FUTURE OUTLOOKS FOR WATER CONSERVATION IN ARIZONA

Sol Resnick[1]

It has been said over and over that Arizona today is the fastest growing state in the Country. I think with the increase in fuel prices in the future, it is going to be more so. We are really going to grow at a faster pace. It has also been said that our groundwater reserves are being depleted and there is a bottom to the barrel. When the crisis comes in the future, what are we going to be looking at in the way of water resources? Cloudseeding does not seem to be effective in Arizona. Desalting is energy intensive; it is expensive. Following the Central Arizona Project, it does not look like there will be any big importation schemes that will be passed in Congress, so what is there really in the future? Hence, it seems to me that it comes down to water conservation.

With regard to water conservation, I think we could look and learn very much at what they did far in the past. We are talking about, for example, going back 300 years B.C. with the Nabateans in the Negev. They were getting by with four inches of rainfall. They were traders; they had six cities, the largest of which had about 20,000 people. On four inches of rainfall, they were supplying all the water needs for their domestic use and for farming to grow the food that they and the people that came through the area would require. How did they do it? Well, if you visit that area, you can see the ruins of cisterns that stored domestic supplies of water

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[1]Director, Water Resources Research Center, University of Arizona, Tucson, Arizona 85721.

collected from runoff from roofs and streets. Agriculturally, what did they do? They gathered water from the side slopes; for example, they would gather water from an area 30 times larger than the area they farmed and grew the crops which maintained them. They get about four inches of rain; and about 25% of it, or one inch, would run off. If you are collecting water from an area 30 times larger, you are collecting 30 inches of water which is enough to grow a crop. Following the Nabateans, the Romans kept the systems going in order to remain in the area for military purposes. The water-related systems ceased functioning with the invasion of the Moslems. Today, these areas are being rehabilitated, and if you go there on a field trip, you will see crops of grapes, almonds, pistachio nuts, olive trees and peach trees; good yields and beautiful crops all on four inches of rainfall. It can be done; and they did it. And I think in the future when this water crisis does hit us, we are going to have to look back to what they did in those days.

Today, though, there is technology which improves on what the Nabateans did 300 years B.C. For example, today regarding domestic supplies, there is double plumbing in houses in the area. They use gray water for landscaping purposes. You could go to plastic catchments and instead of 25% of the rain running off, you could get 75% of the rain running off under controlled conditions and it certainly could be used for domestic purposes. For agriculture, you could use chemicals or common salt and increase the runoff more than 25%. I suspect that in the future chemicals will be available which would be at a price where you could increase runoff for agricultural purposes.

One of the big problems 300 years B.C., on the large projects, was the diversions, built in the wadis to divert the water for farming, that washed out every time you got a sizeable flood. It gets kind of hard replacing diversion structures. Well, today, you could go with collapsible dams. If a large flood comes, the dam collapses and the flood goes on through; after you inflate the dam, you are ready for the next small flow that you could divert.

For evaporation suppression, you could use mulches around plants, so you are not getting evaporation from soils. Hopefully in the future, we will develop antitranspirants in which case you could even cut down on the water that these plants require for transpiration. So, certainly with improved technology, you could improve on what they were doing back there at the time of Christ.

To continue with future outlooks, let us consider evaporation suppression from a free water surface. It is estimated that one and one-half million acre-feet of water is lost annually by evaporation from Lake Mead and Lake Powell: Over 10% of the flow of the Colorado River lost by evaporation from two lakes. Why there is not more research being done in this area I will never understand. And, of course, the water you are losing is in the vapor form and the salt stays behind; hence your quality of water becomes poorer. Brent Cluff of the Water Resources Research Center is working with evaporation suppression methods on small reservoirs. He is using styrofoam rafts hooked together, which are impregnated with wax under pressure. With 100% cover, he gets 100% saving. You probably would not want to be floating styrofoam rafts on Lake Mead or Lake Powell, but the long-chain fatty alcohols that they tried 15-20

years ago have been improved considerably. They have come up with chelated materials that heal much quicker when the film is broken by wave action, and is more resistant to vapor movement through the film. There is a lot of potential for saving water through evaporation suppression, and for some strange reason, none of it being tried at the present time in the West.

Brent Cluff also has developed compartmented tanks wherein you take water from the shallow part of the tank and keep pumping it to a deep separate compartment, with a small surface area so you get reduced surface evaporation. Generally, you line that part of the tank so you are also reducing seepage. You reduce the evaporation loss considerably with these compartmented tanks.

Also in the future is seepage control. Of course, you could get a lot of arguments on seepage control. They say if the water is moving down through the bottom of the tank, it winds up back in the groundwater reserves. However, energy is expensive and it costs money to pump water up if it is just going to go back down. Further, research by Dan Evans indicates that the water may be moving down at the rate of centimeters per year, whereas water tables are dropping at the rate of feet per year, never catching up or it will only catch up far in the future. Brent Cluff is also working with seepage control. The only thing he has found that really works to date is plastic, which is quite expensive. Hopefully, in the future, companies like Proctor & Gamble will come up with by-products of the soap industry, namely waxes which will not be broken down with heat and bacteriological action and give you a low-cost method of seepage control.

