AUGMENTING WATER SUPPLY FOR HOME IRRIGATION

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ABSTRACT

Low rainfall and humidity, and high evapotranspiration, make irrigation necessary for domestic plant growth in the American Southwest. Irrigation supplies are limited.

A large percentage of potable water used in Southwestern homes is used for home irrigation. Another large percentage is returned to sewers. Water and sewer fees are increasing because of rapid urban expansion and increased water-quality standards. As fees increase, supplemental home irrigation sources become attractive and are sought.

Major supplemental water sources are grey water, harvested runoff, and roof runoff. The amount of grey water depends on family size and habits. The amount of harvested runoff depends on land size and slope, soil's and material's properties, and rainfall. The amount of roof runoff depends on roof size and geometry, and rainfall. The quality of these sources is generally suitable for home irrigation.

Engineering systems are required to use supplemental home irrigation water. The most preferred systems will have low capital expenditure and low energy requirements.

A large and significant reduction in municipal costs and services is possible if supplemental home irrigation water is developed. Small-scale analysis indicates that costs are favorable for supplemental irrigation systems.

A suggested research program emphasizes field trials and demonstrations which test design, operation, maintenance, and economics, as well as public and institutional acceptance.

INTRODUCTION

This paper is a written summary of a poster presentation prepared for the 23rd Annual Meeting of the Arizona-Nevada Academy of Science. Essential poster items are presented as figures to this text. Because the figures are self-explanatory, each is not reviewed, unless additional clarification is required.

OBJECTIVE

The objective of this report is to outline supplemental water sources for home irrigation with respect to water availability (quantity), water quality, engineering systems, and economics.

WATER USE

Home irrigation accounts for about 65 percent of domestic water use in the Southwest. About 60 percent of the domestic wastewater load is grey water. Figures 1, 2, and 3 show domestic water use and wastewater load, estimated regional uses and load, and estimated regional grey water, based adaptations from published sources (1, 2, 3).

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SUPPLEMENTAL SOURCES

Supplemental sources include grey water (non-toilet home wastewaters), harvested runoff (water produced from prepared land surfaces), and roof runoff (water produced by rainfall that drains a roof).

AVAILABLE WATER

Figure 4 shows the irrigation possibilities of usable domestic wastewater. Figure 5 shows the quantity of available irrigation, and may be used to estimate irrigation depths from all supplemental water sources. Estimates of water use and water supply can be made from (3), (4), and (5).

WATER QUALITY

Figures 6 and 7 show water-quality characteristics and treatments for selected domestic wastewater. Harvested runoff will be low in salts, but possibly high in suspended solids and turbidity. Roof runoff will have the best quality, though it may show some turbidity. A combination of crop and soil filtration and uptake, dilution, filtration, and storage account for all identified water-quality problems. Water-quality aspects are reviewed in (6).

ENGINEERING SYSTEMS

Figure 8 summarizes engineering systems required to use supplemental irrigation water. Practical designs may be found in (7), (8), and (9).

ECONOMICS

These may be viewed as large scale and small scale.

Large Scale

If potable water usage can be reduced by reducing irrigation use of potable water, a savings in municipal services is achieved. If 65 percent of the used potable water is for home irrigation, it might represent up to 65 percent of the water bill. That amount of water, and its charge, can be reduced by 68 to 100 percent, depending on use and rate structure. If much of this reduction is due to grey-water reuse, sewer-use fees also could be reduced. And, if much of this reduction is due to harvested and roof runoff, then street flooding and storm-runoff costs may be reduced. A large reduction in municipal costs and services is possible if supplemental home irrigation water is developed, and water-use and sewer-fee costs are commensurate with water and sewage reductions. Municipalities could save money from savings in water supply, sewage treatment, and flood damages.

Small Scale

Figure 9 shows minimum repayment periods for integrated three-day storage systems for supplemental irrigation waters. These are for four illustrative cases, and two water sources, with ten adjustments. They assume that each trailer has a 12- by 60-ft roof, that the apartment complex has a 6,250 sq ft roof, and that the double and single family homes each have a 1,500 sq ft roof. They assume that the trailer park, apartment complex, and each home occupies 7.92, 0.41, and 0.18 ac, and that 12, 40, and 4 percent of each is paved. It's assumed that a water-harvest efficiency of 50 percent applies to unpaved areas, and rainfall is ten in/yr.

