CITY OF EL PASO GROUND WATER RECHARGE PROJECT

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INTRODUCTION

In 1986, an average of 4.4 million gallons per day (MGD) of the city of El Paso's wastewater was converted to a potable water resource. This has been made possible by the successful implementation of El Paso's Hueco Bolson Recharge Project, now into its third year of operation. City officials hope to learn more about the benefits of recycling in the coming months and to share this information with others interested in implementing water recharge projects.

The Hueco Bolson Recharge Project began operation in El Paso in May 1985. This project uses the Fred Hervey Water Reclamation Plant to treat wastewater effluent for recharge into the Hueco Bolson aquifer. Experience to date shows that the treatment process used is reliable and can indeed produce a high quality of "product water."

The Hueco Bolson aquifer currently supplies about 65% of El Paso's total water demand of about 100 MGD. Approximately 10% of the city's water supply comes from the Rio Grande and the remaining 25% from ground water sources northwest of El Paso.

Water from the Hueco Bolson is being consumed 20 times faster than its natural rate of recharge. These consumption rates are causing a drop in the water table of between two and six feet per year, depending upon the location in the aquifer.

The Hueco Bolson Recharge Project is viewed as a significant step by the city of El Paso and the city's Public Service Board to use water recycling as a means to guarantee city residents an adequate supply of water for future use. When ultimate design flows are achieved, the project will provide a perpetual water supply for over 50,000 people.

At the time the idea for the Hueco Bolson project was first being evaluated, recycled wastewater was viewed as the least costly large volume supply available to El Paso over the long-term. For this reason, the decision was made to build the Fred Hervey Plant and to use its treated effluent to recharge the dwindling resources of the Hueco Bolson.

PROJECT DESCRIPTION

The project consists of a ten MGD advanced wastewater treatment plant, a pipeline system through the Hueco Bolson and ten injection wells. Wastewater collected in the northeast area of the city is pumped to the treatment plant and subsequently to the injection system. The system layout is shown in Figure 1. The water is injected directly into the fresh water of the Hueco Bolson between existing production wells. A west to east cross section of the bolson is shown in Figure 2.

No special treatment of water produced from the bolson after recharge is planned. As with other water produced from wells, chlorination will be provided prior to the water being released into the city's distribution system.

The Fred Hervey Plant uses technology originally developed to treat industrial wastewater to produce a water meeting drinking water standards. The discharge permit from the Texas Water Commission requires the monitoring of twenty-three parameters, with 30-day average values used on most of these parameters.

Two parallel 5 MGD treatment trains with a 20-step treatment process are used to achieve the required treatment level. Main process units include screening, degritting, primary clarification, flow equalization, two-stage PACT™ treatment, lime treatment, two-stage recarbonation, sand filtration, ozonation, granular activated carbon (GAC) filtration, chlorination and storage as shown in Figure 3.

PROJECT PERFORMANCE

The raw wastewater is processed through convention grit and primary solids removal systems. The primary effluent flow, about 6.6. MGD, is more than can be processed through the aeration system at the present time. Because of this limitation, the PACT system is fed a constant 4.3 MGD. The balance is collected in oxidation ponds and will be held until process modifications are made to the aeration system enabling the plant to process 10 MGD.

The overall performance of the treatment plant is summarized on Table 1. The performance of the process unit is discussed in following paragraphs.

1. Secondary System - PACT

Organic removal across the PACT system is monitored by analyzing for biological oxygen demand (BOD), total organic carbon (TOC), and chemical oxygen demand (COD). Primary effluent, first and second stage PACT effluent BODS

