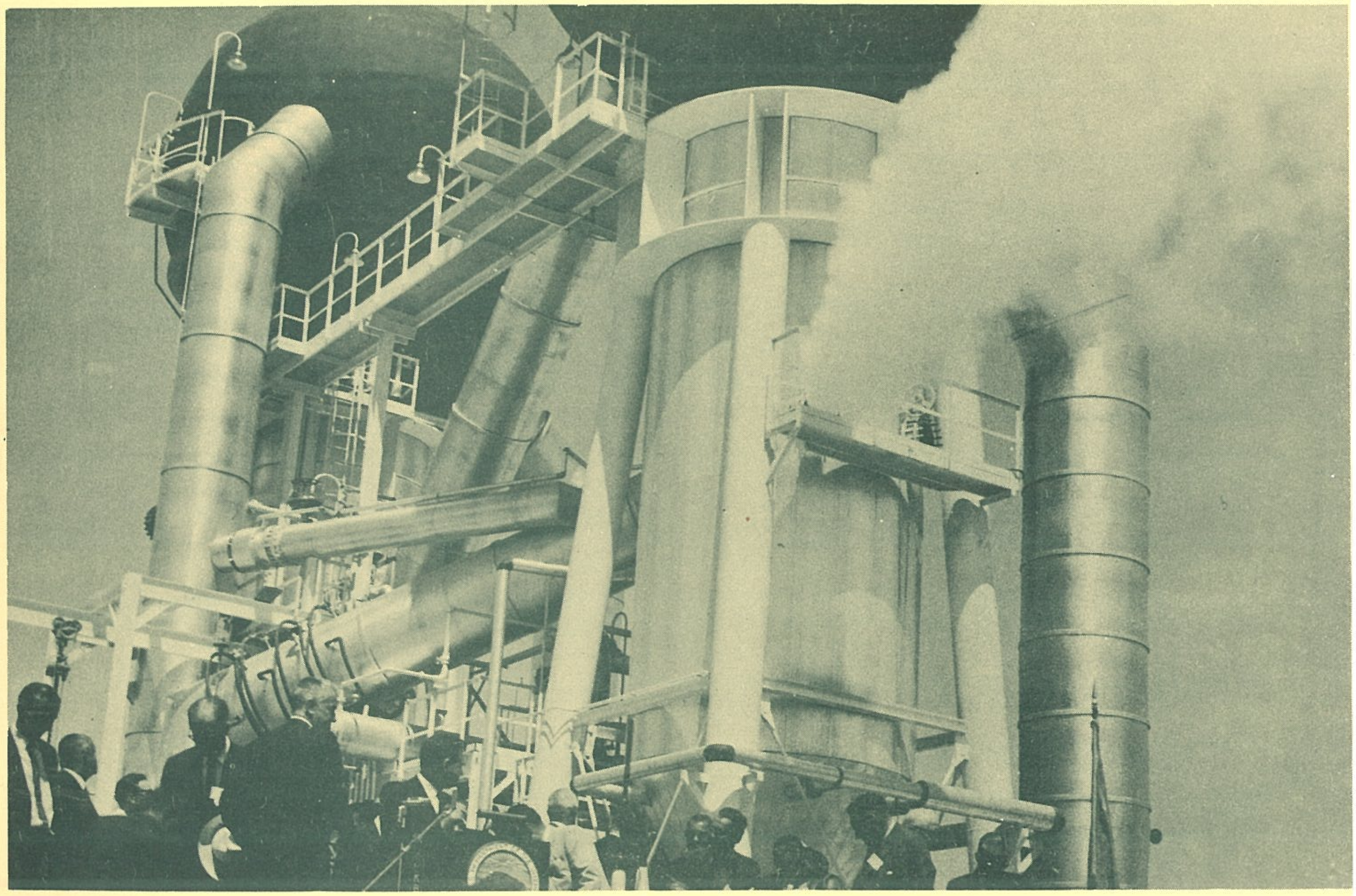
PROCEEDINGS OF THE

Eighth Annual New Mexico Water Conference



Theme : Saline Water Conference *July 1 & 2, 1963*

University Park, New Mexico

New Mexico State University

NEW MEXICO WATER CONFERENCE

Sponsored by

NEW MEXICO STATE UNIVERSITY, DIVISIONS
of

Agricultural Experiment Station
Agricultural Extension Service
College of Agriculture

College of Engineering
Engineering Experiment Station
Cooperative Agent, USDA-ARS, SCS

and the

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From Start . . .

Senator Clinton P. Anderson, who sponsored the Saline Water Conversion Plant legislation in Congress, receives the Resolution from the Third Annual New Mexico Water Conference from Rogers Aston, South Springs Foundation, Roswell. The resolution was in support of securing one of the five authorized plants for New Mexico. Mr. Aston is a member of the New Mexico Water Conference Advisory Committee.

ACKNOWLEDGEMENTS

The Water Conference wishes to give formal recognition in the form of this acknowledgement to the many individuals and organizations for the fine contributions made to the Eighth Annual New Mexico Water Conference. The Conference was held in Roswell on July 1 and 2, in the Pearson Auditorium of the New Mexico Military Institute in connection with the Dedication of the Saline Water Conversion Plant. The following and many more should be given thanks for their fine help and cooperation.

The United States Department of the Interior
Honorable Stewart Udall, Secretary of the Interior
Honorable John M. Kelly, Assistant Secretary for Mineral Resources

The Office of Saline Water - U. S. Department of the Interior
Mr. Charles F. MacGowan, Director
Mr. Ray H. Jebens, Chief, Demonstration Plants Division
Mr. J. W. O'Meara, Staff Assistant, Office of Saline Water

City of Roswell
Mr. Lake Frazier, Major of Roswell
Mr. C. M. Woodbury, City Manager

Roswell Chamber of Commerce
Mr. William Armstrong, President
Mr. Frank Kaufmann, Secretary-Manager

Pecos Valley Aqualantes
Mr. Rogers Aston, Chairman
Mr. Ellis Whitman, Vice Chairman
Mr. Frank Kaufmann, Secretary

The Aqualantes and the Chamber of Commerce together set up the necessary committees, arranged for the facilities, and were in general charge of the Roswell arrangements for the Water Conference. As a result, all of the necessary arrangements were most efficiently handled.

Desk and Derick Club
To all of the secretaries who volunteered their time to assist with the registration for the Dedication and the Water Conference.

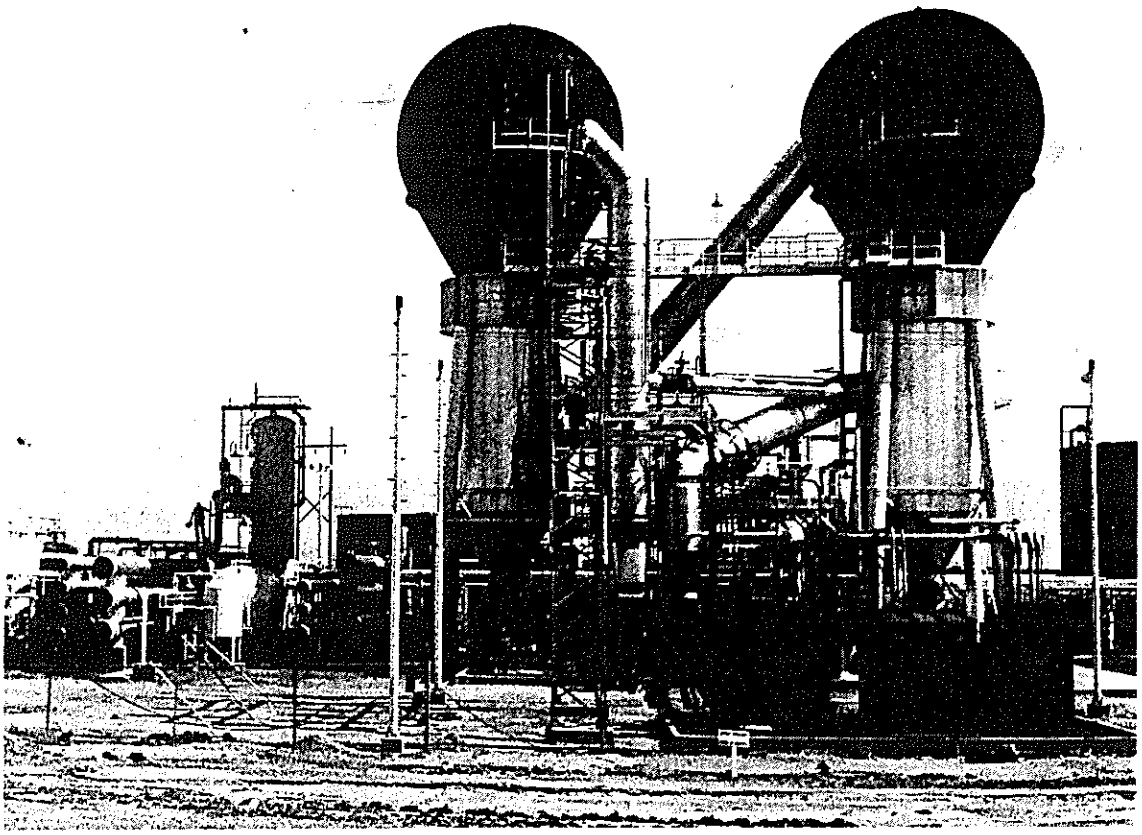
To Major General Samuel W. Agree, President of the New Mexico Military Institute for the use of the fine facilities of Pearson Auditorium where the Water Conference program was held.

To the Press, Radio, and Television of Roswell for the excellent special news coverage of the Conference.

To all of the speakers of the Conference who are listed in the program on the following pages. And,

To the many others in Roswell for their helpfulness and their courtesies in making the Conference an outstanding success.

To Finish



The completed Roswell Saline Water Conversion Plant as it appears on dedication day, July 1, 1963. This plant has a capacity to produce 1,000,000 gallons of almost pure water per day. It is a demonstration plant to be used to test plants of this size and to demonstrate this process to visitors who call at the plant. Visitors are invited.

F O R E W O R D

The Dedication of the Roswell Saline Water Conversion Plant marks a new era in the history of water in New Mexico. It was therefore appropriate that the Eighth Annual New Mexico Water Conference should be held at Roswell and that the theme of the Conference should be Saline Water Conversion.

The Conference was fortunate in having on the program, Senator Clinton P. Anderson who sponsored the Saline Water Conversion legislation and Secretary Stewart Udall of the Department of the Interior who administers the program. The first four speakers introduced by President Roger B. Corbett of New Mexico State University were Governor Jack Campbell, Congressman Montoya, Secretary Udall, and Senator Anderson.

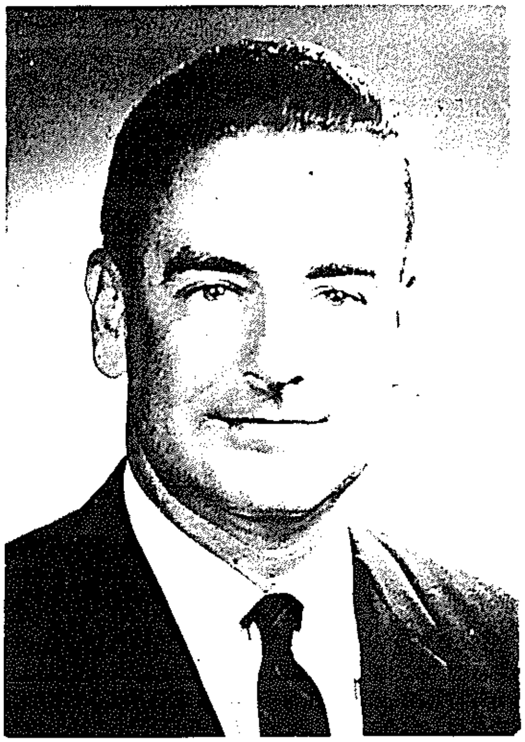
A leader in the promotion of the Saline Water Plant for New Mexico was Rogers Aston, South Springs Foundation and a member of the New Mexico Water Conference Advisory Committee. Mr. Aston carried to Washington, D. C., the Water Conference resolution, passed November 7, 1958, supporting the location of the Saline Conversion Plant in New Mexico. The citizens of Roswell together with Mr. Aston effectively prepared the Roswell application for a plant and it was approved over numerous applications from the states of Arizona, Colorado, Texas, and New Mexico.

The Water Conferences are sponsored by New Mexico State University through the Agricultural Experiment Station, Agricultural Extension Service, College of Agriculture, College of Engineering, and Cooperative Agencies of USDA-Agricultural Research Service, and Soil Conservation Service, with the cooperation of the Water Conference Advisory Committee.

The Conference started at noon on July 1, following the formal dedication of the Saline Water Conversion plant held that morning.

The papers in this publication appear in the order they were presented in the Conference. The program which follows this statement will serve as an index to the papers.

H. R. Stucky, Head, Department of Agricultural
Economics and Agricultural Business
and
General Chairman of New Mexico Water Conference



Governor Jack M. Campbell

Governor Campbell participated in the plant dedication and was one of the lead speakers in the opening of the Eighth Annual New Mexico Water Conference. Governor Campbell has given strong support to the Annual New Mexico Water Conference.

Secretary of Interior Stewart Udall

Secretary Udall was a principal speaker at the dedication and on the Water Conference program. Secretary Udall is a recognized leader in the resource development program in the United States.

Charles F. MacGowan

Mr. MacGowan is Director of the Office of Saline Water, U. S. Department of the Interior, Washington, D.C. This division is directly responsible for the construction and operation of the Saline Water Conversion work.

NEW MEXICO WATER CONFERENCE
July 1, and 2, 1963

THEME OF CONFERENCE - "SALINE WATER CONVERSION"

Dr. Roger B. Corbett, Presdient of New Mexico State University, presenting a bound set of the Annual New Mexico Water Conference Proceedings to Secretary of the Interior Stewart Udall. This presentation was made during the dedication of the Roswell plant on July 1, 1963.

Secretary of the Interior Stewart Udall receiving the Water Conference Report volumes. President Corbett is stepping away from the podium. The Saline Water Conversion Plant is in the background.

Left to Right - Father Evarist Brockman, Roswell; President Roger B. Corbett, New Mexico State University; H. J. Clarke, President, Chicago Bridge and Iron Company, builders of the plant; Mr. Charles MacGowan, Director, Office of Saline Water, Senator Clinton P. Anderson, and Secretary Stewart Udall at the beginning of the Dedication ceremony.

<u>The Plant is Started!!</u>

Under Secretary John Kelly at podium; Mr. Charles MacGowan at left; Senator Anderson right of Mr. Kelly; Congressman Montoya back center; and Secretary Udall facing Senator Anderson

Senator Anderson and Secretary Udall push down the pump handle to symbolically start the plant.

EIGHTH ANNUAL NEW MEXICO WATER CONFERENCE
Roswell, New Mexico
July 1, and 2, 1963

OPENING SESSION

Chairman - PRESIDENT ROGER B. CORBETT
President of New Mexico State University
University Park, New Mexico

Speakers - GOVERNOR JACK M. CAMPBELL
Governor of New Mexico

CONGRESSMAN JOSEPH M. MONTOYA
U. S. Representative From New Mexico

SECRETARY STEWART L. UDALL
Secretary of the Interior
Washington, D. C.

SENATOR CLINTON P. ANDERSON
U. S. Senator From New Mexico

NOTE: The remarks by President Corbett in his introduction will precede the statement made by each speaker. The papers for the four speakers are presented in the order indicated above.

GOVERNOR JACK M. CAMPBELL

Dr. Corbett's Introductory Remarks:

They say that when college presidents have an audience they can't refrain from speaking. We are so very fortunate in our speakers this afternoon that I am going to refrain from speaking and concentrate on the job of being the switch engine that moves these heavily-laden cars to the microphone.

I have a telegram which Senator Anderson was good enough to give me to read to the group. It is from Senator Estes Kefauver. He says:

> "As you and Secretary Udall are dedicating a most important new plant which will mean much to progress in making useable water which may mean much to the progress of civilization everywhere, I extend warm greetings and congratulations from the beautiful Pecos in the Tres Lagunas (in New Mexico). I commend you and your distinguished guests for your foresighted leadership in making this program possible. Best regards from Nancy and me.
>
> Estes Kefauver

As I said, we are very fortunate in having several men in important positions to speak to us. I am going to start with our own Governor of New Mexico, whom we know is keenly interested in conservation--is keenly interested in water. He is one of the men who has contributed to the Conference in the past. I believe he has two papers in the volumes which were presented to Secretary Udall this morning. He is an old timer at the New Mexico Water Conferences. We are very fortunate to have with us our own Governor whom we all know as Jack Campbell. Governor Jack Campbell.

Governor Campbell:

Thank you very much President Corbett. Secretary Udall, Senator Anderson, Congressman Montoya, ladies and gentlemen. It is true that on several occasions in the past, I have had the privilege of participating in these Water Conferences and I am very happy to be here today in my capacity as Governor to express to you on behalf of the people of our state sincere appreciation for your interest in this most important matter.

New Mexico has been blessed with a great many natural resources--mineral resources, water resources, recreational resources. But, of course, none of them can mean very much unless we continue to devote our efforts and energies to the proper conservation, distribution, and use of our somewhat limited water supply because this is the life blood of New Mexico as it is of our country and world. It is always a pleasure to see that through our fine educational institution at Las Cruces, New Mexico State University, we are able to maintain an annual contact with those who are most intimately associated with these matters of conservation of this precious natural resource.

Today, of course, is a very momentous occasion and I notice that today's program is dedicated primarily to the conversion of saline and brackish water which is of so much importance to us in New Mexico, and of course to those in other parts of our country and throughout the world. Again, on behalf of the citizens of New Mexico I wish you well in every important effort that you are going through here today and tomorrow. I know that by annual meetings of this kind, New Mexico will continue to stay abreast of the latest scientific developments and research programs in the field of water conservation. Thank you very much.

CONGRESSMAN JOSEPH M. MONTOYA

Dr. Corbett's Introductory Remarks:

The second man that we are very fortunate to have with us this afternoon is our own Congressman Joe Montoya. Everyone knows him as "Joe."

Congressman Montoya:

Thank you Dr. Corbett. Secretary Udall, Senator Anderson, Governor Campbell, ladies, and gentlemen. Roswell appropriately is the site today for this Conference. First, because it is playing host to the dedication of the Water Plant and secondly, because this area throughout my years in public life has been the pioneer in water research and conservation. I recall when I first went to the Legislature in 1937, I was serving with the distinguished pioneer and gentlemen from this area, E. O. Moore, who has had much to do with the development of the Hagerman-Dexter Soil Conservation District and the development of that particular area. Yes, water conservation means a lot to our country and because it means so much to our country, it means a great deal to the world. Because our country is the leader throughout the world, our country is the real light of hope for all peoples. Unless we continue to progress in this country, our freedoms may be challenged if we become weaker or if we maintain the status quo and that is why, ladies and gentlemen, I want to pass a word of great and sincere commendation to you. Because without men of dedication such as you, our water problems would be more severe and our country's plight would be more accentuated insofar as the needs for water are concerned.

We have here on this platform, two individuals who exemplify on the national landscape the real conservation that is being launched in this epoch known as the "Conservation Epoch" sponsored under the leadership of Secretary Udall. Yes, he served in the Congress with me and I know of his ideals. I knew what kind of man he was, but I never expected him to become the great leader in conservation that he has become. As Secretary of the Interior, he has interested himself in the problems of the West. And through the auspices of his great organization we have been able to lay proper foundations for progress in the future. And, of course, I need not tell you too much about Senator Anderson, I think the words spoken a few weeks ago in Washington when he was named unanimously by great leaders in conservation as "Mr. Conservation, U.S.A." explains the caliber of man and the great contribution which he has made.

But, I want to lay particular emphasis upon this point, that the western area of the United States cannot continue to unfold its vast potential unless the fruits of your labors begin to show on the horizon of our Western landscape. And, because of your dedicated efforts, I believe that we shall succeed, but in that success the future generations should not forget, as I do not today, that you deserve the commendation of all Americans for your dedication in this type of Conference. Thank you very much.

SECRETARY STEWART L. UDALL

Dr. Corbett's Introductory Remarks:

It is not everyday that New Mexico can have a member of the Cabinet in our State. It is a very great pleasure for me to have the opportunity to introduce Secretary Udall, the Secretary of the Interior. Before I ask him to step up to the microphone, there are several things that should be said.

He is the first and only man from Arizona to be in the Cabinet. He is one of the youngest men who has ever served in the Cabinet of the United States. I say with some feeling, being associated with New Mexico State University, that he was a great basketball player. New Mexico State University learned this in competition with him. He played for the University of Arizona and was an "All Conference" player. We were in the Conference at that time. I imagine that athletic prowess stands him in good stead in these strenuous days where he is going day and night as Secretary of the Interior.

Secretary Udall has become one of the great conservation leaders in the short time that he has been in the House of Representatives and the Cabinet. I think it is extremely important to you men and women of this Conference who, for years, have attempted to bring together all of the available knowledge on water problems, that we have as Secretary of the Interior a man from the Southwest. He is familiar with our problems and knows what to do about them, and he is the leader in saline water work. This is important to us. And so, we are extremely fortunate to have as our Secretary of the Interior, Secretary Udall. He is going to speak to us on "The Interests of the United States in Saline Water Conservation." Secretary Udall.

Secretary Udall:

I think this Conference has captured the excitement of the Saline Water program. Over 10 years ago, people like Senator Anderson not only saw the need for a program of reducing the salinity of saline waters--brackish waters and ocean waters--but also had the vision to recognize that this was one of the great and challenging scientific projects our country faced. They undertook to enact a program that has moved ahead steadily for 10 years. In fact, two years ago, a bill by Senator Anderson and Congressman Aspinall from Colorado nearly trebled the scope of the program. Consequently, our efforts are on a much higher level now than they ever were, and this progress is in one sense "The New Frontier" of the whole water field.

Until just a few years ago we were still living, so we thought, in the lap of plenty. We believed we had sufficient supplies, and that there wasn't too much to worry about. Yet, events have moved so rapidly that we can already see that we were very foolish in some of the practices we adopted. We are still today a Nation of water wasters. The quantities of water we are wasting in many of the Eastern parts of this country, such as through the polluting of our rivers, is one of the National scandals in the conservation field.

