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FIELD WATER QUALITY ASSESSMENT AND DESIGN OF COMPREHENSIVE SYSTEMS TO IMPROVE WATER QUALITY – CURIMANÁ DISTRICT, UCAYALI REGION, PERU

FINAL REPORT

FEBRUARY 2007

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The author's views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

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ACRONYMS AND ABBREVIATIONS

CDC	Centers for Disease Control and Prevention
CCSAP	Community SAP Committee
DCSAP	District SAP Committee
DESA	*Direccion Ejecutiva de Salud Ambiental*
DIRESA	*Direccion Regional de Salud Ucayali*
HH	Household
HIP	USAID Hygiene Improvement Project
HMC	Healthy Municipalities/Healthy Communities
IEC	Information, Education, Communication
JVs	*Juntas Vecinales*
LHP	Local Health Posts
LOAS	Local, community-level, operational arm of the RECO-MAP
LTT	Local Technical Teams
MCH	Maternal and Child Health
MIAGUA	The name of a regional water/sanitation project with activities in Ucayali Region
MINSA	*Ministerio de Salud*
MSH	Management Sciences for Health
NEPRAM	*Negociacion de Practicas Mejoradas*
ODL	*Organizacion de Desarrollo Local*
PAHO	Pan American Health Organization
POU	Point-of-Use
RECO-MAP	*Red Comunitaria para el Mejoramiento de Agua Potable*
SAPs	*Sistemas de Agua Potable* (potable water systems)
SERUM	*Servicio Rural Urbano Marginal*
SODIS	Solar Disinfection

TA	Technical Assistance
THMs	Trihalomethanes
ToTs	Training of Trainers
USAID	United States Agency for International Development
WHO	World Health Organization

EXECUTIVE SUMMARY

The Management Sciences for Health (MSH)/Peru Healthy Municipality Project works in six of Peru's regions to improve the ability of municipalities, communities, schools, and households to improve the health of the resident population. Through participatory interactions with these populations, water quality has been identified by project stakeholders as a critical public health issue, and MSH/Peru sought to develop appropriate interventions that would create self-sustaining local capacity to monitor and improve the bacterial quality of drinking water.

To this end, the USAID Hygiene Improvement Project (HIP) is providing MSH technical assistance (TA) to MSH/Peru to build an internal team that will implement these interventions. The first HIP activity in this TA package is a field assessment conducted by two consultants, an engineer and a public health specialist, in a district (Curimaná, Ucayali Region) identified by MSH/Peru that will serve as a pilot for the broader MSH/Peru water quality activity.

This report presents the findings, conclusions, and recommendations of this assessment conducted in the Curimaná District of the Ucayali Region, Peru, over nine days in October 2006 (end of the dry season). The objective of this assessment is to provide information that will permit the MSH/Peru Healthy Municipality Project to address water quality management and monitoring issues in its client municipalities and schools.

The assessment activity included the following evolutions:

- observations and interviews on household knowledge, attitudes, and practices around water collection, handling, storage, treatment, and use;
- quantitative fecal bacteriological testing of source and household (HH) waters;
- water quality parameters related to the design of a HH water treatment (disinfection) protocol:
    - pH, turbidity (visible as well as turbidimeter), conductivity, chlorine demand of waters (Centers for Disease Control and Prevention [CDC] testing protocol), and chlorine content of locally-available chlorine products.

Communities in the District of Curimaná rely on a variety of drinking water sources. Thirteen communities are served by potable water systems (SAPs), with varying levels of service. Households in these thirteen communities, like HHs in the other 16 communities of the district, collect water for HH uses from the Aguaytía River, small streams, formally-constructed "artisan" wells that can serve neighborhoods or households, informal hand-dug wells that can serve neighborhoods or single HHs, and to a lesser extent rainwater harvesting. Water is collected, stored, and used by HHs with minimal attention paid to maintaining water quality. Sources are contaminated for a number of reasons and further contamination of water likely occurs during collection, handling, storage, and use. Thus it was not surprising to find that all water sources, and all water sampled in HHs, show signs of fecal contamination with high levels of fecal coliform bacteria—all of which are of "high risk" to "very high risk" waters according to World Health Organization (WHO) standards. These alarming findings on the bacteriological quality of drinking water in Curimaná should become part of an information, education and communication (IEC) program to create local demand for appropriate water treatment options.

Water sources were observed to lack fundamental infrastructure to prevent contamination. Water treatment was typically absent or otherwise rudimentary and allowed for recontamination to occur. Observed HH treatment practices were not based on empirically-developed protocols.

People are aware of the role of water in human health, water as a disease carrier, and people do take measures (treat water) to address aesthetic issues—i.e., turbidity, taste.

Based on the findings which indicate source contamination, documentation of the significant risk of contamination and re-contamination of boiled water in the HH, and observations of HH economic status and absorptive capacity, it is recommended that MSH promote a HH water treatment system using a chlorine-based approach. Note that this report presents, in addition to a chorine-based treatment/disinfection approach, analysis of solar disinfection (SODIS), as well as analysis of boiling.

The chlorine demand study has informed the design of chlorine dosage protocols for water from different sources and of varying quality (turbidity). These protocols also take into consideration variability in the quality (chlorine concentration) of the locally available chlorine source—HH bleach. Chlorine treatment protocols are developed for four water source/turbidity scenarios:

1. All waters from surface sources except those with very high turbidity;
2. Low turbidity waters from ground water sources;
3. Turbid waters from groundwater sources;
4. Highly turbidity waters from any source (and accompanying protocol for turbidity analysis and turbidity removal).

To enhance the effectiveness of the chlorine-based treatment system and to minimize the risk of re-contaminating water in the HH, we recommend that the chlorine-based system be accompanied by basic HH improvements in water collection, storage, and handling, as well as actions to better protect and maintain water sources.

