Project Sizing and Expansion Options
Two project phasing options were developed to provide adequate capacity for the initial contracted deliveries as well as the future phase capacity anticipated by projected water demands in the area.

The first phasing option for project sizing involves the base case design with an expected single construction phase with a capacity to deliver initial contracted deliveries of 10 mgd. Evaluation for pipe sizes, pressure class, and preferred delivery scheme was conducted for the base case.

Potential expansion of project facilities was evaluated using a phased approach with an initial phase to deliver initial contract deliveries, and a future phase to deliver water that may be made available. This option was evaluated for the most feasible alternatives resulting from evaluation of the base case delivery scheme.

System Demand Distribution
The project demands used for detailed study of the hydraulic alternatives were derived from information obtained from meetings with the potential customers of the system in November and December of 1999.

The requested delivery quantities for both initial conditions (start of project operation in year 2002) and ultimate conditions (year 2012 project operations) are tabulated in Table 1, *Requested Delivery Quantities – Base Project*. The table clearly shows the additional (returnable) deliveries not used in-district during initial operation as distributed to the out-of-district customers. Similarly, the table indicates the full in-district use of those deliveries during ultimate operation.

Hydraulic Criteria and Constraints
The primary hydraulic parameters set for project constraints include the following:

- Minimum internal pressure of 10 psig above any expected local external hydrostatic pressure under all normal conditions in the pipeline. This internal pressure is slightly higher than Texas Natural Resource Conservation Commission (TNRCC) guidelines for potable water transfer lines to account for uncertainties in actual operational conditions.

- Maximum internal pressure of 300 psi in the transfer pipeline. This pressure was selected based on standards in engineering design practice and consideration for feasible pipeline construction and maintenance.

- Minimum velocity of approximately 2 feet per second (fps). This minimum velocity is required for maintaining adequate scour of potential filter sediment entering the transfer system.

***Table 1** – Requested Delivery Quantities –Base Project*

Entity	Requested Delivery	
	Ultimate	Initial

	Annual Ave (acft/yr)	Ave[1] (mgd)	Annual Ave (acft/yr)	Ave[1] (mgd)
IN-DISTRICT				
City of Boerne	1,861	1.74	500	0.47
City of Fair Oaks	1,400	1.31	800	0.75
Comal Independent School District	150	0.14	150	0.14
Apex Water Services	200	0.19	100	0.09
Bulverde Utility Corp. (absorbed by Bexar Met.)	202	0.19	202	0.19
Murcia Development Co.	220	0.21	100	0.09
Lost Owl (Comal Water Co.)	44	0.04	5	0.00
Clyde Johnson	400	0.37	100	0.09
Double J. Ranch	250	0.23	100	0.09
Cordillera	1,000	0.94	400	0.37
Tapatio Springs/Kendall Co. Utility Co.	500	0.47	150	0.14
Others	300	0.28	0	0.00
SUBTOTAL	6,527	6.12	2,607	2.44
OUT-OF-DISTRICT				
San Antonio River Authority	50	0.05	50	0.05
San Antonio Water System	1,813	1.70	4,654	4.36
(commitment)	*(1,813)*	*(1.70)*	*(1,813)*	*(1.70)*
(returnable)	*(0)*	*(0.00)*	*(2,842)*	*(2.66)*
Bexar Metropolitan Water District	2,138	2.00	3,216	3.01
(commitment)	*(2,138)*	*(2.00)*	*(2,138)*	*(2.00)*
(returnable)	*(0)*	*(0.00)*	*(1,079)*	*(1.01)*
SUBTOTAL	4,000	3.7	7,920	7.4
TOTAL IN AND OUT OF DISTRICT	**10,527**	**9.9**	**10,527**	**9.9**

Notes:
[1] Demand values reported in mgd include additional consideration for 5% system losses expected.

Established Decision Criteria

Decision criteria were established for selection of the most feasible hydraulic design alternative for the project. The decision criteria are comprised of both cost and non-cost factors and are characterized by inherent concerns or trade-offs affecting that affect the decision process. The factors and associated concerns are listed below in Table 2, *Decision Criteria.*

***TABLE 2** – Decision Criteria*

Cost Factors	***Concern***
Pipe Pressure Class Pipe Size	Trade-off betweeen pipe size and pump head
Pump Energy Cost	Trade-off with capital cost of pipeline
System Storage	More storage required for remote pump station
Power Connection for Electrical Feed	Less costly for single electrical feed at WTP
Non-Cost Factors	
WTP Location (Elev.)	Affects feasibility of gravity conveyance to system. Affects number of suitable sites.
O&M Staffing Location	Convenience for O&M if single facility
Control Complexity	Complexity of system control increases with off-site facilities.

Additional non-cost concerns that are of less importance to the actual feasibility of the project include system delivery to the customer's preferred hydraulic grade line elevation and electrical feed considerations (facilities within single service area vs. multiple, potential for dual feed vs. generator for backup).

Pipeline and Pump Station Design Alternatives and Hydraulics

The relative elevations of the preliminary location for the water treatment plant site and the customer delivery points provide the opportunity for several different delivery schemes. These include pumped delivery to all customers as well as gravity flow to the customers at lower elevations with pumped delivery to the customers at higher elevations. The most likely options have been identified as follows:

- Alternative 1 – This alternative provides pumped delivery to all customers via a high service pump station at the water treatment plant.
- Alternative 2 – This alternative provides gravity delivery to a remote pump station located west of Road 281 along Road 46, with pumped delivery to Boerne and BMWD.
- Alternative 3 – This alternative provides gravity delivery to Bexar Metropolitan Water District (BMWD) in Bexar County and requires a remote pump station in the vicinity of the Boerne/BMWD junction for pumped delivery to Boerne. To allow for gravity to BMWD,

the pipeline route was reconfigured along Smithson Valley Road between the water treatment plant and the junction to Boerne.

Refer to Figures 2-4 for system map for each alternative.

Results of Hydraulic Analysis – Base Project

The three hydraulic design alternatives to meet current contract delivery quantities were evaluated for resulting hydraulic grade line, required pipe size and pressure class, pumping facilities, and the required storage facilities at those pumping facilities.

A summary of hydraulic results pertinent to the established project hydraulic constraints is tabulated for each alternative in Table 3, *Summary of Hydraulic Results – Phased Project Delivery*. Violation of any project criteria is noted within the comment column of the table.

***TABLE 3** – Summary of Hydraulic Results – Base Project Delivery*

		HYDRAULIC RESULTS - MAINLINE DELIVERY[1]				
Flow Condition		Minimum Velocity (fps)	Maximum Velocity (fps)	Minimum Press. (psi)	Maximum Press. (psi)	Comments
Initial Demand	ALT. 1	3.0	4.7	12.4	242.8	
	ALT.2	3.0	4.7	11.8	234.9	
	ALT.3	1.2	7.0	10.1	234.9	violates min. velocity criteria
Ultimate Demand	ALT. 1	2.8	3.8	26.6	243.1	
	ALT.2	2.8	3.8	12.4	237.1	
	ALT.3	0.8	7.3	12.6	237.1	violates min. velocity criteria

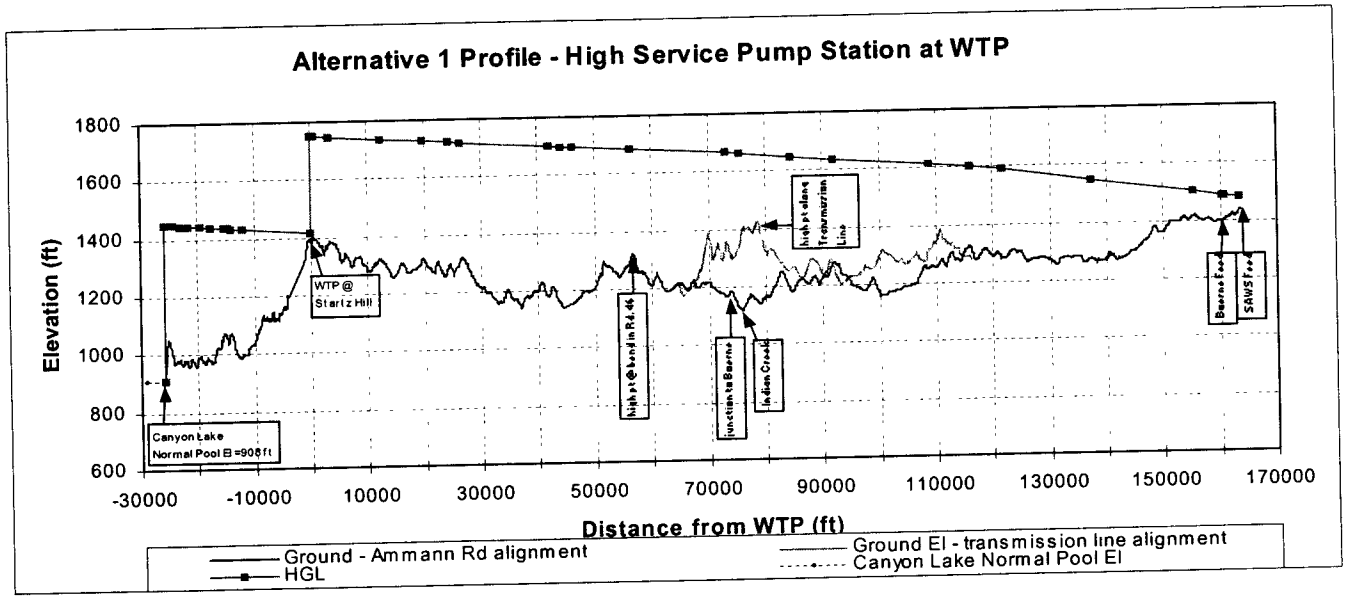
[1] Includes those areas of the mainline deemed subject to hydraulic criteria constraints (exceptions include less significant portions of the line such as branches).

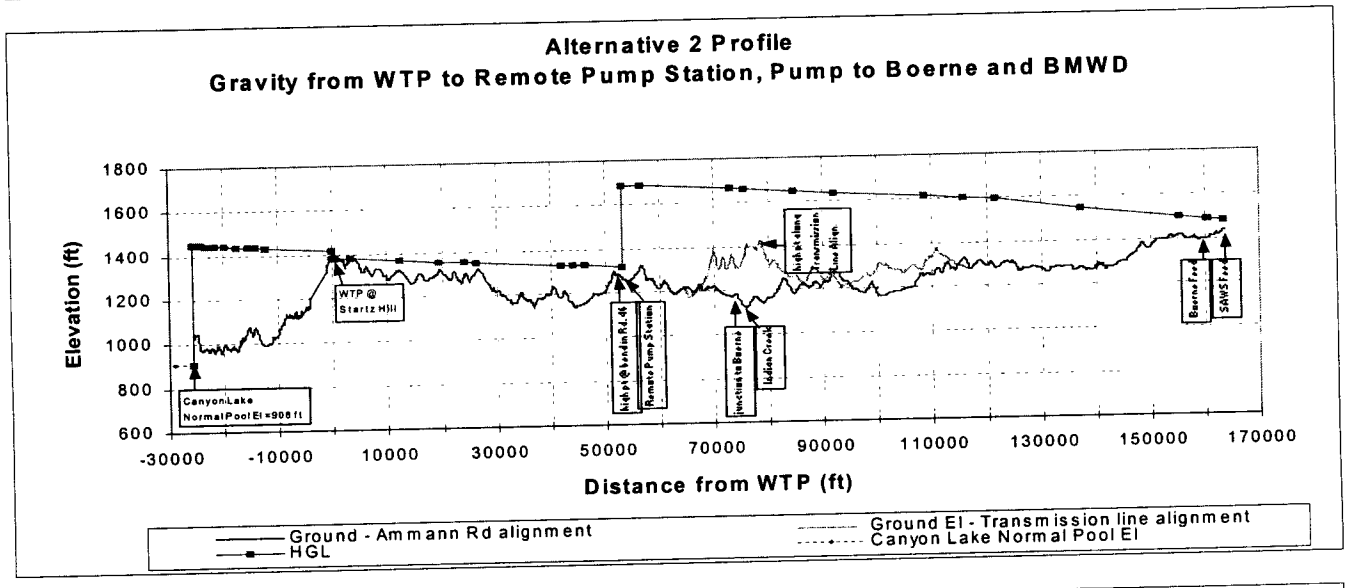
Hydraulic Grade Line (HGL)

Determination of the desired HGL elevation at the furthest termination point, SAWS delivery, was made based on the design criteria that the minimum working pressure be at least 10 psi for the entire pipeline. The Hazen-Williams equation was used to compute the headloss in each segment of pipe. Both spreadsheet models and the hydraulic distribution model, KY Pipe, were used to evaluate the alternatives.

The resulting hydraulic profiles for each alternative from; 1) Canyon Lake to the furthest point of the pipeline at the SAWS delivery location and 2) Boerne/BMWD junction to BMWD are shown in Figures 5 and 6, respectively.

The HGL for Alternative 1 shows that the single high-head boost at the WTP. Profiles for Alternatives 2 and 3 indicate gravity from the WTP to the respective remote pump stations where deliveries further down the line are supplied a boost in HGL.


Alternative 1 Profile - High Service Pump Station at WTP
Elevation (ft)
1800
1600
1400
1200
1000
800
600
-30000
-10000
10000
30000
50000
70000
90000
110000
130000
150000
170000
Distance from WTP (ft)
WTP @ Startz Hill
Canyon Lake Normal Pool El =908 ft
Ground - Ammann Rd alignment
HGL
Ground El - transmission line alignment
Canyon Lake Normal Pool El


Alternative 2 Profile
Gravity from WTP to Remote Pump Station, Pump to Boerne and BMWD
Elevation (ft)
1800
1600
1400
1200
1000
800
600
-30000
-10000
10000
30000
50000
70000
90000
110000
130000
150000
170000
Distance from WTP (ft)
WTP @ Startz Hill
Canyon Lake Normal Pool El =908 ft
Ground - Ammann Rd alignment
HGL
Ground El - Transmission line alignment
Canyon Lake Normal Pool El

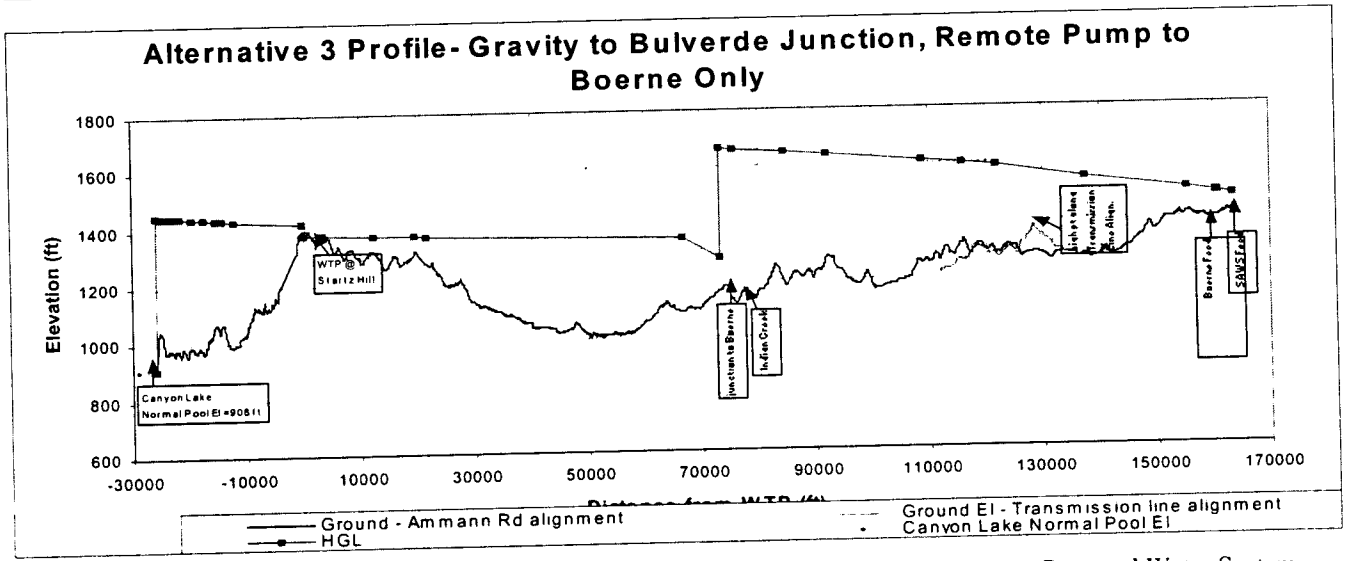
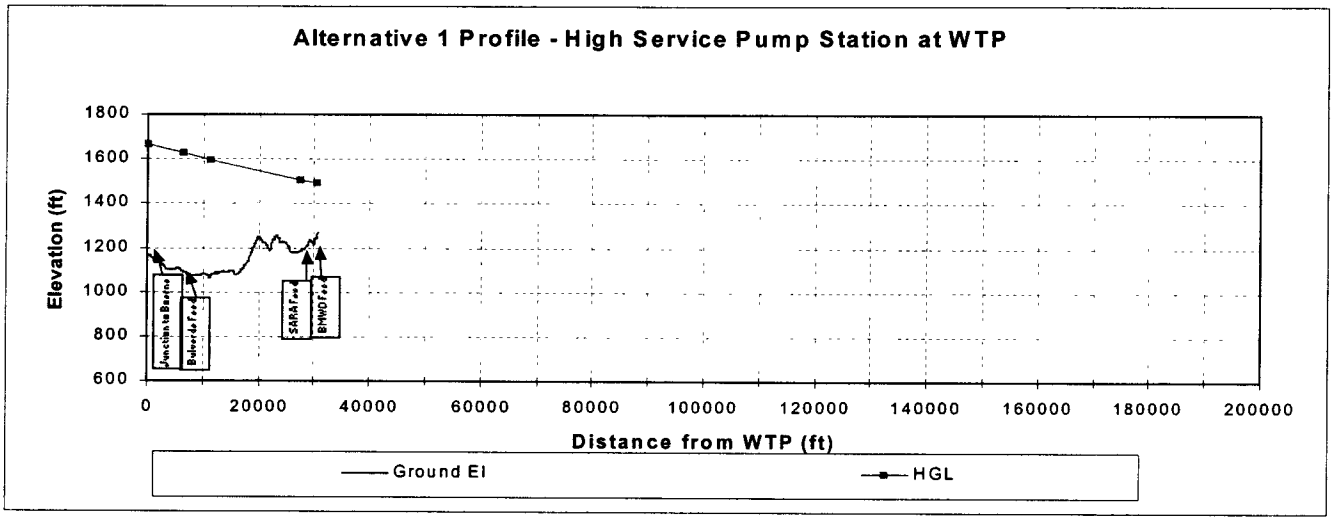
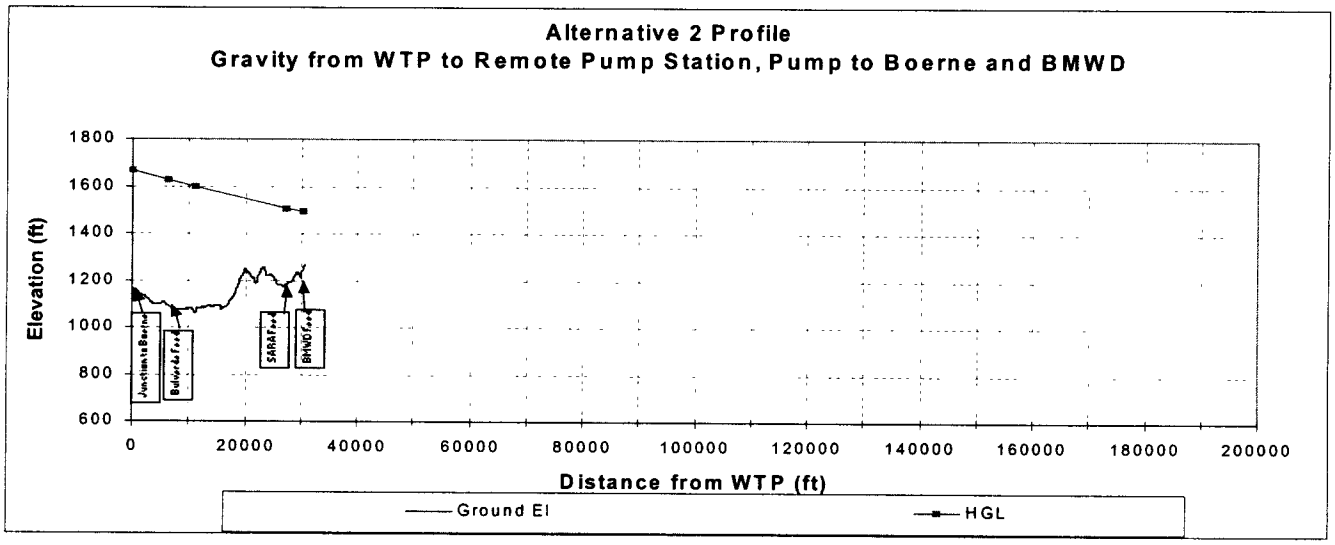
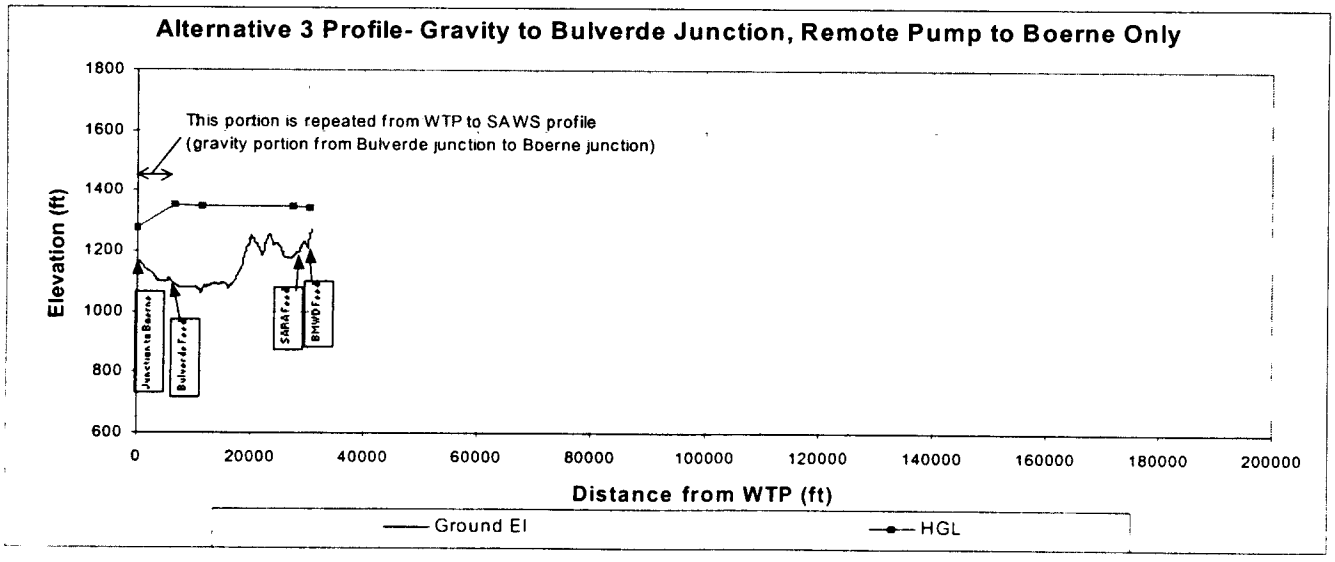

Alternative 3 Profile- Gravity to Bulverde Junction, Remote Pump to Boerne Only
Elevation (ft)
1800
1600
1400
1200
1000
800
600
-30000
-10000
10000
30000
50000
70000
90000
110000
130000
150000
170000
WTP @ Startz Hill
Canyon Lake Normal Pool El =908 ft
Ground - Ammann Rd alignment
HGL
Ground El - Transmission line alignment
Canyon Lake Normal Pool El

Figure 6 *– Hydraulic Profiles, Boerne Junction to BMWD*







Pipe Size and Pressure Class Determination

For the determination of pipe pressure classifications, a Hazen-Williams roughness coefficient of 120 was used as a safety factor to account for the possibility of increased pipe deterioration. The working pressures within the pipe were calculated considering the difference between HGL elevation and relative ground elevation, converted to pressure. Based on the calculated working pressure, a pressure class was assigned to each segment of pipe. Pressure class increments of 50 psi with a minimum pressure class of 100 psi were used.

