Project Evaluation for Complex Systems:

Pure Home Water's Experience Establishing a "Successful" Social Business

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Guest Lecture – Project Evaluation (1.011)
April 21, 2010

World Water

(Introduces household drinking water treatment system design to provide safe water to low-income people in developing countries)

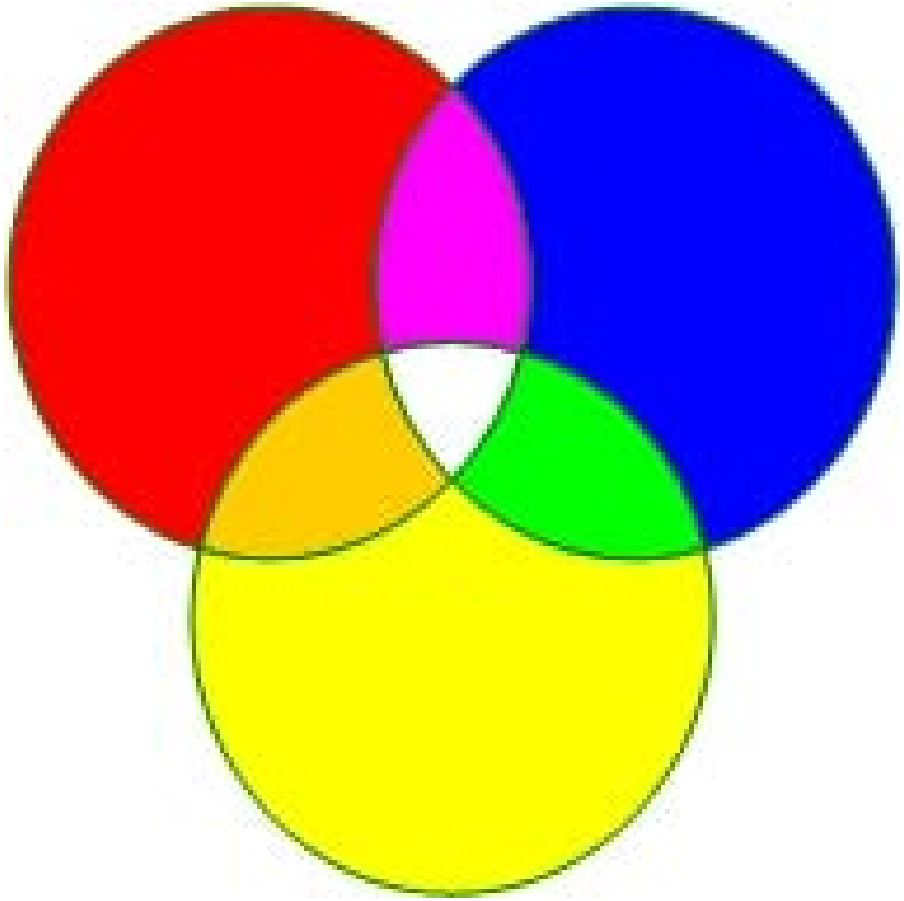
http://web.mit.edu/watsan/media_videos.html

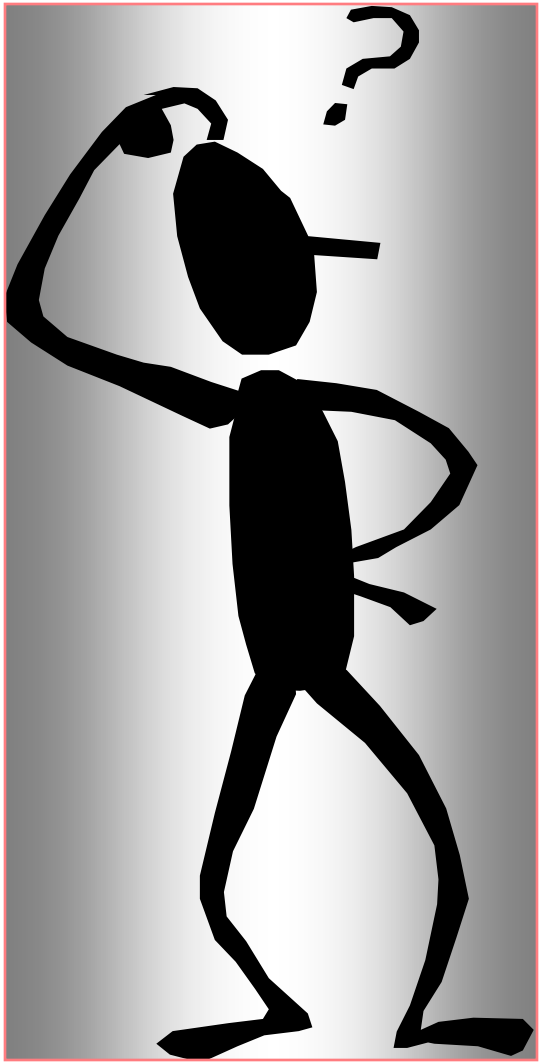
There are many Assessment Methodologies for evaluating large infrastructure engineering projects. Here are a few:

- Cost Benefit Analysis
- Environmental Impact Assessment
- Social Impact Assessment
- Technology Assessment
- Risk Assessment
- Life Cycle Analysis
- Systems Analysis
- Factor 10/Factor X
- Ecological Footprint
- Climate Impact Assessment
- Public Health Assessment
- Environmental Justice Analysis
- Multi-objective/Multi-criteria Analysis
- Expert Opinion (e.g. National Academy of Science studies)
- “Integrated” or Sustainability Assessment

“Integrated” Sustainability Assessments

- A shift away from discipline specific assessments (economic, environment, social) to “integrated” sustainability assessments.
- These have their strengths, but need to be looked at just as critically as any other project evaluation methodologies.





How does one decide which assessment tools to use?

Consider the problem of water…

Water scarcity, access & pollution are among the biggest challenges to human & ecosystem well-being in the 21st century

Millennium Development Goals & Targets

Goal 1: Eradicate extreme poverty and hunger

Goal 2: Achieve universal primary education

Goal 3: Promote gender equality and empower women

Goal 4: Reduce child mortality

Goal 5: Improve maternal health

Goal 6: Combat HIV/AIDS, malaria and other diseases

Goal 7: Ensure environmental sustainability

Goal 8: Develop a global partnership for development

http://www.un.org/millenniumgoals/

MDG – Goal 7 - Target 3

Halve, by 2015, the proportion of people without sustainable access to safe drinking water.

http://www.un.org/millenniumgoals/environ.shtml

Water Access – Drinking Water Coverage, 2010

Today, the U.N. estimates that about 1 billion people lack access to an improved water supply

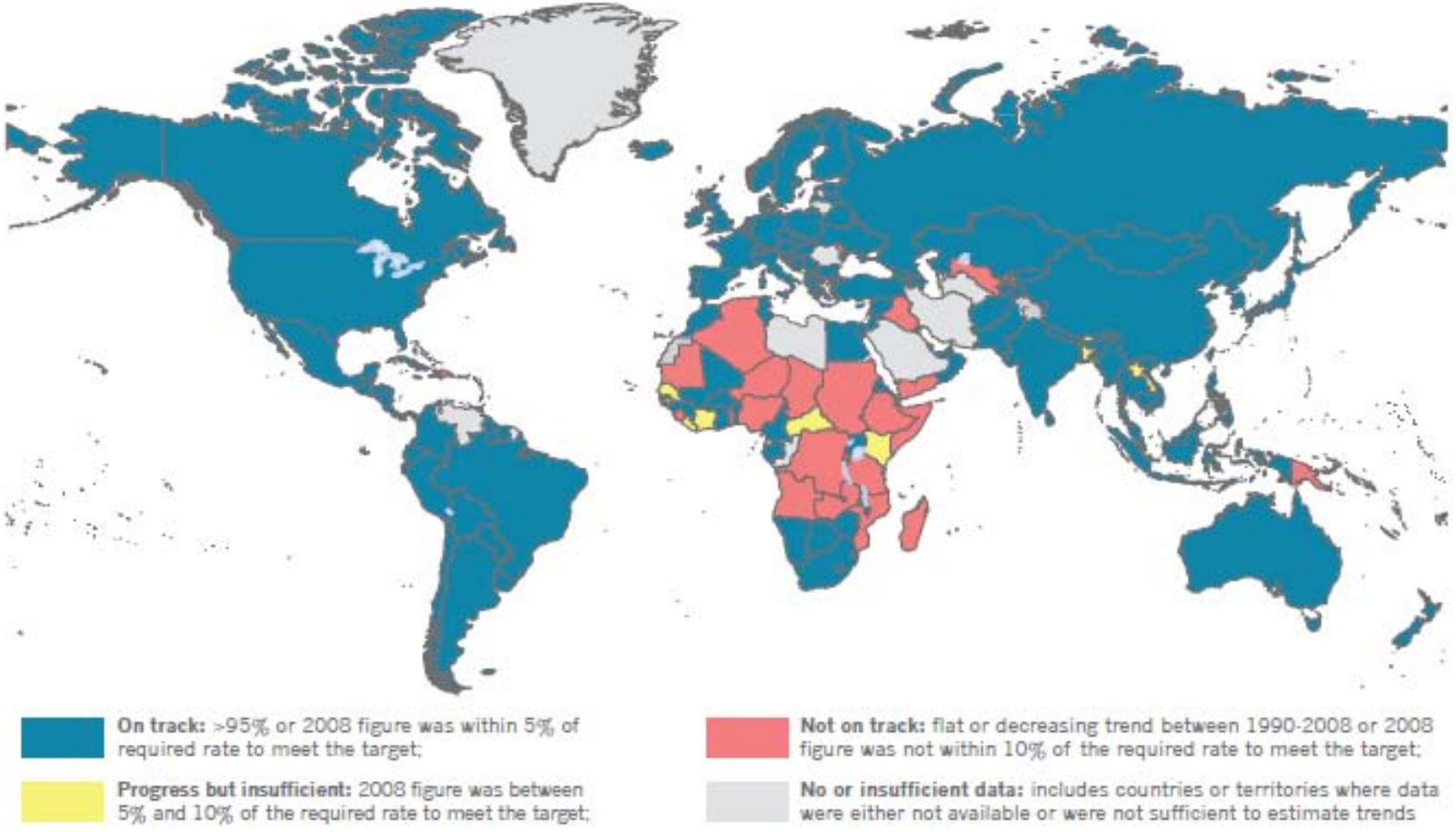
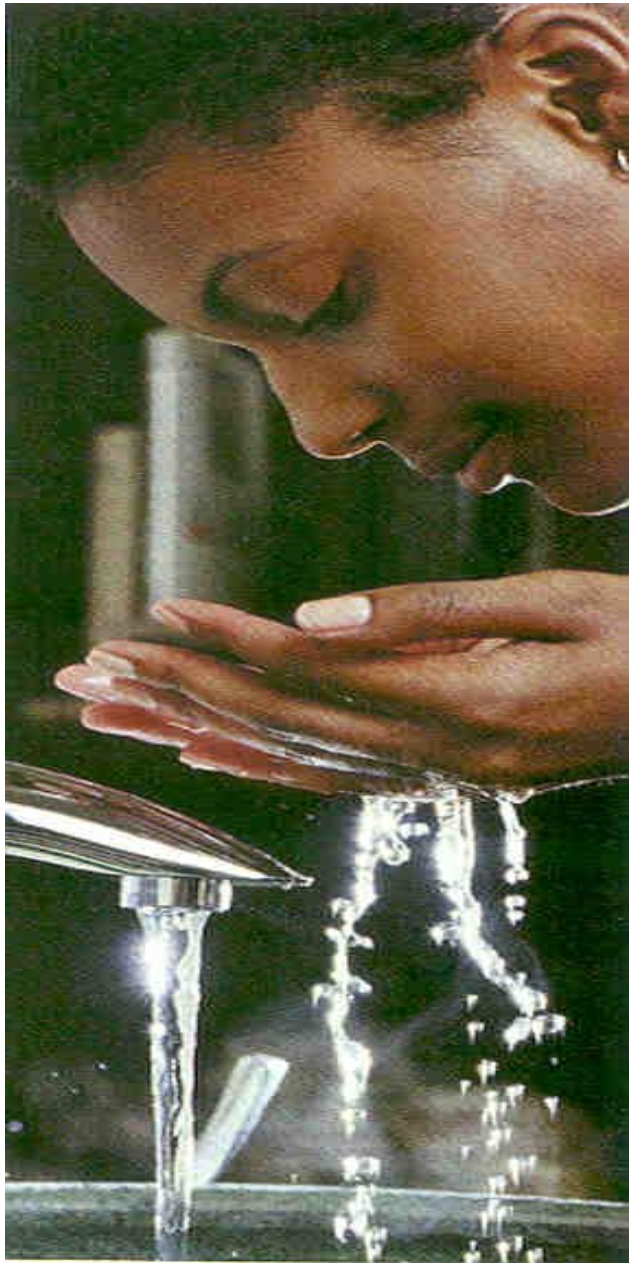


Figure 10 Drinking-water: progress towards the MDG target, 2008

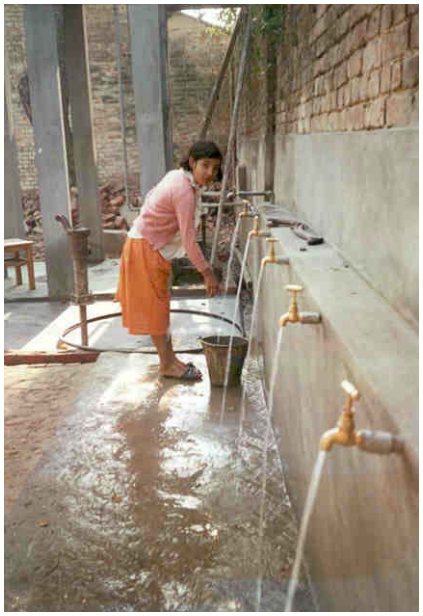
WHO, 2010 http://whqlibdoc.who.int/publications/2010/9789241563956_eng_full_text.pdf

