

**FEASIBILITY STUDY OF TREATING
RIO GRANDE RIVER RETURN FLOW
IN EL PASO, TEXAS**

By

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This paper evaluates the feasibility of treating return flow water from the Rio Grande River at the Robertson/Umbenhauer (Canal) Water Treatment Plant when total dissolved solids levels exceed 1000 mg/l, the maximum contaminant level for drinking water quality. El Paso is experiencing a groundwater deficient situation, especially in the Hueco Bolson aquifer, and therefore must look for ways to supplement its future water supply. In 1990, Boyle Engineering, in its 50 year Water Resource Plan, projected the Hueco Bolson aquifer to lack sufficient fresh water quality, less than 1000 mg/l total dissolved solids, by the year 2026 unless other means is taken to prevent depletion of the groundwater supply. In the 50 year plan, Boyle proposed increased use of surface water as a major component of decreasing groundwater dependence because it is a renewable water resource.

Also, the plan recommended a relatively small amount of desalination of groundwater supplies even though large amounts of brackish water (greater than 1000 mg/l T.D.S.) exist in the Hueco Bolson aquifer. The major objection to the use and treatment of brackish water is the difficulty it poses in the disposal of the brine salts in the El Paso area. Desalination water projects are extensive in coastal areas such as Florida and California because disposal of the brine can be done inexpensively in the ocean. However, El Paso is far inland and must depend upon expensive deep well injection and/or land disposal which are limiting its future use. For example, removal of 2000 mg/l of excess brine (3000mg/l T.D.S. to 1000 mg/l) would amount to disposal of 8 tons of salt per million gallons of water. El Paso currently averages 110 million gallons per day consumption (880 tons per day of excess brine salts). Therefore, it is not difficult to understand the reason Boyle Engineering recommended desalination as a small part of the solution. The treatment of return flow water during the non-irrigation season was not considered as a major future water supply option by the Boyle plan for the same objections or reasons the report had about desalination of groundwater, ie, disposal of brine.

The author will calculate the mass total dissolved solids' loadings to the river from sewage flows in 1996 and compare it to a lower mass TDS input from Canutillo Wells and increased mass TDS elimination through reclaimed water use in order to justify return flow treatment at the Canal Water Plant. This approach should not require expensive brine disposal of the excess total dissolved solids. This plan, if adopted by the El Paso Water Utilities and the El Paso County Water Improvement District #1, could establish a new mechanism for effectively controlling salinity on the river by taking a "holistic approach" in evaluating the mass loading effects by total dissolved solids from the groundwater, sewage, and river.

Introduction

The City of El Paso is located in the far western corner of Texas with a population of 630,000 which ranks fourth in size in Texas and 27th in the nation. El Paso Water Utilities provides water to customers within the City limits as well as the community of Westway and is a wholesale supplier to Fort Bliss and El Paso Lower Valley Water District Authority. About 55% of its water requirements come from locally available underground sources, the Hueco and Mesilla Basins, and the remainder is taken from the Rio Grande River during the irrigation season (February through September). Normally, only ground water from 153 wells is used during the winter period. However, this paper will propose the treatment of return flow from the river during the winter months when total dissolved solids levels exceed 1000 mg/l, the maximum contaminant level for drinking water.

Wells drilled on the west side of the mountain in the general vicinity of Canutillo provide approximately 15 percent of the total requirements. This water supplies the west side of the mountain during the irrigation season but it also supplies the Central area of the City when released irrigation water is not available. Studies by the United States Geological Survey indicate that the better quality water in the deeper formations should be capable of supplying 16,000 acre-feet annually without significant depletions. Water in the shallow formation is not suitable for drinking without blending it with better quality water in the intermediate and deep formations. Currently, the shallow and intermediate wells are used year around leaving the better quality deep wells for peak consumption periods. This paper will evaluate the use of Canutillo shallow and intermediate wells during the irrigation season period (February - October) and using the Canutillo deep wells during the winter period (November - January) when Rio Grande return flow water is available. This plan is optimum for three reasons because 1). It optimizes the Canutillo groundwater quality use from a geo-hydrological basis, 2). The shallow and intermediate wells will be adequate for meeting system demand during the irrigation release period when river water quality is at its best and water system demands are higher, 3). During the winter months, the better quality deep wells will be able to provide sufficient production with lower total dissolved solids to the sewage collection system thereby making it possible to provide mass balance credit towards the treatment of higher total dissolved solids levels from the river at the Canal Plant.

The remaining water requirements that cannot be supplied by the Rio Grande or the Canutillo wells are provided from wells drilled on the east side of the Franklin Mountains. Extensive studies conducted by United States Geological Survey indicated that about 10 million acre feet of good quality water was available in El Paso County for removal by pumping in the area stretching about 10 miles east of the base of the mountains. This area, the Hueco Basin, provides about 40 percent of the total annual requirements. With continued growth and development in the El Paso area, these resources will be adequate to satisfy the needs of the community until about the year 2026. In 1990, the Boyle Engineering Water Resource Plan

recommended increased conversion to surface water and decreased dependence on groundwater in an effort to supply adequate water to 2040.

Currently, the Rio Grande River water is treated at two- 40 million gallon per day surface water treatment plants, the Canal Water Plant located in the Central Area of the City and the Jonathan Rogers Water Plant located in the southeastern part of the city. These plants supply 45 percent of the annual water system requirements. The objective of this paper is to determine the feasibility of treating river return flow during the winter months at the Canal Water Plant in order to increase surface water use and thereby reducing some groundwater use by utilizing a mass balance approach to determine maximum allowable treated river water (1,2).

