ECONOMIC IMPACT OF THE SAFE DRINKING WATER ACT (PUB. L. 93-523) ON THE STATE OF TEXAS

14-60034

Prepared For

THE TEXAS WATER DEVELOPMENT BOARD

By

BERNARD JOHNSON INCORPORATED

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GLOSSARY OF TERMS

Feed Water	Raw water influent which precedes treatment by the physical and/or chemical process.
Product Water	Effluent water from the specific unit treatment process.
Service Water	Effluent water from the treatment plant which is distributed for service.
Blending Water	A quantity of water not treated by the specific unit treatment process, but is used to blend with the product water.
Demand Water	The quantity of treated water which is demanded by a specific community.
Unit Treatment Cost	The cost for treating one thousand gallons of water, expressed in terms of $/Kgal.
O&M Costs	Operation and maintenance cost which includes costs for chemicals, labor, electrical, and power.

CHAPTER I

SUMMARY AND CONCLUSIONS

Based upon an evaluation of available data for cities with populations less than 50,000, there are problems of compliance in over 500 water supplies in the State of Texas relative to the National Interim Primary Drinking Water Regulations issued under the Safe Drinking Water Act (Pub. L. 93–523). These water supplies serve an estimated 557,500 people. The problem addressed in this study and report relates to excessive nitrate and fluoride concentrations only. From investigation of this problem and the respective solutions, the following conclusions can be drawn:

1. There are a total of 501 water supplies exhibiting excessive fluoride. The fluoride concentration ranges from 1.6 to 8.7 ppm relative to a standard of 1.4 to 1.8 ppm F^- which depends upon location within the State.

2. There are a total of 46 water supplies exhibiting excessive nitrate. The nitrate concentrations range from 50 to 150 ppm relative to a standard of 45 ppm as NO_3.

3. There are a total of 7 water supplies which exhibit compliance problems for both nitrate and fluoride.

4. Fluoride problems are found predominantly in the Ogallala, Trinity Group, and Carrizo-Wilcox aquifers. Nitrate problems are essentially undefinable relative to a particular aquifer.

5. There are numerous applicable water treatment processes that can remove fluoride and nitrate.

6. Among the applicable processes, ion exchange demineralization is the most expensive of all on a unit cost basis ($/Kgal).

7. The cost of nitrate removal by reverse osmosis (RO) or selective ion exchange is dependent upon the flow demand and concentration. Selective ion exchange is more economical than RO at a 1 MGD flow rate or higher and a concentration of 86 ppm NO_3^-. But for higher nitrate concentrations or lower flow rates, RO would most likely be selected.

8. The cost of removal of fluoride by either reverse osmosis or tri-calcium phosphate adsorption is also dependent on concentration and flow rate. The economic analysis indicates that as the flow rate and fluoride concentration increases, the use of tri-calcium phosphate adsorption would be preferred.

9. All of the fluoride non-compliant water supplies having fluoride concentrations less than 2.5 ppm and populations less than 1,000 (0.15 MGD) should consider the use of reverse osmosis rather than tri-calcium phosphate adsorption.

10. When both fluoride and nitrate exceed drinking water standards, reverse osmosis is the only process that can remove both contaminants effectively and economically.

11. An estimated total initial capital cost of $73,300,000 would be required based on 1976 dollars to produce compliance with the Interim Primary Standards for cities less than 50,000 population in the State of Texas. This cost will increase annually approximately 10%, along with a compounded population growth rate of 2 percent/year through 1986. Thus if compliance is delayed until 1986, the cost would escalate to $176,000,000.

12. The 1976-based estimate of additional operation and maintenance costs for the State are estimated to be $15,500,000/year. In 1986, these incremental costs would escalate to $43,100,000/year.

CHAPTER II

INTRODUCTION

The U.S. Congress enacted legislation on December 3, 1972, which was signed into law by the President on December 17, 1974, entitled the Safe Drinking Water Act (Pub. L. 93-523). This Act establishes the right of the Environmental Protection Agency to formulate both primary and secondary water quality standards for public water supplies. The primary standards are established to protect the public from adverse health effects. The secondary standards which are not enforceable at the federal level are based primarily on aesthetic criteria such as taste, odor and appearance.

Under this Act, the EPA established and promulgated National Interim Primary Drinking Water Regulations. National Secondary Drinking Water Standards have not been promulgated as of the date of this report.

The Texas Water Development Board (TWDB), in order to develop a preliminary estimate of the economic impact of the Interim Primary Regulations on the State of Texas, contracted with Bernard Johnson Incorporated to conduct a study and prepare a report. The objective of this effort was to establish the technical and economic impact of these regulations. The scope was limited to those cities in the State having a population of less than 50,000. A sampling and analysis program, in addition to a program of site visits, was also included within the scope of this project to establish a first-hand knowledge of individual situations in cities exhibiting compliance problems with these regulations.

Site visits were made to 18 cities and municipalities across the State to establish existing conditions and compliance plans. This information provided additional input information to the cost analysis. A tabulation of the site visits is presented in Appendix B.

The determination of the most technically and economically feasible treatment facilities for the non-compliant water supplies in the State is the primary focus of this report. Contained within this report are discussions of the compliance problems, the geographical distribution of these problems, proposed and recommended methods of control and ultimately the total aggregated cost of compliance. These costs are presented in terms of the capital, operation and maintenance, and unit treatment costs and ultimately as the total and incremental economic impact on the State of Texas.

It is important to emphasize that these are incremental costs which must be added to other supply, treatment and distribution costs to obtain the total water supply costs. For example these do not include the cost for disposal of brine and reject water produced by the reverse osmosis and ion exchange processes or costs that would be incurred if pretreatment other than filtration is needed for the reverse osmosis system.

The incremental costs presented in this report are based upon available information and regulations as they existed in late 1976. As regulations develop to further define the scope of impact of the Safe Drinking Water Act on the State of Texas these incremental costs would necessarily need to be adjusted accordingly.

CHAPTER III

DRINKING WATER STANDARDS

Under the Interim Primary Drinking Water Regulations of the Safe Drinking Water Act (SDWA), maximum limitations have been established for a wide range of organic and inorganic contaminants. A tabulation of the contaminants and their respective maximum limitations is presented on Table III–1.

The Texas Department of Health Resources (TDHR) published most recently in 1974 a report entitled "Chemical Analysis of Public Water Supplies". From that report and supplemental data supplied by the TDHR and the TWDB, the TWDB tabulated data on existing public water supply systems exhibiting non-compliance with the Interim Primary Standards. This listing, which is included as Appendix A to this report, illustrates that the two contaminants which will have the most significant effect on the State of Texas are fluoride and nitrate.

In a majority of cases, the public water supply systems exhibit problems with only one of the parameters. Overall, there are more water supply systems with fluoride problems than with nitrate. The geographical distribution of non-compliance problems is presented in Chapter IV of this report.

The numbers provided by the attached tabulation in Appendix A are the best available at the time of this project. They are used as a basis for estimating the applicability of treatment processes, in addition to the associated treatment cost.

CHAPTER IV

NON-COMPLIANT WATER SUPPLY SYSTEM POPULATIONS AND CONCENTRATIONS

According to the data presented in Appendix A, there are a total of 547 public water supply systems in Texas serving cities of 50,000 population and below where drinking waters exceed the SDWA limitations for nitrate and fluoride. Among these supplies, 501 have excess fluoride, 46 have excess nitrate, and 7 have both excess fluoride and nitrate. These water supply systems are distributed more or less evenly throughout the State of Texas, as shown on Figures IV–1 through IV–3. As an overall group, these locations can be divided into population categories as shown on Table IV–1. The population distribution indicates that over 60% of the total populations served by non-compliant water supply systems live in an area where the water supply serves less than 500 people.

In the non-compliant systems, the nitrate (NO_3^-) concentration of the water supply ranges from 50 to 150 ppm, with an arithmetic average of 86 ppm. The fluoride (F^-) concentration of the water supply varies from 1.6 to 8.7 ppm, with an average concentration of 2.6 ppm of F^-. The TDS content in the non-compliant systems averages 1,250 ppm. The non-compliant water systems and the respective concentrations are tabulated in Appendix A by county.

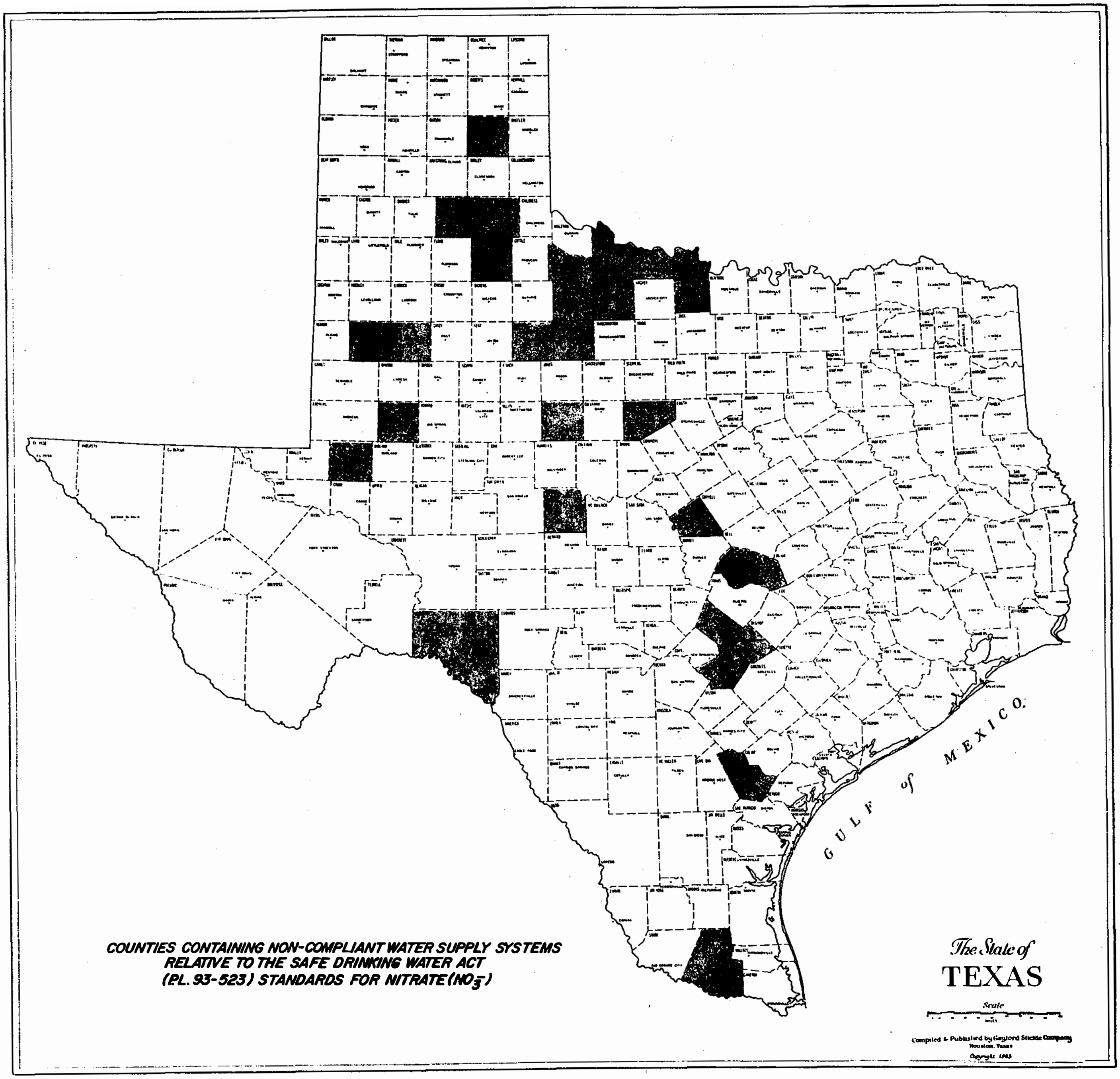

COUNTIES CONTAINING NON-COMPLIANT WATER SUPPLY SYSTEMS
RELATIVE TO THE SAFE DRINKING WATER ACT
(PL. 93-523) STANDARDS FOR NITRATE (NO_3^-)
GULF of MEXICO
The State of
TEXAS
Scale

FIGURE IV-1

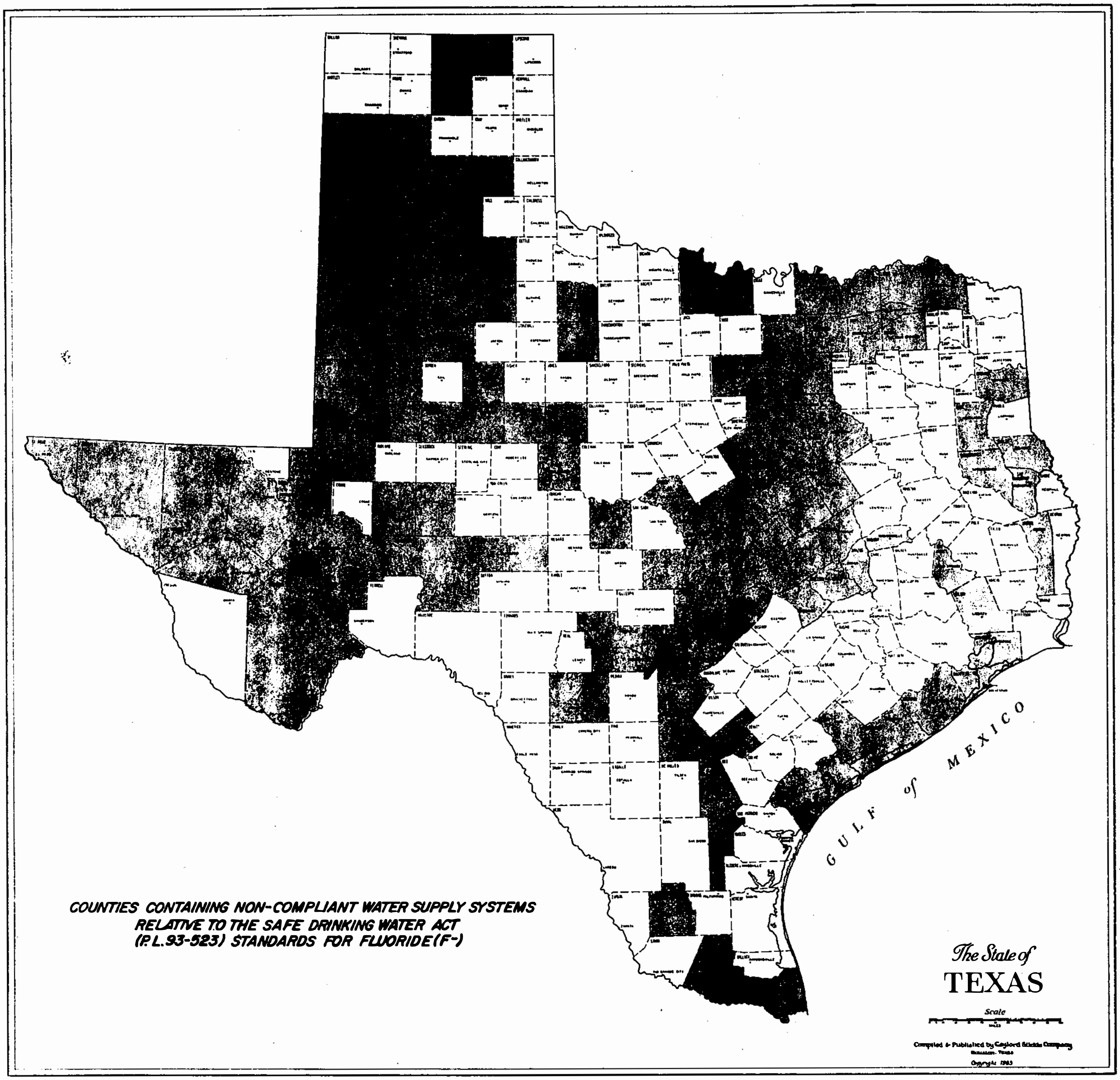
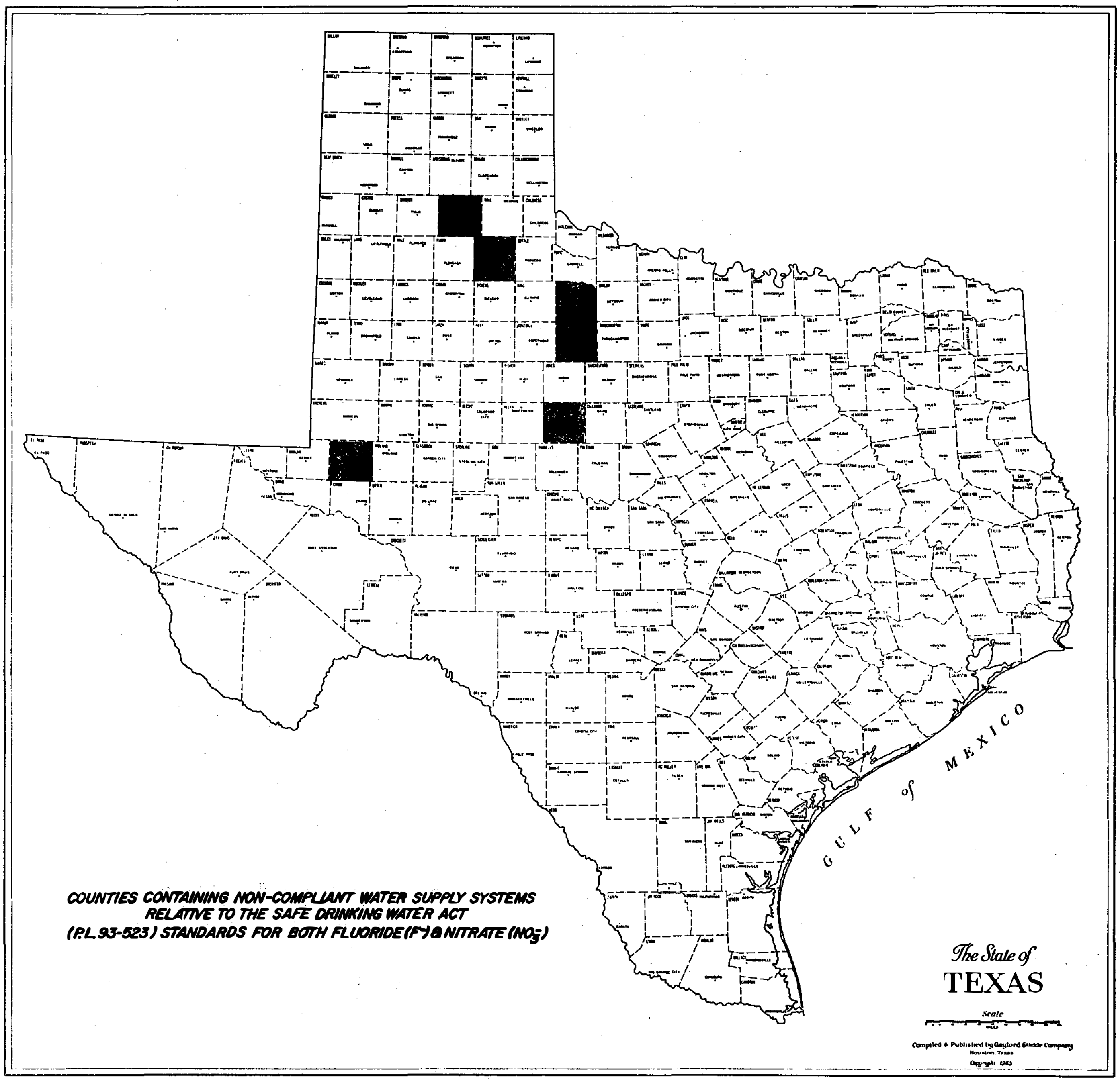

COUNTIES CONTAINING NON-COMPLIANT WATER SUPPLY SYSTEMS
RELATIVE TO THE SAFE DRINKING WATER ACT
(P.L.93-523) STANDARDS FOR FLUORIDE (F-)
GULF of MEXICO
The State of
TEXAS
Scale

FIGURE IV-2



COUNTIES CONTAINING NON-COMPLIANT WATER SUPPLY SYSTEMS
RELATIVE TO THE SAFE DRINKING WATER ACT
(P.L. 93-523) STANDARDS FOR BOTH FLUORIDE (F^-) & NITRATE (NO_3^-)

FIGURE IV-3

TABLE IV-1

POPULATION DISTRIBUTIONS

Population	Number of Locations	% of Total Locations
16,000 - 10,000	8	1.9
10,000 - 5,000	13	2.4
5,000 - 3,000	15	2.7
3,000 - 1,000	85	15.5
1,000 - 500	69	12.5
500 - 100	240	43.7
≤ 100	117	21.3

CHAPTER V

PROCESS EVALUATION

Both nitrate and fluoride are strongly ionized chemical species. Their salts are very soluble and tend to dissociate into individual ionic components in water. Conventional water treatment processes such as chemical precipitation have therefore failed to remove them effectively. Several physical-chemical treatment processes, i.e., reverse osmosis (RO), ion exchange (IX), and adsorption process have reportedly been successful in removing the contaminants in water treatment systems. Each of these processes possesses unique characteristics and limitations for the particular chemical species removed. It is therefore desirable to consider each of these processes individually in a technical sense for either or both nitrate and fluoride removal.

NITRATE REMOVAL PROCESSES

Through a comprehensive investigation, it has been determined that there are only a few treatment systems which have the technical capability of removing nitrates from raw water supplies. This list includes reverse osmosis, selective ion exchange, demineralization by ion exchange, and biological denitrification. Each of these treatment processes has its individual operating and efficiency characteristics relative to the removal of nitrate. The aspects will be discussed in the following narrative.

Reverse Osmosis

Reverse osmosis (RO) is a process in which water under pressure (on the order of 60-600 psig) is forced through a semi-permeable membrane. These RO membranes have porosities which will prevent the transfer of most dissolved minerals, particulate matter, and organics across the membrane while allowing the water to be transferred through the membrane. A typical RO system can produce a product water recovery rate of 75 percent of the input water and subsequently 25 percent concentrated waste solution (reject). In other words, for every gallon of raw water input, this system will produce 0.75 gallon of purified water. With a constant operating pressure, the higher the TDS content in the raw feed water, the less purified water will be produced from the RO process.

The most common method of evaluating a RO membrane's ability to separate dissolved materials is to measure the salt rejection which is the ratio of the weight of dissolved material in the reject stream to the weight of dissolved material in the raw feed water. The overall rejection and the rejection selectivity depends on chemical properties of solute, membrane type, and other water characteristics. The amount of salt passing through a unit area of RO membrane may be expressed as:

$$F\ salt = \beta(C_h - C_l) = \beta \Delta C$$

where:

- F salt - salt flux, g/sq cm/sec
- β - salt permeability coefficient, cm/sec
- C_h - concentration of solute on high pressure side of membrane, g/cc
- C_l - concentration of solute on low-pressure side of membrane (product water side), g/cc

From the equation, normal salt flux is independent of pressure. Theoretically, if the pressure of RO system is increased, the salt will diffuse at a constant rate, while the product water flow rate will increase. Quantitatively, the water flow rate through the membrane is described by:

$$F_{H_2O} = A(\Delta p - \Delta \pi)$$

where:

- A - constant
- Δp - pressure exerted on the feed solution P_f less the pressure on product P_p
- $\Delta \pi$ - osmotic pressure of the feed solution (π_f) less the osmotic pressure on the product side (πp)

The equation can be simplified for high operating pressure ($\simeq$400 psig) by putting all of the constants into a coefficient A'. The flux of water at constant temperature is therefore approximated

$$F_{H_2O} \simeq (A')(P_{feed}).$$

The result of higher feed pressure (P_{feed}) will be a greater production of purified water.

A typical RO membrane's salt rejection ratio for specific solutes is shown in Table V–1, the rejection rate varies somewhat for different commercial brands.

In addition to the property of membranes, certain feedwater characteristics can affect the performance of a RO permeator through chemical interaction with the membrane, such as:

i) pH - should be between 4.0 - 7.5, to avoid RO membrane hydrolysis,

ii) Feedwater Temperature - should not exceed 30°C, or be lower than 0°C, and

iii) Total Dissolved Solids (TDS) - the TDS content of the feedwater will influence the performance of RO in two ways;

a) Generally, if the TDS is less than 2500 ppm, a 75% recovery rate may be expected (Figure V-1). The product water recovery rate decreases as the TDS content increases,

b) The salt passage correction factor increases as feedwater TDS content increases (Figure V-2), if a constant purified water recovery rate is maintained.

One of the first RO systems for municipal water treatment (0.15 MGD) was installed in 1970's at Greenfield, Iowa. The raw water contains 2,250 ppm TDS, the product water from RO contains only 142 ppm, for a 94% reduction in TDS. Table V-2 also indicates the nitrate reduction from 9.0 to 0.06 ppm, which the system is achieving. Recently, more water treatment plants have installed RO for the treatment of brackish water (containing $\leq$ 2500 ppm TDS). Residential developments at Key Largo (0.35 MGD) and Fort Pierce (0.15 MGD), Florida are examples of this type of application for RO. To date, however, there has not been a RO plant installed solely for the purpose of nitrate removal.