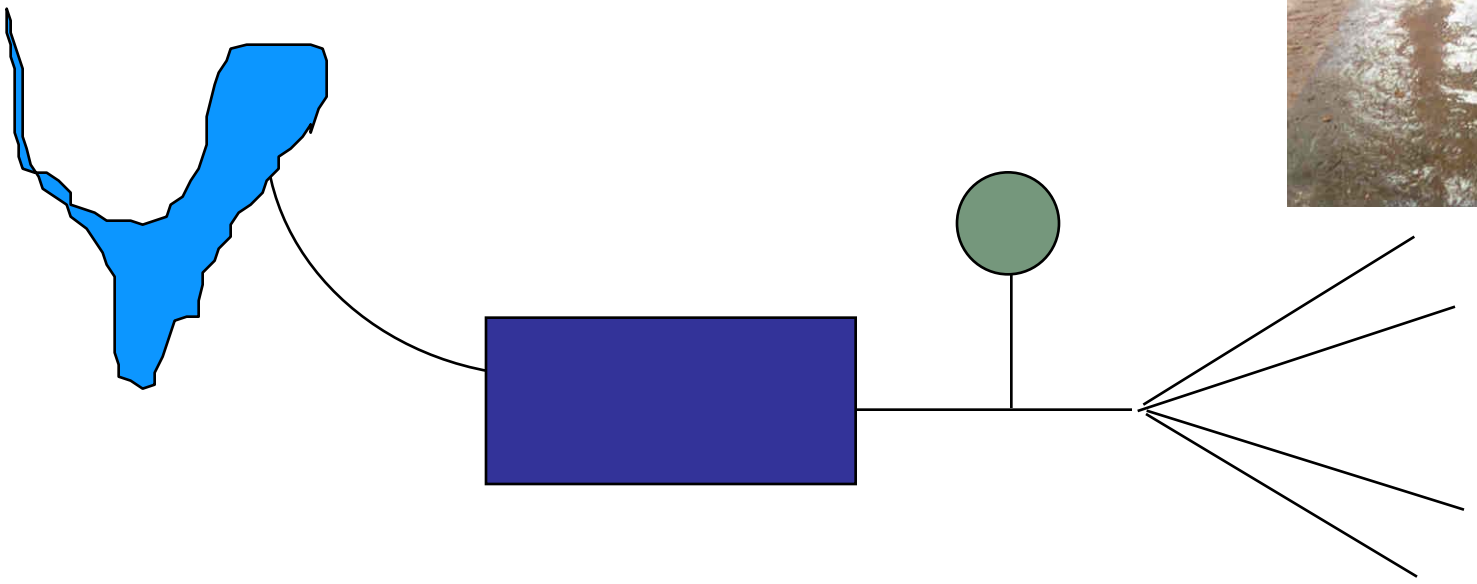
Water Rich - Safe Water



Water Poor - Unsafe Water

Water Rich World
Piped Water Supply





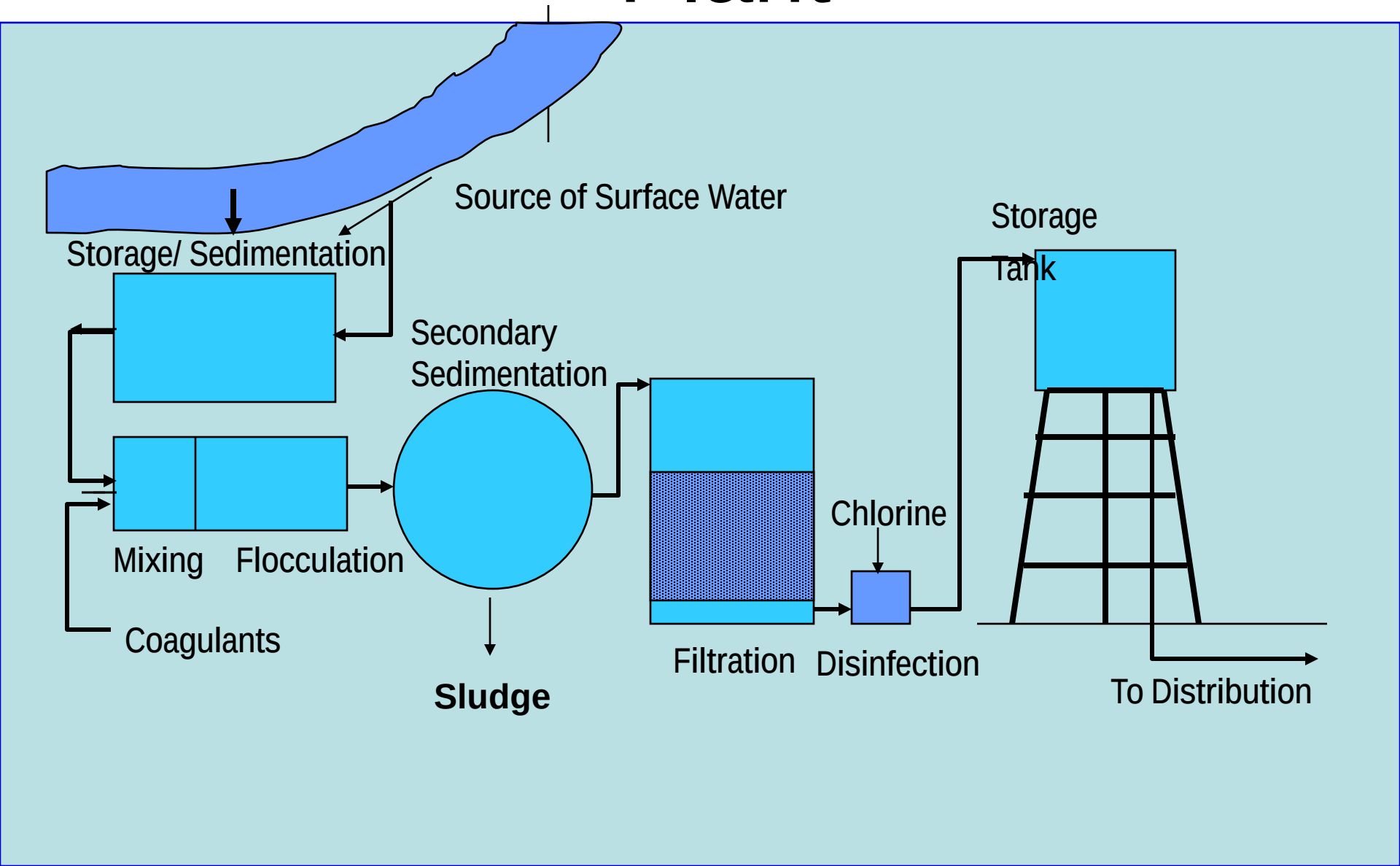
Watershed

Treatment

Primary Distribution System

Community Distribution Systems

Conventional Water Treatment Plant



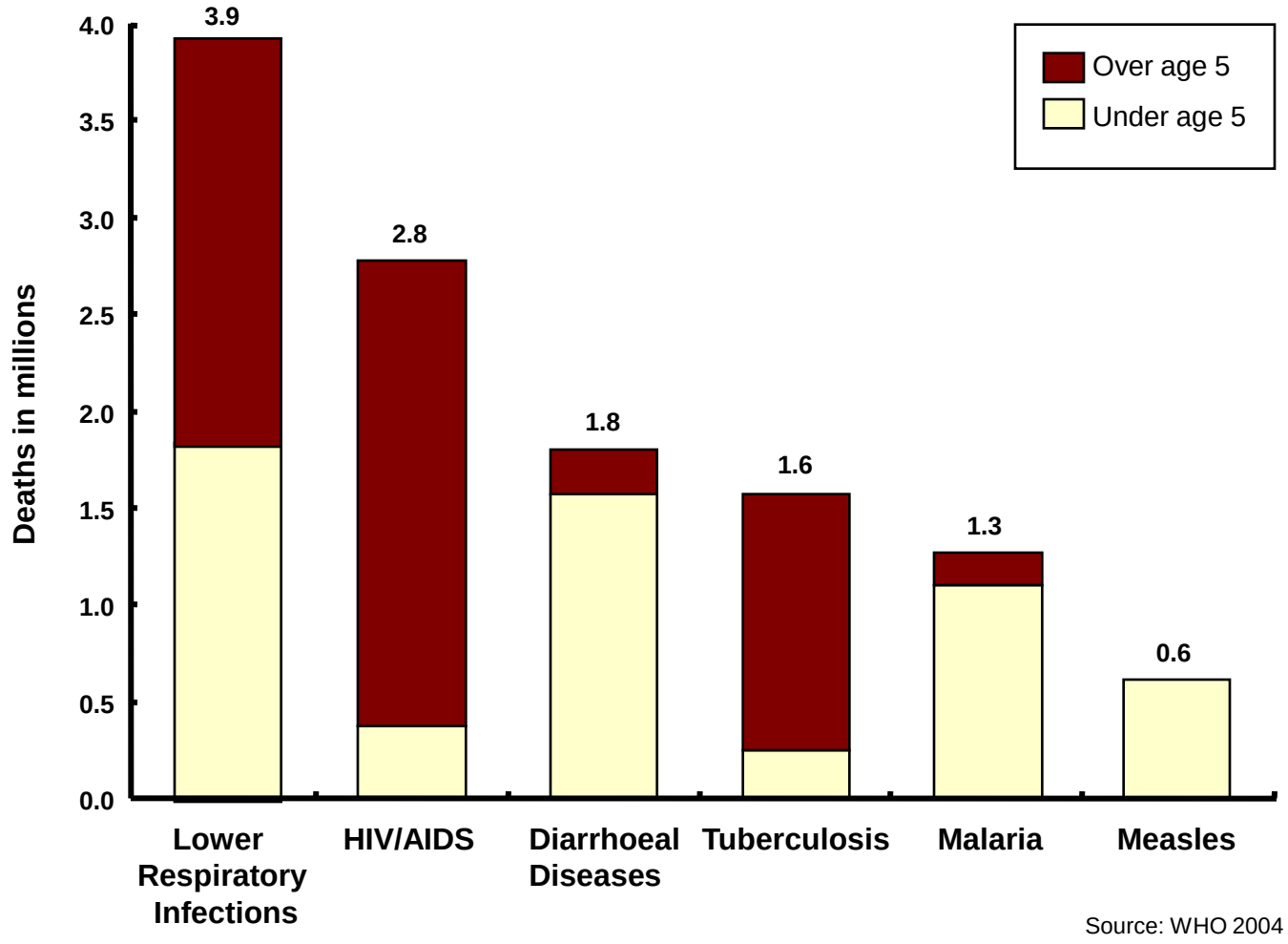
Water Poor World
Non-Piped Water Supply

Watershed **Human (and Animal?) Distribution System** **Home**

Water-Related Diseases

Water-related diseases are estimated to claim 3-7 million lives each year. This includes water-borne, water-washed, water contact diseases, as well as water (insect) vector diseases - i.e. those associated with water habitat (e.g. malaria, dengue) and thus with water resources & habitat management.

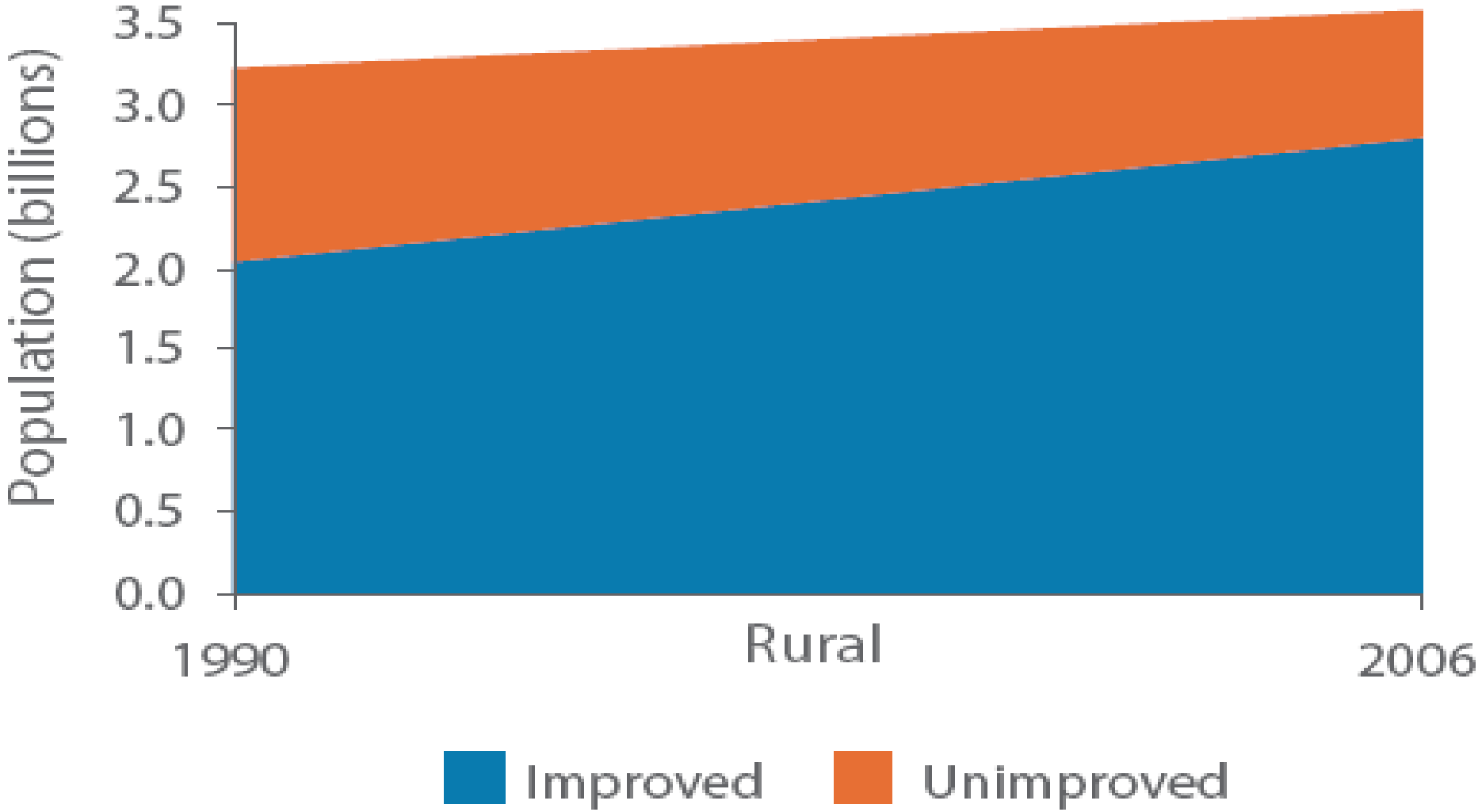
Leading Causes of Death Worldwide from Infectious Diseases - 2002



Who are the people lacking improved water? Where do they live? Rural areas…

(Credit: Time Magazine)

746 million people in rural areas use unimproved water supplies



Rural Drinking Water Coverage 1990 - 2006 (UNICEF/WHO, 2008)

… and Urban / Peri-urban Slums

(Photo: Genevieve Connors)

How do you define and evaluate a “Social Business?

