Rainwater Harvesting and Water Use in the Barrios of Tegucigalpa

Anthony Brand
Bonnie Bradford

Agua para el Pueblo

unicef

Prepared for UNICEF/Honduras' Water Supply and Environmental Sanitation Program.
Bernt Aasen, Urban Development Officer

RAINWATER HARVESTING AND WATER USE IN THE BARRIOS OF TEGUCIGALPA

ANTHONY BRAND
BONNIE BRADFORD

Prepared for UNICEF/Honduras' Water Supply
and Environmental Sanitation Program.
Bernt Aasen, Urban Development Officer

Impreso por:

Edificio San Miguel, 6º piso,
barrio La Plazuela, fte. al Arbolito, Tegucigalpa.
Apartado Postal 3869, Tegucigalpa, Teléfono (504) 37-7668

ACKNOWLEDGMENTS

In addition to Agua Para el Pueblo and UNICEF staff members, the authors would like to thank a number of individuals who participated in planning and carrying out this project. Bernt Aasen of UNICEF and Eduardo Perez, then with Cooperative Housing Foundation (CHF), now with the Water and Sanitation for Health (WASH) project, provided enthusiastic support and insight during many reviews of this work and its concepts.

Special thanks are also due Dan Campbell of WASH, who provided copies of most of the documents listed in the reference section of this report. Our study design was based largely on insights gained from reviewing these sources.

Thanks to John E. Gould, Hon. Secretary of the International Rainwater Catchment Systems Association; Carl Lindblad of Volunteers in Technical Assistance and editor of RAINDROP; and Wanpen Wirojanagud, Faculty of Engineering, Khon Kaen University, Thailand for responding personally to our inquiries and providing useful information.

Sebastiana Carbajal and Sofia Fonseca did an outstanding job as interviewers. Sofia Fonseca tabulated the data collected with care and precision. Dora Yvonne Cárdenas from Israel Norte and Ramón Alberto Sánchez from Villa Nueva provided valuable assistance to our two interviewers as they collected information from key informants and residents of these two neighborhoods.

Many thanks to Becky Myton (Director of the Department of Limnology) and Lourdes Enriquez de Madrid and Manual Figueroa of the Department of Microbiology at the Universidad Nacional Autonoma de Honduras and to UNAH students Beatriz Ponce and Irasema Montoya (Limnology); Manuel Montoya (Medicine); Juana Elsy Méndez, and Leonel Salgado (Microbiology).

Interviews were carried out with several groups based in Tegucigalpa. Special thanks to all those interviewed. Jean Gough and Jose Mario Zuñiga at UEBM were especially helpful, and reviewed drafts of this study. Elizabeth Rivera and Vilma Lopéz helped prepare the final report.

Felipe Burchard, Victor Ney and Evaristo Lopez are three Hondurans whose art and photography enriched these pages, as they have for their whole culture. Steen Johanssen also provided photography. The help of David Tipping at ZAS Publications is evident throughout the report; his skill at editing and layout transformed this study.

Of course, all opinions, content and shortcomings are the responsibility of the authors.

PREFACE

UNICEF, the United Nations Children's Fund, is a semi-autonomous organization of the United Nations. Through its network of offices in 117 countries, UNICEF cooperates with local governments in their efforts to meet the needs of their youngest citizens, especially the children of the least developed nations. The reduction of infant mortality is a principal focus of UNICEF, which orients its support and cooperation in accordance with the situation and priorities of each country. In Honduras — together with projects directly related with children and their mothers — UNICEF has for several years been collaborating with governmental and private voluntary organizations in the improvement of living conditions in low-income urban settlements and rural villages, because of the overwhelming influence that these conditions have on infant mortality and morbidity.

AGUA PARA EL PUEBLO, or Water for the People, is a local Honduran PVO dedicated to bringing water and sanitation to low-income urban and rural families. Founded in 1984, *Agua para el Pueblo* has reached more than 40,000 people with aqueducts, wells, latrines and sewage systems in support of Honduras' National Health Plan. Education and training are a strong emphasis of the institution, and one of the major areas of cooperation with UNICEF. UNICEF and *Agua para el Pueblo* are currently pioneering work in areas besides urban rainwater harvesting, such as the inter-active development of user-maintained handpumps and the formation and training of local Water Boards for sustainable village level operation and maintenance of their wells or aqueducts.

FORWARD

About half of the estimated 660 million children under the age of five living in developing countries have access to safe water and only about one-third have access to adequate sanitation facilities. This dramatic water and sanitation situation is closely linked with the high incidence of diarrhoea and intestinal diseases prevalent in most Central American countries. Tragically, the proportion of under-five mortality rates due to diarrhoea related illnesses ranges from 7 percent in Costa Rica to 38 percent in Honduras.

Although there has been a substantial increase in sector investment in recent years, both water supply and sanitation coverage have gained only slightly in comparison to continuing population growth. While Central America's population increased by 6.1 million, the number of persons served increased by only 5 million. This disparity is especially evident in the marginal urban areas where population growth has put a further strain on the limited existing water sources. Projections for the year 2000 place half of the urban population in the lowest-income *barrios*. Studies by UNICEF and other have shown that the lack of community water source results in poor families spending as much as 20 to 35 percent of their monthly income purchasing water from private vendors.

The 1981-1990 International Drinking Water Supply and Sanitation Decade's goal of providing full access to water supply and sanitation services was clearly not achieved. Yet, the Decade in Central America was able to highlight priority problems which need to be faced in the 90s and the encourage community involvement and innovation in resolving those problems. It demonstrated that the answer to achieving full access is not found in sophisticated technology that puts the community in the role of simple beneficiary. Nor is it found in high- cost installations that depend on conventional sewerage and pipe-borne water-supply with costly supplies of fuel or sophisticated engineering skills for their operation. The answer is found in low-cost technologies managed by the community.

This joint UNICEF - *Agua Para El Pueblo* study on rain-water collection in marginal urban areas of Tegucigalpa, Honduras is one such innovative yet cost-effective and community-oriented means of acheiving water access. Hopefully, sharing these successful Tegucigalpa experiences will lead to similar advances not just in Central America but throughout the developing world so the currently tragic number of child deaths can be greatly reduced. On behalf of those children whose lives can be changed and saved through this experience, I encourage you to read the following study.

Per Engebak
UNICEF Area Representative
Central America and Panama
February 1991

TABLE OF CONTENTS

GLOSSARY

Acronyms

APP	*Agua Para el Pueblo* (Water for the People - a Honduran PVO).
CHF	The Cooperative Housing Foundation (a U.S.-based NGO).
IRC	International Reference Center (Netherlands).
PVO	Private Voluntary Organization.
RW	Rain water (graphs 1A, 1B).
RWCS	Rainwater Collection Systems.
SANAA	*Servicio Autónomo Nacional de Acueductos y Alcantarillado* (national water and sewage agency).
UEBM	*Unidad Ejecutora Barrios Marginados* (Special Unit in SANAA for Executing Projects in Marginal Neighborhoods).
UNAH	*Universidad Nacional Autónoma de Honduras* (National Autonomous University of Honduras).
UNICEF	United Nations Children's Fund.
USAID	United States Agency for International Development.
WASH	Water and Sanitation for Health Project (a U.S. project which houses the WASH/Rainwater Harvesting Information Center).
WHO	World Health Organization.

Special terms

***barrio*:**	marginal urban neighborhoods; informal sector; often squatter areas.
***patronato*::**	neighborhood or community council.
***pila*:**	a small to medium size (up to approx. $0.5m^3$) open cement tank, usually incorporating cement washboards.
PVC pipe:	poly-vinyl chloride pipes used for piped water or sewage systems.
RWCS:	rainwater collection system.
sheet metal:	galvanized metal roofing sheets.
***techón*::**	asphalt-impregnated cardboard roofing sheets.

LIST OF GRAPHS AND TABLES

Graphs

Tables

INTRODUCTION

Like most of her neighbors, Dora Yvonne Cárdenas feels frustrated to see so little improvement in her neighborhood since she and her family moved there four years ago. The same wooden shacks and rusted tin roofs look down a steep hillside into Tegucigalpa, the capital of Honduras. "If anything, there's more of us, and **still** no water here..." in her *barrio*, Israel Norte.

It is certainly not for lack of hard work that Israel Norte and 200 other *barrios* in Tegucigalpa do not have their own water, sewage systems, paved streets, or property titles. Besides raising three children, Dora Yvonne works hard to keep her home, yard and children clean, as do hundreds more women in her *barrio*. Despite their best efforts, however, "...we just don't have all the things we wanted when we came to the city," Dora Yvonne sighs.

For Dora and more than 150,000 other residents of Tegucigalpa's low-income urban settlements, the hunt for water is hard work. Not having a faucet nearby means long, bone-tiring walks up dirt paths and streets with more than forty pounds of water balanced on her head. At least Dora is luckier than her neighbor, María Antonia. Like almost 60% of urban families, the father of María Antonia's three children left and no longer supports them. She must leave the kids, ages five, four and two, locked alone inside her one-room shack while she washes clothes in the filthy stream in the ravine below Israel Norte. "It's dangerous and unprotected. Friends of mine have been attacked when they were washing alone down there," María Antonia whispers.

The almost 25,000 people that migrate to Tegucigalpa from rural areas each year come hoping for a home of their own, better jobs, higher pay, or an education for their children. Others come because what little land they once farmed no longer sustains their growing families, and life seems better in the city. Unfortunately, for the great majority of these families, reality is different.

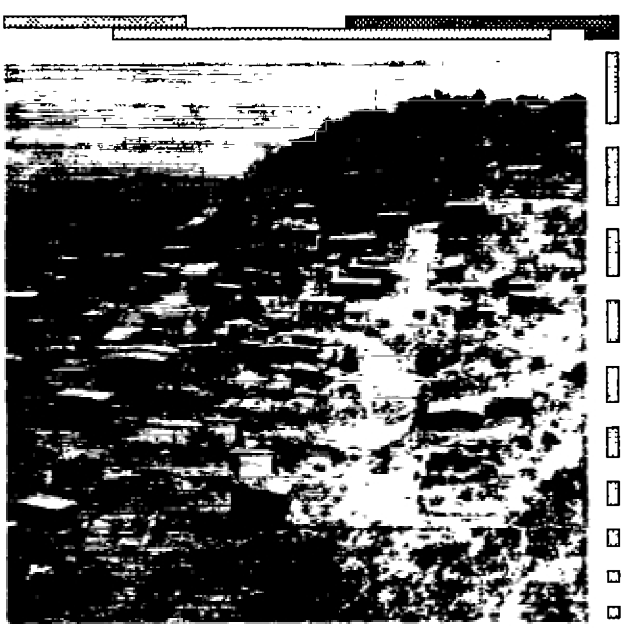
In most of Latin America land ownership patterns and various legal constraints, some of which date from Colonial times, relegate the poor immigrants to renting, buying or just squatting illegally on cities' fringes. Placed as it is within a steep valley, Tegucigalpa's new residents find themselves building their small wooden shacks clinging onto ravines and hillsides where few or no public services are available. Many of these urban settlements are in dispute and many more are deemed by authorities to be squatter "invasions". It is almost impossible to get titles to these lots and homes, no matter how many years families pay.

Without property titles, a neighborhood finds it difficult to petition for public services. Without job skills, wage-earners are condemned to a cycle of underemployment in menial jobs or as domestics. Without a steady income, many basic necessities are not met. Some days they may go without even food. Children often leave school and are pressed into manual labor or begging to support themselves. All of these circumstances are cruel, but not in themselves life threatening. However, unclean water or too little water is life threatening. The illness and disease that are a result of problems with water scarcity and quality haunt the marginal barrios.

In Honduras, an astounding 10 out of every 100 children die before they reach their fifth year. In Tegucigalpa, the regional health authorities point to diarrhoea as the leading health problem for children in the poor barrios. A third of all infant and child deaths in Tegucigalpa are related to dysentery or diarrhoea. Health officials point out that afflictions such as intestinal parasites, acute respiratory infections, and malnutrition are aggravated if not caused by water problems.

The *barrios'* problems are practically unsolvable through conventional programs. Like most of the developing world's governments, for years Honduras' leaders had left the *barrios* to fend for their own basic services like water, sanitation, and housing. Tegucigalpa's Master Plan for water extends until 2015, during which time new water sources will be added and a renewed attempt will be made to reduce water loss through reconditioning the existing system. Unfortunately, these conventional measures will do little to improve the state of most of the urban poor in the marginal barrios. They live above or outside the water distribution network.

Most *barrio* residents have to buy most of the water they use from private vendors or in other neighborhoods at exorbitant prices. Vendors are selling fifty-five gallon drums of water for the equivalent of Lps. 9¢/gallon ($US 1.6¢/g), more than ten times the government's official price for those connected to the public water system. The World Health Organization maintains that no family should have to spend more than 5% of their income on water and sewage. The poorer *barrio* families can easily spend 30 to 40% of their incomes for water that is often of substandard quality and quantities.



Unfortunately, there is no way the city can supply low cost water, through the public distribution system, to all its residents. In 1988, it could only provide an irregular and deficient service to 77% of the capital's population. More than 150,000 people must fend for themselves.

As much as $10 million annually is spent in aggregate in the *barrios* for sub-standard water from private vendors. The Honduran water authority, SANAA (National Water and Sewage Service) realized that there was a tremendous potential to redirect some of these millions spent into organized, secure systems that could provide clean water. With support from UNICEF, SANAA founded the Unit for Marginal Barrios, or UEBM, in 1987.

The UEBM soon established four alternatives for getting water into peripheral neighborhoods: 1) the sale, in block, of SANAA water from the existing network to a communal tank; 2) the drilling of new wells; 3) the trucking of water by SANAA to communal tanks; and 4) household rainwater catchment. Using the first three alternative strategies, the UEBM has had encouraging success in bringing water service to 50,000 people in 25 *barrios* in less than four years. None of these strategies are "traditional" engineering solutions to urban water supply, but all can provide service to otherwise unreachable *barrios* and could serve as examples for other governments.

WHY STUDY URBAN RAINWATER HARVESTING?

UNICEF and the UEBM are investigating some of the alternative sources available, including rainwater, to try and make more water available to more people. In this spirit, UNICEF/Honduras decided to examine rainwater catchment in urban households. Focusing on how impoverished families are already harvesting and using this "free" source of water, UNICEF hoped to discover ways to increase the amount of water available to them, possibly by supporting incremental improvements in their own Rain Water Catchment Systems (RWCS).

This book is principally based on a set of four survey and water testing mechanisms (see Annex 4) developed by the honduran PVO *Agua para el Pueblo* (Water for the People) and a contracted public health consultant. The study probes the physical and human factors involved in the empirical RWCS already in use, as well as opportunities for improvement as perceived by the users themselves.

Two poor urban *barrios*, **Israel Norte** and **Villa Nueva**, were selected as sites for the survey work. Villa Nueva is one of the largest and oldest "invasions" of squatters in the city. It is located next to a paved highway and has a new SANAA/UNICEF water system consisting of a sparse distribution of public taps. Israel Norte, a newer *barrio*, is one of the highest in elevation and has no public services.

This two-month study is based upon observations of 535 houses, (266 in Villa Nueva and 269 in Israel Norte) during the height of the rainy season of 1990 (September and October). Of those homes surveyed, 116 families were selected for in depth surveys and interviews (59 in Villa Nueva and 57 in Israel Norte). The most relevant results are discussed and presented in graphic form throughout this book. In the case of graphs, results are separated between the two *barrios*, with all "A" graphs referring to Israel Norte and all "B" graphs to Villa Nueva.

A SEARCH FOR SOLUTIONS

Water problems are one of the many stresses characteristic of explosive urban growth throughout the third world. Fortunately, Honduras' new leaders are willing to move toward some of the illusive solutions to these problems with new financial and legal strategies.

The founding of the Unit for Urban Barrios by UNICEF and SANAA is one of several creative approaches that the new government has designated for trying to alleviate the oppressive situation in the poor marginal areas of Honduran cities. The UEBM loans money to residents for the construction of an alternative water supply system in their *barrios*. Monies repaid by the new *barrio* Water Boards go into a rotating UEBM fund to finance additional systems in other neighborhoods.

On another front, the government's new PROLOTE urban land bank is making formal titles available to thousands of *barrio* residents. With a title to their home, a whole range of government and private credit opportunities for home improvements and small businesses become available. Previously only "loan-sharks" charging exorbitant rates offered "help".

These programs are examples of an emerging philosophy on the part of the new government. To further advance the struggle for survival in these poor *barrios*, UNICEF and the Honduran government have sought to reorient the prevailing concepts of basic urban services away from limited scale, subsidy and give-away programs. Their goal is to promote credit and community involvement schemes that through user payback provisions will provide funds for future expansion. Each user, by sustaining their part of the cost, becomes a part-owner of the public services that directly benefit them. Owners are more likely to maintain these investments than are "beneficiaries".

Because RWCS are the property of each household, a program that loans money to families interested in improving their present RWCS promises the greatest impact with limited funds. For this reason, the observations and recommendations on RWCS and their components presented in this study are directed at home building and improvement activities, especially loans. This is an area in which governments,

A RWCS LOAN PROGRAM?

UNICEF/Honduras feels that limited subsidy programs for urban water and sanitation have not proved effective at solving the demands of the swelling *barrios*. New programs that loan monies to low-income families so that they might take responsibility for their own basic services promise to recycle loan monies through rotating funds. These cost recovery schemes can make new loans continually available to new families, whereas subsidy programs are finite and closed to future arrivals. The SANAA/UNICEF water program for the *barrios* is one example. The new UNICEF/PVO "Sanitation Loan Program" is another.

