CERAMIC WATER PURIFIER
CAMBODIA FIELD TESTS

IDE Working Paper No. 1

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Cover Photo:
Ceramic Water Purifiers are air-dried for up to one week prior to firing at the Kampong Chhnang production facility in Cambodia.

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Abbreviations

B3M	Baseline and Third-Month (survey)
CG1	Control Group 1
CGC	Control Group Comparison (survey)
CIDA	Canadian International Development Agency
CWP	Ceramic Water Purifier
FHH	Female-headed household
HH	Household
IDE	International Development Enterprises
mL	millilitre
NGO	Non-Governmental Organization
WHO	World Health Organization
riel	Cambodian Currency (4,000 riel = US$1.00)

EXECUTIVE SUMMARY

This report summarizes results from a year-long pilot project in Cambodia to test the Ceramic Water Purifier, a low-cost household water treatment technology that removes microbiological contamination at the point of use. The pilot project was conducted by International Development Enterprises (IDE) with financial assistance from the Health and Nutrition Initiatives Fund supported by the Canadian International Development Agency (CIDA).

The Ceramic Water Purifier (CWP) consists of a porous, pot-shaped filter element made of kiln-fired clay and impregnated with colloidal silver. The ceramic filter element is set in a plastic receptacle tank with a lid and a spigot. Raw water is poured into the filter element and seeps through the clay producing potable water at a rate of 2 to 3 litres per hour. The filter element holds approximately 10 litres, allowing a family to produce 20 to 30 litres of water per day with two to three fillings. Monthly maintenance consists of scrubbing the ceramic filter element to unclog pores and washing the receptacle tank and spigot to prevent bacterial growth. The current cost of the CWP is approximately $7.50 for a complete unit (including manufacturer and retailer profit but not including transportation) and approximately $4.50 for the filter element alone, which needs to be replaced about once every two to three years.

Field Tests

One thousand CWPs were distributed in twelve rural villages to test their performance under conditions of household use. The following investigations were conducted:

- Micro-biological water quality tests were conducted on water samples collected from CWPs prior to installation (n=100), CWPs after installation in rural households (n=686), and input water sources (n=75). Duplicate samples were also tested to check the reliability of lab results (n=75).
- All recipient households (n=1,000) were interviewed prior to receiving their CWP and three months after CWP delivery to assess water-related expenses, adequacy of water volume, compliance with recommended hygiene practices, and user satisfaction.
- A subset of the recipient households (n=101) was interviewed to determine the impact on CWP-users after approximately one-year of use relative to a control group (n=100) that did not have CWPs. The survey measured incidence of diarrhea, time and expense savings, and compliance with recommended hygiene practices.

Results

Under laboratory conditions, water quality tests on 100 CWPs showed 100% removal of faecal *E. coli* and total coliforms. Under conditions of household use, 98% to 99% of CWPs produced water meeting WHO low-risk guidelines or better (i.e., 10 or fewer *E. coli* per 100 mL). This percentage did not depend on the length of time that the CWP had been used in the household but remained constant over the year-long test period. Nor did the percentage depend on the quality of the input water; CWPs were equally effective at purifying water regardless of the input water quality, within the limits of the water sources tested. Input water sources included rivers, lakes, tube wells, lined and unlined open wells, ponds, and rainwater.

The type of benefits experienced by CWP users depended in large part on their water treatment practices prior to receiving the CWP. Households that boiled their drinking water prior to using the CWP saved time and expenses related to water boiling. Sixty-nine percent of recipient households boiled water ‘always’ or ‘sometimes’ prior to using the CWP. Almost all stopped boiling after using the CWP. Most water-boilers (89%) collected their firewood themselves and saved 22 hours per month in time spent gathering firewood and boiling water.

Those water-boilers that purchased firewood (11%) saved an average of about $1.40 per month in firewood expenses and approximately 16 hours per month in time spent boiling water. The household surveys were not able to determine definitively whether using the CWP resulted in health improvements for households that were already boiling their drinking water. This knowledge gap should be the subject of future studies.

Households that did not boil their drinking water prior to using the CWP did not save on water boiling expenses but did show significant health improvements. The CWP allowed recipient households to achieve and/or maintain a lower incidence of diarrhea for less cost than boiling water. When compared to non-boiling, non-CWP households, CWP users had 17% more households reporting no diarrhea in the past month, about half as many diarrhea cases per person, about a third of the diarrhea treatment expenses per person, and about four times fewer work/school days missed per person.

Regardless of prior water treatment practices, all CWP users realized savings in time and/or expenses that would allow the CWP to pay for itself in six months or less.

Almost all households (98%) reported a high degree of satisfaction with the CWP saying that it produced good tasting water, was easy to maintain, and was important to the family because of health benefits and elimination of the need to boil water. Households typically fill the CWP two to three times per day producing 20 to 30 litres of clean water, which was adequate for the daily drinking needs of households with up to nine people (average household size was 5.8). More than one-third of households reported having enough water for additional uses including cooking, vegetable washing, and face washing.

No significant differences were identified between the CWP impacts on female-headed households (who made up 35% of CWP recipients) and male-headed households. Within households, it was found that males suffered from more diarrhea cases than females prior to using the CWP. Accordingly, the use of the CWP resulted in a larger impact on male diarrhea cases (55% reduction) than on females diarrhea cases (26% reduction). Many of the CWP impacts were biased toward improving the situation of women. Women are the primary beneficiaries of time saved in water boiling and care of sick family members. Since women in Cambodia are usually the managers of daily household expenses, they also benefit directly from money saved on purchases of water, firewood, and medications.

During the pilot project training, CWP recipients were advised to clean the ceramic filter element and plastic receptacle twice per week. IDE now believes that this frequency is excessive and that cleaning the filter too often increases the chance of breakage due to handling and contamination due to contact with dirty hands, surfaces, etc. IDE now recommends that the ceramic filter element be cleaned once per month, or when the flow rate drops significantly, and that the plastic receptacle tank should be cleaned at the same time.

The rate of accidental filter breakage during household use was 0.6% per month. In other words, for every thousand CWPs being used in rural households, an average of six were accidentally broken each month. The revised recommendation for cleaning frequency is expected to lead to less filter breakage as a result of reduced handling.

After one year, approximately 20% of recipients had stopped using the CWP regularly. About half of those were due to broken ceramic filter elements. IDE expects that the rate of abandonment will decrease as a result of the revised cleaning recommendations and as replacement filters become available in local markets. Even at 20%, the abandonment rate is relatively low given that the CWPs were distributed free of charge in this pilot project. Abandonment is likely to be less common among households that purchase CWPs using their own funds.

1 INTRODUCTION

From May 2002 through June 2003, International Development Enterprises (IDE) implemented a pilot project to test the effectiveness of the Ceramic Water Purifier (CWP) under conditions of rural household use. The project received financial assistance from the Health and Nutrition Initiatives Fund supported by the Canadian International Development Agency (CIDA). This report summarizes the pilot project methodology and the results from water quality testing and household impact surveys.

1.1 Ceramic Water Purifier

Colloidal silver impregnated ceramic water purification technology was developed in 1981 by ICAITI, an industrial research institute in Guatemala, and intensively promoted since 1998 by Potters for Peace, an NGO operating in Nicaragua.[1] Tens of thousands of Ceramic Water Purifiers (CWPs) are currently in use in Central America, Africa, and Asia.

The CWP consists of a porous, pot-shaped filter element made of kiln-fired clay and impregnated with colloidal silver. The ceramic filter element is set in a plastic receptacle tank with a plastic lid and a spigot. The filter element is manually filled with water from a contaminated source, which seeps through the clay at a rate of 2 to 3 litres per hour. The filter element holds approximately 10 litres, allowing a family to produce 20 to 30 litres of water per day with two to three fillings.

The filtering effect of the clay eliminates a large portion of water-borne pathogens but laboratory tests indicate that the colloidal silver is necessary to achieve complete disinfection. A study funded by USAID in Nicaragua found that the CWP effectively deactivates 98-100 percent of *E. coli*, *Cryptosporidium*, and *Giardia*. The study further concluded that “with an education component for the users, the… filter is an effective and appropriate technology that improves both water quality and human health.”[2]

Colloidal silver is an anti-bacterial agent that was used extensively in medical practice prior to the development of antibiotics in the 1940s and 50s.[3] The amount of silver leached from the CWP to the filtered water is negligible (far below WHO guidelines for silver concentration in drinking water) and therefore has no effect on users’ health.[4]

Maintenance recommendations for the CWP include monthly scrubbing of the filter element using a soft brush or cloth to clear clogged pores and washing the plastic receptacle tank with soapy water to prevent bacterial growth. There is no sand, charcoal, or other media to maintain. The CWP units are lightweight and portable. Care must be taken however during transport and handling to avoid breakage.