It's also assumed that irrigation will occur otherwise exclusively with fresh water. All repayment calculations allow a ten-percent mortgage interest.

The value of water is based on 1978 City of Tucson fees of about $3.56/1000 cu ft. Because of adjustments in sewer-use fees, we assume that grey water and laundry effluent are worth $9.94/1000 cu ft, while harvested and roof runoff are worth only $3.56/1000 cu ft.

Table 1 shows comparative unit costs of supplemental water, for the four illustrative cases, with two water sources, and three storage systems.

A small-scale economic analysis indicates:

1. The unit cost for all sources increases with decreasing number of people, and land and roof size.
2. The cheapest source of supplemental water is most grey water.
3. The most expensive source is harvested runoff, except where dispersed trailers produce more expensive roof runoff.
4. Integrated, short-term storage, considerably reduces unit and total costs.

SUMMARY

It's summarized that:

1. Grey water, harvested runoff, and roof runoff are supplemented water sources for home irrigation in the Southwest.
2. Needed engineering systems can be flexible and innovative.
3. Costs are favorable for future large-scale supplemental water systems.
4. Costs become more favorable as water-use and sewage-fee charges increase.
5. Costs can be reduced considerably by:
   a. Integrating collection, storage, and distribution facilities.
   b. Providing three-day water storage.
   c. Using second-hand materials.
   d. Exploiting home-owner labor.

However, southwestern municipalities, states, and the federal government have discouraged supplemental water use. Municipalities, such as Tucson, have minimum high charges for water and sewer use. (Sewer-use fees are often computed as a flat percentage of water use, plus a minimum charge.) States, such as Arizona (10), explicitly outlaw domestic wastewater reuse. And the government has heretofore provided inadequate research funds to this area.

RESEARCH

A research program is badly needed (11, 12). It should:

1. Emphasize field trials and demonstrations.
2. Test design, operation, and maintenance.
3. Evaluate economics.
4. Address public and institutional acceptance.
5. Review legal problems.