The problem we face is applying science and scientific technology to all of our water problems. But this application is not what we thought a few years ago. Then we thought we could do an adequate job if we simply built the necessary dams and reservoirs on all of our major rivers so we could have hold-over storage and smooth out the water cycle. Of course, this is very essential, and we are moving ahead on this work. In fact, we did some really significant things last year.

In Congress, authorization was given for two vital water projects which involved transmountain diversion--water from the Pacific watershed to the Atlantic watershed. The San Juan-Chama project on the Rio Grande is one, and the Frying Pan-Arkansas project on up the spine of the Rocky Mountains is the other. Here we are, through the techniques of engineering, taking water from one watershed and moving it over to another. This is an example of the long range planning we have to do. But, the necessity for this type of planning is more and more apparent to us in the arid areas of the country, such as this, where you have less than 12 or 15 inches of rainfall a year and where water is so precious. Long range planning is vital to this area's growth potential which is so closely related to the water supplies.

There are many steps that we can take in approaching our water problems properly. We can at least reduce our evaporation losses, and cut the consumption of water by phreatophytes, those water-using plants along our water courses. The entire field of better water management and better water conservation is part of the challenge we face. We must learn to recycle and reuse water; we waste tremendous quantities simply by not understanding what we are doing or by using water extravagantly and wastefully. We must advance on the entire water conservation front.

I think we will live to see many of our major cities such as Albuquerque, Phoenix, and Los Angeles taking their sewage effluent, purifying it, and reusing the water; in other words making maximum use of the water available. Some cities are doing this already. In addition we are going to have to do a better job of controlling evaporation losses. At the Roswell Saline Water Plant the effluent is taken off to pond, spread out, and nature evaporates it. This, of course, makes sense. This is part of the problem, part of the scientific experiment we are all engaged in. Assistant Secretary John Kelly, who is a geologist, tells me that if the effluent were taken out further, that it probably could and should be injected back into the earth. Ultimately, it may be that science will devise ways and means of recovering the minerals and salts from these saline waters.

This is old ground that I am covering, but I mention these factors to set the stage for one of the points I want to make here today. The problem is to understand water, because we cannot manage it or conserve it properly unless we understand it. We can't control the quality of water, we can't determine how to use it best or how to get maximum use from it, unless we understand the behavior of water.

I think one of the most important water measures is pending before the Congress of the United States today. It is Senator Anderson's S.2 Bill which is another example of conservation pioneering on the part of the Senator. The bill sets up at Land-Grant Colleges and Universities in all of our states, Water Resource Research Institutes. Setting up the Federal government and states in partnership, entering into a new bold program in water research is, I think, one of the most significant proposals that has been put forward in many years in the water field.

Senator Anderson in his usual creative way borrowed a concept from another field--this is the way you produce new ideas. You take an idea that has worked over here, and you say, "why not apply it over here?" There has been no more successful scientific program over the last 50 or 75 years in my opinion than the cooperative program between the Federal government and the Land-Grant Colleges with regard to agricultural science, with regard to the programs that the Land-Grant Colleges have had in their Agricultural Experiment Stations, in their effort to determine ways and means of making our farms more productive, of raising better crops, and of doing a better job in managing all of our resources which relate to the land and its products. As a matter of fact, my science advisors have suggested to me that this has been one of the great successful scientific ventures in our country's history. For a long period of years, we have spent more money as a people, more Federal money, in the field of agricultural research than any other place. The results of this research account for the tremendous success today in the agricultural field where our land yields are so high, our crops so bountious. This is one of the great American success stories.

Senator Anderson served as Secretary of Agriculture, and you have heard him discuss this whole problem. But today, we think of our agricultural surplus as a problem--actually it is a great boon to our country since it enables us to help other peoples around the world not only with surplus crops, but with the know-how we have gained over the years of using science to help us understand the land and the proper use of our soils. Based on the success of this program, that has enabled our country to become so prosperous that we are almost embarrassed in terms of agriculture, we have every reason to expect success in water research.

Senator Anderson has suggested to the Congress of the United States, and the Senate has already taken up this suggestion and has passed his bill, that we use the method that worked so well in Agricultural Experiment Stations and apply it to our water problem. The idea is that the Federal government appropriate monies for a joint program with the states to set up more aggressive action in terms of water research in all of the 50 states. Of course, many of our Land-Grant Colleges in many of our states already do have water research programs. Your Water Conference here is evidence of that.

It was obvious to Senator Anderson, and to those of us who studied the national picture with him, that many of our states are not making any effort. In fact, some of them are making a very inadequate effort, considering the problems confronting us. If the projections of water use are sound, twenty years from now we in this country are going to need twice as much water as we are using today to take care of our industrial, municipal, and farming needs.

There are many areas where we have water surpluses in this country, but you can see what a tremendous challenge we face. As any of the Geological Survey people here will tell you, as any of our experts at your institutions such as Dr. Corbett will tell you--there are a lot of basic things that we do not understand about water, about its nature and about its behavior. This is the reason that I have been working closely with Senator Anderson on his legislation so that all of our states become involved in a larger effort--coordinated as the Bill provides with a national effort.

We have got to produce more water scientists in our universities. If we are to do a proper job of water conservation in this country, then we must have more experts. The National Academy of Science has made a study for President Kennedy on water. One of their major conclusions was that we face a very serious shortage of water experts, and people who are knowledgeable in the hydro sciences. The Academy stated that we must make a planned effort or we are going to find ourselves using our geologists and other water experts as emergency squads who run around trying to solve problems when people get into trouble, instead of properly planning our water future and thus eliminating most of the problems.

I think that all of us here and all of the people in the country have a stake in Senator Anderson's bill because it concerns our universities, it concerns all of you here, it concerns, I think, a very vital aspect of our whole water conservation program in this country.

As far as the Saline Water Program itself is concerned, what interested me the most in coming here today was to see this fine new plant, and to survey the progress, problems and opportunities we have here. I have been told that there are tremendous water resources in these arid areas. This is an area where you have a very limited amount of rainfall a year. It means that you have to husband what you have. It means that as far as the growth of your area is concerned, water is now and always will be your most serious problem.

Yet, you have underneath the soil here a great aquifer of water. As you look at the Geological Survey maps, you find that there are tremendous underground aquifers in the Midwest and in parts of the Southwest. Some of this water is usable, some is near the surface. Some of this water, often in enormous quantities as in your case, is saline in character and unusable for farming or other purposes. When I tasted the sample of the water pumped out of your deep saline aquifer here today, I couldn't believe how saline it was. It is half as saline as the waters of the ocean itself. And yet, this is part of the water resource of this region. At present, it is unusable. Until we perfect the means of conserving it, of creating, one might say, a water product that is usable, it will remain merely a potential.

One of the reasons we selected the New Mexico area for this plant is that this is the most interesting of our saline plants. Other plants, one on the Gulf Coast, one on the Atlantic Coast, and one on the Pacific Coast, are working on problems of desalinating ocean water, and the problems of all are quite similar. But here we have a very special problem involving a great underground resource. We have here waters that are highly mineralized, have different types of minerals, and a very high degree of salinity and mineralization. This presents a real challenge to the engineers and water experts who are trying to perfect the saline water technology.

This plant has subtle problems that will not be solved overnight. This is an experiment; it was intended that way by the Congress. We are going to find out a lot of answers relating to your own area with regard to reducing the salinity of soils. We will find out how to take care of an effluent that comes out of a plant of this kind, and what is the best way of handling these very saline, highly mineralized waters. It is this type of engineering and scientific venturing that will provide the answers not only for your state or for this locality but for all of the states that have similar underground brackish aquifers. There are, too, many places in the Middle East and elsewhere that have problems that are quite similar in terms of water potential. Therefore, this project, its operation, its developments, and the solutions it gets, will be watched with much interest all over the world.

It is apparent to me that we are making real progress toward our objective. From antiquity men have been able in one way or another to produce fresh waters from the seas or from brackish waters through various simple but very limited methods. Our basic problem is perfecting techniques whereby we can produce the water in great quantities at minimum cost. We are already strongly convinced that we are nearing the point where we can see this big break-through where in many parts of our country the price will really break down sharply to the point where, for municipal and industrial purposes, the water that can be produced from large saline water plants will be competitive with water that is available from other means. It is obvious to us that the main vehicle for this break-through is to move out of these relatively small plants into very large plants--plants that are 50-100-500 times as large as the plant constructed here.

These will be great water factories, once we have perfected the techniques. Our engineers and others have been working with the Atomic Energy Commission people; and industry people are also rising to the challenge. The combination of a large plant which would produce simultaneously electric power, through thermo-turbines, and usable water offers a very inviting prospect. For such a plant the largest cost requirement is the energy, and of course, part of the requirement for any desalinization plant is the energy to either heat or cool the water; energy is one of the big components.

Most saline water plants are based on the heating principle, using low pressure steam. The turbine is turned in our latest thermogeneration of electricity devices through high pressure steam. Thus, if a plant is producing steam, the high pressure steam could produce electricity and the low pressure steam could be bled off and used for a desalinating plant. The result would be a versatile plant where all of the energy would be used to produce electricity at the peak load and peak time in the evening. At night, the plant would operate at full capacity producing water, which, of course, is stored for use at the proper time. This is something that we see very clearly now as a potential.

We didn't see this too well two and a half years ago, when I first came into the program. So it is not only a matter of perfecting the machinery, perfecting the technology of the desalinization; but it is a matter of putting engineers together to look at the larger aspect so that we can see how a program of this kind can serve the people both in terms of water and perhaps electric power simultaneously. I am very hopeful that, perhaps this year or not long thereafter, we will be ready to discuss with Senator Anderson and others in the Congress various types of alternate proposals for moving into large plants.

I think, and I am being conservative, we are going to see within the next five years a move into the construction of large saline water plants. If we can perfect techniques and perfect the equipment that is needed, this great underground saline aquifer that you have here now practically useless, may have the potential of being converted into a tremendous asset that will help the long-term growth of your area.

You have launched here in New Mexico a very interesting experiment. It is an experiment which holds a great potential for your future and the future of the country. Your Conference will aid everyone to understand better the problems and opportunities available to all. As for us, we are delighted to have another activity in the State of New Mexico. The Department of the Interior has a tradition of fine relations with your state and state officials. I am sure that we all are going to be very excited and interested in this plant as it operates in the months ahead. Thank you very much.

SENATOR CLINTON P. ANDERSON

Dr. Corbett's Introductory Remarks:

This next part of the program is a personal pleasure. I have known Senator Anderson for many years. He was Secretary of Agriculture when our acquaintance began. We have been on a "Clint" and "Roger" basis for about 20 years. It was a pleasure to hear what Secretary Udall had to say about the Anderson Bill. Senator Anderson's S.2 Water Resources Research Bill is a tremendously important step forward in the water program of the country.

I have had few experiences more enjoyable than a recent meeting of our Board of Regents where there was a unanimous vote to name our new Physical Science Laboratory, which devotes itself largely to space work, the "Clinton P. Anderson Hall." Much more space work will be accomplished in this new building. As an indication, yesterday I signed a new contract for 2 million dollars to go into that work, Senator Anderson.

I can best summarize my feelings by saying I think Senator Anderson is the most respected and the most loved man in the State of New Mexico. And so it is a real pleasure for me to turn this microphone over to our own Senator Clinton P. Anderson.

Senator Anderson:

Thank you Roger. Secretary Udall, Congressman Montoya, Governor Campbell. While I was listening to Secretary Udall discuss the water resources bill now pending in the Congress and which the Senate has passed, I thought it might be proper sometime to express a few words of appreciation to some of those people who helped. This is a bill which would turn over to the Land-Grant Colleges, generally, to the universities, certainly, in every one of the states, some responsibility for water research and development. I did not just grab that out of thin air, as Secretary Udall has pointed out. I based it upon the program we have had of Land-Grant Colleges and Agricultural Extension work which has operated so successfully for nearly a century. I did not stop there, after we had drafted a bill, I asked the Land-Grant Colleges to supply me with an advisory committee and to give me their individual feelings about the bill and what might be done to it. I am glad to say that Roger Corbett did not take that as just a mere invitation, but sat down and tried his very best to help me come through with what looked like a decent piece of legislation. It has been very useful to have that kind of advice because when the bill was pending in the Senate a number of efforts were made to amend it. Some of them, I thought, would have been extremely distructive if they had succeeded.

Before the bill got to the floor, one of the members of the Senate came to me and said, "I want you to know that I am going to have to be against your bill, I am sorry, we have been friends for a long time. This time I think you have made a serious mistake and I am going to be against your bill."

And I said, "Is that so, are you acquainted with the people in your state that might be interested in this?"

He said, "I know the problem of education and I know the problem of science. The people who might be interested in this, aren't to be involved in this."

I said, "Are you acquainted with the president of the Land-Grant College in your state."

He said, "Oh, yes."

I said, "What kind of man is he, I would like some advice from him sometime."

He said, "He's a perfectly wonderful man, trustworthy in every regard. Whatever he says I take with great seriousness. I think he is extremely fine and high grade character."

I said, "Thank you. He was chairman of the advisory board that helped me get this bill ready. I hope you will find out from him sometime what he thinks about it." And strangely there wasn't a word said from him when the bill got to the floor, except a few words of commendation. He had recognized that if research is spread all over the map with nobody trying to coordinate it, sometimes some of the money is wasted, sometimes some of the money is lost. But, research well directed seems to be at the present time one of the most precious possessions we Americans have. I was very happy to welcome him into the fold of those who believe there is a function for our Land-Grant Colleges in pioneering in another field in addition to the fields in which they have already pioneered.

Recently, in the Senate Aeronautical and Space Sciences Committee, we invited a group of distinguished scientists to discuss with us their views of the space program. One of these eminant men, Dr. Polykarp Kusch, of the Columbia University, holder of a Nobel Prize, said many problems remain to be solved right here on earth. One of the most pressing is the adequate supplies of fresh water. Dr. Kusch said, "We have a moral obligation not to bequeath to our successors an arid continent." I agree and I believe we can meet that obligation and do the other things essential for the preservation and progress of this Nation, including journeys to the planets.

We are moving in many fields of science with the speed of an olympic runner. At the hearings that I just mentioned, one of the witnesses recalled a book written in 1935 by Dr. Clifford Furnas entitled The Next One Hundred Years in Science. And the speaker then said that everything the author said would take a century to accomplish has already taken place in twenty-five years. Some of us who have been watching this realize that it is possible.

The work in atomic energy, to which I have devoted a great deal of my time, was certainly unheard of in 1935 as far as practical applications which might flow from the splitting of the atom. And in the space program, we have just finished about eight days of long hours devoted to hearings on a 5.7 billion dollar budget. Every item called upon new techniques, new resources which we hadn't realized we had, new skills we have never used, new disciplines which our schools must have. This is part of a great forward movement that has taken place in these last twenty-five years. Incidentally, when I got home I started to finish reading a book called, Red Star in Space, which discusses very frankly the Russian activities in space. This would be, I think, interesting reading for a great many people, because it points out how the Russian scientists did not start their space work with the capture of the German scientists who had been working on the V-2 missile; but, had many years before, been working very effectively in that field and were probably far ahead of the Germans at that time.

Now the conversion plant that we dedicated this morning is an example of how scientific and technological processes are being applied to our urgent national needs. We should keep up this pace, indeed, we should expect to accelerate it as present programs generate new knowledge on which to base further programs. It is hardly necessary for me to tell this gathering of the intimate relationship between water and agriculture and industry. It takes five barrels of water to refine one barrel of crude oil, it takes 150 to 250 gallons to can a case of spinach or tomatoes, and 1.6 million gallons to sustain an acre of land for a growing season. In the little table of statistics from which I got these figures, it told how many gallons of water it took to produce a barrel of beer. Well, I'm a diabetic and can't drink beer, so I just marked that one out. It's of no real use to me.

It may be appropriate here to recall some of the highlights of the saline water program. It was after World War II that the increasing demands of our large urban centers expanding population and industrial growth required a new look at our water needs. To be sure, the Southwest and other similarly affected regions were no less arid than they had been, but, because of population and industrial growth the water issue, as a national matter, received increased public interest. The Truman Administration exhibited real interest in Saline Water Conversion. In hearings before the House Appropriations Committee consideration was given to the possibilities of a supplemental budget request to enable the Bureau of Reclamation, which Secretary Udall now presides over, to initiate an elaborate research program. However, the Committee voted to wait for specific legislative authority before appropriating funds even though water conversion was considered to be a meritorious endeavor this report said.

Early in 1950, President Truman recommended that the Congress enact legislation authorizing the initiation of research to find means of transforming fresh water in large volume at economical cost. That's not too many years ago, you realize, when we see this plant here today. A bill introduced by the late Senator Joe O'Mahoney from Wyoming provided authority for one demonstration plant in a general program designed to increase and conserve existing water supply. It was to have been a twenty-five million dollar program under the direction of the Secretary of the Interior. But, the bill died at the end of the session. No action was taken on the President's proposals until the 82nd Congress when identical bills were presented by Senator O'Mahoney and Representative Engle, now Senator Engle, of California. These bills called for research into and demonstration of practical means for economical production from sea or the saline water or from the atmosphere including cloud formation of water suitable for agriculture, municipal, industrial, and other beneficial consumption uses. After much discussion and a number of amendments Mr. Engle's bill passed and was signed into law July 3, 1952. This statute, known as the Saline Water Act, provided two million dollars for a 5-year research program, but they made no provision for demonstration plants.

No matter how modest the start, the ice had been broken and Federal participation in desalinization research was firmly established. The 1952 Act was amended in 1955. The program was extended from 5 years to 14 years, the funding increased from two million dollars to ten million dollars. It was expected that a stepped up program would bring earlier results. But, demonstration plants still had not entered the picture. In the years between 1955 and 1958, the saline water program was discussed at great length in the Congress with a great amount of concern over the lack of concrete results.

During the second session of the 85th Congress, I introduced a resolution to provide for the construction by the Department of the Interior for a full-scale demonstration plant for the production from sea water or other saline water to water suitable for agricultural, industrial, municipal, and other beneficial uses. The number of demonstration plants was increased finally from one to five.

Maybe I should say that when I introduced a change in the bill from one plant to five, I originally had a provision that there would be three plants in the interior parts of the United States, one on the West Coast, and one on the East Coast. The bill was commented on pretty liberally by writers and other people and I got a call from the then majority leader of the Senate, Lyndon Johnson of Texas, who said, "Don't you know that this country has three coasts, the East Coast, the West Coast, and the Gulf Coast, and if you don't put the Gulf Coast in there, you don't need to expect to pass your bill."

Well, of course, I recognized that there was such a thing as strategy, and I modified my bill to include all three of the coasts and was very happy to see the success it achieved in the Senate soon after. So when we discuss what to do on these bills, Stewart, you and I realize that there are more things to consider than just the geographic limits of the United States as we imagine them. And, I want to say to you that the first plant built, by the way, very accidentally I'm sure, was at Freeport, Texas. You and I all recognize that once you give Texas a chance, it will run with the ball and it did in a very acceptable fashion. Several of us were down to Freeport when that plant was dedicated, and a very fine plant it is. Of course, there was no background noise like we had here today because it wasn't running yet. They didn't get it ready in time.

I commend the people who had our plant ready here today. As a matter of fact, when I listened to that noise I thought once that I would like to have it shut off. But, I remembered something that happened one day. President Truman was given a set of bells by the Dutch government, I guess Queen Wilhelmena had them sent to him. It was a very fine sounding group of bells. An expert player was brought over to play, and we were all invited to go out and listen to them.

I was at a meeting of the World Food Board and didn't think I could quite get away. When I finally finished, I told my car to dash out there. I got there just in time to have a big policeman say, "No, the program has started, you are going to have to stay back here."

So I stayed in the very, very far background and finally after the speeches they started to play on these bells and it was very nice. I turned to the man next to me and said, "That's very fine isn't it?"

And he said, "What did you say?"

And I said, "It's a very pleasant sound from those bells, isn't it?"

He said, "What'd you say?"

And I said, "Excellent music, isn't it?"

And he said, "Stranger to tell you the truth, those damn bells are making so much racket that I can't hear a word you are saying."

Well, the plant this morning made so much racket that I couldn't hear everything that was said, but I was so glad to see it running I didn't care. Despite a good many objections to the construction of these plants, passage of the resolution in the 85th Congress gave us the third big step in our national saline water effort--a large new program to demonstrate the economic possibilities of conversion.

In 1961 the Congress was again concerned with keeping this program moving. As many of you may remember, we had a new administration headed by a former Senate colleague of mine. In his message to Congress that year, President Kennedy requested that this country make every effort to search for low cost processes for converting sea and brackish water into fresh water to meet out future needs and those of our neighbors throughout the world. I had a little something to do with suggesting that there might be a phrase like that somewhere in the message.

I had gone as a representative of this country to a nuclear conference in Geneva, Switzerland. At one of the luncheons I was placed next to Dr. Homi Bhabha who was the chairman of the conference, and a great expert on nuclear power from the government of India. He has recently visited this country again and I had an opportunity to renew my acquaintance with him. As we sat down to lunch in Geneva, seated next to me was Ralph Bunch, because he had gone to school in Albuquerque, I guess, and then Sobolev, a great scientist, who was the Russian representative in the conference, as I was from the United States. I tried to get Homi Bhabha from India into some sort of conversation and I finally got him talking a little bit and he turned to me and said, "I want you to know one thing, and tell your son and colleagues this thing. We are not interested in your bombs, we are not interested in the things you can bring us that you can say to us 'with this you can blow your neighbors to bits'. We are not interested in blowing our neighbors to bits; we are interested in trying to do something to lift from the backs of mankind some of the burdens now upon them."

I think, Mr. Secretary, that's the real virtue of this program today, that the saline water program offers perhaps one of the greatest chances of all to lift some of the burdens from the backs of those people who live around many of these areas; the burdens they now face to make it possible to live as some of our people do.

So, in response to the President's appeal in 1961, Congressman Aspinall from Colorado, and I introduced legislation to further expand the saline water program. The resulting act authorized an additional 75 million dollars for research and vital plant activities. This provided the added emphasis needed to carry on a concentrated Federal effort. The research program has been very rapidly accelerated and problems are now being investigated which may provide us with a series of break throughs necessary for success.

