

**SUMMARY REPORT**

**WASTEWATER  
REUSE FEASIBILITY PROJECT**

**TEXAS WATER DEVELOPMENT BOARD**

**AND**

**CITY OF SWEETWATER, TEXAS**

TWDB CONTRACT NO. 91-483-592

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## TECHNICAL MEMORANDA

- TM-1 Project Definition and Baseline Data
- TM-2 Water Reclamation Evaluation and Selection
- TM-3 Recommended Plan

CITY OF SWEETWATER  
WASTEWATER REUSE FEASIBILITY STUDY

EXECUTIVE SUMMARY

The City of Sweetwater needs additional water to supply the needs of its residents and its contractual customers. This study examines the feasibility of meeting a part of the need for water by reclaiming treated effluent from the Sweetwater Wastewater Treatment Plant. The reclaimed effluent would be used as process water by the City's two largest industries, United States Gypsum Co. and Lone Star Energy Co.

To meet the needs of the proposed industrial users, reclaimed water must be similar in quality to the potable water they currently use. Six alternative processes were identified and evaluated on the basis of their ability to produce water of acceptable quality at a reasonable cost. Bench scale test results were considered in selecting three promising alternatives for preliminary design and cost analysis.

The recommended alternative involves separation of two waste brine streams produced by the Lone Star Energy plant from the main wastewater stream. The remaining domestic wastewater will be treated with a coagulant which causes suspended solids to adhere and settle from the water. The water will then be filtered.

This process of brine separation/coagulation/filtration is the simplest and least expensive of the three alternatives for which a cost analysis was prepared. It produces a water which approaches potable

water quality but is still relatively high in total dissolved solids (TDS) and total organic carbon (TOC).

Both industries have expressed concern regarding the effects of these parameters on their operations. The initial analysis indicates that the impact of TDS and TOC can be adequately addressed to produce a water suitable for the intended uses. The primary concern is the effect of high TOC concentrations on the process water pretreatment equipment at Lone Star Energy's plant. To further assess this situation, a pilot plant incorporating the same processes from the recommended alternative and using the same brand and type of reverse osmosis membrane in use at the cogeneration plant is proposed in the initial phase of the project.

#### WATER DEMAND

The amount of water needed by the industries is a key consideration in the feasibility of the reuse project. Neither industry expects an increase in demand, but Lone Star Energy is considering installing equipment that could considerably reduce its water use. For this reason, the feasibility of the project was tested for both a high-demand and a low-demand scenario.

#### EVALUATION OF FEASIBILITY

Five potential sources of additional water supply for Sweetwater have been considered in two studies within the past five years. Water reuse compares favorably with most of these alternatives and appears to be a good option for increasing the City's water supply.

## LEGAL AND REGULATORY ISSUES

Wastewater reuse involves several legal and regulatory issues. These issues were considered in the study, with the following conclusions:

- o The City should obtain the water rights to its effluent and the title to the land on which the wastewater treatment plant is sited.
- o A water reclamation project would have no impact on the surface water rights of the City or other permit holders.
- o No permits are required for water reclamation, but both the City and the industries using the reclaimed water would have to comply with reporting requirements of the Texas Water Commission.

## RECOMMENDED PLAN

Recommended facilities include:

- o A collection and conveyance system to allow separate handling of the Lone Star Energy waste brine from the domestic wastewater system.
- o Rehabilitation of the existing wastewater treatment plant to achieve a more consistent quality of effluent prior to reuse treatment.
- o Tertiary treatment units including filters, lime storage and feed equipment, rapid mix/flocculation basins, and clarifiers.
- o Reuse water storage and pumping equipment.
- o Modifications at the industry sites to provide for a potable water back-up to the reuse system.

### PRELIMINARY ESTIMATE OF PROBABLE COSTS

Preliminary estimates of probable costs were developed for both scenarios. The estimated capital cost for the high-use scenario was approximately \$3.9 million; for the low-use scenario, \$2.6 million.

### POTENTIAL FINANCING SOURCES

The most likely source of outside financing for the project is the State Revolving Loan Fund administered by the Texas Water Development Board. The project could also be funded through the City's general fund, bonds, or user fees.

### IMPLEMENTATION PLAN

The implementation plan developed for the Sweetwater Reuse Project divides the work into four phases: pilot plant treatability testing, water supply contract negotiations and financing, design and bidding, and construction and start-up. Assuming the first phase begins in early 1993, the project could be on line by the fall of 1995.

### PUBLIC AVAILABILITY OF THE REPORT

A public meeting was held on December 2, 1992 in the City Commission Room at Sweetwater City Hall. No comments were received.

### CONCLUSIONS

- o Water reclamation is feasible from a technical and economic standpoint as a part of the City of Sweetwater's overall approach to meeting its water needs.

- o Reclaimed water is suitable for use by the City's two largest industries, U.S. Gypsum and Lone Star Energy. The study indicates that the industries' concerns regarding high concentrations of TDS and TOC can be resolved. Additional pilot testing is recommended to determine the effects of TOC on the process water pretreatment system at Lone Star Energy's power plant.
  
- o Of the six alternatives considered, a process of brine separation/coagulation/filtration was identified as the most economical alternative capable of producing acceptable water quality.



## 1. PROJECT DEFINITION AND BASELINE DATA

Technical Memorandum No. 1, summarized in this section, defines the purpose of the study and describes existing conditions.

### 1.1 Project Definition

The City of Sweetwater requires 7.02 million gallons of water per day (MGD) to meet the projected future needs of its residents plus those of its numerous contractual customers. Since the city's existing water sources produce a firm yield less than this amount, the City proposes to supplement its supply by reclaiming treated effluent from its wastewater treatment plant. The reclaimed water would be supplied as process water to the city's two largest industries, United States Gypsum Co. and Lone Star Energy Co., which currently use potable water in their processes.

The purpose of this study is to examine the economic, environmental, political, and technical feasibility of water reclamation under these circumstances. The detailed results are presented in three Technical Memoranda; this report summarizes the findings. The study was funded with a 50 percent grant from the Texas Water Development Board and matching funds from the City of Sweetwater.

The goals of this study are to:

1. Determine the difference in water quality between the available effluent and a water that would be acceptable to the industries.
2. Develop and test a treatment process which can achieve acceptable water quality.

3. Develop a preliminary conceptual design with cost estimates and an implementation plan.
4. Develop public support by providing information on project findings and results to an Advisory Committee and the public.

## 1.2 Baseline Data

An assessment of existing conditions included evaluations of the following factors:

Current Potable Water Quality. Twenty-seven water quality parameters are measured periodically at the Sweetwater Water Treatment Plant (WTP) by the Texas Department of Health. In the past three tests levels of dissolved solids have ranged from 381 milligrams per liter (mg/l) to 693 mg/l. Chloride concentrations have ranged from 68 mg/l to 100 mg/l. The water quality varies with the weather and with changes in the mix of surface and ground water.

Historical Water Use. The 1990 average water usage for U.S. Gypsum was 0.28 MGD and 0.53 MGD for Lone Star Energy. Water use at the gypsum plant is relatively consistent throughout the year. Usage at the cogeneration plant is normally higher in the summer.

Wastewater Quality and Availability. The Sweetwater WWTP has a rated capacity of 2 MGD but currently receives only about 1.1 MGD. Apparent metering problems in the past make it difficult to determine accurately how much effluent is being produced by the plant. This situation should be investigated further to find out how much wastewater will be available for reclamation.

Effluent from the Sweetwater WWTP is currently applied to farmland adjacent to the plant. Although limited information is available on the chemical makeup of the effluent, it appears that TDS levels are approximately twice that of the potable water supply.

### 1.3 Legal and Regulatory Issues

The law firm of Lloyd, Gosselink, Fowler, Blevins & Mathews, P.C., studied the legal and regulatory issues involved in the proposed water reclamation.

Water Rights. Two water rights issues have been raised: the rights to the effluent and the effect of wastewater reuse on the surface water rights of the City of Sweetwater and other permit holders.

The WWTP site was granted to the City in exchange for the provision of up to 3.0 MGD of treated effluent for irrigation of the owners' adjacent property. The City must obtain title to the effluent from the current property owner. It may also be desirable to obtain outright title to the WWTP site, which would revert to the former owner if it ceases to be used for wastewater treatment.

The project would have no impact on the surface water rights of the City of Sweetwater or any other permit holders. No amendments or new permits are required.

Permitting and Regulation. Wastewater reclamation in Texas is regulated by the Texas Water Commission (TWC). No permit is required, but the effluent must meet specified limits, and both the City and the

industries must report water quality data to the TWC. The City must also provide the TWC with copies of the contracts between the provider and users.

## 2. WATER RECLAMATION EVALUATION AND SELECTION

Several treatment alternatives for reclamation of effluent from the Sweetwater WWTP were evaluated in Technical Memorandum No. 2, which is summarized below. Evaluations of each alternative were based on the baseline data presented in the previous section and on bench-scale testing. Cost estimates and projections of the anticipated water quality of three selected alternatives were also developed.

### 2.1 Treatment Alternatives

The two industries identified as potential users of the reclaimed water have relatively high water quality standards, particularly for TDS. Excessive TDS or chlorides will reduce the strength of U.S. Gypsum's products and increase water treatment costs at Lone Star Energy's cogeneration plant. Reclaimed water would therefore need to be of similar quality to the potable water currently being supplied to the industries.

For the purpose of evaluating alternatives, it was assumed that the facilities would be designed to produce a maximum flow of approximately 1.2 MGD and to treat an average flow of 0.81 MGD, based on historical water usage by the industries. Lone Star Energy is considering process changes which would significantly lower their water demand; this situation is discussed more fully in the following section and in Technical Memorandum No. 3. Wastewater in excess of the amount required

by the industries would continue to be treated at the existing WWTP and disposed of by irrigation.

Six alternatives were identified for initial screening, based on their compatibility with the existing treatment units and their ease of implementation. The three selected for further evaluation were designated Final Alternatives No. 1, No. 2, and No. 3. Chlorination facilities would be included in any alternative developed.

The initial alternatives considered were:

Filtration Only. Additional filtration of the effluent will improve water quality significantly but not to the level required for the intended uses. This alternative was not considered further.

Brine Separation/Coagulation/Filtration (Final Alternative No. 1). The benefits of filtration can be augmented by the addition of a coagulant followed by flocculation, or slow mixing, and sedimentation to make particles in the effluent adhere and settle. This process reduces turbidity more than filtration alone and produces a water which approaches potable water quality in appearance. However, the water will still have a relatively high concentration of TDS. TDS can be reduced some by softening the water with lime. Additional TDS reduction can be accomplished by diverting the high-TDS brine stream from the Lone Star Energy plant from the main wastewater flow to evaporation ponds. This alternative would produce a final TDS level of 1200 mg/l to 1300 mg/l.

Brine Separation/Coagulation/Filtration/Desalination (Final Alternative No. 2). TDS in the effluent produced by Final Alternative No. 1

can be further reduced by desalination. Several different desalination processes are available which will yield a high quality effluent with a TDS considerably lower than the City's potable water supply. To reduce the expense of treatment, a portion of the available effluent could be desalinated and mixed with filtered effluent to produce water of similar quality to the potable supply.

Coagulation/Filtration/Desalination (Final Alternative No. 3). If desalination is required to achieve the necessary water quality, it may be more cost effective to allow the Lone Star Energy brine stream to remain in the main wastewater stream and desalinate a somewhat larger fraction of the filtered effluent.

Filtration/Membrane Treatment. Some types of desalination equipment may be able to function without upstream coagulation. However, if desalination is limited to a portion of the flow, as described in Final Alternatives 2 and 3, the remaining flow would have a higher turbidity due to the lack of coagulation. In addition, this type of treatment sequence has not been widely used. It was not considered further.

Brine Separation/Coagulation/Filtration/Blending. If the quality achieved without desalination is marginal, the treated effluent could be blended with potable water at the industry sites. This process would produce water of somewhat lesser quality than the unblended potable water and would reduce the usage of reclaimed water. This alternative was not considered further.

## 2.2 Bench-Scale Treatability Testing

Approach. The treatment alternatives involving coagulation/ filtration were evaluated at bench scale using 2-liter jar tests. The primary objective of these tests was to identify primary coagulant and coagulant aid doses that would reduce turbidity and TDS as much as possible. Lime was chosen as the primary coagulant. The coagulant aids tested were alum, ferric sulfate, and a cationic polymer (Catfloc DL).

Test Variables and Results. Five jar tests were conducted to evaluate a range of lime dosages in various combinations with coagulant aids. In general, all lime doses provided excellent floc formation with rapid settling rates. Coagulant aids did not improve TDS or turbidity removal over the test range.

## 2.3 Alternative Comparison

Three alternatives were selected for evaluation and economic comparison. The costs, shown in the table below, are relative and should not be considered estimates of the actual project costs. They do not include allowances for contractor's overhead and profit, engineering, treated water storage, or pumping and transmission.



<u>Alternative</u>	<u>Capital Cost</u>	<u>Annual O&amp;M Cost</u>	<u>Present Worth Cost</u>
1: Brine separation/ coagulation/filtration	\$1,291,000	\$ 70,330	\$2,115,932
2: Brine separation/ coagulation/filtration/ desalination	2,263,300	224,330	4,735,082
3: Coagulation/ filtration/desalination	1,794,400	38,780	4,425,399

Alternative 1: Brine Separation/Coagulation/Filtration. This is the simplest and least expensive alternative, but it will not produce a water comparable in quality to the potable water. The viability of this alternative will depend on the results of pilot testing to demonstrate the suitability of the water for the intended industrial uses. The most serious concern is the presence of organics in the treated water which may have adverse effects on the reverse osmosis membranes used for pretreatment of the process water at the Lone Star Energy plant. To determine whether this is a significant problem, the pilot testing should include a reverse osmosis unit.

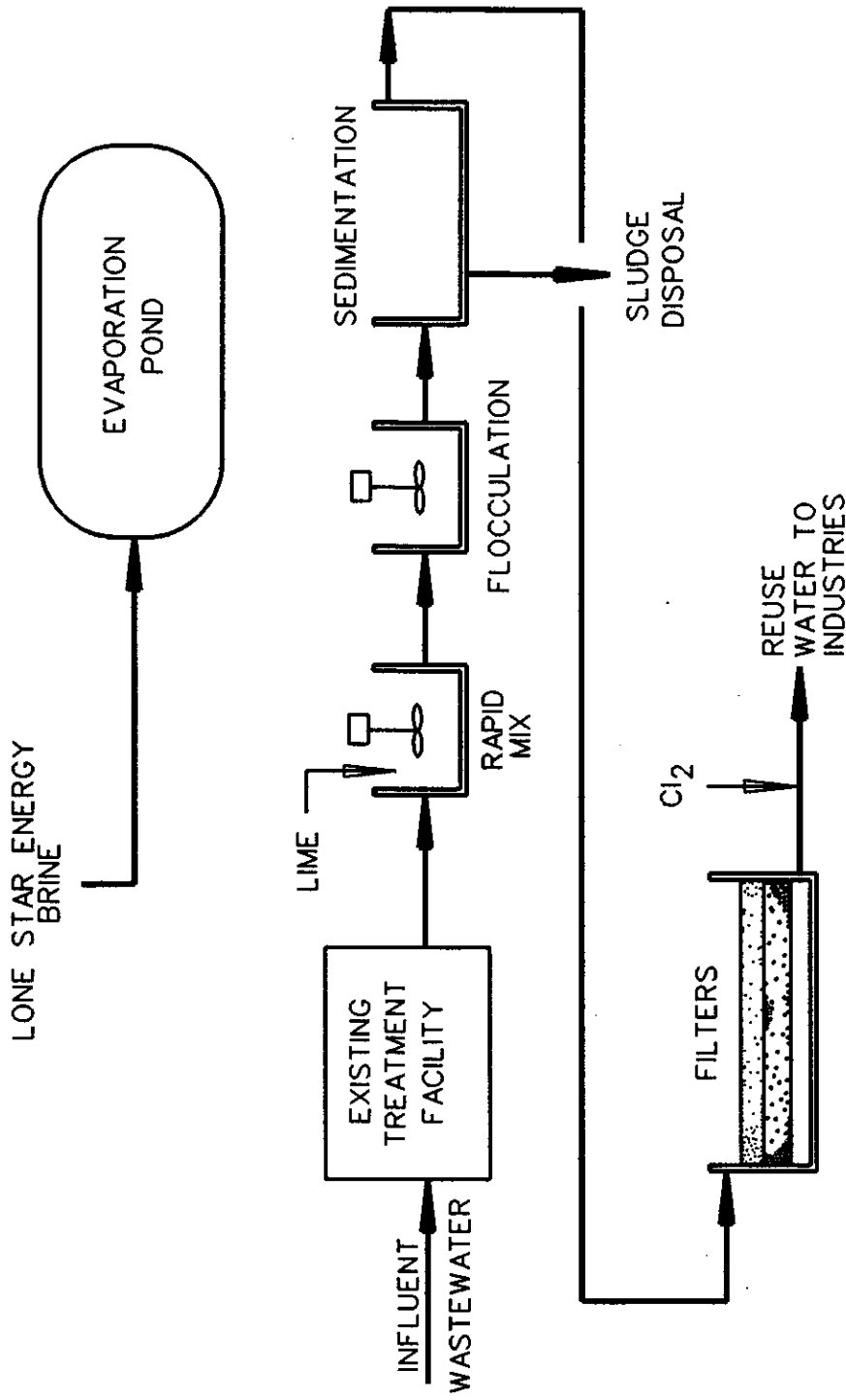
Alternative 2: Brine separation/coagulation/filtration/desalination. By controlling the ratio of demineralized water to filtered effluent, any level of TDS between that of the potable water and that of the filtered effluent may be obtained. Costs have been developed based on a TDS level of approximately 700 mg/l.

