RESIDENTIAL WATER CONSERVATION

PROGRESS REPORT FOR CASA DEL AGUA

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ABSTRACT

Casa del Agua, a research and demonstration water conservation house, was opened to the public in September 1985. This typical 3 bedroom residence has been re-landscaped and retrofitted with storage for rainwater and graywater and low water use plumbing fixtures including toilets. A unique graywater treatment system employs two 300-gallon aquacells and a sand filter to upgrade graywater quality. The house is occupied by a family of three and detailed data are being obtained on water input, use and quality. Qualitative measures include microbiological, physical and chemical characteristics of filtered rainwater and treated, untreated and stored graywater. A model of water efficiency for dwelling units known as the "W-Index" is being formulated as a quantitative measure of residential water conservation options. The numerical evaluation of weighting of the index components will be aided by means of data generated in the monitoring program at Casa del Agua. A nomogram has been developed to provide a ready mechanism to determine the necessary storage volume for rainwater in terms of a specified availability of supply, catchment area, and rate of water use.

INTRODUCTION

As part of the general and continuing need for prudent water use in Tucson, the need for practical application of water-saving methods at the residential level seems especially evident, in view of the growing single-family housing industry. The sparseness of rainfall in this region, along with over-drafting of ground water, combine to make ever more stringent water-supply conditions; accordingly, residential water conservation and reuse are becoming increasingly relevant not only to water savings but also to reduction of capital investment in municipal water distribution systems, wastewater treatment facilities and energy costs for pumping.

In Tucson the application of residential water conservation methods is especially timely, as the provisions of the 1980 Groundwater Management Act are implemented. The cornerstone of that Act is conservation, and its long-term management goal is a balanced water supply/demand condition. In response to that objective, management plans are currently being developed in each Active Management Area of Arizona, with the inclusion of water conservation programs in each water-use sector.

Reconstruction for the Casa del Agua's water conservation system comprises architectural modifications, relandscaping, and other retrofits to accommodate rain harvesting and graywater reuse.

Casa del Agua is a cooperative program between the University of Arizona College of Agriculture (Office of Arid Lands Studies and Division of Landscape Architecture), College of Architecture, Department of Microbiology and Immunology, Tucson Water, Pima County Wastewater Management Department,

Metropolitan Energy Commission, Arizona Department of Water Resources, Southern Arizona Water Resources Association, and the Southern Arizona Home Builders Association. The credits for this program go far beyond the above organizations to the multitude of individuals and local businesses that generously donated labor and materials in support of the educational and research goals of this project. Casa del Agua is truly a community effort.

CONSTRUCTION AND RETROFIT

Major construction was completed by late September 1985 and a dedication was held on September 26, 1985. Architectural modifications included the construction of a greenhouse, which provides passive solar heating for the house. The former garage was converted into an information center, and an open patio on the north side of the house was roofed. The extended roof area increases the rain catchment surface for water harvesting. Water saving devices, shower heads and low-water using toilets were also installed.

The landscaping plan incorporates drought-resistant plants, planters, a food garden, vines for shading and a drip irrigation system. Extensive brick paving is sloped so that it directs rainfall to vegetated areas.

The roof is used to collect rainwater, which is estimated to be an average of 15,500 gallons each year. This collected water is stored in a cistern that is connected to a pump that supplies water to the evaporative cooler, toilets, hose bibbs and drip irrigation lines.

The graywater system, the most costly and experimental part of the

demonstration, is providing the water needed for outdoor irrigation and toilet flushing. This required a modification of the house drain, waste and vent systems. Graywater comes from the washing machine, one side of the kitchen sink, the lavatories, tub and shower. The toilet waste line and garbage disposal were rerouted directly to the municipal sewer. The existing house drain system directs the graywater into a series of treatment tanks. The treated water then flows by gravity to the storage cistern where it is pumped back as a water supply for landscape irrigation or toilet flushing.

GRAYWATER QUALITY

The University of Arizona began the water quality sampling program during December 1985. This experiment will provide information on the quality of graywater, its potential for harboring disease causing micro-organisms, and the effectiveness of the various treatment processes at Casa del Agua for reducing or eliminating the potential threat of disease transmission by graywater. Such information will be invaluable to State and County regulatory agencies and will provide information for the establishment of guidelines for the design of graywater reuse systems.

