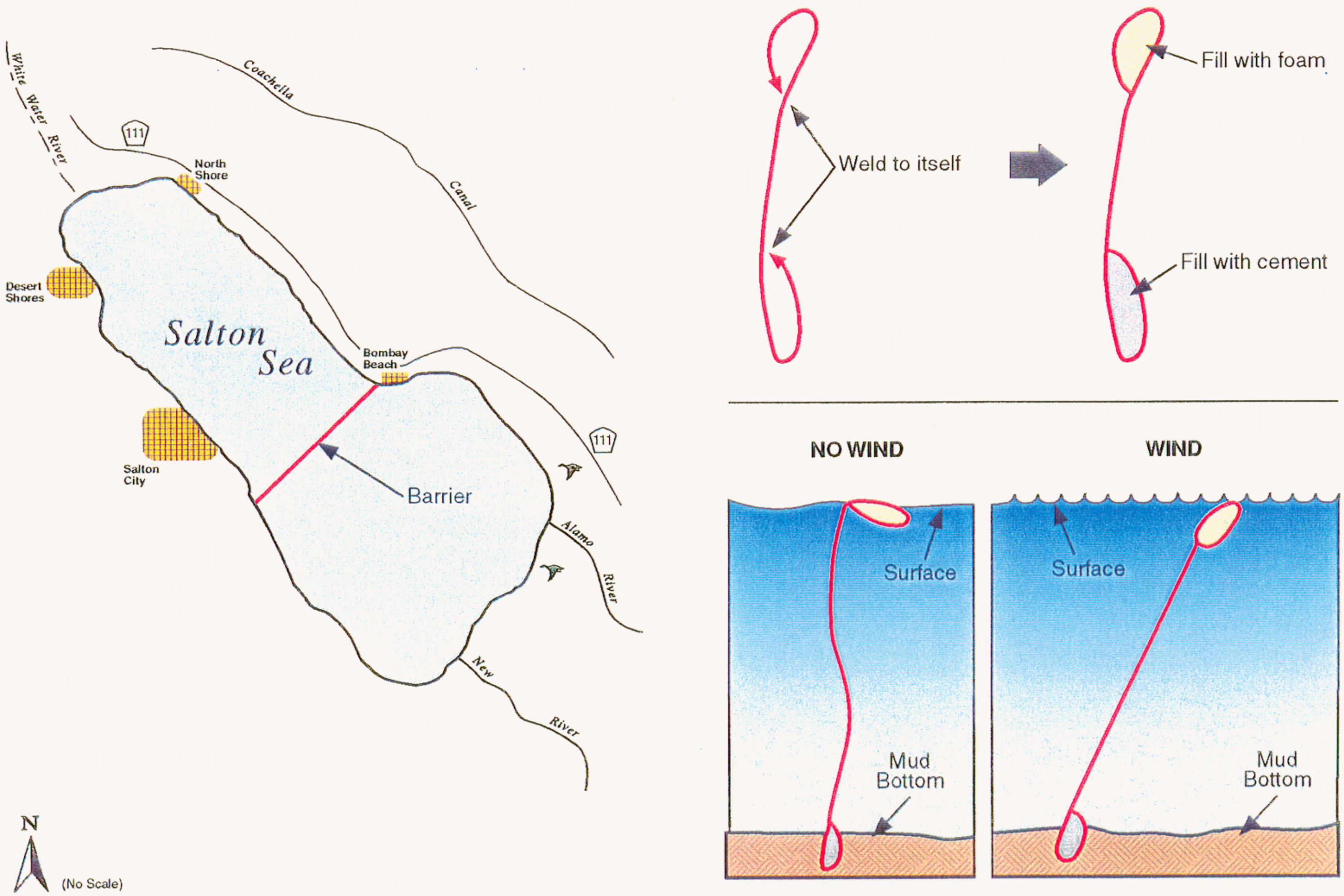
Diked Impoundment

Diked Impoundment - One Half of the Sea

(use polyethylene curtain to divide Sea in half)



Alternative No. 13

Illustration No. 13

There were several attractive features in this proposal. The membrane would be corrosion-resistant and, because of its low profile, would be aesthetically pleasing. The placement method would generate little disturbance to the environment compared to a diking operation with the attendant borrow sites and transport requirements.

There would be, however, major concerns. Although the materials would be available for all the required components and the concept has been tried on a much smaller scale, there is no known precedent for an application of this nature and size. The system would be inaccessible for observation and maintenance except by boat. The system would not provide any freeboard or flexibility to add freeboard at a later date should the level of the Sea rise above it. A freestanding impermeable membrane containment system would provide little protection against damage by boat traffic and/or vandalism. Certain areas, such as the connection between the floats and membrane or Sea floor and membrane, would be subjected to tension and flexing and, as a result, would be especially vulnerable. With no existing application, large-scale research and pilot-scale studies would be required before any field-scale construction. The system would provide limited control over inflow. Geomembrane material typically has a 20-year guarantee on effective life span. Even with a 20-year lifespan, the life cycle costs for membrane replacement would be expected to be much higher than the original earthen dike proposal. It is possible that complete reconstruction would be required in only 10 years.

REASON FOR ELIMINATION

This proposal would require further research before it could be determined to be a feasible option. This alternative did not utilize proven technology and, therefore, did not warrant further consideration. Should additional information become available which satisfies the elimination criteria, further consideration would be given to this alternative to determine its feasibility.

Alternative 14 — **Diked Impoundment**
Various Sized Impoundments Within the Sea
(Plastic Curtains)

HISTORY

This application of the use of plastic material to separate portions of the Sea was proposed by Mr. Gerald Martin (February 1992, revised April 1992 and August 1995) of National Travelers, 1181 East Echo Drive, San Bernardino, California 92404, (909) 883-8780. It was further examined in the Reclamation and TAC report, *A Value Engineering Evaluation of Salton Sea Alternative Dike Structures* (August 1995).

PROPOSAL DESCRIPTION

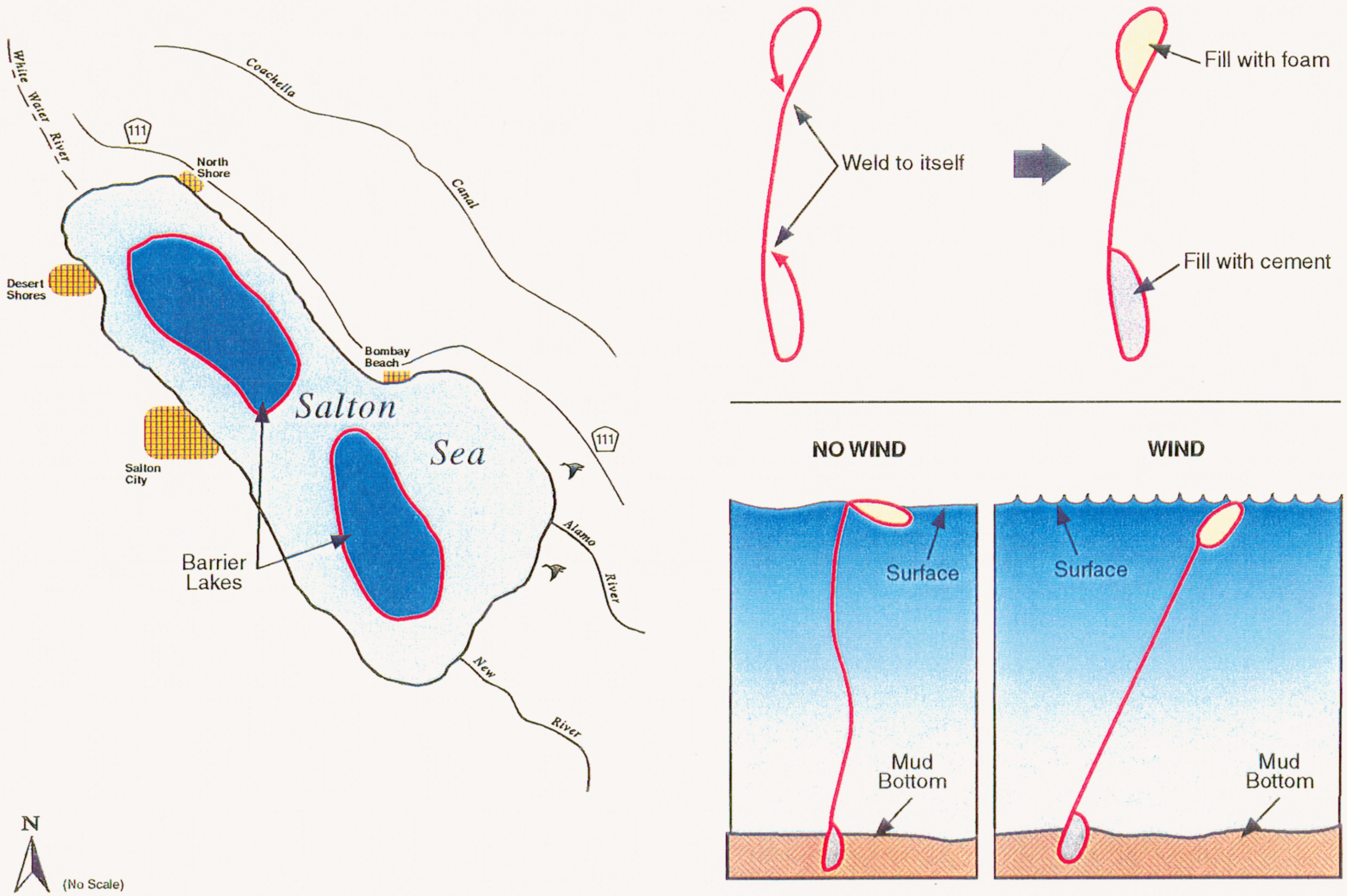
This proposal used a high-density polyethylene dam or curtain to create isolated areas within the Sea which would serve as evaporation ponds (see Illustration 14). The barriers would be placed to protrude 6 to 12 inches above the water surface to discourage water splashing over the top as a result of wave action. The polyethylene material would be weighted on the bottom by a cement-filled tube, which would make them 95 percent water-tight. There would be several one-way gates to permit water to flow from the Sea into the enclosed lakes.

