southwest and Abilene ground tanks will need to serve the upper plane exclusively. It is recommended that 3-4,500 gpm and 3-2,500 gpm new pumps be added to the Southwest and Abilene pump stations respectively. This will bring the firm pumping capacity of the upper pressure plane to 21.6 MGD, exceeding the maximum day demand of 16.5 MGD for the upper pressure plane.

Due to the change in pressure plane delineation, there will not be adequate water distribution lines from the Abilene pump station to serve the expanded service area. A new 16-inch waterline along Mercedes Street and a new 12-inch waterline along Guthrie Street and Abilene Street will be needed. A new 16-inch waterline will need to be constructed along Knickerbocker Road across Lake Nasworthy. The looping of the water system will raise pressures, and add reliability in water service and fire protection. It is recommended to construct a 16-inch waterline along Johnson St. After the 16-inch waterline is constructed it is recommended to remove the

Delmar tank from service.

The projected 2005 maximum day demand for the upper pressure plane is 19.4 MGD. With the expansion of the Southwest and Abilene pump stations, the firm pumping capacity will be 21.6 MGD. Therefore, it is not necessary to increase the pumping capacity in the upper plane. It is anticipated that most of the additional growth will occur in the west and southwest parts of the upper pressure plane. A 24-inch/16-inch waterline will need to be constructed along the Sante Fe R.R. to loop the water system. It is recommended to construct a new 20-inch/16-inch waterline from near the new 3.0 MG tank northward to Southland Boulevard to loop the water system. In addition it is recommended to construct new 12-inch waterlines to provide additional water supply as the southwest area develops, as shown on Plate 5.

6.3 Water System Improvements for 2020 Demands

A.) Lower Pressure Plane

The projected maximum day demand for the combined lower and upper pressure planes is 60.1 MGD. The available pumping capacity at the water treatment plant is 59 MGD. A new 15 MGD pump should be added to bring the firm pumping capacity of the water treatment plant to 76 MGD. The upper pressure plane demand in 2020 will require additional transmission capacity to the upper pressure plane. It is also recommended to construct a new 20-inch waterline along Avenue J. which will increase the amount of water that can be delivered to the Abilene Tank.

The projected 2020 population of the lower pressure plane is 66,700. That population would equal 22,234 connections using three persons per connection. Regulatory requirements

shown in Section 4.2 require 100 gallons of elevated storage per connection. Therefore, the required elevated storage for the lower pressure plane is approximately 2.25 MG. It is recommended that a 0.5 MG elevated storage tank be constructed in the northwest part of the city.

It is anticipated that additional growth will happen in the southeastern part of the City by the year 2020. A 20-inch/16-inch waterline should be constructed along Jack Rabbit Trail and Loop 306 to loop the water system, providing some additional transmission capacity to the upper pressure plane, adding reliability and water supply to the growth in the area. It is also recommended to construct a 12-inch waterline on the southeast side to provide additional water supply to the area.

B.) Upper Pressure Plane

The upper pressure plane has a maximum day water demand of 26.3 MGD. As of 2005, the firm pumping capacity in the upper pressure plane will be 21.6 MGD. It is recommended that a 4,500 gpm pump be added to the Southwest pump station and a 2,500 gpm pumps to the Abilene pump station. This will bring the firm pumping capacity of the upper pressure plane to 30.2 MGD. The pumping capacity in the upper pressure plane will not only meet regulatory requirements, it will also insure that the 3.0 MG elevated tank is not depleted during peak hour demands.

Additional growth is anticipated in the southwestern part of the upper pressure plane. It is recommended to construct a 24-inch/16-inch waterline along Hwy. 64. It is also recommended to construct 12-inch waterlines to provide additional water supply to the area.

7. CAPITAL IMPROVEMENT PLAN

Unit costs used to estimate projected costs of water system improvements are shown in Table 7.1. Costs associated with obtaining right-of-way and permits are not included. These costs are for the principal water distribution facilities in the systems and do not include individual service connections or subdivision internal distribution lines.

Table 7.1
City of San Angelo
Estimated Unit Cost for Water System Construction

8" Waterline	12" Waterline	16" Waterline	20" Waterline	24" Waterline	30" Waterline
$24 per LF	$36 per LF	$48 per LF	$60 per LF	$72 per LF	$90 per LF
36" Waterline	Boring & 24" Casing	Boring & 30" Casing	Boring & 36" Casing	Boring & 48" Casing	Boring & 54" Casing
$108 per LF	$240 per LF	$300 per LF	$360 per LF	$480 per LF	$540 per LF

The costs of water system improvements required to meet future water demands are shown in Tables 7.2 Through 7.4. The costs in these tables are in terms of 1998 dollars and include a 20% allowance for engineering, surveying, and contingencies. It is recommended that these improvements be constructed generally in the order shown. However, it is understood that development in certain parts of the City may make it necessary to construct certain future improvements sooner than anticipated. The total cost of the water system improvements from 1998 through 2000 is $3,158,640. The total cost of water system improvements from 2000-2005 and 2005-2020 are $10,647,360 and $7,961,280 respectively.