River Water Quality versus Monthly Discharge

The first step, in determining the feasibility of treating return flow, began with an overall assessment of river water quality versus quantity or monthly discharge rates. Therefore, an analysis of Rio Grande River water quality, in terms of total dissolved solids levels, versus monthly discharge rates, was performed on data from 1977 through 1995 (3). Figure 1 shows a high correlation between total dissolved solids levels and monthly discharge rates at a R^2 value of 0.87. The data had 216 observations which gave a predictive equation for total dissolved solids levels as follows : $\text{Ln}(\text{TDS, mg/l}) = 10.4457 - 0.35634\text{Ln}(\text{monthly discharge, ac-ft})$. According to the predictive equation, the monthly discharge rate needed to obtain 1000 mg/l total dissolved solids water quality is 20507 acre-feet. This is equivalent to a 333 cubic feet per second discharge rate which is close to the recently reported 300 cfs releases in order to obtain total dissolved solids levels just below 1000 mg/l at the surface water plants.

Since the intent is to treat return flow water during the winter when river flows are low and total dissolved solids levels are the highest, then a frequency distribution analysis of the data showing quality versus quantity available is necessary to determine if sufficient water is available for treatment and to be able to calculate total dissolved solids loading for the mass balance evaluation. Figures 2 and 3 show frequency distributions of Rio Grande River Monthly Discharge typical of return flow periods when TDS exceeds 1000 ppm. The frequency distributions test for normality are high at 0.87 and 0.93 respectively. The range of monthly discharge during the return flow period is 1037 acre feet per month(10.9 mgd) to 37142 acre feet per month(308 mgd). The total dissolved solids levels range from 1007 mg/l to 2398 mg/l with a median value of 1456 mg/l. This paper will evaluate the mass loadings effect at the median value of 1456 mg/l. According to the predictive equation for monthly discharge at 1456 mg/l, the monthly discharge rate needed is 7146 acre-feet (75 mgd). Water quality in the river is an inverse relationship to monthly discharge, ie, the higher the total dissolved solids, the lower the monthly discharge. At the 7146 acre feet monthly discharge rate, the percent frequency distribution value would be about 40% or, i.e., 60% of the time, the water quality in the river would be equal or less than 1456 mg/l during the return flow period. Although this paper will evaluate the mass loading at only one concentration level, a table of TDS values versus amount of treatment allowed at Canal Plant could easily be developed to target a particular mass loading

limit based on 1996 values. The El Paso Water Utilities and the El Paso County Water Improvement District #1 could develop an agreed upon mass loading report for the control volume area identified as the West side and Central Areas of the City, which include the Canutillo Well field, Canal Water Plant, Town Wells, Northwest Sewage Plant, and Haskell Sewage Treatment Plant.

Figure 4 shows the El Paso typical water distribution supply pattern for the period between March and September (4). During the winter months, the Canutillo wells would normally supply the Central area and the West side. However, in this proposal, the Canal Plant would continue to supply the Central area in the winter eliminating the need for the Town wells and reducing the demand from the Canutillo wells.

Comparison of Water & Wastewater Flows

A comparison of water/ wastewater flows in the control volume area (West and Central area) and the total water/wastewater system was done in order to determine if the water/wastewater flow ratio in the control volume area is accurate. Figure 5 shows the ratio of total wastewater to water flows for the past 10 years in the total system. The sewage/water ratio values ranged from 0.51 to 0.66 with a trend towards higher sewage/water ratios resulting from reduced outdoor watering. The flow ratio for sewage to water in 1996 was 0.63 in the control volume area which is higher than the 10 year mean of 0.58 for the total system but in line with the regression projection(5). Figure 6 shows the comparison of water and wastewater flows in 1996 for the control volume area (6,7). In addition, figure 6 shows slightly higher sewage flows in January and December which means this evaluation will be a worst case evaluation for mass loadings. According to Enrique Woo, Sewage Systems Division Manager, the sewage flows for Haskell Sewage Treatment Plant include Phelps Dodge and Chevron Refinery sewage flows which have their own wells. Also, the Fort Bliss sewage flow is outside of the control volume area from the Canutillo wells, Canal Plant and Town Wells. Therefore, in this evaluation, the amount of well water flow from Phelps Dodge and Chevron are not included and explains the higher sewage flows compared to water flows in December and January even with the Fort Bliss flows deducted from the Haskell Sewage Treatment Plant total flows(8).

Comparison of Water & Wastewater TDS Levels

Figure 7 shows the relationship between total dissolved solids levels in water and wastewater during 1996 (9,10, 11). The TDS levels for Canutillo, Canal Plant, Haskell Sewage Plant, and Northwest Sewage Treatment Plant are weighted averages of flow according to total dissolved solids concentration. The 1996 annual flow weighted averages are: Canutillo = 479 mg/l, Canal Plant = 605 mg/l, Haskell Sewage Treatment Plant = 948 mg/l, Northwest Sewage Treatment Plant = 1269 mg/l. The regression curves for Canal Plant and Haskell Sewage Plant are parallel indicating that the chemistry of Canal Plant directly influences the water quality of Haskell Sewage Plant and the Haskell Sewage Plant chemistry is not strongly affected by

groundwater infiltration as the Northwest Sewage Plant. The regression curve for the Northwest Sewage Plant generally was declining during the year possibly due to a dewatering project on the west side and a groundwater infiltration prevention program implemented by the Sewage Division. If the dewatering project had more influence on the decline in total dissolved solids levels to the Northwest Sewage Plant, then it is likely that the mass total dissolved solids loadings could increase in future years. On the other hand, a continuing effort by the Sewage System crews to seal customer's sewer lines from groundwater infiltration may lessen future impact from mass total dissolved solids loadings.