- “A social business is a company that is cause-driven rather than profit driven, with the potential to act as a change agent in the world.
- A social business is not a charity. As long as it relies on subsidies and donations to cover its losses, such an organization remains in the category of a charity.”

(Muhammad Yunus , Creating a World Without Poverty, 2007, p.22)

How do you define and evaluate a “Social Business?

- Once a social-objective-driven project overcomes the gravitational force of financial dependence, it is ready for space flight. Such a project is self-sustaining and enjoys the potential for almost unlimited growth and expansion. As the social business grows, so do the benefits it provides to society.

(Muhammad Yunus , Creating a World Without Poverty, 2007. p. 23)

Evaluation, Decision-Making, Values

- "EVALUATION is "the process of analyzing a # of plans/ projects/policies with a view to searching out comparative advantages and disadvantages and the act of setting down the findings in a logical framework."
- "EVALUATION ≠ DECISION-MAKING." Decision-making is done by institutional players – government, and the political process, engineering and scientific experts, monied interests.
- "EVALUATION is based on VALUES."

(Ortolano, 1997)

- Different values are reflected in different assessment methodologies

The Pure Home Water Story (so far…)

- Pure Home Water (PHW): a social enterprise founded in 2005 to provide safe drinking water via household water treatment and safe storage (HWTS) in Northern Ghana.

PHW has 2 goals:

1. Reach people most in need of safe drinking water in Northern Ghana, the poorest part of Ghana
2. Become financially and locally self-sustaining

Typical Drinking Water Supply for Pure Home Water Customers
Ghanasco Dugout, Tamale, Ghana

Ghanasco Dugout, Tamale

Credit: S.Murcott

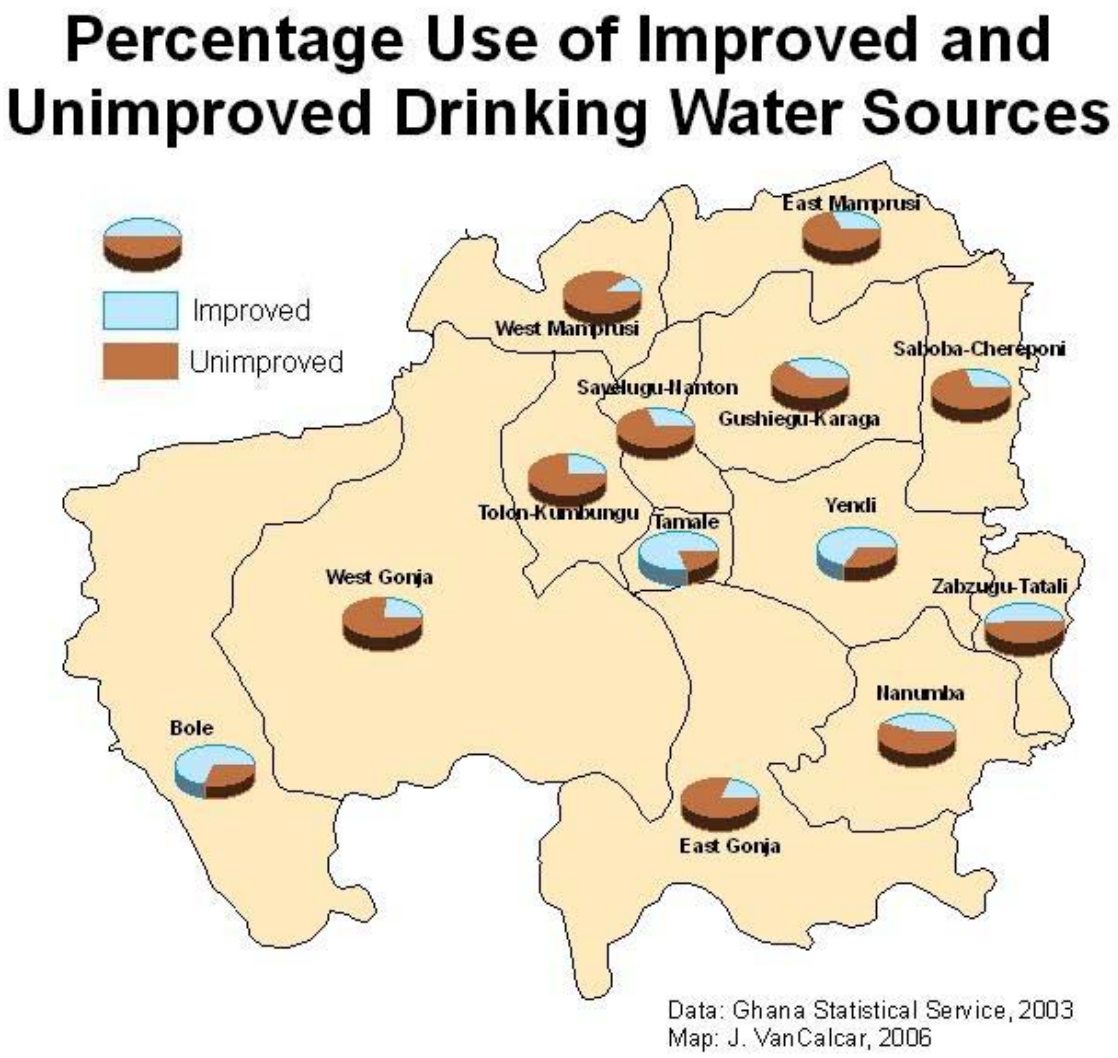
Ghanasco Dugout, Tamale

Credit: Tamar Losleben

Ghanasco Dugout, Tamale

Credit: Tamar Losleben

50% (0.9 million out of 1.8 million people) in Northern Region, Ghana currently use an unimproved source



- Improved Sources
  - Boreholes
  - Household connection
  - Public standpipe
  - Rainwater harvesting
  - Protected springs and dug wells
- Unimproved Sources
  - All surface water sources
  - Unprotected springs and dug wells
  - Tanker trucks
  - Vendor water

Example of Water Quality Data for selected Tamale District Dugouts

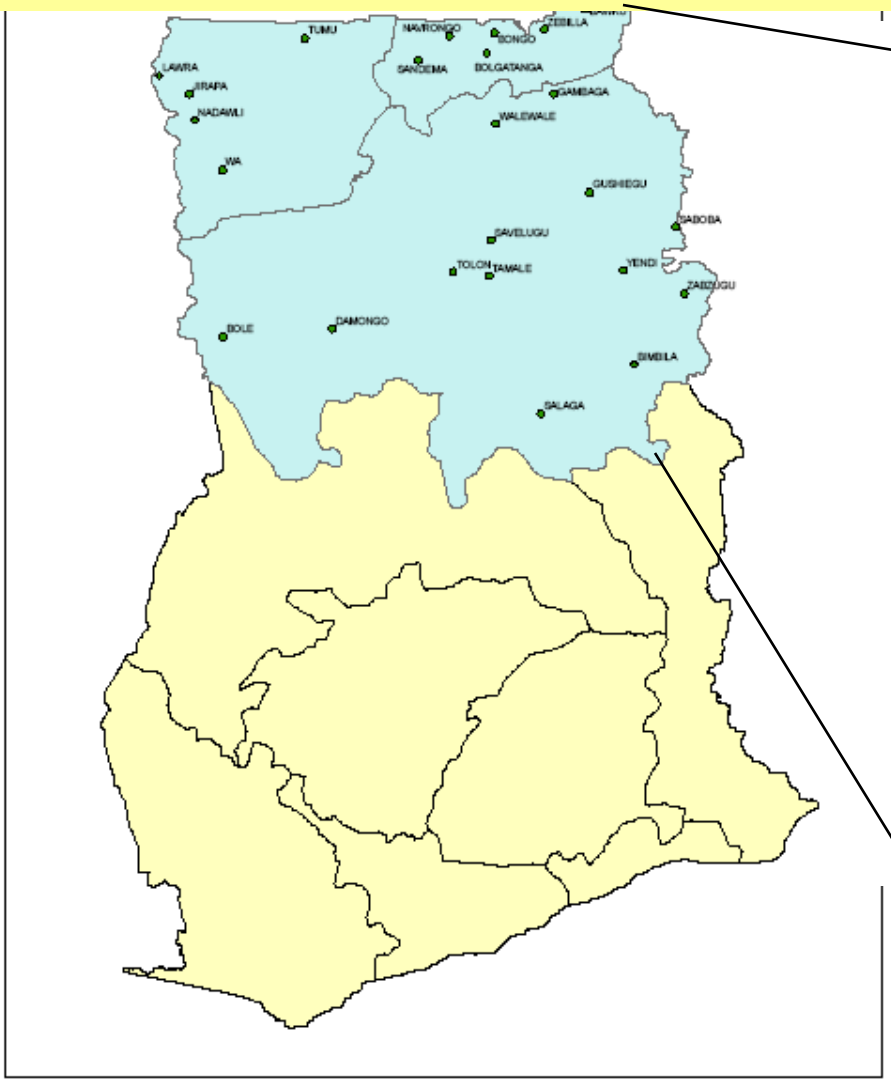
Location	**Date (2006)**	***E. coli*** **(CFU per 100 mL)**	**Total Coliforms (CFU per 100 mL)**	**Turbidity (TU)**
Ghanasco Muali Dam, TD	20-Jun	169	6,621	~1,600
Kaleriga Dam, TD	22-Jun	754	13,475	> 2,000
Bipelar Dam, TD	27-Jun	100	21,667	38
St. Mary's Dam, TD	29-Jun	1,650	52,110	>2,000
Dungu Dam, TD	4-Jul	133	4,540	400
Libga Dam, SD	6-Jul	0	500	75
Bunglung Dam, SD	11-Jul	200	5117	300
Diare Dam, SD	13-Jul	0	3,417	23
Libga Dam, SD	17-Jul	50	1,408	50
Gbanyami Dam, TD	19-Jul	367	19,150	~1,000
Vitting Dam, TD	25-Jul	1,400	12,767	~125
Average		**438**	**12,797**	**690**

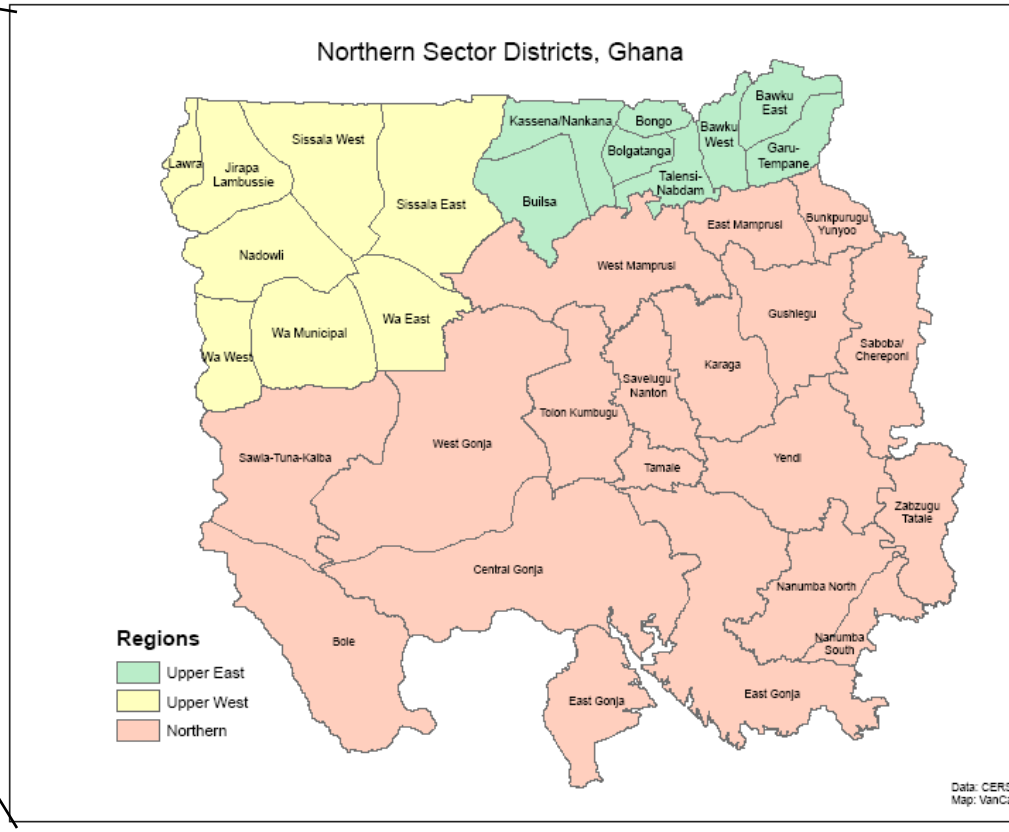
By any standard, this water should be considered unacceptable for drinking!

Ghana is been one of the few remaining guinea worm endemic countries in the world.

Photo: Braimah Apambire, World Vision

Northern Sector - Target Area of Pure Home Water Sales & Distribution





We have a house for office, sales, residence, lab, stock, and a small shop

For the past 18 months, we have had a factory under construction

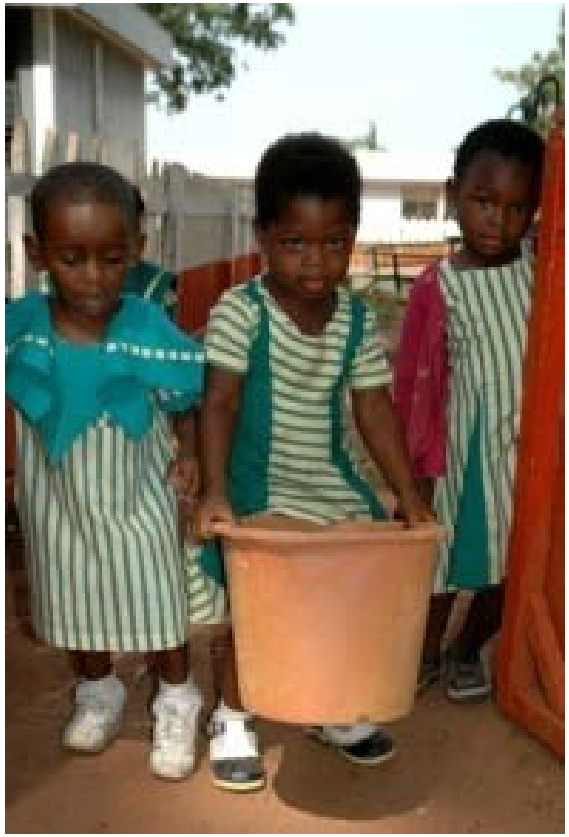
Credit: Claudia Espinoza

Typical Village in Northern Ghana

Since 2005, > 50 MIT M.Eng.,Sloan MBA and other students have assisted Pure Home Water by conducting applied research, water quality tests, product evaluations, monitoring, consumer choice and business assessment studies in Ghana.

