The Feasibility of Siting an 8 MGD Vapor Compression Distillation Desalting Plant at Brownsville, Texas

United States Department of the Interior

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The Feasibility of Siting an 8 MGD Vapor Compression Distillation Desalting Plant at Brownsville, Texas

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United States Department of the Interior • Rogers C. B. Morton, Secretary
James R. Smith, Assistant Secretary for Water and Power Resources
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**FOREWORD**

This is one of a continuing series of reports designed to present accounts of progress in saline water conversion and the economics of its application. Such data are expected to contribute to the long-range development of economical processes applicable to low-cost demineralization of sea and other saline water.

Except for minor editing, the data herein are as contained in a report submitted by the contractor. The data and conclusions given in the report are essentially those of the contractor and are not necessarily endorsed by the Department of the Interior.
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SECTION I

INTRODUCTION, PURPOSE AND SCOPE

Since its establishment in 1952, the United States Office of Saline Water has sponsored research and development on a number of saline water conversion processes. Among others, these processes include multistage flash distillation, multi-effect multistage flash distillation, vapor compression and long tube vertical evaporation. In the late sixties, OSW developed a hybrid saline water conversion plant using a combination of multistage flash, vapor compression and vertical tube evaporation features that appeared to be an economic winner: a non-nuclear powered plant, pitched and sized to today's actual needs and requirements. Under the direction of, and guided by OSW, an engineering study of the design and economics of this plant was made and the results published in 1968 in a report entitled, "Design and Economic Study of a Gas Turbine Powered Vapor Compression Plant for Evaporation of Sea Water," (OSW R & D Progress Report No. 377).

This study indicated that water could be produced for an order of magnitude of $.40 to $.50/1000 gallons depending on siting and fuel costs. Compared to the 1963 Point Loma cost of $1.20, the 1967 Key West cost of $.85, and the 1969 reported Rosarito cost of $.65 per 1000 gallons, the cost of producing water by this combination of equipment appeared very attractive.

Vapor compression distillation is a well established desalting process that is particularly applicable to requirements for compact, low capacity desalting plants. It has been used extensively for small capacity marine applications. In its simplest form, the process consists of brine boiling inside of vertical tubes. The steam produced is pressurized and heated with a mechanical compressor, then condensed on the outside of the vertical tubes, thereby boiling more brine and producing desalted water.

In 1970, the Office of Saline Water, the State of Texas, and the City of
Brownsville, Texas, agreed to study the feasibility and cost of building an 8 million gallon per day prototype (first of its kind) sea water desalting plant embodying the combination design to serve the City of Brownsville, Texas.

The City of Brownsville engaged the Fluor Corporation of Los Angeles to develop the investment and operating cost data, on a Brownsville site basis, for the plant design set forth in the above OSW "Research and Development Progress Report No. 377," and the VTE Modifications prepared for the Office of Saline Water by the Oak Ridge National Laboratory. Portions of these reports have been used in this report.
COST TRENDS OF DESALTING PLANTS

BASIS
7% FIXED CHARGES
7 MILL POWER
30¢ / m Btu FUEL

POINT LOMA
$1.20

VIRGIN ISLANDS
BLH $0.90

KEY WEST
(NORMALIZED) $.94

ROSARITO
$0.86

JIDDA
$0.80

BROWNSVILLE
9% FIXED CHARGES
30¢/m Btu FUEL
1970 PRICES

PRODUCT WATER COST ($/1,000 GALS)


KEY WEST
(REPORTED) $.85

SINGLE PURPOSE

DUAL PURPOSE

$0.53
SECTION II

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

Brownsville, Texas, is located in the extreme southern tip of Texas. The Gulf of Mexico is about 21 miles to the east, and more than half of the land toward the coast is made up of tidal marshlands, which has the effect of moving the coast about 10 miles nearer the City. The area is located on the alluvial soils of the Rio Grande.

The climate is partly man-made. The prevailing winds of the area are from the Gulf of Mexico, but do not produce a truly marine climate. The region could be classified as semi-arid due to the lack of rainfall, the result of low elevation of the area which fails to give the air from the Gulf sufficient lift to cause condensation, and of considerable subsidence of the winds aloft due to the presence of mountains starting about 100 miles to the west. The man-made and most important contributor to the climate of the Brownsville region results from irrigation which has changed the entire lower Rio Grande Valley into a semi-tropical area. The chief agricultural products of the Valley are cotton, citrus fruits, and a wide variety of vegetables, all grown under irrigation.

The normal annual rainfall of 26.75 inches is poorly distributed, with maxima in September and October. Most of the precipitation comes in the form of thunderstorm activity, and often a single thunderstorm will account for the entire month's rainfall.

The principal source of water for Brownsville and the entire Valley is the Rio Grande. Estimates by the Texas Water Development Board in the preliminary Texas Water Plan indicate that water available from the Rio Grande will not be adequate to supply projected future requirements for municipal and industrial water supplies to the Rio Grande Valley cities. These estimates are based on the projected quantity of irrigation water that will have
to be supplied from the river if the irrigated agricultural economy of the Valley is to be maintained. Thus, a desalting plant located in the Valley will help to alleviate the predicted overall future water shortages.

Ground water supplies are generally of poor quality. The bulk of this water fails to meet the U. S. Public Health Service standards of 500 PPM TDS or below.

Brownsville's present water system consists of river water pumping and treatment facilities having a capacity of 20,000,000 gallons per day. In addition, wells in the northwest section of the city having a rated capacity of an additional 8,000,000 gallons per day are maintained in standby for emergency use. The quality of this well water is brackish and averages about 1900 ppm total dissolved solids. Maximum recorded daily peak consumption is 17,000,000 gallons per day. On the basis of normal projected growth, the estimated peak water consumption by 1985 will be 29,000,000 gallons per day. Brownsville has apparent adequate water treatment and storage facilities up to 1985; however, both the river and standby well field water supplies are of poor quality gauged by National Standards. The river water salinity varies from 520 to 1306 PPM TDS, with hardness ranging from 230 to 440 PPM (calcium carbonate equivalent).

Thus, Brownsville's basic need for improvement in the quality of the water makes it a logical location to add to the water supply in the water deficient Rio Grande Valley. Since the product water from a desalting plant contains less than 50 ppm dissolved solids, it could be blended with other water containing an excess of solids to produce a blended water that would meet the recommended U. S. Public Health Service drinking water standard. Three desalting plant sites in the vicinity of Brownsville designated as Sites A, B, and C, as shown on the map on the next page were studied in detail. Each site is described in detail in Section IV of this report.

Site A, located at the Brownsville Main Harbor Turning Basin, represents the closest source of sea water to the City of Brownsville and the shortest
distance for the product water to be delivered to the Brownsville Water System. The plant effluent can be routed via an existing open unlined channel to the saline tidal flats owned by the Brownsville Navigation District.

The Texas Water Development Board, in cooperation with the City of Brownsville, has evaluated the feasibility of disposal of the plant effluent to the tidal area. The results indicate that disposal to the tidal flats is feasible. (See Section VII of this report, prepared by the Texas Water Development Board.)

The estimate cost inside the Site A battery limits including the outfall and intake structure is $9,730,000 which results in a product water cost of $0.53 per 1,000 gallons at the battery limits at rated capacity.

Site B, located at the west side of the Fishing Harbor was selected to evaluate the economic advantages of a site between the Gulf of Mexico and the Brownsville Main Harbor Turning Basin. Sea water feed for the plant is obtained from the Ship Channel and the plant effluent is pumped to the adjacent tidal flats. The product water produced at this site must be pumped approximately 22,000 feet farther than that from Site A in order to tie into the Brownsville Water System. The Texas Water Development Board concludes that it is feasible to transfer the effluent from Site B to the tidal flats.

The estimate capital cost inside the Site B battery limits including the outfall and the intake structures is $9,730,000 which gives a product water cost at rated capacity of $0.53 per 1,000 gallons at the battery limits.

Site C, located 24 miles east of Brownsville on Padre Island with direct access to the Gulf of Mexico was eliminated early in the study because of the large capital cost of a pipeline and the large pumping costs to move the water 20 miles to Brownsville.
The detailed calculations, evaluations and recommendations by the Texas Water Development Board relative to disposal of effluent from the plant are included in this report in Section VII.

CONCLUSIONS

The City of Brownsville needs a source of water with low dissolved solids to improve the quality of its present water supplies. An 8 million gallon per day desalting plant fits in with Brownsville's predicted future water requirements. It is feasible to locate a desalting plant at Site A and dispose of the brine effluent to nearby tidal flats without adverse environmental effects.

RECOMMENDATIONS

Site A located at the Port of Brownsville Turning Basin is recommended as the preferred site for the 8 million gallon per day desalting plant for the following reasons:

1. The total capital cost of the plant located at this site is the lowest.

2. It is the nearest site to the City of Brownsville.

3. The product water, electrical, sea water, and effluent drain tie-in points are all within 500 feet of the site.

4. Annual operating costs are the lowest.
SECTION III

BASIC DATA

STUDY BASIS

This Study to develop investment and operating cost data for a Brownsville Texas Site is based on the plant design set forth in "Research and Development Progress Report No. 377 - Office of Saline Water - United States Department of Interior," entitled "Design and Economic Study of a Gas Turbine Powered Vapor Compression Plant for Evaporation of Sea Water," and the VTE modifications prepared for the Office of Saline Water by the Oak Ridge National Laboratory.

These modifications to the VTE are shown on Figure I through IV (pages V-12 thru V-15) and are described in Section V.