Graywater is domestic wastewater which does not contain excreta, i.e., the water discarded from baths, sinks, basins, etc. There has been an increasing interest in Arizona and other arid regions in the reuse of graywater for toilet flushing and irrigation as a means of conserving water. A major concern with graywater reuse is the presence and fate of pathogenic micro-organisms. Information on the microbialquality of graywater is almost non-existent, making it difficult to assess public health implications of its reuse and if treatment will be required before its

reuse can be allowed.

The collection sump, aquacells (water hyacinth treatment tanks), and the storage tank are being monitored for total bacteria, coliforms, and fecal coliforms (Figures 1, 2 and 3). To date a 90 percent reduction in total fecal coliform concentration occurs as the graywater passes through the aquacells and sand filter.

WATER SUPPLY AND USE

An important aspect of operating Casa del Agua is to quantify all water inputs and outputs in order to assess the overall impact of the various systems on water conservation. All water supplies are metered including graywater, rainwater and city water. Outputs are metered and rooftop runoff storage volumes are monitored. Data are recorded weekly by the residents and analyzed with a spreadsheet program (Super Calc 3, Version 2) on an IBM-PC. Figure 4 illustrates the amount of city water metered at Casa compared to the average amount recorded for single family residences in Tucson. The per capita per day city water input at Casa is approximately 44 gallons compared to the Tucson average of 105 gallons (Figure 5).

The one-gallon per flush toilets installed at Casa have significantly reduced the amount of water used by the toilets. An average of 31 gallons of city water are used per capita per day for flushing traditional 5-7 gallon toilets in Tucson. At Casa only graywater or rainwater are used for toilet flushing and the volume has been reduced to approximately 6 gallons per capita per day (Figure 6).

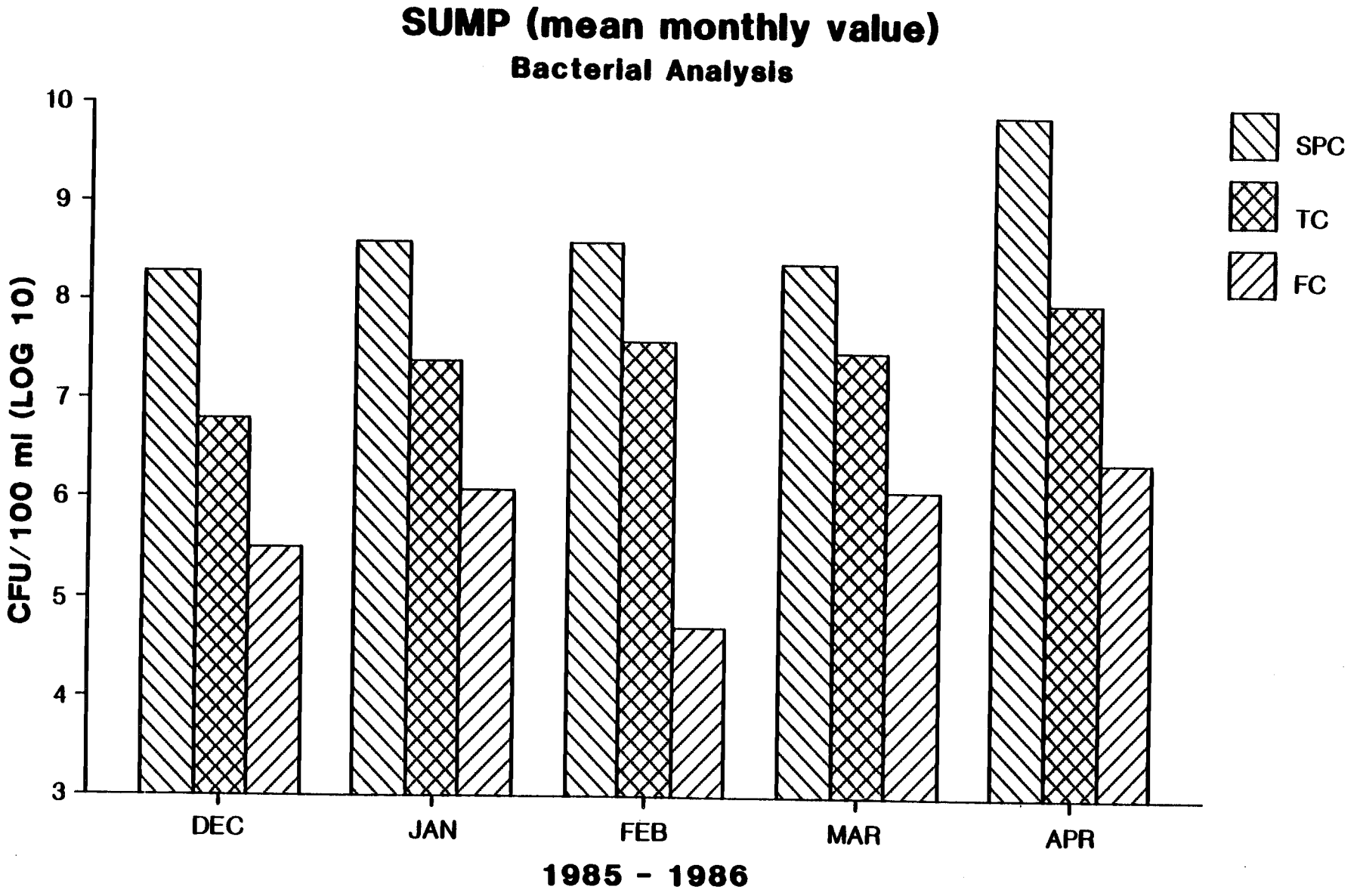
SUMP (mean monthly value)
Bacterial Analysis
CFU/100 ml (LOG 10)
10
9
8
7
6
5
4
3
SPC
TC
FC
DEC
JAN
FEB
MAR
APR
1985 - 1986