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FIGURE 1

DOMESTIC WATER USE AND WASTEWATER LOAD FOR A SOUTHWESTERN FAMILY

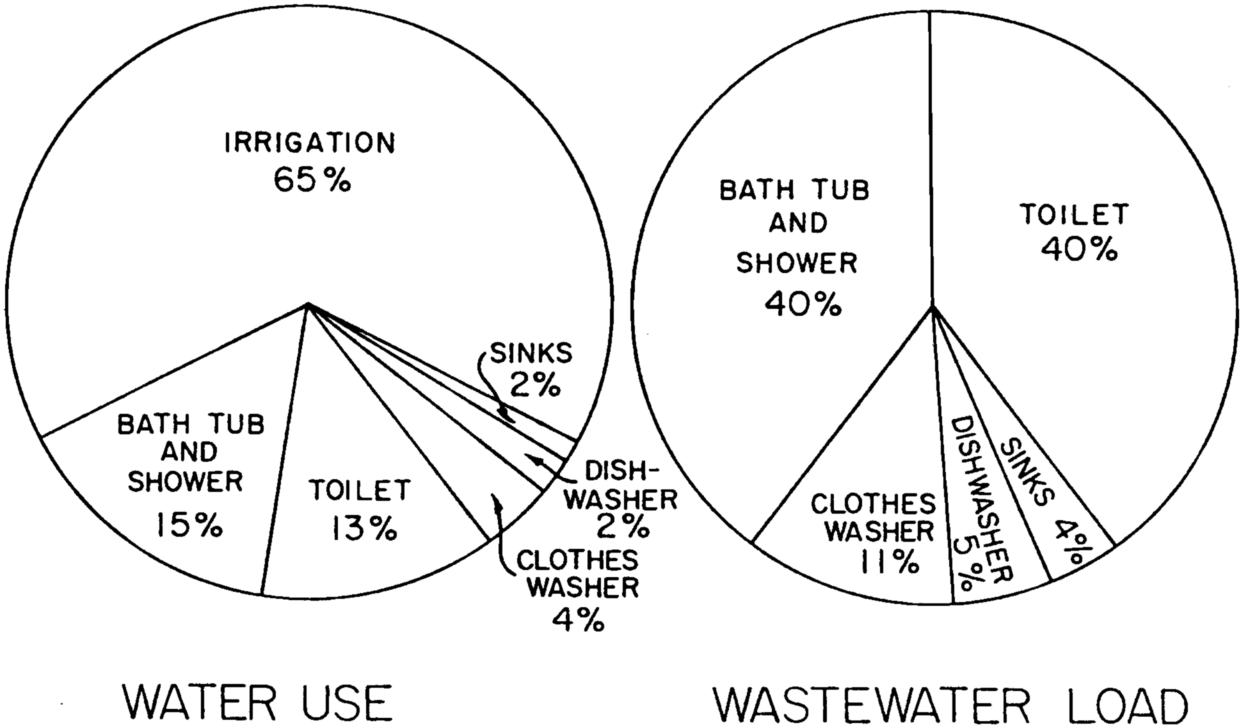