The construction of a circular barrier-curtain to form an enclosure, lake, or pond would be accomplished in the following manner:

1. The polyethylene would be welded together to form a continuous barrier. In addition, there would be a welded tube both at the top and at the bottom of the barrier. The tube at the top, which would act as a float, would be filled with light material, such as urethane, Styrofoam, or air. (High-density polyethylene already has a density of 0.98, which means it would barely float on its own.) A 6- to 12-inch splash guard made from the same material as the barriers would reduce the exchange of water coming over the top. This system would not be intended to be water-tight but, rather, would be to reduce the exchange of water.

2. Almost all of the welding would be done on shore, including insertion of the urethane or Styrofoam in the top tube and the welding of the bottom tube. As the welding was being completed, the barrier would be floated out into the Sea. As each portion was floated into place, the bottom tube would be filled with cement, which would hold the curtain in place and would not allow it to move even if there were a violent storm. This last process would be done with a cement pump mounted on a barge.

Diked Impoundment
Construction of lake(s) within the Sea
(use polyethylene curtains)



Alternative No. 14

Illustration No. 14

3. As the curtain was placed into the Sea and the lower tube was filled with cement, there would be an equal amount of curtain that had not been filled with cement trailing back to shore. This would mean that when the first half of the curtain had been placed into the Sea and filled with cement, the welding on the second half would have been completed.

4. A one-way flapper valve or gate would be installed in the barrier so that water might enter the lake area through the gate but could not flow back into the Sea.

5. Economically, it would be better to install the evaporation ponds in the shallower parts of the Sea, but this would be near the shore and might not be desirable from the users' point of view. The evaporation ponds could be placed in the center of the Sea in the deeper parts, but this would require more material and more welding.

EVALUATION OF ALTERNATIVE

This alternative was very similar to the alternative that proposed dividing the Sea in half using the same means (Alternative 13). The difference would be in the placement of the enclosed areas. As stated in the other plastic liner alternative, the use of the material in this manner was not consistent with normal application and, therefore, further investigation was not warranted. For further information, please refer to the preceding alternative.

REASON FOR ELIMINATION

This proposal would require further research before it could be determined to be a feasible option. This alternative did not utilize proven technology and, therefore, did not warrant further consideration. Should additional information become available which satisfies the elimination criteria, further consideration would be given to this alternative to determine its feasibility.

Alternative 15 — **Pump-out Canal/Dam System to Base of Chocolate Mountains**

HISTORY

This proposal was received by the TAC from Mr. Seth Arnold, North Shore, California, in response to a public workshop held on August 31, 1995.

PROPOSAL DESCRIPTION

Very little detail was provided with this proposal. The proposal used the concept of constructing a canal/dam system, with gates, to transport Sea water to the base of the Chocolate Mountains in order to provide an outlet for the Sea (see Illustration 15). No further explanation of this proposal was available.

EVALUATION OF ALTERNATIVE

Because of the lack of information provided, it was difficult to understand how the proposal would work. Discharging Sea water at the base of the Chocolate Mountain range without construction of an evaporation reservoir would not provide salinity benefits to the Sea because the base of the Chocolate Mountains slopes toward the Sea, and pumped water would drain immediately back to the Sea. Some salts could be left behind initially through evaporation, but these would be picked up by subsequent flows or rainfall.

REASON FOR ELIMINATION

This alternative did not satisfy the elimination criteria of reducing salinity to the targeted level or controlling elevation. Because of this, no further consideration of this alternative was warranted.

Pump Out
Canal/Dam System that transports Sea Water to the Base of Chocolate Mountains

Alternative No. 15
Illustration No. 15

Alternative 16 **Pump-out Diked Impoundment to Gulf of California**

HISTORY

This project was first proposed by Mr. Horace McCracken, McCracken Solar Company, in a letter dated February 4, 1986, and a formal proposal paper written January 26, 1994. The concept was again proposed in 1995 by Mr. McCracken, then of Sunwater Solar, Inc., in response to workshops, received September 25, 1995.

PROPOSAL DESCRIPTION

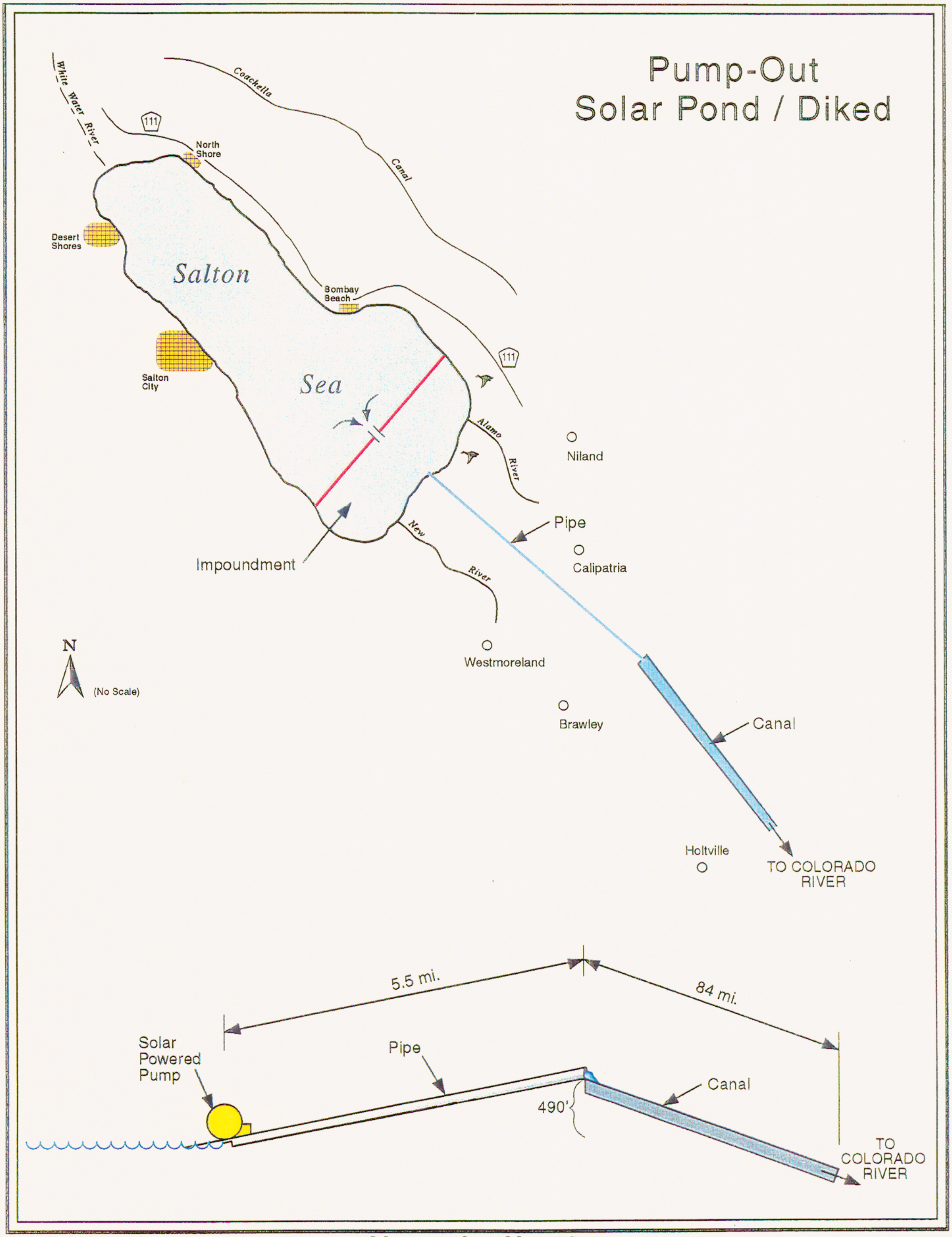
This proposal used a diked impoundment of about 40 mi^2 along the southern shore of the Sea to concentrate Sea water by evaporation before it would be pumped to a height sufficient to allow it to flow by gravity to the Gulf of California (see Illustration 16). A unique feature of this proposal was that discarded tires would be used in the construction of the dike.

Sea water would enter the impoundment area from the west; water concentrated by evaporation would be pumped out of the east end of the impoundment area by solar power and would travel 5.5 miles through a pipeline to an elevation about 260 feet above msl; from there, the water would flow by gravity in a canal 84 miles long to the Colorado River below San Luis. About 60,000 AF of water per year would be evaporated from the impoundment; 30,000 AF per year of concentrated brine would be pumped out.

EVALUATION OF ALTERNATIVE

A 40-mi^2 impoundment would evaporate 145,000 AF per year. The discrepancy between the proposal and this figure was not addressed in the proposal. This option highlighted the use of discarded vehicle tires as armoring for earthen dikes. This feature would have very little impact on the cost of construction because the largest percentage of construction cost would be for items other than armoring. Because synthetic rubber has a specific gravity of 1.20 to 1.30, the tires will not float, but the protection they would offer against wave action is minimal unless they were to be lashed together and tied to the surface of the dikes on both sides. By comparison, the specific gravity of water is 1.0, and rock riprap has a specific gravity of 2.65. The reason that riprap is placed on dikes and shorelines is to stabilize the shoreline material. The tires would offer some protection, but solar radiation would eventually break down the rubber base structures, and the tires could then become a biological hazard (steel cords and wire bead).

The operation of this alternative was uncertain. The proposal included a 40-mi^2 impoundment in the south end of the Sea. An impoundment of this size would evaporate about 145,000 AF of water per year. The proposal indicated an evaporation rate of 60,000 AF per year and pumping



Alternative No. 16
Illustration No. 16

30,000 AF of concentrated water per year. Either the proponent anticipated that the evaporation impoundment would not be full or that there would be some other operational provisions that were not obvious. If only 90,000 AF were allowed into the evaporation pond, not only would the impoundment be partially empty, but the water surface of the rest of the Sea would continue to rise.

The use of solar insolation to create electrical energy is still in the developmental stages. While fuel costs might be low, operation and maintenance costs could be high, depending upon the type of solar plant used. Unless heat or electrical storage were provided, pumping would stop in the evening when the sun no longer provided enough heat to drive the pumps.

No explanation was given on how the Alamo and New Rivers and other drainage at the south end of the Sea would be passed around the evaporation pond. These sources form the primary freshwater inflow to the Sea and, for the alternative to work properly, the inflows would have to be transported to the north end of the Sea where the target salinity and elevation would be maintained. The location of the pump-out brine entering the Colorado River was not discussed with respect to downstream water use or possible environmental impacts.