I am told that since the saline water program began in 1952, the cost of converting 1,000 gallons has dropped from $4.00 to $1.00. This is indeed a significant achievement, but we realize that it is not enough. More demonstration plants will undoubtedly be necessary, such as the one currently under study for the Florida Keys. Mr. MacGowan told me this morning that the reason we may be able to build a plant on the Florida Keys is because of the San Diego plant's success. And that is the way these things go, you move from one success to another, each being a little better than the last, and finally you get to something you want real badly. You heard the Secretary refer to this great demonstration they are planning which will involve tremendous supplies of water and utilize our nuclear power as well. That is being done at Oak Ridge by Philip Hammond who is a scientist at Los Alamos.

Also, there is the possibility Mr. Secretary--I think maybe I can say what you probably won't want to say--there is a possibility, and I say it only as a possibility, that processes may be developed that will produce electric current at 2 to 3 mills, and some people say a mill and a half, and make possible at the same time the production of potable water at as low as 20 cents per thousand gallons. That's a long time in the future. It may never be achieved, but it is a very worthwhile goal. And I compliment day by day our great Secretary of the Interior for his courage in being able to say, "I will try it, I will not just stand back." I am confident that you in water activities will continue to carry on this important work, and I am equally certain that we in Congress will continue to support it in every way that we can.

When he was still the Senior Senator from Texas, Vice-President Lyndon Johnson, commented that a civilization of faucet turners can regard water supply indifferently--the generation of bucket carriers and cloud watchers cannot. We in the Southwest certainly follow in this second category; but, I think even the faucet turners are waking up to the water problem. This is to our advantage for we will all profit from the heightened awareness of a national need to move forward together to meet it.

I compliment this gathering here today. I congratulate the state of New Mexico on its first plant. I know it is the fore-runner to many fine things to come. It will mean a great deal to us industrially and agriculturally, and we will profit for years and years because of the effort now being made in this community and in this state.

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

Charles F. MacGowan[1/]

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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1/ Director, Office of Saline Water, U. S. Department of the Interior, Washington, D. C.

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

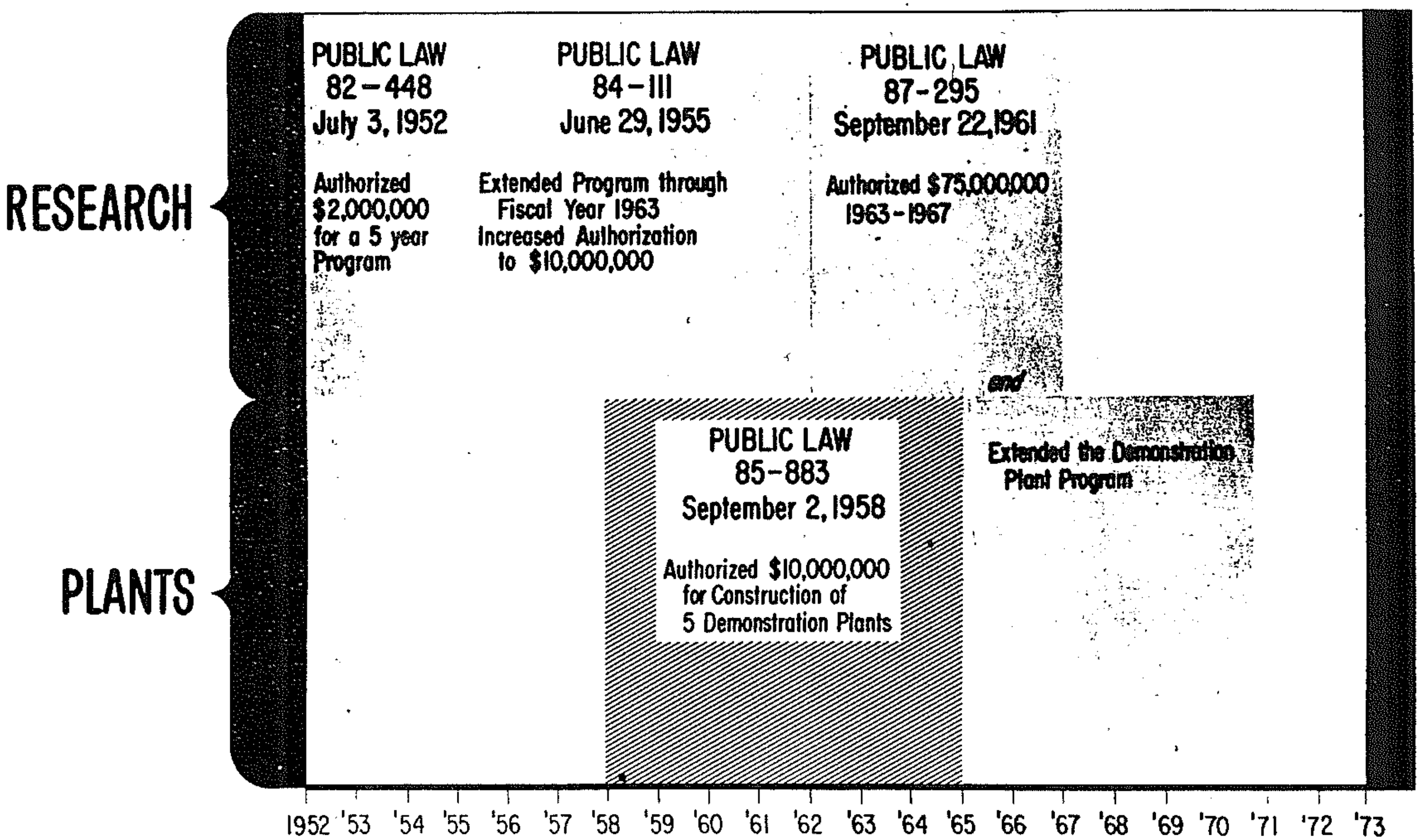
Three of the authorizations deal primarily with research and development. One of the authorizations, that of 1958, has to do with demonstration plants. Briefly, here is their content: Public Law 82-448 of July 3, 1952, authorized a $2 million program, over a five-year period. In 1955, as of June 29, 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)

U.S. DEPARTMENT OF THE INTERIOR

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

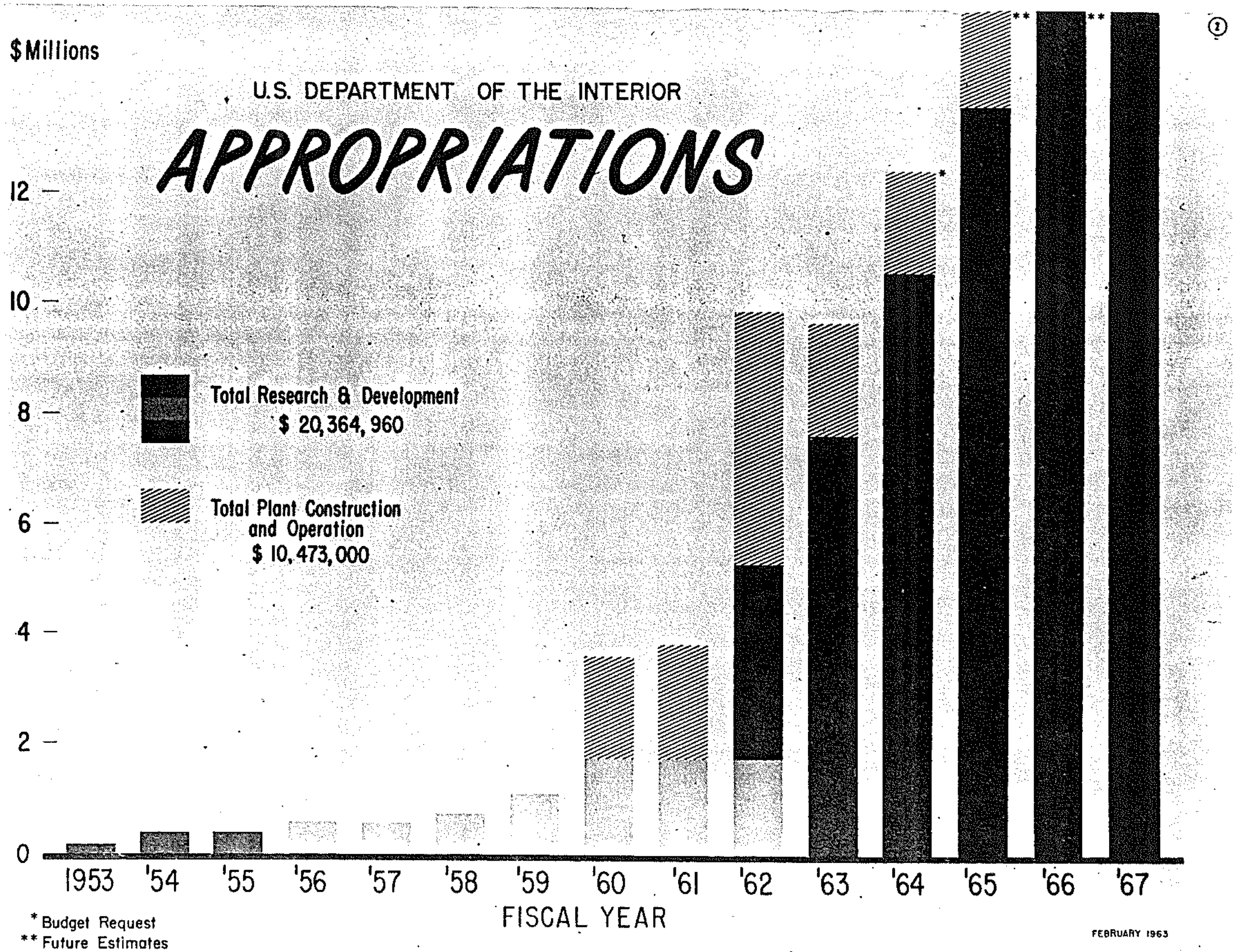
The second slide is a graph that shows the appropriations from 1953 through 1962, a period of 10 years. The annual appropriations are shown in colors which correspond to the four authorizations described earlier. The future columns show the budget request for 1964 and rough estimates of probable future 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
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8
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Total Research & Development
$ 20,364,960
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and Operation
$ 10,473,000
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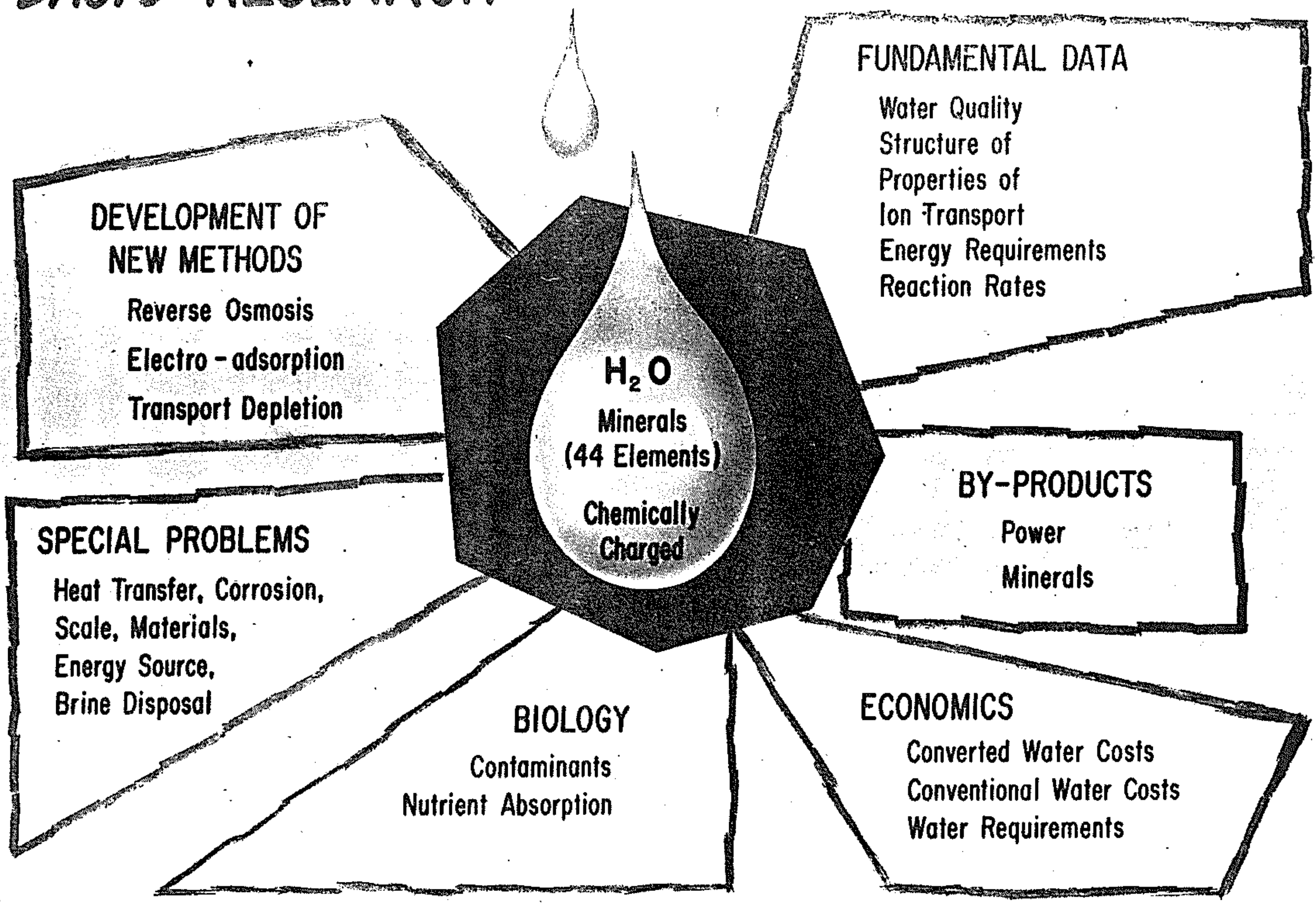
BASIC RESEARCH



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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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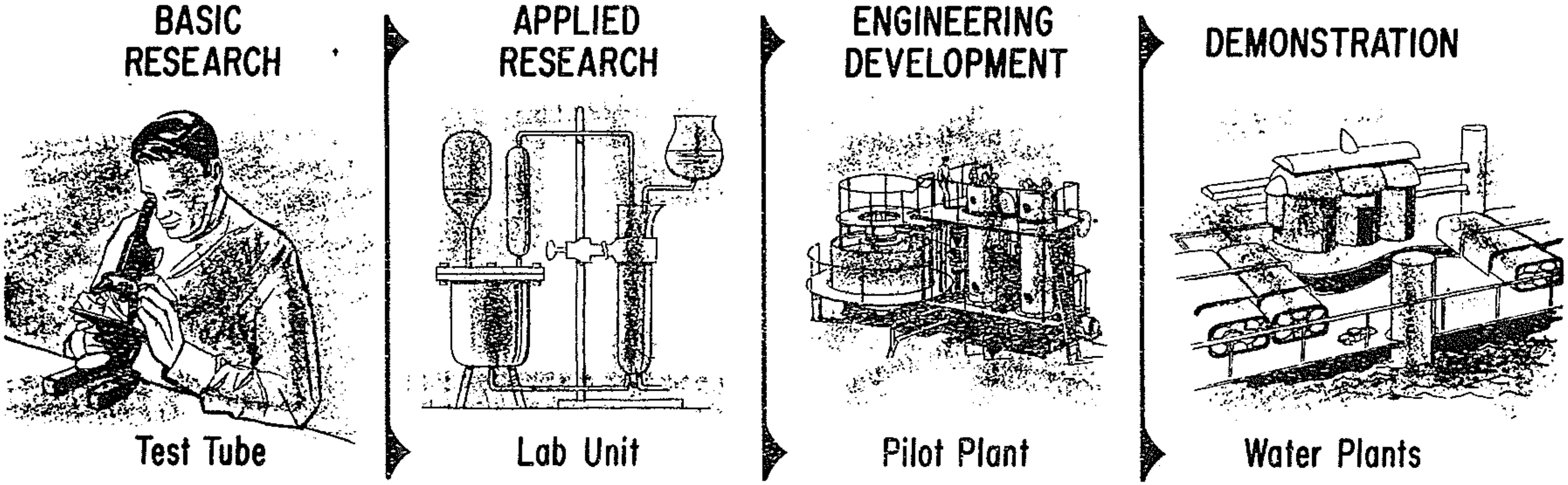
DEVELOPMENT OF CONVERSION PROCESSES



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

U.S. DEPARTMENT OF THE INTERIOR

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.

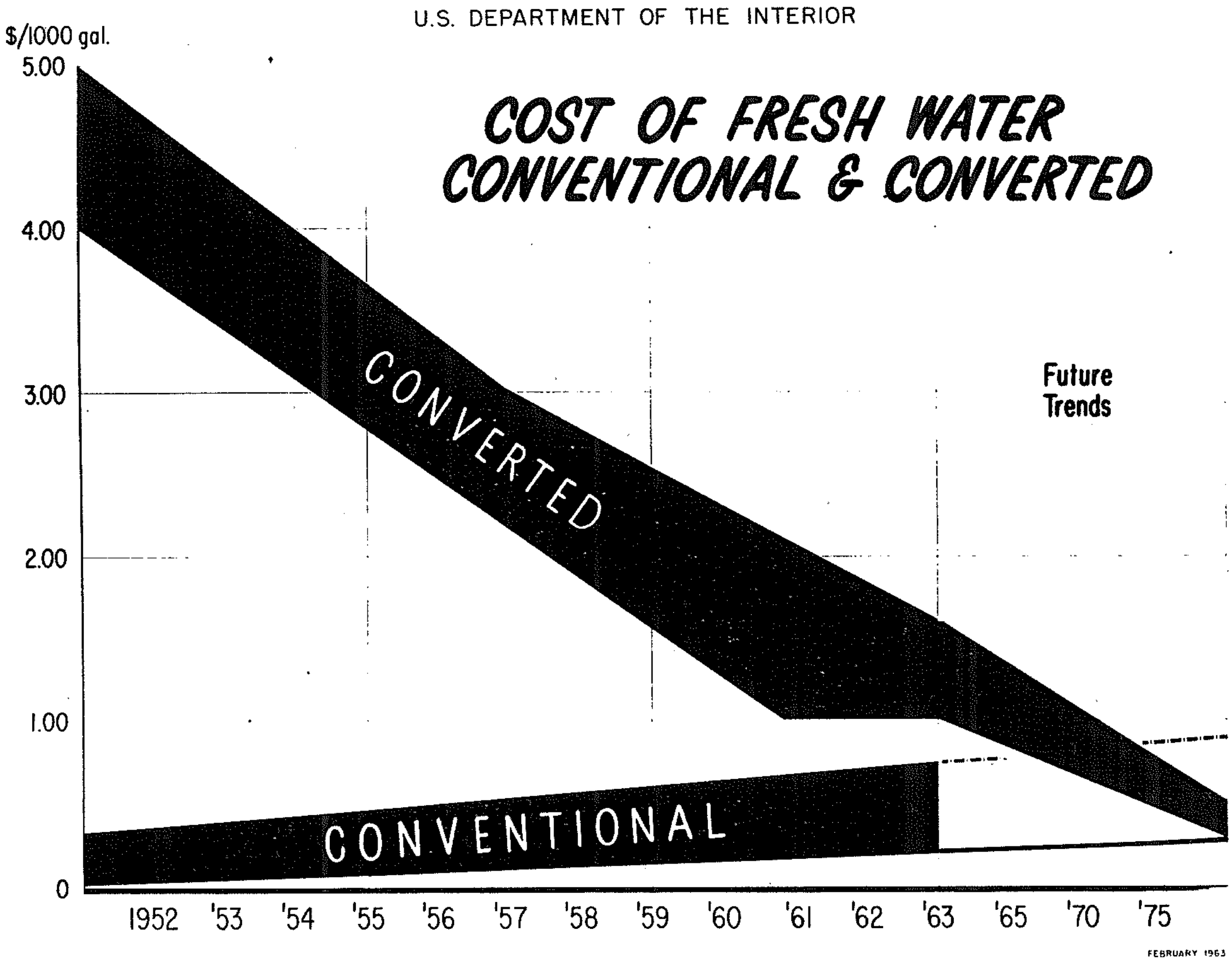
In 1952, the cost of converted sea water varied from about $4.00 to $5.00 per thousand gallons. In 1963, the comparable cost has been reduced from about $1.00 to $1.50. These costs have been kept on the conservative side. They are based on 20-year amortization of capital investment, with 4 percent interest. 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.

