HISTORY, FUNCTION, AND PROGRAM OF THE OFFICE OF SALINE WATER

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The June 1, 1963, issue of Water Resources Review, published by the U. S. Geological Survey, gives the following report:

> New Mexico. -- Runoff was near median in the Gila River basin and deficient elsewhere. At the index station on Fayado Creek near Cimarron, in the Canadian River basin, the monthly mean and the minimum daily flows were lowest for May since records began in 1927; all the snow came off in April, which accounts for the low runoff in May. Storage in Conchas Reservoir decreased to 72 percent of average and was 40 percent less than last year. Combined storage in Elephant Butte and Caballo Reservoirs decreased to 44 percent of average and was 37 percent less than last year. Storage in Navajo Reservoir increased to 335,300 acre-feet. Ground-water levels were lower than a year ago in all areas where ground water is used for irrigation. All time lows were established in the High Plains and the northern part of the Roswell basin. Monthly lows were established in other wells, in the intake area of the Roswell basin and in the Mimbres Valley.

In many instances, when I or other members of the staff of the Office of Saline Water, have an opportunity to describe the saline water conversion program, we must spend considerable time explaining just why we are conducting a research program to desalt sea or brackish water. In view of the U. S. Geological Survey Report which I have just read, I think I can safely assume that a discourse justifying the existence of the Office of Saline Water is not necessary at this meeting. Your very presence here today also clearly demonstrates that you know there is a water problem and that it is of a magnitude that makes all water conservation and development programs vitally important.

In order to inform you of the activities of the Office of Saline Water, we have prepared some slides which outline the

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history of the work of the United States Government in this field since the Congress authorized the Department of the Interior to proceed in 1952. I shall, with the aid of the slides, briefly tell you what authorizations the Department has been given, what appropriations have been made, the methods by which the Department is attacking the problem, some indication of the results, together with the Department's estimates of what can be expected in the future.

Authorizations

The first slide shows the four basic authorizations to the Department of the Interior relating to the saline water conversion program. They are:

Public Law 82-448 of July 3, 1952
Public Law 84-111 of June 29, 1955
Public Law 85-883 of September 2, 1958
Public Law 87-295 of September 22, 1961

Three of the authorizations deal primarily with research and development. One of the authorizations, that of 1958, has to do with demonstration plants. Briefly, here is their content: Public Law 82-448 of July 3, 1952, authorized a $2 million program, over a five-year period. In 1955, as of June 29, Public Law 84-111, extended the program authorized in 1952 through the fiscal year 1963 and increased the $2 million authorization to $10 million. Subsequently, in 1958, Public Law 85-883 of September 2, 1958, authorized a $10 million program, separate from research and development, for the construction of five demonstration plants. The more recent authorization of the Congress, Public Law 87-295, the Anderson-Aspinall Act of September 22, 1961, increased the research and development to $75 million, over a period from 1963 to 1967. At the same time, the Act extended the authorization for demonstration plants (Public Law 85-883) for a period of approximately 10 years. This was to give the Department an opportunity to complete work on certain demonstration plants which had not been constructed at that time and to continue the operation of the demonstration plants over a reasonable period.

Section 2(c) of the Anderson-Aspinall Act provides for the construction of additional demonstration plants as follows:

> "In order to accomplish the purposes of this Act, the Secretary of the Interior shall --
> "(c) recommend to the Congress from time to time authorization for construction and operation, or for participation in the construction and operation, of a demonstration plant for any process which he determines, on the basis of subsections (a) and (b)