Alternative 3: Coagulation/Filtration/Desalination. The quality of water produced by this alternative is essentially the same as for

Alternative 2. Its cost appears to be lower because the area needed for brine evaporation ponds is smaller.

#### 2.4 Recommended Alternative

Alternative 1, shown in the schematic in Figure 2.1, is recommended for further study. This alternative is less expensive and is operationally similar to processes currently used at the City's water treatment plant. Desalination, included in the other alternatives, represents a significant increase in complexity which should be avoided if possible. Although the anticipated water quality produced by this system is lower than that of the City's potable water, it appears to be suitable for the industries' use if the concern about its effects on the reverse osmosis membranes at the Lone Star Energy plant can be adequately addressed.



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CITY OF SWEETWATER, TEXAS  
 WASTEWATER TREATMENT PLANT  
 PROCESS SCHEMATIC FOR  
 WASTEWATER REUSE FEASIBILITY STUDY

Freese  
 AND  
 Nichols, INC.  
 CONSULTING ENGINEERS

FIGURE 2.1

### 3. RECOMMENDED PLAN

Technical Memorandum No. 3, summarized in this section, describes the conceptual design for the recommended facilities. Also included are a summary of the identified environmental concerns and the corresponding permits and agency reviews; a summary of costs; a feasibility evaluation; an assessment of potential funding sources; and a schedule for implementation.

#### 3.1 Summary of Recommended Facilities

The recommended facilities are expected to produce water of similar quality to the potable water currently being used by U.S. Gypsum and Lone Star Energy. The most significant differences would be higher levels of total dissolved solids and total organic carbon. The industries have indicated that the anticipated water quality could be acceptable for their purposes, depending on the results of further testing to predict the effect of the reuse water on the pretreatment facilities at the Lone Star Energy plant.

The recommended facilities include:

- o A collection and conveyance system to allow separate handling of the Lone Star Energy waste brine from the domestic wastewater system.
- o Rehabilitation of the existing WWTP to achieve a more consistent quality of effluent prior to reuse treatment.
- o Tertiary treatment units including filters, lime storage and feed equipment, rapid mix/flocculation basins, and clarifiers.
- o Reuse water storage and pumping equipment.

- o Modifications at the industry sites to provide for a potable water back-up to the reuse system.

### 3.2 Conceptual Design and Layout of Recommended Facilities

Reuse Water Quality. The primary differences between the potable water and the reuse water are the concentrations of total dissolved solids and total organic carbon.

Total Dissolved Solids (TDS). TDS concentrations in the reuse water are estimated at approximately 1150 mg/l or about 45 percent higher than the 810 mg/l TDS concentration in the potable water. The chloride concentration would increase proportionately.

The TDS concentration was of key concern to both industries. It was thought that an elevated mineral content in the process water could affect the manufacturing process at United States Gypsum as well as the strength and marketability of the gypsum wallboard produced at their facility. Tests performed by the company with lab-treated effluent, however, indicated no adverse impacts on the gypsum plaster.

The increased TDS would impact the cost of operating Lone Star Energy's pretreatment plant for process water. The increased cost was addressed in the overall feasibility evaluation of the project.

Total Organic Carbon (TOC). The TOC in the reuse water is estimated at approximately 15 mg/l or about double the 7 mg/l baseline concentration in the potable water.

This level of increase would not impact U.S. Gypsum's operation. It could, however, have a significant impact on Lone Star Energy's

process water pretreatment. The plant has had a history of membrane fouling in its reverse osmosis units, which the plant staff attributes to the trace amounts of organics in the potable water. If this is the case, the plant could not tolerate an increase in TOC. To further examine this situation, a pilot plant using the same brand and type of reverse osmosis membrane in use at the Lone Star Energy plant is proposed in the initial phase of the project.

Remaining Parameters. Comparison of other water quality characteristics indicates that the reuse water would be equally acceptable or better than the potable water supply. The reuse water would tend to be more consistent in quality than the water presently delivered to the industries. However, the reuse water would be more subject to contamination by illegal dumping of toxic compounds into the wastewater system. Safeguards would need to be incorporated into the reuse system to protect the industries.

U.S. Gypsum personnel have expressed concern about odor of a treated effluent sample they received for testing. This sample was several days old when received by U.S. Gypsum and had not been chlorinated. Pilot testing should demonstrate the plant's ability to consistently produce a water free of objectionable odors.

Reuse Water Flows. The amount of water needed by the two industries is a key consideration in the feasibility of the reuse project. Neither industry plans an expansion or process change that would increase their water demand; however, a possible conversion to "dry

combusters" at the Lone Star Energy plant could significantly reduce water use. This change would have a major impact on the feasibility of any reuse project. To take this possibility into consideration, the feasibility of the project was tested for both a high-demand and a low-demand scenario.

Historical data was used to develop the high-demand scenario. On an average annual basis, U.S. Gypsum uses 0.28 MGD and Lone Star Energy uses 0.53 MGD for a total of 0.81 MGD. This flow was used to estimate operational costs for the facility and to evaluate the economic feasibility of the project. Peak month demand for the two industries is estimated at 1.2 MGD. This flow was used for sizing of the treatment units.

The low-demand scenario was based on a two-thirds reduction in Lone Star Energy's water use. In this case, the average flow needed by the two industries would be 0.46 MGD and the peak flow would be 0.68 MGD.

The amount of wastewater available for reuse was estimated to be 0.9 MGD, based on historical flows to the Sweetwater WWTP adjusted to reflect the diversion of Lone Star Energy's brine flow. With little or no growth projected for the area, it was assumed that domestic wastewater flows would remain at their current level. During some months this amount may not be enough to supply the industries' demands. In that event, the additional demand will be supplied from the potable water supply.

Description of Treatment Units and Processes. The proposed treatment process includes improvements to the existing 2.0 MGD trickling filter plant; facilities for the segregation of Lone Star Energy's waste brine stream from the main wastewater stream; additional chemical coagulation, filtration, and disinfection units; facilities to store and pump the reuse water; and means for handling the waste solids.

A summary of the proposed facilities is presented in Tables 3.1 and 3.2. The first table contains the design criteria and sizing for improvements based on the high water demand scenario; the second is based on the low demand scenario. A project site map of the proposed improvements is given in Figure 3.1 and a layout of the proposed treatment units is given in Figure 3.2.

### 3.3 Preliminary Analysis of Environmental Factors

Expected Environmental Impacts. No major environmental impacts are anticipated from the construction of the reuse water line from the Sweetwater WWTP to the U.S. Gypsum and Lone Star Energy plants.

404 Permit. Because the water line will cross two streams, Kildoogan Creek and Sweetwater Creek, a nationwide Corps of Engineers 404 permit will probably be required. The permit application consists of a letter describing the project, the amount of impacted area, and a map of the proposed project area. The construction contract should stipulate that the pre-construction stream contours will be restored when the pipeline is laid.



**TABLE 3.1**  
**Design Criteria and Sizing**  
**High Water Demand Scenario<sup>1</sup>**  
 Reuse Feasibility Project  
 Sweetwater, Texas

Project Flows

-Available Annual Average Wastewater Flows <sup>2</sup>	0.9 mgd
-Design Flows	
Annual Average	0.81 mgd
Maximum Month	1.2 mgd
-LSE Brine Flow	142,000 gpd
-LSE Brine Concentration	3,320 mg/l

Coagulation/Sedimentation

-Primary Coagulant	Hydrated Lime
-Dosage	200 mg/l
-Lime Storage(30 day supply)	1,583 cu. ft.
-Lime Feed System	
Lime Slurry(6% solution)	167 gph
	83 lb/hr
Day Tank with Mixer	1,000 gal
-Rapid Mix	
Number of basins	2
Volume	833 gal
D <sub>t</sub>	60 sec
-Flocculation Basin	
Number of basins	2
Numbe of stages	3
Volume	
-Total	25,000 gal
-Per Stage	8,333 gal
D <sub>t</sub>	30 min
Mixing	
-Stage 1 and 2	Vertical Turbine Variable speed
-Stage 3	Vertical Turbine Constant speed

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<sup>1</sup> High flow scenario reflects the continuation of historical water demands by both industries.

<sup>2</sup>Flows adjusted for brine separation at LSE

-Sedimentation Basin	
Number of basins	2
Basin Size	
-Volume	200,000 gal
$D_t$	4 hr
Type of Sludge Removal	Plow type scraper mechanism

### Filtration

-Type	Automatic Backwash Dual Media
-Number of basins	2
-Surface Loading	3 gpm/sf
-Filter Surface Area (total)	144 sf
-Dimensions	6 ft x 24 ft

### Brine Separation

-Brine Flow at LSE	142,000 gpd
-Duplex submersible pumps	100 gpm @ 93 ft TDH
-Transmission line	4000 LF 8" dia C900
-Evaporation Ponds	
Number of Ponds	2
Net Evaporation	4 ft/yr
Volume	159 ac-ft
Volume	51.83 MG
Dimensions	4.0 SWD

### Reuse Water Storage and Transmission

-Ground Storage Tank	200,000 gal
-High Service Pumps	
Number of Pumps	2
Type	Constant Speed Vertical Turbine Pumps in Cans
Capacity	833 gpm @ 172 ft TDH
-Transmission line	4000 LF 10" dia C900

### Waste Sludge Disposal

-Quantity of Waste Sludge	1115 lb/day
-Volume	5350 gal
-Means of dewatering	Ex. Sludge Drying Beds

**TABLE 3.2**  
**Design Criteria and Sizing**  
**Low Water Demand Scenario<sup>1</sup>**  
**Reuse Feasibility Project**  
**Sweetwater, Texas**

Project Flows

-Available Annual Average Wastewater Flows <sup>2</sup>	0.9 mgd
-Design Flows	
Annual Average	0.46 mgd
Maximum Month	0.68 mgd
-LSE Brine Flow	142,000 gpd
-LSE Brine Concentration	3,320 mg/l

Coagulation/Sedimentation

-Primary Coagulant	Hydrated Lime
-Dosage	200 mg/l
-Lime Storage(30 day supply)	700 cu. ft.
-Lime Feed System	
Lime Slurry(6% solution)	95 gph
	48 lb/hr
Day Tank with Mixer	1,000 gal
-Rapid Mix	
Number of basins	2
Volume	472 gal
D <sub>t</sub>	60 sec
-Flocculation Basin	
Number of basins	2
Numbe of stages	3
Volume	
-Total	14,170 gal
-Per Stage	4,722 gal
D <sub>t</sub>	30 min
Mixing	
-Stage 1 and 2	Vertical Turbine Variable speed
-Stage 3	Vertical Turbine Constant speed

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<sup>1</sup> Low flow scenario reflects the reduction of historical water demands at LSE.

<sup>2</sup>Flows adjusted for brine separation at LSE

-Sedimentation Basin	
Number of basins	2
Basin Size	
-Volume	113,300 gal
$D_t$	4 hr
Type of Sludge Removal	Plow type scraper mechanism

Filtration

-Type	Automatic Backwash Dual Media
-Number of basins	2
-Surface Loading	3 gpm/sf
-Filter Surface Area (total)	144 sf
-Dimensions	6 ft x 24 ft

Brine Separation

-Brine Flow at LSE	50,000 gpd
-Duplex submersible pumps	35 gpm @ 93 ft TDH
-Transmission line	4000 LF 8" dia C900
-Evaporation Ponds	
Number of Ponds	2
Net Evaporation Rate	4 ft/yr
Volume	56 ac-ft
Volume	18.25 MG
Dimensions	4.0 SWD

Reuse Water Storage and Transmission

-Ground Storage Tank	113,000 gal
-High Service Pumps	
Number of Pumps	2
Type	Constant Speed Vertical Turbine Pumps in Cans
Capacity	472 gpm @ 179 ft TDH
-Transmission line	4000 LF 8" dia C900

Waste Sludge Disposal

-Quantity of Waste Sludge	633 lb/day
-Volume	3036 gal
-Means of dewatering	Ex. Sludge Drying Beds

Archeological Survey. An archeological survey probably will be required for the pipeline route; however, jurisdiction over the survey will depend on the sources of funding and the federal permit requirements.

The Texas Water Development Board (TWDB) probably will require an archeological survey if the project is funded under the State Revolving Loan Fund (SRF). The TWDB will perform the survey. If the project is not funded under SRF, and a 404 permit is required, the State Historical Preservation Officer may require an archeological survey. If SRF funding and a federal permit are not involved, the Texas Antiquities Committee will require an archeological study on the City's right-of-way.

#### 3.4 Preliminary Estimate of Probable Costs

Preliminary estimates of probable costs for the recommended facilities were prepared for both the high and low water demand scenarios. The estimated capital cost for the high demand scenario is approximately \$3.9 million; for the low demand scenario, approximately \$2.6 million. More detailed cost information, including estimated annual operations and maintenance costs, is presented in Technical Memorandum No. 3.

Assumptions made in developing these costs include:

- o A six-month test period for a pilot plant treatability study;
- o Rehabilitation of the existing WWTP trickling filter and underdrain;

- o Segregation of the entire Lone Star Energy waste brine stream;
- o Full lining of the evaporation ponds with synthetic liner material; and
- o Connection of the reuse water pipelines at the process water head tanks at the industries.

### 3.5 Evaluation of Feasibility

In the long term, Sweetwater needs an average water annual supply of about 7.0 MGD to supply internal demands and meet its contractual commitments. The reliable supply from reservoirs is about 4.1 MGD. At present the City also purchases approximately 0.6 MGD of water from the Texaco well field south of town. There is no guarantee this water will continue to be available to Sweetwater.

Several alternative sources of additional water supply have been considered within the past five years. These include:

- o Pumping from the Champion Well Field. This source could supply 1.5 to 2.0 MGD for approximately 20 years, after which the ground water in the area would be depleted. Water quality is a concern for this source.
- o Diversion of water from Sweetwater Creek to Lake Sweetwater. This source would increase the lake's yield by about 0.7 MGD.
- o Purchase of raw water from Abilene.
- o Diversion of water from Lake Coleman, owned by the City of Coleman.
- o Diversion of water from Lake E.V. Spence, owned and operated by the Colorado River Municipal Water District. This alternative has been proposed to the voters of Sweetwater several times. It has been defeated each time, with opponents citing water quality concerns and cost.

The costs of each alternative were evaluated on the basis of capital and operating costs per unit of new water supply, 20-year life cycle costs, and average unit cost for a 20-year period. These costs are provided in Tables 4 through 8 in Technical Memorandum No. 3.

One alternative, the Champion Well Field, is significantly less expensive than wastewater reuse but has two significant disadvantages: its relatively short 20-year lifespan and poor water quality resulting from elevated levels of nitrates and selenium in the water.

Under the high use scenario, wastewater reuse is less costly than any surface water supply source except Lake Spence. With low use, wastewater reuse has a lower unit cost than Lake Coleman and a higher unit cost than Abilene, Lake Spence or Sweetwater Creek. However, the costs for the surface water alternatives do not include the purchase of raw water. When this factor is included, the final comparison will be even more favorable for wastewater reuse.

Conclusions from the feasibility analysis are:

- o The unit costs of wastewater reuse are not out of line with the unit costs of other viable water supply projects for Sweetwater.
- o If Sweetwater develops a major surface water project to provide additional water supply, a wastewater reuse project would cause only a relatively small reduction in the amount of surface water required. The capital cost of the surface water supply project would probably not change greatly. Therefore, if Sweetwater plans to move immediately to develop such a major supply, reuse may not be desirable.
- o If Sweetwater plans to develop additional water supply by a series of smaller projects, reuse seems to be a viable part of the water supply system.

### 3.6 Potential Financing Sources

Potential financing for water/wastewater projects include federal, state, and local sources. The most likely source of financial assistance is the State Revolving Loan Fund administered through the Texas Water Development Board. Although the funding is provided on a loan rather than a grant basis, the low interest rate is attractive. Moreover, the loan covers 100 percent of the project cost; thus, local matching funds are not required. The SRF program will not cover pipeline easements and land purchase. The recommended project is contained within the property owned by the City and Lone Star Energy so no easement or land purchase should be required.

A second option is local financing. Design and construction of the project could be financed through the City's general fund; general obligation bonds repaid by property taxes; revenue bonds repaid by service charge revenues; certificates of obligation with ad valorem tax and pledge of surplus revenue; or user fees or charges.

### 3.7 Implementation Plan

The project can be implemented in four phases:

Pilot Plant Treatability Testing Phase. A six-month treatability study will better define the treatment criteria and design parameters and help identify potential impacts to the industries.

Water Supply Contract Negotiations and Financing Phase. Based on results of the pilot study, the City and industries will negotiate the



water quality and quantity to be supplied, provisions for system reliability, and costs. The City will initiate steps for financing the project.