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[1] Potters for Peace board member Manny Hernandez, Professor at Northern Illinois University, and Ron Rivera, Technical Expert with Potters for Peace in Nicaragua, introduced IDE Cambodia to the CWP technology and provided technical support during visits to Cambodia in 2000, 2001, and 2003. Potters for Peace has been a driving force behind the international dissemination of the CWP technology. Their website is at www.potpaz.org.

[2] Lantagne, Daniele S. *Investigations of the Potters for Peace Colloidal Silver Impregnated Ceramic Filter, Report 1: Intrinsic Effectiveness*. Alethia Environmental. Allston, MA. December 2001.

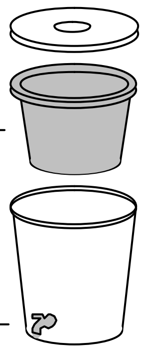
[3] Gibbs, Ronald J., *Silver Colloids: Do They Work?*, Center for Colloidal Science, University of Delaware, 1999

[4] Lantagne, Daniele S., op. cit.

Laboratory tests indicate that the colloidal silver coating will last at least several years before losing effectiveness.[5] Decreasing flow rate due to progressive clogging of pores or accidental breakage of the filter element are likely to be the limiting factors to the CWP lifespan. Clogged or broken filter elements can be replaced at relatively low cost.

The retail price of the CWP in Cambodia is currently about $7.50 for the complete unit and $4.50 for the ceramic filter element alone. These prices include profit margins for manufacturer and retailers but do not include the cost of transportation.

Figure 1: Parts of the Ceramic Water Purifier



2 PILOT PROJECT IMPLEMENTATION

CWP units were distributed to 1,000 households in Kampong Chhnang and Pursat provinces in Western Cambodia. Ten female Field Trainers were seconded from the Departments of Health in each province (five Field Trainers from each province) to assist with CWP distribution, training, and follow-up. The Field Trainers were supported by two female IDE Supervisors based in the project provinces. Field Trainers and Supervisors received training in the operation and maintenance of the CWP and associated hygiene messages.

The CWPs were distributed in twelve villages selected by Provincial Health Departments. Recipient households within each village were selected by village leaders. Summary data for each of the CWP project villages is given in Table 1 below.

Distribution occurred simultaneously in all twelve villages from July 2002 through January 2003. Field Trainers distributed 15 to 20 CWPs on each distribution day. Adult females from the selected households attended a meeting lasting approximately two hours, during which the CWPs were distributed and the recipients received training on the points listed below. Recipients also received printed material with text and photographs conveying the same information:

- The ceramic filter element should be immersed in clear water for 12 hours before using it for the first time. (This removes the clay smell from the filter element.)
- The plastic receptacle and spigot should be cleaned with soapy water before using it for the first time.
- Thereafter, the plastic receptacle and spigot should be cleaned with soapy water two times per week,

[5] Lantagne, Daniele S., op. cit.

- The inside of the ceramic filter element should be scrubbed with a soft brush or cloth two times per week,[6]
- Do not touch the outside of the ceramic filter element, the inside of the plastic receptacle, or the mouth of the spigot with hands. Do not set the ceramic filter element on an unclean surface.
- Clean hands and glasses with soap and water before drinking or eating,
- It is not necessary to boil water after it has been filtered,
- Use only filtered water for drinking.

Field Trainers conducted regular follow-up visits to individual CWP recipients to reinforce training messages and monitor project impacts. Follow-up visits continued from the time of distribution until the end of the project in June 2003. On average, each recipient received a follow-up visit once every month.

Table 1: CWP Project Villages

Province	District/ Commune	Village	Total Households [a]	Total CWP Recipients	Percentage Recipients
Kampong Chhnang	Baribour/ Phsar	Kbal Thnal	178	93	52%
		Komprong	119	80	67%
		Phniet	139	77	55%
	Rolea Bier/ Andoung Snay	Andong Chrey	93	85	91%
		Pahi	117	86	74%
		Tbaeng	114	79	69%
Pursat	Bakan/ Ou Ta Paong	Samrang Pok	103	85	83%
		Sdok Khlok	295	80	27%
		Sras Run	121	85	70%
	Krakor/ Kampong Luong	Phum 2	97	80	82%
		Phum 3	84	84	100%
		Phum 4	227	86	38%

(a) General Population Census of Cambodia (1998)

3 WATER QUALITY TESTING

Micro-biological water quality tests were conducted on a total of 936 water samples collected between August 2002 and June 2003. Tests were conducted at the Ministry of Health's National Laboratory for Drug Quality Control in Phnom Penh using the membrane filtration method.

Water samples were collected by IDE field staff and delivered to the laboratory on a weekly schedule according to the following protocol:

- Sterilized, sealed, 500-milliliter glass sample bottles were obtained from the laboratory on Friday.
- Water samples were collected from the project villages on Monday and Tuesday and delivered to the laboratory on Tuesday evening or Wednesday morning. Between 25 and 32 samples were collected each week

[6] These recommendations for cleaning the ceramic filter element and receptacle tank are now believed to be unnecessarily frequent. IDE now recommends that the ceramic filter element be cleaned once per month, or when the flow rate drops significantly, and the receptacle tank should be cleaned at the same time.

- Before collecting the sample, existing water in the plastic receptacle tank was emptied and new water from the household's normal water source was placed in the ceramic filter element. The first 500 mL of water to seep through the filter element into the plastic receptacle tank was collected in the sample bottle through the spigot at the bottom of the receptacle-tank. This procedure approximated normal household use while eliminating the variable of time that water resides in the plastic receptacle tank.
- The sample collector's hands and the outside of the spigot were cleaned with alcohol before collecting each sample.
- Full sample bottles were immediately sealed and placed in an insulated ice box and kept cold until delivery to the laboratory. At the laboratory, samples were placed in a refrigerator until testing, which occurred one to three weeks after the delivery date.

In this analysis, water quality is assessed based on the count of thermo-tolerant coliform bacteria (faecal *E. coli*) per 100 millilitres of water. The World Health Organization (WHO) recommends the following guidelines for rural water supplies:

Table 2: WHO Water Quality Guidelines for Rural Drinking Water Supplies

Faecal *E. coli* count per 100 mL	Classification
0	Conforms to WHO guidelines
1-10	Low Risk
10-100	Intermediate Risk
100-1000	High Risk
>1000	Very High Risk

Source: Guidelines for drinking-water quality, Second edition, Volume 3, Surveillance and control of community supplies, World Health Organization, Geneva, 1997, p. 78.

3.1 Pre-Installation Tests

Water samples were collected from 100 new CWPs chosen randomly from stock prior to installation and tested under laboratory conditions in Phnom Penh.

Untreated Mekong River water from Phnom Penh was used as the input water for the tests. Four samples collected from the input water gave the following results.

Table 3: Quality of Source Water for Pre-Installation Tests

Sample date	2/10/02	16/10/02	23/10/02	13/11/02
Total coliform (/100mL) [a]	>23	>23	>23	>23
Faecal *E. coli* (/100mL) [a]	1.1	3.6	12	>23

(a) The maximum count in these tests was 23 per 100 mL. Higher values were reported as "more than 23"

All samples showed 100% removal of total coliform and *E. coli*. Under controlled conditions, therefore, the CWP has very high removal rates of coliform bacteria (100% in this test series). Any reduction in effective removal of *E. coli* in the field samples can thus be attributed to household-level factors such as filter operation, maintenance, and hygiene practices.

3.2 Source Water Tests

Water samples were taken from 71 selected water points within the project villages. Sampling sites were selected to provide broad coverage of the normal water sources used by recipient households, including tube wells, open wells, ponds, rivers, and the Tonle Sap lake. Samples were collected in three batches between April and June 2003.

Table 4 below presents the results of source water quality tests. Results are given for the entire sample (n=71), which combines data from all water sources. Results are also disaggregated by the type of water source to indicate the differences in quality of water from the various sources.

Table 4: Quality of Source Water for the Post-Installation Tests

Percentage of samples conforming to each WHO risk level	All Sources	Disaggregated by Type of Water Source			
		Tube well	Open well	Pond	River or Lake
Conforms to WHO Guidelines (zero *E. coli*)	28%	50%	19%	20%	17%
Low Risk (1 - 10 /100mL)	28%	9%	41%	10%	50%
Intermediate Risk (10 - 100 /100 mL)	35%	36%	30%	60%	25%
High Risk (100 - 1000/100 mL)	7%	0%	11%	10%	8%
Very High Risk (>1000 /100 mL)	1%	5%	0%	0%	0%
Intermediate Risk or Worse (>10 /100 mL)	43%	41%	41%	70%	33%
Percentage of recipient households using the specified water source [a]	99%	8%	57%	14%	20%
Sample Size (% of total sample)	71 (100%)	22 (31%)	27 (38%)	10 (14%)	12 (17%)

(a) Data from IDE baseline survey: 99% used the water sources listed here, 1% used rainwater.