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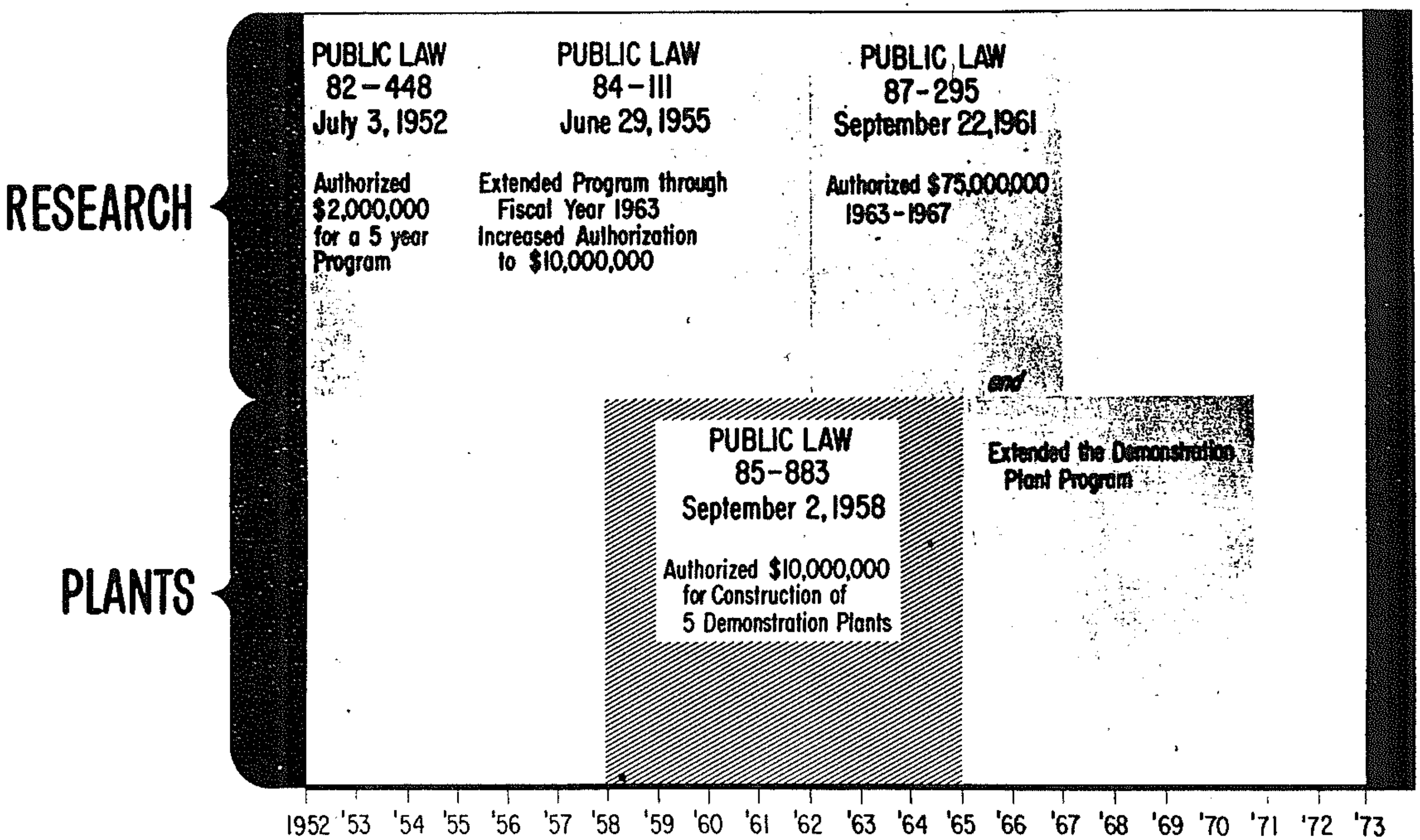
LEGISLATIVE AUTHORIZATIONS



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above, has great promise of accomplishing the purposes of this Act, such recommendation to be accompanied by a report on the size, location, and cost of the proposed plant and the engineering and economic details with respect thereto;"

Further information of the intent of the Congress is contained in the Report of the Committee on Interior and Insular Affairs of the House of Representatives which states:

"The committee intends that this subsection give the Secretary authority to enter into negotiations with a public agency or utility organization with respect to the terms of a proposal for construction of a conversion plant and proceed with such negotiations to the point of a tentative agreement prior to the submission of such proposal to the Congress. The committee wants to make it clear, however, that proposals submitted under section 2(c) must be justified on the basis of serving to advance the science and technology in the field of saline water conversion and contributing materially to low-cost desalination. The committee has no intention of permitting this to be turned into a federally subsidized water supply program. The reports accompanying recommendations under subsection 2(c) should be in such detail as to fully support authorization, including full information with respect to capital costs and water production costs, proposed location, engineering details, etc.

"The following will serve to indicate the committee's thinking with respect to cooperative arrangements where water supply is an important purpose in addition to the advancement of the objectives of the program. First, as already mentioned, justification must be based upon advancing the objectives of the act. In addition to this, the committee believes that the agency or organization obtaining the water should be willing to pay at least 50 percent of the overall cost of producing it, including both capital cost and operation and maintenance cost, and should be in position to take over the plant at the end of the demonstration period and operate it without further Federal subsidy. Another requirement which the committee believes such a proposal should meet is that there is no alternative source from which water could be obtained at a cost appreciably less than the cost of production under the proposal."

When mutual agreement has been reached for a cooperative project, we will make recommendations to the Congress so that the policy of the Government can be established.

Under this authority, we are planning to sponsor a detailed feasibility study of the possibility of erecting a combination thermal-electric sea water conversion plant with a generating capacity of 22 to 44 megawatts and a potable water production in the range of 6-8 million gallons per day. If the results of this study prove favorable, we hope to submit recommendations to the Congress for the construction of this combination plant at the beginning of the next regular session in January 1964.