Design and Bidding Phase. Preliminary and final design and contract advertising and award will be carried out during this phase.

Construction and Start-Up Phase. The physical improvements will be constructed and the treatment systems activated and tested during this phase.

Assuming the first phase begins in February 1993, the project could be on line by September 1995. A more detailed implementation schedule is included in Table 3.3.

**TABLE 3.3**  
**Implementation plan**  
**Reuse Feasibility Project**  
**Sweetwater, Texas**

<u>TASK</u>	<u>DATE</u>
Final Report	DEC 1992
Pilot Plant Treatability Testing	
-Begin	FEB 1993
-Complete	AUG
-Report	SEP
Water Supply Contract Negotiations and Financing Phase	
-Begin	OCT
-Complete	JAN 1994
Design and Bidding Phase	
-Preliminary Design Complete	APR
-Final Design Complete	JUL
-Award of Construction Contract	SEP
Construction and Start-up Phase	
-Construction Complete	AUG 1995
-Reuse System Operational	SEP 1995

CITY OF SWEETWATER, TEXAS  
WASTEWATER REUSE FEASIBILITY STUDY  
TEXAS WATER DEVELOPMENT BOARD CONTRACT NO. 91-483-592

TECHNICAL MEMORANDUM NO. 1  
PROJECT DEFINITION AND BASELINE DATA

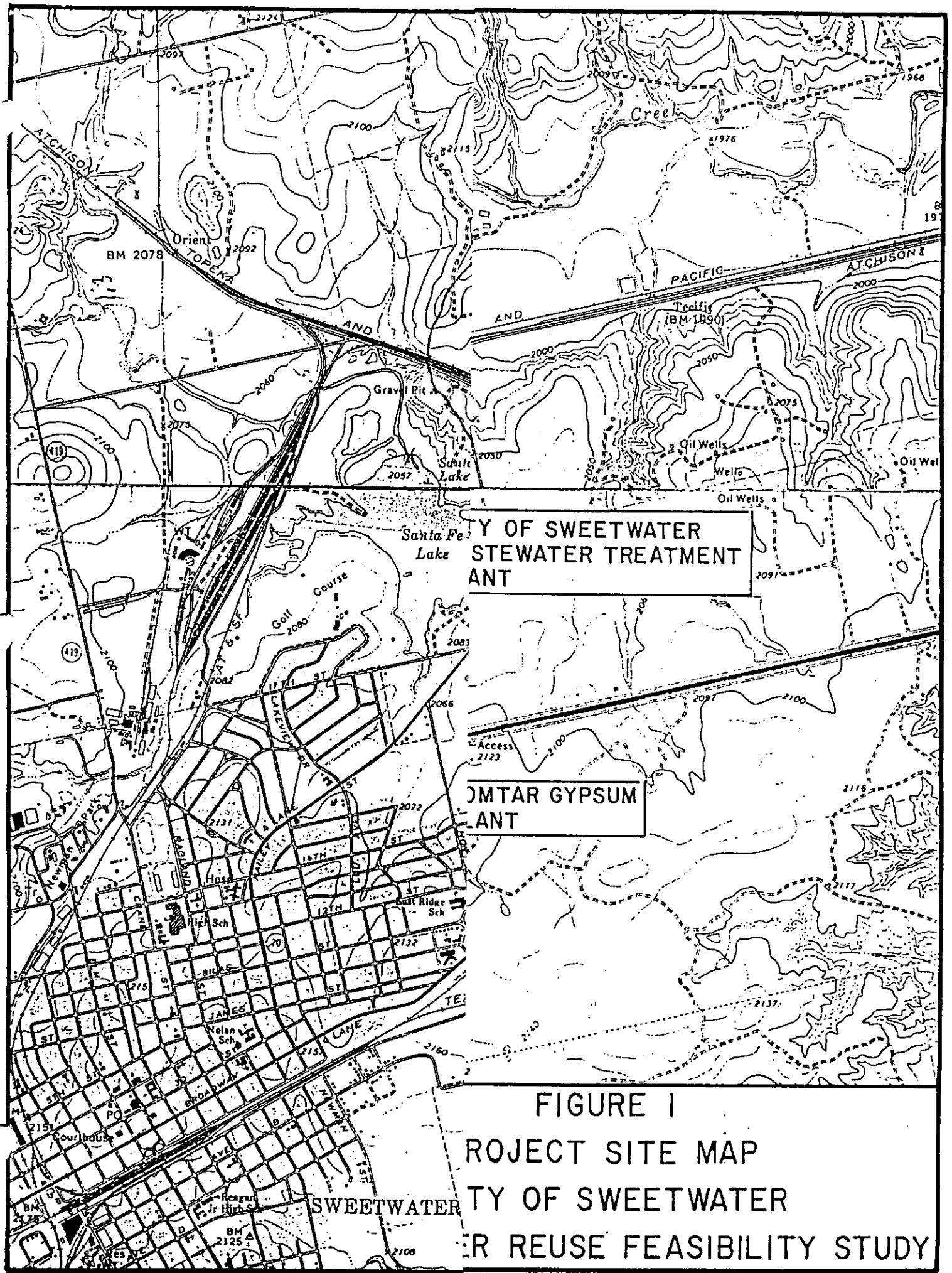
PROJECT DEFINITION

The water supply needs of the City of Sweetwater including commitments to the numerous contractual customers served by the city total 7.02 MGD<sup>1</sup>. The firm yield of the existing water supply sources is less than the amount the City is obligated to supply. This project is a feasibility study for reclaiming treated effluent from the Sweetwater Wastewater Treatment Plant (WWTP) as a potential water supply source to help narrow the gap between what is available and what the City is committed to provide. The reclaimed water would be used as process water for two of the City's largest industries: United States Gypsum Co. and Lone Star Energy Co., a power cogeneration plant. The industries currently use potable water supplied by the City for their process needs. The locations of the industries and the WWTP are indicated in Figure 1.

The study of feasibility includes the economic, environmental, political and technical considerations of treating and distributing the water to the existing points of delivery at the industries. Both industries have relatively high water quality requirements, with the key parameter being Total Dissolved Solids (TDS). Excessive TDS or chlorides will reduce the strength of the gypsum products, and increase water treatment costs at the cogeneration plant which operates an on-site reverse osmosis facility. The objective is to provide water of similar quality (in particular, TDS) as the potable water currently supplied to the industries.

The feasibility study is funded with a 50% grant from the Texas Water Development Board (TWDB) with matching funds from the City of Sweetwater. The study has the following goals:

1. Determine the difference in water quality between the available effluent and a water that would be acceptable to the industries.
2. Develop and test a treatment process which can achieve the acceptable water quality level.
3. Develop a preliminary conceptual design with cost estimates, and an implementation plan.
4. Develop public support by providing information on project findings and results to an Advisory Committee, and the public.



PROJECT SITE

MONTAR GYPSUM  
ANT

FIGURE I  
PROJECT SITE MAP  
CITY OF SWEETWATER  
WATER REUSE FEASIBILITY STUDY

## BASELINE DATA

**Current Potable Water Quality.** Water quality from the Sweetwater Filtration Plant is periodically tested by the Texas Department of Health. The results of the past three tests are summarized in Table 1. Dissolved solids results range from 381 to 693 mg/l and chloride concentrations range from 68 to 100 mg/l. The water quality varies with climatic variations and with changes in the mix of surface and ground water.

**Historical Water Use.** Water use of the subject industries for calendar year 1990 is summarized in Table 2. The average usage is 0.28 MGD for U.S. Gypsum and 0.53 for Lone Star Energy. Water usage at the gypsum plant is related to production and is relatively consistent throughout the year, while usage at the cogeneration plant is more variable, with higher usage in the summer.

**Wastewater Quality and Availability.** The Sweetwater WWTP is a trickling filter plant with land application of the effluent on adjacent farmland. The plant has a rated capacity of 2 MGD but is receiving only about 1.1 MGD. The current no discharge permit limits the effluent BOD<sub>5</sub> concentration to 50 mg/l prior to irrigation. Historical wastewater flows and quality are summarized in Table 3. The recorded flows exhibit a great deal of variability, apparently due to metering problems. The flow values for 1991 are lower than flows in previous years and appear incompatible with the population served. The causes for this should be investigated further as the study progresses.

Quality of the wastewater has been consistently within the permitted limit of 50 mg/l BOD<sub>5</sub>, but little information is available concerning the chemical makeup of the effluent. Samples of final effluent were tested in July and August 1991, and the results are shown in Table 4. Additional sampling is ongoing and will be reported as it becomes available. The critical parameter of TDS has been calculated as 1260-1577 mg/l. From the limited data available it appears the WWTP effluent has a TDS approximately twice that of the potable water supply. A large part of the TDS increase is in the form of chlorides and sulfates, which show a two-to-three-fold increase. The effluent has a relatively high value of hardness, with a range of 477-496 mg/l as CaCO<sub>3</sub>, but the low alkalinity will limit the TDS reduction achievable by lime softening.

## LEGAL AND REGULATORY ISSUES

The legal firm of Lloyd, Gosselink, Fowler, Blevins & Mathews, P.C. has been retained to study the legal and regulatory issues involved in the proposed use of reclaimed wastewater by the industries. They have investigated both the issue of water rights and the issue of permitting and regulation of the reuse of wastewater.

**Water Rights.** Two issues have been raised regarding water rights. The first issue is due to the title of the land at the WWTP site. The site was granted to the city in exchange for the provision of up to 3.0 MGD of treated effluent to the former owners for irrigation of their remaining adjacent property. The City

must obtain title to the effluent from the current owner. It may also be desirable to obtain outright title to the property, which under the current agreement would revert to the former owner if it ceases to be used for wastewater treatment.

The other rights issue is the relation of the wastewater effluent to the City's existing surface water rights and the rights of any other permit holders. The conclusion is that since the proposed use of effluent would be in lieu of potable water supplied from the City's "Municipal Use" permits, there would be no impact on the existing water rights. No amendments or new permits are required for this use.

**Permitting and Regulation.** Wastewater reclamation in Texas is regulated by the Texas Water Commission. Reuse facilities, water quality, and reporting requirements are contained in Chapter 310 of the Texas Water Commission Rules. Effluent to be used for industrial reuse must meet limits of 20 mg/l BOD<sub>5</sub> and fecal coliforms less than 200 CFU/100 ml. A permit is not required, but the City must notify the TWC and provide copies of the contracts between the provider and users. The City and the industries must provide regular reporting information to the TWC.

<sup>1</sup> "Champion Wellfield Collection and Transmission Study" (1988).

TABLE 1  
POTABLE WATER QUALITY  
SWEETWATER WATER TREATMENT PLANT

	<u>06/16/86</u>	<u>06/08/87</u>	<u>02/25/89</u>
Calcium, mg/l	95	92	(Not yet Available)
Chloride, mg/l	100	68	
Fluoride, mg/l	0.3	1.4	
Magnesium, mg/l	45	7	
Nitrate (as N), mg/l	0.18	0.64	
Sodium, mg/l	71	33	
Sulfate, mg/l	296	80	
Total Hardness as CaCO <sub>3</sub> , mg/l	421	258	
pH,	7.4	8.1	
Dil. Conduct (umhos/cm), mg/l	1350	765	
Tot. Alka. as CaCO <sub>3</sub> , mg/l	128	155	
Bicarbonate, mg/l	156	189	
Carbonate, mg/l	0	0	
Dissolved solids, mg/l	693	381	
P. Alkalinity as CaCO <sub>3</sub> , mg/l	0	0	
Arsenic, mg/l	< 0.010	< 0.010	
Barium, mg/l	< 0.50	< 0.50	
Cadmium, mg/l	< 0.005	< 0.005	
Chromium, mg/l	< 0.02	< 0.02	
Copper, mg/l	0.37	< 0.02	
Iron, mg/l	0.13	0.06	
Lead, mg/l	< 0.02	< 0.02	
Manganese, mg/l	0.02	0.04	
Mercury, mg/l	< 0.0002	< 0.0002	
Selenium, mg/l	< 0.002	< 0.002	
Silver, mg/l	< 0.01	< 0.01	
Zinc, mg/l	0.08	0.02	

TABLE 2  
 1990 INDUSTRIAL WATER CONSUMPTION  
 (MILLION GALLONS PER DAY)

	<u>UNITED STATES GYPSUM CO.</u>	<u>LONE STAR ENERGY</u>
January	0.23	0.54
February	0.33	0.63
March	0.25	0.41
April	0.30	0.60
May	0.30	0.67
June	0.27	0.61
July	0.26	0.49
August	0.22	0.39
September	0.37	0.67
October	0.27	0.42
November	0.29	0.37
December	0.31	0.55
 AVERAGE	 0.28	 0.53



TABLE 3  
WASTEWATER FLOWS AND EFFLUENT BOD  
SWEETWATER WWTP

	Flow, 1000 gpd			BOD, mg/l
	Min.	Max.	Avg.	Avg.
Jan-89	739	971	847	
Feb-89	743	1257	918	
Mar-89	815	1550	1088	
Apr-89	857	1158	956	
May-89	843	1122	924	
Jun-89	880	1207	1100	
Jul-89	920	1128	1065	25
Aug-89	818			25
Sep-89	899	1348	1076	24
Oct-89	911	1096	983	16
Nov-89				
Dec-89				
Jan-90	922	1099	1022	20
Feb-90	926	1270	1082	54
Mar-90	940	1248	1153	11
Apr-90	995	1149	1073	23
May-90	946	1104	985	20
Jun-90	940	1200	1117	22
Jul-90				
Aug-90			1168	30
Sep-90	1032	1359	1197	20
Oct-90	928	1314	1108	26
Nov-90	1007	1244	1102	28
Dec-90	1058	3961	1129	28
Jan-91	517	3916	661	30
Feb-91	395	602	493	24
Mar-91	405	558	461	28
Apr-91	504	1131	559	48
May-91	561	762	617	41
Jun-91	530	863	667	38
Jul-91	560	1080	697	29

TABLE 4  
EFFLUENT CHEMICAL ANALYSIS  
SWEETWATER WWTP

	07/08/91 (By Abilene)	08/21/91 (By IDI)	08/21/91 (By CPC/Microfloc)
Temperature	22 C	N/A	N/A
pH	9.7	7.71	7.43
Total Alkalinity, mg/l (as CaCO <sub>3</sub> )	129	169	178
Hardness, mg/l (as CaCO <sub>3</sub> )	496	482	477
Chlorides, mg/l	284	296	N/A
Sulfates, mg/l	728	770	N/A
Nitrate-N, mg/l	< 0.1	N/A	N/A
T.D.S. (calc.), mg/l	1270	1577	1260
Conductivity, umhos	1900	2350	1800
Fecal Coliform (/100 ml)	0	N/A	N/A
Kjeldahl-nitrogen, mg/l	10.5	N/A	N/A
Chlorine, Free, mg/l	0.0	N/A	N/A
o-Phosphate-P, mg/l	0.3	11.4	N/A
Fluoride, mg/l	0.85	3.2	N/A
Carbonate Alkalinity, mg/l	72	0	N/A
Bicarbonate Alkalinity, mg/l	57	169	N/A
Cadmium, mg/l	< 0.008	N/A	N/A
Chromium, mg/l	< 0.020	N/A	N/A
Copper, mg/l	< 0.01	N/A	N/A
Lead, mg/l	< 0.1	N/A	N/A
Nickel, mg/l	0.0244	N/A	N/A
Silver, mg/l	< 0.02	N/A	N/A
Zinc, mg/l	0.017	N/A	N/A
Aluminum, mg/l	0.24	N/A	N/A
Barium, mg/l	0.05	N/A	N/A
Beryllium, mg/l	< 0.001	N/A	N/A
Boron, mg/l	0.44	N/A	N/A
Iron, mg/l	0.208	3.97	0.26
Manganese, mg/l	0.044	0.12	0.2
Phosphorus, mg/l	1.33	12.3	N/A
TSS, mg/l	100	N/A	32
BOD, mg/l	57	N/A	N/A
Turbidity (unfiltered), NTU	N/A	10.1	8.9
True Color, PCU	N/A	27	30
Calcium, mg/l as CaCO <sub>3</sub>	N/A	223	239
Magnesium, mg/l as CaCO <sub>3</sub>	N/A	259	238

CITY OF SWEETWATER, TEXAS  
WASTEWATER REUSE FEASIBILITY STUDY  
TEXAS WATER DEVELOPMENT BOARD CONTRACT NO. 91-483-592

TECHNICAL MEMORANDUM NO. 2  
WATER RECLAMATION EVALUATION AND SELECTION

This technical memorandum presents the alternatives considered for additional treatment of the Sweetwater wastewater effluent and contains an evaluation of the alternatives based on cost and the anticipated quality of the resulting water. This evaluation is based on the data previously presented in Technical Memorandum No. 1, and on bench scale treatability testing.

TREATMENT ALTERNATIVES

Several treatment schemes have been considered for improving the quality of the Sweetwater effluent to make it suitable for the proposed industrial reuse. The treatment objective is to obtain water of similar quality to the potable water currently provided. The resulting water should be free of objectionable odor and color, have a low turbidity (<1.0), and have a total dissolved solids (TDS) concentration at or near 700 mg/l. For the purpose of screening alternatives, it is assumed the facilities will be designed to produce a maximum flow of approximately 1.1 million gallons per day (MGD), and to treat an average of 0.8 MGD, based on historical water usage by the industries. It should be noted however, that Lone Star Energy is considering process changes which will significantly lower their water demand. This situation will be discussed in more detail in Technical Memorandum No. 3. Wastewater in excess of the amount required by the subject industries will continue to be treated by the existing treatment units and disposed of by irrigation.