FIGURE 2

ESTIMATED WATER WITHDRAWALS, CONSUMPTIVE USE, AND SEWAGE LOADS FOR THE SOUTHWEST

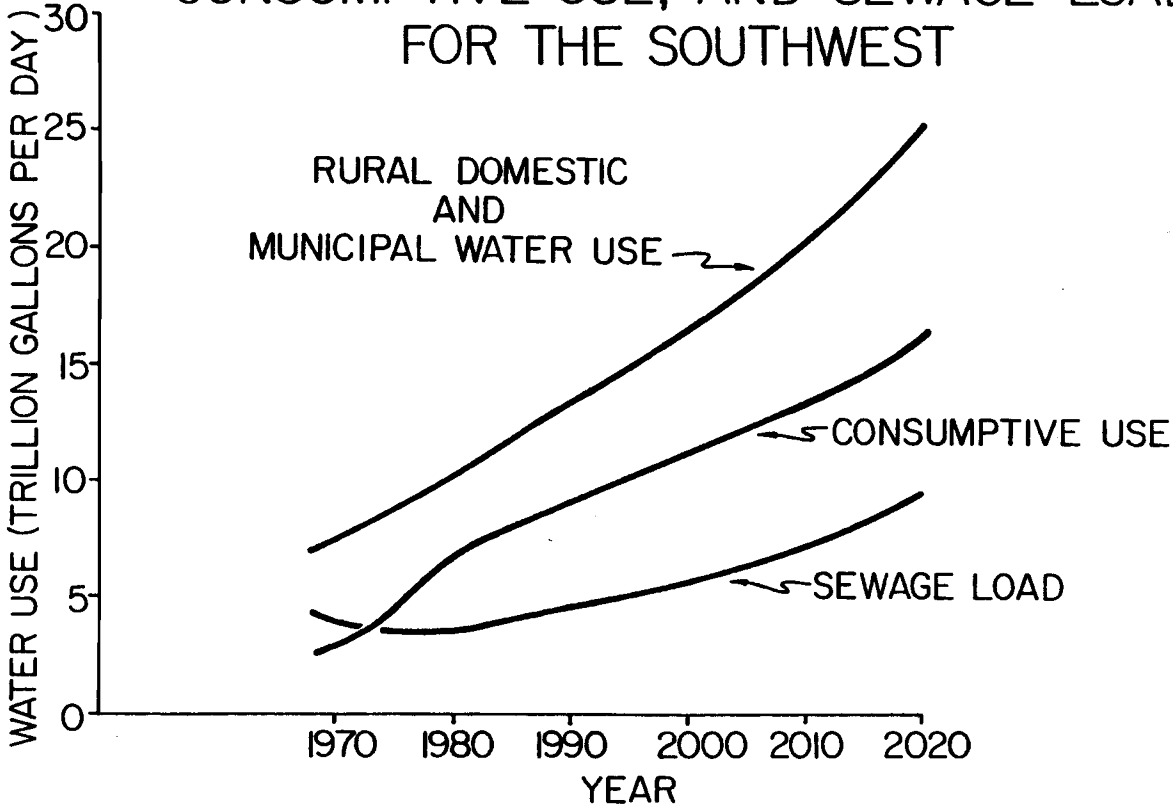


FIGURE 3