Appropriations

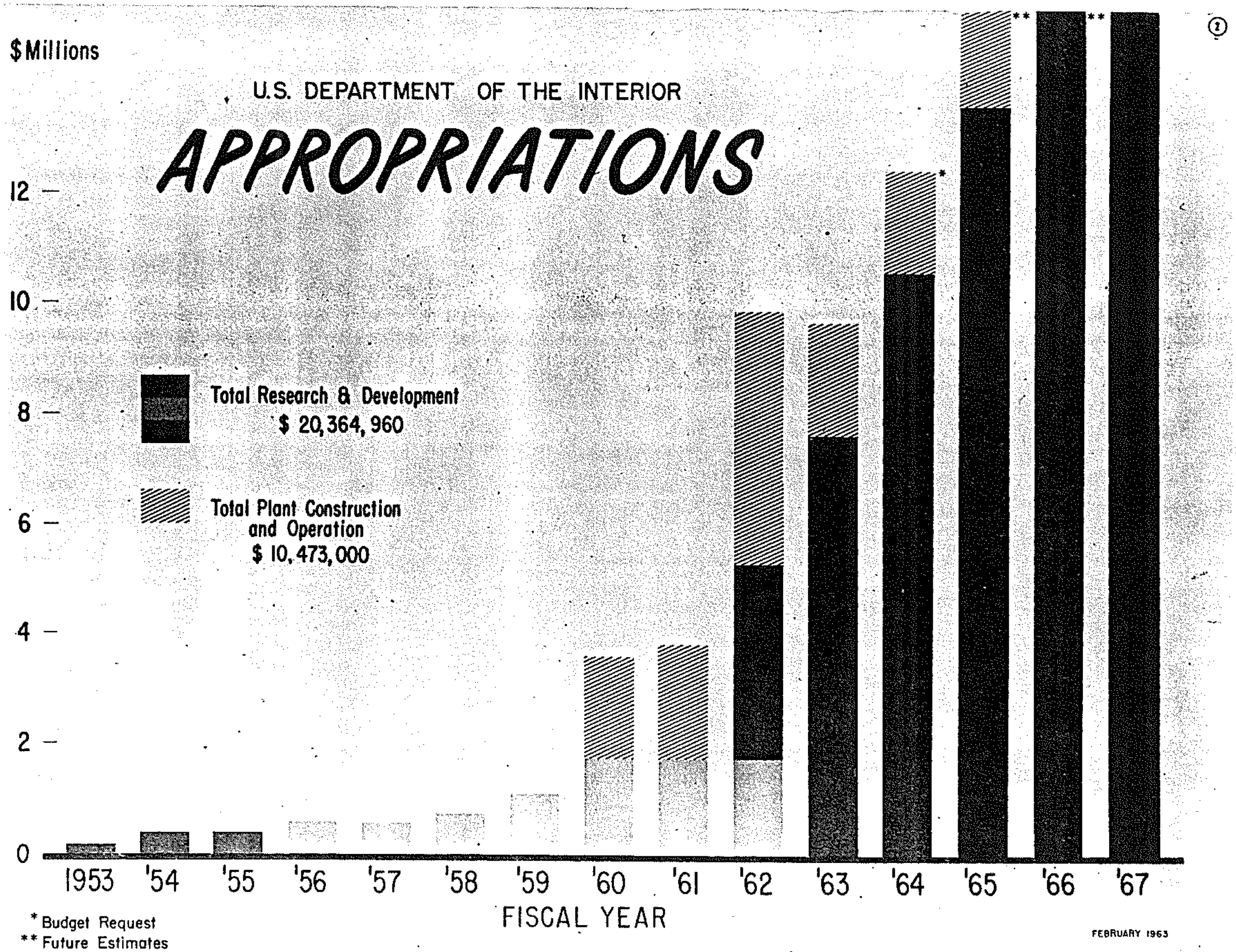
The second slide is a graph that shows the appropriations from 1953 through 1962, a period of 10 years. The annual appropriations are shown in colors which correspond to the four authorizations described earlier. The future columns show the budget request for 1964 and rough estimates of probable future requests for appropriations under the Anderson-Aspinall Act of 1961. They do not include funds for additional demonstration plant construction.

It is significant that appropriations for this program, which the President described as "more important than putting a man on the moon," have totaled over a 10-year period only $30 million--approximately $20 million for research and development and another $10 million for the construction and operation of demonstration plants.

Basic Research

The third slide, labeled "Basic Research," is to acquaint you with some of the research problems that are being studied by OSW. They are divided into six general sub-headings; the development of new methods, special problems, fundamental data, by-products, economics, and biology.

Under the sub-headings, development of new methods, are reverse osmosis, electro-absorption, and transport depletion. The special problems listed include heat transfer, corrosion, scale, materials, energy sources, and brine disposal. Under the sub-heading fundamental data are water quality, structure of and the properties of water, ion transport, energy requirements, reaction rates. By-products--power from combination plants and minerals as a result of the desalination. Under biology--contaminants, which



$Millions
U.S. DEPARTMENT OF THE INTERIOR
APPROPRIATIONS
12
10
8
6
4
2
0
Total Research & Development
$ 20,364, 960
Total Plant Construction
and Operation
$ 10, 473, 000
1953
'54
'55
'56
'57
'58
'59
'60
'61
'62
'63
'64
'65
'66
'67
FISCAL YEAR
* Budget Request
** Future Estimates
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BASIC RESEARCH