Mass Balance for Control Volume

The equation for calculating mass balance is: **Change in Storage of Mass = Mass In - Mass Out + Mass Produced by Sources - Mass Eliminated by Sinks(12)**. Applying this equation to the Control Volume area, you get:

$$\text{Mass In} = (\text{Canutillo Flow, Kgallons} * \text{TDS, mg/l}) + (\text{Canal Flow, Kgals} * \text{TDS, mg/l}) + (\text{Town Wells Flow, Kgals} * \text{TDS, mg/l})$$

$$\text{Mass Out} = (\text{HSSTP - Bliss Flow} * \text{TDS}) + (\text{NWSTP Flow} * \text{TDS})$$

$$\text{Mass Produced by Sources} = (\text{Sewage TDS} - \text{Water TDS}) * \text{Sewage Flows}$$

$$\text{Mass Eliminated by Sinks} = (\text{Water Flows} - \text{Sewage Flows}) * \text{Water TDS}$$

All of the above analyzed TDS levels are based on raw water data that is weighted according to flow. The Canutillo and Town Wells analyses are based on the most recent annual test which, for the most part, was performed in 1996. The sewage analyses were summarized on a monthly basis from weekly tests performed in 1996. The Canal Plant analyses were also summarized on a monthly basis from the same weekly sewage test dates (6,7,8,9,10,11).

Mass Balance Calculations for 1996

Applying the actual flow and total dissolved solids levels to the above mass balance equation, you get the following result:

$$\text{Mass In} = (8478205 \text{Kgals} * 479 \text{ mg/l}) + (6317570 \text{ Kgals} * 605 \text{ mg/l}) + (788225 \text{ Kgals} * 750) = 8.47 \times 10^9 \text{ mg/l-Kgals}$$

$$\text{Mass Out to River} = (7120030 \text{Kgals} * 948 \text{ mg/l}) + (2666800 \text{Kgals} * 1269 \text{mg/l}) = 10.13 \times 10^9 \text{ mg/l-Kgals}$$

$$\text{Mass Produced by Sources} = (1035 \text{ mg/l} - 544 \text{ mg/l}) (9786830 \text{ Kgals}) = 4.81 \times 10^9 \text{ mg/l-Kgals}$$

$$\text{Mass Eliminated by Sinks} = (15584800 \text{ Kgals} - 9786830 \text{ Kgals}) (544 \text{ mg/l}) = 3.15 \times 10^9 \text{ mg/l-Kgals}$$

Water - Sewage + Sources - Sinks = 0	Sewage/Water Mass
$8.47 \times 10^9 - 10.13 \times 10^9 + 4.81 \times 10^9 - 3.15 \times 10^9 = 0$	$10.13/8.47 = 1.20$

Strategies to Use Return Flow Water from River

The following four point operational strategy is proposed to use return flow water from the Rio Grande River during November, December, and January:

- 1). Use better quality deep Canutillo Well Water during November, December, and January in order to improve sewage flow chemistry;
- 2). Use reclaim water from Northwest Sewage Treatment Plant for irrigation purposes as a total dissolved solids sink principally during the February to October period;
- 3). Eliminate the use of Town Wells during the November - January period by substituting surface water from Canal Plant;
- 4). Apply mass balance credit towards using the higher total dissolved solids return flow water treatment at the Canal Plant based on a maximum mass out amount to river in 1996, 10.13×10^9 mg/l-Kgals.

Mass Balance for Treating Return Flow

The mass balance calculations for the above listed strategy to use return flow from the river at the Canal Plant is:

$$\text{Mass In} = \text{Deep Canutillo(Nov-Dec)} + \text{Canutillo Wells(Feb-Oct)} + \text{Canal Plant(Nov-Dec)} + \text{Canal Plant(Feb - Oct.)} + \text{Town Wells(Feb - Oct)} = \text{Mass In}$$

$$(1584148\text{Kgals} * 305 \text{ mg/l}) + (6446412\text{Kgals} * 479\text{mg/l}) + (804963\text{Kgals} * 1456) + (6317570\text{Kgals} * 605 \text{ mg/l}) + (430907\text{Kgals} * 750\text{mg/l}) = 8.88 \times 10^9 \text{ mg/l-Kgals}$$

$$\text{Mass Out to River} = \text{NWSTP(Feb - Oct)} + \text{NWSTP(Nov - Jan)} + \text{HSSTP- Bliss(Feb - Oct)} + \text{HSSTP - Bliss (Nov - Jan)} = \text{Mass Out to River}$$

$$(2048400\text{Kgals} * 1315 \text{ mg/l}) + (618400\text{Kgals} * 960 \text{ mg/l}) + (5392950\text{Kgals} * 960) + (1727080\text{Kgals} * 1271 \text{ mg/l}) = 10.66 \times 10^9 \text{ mg/l-Kgals}$$

$$\text{Mass Produced by Sources} = (\text{Sewage - Water}) * (\text{Sewage})$$

$$(1089\text{mg/l} - 570 \text{ mg/l}) (9786830\text{Kgals}) = 5.07 \times 10^9 \text{ mg/l-Kgals}$$

$$\text{Mass by Sinks} = (\text{Water} - \text{Sewage}) * (\text{Water}) = \text{Mass by Sinks}$$

$$(15584800\text{kgals} - 9786830 \text{ kgals}) (570 \text{ mg/l}) = 3.29 \times 10^9 \text{ mg/l-kgals}$$

$$\text{Mass Balance without Reclaim use} = 8.88 - 10.66 + 5.07 - 3.29 = 0$$

$$\text{Mass to River reduced by Reclaim Use} = \text{Mass to River w/o Reclaim} - \text{Reclaim use}$$

$$9.94 \times 10^9 \text{ mg/l-kgals} < 10.13 \times 10^9 \text{ mg/l-kgals for 1996}$$