ESTIMATED QUANTITIES OF REUSABLE DOMESTIC WASTEWATER FOR THE SOUTHWEST

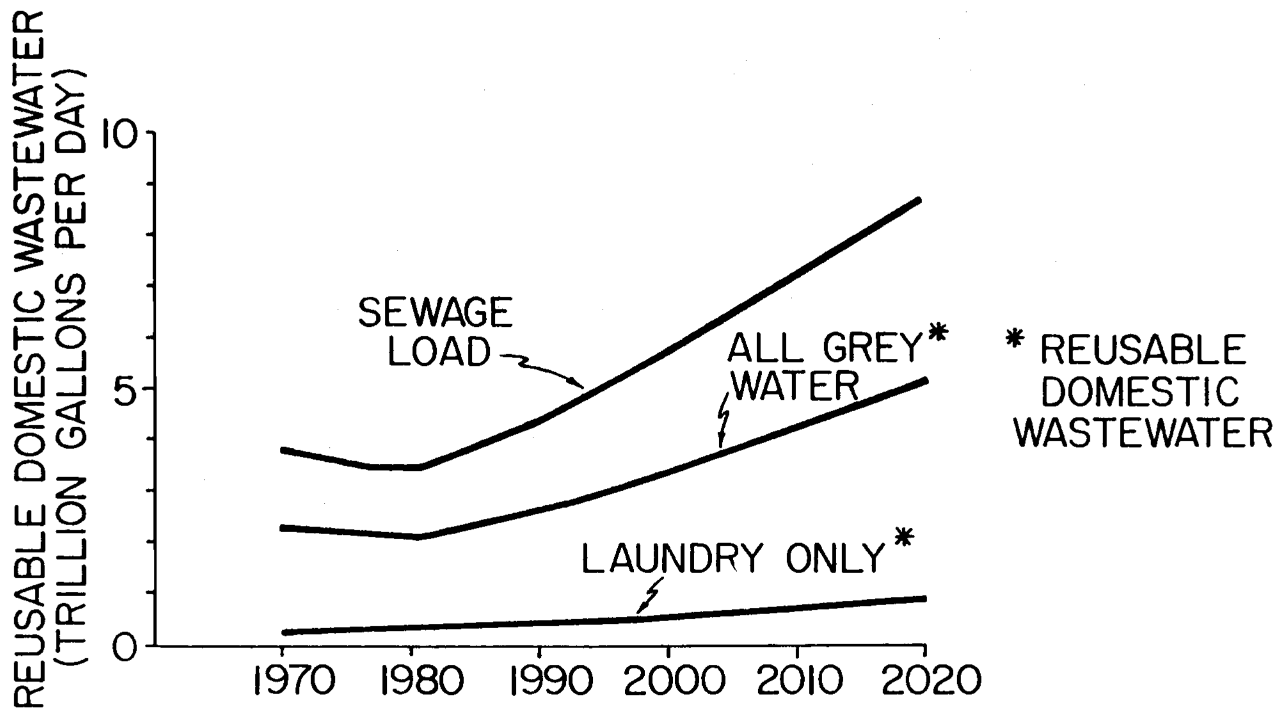
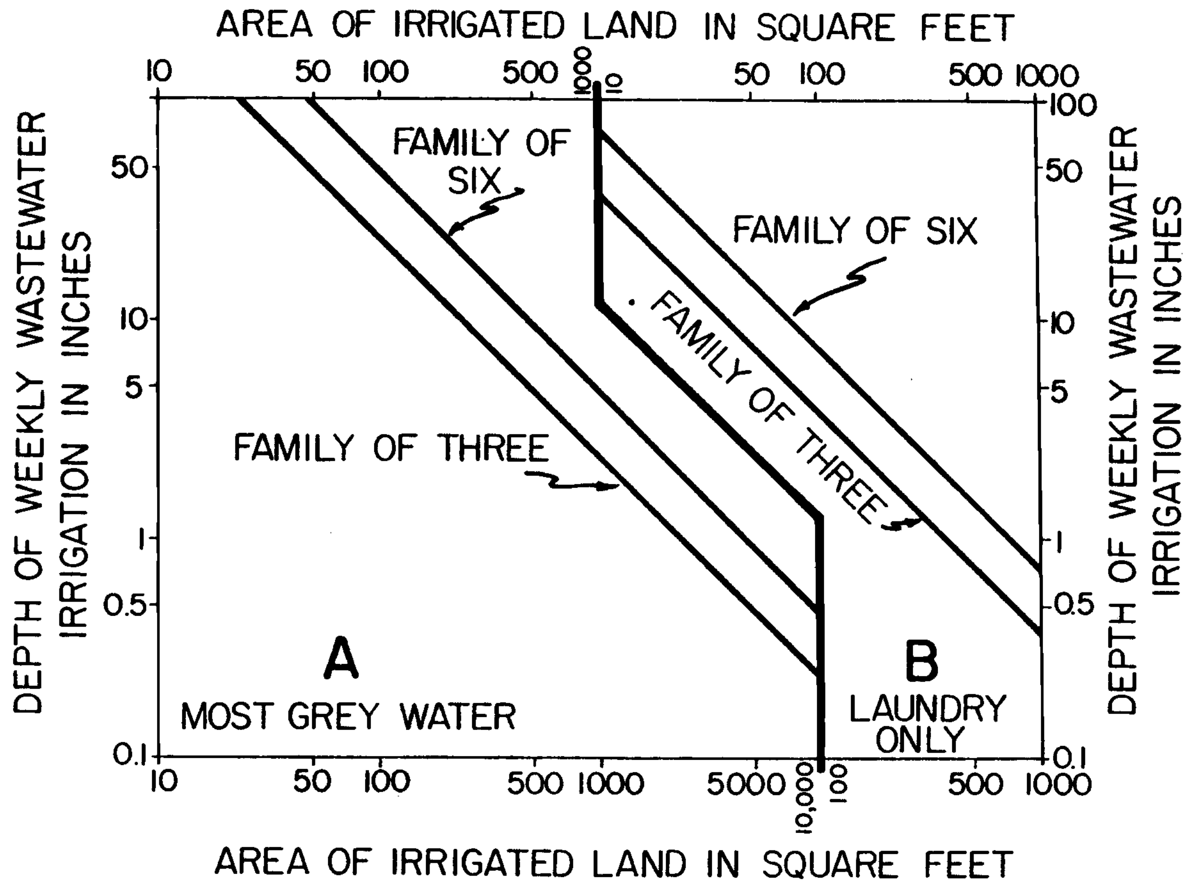