If HHs and communities are to adopt and sustain these new water quality improvement practices, there must be an institutional system that provides appropriate monitoring, extension, and training services. We propose a two-tiered RECO-MAP (*Red Comunitaria para el Mejoramiento de Agua Potable*). This Community Network to Monitor and Improve Water Quality provides capacity for knowledge management and capacity-building at the district-level (coordinated by the *Oficina de Desarollo Local* [ODL]), and IEC and extension at the community-level (coordinated by the *Juntas Vecinales* [JVs]). General recommendations to MSH for creating and supporting the nascent RECO-MAP are presented with the understanding that as a follow-on to this report, HIP will design and implement trainings of trainers (ToTs) with MSH and RECO-MAP participation.

INTRODUCTION/BACKGROUND

This water quality assessment and design of point-of-use (POU) water treatment protocols for communities in the District of Curimaná, Region of Ucayali, Peru is the initial step in an activity implemented by the HIP, with support from USAID/Peru, to assist the MSH/Peru Healthy Municipality Project improve its ability to address water quality management and monitoring issues in its client municipalities and schools.

The support that HIP shall provide to MSH is to be informed by the results of a pilot activity in the Curimaná District, the first step of which is this field assessment activity. The assessment has produced information that will be presented in four key reports:

1. A report on the operational status of 13 SAPs built in the Curimaná District in 2005 through USAID's Alternative Development Project.
2. A report on HH behaviors in Curimaná around water collection, treatment, handling, and use.
3. **This report** which contains the findings, conclusions, and recommendations for developing and institutionalizing water quality improvement actions in Curimaná.
4. A report documenting the lessons learned during this Field Assessment Activity in Curimaná that will recommend a protocol for efficiently replicating this assessment in other parts of Peru to inform an expanded MSH water quality improvement activities.

This particular report is presented in three reports and contains findings, conclusions, and recommendations on:

1. Small, doable actions to improve and protect sources that will result in improvements in water quality and quantity. Improvements to sources will improve ambient water quality which will, in turn lead to improved efficacy of POU water treatment.
2. Source water and HH water quality with recommendations on POU treatment options, HH water collection, handling, storage, and use. This includes recommended POU protocols based on the source water characteristics.
3. An institutional model for a system to initiate and provide sustained support to water quality improvement in source improvement, POU treatment, and water quality monitoring.

These three report sections are presented in a format that allows them to be cut from the main report as stand-alone documents. Therefore each of the three reports has its own introduction, methods and materials, findings and conclusions, and recommendations sections.

REPORT 1: EVALUATION AND IMPROVEMENT OF WATER SOURCES IN CURIMANÁ

1.1 INTRODUCTION – WATER SOURCES

In this first report we present the findings of an evaluation of water sources in Curimaná. Here presented are findings on the condition of the sources and the ambient quality (i.e., turbidity and fecal bacteria) of water collected from those sources. (Note that water quality is addressed in more detail in Report 2: Developing POU Protocols to Improve Drinking Water Quality in Curimaná.)

The product of this assessment of water sources is a list of small, doable (economically and technically feasible) actions to improve and protect water sources that will result in improvements in water quality. These improvements in ambient water quality will, in turn, lead to better performance of POU water treatment procedures.

1.2 METHODS AND MATERIALS – WATER SOURCES

The District of Curimaná is located about two and a half hours away from the regional capital of Pucallpa. It is comprised of the municipality of Curimaná, where we stayed while conducting fieldwork, and of 29 rural communities located at varying distances from the municipality. The majority of the communities were accessible by road, but others were only accessible by boat or foot. Fieldwork was completed in nine days during October 2007 (end of the dry season).

1.2.1 Water Sources Evaluated

With respect to assessing water sources, the trip to Curimaná had the following goals:

- visit as many communities as possible (maximize the sample size),
- determine the water sources being used by community residents,
- describe and evaluate these sources,
- collect water samples from representative water sources, and
- evaluate appropriate water quality parameters—namely, fecal coliform and turbidity.

Fifty-two (52) water sources in 20 communities were visited, their physical/infrastructural soundness evaluated, and water samples collected.

Through observation and through conversations with residents, water sources were identified, evaluated, and sampled. In this manner, we ensured that samples were collected from the sources actually employed by residents. The following **types of water sources** were visited and assessed by members of our team.

- surface sources—large rivers, and small streams;
- community water systems—deep wells and tapstands;
- "artisan wells"—household and neighborhood wells, constructed with external support and technical assistance;
- informal household wells—excavated and maintained by homeowner with rudimentary associated infrastructure; and
- rainwater collection—very minimal; no opportunity to collect/analyze samples.

1.2.2 Analysis of Source Water Quality

The following parameters were analyzed in situ with a portable meter purchased for this assessment of pH, temperature, dissolved solids, conductivity.

Turbidity was analyzed using two techniques:

1. Turbidity assessed in situ using a visual examination that produced a presence/no presence decision for a particular sample. The visual technique consisted of holding a clear glass bottle filled with zero turbidity water against a colored background and comparing the visual clarity of that bottle to an identical clear glass bottle filled with the sample. If the sample was visibly more turbid than the control, the sample was declared to "have turbidity." This visual analysis is presented as a protocol required as part of selecting the appropriate water treatment/disinfection protocol (Report 2, Section 2.4.3)
2. The results of this visual turbidity assessment were corroborated by turbidity analysis conducted in Pucallpa, in the laboratory of the DESA (*Direccion Ejecutiva de Salud Ambiental*), a branch of Peru's Ministry of Health's (MINSA's) DIRESA (*Direccion Regional de Salud Ucayali*). Samples were analyzed in the laboratory using a turbidimeter within six hours of collection.

Of the 52 sources visited, water from 29 sources was analyzed for thermotolerant **(fecal) coliforms** and total coliforms, using a membrane filter technique by the same government laboratory in Pucallpa. Samples for the bacteriological testing were collected from each of the 29 sources in sterile bottles and transported on ice to Pucallpa daily. Standard water analysis methods, using a membrane filter technique, were then used within six hours of sampling by staff of the DESA laboratory, a branch of the MINSA's DIRESA.

1.3 FINDINGS AND CONCLUSIONS – WATER SOURCES

1.3.1 Descriptions of Water Sources

The following section presents both water source descriptions and illustrative water quality data. The formal presentation of water quality analysis findings is found in Section 1.3.2. and in the data sheets in Annex 1.