OME&R COSTS

Pumping 30,000 AF of water up 540 vertical feet and using gravity flow to an open canal to San Luis would incorporate a pumping plant (maybe two pumping plants), pipeline (5.5 miles of pipeline), and an open canal to San Luis.

An assumption of 30,000 AF of water per year at 490 feet of head, with 50 feet of friction loss, over the mountains to the Gulf of California was made using 0.0846 kW to lift 1 ft^3/s by 1 foot. This was calculated as follows:

0.0846 kW/ft^3/s/ft lift (41.25 ft^3/s) (540 feet) = 1,885 kW of pumping capacity.

Due to the solar intensity in the Sea area being greatest only 7 hours per day and overcast skies accounting for 75 days per year, the total demand was calculated as follows:

(7/24 hrs per day) (290/365 days per yr) = 2,044 hrs/yr.

Due to the fact that power could not be generated during the night (only 7 hours per day), the pumping capacity would have to be increased to take care of pumping within the 7-hour window on each clear day with pumping efficiencies at 70 percent. This was converted as follows:

(24 hrs/day) (365 days) / 2,044 hrs/yr = 4.29 times the pumping capacity.

The pumping capacity was then multiplied to meet the annual pumping requirement, 4.29 * 1,885 kW capacity = 8,090 kW of pumping capacity for 30,000 AF per year.

Corrections for efficiency of the pumps were made as follows:

8,090 kW / 0.70 = 11,560 kW.

Using 10,470 kW of capacity and Mr. McCracken's estimate of $7.50 per watt for photovoltaic cells, total solar array panels were calculated to cost as follows (with pumping efficiency):

11,560,000 (converted to watts) * $7.50 = $86,700,000 every 20 years; and
$26,000,000 every 5 years.

This price did not include design costs, land, support structures, batteries, an inverter, wiring, and pumps. PV Power estimated this to nearly triple the cost shown above. Each site would be unique, and the scale of the Project could drive the costs due to pumping efficiency.

Using a 20-year life cycle for the photovoltaic cells, the $87 million replacement cost spread over the period, at 5 percent interest, would amount to $7.0 million per year.

With a 5-year life cycle for the batteries, and a cost of $26 million ($2.50 per watt at 5 percent interest), the annual cost for battery replacement would be $6.0 million per year.

Replacement costs for the pumps would total $888,000 ($245 per HP for 3,625 HP). This cost, spread over the 10-year life of the pump at 5 percent interest, would be $115,000 per year.

Indexing O&M costs from the 1974 report for the pumping plant would be as follows:
$9.04 per HP * 207/65 * 3,625 HP = $104,000 per year.

O&M costs for maintaining the dike for this proposal were not provided. For purposes of this analysis, it was assumed that maintenance costs would be approximately equal to other diking alternatives. O&M costs for the dike were $38,000 per mile, or, for a dike system 25 miles long, $950,000 per year. Total OME&R costs for this alternative were estimated to be $14.2 million per year.

CONSTRUCTION COSTS

With the exception of the cost of the photovoltaic cells and batteries, no specific construction costs were calculated. However, based on a general knowledge of the cost of similar features, a total capital cost of $300 million would seem reasonable. Since the fluid being pumped would be a concentrated brine, special precautions would have to be taken to protect pump impellers, pipes, valves, and other conveyance features. Use of noncorrosive materials or special coatings would add to the cost of this proposal.

REASON FOR ELIMINATION

This proposal exceeded the $10 million annual limitation for OME&R costs. This alternative did not warrant further consideration.

Alternative 17 **Pump-out Frontier Aquadyne Enhanced Evaporation**

HISTORY

This alternative was proposed by Frontier Aquadyne, Inc., 576 B Street, Santa Rosa, California 95401, (707) 579-7999, in *Application of Advanced Evaporation Technology to Wastewater Reduction and Aquifer Remediation Requirements at U.S. Military Installations* (undated).

PROPOSAL DESCRIPTION

This proposal, as presented by Frontier Aquadyne, consisted of pumping water out of the Sea and delivering it to a low-temperature, self-cleaning wastewater system developed by that company for the evaporation and concentration of wastewater with high mineral and solids content. The system would use precision control of temperature and air flows to induce evaporation in midair at low temperatures (see Illustration 17). As a result, the units could be fired by low-grade or waste heat sources and would be non-scaling, which would reportedly translate into dramatically lower operating costs in comparison with conventional technologies. This proposal would use this technology to remove salt from the Sea by desalination.

EVALUATION OF ALTERNATIVE

Frontier Aquadyne's proposal and supporting documentation focused on a pilot and demonstration plant. The costs presented in the Frontier proposal were based on these demonstration projects. It was difficult to extrapolate costs for a demonstration project to a full-scale, on-line desalination plant because operating parameters were unknown, and many performance specifications were not available. Based on figures provided by Frontier, extrapolated cost figures seemed realistic.

If the interpretation of the data on the portable units was accurate, it would take approximately 10,000 units to evaporate 200,000 AF of Sea water. There was some doubt that the technology would be adequate to evaporate these quantities of water. There was no information on the prototype capabilities compared to the specifications on the Cascade 9 series.

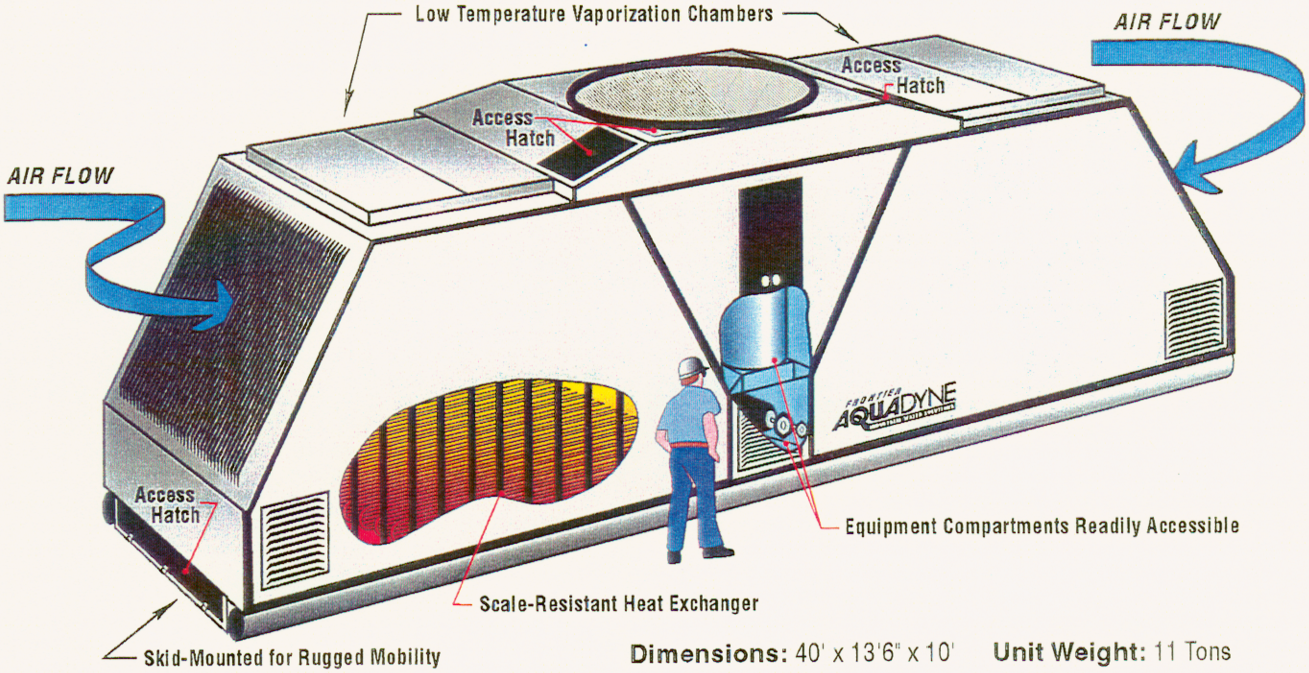
OME&R COSTS

OME&R cost estimates were extrapolated from pilot plant estimates provided by Frontier. Since the annual pilot plant OME&R costs were listed as $250,000 for treatment of 20 AF, treatment of 200,000 AF per year, using the pilot plant figures, would require an annual OME&R budget of $2.5 billion. While there could be economies of scale for larger units, costs would not meet the $10 million per year ceiling used as an elimination criterion.

Cascade 9 Series

Models: M-200 and M-400 (6-12+ GPM/200-400+ bbl/day)

Waste-Water Disposal Units



Dimensions: 40' x 13'6" x 10' **Unit Weight:** 11 Tons

Using vaporization, the **FRONTIER AQUADYNE *Cascade* 9 Water Concentrator** will reduce industrial and contaminated waste-water to a **disposable** concentrated brine or solid.

The ***Cascade* 9** M-200 and M-400 units are fully **modular** and **portable.**

The ***Cascade* 9** series will process 6-12+ GPM /200-400+ bbl/day.

Units will operate using low grade **waste heat** or can be fired directly.

Individualized units can be designed and installed to meet specific engineering projects and industrial applications.

FRONTIER
AQUADYNE
INDUSTRIAL WATER SOLUTIONS

FOR MORE INFORMATION CONTACT
FRONTIER AQUADYNE, Inc.
576B Street
Santa Rosa, CA 95401
Phone: 707/579-7999
FAX: 707/579-8087

Alternative No. 17

Illustration No. 17

CONSTRUCTION COSTS

Based on Frontier's estimates to concentrate 200,000 AF of water per year (each unit could concentrate 20 AF per year), the Project would require 10,000 units. Total capital expenditure would be an estimated $15 billion.

REASON FOR ELIMINATION

This proposal would require further research before it could be determined to be a feasible option. It would also significantly exceed the $10 million annual cost limitation for OME&R costs. Therefore, this alternative did not warrant further consideration.

Alternative 18 **Pump-out**
Environment Enhancing Technologies, Inc.
Solar Still Desalting/Colorado River Water Replenishment

HISTORY

This technology was proposed to be applied to the Sea by Environment Enhancing Technologies, Inc., 6011 Southeast 72nd, Portland, Oregon 97206, in *Proposal for Salton Sea Project* (1990).

