REPORT OF STEERING COMMITTEE
ON
SALINITY CONTROL OF IRRIGATION RETURN FLOWS

U.S. ENVIRONMENTAL PROTECTION AGENCY

REGION VIII - DENVER, COLORADO

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FOREWARD

In view of the continuing and expanding importance of controlling salinity pollution due to irrigation return flows, the Regional Administrator, Environmental Protection Agency, Region VIII, appointed a Task Force to consider the feasibility of applying the permit program to such flows. Subsequently, the passage of the 1972 Amendments to the Federal Water Pollution Control Act and the creation of the Brownell Task Force, appointed by the President to recommend measures for improving the quality of the Colorado River water entering the soverign State of Mexico, made it advisable to increase the personnel and to enlarge the scope of the assignment of the original Region VIII Task Force.

This paper, in brief, has as its purpose a definition of the salinity problem, the enunciation of a proposed Environmental Protection Agency policy for control of salinity from irrigated agriculture, and a recommended course of action to implement those portions of the Federal Water Pollution Control Act (PL 92-500) pertinent to this problem.

The members of the Task Force Steering Committee were:

John A. Green, Regional Administrator, EPA, Region VIII, Chairman.

Louis Striegel, Enforcement Division, EPA, Region VIII, Vice-Chairman.

Michael Glenn, Enforcement Division, EPA, Washington, D.C.

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William C. Shilling, Chief, Non-Point Sources Control Branch Water Quality Division (OWPO), EPA, Washington, D.C.

B. David Clark, Director, Surveillance & Analysis Division, EPA, Region IX

Jack Rademacher, Enforcement Division, EPA, Washington, D.C.

Russ Freeman, Intergovernmental Affairs, EPA, Region IX.

Much of the material in this report results from studies submitted to the Steering Committee by Sub-Groups under the direction of:

Jay Law, Chairman: Sub-Group-Problem Assessment

Joseph Krivak, Chairman: Sub-Group-Implementation

Cooper Wayman, Chairman: Sub-Group-Legal

CONCLUSIONS

1. There are many water quality problems resulting from irrigation return flows in the arid western regions. Salinity problems caused by a complex interrelationship of irrigation return flows; municipal and industrial discharges and natural pollution sources; consumptive water uses and other water depletions, such as reservoir evaporation and exports. However, as future flow depletions cause changes in mineral quality of water resources, control of salinity from irrigation return flows becomes increasingly significant. Thus, basin-wide control programs dealing with all water uses and natural sources are require to solve the problem.

2. Salinity falls within the scope of the Federal Water Pollution Control Act. This Act requires that the Environmental Protection Agency develop a national pollution control program, and further requires that the States develop basin-wide managemen plans to control both point and non-point sources of pollution. The national program should be focused on providing assistance to the States in the development of a series of such basin-wide programs. As a minimum, Environmental Protection Agency programs

should encompass: (a) mechanisms for providing assistance to and review of such State programs; (b) development and demonstration of control technology; and (c) monitoring the effectiveness of established controls.

3. A minor percent of the salinity problem caused by irrigation return flows can be controlled via a national permit program. The most viable approach to control of this problem is through water management.

4. The Federal Water Pollution Control Act places primary responsibility for control of water pollution problems in the State The States have the authority to control both water quality and water quantity which is essential to a complete water management program.

5. Improved water management practices, particularly the use of water at optimum efficiencies on the farm, is the most feasible approach to controlling excessive salt loads from irrigation return flows to many of our western river systems. Present technology would permit the implementation of several salinity control measure that are not now widely employed. The cost of installing available pollution control devices in many cases will be more than individua farmers can manage. However, if the salinity is not controlled, the cost to the Nation will far exceed the cost of the pollution

control. Federal and State financial assistance may be necessary if pollution controls are to be established.

6. Legal and institutional means must be found to control water salvaged through improved water management in order to finally achieve a solution to basin-wide salinity problems.

7. There are at present many federal, state, and local programs which do or could affect mineral water quality control. The mechanisms of existing programs should be utilized in implementing the mandates of the new water quality act.

RECOMMENDATIONS

It is recommended that:

1. The Environmental Protection Agency adopt the following policy with respect to the control of salinity pollution from irrigation return flows.