TABLE V-1

RO MEMBRANE SALT REJECTIONS[1]

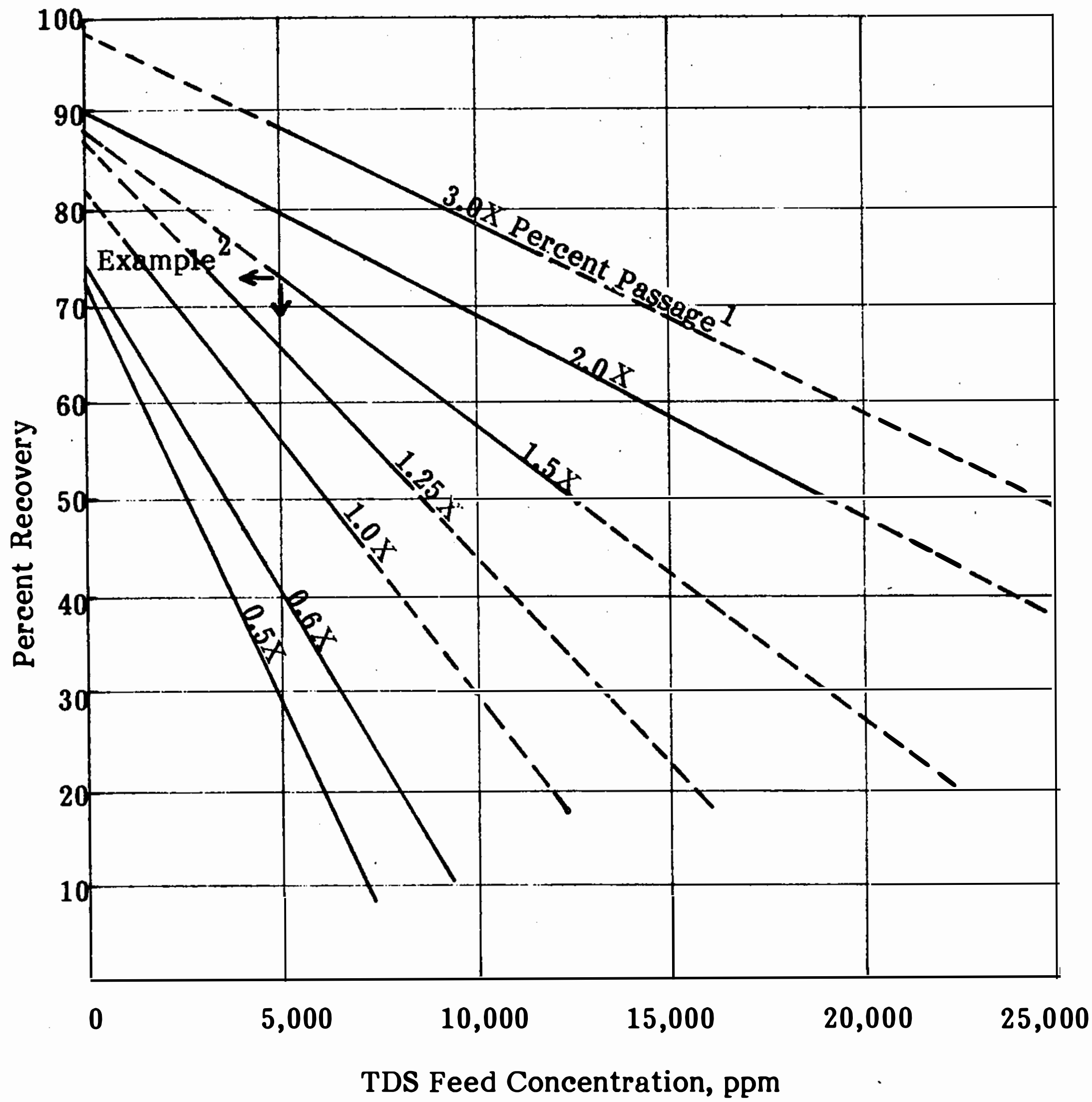
Constituent	Percent Passage	Percent Rejection
NO_3^-	10%	90%
Cl^-	10%	90%
$SO_4^=$	4%	96%
PO_4^{-3}	2%	98%
F^-	10%[2]	90%
Ca^{+2}	4%	96%
Na^+	10%	90%

1 At 75% recovery rate, 25% rejection rate. TDS 2,500 ppm.

2 pH dependent, higher pH produces lower passage rate (higher rejection rate) (refer to Figure V-4, page V-16).

FIGURE V-1

PERCENT RECOVERY VERSUS
TDS FEED CONCENTRATION
RELATIVE TO A REFERENCE CONCENTRATION[3]



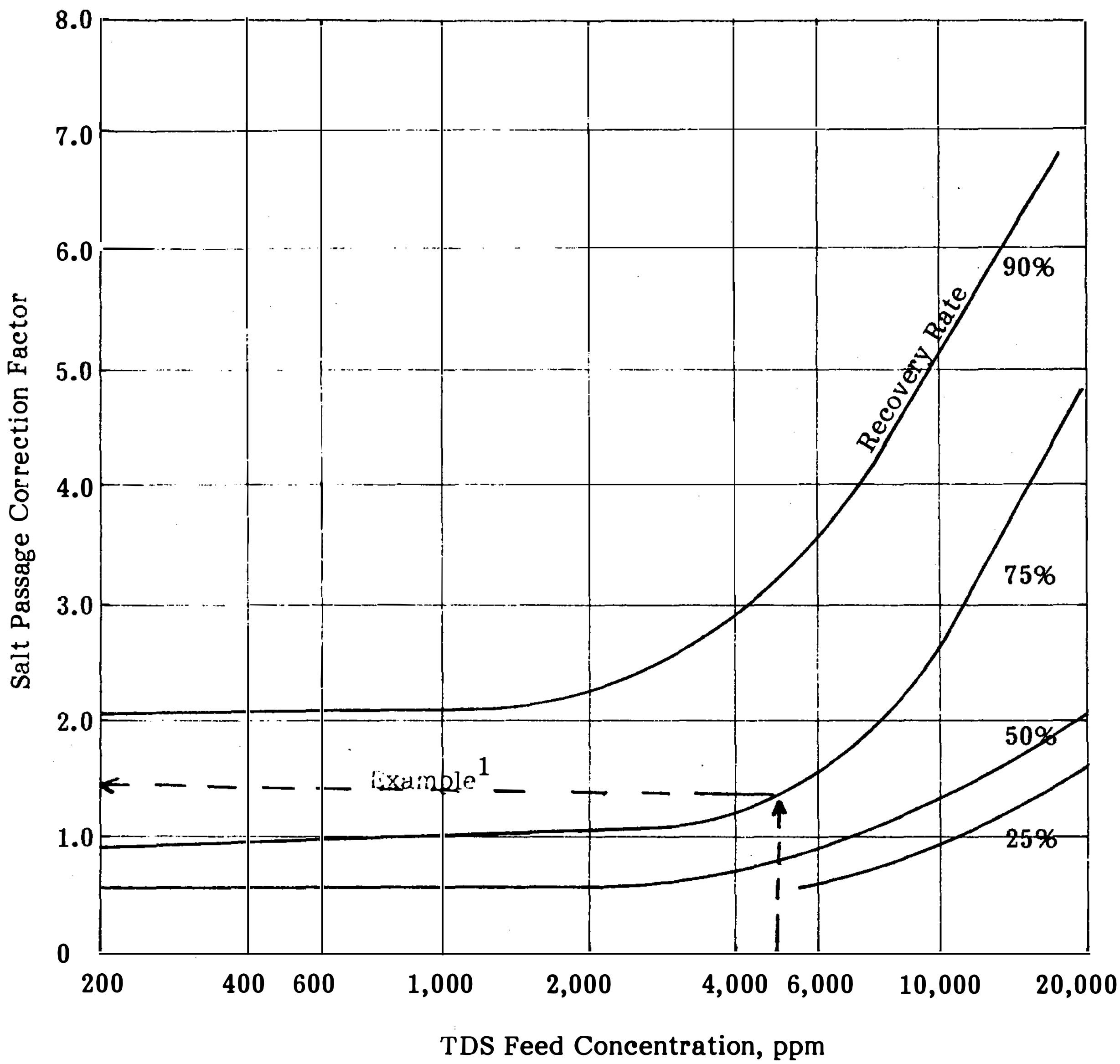
[1]Refer to Table V-1: RO Membrane Salt Rejection.

[2]For example, if a RO feed water contains 5,000 ppm of TDS, the product water will contain 1.5 times as much TDS as a product water produced from a feed water containing only 1,250 ppm of TDS if a recovery rate of 75% is maintained in both systen

[3]1,250 ppm TDS is a reference value for this figure since it represents the average TDS of the non-compliant systems studied. See Page IX-1.

FIGURE V-2

SALT PASSAGE CORRECTION FACTORS RELATIVE TO A REFERENCE CONCENTRATION [2]



[1] For example, if a RO feed water contains 5,000 ppm of TDS, the product water will contain 1.5 times as much TDS as a product water produced from a feed water containing only 1,250 ppm of TDS if a recovery rate of 75% is maintained in both systems.

[2] 1,250 ppm TDS is a reference value for this figure since it represents the average TDS of the non-compliant systems studied. See Page IX-1.

TABLE V-2

RO PRODUCT WATER QUALITY
GREENFIELD, IOWA PLANT

	Pretreated Feed	Actual Product
Calcium	150	1.4
Magnesium	45	0.4
Sodium	474	38
Potassium	24	1.8
Bicarbonate	81	65
Sulfate	1,125	17.5
Chloride	335	17.2
Fluoride	1	0.2
Nitrate	9.0	0.06
Silica	7	0.05
Iron	2.2	0.05
Manganese	0.02	0.02
Phosphate	16.2	0.18
Conductance	3,000	220
pH	5.7	7.5
Hardness	560	5.0
TDS	2,250	142

In addition to the beneficial performance of RO in removing TDS, there are certain advantages, such as: corrosion problems are minimal; low temperature operation is possible; and energy requirements are comparatively small.

Ion Exchange

Ion exchange is the reversible interchange of solute ions between a solid ion exchange resin and a solution. To be effective, solid ion exchange resins must contain ions of their own, be insoluble in water, and provide enough space in their porous inner structure for ions to pass freely in and out of the resin. There are both cationic and anionic exchange resins depending on the chemical composition of the material used to make the resin.

In aqueous media, ion exchange resins are able to exchange their cations (or anions) for other cations (or anions). Cation exchange resins have a negatively charged framework to which the cationic exchange ions are attached thereby maintaining electroneutrality. Anion exchange resins carry just the opposite arrangement of electrical charges. An example of various ion exchange processes is presented on Figure V-3.

The performance of the ion exchange resin depends on its exchange capacity, raw water total dissolved solids concentration, and the regenerant used. As the exchange capacity of a resin nears exhaustion, the level of contaminants in the effluent will increase rapidly. Once the contaminant level in the treated water reaches unacceptable levels, regenerant chemicals are used to remove the contaminant materials from the resin and replace them with either the anionic or cationic portion of the regenerant chemical, thereby recovering the ion exchange capacity.

Nitrate can be removed by either of two ion exchange processes depending on the type of exchange resin used, i.e.,

FIGURE V-3

ION EXCHANGE PROCESS EXAMPLES

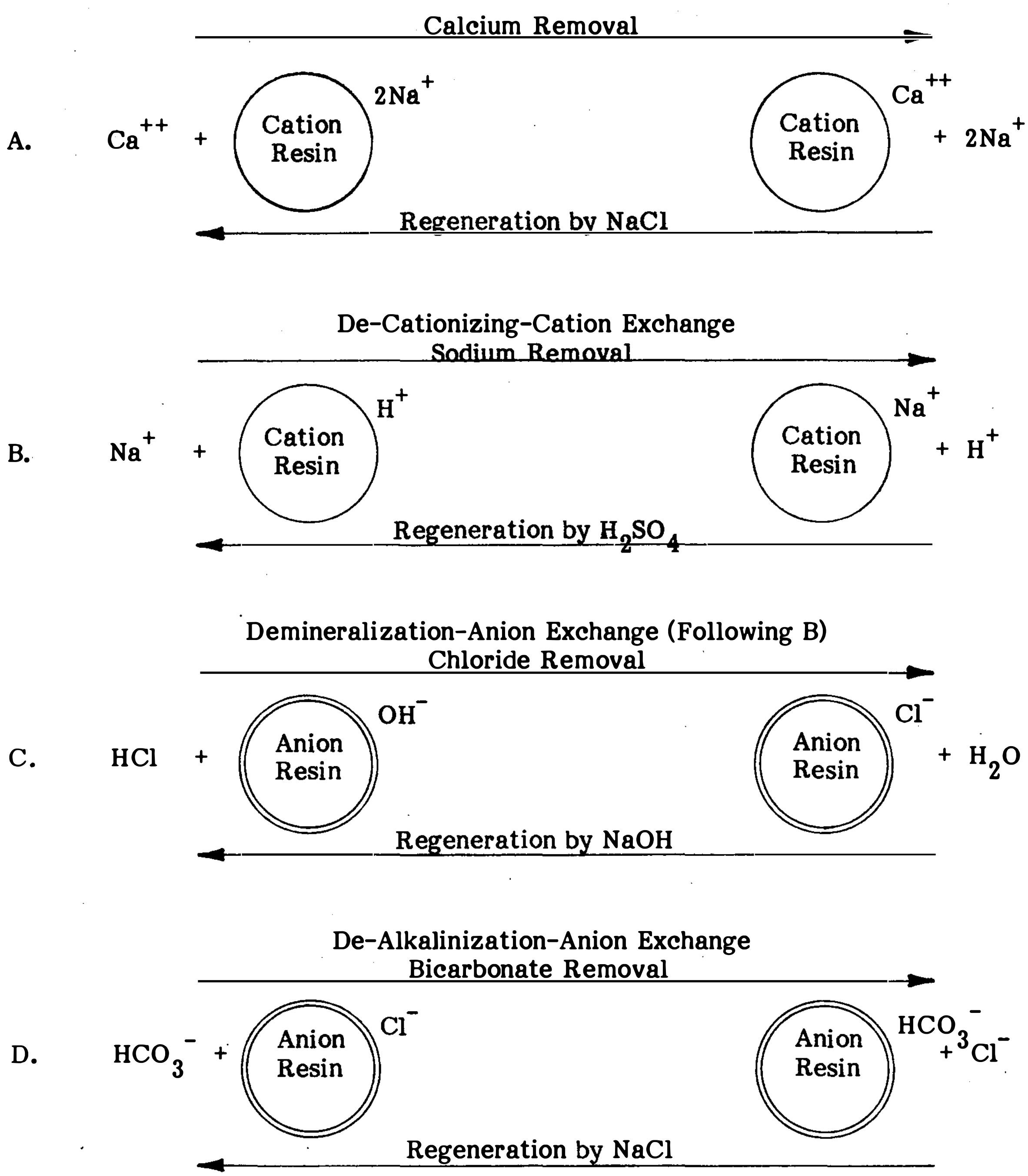
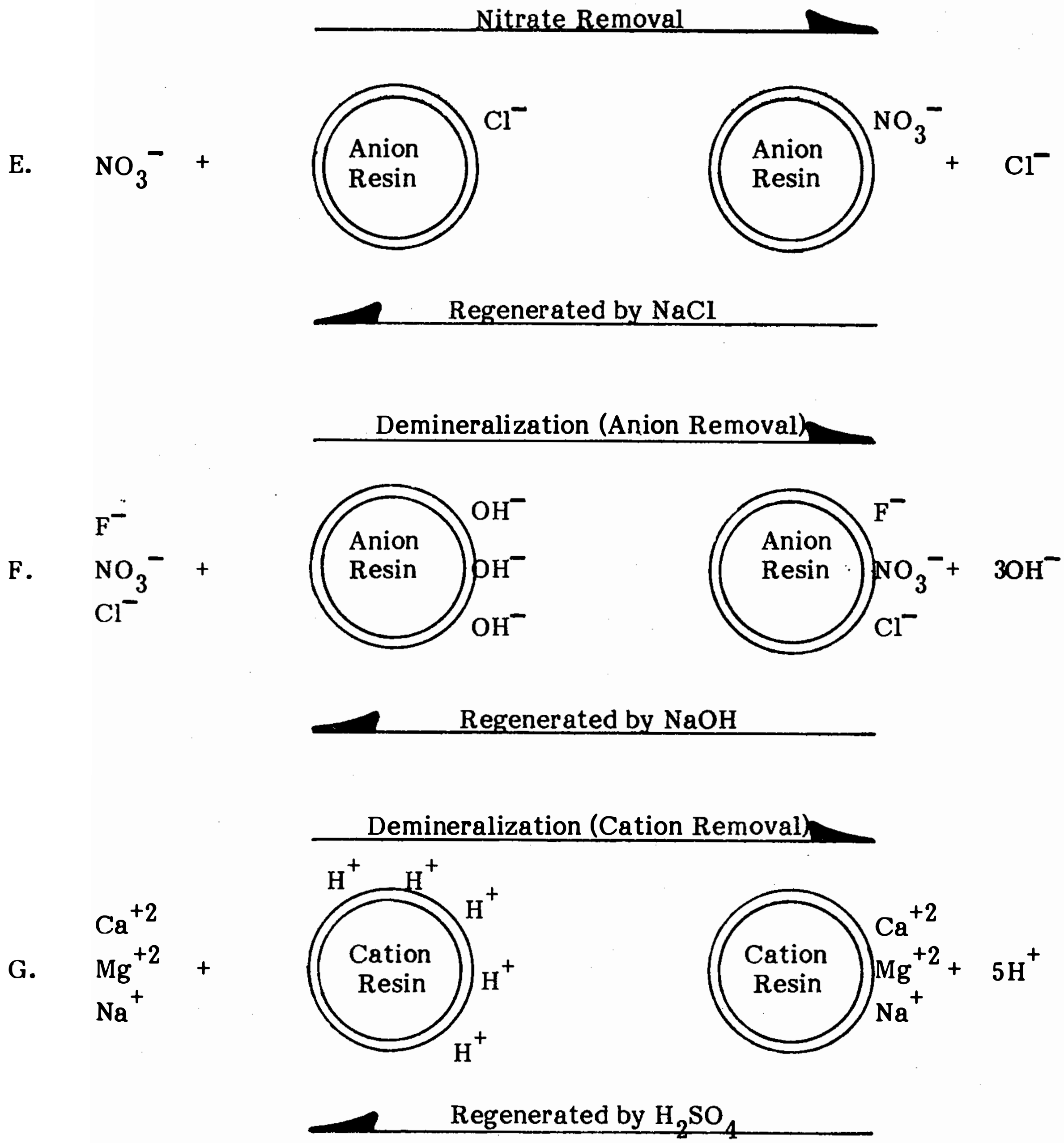


FIGURE V-3 (Continued)



Selective Ion Exchange

The nitrate in a raw water supply is replaced by other anions (chloride). The system was originally developed for recovering ammonium nitrate from fertilizer plant effluents by Chemical Separation Corporation of Oak Ridge, Tennessee. The process uses Dowex synthetic anion ion exchange for the adsorption of nitrate.

The first municipal water supply system that adopted the selective nitrate ion exchange process was in Garden City, Long Island, New York. Their groundwater supplies had an undesirably high level of nitrate. After evaluating a prototype of the selective ion exchange plant's performance, it was confirmed that the process could reduce the nitrate content to well below the drinking water standards. Table V-3 summarizes the results of several sets of test runs (Garden City and Oak Ridge).

These runs conclusively demonstrated the ability of the process to significantly reduce NO_3^- levels. However, these removed nitrate ions are all replaced by chloride (Cl) anion. Thus, the TDS in the influent water will not be reduced, but replaced by more chloride ions. If a water already contains high levels of chloride, the effluent may have an objectional level of chloride ions after the nitrate is removed from the water.

Demineralization

The demineralization of water is generally effected in a two-step process, in which the water is passed successively through a cation exchanger resin in the hydrogen (H^+) form, (H^+R^-) where R represents the resin, and an anion exchanger in the hydroxide (OH^-) form, (R^+OH^-). On entering the cation exchanger, all cations are exchanged for an equivalent quantity of H^+ ions. The effluent, actually a solution of the acids of anions, enters the anion exchanger where all anions are exchanged for hydroxide (OH^-) ions that neutralize the equivalent quantity of H^+ formed in the cation exchanger. A single vessel containing a

TABLE V-3

THE PERFORMANCE OF SELECTIVE NO_3 ION EXCHANGE

Nitrate Removal Test Runs

Water Used	Nitrate Nitrogen Levels-mg/l Feedwater Specific Ion Electrode	Feedwater Wet Chemical Analysis	Treated Water Specific Ion Electrode	Treated Water Wet Chemical Analysis
Garden City well	29	16.0	3.1	0.14
Garden City--with $NaNO_3$ added	47	26.0	4.4	0.38
Oak Ridge--with $NaNO_3$ added	62	88.0	18	14.7
Oak Ridge--with $NaNO_3$ added	29	--	4	--
Oak Ridge--with $NaNO_3$ added	37	26.4	11	4.2
Oak Ridge--with $NaNO_3$ added	43	30.8	19.0	12.4

mixture of equivalent quantities of cationic and anionic exchange resins in a mixed-bed, is a more recent development in water demineralization process. The effluent is generally superior in water quality to the feedwater because most of the TDS was removed.

In water treatment, the common constituents that are removed by these cationic and anionic exchangers are summarized in Table V-4.

If water containing nitrate and fluoride is fed through the demineralization process the resultant product water will be low in TDS, nitrate and fluoride. The quality of the effluent depends on the detention time in the demineralization column, the ion exchange capacity, and the quantity of raw water processed.

Denitrification

The investigation on the removal of nitrates from irrigation return waters in the California San Joaquin Valley in 1968 has indicated that biological denitrificates may be an economical way to remove nitrate, and has proved that denitrification filter beds have the ability and efficiency of operation necessary for treatment of a drinking water supply. Under ideal conditions, the denitrification process can be carried out only if the denitrification organisms are supplied with an organic energy source, and only if dissolved oxygen is not available. Methanol (CH_3OH) had been found to be the most satisfactory and least expensive material for the energy source. Careful control of methanol feeding would be required to prevent problems either from underdosage or overdosage. If an overdosage of methanol was added, excess methanol might be expected in the product water. An underdose would not be able to remove NO_3 effectively. Technically, the process is feasible but practicality is very questionable. A significant amount of research would be required to determine the full-scale feasibility of using denitrificaiton for nitrate removal in water supplies destined for human consumption.

TABLE V-4

TYPICAL IONS REMOVED IN DEMINERALIZATION

Cations		Anions	
Calcium	(Ca^{++})	Bicarbonate	(HCO_3^{-})
Magnesium	(Mg^{++})	Carbonate	(CO_3^{--})
Sodium	(Na^{+})	Sulfate	(SO_4^{--})
Potassium	(K^{+})	Chloride	(Cl^{-})
Iron	(Fe^{++})	Nitrate	(NO_3^{-})
Manganese	(Mn^{++})	Silicate	$(HSiO_3^{-})$
Aluminum	(Al^{+++})	Silicate	(SiO_3^{--})

Electrodialysis

The electrodialysis membrane process which uses electrical forces to separate ions was not considered for this study.

FLUORIDE REMOVAL PROCESSES

Fluoride can be removed by a considerable number of processes which involve primarily physical chemical methods. These systems are discussed in the following narrative.

Reverse Osmosis

Fluoride reduction by RO is a function of feedwater pH (see Figure V-4). Other characteristics of the RO membrane have been discussed in detail previously in the Nitrate Removal Processes section.

Demineralization

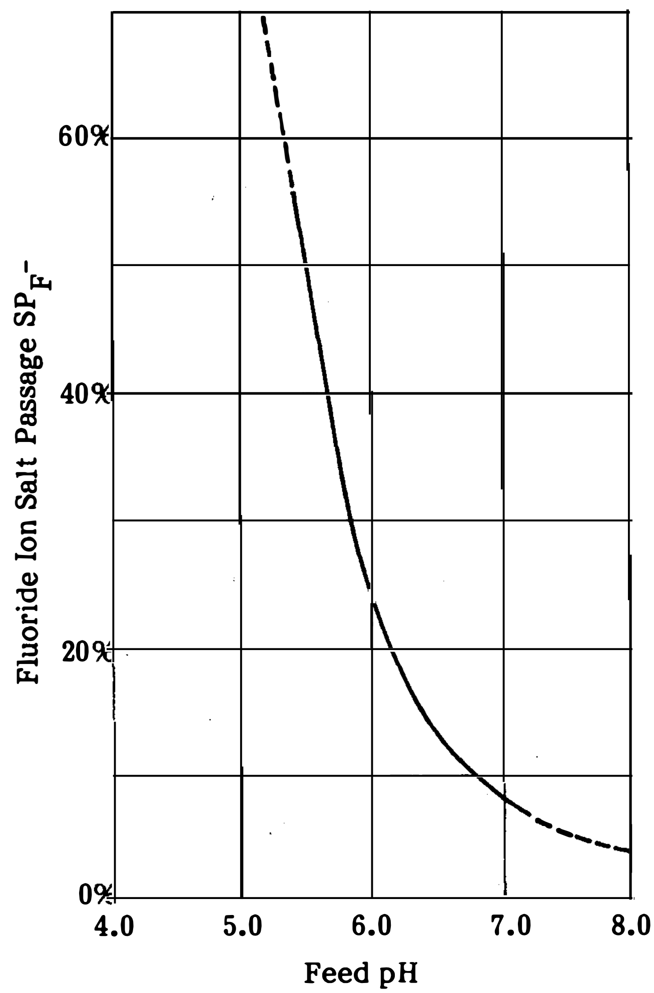
See the Nitrate Removal Processes section.

Bone Char (Tri-Calcium Phosphate) Adsorption

Bone char is a porous, amorphous solid prepared from bones. This material consists principally of tri-calcium phosphate and carbon. The bone has high porosity and physical stability which are both desirable properties. This is evident in the low loss from attrition and in the long life of the filter bed. The water treatment plant at Britton, South Dakota was the earliest system which utilized bone char (1948). When water containing fluoride is passed through a bed of this material, the fluoride is adsorbed, and the effluent water should be practically free of fluoride. The adsorption mechanism for this reaction apparently is not totally understood even by its developers, but it perhaps involves anion exchange properties of apatites. The carbonate radical of the apatite content of bone, $Ca_3(PO_4)_6 \cdot CaCO_3$ during its first use is replaced by fluoride, forming the insoluble fluoroapatite. Caustic soda

FIGURE V-4

EFFECT OF pH ON
FLUORIDE ION SALT PASSAGE*



* Conditions:

Feed Pressure = 400 psig
Conversion = 75%
F^- Concentration = 1 - 10 ppm

used in regeneration converts the fluoroapatite to hydroxyapatite $Ca_3(PO_4)_2 \cdot Ca(OH)_2$. The hydroxy form then becomes the exchangable material in all subsequent exchange reactions, with the hydroxy radical being replaced by fluoride.

The principal chemical component of bone, tri-calcium phosphate, can also be obtained in a porous, relatively insoluble form. A mesh size of 20-40 is the most suitable particle size used in contact filters for fluoride removal.

According to the operation data available, the initial capacity of tri-calcium phosphate for removing fluoride is between 50-60 grams/ft^3 at a flow rate of 4-8 GPM/ft^2. The subsequent capacity after regeneration is approximately 30 grams/ft^3. Replacement, rather than regeneration, is generally considered to be more economical in a smaller unit.

The supply of bone char would be adequate based upon present estimates of demand in the State. Significant demand increases over and above that projected could produce temporary supply problems.