PROPOSAL DESCRIPTION

The Environment Enhancing Technologies, Inc., proposal called for the following measures:

(1) Controlled withdrawals of water from the Sea;
(2) Use of an enhanced solar still (see Illustration 18) constructed on-site to desalt Sea water;
(3) The sale of desalinated water and its by-product (salt);
(4) The return of processed water to the Sea; and
(5) Additional replenishment with freshwater from the Colorado River.

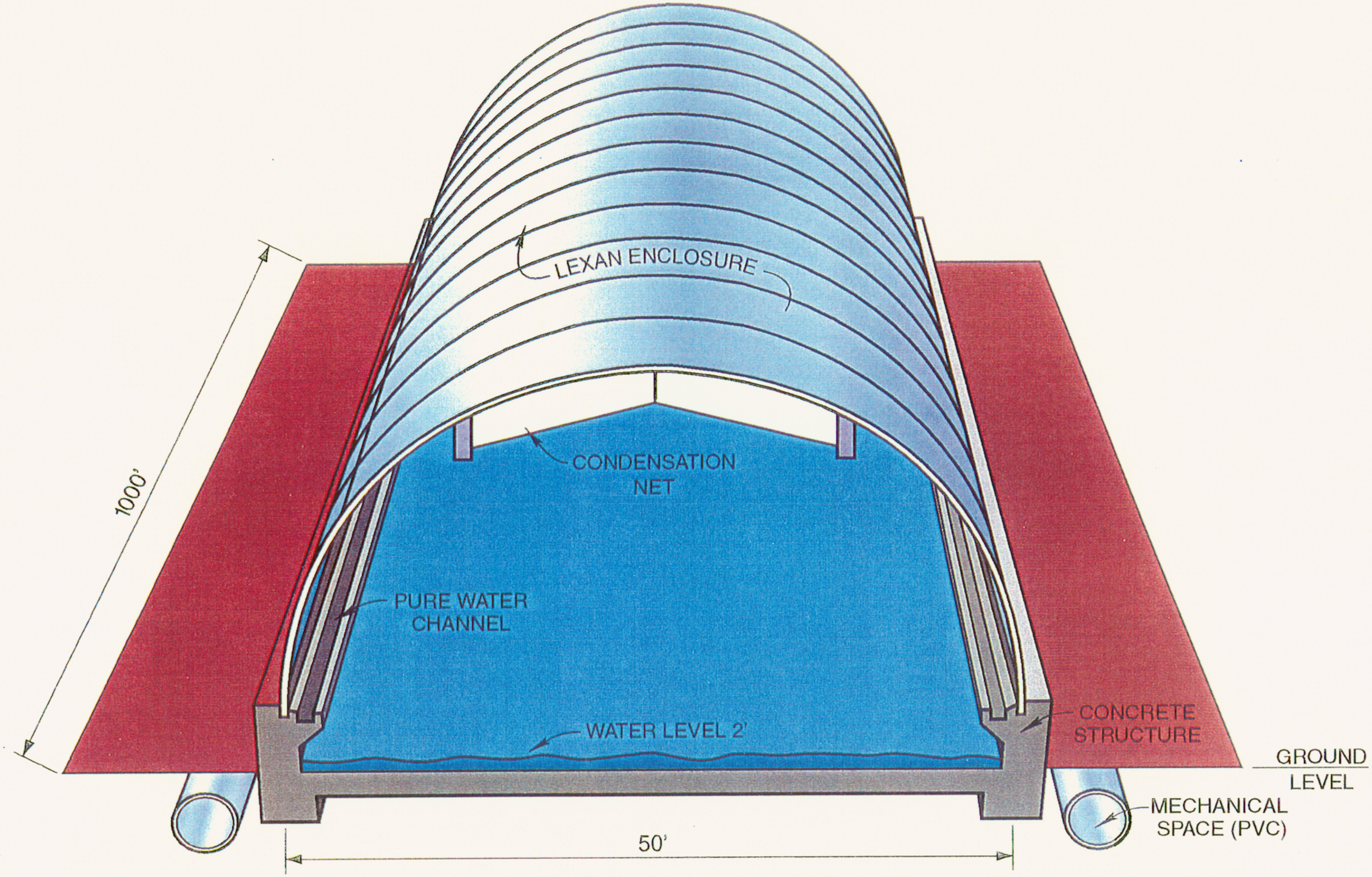
EVALUATION OF ALTERNATIVE

There was no information available that supported the Environment Enhancing Technologies' reported solar still productivity of 1 gallon of freshwater per square foot of solar still area per day (gal/ft^2/day). An evaporation system would be required to concentrate brine for solar ponds and disposal. Costs to distill water typically would be very high.

The economic viability of marketing salt would be problematic. Information obtained from the Western Salt Company in Chula Vista, California, indicated that the market for salt is such that the value of salt should not be considered in the economic evaluation of project. In addition, the quality of salt at the Sea is poor (Interoffice memorandum from Mr. Rich Thiery to Mr. Owen McCook and Mr. Robert Robinson, Coachella Valley Water District, September 28, 1994).

Replenishment of water from the Colorado River would require an additional River allocation. Given the current demands existing on the Colorado River, replenishment water from that source would be highly unlikely.

Significant additional research would be needed to evaluate this alternative in terms of life cycle costs and efficiency of salt removal.



DESALINATION CHAMBER

Alternative No. 18

Illustration No. 18

REASON FOR ELIMINATION

Because of the use of enhanced solar still desalting, this proposal would require further research before it could be determined to be a feasible option. This alternative did not utilize proven technology and, therefore, did not warrant further consideration.

Alternative 19 — **Pump-out**
SNAP Technology Enhanced Evaporation Tower

HISTORY

This proposal was submitted by Professor Dan Zaslavsky of Technion, Israel Institute of Technology, *SNAP Technology - A Source of Low Cost Electric Power and Desalinated Water* (November 1992).

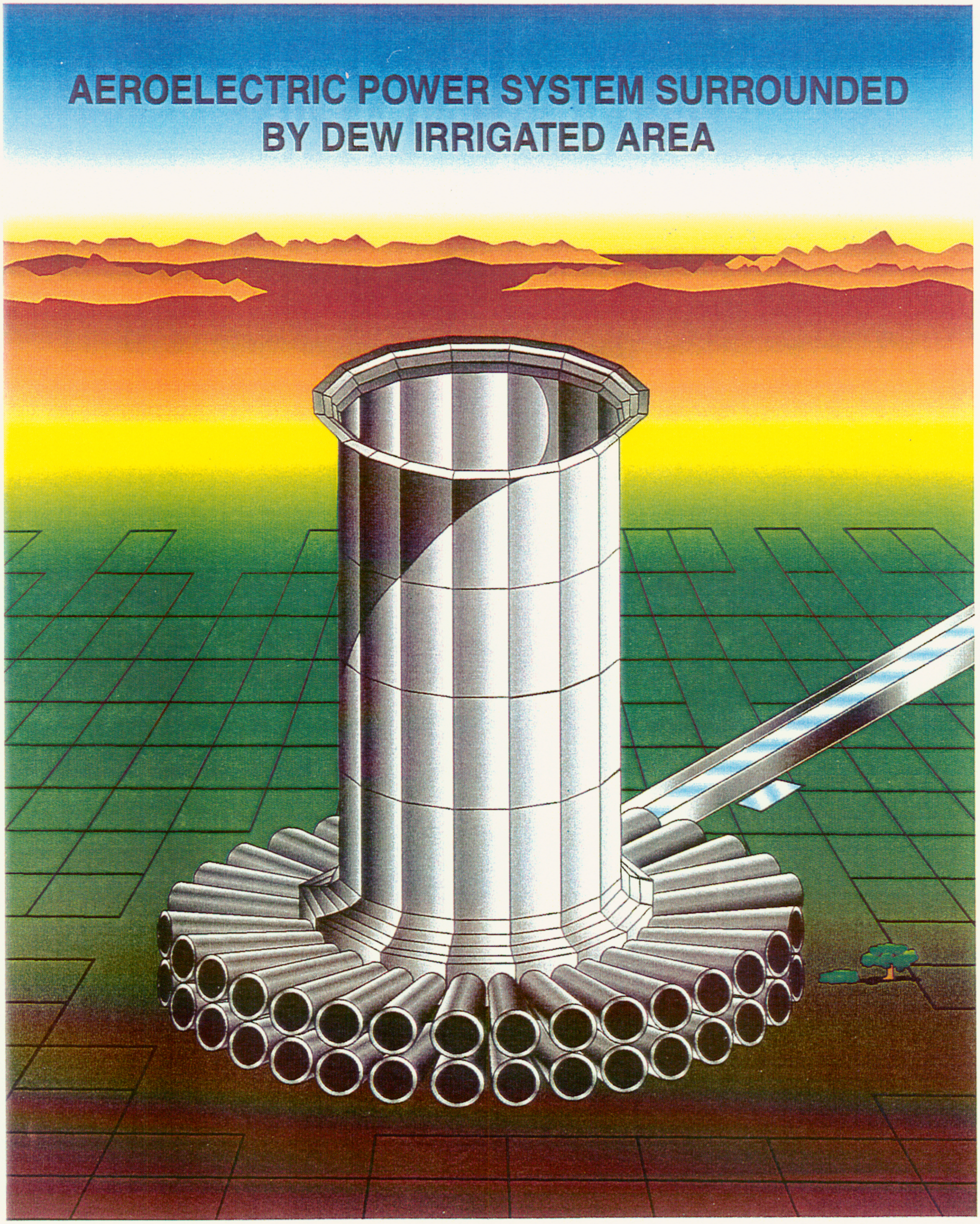
PROPOSAL DESCRIPTION

This proposal used a large tower structure to produce electricity and desalt water from the Sea. A tower 3,300 feet high and 1,500 feet in diameter would be built. During the SNAP process, Sea water would be raised to the top of the tower where it would be atomized or sprayed over the entire area of the flue opening (see Illustration 19). Evaporation and humidification would make the dry air at the top of the tower cooler and denser than the outside air. As it cooled, the air would flow down the tower and out through openings in the bottom. On its way out the bottom of the tower, the air would pass through wind turbines which would drive electric generators. About 400,000 AF of Sea water would be pumped to the height of the tower every year, generating about 80,000 AF of distilled water. About 160,000 AF of concentrated salt water created during the process would need to be conveyed to the Colorado River. The remaining 160,000 AF of water would evaporate within the tower. The proposal anticipated that over 4 billion kilowatt hours (kWh) of electricity would be produced per year.

