DISCUSSION

of

IMPACT OF MODERN TECHNOLOGY ON AMERICAN WATER DEVELOPMENT

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by

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INTRODUCTION

The remarks for this discussion were prepared after a review of the new book "Technology in American Water Development", by Ackerman and Löf. (1) *. The authors are to be complimented for accomplishing effectively their stated purpose of bringing "the technical horizon into better focus for businessmen, social scientists, administrators, and lawyers interested in water development and management... and (introducing) engineers and physical scientists to the administrative problems and opportunities which stem from their works." (1:vi) This writer noted only a few minor items of technical interest with which issue could be taken, and found the portions of the book dealing with administrative organization to be of considerable interest.

Since the book covers a broad range of subject material, and at the time of preparation of this discussion it was not known which phases would be presented by Dr. Löf in his oral presentation, it was necessary to confine these remarks to a limited part of the book. Hence they are not all directly related to the oral presentation just completed by Dr. Löf, but do coincide in part.

In this discussion three major topics are presented: (a) Some problems involved in the continued development of western surface and ground water resources, (b) A case history illustrating problems involved in current attempts at weather modification and (c) Some observations or the desirability of an increased interest at the state administrative level in problems brought about by technological advances.

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(1)* Numbers refer to appended references

SOME PROBLEMS INVOLVED IN THE CONTINUED DEVELOPMENT OF WESTERN SURFACE-WATER AND GROUND-WATER RESOURCES

The Salinity Problem The term "salinity" refers to a concentration of excess soluble salts, and the related term "alkalinity" refers to an excess concentration of sodium salts in the soil profile. Both salinity and alkalinity produce deleterious effects to agricultural soils and reduce the value of the areas affected. The potential for salinity problems exists in nearly all arid areas because adequate precipitation does not occur to effect a net downward movement of these salts through the soil profile. The historical pattern of development of irrigated areas has been favorable for the development of these problems.

First irrigation developments in western valleys typically consisted of little more than a crude diversion structure and a simple turn-out onto irrigated lands immediately adjacent to the stream. By late in the nineteenth century, a large number of storage structures had been constructed, along with suitable transmission and delivery facilities, to permit delivery of water to land at higher elevations than those originally irrigated. Availability of financial support from the federal government for irrigation development after the turn of the century permitted the construction of additional facilities for irrigation at still higher elevations adjacent to the pioneer irrigation developments.

This pattern of development strongly promotes the salinity problem. Excess water applied at the higher elevations inevitably percolates to lower levels, where it evaporates and deposits at the soil surface its burden of soluble salts. This problem has existed in some areas for more than 50 years (2), and continues today (3).

There is little reason to believe that this problem will correct itself. On the contrary, it is likely to be compounded in the future. As water from higher elevations percolates toward the lower irrigated lands, removal of soluble salts in the path of the percolating water provides larger openings for increasing rates of flow from higher to lower elevations. The net effect has been deterioration of irrigated lands, and in many instances, complete abandonment of what were once productive lands. This is illustrated, for example, by a net decrease in irrigated lands in Colorado between 1940 and 1950, concurrent with a net increase in area of drainage enterprises (4), as might be expected from the discussion which follows.

The solution to this problem is simple in theory, but relatively expensive to accomplish in practice. Provision of adequate drainage for the removal of excess water, to accomplish a net downward movement of water through the soil profile, will alleviate the problem. Thus the practice of leaching, or application of sufficient water to assure downward movement of soluble salts, is becoming more common where salinity problems are evident. Provision of adequate drainage facilities is, however, a necessary and usually expensive prerequisite for such treatments.

As necessary steps are taken for drainage and leaching of those lands subject to salinity problems, and water is re-used, the quality of the water involved will inevitably deteriorate. An example is presented by Ackerman and Löf (1:43) of the increase in dissolved solids of the Cache la Poudre river from 37 to 1571 ppm in a distance of 40 miles. It is interesting to note that along this same river, there is total diversion of about 2.5 times as much water as is supplied to the headwaters of the stream from melting snow (5), indicating significant re-use of water along this stream.

The problem of salinity is one that shows little indication of an easy or inexpensive solution. It is a problem that will continue to make both quality and quantity demands on western water resources.

