WATER RESOURCES OF IOWA

A SYMPOSIUM

Held at the Iowa State College
Ames, Iowa
March 7, 1950

OBJECTIVES OF THE CONFERENCE

1. To exchange ideas and recapitulate what is known about water resources of the state on a practical informal basis.

2. To bring into focus <u>all</u> demands on available resources, determine what new data <u>are</u> most urgently needed and what additional educational programs, if any, should be set up to assist in conserving the supply.

3. To point out the interest of Iowa agriculture in the water resources of the state and in their proper use, development and conservation.

4. To express our desire to cooperate with the Iowa Natural Resources Council, particularly in assembling information basic to the solution of the many problems involved and in developing needed educational programs.

5. To consider the effect on quality as well as quantity of present-day uses of water.

FOREWORD

Water is one of the elements essential to all forms of life but, unlike some of the others, demands on its use increase with each advance in civilized living. One example is urban consumption, which has increased from 50 gallons per capita per day to more than 200 within a single generation. With the expansion of industries requiring large quantities of water and the rapid increase in popularity of all kinds of air-conditioning, the rate of use may be expected to rise more sharply in the future than in the past.

In rural areas the same trend is evident. Modern farmsteads and livestock enterprises require more water for domestic use, and as agriculture becomes more and more scientific optimum moisture requirements of crops in all stages of growth must be met.

In the face of this situation and reports of widespread shortages in the public press, President Charles E. Friley appointed a committee of the Iowa State College consisting of Q. C. Ayres, chairman, and deans Andre, Gaskill and Smith to consider the matter and suggest appropriate action.

The result was the calling of a conference at Ames on March 7, 1950, to which were invited Governor Beardsley and all members of the Iowa Natural Resources Council. In addition, the attempt was made to include representatives of all agencies with a vital interest in water conservation and use so that all aspects of the question might be explored.

There follows a list of those who responded and participated in the conference:

Guests

William S. Beardsley
Governor, State of Iowa

Kirk Fox
Editor, Successful Farming

Harry Linn
State Secretary of Agriculture

H. Garland Hershey
State Geologist and Chairman, Iowa Natural Resources Council

Mrs. Addison Parker
Vice-Chairman, Iowa Natural Resources Council

J. Harold Ennis
Secretary and Member, Iowa Natural Resources Council

Chris H. Jensen
Member, Iowa Natural Resources Council; and Chairman, State Soil Conservation Committee

G. L. Ziemer
Director, Iowa Natural Resources Council
Rodney Q. Selby
Director, Iowa Development Commission
P. J. Houser
Director, Division of Public Health Engineering, State Department of Health
J. R. Harlan
Assistant Director, State Conservation Commission
F. M. Dawson
Dean of Engineering, State University of Iowa
V. R. Bennion
United States Geological Survey, Iowa City
Frank H. Mendell
State Conservationist, United States Soil Conservation Service
C. E. Lamoureux
Section Director, United States Weather Bureau
T. W. Thorpe
Thorpe Well Company, Des Moines
Oliver Stevenson
Irrigation Farmer in Western Iowa
W. S. Lynes
Member, State Legislature
Bert Myers
Engineer of Materials and Tests, Iowa State Highway Commission

<u>Faculty</u>

Iowa State College

Charles E. Friley
President
Harold V. Gaskill
Dean and Director of Science
Floyd Andre
Dean and Director of Agriculture
J. F. Downie Smith
Dean and Director of Engineering
George M. Browning
Research Professor, Agriculture
Richard K. Frevert
Professor of Agricultural Engineering
W. E. Galligan
Associate Professor of Civil Engineering
John F. Sandfort
Associate Professor of Mechanical Engineering
Lester E. Clapp
Extension Professor of Soil Conservation

Chalmer J. Roy
Professor and Head of Geology
Charles S. Gwynne
Associate Professor of Geology
Keith M. Hussey
Associate Professor of Geology
W. J. Schlick
Research Professor of Civil Engineering
John F. Timmons
Professor of Agricultural Economics
Don Kirkham
Professor of Physics and Research Professor of Agronomy
Frank F. Riecken
Professor of Agronomy (Soils)
Robert H. Shaw
Associate Professor of Agronomy (Climatology)
Gerald L. Barger
Resident Collaborator in Climatology, United States Weather Bureau
Quincy C. Ayres
Assistant to the President and Professor of Agricultural Engineering

AGENDA

The conference was planned to convene at 10 o'clock, adjourn for a group luncheon at noon and reconvene in the afternoon. Governor Beardsley's inspirational address at the luncheon was much enjoyed and appreciated by all. He stressed the importance of Iowa's water resources and the need for intelligent management and conservation.

At the morning session Rodney Q. Selby presented a paper on Water for Industry, P. J. Houser discussed Water Supply Use and Abuse from the Public Health Standpoint, and James R. Harlan gave a paper on Recreation and Wildlife Values of Water.

In the afternoon W. E. Galligan led off with a paper on Supply and Use of Water in Municipalities and Agricultural Industries of Iowa, and was followed by John F. Sandfort speaking on the topic, The Water Demands of Air Conditioning, Refrigeration, and Heat Pump Equipment, and Its Possible Effect on the Water Resources of Iowa. Next followed a discussion of The Importance of Water to Agriculture by G. M. Browning and R. K. Frevert and the conference concluded with a brief resume of examples of Water Use and Problems in Soil and Water Conservation by Frank H. Mendell.

In keeping with the keynote of informality a discussion period was held following each paper. Notes of some of the more pertinent comments were taken by Messrs. Kirkham and Riecken. These notes appear in the body of the text at appropriate places and in the general discussion at the end.

Although no fixed conclusions were reached, it was unanimously agreed that the conference was very much worthwhile and that the way had been opened to a better over-all understanding and a more realistic approach in the future handling of water problems.

WATER FOR INDUSTRY

Rodney Q. Selby, Director
Iowa Development Commission

The five major water requirements for industry are: water for power, water for processing, water for transportation, water for health and sanitation, and water for recreation. Of these, power and processing call for the greatest quantities.

All industry requires power. Power generation is an industry in itself. Ruling out the obvious demands of water as a prime mover, in every other type of generation whether by steam or internal combustion, the cooling and condensing requirements are large.

Water for processing is by all standards the most important factor in industrial water use. Its requirements are exacting quantitatively and qualitatively. If we seek a broad general classification for the largest industrial water user, the answer is chemical processing. Innumerable specific industries can be included in this general category, but it is the chemical processing phases of their operation that usually require the greatest amounts of water. Textiles, food and fertilizer processing, plastics, synthetics, distillates, fuels, paper and soaps are some of the subdivisions that come to mind immediately. In the making of chemicals themselves water can be considered as the universal raw material.

A few individual examples can illustrate needs. The textile industry may consider fibers and fabrics its principal raw materials, but much of the processing of these is a chemical processing requiring millions of gallons of water. Dyeing, bleaching and washing are examples.

In synthetic fabrics the need is even greater. Making a ton of viscose rayon requires 200,000 gallons of water. Nylon is somewhat the same story.

Soap factories use 500 gallons for every ton of soap turned out.
For every 1,000 bushels of grain mashed, distillers use 600,000 gallons of water.
A paper mill may use as much as 20,000,000 gallons of water a day.
Oil refiners use 770 gallons per 42-gallon barrel.

We here in Iowa have been much interested in the liquification of coal for fuel as a possible profitable development of our coal reserves. It will take as much as 50,000,000 gallons of water a day to make 30,000 barrels of oil from coal.

Quantity is by no means the sole consideration. Qualitative requirements vary with each process and often with the several steps of the processing. Temperature, total solids, hardness, organic and inorganic contaminants and chlorides are important considerations.

Since cooling is one of the major water uses, temperature is probably the No. 1 consideration in quality analysis. Generally, ground water is colder than surface water; it contains less suspended matter and is more apt to be free from contamination by sanitary and industrial wastes. However, ground water often contains higher concentrations of soluble salts.

Characteristics of surface waters vary widely. Lakes, especially like the Great Lakes, are not influenced seriously by drouth conditions. But rivers fluctuate considerably during wet and dry seasons. When runoff is reduced, river water gets harder. Serious operating difficulties occur where engineers fail to take into account these changes in chemical characteristics of flowing streams.

Cooling water requirements of industry are enormous. The volume available and the temperature are of the utmost importance, often far outweighing considerations of quality. An abundant supply of low-temperature water can be evaluated on a dollar basis. It can be interpreted as equivalent refrigeration tonnage. The quality of the cooling water supply cannot be completely ignored, however, for dissolved salts, gases or by-products can corrode heat exchangers.

The magazine Chemical Engineering in an article summing up industrial water requirements outlines some of the problems in meeting a wide variety of specifications.