The pipe sizes, pressure class and corresponding length required for each hydraulic alternative are summarized in Table 4, *Summary of Pipe Size and Pressure Class – Base Project.*

TABLE 4 *– Summary of Pipe Size and Pressure Class – Base Project*

		LENGTH OF PIPING (ft)		
Dia.(in.)	**Pressure Class**	**ALT.1**	**ALT.2**	**ALT.3**
36	150	-	-	45003
	100	-	-	21777
30	250	46647	16693	-
	200	26506	3292	-
	100	-	53168	-
27	150	-	-	21002
	100	-	-	3018
24	250	11407	11407	11407
	200	31323	31323	31323
	150	5937	5937	5937
20	150	33579	33579	33579
	100	5038	5038	5038
18	100	2961	2961	2961
16	150	-	-	6423
14	300	-	-	-
	250	27425	27425	-
	200	3018	3018	-
10	100	-	-	20265
8	100	-	-	4133
Totals		193841	193841	211868

Required Pumping Facilities

The required pumping facilities for each hydraulic design alternative were evaluated as a component contributing to both the capital cost and O&M costs for each alternative. The resulting pumping requirements associated with each alternative is summarized in Table 5, *Summary of Pumping Requirements – Base Project.*

TABLE 5 *– Summary of Pumping Requirements – Base Project*[1]

	ALT.1	ALT.2	ALT.3
Pump Head (ft)	370	399	503
Flow (mgd)	9.9	9.1	6.4
Required hp	910	910	810

(1)Reported values represent average conditions between initial and ultimate demand distributions.

Required System Storage

Because it is a unique component of some hydraulic design alternatives evaluated, the additional storage that may be required at remote pumping facilities was considered. For all practical purposes, the minimum storage needed at a remote pumping facility was assumed as 0.25 million gallons.

Relative Cost Comparison of Alternatives

Costs for facilities and O&M required for each alternative were evaluated to provide a cost comparison between alternatives.

Cost Basis

For the purpose of this comparison, only unique components were evaluated for cost, not including all common components. The resulting cost value is useful for determining the relative difference between alternatives and should in no way be construed as total for any alternative.

The cost comparison included consideration for the following unique components:

- Transmission pipelines
- WTP/Remote Booster Pump Stations
- System Storage
- Electrical Feed
- Additional Land Acquisition (Remote PS and Storage Tank)
- Pumping Costs
- Operation and Maintenance for Pump Stations, Transmission and Storage Facilities

The cost comparison does not include the following common components:

- Intake
- WTP
- RW Pipeline
- Interconnects
- Equilization Tank
- Environmental Studies and Mitigation
- Land ROW Cost

- Engineering and Financing Costs

Base Project Relative Cost Comparison
The cost comparison for the base project hydraulic alternatives is tabulated in Table 6, *Delivery System – Relative Cost Comparison, Base Project – 10,527 acft/yr (10 mgd Capacity)*. The non-cost factors relevant to the established project decision criteria are also included.

As indicated in the relative cost comparison table, Alternative 3 is the most expensive of the alternatives. This fact, in combination with violation of the minimum velocity requirements during ultimate demand distribution (year 2012 demands when out-of-district is reduced) makes Alternative 3 the most infeasible. The Alternative has thus been eliminated from further evaluation.

***TABLE 6** – Delivery System – Relative Cost Comparison, Base Project - 10,527 acft/yr (10 mgd) Capacity*

PRELIMINARY ESTIMATE OF COSTS [1]

Basis of Comparison	Alternative 1	Alternative 2	Alternative 3
Capital Costs			
Transmission Pipelines	$ 16,621,000	$ 15,589,000	$ 16,866,000
	-	-	$ 968,000
WTP Pump Station	$ 1,263,000	-	-
Booster Pump Station	-	$ 1,299,000	$ 1,168,000
System Storage	-	$ 282,000	$ 282,000
Electrical Feed	$ 114,000	$ 118,000	$ 104,000
Total Capital Cost [2]	$ 17,998,000	$ 17,288,000	$ 19,388,000
Add'l Land Acquisition (PS and Storage Tank)	-	$ 6,800	$ 6,800
Total Project Cost [2]	$ 17,998,000	$ 17,295,000	$ 19,395,000
Annual O&M Costs			
Annual Debt Service	$ 1,476,000	$ 1,418,000	$ 1,590,000
(Assuming 25 years, efective interest rate of 6.5%)			
Pumping Costs *(Initial Demands)*	$ 478,000	$ 494,000	$ 412,000
(Ultimate Demands)	$ 478,000	$ 458,000	$ 434,000
(ave)	$ 478,000	$ 476,000	$ 423,000
Operation and Maintenance [3]			
Pump Station	$ 28,000	$ 32,000	$ 29,000
Transmission Facilities	$ 166,000	$ 156,000	$ 169,000
Storage Facilities	-	$ 2,800	$ 2,800
Total Annual Cost [2,3]	$ 2,148,000	$ 2,085,000	$ 2,214,000
Non-Cost Factors			
WTP Location (Elev.)	+	-	-
O&M Staffing Location	+	-	-
Control Complexity	+	-	-

[1] Costs are developed for purposes of preliminary evaluation and include only those costs that vary between the alternatives. Thus, the costs should not be taken as final estimates for any alternative.

[2] Items not included for cost comparison due to equivalence between alternatives include Intake, Intake Pump Station and Water Treatment Plant, Interconnects to all participants, Equilization Tank near Boerne/SAWS Delivery Point, Environmental Studies and Mitigation, Land Acquisition for WTP and Transmission Line, Reserve Account, Financing Costs,and Interest During Construction

[3] O&M costs assume 1% of the total capital costs of pipelines and tanks; 2.5% of the total capital cost of remote pump stations and 2.25% of the total capital cost of on-site pump stations

Phasing Options for Future Capacity Expansion
Hydraulic design Alternatives 1 and 2 were evaluated further to investigate the potential for expansion of the project facilities to deliver water that may be made available by maximizing capacity of the system.

Two expansion options for each alternative were evaluated. A description of the mode of expansion is as follows:

Alternative 1 - Phased

- **ALT 1P-A**. Increase capacity and head of high service pump station at WTP and pressure class of pipelines.
- **ALT 1P-B.** Increase pipe size to west of junction to Boerne by relaxing minimum velocity criteria. Increase pumping capacity at WTP.

Alternative 2 - Phased

- **ALT 2P-A**. Increase pipe size in gravity line from WTP to remote PS, increase capacity of remote PS.
- **ALT 2P-B**. Increase pressure class of pipelines, add booster pump station at WTP, increase capacity of remote pump station.

Refer to Figures 2-4 for system map for changes required by each phasing alternative.

Results of Hydraulic Analysis – Phased Project
The phased project hydraulic alternatives to provide expansion were evaluated for resulting hydraulic grade line, required pipe size and pressure class, pumping facilities, and the required storage facilities at those pumping facilities. For comparison purposes, a Phased Project capacity of 15,683 acft/yr -the maximum capacity of Alternative 1- was evaluated.

A summary of hydraulic results pertinent to the established project hydraulic constraints is tabulated for each alternative in Table 7, *Summary of Hydraulic Results – Phased Project Delivery*. Violation of any project criteria is noted within the comment column of the table.

***TABLE 7** – Summary of Hydraulic Results – Phased Project Delivery*

		HYDRAULIC RESULTS - MAINLINE DELIVERY[1]				
Base Project	Phased Project	Minimum Velocity (fps)	Maximum Velocity (fps)	Minimum Press. (psi)	Maximum Press. (psi)	Comments
ALT. 1	ALT 1P-A	2.9	5.2	11.0	243.1	
	ALT. 1P-B	2.2	4.4	13.8	225.3	violates min. velocity criteria under base demands
ALT. 2	ALT. 2P-A	2.4	5.2	11.0	281.4	
	ALT. 2P-B	2.4	5.2	11 0	281 4	

[1] Includes those areas of the mainline deemed subject to hydraulic criteria constraints (exceptions include less significant portions of the line such as branches).
[2] Flow condition for phased project alternatives consider ultimate base project demand distribution with even distribution of additional demands assuming 75% west and 25% east of the junction to Boerne

Hydraulic Grade Line (HGL)

The procedure for determination of the desired HGL elevation for the phased project is the same as described for the base project. The HGL is modified from the base project by adding elevation where head at a pump station is increased or by change in slope (flattening) of the HGL where the diameter of pipe was increased. Fundamentally, the general characteristics of the HGL are the same as for the base project, where adequate head to provide a minimum of 10 psi either at the next pump lift location or the furthest termination point is provided. Thus, the hydraulic profiles are not presented. Refer to the phased project *Required Pumping Facilities* section for an indication of additional head required at pumping facilities.

Pipe Size and Pressure Class Determination

Determination of pipe pressure classifications for the phased project was done in accordance with the procedure described previously for Base Project determinations.

The pipe sizes, pressure class and corresponding length required for the phasing of each hydraulic alternative are summarized in Table 8, *Summary of Pipe Size and Pressure Class – Phased Project.*

TABLE 8 *– Summary of Pipe Size and Pressure Class – Phased Project*

Dia. (in.)	Pressure Class	LENGTH OF PIPING (ft)			
		ALT.1P-A	ALT.1P-B	ALT.2P-A	ALT.2P-B
36	100	-	-	26506	-
33	100			15536	-
30	300	62893	-	16693	16693
	250	10259	14418	3292	3292
	200	-	58734	-	-
	100	-	-	11126	53168
27	250	-	2523	-	-
	200	-	16373	-	-
	150	-	45281	-	-
	100	-	18070	-	-
24	300	11407	-	2523	2523
	250	7488	-	8884	8884
	200	23835	-	24166	24166
	150	5937	-	13094	13094
	100		5038	-	
20	150	33579	-	15509	15509
	100	5038	-	23108	23108
18	100	2961	2961	2961	2961
14	300	27425	-	11277	11277
	250	3018	27425	16149	16149
	200	-	-	3018	3018
	150	-	3018	-	-
Totals		193841	193841	193841	193841

Required Pumping Facilities

The required pumping facilities for each phased project hydraulic design alternative were evaluated. The resulting pumping requirements associated with each phased alternative is summarized in Table 5, *Summary of Pumping Requirements – Phased Project.*

TABLE 9 *– Summary of Pumping Requirements – Phased Project*[1]

	ALT.1P-A	ALT.1P-B	ALT.2P-A	ALT.2P-B	
				WTP PS	Remote PS
Pump Head (ft)	545	375	522	45	522
Flow (mgd)	14.00	14.00	12.0	14.0	12.0
Required hp	1910	1320	1570	160	1570

[1]Reported values represent ultimate demand distributions (year 2012 operation) and are based on a phased project capacity of 15,683 acft/yr –the maximum capacity of Alternative 1.

Required System Storage

Because it is a unique component of some hydraulic design alternatives evaluated, the additional storage that may be required at remote pumping facilities was considered. As a result of project expansion, the assumption for minimum storage required at a remote pumping facility was increased from 0.25 million gallons to 0.50 million gallons.

Phased Project Relative Cost Comparison

In accordance with the *Cost Basis* for comparison of the hydraulic alternatives, the phased project hydraulic alternatives were evaluated. The cost comparison is tabulated in Table 10, *Delivery System – Relative Cost Comparison, Phased Project Capacity.* The non-cost factors relevant to the established project decision criteria are also included.

***TABLE 10** – Delivery System – Relative Cost Comparison, Phased Project Capacity*

PRELIMINARY ESTIMATE OF COSTS [1]

Basis of Comparison	*Alt. 1P-A*	*Alt. 1P-B*	*Alt. 2P-A*	*Alt. 2P-B*
Capital Costs				
Transmission Pipelines	$ 18,368,000	$ 18,639,000	$ 16,914,000	$ 15,941,000
WTP Pump Station	$ 2,385,000	$ 1,727,000	-	$ 558,000
Booster Pump Station	-	-	$ 2,044,000	$ 2,044,000
System Storage	-	-	$ 399,000	$ 399,000
Electrical Feed	$ 239,000	$ 165,000	$ 196,000	$ 216,000
Total Capital Cost [2]	$ 20,992,000	$ 20,531,000	$ 19,553,000	$ 19,158,000
Add'l Land Acquisition (PS and Storage Tank)	-	-	$ 7,000	$ 7,000
Total Project Cost [2]	$ 20,992,000	$ 20,531,000	$ 19,560,000	$ 19,165,000
Annual O&M Costs				
Annual Debt Service *(Assuming 25 years, efective interest rate of 6.5%)*	$ 1,721,000	$ 1,684,000	$ 1,604,000	$ 1,572,000
Pumping Costs	$ 999,000	$ 688,000	$ 821,000	$ 903,000
Operation and Maintenance [3]				
Pump Station	$ 54,000	$ 39,000	$ 489,000	$ 65,000
Transmission Facilities	$ 184,000	$ 186,000	$ 196,000	$ 159,000
Storage Facilities	-	-	$ 195,600	$ 4,000
Total Annual Cost [4]	$ 2,958,000	$ 2,597,000	$ 3,305,600	$ 2,703,000
Non-Cost Factors				
WTP Location (Elev.)	+	+	-	NA
O&M Staffing Location	+	+	-	-
Control Complexity	+	+	-	-

[1] Costs are developed for purposes of preliminary evaluation and include only those costs that vary between the alternatives. Thus, the costs should not be taken as final estimates for any alternative. For comparison purposes, costs are based on a Phased Project production of 15,683 acft/yr - the maximum capacity of Alternative 1 (Alt. 1P-A and Alt. 1P-B).

[2] Items not included for cost comparison due to equivalence between alternatives include: Intake, Intake Pump Station and Water Treatment Plant, Interconnects to all participants, Equilization Tank near Boerne/SAWS Delivery Point, Environmental Studies and Mitigation, Land Acquisition for WTP and Transmission Line, Reserve Account, Financing Costs,and Interest During Construction.

[3] O&M costs assume 1% of the total capital costs of pipelines and tanks; 2.5% of the total capital cost of remote pump stations and 2.25% of the total capital cost of on-site pump stations.

Although Alternative 1P-B is the least expensive alternative, it should be noted that it significantly violates hydraulic constraints established for the project during base project operation. It is therefore not recommended as a feasible design alternative for the GBRA Regional System.

Conclusion and Recommendations

Based on both cost and non-cost factors established and a maximum system pressure of 300 psi as the project decision criteria, we recommend Alternative 1P-A. This alternative would entail a single high service pump station at the WTP, and allow phasing to full expansion by increasing the pump head. Installation of higher pressure class pipe would be required to permit phasing. Alternative 1P-A was recommended for the following reasons:

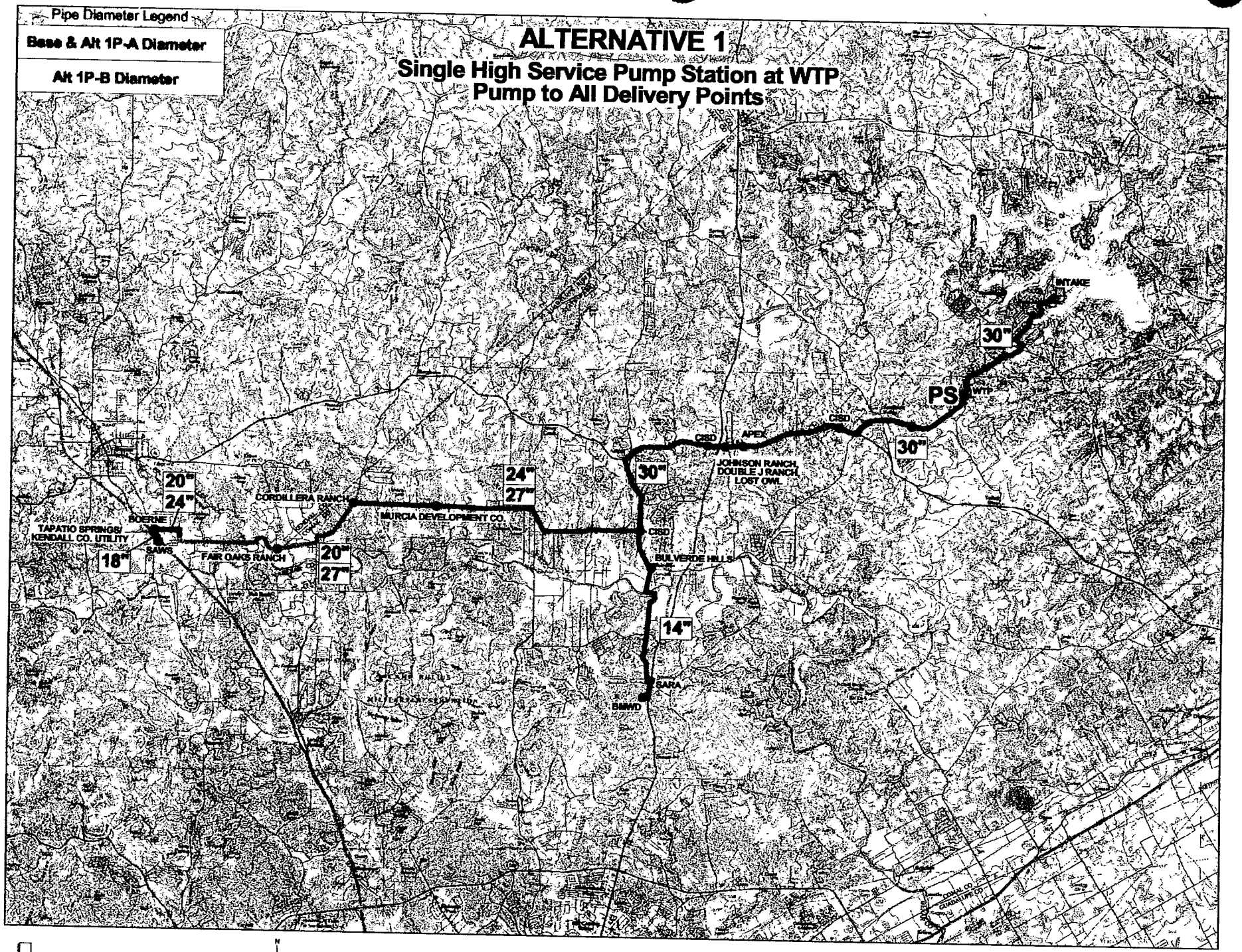
- The relative cost comparison has shown Alternative 1P-A to be comparable to the other alternatives, within less than 10% of the least expensive feasible alternative for phased expansion.
- Pumping to all delivery points allows flexibility in location of the WTP.
- The single pump station located on the WTP site allows convenience for O&M staffing and decreases the complexity of control required for the overall system.
- All established hydraulic criteria and constraints are satisfied for both the base and phased project conditions.

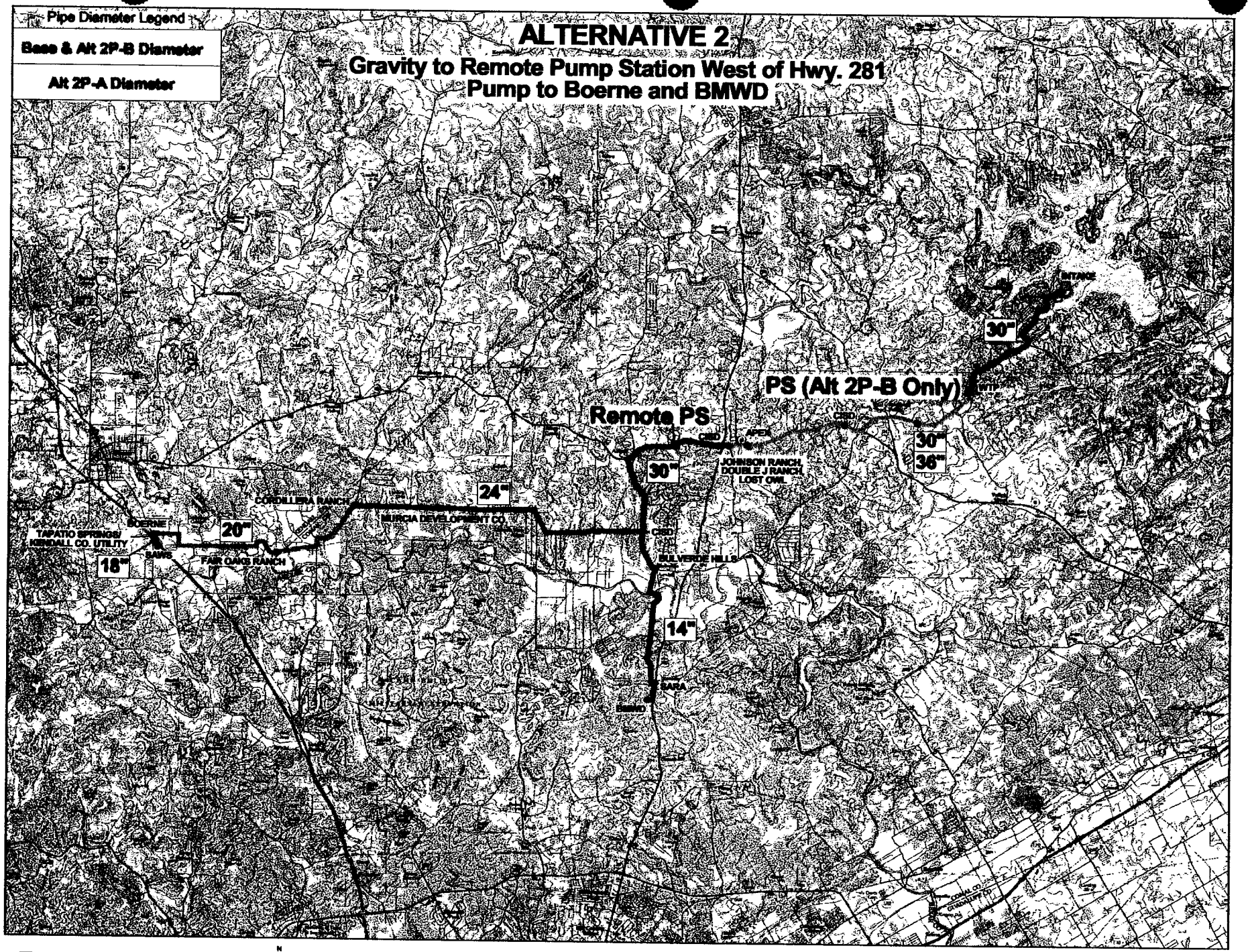
It should be noted that the reported additional cost for phased expansion, Alternative 1P-A, incorporates capital pump and O&M costs during expanded operation. This value is not the cost incurred initially since much of the expanded facilities would not be needed until expansion occurs. The initial project costs would incorporate only the capital costs of the increased pressure class of the pipelines. The required increase in pressure class piping between the base and phased projects has been tabulated for comparative reference in Table 11, *Increase in Pressure Class Piping for Alt. 1P-A*. The estimated cost for the increased pressure class of the transmission pipeline is approximately $1.7 Million.