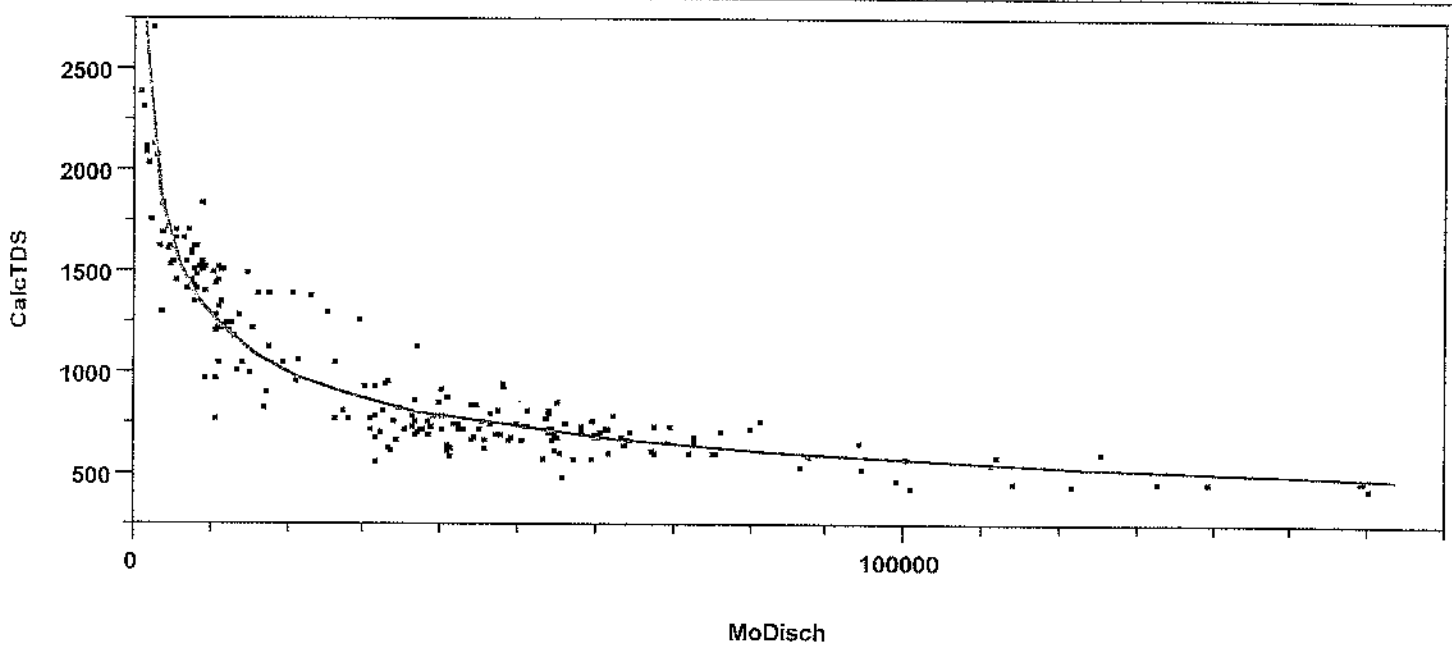
Conclusions and Recommendations

The following conclusions and recommendations can be made with reasonable certainty based on the mass balance analysis:

- 1). During the return flow period of November, December, and January, 8.75 million gallons per day of return flow with a 1456 total dissolved solids level can be treated if 17.219 million gallons per day of better quality deep Canutillo Wells are used and , in addition, 546 million gallons per year of reclaimed water is diverted to irrigation purposes.
- 2). Higher amounts of return flow can be treated if total dissolved solids levels are less than 1456 mg/l during the return flow period and/or higher amounts of reclaimed water use as a sink for total dissolved solids.
- 3). The El Paso Water Utilities and the El Paso County Water Improvement District #1 should enter into an agreement to allow treatment of return flows based upon an agreed upon mass discharge limit of total dissolved solids to the river.
- 4). The recommended discharge mass limit to the river should be 10.13×10^9 mg/l-kgals since it is a worst case evaluation for the defined control area of the West and Central areas of the City.
- 5). The El Paso Water Utilities should install nanofiltration membranes at the Canal Water Plant as soon as an agreement is finalized with the EPCWID #1. Although the evaluation of the nanofiltration treatment is not part of this paper, it is important to reference Dr. Charles Turner of UTEP Civil Engineering who recently stated that membranes can be used to remove certain excessive ions in the river water, such as sulfates and calcium , which should not adversely affect the sodium adsorption ratio , important to irrigation concerns(13).
- 6). The Canutillo well field will be operated in a more beneficial manner in terms of the geo-hydrological concerns.
- 7). There is adequate quantity of Return Flow water available for treatment in El Paso.
- 8). This is a win - win situation for the City of El Paso and the El Paso County Water Improvement District #1 because the City of El Paso will be able to decrease dependence on groundwater use in the Canutillo Well Field and the Town Wells while increasing surface water use, a renewable resource, and the EPCWID#1 will be able to sell a unused water resource to the El Paso Water Utilities.