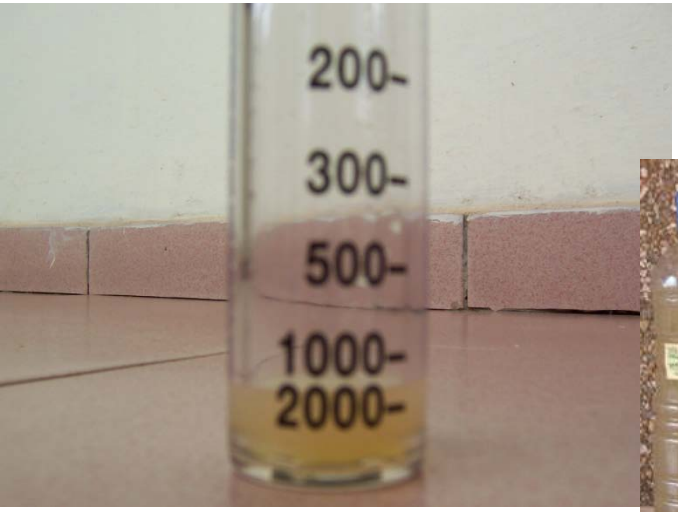
1st Product*: Kosim* Ceramic Pot Filter

Since 2006, we have focused on disseminating the *Kosim* ceramic pot filter.



Why did we choose a ceramic pot filter?

- Extremely high turbidity, even in dry season, in the widely used surface water supplies



Turbidty Test (NTU)

Why did we choose a ceramic pot filter?

- Culturally compatible – rural water in Ghana is universally stored in large clay vessels

Credit: Rachel Peletz

Because it works!
Before and After

Credit: Alexandr Nishichenko

But how do we know it works?
Or, if our social business is “successful?”

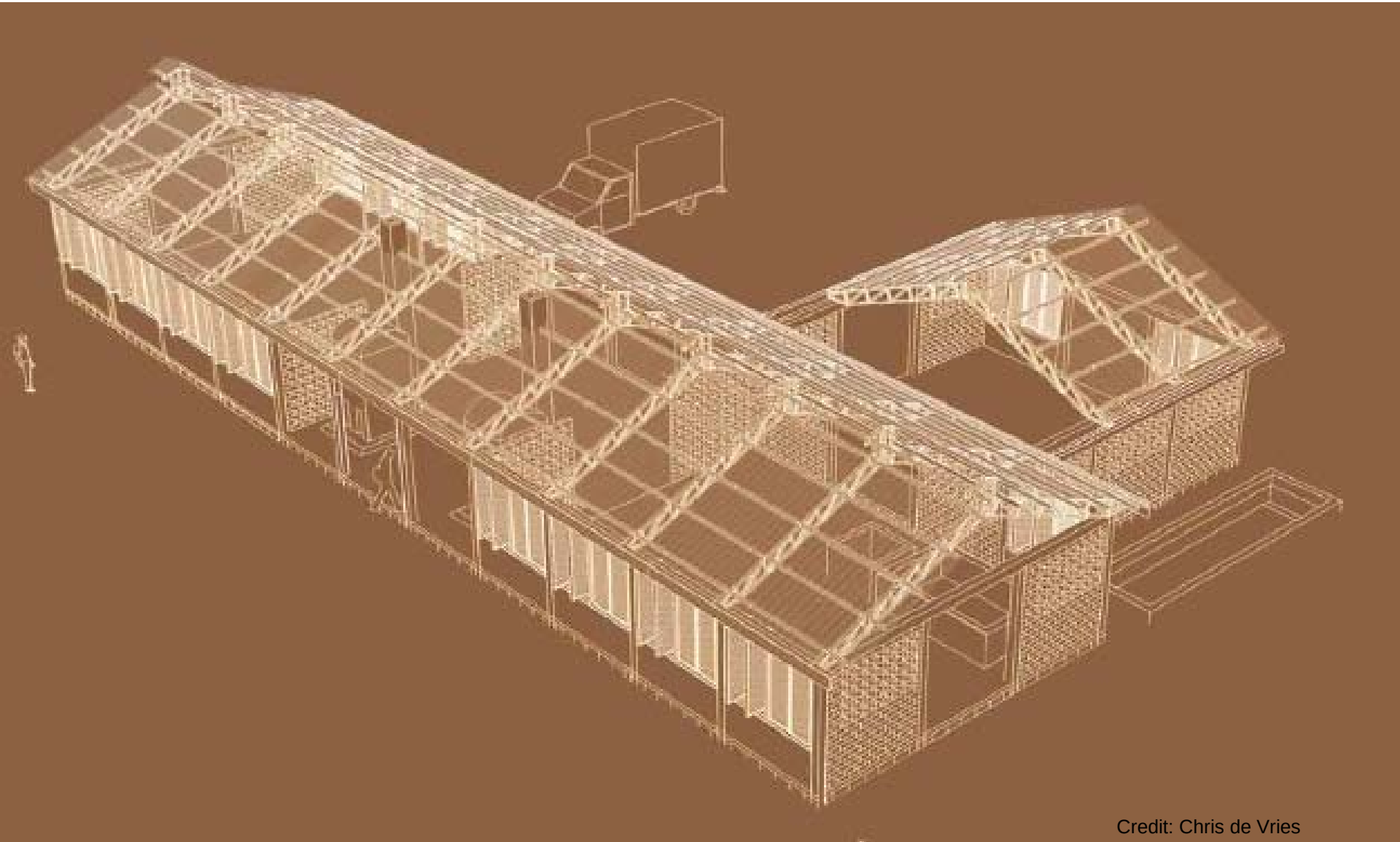
Pure Home Water's Present & Future Plans (2010 – 2015)

- Complete ceramic filter and brick factory in Tamale in 2010-2011
- Produce quality filters and construction materials
- Focus on building markets.
  - Kiosks/retail outlets
  - Advertising (billboards, radio ads demos, village committees)
  - Business capacity developmt
- Extend reach in urban Ghana with new Pure Home Water products

Our factory is on the map!

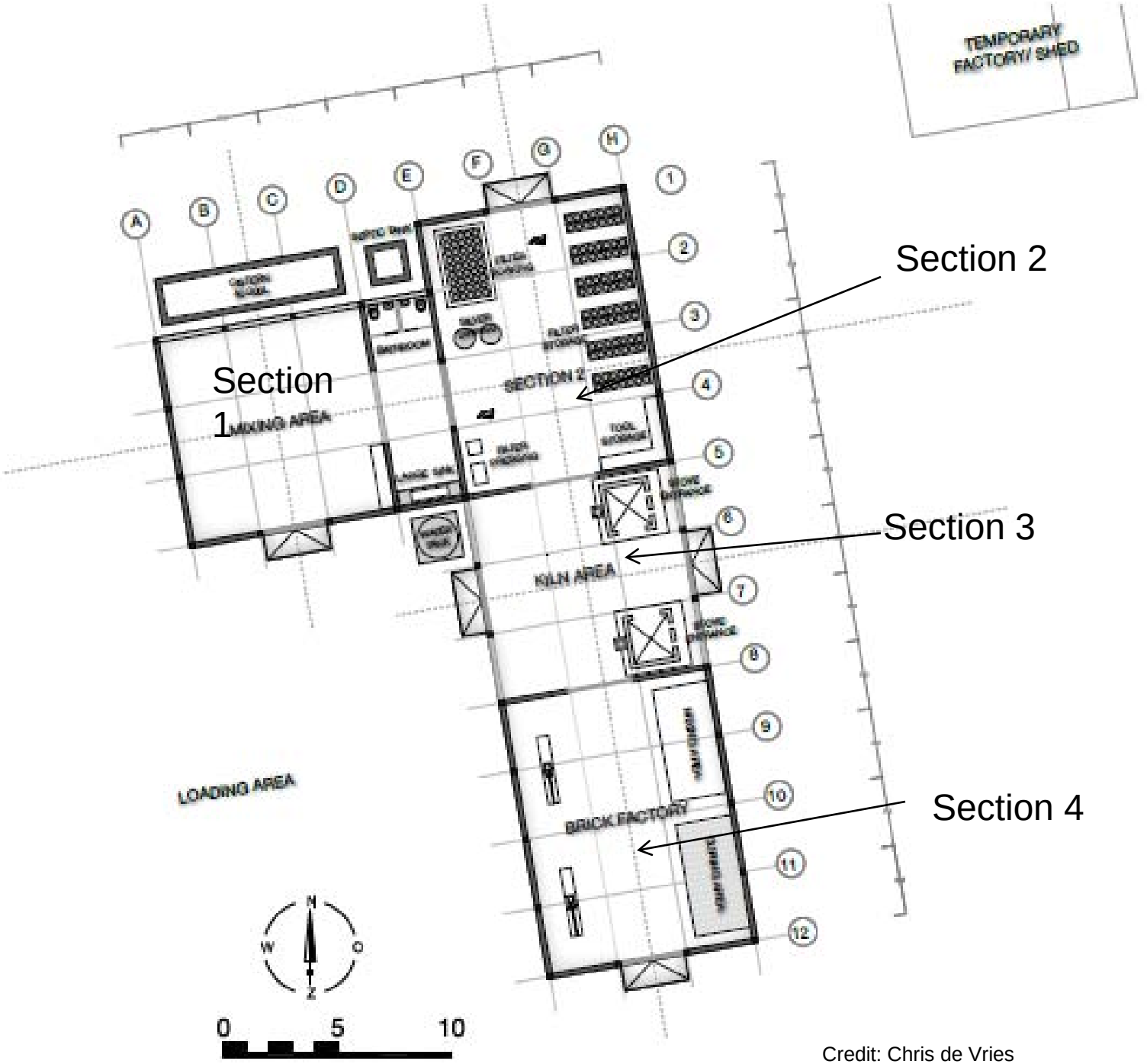
Close-up of Factory Land from Google Earth

Factory Architectural Design Plan



Credit: Chris de Vries

Plan Layout
August 2010



Credit: Chris de Vries

Factory Construction – Summer 2010

Credit: C. DeVries

Factory - January 2011

Factory Floor, Drying Racks, Saturation Tank in Foreground

Rainwater Harvesting Tank Construction – Jan. 2011

Production Steps
Filter Production is comprised of multiple steps

1. Procuring the clay and transporting it to the site

2. Processing the clay

Credit : Leah Nation

3. Sieving the Combustible (Rice Husk or Saw Dust)

Credit: Travis Watters

4. Milling the Combustible (Rice Husk or Saw Dust) – to obtain finer particle size

Inside Hammer mill

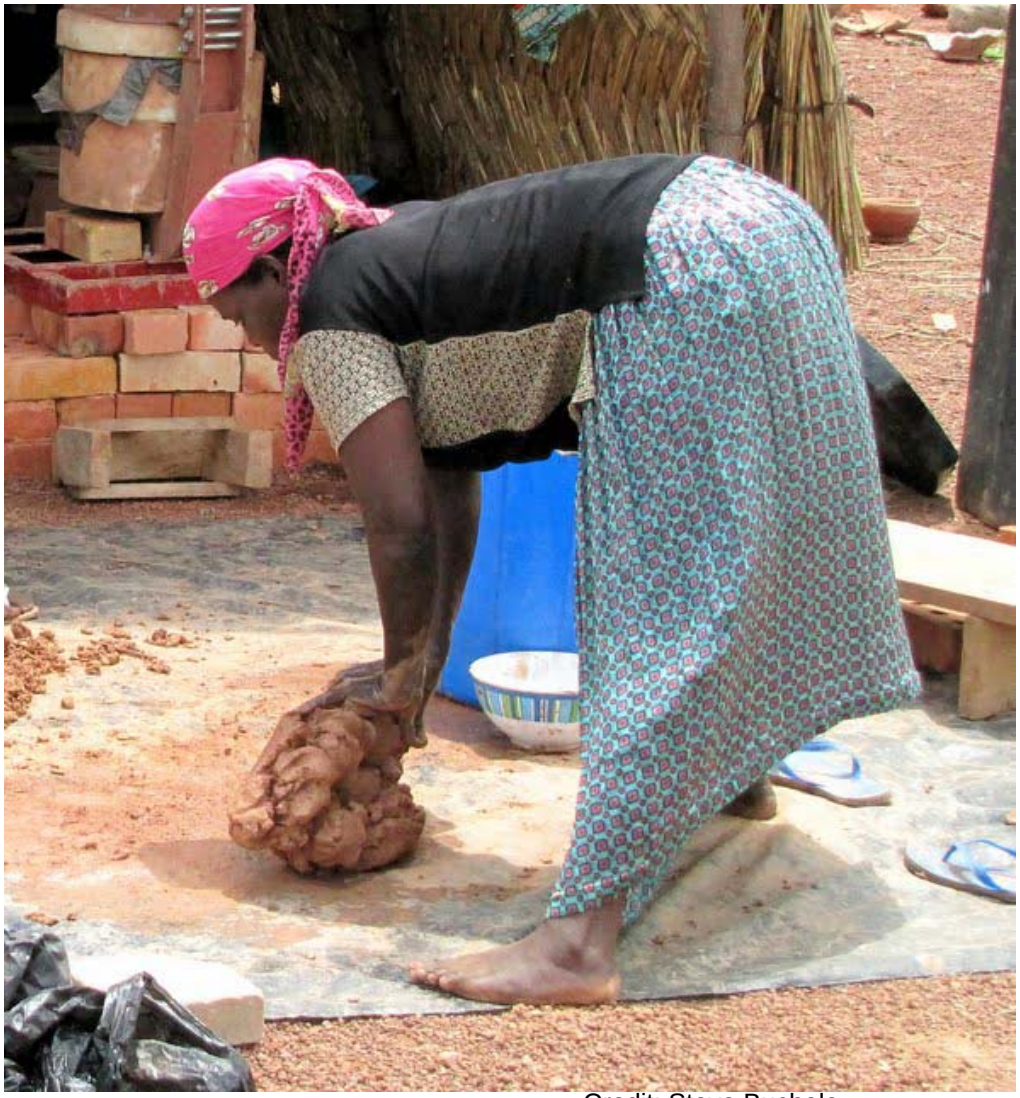
Gerry-rigging hammer mill to make it work for our rice husk