The Problem of Adjustment to the Increasing Demands on the Available Supply of Water in the West In view of the foregoing discussion, it is not surprising that there is general agreement among technically trained persons that irrigation and drainage are in fact closely related, and that supplying water for irrigation without providing adequate drainage is an invitation to trouble in later years. Thus, we find an interesting paradox in planning for the development of new irrigated areas: supplying irrigation water is costly, and is in fact subsidized from other aspects of multiple-purpose projects; yet to provide adequate drainage additional expense often must be incurred for removal of excess water. This paradox is superimposed on a background of a high level of taxation and an increasing public resentment of the high costs involved in maintaining government surplus stocks of food. In view of these facts, it seems reasonable to expect increased political difficulty in securing financial support at the federal level for the initiation of new irrigation projects.

A further problem is the competition with agriculture by industry and municipalities for the available water supplies. Although domestic use enjoys in many states the legal status of a "higher right" as compared to industrial or agricultural use; because of complicating factors such as return flow, the transfer of water rights from agricultural use to municipal use may follow a tortuous legal path. It seems reasonable that western agriculture will encounter increasing competition for water for municipal use from an expanding population; moreover, it can be anticipated that the transfer will be attended by numerous disputes to be settled by the courts.

The Problem of Increasing Dependence on the Federal Level for Action in the Development of Water Resources Ackerman and Löf (1:588) note correctly the prevailing attitude of interests representing the states to encourage federal financing and construction of large-scale water facilities, with later assumption of operational responsibility by the state. The authors' description of the failures on the part of local governmental units to utilize powers of zoning to reduce flood damage (1:590) is an indictment of an attitude of increasing dependence of local governmental units on the federal administrative structure.

For those who consider this trend to be undesirable, several examples of effective action in water resource development on a lower organizational level are worth nothing. One of the most remarkable is the expansion of pump irrigation in the midwest. Available statistics indicate an increase of more than 300 percent in irrigated acreage in the "border" States of North Dakota, South Dakota, Nebraska, Kansas and Oklahoma between 1950 and 1956, with an estimated irrigated acreage of nearly 5,000,000 acres by 1966 (6). Most of this development came from development of underground water supplies. It is worth noting that this development took place almost exclusively at the expense of individual landowners, without direct subsidy, often at a pre-acre cost considerably below that involved in the development of multi-purpose plans.

The development of the California State Water Plan is another example of a state government taking the initiative in water resource development.

Both ot these examples show how action can be initiated at lower levels of administrative organization when the need for action is sufficiently strong. In the case of expanded pump irrigation in the midwest, individual action resulted from the necessity to improve the competitive position of the individual landowner at a time when the agricultural industry as a whole was experiencing considerable difficulty. In the case of the California Water Plan, the impending problem of increased population pressures was a primary factor in promoting action.

In view of these two examples, it seems reasonable to expect that action on an individual, local, or state level, can and will be initiated when such action is clearly indicated by economic factors. An increased attention to the necessity of action in water resources development at this level seems inevitable as economic factors force an increased attention to problems of water resources development at a state or lower organizational level.

It is interesting to note that this is in substantial agreement with Dr. Löf's views that new developments will keep pace with mans' increasing need for water resources.

PROBLEMS INVOLVED IN ATTEMPTS AT WEATHER MODIFICATION

Review of Present Status Modern weather modification attempts have passed through four phases during the past thirteen years. The first phase was that of discovery, by Schaeffer and Vonnegut in 1946, that effects on clouds could be produced by carbon dioxide and silver iodide. The second phase was that of enthusiastic acceptance of the commercial cloud seeding projects, primarily for precipitation increase. By 1951-53 these activities involved sums of 3-5 million dollars, and included up to 10 percent of the nation's land area. (7:8). The third phase was that of doubt and disallusionment as the public became wary of some of the rather extravagant claims of the commercial cloud seeders. The fourth and current phase can be considered that of conditional acceptance of some aspects of weather modification activity. This phase may be considered to have begun in December 1957 with the issuance of the Final Reports of the Advisory Committee on Weather Control (7,8). Principal conclusions reached by the Committee include the following:

1. There has been a 10-15 percent increase in precipitation resulting from seeding winter-type storms in certain mountainous area of the western United States.

2. It was not possible to detect either positive or negative results in non-mountainous areas with the statistical tests employed.