Activated Alumina Adsorption

Calcined (activated) alumina has been tried in field tests in the U.S. Public Health Service Labs, and at the USPHS pilot plant at Bartlett, Texas in the 1950's. These tests indicated that initial fluoride removal capacity was about 30 grams/ft^3 (514 grains/ft^3). The removal was assumed to take place by adsorption. The adsorption capacity after regeneration by caustic and acid was reduced to 50% of initial capacity.

Table V-5 lists the locations in Southern California where activated alumina or bone char/tri-calcium phosphate has been successfully utilized as a fluoride removing medium.

TABLE V-5

CALIFORNIA DEFLUORIDATION SYSTEMS

Place	Date Installed	Defluoridation Media	Units No.	Units Capacity gpm
Twentynine Palms (W. D. Fulton)	1959	Bone meal derivative	1	13
Twentynine Palms (County Water Dist.)	1961	Bone char	1	3
Panamint Springs (State Div. of Hwys. Maint. Sta.)	1951	Bone char	3	—
Death Valley National Monument (National Park Service Residential Area)	1955	Tri-calcium phosphate	1	4½
Fort Irwin	1954	Bone char	2	33 (each)
Desert Center (State Div. of Hwys. Maint.)	1955	Bone char	1	35
Elsinore	1960	Activated alumina	2	25 (each)
Apple Valley (Youngtowne Water Co.)	1961	Tri-calcium phosphate	1	100
Chocolate Mountain	1961	Tri-calcium phosphate	1	100

Chemical Precipitation

Fluorides are removed concurrently with magnesium in a lime softening process. The fluoride is adsorbed by the magnesium hydroxide precipitate. A lime softening water treatment plant in Ohio indicated that the decrease in fluoride was a function of the magnesium removed. Between 45-65 ppm magnesium must be removed to realize a 1 ppm reduction in fluoride. Based upon this relationship, if 1 ppm fluoride is the desired quality of the treated water, 100 ppm of Mg must be removed, when the initial fluoride content is 2.5 ppm.

Because of the large quantities of chemicals required, the process is adaptable primarily to low fluoride waters requiring softening. Moreover, the problems of chemical and sludge handling is complicated.

COMBINED NITRATE/FLUORIDE REMOVAL PROCESSES

There are at least seven public water supply systems in the State where drinking water has both nitrate and fluoride concentrations which exceed drinking water standards. After reviewing the available processes for removing nitrate or fluoride in the previous sections, it is concluded that only reverse osmosis and demineralization can remove both nitrate and fluoride in a single system. It is not considered to be economically justifiable to recommend that an individual system be installed for the removal of each contaminant independently.

SUMMARY

This section has covered all of the technically feasible treatment processes for the removal of nitrate and/or fluoride from drinking water supplies. A summary of the operational characteristics and applicability of the technically feasible systems considered is presented on Table V-6. This technical evaluation will serve as a basis for the forthcoming economic evaluation of these systems. This stepwise approach will provide the required technical and economic evaluation necessary for the selection of the most appropriate treatment systems.

TABLE V-6

TREATMENT PROCESSES SUMMARIZATION

Process	Operational Characteristics	Application
1. Reverse Osmosis	(1) Membrane technique (2) Reject dissolved solids (3) NO_3^- removal - 90% (4) F^- removal - 90% (5) Good for high TDS water	(1) Remove NO_3^- and F^- nonselectively
2. Selective Ion Exchange	(1) A replacement reaction (2) Media requires regeneration with chemicals (3) Specific resins can replace only NO_3^- with Cl^- (4) Best on low TDS water	(1) NO_3^- selectively removed
3. Demineralization	(1) Removes all cations and anions (2) Media requires regeneration with chemicals	(1) Removes NO_3^- and F^- nonselectively
4. Tri-Calcium Phosphate	(1) Replaces only F^- by OH^- (2) No TDS removal (3) Resin either regenerated or replaced	(1) Selective F^- removal

CHAPTER VI

ECONOMIC EVALUATION

The cost analysis of each treatment process which has been determined to be technically feasible must subsequently be economically evaluated to provide a unit treatment cost comparison so that the most technically and economically feasible process may be selected. This is particularly important when the systems to be evaluated cover the range of capacities involved in this study. This economic analysis involved consideration of the following factors:

i) Population, Flow Rate — In order to prepare the unit treatment costs as a function of the general trend variation with flow rate, the analysis covered a flow rate range of 5 MGD to 0.01 MGD.

ii) Financing Interest Rate — A 7½ percent annual interest rate with a 20-year return period was used. This is equivalent to 9.8 percent capital recovery factor (annual capital cost of amortization).

iii) Capital Costs[1] — Consists of major process and ancillary equipment capital costs.

iv) Operation and Maintenance Costs (O&M) — This item includes labor, electric power, chemicals, and equipment maintenance/service costs for major process and ancillary equipment.

v) Feedwater Quality/Product Water Quality — The feedwater quality varies in the non-compliant systems. Product water quality depends greatly on both process efficiency and feedwater quality. In order to compare the

[1] The year 1976 is the latest year that complete cost data is available on all process systems; therefore, capital costs are based on 1976 dollars in this report in order to provide a valid cost comparison basis.

efficiencies, and the cost of each process, an average raw water quality of 86 ppm NO_3^-, 2.0 ppm F^-, and a total dissolved solids (TDS) of 1250 ppm was used.

This average influent water quality is representative of the present water of the overall list of non-compliant systems.

vi) Unit Treatment Costs — Expressed as dollars per thousand gallons ($/Kgal) of service water supplied to the distribution system. This cost is based on the total annual cost which considers the amortization of capital and the O&M costs.

The annual capital amortization costs are converted to unit capital cost ($/Kgal) by the formula:

$$\frac{\text{Total Capital \$ x Capital Recovery Factor}}{\text{Plant size in MGD x } \frac{\text{1000 Kgal/day}}{\text{1 MGD}} \text{ x 365 days/yr.}} = \text{\$/Kgal}$$

The unit costs are applied to the product water supplied.

NITRATE TREATMENT COSTS ANALYSIS

The processes which are considered for cost analysis for nitrate contaminant removals are reverse osmosis, selective ion exchange, and ion exchange demineralization.

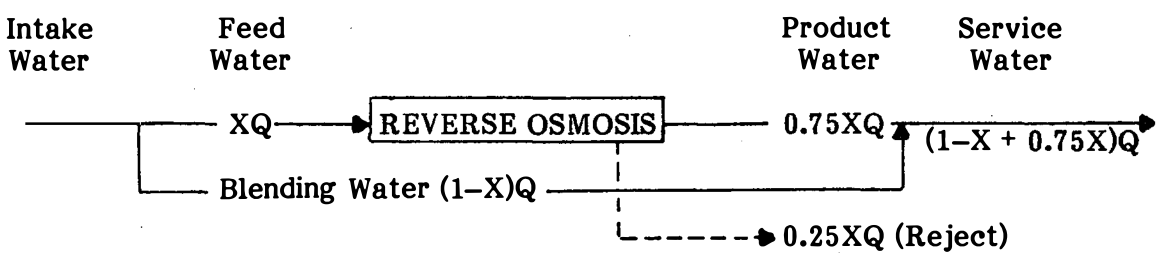
Reverse Osmosis (RO)

RO can reduce NO_3^- concentrations by 90% if the feedwater has TDS less than 2500 ppm. The design influent nitrate concentration of 86 ppm will be reduced to 8.6 ppm in the RO product water. In order to minimize the treatment costs, a portion of untreated water may be blended with the RO product water to provide a supply water which will meet the nitrate drinking water standard of 45 ppm NO_3^-. The percentage of total feedwater that requires RO treatment is calculated as shown on Example VI-1.

EXAMPLE VI-1

RO BLENDING CALCULATION

Assuming that X percent of total flow (Q) will be treated by RO, and that (0.75)(XQ) product water will be produced (75% recovery rate), an amount of (1–X)Q of untreated water blending with (0.75X)Q product water will make a total service water quantity of (1–X + 0.75X)Q.



The X may be solved for as follows for an influent concentration of 86 ppm and a product water concentration of 45 ppm:

$$C_i(1-X) + C_i(0.1)(0.75X) = C_P(1-X + 0.75X) = 86(1-X) + 86(0.1)(0.75)X$$

$$= 45(1-X + 0.75X)$$

$$X = 0.600$$

$$0.75X = 0.450$$

$$(1-X) + 0.75X = 0.850$$

which indicates that for every gallon of influent water containing 86 ppm of NO_3^-, 0.600 gallon has to be treated by RO and blended with raw water to produce 0.85 gallon of water containing 45 ppm NO_3^-.

Based upon this procedure, one can determine (as shown in Example VI–2) the total amount of feed water, RO product water, and blending water if the supply demand and NO_3^- content in the raw water is known. For other selected influent nitrate concentrations, the percentage of total influent water requiring RO treatment, the percent of RO product water, the percent of blending water and the percent of total supply water is presented on Table VI–1. This table demonstrates that the higher the influent concentration, the greater the percentage of water requiring RO treatment.

The total capital cost of an RO facility consists of the capital costs of major process equipment, and ancillary equipment. The major process equipment includes the permeator, cartridge filter, and high pressure pumps. The ancillary equipment includes chemical storage tanks, chemical feeding systems, and an equipment building. The arrangement of the process equipment is shown in Figure VI–1. Major process equipment capital costs and installation in \$/gpd capacity can be calculated as a function of plant product water capacities as shown on Figure VI–2. Figure VI–3 illustrates the ancillary equipment capital costs in \$/gpd as a function of total service water capacity.

For instance, in the previous example, the total capital cost of a 1 MGD supply system would be based on a 0.528 MGD RO product water quantity. For major process equipment, the capital cost would be \$0.70/gpd of product water capacity. For a 1 MGD service water quantity, the ancillary equipment capital cost would be \$0.22/gpd of service water. The capital and O&M cost calculations for this example are illustrated on Table VI–2.

Table VI-3 shows the unit treatment costs for various influent concentrations and demand flows which are obtained following the same computation procedures.

EXAMPLE VI-2

RO SUPPLY CALCULATIONS

A supply volume of 1 $\overline{\text{M}}$GD is required. The influent nitrate concentration is 86 ppm. The total feed water required will be:

$$1\,\overline{\text{M}}\text{GD} \times \frac{1.00}{0.85} = 1.176\,\overline{\text{M}}\text{GD}$$

1.176 x 0.600 = 0.705 $\overline{\text{M}}$GD — treatment by RO

0.705 $\overline{\text{M}}$GD x 0.75 = 0.528 $\overline{\text{M}}$GD — product water from RO

0.705 x 0.25 = 0.176 $\overline{\text{M}}$GD — reject from RO (25%)

Total amount of water available to supply

1.176 - 0.176 = 1.00 $\overline{\text{M}}$GD

Bypass water without RO treatment

1.176 - 0.176 - 0.528 = 0.472 $\overline{\text{M}}$GD

Check mixture nitrate concentration:

$$\frac{(0.472 \times 86) + (0.528 \times 8.6)}{1.0} = 45 \text{ ppm}$$

TABLE VI-1

WATER PROPORTIONS FOR NITRATE REMOVAL
USING REVERSE OSMOSIS

Influent NO_3^-	Percent Treatment	Percent Product	Percent Blending	Percent Supply
200	89.2	66.9	10.8	77.8
150	82.4	61.8	17.6	79.3
100	67.7	50.8	32.3	83.1
50	14.3	10.7	85.7	96.4

FIGURE: VI - 1
REVERSE OSMOSIS PROCESS
MAJOR AND ANCILLARY PROCESS EQUIPMENT.

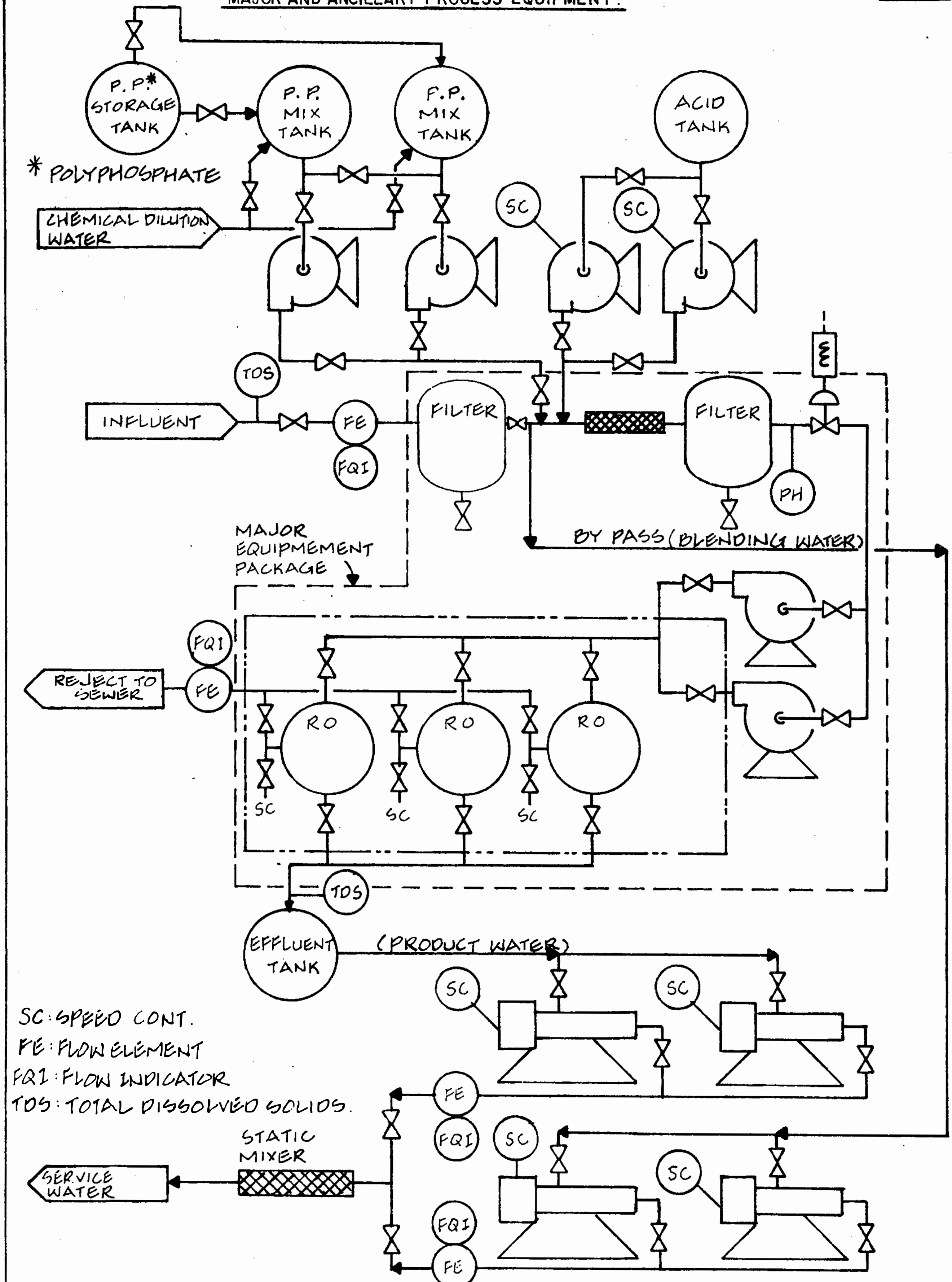


FIGURE VI-2

MAJOR PROCESS EQUIPMENT CAPITAL COST
FOR REVERSE OSMOSIS

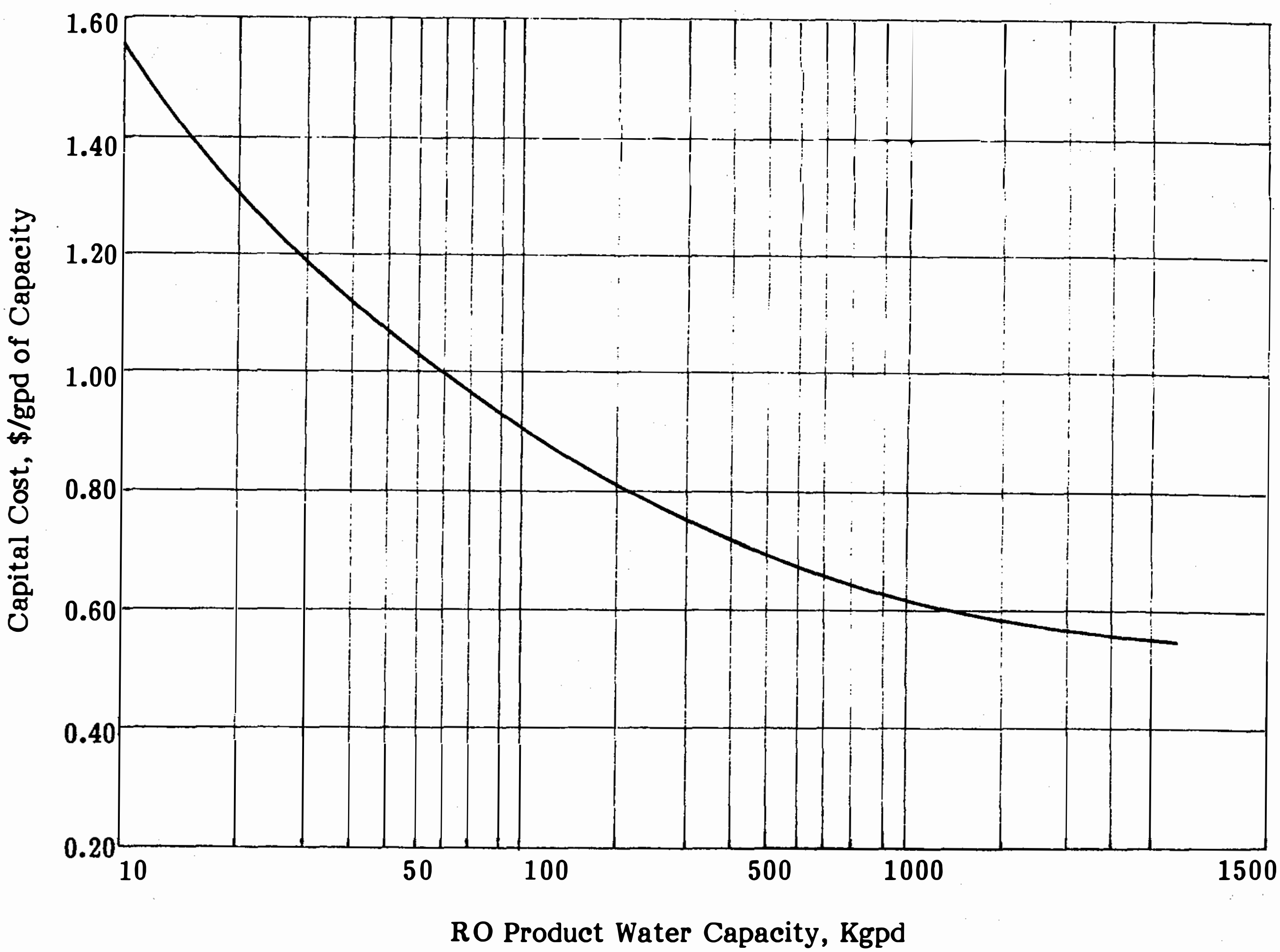


FIGURE VI-3

REVERSE OSMOSIS PROCESS
ANCILLARY EQUIPMENT CAPITAL COST

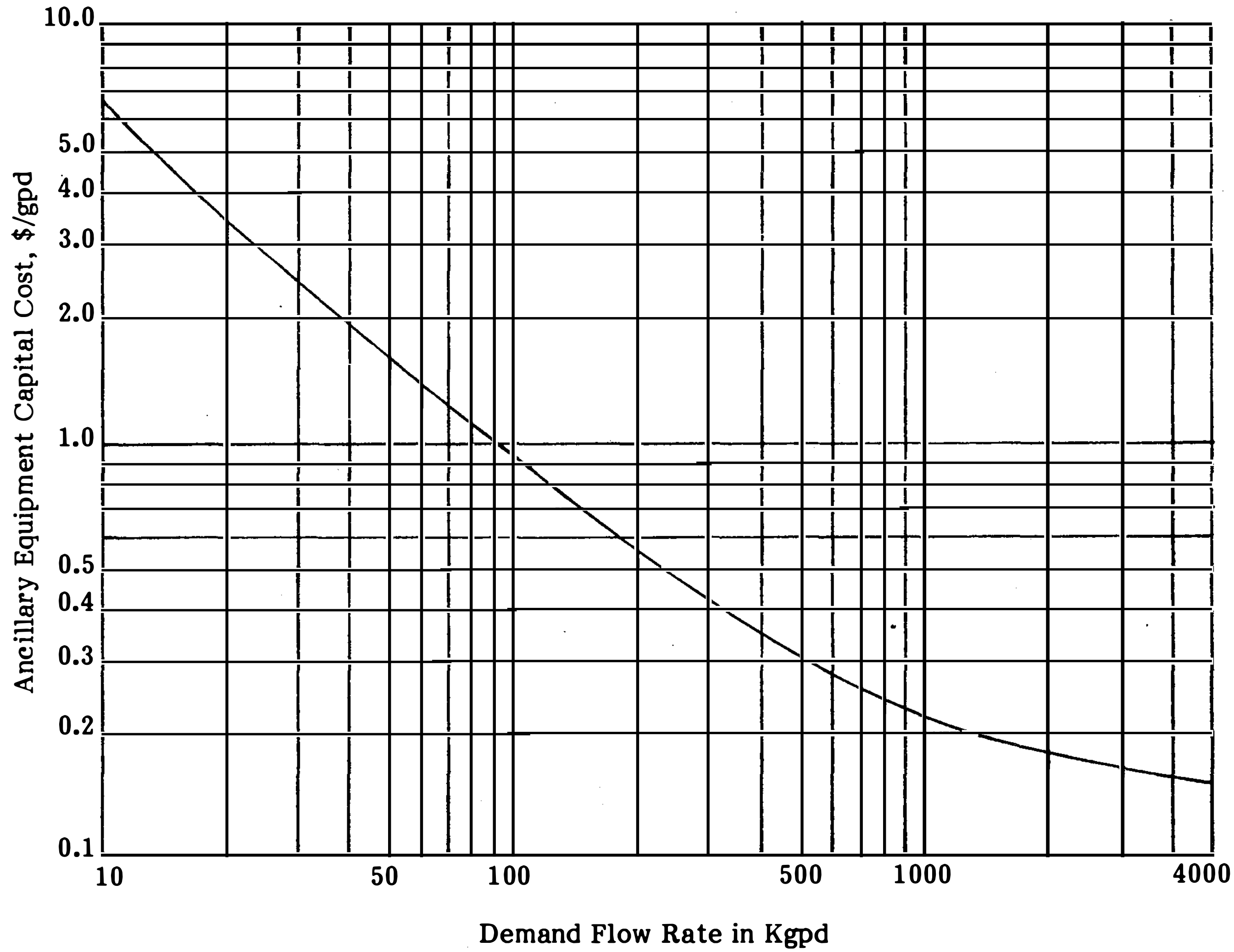


TABLE VI-2

EXEMPLARY RO SYSTEM COST ESTIMATE
FOR NITRATE REMOVAL, 1 MGD

a. Capital Costs

1. Major process equipment capital cost

($0.70/gpd) (528,000 gpd) = $369,600

2. Ancillary equipment capital cost[1] = 223,000

Total capital = $592,600

Capital amortization = $\frac{(\$592{,}600)\ (0.098)}{(365)\ (1000)}$ = $0.158/Kgal

b. O&M Costs[2]

1.	Power Costs (7 kw-hr/Kgal @ 4¢/kw-hr)	$0.28/Kgal RO product water
2.	Membrane Replacement	0.15/Kgal RO product water
3.	Pretreatment (including filter cartridge)	0.15/Kgal RO product water
4.	Chemical Cleansing	0.07/Kgal RO product water
5.	Labor (1 man-day/day @ $60/day)	0.05/Kgal RO product water
		$0.70/Kgal RO product water

Process O&M Costs = $\left(\frac{\$\ 0.70}{\text{Kgal}}\right)\left(\frac{0.528\ \text{MGD}}{1.00\ \text{MGD}}\right)$ = $0.370/Kgal

6. Ancillary equipment O&M cost (assume 5% of capital cost per year)

$\frac{220{,}000 \times 0.05}{365 \times 1.00}$ = $0.030/Kgal

---

Total O&M costs = $0.400/Kgal

Total Unit Treatment Cost = Capital + O&M
= $0.158 + $0.400
= $0.558/Kgal
= $0.56/Kgal

TABLE VI-2 (Continued)

RO Process Ancillary Equipment:[3]

	Material Cost
Chemical Storage Tanks:	
Acid tank	$ 5,000
Polyphosphate tank	5,000
Chemical Feed Pumps (one spare unit each):	6,000
Static inline mixers, 2 pcs. pipe size (8"Ø):	3,000
Flow Measuring Devices, 4 pcs. pipe size (8"Ø)	10,000
Water Pumps (4 pumps, 700 gpm)	12,000
Effluent Tank:	5,000
Pipe, fitting (size 8"Ø), valves etc.	8,000
Instrumentation (pH, TDS)	6,000
Electrical Wiring, Starters, etc.	8,000
Total	68,000
Installed Cost (assume 150% of material cost)	102,000
Building Cost @ $40/sq. ft. (prefabricated steel bldg., with normal lighting and a/c), size (55 ft. x 55 ft.)	121,000
Grand Total Installed Cost	$223,000

[1]Ancillary Equipment listed above.

[2]An average O&M cost of $1.70/Kgal is estimated for RO product water volumes less than 0.3 MGD since the labor cost is relatively larger vs. the total O&M.

[3]Refer to Figure VI-1.

TABLE VI-3

RO UNIT TREATMENT COSTS
FOR NITRATE REMOVAL ($/Kgal)

Service Water Demand MGD	Influent NO_3^- Concentration, ppm				
	200	150	100	80	50
6	0.79	0.71	0.56	0.47	0.16
5	0.79	0.72	0.56	0.47	0.16
4	0.80	0.74	0.58	0.49	0.17
2	0.81	0.74	0.58	0.49	0.18
1	0.83	0.76	0.61	0.52	0.20
0.5	0.90	0.81	0.66	0.56	0.24
0.1	2.10	1.94	1.59	1.39	0.65
0.05	2.43	2.27	1.92	1.72	0.97
0.01	4.66	4.51	4.12	3.90	3.08

Ion Exchange - Selective NO_3^- Removal

For selected service water flow rates, at an influent of 86 ppm NO_3^-, and a 45 ppm NO_3^- effluent concentration, the basic information for major process equipment cost of water treatment by a selective ion exchange process would be as shown on Table VI–4. These capital and O&M factors shown in this table were estimated from basic cost estimate information provided by an independent commercial firm. Figures VI–4 and VI–5 show the ancillary equipment and the capital cost.