Says Chemical Engineering:

"Impurities in cooling water that cause the most trouble are: scale-forming constituents; suspended matter; dissolved corrosive gases; acids; oil or other organic matter; and slime-forming organisms. Well water contains less suspended matter, dissolved oxygen and fewer micro-organisms than surface water. But some deep well water is very hard and contains iron, manganese, fixed sulfides and sometimes ammonia, which corrodes certain metals and alloys. Surface water, used either once-through or recirculated, can also cause trouble due to these same impurities. Suspended solids lodge on heat exchanger surfaces, and, when accompanied by bacterial slimes and corrosive products, impair cooling efficiency and speedily attack metals. High temperatures in heat exchangers accelerate the action of these impurities.

"Specifications for process water in the chemical industries are bewildering in their diversity. Water going directly into the process must be treated to meet the special requirements of the product being manufactured.

"For example, aluminum and certain other metals are objectionable for the manufacture of photographic films. Fermentation processes improve as the sulfate concentration of the water increases.

"Most important requirements in the paper and textile industries are freedom from color, turbidity and suspended matter. There are also limitations on the content of hardness, manganese and iron. Slime formations, algae and microorganisms must be controlled in paper mills, especially where the raw water is heavily polluted.

"Process water for the manufacture of pharmaceuticals and biologicals requires more purification than the water used in any other chemical industry. No matter what its source, the water must be treated. Even clarification and softening do not always suffice. For example, the water used in making serum must be pyrogen-free.

"Boiler feedwater must meet the most exacting of water quality requirements. This is especially true in plants where makeup is a high percentage of the total feedwater. High-pressure steam boilers demand water from which almost all organic and inorganic solids have been eliminated. Even traces of silica can cause trouble."

Industry in the United States and in Iowa is expanding at a rapid pace and with this expansion water demands are mounting to what may appear to be astronomical figures. Water tables are falling and yet the over-all picture is not so discouraging.

The United States has plenty of water. The enormous quantities used are far less than the amount that falls from the sky. Average annual precipitation is enough to cover our entire 3 million square miles to a depth of nearly 30 inches. It amounts to almost 5 billion acre-feet or 15 million billion gallons. Great as are the quantities used, they are still exceeded by the amount of water in streams and underground reservoirs.

The line of 20-inch average annual rainfall corresponds approximately to the 100th meridian. East of the 100th meridian, surface water is normally in excess of the requirements of the population. West of this line dividing water abundance from water deficiency, there is a falling off of precipitation and therefore of available water.

Iowa is in this favored territory between the 90th and 96th meridian. Our average annual rainfall is 32 inches. Snowfall averages 30 inches.

America spends more than 1 million dollars every day for ground water. Use of ground water rose from 10 billion gallons a day in 1935 to 20 billion gallons a day in 1945 and is still increasing. Here is a breakdown of its daily use in 1945:

	Billion Gallons
Irrigation	10
Industrial	5
Municipal	3
Rural	2

In addition to the 5 billion gallons a day it got from its own wells in 1945, industry also used some of the 3 billion gallons a day that came from municipal water supplies.

But ground water accounts for only 20 percent of all water used. The other 80 percent is surface water. This means that in 1945 a total of about 100 billion gallons of water a day was used. With 140 million population in 1945, this was a per capita consumption of about 700 gallons a day for all purposes, excluding generation of hydroelectric power and recreational use.

Today, we may be using as much as 25 billion gallons a day of ground water. Add to that 100 billion gallons a day of surface water. You come up with a total of 125 billion gallons a day, being used for all purposes by 148 million people. This is a per capita consumption of over 800 gallons a day.

Industry generally is keenly aware of the need of not only finding adequate water supplies but also of conserving those already found. Many new and ingenious devices for reclaiming, reusing and recirculating water are coming into common usage.

Whether an industry uses water for its own power generation or for its processing, the mere employment of large numbers of people will mean a large water demand for health and sanitation purposes. More and more it is becoming necessary and certainly desirable to air-condition parts of plants and sometimes the whole system. Air conditioning puts another heavy burden on water production.

Water for transportation is listed as an industrial water use, but this is generally a natural advantage provided by nature, and industry itself can do little to increase or decrease it. Fortunately transportation is not a consuming use.

Water for recreation, however, is a collateral industrial use which is often overlooked but is none the less important. Plant locations are seldom made these days unless there is adequate provision for recreation of employees. In recreation, lakes and streams play a large and important role. If nature has not provided these facilities the people must. This again is quite often a means of conservation more than consumption.

Industry as one of the largest water consumers is interested in conservation measures. Water is an important raw material. Industrialists know that it must be used judiciously. Most industrialists are seriously interested in any integrated program that will not only control ground water depletion but also flood damage and soil erosion.

DISCUSSION

Question -

President Filey asked if industry had been satisfied with Iowa water. Selby replied in some cases it had, in other cases not. Textile industry requires high-quality water, and Iowa water is not satisfactory.

WATER SUPPLY USE AND ABUSE
FROM THE PUBLIC HEALTH STANDPOINT

P. J. Houser, Director, Division of Public Health Engineering
State Department of Health

Stream pollution control is an important element in any program of water conservation and use. Although Iowa does not stand out as an example of heavily polluted streams - in fact the contrary is the rule with the exception of a few places - there remains to be accomplished a program of continued cleanup commensurate with use of the water at and below the point where pollutional material is discharged. The problem of pollution control is twofold. First to be considered is the correction of pollutional conditions known to exist caused by the continuous discharge of pollutional material into the streams and lakes from municipalities and industries. Much has already been accomplished basically in this respect. At the present time there are 281 municipalities in the state with sewage and waste treatment facilities serving an estimated urban population of more than 940,000. Eight of the 16 cities of the first class (population 15,000 or more) are in this category. The remaining seven are located on the Mississippi or Missouri rivers where the flow of dilution water is sufficient to prevent conditions of gross pollution. It should not be inferred, however, that no treatment of the sewage and wastes from these municipalities is or will be necessary. In fact, the five states bordering the upper Mississippi River entered into a sanitation agreement several years ago requiring at least partial treatment when new sewers are installed.

Likewise there is a further need for the installation of sewage and industrial waste treatment plans in cities and towns now discharging raw or partially treated sewage into the inland rivers and smaller streams. In a few places zones of heavy pollution exist which make the water unfit for various uses. The previous speakers mentioned the needs of industry for processing water and the recreational value of clean water for fishing and propagation of other forms of aquatic life. These needs, among others, must be recognized in setting up any program of conservation and water use. Primarily, of course, the streams, lakes, and other bodies of surface water in the state must be kept sufficiently clean to be suitable for a public water supply where such use has already been employed or where it is indicated to be a necessity in the future. Of the 600 municipalities in the state now having public water supplies, 41 are dependent upon surface sources. The modern water purification processes are capable of producing a safe water only when the pollutional load to be removed is within certain limits. Even then many pollutional substances are responsible for objectionable tastes and odors in the purified water, and these materials must be further removed from the raw water in order to produce a water not only safe but potable. This latter quality is important from the public health standpoint, not particularly because the objectionable taste or odor is likely to have a definite physiological effect, but because the average person is inclined to seek his drinking water elsewhere and too often he will use a water of unsafe or at least questionable bacterial quality.

The second phase of the pollutional problem is usually integrated with the first. This is the pollution that occurs intermittently, caused by the breakdown or inefficient operations of an existing treatment plant or by the discharge of some toxic or other objectionable material either through the plant or directly into the stream. Two notable examples of the latter occurred last year with serious results. In one case a toxic chemical material was dumped into a sewage system where an efficient biological treatment plant was in operation, but which was not capable of reducing the chemical to a non-toxic state. As a result the material was discharged into the receiving stream in quantity sufficient to cause a heavy loss of fish much to the disgust - putting it mildly - of the sport fishermen in that locality. The other incident was similar in cause and effect but in this case the toxic material was discharged with the partially treated wastes from an industry. Here again the sportsmen in the area downstream were very much aggravated by the loss of fish life in the stream. But more serious in both cases is the fact that both streams are used as a source of public water supplies below the places where the toxic chemicals were discharged, and it is questionable whether the water purification processes would be effective in reducing the toxicity of these materials. What would have happened had the quantities dumped been sufficient to affect human life is left to your conjecture.

The last legislature enacted certain amendments to the stream and lake pollution law which provide particularly for prevention of pollution. Permits are now required for installation of sewers proposed to discharge into a stream, and in issuing these permits treatment of the sewage or industrial wastes is to be installed at the time or at some practical date in the future. However, this feature of legal control is designed for those conditions where pollutional material will or is being discharged more or less continuously and does not afford effective control over intermittent discharge. It appears that the latter phase of the problem is one for local concern and control. Treatment plants are designed and constructed for certain types of wastes and will not effectively reduce all types of wastes that may possibly be dumped into the sewer system. Had the city officials been contacted before dumping the toxic material in the one case cited previously, the disastrous destruction of fish life would have been prevented. Nevertheless similar situations may arise in the future and there should be effective local control measures set up so that industrial waste products can be disposed of but without damage to others. The rights and privileges to the use of a stream for disposal of sewage and industrial wastes must be recognized by all concerned, but they must not be abused if an effective program of water conservation and use is to be administered.