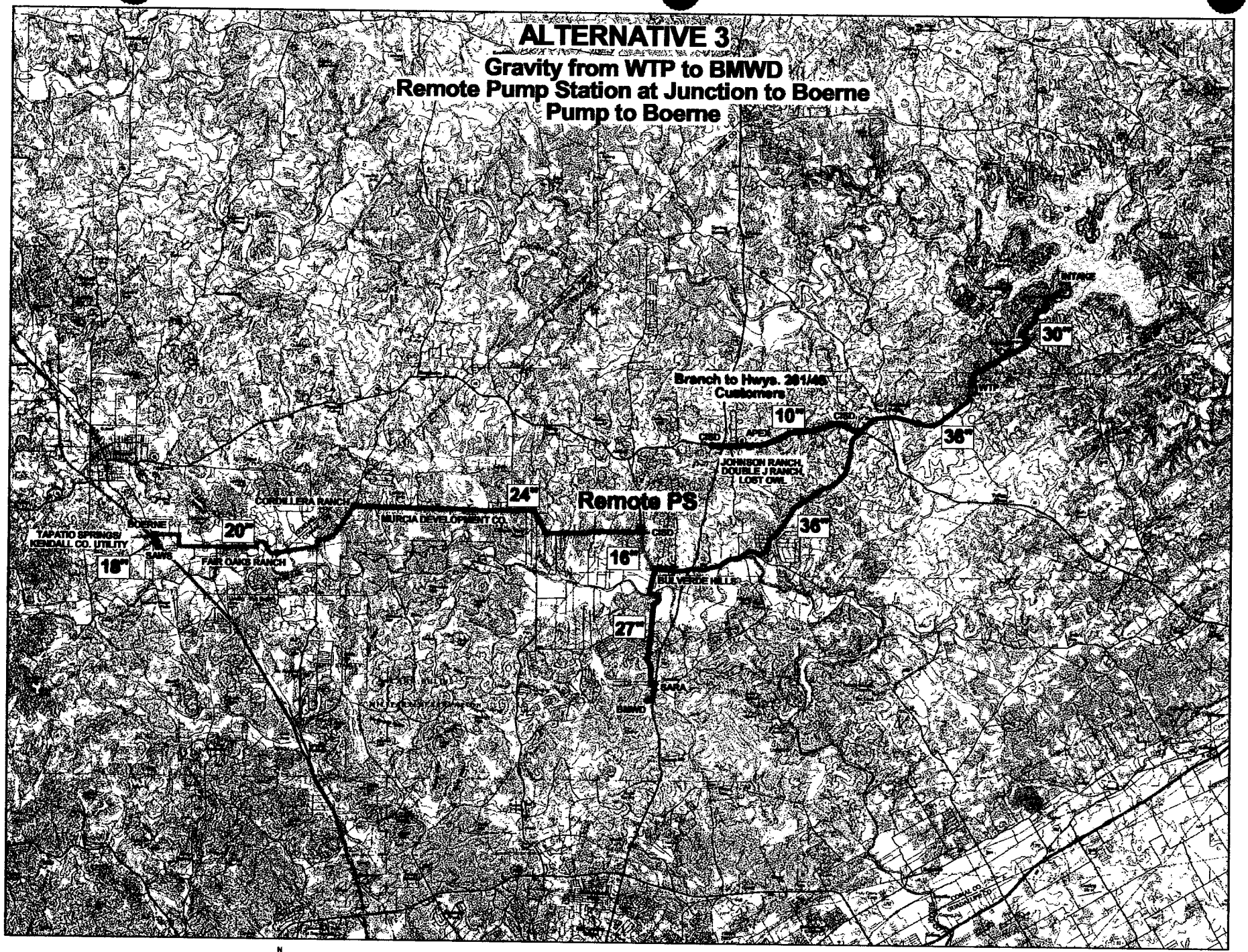
TABLE 11 *– Increase in Pressure Class Piping for Alt. 1P-A*

		LENGTH OF PIPING (ft)	
Dia. (in.)	**Pressure Class**	**ALT.1**	**ALT.1P-A**
30	300	-	62893
	250	46647	10259
	200	26506	-
24	300	-	11407
	250	11407	7488
	200	31323	23835
	150	5937	5937
20	150	33579	33579
	100	5038	5038
18	100	2961	2961
14	300	-	27425
	250	27425	3018
	200	3018	-
Totals		193841	193841

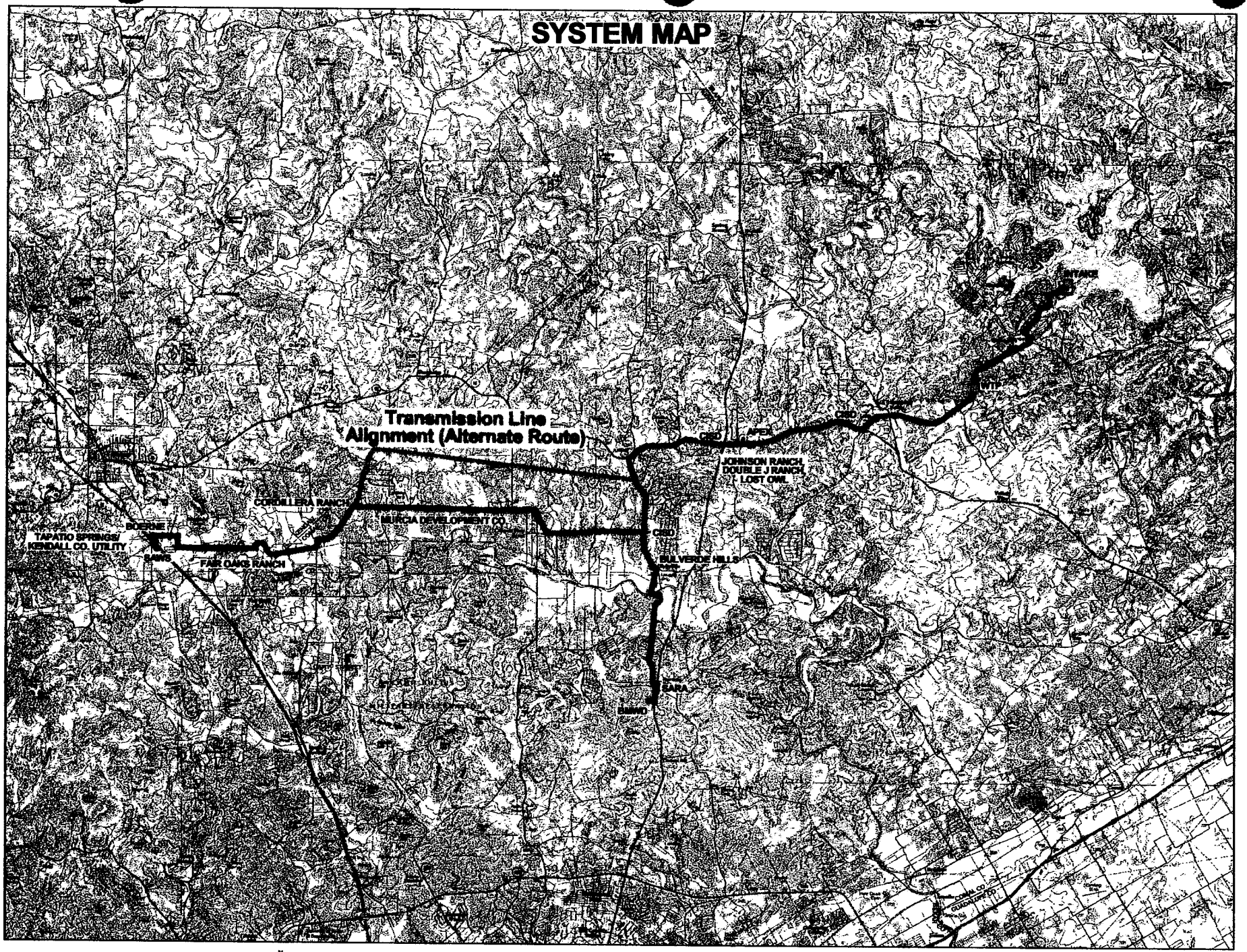
It should be noted that this recommendation is specifically based on the 300 psi maximum pressure assumption, synonymous with reduced operation, maintenance, and control issues associated with a single pumping facility located at the WTP. Re-evaluation of the system is warranted if multiple pumping facilities is preferable to higher system pressures.


Pipe Diameter Legend
Base & Alt 1P-A Diameter
Alt 1P-B Diameter
ALTERNATIVE 1
Single High Service Pump Station at WTP
Pump to All Delivery Points
INTAKE
30"
PS
WTP
CSD
APEX
30"
JOHNSON RANCH
DOUBLE J RANCH
LOST OWL
24"
27"
30"
20"
24"
CORDILLERA RANCH
MURCIA DEVELOPMENT CO.
BOERNE
TAPATIO SPRINGS/
KENDALL CO. UTILITY
SAWS
18"
FAIR OAKS RANCH
20"
27"
BULVERDE HILLS
14"
SARA
BMWD
GBRA Regional Water System


Pipe Diameter Legend
Base & Alt 2P-B Diameter
Alt 2P-A Diameter
ALTERNATIVE 2
Gravity to Remote Pump Station West of Hwy. 281
Pump to Boerne and BMWD
30"
PS (Alt 2P-B Only)
Remote PS
30"
36"
30"
24"
20"
18"
14"
JOHNSON RANCH, DOUBLE J RANCH, LOST OWL
CORDILLERA RANCH
MURCIA DEVELOPMENT CO.
BOERNE
TAPATIO SPRINGS/ KENDALL CO. UTILITY
SAWS
FAIR OAKS RANCH
CSID
BULVERDE HILLS
SARA
BMWD
APEX
GBRA
GBRA Regional Water System
Scale - 1" equals 5000'
0 1 2 3 4 5 Miles
N
HDR


ALTERNATIVE 3
Gravity from WTP to BMWD
Remote Pump Station at Junction to Boerne
Pump to Boerne
Branch to Hwys. 281/46
Customers
10"
APEX
CSD
JOHNSON RANCH,
DOUBLE J RANCH,
LOST OWL
24"
Remote PS
CORDILLERA RANCH
MURCIA DEVELOPMENT CO.
BOERNE
TAPATIO SPRINGS/
KENDALL CO. UTILITY
SAWS
20"
18"
FAIR OAKS RANCH
16"
BLUE VERDE HILLS
27"
SARA
BMWD
36"
30"
INTAKE
WTP
GBRA
GBRA Regional Water System
N
Scale - 1" equals 5000'
0 1 2 3 4 5 Miles
HDR

SYSTEM MAP



GBRA

N

GBRA Regional Water System

Scale - 1" equals 5000'

0 1 2 3 4 5 Miles

HDR

HDR Engineering, Inc

TM No. 1 Appendix

Background and Working Information

GBRA REGIONAL WATER SYSTEM

ALTERNATIVES FOR CONVEYANCE OF POTABLE WATER FROM THE WTP TO GBRA PROJECT CUSTOMERS

PRELIMINARY ESTIMATE OF COSTS [1]

Basis of Comparison	Alternative 1	Alternative 2	Alternative 3
Capital Costs			
Transmission Pipelines	$ 16,621,000	$ 15,589,000	$ 16,866,000
	-	-	$ 968,000
WTP Pump Station	$ 1,263,000	-	-
Booster Pump Station	-	$ 1,299,000	$ 1,168,000
System Storage	-	$ 282,000	$ 282,000
Electrical Feed	$ 114,000	$ 118,000	$ 104,000
Total Capital Cost [2]	$ 17,998,000	$ 17,288,000	$ 19,388,000
Add'l Land Acquisition (PS and Storage Tank)	-	$ 6,800	$ 6,800
Total Project Cost [2]	$ 17,998,000	$ 17,295,000	$ 19,395,000
Annual O&M Costs			
Annual Debt Service	$ 1,476,000	$ 1,418,000	$ 1,590,000
(Assuming 25 years, efective interest rate of 6.5%)			
Pumping Costs *(Initial Demands)*	$ 478,000	$ 494,000	$ 412,000
(Ultimate Demands)	$ 478,000	$ 458,000	$ 434,000
(ave)	$ 478,000	$ 476,000	$ 423,000
Operation and Maintenance [3]			
Pump Station	$ 28,000	$ 32,000	$ 29,000
Transmission Facilities	$ 166,000	$ 156,000	$ 169,000
Storage Facilities	-	$ 2,800	$ 2,800
Total Annual Cost [2]	$ 2,148,000	$ 2,085,000	$ 2,214,000
Non-Cost Factors			
WTP Location (Elev.)	+	-	-
O&M Staffing Location	+	-	-
Control Complexity	+	-	-

[1] Costs are developed for purposes of preliminary evaluation and include only those costs that vary between the alternatives. Thus, the costs should not be taken as final estimates for any alternative

[2] Items not included for cost comparison due to equivalence between alternatives include Intake, Intake Pump Station and Water Treatment Plant, Interconnects to all participants, Equilization Tank near Boerne/SAWS Delivery Point, Environmental Studies and Mitigation, Land Acquisition for WTP and Transmission Line, Reserve Account, Financing Costs,and Interest During Construction.

[3] O&M costs assume 1% of the total capital costs of pipelines and tanks, 2 5% of the total capital cost of remote pump stations and 2.25% of the total capital cost of on-site pump stations

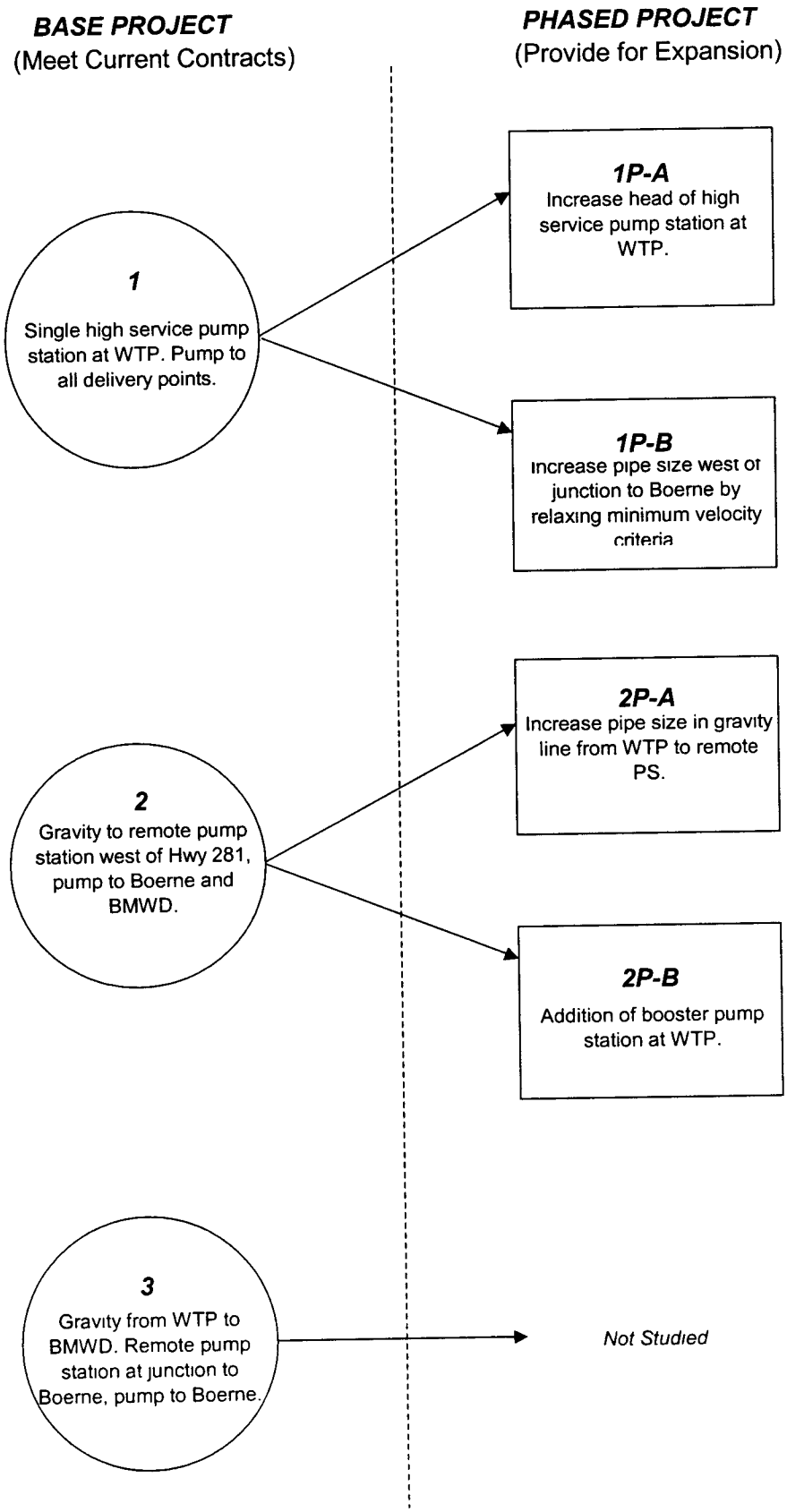
Description of Alternatives

Alt. 1 - Single high service pump station at WTP (route along Rd 46).

Alt. 2 - Gravity from WTP to west of Hwy 281 along Rd 46 to remote pump station, pump to Boerne and BMWD.

Alt 3 - Gravity from WTP to BMWD (route along Smithson Valley Rd), including gravity branch to Rd s 281/46 customers. Remote pump station at/near junction to Boerne, pump to Boerne

DESCRIPTION OF ALTERNATIVES



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Pumping Costs

Equation for pumping/energy costs (assumes continuous operation)

$$\frac{\left(Q_{mgd} \times 694.4 \frac{gpm}{mgd} \times H(ft)\right)}{3960 \times 0.70} \times 0.746 \frac{kW}{hp} \times 8{,}760 \frac{hrs}{yr} \times 0.08 \frac{\$}{kWh} = Cost\ \$/yr$$

where overall efficiency = 0.7
energy rate ($/kWh)= 0 08

ALTERNATIVE 1
-Involves a single high service pumping station to Boerne

	Initial Demand	Ultimate Demand
Pump Head (ft)=	370	370
Flow, Q (mgd)=	9.87	9.87
Pump hp =	910	910
Est PS Capital Cost (mil $)=	1.26	1 26
O&M Energy Cost ($/yr)=	$ 478,119	$ 478,119
Power Connection Cost ($)=	$ 113,750	$ 113,750

ALTERNATIVE 2
-Involves a remote pumping station located near west of Rd 281 along Rd. 46, pumping to Boerne and BMWD

	Initial Demand	Ultimate Demand
Pump Head (ft)=	398	400
Flow, Q (mgd)=	9 49	8 75
Pump hp =	940	880
Est PS Capital Cost (mil $)=	1 30	1 23
O&M Energy Cost ($/yr)=	$ 493,921	$ 457,965
Power Connection Cost ($)=	$ 117,500	$ 110,000

ALTERNATIVE 3
-Involves a remote pumping station located near the junction to Boerne, pumping to Boerne only

	Initial Demand	Ultimate Demand
Pump Head (ft)=	500	506
Flow, Q (mgd)=	6 28	6.56
Pump hp =	790	830
Est PS Capital Cost (mil $)=	1.12	1.17
O&M Energy Cost ($/yr)=	$ 411,733	$ 434,020
Power Connection Cost ($)=	$ 98,750	$ 103,750

ENR=	*6039* Values from 2nd quarter, 1999	*6127* Values from last quarter, 1999
Pumping Station Costs		
(hp)	(mil$)	(mil$)
<400	0.55	0.56
400	0.65	0.66
1000	1.35	1.37
2000	2.45	2.49
3000	3.38	3.43
4000	4.08	4.14
5000	4.61	4.68
6000	5.04	5.11
7000	5.47	5.55
8000	5.76	5.84
9000	6.04	6.13
10000	6.3	6.39
15000	7.28	7.39
3000	9.23	9.36
60000	12 01	12.19
80000	13.05	13 24
100000	13.98	14.18

Reference: HDR Cost Estimating, Section 5 of Studies Level Engineering and Costing Methodology, Senate Bill 1 Report

Costs for pumping stations include costs for pumps, housing, motors, electrical control, site work, and all materials needed.

$$PowerConn\ (\$50{,}000 \min) = \frac{\$125}{1hp} \times Stationhp$$

Costs for electrical power connection include the distance to the nearest power source and the electrical demand of the pumping station. The following equation was developed to estimate power connection costs.