The calculation procedures are shown on Table VI–5. Table VI–6 lists the basic cost estimating information for selective ion exchange at various flow rates.

Ion Exchange - Demineralization

Demineralization will remove a majority of the cations and anions in water. The degree of removal is dependent upon the surface loading rate and the detention time in the process. Both nitrate and fluoride can be reduced by one pass through a dual bed cationic/anionic exchanger system, in addition to other anions and cations.

The total capital and O&M costs of the demineralization process equipment was estimated in a similar manner to the selective ion exchange system to compare the unit treatment costs on an equivalent basis. A cost analysis based on the information presented on Table VI–7 was performed for an influent TDS concentration of 1250 ppm, which is approximately 18 meq/l (milliequivalent per liter), and several flow rates as Table VI–8 illustrates.

Table VI–9 lists the unit treatment costs of demineralization systems for various flow rates, an influent total ion content of 18 meq/l, and an effluent total ion content of 1 meq/l. These influent and effluent ion concentrations are representative of the average water conditions in the non-compliant water systems in the state and their respective treated water condition.

TABLE VI-4

BASIC INFORMATION FOR
SELECTIVE ION EXCHANGE MAJOR PROCESS
EQUIPMENT CAPITAL COST ESTIMATE

Service Water Flow Rate, MGD	0.5	1	3	5	7
NO_3^- Influent, ppm	86	86	86	86	86
NO_3^- Effluent, ppm	45	45	45	45	45
No. of CCIX Units	1	1	1	2	2
Treatment Section Dia., inches	42	54	96	84	96
Regenerant Section Dia., inches	12	18	24	24	24
Materials of Const.	316L SS	316L SS	316L SS	316L SS	316L SS
Resin Volume/CCIX[2] Unit Ft^3	110	200	650	600	650
Equipment Capital[1] Cost $1000 ± 20%	275	300	350	675	700

The O&M factors for all of the units are as follows:

NaCl Consumption	1.7 lbs/1000 gallons treated
Waste Volume	4 gallons/1000 gallons treated
Power	0.7 Killowatt hours/1000 gallons
Operator Attention	1 Man-Day/Day
Maintenance Costs	3% per year of Capital Cost
Resin Attrition	25%/year
Installation Costs	50% of Capital Cost

[1]Equipment capital cost for all flow rates less than 0.3 MGD are estimated at $190,000. The O&M rates are the same over the entire range.

[2]CCIX - Continuous countercurrent ion exchange

FIGURE VI-4

ION EXCHANGE/DEMINERALIZATION PROCESS MAJOR AND ANCILLARY EQUIPMENT

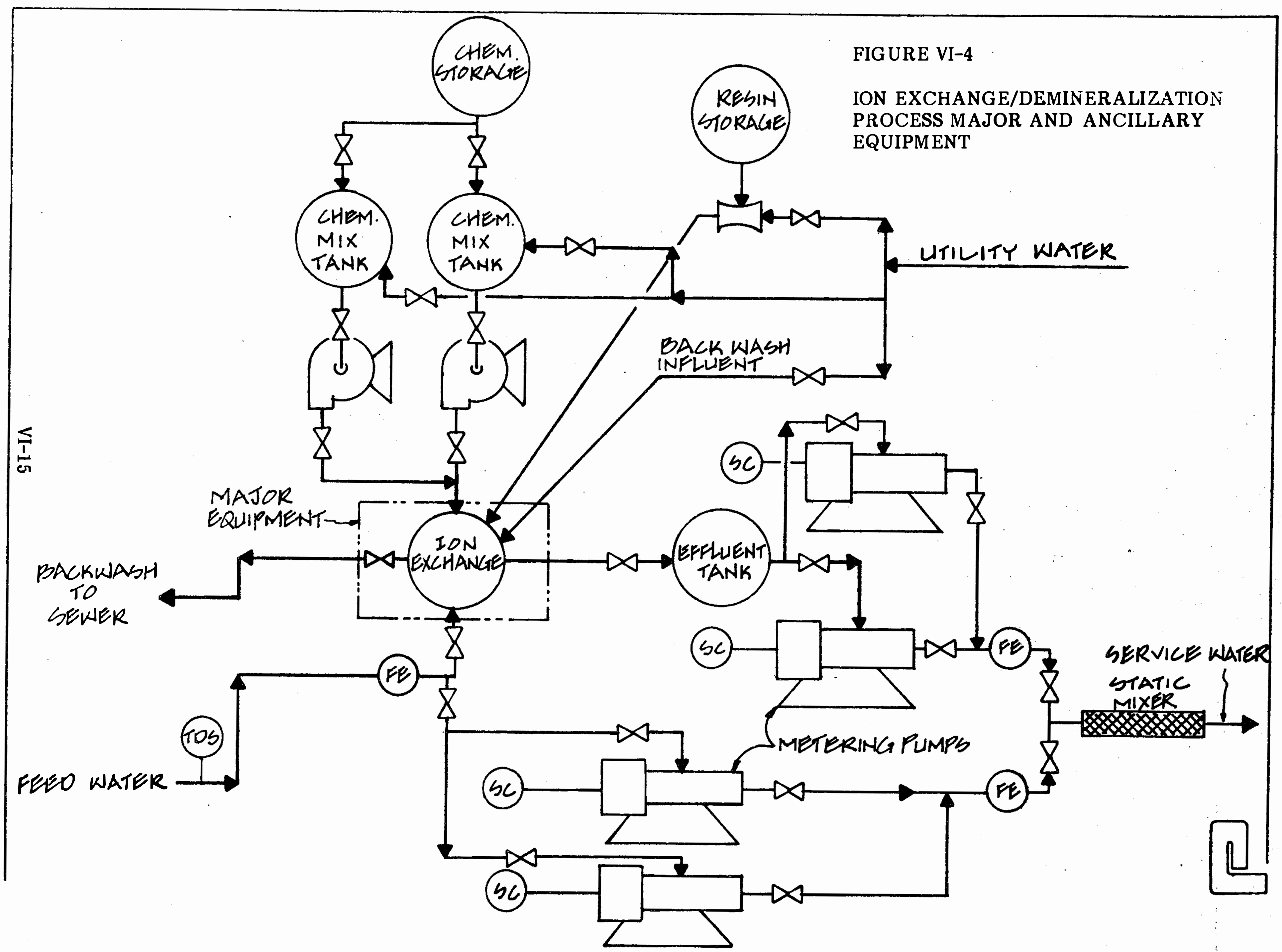


FIGURE VI-5

SELECTIVE ION EXCHANGE/DEMINERALIZATION PROCESS
ANCILLARY EQUIPMENT CAPITAL COST

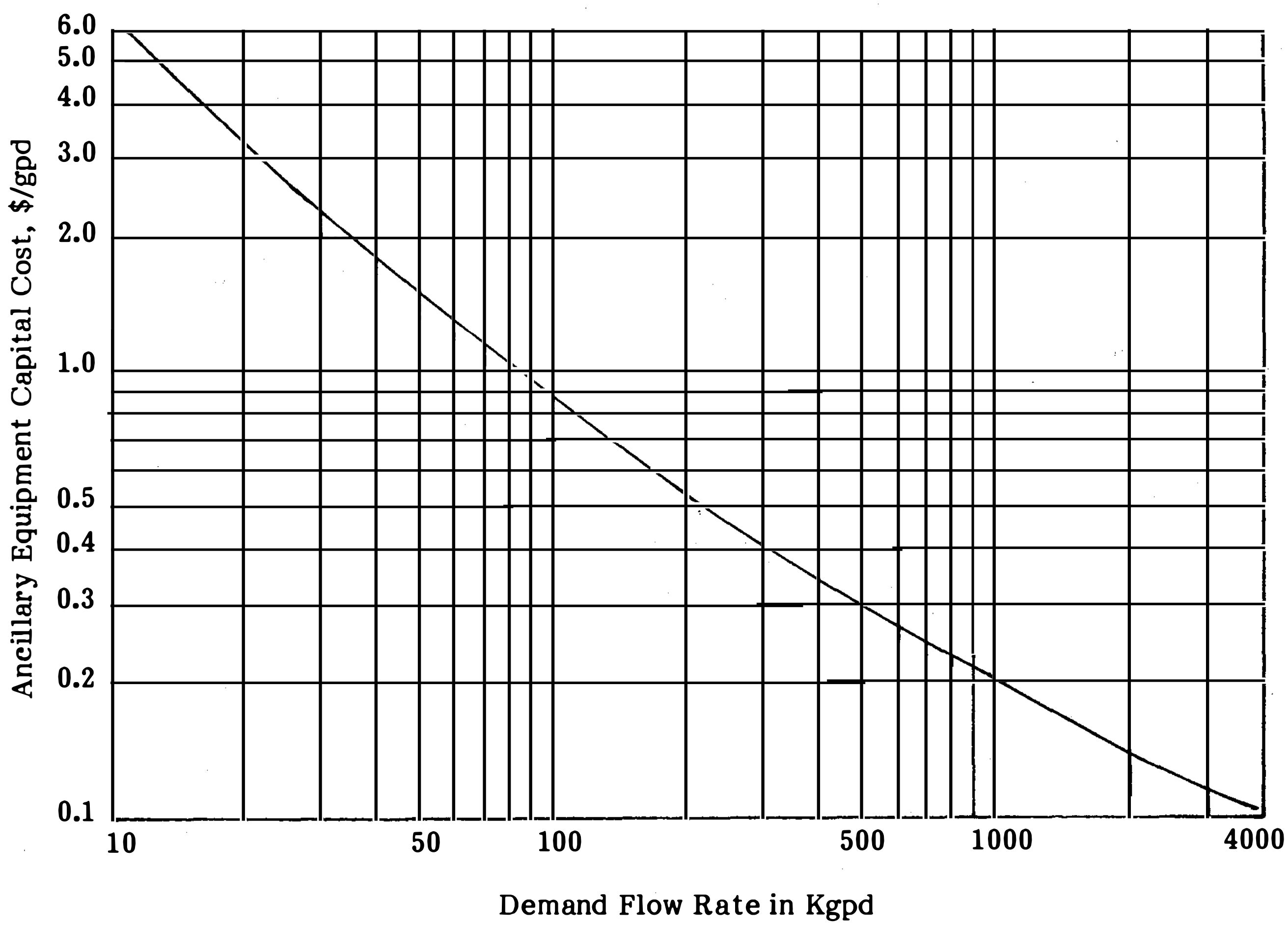


TABLE VI-5

EXEMPLARY SELECTIVE ION EXCHANGE SYSTEM COST ESTIMATE FOR NITRATE REMOVAL (1 MGD)

a. Capital

1. Major Process Equipment (Installed) — $450,000

2. Ancillary Equipment[1] (Installed) — $197,200

Total Capital = $647,200

Capital amortization = $\frac{(647,200)(0.098)}{(365)(1)(1,000)}$ = $0.174/Kgal

b. Operation and Maintenance

1. Resin Volume & Attrition (25%/yr.) - total volume

   200 ft^3 @ $80/$ft^3$

   $\frac{(200)(0.25)(80)}{(365)(1000)}$ = $0.011/Kgal

2. Labor (1 man-day/day @ $60/day) — 0.060/Kgal

3. Power (0.7 kw-hr/Kgal @ 4¢/kw-hr) — 0.028/Kgal

4. Regenerant - NaCl (10¢/lb) — 0.170/Kgal

5. Maintenance Cost — 0.036/Kgal

   Process O&M Cost — $0.305/Kgal

6. Ancillary Equipment O&M costs (assume 5% of ancillary capital per year):

   $\frac{(197,200)(0.05)}{(365)(1)(1000)}$ = $0.027/Kgal

Total O&M = $0.332/Kgal

Total Unit Treatment Cost = Capital + O&M
= $0.174 + $0.332
= $0.506/Kgal
= $0.51/Kgal

[1] Ancillary equipment is the same for demineralization process (refer to Figure VI–4, Figure VI–5, and Table VI–8, page VI-20).

TABLE VI-6

SELECTIVE ION EXCHANGE TREATMENT COSTS
FOR NITRATE REMOVAL ($/Kgal)

Service Water Demand, MGD	Unit Treatment Costs ($/Kgal)[1]
7	0.31
5	0.33
3	0.35
1	0.51
0.5	0.80
0.1	2.05
0.05	3.51
0.01	20.84

[1] Nitrate influent concentration 86 ppm as NO_3^-.
Nitrate effluent concentration 45 ppm as NO_3^-.

TABLE VI-7

BASIC INFORMATION FOR DEMINERALIZATION MAJOR PROCESS EQUIPMENT COST ESTIMATE

Service Water Flow Rate, MGD	0.5 or less	1	3	5	7
Feed water, meq/l	18	18	18	18	18
Effluent water, meq/l	9	9	9	9	9
Demineralized H_2O, gpm	193	386	1158	1930	2702
Blended H_2O, gpm	154	308	924	1540	2156
No. of Cation CCIX Units	1	1	1	2	3
Treatment Section Diameter, Inches	30	42	72	66	66
Regenerant Section Diameter, Inches	18	24	42	42	36
No. of Anion CCIX Units	1	1	2	2	3
Treatment Section Diameter, Inches	30	42	54	66	66
Regenerant Section Diameter, Inches	18	30	30	42	42
Materials of Construction	316 SS	316 SS	316 SS	316 SS	316 SS
Strong-Acid Cation Resin Volume, ft^3/CCIX Unit	100	190	700	650	500
Weak-Base Anion Resin Volume, ft^3/CCIX[1] Unit	100	270	400	650	500
Equipment Capitol Cost $1000 ± 20%	450	600	1000	1400	1800

The O&M factors for all of the units are as follows:

H_2SO_4 Consumption	7.4 lbs/1000 gallons blended effluent
NaOH Consumption	3.6 lbs/1000 gallons blended effluent
Power Consumption	0.8 kilowatt hrs/1000 gallons
Operator Attention	1.5 Man-Day/Day, 1 Man-Day/Day for less than 0.5 MGD
Maintenance Costs	3% per year of capital cost
Resin Attrition	25% per year, cation/anion
Installation Costs	50% of capital cost
Waste	80 gallons/1000 gallons blended effluent

[1]CCIX - Continuous countercurrent ion exchange

TABLE VI-8

EXEMPLARY DEMINERALIZATION COST ESTIMATE FOR NITRATE REMOVAL[1]

The capital costs for a 1 MGD plant:

a. Capital Costs

1. Major Process Equipment Cost:

Equipment	$600,000
Installation	300,000
Total	$900,000

2. Ancillary equipment cost:[2] $197,200

Total Capital Cost = $1,097,200

Capital Amortization $= \frac{(1,097,200)(0.098)}{(365)(1)(1000)}$ = $0.295/Kgal

b. Operation and Maintenance Costs:

1.	H_2SO_4 Consumption (@ 3¢/lb)	$0.222/Kgal
2.	NaOH Consumption (@ 8¢/lb)	0.288/Kgal
3.	Power (@ 4¢/kw-hr)	0.032/Kgal
4.	Labor (1½ man-day/day @ $60/day)	0.090/Kgal
5.	Cation Resin (@ $50/ft^3)	0.006/Kgal
6.	Anion Resin (@ $120/ft^3)	0.022/Kgal
7.	Maintenance (@ 3% capital/yr)	0.074/Kgal
	Process O&M Cost	= $0.734/Kgal

8. Ancillary Equipment O&M Cost (assume 5% of ancillary equipment capital cost per year):

$\frac{(197,200)(0.05)}{(365)(1)(1000)}$ = $0.027/Kgal

Total O&M Cost = $0.759/Kgal
= $0.76/Kgal

TABLE VI-8 (Continued)

Total Unit Treatment Cost	=	Capital Amortization + O&M Cost
	=	\$0.295 + \$0.759
	=	\$1.054/Kgal
	=	\$1.05/Kgal

Ancillary Equipment:

	Material Cost
Chemical Storage Tanks:	
Resin Storage Bin	\$ 6,000
Reagent Solution Tank	3,000
Chemical Feed Pumps (one spare unit each):	6,000
Static Inline Mixers, 2 pcs. pipe size (8"Ø):	1,500
Flow Measuring Devices, 4 pcs. pipe size (8"Ø):	8,800
Water Pumps (4 pumps, 700 gpm ea.):	10,000
Effluent Tank:	5,000
Pipe, Fitting, (size 8"Ø), valves, etc.	10,000
Instrumentation (pH, TDS)	3,000
Electrical Wiring, Starters, etc.	10,000
Venturimeter:	1,500
Total Material Cost	64,800
Installed Cost (150% of material cost)	97,200
Building Cost @ \$40/sq. ft. (prefabricated steel bldg., with normal lighting and a/c), size: (50 ft. x 50 ft.)	100,000
Grand Total Installed Cost	197,200

[1]This estimate would also be applicable for fluoride removal.

[2]Ancillary Equipment listed above (refer to Figures VI-4 and VI-5).

TABLE VI-9

DEMINERALIZATION COST ESTIMATE FOR NITRATE AND FLUORIDE REMOVAL

Flow Rate, MGD	Treatment Cost ($/Kgal)
7	0.75
6	0.76
5	0.77
4	0.79
3	0.81
2	0.92
1	1.06
0.5	1.38
0.1	4.06
0.05	4.61
0.01	33.28

Special Nitrate Case

A special case exists for isolated rural communities where raw water is supplied by pumping from miles away and also where no treatment facilities are available. To treat the excess nitrate by reverse osmosis, ion exchange, or demineralization would be very costly, compared to a relatively large treatment plant.

The solution for obtaining water of suitable quality could be achieved by other means. The noncompliant supply can be rejected and a better quality raw water which has no excess nitrate can be sought. Bottled drinking water can also be purchased for potable use and the existing water utilized for other household uses.

FLUORIDE TREATMENT COST ANALYSIS

After evaluation and comparisons of the various processes of fluoride removal, it can be concluded that RO, demineralization, and bone char (tri-calcium phosphate) adsorption can remove the fluoride effectively. The process efficiencies and the treatment costs are discussed in the following narrative.

Reverse Osmosis

RO can reduce fluoride by 90% if the feedwater pH is maintained around 7.0, following the same principle of RO operation characteristics and feedwater quality assumptions used for nitrate removal. The percentage of feedwater, product water, and total service water will be as shown on Table VI–10.

An example unit treatment cost calculation for a 1 MGD plant, with influent fluoride of 2 ppm, effluent requirement of 1.4 ppm at pH = 7, and a TDS of 1250 ppm is presented on Example VI–3 and the costs are presented on Table VI–11. Table VI–12 is a summarized list of unit treatment costs of various flow rates and influent fluoride concentrations.

TABLE VI-10

WATER PROPORTIONS FOR FLUORIDE REMOVAL

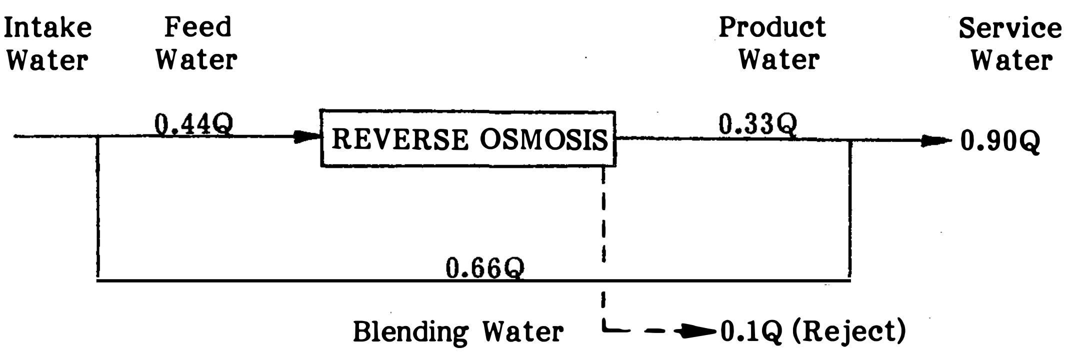
Influent F ppm[1]	Percent RO Treatment	Percent Blending	Percent RO Product	Percent Service
10	96.6	3.4	72.5	75.9
5	84.2	15.8	63.2	79.0
2	40.0	60.0	30.0	90.0
1.6	17.7	82.3	13.3	95.6

[1]Assumes that 1.4 ppm F^- effluent water must be met.

EXAMPLE VI-3

FLUORIDE BLENDING CALCULATION

From Example VI-1 it can be proven that



If the supply demand flow is 1 $\overline{M}$GD, the total raw water input required

$$= \frac{1}{0.9} = 1.1\ \overline{M}GD$$

The product water from RO would be (0.4)(1.1 $\overline{M}$GD)(0.75 recovery rate) = 0.33 $\overline{M}$GD and 0.44 - 0.33 = 0.11 $\overline{M}$GD to waste (reject). The effluent concentration at 90 percent removal would be

$$(0.10)(2) = 0.2 \text{ ppm}$$

The untreated blending water to supply would be

$$(0.6)(1.1) = 0.66\ \overline{M}GD$$

Check total fluoride concentration in the mixture:

$$\frac{(0.66\ \overline{M}GD)(2 \text{ ppm}) + (0.33\ \overline{M}GD)(0.2 \text{ ppm})}{(1.0\ MGD)} = 1.4 \text{ ppm}$$

TABLE VI-11

EXEMPLARY REVERSE OSMOSIS SYSTEM
COST ESTIMATE FOR FLUORIDE REMOVAL

a. Capital Costs

1. Major Process Equipment Cost

($0.76/Kgal)[1](330,000 gpd)	=	$250,000
2. Ancillary Equipment Cost[2]	=	$220,000
Total Capital	=	$470,000
Capital Amortization = $\frac{(470{,}000)(0.098)}{(365)(1)(1000)}$	=	$0.126/Kgal

b. O&M Costs

1. Process O&M Costs

($0.70/Kgal product water)[3] x $\frac{0.33\ \text{MGD}}{1.00\ \text{MGD}}$	=	$0.231/Kgal
2. Ancillary Equipment O&M Costs[4]		
$\frac{\$220{,}000 \times 0.05}{365 \times 1{,}000}$	=	$0.030 Kgal
Total O&M Costs	=	$0.261/Kgal
Total Unit Treatment Costs	=	$0.126 + $0.261
	=	$0.387/Kgal
	=	$0.39/Kgal

[1]See Figure VI-2, page VI-8.

[2]See Table VI-2, Ancillary Equipment List, page VI-11.

[3]See Table VI-2, page VI-10.

[4]Assume 5% of ancillary equipment capital cost per year.

TABLE VI-12

FLUORIDE REMOVAL BY RO TREATMENT
UNIT TREATMENT COSTS ($/Kgal)

Service Water Demand MGD	Influent Concentration, ppm[1]			
	10	5	2	1.6
6	0.86	0.74	0.34	0.18
4	0.88	0.74	0.35	0.19
2	0.89	0.76	0.36	0.19
1	0.92	0.79	0.39	0.22
0.5	0.98	0.84	0.44	0.26
0.1	2.54	1.98	1.09	0.76
0.05	2.63	2.32	1.41	1.11
0.01	4.80	4.48	3.51	3.25

[1]Effluent fluoride concentration 1.4 ppm.

Demineralization

The unit treatment costs of an influent water containing 2 ppm fluoride have been discussed in the nitrate demineralization process section (see Table VI–8, pages VI–20 and VI–21).

Bone Char (Tri-Calcium Phosphate) Adsorption

Bone char or tri-calcium phosphate has a greater adsorption (or exchange capacity) than activiated alumina, which has been discussed earlier in this report. We shall exclude the discussion of the unit treatment costs of the activated alumina due to this relative inefficiency.

According to research and operation data, fluoride has been satisfactorily removed at flow rates of 4 to 8 GPM/ft^2. The regenerated capacity of tri-calcium phosphate is 30 grams/ft^3. The density of tri-calcium phosphate is 29 lb/ft^3 and the current price is $26.50/100 lb.

Assuming a 1 MGD plant has an incoming fluoride concentration of 2 ppm, the process design and its unit treatment costs are shown on Example VI–4 and Table VI–13.

Table VI–14 presents the unit treatment costs of various demand flow and influent fluoride concentrations based upon the process flow diagram presented on Figure VI–6.

Special Fluoride Cases

An evaluation of unit treatment costs reveals that tri-calcium phosphate is the best process for isolated households to treat the fluoride contaminant. The process can use gravity feed without complicated operation and regeneration requirements. The unit treatment cost is estimated upon the assumption that 4 persons are in the average household, with each person consuming 150 gpd of water. The consumption rate varies throughout the State with this number being assumed as representative of household consumption. The cost curve for a small system fluoride removal is shown on Figure VI–8.

EXAMPLE VI-4

TRI-CALCIUM PHOSPHATE ADSORPTION SYSTEM DESIGN FOR FLUORIDE REMOVAL

1 MGD = 694.4 GPM

Fluoride to be removed in grams/day:

2.0 - 1.4 = 0.6 ppm, or

1 x 8.33 x 0.6 x 454 = 2270 grams/day

Tri-calcium phosphate required:

(2270 grams/day)/(30 grams/ft^3) = 76 ft^3/day

Density of tri-calcium phosphate = 29 lb/ft^3

76 x 29 = 2200 lb/day

Surface area required (6 GPM/ft^2)

694.4/6 = 115 ft^2

Use 2 vessels @ 10'Ø x 6' S.W.D.

Tri-calcium phosphate process flow diagram and ancillary equipment capital cost versus plant capacity are shown on Figures VI-6 and VI-7, respectively.