So far I have commented on only that phase of the subject that pertains to use and abuse of surface waters. As mentioned previously, a large majority of the water supplies in the state are from ground sources. These supplies must also be protected against undue pollution. One of the major problems in this respect is the possibility of returning ground water to the ground after use such as has been previously proposed in connection with air conditioning systems. In some types of these systems the water is exposed to contamination and it would be necessary to provide some treatment to remove or make harmless this material. There are also the mineral characteristics of the water to be considered, in that some of these may be changed to the extent that other ground water supplies would be affected.

From the standpoint of public health, a water supply must be bacterially safe, palatable, and in sufficient quantity for health and sanitation purposes. But in the development of a supply an additional quantity is provided, if at all possible, for fire protection and other purposes. This additional quantity is usually the prime requisite of a supply and is the most important in considering the possible drain or other disturbances of our underground resources. A few municipalities in the state have felt a shortage of ground water lately, due presumably to the prolonged dry weather period last year. These supplies have been developed from shallow formations and I have not been informed of any failures of deep well supplies that could be attributed to this same condition. My only purpose in mentioning the quantity aspect of the ground water problem is to invite attention to the correlation between it and the public health aspect in that any disturbance in quantity may also disturb the quality of the supply available, particularly in the immediate locality.

I have attempted to cover only briefly the water supply situation under the subject assigned to me but will be glad to answer any questions if I can.

DISCUSSION

Question:

Are polluted streams polluting ground water?

Houser:

Probably.

Ayres:

Is a shortage of water damaging public health?

Houser:

In drouth, yes. In 1934 water was shipped into Iowa. Several towns are short in Iowa now. Southern part of state needs surface water from catchment areas. Ottumwa in 1947 had no pure water because water system was flooded.

Roy:

What materials get through standard chlorination and sedimentation process?

Houser:

Phenols (gas plant waste) are an example.

Ziemer:

Is silt a bad pollutant?

Houser:

Silt won't harm health. Too much silt harms spawning beds.

Thorpe:

Do drainage wells for tile outlets result in pollution of underground water?

Houser:

Yes, some sewage discharge from farm tile drains in small towns causes pollution. Not aware of pollution in open areas.

Fox:

Are blue babies more frequent in areas where drains empty into sink holes?

Houser:

No.

Fox:

Only 20 per cent of farms have sanitation. If the 80 per cent remainder install sanitation without care, pollution may become a problem.

Lynes:

Quotes a Minnesota case of pollution due to tiling into a sink hole. Tile water goes down these sink holes unfiltered. There should be a law prohibiting the emptying of tiles into drain sinks.

RECREATION AND WILDLIFE VALUES OF WATER

James R. Harlan, Assistant Director
State Conservation Commission

Mr. Bruce Stiles, Director of the State Conservation Commission, has asked me to express regret that the dates of the North American Wildlife Conference conflict with this meeting, and that he is unable to be here.

I don't believe that there is a man within the sound of my voice who does not dream that in his twilight years he may sit in peace and quiet meditation beside clean water. The setting of our dreams may be along the Gulf, a Minnesota lake or a Colorado stream, but always it is beside quality waters. "He leadeth me beside the still waters. He restoreth my soul."

I wish to show that no public water use plan in Iowa can or should succeed unless the recreational aspects of water are given major consideration in such plan.

We cannot count noses of all who are interested in the recreational use of our waters. We can, however, bring out some figures that prove that large segments of our population are directly concerned.

Hunters and fishermen are opinionated and outspoken. They are not organized as a labor union or a manufacturers' group. They are disorganized in that sense for the most part--yet they are organized, for they are unanimous in that they want better hunting and fishing amid better surroundings. They are absolutely certain that the manner in which the water resources of the state are used affects their sport.

The 332,000 licensed hunters and 372,000 fishermen total more than 534,000 people--more than one-fifth of the entire population of the state.

The licensed trappers approximate 10,000. In a recent year they took from our lakes, streams and marshes fur-bearing animals worth a million dollars more than the total taken in the entire territory of Alaska during the same period.

It is impossible to count the number of boat operators, owners and users. We can, however, cite a few figures that indicate the numerical importance of this group. In 1949 there were 2,200 commercial row boats and 2,500 motor boats licensed. The number of boats of one type or another in use on our public waters is conservatively estimated at 20,000.

Bathers, too, constitute a large group interested in quality, quantity and location of public water. I believe no one can give an estimate of the number of bathing enthusiasts. We do now that during the past year 3,700,000 citizens attended the state parks. A large majority attended parks with beaches, and the peak load in these parks was reached in the hot months when swimming was popular.

In addition to the above mentioned groups, there are numerous others directly interested in the recreation uses of water.

The manufacturers of firearms and ammunitions, fishing tackle, boats and motors, gasoline and automobiles, and hotels and restaurants all are interested in water from a recreation use standpoint.

It is hard to believe that there is a single Iowa citizen who does not have a voting interest in clean water abundantly available. This fact is reflected in recent appropriations of millions of dollars by the state legislature for the specific purpose of creating recreation waters where they have been destroyed or never existed.

What are our recreation waters in the order of their importance? We have 15,000 miles of streams, 45,000 acres of natural lakes, 3,000 acres of state-owned artificial lakes, thousands of additional acres of privately and publicly owned marsh and slough, unknown numbers of gravel pits and reservoirs, and an ever-increasing number of farm ponds. Every mile and every acre of this water is of potential worth for wildlife and recreation.

What is the recreation value of Iowa waters? Many attempts have been made to put a dollar value on these resources. In my opinion they have all been the wildest of guesses, with tangibles and intangibles thrown into the same hopper and magically coming out in the hard coin of the realm.

I think that attempts to give dollar evaluation to water for recreational use show dangerous and sloppy thinking. What is the value of this great college? What is the value of our churches? What is the value of our inheritance of freedom? What was the value to society of the 7,000 Des Moines citizens who fished and relaxed in the sun in a single day after the Des Moines city waterworks impoundment was opened to public fishing? What is the value of your dream of peace beside clean water?

We must leave evaluations by the dollar sign to those who sell dandruff remover, automobiles and baseball players, and judge clean water in the light of Moffatt's translation of the Twenty-third Psalm, "He leads me to refreshing streams. He revives life in me."

In what condition is our recreational water, and what of its future?

For most classifications of water the outlook is at least fair.

The primary use for our natural lakes is firmly established in the public mind. Recreation has the green light over every other. As a result pollution is being controlled, siltation retarded, dredging continued, public access acquired, and fishing improved. For natural lakes the future looks rosy.

The pattern for artificial lakes also is definite. The plan of a body of recreation water within 25 miles of every Iowa citizen is undeniably taking that form. Better artificial lakes, both in quality and size, are blueprinted for the future. Five new lakes are now in various stages of construction.

Industrial pits and municipal reservoirs for obvious reasons are increasing in numbers. With their recreational values more widely understood and accepted, it is probable that they will provide more recreation in the future.

Farm ponds in astronomical numbers are appearing on the horizon; each one to a greater or lesser degree has both wildlife and recreation possibilities.

The marsh picture has both a bright and a dark side, and these are very important from a recreation and wildlife standpoint.

It is probable that no more large marshes will be drained--certainly not today or tomorrow for the production of potatoes. The Conservation Commission is acquiring the <u>large recreation marshes</u> at an ever-increasing tempo, building control structures and otherwise managing them with the primary objective of increasing their wildlife and recreation values.

It is in the case of the small marsh, the pothole and slough that recreation is losing to the tiling spade. We are losing dozens each year. These numberless small water areas have incalculable value as fur and game producing areas. We cannot afford to lose a single one, for this, if for no other reason.

It is our streams that give us most concern. These are our priceless 15,000 miles of recreational arteries. Their use for this purpose is much greater than generally believed. I doubt that there is a single foot of fishing stream in the entire state that does not feel the tread of one or more anglers each season. A count on 15 miles of the Des Moines River from the Des Moines Grand Avenue bridge upstream last year revealed 5,000 fishermen.

Twenty-five years earlier I worked at a beach on the same stretch of river where paid admissions for bathing totaled 5, 000 on an average Sunday, and the beach would still be there if the Des Moines were a clean stream.

It is our streams that give us our most complicated and knotty water use problems and where we seem to work at cross purposes.