Six alternatives have been identified for initial screening. These were chosen for their compatibility with the existing treatment units and the ability to be readily implemented. Chlorination sufficient to maintain a 0.5 mg/l residual at the point of use will be included for the selected alternative. Advantages and disadvantages of the six initial alternatives are briefly discussed below.

**Filtration Only.** The simplest alternative to significantly improve the quality of the wastewater effluent is the addition of low-head automatic-backwash filters. This would remove a large fraction of the suspended solids and associated particulate BOD. These units are in widespread use for wastewater treatment and are simple to operate. However, filtration alone will not remove dissolved solids and will also allow passage of colloidal matter which is observed as turbidity (cloudiness). The resulting quality is expected to be inferior to the existing potable water and unsuitable for the intended uses. Therefore this alternative will not be considered further.

**Brine Separation/Coagulation/Filtration (Final Alternative No. 1).** Additional improvement can be realized by chemical coagulation prior to filtration. This

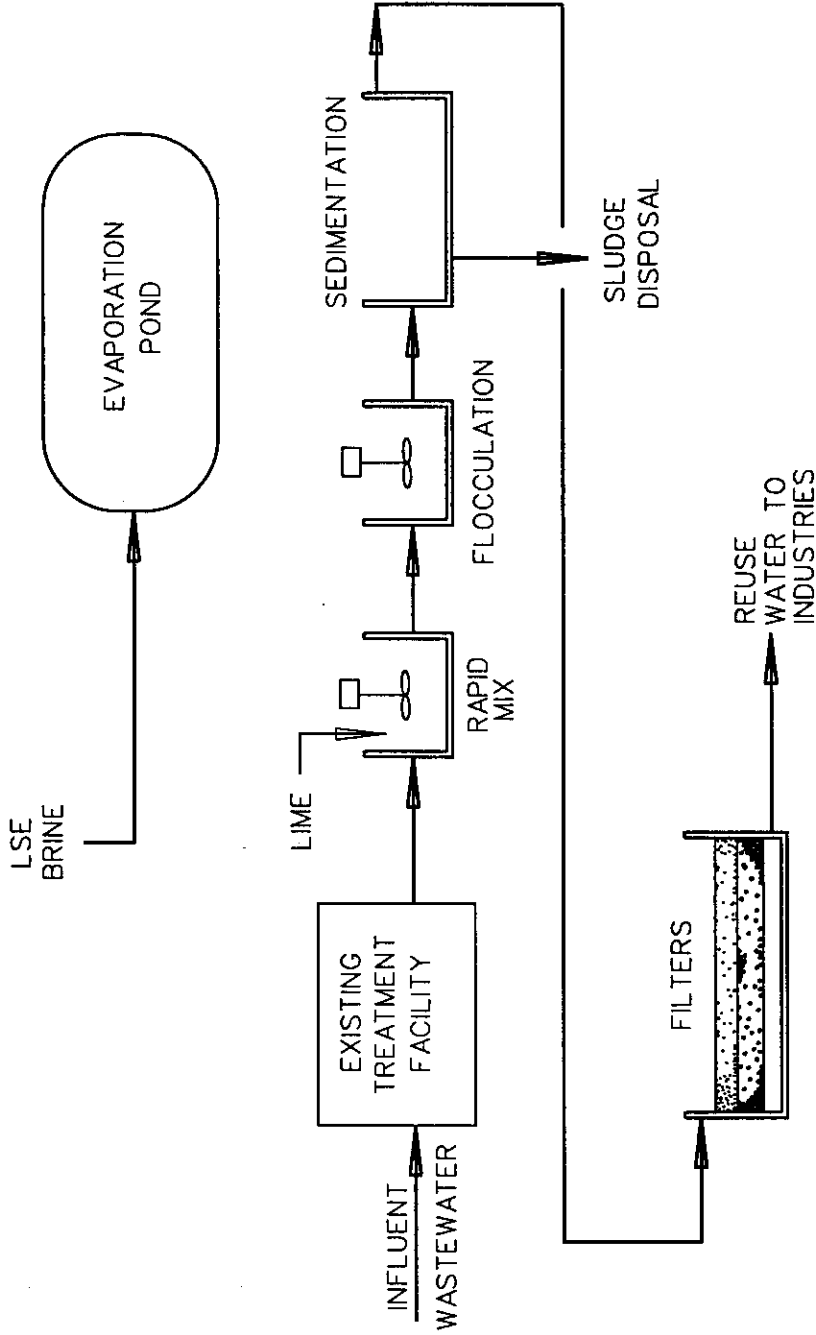
is accomplished by the addition of a coagulant (lime, alum, or ferric sulfate), followed by flocculation, or slow mixing, and sedimentation. In conjunction with filtration, coagulation further reduces the turbidity, yielding a water which approaches potable water quality in appearance. However, the resulting water will still have a relatively high concentration of Total Dissolved Solids (TDS). Some reduction in TDS (100-150 mg/l) may be effected by softening, using lime as the coagulant, but the effluent TDS will still exceed that of the potable supply. Additional TDS reduction can be accomplished by separate handling of brine waste streams from the Lone Star Energy plant which currently enters the City's wastewater collection system. By pumping this concentrated waste (approximately 140,000 gpd at 3000-3500 TDS) to an evaporation pond, an effluent TDS reduction of approximately 250 mg/l can be achieved. This reduction is in addition to any TDS reduction accomplished by lime softening. A final TDS level of 1200-1300 mg/l is anticipated from this alternative. A schematic of this alternative is presented in Figure 1.

**Brine Separation/Coagulation/Filtration/Desalination (Final Alternative No. 2).** Some form of desalination will be required to achieve TDS reductions lower than that accomplished by softening and separation of the Lone Star Energy brine streams. Membrane treatment is gaining widespread usage for demineralizing water for various uses, including reuse of treated wastewater. The most common membrane processes for wastewater treatment are reverse osmosis (RO) and electrodialysis reversal (EDR). These processes use semipermeable membranes to separate dissolved minerals from water, concentrating the minerals into a brine. Other potential desalination techniques include ion exchange and vacuum distillation. A desalination process will yield a high quality effluent with a TDS considerably lower than the City's potable supply. This would allow desalination to be limited to a portion of the flow (approximately half), with the demineralized effluent mixed with filter effluent to provide water of approximately equal quality to the potable supply. A schematic of this alternative is presented in Figure 2.

**Coagulation/Filtration/Desalination (Final Alternative No. 3).** If desalination is required to achieve water quality suitable for the target industries, it may be more cost effective to allow the LSE brine stream to remain in the main wastewater stream and desalinate a somewhat larger fraction of the filtered effluent. Figure 3 contains a schematic of this alternative.

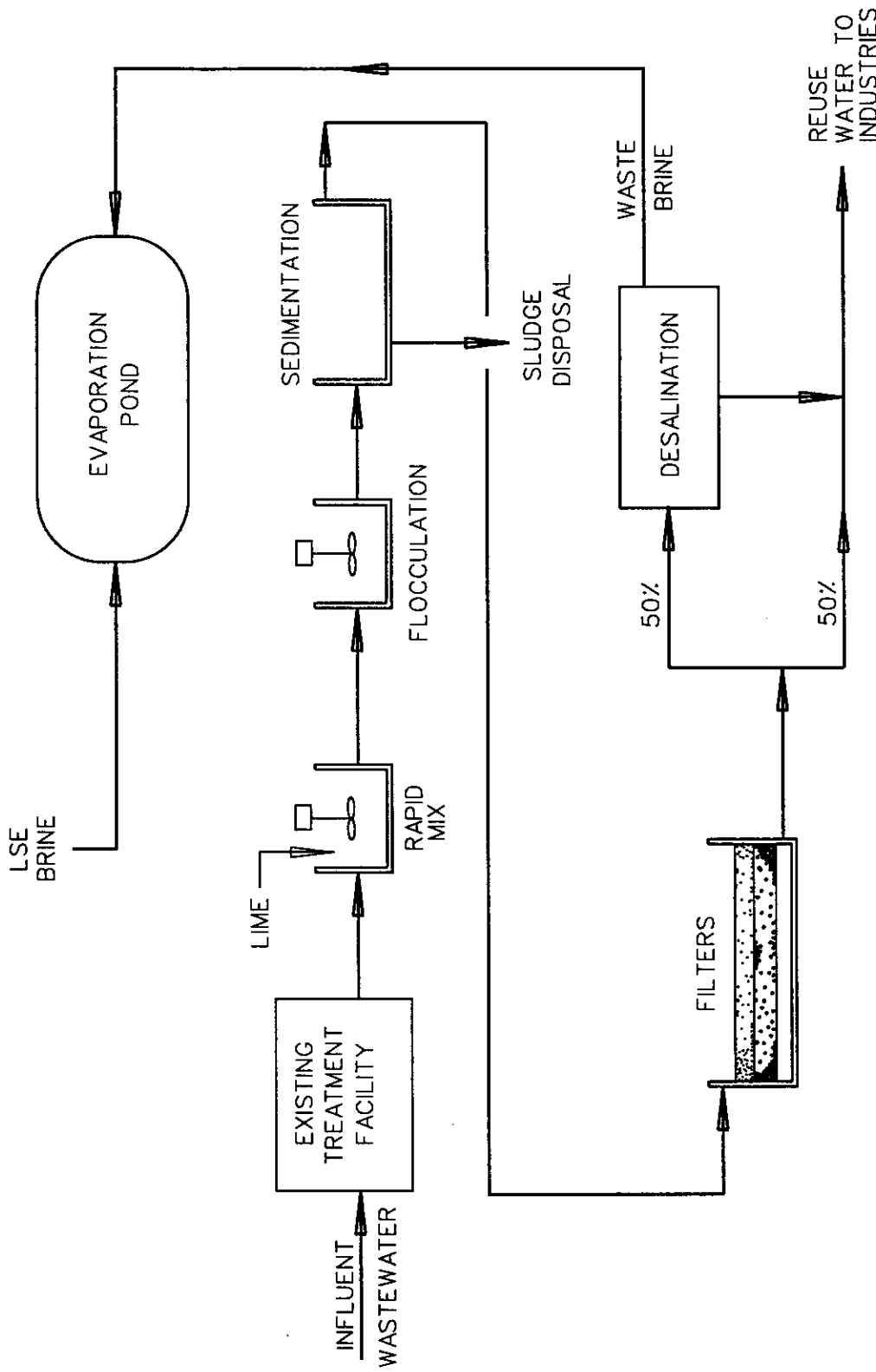
**Filtration/Membrane Treatment.** Certain types of desalination equipment may be able to operate without upstream coagulation. However, if desalination is limited to a portion of the flow, as described above, the remaining flow would have a higher turbidity, due to the lack of coagulation. There is also limited experience with this type of treatment sequence, and it will not be considered further for this project.

**Brine Separation/Coagulation/Filtration/Blending.** If the quality achieved without desalination is marginal, the treated effluent could be blended at each industry site with potable water as currently received. However, this would result in water of somewhat lesser quality than the unblended potable water and



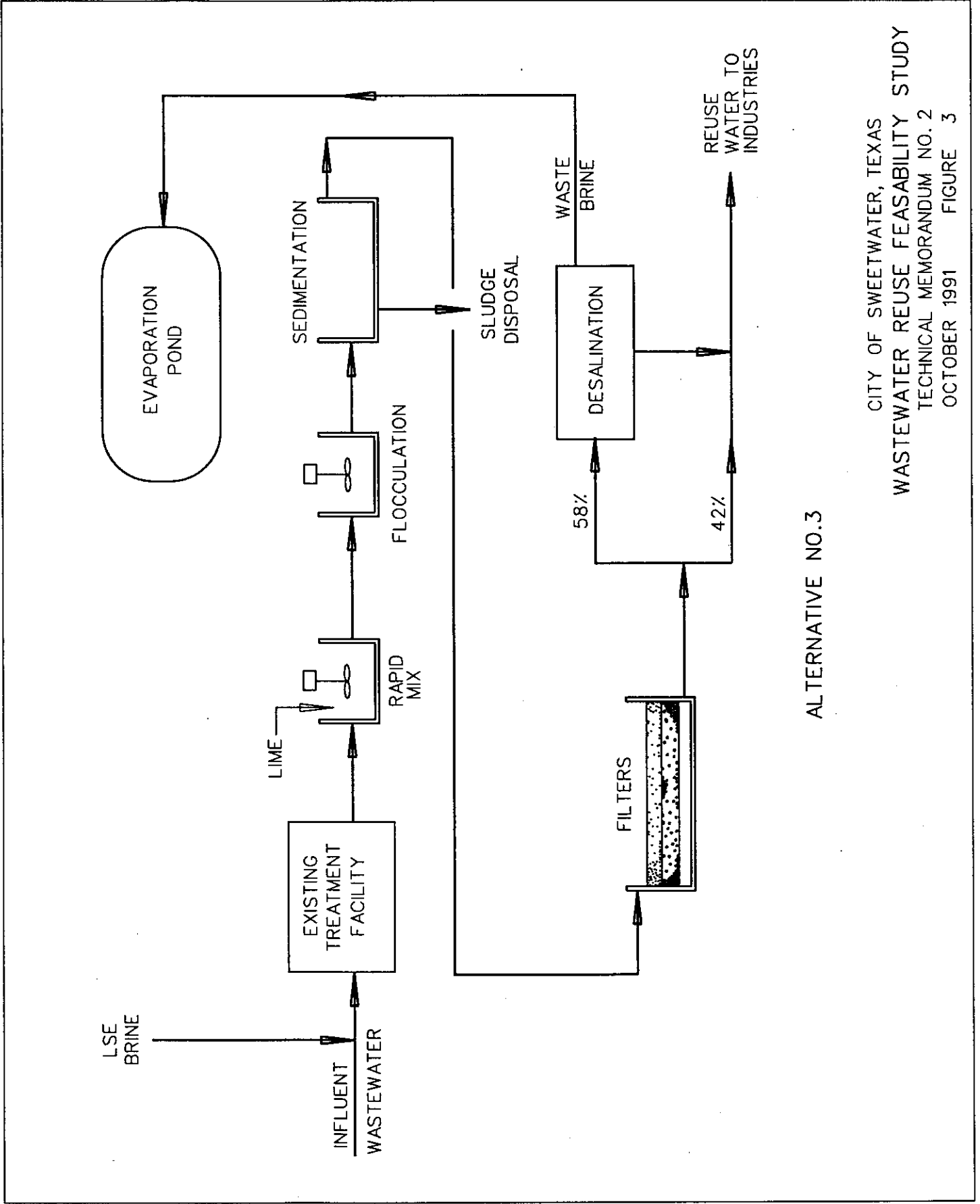
ALTERNATIVE NO.1

CITY OF SWEETWATER, TEXAS  
 WASTEWATER REUSE FEASIBILITY STUDY  
 TECHNICAL MEMORANDUM NO. 2  
 OCTOBER 1991 FIGURE 1



ALTERNATIVE NO.2

CITY OF SWEETWATER, TEXAS  
 WASTEWATER REUSE FEASIBILITY STUDY  
 TECHNICAL MEMORANDUM NO. 2  
 OCTOBER 1991 FIGURE 2



ALTERNATIVE NO.3

CITY OF SWEETWATER, TEXAS  
 WASTEWATER REUSE FEASIBILITY STUDY  
 TECHNICAL MEMORANDUM NO. 2  
 OCTOBER 1991 FIGURE 3

would reduce the amount of water reclaimed. Therefore, this alternative will not be considered further for this project.

#### BENCH-SCALE TREATABILITY TESTING

**Approach.** The coagulation/filtration options identified in the treatment alternative development were evaluated at bench-scale using 2-liter jar tests. Primary objectives of the bench-scale tests were to identify primary coagulant and coagulant aid doses that would reduce turbidity and TDS as much as possible. Since the primary mechanism for TDS removal in any of the coagulation/filtration options would be precipitation of hardness, lime was chosen as the primary coagulant. Lime-soda softening was rejected because the increased hardness removal would be offset by the added TDS of the soda. Coagulant aids evaluated during the testing included alum, ferric sulfate, and a cationic polymer (Catfloc DL). To simulate filtration at bench scale, settled water was vacuum filtered through Whatman #3 paper (a medium qualitative grade) to remove colloidal solids and floc fines. The bench-scale filtration was not intended to provide design information for full-scale information.

**Test Variables and Results.** Five jar test runs (A through E) were conducted to evaluate various combinations of the test variables, as summarized below.

09/10/91	Run A:	Excess lime doses, with varying alum doses and flocculation times
	Run B:	80/100/120% stoichiometric lime, varying alum doses and flocculation times
	Run C:	70/80/90% stoichiometric lime, varying polymer doses
09/11/91	Run D:	60/80/100% stoichiometric lime, polymer versus alum versus no coagulant aid
09/19/91	Run E:	60/80/100% stoichiometric lime, varying ferric sulfate dose

The data sheets for all of the jar tests, with test variables and results, are at the end of this Technical Memorandum. In general, all lime doses provided excellent floc formation with rapid settling rates. The lowest lime dose tested, 60% of stoichiometric, was sufficient to raise the water pH to 10.6 or higher. Coagulant aids did not improve TDS or turbidity removal over the test range.