TABLE 7.2
City of San Angelo
Water Distribution System Capital Improvements
Opinions of Probable Project Costs
Water System Improvements Year 1998-2000

Project Number	Project Description	Construction Items	Quantity	Units	Unit Price	Costs
1	New 1.25 MG Elevated Tank & 20" Waterline from New Elevated along Grape Creek Rd. to Mimosa Dr.	20" W.L. & Appurtenances	3500	LF	$60	$210,000
		1.0 MG Elevated Tank	1	LS	$1,250,000	$1,250,000
		Misc. Site Piping	1	LS	$50,000	$50,000
					Subtotal	$1,510,000
					Engin. & Contingency @ 20%	$302,000
					Total Project Cost	$1,812,000
2	Standby Generator at S.W. P.S.	1,000 KW Standby Diesel Generator with Automatic Transfer Switch	1	LS	$260,000	$260,000
					Subtotal	$260,000
					Engin. & Contingency @ 20%	$52,000
					Total Project Cost	$312,000
3	30" Waterline along College Hills Blvd.	30" W.L. & Appurtenances	3000	LF	$90	$270,000
					Subtotal	$270,000
					Engin. & Contingency @ 20%	$54,000
					Total Project Cost	$324,000
4	30" Waterline from College Hills Blvd. To Existing 27" W.L.	30" W.L. & Appurtenances	6500	LF	$90	$585,000
					Subtotal	$585,000
					Engin. & Contingency @ 20%	$117,000
					Total Project Cost	$702,000
5	8" Waterline Along Loch Lomond Rd.	8" W.L. & Appurtenances	300	LF	$24	$7,200
					Subtotal	$7,200
					Engin. & Contingency @ 20%	$1,440
					Total Project Cost	$8,640

CAPITAL IMPROVEMENT COSTS FOR YEAR 1998 TO YEAR 2000	**$2,632,200**
ENGINEERING & CONTINGENCY COSTS FOR YEAR 1998 TO YEAR 2000	**$526,440**
TOTAL WATER SYSTEM IMPROVEMENT COSTS FOR YEAR 1998 TO YEAR 2000	**$3,158,640**

TABLE 7.3
City of San Angelo
Water Distribution System Capital Improvements
Opinions of Probable Project Costs
Water System Improvements Year 2000-2005

Project Number	Project Description	Construction Items	Quantity	Units	Unit Price	Costs
6	New 3.0 MG Elevated Tank & 36" Waterline from New Elevated along Hwy 67 (Mertzon Hwy) to Southland Blvd. And 16" W.L.	36" W.L. & Appurtenances	11500	LF	$108	$1,242,000
		54" Bore & Casing	150	LF	$540	$81,000
		16" W.L. & Appurtenances	300	LF	$48	$14,400
		3.0 MG Elevated Tank	1	LS	$1,050,000	$1,050,000
		Misc. Site Piping	1	LS	$50,000	$50,000
					Subtotal	$2,437,400
					Engin. & Contingency @ 20%	$487,480
					Total Project Cost	$2,924,880
7	Abilene P.S. Expansion	New P.S. with 3-2,500 gpm Horizontal Pumps Initially with 4 Pumps Ultimately	1	LS	$425,000	$425,000
					Subtotal	$425,000
					Engin. & Contingency @ 20%	$85,000
					Total Project Cost	$510,000
8	Southwest P.S. Expansion	New P.S. with 3-Higher Head 4,500 gpm Pumps	1	LS	$380,000	$380,000
					Subtotal	$380,000
					Engin. & Contingency @ 20%	$76,000
					Total Project Cost	$456,000
9	16" Waterline along Mercedes St from Guthrie St. to Arroyo Rd.	16" W.L. & Appurtenances	5900	LF	$48	$283,200
					Subtotal	$283,200
					Engin. & Contingency @ 20%	$56,640
					Total Project Cost	$339,840
10	12" Waterline along Guthrie St. and Abilene St. from Junius St. to Childress St.	12" W.L. & Appurtenances	5800	LF	$36	$208,800
					Subtotal	$208,800
					Engin. & Contingency @ 20%	$41,760
					Total Project Cost	$250,560
11	16" Waterline along Johnson Rd. from Existing 20" W.L. to Existing 12" W.L.	16" W.L. & Appurtenances	1600	LF	$48	$76,800
					Subtotal	$76,800
					Engin. & Contingency @ 20%	$15,360
					Total Project Cost	$92,160
12	20" Waterline along Chadbourne St. from Existing 33" W.L. to Existing 12" W.L.	20" W.L. & Appurtenances	2300	LF	$60	$138,000
					Subtotal	$138,000
					Engin. & Contingency @ 20%	$27,600
					Total Project Cost	$165,600
13	16" Waterline along Knickerbocker Rd. from Existing 16" W.L. to Existing 12" W.L.	16" W.L. & Appurtenances	3600	LF	$48	$172,800
					Subtotal	$172,800
					Engin. & Contingency @ 20%	$34,560
					Total Project Cost	$207,360