Out of the 71 water sources tested, 43% had water quality at the WHO ‘intermediate risk’ level or worse. Among the water sources commonly used by CWP recipients, rivers/lakes were found to have the best water quality (33% ‘intermediate risk’ or worse), followed by tube wells and open wells (each with 41% ‘intermediate risk’ or worse), and finally pond water (70% ‘intermediate risk’ or worse).

Water from all sources was of significantly lower quality than the CWP output water (see Post-Installation tests, Section 3.3), indicating that the CWPs are in fact improving the quality of the source water.

3.3 Post-Installation Tests

A total of 686 samples were chosen randomly from the entire population of CWP recipients. Distribution was continuing at the same time as the water quality testing so the total population from which samples were selected was continually growing. It was possible for individual households to be selected more than once but at different times (this occurred in 59 out of the 686 samples). The length of time that had elapsed between the date of CWP installation in the household and the water sampling date varied from 12 days to 348 days with a mean of 113 days (3.7 months).

The input water for the tests consisted of untreated water from the normal water source of the recipient household. The type of water sources used by CWP recipients and the quality of water from those sources is discussed in Section 3.2.

Table 5 presents the results of the post-installation tests. The first column of the table gives results for the entire sample (n=686). Ninety-nine percent of the CWPs installed in rural households produced water meeting WHO ‘low risk’ guidelines or better, and 1% of the CWPs produced ‘intermediate risk’ water. No CWPs produced ‘high risk’ or ‘very high risk’ water.

The water-quality results in Table 5 are disaggregated in three ways. First, results are broken down by the length of time that had elapsed since installing the CWP to test the hypothesis that the number of CWPs producing good quality water would decrease over time. The relationship between elapsed time and water quality is also illustrated in Figure 2. The data indicate that the percentage of CWPs producing ‘low risk or better’ water remains fairly constant, varying only slightly between 98% and 100%. There was, however, a shift over time toward more ‘low risk’ samples and fewer ‘zero *E. coli*’ samples, indicating a reduction in water quality for some users, but still within safe limits. The trend appears to stabilize after one year with approximately 64% of CWPs producing ‘zero *E. coli*’ water and approximately 34% producing ‘low risk’ water (Figure 2).

Second, results are broken down by water source to test the hypothesis that the quality of output water would vary with the quality of the input water. Results in parentheses have been adjusted to account for the length of time elapsed since installation. The time-corrected values show relatively little variation in the proportion of ‘zero *E. coli*’ samples and ‘low risk samples.’ The variation that does exist is not strongly correlated to the quality of the input water (Section 3.2). Thus, CWPs appear to be equally effective at purifying water regardless of the input water quality, within the limits of the input sources tested.

Third, results in Table 5 are disaggregated by the gender of the household head to test the hypothesis that the CWP effectiveness would differ in male- and female-headed households. Results indicate that the quality of the CWP water produced in female-headed households was better than in male-headed households, but only marginally so. No time correction was needed for the gender disaggregated data since the average elapsed time of both the male- and female-headed household groups was approximately equal to the benchmark time of 3.7 months (i.e., the average elapsed time for the entire sample).

Table 5: Results of Post-Installation Water Quality Tests

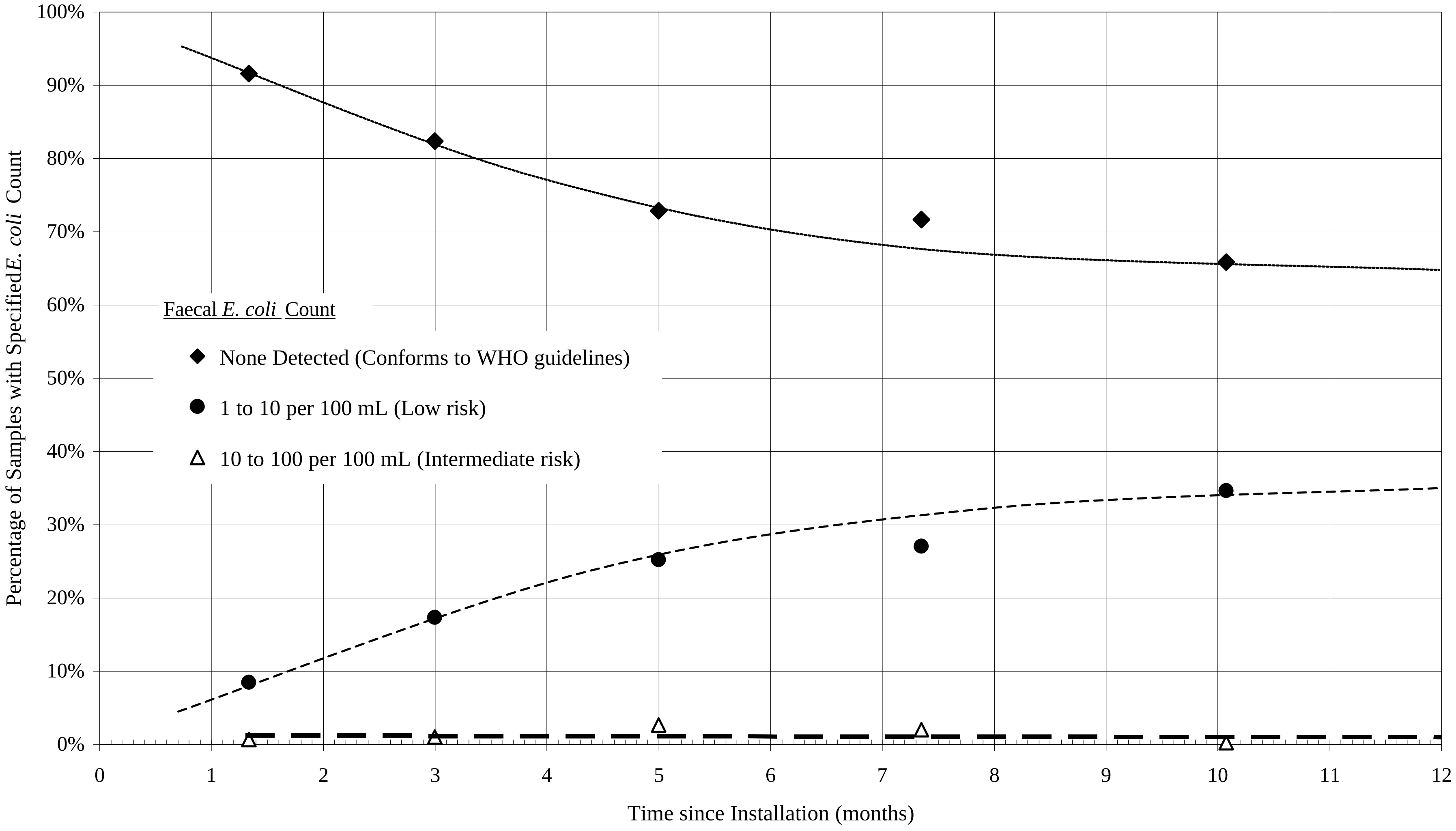
Percentage of samples conforming to each WHO risk level	Entire sample	Disaggregated by elapsed time since installation					Disaggregated by water source					Disaggregated by gender	
		0 to 2 months	2 to 4 months	4 to 6 months	6 to 9 months	9 to 12 months	Tube well	Open well	Pond	River or lake	Rain water	Male-headed HH [c]	Female-headed HH
Conforms to WHO Guidelines (zero *E. coli*)	81%	91%	82%	73%	71%	66%	87% (83%)[a]	82% (81%)	77% (78%)	77% (80%)	100% (100%)	79%	83%
Low Risk (1 to 10 /100mL)	17%	8%	17%	25%	27%	34%	11% (15%)	17% (18%)	22% (21%)	21% (17%)	0% (0%)	19%	16%
Intermediate Risk (10 to 100 /100 mL)	1%	1%	1%	2%	2%	0%	2%	1%	1%	3%	0%	2%	1%
High or Very High Risk (>100 /100 mL)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Low Risk or better (0 to 10 /100 mL)	99%	99%	99%	98%	98%	100%	98%	99%	99%	97%	100%	98%	99%
Average elapsed time (months)	3.7	1.3	3.0	5.0	7.3	10.1	3.1	3.5	4.0	4.7	3.9	3.7	3.8
Sample size [b]	686	219	123	168	56	32	54	386	94	107	7	394	256

(a) Data in parentheses ( ) have been corrected for elapsed time using the relationships illustrated in Figure 2. All values were adjusted to the benchmark time of 3.7 months, which is the average elapsed time of the entire sample.