Following jar tests A through E, the following variable levels were chosen for repeated jar tests to produce several gallons of treated effluent:

Lime dose	80% (154 mg/l)
Coagulant aid	none
Rapid mix	1 minute @ full speed
Flocculation	10 minutes @ 30 rpm (G = 25/sec)
Settling	20 minutes



## ALTERNATIVE COMPARISON

Three alternatives have been selected for evaluation and economic comparison. Capital, operating and maintenance cost values have been prepared using a computer program (WATERCOST) designed for comparison of water and wastewater treatment process costs. The costs are relative and should not be considered as estimates of the actual project costs. The costs shown do not include allowances for Contractor's overhead and profit, engineering, treated water storage, or pumping and transmission. The relative costs are summarized in Table 1, and each of the alternatives is discussed below.

**Alternative 1: Brine Separation/Coagulation/Filtration.** This is the simplest, least cost alternative, but will not produce a water quality comparable to the existing potable water quality. The viability of this alternative will depend upon the results of pilot testing to demonstrate the suitability of this water for their use. The most serious concern is the presence of organics in the treated water which may have deleterious effects on the reverse osmosis membranes used by Lone Star Energy. To determine whether this is a significant problem, the pilot testing should include a reverse osmosis unit as well as the conventional treatment included in this alternative.

**Alternative 2: Brine Separation/Coagulation/Filtration/Desalination.** By controlling the ratio of demineralized water to filtered effluent, any level of TDS between that of the potable water and that of the filtered effluent may be obtained. Costs have been prepared for a TDS level of approximately 700 mg/l. The combination of two brine streams results in a very large evaporation area requirement, but minimizes the requirement for desalination.

**Alternative 3: Coagulation/Filtration/Desalination.** The quality of this alternative is essentially the same as for Alternative 2. By allowing the Lone Star Energy brine stream to remain in the wastewater influent, the flow fraction requiring desalination increases, but the area required for evaporation is significantly reduced. This appears to be the lower cost alternative if desalination is required.

## RECOMMENDED ALTERNATIVE

Alternative 1 is recommended for the final determination of feasibility, to be developed in Technical Memorandum No. 3. This alternative is less expensive, and is operationally similar to processes currently used at the City's water treatment plant. Desalination, included in the other alternatives, represents a significant increase in complexity which should be avoided if possible. Although the anticipated water quality of the proposed system is not equal to the City's potable water, it appears to be suitable for the industries' use if the concern about membrane fouling can be adequately addressed.

TABLE 1  
Relative Present Worth Cost Comparison  
Wastewater Reuse Treatment Alternatives

	Capital Cost	Annual O & M Cost	Present Worth Cost
<b>Alternative 1</b>			
Pilot Plant Testing			\$50,000
LSE Brine Pumping	\$16,200	\$1,200	
Evaporation Pond	580,000	1,200	
Lime Feed Facilities	222,700	28,280	
Rapid Mix	21,000	6,880	
Flocculation	29,000	2,370	
Sedimentation	152,000	6,840	
Chlorination	21,300	9,370	
Filtration	<u>248,800</u>	<u>14,190</u>	
TOTAL	\$1,291,000	\$70,330	\$2,115,932
<b>Alternative 2</b>			
LSE Brine Pumping	\$16,200	\$1,200	
Lime Feed Facilities	222,700	28,280	
Rapid Mix	21,000	6,880	
Flocculation	29,000	2,370	
Sedimentation	152,000	6,840	
Filtration	248,800	14,190	
Reverse Osmosis	607,600	162,670	
Evaporation Pond	<u>966,000</u>	<u>1,900</u>	
TOTAL	\$2,263,300	\$224,330	\$4,735,082
<b>Alternative 3</b>			
Lime Feed Facilities	\$222,700	\$28,280	
Rapid Mix	21,000	6,880	
Flocculation	29,000	2,370	
Sedimentation	152,000	6,840	
Filtration	248,800	14,190	
Reverse Osmosis	677,900	179,320	
Evaporation Pond	<u>443,000</u>	<u>900</u>	
TOTAL	\$1,794,400	\$238,780	\$4,425,399

Notes:

Costs are in 1992 dollars.

Costs for treated water storage and pumping, sludge disposal, and other miscellaneous costs are not included.

Costs do not include allowance for Contractor's Overhead and Profit or Engineering.

CITY OF SWEETWATER, TEXAS  
WASTEWATER REUSE FEASIBILITY STUDY  
TEXAS WATER DEVELOPMENT BOARD CONTRACT NO. 91-483-592

TECHNICAL MEMORANDUM NO. 3  
RECOMMENDED PLAN

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This technical memorandum presents the recommended plan including a description of the conceptual design of the recommended water treatment, transmission, and waste disposal improvements and a summary of the identified environmental concerns and the corresponding permits and agency reviews that will be required. A summary of the costs, evaluation of feasibility, potential funding sources and project implementation also are included. The recommended plan is based on the recommended alternative previously presented in Technical Memorandum No. 2.

SUMMARY OF RECOMMENDED FACILITIES

The recommended facilities are based on a water treatment level that produces a water of similar quality to the potable water currently used by the industries. A comparison of the water quality of the proposed reuse water and the potable water is presented in Table 1. Historical effluent quality from the existing trickling filter plant also is presented in this table. The two industries involved in the project indicated that the level of water quality identified for the reuse project could be acceptable depending on the results of further testing which was recommended in a workshop with the industries' representatives on March 4, 1992. The additional testing is necessary to better predict the effect of the reuse water on the pretreatment equipment at Lone Star Energy's (LSE) Encogen One plant.

The recommended facilities include the following:

- Collection manhole to allow segregation of the waste brine at LSE from the domestic wastewater and a pump station and pipeline to convey the waste brine to the existing WWTP site for disposal in brine evaporation ponds.
- Rehabilitation of the existing WWTP to achieve a more consistent quality of effluent to the proposed reuse treatment units. The majority of the required work involves cleaning the trickling filters and replacing the media.
- Tertiary treatment units to include:
  - Dual media automatic backwash tertiary filters.
  - Lime storage and feed equipment.
  - Dual rapid mix/flocculation basins
  - Dual circular clarifiers

- Reuse water storage and pumping equipment.
- Improvements at the head tanks at the industries to allow potable water to serve as an automatic back-up to the reuse system.

A schematic drawing of the recommended facilities is given in Figure 1. The proposed pilot plant testing will be based on the tertiary treatment units described above. A more detailed description of the pilot plant testing phase is given later in this document.

### CONCEPTUAL DESIGN AND LAYOUT OF RECOMMENDED FACILITIES

**Reuse Water Quality.** Varying levels of reuse water quality were identified for evaluation in the previous phase of work. A water quality level similar to the baseline potable water quality was selected. In the evaluation it is identified as Type II water and is the proposed water quality presented in Table 1. Historical data also is presented for the potable water supply and the wastewater effluent. Type II water is secondary effluent which is chemically coagulated, filtered, and disinfected. This water does not receive membrane treatment at the plant but does involve segregation of LSE's brine from the wastewater flow stream. Type II water was targeted because the required treatment facilities were less expensive than for the other alternatives and because it was operationally similar to the processes currently in use at the City's water treatment plant. Although the anticipated water quality of the proposed system is not equal to the City's potable water, it appears to be suitable for the industries' use if the concern about reverse osmosis membrane fouling at LSE's pretreatment plant can be addressed adequately.

The quality of the reuse water differs from the potable water in the following two areas:

- (1) Total Dissolved Solids. It is estimated that the baseline total dissolved solids (TDS) concentration in the reuse water will be about 1150 mg/l or about 45 percent higher than the 810 TDS concentration mg/l of the potable water. The chloride concentration would increase proportionately.
- (2) Total Organic Carbon. The Total Organic Carbon (TOC) is estimated to be approximately 15 mg/l or about double the 7 mg/l baseline concentration in the potable water.

The total dissolved solids concentration was of key concern to both of the industries. An elevated mineral content in the process water could affect the manufacturing process at United States Gypsum (USG) as well as impact the strength and marketability of the gypsum wallboard produced at their facility. The increased TDS was not believed to impact LSE's finished product directly, but would impact the cost of operating their process water pretreatment plant.

USG has performed testing with lab-treated effluent, both at the corporate research center in Libertyville, Illinois, and at the local plant in Sweetwater.

Various tests of setting time, strength, etc., have indicated no adverse impacts of the anticipated reuse water quality on the gypsum plaster. The TDS concentration did not pose a technical problem to LSE as long as the increased cost of their operations was addressed in the overall feasibility evaluation of the project.

The Total Organic Carbon parameter would not impact USG's operation. Although excessive organics in the process water could lead to an increase in biological activity in their product, the concentrations involved (10-20 mg/l) are not high enough to make an impact. However, the TOC could have a significant impact on the process pretreatment plant at LSE's cogeneration plant. There has been a history of problems with membrane fouling in the reverse osmosis units. The plant staff has attributed the problem to the trace amounts of organics that exist even in the potable water. In this event, the increase in TOC could not be tolerated. It was established that pilot plant treatability testing to determine the impact of the reuse water on an identical brand and type of reverse osmosis membrane would be necessary to establish the acceptability of this process water supply for LSE.

With respect to the remaining parameters on Table 1, the quality would be equally acceptable or more acceptable than the potable water. Pathogens would be more effectively removed in the proposed system since the City could chlorinate at a higher dosage than they can at the water plant. For a non-potable water supply the City would not be constrained by the need to minimize the formation of disinfection by-products. The addition of free chlorine through breakpoint also would remove ammonia-nitrogen. The lime coagulation step also would serve to reduce pathogens, phosphorous, hardness and the organic concentration. The biological waste treatment would be effective in reducing trace metals to levels under 0.5 mg/l.

USG personnel have expressed concern about odor of a treated effluent sample they received for testing. However, this sample was several days old when received by USG and had not been chlorinated. Pilot testing should demonstrate the ability to consistently produce a water free of objectionable odors.

The reuse water would tend to be more consistent in quality than the water presently delivered to the industries. The water still would display some variance but not to the level exhibited by the potable water in recent history. However, this water supply would be more subject to contamination by illegal dumping of toxic compounds into the wastewater system. Safeguards would need to be provided to identify these occurrences so the industries would be protected.

**Reuse Water Flows.** The historical process water demands for the two industries were presented in Technical Memorandum No. 1 "Project Definition and Baseline Data". On an average annual basis, USG uses 0.28 gpd and LSE uses 0.53 gpd for a total of 0.81 gpd. This flow will be used for estimating operational costs for the facility as well as for evaluating the economic feasibility of the project. Peak month demand for the two industries is estimated at 1.2 MGD. This is based

on the coincidence of the maximum month demand for both industries in the same month. This flow will be used for sizing of the treatment units.

Neither of the industries have any plans for expansion or process changes that would increase their water demand. Staff at LSE's Encogen One plant have identified a possible process change which would significantly reduce their water demand. The conversion to "dry combusters" would reduce their demand for process water to approximately one-third of the current demand. Since the current demand is such a large percentage of the potential reuse demand the process change would have a large impact on the feasibility of any reuse project.

Therefore, the feasibility of the project will be tested for both a high demand and a low demand scenario. High demand flow is based on the historical value and is set at  $Q_{avg} = 0.81/Q_D = 1.2$  MGD. The low demand is based on LSE's requirements being one-third of their historical demand. The low demand flows are  $Q_{avg} = 0.46/Q_D = 0.68$  MGD.

Available wastewater to supply the reuse demand is based on historical flows to the plant adjusted to reflect the segregation of LSE's brine flow from the main wastewater stream. The adjusted flow estimate is 0.9 MGD. With little or no growth projected for the area it was assumed that domestic wastewater flows would not increase over time. A comparison of the monthly water demands by the industries to the wastewater flows at the plant suggests that during certain months there may not be sufficient wastewater to satisfy the high demand flows. In that event, the additional demand will be supplied from the potable water supply.

**Description of Treatment Units and Processes.** The proposed treatment process includes improvements to the existing 2.0 mgd trickling filter plant, segregation of a waste brine stream currently discharged into the wastewater system by an industry, and the addition of chemical coagulation, filtration, and disinfection units, as well as facilities to store and pump the reuse water, and means for handling the waste solids.

Improvements to the existing facilities involves the cleaning and possible replacement of the trickling filter media and filter bottoms. The performance of the units have been diminished somewhat by the presence of snails in the basins. Cleaning of the snails will require removal of the media. Upon examination of the media and the underlying filter bottoms recommendations would be made concerning the need for replacement. A current limitation of the existing plant is the lack of redundancy of the treatment units. Initial consideration was given to providing back-up facilities for these units. Although it is recommended the City consider adding the back-up units to improve operational flexibility at the plant it is not a requirement for the reuse project. Process water can be provided to the industries from the potable water system back-up if one of these units has to be taken out of service.

A fundamental component of the recommended treatment process is the segregation of the waste brine streams from LSE prior to it entering the domestic wastewater

collection system. The identified brine streams will be routed to a duplex submersible pump lift station to be located at LSE. The brine will be pumped to the proposed evaporation ponds at the existing WWTP site.

Additional units proposed include:

Chemical Coagulation Facilities. The results of the bench scale treatability testing indicated that lime, fed as the primary coagulant without any coagulant aids would be effective in consistently providing a water of Type II quality. Input from the treatability tests and from process equipment manufacturers suggested that a conventional water plant design basis would be appropriate. The chemical coagulation facilities include lime storage and feed equipment, rapid mix basins, three-stage flocculation basins, and circular sedimentation basins. The design of the proposed facilities will be based on multiple units, with the units being able to operate at 50 percent of rated capacity with the largest unit out of service. The remaining industrial water demand would be supplied from the potable water supply.

Filtration Facilities. Additional treatment will be provided by dual media automatic backwashing gravity filters. The filters provide removal of solids, turbidity, and some of the pathogens remaining in the water.

Disinfection Facilities. Disinfection facilities to further remove pathogens in the water will feed chlorine in sufficient quantity to maintain a chlorine residual of up to 5.0 mg/l in the water leaving the plant. The target residual leaving the plant will be set to achieve the desired residual at the point of use at the industries. Chlorination will be paced by flow and chlorine residual.

The treated reuse water will flow to a clearwell/storage tank sized to provide storage equal to 25 percent of the plant capacity. High service pumps will deliver the treated water to the headtanks at the two industries.

The waste solids from the chemical coagulation step will be dewatered in the existing sludge drying beds and disposed of in the landfill. The brine will be disposed of in the evaporation beds.

A summary of the proposed facilities is presented in Tables 2A and 2B. The first table contains the design criteria and sizing for improvements based on the high water demand scenario, and the second based on the low water demand scenario. An overall layout of the proposed improvements is given in Figure 2 and a layout of the proposed treatment units is given in Figure 3.

### PRELIMINARY ANALYSIS OF ENVIRONMENTAL FACTORS

The proposed project site is located in the southern portion of the Rolling Plains vegetational region of Texas. Vegetation at the site is divided into two distinct types. The eastern portion consists of open mesquite (Prosopis glandulosa) brushland. Bare ground and grassy clumps comprise the ground cover within this community. Woody components consists almost entirely of mesquite. The western portion consists of thick woody vegetation located along the creeks. Willow (Salix nigra) dominate the vegetation in this area.

The waterline will originate at the City of Sweetwater's wastewater treatment facility and extend in a southwesterly direction. Before entering U.S. Gypsum's (USG) property to the west, the waterline must cross two rail lines and, potentially, two streams. No major environmental impacts are expected from the proposed project because of the limited area to be effected. Geologic, climatic, and biologic elements should not be significantly impacted by the waterline. Surrounding land uses are characterized by rangeland and will not be adversely impacted. Groundwater supplies, surface water, and wetlands are not expected to be impacted. Because the pipeline will be buried, there will be no impact on water surface elevations during flood events.

The waterline would eventually have to cross Kildoogan and Sweetwater Creeks. The crossing of Kildoogan Creek and Sweetwater Creek will probably require a nationwide 404 Corps of Engineers (COE) permit. A nationwide 404 permit requires that a letter be sent to the COE describing the project, the amount of impacted area, and a map of the proposed project area. It should be stipulated in the construction contract that the pre-construction stream contours will be restored when the pipeline is laid.

The Texas Water Development Board (TWDB) probably will require an archeological survey of the pipeline route if funded under SRF. The TWDB will do the survey. If the Contractor does not get SRF funding, and a 404 permit is required, the State Historical Preservation Officer (SHPO) may require an archeological survey. If SRF funding and a federal permit are not involved, the Texas Antiquities Committee will require an archeological study on the City's right-of-way.

### PRELIMINARY ESTIMATE OF PROBABLE COSTS

Preliminary estimates of probable costs were prepared for the recommended facilities for both the high and low water demand scenarios and are presented in Table 3. The costs are presented both in terms of capital and annual operations and maintenance costs, and present worth costs. The estimated capital costs for the high demand and low demand water scenarios are \$3,869,000 and \$2,622,000 respectively. The associated present worth costs are \$4,973,000 and \$3,472,000, respectively.

