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INCREASING WATER SUPPLY FOR HOME IRRIGATION*

Barney P. Popkin
Research Assistant
Water Resources Research Center
The University of Arizona
Tucson, Arizona 85721

ABSTRACT

Low rainfall and humidity, and high evapotranspiration, make irrigation necessary for domestic plant growth and commercial crop production in the American Southwest. Irrigation is restricted to dwindling ground-water supplies, and rainfall- or snowmelt- dependent streamflow. Both sources are susceptible to droughts and overdrafts.

A large percentage of potable water used in Southwestern homes is used for irrigation of domestic gardens and yards. Another large percentage is returned to sewers. Water fees increase with dwindling supplies, increasing depths to ground water, scarce surface water, and high treatment costs. Sewer-user fees increase because of high construction and treatment costs. Both water and sewer fees increase 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. Grey water is all home sewage effluent other than from toilets; it includes effluent from sinks, showers, tubs, dishwashers, clotheswashers, swimming pools, and evaporative coolers. Harvested runoff is all water produced from specially landscaped or prepared surfaces; such as driveways, streets, walks, or treated land. Roof runoff is all water produced by rainfall that drains a roof. 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 grey water, harvested runoff, and roof runoff is generally suitable for home irrigation.

Engineering systems are required to collect, store, treat, distribute, and apply supplemental home irrigation water. There are many possible combinations of components, but the most preferred systems will have low capital expenditure and low energy requirements.

Economic considerations are different for large and small scales. Large-scale analysis indicates that a large and significant reduction in municipal costs and services is possible if supplemental home irrigation water is developed. Small-scale analysis for the 100-unit trailer park, 50-unit two-story apartment complex, double family home of six, and single family home of three, indicates that costs are favorable for supplemental irrigation systems, particularly for future large-scale units.

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

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INTRODUCTION

This paper is a written summary of a poster presentation prepared for the American Water Works Association's Water Reuse Symposium. The essential poster items, with additional items, are presented as figures to this text, submitted in a logical presentation order. Because the figures are self-explanatory, each is not reviewed in the text, unless additional clarification, definition, or expansion is required.

DEFINITIONS AND WATER USE

Figures 1 to 4 give the title, objective, supplemental water sources and definitions. Figures 5 to 7 give domestic water and wastewater load for a Southwestern family, and estimated water withdrawals, consumptive use, and sewage loads, and estimated reusable domestic wastewater for the Southwestern United States. Some of this information is adapted from published sources (1,2,3).

AVAILABLE WATER

Figures 8 to 11 show the depth of weekly irrigation possible for typical family's grey water, grey water available for different populations, irrigation available from roof runoff, and irrigation areas possible for various applied water volumes. Figures 10 and 11 can be used to estimate the contribution from harvested runoff, if the percentage of rainfall which can be harvested from treated land surface is estimated (4). The University of Arizona (3) produced a useful booklet to help select outdoor plants with low and moderate water requirements. See (5) for more information.

WATER QUALITY

Figure 12 summarizes water-quality characteristics of selected grey water. 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. Figure 13 summarizes water-quality treatments. Note that a combination of crop filtration and uptake, dilution, filtration, soil filtration and uptake, and storage account for all listed quality variables. Water-quality aspects are reviewed in (6).

ENGINEERING SYSTEMS

These are summarized in Figure 14. The Farallones Institute (7) and others (8,9) give some practical designs.

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

Figures 15 to 17 show minimum repayment periods for non-integrated and integrated seven-day storage systems, and integrated three-day storage systems. 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 occcupies 7.92, 0.41, and 0.18 acres of land, 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. Rainfall is assumed to be ten inches a year.