(b) The sum of the disaggregated sample sizes is less than the total sample size because the elapsed time, water source, and household gender were not available for every CWP test.

(c) HH = Household

Figure 2: CWP Water Quality versus Time since Installation in Household



3.4 Duplicate Tests

In order to check the reliability and consistency of the laboratory results, 75 duplicate samples were submitted for testing. Each batch of samples sent to the laboratory had between two and five duplicate samples. Duplicate samples were taken from the same source at the same time as one of the other samples. Laboratory staff did not know which samples were duplicates or even that duplicate samples were submitted. The samples to be duplicated were selected randomly from the weekly collection schedule. Approximately 10% of the Post-Installation samples were selected for duplication and approximately 20% of the Source Water samples were selected for duplication.

Four out of the 75 duplicate samples (5%) showed an inconsistency in the count of fecal *E. coli*. An inconsistency was defined as a variance of at least one order of magnitude (i.e., one multiple of ten) between two samples from the same source. Differences of this scale would lead to classification of the sample in a different WHO risk level.

We conclude that the National Laboratory for Drug Quality Control produces reasonably consistent and replicable water quality results.

4 BASELINE AND THIRD-MONTH SURVEY

4.1 Methodology

In the Baseline and Third Month (B3M) survey, all 1,000 CWP-recipient households were interviewed by the Field Trainers prior to receiving their CWP (baseline) and at three months after CWP delivery. The surveyors gathered information on health, water-related expenses, adequacy of water volume, compliance with recommended hygiene practices, and user satisfaction. Questions from the survey questionnaire are included in Appendix A.

Methodological difficulties with the health-related questions prevented any useful conclusions and therefore that data is not presented here. Health-related impacts are instead addressed in the Control Group Comparison Survey (Section 5).

4.2 Results

Table 6 compares and summarizes the household situation at baseline and after using the CWP for three months. The Table also separates out results from female-headed households, which made up 35% of the entire sample. The main findings of the survey include:

- The CWP resulted in time and expense savings for 69% of the respondents by eliminating the need for water boiling,
- The CWP resulted in expense savings for 9% of the respondents by eliminating the need to purchase drinking water,
- The majority of respondents followed hygiene recommendations,
- The CWP provided an adequate volume of water for the respondent households,
- Users indicated a high level of satisfaction with the CWP, and
- Results for female-headed households did not differ significantly from results for the entire survey population.

Table 6: Results of Baseline and Third-Month Survey

Respondent Data			**Total [a]**	**FHH [b]**
	Sample size		1,000 (100%)	354 (35%)
	Number of household members	90th percentile Mean 10th percentile	9 5.8 3	8 5.2 2
	Average monthly cash income		47,674 riel ($11.92)	44,972 riel ($11.24)
	Average distance to nearest water source		283 m	300 m
	HHs with the following water sources:	Open well River Pond Tube well Lake Rainwater	57% 18% 14% 8% 2% 1%	54% 25% 13% 8% 1% 1%
Water Boiling			**Total**	**FHH**
Baseline	HHs that always boil HHs that sometimes boil HHs that never boil		28% 41% 31%	33% 32% 35%
	Average monthly firewood expense for those who boil		5,591 riel ($1.40)	5,690 riel ($1.42)
Third month	HHs that still boil		0.5%	0.3%
Conclusion	69% of households boiled water prior to using the CWP. Almost all stopped boiling after using the CWP, saving an unquantified amount of time on water boiling and an average of $1.40 per month on firewood. (For those respondents who collected firewood instead of purchasing it, the market value of the collected firewood was recorded during the survey). Results for FHHs were similar to the results for the entire survey population.			
Water Purchases			**Total**	**FHH**
Baseline	HHs that purchase clean water for drinking		9%	13%
	Average monthly water expense for those who purchase		8,438 riel ($2.11)	8,068 riel ($2.02)
Third month	HHs that still purchase water		0%	0%
Conclusion	Prior to using the CWP, 9% of households purchased water regularly. After receiving the CWP, none of the respondents continued purchasing water resulting in an average cost savings of $2.11 per month. FHHs were more likely to purchase drinking water (13%) and the CWP allowed them to save $2.02 per month in water expenses.			

…continued

Hygiene		**Total**	**FHH**
Baseline	No baseline		
Third month	HHs that clean their CWP two or more times per week HHs that clean their drinking cups daily	97% 71%	98% 74%
Conclusion	Households report a high rate of compliance with CWP operation and hygiene recommendations. FHH results did not differ significantly.		
Adequacy of Water Volume		**Total**	**FHH**
Baseline	Average reported household water use: Drinking Other uses	11 L/day 90 L/day	11 L/day 79 L/day
Third month	Number of people using each CWP: 90th percentile Mean 10th percentile	9 5.7 3	8 5.1 2
	HHs using CWP for drinking water	99%	99%
	HHs using CWP as their sole source of drinking water	90%	92%
	Water uses in addition to drinking: Cooking Wash vegetables Wash face Other	38% 31% 11% 38%	45% 30% 9% 37%
	Average number of times CWP filled per day (one filling = ~10 litres)	2.2	2.2
	HHs reporting that the CWP provides sufficient water	99%	99%
Conclusion	With 2 to 3 fillings per day, the CWP provides enough water for the drinking needs of households with up to nine members. Many households had enough for additional uses such as cooking, vegetable washing, and face washing. FHH results were similar to the results from the entire sample, except for a slightly smaller number of CWP users.		
User Satisfaction		**Total**	**FHH**
Baseline	No baseline		
Third month	HHs reporting that water from the CWP has good taste	99%	99%
	HHs reporting that CWP maintenance is easy	97%	98%
	HHs reporting that CWP is important to their family	99%	100%
	Reasons for importance: Health improvement No need to boil Save money Easy to use Other	25% 11% 5% 3% 4%	28% 11% 6% 2% 5%
	Overall satisfaction with CWP: High Moderate Low	95% 5% 0%	95% 5% 0%
Conclusion	Households report a high degree of satisfaction with the CWP. Health improvement was the most important benefit cited by users. FHH results were nearly identical.		

(a) Total = all respondents including male- and female-headed households

(b) FHH = female-headed households only

5 CONTROL GROUP COMPARISON SURVEY

In August 2003, IDE surveyed a sub-set (n=101) of the total CWP-recipient population to determine the impact on CWP households relative to a control group (n=100) that did not have CWPs. The survey measured incidence of diarrhea, time and cost savings, and compliance with recommended hygiene practices after approximately one year of CWP use.

5.1 Methodology

Only households that used open wells and/or ponds as their primary water source were included in the Control Group Comparison (CGC) survey. These are two of the poorer quality water sources commonly used in rural Cambodia (see Table 4 and Table 10) and thus provided an opportunity to assess the CWP under 'worst case' conditions. Two CWP project villages were selected based on the large number of residents using open wells and ponds as water sources. 101 respondents were selected randomly in the two villages from a list of CWP recipients who used those water sources.[7] Since the CGC survey respondents were biased toward users of ponds and open wells and were located in only two of the original twelve villages, they do not necessarily form a representative sub-set of the 1,000 respondents in the B3M survey (Section 4). Thus, comparisons between the two surveys should be considered indicative only.

For each of the project villages, a nearby control village was selected where CWPs had not been distributed. Selection of the control villages was based on proximity, similar village size, similar water sources, and similar socioeconomic conditions (based on the qualitative assessment of local officials). Within each control village, a list of households using ponds and open wells as their primary water source was compiled with the help of village leaders and residents. 100 respondents were selected randomly, 50 from each village list.

All villages for the CGC survey were located in Ou Ta Paong commune, Bakan district, Pursat province. IDE staff conducted questionnaire interviews with a total of 201 respondents from the four villages. Summary data for each village is given in Table 7 below and the survey questionnaire is included in Appendix B.

Table 7: Villages for Control Group Comparison Survey

	Village Set 1		Village Set 2	
	CWP	Control	CWP	Control
Village name	Srah Run	Oknha Moan	Samraong Pok	Prey Krabau
Total households [a]	120	147	127	97
Total survey respondents	50	50	51	50
Open wells (lined and unlined)				
Number of wells	4	12	7	7
% Respondents using wells	34%	98%	76%	98%
Ponds				
Number of ponds	3	7	15	2
% Respondents using ponds	58%	4%	10%	24%
Rainwater				
% Respondents using rainwater	38%	16%	14%	6%

(a) Count obtained at the time of the survey from the household list maintained by the village chief.