The cost shown for the pilot plant treatability testing is based on a six-month test period to include chemical coagulation, filtration, disinfection and reverse osmosis. The reverse osmosis unit is included to assess the impact of the reuse



water on the membrane maintenance and life. The modification to the existing plant involves rehabilitation of the trickling filter media and underdrain. The costs for the brine pumping are based on segregating the total brine waste stream for the high demand scenario but only a portion of the brine for the low demand scenario. The evaporation ponds are assumed to be fully lined with synthetic liner material. The estimated costs for the process treatment units are based on costs for similar structures on recently completed or ongoing projects. The costs presented for the pipelines includes the linework and connections at the process water headtanks at the industries.

Operation and maintenance costs are based on a percentage of the estimated capital cost and where applicable the annual chemical costs. For units with mechanical equipment the annual O&M cost is assumed to be 3% of the estimated capital cost. For the other units the cost is based on 1%.

#### EVALUATION OF FEASIBILITY

Sweetwater needs additional water supply. In the long term, the City needs an average annual supply of about 7.0 mgd to supply internal demands and meet its contractual commitments. The reliable supply from Sweetwater's reservoirs is about 4.1 mgd. The City is also purchasing water from the Texaco well field south of town on a temporary basis. This well field supplies about 0.6 mgd, and there is no guarantee it will continue to be available to Sweetwater.

The following two reports describe several alternative sources of additional water supply for Sweetwater:

- (1) Freese and Nichols, Inc.: Champion Well Field Collection and Transmission Study, prepared for the City of Sweetwater, 1988, Fort Worth.
- (2) Freese and Nichols, Inc.; Jacob and Martin, Inc.; and Todd Engineering, Inc.: Regional Water Supply Plan, prepared for the West Central Texas Municipal Water District in conjunction with the Texas Water Development Board, 1991, Fort Worth.

The alternative sources of water supply for Sweetwater considered in the two reports include the following:

Champion Well Field. The Champion Well Field is a proposed ground water supply source southwest of Sweetwater. According to analyses by W. F. Guyton Associates, Inc., the well field could provide 1.5 to 2.0 mgd for approximately 20 years, after which the ground water in the area would be depleted. There are water quality concerns with the Champion Well Field, particularly nitrate and selenium levels (1).

Sweetwater Creek Diversion. One surface water supply alternative considered for Sweetwater is a diversion from Sweetwater Creek to Lake Sweetwater, which would increase the yield of the lake by about 0.7 mgd (2).

Abilene. One alternative considered in the Regional Water Supply Plan is the purchase of raw water for Sweetwater from Abilene (2).

Lake Coleman. Another surface water supply source considered for Sweetwater is diversion from Lake Coleman, which is owned by the City of Coleman (2).

Lake E. V. Spence. The diversion of water from Lake E. V. Spence, owned and operated by the Colorado River MWD, has also been considered as a source of water supply for Sweetwater. Diversion from Lake E. V. Spence has been proposed to the voters of Sweetwater several times. It has been defeated each time, with opponents citing water quality concerns and cost.

Table 4 shows estimated costs and the average annual water supply which might be available for Sweetwater from these sources. Capital costs for all alternatives except wastewater reuse are taken from the previous reports (1,2), with the following adjustments:

- Capital costs for water treatment plant expansion are removed from the surface water alternatives. (Although water treatment plant expansions would be required to make full use of the available supply, they would probably not be needed in the 20-year period analyzed for this report).
- An estimated water treatment cost of \$0.25 per thousand gallons is added to the operating costs for the surface water alternatives.
- Capital costs are updated to 1992 levels using the Bureau of Reclamation water and power construction cost index.
- Operating costs are adjusted to 1992 levels assuming inflation of 4 percent per year.

It should be noted that the operating costs for surface water sources do not include the cost of purchasing raw water. Table 4 shows that the capital and operating costs for wastewater reuse are low in comparison to most other alternatives, but that the amount of water supplied is also low.

Table 5 shows the comparison of capital and operating costs per mgd of new water supply for the various alternatives. The unit capital costs of wastewater reuse are relatively high, but the unit operating costs for reuse are quite low.

Tables 6 and 7 show 20-year life cycle costs for wastewater reuse with high and low demands, assuming that the projects are built immediately. Debt service costs are based on 20 equal annual payments with 8 percent per year interest. Operating costs are assumed to increase by 4 percent per year due to inflation.

Similar life cycle cost estimates were developed for the Champion Well Field and for the four surface water supply alternatives considered in the Regional Water Supply Plan (2). None of the surface water supply alternatives include the cost

of purchasing raw water at the source, which would add to the unit costs shown. Figures 4 and 5 show the comparative unit costs for the various alternatives. Table 8 gives the average unit cost for the 20-year period for each alternative. The financial analyses summarized in Tables 6, 7, and 8 and Figures 4 and 5 do not consider the differences in time required to develop the various alternatives.

Figure 4 shows that the Champion Well Field is significantly less expensive than wastewater reuse. However, the Champion Field has two significant disadvantages which do not show up in the cost analysis:

- The ground water supply will be exhausted after 20 years, and the facilities will have to be abandoned. (Other alternatives, including reuse, would be expected to last longer than 20 years.)
- Water from the Champion Well Field is likely to have elevated levels of nitrates and may also have high selenium levels.

Figure 5 shows that the high use wastewater reuse alternative has a lower unit cost than any surface water supply source, except Lake Spence. With low use, wastewater reuse has a lower unit cost than Lake Coleman and a higher unit cost than Abilene, Lake Spence, or Sweetwater Creek. Since the costs for the surface water alternatives do not include the purchase of raw water, the final comparison will be even more favorable for wastewater reuse.

The unit cost comparisons shown on Figure 5 and Table 8 are based on full use of the new water supplies. In fact, the large supplies from Abilene, Lake Spence, or Lake Coleman would not be utilized in full in the near future. Since the full capital costs and debt service costs would be spread over a smaller water use, the unit cost for this partial use of the major surface water supplies would be very high in the early years of their operation.

Based on these preliminary analyses, the following conclusions can be reached:

- The unit costs of wastewater reuse are not out of line with the unit costs of other viable water supply projects for Sweetwater.
- If Sweetwater develops a major surface water supply project to provide the additional water supply it needs, a wastewater reuse project would only result in a relatively small change in the amount of surface water required. The capital cost of the surface water supply project would probably not change greatly. Therefore, if Sweetwater plans to move immediately to develop such a major supply, reuse may not be desirable.
- If Sweetwater plans to develop additional water supply by a series of smaller projects, reuse seems to be a viable part of the water supply system.

### POTENTIAL FINANCING SOURCES

Potential financing for a water/wastewater projects include federal, state, and local sources.

Federal Financing Options. The two major legislative acts which address water projects are the Clean Water Act(wastewater) and the Safe Drinking Water Act(water). Funds are no longer available through the Clean Water Act (CWA) for construction projects. The Construction Grants program of the CWA has been phased out and has been replaced by the State Revolving Loan (SRF) program administered by the States. No funds for construction are available through the SDWA either. Therefore, federal funding would not be a viable option.

State Financing Options. Financing for water and wastewater projects in the State of Texas are administered through the Texas Water Development Board (TWDB). The current phase of the Sweetwater Reuse Feasibility project is financed as a matching grant through the TWDB's Research and Planning Fund. Financing options which would be applicable for the following phases include the State Revolving Fund Program; the Water Development Fund; the Wastewater and Storage Acquisition Program; the Water Assistance Fund; and the Texas Capital Access Program.

Only one of the State of Texas financing options described above is recommended for further consideration by the City of Sweetwater. The State Revolving Loan Program is compatible with the requirements and needs of both the City and the project. Although the funding is provided on a loan rather than a grant basis, the low interest rate is attractive. Moreover, the loan covers 100 percent of the project cost; thus, local contribution or matching funds are not required.

Local Financing Options. Local financing options which could be used for financing the design and construction phases of the reuse project include General Fund; General Obligation Bonds repaid by property taxes; Revenue Bonds repaid by service charge revenues; Certificates of Obligation with Ad Valorem Tax and Pledge of Surplus Revenue; and User Fees or Charges. Input will be received from the City Finance Officer on the relative merits of these options for this project and will be included in the Summary Report.

### IMPLEMENTATION PLAN

Implementation of the Sweetwater Reuse Project would involve the following phases:

- Pilot Plant Treatability Testing Phase
- Water Supply Contract Negotiations and Financing Phase
- Design and Bidding Phase
- Construction and Start-up Phase

Pilot Plant Treatability Testing Phase. A six-month pilot plant treatability test will be conducted to better define the treatment criteria and design parameters and to help identify potential impacts to the industries. Testing

will include chemical coagulation, filtration, disinfection and reverse osmosis treatment units.

Water Supply Contract Negotiations and Financing Phase. Based on results of the previous phase, negotiations would begin with the industries on the reuse water quality, water quantity, system reliability, and costs. Steps would commence for financing the project.

Design and Bidding Phase. Preliminary and final design and contract advertising and award for the project would be completed during this phase.

Construction and Start-up Phase. The physical improvements would be constructed and the treatment systems activated and tested during this phase.

A suggested schedule for implementation of the wastewater reuse project is presented in Table 9.

**TABLE 1**  
**Water Quality Characteristics**  
**Reuse Feasibility Project**  
**Sweetwater, Texas**

<u>Parameter<sup>1</sup></u>	<u>Historical Effluent Value</u>	<u>Treated Reuse Effluent Value (Type II Water)</u>	<u>Historical Potable Water</u>
BOD <sub>5</sub>	50	2	N/A
TOC	35	10-20	5-10
NH <sub>3</sub> -N	15	5-7	5.1
KJN	10	2	-
o-Phos	1.8	0.1	0.1
TSS	90	2	-
Turbidity	90	0.5-1.0	0.1-0.9
Temperature(C)	22	22	20
pH	8	9.8	7.05
Alkalinity			
-Total	180	68	100
-Carbonate	72	-	0
-Bicarbonate	57	-	110
Hardness	460	380	410
TDS	1600	1100-1200	810
Anion/Cation Balance (meg/meg)	24.4/23.3	19.7/20.5	12.3/12.2
Chlorides	220	180	120
Sulfates	700	580	330
Trace Metals <sup>2</sup>			
Aluminum	0.68	0.05	0.41
Boron	0.44	-	-
Iron	0.21		
Phosphorus	1.33		
Chlorine Residual	N/A <sup>3</sup>	1-2	1
Fecal Coliform	200	Not Present	Not Present

<sup>1</sup>Units are mg/l unless otherwise noted

<sup>2</sup>All trace metals samples were below 0.1 mg/l except those noted

<sup>3</sup>Effluent currently is not chlorinated.

TABLE 2A  
 Design Criteria and Sizing  
 High Water Demand Scenario<sup>1</sup>  
 Reuse Feasibility Project  
 Sweetwater, Texas

<u>Project Flows</u>	
-Available Annual Average Wastewater Flows <sup>2</sup>	0.9 mgd
-Design Flows	
Annual Average	0.81 mgd
Maximum Month	1.2 mgd
-LSE Brine Flow	142,000 gpd
-LSE Brine Concentration	3,320 mg/l
<u>Coagulation/Sedimentation</u>	
-Primary Coagulant	Hydrated Lime
-Dosage	200 mg/l
-Lime Storage(30 day supply)	1,583 cu. ft.
-Lime Feed System	
Lime Slurry(6% solution)	167 gph
	83 lb/hr
Day Tank with Mixer	1,000 gal
-Rapid Mix	
Number of basins	2
Volume	833 gal
D <sub>t</sub>	60 sec
-Flocculation Basin	
Number of basins	2
Numbe of stages	3
Volume	
-Total	25,000 gal
-Per Stage	8,333 gal
D <sub>t</sub>	30 min
Mixing	
-Stage 1 and 2	Vertical Turbine Variable speed
-Stage 3	Vertical Turbine Constant speed

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<sup>1</sup> High flow scenario reflects the continuation of historical water demands by both industries.

<sup>2</sup>Flows adjusted for brine separation at LSE

-Sedimentation Basin	
Number of basins	2
Basin Size	
-Volume	200,000 gal
D <sub>t</sub>	4 hr
Type of Sludge Removal	Plow type scraper mechanism

### Filtration

-Type	Automatic Backwash Dual Media
-Number of basins	2
-Surface Loading	3 gpm/sf
-Filter Surface Area (total)	144 sf
-Dimensions	6 ft x 24 ft

### Brine Separation

-Brine Flow at LSE	142,000 gpd
-Duplex submersible pumps	100 gpm @ 93 ft TDH
-Transmission line	4000 LF 8" dia C900
-Evaporation Ponds	
Number of Ponds	2
Net Evaporation	4 ft/yr
Volume	159 ac-ft
Volume	51.83 MG
Dimensions	4.0 SWD

### Reuse Water Storage and Transmission

-Ground Storage Tank	200,000 gal
-High Service Pumps	
Number of Pumps	2
Type	Constant Speed Vertical Turbine Pumps in Cans
Capacity	833 gpm @ 172 ft TDH
-Transmission line	4000 LF 10" dia C900

### Waste Sludge Disposal

-Quantity of Waste Sludge	1115 lb/day
-Volume	5350 gal
-Means of dewatering	Ex. Sludge Drying Beds



TABLE 2B  
 Design Criteria and Sizing  
 Low Water Demand Scenario<sup>1</sup>  
 Reuse Feasibility Project  
 Sweetwater, Texas

Project Flows

-Available Annual Average Wastewater Flows <sup>2</sup>	0.9 mgd
-Design Flows	
Annual Average	0.46 mgd
Maximum Month	0.68 mgd
-LSE Brine Flow	142,000 gpd
-LSE Brine Concentration	3,320 mg/l

Coagulation/Sedimentation

-Primary Coagulant	Hydrated Lime
-Dosage	200 mg/l
-Lime Storage(30 day supply)	700 cu. ft.
-Lime Feed System	
Lime Slurry(6% solution)	95 gph
	48 lb/hr
Day Tank with Mixer	1,000 gal
-Rapid Mix	
Number of basins	2
Volume	472 gal
D <sub>t</sub>	60 sec
-Flocculation Basin	
Number of basins	2
Numbe of stages	3
Volume	
-Total	14,170 gal
-Per Stage	4,722 gal
D <sub>t</sub>	30 min
Mixing	
-Stage 1 and 2	Vertical Turbine Variable speed
-Stage 3	Vertical Turbine Constant speed

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<sup>1</sup> Low flow scenario reflects the reduction of historical water demands at LSE.

<sup>2</sup>Flows adjusted for brine separation at LSE

-Sedimentation Basin	
Number of basins	2
Basin Size	
-Volume	113,300 gal
D <sub>t</sub>	4 hr
Type of Sludge Removal	Plow type scraper mechanism

### Filtration

-Type	Automatic Backwash Dual Media
-Number of basins	2
-Surface Loading	3 gpm/sf
-Filter Surface Area (total)	144 sf
-Dimensions	6 ft x 24 ft

### Brine Separation

-Brine Flow at LSE	50,000 gpd
-Duplex submersible pumps	35 gpm @ 93 ft TDH
-Transmission line	4000 LF 8" dia C900
-Evaporation Ponds	
Number of Ponds	2
Net Evaporation Rate	4 ft/yr
Volume	56 ac-ft
Volume	18.25 MG
Dimensions	4.0 SWD

### Reuse Water Storage and Transmission

-Ground Storage Tank	113,000 gal
-High Service Pumps	
Number of Pumps	2
Type	Constant Speed Vertical Turbine Pumps in Cans
Capacity	472 gpm @ 179 ft TDH
-Transmission line	4000 LF 8" dia C900

### Waste Sludge Disposal

-Quantity of Waste Sludge	633 lb/day
-Volume	3036 gal
-Means of dewatering	Ex. Sludge Drying Beds

**TABLE 3**  
**Opinion of Probable Construction Cost**  
**Reuse Feasibility Project**  
**Sweetwater, Texas**

	<u>Capital Cost</u>	<u>Annual O &amp; M Cost</u>	<u>Present Worth Cost</u>
<b>High Water Demand Scenario</b>			
Pilot Plant Testing			\$150,000
Existing WWTP Modifications			100,000
LSE Brine Pumping	\$50,000	\$3,100	
Evaporation Pond	1,143,000	3,000	
Lime Feed Facilities	108,000	21,733	
Rapid Mix/Flocculation	205,000	6,150	
Sedimentation	260,000	7,800	
Chlorination	25,000	5,681	
Filtration	200,000	6,000	
Pipelines	300,000	3,000	
Finished Water Pumping	50,000	17,500	
Storage Tank	100,000	1,000	
Electrical & Instrumentation	<u>250,000</u>	2,500	
Subtotal	2,691,000		
25% Contingency	673,000		
15% Engr/surv/admin	<u>505,000</u>		
TOTAL	\$3,869,000	\$77,464	\$4,973,000
<b>Low Water Demand Scenario</b>			
Pilot Plant Testing			\$150,000
Existing WWTP Modifications			100,000
LSE Brine Pumping	\$50,000	\$2,000	
Evaporation Pond	403,000	1,000	
Lime Feed Facilities	108,000	13,514	
Rapid Mix/Flocculation	190,000	5,700	
Sedimentation	220,000	6,600	
Chlorination	25,000	3,490	
Filtration	180,000	5,400	
Pipelines	280,000	2,800	
Finished Water Pumping	50,000	10,800	
Storage Tank	68,000	680	
Electrical & Instrumentation	<u>250,000</u>	2,500	
Subtotal	1,824,000		
25% Contingency	456,000		
15% Engr/surv/admin	<u>342,000</u>		
TOTAL	\$2,622,000	\$54,484	\$3,472,000

Notes: Costs are in 1992 dollars.