Figure 1 - Rio Grande River Monthly Discharge Rates versus T.D.S.

CalcTDS By MoDisch



— Transformed Fit Log to Log

Transformed Fit Log to Log

$$\text{Log(CalcTDS)} = 10.4457 - 0.35634 \text{ Log(MoDisch)}$$

Summary of Fit

RSquare	0.871744
RSquare Adj	0.871145
Root Mean Square Error	0.144705
Mean of Response	6.829728
Observations (or Sum Wgts)	216

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	30.457275	30.4573	1454.542
Error	214	4.481038	0.0209	Prob>F
C Total	215	34.938313		<.0001

Parameter Estimates

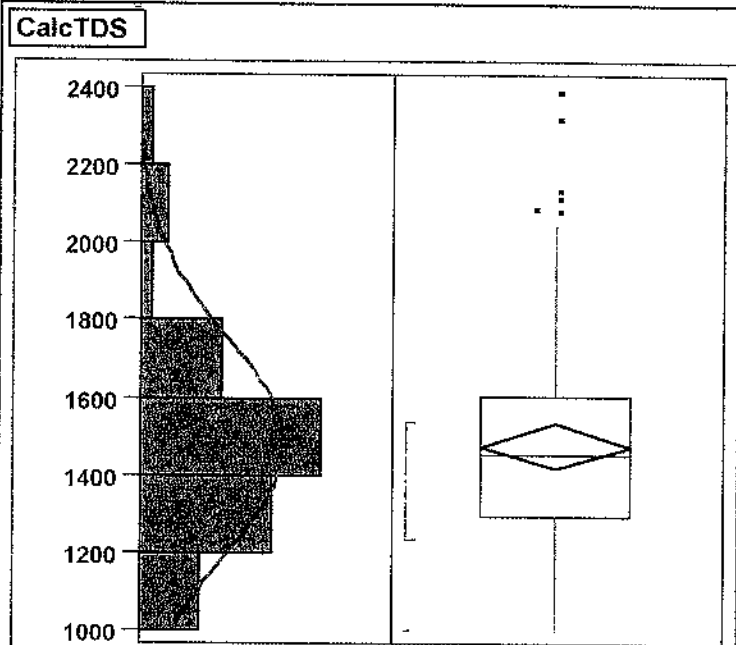
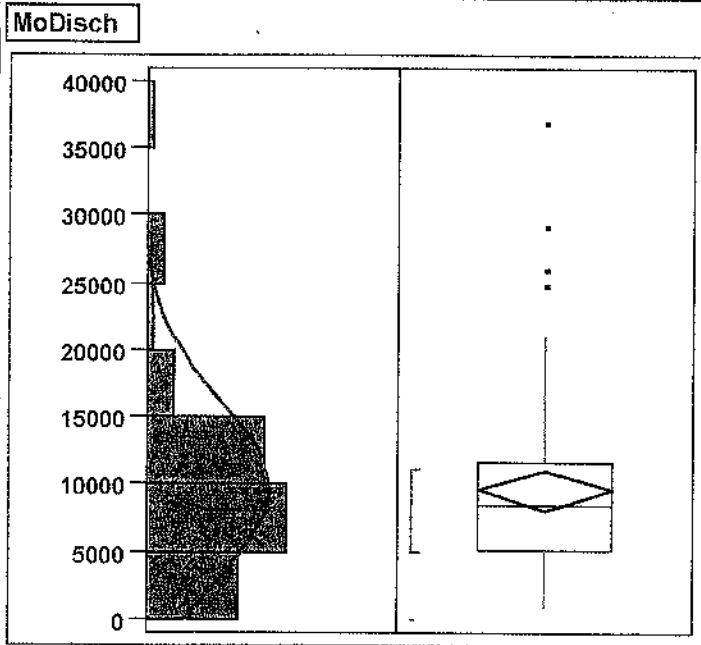
Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	10.44572	0.095322	109.58	<.0001
Log(MoDisch)	-0.35634	0.009343	-38.14	<.0001

Fit Measured on Original Scale

Sum of Squared Error	5820103.8
Root Mean Square Error	164.91436
R-square	0.8611466
Sum of Residuals	1748.8807

Figure 2- Return Flow Monthly Discharge Distribution

Figure 3 - Distribution When TDS exceeds 1000ppm



Quantiles		
maximum	100.0%	37142
	99.5%	37142
	97.5%	30104
	90.0%	16739
quartile	75.0%	11823
median	50.0%	8688
quartile	25.0%	5240
	10.0%	2795
	2.5%	1347
	0.5%	1037
minimum	0.0%	1037

Quantiles		
maximum	100.0%	2398.0
	99.5%	2398.0
	97.5%	2268.2
	90.0%	1819.3
quartile	75.0%	1609.8
median	50.0%	1456.0
quartile	25.0%	1296.0
	10.0%	1148.5
	2.5%	1031.3
	0.5%	1007.0
minimum	0.0%	1007.0