> "Control of salinity is necessary if the quality of the Nation's waters is to be maintained and enhanced. The Environmental Protection Agency recognizes that while irrigation return flows are only a part of the problem, they contribute materially to the total salinity problem in many of the Nation's basins. There are several principles which should be applied to the control of irrigation return flows including:
>
> a. Responsibility for control of pollution should be placed upon the parties responsible for such pollution.
>
> b. Pollution should be minimized by applying management control at the source rather than through treatment of return flows.
>
> c. Management control should utilize the most efficient techniques now available for limiting water usage."

2. The States assume the primary responsibility for the implementation of a program to control salinity from irrigation return flows.

3. At present, the Environmental Protection Agency not require application of Section 402 of the Federal Water Pollution Control Act to irrigation return flows, provided such return flows are brought under broader state or interstate programs which meet the mandatory requirements of the new water quality act.

4. The Environmental Protection Agency undertake a salinity control program in support of federal programs and the state or interstate control programs recommended in (2) above.

5. Any basin-wide plan developed under Sections 102, 208, 303, or 305 of the Federal Water Pollution Control Act include a plan to control salinity where it has been identified as a water quality problem.

6. Where a salinity problem already exists new lands should not be brought under irrigation development unless at the same time a program for a comparable reduction of the salt load is implemented.

INTRODUCTION

Irrigation is one of the most important agricultural practices developed by man, having been practiced in some form since the earliest recorded history of agriculture. Indians of the western hemisphere were irrigating crops long before the discovery of the New World. Irrigation has been the dominant factor in the development of land and water recources in the arid and semi-arid areas of the Western United States, and has greatly influenced the basic economy of that region. Irrigation is practiced in about ten percent of the total cropped land in the United States and produces about twenty-five percent of the Nation's total crop value. Irrigation farming not only increases productivity, but it also permits a shift from the relatively few dryland crops to many others which may be in greater demand. Irrigation strengthens other facets of a region's economy by creating employment opportunities in harvesting, processing, and marketing agricultural products. However, National Water Commission studies indicate that United States food and fiber demands through the year 2000 could be met using less irrigated land than is being used at present. Compensation for the loss in production would be achieved by returning lands not requiring irrigation (presently idle under government control programs) to production.

The water quality problems associated with irrigation return flows are of special concern because irrigated agriculture is the largest consumer of water resources. In addition, it is of major importance to the Nation as the source of a significant part of the food and fiber produced annually. Irrigation return flows constitute a large portion of the flow in many streams of the Western United States. Due to the consumptive nature of irrigation, some degree of salt concentration must be accepted as the price for irrigation development. However, there are areas where water quality degradation has been unduly serious and excessive. As pressures on water resources increase, there is mounting concern for proper and adequate control of such serious water quality deterioration. The exact role of irrigation return flows in both surface and groundwater quality problems must be examined more closely to develop and implement measures to control or alleviate the unnecessary detrimental effects. The need for more precise information as a basis for wise action has been brought sharply into focus.

SUPPORTING MATERIAL

Before addressing the salinity problems and solutions to irrigation return flows, it is necessary to understand that irrigation return flows are only one contributing factor to the problems, and that the salinity problems as a whole must be considered on a basin-wide basis with due consideration to the many other factors involved.

Salinity concentrations progressively increase from the headwaters to the mouth of western rivers. This increase results from two basic processes - salt loading and salt concentrating. Salt loading, the addition of mineral salts from various natural and man-made sources, increases salinity by increasing the total salt burden carried by the river. In contrast, salt concentrating effects are produced by stream flow depletions and increase salinity by concentrating the salt burden in a lesser volume of water.

Salt loads are contributed to the river system by natural and man-made sources. Natural sources include surface runoff and diffuse groundwater discharges, and discrete sources such as mineral springs, seeps, and other identifiable point discharges of saline waters. Man-made sources include municipal and industrial waste discharges and return flows from irrigated lands.

Streamflow depletions contribute significantly to salinity increases. Consumptive use of water for irrigation is responsible for the largest depletions. Consumptive use of water for municipal and industrial purposes accounts for a much smaller depletion. Evaporation from reservoir and stream surfaces also produces large depletions. Phreatophytes cause significant water losses by evapotranspiration.