Also for the future is artificial groundwater recharge, which is putting water underground and storing it there. You do not get the losses

by evaporation and transpiration, if the groundwater table is deep enough. We would have to change our laws, as today, if you put water underground; anybody can put in a well and pump the water without resorting to the cost of putting it underground. But, hopefully, when this water crisis does reach us in the future, the power groups that are keeping these laws from being enacted will reconsider and allow some meaningful legislation to be passed with which you could conserve water and manage it effectively.

With regard to control and use of storm runoff, one way of course is by creating green belts and parks and golf courses in the flood plains. It is being done today like at Indian Bend Wash in Phoenix, Arizona. That is what belongs in these flood plains: your green belts, your recreation areas, your parks.

With regard to medians, why are they raised and irrigated and allowed to shed water onto the streets? Maybe we will wake up in the future, depress them, and get the water off the streets into the medians. There is enough storm runoff usually in summer to keep things green and even though it appears that the civil engineer has only learned to raise them, depressing the medians is not a bad idea.

Since 90% of the water is used for irrigated agriculture, that is where the saving really is in conservation. I know that for a good part of today's conference we have heard about water conservation with regard to agriculture, but if you really want to look at the future, just take a trip to Israel and see what they're doing with water. They have a little over a million acre-feet of water for all uses annually. They only use their safe yield. They plan on being there for a long time. They do not overdraw their

groundwater reserves like we are doing in Arizona, as apparently we are not worrying about tomorrow at all. With a little over a million acre-feet, they have got enough water for over 3,000,000 people and agriculture, and they are doing it by using water at 92% efficiency. They have to--they have to use every drop of water effectively. How are they doing it? Well, take a look at their agricultural systems: they are computer operated--every drop of water is metered; when it starts to rain, a signal is sent to the computer and the irrigation system goes off (how many times have you driven through the countryside and even though it is raining, the sprinklers are going--again, like there is no tomorrow); when it gets too cold, a signal is sent to the computer, and the irrigation system goes on to keep the plants from freezing; when it gets too hot, a signal goes to the computer, and it starts the water going to keep the plant from scaling. When you have a computer-operated system, everything operating automatically and everything metered, you get down to a very fine management. For example, they determined for maximum yields of carrots at one period of time, 30 minutes per day of irrigation is required; when they defoliate potatoes, if the ground cracks, the potatoes are subject to diseases, hence, after defoliation they irrigate very lightly everyday to keep the ground from cracking and protect the potatoes from diseases. They know how to get those maximum yields. It is all automatic; it is all in a computer; and everything is metered.

In the future, we must consider the use of brackish water. When water gets up to 3000 parts per million TDS in this Country, the farmers refuse to use it. You go to the Negev and you see them growing four bales of cotton, a long-staple Egyptian cotton, to the acre. There is usually a race between Arizona and California as to the highest yield per acre of cotton and 3-1/2 or

3-3/4 bales per acre will win; in Israel, they are growing four bales of cotton on water over 3000 parts per million TDS. How do they do it? They make the salts work for them actually. They have learned how to do it. All they use is drip irrigation with continuous flow to keep the salts moving downward. They put a mulch on the surface, a plastic mulch, so you do not get any evaporation from the surface and an accumulation of salts on the surface. They add calcium and phosphates. They find the increased salts in the water cause the leaf to resist water loss; now that sounds good except when it is hot, you damage the plant; well, to counteract that, they enrich the atmosphere around the plant with carbon dioxide with the use of plastic tunnels. They find salt is a stimulus to growth and they actually get higher yields because of the salts. They find the salts make the plant more resistant to freezing and diseases. So, they find the salts actually work for them. And it is not a case of running away from it; it is a case of knowing how to work with it and use it.

And, lastly, I think if you're looking into the future, you certainly need to look at closed systems of agriculture. For photosynthesis, you need energy, you need water and you need CO_2. Under our conditions, there is usually plenty of energy. If you are irrigating, there is plenty of water. Hence, the limiting factor is CO_2; there are about 400 parts per million CO_2 in the atmosphere. They find if they raise the CO_2 to about 1200 parts per million, they could triple the yield. With closed systems, you could raise the CO_2 up to 1200 parts per million to triple your yields. In fact, with the other controls, you get much more than triple yields. They have greenhouses with double roofs wherein they pump sea water or any water that has not much

value over the lower roof; with the sun's heat you get evaporation and the vapor goes to the upper plastic roof, runs along the roof, is collected in gutters and is used for farming the crop that is in the greenhouse. Because the system is enclosed and because the humidity is about 100%, theoretically you need about 1% of the water that you need for a comparable farming area on the outside, but actually, you have losses and you are using about 5% of the water. They are producing their own 5% to grow crops in these greenhouses, adding CO_2, and coming up with vastly increased yields. Closed systems definitely have a part to play in the future.

When the future comes in Arizona, I am optimistic that the technology will be available; hopefully we will have the laws that allow the technology to be used; and we will become water efficient and conservation minded.