O&M costs based on 3% per yr for units with mechanical equipment and 1% for all other units. Chemical costs are added to lime feed and chlorination units as well.

Table 4

## Capital and Operating Costs for Water Supply Alternatives

Source of Water Supply	Avg. Annual Supply (MGD)	Year	Original Cost Estimate		Estimated 1992 Cost	
			Capital Cost	Operating Cost	Capital Cost	Operating Cost
Reuse - High Water Demand	0.81	1992	\$4,119,000	\$77,464	\$4,119,000	\$77,464
Reuse - Low Water Demand	0.46	1992	\$2,872,000	\$54,484	\$2,872,000	\$54,484
Champion Well Field - 1.5 mgd	1.50	1988	\$4,122,861	\$239,877	\$4,622,602	\$280,622
Champion Well Field - 2.0 mgd	2.00	1988	\$4,593,638	\$300,108	\$5,150,443	\$351,084
Sweetwater Creek Diversion	0.70	1991	\$2,865,000	\$122,614	\$2,896,311	\$127,519
Abilene	3.88	1991	\$11,021,000	\$949,256	\$11,141,448	\$987,226
Lake Coleman	3.88	1991	\$17,500,000	\$1,185,730	\$17,691,257	\$1,233,159
Lake Spence	3.88	1991	\$6,966,000	\$864,850	\$7,042,131	\$899,444

- Notes:
- Champion Well Field costs are from the 1988 Freese and Nichols report "Champion Well Field Collection and Transmission Study."
  - Costs for Sweetwater Creek Diversion, Abilene, Lake Coleman, and Lake Spence are from the 1991 Freese and Nichols report "Regional Water Supply Plan," prepared for the West Central Texas MWD. The costs do not include water treatment plant expansion, which is not projected as necessary in the next 20 years. The annual costs from the "Regional Water Supply Plan" are increased by \$0.25 per thousand gallons to cover water treatment plant operation.
  - Capital costs are adjusted to 1992 levels using the Bureau of Reclamation water and power construction cost index from "Engineering News-Record."
  - Annual costs are adjusted to 1992 levels assuming 4 percent per year inflation. Annual costs for surface water sources do not include the purchase of raw water.

Table 5

## Comparison of 1992 Capital and Operating Costs per MGD of Water Supply

Source of Water Supply	Avg. Annual Supply (MGD)	1992 Cost per MGD of Water Supply	
		Capital Cost	Operating Cost
Reuse - High Water Demand	0.81	\$5,085,185	\$95,635
Reuse - Low Water Demand	0.46	\$6,243,478	\$118,443
Champion Well Field - 1.5 mgd	1.50	\$3,081,735	\$187,081
Champion Well Field - 2.0 mgd	2.00	\$2,575,222	\$175,542
Sweetwater Creek Diversion	0.70	\$4,137,587	\$182,170
Abilene	3.88	\$2,871,507	\$254,440
Lake Coleman	3.88	\$4,559,602	\$317,824
Lake Spence	3.88	\$1,814,982	\$231,815

Note: Operating costs for surface water sources do not include the purchase of raw water.

Table 6

## 20-Year Life Cycle Costs for Wastewater Reuse with High Water Demand

Year	Supply in MGD	Annual Costs with Inflation			Total Unit Cost per Thousand Gallons
		Debt Service	Operating Costs	Total Costs	
1	0.81	\$419,536	\$77,464	\$497,000	\$1.68
2	0.81	419,536	80,563	500,099	1.69
3	0.81	419,536	83,785	503,321	1.70
4	0.81	419,536	87,136	506,672	1.71
5	0.81	419,536	90,622	510,158	1.73
6	0.81	419,536	94,247	513,783	1.74
7	0.81	419,536	98,017	517,553	1.75
8	0.81	419,536	101,937	521,473	1.76
9	0.81	419,536	106,015	525,551	1.78
10	0.81	419,536	110,255	529,791	1.79
11	0.81	419,536	114,666	534,202	1.81
12	0.81	419,536	119,252	538,788	1.82
13	0.81	419,536	124,022	543,558	1.84
14	0.81	419,536	128,983	548,519	1.86
15	0.81	419,536	134,143	553,679	1.87
16	0.81	419,536	139,508	559,044	1.89
17	0.81	419,536	145,089	564,625	1.91
18	0.81	419,536	150,892	570,428	1.93
19	0.81	419,536	156,928	576,464	1.95
20	0.81	419,536	163,205	582,741	1.97
Average					\$1.81

Table 7

## 20-Year Life Cycle Costs for Wastewater Reuse with Low Water Demand

Year	Supply in MGD	Annual Costs with Inflation			Total Unit Cost per Thousand Gallons
		Debt Service	Operating Costs	Total Costs	
1	0.46	\$292,524	\$54,484	\$347,008	\$2.07
2	0.46	292,524	56,663	349,187	2.08
3	0.46	292,524	58,930	351,454	2.09
4	0.46	292,524	61,287	353,811	2.11
5	0.46	292,524	63,739	356,263	2.12
6	0.46	292,524	66,288	358,812	2.14
7	0.46	292,524	68,940	361,464	2.15
8	0.46	292,524	71,697	364,221	2.17
9	0.46	292,524	74,565	367,089	2.19
10	0.46	292,524	77,548	370,072	2.20
11	0.46	292,524	80,650	373,174	2.22
12	0.46	292,524	83,876	376,400	2.24
13	0.46	292,524	87,231	379,755	2.26
14	0.46	292,524	90,720	383,244	2.28
15	0.46	292,524	94,349	386,873	2.30
16	0.46	292,524	98,123	390,647	2.33
17	0.46	292,524	102,048	394,572	2.35
18	0.46	292,524	106,129	398,653	2.37
19	0.46	292,524	110,375	402,899	2.40
20	0.46	292,524	114,790	407,314	2.43
Average					\$2.23

Table 8

## 20-Year Average Unit Cost of Water

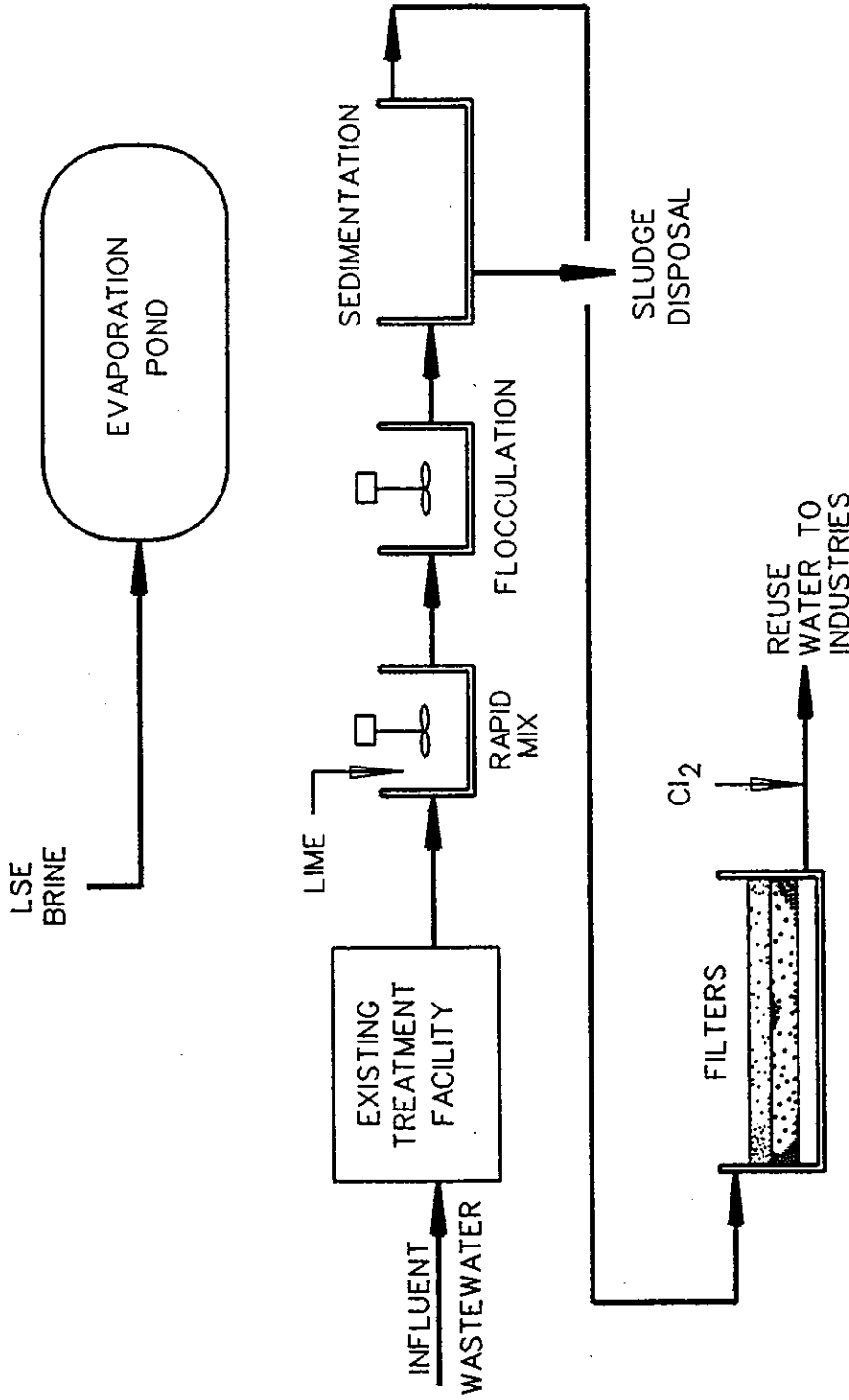
Source of Water Supply	Avg. Annual Supply (MGD)	Avg. Annual Unit Cost
Reuse - High Water Demand	0.81	\$1.81
Reuse - Low Water Demand	0.46	\$2.23
Champion Well Field - 1.5 mgd	1.50	\$1.62
Champion Well Field - 2.0 mgd	2.00	\$1.43
Sweetwater Creek Diversion	0.70	\$1.90
Abilene	3.88	\$1.84
Lake Coleman	3.88	\$2.57
Lake Spence	3.88	\$1.45

Note: The average annual unit costs for surface water alternatives do not include the cost of purchasing raw water.



TABLE 9  
 Implementation plan  
 Reuse Feasibility Project  
 Sweetwater, Texas

<u>TASK</u>	<u>DATE</u>
Final Report	DEC 1992
Pilot Plant Treatability Testing	
-Begin	FEB 1993
-Complete	AUG
-Report	SEP
Water Supply Contract Negotiations and Financing Phase	
-Begin	OCT
-Complete	JAN 1994
Design and Bidding Phase	
-Preliminary Design Complete	APR
-Final Design Complete	JUL
-Award of Construction Contract	SEP
Construction and Start-up Phase	
-Construction Complete	AUG 1995
-Reuse System Operational	SEP 1995