For recreation and wildlife we ask only the use of clean water. We give it back to agriculture and industry undiminished in quantity and unspoiled in quality. Do we not have the right to demand from others care in the use of that which is theirs on public loan? Can ignorant or selfish use that destroys public values be condoned or tolerated?

May I ask, has stream straightening, marsh draining, destruction of soil humus, and downhill plowing despoiled our streams and increased the peaks and valleys of stream flow? Have these engineering and agricultural activities destroyed the innumerable stream bank springs? Have they choked our rivers with undigested sand and destroyed game fish environment?

Has unnecessary municipal and industrial pollution driven the smallmouth, walleye and northern pike into the clean headwaters of our rivers? Must the wastes of industry drive pleasure boats and bankside slick butts of small boys from our streams? Does civilization require the destruction of the esthetic value of our rivers? Who has these answers?

Great is the need of an understanding of Iowa's hydrologic cycle. Great and diverse are the claims of our water-users, but greater than ever before is the human spiritual need expressed in David's song, "He leads me to refreshing streams. He revives life in me."

DISCUSSION

Riecken:

What size pot holes should not be drained?

Harlan:

Pot holes from size of table to 3 or 4 acres should not be drained.

Riecken:

Believes attitude about not draining pot holes is unrealistic. Farmers do not want pot holes.

Frevert:

Pot holes slow up a farmer so he can't go fishing or hunting. They result in wasted power and energy. Raise corn on flat lands where there are no soil losses.

Drainage now is a problem of replacement of inoperative systems and one of alleviating water damage in special problem areas.

SUPPLY AND USE OF WATER IN MUNICIPALITIES AND AGRICULTURAL INDUSTRIES IN IOWA

William E. Galligan, Associate Professor of Civil Engineering
Iowa State College

The two problems connected with the use of water by municipalities and agricultural industries in Iowa are, (a) the procuring of the supply and (b) the adequate disposal of the used water.

The problem of supply exists not because of any deficit over the state as a whole, but because of the excessive demand in populous communities. An analysis of the water resources in Iowa shows that we are not in any grave danger of a water famine, but it reveals the difficulties involved in developing a greater supply in certain localities. It also indicates the need for careful and thoughtful planning by qualified groups or agencies on a state level.

Let us examine the water resources in Iowa so as to avoid the occurrence of a critical shortage before it is too late. Such an examination should include a study relating precipitation to the demands that are made upon it. We have an average of 30.9 inches of precipitation annually. Water leaving the state in the form of stream flow amounts to 5.2 inches annually as computed from a combined stream flow record of 114 years on the following streams:

1. The Big Sioux River at Akron
2. The Boyer River at Logan
3. The Iowa River at Wapello
4. The Des Moines River at Keosauqua
5. The Little Sioux River at Correctionville
6. The Nishnabotna River at Hamburg
7. The Nodaway River at Clarinda
8. The Skunk River at Augusta
9. The Thompson River at Davis City
10. The Maquoketa River at Maquoketa
11. The Turkey River at Garber
12. The Upper Iowa River at Decorah
13. The Wapsipinicon River at DeWitt

The 12 mean monthly flows for each year on each watershed were averaged and converted to inches of water on each basin. The tributary areas were used in weighting these values, resulting in an average state-wide runoff figure of 5.2 inches water depth annually.

The difference between the 30.9 inches, average annual precipitation over the state, and the 5.2 inches, average yearly runoff, leaves 25.7 inches to be disposed of in three ways: (a) unnatural use (b) evapo-transpiration and (c) ground water recharge. Unnatural use is defined as the water used for human consumption for domestic purposes, water used to meet livestock demands, and the water used in industrial operations. Evapo-transpiration is defined as the water evaporated from land and water surfaces, detained water and water transpired in the process of vegetable growth. Ground water recharge is defined as that water that enters the ground and finds its way down to the saturation zone.

Iowa's population as estimated in 1945 was 2,260,000 persons. Of these 792,000 lived in urban communities. There were 21 cities in the 99 counties with population greater than 10,000. There were 208,934 farms in the state in 1945. If the population figures just given are used and if it is assumed that the average daily consumption of water in rural areas is 60 gallons per capita and in urban areas is 100 gallons per capita for domestic use only, then the domestic use of water is equivalent to 0.1 inch water depth per year.

In 1946 the estimated livestock population in Iowa and the assumed water consumption per animal per day is given in the following table:

6,555,000	cattle and calves	@	12 gallons
496,000	horses	@	10 "
853,000	sheep	@	5 "
10,698,000	hogs	@	5 "
7,271,000	chickens and turkeys	@	0.5 "

The equivalent water requirement annually for livestock is 0.15 inch water depth.

Industrial Water Requirements

Until about 1930, industry was steadily expanding and increasing in Iowa. In about 1931 it started to decline. During World War II it increased and since the beginning of the trend to decentralize industry in the country it has soared. The city of Fort Dodge, for example, had 25 industries in 1930; it has 70 today. How many other cities and towns have expanded industrially is indicated in a report for 1947 rendered by the Iowa State Bureau of Labor showing firms employing over 50 persons. An extract of this report, listing principal industrial cities and the numbers of firms in each employing 50 or more, 500 or more, and 1,000 or more persons, follows. The report states that in Iowa 907 firms employ 50 or more persons. Of these, 57 employ over 500 persons and 24 employ over 1,000 persons.

Industries in order of their importance in Iowa are:

1. Meat Packing
2. Dairy Products
3. Flour and Gristmill Products
4. Lumber and Timber (declining).

Meat packing houses, canning and other food preparation houses, large hospitals, large hotels, light power companies, and large laundry and cleaning plants use relatively large quantities of water. It is assumed that industry requires an amount of water equivalent to a depth of 0.3 inch annually.

Maximum yields of corn and oat crops and of hogs and cattle have been brought about largely because of two favorable meteorological conditions, (1) an abundant supply of moisture and (2) an optimum pattern of distribution of precipitation throughout the year. Approximately 73 percent of the annual precipitation occurs during the 6-month growing season from April through September. On the average, monthly precipitation reaches and remains at a peak during May, June and July and declines only slightly in August.

King shows the marked effect of water transpiration on crop returns in terms of inches of water consumed:

Yield bu. per A.	40	50	60	70	80	100
Wheat	12	15	18	--	--	--
Barley	8.6	10.7	12.8	20	--	--
Oats	6.3	7.8	9.4	11	12.5	15.7
Corn	6.7	8.4	10.1	11.7	13.4	16.8

Risler's evapo-transpiration rates, in inches of water per day are:

Meadow grass	0.134 -- 0.267
Oats	0.140 -- 0.193
Corn	0.110 -- 0.157
Clover	0.140 --
Vineyards	0.035 -- 0.031
Wheat	0,106 -- 0.110
Rye	0.091
Potatoes	0.038 -- 0.055
Oak trees	0.038 -- 0.035
Fir trees	0.020 -- 0.043

Using the maximum rates according to Risler, and considering a 6-month growing season, corn requires 28.6 inches of rainfall for a maximum crop; oats require 35 inches. Hay requires 25.5 inches, other crops average 18.25 inches, and deciduous forests, about 7 inches.

The principal crops listed with their acreage in 1946 are;

Wheat	143,000	acres
Rye	28,000	"
Corn	11,064,000	"
Oats	5,920,000	"
Barley	12,000	"
Soybeans	1,559,000	"
Hay	3,276,000	"
Forest	2,248,000	"
Other Crops	2,362,000	"

Calculations based on the foregoing figures, assuming a bumper crop year, indicate a water demand equivalent to 78 percent of the annual precipitation or 22.8 inches per year.

Thus the average annual precipitation in Iowa is distributed as follows:

Runoff	5.20	inches	water	depth
Human consumption	0.10	"	"	"
Livestock "	0.15	"	"	"
Industry	0.30	"	"	"
Evapo-transpiration	22.80	"	"	"
Ground water recharge	2.35	"	"	"
	30.90			

Except for "below average annual rainfall," an adequate amount of water is available to prevent recession of the ground water over the state as a whole. While the question of adequacy of rainfall seems to be answered in the affirmative, there still remains the question of meeting high demands in areas where municipalities and industries are located. It appears that the amount of ground water available to supply high rates of demand is becoming very inadequate in some places considering the nature of developing large ground water supplies.

In this analysis so far average annual precipitation figures have been used. When a low rate year or several low rate years occur in a group, local problems will become serious because the normal excess in supply dwindles and disappears and may not be replenished soon enough to avoid expensive improvisation in the water utility.

Thus far in considering water supply, no account has been taken of surface water separate from ground water. Water used from streams in most instances is returned to the stream and thus becomes available for future use. It has been said that the water in the Arkansas River flowing through Kansas is used and reused five times. This practice represents, in effect, an increase in the water resources of a region, and as water shortage develops in other regions like practice is resorted to.