	ALT 1	ALT.2	ALT.3
Pump Head (ft)	370	399	503
Flow (mgd)	9 87	9.12	6.42
Required hp	910	910	810

Pipe Material/Installation Costs

ALTERNATIVE 1

Dia. (in.)	Pressure Class	Length (ft.)	$/LF	Cost, $
30	250	46647	117	5438782
	200	26506	103	2734908
24	250	11407	91	1034469
	200	31323	80	2513755
	150	5937	71	421663
20	150	33579	63	2112267
	100	5038	63	316888
18	100	2961	60	177233
14	300	0	70	0
	250	27425	62	1705426
	200	3018	55	166086
	checks	193841		

TOTAL= $ 16,621,477

ALTERNATIVE 2

Dia. (in.)	Pressure Class	Length (ft.)	$/LF	Cost, $
30	250	16693	117	1946288
	200	3292	103	339650
	100	53168	91	4854832
24	250	11407	91	1034469
	200	31323	80	2513755
	150	5937	71	421663
20	150	33579	63	2112267
	100	5038	63	316888
18	100	2961	60	177233
14	300	0	70	0
	250	27425	62	1705426
	200	3018	55	166086
	150	0	49	0
	checks	193841		

TOTAL= $ 15,588,557

ALTERNATIVE 3

Dia. (in.)	Pressure Class	Length (ft.)	$/LF	Cost, $
36	150	45003	120	5387788
	100	21777	120	2607099
27	150	21002	81	1704635
	100	3018	81	244965
24	250	11407	91	1034469
	200	31323	80	2513755
	150	5937	71	421663
20	150	33579	63	2112267
	100	5038	63	316888
18	100	2961	60	177233
16	150	6423	54	345403
10	100	20265	40	810618
8	100	4133	38	157057
	checks	211868		

		length (ft)
TOTAL=	$ 17,833,839	211868
(gravity branch to 281/46 alone)=	$ 967,675	24399
(All w/o gravity branch)=	$ 16,866,164	181046

Assumes 13% increase per 50 psi pressure class above 150 psi.

ENR= 6039 (June 1999)

	Pipeline Costs for Rock in Rural Areas				
	100 psi	150 psi	200 psi	250 psi	300 psi
Pipe Dia (in.)	$/ft	$/ft	$/ft	$/ft	$/ft
12	42	42	47	54	61
14	48	48	54	61	69
16	53	53	60	68	76
18	59	59	67	75	85
20	62	62	70	79	89
24	70	70	79	89	101
27	80	80	90	102	115
30	90	90	102	115	130
33	104	104	118	133	150
36	118	118	133	151	170

Reference: HDR Cost Estimating, Section 5 of Studies Level Engineering and Costing Methodology, Senate Bill 1 Report.

Costs for piping are for installed piping and appurtenances, including markers, valves, thrust resraint systems, corrosion monitoring and control equipment, air vacuum valves, blow-off valves, erosion control, revegetation of ROW, fencing, and gates. Costs do not inclue crossings.

ENR= 6127 (Dec. 1999)

	Pipeline Costs for Rock in Rural Areas				
	100 psi	150 psi	200 psi	250 psi	300 psi
Pipe Dia (in.)	$/ft	$/ft	$/ft	$/ft	$/ft
12	43	43	48	54	61
14	49	49	55	62	70
16	54	54	61	69	78
18	60	60	68	76	86
20	63	63	71	80	91
24	71	71	80	91	102
27	81	81	92	104	117
30	91	91	103	117	132
33	106	106	119	135	152
36	120	120	135	153	173

Reference: HDR Cost Estimating, Section 5 of Studies Level Engineering and Costing Methodology, Senate Bill 1 Report.

Storage Costs

Look at storage costs in addition to tank used for equilization (Equilization tank is same for all alternatives and is not included in cost comparison)

ALTERNATIVE 1

-Involves a single high service pumping station to Boerne
No additional system storage is required.

ALTERNATIVE 2

-Involves a remote pumping station located near west of Rd. 281 along Rd. 46, pumping to Boerne and BMWD.

Assume required system storage at booster PS(MG)=		0.25	
Ground Storage Tank ($)=	$	282,470	
Req'd Land Acquisition (acres)=		4	(pump station and tank)
Land value ($/acre)=	$	1,700	(1999 value)
Req'd Land Acquisition Cost ($)=	$	6,800	

ALTERNATIVE 3

-Involves a remote pumping station located near the junction to Boerne, pumping to Boerne only

Assume required system storage at booster PS(MG)=		0.25	
Ground Storage Tank ($)=	$	282,470	
Req'd Land Acquisition (acres)=		4	(pump station and tank)
Land value ($/acre)=	$	1,700	(1999 value)
Req'd Land Acquisition Cost ($)=	$	6,800	

	Values from 2nd quarter, 1999	Values from last quarter, 1999
ENR=	*6039*	*6127*
Ground Storage Tank Costs		
(MG)	($)	($)
0.01	86400	87659
0.05	146400	148533
0.1	209300	212350
0.5	393600	399336
1	679100	688996
2	1129300	1145756
4	1768600	1794372
6	2408000	2443089
7.5	2926600	2969246
9	329920	334728

Reference: HDR Cost Estimating, Section 5 of Studies Level Engineering and Costing Methodology,Senate Bill 1 Report.

ALT 1 ***MODEL OUTPUT -High Service Pump Station at WTP***

	Location	Model Node	Model Piping	Node El (ft)	Pipe Dia (in)	Pipe Length (ft)	Sum Length (ft)	Initial ΔQ (mgd)	Initial v(fps)	Initial HGL (ft)	Initial Press Head (psi)	Ultimate ΔQ (mgd)	Ultimate v(fps)	Ultimate HGL (ft)	Ultimate Press Head (psi)	Max Pipe Pressure Class
	Reservoir (WTP)	R-1		1380		0	0			1750				1750		
	Reservoir (WTP)	J-1	P-1	1380	30	139 3	139	9 87	3 1	1749 8	160 1	9 87	3 1	1749.8	160 1	200
	Reservoir (WTP)	RV-1	P-5	1380	30	142 9	282	0 00	0 0	1750	0.0	0 00	0 0	1750	0.0	200
	Flow Control Element	J-5	P-4	1380	30	100 5	383	-9.87	0 0	1749 8	160.1	-9.87	0 0	1749 8	160 1	200
	High Point	J-16	P-25	1398	30	208 0	591	0 00	3 1	1749 6	152 2	0 00	3 1	1749.6	152 2	200
	High Point	J-25	P-16	1385	30	2804 6	3395	0 00	3 1	1746.2	156 4	0 00	3 1	1746 2	156 4	200
	Curtis Bremer Feed	J-7	P-26	1310	30	8877 0	12272	0 00	3.1	1735.6	184 3	0.09	3 1	1735 6	184 3	200
	High Point	J-26	P-7	1321	30	7369 4	19642	0 00	3.1	1726 8	175.7	0 00	3 1	1726.9	175.8	200
	CISD School Feed	J-9	P-27	1299	30	4657.5	24299	0.05	3.1	1721 2	182.8	0.05	3 1	1721 4	182.9	200
	High Point	J-27	P-9	1320	30	2206 4	26506	0.00	3.1	1718.5	172 6	0 00	3 1	1718 9	172 7	200
	Apex Feed	J-8	P-28	1205	30	15536 1	42042	0.09	3 1	1700.1	214.4	0 19	3 1	1700 7	214 6	250
	Craig Elbel, Double J Ranch, C	J-10	P-8	1137	30	2059 6	44101	0 19	3 1	1697 7	242.8	0.74	3 0	1698 4	243 1	250
	CISD School Feed	J-11	P-10	1160	30	2073 4	46175	0 05	3 0	1695 4	231 8	0 05	2 8	1696 4	232 3	250
	High Point	J-12	P-11	1321	30	10284 8	56460	0 00	3 0	1683 9	157 1	0 00	2 8	1686 6	158 3	250
	CISD School Feed	J-3	P-12	1165	30	16692 6	73152	0 05	3.0	1665 3	216 6	0 05	2 8	1670 5	218.9	250
Junction to Boerne →	Low Point	J-28	P-2	1119	24	2523 0	75675	0 00	3 0	1661 5	234 9	0 00	3 2	1666 5	237 1	250
	Low Point	J-13	P-29	1177	24	8884 3	84559	0 00	3 0	1648 2	204 0	0 00	3 2	1652 1	205 7	250
	High Point	J-14	P-13	1279	24	7488 4	92048	0.00	3 0	1637	155 0	0 00	3 2	1639 9	156 3	200
	Murcia Feed (low point)	J-15	P-14	1247	24	16677 7	108725	0 09	3 0	1612	158 0	0 21	3 2	1612 9	158 4	200
	High Point	J-6	P-15	1329	24	7157 0	115882	0 00	3 0	1601.6	118 0	0 00	3 1	1601 9	118 2	200
	Cordillera Feed (low point)	J-17	P-6	1280	24	5937 2	121820	0 38	3 0	1592 9	135 5	0 94	3 1	1592 9	135 5	150
	Fair Oaks Feed	J-18	P-17	1260	20	15509 4	137329	0 75	4 1	1544 1	123 0	1 31	3 8	1550 3	125 7	150
	High Point	J-19	P-18	1416	20	18070 1	155399	0 00	3 5	1500 3	36 5	0 09	2 8	1520 9	45 4	150
	Boerne Feed	J-20	P-19	1405	20	5037 7	160437	0 47	3 5	1488 1	36.0	1.74	2 8	1513.1	46 8	100
	Tapatio/Kendall Co Utility Co	J-21	P-20	1405	18	134 0	160571	0.14	3.9	1487.6	35.8	0 47	1 9	1512 9	46.7	100
SAWS →	SAWS Feed	J-2	P-21	1450	18	2826 8	163398	4.36	3 8	1478.7	12 4	1 70	1 5	1511 4	26 6	100
	Bulverde Hills	J-22	P-3	1080	14	6423 4	169821	0 19	4 7	1625	236 0	0.19	3 2	1650 3	246 9	250
	Low Point	J-23	P-22	1061	14	4853 1	174674	0.00	4 4	1597 8	232 4	0 00	3 0	1637 4	249.6	250
	SARA Feed	J-24	P-23	1185	14	16148 8	190823	0.05	4 4	1507 2	139.5	0 05	3 0	1594 2	177 2	250
BMWD →	Bexar MWD Feed	J-4	P-24	1320	14	3018 1	193841	3.01	4.4	1490 7	73 9	2.00	2 9	1586 5	115.4	200
							193841 1 ft									
							36 7 mi									

distance from high pt (El 1321) to Boerne junct
53510 ft
10 1 mi

Location	Model Node	Model Piping	Node El (ft)	Pipe Dia (in)	Pipe Length (ft)	Sum Length (ft)	ΔQ (mgd)	v(fps)	HGL (ft)	Press Head (psi)
CISD School Feed	J-3	P-12	1165	30		0	0 047	3	1665 3	216 63
Bulverde Hills	J-22	P-3	1080	14	6423 433	6423 4	0 189	4 7	1625	235 985
Low Point	J-23	P-22	1061	14	4853 106	11276 5	0	4 4	1597 8	232 434
SARA Feed	J-24	P-23	1185	14	16148 8	27425 3	0 047	4 4	1507 2	139 513
Bexar MWD Feed	J-4	P-24	1320	14	3018 077	30443 4	3 014	4 4	1490 7	73 9131

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ALT 2 ***GRAVITY CONVEYANCE FROM WTP TO WEST OF RD 281 ALONG RD 46 TO REMOTE PUMP STATION, PUMP TO BOERNE AND BMWD***

Assume required system storage at booster PS(MG)= 0 25
C= 120

Mainline (Gravity)

	Junct	El (ft)	Dia (in)	Pipe Length (ft)	Sum Length ft)	Initial Q (mgd)	Initial v(fps)	HL (ft)	HGL (ft)	Press Head (psi)	Ultimate Q (mgd)	Ultimate v(fps)	HL (ft)	HGL (ft)	Press Head (psi)	Max Pipe Pressure Class
	Reservoir (WTP)	1380			0	9 87			1380		9 87			1380		
Can reroute around hills →	High Point	1398	30	591	591	9 867	3 12	0 71	1379.3	-8 1	9 867	3 12	0 71	1379 3	-8 1	100
→	High Point	1385	30	2805	3395	9 867	3 12	3 38	1375.9	-3.9	9 867	3 12	3 38	1375 9	-3.9	100
	Curtis Bremer Feed	1310	30	8877	12272	9 867	3.12	10 71	1365 2	23 9	9 773	3 09	10 52	1365 4	24 0	100
	High Point	1321	30	7369	19642	9 867	3.12	8 89	1356.3	15 3	9 773	3 09	8 74	1356 6	15 4	100
	CISD School Feed	1299	30	4658	24299	9 820	3 10	5 57	1350.7	22 4	9 726	3 07	5 47	1351 2	22.6	100
	High Point	1320	30	2206	26506	9 820	3 10	2.64	1348.1	12 2	9 726	3 07	2 59	1348 6	12 4	100
	Apex Feed	1205	30	15536	42042	9 726	3 07	18 26	1329 8	54 1	9 539	3.01	17.61	1331 0	54.5	100
	Craig Elbel, Double J	1137	30	2060	44101	9 533	3 01	2 33	1327 5	82.5	8.795	2 78	2 01	1329 0	83 1	100
Can easily reroute to EL1280 →	CISD School Feed	1160	30	2073	46175	9 486	3 00	2 33	1325.2	71 5	8 748	2 76	2 00	1327 0	72 3	100
→	Remote Pump Sta	1290	30	6993	53168	9 486	3 00	7 85	1317 3	**11.8**	8 748	2.76	6 75	1320 2	**13.1**	100
				53168 ft												
				10 1 mi												

Pump from remote pump station to BMWD and Boerne (same as Alt. 1 from remote pump station to Boerne and BMWD)

	Junct	El (ft)	Dia (in)	Pipe Length (ft)	Sum Length ft)	Initial ΔQ (mgd)	Initial v(fps)	HL (ft)	HGL (ft)	Press Head (psi)	Ultimate ΔQ (mgd)	Ultimate v(fps)	HL (ft)	HGL (ft)	Press Head (psi)	Max Pipe Pressure Class
	Remote Pump Sta	1290			53168				1687 6					1689 7		
	High Point	1321	30	3292	56460	0 000	3 0	3 7	1683 9	157 1	0 000	2.8		1686 6	158 3	200
	CISD School Feed	1165	30	16693	73152	0 047	3 0	18 6	1665 3	216 6	0 047	2 8	16 1	1670 5	218 9	250
	Low Point	1119	24	2523	75675	0 000	3 0	3 8	1661 5	234 9	0 000	3 2	4 0	1666 5	237 1	250
	Low Point	1177	24	8884	84559	0 000	3 0	13 3	1648 2	204 0	0.000	3 2	14 4	1652 1	205 7	250
	High Point	1279	24	7488	92048	0 000	3 0	11 2	1637 0	155 0	0 000	3 2	12 2	1639 9	156 3	200
	Murcia Feed (low poin	1247	24	16678	108725	0 094	3.0	25 0	1612.0	158 0	0 206	3.2	27 0	1612 9	158 4	200
	High Point	1329	24	7157	115882	0 000	3.0	10 4	1601.6	118 0	0 000	3 1	11.0	1601 9	118 2	200
	Cordillera Feed (low p	1280	24	5937	121820	0 375	3 0	8 7	1592.9	135 5	0 937	3 1	9 0	1592 9	135 5	150
	Fair Oaks Feed	1260	20	15509	137329	0 750	4 1	48 8	1544.1	123 0	1 312	3 8	42.6	1550.3	125.7	150
	High Point	1416	20	18070	155399	0 000	3 5	43 8	1500 3	36 5	0 094	2 8	29.4	1520 9	45.4	150
	Boerne Feed	1405	20	5038	160437	0 469	3 5	12 2	1488 1	36 0	1 744	2 8	7 8	1513.1	46.8	100
	Tapatio/Kendall Co U	1405	18	134	160571	0 141	3.9	0 5	1487 6	35.8	0 469	1 9	0.2	1512 9	46 7	100
SAWS →	SAWS Feed	1450	18	2827	163398	4 362	3 8	8 9	1478 7	**12.4**	1 699	1 5	1 5	1511 4	26 6	100
	Bulverde Hills	1080	14	6423	169821	0.189	4 7	40 3	1625.0	236 0	0.189	3 2	20 2	1650 3	246 9	250
	Low Point	1061	14	4853	174674	0 000	4 4	27 2	1597 8	232.4	0 000	3 0	12 9	1637 4	249 6	250
	SARA Feed	1185	14	16149	190823	0.047	4 4	90 6	1507.2	139 5	0 047	3 0	43.2	1594 2	177 2	250
BMWD →	Bexar MWD Feed	1320	14	3018	193841	3 014	4 4	16 5	1490.7	73 9	2 004	2 9	7 7	1586 5	115 4	200
				140673 ft				379 8					259 2			
				26 6 mi												
				193841 ft												
				36 7 mi												

Junct	El (ft)	Dia (in)	Pipe Length (ft)	Sum Length ft)	Initial ΔQ (mgd)	Initial v(fps)	HL (ft)	HGL (ft)	Press. Head (psi)
CISD School Feed	1165	30		0	0 047	3 0	18 6	1665 3	216 6
Bulverde Hills	1080	14	6423	6423	0 189	4 7	40 3	1625 0	236 0
Low Point	1061	14	4853	11277	0 000	4 4	27.2	1597 8	232 4
SARA Feed	1185	14	16149	27425	0 047	4 4	90 6	1507 2	139 5
Bexar MWD Feed	1320	14	3018	30443	3 014	4 4	16 5	1490 7	73.9

ALT 3 ***GRAVITY CONVEYANCE FROM WTP TO BMWD, ALONG SMITHSON VALLEY ROAD***

Assume required system storage at booster PS(MG)= 0.25
C= 120

Mainline (Gravity)

Junct	Pipe	El (ft)	Dia (in)	Pipe Length (ft)	Length from WTP (ft)	Initial Q (mgd)	Initial v(fps)	HL (ft)	HGL (ft)	Press Head (psi)	Ultimate Q (mgd)	Ultimate v(fps)	HL (ft)	HGL (ft)	Press. Head (psi)	Max Pipe Pressure Class
WTP		1380		0	0	9.87			1380		9.87			1380		
Can reroute around hill → high point	P-16	1385	36	3395	3395	9.87	2.16	1.69	1378.3	-2.9	9.87	2.16	1.69	1378.3	-2.9	100
Curtis Bremer	P-26	1310	36	8877	12272	9.87	2.16	4.41	1373.9	27.7	9.77	2.14	4.33	1374.0	27.7	100
high point	P-7	1321	36	7369	19642	9.87	2.16	3.66	1370.2	21.3	9.77	2.14	3.60	1370.4	21.4	100
low point	P-27	1267	36	2135	21777	9.87	2.16	1.06	1369.2	44.2	9.77	2.14	1.04	1369.3	44.3	100
Bulverde junct.	P-31	1080	36	45003	66780	9.39	2.06	20.42	1348.8	116.4	8.65	1.90	17.55	1351.8	117.7	150
low point	P-22	1061	27	4853	71633	3.06	1.19	1.12	1347.6	124.1	2.05	0.80	0.53	1351.3	125.7	150
SARA Feed	P-23	1185	27	16149	87782	3.06	1.19	3.73	1343.9	68.8	2.05	0.80	1.78	1349.5	71.2	150
BMWD	P-24	**1320**	27	3018	90800	3.01	1.17	0.68	**1343.2**	10.1	2.00	0.78	0.32	**1349.2**	12.6	100
				90800 ft				36.77					30.84			
				17.2 mi												

Velocity criteria (2 fps min) is not satisfied within
69023 ft
13.1 mi

Line to Customers near Rd. 281 and 46 Intersection (Gravity)

Junct	Pipe	El (ft)	Dia (in)	Pipe Length (ft)	Sum Length from WTP (ft)	Initial Q (mgd)	Initial v(fps)	HL (ft)	HGL (ft)	Press. Head (psi)	Ultimate Q (mgd)	Ultimate v(fps)	HL (ft)	HGL (ft)	Press. Head (psi)	Max Pipe Pressure Class
CISD		1299	10	2523	22165	0.48	1.35	2.33	1366.8	29.4	1.12	3.18	11.38	1358.0	25.5	100
high point		1320	10	2206	24371	0.38	1.08	1.36	1365.5	19.7	1.03	2.91	8.46	1349.5	12.8	100
Apex		1205	10	15536	39907	0.38	1.08	9.55	1355.9	65.4	1.03	2.91	59.56	1289.9	36.8	100
Elbel Double J Johnson, Lost Owl CISD	1137	8	2060	41967	0.29	1.27	2.22	1353.7	93.8	0.84	3.72	16.11	1273.8	59.2	100	
	1160	8	2073	44040	0.09	0.42	0.28	**1353.4**	83.8	0.09	0.42	0.28	**1273.5**	49.2	100	
			24399 ft				15.74					95.80				
			4.6 mi													

From Bulverde Junction to Boerne Junction (Gravity)

Junct	Pipe	El (ft)	Dia (in)	Pipe Length (ft)	Sum Length from WTP (ft)	Initial Q (mgd)	Initial v(fps)	HL (ft)	HGL (ft)	Press Head (psi)	Ultimate Q (mgd)	Ultimate v(fps)	HL (ft)	HGL (ft)	Press Head (psi)	Max Pipe Pressure Class
Bulverde junct.	P-31	1080	36		66780				1348.8	116.4				1351.8	117.7	150
Boerne junct.		1165	16	6423	73204	6.33	7.03	72.64	1276.1	48.1	6.60	7.33	78.51	1273.3	46.9	150
				6423 ft				72.64					78.51			
				1.2 mi												

From Bulverde Junction to Boerne (same as Alt. 1 from junction to Boerne) (Pumped)