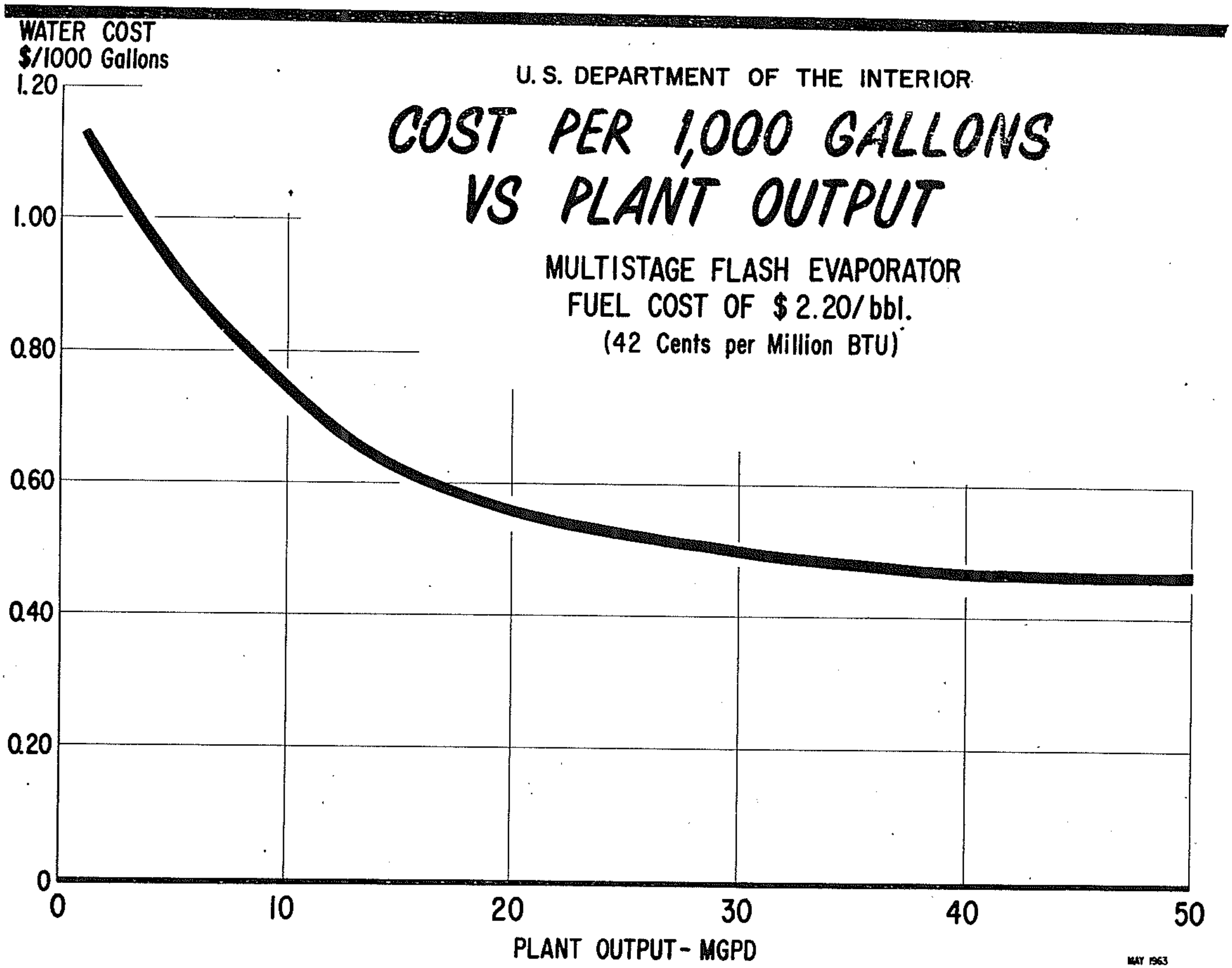
The chart also shows possible future trends. If plants of sufficient size are constructed, the cost could drop so that the cost of saline water may well be competitive with conventional sources.

Cost Per Thousand Gallons Versus Plant Output

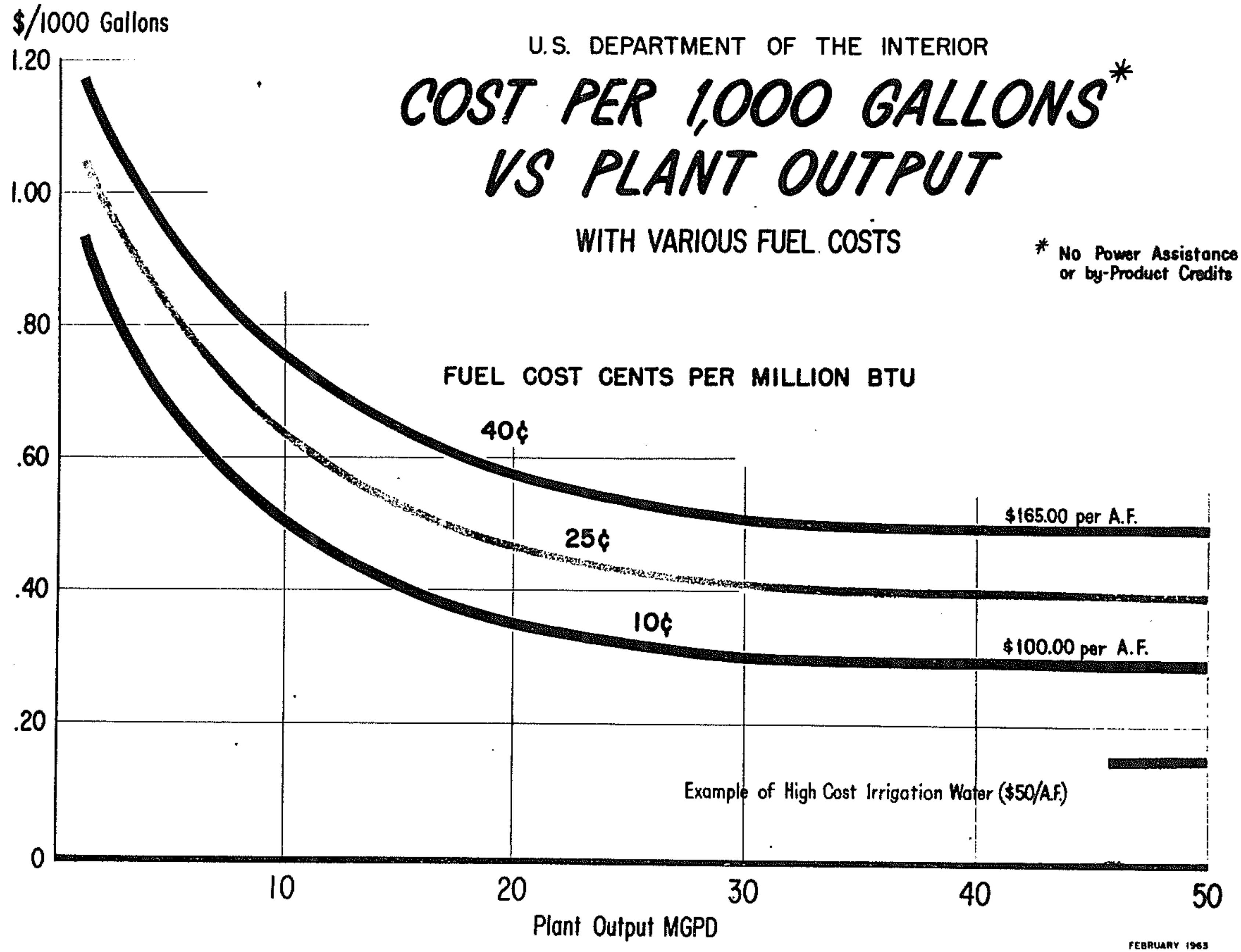
The next slide, entitled, "Cost Per Thousand Gallons versus Plant Output," is more specific as to the cost of converting sea water to fresh water. For this chart, we have assumed a fuel cost of 42¢ per million B.T.U. You will note that the vertical ordinate



U.S. DEPARTMENT OF THE INTERIOR
$/1000 gal.
5.00
4.00
3.00
2.00
1.00
0
COST OF FRESH WATER
CONVENTIONAL & CONVERTED
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
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)
1.20
1.00
0.80
0.60
0.40
0.20
0
0
10
20
30
40
50
PLANT OUTPUT - MGPD
MAY 1963


$/1000 Gallons
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.)
1.20
1.00
.80
.60
.40
.20
0
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.

THE ROSWELL SALINE WATER CONVERSION PLANT--
ITS IMPORTANCE AND MEANING TO NEW MEXICO

S. E. Reynolds[1/]

New Mexico has a considerable stake in experimentation with various processes of desalinization currently being carried on by industry and government, and she has expressed her interest in a variety of ways.

Public Law 85-883, sponsored by New Mexico's Senator Clinton P. Anderson, authorized the Secretary of the Interior to construct, operate, and maintain for a limited period of time not less than five demonstration plants to produce, from the sea or from brackish sources, water suitable for agricultural, industrial, municipal, and other beneficial uses. Under terms of the act, which became effective on September 2, 1958, at least one of the five plants was to be located in the semiarid Southwest.

In October 1958, Governor Edwin L. Mechem of New Mexico by letter advised Secretary of the Interior, Fred E. Seaton, of benefits which would result from construction of a brackish-water conversion plant in New Mexico. The letter cited 16 New Mexico communities of more than 1,000 population which were utilizing, for public supply, water whose quality was below recommended standards of the United States Public Health Service. The 16 communities were Artesia; Carlsbad; Fort Sumner; Hagerman; Jal; Roswell; Santa Rosa; and Vaughn in the Pecos Valley; Espanola and Truth or Consequences in the Rio Grande Valley; Alamogordo, Carrizozo, and Tularosa in the Tularosa Basin; Aztec and Farmington in the San Juan Basin; and Hurley in Grant County. The letter also invited attention to the tremendous saline-water resources of New Mexico, and expressed the hope that means could be devised to render this potentially valuable resource available for beneficial use.

Secretary Seaton's reply to the Governor's letter, dated November 5, 1958, suggested a cooperative agreement between the Department of the Interior and the State of New Mexico providing for mutual technical assistance and exchange of information concerning techniques of brackish-water conversion. This agreement subsequently was executed. A similar agreement was entered by the Department of the Interior and New Mexico State University.

The third New Mexico Water Conference, held at University Park, on November 6 and 7, 1958, had as its theme "New Mexico

1/ State Engineer for New Mexico, State Engineers Office, Santa Fe, New Mexico.

Water--Present Use and New Sources," and Public Law 85-883 received considerable conference attention. Senator Anderson delivered an address on the subject of congressional interest in the Nation's water resources. David Miller, eminent consulting ground-water geologist, presented a paper titled "Development and Utilization of Saline Ground-Water Resources." John O'Meara, special assistant to the Secretary of the Interior, described various tried methods of desalinizing water.

On November 7, 1958, the third Water Conference adopted a resolution commending Senator Anderson, Secretary Seaton, and others instrumental in enactment of the conversion plant statute, and urging that the authorized southwestern plant be located in New Mexico. The resolution established a standing committee to cooperate with the Senator and the Secretary to work with the State Engineer and other officials in selecting potential plant sites within the State, to keep appropriate officials in Washington keenly aware of New Mexico's interest during the period in which various potential sites were being considered, and to do all things possible to establish the feasibility of constructing a conversion plant in this State. The committee was headed by Mr. Rogers Aston of Roswell, a member of the Water Conference Advisory Committee. Organizations cooperating with the standing committee in its efforts included the New Mexico Geological Society, New Mexico Oil and Gas Association, New Mexico Bankers Association, New Mexico Economic Development Commission, Southeastern New Mexico Chapter of the American Petroleum Institute, Realtors Association of New Mexico, and the New Mexico Farm and Livestock Bureau.

On November 17, 1958, the State Engineer transmitted to the 16 New Mexico municipalities cited by the Governor as utilizing inferior water supplies questionnaire forms suggested by the Department of the Interior's Office of Saline Water for assembly of data required to evaluate the merits of each community as a potential site for the southwestern plant. Eleven of the municipalities completed questionnaires and forwarded them to the OSW in Washington, together with requests that their communities be considered as sites for the plant.

Owing in no small measure to efforts of the Water Conference Standing Committee and its supporting groups and associations, the 24th Lesgislature of New Mexico in 1959 authorized the State Engineer to enter a second cooperative agreement with the Office of Saline Water, under which New Mexico would pay 10 percent of the cost of constructing a brackish-water conversion plant, up to a maximum expenditure of $100,000 provided the plant should be located in New Mexico.

Later in that month, Mr. W. W. Rinne of the Office of Saline Water made a preliminary inspection of the 11 proposed New Mexico sites. He was accompanied during the inspection by personnel of the State Engineer Office and the Ground Water Branch of the Geological Survey. These agencies also supplied to the OSW basic and interpretive data pertaining to the water resources of each of the New Mexico sites under consideration.

On the basis of Mr. Rinne's preliminary investigation, the Site Selection Board of the OSW narrowed the field of potential sites for the southwestern plant from the 55 originally considered to 10--5 in Texas, 4 in New Mexico, and 1 in Arizona. New Mexico communities still in the running were Alamogordo, Carlsbad, Roswell, and Santa Rosa. Accompanied by personnel of the State Engineer Office and the Geological Survey, the Site Selection Board visited the four New Mexico communities between November 7 and 11, 1959, to inspect proposed sites and to interview municipal officials with regard to the various problems associated with final site selection.

On February 3, 1960, Secretary Seaton announced that Roswell had been selected as the site for the southwestern brackish-water conversion plant, and that the forced-circulation vapor-compression distillation process would be used, in a plant to be designed and constructed to produce at least 250,000 gallons of fresh water daily. Production capacity of the plant later was increased to about a million gallons a day.

Under contractual agreement with the Office of Saline Water, the City of Roswell provided a 7-acre site for the plant and agreed to deliver to the plant daily about 4 acre-feet of raw water containing some 25,000 parts per million total dissolved solids, for conversion to nearly pure water containing less than 50 parts per million. The city agreed further to purchase the product water and to dispose of the brine effluent, which will amount to from 1 to 1½ acre-feet per day of water, with a dissolved salt content of approximately 100,000 parts per million (three times the salinity of sea water, four times the salinity of the raw water feed).

On April 6, 1962, Secretary of the Interior Stewart L. Udall announced the award of a contract in amount of $1,794,000 to the Chicago Bridge and Iron Company for construction of the plant. The installation was to be completed within 1 year, followed by an acceptance-test period of 75 days. The contract was fulfilled, and the first brackish-water conversion plant in the Southwest using the vapor compression process is now operating.

No one believes that this plant will solve all the water problems of the Roswell Basin. Overall, we can expect only a very modest measure of relief from this first desalting plant, but it will help improve conditions locally by slightly reducing the amount of fresh water being withdrawn from the basin, and by slightly decreasing the tendency for saline water to move into portions of the aquifer where the water is still fresh. Also, the plant's product water, which will amount to about 10 percent of the city's annual usage, can be used to give the people of Roswell water of a little better quality, to attract specialized industries requiring water with a very low concentration of dissolved solids--or both.

Perhaps the most significant fact of all is that, by acting with dispatch and great determination to have the southwestern conversion plant located in New Mexico, the people of Roswell and the State as a whole demonstrated clear recognition of their obligation as custodians of our resources by contributing materially to a program which promises to enhance the future of the State, and the nation as a whole, by increasing the quantity and improving the quality of our usable water supplies. These contributions undoubtedly were determinative in the site-selection committee's decision that this plant should be located in Roswell.

What are the potential benefits to the rest of the State?

New Mexico reportedly has about 15 billion acre-feet of saline ground waters of a quality which ranges from brackish to brine. If only one-tenth of these saline waters could be mined, desalinized, and conveyed to places where water is or will be needed, we could supply for 1,000 years as much water as we are presently pumping from our ground-water reservoirs. These salt-laden waters, which in the past have usually been considered a curse in this arid land, may yet become one of our greatest blessings.

As has been noted, the desalinization techniques being developed and evaluated in this and the other demonstration plants across the nation promise not only to increase the total quantity of water available for beneficial use but also to improve the quality and utility of waters presently being used. In New Mexico, there still are at least 16 communities of more than 1,000 population using substandard water for public supply. Desalinization of these supplies could make an important contribution to the welfare and comfort of the citizens of these communities and their visitors.

In addition to the potential for improving the utility of presently developed water supplies, there are important potentialities for applying desalinized water to new uses in New Mexico. Let us take, for example, Lea County on the Southern High Plains.

As everyone here probably is aware, Northern Lea County contains one of New Mexico's most intensive ground-water developments--primarily for agricultural use. Water there is being mined; that is, the annual withdrawals, currently averaging about 170,000 acre-feet annually, greatly exceed the average annual recharge of 30,000 acre-feet and the estimated 25 million acre-feet in storage is being depleted. Controls instituted in 1952 envision withdrawals of up to 440,000 acre-feet per year with a resultant economic life for agriculture of about 40 years--at the end of which period it was believed that the aquifer would be so depleted that agriculture could not thereafter pump water economically for irrigation.

I might remark that recent studies indicate that rates of withdrawal in Lea County have not been as great as anticipated and water may remain economically available for a somewhat longer period than was originally estimated. But, whenever and wherever water is mined on a sustained basis, there ultimately must come a time when the supply will be depleted.

Lea County also contains rich oil and gas fields where the estimated reserves are increasing as a result of exploration and discovery despite steady production. When the saturated thickness of the fresh-water aquifer in Lea County has been reduced by about two-thirds, well-production capacity will be low and it probably will be uneconomic to produce water for irrigation. It probably will be economically feasible for municipalities and industries to pump much of the remaining water for their use, utilizing numerous low-production wells. Nonetheless, it seems reasonable at this time to anticipate that there will be demands for water for oil and gas production and processing and other industries, as well as for municipalities, when the fresh water resources of the area are essentially depleted. If the practicability of desalination can be demonstrated, saline waters and brines--abundant in Lea County--can be used to meet these demands for an indefinite period of time.

Another area that comes to mind is the Tularosa Basin. This arid valley has become an important center of military and space research and development. Rocketry is still in its infancy and there are indications that these activities in the basin may be stepped up.

Research and development and the people associated with it require water. If the program continues to grow it could ultimately overtax the fresh water resources of the Basin. Water is already being imported from the Hondo Valley to the east and more could be imported from other drainages, for example, the Rio Grande, to meet the needs of almost any conceivable program.

However, the USGS has estimated that 143 million acre-feet of saline water underlies the arid floor of the Tularosa Basin, and this water--right at the doorstep--could be developed and refined by one of several proven processes being demonstrated here in Roswell and elsewhere. Under the program of the Office of Saline Water the cost of desalination is steadily being driven downward. Under Secretary of the Interior Carr recently told a Congressional Committee that fresh water from ocean water could be produced from known processes at about 30 cents per thousand gallons.

It does not seem visionary to suggest that when more water is needed in the Tularosa Valley it may be found more economical to pump and refine water from the local saline aquifers than to pipe another auxiliary supply into the basin from a distant river whose supply is already fully appropriated. This solution to the problem would be especially attractive inasmuch as it would accomplish the end desired without buying and transferring water rights and uses and disturbing going economies elsewhere.

There are many other areas in New Mexico where fresh water for new uses could be obtained by conventional means only at great expense by transportation over long distances. In general, there also would be the added expense of acquiring rights from present users of fresh water, as well as attendant disruptions of going economies. The unit cost of water obtained in this fashion would be particularly high in cases wherein the quantity needed is relatively small.

The Raton and Las Vegas Plateaus in the northern part of the State provide an example of a large area deficient in fresh surface-water and ground-water supplies. However, there almost undoubtedly are large amounts of saline water available from the Upper Cretaceous Formation which is 3,200 feet thick under much of the region. Similar conditions exist in the Gallup area, in much of Rio Arriba County, and elsewhere in the State where rocks of Cretaceous age occur.

Even at the present stage of development of desalinization processes, it could be economic to develop and convert saline water for municipal and industrial uses in such areas.

Desalinization demonstration plants such as the one dedicated at Roswell today will make it possible for us to evaluate the economic feasibility of enhancing our total water resources through use of treated saline water and will give us the experience needed to do this in the most practical and economic fashion. In this direction, it may be noted that most saline water in New Mexico contains relatively high concentrations of sulfate; the process chosen for demonstration at the Roswell plant is particularly adapted to handle water whose sulfate content is high.

I think we all may be proud of the pioneer work the United States is doing in the field of water desalinization to improve and insure the welfare of people the world over. I think we may be particularly proud of the contribution to this work that is being made by the people of Roswell and the State of New Mexico.

ENGINEERING DESIGN OF THE ROSWELL WATER CONVERSION PLANT

Edward H. Lebeis, Jr.[1/]

This paper describes the saline water conversion plant located at Roswell, New Mexico. This plant, with an output capacity of one million gallons of fresh water per day, is the fourth of the demonstration plants authorized by the Office of Saline Water of the U. S. Department of the Interior, under Public Law 85-883. The selection of Roswell as the plant site was made by a board empaneled by the Office of Saline Water (OSW), and the OSW had stipulated that this plant employ a forced circulation vapor compression distillation process.

Catalytic Construction Company was engaged by the OSW as the engineering design contractor late in 1960. Under this contract, Catalytic's primary responsibilities were to establish the conceptual process design and to prepare definitive drawings and specifications as a basis for competitive bidding for the plant construction contract. The final design drawings and specifications were issued by the OSW in the fall of 1961, and the construction contract was awarded in the spring of 1962.

While the vapor compression process is not new, relatively few large scale plants have been built incorporating this feature and none with a capacity as large as one million gallons per day. This is the first high capacity plant to couple series staging of evaporators with vapor compression. Another distinctive feature of this plant is that it is designed for a brackish water feed which is probably the most difficult to handle of any water ever to be fed to a conversion plant. The concentration of the calcium sulfate (gypsum) can reach very high levels. The natural tendency is for much of this gypsum to deposit on the heated surfaces. In the Roswell installation, the problem of fouling of heat exchange surface with calcium sulfate scale is avoided by ion exchange pretreatment of the feed brine. This represents the first large-scale adaptation of this technique to this problem. An alternative scale prevention technique is also incorporated--recycling of calcium sulfate crystals, generally referred to as the sludge recycle technique.

In the following sections the major design problems are discussed, with particular emphasis on those problems arising from the water composition and from the fact that this is an inland

1/ Process Designer, Catalytic Construction Company, Philadelphia, Pennsylvania.

installation. Following this, the process is described and the reasons are given for the selection of various features of the design. Lastly, the efficiency of this process is treated.

DESIGN PROBLEMS

Feed Brine Composition

The feed to the vapor compression plant is drawn from a well near the eastern edge of the plant site. Emerging at the well head, it has the current analysis shown in Table I. The total dissolved salts content is 16,000 parts per million (1.6 weight per cent). While common salt, sodium chloride, is the major constituent, accounting for about 80% of the total salinity, the bulk of the remainder consists of calcium and magnesium sulfates. Calcium and magnesium bicarbonates (alkalinity) represent minor constituents; nevertheless, almost all of this can decompose thermally to form a scale of calcium carbonate and magnesium hydroxide on heat transfer surfaces.

At the time that the engineering design work was in progress, the supply well had not yet been drilled. Based upon the analyses of test wells available then, the plant design was set up to handle water with total concentrations up to 24,000 parts per million of total salts. Thus, a considerable increase in salt content can be tolerated without prejudicing the operation of the conversion plant. The design analysis is also shown in Table I.

The brackish water feed analyses, both design and current, are compared with normal sea water in Table II. Although Roswell water has only one-half to two-thirds the salinity of sea water, it is richer in scale formers. According to the current analysis the calcium content is 35% higher than that of sea water, sulfate is 43% lower, and bicarbonate is 75% higher. Although sea water has a very much higher magnesium content, this is of minor significance since magnesium sulfate is very soluble.

Should the total salinity reach the value on which the plant design is based, the calcium content would be more than twice that of sea water, and the sulfate content about 20% higher than that of sea water. This water is essentially saturated with respect to calcium sulfate, so that scaling could take place upon evaporation of only a small amount of water.