[7] Because the survey was conducted in the wet season, many respondent households were also using rainwater in addition to open wells and/or ponds.

Out of the 101 households surveyed in the CWP villages, 40 had stopped using their CWPs regularly (reasons for stopping are discussed in Section 5.2.1). The presence of CWP recipients that had stopped using their CWPs prior to the survey provided an opportunity to define an additional control group. Thus, the CWP users in the pilot project villages can be compared with the non-users in the same villages *and* with the non-users in the control villages. Table 8, below, characterizes the Test Group and Control Groups according to their water treatment practices.

Table 8: Test Group and Control Group Profiles

Group	Sample size	Location	CWP use	Water boiling
Test Group	61	CWP villages	Users	90% never
Control 1 (CG1)	40	CWP villages	Stopped use [a]	95% never
Control 2 (CG2)	26	Control villages	Non-users	100% usually or always
Control 3 (CG3)	23	Control villages	Non-users	100% sometimes
Control 4 (CG4)	51	Control villages	Non-users	100% never

(a) Households that had received CWPs but stopped using them at least one month prior to the survey.

5.2 Results

Results of the CGC survey are summarized in Table 9 and discussed in the following sections.

5.2.1 Rate of Abandonment

In the two villages that had received CWPs, it was found that 40 out of 101 households surveyed had stopped using their CWPs regularly. Five respondents reported that they used their CWP sometimes and 35 reported that they never used it.

Out of the 35 never-users, 25 stopped when their plastic spigot broke. The plastic spigot that was included with the pilot project CWPs has since been replaced by a more durable metal spigot on new CWPs, effectively eliminating the spigot breakage problem.[8]

Another seven never-users stopped using the CWP when their clay filter element broke. Seven broken filter elements out of a total sample of 101 over a time period of approximately one year is consistent with the breakage rate of 0.6% per month calculated in Section 6. Recent revisions to the recommended cleaning frequency (from twice per week to once per month) are expected to reduce filter breakage as a result of less handling.

IDE expects that CWP abandonment will be reduced further when affordable replacement filter elements are available through local market channels. IDE is currently working to lower the CWP cost and to develop a private sector distribution system. No such distribution system existed during the pilot project.

[8] During the survey, respondents were told where they could obtain a replacement spigot if they wished to resume using their CWP.

Table 9: Results of the Control Group Comparison Survey

	CWP Villages		Control Villages		
	Test Group	CG1 [a]	CG2	CG3	CG4
	Always/ Usually Use the CWP	Sometimes/ Never Use the CWP	Always/ Usually Boil Water	Sometimes/ Boil Water	Never Boil Water
Respondent data					
Sample size	61	40	26	23	51
Average HH size	5.8	6.1	5.0	6.3	6.0
Average time since CWP delivered (months)	11.3	11.4	---	---	---
% Female-headed HHs	15%	13%	19%	17%	18%
% Female survey respondents	66%	63%	73%	57%	59%
% Respondents from					
Srah Run	57%	38%	---	---	---
Samraong Pok	43%	62%	---	---	---
Oknha Moan	---	---	42%	65%	47%
Prey Krabau	---	---	58%	35%	53%
Water source [b]					
% HH that use					
Lined open wells	31%	63%	85%	96%	100%
Unlined open wells	10%	15%	8%	4%	0%
Ponds	44%	18%	12%	9%	18%
Rainwater	36%	10%	19%	9%	8%
Water boiling					
% HH that					
Usually/Always boil	7%	2.5%	100%	---	---
Sometimes boil	3%	2.5%	---	100%	---
Never boil	90%	95%	---	---	100%
Incidence of diarrhea during the past month					
Percentage of HHs reporting no diarrhea cases	82%	65%	62%	30%	43%
Average number of diarrhea cases per HH member (total and disaggregated by sex of HH member)	0.17 M 0.21 F 0.13	0.32 0.46 0.18	0.30 0.48 0.17	1.11 1.11 1.11	0.59 0.63 0.55
Average diarrhea treatment cost per HH member (riel)	556	1,509	1,138	6,074	2,879
Average number of missed school or work days per HH member	0.07	0.30	0.35	1.66	0.90

(a) CG = Control Group

(b) Sum of percentages for each group is greater than 100 because 20% of households reported more than one water source.

Another factor that may have influenced the rate of abandonment is the fact that the CWPs were distributed free of charge to the pilot project households. Recipients who make no financial investment may have a lower sense of ownership and may be more prone to abandonment of the technology. IDE expects that the rate of abandonment will be lower among households that pay partial or full price for the CWPs out of their own resources.

Other reasons stated by respondents for stopping or reducing use of the CWP included a preference for boiled water, forgetting or being too busy to fill the CWP, a belief that the current water source is clean enough, inadequate water volume provided by the CWP, and an unwillingness to clean the CWP frequently (each reason given by one or two respondents).

Assuming that spigot breakage will not be a significant cause of CWP abandonment in the future, the abandonment rate can be estimated as 15 out of 76 (i.e., eliminating the broken spigots from the calculation), which is approximately 20% over a period of one year. IDE considers this a relatively low rate of abandonment given that the CWPs were distributed free of charge, and considering the opportunities, as noted above, to further reduce abandonment due to filter breakage.

5.2.2 Water Sources

Water samples were collected from 50 water sources in the CGC survey villages at the same time as the interviews were being conducted. Sampling sites were selected to provide broad coverage of the pond and open well water sources used by the survey respondents. Samples were analyzed for faecal *E. coli* at the National Laboratory for Drug Quality Control in Phnom Penh using the membrane filtration method. Results are presented in Table 10 below.

Table 10: Quality of Source Water for the Control Group Comparison Survey

Percentage of samples conforming to each WHO risk level	All Sources	Disaggregated by Water Source	
		Open Wells [a]	Ponds
Conforms to WHO Guidelines (zero *E. coli*)	2%	3%	0%
Low Risk (1 - 10 /100mL)	8%	10%	5%
Intermediate Risk (10 - 100 /100 mL)	50%	48%	52%
High Risk (100 - 1000/100 mL)	38%	35%	43%
Very High Risk (>1000 /100 mL)	2%	3%	0%
Intermediate Risk or Worse (>10 /100 mL)	90%	86%	95%
Sample Size (% of total sample)	50 (100%)	29 (58%)	21 (42%)

(a) Sample includes 28 lined open wells and 1 unlined open well

The data in Table 9 (previous page) indicate that the distribution of water sources among households from CG2, CG3, and CG4 is relatively uniform, showing a predominance of lined open wells (85%-100%), a small but significant number of ponds and rainwater users (8%-19%), and a lesser number of unlined open wells (0%-8%). CG1 shows a similar although somewhat smaller prevalence of lined open wells (63%) and a roughly even distribution among the other three water sources.

The distribution of water sources within the Test Group is more distinctive, with a significantly lower number of households using lined open wells (31%) and a significantly higher number of families using ponds (44%) and rainwater (36%). In general, pond water in the survey villages is of lower quality than open well water (Table 10). No rainwater samples were tested during the survey but it is likely that rainwater has higher quality than open well water (depending on how water is handled and stored in the household). The higher number of ponds and lower number of open wells in the Test Group would tend to reduce overall water quality relative to the control groups but the higher use of rainwater may have the opposite effect. In any case, the differences between the Test Group and Control Group water sources are not expected to affect survey results since the CWP output water quality is highly uniform regardless of input water quality (see discussion in Section 3.3).

Twenty percent of the respondent households reported more than one water source. These households generally use the higher quality sources until they run out and then resort to lower quality sources. After a rain, for instance, households will use the rainwater collected in their concrete jar until it is gone, after which they will carry water from the nearest open well or pond. Often, but not always, households will keep separate jars for rainwater and for their other source.

5.2.3 Incidence of Diarrhea

The CGC survey used four indicators to measure the incidence of diarrhea in the month preceding the survey: 1) the percentage of households reporting no cases of diarrhea, 2) the average number of diarrhea cases per household member, 3) the average cost for diarrhea treatment per household member, and 4) the average number of school or work days lost due to diarrhea per household member.

For all diarrhea indicators, the Test Group (CWP users) reported better results than the Control Groups. When compared to CG1 and CG2, which had the next best results, the Test Group had 17% to 20% more households reporting no diarrhea, approximately half as many diarrhea cases per person, one half to one third of the treatment expenses per person, and four to five times fewer work/school days missed per person.