3. No conclusions as to the effectiveness of hail suppression projects could be reached.

The present phase of conditional acceptance of weather modification activity is illustrated by a quotation from Ackerman and Löf (1:360) "... if a cloud does not have sufficient quantities of ice-forming nuclei, but if other conditions such as temperature, air motion, water droplet size and distribution are satisfactory, the artificial addition of crystallization nuclei may initiate the precipitation process". (Emphasis supplied.)

The present status of weather modification can be summarized by stating that existing knowledge leaves unsolved the problem of the economic feasibility of large-scale commercial cloud seeding projects in non-mountainous areas.

A Case History of a Weather Modification Project Illustrating Some of Problems Involved in Applying this Phase of Technology to Water Resources Development This case involved the efforts by a voluntary organization of farmers and businessmen in northeastern Colorado to combat a common enemy--hail. Concern with the problem is not surprising, since the area has a greater average frequency of hail days than any other location in the United States (9), and individual hailstorms producing losses in excess of $1,000,000 are relatively common (10).

Action was taken in 1958 to begin a limited program of hail suppression. Efforts to collect funds by a voluntary organization began concurrently with the first hailstorms of the season. By the time monies were collected and equipment was in the field and ready for operation, several hailstorms had occurred. The operation, which consisted of ground-based silver iodide generators supplemented by air-borne generators, continued through the summer. By the end of the season, a large number of individual storms had been seeded. These seeding efforts were not uniformly successful in suppressing hail, but they were generally successful in producing rather marked changes in the physical appearance of the clouds, in most cases associated with an apparent decrease in intensity of the storm. At the end of the season no evaluation of results was made, so the question of effectiveness of the operation was not answered.

In the spring of 1959 an effort was made to collect money for another hail suppression program. More than $60,000 was collected.

Much of the success for the collection of this sum can be attributed to the marked changes in the physical appearance of the clouds undergoing seeding during the preceding season. A contract was negotiated between the local group and a commercial cloud seeding organization. Under the terms of the agreement, all potential hail-bearing clouds were to be seeded with silver iodide, using a network of about 125 ground-based silver iodide generators and five airplanes to protect an area of about 3,400 square miles in the extreme northeastern corner of Colorado.

This operation has been in progress since May 15 and will continue through September 15, 1959. The writer has had occasion to observe this operation, and believes that several observations are worthy of mention.

Some question has existed as to whether the silver iodide does in fact reach the clouds to become effective as nuclei (1:368). It is the writer's opinion that there is no doubt whatsoever that silver iodide does reach the clouds and does produce marked effects on most occasions when seeding is taking place. These effects consist of a change in the cumulus cloud form from a well-defined water droplet cloud to a rather diffuse and fuzzy cloud outline associated with ice-crystal clouds. These effects noted over small areas by Schaeffer and Dieterich (11), are wide-spread over the target area on days when seeding occurs. Note that this observation applies for convective clouds only - it does not necessarily apply to other meteorological conditions. The reason for these effects can be given in terms of the tremendous numbers of nuclei which are present during the days of operation. Effective nuclei numbers on the order of 100,000 per cubic yard have been estimated to be present during some days of the operation (12). This is approximately 100 times the numbers currently postulated to be a desirable minimum for effective artificial nucleation (13).

Unfortunately no positive statements can be made regarding the effect on hail intensity of these marked changes in cloud appearance. Damaging hail has occurred, both inside and outside of the target area. It is interesting to note, however, that as of the time of preparation of this discussion, there has not been an occurrence this year of a continuous path of hail damage through the target area, while several such cases have occurred this summer on either side of the seeded area.

In the absence of conclusive proof regarding the effects of hail intensity and concurrent effects on precipitation amounts caused by a cloud-seeding program, one must speculate on some of the problems that will attend future activity of this type.

In the first place, it is reasonable to expect that the effects due to seeding will likely be small, since their existence have not as yet been established beyond doubt.

Second, since numerous observations have been made of an apparent decrease in intensity of convective activity concurrent with seeding, let us speculate that a hail suppression effect of some magnitude does exist.

Third, since the seeding effect seems to produce a decrease in convective activity, let us speculate that the net effect of heavy seeding of cumulus clouds by silver iodide is to produce a small decrease in total precipitation.

