DEVELOPMENT OF BRACKISH GROUND WATER RESOURCES IN THE BROWNSVILLE AREA

TWDB Contract No. 95-483-141

FINAL REPORT

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CHAPTER 1 - EXECUTIVE SUMMARY

1.1 PURPOSE

The purpose of this report is to evaluate the feasibility of developing and treating brackish ground-water resources available in the Brownsville area. This study was conducted in a two step process. The first step was to determine, from existing data if the project appeared to be feasible. Upon determination that the project could be accomplished at a reasonable cost, the second step was to develop test wells and operate a pilot reverse osmosis facility.

1.2 BACKGROUND

The Brownsville Public Utilities Board (PUB) obtains raw water for treatment from the Rio Grande. Over the past three years, the reservoirs supplying the Rio Grande have continued to deplete due to the drought conditions in the South Texas Region. The PUB has serious concerns that a continuation of this drought, coupled with increased demands from other users and the potential for water theft will severely limit the PUB's ability to meet it's customers demands. The record low flows in the Rio Grande, which represents the only source of water to the PUB, have dramatically increased the potential for water quality problems to occur, especially given the chronically poor water quality within the river caused by wastewater discharges, brackish seepage from irrigation leach drains, and irrigation return flows. Without a means to utilize alternative sources during times of unacceptable water quality or quantity, the PUB and it's customers are likely to be faced with a very critical situation.

Demineralization of groundwater has the potential to partially solve the PUB's long-term drought water storage problems. Currently, the only water available to PUB is the storage in Amistad and Falcon Reservoirs associated with raw water rights. If the PUB was able to demineralize brackish ground water to supplement their daily requirements, then reliance on this reservoir-based storage system would be diminished, and both the quantity and quality of their supplies would potentially be assured.

As part of the PUB's effort to decrease their dependancy on the Rio Grande, this study was authorized by the PUB and the Texas Water Development Board (TWDB). This study was completed in conjunction with the Aquifer Storage and Recovery Project (ASR) and the TWDB drilling crews. Common resources were used to reduce the overall cost to the PUB and the TWDB. This project, which includes the demineralization of brackish ground water, would allow ground water to be treated and distributed to supplement surface water supply and treatment and improve overall water quality.

1.3 SCOPE

The principal elements of the study include:

1.3.1 Phase I - Preliminary evaluation

- Data Collection and Evaluation
- Preliminary Ground-water quality and quantity estimates
- Establish Optimum Water Quality for Treatment

- Treatment Alternatives
- Develop Range of Costs for Treatment
- Develop preliminary treatment costs
- Concentrate disposal alternatives
- Prepare summary report

1.3.2 Phase II - Field Drilling and Testing Program

- Design field drilling and testing program
- Conduct, in conjunction with TWDB, field drilling and testing
- Develop ground-water quality and quantity estimates
- Conduct pilot plant study to include:
    - Development of design criteria
    - Evaluate membrane fouling characteristics
    - Service life of membranes
    - Concentrate characteristics
    - Pretreatment requirements
- Monitoring of Pilot Plant
- Evaluate test results
- Provide Final Report of Findings

1.4 GROUND-WATER ASSESSMENT

Several geologic and hydrologic studies and investigations have been conducted within and near the City of Brownsville. Readily available information from published and unpublished sources was utilized in order to assess the geologic and hydrologic conditions, and the availability of ground water in the area. Work for this report has included review of previous reports, records, and data; evaluations of well records in the area; analyses of geophysical logs of wells and test holes in the area; a limited field drilling program and preliminary computer modeling.

Ground-water conditions in and near the City vary considerably vertically and laterally. Geologic units are characterized by complex series of gravel, sand, silt, and clay zones within the Recent Alluvium and the underlying Pleistocene formations. These conditions generally result in extremely variable productivity and water-quality characteristics within the various water-producing zones. For purposes of this evaluation, three potential producing zones have been identified; the Gravel Zone, the Intermediate Zone, and the Lower Zone. Most previous studies have been limited to the Gravel Zone.

Based on preliminary evaluations and computer modeling, 8.0 MGD appears available from the Gravel Zone. In addition another 2.5 MGD may be available for development from the Intermediate Zone. However test drilling indicated little Intermediate Zone materials in Brownsville and development of water from the Intermediate Zone may only be available northwest of Brownsville. For costing purposes and based on preliminary parameters utilized in model calculations, about 26 wells are estimated to be required for a 10.5 MGD supply from these two zones. Projections are based on a 10.5 MGD supply for a 30-year planning period. The developed ground water supply will be available beyond 30 years, although additional wells may be required to maintain the supply at 10.5 MGD.

Additional resources appear to be available from the Gravel Zone and/or Intermediate Zone, although at a higher cost, by extending the well field further northwest.

For costing purposes the projected well field is estimated to extend from about the PUB's Water Treatment Plant No. 1 to the northwest along Military Highway approximately eight miles. The actual number of wells required, well yields, well locations and well field extent will be dependent on property availability, aquifer productivity characteristics at each site, regional hydrologic characteristics of the aquifers and actual well field use. Further work needs to be conducted in this area to firm up these projections. Water availability from these aquifers is independent of Rio Grande river flows and can supply water during drought conditions.

Ground-water quality is extremely variable laterally and vertically in the area. Based on existing data some relatively good quality water is available within the Gravel Zone in and to the west/northwest of the City along the Rio Grande. Away from the river, water within the Gravel Zone ranges from relatively fresh west of the City to brackish within the City to saline east of the City. While some fresh water appears to be available near and west of the City, any well field in this area will with time produce poorer quality water as more highly mineralized water will be induced to flow from the east to the well field. Assuming an initial well field location as herein described, the estimated total dissolved solids in water produced by this proposed well field would be about 1,500 to 2,000 mg/l initially and with pumping time, increase an estimated two to three times over twenty years. Little water-quality information is available for the Intermediate and Lower zones. Preliminary calculations indicate that if the well field is favorably located from water quality standpoints, water quality deterioration will be gradual. Immediate changes will not be required to meet these gradual changes. As wells become less productive in terms of quality over time, either additional wells will be added with expected higher quality and/or treatment technology will increase the efficiencies and costs of treating poorer quality supplies at equal or less costs.

Sufficient ground water is available for the planned project. However, specifics with regard to well field location, number of wells, actual producing zones and water quality, initially and in the future need to be further refined during the later phases of the project. Later phases of the project will include the investigations discussed in Chapter 2 of this report and include more detailed and extensive drilling and testing are required to better define subsurface local and regional hydrologic conditions, verify existing data and better evaluate the feasibility of finding suitable production well sites from quality and quantity standpoints. With this additional work, the cost-effectiveness and development of a 3.5 MGD to 10.5 MGD well field can be further refined.

1.5 TREATMENT REQUIREMENTS

Brackish or highly mineralized water (groundwater) contain excess salts and minerals or total dissolved solids mainly sodium, calcium, magnesium, sulfate, chlorides, and bicarbonates. Nitrates, fluorides, and potassium are found in smaller amounts. The EPA has recommended a maximum total dissolved solids content of domestic water supplies of 500 ppm. Texas standards currently require a total dissolved solids not to exceed 1,000 ppm. At times, the Rio Grande supply exceeds the 1,000 ppm and conventional treatment methods do not remove the TDS in the water. Exceeding this amount is acceptable if no better supplies are available.

Safe Drinking Water Act Standards (SDWA) can only be met through the use of special processes, to remove excess mineral content from brackish water. Two processes are suitable for treating brackish water and generating a product which would meet SDWA standards. These are Reverse Osmosis (R.O.) and Electrodialysis Reversal (EDR). With the feedwater quality information available, both processes were evaluated and determined that both could easily reduce total dissolved solids levels within the recommended concentration value. Because of the projected higher capital and operational costs associated with the EDR process, the reverse osmosis was installed for testing purposes.

1.6 PILOT PLANT OPERATIONS

A reverse osmosis pilot plant was installed and started on May 8, 1996 and operated successfully for three consecutive months. The purpose of the pilot testing was to determine if there are potential fouling agents found in the ground water that would prematurely cause the plant membranes to foul. During the three month operational period, no excess fouling occurred. The plant testing helped to further refine the costs associated with operation and maintenance of this type of facility.

The pilot plant began operation at a recovery of 75 percent. Recovery is defined as the percentage of feed water that is converted to "treated water", or permeate. This recovery was established from preliminary water quality analyses of the expected feed water. After approximately 2000 hours of operation, the recovery was increased to 80% for the duration of the pilot study.

During the first 2000 hours the membranes displayed no detrimental effects from exposure to the water. Premature replacement of the membrane elements due to deterioration or extensive fouling should not be a concern as long as the wells produce water free of suspended material. Membrane life of at least 5 years should be expected. Chemical cleaning of the membrane elements should be at intervals greater than 2000 hours, or four times a year.

The project could be constructed in three phases, each having a supply capacity of approximately 3.5 mgd. The wells will be located along an eight mile stretch of the Rio Grande northwest of Brownsville. The product water goal for this plant is a TDS of less than 750 mg/l. To achieve this goal, a product water blending rate of 71% permeate was required. This projection is based on a 75% recovery in the RO system, giving an overall system recovery of 80.8%. Assuming that each phase will produce 3.5 mgd in well field capacity, each phase of the RO system will be designed to produce 2.01 mgd of permeate and 0.67 mgd of concentrate. With blending, a total product capacity for each phase would yield 2.83 million gallons per day.

To achieve the most cost effective project, the goal of 750 mg/l TDS level was used. At this level, water quality would be an excellent water that exceeds current standards and this quality would be consistent over time. If the PUB were to use the permeate directly, with out blending with the other groundwater, the water would not be suitable for the distribution system without the addition of chemicals to meet the corrosion control guidelines of the Safe Drinking Water Act. From a design standpoint, a plant should be designed achieve a maximum TDS level of 1,000 mg/l, with blending. The plant would also be able to produce the product water that removes in excess of 90% of most minerals in the water. The yield from each phase of the reverse osmosis only plant (no blending) would yield 2.63 million gallons per day of permeate and 0.87 mgd of concentrate. Traditionally, plants have been designed to meet primary and secondary treatment standards, not to the reverse osmosis permeate level.

The amount of blending required by the PUB and it's customers depends upon two key factors. The primary factor is meeting drinking water standards. The combination of a consistent ground water source treated with membrane technology will yield more consistent quality to the consumer. Any changes in groundwater quality will be gradual over time. Quality of feed water and product is constantly monitored to achieve the desired quality. The cost is also a primary factor in the determination of blending. The greater amount of water that is blended yields a greater total product water for the same capital expenditure. Without blending, additional chemicals would be required to stabilize the water from the R.O. unit. The unit cost per 1,000 gallons produced is considerably higher for the unblended product water.

1.7 SUMMARY OF COST PROJECTIONS

Based on available information and work performed in this study, a reverse osmosis facility utilizing brackish ground water appears to be a viable alternative to supplement Brownsville's current surface water supply from the Rio Grande. The development of a reverse osmosis membrane treatment system, well field and transmission system, an 8.5 mgd product water can be developed at a cost for $0.56 per 1000 gallons capital cost and $0.37 per 1,000 gallons operational cost. These figures do not include the cost savings of the value of the surface water rights valued to $8.1 million. A summary of costs associated with each phase can be found in Table 1.1.

1.8 RECOMMENDATIONS

In order for the PUB to reduce it's overall dependancy on the Rio Grande, an alternative source of water should be established if economically feasible. The use of groundwater can be an alternate water supply that can partially supply current demands on the system that is independent of the Rio Grande supplies. The project recommended in this report is broken down into three phases. Costs contained in Phase I are higher per 1,000 gallons produced due to over sizing of buildings and pipelines to accommodate future phases. If all phases were completed at one time, the economy of scale would lower the overall cost per 1,000 gallons.

The three phase approach may prove to be most feasible at this time. Membrane process continue to be the subject of considerable research. With continued development of technology, the capital and operation and maintenance costs of membrane treatment are expected to decline. As the level of total dissolved solids increase over time from the well field, improved technology is expected to lower the cost of treating the higher mineral content of the water supply.

With the development of the second and third phase of this project, overall costs for treatment would decrease for brackish water treatment. Future membrane expansion could include the PUB's treated surface water to meet future Safe Drinking Water Act regulations.

1.8.1 Implementation Plan

The PUB should complete this project in phases for reasons stated above. To accomplish this, the following items should be completed in the order shown.

1.8.1.1 Initial 3.5 MGD Supply - Part I

- Initiate the permitting process to discharge well water concentrate into the City's North Main Drainage Ditch with ultimate discharge in the Brownsville Ship Channel.
- Compile and review available geologic data, water quality information, and hydraulic characteristics of the Gravel and Intermediate Zones on the Mexican side of the River.
- Conduct additional test drilling to verify that water can be produced from the intermediate zone, to better

define the location, feasibility and likelihood of finding favorable sites in the gravel and intermediate zones. An estimated ten to fourteen test hole sites with water samples will be required for this effort.

- Assuming favorable test hole results, construct a pilot production well in the gravel zone, with approximately four associated piezometers, and conduct a long-term pumping test to evaluate the regional hydraulic and boundary conditions of the gravel zone aquifer.
- As applicable, construct a pilot production well in the Intermediate Zone, with approximately four associated piezometers, and conduct a long term pumping test to evaluate the regional hydraulic and boundary conditions in the Intermediate Zone aquifer. Depending on the test drilling and pilot production well test results in the Gravel Zone, this task may not be required to finalize the supply, or it may be possible to delay this task until subsequent phases.
- Develop water quality testing parameter to develop treatment needs.

The pilot production well(s) constructed during these testing programs will be the initial production well(s) in the permanent well field. It is recommended that land purchase options be obtained for test drilling sites, as 50% or more of the sites may not be suitable for construction of production wells. Sites should not be bought until test drilling at each site has indicated favorable subsurface conditions.

1.8.1.2 Initial 3.5 MGD Supply - Part II

- From the data found in Part I, the design and construction of the well field, pipeline and treatment system can be completed. Based on the information found in Part I, the PUB can determine the degree of oversizing of the supply system to accommodate future well field development.
- Design of the treatment facility should accommodate future expansion needs of the ground water system.

1.8.1.3 Subsequent Supplies

- Previous permitting should account for the subsequent supplies.
- The development of subsequent phases will be identical to those mentioned in the initial 3.5 MGD supply.

Table 1.1 - Summary of Costs

CAPITAL COST PROJECTIONS	PHASE I	PHASE II	PHASE III	TOTAL
REVERSE OSMOSIS	$6,251,850	$2,187,900	$2,187,900	$10,627,650
OFFSITE TRANSMISSION[1] & CONCENTRATE DISPOSAL	$1,130,155	$1,663,253	$372,223	$3,165,630
WELL FIELD DEVELOPMENT	$1,720,000	$2,110,000	$2,200,000	$6,030,000
TOTAL CAPITAL	$9,102,005	$5,961,153	$4,760,123	$19,823,280
PRODUCT WATER EA. PHASE, MGD	2,830,000	2,830,000	2,830,000	8,490,000
ANNUAL DEBT SERVICE @6%, 20 YRS.	$793,554	$519,720	$415,009	$1,728,284
DEBT SERVICE PER 1000 GALLONS	**$0.77**	**$0.50**	**$0.40**	**$0.56**
OPERATION AND MAINTENANCE PROJECTIONS	***(CUMULATIVE TOTALS)***			
POWER @ $0.038/KWH	$81,508	$172,537	$298,083	
MEMBRANE REPLACEMENT	$70,000	$140,000	$210,000	
CHEMICAL	$92,000	$184,000	$276,000	
LABOR	$100,000	$100,000	$100,000	
MAINTENANCE	$50,000	$70,000	$90,000	
CARTRIDGE FILTER REPLACEMENT	$35,000	$70,000	$105,000	
WELL PUMP REPLACEMENT	$20,000	$40,000	$60,000	
TOTAL TREATMENT O&M PER YEAR	$448,508	$776,537	$1,139,083	
OPERATIONAL COST/1000 GALLONS	**$0.43**	**$0.38**	**$0.37**	(Blended)
TOTAL ANNUAL COST COMPARISONS				
TOTAL $$ PER YEAR	$1,242,062	$2,089,812	$2,867,367	
TOTAL $$/1,000 GALLONS (Blended)	**$1.20**	**$1.01**	**$0.93**	(Blended)
TOTAL $$/ACRE FOOT OF WATER PRODUCED	$391.79	$329.60	$301.49	
COMPARISON TO 100% RO PRODUCT WATER				
TOTAL $$/1,000 GALLONS	*$1.79*	*$1.48*	*$1.40*	(Pure RO)
COMPARISON OF WATER RIGHTS VALUES				
VALUE OF WATER RIGHTS SAVED	$2,694,690	$5,389,379	$8,084,069	
ANNUALIZED COST OF WATER RIGHTS	$234,935	$469,871	$704,806	
COST PER 1000 GAL WATER RIGHTS SAVED (Not deducted from project costs)	$0.23	$0.23	$0.23	

Note 1 - Offsite transmission costs assume an ultimate pipeline capacity of 10.5 mgd. The total cost to oversize the pipeline to accommodate a 20 mgd ultimate well field capacity would be approximately $5.9 million. Detailed costs can be found in Table 5.3.

CHAPTER 2 - GROUND-WATER ASSESSMENT

2.1 INTRODUCTION

2.1.1 Purpose

The purpose of this investigation is to conduct a preliminary assessment of the feasibility of developing up to a 10.5 MGD brackish ground-water supply for use as make-up water in desalting treatment processes so that the water can be used as a municipal water supply by the Brownsville Public Utilities Board (PUB). The work conducted is primarily a review of existing information in previous investigations. In addition, a limited field program was conducted.

2.1.2 Previous Investigation

The information included in this report is based primarily on previous investigations within and near the City of Brownsville (see References). Previous investigations have included work by the City of Brownsville in 1953 which included siting and constructing a well field within the City. Also the Texas Water Development Board (TWDB) conducted a detailed test drilling program to investigate ground-water conditions within the City and in an area extending approximately 20 miles west of the City; the results are published in TWDB Report No. 279. Several other investigations have been conducted, including an aquifer storage and recovery study (ASR) conducted by the PUB in Brownsville and studies by R.W. Harden & Associates, Inc. (RWH&A) for a potable ground-water supply located approximately 20 miles west of the City. Most of the previous work has been limited to relatively shallow depths, typically between 200 and 400 feet.

2.1.3 Work Conducted

The work conducted during this investigation consisted primarily of compilation of data, review of previous investigations and information including driller's logs, geophysical logs and water quality information, computer modeling for preliminary evaluation of the quantity and quality of ground-water reserves available and some limited field investigations. The field investigations principally consisted of the following:

- PUB Water Treatment Plant No. 1 (W.P.1.) Site: Drilling and construction of a 4-inch well in the Gravel Zone for use in the pilot water treatment testing;
- Riverbend Site: Drilling and geophysical logging of one test hole.
- Firefighter (F.F.) Site: Drilling and geophysical logging of one test hole and water sampling of water in the Intermediate Zone at the site.

Geologic data from the field drilling program conducted specifically for this project is included in Appendix 1. The information includes geologic logs and well construction information.

2.1.4 Acknowledgment

Special thanks are given to the TWDB for providing drilling, geophysical logging and technical support during the field operations. TWDB personnel who provided invaluable assistance included Messrs. Henry Alvarez, Randy Williams, Glen Haskin and Richard Preston.

This report provides a summary of the geohydrologic conditions in the Brownsville area based on available information. In addition, a general and preliminary evaluation of the availability and quality of ground water is included. Finally this report provides recommendations which are required to more fully assess the feasibility and cost-effectiveness of developing a system to produce between 3.5 and 10.5 MGD of moderately fresh to brackish ground water.

2.2 GEOHYDROLOGIC SETTING

The Brownsville area lies in the Rio Grande embayment of the Gulf Coastal Plain, which is characterized by complexly interbedded sedimentary deposits of gravel, sand, silt and clay of fluvial and deltaic origins. From shallowest to deepest, these geologic materials include Recent alluvium, the Beaumont and Lissie Formation of Pleistocene age, the Uvalde Gravel of Pleistocene or Pliocene age and the Goliad Formation of Pliocene age. Geologic units generally dip toward the Gulf of Mexico, except in local areas that have been disrupted by salt domes, faults, and folds. Historically, geologic strata from Miocene to Recent have been classified as the Gulf Coast Aquifer. However, these deposits have also been designated as the Lower Rio Grande Valley Aquifer and the Chico and Evangeline Aquifers. Table 1 provides a stratigraphic description of the geologic units in the City of Brownsville area.

For purposes of this report three distinct geologic/hydrologic units are designated; the Gravel Zone, the Intermediate Zone, and the Lower Zone. The Gravel Zone occurs entirely within the Alluvium. The Intermediate Zone is composed of the Alluvium or underlying Pleistocene deposits depending on location. The Lower Zone consists of the Beaumont, Lissie, Uvalde Gravel and Goliad Formations. Figure 2.1 provides a stratigraphic cross-section showing the general relationship of the different zones identified.

The thickness of the alluvial deposits is difficult to estimate due to similarity with the underlying formations and is likely extremely variable, ranging from 200 to 400 feet thick. The Alluvium was deposited by the Rio Grande system which accounts for a wide variation in depth, thickness and composition. The Alluvium extends laterally from the river to approximately 20 miles north of the City, and apparently about the same distance to the south. It is believed the Alluvium typically thins in a northerly and southerly direction away from the Rio Grande. The lateral extent of the alluvial deposits narrows upstream.

The complex series of gravel, sand, silt and clay zones throughout the entire thickness of this alluvial material results in a complex geohydrologic system with numerous water-bearing zones. The two primary water-bearing zones, the shallower Gravel Zone and the Intermediate Zone, as well as the underlying Lower Zone are discussed below.

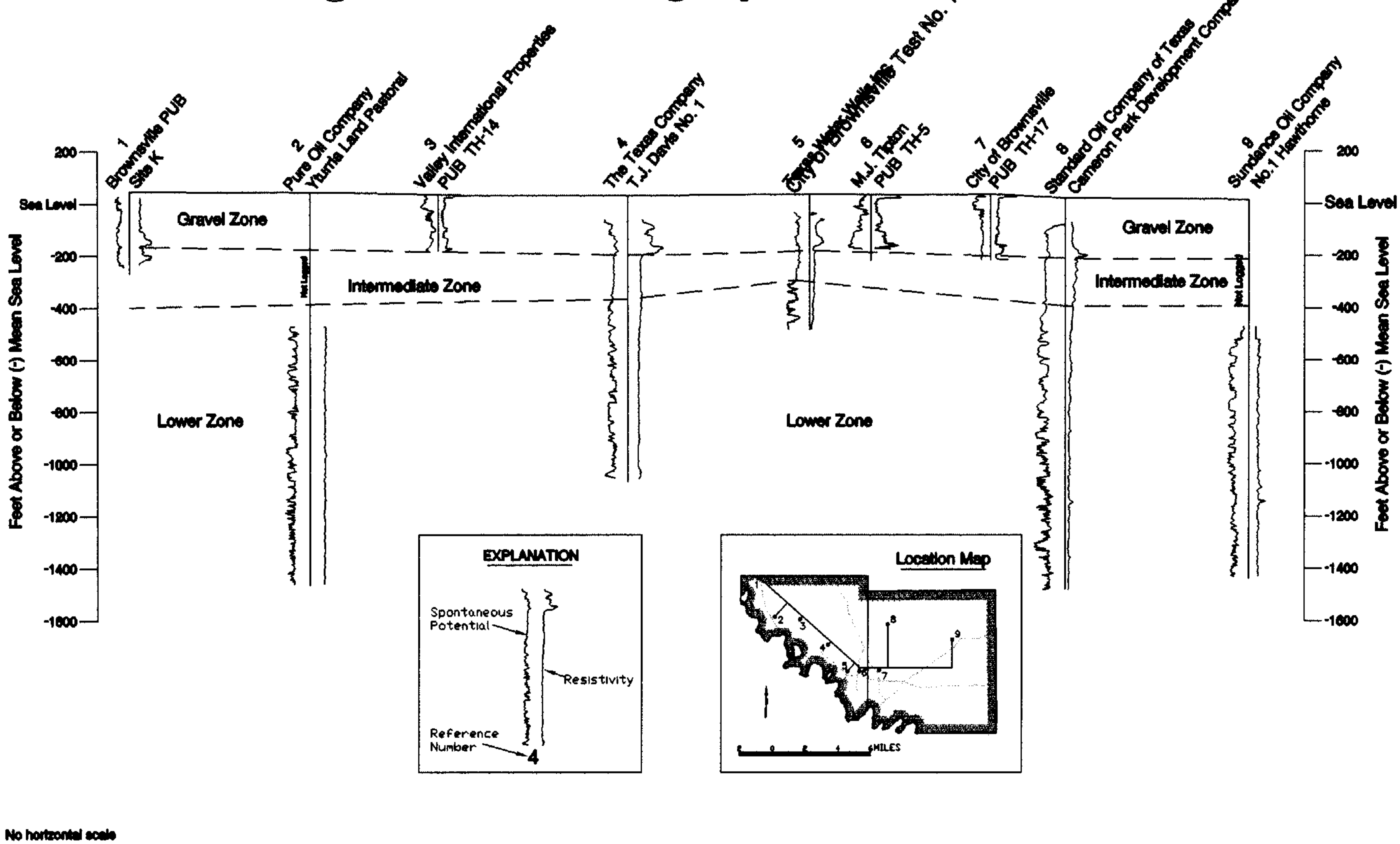
Table 2.1 - Stratigraphic Units in the City of Brownsville Area

Era	System	Series	Stratigraphic Unit	Character of Material	Geologic/Hydrologic Designations Used in this Report		Geologic/Hydrologic Designation Used in TWDB Report 316		Geologic/Hydrologic Designation Used in TWDB Report 279
Cen-o-zoic	Quater-nary	Recent (Holocene)	Alluvium	Gravel, sand, silt and clay	Alluvium	Gravel Zone Intermediate Zone	Chicot Aquifer	Gulf Coast Aquifer	Lower Rio Grande Aquifer
		Pleistocene	Beaumont Formation	Mostly clay with some sand and silt.	Lower Zone				
			Lissie Formation	Clay, silt, sand, gravel and caliche					
	Terti-ary	Pleistocene or Pliocene	Uvalde Gravel	Sand and gravel			Evangeline		
		Pliocene	Goliad Formation	Clay, sand, sandstone, marl, caliche, limestone, and conglomerate.					
		Miocene	Miocene Formations Undifferentiated	Mudstone, claystone, sandstone, tuff, and clay.					

2.2.1 Gravel Zone

Within the study area, the Gravel Zone generally occurs between depths of approximately 150 and 225 feet, and consists of unconsolidated gravels, with pebbles sometimes exceeding two inches in diameter, with interbedded fine sands. Thickness of gravel in the Gravel Zone can vary from zero to about 50 feet. Where the gravel is not present, the zone typically consists of very fine to medium grained sands with occasional interbedded clays and silts. Figure 2.2 indicates the thickness and variability of gravel in the Gravel Zone. Gravel in the Gravel Zone is erratic in occurrence and, based on analysis of historical available driller's logs, is typically only found in sufficient thicknesses suitable for large production wells at about 50 percent of the sites drilled. In the Brownsville area, it is reported that there is a gradual lessening of coarser materials towards the Gulf. Recent test drilling indicates the success rate at finding favorable sites for production wells may be less than 50 percent. Of the six sites recently drilled in conjunction with this study and the ASR study, only two out of six sites (33%) drilled had significant gravel thicknesses. The historical data may indicate a more favorable occurrence of gravel in the Brownsville area than may actually exist as unsuccessful test holes may not have been reported. However, based on TWDB work and results of City of Brownsville work conducted in the 1950's, it is believed that with sufficient test drilling, sites can be found having thick sections of coarse gravel favorable for production well construction. The amount of test drilling required to find the required number of sites is unknown. Two areas believed to have favorable Gravel Zone characteristics are near the City's old well field (northwest portion of the City) and about 8 miles northwest of the City near San Pedro. However, the Gravel Zone is extremely variable over very short distances, as shown in Figure 2.2, and drilling in the very near vicinity of sites having known favorable gravel thicknesses does not guarantee favorable results.

Figure 2.1 Stratigraphic Section



Brownsville Public Utilities Board

FIGURE 2.1

Stratigraphic Section

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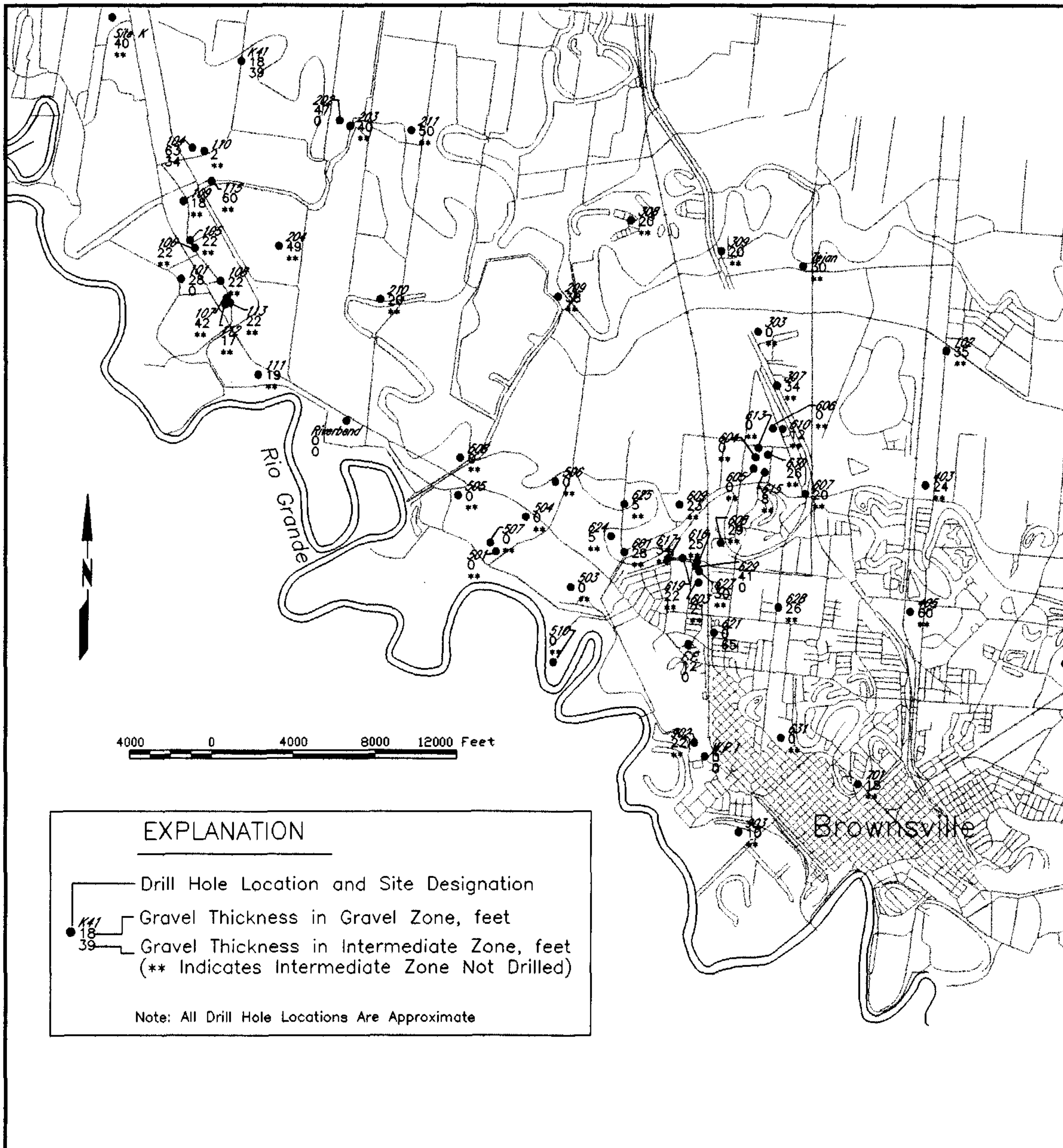

Brownsville Public Utilities Board

FIGURE 2.2

Occurence of Gravel in Gravel and Intermediate Zones

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NRS / BOYLE / HARDEN

The Gravel Zone is the primary zone where past test drilling and well construction activities have been conducted and is therefore the zone with the most data available. The hydraulic characteristics (production capability) of the Gravel Zone are dependent upon the amount and thickness of gravel encountered at each site. Where no gravel is found, only silts, clays and fine sands, the hydraulic conductivity, transmissivity and resulting production capability of the Gravel Zone are low. Where sufficiently thick gravel is found, the transmissivity and related production capability can be quite high. Hydraulic characteristics have been determined based on about 12 tests previously conducted in Cameron and Hidalgo Counties in the Gravel Zone. These aquifer tests indicate hydraulic conductivities ranging from approximately 50 gpd/ft^2 (gallons per day per foot squared) to about 4,000 gpd/ft^2. Transmissivities range from approximately 4,000 gpd/ft (gallons per day per foot) to about 80,000 gpd/ft depending on types of materials composing the Gravel Zone. Most significant to this study are several pumping tests conducted by the U.S. Geological Survey and TWDB on City of Brownsville wells. The U.S. Geological Survey reported an average transmissivity of 54,000 gpd/ft, a hydraulic conductivity of 900 gpd/ft^2 and a storage coefficient of .00044 (Preston, 1983). The TWDB test results indicated an average transmissivity of 80,000 gpd/ft, an approximate hydraulic conductivity of about 3,000 gpd/ft^2 and an average storage coefficient of 0.000025 (Preston, 1983). The test results indicate a reasonably productive aquifer which can yield significant quantities of water but which is also extremely variable. These test results likely represent more prolific sites and the average transmissivity of the Gravel Zone likely is less. On average, it is estimated that a reasonably suitable site for a production well in the Gravel Zone would have a minimum of about 20 feet of very coarse gravel and a transmissivity of 30,000 gpd/ft or greater. The difficulty in developing water from the Gravel Zone is finding sufficiently thick gravel deposits suitable for production wells. The Gravel Zone is under artesian conditions in the Brownsville area, and a storage coefficient of about 0.0005 is estimated.

Depths to water in wells in the Gravel Zone are generally shallow, typically ranging between 10 and 30 feet below ground level, depending principally on surface elevations and relationships to recharge and discharge areas. Water-level elevations typically range from approximately 20 feet above sea level in the western portion of the study area to approximately 10 feet above sea level near and in Brownsville. Based on water-level measurements between 1953 and 1987, the maximum water-level fluctuation appears to be approximately 12 feet. In the Brownsville area the Gravel Zone as well as the Intermediate and Lower Zones are not in significant hydraulic communication with the Rio Grande and these aquifers are capable of supplying water during drought conditions.

2.2.2 Intermediate Zone

For purposes of this report the Intermediate Zone is composed of geologic materials below the Gravel Zone to about 400 feet in depth. The Intermediate Zone generally extends from a depth of approximately 225 feet to about 400 feet below ground level. The zone consists of a complex series of interbedded sands, silts and clays, with some occasional gravel layers. The Intermediate Zone has from less than a few tens of feet up to approximately 150 feet of sands and, on occasion, some gravel within its thickness. Interbedded silts and clays are common. The character and composition of the Intermediate Zone is extremely variable over relatively short distances. The Intermediate Zone is either composed of Alluvium and typically overlies older Pleistocene units, or is composed of older Pleistocene materials. Information on the Intermediate Zone is limited as most past drilling conducted for ground-water exploration in the area was limited to the Gravel Zone. Figure 2.2 indicates the limited availability of data and occurrence of gravel in the Intermediate Zone. Some reports indicate that the Intermediate Zone may solely be composed of the older Pleistocene Beaumont and Lissie formations. Test drilling conducted to the west indicates some occasional very coarse gravels in the Intermediate Zone, generally indicating that where coarse gravel is found it is likely associated with the Rio Grande Alluvium. However, due to the variable erosional surface of the underlying Pleistocene beds, the Intermediate Zone at any location may consist of alluvial materials and/or older Pleistocene materials. The recent test drilling conducted indicates that in the Brownsville area the Intermediate Zone may be composed predominately of Pleistocene clays and silty clays which typically would not have significant water producing capabilities. Current data indicates that the only favorable areas for water production from the Intermediate Zone are to the northwest of the City near the San Pedro area. This needs to be confirmed by additional test drilling.

No aquifer or pumping test information is available specifically for the Intermediate Zone. The hydraulic characteristics of the Intermediate Zone will vary dramatically depending on the amount and character of sand and gravel in the zone at each site. However, based on analysis of geophysical logs and some specific capacity information representing the Intermediate Zone in areas to the northwest of Brownsville, it is believed that fine to medium grained sands, where present, may have a hydraulic conductivity on the order of 100 to 150 gpd/ft^2, while coarser gravels, if present, may have hydraulic conductivities equal to or in excess of the Gravel Zone. With sufficient sand, estimated Transmissivities at better sites could be in excess of 10,000 gpd/ft when about 70 feet of sand is present. However, this can vary considerably and transmissivities at sites having significant gravels may exceed 30,000 gpd/ft. One well located several miles northwest of the City and reported to be screened in the Intermediate Zone, but which may also be screened in the Gravel Zone, was tested to have a transmissivity of 100,000 gpd/ft. This well had over 25 feet of large gravel in the Intermediate Zone, thus indicating the extreme variability of this zone and the potential for it to be as productive or more productive than the Gravel Zone at some sites. The Intermediate Zone is under artesian conditions and a storage coefficient on the order of 0.0005 is estimated.

Little information is available regarding depths to water in wells and elevations of the potentiometric surface in the Intermediate Zone in the study area. However, work conducted approximately 20 miles to the west of Brownsville indicates that the depths to water in the Intermediate Zone approximate the depths to water in the Gravel Zone. It is estimated that depths to water in the Intermediate Zone will range from 10 to 30 feet below ground level. This is consistent with depths to water in the Intermediate Zone further to the west.

2.2.3 The Lower Zone

The Lower Zone is comprised of, from shallowest to deepest, the Beaumont Formation, Lissie Formation, Uvalde Gravel and Goliad Formation. The Lower Zone is made up of a complex depositional framework of interbedded layers and lenses of predominately sand, silt and clay. Typically, the Beaumont consists of massive clay with thin lenses and layers of sand. However, within the Rio Grande Valley the portion of fine to medium grained sand is reported to be much larger. The Beaumont clay is underlain conformably by the Lissie Formation, which consists of alternating layers of unconsolidated sand, silt and clay, oftentimes interbedded with sandy caliche. The Lissie Formation is typically composed of 60 percent fine to medium grained sand, 20 percent sandy clay, 10 percent gravel and 10 percent clay (Sellards, 1958). The Uvalde Gravel, which underlies the Lissie Formation, is a thin unit no greater than about 20 feet thick, consisting of well rounded chert pebbles and cobbles (Fisher, 1976). However, the Uvalde Gravel is likely not present throughout most of the study area. Beneath the Uvalde Gravel lies the Goliad Formation typically consisting of about 10 percent clay, 85 percent sand, gravel and sandstone, and 15 percent calcium carbonate (Sellards, 1958). The combined thicknesses of the Beaumont, Lissie, and Goliad formations can be in excess of 3,000 feet. Based on geophysical log analyses, it is estimated that approximately 40 percent of the combined Lissie and Goliad Formations have sand capable of yielding reasonable quantities of water to wells.