The design modifications consisted of rearranging the four VTE effects from a vertical stacked vessel to a horizontal configuration. The horizontal arrangement of the VTE is considered a more conservative design due to:

1. The industrial experience in the fabrication and operation of similar plants.

2. The positive control over the effect feed rate and facilitation of turn-down provided by the effect pumps.

3. The added assurance of product purity by the placement of entrainment separation in each effect.

INFLATION

All costs in the estimate are to be on the basis of the purchasing power of 1970 dollars.

COST OF MONEY

Municipal bond financing is assumed. Bond interest rate is taken as 6%.
REPAYMENT PERIOD

Investment costs are to be amortized over a 30-year period corresponding to the estimated life of the desalination plant. The amortization factor of 1.27% is based on a sinking fund repayment method for 30 years at 6%.

MAINTENANCE

Maintenance cost for overhaul of the process equipment other than the gas turbine is estimated to be 0.5% per annum of the plant investment, less the cost of the gas turbine. See VI-10, VI-21 for gas turbine costs.

INSURANCE

The annual insurance premium is assumed to be 0.30% of capital cost.

TAXES

It is assumed that Ad Valorem, State, and Federal Income, and Sales Taxes do not apply to this installation.

FIXED CHARGES ON NEW PLANT COSTS

Annual fixed charges are based on the following percentages of capital investment:

1. Cost of money 6.00%
2. Bond amortization factor (30 years) 1.27%
3. Maintenance .50%
4. Insurance .30%
5. Taxes None

INTEREST DURING CONSTRUCTION

This cost is estimated to be 3% of direct capital costs.
INTEREST ON WORKING CAPITAL

Interest on working capital is calculated at 60 days @ 6% per year and is included in the operating costs.

DESALINATION PLANT ON-STREAM FACTORS

It is assumed that the plant will be on-stream 90% of the time or 7,884 hours per year. It is assumed to be shut down for maintenance, repairs, etc., the other 10% of the time.

The full load daily production of the plant is 8.04 million gallons per day for 7,884 hours per year.
SECTION IV

DESCRIPTION AND ANALYSIS OF SITES A, B, AND C

GENERAL

Three sites in the vicinity of Brownsville, designated as Sites A, B, and C, were selected to determine the cost of producing and moving water to the Brownsville system and to study the discharge of the effluent to the environs. Following is a detailed description of each site.

SITE A

Site A is located approximately four miles east of Brownsville, Texas, and 500 feet from the northwest tip of the Port of Brownsville Main Harbor Turning Basin and on the extension of Texas State Highway No. 48, as shown on the map on the following page. This Site represents the closest source of salt water to the City of Brownsville and the shortest distance for the product water to be delivered to the Brownsville Water System. Also, the effluent from the plant can be conveniently pumped to an on-site drainage ditch which drains to the tidal flats. The Texas Water Development Board made a detailed study and evaluation of the effluent drainage to the tidal flats and the results are included in this report.

The land for Site A is owned by the Brownsville Navigation District, an independent public body created and operated under the statutes of the State of Texas. The District has the statutory power to purchase, construct, own, operate, and lease marine terminal and related facilities. The District can and does develop industrial plant sites to encourage the industrial development of this area. The Navigation District has been cooperating with the City of Brownsville on this project and has indicated that the land for Site A is available for a Saline Plant. Site A consists of parts of parcels 20 and 22, consisting of 6.3 and 7.37 acres, respectively. A value of $6000 per acre is used in the cost estimate for this site.
SITE "A"
PORT OF BROWNSVILLE'S TURNING BASIN
Deep sea and barge facilities are located at the Turning Basin. Both the Missouri Pacific and the Southern Pacific Railroads and seven common carrier truck lines serve the area. The nearest Missouri Pacific Railroad siding is less than 500 feet from the Site and Texas State Highway No. 48, zoned for 70,000 lbs. weight limit, is contiguous to the Site. Thus, the Site is easily accessible by paved highway, railroads, deep sea and barge lines.

Site A is reasonably level and clear. The Site elevation ranges from 10.5 to 11.0 feet. A 1958 test boring made within 500 feet of Site A indicates the following from elevation + 14 feet. The top ten (10) feet (approximate) of soil is firm, tan and gray clay with very soft pockets below eight (8) feet. This is underlain by seven (7) feet of firm, gray and tan clay, slightly sandy with shell fragment, and under this strata are about nine (9) feet of very stiff, gray and tan sandy clay calcareons with vertical sand seams, thence continuing on down to 100 feet as shown in the log of the test boring on file with the Port of Brownsville Navigation District. Based on the borings made in the general vicinity of Site A, for purposes of this preliminary engineering construction cost estimate, we assumed a design soil loading of 1,700 lbs. per sq. ft. The plant floor elevation is assumed to be + 15.0 feet. This is our estimate of the minimum site elevation for protection against hurricane tides. Thus, Site A will require approximately 4-1/2 feet of fill which is available within 1/2 mile from the Site at $1.10 per cubic yard.

The concrete intake structure housing the three sea water pumps; two screen wash pumps; and the traveling screen and trash rake is located at the site. A four foot diameter reinforced pipe culvert is installed between the Turning Basin and the concrete intake structure extending under two railroad tracks and the extension of State Highway No. 48. The entrance to the concrete pipe culvert at the Turning Basin will be fortified with sheet piling and concrete bulkhead.

The discharge outfall would consist of an on-site concrete riprap apron at
the discharge of the blowdown line. The effluent would flow through an open dredged channel to the tidal flats.

Fuel gas can easily be furnished at the 350 psig delivery pressure at Site A by the Rio Grande Valley Gas Company, a division of the Coastal States Gas Company. The gas company has estimated that the required facilities, including metering and regulation, would cost $5,075.

The Brownsville Public Utilities Board has 12,500 volt, 3 phase, electric power available and is willing to furnish meters and transformers to standard voltage for this site.

A 6" or larger water line is available for plant water uses during construction.

Fire protection can be provided by the City of Brownsville equipment and a fire line tie-in point is within 100 feet from the Site.

Sulfuric acid for feedwater treatment can be delivered to the site by tank truck or by barge.

The product water from Site A can be moved to the Brownsville Water System with a minimum of capital investment, as a tie-in point is located within 500 feet of the Site.

SITE B
Site B is located eight miles east of Brownsville, Texas, on the west side of the Fishing Harbor and south of Highway FM 1792 as shown on the following page. This site represents an intermediate site between the Main Harbor and the Gulf of Mexico. The existing drainage ditch on the east side of the site can easily be converted to an inexpensive intake channel for the source of sea water, and effluent need only be pumped across Highway FM 1792 for drainage to the tidal flats. As mentioned previously, the Texas Water Development Board made a detailed study and evaluation of the effluent disposal to the tidal flats and the results are included in this report in Section VII.
FIGURE 5

SITE "B"
DISCHARGE

FISHING
HARBOR

60' ROAD

SITE "B"
SEA WATER
INTAKE
CHANNEL

SITE "B"
PORT OF BROWNSVILLE'S FISHING HARBOR
The land for Site B is owned by the Brownsville Navigation District and a value of $3000 per acre is used in the cost estimate for this site.

As in Site A, Site B is also served by deep sea and intercoastal barge lines, the Missouri Pacific and Southern Pacific Railroads and seven common carrier truck lines. The nearest Missouri Pacific railroad siding is 3-1/2 miles away and the asphalt paved highway which runs along the north side of the site is zoned for 48,000 lbs. loading. Thus, Site B is readily accessible by paved highway, railroads, and barge.

Site B is reasonably level and clear with an elevation range of + 7.5 to + 8.0 feet, thus requiring approximately 7-1/2 feet of fill to bring to a site elevation of + 15.0 feet. Fill material is available for this site within 1/4 mile and at $0.95 per cubic yard. A test boring made within 2,500 feet of Site B at the Marine Way and Boat Repairs area indicated the following: the top six (6) feet (approximate) of soil in the area is fill soil, which is underlaid by roughly twelve (12) feet of sandy clay soil, and under this strata are about eight (8) feet of clayey sand, thence continuing down to 81 feet, as shown in the log of test boring No. 4 on file with the Brownsville Navigation District. A bearing capacity test made close to the above boring No. 4 revealed that the first major deflection, as shown on the graph, occurred at 3,500 lbs. per sq. ft. Using a safe bearing capacity of two to one, this would indicate 1,750 lbs. per sq. ft. as an allowable soil loading pressure.

The concrete intake structure housing the three sea water pumps, two screen wash pumps, and the traveling screen and trash rake will be of the same design as that for Site A. Sea water flow from the ship channel to the intake through an open dredged channel.

The discharge outfall could be of the same design as that for Site A and would consist of an on-site concrete riprap apron at the discharge of the blowdown line and the effluent would flow through an open dredged channel into the tidal flats.
The Rio Grande Valley Gas Company has indicated that the requisite size of fuel gas supply line, including meters and regulation, can easily be furnished at the 350 psig delivery pressure at Site B for an estimated cost of $7,475. The Brownsville Public Utilities Board has 12,500 volt, 3 phase electric power available and is willing to furnish meters and transformers to standard voltage for this site.

A 6" or larger potable water supply line is available for general plant water use at this site and a fire line tie-in point is located within the area of the site.

Sulfuric acid for feedwater treatment is delivered to the site by tank truck or barge.

To move the product water from Site B to the Brownsville system would require 22,000 feet of 18" concrete-lined steel pipe to tie into the existing system in the vicinity of the Main Harbor Turning Basin. At an estimated cost of $20 per lineal foot, Site B would require an additional capital investment of $440,000 over Site A. Also, the annual pumping cost to overcome the pipeline friction would amount to $18,000 per year above that of Site A.

**SITE C**

Site C is located 24 miles east of Brownsville, Texas, on the southern end of Padre Island. This site has direct access to the Gulf of Mexico and represents the best site for the plant discharge system. However, this site is the most distant from the City of Brownsville and would represent a considerable capital investment for a pipeline to move the product water to the Brownsville system tie-in point. At approximately $20 per lineal foot, the pipeline would cost over $2,000,000.