1) Surface Sources – River

Above: Surface water from rivers, such as the Aguaytía River, have a high turbidity especially during the rainy season and are often accessed by muddy inclines to the water's edge.

Respondents in four communities reported collecting and consuming water from the Aguaytía River. These communities were **Las Mercedes, Zorrillos, Sol Naciente, and San Juan de Tahuapoa**. At the time of sampling, the river had a strong, fast flow and was a muddy brown, which increased when there were heavy rains in the upstream region of Aguaytía and the river grew and carried with it trees and detritus. The turbidity of river water was very high. (Two samples analyzed in the laboratory had turbidities of 573 NTU and 129 NTU.)

Respondents reported that in the rainy season (winter) the water is much more turbid. Collection points were not improved in any way and were generally accessed by a steep, muddy incline to the water's edge.

2) Surface Sources – Quebradas/Riachuelos

- Residents in five communities collected water by hand from nearby small streams, called riachuelos or quebradas. Agua Dulce had a formal system that collected water from a nearby surface source, channeling it through a poorly maintained, slow filtration system directly to the community's standpipes.
- The water samples from all of the streams were non-turbid but four (57%) of seven samples were yellow in color (not orange, nor were other signs of iron present), a possible indicator of dissolved organic matter (tannins) which can impact the efficacy of chlorination.
- Rainfall can increase turbidity in these sources.
- No works or signs were in place to prevent animals or people from entering the water sources upstream of the water intake zone.
- No local policies addressed water quality issues and protection of these surface sources.


Above: Examples of *quebradas/riachuelos* in the Curimaná District. Although water from these sources has a low turbidity, it may contain dissolved organic material which can affect efficacy of disinfection by chlorination.

3) Potable Water Systems (SAPs)

Note that a detailed presentation of the status and condition of these sources is found in a separate report prepared for USAID/Peru that focuses solely on these SAPs, all of which were built in 2005 with USAID/Peru support.


Above: Infrastructure from community water supply systems in Curimaná District

- In communities with a functioning water system, the deep wells (hand-dug, with casing) were examined to the extent possible by visual inspection and by review of any design documents. The deep wells constructed for the 13 SAPs that were assessed are all hand-dug (no boreholes), with different degrees of interior well protection (impervious casing, perforated casing, surface capping).
- The well-heads were more or less sealed in all systems (insects and other small animals were able to enter the wells, but children could not throw things into them).
- The areas around these wells were not protected—animals and children could come to the well-head area, surface runoff was not directed away from the wells, and nearby homes had latrines within 30 meters of the well.

- Wells were lined to prevent collapse and perhaps to prevent the infiltration of surface waters into the well, although, design criteria were not available nor was it possible to enter many of the wells to ascertain if a standard design was used.
- No local policies limited access to, or activities that could take place around, these surface sources.
- Some communities reported that they periodically disinfected their systems with chlorine but no schedule was noted. No SAP had a functioning system for chlorination of water.

4) Artisan Wells

Above: Examples of *pozos artisanos*, or artisan wells, found in Curimaná District

The term "artisan wells" is used to describe these *pozos artisanos* that were built using some kind of basic design criteria that improved the sanitation of the well, typically through the use of qualified third party labor. These wells were frequently encountered in the communities visited. Some were built during the Fujimori era for the benefit of the entire community; while others were privately built for the use of individual households.

- The construction quality and design ranged greatly. Wells were generally lined to some depth below the surface, somewhat protected from run-off. Most were roofed with corrugated iron to protect them from rain and leaves.
- The well covers ranged from nothing to loose boards or pieces of corrugated iron to a fitted hinged lid.
- Various wells were observed to be infested with mosquitoes and other insects.
- Water was collected from all of these wells by a rope and bucket system, even where a pump and tank system was in place.
- No significant efforts to control surface runoff around the wells were observed.
- Residents reported that they did not periodically disinfect these wells.
- Seven of 15 water samples collected from artisan wells were visually turbid.

5) Informal Hand-dug Wells

These wells were common HH water sources in all communities—in those without water systems, in communities with non-functioning or intermittent water systems, and were often used for the sake of convenience during the rainy season in those communities with functional community water systems. (nearby shallow wells fill during rains, while public tapstands are an inconvenient distance away)

Above: Examples of informal hand-dug wells common in the Curimana District

- The informal wells are characterized by a shallow depth, rudimentary or no protection of the well, and were rarely covered.
- Informal wells can dry up during the latter months of the dry season. Water was obtained from deeper wells with a rope and bucket, but others were shallow enough for the water to be collected directly with just a bucket.
- No significant efforts to control surface runoff around the wells were observed.
- Residents reported that they did not periodically disinfect these wells.
- Six of seven (86%) sampled waters were visually turbid. See Report 1, Section 1.3.2 for results.

6) Rainwater Collection

Rainwater collection is not assessed in this report because of its minimal contribution as a water source in Curimaná. Rainwater harvesting is not widely practiced in Curimaná, mainly because most buildings are roofed with woven palm fronds, which makes rainwater collection very difficult. Nevertheless, rainwater collection was observed in the community of 10 de Marzo, which we visited on a day when it had rained the night before. In this community, however, the roof guttering of the school was being used to fill a small barrel. The water collected was not seen or analyzed, but it should be noted that the roof had been painted with an anti-rust paint, which was flaking off and would probably be present in any water collected.

Above: Rainwater harvesting is not widely practiced in Curimaná. However, in this example where rainwater is collected from a painted roof, the collected water is likely contaminated with paint flakes.

1.3.2 Water Quality of Sources

Annex 1 contains the complete results of water quality testing—pH, temperature, conductivity, dissolved solids, turbidity, total coliform and fecal coliform. Chlorine demand data is in Annex 2.

1) pH, Conductivity, and Temperature

Virtually all pH, conductivity, and temperature values were in a range acceptable to human health and to the performance of POU water treatment approaches, namely chlorination. The lone exception was the pH of one water from a surface *quebrada* that had a pH of 8.7 which is slightly outside the optimal range for chlorination.

2) Bacteria

All samples analyzed for bacteria were found to be polluted with high levels of fecal coliform bacteria (see Table 3.2.1). Note here that we also include analysis of water samples from households to illustrate the degree to which contaminated water is consumed in the house. Note the very high fecal coliform levels for the boiled household water.