FIGURE 1

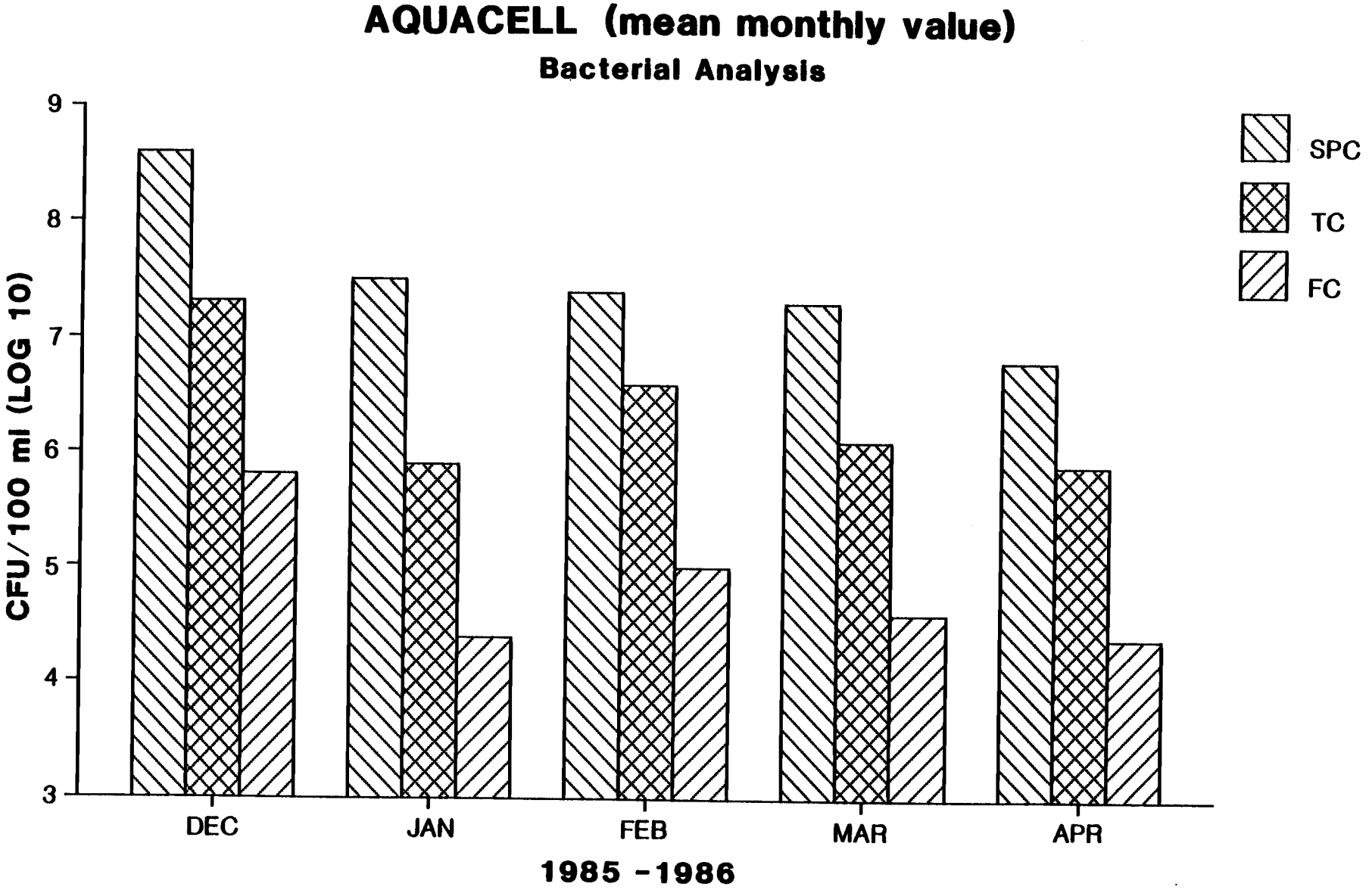
AQUACELL (mean monthly value)
Bacterial Analysis
CFU/100 ml (LOG 10)
9
8
7
6
5
4
3
SPC
TC
FC
DEC
JAN
FEB
MAR
APR
1985 -1986