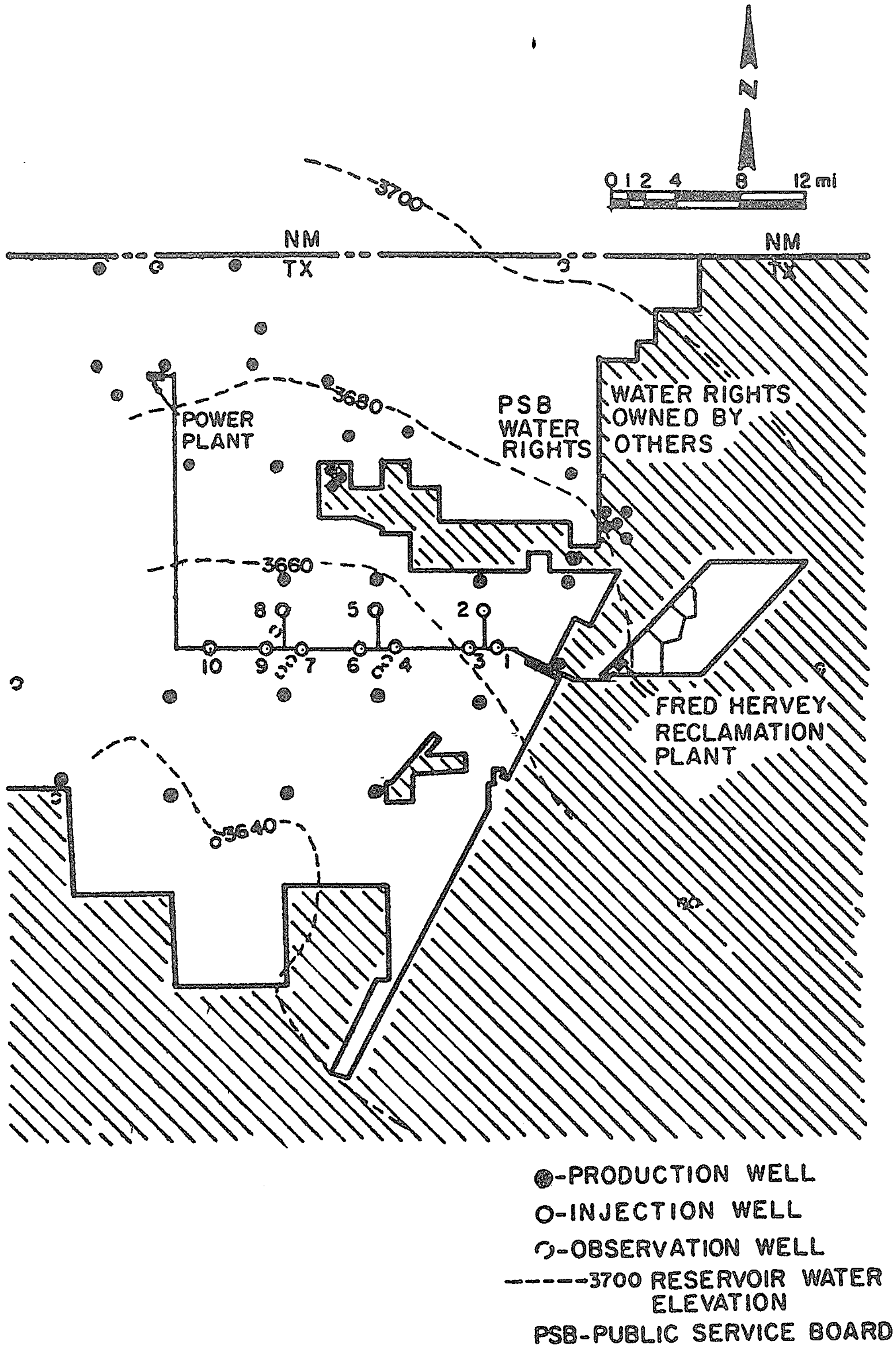

Figure 1. System Layout

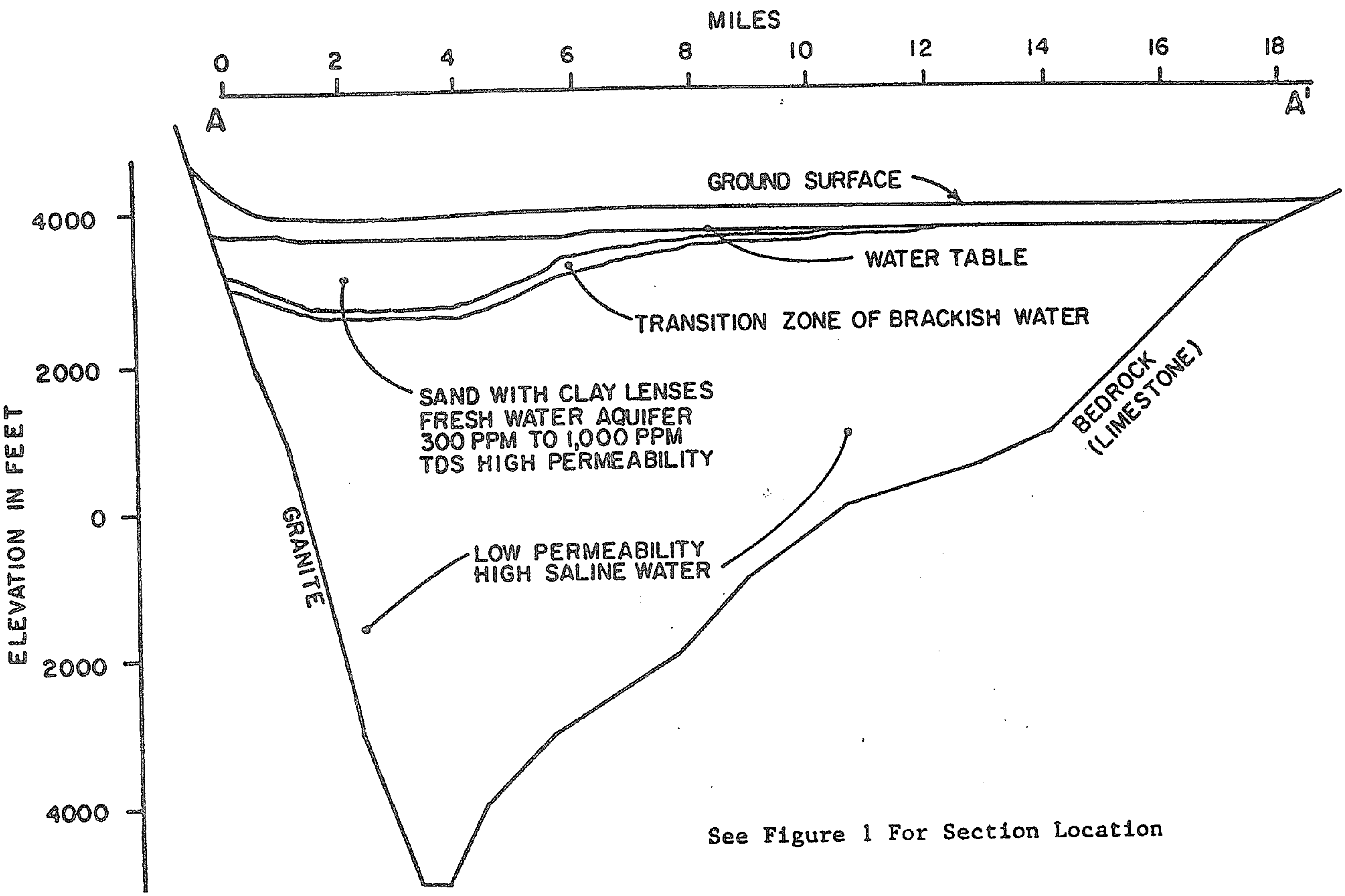

Figure 2. Ground Water Occurrence, Mesa Area of Hueco Bolson

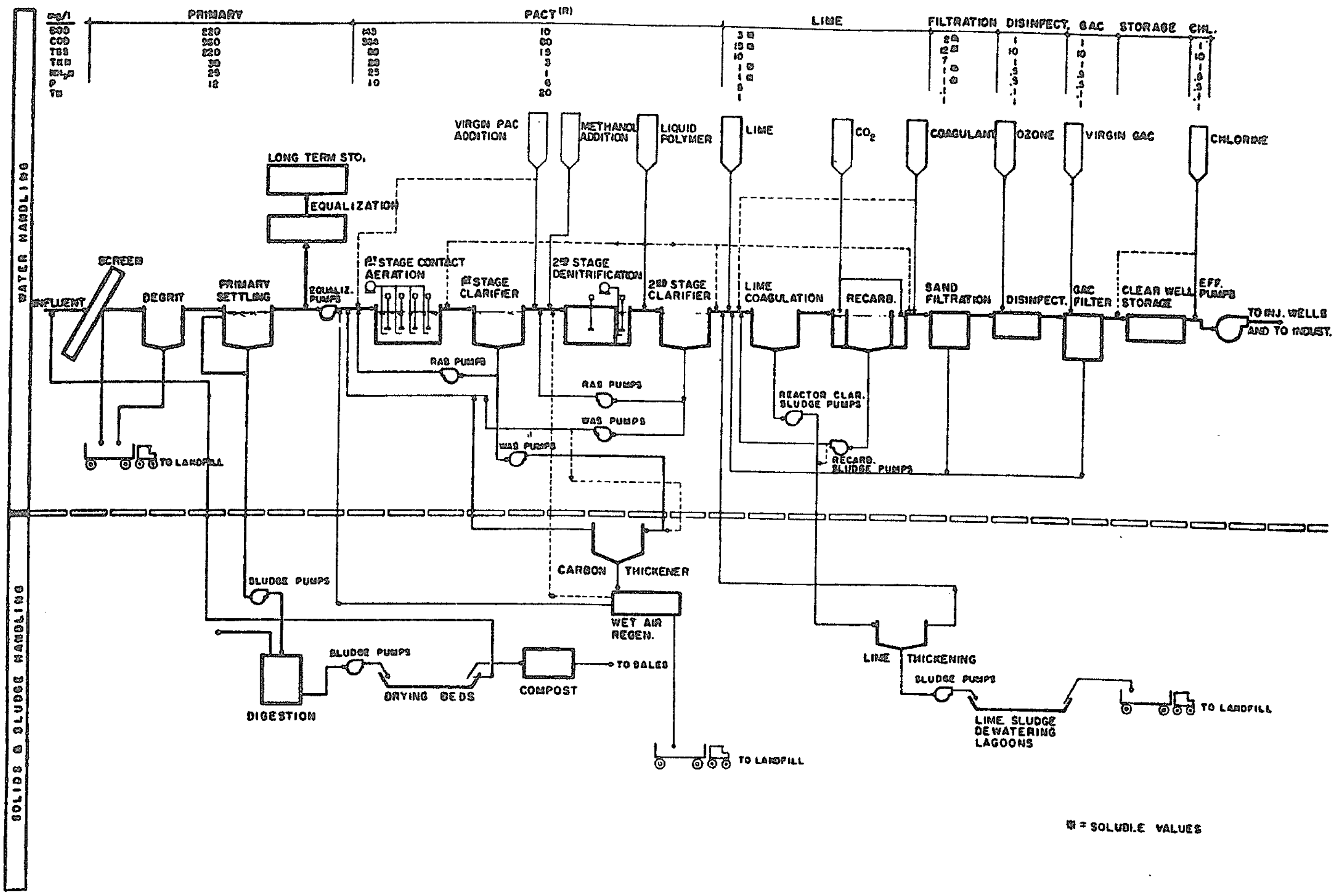

Figure 3. Process Design

Table 1

1986
AVERAGE OPERATING VALUES

Constituent	Influent Concentration	Product Water Concentration
BOD mg/l	165	
NH_3-N mg/l		0.18
NO_3-N mg/l		1.59
COD mg/l	254	24.4
TOC mg/l	27.0*	0.80
TSS mg/l	127.83	
TDS mg/l		611.83
Turbidity NTU		.21
PO_4-P mg/l		0.6
Chloride		200.67
Sulfate		88.67
Total Coliform colonies/100ml		0

*settled value

Table 2

1986 EL PASO TOTAL NITROGEN DATA ($TKN + NO_3$)

	Primary Effluent mg/l	First Stage Effluent mg/l	Second Stage Effluent mg/l	Overall % Removal