Out-of-basin diversions from the upper reaches of a basin contribute significantly to streamflow depletions and produce a salt concentrating effect similar to consumptive use. The water diverted is high in quality and low in salt content. Thus, while these diversions remove substantial quantities of water from the basin, they remove only a small portion of the salt load.

The Colorado River Basin offers an example of this situation. Analysis of the relative effects of the various salt loading and salt concentrating factors on salinity concentrations of the Colorado River at Hoover Dam indicates that only about half of the average salinity concentrations are attributed to natural factors. While in the past, salt loading has been the dominant factor affecting salinity concentrations, future increases in salinity levels will result primarily from flow depletions caused by out-of-basin exports, reservoir evaporation and consumptive use of water for municipal, industrial, and agricultural purposes.

Projections for Hoover Dam indicate a relatively constant, average salt load over the next 40 years, but a substantial drop in water flow. Over 80% of the future increases in salinity concentrations at Hoover Dam will be the result of increases in flow depletions. Over three-fourths of the projected salinity increase between 1960 and 2010 will be the result of increases in reservoir evaporation brought about by the filling of major storage reservoirs completed since 1960, and of increases in consumptive use brought about by the expansion of irrigated agriculture.

From the discussion it is clear that any solution to the overall salinity problem of a river basin must be basin-wide in scope, and it must take into account water diversions and consumptive uses as well as natural and man-caused sources of salinity loads.

There are several factors which influence the severity of irrigation return flow quality problems. Major among these are: (1) quality of irrigation water applied; (2) climate of the region; (3) quantity of water applied; (4) geology and soil types in the basin; and (5) total irrigated acreage in a river basin.

Usually, the quality of the water coming from the mountanious watersheds in the West is excellent. At the base of the mountain range, large quantities of water are diverted to valley croplands. Much of the diverted water is lost to the atmosphere by evapotranspiration (perhaps one-half to two-thirds of the diverted water) with the remaining water supply being irrigation return flow. This return flow will either be surface runoff, shallow horizontal subsurface flow, or will move vertically through the soil profile until it reaches a perched water table or the groundwater reservoir. There it will remain in storage or be transported through the groundwater reservoir until it reaches a river channel.

That portion of the water supply which has been diverted for irrigation, but lost by evapotranspiration (consumed) is essentially salt-free. Therefore, the irrigation return flow will contain most of the salts originally in the water supply. The surface irrigation return flow will usually contain only slightly higher salt concentrations than the original water supply.

Whether irrigation return flows come from surface runoff or have returned to the system via the soil profile, the water can be expected to undergo a variety of quality changes due to varying exposure conditions. Drainage from surface sources consists mainly of surface runoff from irrigated land (there will be some precipitation runoff). Because of its limited contact and exposure to the soil surface, the following changes in quality might be expected between application and runoff: (a) dissolved solids concentrations only slightly increased; (b) addition of variable and fluctuating amounts of pesticides; (c) addition of variable amounts of fertilizer elements; (d) an increase in sediments and other colloidal material; (e) crop residues and other debris floated from the soil surface; and (f) increased bacterial content.

Drainage water that has moved through the soil profile will experience changes in quality different from surface runoff. Because of its more intimate contact with the soil and the dynamic soil-plant-water regime, the following changes in quality are predictable: (a) considerable increase in dissolved solids concentrations; (b) the distribution of various cations and anions may be quite different; (c) variation in the total salt load depending on whether there has been deposition or leaching; (d) little or no sediment or colloidal material; (e) generally increased nitrate content; (f) little or no phosphorus content; (g) general reduction of oxidizable organic substances; and (h) reduction of pathogenic organisms and coliform bacteria. Each type of return flow will affect the receiving water in proportion to respective discharges and the relative quality of the receiving water.

Many of the western rivers show the effects of irrigation return flows on the quality of water. Along a 200-mile stretch of the Sevier River in central Utah, there are seven complete stream diversions for irrigation. Although there are several high-quality streams entering the valley, the total dissolved solids (TDS) concentration shows a 20-fold increase to a value of over 900 mg/l.