When operating at a concentration factor of 4 (75% potable water yield) the scaling potential of Roswell brine is about 5 tons per day based on the current feed analysis. The corresponding figure is 10 tons per day based on the design feed analysis. This is the quantity of calcium sulfate, calcium carbonate and

TABLE I

ANALYSIS OF ROSWELL BRINE

(Units: Parts Per Million)

	Design	Current
Total hardness (as $CaCO_3$)	3,262	2,145
Calcium hardness (as $CaCO_3$)	2,340	1,370
Magnesium hardness (as $CaCO_3$)	922	775
Alkalinity (as $CaCO_3$)	155	202
Chlorides (as Cl)	11,820	8,064
Sulfate (as SO_4)	3,200	1,528
Iron (as Fe)	0.38	Tr.
Silica (as SiO_2)	15	Tr.
Calcium (as Ca)	936	549
Magnesium (as Mg)	224	303
Sodium (as Na), by difference	7,780	5,000
Total dissolved solids	24,470	15,860
pH	7.1	7.4

TABLE II

COMPARISON OF ROSWELL WATER AND SEA WATER

(Units: Equivalents Per Million)

	Sea Water	Roswell Design	Roswell Current
CATIONS			
Sodium & Potassium	478	339	214
Magnesium	106	18	25
Calcium	20	47	28
Total	604	404	267
ANIONS			
Chloride	545	334	227
Bicarbonate	2.3	3.1	4.0
Sulfate	56	67	32
Total	603.3	404.1	263

magnesium hydroxide which could precipitate on heat exchange surfaces if adequate preventive measures were not incorporated in the design.

Although this brackish water is more difficult to process than sea water, there are several reasons to justify a conversion plant based on this type of feed.

First, heavily mineralized waters of this type occur widely, not only in the arid regions of the Southwest, but also in a broad belt extending up into the Dakotas. With the ever-increasing demand for water, it becomes more and more necessary to utilize this kind of water.

Second, these saline ground waters are encroaching upon fresh water supplies. At Roswell, two artesian aquifers oppose each other (1). Municipal water is drawn from a relatively pure aquifer flowing from the west. With increasing consumption, more saline water flowing underground from the east is entering the city supply. When the Roswell site was picked by the independent selection board, it was noted that a conversion plant located here would be of benefit in two ways. On one hand, the consumption from the municipal supply would be decreased by one million gallons a day, thereby increasing the hydrostatic head in the fresh aquifer. On the other hand, the withdrawal of saline water for feed to the conversion plant would decrease the head in the brackish aquifer.

A final reason for this selection may be found in the comments of several water experts to the effect that if this water can be converted successfully, then almost any water can be handled in a distillation, or evaporation, plant.

Inland Plant Location

Almost all of the saline water conversion plants in existence operate on a sea water feed. A notable exception is the OSW demonstration plant in operation at Webster, S. D. This is an electrodialysis plant of lower capacity with a feed of much lower salinity.

It does not take the designer of an inland plant long to encounter a somewhat distressing fact--there is no extraneous cooling water. While a sea water plant has available an unlimited supply of cooling water at a low temperature, an inland plant has only its feed water.

It will be seen that the favorable economics of the vapor compression cycle depends in large measure upon efficient exchange of heat between the hot products and the cold feed. Nevertheless, there are times when it would be desirable to have an outside source of cooling water, such as when one is considering a condensing steam turbine drive for the vapor compressor.

While the sea is a convenient repository for the concentrated brine blowdown from a sea water conversion plant, an inland site has no sea. At Roswell, the blowdown is pumped to evaporating ponds for disposal. It is obvious that the smaller the quantity of blowdown, the less the disposal problem.

The volume of blowdown brine is an inverse function of the concentration factor. This is the ratio of the weight of feed brine to that of the blowdown. It is also the ratio of the concentration of salts in the blowdown to that in the feed.

With a brine feed rich in salts, an upper limit on concentration factor is imposed by boiling point elevation. This represents a thermodynamic inefficiency which makes increasing amounts of the energy supplied to the process unavailable as the final salt concentration rises.

The maximum concentration factor is dictated not only by boiling point elevation, but even more by scaling considerations. Although scale formation can be prevented by the use of ion exchange up to a concentration factor of 4, there is a concentration factor limit past which this technique will not be effective.

PROCESS DESCRIPTION

The vapor compression plant is designed to operate with either of two methods of scale prevention. The process will be described for both methods. A simplified process flowsheet is shown in Figure 1 appended.

Ion Exchange Process

In the first step of this process the feed brine exchanges a major portion of its calcium for sodium in an ion exchange unit. This operation is identical to the well-known softening of water with zeolites. The brine is then warmed to about 145°F by heat exchange with product water and blowdown, followed by acidification to break down bicarbonates. Carbon dioxide and dissolved gases are removed under vacuum in the degasifier. The effluent brine is then neutralized and further heated by exchange with product water and blowdown.

Having reached a temperature at which the evaporator system can operate at thermal equilibrium, the feed brine is introduced into the first evaporator. In each evaporator about 90,000 gallons of water per minute is constantly recirculated by an axial-flow pump. The flow is from the vapor body down to the pump and then up through the tubes of the evaporator heat exchanger, emerging again in the vapor body. A high liquid level is maintained in the vapor body. This imposes sufficient hydrostatic head on the liquid that boiling cannot occur in the tubes. Boiling can, and does, occur as the hot liquid rises up into the vapor body.

Approximately, 250 pounds of water is recirculated for every pound vaporized. The water temperature rises 4°F as it passes through the heater tubes. After leaving the tubes, the excess heat represented by the 4°F temperature rise is absorbed by the boiling operation, with the unvaporized liquid returning to the original temperature before starting upon another recirculation through the pump and heater.

Reduced to essentials, the heat required to vaporize one pound of water is supplied by cooling 250 pounds of water 4°F. The 250 pounds is then reheated 4°F by pumping it through the evaporator heater.

The heat taken up by the water is obtained from the condensation of steam on the outside of the tubes in the evaporator heater. The steam condenses at a temperature slightly higher than the temperature of the water in the tubes.

The steam produced in the first evaporator is separated from the unvaporized water in the vapor body, which is a large chamber designed to effect the separation with a minimum of entrainment of liquid in the steam.

From the vapor body of the first effect, the generated steam flows to the steam chest of the heater of the second effect evaporator. Here it condenses on the outside of the tubes in that heater, transferring its heat to the water circulating through the tubes. The heating and boiling operation in the second effect is identical to that described for the first effect, except that the temperatures and pressures are lower.

In order to recover the major portion of the heat energy of the steam generated in the second effect, the steam temperature and pressure must be raised. This is the function of the vapor compressor. This machine compresses 75,000 cubic feet per minute of steam from 2 pounds per square inch gauge to 8.5 pounds per square inch gauge. The higher pressure steam discharged by the compressor condenses in the first effect evaporator heater, furnishing the heat for evaporation in that effect.

Partly concentrated brine is withdrawn at a regulated rate from the recirculating stream in the first effect evaporator and added to the recirculating stream in the second effect. These two rates and the rate of admission of preheated feed are set so as to maintain a constant liquid level in the evaporator bodies.

The hot concentrated brine leaving the evaporation system is termed blowdown. Its sensible heat content is recuperated in large measure by heat exchange with a portion of the feed brine, the feed brine becoming heated and the blowdown becoming cooled. The cool blowdown is used to regenerate the ion exchange resin after which it is pumped to the disposal pond.

The other hot stream leaving the evaporators is the essentially pure water resulting from the condensation of steam in the steam chests of the two evaporators. The heat content of this condensate is also largely recuperated by exchange with another portion of the feed brine. Leaving the heat exchangers, the cooled condensate becomes the potable product water. According to the plant specifications, this product water must contain less than 50 parts per million of solids.

Sludge Recycle Process (Alternate Method of Scale Prevention)

When the sludge recycle system is in operation, the feed brine bypasses the ion exchange system. With the sludge recycle technique, calcium sulfate crystals are maintained in suspension in the brine at all points of the system where supersaturation with respect to calcium sulfate can be encountered.

The crystal suspension, or "sludge," is introduced downstream of the degasifier. A sludge concentration of about 1% by weight is maintained in the first evaporator effect. Leaving the second effect, the blowdown contains about 4% sludge. After exchange of heat between the blowdown and the feed brine, about 80% of the crystals are recovered. Following grinding to bring the particle size distribution within the desired range, the crystals are returned to the preheat and evaporation system. The unrecovered crystals flow to the disposal pond along with the blowdown.

DISCUSSION OF MAJOR OPERATIONS

Ion Exchange

The amount of calcium that must be removed is a function both of the concentration factor and of the temperature in the final effect of evaporation where the calcium content is highest. At a concentration factor of 4 (4 parts feed to 1 part blowdown) up to 75% of the calcium in the feed brine must be replaced by sodium to avoid precipitation of calcium sulfate. At a factor of 3, the corresponding value is about 65%.

The most interesting feature of the ion exchange system is the use of the evaporator blowdown for regeneration of the ion exchange resin. At first glance this would appear impossible because the blowdown contains exactly the same quantity of chemical constituents as the "softened" brine leaving the ion exchange system. The only difference is that about 3/4 of the water has been removed so that the concentration of each chemical in the blowdown is four times as great as in the "softened" ion exchange effluent.

The equilibrium relationship between calcium and sodium ions in the brine and calcium and sodium ions held by the resin is markedly affected by total salt concentration. It is this factor which makes it possible to regenerate with the concentrated blowdown.

This ion exchange technique had been studied by the Dow Chemical Company in connection with sea water distillation, under contract with the OSW. Because this technique could be so advantageous at Roswell, additional studies using Roswell brine were authorized by the OSW. These studies (2) proved the feasibility of ion exchange pretreatment on both laboratory and pilot plant scale. In the pilot plant, 20,000 gallons of Roswell water were fed to a vapor compression still. No calcium sulfate scale formed, and regeneration with blowdown brine was successful.

<u>Sludge Recycle</u>

The sludge recycle technique was studied experimentally by W. L. Badger and Associates under contract to the OSW. This work was performed in a forced circulation pilot plant. The results (3) showed that calcium sulfate scale would not form at the design conditions for the Roswell plant provided the slurry concentration in the first effect is maintained at or above one per cent by weight when the particle size distribution is maintained in the proper range.

Since only 80% of the solids must be recovered from the blowdown for recycle, the separation system is set up to recover the coarsest fraction, which is easiest to recover. The recovered solids are then reduced to the proper size by grinding.

Evaporation

In the distillation system, the evaporators are arranged in series with forced circulation within each effect, and forward flow of brine from the first to second effect.

Series staging in multiple effects has two advantages. One, it reduces mixing of feed and blowdown and, therefore, permits evaporation of a large part of the water from more dilute solution, resulting in a lower expenditure of work (4). Second, for each pound of steam handled by the compressor and entering the first effect heater, the number of pounds of distilled water produced is approximately equal to the number of effects.

The design specifications permitted a choice between a two-effect and a three-effect system. It was realized that a two-effect system would pose a difficult, but challenging, design problem because of the physical size of the evaporators required. The construction contractor, Chicago Bridge & Iron Co., successfully met that challenge and installed a two-effect system.

An interesting feature of the evaporators is the specification that the effective temperature difference between the condensing steam and the brine in the tubes be in the range 4.5°F to 5.5°F. This is considerably below the range of temperature differences normally employed in evaporators. Since this temperature difference is created by the vapor compressor, specifying a low value minimizes the power consumption of the compressor. The range noted above was determined in an optimizing study involving electronic computation which was made as part of the engineering design effort. The results were in substantial agreement with those of an earlier study for the OSW (5).

Another advantage of the low temperature difference is that it minimizes the possibility of scale formation. It follows that the vapor compression process is a very good choice when heavily mineralized feed must be treated.

VAPOR COMPRESSION AND EFFICIENCY

If the evaporators were rated as boilers, the rating would be 1,320,000 horsepower. The power consumption of the vapor compressor is of the order of 2300 horsepower, which represents less than 2% of the work accomplished in the evaporation system. This gives some idea of the very high efficiency which can be achieved in a vapor compression plant.

Looked at another way, about 1000 BTU's are required to vaporize a pound of water. In the Roswell plant, this is accomplished by the consumption of only 17 BTU's at the shaft of the compressor. A conventional multiple-effect evaporator would require more than 25 effects in series to equal this economy, based on the heat content of the steam consumed.

There are a number of pumps in the plant which also consume power; however, the compressor accounts for about 75% of the total power consumption.

In order to achieve this high degree of efficiency, it is necessary to preheat the brine feed to a temperature close to that in the first effect evaporator. This, in turn, requires very efficient heat exchange between the cold feed and the hot condensate and blowdown. This is achieved by utilization of true counterflow heat exchangers.

SUMMARY

The Roswell forced circulation vapor compression evaporation plant has been designed to produce one million gallons per day of high purity potable water. The brine feed to this plant may well be the most difficult to convert of any because of its high concentration of calcium sulfate. This can form scale on heat transfer surfaces to an extent that the plant could become inoperable.

Two alternate methods of prevention of scaling are incorporated in the design. One is the removal of part of the calcium by ion exchange, using the concentrated blowdown to regenerate the ion exchange resin. The other is the recycling of calcium sulfate crystals to the evaporators.

The Roswell conversion plant represents a synthesis of a number of proven operations into a novel combination characterized by very high efficiency of energy conversion. Several of these operations are being conducted on a size or capacity scale never before achieved.

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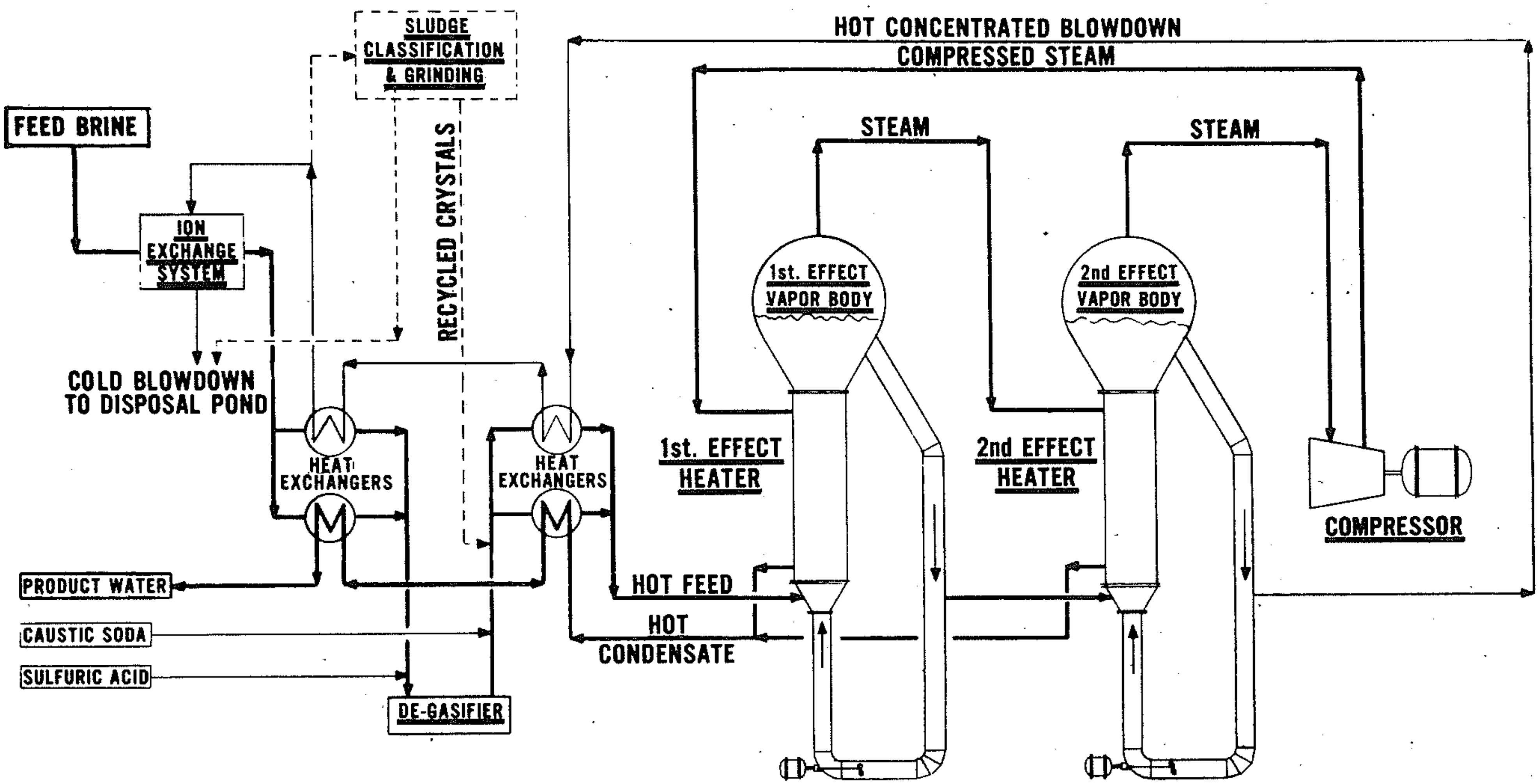

SIMPLIFIED FLOW DIAGRAM

FUTURE OF SALINE WATER CONVERSION

Francis X. Bushman[1/]

Mr. Chairman, members of panel, and ladies and gentlemen of the water conference: I am very happy to be with you today, and feel honored indeed to have been asked to say a few words. Having arrived on the New Mexico scene a dozen years ago, I have spent a good part of my time looking for water, good or bad, but looking for water. Though I have not been associated with the saline water program, I have followed the developments as reported in the press and trade journals. The dedication which most of us attended yesterday means much to us now and will mean a great deal more as time goes on.

In discussions of saline water conversion we often hear comments about the unlimited resources in the oceans, and how we may expect to get all the useable water we will need from that source as power becomes cheaper. In New Mexico, it may be a long time--if ever--before we can convert ocean water for use for irrigation at this altitude. Even when the day arrives that conversion costs are reduced to the 30 cents per 1,000 gallons range reported to a congressional committee by Under Secretary Carr early this year, the costs of lifting the water to New Mexico fields will nearly double that figure and we will still be talking in terms of $200 per acre-foot. The industrial and domestic consumer may well afford such prices, but I doubt if this will ever be true for the agricultural consumer. This then means that we need to look to supplies of saline water occurring at this elevation, which can be brought to the surface for a penny or two per 1,000 gallons, and which can perhaps be treated for less since most of these waters will be much less mineralized than sea water. Much information is already available, both as to saline water resources and as to methods of conversion. Our State Engineer, Mr. Steve Reynolds, gave us an estimate of 15 billion acre-feet of ground water in the state ranging from brackish to brine. He pointed out, you will recall, that 10% of this water--made useable--would last a long time. According to the most recent biennial report of the State Engineer this 15 billion acre-feet represents about three-fourths of the ground water of the state. The U. S. Geological Survey's district staff in Albuquerque have prepared a number of reports that will be of much help to all who are concerned with the problem.

James W. Hood and Lester R. Kister of the Survey describe the general geology of the state and the saline-water aquifers in

1/ New Mexico Institute of Mining and Technology, Socorro, New Mexico.

U. S. Geological Survey Water Supply Paper 1601, "Saline-Water Resources of New Mexico," published in 1962. They state: "Parts of most aquifers in New Mexico contain saline waters, and some of the aquifers can yield large quantities of saline water to wells." And, "Few of the aquifers in New Mexico contain exclusively fresh or saline water." Aquifers are described and tabulated, and selected examples of well discharges are noted, together with discussions of the dissolved minerals. Analyses of saline waters are tabulated and locations of wells and springs sampled are shown on maps arranged according to source aquifer. Saline surface waters are also described with particulars included for many streams and localities. This work is an excellent guide to the selection of areas meriting additional study, particularly in terms of reserves (or total supplies of saline water).

Water Supply Paper 1374, "Preliminary Survey of the Saline-Water Resources of the United States," by Krieger, Hatchett, and Poole, not of the Albuquerque District, published in 1957, provides saline surface and ground-water data on a country-wide basis.

James W. Hood, co-author of the New Mexico study is also the author of Water Supply Paper 1939-M, "Saline Ground Water in the Roswell Basin, Chaves and Eddy Counties, New Mexico, 1958-59," published earlier this year. Mr. Hood indicates that encroachment of saline water in the San Andres limestone is a serious problem in a number of areas. The work of Mr. Hood probably provided much of the source data which was used in the evaluation of this desalination plant site.

The Demonstration Plant Program of the Office of Saline Water is showing what can be done in the field of conversion. Plants in operation for some time have been performing beyond expectations and more improvements will be forthcoming. Large quantities of lower-cost water will be coming our way.

At this point, I should like to inject the thought that there is also a very real need to develop the small-quantity conversion technique to the point where it is sufficiently reliable and sufficiently non-technical so that the average home owner can operate his own unit. During the past few years, each time I read about a large unit, particularly of the electrodialysis type, going into production, I felt the need--an urgent need, for units of a size adequate to treat domestic supplies for the ranch housewife--and to treat supplies for stock watering. For example, as you travel westward from Carrizozo, and cross the Jornada del Muerto, you can see windmills on either side of the highway, some near ranch headquarters, some just "high lonesome." And everyone of these produces water in the saline range--some as high as 4,000 ppm of dissolved solids. This is just an example of one area in the arid Southwest, but it is an example which we should not and will not forget. It is my understanding that at least one manufacturer has installed a number of low-capacity units in a community in a neighboring state; in a city where it was possible to have a maintenance man readily available. I have neither read nor heard about results of those installations, but more than likely the large distances between installations in a place like the Jornada, and, the need for some servicing may keep manufacturers from actively seeking sales in such an area until all the "bugs" are finally ironed out of the units. The ranchers are undoubtedly there to stay, and we need to help provide them with a satisfactory water supply.

Along with these few random comments, I believe I was expected to say a few words about our efforts in the field of water resources at the Institute of Mining and Technology at Socorro. J. A. Schufle of the Chemistry Department has perhaps been most closely associated with the demineralization program. In an article entitled "Deionized Water by Electrodialysis" Dr. Schufle pointed out that costs of deionizing by this process are exceptionally low and that the water is equivalent in quality to distilled water. He stated further that the method is most efficient in this range, and the cell can produce water at a power consumption many times less than for a conventional still. To date his interest has been in producing a "distilled quality water" from already potable supplies. The cells used in his studies produced about 100 gallons of water per day, one of which was displayed at the Water Conference at New Mexico State University in November 1961.