For site cost comparison purposes, the cost of the Desalting Plant at Site C within the boundary limits can be assumed to be approximately the same as that at Sites A and B. Thus, the pipeline cost and pipeline pumping costs, when added to the desalting plant construction and operating costs, eliminated this site from further consideration early in the study.
INTAKE STRUCTURE

The intake structure is a reinforced concrete chamber approximately 15 ft. x 35 ft. outside dimensions. Within this structure are located a trash rack with cleaning rake, traveling screens, the sea water pumps, and screen wash pumps as shown in Sketch 4379-SK-4-01.

The trash rack is intended to remove coarse trash from the flowing water. A rake operated from a car traveling above the rack facilitates removal of trash from the rack. Control of the trash rack is effected by manual operation of a local push-button station.

The traveling screens are intended to remove small trash, shells, and fish which may pass the trash rack. The operations of the traveling water screens may be controlled by manual operation of a locally mounted push-button station or automatically through a differential level switch located across the screens. If the differential level across the screens should increase due to screen fouling to more than the setting of the level switch the screen wash pumps will automatically start. A pressure switch located in the screen wash pump discharge header acts to start the traveling water screen. The pumps supply water to spray nozzles which wash debris from the screen panels into a sluiceway onto the trash apron where it can be removed. The screen is so interlocked with the wash pumps that the pumps must be in operation before the screens can be operated. When the differential level drops below 10", the traveling water screen, as a result of a timing device, will make one complete revolution and then come to rest.

Positions are provided for three 50% capacity sea water pumps, and two 100% capacity screen wash pumps.
SEA WATER ANALYSIS

Analysis of the Brownsville Ship Channel sea water sample, by the Texas Water Development Board, indicates the following typical composition:

<table>
<thead>
<tr>
<th></th>
<th>Standard Sea Water</th>
<th>Location No. 1</th>
<th>Location No. 3</th>
<th>Location No. 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dissolved solids, Mg/L</td>
<td>35,000</td>
<td>34,800</td>
<td>34,700</td>
<td>33,400</td>
</tr>
<tr>
<td>Chloride, ppm</td>
<td>19,350</td>
<td>19,400</td>
<td>19,300</td>
<td>18,600</td>
</tr>
<tr>
<td>Sulfate, ppm</td>
<td>2,712</td>
<td>2,640</td>
<td>2,700</td>
<td>2,600</td>
</tr>
<tr>
<td>Bicarbonate, ppm</td>
<td>142</td>
<td>162</td>
<td>154</td>
<td>178</td>
</tr>
<tr>
<td>Bromide, ppm</td>
<td>67</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sodium, ppm</td>
<td>10,760</td>
<td>10,900</td>
<td>10,900</td>
<td>10,300</td>
</tr>
<tr>
<td>Magnesium, ppm</td>
<td>1,294</td>
<td>1,370</td>
<td>1,300</td>
<td>1,310</td>
</tr>
<tr>
<td>Calcium, ppm</td>
<td>413</td>
<td>437</td>
<td>434</td>
<td>449</td>
</tr>
<tr>
<td>Potassium, ppm</td>
<td>387</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Strontium, ppm</td>
<td>8</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>pH</td>
<td>8.2</td>
<td>8.1</td>
<td>7.9</td>
<td>7.3</td>
</tr>
<tr>
<td>Date of Sample</td>
<td>-</td>
<td>7-13-70</td>
<td>7-13-70</td>
<td>7-13-70</td>
</tr>
<tr>
<td>Location</td>
<td>Turning</td>
<td>Fishing</td>
<td>Sen Martin</td>
<td>Outlet</td>
</tr>
<tr>
<td></td>
<td>Basin</td>
<td>Harbor</td>
<td>Outlet</td>
<td></td>
</tr>
</tbody>
</table>

Additional monthly sampling for the balance of 1970 has been scheduled by the Board and the results will be made available to the City of Brownsville.

Additional detailed information and maps are on file at the offices of the Texas Water Development Board.

MAXIMUM NOISE LEVEL FOR THE GAS GENERATOR AND VAPOR COMPRESSOR

The Walsh-Healey Act establishes permissible noise standards for all companies holding government contracts worth $10,000 or more. The gas generator and vapor compressor for this installation should comply to these standards and we recommend that a field test be made when the plant is operating.
The new criteria are illustrated as a series of contours in the diagram shown. When sound-pressure levels from a noise source are superimposed on these curves, the highest contour reached defines the equivalent sound level. This value is then compared with values in Table I to get allowable exposure limits. Reason for the shape of the curves is that low frequencies are less harmful to the ear than high frequencies. The particular manner in which the effects of sounds were weighted to produce these curves is called A-weighing, hence addition of the letter A to the single equivalent dB value for noise.

Occupational Noise Exposure

Reprinted from FEDERAL REGISTER - Volume 34, No. 96 - Tuesday, May 20, 1969 50-204.10 Occupational Noise Exposure:

(a) Protection against the effects of noise exposure shall be provided when the sound levels exceed those shown in Table I of this section when measured on the A scale of a standard sound level meter at slow response. When noise levels are determined by octave band analysis, the equivalent A-weighted sound level may be determined as follows:

(b) When employees are subjected to sound levels exceeding those listed in Table I of this section, feasible administrative or engineering controls shall be utilized. If such controls fail to reduce sound levels within the levels of the Table, personal protective equipment shall be provided and used to reduce sound levels within the levels of the Table.

(c) If the variations in noise levels involve maxima at intervals of 1 second or less, it is to be considered intermittent. In such cases, where the duration of the maxima are less than 1 second, they shall be treated as of 1 second duration.

(d) In all cases where the sound levels exceed the values shown herein, a continuing, effective hearing conservation program shall be administered.
<table>
<thead>
<tr>
<th>Duration per day, hour</th>
<th>Sound Level dBA</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>90</td>
</tr>
<tr>
<td>6</td>
<td>92</td>
</tr>
<tr>
<td>4</td>
<td>95</td>
</tr>
<tr>
<td>3</td>
<td>97</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>1-1/2</td>
<td>102</td>
</tr>
<tr>
<td>1</td>
<td>105</td>
</tr>
<tr>
<td>1/2</td>
<td>110</td>
</tr>
<tr>
<td>1/4 or less</td>
<td>115</td>
</tr>
</tbody>
</table>

When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions, C1/T1+C2/Ta...Cn/Tn exceeds unity, then the mixed exposure should be considered to exceed the limit value. Cn indicates the total time of exposure at a specified noise level and Tn indicates the total time of exposure permitted at that level. Exposure to impulsive or impact noise should not exceed 140 dBA peak sound pressure level.
Equivalent Sound Level Contours

Octave band sound pressure levels may be converted to the equivalent A-weighted sound level by plotting them on this graph and noting the A-weighted sound level corresponding to the point of highest penetration into the sound level contours. This equivalent A-weighted sound level which may differ from the actual A-weighted sound level of the noise, is used to determine exposure limits from Table I.
EFFLUENT DISPOSAL

Most oceanographers use as their standard of sea water composition that which is defined by the Hydrographic Laboratories of Copenhagen, Denmark. This standard sea water contains 3.517% equivalent NaCl solution. If one cubic foot of the standard sea water were to be pumped through a desalting plant such as proposed for Brownsville, the percentage of salt in the sea water leaving the plant will only increase from 3.5% to 7.9%. Approximately 1-1/4 cubic feet of fresh water could dilute each cubic foot of plant effluent back to its original sea water status. Thus, effluent from a desalting plant should not be confused with a saturated brine solution which contains 5 times as much dissolved salt. We might classify the effluent from a desalting plant as a very weak brine solution since the plant effluent contains only 1/5 of the salts that sea water is capable of dissolving.

The Texas Water Development Board in cooperation with the Brownsville Navigation District has studied and evaluated all flows into and out of the tidal flats including rainfall and surface evaporation. The results of the above study are included in Section VII of this report. The Texas Water Development Board concludes that it is feasible to dispose of the plant brine effluent to the tidal flats without adverse environmental effects.

AIR POLLUTION

According to reports from the 63rd annual meeting of the Air Pollution Control Association held in St. Louis in June, 1970, it is anticipated that the U. S. Congress will establish a National Emissions Standard this year (1970). It is anticipated that the initial bill will pertain only to pollutants that may be hazardous to the public health. The only industries now put in that category are asbestos, beryllium, cadmium, biological aerosols, and chlorinated hydrocarbons.

However, passage of the bill and the listing of some pollutants for national emission standards, is sure to bring pressure for standards for pollutants such as SO₂. Control of the nitric oxides is not predicted at this time.
The following typical pollutants result from burning natural gas.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aldehydes (HCHO)</td>
<td>2 lbs. per MM cu. ft. gas burned</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>0.4 lbs. per MM cu. ft. gas burned</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>Neg. lbs. per MM cu. ft. gas burned</td>
</tr>
<tr>
<td>Oxides of Nitrogen (NO₂)</td>
<td>214 lbs. per MM cu. ft. gas burned</td>
</tr>
<tr>
<td>Oxides of Sulphur (SO₂)</td>
<td>0.4 lbs. per MM cu. ft. gas burned</td>
</tr>
<tr>
<td>Other organics</td>
<td>5 lbs. per MM cu. ft. gas burned</td>
</tr>
<tr>
<td>Particulates</td>
<td>18 lbs. per MM cu. ft. gas burned</td>
</tr>
</tbody>
</table>

Nitric oxide is not a very toxic gas by itself but nevertheless plays a harmful role in the atmosphere where it oxidizes to nitrogen dioxide, a lung irritant. Under the action of sunlight, nitrogen dioxide dissociates into nitric oxide and atomic oxygen. Some of the atomic oxygen then combines with molecular oxygen to form ozone, a highly irritating gas and a specific health hazard. As a result of a series of chain reactions, nitric oxide is converted to nitrogen dioxide and the nitrogen dioxide combines with hydrocarbons to form organic nitrogen compounds. Since nitrogen oxides are produced by stationary and vehicular combustion sources, both of these sources contribute to photochemical smog. The exact role of each of these sources has not been clearly defined due to dilution effects in relation to hydrocarbons that are emitted principally by vehicles.