TABLE 7.3 (Continued)
City of San Angelo
Water Distribution System Capital Improvements
Opinions of Probable Project Costs
Water System Improvements Year 2000-2005

Project Number	Project Description	Construction Items	Quantity	Units	Unit Price	Costs
14	New Electrical Switch Gear for the Raw Water P.S.	Electrical Switch Gear	1	LS	$140,000	$140,000
					Subtotal	$140,000
					Engin. & Contingency @ 20%	$28,000
					Total Project Cost	$168,000
15	W.T.P. Raw Water P.S. Expansion	10.0 MGD Pump	1	LS	$250,000	$250,000
					Subtotal	$250,000
					Engin. & Contingency @ 20%	$50,000
					Total Project Cost	$300,000
16	36" & 30" Waterlines along Ave. I & the Sante Fe R.R. from W.T.P. to Existing 24" W.L.	36" W.L. & Appurtenances	4500	LF	$108	$486,000
		30" W.L. & Appurtenances	10900	LF	$90	$981,000
		48" Bore & Casing	100	LF	$480	$48,000
					Subtotal	$1,515,000
					Engin. & Contingency @ 20%	$303,000
					Total Project Cost	$1,818,000
17	20" Waterline along Howard St. from Guadalupe St. to Colorado Ave.	20" W.L. & Appurtenances	2900	LF	$60	$174,000
		36" Bore & Casing	100	LF	$360	$36,000
					Subtotal	$210,000
					Engin. & Contingency @ 20%	$42,000
					Total Project Cost	$252,000
18	24" Waterline along Sante Fe R.R. from Hwy 67 to Southwest Blvd.	24" W.L. & Appurtenances	9600	LF	$72	$691,200
					Subtotal	$691,200
					Engin. & Contingency @ 20%	$138,240
					Total Project Cost	$829,440
19	20" & 16" Waterline along Arden Rd. from Existing 16" W.L. to New 36" W.L.	20" W.L. & Appurtenances	6800	LF	$60	$408,000
		16" W.L. & Appurtenances	4200	LF	$48	$201,600
		36" Bore & Casing	100	LF	$360	$36,000
		30" Bore & Casing	100	LF	$300	$30,000
					Subtotal	$675,600
					Engin. & Contingency @ 20%	$135,120
					Total Project Cost	$810,720
20	16" Waterline Along Southwest Blvd. From Valleyview Blvd. To Red Bluff Rd.	16" W.L. & Appurtenances	3500	LF	$48	$168,000
		30" Bore & Casing	150	LF	$300	$45,000
					Subtotal	$213,000
					Engin. & Contingency @ 20%	$42,600
					Total Project Cost	$255,600

TABLE 7.3 (Continued)
City of San Angelo
Water Distribution System Capital Improvements
Opinions of Probable Project Costs
Water System Improvements Year 2000-2005

Project Number	Project Description	Construction Items	Quantity	Units	Unit Price	Costs
21	12" Waterline Oak Grove Rd. from Southland Blvd. To Red Bluff Rd.	12" W.L. & Appurtenances	17700	LF	$36	$637,200
		24" Bore & Casing	200	LF	$240	$48,000
					Subtotal	$685,200
					Engin. & Contingency @ 20%	$137,040
					Total Project Cost	$822,240
22	12" Waterline in Northwest from New 20" W.L. to Existing 16" W.L.	12" W.L. & Appurtenances	9300	LF	$36	$334,800
					Subtotal	$334,800
					Engin. & Contingency @ 20%	$66,960
					Total Project Cost	$401,760
23	8" Waterline Along Lake Dr. from W. 48th St. to Cauley Ln.	8" W.L. & Appurtenances	1500	LF	$24	$36,000
					Subtotal	$36,000
					Engin. & Contingency @ 20%	$7,200
					Total Project Cost	$43,200
	CAPITAL IMPROVEMENT COSTS FOR YEAR 2000 TO YEAR 2005					**$8,872,800**
	ENGINEERING & CONTINGENCY COSTS FOR YEAR 2000 TO YEAR 2005					**$1,774,560**
	WATER SYSTEM IMPROVEMENT COSTS FOR YEAR 2000 TO YEAR 2005					**$10,647,360**