TABLE 1.1: FECAL BACTERIA CONTAMINATION[1] OF WATER SAMPLES ACCORDING TO TYPE OF SOURCE

Source Type	Number of Samples	Mean FC/Median FC (Org/100ml)	Range FC (Org/100ml)	Risk Level*
River	2	19,020/19,020	2,040–36,000	Very High Risk
Stream	2	480/480	60–900	High Risk
SAP Deep Well**	8	4754/700	100–28,200	High Risk
SAP Tapstand**	5	8,308/400	20–40,400	High Risk
Artisan Well	6	8,900/2,700	200–30,000	Very High Risk
Informal Well	6	2,950/3,100	200–4,500	Very High Risk
House/School (not boiled)	*5*	*8,700/8,000*	*100–17,600*	*Very High Risk*
House (boiled)	*2*	*19,700/*	*540–90,000*	*Very High Risk*

* WHO risk classifications based on median fecal coliform counts detected in water sources.

** System water was tested **in 11 communities: Bello Horizonte, Zorrillos, Nueva Alianza, Roca Fuerte, Maronal, Monte Sinai, Las Mercedes, Vista Alegre, Cambio 90, Curimaná, and Malvinas**.

3) Turbidity

Results from turbidity measurements performed by a certified Peruvian water quality laboratory in Pucallpa are found in Table 1.2. Note that the samples analyzed for turbidity are not necessarily the same as those analyzed for fecal coliform. (See Annex 1.)

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[1] Thermotolerant or fecal coliform bacteria are able to ferment lactose at 44-45°C. Although some thermotolerant species other than *Escherichia coli* can include environmental organisms, in most circumstances populations of thermotolerant coliforms are primarily composed of *E. coli*, which are rarely found in the absence of fecal pollution. As such thermotolerant coliform bacteria are considered a less reliable but acceptable indicator of fecal pollution. The presence of fecal coliform bacteria provides evidence of recent fecal contamination.

TABLE 1.2: TURBIDITY OF WATER FROM DIFFERENT SOURCES

Source Type	Number of Samples (36 total)	Mean/Median NTU	Range NTU	Impact on POU treatment (other than boiling)
River	2	351/NA	129–573	Significant—turbidity removal required
Stream	3*	5.4/5.6	4.4–6.1	Insignificant
SAP Deep Well	8	9.2/1.5	1.3–50	Insignificant. High in Bello Horizonte
SAP Tapstand	7	4.4/1.3	0.8–18	Turbidity of 18 in Cambia 90
Artisan Well	10	8.0 / 6.6	2–30	Insignificant unless turbidity visible
Informal Well	6	40/43	10 - 85	Moderate to significant

* Streams measured during dry season. Turbidity typically increases after heavy rains. Most of these samples were stained yellow, most likely indicating a high content of dissolved organic matter (as opposed to iron).

All water samples were analyzed visually for turbidity as well. This was done to gauge the utility of adopting a visual turbidity test as a criteria for the selection of a POU treatment protocol by local inhabitants.

A glass bottle filled with purified water was considered a blank and compared alongside the same type of bottle filled with sample water in front of a dark background. The visual and laboratory results for 43 samples analyzed for actual turbidity in the laboratory in Pucallpa were compared. As the following table shows, this easy method correctly identified 89% (17/19) of turbid samples and 88% (21/24) of non-turbid (<10 NTU) samples. When the cutoff for turbid and non-turbid was 30 NTUs, this visual method identified 50% (10/20) of turbid samples and 100% (23/23) of non-turbid samples. The number of false positives (visibly turbid, yet <30NTU) is high, but it would only lead to a protocol that tended to over-dose with chlorine not under-dose.

TABLE 1.3: VALIDITY OF VISUAL EXAMINATION FOR TURBIDITY, 10 NTU AND 30 NTU THRESHOLDS

Visual identification as:	Turbidimeter reading indicated turbidity of:		Total examined
	≥10NTU	<10 NTU	
Visibly Turbid	17	3	20
Visibly Non-turbid	2	21	23
Total number of samples in each turbidity range	19	24	43
SUMMARY	Visual method correctly identified that 89% (17/19) of turbid samples were of a turbidity greater than 10 NTUs, and 88% (21/24) of samples visually identified as non-turbid were of less than 10 NTUs		
	≥30 NTU	<30 NTU	
Visibly Turbid	10	10	20
Visibly Non-turbid	0	23	23
Total number of samples in each turbidity range	10	33	43
SUMMARY	50% (10/20) of samples visually identified as turbid were of a turbidity greater than 30NTUs, and 100% (23/23) of samples identified as non-turbid were under 30 NTUs.		

1.3.3 Principal Conclusions of Source Evaluation

- **All** water sources sampled present high level of risk to users because of bacterial contamination. Surface sources, in addition to some wells, produce water of high turbidity that can impact the efficacy of HH treatment methods.
- Certain surface *quebrada* sources, show evidence of high iron levels which can also impact the efficacy of HH treatment methods (i.e., chlorine).
- pH levels of all waters tested were within a range that does not adversely impact the efficacy of chlorine disinfection.
- All sources were observed to have shortcomings in their infrastructure that increased the risk of bacterial contamination.
- Lack of protection of the area around well-heads or source collection points was universal. Observed were nearby latrines and the presence of animals and children.
- Informal hand-dug wells were most vulnerable to contamination.
- Simple, "small, doable" improvements to these sources—infrastructure, operation, and maintenance—exist that can reduce bacterial contamination and turbidity levels in these waters.

