THE CHANGING WATER RESOURCE [1/]

By

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It is a great pleasure for me to take part in this opening panel discussion and to present a few comments I hope will stimulate some meaningful discussion in the next hour.

"The Changing Water Resource" is a subject much too broad and far-reaching for any microscopic pursuit in these few minutes. The dating of man's attempt to influence the natural patterns of water supply is as early as man himself. One could cite the early and simple example of a first small trench scratched out to divert rain water away from the cave. Or perhaps a handful or two of dirt packed across some trickle of water to provide storage for a single drink. These few elementary examples gain some significance when one realizes that over a sizeable portion of our earth, the identical practices are applied -- masii tribesmen in East Africa or the aborigines in Australia.

But these are only small scale attempts by man to influence the total water supply pattern. Man has been, and is, capable of much larger efforts and here I feel the title of this presentation is somewhat misleading. At least until present day, it is not the basic resource which is changing but rather man's influence on this resource that is producing an ever-increasing change.

Let's take a quick look at this basic resource just to see what we have in hand. I started out to do this on a global basis but the figures got so large they became nothing but numbers on pages. The Continental United States seemed a more illustrative approach. In any event, studies on the distribution of precipitation show average annual amounts over the U.S. equal something between 4.8 and 5.0 billion acre feet. Evaporation and evapotranspiration from non-irrigated lands takes care of about 3.5 billion acre feet of this (70%), and streamflow, including the amount taken from the aquifer, takes care of the other 1.5 billion acre feet (30%). These primary categories can be broken down into sub-units, but it's enough to point out here that all of the 70% mentioned above as well as a portion of the 30% goes directly back to the atmosphere, the rest goes to the ocean reservoir.

With that sort of rough estimate of precipitation, lets take a look at the distribution of actual water over, on and under the Continental United States. This can best be shown in the following table:

TABLE 1

UNITED STATES WATER DISTRIBUTION
(Source: U.S. Geological Survey)

	Area (sq.mi.)	Volume (cu.mi.)	Annual circulation (million acre-ft per year)	Detention period(yr)
Frozen water:				
Glaciers	200	16	1.3	40
Ground ice		(seasonal only)		
Liquid water:				
Fresh-water lakes [1]	61,000	4,500	150	100
Salt lakes	2,600	14	4.6	10
Average in stream chan.	-	12	1,500	.03

[1] United States part of Great Lakes only.

1/ Presented at the Keynote Seminar, Western Snow Conference, Phoenix, Arizona, April 18-20, 1972

2/ Atmospherics Incorporated, Fresno, California

TABLE 1 - Con't.

	Area (sq.mi.)	Volume (cu.mi.)	Annual circulation (million acre-ft per year)	Detention period(yr)
Ground Water:				
Shallow	3,000,000	15,000	250	200
Deep	3,000,000	15,000	5	10,000
Soil Moisture (3-ft. root zone)	3,000,000	150	2,500	.2
Gaseous Water:				
Atmosphere	3,000,000	45	5,000	.03

We have spoken about precipitation and the distribution of water over the United States, now let's take a look at some of the things man has been doing to change these natural patterns. Probably the single most influential category of change has to do with the effects of urbanization. If not the most influential, certainly a major contributor. The following lists provide three categories of stages in urbanization and the possible hydrologic effects within these categories.

TABLE 2

HYDROLOGIC EFFECTS OF URBANIZATION
(Source: U.S. Geological Survey)

CHANGE IN LAND OR WATER USE	POSSIBLE HYDROLOGIC EFFECT
TRANSITION FROM PREURBAN TO EARLY-URBAN STAGE:	
Removal of trees or vegatation Construction of scattered city-type houses and limited water and sewage facilities.	Decrease in transpiration and increase in storm flow. Increased sedimentation of streams.
Drilling of wells.	Some lowering of water table.
Construction of septic tanks and sanitary drains.	Some increase in soil moisture and perhaps a rise in water table. Perhaps some waterlogging of land and contamination of nearby wells or streams from overloaded sanitary drain systems.
TRANSITION FROM EARLY-URBAN TO MIDDLE-URBAN STAGE:	
Bulldozing of land for mass housing, some topsoil removed, farm ponds filled in	Accelerated land erosion and stream sedimentation and aggradation. Increased flood flows. Elimination of smallest streams.
Mass construction of houses, paving of streets, building of culverts	Decreased infiltration, resulting in increased flood flows and lowered groundwater levels. Occasional flooding at channel constrictions (culverts) on remaining small streams. Occasional overtopping or undermining of banks of artificial channels on small streams.
Discontinued use and abandonment of some shallow wells.	Rise in water table.
Diversion of nearby streams for public water supply	Decrease in runoff between points of diversion and disposal.

TABLE 2 - Con't.