No site-specific information is available on the hydraulic characteristics of the Lower Zone in the vicinity of Brownsville, as this zone contains poor quality water and has therefore not been extensively investigated for ground-water production purposes. However, four pumping tests were conducted in sand zones in the Lower Zone in Willacy and Hidalgo Counties. In addition, as the Lower Zone is part of the Gulf Coastal Plain Aquifer, assumptions and preliminary analysis can be made regarding the hydraulic characteristics of the Lower Zone from data available to the north and as estimated by Ryder (1988). Based on this information, the hydraulic conductivity in the cleaner, more permeable sand zones ranges from about 80 to 150 gpd/ft^2. Where the sands contain clay, silt and/or clay breaks, hydraulic conductivity will be significantly less. The transmissivity of Lower Zone wells is dependent on how much sand is present at the site and is screened in a production well. Approximately 40 percent of the full thickness of the Lower Zone is estimated to be sand. Therefore, if 1,000 feet of Lower Zone material were targeted for development at a well site, a transmissivity of on the order of 40,000 gpd/ft is estimated. However, contiguous sands in the Lower Zone are typically on the order of 30 to 70 feet thick and rarely more than 100 feet thick. For each clean sand zone averaging 50 feet in thickness, a transmissivity of about 6,000 gpd/ft is estimated. Values will vary considerably based on sand character and thickness at specific locations. Detailed local test drilling needs to be conducted to confirm this reported data. The Lower Zone is under artesian conditions, and a storage coefficient of about 0.0005 appears applicable based on available information.

No specific information is available regarding the depth to water, water-level elevation or hydraulic gradient of the potentiometric surface in the Lower Zone. Based on regional comparisons, depths to water in wells is estimated to be shallow, generally less than about 30 feet below ground level and may be slightly above ground level in some sand zones and locations.

2.3 WATER QUALITY

Ground-water quality in the Brownsville area is characterized by a wide variation in chemical composition. The water quality varies significantly, both laterally and vertically, generally increasing in mineralization from west to east and also vertically from shallow to deep. Existing information appears adequate to generally identify and quantify the water-quality in the Gravel Zone. Detailed water-quality information for the Intermediate and Lower Zones is limited and can mostly only be estimated from available geophysical logs. Water quality analysis for testing completed for this project can be found in Appendix II. The following provides information with regard to water quality in the targeted zones.

2.3.1 Gravel Zone

Water quality in the Gravel Zone is reasonably well mapped mostly based on chemical analyses from wells in the area. Figure 2.3 shows the estimated total dissolved solids (TDS) of water for the Gravel Zone. Much of this information comes from historical records for wells in the area. Due to the construction of many of these older wells and the overlying different quality water, the reliability of many of these historic analyses is questionable as to whether they actually represents water quality in the Gravel Zone. However, the data as a whole indicate an increasing trend in mineralization of water in the Gravel Zone from west to east. Data also indicate large variability in water quality locally in the Gravel Zone, and exceptions to this overall trend exist.

Also shown on Figure 2.3 are locations of selected wells for which specific chemical analyses have been provided in this report. The chemical analyses of water from these wells are provided in Table 2.2, most of these chemical analyses are representative of water quality from the Gravel Zone. Table 2.2 generally shows the range of individual constituents in water from the Gravel Zone. The water-quality analyses provided in Table 2.2 for the Gravel Zone are based on test drilling conducted by the TWDB in 1973, or work conducted for the PUB. Generally the water quality testing conducted for this study is in agreement with previous mappings. However, other data indicates varying water quality not consistent with previous mappings. The reasons for this are currently unknown but may indicate the quality of previous data and/or variability of water quality in the Gravel Zone. Further work is required to verify current water quality mappings. The water in the Gravel zone is believed to have significant concentrations of iron and manganese. To the west along the Rio Grande, data indicate some limited areas of water quality of less than 1,000 mg/l total dissolved solids.

2.3.2 Intermediate Zone

Water quality in the Intermediate Zone is specifically known at only two sites in the general study area; Site K and Site F.F. Analytical results for these two sites are shown in Table 2.2. The location of these sites are shown on Figure 2.3. Site K was drilled during the PUB's potable well field investigations and Site F.F. was drilled during these investigations. Both analyses represent water quality in the Intermediate Zone. Based on these analyses and work conducted to the west, it is generally believed the water quality in the Intermediate Zone is slightly to significantly higher in mineralization than in the Gravel Zone. In and around Brownsville, little or no water quality analyses are available which are believed to represent the Intermediate Zone other than Site F.F. It is estimated that in the Brownsville area, the vertical water quality gradient from the Gravel to the Intermediate Zone is greater than to the west of Brownsville where the Intermediate Zone appears to be composed predominantly of alluvial materials. It is generally estimated that the water quality in the Intermediate Zone will be slightly to significantly higher in mineralization than in the Gravel Zone, depending on depth, location and composition of materials. The water in the Intermediate Zone will likely increase in mineralization and change to a sodium chloride type water eastward and with depth. In the Brownsville area, it is estimated that water quality in the Intermediate Zone ranges from about 1,500 mg/l to about 20,000 mg/l total dissolved solids, depending on depth, location in Brownsville and the type of geologic materials present.

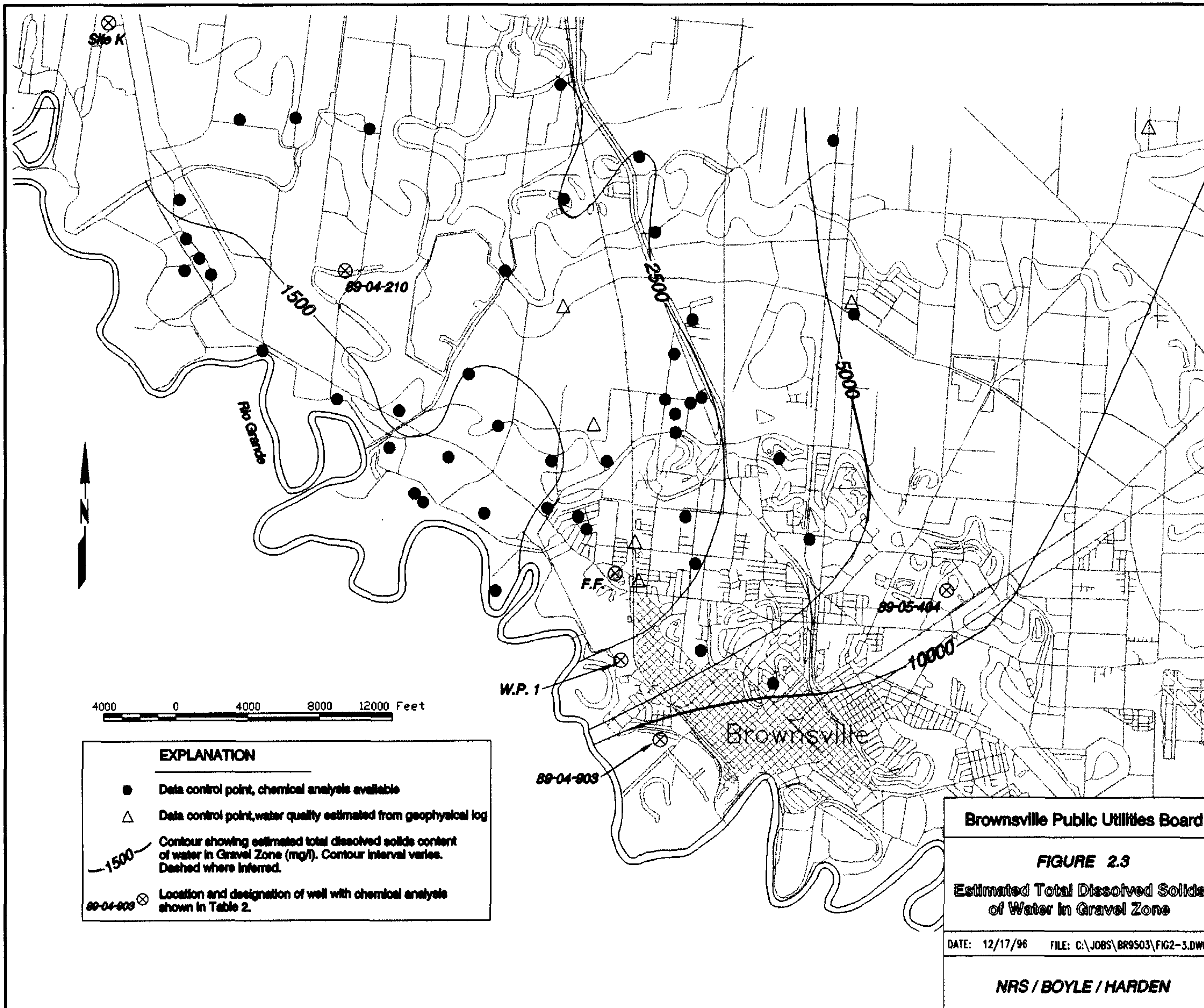

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FIGURE 2.3

Estimated Total Dissolved Solids of Water in Gravel Zone

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Table 2.2 - Representative Water Quality

Well/Site Designation:	89-04-210	W.P. 1	89-04-903	89-05-404	Site K	F.F.	88-59-411*
Zone:	Gravel	Gravel	Gravel	Gravel	Intermediate	Intermediate	Lower
Producing Interval (Ft. BGL):	194-217	160-200	166-188	165-225	220-260	316-336	932-952
Constituents:							
pH, units	8.2	7.2	7.8	7.4	8.0	7.3	7.7
Total Dissolved Solids, mg/l	2,280	2,700	11,900	8,400	1,480	9,900	26,277
Total Alkalinity, mg/l ($CaCO_3$)	402	380	328	246	370	190	95
Total Hardness, mg/l ($CaCO_3$)	476	-	2,800	1,990	278	-	4,347
Specific Conductance, umhos	3,060	5,000	12,000	10, 540	2,200	16,000	53,760
Cations:							
Boron, mg/l (B)	2.5	-	6.6	3.6	<1	-	-
Calcium, mg/l (Ca)	90	73	510	369	61	580	1,048
Magnesium, mg/l (Mg)	61	45	370	258	30.5	260	420
Potassium, mg/l (K)	-	4.80	-	16	7.1	40	34
Silica, mg/l (SiO_2)	34	33	36	19	30.4	54	12
Sodium, mg/l (Na)	600	1,000	3,260	2,260	440	3,200	7,946
Anions:							
Bicarbonate, mg/l (HCO_3)	490	379	400	300	451	190	116
Chloride, mg/l (Cl)	357	780	5,430	3,680	229	4,000	11,904
Fluoride, mg/l (F)	0.9	1.7	1.2	1.7	0.72	0.90	0.9
Nitrate, mg/l (NO_3)	0.5	<0.2	5.5	<0.4	0.95	<0.22	0.04
Sulfate, mg/l (SO_4)	890	860	2,080	1,610	481	1,600	4,855
Metals:							
Total Iron, mg/l (Fe)	0.82	<0.05	1.6	3.74	0.43	3.6	-
Total Manganese, mg/l (Mn)	-	0.066	-	<0.05	0.052	0.54	-

* Site located approximately 20 miles west of Brownsville in Los Indios area.

2.3.3 Lower Zone

Mineralization of water in the Lower Zone likely increases from shallow to deep and from west to east. Based on analyses of geophysical logs, it is estimated that in the immediate Brownsville area at a depth of about 400 to 600 feet below ground level, water in the Lower Zone will likely exceed 20,000 mg/l total dissolved solids. Water-quality estimates from geophysical logs are only approximations and as such should be used accordingly. Estimates of water quality with depth for waters above 20,000 mg/l total dissolved solids were attempted but could not be made from available geophysical logs, due to the presence of clay and thin-bedded sand zones, the use of conflicting drilling fluids, and/or electrochemical effects. Table 2.2 includes a water quality analysis which likely represents typical individual constituent concentrations for water in the Lower Zone having a total dissolved solids concentration of about 26,000 mg/l. These data were obtained from a test hole drilled approximately 20 miles to the west of Brownsville by the TWDB. Additional water quality information for the Lower Zone may be available from the PUB's ASR study.

2.4 AVAILABILITY AND QUALITY OF GROUND WATER FROM PROJECTED WELL FIELD

Based on the available geologic and hydrologic information summarized herein, the availability of ground-water near the City of Brownsville has been evaluated on a preliminary basis. The work included making estimates of aquifer hydraulic parameters and boundary conditions and preliminary computer modeling to assist in availability and water quality estimates. Based on results of these investigations, preliminary assessments of the availability and quality of ground water to supply a 3.5 MGD to 10.5 MGD well field are included herein. Additional work is needed to verify the feasibility of such a water supply.

2.4.1 Gravel and Intermediate Zones

Quantity: Based on work done to date, specifically drilling programs to the west of the City and evaluations of geophysical logs, pumping test data and well records near and within the City of Brownsville, 3.5 to 10.5 MGD of brackish ground water appears available to a well field(s) within and near the City. Based on modeling results, a 10.5 MGD, 20 year supply would likely consist of about 8.0 MGD from the Gravel Zone and if favorable conditions could be found, 2.5 MGD from the Intermediate Zone. Projections were made assuming full production (10.5 MGD) continuously for 30 years. However, the longevity of the supply will likely significantly exceed 30 years, although additional wells may be required to maintain the 10.5 MGD supply. Further work needs to be conducted to verify the assumptions used in these analyses.

The ability to develop a 3.5 to 10.5 MGD ground-water supply cost effectively is dependent upon a number of factors including obtaining a sufficient number of productive sites, favorable regional hydraulic conditions and for larger amounts of production the existence of coarse sands and gravels in the Intermediate Zone. Based on historical records, favorable sites in the Gravel Zone are known to exist within and near the City. While the data indicate that favorable sites in the Gravel Zone occur within and near the City, the amount of test drilling required to find such sites and whether a sufficient number of sites can be found is unknown but likely possible with sufficient test drilling. Production from the Intermediate Zone does not appear favorable from water quantity or quality standpoints in Brownsville. However, northwest in the San Pedro area it appears with sufficient test drilling that some water from the Intermediate Zone can be developed. To firm up quantity estimates significant local test drilling and long-term pump testing will be needed in order to better determine the frequency and distribution of productive sites and regional hydraulic conditions.

Wells and Well Fields: Well and well-field design, spacings, locations, and completion zones are dependent upon site-specific and regional aquifer productivity, and water quality. In addition, site availability and engineering considerations are also determining factors. Figure 2.4 provides an example well field for a 3.5 MGD, a 7.0 MGD and a 10.5 MGD system producing from the Gravel and Intermediate Zones and targeting the better water quality available. The example well field is sited along Military Highway due to ease of right-of-way and water quality considerations. The schematic well field layout sites wells generally consistent with Figure 2.2; by-passing areas where current mappings indicate little gravel and locating Gravel and Intermediate Zone wells in areas which appear favorable. However, only test drilling can prove-up well sites. Based on preliminary modeling using an in-house modification of the TWDB well field model IMAGEW-1 and assumed aquifer conditions consistent with the data, calculations were conducted to make a preliminary evaluation of appropriate well spacings, the number of wells required and approximate well yields for development of a 3.5 MGD, 7.0 MGD and 10.5 MGD well field. The following provides the results of this work:

Well Field Supply (MGD)	Number of Wells	Estimated Pumping Rate per Well (gpm)	Well Spacing (ft)
3.5	7	350	2,500
7.0	16	300	2,500
10.5	26	280	2,500

The locations and capacities of the well field, individual wells and the actual number of wells is determined by aquifer productivity at each site, long-term regional aquifer hydraulic conditions and how the well field is used. In addition it is assumed that a sufficient number of suitable sites can be found.

As mentioned earlier, little information is available pertaining to the Intermediate Zone and present data indicates poor quality water and little Intermediate Zone gravels near Brownsville. Therefore, development of the Intermediate Zone is proposed to the far northwest extent of the well field. To the extent favorable production characteristics are not found near Brownsville the well field can be extended northwest at additional cost to obtain the quality and quantity of water needed. However, the well field layout as discussed provides a preliminary indication and cost basis for evaluating the feasibility of developing such a supply.

Water Quality: The quality of ground water within the Gravel and Intermediate Zones varies significantly laterally and vertically. As indicated by Figure 2.3, total dissolved solids generally increases within the Gravel Zone from west to east. In some limited areas near the river west of the City, good quality water meeting drinking water standards (i.e. TDS < 1,000 mg/l) could be available initially. The initial quality of water produced by the well field(s) is primarily a function of well field location. The location of the well field is primarily dependent on availability of well sites, right of way and finding suitable subsurface conditions. If the best quality water were targeted and enough suitable sites could be found, water initially produced from the Gravel Zone could have a total dissolved solids of about 1,500 mg/l. However the quality of water produced will deteriorate with production as poorer-quality water is drawn into the well field(s).

Preliminary estimates have been made to generally quantify the potential for deterioration of water quality as production from the well field occurs. These estimations were conducted using the USGS ground-water flow models MODFLOW and MODPATH. Hydraulic parameters for the modeling were generally consistent with those used to estimate ground water quantity amounts and are based on existing data. The beginning water quality gradient was assumed as that shown on Figure 2.3. The well field location was assumed as that shown on Figure 2.4. Water quality on the south side of the Rio Grande was assumed to be a mirror image of the water quality on the United States side. Using the assumed aquifer hydraulic characteristics and water quality the Gravel Zone well field was pumped continuously at 7.5 MGD for 20 years. The models project the movement of more brackish water towards the well field and the resultant increase in total dissolved solids of produced water. As shown, with pumping time, water quality deteriorates. Figure 2.5 generally indicates the change in total dissolved solids produced from the well field with time, as determined from model results.

Figure 2.5 generally brackets conditions that we believe, at this time, take into account the likely variability in subsurface materials. However, due to the high variability in the Gravel Zone and preferential movement through higher permeability gravel channels, this estimate of deterioration of water quality with time is only approximate.

This work indicates that water quality deterioration is not an overly large problem and will occur gradually. In addition, due to the distribution of the natural water quality, the well field water quality can be maintained at better quality levels by dropping out wells on the southeast side of the well field as they become more mineralized and adding wells on the northwest side of the well field.

Insufficient water quality information is available for the Intermediate Zone to determine the impacts of Intermediate Zone production on well field water quality deterioration. However, based on present information the Intermediate Zone, if developed, would probably be on the northwest side of the well field in the area of best water quality. In addition, Intermediate Zone water would be only about 25 percent of total production therefore it is estimated that production in the Intermediate Zone will likely have only slight effect on well field water quality.

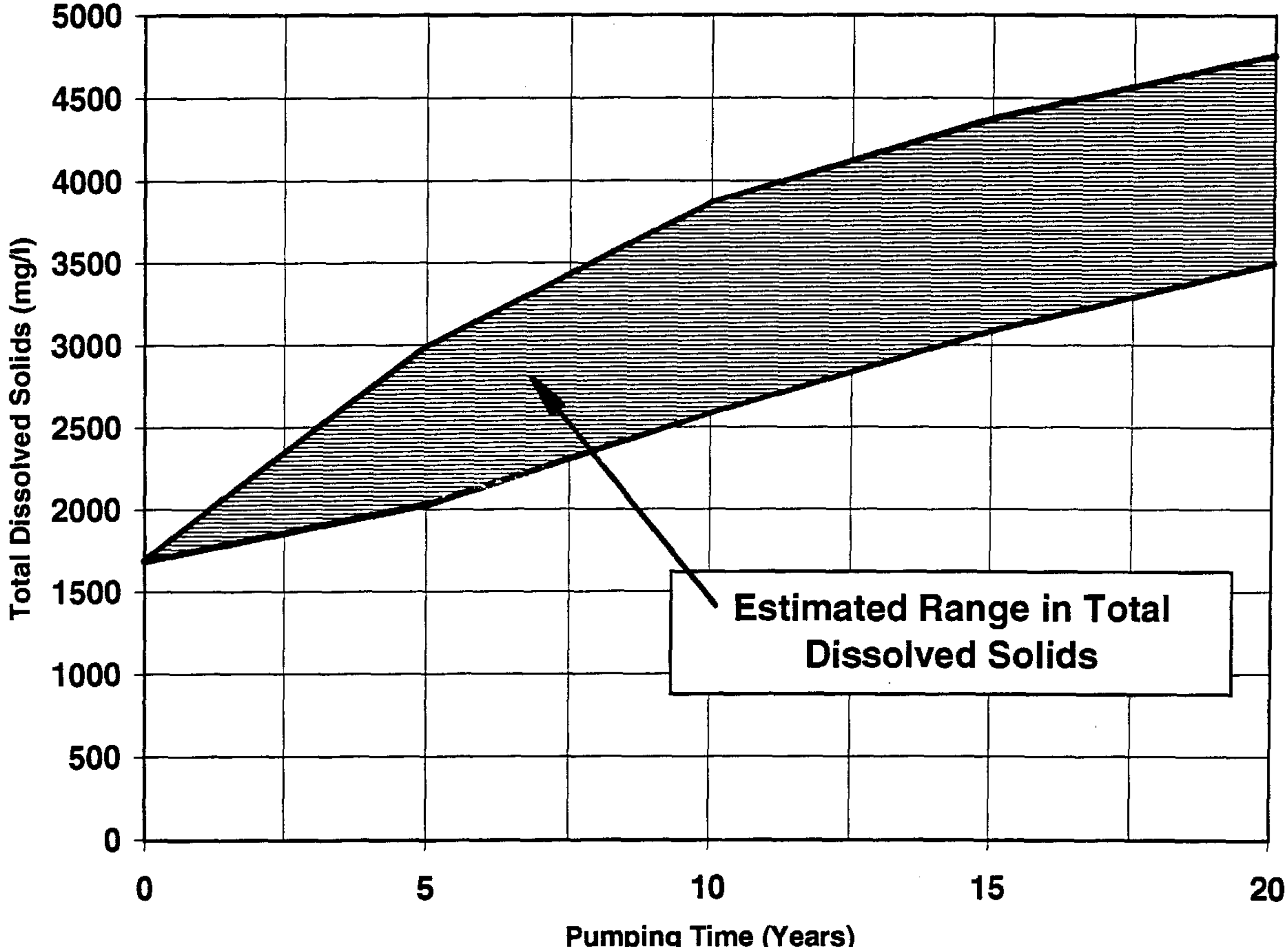
2.4.2 The Lower Zone

Quantity: While little information is available for the Lower Zone in the area, it is likely capable of producing significant volumes of water to wells due to its depth and thickness. Assuming wells about 2,000 feet or deeper, screening about 400 feet of more permeable sand, individual wells would likely be capable of producing up to 1,400 gpm. Therefore, it is possible that a well field of five wells could supply up to 10 MGD of ground water. However, actual well yields may largely be governed by required water quality and site sand thicknesses. Water quality deteriorates with depth in the Lower Zone. If no water quality restrictions are placed on development of the well field, wells could screen more sands deeper and larger well yields could be obtained. If treatment considerations require only the better quality water in the Lower Zone, wells may have to screen only shallower Lower Zone sands and well yields will be proportionally smaller. As the vertical water quality gradient in the Lower Zone is at present unknown, further evaluation of water quality versus well yield cannot be conducted.

Quality: Based on very limited information, water within the Lower Zone is highly mineralized. All water produced from the Lower Zone in the area will likely exceed 20,000 mg/l total dissolved solids, and much may contain concentrations of over 40,000 mg/l total dissolved solids.

Wells and Well Fields: Though lateral lithological changes are present, the Lower Zone is likely more uniform in terms of well-yield capacities than the Gravel and Intermediate Zones due to its large thickness. Due to its thickness and lateral extent, wells in the Lower Zone can more likely be conveniently located in the study area. However recommended well spacings are between 2,000 and 2,500 feet.

Figure 2.5
Estimated Water Quality From Well Field



Note: Estimates based on results of U.S.G.S. Modflow and Modpath ground water models.

296/modflow\wqbalance2.xls

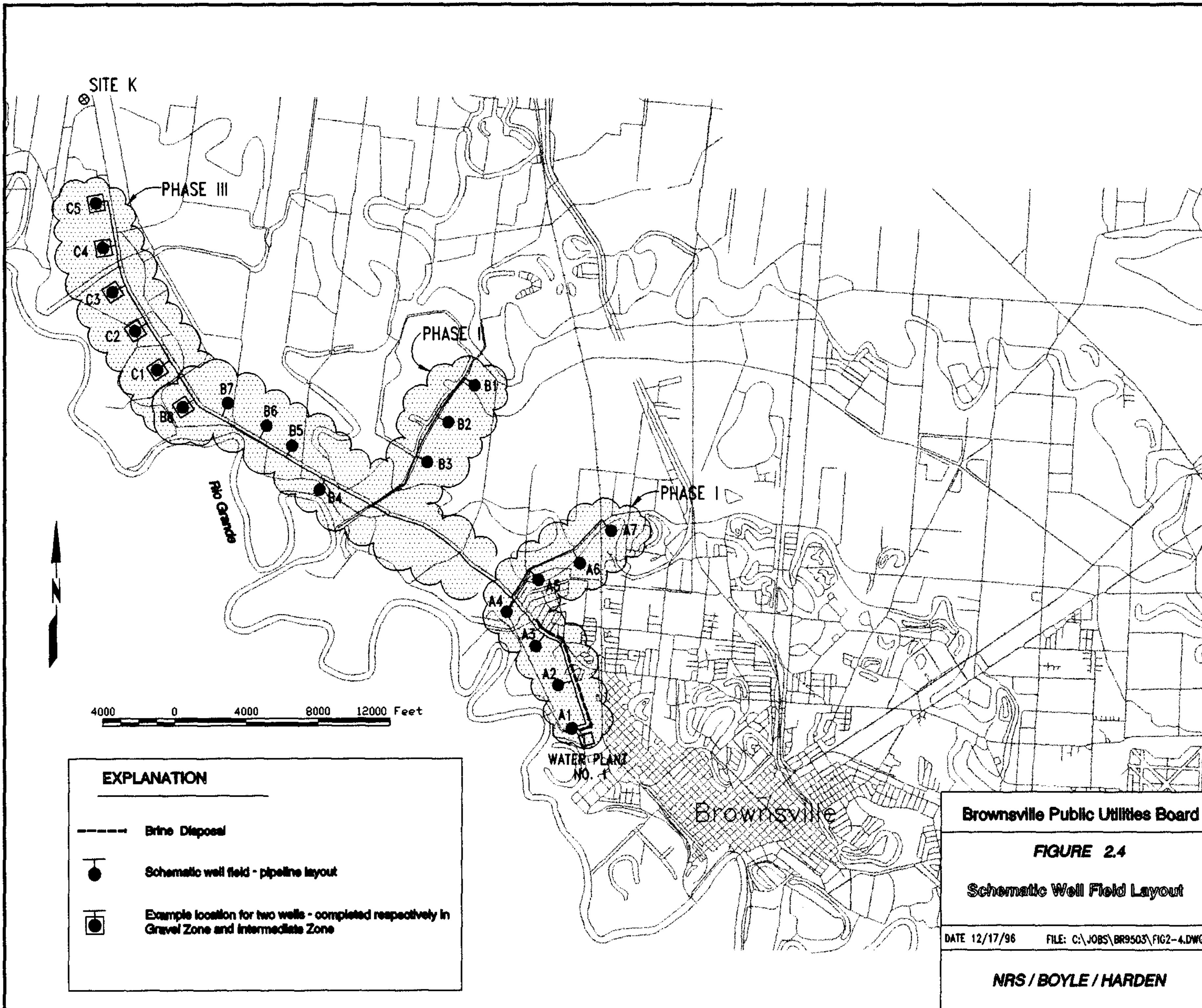


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FIGURE 2.4

Schematic Well Field Layout

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2.5 RECOMMENDATIONS

To further define the feasibility and cost-effectiveness of a brackish ground water supply in the Brownsville area the following work is recommended:

- Compile and review available geologic data, water quality information, and hydraulic characteristics of the Gravel and Intermediate Zones on the Mexican side of the River.
- Conduct additional test drilling to verify that water can be produced from the intermediate zone, to better define the location, feasibility and likelihood of finding favorable sites in the gravel and intermediate zones. An estimated ten to fourteen test hole sites with water samples will be required for this effort.
- Assuming favorable test hole results, construct a pilot production well in the gravel zone, with approximately four associated piezometers, and conduct a long-term pumping test to evaluate the regional hydraulic and boundary conditions of the gravel zone aquifer.
- As applicable, construct a pilot production well in the Intermediate Zone, with approximately four associated piezometers, and conduct a long term pumping test to evaluate the regional hydraulic and boundary conditions in the Intermediate Zone aquifer. Depending on the test drilling and pilot production well test results in the Gravel Zone, this task may not be required to finalize the supply, or it may be possible to delay this task until subsequent phases.
- Develop water quality testing parameter to develop treatment needs.

The pilot production well(s) constructed during these testing programs will be the initial production well(s) in the permanent well field. It is recommended that land purchase options be obtained for test drilling sites, as 50% or more of the sites may not be suitable for construction of production wells. Sites should not be bought until test drilling at each site has indicated favorable subsurface conditions.

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Unpublished

Layne-Western Co., Inc., 1994, P.U.B. City of Brownsville Ground Water Development Project.

Texas Water Development Board, undated, located and plotted well records, Grids 89-04 and 89-05, file data.

Geophysical Logs for water, oil and gas test holes, including:

City of Brownsville, P.U.B. Site K

City of Brownsville, P.U.B. TH-17.

City of Brownsville/TWDB:

88-60-806	89-04-628
88-60-902	89-04-629
89-04-208	89-04-630
89-04-209	89-04-631
89-04-210	89-04-902
89-04-211	89-05-102
89-04-308	89-05-404

89-04-309	89-05-405
89-04-510	89-05-701
89-04-627	89-05-903

City of Brownsville Water Well 1
City of Brownsville Water Well 3
City of Brownsville Water Well 4
City of Brownsville Water Well 6
City of Brownsville Water Well 7
City of Brownsville Water Well 8
Discorbis Oil Company, Granada Unit 1
Engelke, R. H., City of Brownsville, No. 1
Grand-Lienard Water Well 2
Pure Oil Company, Ytussia Land Pastoral.
Sohio Petroleum Company, First National Bank No. 1
Standard Oil Company, Cameron Park Development Company No. 1
Sundance Oil Company, Gonzales No. 1
Sundance Oil Company, Hawthorne No. 1
Sundance Oil Company, Hawthorne No. 2
Tejas Production Company, Thelma, Dawson No. 1
The Texas Land Company, T. J. Davis No. 1.
Texas Water Wells, Inc., City of Brownsville Test No. 1.
Tipton, M. J., P.U.B. TH-5
Turnbull & Zoch, Loop Brothers No. 1
Valley International Properties, P.U.B TH-14.
Wardner Water Well 5

CHAPTER 3 - TREATMENT ALTERNATIVES

3.1 SCOPE

One of the main objectives of this project is to present recommendations regarding the treatment of groundwater to produce a product water that would meet regulatory guidelines and requirements of the Safe Drinking Water Act (SDWA). The following guidelines will be followed to evaluate the feasibility of potabilization of groundwater.

- Compare available water quality parameters of the groundwater source with regulatory drinking water standards.
- Identify treatment alternatives.
- Evaluate Membrane Process.
- Identify Range of costs.
- Evaluate Concentrate Disposal.

3.2 GROUNDWATER QUALITY

Groundwater quality in the Brownsville area varies significantly in chemical composition generally increasing in dissolved solid content from west to east and also vertically from shallow to deep. Table 3.1 illustrates the comparison of some of the constituents of the groundwater source found at the Water Plant No. 1 site and the Central Drive site with current Safe Drinking Water Act Standards.

The quality of the groundwater for the well developed at Water Treatment Plant No. 1, was established during the Reverse Osmosis Pilot Study. Samples collected at the well site were analyzed for Synthetic Organic Chemicals (SOC's), Volatile Organic Chemicals (VOC's), some of the Inorganic Chemicals (IOC's), secondary contaminants and disinfection by-products formation potential.

The results summarized in Table 3.1 and further detailed in Appendix II, indicate that the groundwater source complies with the SOC's, VOC's, and IOC's maximum contaminant limits (MCL's) established by the EPA and the Texas Natural Resource Conservation Commission (TNRCC). The secondary contaminant levels are limits applicable to all public water systems. In Texas, a drinking water supply that does not meet the secondary standards cannot be used without written approval of the TNRCC. Of the secondary constituents analyzed, total dissolved solids, chlorides, sulfates and manganese exceed the recommended limits established by the TNRCC and the EPA.

Microbiological analysis were also conducted by the PUB lab personnel. Negative results were obtained for the Total Coliform tests. As indicated in Table 3.1, the potential for the source to form disinfection by-products, such as Trihalomethanes (THM'S) and Haloacetic Acids (HAA5), would not be in excess of maximum contaminant level established or proposed by the EPA.

Table 3.1 - Drinking Water Standards Comparison

Contaminant	EPA Standards (mg/l)	TNRCC Standards (mg/L)	Groundwater Source		
			Plant 1 4/4/96	Plant 1 7/1/96	Central 3/29/96
ORGANIC CONTAMINANTS (See complete results in App. II)	Variable	Variable	No Sample	None Detected	No Sample
DISINFECTION BYPRODUCTS					
THM Total *These are formation potential results	0.1	0.1	-	0.026*	-
HAA(5)	0.06	-	-	N.D.	-
INORGANIC CONTAMINANTS					
Barium	2.0	2.0	0.016	0.020	-
Fluoride	4.0	4.0	1.60	1.50	0.95
Nitrate-Nitrite (as N)	10.0	10.0	Nd	nd	nd
SECONDARY STANDARDS					
Chloride	250	300	780	1,000	930
Fluoride	2.0	2.0	1.60	1.50	0.95
Iron	0.3	0.3	Nd	0.075	0.300
Manganese	0.05	0.05	0.070	0.082	0.190
pH	6.5-8.5	≥7.0	7.2	7.3	7.3
Sulfate	250	300	860	680	1,000
Total Dissolved Solids	500	1,000	2,700	3,200	2,700
Hydrogen Sulfide	-	0.05	nd	nd	-

3.3 TREATMENT ALTERNATIVES

Groundwater resources present the opportunity to alleviate potential shortages of raw feedwater supplies for a municipality. Water supplies have traditionally, in South Texas and the Rio Grande Valley, obtained water supplies from fresh water sources such as rivers and lakes. Mechanical and chemical treatment methods have been used to remove from fresh water impurities such as bacteria, turbidity, color, tastes, odors, iron, or hardness. Groundwater found in the Rio Grande Valley has been found to be brackish and contain impurities which cannot be removed by available conventional treatment processes.

Brackish or highly mineralized water (groundwater) contain excess salts and minerals or total dissolved solids mainly sodium, calcium, magnesium, sulfate, chlorides, and bicarbonates. Nitrates, fluorides, and potassium are found in smaller amounts. The EPA has recommended a maximum total dissolved solids content of domestic water supplies of 500 ppm whereas Texas standards are set at 1,000 ppm. Water exceeding 1,000 ppm is acceptable if no better supplies are available.

Only through the use of special processes to remove excess mineral content from brackish water can the Safe Drinking Water Act Standards (SDWA) be met. Two processes are suitable for treating brackish water and generating a product which would meet SDWA standards. These are Reverse Osmosis (R.O.) and Electrodialysis Reversal (EDR). With the feedwater quality information available, both processes were evaluated and determined that both could easily reduce total dissolved solids levels within the recommended concentration value.

3.3.1 Electrodialysis (Reversal) - Process Description

Electrodialysis (ED) is a membrane desalting process which uses electrical potential, rather than pressure, as its driving force. The process requires the use of ion exchange membranes, which are sheets of ion exchange material. These membranes are available in two forms, cation and anion, which allow passage of cations (positively charged ions) and anions (negatively charged ions) respectively. The membranes are placed into stacks of typically 500 membranes, with cation and anion membranes alternating. An electrode is placed at the end of each stack. Water is then pumped through the spaces in between the membranes, with alternate spaces connected to different piping systems.

When an electrical potential (voltage) is placed upon the electrodes, it causes ions dissolved in the water to move. Cations migrate toward the negative electrode, while anions migrate toward the positive electrode. As the ions move, they eventually come up against a membrane. If possible, they will pass through the membrane (cations will pass through cation membranes, etc.) into the adjacent flow space. But, since the next membrane will not allow passage of that ion, it will remain in that space. Because of this arrangement, alternate spaces will be depleted in ions, while the other spaces concentrate the ions. Thus, two product streams are produced, one desalted and the other concentrated. These streams are termed "dilute" and "concentrate".

Unlike reverse osmosis, treated water does not pass through an ED membrane. Thus, there is no barrier to microbial passage. In addition, since it is an electrochemical process, only electrically charged substances are affected by ED. Thus, silica and most organics are not affected. In this case, these characteristics are not an impediment to use of ED. Organic contamination is not expected to be a problem, and the lack of silica removal is actually a benefit in allowing increased water recovery. In addition, because the water does not pass through the membranes, EDR is somewhat more tolerant of suspended solids in the feedwater than is RO.

ED requires the use of acid and scale inhibitor to prevent precipitation of scaling materials on the membranes, in a manner very similar to reverse osmosis. A significant modification to ED is the electrodialysis reversal process (EDR). In this process, the electrical potential applied by the electrodes is periodically reversed (the positive electrode becomes the negative electrode, and vice versa). This causes the direction of migration of the ions to reverse, and switches the functions of the flow channels so that the dilute channel becomes the concentrate channel, and vice versa. EDR thus tends to prevent the buildup of scale and foulants on the membrane surfaces, and will in fact tend to remove any scale that may have built up. This will extend the life of the membranes, and can allow higher water recovery than the simple ED process. EDR is a patented process of Ionics, Inc., which is the sole supplier. There are other suppliers of the ED process. (While there is justifiable concern that the use of EDR will lock a user into a proprietary system, in practice it must be remembered that Ionics is in competition with reverse osmosis suppliers. Users have been able to establish long term contracts for supplies and maintenance.)

Ionics has not released their design parameters to the engineering public. It is necessary to obtain process designs and costs directly from them. A preliminary quotation from Ionics was therefore solicited, based upon the design parameters of the Brownsville system.