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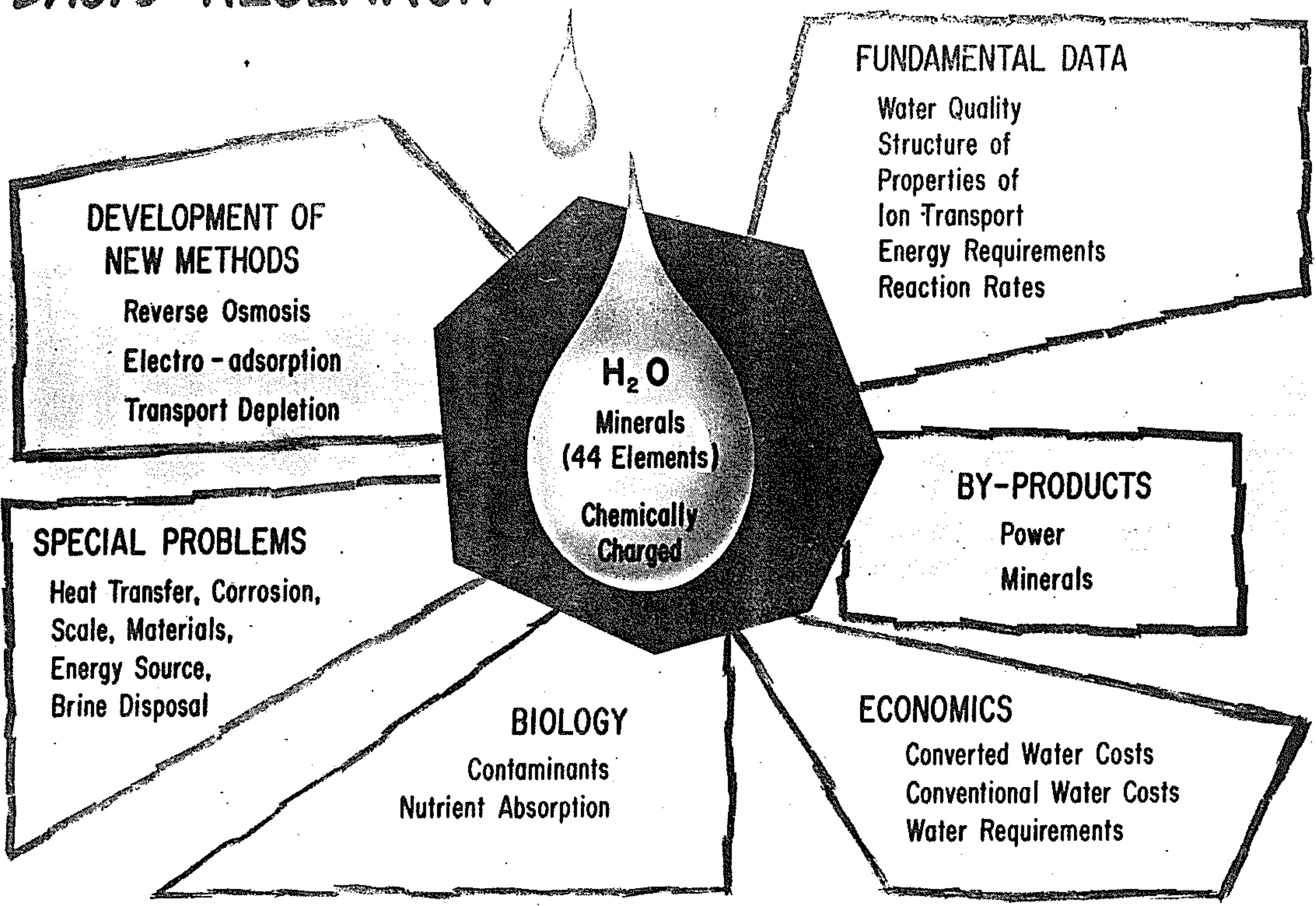

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include problems caused by industrial wastes which have polluted many of our rivers and streams as well as problems that might be created by the effluent from a conversion plant.

As far as the economics of desalting saline water are concerned, the problems boil down to this: Cost of heat, capital investment for necessary equipment, and cost of distribution. Heat can be supplied from either fossil fuel or nuclear sources, depending upon which is the cheaper. So, all our economic studies are related in some way to these three costs. To discover if a process is economically feasible, we must also find out the cost of water from other means against which we can compare the conversion cost in a given area. And, above all, we have to determine what are the actual, real water requirements for a particular area or type of use.

The research and development program on saline water conversion follows the progressive steps successfully used in many scientific endeavors. The fourth slide illustrates this approach where ideas and proposals are considered or generated through basic research and fundamental studies. Next, laboratory equipment is used in applied research on promising results of basic research to give initial answers on feasibility. If answers are favorable, and I emphasize the _if_, then the next step could be a larger experimental unit we call a pilot plant. At this point in the progress toward practical processes, engineering design data and some economic data are obtained sufficient for use in building a larger plant with considerable water production capacity; this type we call demonstration plants and they are the "proof of the pudding."

We know that one method, or even several methods or processes, will not meet the variety of saline water conversion needs. We are searching for lowest water costs under the specific conditions existing in any locality. Conversion plant size is an important factor in the type of process used. Converted water from brackish water sources in inland areas usually require different processes than used on sea water to get lowest cost.

Throughout such a development program, there is much important research underway on problems closely related to conversion processes; i.e., obtaining by-products from waste brine, disposal of brine, corrosion of metals that go into a plant, and obtaining efficient use of heat or other energy. On the fourth slide, we have set forth the five broad groups into which the various processes under development can be conveniently classified:

Distillation: The oldest of these and the one in widest commercial use to desalt water is distillation. A number of

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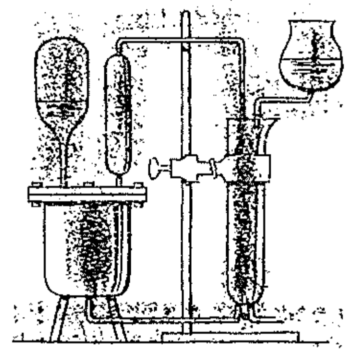
DEVELOPMENT OF CONVERSION PROCESSES