CHANGE IN LAND OR WATER USE	POSSIBLE HYDROLOGIC EFFECT
Untreated or inadequately treated sewage discharged into streams or disposal wells	Pollution of stream or wells. Death of fish and other aquatic life. Inferior quality of water available for supply and recreation at downstream populated areas.
TRANSITION FROM MIDDLE-URBAN TO LATE-URBAN STAGE:	
Urbanization of area completed by addition of more houses and streets and of public, commercial, and industrial buildings	Reduced infiltration and lowered water table. Streets and gutters act as storm drains, creating higher flood peaks and lower base flow of local streams.
Larger quantities of untreated waste discharged into local streams	Increased pollution of streams and concurrent increased loss of aquatic life. Additional degradation of aquatic life. Additional degradation of water available to downstream users.
Abandonment of remaining shallow wells because of pollution.	Rise in water table.
Increase in population requires establishment of new water-supply and distribution systems, construction of distant reservoirs diverting water from upstream sources within or outside basin.	Increase in local streamflow if supply is from outside basin.
Channels of streams restricted at least in part to artificial channels and tunnels	Increased flood damage (higher stage for a given flow). Changes in channel geometry and sediment load. Aggradation.
Construction of sanitary drainage system and treatment plant for sewage	Removal of additional water from the area, further reducing infiltration and recharge of aquifer.
Improvement of storm drainage system	A definite effect is alleviation or elimination of flooding of basements, streets, and yards, with consequent reduction in damages, particularly with respect to frequency of flooding.
Drilling of deeper, large-capacity industrial wells	Lowered water-pressure surface of artesian aquifer; perhaps some local overdrafts (withdrawal from storage) and land subsidence. Overdraft of aquifer may result in salt water enroachment in coastal areas and in pollution or contamination by inferior or brackish waters.
Increased use of water for air conditioning	Overloading of sewers and other drainage facilities. Possibly some recharge to water table, due to leakage of disposal lines.
Drilling of recharge wells	Raising of water-pressure surface.
Waste-water reclamation and utilization	Recharge to groundwater aquifers. More efficient use of water resources.

The urbanization effects listed in Table 2 are largely inadvertent efforts of man on the natural patterns of water supply. What of man's intentional efforts to influence these patterns? Again, we can return to the cave man or his modern counterpart and observe the small trench or historic coffer dam. But as we said, man has done bigger things. He has built dams, diverted large rivers, drained swamps, reclaimed deltas, developed enormous irrigation schemes, scratched at the surface of salt water conversion, and....has modified the weather!

And this brings me to the point I started to reach all the time. It is one of my favorite subjects, and certainly one indication of how man's influence may improve the environment for either more direct benefit or greater esthetic advantage.

Table 3 shows the potential precipitation increases by cloud seeding in the Western United States.

TABLE 3

POTENTIAL PRECIPITATION INCREASES BY CLOUD SEEDING
IN THE WESTERN UNITED STATES
(Technology in American Water Development, John Hopkins Press)

STATE	Total area (acres)	Annual precip (in.)	Estimated part of annual precip from orographic clouds (%)	Est. possible max increase in precip by artificial seeding (thousand acre ft)	Est. possible max increase in runoff by artificial seeding (thousand acre ft)
Arizona	72,901,760	12.5	20	2,300	100
Calif.	101,563,520	20.9	50	8,500	3,400
Colo.	66,724,480	16.5	40	3,900	1,100
Idaho	53,476,480	17.2	60	4,500	2,200
Montana	94,168,320	14.8	30	3,100	800
Nevada	70,745,600	8.6	20	1,200	100
New Mex.	77,866,240	14.3	20	1,900	100
Oregon	62,067,840	27.8	40	5,700	3,100
Utah	54,346,624	13.2	30	1,800	200
Wash.	43,624,880	32.0	50	5,700	3,600
Wyoming	62,664,960	14.6	30	2,100	500
Total	760,168,704	-	-	40,700	15,200
Total 5 Pacific Coast and Rocky Mountain States[2]					13,400
Percentage in 5 states					88

[1]Computed by use of natural ratio of runoff to precipitation.

[2]Washington, Oregon, California, Idaho and Colorado

Most of us here have given much thought to our influence on the natural patterns of water supply, and other ingredients necessary for our own preservation. I've never believed that all acts of man are destructive. Neither do I believe that any single act is totally free from disbenefit to one or more persons under the influence of this act. If we wished to tally the score from the past behavior of man, we would find many acts falling in both camps. With thoughtful purpose, I believe man's influence can improve his environment, particularly with respect to the intelligent influence on the natural patterns of water supply.

And, Mr. Chairman, with those comments I return this seminar to your capable hands with a final hopeful note that a few of these comments might just provoke some later discussion.