It is possible to vary the amount of desalting to some extent by varying the electrical potential across the stack. However, the potential must be kept below a limiting value at which water decomposes to hydrogen and hydroxide ions. As a result, the level of desalting in a stack is limited. In order to obtain the amount of desalting in this case (750 mg/L TDS), it will be necessary to pass the water through two stacks in series.

Like reverse osmosis, EDR is a modular process, with various models of EDR systems capable of treating different amounts of water. In this case, Ionics has recommended the use of four trains, each capable of producing 750,000 gallons of treated water per day. Overall system recovery will be 85 percent (85 percent of the feed water will become product water, while 15 percent will become waste).

Blending with untreated water will not be practiced. The most efficient way to operate EDR is to design the system to meet the desired product water quality. Unlike RO, EDR has the ability to produce a variable product water quality by varying the voltage applied to the system. If blending were required, the system would need to be designed to produce a product quality greater than desired and then blend using a by pass system. This may require an additional stage to the EDR system which adds to the complexity and the capital cost of the system. For comparison with the RO, a product water quality of 750 mg/l total dissolved solids is used.

Table 3.2 presents important design considerations for EDR.

Table 3.2 - Design Parameters Electrodialysis Reversal

Plant feed flow, MGD	3.5
Recovery	85%
Product flow, MGD	3.0
Concentrate flow, MGD	0.5
Number of Trains	4.0
Product TDS, mg/L	750

3.3.2 Reverse Osmosis Process Description

Reverse osmosis is a water treatment process that utilizes a semipermeable membrane. The membrane allows water to pass while restricting the passage of dissolved solids thereby separating the water from substances dissolved in it. Water treatment by Reverse Osmosis is generally referred to by three broad categories depending upon the raw water quality and treatment requirements as follows:

- **Seawater RO** - These systems operate at high pressure (900 psig and higher) to treat salt water with total dissolved solids (TDS) greater than 15,000 mg/L.

- **Brackish Water RO (BWRO)** - These systems treat water with TDS in the range of approximately 2,000 mg/L to 15,000 mg/L. They operate at pressures from about 250 psig up to 600 psig. Recent advances allow some membranes to operate at pressures as low as 120 psig.

- **Nanofiltration (NF) (or Membrane Softening Reverse Osmosis (MSRO) -** These systems treat water with up to about 2,000 mg/L TDS for removal of divalent ions such as calcium and sulfate. Since these systems do not remove significant amounts of monovalent ions such as sodium, chloride, and nitrate they are referred to as softening systems. MSRO typically operates at pressures around 125 psig.

The TDS level of the groundwater located at Water Plant No. 1 in the Brownsville area is approximately 2,700 mg/l, therefore, a BWRO system is appropriate for this condition. The objectives of the pilot plant test were to:

- Establish the design basis for the full-scale treatment plant.
- Establish the raw well water quality data.
- Determine the attainable "treated" (or product) water quality.
- Determine the reject (or concentrate) volume and quality for evaluating disposal options.

3.3.2.1 BWRO Process Description

A typical BWRO process is depicted in Figure 3.1. Brackish water from the wells or other source enters the plant through a pretreatment process designed to protect the membrane system. Pretreatment may include removal of solids or specific contaminants that could damage or foul the membranes, and the addition of acid to adjust pH and scale inhibitor to reduce scaling potential in the membranes. The feed water then passes through cartridge filters as a final barrier to protect the membranes. After cartridge filtration, RO feed pumps increase the feed water pressure to overcome the osmotic pressure, back pressure, and friction losses through the system. The RO membranes separate the feed stream into two parts: the relatively salt free permeate (typically between 70 and 85 percent of the feed water depending on the raw water quality), and a concentrate stream containing the majority of the salts (TDS) and the remaining feed water.

In some cases, raw water can be blended with the permeate at a ratio which produces an acceptable TDS and hardness concentrations. The blending of the permeate and raw waters can reduce the total volume of brackish water that must be treated as well as reduce the product water's corrosivity.

Reverse osmosis membrane performance may be impaired by scaling or fouling from a variety of substances in the water. Scaling occurs as the salts in the feed water are concentrated through the membrane system until the concentration exceeds saturation. This causes salts to precipitate out of solution onto the membrane surface. Precipitation of sparingly soluble salts such as calcium carbonate, calcium sulfate, barium sulfate, and strontium sulfate is a particular problem.

To reduce precipitation and scaling, either a scale inhibitor or an acid are injected into the feed water upstream of the RO feed pump. Scale inhibitor helps to reduce the precipitation of sulfate and carbonate scale forming materials, allowing the concentrated feed water (concentrate) to exit the membranes before precipitation occurs. Acid (typically either sulfuric or hydrochloric) may be injected into the feed water to reduce the pH, converting bicarbonate to carbon dioxide and water, thereby reducing the carbonate scaling potential to a level which can be co-controlled with the sulfates by the scale inhibitor.

Fouling occurs when particulate, organic or biological material (bacteria) accumulates on the membrane surface, building a layer which restricts flow through the membrane. Fouling is limited by ensuring that the feed stream remains within the design limits of the feed water quality and is biologically inert. Typically the quantity of these materials is not a problem with ground water if the wells producing the water are well maintained and in good condition. Occasionally the raw water contains sufficient suspended solids to foul the membranes. In these cases, filters are included in the pretreatment system. If iron or manganese are present in the feed water, it is necessary to prevent their oxidation or provide for their removal in the pretreatment process. Biological material requires oxidation and filtration as part of pretreatment. Many membrane materials are sensitive to oxidants in the feed water which could limit the membrane selection unless the pretreatment is designed to remove them or they can be prevented from forming.

Cartridge filters are the last pretreatment element prior to the membranes providing a "last ditch" protection in case of failure upstream of the RO system which could allow suspended solids that could foul or plug the membrane elements to enter the system. Cartridge filters are not intended to provide continuous removal of particulate matter from the RO feed stream. If continuous removal of suspended solids is required, additional pretreatment is necessary.

The membranes will loose some productivity over time. This is normal, even with high quality feed water and appropriate protection for the membranes. It is then necessary to chemically clean the membranes. This is done with various detergents, acids, or bases as required to return the membrane performance to a level close to initial. Cleaning is normally required about two to three times per year with a groundwater system.

Membrane life for a groundwater reverse osmosis plant can be expected to range from five to nine years with proper care and correct plant operation.

3.4 CONCENTRATE DISPOSAL

Concentrate disposal can have a considerable impact on the construction and operating costs of a membrane process. Three methods are available:

- Disposal to a brackish surface body - Brownsville is in an area that is most conducive and cost-effective to dispose of concentrate to a brackish surface water body due to it's proximity to the Gulf of Mexico. By utilizing a drainage ditch, that ultimately discharges into the Brownsville Ship Channel and then to the Gulf of Mexico, there is minimal impact of the concentrated well water solution due to the high total dissolved solids of the receiving stream. Discharge into the Rio Grande is not recommended upstream of any water intake from the Rio Grande. By utilizing a common ditch for the supply and concentrate disposal, the capital cost for the line would be approximately $200,000.

- Disposal to a sewer system - Based on the proposed design of 10.5 mgd supply water, there would be a need to dispose of 2.0 million gallons per day of concentrate. Based on a capital cost of $2.00/ gallon of treatment, this would cost $4,000,000 dollars to add the additional hydraulic capacity to the existing wastewater treatment plant. This does not include any additional costs associated with the collection system or additional operation and maintenance of the sewer system. The addition of a TDS of approximately 10,000 mg/l would minimize the potential for reuse of the water from the wastewater treatment plant for irrigation purposes due to the salinity content of the concentrate.

- Deep well injection - Disposal of the concentrate can be discharged into aquifers of higher TDS level than the concentrate discharge. Based on limited information regarding the deep zone, it is expected that a deep well for injection would be 3,000 feet deep. One well would be constructed for each of the three phases with a capacity of 500 gpm for each phase. It is estimated that the total cost for each well would be $1.2 million including well construction, test hole, permitting and engineering. The total cost for all phases would be $3.6

million.

From a cost standpoint, the pursued option at this point would be disposal to a brackish surface body such as a drainage ditch which eventually discharges into the Brownsville Ship Channel. A discharge permit is required by the Texas Natural Resource Conservation Commission (TNRCC). For the purpose of this project, a pipeline is included in the estimated costs to deliver the concentrate into the City's North Main Drainage Ditch, which ultimately discharges into the Brownsville Ship Channel. This pipeline could be installed in the same ditch as the well field delivery pipeline.

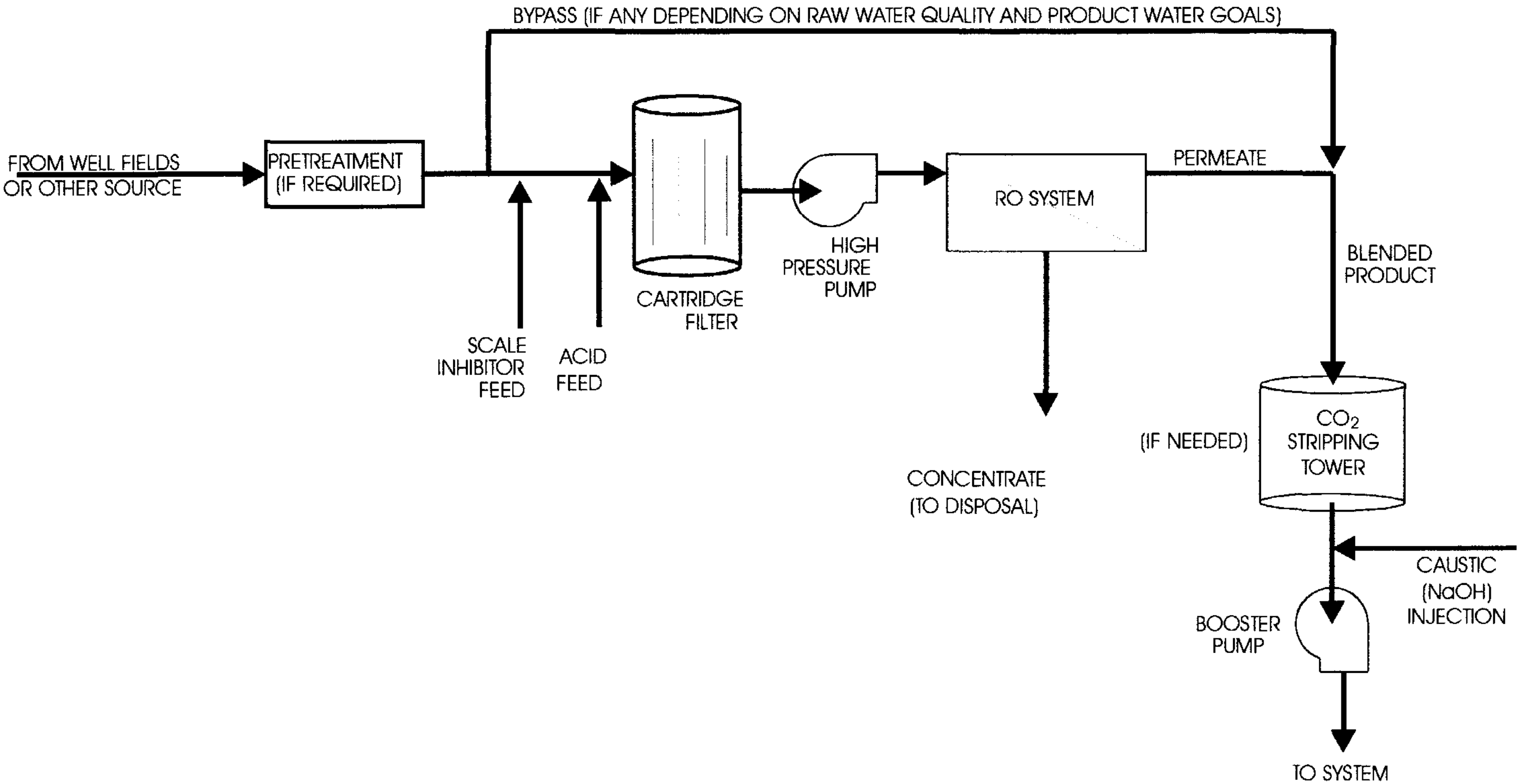


FIGURE 3.1
BROWNSVILLE PUBLIC UTILITIES BOARD
TYPICAL BRACKISH WATER RO WATER TREATMENT
SIMPLIFIED FLOW DIAGRAM

NRS/BOYLE/HARDEN

CHAPTER 4 - REVERSE OSMOSIS PILOT STUDY

4.1 PILOT PLANT DESCRIPTION

This self-contained trailer mounted system, provided by Boyle Engineering Corporation, includes the RO membranes housed in stainless steel pressure vessels, a chemical feed system, a 12 stage 15 Hp centrifugal pump and motor, a semi-automatic control system, and analytical instrumentation. This unit can accommodate a maximum feed water flow rate of 20 gpm. The process and instrumentation diagram on Figure 4.1 illustrates the system.

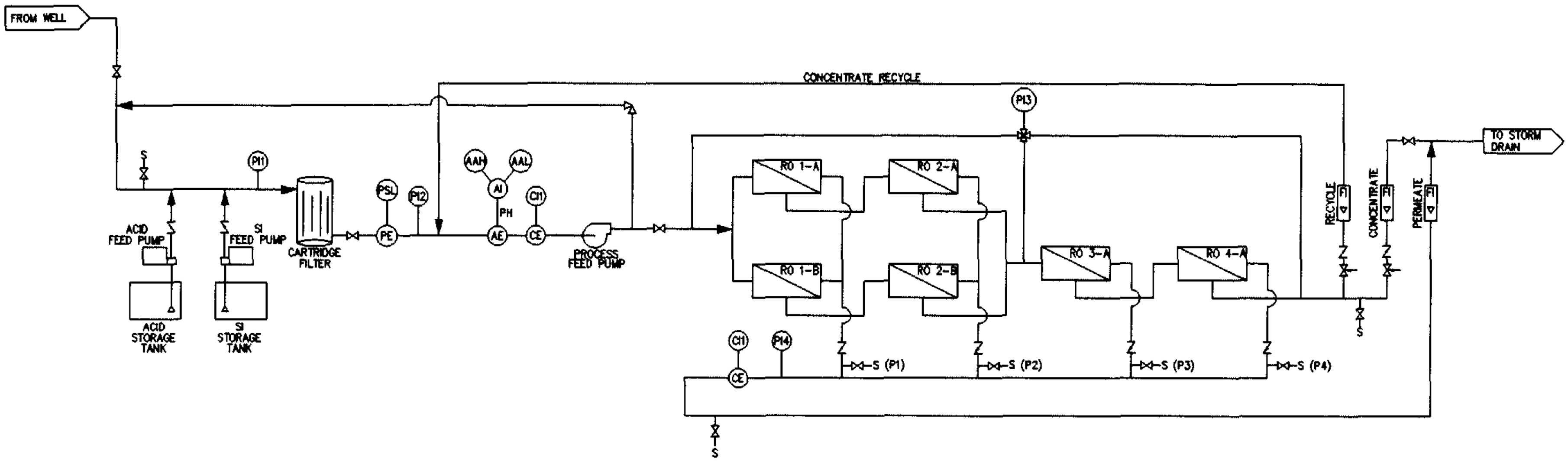
The RO system comes standard with six stainless steel pressure vessels arranged into two stages. The first stage contains four vessels in series/parallel arrangement and the second stage contains the remaining two vessels in series. The two stages are interconnected such that the concentrate stream from stage one makes up the feed water for stage two. Each vessel houses three membrane elements for a total of 18 membranes. The Fluid Systems Model 4820HR membrane elements were selected for this study. These are high rejection thin film composite membranes. Each of the three major membrane manufactures (Hydronautics, Fluid Systems, and Dow Filmtec) make a membrane yielding similar performance.

The chemical feed system allows for both scale inhibitor and acid to be introduced into the flow stream upstream of the membranes. The system includes two 25 gallon chemical storage tanks and chemical metering pumps. The pilot plant's control system monitors the chemical levels in each of the storage tanks and shuts the pilot plant down if the levels drops below a preset depth.

Analytical instrumentation installed on the RO system monitors water temperature, electrical conductivity of the feed, and permeate flow streams, pH of the feed water, and pressures through out the system. The RO control system monitors each of these parameters. Rotometers measure the concentrate, permeate and recycle flow streams. A cartridge filter mounted upstream of the membranes protects the membranes from suspended material contained in the feed water.

Initial water quality analyses indicated that the feed water contained a high concentration of silica. A silica scale inhibitor was used to prevent the silica from precipitating onto the membrane. Sulfuric acid was also used, as explained in the previous section, to reduce the carbonate scaling potential. Both the acid and scale inhibitor were injected into the feed water upstream of the cartridge filters.

Brownsville PUB constructed a temporary test well for the pilot study. This well has a capacity of 80 gpm which is more than adequate to supply the pilot plant. The permeate and concentrate produced from the pilot plant were recombined and disposed of in an existing sanitary sewer.



R.O. PILOT PROCESS AND INSTRUMENTATION DIAGRAM

Brownsville Public Utilities Board

FIGURE 4.1

R.O. PROCESS AND INSTRUMENTATION DIAGRAM

DATE: 12/19/96 FILE: C:\JOBS\BR9501\FIG4-1.DWG

NRS / BOYLE / HARDEN

4.2 PILOT PLANT OPERATION

The RO pilot unit was delivered to Brownsville PUB on April 30,1996. After set up and operator training to the PUB staff, the pilot plant began operating on May 8, 1996 and ran continuously for the three month duration of the pilot study with the exception of one brief power outage on 5/28/96 and several brief periods for periodic maintenance.

The PUB operators recorded operating data three times a day. These readings consisted of feed water temperature, permeate and concentrate flow rates, pressures through out the system including feed, concentrate, permeate, interstage, and the pressure drop across the cartridge filter, and the electric conductivity of the feed, and permeate flow streams. Periodic readings of the permeate conductivity at four points between the pressure vessels and concentrate conductive were also taken. In addition, a SDI test was performed daily. Samples of the permeate and concentrate were also taken and sent to a laboratory for analysis. The complete set of the PUB operating data is included as Appendix III.

The pilot plant began operation at a recovery of 75 percent. Recovery is defined as the percentage of feed water that is converted to "treated water", or permeate. This recovery was established from preliminary water quality analyses of the expected feed water. After approximately 2000 hours of operation, the recovery was increased to 80% for the duration of the pilot study. Table 4.1 summarizes the operating conditions of the pilot plant.

Table 4.1 - Pilot Plant Operating Conditions

Raw/Feed Water Flow Stream (gpm)	Permeate Flow Stream(gpm)	Concentrate Flow Stream (gpm)	Recovery
18.7	14.0	4.7	75%
17.5	14.0	3.5	80%

Increasing the recovery of the pilot plant will further define the scaling potential of the feed water. The concentration of soluble salts in the concentrate stream increases dramatically as the recovery increase. This "concentration factor" is the multiple of the soluble salt concentration in the raw water that exists in the concentrate stream. At 75% recovery the concentration factor is 4. This increased to 5 as the recovery was increased to 80%.

4.3 OPERATING DATA

The data collected at the pilot plant was tabulated and analyzed. The following discussion is a summary of the findings and conclusions of the analysis.

The pilot plant operation was plagued by frequent disruptions due to maintenance shut downs. A power outage was responsible for only one shut down. Due to work taking place at the power plant. These disruptions prevented the plant to from stabilizing for a significant period of time. Field documentation noted a number of the shutdowns, however, the pilot plant's automatic start mechanism would automatically restart the pilot plant, in the absence of an operator, when power was restored. These shut downs can be identified in the data.

4.3.1 Pretreatment

Measuring the pressure drop across the cartridge filter gives an indication of the amount of suspended material in the feed water. Cartridge filter elements were replaced when the pressure drop reached approximately 15 psi. As discussed in a previous section, cartridge filters are intended as a last line of protection before the membranes. If suspended material persists in the feed water, an additional pretreatment process, such as a de-sander, will be required. Figure 4.2 illustrates the pressure drop across the cartridge filter.

The cartridge filter elements were replaced two times during the study. During the first 219 hours of operation, the pressure drop (delta P) remained constant at 4 psi. The delta P then increased to 15 psi at an increasing rate over the next 525 hours of operation. The cartridge filter elements were replaced after 811 hours of operation. After changing the cartridge filters the delta P dropped to the original 4 psi. It stayed at this level for approximately 300 hours before increasing sharply. Over the next 344 hours (operating hours 1107 through 1451) delta P increased at a fairly constant rate to 17.5 psi. The second cartridge filter was changed after only 640 hours of operation, significantly less than the first. It appears that the rate of fouling is decreasing, indicating that there is less suspended material in the feed water.

Comparing this data with shutdown information indicates that the first increase in delta P corresponds with the first disruption in the system. Additionally, subsequent sharp increases in delta P appear to correspond with disruptions in the system. This leads to the conclusion that sand from the gravel pack is being pulled into the feed water during start up. This problem can be eliminated in the design of the production wells and by providing a reliable power supply. If this problem cannot be eliminated through the well design, then an additional pretreatment process would be required to remove the suspended material.

4.3.2 Membrane Performance

The performance of the membrane elements is generally monitored by observing the relationship between flux and pressure. Flux is expressed as permeate flow through a unit of membrane area measured in volume per square unit of membrane surface area per day. In the United States flux has the units of gallons per square foot per day or GFD. Normalizing the flux consists of compensating for feed water temperature fluctuations and for osmotic pressure variations (a function of the feed, concentrate, and permeate TDS).

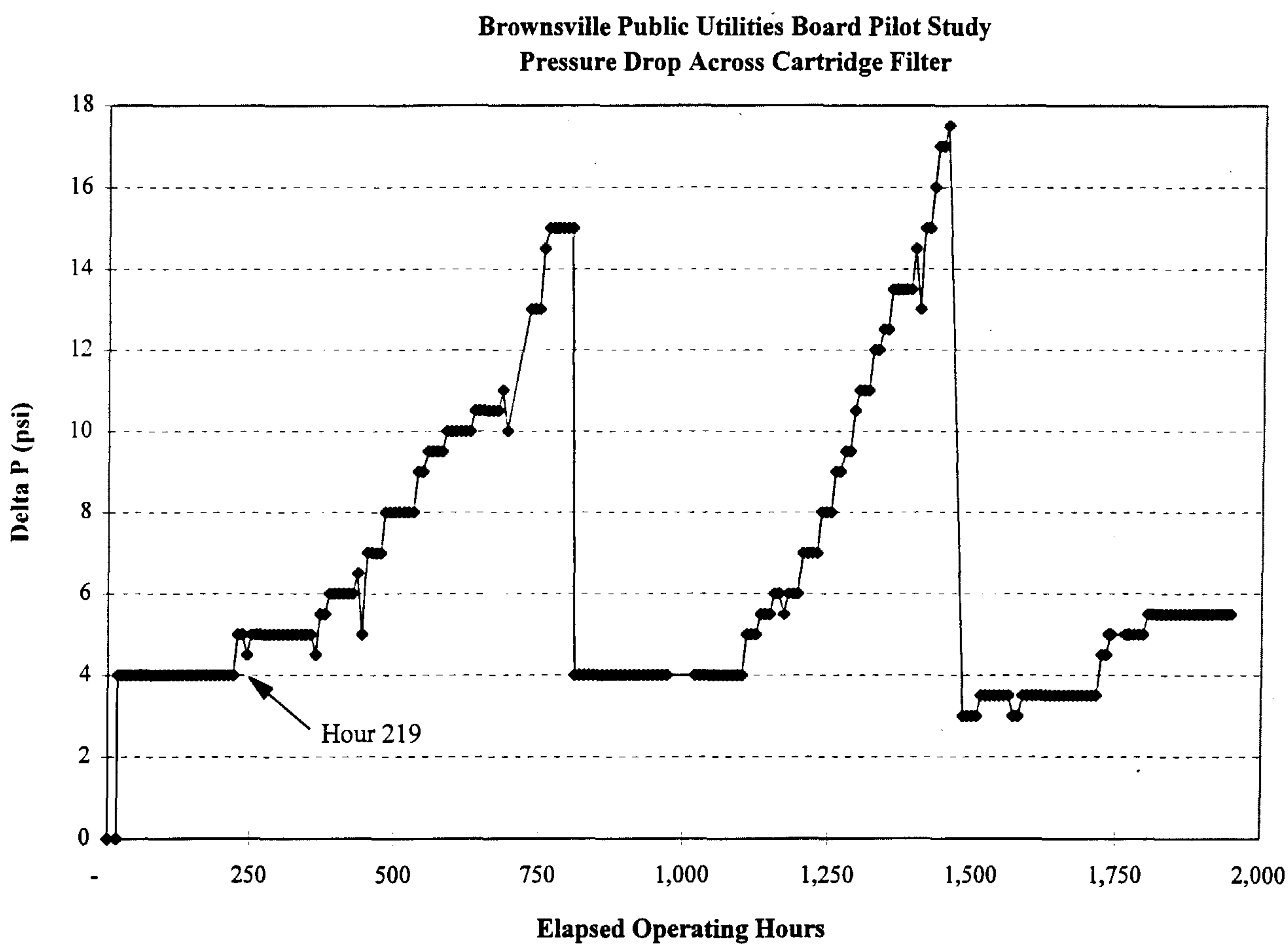


FIGURE 4.2
PRESSURE DROP ACROSS CARTRIDGE FILTER

NRS/BOYLE/HARDEN

Ideally the normalized flux would be constant through out the pilot study. A decrease in normalized flux indicates that the membranes are scaling or fouling and that additional pressure is required to produce the same permeate flow. An increase in normalized flux indicates that less pressure is required to produce the same permeate flow. Increases in normalized flux generally indicates a shifting or tearing of the membranes which allows feed water to by-pass the membranes.

The normalized flux for the pilot plant is plotted against hours of operation in Figure 4.3. After an initial period of instability due to variations in the feed water quality and temperature, the normalized flux stabilizes at approximately 0.118 gfd/psi. At hour 219, the normalized flux increases sharply to 0.124 gfd/psi and does not drop below 0.120 gfd/psi, for an extended period of time, until hour 779. At hour 779 the normalized flux drops back to the original stability range of 0.117 to 0.119 gfd/psi and stays within this range for the next 704 hours (hour 1483). At hour 1483 the normalized flux drops sharply to 0.1 gfd/psi and remains at this point until the end of the data at hour 1947.

The increase in normalized flux at hour 219 corresponds to the first disruption of the system as described in the pretreatment section. This point can also be seen in Figure 4.4 which plots the permeate stream conductivity and Figures 4-6 and 4-7 which plot the process pressures. It appears that this disruption caused the membranes to shift allowing feed water to bypass the membranes. The membranes appear to have reset themselves at approximately hour 779, indicated by the flux dropping to the original stability range. This conclusion is supported by a general increase in permeate TDS over this time frame. The sharp peaks in the permeate TDS are attributed to system shut downs. Typically the permeate conductivity increase after the system is started and then decreases as the system stabilizes. Sharp fluctuations in the process pressures are also evident at these points. If the membranes were torn, the normalized flux would continue to increase. Since, this did not occur, it can be assumed that the membranes remained intact.

Between hours 779 and 1483, represents a period of relative stability for the system. The normalized flux and process pressures returned to their original stability points (see Figure 4.4, 4.5 & 4.6). The permeate conductivity also shows a general decreasing trend. Again, the sharp spikes in permeate TDS are attributed to shutdowns in the system. The stability in the flux, over this time period, indicates that the membranes are functioning properly and that they are not experiencing scaling or fouling. If the membranes were scaling or fouling, a decreasing trend in the normalized flux would be apparent.

The sharp decrease in the normalized flux at hour 1483 indicates that something caused the membranes to immediately foul. Coincidentally, this point corresponds to the second changing of the cartridge filter elements, This leads to the conclusion that sand or other material was introduced into the system during changing of the cartridge filter. This point is also apparent in the process pressures (Figure 4.5 & 4.6).

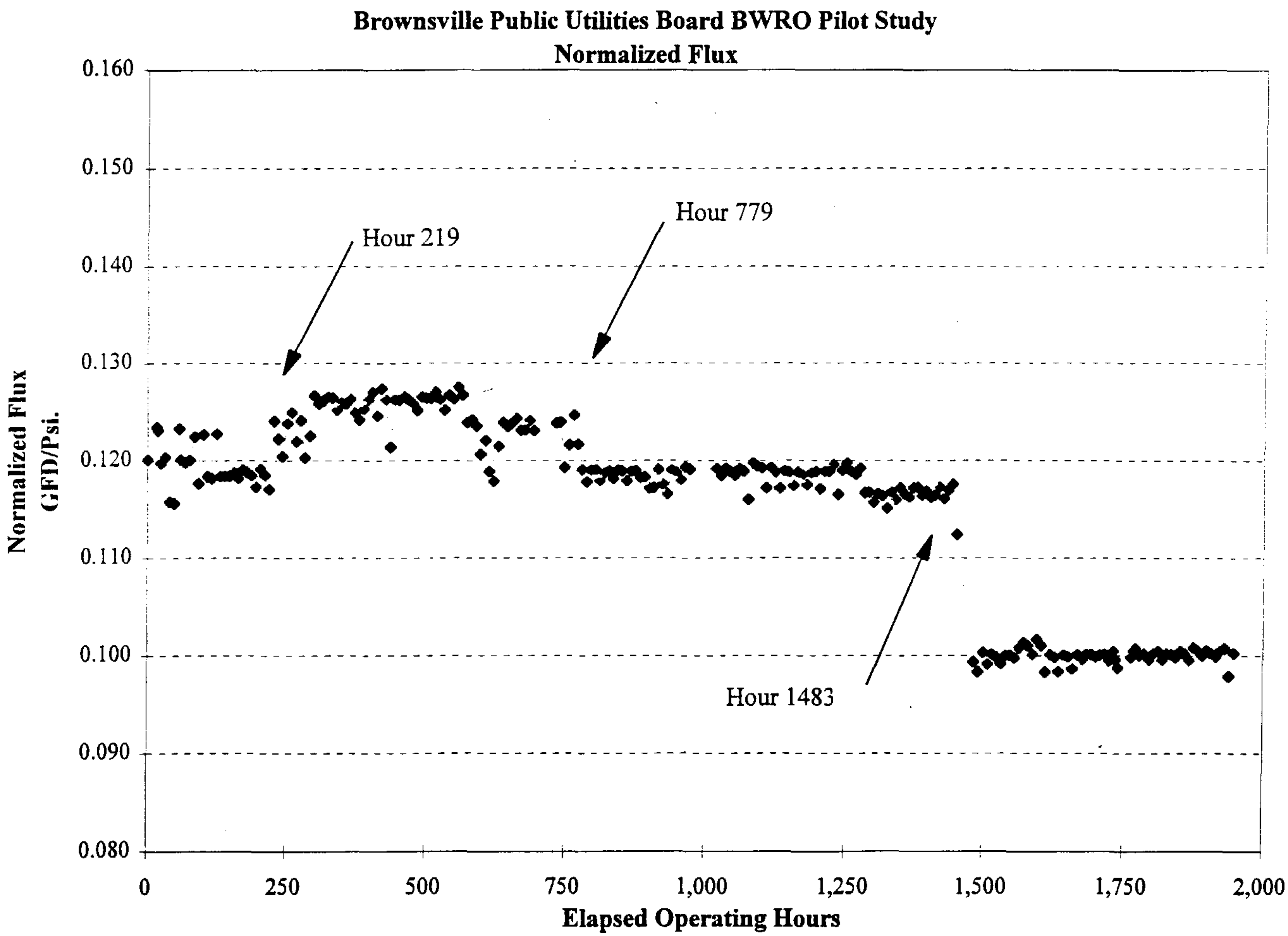


FIGURE 4.3
NORMALIZED FLUX

NRS/BOYLE/HARDEN

The stability in the system after hour 1483 indicates that, again, the membranes are functioning properly and that they are not experiencing scaling or fouling from a component of the feed water. The silica inhibitor appears to have prevented the silica from precipitating on to the membranes.

4.3.3 Membrane Performance vs. Simulated Performance

The membrane element supplier, Fluid Systems, maintains a proprietary computer program, ROPRO6, which approximates membrane performance under defined operating conditions and raw water quality. Boyle performed an initial projection by assuming a feed water quality and using the initial operating condition identified in the previous section. The feed water quality was established by data collected during the geotechnical portion of the study. Table 4.2 compares feed water quality analysis from the projection with data collected from the pilot study.

Table 4.2 - Feed Water Quality

Constituent	Preliminary Projection Feed (mg/l)	Sample (7/1/96) Feed(mg/l)
Calcium	73	76
Magnesium	45	49
Sodium	1000	1000
Potassium	4.8	4.4
Ammonia		
Strontium	2.9	3.3
Barium	0.01	0.02
Iron		0.075
Manganese	0.07	0.082
Carbonate		
Bicarbonate	463	429
Sulfate	860	680
Chloride	780	1000
Nitrate		
Fluoride	1.7	1.5
Silica	33	36
Carbon Dioxide	47.42	
TDS	3263	3200

The computer simulation predicted the pilot unit operation pressure at 188 psig (216.2 psig with a 15% fouling allowance). This prediction was based on the initially operating condition of 75% recovery and 14.0 gpm permeate flow. The actual operating pressure ranged from 220-250 psig. Part of the discrepancy between the projection and the actual pressure is due to friction losses in the concentrate manifold, which due to the nature of the pilot unit are not as efficient as a full scale operation. Fouling of the membranes as described in previous sections also contributed to the increase in the actual operating pressure.