BASIC RESEARCH

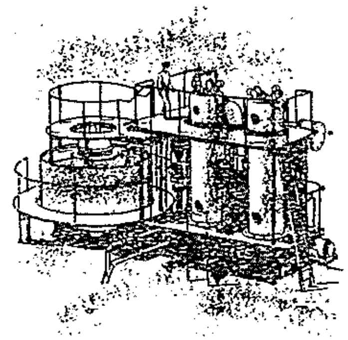
Test Tube

APPLIED RESEARCH



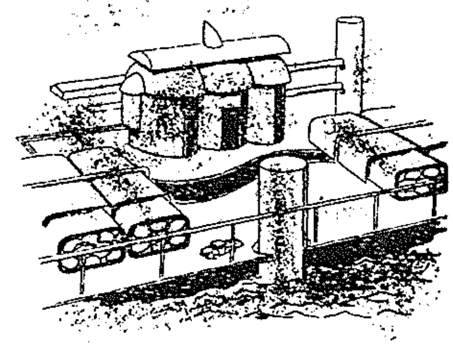
Lab Unit

ENGINEERING DEVELOPMENT



Pilot Plant

DEMONSTRATION



Water Plants

Types of Processes

DISTILLATION Fossil Fuel-Nuclear Energy	Multistage Flash L. T. V. Multiple Effect Vapor Compression	Thin Film Vapor Re-heat
MEMBRANE	Electrodialysis	Reverse Osmosis
FREEZING	Secondary Refrigerant	Vacuum
HUMIDIFICATION	Solar	Diffusion
CHEMICAL	Hydrate	Solvent Extraction

distillation processes are now being developed or further improved. Several types are now being used in demonstration plants. Major distillation processes include multistage flash, long tube vertical multiple effect, vapor compression, vapor reheat multistage, and special thin film applications to several types. While these processes are essentially alike in that they all boil the salt water and condense the resulting vapor to fresh water, there are many differences in types of equipment used for boiling chambers, condensers, for control of scale, heat recovery, etc. These differences affect the cost of the converted water.

Membranes: Membrane processes include electrodialysis and reverse osmosis as major types. Electrodialysis is now in commercial use and is particularly adapted to brackish water. The first brackish water demonstration plant uses an electrodialysis process. This method uses electric current with a special type of ion exchange membrane to recover salt from the saline water being treated. Reverse osmosis makes use of a different type of membrane or plastic sheet which can be thought of as acting as a type of filter which will let fresh water pass through when salt water on the one side of the membrane is placed under high pressure.

Freezing: Freezing processes make use of the natural principle that ice frozen from salt water is free of salt and when separated and melted, gives fresh water. Two principle processes are being developed. One makes use of freezing by application of vacuum; the other produces ice from salt water by direct contact of a refrigerating material. One of the freezing pilot plants with a capacity of about 50,000 gpd is successfully operating here in Florida near St. Petersburg. When fully developed, several advantages they have could make them very competitive with distillation methods.

Humidification: Humidification processes differ from conventional distillation in that the water vapor is first absorped by dry air and then released as fresh water by condensation from the air. Solar energy can be effectively used in these processes. Other low-level energy such as waste steam may be a heat source since temperatures are below those of normal boiling water. Solar distillation is particularly useful in areas of high solar intensity, in arid regions and where fossil fuels are scarce. At the present, applications are of small size. Use of these conversion principles is also being made in a diffusion type still for a household unit.

Chemical: Although conversion processes are concerned with applications of chemistry, several can be thought of as especially chemical in nature. Among these are hydrate processes and solvent extraction. Certain hydrocarbons such as propane combine with water to form types of insoluble compounds known as gas hydrates. Such compounds are crystalline solids and when formed from salt water are free of salts. This is a very new method which has shown promise in the laboratory stage of development. Pilot plants are being built. Solvent extraction makes use of certain liquid materials which can "pick up" fresh water from salt water. This material or solvent does not dissolve in the salt solution but remains a separate liquid which can be removed. The fresh water it carries can be released as product water by a small change in temperature. This process, yet in the laboratory, appears useful with certain brackish waters. A small pilot unit is being built.

Different conditions prompt approaches by different methods. Also, the salinity of the water available has an effect on the process selected.

Demonstration Plants

The fifth slide is a chart which shows the current status of the demonstration plant program. Three demonstration plants are operating and construction of a fourth plant has just been completed. They are located at Freeport, Texas; Webster, South Dakota; San Diego, California; and Roswell, New Mexico.

The Freeport, Texas, plant has a capacity of 1,000,000 gallons per day. It cost $1,255,712.00. The process is the long tube, vertical multieffect distillation. The plant was dedicated by Vice-President Johnson on June 21, 1961.

The Webster, South Dakota, demonstration plant has a capacity of 250,000 gallons per day. It cost $433,470.00. It is an electrodialysis plant, using plastic membranes. It was dedicated on October 20, 1961.

The third demonstration plant at San Diego, California, has a capacity of 1,000,000 gallons per day. The cost was $1,663,246.00. It is a multistage flash distillation plant. It was dedicated on March 10, 1962, by Secretary Udall and Governor Brown of California.

The fourth demonstration plant, which we dedicated today, has a capacity of 1,000,000 gallons per day. The cost of it is $1,794,000.00. It is a vapor compression process.

DEMONSTRATION PLANTS

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operating or under construction

LOCATION	SIZE	COST	PROCESS	DEDICATED
FREEPORT, TEXAS	1 MILLION gal per day	$ 1,255,712	L.T.V. DISTILLATION	JUNE 21, 1961
WEBSTER, SO. DAK.	250,000 gal per day	$ 433,470	ELECTRO-DIALYSIS	OCT 20, 1961
SAN DIEGO, CALIF.	1 MILLION gal per day	$ 1,663,246	MULTISTAGE FLASH	MARCH 10, 1962
ROSWELL, NEW MEX.	1 MILLION gal per day	$ 1,794,000	VAPOR COMPRESSION	JULY 1, 1963
WRIGHTSVILLE BEACH, N.C.	200,000 gal per day	$1,232,000	DIRECT FREEZING	APRIL 1964 (Tentative)

The fifth plant is a special case. It will be constructed at Wrightsville Beach, North Carolina, and will employ the direct freezing process. Cost will approximate $1,232,000.00.