FAFH (Honduran Federation of Women's Associations) is an active Honduran PVO working with low-income urban women in areas such as training, small business loans and legal support. Recently, FAFH began offering sanitation loans, including a variety of latrines, with Cooperative Housing Foundation (CHF) technical assistance and UNICEF financing. FAFH has 40 years of work experience with women, and has come to understand many things essential for success in these depressed neighborhoods.

In Tegucigalpa, almost 60% of families are run by single mothers. Between caring for children, hauling water, washing clothes and looking for firewood, a mother has no free time. It is a myth that these families have "surplus labor" with which to carry out home improvements. Women also traditionally have problems securing financing, especially without titles to their homes.

NGOs and local PVOs are active, and beginning to coordinate efforts. Public and private programs that incorporate RWCS and their improvements as part of their loan portfolio should find an attentive urban clientele. If expanded over time, RWCS programs will make a significant impact on household water supply and health for an exploding population.

Existing home-improvement loan programs also need to have the capability of assessing the existing components of RWCS in a house in order to discuss options for improvements with the client family. Decisions about replacement or modifications for each component should be considered in light of the materials, physical condition, and type of installation used. While not being the correct medium for elaborating a definitive field manual for rooftop rainwater collection, this study does have within its scope an assessment of existing RWCS components and potential improvements that could be made to them. The information can be of use for both present and future loan planners.

FAFH has been able to break the myth that poor families can not administer funds. Through sensitive promoters and staff that have been able to reach these families and single mothers, FAFH offers flexible loans for small businesses or home-improvement of between Lps. 500 - 7,000 (US $ 94 - 1,320) for periods of between one and six years. Families manage the cash, and determine which materials to use, where to buy them, and who to hire for the construction itself. The delinquency of FAFH loans to low-income families is an amazing 1%.

If more and better rainwater harvesting systems were to be incorporated as part of the Sanitation Loan Program, UNICEF/CHF could make funds available to PVOs for financing improvements in RWCS (such as roofs, gutter, downpipes and *pilas*). UNICEF and *Agua Para el Pueblo* could assist in refining some of the technical aspects of designing and implementing this program. FAFH is already reporting a tremendous interest in loans for *pilas*, a RWCS component that is not yet included in the Sanitation Loan package.

For two reasons, a RWCS loan program should be large. Most obviously, only a large scale effort to increase RWCS yields will significantly help relieve Tegucigalpa's water deficit in the *barrios.* Less visible is the scale such a program must have in order to support staff and administration. If subsidies for the PVO are not available for the administration of these loans, then a portion of the loan must be retained by the PVO for their costs. Unfortunately, a loan portfolio must be significant in order to absorb these expenses.

A loan program that would incorporate loans for RWCS would fit well into existing home improvement programs, with which costs of managing the loans might be shared. Since this is a new area of collaboration, heavy emphasis should be placed on the involvement of *barrio* families in the design and costing of rainwater collection systems. Monitoring and revision of designs by masons and users will be needed. New ideas will likely develop based on experimentation by households which can be expected to lead locally-inspired improvements in future RWCS designs. PVOs have historically demonstrated this sensitivity to feed-back from their client bases.

TEGUCIGALPA AND RAINWATER

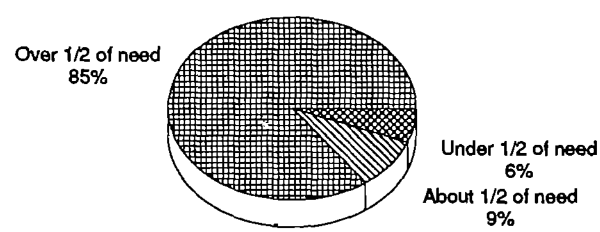
Tegucigalpa already has a deficit of 20 thousand cubic meters of water daily, and urban migration is not expected to peak until after the year 2000. Every year, two-thirds of Tegucigalpa's 35,000 new residents come from the rural areas, people like Dora Cárdenas and her family. Urban migration and new births have pushed Tegucigalpa's growth rate to an alarming 5.2%. The already crowded city will be home to more than twice today's population within the next fifteen years.

Many of the more than 200 *barrios* in Tegucigalpa are at, or exceed, 1,150 meters above sea level. This is the case with all of Israel Norte and more than half of Villa Nueva. Begun so many years ago, the city's present water system will never be capable of delivering water above 1,150 meters, the height of the highest tanks. Over 150,000 people, plus most future immigrants, would be obliged to live without any public water service until the next city-wide water system review, early next century. One of the UNICEF/SANAA program's main goals is to provide some kind of interim, alternative service to these families.

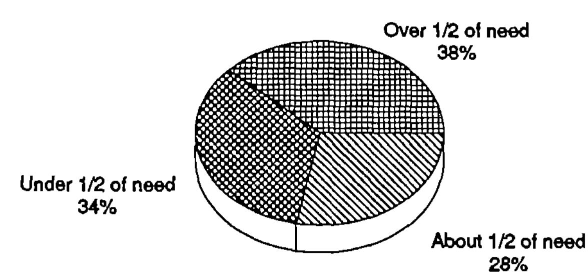
Unfortunately, it is unlikely that even the ambitious UEBM program is going to solve the water problems of all these *barrios* and their future residents. Based on current projections, the city's water shortage will triple by 2015 if no urgent measures are taken. The UEBM, and rainwater harvesting, are two important ways to try to reduce the shortage.

Rainwater is already the single principal source of water for the urban poor unreached by the city system. Even in *barrios* where UNICEF/SANAA have achieved some level of interim service, rainwater is still used by almost everyone. Data from this study indicate that close to 90% of the families in these barrios collect rainwater. In Israel Norte, 94% of the families interviewed think they depend on rainwater for about half or more of their water needs during the wet season.

Graph 1A ISRAEL NORTE
Opinion: % of Water Needs Met by RW



Graph 1B VILLA NUEVA
Opinion: % of Water Needs Met by RW



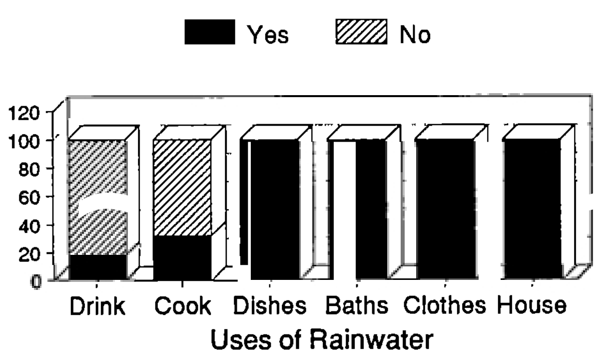
In Villa Nueva, 66% gave the same response. Most importantly, rainwater is the only source available that can continuously increase its yield as long as new or improved roofs, gutters and tanks are built.

How is rainwater used?

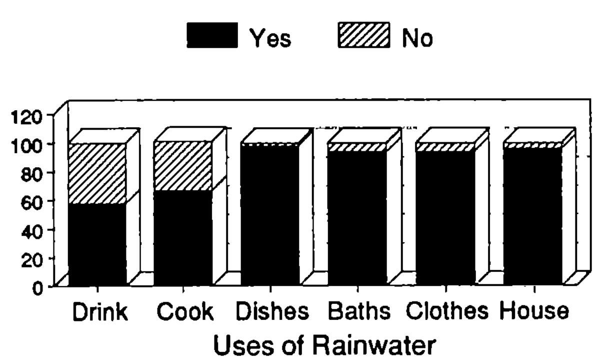
A large number of families use rainwater for drinking and cooking. In Villa Nueva, despite the fact that SANAA/UEBM have recently installed a system of public taps in parts of the barrio providing around 14 liters of water per person daily, and almost 60% of the families interviewed say they drink rainwater when it is available. In Israel Norte, 18% reported drinking rainwater.

While apparently inconsistent with the Villa Nueva data, interviews in Israel Norte revealed a possible explanation for the disparity in the percentages who drink rainwater in the two *barrios*. At a location below Israel Norte, women are clandestinely allowed access, at no cost, to a limited amount of water from a large SANAA tank serving a nearby middle-income neighborhood. This water is perceived as being cleaner than stored rainwater, and hence is used more for drinking.

Graph 2A ISRAEL NORTE
Rainwater Uses



Graph 2B VILLA NUEVA
Rainwater Uses



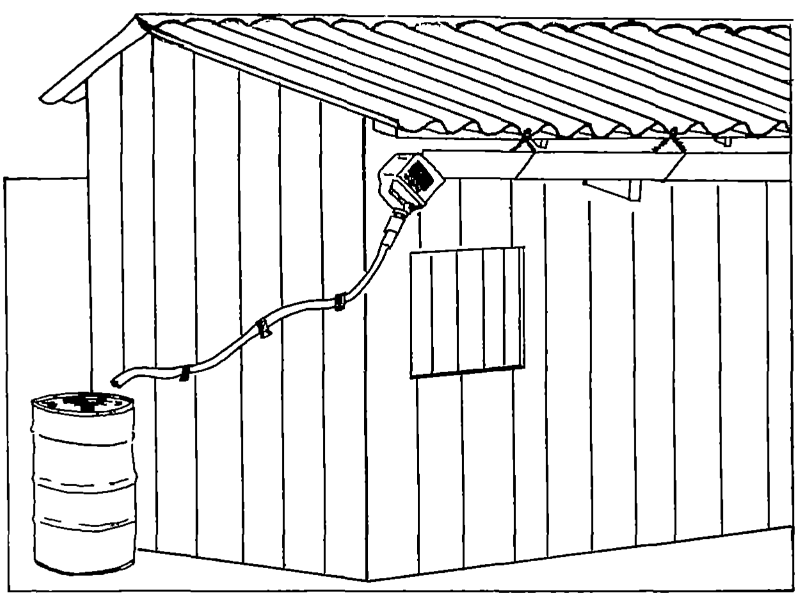
Villa Nueva residents, especially those outside the reach of the SANAA/UNICEF system, rely on rainwater for all uses. A UEBM engineer even commented that "when the first rains start, we have to cut back our deliveries by SANAA water trucks by a third or a half because the people just won't spend the money. They use rainwater; its free."

A TYPICAL URBAN RAIN WATER CATCHMENT SYSTEM

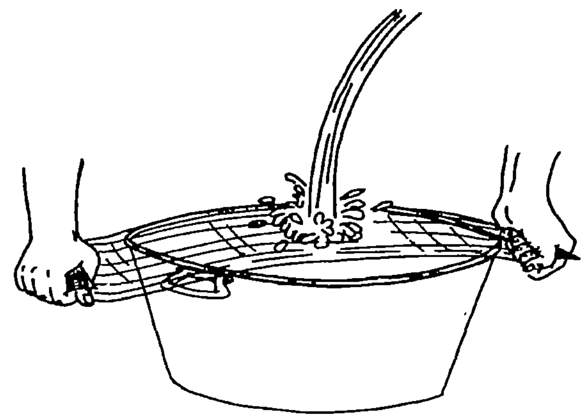
The better single-family RWCS found in the two *barrios* studied included the following elements:

- Hard-surfaced Roof
- Gutter(s)
- Downpipe(s)
- Storage: barrels, *pilas* (open, above ground cement water tanks of up to 0.5m3 capacity, frequently incorporating a washboard), and jugs and buckets.

Of these elements, only the roof and storage vessels are essential. Some families use pots and pans directly under their eaves, eliminating the gutter (and drastically reducing the system's potential). Most systems however have barrels or *pilas*, which are the family's principal storage container. Downpipes may or may not lead water directly to the storage container. Rarely do the downpipes incorporate a trash screen or filtration system. No such precautions were seen during this study. The most innovative systems found incorperated hose for downpipes, leading rain-water to a remote barrel or *pila*.



Many families that drink and cook with rainwater use a more labor intensive process to separately capture smaller amounts of runoff than for water intended for other domestic chores. Typically, the mother/housewife will place a board or two across the top of the larger container (barrel or *pila*), where she places a smaller pot. Often she will stretch a piece of cloth over the top of the smaller pot. Interviews



revealed that women see these cloths as "filters" for the rainwater to pass through. Part way through the rainstorm, the pot will be removed to the kitchen for separate storage, and the boards withdrawn so the remainder of the runoff can be collected in the main family storage container.

In these cases, the family will have two principal storage points: the barrel/*pila* for domestic uses, and jugs in the kitchen where the drinking water is stored. For those families that use the outdoor barrel/*pila* for all their needs, there is little difference in the storage or quality of the water for drinking or domestic use. Water is extracted for all uses by dipping a hand-held pot into the container (barrel, *pila*, bucket). Even those that use more care separately collecting and storing their water for drinking, still dip hand-help cups into the container to extract the water they use. Such measures are likely to add contaminants to the water. Chapter 2 will discuss in greater detail the various elements of the RWCS reviewed here.

Rainwater catchment system yields in Tegucigalpa

The volume of water that any particular family can harvest from their rooftop is dependent upon two factors: local rainfall patterns and the catchment system itself. For a year-round supply, a minimum rainfall level of approximately 1,000-1,500 mm per year, a rooftop catchment area of at least 100m^2, and a sufficiently large storage tank are recommended[1].

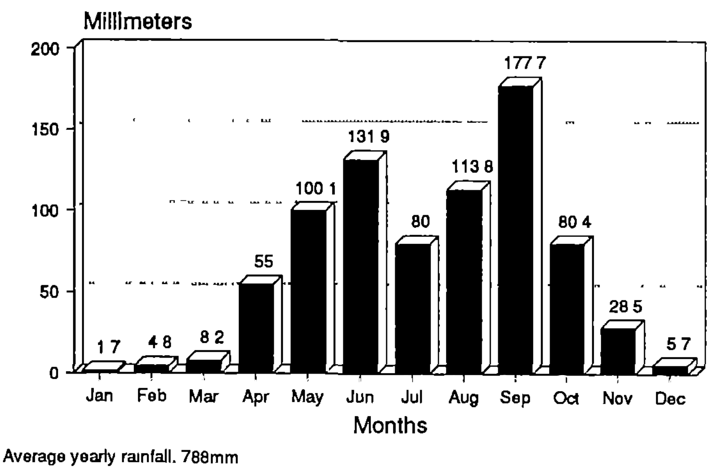
Local roof sizes

Undoubtedly due to families' economic limitations, the roofs of the 66 homes measured in the two *barrios* studied are far smaller than the 100m^2 size recommendations. Homes in Israel Norte are half the size of those in Villa Nueva (27m^2 vs. 45m^2). In these cases, an average of only half of all available roof area was actually being used for catching rainwater (13m^2 and 23m^2, respectively). However, with this data and the average rainfall information, we can roughly calculate the supplementary water that RWCS yield for families in these two urban areas in Tegucigalpa (see diagram pages 12 and 13).

Local Rainfall

In the case of Tegucigalpa, the general conditions are not favorable for year-round rainwater use. Rainfall in Tegucigalpa over the last five years averaged only 788 mm. annually (Graph 3). This is significantly lower than the 1,000 - 1,500 mm ideal. The actual rainy season, when good amounts of rain water can be collected, only occurs over a maximum period of six to seven months. In the six months between May and October, usually recognized as the "rainy season", an average total of only 684 mm of rain falls. Even this though is sufficient to relieve a considerable burden on those paying high prices for each gallon they buy.