5. Mixing the clay and combustible materials together in the proper ratio of clay to combustible

Credit: Steve Buchele

6. Measuring and adding water to clay mixture

7. Kneading clay until uniform mixture is obtained



Credit: Steve Buchele

8. Weighing mixture

Credit: Steve Buchele

9. Pre-forming clay

Credit: Steve Buchele

10. Pressing Filter using Two-part Mold

Credit: Leah Nation

Credit: Steve Buchele

12. Drying Pots in the Sun

Credit: Travis Watters

13. Stacking Filters in the Kiln

14. Firing in Small Kiln: Ramping up to the Correct Maximum Temperature for the Right Time Duration

14. Firing – Big Kiln (Jan. 2011)

14. Factory Manager, John Adams, firing kiln – March 2011

15. Dipping or Painting Filters in Colloidal Silver Solution

16. Flow testing Filters

17. Packaging and sending out to market

(pictures from EcoFiltro, Antigua, Guatemala)

16. Flow Rate Testing

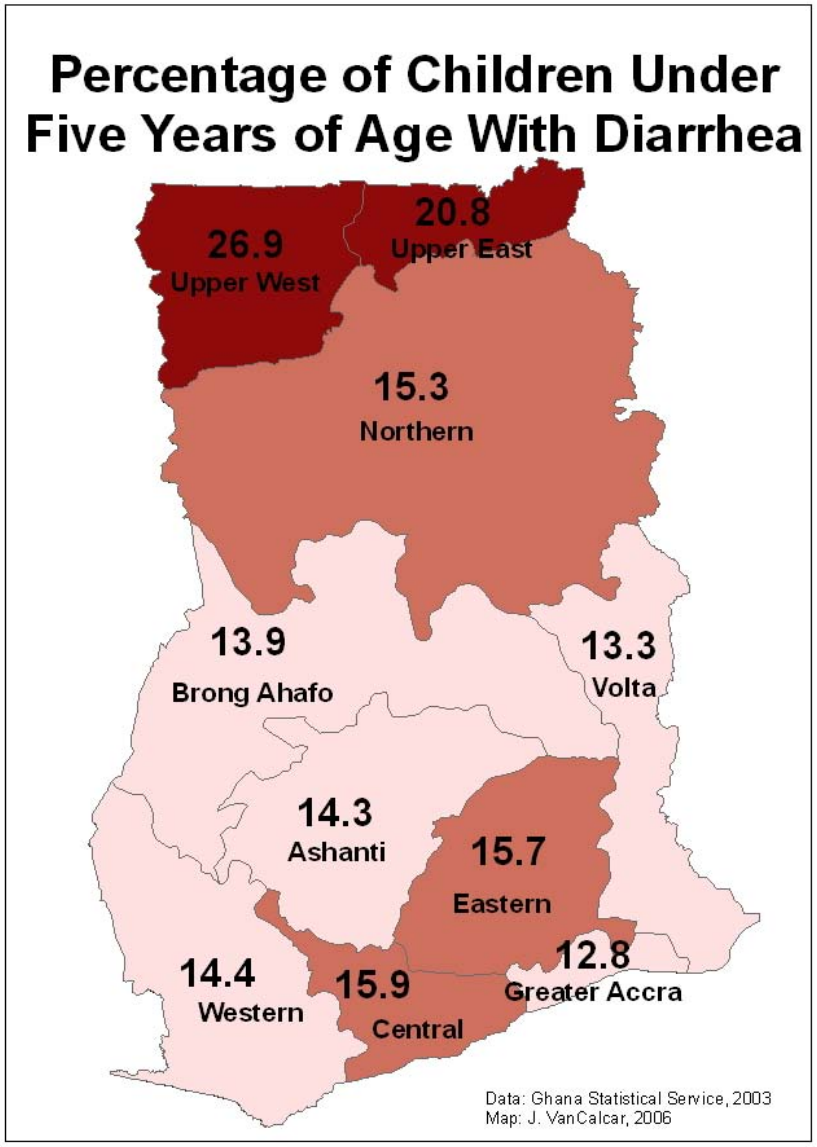
Pure Home Water's Monitoring & Evaluation Approaches

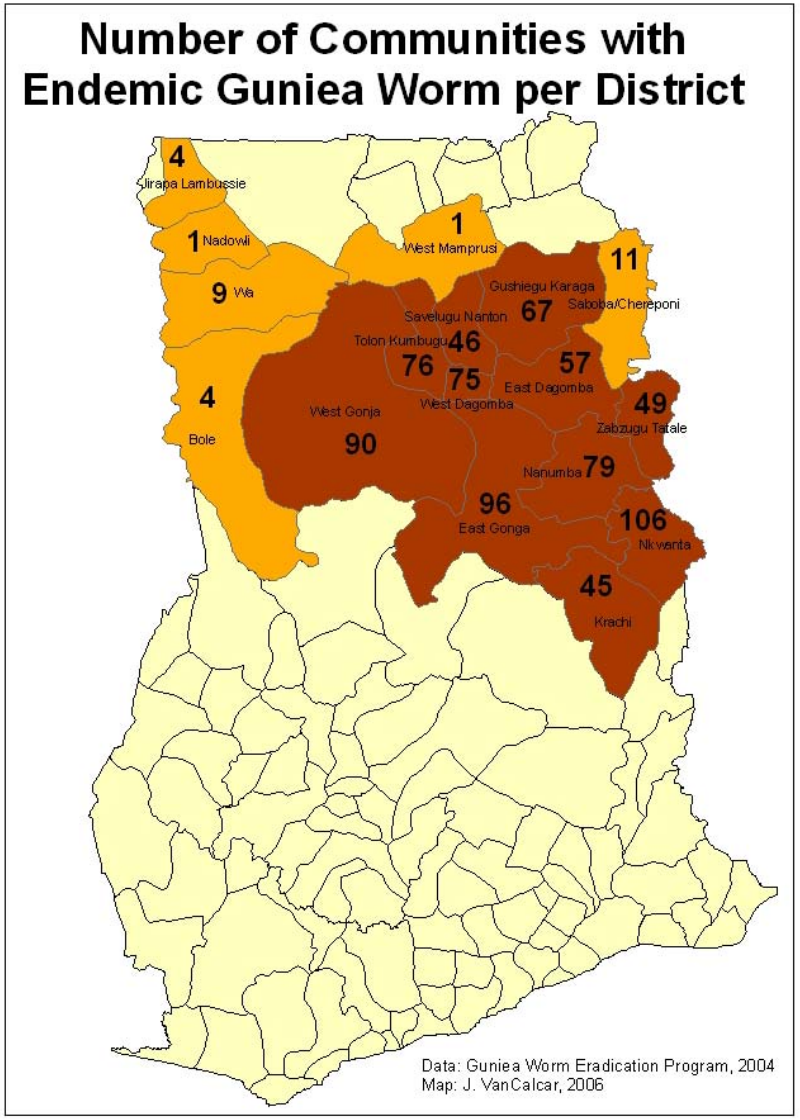
(many, but not all of which, are supported by MIT M.Eng teamwork, while PHW staff sell, distribute, and train users in filter use)

	Identified in the WHO Guidelines for Drinking Water Quality as a M&E approach to ensure safe drinking water
1. Mapping	
2. Health Outcomes	Yes
3. Water Quality	Yes
4. Technology Performance (flow rate, O&M, durability, service requirements, etc.)	Yes
5. Behavioral Outcomes	Yes
6. Extent of coverage, sales #s, people served, sustained use	
7. Financial & programmatic	

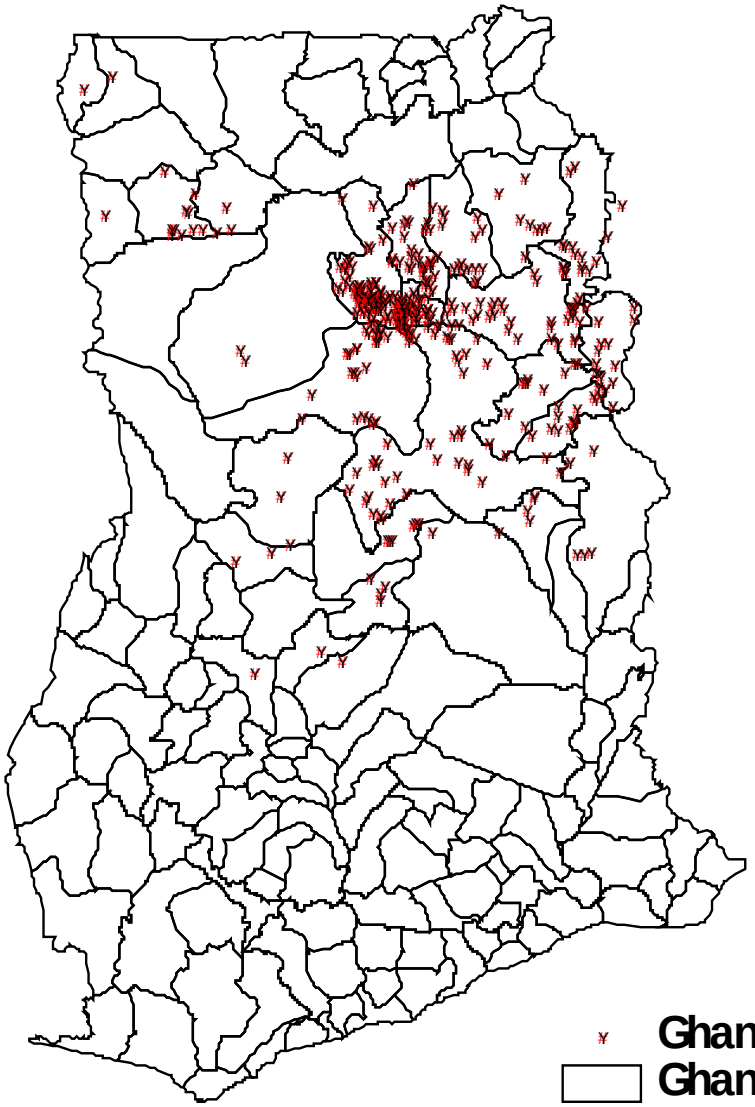
Mapping

Maps of Diarrhea and Guinea Worm Show us Where to Focus HWTS

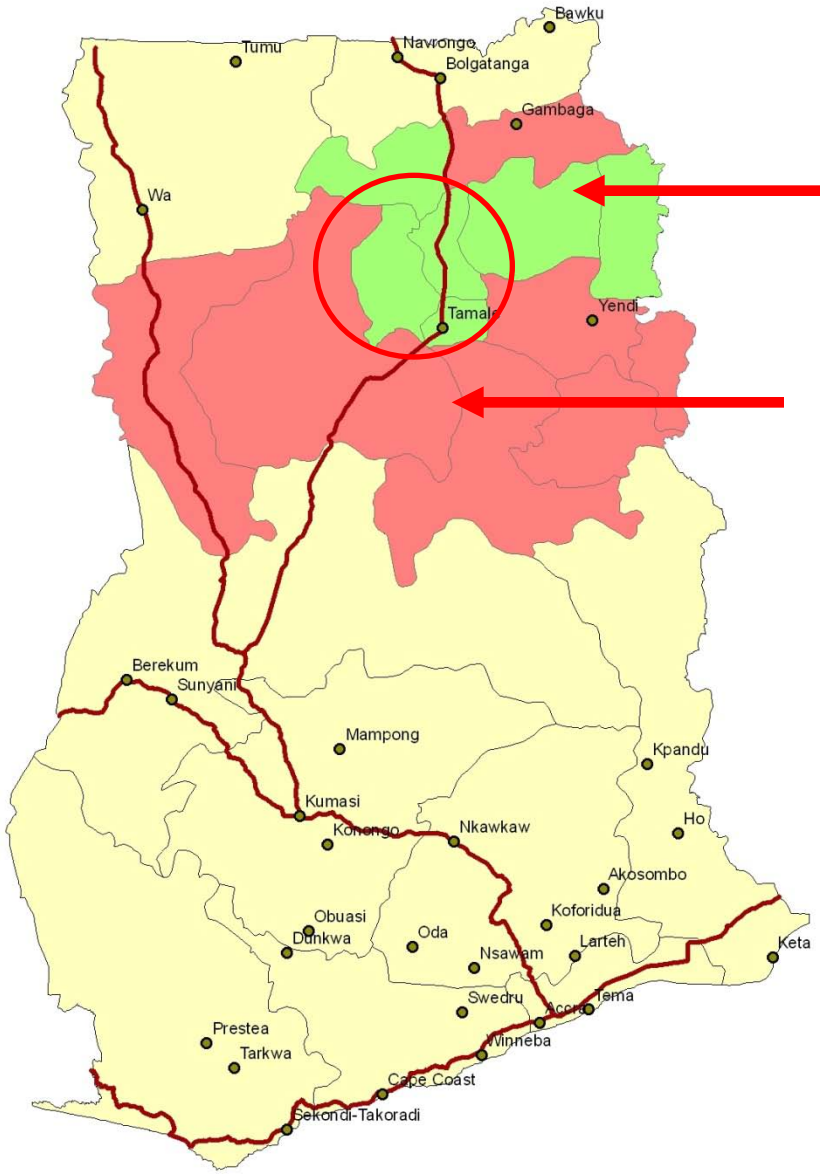




Endemic Villages 2005 - 2006



PROJECT LOCATION

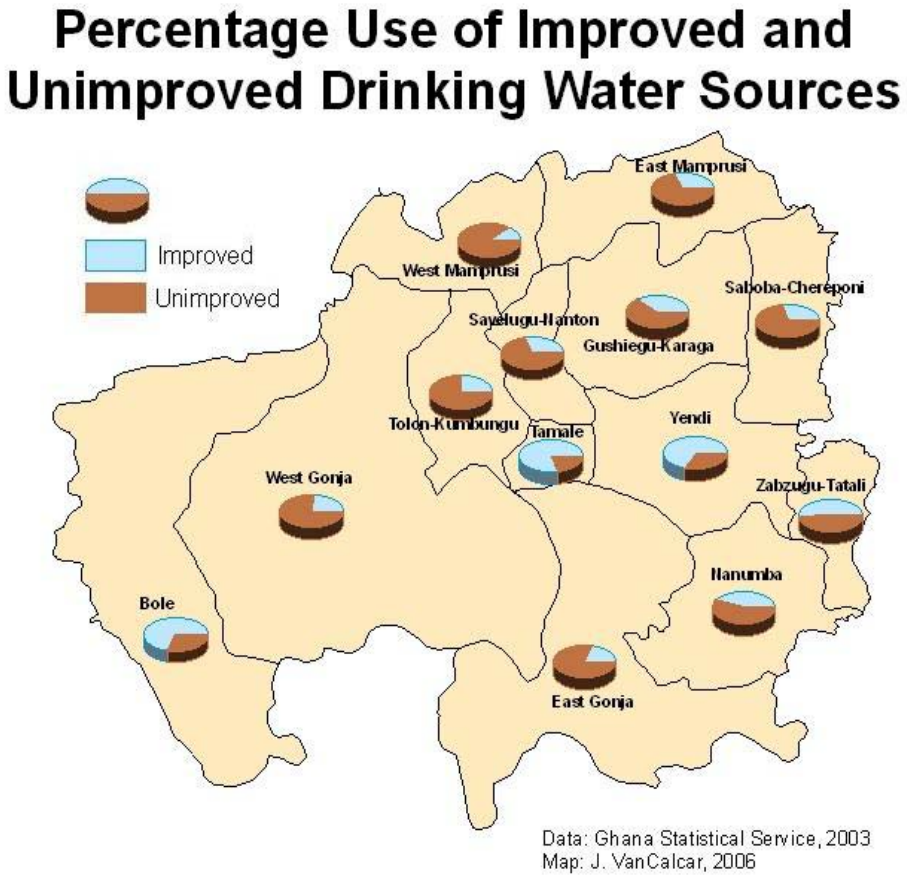


Six Districts of Pure Home Water Focus

Northern Region

Target Population

1 million out of 1.8 million people in the Northern Region currently drink water from an *unimproved* source.