Since the 8 MGD vapor compression distillation plant proposed for Brownsville would burn natural gas only in the gas generator and in the waste heat boiler, the pollutants emitted are not considered likely to come under any type of controls that are presently being considered for enactment by the present Federal or the Texas authorities.
SECTION V

PLANT DESCRIPTION

PROCESS DESCRIPTION

The process consists of a gas turbine powering a vapor compressor which operates across a four-effect vertical tube evaporator. A heat recovery boiler is employed to recover waste heat from the gas turbine exhaust. Steam at two energy levels is generated in the heat recovery boiler; one level is approximately 260°F saturated, and the other is 650°F, 400 psig superheated steam which is used to power a back pressure steam turbine. The back pressure steam turbine is coupled to an electric generator which produces all the required auxiliary power for this facility. The exhaust steam at 257°F from the back pressure turbine is combined with the steam from the low pressure boiler. This steam is used as the heat input to the first effect of the vertical tube evaporator. The vapor compressor receives the low pressure steam from the fourth VTE effect at 227.7°F and increases its temperature to 343.4°F superheated steam which is then desuperheated to 256.6°F. The boiler steam is held separate from the process steam.

A multistage flash plant is used for pre-heating the incoming sea water at a rate of $5.0 \times 10^6$ lbs/hr. This process is a once-through system without recirculation. The makeup feed is first preheated in several MSF stage to 108.6°F. At this temperature, sulfuric acid is injected for scale control and then the feed is decarbonated and deaerated. The makeup feed is then further preheated through the MSF train to a temperature of 208.8°F. This feed stream then proceeds through four feed heaters, one between each VTE effect. The feed is thus further heated by a portion of the steam from each of the VTE effects.

A vertical tube evaporator consists of nominal 2 inches O.D. double fluted, aluminum brass tubes which have a tube length of 15 feet. The feed brine to the first effect is combined with the recycle stream from the first
effect recycle-interstage transfer pump and sprayed through distribution nozzles to the inside of the fluted tubes at a rate of 2.5 gpm/tube. The steam from the low pressure boiler and from the vapor compressor outlet is used to heat this incoming brine to a point where evaporation occurs. Essentially, all heat of vaporization from the steam is transferred thru the fluted tubes to the incoming brine, consequently generating an equivalent amount of fresh water boiled from the brine. The brine transferred from the first effect combines with the stream from the second effect recycle transfer pump and serves as the feed for the second effect. The steam generated from the evaporating brine in the first effect thus becomes the product from the second effect. This process is repeated through all four vertical tube effects. The blowdown brine from the fourth effect then enters the vertical tube evaporator and is flashed down through the MSF train to recover its sensible heat.

The MSF train is a conventional, commercially available system; however, it has the unique feature of having a product stream enter at the high temperature end which is approximately equal to the flashing brine flow rate. The duty of the MSF is approximately double that required by a single MSF train producing product in a conventional manner from a brine stream.

This plant, as described herein, is designed to produce 8.0 MGD of distilled water when:

a. using 12,500 hp power input to the vapor compressor
b. ambient air temperature is 73°F
c. ambient sea water temperature is 75°F
d. VTE and MSF heating surfaces have the degree of cleanliness allowed for in the design.

However, the plant is capable of operating efficiently at other desired production rates for any reasonable departure from the above assumptions.
The plant described in this report may be summarized by the following list of essential characteristics:

**Process:** Single purpose, sea water distillation desalination plant, with a nominal capacity of 8.0 MGD product water. The process utilizes a gas turbine powered vapor compressor operating across four effects of a vertical tube evaporator. A multistage flash evaporator is used as a low temperature brine heater. Brine recirculation is not used in the MSF portion of the plant. All process power requirements are furnished by a noncondensing steam turbo-generator. Steam is provided from a heat recovery boiler.

<table>
<thead>
<tr>
<th>Capacity, MGD</th>
<th>8.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of streams</td>
<td>1</td>
</tr>
<tr>
<td>Performance ratio, lbs. of product/1000 Btu of fuel</td>
<td>19.05</td>
</tr>
<tr>
<td>Number of effects in VTE</td>
<td>4</td>
</tr>
<tr>
<td>Number of stages in MSF</td>
<td>24</td>
</tr>
<tr>
<td>Maximum brine temperature, °F</td>
<td>250</td>
</tr>
<tr>
<td>Fuel required, Btu/hr. (HHV)</td>
<td>149.3 x 10^6</td>
</tr>
<tr>
<td>Steam required @ 19 psig saturated, lbs/hr (generated within plant)</td>
<td>61,600</td>
</tr>
<tr>
<td>Electricity required, kw (generated within plant)</td>
<td>2,050 total</td>
</tr>
<tr>
<td>Acreage required</td>
<td>4</td>
</tr>
<tr>
<td>Method of scale control</td>
<td>H₂SO₄ cont. feed 555 lb/hr</td>
</tr>
<tr>
<td>Sea water flow rate @ 75°F, gpm</td>
<td>11,295</td>
</tr>
<tr>
<td>Feed water flow rate @ 108.6°F, gpm</td>
<td>9,790</td>
</tr>
<tr>
<td>Blowdown flow rate @ 93.8°F, gpm</td>
<td>4,195</td>
</tr>
<tr>
<td>Effluent flow rate @ 90.7°F, gpm and 67,500 ppm TDS</td>
<td>5,960</td>
</tr>
</tbody>
</table>
Product water flow rate @ 92.3°F, gpm  

5,585

Brine Concentration Factor

Max. from VTE design  
2.0  
Max. from MSF design  
2.26  
Effluent Concentration Factor  
1.93  
Number of MSF trains  
4 in series

Dimensions of vessels

VTE  
32' wide x 85' long

MSF (per train)  
1 - 18' wide x 55' long  
2 - 13' wide x 55' long  
3 - 11' wide x 55' long  
4 - 11' wide x 55' long

Vessel Material

VTE  
Carbon steel - partially clad w/90-10 Cu Ni

MSF  
Carbon steel - waterboxes clad w/90-10 Cu Ni

Vessel Thickness

VTE  
3/4" thick except where 1/16" cladding is used

MSF  
1/2" thick

Coating or Lining

VTE  
90-10 Cu Ni where applicable. Pourable silicone rubber top of tube sheet

MSF  
90-10 Cu Ni in waterboxes

Min. brine flow in VTE tubes, gpm  

2.5

VTE tube material  
Al-Br

MSF tube material  
90-10 Cu Ni

Assumed tube life, years  
30

Tube type or configuration
VTE  
MSF  

Tube diameter, inches O.D.  

VTE  2  
MSF recovery  5/8  
MSF reject  5/8  

Tube wall (finished)  

VTE  0.035 in.  
MSF  0.035 in.  

Tube length  

VTE  15 ft.  
MSF  55 ft.  

Total VTE surface, ft$^2$  282,160  

Total VTE tubes  28,216  

Average U, btu/ft$^2$ hr °F  

VTE I Effect  1,420  
VTE II Effect  1,400  
VTE III Effect  1,380  
VTE IV Effect  1,360  

Feed Heaters  

Tube material  90-10 Cu Ni  
Tube diameter, inches  7/8  
Tube gauge  19  
Tube length, ft.  18  
Number of tubes per heater  1,090  

Deaerator  

Type  Vacuum, packed column  
Lining  Rubber
EQUIPMENT LIST

VTE

Four effects in horizontal rectangular steel (or steel-lined concrete) vessel 76' long x 33' wide x 29' high.

Design Pressure: 35 psig and 20 in. Hg Abs.
Design Temperature: 285°F
Corrosion Allowance: 3/16" for steel in vapor or product water
3/8" for steel in brine
0" for 90-10 Cu-Ni and monel surfaces

All unprotected steel in brine upstream of spray nozzles shall be lined.

Bundle Description

| Width     | 28-1/8 ft. |
| Depth     | 10-1/2 ft. |
| Height    | 15-1/2 ft. |
| No. of tubes | 7,054 |
| Heat Transfer Area | 70,540 ft.² |
| Tubes     | Double-fluted aluminum - brass - 0.035 finished wall |

Entrainment Separators

Vertical stainless hook-and-vane type for horizontal vapor flow. Vertically centered and across the entire width of the vapor space at the outlet of each effect.

Nozzles

Ceramic, with tangential orifice. Cemented to the top tube sheet with pourable silicone between the nozzles (permitting tube sheet to be steel). One required for each 2 inch vertical tube - 7054/effect.
Flash Tanks - 4 required

6' O.D. x 16' T-T carbon steel tanks. Design conditions same as VTE.