The value of water is based on current Tucson rates from the author's bills, or \$36 per person per year using 208 gpcd, or \$3.56 per 1,000 cu ft. Grey water and laundry effluent have an added value in reducing sewer-use fees in this calculation, or \$31 per person per year for 100 gpcd, or \$6.38 per 1,000 cu ft. The unspecified value in reducing street runoff, which may cause erosion, street repairs, and flooding, is not computed. In short, grey water and laundry effluent are worth \$9.94 per 1,000 cu ft, and harvested and roof runoff are worth only \$3.56 per 1,000 cu ft in this exercise.

The calculations also assume that irrigation will occur otherwise exclusively with fresh water. All repayment calculations allow a ten-percent mortgage interest.

Table 1 shows comparative costs of supplemental water. Comparative unit costs for supplemental water systems indicate that:

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 storage, and short-term storage, considerably reduce unit and total costs.

SUMMARY AND RESEARCH

Figure 18 summarizes the presentation. Additionally,

1. Municipalities often discourage supplemental water use by minimum charges for water use and sewer use. Tucson, Arizona, is such a case.

2. States often discourage supplemental water use by outlawing its application. Arizona is such a state (10).

3. The federal government has discouraged such water sources by heretofore inadequate research funds.

A research program is badly needed (11). 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.

ACKNOWLEDGMENT

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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.

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FIGURE 1

OBJECTIVE

- Review Supplemental Water Sources For Home Irrigation With Respect To
  - Water Availability (Quantity)
  - Water Quality
  - Engineering Systems
  - Economics

FIGURE 2

SUPPLEMENTAL WATER SOURCES

- Grey Water
- Harvested Runoff
- Roof Runoff

FIGURE 3

GREY WATER

- All Home Sewage Effluent Other Than Toilet Wastes. Effluent From Sinks, Clothes Washers, Swimming Pools, Evaporative Coolers, Showers, Tubs

HARVESTED RUNOFF

- Water Produced From Prepared Land Surfaces. Runoff From Driveways, Streets, Walks, Lawns.