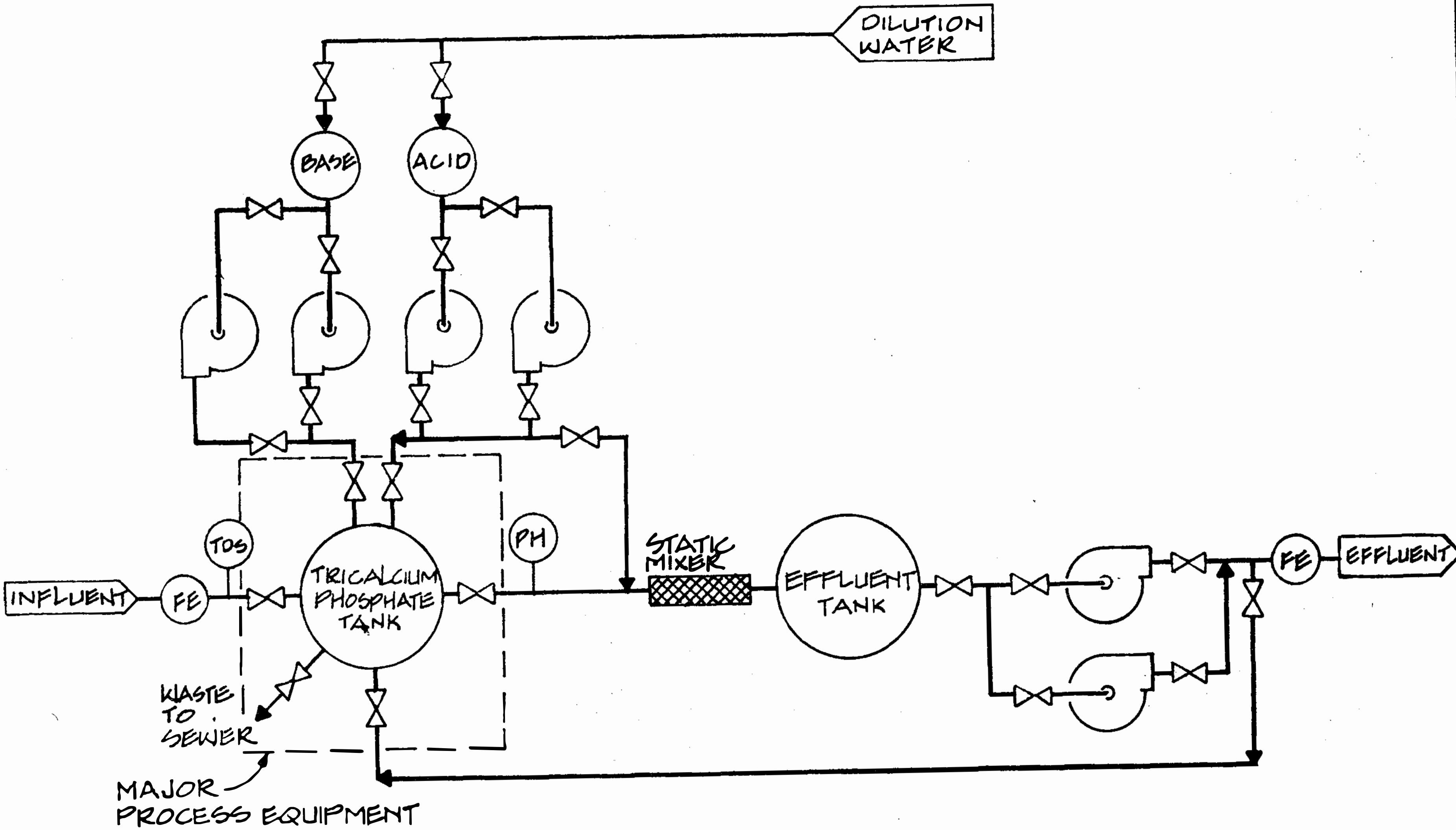


FIGURE VI-6

TRICALCIUM PHOSPHATE PROCESS FLOW DIAGRAM

FIGURE VI-7

TRI-CALCIUM PHOSPHATE PROCESS
ANCILLARY EQUIPMENT CAPITAL COST

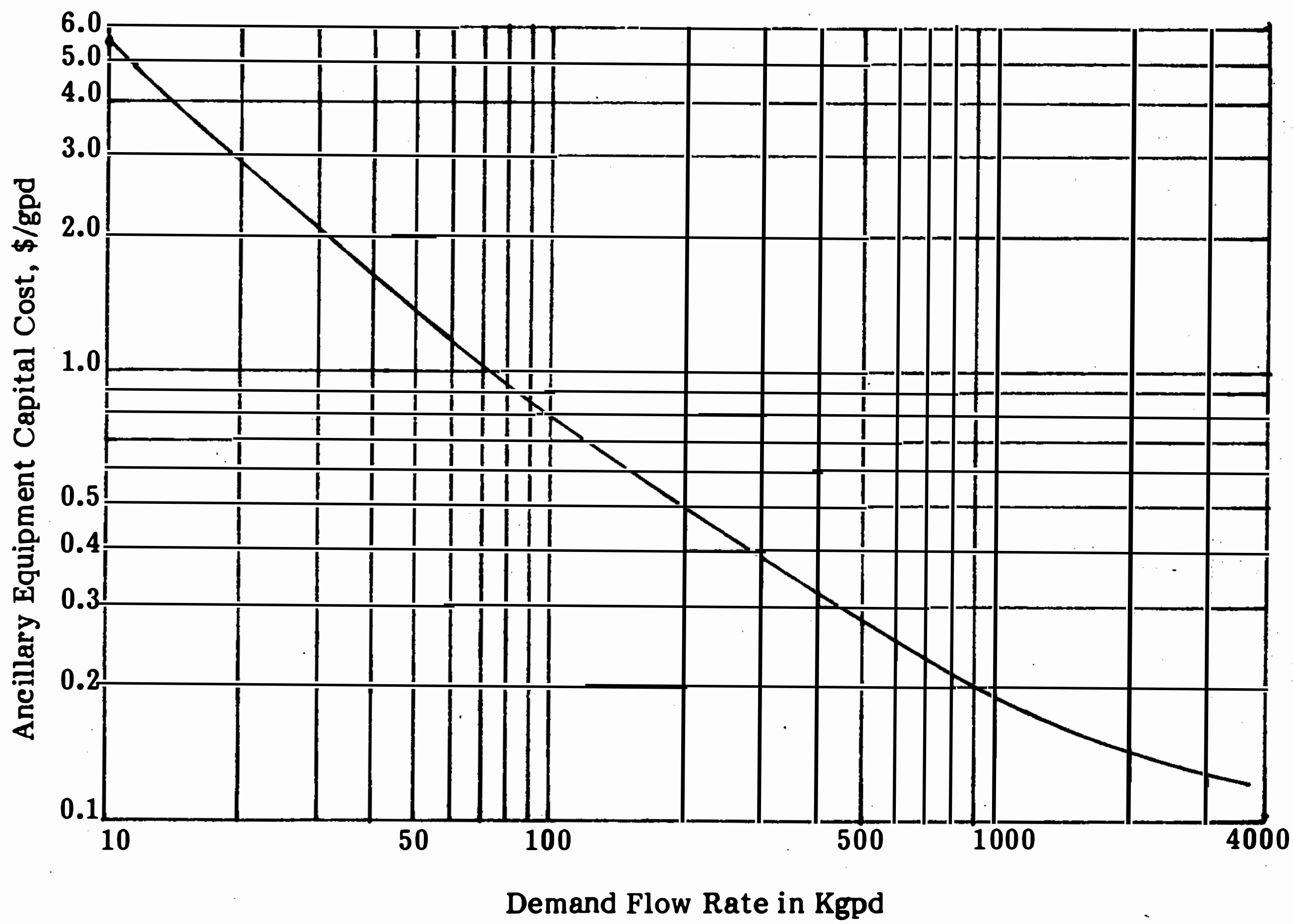


TABLE VI-13

TRI-CALCIUM PHOSPHATE EXEMPLARY COSTS

a. Capital Costs

1.	Major Process Equipment		$130,000
2.	Ancillary Equipment[1]		$199,000
	Total Capital		$329,000
	Capital Amortization		
	$\frac{(329,000)(0.098)}{(365)(1)(1000)}$	=	$0.088/Kgal

b. O&M Costs

1.	Chemicals ($30/day)		$0.030/Kgal
2.	Labor (1 man-day/day @ $60/day)		0.060/Kgal
3.	Maintenance (3% capital/year)		0.039/Kgal
4.	Power (1 kw-hr/Kgal @ 4¢/kw-hr)		0.040/Kgal
5.	Media attrition, assumed 100% replaced per month @ $26.50/100 lb, monthly consumption 2200 lb		0.019/Kgal
	Process O&M Costs	=	$0.148/Kgal
6.	Ancillary O&M Cost[2]		
	$\frac{(198,500)(0.05)}{(365)(1)(1000)}$	=	$0.027/Kgal
	Total O&M Costs	=	$0.175/Kgal
	Total Unit Treatment Costs	=	$0.088 + $0.175
		=	$0.263/Kgal
		=	$0.26/Kgal

TABLE VI-13 (Continued)

Tri-Calcium Phosphate Process Ancillary Equipment List and Estimate

Chemical Storage Tanks:	
HCl	$ 6,000
NaOH	6,000
Chemical Feed Pumps (one spare unit each)	6,000
Static Inline Mixers, 1pc., pipe size (8"Ø)	4,000
Flow measuring devices, 2 pcs. (8"Ø)	8,000
Water Pumps (2 pumps, 695 gpm ea.) 2 pcs.	8,000
Effluent Tank	6,000
Pipe, Fitting (size 8"Ø), Valves	8,000
Instrumentation (pH, TDS), 4 pcs.	6,000
Electrical Wiring, Starters, etc.	8,000
TOTAL	$ 66,000
Installed Cost (150% of material cost)	$ 99,000
Building Cost @ $40/sq. ft. (50 ft. x 50 ft.)(prefabricated steel bldg. with normal lighting and a/c)	100,000
GRAND TOTAL INSTALLED COST	$199,000

[1]Refer to Figure VI-6 for Tri-calcium Phosphate Process major equipment and ancillary equipment, Figure VI-7 for Tri-Calcium Phosphate ancillary equipment capital cost.

[2]5 percent of ancillary capital per year.

TABLE VI-14

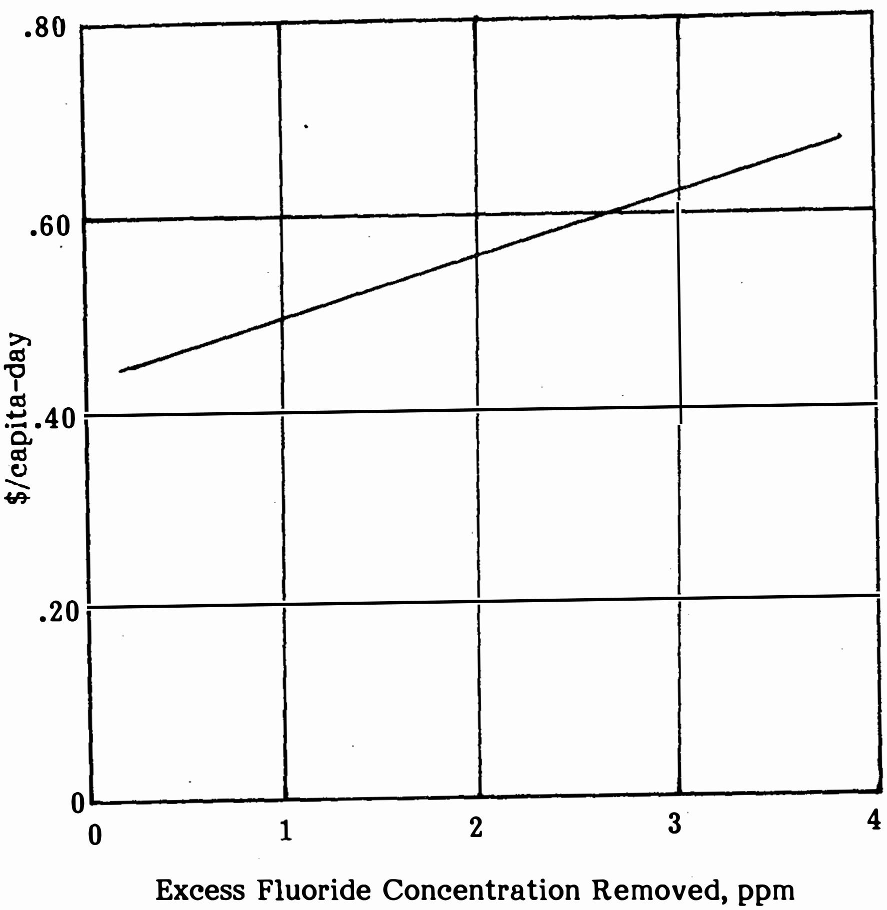
UNIT TREATMENT COSTS FOR TRI-CALCIUM PHOSPHATE PROCESS FLUORIDE REMOVAL ($/Kgal)

Service Demand MGD	Influent Concentration, PPM[1]			
	10	5	2	1.6
6	0.33	0.27	0.18	0.18
4	0.33	0.28	0.19	0.18
2	0.39	0.35	0.22	0.22
1	0.45	0.38	0.26	0.25
0.5	0.55	0.46	0.36	0.35
0.1	1.44	1.21	1.08	1.04
0.05	1.72	.145	1.33	1.28
0.01	4.62	3.89	3.79	3.66

[1]Effluent concentration - 1.4 ppm.

FIGURE VI-8

SMALL SYSTEM FLUORIDE REMOVAL COST



COST ESCALATION FACTORS

The unit treatment costs for each of the processes discussed will increase continually due to inflation and other economic factors. Both the capital and O&M costs will be increased according to the following projected percentage increases:

a.	Capital		
	i.	Steel	10 percent/year
	ii.	Process Equipment	7.5 percent/year
b.	O&M		
	i.	Chemicals	10 percent/year
	ii.	Skilled Labor	10 percent/year
	iii.	Power	15 percent/year
	iv.	Maintenance	10 percent/year

(The above percentages were obtained through the Engineering News Record and Chemical Engineering and were finalized in coordination with the Texas Water Development Board staff.)

On the forthcoming Tables VI–15 through VI–19, the projected unit treatment costs of the different applicable fluorides and nitrate removal systems are presented on the basis of 1986 costs. Generally speaking, the projected 1986 unit treatment costs will more than double the predicted 1976 costs presented previously.

COST ANALYSIS DISCUSSION

The previous cost analyses have discussed the unit treatment costs of various influent and effluent concentrations of nitrate and fluoride along with varying flow rates. From Figures VI–9 and VI–10, it can be seen that demineralization is the most expensive process for removal of both nitrate and fluoride. In the case of an average influent nitrate concentration of 86 ppm, selective ion exchange is more economical where the flow rate is greater than 1.0 MGD. The tri-calcium phosphate process shows a lower unit treatment cost than reverse osmosis over the entire range of flows considered.

TABLE VI-15

PROJECTED 1986 RO NITRATE
UNIT TREATMENT COSTS ($/Kgal)

Service Water Demand MGD	Influent Nitrate Concentration, ppm			
	200	150	100	50
6	1.76	1.61	1.24	0.35
5	1.76	1.63	1.24	0.35
4	1.78	1.67	1.29	0.37
2	1.81	1.67	1.29	0.40
1	1.85	1.72	1.35	0.44
0.5	2.00	1.83	1.47	0.53
0.1	4.69	4.39	3.53	1.43
0.05	5.43	5.13	4.26	2.13
0.01	10.40	10.20	9.14	6.78

TABLE VI-16

PROJECTED 1986 DEMINERALIZATION PROCESS UNIT TREATMENT COSTS

Service Water Demand MGD	$/Kgal
5	1.55
3	1.64
1	2.14
0.5	2.84
0.1	5.95
0.05	9.49
0.01	66.57

Influent nitrate	86 ppm
Effluent nitrate	45 ppm
Influent fluoride	2 ppm
Effluent fluoride	1.4 ppm

TABLE VI-17

PROJECTED 1986 SELECTIVE ION EXCHANGE NITRATE UNIT TREATMENT COSTS

Service Water Demand MGD	($/Kgal)
5	0.69
3	0.69
1	0.96
0.5	1.61
0.1	4.12
0.05	7.03
0.01	41.70

Influent nitrate	86 ppm
Effluent nitrate	45 ppm

TABLE VI-18

PROJECTED 1986 RO FLUORIDE
UNIT TREATMENT COSTS ($/Kgal)

Service Water Demand MGD	Influent Fluoride Concentration, ppm			
	10	5	2	1.6
6	1.95	1.65	0.77	0.41
4	1.99	1.65	0.79	0.43
2	2.02	1.69	0.81	0.43
1	2.08	1.76	0.81	0.50
0.5	2.23	1.87	0.99	0.59
0.1	5.11	4.43	2.45	1.71
0.05	5.38	5.19	3.17	2.50
0.01	9.71	8.98	7.90	7.31

TABLE VI-19

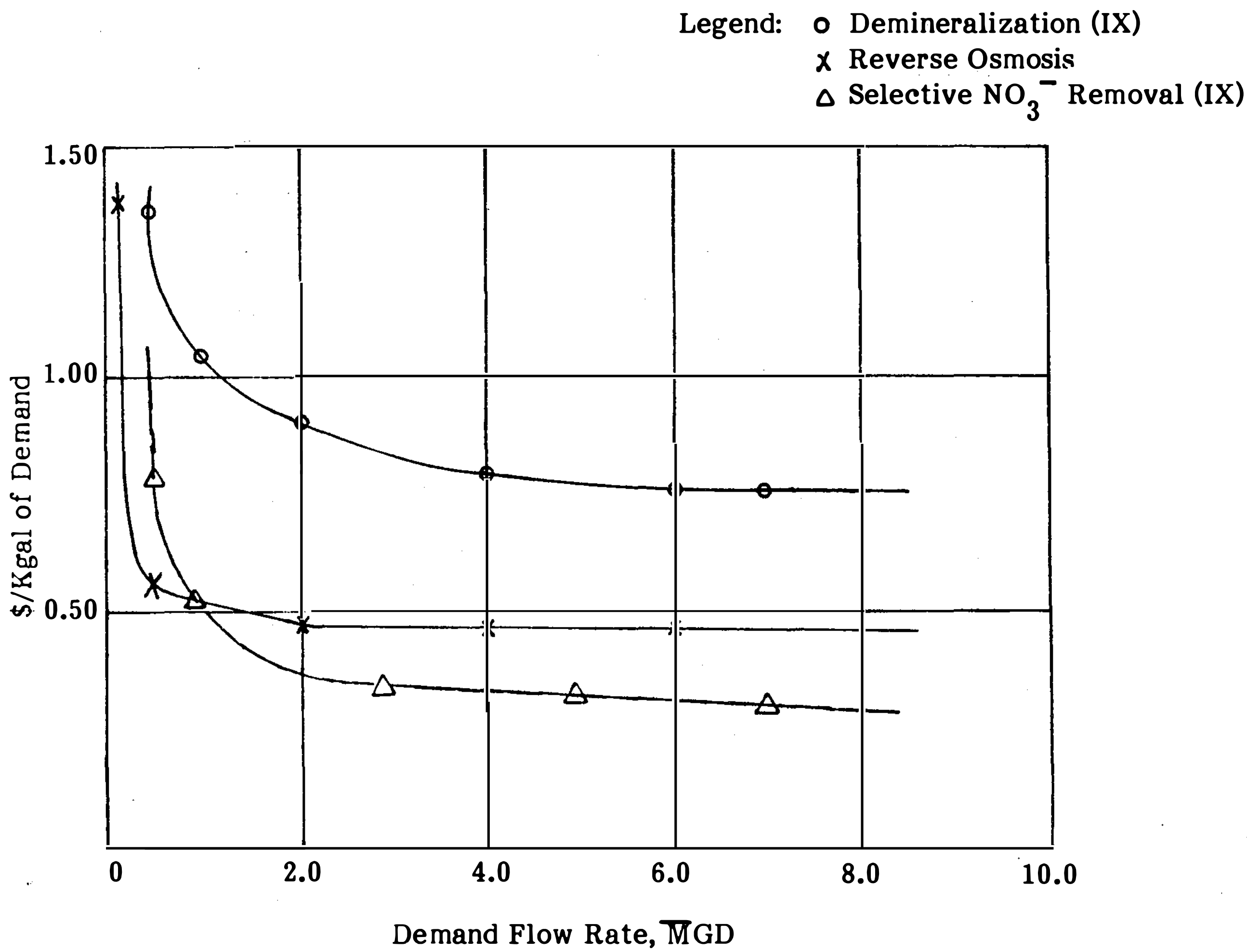
PROJECTED 1986 TRI-CALCIUM PHOSPHATE
UNIT TREATMENT COSTS ($/Kgal)

Service Demand MGD	Influent Fluoride Concentration, PPM[1]			
	10	6	2	1.6
6	0.73	0.60	0.39	0.39
4	0.73	0.62	0.41	0.39
2	0.86	0.77	0.47	0.47
1	0.99	0.84	0.57	0.54
0.5	1.22	1.06	0.82	0.76
0.1	3.18	2.60	2.32	2.24
0.05	3.80	3.11	2.86	2.76
0.01	10.21	8.33	8.13	7.90

[1]Effluent Concentration - 1.4 ppm

FIGURE VI-9

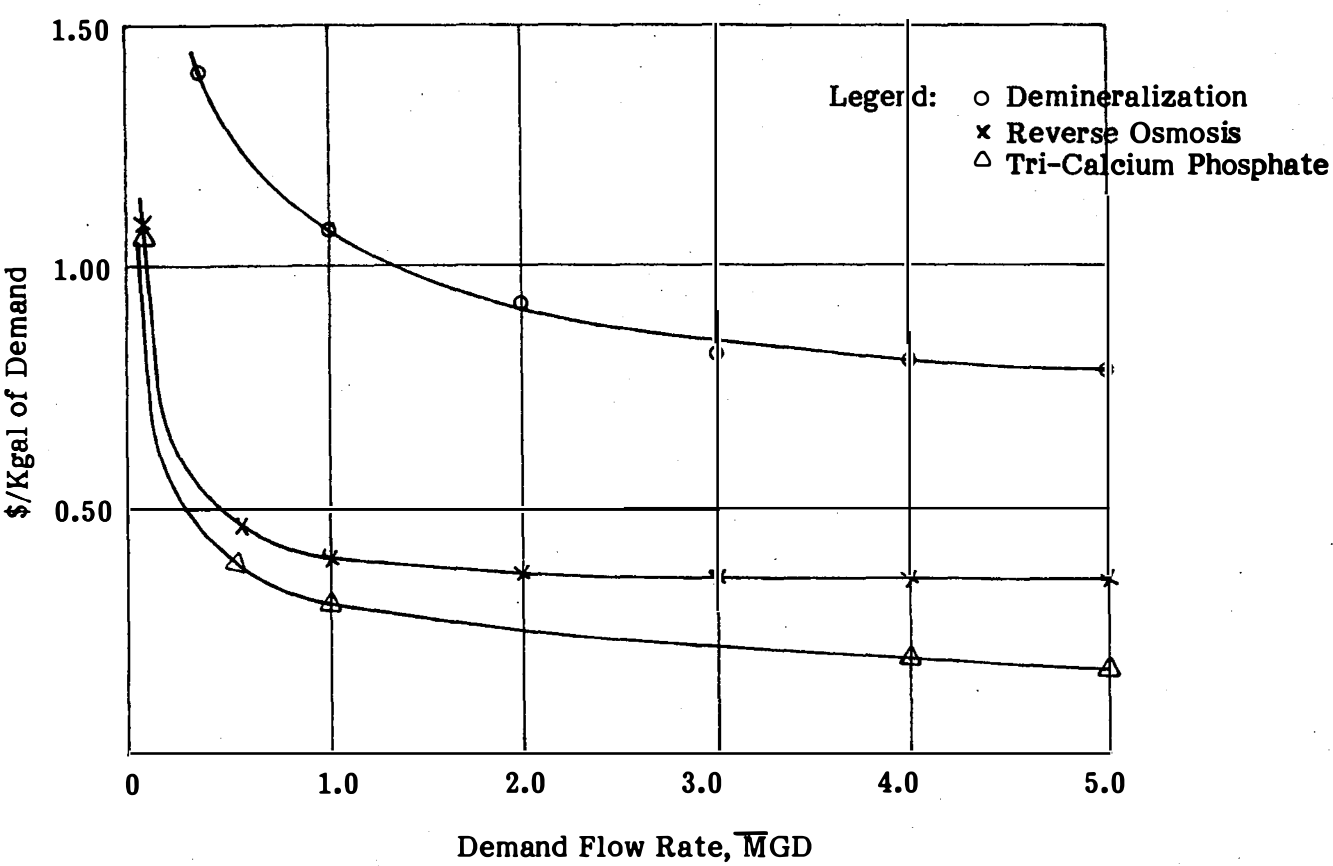
NITRATE REMOVAL UNIT TREATMENT COSTS[1]



[1] NO_3^- influent = 86 ppm
NO_3^- effluent = 45 ppm

FIGURE VI-10

FLUORIDE REMOVAL UNIT TREATMENT COSTS[1]



[1]Influent concentration: 2 ppm fluoride

CHAPTER VII

AGGREGATED ECONOMIC IMPACT

The preceeding chapters of this report have developed the basic scope and objective of this project. To this point, the full range of applicable processes have been considered for the removal of nitrate and fluoride from water supplies. Subsequently, each of these processes has been evaluated on a technical basis to establish the scope of treatment facilities to receive further consideration. In Chapter VI, the selected processes were subjected to an economic evaluation to ascertain the most cost effective systems. The Chapter VI evaluation took several base case conditions as a framework for the economic comparisons. These base cases are considered to be a suitably sound basis to establish the processes which would be chosen for the system. In the case of low flows (0.5 MGD and below) relative to the average, special consideration had to be taken to assure that the economic projections of capital, O&M, and subsequently the unit treatment cost were properly determined due to the disproportionate and non-linear share of the unit costs created by factors such as labor and equipment. Within this chapter, the total aggregated costs for the State of Texas to comply with the Safe Drinking Water Act are compiled.

According to the information in Appendix A, approximately 90 percent of the total number of non-compliant water systems have populations less than 3,000 people, and 20 percent have less than 100 people. This indicates that a vast majority of non-compliant water systems have average demand supply flows less than 0.5 MGD.

The distribution of non-compliant systems for the purpose of this cost aggregation was divided into three groups initially, i.e., nitrate, fluoride, and both nitrate and fluoride non-compliant. Each of these three groups were subsequently divided within each of the groups by concentration into representative subgroups. These subgroups were arbitrarily selected based upon the involved flow/concentration distributions and cost of treatment. The capital, O&M, and unit treatment costs (UTC) are estimated within each of these subgroups. An estimated 150 gpcd flow rate was utilized to provide a representative estimate of flow.