The authorization for these five demonstration plants is $10 million. The total construction contracts for the five plants amount to $6,378,428.00, of which the State of California provided $800,000.00 and the State of New Mexico $100,000.00, leaving an unexpended balance of $4,521,572.00.

Cost of Fresh Water--Conventional and Converted

The next chart gets closer to the main point--the cost of fresh water from saline plants as compared to conventional means of getting water.

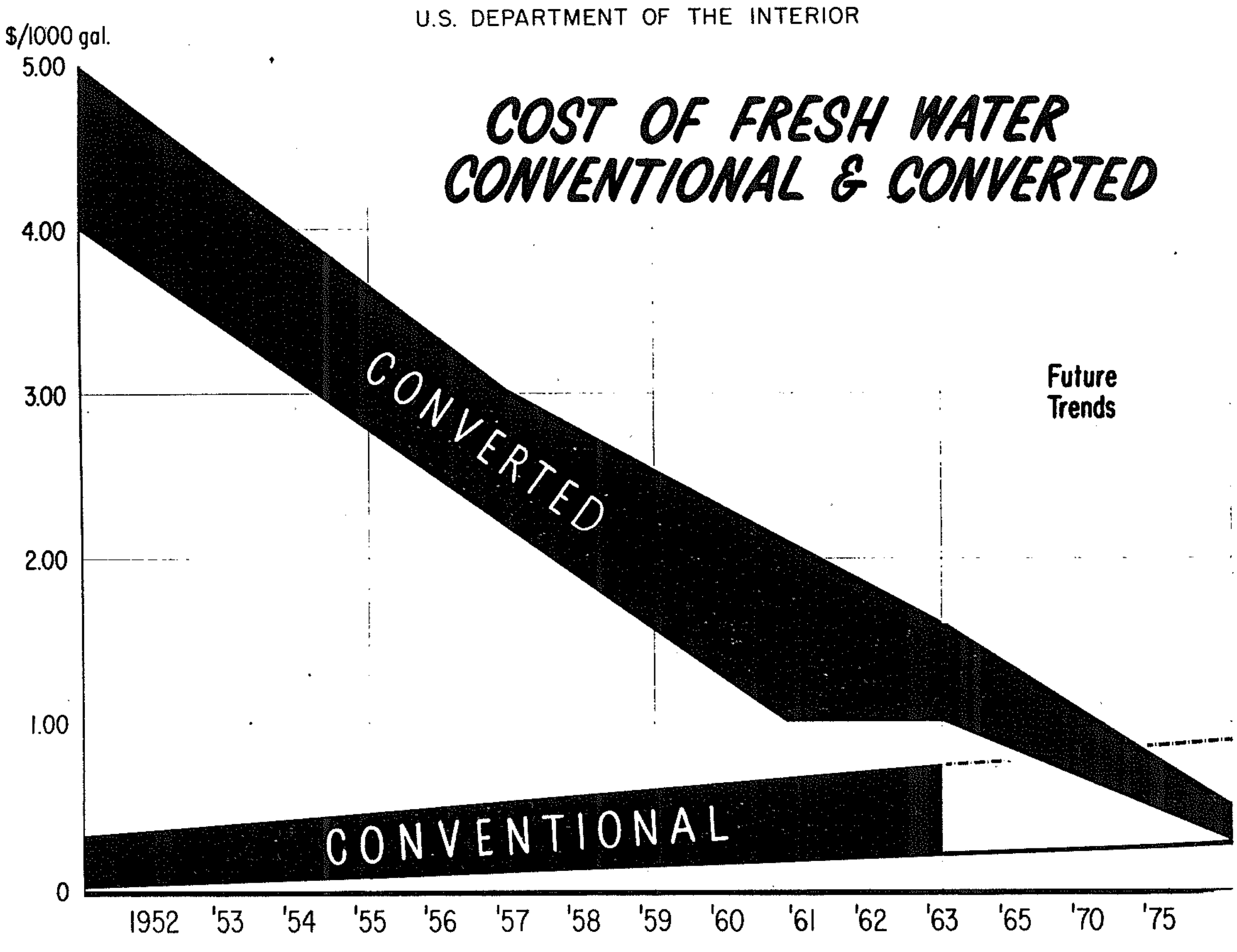
In 1952, the cost of converted sea water varied from about $4.00 to $5.00 per thousand gallons. In 1963, the comparable cost has been reduced from about $1.00 to $1.50. These costs have been kept on the conservative side. They are based on 20-year amortization of capital investment, with 4 percent interest. We are now engaged in economic studies in an attempt to put the multiplicity of water costs in various states on a comparable basis.

The conventional types of water development through reservoirs and wells, in 1952, ranged from about 1¢, in some cases, to approximately 30¢ per thousand gallons. The range of cost for conventional surface water and well-water supplies has widened somewhat since that time. Conventional water costs have been climbing slowly from about 20¢ per thousand gallons to about 75¢ per thousand gallons. As you are well aware, there are water costs that do not fall in this range. I should like to point out that this is a subject where it is possible to get a wide variety of costs. Many are not comparable, but these figures will give you an idea of the range of costs.