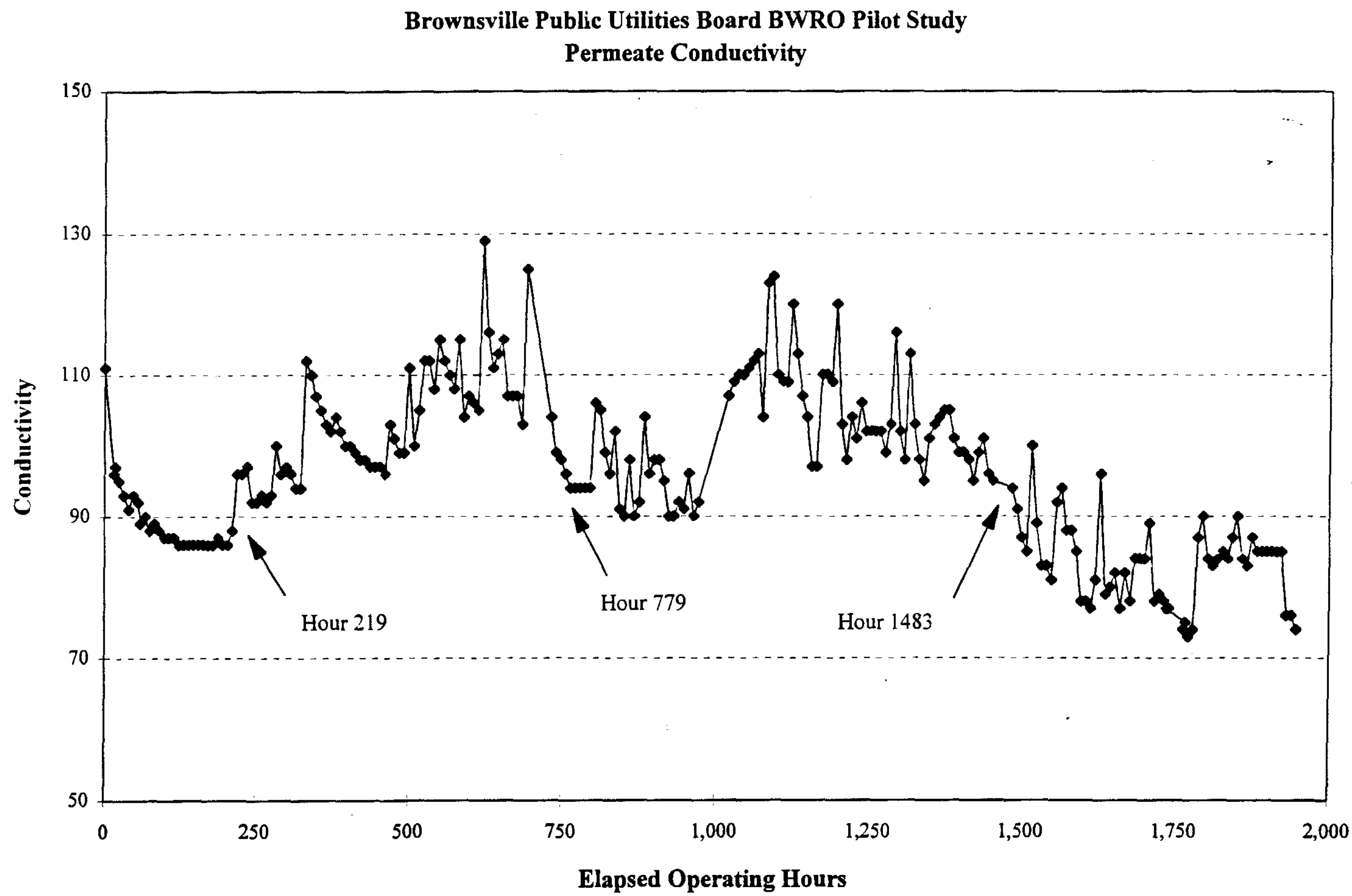


FIGURE 4.4
PERMEATE CONDUCTIVITY

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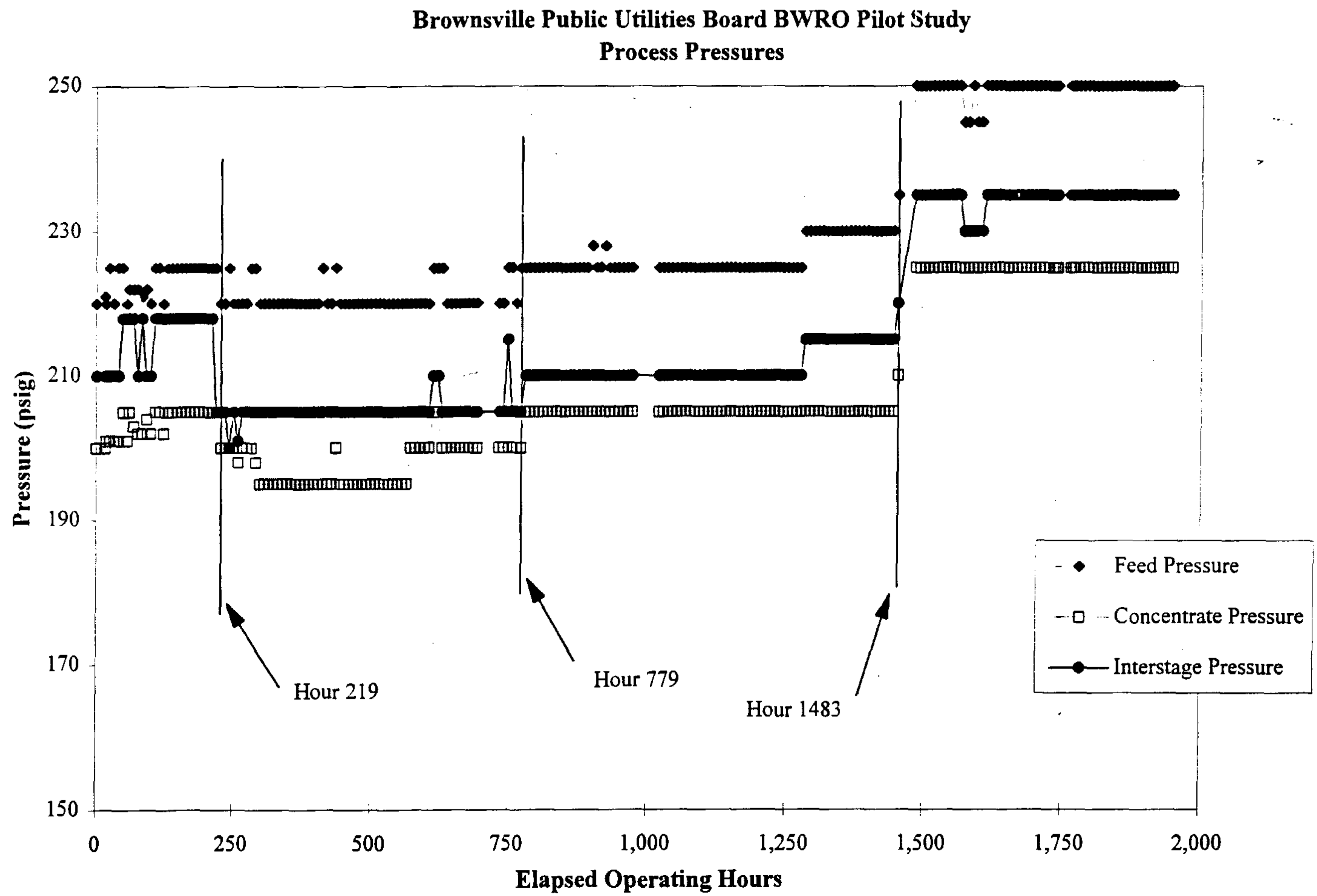


FIGURE 4.5
PROCESS PRESSURES

NRS/BOYLE/HARDEN

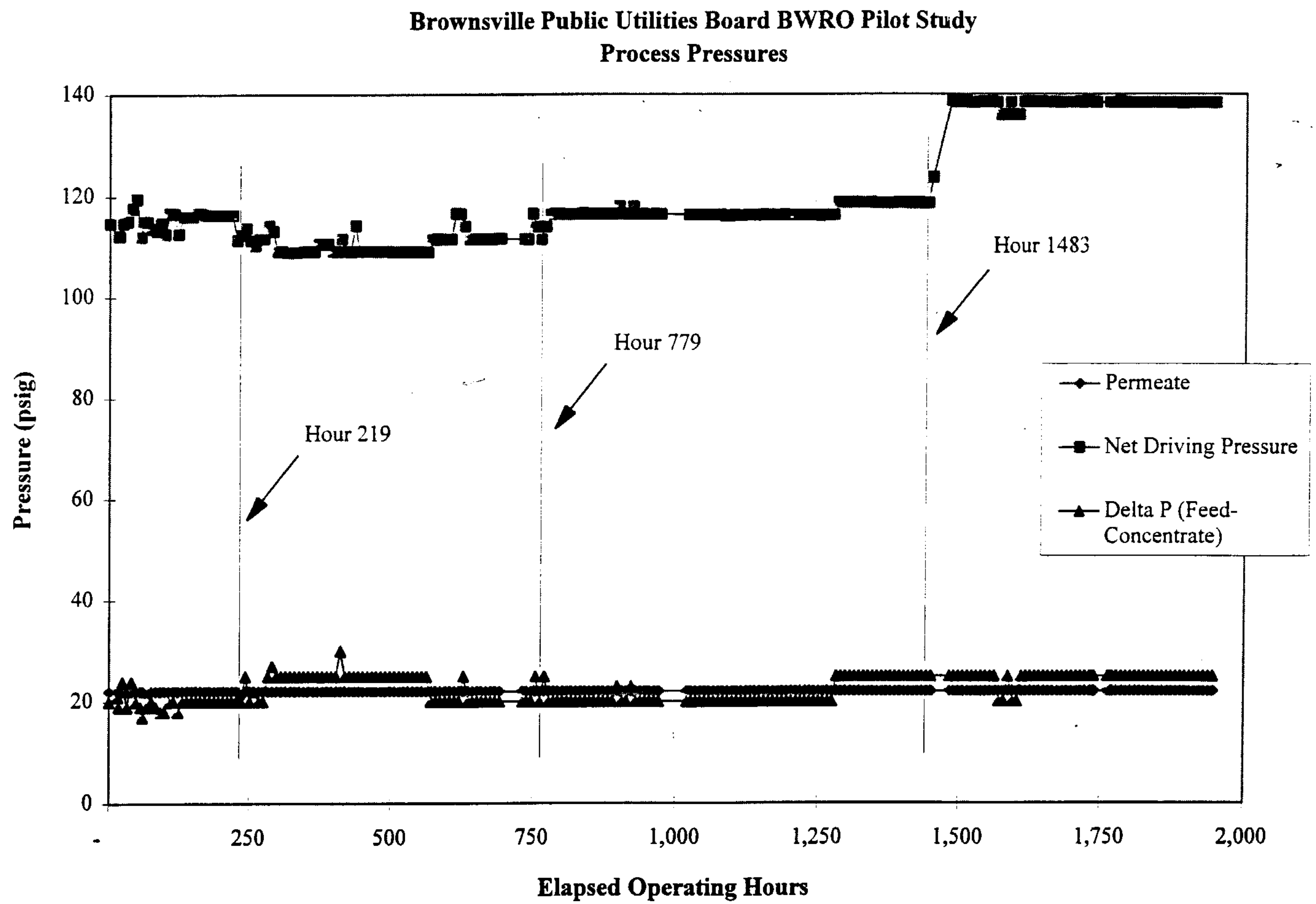


FIGURE 4.6
PROCESS PRESSURES

NRS/BOYLE/HARDEN

4.4 FULL SCALE OPERATIONAL PARAMETERS

4.4.1 Pretreatment

The pilot plant required repeated changing of the cartridge filter elements due to sandy material being pulled into the feed water during start up. This problem maybe solved through design considerations and well placement. However as a precaution, in the event suspended material is still present in the feed water, space for the addition of a desander will be made available in the design of the RO facility.

The pilot study required both acid and silica scale inhibitor injection to prevent scale formation. Both these pretreatment processes will be required in the full scale plant.

4.4.2 Membrane Performance

The plant operated for approximately 2000 hours at 75% recovery and 360 hours at 80% recovery for a total of 2,360 hours. During the first 2000 hours the membranes displayed no detrimental effects from exposure to the water, other than the operational problems discussed in the previous section. Premature replacement of the membrane elements due to deterioration or extensive fouling should not be a concern as long as the wells produce water free of suspended material. Membrane life of at least 5 years should be expected. Chemical cleaning of the membrane elements should be at intervals greater than 2000 hours, or four times a year.

4.4.3 Water Quality

The well field will be constructed in three phases each having a production capacity of approximately 3.5 mgd. The wells will be located along an eight mile stretch of the Rio Grande northeast of Brownsville. Since the ground water quality varies considerably in this area, a design feed water quality was established from historical and collected data during the geotechnical investigation as well as data collected during this pilot study. The design feed water analysis along with the Fluid Systems ROPRO6 computer program was used to determine the expected full scale water quality. This projection includes the feed, by-pass, permeate, concentrate and product flow streams. Table 4.3 summarizes the expected water quality for each of the flow streams.

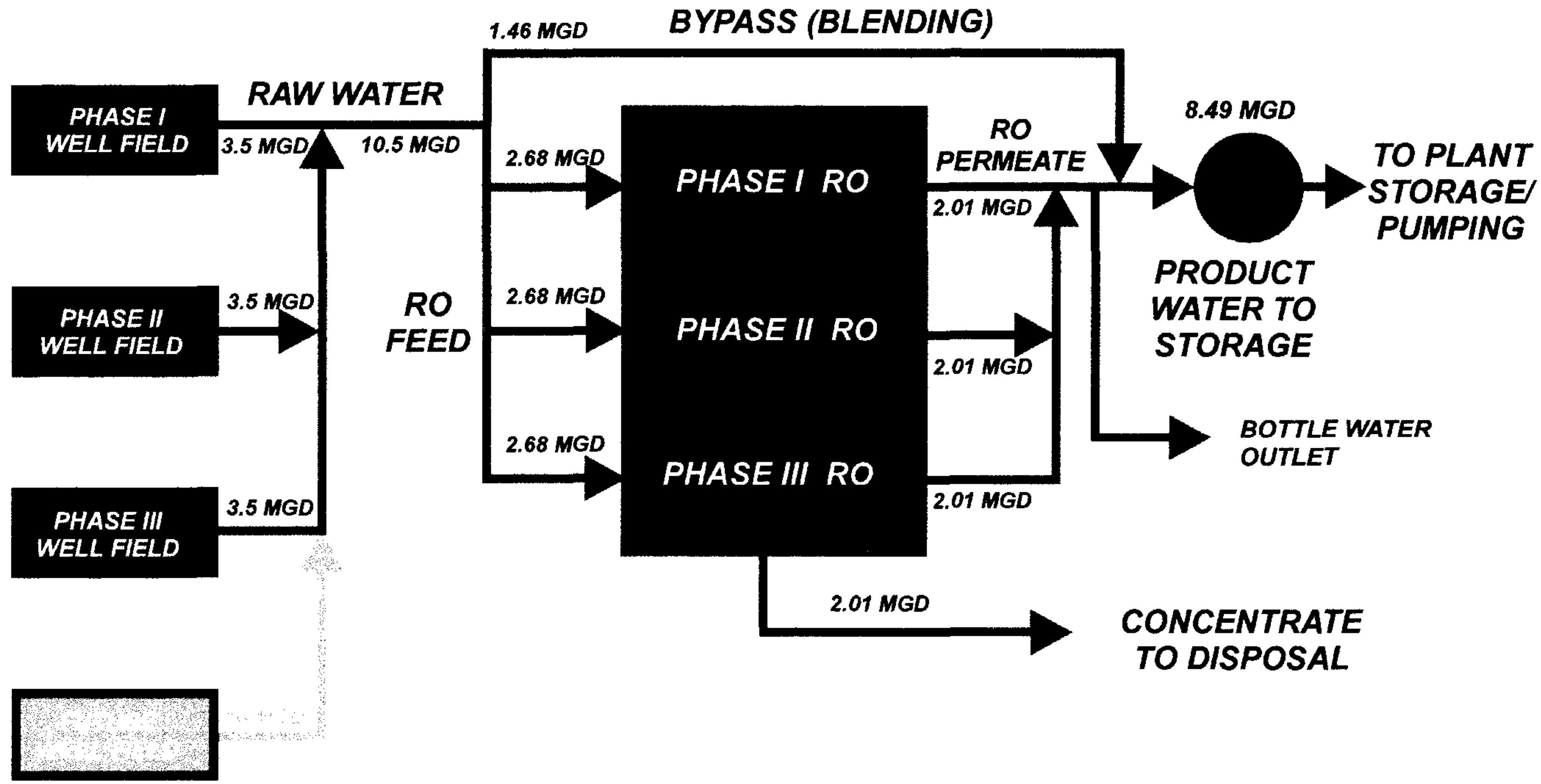
Table 4.3 - Water Quality Summary

Constituent	Process Streams Feed (mg/l)	Permeate (mg/l)	Concentrate (mg/l)	Bypass (mg/l)	Product (mg/l)
Calcium	66.7	0.21	266.17	66.7	19.47
Magnesium	19.5	0.06	77.82	19.5	5.69
Sodium	754.2	13.68	2975.75	754.2	228.52
Potassium					
Ammonia					
Strontium	0.3		1.2	0.3	0.09
Barium	0.02		0.08	0.02	0.01
Iron	0.1		0.4	0.1	0.03
Manganese	0.1		0.4	0.1	0.03
Carbonate			0.83		
Bicarbonate	424.7	14.44	1353.46	424.7	133.31
Sulfate	617.6	2.42	2701.15	617.6	180.67
Chloride	558.4	11.58	2198.87	558.4	170.02
Nitrate					
Fluoride	1.4	0.01	5.56	1.4	0.42
Silica	36.9	0.7	145.5	36.9	11.19
Carbon Dioxide	34.08	88.39	88.55	34.08	16.98
TDS	2500	43	9730	2500	750

The product water goal for this plant is to have a TDS of less than 750 mg/l as the most cost effective means of producing a better quality water than is currently available while still meeting the secondary water standards. The plant can be designed to meet 500 mg/l TDS with out much difficulty. By increasing the goal to 750 mg/l, the maximum use of the available water source is achieved. The actual plant design would include the flexibility to maximize the quantity of water produced during drought conditions.

At the proposed goal of 750 mg/l, TDS, the addition of 23 mg/l of caustic is added for pH adjustment. As the blending ratio is decreased, the caustic dosage will increase. If blending is reduced significantly, additional post treatment, such as lime beds would be required for corrosion control. This would add approximately $0.10 per 1,000 gallons of water produced. Rather than designing a plant that produces only permeate, setting a particular goal such as 750 or 500 mg/l, would produce a consistent and superior water quality most cost effectively.

To achieve a goal of 750, a product water blending rate of 71% permeate was required. This projection is based on a 75% recovery in the RO system, giving an overall system recovery of 80.8%. Assuming that each phase will produce 3.5 mgd in well field capacity, each phase of the RO system will be designed to produce 2.01 mgd of permeate and 0.67 mgd of concentrate. Figure 4.7 summarizes the flow streams and water quality of the system.



	RAW WATER	RO FEED	BYPASS	RO PERMEATE	CONCENTRATE	PRODUCT WATER
PHASE I (MGD)	3.5	2.68	0.82	2.01	0.67	2.83
PHASE II (MGD)	7.0	5.36	1.64	4.02	1.34	5.66
PHASE III (MGD)	10.5	8.04	1.46	6.03	2.01	8.49
QUALITY (mg/l)	2,500	2,500	2,500	40	9,730	<750

FIGURE 4.7
BROWNSVILLE PUB RO FLOW SCHEMATIC

br9503/fnlrpt/fig4-7.cdr

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CHAPTER 5 - PROJECTED COSTS

5.1 Treatment Facility

For the purpose of this cost projection, basic assumptions were made and the best available information, including well water data, previous reports and actual pilot reverse osmosis operations, was used to determine the feasibility of treating brackish ground water in the Brownsville area. In comparing the capital cost of Electrodialysis Reversal (EDR) to Reverse Osmosis (RO), the EDR plants are usually 15% to 20% higher in capital costs for the type of water expected in the Brownsville area. The projected capital cost for each treatment system is shown in Table 5.1.

5.1.1 Capital Cost Factors

- LOCATION - The location of the proposed demineralization facility will attribute to the total cost of the project. The initial planned location of the plant would be located at Water Treatment Plant No. 1. This offers several apparent advantages regarding the capital cost of the facility. One major advantage is the utilization of the existing plant high service pump station to deliver water to the system. This would save the cost of an additional pumping facility. In addition, offices, land and other site facilities are already in existence at this site.

  The major disadvantage to utilizing this site relates to the cost of the transmission system. As shown in Figure 5.1, the perceived project shows that all water is transported through a single pipeline to Plant No. 1. As it approaches Plant No. 1, the lines become larger in size. An alternative would be to locate the plant in a central location with respect to the well field and be served by smaller lines. The previously mentioned benefits would not be available. The cost savings utilizing the smaller lines would not be great enough to offset savings of capital and operation and maintenance costs at the Plant No. 1 location.

- SOURCE WATER QUALITY - The quality of water is the most critical parameter with regard to membrane treatment processes. The key element in the ground water to be removed is the total dissolved solids (TDS). As the TDS increases, the pressure required increases, yielding higher capital and operation and maintenance costs. Blending of the feedwater to achieve a product water not exceeding 750 mg/l TDS can also be achieved if TDS of the feed water is generally less than 3,000 mg/l. With blending, it is projected that the recovery for this RO system would be 80.8%. The recovery for the EDR system is projected to be 85%. Estimated costs are projected with a recovery rate of 80.8% for the RO system and 85% for the EDR system.

- CONCENTRATE DISPOSAL - The disposal of concentrate solution from the RO plant must be disposed of by means mentioned in the previous chapter. For the purposes of this analysis, it is expected that the concentrate discharge can be permitted to discharge into a drainage ditch and ultimately into the Brownsville Ship Channel, a saline water body. This is shown in Figure 5.1. The cost for the concentrate disposal pipeline can be minimized by the utilization of the same ditch as the pipeline for the well field supply. It is estimated that the capital cost for the construction of the disposal line in the same ditch would be an additional $200,000.

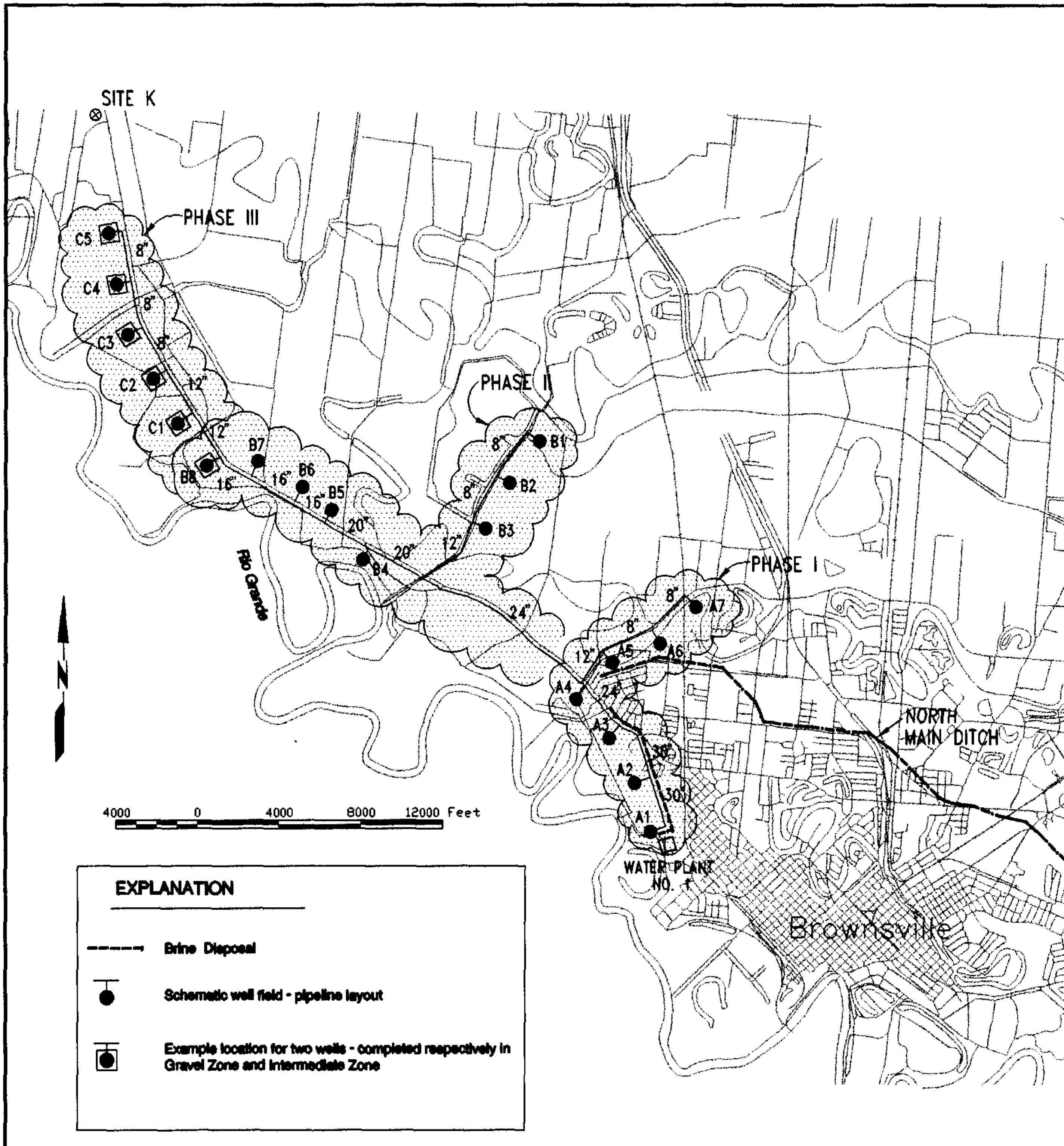
- SIZE OF FACILITY - With the size range of the treatment facility between approximately 2.5 mgd and 8 mgd, the economy of scale is favorable to achieve a capital cost of the treatment plant, site work, building, yard piping, electrical and instrumentation for a range of $1.25 to $2.20/gallon installed. A phased approach appears to be more costly in Phase I, however, this phase includes the over sizing of the facilities to accommodate subsequent phases.

Table 5.1 - Projected Capital and O&M Cost for Reverse Osmosis System

CAPITAL COSTS	*PHASE I*	*PHASE II*	*PHASE III*	*TOTAL*
PROCESS	$1,064,000	$926,000	$926,000	$2,916,000
PRETREATMENT (DESANDER)	$100,000	$100,000	$100,000	$300,000
PIPING	$300,000	$50,000	$50,000	400000
CHEMICAL FEED	$300,000	$0	$0	300000
INSTRUMENTATION & CONTROL	$300,000	$50,000	$50,000	400000
CLEANING SYSTEM	$125,000	$0	$0	125000
BUILDING	$200,000	$100,000	$100,000	400000
ELECTRICAL	$500,000	$100,000	$100,000	700000
STORAGE	$750,000	$0	$0	750000
SITE CIVIL	$150,000	$0	$0	150000
REVERSE OSMOSIS	$3,789,000	$1,326,000	$1,326,000	6441000
Contr OH & Profit @25%	$947,250	$331,500	$331,500	1610250
Engr. Fiscal, Legal Admin @20%	$757,800	$265,200	$265,200	$1,288,200
Contingency @2 0%	$757,800	$265,200	$265,200	1,288,200
RO SYSTEM COSTS	$6,251,850	$2,187,900	$2,187,900	$10,627,650
OPERATION AND MAINTENANCE COSTS(CUMULATIVE)				
POWER @ $0.038/kWH	$81,508	$172,537	$298,083	
MEMBRANE REPLACEMENT	$70,000	$140,000	$210,000	
CHEMICAL	$92,000	$184,000	$276,000	
LABOR	$100,000	$100,000	$100,000	
MAINTENANCE	$50,000	$70,000	$90,000	
CARTRIDGE FILTER REPLACEMENT	$35,000	$70,000	$105,000	
WELL PUMP REPLACEMENT	$20,000	$40,000	$60,000	
TOTAL $$ PER YEAR	$448,508	$776,537	$1,139,083	

Table 5.2 - Projected Capital and O&M Cost for EDR System

CAPITAL COSTS	***PHASE I***	***PHASE II***	***PHASE III***	***TOTAL***
PROCESS	$1,774,850	$1,774,850	$1,774,850	$5,324,550
PRETREATMENT (DESANDER)	$100,000	$100,000	$100,000	$300,000
PIPING	$300,000	$25,000	$25,000	$350,000
CHEMICAL FEED	$50,000	$0	$0	$50,000
INSTRUMENTATION & CONTROL	$150,000	INCL	INCL	$150,000
CLEANING SYSTEM	INCL	INCL	INCL	$0
BUILDING	$250,000	$100,000	$100,000	$450,000
ELECTRICAL	$450,000	$100,000	$100,000	$650,000
STORAGE	$750,000	$0	$0	$750,000
SITE CIVIL	$150,000	$0	$0	$150,000
EDR SYSTEM	$3,974,850	$2,099,850	$2,099,850	$8,174,550
Contr OH & Profit @25%	$993,713	$524,963	$524,963	$2,043,638
Engr. Fiscal, Legal Admin @20%	$794,970	$419,970	$419,970	$1,634,910
Contingency @2 0%	$794,970	$419,970	$419,970	$1,634,910
EDR SYSTEM COSTS	$6,558,503	$3,464,753	$3,464,753	$13,488,008
OPERATION AND MAINTENANCE COSTS(CUMULATIVE)				
POWER @ $0.038/kWH	$230,500	$458,000	$657,000	
MEMBRANE REPLACEMENT	$70,000	$140,000	$210,000	
CHEMICAL	$37,000	$74,000	$111,000	
LABOR	$100,000	$100,000	$100,000	
MAINTENANCE	$50,000	$80,000	$100,000	
CARTRIDGE FILTER REPLACEMENT	$17,000	$34,000	$51,000	
WELL PUMP REPLACEMENT	$20,000	$40,000	$60,000	
TOTAL $$ PER YEAR	$524,500	$926,000	$1,289,000	



Brownsville Public Utilities Board

FIGURE 5.1

Well Field Transmission System And Brine Disposal

DATE 12/17/96 FILE: C:\JOBS\BR9503\FIG2-5.DWG

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- WATER RIGHTS - The PUB requires developers to transfer water rights in the amount of 1.5 acre-feet per acre of development. While the savings of water rights, by utilizing well water, does not directly affect the PUB's purchase of water rights, it will build up the available supply that the PUB maintains. At a value of $850 per acre foot of Class "A" water rights, the capital cost associated with a projected 2.8 to 8.5 million gallons per day ranges from $2.5 million to $7.6 million.

5.1.2 Operational Cost Factors

- GROUND WATER QUALITY/BLENDING - A major factor in the operational cost of membrane treatment is attributed with the quality of water. In this case, as the TDS increases, the pressure requirements increase to remove the dissolved solids in the feed water. If water quality is maintained at a level less than 3,000 mg/l, blending of the permeate with raw feed will reduce the size of the treatment system and the associated operational costs. Other constituents and properties in the feed water, that can attribute to higher operational costs include silt density, silica, organics, temperature and the hardness of the water.

- ENERGY COSTS - Brownsville has an advantage over other areas with regard to power costs, since they generate their own power. With costs per kW-hour of less than $0.04 for power, power costs are not as significant as with other areas of much higher costs.

- PRETREATMENT - It is projected that pH will be adjusted before and after treatment and an antiscalant will be utilized to prevent premature fouling of the membranes. Based on field data collected, there could be a need for a desanding facility. This is included in the projected costs.

- LOCATION - With respect to location, if the plant is located at Water Plant No. 1, operational personnel are currently located at this site. While additional personnel are anticipated, locating at Plant No. 1 would minimize the need for additional operators.

5.2 Transmission Costs

A major cost factor in the overall project is the cost to deliver the water to the plant site. For the projected project as shown in Figure 5.1, piping size would range from 8-inches to 30-inches in diameter for a total of 12.5 miles to deliver the 10.5 mgd feed water in three phases. It is not anticipated that there will be additional storage or repumping utilized for these options. The estimated cost for each system is shown in Table 5.3. Pipeline costs were developed using 1996 pipe prices and experience in the area for the installation and construction of pipeline facilities similar in nature.

To oversize the transmission system to allow for the future expansion of the well field, beyond the 10.5 mgd capacity, to 20 mgd, Table 5.3 also indicates what the estimated construction cost to oversize the pipeline. The pipeline size would range from 8-inches to 36-inches in diameter. For all three phases, it is estimated that the additional cost to oversize the transmission system would be approximately $2.7 million.

Table 5.3 - Transmission Costs

COST PROJECTION FOR 10.5 MGD WELL FIELD TRANSMISSION SYSTEM							
PIPE SIZE, in.	***PIPE PRICE/FT***	***PHASE I - 3.5 MGD FEET***	***COST***	***PHASE II - 7.0 MGD FEET***	***COST***	***PHASE III - 10.5 MGD FEET***	***COST***
8	$15	5,000	$75,250	5,000	$75,250	5,000	$75,250
12	$25	2,500	$61,825	2,500	$61,825	5,000	$123,650
14	$30	0	$0	0	$0	0	$0
16	$35	0	$0	5,000	$174,850	2,500	$87,425
18	$39	0	$0	0	$0	0	$0
20	$46	0	$0	5,000	$230,000	0	$0
24	$59	2,500	$147,500	12,500	$737,500	0	$0
30	$75	6,000	$450,000	0	$0	0	$0
CONCENTRATE (In same ditch as supply line)							
16	$18	7,500	$134,775	0	$0	0	$0
SUBTOTAL		23,500	$869,350	30,000	$1,279,425	12,500	$286,325
ENGR/ CONTINGENCY. @30%			$260,805		$383,828		$85,898
TOTAL OFFSITE COST EACH			$1,130,155		$1,663,253		$372,223
CUMULATIVE COSTS			$1,130,155		$2,793,408		$3,165,630
PROJECTED COST FOR OVERSIZING TRANSMISSION SYSTEM - 20 MGD PIPELINE CAPACITY. The following cost estimate represents the option of constructing a pipeline system capable of delivering 20 mgd to the proposed treatment plant. This will allow the extension of the transmission system to deliver water from an expanded well field in the future without constructing a second line to the proposed plant.							
PIPE SIZE, in.	PRICE/FT	PHASE I FEET	PRICE	PHASE II FEET	PRICE	PHASE II FEET	PRICE
8	$15	5,000	$75,250	5,000	$75,250	0	$0
12	$25	2,500	$61,825	2,500	$61,825	0	$0
14	$30	0	$0	0	$0	0	$0
16	$35	0	$0	0	$0	0	$0
18	$39	0	$0	0	$0	0	$0
20	$46	0	$0	0	$0	0	$0
24	$59	0	$0	0	$0	0	$0
30	$75	0	$0	0	$0	12,500	$937,500
36	$90	8,500	$765,000	22,500	$2,025,000	2,500	$225,000
CONCENTRATE (In same ditch as supply line)							
24	$37	7,500	$277,500	0	$0	0	$0
SUBTOTAL		23,500	$1,179,575	30,000	$2,162,075	15,000	$1,162,500
ENGR/CONTINGENCY @30%			$353,873		$648,623		$348,750
TOTAL OFFSITE COST			$1,533,448		$2,810,698		$1,511,250
CUMULATIVE COSTS			$1,533,448		$4,344,145		$5,855,395
COST DIFFERENTIAL (CUM.)			$403,293		$1,550,738		$2,689,765

5.3 Well Field Development Costs

For a supply of 3.5 mgd to 10.5 mgd brackish ground water, it is anticipated that 7 to 25 wells will be constructed. Capital cost shown in Table 5.4 include test drilling, property acquisition, wells, pumps and engineering. It is assumed that property options could be obtained and only the sites with favorable subsurface conditions for the construction of production wells be purchased. Costs to develop production wells include 21 gravel zone wells and 5 intermediate wells. The cost for Phase III well field development is higher due to the development of more wells and deeper wells to accomplish the capacity required.

Table 5.4 - Well Field Development Costs

WELL FIELD DEVELOPMENT FOR 3.5 MGD SUPPLY - PHASE I				CUMULATIVE COSTS
DESCRIPTION	QTY..	UNIT COST	TOTAL	
TEST DRILLING	14	$30,000	$420,000	
PROPERTY	7	$15,000	$105,000	
WELLS & PUMPS	7	$135,000	$945,000	
ENGINEERING/CONTINGENCY		L.S.	$250,000	
		TOTAL COSTS	$1,720,000	$1,720,000
WELL FIELD DEVELOPMENT FOR 3.5 MGD SUPPLY - PHASE II				
DESCRIPTION	QTY.	UNIT COST	TOTAL	
TEST DRILLING	16	$30,000	$480,000	
PROPERTY	8	$15,000	$120,000	
GRAVEL ZONE WELLS/PUMPS	8	$135,000	$1,080,000	
INTERMED. ZONE WELLS/PUMPS	1	$180,000	$180,000	
ENGINEERING/HYDROLOGY/CONTINGENCY		L.S.	$250,000	
		TOTAL COSTS	$2,110,000	$3,830,000
WELL FIELD DEVELOPMENT FOR 3.5 MGD SUPPLY - PHASE III				
DESCRIPTION	QTY.	UNIT COST	TOTAL	
TEST DRILLING	10	$30,000	$300,000	
PROPERTY	5	$15,000	$75,000	
GRAVEL ZONE WELLS/PUMPS	5	$135,000	$675,000	
INTERMED. ZONE WELLS/PUMPS	5	$180,000	$900,000	
ENGINEERING/HYDROLOGY/CONTINGENCY		L.S.	$250,000	
		TOTAL COSTS	$2,200,000	$6,030,000

5.4 Summary of Costs

A summary of costs for both the RO and EDR systems can be found in Tables 5.5 and 5.6. Costs include are for the construction of a treatment facility located at the PUB's Water Treatment Plant No. 1. Operational costs have been added to the previous plant operation and maintenance costs to allow for pumping, transmission, labor and pump replacement costs. An interest rate of 6% was used to arrive at an annual payment for capital costs for 20 years. For the first phase, the costs per 1000 gallons of treatment are comparable. For each additional phase, the RO system overall cost are less than that of the EDR system. Due to the cost factor, non proprietary nature, and flexibility of the RO system, it is the recommended process for the PUB for the development of the brackish groundwater resources in the Brownsville area

Table 5.5 - Summary of Costs RO System

CAPITAL COST PROJECTIONS	PHASE I	PHASE II	PHASE III	TOTAL
REVERSE OSMOSIS	$6,251,850	$2,187,900	$2,187,900	$10,627,650
OFFSITE TRANSMISSION & CONCENTRATE	$1,130,155	$1,663,253	$372,223	$3,165,630
WELL FIELD DEVELOPMENT	$1,720,000	$2,110,000	$2,200,000	$6,030,000
TOTAL CAPITAL	$9,102,005	$5,961,153	$4,760,123	$19,823,280
PRODUCT WATER EA. PHASE, MGD	2,830,000	2,830,000	2,830,000	8,490,000
ANNUAL DEBT SERVICE @6%, 20 YRS.	$793,554	$519,720	$415,009	$1,728,284
DEBT SERVICE PER 1000 GALLONS	**$0.768**	**$0.503**	**$0.402**	**$0.558**
OPERATION AND MAINTENANCE PROJECTIONS (CUMULATIVE TOTALS)				
TOTAL O&M PER YEAR	$448,508	$776,537	$1,139,083	
OPERATIONAL COST/1000 GALLONS	**$0.434**	**$0.376**	**$0.368**	
TOTAL ANNUAL COST COMPARISONS				
TOTAL $$ PER YEAR	$1,242,062	$2,089,812	$2,867,367	
TOTAL $$/1,000 GALLONS	**$1.202**	**$1.012**	**$0.925**	
TOTAL $$/ACRE FOOT	$391.79	$329.60	$301.49	
COMPARISON TO 100% RO PRODUCT WATER				
TOTAL $$/1,000 GALLONS	*$1.79*	*$1.48*	*$1.40*	

Table 5.6 - Summary of Costs EDR System

CAPITAL COST PROJECTIONS	PHASE I	PHASE II	PHASE III	TOTAL
ELECTRODIALYSES REVERSAL	$6,558,503	$3,464,753	$3,464,753	$13,488,009
OFFSITE TRANSMISSION & CONCENTRATE	$1,130,155	$1,663,253	$372,223	$3,165,630
WELL FIELD DEVELOPMENT	$1,720,000	$2,110,000	$2,200,000	$6,030,000
TOTAL CAPITAL	$9,067,005	$5,536,153	$5,145,123	$22,683,639
PRODUCT WATER EA. PHASE, MGD	3,000,000	3,000,000	3,000,000	9,000,000
ANNUAL DEBT SERVICE @6%, 20 YRS.	$793,554	$519,720	$415,009	$1,728,284
DEBT SERVICE PER 1000 GALLONS	**$0.749**	**$0.576**	**$0.481**	**$0.602**
OPERATION AND MAINTENANCE PROJECTIONS (CUMULATIVE TOTALS)				
TOTAL O&M PER YEAR	$524,500	$926,000	$1,289,000	
OPERATIONAL COST/1000 GALLONS	**$0.479**	**$0.423**	**$0.392**	
TOTAL ANNUAL COST COMPARISONS				
TOTAL $$ PER YEAR	$1,344,790	$2,377,332	$3,266,663	
TOTAL $$/1,000 GALLONS	**$1.228**	**$1.086**	**$0.994**	
TOTAL $$/ACRE FOOT	$400.16	$353.70	$324.01	

APPENDIX I - GEOLOGIC DATA

SITE

Designation: W.P. 1

Owner: Brownsville P.U.B.

Inspector: A. Bowen

Company: R.W. Harden & Associates, Inc.

Location: Brownsville, Tx - Water Treatment Plant

Elevation: Ground Level: ~ 35 Ft. (7 1/2 min topo)

Measuring Point: + 1.0 A.G.L.

DRILLING/CONSTRUCTION

Tour Length: 10 Tours/Day: 1

Task	Start (Date/Time)	Finish (Date/Time)
Drilling	3-27-96/11:00AM	3-27-96/3:00PM
Construction	4-1-96/11:00AM	4-1-96/3:00PM

Drilling Company: TWDB

Driller: Romeo Cano

Drilling Method: Mud Rotary

Mud Type: Natural

Bit Size and Type: 7 7/8"; reamed to 9 7/8"

Depth Drilled: 230 Ft. B.G.L.