Jan.	29.6	19.7	3.5	88.2
Febr.	30.3	22.7	3.6	88.1
Mar.	31.7	16.5	1.2	96.2
April	27.8	8.8	1.0	96.4
May	27.3	5.6	0.6	97.8
June	25.2	6.3	1.0	96.0
July	22.3	7.0	1.3	94.2
Aug.	17.7	14.7	2.6	85.3
Sept.	19.4	16.2	4.3	77.8
Oct.	20.8	15.7	1.7	91.8
Nov.	24.7	11.3	3.8	84.6
	25.2	13.1	2.2	90.5

averaged 85 mg/l, 3 mg/l and 1 mg/l for 1986, respectively. Overall removal of BOD is greater than 98%. BOD removal was stable throughout the year, without exception.

Average TOC concentrations through the PACT system as above were 29 mg/l, 2.9 mg/l, and 2.4 mg/l, respectively. Overall removal was greater than 90%. Soluble COD is also monitored. Yearly average values were 155 mg/l, 36 mg/l, and 31 mg/l for the sample points mentioned above.

Nitrogen removal across the PACT system was very stable throughout the year. Total Kjeldahl Nitrogen (TKN) removal in the first stage ran 96%. The primary, first, and second stages averaged 25.4 mg/l, 1.0 mg/l and 0.6 mg/l, respectively.

Ammonia nitrogen removals mirrored this performance with primary, first and second stage concentrations of 20.4 mg\l, 0.4 mg/l, and 0.2 mg/l, respectively, for a 99% overall removal.

Nitrate removal overall was relatively stable across the process as a whole. The first stage nitrate concentration ranged from 22 mg/l to 5 mg/l. The yearly average was 11.6 mg/l. The second stage nitrate averaged 1.6 mg/l. Table 2 shows the total nitrogen removal across the PACT system.