These three assumptions are not unreasonable in light of the available evidence. They bring into sharper focus another major problem--that of a conflict in local interest between those on one hand who are most concerned with hail suppression, and those on the other hand who are primarily concerned with total available moisture supply. That this problem is real is evidenced by the fact that protests are being made in northeastern Colorado this summer that moisture supplies are being reduced because of the seeding program.

This conflict of interest was an important factor that resulted in legal action preventing continuation of a hail suppression program in the North Platte Valley of Nebraska near Scottsbluff (14). It also was a factor which lead to a provision in a newly-passed law in Nebraska which requires that seeding operations must be confined within the district, and that if damages occur outside of the district, the operator is liable for these damages (15). A similar provision exists in Colorado law, which prohibits weather modification activities in Colorado "...for the purpose of affecting weather in any other State which prohibits such operations in that other State..." (16).

Since weather modification is a relatively recent technological development, it appears likely that problems concerning the relative value of hail suppression as related to total moisture supply will ultimately be settled in the courts. In view of the present state of ignorance concerning the presence or absence of given effects, not to mention the magnitude of these effects, it is likely that satisfactory legal decisions must await further factual information.

There are lessons to be learned from this case history of attempts at weather modification. They may be summarized as follows:

1. Since marked visual changes in cloud form are associated with a seeding program, it is likely that there will be clients for weather modification projects unless and until irrefutable proof is presented that such activity is uneconomical. The reason is that even though effects of seeding are small, and difficult to detect, a considerable economic loss could result from rejection of a seeding program if it did in fact produce some effect.

2. Conflicts of interest at local, state, and perhaps regional levels over weather modification activity are likely to continue.

3. In the absence of detailed knowledge concerning the magnitude of cloud seeding effects, it is to be hoped that legal actions which might be construed as final decisions in matters of conflict will be based on a more solid body of factual evidence than is currently available.

4. The need is great for additional factual evidence in these matters. As correctly pointed out by Ackerman and Löf (1:378), there is a need for additional data, not only to supply a "yes or no" answer to the question of effectiveness of the seeding, but also to provide the basic information required in the complex regulatory machinery for water resources at the local, state, and federal levels.

THE DESIRABILITY OF AN INCREASED INTEREST AT THE STATE ADMINISTRATIVE LEVEL IN PROBLEMS OF WATER RESOURCE DEVELOPMENT

Federal--State--Local--Private Enterprise Relations In the last part of their book Ackerman and Löf (1:Chap. 22) point out some of the problems resulting from parallel or overlapping functions at the various levels of administrative organization in the field of water resources development. The question of which administrative level should have prime responsibility in a particular phase of resource development is in large measure a question to be answered.by each individual, based on his concept of a proper balance between administrative levels. The question embodies the relative value of decisions made from the "top-down" as opposed to "bottom-up". This question has been involved continually in our political decision-making processes.

Resource Development not a Function of Regional and Federal Levels Only In this discussion, several examples were noted wherein effective action for water resources development have been taken by administrative levels at the state level or lower. These examples included the development of ground-water resources by individual action, and local action in promoting weather modification activity. An example of effective action at the state level in studying problems in atmospheric processes is the Arizona Institute of Atmospheric Physics. These examples point to a feasibility of action at the state and local levels in problems of water resources development.

Regional oranizational structures will, no doubt, evolve as the need increases for effecting the scale economies which regional organization can bring. To a large extent, however, regional organizations are not now in being as working and effective machinery for water resources development.

Action Desirable at the State Level Now Problems and conflicts if interest which are developing now within the boundaries of a state and on the borders of adjoining states are of prime interest to those directly involved. A primary interest of the states should be the collection and analysis of such basic hydrologic data as are required so the decisions made by regulatory bodies are based on a solid foundation of fact. Accomplishing this objective is not beyond the capability of the states; on the contrary, it is to the best interest of the individual states to accomplish the task of collection of this information.

Problems in water resources development are present now; the need for their solution is important now; some examples of effective action at the state and local level can be found now--and there is no reason to believe that the problems involved will be less serious nor their solution less costly in the future than at present.

As we await the evolution of regional organizations to become intimately involved with these problems, it should be evident that the time for the individual states to increase their attention to the problem of water resources development--is now.

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