EVALUATION OF ALTERNATIVE

The cost of electricity generated by this proposal was reported to be as low as 2 cents per kWh; however, these costs are conjectural since the process has not been actually tested. Obvious structural, environmental, safety, and aesthetic problems associated with the physical dimensions of the tower contemplated would have to be addressed.

The idea of using the proposed thermodynamic process to generate electricity and freshwater is innovative and theoretically plausible, but enough doubt remained about the feasibility of this option that extensive research would be necessary before performance of this alternative could be proved.



Alternative No. 19
Illustration No. 19

REASON FOR ELIMINATION

This proposal would require further research before it could be determined to be a feasible option. For this reason, this alternative did not warrant further consideration. Should additional information become available which satisfies the elimination criteria, further consideration would be given to this alternative to determine its feasibility.

Alternative 20	Pump-out Aquaculture/Evaporation Ponds

HISTORY

This alternative was proposed by Dov Grajcer, Ph.D., and Ms. Becky Broughton, Aquafarms International, in a *Concept Strategy Commercializing Control of Salinity in the Salton Sea - Salton Sea Aquaculture Facilities* (1994).

PROPOSAL DESCRIPTION

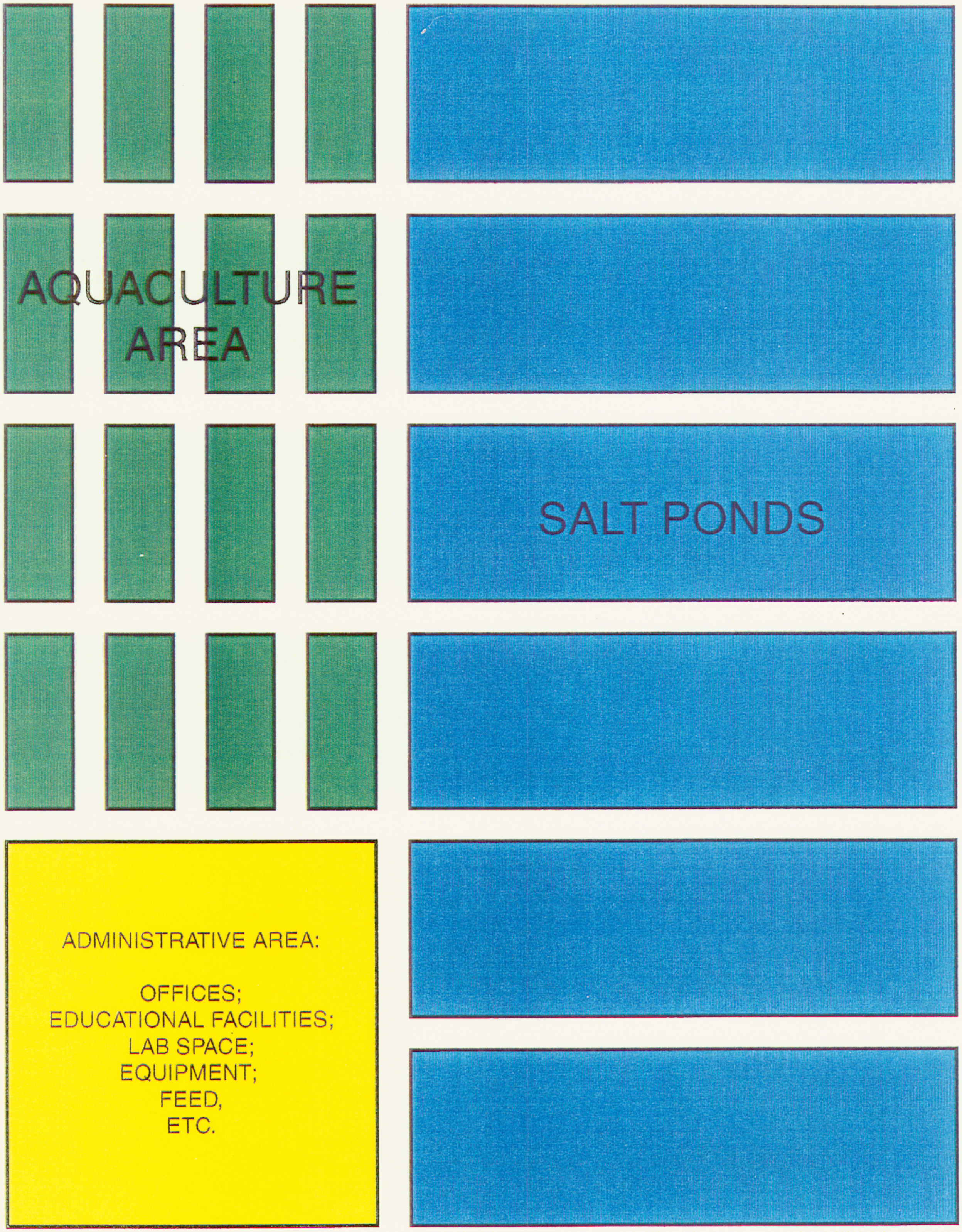
This proposal used saltwater aquaculture facilities to raise fish in ponds created with water pumped from the Sea. Water from the fish rearing ponds would be disposed by transferring it into evaporation ponds (see Illustration 20). Initially, a benchmark facility consisting of one 200-acre fish pond, one 400-acre evaporation pond, and 40 acres of support structure would be built to raise tilapia, a fish commonly produced in the area. The final stage of the plan called for 70 or more saltwater aquaculture facilities of similar composition and size, each utilizing 2,000 to 4,000 AF of Sea water per year.

EVALUATION OF ALTERNATIVE

About 45,000 acres of land (70 by 640 acres) would be needed for the fish ponds, evaporation ponds, and associated structures. There was no mention of how 150,000 AF of water would be transported to the fish farms. In addition, the proposal did not include evaporation from the fish ponds in calculating the overall water usage for the system. Each of the 70 facilities, with a 200-acre fish pond and a 400-acre drying pond, would evaporate 3,420 AF per year (evaporation rate of 5.7 AF per year). For all 70 facilities, this would total nearly 240,000 AF per year. For further evaluation purposes, it was assumed that the evaporation ponds would be sized at 200 acres each so that the entire system would evaporate about 150,000 AF per year, as noted in the proposal.

Evaporation would eventually result in large quantities of salt accumulation. Salt was proposed to be trucked out and disposed of in the Pacific Ocean. This raised a logistics issue. If 150,000 AF of Sea water per year containing 60 tons of salt per acre-foot eventually would need to be disposed by trucking to the ocean, provisions would have to be made to truck 9 million tons per year. To put this in perspective, if a trailer could haul 80,000 pounds or 40 tons of salt, 225,000 truck trips would be required every year, or 617 truck trips every day, 365 days a year.

CONCEPT SALTON SEA FISH FARM



Alternative No. 20
Illustration No. 20

OME&R COSTS

Assuming the fish ponds were 100 feet above the elevation of the Sea with a friction loss of 35 feet for 5 miles of pipeline, total energy costs for pumping 150,000 AF per year would be as follows:

206 ft^3/s = 150,000 AF/yr = 92,600 gal/min

92,600 gal/min * 135 ft/3,960 * 0.70 = 4,510 HP

4,510 HP * 0.746 kW/HP = 3,364 kW

3,364 kW * 24 hrs * 365 days * $0.07 = $2.1 million per year.

Replacement costs for the pump system were calculated as follows:

$245/HP * 4,510 HP = $1.1 million

Calculated annually over 10 years at 5 percent interest = $142,000 per year.

Assuming a 10-year life for the lining under both the fish ponds and the drying ponds, replacement costs would total about $196 million every 10 years, calculated as follows: (400 acres per facility * 70 facilities * $7,000 per acre for placement of liner). When spread over 10 years, the costs for replacing the liner system for 70 facilities would be nearly $20 million per year.

To be consistent with other alternatives, the cost of disposal of the salt brine was not included in OME&R costs. It was assumed that salt from this alternative would be handled in a similar nature as salt from the other alternatives.

Total OME&R costs for this alternative were calculated to be $22.2 million.

CONSTRUCTION COSTS

Construction costs were not calculated since annual OME&R costs would exceed the $10 million limit.

REASON FOR ELIMINATION

This proposal would exceed the $10 million annual limit for OME&R costs. For this reason, the proposal did not warrant further consideration.

Alternative 21 — **Pump-out to Laguna Salada/Gulf of California (Pump-out Only)**

HISTORY

The first formal proposal of this alternative was in the Aerospace Corporation, *Salinity Control Study Salton Sea Project*, Report No. ATR-71(S990)-5 (1971). It was also discussed in the Reclamation and RAC report, *Salton Sea Project, California, Federal-State Feasibility Report* (1974) and by Reclamation in *Controlling the Salinity of the Salton Sea by Transferring Water to the Gulf of California* (October 1991). The latest examination of this pump-out concept was performed by IID in the *Imperial Irrigation District Concept Paper on Salton Sea Pumping Proposal* (1994).