Graph 3 Average Monthly Rainfall in Tegucigalpa (1985-1989)

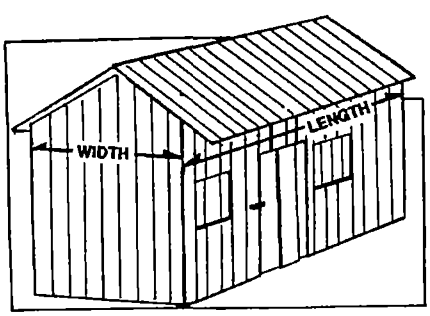


RWCS Yields

The general formula recommended by many sources[3] for calculating approximate yields from rooftop RWCS is:

Rainfall (m) x Catchment Area (m^2) x 0.8 = Volume (m^3)

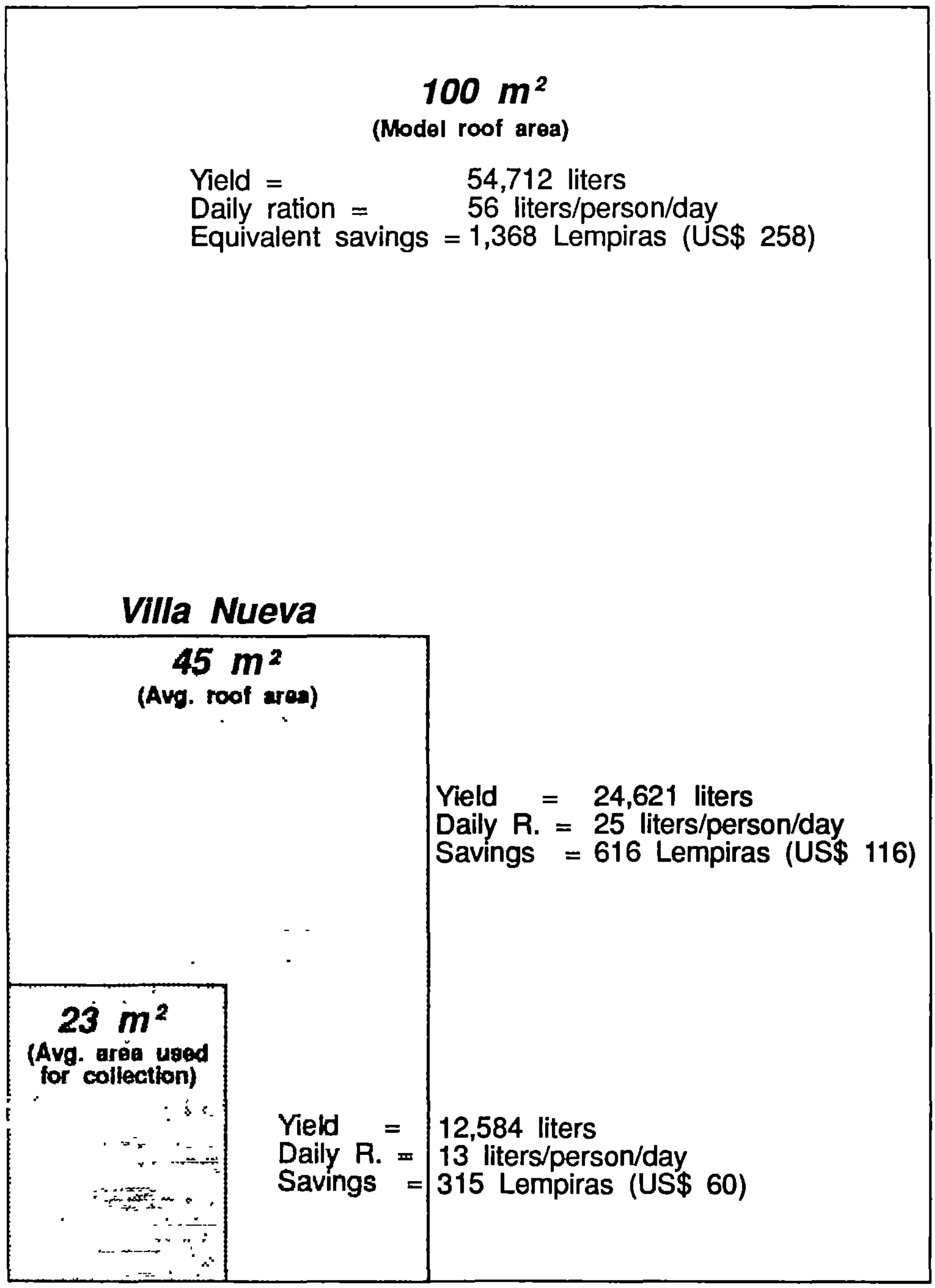
- ***Rainfall*** levels should be averaged over at least five years and be measurements from as close to the "target" area as possible.
- Rooftop ***Catchment Area*** is only that part of the roof with gutters, calculated as horizontal width multiplied by length:

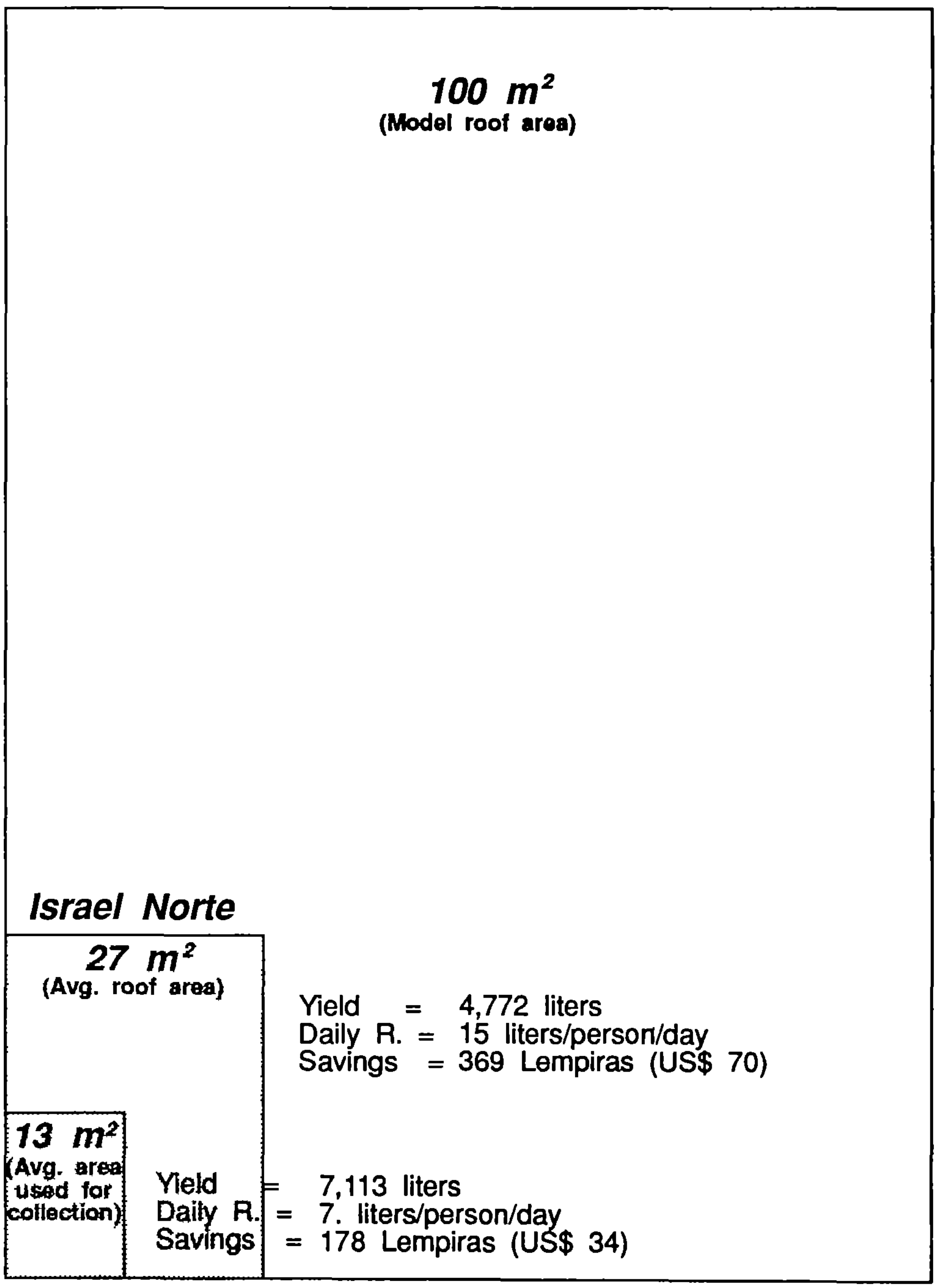


- The ***0.8*** factor is a rough approximation of the "efficiency" of a RWCS. Usually, it is estimated that between 70% and 90% of the rainfall that hits a rooftop is actually captured and stored. Hence, the 80% average, or "0.8" in these calculations.

YIELDS AND "SAVINGS" FROM RAINWATER

Private water vendors are selling a gallon of water, frequently contaminated, at almost Lps. 9¢ (US$ 1.6¢). Considering the local rainfall patterns and roof sizes, one can calculate rainwater harvests, both currently (where a functioning RWCS exists) and potentially (including the roof area not yet used for a RWCS), in Vila Nueva and Israel Norte:




100 m²
(Model roof area)
Israel Norte
27 m²
(Avg. roof area)
Yield = 4,772 liters
Daily R. = 15 liters/person/day
Savings = 369 Lempiras (US$ 70)
13 m²
(Avg. area used for collection)
Yield = 7,113 liters
Daily R. = 7. liters/person/day
Savings = 178 Lempiras (US$ 34)

Future Possibilities

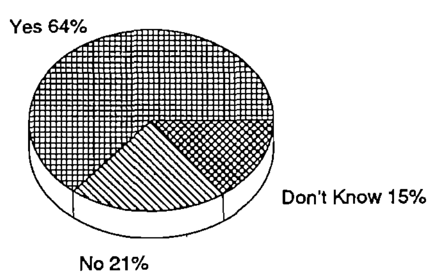
Even houses of the limited sizes found in Israel Norte and Villa Nueva have the potential to provide substantial volumes of captured rainwater if all the roof area could be used for catchment (ie. if gutters were installed on all available slopes of the roof).

If home-improvement loan programs were to provide credit for more gutters and larger capacity storage, the potential delivery of RWCS averaged over a six month wet season in these two *barrios* could be as high as:

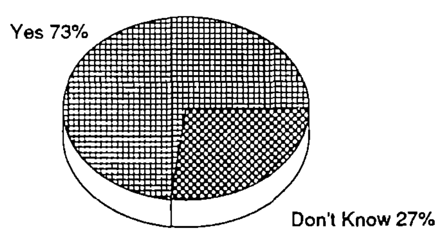
- 15 liters/person/day in Israel Norte and
- 25 liters/person/day in Villa Nueva. *(average of 5.4 people / house)*

In Villa Nueva, almost 25,000 liters of rainwater could be harvested off the average roof during the rainy season. If purchased, this amount of water from a vendor costs Lps. 600 (US$ 110) or more. These significant volumes of water would lead to better hygiene without straining family budgets.

Graph 4A ISRAEL NORTE
Interested in Credit to Improve RWCS



Graph 4B VILLA NUEVA
Interested in Credit to Improve RWCS



The concept of rainwater harvesting as a supplementary source of water during the rainy season is well known to the urban poor. The total amount of storage capacity the residents approximated they would need to have, including the new storage containers they desire, corresponds with the amount a good RWCS could collect during the rainy season, even on roofs this small.

Most families said they would be interested in using credit for improving their existing rainwater collection system (64% in Israel Norte and 73% in Villa Nueva). This demonstrates that "effective demand" exists in these *barrios* for making and paying for realistic improvements. This, plus trained home-improvement promoters, make for a good foundation for success in bringing more water to the impoverished *barrios*.

RAINWATER HARVESTING AND QUALITY

MAJOR COMPONENTS OF A RWCS

As pointed out before, there are various components of a model RWCS. Though often not all the components exist together in a single dwelling, they can be broken down into six basic elements:

- safe, hard roofing;
- quality gutters of sufficient size with adequate hangers;
- downpipes of sufficient diameter;
- trash screens and filter;
- a first flush mechanism; and
- a durable storage tank of appropriate design, size, and construction.

This discussion of each RWCS component will incorporate survey data from this study and general recommendations from literature and programs from other parts of the third world.

ROOFING

The roof of the dwelling is an essential element in the collection of rainwater. The main reason RWCS have become much more popular worldwide in the last ten years has been the gradual change toward the use of hard roofing materials. Grasses and thatch have been substituted for sheet metal, asbestos/cement mixtures and clay tile. Families in urban Tegucigalpa now, almost uniformly, utilize these harder materials.

Newer roofing materials provide a much more efficient catchment for rainwater. Less of the water seeps through or is held within the roof during and after rainstorms. However, each material has it's drawbacks, and as will be discussed here and later in the chapter, each may affect the quantity or quality of the rainwater runoff.

Not only is the roof area important, but the roofing materials themselves may play a role in the amount and quality of water collected. Results are still unclear from testing in other parts of the world on whether or not particular roofing materials might introduce contaminates into collected rainwater. These contaminants could include heavy metals or chemicals (from leaching or breakdown of the roofing material itself) and bacteria (sometimes deposited by birds, lizards and other animals or trapped by foreign objects on the roof). Interviews during this study indicated that the choices on which roofing material was used had less to do with health concerns than with availability, cost, and ease of installation.

Table 2.1
COMMON ROOFING MATERIALS

MATERIAL	ISRAEL NORTE	VILLA NUEVA
Sheet metal	76%	77%
Asbestos/cement sheets	7%	11%
Techón (asphalt treated pressed paper sheets)	10%	5%
Previously discarded materials (plastic, sheet metal, *techón*, etc.)	4%	4%
Clay tile	3%	3%

Roofing in Tegucigalpa

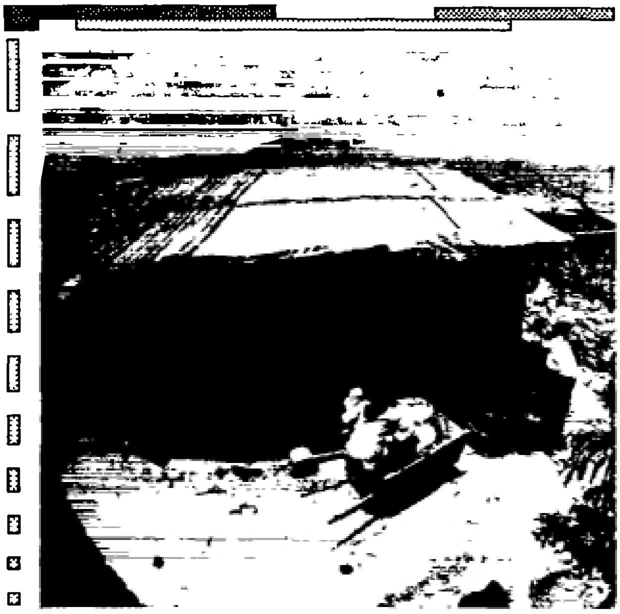
In the marginal urban areas of Tegucigalpa surveyed, five distinct types of roofing material are used. In order of predominance, they are shown in table 2.1.

Sheet Metal Roofing

Worldwide, galvanized metal roofing sheets have proven to be the most popular material for RWCS. There have been concerns about whether heavy metals such as lead are leached out of metal sheets into rainwater. At least in Thailand and Trinidad, studies have shown that heavy metal leaching from sheet metal has been minimal, with excesses limited to manganese and zinc in a very few samples, and at levels which are considered harmless to human health[4]. Sheet metal's low cost and ease of installation, high rainwater runoff, and the possible effects of "solar disinfection" (the killing off of bacteria possibly caused by irradiation from direct sunlight)[5] appear to make it superior to other roofing materials in many different countries.

However, it should be kept in mind that high quality sheet metal was used on the middle-income homes in the Thailand rainwater quality study, and factory-new roofing sheets were the subjects of the controlled Trinidad experiments. There may be cause for concern when the quality of sheet metal used on low-income urban roofs, such as in Tegucigalpa, is considered. Many roofing sheets seen during this study were discards from previous users and are in varying states of decay. Early rains (May-June) in Tegucigalpa have been found by the Limnology researchers at the UNAH to be acidic[6], which could promote leaching, especially if the galvanization process is not of high quality.

It is also common to find rocks, old tires, boards, and other objects holding sheet metal and other roofing materials in place on many low-income homes. These foreign objects can trap bacteria and organic material, later releasing them into the rainwater runoff. Most nails and accessories used are not galvanized and many metal roofs and gutters are painted, but no research into the potential lead contamination from these products is available. Future research into the leaching of heavy metals from substandard roofing and paints available locally would be valuable.



"*Techón*" Roofing Sheets

Pressed paper sheeting treated with asphalt, locally known as *techón*, was used on 10% of the roofs observed in Israel Norte and 5% in Villa Nueva. This material tends to deteriorate more rapidly than hard roofing materials. Damaged or cut *techón* may harbor foreign material and bacteria leading to drinking water of suspect quality. Although runoff from *techón* is probably less than off of harder materials, rainwater delivered from *techón* could still be useful for many purposes.

The low price and ease of cutting and installation appear to be reasons for some homeowners to use *techón* sheets for their roof. By the same token these are the very reasons so much scrap *techón* is used for the most haphazard roofs found in this study. The durability of *techón* appears to be less than that of the harder materials.

Asbestos/Cement Roofing Sheets

These sheets are frequently seen, appearing on 7% of the roofs in Israel Norte and 11% in Villa Nueva. The danger of asbestos fibers from interior ceiling tiles is well known, but the authors could find no definitive references to exterior asbestos roofing contaminating rainwater with asbestos fibers or its possible health consequences. Some experts maintain that asbestos material should be avoided because fibers could be loosened if sheets are cut or damaged. USAID in Honduras, for example, determined that RWCS should no longer be included on rural schools they finance in Honduras because the school construction department of the Ministry of Education insisted on switching to locally manufactured asbestos/cement roofing sheets. This decision was made despite the fact that communal RWCS in large schools had been very successful where active teachers were involved[7].

Paradoxically, studies in Thailand[8] showed iron levels in rain runoff to be higher from asbestos/cement roofing sheets than from sheets of galvanized iron, although not rising to harmful levels. Of even greater interest, the same study showed that E. coli levels were considerably higher in runoff from asbestos/cement roofs than from galvanized iron. Some researchers have explained this by proposing the already mentioned phenomenon of "solar disinfection". The killing off of bacteria by sunlight alone appears to be more effective with metal or glass than with other materials[9].

Asbestos/cement roofing sheets are common in the urban areas due to its local manufacture, relatively low price, and durability. Indeed, many roofs observed in low-income neighborhoods that are in good shape are asbestos/cement. To ignore the positive impacts that asbestos/cement roofing sheets in RWCS are providing to thousands of families because of untested suspicions about asbestos or other contamination would be counterproductive.

On a positive note, due to public pressure, local manufacturers claim to have eliminated asbestos from their roofing sheets in the last few years. New "fiber-cement" roofing sheets are on the market, and although their effects on rainwater have not been tested, they are commercially promoted as having no ill effects on human health. These are frequently purchased by families receiving home-improvement loans.

Discarded Materials as Roofing

Discarded plastic, metal and techón sheets, and other materials, are used as "repairs" on many roofs, and constitute the principle materials on 4% of the roofs in both Israel Norte and Villa Nueva. Pieces of plastic are usually loosely installed, and are often held in place by foreign objects such as rocks or boards. Pockets of water, and probably bacteria, are left between rains. This could cause increased contamination if water when the next rain enters storage. Many of the metal scraps used are not galvanized. These households would benefit from totally replacing such a roof. Home-improvement loans may be the only way a family can afford such an expensive project.