In Iowa considerable thought is being given in engineering design offices to the feasibility of augmenting or replacing existing ground water supplies with water from streams. In general, a ground water supply is continued until its further use becomes definitely economically unsound. People generally prefer a ground water source of supply.

This brings us to the problem of the potability of river water. No river water in Iowa is safe to use without treatment of some kind. The degree of treatment needed depends upon the antecedent history of the water. If one or more unnatural uses have been made of the water, its quality may have been impaired to the extent of rendering it difficult to treat. Municipal sewage and some industrial wastes pollute streams, other wastes merely add contaminable materials, but it all adds up to the need generally for rather complete and expensive treatment. This is true even after the sewage and waste water have received treatment prior to discharge into the stream.

The cost of treating some of these wastes imposes a heavy burden on our agricultural industries. Creameries, packing plants, beet sugar processing plants and poultry stations are especially hard hit. A good example of the effect is the case of the former beet sugar processing plant at Belmond. In some instances the facilities for waste disposal seem to be almost disregarded by personnel of incoming industries. It seems also that in some cases authorities fail either to adequately inform these people or else fail to insist upon selection of a location for the best interests of both the industry and the state. One reason for this may be the apparent failure to ascribe suitable values to the increased capacity of our large bordering streams for sewage and waste disposal. Stream improvement programs like those being carried on on the Mississippi and the Missouri rivers should emphasize this phase of values. The low flow of the Missouri River will be increased something like 800 percent. Primary treatment alone should suffice in processing water prior to discharge into these streams in most cases at the present time. Some industries could well afford to suffer the disadvantages attendant to location in order to escape the need for the complete treatment of their wastes. Studies should be carried on along these lines so that our state might more ably advise on these matters.

DISCUSSION

Barger:

Disagrees with Galligan on quantity of water needed to grow corn. He thinks 19 inches plenty for corn. Galligan's 28.6 inches too high.

Galligan:

Says he can rely on figures only insofar as the sources he copied them from are correct. They may be high.

Roy:

What is ground water production in inches?

Hershey:

Can't be said offhand, but could be calculated.

Question:

Is overpumping of ground water causing trouble in Iowa?

Galligan:

Fort Dodge, Marshalltown and Davenport are in a bad way insofar as economics are involved. They have to pump huge distances for enough water. There are several reasons why wells lose productivity:

(1) An aquifer may consolidate because of release of pressure in it.

(2) Release of pressure lets CO_2 form carbonates which clog water-bearing pores.

(3) Wells sand up.

Thorpe:

We should install new wells so that old wells can recharge -- as in Fort Dodge. We should study aquifers. There should be a law to seal aquifers. There may be a dozen aquifers struck in a single well boring. All should be sealed except bottom one. If sealing is not done, water in upper strata may contaminate lower strata.

THE WATER DEMANDS OF AIR CONDITIONING, REFRIGERATION AND HEAT PUMP EQUIPMENT, AND ITS POSSIBLE EFFECT ON THE WATER RESOURCES OF IOWA

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For those not familiar with this equipment it would be helpful to first explain the units of capacity and the manner in which this equipment utilizes water. Air conditioning and refrigeration units are rated in terms of tons of refrigeration while the heat pump is usually rated in Btu per hour heating capacity. Since the heat pump is only a different application of refrigeration equipment it is also occasionally rated in tons capacity.

The ton of refrigeration is a rate of heat transfer, specifically 12,000 Btu per hour. The origin of this term is based on the fact that it requires approximately 12,000 Btu per hour to melt a ton of ice in 24 hours. To obtain some idea of the relative size of air conditioning equipment we might assume that a medium sized insulated residence in Iowa might require from 2 to 3 tons of refrigeration for summer cooling, a typical Main Street store or shop might require 3 to 10 tons, while the Memorial Union on the Iowa State College campus will probably require about 600 tons to be completely air conditioned. Another "rule of thumb" which is sometimes used in air conditioning estimates is the fact that 1 horsepower will produce about 1 ton of air conditioning.

An item to remember is that air conditioning and refrigeration systems above about 3 tons capacity always have water-cooled condensers, while those below 3 tons may have either water- or air-cooled condensers. Air-cooled units of course require no water but they are usually more expensive to operate because of the higher condensing pressures.

The amount of water used by water-cooled condensing units will depend on the temperature of the water available, together with some other factors, but for estimating purposes it can be assumed to average about 2.5 gallons per minute per ton where used but once. However, when recirculated through water conservation equipment it will only use about 2 percent of this amount or 0.05 gallons per minute per ton. This water conservation equipment consists primarily of natural draft cooling towers, forced draft cooling towers and evaporative condensers. This equipment all operates on the principle that water when sprayed into the air will cool down to a temperature approaching the wet bulb temperature of the air. The cooling effect comes from evaporating a small portion of the water itself, and when we realize that the wet bulb temperature is usually 10 to 15 degrees below the ordinary dry bulb temperature the advantage of this equipment as a cooling device becomes apparent. Natural draft cooling towers must always be placed outside of the building, usually on the roof, while the forced draft towers and evaporative condensers may be placed in the equipment room of the building.

Using the above figures for estimating, then, we might expect the air-conditioned residence referred to, to use 5 to 7 gallons of water per minute, the Main Street store from 7 to 25 gallons per minute and the Memorial Union about 1,500 gallons per minute. These figures are based on the use of condenser water without conservation equipment. So far as known there are no regulations requiring such equipment in Iowa, unless at the local level somewhere, and therefore it would not be used unless economically justified on the basis of prevailing water rates or well water pumping cost. A comparison which has been made of condensing unit vs. water conservation equipment sales in 1947 indicates that over 90 percent of air conditioning and refrigeration systems were installed without water conservation equipment. Most of these, however, would be systems under 30 tons capacity.

A second method of using water in air conditioning systems is to pass it through cooling coils arranged to cool the air directly without the use of intervening refrigeration compressors. To air-condition in this manner and still control the dew point requires water temperature below about 60 degrees. Well water throughout Iowa is generally below this temperature, and where it is available in sufficient quantities has become a very popular method of air conditioning. This is because of the lower equipment cost, and in some cases lower operating cost as well. Although the entire cooling load must be removed by water in either compressor systems or direct water coil systems, the latter arrangement may use from 100 percent to 200 percent more water per ton because the temperature rise of the water through the cooling coil must be kept relatively low. Also there is no opportunity of using water conservation equipment because of the low temperatures required. However, it would be possible to salvage all of this water through the use of diffusion wells which will be described later.

There is considerable interest at present in the heat pump for heating buildings. The heat pump, air conditioning and refrigeration equipment are basically one and the same thing, the only difference being in the application of the equipment. In heat pump systems the effect desired is the heat output of the condensers which is used to heat the buildings. However, this heat must ultimately be supplied from some readily available energy reservoir. One of the most convenient and widely used sources of heat for this purpose is well water from which heat is extracted by passing over evaporators which cool it down to some lower temperature.

At present heat pumps are unimportant in Iowa as competitive commercial heating equipment, since there are only a few scattered installations around the state. The low cost of gas and oil when compared to electric power rates, together with the fact that the climate is such that heating and air conditioning loads are inherently out of balance, makes Iowa an unfavorable area for extensive heat pump development. However, the situation could change, and it should be understood that any significant trend in this direction could place a tremendous drain on our underground water reserves.

What effect then is air conditioning and refrigeration likely to have on the water resources of Iowa? A review of some of the experiences of other states and communities around the country might be helpful in answering this question. These may be summarized as follows:

1. Peak demands in hot weather overtax municipal water systems. Air conditioning manufacturers estimate that over 90 percent of installed condensing units are supplied from city mains.
2. Problems of disposal are created by overtaxing sewer systems.
3. Ground water supplies for both municipal systems and private wells may be imperiled,
   a. in metropolitan areas having a heavy concentration of air conditioning, and
   b. in areas where underground supplies are limited.

The following specific examples illustrate the gravity of the problem in some areas and show what has been done to control the situation.

URBANA, ILLINOIS, STUDY. Fifty-four degree well water was available and used extensively for direct cooling. In the late 1930's a serious problem of supply developed. The water rate schedule ranged from 25 cents to 6 cents per 100 cubic feet. In an attempt to reduce the water usage for air conditioning the rate reduction for quantity usage was eliminated, but it was found that this did not solve the problem. Finally regulations had to be adopted in 1946 which (1) prohibited direct cooling with water, (2) required air-cooled condensers in installations below 1 1/2 tons, and (3) required water conservation equipment to be used on all installations over 5 tons.