MSF Unit

Shells

No. of stages 24
No. of trains 4 (6 stages each)
1 - 18' wide x 55' long
2 - 13' wide x 55' long
3 - 11' wide x 55' long
4 - 11' wide x 55' long
Material of Cons. - Vessel Carbon Steel with 1/8" 90-10 Cu-Ni clad water boxes
Design Pressure 15 psig and F.V.
Design Temperature 250°F
Corrosion Allowance Shell & Dividers 3/16"

Bundle Description

Design Pressure 75 psig
Design Temperature 250°F
Tubes 90-10 Cu-Ni 5/8" 18 gage 55' long

Entrainment Separators

Horizontal type - 316 Stainless Steel

Deaerator

Packed column type - 90-10 Cu-Ni lined steel shell; Spray nozzles-bronze; Packing-plastic pall rings

Decarbonator

Wood slat construction w/electric air fan
Air Ejector and Baro Conditions

Hogging ejector
2-stage ejector w/intercondenser

Steam Chest      Bronze
Diffuser         Bronze
Nozzle           Stainless Steel

Gas Turbine and Vapor Compressor

12,500 hp gas turbine driving a vapor compressor which compresses 593,000 lbs steam/hour from 19 psia @ 227.7°F to 256.6°F

Heat Recovery Boiler

Low and high pressure boiler and superheater utilizes 597,000 lbs. 713°F exhaust gas/hour + supplementary gas firing to produce:

14,460 lbs. Sat. Stm. @ 19 psig & 257°F
48,000 lbs. Supht. Stm. @ 400 psig & 650°F

<table>
<thead>
<tr>
<th>Service</th>
<th>Design Press. psig</th>
<th>Design Temp. °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.P. Boiler</td>
<td>100</td>
<td>400</td>
</tr>
<tr>
<td>H.P. Boiler</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Superheater</td>
<td>500</td>
<td>750</td>
</tr>
</tbody>
</table>

Steam Turbo-Generator

Noncondensing, non-reheat back pressure machine rated to produce 2,050 kw with 400 psig, 650°F steam in and 19 psig exhaust. The generator is rated for 2,560 kva, 480 volt, 3 phase, 60 cycle, 0.8 pf.

Auxiliary Generator and Gas Engine Driver

Deleted - Auxiliary Power and Lighting will be supplied by the City of Brownsville.
Feed Heaters - 4 required

Duty: 41,051,00
Code: ASME, TEMA

<table>
<thead>
<tr>
<th></th>
<th>Shell</th>
<th>Tube</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Press:</td>
<td>psig</td>
<td>35&amp;FV</td>
</tr>
<tr>
<td>Design Temp:</td>
<td>°F</td>
<td>300</td>
</tr>
</tbody>
</table>

Single Pass - Fixed tube sheet

Sea Water Intake System

Includes intake structure and piping, chlorination system, screening system

Tanks

Acid tank - Steel Vertical - 40'0" x 30'0" T-T 300,000 Gal.

Condensate tank- Steel Vertical 6,000 Gal.

Miscellaneous Equipment

3 - 10,000 lb. Jib Cranes & Fall
<table>
<thead>
<tr>
<th>Service</th>
<th>No. Req'd</th>
<th>GPM</th>
<th>HD-FT</th>
<th>Horsepower Theo/Installed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect Pumps</td>
<td>12</td>
<td>8850</td>
<td>42</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>125</td>
</tr>
<tr>
<td>Dea. S.W. Fd. Pumps</td>
<td>3</td>
<td>5350</td>
<td>214</td>
<td>298</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>400</td>
</tr>
<tr>
<td>Distillate Pumps</td>
<td>3</td>
<td>2850</td>
<td>112</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>125</td>
</tr>
<tr>
<td>Brine Blowdown Pumps</td>
<td>3</td>
<td>3340</td>
<td>58</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td>75</td>
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<tr>
<td>Raw S.W. Feed Pumps</td>
<td>3</td>
<td>5950</td>
<td>117</td>
<td>182</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>250</td>
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<tr>
<td>Low Press. Condensate Pump</td>
<td>2</td>
<td>64</td>
<td>82</td>
<td>1.33</td>
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<td></td>
<td></td>
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<td>5</td>
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<tr>
<td>Boiler Feed Pump</td>
<td>3</td>
<td>32</td>
<td>1080</td>
<td>8.77</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>Screen Wash Pump</td>
<td>2</td>
<td>134</td>
<td>230</td>
<td>7.82</td>
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<td></td>
<td></td>
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<td></td>
<td>15</td>
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<tr>
<td>Acid Treatment Pump</td>
<td>2</td>
<td>1/2</td>
<td></td>
<td>1/2</td>
</tr>
<tr>
<td>Anti-foam Injection Pump</td>
<td>2</td>
<td>1/60</td>
<td></td>
<td>1/20</td>
</tr>
<tr>
<td>Chlorine Scavaging Pump</td>
<td>2</td>
<td>1/30</td>
<td></td>
<td>1/10</td>
</tr>
<tr>
<td>Sump Pumps</td>
<td>2</td>
<td>30</td>
<td>50</td>
<td>0.380</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3/4</td>
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</tbody>
</table>
SECTION VI

CAPITAL AND ANNUAL PRODUCTION COSTS

The cost estimate presented in this section of the report is based on the format as developed for the Office of Saline Water in R & D Report No. 377. It is presented in this manner for ease of comparing the Fluor updated estimate with the 1968 OSW estimate.

Inflation has increased the original 1968 desalting estimate by 11¢/1000 gallons. This 11¢ increase is attributed to the following three inflation factors:

1. Increased cost of fuel (25¢ to 30¢) 2¢/1000 gal.
2. Increased cost of money (4-1/4% to 6%) 5¢/1000 gal.
3. Increased cost of construction labor and equipment 1¢/1000 gal.
   11¢/1000 gal.

The labor and materials in this estimate are on the basis of third-quarter 1970 prices. All manufacturers' prices, whether verbal or written, are not considered firm prices, but were the vendors' most accurate estimate of their selling price for mid-1970.

The erection labor estimate is prepared on the basis of labor availability within an approximate 50-mile radius of the proposed site. Also, the erection estimate is based on a combination of labor wages and mix of crafts as required for erection at the site. Prevailing wage rates and fringe benefits of Corpus Christi were used as a guide in preparation of the estimate.

Spare parts and maintenance supervision by vendors has not been included in the estimate.
# TABLE 3

**CAPITAL COSTS**

for

\[8.04 \times 10^6\] MGD Gas Turbine Powdered Vapor Compressor VTE - MSF Distillation Plant

<table>
<thead>
<tr>
<th>Special Equipment</th>
<th>Capital Cost $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical Tube Evaporator including tubes and spray nozzle</td>
<td>2,200,000</td>
</tr>
<tr>
<td>Multistage Flash Evaporator Complete: including pumps, piping, deaerator, degasifier, and tube bundles</td>
<td>2,050,000</td>
</tr>
<tr>
<td>Gas Turbine - Vapor Compressor Power Train Complete</td>
<td>1,240,000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>5,490,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard Engineering Equipment</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Recovery Boiler Complete</td>
<td>379,000</td>
</tr>
<tr>
<td>Steam Turbo-Generator Complete with Switchgear</td>
<td>372,000</td>
</tr>
<tr>
<td>Auxiliary Generator and Engine Driver</td>
<td>Deleted</td>
</tr>
<tr>
<td>Pumps and Motors (excluding MSF plant)</td>
<td>307,000</td>
</tr>
<tr>
<td>Feed Heaters</td>
<td>182,000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>1,240,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Process Facilities (excluding MSF plant)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea Water Intake Structure (excluding pumps)</td>
<td>**</td>
</tr>
<tr>
<td>Site Development, Buildings and Foundations</td>
<td>942,000</td>
</tr>
<tr>
<td>Insulation &amp; Painting (excluding heat recovery boiler)</td>
<td>80,000</td>
</tr>
<tr>
<td>Piping, Electrical and Instrumentation</td>
<td>833,000</td>
</tr>
<tr>
<td>Monorails and Other Mechanical Equipment</td>
<td>108,000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>1,963,000</td>
</tr>
</tbody>
</table>

**TOTAL DIRECT CAPITAL COST** ............................................................................. $8,693,000

*Capital Costs include materials, vendor profit, vendor contingency, shop and field labor, overhead, erection and freight.

**Cost included in Site Development, Buildings and Foundations.
Other Plant Costs

Engineering Expense of A/E (8% Direct Capital Costs per OSW R & D Report No. 377) $695,000
Interest During Construction (3% Direct Capital Costs) 282,000
Startup Expense See Page 15
Site Cost 60,000
Construction Equipment Rental See Page 16
Subtotal $1,037,000
A/E's Contingency See Page 17

TOTAL CAPITAL COSTS $9,730,000

Capital Cost per Gallon of Daily Capacity (@ 8.04 MGD) $1.21
TABLE 4

DETAILED CAPITAL COSTS

I. VTE Evaporator including the following equipment:

Steel
Heads
Pipe Nozzles
Reinforcing Plates
Tube Bundle Supports
Deck Plates
Nozzles
Separators
Vertical Double Fluted Tubes
Spray Nozzles
Design Engineering
Shop Labor
Field Labor
Contingency
Freight

Total Erected Price ................................ $2,200,000

II. MSF Unit including:

Deaerator
Decarbonator
Vacuum Equipment
Instruments and Control Valves
Valves
Insulation
Acid Pumps (2)
Antifoam Pumps (2)
Antifoam Mix Tank
Distillate Pumps and Drivers (3)
Brine Pumps and Drivers (3)
Feed Pumps and Drivers
Decarbonator Fans (2)
Piping
Acid Tank
Freight and Erection

Total Erected Price ..................... $2,050,000

III. Gas Turbine and Vapor Compressor including:

Inlet Housing and Inlet Silencing
Lube System
Emergency D.C. Lube Pump
Fire Protection System
Controls and Instrumentation
Gas Generator
Power Turbine
Vapor Compressor
Freight
Erection
Startup
Base and Mounts