Clay Tile Roofs

Fired clay tiles were seen on 3% of the roofs observed in both Israel Norte and Villa Nueva. Clay tile often delivers discolored water, and the possibility exists that foreign matter/bacteria could be trapped in its irregular surface and joints. Its use for untreated drinking water, as with pressed paper sheets, does not appear to have been adequately analyzed. However, tile's hardness makes a superb catchment surface, and its efficiency for collecting water for domestic needs is high. Clay tiles though are more expensive, labor intensive and not as readily available in the urban area as are other materials. These reasons may explain the lower percentage of use of tile in comparison with other options.

In summary, it appears that the new "fiber-cement" (without asbestos) and high quality sheet metal roofing materials may best meet the requirements of durability and suitability for rainwater catchment in urban Honduras. Most home-improvement loan programs leave decisions on roofing materials to the client-family. No statistics were yet available as to whether home-improvement "upgrades" prefer sheet metal or fiber-cement sheets. These materials should be studied in the future looking into such areas as, affects on water quality, the effects on sheet metal when exposed to corrosion and acidic rain, and the overall durability of metal vs. cement-based roofing sheets.

Whatever roofing material is chosen, if rainwater is to be used for drinking or cooking an additional note should be made. Trees or shrubs overhanging the roof, gutter or barrel/*pila* should be cut back to keep contamination from animals and foreign matter to a minimum. In addition old tires, toys, construction materials, rocks, etc. should be removed from the roof and the roof cleaned if possible before rains start.

Gutters

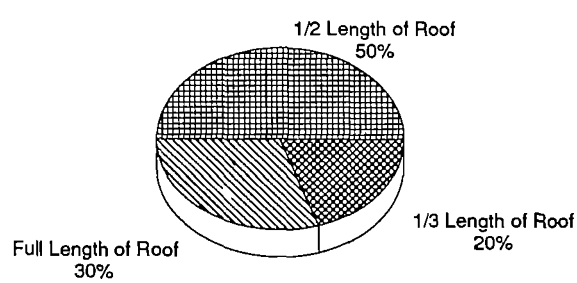
Along with the roof, the gutter is another indispensable component in collecting large volumes of rainwater. Gutters, as all RWCS components, should not contain lead-alloys or be painted with lead-based paints. Of the few references that offer recommendations, some say that gutters should be at least 200 mm (8") in diameter, and others that gutters should have cross-sections of 100 cm^2, although the authors found very few gutters of these sizes during this urban study. If the greatest volume possible of captured rainwater is desired, then gutters should be even wider than the recommended 8" in areas like Tegucigalpa that are subject to severe downpours[10].

Many materials can be used for gutters, including PVC (Polyvinyl Chloride) pipe, metal, wood and bamboo. Gutters should be installed along as much of the roof catchment area as possible, have no depressions, and have a gradual slope of between 8-10 cm per meter of length[11].

Gutters in Tegucigalpa

In the barrios studied, the efficiency of RWCS varied greatly because of the length and quality of the gutters used. Very few houses use all the catchment area their roof could provide. Only 12% of houses observed in Israel Norte and 21% in Villa Nueva used all of their roof for catchment, achieved by using the greatest gutter length possible. This suggests that there could be a sizable need for urban residents who want to capture more rainwater to improve their gutters, meriting the attention of loan programs.

Graph 5A ISRAEL NORTE
Length of Gutter Across Side of Roof



Graph 5B VILLA NUEVA
Length of Gutter Across Side of Roof

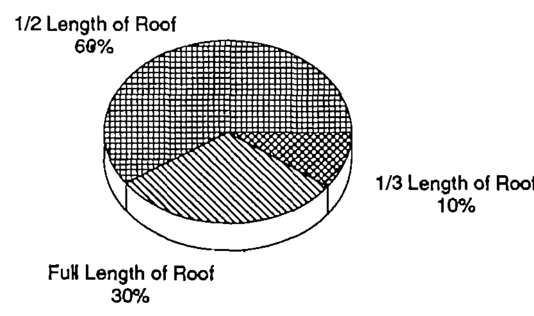


Table 2.2

COMMON GUTTER MATERIALS

MATERIAL	ISRAEL NORTE	VILLA NUEVA
Sheet metal	75%	76%
PVC Pipe (cut in half)	10%	13%
Asbestos/cement sheets (cut)	8%	4%
Other (eg., wood, tin cans, plastic soda bottles)	7%	7%

Again, interviews during this study indicated that the family's decisions on which material to use for gutters are related to cost, availability and ease of installation.

The many materials used, the varying efficiency of their installation, and their physical states makes a typology of gutters difficult. In the marginal urban areas of Tegucigalpa surveyed, four types of materials appear to be used for gutters. Table 2.2 shows the predominance of the gutters in order of their popularity.

Sheet metal was the most common gutter material found in the *barrios* studied (75% in Israel Norte and 76% in Villa Nueva). The metal used in gutters is frequently salvaged from other uses, and is often very corroded. Gutter installation is usually haphazard, resulting from using many pieces of varying sizes.

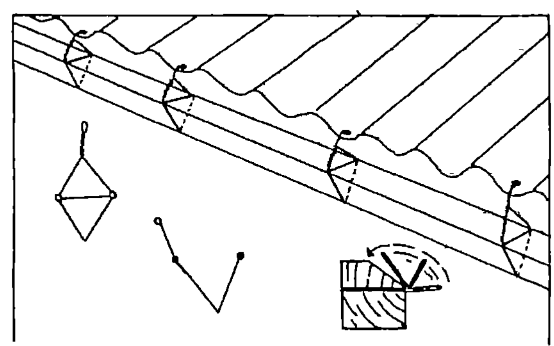
Good quality, pre-fabricated sheet metal gutters of wide diameters were also seen, and appeared to give good service in terms of conducting the greatest amount of runoff from catchment to storage. Presumably because of their higher cost, most of these gutters were well attached, with substantial wood or bent metal rebar supports. The pre-fabricated gutters come with a "neck" at the drainage point specifically provided to ease downpipe attachment. Many of the metal gutters observed in this study had plastic hose or PVC downpipes fastened securely. Owners tended to express pride in these gutters. Pre-fabricated metal gutters currently cost US$36 for 20 foot lengths, approximately the length of many urban roofs.

PVC Pipe gutters

PVC pipes are also seen frequently in gutters, as are scraps and pieces glued together (10% in Israel Norte and 13% in Villa Nueva). All these appear to work well, if carefully assembled. PVC pipe in the 8" diameters some sources recommend[12] costs Lps. 200 ($US 37.75) for a 20 foot length, an equal price to that of pre-fabricated metal gutters. However, when split in half to make a gutter, the cost of a single PVC gutter is half the cost ($19) of a pre-fabricated metal gutter of the same size. In addition to the low over-all cost, the ease of assembling PVC gutters and the high quality of available PVC scrap has resulted in some of the larger and more efficient gutters in the surveyed neighborhoods. The durability and light weight of PVC and sheet metal makes both superior over comparably sized wooden gutters.

A KENYAN GUTTER DESIGN

As gutters are often heavy and costly, a Danida project, in Mobuto, Kenya has developed simple, low-cost gutters, deflectors and hangers out of sheet metal and galvanized wire.



Wood and Other Gutters

Scrap materials like broken asbestos/cement sheets, tin cans or plastic soda bottles were often tied or fixed together to make gutters. Most of these cases seen were of sub-standard quality in terms of diameter and installation. Wood gutters were also seen occasionally. Hardwoods like cedar, mahogany, and others can resist rotting well, but are becoming expensive. Also, wooden gutters of sufficient size are very heavy and require considerable support from their hangers. Eventually, wooden installations degrade to the point that they can contaminate runoff. The use of wood, unless of a high quality hardwood variety with strong hangers and a non-toxic sealer applied, is probably not advisable since more durable and less expensive alternatives are available.

Gutter Installation in Tegucigalpa

There appears to be no "standard" method of mounting the gutters in these two *barrios*, but wooden scraps nailed in triangles or angles are often nailed to rafters. Wire hoops and string are also seen quite frequently. Poorly hung gutters with depressions that allow water to pool probably increase corrosion and contamination of rainwater.

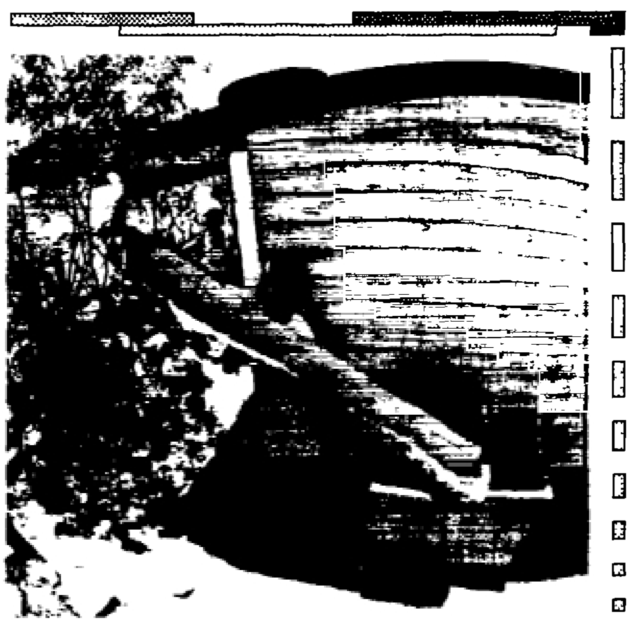
A decision at any particular time on whether to promote pre-fabricated metal or PVC gutters depends largely on current prices and materials. Their hangers can be similar. Wood or rebar braces can be used, and strong galvanized wire was recommended for the metal gutters in a Kenyan design[13].

At various times during the wet season, even poor guttering is likely to overwhelm the very limited water storage that most of the urban homes in Tegucigalpa have. As gutters become larger or more efficient (eg., by repairing or cleaning gutters or correcting their slope) the storage container will receive more water. Increased gutter efficiency may need a corresponding increase in storage capacity to store the additional water captured.

Screens and filters

Although none were seen on the homes covered by this study, most references agree that screens in the RWCS are a necessity for harvesting cleaner rainwater, especially if this water is to be used for drinking. Trash screens might be placed at the connection between the gutters and the downpipe, eliminating larger debris from entering the downpipe and subsequent storage containers.

Filters are more of a luxury, advisable only for those families that can maintain them. Since few low-income urban families are likely to want or adequately maintain a true filter at this point, it might be more relevant to design a trash screen between the gutter and downpipe than a filtering device.



Well installed and maintained screens can 1) reduce the time and labor needed to remove sediment; 2) reduce system down-time; 3) reduce contamination risks[14] and 4) increase rainwater flowing into storage. Screens are apparently rarely used in the urban RWCS seen, which accounts for the excessive amount of leaves and foreign material observed in downpipes, barrels, and *pilas*.

In the urban *barrios*, the gutter/downpipe connection is usually made by fixing, hanging or simply jamming one-half of a plastic jug or bottle into the gutter's lowest point. In effect, this serves as a trap that prevents some large material on the roof or gutter from entering the RWCS, but leaves and twigs very quickly cut down the flow into the downpipe and/or recipients. The trapped material may contribute to the contamination of stored rainwater. This restrictive funnel design has the added problem of being overwhelmed by even moderate storms.

Among the RWCS subject of this study, rainwater is usually delivered "unscreened" to a barrel or *pila*. However, families that collect water from the downpipe or gutter in containers for drinking purposes do sometimes strain this water through a cloth placed on top of the recipient. This can be expected to trap some material, however at this late stage most of the larger debris has already been trapped somewhere in the gutter or downpipe, or at their joint.

This manual straining practice, if supplemented by a trash screen at the gutter/downpipe joint, could be very effective eliminating large sized foreign matter. It would be useful to design jointly with artisans and users a set of removable galvanized screens or metal meshes that could be easily cleaned and replaced.

A home improvement program might design an alternative to these makeshift plastic funnels, possibly including a gutter with trash screen and a hose downpipe attached semi-permanently to the gutter outlet by plastic connectors, which are commercially available.

DOWNPIPES

Downpipes, as the name implies, takes the water collected in the gutters down to the storage container. There are few references in the literature about design parameters for downpipes, other than a recommended diameter of 4"[15]. It is unlikely that very many downpipes with this diameter would be found in these marginal urban neighborhoods. Downpipes of large diameters would permit *pilas* or storage containers to collect more water than the small hoses often found in the two *barrios* studied.

Downpipes in Tegucigalpa

Most families view downpipes as an option and not a necessary component of their empirical RWCS. Downpipes are frequently left out of the RWCS analyzed in Tegucigalpa. Most barrio homes rely on runoff falling from a gutter into a storage container. Only 11% of the houses on Israel Norte and 26% in Villa Nueva use some type of downpipe after the gutter.

Again, interviews during this study indicated that the family's decisions on whether to use downpipes, and which material to use, are related to cost, availability, and ease of installation and manipulation. Many of those families that have downpipes use them to conduct rainwater from a gutter through the wall of their home to an indoor barrel or *pila*. Others conduct water to a "remote" *pila* or barrel at a designated place for washingwithin the yard.

Table 2.3
COMMON DOWNPIPE MATERIALS

MATERIAL	ISRAEL NORTE	VILLA NUEVA
Gutter without downpipe drops into container	89%	74%
Plastic hose into house or to romote *pila* / barrel	9%	18%
Sheet metal	1%	4%
Previously discarded materials	1%	4%

In the marginal urban homes surveyed that had gutters and containers for rainwater collection, four arrangements were found, Table 2.3.

Black Plastic Hose

Black plastic hose is the most common downpipe material utilized, but always of a smaller diameter than the 4" downpipes recommended. Commercially, diameters of up to 2" are available locally, but 1/2" to 1" diameters are most commonly seen in the *barrios*. Practical experimentation is needed to determine if larger diameters will make a larger volume of water available for longer periods without overwhelming existing storage during periods of heavy rainfall.

Surprisingly, few people use the accessories and fittings available for plastic hose, such as adapters, connectors and valves. These could be useful in making better semi-fixed installations of RWCS components.

PVC and Sheet Metal Tubing

A few examples of PVC and sheet metal downpipes were seen in the two *barrios* (2% in Israel Norte and 8% in Villa Nueva). It is likely the greater expense and lesser maneuverability of these materials compared to plastic hose make them less desirable to many low-income families for use as downpipes. They are harder to divert away from barrels or containers when a dirty roof is being "flushed" or when containers are full.

The quality of much of the scrap metal used is suspect, and pre-fab metal downpipes would require specialized labor and house specific-designs, unlike plastic hose. A single 20 foot length of 2" PVC drainage pipe retails locally for Lps. 23 (US$ 4.34), and 4" pipe for Lps. 58 (US$ 10.94). Many families expressed a reluctance to install "expensive" PVC downpipes because they might be stolen.

Potential Hazards from Downpipes

One potential hazard from downpipes that did not appear to be addressed in the literature reviewed, yet which should be investigated, is the concentration of large volumes of storm water through a single outlet. Once storage is full, or if the downpipe is not inserted into a storage container, concentrated runoff can create erosion problems in what are often precarious housing lots. Most of Tegucigalpa's marginal neighborhoods are located on steep hill sides without controlled drainage. The concentration of this runoff near the base of a *pila*, tank, or foundations of a home could cause serious damage to these investments.

It may be necessary to closely monitor erosion related to any improved RWCS installed, as well as the potential health hazards if large amounts of stagnant water pool on a lot as the result of concentrated runoff. Soakpits are not common in urban households. Many of the lots have ground too hard to excavate without considerable work and high labor costs. However, future credit programs may need to require this work be done within the financing if monitoring reveals erosion or stagnant water to be major problems.

First Flush Mechanisms

Although the health "hazards" of rainwater are frequently overrated[16], the accumulation of contaminants on rooftops over dry spells can be of concern, especially if the rainwater will be used for human consumption. Birds, cats, lizards and other animals that get on roofs can contaminate them. In RWCS that lead to closed storage tanks these contaminants are not usually harmful because bacteria quickly die off when sealed in storage tanks. However, when unclosed storage containers are used, especially for drinking water, it is important to keep from introducing bacteria.

Therefore, it is necessary to frequently "flush" or clean a roof and RWCS.

The "first flush" is the cleaning of the RWCS by the first few minutes of rain flowing through it. Some sources maintain that after two days without rain, a RWCS should be flushed. Five to ten minutes of flushing is usually recommended before collecting runoff for use.[17]

Probably the most inventive thinking in rainwater catchment worldwide has gone into attempts to develop a workable first flush device. "Device" is a key word because many designers have felt it necessary to include an automatic component in their first flush mechanisms. In most of the low-income situations, rural and urban, women and/ or children handle the flushing of their roof themselves.

Many families in Israel Norte and Villa Nueva that have no downpipes use the labor intensive process of placing plastic or metal containers under the gutter, many times after the roof has initially flushed itself. Moveable pots, gutters and hoses, and detachable funnels are not automatic but they are all first flush mechanisms used in practically every urban, low-income RWCS seen during this study, and they can work quite adequately.

In Tegucigalpa, these manual first flush mechanisms appear to be more faithfully utilized at the beginning of a rainy season. With the initial rains, the runoff water flushes out the collected dust, debris and other contaminants that have accumulated during the long dry season However, it would be important to reinforce the concept of flushing after short dry periods as well.

SOME RWCS INNOVATIONS THAT HAVE HELPED, AND SOME THAT HAVE NOT, IN AFRICA AND ASIA.