Francis R. Hall of the Research and Development Staff at the Institute of Socorro has been making a study of the quality of water in a number of areas in the State. One of Dr. Hall's areas of prime concern has been the Pecos Valley. He has tabulated and plotted, made equilibrium studies and constitutent correlations, of several hundred samples in this area. His objective is to learn as much as possible about what happens to water in a limestone aquifer--what causes the changes in quality between the recharge water and the discharge area. Work such as this may have an important bearing on water management of the basin at some future time.

There are on file in the petroleum section of the Bureau of Mines Division of the Institute more than 28,000 oil and gas well records. We know from preliminary and spot inspections that most of the logs make little or no reference to water, but have hopes that a careful "swabbing" of the files may yield sufficient valuable data about the saline water resources that such a study would be well worthwhile.

From Dr. Workman, President of the Institute and Director of the Research and Development Division, on down through the ranks we have many others working in the field of water resources--on varied studies ranging from thunderstorm projects and ice studies to quantitative ground-water movement formulas such as those developed by Dr. Hantush. Other projects which have a bearing on the water resource picture include seismic studies, earth resistivity studies, and induced polarization studies, in which the emphasis has been on the improvement of techniques and instrumentation toward a better understanding of the earth below.

It should, of course, be noted that geologists of the Institute have played a large part in their mapping of goodly portions of the State. Much of this mapping was done for other studies but it certainly provides the basic guidelines for more detailed studies for ground-water evaluation.

With the mention of just one more project, I shall have about used my allotment of time. Tritium is a heavy radioactive isotope of hydrogen having a half-life of about 12-1/2 years. This property, plus the fact that it is almost nonexistent in nature, makes it valuable in tracing the flow of water in aquifers. Bomb-produced tritium, which increased the total quantity of tritium many-fold, has been of much help in the age-dating process as applied to ground water in determining how long waters--as, for example, spring waters--have been underground.

During the discussion period, I shall be happy to answer any questions you may have, regarding any of my remarks or regarding our work at Socorro.

Upon the future of saline water conversion depend the futures of many areas of the world, and these futures have a bright outlook.

THE LAW AND THE FUTURE OF SALINE WATER CONVERSION

Robert Emmet Clark[1/]

Mr. Chairman, Mr. Moderator, Members of the Conference and Guests:

As a lawyer and law professor on this program which is devoted mainly to technical and technological matters, I feel somewhat like Congressman Chenowitz of Colorado did at the dedication ceremony this morning--except that I am not a Republican. In any case, I assume that I am here as a representative of the social sciences of which the law is the oldest. And, since law is concerned with human beings rather than spiritless matter, I shall emphasize the responsibilities of human conduct.

We have heard much (the past day) about the promise that saline water conversion--and science and technology generally--hold for New Mexico and the semiarid Southwest. We are all impressed with the role science and technology are playing in the development of this new source of useable water supply. And, no doubt science and technology will eventually find a way to make it economically feasible to convert large quantities of briny water. But, it is important to remember that saline water conversion--as in other matters involving the use of natural resources--does not depend entirely, or even primarily, on science or technology. On the contrary, the dependency is just the other way around; science and technology have produced the marvels they have in our society because of the free institutions and the range of choices that we have encouraged. Science and technology do not make a free society, but a society that encourages inquiry and criticism advances science and technology. And such inquiry must not be limited, as is the case in some countries of the world, to problems of the physical world only. Galileo's discoveries about the physical universe had some of their greatest impact on the institutions of his day. We should be reminded here that our future rests as much upon our institutions and upon the inquiring nature of the human mind as upon science and technology.

I suppose the obvious example I can cite for this proposition is the prolonged and frustrating efforts we are making as a nation to get a treaty, or agreement of some kind, that will limit danger from nuclear war, or perhaps ban it, or perhaps require some kind of partial disarmament. Such an effort will, we all

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hope, end in the development of some form of institution to handle critical international situations. Such an institution will be just as much an institution as is the Pecos River Compact or the Rio Grande Compact or the Colorado River Compact.

By institution I mean no more than a man-made social, political, economic, or legal, or other device, by which groups of people solve, or perhaps only resolve, problems. (You may say that some of these institutions have not been notably successful or felicitous and you might cite the "institution of marriage" or chattel slavery which Robert E. Lee always called the "peculiar institution.")

Now some people think, and no one here is in that group I am sure, that our institutions are perfect, or nearly so, or that there is really little ground for improvement. Unfortunately, these same people often think the same way about law and particularly about water law. Some of them are still crying loudly that prior appropriation, the law of capture, the law of first in time first in right, is the West's unique and perfect contribution to jurisprudence--some of them are asserting this in spite of the fact that the crude law of capture was greatly modified in New Mexico in 1907 and has been changed still more in the past 30 years especially with respect to ground water; changed so much in fact that prior appropriation is not in fact the same institution in the Lea County or Roswell ground-water basins as it was on the Rio Grande and the Pecos 75 years ago.

New Mexico ground-water law offers a fine example of the development and also the modification of institutions.

Some of you know the history of this valley. Maybe some of you don't know that in the 1920's the entire valley was in a bankrupt state. There were many causes that contributed to the conditions but one of the principal remedies that saved this valley was an institution: the 1927 ground-water law. This law, more than any other factor, has made this fine valley what it is. And, what did this law do? In summary, it offered a new and combined approach to the practice of prior appropriation. It combined scientific inquiry, administrative fact finding and efficiency, and concern for the public good, all within the judicial framework of fairness and judicial review and the tested methods of the adversary process. Public management of <u>ground</u>-water supplies provided in the 1927 legislature thus became a new institution.

The interstate river compacts previously referred to are also institutions for the development, use and protection of a valuable resource. The recent decision of the United States Supreme Court in Arizona v. California will no doubt produce new institutions for the fair management of the supplies of the Lower Colorado over which the lower basin states have not, up to this time, been able to agree. Happily, the upper basin states devised an institution in 1948 called the Upper Colorado Compact which is making possible development of the upper areas of the stream including the San Juan-Chama diversion.

Laws and the institutions they embody or contemplate are only tentative answers of rational minds to community problems that may be only dimly and incompletely seen. I say "tentative" because no law, and indeed no human institution, is perfect because all are the product of the imperfect human intelligence. The same is true of ground water law. The validity of this statement will be readily apparent when one realizes the number and nature of amendments and revisions made in the ground-water law of New Mexico. Saline water conversion, when it becomes commercially feasible, will require a further and careful look at the same ground-water law. For example, what provision should be made, if any, for administrative control over withdrawals of large quantities of briny ground water? The same controls which now exist over fresh water? As I understand the present arrangements for this plant, withdrawals are being made under the City of Roswell's water right. And, of course, the City is benefited by the potable supply that reaches its mains. But, is the City's water right--if it is a right to a fresh supply--really involved at all? And, suppose it become financially possible for a large private firm to convert saline water, would the firm be entitled to the amount it could purify? As more and more public and private funds are encouraged in this effort, there will be more and more problems of the nature I have indicated. It is clear that the present law does not anticipate these developments and therefore will have to be re-examined and at the same time some principles of reuse and of ownership rights in the conversion process, itself now a monopoly of the government, etc., all will need examination.

Of course, all I am doing is pointing out that the law must be adaptable, and also clear and, above all, fair. These are matters that cannot be decided by slide rules or computers. They involve human judgment and human choices. And, they involve all the other intellectual forces that must be brought to bear which may be divided roughly into three kinds:

1. Physical, scientific and technical approaches--

e.g., the conversion processes themselves, the hydrology of supply, etc.

2. <u>The economic alternatives and goals that are available</u>--

e.g., is it better in New Mexico to grow price-supported cotton on warm, lower reaches of streams, or better to grow Texas (and other) tourists on the cool, upper reaches? Some still believe here in a mystical, and also iron, law of the market place to resolve this problem of choice, although it is quite clear such a "law" had nothing to do with establishing the Saline Water Conversion Plant in Roswell. Some think only private investment should be allowed to develop such supplies (except of course when a large public investment will benefit them).

3. <u>The institutional and social forces, including the law, and their interplay with the other forces</u>--

e.g., the 160-acre water right limitation, the family farm institution that is written into the Reclamation Law. The political and legal choices--ground-water law or not, public management or not. Should government have a large or small share in development? What about control of pollution? Atomic waste pollution? These are the factors that Committees of Congress consider. H.R. No. 71, 1961, 87th Congress, on Research Needs for Salt Water Conversion says, "Vested interests, legal barriers, financial limitations, political considerations, etc., will retard if not block many of the desirable reforms (in water management)." These are considerations that are before Committees of Congress that are investigating pollution of water supplies, including atomic waste pollution. These are the kinds of inquiries that are contemplated in Senator Anderson's Water Research Institute Legislation S.2 now before Congress. Research in all the disciplines is contemplated.

All of these inquiries encompass human conduct and the human will, and all need study. Here I suppose I could say that the future of saline water conversion in the Southwest offers a chance for basic research in law and human institutions just as readily, and perhaps more necessarily, than in scientific fields. Why not? Men live by their beliefs and a consensus of belief is the essence of an institution. This matter of beliefs and the divergence of views are covered by two poems I will read:

A Conservationist's Lament

The world is finite, resources are scarce,
Things are bad and will get worse.
Coal is burned and gas exploded,
Forests cut and soils eroded.
Wells are dry and air's polluted,
Dust is blowing, trees uprooted.

Oil is going, ores depleted,
Drains receive what is excreted.
Land is sinking, seas are rising,
Man is far too enterprising.
Fire will rage with Man to fan it,
Soon we'll have a plundered planet.
People breed like fertile rabbits,
People have disgusting habits.
Moral:
    The evolutionary plan
    Went astray by evolving Man.

by Professor Kenneth Boulding
University of Michigan

The Technologist's Reply

Man's potential is quite terrific,
You can't go back to the Neolithic.
The cream is there for us to skim it,
Knowledge is power, and the sky's the limit.
Every mouth has hands to feed it,
Food is found when the people need it.
All we need is found in granite,
Once we have the man to plan it.
Yeast and algae give us meat,
Soil is almost obsolete.
Men can grow to pastures greener,
Till all the earth is Pasadena.
Moral:
    Man's a nuisance, Man's a crackpot,
    But only Man can hit the jackpot.

by Professor Kenneth Boulding
University of Michigan

Reprinted from Man's Role in Changing the Face of the Earth (Thomas ed. 1956) Wenner-Gren Foundation, University of Chicago Press. Professor Boulding's poems appear on page 1087.

THE FUTURE OF SALINE WATER CONVERSION, 1963

Ray H. Jebens[1/]

Before the future of saline water desalting processes is discussed, it will be well to discuss the basis for Federal action in the future and to review the basis for work carried out to date. Public Law 85-883, dated September 2, 1958, provides for the construction, operation, and maintenance of not less than five demonstration plants for the production (from sea water or brackish water) of water suitable for agricultural, industrial, municipal, and other beneficial comsumptive uses. This Act specifies that such plants shall demonstrate the reliability, engineering, operating, and economic potentials of sea and brackish water conversion by five of the most promising processes, to be selected by the Secretary of the Interior from among the most promising of the presently known processes.

In order to achieve the objectives of Public Law 85-883, five processes and sites were selected for the first-generation plants. The processes, sites, construction contractors, operation contractors, and the dates when four of these various activities occurred are given in Table 1. The 1-million gpd LTV falling film distillation plant at Freeport, Texas, has been operating since June 1961, providing data for the design and evaluation of a large-scale, second-generation plant. Similarly, both the 1-million gpd multistage flash distillation plant at San Diego, California, and the 250,000 gpd electrodialysis plant at Webster, South Dakota, have been operating since March 1962.

In April 1962 construction was begun on the forced circulation vapor compression distillation plant at Roswell, New Mexico.

Specifications were prepared and bids received for a fifth plant in July 1962, to demonstrate the freeze process in a 250,000 gpd plant at Wrightsville Beach, North Carolina. When considering the award of the construction contract, however, it was realized that, in the light of new evidence, the size selected was too small to demonstrate the process on a large and practical scale, and therefore, the bids were rejected. The process is now relegated to further pilot plant work.

Public Law 87-295, dated September 22, 1961, extends and modifies the Demonstration Plants Act of 1958 in several respects. It provides that the Secretary shall conduct engineering research

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TABLE 1. STATUS OF DEMONSTRATION PLANTS PROGRAM, OCTOBER 1962

Plant No.	1	2	3	4
Process selected	Distillation, falling film, 12-effect.	Distillation, flash 36-stage.	Electrodialysis, 4-stage.	Distillation, vapor compression.
Capacity, gpd	1,000,000	1,000,000	250,000	1,000,000.
Date process selected	Mar. 2, 1959	May 14, 1959	June 22, 1959	Dec. 2, 1959.
Scale prevention tech	pH control	Hagevap (3 ppm)	Low current density	Ion exchange or slurry.
Top temperature, °F	250	200	50	232.
Power consumed, KWH/M gal	8.11	3.18	6.4 (10.2)	55.9.
Fuel, Btu/M gal	0	0.95×10^6	0	3,120.
Steam, Btu/M gal	0.846×10^6	0	0	0.
Concentration factor	3.0	2.0	2.2	4.0.
Location of plant	Freeport, Tex	San Diego, Calif	Webster, S. Dak	Roswell, N. Mex.
Date site selected	July 14, 1959	Oct. 6, 1959	Feb. 3, 1960	Feb. 3, 1960.
Date of groundbreaking	Aug. 30, 1959	Dec. 19, 1960	May 19, 1961	July 10, 1962.
Date of dedication	June 21, 1961	Mar. 10, 1962	Oct. 20, 1961	
Architect-engineer firm	W. L. Badger Associates.	Fluor Corp	Bureau Reclamation	Catalytic Construction Co.
Amount of contract	$116,950	$108,283	$49,900	$96,700.
Date of specs issue	Apr. 1, 1960	Sept. 1, 1960	Aug. 1, 1960	Oct. 12, 1961.
Bid opening date	May 24, 1960	Oct. 18, 1960	Oct. 3, 1960	Dec. 12, 1961.
Construction firm	Chicago Bridge & Iron.	Westinghouse Electric.	Asahi Chem. Ind. Co., Ltd.	Chicago Bridge & Iron.
Amount of contract	$1,255,712	$1,663,246	$485,900	$1,794,000.
Date of contract award	June 8, 1960	Nov. 5, 1960	Nov. 11, 1960	Apr. 6, 1962.
Construction period	365 days	365 days	300 days	365 days.
Operation and Management firm	Stearns-Roger Manufacturing Co.	Burns & Roe, Inc	Mason-Rust	
Amount of annual contract	$241,249	$183,189	$113,729	
Date of contract award	Apr. 28, 1961	Jan. 3, 1962	Nov. 30, 1961	
Date operation started	May 31, 1961	Mar. 5, 1962	Mar. 8, 1962	

and technical development work, by laboratory and pilot-plant testing, to develop processes and plant design to the point where they can be demonstrated on a large and practical scale. He shall recommend to the Congress for construction and operation, or for participation in the construction and operation, of a demonstration plant for any process which he determines shows great promise of accomplishing the purposes of the Act.

In the original law it was proposed to build first-generation demonstration plants of a capacity sufficient to develop to the highest degree the potentials of operating reliability and economics. The results of research work would be evaluated in these plants and the data obtained would be developed for use in the design, construction, and operation of second-generation plants which would demonstrate processes on a large and practical scale.

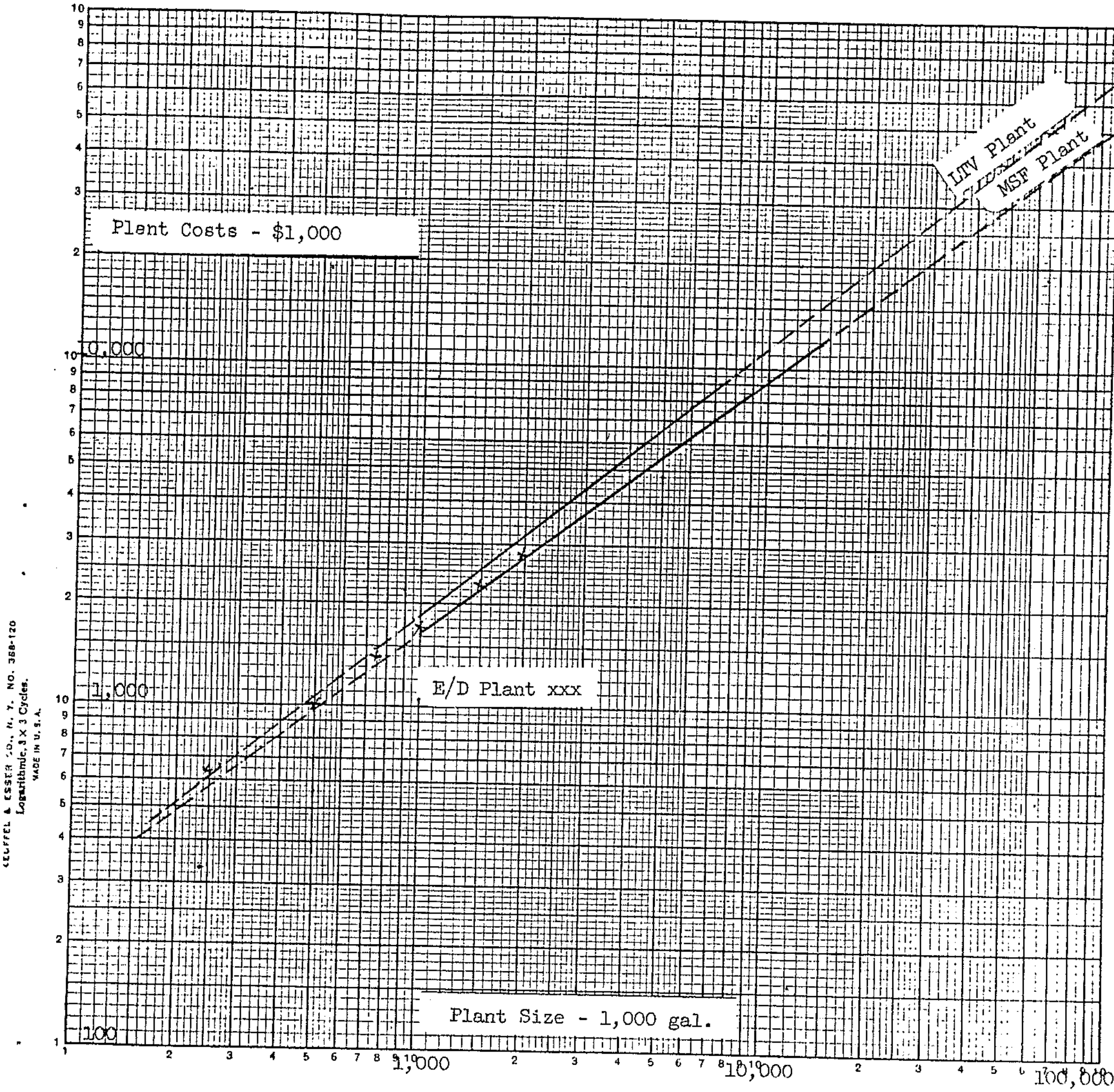
The development of any low-cost process will require operation without formation of scale in the equipment. In order to achieve low costs, it is also necessary to develop a high volume of water output per unit dollar value of equipment used. So far, only the distillation and the electrodialysis processes have been demonstrated to be capable of these objectives over an extended period of time.

A measure of success has been achieved in this respect for the distillation process by use of the scale control method known as "pH control" which has permitted increased output for 40% from the San Diego plant with only slightly higher daily costs while operating at somewhat higher temperature than originally planned. The electrodialysis process is subject to scale formation on the membranes due to the pressure of insoluble ingredients in the waters being processed. Through the use of reverse polarity, it has been possible to operate at higher current densities and obtain results desired in three stages formerly not attainable in four stages. There are studies under way in process development which will, if successful, permit markedly greater production from these two processes with lower dollar value of the equipment. The results of operation of the first three plants for a short period of time are published in Office of Technical Services Report No. PB which indicates the costs for plants and water produced from the present plants and that expected from larger plants. Figures 1 and 2 show the expected costs from the three plants as the size is increased. The solid portion of the lines indicate the size of plants for which detailed costs have been studied. The most favorable distillation process at the moment is the flash distillation process in use at the San Diego plant, the flowsheet for which is shown in Figure 3.