Methanol is added to the denitrification (second) stage as a carbon source. Because of sensing control problems in the NO_3-MeOH loop, methanol is fed manually. As a result, methanol is generally overfed. Even though this occurs, based on total nitrogen removed across the PACT system, methanol consumption is 2.1 lb per pound of nitrogen removed.

The plant staff is satisfied with the performance of nitrification-denitrification aspects of the PACT system citing much greater stability than has been their experience with other nitrification processes.

2. Secondary Solids Processing - Wet Air Regeneration

Solids wasted from the PACT system to control solids residence time are processed through a wet air regeneration unit as shown in Figure 4. The unit regenerates the spent powdered carbon for reuse in the PACT process. In addition to carbon regeneration, the process destroys the spent sludges' biomass and oxidizes about 85% of all organics submitted to it. Because of conditions maintained therein, the balance of the organics exit the process in the form of low molecular weight oxygenated organics, mainly acetic acid.

Proper operation of the wet air regeneration unit requires an adequate temperature (greater than 440 °F to drive the reaction to proper completion),

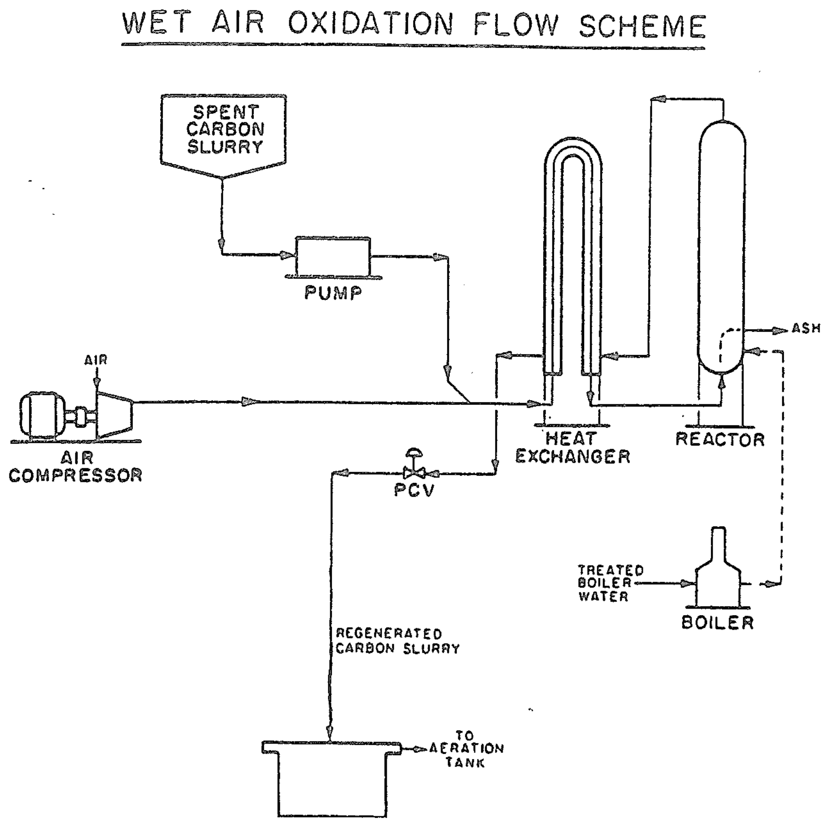

Figure 4.

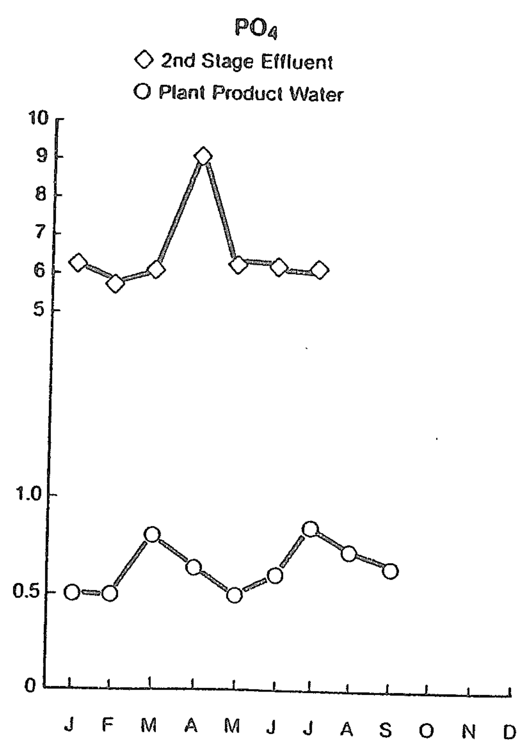

Figure 5.

adequate pressure (greater than 700 psig to control evaporation of water), and adequate residual oxygen in the off-gas (2-3% to assure a minimum recycle of COD to the PACT system).