The Colorado River shows at least a 20-fold increase in salinity from Grand Lake to Imperial Dam, where the average concentration is about 850 mg/l. There are several reservoirs and irrigation diversions along the Rio Grande in New Mexico. Salinity increases from about 200 mg/l near Sante Fe to over 2,000 mg/l below El Paso Valley. These salinity levels are in excess of the 500 mg/l TDS criterion recommended for public water supplies. The public water supply criteria for both chloride and sulfate are 250 mg/l. These values are also exceeded under these conditions described since these are ordinarily the predominant anions in irrigation return flows.

Water quality degradation in a river basin due to irrigation return flows bears a somewhat linear relationship to the total irrigated acreage in the basin. For instance, an increase in irrigated acres would be expected to further degrade the downstream water quality, assuming no concerted effort to implement basin-wide salinity control measures.

The total irrigated land in the United States has increased from under four million acres in the 1890's to almost 44 million acres in 1969. During the last two decades, the value of supplemental irrigation has been recognized in the humid Eastern United States, with a total irrigated acreage of 3.6 million acres in 1960 which reflects more than a two-fold increase in the last ten years. The

Economic Research Service (U. S. Department of Agriculture) has made projections of irrigated acreage in the United States to the year 2020. If these projections hold true, irrigated acreage could continue to increase by five to ten percent per decade for the next half century.

Arid regions are characterized by inadequate rainfall and high evaporative losses. In those areas, economic crop production is not possible without irrigation. In contrast, supplemental irrigation in more humid regions is employed only to assure adequate soil moisture through the growing season when extended dry periods occur. In rainfall-deficient areas, soils may be salt-laden and/or high in exchangable sodium due to insufficient natural leaching. The U. S. Salinity Laboratory estimates that crop production is reduced on one-fourth of the irrigated land in the Western United States due to saline soils. Salinity is a potential hazard to half of the irrigated land in the West. The complete reclamation of saline soils can require long periods of time and large quantitie of salt may be displaced to surface streams or groundwater.

Excessive water use is the greatest cause of water quality degradation associated with irrigation. This is especially true whe saline aquifers and/or salt-bearing geologic formations underlie the irrigated area. Excessive deep percolation (over and above the leaching requirement) will flush more salt to the river drainage system and increase the total salt load of the river. Excessive irrigation will also increase non-beneficial water losses resulting in added streamflow depletions and an increased salinity concentrating effect. Thus, efficient water use is the key to controlling both the salinity loading and salinity concentrating effects attributable to irrigation.

Although there are many factors which affect efficient farm water management, it is generally agreed that much higher irrigation efficiencies are attainable than are normally achieved. Optimum irrigation efficiencies are achieved when just enough water is applied to meet the crop needs and leaching requirement. The water needs of various crops at different stages of growth and maturity have been determined for different climatic regions. The leaching requirement is based on the quality of irrigation water and the salt concentration that can be tolerated in the root zone of the crop. There are standard procedures for determining the leaching requirement for any given set of conditions. It has been demonstrated (at the Riverside Laboratory of the U. S. Department of Agriculture) on small plots that leaching requirements as low as three to five percent (indicating field irrigation efficiencies as high as 95-97%) are attainable. However, such low leaching fractions (high efficiencies) have not been obtained in general practice. In order to achieve higher irrigation efficiencies, a substantial investment in improved irrigation technology would be required.

U. S. Bureau of Reclamation studies reported to the Brownell Task Force indicates the following costs for improvement of irrigation efficiency:

Farm Irrigation Efficiency	Approximate Equivalent Annual Cost ($/Acre)
50% (pres)	0
75%	15
80%	30
90%	50
95%	70

These cost estimates are based on use of increasingly complex controls to improve the timing and volume of applied water in accordance with crop water requirements. It is also noted that practical considerations might preclude achieving farm efficiencies in the 90% range. Treatment of return flows appears to be the only other visible control alternative. A case study of the Wellton-Mohawk Project in the Lower Colorado River Basin, indicated that through the range of practical applicability reducing return flows through more efficient irrigation was less expensive than treatment of return flows by desalting.