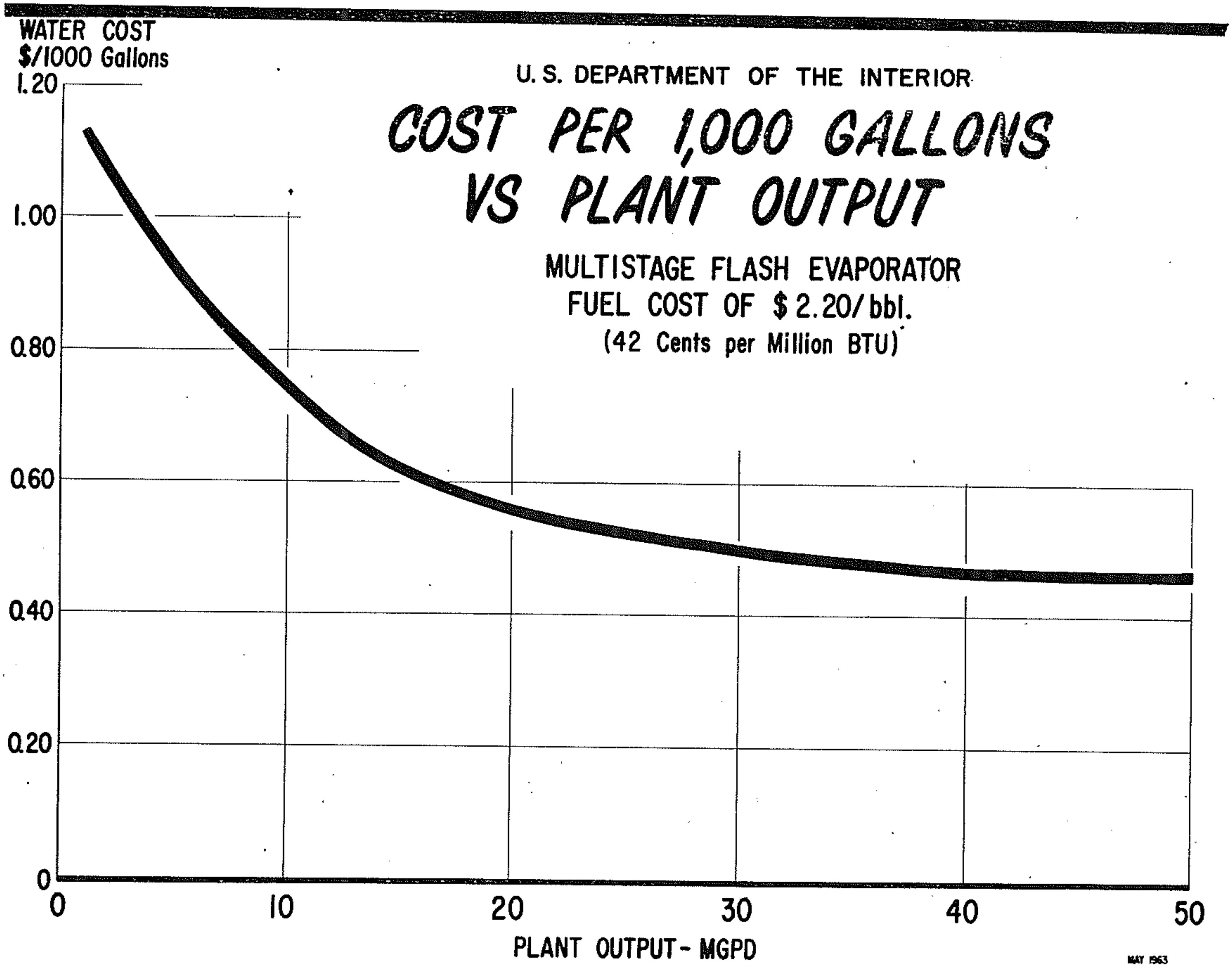
The chart also shows possible future trends. If plants of sufficient size are constructed, the cost could drop so that the cost of saline water may well be competitive with conventional sources.