Some of improvements to empirical RWCS have indeed been subjected to analysis in Asia and Africa. In Thailand, it was found that rainjars are too high to reach into or to decant from, which limited handling, as did taps on those jars that had them. Mosquito screens on top of the jars improved quality significantly ($P<0.05$), probably by eliminating access to small lizards. Mosquito screens on jars reduced Fecal Streptococcus concentrations (contamination originating from animals) by 10 times and E. coli contamination by almost 3 times. E. coli contamination is from human contact, which indicates that in the case of rainjars with insect screens covering them also limited contamination of stored rainwater by the users themselves.[1]

Other "innovations" have not succeeded. First flush devices have not emerged well from field analysis, and appear to be of little use compared with their cost and their maintenance needs. Latham found that in Thailand, first flush reservoirs are common but are difficult to empty, and many were seen that could not be drained. The insistence of some first world designers on incorporating untried first flush devices is paradoxical, because in the developed world they are rarely used. First flush devices are seldom found on RWCS found in Australia (where a million Outback homes have RWCS), Hawaii, Pennsylvania, Bermuda, Nova Scotia and Dutch homes that have been studied, even though they were frequently recommended by water authorities.[2]

The system prevalent in Tegucigalpa is also frequently used in Asia and Africa--the moveable hose, a very efficient first flush mechanism. Indeed, it shows more concern for first flushing than first world users have.

Unfortunately, most of the so called "low cost" options and materials proposed for building rainwater tanks have usually meant low quality or short-lived tanks. The Ghala Basket, (a cement plastered natural fiber basket), was promoted in Kenya by UNICEF until it was determined that the inconsistent quality of labor led to an unacceptable number of leaking baskets. In Botswana, 25% of the groundtanks ALDEP financed cracked and leaked in their first two years (1982-1984), demonstrating that even known technologies applied in new ways require a period of trial.[3]

The more expensive tank designs have many of the features considered necessary, but few, if any, had all such features. For example, some Thai jumbo jars came purchased without a cover or tap Where there was a cover, it is not always used. In Kenya, similar cement jars are common, but incorporating a base, tap and cover. Neither the Kenya or Thai models had sumps or drains.[4]

In contrast, in Kenya, the Mutomo Soil and Water Conservation Project and the Machakos Diocese Project are successful because they used "well tried and well tested hardware".[5]

Sources.1 Pinfold, Horan and Wirojanagud, 1990 2 Latham and Gould, 1986. 3 Lee and Visscher, IRC for UNICEF, 1990 4 Latham and Gould, 1986 5 Gould, "Developments in Rain Water Catchment Systems ..", 1990.

There are families whose work schedules require their house be left unattended throughout the day. If they wanted to have a system capable of "first flushing" itself while they are away, some type of automation would be required. However, no "tried and true" designs for low-income contexts exist yet. First flush devices even seem to have created some of the worst design and maintenance problems involved with RWCS in many other countries[18] (see box page 25).

Storage

More than with the other components of RWCS, the type of storage container is determined by the uses the water will have within the home. In Asia and Africa, as well as parts of the developed world where water supply is a problem, rainwater storage tanks of all sizes and descriptions are available, and there has been several years of large scale experimentation with ferrocement and other alternative construction techniques.

Table 2.4
COMMON STORAGE ARRANGEMENTS

MATERIAL	ISRAEL NORTE	VILLA NUEVA
Metal barrel	74%	59%
Cement Pila	15%	31%
Plastic barrel	5%	4%
Other	3%	5%
Plastic hose through wall wall into house	3%	1%
Among all containeres, how many were partially or completely covered?	*1%*	*9%*

Low-income Water Storage in Tegucigalpa

In Honduras, commercial tanks are expensive and alternative tank materials appear to be limited. Metal, brick masonry, concrete and fiber-cement tanks seem to be the only medium and large storage options locally produced. For small storage, the ubiquitous metal 55 gallon (0.2 m^3) barrels are predominant, with plastic barrels and smaller containers also common.

In the two marginal urban areas of Tegucigalpa surveyed, five storage arrangements were found. Among the 210 homes with gutters and containers surveyed, table 2.4 shows their order of preference.

Barrels

Among the households with external RWCS collection containers, the most common type used is a metal 55 gallon barrel (usually one, but sometimes up to 3 or more). Seventy-four percent (74%) of houses in Israel Norte and 59% in Villa Nueva use a metal barrel as their largest container for collecting water.

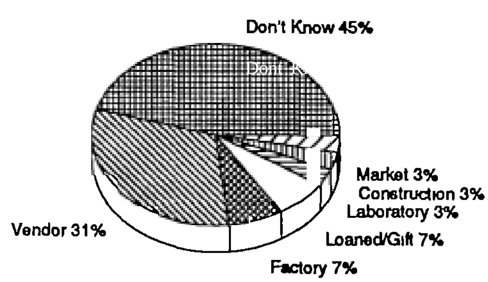
Many of these barrels are corroded and in extremely poor condition. While some barrels have been painted on the inside, and in a few cases even lined with a thin cement coating, most are not protected from residues or corrosion in any way.

According to collected information, while Honduran law prohibits anyone to resell barrels. However, many barrels that once contained pesticides, chemicals, and toxic materials find their way into the homes of residents of urban marginal areas, probably by way of roving vendors. A used barrel can cost Lps. 70 (US$ 13).

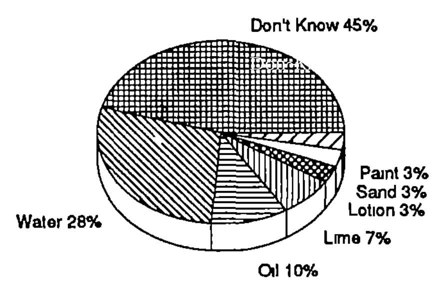
As Graph 6 shows, only 16% of households in Israel Norte and 13% in Villa Nueva were able to say where the barrel they use was obtained. Known sources included factories, gas stations, and construction sites. In Graph 7, it can be seen that very few families really know what their barrels actually contained before they purchased them. Most responded they did not know, (53% in Israel Norte and 45% in Villa Nueva). Of those who said they did know what the barrel contained, the highest percentage said water (31% in Israel Norte and 28% in Villa Nueva). This could be accounted for by the fact that private water vendors are also selling barrels from their trucks. However, these barrels probably did not originally contain water.

Prior barrel contents, for those few who stated they knew, included oil, lime (used in construction), lotion, sand, and paint. Further investigation is recommended regarding barrels and their influence on water quality and health. This is especially warranted given the potential ill-effects on human health of using water for drinking and food preparation that contains dangerous chemical and petro-chemical residues. Of special concern are those frequent cases where families use this water for cooking and food preparation. Uncooked grains of corn and beans were frequently seen at the bottom of uncovered barrels and *pilas* throughout this study.

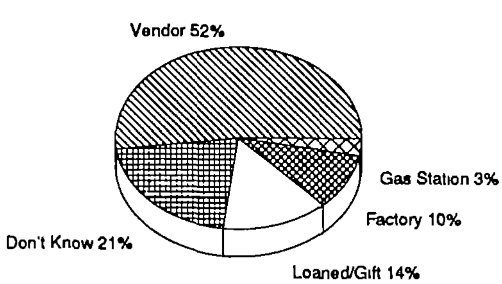
Graph 6A ISRAEL NORTE
Where Barrel Was Obtained



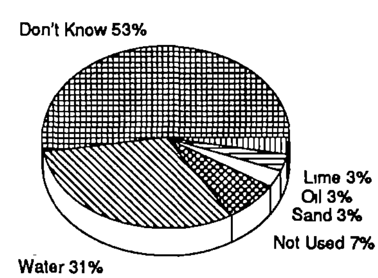
Graph 7B VILLA NUEVA
What Did Barrel Contain Before



Graph 6B VILLA NUEVA
Where Barrel Was Obtained



Graph 7A ISRAEL NORTE
What Did Barrel Contain Before



Pilas

Cement *pilas* of various sizes are the next most common type of container for water seen in these two neighborhoods. These *pilas* are located either directly below the canal, or with a downpipe of some type (such as a plastic hose or PVC pipe) entering the pila from the gutter. They are easy to clean, often can hold large quantities of water, and usually incorporate a surface as a washboard. *Pilas* can be somewhat expensive for the urban poor as they are principally constructed, by hired labor, out of brick and cement. Small pilas can cost 120 Lempiras (US$ 23) or more.

Plastic barrels

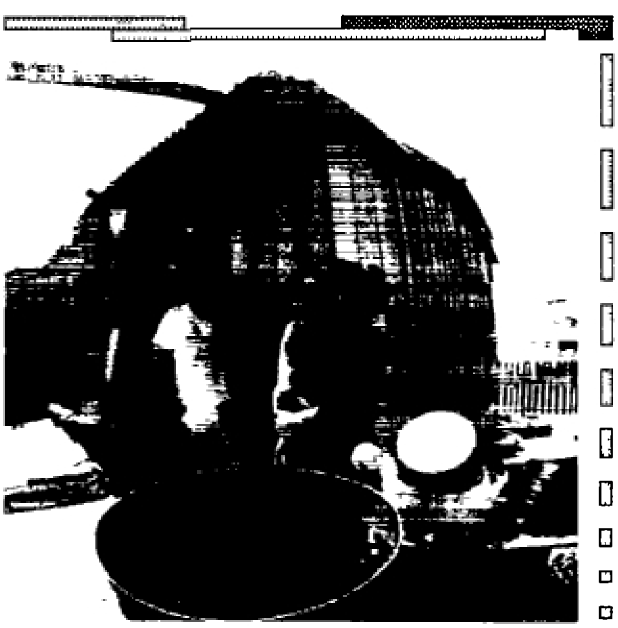
Plastic barrels are less common (only 5% in Israel Norte and 4% in Villa Nueva). These plastic barrels hold up to 60 gallons, and many originally contained dyes, insecticides and other chemicals imported by local and multinational companies.

Covers

One of the observations made in each community's first round visit was whether the container under the gutter (if one was visible outside) was covered. Of all the barrels (metal or plastic) and *pilas* observed under gutters in Israel Norte, only 1% were either partially or completely covered. In Villa Nueva only 9% were partially or completely covered. Obviously, efforts should be made to promote the covering of these containers for the protection of their water.

"Model Systems" Exist

A few houses used downpipes (either plastic hoses or PVC pipes) connecting the gutter, sometimes through the dwelling's wall, with a remote container, inside the house. These storage solutions provided the most interesting examples of creative ingenuity in rainwater collection systems. The downpipes were used to fill various types of containers, including barrels (both metal and plastic), *pilas*, and smaller containers (some of which were designated as drinking water containers). An interested loan program could look at these homes as potential models for RWCS plans, because the permanent nature of these fixtures could allow larger storage containers as well as less frequent human contact with water during collection.



RWCS means more water in the home

Interviewers were asked to record all the containers the family currently uses for storing water (both rainwater and water from other sources), as well as the approximate number of gallons each container could hold. Families who have no gutter on the roof have the least amount of available water storage (this includes water from all sources) in both Israel Norte (28 gallons) and Villa Nueva (78 gallons). This small amount of storage capacity probably reflects, in many cases, the lack of available funds to invest in RWCS. Families that can afford to invest in a gutter and some containers have the largest current water storage volumes (123 gallons in Israel Norte and 196 gallons in Villa Nueva). As would be expected, families in this category with pilas have significantly more potential storage than families with other types of containers such as plastic or metal barrels.

CEMENT

World-wide research[1] has indicated that there are several characteristics of cement that are worth mentioning, these include:

- During the first few years of use, acid rain (as in Tegucigalpa at the beginning of rainy seasons) is neutralized by the lime in cement.
- Natural alkaline leaching from cement raises Calcium to five times the levels found in metal or fiberglass tanks. Also raised are Iron, Nitrate and pH levels. No factors were harmful because the levels are not extreme. This change is most pronounced in new tanks, as the leaching diminishes with age. If this change is not desired by the users, more frequent cleaning will mitigate the effect.
- Cement keeps water cooler.
- Lower temperatures and higher pH inhibit bacterial growth (in closed tanks).
- Some people prefer the taste of rainwater stored in cement to drinking it directly.

There are several precautions to be noted about the way cement and concrete are normally used in Central America. For example:

- All materials, cement, rebar reinforcement, sand and gravel produced nationally. There is a surplus of experienced labor in masonry, both urban and rural, that is usually underemployed.
- Possibly the most significant problem in terms of failure in local tank or *pila* construction is insufficient steel rebar reinforcement and poor quality sand. Quality rebar of adequate size should be utilized;
- It is essential to use high quality, clean sand, as dirt and organic matter will cause porous cement or cracking as it dries. Sand should not be too fine either, as a coarser sand makes cement more resistant to shrinkage cracks;
- For concrete, a 1:2:3 (cement:sand:gravel) mixture should be observed. Pre-measured boxes might be considered;
- Many local masons have the custom of using to much water in mixing cement. Mortar should be adhesive and not run off the trowel;
- Lime is frequently used in Central America for extending the coverage of mortar by economizing on cement or for "whitewashing" cement plaster. It should not be used with water tanks, as it could result in porous cement unsuitable for waterproof work.
- Cement water storage tanks should cure, (remain wet and covered from direct sunlight) for 10 - 20 days.
- If thestorage will be exposed to direct sunlight, cement or concrete could be painted white to keep the surface cooler and lessen thermal expansion and shrinking, which can result in cracking. This is especially true for cement and thin ferrocement constructions.

Sources 1 Bunyaratapan, et al, 1983, 1984, 1987; Haebler and Waller, 1987; Scott and Waller, 1987.

Water quality

It is important to know the quality of water available for the home so as to 1) choose the cleanest sources, 2) identify the origins of contamination and 3) control and monitor this contamination. In the latter two cases, comprehensive programs with repeated testing for different contaminants over time is necessary. In this study, it was necessary to limit testing to determine, for the first time in Honduras, how rainwater quality compared with water from other sources, and refer through induction possible steps for identifying and controlling contamination.

In order to evaluate the quality of stored rainwater against water from other sources available to the family, the major sources of drinking water for each *barrio* were determined through the 116 conducted interviews. In approximate order of use, from most frequent to less, table 2.5 relates the principal non-rainwater sources used by these families in Israel Norte and Villa Nueva.

Table 2.5

IDENTIFIED NON-RWCS WATER SOURCES

ISRAEL NORTE

- Nearby SANAA tank, supplying a lower neighborhood;
- Private homes in adjacent neighborhoods with SANAA piped water;
- A small, infrequently filled water tank built in Israel Norte by the community council (*"patronato"*);
- Various private water vendors using small trucks that arrive infrequently and irregularly.

VILLA NUEVA

- SANAA/UNICEF public taps sparsely distributed in some sectors;
- Various private water vendors using small trucks that arrive frequently;
- SANAA/UNICEF tank trucks that arrive less frequently to supply sections that are distant from the public taps;
- Unprotected, empirically constructed superficial wells, both private and public, in the highest elevations of the barrio;
- Water originally bought from traveling vendors resold by small neighborhood stores who also sell food, soft drinks, and other small items.

Of three potential areas of water contamination, physical, chemical and microbiological, the team decided to limit the study to the investigation of the bacteriological indicator E. coli. The E. coli levels are the important indicators of whether or not water is safe to drink, as these Fecal Coliforms (FC) can suggest whether contamination vectors have contacted the water. Table 2.6 presents the E. coli colony counts revealed through the membrane filtration method of 100ml samples at the national university's Microbiological Department. Due to the limited scope of the testing, some identified sources that were not in use during the seven day testing period were not sampled. Also, the study of bacteria present in runoff from the roof itself would require automatic samplers, (such as those used in Thailand and Germany[19]), which were outside the present scope of this study.

The cleanest sources of water in both *barrios* appear to be SANAA supplied. For those families that must resort to the free, unprotected superficial wells in Villa Nueva, the test results are alarming. As expected, the worst danger was found in these wells. Every sample was exceedingly contaminated. While some key informants said most people use water from these wells for bathing and washing clothes, several homes visited in the uppermost sections of Villa Nueva also used these wells for their drinking water.

Results from water vendors are spotty. One had clean water, and the other two had very contaminated water. It is likely that water quality from vendors will depend upon the source of their water, the quality of which is likely to vary throughout the year. This variation points out another reason for testing various water sources periodically in order to truly assess water quality. Sweeping conclusions should not be made about the quality of water sold by private water vendors, or any other source, on the basis of this preliminary round of testing. It should also be remembered that these private vendors operating trucks have a very thin profit margin, as demonstrated by a 1986 WASH study on water vendors that included Villa Nueva[20]. Drastic attempts to control these vendors could result in their withdrawal from the business of providing water.

Table 2.6

E. COLI LEVELS IN 100ml. SAMPLES FROM IDENTIFIED WATER SOURCES

ISRAEL NORTE	
Nearby SANAA tank, samples from collection point:	0 Coliforms
Private home selling SANAA piped water, samples from tap:	0 Coliforms
Community water tank:	(unavailable)
Private venders trucking water, samples from hoses of two venders:	a) 100 Coliforms b) 0 Coliforms
VILLA NUEVA	
SANAA/UNICEF public taps samples from taps:	0 Coliforms
Private water vendors samples from hose:	Uncountable
SANAA/UNICEF tank trucks:	(unavailable)
Unprotected superficial wells, samples from wells:	a) Uncountable b) 2,000 Coliforms c) Uncountable d) 650 Coliforms
Store reportedly selling water bought from SANAA/UNICEF truck:	0 Coliforms

Secondary water contamination by the users

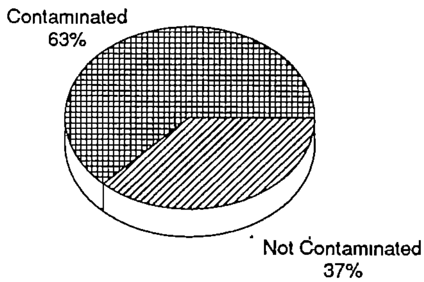
Interviewed families have varying opinions about the quality of rainwater. In Israel Norte, 60% of those interviewed felt rainwater was of average or bad quality. Villa Nueva residents had a higher opinion of rainwater quality; 63% of them thought rainwater was of good quality.