Total Erected Price ..................... $1,240,000

IV. Heat Recovery Boiler & Accessories including:

Dump Stack with Valve
Superheaters
H.P. Boiler
Economizer
L.P. Boiler
Exhaust Stack
Boiler Instrumentation & Controls
Process Piping and Insulation
Valves
Refiring System
Isolating Damper
Erection
Freight
H.P. Boiler Feed Pumps and Drivers (2)
L.P. Boiler Feed Pump (2)
Auxiliary Condensate Storage Tank
Inlet Duct and Expansion Joint
F.D. Fan and Engine Driver Complete

Total Erected Price .......................... $ 379,000

V. Steam Turbo-Generator including:

Lubricating Oil System
Instruments and Controls
Emergency
Freight
Technical Supervision
Erection on Furnished Foundations
Switchgear including:
  48 V DC Battery System
  Electrically Operated Main Breaker
  2 Manually Operated Breakers
  Lightning Arrestors
  Surge Capacitors
Freight
Erection
Technical Supervision

Total Erected Price .......................... $ 372,000

VI. Auxiliary Generator and Gas Engine Driver including:

Instruments and Controls
Housing
Fuel Strainer
12 V Starting Batteries
Freight
Field Labor for Unloading

Total Erected Price ........................................ $ *

VII. Pumps and Motors:

Raw Sea Water Feed Pumps and Motors (3)
Screen Wash Pumps and Motors (2)
Sodium Metasilicate Pumps and Motors (2)
Effect Pumps (12)

Total Erected Price ........................................ $ 307,000

VIII. Feed Heaters and Flash Tanks:

Tubes
Shells
Nozzles
Freight
Mounting on Furnished Foundations

Total Erected Price ........................................ $ 182,000

IX. Sea Water Intake Structure includes:

Concrete Structures
Intake Pipe
Blowdown Pipe
Traveling Rake
Erection
Overhead and Profit

Total Erected Price ....................................Included in Item X

* This item deleted in this estimate.
X. Site, Buildings and Foundations including:

Excavation and Backfill
Roadways
Concrete Foundations
Steel and Steel Buildings
Operations Building and Shop including:
  Foundation
  Building and Air Conditioning
  Lab, Furniture and Supplies

Total Erected Price ........................ $ 942,000

XI. Insulation Subcontract (excluding MSF, Gas Turbine, and Heat Recovery Boiler);

VTE
Feed Heaters
Vapor Compressor
Piping
Painting
Freight

Total Erected Price ........................ $ 80,000

XII. Piping, Electrical and Instrumentation

A. Piping and Valves (excluding MSF and between intake and channel)
  Freight
  Field Labor

Subtotal ................................. $ 529,000

B. Electrical (excluding MSF unit and motors) includes:
  Motor Control Center
  Lighting Panel
  Lighting Transformer
  Conduit and Cable
Code call and P/A System
Freight
Field Labor

Subtotal ......................... $ 230,000

C. Instrumentation (excluding MSF, Gas Turbine, Vapor Compressor, Heat Recovery Boiler)

VTE
Supplementary Steam Turbo-Generator
Intake Structure & Pumps
Process Pipe

Subtotal ......................... $ 74,000

Total Erected Price ................ $ 833,000

XIII. Monorail Cranes and other Mechanical Equipment (excluding gas turbine and all supporting steel) includes:

Monorail
Air Compressors
Traveling Screens
Trash Rack
Chlorination Equipment
Freight

Total Erected Price ................ $ 108,000

GRAND TOTAL ..................... $8,693,000
### TABLE 5
ANNUAL PRODUCTION COSTS
for
8.04 x 10⁶ MGD Gas Turbine Powered Vapor

<table>
<thead>
<tr>
<th>Product Line</th>
<th>$/Year</th>
<th>$/1000 Gal.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fuel Cost Base</strong></td>
<td>$0.30/10⁶ Btu</td>
<td></td>
</tr>
<tr>
<td><strong>Direct Production Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel @ 90% Load Factor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas Turbine (144.3 x 10⁶ Btu/hr HHV)</td>
<td>$341,000</td>
<td>$0.1291</td>
</tr>
<tr>
<td>Boiler Trimming (5.0 x 10⁶ Btu/hr HHV)</td>
<td>12,000</td>
<td>0.0045</td>
</tr>
<tr>
<td>Chemicals</td>
<td>90,900</td>
<td>0.0344</td>
</tr>
<tr>
<td><strong>Direct Operating Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Payroll (13 people)</td>
<td>67,060</td>
<td>0.0254</td>
</tr>
<tr>
<td>Maintenance for G.T.</td>
<td>53,220</td>
<td>0.0201</td>
</tr>
<tr>
<td>Lube Oil</td>
<td>7,200</td>
<td>0.0027</td>
</tr>
<tr>
<td>Other Maintenance @ 0.5% of Capital</td>
<td>48,400</td>
<td>0.0183</td>
</tr>
<tr>
<td>Cost minus G.T.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Direct Costs</strong></td>
<td>619,780</td>
<td>0.2345</td>
</tr>
<tr>
<td><strong>Indirect Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General and Administrative and Fringe @ 75%</td>
<td>50,300</td>
<td>0.0190</td>
</tr>
<tr>
<td>Depreciation (30 year) and Int. (6%) (Cap. Rec. Fact. - 7.265%)</td>
<td>703,000</td>
<td>0.2661</td>
</tr>
<tr>
<td>Insurance (0.30% of Capital Cost)</td>
<td>29,030</td>
<td>0.0110</td>
</tr>
<tr>
<td>Interest on Working Capital (60 days @ 6%/year)</td>
<td>7,530</td>
<td>0.0029</td>
</tr>
<tr>
<td><strong>Total Indirect Costs</strong></td>
<td>789,860</td>
<td>0.2990</td>
</tr>
</tbody>
</table>

**TOTAL ANNUAL PRODUCTION COST**
Based on 2642 x 10⁶ Gal/Year . . . . . . . . . . . . . . . . . . . $1,409,640 $0.5335
2.0 Capital Cost Qualifications

2.1 Vertical Tube Evaporator

The capital cost of the VTE is estimated from material take-offs made from general arrangement drawings of the unit and from tube sheet detail drawings. Because of the tube sheet size, tube bundle shipment and erection methods had to be considered. The VTE estimate is based on building the tube bundles in the shop and welding them in place in the field.

Supplier prices were obtained for the furnishing of 28,216 2" O.D. aluminum brass double fluted tubes required in the four effects of the VTE. Each tube is 15'-6" long and has an active fluted length of 15'-0".

The price of the porcelain distribution nozzles is based on a 1970 price from a supplier.

The tube sheet costs is based on not using a clad steel. A pourable silicone rubber is used in securing the porcelain nozzles to the tube tops, thus isolating the majority of the top tube sheet from the brine solution. The tube sheets have sufficient thickness to allow up to 3/8" corrosion to take place in any unprotected area without damaging the structural integrity.

The price of the stainless steel hook-and-vane entrainment separators is based on a price cost from a supplier.

2.2 Multistage Flash Evaporator

The cost estimate of the MSF unit is based on a cost estimate by an equipment manufacturer.
An acid tank was added (300,000 gallons) in order to take advantage of savings to be realized in acid costs by barging in the chemical from Corpus Christi, Texas.

2.3 Gas Turbine and Vapor Compressor Power Train

Vapor compressor and power turbine price is based on current pricing policies. The lubrication system and coupling is included in this package. Surge control and instrumentation for controlling surge as well as vapor ducting to and from the compressor is included elsewhere.

This cost estimate for the gas generator includes the following: Industrial sound treated insulation and aluminum housing, overhead monorail crane for light maintenance, inlet filter and silencer, fire protection system, complete lubrication system, natural gas starters, and sequencing controls with instrumentation to be mounted in main control room.

2.4 Heat Recovery Boiler

The cost estimate for this piece of equipment is based on current pricing policies. Prices were obtained for the boiler feed pumps and for the F.D. fan and natural gas engine.

2.5 Operations Building

A more complete breakdown of the estimated cost of the operations building is provided in Table VI-4.

2.6 Site Costs

Costs are included to prepare site and build necessary hard-surfaced roadway to serve as access to the property and access among the pieces of equipment. A fence around the periphery of the 400 foot square plant site is provided. Property costs of $6000 (Site A) and $3000 (Site B) per acre were established by the Brownsville Navigation District.
2.7 Other Plant Costs

The costs for the construction equipment to be rented in the field is shown on Table VI-6.