TABLE 1.4: SUMMARY OF PROBLEMS CAUSING CONTAMINATION OF WATER SOURCES IN CURIMANÁ

	Problem (U=Universal, C=Common, NP=Not a Problem, NA=Not Applicable)						
Source	Unprotected perimeter – animals, runoff	Well lacks cover	Cover not hermetic	Non sanitary collection	Inadequate casing to prevent infiltration	No periodic disinfection practiced	Comments
River	U	NA	NA	U	NA	NA	High turbidity and coliform
Surface Quebrada	U	NA	NA	C	NA	NA	Variable turbidity
SAP Deep Well	U	NP	C	NP	C	U	Contamination from insects, infiltration; casing not consistent
Artisan Well	U	C	U	U	C	U	High risk of contamination but amenable to improvement
Informal Well	U	U	U	U	U	U	Highest risk source. Very little actual infrastructure

1.3.4 Recommendations for Water Source Improvement

Considering the high levels of fecal contamination and turbidity in the sources utilized by community residents, some basic measures must be promoted to improve the quality of water at the source level. These actions could reduce risks to human health and improve the effectiveness of household treatment at the point-of-use. It is worth noting here that the recommendations for improvement of the three types of wells (deep, artisan, and informal) are quite similar and involve three key actions to prevent contamination from entering the well:

1. To the extent possible provide a cover that is hermetically sealed and control the water collection system;
2. To the extent possible control human activities and runoff water in the areas around the well; and
3. Make infrastructure improvements to wells that reduce the chance of rapid infiltration of surface waters into the well.

In addition, wells must be periodically disinfected. See well disinfection protocol in Report 2, Section 2.4.4.

The recommendations for source improvement are presented below by water source.

1) Recommendations for Surface Sources – River

- Construction of informal shallow hand-dug wells near the bank of the river provides water of much higher quality (turbidity in particular) than that from the river itself. Such a situation was encountered in Bello Horizonte, and water from the well had a turbidity of 10.3 NTU, which is a drastic decrease in turbidity in comparison to river water.
- The construction of these hand-dug wells should be promoted in communities such as San Juan de Tahuapoa or Zorrillos, where part of the community is reliant solely on the river for water.
- These hand-dug wells adjacent to the river may be difficult to promote in communities where the river is a secondary source, used frequently but only as an alternative. In such cases, pre-treatment options should be promoted (a locally-viable turbidity reduction protocol is presented in Report 2).

2) Recommendations for Surface Sources – Small Stream (Riachuelo, Quebrada)

- Communities should organize to discuss steps that can be taken to improve or maintain the quality of the *quebrada* sources. This can include regulations to control activities in the watershed—cattle grazing, agriculture, forest clearing, clothes washing, and bathing.
- For those sources where water is collected from shore by bucket, construct simple collection works, perhaps with low dams that divert small amounts of water through a tube or over a lip allowing for hygienic collection.
- Fencing near the collection point to prevent animals from entering the immediate area where people are collecting water.
- Shallow hand-dug wells adjacent to these streams in proper areas can provide water of lower turbidity, reduced levels of dissolved organic matter (chorine demand), and better bacterial quality

3) Recommendations for Potable Water Systems (SAP) with Deep Wells

(The SAP Assessment Report contains significantly more detail on these recommendations.)

- Landscape, as necessary, area surrounding well to prevent surface runoff from pooling within 10 meters of the well. (Ideally surface water should flow away from the well.) Create low berm around well to prevent surface water from flowing up to the well casing (and into the well along the casing face).
- Pack the seam between the face of the well casing and the well with clay to thwart surface infiltration into the well along the face of the casing.
- Prevent the construction of pit latrines within 20 meters of any well and close out existing latrines in this radius. Erect a fence around the well at a 10m radius to prevent entry of children and animals into the immediate infiltration zone around the well.
- Inspect all well casings and ensure that imperforated casing extends at least eight meters deep or into the aquifer.
- Inspect all well caps and ensure that they are hermetically sealed. Insects and other small vermin transport bacteria into wells.
- Develop and apply a simple disinfection protocol for the well, storage tank, and distribution system. This must be developed individually for each system. See the separate HIP SAP Assessment Report for details on designing a system-specific disinfection protocol for initial shock chlorination and for ongoing periodic disinfection. Section 2.4.5 of this report contains disinfection protocols for small wells.
- Establish a regular disinfection and cleaning schedule for deep wells under the supervision of the community water committee.

4) Recommendations for Artisan Wells

- Landscape, as necessary, area surrounding well to prevent surface runoff from pooling within 10 meters of the well. (Ideally surface water should flow away from the well.) Create low berm around well to prevent surface water from flowing up to the well casing (and into the well along the casing face).
- Pack the seam between the face of the well liner and the well with clay to thwart surface infiltration.
- Prevent the construction of pit latrines within 20 meters of any well and close out existing latrines in this radius. Erect a fence around the well at a five meter radius to prevent entry of children and animals into the immediate infiltration zone around the well.
- Inspect all well casings and ensure that imperforated casing extends at least six meters deep or at least into the aquifer.
- Cap these wells with a concrete lid and the smallest necessary opening for water withdrawal. Cover this small opening when not in use. Consider installing a pump (handpump, *mecate*) to facilitate hygienic withdrawal of the water.
- Develop and apply a simple disinfection protocol for the well. This must be developed individually for each system. See Section 2.4.5 for details on designing a system-specific disinfection protocol for initial shock chlorination and for ongoing periodic disinfection of artisan wells.
- Establish a regular disinfection and cleaning schedule for each well.

- Establish a daily cleaning protocol, for all rope and bucket systems, which includes washing the bucket with chlorinated water and adding a small daily dose of chlorine to the well.
- A hand-disinfecting station with alcohol could be placed at the well to reduce the introduction of fecal contamination into well water by means of bucket-handling.
- Establish a regular disinfection and cleaning schedule for wells under the supervision of a community water quality committee. (See Section 2.4.5 for cleaning protocols.)
- Develop a simple disinfection protocol and schedule that can be used by households. (See 2.4.5 for cleaning protocols.)
- In situations where the wells are dry seasonally or permanently, as in 10 de Marzo, determine if the wells can be deepened to reach the water table.
- To reduce the introduction of fecal contamination, determine if nearby latrines can be emptied and filled-in.
- These improvement activities should at least be centered on wells utilized in communities as a school source.