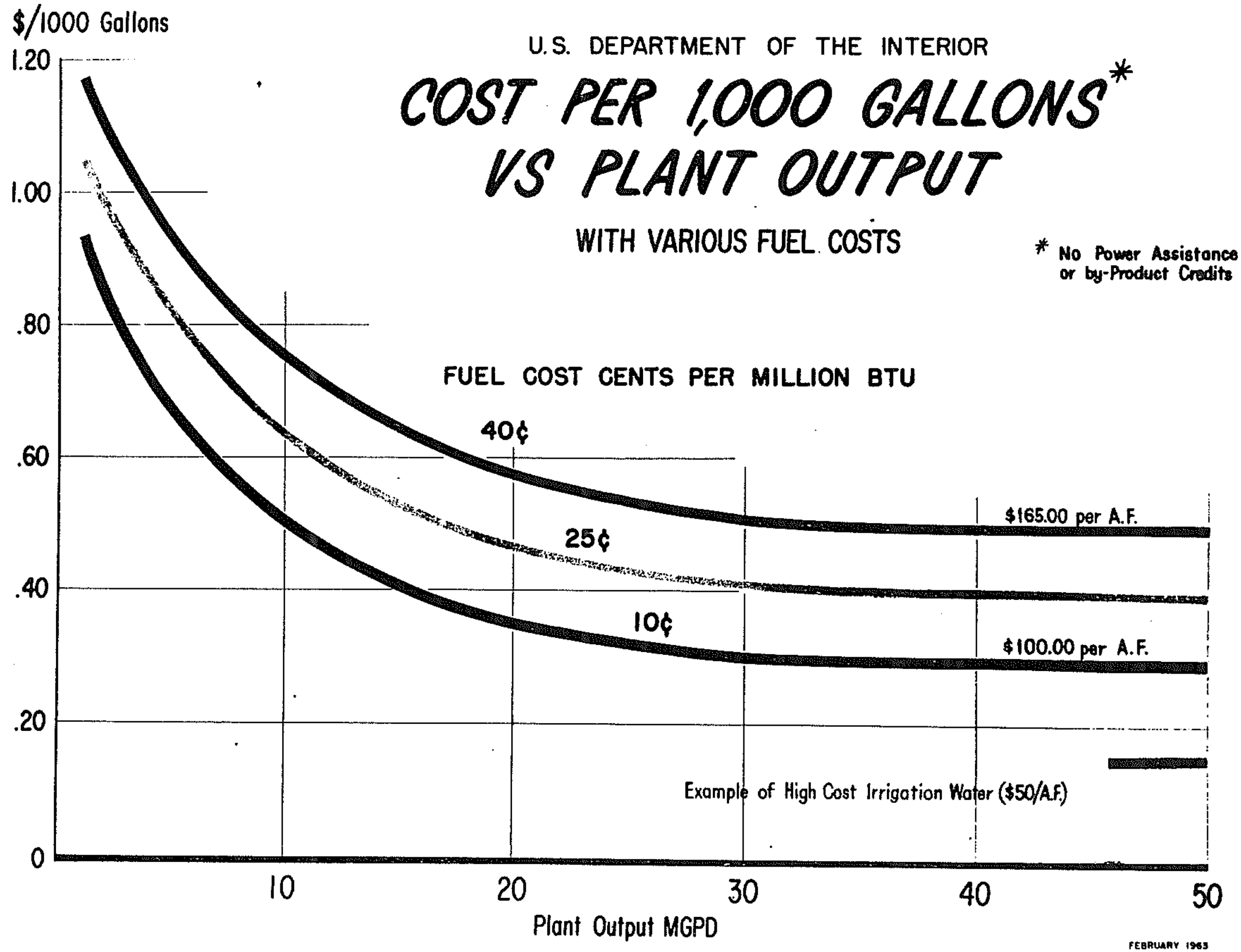
Cost Per Thousand Gallons Versus Plant Output

The next slide, entitled, "Cost Per Thousand Gallons versus Plant Output," is more specific as to the cost of converting sea water to fresh water. For this chart, we have assumed a fuel cost of 42¢ per million B.T.U. You will note that the vertical ordinate



U.S. DEPARTMENT OF THE INTERIOR
COST OF FRESH WATER
CONVENTIONAL & CONVERTED
$/1000 gal.
5.00
4.00
3.00
2.00
1.00
0
CONVERTED
CONVENTIONAL
Future Trends
1952
'53
'54
'55
'56
'57
'58
'59
'60
'61
'62
'63
'65
'70
'75
FEBRUARY 1963


WATER COST
$/1000 Gallons
1.20
1.00
0.80
0.60
0.40
0.20
0
U. S. DEPARTMENT OF THE INTERIOR
COST PER 1,000 GALLONS
VS PLANT OUTPUT
MULTISTAGE FLASH EVAPORATOR
FUEL COST OF $ 2.20/bbl.
(42 Cents per Million BTU)
0
10
20
30
40
50
PLANT OUTPUT - MGPD
MAY 1963



$/1000 Gallons
1.20
1.00
.80
.60
.40
.20
0
U.S. DEPARTMENT OF THE INTERIOR
COST PER 1,000 GALLONS*
VS PLANT OUTPUT
WITH VARIOUS FUEL COSTS
* No Power Assistance or by-Product Credits
FUEL COST CENTS PER MILLION BTU
40¢
25¢
10¢
$165.00 per A.F.
$100.00 per A.F.
Example of High Cost Irrigation Water ($50/A.F.)
10
20
30
40
50
Plant Output MGPD
FEBRUARY 1963

represents the cost of water per thousand gallons. The horizontal ordinate represents the plant output in million gallons per day. The Department's largest sea water conversion plants, the one in Freeport, Texas, and also the one at San Diego, California, both have a capacity of 1,000,000 gallons per day. Their costs are about $1.00 to $1.25 per 1,000 gallons. You can see the economies we anticipate as we construct larger plants utilizing presently known processes.

It is possible, under known processes, with the larger size plants, to reach approximately 30 - 35¢ per 1,000 gallons as the wholesale water price.

With these costs within our grasp, and with the hope that our research and development program will provide new or improved processes to desalt water at even lower cost, it seems certain that cities and industries in many areas, where natural fresh water is in limited supply, will be able soon to utilize converted water to supplement existing supplies at a price they can readily afford to pay.

The program of the Office of Saline Water is now in a transitional phase. We are moving rapidly from the realm of speculativeness into the arena of economic practicality. The question, is it possible to develop processes for the economic conversion of saline water, has been answered with a resounding yes. We are now proceeding toward our ultimate goal of driving down the cost of winning fresh water from salt to the lowest possible price.