The estimated value of the A/E's field work and the corresponding contingency is shown in Table VI-7.
<table>
<thead>
<tr>
<th>Item</th>
<th>Total Cost $</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Foundations &amp; Floor Slab</td>
<td>*</td>
<td>Concrete</td>
</tr>
<tr>
<td>2. Building</td>
<td>*</td>
<td>Concrete block - Includes all utilities, heat and air conditioning, vinyl tile floor in lab, office and hallways, painting, built-in benches and cupboards, toilet facilities, sinks and shower. Current Prices</td>
</tr>
<tr>
<td>3. Equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Laboratory</td>
<td>*</td>
<td>Includes all necessary equipment apparatus and chemicals to adequately service the complete plant. Current Prices</td>
</tr>
<tr>
<td>b. Office</td>
<td>*</td>
<td>Includes all desks, chairs, filing cabinets, waste baskets, typewriter, calculator, desk lamps, office supplies and forms needed for small production office. Current Prices</td>
</tr>
<tr>
<td>c. Maintenance</td>
<td>*</td>
<td>Minimal equipment to service plant. Major maintenance will be contracted. Current Prices</td>
</tr>
<tr>
<td>(1) Spare Parts</td>
<td>*</td>
<td>Spare parts are minimal</td>
</tr>
<tr>
<td>d. Janitors equip. and supplies</td>
<td>*</td>
<td>Includes all equipment and supplies needed to service plant and office. Current Prices.</td>
</tr>
<tr>
<td>e. Air compressor system</td>
<td>*</td>
<td>Includes 2 compressors, 1 instrument air dryer, 1 air receiver, 1 filter and silencer, 2 motors and starters, 1 lot of piping. Current Prices.</td>
</tr>
<tr>
<td>TOTAL</td>
<td>*</td>
<td>*These costs included in Item X Site, Buildings and Foundations</td>
</tr>
</tbody>
</table>
## MANPOWER REQUIREMENTS FOR STARTUP

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>No. of</th>
<th>Duration</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VTE</td>
<td>2 Engr.</td>
<td>One Week</td>
<td>80</td>
</tr>
<tr>
<td>2</td>
<td>MSF</td>
<td>2 Engr.</td>
<td>Two Weeks</td>
<td>160</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 Fact.</td>
<td>Two Weeks</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>G.T. &amp; V.C. Compressor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Steam Turbo-Gen. &amp; Switchgear</td>
<td>2 Engr.</td>
<td>One Week</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 Fact.</td>
<td>One Day</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>Emergency Generator (This equipment deleted from Brownsville project)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Boiler and F.C. Fan</td>
<td>1 Engr.</td>
<td>One Week</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 Fact.</td>
<td>One Day</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>Pumps</td>
<td>1 Engr.</td>
<td>One Week</td>
<td>40</td>
</tr>
<tr>
<td>8</td>
<td>Feed Heaters</td>
<td>2 Engr.</td>
<td>Two Weeks</td>
<td>80</td>
</tr>
<tr>
<td>9</td>
<td>Intake Structure, screens</td>
<td>1 Engr.</td>
<td>Three Days</td>
<td>24</td>
</tr>
</tbody>
</table>

VTE Hydro  
Boiler Hydro

Assume 3.0 Men/Eng. manhour

**NOTE:** All of these costs were included in the bid packages.
### TABLE 8

**EQUIPMENT RENTAL**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scaffolding</td>
</tr>
<tr>
<td></td>
<td>Erection and Removal</td>
</tr>
<tr>
<td>1</td>
<td>Concrete testing</td>
</tr>
<tr>
<td>2</td>
<td>Air compressor</td>
</tr>
<tr>
<td>1</td>
<td>Air compressor</td>
</tr>
<tr>
<td>1</td>
<td>Back hoe</td>
</tr>
<tr>
<td>1</td>
<td>1/2 cy cement bucket</td>
</tr>
<tr>
<td>1</td>
<td>1 cy cement bucket</td>
</tr>
<tr>
<td>1</td>
<td>Compactor, gas</td>
</tr>
<tr>
<td>1</td>
<td>130 ton crane</td>
</tr>
<tr>
<td>2</td>
<td>2OT hydraulic's (wheel)</td>
</tr>
<tr>
<td>1</td>
<td>Loader 3 yd. cap.</td>
</tr>
<tr>
<td>2</td>
<td>Trucks</td>
</tr>
<tr>
<td>5</td>
<td>Welders (gas)</td>
</tr>
<tr>
<td>5</td>
<td>Welders (gas)</td>
</tr>
<tr>
<td>2</td>
<td>Generators (gas)</td>
</tr>
<tr>
<td>3</td>
<td>Pumps (gas)</td>
</tr>
<tr>
<td>1</td>
<td>Dozer 65 HP</td>
</tr>
<tr>
<td>1</td>
<td>Clean-up</td>
</tr>
<tr>
<td>1 Lot</td>
<td>Welding rod</td>
</tr>
</tbody>
</table>

**NOTE:** Above prorated to bid packages. Previous OSW estimates broke out the equipment rental costs as a separate item in the cost summaries.
### TABLE 9

**A/E's CONTINGENCY**

1. Steam Turbogenerator  
   Installation & Switchgear

2. Emergency Generator Installation (deleted)

3. Pumps Installation

4. Feed Heater Erection

5. Site, Buildings, and Foundations

6. Piping, Electrical, Instrumentation

7. Monorails

8. Equipment Rentals

**NOTE:** All contingency prorated to bid packages. Previous OSW estimates broke out the A/E's contingency and carried it as a separate item in the previous cost summaries.
3.0 Annual Cost Qualifications

Table VI-3 shows the annual operating costs for this facility. The fuel cost is expressed on two different bases, viz., one in dollars per year and the other in dollars per 1000 gallons of product water.

It should be noted that the cost tables are based on producing full load production (8.04 MGD) for 7,884 hours per year.

3.1 Fuel Costs

The estimated fuel consumption for the gas turbine when operated at 12,500 bhp with 2" inlet loss, 9" exhaust back pressure, 73°F ambient temperature, and sea level is $149.3 \times 10^6$ Btu's (HHV) per hour when burning the natural gas fuel specified.

The $.30 per million Btu (HHV) cost was furnished by the City of Brownsville. This cost corresponds to the 1970 cost quoted by local gas producers in the Brownsville area on a long-term contract basis, not including escalation provisions.

3.2 Chemical Costs

Prices for chemicals to be used in the plant are shown in Table VI-8.

3.3 Payroll Costs

The direct operating costs associated with manpower are shown in Table VI-9.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sulfuric Acid</td>
<td>1.572</td>
<td>111.</td>
<td>1.656</td>
<td>2.6032</td>
</tr>
<tr>
<td>2. Antifoam</td>
<td>45.5</td>
<td>.5</td>
<td>0.0075</td>
<td>0.3412</td>
</tr>
<tr>
<td>3. Chlorine</td>
<td>6.94</td>
<td>2.5</td>
<td>0.0435</td>
<td>0.3019</td>
</tr>
<tr>
<td>4. Sodium metasilicate</td>
<td>11.15</td>
<td>2.0</td>
<td>0.0167</td>
<td>0.1862</td>
</tr>
</tbody>
</table>

3.4325
TABLE 11

GAS TURBINE-VAPOR COMPRESSION CYCLE
8 MGD SEA WATER EVAPORATOR

DIRECT OPERATING COSTS - MANPOWER

<table>
<thead>
<tr>
<th>Position</th>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Superintendent</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Operator</td>
<td>1/4</td>
<td></td>
</tr>
<tr>
<td>Oper. Main</td>
<td>1/4</td>
<td></td>
</tr>
<tr>
<td>Oper. Swing</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Timekeeper,</td>
<td>-1</td>
<td>Payroll, Clerical, Stores</td>
</tr>
<tr>
<td>Painter,</td>
<td>1</td>
<td>Janitor, Laborer</td>
</tr>
<tr>
<td>Technician</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Using Rates Applicable for Texas Gulf Coast Area

1 - Plant Superintendent .................. $8,700
1 - Technician .......................... 5,400
9 - Operators @ $5100 .................... 45,900
1 - Clerical ............................ 3,780
1 - Janitor and Laborer .................. 3,276

13 .......................... $67,056

Plus G and A and fringe @ 75% ........ 50,292
TOTAL ................................ $117,348
3.4 Maintenance Costs

The estimated cost of maintenance required to maintain the generator is based on being operated at no greater than 12,500 hp on natural gas fuel, 7,884 hours per year. The 12,500 hp is the base load rating at 73°F which is the mean ambient temperature for the Texas Gulf Coast area. It is assumed that the number of hours of operation above and below 73°F will be equal over the period between overhauls. The estimate is based on the following:

1. A spare gas generator will be leased for use during scheduled overhaul periods.

2. The gas generator will receive a hot section inspection after every 4,000 hours and be overhauled after every 16,000 hours of operation at design rating.

3. The free turbine will be inspected once per year and be overhauled after every 100,000 hours of base load operation.

4. The vapor compressor will be inspected once per year. The vapor compressor will be overhauled once in the 30-year life. Spare vapor compressor parts are not included in the estimate.

5. Supervision and parts are available for any unexpected repairs due to wear and tear on the machinery required on the gas generator, free turbine and vapor compressor.

6. Maintenance estimate does not cover repairs brought on by the forces of nature, fire, or operator error.
The annual cost for lubricating oil includes the oil consumed in operation, oil changes and oil flush. The oil cost is based on two complete lubrication systems, one for the gas generator and one to be shared by the power turbine and vapor compressor.

Other maintenance costs expected to be encountered will be for outside assistance in the overhaul of various equipment and pumps. One-half (1/2) per cent of the original capital costs, not including the gas generator, have been assumed to be able to cover all other maintenance expenses.

3.5 Other Indirect Annual Costs

Depreciation (30 years) and interest of 6.00% is assumed. This corresponds to a capital recovery factor of 7.265%.

The water plant is assumed to be a municipal plant and tax exempt.
SECTION VII

REPORT OF THE CITY OF BROWNSVILLE, TEXAS AND THE
PUBLIC UTILITIES BOARD OF THE CITY OF BROWNSVILLE, TEXAS,
REGARDING FEASIBILITY OF THE CITY TO COLLECT AND DISTRIBUTE
THE PRODUCT WATER FROM A PROPOSED 8 MGD DESALINIZATION PLANT
AT BROWNSVILLE, TEXAS

I. CONCLUSIONS

1. The City has the capability to collect, blend and distribute the
   product water from the proposed 8 MGD Desalinization Plant at
   Site A to its consumers through either existing or proposed
   facilities.

2. The City considers the collection, blending and distribution of
   the product water from Site A to its consumers to be totally
   feasible, technically and economically.

II. GENERAL DESCRIPTION OF METHOD OF COLLECTING,
    BLENDING, AND DISTRIBUTING PRODUCT WATER

It is proposed to construct a 500,000 gallon reinforced concrete surge
tank and clearwell at Site A to receive the product water from the
plant.