Although annual costs in the range reported above exceed the repayment capacity of most farmers, studies supported by the Enviro mental Protection Agency in the Colorado River Basin indicate that benefits resulting from salinity control throughout a river basin generally exceed the cost of controls. When such a situation occurs, the normal practice is to share costs between the irrigation and other beneficiaries elsewhere in the basin.

The initial charge to this study group was to determine the applicability of an effluent-permit program to the control of irrigation return flow. This approach does not appear to be practical for several reasons:

1. Control of return flow salinity does not deal with the total aspect of irrigation effects on salinity, particularly the concentrating effects stemming from non-beneficial consumptive use of water.

2. The best approach to control return flow is water management; water management can best be regulated by control on diversions or beneficial consumptive use, rather than by irrigation return flows

3. There are technical problems in identifying, measuring, and regulating sub-surface return flows.

4. Permits should have only a minimal effect since most of the salinity problems result from sub-surface return flows. It is estimated that only a small fraction of sub-surface return flows would appear to meet the definition of "point source" and would come within the scope of the Federal Water Pollution Control Act.

5. Severe administrative problems would be involved in application of a permit program because of the potentially large number of applicants involved.

These points are discussed in more detail as follows:

Approximately 40-60% of the return flows from irrigation are tailwater losses. Since this water is about the same quality as that of the diversion water, tailwater does not create major salinity problems. The salinity problems to a great extent are associated with sub-surface drainage from the irrigation projects. There are serious technical problems in identifying, measuring, and monitoring these sub-surface return flows. Tile drainage is the only fraction of sub-surface return flows which can be measurec It is estimated that only 15% of all irrigated lands are tile drained. Thus, only a small percentage of the sub-surface waters could reasonably come within the scope of the permit program, as provided in the Act.

The administrative problems of dealing with all farm units discharging into navigable waters would be overwhelming. There are perhaps about 100,000 industries generating wastes in the United States. Only 25,000 to 30,000 of these require permits to discharge to navigable waters or their tributaries. All others dispose of their waste to municipal treatment facilities or are no-discharge situations. The 1969 Census of Agriculture shows that more than 39,000,000 acres were irrigated on more than 230,000 farms in the United States. Obviously it would be very difficult to issue permits for irrigation return flows from each farm, even if technically feasible, since the work load would be about ten-fold that necessitated all other industries combined. Also, each individual farmer would not have the technical capabilities for chemical or other analyses which are required in the permit application, or to show compliance with the permit requirement. For this reason, if a permit program is to be implemented, it would be more efficient to consider a permit for a larger entity such as an irrigation district, river basin, valley, or a block of lands.

Given the relative merits and cost of administration of Section 402 of the Act, as compared to the development and operation of an effective administrative institution for water management, the latter is clearly preferred.

For the foregoing reasons, it has been recommended that a "permits" not be applied to irrigation return flows at present. Rather, basin-wide control programs should be developed which embodies the following principles:

1. Water management is the key to control of salinity in water use, particularly in irrigation.

2. All sources of pollution, both natural and man-made, and all concentrating effects should be recognized. Concentrating effects related to man's activity should be controlled.

3. The resulting water quality control program must be compatable with other water management institutions. However, it is recognized that this approach may involve changes in western water law.1/

1/ There are two potential benefits of water salvage: (1) reduced return flows generally imply reduced salinity loads; and (2) salvaged water may be made available to dilute downstream pollution sources. In order to assure that the latter type of salinity control benefit will result, some change in western water law may b required. Instream uses are not now generally held to come within the definition of beneficial use. If the definition of beneficial use were expanded to include instream use of water, the State would be allowed to acquire and hold water rights for environmenta and recreational needs. Western water law generally: (1) limits the definition of beneficial use to agriculture, municipal, industrial, and domestic uses; (2) holds any one (including the State) who intends to acquire, or holds a water right, must be abl to demonstrate a beneficial use; and (3) allows all water to be appropriated. Therefore, water salvaged becomes vulnerable to subsequent allocations. At present, the State is unable to acquir and hold water rights for instream uses.

The 1972 Amendments to the Federal Water Pollution Control Act provide a basis for States to accomplish these broad basin-wide salinity control programs in cooperation with the Environmental Protection Agency.