Drinking water

Once water was stored indoors, neither rainwater nor water from other sources provided a safe source of drinking water in over half the households tested. Graphs 8 and 9 (see following page) show that the percentages of contaminated drinking water found in 27 homes during the seven days of testing were very similar (63% of the rainwater samples and 61% of the samples from other sources had more than 0 fecal coliform, the standard established by WHO).

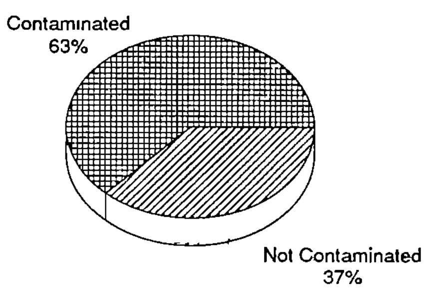
Generally speaking, water stored in households that was carried from a SANAA source (such as the SANAA water tank near Israel Norte and the SANAA/UNICEF public tap in Villa Nueva) fared better than water from other sources, such as water vendors or superficial wells. However, there were a number of cases in which SANAA water stored in the household also showed high levels of fecal contamination.

Graph 8 WATER QUALITY TESTING
Drinking Water: Rainwater



Contaminated > 0 E coli/100ml

Graph 9 WATER QUALITY TESTING
Drinking Water: Rainwater



Contaminated > 0 E coli/100ml

Since SANAA source points were found in these tests to be uncontaminated, it follows logically that such high levels of contamination in the same water once it is stored in homes are due to secondary contamination by the users during transport, storage or extraction.

Water for domestic uses

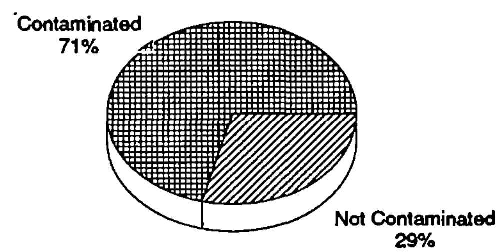
The domestic purposes for which water is used might include preparing and cooking food; washing dishes; bathing; washing clothes; cleaning the house; and watering fruit, vegetable, or other plants that belong to the household.

As expected, rainwater collected for domestic uses, without the special processes described earlier (straining through cloth into smaller, dedicated containers stored indoors), is more contaminated than rainwater collected separately for drinking. Samples were taken from whatever container the family uses to store water for general purposes. In the case of rainwater, this was usually from an open barrel or *pila* often situated just below the gutter used to channel rainwater from the roof. For water gathered from other sources, this was usually collected and stored in a smaller container.

Graph 10 shows that 71% of rainwater for domestic uses was contaminated, versus the 63% contamination of rainwater for drinking shown previously in Graph 8. This may reflect in part the fact that special treatment (in terms of collection and handling) of rainwater for drinking may have positive effects overall when a large enough number of houses are considered. Most likely, it is not the straining through cloth that lessens the contamination, but the fact that specially handled rainwater for drinking is stored in a smaller, closed, dedicated container and not in an open, all purpose barrel.

Apparently, SANAA and SANAA/ UNICEF can provide safe water, and many families use careful practices to try and collect clean rainwater for drinking. Unfortunately, these positive points are probably far outweighed by the unclean habits of hand-extraction of water from containers at the time of use and the infrequent cleaning of barrels, *pilas*, containers and extraction utensils.

Graph 10 WATER QUALITY TESTING
Water for Domestic Uses: Rainwater



Contaminated: more than 0 F.C/100 ml

CONCLUSIONS AND RECOMMENDATIONS

The urban poor who are not connected to Tegucigalpa's municipal water system must spend up to 30 or 40% of their income to buy modest quantities of water. Rainwater catchment systems offer some relief from this burden; practically every one of these households harvests rainwater. The study demonstrated an even greater dependence upon rainwater than had previous estimates[21]. Over 90% of the families in Israel Norte for example, say that between half and all their water needs are met by rainfall during the wet season.

Almost all the families that collect rainwater in the two *barrios* use it for domestic tasks: bathing, washing clothes, and cleaning the house. A significant number of people also use rainwater for drinking. In Villa Nueva, almost 60% of the families interviewed said they drink rainwater when it is available. But even by using rainwater, families unconnected to city water service have far less water than they need to adequately maintain a home and keep their children healthy. Unfortunately, it appears that unclean handling and storage practices in the home can contaminate what little water the family gets, even when the water was delivered clean. Younger children, as always, are at greatest risk of illness and early death.

POTENTIAL INTERVENTIONS

Conventional responses to urban water supply deficits, in Tegucigalpa and throughout the third world, have been limited to reconditioning and adding new water sources to existing systems. Unfortunately, with urban populations exploding, existing systems provide little hope for bringing water to their homes. For professionals in the health and sanitation field to leave rainwater out of water supply programs for the barrios would be counter-productive and ignore reality. A better approach is to recognize rainwater's role as the single principal source of water for the urban poor during the wet season. Having done so, programs could try to increase the water volumes harvested and to change the practices that lead to contaminated water.

Increasing the quantity of water available should be the immediate goal of improvements in RWCS. Recently, many studies have shown that making increased quantities of water available for domestic uses and personal hygiene can have an even greater potential impact on health than would improvements of water quality.

Indeed, providing greater volumes of water for domestic uses could have a decisive impact on family health, even if only available during the rainy season. It is precisely during this season that more infants and children die from water and sanitation related illnesses, as contamination is spread throughout barrios and villages by uncontrolled runoff. During the rains, an average of 80 children die daily in Honduras from gastro-intestinal afflictions. This is precisely the period when the rains could provide more water for more frequent bathing and washing. If harvested, the same rains could save, instead of kill, many children.

Basic systems for collecting and storing rainwater already exist in the barrios. At least in the short term, incremental improvements can and should be based on the systems and practices that already exist rather than trying to introduce new types of technologies. Relatively simple and inexpensive improvements in rainwater collection elements such as roofs, gutters and *pilas* would meet family home-improvement aspirations and likely result in an increase supply of water and a decreased amount of money spent buying water during the rainy season.

There are three major recommendations that the results of this study support:

1 **Expand existing home-improvement loan programs to include a targeted loan fund specifically for RWCS;**

2 **Incorporate RWCS, including proper water storage and handling, in an urban health awareness program;**

3 **Design a new hygienic storage container for drinking water.**

LOANS FOR LOW-INCOME FAMILY RWCS

This study found families interested in making improvements in their existing rainwater catchment systems, and in funding these renovations with credit. If loan monies were made available to barrio residents, there could be a significant demand for a RWCS-improvement program. Opening up significant new lines of credit and focusing them on RWCS is an important first step to:

1 **Expand existing home-improvement loan programs to include a targeted loan fund for RWCS.**

The Honduran government, its international partners, and local PVOs can assist in basic household RWCS improvements by making available RWCS and home-improvement loans targeted at low-income families. All such existing programs currently offer credits for roofs, and a few for *pilas*. None have loan portfolios that yet include gutters, trash screens and downpipes. Special emphasis should be placed on getting these loans to families headed by single mothers. Graph 12 (see page 38) shows the type of RWCS improvements families interviewed during this study said they would be willing to do with credits.

Recognizing that 80% of the housing solutions generated in Honduras come from the informal sector and not from institutionalized assistance programs, every effort should be made to document and replicate these RWCS systems throughout the city. Housing assistance programs should serve as catalysts for introducing these improved RWCS into the *barrios*. A range of technologies and costs could be developed as a "menu" of possibilities for interested families.

"Rainwater *Pilas*"

Many of the families identified "rainwater *pilas*" as a specific aspect of RWCS that they would like to build or improve. *Pilas* (a combination open tank, sink and washboard made of cement or concrete) are relatively simple to construct using local materials and experienced, frequently underemployed labor. *Pilas* however can be somewhat expensive for families in the *barrios*. The factor which seemed to determine whether or not urban households in this study have *pilas* appears to be family budgets. Loan programs could bring into reach this fundamental part of any household. Many of the low-income families interviewed in this study have managed to have built *pilas*, yet a large number of these were poorly constructed and have cracked or broken.

Besides providing "free" water from runoff, a "rainwater *pila*" could be a specific answer to several needs during the rainy season, among them: 1) reduce the need to leave the home (and children) for washing clothes; 2) make more water available, due to the large size of the *pila*, than if transported from elsewhere with hand-carried containers; 3) provide a place for bathing infants and children; 4) a *pila* cannot be stolen, a very real concern with the other components, like PVC pipe and barrels; and 5) provide a desired home-improvement in many households.

The design of a "rainwater *pila*" should not be drawn up at a desk. It needs to be part of an interactive process involving users/clients (especially the women that will use them), PVOs, masons, and the private sector. However, a few general guidelines, based on observations made during this study, are worth including. A typical "rainwater *pila*" should:

- Connect with already installed rainwater catchment hardware;
- Be combined with other home improvements, such as roofs, gutters and downpipes, so as to capture even more water;
- Be well built and steel rebar reinforced for durability;
- Have ample washboards, as children are often bathed there;
- Have an inclined floor and a drain, and be easy to clean;
- Have a wide concrete walkway and drainage around the entire perimeter to control waste water and keep feet out of the mud when using the pila;
- Be located on the latrine to house path, thereby facilitating hand washing after using the latrine;
- Have a tight-fitting (probably wood or sheet metal) cover to minimize contamination and to inhibit mosquito breeding.

Future rainwater *pilas* could incorporate features desired by the customer and beneficial to family hygiene, such as taps for extraction, shower stalls for adult bathing privacy, and eventually even closed storage for safeguarding high quality rainwater for drinking.

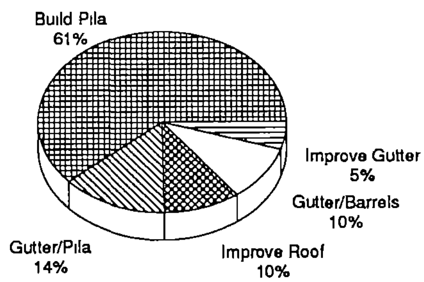
Families that collect rainwater were asked how many additional containers they would need to collect and store all the water they need in the rainy season. Adding this information to the storage volume that these households have now gives an estimate of "desired" water storage for "rainwater *pilas*".

As previously mentioned, Villa Nueva families have greater current storage volumes than in Israel Norte. Families in Villa Nueva also predicted they would need more future water storage than Israel Norte families. The average "desired" storage capacity in Villa Nueva was 375 gallons, and 246 gallons in Israel Norte. This is equivalent to about 70 and 45 gallons per person in each barrio respectively.

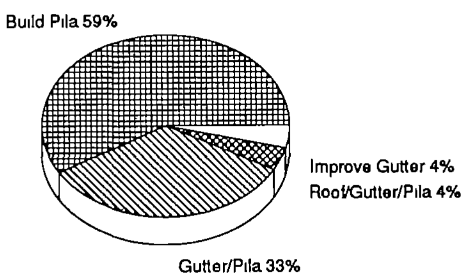
In both surveyed areas, more then half of each population estimated that they would like to increase their future storage capacity by 100%. The actual desired quantity averages around 400 gallons. Many feel a that a loan for *pilas* could help them meet these aspirations. A home-improvement loan program would need to develop cost estimates for "rainwater *pilas*" of various sizes in order to satisfy the demands of families with varying water needs and budgets. For example, *pila* sizes of 200, 400, and 600 gallons would appear to meet the desires of most families interviewed and the capacities of the RWCS seen in the two *barrios* studied.

Such estimates would allow an interested government agency or PVO to design and price a number of options before promoting these to community groups and borrowers.

Graph 11A ISRAEL NORTE
What Would You Use Credit to Do?



Graph 11B VILLA NUEVA
What Would You Use Credit to Do?



Field Manuals, plans and training materials can be published and openly distributed to reach the informal sector. Training opportunities and materials are needed for interested agencies, promoters in home-improvement loan programs, masons, carpenters, and families interested in RWCS construction, operation, and care.

CONTAMINATION IN THE HOME, AND URBAN HEALTH EDUCATION

The family itself appears to be a significant source of secondary contamination of the precious little water they purchase and collect. Water found at many of the sources used by the urban poor was of good quality yet that same water was found to be contaminated after it was collected, transported and handled in the home. The only way to win the battle against unhealthy practices is by replacing them with new, safe habits. This transformation can be made possible on a massive scale by thorough, long-term health education. A second recommendation of this study is to:

2 Incorporate RWCS, including proper water storage and handling, into an urban health awareness program.

Designing and implementing an active urban health education program should be a priority, whether or not other improvements in water supply are contemplated. This new program would have to including education and training on rainwater catchment and other aspects of water handling, subjects which are not yet a focus

FAMILY OPERATION AND MAINTENANCE OF RWCS

Despite the worldwide increase in RWCS over the past 20 years, there is still little agreement among programs on some basic points. Most activities appear to be supply-oriented and offer little education on RWCS operation and maintenance, even though good habits in RWCS maintenance are important for protecting water quality. In Thailand, installations deemed to be "well maintained RWCSs" had lower Iron, Sulfate, Color and Turbidity levels than systems given "little or no maintenance". Significantly, the "little or no maintainance" systems had mean total coliform counts more than 500% of those found in the "well maintained" installations.

The International Reference Center (IRC), in a document prepared for UNICEF in Africa, determined that good operation and maintenance training and practices were lacking in the entire RWCS sector. Few guidelines or simple drawings were available. Seasonal operation and maintenance timetables for cleaning and maintenance were seldom found. Often, only verbal instructions had been given to "leaders", but almost never to the users (mostly women) responsible for operating and cleaning RWCS and containers in the home. Therefore, simple steps to protect water quality were often ignored. Where guidelines were issued and training occurred, systems fared better.

Only a few programs, like Plan International at Embu, Kenya, provide training that includes detailed written instructions and operation and maintenance timetables.

GUIDELINES ISSUED BY PLAN INT'L TO ROOFTOP CATCHMENT TANK OWNERS,KENYA (1989)

Use

- The roof surface and the gutters must be kept free from the excreta of birds and animals, dust and leaves. This is to safeguard the quality of the rainwater entering from the roof surface.
- The gutters and inflow pipe must be regularly cleaned of leaves and other rubbish which may collect in them. This prevents clogging of the inflow pipe with washed off materials which would prevent water from entering the storage tank.
- If there has been no rain for two or more days, the inflow pipe should be placed so that it is not leading into the reservoir but hanging beside it. Five to ten minutes after rains begin, the inflow pipe can be connected to the reservoir again.
- The mosquito protection screen over the inflow pipe must be checked regularly and if necessary should be repaired.
- To keep the water consumption (for drinking and feeding only) under control the tap should be closed with a padlock.
- The water level in the tank should be measured and noted once a week using the same measuring stick (which is not to be used for any other purpose).
- A drop of 1 cm in the tank water level corresponds to approximately 20 litres (one jerry can) consumption. Storage capacity of 12000 gallons supplies 5 litres per person for a period of 125 days for a family of eight persons (two jerry cans/day), and 900 gallons can supply 4 litres per day (one and half jerry cans). During dry periods, the drop in water level should correspond approximately with consumption. If this is not the case, the reservoir is leaking and wet spots will be visible.
- To prevent the place becoming a breeding place for mosquitoes, the drain pit should remain clean and dry.
- Keep the drain to the seepage pit open and avoid blocking to prevent mosquitoes and insects breeding.
- The water must be boiled before drinking.

Annual Maintenance

- Annual maintenance is carried out at the end of the dry period, when the reservoir is "almost" empty.
- Any leaks that have been noticed during the preceding wet season must be repaired. Wet spots on the wall are treated on the inside with a cement/water mixture (proportions 1:2 parts by volume). If leakage is evident but no wet patches have been discovered in the walls of the reservoir, the floor of the reservoir must be treated with a cement/water mixture and finished off with a layer of plaster (portions 1:2 sand: cement by volume).
- The interior of the reservoir is cleaned by removing deposits from the bottom and scrubbing the bottom and walls with clean water. The water used is discharged through the drain.
- The roof surface, suspending hooks and the inflow pipe are checked and if necessary, repaired.
- The gutter lining should be checked and sags and leakages repaired.

Sources Lee and Visscher, IRC for UNICEF, 1990 (Plan Int'l guidelines apparently were adapted originally from IWACO, Rotterdam, guidelines published in 1982, reproduced in Pacey and Cullis, 1986).

in local urban health programs. For example, when asked what measures they might take to preserve water quality, only 8% of the residents of Villa Nueva mentioned cleaning their water containers or gutters, and no one in Israel Norte even mentioned these basic preventative steps. In Villa Nueva, SANAA/UNICEF programs may have begun to change some attitudes and practices regarding water and hygiene.

Using promoters and mass communication, an urban health program could seek to improve hygiene and water practices among a massive audience. This type of program is essential for improving the quality of all water in the home, whatever its source. Some of those interviewed felt that funds spent in health promotion would possibly do more good for more people than any other water supply-oriented intervention[22].