TABLE 7.4
City of San Angelo
Water Distribution System Capital Improvements
Opinions of Probable Project Costs
Water System Improvements Year 2005-2020

Project Number	Project Description	Construction Items	Quantity	Units	Unit Price	Costs
24	W.T.P. High Service P.S. Expansion	15.0 MGD Pump	1	LS	$375,000	$375,000
					Subtotal	$375,000
					Engin. & Contingency @ 20%	$75,000
					Total Project Cost	$450,000
25	W.T.P. Raw Water P.S. Expansion	10.0 MGD Pump	1	LS	$250,000	$250,000
					Subtotal	$250,000
					Engin. & Contingency @ 20%	$50,000
					Total Project Cost	$300,000
26	Abilene P.S. Expansion	1-2,500 gpm Pumps	1	LS	$90,000	$90,000
					Subtotal	$90,000
					Engin. & Contingency @ 20%	$18,000
					Total Project Cost	$108,000
27	Southwest P.S. Expansion	1-4,500 gpm Pump	1	LS	$162,000	$162,000
					Subtotal	$162,000
					Engin. & Contingency @ 20%	$32,400
					Total Project Cost	$194,400
28	24" & 16" Waterline along Hwy 64 (Mertzon Hwy)	24" W.L. & Appurtenances	5000	LF	$72	$360,000
		16" W.L. & Appurtenances	5000	LF	$48	$240,000
					Subtotal	$600,000
					Engin. & Contingency @ 20%	$120,000
					Total Project Cost	$720,000
29	20" & 16" Waterlines along Loop 306 and Jackrabbit Tr.	20" W.L. & Appurtenances	3500	LF	$60	$210,000
		16" W.L. & Appurtenances	14500	LF	$48	$696,000
		30" Bore & Casing	1500	LF	$300	$450,000
					Subtotal	$1,356,000
					Engin. & Contingency @ 20%	$271,200
					Total Project Cost	$1,627,200
30	12" Waterline along Canal on Southeast side	12" W.L. & Appurtenances	10800	LF	$36	$388,800
		24" Bore & Casing	800	LF	$240	$192,000
					Subtotal	$580,800
					Engin. & Contingency @ 20%	$116,160
					Total Project Cost	$696,960

TABLE 7.4 (Continued)
City of San Angelo
Water Distribution System Capital Improvements
Opinions of Probable Project Costs
Water System Improvements Year 2005-2020

Project Number	Project Description	Construction Items	Quantity	Units	Unit Price	Costs
31	20" Waterline along Ave. J from New 36" W.L. to Existing 20" W.L.	20" W.L. & Appurtenances	2800	LF	$60	$168,000
					Subtotal	$168,000
					Engin. & Contingency @ 20%	$33,600
					Total Project Cost	$201,600
32	New 0.5 MG Elevated Tank & 16" Waterline from New Elevated Tank South to Existing 16" W.L.	16" W.L. & Appurtenances	7900	LF	$108	$853,200
		30" Bore & Casing	150	LF	$300	$45,000
		0.5 MG Elevated Tank	1	LS	$500,000	$500,000
		Misc. Site Piping	1	LS	$50,000	$50,000
					Subtotal	$1,448,200
					Engin. & Contingency @ 20%	$289,640
					Total Project Cost	$1,737,840
33	12" Waterlines on Southwest side	12" W.L. & Appurtenances	32600	LF	$36	$1,173,600
		24" Bore & Casing	700	LF	$240	$168,000
					Subtotal	$1,341,600
					Engin. & Contingency @ 20%	$268,320
					Total Project Cost	$1,609,920
34	12" Waterline along Fish Hatchery Rd.	12" W.L. & Appurtenances	7300	LF	$36	$262,800
					Subtotal	$262,800
					Engin. & Contingency @ 20%	$52,560
					Total Project Cost	$315,360

CAPITAL IMPROVEMENT COSTS FOR YEAR 2005 TO YEAR 2020	**$6,634,400**
ENGINEERING & CONTINGENCY COSTS FOR YEAR 2005 TO YEAR 2020	**$1,326,880**
WATER SYSTEM IMPROVEMENT COSTS FOR YEAR 2005 TO YEAR 2020	**$7,961,280**