Casing Diameter and Type: 4" ID Steel

Casing Weight: Schedule 40

Cased Interval: +2' to 160'

Screen Diameter and Type: 4"ID/Steel, Mill Slotted

Screen Gauge: 0.002

Screened Interval: 160' to 202.15'

Bottom Construction: Steel Plate

Gravel Volume and Type: 30 Sk/Brady Silica Sand(8/16)

Gravel Setting: 145' to 210'

Seal Type: Cement

Cement Volume and Type: 75 Sacks/Portland

Cement Setting: 0' to 145'

GEOPHYSICAL LOG

Start (Date/Time)	Finish (Date/Time)
3-28-96	3-28-96

Logging Company: TWDB

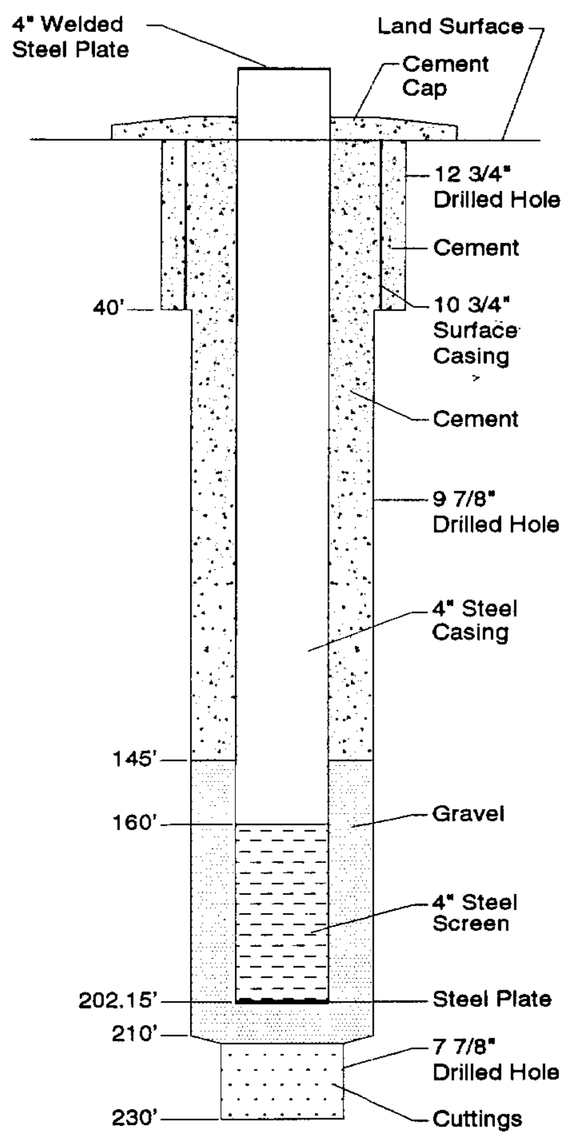
Logger: Randy Williams

Depth Logged: 220'

REMARKS

4'x4'x6" Concrete pad

WELL CONSTRUCTION DIAGRAM



DEVELOPMENT

Start (Date/Time)	Finish (Date/Time)
4-2-96/10:00AM	4-2-96/2:00PM

Method(s): Pump

Pumping Rate: 60 GPM

Water Level: Static: 15.1 from M.P.

Pumping: 32.90 (1 hr.) from M.P.

Geologic Log
for
Water Treatment Plant 1 (W.P.1)

Date Drilled: 3/17/96
Total Depth Drilled: 230 feet
Hole size: 7-7/8 inches
Driller: TWDB / Romeo Cano

Drilling Fluid: Water
Drilling Fluid Conductivity: 1275 umhos
Mud Viscosity (Secs): 36

Depth Interval (ft)	Sample Description
0-30	Top soil, silty sand
30-63	Clay, silty clay
63-95	Fine sand
95-153	Clay, sandy clay
153-160	Very fine sand
160-170	Very fine sand
170-180	Very fine sand
180-190	Very fine sand
190-200	Fine sand
200-210	Fine sand with minor amounts of gravel
210-220	Fine sand with minor amounts of gravel
220-230	Fine sand with minor amounts of gravel and a few clay lenses

SITE

Designation: Firefighter

Owner: Brownsville P.U.B.

Inspector: A. Bowen

Company: R.W. Harden & Associates, Inc.

Location: Brownsville, Tx

Elevation: Ground Level: ~ 35 Ft. (7 1/2 min topo)

Measuring Point: + 2.5 Ft. A.G.L.

DRILLING/CONSTRUCTION

Tour Length: 10 | Tours/Day: 1

Task	Start (Date/Time)	Finish (Date/Time)
Drilling	5-26-96	5-26-96
Construction	6-5-96/11:00AM	6-5-96/5:00PM

Drilling Company: TWDB

Driller: Romeo Cano

Drilling Method: Mud Rotary

Mud Type: Natural

Bit Size and Type: 7 7/8"; reamed to 9 7/8"

Depth Drilled: 450 Ft. B.G.L.

Casing Diameter and Type: 4" ID PVC

Casing Weight: Schedule 40

Cased Interval: 0' to 316'

Screen Diameter and Type: 4"ID/PVC, Mill Slotted

Screen Gauge: 0.0035

Screened Interval: 316' to 336'

Bottom Construction: PVC Cap

Gravel Volume and Type: 20 Sk/Brady Silica Sand(8/16)

Gravel Setting: 268' to 340'

Seal Type: Cement

Cement Volume and Type: 17 Sacks/Portland

Cement Setting: 0' to 10', 100' to 115' and 250' to 268'

GEOPHYSICAL LOG

Start (Date/Time)	Finish (Date/Time)
5-27-96	5-27-96

Logging Company: TWDB

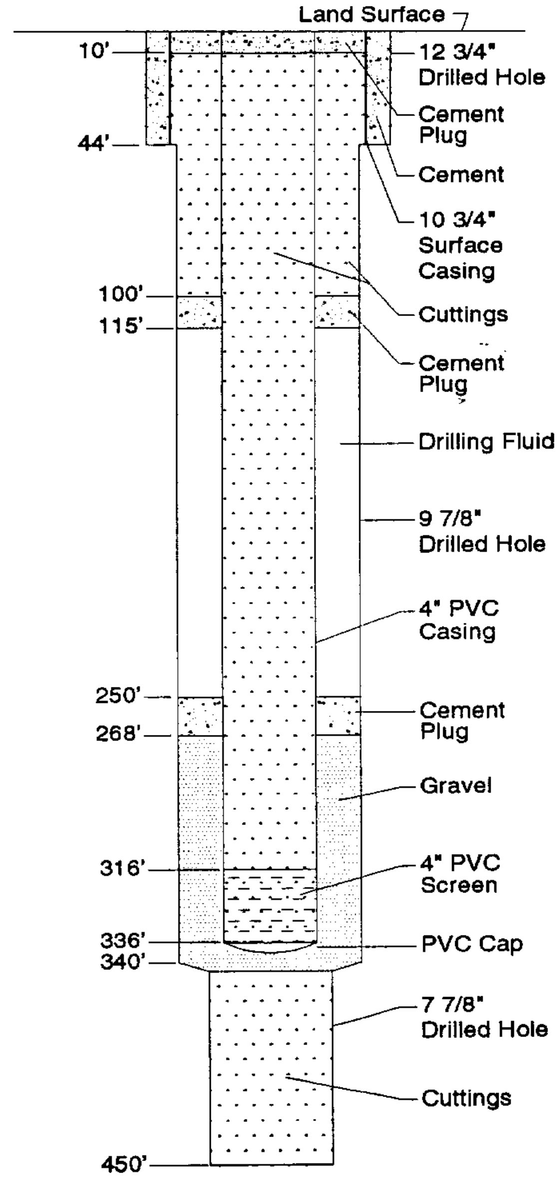
Logger: Randy Williams

Depth Logged: 450'

REMARKS

Well Plugged

WELL CONSTRUCTION DIAGRAM



DEVELOPMENT

Start (Date/Time)	Finish (Date/Time)
6-6-96	6-9-96

Method(s): Pump

Pumping Rate: 70 GPM

Water Level: Static: 17.3 from M.P.

Pumping: 91.7 (1 hr.) from M.P.

Geologic Log
for
Fire Fighter Site

Date Drilled: 5/26/96
Total Depth Drilled: 450 feet
Hole size: 6-1/4 inches
Driller: TWDB / Romeo Cano

Drilling Fluid: Water
Drilling Fluid Conductivity: 1510 umhos
Mud Viscosity (Secs): 29

Depth Interval (ft)	Sample Description
0-45	No information available
45-65	Fine sand
65-70	Clay
70-89	Sand
89-109	Tan clay
109-129	Tan clay
145-149	Fine brown sand
149-159	Fine brown sand
159-169	Fine brown sand
169-179	Fine brown sand
179-189	Fine brown, gravel at 187'
189-198	Fine brown sand and 1/16" to 1/4" gravel
198-219	Tan, white, gray & red clay
219-308	Tan, white, gray & red clay
308-316	Sandy clay
316-335	Sand with clay streaks
335-349	Sandy clay
349-351	Sandy clay
351-367	Fine brown sand
367-450	Tan, white, clay

Firefighter Site Recovery Test

Date	Time	Depth to Water Below M.P. (ft.)	Pumping Rate (gpm)	Remarks
06/07/96	7:45 AM			Pump on
	8:20 AM		71	Conductivity = 14,500 umhos, water muddy, lots of fine sand
	8:25 AM	94.25	71	
	8:42 AM	94.15	71	
	8:58 AM	94.20	71	
	9:00 AM			Pump off
	9:01 AM		0	
	9:02 AM	35.13	0	
	9:03 AM	33.01	0	
	9:04 AM	31.83	0	
	9:05 AM	30.62	0	
	9:06 AM	29.10	0	
	9:07 AM	28.65	0	
	9:08 AM	27.97	0	
	9:09 AM	27.35	0	
	9:10 AM	26.78	0	
	9:15 AM	24.97	0	
	9:20 AM	23.68	0	
	9:25 AM	22.86	0	
	9:30 AM	22.22	0	
	9:40 AM	21.44	0	
	9:50 AM	21.02	0	
	10:00 AM	20.60	0	
	10:10 AM	20.21	0	
	10:20 AM	19.98	0	
	10:30 AM	19.81	0	End test, resume development of well

Geologic Log
for
River Bend Site

Date Drilled: 5/22/96-5/23/96
Total Depth Drilled: 450 feet
Hole size: 6-1/4 inches
Driller: TWDB / Romeo Cano

Drilling Fluid: Water
Drilling Fluid Conductivity: 1575 umhos
Mud Viscosity (Secs): 30

Depth Interval (ft)	Sample Description
0-46	No information available
46-92	Clay
92-113	Fine sand
113-130	Tan and gray clay
130-140	Tan and gray clay
140-145	Tan and gray clay
145-150	Sand with clay streaks
150-160	Sand, shell material and gravel
160-170	Sand with clay streaks
170-180	Sandy clay
180-210	Tan, white, gray and red clay
210-220	Tan, gray and red sandy clay
220-270	Tan, gray and red clay
270-290	Tan, gray and red sandy clay
290-313	Tan, gray and red clay
313-450	Tan and red clay, indurated

APPENDIX II - WATER QUALITY DATA

CHEMICAL ANALYSIS

(1) Location:

Water Treatment Plant No. 1 Well Site (R.O. Pilot Plant Location)

(2) Sampling Point:

Well Head

(3) Date:

4/4/96 (Filtered and Unfiltered)

7/1/96 (Unfiltered)

(4) Analysis:

Anions and Cations

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TEST REPORT: X15160

NRS Consulting Engineers
P.O. Box 2544
Harlingen, TX 78550-
Attention: Bill Norris

RECEIVED SEP 9 1996

Sample Identification: Well Water RR
Identificacion de Muestra
Collected By: David Garza Jr.
Colectado Por
Date & Time Taken: 08/15/96 1415
Tiempo y Fecha Tomado

Bottle Data:
Datos de Recipientes:

#01 - Unpreserved Glass
#01 - Sin Preservativo Vidrio
#02 - Unpreserved Glass
#02 - Sin Preservativo Vidrio
#03 - Unpreserved Glass
#03 - Sin Preservativo Vidrio
#07 - 40 ml glass Vial for VOA (Zero Headspace)
#07 - Botellita de vidrio de 40 ml con una Tapadera de Teflon (Sin
#08 - 40 ml glass Vial for VOA (Zero Headspace)
#08 - Botellita de vidrio de 40 ml con una Tapadera de Teflon (Sin
#09 - 40 ml glass Vial for VOA (Zero Headspace)
#09 - Botellita de vidrio de 40 ml con una Tapadera de Teflon (Sin
#04 - 1+1 H2SO4 40 ml Glass Vial
#04 - Botellita de Vidrio de 40 ml con una Tapadera de Teflon Pres
#05 - 1+1 H2SO4 40 ml Glass Vial
#05 - Botellita de Vidrio de 40 ml con una Tapadera de Teflon Pres
#06 - 1+1 H2SO4 40 ml Glass Vial
#06 - Botellita de Vidrio de 40 ml con una Tapadera de Teflon Pres
#10 - 2 ml Autosampler Vial — Amount: 1.000
Derived in lab from: 01 (740.000 ml)
#11 - 2 ml Autosampler Vial — Amount: 10.000
Derived in lab from: 01 (860.000 mls)
#12 - 2 ml Autosampler Vial — Amount: 10.000
Derived in lab from: 02 (800.000 mls)
#13 - 40 ML VIAL EXTRACT — Amount: 5.000
Derived in lab from: 02 (100.000 mls)

Sample Matrix: Aqueous Liquid
Report Date: 09/06/96 **Received:** 08/15/96 **Client:** NRS
No. de Muestra **Recibido** **Cliente**

PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PC
Dalapon	ND	ug/l	1741 09/04/96	58	EPA Method 515.1	KL

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09/06/96

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PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PC
Dinoseb	ND	ug/l	1741 09/04/96	7.0	EPA Method 515.1	KL
Epichlorohydrin	ND	mg/l	1100 09/04/96	100		KL
Bromochloroacetic acid	ND	ug/l	1641 09/05/96	1.0	EPA Method 552	KL
Dibromoacetic acid	ND	ug/l	1641 09/05/96	10	EPA Method 552	KL
Dichloroacetic acid	ND	ug/l	1641 09/05/96	1.0	EPA Method 552	KL
Bromoacetic acid	ND	ug/l	1641 09/05/96	1.0	EPA Method 552	KL
Chloroacetic acid	ND	ug/l	1641 09/05/96	1.0	EPA Method 552	KL
Trichloroacetic acid	ND	ug/l	1641 09/05/96	10	EPA Method 552	KL
Total Organic Carbon	1.2	mg/l	0900 08/27/96	.3	EPA 415.2	RS
Total Organic Halogens, Liquid	0.06	mg/l	1430 08/22/96	0.01	EPA Method 9020A	JW
1,2-Dibromoethane	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KL
Bromochloromethane	ND	ug/l	1436 08/23/96	5.0		KL
1,2,3-Trichloropropane 1,2,3-Tricloropropano	ND	ug/l	1436 08/23/96	5.0	EPA Method 624	KL
Aldrin Aldrin	ND	ug/l	0310 09/06/96	0.04	EPA Method 508	KL
Alpha-BHC Alfa-BHC (Benceno Exacloruro	ND	ug/l	0310 09/06/96	0.041	EPA Method 508	KL
Beta-BHC Beta-BHC	ND	ug/l	0310 09/06/96	0.027	EPA Method 508	KL
Delta-BHC Delta-BHC	ND	ug/l	0310 09/06/96	0.058	EPA Method 508	KL
Gamma-BHC (Lindane) Gamma-BHC	ND	ug/l	0310 09/06/96	0.047	EPA Method 508	KL
Chlordane Clordano	ND	ug/l	0310 09/06/96	0.16	EPA Method 508	KL

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PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PO
4,4-DDD 4,4 - DDD	ND	ug/l	0310 09/06/96	0.12	EPA Method 508	KL
4,4-DDE 4,4 - DDE	ND	ug/l	0310 09/06/96	0.047	EPA Method 508	KL
4,4-DDT 4,4 - DDT	ND	ug/l	0310 09/06/96	0.12	EPA Method 508	KL
Dieldrin	ND	ug/l	0310 09/06/96	0.023	EPA Method 508	KL
Endosulfan I	ND	ug/l	0310 09/06/96	0.12	EPA Method 508	KL
Endosulfan II	ND	ug/l	0310 09/06/96	0.047	EPA Method 508	KL
Endosulfan sulfate	ND	ug/l	0310 09/06/96	0.12	EPA Method 508	KL
Endrin	ND	ug/l	0310 09/06/96	0.07	EPA Method 508	KL
Endrin aldehyde	ND	ug/l	0310 09/06/96	0.12	EPA Method 508	KL
Heptachlor	ND	ug/l	0310 09/06/96	0.035	EPA Method 508	KL
Heptachlor epoxide	ND	ug/l	0310 09/06/96	0.037	EPA Method 508	KL
PCB-1016	ND	ug/l	0310 09/06/96	1.0	EPA Method 508	KL
PCB-1221	ND	ug/l	0310 09/06/96	1.0	EPA Method 508	KL
PCB-1232	ND	ug/l	0310 09/06/96	1.0	EPA Method 508	KL
PCB-1242	ND	ug/l	0310 09/06/96	1.0	EPA Method 508	KL
PCB-1248	ND	ug/l	0310 09/06/96	1.0	EPA Method 508	KL
PCB-1254	ND	ug/l	0310 09/06/96	1.0	EPA Method 508	KL
PCB-1260	ND	ug/l	0310 09/06/96	1.0	EPA Method 508	KL
Toxaphene	ND	ug/l	0310 09/06/96	2.8	EPA Method 508	KL
2,4,5-TP (Silvex)	ND	ug/l	1741 09/04/96	1.7	EPA Method 515.1	KL
2,4 Dichlorophenoxyacetic acid Acido 2,4-Diclorofenoxiacetico	ND	ug/l	1741 09/04/96	12	EPA Method 515.1	KL

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PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PC
Methoxychlor Metoxicloro	ND	ug/l	0310 09/06/96	2.0	EPA Method 508	KLI
Acenaphthene	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLI
Acenaphthylene Acenaftileno	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLI
Acrolein Acroleina	ND	ug/l	1436 08/23/96	50	EPA Method 524	KLI
Acrylonitrile Acrilonitrilo	ND	ug/l	1436 08/23/96	20	EPA Method 524	KLI
Anthracene	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLI
Benzene Benceno	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLI
Benzidine Bencidina	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLI
Benzo(a)anthracene	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLI
Benzo(a)pyrene	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLI
Benzo(b)fluoranthene	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLI
Benzo(ghi)perylene	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLI
Benzo(k)fluoranthene	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLI
Bis(2-chloroethyl)ether Eter Bis(2-Cloroetilico)	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLI
Bis(2-chloroethoxy)methane Metano Bis(2-Cloroetoxio)	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLI
Bis(2-chloroisopropyl)ether	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLI
4-Bromophenyl phenyl ether	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLI
Bis(2-ethylhexyl)phthalate	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLI

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PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PC
Bromoform	ND	ug/l	1436 08/23/96	10	EPA Method 524	KLE
Bromomethane	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
4-Chlorophenyl phenyl ether	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLE
Benzyl butyl phthalate	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLE
Carbon Tetrachloride	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
4-Chloro-3-methylphenol	ND	ug/l	2308 09/05/96	27	EPA Method 525	KLE
Chlorobenzene	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
Chloroethane	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
2-Chloroethylvinyl ether Eter 2-Cloroetilvinilo	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
Chloroform	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
Chloromethane Clorometano	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
2-Chloronaphthalene	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLE
2-Chlorophenol 2-Clorofenol	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLE
Chrysene	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLE
Dibenzo(a,h)anthracene	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLE
Dibromochloromethane	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
1,3-Dichlorobenzene 1,3-Diclorobenceno	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLE
1,2-Dichlorobenzene 1,2-Diclorobenceno	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLE
1,4-Dichlorobenzene 1,4-Diclorobenceno	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLE
3,3'-Dichlorobenzidine 3,3'-Diclorobencidina	ND	ug/l	2308 09/05/96	27	EPA Method 525	KLE

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PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PC
Bromodichloromethane	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KL
1,1-Dichloroethane 1,1-Dicloroetano	ND	ug/l	1436 08/23/96	5.0	EPA Method 525	KL
1,2-Dichloroethane 1,2-Dicloroetano	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KL
1,1-Dichloroethene 1,1-Dicloroeteno	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KL
trans-1,2-Dichloroethene	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KL
2,4-Dichlorophenol 2,4-Diclorofenol	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
Dichlorodiflouromethane	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KL
1,2-Dichloropropane 1,2-Dicloropropano	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KL
cis-1,3-Dichloropropene	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KL
Diethyl phthalate	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
2,4-Dimethylphenol 2,4-Dimetilfenol	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
Dimethyl phthalate	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
Di-n-butylphthalate	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
Di-n-octylphthalate	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
2-Methyl-4,6-dinitrophenol	ND	ug/l	2308 09/05/96	68	EPA Method 525	KL
2,4-Dinitrophenol 2,4-Dinitrofenol	ND	ug/l	2308 09/05/96	68	EPA Method 525	KL
2,4-Dinitrotoluene 2,4-Dinitrotolueno	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
2,6-Dinitrotoluene 2,6-Dinitrotolueno	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL

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PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PC
1,2-DPH (as azobenzene)	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
Ethyl benzene	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KL
Fluoranthene	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
Fluorene	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
Hexachlorobenzene	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
Hexachlorobutadiene Hexaclorobutadieno	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
Hexachlorocyclopentadiene	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
Hexachloroethane	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
Indeno(1,2,3-cd)pyrene	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
Isophorone	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
Methylene Chloride	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KL
Naphthalene	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
Nitrobenzene	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
2-Nitrophenol 2-Nitrofenol	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
4-Nitrophenol 4-Nitrofenol	ND	ug/l	2308 09/05/96	68	EPA Method 525	KL
N-nitrosodimethylamine	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
N-Nitrosodi-n-propylamine	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
N-nitrosodiphenylamine (as DPA)	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
Pentachlorophenol	ND	ug/l	2308 09/05/96	68	EPA Method 525	KL
Phenanthrene	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL
Phenol	ND	ug/l	2308 09/05/96	14	EPA Method 525	KL

Continued
Continuacion

PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PO
Pyrene	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLE
1,2,4-Trimethylbenzene 1,2,4-Trimetilbenceno	ND	ug/l	1436 08/23/96	5.0	EPA Method 624	KLE
1,1,2,2-Tetrachloroethane 1,1,2,2-Tetracloroetano	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
Tetrachloroethene	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
Toluene	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
1,2,4-Trichlorobenzene 1,2,4-Triclorobenceno	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLE
1,1,1-Trichloroethane 1,1,1-Tricloroetano	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
1,1,2-Trichloroethane 1,1,2-Tricloroetano	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
Trichloroethene	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
Trichlorofluoromethane	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLB
2,4,6-Trichlorophenol 2,4,6-Triclorofenol	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLE
Vinyl Chloride	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
trans-1,3-Dichloropropene	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
1,1,1,2-Tetrachloroethane 1,1,1,2-Tetracloroetano	ND	ug/l	1436 08/23/96	5.0	EPA Method 624	KLE
2,4,5-Trichlorophenol 2,4,5-Triclorofenol	ND	ug/l	2308 09/05/96	14	EPA Method 625	KLE
2,2-Dichloropropane 2,2-Dicloropropano	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
1,1-Dichloropropene 1,1-Dicloropropeno	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE

Continued
Continuacion

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Analytical Chemistry • Utility Operations

PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PC
1,3-Dichloropropane 1,3-Dicloropropano	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
Styrene	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
Isopropyl Benzene	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KL
n-Propylbenzene	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
Bromobenzene	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
1,3,5-Trimethylbenzene 1,3,5-Trimetilbenceno	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
2-Chlorotoluene 2-Clorotolueno	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
4-Chlorotoluene 4-Clorotolueno	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
tert-Butylbenzene	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
sec-Butylbenzene	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
p-Isopropyltoluene	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
1,3-Dichlorobenzene 1,3-Diclorobenceno	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
n-Butylbenzene	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
1,2-Dichlorobenzene 1,2-Diclorobenceno	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
1,2-Dibromo-3-chloropropane	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
1,2,4-Trichlorobenzene 1,2,4-Triclorobenceno	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
Hexachlorobutadiene	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
Naphthalene	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE
1,2,3-Tichlorobenzene 1,2,3-Ticlorobenceno	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLE

Continued
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Analytical Chemistry • Utility Operations

PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PO
Carbofuran	ND	ug/l	2308 09/05/96	14	EPA Method 525	KLB
Methyl Isobutyl Ketone	ND	ug/l	1436 08/23/96	5.0	EPA Method 624	KLB
Methyl Ethyl Ketone	ND	ug/l	1436 08/23/96	50	EPA Method 624	KLB
1,4-Dichlorobenzene 1,4-Diclorobenceno	ND	ug/l	1436 08/23/96	5.0		KLB
Xylenes	ND	ug/l	1436 08/23/96	5.0	EPA Method 524	KLB
1,2-Dibromo-3-chloropropane DBCP	ND	ug/l	1238 08/29/96	0.2	EPA Method 504	KLB
Alachlor	ND	ug/l	0310 09/06/96	2.0	EPA Method 507	KLB
Atrazine	ND	ug/l	0310 09/06/96	3.0	EPA Method 507	KLB
Dibromomethane	ND	ug/l	1436 08/23/96	5.0		KLB
Cis-1,2-Dichloroethene	ND	ug/l	1436 08/23/96	5.0		KLB
Ethylene dibromide (EDB)	ND	ug/l	1238 08/29/96	0.05	EPA Method 504	KLB
Endothall	ND	ug/l	0811 09/06/96	100	EPA Method 548	KLB
Simazine	ND	ug/l	0310 09/06/96	4.0	EPA Method 507	KLB

Sample Preparation Steps for R15160

Total Polychlorinated Biphenyls	Verified	ppm	0310 09/06/96	EPA Method 508	KLB
Fax This Report AS Soon As DONE!	FAXED		16:2509/06/96		
Haloacetic Acids (HAA5)	Verified		1641 09/05/96	EPA Method 552	KLB
Haloacetic Acids Extraction	5/100	mls/mls	1400 09/03/96	EPA Method 552	LMB
EDB and DBCP Analysis by GC/ECD	Verified		1238 08/29/96	EPA Method 504	KLB
NP Pesticides Analysis	Verified		0310 09/06/96	EPA Method 507	KLB
Method 515 Herbicides	Verified		1741 09/04/96	EPA Method 515	KLB
Endothall Analysis by GC/ECD	Verified		0811 09/06/96	EPA Method 548	KLB
Esterification of Sample Esterificacion del Exracto	10/800	mls/mls	1400 09/03/96	EPA Method 515.1	LMB
Liquid-Liquid Extraction, BNA Extraccion de Liquido/Liquido	1/740	ml/ml	1700 08/26/96	EPA Method 3520	PCT
Liquid-Liquid Extr. W/Hex Exch. Extraccion de L/L con cambio Hex	1/860	mls/mls	1000 08/28/96	EPA Method 508	LMB

Continued
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Analytical Chemistry • Utility Operations

PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PC

* EPA Method 8270 internal standard recovery low due to matrix effects. Quantitative results are estimated.

MAL is our Minimum Analytical Level/Minimum Quantitation Level. The MAL takes into account the Instrument Detection Limit (IDL), Method Detection Limit (MDL), and Practical Quantitation Limit (PQL), and any dilutions and/or concentrations performed during sample preparation (EQL).

Our analytical result must be above this MAL before we report a value in the "Results" column of our report. Otherwise, we report ND (Not Detected above MAL), because the result is "<" (less than) the number in the MAL column.

"MAL" es nuestro Nivel Minimo Analitico/Nivel Cuatitativo Minimo. El "MAL" tomo en consideracion el Limite Deteccion del Instrumento (Instrument Detection Limit-IDL), el Limite Deteccion de Metodo (Method Detection Limit-MDL), y el Limite Deteccion Practico (Pratical Detection Limit-PDL), y cualquier diluciones y/o concentrationes llevado a cabo durante la preparacion de la muestra.

Nuestro resultado analitico de las muestras tienen que ser mayor del "MAL" antes que entregamos un valor in la columna "Resultados" (Results) en nuestro reporte. Si no, se reportarara "ND" Nada Dectado mayor del "MAL" (Not detected above MAL), porque el resultado es menos que "<" (less than) el numero reportado bajo la columna "MAL".

These analytical results relate to the sample tested. This report may NOT be reproduced EXCEPT in FULL without written approval of Ana-Lab Corp.

I certify that the results were generated using the above specified methods.

C. H. Whiteside

C. H. Whiteside, Ph.D., President

Note: Pages 11, 12, 13, 14, 15, 16 remov.
These pages are QA data only.

CHEMICAL ANALYSIS

(1) Location:

Water Treatment Plant No. 1 Well Site (R.O. Pilot Plant Location)

(2) Sampling Point:

Well Head

(3) Date:

7/1/96 (Unfiltered)

(4) Analysis:

THM Formation Potential

TOX Formation Potential

HAA5 Formation Potential

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Analytical Chemistry • Utility Operations

ANA-LAB CORP.
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TEST REPORT: R00001

NRS Consulting Engineers
P.O. Box 2544
Harlingen, TX 78550-
Attention: Bill Norris

RECEIVED SEP 11 1996

Sample Identification:WWTP1 Well Site1 WELL WATER
Identificacion de Muestra
Collected By: David Garza Jr.
Colectado Por
Date & Time Taken:07/01/96 1600
Tiempo y Fecha Tomado

Other Data:
Otros Datos After Superchlorination

Sample Matrix: Aqueous Liquid
Report Date: 07/18/96 **Received:** 07/02/96 **Client:** NRS
No. de Muestra **Recibido** **Cliente**

PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PC
Haloacetic Acid Formation Pot.	ND	ug/l	2251 07/16/96	1		KB
TOX Formation Potential	0.11	mg/l	1906 07/16/96	.01		JW:
THM Formation Potential	26	ug/l	1416 07/11/96	1		KB

MAL is our Minimum Analytical Level/Minimum Quantitation Level. The MAL takes into account the Instrument Detection Limit (IDL), Method Detection Limit (MDL), and Practical Quantitation Limit (PQL), and any dilutions and/or concentrations performed during sample preparation (EQL).

Our analytical result must be above this MAL before we report a value in the "Results" column of our report. Otherwise, we report ND (Not Detected above MAL), because the result is "<" (less than) the number in the MAL column.

"MAL" es nuestro Nivel Minimo Analitico/Nivel Cuatitativo Minimo. El "MAL" tomo en consideracion el Limite Deteccion del Instrumento (Instrument Detection Limit-IDL), el Limite Deteccion de Metodo (Method Detection Limit-MDL), y el Limite Deteccion Practico (Pratical Detection Limit-PDL), y cualquier diluciones y/o concentrationes llevado a cabo durante la preparacion de la muestra.

Nuestro resultado analitico de las muestras tienen que ser mayor del "MAL" antes que entregamos un valor in la columna "Resultados" (Results) en nuestro reporte. Si no, se reportarara "ND" Nada Dectado mayor del "MAL" (Not detected above MAL), porque el resultad es menos que "<" (less than) el numero reportado bajo la columna "MAL".

Continued
Continuacion

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These analytical results relate to the sample tested. This report may NOT be reproduced EXCEPT in FULL without written approval c
Ana-Lab Corp.

I certify that the results were generated using the above specified methods.

C. H. Whiteside

C. H. Whiteside, Ph.D., President

CHEMICAL ANALYSIS

(1) Location:

Water Treatment Plant No. 1 Well Site (R.O. Pilot Plant Location)

(2) Sampling Point:

Permeate (Product Water) from R.O. Pilot Plant

(3) Date:

7/1/96

(4) Analysis:

Anions and Cations

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Analytical Chemistry • Utility Operations

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TEST REPORT: R14687

NRS Consulting Engineers
P.O. Box 2544
Harlingen, TX 78550-
Attention: Bill Norris

RECEIVED JUL 22 1996

Sample Identification:WWTP1 Well Site1 PERMEATE WTR.
Collected By: David Garza Jr.
Date & Time Taken:07/01/96 1615

Bottle Data:

#03 - Unpreserved Glass		
#04 - Unpreserved Glass		
#05 - Unpreserved Glass		
#06 - Unpreserved Glass		
#07 - Unpreserved Glass		
#08 - Unpreserved Glass		
#09 - Unpreserved Glass		
#10 - Unpreserved Glass		
#11 - Unpreserved Glass		
#12 - Unpreserved Glass		
#13 - Unpreserved Glass		
#01 - H2SO4 Preserved Glass with a Teflon Lid		
#02 - H2SO4 Preserved Glass with a Teflon Lid		
#12 - HNO3 Preserved Sample (Plastic or Glass)		
#13 - HNO3 Preserved Sample (Plastic or Glass)		
#14 - HNO3 Preserved Sample (Plastic or Glass)		
#15 - ICP Digestion Derived in lab from: 13 (50 ml)	Amount:	50
#16 - ICP Digestion Derived in lab from: 13 (50 ml)	Amount:	50
#17 - ICP Digestion Derived in lab from: 13 (50 ml)	Amount:	50
#18 - Glass Flask: NH3 Distillation Derived in lab from: 02 (500 ml)	Amount:	338

Sample Matrix: Aqueous Liquid
Report Date: 07/16/96 **Received:** 07/01/96 **Client:** NRS

PARAMETER	RESULTS	UNITS	ANALYZED	EQL	METHOD	BY
Chloride	17	mg/l	1600 07/03/96	0.10	EPA Method 325.2	SK
Ammonia Nitrogen	ND	mg/L	1330 07/09/96	0.034	EPA 350.1	SK
Nitrate - Nitrite	ND	mg/l	1300 07/08/96	0.20	EPA Method 353.1	SK
Total Organic Carbon	0.46	mg/l	2300 07/12/96	.3	EPA 415.2	JW

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Analytical Chemistry • Utility Operations

PARAMETER	RESULTS	UNITS	ANALYZED	EQL	METHOD	BY
Alkalinity	16	mg/l	1600 07/05/96	2	EPA Method 310.1	BRE
Cation-Anion Balance	1.01 / 0.742	meq/meq	17:3107/08/96			WJE
Carbon Dioxide	22.4	ppm	1023 07/08/96	0.5	APHA Meth 4500-CO2 D	NGT
Carbonate	ND	ppm	1023 07/08/96	0.5	APHA Meth 4500-CO2 D	NGT
Specific Conductance at 25 C	112	umho/cm	1635 07/01/96		EPA Method 120.1	DGJ
Fluoride	ND	mg/l	0800 07/05/96	.2	EPA Method 340.2	CWT
Bicarbonate	16.0	ppm	1023 07/08/96	0.5	APHA Meth 4500-CO2 D	NGT
Hydroxide	ND	mg/l	1023 07/08/96	0.5	APHA 4500-CO2 D	NGT
Sulfate	ND	mg/l	1400 07/06/96	5	EPA Method 375.4	WMF
Total Dissolved Solids	110	mg/l	1600 07/13/96	10	EPA Method 160.1	BRE
emperature	28	degrees C	1640 07/01/96	.1	EPA Method 170.1	DGJ
pH (On Site)	5.3	SU	1640 07/01/96		EPA Method 150.1	DGJ
Total Barium	14	ug/l	1144 07/08/96	10	EPA Method 200.7	GDG
Total Calcium	0.66	mg/l	1242 07/05/96	0.05	EPA Method 200.7	GDG
Total Iron	0.062	mg/l	1242 07/05/96	0.05	EPA Method 200.7	GDG
Total Potassium	ND	mg/l	1242 07/05/96	2	EPA Method 258.1	GDG
Total Magnesium	0.16	mg/l	1242 07/05/96	0.1	EPA Method 6010	GDG
Total Manganese	ND	mg/l	1242 07/05/96	0.03	EPA Method 200.7	GDG
Total Sodium	22	mg/l	1242 07/05/96	1	EPA Method 6010	GDG
Silicon (as Silica, SiO2)	0.73	mg/l	0905 07/09/96	0.1	EPA Method 200.7	GDG
Total Strontium	ND	ug/l	1023 07/09/96	10	EPA Method 200.7	GDG
Total Coliform Plate Count	1	#/100 mls	1630 07/03/96	1	APHA Method 9222 B	LMF
Sulfide	ND	mg/l	1100 07/05/96	2	EPA Method 376.1	CWT

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Analytical Chemistry • Utility Operations

Sample Preparation Steps for R14687

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Ammonia Distillation	338/500	ml/ml	1000 07/08/96	EPA Method 350.2	RSV
Metals Digestion - Liquid	50/50 S/B/A	ml/ml	0600 07/03/96	EPA Method 200.7	KLC
Total Coliform Plate Ct Started	STARTED		1745 07/02/96		LMK

Quality Assurance for the SET with Sample R14687

Sample #	Description	Result	Units	Dup/Std Value	Spk Conc.	Percent	Time	Date	By
Chloride									
	Standard	28	ppm	25		112	1600	07/03/96	SK
	Standard	50	ppm	50		100	1600	07/03/96	SK
	Standard	50	ppm	50		100	1600	07/03/96	SK
325901	Duplicate	34	mg/l	36		6	1600	07/03/96	SK
325901	Spike		%		20	85	1600	07/03/96	SK
Ammonia Nitrogen									
	Blank	<0.05	ppm				1330	07/09/96	SK
	Blank	<0.05	ppm				1330	07/09/96	SK
	Standard	3.0	ppm	3.0		100	1330	07/09/96	SK
	Standard	3.0	ppm	3.0		100	1330	07/09/96	SK
	Standard	3.0	ppm	3.0		100	1330	07/09/96	SK
	Standard	3.0	ppm	3.0		100	1330	07/09/96	SK
R14686	Duplicate	ND	mg/L	ND		0	1330	07/09/96	SK
P9431	Spike		%		2.0	65	1330	07/09/96	SK
R14686	Spike		%		2.0	80	1330	07/09/96	SK
Nitrate - Nitrite									
	Standard	1.9	ppm	2.0		95	1300	07/08/96	SK
	Standard	2.0	ppm	2.0		100	1300	07/08/96	SK
	Standard	2.0	ppm	2.0		100	1300	07/08/96	SK
	Standard	2.0	ppm	2.0		100	1300	07/08/96	SK
	Standard	2.0	ppm	2.0		100	1300	07/08/96	SK
325840	Duplicate	0.68	mg/kg	0.68		0	1300	07/08/96	SK
325943	Duplicate	ND	mg/l	ND		0	1300	07/08/96	SK
P9537	Duplicate	1.0	mg/l	1.1		10	1300	07/08/96	SK
R14687	Duplicate	ND	mg/l	ND		0	1300	07/08/96	SK
P9537	Spike		%		1.0	75	1300	07/08/96	SK
R14687	Spike		%		4.43	95	1300	07/08/96	SK
Total Organic Carbon									
	Standard	10.0	mg/l	10.0		100	2300	07/12/96	JK
	Standard	10.0	mg/l	10.0		100	2300	07/12/96	JK
R14687	Duplicate	0.50	mg/l	0.42		17	2300	07/12/96	JK
R14687	Spike		mg/l		10.0	101	2300	07/12/96	JK

Continued

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Analytical Chemistry • Utility Operations

Sample #	Description	Result	Units	Dup/Std Value	Spk Conc.	Percent	Time	Date	By
R14687	Duplicate	1.0	mg/l	0.45		76	0905	07/09/96	GI
R14687	Spike		ppm		5.0	90	0905	07/09/96	GI
	Total Strontium								
	Blank	<0.010	ppm				1023	07/09/96	GI
	Standard	1.0	ppm	1.0		100	1023	07/09/96	GI
	Standard	0.52	ppm	0.50		104	1023	07/09/96	GI
	Standard	0.50	ppm	0.50		100	1023	07/09/96	GI
R14687	Duplicate	ND	ug/l	ND		0	1023	07/09/96	GI
R14687	Spike		ppm		0.50	113	1023	07/09/96	GI
	Total Coliform Plate Count								
	Blank	<1	#/100 MLS				1630	07/03/96	LM
R14687	Duplicate	1	#/100 MLS	1		0	1630	07/03/96	LM
	Sulfide								
	Blank	<2	mg/l				1100	07/05/96	C
R14686	Duplicate	ND	mg/l	ND		0	1100	07/05/96	C

EQL is Estimated Quantitation Limit. The EQL takes into account the Instrument Detection Limit (IDL), Method Detection Limit (MDL), and Practical Quantitation Limit (PQL). Our analytical result must be above our EQL before we report a value for any parameter. Otherwise, we report ND (Not Detected above EQL).