A MORE HYGIENIC CONTAINER

After educational and training programs. the most likely "hardware" interventions capable of improving drinking water quality in the home are household treatment and improved drinking water containers. The results of the observations, interviews and preliminary water testing in this study support a recommendation to:

3 Design a new hygienic storage for drinking water.

Household water treatment by boiling can be too costly for the very poor, whether done with firewood, gas or electricity. Water treatment often takes a lower priority than other demands for limited household cash and time. One potential intervention that should be studied is the bulk purchase of commercial chlorine compounds, then repackaging them for neighborhood sale in small amounts for common household water containers. This treatment may actually be cheaper and less time consuming for the family than boiling, as well as more effective at preventing contamination after treatment. Boiled water is unprotected from subsequent secondary contamination.

And yet, the costs of such treatments would be incurred every time new drinking water is brought into the kitchen. Treatment may not be often practiced, more because of the costs and effort involved than because of lack of knowledge. Designing a more hygienic water container might also lead to better water handling practices on an even wider scale, helping to prevent rather than to correct water contamination.

The size of the new container would depend on whether the downpipe can reach the storage point, as it does in the more complete systems found during this study. If downpipes reach the container, this could be large, perhaps 20 or more gallons. If the storage location is not close to the downpipe, then smaller sizes (5 gallons or so) could be transported by women and children

There is no product currently on the market that low-income families can afford that meets the requirements for a hygienic storage container for drinking water. It would be appropriate to look to the private sector, including micro-and small-entrepreneurs, for assistance in the design, manufacture, and marketing of a new drinking water container, as well as gutters, downpipes and tanks. Women themselves may be able to make their own barrels or drinking water containers now that resins are being commercially promoted which could make very hygienic, lightweight and easy to clean containers.

Credits for buying a commercially produced container, or for the user-fabrication of their own recipients, could be provided through the same home-improvement loan programs, or even through other agencies or groups. For example, the local Water Boards, elected from among neighbors within each *barrio* served by SANAA/UNICEF, might be strengthened if these credits and even a new Urban Health Education program were to involve them actively. A social marketing campaign might be necessary to create an effective demand for these containers, along with an educational campaign on how to use and clean them.

DESIGNING A DRINKING WATER CONTAINER

In the *barrios* of Tegucigalpa, the correct use of a special container for drinking water would have a tremendous impact on water quality from all sources, as handling of drinking water would be minimized. Applied, interactive research into the design, manufacture and marketing of an affordable drinking water storage container is highly recommended, and could incorporate the following features:

- Wherever possible, a direct, covered connection between a RWCS downpipe and the container to minimize handling of the hose ends and container openings;
- A closeable aperture to be used only for cleaning the container. If possible, the cleaning aperture and/or the opening for introducing water should not allow convenient decanting or manual extraction;
- All extraction should be from a tap at least 10 cm. off the bottom of the container;
- To eliminate the transfer of water among multiple containers during collection, it should have handles for carrying full of water from the downpipe/filling point to storage location. It must also be light enough for women and children to turn over and clean. Plastic and resins would have advantages over metal or glass.

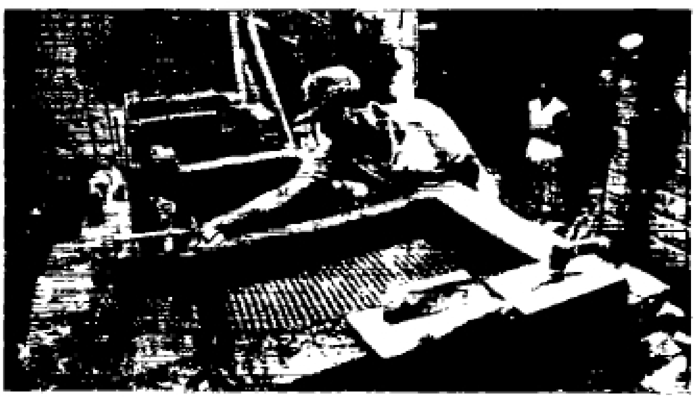
LARGE-SCALE RWCS PROGRAMS ARE NEEDED

The residents of Tegucigalpa's low-income neighborhoods have already done most of the research needed on rainwater catchment in urban Tegucigalpa — and they have done it with their own money. Some, like Dora Yvonne Cárdenas and her family, have spent little on their rainwater system. Her gutter and roof are from the sheet metal pieces from which they originally built their one room wooden shack four years ago. The plastic coke bottle was refuse that she cleaned and cut in half to capture the runoff from her gutter. The short length of plastic hose she uses as a downpipe to fill her drinking water bottles was bought from a neighbor for almost nothing. A salvaged scrap of bent sheet metal serves as a downpipe to her *pila* (which did cost her almost 15 dollars at the time). Even though its washboard is broken off, their *pila* still serves them for water storage, washing clothes and bathing. "Especially the two little ones", she says as she scoops a crawling infant clothed only in a diaper, "I have to clean them all the time."

For other mothers, it is not quite so easy to keep their children clean. Frequent washing means no water for some other task. "It may not be much," Dora Yvonne says as she rehangs her soda bottle funnel, "but I don't know what I'd do without the rainwater we collect."

Programs should respond to families like Dora Yvonne's that recognize how important rainwater is to them and are willing to repay a loan that would help them collect still more water. In the long run, rainwater harvesting is the only source that can **increase** the water it provides to Tegucigalpa with each new family involved. Conventional sources like wells and rivers are finite, and alone cannot satisfy the needs of the city's exploding population. But for each household that can collect extra rainwater, their investment means that more water is available in Tegucigalpa.

In order to really make a difference, programs that support rainwater catchment systems must continually expand their operations to keep pace with population growth and thereby help alleviate pressure on traditional water sources. Rainwater harvesting, if improved in thousands of *barrio* homes, could mean less stress on society as a whole, and provide the time, money and health for an urban family to develop other opportunities, which is why they came to the city in the first place.



Annex 1

SUMMARY OF MAJOR SURVEY AND TESTING RESULTS

The major results of the surveys and water testing that were carried out in Israel Norte and Villa Nueva during the height of the rainy season - September and October, 1990 - include:

- Most families in both neighborhoods collect rainwater (87% in Israel Norte and 83% in Villa Nueva).
- The basic components of the existing rainwater collection systems (RWCS) used by most families include sheet metal roofs; discarded pieces of sheet metal fashioned into crude gutters; and either a 55-60 gallon metal or plastic barrel, a cement *pila* (an open cement tank with cement washboards), or small plastic containers or metal pots for collecting and storing rainwater.
- Over half (58%) of households in Villa Nueva said they drink rainwater. A smaller number of families in Israel Norte say they drink rainwater (18%).
- Two-thirds of families (67%) in Villa Nueva use rainwater for preparing/cooking foods. Nearly one-third (32%) of families in Israel Norte use rainwater for this purpose.
- Almost all (between 94% and 100%) families who collect rainwater use it for domestic purposes such as washing dishes; taking baths; washing clothes; and cleaning the house.
- Most families in Israel Norte (94%) say that rainwater provides them with at least 1/2 of the water they need in the rainy season. Sixty-six percent (66%) of families in Villa Nueva gave this same response.
- The majority of families in both Villa Nueva (91%) and Israel Norte (85%) said they could collect more rainwater than they do now if they had more or bigger containers.
- Most families said they would be interested in using credit for improving their existing RWCS (64% in Israel Norte and 73% in Villa Nueva). Apparently, an "effective demand" exists in these *barrios* making and paying for improvements.
- Among those families expressing interest in using credit, the most popular improvement mentioned was building a *pila*, or a *pila* in combination with improving the gutter and/or the roof (75% in Israel Norte and 96% in Villa Nueva).
- Families interested in credit estimated they would need between Lps. 95 and Lps. 2,600 (US$ 18 to US$ 490) for desired RWCS improvements, ranging from new gutters only to entire new roof, gutter, downpipe and storage systems. Loans at these amounts (through existing home-improvement loan programs) could be paid back in less than two years.

- Rainwater used for drinking generally did not meet microbiological standards set by the World Health Organization for fecal coliform in drinking water, but neither did water stored in the home from other sources. Almost identical levels of fecal contamination were found in both rainwater (63% >0 coliform) and other sources of water (61% >0 coliform) stored in the home to be used as drinking water.

- All (4/4) of the water sources providing water from SANAA and SANAA/UNICEF were found to be free of fecal coliform. However this water, and water from all other sources presented high levels of contamination once the water was handled and stored in the home (61% >0 coliform).

ANNEX 2

END NOTES

All references referred to in the end notes are fully cited in the Bibliography.

1: Gould, J.E. (no date); Gould, J.E. (1990); IRC (1981); Latham, B. & Gould, J.E. (1986); Lee, M.D. & Visscher, J.T. (IRC/UNICEF), (1990); Pacey, A. & Cullis, A., (1986).

2: Dirreción General de Aeronautico Civíl, Ministerio de Communicaciones, Obras Públicas y Transporte, Tegucigalpa, Honduras. Table 1.1 was derived from their report entitled "Average Daily Rainfall (1985-1989)", measured at Toncontín International Airport in downtown Tegucigalpa. Report dated October 22, 1990.

3: Edwards, D., Keller, K., & Yohalem, D., (1984); Gould, J.E. op cit (no date); IRC op cit; Keller, K., (1982); Pacey, A. & Cullis, A. op cit; WASH Raindrop newsletter, issues no. 39 & 40.

4: Bunyaratpan, V. & Sinsupan, S., (1983); Bunyaratpan, V. & Sinsupan, S., (1984); Bunyaratpan, V. & Sinsupan, S., (1987); Haebler, R.H. & Waller, D.H., (1987); Khon Kaen University, Khon Kaen, Thailand, (1989); Wirojanagud, W., (1987).

5: Bunyaratpan, V. op cit, (1983);Bunyaratpan, V. op cit, (1984).

6: Personal interview, Becky Myton, Limnology Laboratory, Univesidad Nacional Autonoma de Honduras, October, 1990.

7: Pacey, A. & Cullis, A. op cit; Personal Interview, Rolando Chavarría, USAID/Honduras, October, 1990.

8: Bunyaratpan, V. & Sinsupan, S. op cit, (1987); Khon Kaen University op cit, (1989).

9: Bunyaratpan, V. op cit, (1983);Bunyaratpan, V. op cit, (1984).

10: Keller, K. op cit; Pacey, A. & Cullis, A. op cit.

11: Latham, B. & Schiller, E., (1987); USAID, Water for the World Technical Notes, No. RWS.1.C.4.

12: Gould, J.E. op cit, (no date); Pacey, A. & Cullis, A. op cit.

13: DANIDA project in Mobuto, Kenya, drawing reproduced in Lee, M.D. & Visscher, J.T. op cit.

14: Scott, R.S. & Waller, D.H., (1987).

15: Keller, K. op cit; Pacey, A. & Cullis, A. op cit.

16: Latham, B. and Gould, J.E. op cit.

17: Plan International at Embu, Kenya cited in Lee and Visscher op cit, (1990).

18: Gould, J.E. op cit, (no date); Latham, B. & Gould, J.E. op cit; Pacey, A. & Cullis, A. op cit.

19: Bunyaratpan, V. op cit, (1987); Papers compiled from the Fourth International Conference on Rainwater Catchment Systems; Khon Kaen University op cit.

20: Whittington, D. et al, (1988)

21: The informative WASH report by, Water Vending and Development: Lessons from Two Countries, Whittington, D. et al, (1988), used the barrio Villa Nueva as one of two areas for observation and surveys on water vendors and general water issues. This study estimated that rainwater provides 1.7m3 of the 3.7m3 of water obtained monthly by the average Villa Nueva family during the rains, representing 45% of their available water.

22: Personal interview, Mario Martin, (then Director of the Honduran government's National Housing Institute, and currently Director of the government's new Social Housing Fund) Tegucigalpa, Honduras, October, 1990.

Annex 3

BIBLIOGRAPHY

1. Appan, A. & L.K. Wing. "A Total Approach Towards the Establishment of Rainwater Cistern Systems in Developing Countries". Nanyang Technological Institute and International Development Research Centre (IDRC) Regional Office. Singapore. 1987.

2. Bunyaratpan, V. & S. Sinsupan. Final Report - Collection and Storage of Roof Runoff for Drinking Purposes: Studies of Rainwater Quality. Submitted to IDRC. Khon Kaen University. Khon Kaen, Thailand. August 1984.

3. Bunyaratpan, V. & S. Sinsupan. "Rain Water Quality from Roof Catchment and Storage". Khon Kaen University. Khon Kaen, Thailand. July 1983.

4. Bunyaratpan, V. & S. Sinsupan. "Roof Catchment: Water Quality". Khon Kaen University. Khon Kaen, Thailand. 1987.

5. Castaldi, J.C. La Tenencia de la Tierra en las Colonias de Origen Informal de Distrito Central (Land Tenancy in Informal Sector Settlements in the Central District). Tegucigalpa, Honduras. Cooperative Housing Foundation (CHF) and UNICEF. July 1990.

6. Chindaprasirt, P., S. Sethaputra, & C. Vadhanavikkit. "Proceedings of the Third International Conference on Rainwater Cistern Systems". January 14-16, 1987. Khon Kaen University. Khon Kaen, Thailand. (Selected Papers).

7. Educación Comunitaria para la Salud (EDUCSA). Manual de Capacitación Popular: Saneamiento Ambiental (Training Handbook: Environment Sanitation). Tegucigalpa, Honduras. (no date).

8. Edwards, D., K. Keller, & D. Yohalem. A Workshop Design for Rain Water Roof Catchment Systems: A Training Guide. WASH (Water and Sanitation for Health Project) Technical Report No. 27. June 1984.

9. "Fourth International Conference on Rainwater Catchment Systems". Papers from Section on Environment and Water Quality Aspects.

10. Fujioka, R.S. & R.D. Chinn. "The Microbiological Quality of Cistern Waters in the Tantalus Area of Honolulu, Hawaii". University of Hawaii. Honolulu, Hawaii. 1987.

11. Gould, J.E. "Developments in Rain Water Catchment Systems: Technology and Implementation Strategies in the 1980's and Lessons for the 1990's". International Symposium on Development of Small Scale Water Resources in Rural Areas. Bangkok and Khon Kaen, Thailand. May 21-25, 1990.

12. Gould, J.E. Hon. Secretary of the International Rainwater Catchment Systems Association. Personal Communication. September 4, 1990.

13. Gould, J.E. "Rain Water Harvesting Systems for Drinking Water Supply". Draft. (no date).

14. Gould, J.E. Report to WASH on Rainwater Catchment Systems in Thailand. June 1990.

15. Haebler, R.H. & D.H. Waller. "Water Quality of Rainwater Collection Systems in the Eastern Caribbean". Halifax, N.S. Canada. 1987.

16. Hofkes, E.H. Small Community Water Supplies: Technology of Small Water Supply Systems in Developing Countries. International Reference Centre for Community Water Supply and Sanitation (IRC). The Netherlands. 1981.

17. IRC. Rainwater Harvesting for Drinking Water Supply. Training Module Series. IRC. The Netherlands. August 1981.

18. Keller, K. Rainwater Harvesting for Domestic Water Supplies in Developing Countries. WASH Working Paper No. 20. September 1982.

19. Khon Kaen University. Evaluation of Rainwater Quality: Heavy metals & Pathogens. Submitted to: IDRC. Khon Kaen University. Khon Kaen, Thailand. June 1989.

20. Latham, B. & J. Gould. "Lessons from Field Experience with Rainwater Collection Systems in Africa and Asia." Agua, Pergamon Journals Limited, No. 4, pages 183-189, 1986.

21. Latham, B. & E. Schiller. "Use of Rainwater Collection in Urban Areas". University of Ottowa. Ottawa, Canada. 1987.

22. Lee, M.D. & J.T. Visscher. Water Harvesting in Five African Countries. IRC International Water and Sanitation Centre. Submitted to: UNICEF. The Netherlands. July 1990.

23. Lindblad, C. Volunteers in Technical Assistance (VITA). Personal Communication. August 21, 1990.

24. Luria, D.T. Strategy for Planning Periurban Water Systems:A Case Study from Guatemala. WASH Field Report No. 310. June 1990.

25. Martin, Mario, Editor. LLegando al Pobre del Sector Informal Urbano - Ejemplos Hondureños. Privately published by UNICEF/Honduras and Cooperative Housing Foundation/Honduras. Tegucigalpa, Honduras. 1991.

26. Millipore Corporation. Water Microbiology: Laboratory and Field Procedures. Millipore Corporation. Bedford, Massachusetts. 1986.

27. Ministerio de Comunicaciones, Dirección General de Aeronaútica Civil, Tegucigalpa, D.C., Honduras. Table of Average Daily Rainfall (1985-1989) in Tegucigalpa. October 22, 1990.

28. Neri, L.C., C.K. Li, & E.J. Schiller. "Use of Rainwater for Drinking Purposes: Its Health Implications". University of Ottowa. Ottawa, Canada. 1984.

29. Owen, M.C.R. & C.P. Gerba. "A Case History of Disinfection of Water in Rural Areas of Mexico". Cheyne Owen, Ltd. and University of Arizona. Tucson, Arizona. 1987.

30. Pacey, A. & A. Cullis. Rainwater Harvesting: The Collection of Rainfall and Runoff in Rural Areas. Intermediate Technology Publications. London, England. 1986.

31. Pinfold, J.V., N.J. Horan, & W. Wirojanagud. "The Bacteriological Quality of Water Collected in Rainjars in Rural Northeast Thailand with Respect to Drinking Water Quality Guidelines". Submitted to: Water Research. March 15, 1990.

32. Ruskin, R.H. & P.S. Callender. Maintenance of Cistern Water Quality and Quantity in the Virgin Islands. Caribbean Research Institute. St. Thomas, U.S.V.I. Technical Report No. 30. February 1988.

33. Scott, R.S. & D.H. Waller. "Water Quality Aspects of a Rainwater Cistern System in Nova Scotia, Canada". Technical University of Nova Scotia. Halifax, Canada. 1987.