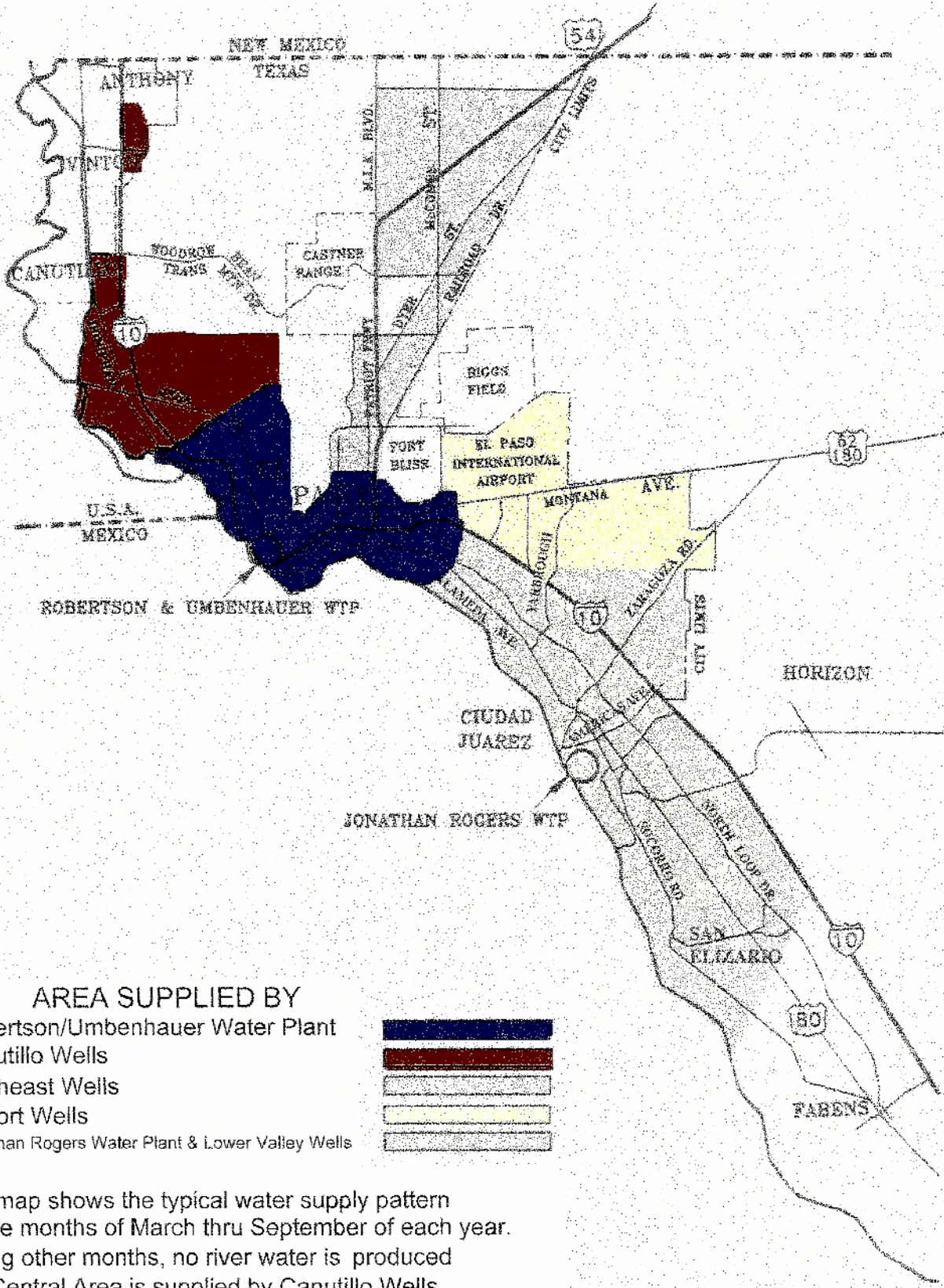
Moments	
Mean	9727.01
Std Dev	6480.60
Std Error Mean	748.32
Upper 95% Mean	11218.07
Lower 95% Mean	8235.96
N	75.00
Sum Weights	75.00

Moments	
Mean	1479.511
Std Dev	278.137
Std Error Mean	28.998
Upper 95% Mean	1537.112
Lower 95% Mean	1421.910
N	92.000
Sum Weights	92.000

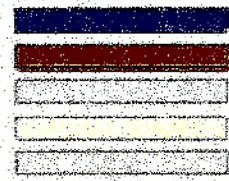
Test for Normality		
Shapiro-Wilk W Test		
	W	Prob<W
	0.871018	<.0001