CG1 and CG2 were almost identical in terms of diarrhea indicators. The similarity between these two groups is surprising given that (a) CG1 includes mostly never-boilers and CG2 consists exclusively of usually/always-boilers, and (b) CG1 has a higher percentage of households using ponds and unlined open wells, suggesting that CG1 water sources are likely lower quality than CG2. Both of these factors would suggest that CG1 should have higher incidence of diarrhea than CG2. It may be that the hygiene messages imparted during the pilot project (washing of hands and drinking glasses for instance) had a positive effect on the CG1 households, even in the absence of CWP use.

Another unexpected result was that the sometimes-boilers in CG3 had more incidence of diarrhea than the never-boilers in CG4, despite a close similarity in the types of water sources used. Counter-intuitive results such as these point to the complexity of the relationship between environment, behaviour, and health.

Despite these complexities, at least two solid conclusions can be drawn from the survey data:

- CWP users (Test Group) exhibited a lower incidence of diarrhea than households in the same villages who did not use the CWP and who, for the most part (95%), did not boil their drinking water either (CG1). This confirms that the CWP provides health benefits for households that initially practice no water boiling.
- In the control villages, where no CWPs were used, the households that usually/always boiled their drinking water (CG2) had a lower incidence of diarrhea than the sometimes-

and never-boilers in the same villages (CG3 and CG4). This confirms that water boiling leads to health benefits for households that that initially practice no water boiling.

The fact that CWP users (Test Group) had a lower incidence of diarrhea than households in the control villages that usually/always boiled their drinking water (CG2) suggests that the CWP may be more effective than water boiling in the prevention of diarrhea. However, this hypothesis is called into question by the observation that the difference in diarrhea indicators between the usually/always boilers in the control villages (CG2) and the never boilers in the same villages (CG4), is similar in magnitude to the difference between the CWP users (Test Group) and non-CWP never-boilers in the CWP villages (CG1). Therefore, if the CG1 households began boiling their water, it is possible that they could achieve the same or even lower incidence of diarrhea than the CWP-users, which would disprove the hypothesis. Since there was not enough data to compare CWP-users to always-boilers without CWPs in the same CWP villages, it is not possible to determine with certainty the relative effectiveness of the CWP and water boiling in the prevention of diarrhea. Similarly, it is not possible to predict whether CWP use will result in health improvement for households that are already boiling their drinking water. This question should be the subject of future studies.

The gender breakdown of diarrhea cases per household member (Table 9) indicates that male household members suffered a greater number of diarrhea cases in all study groups, except CG3, in which male and female cases were equal. When compared with CG1 and CG2, the use of the CWP by the Test Group resulted in a reduction of approximately 55% in male diarrhea cases and a reduction of approximately 26% in female diarrhea cases.

5.2.4 Expense and Time Saved in Water Boiling

The training that CWP recipients received during the pilot project included a recommendation that they did not have to boil water that had already been filtered using the CWP. Most recipients followed this advice. In the CGC survey, 10% of CWP-users (n=61) reported that they boil their water, compared with 49% of households in the control villages (n=100). In the B3M survey (Section 4), the percentage of water-boiling households dropped from 69% prior to using the CWP to 0.5% after using the CWP (n=1,000).

Households that stopped boiling water after receiving the CWP benefited from reductions in time and expenses related to water boiling activities. Table 11 quantifies those savings based on practices reported by water-boiling households (n=57). Households that collected firewood prior to receiving the CWP saved an average of 22 hours per month. Households that purchased firewood before receiving the CWP saved and average of 15.9 hours and $1.45 per month.

Table 11: Cost and Time Saved in Water Boiling

A	Average number of times boiling water per day	2.0
B	Average number of minutes to boil water each time	18.5 min
C	*Average time spent boiling water (A x B x 30 days/month)*	*18.5 hrs/month* [a]
D	Average proportion of firewood used for water boiling [b]	29%
E	Percentage of HHs that purchase firewood	11%
F	Average monthly firewood expenses	20,000 riel/month [c]
G	*Average firewood expenses for water boiling (D x F)*	*5,800 riel/month ($1.45/month)*
H	Percentage of HHs that collect firewood	89%
J	Average time spent collecting firewood each month	20.9 hrs/month
K	*Average time spent collecting firewood for water boiling (D x J)*	*6.1 hrs/month*
L	Average number of times CWP cleaned per month (from Table 12)	10.4
M	Average time to clean the CWP each time (estimated)	15 min
N	*Average time spent cleaning the CWP per month (L x M)*	*2.6 hrs/month* [d]
	Time and expense savings for HHs that stop boiling water after obtaining a CWP	
	For those who previously collected firewood (89% of HHs)	
	Time saving (C + K – N)	*22.0 hrs/month*
	Cost saving	*none*
	For those who previously purchased firewood (11% of HHs)	
	Time saving (C – N)	*15.9 hrs/month*
	Cost saving (G)	*$1.45/month*

(a) Values in italics are calculated.

(b) All HHs surveyed used firewood for cooking and water boiling. No other fuel was used.

(c) Based on prevailing market rate for firewood: approximately 10,000 riel per cart load = approximately a two-week supply.

(d) This value is only 0.25 hours per month if cleaning frequency is reduced from twice weekly to once monthly.

5.2.5 CWP Operation and Cleaning

The CGC survey asked CWP-users about CWP operation and cleaning. Results are tabulated in Table 12 along with corresponding results from the B3M survey to provide an indicative comparison between (a) CWP users after three months of use, and (b) CWP users after nearly one year of use and two months after the IDE follow-up visits had stopped.

The operation practices of the CWP users in both surveys were similar; the average household fills their CWP about two times per day and nearly all households find this amount sufficient for their drinking water needs. The majority of respondents (95%) also reported that the storage volume in the receptacle tank is sufficient for their needs, and most (92%) reported no drop in CWP flow rate.

There was however a decline in the frequency of cleaning both drinking glasses and the CWP filter element. After three months of use, 70% of households reported cleaning their glasses at least daily while only 34% reported the same frequency after one year. Similarly, after the first three months of use 96% of households cleaned the ceramic filter element at least twice weekly (the recommended frequency at the time of CWP distribution and training), while only 80% reported the same frequency after one year.

Twice weekly cleaning was in accordance with the recommendation given during the CWP training. IDE now believes that this frequency is excessive and that cleaning the filter too often increases the chance of breakage due to handling and contamination due to contact with dirty hands, surfaces, etc. The current recommendation is to clean the ceramic filter element once per month, or when the flow rate drops significantly, and to clean the plastic receptacle tank at the same time.

Table 12: CWP Operation and Cleaning

	B3M Survey [a]	CGC Survey
Sample size	1,000	61
Average time since CWP delivered (months)	3.0	11.3
Operation		
Average number of times CWP is filled per day (one filling = ~10 litres)	2.2	2.0
HHs reporting that the CWP provides sufficient water	98%	97%
HHs reporting that the receptacle tank provides sufficient water storage [b]	n/a	95%
HHs reporting that the CWP flow rate has not changed over time	n/a	92%
Cleaning		
Average number of times that drinking glasses are cleaned each week	n/a	4.4
% HHs that clean their drinking glasses at least daily	70%	34%
Average number of times that the ceramic filter element is cleaned each week	n/a	2.4
% HHs that clean the ceramic filter element 2 or more times per week [c]	96%	80%
Average number of times that the receptacle tank is cleaned each week	n/a	2.4
% HHs that clean the receptacle tank 2 or more times per week [c]	n/a	85%

(a) The comparison between the Baseline and Third-Month (B3M) survey and the Control Group Comparison (CGC) survey is indicative only as discussed in Section 5.1.

(b) The free storage volume in the receptacle tank is 8 litres. It is possible to store up to 12 litres by allowing the ceramic filter element to become submerged. This causes no harm but slows the filtration rate.