5) Recommendations for Informal Hand-dug Wells

- Landscape as necessary area surrounding well to prevent surface runoff from pooling within 10 meters of the well. (Ideally surface water should flow away from the well.) Create low berm around well to prevent surface water from flowing into the well.
- Prevent the construction of pit latrines within 20 meters of any well and close out existing latrines in this radius. Prevent entry of children and animals into the immediate infiltration zone around the well (five meters radius) by building a fence or other means.
- Inspect all well casings and ensure that imperforated casing extends at least six meters deep or at least into the aquifer.
- Add a wooden or concrete liner at the surface of the well that extends at least 30cm above the ground and one meter below.
- Pack the seam between the face of the well liner and the well with clay to thwart surface infiltration along the face of the casing.
- Construct a cover for the well out of available materials that seals the well as tightly as possible—perhaps contract a local artisan/maestro to come up with an appropriate affordable well cover.
- Develop and apply a simple cleaning and disinfection protocol for the well. This must be developed individually for each system. See Section 2.4.5 for details on designing a system-specific disinfection protocol for initial shock chlorination and for ongoing periodic disinfection.
- Establish a regular disinfection and cleaning schedule for each well.
- Establish a daily cleaning protocol for all rope and bucket systems which includes washing the bucket with chlorinated water and adding a small daily dose of chlorine to the well.
- A hand-disinfecting station with alcohol could be placed at the well to reduce the introduction of fecal contamination into well water by means of bucket-handling.

- Establish a regular disinfection and cleaning schedule for wells under the supervision of a community water quality committee. (See Section 2.4.5)
- In situations where the wells are dry seasonally or permanently, as in 10 de Marzo, determine if the wells can be deepened to reach the water table.
- These improvement activities should at least be centered on wells utilized in communities as a school source.
- A dedicated rope and bucket system should be installed at the well, if applicable, and the use of private buckets and ropes should be prevented.
- Wells should be roofed if they cannot be covered.
- Wells should be covered for the safety of children, cleanliness, and prevention of mosquito infestation.
- Well protection methods should be taught and the community mobilized to participate in these activities.
- Establish a regular disinfection and cleaning schedule for wells under the supervision of the community water committee.
- Develop a simple disinfection protocol. This must be evaluated and developed in order to determine how often both cleaning and disinfection should take place and how much chlorine/bleach should be added to provide effective disinfection.

REPORT 2: DEVELOPING POU PROTOCOLS TO IMPROVE DRINKNG WATER QUALITY IN CURIMANÁ

2.1 INTRODUCTION – POU WATER TREATMENT PROTOCOLS

This second report presents an assessment of the quality of water in the households in Curimaná, as well as HH practices around water collection, storage, and handling (note that results of HH behaviors are presented in greater detail in the Behaviors Report). Water quality and water use information is used to inform the design of HH POU water treatment (disinfection) protocols and recommendations for improved HH water collection, storage, and handling. The key parameters analyzed in this water quality assessment are presented in Table 2.1.

TABLE 2.1: KEY WATER QUALITY PARAMETERS STUDIED IN THIS ASSESSMENT

Water Quality Parameter	Data Used To…	Comments
Fecal Coliforms	Confirm and quantify extent of suspected contamination of drinking water, inform design of IEC materials to motivate residents, confirm that recontamination of boiled water is occurring.	Total coliforms also evaluated; fecal coliforms in source water presented in Report 1.
Turbidity	Inform selection of HH POU approaches, inform design of turbidity removal protocols, inform actions to be taken to improve water sources.	Key POU treatment systems (chlorination, SODIS) undermined by turbidity.
Chlorine Demand	Select proper chlorine dosage for different source waters.	Turbidity often is key parameter in selecting disinfection protocol.

With respect to developing HH POU treatment protocols, the assessment also examined:

- the quality of local chlorine sources—which will likely have to be chlorine bleach—which is purchased over the counter in local shops;
- the concentration of a chlorine solution that is produced by the district health post;
- the economics of using certain locally-available chlorine sources, and water containers;
- locally-available means to ensure proper chlorine dosages; and
- household practices related to water collection, storage, and handling.

The final products of these assessments are:

- a protocol to disinfect water by boiling;
- a SODIS protocol for disinfection of turbidity free water;
- four chlorine disinfection protocols for waters from different sources and different turbidities;
- a protocol for visual turbidity measurement and turbidity removal to allow for the use of one of the chlorine or SODIS disinfections; and
- recommendations on improvements for HH water collection, storage, handling, and cleaning and disinfection.

2.2 METHODS AND MATERIALS – POU WATER TREATMENT PROTOCOLS

The District of Curimaná is located about two and a half hours away from the regional capital of Pucallpa. It is comprised of the municipality of Curimaná, where the assessment team stayed while conducting fieldwork, and of 29 rural communities located at varying distances from the municipality. The majority of the communities were accessible by road, but others were only accessible by boat or foot. Fieldwork was completed in nine days during October 2007 (end of the dry season). A second round of chlorine demand testing was conducted at the end of November 2007 to address shortcomings in the techniques employed during the October testing.

2.2.1 Water Samples Evaluated – POU Water Treatment Protocols

With respect to assessing water sources to determine their potential for POU treatment, the trip to Curimaná had the following goals:

- visit as many communities as possible (maximize the sample size);
- determine the water sources being used by community residents;
- collect water samples from representative water sources; and
- evaluate appropriate water quality parameters, namely pH, chlorine demand, and turbidity.

Twenty communities were visited, 52 sources visited, and water from 49 different sources (i.e., river, *quebrada*, well, water system) were analyzed as follows:

- All 49 samples were analyzed in situ for **pH, total dissolved solids, and conductivity** using a portable meter purchased for this assessment.

- All 49 samples were analyzed for chlorine demand.
- All 49 samples were visually assessed for turbidity and 36 of these were further analyzed for turbidity using a turbidimeter.

Samples from seven (7) households and 29 sources were analyzed for bacterial contamination (**fecal coliform**).

In addition, in each of these 20 communities, two households with children under the age of five were non-randomly selected to participate in a survey on knowledge, beliefs, and practices around drinking water. The mother of the child/children participated in these surveys and supplied informed consent.