FLUORIDE GROUP

Subgroup 1

This subgroup includes those non-compliant water supplies where the fluoride concentration averages 2.5 ppm. Tables VII–1a and b present the capital, O&M, and UTC for both reverse osmosis and tri-calcium phosphate adsorption. As indicated by the dashed line, the most economical treatment process switches from RO to tri-calcium phosphate adsorption as the flow increases above 150 Kgal/day at this concentration level.

Based upon these conclusions, this subgroup will require a total capital expenditure of $56,081,500, $11,622,700/year in O&M expense and a total annual cost of $17,119,100. In this subgroup there are a total of approximately 445,000 people served in 391 supply systems for an average of $126.03/capita, $0.07/capita-day and $0.11/capita-day for capital, O&M, and treatment respectively.

TABLE VII-1a

FLUORIDE SUBGROUP 1 (2.5 ppm)
TRI-CALCIUM PHOSPHATE

N[1]	Demand Flow Kgpd	Major Process Equipment Capital Cost $	Ancillary Equipment Capital Cost $	Total Capital Cost $	Total O&M Cost $/year	Total Annual Cost $/year	UTC $/Kgal
83	15	25,000	60,750	85,750	8,293	16,700	3.04
55	37.5	25,000	66,250	91,250	13,990	22,930	1.67
97	87.5	35,000	78,470	113,470	25,000	36,120	1.13
26	110	35,000	84,000	119,000	30,700	42,360	1.06
40	150	35,000	93,750	128,750	40,990	53,604	0.98
23	220	35,000	102,000	137,000	55,850	69,300	0.86
20	300	35,000	111,000	146,000	66,870	81,180	0.74
16	450	67,000	128,500	195,500	42,560	61,720	0.38
8	600	67,000	145,700	212,700	62,035	82,880	0.38
4	750	67,000	163,000	230,000	68,375	90,915	0.33
4	900	67,000	180,000	247,000	81,270	105,500	0.32
3	1,200	125,000	235,000	360,000	83,700	118,980	0.27
2	1,350	125,000	262,500	387,500	87,040	125,015	0.25
3	1,500	125,000	289,850	414,850	96,620	137,270	0.25
1	1,650	200,000	317,250	517,250	106,200	156,890	0.26
1	1,800	200,000	326,750	526,750	114,890	166,510	0.25
1	1,950	200,000	336,250	536,250	123,575	176,130	0.25
1	2,100	250,000	345,750	595,750	132,260	190,650	0.25
2	2,250	250,000	355,250	605,250	140,950	200,265	0.24
1	2,400	250,000	364,750	614,750	149,640	209,890	0.24
391	75,515	15,154,000	35,891,990	51,045,990	12,341,844	$17,369,510	

[1]Number of Water Supplies

TABLE VII-1b

FLUORIDE SUBGROUP 1 (2.5 ppm)
REVERSE OSMOSIS

N[1]	Demand Flow Kgpd	Major Process Equipment Capital Cost $	Ancillary Equipment Capital Cost $	Total Capital Cost $/year	Total O&M Cost $/year	Total Annual Cost $/year	UTC $/Kgal
83	15	10,800	76,750	87,550	6,903	15,482	2.82
55	37.5	18,375	82,000	100,375	11,765	21,601	1.57
97	87.5	35,040	98,000	133,040	22,785	35,822	1.12
26	110	42,920	104,000	146,920	27,684	42,082	1.05
40	150	54,000	112,500	166,500	36,285	52,602	0.96
23	220	70,000	122,000	192,000	51,068	69,884	0.87
20	300	93,000	130,000	223,000	67,820	89,670	0.82
16	450	129,000	150,000	279,000	45,278	72,620	0.44
8	600	162,000	165,000	327,000	58,620	90,666	0.41
4	750	195,000	180,000	375,000	71,963	108,713	0.40
4	900	228,000	202,000	430,000	85,656	127,800	0.39
3	1,200	288,000	250,000	538,000	113,240	166,000	0.38
2	1,350	315,000	270,000	585,000	126,833	184,200	0.37
3	1,500	350,000	290,000	640,000	140,425	203,150	0.37
1	1,650	374,000	317,000	691,000	154,370	222,100	0.37
1	1,800	408,000	335,000	743,000	167,860	240,700	0.37
1	1,950	430,000	355,000	785,000	181,450	258,400	0.36
1	2,100	455,000	380,000	835,000	195,300	277,125	0.36
2	2,250	480,000	400,000	880,000	208,900	295,140	0.36
1	2,400	520,000	418,000	938,000	222,400	314,300	0.36
381	75,515	22,794,825	43,009,250	65,804,075	12,310,333	$18,758,794	

[1]Number of Water Supplies

Subgroup 2

For the water supplies exhibiting fluoride concentrations averaging 5.0 ppm a second subgroup was established. Regardless of the flow rate, all systems in the subgroup would use tri-calcium phosphate adsorption rather than RO as indicated by the costs on Table VII–2. The total population served in this subgroup is 80,000 in 80 water systems. The total estimated capital cost would be $10,609,200 and $2,576,900/year in O&M costs. The average costs equal to $132.60/capita, $0.09/capita/day and $0.12/capita/day for capital, O&M and treatment respectively.

NITRATE GROUP

Subgroup 1

One of the four nitrate subgroups established covers those water supplies with nitrate concentrations averaging 50 ppm. Table VII–3 presents a comparison between selective ion exchange and RO. The total aggregated capital cost for this subgroup using the selected process of RO is $2,113,600. The O&M cost is $234,100/year. The total annual cost is $441,200. This averages to $63/capita of capital, $0.02/capita/day for O&M and $0.04/capita/day for treatment for the total subgroup population of 33,700 people.

Subgroup 2

The second nitrate subgroup has an influent nitrate content averaging 80 ppm. The costs are presented on Table VII–4. RO is the most cost effective system on a unit cost basis. The capital totals $2,500,000. The O&M totals $526,500/year and the total annual cost is $771,400. This subgroup covers a population of 9,800 people. The equivalent costs are $255/capita, $0.15/capita/day and $0.22/capita/day for capital, O&M and treatment respectively.

TABLE VII-2

FLUORIDE SUBGROUP 2 COST ANALYSIS
(5.0 ppm)

		Reverse Osmosis						Tri-Calcium Phosphate					
	Demand Flow	Major Process Equipment Capital Cost	Ancillary Equipment Capital Cost	Total Capital Cost	Total O&M Cost	Total Annual Cost	UTC	Major Process Equipment Capital Cost	Ancillary Equipment Capital Cost	Total Capital Cost	Total O&M Cost	Total Annual Cost	UTC
N[1]	Kgpd	$	$	$	$/year	$/year	$/Kgal	$	$	$	$/year	$/year	$/Kgal
27	15	18,000	76,750	94,750	11,280	20,565	3.75	25,000	60,750	85,750	8,950	17,353	3.17
11	37.5	36,000	82,700	118,700	22,750	34,382	2.51	25,000	66,250	91,250	15,357	24,300	1.77
10	87.5	70,000	95,950	165,950	48,230	64,495	2.02	35,000	78,450	113,450	28,510	39,630	1.24
11	110	83,600	102,000	185,600	59,700	77,888	1.94	35,000	83,975	118,975	33,910	45,570	1.13
4	220	147,800	110,000	257,800	114,700[2]	139,970	1.74	35,000	101,825	136,825	59,700	73,100	0.91
3	300	189,600	130,400	320,000	67,840	99,200	0.90	45,000	111,150	156,150	64,687	79,980	0.73
6	450	267,100	148,300	415,400	99,400	140,100	0.85	67,000	128,350	195,350	68,832	87,980	0.54
3	600	336,000	166,200	502,200	131,000	180,215	0.82	67,000	145,650	212,650	70,792	91,631	0.42
2	750	408,000	184,100	592,100	162,500	220,525	0.81	67,000	162,950	229,950	84,800	107,335	0.39
2	1,650	805,000	317,000	1,122,000	353,100	463,066	0.76	200,000	317,250	517,250	100,400	211,100	0.35
1	1,800	864,000	333,600	1,197,600	384,600	502,000	0.76	200,000	326,750	526,750	174,000	225,620	0.34
80	15,782.5	9,562,200	8,572,650	18,134,850	4,781,234	$6,558,841		3,297,000	7,312,175	10,609,175	2,576,938	$3,570,240	

[1] Number of Water Supplies

[2] Based on the assumption that O&M costs for flows less than 300 Kgal are $1.70/Kgal of product water and $0.70/Kgal for flows greater than 300 Kgal, a large variation in total O&M cost occurs at or near this breakpoint.

TABLE VII-3

NITRATE SUBGROUP 1 COST ANALYSIS
(50.0 ppm)

		Selective Ion Exchange Process						Reverse Osmosis Process					
	Demand Flow	Major Process Equipment Cost	Ancillary Equipment Cost	Total Capital Cost	Total O&M Cost	Total Annual Cost	UTC	Major Process Equipment Cost	Ancillary Equipment Cost	Total Capital Cost	Total O&M Cost	To Annual Cost	UTC
N[1]	Kgpd	$	$	$	$/year	$/year	$/Kgal	$	$	$	$/year	$/year	K/Kgal
4	22.5	285,000	69,750	354,750	27,300	62,066	7.55	7,500	78,800	86,300	5,500	13,958	1.70
1	45	285,000	74,000	359,000	29,488	64,670	3.94	12,000	84,700	96,700	7,355	16,833	1.03
2	120	285,000	88,200	373,200	36,822	73,396	1.68	17,520	104,600	122,120	13,552	25,520	0.58
1	150	285,000	93,850	378,850	39,733	76,850	1.40	21,000	112,500	133,500	16,028	29,111	0.53
1	525	412,500	161,850	574,350	96,240	152,525	0.80	60,700	157,250	217,950	23,193	44,552	0.23
2	2,000	450,000	271,500	721,500	349,375	420,082	0.58	176,000	362,000	538,000	69,200	121,924	0.17
11	3,050	3,592,500	1,328,100	4,920,600	1,047,054	$1,537,660		510,740	1,602,850	2,113,590	234,081	$441,213	

[1]Number of Water Supplies

TABLE VII-4

NITRATE SUBGROUP 2 COST ANALYSIS
(80 ppm)

		Selective Ion Exchange Process						Reverse Osmosis Process					
	Demand Flow	Major Process Equipment Capital Cost	Ancillary Equipment Capital Cost	Total Capital Cost	Total O&M Cost	Total Annual Cost	UTC	Major Process Equipment Capital Cost	Ancillary Equipment Capital Cost	Total Capital Cost	Total O&M Cost	Total Annual Cost	UTC
N[1]	Kgpd	$	$	$	$/year	$/year	$/Kgal	$	$	$	$/year	$/year	$/Kgal
8	15	285,000	68,300	353,300	26,848	61,471	11.23	14,400	76,750	91,150	8,336	17,268	3.15
3	30	285,000	71,200	356,200	28,966	63,874	5.83	20,304	80,700	101,004	13,014	22,912	2.09
4	90	285,000	82,500	367,500	35,332	71,348	2.17	47,520	96,700	144,200	31,772	45,903	1.39
2	150	285,000	93,850	378,850	41,922	79,050	1.44	72,000	112,500	184,500	50,520	68,601	1.25
2	300	285,000	122,200	407,200	58,670	98,576	0.90	130,000	130,400	260,400	96,310	121,830	1.11
19	1,470	5,415,000	1,522,100	6,937,100	644,197	$1,324,034		770,192	1,728,700	2,498,892	526,478	$771,350	

[1]Number of Water Supplies

Subgroup 3

This nitrate subgroup includes those water supplies with influent nitrate averaging 100 ppm. As shown on Table VII–5, the RO system would again be selected over selective ion exchange. The capital cost for this group totals $454,200, and the O&M totals $82,330/year. The total annual cost is $126,800. For the 1,100 people served, the equivalent costs are $413/capita, $0.21/capita/day, and $0.32/capita/day for capital, O&M, and treatment respectively.

Subgroup 4

This nitrate subgroup covers those water supplies with nitrate concentrations above 150 ppm. As shown on Table VII–6, the RO system is the most cost effective. The capital cost totals $269,000, and the O&M totals $63,000/year. The total annual cost is $89,400. For the 750 people served, the equivalent costs are $358/capita, $0.23/capita/day and $0.32/capita/day for capital, O&M, and treatment respectively.

NITRATE AND FLUORIDE GROUP

For those water supplies which are contaminated by both nitrate and fluoride, RO is the only system which has both the technical and economic advantage. In the treatment process, nitrate is the controlling parameter. Nitrate requires a larger percent reduction to meet the State standard than does fluoride.

Subgroup 1

This subgroup includes those water supplies with influent nitrate averaging 60 ppm. As shown on Table VII–7, the capital cost totals $254,500, and the O&M cost totals $63,400/year. The total annual cost is $88,400. For the 1,990 people served, the equivalent costs are $128/capita, $0.09/capita/day and $0.12/capita/day for capital, O&M, and treatment respectively.

TABLE VII-5

NITRATE SUBGROUP 3 COST ANALYSIS
(100.0 ppm)

		Selective Ion Exchange Process						Reverse Osmosis Process					
	Demand Flow	Major Process Equipment Capital Cost	Ancillary Equipment Capital Cost	Total Capital Cost	Total O&M Cost	Total Annual Cost	UTC	Major Process Equipment Capital Cost	Ancillary Equipment Capital Cost	Total Capital Cost	Total O&M Cost	Total Annual Cost	UTC
N[1]	Kgpd	$	$	$	$/year	$/year	$/Kgal	$	$	$	$/year	$/year	$/Kgal
2	30	285,000	71,200	356,200	28,526	63,434	5.79	23,500	80,700	104,200	16,050	26,263	2.40
1	45	285,000	74,000	359,000	30,144	65,327	3.98	32,400	84,700	117,100	22,116	33,592	2.05
1	60	285,000	76,850	361,850	31,875	67,336	3.08	40,020	88,650	128,670	28,115	40,725	1.86
4	135	1,140,000	293,250	1,433,250	119,071	$259,529		119,420	334,750	454,170	82,332	$126,840	

[1]Number of Water Supplies

TABLE VII-6

NITRATE SUBGROUP 4 COST ANALYSIS
(150.0 ppm)

		Selective Ion Exchange Process						Reverse Osmosis Process					
	Demand Flow	Major Process Equipment Capital Cost	Ancillary Equipment Capital Cost	Total Capital Cost	Total O&M Cost	Total Annual Cost	UTC	Major Process Equipment Capital Cost	Ancillary Equipment Capital Cost	Total Capital Cost	Total O&M Cost	Total Annual Cost	UTC
N[1]	Kgpd	$	$	$	$/year	$/year	$/Kgal	$	$	$	$/year	$/year	$/Kgal
1	22.5	285,000	69,750	354,750	27,632	62,398	7.60	23,600	78,736	102,336	14,777	24,806	3.02
1	90	285,000	82,500	367,500	35,332	71,348	2.17	70,000	96,611	166,611	48,193	64,520	1.96
2	112.5	570,000	152,250	722,250	62,964	$133,745		93,600	175,347	268,947	62,970	$89,326	

[1]Number of Water Supplies

TABLE VII-7

F^- AND NO_3^- SUBGROUP 1 (60 ppm)
REVERSE OSMOSIS PROCESS

N[1]	Demand Flow Kgpd	Major Process Equipment Capital Cost $	Ancillary Equipment Capital Cost $	Total Capital Cost $	Total O&M Cost $/year	Total Annual Cost $/year	UTC $/Kgal
1	40	11,000	85,000	96,000	11,550	20,960	1.43
1	250	33,500	125,000	158,500	51,875	67,408	0.74
2	290	44,500	210,000	254,500	63,425	$88,368	

[1] Number of Water Supplies

Subgroup 2

This subgroup includes those water supplies with influent nitrate averaging 100 ppm. As shown on Table VII-8, the capital cost totals $355,000, and the O&M cost totals $62,300/year. The total annual cost is $97,100. For the 900 people served, the equivalent costs are $394/capita, $0.19/capita/day and $0.30/capita/day for capital,O&M, and treatment respectively.

Subgroup 3

This subgroup includes those water supplies with influent nitrate averaging 150 ppm. As shown on Table VII-9, the capital cost and O&M cost totals $549,000 and $168,200/year respectively. The total annual cost is $232,800. For the 4,200 people served, the equivalent costs are $157/capita, $0.11/capita/day and $0.15/capita/day for capital, O&M, and treatment respectively.

TABLE VII-8

F^- AND NO_3^- SUBGROUP 2 (100 ppm)
REVERSE OSMOSIS PROCESS

N[1]	Demand Flow Kgpd	Major Process Equipment Capital Cost $	Ancillary Equipment Capital Cost $	Total Capital Cost $	Total O&M Cost $/year	Total Annual Cost $/year	UTC $/Kgal
1	18.75	16,530	80,000	96,530	10,810	20,270	2.96
1	27	23,500	81,000	103,500	13,855	24,000	2.43
1	90	55,700	100,000	155,000	37,670	52,860	1.61
3	135.75	95,730	261,000	355,030	62,335	$97,130	

[1]Number of Water Supplies

TABLE VII-9

F^- AND NO_3^- SUBGROUP 3 (150 ppm)
REVERSE OSMOSIS PROCESS

N[1]	Demand Flow Kgpd	Major Process Equipment Capital Cost $	Ancillary Equipment Capital Cost $	Total Capital Cost $	Total O&M Cost $/year	Total Annual Cost $/year	UTC $Kgal
1	100	100,000	102,000	202,000	53,280	73,100	2.00
1	540	302,000	155,000	457,000	114,900	159,690	0.81
2	640	402,000	257,000	659,000	168,180	$232,790	

[1]Number of Water Supplies

SUMMARY

The preceeding estimates of total capital, annual O&M, and annual UTC are summarized on Table VII–10. These data indicate that an estimated $73.3 million in capital, and $15.5 million per year in O&M costs shall be spent by these non-compliant water supply systems. These systems serve an approximate 557,500 people. The average capital investment amounts to $131/capita. The average O&M cost equates to $0.08/capita-day. The total amortized capital, along with the O&M costs, averages to $0.11/capita-day in treatment cost. These costs will be increased at an average rate of 10 percent per year according to trends in representative cost indices due to economic inflation. Assuming a population growth rate of 2 percent per year and an estimate of $176 million in capital and $43.1 million/year in O&M cost, the total annual cost will equate to $60.2 million/year if construction is delayed until 1986.

TABLE VII-10

SUMMARIZED CAPITAL, O&M, UTC
1976 Costs

Contaminant Groups	Total Capital $	Total O&M $/year	Total Annual Cost $/year
Group 1 -- Fluoride			
Subgroup 1[1]	56,081,500	11,622,700	17,119,100
Subgroup 2	10,609,200	2,713,600	3,706,000
Group 2 -- Nitrate			
Subgroup 1	2,113,600	234,100	441,200
Subgroup 2	2,500,000	526,500	771,400
Subgroup 3	454,200	82,330	126,800
Subgroup 4	269,000	63,000	89,400
Group 3 -- Fluoride and Nitrate			
Subgroup 1	254,500	63,400	88,400
Subgroup 2	355,000	62,300	97,100
Subgroup 3	659,000	168,200	232,800
Total	73,296,000	15,496,430	22,652,500
Total (1986)	176,000,000	43,116,000	60,229,700

[1]Refer to Pg. VII-3 for combination of most economical system.

APPENDIX A

EVALUATION OF TEXAS PUBLIC WATER SYSTEMS
IN TERMS OF WATER QUALITY USING
EPA INTERIM PRIMARY STANDARDS, BY COUNTY[1]

[1]Source is as listed in Item 1 in Bibliography and has been reproduced in its entirety.

Appendix 5a--Evaluation of Texas' Public Water Systems in Terms of Water Quality Using EPA Interim Primary Standards, by County 1/, 2/

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Andrews	1	Andrews	C	10,000	3,248	b/	Ogallala	4.8/1.6									
Aransas	21	Lamar WSC	C	250	89	b/	Gulf Coast	1.6/1.6									
Armstrong	2	Claude	C	992	445	b/	Ogallala	2.5/1.6									
		Hidden Falls Ranch	C	--	--	d/	--	2.4/1.6									
Atascosa	13	Lytle	C	1,271	529	b/	Edwards (Balcones Fault Zone)	1.7/1.4									
Bailey	3	Maple WSC	C	285	69	b/	Ogallala	3.0/1.6									
		Muleshoe	C	4,823	1,946	b/	Do.	1.9/1.6									
Bandera	8	WCID #1 - Bandera	C	1,100	575	b/	Trinity Group	2.0/1.6									
		Flying "L" Ranch DUL	C	22	9	d/	--	2.5/1.4-1.6									
		Medina Children's Home, Inc.	C	125	12	d/	--	2.4/1.4-1.6									
		Medina WSC	C	350	107	b/	Trinity Group	2.5/1.6									
Baylor	1	Seymour	C	3,500	1,486	b/	Alluvium		50								
Bee	28	El Ranchita Cafe	N	30	1	b/	Gulf Coast		64								
		Pawnee's Independent School District	N	--	3	b/	Do.		45								
Bell	77	WCID #2 - Littleriver	C	900	330	b/	Trinity Group	2.3/1.6									
		Acres WSC	C	363	126	b/	Do.	2.4/1.4-1.6									
		Armstrong WSC	C	258	254	b/	--	4.7/1.4-1.6									
		Barbara Dee Tr. Pk.	C	45	29	d/	--	.5.2/1.4-1.6									
		Bell-Falls-Milam WSC	C	1,865	746	b/	Trinity Group	1.9/1.4-1.6									
		Big "C" Tr. Pk.	C	90	30	d/	--	5.0/1.4-1.6									
		Chastain's Lake Way Int. (Chastain's Lakeside MHP)	C	40	21	d/	--	2.7/1.4-1.6									
		Curtsinger (WS)	C	25	10	d/	--	2.1/1.4-1.6									
		Deer Park Tr. Pk.	C	150	50	d/	--	7.7/1.4-1.6									
		Dog Ridge WSC	C	1,000	375	b/	Trinity Group	6.3/1.4-1.6									

See footnotes at end of table.

Appendix 5a—Evaluation of Texas' Public Water Systems in Terms of Water Quality
Using EPA Interim Primary Standards, by County 1/, 2/—Cont'd.

County	No. of County Systems Evaluated	Name of Systems	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l									
								F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Bell (cont'd.)		East Bell WSC	C	1,250	495	b/	Trinity Gr.	2.7/1.4-1.6									
		Echo Tr. Pk.	C	60	28	d/	--	4.5/1.4-1.6									
		Fisherman's Haven Tr. Pk.	C	30	15	d/	--	2.5/1.4-1.6									
		Gohlke Water System	C	12	5	d/	--	4.4/1.4-1.6									
		Heidenheimer Water District-Bell County Imp. Dist. #5	C	250	73	b/	Trinity Group	1.8/1.4-1.6									
		Hideway Mobil Pk.	C	30	12	d/	--	7.9/1.4-1.6									
		Holland	C	850	326	b/	Trinity Group	3.3/1.4									
		J. & R. Water Supply	C	400	170	d/	--	5.7/1.4-1.6									
		Little Elm Valley WSC	C	625	249	b/	--	2.1/1.4-1.6									
		Live Oak MHP	C	15	3	d/	--	3.4/1.4-1.6									
		Mitchell, Gertrude, M. Water System	C	—	—	d/	--	1.9/1.4-1.6									
		Moffatt WSC	C	561	187	b/	Trinity Group	1.6/1.6									
		Mountain View MHP	C	40	23	d/	--	3.4/1.4-1.6									
		Oenaville & Belfalls (O. & B. WSC)	C	275	109	b/	Trinity Group	2.4/1.4-1.6									
		Parks (Don) Water Supply	C	75	24	d/	--	5.3/1.4-1.6									
		Pecan Utility Co.-Cliff Estates	C	60	20	d/	--	2.4/1.4-1.6									
		Pepper's Creek WSC	C	1,500	407	b/	--	2.2/1.4-1.6									
		Roadrunner Tr. Pk.	C	35	13	d/	--	7.2/1.4-1.6									
		Rocking "E" Mobil Park	C	60	20	b/	—	4.7/1.4-1.6									
		Rogers	C	1,200	437	b/	Trinity Group	2.8/1.6									
		R. & R. Tr. Ct.	C	38	14	d/	--	6.0/1.4-1.6									
		7 Gables MHP	C	63	25	d/	--	4.6/1.4-1.6									
		Shady Acres (Spring Creek Water Coop.) Subd.	C	120	40	d/	--	2.8/1.4-1.6									
		Southshore	C	50	21	d/	—	3.8/1.4-1.6									
		Southwest Tr. Pk.	C	60	26	d/	--	5.7/1.4-1.6									
		Stage Coach MHP	C	150	52	b/	—	5.4/1.4-1.6									
		Stonegate MHP	C	69	23	d/	--	4.3/1.4-1.6									
		Suburbia MHP	C	200	70	d/	—	5.2/1.4-1.6									
		Taylor's Valley WSC	C	463	185	b/	Trinity Group	2.1/1.4-1.6									
		Tom's MHP	C	35	22	d/	--	3.5/1.4-1.6									
		Trimmer MHP	C	45	20	d/	--	8.7/1.4-1.6									
		Troy	C	700	290	b/	Trinity Group	1.9/1.6									
		2410 MHP	C	25	8	d/	—	5.9/1.4-1.6									
		Wells Ranch Apts.	C	15	5	d/	--	3.0/1.4-1.6									

See footnotes at end of table.

Appendix 5a--Evaluation of Texas' Public Water Systems in Terms of Water Quality
Using EPA Interim Primary Standards, by County 1/, 2/--Cont'd.