ROOF RUNOFF

- Water Produced By Rainfall That Drains Off A Roof

FIGURE 4

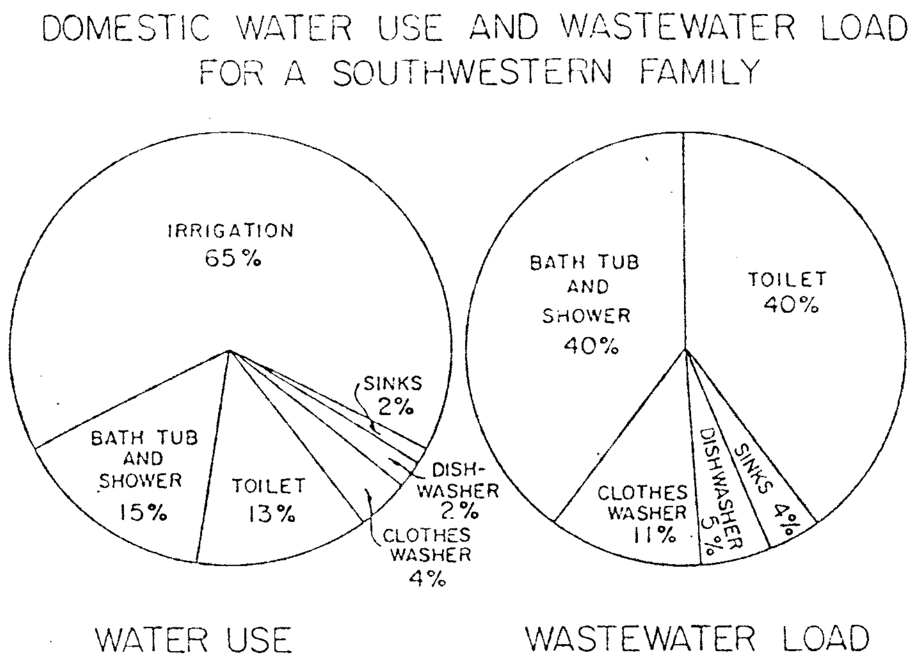

FIGURE 5

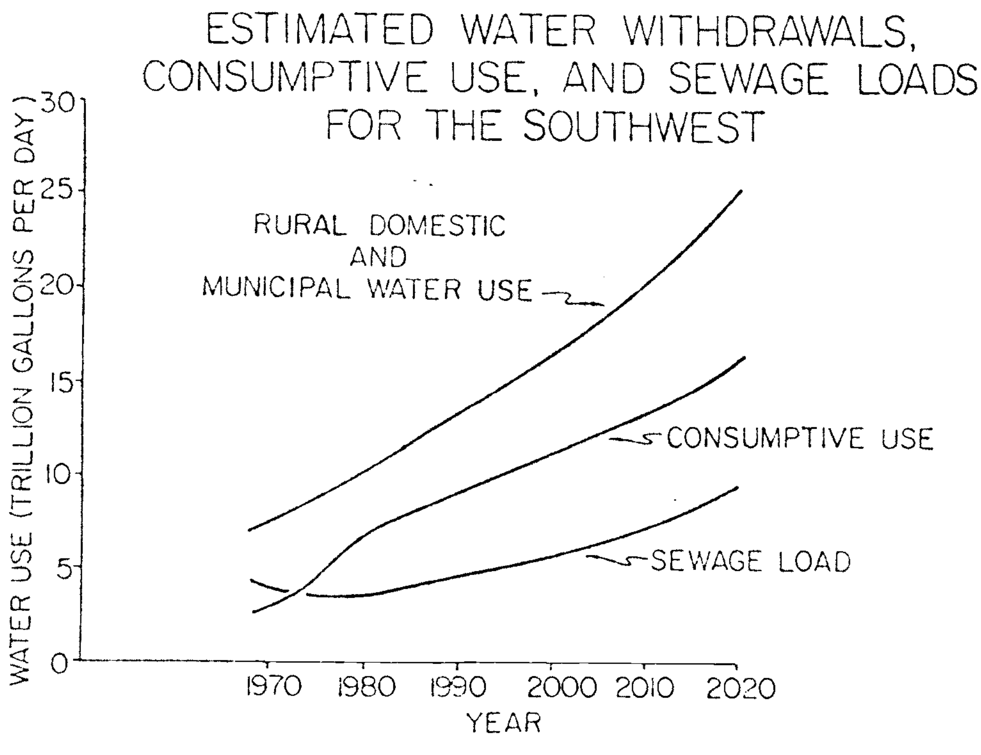

FIGURE 6

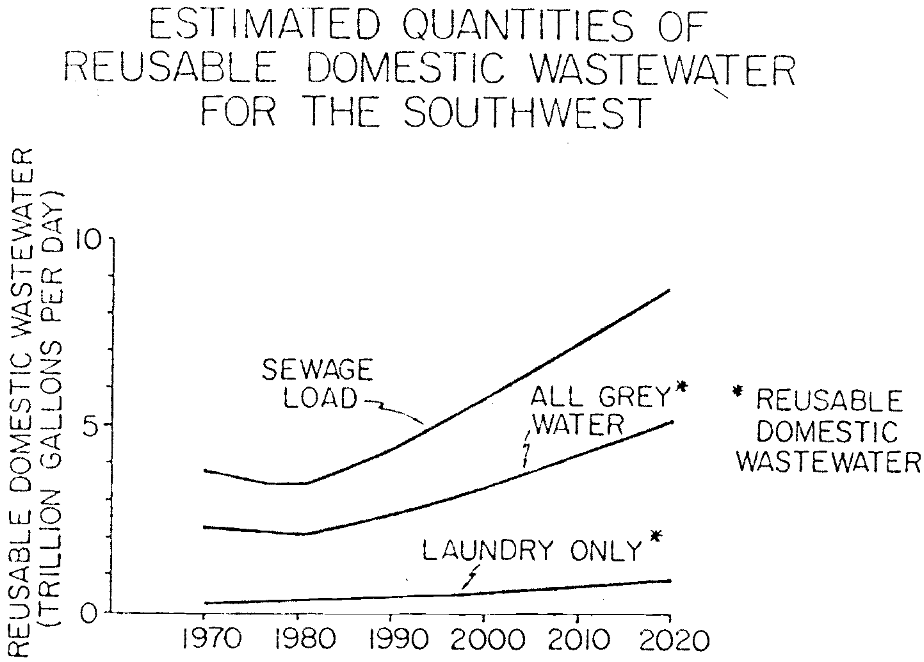

FIGURE 7

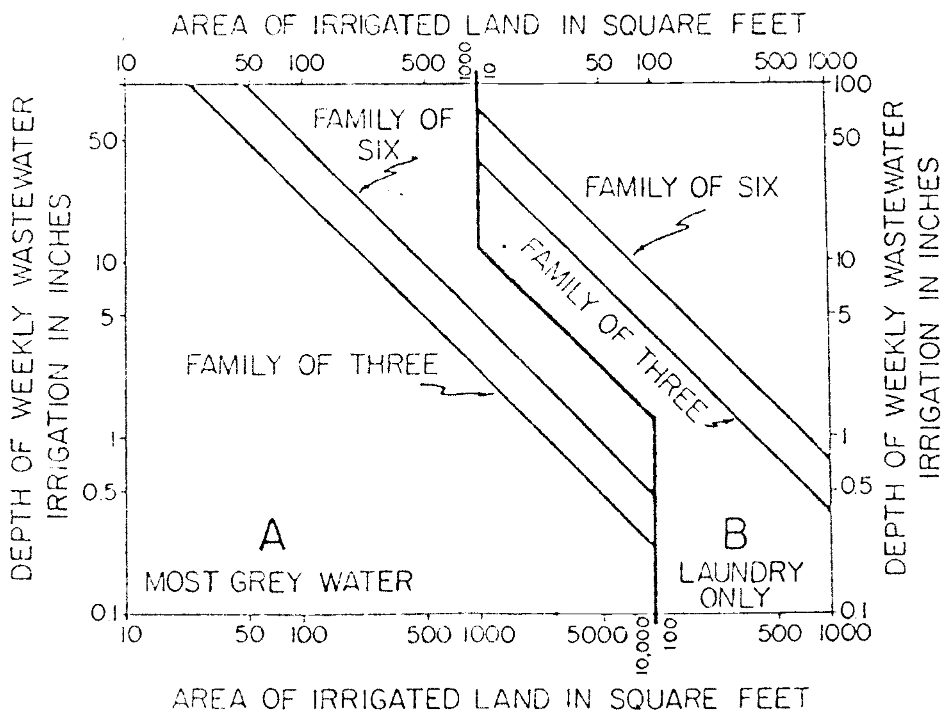

FIGURE 8

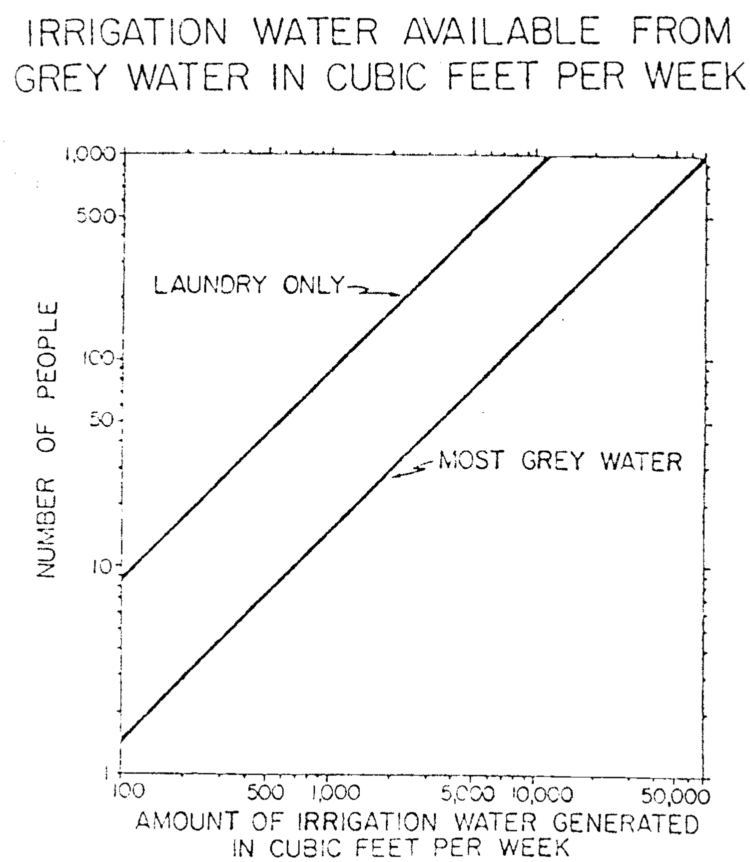

FIGURE 9

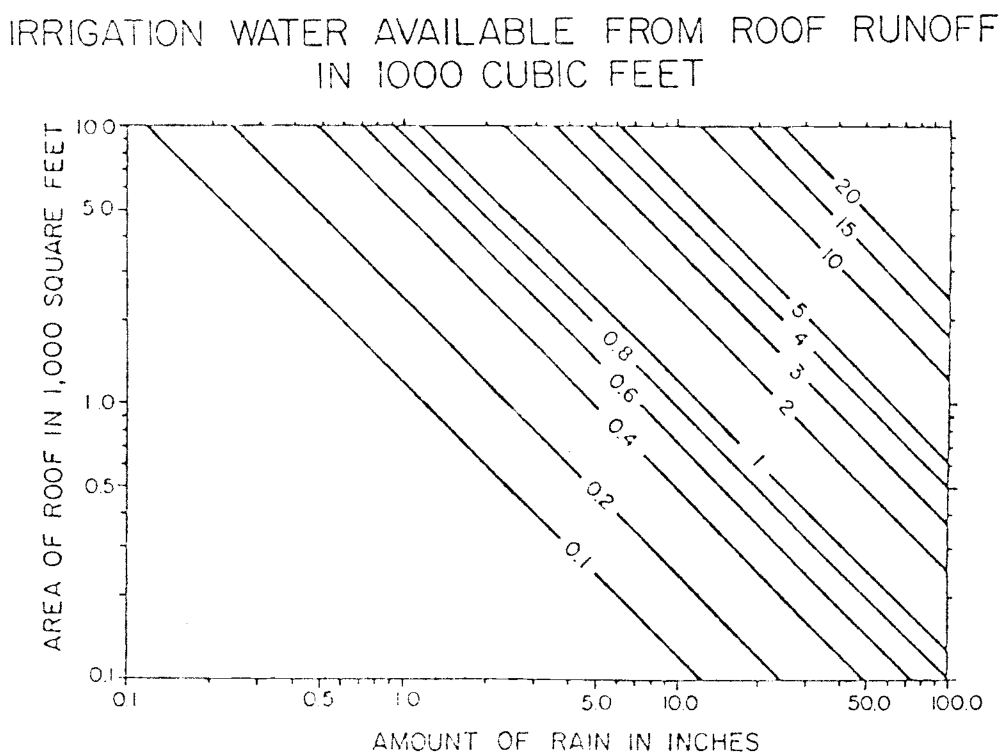

FIGURE 10

QUANTITY OF AVAILABLE IRRIGATION IN INCHES OF DEPTH

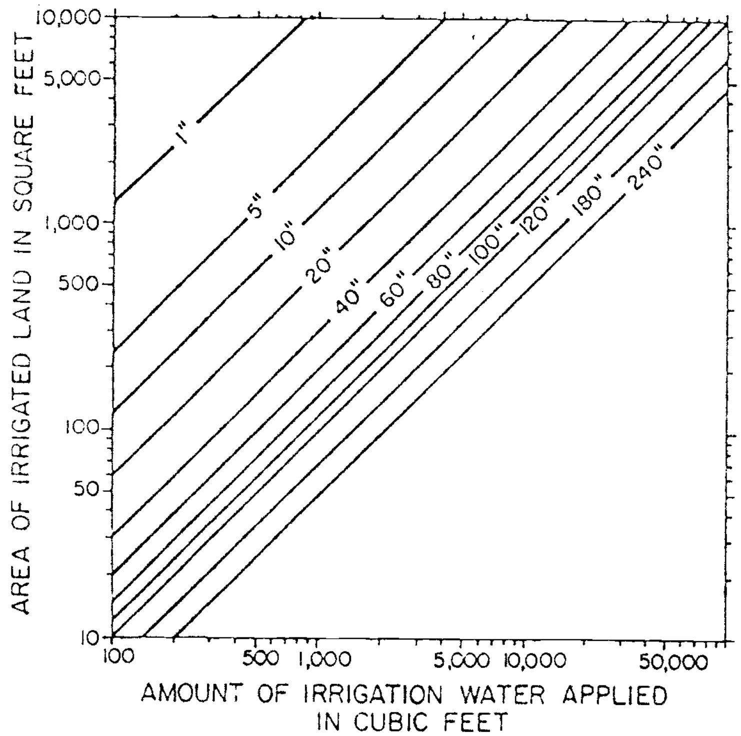

FIGURE 11

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			●												●				

(The column headings above are grouped under the heading CHARACTERISTIC.)