34. Sivaborvorn, K. "Bacteriological Property of Rainwater". Mahidol University. Bangkok, Thailand. (no date).

35. UNICEF. Urban Example - Prospective for the Future. Water Supply and Sanitation to Urban Marginal Areas of Tegucigalpa, Honduras. UNICEF Guatemala. Guatemala City, Guatemala. (no date).

36. USAID. "Constructing Operating and Maintaining Roof Catchments". Water for the World. Technical Note No. RWS. 1.C.4. USAID. Washington, D.C. (no date).

37. USAID. "Designing Roof Catchments". Water for the World. Technical Note No. RWS. 1.D.4. USAID. Washington, D.C. (no date).

38. USAID. "Evaluating Rainfall Catchments". Water for the World. Technical Note No. RWS. 1.P.5. USAID. Washington, D.C. (no date).

39. Waller, D.H. "Rainwater - An Alternative Source in Developing and Developed Countries". Water International. 14 (1989) 27-36.

40. WASH. RAINDROP: Rainwater Harvesting Bulletin. Volume 1, No. 1. November 1, 1988.

41. WASH. RAINDROP: Rainwater Harvesting Bulletin. Volume 3. April 1990.

42. Whittington, D., et al. Water Vending and Development: Lessons from Two Countries. WASH Technical Report No. 45. May 1988.

43. Wirojanagud, W. Khon Kaen University. Khon Kaen, Thailand. Personal communication. September 17, 1990.

44. Wirojanagud, W. "Rainwater Contamination". Khon Kaen University. Khon Kaen, Thailand. 1987.

ANNEX 4

METHODOLOGY AND SURVEY INSTRUMENTS

The two neighborhoods, Israel Norte and Villa Nueva, were selected jointly by *Agua Para el Pueblo* and UNICEF. Israel Norte was originally chosen because it was thought to represent a neighborhood in which families have no access to a water supply within the boundaries of the neighborhood (either rivers, streams, public taps, or house-to-house connections). Villa Nueva was selected because it represents a neighborhood with access to various types of water sources within its boundaries, including a few public taps recently installed by SANAA with UNICEF financing.

A total of 535 homes were included in this study, 269 in Israel Norte and 266 in Villa Nueva. Of these homes, a smaller number was chosen in three categories (strata) for in depth observations and interviews. Sub-samples were drawn randomly (using every "nth" house within each category so that the sub-sample would cover the entire geographic area of both neighborhoods) from each strata. The strata, the actual number of houses within each category and the number of houses included in the sub-sample are shown in Table Annex 4.1 for Israel Norte and Table Annex 4.2 for Villa Nueva.

Copies of the structured questionnaires used for each sub-sample are included as Annexes 4a, 4b, 4c and 4d of this report.

TABLE ANNEX 4.1

ISRAEL NORTE

TYPES AND SIZES OF STRATA AND SUB-SAMPLES DRAWN WITHIN EACH STRATA

Elements of Rainwater Collection System	Number in Strata (N)	Number in Sub-sample (Surveys Done)
No Gutter on Roof	55 (20%)	11 (20% of N)
Gutter & No Container	62 (23%)	13 (21% of N)
Gutter & Container or Hose/Pipe into House	152 (57%)	33 (22% of N)
TOTAL:	**269 (100%)**	**57 surveys**

CHART ANNEX 4.1

ISRAEL NORTE

TYPES AND SIZES OF STRATA AND SUB-SAMPLES DRAWN WITHIN EACH STRATA

Elements of Rainwater Collection System	Number in Strata (N)	Number in Sub-sample (Surveys Done)
No Gutter on Roof	78 (29%)	17 (22% of N)
Gutter & No Container	28 (11%)	9 (32% of N)
Gutter & Container or Hose/Pipe into House	160 (60%)	33 (21% of N)
TOTAL:	**266 (100%)**	**59 surveys**

ANNEX 4A

RAINWATER STUDY
AGUA PARA EL PUEBLO AND UNICEF
TEGUCIGALPA, HONDURAS
SEPTEMBER/OCTOBER 1990
FIRST ROUND OBSERVATIONAL GUIDE

1. **House number:** ____________
   (from map)
2. **Date:** ____ ____ **1990**
   day month
3. **Neighborhood:** 1 - Villa Nueva
   2 - Israel Norte
4. **Roof Material (exterior)**
   1 - sheet metal
   2 - clay tile
   3 - cement/asbestos sheets
   4 - tin cans or other discarded materials
   5 - asphalt-impregnated cardboard
   6 - palm leaf, or straw
   7 - flat cement sheets
   8 - other, specify ____________
5. **Gutter Material**
   1 - sheet metal
   2 - clay tiles
   3 - PVC pipe cut in half
   5 - other, specify ____________
   9 - not applicable (no gutter)

IF THE ANSWER TO NUMBER 5 IS CODE 9, NO OTHER INFORMATION IS NEEDED.

6. **Approximate length of the gutter across the roof:**
   1 - completely across one side of the roof
   2 - approximately 1/2 of one side
   3 - approximately 1/3 of one side
   4 - other, specify ____________________

7. **Type of drop from gutter to container:**
   1 - gutter to container (gutter does NOT enter container)
   2 - gutter to container (gutter DOES enter container)
   3 - metal pipe
   4 - PVC pipe into house or outside with no container underneath
   5 - plastic hose into house or outside with no container underneath
   6 - plastic hose to container underneath
   7 - other, specify ________________

8. **Container(s) seen below gutter:**
   Codes for "Covering":
   (1 - no; 2 - yes, part; 3 - yes, all)

Container(s)		**Number**	**Covering**
1 - metal barrel	(55 gals)	____	____
2 - plastic barrel	(gals)	____	____
3 - cement pila		____	____
4 - no container under gutter		____	____
5 - other, specify: ____________	(gals)	____	____
6 - other, specify: ____________	(gals)	____	____

Other observations on rainwater system of this house:
____
____

ANNEX 4b

RAINWATER STUDY
AGUA PARA EL PUEBLO AND UNICEF
TEGUCIGALPA, HONDURAS
SEPTEMBER/OCTOBER 1990
SECOND ROUND VISIT
SURVEY WITH FAMILIES WITH NO GUTTER ON ROOF

1. **House number:** __________
   (from map)

2. **Date:** ____ ____ **1990**
   day month

3. **Neighborhood:** 1 - Villa Nueva
   2 - Israel Norte

4. **The house is:** 1 - occupied, someone home
2 - uninhabited/abandoned
3 - occupied, no one home

VERIFY WITH NEIGHBORS IF THE HOUSE IS UNINHABITED. IF IT IS UNINHABITED, REPLACE WITH ANOTHER HOUSE FROM REPLACEMENT LIST.

5. **NAME OF HEAD OF HOUSEHOLD:**

____

6. **Do you collect rainwater?**

__________ yes/no

IF THE ANSWER IS YES, GO TO QUESTION 8. IF NO, ASK QUESTIONS 7 AND 15, THANK THE INTERVIEWEE AND END THE INTERVIEW.

7. **Why don't you collect rainwater?**
   1 - don't have money to buy gutter/containers
   2 - we don't like using rainwater
   3 - don't need much water
   4 - the roof is not good for collecting rainwater
   5 - other, specify ______________________________
8. **How do you collect rainwater?**
   1 - bring small containers out (free fall)
   2 - bring small containers out (put under roof)
   3 - use barrels from the yard
   4 - bring barrel from inside
   5 - use pila in yard
   6 - other, specify ______________________________

ASK QUESTION 9 IF FAMILY DOESN'T USE A BARREL OR OTHER LARGE CONTAINER (50 GALLONS OR MORE) TO COLLECT RAINWATER.

9. **Have you ever used a barrel or a larger container to collect rainwater?**

   __________ yes/no
10. **Why don't you use a barrel or larger container now?**
    1 - don't have money to buy barrel
    2 - don't need much water
    3 - other, specify ______________________________
11. **Have you ever used a gutter on the roof to collect rainwater?**

    __________ yes/no
12. **Why don't you use a gutter, now?**
    1 - don't have money to buy gutter
    2 - the roof is not good for collecting rainwater
    3 - have recently moved into this house
    4 - other, specify ______________________________
13. **During the rainy season, do you usually use rainwater for:**

    drinking? ________ yes/no

    cooking? ________

washing dishes? ________
bathing? ________
washing clothes? ________
cleaning house? ________

14. Would you show me the containers you usually use for collecting and storing rainwater?
LIST ALL CONTAINERS AND APPROXIMATE CAPACITY IN GALLONS.
Type of Container **Gallons**

____
____
____
____

SUBTOTAL GALLONS:__________

15. Do you use any other containers to store water from other sources (other than rainwater)?
___________ yes/no

IF THE ANSWER IS YES, LIST ALL CONTAINERS AND APPROXIMATE CAPACITY IN GALLONS.
Source of Water **Type of Container** **Gallons**

____
____
____
____

SUBTOTAL GALLONS:__________
TOTAL GALLONS: _________

ANNEX 4c

RAINWATER STUDY
AGUA PARA EL PUEBLO AND UNICEF
TEGUCIGALPA, HONDURAS
SEPTEMBER/OCTOBER 1990
SECOND ROUND VISIT
SURVEY WITH FAMILIES WITH A GUTTER ON ROOF
BUT NO CONTAINER UNDER GUTTER

1. **House number:** ___________
(from map)

2. **Date:** ____ ____ 1990
day month

3. **Neighborhood:** 1 - Villa Nueva
2 - Israel Norte

4. **The house is:** 1 - occupied, someone home
2 - uninhabited/abandoned
3 - occupied, no one home

VERIFY WITH NEIGHBORS IF THE HOUSE IS UNINHABITED. IF IT IS UNINHABITED, REPLACE WITH ANOTHER HOUSE FROM REPLACEMENT LIST.

5. **NAME OF HEAD OF HOUSEHOLD:**

____

6. **You have a gutter, but you don't have containers underneath. Do you collect rainwater?**

__________ yes/no

IF THE ANSWER IS YES, GO TO QUESTION 8. IF NO, ASK QUESTIONS 7 AND 13 AND THEN FINISH INTERVIEW.

7. **Why don't you collect rainwater?**
   1 - don't have money to buy gutter/containers
   2 - we don't like using rainwater
   3 - don't need much water
   4 - the roof is not good for collecting rainwater
   5 - other, specify ______________________________
8. **How do you collect rainwater?**
   1 - bring small containers out (free fall)
   2 - bring small containers out (put under gutter)
   3 - use barrels from the yard (put under gutter)
   4 - bring barrel from inside (put under gutter)
   5 - use pila in yard (use with gutter)
   6 - other, specify ______________________________

ASK QUESTION 9 IF FAMILY DOESN'T USE A BARREL OR OTHER LARGE CONTAINER (50 GALLONS OR MORE) TO COLLECT RAINWATER

9. **Have you ever used a barrel or larger container underneath the gutter to collect rainwater?**
   __________ yes/no
10. **Why don't you use a barrel or larger container now?**
    1 - don't have money to buy barrel
    2 - don't need much water
    3 - other, specify ______________________________
11. **During the rainy season, do you usually use rainwater for:**

drinking?	______	yes/no
cooking?	______	
washing dishes?	______	
bathing?	______	
washing clothes?	______	
cleaning house?	______	

12. **Would you show me the containers you usually use for collecting and storing rainwater?**
    LIST ALL CONTAINERS AND APPROXIMATE CAPACITY IN GALLONS.

Type of Container	**Gallons**

SUBTOTAL GALLONS:________

13. **Do you use any other containers to store water from other sources (other than rainwater)?**
___________ yes/no

IF THE ANSWER IS YES, LIST ALL CONTAINERS AND APPROXIMATE CAPACITY IN GALLONS.

Source of Water	Type of Container	Gallons

SUBTOTAL GALLONS: ___________
TOTAL GALLONS: ___________

ANNEX 4d

RAINWATER STUDY
AGUA PARA EL PUEBLO AND UNICEF
TEGUCIGALPA, HONDURAS
SEPTEMBER/OCTOBER 1990
SECOND ROUND VISIT
SURVEY WITH FAMILIES WITH A GUTTER ON ROOF AND SOME KIND OF CONTAINER UNDER GUTTER OR A HOSE/PIPE ENTERING THE HOUSE

1. **House number:** ___________
(from map)
2. **Date:** ____ ____ 1990
day month
3. **Neighborhood:** 1 - Villa Nueva
2 - Israel Norte
4. **The house is:** 1 - occupied, someone home
2 - uninhabited/abandoned
3 - occupied, no one home

VERIFY WITH NEIGHBORS IF THE HOUSE IS UNINHABITED. IF IT IS UNINHABITED, REPLACE WITH ANOTHER HOUSE FROM REPLACEMENT LIST.

5. **NAME OF HEAD OF HOUSEHOLD:**
____
6. **How many people live in this house?** ___________
7. **Do you collect rainwater?**
___________ yes/no

IF THE ANSWER IS YES, GO TO QUESTION 9. IF NO, ASK QUESTIONS 8 AND 12, THANK THE INTERVIEWEE AND FINISH THE INTERVIEW.

8. **Why don't you collect rainwater?**
   1 - don't have money to buy gutter/containers
   2 - we don't like using rainwater
   3 - don't need much water
   4 - the roof is not good for collecting rainwater
   5 - other, specify ______________________________

9. During the rainy season, do you usually use rainwater for:

If no, where do you usually get water

drinking? ________ ____________________
cooking? ________ ____________________
washing dishes? ________ ____________________
bathing? ________ ____________________
washing clothes? ________ ____________________
cleaning house? ________ ____________________

10a. How do you collect and save rainwater?

____

____

b. Do you take out more containers or do you use only the barrel/pila?

____

c. Do you use all the water or do you discard the first water from the roof?

____

d. Do you usually mix rainwater with water from other sources?

____

e. If you drink rainwater, how do you collect and store it to drink? Do you use the gutter?

____

f. If you drink rainwater, do you store it apart from other water? If so, how?

____

g. If you drink rainwater, do you mix rainwater to drink with water from other sources?

____

h. If you drink rainwater, do you treat in any way? If so, what kind of treatment do you use?

____

11. Would you show me the containers you usually use for collecting and storing rainwater?

LIST ALL CONTAINERS AND APPROXIMATE CAPACITY IN GALLONS.

Type of Container **Gallons**

____

____

____

____

SUBTOTAL GALLONS:__________

12. Do you use any other containers to store water from other sources (other than rainwater)?

___________ yes/no

IF THE ANSWER IS YES, LIST ALL CONTAINERS AND APPROXIMATE CAPACITY IN GALLONS.

Source of Water **Type of Container** **Gallons**

____

____

____

____

SUBTOTAL GALLONS: ___________

TOTAL GALLONS: ___________

IF THE FAMILY USES BARRELS TO COLLECT RAINWATER, ASK QUESTIONS 13 TO 15. IF THEY

DON'T USE BARRELS, GO TO QUESTION 16.

13. Do you use rainwater directly from the barrel for:

drinking? ________ yes/no
cooking? ________
washing dishes? ________
bathing? ________
washing clothes? ________
cleaning house? ________

14. Where did you get the barrel you are using to collect rainwater?

1 - gas station
2 - factory
3 - laboratory
4 - bought it from vendor in the neighborhood
5 - it was given to me
6 - from a construction site
8 - don't know

15. Do you know what the barrel was used for before you got it?

1 - water
2 - oil
3 - grease
4 - corn
5 - glue
6 - lime
7 - paint
8 - it was new
9 - don't know

16. During the rainy season, does rainwater provides you with:

1 - less than half the water you need
2 - about half the water you need
3 - more than half the water you need

17. Do you think you could collect more rainwater than you do now if you had more or larger containers?

____________ yes/no

IF THE ANSWER IS YES, ASK QUESTION 18. IF NO, GO TO QUESTION 19.

18. How many additional containers do you think you would need to collect all the water you need in the rainy season?

LIST THE TYPE AND NUMBER OF CONTAINER AND THE ESTIMATED NUMBER OF ADDITIONAL GALLONS NEEDED.

Type of Container	Number	Gallons

19. What do you think about the quality of the rainwater you collect? Do you think that FOR DRINKING rainwater is:

1 - good quality
2 - more or less regular quality
3 - bad quality

20. Do you think you could improve the quality of the rainwater you collect?
___________ yes/no

IF THE ANSWER IS YES, ASK QUESTION 21. IF NO, GO TO QUESTION 22.

21. What could be done to improve rainwater quality?
____
____

22. Can you think of any other ways, in addition to the ones we have discussed, you could improve the rainwater system that you have now?
___________ yes/no

IF THE ANSWER IS YES, ASK QUESTION 23. IF NO, GO TO QUESTION 24.

23. What other kinds of improvements could you make?
____
____

24. If you had access to credit to improve your system of rainwater collection, would you be interested in using credit?
_____________ yes/no

IF THE ANSWER IS YES, ASK QUESTION 25. IF NO, GO TO NUMBER 26.

25. What kind of improvements would you make using credit? How much do you think each of these improvements would cost?

Improvement	Cost

26. Roof measurements _______ **x** _______ **=** _________ **mt²**

27. Measurement of gutter #1: ___________ mt
gutter #2: ___________ mt

UNICEF / HONDURAS
Apartado Postal 2850
Tegucigalpa, Honduras
Central America
Telephone, (504) 31-1612/1614
Fax, (504) 32-5884
Telex, 1702UNICEF HO

AGUA PARA EL PUEBLO
Apartado Postal 1149
Tegucigalpa, Honduras
Central America
Telephone, (504) 31-4359
Fax, (504) 31-4328