Figure 1

BECHTEL STUDY PLANT COSTS

R. H. Jebens



R. H. Jebens

BECHTEL STUDY WATER COSTS

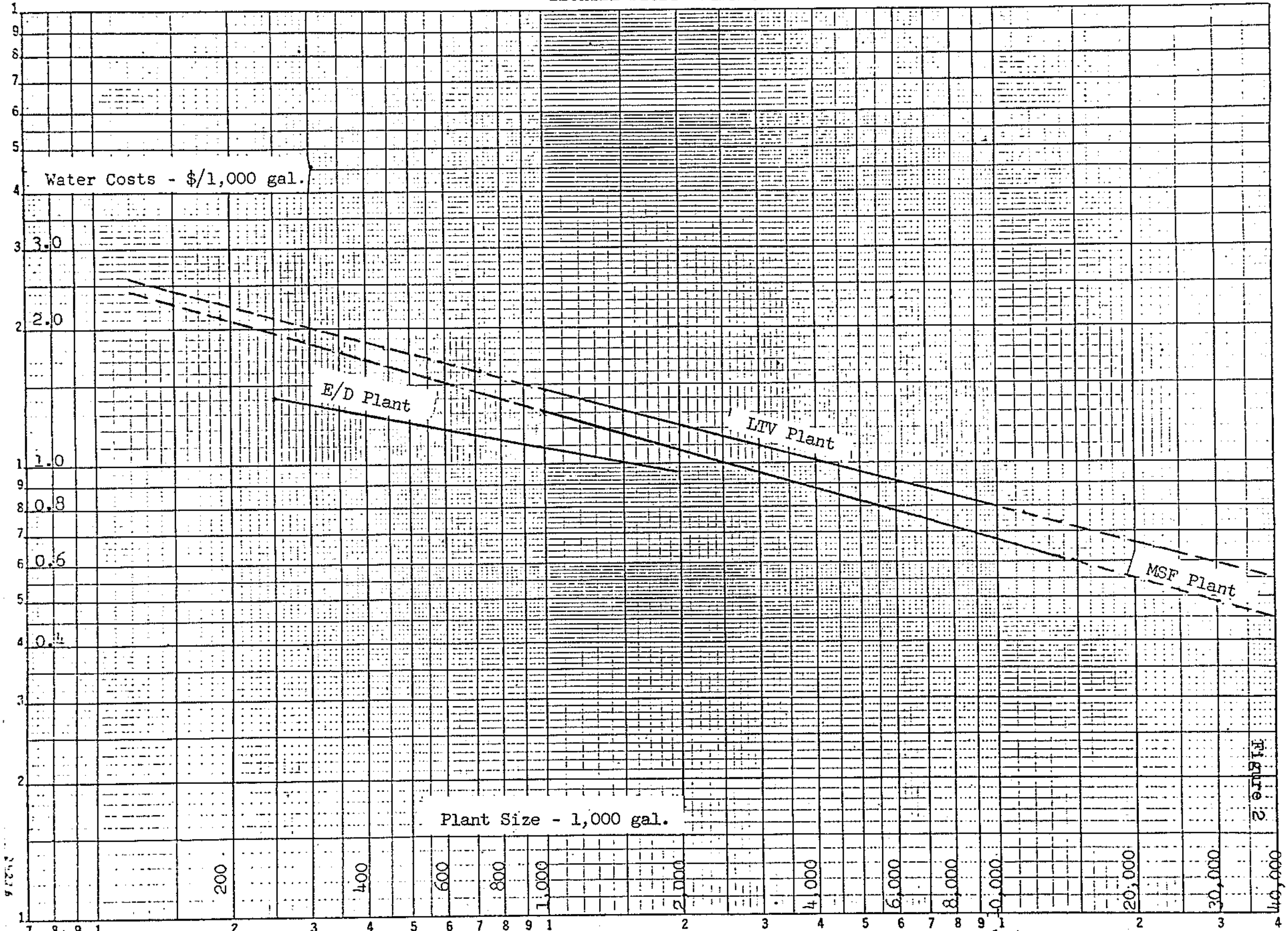


Figure 2

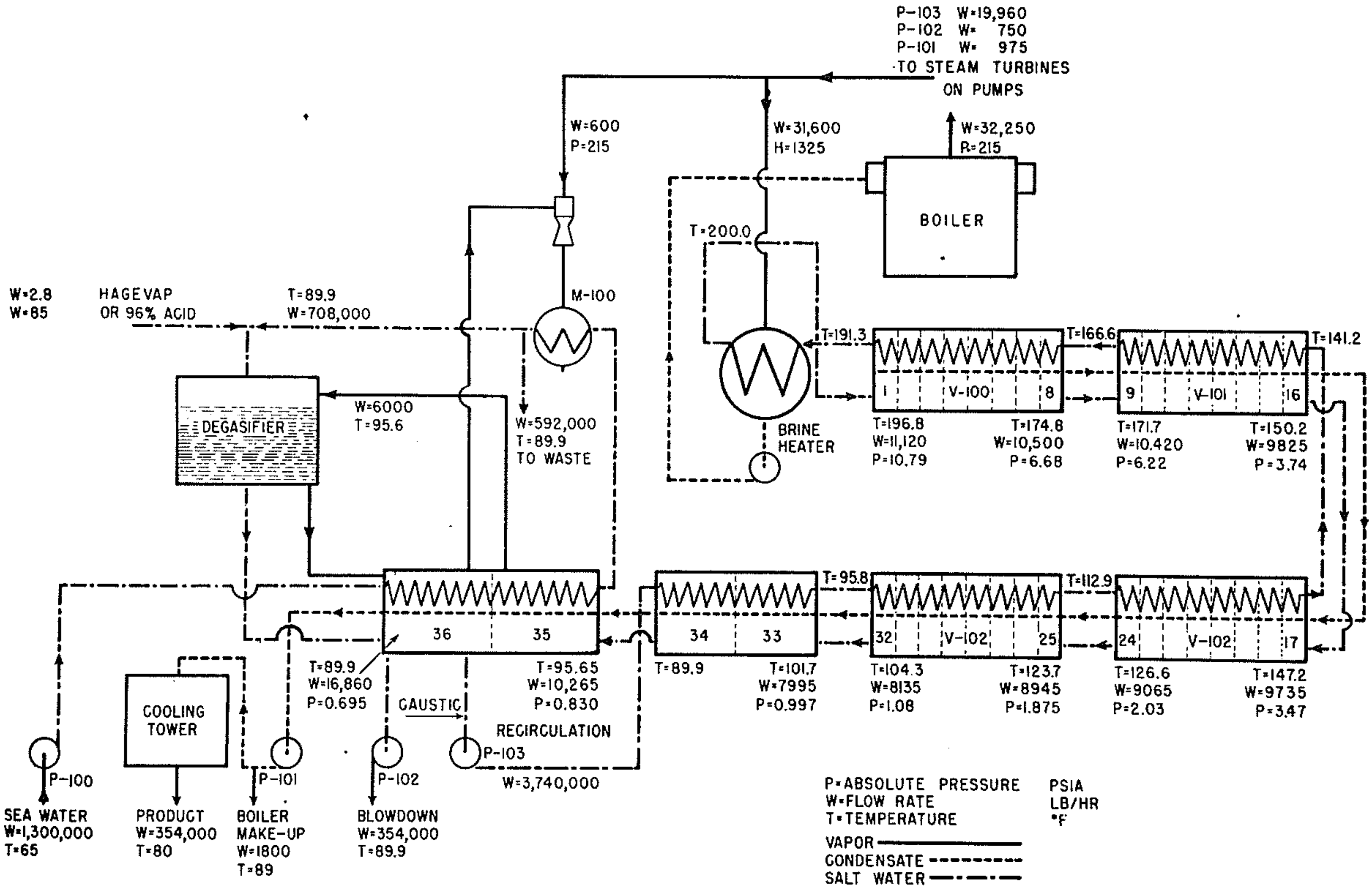


FIGURE 8. FLOW SHEET FOR FLASH DISTILLATION PLANT
FOR 200°F OPERATION
36 STAGE

U.S. DEPARTMENT OF THE INTERIOR
OFFICE OF SALINE WATER
WASHINGTON, D.C.

R.H.J.

A considerable amount of work is under way in the Research and Process Development Divisions and the attainment of lower-cost water will depend upon a continued effort in this direction. The freezing and hydrate processes are developing to the pre-demonstration plant stage. These are both thermal processes, and thermal economy is dependent upon heat exchange between incoming and outgoing streams, much the same as in the distillation process. Osmosis of one sort or another may be a possibility--much is yet to be discovered before a low-cost product water is obtained. Modifications to the electrodialysis process offer possibilities for cost reduction. The objective of low-cost water will probably be achieved only by the whittling away of costs from the present values by continued effort to pare off a little at a time.

As mentioned above, water costs from normalized plants have been developed for large-scale plants. These studies provided preliminary designs and detailed cost estimates. They show that energy costs and investment costs become more important as size of plant is increased. By associating the desalting plant with a thermal-power generating plant, it is possible to decrease both the energy and investment cost appreciably. For large plants, one-million gallons of water (3 acre feet) can be produced for each 3 MWE of generating capacity. High quality water from such a plant is expected to cost $0.30 to $0.35 per 1000 gallons ($93 to $108 per acre-foot) in the 50-to 1000-million gallon per day size. This would be 5,000 to 10,000 acre-feet per year size associated with 150 to 300 MWE power plants.

The population increase for the next five decades for New Mexico and the Southwest will be tremendous, probably tripling the population in this time. The present irrigated lands will be converted to municipal subdivisions and the existing water supply used for civilian use. The water and power demand and supply for New Mexico must be coordinated with that of the Southwest. A comprehensive plant for augmenting the existing supplies and developing and financing additional water and related power resources for the future benefit of this area must be organized.

Additional water supplies to alleviate present water deficiencies and to meet the demands resulting from Southwest population growth would be obtained by conservation of existing supplies, desalination of saline water and import from areas with future water supplies.

The electric power demands for projected water pumping and commercial uses are of such magnitude that it will require a proportion of power produced by sources other than the hydro-electric capability. The promotion of the greatest economics of both water and power users will require that the power loads should be integrated and each source used to serve the portion of the load to which it is best suited. This principle will result in hydroelèctric power plant capacity being devoted to peaking capacity, and the thermal power devoted to base load use. The thermal plants would be used for water pumping and water desalting plants.

THE DISPOSAL OF DESALINATION BRINE WASTES

Warren Viessman[1/]

With ever increasing demands being placed on the water resources of this and other nations, men have begun thinking seriously about developing the saline waters of the oceans and underground aquifers.

Fresh water derived in this manner can contribute materially to the spectrum of useable water supplies. In some regions it appears that this means of fresh water production is almost the only alternative. Research continues on conversion methods with emphasis on cost reduction. Practical conversion may be approaching reality. Many people are beginning to believe that major water supply problems will soon be solved in this manner. These considerations stimulate interest in saline water conversion and provide the impetus for advanced research.

Cost Consideration

A major goal of current experimentation with process design is the production of water at rates which compare favorably with average prices by other methods of production. Prices are related to the need and availability of water supplies and range from 1 to 5 cents per 1,000 gallons for irrigation; 2 to 15 cents per 1,000 gallons for industrial use; and 5 cents to 7 dollars per 1,000 gallons for domestic use. Chemical and Engineering News (June 1963) reports that the investment costs per 1,000 gallons for the three currently operating saline water conversion plants are approximately $1.40 at Webster, $1.46 at Freeport, and $1.30 at San Diego. These costs while well below the stated maximum domestic cost, are still considerably higher than most current prices.

There is an addition, and of signal importance, the consideration of the cost associated with the disposal of wastes from the various water conversion operations. The production of fresh water by desalination is essentially unique in this respect. Except for sludges produced in major water softening plants, most current operations produce only small quantities of readily disposable wastes.

Cost estimates for saline water disposal operations are at present still greatly subject to question. In 1958 Koenig made the following statement in a report to the Office of Saline Water:

1/ Associate Professor, Civil Engineering Department, New Mexico State University, University Park, New Mexico.

"Thus the various cost estimates for converted water lacked an essential element of total cost which might indeed prove even greater than, in fact much greater than, the cost of conversion itself. Obviously, economic judgements cannot be made except on the basis of total costs."

The Magnitude of the Disposal Problem

Disposal of waste brine is not a new problem although most previous considerations have been relative to the production of oil field brines. Lewis (1956) stated that:

"Some idea of the magnitude of salt production may be gained when one realizes that a "good" well producing only ten barrels of brine per day, with a 15% sodium chloride content, is producing 525 pounds of pure salt every 24 hours, or nearly 100 tons of salt per year. The maximum well, producing 190 barrels of brine per day yields nearly five tons of salt per day and 1,823 tons of salt per year."

Contrasting this with a consideration of the Roswell, New Mexico plant gives some indication of the expanded problem derived from saline water conversion operations. The Roswell plant will deliver 1 million gallons of pure water daily and about 1/3 million gallons of waste effluent per day. This waste flow will contain about 130 tons of solids per day, about 1.3 times that produced in an entire year by the oil well in the first example.

A consideration of the enormous volumes of waste which might be produced by future saline water conversion plants is cause for concern. It should also be emphasized that the volumes of fresh water produced by plants of the size currently in operation at Roswell, Freeport, Webster, and San Diego are not large, in fact, for a community of about 40,000 people. One million gallons per day might represent only 15 percent or less of the average domestic consumption.

An additional example of the relative size of the waste operation can be had by comparing the wastes produced by a complete sewage treatment facility with those derived from a saline water conversion plant. Consider a community of 40,000 people with a portion of the domestic water supplied by desalination. Assume this portion to be 1 million gallons per day and to represent 15 percent of the average daily consumption. The daily volume of sludge developed in the community sewage treatment plant (consider the plant to utilize sludge digesters and dewatering operations) would be about 160 cubic feet. The solid waste derived from treatment of only 15 percent of the community water supply might be as high as 2,500 cubic feet per day, nearly 16 times the volume produced by the entire sewage treatment operation. This prototype problem clearly illustrates the comparative magnitudes of waste production with which we must be concerned.

The preceding remarks should serve to indicate the magnitude of the waste problem and thus illustrate that the costs of handling brine wastes can be highly significant. Consideration of these costs is vitally important even in process research as some methods produce less waste per unit product produced than others. In fact, given a specific location, the waste operation should be considered an integral part of the process design so that the most economical overall operation can be produced.

Disposal Operations

In 1958, Koenig set forth twelve processes for handling saline water conversion brine wastes. These are summarized as follows:

1. Transport to the sea.
2. Evaporate to saturation and convey to the sea.
3. Evaporate to dryness and transport the solid residue to the sea.
4. Convey to a remote land dump.
5. Evaporate to saturation and transport to a land dump.
6. Evaporate to dryness and transport the residue to a land dump.
7. Evaporate to dryness and abandon residue at location.
8. Inject into underground strata.
9. Inject waste after bringing to saturation.
10. Use abandoned oil wells for injection.
11. Evaporate to reduce costs of conveyance and injection.
12. Discharge wastes into flood flows.

There is obviously some overlap in these operations but in general they indicate current possibilities for disposal. A careful study indicates that some of these operations (abandonment, land dumping, injection for example), if used indiscriminately, could result in serious pollution problems. It is also apparent that the disposal method selected as most appropriate for one particular plant might not be feasible for another. Individual studies of the economics and pollutional aspects of waste disposal must therefore be given primary consideration in evaluating the potentialities of any region for saline water conversion development.

Conclusions

It has been the intent of this paper to discuss the brine waste disposal problem, the other side of the desalination story. Considerable literature has been produced in the last few years regarding the importance of saline water conversion and discussing the various processes which are under development. Relatively little has been said about the very significant waste disposal problem that is associated with all of these processes. Saline water conversion holds the promise of providing fresh water for many areas where existing supplies of adequate quality water are limited. It is an important part of the development of technology for increasing our useable water supplies. The associated waste problem is also of considerable importance from both an economic and pollutional point of view. It should not be overlooked or de-emphasized in the early stages of planning, research, or development. If it is neglected now, it will strikingly present itself in compounded form once large scale operations commence.

List of References

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2. Lewis, Leo D., "Pollution of the Lower Part of the Big Wichita River by Oil Field Brine from Surface Storage Pits," Texas State Game and Fish Commission, Job Completion Report, Project No. F7R3, Job C-1, Part 1, 1955-1956.

3. "More Stress Put on Basics in Saline Water Technology," Chemical and Engineering News, June 10, 1963.

THE ROSWELL PLANT CONSTRUCTION

Donald P. Miller[1/]

Chicago Bridge and Iron Company was awarded a firm price contract in April of last year to design and construct a million gallon a day brackish water plant at Roswell.

The major steps in building a process plant are:

1. Preparing a heat balance and flow diaphragm.

2. Sizing, specifying and buying or designing and building the component parts.

3. Preparing drawings including foundations, mechanical, electrical and instrumentation.

4. The physical erection of the units.

5. Testing the parts and putting the plants on stream.

The first two steps were pretty well roughed out before the actual bidding, however, there are three units of this plant that are quire unique. The first consists of two circulation pumps with propeller type impellers approximately 5 feet in diameter which move 92,000 gallons of hot water per minute against a 6-foot head. They also must be capable of starting up against a 12-foot head of cold water. These were purchased from the Bingham Company and they extrapolated pump curves from smaller existing pumps of this type.

The second unit was the steam compressor. This along with the electric driver, transformers and starting gear was purchased from the Allis Chalmers Company. Their designer, Mr. Russell John, designed this machine, followed it through the shop construction and testing, and was present on the job when we started up the unit. The process flowsheet calls for a 6-pound compression of 173,000 pounds of steam per hour at approximately atmospheric pressure. This could have been handled by a two stage centrifical compressor but because of the large volume, Mr. John designed a more efficient five stage axial flow compressor. This is, we believe, the first time an axial compressor has been used for steam service.

1/ Project Manager, Roswell Plant, Chicago Bridge and Iron Company.

Due to possible entrainment and carry over of corrosive water the first stage blading is amcoloy #45. The remaining stages are standard 403 stainless steel. It will be interesting to find out how the blading stands up in this service. The machine is extremely well balanced and has evidenced no harmonic vibrations on starting. It runs quitely and is operating slightly above its design curve.

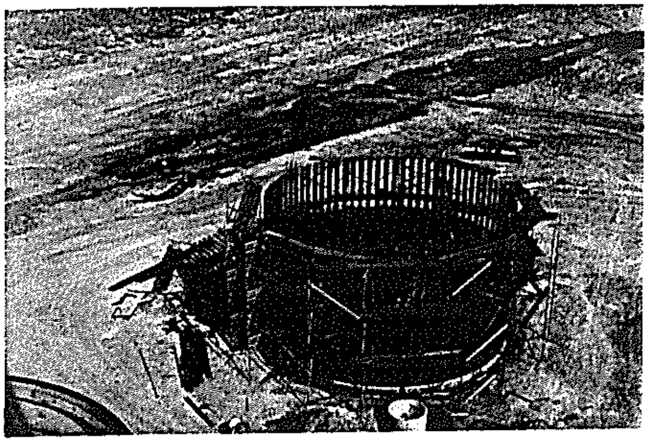
The third units are the heater sections of the two evaporators. These have the largest tube sheets our company has ever installed, and we believe the larges ever built in this country. The sheets are 12 feet in diameter and 2-1/2 inches thick, each unit has 7200 one-inch in diameter tubes 28 feet long and the heaters are baffled and vented by four 2-1/2 inches in diameter perforated pipes. These evaporators were field erected because of there overall size:

The construction of the plant has handled by our field superintendent, Mr. Don Hull. The foundations were started in August and were all installed before winter. No unusual construction problems were encountered and the plant was completed on schedule.

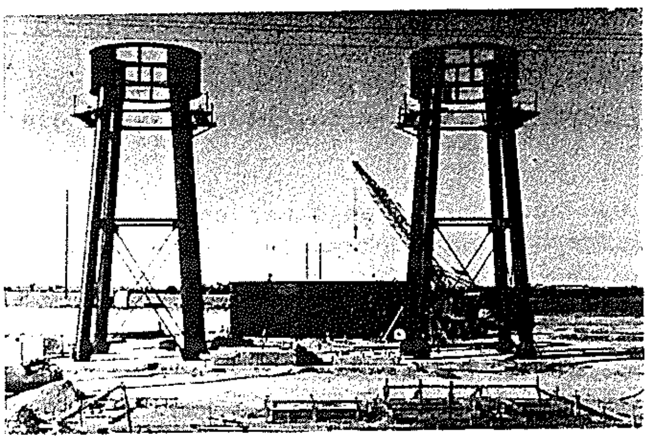
Mr. Joe Lawrence was our process engineer assigned to this job. He is also in charge of start up and the 30-day test run which is now going on. The future plant operators are also being trained during this period.

Instructions and maintenance manuals describing the operation procedure in detail have been prepared and made available to the operating contractor.

I would now like to present a few pictures showing the construction at different stages of the plant.

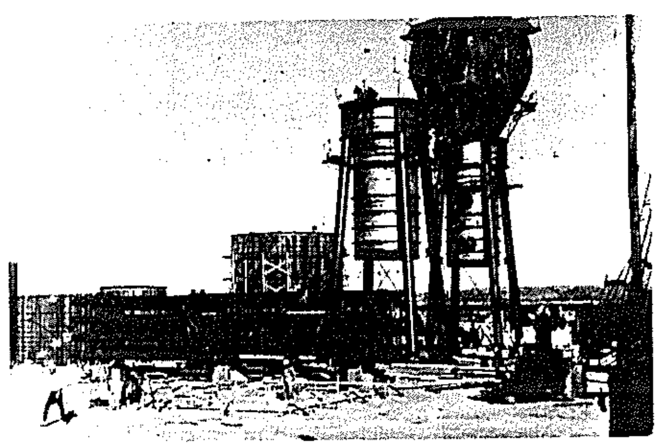


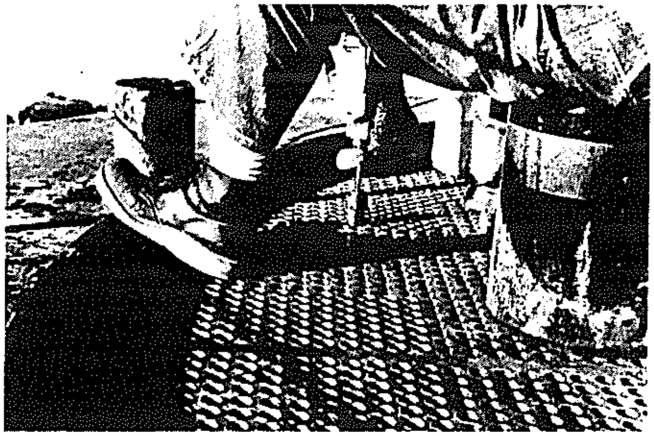
Horizontal heat exchangers in place in the foreground, the two heating elements in place and the vapor dome partially constructed on the far evaporator.



Clarifier thickner tank completed in the background and the framework of the two evaporators erected.

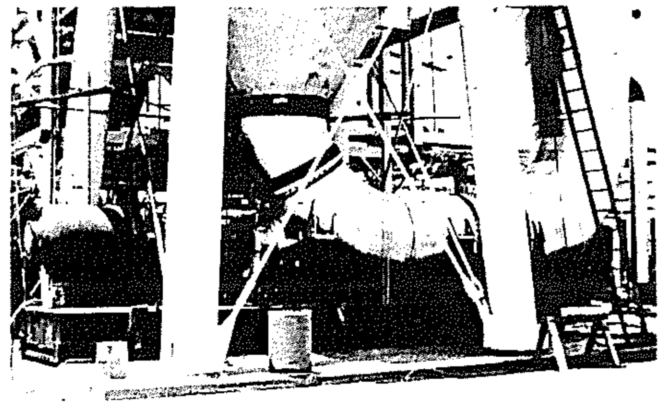
Construction of one of the redwood tanks of which there are six on this project. Wood was used because of its superior corrosive resistant qualities compared to steel.