The product water will be pumped, under pressure, from the Surge Tank
to Water Treatment Plant No. 2, using an existing 30" concrete steel
transmission line, where it will be either discharged directly into
an existing 1,000,000 gallon reinforced concrete clearwell, for blend-
ing with treated water in an adjacent 1,000,000 gallon reinforced
concrete clearwell, or pumped through a new 16" transite line to
Water Plant No. 1, for storage in an existing 1,000,000 gallon re-
forced concrete clearwell.

The blended water will be pumped into the City's existing transmission,
distribution and storage facilities from both Water Plant No. 1 and
Water Plant No. 2 in accord with the demand therefor.

Proper valving and instrumentation at Site A, Water Plant No. 1 and
Water Plant No. 2 will provide optimum usage of both the product and
blended water.
SECTION VII

EVALUATION OF PLANT EFFLUENT DISPOSAL

Prepared By
Texas Water Development Board

CONCLUSIONS

Effluent from the desalting plant can be discharged into either San Martin Lake or Bahia Grande without any adverse effects upon the ecology of the receiving waters.

If the effluent is discharged into San Martin Lake, this could during the dry seasons of the year result in an increase in the dissolved solids content of the intake saline water utilized by a nearby large petro-chemical complex. However, any such salinity increase can be offset by dilution with relatively fresh water pumped either from the Rio Grande, when available, or from wells owned by the City of Brownsville. The introduction of relatively fresh blending water to the brine disposal system should be required for only short periods of time.

Disposal of the effluent into Bahia Grande would require no dilution measures during drought periods.

GENERAL DESCRIPTION AND ANALYSIS OF PLANT EFFLUENT DISPOSAL SITES

The desalting plant has a sea water intake of 16.3 MGD (million of gallons per day). The salinity of the water in the ship channel at the intake area ranges from 24,500 to 44,000 mg/l (milligrams per liter). The wide range of analyses reflect changes in fresh water inflow from drainage ditches to the ship channel and tidal flats, and the evaporation occurring during the time of low fresh-water flows. The effluent discharge from the plant will be approximately 8.2 MGD with dissolved solids content of 67,500 mg/l.

There are numerous saline tidal flats in the vicinity of the ship channel which may be used effectively for disposal of the effluent from the plant. The value of the tidal flats as a marine fisheries habitat is very limited and the discharge of the effluent into them would have little detrimental
affect; subsequent discharge of a brine solution directly to the Gulf of Mexico would also have insignificant affect on the fisheries habitat.

There is no fresh to slightly saline ground water in the vicinity of the ship channel or tidal flats which could be affected by the disposal of the effluent from the plant.

Two sites (San Martin Lake and Bahia Grande) were considered for disposal of effluent from the desalting plant. Calculations, tables of water analyses, and a map showing the location of the sampling points and the proposed disposal sites are on file at the offices of the Texas Water Development Board. The discussions on the San Martin Lake and Bahia Grande disposal sites are based on the plant being built at Plant Site A.

SAN MARTIN DISPOSAL SITE

San Martin Lake consists of a series of interconnected tidal flats located north of the ship channel. These tidal flats are open to the ship channel. A large petro-chemical complex is located on the ship channel. Operation of this complex requires the use of large volumes (100 MGD) or more of cooling water. The effluent cooling water is discharged into San Martin Lake via an unlined ditch north, thence east of the plant. The salinity of the discharged water is essentially the same as that of the intake water from the ship channel. Measurements indicate that some recycle occurs from the ship channel intake of the plant to the plant outfall into San Martin Lake and thence back to the ship channel.

The concentration of dissolved solids of the feed water from the ship channel is effected by evaporation and by relatively fresh water runoff into San Martin Lake and the ship channel through drainage ditches. Flows of relatively fresh water from these ditches dilute the sea water, producing water containing dissolved solids less than standard sea water in the ship channel.
During periods of high runoff and low salinity in the ship channel (below 35,000 mg/l), the effluent from the desalting plant can be received into the system in the absence of salinity buildup above present values.

During drought periods, when the inflows from the ditches are negligible and there is not sufficient dilution to offset a concentration increase due to the evaporation of the surface area of the system, there would be an additional increase in salinity due to the disposal of the 8.2 MGD of 67,500 mg/l brine effluent from the desalting plant. When such conditions exist, the salinity of the effluent can be diluted with water from the existing City wells, additionally drilled wells, or the Rio Grande. An amount of well water equivalent to the desalting plant brine effluent volume (8.2 MGD) could be added to the system to reduce the effluent to the salinity of standard sea water, thus resulting in no increase in salinity due to the effluent from the desalting plant. The dilution water, when needed, could be transported to the system through existing facilities.

The disposal of effluent from Plant Site A into San Martin Lake can be made by gravity flow in an existing drainage ditch, thus requiring no additional facilities for disposing of the effluent.

San Martin Lake is wholly owned by the Brownsville Navigation District.

**BAHIA GRANDE DISPOSAL SITE**

Bahia Grande is a large tidal flat which does not have a normal flow to and from the ship channel. The area is normally dry and receives water from the ship channel only during abnormally high tides caused by large storms. The size of Bahia Grande and the net evaporation rate in the Brownsville area is sufficient to evaporate all of the 8.2 MGD effluent from the desalting plant.

Approximately 7.5 miles of pipeline and ditch would be required to take the effluent by gravity flow from Plant Site A to the Bahia Grande disposal site.
The Bahia Grande disposal site will require the purchase or leasing of the area from individual landowners.

DISPOSAL OF EFFLUENT FROM PLANT SITE B

If the desalting plant were built at Plant Site B, .5 miles of pipeline or ditch would be required to carry the effluent to San Martin Lake; and 4.7 miles of pipeline or ditch to Bahia Grande.

DISPOSAL OF EFFLUENT FROM PLANT SITE C

If the plant were to be located at Plant Site C, the discharge of effluent would be directly into the Gulf of Mexico.

RECOMMENDATIONS

It is recommended that San Martin Lake be used as the disposal system for the desalting plant effluent. There is no additional cost for conveyance required to dispose of the effluent.

Water-quality monitoring of the intake area should continue during the operation of the desalting plant. Should the chloride concentration of the intake water ever exceed that of standard sea water (approximately 19,500 mg/l), 8.2 MGD of well water or Rio Grande water should be mixed with the brine effluent to prevent objectionable salinity buildup.
EXCERPTS TAKEN FROM THE MINUTES
OF THE REGULAR MEETING OF THE
BOARD OF COMMISSIONERS OF THE
BROWNSVILLE NAVIGATION DISTRICT
HELD ON WEDNESDAY, SEPTEMBER 16,
1970 AT 3:00 O'CLOCK P. M.

"***********

It was moved by Secretary Batsell that the District will pro-
vide a location for the Desalting Plant at the head of its
turning basin and will continue its effort to procure a waste
disposal permit covering the Bahia Grande and San Martin Lake
Areas. The motion was duly seconded by Commissioner Tipton
and upon being put to a vote by Chairman Garza, carried unani-
mously.

***********"

THE STATE OF TEXAS  X
COUNTY OF CAMERON  X

I, JAMES R. BATSELL, do hereby certify that I am
Secretary of the Board of Navigation and Canal Commissioners
of the Brownsville Navigation District of Cameron County,
Texas.

I further certify that the above and foregoing con-
stitutes a true and correct copy of excerpts from the Minutes
of a Regular Meeting of the Board of Navigation and Canal
Commissioners held on Wednesday, September 16, 1970 at 3:00
O'clock P. M.

IN WITNESS WHEREOF, I have hereunto subscribed my
official signature and impressed hereon the official seal
of said District this 21 day of September, A. D. 1970.

James R. Batsell, Secretary

(SEAL)
# PROJECT PERSONNEL DIRECTORY

## 8 MILLION GALLON PER DAY DESALTING PLANT

**FEASIBILITY STUDY FOR CITY OF BROWNSVILLE, TEXAS**

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
<th>Position</th>
</tr>
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<tbody>
<tr>
<td>A. Gonzales</td>
<td>City of Brownsville</td>
<td>Mayor</td>
</tr>
<tr>
<td>K. Lilljedahl</td>
<td>City of Brownsville</td>
<td>City Manager</td>
</tr>
<tr>
<td>G. E. Henry</td>
<td>City of Brownsville</td>
<td>City Engineer</td>
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<tr>
<td>W. M. Peterson</td>
<td>City of Brownsville</td>
<td>Consultant</td>
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<tr>
<td>K. Morgan</td>
<td>Brownsville P.U.B.</td>
<td>General Mgr. P.U.B.</td>
</tr>
<tr>
<td>C. R. Hernandez</td>
<td>Brownsville P.U.B.</td>
<td>Supt., Water Dept.</td>
</tr>
<tr>
<td>A. Cisneros</td>
<td>Brownsville Navigation District</td>
<td>Gen. Mgr. &amp; Dir. of Port</td>
</tr>
<tr>
<td>E. G. Lantz</td>
<td>Brownsville Navigation District</td>
<td>Dir. of Eng. &amp; Port Devel.</td>
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<tr>
<td>R. C. Peckham</td>
<td>Texas Water Development Board</td>
<td>Director, Ground Water Div.</td>
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<tr>
<td>R. L. Bluntzer</td>
<td>Texas Water Development Board</td>
<td>Ass't. Director, Ground Water Div.</td>
</tr>
<tr>
<td>E. F. Miller</td>
<td>U. S. Office of Saline Water</td>
<td>Project Manager</td>
</tr>
<tr>
<td>J. Biegel</td>
<td>Fluor - Houston</td>
<td>Vice President - Sales</td>
</tr>
<tr>
<td>R. W. Newkirk</td>
<td>Fluor - Los Angeles</td>
<td>Manager of Projects</td>
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<tr>
<td>M. E. Marwede</td>
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<tr>
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<td>R. C. Sears</td>
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