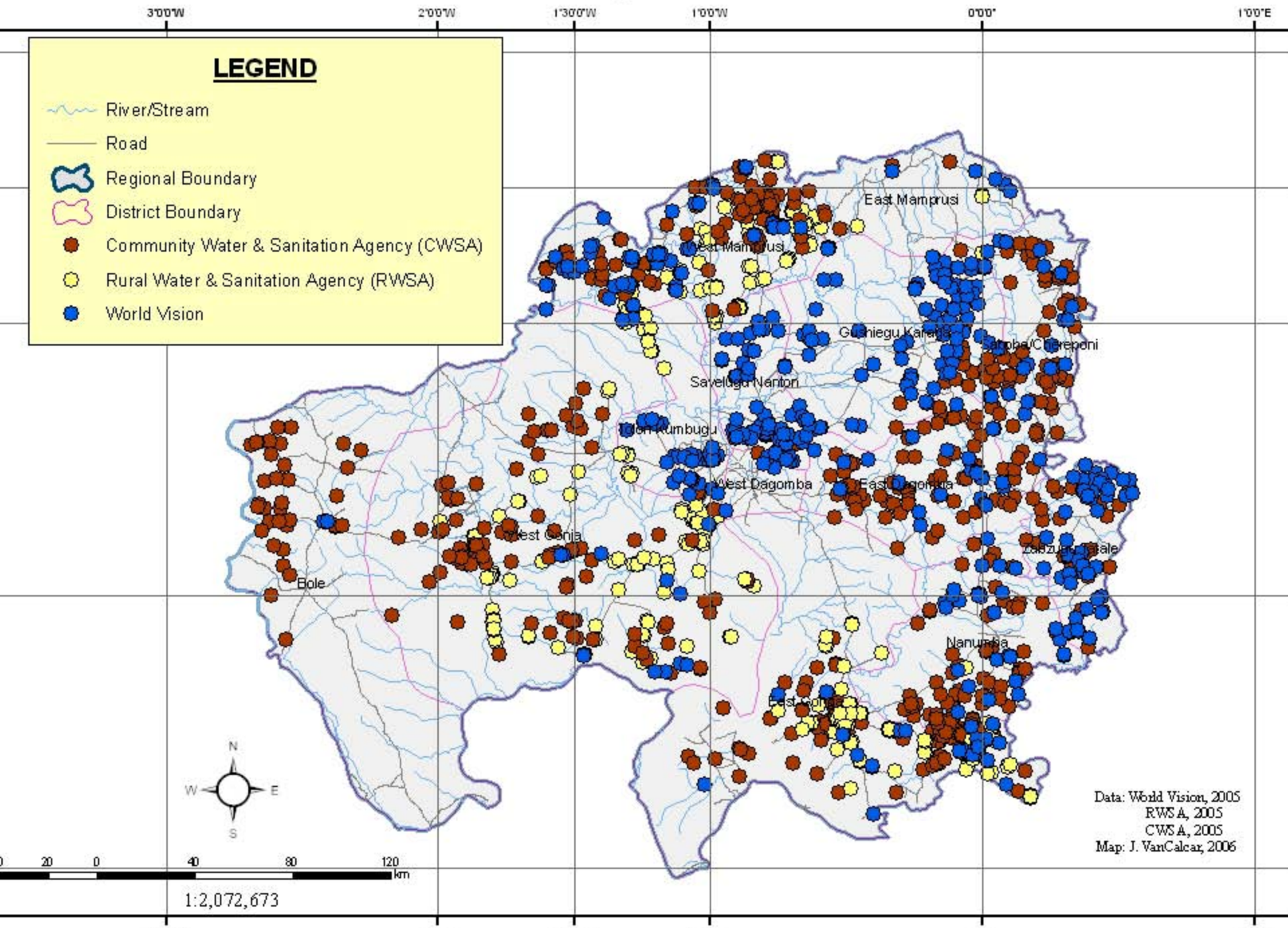
Improved Sources

- Boreholes
- Household connection
- Public standpipe
- Rainwater harvesting
- Protected springs and dug wells

Unimproved Sources

- All surface water sources
- Unprotected springs and dug wells
- Tanker trucks
- Vendor water

Northern Region Boreholes



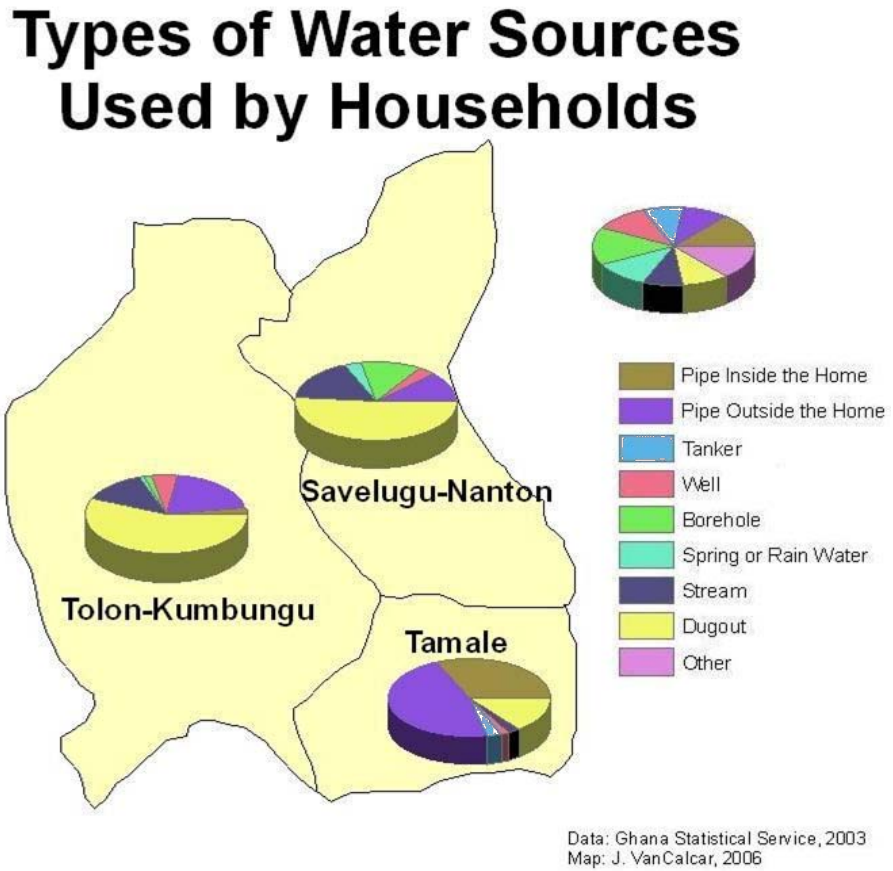
Typical Unimproved Sources in Northern Ghana

Tanker

Open Well

Stream

Dugout



Health

Health Outcome

- Quantifiable reduction in the overall level of disease

- Primarily applicable to some microbial hazards in developing countries and chemical hazards with clearly defined health effects

(WHO 3rd Edition – Guidelines for Drinking Water Quality)

Health Outcome in Ghana

- Reported incidence of diarrhea in household in the past week.
- 50 households (2006), 110 households (2007) from traditional, rural and modern, urban households surveyed on diarrhea

  – Half with ceramic filters; half without

(WHO 3rd Edition – Guidelines for Drinking Water Quality)

COMMUNITIES

Traditional

Modern

DIARRHEAL PREVALENCE (2006)

- *Overall Prevalence = **5%***
  - 5% (39/724) of all people suffered from diarrhea at time of study
- *Children under five years = **16%***
  - 16% (17/109) of children under five suffered from diarrhea at time of study

Children under 5 are at the greatest risk for diarrheal illnesses

RELATIVE RISK ANALYSIS

	Diarrhea	No Diarrhea
Filter	4	219
No Filter	12	203

Odds Ratio= $\frac{(4x203)}{(12x219)}$ = 31%

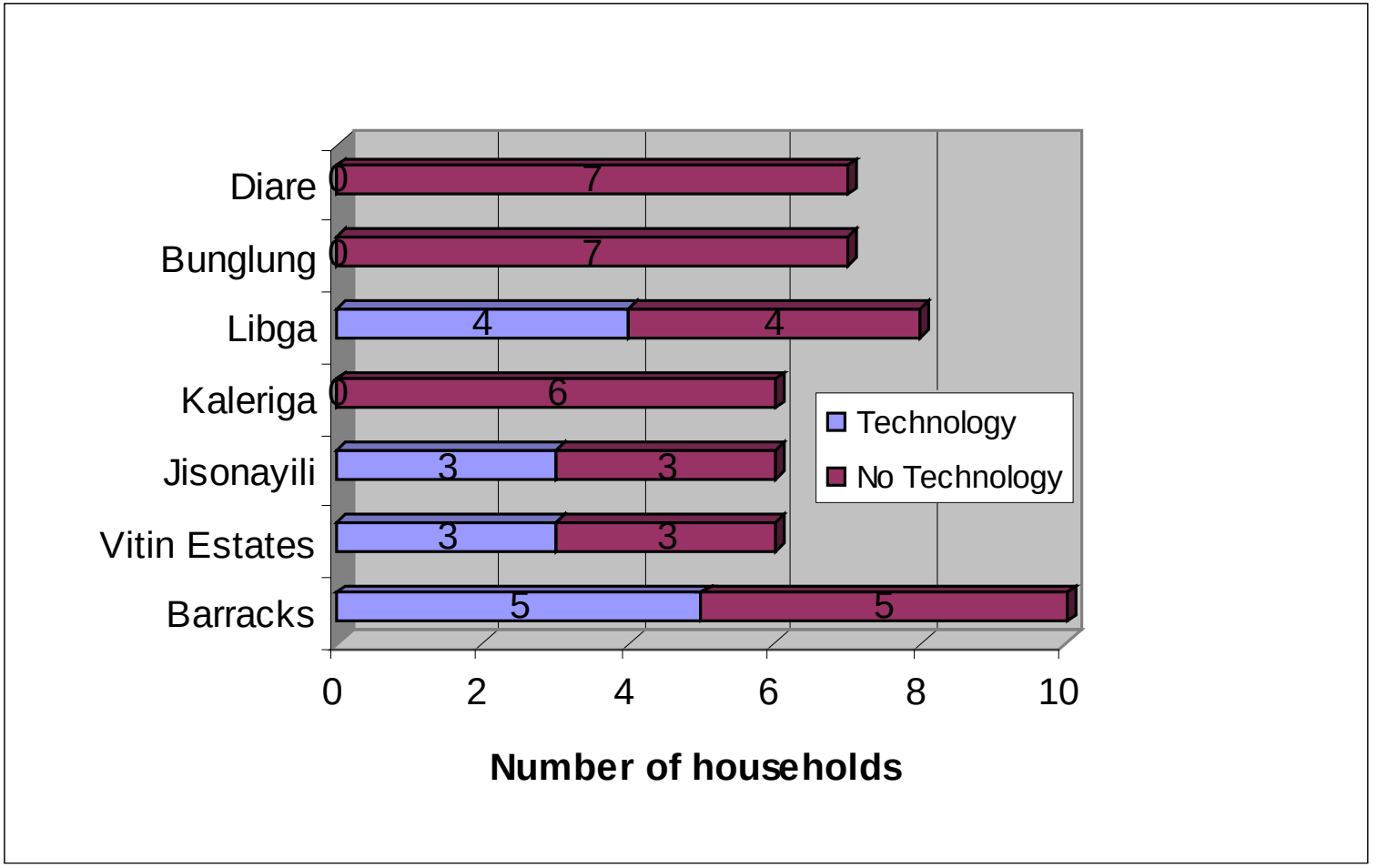
Statistically significant ($p<0.035$)

*Traditional rural households with filters have **31% of the risk** (69% less risk) of having diarrheal illness compared to households without filters*

(Johnson, 2007)

COMMUNITIES SURVEYED

50 Households, 7 Communities, Mothers Interviewed (Jan. 2006)



(Peletz, R. 2006)

Water Quality

Water Quality

- Established for individual drinking water constituents that are a health risk from long-term exposure, where fluctuations are small or occurring over long periods

- Typically expressed as guidelines values (concentrations) of the substance or chemical of concern

- In Ghana, we have a established and trained local technicians in simple water quality testing for turbidity and 3 low-cost indicator tests: 3M petrifilm (*E.coli* and total coliform), membrane filtration (*E.coli* and total coliform) and hydrogen sulfide bacteria presence/absence testing.