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l									
								F 5/,8/	NO_3 6/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Bexar	114	Canyon Lake Forest Utility	C	425	70	d/	—	3.8/1.4									
		Cozy Cove Tr. Pk.	C	120	52	b/	—	1.8/1.4									
		Ramsey Ranch Acres MHP	C	15	6	d/	--	3.1/1.4									
		Stillwell Tr. Pk.	C	60	20	d/	—	2.8/1.4									
		Summit Oaks Water Co.	C	90	29	d/	--	2.6/1.4									
Blanco	8	Lake Of The Hills	C	60	20	d/	—	1.7/1.4-1.6									
Bosque	23	Best View Village (Best View WSC)	C	100	32	d/	—	8.2/1.4-1.6									
		Steele Creek Acres Water System	C	250	80	b/	--	5.2/1.4-1.6									
		Steele Creek Harbor Water Supply	C	30	13	d/	—	5.3/1.4-1.6									
Brazoria	44	Hillcrest Village	C	450	135	b/	Gulf Coast	1.6/1.4-1.6									
Brazos	14	Wixon WSC	C	1,900	600	b/	—	2.0/1.6									
Brewster	10	Alpine	C	5,900	1,820	b/	Igneous Rocks	2.9/1.6									
		Roadrunner MUP	C	36	12	d/	--	2.1/1.4-1.6									
		Terlingua Ghost Town Tr. Pk.	C	—	—	d/	—	2.1/1.6									
		Wedin Water Corp.-Marathon	C	200	65	b/	Alluvium & Bolson	1.9/1.6									
Briscoe	4	Caprock Canyon State Park	N	—	—	d/	—		68								
		Quitaque	C	632	294	b/	Other (Ochoa)	4.7/1.6	150								
		Silverton	C	1,056	457	b/	Ogallala	4.4/1.6									
Burleson	19	Summerville Place Subd.	C	150	65	d/	—	1.9/1.4-1.6									
Burnet	27	River Bend Tr. Pk.	C	40	18	d/	—	2.3/1.4-1.6									
		Spring Creek Hills (Spring Creek W. Corp.)	C	50	12	d/	—	2.5/1.4-1.6									
Caldwell	11	Pecan Tr. Pk.	C	200	55	d/	--		111								
Calhoun	11	Sea-Lake Subd. Water System	C	—	—	d/	--	2.2/1.6									

See footnotes at end of table.

Appendix 5a--Evaluation of Texas' Public Water Systems in Terms of Water Quality
Using EPA Interim Primary Standards, by County 1/, 2/--Cont'd.

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Cameron	43	Arroyo WSC	C	800	325	b/	Gulf Coast	1.7/1.4-1.6									
		Heart of the Valley	C	50	25	d/	—	1.5/1.4-1.6									
		Highland Tr. Pk. #2	C	100	45	b/	Gulf Coast	2.0/1.4-1.6									
		Pleasant Acres Tr. Pk.	C	80	39	d/	—	3.0/1.4-1.6									
		P. M. P. MHP, Inc.	C	100	45	d/	--	1.8/1.4-1.6									
		Poff's Travel Tr. Pk.	C	60	30	d/	—	4.9/1.4-1.6									
		Santa Rosa-Cameron Co. WCID	C	1,500	340	b/	Gulf Coast	1.6/1.4-1.6									
		WIN Mobil Home Sales & Service	C	45	35	b/	Do.	1.9/1.4-1.6									
Castro	5	Dimmit	C	4,327	1,688	b/	Ogallala	2.6/1.6									
		Hart	C	1,009	320	b/	Do.	1.7/1.6									
Chambers	19	Bayridge Subd.	C	160	46	d/	—	2.4/1.6									
		Cotton Bayou Manor MHP	C	50	24	b/	Gulf Coast	2.4/1.6									
		Mount Belview, WCID	C	1,300	460	b/	Do.	2.0/1.6									
		Old River County Subd.	C	--	—	d/	—	2.0/1.6									
		Staples (C. T.) Subd.	C	75	25	b/	Gulf Coast	1.7/1.6									
Clay	6	Belleview	C	355	140	b/	Other (Cisco Group)	2.0/1.6									
		Byers	C	500	270	b/	Alluvium		59								
		Charlie WSC	C	100	33	b/	Do.		64								
Cochran	3	Bledesoe WSC	C	120	60	b/	Ogallala	2.1/1.6									
		Morton	C	2,850	1,023	b/	Do.	4.1/1.6									
		Whiteface	C	394	185	b/	Do.	2.8/1.6									
Collin	33	Allen	C	3,700	1,086	b/	Woodbine	2.6/1.6									
		Altoga WSC	C	300	104	b/	Do.	1.7/1.6									
		Anna	C	750	277	b/	Do.	1.6/1.6									
		Lebanon WSC	C	522	174	b/	Trinity Group	1.6/1.6									
		Melissa (WSC)	C	405	203	b/	Woodbine	1.7/1.6									
		Renner Water Co.	C	485	203	b/	Do.	—									
		(Preston Highlands)						3.6/1.6									
		(Preston Villa)						4.1/1.6									
		(Renner)						1.7/1.6									
		Westminster WSC	C	250	115	b/	Woodbine	1.7/1.6									
		Weston WSC	C	270	91	b/	Do.	3.1/1.6									

See footnotes at end of table.

Appendix 5a--Evaluation of Texas' Public Water Systems in Terms of Water Quality
Using EPA Interim Primary Standards, by County 1/, 2/--Cont'd.

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l									
								F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Collingsworth	2	Dodson	C	260	99	b/	Alluvium		53								
Comal	48	Cadillac Canyon	C	40	16	d/	--	3.3/1.4									
		Canyon Creek Estates	C	20	4	d/	—	2.9/1.4									
		Canyon Lake Village	C	225	85	d/	--	1.7/1.4									
		Deep Acres	C	48	16	d/	—	4.3/1.4									
		Horseshoe Falls	C	130	49	b/	Edwards (Balcones Fault Zone)	4.6/1.4									
		Mount Lookout Development	C	60	22	d/	—	3.6/1.4									
		North Point Subd.	C	140	37	d/	—	2.2/1.4									
		Scenic Heights Subd.	C	60	21	d/	--	4.0/1.4									
		Triple Peak Ranch Estates	C	70	25	b/	—	4.3/1.4									
Concho	5	Eola WSC	C	150	57	b/	Other (Leona)		136								
		Lowake Steak House	N	—	—	d/	—		140								
		Original Lowake Inn Steak House	N	—	—	d/	—		130								
Coryell	18	Bluestem Subd.	C	150	55	d/	—	3.1/1.4-1.6									
		Duren Tr. Pk.	C	100	28	d/	—	3.1/1.4-1.6									
		Evant WSC	C	1,000	235	b/	Trinity Group	1.7/1.6									
		Flat WSC	C	300	135	b/	Do.	2.4/1.4-1.6									
		Fort Gates WSC	C	900	302	b/	Do.	1.7/1.4									
		Gatesville	C	5,500	2,393	b/	Do.	2.2/1.4									
		Gatesville State School for Boys-Mountain View	C	455	--	c/	-,U. Leon River Diversion	2.0/1.4									
		Levita WSC	C	120	37	b/	Trinity Group	4.3/1.4									
		Mountain WSC	C	850	204	d/	--	1.5/1.4									
		Oak Villa MHP	C	300	100	d/	--	4.3/1.4-1.6									
		Oglesby	C	450	185	b/	Trinity Group	1.8/1.6									
		Tanglewood Tr. Pk.	C	20	4	d/	—	3.1/1.4-1.6									
Crockett	3	WCID #1 - Ozona	C	140	30	b/	Edwards-Trinity (Plateau)	2.5/1.4									

See footnotes at end of table.

Appendix 5a.--Evaluation of Texas' Public Water Systems in Terms of Water Quality Using EPA Interim Primary Standards, by County 1/, 2/ — Cont'd.

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l									
								F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Crosby	5	Crosbyton	C	2,500	829	a/	White River Res.	2.0/1.6									
		Lorenzo	C	1,209	466	b/	Ogallala	2.8/1.6									
		Ralls	C	2,200	860	a/	White River Res.	1.8/1.6									
		White River MWD	C	10,000	--	a/	Do.	1.9/1.6									
Culberson	6	Van Horn	C	2,750	802	b/	Alluvium & Bolson	2.2/1.6									
Dallas	40	FWSD #15-Buckingham Estates	C	250	61	d/	--	3.6/1.6									
		WCID #7 - Kleberg	C	8,000	2,500	c/	Purchased from Dallas 10/	3.2/1.6									
		Addison	C	300	135	d/	—	2.3/1.6									
		Clover Haven	C	--	—	b/	Woodbine, Trinity Group	4.5/1.6									
		Coppell	C	2,350	318	b/	Trinity Group	2.6/1.6									
		Danieldale	C	300	105	d/	--	2.2/1.6 9/									
		Desoto	C	10,000	3,000	b/	Trinity Group	1.8/1.6									
		Grand Prairie Community Water Service	C	120	40	c/	Woodbine, Purchases from Dallas 10/	2.2/1.6 9/									
		Highland Park	C	10,133	3,500	a/	Purchased from Dallas Co. MWD	3.9/1.6									
		Hutchins	C	2,400	675	c/	Woodbine,-	2.3/1.6									
		Lancaster	C	14,000	4,234	c/	Woodbine, Trinity Group	2.0/1.6									
		Meadow Lake Community Water Service	C	150	38	d/	—	4.5/1.6 9/									
		Neuhoff	C	600	—	d/	--	3.9/1.6									
		Pleasant Grove Community Water Service (Well #67)	C	1,300	430	d/	--	3.9/1.6 9/									
		Wilmer	C	2,500	635	b/	Trinity Group	2.3/1.6									
Dawson	4	Ackerly	C	348	104	b/	Ogallala	4.4/1.6									
		Welch WSC	C	290	101	b/	Do.	3.5/1.6									

See footnotes at end of table.

Appendix 5a-Evaluation of Texas' Public Water Systems in Terms of Water Quality Using EPA Interim Primary Standards, by County 1/, 2/—Cont'd.

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l									
								F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Deaf Smith	2	Hereford	C	16,000	4,821	b/	Ogallala	2.0/1.6									
		Hereford Housing Project	C	500	100	b/	Do.	1.9/1.6									
Delta	5	Ben Franklin WSC	C	210	70	b/	Other (Navarro)	3.1/1.6									
Denton	43	Flower Mound (Well No.1)	C	1,600	415	b/	Trinity Group	3.2/1.6									
		Lakewood Village Util. Co.	C	15	5	b/	—	3.1/1.6									
		Morris Terrace	C	—	—	d/	—	1.9/1.6									
		North Lake Highlands #2	C	—	—	b/	Trinity Group	1.7/1.6									
		Vacation Village Estates	C	300	100	d/	—	2.5/1.6									
		Wynnewood Haven Water System	C	—	—	d/	—	3.1/1.6									
Dickens	3	McAdoo WSC	C	135	53	b/	Ogallala	1.8/1.6									
		Spur	C	1,747	824	a/	White River Res.	1.7/1.6									
Donley	4	Sherwood Shores #9	C	680	254	b/	Ogallala	2.0/1.6									
Eastland	10	Rising Star	C	1,009	550	b/	Trinity Group		58								
Ector	66	Barnet Water Supply	C	--	--	d/	--	1.6/1.6									
		B. & H. MHP (Broadwell)	C	--	—	d/	--		51								
		Beasley's MHP	C	—	—	d/	—	2.4/1.4-1.6									
		Belle MHP	C	215	91	c/	Edwards-Trinity (Plateau), Colorado MUD purchased Odessa	2.5/1.4-1.6									
		Big "T", Texaco Campground	C	--	—	d/	--	2.9/1.4-1.6									
		Brett's Tr. Pk.	C	--	—	d/	—	1.7/1.4-1.6									
		Canyon Dam (#1 Mobil Ranch?) Tr. Pk. #1	C	---	—	d/	—	4.1/1.4-1.6									
		Coliseum Tr. Pk.	C	--	—	d/	—	2.3/1.4-1.6									
		Colvin's High Sky Lodges	C	--	—	d/	—	2.0/1.4-1.6									
		D. & M. MHP	C	—	—	d/	—	2.8/1.4-1.6									

See footnotes at end of table.

Appendix 5a--Evaluation of Texas' Public Water Systems in Terms of Water Quality
Using EPA Interim Primary Standards, by County 1/, 2/--Cont'd.

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l									
								F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Ector (cont'd.)		De Villa Tr. Pk.	C	--	--	d/	--	1.6/1.6									
		Eaves Tr. Pk.	C	--	--	d/	--	3.6/1.4-1.6	53								
		Elm Tr. Pk.	C	--	--	d/	--	2.3/1.4-1.6	43								
		Flying "W" MHP	C	80	22	d/	--	2.8/1.4-1.6									
		Gene's MHP	C	--	--	d/	--	1.6/1.6									
		Goldsmith	C	400	156	b/	Edwards-Trinity (Plateau)	2.0/1.6									
		Gregg's Tr. Pk.	C	--	--	d/	--	1.7/1.4-1.6									
		Hughes Tr. Pk.	C	--	--	d/	--	2.1/1.4-1.6									
		Jones MHP	C	24	11	d/	--	2.6/1.4-1.6									
		Moffitt's Mobile Courts	C	--	--	d/	--	1.9/1.4-1.6									
		M. C. Tr. Pk.	C	--	--	d/	--	2.3/1.4-1.6									
		Northgate Park	C	--	--	d/	--	3.2/1.4-1.6									
		Orchard Water System	C	180	50	b/	Edwards-Trinity (Plateau)	1.7/1.4-1.6									
		Ponderosa Tr. Pk.	C	40	15	d/	--	2.1/1.4-1.6									
		Radio City Tr. Pk.	C	--	--	d/	--	3.2/1.4-1.6									
		Sam's Tr. Pk.	C	--	--	d/	--	1.8/1.4-1.6									
		Sunset Tr. Pk.	C	--	--	d/	--	1.9/1.4-1.6									
		Tisdale Tr. Pk.	C	--	--	d/	--	2.9/1.4-1.6									
		Todd & Todd Real Estate-Project 82	C	234	78	d/	--	2.9/1.4-1.6									
		University Tr. Pk.	C	30	10	d/	--	2.2/1.4-1.6									
		Vega Tr. Pk.	C	25	7	d/	--	2.3/1.4-1.6									
		Vick's Tr. Pk.	C	--	--	d/	--	1.7/1.4-1.6									
		Victory Village Tr. Pk.	C	--	--	d/	--	1.9/1.4-1.6									
		Wagon Yard Tr. Pk.	C	--	--	d/	--	2.3/1.4-1.6									
		Well's Tr. Pk.	C	--	--	d/	--	1.6/1.6									
		Westover MHP	C	--	--	d/	--	2.2/1.4-1.6									
		William's Tr. Pk.	C	--	--	d/	--	1.8/1.4-1.6									
		Wilson's Mobile Villa	C	--	--	d/	--	1.6/1.6									
		Wright's Tr. Pk.	C	--	--	d/	--	1.8/1.4-1.6									
Ellis	30	Avalon WSC	C	180	60	b/	Woodbine	5.0/1.6									
		Bardwell	C	277	135	b/	Do.	7.9/1.6									
		Boyce WSC	C	515	192	b/	Do.	4.5/1.6									
		Bristol WSC	C	500	149	b/	Do.	5.1/1.6									
		Ferris	C	2,200	800	b/	Do.	5.0/1.6									
		Howard Water Co.	C	--	--	d/	--	5.8/1.6									
		Italy	C	1,400	539	b/	Woodbine	3.5/1.6									
		Maypear	C	500	225	b/	Do.	2.0/1.6									
		Milford	C	675	295	b/	Woodbine, Trinity Group	2.3/1.6									

See footnotes at end of table.

Appendix 5a--Evaluation of Texas' Public Water Systems in Terms of Water Quality Using EPA Interim Primary Standards, by County 1/, 2/—Cont'd.

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l									
								F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Ellis (cont'd.)		Nash-Forreston WSC	C	1,200	296	b/	Trinity Group	2.0/1.6									
		Ovilla Community Center WSC	C	250	135	b/	Woodbine	2.1/1.6									
		Palmer	C	800	300	b/	Do.	4.6/1.6									
		Red Oak	C	1,200	395	b/	Do.	2.2/1.6									
		Red Oak Community Water Service	C	150	80	b/	Woodbine	2.2/1.6									
		Rockett WSC	C	3,000	1,018	b/	Trinity Group	2.4/1.6									
		South Ellis Co. WSC	C	1,000	235	b/	—	2.2/1.6									
El Paso	53	WCID - Westway	C	1,000	210	b/	Alluvium & Bolson	2.0/1.6									
		Bonanza MHP	C	225	76	b/	Do.	1.7/1.6									
		Borderland Addn.	C	60	25	d/	--	1.9/1.6									
		Buckaroo Apts.	C	14	4	d/	—	3.8/1.6									
		Gaslight Square MHP, Inc.	C	200	175	d/	--	1.9/1.6									
		Leonard MHP	C	30	8	d/	—	2.1/1.6									
		Mahorney MHP	C	—	19	d/	--	1.8/1.6									
		Snug Harber Motel & Tr. Town	C	40	25	d/	—	2.9/1.6									
		Urioste's MHP	C	15	5	d/	—	2.2/1.6									
Falls	11	Cego - Durango WSC	C	600	175	b/	Trinity Group	2.1/1.6									
		Chilton	C	600	250	b/	Do.	2.3/1.6									
		Lott WSC	C	1,287	300	c/	Trinity Group, City Lake	2.3/1.6									
		Mooreville WSC	C	160	46	b/	Trinity Group	2.5/1.6									
		Perry WSC	C	480	123	b/	Do.	3.1/1.6									
		Tri-County WSC	C	2,200	775	b/	—	2.1/1.6									
		Westphalia WSC	C	300	72	b/	Trinity Group	2.8/1.6									
Fannin	24	Dial WSC	C	180	60	b/	—	3.0/1.6									
		Ector	C	519	253	b/	Woodbine	2.9/1.6									
		Gober WSC	C	250	88	b/	Do.	1.7/1.6									
		Honey Grove	C	2,000	935	b/	Do.	2.0/1.6									
		Ladonia WSC	C	900	355	b/	Do.	2.7/1.6									
		Leonard	C	1,475	752	b/	Do.	1.6/1.6									
		Self's WSC	C	120	42	b/	Trinity Group	1.7/1.6									

See footnotes at end of table.

Appendix 5a.—Evaluation of Texas' Public Water Systems in Terms of Water Quality
Using EPA Interim Primary Standards, by County 1/, 2/—Cont'd.

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l									
								F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Fannin (cont'd.)		White Shed WSC	C	1,200	400	d/	--	1.6/1.6									
Floyd	3	Dougherty	C	100	35	b/	Ogallala	3.9/1.6									
		Flovdada	C	4,160	1,523	b/	Do.	3.6/1.6									
		Lockney	C	2,094	801	b/	Do.	2.6/1.6									
Foard	2	Thalia WSC	C	210	69	d/	—		73								
Gaines	4	Loop WSC	C	300	104	b/	Ogallala	5.0/1.6									
		Seagraves	C	2,785	831	b/	Do.	4.7/1.6									
		Seminole	C	5,007	2,186	b/	Edwards-Trinity (High Plains) & Ogallala	4.2/1.6									
Galveston	38	Bermuda Beach & Spanish Grant	C	150	50	a/	Galveston Co. Wtr. Auth.	1.6/1.6									
		Pine Oak Tr. Ct.	C	60	20	d/	--	3.0/1.6									
		San Leon-Fiesta Estates	C	80	15	b/	Gulf Coast	1.7/1.6									
Garza	4	Caprock WSC	C	40	17	d/	--	1.6/1.6									
		Post	C	3,854	1,392	a/	White River Res.	1.9/1.6									
Gray	5	McLean	C	1,000	563	b/	Ogallala		47								
Grayson	34	Bells	C	778	250	b/	Woodbine	1.6/1.6									
		Elmont-Farmington WSC	C	216	---	b/	Trinity Group	1.7/1.6									
		Gunter WSC	C	1,500	408	b/	Woodbine	2.3/1.6									
		Oak Ridge-Southgale WSC	C	1,050	350	d/	—	2.7/1.6									
		Tom Bean	C	540	230	b/	Woodbine	1.9/1.6									
		Van Alstyne	C	1,986	784	b/	Do.	2.0/1.6									
		Wright (W.O.) MHP	C	—	—	d/	—	4.5/1.6									
Guadalupe	12	Featherland Egg Farms	N	—	—	d/	—		75								
Hale	6	Abernathy	C	3,000	1,150	b/	Ogallala & Edwards-Trinity (High Plains)	2.3/1.6									
		Cotton Center WSC	C	230	64	b/	--	2.0/1.6									
		Hale Center	C	1,964	730	b/	Ogallala	3.2/1.6									

See footnotes at end of table.

Appendix 5a--Evaluation of Texas' Public Water Systems in Terms of Water Quality
Using EPA Interim Primary Standards, by County 1/, 2/--Cont'd.

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/1									
								F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Hale (cont'd)		Halfway WSC	C	75	59	b/	Ogallala	2.3/1.6									
		Petersburg	C	1,400	485	b/	Do.	3.3/1.6									
Hall	6	Lakeview WSC	C	275	126	b/	Alluvium		50								
		Turkey	C	800	310	b/	Do.		47								
Hansford	[illegible]	Hi-Plains Utility Co.	C	1,700	623	d/	--	2.3/1.6-1.8									
		Morse (Water Co.)	C	150	58	b/	Ogallala	2.3/1.8									
		Spearman	C	4,000	1,458	b/	Do.	1.6/1.6									
Harrison	23	Gill WSC	C	780	260	d/	--	1.9/1.6									
Haskell	7	Haskell	C	3,600	1,599	b/	Alluvium	1.8/1.6	140								
		O'Brien	C	286	60	b/	Do.		113								
		Paint Creek WSC	C	600	170	b/	Do.	2.5/1.6	86								
		Rochester	C	500	230	b/	Do.		62								
		Rule	C	1,050	450	b/	Do.		70								
		Weinert	C	265	105	b/	Do.	1.7/1.6	53								
Hays	22	Cypress Creek Acres	C	20	8	d/	--	2.8/1.4									
		Dripping Springs WSC	C	520	140	b/	Trinity Group	2.5/1.4									
		Goforth SWC	C	700	247	b/	Edwards (Balcones Fault Zone)	1.4/1.4									
		Green Pastures Water Co.	C	120	65	d/	--	2.3/1.4									
		Kyle	C	~~2,500~~	651	b/	Edwards (Balcones Fault Zone)	3.7/1.4									
		Moss Cliff Restaurant	N	100	1	d/	--		73								
		Sunny Acres MHP	C	45	17	d/	--		66								
Hidalgo	42	A. & A. Water Co.	C	400	100	d/	--	2.2/1.4									
		Clark's MH Homesties	C	100	26	d/	--		115								
		Clearview MHP	C	40	16	d/	--		81								
		Penitas Tr. Pk.	C	90	56	d/	--	1.5/1.4									
Hill	30	Arrowhead Lodge	C	350	106	d/	--	2.0/1.6									
		Birome WSC	C	1,000	260	b/	Trinity Group	2.1/1.6									
		Blackland Water Co.	C	220	100	d/	--	5.3/1.6									

See footnotes at end of table.

Appendix 5a--Evaluation of Texas' Public Water Systems in Terms of Water Quality
Using EPA Interim Primary Standards, by County 1/, 2/--Cont'd.

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l									
								F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Hill (cont'd.)		Brandon-Irene WSC	C	1,100	346	b/	Trinity Group	1.8/1.6									
		Covington	C	300	200	b/	Do.	2.3/1.6									
		Gilmore Acres (Water Supply)	C	100	44	b/	Trinity Group	5.2/1.6									
		Hillsboro	C	11,000	2,971	b/	Trinity Group, Woodbine	2.0/1.6									
		Mertens	C	228	76	b/	Woodbine	3.1/1.6									
		Mount Calm	C	375	175	b/	Trinity Group	2.4/1.6									
		Whitney	C	2,400	807	b/	Do.	3.3/1.6									
Hockley	7	Anton	C	1,050	426	b/	Ogallala	1.7/1.6									
		Ropesville	C	483	193	b/	Do.	4.6/1.6									
		Sundown	C	1,500	514	b/	Do.	3.7/1.6									
		Witharral WSC	C	250	74	b/	Do.	4.4/1.6									
Hopkins	10	Miller Grove WSC	C	528	176	b/	--	2.6/1.6									
Howard	5	Hillside Tr. Pk.	C	98	38	d/	--	2.1/1.6									
Hudspeth	5	WCID-Ft. Hancock	C	500	156	b/	Alluvium & Bolson	2.2/1.6									
		WCID #1 - Sierra Blanca	C	900	250	b/	Do.	1.6/1.6									
		Sierra Blanca Corp.	C	40	16	b/	Do.	4.4/1.6									
Hunt	25	Celeste	C	900	290	b/	Woodbine	1.6/1.6									
		Lone Oak	C	650	225	b/	Other (Midway)	4.9/1.6									
		Mulberry Cove Estates	C	100	40	d/	--	4.3/1.6									
		North Hunt WSC	C	1,500	654	d/	--	3.1/1.6									
Hutchinson	8	Bug Bee Shores	C	135	45	d/	--	1.8/1.8									
Jackson	5	WCID #2-Vanderbilt	C	450	120	b/	Gulf Coast	1.7/1.6									
		Ganada	C	1,640	619	b/	Do.	1.7/1.4									
Jasper	13	Holly Huff WSC	C	450	150	b/	Gulf Coast	1.6/1.6									

See footnotes at end of table.

Appendix 5a--Evaluation of Texas' Public Water Systems in Terms of Water Quality Using EPA Interim Primary Standards, by County 1/, 2/--Cont'd.