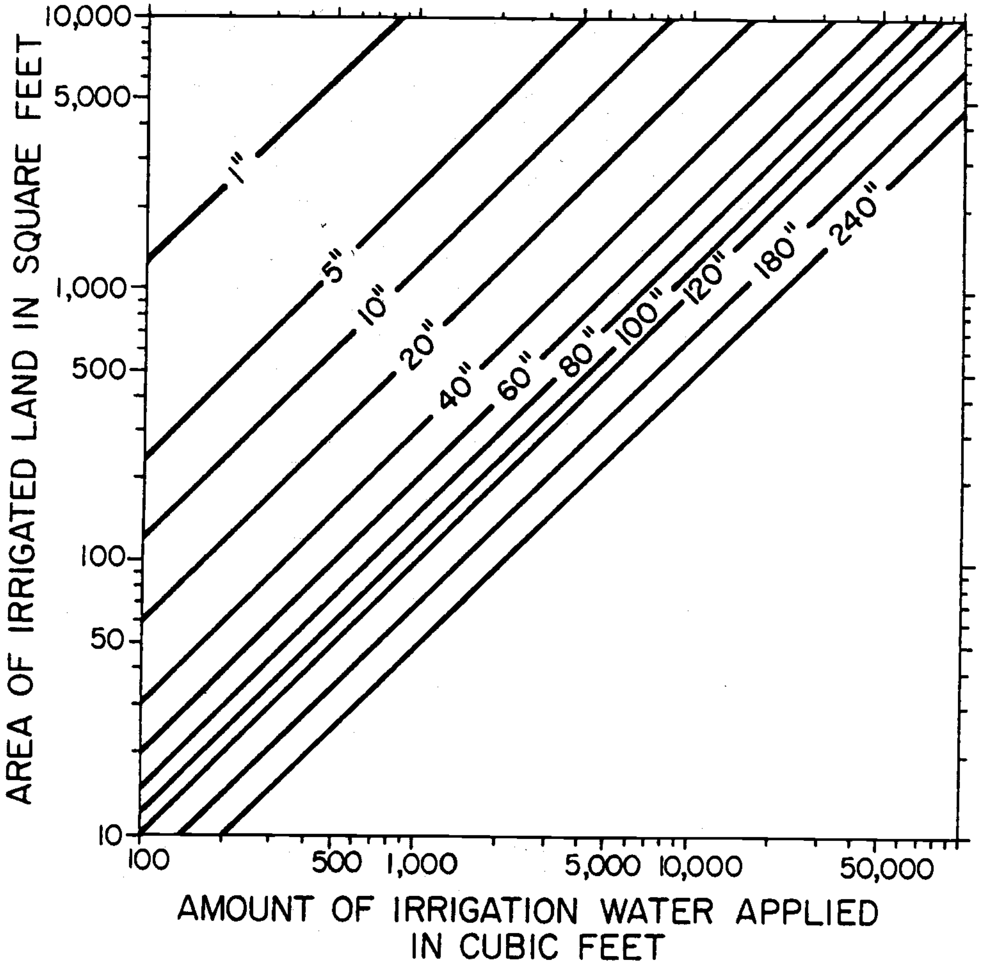
FIGURE 4



AREA OF IRRIGATED LAND IN SQUARE FEET
DEPTH OF WEEKLY WASTEWATER IRRIGATION IN INCHES
FAMILY OF SIX
FAMILY OF THREE
FAMILY OF SIX
FAMILY OF THREE
A
MOST GREY WATER
B
LAUNDRY ONLY

FIGURE 5

QUANTITY OF AVAILABLE IRRIGATION IN INCHES OF DEPTH



WATER SOURCE	BACTERIA	BLEACH	CHLORINE	FOAM	FOOD PARTICLES	HAIR	HIGH pH	HOT WATER	NITRATE	ODOR	OIL AND GREASE	ORGANIC MATTER	OXYGEN DEMAND	PHOSPHATE	SALINITY	SOAPS	SODIUM	SUSPENDED SOLIDS	TURBIDITY
AUTOMATIC CLOTHES WASHER		●		●			●	●	●		●		●	●	●	●	●	●	●
AUTOMATIC DISH WASHER	●			●	●		●	●		●	●	●	●		●	●		●	●
BATH TUB AND SHOWER	●					●		●		●	●		●			●		●	●
EVAPORATIVE COOLER															●				
SINKS, INCLUDING KITCHEN	●				●			●		●	●	●	●			●		●	●
SWIMMING POOL			●												●				

WATER QUALITY CHARACTERISTICS OF SELECTED DOMESTIC WASTEWATER

FIGURE 6

TREATMENT	BACTERIA	BLEACH	CHLORINE	FOAM	FOOD PARTICLES	HOT WATER	NITRATE	ODOR	OIL AND GREASE	ORGANIC MATTER	OXYGEN DEMAND	pH	PHOSPHATE	SALINITY	SOAPS	SODIUM	SUSPENDED SOLIDS	TURBIDITY
AERATION								●		●	●	●						
ALUM															●			●
CARBON FILTRATION								●										
CHLORINATION	●							●										
CROP FILTRATION	●				●												●	●
CROP UPTAKE							●						●		●	●		
DILUTION						●	●					●	●	●		●		
FILTRATION					●				●	●					●		●	●
FLOTATION									●									
HYDROGEN PEROXIDE	●							●										
LIME	●							●								●		
SETTLING				●	●	●				●	●						●	
SOIL FILTRATION	●	●	●	●	●					●	●						●	●
SOIL UPTAKE							●						●		●	●		
STORAGE				●	●	●				●	●	●					●	