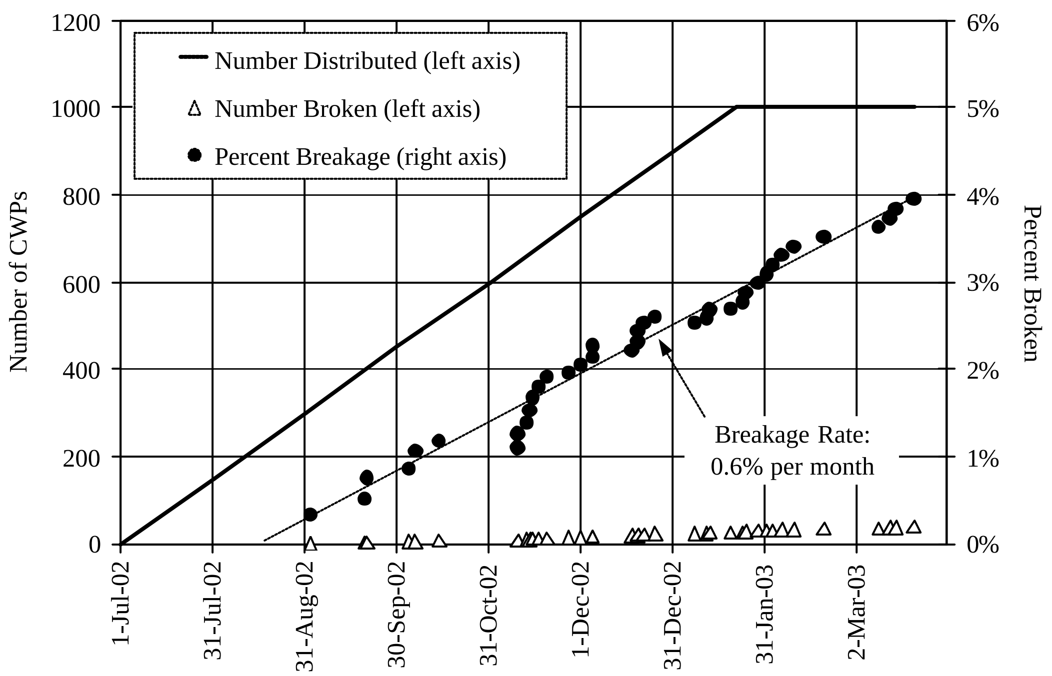
(c) Twice weekly cleaning was in accordance with the recommendation given during the CWP training. The recommended cleaning frequency has since been revised to once monthly.

6 BREAKAGE RATE

If handled roughly, the ceramic filter element can be damaged during transport or household use. From the beginning of CWP distribution in July 2002 to the end of March 2003, a total of 38 filters were broken in the recipient households. Figure 3 indicates that the percentage of broken filters increased at a relatively uniform rate of 0.6% per month. In other words, for every thousand CWPs being used in rural households, an average of six were accidentally broken each month. IDE expects that this breakage rate will decrease due to the recent revision to the recommended CWP cleaning frequency (Section 5.2.5), which will encourage less handling and therefore less breakage of the ceramic filter elements.

In a separate project, IDE shipped 4,200 CWPs to four NE Cambodian provinces, an average distance of approximately 300 km by boat and another 300 km by truck. In total, 15 ceramic filter elements were broken during transport, for a transport breakage rate of 0.36%. Most of the breakages occurred during loading and unloading of the CWP units, suggesting that the breakage rate is related more to the amount of handling than to the distance traveled.

Figure 3: Rate of CWP Breakage under Conditions of Household Use



7 SUMMARY OF IMPACTS

Table 13 summarizes the main CWP impacts that were identified in this pilot project. The type of impact experienced by CWP users depended in large part on their water treatment practices prior to receiving the CWP. Households that boiled their drinking water prior to using the CWP saved time and expenses related to water boiling. Households that did not boil their drinking water previously did not save on water boiling expenses but did show significant health improvements.

Regardless of prior water treatment practices, all CWP users realized savings in time and/or expenses that would allow the CWP to pay for itself in six months or less.[9] It is unclear, however, whether users and potential users will recognize the financial benefits of using a CWP since gains come in the form of (a) expense reduction rather than income generation, and (b) time savings, which are unlikely to be perceived in monetary terms.

Ultimately, however, the time and expense savings are trivial in comparison with the potential long-term impact on mortality due to water-borne diseases, especially among children under five years of age. In this short-term study, the best indicator of potential impact on child mortality is the incidence of diarrhea. The CWP allowed recipient households to achieve and/or maintain a lower incidence of diarrhea for less cost and using less time than boiling water.

Many of the CWP impacts are biased toward improving the situation of women. Women are the primary beneficiaries of time saved in water boiling and care of sick family members. Since women in Cambodia are usually the managers of daily household expenses, they also benefit directly from money saved on purchases of water, firewood, and medications.

To date, approximately 6,500 CWPs have been distributed in Cambodia by IDE and other organizations. The experience of other organizations, as summarized in Appendix C, has been consistent with the results from this IDE pilot project.

[9] The six-month payback period assumes a CWP retail cost of $8.00 (including transportation) and a labour value of $0.50 per eight-hour day.

Table 13: Summary of CWP Impacts on Health, Time, and Expenses

Impact Parameter	Pre-CWP Situation	Post-CWP Situation	Impact	Applies to
Health Improvement				
Percentage of HHs reporting no diarrhea in the past month	65% [a]	82%	17% improvement	Households that *did not boil* their drinking water prior to using the CWP (31% of respondents) [b]
Diarrhea cases per person per month	0.32	0.17	0.75 fewer cases per month for a five-person HH	
Number of missed school/ work days per person per month	0.30	0.07	1.15 fewer missed days per month for a five-person HH	
Diarrhea treatment expenses per person per month	1,509 riel	556 riel	4,765 riel ($1.20) saved per month for a five-person HH	
Time and Expense Savings				
Time spent collecting firewood and boiling water per month	24.6 hours	No time spent boiling but 2.6 hrs/month for CWP cleaning [c]	22.0 hours saved per HH per month	Households that *did boil* their drinking water prior to using the CWP with firewood that they *collected* themselves (25% of respondents)
Time and expense for boiling water and purchasing firewood per month	18.5 hours for boiling $1.40 average firewood expense	No time or expense for boiling but 2.6 hrs per month for CWP cleaning [c]	15.9 hours and $1.40 saved per HH per month	Households that *did boil* their drinking water prior to using the CWP with *purchased* firewood (3% of respondents)
Monthly water purchases	$2.11 average water expense	No water expense	$2.11 saved per HH per month	Households that purchased drinking water prior to using the CWP (9% of respondents)

(a) All Pre-CWP values for the Health Improvement parameters are from Control Group 1 (non-CWP users, 95% of whom never boil their drinking water), which had the next best results after the Test Group (CWP users). Thus, the impacts reported here are the minimum expected impacts.

(b) Percentages of respondents are from the Baseline and Third Month survey population (n=1,000). The 31% that never boiled drinking water received primarily health improvements. The 28% that always boiled drinking water received primarily time/expense savings. The remaining 41% that 'sometimes' boiled their drinking water received a mixture of health and time/expense savings. The 9% that purchased drinking water comprised respondents from all three of the other groups (never-, always-, and sometimes-boilers).

(c) Cleaning time quoted here is for twice weekly cleaning (old recommendation). Cleaning the CWP once per month (current recommendation) would require only 0.25 hours per month.

Appendix A: Questionnaires for Baseline and Third-Month Survey

BASELINE SURVEY QUESTIONS
(Compressed format for Appendix)

Name of Province:	______________	User's Name: ______________________
Name of District:	______________	Household Head: Male/Female
Name of Commune:	______________	Water Purifier #: __________________
Name of Village:	______________	Interview Date: ______/_____/______
Interviewer's Name:	______________	

1. How many members are there in your family?
2. What is your average income per month?
3. What sources of water do you and your family drink?
   Hand-Dug/Open Well ❑ Tube Well ❑ Pond ❑ Lake ❑ River ❑ Other (specify).
4. Do you usually boil water before drinking? Yes ❑ No ❑ Sometimes ❑ Other (specify).
5. If you boil water for drinking, on average, how much money do you spend on firewood per month?
6. Do you buy safe drinking water for your family? No ❑ Yes ❑.
7. If yes, how much money do you spend on purchasing pure drinking water per month?
8. How far is it from your house to the water sources?
9. How much water does your family need for drinking only per day? (Litres)
10. How much water does your household need for cooking, drinking, and washing face? (Litres)

THIRD-MONTH FOLLOW-UP SURVEY QUESTIONS
(Compressed format for Appendix)

Name of Province:	______________	User's Name: ______________________
Name of District:	______________	Household Head: Male/Female
Name of Commune:	______________	Water Purifier #: __________________
Name of Village:	______________	Interview Date: ______/_____/______
Interviewer's Name:	______________	

1. How many people in the household use/drink water from the purifier?
2. How many times do you fill water into the purifier in order to have sufficient safe drinking water for the family?
3. Is amount of clean water from the purifier enough for drinking in the family? Yes ❑ No ❑.
4. Do you still buy safe drinking water for your family?
   If yes, how much money do you spend on purchasing safe drinking water per month?
   Why do you need to buy clean water?
5. Do you boil purified water before drinking it? If yes, why? How much money do you spend on firewood for boiling water a month?
6. Besides drinking, what else do you use purified water for?
   Cooking ❑ Washing vegetables ❑ Washing faces ❑ Make milk for baby ❑ Other (specify).
7. Do family members always drink water from the purifier? Yes ❑ No ❑ Other (specify).
8. Do family members use any other sources of drinking water? Yes ❑ No ❑. If yes, specify
9. Overall satisfaction with the purifier? High ❑ Moderate ❑ Low ❑.
10. Do you think that the water purifier is important to your family? Yes ❑ No ❑. If yes, why?
11. How do you like the taste of purified water? Good taste ❑ Clay smell ❑ Foul ❑.
12. How often do you clean your purifier and its container?
    Once a week ❑ Twice a week ❑ 3 times a week ❑ Other (specify).
13. Do you clean your purifier with soap powder? Yes ❑ No ❑.
14. How often do you clean your water serving glasses?
15. Do you find it difficult to clean and maintain the purifier and its container? Yes ❑ No ❑.