FIGURE 2

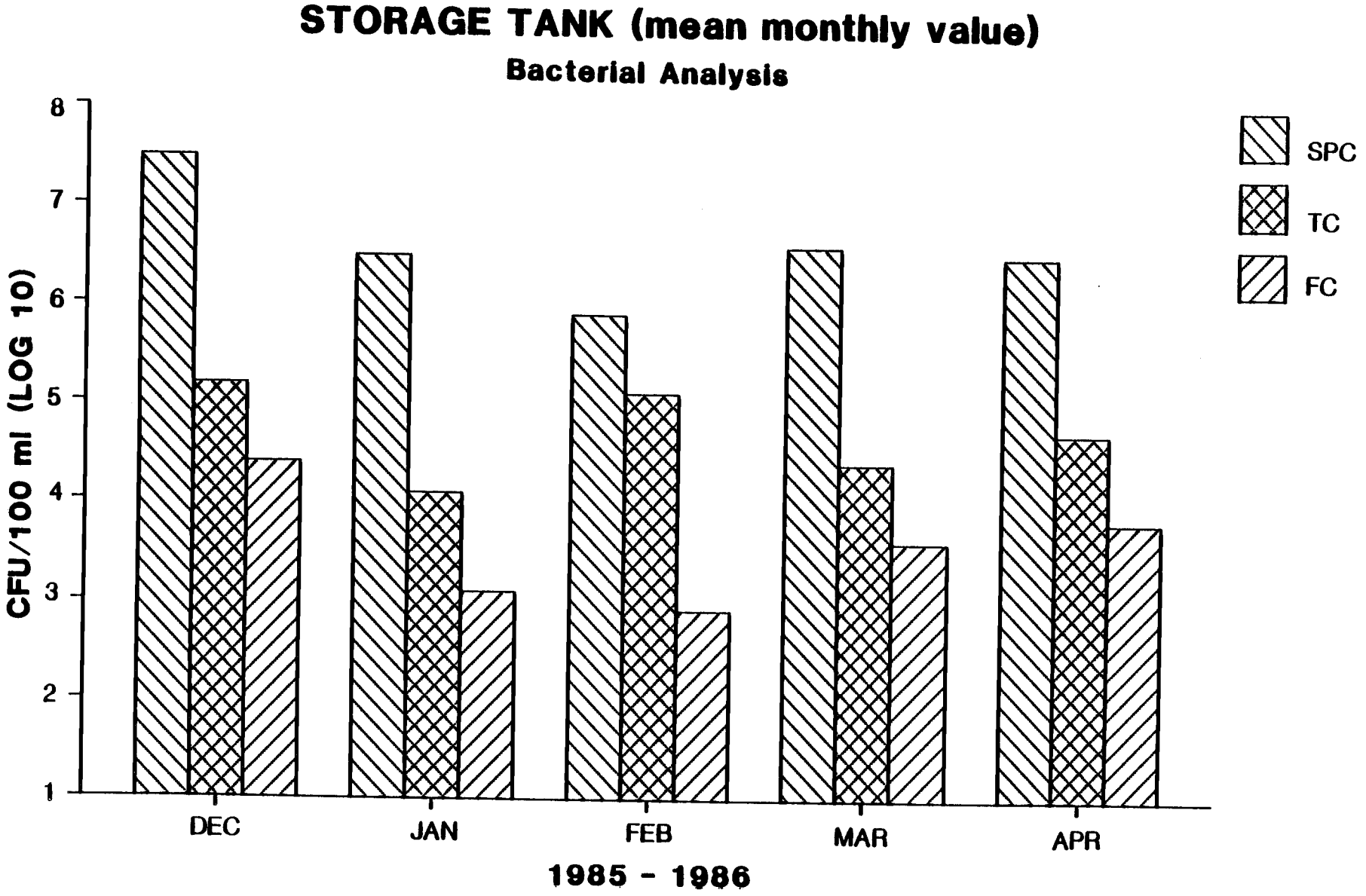
STORAGE TANK (mean monthly value)
Bacterial Analysis
CFU/100 ml (LOG 10)
8
7
6
5
4
3
2
1
DEC
JAN
FEB
MAR
APR
1985 - 1986
SPC
TC
FC