Passage of the 1972 Amendments to the Federal Water Pollution Control Act (PL 92-500) ushered in a new era in the field of water pollution control. The Act's stated objective is "to restore and maintain the chemical...quality of the Nation's waters" (Section 101), and the Administrator is required, in cooperation with other Federal, State, and local agencies "to develop comprehensive programs for preventing, reducing, or eliminating the pollution of navigable waters and groundwaters" (Section 102(a)). Salinity, technically described as Total Dissolved Solids (TDS) is the composite of chemical ions which have known adverse physiological, aesthetic, and economic effects. Thus, TDS is considered to be a pollutant, within the meaning of the Act, and its control falls with the purview of the Act.

Section 208 provides for the development of aera-wide waste treatment management plans by an agency designated by a state or a group of states. Any plan prepared is to include a process to identify and set forth procedures to control pollution from agriculturally related non-point sources. Section 208 further provides that the Governor or Governors designate one or more waste treatment management agency(ies) to carryout the plans. Provision is made for full Federal funding of costs of developing and operating a continuing aera-wide waste treatment planning process for the first three years and for 75% funding thereafter.

Under Section 305, each State is to prepare a report by January 1, 1975, which is to include a description of the water quality of all navigable waters in such State. The report must include a description of the nature and extent of the non-point sources of pollutants and recommendations as to programs to control these sources.

The Environmental Protection Agency under Section 304(e) is to issue informational guidelines for identifying and evaluating non-point pollution sources and information on processes, methods, and procedures for controlling these sources. Agricultural activities are to be covered.

Activities under Sections 208, 305, and 304, as well as other pertinent sections of the Act are brought together under Section 303. This Section provides for the establishment of water quality standards by the States, and for the Environmental Protection Agency to approve these standards. At the same time, the States must submit plans acceptable to the Environmental Protection Agency which will insure compliance with the established water quality standards.

Section 104 provides for research and demonstrations by the Environmental Protection Agency with specific reference to agriculture wastes.

It is clear from a review of the various sections of PL 92-500 that it is intended that pollution control programs are to be developed by State and local agencies. It is also clear that there are to be national programs in support of the State and local programs.

Specific requirements are spelled out in the various sections of the Act which provide for development of basin-wide water management plans for both point and non-point sources. The States have the primary role in their development and implementation with the Environmental Protection Agency providing instructional guidelines, funding, and an overall mechanism for review and approval. Where a river basin is interstate, an institution developed by the affected States is encouraged to develop and implement an effective basin-wide water quality management program. Meeting the requirements of the Act will necessitate a close working relationship among the States and Federal agencies.

PROPOSED EPA PROGRAM
(Re: Section 102)

A salinity control program to implement the recommendations contained in this report is outlined below. This outline contemplates that EPA would take implementing actions directly only where states failed to do so in conformance with EPA guidelines

Elements of a Salinity Control Program

I. Develop and issue information and guidelines (re: Sections 208, 209, 303, 304, 402, etc.).

II. Review and approve state continuing planning process, water quality standards implementation plans; and other actions taken in response to information and guidelines.

III. Establish interagency coordination.

IV. Priority Research and Demonstration Projects

- A. Western water law in relation to water management.
- B. Institutional study of interstate water management.
- C. Irrigation technology demonstration (with USDA).

V. Plan and Implement Other EPA Programs Elements Including But Not Limited to:

- A. Program monitoring and control.
- B. Grant Administration.
- C. Acceptance and promulgation of regulations.
- D. Key enforcement actions.

Table I, Continued:

VI. Colorado River Pilot Control Program:

A. Establish basin-wide institution consistent with requirements of Section 208.

B. Develop technical plan with proposed regulations; implementation process; financing procedures; and legislative and institutional recommendations.

C. Accomplish required designations and other implementing actions.

D. Promulgate regulatory controls.

E. Implement three (3) accelerated control projects as recommended by the Colorado River Enforcement Conference.

There are a number of actions which should be accomplished to implement this program: designate a program manager; develop a detailed work plan; allocate a budget for the program; establish responsibility for executing each of the elements or sub-elements; and create a program coordination and control mechanism.

It is recommended that the Assistant Administrator for the Air and Water Programs Division be designated as program manager.

This committee stands ready to develop a budget and work plan to implement this program upon approval by the Administrator.