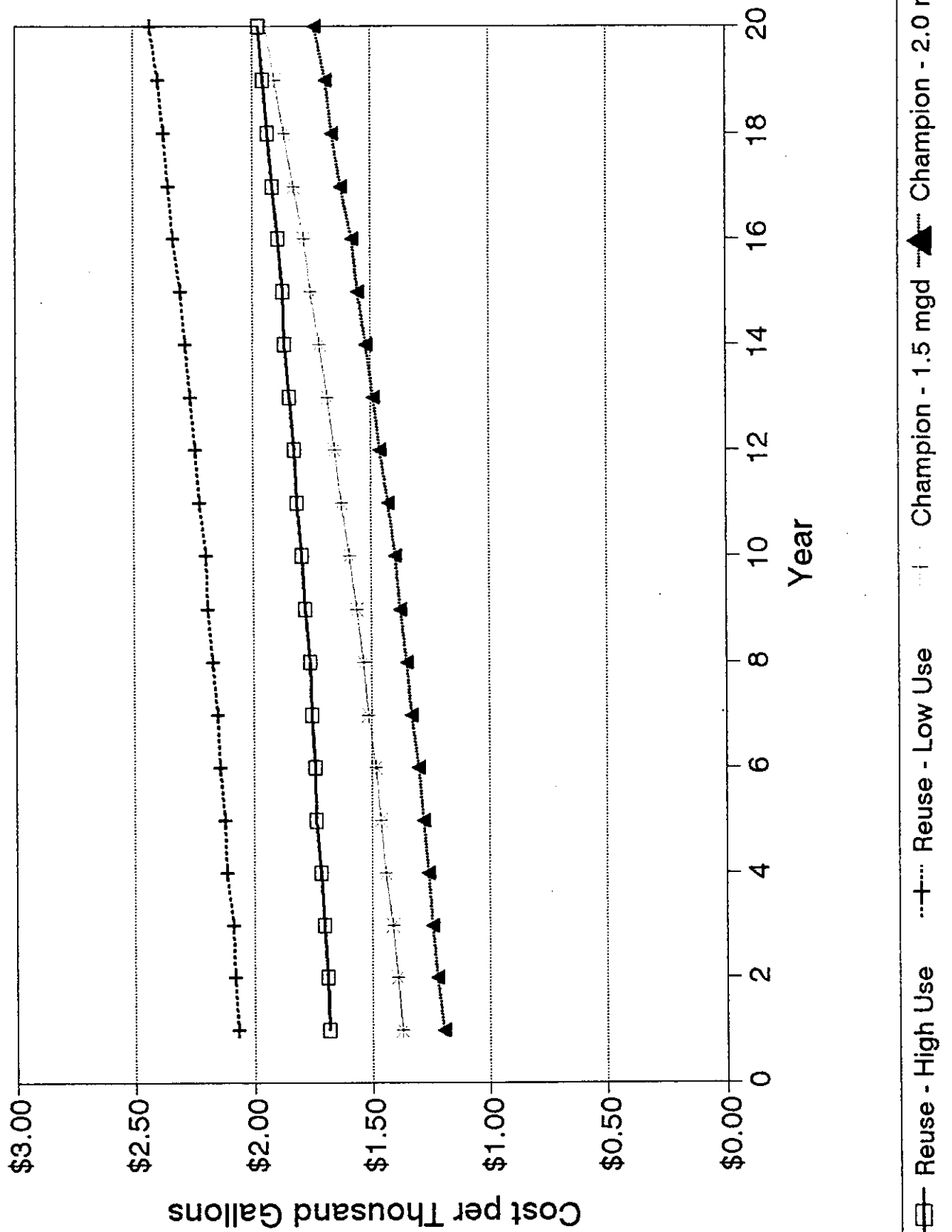


CITY OF SWEETWATER, TEXAS  
 WASTEWATER TREATMENT PLANT  
 PROCESS SCHEMATIC  
 WASTEWATER REUSE FEASIBILITY STUDY

**Freese**  
 AND  
**Nichols**  
 CONSULTING ENGINEERS

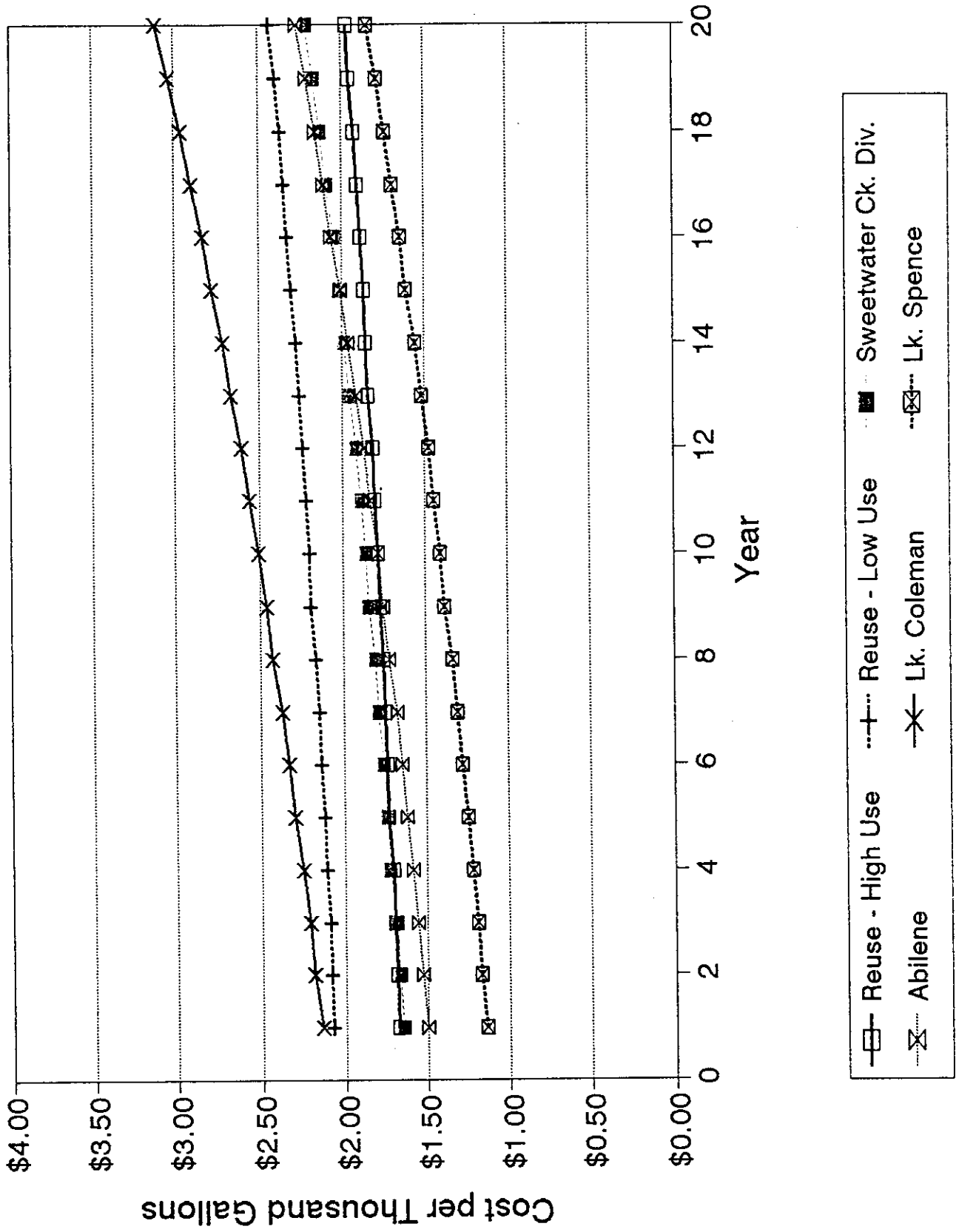
FIGURE 1

Figure 4  
Comparison of Reuse and Champion Field



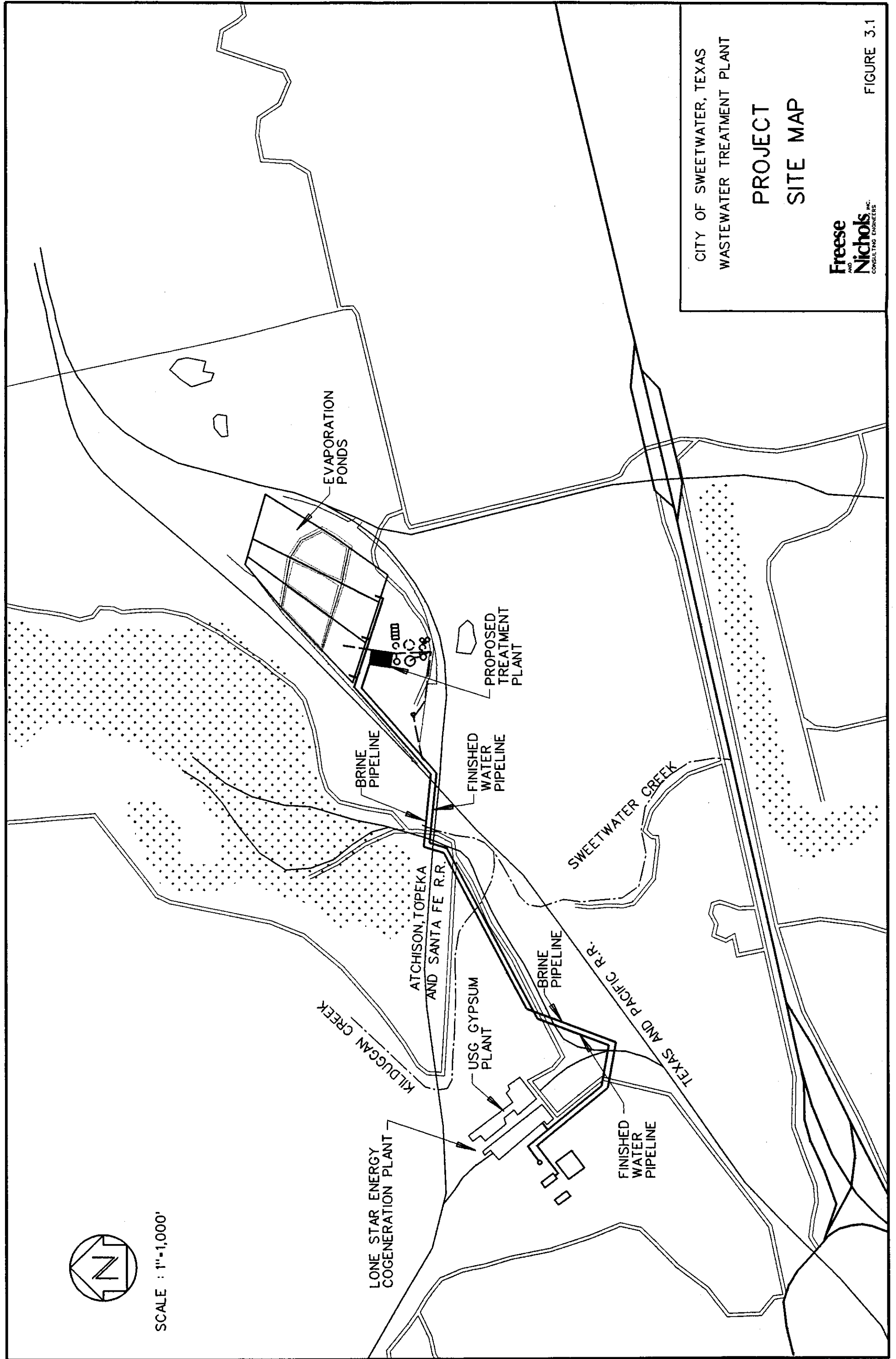
# Figure 5

## Comparison of Reuse and Surface Water





SCALE : 1"=1,000'



CITY OF SWEETWATER, TEXAS  
WASTEWATER TREATMENT PLANT

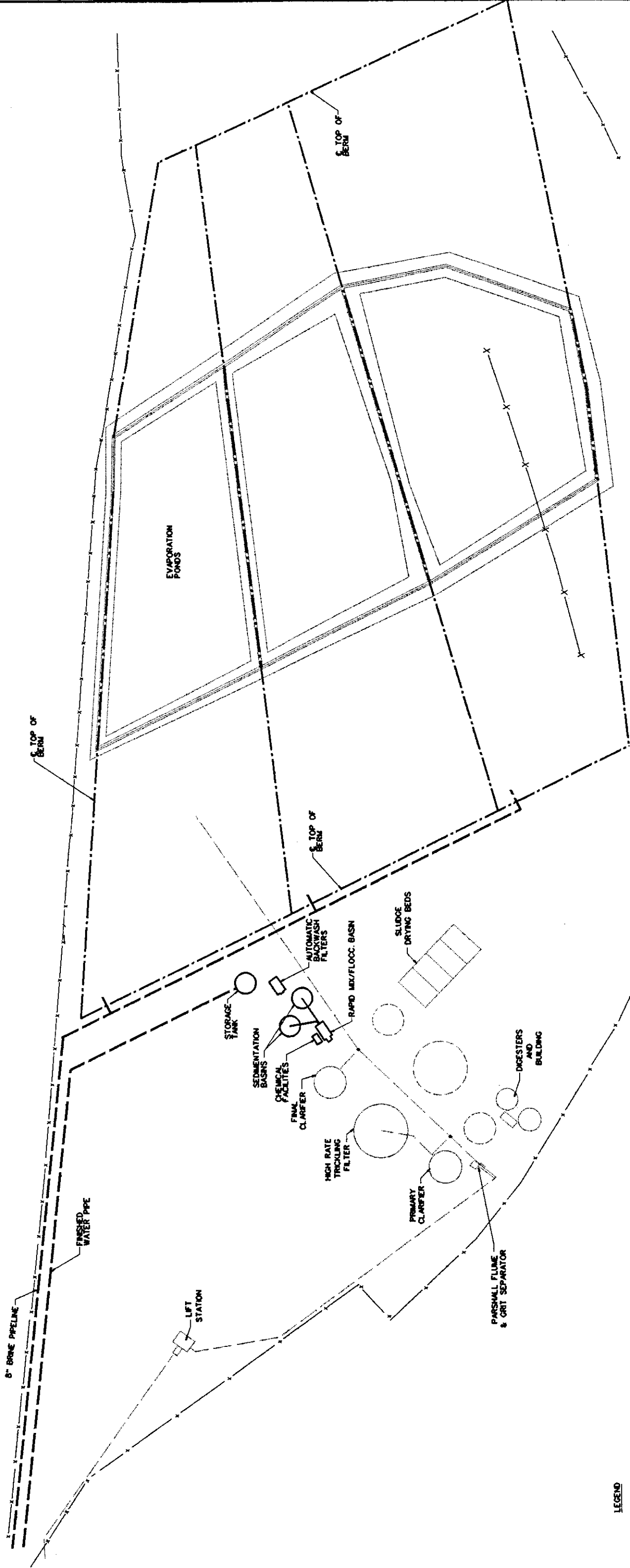
# PROJECT SITE MAP

**Freese  
AND  
Nichols** INC.  
CONSULTING ENGINEERS

FIGURE 3.1



SCALE: 1"=200'



LEGEND

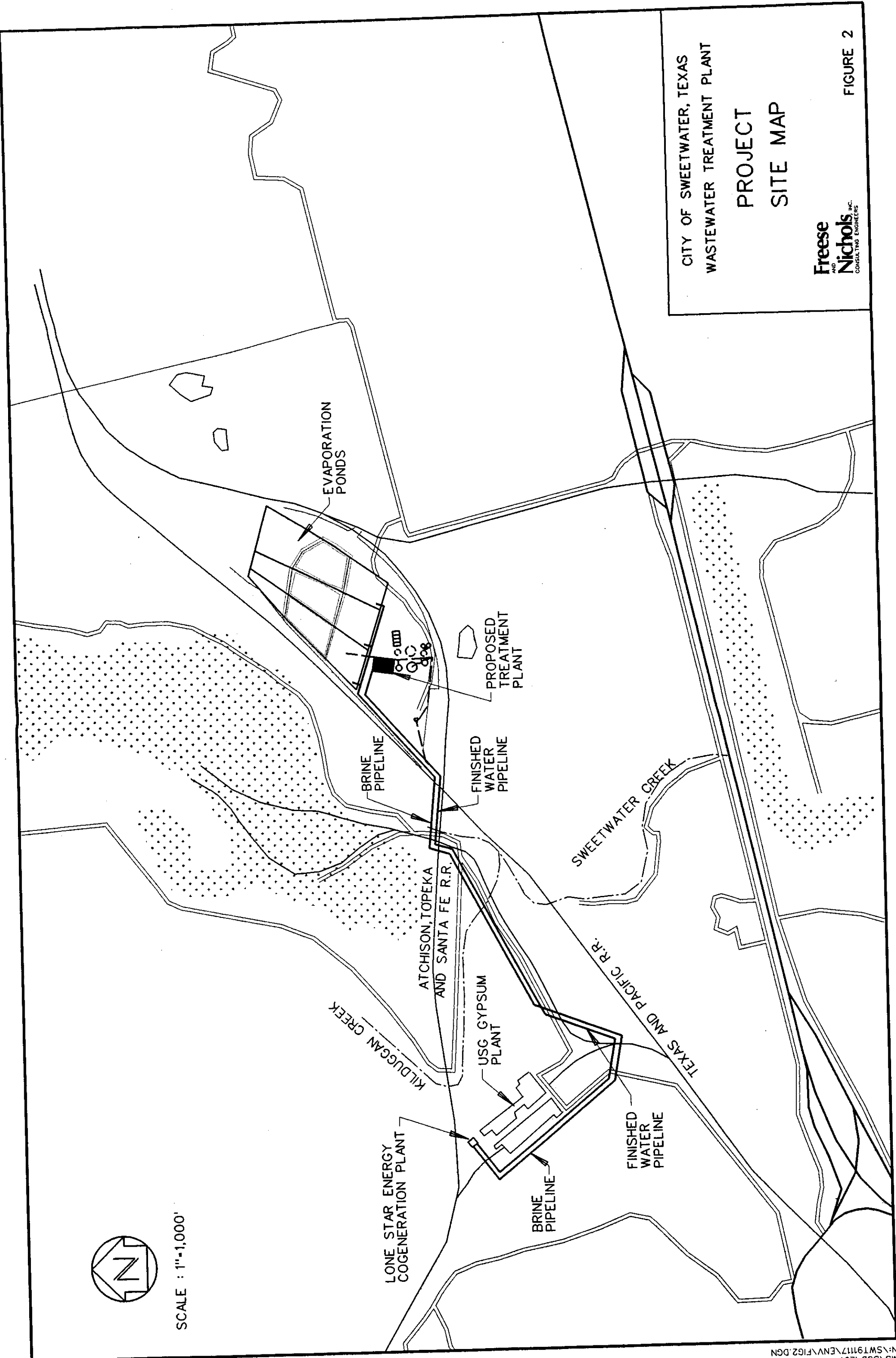
- PROPOSED IMPROVEMENTS
- - - EXISTING FACILITIES
- - - PIPELINE
- - - 8" OF EVAPORATION POND BERMS

CITY OF SWEETWATER, TEXAS  
WASTEWATER TREATMENT PLANT

PLANT MAP



SCALE : 1"=1,000'



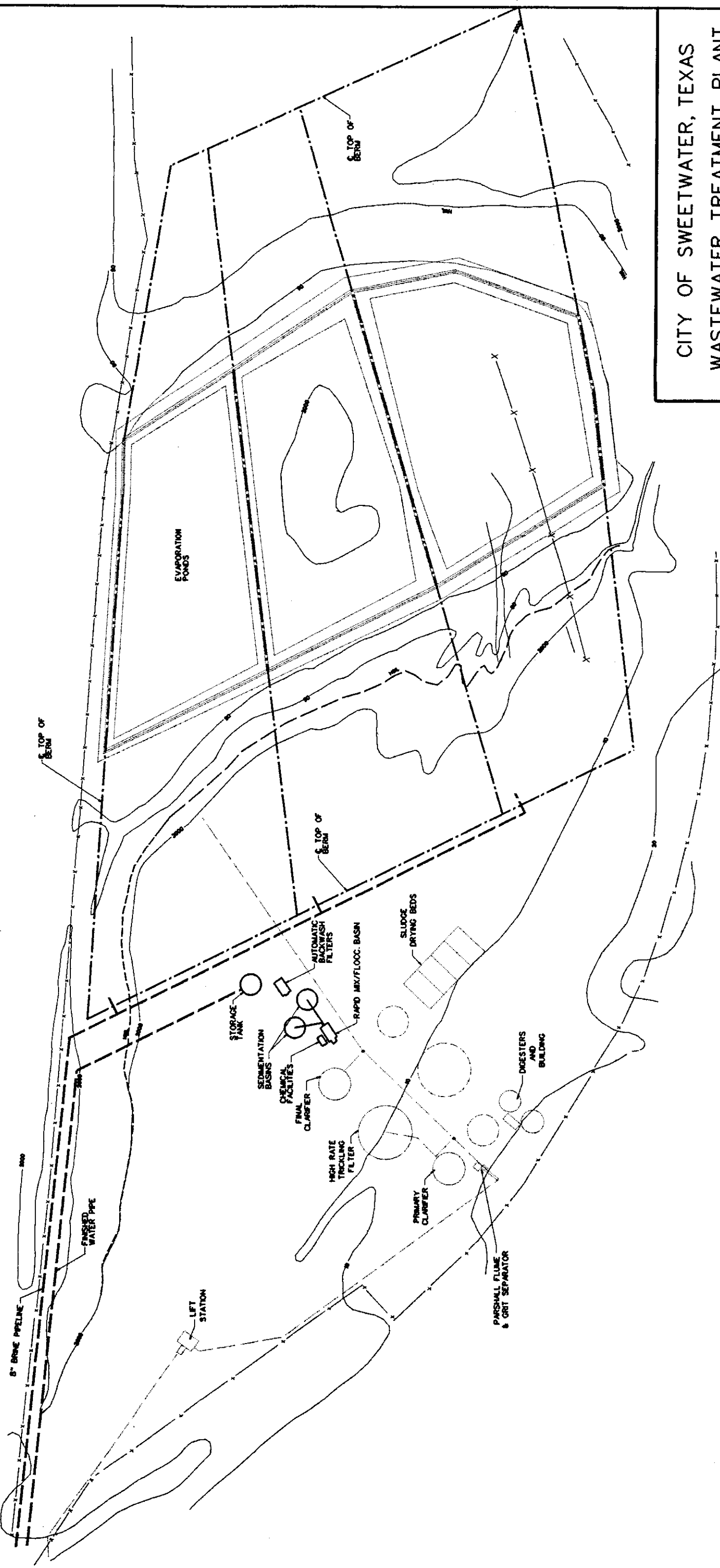
CITY OF SWEETWATER, TEXAS  
WASTEWATER TREATMENT PLANT

# PROJECT SITE MAP

**Freese  
AND  
Nichols**  
CONSULTING ENGINEERS



SCALE: 1"=200'



CITY OF SWEETWATER, TEXAS  
WASTEWATER TREATMENT PLANT

PLANT MAP

Freese  
and  
Nichols  
INC.  
CONSULTING ENGINEERS