FIGURE 3

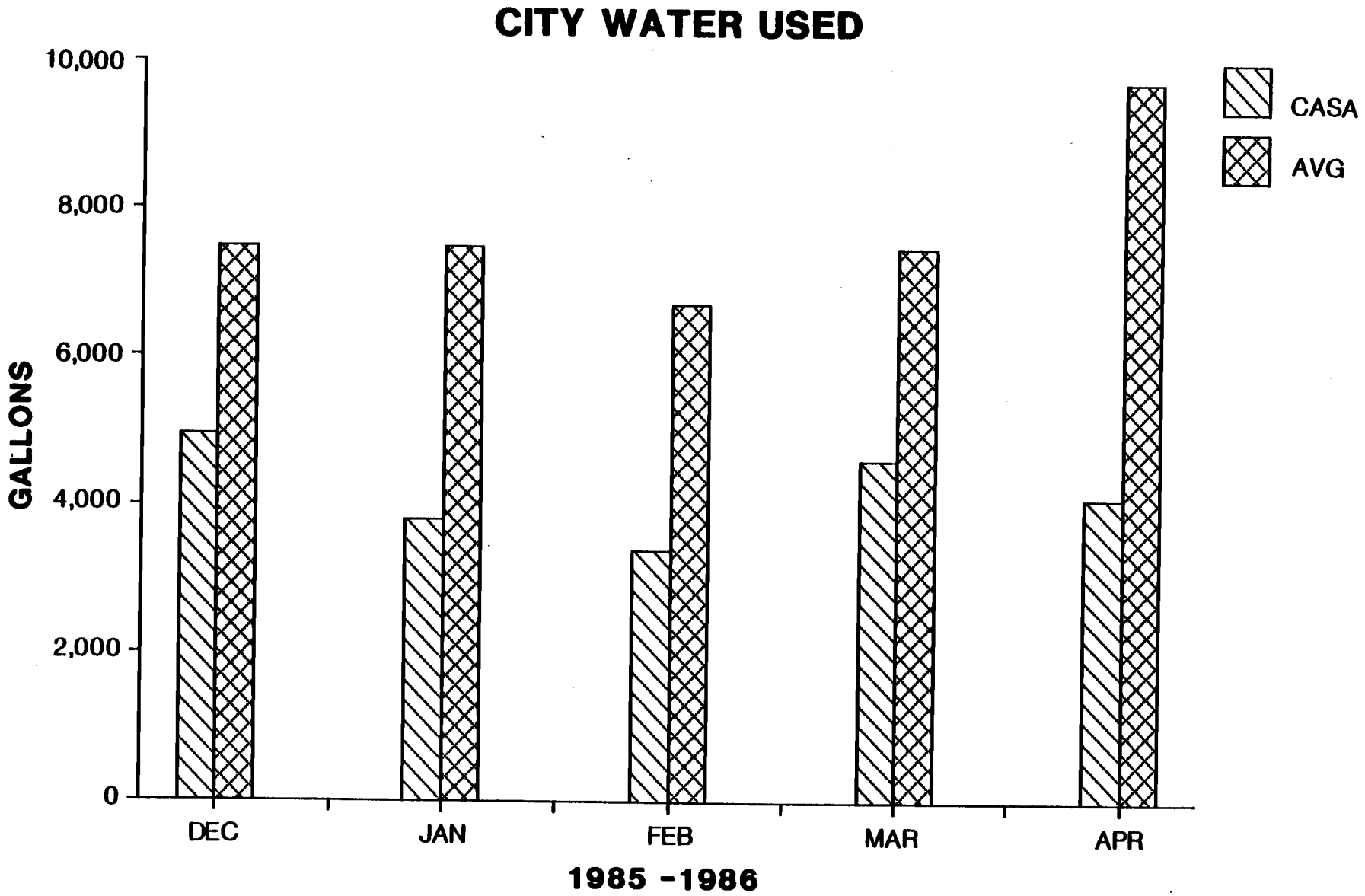
CITY WATER USED
10,000
8,000
6,000
4,000
2,000
0
GALLONS
CASA
AVG
DEC
JAN
FEB
MAR
APR
1985 -1986