Junct	Pipe	El (ft)	Dia (in)	Pipe Length (ft)	Sum Length from WTP (ft)	Initial ΔQ (mgd)	Initial v(fps)	HL (ft)	HGL (ft)	Press. Head (psi)	Ultimate ΔQ (mgd)	Ultimate v(fps)	HL (ft)	HGL (ft)	Press Head (psi)	Max Pipe Pressure Class
CISD School Feed	P-12	1165			73204	0.05			1665.3	216.6	0.05			1670.5	218.9	250
Low Point	P-2	1119	24	2523	75727	0.00	3.00	3.8	1661.5	234.9	0.00	3.20	4.0	1666.5	237.1	250
Low Point	P-29	1177	24	8884	84611	0.00	3.00	13.3	1648.2	204.0	0.00	3.20	14.4	1652.1	205.7	250
High Point	P-13	1279	24	7488	92099	0.00	3.00	11.2	1637	155.0	0.00	3.20	12.2	1639.9	156.3	200
Murcia Feed (low point)	P-14	1247	24	16678	108777	0.09	3.00	25.0	1612	158.0	0.21	3.20	27.0	1612.9	158.4	200
High Point	P-15	1329	24	7157	115934	0.00	3.00	10.4	1601.6	118.0	0.00	3.10	11.0	1601.9	118.2	200
Cordillera Feed (low point)	P-6	1280	24	5937	121871	0.38	3.00	8.7	1592.9	135.5	0.94	3.10	9.0	1592.9	135.5	150
Fair Oaks Feed	P-17	1260	20	15509	137381	0.75	4.10	48.8	1544.1	123.0	1.31	3.80	42.6	1550.3	125.7	150
High Point	P-18	1416	20	18070	155451	0.00	3.50	43.8	1500.3	36.5	0.09	2.80	29.4	1520.9	45.4	150
Boerne Feed	P-19	1405	20	5038	160488	0.47	3.50	12.2	1488.1	36.0	1.74	2.80	7.8	1513.1	46.8	100
Tapatio/Kendall Co Utility Co.	P-20	1405	18	134	160622	0.14	3.90	0.5	1487.6	35.8	0.47	1.90	0.2	1512.9	46.7	100
SAWS Feed	P-21	1450	18	2827	163449	4.36	3.80	8.9	1478.7	12.4	1.70	1.50	1.5	1511.4	26.6	100
				90245 ft				186.6					159.1			
				17.1 mi												

distance from high pt (El 1321) to Boerne junct.
53562 ft
10.1 mi

211868 ft (project total)
40.1 mi

187469 ft (project total without approach main to 281/46)
35.5 mi

Junct	Pipe	El (ft)	Dia (in)	Pipe Leng	Sum Length	Initial DQ (	Initial v(fps	HL (ft)	HGL (ft)	Press. Head (psi)
Boerne junct.		1165	16		0	6.33	7.03	72.64	1276	48.1
Bulverde junct.	P-31	1080	36	6423	6423	9.392	2.059479	20.41583	1349	116.3735
low point	P-22	1061	27	4853.106	11277	3.061	1.193274	1.121697	1348	124.1148
SARA Feed	P-23	1185	27	16148.8	27425	3.061	1.193274	3.732465	1344	68.80666
BMWD	P-24	1320	27	3018.077	30443	3.014	1.174952	0.677882	1343	10.05814

5/23/00,alts.xls
r:\07081033\hyd

HYDRAULIC MODEL

Base Condition

Piping	Node 1	Node 2	Length (ft)	Dia (in)*	HW C-value	Initial Vel (fps)	Initial Flow (mgd)	Initial HL/1000 (ft/ft)	Ultimate Vel (fps)	Ultimate Flow (mgd)	Ultimate HL/1000 (ft/ft)	Pipe Pressure Class (Initial)	Pipe Pressure Class (Ultimate)	Δ?
P-1	R-1	J-1	139	30	120	3 1	9 9	1 20	3 1	9 9	1 2	200	200	no
P-10	J-10	J-11	2073	30	120	3	9 5	1 10	2 8	8 8	1	250	250	no
P-11	J-11	J-12	10285	30	120	3	9 5	1 1	2 8	8 7	1	250	250	no
P-12	J-12	J-3	16693	30	120	3	9 5	1 1	2 8	8 7	1	250	250	no
P-13	J-13	J-14	7488	24	120	3	6 2	1 5	3 2	6 5	1 6	250	250	no
P-14	J-14	J-15	16678	24	120	3	6 2	1 5	3 2	6 5	1 6	200	200	no
P-15	J-15	J-6	7157	24	120	3	6 1	1 5	3 1	6 3	1 5	200	200	no
P-16	J-16	J-25	2805	30	120	3 1	9 9	1 2	3 1	9.9	1 2	200	200	no
P-17	J-17	J-18	15509	20	120	4 1	5 7	3 1	3 8	5 3	2 7	150	150	no
P-18	J-18	J-19	18070	20	120	3 5	5	2 4	2 8	4	1 6	150	150	no
P-19	J-19	J-20	5038	20	120	3 5	5	2 4	2 8	3 9	1 6	100	100	no
P-2	J-3	J-28	2523	24	120	3	6 2	1 5	3 2	6 5	1 6	250	250	no
P-20	J-20	J-21	134	[illegible]	120	3 9	4 5	3 4	1 9	2 2	0 9	100	100	no
P-21	J-21	J-2	2827	[illegible]	120	3 8	4 4	3 2	1 5	1 7	0 6	100	100	no
P-22	J-22	J-23	4853	14	120	4 4	3 1	5 6	3	2 1	2 7	250	250	no
P-23	J-23	J-24	16149	14	120	4 4	3 1	5 6	3	2 1	2 7	250	250	no
P-24	J-24	J-4	3018	14	120	4 4	3	5 5	2 9	2	2 6	150	200	change
P-25	J-5	J-16	208	30	120	3 1	9 9	1 2	3 1	9 9	1 2	200	200	no
P-26	J-25	J-7	8877	30	120	3 1	9 9	1 2	3 1	9 9	1 2	200	200	no
P-27	J-26	J-9	4658	30	120	3 1	9 9	1.2	3 1	9 8	1 2	200	200	no
P-28	J-27	J-8	15536	30	120	3 1	9 8	1 2	3 1	9 7	1 2	250	250	no
P-29	J-28	J-13	8884	24	120	3	6 2	1 5	3 2	6 5	1 6	250	250	no
P-3	J-3	J-22	6423	14	120	4 7	3 3	6 3	3 2	2 2	3 1	250	250	no
P-4	RV-1	J-5	100	30	120	0	0	0	0	0	0	200	200	no
P-5	J-1	RV-1	143	30	120	0	0	0	0	0	0	200	200	no
P-6	J-6	J-17	5937	24	120	3	6 1	1 5	3 1	6 3	1 5	150	150	no
P-7	J-7	J-26	7369	30	120	3 1	9 9	1 2	3 1	9 8	1 2	200	200	no
P-8	J-8	J-10	2060	30	120	3 1	9 7	1 2	3	9 5	1 1	250	250	no
P-9	J-9	J-27	2206	30	120	3 1	9 8	1 2	3 1	9 7	1 2	200	200	no
		Total	193841 ft											
			36 7 mi											

HYDRAULIC MODEL

Variable System Characteristics

Node	Reference Pt.	El (ft.)	Initial Demand (mgd)	Initial HGL (ft)	Initial Pressure (psi)	Ultimate Demand (mgd)	Ultimate HGL (ft)	Ultimate Pressure (psi)
J-1	Reservoir (WTP)	1380	9 867	1749 8	160 1	9 867	1749 8	160 1
J-10	Craig Elbel, Double J. Ranch, Clyde Johnson, Lost Owl	1137	0 193	1697 7	242 8	0 744	1698 4	243 1
J-11	CISD School Feed	1160	0 047	1695 4	231 8	0.047	1696 4	232.3
J-12	High Point	1321	0	1683 9	157 1	0	1686.6	158.3
J-13	Low Point	1177	0	1648 2	204 0	0	1652 1	205.7
J-14	High Point	1279	0	1637	155 0	0	1639 9	156.3
J-15	Murcia Feed (low point)	1247	0 094	1612	158 0	0.206	1612 9	158 4
J-16	High Point	1398	0	1749 6	152 2	0	1749 6	152.2
J-17	Cordillera Feed (low point)	1280	0.375	1592.9	135 5	0 937	1592 9	135.5
J-18	Fair Oaks Feed	1260	0 75	1544 1	123 0	1 312	1550 3	125 7
J-19	High Point	1416	0	1500 3	36 5	0 094	1520.9	45.4
J-2	SAWS Feed	1450	4 362	1478 7	12 4	1 699	1511 4	26 6
J-20	Boerne Feed	1405	0 469	1488 1	36 0	1.744	1513 1	46 8
J-21	Tapatio/Kendall Co. Utility Co	1405	0 141	1487 6	35.8	0.469	1512 9	46 7
J-22	Bulverde Hills	1080	0 189	1625	236 0	0 189	1650 3	246 9
J-23	Low Point	1061	0	1597 8	232.4	0	1637 4	249.6
J-24	SARA Feed	1185	0 047	1507 2	139 5	0 047	1594 2	177 2
J-25	High Point	1385	0	1746 2	156 4	0	1746 2	156.4
J-26	High Point	1321	0	1726 8	175 7	0	1726 9	175 8
J-27	High Point	1320	0	1718 5	172.6	0	1718 9	172 7
J-28	Low Point	1119	0	1661 5	234 9	0	1666.5	237 1
J-3	CISD School Feed	1165	0 047	1665 3	216 6	0 047	1670 5	218.9
J-4	Bexar MWD Feed	1320	3 014	1490 7	73.9	2.004	1586 5	115 4
J-5	Flow Control Element	1380	-9 867	1749 8	160 1	-9 867	1749 8	160 1
J-6	High Point	1329	0	1601 6	118 0	0	1601 9	118 2
J-7	Curtis Bremer Feed	1310	0	1735 6	184 3	0 094	1735 6	184 3
J-8	Apex Feed	1205	0.094	1700.1	214 4	0 187	1700 7	214 6
J-9	CISD School Feed	1299	0 047	1721 2	182 8	0 047	1721.4	182 9
R-1	Reservoir (WTP)	1380		1750			1750	
	Total		9 87			9 87		

SIZE RW LINE FROM CANYON LAKE INTAKE PS TO WTP

Canyon Lake
Normal Pool Elev (ft)= 908
Min Pool Elev. (ft)= 808

C= 120
PS @ Intake, Head (ft)= 668

PS @ Intake, Head (ft)= 640

						Future Phase, Q = 14 MGD					**Initial Phase, Q = 9.9 MGD**				
Junct.	Node El (ft)	Dia (in.)	Pipe Length (ft)	Profile Length (ft)	Sum Length (ft)	Full Q (mgd)	Full v(fps)	HL (ft)	HGL (ft)	Press. Head (psi)	Base (Ultimate) Q (mgd)	Base (Ult.) v(fps)	HL (ft)	HGL (ft)	Press. Head (psi)
				-25758					908					908	
									1476		9.87			1448.00	
Canyon Lake	921		0	-25758	0	14.0					9.87	3.12	0.60	1447.4	172.4
High Point	1049	30	498	-25260	498	14.0	4.42	1.15	1474.9	184.3	9.87	3.12	1.30	1446.1	206.0
Low Point	970	30	1078	-24182	1576	14.0	4.42	2.48	1472.4	217.4	9.87	3.12	1.23	1444.9	199.9
High Point	983	30	1020	-23162	2596	14.0	4.42	2.35	1470.0	210.8	9.87	3.12	1.88	1443.0	210.4
Low Point	957	30	1559	-21603	4155	14.0	4.42	3.59	1466.4	220.6	9.87	3.12	2.37	1440.6	193.5
High Point	994	30	1965	-19638	6119	14.0	4.42	4.53	1461.9	202.8	9.87	3.12	2.51	1438.1	204.2
Low Point	967	30	2076	-17562	8196	14.0	4.42	4.79	1457.1	212.4	9.87	3.12	2.81	1435.3	157.5
High Point	1072	30	2331	-15231	10527	14.0	4.42	5.37	1451.7	164.6	9.87	3.12	0.76	1434.5	172.2
Low Point	1037	30	626	-14604	11153	14.0	4.42	1.44	1450.3	179.0	9.87	3.12	0.67	1433.9	157.1
High Point	1071	30	557	-14048	11710	14.0	4.42	1.28	1449.0	163.7	9.87	3.12	2.32	1431.6	190.8
Low Point	991	30	1921	-12126	13631	14.0	4.42	4.43	1444.6	196.5	9.87	3.12	14.53	1417.0	10.2
High Point	1393	30	12042	-84	25674	14.0	4.42	27.76	1416.8	10.1	9.87	3.12	0.10	1416.9	11.4
WTP	1391	30	84	0	25758	14.0	4.42	0.19	1416.6	11.2			31.08	1750	
			25758	0				59.38	1750						

GBRA REGIONAL WATER SYSTEM

ALTERNATIVES FOR PHASED DELIVERY FROM PROPOSED WTP TO GBRA PROJECT CUSTOMERS

Comparison of Alternatives 1P and 2P

PRELIMINARY ESTIMATE OF COSTS [1]

Basis of Comparison	*Alt. 1P-A*	*Alt. 1P-B*	*Alt. 2P-A*	*Alt. 2P-B*
Capital Costs				
Transmission Pipelines	$ 18,368,000	$ 18,639,000	$ 16,914,000	$ 15,941,000
WTP Pump Station	$ 2,385,000	$ 1,727,000	-	$ 558,000
Booster Pump Station	-	-	$ 2,044,000	$ 2,044,000
System Storage	-	-	$ 399,000	$ 399,000
Electrical Feed	$ 239,000	$ 165,000	$ 196,000	$ 216,000
Total Capital Cost [2]	$ 20,992,000	$ 20,531,000	$ 19,553,000	$ 19,158,000
Add'l Land Acquisition (PS and Storage Tank)	-	-	$ 7,000	$ 7,000
Total Project Cost [2]	$ 20,992,000	$ 20,531,000	$ 19,560,000	$ 19,165,000
Annual O&M Costs				
Annual Debt Service *(Assuming 25 years, efective interest rate of 6.5%)*	$ 1,721,000	$ 1,684,000	$ 1,604,000	$ 1,572,000
Pumping Costs	$ 999,000	$ 688,000	$ 821,000	$ 903,000
Operation and Maintenance [3]				
Pump Station	$ 54,000	$ 39,000	$ 489,000	$ 65,000
Transmission Facilities	$ 184,000	$ 186,000	$ 196,000	$ 159,000
Storage Facilities	-	-	$ 195,600	$ 4,000
Total Annual Cost [4]	$ 2,958,000	$ 2,597,000	$ 3,305,600	$ 2,703,000
Non-Cost Factors				
WTP Location (Elev.)	+	+	-	NA
O&M Staffing Location	+	+	-	-
Control Complexity	+	+	-	-

[1] Costs are developed for purposes of preliminary evaluation and include only those costs that vary between the alternatives. Thus, the costs should not be taken as final estimates for any alternative. For comparison purposes, costs are based on a Phased Project production of 15,683 acft/yr - the maximum capacity of Alternative 1.

[2] Items not included for cost comparison due to equivalence between alternatives include. Intake, Intake Pump Station and Water Treatment Plant, Interconnects to all participants, Equilization Tank near Boerne/SAWS Delivery Point, Environmental Studies and Mitigation, Land Acquisition for WTP and Transmission Line, Reserve Account, Financing Costs,and Interest During Construction

[3] O&M costs assume 1% of the total capital costs of pipelines and tanks; 2.5% of the total capital cost of remote pump stations and 2.25% of the total capital cost of on-site pump stations.

Description of Alternatives

Alt. 1: Single high service pump station at WTP (route along Rd 46)
Alt 1P-A. Add'l head to high service pump station at WTP (route along Rd 46)
Alt 1P-B Upsize diameters at west end of transmission line (furthest delivery points) by relaxing minimum velocity criteria
Alt 2 Gravity from WTP to west of Rd 281 along Rd 46 to remote pump station, pump to Boerne and BMWD
Alt 2P-A Increase pipe size in gravity line to provide Max capacity of 14 mgd
Alt 2P-B Addition of booster pump station at WTP to provide Max capacity of 14 mgd

GBRA REGIONAL WATER SYSTEM

PHASED DELIVERY 9.9 MGD AND 14 MGD FROM PROPOSED WTP TO GBRA PROJECT CUSTOMERS

Alternative 1 - Single high service pump station at WTP.

PRELIMINARY ESTIMATE OF COSTS [1]

	Alt. 1	Alt. 1P-A		Alt. 1P-B	
Basis of Comparison	Initial Case, 9 9 MGD	Build Out, 14 MGD	Incremental Cost	Build Out, 14 MGD	Incremental Cost
Capital Costs					
Transmission Pipelines	$ 16,621,000	$ 18,368,000	$ 1,747,000	$ 18,639,000	$ 2,018,000
WTP Booster Pump Station	$ 1,263,000	$ 2,385,000	$ 1,122,000	$ 1,727,000	$ 464,000
Booster Pump Station	-	-	-	-	-
System Storage	-	-	-	-	-
Electrical Feed	$ 114,000	$ 239,000	$ 125,000	$ 165,000	$ 51,000
Total Capital Cost [2]	$ 17,998,000	$ 20,992,000	$ 2,994,000	$ 20,531,000	$ 2,533,000
Annual O&M Costs					
Annual Debt Service	$ 1,476,000	$ 1,721,000	$ 245,000	$ 1,684,000	$ 208,000
(Assuming 25 years, efective interest rate of 6.5%)					
Pumping Costs	$ 478,000	$ 999,000	$ 521,000	$ 688,000	$ 210,000
Operation and Maintenance [3]					
Pump Station	$ 28,000	$ 54,000	$ 26,000	$ 39,000	$ 11,000
Transmission Facilities	$ 166,000	$ 184,000	$ 18,000	$ 186,000	$ 20,000
Total Annual Cost [2]	$ 2,148,000	$ 2,958,000	$ 810,000	$ 2,597,000	$ 449,000

[1] Costs are developed for purposes of preliminary evaluation and include only those costs that vary between the alternatives. Thus, the costs should not be taken as final estimates for any alternative.

[2] Items not included for cost comparison due to equivalence between alternatives include: Intake, Intake Pump Station and Water Treatment Plant, Interconnects to all participants, Equilization Tank near Boerne/SAWS Delivery Point, Environmental Studies and Mitigation, Land Acquisition for WTP and Transmission Line, Reserve Account, Financing Costs,and Interest During Construction.

[3] O&M costs assume 1% of the total capital costs of pipelines and tanks; 2.5% of the total capital cost of remote pump stations and 2.25% of the total capital cost of on-site pump stations.

Description of Alternative/Options

Alt. 1. Single high service pump station at WTP (route along Rd 46).

Alt 1P-A Add'l head to high service pump station at WTP (route along Rd 46).

Alt 1P-B· Upsize diameters at west end of transmission line (furthest delivery points) by relaxing minimum velocity criteria.

GBRA REGIONAL WATER SYSTEM

PHASED DELIVERY 9.9 MGD AND 14 MGD FROM PROPOSED WTP TO GBRA PROJECT CUSTOMERS

ALTERNATIVE 2 - Gravity from WTP to remote pump station at/near junction to Boerne, pump to Boerne.

PRELIMINARY ESTIMATE OF COSTS [1]

	Alt. 2	Alt. 2P-A		Alt. 2P-B	
Basis of Comparison	Initial Case, 9.9 MGD	Build Out, 14 MGD	Incremental Cost	Build Out, 14 MGD	Incremental Cost
Capital Costs					
Transmission Pipelines	$ 15,589,000	$ 16,914,000	$ 1,325,000	$ 15,941,000	$ 352,000
WTP Booster Pump Station	0	0	$ -	$ 558,000	$ 558,000
Booster Pump Station	$ 1,322,000	$ 2,044,000	$ 722,000	$ 2,044,000	$ 722,000
System Storage	$ 282,000	$ 399,000	$ 117,000	$ 399,000	$ 117,000
Electrical Feed	$ 110,000	$ 196,000	$ 86,000	$ 216,000	$ 106,000
Total Capital Cost [2]	$ 17,303,000	$ 19,553,000	$ 2,250,000	$ 19,158,000	$ 1,855,000
Add'l Land Acquisition (PS and Storage Tank)	$ 6,800	$ 6,800	$ -	$ 6,800	$ -
Total Project Cost [2]	$ 17,309,800	$ 19,559,800	$ 2,250,000	$ 19,164,800	$ 1,855,000
Annual O&M Costs					
Annual Debt Service *(Assuming 25 years, efective interest rate of 6.5%)*	$ 1,419,000	$ 1,604,000	$ 185,000	$ 1,572,000	$ 153,000
Pumping Costs	$ 458,000	$ 821,000	$ 363,000	$ 903,000	$ 445,000
Operation and Maintenance [3]					
Pump Station	$ 33,000	$ 51,000	$ 18,000	$ 65,000	$ 32,000
Transmission Facilities	$ 156,000	$ 169,000	$ 13,000	$ 159,000	$ 3,000
Storage Facilities	$ 2,800	$ 4,000	$ 1,200	$ 4,000	$ 1,200
Total Annual Cost [2]	$ 2,068,800	$ 2,649,000	$ 580,200	$ 2,703,000	$ 634,200

[1] Costs are developed for purposes of preliminary evaluation and include only those costs that vary between the alternatives Thus, the costs should not be taken as final estimates for any alternative

[2] Items not included for cost comparison due to equivalence between alternatives include Intake, Intake Pump Station and Water Treatment Plant, Interconnects to all participants, Equilization Tank near Boerne/SAWS Delivery Point, Environmental Studies and Mitigation, Land Acquisition for WTP and Transmission Line, Reserve Account, Financing Costs,and Interest During Construction

[3] O&M costs assume 1% of the total capital costs of pipelines and tanks, 2 5% of the total capital cost of remote pump stations and 2.25% of the total capital cost of on-site pump stations

Description of Alternative/Options

Alternative 2 - Gravity from WTP to remote pump station at/near junction to Boerne, pump to Boerne

Alt 2P-A Increase pipe size in gravity line to provide Max capacity of 14 mgd

Alt 2P-B Addition of booster pump station at WTP to provide Max capacity of 14 mgd

Pumping Costs

Phasing

Equation for pumping/energy costs (assumes continuous operation)

$$\frac{\left(Q_{mgd} \times 694 \; 4 \frac{gpm}{mgd} \times H(ft)\right)}{3960 \times 0.70} \times 0.746 \frac{kW}{hp} \times 8{,}760 \frac{hrs}{yr} \times 0.08 \frac{\$}{kWh} = Cost\,\$/yr$$

where overall efficiency = 0 7
energy rate ($/kWh)= 0 08

Alt. 1 - Base Case, Q= 9 9 MGD

-Involves a single high service pumping station to Boerne
-Ultimate Demand Scenario

Pump Head (ft)=	370
Flow, Q (mgd)=	9 87
Pump hp =	910
Est PS Capital Cost (mil $)=	1 26
O&M Energy Cost ($/yr)=	$ 478,119
Power Connection Cost ($)=	$ 113,750

Alt. 1P-A -Full Capacity, Q= 14 MGD

-Involves a single high service pumping station to Boerne

Pump Head (ft)=	545
Flow, Q (mgd)=	14 00
Pump hp =	1910
Est PS Capital Cost ($)=	2 39
O&M Energy Cost ($/yr)=	$ 999,250
Power Connection Cost ($)=	$ 238,750

Alt. 1P-B -Full Capacity, Q= 14 MGD

-Involves a single high service pumping station to Boerne

Pump Head (ft)=	375
Flow, Q (mgd)=	14 0
Pump hp =	1320
Est PS Capital Cost ($)=	1 73
O&M Energy Cost ($/yr)=	$ 687,557
Power Connection Cost ($)=	$ 165,000

Alt. 2 - Base Case, Q= 9.9 MGD

	Initial Demand	Ultimate Demand
Pump Head (ft)=	403	400
Flow, Q (mgd)=	9 49	8 75
Pump hp =	960	880
Est PS Capital Cost ($)=	1 22	1 23
O&M Energy Cost ($/yr)=	$ 500 133	$ 457,965
Power Connection Cost ($)=	$ 120,000	$ 110,000
	(from alts xls,1 13,00)	

Alt. 2P-A - Upsize Dia.s in Gravity Line, Q= 14 MGD

Pump Head (ft)=	522
Flow, Q (mgd)=	12 01
Pump hp =	1570
Est PS Capital Cost ($)=	2 04
O&M Energy Cost ($/yr)=	$ 820,736
Power Connection Cost ($)=	$ 196,250

Alt. 2P-B - Add Booster PS at WTP, Q= 14 MGD

WTP Booster PS

Pump Head (ft)=	45
Flow, Q (mgd)=	14 0
Pump hp =	160
Est PS Capital Cost ($)=	0 56
O&M Energy Cost ($/yr)=	$ 82,507
Power Connection Cost ($)=	$ 20,000

Remote PS

Pump Head (ft)=	522
Flow, Q (mgd)=	12 01
Pump hp =	1570
Est PS Capital Cost ($)=	2 04
O&M Energy Cost ($/yr)=	$ 820,736
Power Connection Cost ($)=	$ 196,250

ENR=	6039	6127
	2nd quarter, 1999	last quarter, 1999

Pumping Station Costs

(hp)	(mil$)	(mil$)
<400	0 55	0 56
400	0 65	0 66
1000	1 35	1 37
2000	2 45	2 49
3000	3 38	3 43
4000	4 08	4 14
5000	4 61	4 68
6000	5 04	5 11
7000	5 47	5 55
8000	5 76	5 84
9000	6 04	6 13
10000	6 3	6 39
15000	7 28	7 39
3000	9 23	9 36
60000	12 01	12 19
80000	13 05	13 24
100000	13 98	14 18

Reference HDR Cost Estimating, Section 5 of Studies Level Engineering and Costing Methodology,Senate Bill 1 Report.