PROPOSAL DESCRIPTION

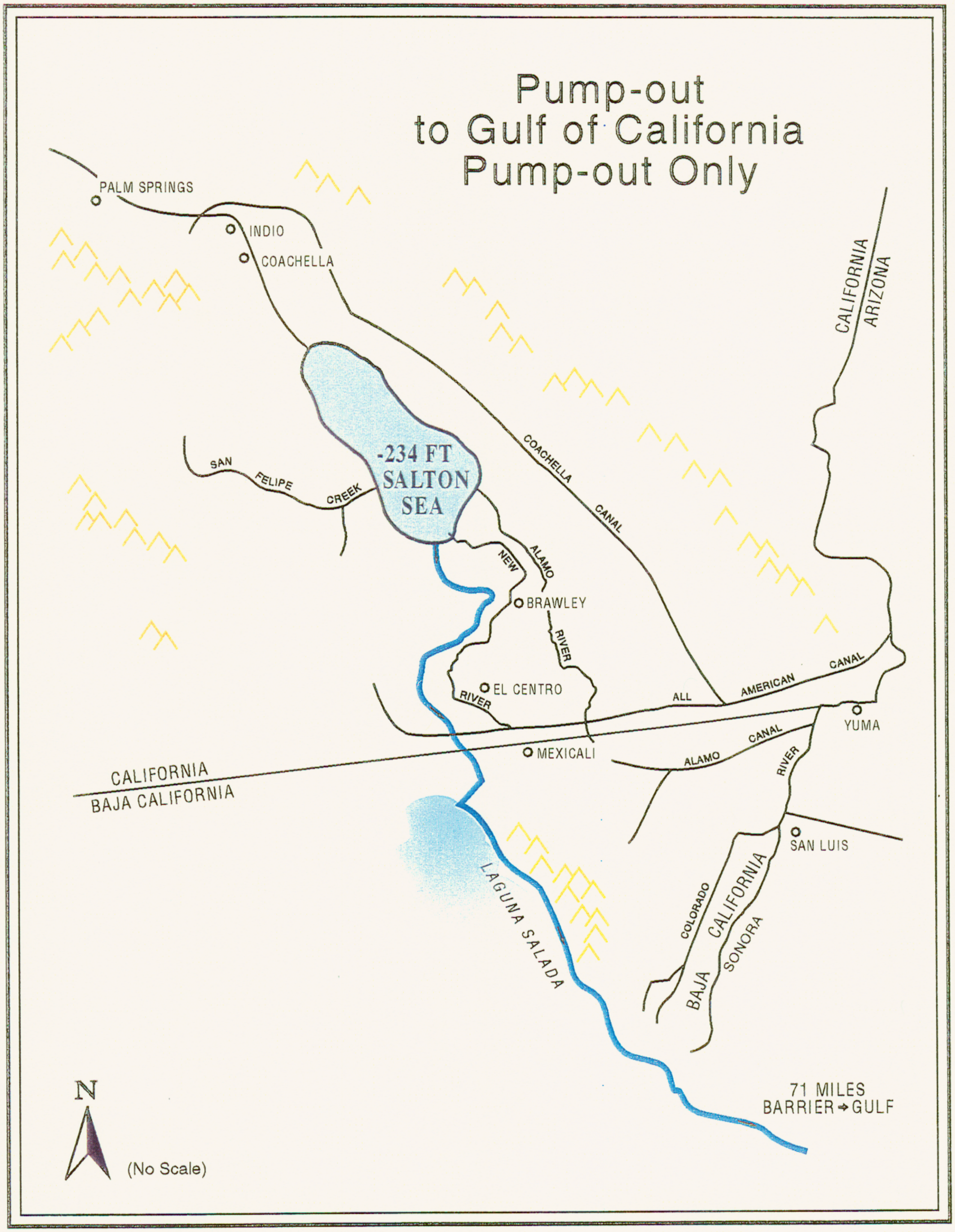
This alternative would transport anywhere from 100,000 to 400,000 AF of Sea water per year to the Laguna Salada or the Gulf of California (see Illustration 21), with the higher volumes resulting in reaching the target salinity level more quickly. An alignment of the pipeline/canal was assumed for the purposes of cost calculations, but this alignment would be subject to change during more detailed studies. Canals would be used when transporting water on a down-gradient, and pipelines would be used when pumping water uphill or for outfalls.

The Reclamation report (1991) provided an assumed alignment and specific design features of the conveyance facilities. The IID analysis (1994) assumed the same alignment but added an extension canal through the Laguna Salada to the Gulf. Either a pipeline only and the required pumping plants or a combination of pipeline and open canal could be used to transport water. In general, the pipeline/canal combination would be cheaper.

EVALUATION OF ALTERNATIVE

This proposal would provide a direct artificial outlet from the Sea to the Laguna Salada and, perhaps, eventually to the Gulf. Proven technology would be used for conveyance. Some farm land would likely be impacted along the conveyance alignment. The cooperation of Mexico would be required for project construction and operation.

The rate of salinity decline in the Sea would be dependent upon the volume pumped and the final stabilized salinity level. A higher rate of pumping would quickly reduce salinity to target levels. However, continued pumping at that level would reduce salinity further. The operational plan, then, would probably include the higher level of pumping early in the operation of the project and no, or reduced, pumping in the later years. In 1994, IID estimated that an annual pumping



Alternative No. 21
Illustration No. 21

rate of 400,000 AF would reduce salinity to 40 ppt within 10 years, at which time pumping could stop altogether for over 30 years, and the salinity would still remain within target levels.

OME&R COSTS

Operational costs would consist of power for pumping and regulating flows in canals and pipelines. OME&R costs calculated for various pumping rates is provided in Table 15.

CONSTRUCTION COSTS

No construction costs were calculated for this proposal since OME&R costs exceeded the $10 million annual threshold.

REASON FOR ELIMINATION

As noted in the table of costs for pumping various volumes of water to the Gulf of California, 100,000 AF per year was the only pumping rate that met the OME&R cost criteria. However, it would take more than 100 years to reduce salinity to the target level of 35 ppt. Higher rates of pumping that would reduce salinity levels in an acceptable timeframe would have OME&R costs that exceed $10 million per year. Therefore, this alternative did not warrant further consideration.

Table 15
Alternative 21
100,000 AF to 400,000 AF to Gulf of California

Flow AF	Flow ft^3/s	Flow gal/min	Elevation head	Friction head	Total head	hp
100,000	137.33	61,733.33	500	40	540	12,02[illegible].97
200,000	274.67	123,466.67	500	40	540	24,051.95
300,000	412.00	185,200.00	500	40	540	36,077.92
400,000	549.33	246,933.33	500	40	540	48,103.90

kW	kWh/yr	Electric cost	Replace cost	Annual replace cost	Annual O&M	Total OME&R
8,971.38	78,589,259.22	5,501,248.15	2,946,363.64	294,636.36	346,348.05	6,142,232.56
17,942.75	157,178,518.44	11,002,496.29	5,892,727.27	589,272.73	692,696.10	12,284,465.12
26,914.13	235,767,777.66	16,503,744.44	8,839,090.91	883,909.09	1,039,044.16	18,426,697.68
35,885.51	314,357,036.88	22,004,992.58	11,785,454.55	1,178,545.45	1,385,392.21	24,568,930.24

hp = (gal/min * total head) / (3,960 * efficiency)
kW = hp * 0.746
kW/yr = kW * 24 hrs/day * 365 days/yr
Electric cost = kW/yr * $0.07/kWh
Replacement cost = $245 per hp
Annual O&M costs = $28.80 per hp

Alternative 22 | **Pump-out to Laguna Salada/Gulf of California (Pump-out and Replenish)**

HISTORY

This pump-out proposal was discussed in the Reclamation and the RAC report, *Salton Sea Project, California, Federal-State Reconnaissance Report* (October 1969). The concept was revised and new costs were estimated in the Reclamation report, *Controlling the Salinity of the Salton Sea by Transferring Water to the Gulf of California* (October 1991). IID also presented a pump-out/replenishment concept in its report, *Imperial Irrigation District Concept Paper on Salton Sea Pumping Proposals* (1994).

PROPOSAL DESCRIPTION

This proposal contemplated pumping water from the Sea to Laguna Salada in northern Mexico west of Mexicali (see Illustration 22) and providing replenishment water by pumping water from the Gulf of California to the Sea. Two-way pumping would allow water surface control in the Sea as well as salinity control. However, since ocean water is nearly as salty as Sea water, large volumes water would have to be moved between the Sea and the ocean in order to provide salinity benefits to the Sea. The proposal involved pumping 415,000 AF per year from the Sea to Laguna Salada and pumping 400,000 AF per year back to the Sea from the Gulf.

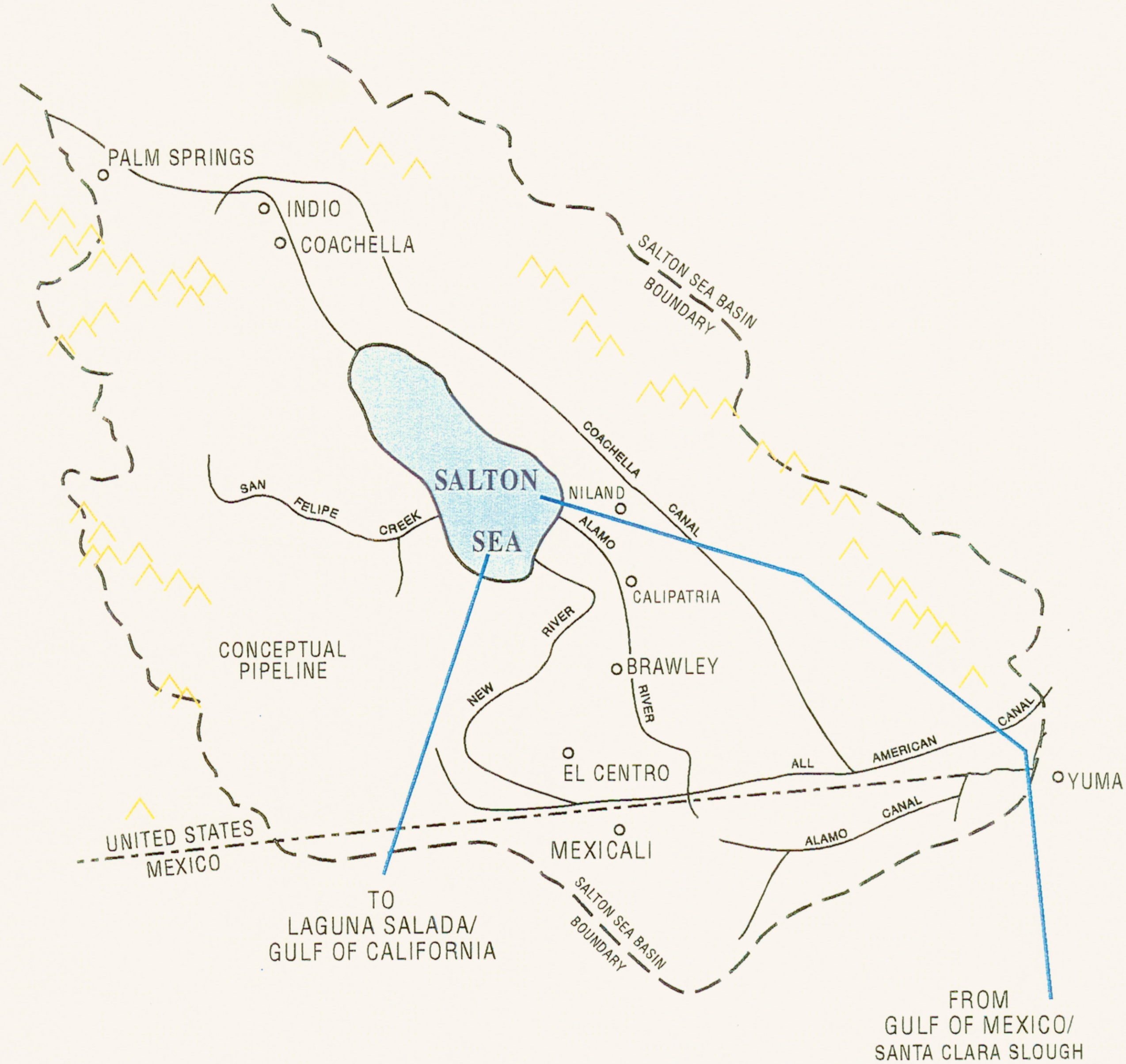
Multiple pumping plants, intake and outlet channels, and a combination of pipeline and canal were the main features of this proposal. Energy recovery would be considered when conditions were favorable.