PHILADELPHIA STUDY. A complete study of the water requirements for air conditioning and refrigeration in Philadelphia has been published. In 1947 they had installed 60,000 tons of air conditioning and 13,000 tons of refrigeration. Present regulations require conservation equipment in all systems over 30 horsepower (30 tons), and the present hot day demand is estimated at about 29 million gallons per day for air conditioning and refrigeration. It is estimated that this could be cut to 2.8 million gallons per day if the 30-horsepower limit for systems without conservation equipment were lowered to 3 horsepower. Their engineers estimate present use for refrigeration and air conditioning at about five percent of the total demand, with a probable future increase to over 25 percent if present regulations remain in effect.

LONG ISLAND STUDY. Long Island, New York, has an unusually heavy concentration of air conditioning. In 1933 its water resources were placed under control of a water power and control commission after widespread depression of the water table and a progressive intrusion of salt water underground. The commission limited new wells to 70 gallons per minute unless diffusion wells or other devices were used to return the water underground. Experience has shown that diffusion wells are highly successful when special construction is used. In January, 1947, 197 air conditioning and 25 industrial wells were diffusing about 50 million gallons per day during the cooling season with capacities varying from 100 to 550 gallons per minute. One phase of the problem which is getting progressively worse is the rise in temperature of ground water used for cooling, in areas of concentrated pumping.

OTHER STATES. Ground water for air conditioning use is controlled in some manner in Minnesota, Maryland, New Mexico, New York, Ohio, Utah and Wisconsin. Regulatory powers are available if needed in Kansas, Massachusetts, North Carolina and North Dakota. A recent Indiana law prohibits the use of well water in excess of 200 gallons per minute for air conditioning unless a permit is first obtained from the Indiana Department of Conservation, or unless diffusion wells are constructed.

PHOENIX, ARIZONA. It should be recognized that in some quarters the opposite view is taken. The Phoenix water department opposes restrictive measures on the use of water for air conditioning. It considers itself in the business of selling water and encourages its use for air conditioning. It claims more air conditioning installations than any other city in the country and that water reserves are adequate.

PRESENT SITUATION IN IOWA. It is not known whether Iowa has a problem in this respect or not, or whether there have been any attempts to investigate the matter. If the situation should warrant, surveys could be made of the installed air conditioning and refrigeration equipment in Iowa cities and farms, and reliable estimates made of the present and probable future water demands of this equipment. Undoubtedly the most serious drain comes from direct well water cooling systems where water is used in large quantities and then wasted.

The situation in Ames, Iowa, can be briefly described and may be regarded as typical of a small Iowa city whose entire water supply comes from wells. Considerable air conditioning has been installed, most of which uses direct water cooling coils connected to the city mains. Larger systems employ private wells. The city is supplying all requests for air conditioning without restriction, and to date there has been no indication of any drop in the water table. However, the installers of this type of equipment are being warned that they should be prepared to convert to water conservation equipment if any future shortage should develop. The concern being felt in Ames at present is with the overtaxing of the storm sewers with this waste water during the hot summer months.

CONCLUSION.

What methods of conservation and control are possible in Iowa if such measures become necessary? Fortunately, air conditioning systems use water only as a medium for transferring heat, and practical methods and proven commercial equipment are available for minimizing this waste to whatever degree desired. They consist of:

1. Water conservation equipment such as cooling towers and evaporative condensers. These would reduce demand by about 98 percent.
2. Diffusion wells or areas which could entirely eliminate water waste.
3. Equipment for transferring heat directly to or from the earth.
   (a) The thermal storage capacity of the earth is enormous and could easily supply all our heating and cooling needs if more effective ways could be found for transferring this energy to where we could use it or dispose of it. Much of the current heat pump research is being directed toward this problem with encouraging results, but much remains to be done. Additional work and investigation in this field may go a long way toward preventing the water demands of air conditioning, refrigeration and heat pump equipment from ever becoming a serious threat to the water resources of Iowa.

DISCUSSION

Selby:

Is Iowa doing research on heat pumps?

Smith:

The College is getting started on heat pump research.

Dawson:

The situation is about the same at the State University of Iowa.

THE IMPORTANCE OF WATER TO AGRICULTURE

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The importance of water to agriculture has already been mentioned by a number of speakers. Iowa's average rainfall is about 32 inches. It varies widely for different parts of the state. At Akron, in northwestern Iowa, the long-time average is about 24 inches. In contrast the highest average annual rainfall is about 37 inches at Fairfield, Iowa.

The requirements for water by different crops vary widely. The amount required by different crops for maximum production ranges from 12 to 18 inches of water. Average annual rainfall is not a good measure of the moisture available for crops during the critical growing period. This is evident by comparing average annual rainfall and the yield of corn. The records show a number of years when average annual rainfall was high and average corn yields low. In other years when average annual rainfall was below normal crop yields were higher than average. The important thing is "when did it rain." With 10-12 inches of rain well distributed through June, July and August we usually have high crop yields. Limited rainfall in July and August frequently cuts corn yields.

Water Conservation Critical In Western Iowa

The importance of and need for maximum conservation of water is most evident in western Iowa. The average rainfall varies from about 24 inches in northwest Iowa to 30 inches in southwest Iowa. Let's assume an average annual rainfall of 26 inches. Under present systems of farming about 7 inches of the 26 inches is lost as runoff and not available for crop production. Alfalfa is the common hay and pasture crop in the area. Studies show that about 8 inches of water is required to produce 1 ton of alfalfa. Alfalfa yields of from 3 to 4 tons per acre are not uncommon in years when rainfall is adequate. With 32 inches of water required to produce a 4-ton crop of alfalfa, it is obvious why moisture conservation is necessary if maximum yields of alfalfa are to be obtained. Farmers have found yields are high for the first cutting. The second cutting frequently is short. Later cuttings usually are small. The reason for the low yields is lack of water for the plants unless distribution of rainfall has been unusually favorable and unless conservation measures are used to reduce runoff. During the last 3 or 4 years we have studied the moisture content under stands of alfalfa that have been down from 1 to 6 years. These figures show that there is little or no water available for plants to a depth of 8 feet in fields that have been down to alfalfa for 2 or more years. We do not know how deep soil moisture has been depleted by alfalfa because samples were taken only to a depth of 8 feet. But studies in Kansas and Nebraska show that alfalfa depleted soil moisture to a depth of 20 to 30 feet in 4 or 5 years. It is easy to imagine what will happen to the corn crop that follows a meadow crop that has depleted the reserve subsoil moisture. Farmers know from experience that low corn yields can be expected unless summer rainfall is unusually abundant.

Sheet and gully erosion has caused serious damage in western Iowa. The rapid rates of runoff from the steep slopes, the highly erosive nature of the soils and a cropping system high in erosive intertilled crops with too little of the area in conserving grasses and legumes are all contributing factors. One of the major changes needed is a reduction in the acres of intertilled crops and increase in the acreage of conserving grasses and legumes. If this shift is made, and the alfalfa depletes the soil moisture, yields of succeeding crops will decline. Shifting to more grasses and legumes will help maintain soil fertility, but it intensifies the moisture problem. This serves to emphasize the importance of adopting conservation measures that will reduce runoff making more of the water available for the crop.

Cropping Systems Affect Runoff And Erosion

Studies of factors affecting runoff and erosion and methods of control were started on Marshall silt loam in Page County in 1931. Similar studies were made on Shelby soils at Bethany, Missouri, and on Fayette soils at La Crosse, Wis. These studies provide information on the effect of different soils and crop management practices on runoff and erosion. Soil and water losses were measured from different crops handled in small plots. I believe you will be interested in a brief summary of these results which represent the averages from 128 rains during an 11-year period. Under continuous corn 18.7 percent of the rainfall was lost as runoff whereas only 1.2 percent, or 0.4 of an inch of water, was lost as runoff from continuous bluegrass. Meadow in this same rotation lost 3.8 percent of the total rainfall as runoff.

There was also a marked contrast in erosion between these different crops. Soil lost in tons per acre under continuous corn was 38.3, corn in rotation 18.4, meadow in rotation 0.2, and continuous bluegrass 0.03 tons per acre. These figures emphasize the value of crop rotation in controlling runoff and reducing erosion. In general, increasing the acreage of grasses and legumes and reducing the acreage of intertilled crops has reduced both runoff and erosion.

The cropping system is also of equal importance in maintaining high crop yields. As an average of the last 5 years, yields under continuous corn are 20 bushels per acre in contrast with a 90-bushel yield of corn grown in a corn-oats-meadow rotation. The average runoff and erosion from all rains is of interest, but the critical losses of both water and soil occur from a few hard driving rains. This type of rain occurs most frequently in May and June when land on intertilled crops is bare and unprotected. On June 10, 1941, 3.76 inches of rain fell in about 2 hours. From continuous corn 2.6 inches, or 70 percent, of the rainfall was lost as runoff. From rotation corn, 2.2 inches, or 58%, of the rainfall was lost as runoff. From rotation meadow, 0.06 inches, or 1.5 percent, of the rainfall was lost as runoff. Erosion in tons per acre during the same rain was 37 from continuous corn, 14 from rotation corn, and 0.02 from rotation meadow. An acre inch of this soil weighs about 130 tons. This emphasizes the importance of including close-growing grasses and legumes regularly in the cropping system to reduce runoff and help control erosion.