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l: F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Jeff Davis	[illegible]	Ft. Davis WSC	C	700	154	b/	--	2.7/1.6									
Jim Hogg	[illegible]	WCID #2-Hebbronville	C	4,500	1,300	b/	Gulf Coast	2.3/1.4									
Jim Wells	15	Green Acres WSC	C	26	6	b/	Gulf Coast	2.2/1.4									
Johnson	24	Alvarado	C	2,200	811	b/	Trinity Group	2.9/1.6									
		Bethesda WSC	C	9,000	2,600	b/	Do.	2.3/1.6									
Karnes	5	Karnes City	C	2,926	1,017	b/	Gulf Coast	2.6/1.4									
Kendall	12	WCID #1-Comfort	C	1,100	403	b/	Trinity Group	1.8/1.6									
		Camp Alzafar Tr. Pk.	C	405	135	b/	--	1.7/1.6									
		Foothills M H Ranch	C	200	100	d/	--	4.1/1.6									
Kerr	34	Cedar Springs	C	80	31	b/	--	1.9/1.6									
		Center Point Water Works	C	306	110	d/	--	2.0/1.6									
		Erlund (O.J.) Water System	C	9	3	d/	--	1.6/1.6									
		Hill Country MHP	C	24	13	d/	--	1.8/1.6									
		Kerrville Hills Ranchettes	C	12	6	b/	--	1.7/1.6									
		Royal Oaks Water Co.	C	75	30	d/	--	1.6/1.6									
		Westwood Park Tr. Pk. (Water System)	C	35	17	d/	--	1.8/1.6									
Knox	5	WCID #1-Benjamin	C	320	140	b/	Alluvium	1.9/1.6									
		Goree	C	534	200	b/	Do.	2.3/1.6									
		Knox City	C	1,536	580	b/	Do.		82								
		Munday	C	1,726	650	b/	Do.	1.9/1.6	59								
Lamar	12	Cunningham WSC	C	255	85	d/	--	3.8/1.6									
		Forest Hills WSC	C	120	35	d/	--	2.0/1.6									
		MJC WSC	C	360	120	d/	--	3.8/1.6									
		Pattonville	C	400	116	b/	Other (Austin Chalk)	4.0/1.6									
		Petty WSC	C	196	56	b/	--	1.9/1.6									
		Reno WSC	C	631	106	d/	--	3.1/1.6									

See footnotes at end of table.

Appendix 5a.—Evaluation of Texas' Public Water Systems in Terms of Water Quality Using EPA Interim Primary Standards, by County 1/, 2/—Cont'd.

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l									
								F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr 6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Lamb	8	Earth MWS	C	1,223	427	b/	Ogallala	2.0/1.6									
		Littlefield	C	7,300	2,518	b/	Do.	1.8/1.6									
		Olton	C	1,782	766	b/	Do.	2.5/1.6									
		Spade WSC	C	150	63	b/	Do.	2.2/1.6									
		Springlake	C	210	87	b/	Do.	2.1/1.6									
Lampasas	19	Allen Estates-Section II	C	12	3	d/	—	4.3/1.6									
		Big T's MHP	C	40	12-45	d/	—	2.3/1.6									
		Brookdale Villa MHP	C	30	8-12	d/	—	3.6/1.6									
		Circle "T" MHP	C	25	7	d/	—	3.4/1.6									
		Lightfoot Tr. Pk.	C	50	15	d/	—	3.9/1.6									
		Oak Springs (Spring Creek W. Coop.)	C	150	50	d/	—	2.6/1.6									
		Pat's MHP	C	80	25	d/	—										
		Quiet Haven MHP	C	40	12-20	d/	—	2.9/1.6									
		S. & M. MHP	C	30	12	d/	—	2.8/1.6									
		Sioux City MHP	C	100	33	d/	—	2.2/1.6									
		Thompson's MHP	C	100	37	d/	—	3.6/1.6									
		Triple "J" MHP	C	200	70	d/	—	2.7/1.6									
Lee	6	290 WSC	C	175	60	b/	Queen City, Purchased Giddings	1.5/1.4									
Liberty	25	Cleveland	C	5,627	1,948	b/	Gulf Coast	1.8/1.4-1.6									
Limestone	15	Prairie Hill WSC	C	1,000	260	d/	—	1.9/1.6									
Live Oak	12	Lake Vista Utility Co.	C	1,000	210	d/	—	1.5/1.4									
Llano	20	A. & D. Acres	C	30	12	d/	—	2.1/1.4-1.6									
		Edgewater Cottages Tr. Pk.	C	100	45	d/	—	1.8/1.4-1.6									
		Marsh Mobile Manor	C	60	17	d/	—	3.1/1.4-1.6									
		Stovers MHP	C	50	30	d/	—	2.4/1.4-1.6									
Lubbock	37	WCID #1-Buffalo Springs	C	350	319	d/	—	2.3/1.6									
		Alexander (F.L.) Water System	C	30	12	d/	—	3.6/1.6									

See footnotes at end of table.

Appendix 5a.--Evaluation of Texas' Public Water Systems in Terms of Water Quality Using EPA Interim Primary Standards, by County 1/, 2/

County	No. of County Systems Evaluated	Name of Systems	Type of Systems 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l									
								F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Lubbock (cont'd.)		Applegate, Shady Acres Tr. Pk.	C	700	275	b/	--	4.8/1.6									
		Big "Q" Mobile Park	C	195	65	d/	—	6.6/1.6									
		Buster's MHP	C	25	7	d/	--	6.0/1.6									
		Executive Mobile Home Village	C	252	84	d/	—	5.7/1.6									
		Family Com. Housing MHP	C	140	52	d/	—	2.1/1.6									
		Green Acres MHP	C	15	10	d/	—	4.0/1.6									
		Herford Sh. Water System	C	200	35	b/	Ogallala	4.4/1.6									
		Idalou	C	2,000	710	b/	Do.	2.9/1.6									
		Jones Tr. Pk.	C	24	8	d/	—	2.3/1.6									
		Lubbock Christian College	C	1,000	15	b/	—	4.5/1.6									
		McKinley Water System	C	175	50	d/	—	4.0/1.6									
		Mathis Tr. Pk.	C	126	42	d/	—	5.5/1.6									
		New Deal WSC	C	500	145	b/	Ogallala	2.8/1.6									
		Pecan Grove MHP	C	99	33	d/	—	4.2/1.6									
		Ponderosa Tr. Pk.	C	27	9	d/	—	6.1/1.6									
		Porter Water Co.	C	280	93	b/	—	1.9/1.6									
		Shallowater	C	1,800	495	b/	Ogallala	4.3/1.6									
		Sky-Vue MHP	C	56	21	d/	—	1.9/1.6									
		South 87 MHP	C	30	12	d/	—	4.6/1.6									
		Stahl No. 1	C	--	--	d/	--	2.0/1.6									
		Sycamore MHP	C	37	16	d/	—	2.4/1.6									
		Texas Boys Ranch	C	13	1	d/	—	2.6/1.6									
		Town & Country Mobile Estates	C	300	113	d/	—	5.1/1.6									
		Vagabond Trailer Court	C	104	49	b/	—	5.0/1.6									
		Vista Villa MHP	C	36	13	d/	—	4.6/1.6									
		Western Terrace MHP	C	36	12	d/	--	5.8/1.6									
		Wolffort	C	1,114	412	b/	Ogallala	5.2/1.6									
		Yellowhouse Canyon-WCID	C	336	112	b/	—	3.6/1.6									
		Yellowhouse Water System	C	350	59	d/	—	4.3/1.6									
Lynn	7	Grassland WSC	C	60	27	b/	Ogallala	5.5/1.6									
		New Home	C	252	97	b/	Do.	5.3/1.6									
		Wells Coop. Gin	N	70	14	d/	—										
		Wilson	C	433	181	b/	Ogallala	4.3/1.6									

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See footnotes at end of table.

Appendix 5a.--Evaluation of Texas' Public Water Systems in Terms of Water Quality
Using EPA Interim Primary Standards, by County 1/, 2/--Cont'd.

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer of Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l									
								F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
McCulloch	6	Brady Race Track	C	(?)5,600	(?)2,500	d/	—	2.7/1.6									
McLennan	49	Axtell WSC	C	450	239	b/	Trinity Group	2.3/1.6									
		Brettwood Estates Corp.	C	48	—	b/	—	1.9/1.6									
		Bruceville Water System	C	250	97	b/	Trinity Group	2.6/1.6									
		China Springs-Community Water Co.	C	132	44	b/	Do.	2.1/1.6									
		Eddy	C	400	220	b/	Do.	2.0/1.6									
		Elk-Oak Lake WSC	C	700	200	b/	Trinity Group	1.9/1.6									
		Elm Creek WSC	C	500	149	d/	—	2.4/1.6									
		Friendly Oaks Water System	C	—	—	d/	—	2.2/1.6									
		H. & H. WSC	C	650	140	b/	Trinity Group	1.8/1.6									
		Harris Creek Water Co.	C	—	—	b/	Trinity Group	1.6/1.6									
		Leroy-Tours-Gerald WSC	C	1,000	250	b/	Do.	1.7/1.6									
		Lorena WSC	C	600	215	b/	Do.	1.6/1.6									
		M. S. WSC	C	520	131	b/	Do.	1.6/1.6									
		Mart	C	3,000	1,010	b/	Do.	2.0/1.6									
		Moody	C	1,285	500	b/	Do.	2.1/1.6									
		Riesel MUD	C	620	260	b/	Do.	2.3/1.6									
		Rolling Hills Country Club, Inc.	C	—	—	b/	Do.	3.2/1.6									
		Speegleville Water System	C	—	—	d/	—	2.1/1.6									
		Spring Valley WSC	C	350	120	b/	Trinity Group	2.1/1.6									
		Valley View Water Co.	C	—	—	b/	Do.	1.8/1.6									
		Western Hills Water System	C	—	—	d/	—	1.7/1.6									
Madison	7	Midway WSC	C	225	94	b/	Other (Yegua)	1.6/1.6									
Martin	3	Flower Grove Co-op Gin	N	90	9	d/	—		101								
		Stanton	C	2,270	702	c/	Ogallala, Colorado River MUD	3.2/1.6									

See footnotes at end of table.

Appendix 5a--Evaluation of Texas' Public Water Systems in Terms of Water Quality
Using EPA Interim Primary Standards, by County 1/, 2/--Cont'd.

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l									
								F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Matagorda	20	Holiday Harbor Subd. Water System	C	52	14	b/	Gulf Coast	2.0/1.6									
Milam	11	Buckholts	C	350	170	b/	Trinity Group	3.2/1.6									
Mills	2	Priddy	C	250	73	b/	Trinity Group	1.7/1.6									
Mitchell	5	Loraine	C	700	345	b/	Santa Rosa	2.0/1.6									
Montague	8	Ringold WSC	C	275	86	d/	—	3.3/1.6									
Motley	3	Flomont WSC	C	180	62	b/	—	2.0/1.6	80								
		Matador	C	1,091	446	b/	Alluvium		63								
		Roaring Springs	C	398	143	b/	Do.	1.9/1.6									
Nacogdoches	23	Lilbert-Looneyville WSC	C	252	84	b/	Carrizo-Wilcox	4.3/1.6									
		Nacalina Subd.	C	30	12	b/	Other (Alluvium)	3.6/1.6									
Navarro	17	Blooming Grove	C	750	350	b/	Woodbine	6.2/1.6									
		Frost	C	548	265	b/	Do.	4.6/1.6									
Nolan	5	Roscoe	C	1,720	560	b/	Santa Rosa	1.8/1.6									
Nueces	20	Bruni	C	--	--	b/	Gulf Coast			0.058							
Ochiltree	3	Farnsworth Water Service	C	115	46	b/	Ogallala	2.1/1.6									
		Perryton	C	7,850	2,821	b/	Do.	2.1/1.6									
		Waka WSC	C	110	44	b/	Do.	1.7/1.6									
Oldham	4	Vega	C	935	445	b/	Ogallala	2.3/1.6									
Parker	23	Whitt WSC	C	140	42	b/	Trinity Group	2.1/1.6									
Parmer	3	Bovina	C	1,428	601	b/	Ogallala	1.9/1.6									
		Farwell	C	1,393	514	b/	Do.	2.7/1.6									
		Friona	C	3,600	1,334	b/	Do.	2.1/1.6									
Pecos	5	Fort Stockton	C	8,400	2,666	b/	Alluvium & Bolson, Edwards-Trinity (Plateau)	1.5/1.4									

See footnotes at end of table.

Appendix 5a--Evaluation of Texas' Public Water Systems in Terms of Water Quality
Using EPA Interim Primary Standards, by County 1/, 2/—Cont'd.

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l									
								F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Potter	2	Bushland WSC	C	125	51	b/	Ogallala	2.5/1.6-1.8									
Randall	10	Canyon	C	9,600	2,550	b/	Ogallala, Santa Rosa	3.1/1.6									
		Country Estates MHP	C	160	70	b/	Ogallala	3.0/1.6									
		Lake Tanglewood Subd.	C	400	50	d/	—	4.1/1.6									
		Pioneer Village	C	80	60	d/	--	2.3/1.6									
		Siesta Plaza MHP	C	490	150	d/	—	2.5/1.6									
Reagan	2	Big Lake	C	2,490	900	b/	Edwards-Trinity (Plateau)	2.6/1.4									
Red River	8	Detroit	C	697	250	b/	--	3.2/1.6									
Reeves	5	Pecos	C	13,900	3,735	b/	Santa Rosa	1.5/1.4									
Refugio	8	WCID #1-Tivoli	C	780	260	b/	Gulf Coast	2.7/1.6									
		Bayside Water Supply	C	215	48	b/	Do.	3.8/1.6									
		Refugio	C	4,300	1,475	b/	Do.	1.6/1.6									
Robertson	9	Wheelock WSC	C	250	70	b/	Carrizo-Wilcox	1.6/1.6									
Runnels	4	Miles	C	650	280	b/	Other (Clearfork Group)	1.6/1.6									
Rusk	21	Pleasant Hill WSC	C	375	125	b/	—	2.5/1.6									
		Price WSC	C	600	200	b/	Other (Midway)	1.9/1.6									
San Augustine	11	Anthony Harbor	C	120	40	b/	--	2.2/1.6									
		El Pinon Estates Water System	C	33	11	d/	--	1.7/1.6									
		Lakewood Subd.	C	150	50	b/	—	1.9/1.6									
San Jacinto	14	Shepherd	C	1,500	500	b/	Gulf Coast	2.5/1.4									
Schleicher	1	Eldorado	C	1,600	700	b/	Edwards-Trinity (Plateau)	2.2/1.4									

See footnotes at end of table.

Appendix 5a.--Evaluation of Texas' Public Water Systems in Terms of Water Quality Using EPA Interim Primary Standards, by County 1/, 2/--Cont'd.

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Scurry	5	Key MHP	C	140	38	d/	--	2.0/1.6									
Shelby	18	Joaquin	C	823	283	b/	Carrizo-Wilcox	2.2/1.6									
		Paxton WSC	C	324	108	b/	--	1.8/1.6									
		Shelby Beach Marina & Subd.	C	135	45	d/	--	2.0/1.6									
		Tenaha	C	1,094	400	b/	Carrizo-Wilcox	1.6/1.6									
Stonewall	2	Aspermont	C	1,860	590	b/	Alluvium		62								
		Swenson WSC	C	90	26	b/	Do.		51								
Swisher	4	Happy	C	772	270	b/	Ogallala	2.7/1.6									
		Kress	C	560	270	b/	Do.	2.0/1.6									
		Tulia	C	5,250	2,022	b/	Do.	1.7/1.6									
Tarrant	64	Dalworthington Gardens	C	975	320	b/	Trinity Group	2.4/1.6									
		Eagle's Nest	C	--	--	d/	--	2.9/1.6									
		Everman	C	5,600	1,559	c/	Trinity Group, Purchased Ft. Worth 11/	1.6/1.6									
		Haslet	C	300	108	b/	Trinity Group	1.6/1.6									
		Keller Rural WSC	C	3,500	1,015	b/	Do.	2.1/1.6									
		Pantego	C	2,612	864	b/	Do.	1.8/1.6									
		Pelican Bay MHP	C	480	160	b/	--	1.8/1.6									
		Pleasant Acres MHP	C	20	8	d/	--	1.9/1.6									
		Post Oak Water Co.	C	40	10	d/	--	1.7/1.6									
		Westside WSC	C	150	52	b/	Trinity Group	1.6/1.6									
Taylor	14	WCID #1-Tuscola	C	735	225	b/	Other (Alluvium)		49								
		Ovalo	C	125	39	b/	Do.	1.7/1.6	90								
Terry	3	Brownfield	C	9,752	3,449	c/	Ogallala, Lake Meredith		51								
		Meadow	C	498	211	b/	Ogallala	4.9/1.6									
		Wellman WSC	C	300	68	b/	Do.	4.0/1.6									

See footnotes at end of table.

Appendix 5a--Evaluation of Texas' Public Water Systems in Terms of Water Quality
Using EPA Interim Primary Standards, by County 1/, 2/ --Cont'd.

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l									
								F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Travis	63	Apache Shores	C	375	125	b/	Trinity Group	2.6/1.4-1.6									
		Camelot Addn.	C	126	43	b/	Do.	1.6/1.4-1.6									
		Cross Creek Subd.	C	45	16	d/	--	2.9/1.4-1.6									
		Draper Subd.	C	45	15	d/	--	2.1/1.4-1.6									
		Gill MHP	C	41	19	d/	--	2.9/1.4-1.6									
		Jonestown Imp. (District) Corp.	C	675	270	b/	Trinity Group	3.5/1.6									
		Lakeview (Hills) Estates	C	--	--	d/	--	3.7/1.4-1.6									
		Malone Addn.	C	--	--	d/	--	2.3/1.4-1.6									
		Manor	C	940	315	b/	Trinity Group	3.8/1.6									
		Mt. Chalet Subd.	C	15	5	d/	--	3.1/1.4-1.6									
		Mystic Oaks Estates	C	156	39	d/	--	4.4/1.4-1.6									
		Onion Creek Meadows	C	352	88	b/	Edwards (Balcones Fault Zone)	3.8/1.4-1.6									
		Panoramic Hills Water Coop.	C	--	--	b/	--	1.6/1.4-1.6									
		St. Stephens School	C	250	27	c/	Trinity Group, Lake Austin	2.4/1.4-1.6									
		San Leanna Water Corp.	C	200	60	b/	Edwards (Balcones Fault Zone)	1.8/1.4									
		Signal Hills	C	35	--	d/	--	6.4/1.4-1.6									
		Slaughter Creek Acres	C	323	58	b/	Trinity Group	2.5/1.4-1.6									
		Spring Valley Subd.	C	135	50	d/	--	4.5/1.4-1.6									
		Twin Creek Park Subd.	C	168	56	d/	--	2.3/1.4-1.6									
		Val Verde Beach	C	--	--	d/	--	3.7/1.4-1.6									
		West Oak Water Co.	C	--	--	d/	--	3.8/1.4-1.6									
Upton	2	Rankin	C	1,190	453	b/	Edwards-Trinity (Plateau)	2.1/1.4									
Uvalde	8	Knippa WSC	C	365	130	b/	Edwards (Balcones Fault Zone)	3.6/1.4									

See footnotes at end of table.

Appendix 5a.--Evaluation of Texas' Public Water Systems in Terms of Water Quality
Using EPA Interim Primary Standards, by County 1/, 2/ -- Cont'd.

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l: F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Val Verde	5	Rough Canyon Marina	N	195	65	d/	--		67								
Ward	7	Avery & Walker Water Co.	C	550	--	d/	--	2.7/1.4									
		Barstow	C	650	241	b/	Santa Rosa	3.8/1.4									
		Grandfalls	C	736	237	b/	Alluvium	2.0/1.4									
		Ward Rural WSC	C	135	41	b/	Santa Rosa	3.5/1.4									
		Wickett	C	610	270	b/	Alluvium	2.0/1.4									
Wichita	8	Perkins Scout Reservation	N	300	--	d/	--		80								
Wilbarger	6	Thirsty WSC (Box System)	C	150	52	b/	Alluvium		52								
		Do. (Hinds-Wildcat Comm.)	C	150	52	b/	Do.		52								
		Do. (Lockett System)	C	600	185	b/	Do.		84								
		Vernon	C	13,000	4,822	b/	Do.		49								
Williamson	36	Andice	C	45	15	b/	Trinity Group	3.0/1.6									
		Bartlett	C	1,700	650	b/	Do.	3.9/1.4									
		Bushy Bend Park Subd.	C	165	55	d/	--	2.0/1.4-1.6									
		Florence	C	1,000	300	b/	Trinity Group	2.5/1.6									
		Granger	C	1,250	543	b/	Do.	3.0/1.4									
		Hernando's Hide-A-Way	C	30	8	b/	--	5.2/1.4-1.6									
		High Chaparall MHP	C	220	55	d/	--	2.8/1.4-1.6									
		Hutto	C	545	200	b/	Edwards (Balcones Fault Zone)	4.3/1.6									
		Jonah WSC	C	620	417	b/	Do.	2.8/1.6									
		Leander WSC	C	624	208	b/	Trinity Group	2.0/1.6									
		McSheppard Ranches	C	10	3	d/	--	4.6/1.4-1.6									
		Noack WSC	C	145	52	b/	Other (Alluvium)		53								
		Southern Hills Subd.	C	18	6	d/	--	3.2/1.4-1.6									
		South San Gabriel Ranches	C	30	13	d/	--	2.9/1.6									
		Taylor	C	9,616	3,600	b/	Trinity Group	3.7/1.4-1.6									
		Thrall	C	619	236	b/	Other (Navarro Group)		75								
		Timberline West	C	80	28	d/	--	3.6/1.4-1.6									

See footnotes at end of table.

Appendix 5a--Evaluation of Texas' Public Water Systems in Terms of Water Quality
Using EPA Interim Primary Standards, by County 1/, 2/—Cont'd.

County	No. of County Systems Evaluated	Name of System	Type of System 3/	Approximate Population Served 4/	No. of Connections 4/	Source of Water 7/	Aquifer or Reservoir	EPA Interim Primary Standard "Contaminants" Considered, mg/l									
								F 5/,8/	NO_3 5/	As 6/	Ba 6/	Cd 6/	Cr^6 6/	Pb 6/	Hg 6/	Se 6/	Au 6/
Williamson (cont'd.)		Walburg	C	100	34	b/	Edwards (Balcones Fault Zone)	3.7/1.6									
		Wier	C	100	45	b/	Do.	3.4/1.6									
Winkler	2	Wink	C	1,023	340	b/	Alluvium	2.2/1.4									
Yoakum	3	Denver City	C	4,400	1,447	b/	Ogallala	2.3/1.6									
		Plains	C	1,290	479	b/	Do.	3.6/1.6									

1/ Quality evaluation based on data secured from records of Texas Department of Health Resources as of 5-14-76.

2/ EPA Interim Primary Standard "contaminants" and the maximum permitted levels, except flouride, which are applicable to "community water systems" and were used in this evaluation are as follows:

Contaminant	Maximum Level, mg/l
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.010
Chromium (Cr^6)	0.05
Lead (Pb)	0.05
Mercury (Hg)	0.002
Selenium (Se)	0.01
Silver (Au)	0.05
*Nitrate (NO_3)	45.00
(as N)	10.00

*The maximum contaminant level for nitrate applies to both community and non-community systems.

Maximum fluoride contaminant levels vary with the annual average of the maximum daily air temperature at the location of the community system. The limits for Texas are as follows:

Temperature (°F)	Level, mg/l
< 70.6	1.8
70.7 - 79.2	1.6
79.3 - 90.5	1.4

3/ C denotes a community water system which supplies at least 15 service connection used by year-round residents or serves at least 25 year-round residents. N denotes a non-community system which is a public water system that is not a community water system or one which basically serves transients.

4/ Data secured from files of the Texas Department of Health Resources.

5/ The system's reported concentration level as reported by the Texas Department of Health Resources (TDHR) or an approved laboratory sanctioned by the TDHR as reported in their prepared tabulations entitled, Community Water Systems In Texas Which Exceed The Maximum Contaminant Level For Fluorides As Set By The "National Interim Primary Drinking Water Regulations" and/or Community Water Systems In Texas Which Exceed The Maximum Contaminant Level For Nitrates As Set By The "National Interim Primary Drinking Water Regulations", May 17, 1976.

6/ Data presently available only on interstate carrier systems, of which there are 57 in the State. Quality evaluation for these systems are based on data given in Chemical Analysis of Interstate Water Supply Systems, U. S. Environmental Protection Agency, October 1973.

7/ The source of water for each system was furnished by the Board's Economics, Water Requirements and Uses Division and are as follows:
- a/ A surface water source.
- b/ A ground-water source
- c/ A combination of surface and ground-water sources
- d/ Source of water could not be determined.

8/ The maximum permitted level in the county for the system.

9/ F Level from old chemical analysis and system is not now designated as being in violation of EPA standards by the Texas Department of Health Resources.

10/ Surface water purchased from the City of Dallas system and water may be from one, several, or all of the following reservoirs (from 1968 Texas Water Plan): Garza-Little Elm, Grapevine, North Lake, White Rock, Lavon Enlargement, and Ray Hubbard. Water applied to system by North Texas Municipal Water District and Sabine River Authority.

11/ Surface water purchased from the City of Fort Worth system and water may be from one, several, or all of the following reservoirs (from 1968 Texas Water Plan): Benbrook, Bridgeport enlargement, Eagle Mountain, Lake Worth, Mountain Creek, and Joe B. Hoggett (Cedar Creek). Water supplied to system by Tarrant County Water Control and Improvement District.

APPENDIX B

CITIES AND MUNICIPALITIES
SITE INVESTIGATION

APPENDIX B

CITIES AND MUNICIPALITIES
SITE INVESTIGATION

City/Municipality	Population	Water Source	Treatment	Consumption (GPCD)[1]
A	23,000	18 Wells/Lake	Clarification, Filtration and Chlorination	256 (Max.) 79 (Min.)
B	14,050	4 Wells	Aeration/Chlorination	141 (Max.) 66 (Min.)
C	12,500	46 Wells	Chlorination	400 (Max.) 187 (Min.)
D	11,000	4 Wells	Chlorination	339 (Max.) 131 (Min.)
E	10,311	River	Clarification, Filtration and Chlorination	352 (Max.) 212 (Min.)
F	10,308	14 Wells	Chlorination	271 (Max.) 100 (Min.)
G	8,600	5 Wells	Chlorination	372 (Max.) 116 (Min.)
H	8,500	9 Wells	Chlorination	231 (Max.) 82 (Min.)
I	7,000	13 Wells	Chlorination	331 (Max.) 103 (Min.)
J	3,000	18 Wells	Chlorination	311 (Max.)
K	2,647	3 Wells	Chlorination	410 (Max.) 88 (Min.)
L	2,500	4 Wells	Chlorination	------
M	2,300	3 Wells	Chlorination	87 (Ave.)
N	1,536	4 Wells	Chlorination	133 (Max.) 74 (Min.)
O	1,500	3 Wells	Hypochlorination	------

City/Municipality	Population	Water Source	Treatment	Consumption (GPCD)[1]
P	1,120	15 Wells	None	249 (Max.) 90 (Min.)
Q	1,050	4 Wells	Chlorination	243 (Max.) 81 (Min.)
R	800	1 Well	Chlorination	------

[1] Consumption in gallons per capita per day (GPCD) based on the maximum and minimum monthly consumption for the year 1976.

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