Test for Normality		
Shapiro-Wilk W Test		
	W	Prob<W
	0.929021	<.0001

Figure 4 - Typical Water Distribution Supply Pattern

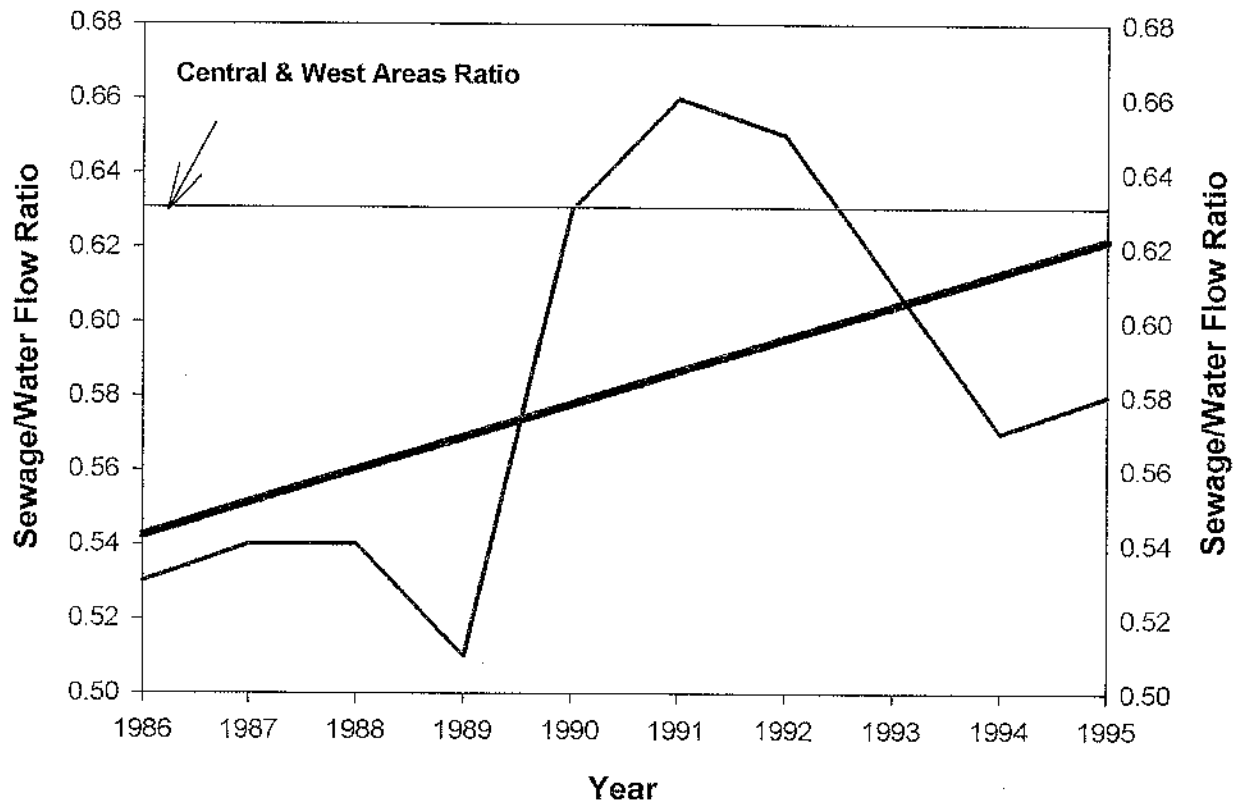


- AREA SUPPLIED BY**
- Robertson/Umbenhauer Water Plant
 - Canutillo Wells
 - Northeast Wells
 - Airport Wells
 - Jonathan Rogers Water Plant & Lower Valley Wells



This map shows the typical water supply pattern for the months of March thru September of each year. During other months, no river water is produced. The Central Area is supplied by Canutillo Wells and the Lower Valley supplied by Airport and Lower Valley Well Field.