You are probably all familiar with the reasons why meadow crops reduce runoff and erosion. In the first place, the close-growing type of vegetation breaks the impact of the raindrops and keeps the soil from crusting over. This allows maximum infiltration of water into the soil. If water goes into the soil it doesn't run off. And, if it doesn't run off, obviously there is no soil loss. In contrast to the conserving grasses and legumes, intertilled crops planted in rows leave the surface unprotected from the beating action of raindrops. The surface soon becomes crusted over, unless grasses and legumes have been used regularly in the cropping system to build up the physical condition of the soil so that it will resist the beating action of raindrops. When the soil surface seals shut the rate of runoff increases. It has been shown that size of watershed influences the amount and rate of runoff. Losses from small plots may be widely different than losses from large watersheds. Recognizing the limitations in extrapolating small plot data to large watershed, the results from small plots are valuable to show the relative effect of different crops on runoff and erosion.

Forests Help Control Runoff And Erosion

The acreage of land in forests in Iowa is small compared to land in other agricultural crops. There are large areas too rough for general crop production that are, and should remain, in timber. Other areas might be planted to advantage. Studies show that well managed woodlands are effective in reducing runoff and erosion as well as supplying income and a source of posts and lumber for the farm.

Field Studies Of Sedimentation

The Soil Conservation Service has recently completed sedimentation surveys on a number of watersheds in western Iowa. Gully control structures were installed in these watersheds as part of the soil conservation program. Surveys were made of the reservoirs at the time of construction. Later the reservoirs were re-surveyed which gives an accurate picture of the accumulation of sediment from the watershed. There is a wide variation in the rate that sediment accumulates in different reservoirs. The difference in rate of sedimentation may be explained by variation in the size of watershed, slope, type of soil, cropping system, and the conservation practices on the land. The watersheds in this study range from less than 100 acres up to 23 square miles. We will use two or three examples to emphasize the wide range in rate of sedimentation in different watersheds. In an 83-acre watershed near Stennet, Iowa, 95 percent of the storage capacity of the reservoir was depleted in less than 3 years. This is an average loss in storage capacity of about 33 percent each year. Transposing the sediment accumulation in the reservoir back to the 83-acre watershed we find an annual soil loss from the watershed of 1.1 inches per year. In other words, on the average this watershed has lost an inch of soil from the entire watershed in .9 of a year.

On a 157-acre watershed near Vail, Iowa, only 18 percent depletion in total storage capacity occurred in about 9 years. The annual percentage depletion in storage capacity on this reservoir was 2 percent in contrast to 33 percent annual reduction on the other watershed. Transposing the sediment accumulation in the reservoir to the entire 157 acres in the watershed, the average annual soil lost from the watershed was 0.07 inches per year. Or, at this rate, 17 years would be required for 1 inch of soil to erode from the entire watershed. These comparisons show the extreme variation between soil losses on two small watersheds. How are such differences to be explained? Part of the answer is that a better conservation program was on the second watershed.

Now let's take a look at a 23-square-mile watershed in Woodbury County. A desilting basin has been constructed at the lower end of this watershed to prevent the silt from going into the farmers' drainage ditch. This desilting basin is located near Bronson, Iowa. You may be familiar with it. In the 3.8 years that this desilting basin has been in operation 59 percent of the storage capacity has been filled. This is an average annual depletion of the storage capacity of 15.6 percent. Transposing the sediment accumulated in the basin back to the entire watershed we find an average annual soil loss of 0.11 inches per year. In other words, 9 years would be required for an inch of soil to be lost from the entire watershed. There are some large gullies in this watershed. Part of the silt comes from the gullies.

We would not want you to think that since we've only examples from western Iowa that this is the only area in the state where runoff and erosion problems occur. It is true that some of our most serious erosion problems are in western Iowa. But, similar problems, some of which are less serious than in western Iowa, are to be found on sloping land in all parts of Iowa.

Supporting Conservation Practices Help Control Runoff And Erosion

We have already cited examples showing the effect of cropping systems on runoff and erosion. Cropping systems with grasses and legumes regularly in the rotation are probably the first and most important single conservation practice that we have. It is the basis of building a good land-use and conservation program. But, crop rotations alone are not enough. It is well recognized that supporting practices such as contouring, strip-cropping and terracing are needed, in addition to good rotations, if erosion is to be controlled and productivity of our soil maintained.

We now have organized Soil Conservation Districts, or have districts in the process of being formed, in all but one of the 99 counties in Iowa. The district program is directed towards land-use practices that will control runoff and erosion and maintain soil productivity. Much progress has been made in getting conservation on the land, but, actually in most parts of the state the big end of the job remains to be done.

How effective are supporting practices such as contouring, strip-cropping and terracing in reducing runoff and erosion? Our studies show that contour farming reduces soil losses about 50 percent. Contour listing, a practice commonly used in southwestern Iowa, and which we believe can be expanded to advantage on some other soils in the state, is more than twice as effective as contour surface planting reducing runoff and erosion. Studies show contour strip-cropping to be about twice as effective as contouring alone. This is to be expected since row-crops in a strip-cropping system are on the contour, interspaced with conserving grasses and legumes. Here's how strip-cropping works. Water that moves out of the intertilled crops moves into the meadow strip. Its velocity is reduced and much of the silt is dropped in the grass strip instead of moving down the slope to be lost from the field.

Terracing is the most effective supporting conservation practice that we have. Much progress is being made today in some parts of the state, but in general terracing is limited to a relatively small acreage as compared to practices such as contouring. We have measured the soil and water lost from terraced and unterraced areas at the Soil Conservation Experimental Farm since 1931. In an 8-year period on an 80-acre terraced area the average annual runoff was less than 5 inches. Contrasting this with runoff from a similar area farmed in the conventional manner, about 23 inches of water would have been lost as runoff. This represents a saving of about 3 inches of water per year. It is known that not all of this water is available for crop production. But it is logical to assume that some of it will be utilized by the plants. These figures are from graded terraces, the type that are commonly used on the less permeable soils in other parts of Iowa. On the deep loess soils found in the two western tiers of counties in western Iowa level terraces are being used to advantage. On several level terraces at the Clarinda farm where a good rotation and contour listing have been used in addition to the terraces, there has been no loss of soil and water from these areas during the last 17 years. We wouldn't want you to believe that we thought it possible to put level terraces on all the land in western Iowa and completely control runoff and erosion. On a practical farm basis there is at least part of the area that is not suitable for terracing. Experience has shown, though, that it is practical to terrace from 30 to 50 percent or more of the land on the average farm in western Iowa.

The precise effect these various erosion control practices have on total runoff and erosion from large watersheds is not known. In fact, very little information is available on the runoff and soil losses from watersheds of from 100 to 3,000 acres. The previously discussed runoff data, which were obtained from plots of a few hundred square feet, are very valuable as they provide our only basis for estimating the effect of different erosion control treatments on the soil and water losses. There are admittedly, however, inherent errors in multiplying the data from these plots and assuming that the results are representative of those from large watersheds. Information of this type is urgently needed on a watershed basis. At present erosion control measures are being designed based on runoff data from watersheds in other parts of the country. It is recognized generally that the soils on those areas are widely different than the deep permeable soils of western Iowa. Only when we have specific runoff information from soils of that area will it be possible to efficiently design erosion control measures. Neither do we have the effects of cropping systems and supporting practices on runoff on a watershed basis. We feel that there is evidence to indicate that we are underestimating the effectiveness of practices such as contour listing and terracing in reducing runoff and erosion in that area. If that is the case, when we obtain specific information to show how effective these practices are it should make possible more efficient development of soil conservation and flood control practices for that area as well as other areas in the state.

A series of studies is now under way in western Iowa to determine, on a watershed basis, the effect of various conservation practices. The two objectives of these studies are first to determine the effectiveness of various plans for reducing runoff and soil losses, and second to check data and procedures currently used in designing flood and erosion control structures. The effect of good erosion control practices as compared to no

The use of portable sprinkler irrigation systems presents some very interesting possibilities. The sprinklers are commonly installed at 40 to 60-foot spacings and furnish water through 20-foot sections of aluminum pipe. While systems of this type have been used in Iowa for some time on truck crops, there have been some recent installations for field crops. Considerable interest in this type of irrigation has arisen during the past few months, and future developments may be worth watching.