Costs for pumping stations include costs for pumps, housing, motors, electrical control, site work, and all materials needed.

$$PowerConn \;\; (\$50{,}000\,\min) = \frac{\$125}{1hp} \times Stationhp$$

Costs for electrical power connection include the distance to the nearest power source and the electrical demand of the pumping station The following equation was developed to estimate power connection costs

Description of Alternatives

Alt 1 - Single high service pump station at WTP (route along Rd 46)
- Alt. 1P-A Add'l head to high service pump station at WTP
- Alt. 1P-B Upsize diameters at west end of transmission line (furthest delivery points) by relaxing minimum velocity criteria

Alt 2 - Gravity from WTP to west of Rd 281 along Rd 46 to remote pump station, pump to Boerne
- Alt 2P-A Increase pipe size in gravity line to provide Max capacity of 14 mgd
- Alt 2P-B Addition of booster pump station at WTP to provide Max capacity of 14 mgd

Pipe Material/Installation Costs
Phasing

Alt. 1 - Base Case, Q= 9.9 MGD

Dia (in.)	Pressure Class	Length (ft.)	$/LF	Cost $
30	250	46647	117	5438782
	200	26506	103	2734908
24	250	11407	91	1034469
	200	31323	80	2513755
	150	5937	71	421663
20	150	33579	63	2112267
	100	5038	63	316888
18	100	2961	60	177233
14	250	27425	62	1705426
	200	3018	55	166086
	checks	193841		

TOTAL= $ 16,621,477

Alt. 1P-A -Full Capacity, Q= 14 MGD

Dia (in.)	Pressure Class	Length (ft.)	$/LF	Cost, $
30	300	62893	132	8286336
	250	10259	117	1196187
24	300	11407	102	1168950
	250	7488	91	679087
	200	23835	80	1912793
	150	5937	71	421663
20	150	33579	63	2112267
	100	5038	63	316888
18	100	2961	54	159209
14	300	27425	70	1927131
	250	3018	62	187677
	checks	193841		

TOTAL= $ 18,368,189

Alt. 1P-B -Full Capacity, Q= 14 MGD

Dia (in.)	Pressure Class	Length (ft.)	$/LF	Cost $
30	250	14418	117	1681057
	200	58734	103	6060328
27	250	2523	104	261481
	200	16373	92	1501654
	150	45281	81	3675292
	100	18070	81	1466670
24	250	0	91	0
	100	5038	80	404288
18	100	2961	60	177233
14	250	27425	62	1705426
	150	3018	49	1705426
	checks	193841		

TOTAL= $ 18,638,856

Alt. 2 - Base Case, Q= 9.9 MGD

Dia (in.)	Pressure Class	Length (ft.)	$/LF	Cost, $
30	250	16693	117	1946288
	200	3292	103	339650
	100	53168	91	4854832
24	250	11407	91	1034469
	200	31323	80	2513755
	150	5937	71	421663
20	150	33579	63	2112267
	100	5038	63	316888
18	100	2961	60	177233
14	300	0	70	0
	250	27425	62	1705426
	200	3018	55	166086
	150	0	49	0
	checks	193841		

TOTAL= $ 15,588,557

Alt. 2P-A - Upsize Dia.s in Gravity Line, Q= 14 MGD

Dia (in.)	Pressure Class	Length (ft.)	$/LF	Cost, $
36	100	26506	120	3173246
33	100	15536	106	1639295
30	300	16693	132	2199306
	250	3292	117	383804
	100	11126	91	1015940
24	300	2523	102	258540
	250	8884	91	805673
	200	24166	80	1939388
	150	13094	71	929952
20	150	15509	63	975597
	100	23108	63	1453558
18	100	2961	60	177233
14	300	11277	70	792383
	250	16149	62	1004202
	200	3018	55	166086
	checks	193841		

TOTAL= $ 16,914,202

Alt. 2P-B - Add Booster PS at WTP, Q= 14 MGD

Dia (in.)	Pressure Class	Length (ft.)	$/LF	Cost, $
30	300	16693	132	2199306
	250	3292	117	383804
	100	53168	91	4854832
24	300	2523	102	258540
	250	8884	91	805673
	200	24166	80	1939388
	150	13094	71	929952
20	150	15509	63	975597
	100	23108	63	1453558
18	100	2961	60	177233
14	300	11277	70	792383
	250	16149	62	1004202
	200	3018	55	166086
	checks	193841		

TOTAL= $ 15,940,554

Pipe Material/Installation Costs
Assumes 13% increase per 50 psi pressure class above 150 psi.

ENR= 6039 (June 1999)

Pipeline Costs for Rock in Rural Areas

Pipe Dia (in.)	100 psi $/ft	150 psi $/ft	200 psi $/ft	250 psi $/ft	300 psi $/ft
12	42	42	47	54	61
14	48	48	54	61	69
16	53	53	60	68	76
18	59	59	67	75	85
20	62	62	70	79	89
24	70	70	79	89	101
27	80	80	90	102	115
30	90	90	102	115	130
33	104	104	118	133	150
36	118	118	133	151	170

Reference HDR Cost Estimating, Section 5 of Studies Level Engineering and Costing Methodology, Senate Bill 1 Report.

Costs for piping are for installed piping and appurtenances, including markers, valves, thrust resraint systems, corrosion monitoring and control equipment, air vacuum valves, blow-off valves, erosion control, revegetation of ROW, fencing, and gates. Costs do not inclue crossings.

ENR= 6127 (Dec 1999)

Pipeline Costs for Rock in Rural Areas

Pipe Dia (in.)	100 psi $/ft	150 psi $/ft	200 psi $/ft	250 psi $/ft	300 psi $/ft
12	43	43	48	54	61
14	49	49	55	62	70
16	54	54	61	69	78
18	60	60	68	76	86
20	63	63	71	80	91
24	71	71	80	91	102
27	81	81	92	104	117
30	91	91	103	117	132
33	106	106	119	135	152
36	120	120	135	153	173

Reference HDR Cost Estimating, Section 5 of Studies Level Engineering and Costing Methodology, Senate Bill 1 Report.

SUMMARY

		Length of Piping (ft)					
Dia	Class	ALT 1P-A	ALT 1P-B	ALT 2P-A	ALT 2P-B	ALT 1	ALT 2
36	100	-	-	26506	-	-	-
33	100	-	-	15536	-	-	-
30	300	62893	-	16693	16693		
	250	10259	14418	3292	3292	46646.5	16692.6
	200	-	58734	-	-	26505.7	3291.8
	100	-	-	11126	53168	-	53167.8
27	250	-	2523	-	-	-	-
	200	-	16373	-	-	-	-
	150	-	45281	-	-	-	-
	100	-	18070	-	-	-	-
24	300	11407	-	2523	2523		
	250	7488	-	8884	8884	11407.2	11407.2
	200	23835	-	24166	24166	31323.0	31323.0
	150	5937	-	13094	13094	5937.2	5937.2
	100	-	5038	-	-	-	-
20	150	33579	-	15509	15509	33579.5	33579.5
	100	5038	-	23108	23108	5037.7	5037.7
18	100	2961	2961	2961	2961	2960.8	2960.8
14	300	27425	-	11277	11277	-	-
	250	3018	27425	16149	16149	27425.3	27425.3
	200	-	-	3018	3018	3018.1	3018.1
	150	-	3018	-	-	-	-
Totals		193841	193841	193841	193841	193841	193841

		Length of Piping (ft)		
Dia	Class	ALT 1	ALT 1P-A	
30	300	-	62893	
	250	46647	10259	
	200	26506	-	
24	300	-	11407	
	250	11407	7488	
	200	31323	23835	
	150	5937	5937	
20	150	33579	33579	
	100	5038	5038	
18	100	2961	2961	
14	300	-	27425	
	250	27425	3018	
	200	3018	-	
Totals		193841	193841	
		$16,621,477	$18,368,189	Difference $1,746,712

Storage Costs -Phasing

Look at storage costs in addition to tank used for equilization (Equilization tank is same for all alternatives and is not included in cost comparison)

ALTERNATIVE 1

-Involves a single high service pumping station to Boerne
No additional system storage is required.

ALTERNATIVE 2

-Involves a remote pumping station located near west of Rd. 281 along Rd. 46, pumping to Boerne and BMWD.

		Max, Q=14 MGD		**Base, Q=9.9 MGD**	
Assume required system storage at booster PS(MG)=		0.5		0.25	
Ground Storage Tank ($)=	$	399,336		$ 282,470	
Req'd Land Acquisition (acres)=		4	(pump station and tank)	4	(pump station and tank)
Land value ($/acre)=	$	1,700	(1999 value)	$ 1,700	(1999 value)
Req'd Land Acquisition Cost ($)=	$	6,800		$ 6,800	

	Values from 2nd quarter, 1999	Values from last quarter, 1999
ENR=	*6039*	*6127*
Ground Storage Tank Costs		
(MG)	($)	($)
0.01	86400	87659
0.05	146400	148533
0.1	209300	212350
0.5	393600	399336
1	679100	688996
2	1129300	1145756
4	1768600	1794372
6	2408000	2443089
7.5	2926600	2969246
9	329920	334728

Reference: HDR Cost Estimating, Section 5 of Studies Level Engineering and Costing Methodology,Senate Bill 1 Report.

ALT 1P-A **HIGH SERVICE PUMP STATION AT WTP**

MAX CAPACITY Same Size Piping as Base Condition

MODEL OUTPUT

Vary Ground Profile for Pressure Class Categories

	Location	Model Node	Model Piping	Node El (ft)	Pipe Dia (in)	150 psi Node El (ft)	200 psi Node El (ft)	250 psi Node El (ft)	300 psi Node El (ft)	Pipe Length (ft)	Sum Length (ft)	Full Capacity Q (mgd)	Full Capacity v(fps)	Full Capacity HGL (ft)	Full Capacity Press Head (ft)	Base (Ultimate) Q (mgd)	Base (Ultimate) v(fps)	Base (Ultimate) HGL (ft)	Base (Ultimate) Press Head (ft)	Full Capacity Pipe Pressure Class
	Reservoir (WTP)	R-1		1380		1727	1842	1958	2073		0			1925				1750		
	Reservoir (WTP)	J-1	P-1	1380	30	1727	1842	1958	2073	139.3	139	14.00	4.4	1924.7	235.9	9.87	3.1	1749.8	160.1	250
	Reservoir (WTP)	RV-1	P-5	1380	30	1727	1842	1958	2073	142.9	282	0.00	0.0	1925	0.0	0.00	0.0	1750	0.0	250
	Flow Control Element	J-5	P-4	1380	30	1727	1842	1958	2073	100.5	383	-14.00	0.0	1924.7	235.9	-9.87	0.0	1749.8	160.1	250
	High Point	J-16	P-25	1398	30	1745	1860	1976	2091	208.0	591	0.00	4.4	1924.2	227.8	0.00	3.1	1749.6	152.2	250
	High Point	J-25	P-16	1385	30	1732	1847	1963	2078	2804.6	3395	0.00	4.4	1917.8	230.7	0.00	3.1	1746.2	156.4	250
	Curtis Bremer Feed	J-7	P-26	1310	30	1657	1772	1888	2003	8877.0	12272	0.23	4.4	1897.4	254.3	0.09	3.1	1735.6	184.3	300
	High Point	J-26	P-7	1321	30	1668	1783	1899	2014	7369.4	19642	0.00	4.3	1881.1	242.5	0.00	3.1	1726.9	175.8	300
	CISD School Feed	J-9	P-27	1299	30	1646	1761	1877	1992	4657.5	24299	0.09	4.3	1870.7	247.5	0.05	3.1	1721.4	182.9	250
	High Point	J-27	P-9	1320	30	1667	1782	1898	2013	2206.4	26506	0.00	4.3	1865.9	236.4	0.00	3.1	1718.9	172.7	250
	Apex Feed	J-8	P-28	1205	30	1552	1667	1783	1898	15536.1	42042	0.32	4.3	1831.8	271.4	0.19	3.1	1700.7	214.6	300
	Craig Elbel, Double J Ranch,	J-10	P-8	1137	30	1484	1599	1715	1830	2059.6	44101	1.26	4.2	1827.4	298.9	0.74	3.0	1698.4	243.1	300
	CISD School Feed	J-11	P-10	1160	30	1507	1622	1738	1853	2073.4	46175	0.09	3.8	1823.8	287.4	0.05	2.8	1696.4	232.3	300
	High Point	J-12	P-11	1321	30	1668	1783	1899	2014	10284.8	56460	0.00	3.8	1806.1	210.0	0.00	2.8	1686.6	158.3	300
Bulverde Junction →	CISD School Feed	J-3	P-12	1165	30	1512	1627	1743	1858	16692.6	73152	0.09	3.8	1777.3	265.1	0.05	2.8	1670.5	218.9	300
	Low Point	J-28	P-2	1119	24	1466	1581	1697	1812	2523.0	75675	0.00	4.7	1768.8	281.4	0.00	3.2	1666.5	237.1	300
	Low Point	J-13	P-29	1177	24	1524	1639	1755	1870	8884.3	84559	0.00	4.7	1739.1	243.4	0.00	3.2	1652.1	205.7	300
	High Point	J-14	P-13	1279	24	1626	1741	1857	1972	7488.4	92048	0.00	4.7	1714.1	188.4	0.00	3.2	1639.9	156.3	250
	Murcia Feed (low point)	J-15	P-14	1247	24	1594	1709	1825	1940	16677.7	108725	0.75	4.7	1658.3	178.1	0.21	3.2	1612.9	158.4	200
	High Point	J-6	P-15	1329	24	1676	1791	1907	2022	7157.0	115882	0.00	4.3	1637.7	133.7	0.00	3.1	1601.9	118.2	200
	Cordillera Feed (low point)	J-17	P-6	1280	24	1627	1742	1858	1973	5937.2	121820	1.45	4.3	1620.7	147.5	0.94	3.1	1592.9	135.5	150
	Fair Oaks Feed	J-18	P-17	1260	20	1607	1722	1838	1953	15509.4	137329	1.80	5.2	1542.9	122.5	1.31	3.8	1550.3	125.7	150
	High Point (Kendall Prop)	J-19	P-18	1416	20	1763	1878	1994	2109	18070.1	155399	0.64	3.9	1489.1	31.7	0.09	2.8	1520.9	45.4	150
	Boerne Feed	J-20	P-19	1405	20	1752	1867	1983	2098	5037.7	160437	2.21	3.5	1477.2	31.3	1.74	2.8	1513.1	46.8	100
	Tapatio/Kendall Co Utility Co	J-21	P-20	1405	18	1752	1867	1983	2098	134.0	160571	1.00	2.4	1477	31.2	0.47	1.9	1512.9	46.7	100
SAWS →	SAWS Feed	J-2	P-21	1450	18	1797	1912	2028	2143	2826.8	163398	1.70	1.5	1475.4	11.0	1.70	1.5	1511.4	26.6	100
	Bulverde Hills	J-22	P-3	1080	14	1427	1542	1658	1773	6423.4	169821	0.32	3.4	1754.8	292.2	0.19	3.2	1650.3	246.9	300
	Low Point	J-23	P-22	1061	14	1408	1523	1639	1754	4853.1	174674	0.00	3.0	1741.9	294.8	0.00	3.0	1637.4	249.6	300
	SARA Feed	J-24	P-23	1185	14	1532	1647	1763	1878	16148.8	190823	0.05	3.0	1698.7	222.4	0.05	3.0	1594.2	177.2	300
BMWD →	Bexar MWD Feed	J-4	P-24	1320	14	1667	1782	1898	2013	3018.1	193841	2.00	2.9	1691	160.6	2.00	2.9	1586.5	115.4	250
											193841.1 ft									
											36.7 mi									

ALT 1 - Base Condition

MODEL OUTPUT

	Location	Model Node	Model Piping	Node El (ft)	Pipe Dia. (in)	Pipe Length (ft)	Base (Ultimate) Q (mgd)	Base (Ultimate) v(fps)	Base (Ultimate) HGL (ft)	Base (Ultimate) Press Head (ft)	Base (Ultimate) Q (mgd)	Base (Ultimate) v(fps)	Base (Ultimate) HGL (ft)	Base (Ultimate) Press Head (ft)	Full Capacity Pipe Pressure Class
	Reservoir (WTP)	R-1		0					0				0		
	Reservoir (WTP)	J-1	P-1	1380	30	139.3	9.87	3.1	1749.8	160.1	9.87	3.1	1749.8	160.1	200
	Reservoir (WTP)	RV-1	P-5	1380	30	142.9	0.00	0.0	1750.0	0.0	0.00	0.0	1750	0.0	200
	Flow Control Element	J-5	P-4	1380	30	100.5	-9.87	0.0	1749.8	160.1	-9.87	0.0	1749.8	160.1	200
	High Point	J-16	P-25	1398	30	208.0	0.00	3.1	1749.6	152.2	0.00	3.1	1749.6	152.2	200
	High Point	J-25	P-16	1385	30	2804.6	0.00	3.1	1746.2	156.4	0.00	3.1	1746.2	156.4	200
	Curtis Bremer Feed	J-7	P-26	1310	30	8877.0	0.09	3.1	1735.6	184.3	0.09	3.1	1735.6	184.3	200
	High Point	J-26	P-7	1321	30	7369.4	0.00	3.1	1726.9	175.8	0.00	3.1	1726.9	175.8	200
	CISD School Feed	J-9	P-27	1299	30	4657.5	0.05	3.1	1721.4	182.9	0.05	3.1	1721.4	182.9	200
	High Point	J-27	P-9	1320	30	2206.4	0.00	3.1	1718.9	172.7	0.00	3.1	1718.9	172.7	200
	Apex Feed	J-8	P-28	1205	30	15536.1	0.19	3.1	1700.7	214.6	0.19	3.1	1700.7	214.6	250
	Craig Elbel Double J Ranch	J-10	P-8	1137	30	2059.6	0.74	3.0	1698.4	243.1	0.74	3.0	1698.4	243.1	250
	CISD School Feed	J-11	P-10	1160	30	2073.4	0.05	2.8	1696.4	232.3	0.05	2.8	1696.4	232.3	250
	High Point	J-12	P-11	1321	30	10284.8	0.00	2.8	1686.6	158.3	0.00	2.8	1686.6	158.3	250
Bulverde Junction →	CISD School Feed	J-3	P-12	1165	30	16692.6	0.05	2.8	1670.5	218.9	0.05	2.8	1670.5	218.9	250
	Low Point	J-28	P-2	1119	24	2523.0	0.00	3.2	1666.5	237.1	0.00	3.2	1666.5	237.1	250
	Low Point	J-13	P-29	1177	24	8884.3	0.00	3.2	1652.1	205.7	0.00	3.2	1652.1	205.7	250
	High Point	J-14	P-13	1279	24	7488.4	0.00	3.2	1639.9	156.3	0.00	3.2	1639.9	156.3	200
	Murcia Feed (low point)	J-15	P-14	1247	24	16677.7	0.21	3.2	1612.9	158.4	0.21	3.2	1612.9	158.4	200
	High Point	J-6	P-15	1329	24	7157.0	0.00	3.1	1601.9	118.2	0.00	3.1	1601.9	118.2	200
	Cordillera Feed (low point)	J-17	P-6	1280	24	5937.2	0.94	3.1	1592.9	135.5	0.94	3.1	1592.9	135.5	150
	Fair Oaks Feed	J-18	P-17	1260	20	15509.4	1.31	3.8	1550.3	125.7	1.31	3.8	1550.3	125.7	150
	High Point (Kendall Prop)	J-19	P-18	1416	20	18070.1	0.09	2.8	1520.9	45.4	0.09	2.8	1520.9	45.4	150
	Boerne Feed	J-20	P-19	1405	20	5037.7	1.74	2.8	1513.1	46.8	1.74	2.8	1513.1	46.8	100
	Tapatio/Kendall Co Utility Co	J-21	P-20	1405	18	134.0	0.47	1.9	1512.9	46.7	0.47	1.9	1512.9	46.7	100
SAWS →	SAWS Feed	J-2	P-21	1450	18	2826.8	1.70	1.5	1511.4	26.6	1.70	1.5	1511.4	26.6	100
	Bulverde Hills	J-22	P-3	1080	14	6423.4	0.19	3.2	1650.3	246.9	0.19	3.2	1650.3	246.9	250
	Low Point	J-23	P-22	1061	14	4853.1	0.00	3.0	1637.4	249.6	0.00	3.0	1637.4	249.6	250
	SARA Feed	J-24	P-23	1185	14	16148.8	0.05	3.0	1594.2	177.2	0.05	3.0	1594.2	177.2	250
BMWD →	Bexar MWD Feed	J-4	P-24	1320	14	3018.1	2.00	2.9	1586.5	115.4	2.00	2.9	1586.5	115.4	200
						193841.1 ft									
						36.7 mi									