2.2.2 Turbidity Analysis – POU Water Treatment Protocols

Turbidity was analyzed using two techniques:

1. Turbidity assessed in situ using a visual examination that produced a presence/no presence decision for a particular sample. The visual technique consisted of holding a clear glass bottle filled with zero turbidity water against a colored background and comparing the visual clarity of that bottle to an identical clear glass bottle filled with sample. If the sample was visibly more turbid than the control, the sample was declared to "have turbidity."
2. The results of this visual turbidity assessment were corroborated by turbidity analysis conducted in Pucallpa, in the laboratory of the DESA (Direccion Ejecutiva de Salud Ambiental), a branch of Peru's MINSA's DIRESA (Direccion Regional de Salud Ucayali). Samples were analyzed in the laboratory using a turbidimeter within six hours of collection.

2.2.3 Fecal Coliform Analysis – POU Water Treatment Protocols

The sources were also analyzed for thermotolerant **(fecal) coliforms** and total coliforms, using a membrane filter technique by the same government laboratory in Pucallpa. Samples for the bacteriological testing were collected from each of the 29 sources in sterile bottles and transported on ice to Pucallpa daily. Standard water analysis methods, using a membrane filter technique, were then used within six hours of sampling by staff of the DESA laboratory a branch of the MINSA's DIRESA.

2.2.4 Chlorine Demand Testing – POU Water Treatment Protocols

Notes on the Testing Activity

Two rounds of testing to determine the chlorine demand of ambient waters were implemented in Curimaná. In the first round, conducted concurrently with the rest of the previously described water quality analysis, 49 water samples were tested for their chlorine demand and three locally-purchased bleaches were tested for their ambient chlorine content. All of these analyses were performed in situ by HIP consultant using an electronic chlorine meter purchased specifically for this activity in Curimaná.

However, problems with analytical techniques used in the first round of testing resulted in a decision to conduct a second round of chlorine demand testing. This second round was implemented at the end of November 2007 and re-tested nine samples that had been analyzed in the first round. The same analytical technique was used in this second round to establish the chlorine demand of water samples as were employed in the first round of testing. In the second round, the same three locally available bleaches were analyzed for their ambient chlorine content in a Lima laboratory.

Background on Chorine Demand Testing

According to the US Environmental Protection Agency, chlorine demand is the difference between the amount of chlorine added to water and the amount of residual chlorine remaining after a given contact time. This measure is influenced by temperature, pH, and the amounts of organic and certain inorganic materials, meaning that water from different sources exerts a different demand and will require a different amount of chlorine to ensure a minimal level of residual chlorine following treatment.

Dose testing of water from different sources is performed to evaluate the different demands so that a dosing protocol can be developed. For dose testing, the Centers for Disease Control and Prevention recommends that the chlorine dose used be sufficient so that at 30 minutes after the addition of sodium hypochlorite there be no more than 2.0 mg/L of free chlorine residual present in the sample and after 24 hours of storage there should be a minimum of 0.2mg/L of free residual chlorine in the water. The details of the chlorine demand testing protocol that was used (based on the CDC's SafeWater) is in Annex 2. Note that the CDC designs nationwide SafeWater recommendations on a relatively limited volume of samples—e.g., 18 samples from two communities in Liberia were used to determine nationwide chlorine dosing protocols.

The First Round of Chlorine Demand Testing in Curimaná

Because of variations in the sources found in Curimaná (surface, shallow well, deep well) a total of 49 samples were collected, dosed, and the chlorine residual measured at one hour, two hours, and 24 hours, to provide a wide survey of the different water sources utilized in the District of Curimaná. This sampling and analysis was implemented over seven days from the 13th to 19th October 2007.

Of 129 free chlorine measures, 20 (16%) were duplicated over three different days for quality control. The average relative percent difference between the duplicate measures was 9.96%, which is just below the accepted range of error for free chlorine residual of a maximum relative percent difference of 10%.

Additionally, the analyses of five water samples were duplicated in order to determine the range of error of all analysis techniques. The average relative percent difference between the duplicate measures was 16.82%.

Problems Encountered with Chlorine Demand Testing (see Annex 3 for detailed discussion)

Unfortunately problems occurred in the chlorine demand testing that necessitated a second round of sampling and analysis. These problems were 1) not properly establishing the concentration of the Cl reagent used to dose these waters for the chlorine demand testing; 2) using a water source for producing reagents and dilutions that was not distilled or deionized and therefore not of consistent quality; 3) equipment used in the field analysis was of questionable quality (droppers, not pipettes) which likely impacted both precision and accuracy of the results; and 4) applying initial doses of chlorine reagent that were below recommended levels (resulting in complete consumption of the chlorine by the sample water, rendering a number of the analysis non-conclusive). It was decided that although the chlorine demand results from this first round of testing might be useful for indicating certain trends that could be further investigated, the results of neither the chlorine demand tests, nor the tests done to determine chlorine concentration in locally-available bleaches could be used to establish HH POU chlorine disinfection protocols for Curimaná waters.

The Second Round of Chlorine Demand Testing in Curimaná

To address these problems, nine representative samples were taken again several weeks later and the chlorine demand tests repeated, ensuring that the chlorine concentration of the chlorine reagent was properly established, that distilled water and better dosing equipment were used, and that dosing was correct. All shortcomings identified in the first round of testing were rectified. The chlorine concentration of locally available chlorine bleach products (that will likely be used by local residents as their source of chlorine for HH water treatment) were analyzed in a Lima laboratory. The methods used in the second round of testing were as follows:

a) *Stock Bleach Solution Preparation and Confirmation:*

A diluted stock bleach solution was prepared by diluting 100mL of 5.25% (Clorox) bleach in 900mL of distilled water.

The chlorine concentration of the stock solution was analyzed according to the CDC's serial dilution method where the bleach is diluted into a solution with a chlorine content that is in the detection range of the chlorine meter.

Three serial dilutions were performed (1ml of bleach to 100ml of total solution) and for each, the chlorine concentration of the dilution was measured twice using a Hanna-free chlorine meter. This measure represents the actual concentration of the stock solution. The stock solution used had a chlorine concentration of 0.45%.

b) *Sample Collection*

Ten 5 liter samples were collected in Curimaná on the 2nd of December. Five liters were collected from each source using a one liter jug to fill an eight liter plastic jerrycan.