Water For Livestock

Iowa is primarily an agricultural state. Industry has expanded rapidly in the last several years, but directly or indirectly, most of our income comes from agriculture. Of the total feed produced on Iowa farms about 80 percent of it is marketed as livestock and livestock products. Livestock, then, is an integral part of our over-all farming program. This calls for an adequate supply of water for the livestock and in the manufacturing of the products. In many parts of Iowa during the middle thirties water became a limiting factor, not only for livestock but for human consumption. Even in recent years when rainfall conditions have been more normal in most parts of the state there occur periods during the summer when adequate supplies of water are not available for livestock. Unless the water and feed supply for livestock can be assured, the livestock program will never be on a stable basis. There is nothing more discouraging to the farmer than to find water supply short, making it necessary to dispose of his livestock at a time when financial conditions are less favorable than if he could hold them for a later market. This emphasizes the importance of having adequate information on the water supplies that can be obtained by wells. Also more consideration needs to be given to ponds as a water supply in those parts of the state where a supply of water of good quality from wells can't be obtained efficiently.

From the agricultural point of view we are therefore concerned with a wide variety of phases of water control including infiltration into the soil, runoff, transportation of sediment, removal of excess water by proper surface drainage, removal of excess soil moisture by subsurface drainage, and the provision of water to supplement the rainfall by means of irrigation. Research in most of these fields is now being actively undertaken by the Iowa Agricultural Experiment Station.

WATER USE AND PROBLEMS IN SOIL AND WATER CONSERVATION

Frank H. Mendell, State Conservationist
U. S. Soil Conservation Service

The words soil and water are usually linked together whenever we talk about conservation as it relates to the land itself.

The place of water in the conservation program is frequently not recognized because many people do not associate water with the production of crops. The most extensive use and that of perhaps the most economic importance is water for crop production in Iowa.

For example it requires about 8 inches of water to produce a ton of alfalfa. This good yield of say 4 tons per acre would require 32 inches or near the average annual rainfall in Iowa. Corn, oats, grass and other crops require large amounts of water.

The soil conservationist is concerned first of all about adopting methods that will conserve water for crop production. Secondly, he is concerned about the damages caused by excessive runoff from the land. This results in erosion and permanent damage to the land. Third, excessive runoff causes floods which in turn cause tremendous damage to the land, highways, fences, city property and cause much human misery and suffering. The fourth important consideration that the conservationist gives to water is its use for livestock and household use.

When the conservationist works with the farmer he must consider all phases of water use and control. For example he must consider measures needed to conserve water where and when this is needed for maximum production. He must also consider ways and means of conducting excessive water from the land by terraces, waterways and drainage. He must also consider erosion control measures and how livestock needs can best fit into the pastures and field arrangements.

Now for a few specific experiences of farmers who have observed changes in their livestock water supply after soil and water conservation measures have been adopted.

Waldo Penton -- Montgomery County Soil Conservation District. Had a well dug 35 feet deep that furnished water for 10 cows and 40 hogs. A gully 20 feet deep not over 100 feet from the well was dry most of the time.

The watershed above was partly terraced and a dam built in the gully below the well. This was completed about 4 or 5 years ago.

The water level in the well was raised about 16 feet and has been quite constant since. Last year the well furnished water for 50 cattle and 250 hogs. It was estimated that this water supply was worth $1,000.

Joe Scheel -- East Pottawattamie County Soil Conservation District. Water supply was not sufficient for livestock in dry seasons. Terraces and a large dam were installed and at present there is more than enough water for livestock.

Frank McArthur -- East Pottawattamie County Soil Conservation District. In 1937 on this 1,600-acre farm the water supply was not enough to supply one-half of the livestock normally kept on the farm. Wells were dry--side hills that used to be seepy were dried out, and crop growth was hampered.

A soil conservation program was set up including improved land use--rotations, terracing, contouring, waterways and dams. Now the wells are full. The waterways are grassed, and with ponds and the wells reestablished, Mr. McArthur feels that his conservation program insures his water supply for now and time to come.

Dudley Stupfell -- West Pottawattamie County Soil Conservation District. Since the adoption of conservation measures in the watershed, Mr. Stupfell says that the water level was raised 25 feet in his well. Previous to the adoption of the program Mr. Stupfell said that he could pump his well dry in 1 hour.

Mildred Roy -- East Pottawattamie County Soil Conservation District. Since the construction of a dam it is impossible to pump the well dry. Mildred Roy said that before the dam was constructed the water supply was very limited.

William Strohbehn -- West Pottawattamie County Soil Conservation District. Before adopting soil and water conservation program he pumped his well dry in 1 1/2 to 2 hours. With the conservation program of good land use rotation with lots of forages, he has had plenty of water for 160 head of cattle and the well has never given any trouble.

Carl Lundee -- Crawford County Soil Conservation District. Has had sufficient water for livestock and household since the conservation program was adopted in 1939-40.

John Judy -- Crawford County Soil Conservation District. Installed a cistern adjacent to a large earth fill which supplies adequate water supply for the household and other needs on the farm.

Twenty-six examples were recently cited in the Crawford County Soil Conservation District of where conservation work on the land alone or in combination with dams had materially improved the water supply on the farm.

Numerous other examples could be given to show how conservation ties in with an adequate water supply for the farm. The program on the Ben Cole Farm near Osceola and Don Bellman Farm near Indianola are other examples of where the water supply has been stablized as a result of the conservation work.

The use of farm ponds for a water supply for livestock is on the increase particularly in southern Iowa. This is the surest water supply in that area in the opinion of many.

GENERAL DISCUSSION

Lester Clapp:

Do we need more educational programs? College Extension Service is putting out information as fast as it becomes available. Rural school children are being taught conservation. Farm magazines and newspapers help in the educational program. People now recognize that there is a water use problem. We need more information to take to the people.

Lamoureaux:

Cites figures showing that distribution of rainfall is important. In 1910, with rainfall for year at a minimum 19.89 inches (normal 31.61"), corn yields approached all-time high values (as of 1910 for open-pollinated varieties). Rainfall records indicate that we are not now in a dry cycle.

Hershey:

Iowa has much ground water. Ninety percent of Iowans depend on ground water as domestic source. In the Jordan sandstone, at 2,300 feet depth, water comes from southeastern Minnesota. This sandstone probably yields springs near St. Louis. In Mason City, Cedar Rapids and Ottumwa, ground water is gradually dropping.

Harlan:

Is sandstone water ancient?

Hershey:

It could be. Water in Jordan sandstone was originally salty. Sink holes could be used for drainage for recharging ground water providing there is some filtering action before water gets into subterranean streams.

Ayres:

Is water loss due to discharge from artesian wells a problem in Iowa?

Hershey:

There are many artesian flowing wells along the Mississippi which should be plugged.

Gwynne:

What do other states do to stop waste from flowing wells?

Ayres:

Texas has underground water districts.

Hershey:

Underground leakage (as well as surface seepage) is of great importance. Wells should be sealed from top to bottom preferably. But this would cost money.

Timmons:

Physical, institutional and economic supplies are the supplies of water we have. We have stressed so far only the physical supplies. The physical supply appears adequate. What about institutional supply? Will recreation, for example, take precedence over irrigation?

Ziemer:

We haven't reached the time yet where decisions on institutional policy are necessary.

Timmons:

We should foresee institutional needs before it is too late.

Stevenson:

Discusses supplemental irrigation. Points out that 28 inches of rain in Minnesota is equivalent to 35 inches on 99th meridian, because evapo-transpiration is lower in Minnesota. Sprinklers should be used for undulating land. On one of his farms irrigation was done on the 20th of July and the 4th of August in 2 inch irrigations. Yields were doubled. As much as $280 worth of milk per acre has been obtained from cows on irrigated pastures. He uses 60-foot long planer to prepare land for irrigation. Says Council Bluffs boys' institution had to get rid of 150 cows because of feed costs. Supplementary irrigation would have resulted in adequate feed for these animals.

Dean Gaskill:

Thanks people for coming. Says he would make same point as Timmons made. We need more data and we need more education.

A gold miner in the Dakotas said that ground water was more valuable than gold. How can we get water economically. Mentions irrigation in Guatemala. Says methods of physicists should be used for locating ground water. Hopes we will have more meetings.

Ayres quotes Fox's resume:

Iowa has adequate water supply for all the discussed needs. Our problem consists of obtaining facts for placing water where it is needed.

Dawson:

Disagrees. Says in drouth years we won't have enough water.

Ayres:

All members of conference should get copies of papers.

Gaskill:

A monograph or bulletin of the conference should be prepared.

Riecken:

In considering water, it must be considered with the soil type and with the crop to be grown on the soil. There is an optimum crop-soil-water relation which should be determined for best use of land.

Ayres: Conference adjourned