The wet air regeneration unit allows some flexibility in the feed solids composition the unit can process. For instance, solids to regeneration have ranged from 5.7% to 12.4%. As long as the unit's residual O_2 content is sufficient, the slurry feed rate can be matched to the air compressor rate.

The percent oxidation achieved by the regeneration unit averaged 81%, within an acceptable range for the PACT/wet air regeneration systems.

There have been some problems associated with the regeneration system. Process air is supplied by one of two large reciprocating air compressors. Initially, both compressors suffered from lubrication problems which ultimately lead to the rebuilding of various stages of the machine. The supplier and manufacturer worked together to locate the cause of the problems and to resolve it.

Another problem has been heat exchanger scaling. In wet air regeneration, scales are removed by recirculating a solution of dilute nitric acid, HNO_3.

3. Lime - Recarbonation

The lime treatment step is used for removing phosphorus, heavy metals and killing virus. Lime is added for pH control to pH 11.1. Average lime dose for 1986 was 265 mg/l as CaO. Phosphorus removal is shown in Figure 5. Metals have not been a problem in the plant product water.

Virus analyses have been run on plant product water annually and no virus have been detected. Additionally, virus analyses were run on internal plant streams with no virus detected except in the primary clarifier effluent.

The lime reactor and first stage recarbonation tank require descaling about every four months. This is not considered unusual for such a process.

The recarbonation process drops the pH to 7.5 in two stages, by dissolving carbon dioxide in the water. Chemical consumption for the lime processes are about as anticipated.

4. Sand Filtration

Sand filtration is done with traveling bridge type sand filters. Effluent turbidity has averaged 1.05 NTU during 1986. During the summer, an algae film develops on the surface of the water above the sand. It poses only an appearance problem and does not affect performance. The algae film is skimmed off manually about once per week.

5. Ozone Disinfection

Disinfection is provided by one of two ozone units. Operation has been very good with no coliform detected in the effluent. Ozone dose has averaged 1.75 mg/l in 1986. Control of the dose is based upon contactor efficiency rather than ozone residual. High pH to the contactor has resulted in loss of ozone residual due to the conversion of ozone to the OH radical. Disinfection capability remains high during this situation but control on residual is not feasible.

Pitting corrosion of the cooling water jackets was experienced and was apparently due to chloride pitting of the 304 stainless steel. The problem was resolved by installing a closed loop cooling system for the ozone units.

6. Granular Carbon Filter (GAC)

The granular carbon filter was installed to provide a final polishing removal or organic compounds. The 1986 average loading to the GAC filter was 1.84 mg/l TOC with only four occasions exceeding 5 mg/l. The average loading for 1986 was 0.00023 pounds of TOC per pound of carbon. No granular activated carbon has been regenerated or replaced.

Since adsorption on activated carbon (Calgon Filtersorb 300) is an equilibrium process, the carbon bed acts very much as a peak leveler. Adsorption occurs when either high feed organic concentrations or very low levels of adsorbed materials on the carbon are encountered. When the feed organics drop off or the carbon bed becomes saturated, organics desorb according to the equilibrium of the process. Table 3 shows this phenomenon occurring where the influent Trihalomethane Formation Potential (THMFP) in nanomoles is sometimes less than the effluent value. This nanomole value can be multiplied by 20% to approximate the concentration in micrograms per liter. Initial indications demonstrate that reduced regeneration of PACT carbon caused the higher influent THMFP values in late 1985. For the dates sampled, several show negative removals, but during these periods product water remained within standards. Plant personnel are currently concerned that the procedure used to determine THMFP may not be accurately representing the influent THMFP concentrations. Other methods of analysis are being considered.