Appendix B: Questionnaires for Control Group Comparison Survey

Questionnaire for Households that DO NOT HAVE a Ceramic Water Filter
(Compressed format for Appendix)

Village	________________________	Respondent name	________________________
Interviewer name	________________________	Sex of household head ______ respondent _____	
Interview date	________________________	HH wealth rank	________________________

1. What is the main water source that this household currently uses for drinking?
   - ☐ Lined Open Well ☐ Pond ☐ Rain water
   - ☐ Unlined Open Well ☐ Lake ☐ Other
   - ☐ Tube Well ☐ Stream/River
2. Do you boil your water before drinking?
   - ☐ Always ☐ Usually ☐ Sometimes ☐ Never ☐ Don't know

   If Always, Usually, or Sometimes:
   - 2.1 How many times per day do you boil water? ________
   - 2.2 How long does it take to boil water each time? _______ minutes
   - 2.3 What fuel do you use to boil water?
     - ☐ Firewood ☐ Charcoal ☐ Other ☐ Don't know
   - 2.4 What percentage of your weekly (FUEL) use is used for boiling water? ____%
   - 2.5 How do you get the (FUEL)?
     - ☐ Purchase ☐ Collect ☐ Other ☐ Don't know

     If purchased:
     - 2.5.1 How much do you spend each week on (FUEL)? _________ riel/week

     If collected:
     - 2.5.2 How much time do you spend each week to collect (FUEL)? ___ hrs/week
3. Have you seen or heard of the Rabbit Ceramic Water Filter for producing clean water?
   - ☐ Yes ☐ No
4. If there was a reliable product in the market that produced clean water in your house, would you be interested to buy one? ☐ Yes ☐ No
5. How much would you be willing to pay for a reliable product like that? _________riel

6. Fill out the following table for all people currently living in the household.

	6.1 Age	6.2 Sex	6.3 How many times has this person had diarrhea in the past 2 weeks?	6.4 How many times has this person had diarrhea in the past month? (total # for whole month)	6.5 How was the diarrhea treated? (Enter as many codes as are applicable)	6.6 What was the cost of treatment for these cases of diarrhea? (riel)	6.7 How many days of school or work did this person miss due to this case of diarrhea?
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
			Do not try to determine if the diarrhea was caused by drinking water or not. Just record whether they have had diarrhea or not. If no cases of diarrhea, enter zero.	If no cases of diarrhea, enter zero.	0=Not treated 1=Re-hydration fluid from a packet (e.g., ORALYTE) 2=Other "western" medicine 3=Traditional medicine 4=Homemade re-hydration fluid (water, salt & sugar) 5=Rice water 6=Other 7=Don't know	If there was more than one case for this person, put the total cost for all treatments. If there was no cost, enter zero.	If no school or work was missed, enter zero. Round to the nearest half day

Questionnaire for Households that HAVE a Ceramic Water Filter
(Compressed format for Appendix)

Village	________________________	Respondent name	________________________
Interviewer name	________________________	Sex of household head ______ respondent _____	
Interview date	________________________	HH wealth rank	________________________
		CWF number	________________________

1. When did you receive your CWF? Year ______ Month _______ Day ______
2. What is the main water source that this household currently uses for drinking?
   ☐ Lined Open Well ☐ Pond ☐ Rain water
   ☐ Unlined Open Well ☐ Lake ☐ Other
   ☐ Tube Well ☐ Stream/River
3. Does your household still use the CWF for drinking water?
   ☐ Always ☐ Usually ☐ Sometimes ☐ Never ☐ Don't know
   If Usually, Sometimes, or Never:
   3.1 Why don't you always use the filter? ___________________________________
4. How many times do you usually fill the filter each day? ________
5. Does the filter provide enough water for your household drinking needs? ☐ Yes ☐ No
6. Is the amount of storage in the receptacle tank enough for your needs? ☐ Yes ☐ No
7. Has the flow rate of the filter slowed down since you began using it? ☐ Yes ☐ No
8. How often do you clean the clay filter pot? __________ times/week
9. How often do you clean the plastic receptacle tank? _________ times/week
10. How often do you clean your drinking glasses/bowls? _________ times/week
11. Do you boil your filtered water before drinking?
   ☐ Always ☐ Usually ☐ Sometimes ☐ Never ☐ Don't know
   If Always, Usually, or Sometimes:
   11.1 How many times per day do you boil water? ________
   11.2 How long does it take to boil water each time? _______ minutes
   11.3 What fuel do you use to boil water?
   ☐ Firewood ☐ Charcoal ☐ Other ☐ Don't know
   11.4 What percentage of your weekly (FUEL) use is used for boiling water? ____%
   11.5 How do you get the (FUEL)?
   ☐ Purchase ☐ Collect ☐ Other ☐ Don't know
   If purchased:
   11.5.1 How much do you spend each week on (FUEL)? _________ riel/week
   If collected:
   11.5.2 How much time do you spend each week to collect (FUEL)? __ hrs/week

12. Fill out the following table for all people currently living in the household.

	12.1 Age	12.2 Sex	12.3 How many times has this person had diarrhea in the past 2 weeks?	12.4 How many times has this person had diarrhea in the past month? (total # for whole month)	12.5 How was the diarrhea treated? (Enter as many codes as are applicable)	12.6 What was the cost of treatment for these cases of diarrhea? (riel)	12.7 How many days of school or work did this person miss due to this case of diarrhea?
1							
2							
3							
4							
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6							
7							
8							
9							
10							
			Do not try to determine if the diarrhea was caused by drinking water or not. Just record whether they have had diarrhea or not. If no cases of diarrhea, enter zero.	If no cases of diarrhea, enter zero.	0=Not treated 1=Re-hydration fluid from a packet (e.g., ORALYTE) 2=Other "western" medicine 3=Traditional medicine 4=Homemade re-hydration fluid (water, salt & sugar) 5=Rice water 6=Other 7=Don't know	If there was more than one case for this person, put the total cost for all treatments. If there was no cost, enter zero.	If no school or work was missed, enter zero. Round to the nearest half day

Appendix C: Experience of Other Organizations

Partners for Development (PFD) installed 92 CWPs in Kratie province and 43 in Stung Treng in May 2002. Results of water sample testing indicated that 93% to 96% of CWPs produced water meeting WHO low-risk guidelines or better.

Table C-1: Results of CWP Field Tests by PFD

	Kratie	Stung Treng
Sample size	92	43
Average users per household:	6.1	5.9
Average fillings per day:	1.9	1.8
HHs reporting water volume is sufficient:	84%	86%
Percentage of samples conforming to WHO risk levels		
Conforms to WHO Guidelines (zero *E. coli*)	48%	81%
Low Risk (1 to 10 /100mL)	48%	12%
Intermediate Risk (10 to 100 /100 mL)	4%	7%
High or Very High Risk (>100 /100 mL)	0%	0%
Low Risk or better (0 to 10 /100 mL)	96%	93%

A number of other organizations have provided feedback on their field experience with the CWP and/or are currently conducting impact assessments.

- Resource Development International (RDI) purchased 70 CWPs for water quality testing and village installation. Water quality test results and field experience were positive. RDI plans to promote the CWP as a means to treat surface water as an alternative to arsenic contaminated groundwater, which is an urgent problem in parts of Cambodia. RDI began CWP production trials in Kien Svay district in March 2003.
- ZOA Refugee Care installed 37 filters in Banteay Meanchey province in February 2003. Detailed household surveys and water quality tests have been conducted and results are expected soon.
- Beginning in April 2003, American Red Cross, in partnership with the Cambodia Red Cross and IDE, distributed more than 4,200 CWPs in the NE provinces of Stung Treng, Ratanakiri, Kratie, and Mondulkiri. Another 1,800 CWPs will be delivered by the end of December 2003. Household impact surveys are currently underway.
- CARE Cambodia installed 458 CWPs in four villages in Oddar Meanchey province in May 2003. Initial feedback indicates a high level of technology adoption and user satisfaction. Fieldwork for a household impact survey has been completed and a report will be issued shortly.