I certify that the results were generated using the above specified methods.

Note: Pages 4+5 removed. These pages are QA data only.

Donald L. Cook

C. H. Whiteside, Ph.D., President

CHEMICAL ANALYSIS

(1) Location:

Water Treatment Plant No. 1 Well Site (R.O. Pilot Plant Location)

(2) Sampling Point:

Permeate (Product Water) from R.O. Pilot Unit

(3) Date:

8/15/96

(4) Analysis:

Synthetic Organic Chemicals (SOC's)

Volatile Organic Chemicals (VOC's)

Total Organic Carbon (TOC's)

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ANA-LAB CORP. THE COMPLETE SERVICE LAB

Analytical Chemistry • Utility Operations

TEST REPORT: X15161

NRS Consulting Engineers
P.O. Box 2544
Harlingen, TX 78550-
Attention: Bill Norris

RECEIVED SEP 9 1996

Sample Identification: Permeate RR
Identificacion de Muestra
Collected By: David Garza Jr.
Colectado Por
Date & Time Taken: 08/15/96 1430
Tiempo y Fecha Tomado

Bottle Data:
Datos de Recipientes:

#01 - Unpreserved Glass
#01 - Sin Preservativo Vidrio
#02 - Unpreserved Glass
#02 - Sin Preservativo Vidrio
#03 - Unpreserved Glass
#03 - Sin Preservativo Vidrio
#07 - 40 ml glass Vial for VOA (Zero Headspace)
#07 - Botellita de vidrio de 40 ml con una Tapadera de Teflon (Sin
#08 - 40 ml glass Vial for VOA (Zero Headspace)
#08 - Botellita de vidrio de 40 ml con una Tapadera de Teflon (Sin
#09 - 40 ml glass Vial for VOA (Zero Headspace)
#09 - Botellita de vidrio de 40 ml con una Tapadera de Teflon (Sin
#04 - 1+1 H2SO4 40 ml Glass Vial
#04 - Botellita de Vidrio de 40 ml con una Tapadera de Teflon Pres
#05 - 1+1 H2SO4 40 ml Glass Vial
#05 - Botellita de Vidrio de 40 ml con una Tapadera de Teflon Pres
#06 - 1+1 H2SO4 40 ml Glass Vial
#06 - Botellita de Vidrio de 40 ml con una Tapadera de Teflon Pres
#10 - 2 ml Autosampler Vial — Amount: 1.000
Derived in lab from: 01 (860.000 ml)
#11 - 2 ml Autosampler Vial — Amount: 10.000
Derived in lab from: 01 (890.000 mls)
#12 - 2 ml Autosampler Vial — Amount: 10.000
Derived in lab from: 02 (595.000 mls)
#13 - 40 ML VIAL EXTRACT — Amount: 5.000
Derived in lab from: 02 (100.000 mls)

Sample Matrix: Aqueous Liquid
Report Date: 09/06/96 **Received:** 08/15/96 **Client:** NRS
No. de Muestra **Recibido** **Cliente**

PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PC
Dalapon	ND	ug/l	1816 09/04/96	58	EPA Method 515.1	KL

Continued
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Analytical Chemistry • Utility Operations

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PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY POR
Dinoseb	ND	ug/l	1816 09/04/96	7.0	EPA Method 515.1	KLB
Epichlorohydrin	ND	mg/l	1100 09/04/96	100		KLB
Bromochloroacetic acid	ND	ug/l	1715 09/05/96	1.0	EPA Method 552	KLB
Dibromoacetic acid	ND	ug/l	1715 09/05/96	10	EPA Method 552	KLB
Dichloroacetic acid	ND	ug/l	1715 09/05/96	1.0	EPA Method 552	KLB
Bromoacetic acid	ND	ug/l	1715 09/05/96	1.0	EPA Method 552	KLB
Chloroacetic acid	ND	ug/l	1715 09/05/96	1.0	EPA Method 552	KLB
Trichloroacetic acid	ND	ug/l	1715 09/05/96	10	EPA Method 552	KLB
Total Organic Carbon	0.59	mg/l	2200 08/20/96	.3	EPA 415.2	JWB
Total Organic Halogens, Liquid	0.04	mg/l	1430 08/22/96	0.01	EPA Method 9020A	JWB
1,2-Dibromoethane	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLB
Bromochloromethane	ND	ug/l	1304 08/23/96	5.0		KLB
1,2,3-Trichloropropane 1,2,3-Tricloropropano	ND	ug/l	1304 08/23/96	5.0	EPA Method 624	KLB
Aldrin Aldrin	ND	ug/l	0340 09/06/96	0.034	EPA Method 508	KLB
Alpha-BHC Alfa-BHC (Benceno Exacloruro	ND	ug/l	0340 09/06/96	0.035	EPA Method 508	KLB
Beta-BHC Beta-BHC	ND	ug/l	0340 09/06/96	0.023	EPA Method 508	KLB
Delta-BHC Delta-BHC	ND	ug/l	0340 09/06/96	0.05	EPA Method 508	KLB
Gamma-BHC (Lindane) Gamma-BHC	ND	ug/l	0340 09/06/96	0.04	EPA Method 508	KLB
Chlordane Clordano	ND	ug/l	0340 09/06/96	0.14	EPA Method 508	KLB

Continued
Continuacion

P. O. BOX 9000 - KILGORE, TEXAS 75663-9000 - 903/984-0551 - FAX 903/984-5914

PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PC
4,4-DDD 4,4 - DDD	ND	ug/l	0340 09/06/96	0.1	EPA Method 508	KL
4,4-DDE 4,4 - DDE	ND	ug/l	0340 09/06/96	0.04	EPA Method 508	KL
4,4-DDT 4,4 - DDT	ND	ug/l	0340 09/06/96	0.1	EPA Method 508	KL
Dieldrin	ND	ug/l	0340 09/06/96	0.02	EPA Method 508	KL
Endosulfan I	ND	ug/l	0340 09/06/96	0.1	EPA Method 508	KL
Endosulfan II	ND	ug/l	0340 09/06/96	0.04	EPA Method 508	KL
Endosulfan sulfate	ND	ug/l	0340 09/06/96	0.1	EPA Method 508	KL
Endrin	ND	ug/l	0340 09/06/96	0.06	EPA Method 508	KL
Endrin aldehyde	ND	ug/l	0340 09/06/96	0.1	EPA Method 508	KL
Heptachlor	ND	ug/l	0340 09/06/96	0.03	EPA Method 508	KL
Heptachlor epoxide	ND	ug/l	0340 09/06/96	0.032	EPA Method 508	KL
PCB-1016	ND	ug/l	0340 09/06/96	1.0	EPA Method 508	KL
PCB-1221	ND	ug/l	0340 09/06/96	1.0	EPA Method 508	KL
PCB-1232	ND	ug/l	0340 09/06/96	1.0	EPA Method 508	KL
PCB-1242	ND	ug/l	0340 09/06/96	1.0	EPA Method 508	KL
PCB-1248	ND	ug/l	0340 09/06/96	1.0	EPA Method 508	KL
PCB-1254	ND	ug/l	0340 09/06/96	1.0	EPA Method 508	KL
PCB-1260	ND	ug/l	0340 09/06/96	1.0	EPA Method 508	KL
Toxaphene	ND	ug/l	0340 09/06/96	2.4	EPA Method 508	KL
2,4,5-TP (Silvex)	ND	ug/l	1816 09/04/96	1.7	EPA Method 515.1	KL
2,4 Dichlorophenoxyacetic acid Acido 2,4-Diclorofenoxiacetico	ND	ug/l	1816 09/04/96	12	EPA Method 515.1	KL

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THE COMPLETE SERVICE LAB
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Analytical Chemistry • Utility Operations

09/06/96

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Continuacion

PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PC
Methoxychlor Metoxicloro	ND	ug/l	0340 09/06/96	1.8	EPA Method 508	KL
Acenaphthene	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Acenaphthylene Acenaftileno	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Acrolein Acroleina	ND	ug/l	1304 08/23/96	50	EPA Method 524	KL
Acrylonitrile Acrilonitrilo	ND	ug/l	1304 08/23/96	20	EPA Method 524	KL
Anthracene	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Benzene Benceno	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KL
Benzidine Bencidina	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Benzo(a)anthracene	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Benzo(a)pyrene	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Benzo(b)fluoranthene	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Benzo(ghi)perylene	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Benzo(k)fluoranthene	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Bis(2-chloroethyl)ether Eter Bis(2-Cloroetilico)	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Bis(2-chloroethoxy)methane Metano Bis(2-Cloroetoxio)	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Bis(2-chloroisopropyl)ether	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
4-Bromophenyl phenyl ether	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Bis(2-ethylhexyl)phthalate	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL

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Analytical Chemistry • Utility Operations

PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PO
Bromoform	ND	ug/l	1304 08/23/96	10	EPA Method 524	KL
Bromomethane	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KL
4-Chlorophenyl phenyl ether	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Benzyl butyl phthalate	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Carbon Tetrachloride	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KL
4-Chloro-3-methylphenol	ND	ug/l	2348 09/05/96	23	EPA Method 525	KL
Chlorobenzene	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KL
Chloroethane	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KL
2-Chloroethylvinyl ether Eter 2-Cloroetilvinilo	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KL
Chloroform	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KL
Chloromethane Clorometano	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KL
2-Chloronaphthalene	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
2-Chlorophenol 2-Clorofenol	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Chrysene	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Dibenzo(a,h)anthracene	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Dibromochloromethane	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KL
1,3-Dichlorobenzene 1,3-Diclorobenceno	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
1,2-Dichlorobenzene 1,2-Diclorobenceno	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
1,4-Dichlorobenzene 1,4-Diclorobenceno	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
3,3'-Dichlorobenzidine 3,3'-Diclorobencidina	ND	ug/l	2348 09/05/96	23	EPA Method 525	KL

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Analytical Chemistry • Utility Operations

PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PO
Bromodichloromethane	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLE
1,1-Dichloroethane 1,1-Dicloroetano	ND	ug/l	1304 08/23/96	5.0	EPA Method 525	KLE
1,2-Dichloroethane 1,2-Dicloroetano	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLE
1,1-Dichloroethene 1,1-Dicloroeteno	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLE
trans-1,2-Dichloroethene	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLE
2,4-Dichlorophenol 2,4-Diclorofenol	ND	ug/l	2348 09/05/96	12	EPA Method 525	KLE
Dichlorodiflouromethane	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLE
1,2-Dichloropropane 1,2-Dicloropropano	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLE
cis-1,3-Dichloropropene	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLE
Diethyl phthalate	ND	ug/l	2348 09/05/96	12	EPA Method 525	KLE
2,4-Dimethylphenol 2,4-Dimetilfenol	ND	ug/l	2348 09/05/96	12	EPA Method 525	KLE
Dimethyl phthalate	ND	ug/l	2348 09/05/96	12	EPA Method 525	KLE
Di-n-butylphthalate	ND	ug/l	2348 09/05/96	12	EPA Method 525	KLE
Di-n-octylphthalate	ND	ug/l	2348 09/05/96	12	EPA Method 525	KLE
2-Methyl-4,6-dinitrophenol	ND	ug/l	2348 09/05/96	58	EPA Method 525	KLE
2,4-Dinitrophenol 2,4-Dinitrofenol	ND	ug/l	2348 09/05/96	58	EPA Method 525	KLE
2,4-Dinitrotoluene 2,4-Dinitrotolueno	ND	ug/l	2348 09/05/96	12	EPA Method 525	KLE
2,6-Dinitrotoluene 2,6-Dinitrotolueno	ND	ug/l	2348 09/05/96	12	EPA Method 525	KLE

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Analytical Chemistry • Utility Operations

PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PC
1,2-DPH (as azobenzene)	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Ethyl benzene	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KL
Fluoranthene	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Fluorene	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Hexachlorobenzene	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Hexachlorobutadiene Hexaclorobutadieno	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Hexachlorocyclopentadiene	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Hexachloroethane	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Indeno(1,2,3-cd)pyrene	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Isophorone	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Methylene Chloride	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KL
Naphthalene	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Nitrobenzene	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
2-Nitrophenol 2-Nitrofenol	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
4-Nitrophenol 4-Nitrofenol	ND	ug/l	2348 09/05/96	58	EPA Method 525	KL
N-nitrosodimethylamine	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
N-Nitrosodi-n-propylamine	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
N-nitrosodiphenylamine (as DPA)	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Pentachlorophenol	ND	ug/l	2348 09/05/96	58	EPA Method 525	KL
Phenanthrene	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL
Phenol	ND	ug/l	2348 09/05/96	12	EPA Method 525	KL

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Analytical Chemistry • Utility Operations

PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PO.
Pyrene	ND	ug/l	2348 09/05/96	12	EPA Method 525	KLE
1,2,4-Trimethylbenzene 1,2,4-Trimetilbenceno	ND	ug/l	1304 08/23/96	5.0	EPA Method 624	KLE
1,1,2,2-Tetrachloroethane 1,1,2,2-Tetracloroetano	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLE
Tetrachloroethene	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLE
Toluene	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLE
1,2,4-Trichlorobenzene 1,2,4-Triclorobenceno	ND	ug/l	2348 09/05/96	12	EPA Method 525	KLE
1,1,1-Trichloroethane 1,1,1-Tricloroetano	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLE
1,1,2-Trichloroethane 1,1,2-Tricloroetano	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLE
Trichloroethene	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLE
Trichlorofluoromethane	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLE
2,4,6-Trichlorophenol 2,4,6-Triclorofenol	ND	ug/l	2348 09/05/96	12	EPA Method 525	KLE
Vinyl Chloride	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLE
trans-1,3-Dichloropropene	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLE
1,1,1,2-Tetrachloroethane 1,1,1,2-Tetracloroetano	ND	ug/l	1304 08/23/96	5.0	EPA Method 624	KLE
2,4,5-Trichlorophenol 2,4,5-Triclorofenol	ND	ug/l	2348 09/05/96	12	EPA Method 625	KLE
2,2-Dichloropropane 2,2-Dicloropropano	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLE
1,1-Dichloropropene 1,1-Dicloropropeno	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLE

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PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PC
1,3-Dichloropropane 1,3-Dicloropropano	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI
Styrene	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI
Isopropyl Benzene	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI
n-Propylbenzene	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI
Bromobenzene	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI
1,3,5-Trimethylbenzene 1,3,5-Trimetilbenceno	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI
2-Chlorotoluene 2-Clorotolueno	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI
4-Chlorotoluene 4-Clorotolueno	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI
tert-Butylbenzene	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI
sec-Butylbenzene	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI
p-Isopropyltoluene	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI
1,3-Dichlorobenzene 1,3-Diclorobenceno	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI
n-Butylbenzene	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI
1,2-Dichlorobenzene 1,2-Diclorobenceno	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI
1,2-Dibromo-3-chloropropane	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI
1,2,4-Trichlorobenzene 1,2,4-Triclorobenceno	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI
Hexachlorobutadiene	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI
Naphthalene	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI
1,2,3-Tichlorobenzene 1,2,3-Ticlorobenceno	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI

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PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PC
Carbofuran	ND	ug/l	2348 09/05/96	12	EPA Method 525	KLI
Methyl Isobutyl Ketone	ND	ug/l	1304 08/23/96	5.0	EPA Method 624	KLI
Methyl Ethyl Ketone	ND	ug/l	1304 08/23/96	50	EPA Method 624	KLI
1,4-Dichlorobenzene 1,4-Diclorobenceno	ND	ug/l	1304 08/23/96	5.0		KLI
Xylenes	ND	ug/l	1304 08/23/96	5.0	EPA Method 524	KLI
1,2-Dibromo-3-chloropropane DBCP	ND	ug/l	1303 08/29/96	0.2	EPA Method 504	KLI
Alachlor	ND	ug/l	0340 09/06/96	2.0	EPA Method 507	KLI
Atrazine	ND	ug/l	0340 09/06/96	3.0	EPA Method 507	KLI
Dibromomethane	ND	ug/l	1304 08/23/96	5.0		KLI
Cis-1,2-Dichloroethene	ND	ug/l	1304 08/23/96	5.0		KLI
Ethylene dibromide (EDB)	ND	ug/l	1303 08/29/96	0.05	EPA Method 504	KLI
Endothall	ND	ug/l	0841 09/06/96	100	EPA Method 548	KLI
Simazine	ND	ug/l	0340 09/06/96	4.0	EPA Method 507	KLI

Sample Preparation Steps for R15161

Total Polychlorinated Biphenyls	Verified	ppm	0340 09/06/96	EPA Method 508	KLI
Fax This Report AS Soon As DONE!	FAXED		16:2609/06/96		
Haloacetic Acids (HAA5)	Verified		1715 09/05/96	EPA Method 552	KLI
Haloacetic Acids Extraction	5/100	mls/mls	1400 09/03/96	EPA Method 552	LMI
EDB and DBCP Analysis by GC/ECD	Verified		1303 08/29/96	EPA Method 504	KLI
NP Pesticides Analysis	Verified		0340 09/06/96	EPA Method 507	KLI
Method 515 Herbicides	Verified		1816 09/04/96	EPA Method 515	KLI
Endothall Analysis by GC/ECD	Verified		0841 09/06/96	EPA Method 548	KLI
Esterification of Sample Esterificacion del Exracto	10/595	mls/mls	1400 09/03/96	EPA Method 515.1	LMI
Liquid-Liquid Extraction, BNA Extraccion de Liquido/Liquido	1/860	ml/ml	1700 08/26/96	EPA Method 3520	PC
Liquid-Liquid Extr. W/Hex Exch. Extraccion de L/L con cambio Hex	1/890	mls/mls	1000 08/28/96	EPA Method 508	LMI

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MAL is our Minimum Analytical Level/Minimum Quantitation Level. The MAL takes into account the Instrument Detection Limit (IDL), Method Detection Limit (MDL), and Practical Quantitation Limit (PQL), and any dilutions and/or concentrations performed during sample preparation (EQL).

Our analytical result must be above this MAL before we report a value in the "Results" column of our report. Otherwise, we report ND (Not Detected above MAL), because the result is "<" (less than) the number in the MAL column.

"MAL" es nuestro Nivel Minimo Analitico/Nivel Cuatitativo Minimo. El "MAL" tomo en consideracion el Limite Deteccion del Instrumento (Instrument Detection Limit-IDL), el Limite Deteccion de Metodo (Method Detection Limit-MDL), y el Limite Deteccion Practico (Pratical Detection Limit-PDL), y cualquier diluciones y/o concentrationes llevado a cabo durante la preparacion de la muestra.

Nuestro resultado analitico de las muestras tienen que ser mayor del "MAL" antes que entregamos un valor in la columna "Resultados" (Results) en nuestro reporte. Si no, se reportarara "ND" Nada Dectado mayor del "MAL" (Not detected above MAL), porque el resultado es menos que "<" (less than) el numero reportado bajo la columna "MAL".

These analytical results relate to the sample tested. This report may NOT be reproduced EXCEPT in FULL without written approval of Ana-Lab Corp.

I certify that the results were generated using the above specified methods.

C. H. Whiteside

C. H. Whiteside, Ph.D., President

Notes: Pages 11, 12, 13, 14, 15, + 16 remo[illegible]
These pages are QA data only.

CHEMICAL ANALYSIS

(1) Location:

Water Treatment Plant No. 1 Well Site (R.O. Pilot Plant Location)

(2) Sampling Point:

Permeate (Product Water) from R.O. Pilot Plant

(3) Date:

7/1/96

(4) Analysis:

THM Formation Potential

TOX Formation Potential

HAA5 Formation Potential

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P. O. BOX 9000 – KILGORE, TEXAS 75663-9000 – 903/984-0551 – FAX 903/984-5914

Analytical Chemistry • Utility Operations

TEST REPORT: R00002

NRS Consulting Engineers
P.O. Box 2544
Harlingen, TX 78550-
Attention: Bill Norris

SEP 11 1996

Sample Identification:WWTP1 Well Site1 PERMEATE WTR.
Identificacion de Muestra
Collected By: David Garza Jr.
Colectado Por
Date & Time Taken:07/01/96 1615
Tiempo y Fecha Tomado

Other Data:
Otros Datos After Superchlorination

Sample Matrix: Aqueous Liquid
Report Date: 07/18/96 **Received:** 07/02/96 **Client:** NRS
No. de Muestra **Recibido** **Cliente**

PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PO
Haloacetic Acid Formation Pot.	ND	ug/l	2251 07/16/96	1		KB
TOX Formation Potential	0.07	mg/l	1906 07/16/96	0.01		JWF
THM Formation Potential	ND	ug/l	1416 07/11/96	5		JWE

MAL is our Minimum Analytical Level/Minimum Quantitation Level. The MAL takes into account the Instrument Detection Limit (IDL), Method Detection Limit (MDL), and Practical Quantitation Limit (PQL), and any dilutions and/or concentrations performed during sample preparation (EQL).

Our analytical result must be above this MAL before we report a value in the "Results" column of our report. Otherwise, we report ND (Not Detected above MAL), because the result is "<" (less than) the number in the MAL column.

"MAL" es nuestro Nivel Minimo Analitico/Nivel Cuatitativo Minimo. El "MAL" tomo en consideracion el Limite Deteccion del Instrumento (Instrument Detection Limit-IDL), el Limite Deteccion de Metodo (Method Detection Limit-MDL), y el Limite Deteccion Practico (Pratical Detection Limit-PDL), y cualquier diluciones y/o concentrationes llevado a cabo durante la preparacion de la muestra.

Nuestro resultado analitico de las muestras tienen que ser mayor del "MAL" antes que entregamos un valor in la columna "Resultados" (Results) en nuestro reporte. Si no, se reportarara "ND" Nada Dectado mayor del "MAL" (Not detected above MAL), porque el resultado es menos que "<" (less than) el numero reportado bajo la columna "MAL".

Continued
Continuacion

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07/18/96

R00002 Continued
Continuacion

I certify that the results were generated using the above specified methods.

C. H. Whiteside

C. H. Whiteside, Ph.D., President

CHEMICAL ANALYSIS

(1) Location:

Water Treatment Plant No. 1 Well Site (R.O. Pilot Plant Location)

(2) Sampling Point:

Concentrate from R.O. Pilot Unit

(3) Date:

8/15/96

(4) Analysis:

Total Organic Carbon (TOC)

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TEST REPORT: R15162

NRS Consulting Engineers
P.O. Box 2544
Harlingen, TX 78550-
Attention: Bill Norris

RECEIVED AUG 26 1996

Sample Identification: Concentrate
Identificacion de Muestra
Collected By: David Garza Jr.
Colectado Por
Date & Time Taken: 08/15/96 1445
Tiempo y Fecha Tomado

Bottle Data:
Datos de Recipientes:

#01 - 1+1 H2SO4 40 ml Glass Vial
#01 - Botellita de Vidrio de 40 ml con una Tapadera de Teflon Pres
#02 - 1+1 H2SO4 40 ml Glass Vial
#02 - Botellita de Vidrio de 40 ml con una Tapadera de Teflon Pres
#03 - 1+1 H2SO4 40 ml Glass Vial
#03 - Botellita de Vidrio de 40 ml con una Tapadera de Teflon Pres

Sample Matrix: Aqueous Liquid
Report Date: 08/22/96 **Received:** 08/15/96 **Client:** NRS
No. de Muestra **Recibido** **Cliente**

PARAMETER PARAMETRO	RESULTS RESULTADOS	UNITS UNIDADES	ANALYZED ANALIZADO	MAL	METHOD METODO	BY PC
Total Organic Carbon	0.82	mg/l	2200 08/20/96	.3	EPA 415.2	JW

Sample Preparation Steps for R15162

Fax This Report AS Soon As DONE! FAXED 17:4508/21/96

Quality Assurance for the SET with Sample R15162
Certeza de Calidad por el Juego con el Numero R15162

Sample # No. de Muestra	Description Descripcion	Result Resultado	Units Unidades	Dup/Std Value Dup/Std	Spk Conc. Estandard	Percent Por Ciento	Time Tiempo	Date Fecha	B P
	Total Organic Carbon								
	Standard	9.8	mg/l	10.0		98	2200	08/20/96	J
	Standard	9.2	mg/l	10.0		92	2200	08/20/96	J
R15164	Duplicate	ND	mg/l	ND		0	2200	08/20/96	J
R15164	Spike		mg/l		10.0	90	2200	08/20/96	J

MAL is our Minimum Analytical Level/Minimum Quantitation Level. The MAL takes into account the Instrument Detection Limit (IDL),

Continued
Continuacion

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08/22/96

R15162 Continued
Continuacion

Method Detection Limit (MDL), and Practical Quantitation Limit (PQL), and any dilutions and/or concentrations performed during sample preparation.

Our analytical result must be above this MAL before we report a value in the "Results" column of our report. Otherwise, we report ND (Not Detected above MAL), because the result is "<" (less than) the number in the MAL column.

"MAL" es nuestro Nivel Minimo Analitico/Nivel Cuatitativo Minimo. El "MAL" tomo en consideracion el Limite Deteccion del Instrumento (Instrument Detection Limit-IDL), el Limite Deteccion de Metodo (Method Detection Limit-MDL), y el Limite Deteccion Practico (Pratical Detection Limit-PDL), y cualquier diluciones y/o concentrationes llevado a cabo durante la preparacion de la muestra.

Nuestro resultado analitico de las muestras tienen que ser mayor del "MAL" antes que entregamos un valor in la columna "Resultados" (Results) en nuestro reporte. Si no, se reportarara "ND" Nada Dectado mayor del "MAL" (Not detected above MAL), porque el resultadc es menos que "<" (less than) el numero reportado bajo la columna "MAL".

I certify that the results were generated using the above specified methods.

Bill Peery, Jr., M.S., Lab Manager

AUG 26 1996

CHEMICAL ANALYSIS

(1) Location:

Central Drive Well Site (Drilled by CH2M-Hill/TWDB as part of ASR Project)

(2) Sampling Point:

Well Head

(3) Date:

3/29/96 (Filtered and Unfiltered)

(4) Analysis:

Anions and Cations

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Analytical Chemistry • Utility Operations

TEST REPORT: R14187

NRS Consulting Engineers
P.O. Box 2544
Harlingen, TX 78550-
Attention: Bill Norris

Sample Identification: Unfiltered Groundwater Sample
Collected By: CecilioBaÊuelos
Date & Time Taken: 03/29/96 1345

Other Data:

Central Drive Well Site

Bottle Data:

#06 - Unpreserved Glass
#07 - Unpreserved Glass
#08 - Unpreserved Glass
#09 - Unpreserved Glass
#10 - Unpreserved Glass
#11 - Unpreserved Glass
#04 - H2SO4 Preserved Glass with a Teflon Lid
#05 - H2SO4 Preserved Glass with a Teflon Lid
#01 - HNO3 Preserved Sample (Plastic or Glass)
#01 - HNO3 Preserved Sample (Plastic or Glass)
#02 - HNO3 Preserved Sample (Plastic or Glass)
#02 - HNO3 Preserved Sample (Plastic or Glass)
#03 - HNO3 Preserved Sample (Plastic or Glass)
#03 - HNO3 Preserved Sample (Plastic or Glass)
#12 - Sterilized Glass Bottle with .008% Na2S2O3
#13 - Sterilized Glass Bottle with .008% Na2S2O3
#14 - 1+1 H2SO4 40 ml Glass Vial
#15 - ICP Digestion
Derived in lab from: 02 (50 ml)
#16 - ICP Digestion
Derived in lab from: 02 (50 ml)
#17 - ICP Digestion
Derived in lab from: 02 (50 ml)
#18 - Glass Flask: NH3 Distillation
Derived in lab from: 04 (500 ml)

Sample Matrix: Aqueous Liquid
Report Date: 04/05/96 **Received:** 03/29/96 **Client:** NRS

PARAMETER	RESULTS	UNITS	ANALYZED	EQL	METHOD	BY
Total Barium	30	ug/l	1133 04/04/96	10	EPA Method 200.7	GDC
Total Calcium	99	mg/l	1021 04/04/96	0.05	EPA Method 200.7	GDC

Continued

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PARAMETER	RESULTS	UNITS	ANALYZED	EQL	METHOD	BY
Total Iron	0.30	mg/l	1006 04/03/96	0.05	EPA Method 200.7	MCI
Total Potassium	7.6	mg/l	1021 04/04/96	2	EPA Method 258.1	GDC
Total Magnesium	60	mg/l	1021 04/04/96	0.1	EPA Method 6010	GDC
Total Manganese	0.19	mg/l	1431 04/04/96	0.03	EPA Method 6010	GDC
Total Sodium	980	mg/l	1021 04/04/96	20	EPA Method 6010	GDC
Silicon (as Silica, SiO2)	34000	ug/l	1517 04/04/96	1100	EPA Method 200.7	GDC
Total Strontium	3500	ug/l	1615 04/04/96	100	EPA Method 200.7	GDC
Carbonate	ND	ppm	0928 04/05/96	0.5	APHA Meth 4500-CO2 D	WJI
Chloride	930	mg/l	1500 04/02/96	20	EPA 325.2	RS\
Specific Conductance at 25 C	4810	umho/cm	1410 03/29/96		EPA Method 120.1	CME
issolved Oxygen	1.6	mg/l	1405 03/29/96	.1	EPA Method 360.1	CME
Fluoride	0.95	mg/l	0830 04/04/96	.25	EPA Method 340.2	CWT
Sulfide as Hydrogen Sulfide	ND	mg/l	1230 04/03/96	2	EPA 376.1	CW
Bicarbonate	429	ppm	0928 04/05/96	0.5	APHA Meth 4500-CO2 D	WJI
Ammonia Nitrogen	.06	mg/L	1200 04/04/96	.05	EPA 350.1	RS\
Nitrate-Nitrite	ND	mg/l	1200 04/03/96	.2	EPA 353.1	RS\
Sulfate	1000	mg/l	1615 04/04/96	50	EPA Method 375.4	WMI
Total Coliform Plate Count	ND	#/100 mls	2145 04/03/96	1	APHA Method 9222 B	LMI
Total Dissolved Solids	2700	mg/l	2300 04/01/96	10	EPA Method 160.1	BRI
Total Organic Carbon	27.0	mg/l	0900 04/05/96	.3	EPA Method 415.2	RS\
Turbidity	1.8	NTU	1645 04/04/96	1	EPA Method 180.1	WMI
Temperature	27	degrees C	1400 03/29/96	.1	EPA Method 170.1	CM
pH (On Site)	7.3	SU	1400 03/29/96		EPA Method 150.1	CM
lkalinity	430	mg/l	1628 04/04/96	4	EPA Method 310.1	JW

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PARAMETER	RESULTS	UNITS	ANALYZED	EQL	METHOD	BY
Cation-Anion Balance	52.5 / 58.3	meq/meq	09:2804/05/96			WJP
Carbon Dioxide	ND	ppm	0928 04/05/96	0.5	APHA Meth 4500-CO2 D	WJP
Hydroxide	ND	mg/l	0928 04/05/96	0.5	APHA 4500-CO2 D	WJP

Sample Preparation Steps for R14187

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Ammonia Distillation	350/500	ml/ml	1430 04/03/96	EPA Method 350.2	KBW
Metals Digestion - Liquid	50/50 S/B/A	ml/ml	0800 04/02/96	EPA Method 200.7	KLG
Total Coliform Plate Ct Started	STARTED		1030 04/01/96		SKL
Total Coliform Plate Ct Started	STARTED		2255 04/02/96		LMK

Quality Assurance for the SET with Sample R14187

Sample #	Description	Result	Units	Dup/Std Value	Spk Conc.	Percent	Time	Date	By
	Total Barium								
	Blank	<0.010	ppm				1133	04/04/96	GD
	Standard	9.8	ppm	10		98	1133	04/04/96	GD
	Standard	5.0	ppm	5.0		100	1133	04/04/96	GD
R14187	Duplicate	30	ug/l	30		0	1133	04/04/96	GD
R14187	Spike		ppm		5.0	96	1133	04/04/96	GD
	Total Calcium								
	Blank	<0.050	ppm				1021	04/04/96	GD
	Standard	99	ppm	100		99	1021	04/04/96	GD
	Standard	49	ppm	50		98	1021	04/04/96	GD
R14187	Duplicate	98	mg/l	100		2	1021	04/04/96	GD
R14187	Spike		ppm		20	82	1021	04/04/96	GD
	Total Iron								
	Blank	0.052	ppm				1006	04/03/96	MC
	Blank	<0.050	ppm				1006	04/03/96	MC
	Standard	9.7	ppm	10		97	1006	04/03/96	MC
	Standard	5.1	ppm	5.0		102	1006	04/03/96	MC
	Standard	5.0	ppm	5.0		100	1006	04/03/96	MC
	Standard	5.0	ppm	5.0		100	1006	04/03/96	MC
319912	Duplicate	0.055	mg/l	0.053		4	1006	04/03/96	MC
R14187	Duplicate	0.30	mg/l	0.30		0	1006	04/03/96	MC
319913	Spike		ppm		5.0	102	1006	04/03/96	MC
R14187	Spike		ppm		5.0	102	1006	04/03/96	MC
	Total Potassium								
	Blank	<2.0	ppm				1021	04/04/96	GD

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Sample #	Description	Result	Units	Dup/Std Value	Spk Conc.	Percent	Time	Date	By
R14187	Spike		mg/l		100	84	1615	04/04/96	WM
			Total Coliform Plate Count						
	Blank	<1	#/100 MLS				2145	04/03/96	LM
R14187	Duplicate	ND	#/100 MLS	ND		0	2145	04/03/96	LM
			Total Dissolved Solids						
	Blank	0.0000	g				2300	04/01/96	BR
	Standard	90	mg/L	100		90	2300	04/01/96	BR
319881	Duplicate	200	mg/L	210		5	2300	04/01/96	BR
			Total Organic Carbon						
	Standard	10.0	mg/l	10.0		100	0900	04/05/96	RS
	Standard	10.4	mg/l	10.0		104	0900	04/05/96	RS
R14188	Duplicate	22.9	mg/l	22.0		4	0900	04/05/96	RS
			Turbidity						
	Standard	Calibrate	NTU	.10		0	1645	04/04/96	WM
R14188	Duplicate	0.60	NTU	0.60		0	1645	04/04/96	WM
			Alkalinity						
	Blank	<1	mg/l				1628	04/04/96	JW
	Standard	2300	mg/l	2400		96	1628	04/04/96	JW
R14188	Duplicate	460	mg/l	460		0	1628	04/04/96	JW
R14188	Spike		mg/l		1200	100	1628	04/04/96	JW

CAS is Chemical Abstract Service Registry Number.

EQL is Estimated Quantitation Limit. The EQL takes into account the Instrument Detection Limit (IDL), Method Detection Limit (MDL), and Practical Quantitation Limit (PQL). Our analytical result must be above our EQL before we report a value for any parameter. Otherwise, we report ND (Not Detected above EQL).

I certify that the results were generated using the above specified methods.

Note: Pages 4 & 5 removed. These are QA pages only.