7. Injection Wells

There are ten injection wells in the project. The water bearing strata is a fine grained alluvium under water table conditions. Each well is approximately 800 feet deep and is completed about 450 feet into the water table. Normal static water

Table 3

EL PASO GAC FILTER THMFP

Month	GAC Inf. (Nanomole)	GAC Eff.	Removal Eff.
Oct.85	76	41	35
Nov.85	26	19	7
Dec.85	3	15	-12
Jan.86	1	5	-4
Mar.86	1	7	-6
Jan.87	7	12	-5
Mar.87	0	0	
May 87	3	14	-11

Table 4

1986 COST BREAKDOWN

	$/1000 gal.	%
Labor	0.49	32
Power	0.51	33
Chemicals	0.28	18
Maintenance	0.12	8
Miscellaneous	0.13	9

Table 5

CHEMICAL COST, 1986

Chemical	Cost, $/1000 gal.	%
CO_2	0.063	22
Lime	0.083	30
HNO_3	0.012	4
Methanol	0.035	13
Powdered Carbon	0.016	5
Granular Carbon	0.000	0
Polymer	0.015	5
Miscellaneous	0.055	20
TOTAL	0.280	

levels are about 350 feet below the surface. A 16" casing is used and is perforated (wire wrap screen) from the water table to total depth.

To date, all of the wells have been used for injection on a routine basis. Water is injected down a 3.5" tubing sized to dissipate the hydrostatic head and eliminate freefall into the well. It has been found that the wells will operate at an injection rate of between 500 and 800 gpm. Injection rates are held constant by a rate of flow controller. Hydrostatic buildup under injection conditions ranges from 100 feet to 150 feet initially and builds to approximately 250 feet before the well is backwashed with a pump installed in the well.

Backwashing procedures are initiated when the water table rises to within 100 feet of the surface. Each well is continuously monitored electronically with a downhole pressure transducer to indicate the water level in the well. Backwashing consists of pumping the well at a rate of 1000 gpm for several 30 minute periods so the well is surged. After the well blowndown clears up, usually after 3 or 4 cycles, the well is allowed to pump continuously for about two hours. This procedure is usually done every three months although the range is from two to four months. After backwashing, the hydrostatic buildup, after injection is resumed, will be about the same as it was initially. Figure 6 shows the buildup experience on recharge well number 1 during 1986 and shows the effect of backwashing.

There are six observation wells in use. These wells are clustered in groups of two around two of the injection wells and are located 300' and 700' downgradient from the injection well. Two more observation wells are each located 300 feet upgradient from different injection wells. These wells are monitored quarterly with fluid resistivity logs and samples are taken at points indicated by the logs.

To date, the only significant change in the water, based upon sampling results, has been an indication of trihalomethanes (THM) in the observation wells. The THMs have been detected at depths of 400 to 450 feet with the maximum value being 6.1 micrograms per liter. Dibromochloromethane and bromoform are the predominant forms detected. There have been no THMs detected in the produced water. The THMs could be formed as a result of the 0.1 milligram per liter free chlorine residual carried in the injected water and the organic material in the aquifer.

8. <u>Reliability</u>

Reliability has been high in that no "off spec" material has been injected based upon laboratory analysis of water in the holding basins. The treatment plant has the capability of "wasting" after most process units, thus an upset in one process will