EVALUATION OF ALTERNATIVE

Since alternatives that would provide a surrogate outlet to the Sea without replenishing the discharged water from some source would not provide elevation control, this alternative would include returning water to the Sea from the Gulf of California. The Gulf would provide an ample water source without the problems of water supply, water allocation, and water rights that limit the availability of water in the United States.

The use of water from the Gulf, however, would come with a cost. At a salt concentration of about 35 ppt, each acre-foot of water delivered to the Sea from the Gulf would contain about 47.6 tons of salt, and importation of 400,000 AF per year would mean bringing in 19 million tons of salt into the Sea every year. In order to provide salinity control, the salt load difference between water pumped out of the Sea and water delivered to the Sea for replenishment would have to be high enough to reduce Sea salt concentrations within a reasonable time. Under this

Pump-out Replenish



Alternative No. 22
Illustration No. 22

proposal, the salt load difference would be about 6 million tons per year, half of the salt load removed by simply pumping 200,000 AF of water per year out of the Sea or by diverting 200,000 AF per year into an evaporation impoundment. This means that, while salinity in the Sea could be reduced with this proposal, it would take much longer to achieve.

This proposal would require some operational sophistication since a balance would have to be maintained between salt concentration in the Sea and water surface elevation.

While the delivery of replenishment water from the Gulf to the Sea was considered here, another concept would involve delivery of replenishment water to the Sea from the Colorado River (IID, 1994). While this water source would be cheaper and the water quality much better, water rights and beneficial use considerations would be major impediments.

OME&R COSTS

A large portion of the operational costs would consist of power for lifting water over the divide between the Sea and Laguna Salada and between the Gulf and the Sea. OME&R costs were projected to be $12.6 million per year for pumping water one way (identified in *Salton Sea Management Project Evaluation of Salinity and Elevation Management Alternatives* by Ogden Environmental and Energy Services Co., Inc., June 1996). Pumping water in both directions using the same pumping plants and facilities or parallel plants and facilities would, of course, be much higher. By way of comparison, energy cost alone reported by Reclamation would amount to about $14 million (257,000,000 kWh/yr energy use minus 53,000,000 kWh/yr energy recovery [Reclamation, 1991] times $0.07/kWh).

CONSTRUCTION COSTS

Construction cost estimates, based on indexing from costs in the 1991 Reclamation report, would be in the range of $1 billion to $1.7 billion.

REASON FOR ELIMINATION

This proposal exceeded the $10 million annual limitation for OME&R costs. Therefore, the alternative did not warrant further consideration.

Alternative 23 — **Pump-out**
Pumped Storage Canal to Gulf of California
(Pump-out and Replenish)

HISTORY

This proposal was developed by Dangermond and Associates, Inc., for Riverside County and the Coachella Valley Water District. It was documented in the report, *Strategies for the Restoration and Enhancement of the Salton Sea* (July 1994).

PROPOSAL DESCRIPTION

This proposal was a variation of the two-way pumping between the Sea and Gulf of California concept. It combined two main concepts—a pumped-storage power generation facility and a large canal/pipeline linking the Sea with the Gulf of California.

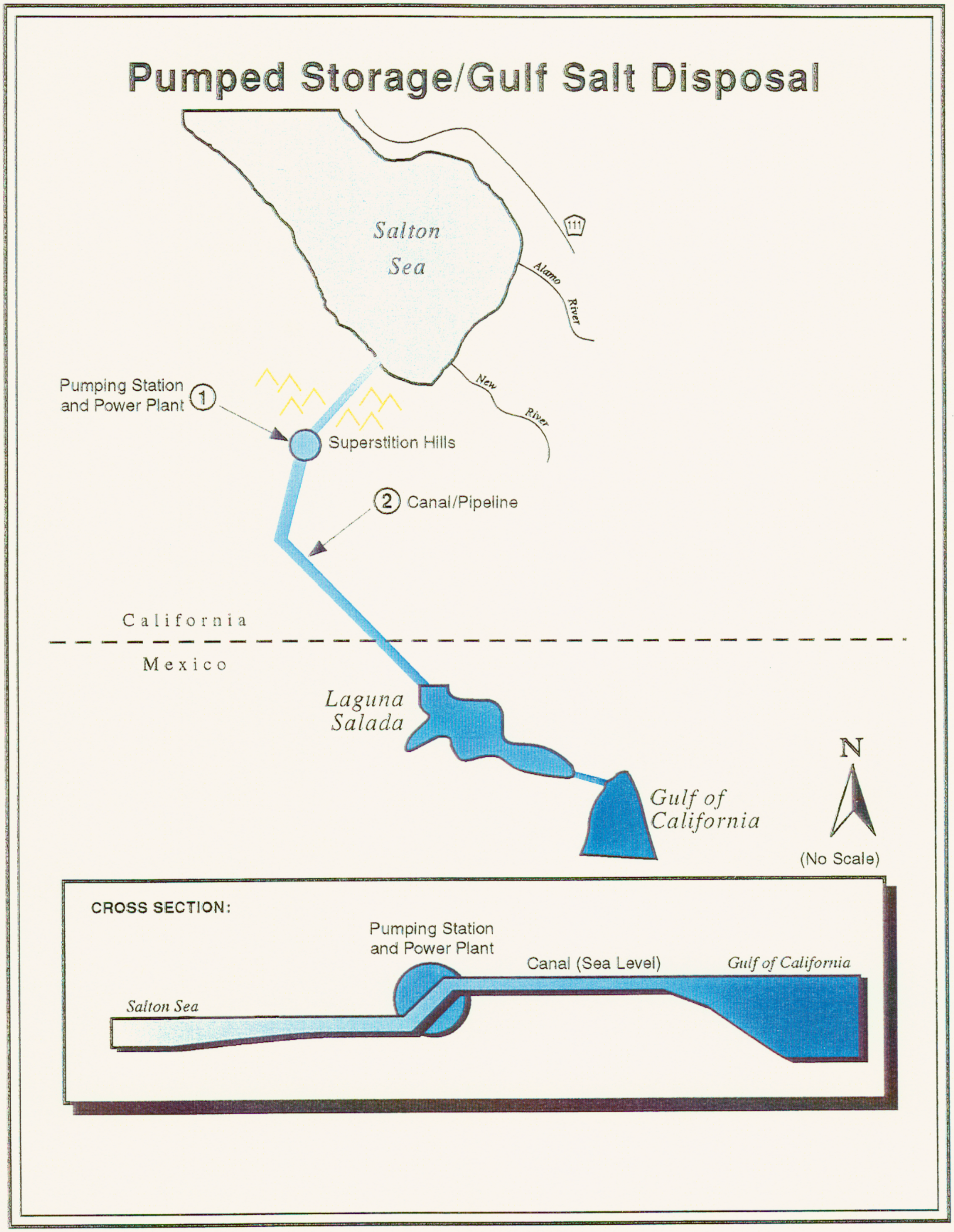
A pumped storage facility would be created using the Sea as a lower reservoir and a canal connected to the Gulf of California as the upper reservoir. A canal would be constructed approximately on the sea-level elevation contour, creating an extension to the Gulf of California (see Illustration 23). This canal, terminating near the Sea, would act as an upper reservoir for a pumped-storage facility. Water then would be pumped from the Sea into the canal (Gulf) during off-peak power periods when prices are low. During peak periods, when rates would be much higher, water would flow back into the Sea through reversible pump-turbines. The volume of water pumped from the Sea to the canal would exceed the volume returned to the Sea, thus creating a pumped outlet to the Sea and reducing Sea salinity.

EVALUATION OF ALTERNATIVE

The gradual exchange of water between the Sea and the Gulf of California would stabilize the salinity of the Sea at the level of the Gulf fairly quickly—perhaps in less than 10 years, depending upon the volume of water exchanged between the Sea and the Gulf. Elevation of the Sea could also be managed by controlling the water exchange.

The volume of water pumped each day would depend on the size of the power plant. However, even with a 500-MW plant, the elevation of the Sea would fluctuate less than 1 inch per year.

Since the Sea's elevation presently fluctuates between spring and fall, the amount pumped could vary as well. A monthly cycle could be established with extra water pumped each day from the Sea for 2 weeks, then extra power generated for the next 2 weeks as water would be brought from the Gulf of California to the Sea. This would allow the Sea to fluctuate about 1 foot per



Alternative No. 23
Illustration No. 23

month, while exchanging the total volume of the Sea every few years. Functionally, at least to an extent, the Sea would become an extension of the Gulf. The connection would be accomplished with a canal approximately 1/4-mile wide following the sea-level contour and terminating at Superstition Hills.

The proposal contemplated an installed pumped storage capacity of between 500 and 800 MW. On-peak production of energy would provide a revenue stream to help offset costs. In addition, proposal proponents expected that stabilization of the surface elevation would create new property development and land value enhancement opportunities by eliminating water surface fluctuations.