HYDRAULIC MODEL ALTIP A

Phased Condition - Min [illegible] with Same Size Pipes as Base Condition

Piping	Node 1	Node 2	Length (ft)	Dia (in)*	HW C-value	Difference from Base Condition: Full Capacity Vel (fps)	Full Capacity Flow (mgd)	Full Capacity HL/1000 (ft/ft)	Base (Ultimate) Vel (fps)	Base (Ultimate) Flow (mgd)	Base (Ultimate) HL/1000 (ft/ft)	Pipe Pressure Class (Full)	Pipe Pressure Class (Base Ult.)	Δ?
P-1	R-1	J-1	139	30	120	4 4	14 0	2 30	3 1	9 9	1 2	250	200	change
P-10	J-10	J-11	2073	30	120	3 8	12 1	1 70	2 8	8 8	1	300	250	change
P-11	J-11	J-12	10285	30	120	3 8	12	1 7	2 8	8 7	1	300	250	change
P-12	J-12	J-3	16693	30	120	3 8	12	1 7	2 8	8 7	1	300	250	change
P-13	J-13	J-14	7488	24	120	4 7	9 6	3 3	3 2	6 5	1 6	250	250	no
P-14	J-14	J-15	16678	24	120	4 7	9 6	3 3	3 2	6 5	1 6	200	200	no
P-15	J-15	J-6	7157	24	120	4 3	8 8	2 9	3 1	6 3	1 5	200	200	no
P-16	J-16	J-25	2805	30	120	4 4	14	2 3	3 1	9 9	1 2	250	200	change
P-17	J 17	J-18	15509	20	120	5 2	7 4	5	3 8	5 3	2 7	150	150	no
P-18	J-18	J-19	18070	20	120	3 9	5 6	3	2 8	4	1 6	150	150	no
P-19	J-19	J-20	5038	20	120	3 5	4 9	2 4	2 8	3 9	1 6	100	100	no
P-2	J-3	J-28	2523	24	120	4 7	9 6	3 3	3 2	6 5	1 6	300	250	change
P-20	J-20	J-21	134		120	2 4	2 7	1 3	1 9	2 2	0 9	100	100	no
P-21	J-21	J-2	2827		120	1 5	1 7	0 6	1 5	1 7	0 6	100	100	no
P-22	J-22	J-23	4853	14	120	3	2 1	2 7	3	2 1	2 7	300	250	change
P-23	J-23	J-24	16149	14	120	3	2 1	2 7	3	2 1	2 7	300	250	change
P-24	J-24	J-4	3018	14	120	2 9	2	2 6	2 9	2	2 6	250	200	change
P-25	J-5	J-16	208	30	120	4 4	14	2 3	3 1	9 9	1 2	250	200	change
P-26	J-25	J-7	8877	30	120	4 4	14	2 3	3 1	9 9	1 2	300	200	change
P-27	J-26	J-9	4658	30	120	4 3	13 8	2 2	3 1	9 8	1 2	250	200	change
P-28	J-27	J-8	15536	30	120	4 3	13 7	2 2	3 1	9 7	1 2	300	250	change
P-29	J-28	J-13	8884	24	120	4 7	9 6	3 3	3 2	6 5	1 6	300	250	change
P-3	J-3	J-22	6423	14	120	3 4	2 4	3 5	3 2	2 2	3 1	300	250	change
P-4	RV-1	J-5	100	30	120	0	0	0	0	0	0	250	200	change
P-5	J-1	RV-1	143	30	120	0	0	0	0	0	0	250	200	change
P-6	J-6	J-17	5937	24	120	4 3	8 8	2 9	3 1	6 3	1 5	150	150	no
P-7	J-7	J-26	7369	30	120	4 3	13 8	2 2	3 1	9 8	1 2	300	200	change
P-8	J-8	J-10	2060	30	120	4 2	13 4	2 1	3	9 5	1 1	300	250	change
P-9	J-9	J-27	2206	30	120	4 3	13 7	2 2	3 1	9 7	1 2	250	200	change
		Total	193841 1 ft											
			36 71 mi											

HYDRAULIC MODEL

Node	Reference Pt	El (ft.)	Full Capacity Demand (mgd)	Full Capacity HGL (ft)	Full Capacity Pressure (psi)	Base (Ultimate) Demand (mgd)	Base (Ultimate) HGL (ft)	Base (Ultimate) Pressure (psi)
J-1	Reservoir (WTP)	1380	14	1924 7	235 9	9 867	1749 8	160 1
J-10	Craig Elbel, Double J Ranch, Clyde Johnson, Lost Owl	1137	1 262	1827 4	298 9	0 744	1698 4	243 1
J-11	CISD School Feed	1160	0 091	1823 8	287 4	0 047	1696 4	232 3
J-12	High Point	1321	0	1806 1	210 0	0	1686 6	158 3
J-13	Low Point	1177	0	1739 1	243 4	0	1652 1	205 7
J-14	High Point	1279	0	1714 1	188 4	0	1639 9	156 3
J-15	Murcia Feed (low point)	1247	0 749	1658 3	178 1	0 206	1612 9	158 4
J-16	High Point	1398	0	1924 2	227 8	0	1749 6	152 2
J-17	Cordillera Feed (low point)	1280	1 446	1620 7	147 5	0 937	1592 9	135 5
J-18	Fair Oaks Feed	1260	1 803	1542 9	122 5	1 312	1550 3	125 7
J-19	High Point (Kendall Prop)	1416	0 642	1489 1	31 7	0 094	1520 9	45 4
J-2	SAWS Feed	1450	1 699	1475 4	11 0	1 699	1511 4	26 6
J-20	Boerne Feed	1405	2 214	1477 2	31 3	1 744	1513 1	46 8
J-21	Tapatio/Kendall Co Utility Co	1405	0 999	1477	31 2	0 469	1512 9	46 7
J-22	Bulverde Hills	1080	0 319	1754 8	292 2	0 189	1650 3	246 9
J-23	Low Point	1061	0	1741 9	294 8	0	1637 4	249 6
J-24	SARA Feed	1185	0 047	1698 7	222 4	0 047	1594 2	177 2
J-25	High Point	1385	0	1917 8	230 7	0	1746 2	156 4
J-26	High Point	1321	0	1881 1	242 5	0	1726 9	175 8
J-27	High Point	1320	0	1865 9	236 4	0	1718 9	172 7
J-28	Low Point	1119	0	1768 8	281 4	0	1666 5	237 1
J-3	CISD School Feed	1165	0 091	1777 3	265 1	0 047	1670 5	218 9
J-4	Bexar MWD Feed	1320	2 004	1691	160 6	2 004	1586 5	115 4
J-5	Flow Control Element	1380	-14	1924 7	235 9	-9 867	1749 8	160 1
J-6	High Point	1329	0	1637 7	133 7	0	1601 9	118 2
J-7	Curtis Bremer Feed	1310	0 228	1897 4	254 3	0 094	1735 6	184 3
J-8	Apex Feed	1205	0 317	1831 8	271 4	0 187	1700 7	214 6
J-9	CISD School Feed	1299	0 091	1870 7	247 5	0 047	1721 4	182 9
R-1	Reservoir (WTP)	1380		1925			1750	
	Total		14 00			9 87		

ALT.1P-B ***HIGH SERVICE PUMP STATION AT WTP***

MAX CAPACITY- Increase Size of Base Condition Piping

MODEL OUTPUT

	Location	Model Node	Model Piping	Node El (ft)	Pipe Length (ft)	Sum Length (ft)	ALT 1P-B, Full Capacity: Pipe Dia (in)	Q (mgd)	v(fps)	HGL (ft)	Press Head (ft)	Alt 1, (Ultimate Demands): Pipe Dia (in)	Q (mgd)	v(fps)	HGL (ft)	Press Head (ft)	Full Capacity Pipe Pressure Class
	Reservoir (WTP)	R-1		1380		0				1755					1625		
	Reservoir (WTP)	J-1	P-1	1380	139	139	30	14 00	4 4	1754 7	162 2	30	9 87	3 1	1624 8	106.0	200
	Reservoir (WTP)	RV-1	P-5	1380	143	282	30	0 00	0 0	1755	0 0	30	0 00	0 0	1625	0 0	200
	Flow Control Element	J-5	P-4	1380	100	383	30	-14 00	0 0	1754 7	162.2	30	-9 87	0 0	1624 8	106 0	200
	High Point	J-16	P-25	1398	208	591	30	0 00	4 4	1754.2	154 2	30	0 00	3 1	1624 6	98 1	200
	High Point	J-25	P-16	1385	2805	3395	30	0 00	4.4	1747 8	157.1	30	0 00	3.1	1621.2	102 3	200
	Curtis Bremer Feed	J-7	P-26	1310	8877	12272	30	0 23	4 4	1727.4	180 7	30	0.09	3.1	1610 6	130 2	200
	High Point	J-26	P-7	1321	7369	19642	30	0.00	4 3	1711 1	168 9	30	0 00	3.1	1601 9	121 6	200
	CISD School Feed	J-9	P-27	1299	4658	24299	30	0 09	4 3	1700.7	173 9	30	0 05	3 1	1596 4	128 8	200
	High Point	J-27	P-9	1320	2206	26506	30	0 00	4.3	1695 9	162.8	30	0 00	3 1	1593 9	118 6	200
	Apex Feed	J-8	P-28	1205	15536	42042	30	0.32	4 3	1661 8	197 8	30	0 19	3 1	1575 7	160 5	200
	Craig Elbel, Double J Ranch, (	J-10	P-8	1137	2060	44101	30	1 26	4 2	1657 4	225 3	30	0 74	3 0	1573 4	189 0	250
	CISD School Feed	J-11	P-10	1160	2073	46175	30	0.09	3.8	1653.8	213.8	30	0 05	2 8	1571 4	178 1	250
	High Point	J-12	P-11	1321	10285	56460	30	0.00	3 8	1636.1	136.4	30	0 00	2 8	1561 6	104.2	250
Bulverde Junction →	CISD School Feed	J-3	P-12	1165	16693	73152	30	0 09	3 8	1607.3	191 5	30	0 05	2 8	1545 5	164 8	200
	Low Point	J-28	P-2	1119	2523	75675	27	0.00	3 7	1602 5	209 4	27	0.00	2.5	1543 2	183 7	250
	Low Point	J-13	P-29	1177	8884	84559	27	0 00	3 7	1585.8	177.0	27	0 00	2 5	1535 1	155 1	200
	High Point	J-14	P-13	1279	7488	92048	27	0.00	3 7	1571.7	126.7	27	0.00	2 5	1528 3	107 9	200
	Murcia Feed (low point)	J-15	P-14	1247	16678	108725	27	0 75	3.7	1540.2	127 0	27	0 21	2 5	1513	115 2	150
	High Point	J-6	P-15	1329	7157	115882	27	0 00	3.4	1528.6	86.4	27	0 00	2 4	1506 9	77 0	150
	Cordillera Feed (low point)	J-17	P-6	1280	5937	121820	27	1 45	3.4	1519	103 5	27	0.94	2 4	1501 8	96 0	150
	Fair Oaks Feed	J-18	P-17	1260	15509	137329	27	1 80	2.9	1501	104.4	27	1 31	2 1	1491.9	100.4	150
	High Point (Kendall Prop)	J-19	P-18	1416	18070	155399	27	0 64	2.2	1488 5	31 4	27	0 09	1 6	1485.1	29 9	100
	Boerne Feed	J-20	P-19	1405	5038	160437	24	2 21	2.4	1483 6	34 0	24	1 74	1 9	1481.9	33 3	100
	Tapatio/Kendall Co Utility Co	J-21	P-20	1405	134	160571	18	1 00	2 4	1483 4	33.9	18	0 47	1 9	1481 7	33.2	100
SAWS →	SAWS Feed	J-2	P-21	1450	2827	163398	18	1 70	1 5	1481 9	13 8	18	1 70	1 5	1480 2	13 1	100
	Bulverde Hills	J-22	P-3	1080	6423	169821	14	0 32	3 4	1584.8	218 6	14	0 19	3 2	1525 3	192 8	250
	Low Point	J-23	P-22	1061	4853	174674	14	0 00	3 0	1571 9	221 2	14	0 00	3 0	1512.4	195 5	250
	SARA Feed	J-24	P-23	1185	16149	190823	14	0.05	3 0	1528 7	148 8	14	0.05	3 0	1469 2	123.1	250
BMWD →	Bexar MWD Feed	J-4	P-24	1320	3018	193841	14	2.00	2 9	1521	87 0	14	2.00	2 9	1461 5	61 3	150
						193841 ft											
						36 7 mi											

Velocity criteria (2 fps min) is not satisfied with
26069 ft
4 9 mi

ALT 2P-A ***GRAVITY CONVEYANCE FROM WTP TO WEST OF RD 281 ALONG RD 46 TO REMOTE PUMP STATION, PUMP TO BOERNE AND BMWD***

MAX CAPACITY - Increase pipe diameters (gravity), Increase HGL at Remote PS

Assume required system storage at booster PS(MG)= 0 5
C= 120

Mainline (Gravity)

Vary Ground Profile for Pressure Class Categories

Max Capacity, Q = 14 MGD

Initial Phase, Q = 9.9 MGD

	Junct	El (ft)	Dia (in)	Pipe Length (ft)	150 psi Node El (ft)	200 psi Node El (ft)	250 psi Node El (ft)	300 psi Node El (ft)	Sum Length ft)	Full ΔQ (mgd)	Full Q (mgd)	Full v(fps)	HL (ft)	HGL (ft)	Press Head (psi)	Base (Ult) ΔQ (mgd)	Base (Ultimate) Q (mgd)	Base (Ult) v(fps)	HL (ft)	HGL (ft)	Press Head (psi)	Pipe Pressure Class
	Reservoir (WTP)	1380			1727	1842	1958	2073	0		14 00			1380			9 87					
Can reroute around hills	High Point	1398	36	591	1745	1860	1976	2091	591	0 00	14 00	3 07	0 56	1379 4	-8 0	0 000	9 867	2 16	0 71	1379 29	-8 10	100
→	High Point	1385	36	2805	1732	1847	1963	2078	3395	0 00	14 00	3 07	2 66	1376 8	-3 6	0 000	9 867	2 16	3 38	1375 90	-3 94	100
	Curtis Bremer Feed	1310	36	8877	1657	1772	1888	2003	12272	0 23	13 77	3 02	8 18	1368 6	25 4	0 094	9 773	2 14	10 52	1365 38	23 98	100
	High Point	1321	36	7369	1668	1783	1899	2014	19642	0 00	13 77	3 02	6 79	1361 8	17 7	0 000	9 773	2 14	8 74	1356 64	15 43	100
	CISD School Feed	1299	36	4658	1646	1761	1877	1992	24299	0 09	13 68	3 00	4 24	1357 6	25 4	0 047	9 726	2 13	5 47	1351 17	22 59	100
	High Point	1320	36	2206	1667	1782	1898	2013	26506	0 00	13 68	3 00	2 01	1355 6	15 4	0 000	9 726	2 13	2 59	1348 58	12 37	100
	Apex Feed	1205	33	15536	1552	1667	1783	1898	42042	0 32	13 36	3 49	20 67	1334 9	56 2	0 187	9 539	2 49	17 61	1330 96	54 54	100
	Craig Elbel, Double J	1137	30	2060	1484	1599	1715	1830	44101	1 26	12 10	3 82	3 63	1331 3	84 1	0 744	8 795	2 78	2 01	1328 96	83 12	100
	CISD School Feed	1160	30	2073	1507	1622	1738	1853	46175	0 09	12 01	3 79	3 60	1327 7	72 6	0 047	8 748	2 76	2 00	1326 95	72 29	100
Can easily reroute to EL1280	Remote Pump Sta	1290	30	6993	1637	1752	1868	1983	53168	0 00	12 01	3 79	12 14	1315 5	**11.1**	0 000	8 748	2 76	6 75	1320 20	**13.08**	100
→				53168					ft													
				10 1					mi													

Pump from remote pump station to BMWD and Boerne (same as Alt. 1 from remote pump station to Boerne and BMWD)

Max Capacity, Q = 14 MGD

Initial Phase, Q = 9.9 MGD

	Junct	El (ft)	Dia (in)	Pipe Length (ft)	150 psi Node El (ft)	200 psi Node El (ft)	250 psi Node El (ft)	300 psi Node El (ft)	Sum Length ft)	Full ΔQ (mgd)	Full Q (mgd)	Full v(fps)	HL (ft)	HGL (ft)	Press Head (psi)	Base (Ult) ΔQ (mgd)	Base (Ultimate) Q (mgd)	Base (Ult) v(fps)	HL (ft)	HGL (ft)	Press Head (psi)	Pipe Pressure Class
	Remote Pump Sta	1290			1637	1752	1868	1983	53168		12 01			1811 8			8 75			1689 7		
	High Point	1321	30	3292	1668	1783	1899	2014	56460	0 00	12 01	3 79	0 00	1806 1	210 0	0 000	8 75	2 80		1686 6	158 3	250
	CISD School Feed	1165	30	16693	1512	1627	1743	1858	73152	0 09	12 01	3 79	28 8	1777 3	265 1	0 047	8 75	2 80	16 1	1670 5	218 9	300
	Low Point	1119	24	2523	1466	1581	1697	1812	75675	0 00	9 55	4 71	8 5	1768 8	281 4	0 000	6 33	3 20	4 0	1666 5	237 1	300
	Low Point	1177	24	8884	1524	1639	1755	1870	84559	0 00	9 55	4 71	29 7	1739 1	243 4	0 000	6 33	3 20	14 4	1652 1	205 7	250
	High Point	1279	24	7488	1626	1741	1857	1972	92048	0 00	9 55	4 71	25 0	1714 1	188 4	0 000	6 33	3 20	12 2	1639 9	156 3	200
	Murcia Feed (low poin	1247	24	16678	1594	1709	1825	1940	108725	0 75	9 55	4 71	55 8	1658 3	178 1	0 206	6 33	3 20	27 0	1612 9	158 4	200
	High Point	1329	24	7157	1676	1791	1907	2022	115882	0 00	8 80	4 34	20 6	1637 7	133 7	0 000	6 13	3 10	11 0	1601 9	118 2	150
	Cordillera Feed (low p	1280	24	5937	1627	1742	1858	1973	121820	1 45	8 80	4 34	17 0	1620 7	147 5	0 937	6 13	3 10	9 0	1592 9	135 5	150
	Fair Oaks Feed	1260	20	15509	1607	1722	1838	1953	137329	1 80	7 36	5 23	77 8	1542 9	122 5	1 312	5 19	3 80	42 6	1550 3	125 7	150
	High Point	1416	20	18070	1763	1878	1994	2109	155399	0 64	5 55	3 94	53 8	1489 1	31 7	0 094	3 88	2 80	29 4	1520 9	45 4	100
	Boerne Feed	1405	20	5038	1752	1867	1983	2098	160437	2 21	4 91	3 49	11 9	1477 2	31 3	1 744	3 78	2 80	7 8	1513 1	46 8	100
	Tapatio/Kendall Co U	1405	18	134	1752	1867	1983	2098	160571	1 00	2 70	2 36	0 2	1477 0	31 2	0 469	2 04	1 90	0 2	1512 9	46 7	100
SAWS →	SAWS Feed	1450	18	2827	1797	1912	2028	2143	163398	1 70	1 70	1 49	1 6	1475 4	11 0	1 699	1 57	1 50	1 5	1511 4	26 6	100
	Bulverde Hills	1080	14	6423	1427	1542	1658	1773	169821	0 32	2 37	3 44	22 5	1754 8	292 2	0 189	2 37	3 20	20 2	1650 3	246 9	300
	Low Point	1061	14	4853	1408	1523	1639	1754	174674	0 00	2 05	2 97	12 9	1741 9	294 8	0 000	2 18	3 00	12 9	1637 4	249 6	300
	SARA Feed	1185	14	16149	1532	1647	1763	1878	190823	0 05	2 05	2 97	43 2	1698 7	222 4	0 047	2 18	3 00	43 2	1594 2	177 2	250
BMWD →	Bexar MWD Feed	1320	14	3018	1667	1782	1898	2013	193841	2 00	2 00	2 91	7 7	1691 0	160 6	2 004	2 13	2 90	7 7	1586 5	115 4	200
				140673					ft				417 0						259 2			
				26 6					mi													

ALT 2P-B *GRAVITY CONVEYANCE FROM WTP TO WEST OF RD 281 ALONG RD 46 TO REMOTE PUMP STATION, PUMP TO BOERNE AND BMWD*

Assume required system storage at booster PS(MG)= 0.5
C= 120
Adding Booster PS @ WTP, Add'l Head (ft)= 45

Mainline (Gravity)

						Max Capacity, Q = 14 MGD					Initial Phase, Q = 9.9 MGD						Full Capacity
	Junct	El (ft)	Dia (in)	Pipe Length (ft)	Sum Length ft)	Full ΔQ (mgd)	Full Q (mgd)	Full v(fps)	HL (ft)	HGL (ft)	Press Head (psi)	Base (Ult) ΔQ (mgd)	Base (Ultimate) Q (mgd)	Base (Ult.) v(fps)	HL (ft)	HGL (ft)	Press Head (psi)	Pipe Pressure Class
	Reservoir (WTP)	1380			0		14 00			1425			9 87			1380 00		
Can reroute around hills →	High Point	1398	30	591	591	0 00	14 00	4 42	1 36	1423 6	11 1							
→	High Point	1385	30	2805	3395	0.00	14 00	4 42	6 47	1417.2	13 9	0 000	9 867	3 12	0 71	1379 29	-8.10	100
	Curtis Bremer Feed	1310	30	8877	12272	0 23	13 77	4 35	19 85	1397.3	37.8	0 000	9 867	3 12	3 38	1375 90	-3 94	100
	High Point	1321	30	7369	19642	0 00	13 77	4.35	16 48	1380 8	25.9	0 094	9.773	3.09	10.52	1365 38	23 98	100
	CISD School Feed	1299	30	4658	24299	0 09	13 68	4 32	10 29	1370 6	31 0	0.000	9.773	3 09	8 74	1356 64	15 43	100
	High Point	1320	30	2206	26506	0 00	13 68	4 32	4 87	1365 7	19.8	0 047	9.726	3.07	5 47	1351 17	22 59	100
	Apex Feed	1205	30	15536	42042	0 32	13 36	4 22	32 86	1332 8	55 3	0.000	9.726	3 07	2 59	1348.58	12 37	100
	Craig Elbel, Double J	1137	30	2060	44101	1 26	12.10	3 82	3 63	1329 2	83 2	0 187	9 539	3 01	17 61	1330 96	54.54	100
Can easily reroute to EL1280 →	CISD School Feed	1160	30	2073	46175	0 09	12 01	3 79	3 60	1325.6	71 7	0.744	8 795	2 78	2 01	1328 96	83.12	100
	Remote Pump Sta	1290	30	6993	53168	0 00	12.01	3.79	12.14	1313 5	**10.2**	0.047	8.748	2 76	2.00	1326 95	72 29	100
				53168 ft								0.000	8.748	2 76	6 75	1320 20	**13.08**	100
				10 1 mi														