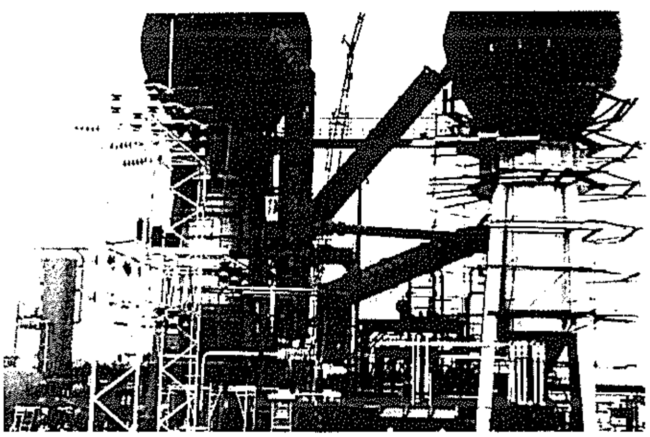




Operation of rolling in a tube into the top tube sheet of one of the heaters. There were 7,200 tubes installed in each heater section.

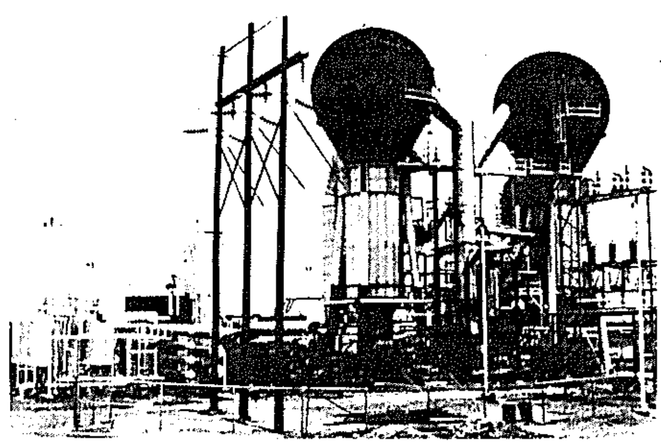
Horizontal propeller type water pump driven by a 250 horse motor left side. This is one of the two large recirculating pumps that moves 92,000 gallons of water a minute.





Two evaporators with the large inner connecting piping in place. The insulation is being applied to the vapor dome and heater body of the unit on the right.

The completed plant. On the extreme left is the ion exchange equipment which treats the incoming water, next a double bank of heat exchangers, then the degasifier, then two more banks of heat exchangers and finally the large evaporators.



PRESENT AND FUTURE WATER CONVERSION PLANTS
THEIR OPERATION AND DESIGN

Paul L. Geiringer[1/]

All of man's endeavor begins with a concept. This is the initial design of thought but, in itself, incomplete. From concept to effective and efficient execution is an arduous road whereby theory alone will not suffice. The practical realities and the multifarious involvements which this entails, are the forces which must act directly on the concept to bring its potentiality to fruition.

Also, here at Roswell, a grand plan has been conceived and constructed by capable engineers, and our organization has been called to the task of managing this fine facility efficiently.

It was suggested to me that we outline briefly the problems and the important aspects of this assignment. Our task is threefold:

First, to manage and operate the installed equipment in the most orderly fashion, and produce potable water at design conditions in respect to quality and quantity;

Second, to determine whether improvements in the design of such types of plants could be suggested; and

Thirdly, to investigate and to try out various operating methods which might reduce operating costs, increase the quality of the water, or the output of the plant without increasing investments.

A well-organized operation will be achieved by careful selection of personnel, which must be intelligent, resourceful, and accurate. Instruction and schooling for the personnel will be conducted by the two managing engineers--Dr. Charles W. Deane, a highly qualified doctor of chemical engineering (and co-author of this paper), and Mr. Anthony Pascale, an experienced professional mechanical engineer.

Exact schedules for taking water samples for laboratory investigation will be set up, and the chemical tests which we have evolved will be carried out in the plant laboratory. Equipment maintenance schedules will be established. All the work

1/ President, American Hydrotherm Corporation, Long Island City 1, New York, New York.

will be recorded and instruction books--based on actual operating experience--will be prepared. These books will describe the duties of each of the various operators, and will supplement the available fine instruction manual. These new instruction booklets will be written after sufficient experience in the operation of this new plant has been obtained.

During the first six to nine months, the greatest effort, however, will be concentrated on establishing practical operating schedules, and producing water of high quality and of a quantity commensurate with the plans of the designers.

Should it be found that certain small changes in design or construction are needed in order to obtain a uniform and satisfactory output, they will be reported and probably be immediately carried out., Generally, minor alterations are expected in a plant of this type.

Insight into the reliability of the equipment will be gained, and conclusions and recommendations for improvement in the design of future plants will therefore be forthcoming.

After a standard operation has been established for a few months, the field operation will be free to try out new techniques which should lead to cost reduction, increased output, maintaining at the same time, the quality of the water.

This we hope to achieve by:

1. Change in Operation of the Pre-Purification System

Deposit which is precipitated out may adhere to the walls of the equipment in the form of scale. In order to avoid scale formation, $CaSO_4$, in the form of a very fine powder, is introduced and circulated so that the precipitate may deposit on the particles and not on the walls. The so-increased slurry particles are then drained off. In this way, reduction in the cost of chemicals and equipment will be obtained. It may also be proven in this way that future plants can operate with a pre-purification system of reduced size, and using smaller amounts of the costly ion exchange resins, or eliminating it completely.

2. Drop-Wise Condensation

A second area of improvement may be found in the promotion of drop-wise condensation within our large evaporators. There are certain fatty substances which, when introduced in minor quantities into the water, provide a drop-wise, instead of a film type, of condensation. Experiments are currently under way at Franklin Institute on the use of sulfide films of copper and silver. Drop-wise condensation provides an appreciably higher rate of heat transfer and, in this way, should increase the output of the evaporators, or effectively reduce power consumption per gallon of water.

Other operating methods may also be tried, but it is perhaps a little too early to speak of the various ideas which have been developed by our staff.

In concluding, I would like to say a few words about the future of this type of plant, and how considerable reduction in the cost of producing potable water could be achieved.

There are several avenues of thought which may be pursued in order to reduce the cost of the end product. Here is a drawing which incorporates our thinking along these lines. The different methods which may be followed can be categorized as follows:

1. Increasing the Size of the Plant by increasing the plant to outputs of 25, 50, or 100 million gallons per day, considerable operating and investment savings can be derived.

2. Combining Different Types of Design in One Plant in combination with electrical power production would achieve considerable savings.

3. Figure 1 shows how a vapor compression plant could be combined with a long-tube, or flash-type evaporator plant, whereby the power plant which is installed within the compound, would furnish power to the vapor compressing plant, and recover the waste heat by the flash evaporator plant. Power production in combination with the two different types of plant would decrease the cost of the utilities and product water considerably.

4. Finally, the recovery and utilization of the wealth of chemicals contained in the saline water would be a most valuable avenue and, in pursuing this thought, it may be most practical in the first instance to think of the production of chlorine and caustic. These raw materials can be gained, by means of electric power, from a concentrated brine which otherwise has to be disposed of. For instance, at the Roswell plant, the brine disposal requires three large 30-acre ponds.

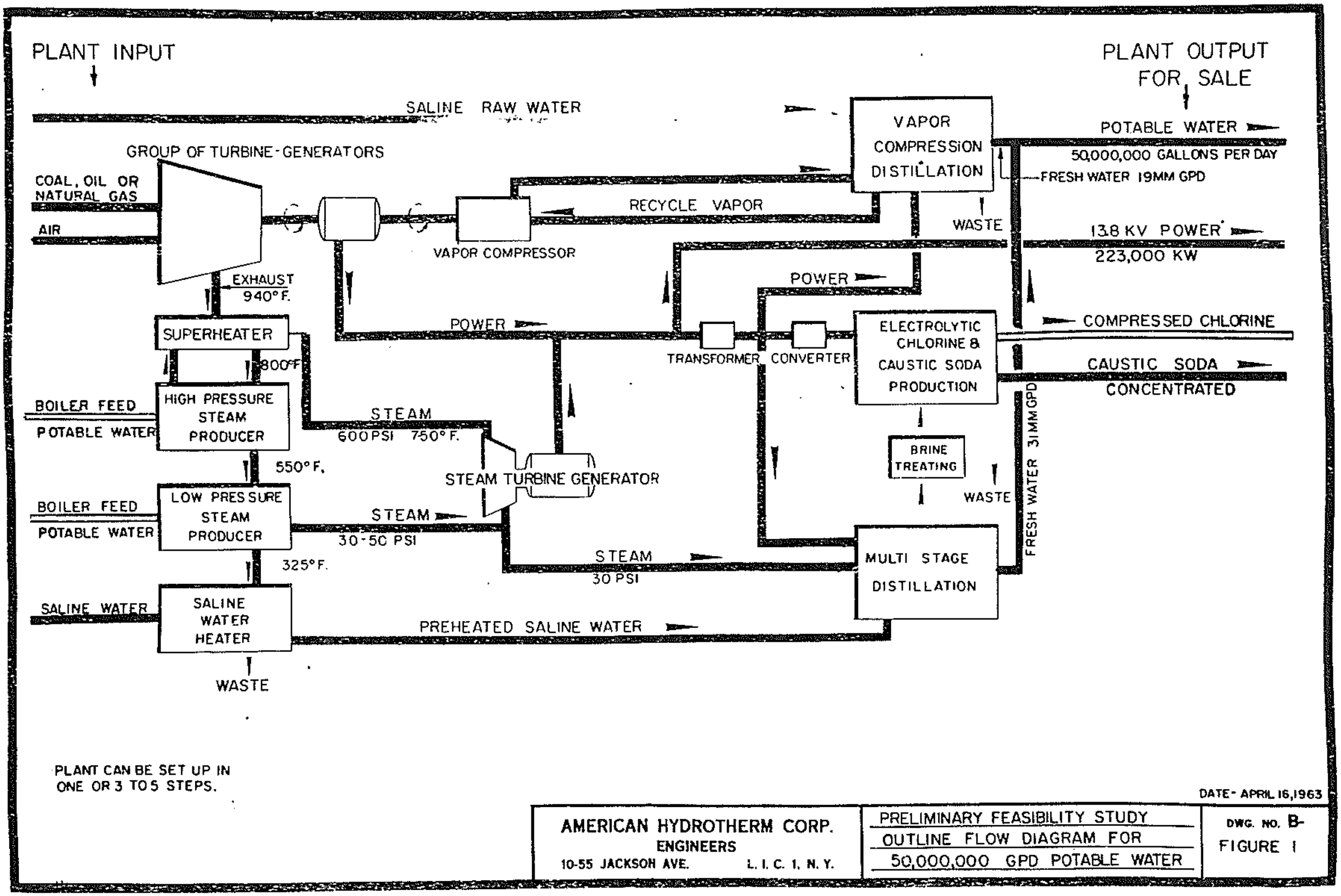
A considerable amount of electricity is needed for these plants. This has to be available at low cost. The economical production of electricity is certainly possible if the fuel is low-priced and, at the same time, the waste heat is economically utilized. Fortunately, most areas which have arid conditions, have gas or oil fuel available at relatively low cost. Therefore, in most cases, the production cost of heat for power production and evaporation purposes is relatively low.

Figure 1 illustrates such a plant, where the water production cost, we predict, can certainly be achieved at 30 cents per 1,000 gallons, or below.

This we consider a future potential for our potable water plant.

FUTURE SEA WATER CONVERSION PLANT

PRODUCING POTABLE WATER, ELECTRIC POWER, AND CHEMICALS



MUNICIPAL REQUIREMENTS OF A SALINE CONVERSION PLANT

John Russell[1/]

I have been asked to briefly discuss some of the background which let to Roswell being designated as a site for a demonstration plant to convert brackish water into potable water suitable for municipal and industrial use. I shall also point out some of the problems which the City had to overcome to meet various requrements of the government and what we hope to achieve by the location of this plant at Roswell.

The problem of saline water has been present in the Roswell Artesian Basin for many years. The analysis of water from ten irrigation wells west of the Pecos River during the early days of irrigation showed a range in chloride content of 69 parts per million to 287 parts per million. As pumping continued, the chloride content of water in the artesian wells between Roswell and the river increased. By 1958, the chloride content of the water in the wells ranged from 500 parts per million near the eastern limits of Roswell to more than 5,000 parts per million near the Pecos River east of Roswell. This encroachment of sodium chloride posed a serious problem for the City of Roswell and the farmers in this area.

The United States Geological Survey, in cooperation with the State Engineer of New Mexico, began a study of this saline area in 1952. The Pecos Valley Artesian Conservancy District entered into a Cooperative Agreement with the United States Geological Survey covering the period of 1956 through 1958 to continue the study of the salt water encroachment. The results of these studies were published by the New Mexico State Engineer as Technical Report 17.

One of the proposed methods for inhibiting the encroachment involved the reducing of the artesian pressure in the source area of the saline water which is East and Northeast of the City. It was apparent that steps should be taken immediately to retard this salt water encroachment.

In 1958, the City of Roswell, received information concerning the government's plan to establish five saline water conversion plants in the United States, each to utilize a different method of conversion, with one of the plants to be located in the arid Southwest. The matter was discussed fully by City officials,

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1/ Attorney for Pecos Valley Conservancy District

the directors of the Pecos Valley Artesian Conservancy District, and the Chamber of Commerce. It was decided that Roswell should make an all out effort to obtain the plant designated for the arid Southwest.

The interested groups were of the opinion that this plant might establish that the large quantity of highly saline water in the area might be salvaged to furnish the entire municipal needs of the City at a cost which would not be prohibitive. In the event this could be established, such operation would eliminate pumping the City wells in the fresh water areas, resulting in increased artesian pressure in this area which would retard or hold back the salt water encroachment.

These groups also felt that the demonstration plant might prove the effectiveness of retarding the encroachment by reducing the artesian pressure in the source area of the saline water as suggested by Technical Report 17.

The City obtained from the Office of Saline Water a questionnaire listing the various types of information needed by that office for site selection purposes. A bound brochure covering all the various types of information needed was complied by the City and the Chamber of Commerce, which accompanied the City's application which was sent to Washington on January 29, 1959. The format of this brochure, the imagination and the hard work which went into its preparation, returned large dividends to the City. It was this brochure which resulted in Roswell being selected as one of ten cities out of 55 applicants from the arid Southwest, for a physical inspection by the Site Selection Board.

The Site Selection Board at that time used the following rating system:

A.	Technical Factors	62%
B.	Demonstration Value	24%
C.	Assistance Offered	14%

The New Mexico State Legislature contributed to the effort of New Mexico cities in obtaining a plant site for the state by appropriating $100,000.00 toward the construction cost of the plant.

The Site Selection Board visited Roswell on November 9, 1959. An informal dinner and meeting was held at Walker Air Force Base. It was attended by city officials, members of the Chamber of Commerce, Pecos Valley Artesian Conservancy District Directors and other interested citizens. This informal meeting was extremely helpful in enabling the working committees to become personally acquainted with the Site Selection Board members and paved the way for a very successful meeting with them the following day.

This informal get together enabled the various officials to determine in advance the information in which the Board was primarily interested and the various physical facilities the Board wished to visit. This permitted these officials to insure that all required information was available at the meeting and the tour of the plant site and other physical facilities of interest to the Board was arranged in a most efficient manner.

The City of Roswell was advised on February 3, 1960, that the saline water plant was to be awarded to Roswell, New Mexico. In May of 1960, it appeared that Roswell might acquire a larger conversion plant capable of producing one million gallons of product water per day to be powered by atomic energy. This was a plant that was originally scheduled for the West Coast. It was finally determined that because of the availability of gas and electric power close to the plant site in Roswell, there was no justification for the atomic powered type of plant with its resulting high cost of atomic power.

The original plan was for Roswell to have an electrodialysis plant which was later switched to Brewster, North Dakota. A Cooperative Agreement between the United States of America and the City of Roswell was entered into on September 7, 1960, which set out the various obligations of the City and the United States in connection with the construction and operation of the salt water conversion plant. These obligations are as follows:

I.

The City was required to obtain a fee simple title to the land upon which the plant would be constructed and convey this land to the government. A tract containing approximately 6.9 acres was acquired for this purpose.

Examination of the title covering this property disclosed that there was an outstanding oil and gas lease on the property which would not expire until late in 1961. The City was unsuccessful in running down the various owners of interest in this oil and gas lease and, therefore, could not get it released. The City finally agreed to furnish an indemnity or hold-harmless agreement to the United States covering any possible adverse claim during the remaining period of this oil and gas lease.

II.

The United States agreed to use its best efforts to design, construct and operate on the site a demonstration plant designed to process from brackish water 250,000 to 1,000,000 gallons per day of fresh water by the forced circulation vapor-compression-distillation process. The United States was to own, be responsible for, and exercise exclusive control over the design, construction and operation of the plant during the period of the contract.

III.

The City was required, at its sole expense, to construct, install, and furnish pipe lines and other mechanical and storage equipment and facilities necessary to deliver to the plant brackish water of a saline concentration of approximately 11,200 parts per million and to dispose of the brine effluent from the plant, transport product water from the plant and deliver the same to the city water system. These obligations created a number of problems for the City of Roswell.

The Roswell Artesian Basin has been closed to any further appropriations of water from the artesian aquifer since 1931. The saline water is encountered in the artesian aquifer which raised a legal problem. Could a new appropriation of this water be legally made in this closed basin, particularly in view of the fact that the water to be appropriated could not be placed to any other beneficial use? A companion question was, would it be necessary to secure an appropriation for the full quantity delivered to the plant or just in the amount of the product water which the plant produced? These questions have not been resolved at this time. Fortunately, the City of Roswell owned sufficient valid water rights, in excess of their present needs, to supply the requirements of the plant. The matter has been temporarily solved by designating the plant well as a supplemental City well and the total water produced is charged against the City's water rights.

The Pecos Valley Artesian Conservancy District drilled test wells in the area of the plant site to determine whether they could secure an adequate supply of water with the salinity content required by the United States. Three such test wells were drilled prior to the drilling of the present well which is furnishing the water to the plant. The Pecos Valley Artesian Conservancy District drilled all of these wells and also furnished the casing for the production well which was drilled 32 feet into the San Andres Formation and which, upon completion, flowed 1,150 gallons per minute from a stand pipe 4 feet above the ground.

IV.

The City was required to deliver to the plant at the rate of not less than 600,000 to 2,400,000 gallons per day of brackish water, the salinity concentration of which would be approximately 11,200 parts per million. The chloride content of the water from the present plant well varied from 8,130 parts per million to 8,190 parts per million and will undoubtedly increase as the well is pumped.

V.

The City was required to dispose of the brine effluent from the plant at a rate of approximately 350,000 to 1,400,000 gallons per day at the site and by a method mutually agreeable to the State of New Mexico, the City, and the contracting officer. This requirement presented the greatest problem of any insofar as the City of Roswell was concerned.

The City had originally planned to construct large earthen tanks into which the effluent would be deposited and the fluids evaporated therefrom. There arose a serious difference of opinion between various agencies as to whether the depositing of this effluent in unlined tanks would contaminate the shallow ground-water basin underlying the tanks and resulting contamination of the Pecos River. One of the main problems, of course, would be the effect upon wells in the immediate area of the tanks.

In an effort to solve this problem, the Roswell Geological Society was requested to make a study of the problem and give its recommendation as to how the effluent should be handled. The New Mexico Institute of Mining and Technology was also asked for their recommendation. Due to the time element, extensive studies could not be carried out by either of these groups. It was the opinion of both the Geological Society and the Institute that, because of the possibility of leakage and subsequent contamination of the Pecos River and the existing shallow ground-water supplies, the initial disposal would be done more safely by injecting the effluent into the deep lying formations east of the river. It was estimated that the initial cost of transporting the effluent by pipe line and injecting into an abandoned oil test well some ten miles from the plant site would be $182,000.00 with an annual operating cost of $2,000.00. This method was ruled out because of the cost.

To prevent any possible contamination of the underground waters, or the waters of the Pecos River, the City finally agreed to construct and line these tanks and when they are completed, will be the largest lined tanks in the world. The City of Roswell purchased 240 acres of land adjacent to the proposed plant site from the State of New Mexico upon which these tanks were constructed. The tanks were constructed in three parts--one covering 40 acres, another 30 acres, and the third one 20 acres. Each of the tanks are to be filled with effluent by stage. The tanks are being lined with polyethylene and it took 4,400,000 square feet of lining at a cost of $35,000 for the material and approximately 1 cent per square foot for laying the lining or approximarely, $40,000.00. All of the work in the constructing of the tanks and laying of the liner was accomplished by the regular City employees. Prior to the construction of the tanks it was necessary that the land underlying these tanks be drained. The shallow water table was so close to the surface in this area that it was impossible to get heavy equipment in to construct the tanks. These tanks are 7 feet high, approximately 2 miles in length, and have a 16-foot top. After the polyethylene liner was laid, then it was necessary to cover it with a minimum of 6 inches of dirt to prevent the sun from deteriorating the polyethylene. It is estimated that the effluent from the plant will produce 130 tons of minerals per day. The Department of Health, Education and Wefare agreed to provide 30% of the total cost of lining the tanks on the basis that it would prevent the pollution of an interstate stream, being the Pecos River, to which the shallow water basin would normally drain.

VI.

The City agreed to transport the product water from the plant and deliver the same to the City water system at a rate of approximately 250,000 to 1,000,000 gallons per day. The City was also required to provide fresh water at the plant site to the United States, and its contractors, as needed for the constructing, operation and maintenance of the plant or any part thereof.

VII.

During the period that the plant is owned and operated by the United States, the City agreed to purchase from the United States at the government's actual cost of production, not to exceed the price of 60 cents per thousand gallons, the product water estimated to be 250,000 gallons per day and not to exceed the price of 40 cents per one thousand gallons of product water estimated to be from 250,000 to 1,000,000 gallons per day. Under the terms of this Agreement, the United States, in accordance with the provision of Section 4 of Public Law 85-883, must proceed as promptly as practicable after September 2, 1965, to dispose of the plant by sale to the highest bidder unless otherwise directed by act of Congress.

We hope that this demonstration plant will come up with the answers which will solve some of our problems.