Figure 5 - Ten Year Historical Sewage/Water Flow Ratios



— Year vs Sewage/Water
— Plot 1 Regression

Figure 6 - Comparison of Water and Wastewater Flows

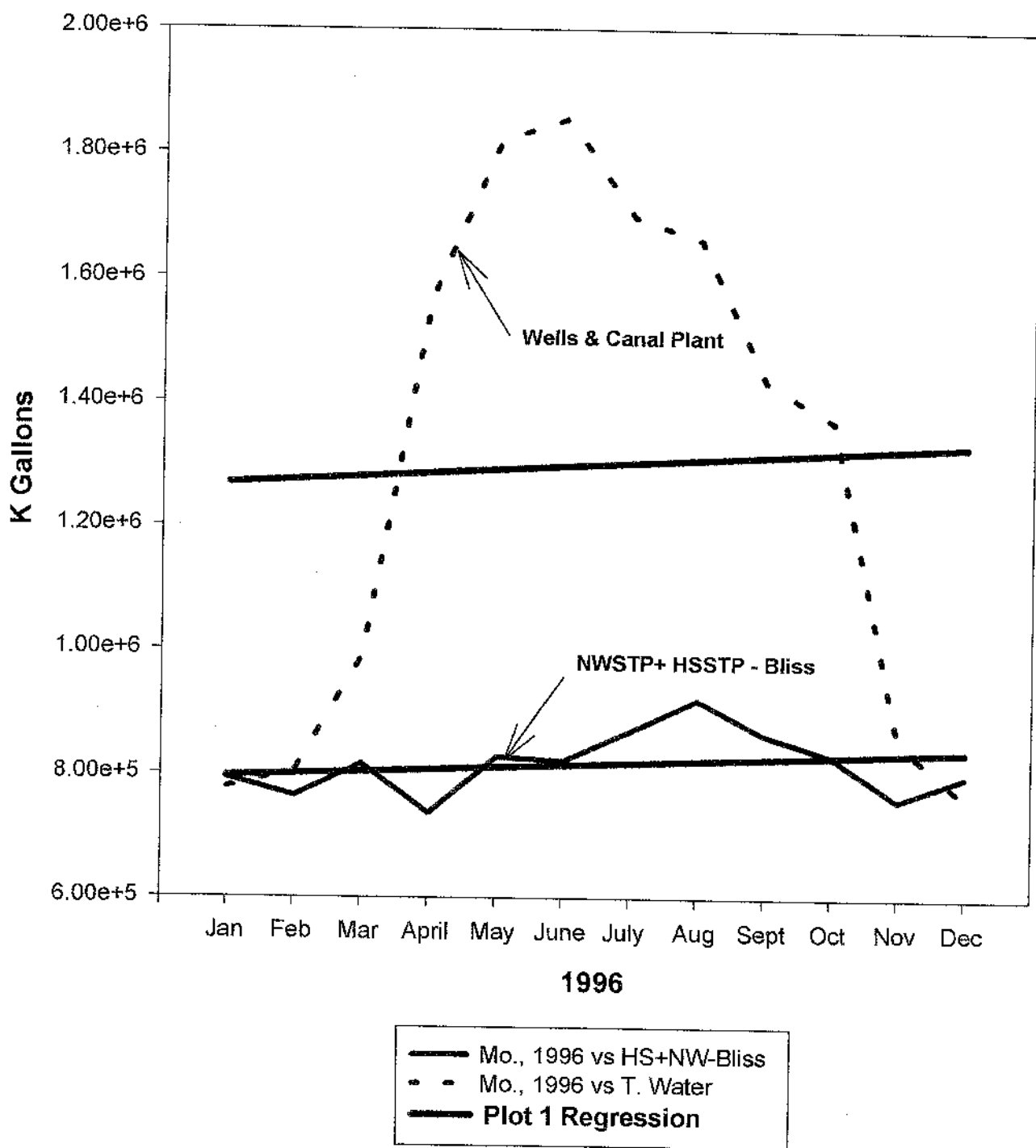
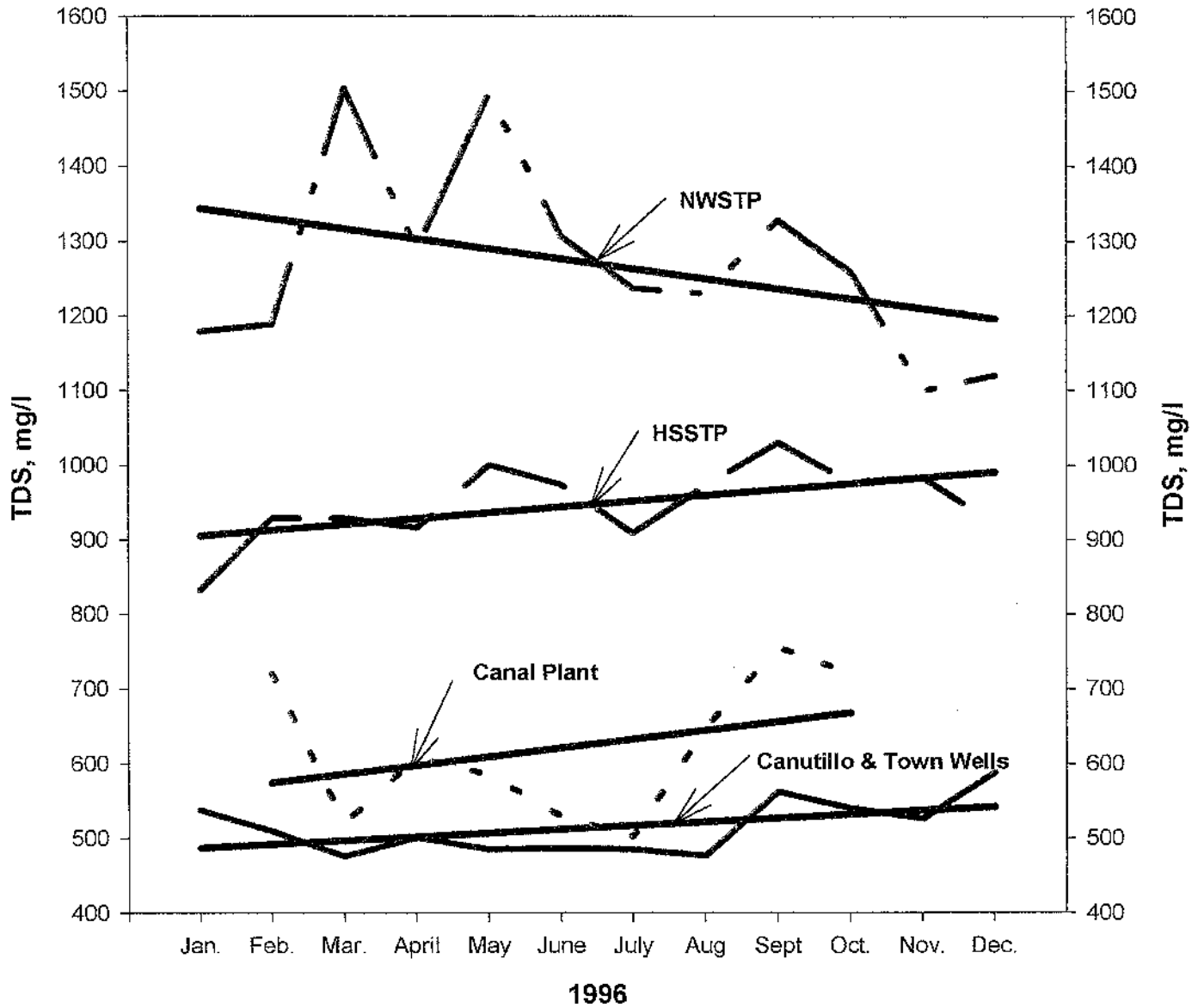


Figure 7 - Comparison of Water & Wastewater TDS Levels



- Mo., 1996 vs Wells
- - Mo., 1996 vs Canal TDS
- Mo., 1996 vs HS TDS
- Mo., 1996 vs NW TDS
- Plot 1 Regression

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