TREATMENT FOR WATER-QUALITY VARIABLES

FIGURE 7

FIGURE 8

SUMMARY OF ENGINEERING REQUIREMENTS BY WASTEWATER SOURCE

WASTEWATER SOURCE	COLLECTION TO DIRECT USE	COLLECTION TO STORAGE	STORAGE	TREATMENT	DISTRIBUTION
① BATHROOM: SINK, BATHTUB, SHOWER	PLUMBING & PIPES		MINIMAL TO EXTENSIVE. MAY REQUIRE EXCAVATION, TUBS, TANKS, OR PONDS	MODERATE	PLUMBING OR HOSES. MAY REQUIRE PUMPS
② EVAPORATIVE COOLER	HOSE OR PIPE, NOZZLE OR FAUCET	EASY PLUMBING, HOSE OR PIPES, OR SAME AS ①		LITTLE	
③ KITCHEN: SINK, DISH WASHER	SAME AS ①			MODERATE	
④ LAUNDRY: CLOTHES WASHER	SAME AS ②			LITTLE	
⑤ SWIMMING POOL	SAME AS ②			LITTLE	

<u>APPLICATION</u>: <u>FLOOD AND OVERLAND FLOW</u> — LOWEST COST. REQUIRES LANDSCAPING FOR SLOPES, FURROWS OR FLOOD BASINS.

<u>SPRINKLER</u> — REQUIRES SPRINKLER HEADS AND PRESSURE.

<u>TRICKLE</u> — HIGHEST COST. REQUIRES FILTERS AND EMITTERS.

FIGURE 9

REPAYMENT PERIOD FOR INTEGRATED THREE—DAY STORAGE

CASE AND WATER SOURCE	NORMAL	(1) CUT LABOR COSTS IN HALF	(2) SECOND-HAND MATERIALS	(3) WATER-VALUE DOUBLES	(1) AND (2)	(1) AND (3)	(2) AND (3)	(1), (2) AND (3)	(4) WATER VALUE TRIPLES	(1), (2) AND (4)
1A	3	3	3	2	3	2	2	1	1	1
1B	13	12	9	5	8	5	4	3	3	2
2A	4	4	3	2	3	2	2	2	2	1
2B	17	12	12	6	7	5	5	3	4	2
3A	*	14	16	7	10	5	6	4	4	3
3B	**	**	**	**	**	**	**	**	**	17
4A	**	**	**	19	**	11	13	8	9	5
4B	**	**	**	**	**	**	**	**	**	**

NOTES: CASES, 1 = 100-UNIT TRAILER PARK WITH FIVE COMMON LAUNDRIES.
2 = 50-UNIT TWO-STORY APARTMENT COMPLEX WITH FOUR COMMON LAUNDRIES.
3 = DOUBLE FAMILY HOME OF SIX.
4 = SINGLE FAMILY HOME OF THREE.

WATER SOURCES, A = MOST GREY WATER, ROOF RUNOFF, HARVESTED RUNOFF.
B = LAUNDRY EFFLUENT, ROOF RUNOFF, HARVESTED RUNOFF.

* REPAYABLE IN MORE THAN 25 YEARS.
** NOT FINANCEABLE, AS MONTHLY VALUE IS SMALLER THAN INTEREST.

TABLE 1

Comparison of Dollar Costs of Supplemental Water
For 1,000 Cubic Feet Over a Ten-Year Period

WATER SOURCE	TRAILER PARK	APARTMENT COMPLEX	DOUBLE FAMILY HOUSE	SINGLE FAMILY HOUSE	
A	8.44	8.90	30.50	48.73	Seven-day Nonintegrated Storage
B	18.72	24.37	77.95	103.37	
A	0.69	0.95	2.45	3.98	Seven-day Integrated Storage
B	1.41	2.19	7.10	7.74	
A	0.30	0.42	1.12	1.82	Three-day Integrated Storage
B	0.62	0.98	3.20	3.52	

A: Most grey water, and harvested and roof runoff.
B: Laundry effluent, and harvested and roof runoff.