WATER QUALITY CHARACTERISTICS OF SELECTED DOMESTIC WASTEWATER

FIGURE 12

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
	VARIABLE																	
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 13

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	

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

SPRINKLER — REQUIRES SPRINKLER HEADS AND PRESSURE.

TRICKLE — HIGHEST COST. REQUIRES FILTERS AND EMITTERS.

FIGURE 14

REPAYMENT PERIOD FOR NONINTEGRATED SEVEN-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	*	23	15	7	12	6	5	5	4	3
1B	**	**	**	**	**	**	**	*	*	12
2A	25	19	13	7	11	6	5	4	4	3
2B	**	**	**	**	**	**	**	25	24	10
3A	**	**	**	**	**	**	**	**	**	14
3B	**	**	**	**	**	**	**	**	**	**
4A	**	**	**	**	**	**	**	**	**	**
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.

FIGURE 15

REPAYMENT PERIOD FOR INTEGRATED SEVEN-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	9	9	7	4	6	4	3	3	3	2
1B	**	**	**	18	**	15	11	9	9	6
2A	14	12	9	5	8	4	4	4	3	2
2B	**	**	**	25	**	17	14	10	10	6
3A	**	**	**	**	**	19	21	12	12	7
3B	**	**	**	**	**	**	**	**	**	**
4A	**	**	**	**	**	**	**	**	**	17
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.

** NOT FINANCEABLE, AS MONTHLY VALUE IS SMALLER THAN INTEREST.

FIGURE 16

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.

FIGURE 17

SUMMARY

- Grey Water, Harvested Runoff, And Roof Runoff Are Supplemental Water Sources For Home Irrigation In The Southwest.
- Needed Engineering Systems Can Be Flexible And Innovative.
- Economics Are Favorable For Future Large-Scale Supplemental Water Systems.
- Economics Become More Favorable As Water-Use And Sewage-Fee Charges Increase.
- Costs Can Be Reduced Considerably By
  - Providing Three-Day Water Storage.
  - Integrating Collection, Storage, And Distribution Facilities.
  - Using Second-Hand Materials.
  - Exploiting Home-Owner Labor.

FIGURE 18