FIGURE 4

MONTHLY GROUND WATER INPUT
CASA DEL AGUA

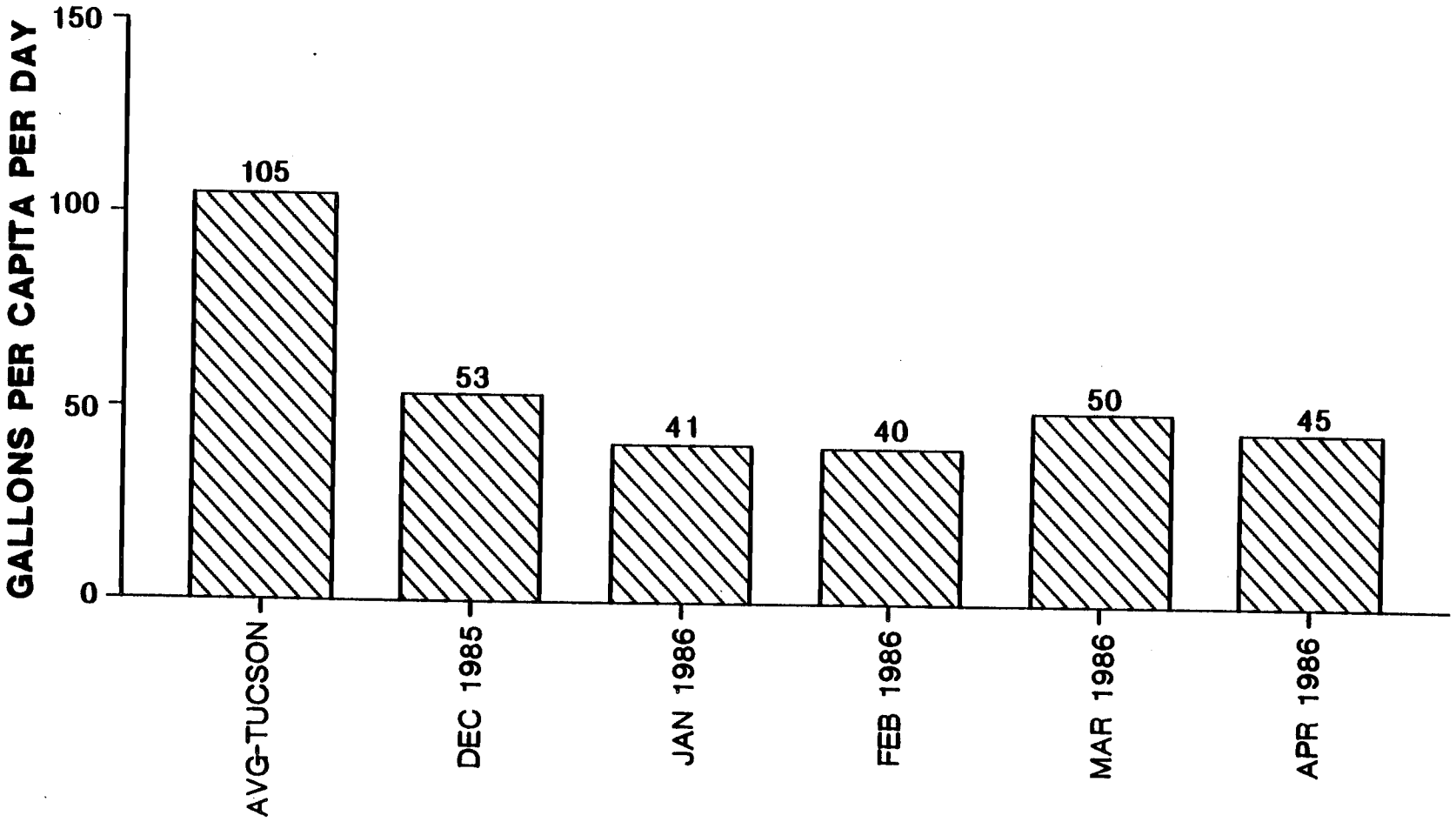

FIGURE 5

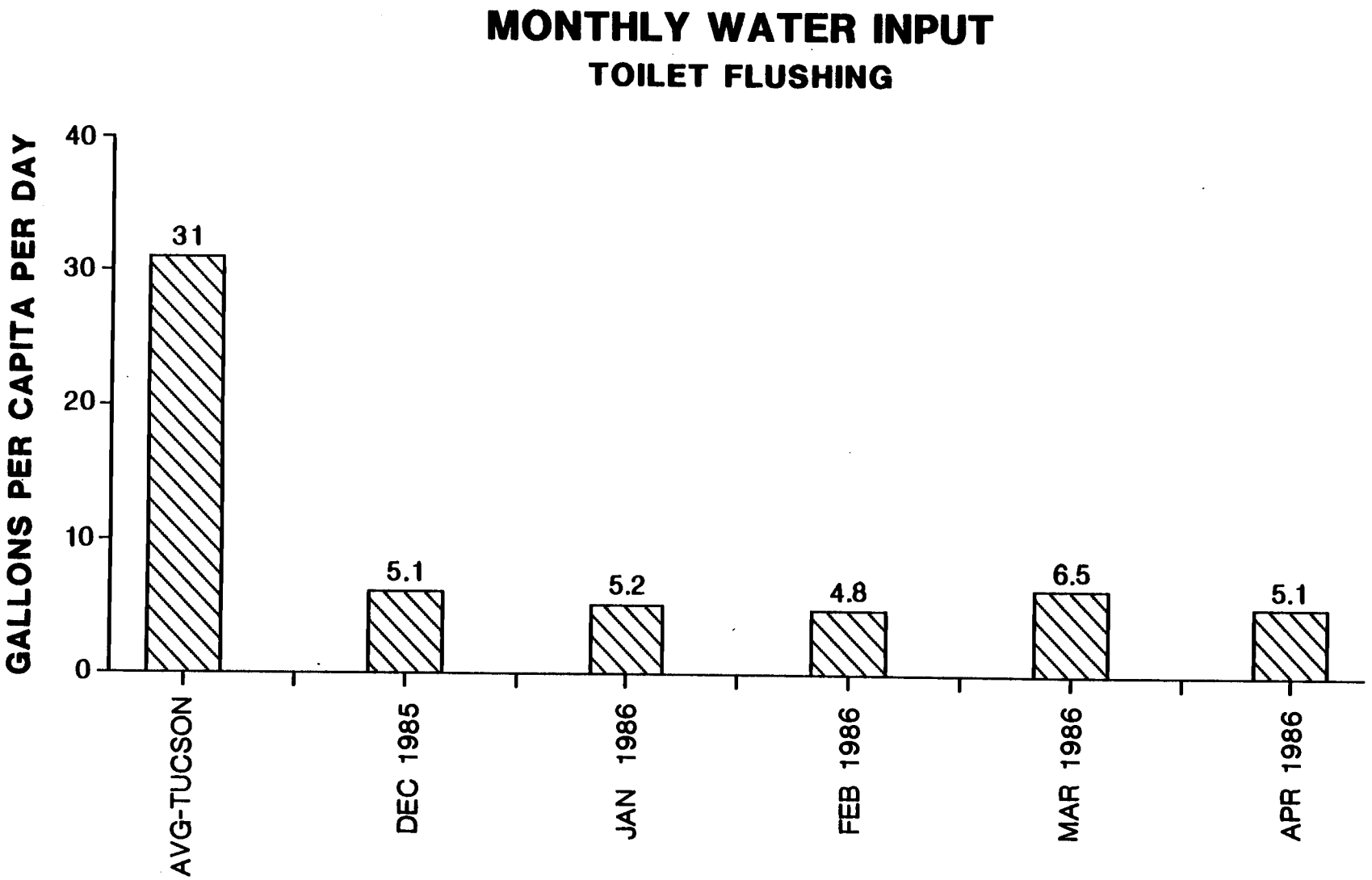
MONTHLY WATER INPUT
TOILET FLUSHING
GALLONS PER CAPITA PER DAY
40
30
20
10
0
31
5.1
5.2
4.8
6.5
5.1
AVG-TUCSON
DEC 1985
JAN 1986
FEB 1986
MAR 1986
APR 1986