(WHO 3rd Edition – Guidelines for Drinking Water Quality)

Water Quality Testing

3M PetriFilm

Esherishia coli

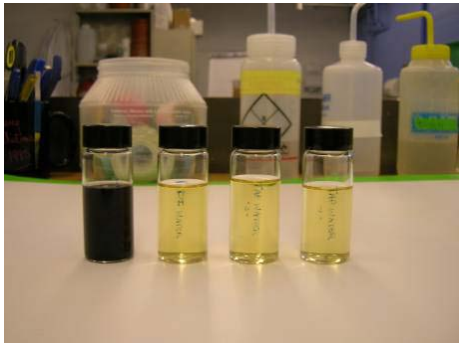
+ Total coliform

Membrane Filtration (m-ColiBlue)

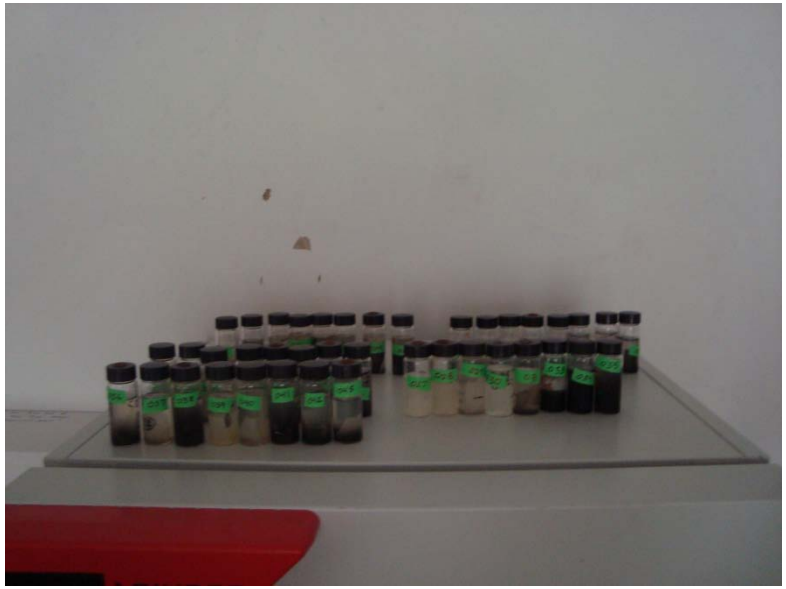
Esherishia coli + Total coliform

P/A H_2S test

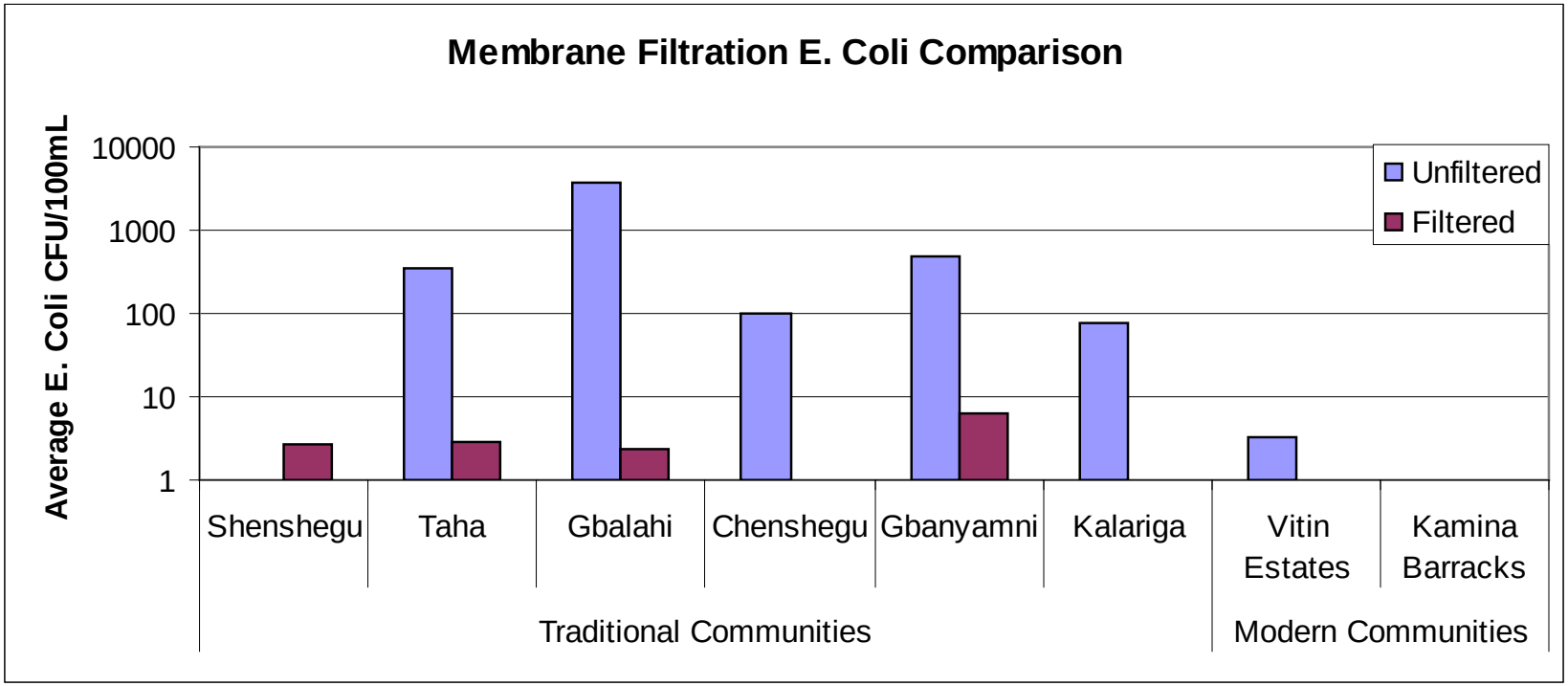
H_2S-producing bacteria



17.Water QualityTesting



Water Quality Results



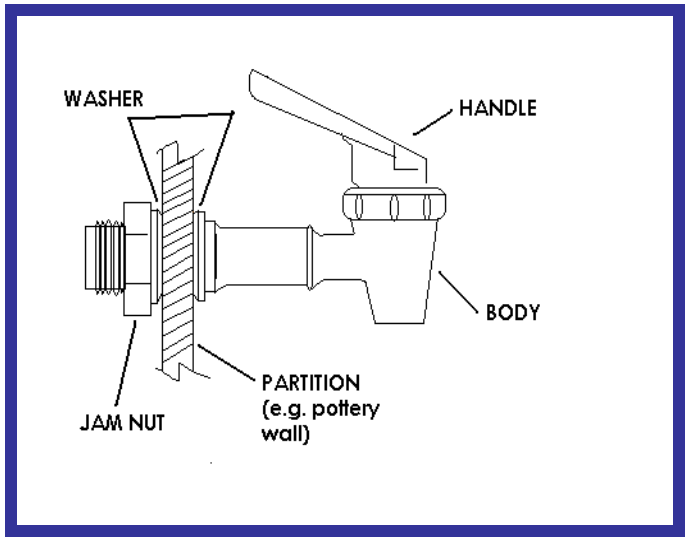
Water Quality Results: Filtered vs. Source Water

	Traditional Households	Modern Households
E. coli Reduction	99.7%	85%
Total Coliform Reduction	99.4%	90%
Turbidity Reduction	92%	68%

Technology Performance

Technology Performance

- Flow rate (post-manufacture & in use)
- Cracks and manufacturing defects
- Broken lip
- Broken spigots



Behavioral Outcomes

Behavior and User Perceptions

Technology still in use	93%
Changes in water	80% = Better 20% = The Same
Recommend technology to others	100%
Noticeable health improvements	87%

94% of households without product are interested in treating their water

Proper Cleaning & Maintenance

% households performing proper cleaning and maintenance

HOW TO USE YOUR FILTER

1) Before using the new filter,

A) Fill the filter receptacle halfway with water and.
B) Add 10 drops of chlorine bleach or 16 drops of iodine to this water.
C) Let it sit for 30 minutes.
D) Use this water to rinse the receptacle, clay filter, lid and faucet and your hands. If chlorine or iodine is not available fill the receptacle halfway with boiled water and when it cools pour this water over the lid, faucet and filter. Discard all the water.

Only chlorinated, boiled, or water treated with iodine will kill bacteria in the receptacle.

2) Place the clay filter in the plastic receptacle immediately.

3) Fill the filter several times and discard the filtered water. This will remove the taste of the clay.

4) If your river or well water is cloudy, use a piece of cloth over the filter element to prefilter the water each time. Tie a string around the cloth so that it does not fall into the filter.

5) Your filter will flow faster when it is full, so fill it often.

Prefiltering will help your filter to flow faster.

HOW TO CLEAN YOUR FILTER AND RECEPTACLE

1) FILTER CLEANING
You do not need to clean your filter more than once a month unless it starts to filter too slowly.

When this happens, carefully remove the filter. Leave the receptacle at least half full of filtered water. Place the filter on a cloth that has been washed in chlorinated or boiled water.

2) Using water from the receptacle, fill the filter half way and scrub it vigorously with a brush to unclog the pores. Discard the dirty water. You will have some small particles of clay come off if you are scrubbing hard enough.

3) CLEANING THE RECEPTACLE
The filter receptacle should be cleaned each month. Follow the directions above beginning with "1-A" for cleaning your receptacle.

The clay filter will usually last a year before it becomes too clogged to provide enough water. At this time it should be replaced. If cleaning still restores the flow, it does not need to be replaced. To replace your filter contact _____.

Awareness of Educational Materials

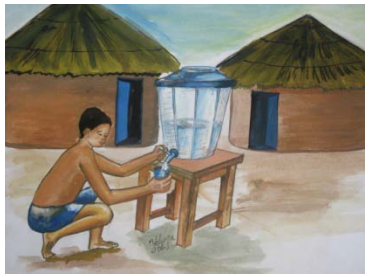
% of people aware of educational / promotional messages

A lesson in pictures:

Water drunk straight from the dugout leads to guinea worm and the hospital.



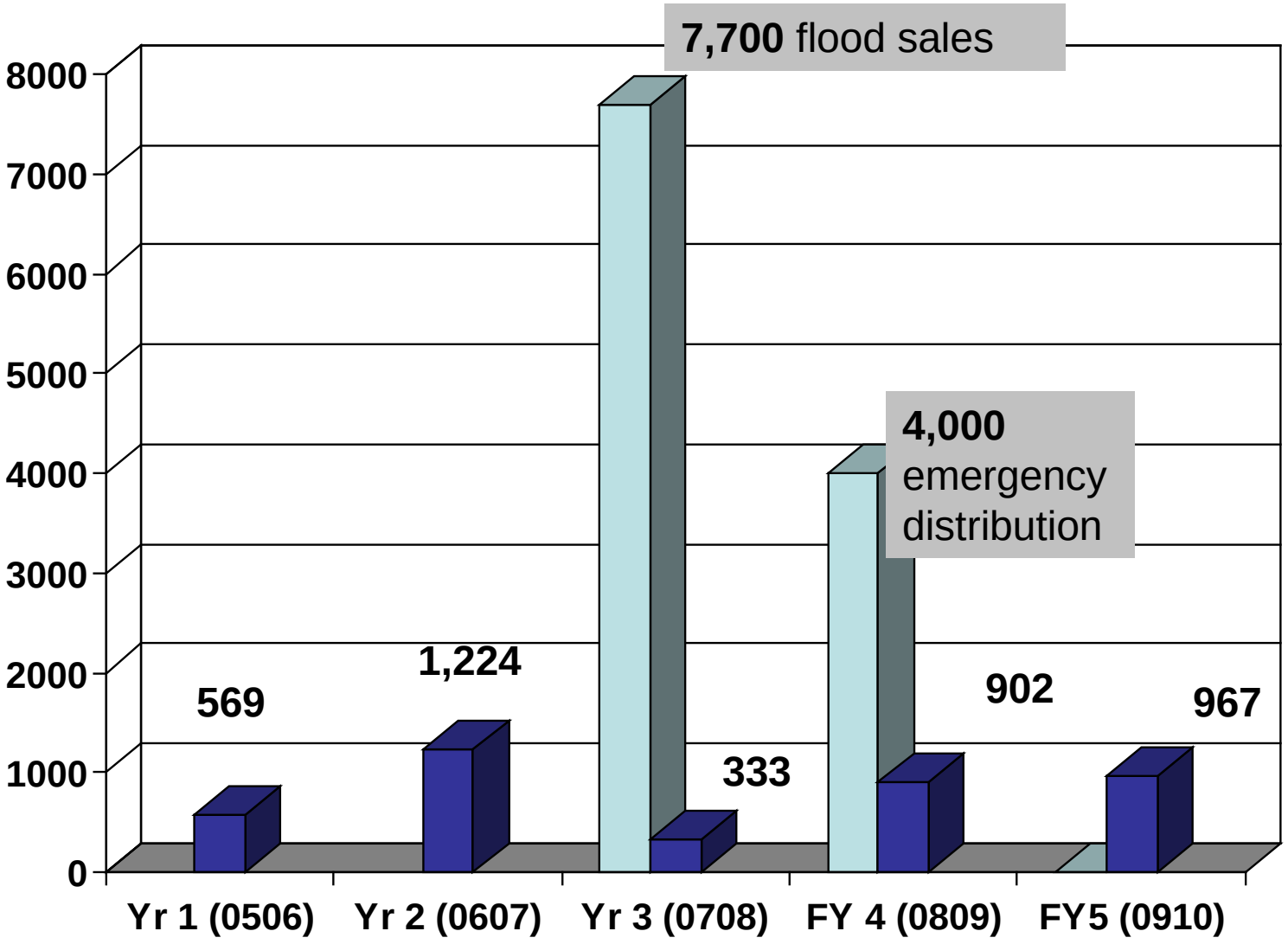

Water drunk from the filter leads to school and happy family




of Sales
of People Reached
Use/Sustained Use

Accomplishments: Pure Home Water Filter Sales (2005 – 2010)

We have reached over 100,000 people to date!



of People Reached
(July ’05 to Feb. 10)

	Units Sold	People per HH	# People Reached
Urban/Retail	4,108	6	24,648
Emergency (free)	11,820	6	70,920
Schools & Clinics (free)	115	40	4,600
Intern’l-Burkina Faso	200	6	1,200
TOTAL	16,243		***101,368***

2008 Flood Distribution

- 5,500 filters sold by PHW to UNICEF and Oxfam in Nov. 2007
- 2000 Distributed to end user by PHW, remainder by NGO or Government (Jan. – April, 2008)
- Free of charge
- PHW has monitored > 1,000 filters in households (June – Aug, 2008)

(Credit: M.Stevenson)

2009 Guinea Worm Distribution - 4000 Filters

Training, Dissemination, Monitoring

Woman from Yesapi, Central Gonja, with bandage covering guinea worm-infected foot

Use/Sustained Use

- See Masters of Science thesis of Kate Clopeck (Ghana, 2009):

- http://web.mit.edu/watsan/docs_theses_ghana.html

Financial Evaluations

Clear and Transparent Accounting, Prices, Breakeven Analysis

- Our project aims for locally managed, clear and transparent accounting
- We have invested in accounting training for one of our staff
- Clear accounting includes precise tracking of production, distribution, retail costs and any subsidies.
- Break-even analysis – shows us how many products we must sell on a monthly basis to break-even