Pump from remote pump station to BMWD and Boerne (same as Alt. 1 from remote pump station to Boerne and BMWD)

						Max Capacity, Q = 14 MGD					Initial Phase, Q = 9.9 MGD						Full Capacity
	Junct	El (ft)	Dia (in)	Pipe Length (ft)	Sum Length ft)	Full ΔQ (mgd)	Full Q (mgd)	Full v(fps)	HL (ft)	HGL (ft)	Press Head (psi)	Base (Ult) ΔQ (mgd)	Base (Ultimate) Q (mgd)	Base (Ult.) v(fps)	HL (ft)	HGL (ft)	Press Head (psi)	Pipe Pressure Class
	Remote Pump Sta	1290			53168		12 01			1811 8			8 75			1689 7		
	High Point	1321	30	3292	56460	0 00	12 01	3 79	0 00	1806 1	210 0	0 000	8.75	2.80		1686 6	158 3	250
	CISD School Feed	1165	30	16693	73152	0 09	12 01	3 79	28 8	1777.3	265.1	0.047	8 75	2.80	16 1	1670 5	218 9	300
	Low Point	1119	24	2523	75675	0 00	9 55	4 71	8 5	1768.8	281.4	0.000	6.33	3.20	4.0	1666 5	237.1	300
	Low Point	1177	24	8884	84559	0 00	9 55	4 71	29.7	1739.1	243.4	0.000	6 33	3 20	14 4	1652.1	205.7	250
	High Point	1279	24	7488	92048	0 00	9 55	4 71	25.0	1714.1	188.4	0.000	6 33	3.20	12.2	1639 9	156 3	200
	Murcia Feed (low point	1247	24	16678	108725	0.75	9.55	4.71	55 8	1658.3	178 1	0 206	6 33	3 20	27 0	1612 9	158 4	200
	High Point	1329	24	7157	115882	0 00	8 80	4 34	20 6	1637.7	133.7	0 000	6 13	3 10	11 0	1601 9	118 2	150
	Cordillera Feed (low p	1280	24	5937	121820	1 45	8 80	4 34	17.0	1620 7	147 5	0.937	6 13	3 10	9 0	1592 9	135.5	150
	Fair Oaks Feed	1260	20	15509	137329	1 80	7 36	5 23	77 8	1542.9	122 5	1.312	5 19	3 80	42 6	1550 3	125 7	150
	High Point	1416	20	18070	155399	0 64	5 55	3 94	53 8	1489.1	31 7	0.094	3.88	2 80	29 4	1520 9	45 4	100
	Boerne Feed	1405	20	5038	160437	2 21	4 91	3 49	11 9	1477.2	31.3	1.744	3.78	2 80	7 8	1513 1	46 8	100
	Tapatio/Kendall Co Ut	1405	18	134	160571	1 00	2 70	2 36	0 2	1477 0	31 2	0 469	2 04	1 90	0 2	1512 9	46 7	100
SAWS →	SAWS Feed	1450	18	2827	163398	1 70	1 70	1 49	1 6	1475 4	11 0	1 699	1 57	1 50	1 5	1511 4	26 6	100
	Bulverde Hills	1080	14	6423	169821	0 32	2.37	3 44	22 5	1754 8	292 2	0 189	2.37	3 20	20 2	1650 3	246 9	300
	Low Point	1061	14	4853	174674	0 00	2 05	2 97	12 9	1741 9	294 8	0 000	2.18	3.00	12 9	1637 4	249 6	300
	SARA Feed	1185	14	16149	190823	0 05	2 05	2 97	43 2	1698 7	222 4	0 047	2 18	3 00	43 2	1594 2	177 2	250
BMWD →	Bexar MWD Feed	1320	14	3018	193841	2 00	2 00	2 91	7.7	1691 0	160 6	2 004	2 13	2 90	7.7	1586 5	115 4	200
				140673 ft					417 0						259 2			
				26 6 mi														

GBRA REGIONAL WATER SUPPLY SYSTEM
REQUESTED WATER SUPPLY AND AMOUNT AVAILABLE

*Phasing Scenario - Max Capacity of Base Condition**

15,683 **14.00** **mgd**

Entity	Build Out Delivery			
	Build Out		*Phase 1-'Ultimate' Demand*	
	Annual Ave (acft/yr)	*Ave* (mgd)	*Annual Ave* (acft/yr)	*Max* (mgd)
IN-DISTRICT				
City of Boerne	2,481	2.21	1,954	1.74
City of Fair Oaks	2,020	1.80	1,470	1.31
Comal Independent School District	305	0.27	158	0.14
Apex Water Services	355	0.32	210	0.19
Bulverde Utility Corporation (absorbed by Bexar Met.)	357	0.32	212	0.19
Murcia Development Co.	840	0.75	231	0.21
Lost Owl (Comal Water Co.)	199	0.18	46	0.04
Clyde Johnson	555	0.50	420	0.37
Double J. Ranch	405	0.36	263	0.23
Cordillera	1,620	1.45	1,050	0.94
Tapatio Springs/Kendall Co. Utility Co.	1,120	1.00	525	0.47
Curtis Bremer	255	0.23	105	0.09
Kendall Properties	720	0.64	105	0.09
Inland Estates (1)	53	0.05	53	0.05
Craig Elbel	255	0.23	105	0.09
Blanco, City of	-	-	-	-
Dominion Advisory Group, Inc.	-	-	-	-
SUBTOTAL (transmission pipeline)	**11,483**	**10.25**	**6,853**	**6.12**
OUT-OF-DISTRICT				
San Antonio River Authority	53	0.05	53	0.05
San Antonio Water System	1,903	1.70	1,903	1.70
Bexar Metropolitan Water District	2,244	2.00	2,244	2.00
SUBTOTAL (transmission pipeline)	**4,200**	**3.75**	**4,200**	**3.75**
TOTAL IN AND OUT OF DISTRICT (transmission pipeline)	**15,683**	**14.00**	**11,053**	**9.87**

VALUES INPUT TO MODEL

Node	Reference Pt	Demand (mgd)
J-1	Reservoir (WTP)	14 000
J-10	Craig Elbel, Double J Ranch, Clyde Johnson, Lost Owl	1.262
J-11	CISD School Feed	0.091
J-12	High Point	0.000
J-13	Low Point	0 000
J-14	High Point	0.000
J-15	Murcia Feed (low point)	0 749
J-16	High Point	0.000
J-17	Cordillera Feed (low point)	1 446
J-18	Fair Oaks Feed	1.803
J-19	High Point (Kendall Prop)	0 642
J-2	SAWS Feed	1 699
J-20	Boerne Feed	2 214
J-21	Tapatio/Kendall Co Utility Co	0 999
J-22	Bulverde Hills	0 319
J-23	Low Point	0 000
J-24	SARA Feed	0.047
J-25	High Point	0.000
J-26	High Point	0 000
J-27	High Point	0 000
J-28	Low Point	0 000
J-3	CISD School Feed	0 091
J-4	Bexar MWD Feed	2.004
J-5	Flow Control Element	-14 000
J-6	High Point	0 000
J-7	Curtis Bremer Feed	0 228
J-8	Apex Feed	0 317
J-9	CISD School Feed	0 091
		14 000

Notes

* Demands in addition to the base case ultimate demand scenario were distributed by proportioning feed locations west of the junction to Boerne by 75% and east of the junction by 25%

(1) Inland Estates water would probably not be delivered through high svc PS or transmission pipeline due to close proximity to treatment plant Thus, the delivery quantity is not include

GBRA REGIONAL WATER SUPPLY SYSTEM
REQUESTED WATER SUPPLY AND AMOUNT AVAILABLE

Entity	Requested Commitment Delivery				Design Condition			
	Ultimate		Initial		Initial		Ultimate	
	Annual Ave (acft/yr)	Ave [1] (mgd)	Annual Ave (acft/yr)	Ave [1] (mgd)	Annual Ave (acft/yr)	Ave [1] (mgd)	Annual Ave (acft/yr)	Ave [1] (mgd)
IN-DISTRICT								
City of Boerne	1,861	1.74	500	0.47	500	0.47	1,861	1.74
City of Fair Oaks	1,400	1.31	800	0.75	800	0.75	1,400	1.31
Comal Independent School District	150	0.14	150	0.14	150	0.14	150	0.14
Apex Water Services	200	0.19	100	0.09	100	0.09	200	0.19
Bulverde Utility Corporation (absorbed by Bexar Met.)	202	0.19	202	0.19	202	0.19	202	0.19
Murcia Development Co.	220	0.21	100	0.09	100	0.09	220	0.21
Lost Owl (Comal Water Co.)	44	0.04	5	0.00	5	0.00	44	0.04
Clyde Johnson	400	0.37	100	0.09	100	0.09	400	0.37
Double J. Ranch	250	0.23	100	0.09	100	0.09	250	0.23
Cordillera	1,000	0.94	400	0.37	400	0.37	1,000	0.94
Tapatio Springs/Kendall Co. Utility Co.	500	0.47	150	0.14	150	0.14	500	0.47
Curtis Bremer	100	0.09	0	0.00	0	0.00	100	0.09
Kendall Properties	100	0.09	0	0.00	0	0.00	100	0.09
Inland Estates [2]	50	0.05	50	0.05	50	0.05	50	0.05
Craig Elbel	100	0.09	0	0.00	0	0.00	100	0.09
Blanco, City of	-	-	0	0.00	0	0.00	-	-
Dominion Advisory Group, Inc.	-	-	0	0.00	0	0.00	-	-
SUBTOTAL (transmission pipeline)	**6,527**	**6.12**	**2,607**	**2.44**	**2,607**	**2.44**	**6,527**	**6.12**
OUT-OF-DISTRICT								
San Antonio River Authority	50	0.05	50	0.05	50	0.05	50	0.05
San Antonio Water System	1,813	1.70	1,813	1.70	4,654	4.36	1,813	1.70
Bexar Metropolitan Water District	2,138	2.00	2,138	2.00	3,216	3.01	2,138	2.00
SUBTOTAL (transmission pipeline)	**4,000**	**3.75**	**4,000**	**3.75**	**7,920**	**7.42**	**4,000**	**3.75**
TOTAL IN AND OUT OF DISTRICT (transmission pipeline)	**10,527**	**9.87**	**6,607**	**6.19**	**10,527**	**9.87**	**10,527**	**9.87**

Notes

[1] Demand values reported in mgd include additional consideration for 5% system losses expected

Appendix B
Technical Memorandum No. 2

To: File: 07081-033-036

From: Christianne Gaylord
(Registered in California, C57977)

Date: February 3, 2000 (Revised May 23, 2000)

HDR

Technical Memorandum

Subject: **Guadalupe-Blanco River Authority Regional Water System**
For Portions of Comal, Kendall, and Bexar Counties
HDR Project No. 07081-033-036
Technical Memorandum No. 2
Determination of Maximum Pipe Pressure Class

Purpose

The purpose of this technical memorandum (TM) is to supplement previous hydraulic analysis of design alternatives evaluated for the Guadalupe-Blanco River Authority (GBRA) Regional Water System for portions of Comal, Kendall, and Bexar Counties. In response to concerns raised during Milestone Meeting No. 1, the maximum pipe pressure class criteria for the mainline of the system has been evaluated further to establish the optimum pressure class for the hydraulic design alternatives. Evaluation includes a comparison of the differential probable costs for the alternative pipeline and pumping station scenarios presented in TM No. 1, *Water Delivery System Hydraulic Design and Expansion Alternatives*, for a phased project expansion.

Basis of Analysis

This analysis is intended to supplement previous analyses presented in TM No. 1 and utilizes the following basic information:

- Preliminary Pipeline Route
- Ground Profile
- System Demand Distribution and Phasing Distribution
- Basic Hydraulic Design Alternatives
  Alternative 1 – Pump to all delivery points.
  Alternative 2 – Pressurized gravity from WTP to remote pump station. Pump to downstream delivery points.
- Phased Project Equivalent Pipe Sizing
- Hazen-Williams Friction Coefficient of 120.

Refer to TM No. 1 for a detailed description of the above information. TM No. 2 serves to further evaluate the hydraulic criteria presented in TM No.1, specifically the set maximum pressure within the transfer piping. The maximum value was previously set at 300 psi. The analysis described herein evaluates piping and pumping options for reduced maximum pressures, and details the additional facilities required to accomplish phased project capacity expansion.

Phasing Options for Future Capacity Expansion

In TM No. 1, hydraulic design Alternatives 1 and 2 were evaluated to investigate the potential for expansion of the project facilities to deliver water that may be made available by maximizing capacity of the system. The most feasible expansion options have been evaluated further for the purposes of this TM and include the following:

Alternative 1 - Phased

- **ALT 1P-A**. Increase capacity and head of high service pump station at WTP and pressure class of pipelines.

Alternative 2 - Phased

- **ALT 2P-A**. Increase pipe size in gravity line from WTP to remote PS, increase capacity of remote PS.

Methodology for Evaluation of Preferred Maximum Pipe Pressure Class

The methodology for determination of the preferred maximum pipe pressure class consisted of utilizing the hydraulic grade lines (HGLs) developed in the previous analysis. Since the piping diameters and flows for each phased alternative remain unchanged, the slope of the HGL also remains the same. For simplicity, graphical analysis using the resulting HGLs was conducted to provide a quick, yet reasonable, comparison between the alternatives for varying maximum pipe pressure classes.

The HGL required for each maximum pipe pressure class condition was mapped to provide a minimum working pressure of 10 psi at any point in the line, requiring addition of a booster pump station once the minimum pressure is reached midway through the pipeline. The maximum pipe pressure class values evaluated include the following:

- 300 psi maximum pressure,
- 250 psi maximum pressure,
- 200 psi maximum pressure, and
- Maximum pressures equal or less than 150 psi.

The resulting HGL profiles for the 150 psi, 200 psi, and 250 psi maximum pressure class requirements have been graphed with the resulting 300 psi HGL from TM No. 1 for reference in Figures 1-6 from the WTP to SAWS and in Figures 7-12 from the Boerne junction to BMWD.

Required Piping Lengths

The required piping lengths for each maximum pressure class requirement were evaluated directly from the HGL profiles. Since this graphic methodology varies distinctly from the spreadsheet calculation methodology used in TM No.1, the resulting distances are not equivalent. In fact, since only the extreme high and low ground points were used to create the HGL profiles, estimation of required pressure class by graphical methods results in an averaged value, rather than the maximum estimated value predicted from TM No. 1 spreadsheet calculations. However, for the purposes of this comparison, the 300 psi pressure class maximum originally evaluated in TM No. 1 was estimated graphically to produce an averaged value comparable to the remaining

analyses. The resulting measured lengths are tabulated for each size of pipe and corresponding pressure class in Table 1, *Summary of Required Piping – Maximum Pressure Class Evaluation.*

TABLE 1 *– Summary of Required Piping – Maximum Pressure Class Evaluation*

	ALT 1P-A				ALT 2P-A			
	Max. Pressure Class[1] (psi)				Max. Pressure Class[1] (psi)			
	150 psi	200 psi	250 psi	300 psi	150 psi	200 psi	250 psi	300 psi
Pipe length, ft (p<150psi)	193841	137689	75841	50898	193841	147341	125841	103398
Pipe length, ft (150<p<200psi)	0	56152	73000	23943	0	38500	35500	24443
Pipe length, ft (200<p<250psi)	0	0	45000	57500	0	8000	24500	28500
Pipe length, ft (250<p<300psi)	0	0	0	61500	0	0	8000	37500

[1] Represents maximum pressure class in main pipeline and does not include branch to BMWD.

Required Pumping Facilities

The required pumping facilities for each phased hydraulic design alternative were evaluated. The resulting pumping requirements associated with each maximum pressure class requirement for each alternative is summarized in Table 2, *Summary of Pumping Requirements – Maximum Pressure Class Evaluation.*

TABLE 2 *– Summary of Pumping Requirements – Maximum Pressure Class Evaluation*

	ALT 1P-A				ALT 2P-A			
	Max. Pressure Class[1] (psi)				Max. Pressure Class[1] (psi)			
	150 psi	200 psi	250 psi	300 psi	150 psi	200 psi	250 psi	300 psi
No. of Req'd PS	3	2	2	1	3	2	2	1
PS_1 hp	680	1050	1440	1910	630	990	1350	1570
PS_2 hp	840	490	290	-	900	480	250	-
PS_3 hp	20	-	-	-	100	-	-	-

[1] Represents maximum pressure class in main pipeline and does not include branch to BMWD.

Required System Storage
Because it is a unique component of some hydraulic design alternatives evaluated, the additional storage that may be required at remote pumping facilities was considered. For all practical purposes, the minimum storage needed at a remote pumping facility was assumed as 0.5 million gallons.

Relative Cost Comparison of Alternatives
Costs for facilities and O&M required for each alternative were evaluated to provide a cost comparison between alternatives.

Cost Basis
For the purpose of this comparison, only unique components were evaluated for cost, not including all common components. The resulting cost value is useful for determining the relative difference between alternatives and should in no way be construed as total for any alternative.

The cost comparison included consideration for the following unique components:

- Transmission pipelines
- WTP/Remote Booster Pump Stations
- System Storage
- Electrical Feed
- Additional Land Acquisition (Remote PS and Storage Tank)
- Pumping Costs
- Operation and Maintenance for Pump Stations, Transmission and Storage Facilities

The cost comparison does not include the following common components:

- Intake
- WTP
- RW Pipeline
- Interconnects
- Equilization Tank
- Environmental Studies and Mitigation
- Land ROW Cost
- Engineering and Financing Costs

The resulting costs for each maximum pressure class requirement for each evaluated alternative is listed in Table 3, *Preliminary Estimate of Costs – Maximum Pressure Class Evaluation.*

***TABLE 3** – Preliminary Estimate of Costs – Maximum Pressure Class Evaluation*

PRELIMINARY ESTIMATE OF COSTS [1]

	ALT 1P-A				ALT 2P-A			
Basis of Comparison	**150 psi Max**	**200 psi Max**	**250 psi Max**	**300 psi Max**	**150 psi Max**	**200 psi Max**	**250 psi Max**	**300 psi Max**
Capital Costs								
Transmission Pipelines[2]	$ 14,225,000	$ 14,746,000	$ 15,889,000	$ 17,754,000	$ 15,199,000	$ 15,641,000	$ 16,184,000	$ 17,031,000
WTP Pump Station	$ 991,000	$ 1,425,000	$ 1,861,000	$ 2,385,000	-	-	-	-
Booster Pump Station 1	$ 1,180,000	$ 766,000	$ 558,000	-	$ 932,000	$ 1,358,000	$ 1,760,000	$ 2,006,000
Booster Pump Station 2	$ 558,000	-	-	-	$ 1,251,000	$ 754,000	$ 558,000	-
Booster Pump Station 3	-	-	-	-	$ 558,000	-	-	-
System Storage	$ 799,000	$ 399,000	$ 399,000	$ -	$ 1,198,000	$ 799,000	$ 799,000	$ 399,000
Electrical Feed	$ 193,000	$ 193,000	$ 216,000	$ 239,000	$ 204,000	$ 184,000	$ 200,000	$ 196,000
Total Capital Cost [3]	$ 17,946,000	$ 17,529,000	$ 18,923,000	$ 20,378,000	$ 19,342,000	$ 18,736,000	$ 19,501,000	$ 19,632,000
Add'l Land Acquisition (PS and Storage Tank)	$ 14,000	$ 7,000	$ 7,000	$ -	$ 20,000	$ 14,000	$ 14,000	$ 7,000
Total Project Cost [3]	$ 17,960,000	$ 17,536,000	$ 18,930,000	$ 20,378,000	$ 19,362,000	$ 18,750,000	$ 19,515,000	$ 19,639,000
Annual O&M Costs								
Annual Debt Service *(Assuming 25 years, efective interest rate of 6.5%)*	$ 1,473,000	$ 1,438,000	$ 1,552,000	$ 1,671,000	$ 1,588,000	$ 1,538,000	$ 1,600,000	$ 1,610,000
Pumping Costs	$ 808,000	$ 809,000	$ 902,000	$ 999,000	$ 849,000	$ 772,000	$ 837,000	$ 820,000
Operation and Maintenance [4]								
Pump Station	$ 68,000	$ 55,000	$ 60,000	$ 60,000	$ 69,000	$ 53,000	$ 58,000	$ 50,000
Transmission Facilities	$ 142,000	$ 147,000	$ 159,000	$ 178,000	$ 152,000	$ 156,000	$ 162,000	$ 170,000
Storage Facilities	$ 8,000	$ 4,000	$ 4,000	$ -	$ 12,000	$ 8,000	$ 8,000	$ 4,000
	$ 1,026,000	$ 1,015,000	$ 1,125,000	$ 1,237,000	$ 1,082,000	$ 989,000	$ 1,065,000	$ 1,044,000
Total Annual Cost [3]	$ 2,499,000	$ 2,453,000	$ 2,677,000	$ 2,908,000	$ 2,670,000	$ 2,527,000	$ 2,665,000	$ 2,654,000

[1] Costs are developed for purposes of preliminary evaluation and include only those costs that vary between the alternatives. Thus, the costs should not be taken as final estimates for any alternative. Maximum pressures represent max pressures in main pipeline, not including branch to BMWD. For comparison purposes, costs are based on a Phased Project production of 15,683 acft/yr (14 mgd) - the maximum capacity of Alternative 1.

[2] Lengths obtained by graphical analysis of hydraulic profile using only a limited number of ground points for reference. This methodology was applied for comparative analysis only. Actual piping lengths will vary in design.

[3] Items not included for cost comparison due to equivalence between alternatives include: Intake, Intake Pump Station and Water Treatment Plant, Interconnects to all participants, Equilization Tank near Boerne/SAWS Delivery Point, Environmental Studies

[4] O&M costs assume 1% of the total capital costs of pipelines and tanks; 2.5% of the total capital cost of pump stations.

Conclusion

The results of this analysis indicate that there exists an optimum maximum pressure class at which both piping and pumping requirements are optimized for cost savings. For both hydraulic design alternatives, under full capacity expansion, the maximum pressure class requirement of 200 psi proves to be preferable on a cost basis.

Comparing the 200 psi maximum pressure class of both alternatives, ALT 1P-A and ALT 2P-A, indicates ALT 1P-A – pumped delivery to all customers- to be most preferable. Although the O&M costs for ALT 1P-A exceed those associated with partial pressurized gravity conveyance of ALT 2P-A, the cost savings is obtained from the capital cost of transmission facilities for the smaller diameter piping required for ALT 1P-A.