FIGURE 6

W-INDEX

As Tucson enters into an era of more stringent water conservation, an index needs to be developed that rates a single-family home or multi-family complex based on water conserving technologies incorporated into the residence. This index can then be used by realtors and homebuilders as a basis for consumer information and home value.

Table 1 shows a suggested procedural format for numerical evaluation using the W-Index. In this example, future incentives, in addition to enhanced home value, could be suggested whereby retrofit or new construction with a value of W-100 (maximum) be given a reduction on water bill, a state tax break (like solar for energy saving), reduced property taxes, or reduced sewer fees. Similar, but lesser, incentives might be offered for a lower W rating (e.g., W-60).

RAINFALL HARVESTING NOMOGRAM

A nomogram, or precalculated series of graphs, has been developed as a useful tool for the designer or homeowner in determining the relationship among variables in a rainfall utilization system. Specifically, based on monthly rainfall amounts in the Tucson area, the nomogram shows the relationship of rainfall catchment area to rainfall storage volume, rate of use of rainwater in the residence, and dependability of supply. The nomogram and examples of its application will be included in one or more reports presently in preparation.

TABLE 1

RESIDENTIAL "W-INDEX": EXAMPLE OF NUMERICAL EVALUATION

Conservation Measure	Index Points Based on Potential Water Savings (gpcpd)*
I. Water Sources (Increase Supply)	
A. Outdoors	
1. Rooftop rainwater collection system	6
2. Rainwater filter, storage and distribution system	12
3. Landscape contouring to concentrate and direct runoff	10
B. Indoors	
1. Graywater collection, treatment, storage, and distribution system	24
II. Water Uses (Decrease Demand)	
A. Outdoors	
1. Low-water-use plants	12
2. Drip irrigation system	6
B. Indoors	
1. Water-efficient toilets (1 gal. rating)	20
2. Water-efficient shower heads and faucet fixtures**	10
Possible Points, TOTAL	100

*Not all water savings are additive; numerical values are illustrative only.

**Requirements under present (1982) City and County regulations specify maximum of 3 gpm for shower heads, 4 gpm for faucets, and 4 gal. per toilet flush. Index points as shown indicate compliance, either by retrofit or in new construction.

CONCLUSIONS

At this time only tentative conclusions can be drawn about the various systems used at Casa del Agua:

1. For the brief period of monitoring to date, use of municipal groundwater at Casa is about 40 percent of that used in "average" homes.
2. Quantity of water used for toilet flushing at Casa is about 20 percent of that used by conventional fixtures.
3. Total fecal coliform concentration in graywater appears to be reduced by about 90 percent in passing through the water hyacinth aquacells and sand filter.

The research program is ongoing. The systems are operating, recording data and providing tours to visitors. Since the September 1985 dedication more than 1,000 persons have toured the home. Many of these visitors have expressed their serious interest in incorporating some of the technology at their residences.