Pure Home Water: Income Statement (US$)

From 31 July 2006 to 15 January 2007

	Year-to-Date (US$)	Projected (US$)
Revenue		
Sales	3191.11	7,200.00
Total Revenue	**3191.11**	**7,200.00**
Other Income	**30,500.00**	**129,024.00**
Costs of Goods Sold		
Capital Equipment and Supplies	22.00	29,114.44
Transportation	255.78	2,177.78
Labor Costs	15,500.00	47,014.67
Total Costs of Goods Sold	**15,777.78**	**78,306.89**
Gross Profit	**-12,586.67**	**-71,106.89**
Operating Expenses		
SG&A	5,456.23	22,133.63
Tuition	1,007.24	6,000.00
Travel	1,500.00	7,500.00
Other Operating Expenses	5,169.29	5,500.00
Total Operating Expenses	**13,132.76**	**41,133.63**
Total Expenses	**13,132.76**	**41,133.63**
Net Income	**4,780.57**	**16,783.48**

Rates of sales would mean $6,500/year with manufacturing

FY end balance means 3 months operating

Prices and Subsidies

- Urban Retail

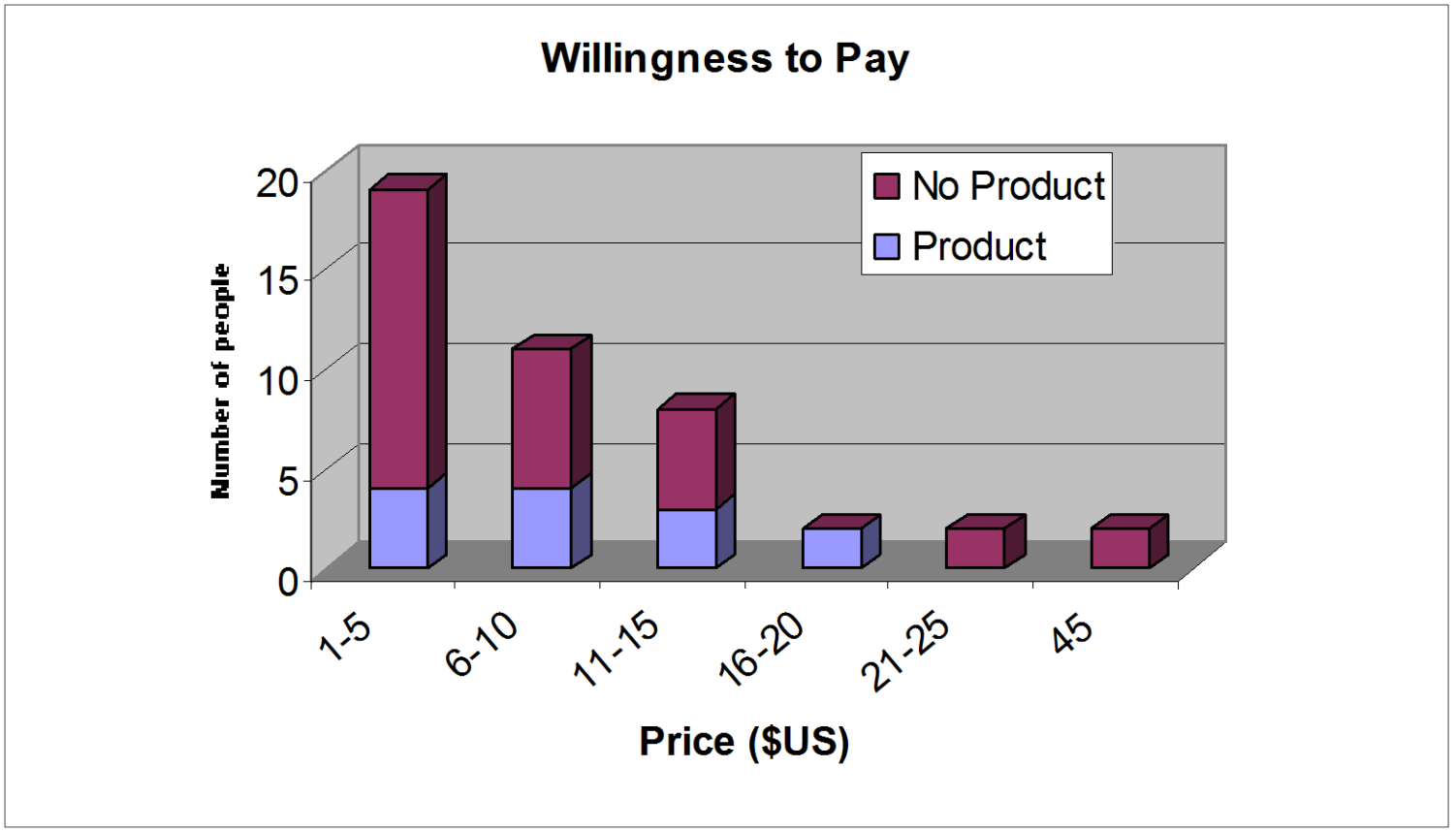
PHW Cost	Retailer Price	Customer Price
137,000	100,000	120,000 (Cash)
137,000	100,000	130,000 (Credit)

- Rural

PHW Cost	Liaison	Customer
137,000	50,000	60,000 (Cash/Credit)

PRODUCT PRICING FEEDBACK

Average willingness to pay = $9
Cost to purchase and transport from Accra = $15
Estimated cost of local manufacture = $6



Breakeven Analysis

- Formula

  Revenue = Unit sold × Price

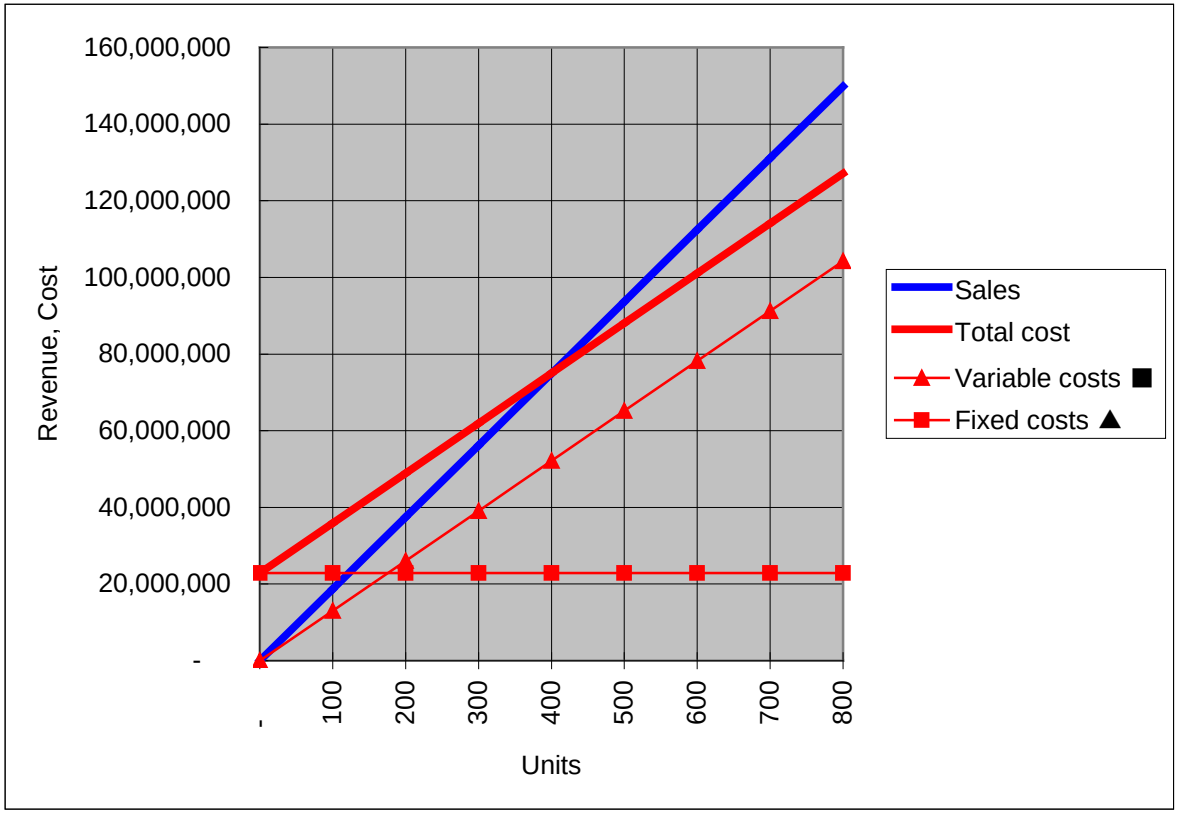
  Cost = Fixed Cost + Variable Cost

  = FC + Unit sold × VC Ratio

  (Fixed cost) (Variable cost)

Breakeven analysis

Price	187,316								
Margin	50,000								
Unit	-	*100*	*200*	*300*	*400*	*500*	*600*	*700*	*800*
Sales	-	18,731,579	37,463,158	56,194,737	74,926,316	93,657,895	112,389,474	131,121,053	149,852,632
Total cost	22,872,874	35,904,452	48,936,031	61,967,610	74,999,189	88,030,768	101,062,347	114,093,926	127,125,505
Variable costs ?	-	13,031,579	26,063,158	39,094,737	52,126,316	65,157,895	78,189,474	91,221,053	104,252,632
Fixed costs ?	22,872,874	22,872,874	22,872,874	22,872,874	22,872,874	22,872,874	22,872,874	22,872,874	22,872,874



Breakeven Analysis

2005 MARGIN ANALYSIS FOR PURE HOME WATER PROJECT
CERAMICA TAMAKLOE FILTER

#	VARIABLE COST	Cedis Unit Price
V1	Purchase price	110,000
V2	Transportation (Accra-Tamale)	16,316
V3	Brush	2,500
V4	Manual	1,000
V5	Tap Fixing	500
V6	Sales Commission	7,000
M	Margin	14,684
	Retail price	152,000

10,000	20,000	30,000	40,000	50,000	60,000
147,316	157,316	167,316	177,316	187,316	197,316
Margin %	7.3%	14.6%	21.8%	29.1%	36.4%	43.7%

#	FIXED COST (PER MONTH)	Cedis
F1	Average fixed cost per month	22,872,874

F1/V6	**Breakeven sales volume**	1,558	2,287	1,144	762	572	457	381
						381.214559		

Programmatic Evaluations

Business Results: 4Ps

- *Product* is acceptable to users:
  - 100% of users said it is easy-to-use, that they use it daily, and that they would recommend it to others
  - Spigot problems in filters in use >1 year
- *Promotion* channels are effective:
  - 94% of non-users were aware of ceramic filters in their community
- *Price* is affordable to low-income families:
  - Non-filter users actually reported a higher monthly income per person than filter users (US $ 7.60 vs. US $5.50)
- *Place* of focus is in communities that need the filters the most
  - 0% of targeted communities have improved water supplies or sanitation

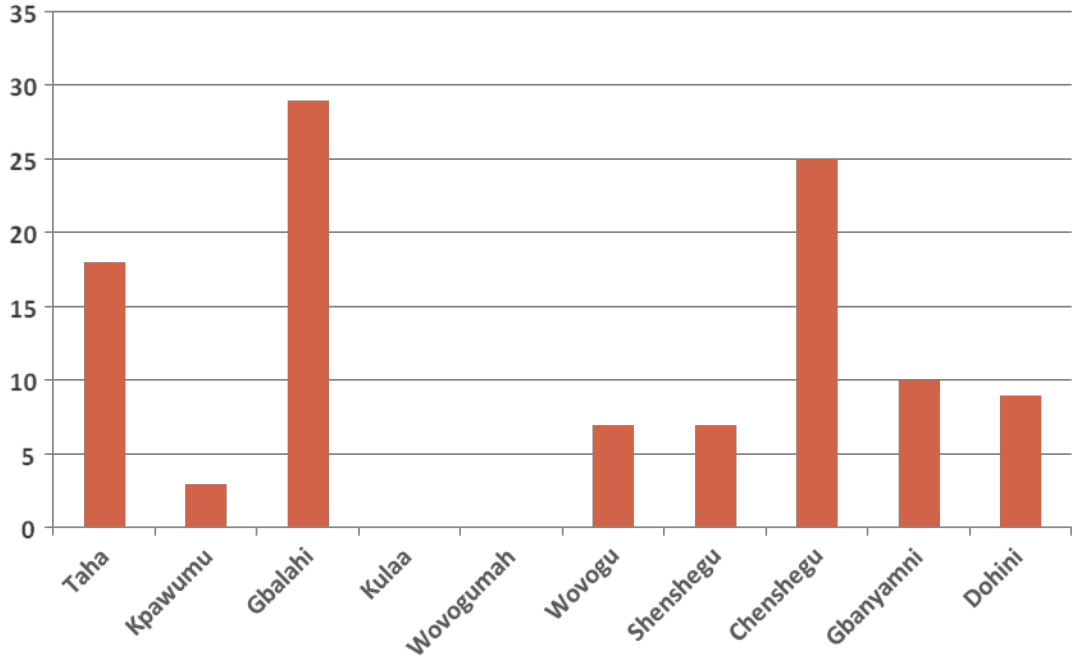
Urban Outreach

– Train retailers in filter use and maintenance and provide them, at no upfront cost, with filters and educational/promotional materials

PHW Cost	Retailer Price	Customer Price
137,000	100,000	120,000 (Cash)
137,000	100,000	130,000 (Credit)

– **Indicators**: # of active retailers/# trained (=10 active retailers/salespeople out of 17 trained)
– Amount of money collected as filters are sold

Rural Outreach: Sales



Outreach took place in 9 communities in one month and led to sales in 7

Social Business?

- In our 6 years, Pure Home Water has explored a range of monitoring and evaluation (M&E) approaches
- All the M&E approaches are important to us to ensure safe drinking water, however, our capacity to handles M&E is limited (time, money, skill sets)
- PHW has mainly focused on the “double bottom line” of reaching high risk/low income families and attempting to be financially and locally self-sustaining
- MIT graduate students have provided M&E services to Pure Home Water (mapping, health, water quality, financial)
- We have not succeeded yet as a social business by Muhammad Yunus’ (strict) definition

Pure Home Water Factory & MIT Team 2010-2011

For More Information

http://web.mit.edu/watsan/meng_ghana.html

http://www.purehomeh2o.com

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1.011 Project Evaluation

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