A rule of thumb for pumped storage projects is that the lower the ratio of the length of waterway between the upper and lower reservoirs (L) and the vertical distance between them (H), the more likely the project would be economically viable. A L/H ratio of 7 is considered good; a ratio of twice that would be approaching the poor range. In this proposal, with a head of only 450 feet, the L/H ratio was in the 100 range, probably making the pumped storage concept economically suspect.

As with other proposals to pump Sea water to the Gulf or Laguna Salada, there would be no residual salt disposal.

COSTS

No costs were provided by Dangermond and Associates. However, this proposal was similar enough to other alternatives that included pumping water from the Sea to the Gulf to estimate operational costs. Based on those comparisons, annual OME&R costs would be in the $20 to $30 million range. Any revenue generated by power sales would offset the operational costs, but, as noted, the ability of pumped storage to produce significant revenue would be unlikely.

REASON FOR ELIMINATION

This proposal exceeded the $10 million annual limitation for OME&R costs. Therefore, the alternative did not warrant further consideration.

Alternative 24	Heated Pump-out Solar Membrane Distillation

HISTORY

This proposal was discussed in a letter dated February 13, 1995, to Ms. Roberta Burns from the National Water Research Institute, with an attached report titled *Final Report, Solar Heated Membrane Distillation, NERDDC Project No.1281* (Hogan et al., June 1992).

PROPOSAL DESCRIPTION

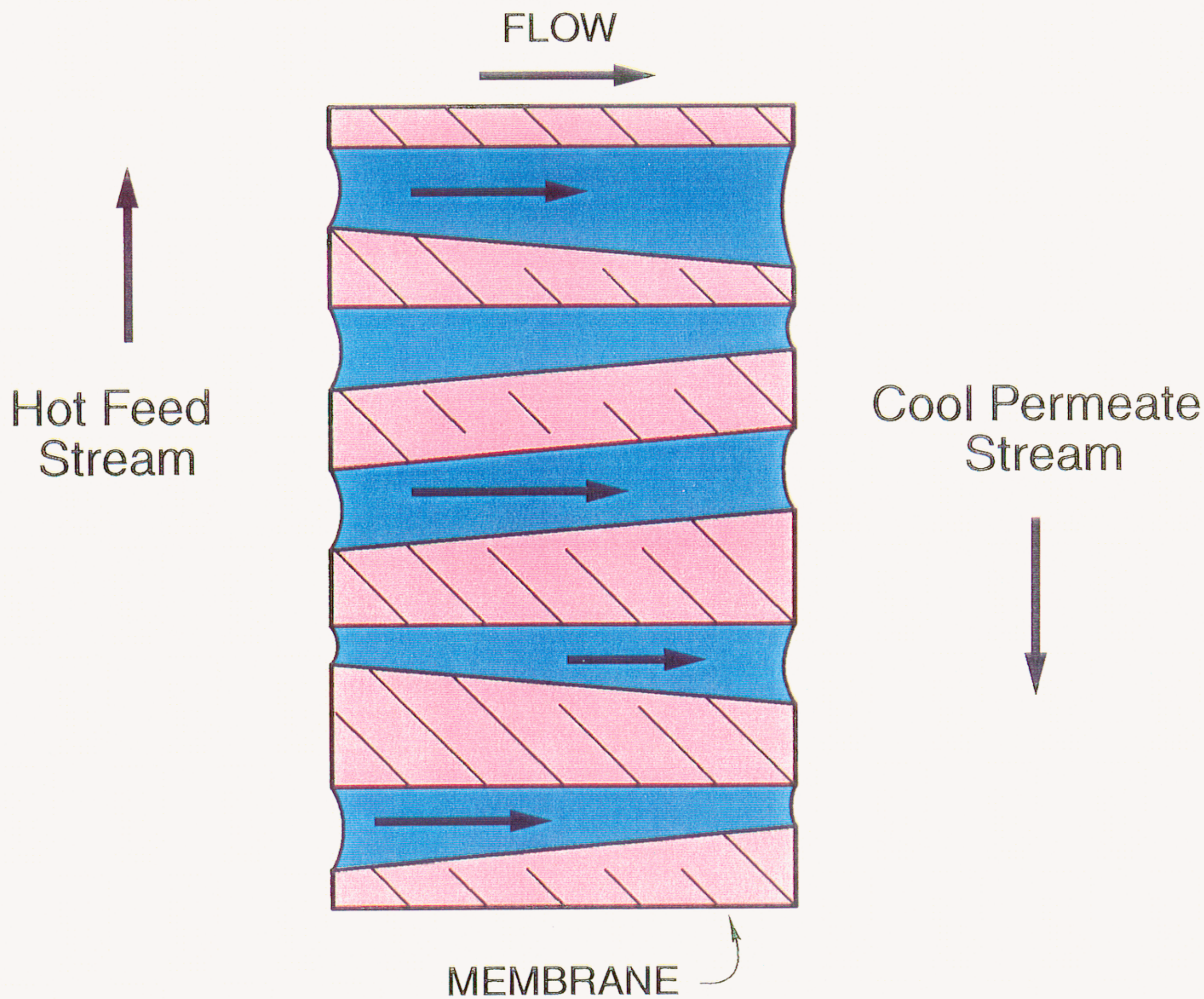
This proposal involved the design, construction, and operation of a pilot solar-powered membrane distillation plant for use in the desalination of Sea water. Membrane distillation is a heat-driven process in which a hydrophobic microfilter separates vapor and liquid streams of water. The water-repellent nature of the filter would prevent the passage of liquid through the pores while allowing the passage of water vapor (see Illustrations 24 and 25). The temperature difference across the membrane would produce a vapor pressure gradient, which causes water vapor to pass through the filter media and condense on the colder liquid surface. Water vapor condensate produced would be of very high purity and should contain no non-volatile solutes.

EVALUATION OF ALTERNATIVE

A pilot project, referenced in the *Final Report* mentioned above, was successful in demonstrating the concept of solar-heated membrane distillation. The design, however, is currently not considered sufficiently developed for commercialization. The aspects of the design that require attention have been identified, but further development work would be required. The proposal proponents have reportedly received inquiries from a group in India about the prospect of commercializing the unit. Much more research would have to be done to prove this alternative's feasibility on such a large scale.

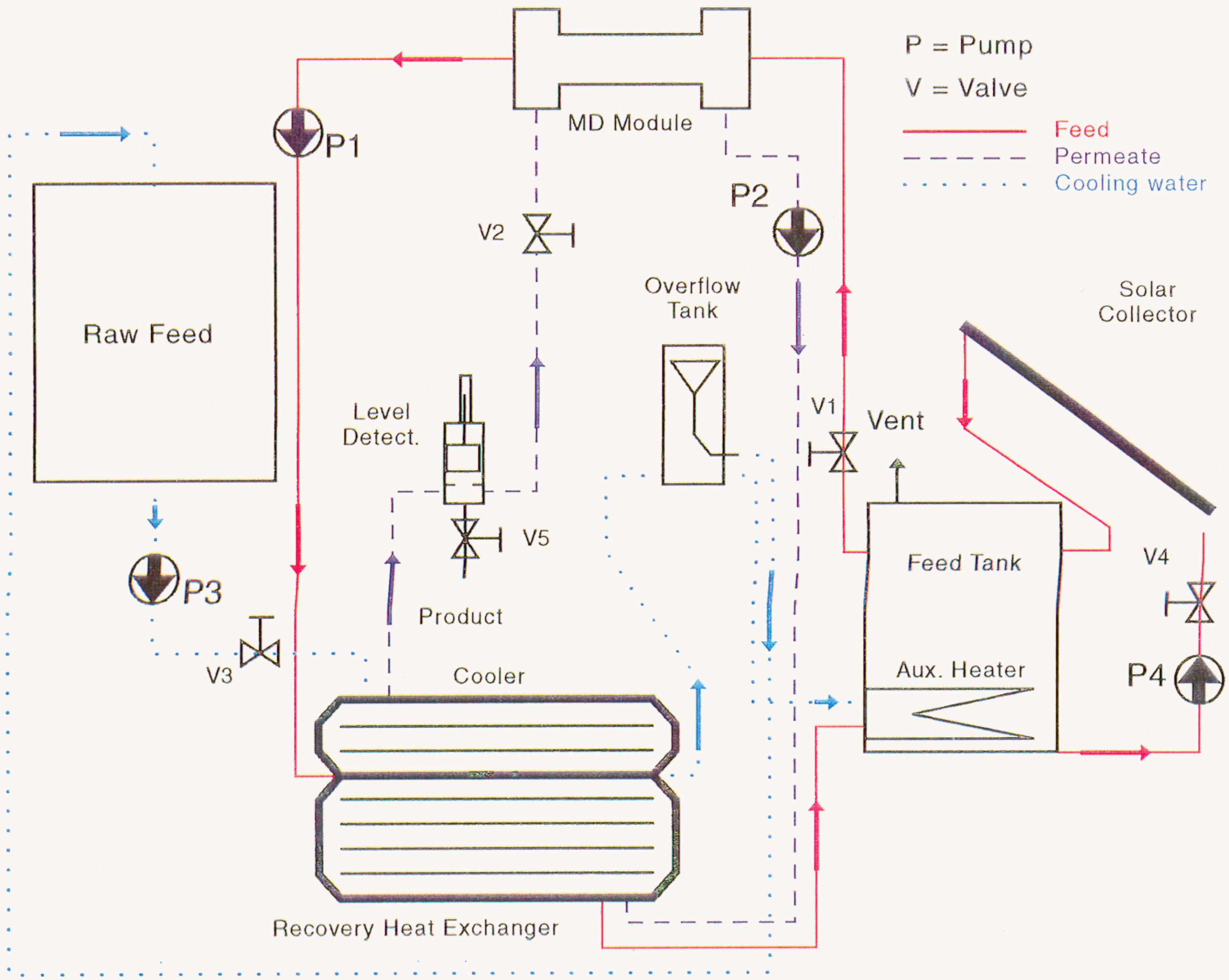
REASON FOR ELIMINATION

This proposal would require further research before it could be determined to be a feasible option. For this reason, this alternative did not warrant further consideration. Should additional information become available which satisfies the elimination criteria, further consideration would be given to this alternative to determine its feasibility.



Membrane Distillation

Alternative No. 24
Illustration No. 24



SHMD Piping and Instrumentation

Alternative No. 24
Illustration No. 25