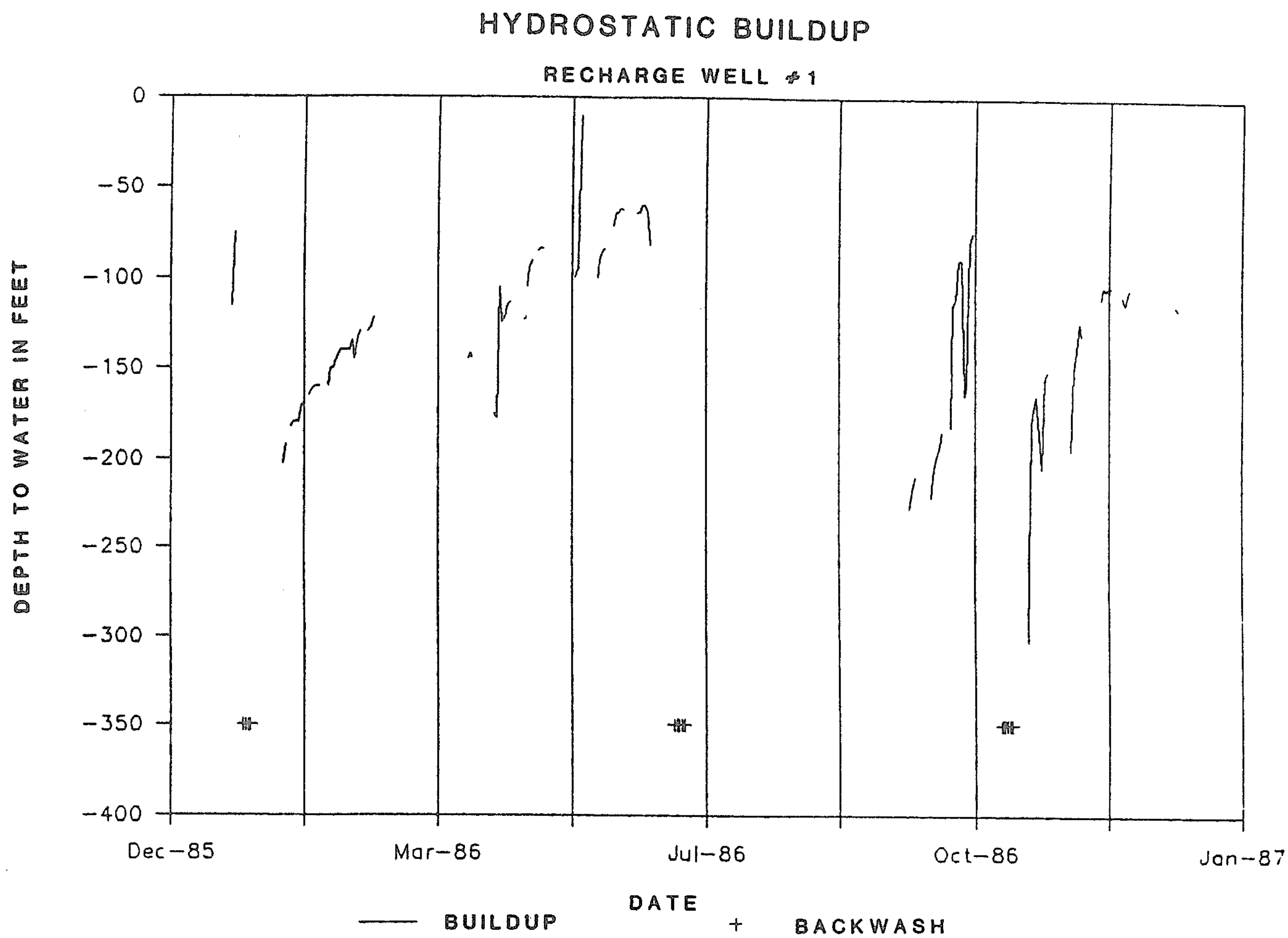

Figure 6. Hydrostatic Buildup
Recharge Well #1

not propagate through the plant. This system has been used on occasions where ammonia bleed through, loss of methanol feed or electrical problems were encountered.

9. Costs

Capital costs on the project were approximately $33 million for all costs including the plant, reclaimed water pipelines, and injection wells. The United States Environmental Protection Agency provided approximately $20 million toward the project.

In 1986, a total of 1.4 billion gallons of drinking quality water was returned to the Hueco Bolson reservoir by the Fred Hervey Water Reclamation Plant. The cost of this water was approximately $1.55/1000 gallons. Table 4 shows the breakdown of costs into major categories. Power and labor costs were nearly equal and made up a total of 65% of the overall costs. Chemical costs made up another 18%, with powdered carbon being only 5% of the chemical costs.

The chemical costs are broken down in Table 5. The major chemical costs are lime, carbon dioxide and methanol. The other major miscellaneous cost item was largely contributed by liquid oxygen fed to the force main to help reduce sulfides entering the plant.

No granular carbon was purchased in 1986. The product water never failed to meet the effluent organic requirement.

The operating costs have increased over the first two years of operation. During roughly the first five months of operation, the costs were reported to be $1.00/1000 gallons. The records show that the second half of 1985 ran at $1.17/1000 gallons and 1986 ran at $1.55/1000 gallons.

The major areas of cost increases have been power, chemicals and maintenance. Chemicals, alone, rose $ .10/1000 gallons. Another $ .045/1000 gallons is attributed to miscellaneous, with most of the remainder associated with power.

It is reasonable to expect some increase in maintenance costs. Equipment warranties will expire and the costs will shift from the supplier to the owner.

10. Conclusion

Since the Fred Hervey Water Reclamation Plant was placed in service in 1985, the facility has consistently met priority established aquifer recharge goals. The amounts of water recycled to the potable water system to date are felt to be minor based upon injected volumes and the displacement volumes involved in traveling to the production wells.

This project has many unique features and much is being learned about treatment of waters for reuse and recharge. El Paso Water Utilities has submitted a request for funding from the U.S. Bureau of Reclamation under the High Plains States Groundwater Recharge Demonstration Program to support additional study of operational data on the Hueco Bolson Recharge Project. Data from this proposed project could be helpful to other municipalities that now have or are planning advanced wastewater treatment facilities capable of producing high quality effluent which may be used to replenish diminishing local ground water supplies.