C.H. Whiteside, Ph.D., President

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Analytical Chemistry • Utility Operations

TEST REPORT: R14188

NRS Consulting Engineers
P.O. Box 2544
Harlingen, TX 78550-
Attention: Bill Norris

Sample Identification: Filtered Groundwater Sample
Collected By: CecilioBaÊuelos
Date & Time Taken: 03/29/96 1345

Other Data: Filtered in lab @1530 by CMB

Central Drive Well Site

Bottle Data:

- #06 - Unpreserved Glass
- #07 - Unpreserved Glass
- #08 - Unpreserved Glass
- #09 - Unpreserved Glass
- #04 - H2SO4 Preserved Glass with a Teflon Lid
- #05 - H2SO4 Preserved Glass with a Teflon Lid
- #01 - HNO3 Preserved Sample (Plastic or Glass)
- #02 - HNO3 Preserved Sample (Plastic or Glass)
- #03 - HNO3 Preserved Sample (Plastic or Glass)
- #10 - Sterilized Glass Bottle with .008% Na2S2O3
- #11 - Sterilized Glass Bottle with .008% Na2S2O3
- #12 - 1+1 H2SO4 40 ml Glass Vial
- #13 - ICP Digestion
  Derived in lab from: 02 (50 ml)
- #14 - Glass Flask: NH3 Distillation
  Derived in lab from: 04 (500 ml)

Sample Matrix: Aqueous Liquid
Report Date: 04/05/96 **Received:** 03/29/96 **Client:** NRS

PARAMETER	RESULTS	UNITS	ANALYZED	EQL	METHOD	BY
Total Barium	30	ug/l	1133 04/04/96	10	EPA Method 200.7	GD
Total Calcium	94	mg/l	1021 04/04/96	0.05	EPA Method 200.7	GD
Total Iron	0.060	mg/l	1006 04/03/96	0.05	EPA Method 200.7	MC
Total Potassium	8.1	mg/l	1021 04/04/96	2	EPA Method 258.1	GD
Total Magnesium	60	mg/l	1021 04/04/96	0.1	EPA Method 6010	GD
Total Manganese	0.18	mg/l	1431 04/04/96	0.03	EPA Method 6010	GD

Continued

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PARAMETER	RESULTS	UNITS	ANALYZED	EQL	METHOD	BY
Total Sodium	920	mg/l	1021 04/04/96	20	EPA Method 6010	GDG
Silicon (as Silica, SiO2)	33000	ug/l	1517 04/04/96	1100	EPA Method 200.7	GDG
Total Strontium	3300	ug/l	1615 04/04/96	100	EPA Method 200.7	GDG
Carbonate	ND	ppm	0923 04/05/96	0.5	APHA Meth 4500-CO2 D	WJF
Chloride	920	mg/l	1500 04/02/96	20	EPA 325.2	RSV
Specific Conductance at 25 C	4810	umho/cm	1410 03/29/96		EPA Method 120.1	CMB
Dissolved Oxygen	1.6	mg/l	1405 03/29/96	.1	EPA Method 360.1	CMB
Fluoride	0.92	mg/l	0830 04/04/96	.25	EPA Method 340.2	CWT
Sulfide as Hydrogen Sulfide	ND	mg/l	1230 04/03/96	2	EPA 376.1	CWT
Bicarbonate	459	ppm	0923 04/05/96	0.5	APHA Meth 4500-CO2 D	WJF
mmonia Nitrogen	.05	mg/L	1200 04/04/96	.05	EPA 350.1	RSV
Nitrate-Nitrite	ND	mg/l	1200 04/03/96	.2	EPA 353.1	RSV
Sulfate	870	mg/l	1615 04/04/96	20	EPA Method 375.4	WME
Total Coliform Plate Count	4	#/100 mls	1630 04/02/96	1	APHA Method 9222 B	LMK
Total Dissolved Solids	2700	mg/l	2300 04/01/96	10	EPA Method 160.1	BRP
Total Organic Carbon	22.4	mg/l	0900 04/05/96	.3	EPA Method 415.2	RSV
Turbidity	0.60	NTU	1645 04/04/96	.1	EPA Method 180.1	WME
Temperature	27	degrees C	1400 03/29/96	.1	EPA Method 170.1	CME
pH (On Site)	7.3	SU	1400 03/29/96		EPA Method 150.1	CME
Alkalinity	460	mg/l	1628 04/04/96	4	EPA Method 310.1	JWE
Cation-Anion Balance	52.3 / 55.3	meq/meq	09:3004/05/96			WJF
Carbon Dioxide	ND	ppm	0923 04/05/96	0.5	APHA Meth 4500-C02 D	WJI
Hydroxide	ND	mg/l	0923 04/05/96	0.5	APHA 4500-CO2 D	WJI

Continued

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Analytical Chemistry • Utility Operations

Sample Preparation Steps for R14188

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Ammonia Distillation	324/500	ml/ml	1430 04/03/96	EPA Method 350.2	KBW
Metals Digestion - Liquid	50/50	ml/ml	0800 04/02/96	EPA Method 200.7	KLC
Total Coliform Plate Ct Started	STARTED		1030 04/01/96		SKL

Quality Assurance for the SET with Sample R14188

Sample #	Description	Result	Units	Dup/Std Value	Spk Conc.	Percent	Time	Date	By
	Total Barium								
	Blank	<0.010	ppm				1133	04/04/96	GC
	Standard	9.8	ppm	10		98	1133	04/04/96	GC
	Standard	5.0	ppm	5.0		100	1133	04/04/96	GC
R14187	Duplicate	30	ug/l	30		0	1133	04/04/96	GC
R14187	Spike		ppm		5.0	96	1133	04/04/96	GC
	Total Calcium								
	Blank	<0.050	ppm				1021	04/04/96	GC
	Standard	99	ppm	100		99	1021	04/04/96	GC
	Standard	49	ppm	50		98	1021	04/04/96	GC
14187	Duplicate	98	mg/l	100		2	1021	04/04/96	GC
R14187	Spike		ppm		20	82	1021	04/04/96	GC
	Total Iron								
	Blank	0.052	ppm				1006	04/03/96	MC
	Blank	<0.050	ppm				1006	04/03/96	MC
	Standard	9.7	ppm	10		97	1006	04/03/96	MC
	Standard	5.1	ppm	5.0		102	1006	04/03/96	MC
	Standard	5.0	ppm	5.0		100	1006	04/03/96	MC
	Standard	5.0	ppm	5.0		100	1006	04/03/96	MC
319912	Duplicate	0.055	mg/l	0.053		4	1006	04/03/96	MC
R14187	Duplicate	0.30	mg/l	0.30		0	1006	04/03/96	MC
319913	Spike		ppm		5.0	102	1006	04/03/96	MC
R14187	Spike		ppm		5.0	102	1006	04/03/96	MC
	Total Potassium								
	Blank	<2.0	ppm				1021	04/04/96	GC
	Standard	104	ppm	100		104	1021	04/04/96	GC
	Standard	50	ppm	50		100	1021	04/04/96	GC
R14187	Duplicate	7.6	mg/l	7.7		1	1021	04/04/96	GC
R14187	Spike		ppm		20	113	1021	04/04/96	GC
	Total Magnesium								
	Blank	<0.10	ppm				1021	04/04/96	GC
	Standard	98	ppm	100		98	1021	04/04/96	GC
	Standard	49	ppm	50		98	1021	04/04/96	GC

Continued

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Analytical Chemistry • Utility Operations

Sample #	Description	Result	Units	Dup/Std Value	Spk Conc.	Percent	Time	Date	By
Total Organic Carbon									
	Standard	10.0	mg/l	10.0		100	0900	04/05/96	RS
	Standard	10.4	mg/l	10.0		104	0900	04/05/96	RS
R14188	Duplicate	22.9	mg/l	22.0		4	0900	04/05/96	RS
Turbidity									
	Standard	Calibrate	NTU	.10		0	1645	04/04/96	WM
R14188	Duplicate	0.60	NTU	0.60		0	1645	04/04/96	WM
Alkalinity									
	Blank	<1	mg/l				1628	04/04/96	JW
	Standard	2300	mg/l	2400		96	1628	04/04/96	JW
R14188	Duplicate	460	mg/l	460		0	1628	04/04/96	JW
R14188	Spike		mg/l		1200	100	1628	04/04/96	JW

CAS is Chemical Abstract Service Registry Number.

EQL is Estimated Quantitation Limit. The EQL takes into account the Instrument Detection Limit (IDL), Method Detection Limit (MDL), Practical Quantitation Limit (PQL). Our analytical result must be above our EQL before we report a value for any parameter. Otherwise, we report ND (Not Detected above EQL).

These analytical results relate to the sample tested. This report may NOT be reproduced EXCEPT in FULL without written approval of Ana-Lab Corp.

I certify that the results were generated using the above specified methods.

C. H. Whiteside

C.H. Whiteside, Ph.D., President

Notes: Pages 4+5 removed
These pages are QA
data only.

CHEMICAL ANALYSIS

(1) Location:

Brownsville Firefighters Association Well site

(2) Sampling Point:

Well Head

(3) Date:

6/10/96 (Filtered and Unfiltered)

(4) Analysis:

Anions and Cations

ANA·LAB CORP.
THE COMPLETE SERVICE LAB

P. O. BOX 9000 - KILGORE, TEXAS 75663-9000 - 903/984-0551 - FAX 903/984-5914

Analytical Chemistry • Utility Operations

NRS Consulting Engineers
P.O. Box 2544
Harlingen, TX 78550-
Attention: Bill Norris

RECEIVED
JUL 08 1996

TEST REPORT: R14594

UNFILTERED SAMPLE

Sample Identification: Well-B'ville Firefighter Asso.
Collected By: David Garza Jr.
Date & Time Taken: 06/10/96 1115

Bottle Data:

#03 - Unpreserved Glass
#04 - Unpreserved Glass
#05 - Unpreserved Glass
#06 - Unpreserved Glass
#07 - Unpreserved Glass
#14 - H2SO4 Preserved Glass with a Teflon Lid
#01 - HNO3 Preserved Sample (Plastic or Glass)
#02 - HNO3 Preserved Sample (Plastic or Glass)
#08 - HNO3 Preserved Sample (Plastic or Glass)
#09 - HNO3 Preserved Sample (Plastic or Glass)
#10 - Sterilized Glass Bottle with .008% Na2S2O3
#15 - Preserved with NaOH and Zinc Acetate (Plastic or G
#11 - 1+1 H2SO4 40 ml Glass Vial
#12 - 1+1 H2SO4 40 ml Glass Vial
#13 - 1+1 H2SO4 40 ml Glass Vial
#16 - ICP Digestion Amount: 50
Derived in lab from: 01 (50 ml)
#17 - ICP Digestion Amount: 50
Derived in lab from: 01 (50 ml)
#18 - ICP Digestion Amount: 50
Derived in lab from: 01 (50 ml)
#20 - ICP Digestion Amount: 50
Derived in lab from: 01 (50 ml)
#21 - ICP Digestion Amount: 50
Derived in lab from: 01 (50 ml)
#22 - ICP Digestion Amount: 50
Derived in lab from: 01 (50 ml)
#19 - Glass Flask: NH3 Distillation Amount: 360
Derived in lab from: 14 (500 ml)
#23 - Glass Flask: NH3 Distillation Amount: 315
Derived in lab from: 04 (500 mls)

Sample Matrix: Aqueous Liquid
Report Date: / / **Received:** 06/10/96 **Client:** NRS

PARAMETER	RESULTS	UNITS	ANALYZED	EQL	METHOD	BY
otal Barium	56	ug/l	1241 06/18/96	10	EPA Method 200.7	GD

Continued

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PARAMETER	RESULTS	UNITS	ANALYZED	EQL	METHOD	BY
Total Calcium	580	mg/l	1741 06/21/96	1	EPA Method 200.7	GD
Total Iron	3.8	mg/l	1741 06/21/96	0.05	EPA Method 200.7	GD
Total Potassium	40	mg/l	1741 06/21/96	2	EPA Method 258.1	GD
Total Magnesium	260	mg/l	1741 06/21/96	2	EPA Method 6010	GD
Total Manganese	0.54	mg/l	1741 06/21/96	0.03	EPA Method 6010	GD
Total Sodium	3200	mg/l	1741 06/21/96	200	EPA Method 6010	GD
Silicon (as Silica, SiO2)	54	mg/l	1342 07/01/96	1	EPA Method 200.7	GD
Total Strontium	17000	ug/l	1511 07/01/96	500	EPA Method 200.7	GD
Carbonate	ND	ppm	1201 06/18/96	0.5	APHA Meth 4500-CO2 D	WJ
Chloride	4000	mg/l	1500 06/13/96	10	EPA Method 325.2	SKI
Specific Conductance at 25 C	16000	umho/cm	1120 06/10/96		EPA Method 120.1	DG
Fluoride	0.90	mg/l	0800 06/17/96	.2	EPA Method 340.2	CW
Sulfide as Hydrogen Sulfide	ND	mg/l	1200 06/13/96	2	EPA 376.1	CW
Bicarbonate	190	ppm	1201 06/18/96	0.5	APHA Meth 4500-CO2 D	WJI
Ammonia Nitrogen	ND	mg/L	1600 06/19/96	0.036	EPA 350.1	RS
Nitrate Nitrogen	ND	mg/l	1000 06/19/96	0.050	EPA Method 353.1	RS
Sulfate	1600	mg/l	1315 06/24/96	100	EPA Method 375.4	WM
Total Coliform Plate Count	ND	#/100 mls	2205 06/12/96	1	APHA Method 9222 B	LM
Total Organic Carbon	0.93	mg/l	1600 07/01/96	.3	EPA 415.2	JW
Temperature	29	degrees C	1125 06/10/96	.1	EPA Method 170.1	DG
pH (On Site)	7.3	SU	1125 06/10/96		EPA Method 150.1	DG
Alkalinity	190	mg/l	1800 06/13/96	4	EPA Method 310.1	BR
Cation-Anion Balance	190 / 156	meq/meq	09:5307/02/96			WJI

Continued

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Analytical Chemistry • Utility Operations

/ /

PARAMETER	RESULTS	UNITS	ANALYZED	EQL	METHOD	BY
Carbon Dioxide	ND	ppm	1201 06/18/96	0.5	APHA Meth 4500-C02 D	WJI
Hydroxide	ND	mg/l	1201 06/18/96	0.5	APHA 4500-CO2 D	WJI
Turbidity	34	NTU	1110 06/12/96	10	EPA Method 180.1	WME

Sample Preparation Steps for R14594

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Metals Digestion - Liquid	50/50 S/B/A	ml/ml	1730 06/18/96	EPA Method 3005	PJI
Metals Digestion - Liquid	50/50 S/B/A	ml/ml	1700 06/17/96	EPA Method 200.7	PJI
Total Coliform Plate Ct Started	STARTED		0010 06/12/96		LMH

Quality Assurance for the SET with Sample R14594

Sample #	Description	Result	Units	Dup/Std Value	Spk Conc.	Percent	Time	Date	By
Total Barium									
	Blank	<0.010	ppm				1241	06/18/96	GI
	Standard	9.8	ppm	10		98	1241	06/18/96	GI
	Standard	5.0	ppm	5.0		100	1241	06/18/96	GI
	Standard	4.9	ppm	5.0		98	1241	06/18/96	GI
324377	Duplicate	10000	ug/l	10000		0	1241	06/18/96	GI
R14594	Duplicate	56	ppm	56		0	1241	06/18/96	GI
324377	Spike		ppm		5.0	104	1241	06/18/96	GI
R14594	Spike		ppm		5.0	93	1241	06/18/96	GI
Total Calcium									
	Blank	0.80	ppm				1741	06/21/96	GI
	Blank	0.42	ppm				1741	06/21/96	GI
	Standard	98	ppm	100		98	1741	06/21/96	GI
	Standard	50	ppm	50		100	1741	06/21/96	GI
	Standard	49	ppm	50		98	1741	06/21/96	GI
	Standard	48	ppm	50		96	1741	06/21/96	GI
	Standard	101	ppm	100		101	1741	06/21/96	GI
	Standard	51	ppm	50		102	1741	06/21/96	GI
	Standard	50	ppm	50		100	1741	06/21/96	GI
	Standard	50	ppm	50		100	1741	06/21/96	GI
324969	Duplicate	37	mg/l	36		3	1741	06/21/96	GI
R14594	Duplicate	560	mg/l	590		5	1741	06/21/96	GI
324969	Spike		ppm		20	104	1741	06/21/96	GI
R14594	Spike		ppm		20	105	1741	06/21/96	GI
Total Iron									
	Blank	0.074	ppm				1741	06/21/96	GI
	Blank	0.15	ppm				1741	06/21/96	GI
	Standard	9.6	ppm	10		96	1741	06/21/96	GI

Continued

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Sample #	Description	Result	Units	Dup/Std Value	Spk Conc.	Percent	Time	Date	By
	Blank	<1	#/100 MLS				2205	06/12/96	LA
R14594	Duplicate	ND	#/100 MLS	ND		0	2205	06/12/96	LA

Total Organic Carbon

Sample #	Description	Result	Units	Dup/Std Value	Spk Conc.	Percent	Time	Date	By
	Standard	10.0	mg/l	10.0		100	1600	07/01/96	JV
	Standard	10.2	mg/l	10.0		102	1600	07/01/96	JV
	Standard	10.1	mg/l	10.0		101	1600	07/01/96	JV
325220	Duplicate	34.0	mg/l	33.2		2	1600	07/01/96	JV
R14629	Duplicate	5.7	mg/l	5.7		0	1600	07/01/96	JV
325220	Spike		mg/l		10.0	122	1600	07/01/96	JV
R14629	Spike		mg/l		10.0	86	1600	07/01/96	JV

Alkalinity

Sample #	Description	Result	Units	Dup/Std Value	Spk Conc.	Percent	Time	Date	By
	Blank	<1	mg/L				1800	06/13/96	BF
	Standard	2500	mg/L	2400		104	1800	06/13/96	BF
324434	Duplicate	74	mg/L	76		3	1800	06/13/96	BF
R14594	Duplicate	180	mg/L	200		11	1800	06/13/96	BF
324434	Spike		mg/L		2400	106	1800	06/13/96	BF
R14594	Spike		mg/L		2400	106	1800	06/13/96	BF

Turbidity

Sample #	Description	Result	Units	Dup/Std Value	Spk Conc.	Percent	Time	Date	By
	Standard	Calibrate	NTU	.10		0	1110	06/12/96	WK
.14594	Duplicate	34	NTU	34		0	1110	06/12/96	WK

EQL is Estimated Quantitation Limit. The EQL takes into account the Instrument Detection Limit (IDL), Method Detection Limit (MDL), and Practical Quantitation Limit (PQL). Our analytical result must be above our EQL before we report a value for any parameter. Otherwise, we report ND (Not Detected above EQL).

These analytical results relate to the sample tested. This report may NOT be reproduced EXCEPT in FULL without written approval of Ana-Lab Corp.

I certify that the results were generated using the above specified methods.

C. H. Whiteside

C.H. Whiteside, Ph.D., President

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Analytical Chemistry • Utility Operations

TEST REPORT: R14621

NRS Consulting Engineers
P.O. Box 2544
Harlingen, TX 78550-
Attention: Bill Norris

RECEIVED
JUL 08 1996

FILTERED SAMPLE

Sample Identification: B'ville Firefighter Assoc.
Collected By: David Garza Jr.
Date & Time Taken: 06/10/96 1115

Other Data: Filtered
Bottle Data:

#03 - Unpreserved Glass		
#04 - Unpreserved Glass		
#05 - Unpreserved Glass		
#06 - Unpreserved Glass		
#07 - Unpreserved Glass		
#14 - H2SO4 Preserved Glass with a Teflon Lid		
#01 - HNO3 Preserved Sample (Plastic or Glass)		
#02 - HNO3 Preserved Sample (Plastic or Glass)		
#08 - HNO3 Preserved Sample (Plastic or Glass)		
#09 - HNO3 Preserved Sample (Plastic or Glass)		
#10 - Sterilized Glass Bottle with .008% Na2S2O3		
#15 - Preserved with NaOH and Zinc Acetate (Plastic or G		
#11 - 1+1 H2SO4 40 ml Glass Vial		
#12 - 1+1 H2SO4 40 ml Glass Vial		
#13 - 1+1 H2SO4 40 ml Glass Vial		
#16 - ICP Digestion	Amount:	50
#17 - ICP Digestion	Amount:	50
#18 - ICP Digestion	Amount:	50
#20 - ICP Digestion	Amount:	50
#21 - ICP Digestion	Amount:	50
#22 - ICP Digestion	Amount:	50
#19 - Glass Flask: NH3 Distillation	Amount:	360
#23 - Glass Flask: NH3 Distillation	Amount:	315

Sample Matrix: Aqueous Liquid
Report Date: 07/03/96 **Received:** 06/19/96 **Client:** NRS

PARAMETER	RESULTS	UNITS	ANALYZED	EQL	METHOD	BY
Dissolved Barium	55	ug/l	1130 07/01/96	10	EPA Method 200.7	GDC
Dissolved Iron	3.8	mg/l	1741 06/21/96	0.05	EPA Method 200.7	GDC
Dissolved Manganese	0.58	mg/l	1741 06/21/96	0.03	EPA Method 200.7	GDC
Dissolved Silicon	46	mg/l	1342 07/01/96	1	EPA Method 200.7	GDC

Continued

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Analytical Chemistry • Utility Operations

PARAMETER	RESULTS	UNITS	ANALYZED	EQL	METHOD	BY
Dissolved Strontium	15000	ug/l	1511 07/01/96	200	EPA Method 200.7	GD
Dissolved Carbonate	ND	MG/L	0800 07/02/96	.5		WJ
Dissolved Chloride	3900		1000 06/18/96	10		RS
Dissolved Oxygen	.8	mg/l	1130 06/10/96	.1	EPA Method 360.1	DG
Dissolved Fluoride	0.90		0800 06/17/96	.2		CW
Dissolved Bicarbonate	190	MG/L	0800 07/02/96	.5		WJ
Dissolved Ammonia Nitrogen	.09	mg/l	1500 06/27/96	.032		RS
Dissolved Nitrate Nitrogen	ND	mg/l	1000 06/19/96	.05		RS
Total Dissolved Solids	9900	mg/l	1500 06/18/96	10	EPA Method 160.1	BR
Organic Carbon, Dissolved	0.28	mg/l	1050 07/02/96	.2	EPA Method 415.2	JW
issolved Calcium	590	mg/l	1741 06/21/96	1	EPA Method 200.7	GD
Dissolved Potassium	26	mg/l	1741 06/21/96	2	EPA Method 258.1	GD
Dissolved Magnesium	270	mg/l	1741 06/21/96	2	EPA Method 200.7	GD
Dissolved Sodium	3200	mg/l	1741 06/21/96	200	EPA Method 6010	GD

Sample Preparation Steps for R14621

Fax This Report AS Soon As DONE!	FAXED		16:3206/19/96		
Dissolved Ammonia N Distillation	315/500	mls/mls	1010 06/26/96	EPA 350.2	KB
Dissolved Metals Filtering	filtered	.45 micron	1400 06/10/96	APHA 3030 B	DG
Ammonia Distillation	360/500	ml/ml	1200 06/18/96	EPA Method 350.2	KB

Quality Assurance for the SET with Sample R14621

Dissolved Barium

Sample #	Description	Result	Units	Dup/Std Value	Spk Conc.	Percent	Time	Date	By
	Blank	<0.010	ppm				1130	07/01/96	GI
	Standard	10	ppm	10		100	1130	07/01/96	GI
	Standard	5.2	ppm	5.0		104	1130	07/01/96	G
	Standard	5.0	ppm	5.0		100	1130	07/01/96	G
R14594	Duplicate	53	ug/l	57		7	1130	07/01/96	G
R14594	Spike		ppm		5.0	86	1130	07/01/96	GI

Dissolved Iron

Continued

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P. O. BOX 9000 - KILGORE, TEXAS 75663-9000 - 903/984-0551 - FAX 903/984-5914

Analytical Chemistry • Utility Operations

07/03/96 R14621 Continued

Sample #	Description	Result	Units	Dup/Std Value	Spk Conc.	Percent	Time	Date	B
	Standard	49	ppm	50		98	1741	06/21/96	G
	Standard	48	ppm	50		96	1741	06/21/96	G
	Standard	51	ppm	50		102	1741	06/21/96	G
	Standard	50	ppm	50		100	1741	06/21/96	G
R14594	Duplicate	270	mg/l	270		0	1741	06/21/96	G
R14594	Spike		ppm		20	86	1741	06/21/96	G
	Dissolved Sodium								
	Blank	1.7	ppm				1741	06/21/96	G
	Standard	95	ppm	100		95	1741	06/21/96	G
	Standard	49	ppm	50		98	1741	06/21/96	G
	Standard	48	ppm	50		96	1741	06/21/96	G
R14594	Duplicate	3600	mg/l	2900		22	1741	06/21/96	G
R14594	Spike		ppm		10	119	1741	06/21/96	G

EQL is Estimated Quantitation Limit. The EQL takes into account the Instrument Detection Limit (IDL), Method Detection Limit (MDL) and Practical Quantitation Limit (PQL). Our analytical result must be above our EQL before we report a value for any parameter. Otherwise, we report ND (Not Detected above EQL).

I certify that the results were generated using the above specified methods.

Note: Pages 3+4 remove
These pages are
QA data only.

C. H. Whiteside, Ph.D., President

APPENDIX III - OPERATIONAL DATA

REVERSE OSMOSIS PILOT PLANT DATA
WATER TREATMENT PLANT NO.1 SITE
PUB BROWNSVILLE

Date	Time	Flows			Pressures						Conductivity		Feed		SDI			Comments
		Permeate	Concentrate	Recycle	Feed	Interstage	Concentrate	Permeate	F_{in}	F_{out}	Feed	Permeate	pH	Temp	T_c	T_f	SDI	
5-9	9:30A.	14	4.7	0	220	210	201	22	37	33	5040	97		26.3	32.4	33.7	0.26	
	4:00P.	14	4.7	0	225	210	201	22	37	33	5040	95		26.5				
	12:00M.	14	4.7	0	[illegible]	210	[illegible]	22	37	[illegible]	5030	93		26.2				
5-10	8:00A.	14	4.7	0	225	210	201	22	37	33	5030	91	6.7	26.8	28	30	0.44	
	4:00P.	14	4.7	0	225	218	205	22	37	33	5050	93		26.4				
	12:00M	14	4.7	0	220	218	201	22	37	33	5060	92		26.3				
5-11	8:00A	14	4.7	0	222	218	205	22	37	33	5060	89		26.3				
	4:00P	14	4.7	0	222	218	203	21	37	33	5070	90		26.4				
	12:00M	14	4.7	0	222	210	202	22	37	33	5030	88		26.7				
5-12	8:00A	14	4.7	0	221	218	202	22	37	33	5040	89		26.2°				
	4:00P.	14	4.7	0	222	210	204	22	37	33	5030	88		27.1				
	12:00M	14	4.7	0	220	210	202	22	37	33	5050	87		26.3				
5-13	8:00A	14	4.7	0	225	218	205	22	37	33	5030	87	6.5	26.3	28.1	29.5	0.32	
	4:00P.	14	4.7	0	225	218	205	22	37	33	5050	87		26.4				
	12:00M	14	4.7	0	225	218	202	22	37	33	5050	86		26.3				
5-14	8:00A	14	4.7	0	225	218	205	22	37	33	5050	86		26.5	30	31.2	0.26	
	4:00P	14	4.7	0	225	218	205	22	37	33	5050	88	6.54	26.5				
	12:00M	14	4.7	0	225	218	205	22	37	33	5060	86		26.6				

REVERSE OSMOSIS PILOT PLANT DATA
WATER TREATMENT PLANT No. 1 SITE
P. U. B. BROWNSVILLE

Date	Time	FLOWS			PRESSURES						CONDUCTIVITY		FEED		SDI			BACT.
		Permeate	Concentrate	Recycle	Feed	Interstage	Concentrate	Permeate	F (in)	F (out)	Feed	Permeate	PH	Temp	Tc	TF	SDI	MMO-MUG
5-15-96	8:00AM	14	4.7	0	225	218	205	22	37	33	5040	86	6.66	26.2	29.4	31.3	0.40	Negative
	4:00 PM	14	4.7	0	225	218	205	22	37	33	5050	86	6.67	26.4				
	12:00MN	14	4.7	0	225	218	205	22	37	33	5040	86	6.70	26.2				
5-16-96	8:00AM	14	4.7	0	225	218	205	22	37	33	5050	86	6.68	26.3	31.7	33.4	0.34	Negative
	4:00 PM	14	4.7	0	225	218	205	22	37	33	5050	87	6.67	26.4				
	12:00MN	14	4.7	0	225	218	205	22	37	33	5040	86	6.72	26.7				
5-17-96	8:00AM	14	4.7	0	225	218	205	22	37	33	5050	86	6.79	26.2	30.5	31.1	0.13	
	4:00 PM	14	4.7	0	225	218	205	22	37	33	5060	88	6.70	26.4				
	12:00MN	24	4.7	0	225	205	205	22	37	33	5060	96	6.71	26.8				
5-18-96	8:00AM	14	4.7	0	220	205	200	22	38	33	5050	96	6.73	26.3				
	4:00 PM	14	4.7	0	220	205	200	21	38	33	5050	97	6.74	26.5				
	12:00MN	14	4.7	0	225	200	200	22	37.5	33	5070	92	6.81	26.6				
5-19-96	8:00AM	14	4.7	0	220	205	200	22	37.5	32.5	5060	92	6.9	26.4				
	4:00 PM	14	4.7	0	220	201	198	22	37.5	32.5	5060	93	6.9	26.4				
	12:00MN	14	4.7	0	220	205	200	22	37.5	32.5	5050	92	6.88	26.8				
5-20-96	8:00AM	14	4.7	0	220	205	200	22	37.5	32.5	5050	93	6.85	26.2	30.5	31.4	0.20	Negative
	4:00 PM	14	4.7	0	225	205	200	22	37	32	5050	100	6.51	26.5				
	12:00MN	14	4.7	0	225	205	198	22	37	32	5060	96	6.65	26.2				

COMMENTS: PERMEATE flow Regulated AT 0:45 AM. TO 14 GPM D.P.S. 5-18-96

REVERSE OSMOSIS PILOT PLANT DATA
WATER TREATMENT PLANT No. 1 SITE
P. U. B. BROWNSVILLE

Date	Time	FLOWS			PRESSURES						CONDUCTIVITY		FEED		SDI			BACT.
		Permeate	Concentrate	Recycle	Feed	Interstage	Concentrate	Permeate	F (in)	F (out)	Feed	Permeate	PH	Temp	T_C	T_F	SDI	MMO-MUG
5-21-96	8:00AM	14	4.7	0	220	205	195	22	37	32	5060	97	6.67	26.3	30.9	32.1	0.25	Negative
	4:00 PM	14	4.7	0	220	205	195	22	37	32	5050	96	6.74	26.5				
	12:00MN	14	4.7	0	220	205	195	22	37	32	5050	94	6.74	26.7				
5-22-96	8:00AM	14	4.7	0	220	205	195	22	37	32	5030	94	6.78	26.4	44.8	45.2	0.06	Negative
	4:00 PM	14	4.7	0	220	205	195	22	37	32	5050	112	6.24	26.4				
	12:00MN	14	4.7	0	220	205	195	22	37	32	5080	110	6.16	26.7				
5-23-96	8:00AM	14	4.7	0	220	205	195	22	37	32	5070	107	6.35	26.4	66.1	67.3	0.12	Negative
	4:00 PM	14	4.7	0	220	205	195	22	37	32	5060	105	6.37	26.5				
	12:00MN	14	4.7	0	220	205	195	22	37	32.5	5070	103	6.34	26.8				
5-24-96	8:00AM	14	4.7	0	220	205	195	22	37	31.5	5060	102	6.38	26.3	53.6	53.6	Ø	
	4:00 PM	14	4.7	0	220	205	195	22	37	31.5	5060	104	6.43	26.5				
	12:00MN	14	4.7	0	220	205	195	22	37	31	5060	102	6.47	26.2				
5-25-96	8:00AM	14	4.7	0	220	205	195	22	37	31	5060	100	6.52	26.4				
	4:00 PM	14	4.7	0	220	205	195	22	37	31	5060	100	6.53	26.2				
	12:00MN	14	4.7	0	225	205	195	22	37	31	5070	99	6.47	26.1				
5-26-96	8:00AM	14	4.7	0	220	205	195	22	37	31	5060	98	6.54	26.1				
	4:00 PM	14	4.7	0	220	205	195	22	37	31	5060	98	6.64	26.4				
	12:00MN	14	4.7	0	225	205	200	22	37	30.5	5050	97	6.62	26.2				

COMMENTS:

REVERSE OSMOSIS PILOT PLANT DATA
WATER TREATMENT PLANT No. 1 SITE
P. U. B. BROWNSVILLE

Date	Time	FLOWS			PRESSURES						CONDUCTIVITY		FEED		SDI			BACT.
		Permeate	Concentrate	Recycle	Feed	Interstage	Concentrate	Permeate	F (in)	F (out)	Feed	Permeate	PH	Temp	T_C	T_F	SDI	MMO-MUG
5-27-96	8:00AM	14	4.7	0	220	205	195	22	37	30	5060	96	6.62	26.2				
	4:00 PM	14	4.7	0	220	205	195	22	37	30	5050	97	6.67	26.4				
	12:00MN	14	4.7	0	220	205	195	22	37	30	5050	96		26.3				
5-28-96	8:00AM	14	4.7	0	220	205	195	22	37	30	5060	103	6.5	26.4	51.9	54.4	0.31	Negative
	4:00 PM	14	4.7	0	220	205	195	22	37	30	5050	101	6.79	26.5				
	12:00MN	14	4.7	0	220	205	195	22	37	30	5060	99	6.65	26.7				
5-29-96	8:00AM	14	4.7	0	220	205	195	22	37	29	5050	99	6.68	26.3	48.5	54.4	0.72	Negative
	4:00 PM	14	4.7	0	220	205	195	22	37	29	5090	111	6.47	26.4				
	12:00MN	14	4.7	0	220	205	195	22	37	29	5080	108	6.52	26.7				
5-30-96	8:00AM	14	4.7	0	220	205	195	22	37	29	5070	105	6.59	26.2	29.2	33.5	0.86	Negative
	4:00 PM	14	4.7	0	220	205	195	22	36.5	28.5	5070	112	6.42	26.4				
	12:00MN	14	4.7	0	220	205	195	22	37	29	5080	112	6.54	26.7				
5-31-96	8:00AM	14	4.7	0	220	205	195	22	37	28	5080	108	6.53	26.3	43.6	50.0	0.85	
	4:00 PM	14	4.7	0	220	205	195	22	37	28	5080	115	6.41	26.4				
	12:00MN	14	4.7	0	220	205	195	22	37	27.5	5090	112	6.48	26.1				
6-1-96	8:00AM	14	4.7	0	220	205	195	22	37	27.5	5080	110	6.51	26.3				
	4:00 PM	14	4.7	0	220	205	200	22	37	27.5	5070	108	6.45	26.3				
	12:00MN	14	4.7	0	220	205	200	22	37	27.5	5080	115	6.37	26.2				

COMMENTS: POWER FAILURE ON 5-28-96 at 8:30 A.M. to 8:45 A.M. w

REVERSE OSMOSIS PILOT PLANT DATA
WATER TREATMENT PLANT No. 1 SITE
P. U. B. BROWNSVILLE

Date	Time	FLOWS			PRESSURES						CONDUCTIVITY		FEED		SDI			BACT.
		Permeate	Concentrate	Recycle	Feed	Interstage	Concentrate	Permeate	F (in)	F (out)	Feed	Permeate	PH	Temp	Tc	TF	SDI	MMO-MUG
6-2-96	8:00AM	14	4.7	0	220	205	200	22	37	27	5080	104	6.58	26.4				
	4:00 PM	14	4.7	0	220	205	200	22	37	27	5080	107	6.47	27.2				
	12:00MN	14	4.7	0	220	205	200	22	37	27	5080	106	6.52	26.8				
6-3-96	8:00AM	14	4.5	0	225	210	205	22	37	27	5070	105	6.58	26.2	69.6	55.1	1.4	Negative
	4:00 PM	14	4.3	0	225	210	205	22	37	27	5100	129	6.20	26.5				
	12:00MN	14	4.7	0	225	205	200	22	37	27	5080	116	6.38	26.2				
6-4-96	8:00AM	14	4.7	0	220	205	200	22	37	26.5	5090	111	6.45	26.3	47.9	50.9	0.39	Negative
	4:00 PM	14	4.5	0	220	205	200	22	37	26.5	5080	113	6.49	26.4				
	12:00MN	14	4.7	0	220	205	200	22	37	26.5	5080	115	6.45	26.3				
6-5-96	8:00AM	14	4.5	0	220	205	200	22	37	26.5	5090	107	6.51	26.2	49.6	51.1	0.20	Negative
	4:00 PM	14	4.5	0	220	205	200	22	37	26.5	5070	107	6.66	26.5				
	12:00MN	14	4.5	0	220	205	200	22	37	26.5	5080	107	6.53	26.5				
6-6-96	8:00AM	14	4.7	0	220	205	200	22	37	26	5050	103	6.62	26.2	48.2	53.1	0.62	Negative
	4:00 PM	14	4.7	0	220	205	200	22	37	27	5080	125	6.17	26.5				
	12:00MN	14	4.7	0	220	205	200	22	37	26.5	5080	97	6.69	26.8				
6-7-96	8:00AM	14	4.7	0	220	205	200	22	37	26	5070	96	6.67	26.3	43.5	56.6	1.54	
	4:00 PM	14	4.7	0	220	205	200	22	37	25.5	5100	117	6.17	26.2				
	12:00MN	14	4.7	0	220	205	200	22	37	24.5	5090	108	6.33	26.1				

COMMENTS: R.O. System Tripped on 6-2-96 at 1:00 A.M. FOR 5 minutes. A.H.
R.O. System Shut-down FOR Testing WeLL on 6-6-96 at 3:30 P.M. to 4:15 P.M. W
R.O. System Shut-down FOR Repair on drain Line 6-7-96 at 8:40 A.M. to 8:55 A.M. W

REVERSE OSMOSIS PILOT PLANT DATA
WATER TREATMENT PLANT No. 1 SITE
P. U. B. BROWNSVILLE

Date	Time	FLOWS			PRESSURES						CONDUCTIVITY		FEED		SDI			BACT.
		Permeate	Concentrate	Recycle	Feed	Interstage	Concentrate	Permeate	F (in)	F (out)	Feed	Permeate	PH	Temp	T_C	T_F	SDI	MMO-MUG
6-8-96	8:00AM	14	4.7	0	220	205	200	22	37	24	5070	104	6.56	26.3				
	4:00 PM	14	4.7	0	220	205	200	22	37	24	5080	99	6.62	26.3				
	12:00MN	14	4.7	0	225	215	205	22	37	24	5070	98	6.7	26.1				
6-9-96	8:00AM	14	4.7	0	225	205	200	22	37	22.5	5080	96	6.71	26.2				
	4:00 PM	14	4.7	0	220	205	200	22	37	22	5070	94	6.8	26.1				
	12:00MN	14	4.7	0	220	205	200	22	37	22	5080	94	6.8	26.2				
6-10-96	8:00AM	14	4.7	0	225	210	205	22	37	22	5070	94	6.62	26.2	48.8	58.3	1.09	Negative
	4:00 PM	14	4.7	0	225	210	205	22	37	22	5060	94	6.60	26.5				
	12:00MN	14	4.7	0	225	210	205	22	37	22	5090	94	6.40	26.2				
6-11-96	8:00AM	14	4.7	0	225	210	205	22	37	22	5100	106	6.35	26.2	49.5	55.5	0.72	Negative
	4:00 PM	14	4.7	0	225	210	205	22	37	33	5090	105	6.44	26.5				
	12:00MN	14	4.7	0	225	210	205	22	37	33	5090	99	6.56	26.8				
6-12-96	8:00AM	14	4.7	0	225	210	205	22	37	33	5080	96	6.54	26.2	48.1	52.9	0.60	Negative
	4:00 PM	14	4.7	0	225	210	205	22	37	33	5060	102	6.50	26.4				
	12:00MN	14	4.7	0	225	210	205	22	37	33	5080	91	6.54	26.2				
6-13-96	8:00AM	14	4.7	0	225	210	205	22	37	33	5060	90	6.55	26.2	49.2	50.5	0.17	Negative
	4:00 PM	14	4.7	0	225	210	205	22	37	33	5080	98	6.45	26.5				
	12:00MN	14	4.7	0	225	210	205	22	37	33	5080	94	6.51	26.2				

COMMENTS: System Shut-down to Replace Cartridge Filters on 6-11-96 at 1:30 P.M. to 2:00 P.M. w Filter-Out went Back to 33 PSI!

REVERSE OSMOSIS PILOT PLANT DATA
WATER TREATMENT PLANT No. 1 SITE
P. U. B. BROWNSVILLE

Date	Time	FLOWS			PRESSURES						CONDUCTIVITY		FEED		SDI			BACT.
		Permeate	Concentrate	Recycle	Feed	Interstage	Concentrate	Permeate	F (in)	F (out)	Feed	Permeate	PH	Temp	T_C	T_F	SDI	MMO-MUG
6-14-96	8:00AM	14	4.7	0	225	210	205	22	37	33	5070	92	6.49	26.2	47.0	52.5	0.70	
	4:00 PM	14	4.7	0	225	210	205	22	37	33	5080	104	6.51	26.4				
	12:00MN	14	4.7	0	225	210	205	22	37	33	5080	96	6.56	26.1				
6-15-96	8:00AM	14	4.7	0	228	210	205	22	37	33	5090	98	6.60	26.3				
	4:00 PM	14	4.7	0	225	210	205	22	37	33	5080	98	6.81	26.7				
	12:00MN	14	4.7	0	225	210	205	22	37	33	5090	95	6.71	26.2				
6-16-96	8:00AM	14	4.7	0	228	210	205	22	37	33	5090	90	6.86	26.2				
	4:00 PM	14	4.7	0	225	210	205	22	37	33	5080	90	6.84	26.9				
	12:00MN	14	4.7	0	225	210	205	22	37	33	5080	92	6.75	26.2				
6-17-96	8:00AM	14	4.7	0	225	210	205	22	37	33	5090	91	6.70	26.3	53.6	54.9	0.16	Negative
	4:00 PM	14	4.7	0	225	210	205	22	37	33	5090	96	6.45	26.5				
	12:00MN	14	4.7	0	225	210	205	22	37	33	5080	90	6.62	26.1				
6-18-96	8:00AM	14	4.7	0	225	210	205	22	37	33	5090	92	6.52	26.2	44.3	50.2	0.78	Negative
	4:00 PM	14	4.7	0	225	210	205	22	37	33	5090	93	6.58	26.4				
	12:00MN	14	4.7	0	225	210	205	22	37	33	5080	89	6.62	26.2				
6-19-96	8:00AM	14	4.7	0	225	210	205	22	37	33	5100	91	6.60	26.3	49.6	57.7	0.94	Negative
	4:00 PM	14	4.7	0	225	210	205	22	37	33	5110	107	6.40	26.6				
	12:00MN	14	4.7	0	225	210	205	22	37	33	5130	108	6.25	26.3				

COMMENTS:

REVERSE OSMOSIS PILOT PLANT DATA
WATER TREATMENT PLANT No. 1 SITE
P. U. B. BROWNSVILLE

Date	Time	FLOWS			PRESSURES						CONDUCTIVITY		FEED		SDI			BACT.
		Permeate	Concentrate	Recycle	Feed	Interstage	Concentrate	Permeate	F (in)	F (out)	Feed	Permeate	PH	Temp	Tc	TF	SDI	MMO-MUG
6-20-96	8:00AM	14	4.7	0	225	210	205	22	37	33	5120	107	6.30	26.2	56.1	60.2	0.45	Negative
	4:00 PM	14	4.7	0	225	210	205	22	37	33	5120	109	6.27	26.4				
	12:00MN	14	4.7	0	225	210	205	22	37	33	5130	110	6.21	26.2				
6-21-96	8:00AM	14	4.7	0	225	210	205	22	37	33	5130	110	6.19	26.3	46.7	51.6	0.63	
	4:00 PM	14	4.7	0	225	210	205	22	37	33	5120	111	6.24	26.4				
	12:00MN	14	4.7	0	225	210	205	22	37	33	5130	112	6.16	26.2				
6-22-96	8:00AM	14	4.7	0	225	210	205	22	37	33	5140	113	6.11	26.3				
	4:00 PM	14	4.7	0	225	210	205	22	37	33	5110	104	6.14	27.1				
	12:00MN	14	4.7	0	225	210	205	22	37	35	5170	123	5.85	26.1				
6-23-96	8:00AM	14	4.7	0	225	210	205	22	37	33	5170	124	5.69	26.2				
	4:00 PM	14	4.7	0	225	210	205	22	37	32	5130	110	6.2	26.2				
	12:00MN	14	4.7	0	225	210	205	22	37.5	32.5	5140	109	6.19	26.8				
6-24-96	8:00AM	14	4.7	0	225	210	205	22	37.5	32.5	5140	109	6.23	26.2	47.6	54.6	0.85	Negative
	4:00 PM	14	4.7	0	225	210	205	22	37.5	32.5	5130	120	6.01	26.3				
	12:00MN	14	4.7	0	225	210	205	22	37.5	32	5140	113	6.17	26.8				
6-25-96	8:00AM	14	4.7	0	225	210	205	22	37.5	32	5140	107	6.28	26.3	50.2	53.9	0.46	Well-Neg
	4:00 PM	14	4.7	0	225	210	205	22	37.5	32	5110	104	6.48	26.4				Perm-Neg
	12:00MN	14	4.7	0	225	210	205	22	37.5	31.5	5120	97	6.62	26.7				

COMMENTS:

REVERSE OSMOSIS PILOT PLANT DATA
WATER TREATMENT PLANT No. 1 SITE
P. U. B. BROWNSVILLE

Date	Time	FLOWS			PRESSURES						CONDUCTIVITY		FEED		SDI			BACT.
		Permeate	Concentrate	Recycle	Feed	Interstage	Concentrate	Permeate	$F_{(in)}$	$F_{(out)}$	Feed	Permeate	PH	Temp	T_C	T_F	SDI	MMO-MUG
6-26-96	8:00AM	14	4.7	0	225	210	205	22	37.5	31.5	5110	97	6.60	26.3	49.8	57.1	0.85	Well-Pos
	4:00 PM	14	4.7	0	225	210	205	22	37	31.5	5130	110	6.26	26.4				Perm-Neg
	12:00MN	14	4.7	0	225	210	205	22	37	31	5140	110	6.19	26.7				
6-27-96	8:00AM	14	4.7	0	225	210	205	22	37	31	5110	109	6.25	26.3	55.6	62.0	0.69	Well-Pos
	4:00 PM	14	4.7	0	225	210	205	22	37	31	5140	120	6.22	26.3				Perm-Neg
	12:00MN	14	4.7	0	225	210	205	22	37	30	5120	103	6.44	26.8				
6-28-96	8:00AM	14	4.7	0	225	210	205	22	37	30	5120	98	6.48	26.3	49.8	55.0	0.63	
	4:00 PM	14	4.7	0	225	210	205	22	37	30	5130	104	6.42	26.3				
	12:00MN	14	4.7	0	225	210	205	22	37	30	5120	101	6.47	26.1				
6-29-96	8:00AM	14	4.7	0	225	210	205	22	37	29	5140	106	6.33	27.0				
	4:00 PM	14	4.7	0	[illegible]	210	205	[illegible]	[illegible]	[illegible]	[illegible]	102	[illegible]	[illegible]				
	12:00MN	14	4.7	0	225	210	205	22	37	29	5150	102	6.42	26.1				
6-30-96	8:00AM	14	4.7	0	225	210	205	22	37	28	5120	102	6.48	26.3				
	4:00 PM	14	4.7	0	225	210	205	22	[illegible]	28	[illegible]	102	[illegible]	[illegible]				
	12:00MN	14	4.7	0	225	210	205	22	37.5	28	5120	99	6.49	26.2				

[redacted]

COMMENTS

REVERSE OSMOSIS PILOT PLANT DATA
WATER TREATMENT PLANT No. 1 SITE
P. U. B. BROWNSVILLE

Date	Time	FLOWS			PRESSURES						CONDUCTIVITY		FEED		SDI			BACT.	
		Permeate	Concentrate	Recycle	Feed	Interstage	Concentrate	Permeate	F (in)	F (out)	Feed	Permeate	PH	Temp	Tc	TF	SDI	MMO	MUG
MONDAY																			
7-1-96	8:00AM	14	4.7	0	230	215	205	22	37.5	28	5130	103	6.38	26.2	50.9	59.3	0.94	Permeate	Well
	4:00 PM	14	4.7	0	230	215	205	22	37.5	27	5150	116	6.24	26.4				Neg	Neg
	12:00MN	14	4.7	0	230	215	205	22	37.5	26.5	5140	102	6.39	26.6					
TUESDAY																			
7-2-96	8:00AM	14	4.7	0	230	215	205	22	37.5	26.5	5110	98	6.50	26.2	50.5	58.5	0.91	Permeate	Well
	4:00 PM	14	4.7	0	230	215	205	22	37.5	26.5	5140	113	6.21	26.3				Neg	Pos
	12:00MN	14	4.7	0	230	215	205	22	37.5	25.5	5140	103	6.36	26.7					
WEDNESDAY																			
7-3-96	8:00AM	14	4.7	0	230	215	205	22	37.5	25.5	5140	98	6.45	26.2	49.8	58.1	0.95	Permeate	Well
	4:00 PM	14	4.7	0	230	215	205	22	37.5	25	5110	95	6.48	26.4					
	12:00MN	14	4.7	0	230	215	205	22	37.5	25	5150	104	6.29	26.1					
THURSDAY																			
7-4-96	8:00AM	14	4.7	0	230	215	205	22	37.5	24	5160	103	6.31	26.3				Permeate	Well
	4:00 PM	14	4.7	0	230	215	205	22	37.5	24	5160	104	6.30	26.4					
	12:00MN	14	4.7	0	230	215	205	22	37.5	23.5	5150	105	6.24	26.1					
FRIDAY																			
7-5-96	8:00AM	14	4.7	0	230	215	205	22	37.5	24	5160	105	6.41	26.1				Permeate	Well
	4:00 PM	14	4.7	0	230	215	205	22	37.5	24	5130	101	6.45	26.3					
	12:00MN	14	4.7	0	230	215	205	22	37.5	23	5140	99	6.42	26.2					
SATURDAY																			
7-6-96	8:00AM	14	4.7	0	230	210	205	22	37	24	5150	99	6.49	26.4				Permeate	Well
	4:00 PM	14	4.7	0	230	215	205	22	37	22	5130	99	6.51	26.3					
	12:00MN	14	4.7	0	230	215	205	22	37	22	5150	95	6.53	26.1					
SUNDAY																			
7-7-96	8:00AM	14	4.2	0	230	215	205	22	37	21	5130	99	6.55	26.4				Permeate	Well
	4:00 PM	14	4.5	0	230	215	205	22	37	20	5160	101	6.56	26.2					
	12:00MN	14	4.5	0	230	215	205	22	37.5	20	5140	96	6.52	26.0					

WATER TREATMENT PLANT No. 1 SITE
P. U. B. BROWNSVILLE

Date	Time	FLOWS			PRESSURES						CONDUCTIVITY		FEED		SDI			BACT.	
		Permeate	Concentrate	Recycle	Feed	Interstage	Concentrate	Permeate	F (in)	F (out)	Feed	Permeate	PH	Temp	T_C	T_F	SDI	MMO	MUG
MONDAY																			
7-8-96	8:00AM	14	4.7	0	235	220	210	22	37.5	20	5130	95	6.48	26.1				Permeate	Well
	4:00 PM	Plant Shut-Down at 2:00 P.M.																Neg	Pos
	12:00MN																		
TUESDAY																			
7-9-96	8:00AM		Plant Start-up At 2:00 P.M.															Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	34	5320	94	6.21	26.4				–	–
	12:00MN	14	4.7	0	250	235	225	22	37	34	5160	91	6.25	26.8					
WEDNESDAY																			
7-10-96	8:00AM	14	4.7	0	250	235	225	22	37	34	5150	87	6.40	26.1	54.0	70.0	1.52	Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	34	5130	85	6.48	26.5				Neg	Neg
	12:00MN	14	4.7	0	250	235	225	22	37	33.5	5180	100	6.01	26.2					
THURSDAY																			
7-11-96	8:00AM	14	4.7	0	250	235	225	22	37	33.5	5170	89	6.27	26.3	56.2	57.1	0.11	Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	33.5	5150	83	6.48	26.5				Neg	Neg
	12:00MN	14	4.7	0	250	235	225	22	37	33.5	5140	83	6.46	26.2					
FRIDAY																			
7-12-96	8:00AM	14	4.7	0	250	235	225	22	37	33.5	5140	81	6.51	26.2	52.2	56.1	0.46	Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	33.5	5150	92	6.21	26.3					
	12:00MN	14	4.7	0	250	235	225	22	37	33.5	5180	94	6.05	26.0					
SATURDAY																			
7-13-96	8:00AM	14	4.7	0	245	230	225	22	37	34	5160	88	6.30	26.4				Permeate	Well
	4:00 PM	14	4.7	0	245	230	225	22	37	34	5150	88	6.31	26.5					
	12:00MN	14	4.7	0	250	230	225	22	37	33.5	5160	85	6.36	26.2					
SUNDAY																			
7-14-96	8:00AM	14	4.7	0	245	230	225	22	37	33.5	5150	78	6.57	26.3				Permeate	Well
	4:00 PM	14	4.7	0	245	230	225	22	37	33.5	5110	78	6.53	26.5					
	12:00MN	14	4.7	0	250	235	225	22	37	33.5	5140	77	6.59	26.8					

COMMENTS: Plant Shut-down due to Low pressure on 7-8-96 at 2:00 P.M. —Turn Page—

REVERSE OSMOSIS PILOT PLANT DATA
WATER TREATMENT PLANT No. 1 SITE
P. U. B. BROWNSVILLE

Date	Time	FLOWS			PRESSURES						CONDUCTIVITY		FEED		SDI			BACT.	
		Permeate	Concentrate	Recycle	Feed	Interstage	Concentrate	Permeate	F (in)	F (out)	Feed	Permeate	PH	Temp	Tc	TF	SDI	MMO	MUG
MONDAY																			
7-15-96	8:00AM	14	4.7	0	250	235	225	22	37	33.5	5150	81	6.46	26.2	54.4	60.0	0.62	Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	33.5	5160	96	6.20	26.3				Neg	Neg
	12:00MN	14	4.7	0	250	235	225	22	37	33.5	5130	79	6.50	26.8					
TUESDAY																			
7-16-96	8:00AM	14	4.7	0	250	235	225	22	37	33.5	5140	80	6.47	26.2	54.9	57.5	0.30	Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	33.5	5160	82	6.44	26.3				Neg	Neg
	12:00MN	14	4.7	0	250	235	225	22	37	33.5	5150	77	6.56	26.7					
WEDNESDAY																			
7-17-96	8:00AM	14	4.7	0	250	235	225	22	37	33.5	5150	82	6.46	26.2	52.9	57.6	0.54	Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	33.5	5170	78	6.44	26.4				Neg	Pos
	12:00MN	14	4.7	0	250	235	225	22	37	33.5	5160	84	6.32	26.2					
THURSDAY																			
7-18-96	8:00AM	14	4.7	0	250	235	225	22	37	33.5	5160	84	6.34	26.2	48.5	52.9	0.55	Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	33.5	5160	84	6.43	26.3				Neg	Neg
	12:00MN	14	4.7	0	250	235	225	22	37	33	5150	89	6.25	26.2					
FRIDAY																			
7-19-96	8:00AM	14	4.7	0	250	235	225	22	37	33	5160	78	6.59	26.2				Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	32.5	5130	79	6.57	26.4					
	12:00MN	14	4.7	0	250	235	225	22	37	32.5	5150	78	6.59	26.1					
SATURDAY																			
7-20-96	8:00AM	14	4.7	0	250	235	225	22	37	32	5160	77	6.64	26.1				Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	32	5150	74	6.73	26.4					
	12:00MN	14	4.7	0	250	235	225	22	37	32	5160	75	6.70	26.1					
SUNDAY																			
7-21-96	8:00AM	14	4.7	0	250	235	225	22	37	32	5150	74	6.72	26.3				Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	32	5156	73	6.74	26.0					
	12:00MN	14	4.7	0	250	235	225	22	37	32	5150	74	6.75	26.2					

COMMENTS:

REVERSE OSMOSIS PILOT PLANT DATA
WATER TREATMENT PLANT No. 1 SITE
P. U. B. BROWNSVILLE

Date	Time	FLOWS			PRESSURES						CONDUCTIVITY		FEED		SDI			BACT.	
		Permeate	Concentrate	Recycle	Feed	Interstage	Concentrate	Permeate	F (in)	F (out)	Feed	Permeate	PH	Temp	Tc	T_F	SDI	MMO	MUG
MONDAY																			
7-22-96	8:00AM	14	4.7	0	250	235	225	22	37	32	5170	87	6.33	26.2	51.8	56.9	0.60	Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	32	5170	90	6.30	26.4				Neg	Neg
	12:00MN	14	4.7	0	250	235	225	22	37	31.5	5170	84	6.43	26.2					
TUESDAY																			
7-23-96	8:00AM	14	4.7	0	250	235	225	22	37	31.5	5170	83	6.46	26.1	51.9	57.5	0.65	Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	31.5	5170	84	6.43	26.4				Neg	Neg
	12:00MN	14	4.7	0	250	235	225	22	37	31.5	5170	85	6.38	26.2					
WEDNESDAY																			
7-24-96	8:00AM	14	4.7	0	250	235	225	22	37	31.5	5160	84	6.40	26.2	51.7	55.8	0.49	Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	31.5	5160	87	6.42	26.3				Neg	Neg
	12:00MN	14	4.7	0	250	235	225	22	37	31.5	5180	90	6.28	26.1					
THURSDAY																			
7-25-96	8:00AM	14	4.7	0	250	235	225	22	37	31.5	5170	84	6.39	26.2	52.3	56.6	0.51	Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	31.5	5160	83	6.46	26.4				Neg	Neg
	12:00MN	14	4.7	0	250	235	225	22	37	31.5	5180	87	6.31	26.0					
FRIDAY																			
7-26-96	8:00AM	14	4.7	0	250	235	225	22	37	31.5	5170	85	6.39	26.1	52.2	54.2	0.25	Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	31.5	5190	85	6.20	26.3					
	12:00MN	14	4.7	0	250	235	225	22	37	31.5	5180	85	6.37	26.1					
SATURDAY																			
7-27-96	8:00AM	14	4.7	0	250	235	225	22	37	31.5	5180	85	6.40	26.2				Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	31.5	5170	85	6.54	26.3					
	12:00MN	14	4.7	0	250	235	225	22	37	31.5	5170	85	6.59	26.1					
SUNDAY																			
7-28-96	8:00AM	14	4.7	0	250	235	225	22	37	31.5	5160	76	6.67	26.0				Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	31.5	5180	76	6.70	27.0					
	12:00MN	14	4.7	0	250	235	225	22	37	31.5	5170	74	6.77	26.2					

REVERSE OSMOSIS PILOT PLANT DATA
WATER TREATMENT PLANT No. 1 SITE
P. U. B. BROWNSVILLE

Flow changes at 11:50 A.M.
Concentrate 3.5 GPM 7-31-96
Recycle 1.2 GPM

Date	Time	FLOWS			PRESSURES						CONDUCTIVITY		FEED		SDI			BACT.	
		Permeate	Concentrate	Recycle	Feed	Interstage	Concentrate	Permeate	F (in)	F (out)	Feed	Permeate	PH	Temp	Tc	TF	SDI	MMO	MUG
MONDAY																			
7-29-96	8:00AM	14	4.7	0	250	235	225	22	37	31.5	5180	92	6.24	26.2	52.6	58.2	0.64	Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	31.5	5190	101	6.10	26.3				Neg	Neg
	12:00MN	14	4.7	0	250	235	225	22	37	31.5	5190	84	6.46	26.1					
TUESDAY																			
7-30-96	8:00AM	14	4.7	0	250	235	225	22	37	31.5	5190	82	6.51	26.1	52.2	53.6	0.17	Permeate	Well
	4:00 PM	14	4.7	0	250	235	225	22	37	31.5	5190	95	6.18	26.2				Neg	Neg
	12:00MN	14	4.7	0	250	235	225	22	37	31.5	5200	88	6.32	26.1					
WEDNESDAY																			
7-31-96	8:00AM	14	4.7	0	250	235	225	22	37	31.5	5200	84	6.43	26.1	50.3	55.2	0.59	Permeate	Well
	4:00 PM	14	3.5	1.2	255	240	235	22	37	32	6990	109	6.40	26.4				Neg	Neg
	12:00MN	14	3.5	1.2	260	245	240	22	37.5	32	7130	116	6.24	26.3					
THURSDAY																			
8-1-96	8:00AM	14	3.5	1.2	260	245	240	22	37.5	32	7560	109	6.45	26.3	51.6	57.8	0.72	Permeate	Well
	4:00 PM	14	3.5	1.2	265	250	240	22	37	31.5	7340	110	6.39	26.5				Neg	Neg
	12:00MN	14	3.5	1.2	265	250	240	22	37.5	31.5	7360	110	6.30	26.3					
FRIDAY																			
8-2-96	8:00AM	14	3.5	1.2	265	250	240	22	37.5	31.5	7510	108	6.38	26.3	51.6	54.3	0.33	Permeate	Well
	4:00 PM	14	3.5	1.2	265	250	240	22	37	31.5	7400	114	6.33	26.6					
	12:00MN	14	3.5	1.2	265	250	240	22	37.5	31.5	7530	112	6.29	26.3					
SATURDAY																			
8-3-96	8:00AM	14	3.5	1.2	265	250	240	22	37.5	31.5	[illegible]	[illegible]	[illegible]	26.1				Permeate	Well
	4:00 PM	14	3.5	1.2	265	250	240	22	37.5	31.5	7540	93	7.0	26.5					
	12:00MN	14	3.5	1.2	265	250	240	22	37.5	31.5	7320	95	6.83	26.2					
SUNDAY																			
8-4-96	8:00AM	14	3.5	1.2	265	250	240	22	37.5	31.5	[illegible]	91	6.18	[illegible]				Permeate	Well
	4:00 PM	14	3.5	1.2	265	250	240	22	37.5	31.5	7530	98	6.73	26.2					
	12:00MN	14	3.5	1.2	265	250	240	22	37.5	31.5	7280	100	6.61	26.2					

COMMENTS: 7-31-96 at 11:50 AM [illegible]

REVERSE OSMOSIS PILOT PLANT DATA
WATER TREATMENT PLANT No. 1 SITE
P. U. B. BROWNSVILLE

Date	Time	FLOWS			PRESSURES						CONDUCTIVITY		FEED		SDI			BACT.	
		Permeate	Concentrate	Recycle	Feed	Interstage	Concentrate	Permeate	F (in)	F (out)	Feed	Permeate	PH	Temp	Tc	TF	SDI	MMO	MUG
MONDAY																			
8-5-96	8:00AM	14	3.5	1.2	265	250	240	22	37.5	31.5	7550	112	6.30	26.3	51.2	54.4	0.39	Permeate	Well
	4:00 PM	14	3.5	1.2	265	250	240	22	37	31.5	7520	109	6.48	26.5				Neg	Neg
	12:00MN	14	3.5	1.2	265	250	240	22	37.5	32	7490	118	6.10	26.3					
TUESDAY																			
8-6-96	8:00AM	14	3.5	1.2	265	250	240	22	37.5	31.5	7510	106	6.47	26.2	55.3	59.8	0.50	Permeate	Well
	4:00 PM	14	3.5	1.2	265	250	240	22	37.5	31.5	7650	108	6.49	26.5				Neg	Neg
	12:00MN	14	3.5	1.2	265	250	240	22	37.5	31.5	7550	110	6.34	26.2					
WEDNESDAY																			
8-7-96	8:00AM	14	3.5	1.2	265	250	240	22	37.5	31.5	7580	107	6.43	26.2	54.3	58.6	0.49	Permeate	Well
	4:00 PM	14	3.5	1.2	265	250	240	22	37.5	31.5	7510	116	6.28	26.5				Neg	Neg
	12:00MN	14	3.5	1.2	265	250	240	22	37.5	31.5	7580	113	6.31	26.2					
THURSDAY																			
8-8-96	8:00AM	14	3.5	1.2	265	250	240	22	37.5	31.5	7310	105	6.52	26.2	55.3	59.0	0.42	Permeate	Well
	4:00 PM	14	3.5	1.2	265	250	240	22	37.5	31.5	7580	111	6.39	26.5				Neg	Neg
	12:00MN	14	3.5	1.2	265	250	240	22	37.5	31.5	7630	110	6.35	26.1					
FRIDAY																			
8-9-96	8:00AM	14	3.5	1.2	265	250	240	22	37.5	31.5	7540	113	6.32	26.2	54.4	57.6	0.37	Permeate	Well
	4:00 PM	14	3.5	1.2	265	250	240	22	37.5	31.5	7580	108	6.39	26.4					
	12:00MN	14	3.5	1.2	265	250	240	22	37.5	31.5	7530	102	6.67	26.1					
SATURDAY																			
8-10-96	8:00AM	14	3.5	1.2	265	250	240	22	37.5	31.5	7570	[illegible]	[illegible]	26.2				Permeate	Well
	4:00 PM	14	3.5	1.2	265	250	240	22	37.5	31.5	7560	102	6.63	26.2					
	12:00MN	14	3.5	1.2	265	250	240	22	37.5	31.5	7410	111	6.34	26.2					
SUNDAY																			
8-11-96	8:00AM	14	3.5	1.2	[illegible]	250	240	22	37.5	31.5	[illegible]	105	6.59	26.3				Permeate	Well
	4:00 PM	14	3.5	1.2	265	250	240	22	37.5	31.5	7560	102	[illegible]	26.2					
	12:00MN	14	3.5	1.2	265	250	240	22	37.5	31.5	7460	104	6.53	26.2					

COMMENTS [illegible]

8/11/96

REVERSE OSMOSIS PILOT PLANT DATA
WATER TREATMENT PLANT No. 1 SITE
P. U. B. BROWNSVILLE

Date	Time	FLOWS			PRESSURES						CONDUCTIVITY		FEED		SDI			BACT.	
		Permeate	Concentrate	Recycle	Feed	Interstage	Concentrate	Permeate	F (in)	F (out)	Feed	Permeate	PH	Temp	Tc	TF	SDI	MMO	MUG
MONDAY																			
8-12-96	8:00AM	14	3.5	1.2	265	250	240	22	37.5	31.5	7560	103	6.52	26.2	55.4	59.9	0.50	Permeate	Well
	4:00 PM	14	3.5	1.2	265	250	240	22	37.5	31.5	7660	121	6.23	26.5				Neg	Neg
	12:00MN	14	3.5	1.2	265	250	240	22	37.5	31.5	7470	119	6.15	26.2					
TUESDAY																			
8-13-96	8:00AM	14	3.5	1.2	265	250	240	22	37.5	31.5	7650	109	6.48	26.2	54.7	57.5	0.32	Permeate	Well
	4:00 PM	14	3.5	1.2	265	250	240	22	37.5	31.5	7140	109	6.49	26.5				Neg	Neg
	12:00MN	14	3.5	1.2	265	250	240	22	37.5	31.5	7440	112	6.33	26.0					
WEDNESDAY																			
8-14-96	8:00AM	14	3.5	1.2	265	250	240	22	37.5	31.5	7410	107	6.47	26.2	53.4	58.1	0.54	Permeate	Well
	4:00 PM	14	3.5	1.2	265	250	240	22	37.5	31.5	7640	125	6.29	26.5				Neg	Neg
	12:00MN	14	3.5	1.2	265	250	240	22	37.5	31.5	7360	108	6.56	26.1					
THURSDAY																			
8-15-96	8:00AM	14	3.5	1.2	265	250	240	22	37.5	31.5	7310	103	6.52	26.2	52.6	59.3	0.75	Permeate	Well
	4:00 PM	14	3.5	1.2	260	240	235	22	37.5	31.5	7590	123	6.39	26.2				Neg	Neg
	12:00MN	14	3.5	1.2	260	240	235	22	37.5	31.5	7550	117	6.40	26.2					
FRIDAY																			
8-16-96	8:00AM																	Permeate	Well
	4:00 PM																		
	12:00MN																		
SATURDAY																			
	8:00AM																	Permeate	Well
	4:00 PM																		
	12:00MN																		
SUNDAY																			
	8:00AM																	Permeate	Well
	4:00 PM																		
	12:00MN																		

COMMENTS:

REVERSE OSMOSIS PILOT PLANT DATA
WATER TREATMENT PLANT No. 1 SITE
P. U. B. BROWNSVILLE

Date	Time	Wellwater	Feed			Permeate			Concentrate		P1	P2	P3	P4
		Chlorides	Conductivity	PH	Turbidity	Conductivity	PH	Turbidity	Conductivity	PH	Conductivity	Conductivity	Conductivity	Conductivity
5-10-96	10:30 A.	810	5100	6.98	0.24	223	5.09	0.11	15,000	7.50	64	81	120	280
5-13-96	11:30 A.	810	5100	7.17	0.22	240	5.61	0.20	16,000	7.74	97	119	175	320
5-14-96	9:30 A.	810	5100	7.24	0.14	138	5.79	0.08	16,200	7.85	57	82	162	300
5-15-96	11:30 A.	820	5100	6.98	0.34	122	5.43	0.11	16,000	7.51	60	92	182	330
5-16-96	10:00 A.	660	5100	7.29	0.12	150	5.60	0.22	16,100	7.77	51	82	169	319
5-17-96	9:00 A.	770	5100	7.26	0.14	109	5.63	0.09	16,100	7.78	60	75	165	300
5-20-96	8:45 A.	730	5100	7.15	0.13	100	5.78	0.08	16,000	7.67	51	90	180	300
5-21-96	8:45 A	810	5100	7.10	0.09	105	5.74	0.07	16,000	7.64	75	90	172	340
5-22-96	8:45 A.	760	5100	7.05	0.13	110	5.93	0.08	16,100	7.72	70	88	177	362
5-23-96	8:45 A	780	5100	6.76	0.08	116	5.62	0.09	16,000	7.46	63	93	180	364
5-24-96	8:45 A	780	5,000	6.64	0.09	111	5.55	0.11	15,500	7.43	65	91	179	320
5-28-96	8:45 A	790	5,100	6.78	0.10	138	5.59	0.11	16,000	7.42	72	95	172	350
5-29-96	8:45 A	730	5,100	6.83	0.10	130	5.58	0.11	16,000	7.49	100	105	175	375
5-30-96	8:45 A	720	5100	6.64	0.09	122	5.59	0.12	16,000	7.32	62	100	185	350
5-31-96	11:00 A.	730	5100	6.57	0.09	265	3.59	0.11	16,000	7.18	85	115	195	400
6-3-96	8:45 A.	810	5100	6.64	0.11	132	5.42	0.10	16,000	7.25	68	100	190	405
6-4-96	10:45 A.	720	5,000	6.47	0.11	145	5.42	0.10	16,000	7.10	80	113	210	450

REVERSE OSMOSIS PILOT PLANT DATA
WATER TREATMENT PLANT No. 1 SITE
P. U. B. BROWNSVILLE

Date	Time	Wellwater	Feed			Permeate			Concentrate		P1	P2	P3	P4
		Chlorides	Conductivity	PH	Turbidity	Conductivity	PH	Turbidity	Conductivity	PH	Conductivity	Conductivity	Conductivity	Conductivity
6-5-96	8:45Am	710	5100	6.55	0.11	155	5.42	0.09	15,500	7.24	72	102	190	410
6-6-96	8:45AM	770	5100	6.75	0.11	120	5.57	0.10	16,000	7.40	72	100	180	405
6-7-96	10:00AM	770	5100	6.45	0.12	140	5.35	0.09	16,500	7.35	68	95	180	410
6-10-96	8:45AM	710	5100	7.07	0.13	110	5.67	0.08	16,000	7.56	60	90	185	400
6-11-96	10:00AM	730	5100	6.60	0.12	130	5.48	0.11	16,000	7.20	78	105	190	380
6-12-96	10:00AM	780	5100	6.85	0.11	122	5.75	0.10	16,500	7.43	76	98	190	385
6-13-96	9:00AM	730	5100	6.90	0.13	120	5.68	0.11	16,500	7.61	65	95	180	375
6-14-96	9:30AM	750	5100	6.98	0.11	110	5.70	0.09	16,000	7.58	60	90	175	370
6-17-96	8:45AM	710	5100	6.91	0.11	120	5.35	0.10	16,500	7.57	60	90	175	362
6-18-96	10:00AM	730	5100	6.89	0.11	110	5.60	0.09	16,500	7.57	60	90	175	370
6-19-96	10:00AM	750	5100	6.94	0.10	110	5.60	0.09	16,500	7.61	58	90	175	380
6-20-96	8:45AM	710	5100	6.31	0.11	115	5.51	0.09	16,500	7.10	70	102	185	380
6-21-96	8:45AM	730	5100	6.33	0.10	128	5.40	0.10	16,500	6.92	78	105	190	385
6-24-96	8:45AM	740	5100	6.43	0.11	130	5.32	0.09	16,500	6.91	78	105	185	380
6-25-96	10:00AM	710	5000	6.55	0.11	110	5.24	0.08	15,500	7.16	75	92	188	395
6-26-96	10:00A.M.	710	5100	7.01	0.12	120	5.63	0.11	16,500	7.37	68	98	180	395
6-27-96	10:00A.M.	730	5100	6.62	0.11	135	5.52	0.09	16,500	7.11	72	110	180	395

REVERSE OSMOSIS PILOT PLANT DATA
WATER TREATMENT PLANT No. 1 SITE
P. U. B. BROWNSVILLE

Date	Time	Wellwater	Feed			Permeate			Concentrate		P1	P2	P3	P4
		Chlorides	Conductivity	PH	Turbidity	Conductivity	PH	Turbidity	Conductivity	PH	Conductivity	Conductivity	Conductivity	Conductivity
6-28-96	10:30AM.	740	5100	6.94	0.09	118	5.62	0.07	16,500	7.42	70	92	172	385
7-1-96	8:45AM.	800	5100	6.56	0.10	118	5.36	0.07	16,000	7.15	70	98	165	360
7-2-96	10:00AM	840	5100	6.75	0.09	128	5.53	0.06	16,500	7.38	68	92	165	375
7-3-96	10:00AM	750	5100	6.55	0.07	124	5.47	0.07	15,500	7.09	62	90	162	365
7-8-96	1:00PM.	760	5100	6.70	0.11	120	4.98	0.09	16,500	7.31	66	92	170	380
7-10-96	10:00AM.	770	5100	7.43	0.09	125	8.35	0.06	16,500	6.81	84	90	155	248
7-11-96	9:00AM	810	5100	6.53	0.10	150	4.80	0.06	16,500	7.23	62	84	144	220
7-12-96	10:00AM.	830	5100	6.60	0.09	125	5.44	0.06	16,000	7.26	60	82	140	212
7-15-96	8:45AM	770	5100	6.62	0.11	82	5.28	0.09	16,000	7.23	60	79	132	210
7-16-96	10:00AM.	730	5100	6.73	0.10	92	5.54	0.07	16,500	7.31	60	75	132	210
7-17-96	1:30P.M.	700	5100	6.71	0.11	105	5.58	0.07	16,500	7.21	65	80	140	225
7-18-96	8:45AM	800	5100	6.53	0.09	95	5.52	0.07	16,500	7.21	67	82	135	215
7-19-96	10:15AM	790	5100	6.71	0.08	110	5.51	0.06	16,500	7.31	62	72	130	222
7-22-96	8:45AM.	710	5100	6.10	0.10	115	5.30	0.07	16,000	7.05	78	90	148	240
7-23-96	10:30AM	730	5100	6.64	0.11	98	5.30	0.08	16,000	7.42	68	88	138	238
7-24-96	11:30AM	730	5100	6.76	0.08	100	5.42	0.05	16,500	7.37	78	90	140	242
7-25-96	11:00AM.	770	5100	6.53	0.10	98	5.30	0.06	16,500	7.26	70	90	142	240

REVERSE OSMOSIS PILOT PLANT DATA
WATER TREATMENT PLANT No. 1 SITE
P. U. B. BROWNSVILLE

Date	Time	Wellwater	Feed			Permeate			Concentrate		P1	P2	P3	P4
		Chlorides	Conductivity	PH	Turbidity	Conductivity	PH	Turbidity	Conductivity	PH	Conductivity	Conductivity	Conductivity	Conductivity
7-26-96	10:30AM	750	5100	6.52	0.08	100	5.44	0.06	16,500	7.26	70	90	140	240
7-29-96	10:30AM	790	5100	6.24	0.08	110	5.04	0.06	16,500	7.13	80	98	152	258
7-30-96	11:30A.M.	770	5100	6.39	0.09	108	5.37	0.05	16,500	7.11	70	94	150	258
7-31-96	10:30AM	710	5100	6.56	0.06	100	5.42	0.06	16,500	7.28	70	90	144	250
8-1-96	11:00A.M.	760	5100	6.44	0.09	125	5.41	0.06	20,000	7.28	72	105	195	375
8-2-96	10:30AM	710	5100	6.44	0.09	128	5.41	0.06	20,000	7.28	72	110	195	370
8-5-96	11:00AM	680	5100	6.31	0.09	130	5.34	0.06	20,000	7.21	78	115	198	360
8-6-96	10:30AM	710	5100	6.31	0.08	130	5.28	0.06	20,000	7.31	72	108	198	372
8-7-96	11:00AM.	680	5100	6.49	0.09	127	5.35	0.06	19,000	7.35	72	108	192	362
8-8-96	11:00AM	740	5100	6.41	0.09	135	5.25	0.06	20,000	7.21	64	108	198	370
8-9-96	10:00AM	760	5100	6.48	0.10	102	5.31	0.06	17,500	7.26	78	112	170	310
8-12-96	10:30A.M.	740	5100	6.54	0.09	120	5.32	0.06	19,500	7.39	68	102	190	350
8-13-96	10:30AM	760	5100	6.49	0.09	130	5.25	0.06	20,000	7.39	72	110	198	380
8-14-96	11:00AM	760	5100	6.51	0.09	130	5.29	0.06	20,000	7.36	72	110	202	380
8-15-96	10:30A.M.	730	5100	6.36	0.09	135	5.17	0.06	20,000	7.15	78	120	210	390
8-16-96														

7-31-96 11:50 A.M. > Concentrate Flow was changed FROM 4.7 GPM to 3.5 GPM
Recycle Flow was opened FROM 0 GPM to 1.2 GPM

APPENDIX IV - TWDB COMMENTS

luun, who is this? J

TEXAS WATER DEVELOPMENT BOARD

FILE: BGWT STUDY

October 28, 1996

NOV 1996 RECEIVED PUB

NOTED NOV 5 1996 DON A. OUCHLEY

RECEIVED NOV 05 1996

Mr. Don Ouchley
General Manager and CEO
Public Utilities Board
1425 Robinhood Drive
P.O. Box 3270
Brownsville, Texas 78620-3270

Re: Review Comments for a Draft Report on Regional Water Supply Contract Between the Brownsville Public Utilities Board (PUB) and the Texas Water Development Board (Board), TWDB Contract No. 95-483-141

Dear Mr. Ouchley:

Staff members of the Texas Water Development Board have completed a review of the draft final report submitted for TWDB Contract No. 95-483-141 and have determined that the report is acceptable.

The Board looks forward to receiving the one (1) unbound camera ready original and nine (9) bound double-sided copies of the final report.

If you have any questions concerning the project, please contact Mr. J.D. Beffort , the Board's designated Contract Manager, at (512) 463-7989.

Sincerely,

Tommy Knowles

Tommy Knowles
Deputy Executive Administrator
for Planning

cc: J.D. Beffort

v:rpp\draft\95483141.ltr

Our Mission
Exercise leadership in the conservation and responsible development of water resources for the benefit of the citizens, economy, and environment of Texas.

P.O. Box 13231 • 1700 N. Congress Avenue • Austin, Texas 78711-3231
Telephone (512) 463-7847 • Telefax (512) 475-2053 • 1-800- RELAY TX (for the hearing impaired)
URL Address: http://www.twdb.state.tx.us • E-Mail Address: info@twdb.state.tx.us