The number and sampling site were as follows: four samples were collected from the river in Curimaná; one sample was collected from a hand-dug well in 10 de Marzo; one sample from the borehole in Vista Alegre; one sample from a standpipe in Malvinas; one sample from a hand-dug well in Nueva Meriba; one sample from an artisan well in Pueblo Libre; and one sample from a stream in Canaan de Piedra.

These sites were previously sampled in October and were selected for the second sampling based on their easy accessibility by road and the chlorine dosage previously tested. All samples were shipped by air to Lima and analyzed on the 4th and 5th of December.

c) *Sampling Dosing*

The volume of the chlorine dosage was based on the prepared stock bleach solution having a concentration of 0.45mg/L. The CDC recommends dosing concentrations of 1.88 mg/L for samples of turbidity of below 10 NTUs, and 3.75 mg/L for samples with turbidities of above 10 NTUs and below 50 NTUs . The dose volumes required for an initial dose of 1.88 mg/L and of 3.75 mg/L in 5L of sample were, respectively, 2.1mL and 4.2mL.

Samples were shaken to mix contents and the dose was added using a 10mL pipette with graduations at 0.1mL. After the dosing, samples were again shaken.

d) *Chlorine Measurement*

Chlorine concentration was measured in the second round of testing in the same way as in the first round. That is, a colormetric test was used. A portable Hanna-free chlorine meter was used to read the colormetric reaction between an added reagent and a predetermined sample volume. These readings were conducted at one hour after dosing, two hours after dosing, and 24 hours after dosing to generate time versus free chlorine (mg/l) curves.

On the second day, at 24 hours since dosing, two chlorine measures were taken on each container. The relative percent difference was calculated to be 10.98, but all measures were within the plus/minus 0.03 accuracy of the chlorine meter.

2.3 FINDINGS AND CONCLUSIONS – POU WATER TREATMENT PROTOCOLS

This section presents the findings and conclusions of the assessment as follows:

- household behaviors impacting water quality;
- contamination of household drinking water as indicated by presence of fecal coliforms;
- turbidity and other physical characteristics; and
- chlorine demand.

2.3.1 Household Behaviors Impacting Water Quality – POU Water Treatment Protocols

With the aim of assembling a protocol of simple, doable actions to improve drinking water quality at the point-of-use, it was necessary to determine and evaluate current water collection, storage, and treatment practices in addition to user perceptions of water quality and the risk of disease. The effectiveness of user water treatment and the safety of water storage were also evaluated through water sampling and bacteriological analysis. The following findings are based on this sampling, observations during visits, and interviews with mothers of children under the age of five (see Behavioral Report).

Above: Water is frequently stored in the same 20L plastic buckets it is collected in which originally contained vegetable oil or motor lubricant.

Water Collection & Storage

- Water collection is frequent, probably on a daily basis, and household water storage volume is low and most-likely day-to-day.
- Water was most frequently stored in the same 20L plastic buckets with which it had been collected. These buckets had originally contained vegetable oil or motor lubricant.

Above: Plastic bottles, which originally contained vegetable oil, are used to store water in some houses.
Right: Taking the daily trip to the river to collect water for HH use.

- Round, plastic, 20L jerrycans, originally used to store vegetable oil but also to sell gasoline, were also used to store drinking water.
- Plastic bottles, also originally containing vegetable oil, were also used in some houses.
- Stored water was covered mostly to protect it from visible pollution, such as leaves, dirt from the ceiling, and insects. In only a few cases, water was covered to prevent the introduction of germs or prevent the access of children.

Perceptions of Water

- Water may be considered safe if clean and free of visible detritus and insects. The safety of water could also be attributed to the source, since some sources are recognized as being dirty, such as the river and streams.
- Turbid water or water with mud that settled to the bottom of the bucket was identified as dirty.

Water Treatment Practices in General

- Knowledge of water treatment options exists, but these options are not regularly practiced.

Water Treatment Practice of Boiling in Curimaná

- Boiling is practiced by some for the safety of their families or just for the children/infants. Others boil water to improve the taste of the water by adding herbs or teas. Some only boil their water when they are sick or have recently been sick.
- Boiling is considered easy, but the taste must be accustomed to. Respondents reported that boiling requires time, can be forgotten, and it takes time for the water to cool.
- There is ample firewood, but some respondents recognized that the supply is dwindling and must be brought from further away each time. During the rainy season it is difficult to gather firewood.
- The use of wood fuels contributes to the loss of jungle and the environmental degradation that accompanies deforestation.
- Storage of boiled water may lead to microbial re-contamination of the treated water, particularly as introduced by hands, utensils, and other sources.
- The lack of a water supply has been associated with a greater risk of burns in children because of the need to boil water in poor Peruvian households.
- Because boiling does not provide a residual disinfecting action, boiling must be accompanied by protocols for safe storage, and handling and use of water after the boiling treatment is applied.

Water Treatment Practice of HH chlorination

- No respondents mentioned that they chose not to use bleach because it was a cleaning product. The most frequently reported reason for not using bleach was the associated taste, which indicates an improper dosing procedure.
- The taste of chlorine must be accustomed to. Chlorine from the health posts is “smoother” than bleach and is preferred by some. Bleach is easy to get, however, and cheaper than chlorine. Additionally, bleach is widely available and already used for laundering clothing.

Water Treatment Practice of SODIS in Curimaná

- SODIS was not observed to be practiced in Curimaná, nor is the use of SODIS reported or recognized by the population as an approach to water disinfection.
- There appears to exist an opportunity to promote SODIS based on the sunshine and temperature regimes in the area and on the availability of materials required to optimize the results of the approach.
- SODIS works best when bottles are placed on a corrugated iron sheet. Few houses in these communities are roofed with this material, but it is available in the area, since some artisan wells, clinics, and schools were roofed with this material.
- SODIS works best with 2L plastic bottles. Two liter plastic bottles are available in most communities from the sale of soda drinks and were observed being used to store water.

Risk of Disease

- Children's diarrhea is frequently attributed to water and the consumption of dirtiness in various forms.
- General cleanliness was more frequently reported than water treatment as the means of preventing diarrhea. Cleanliness could also extend to the water itself, since giving children clean water was reported as opposed to giving them dirty water.

2.3.2 Fecal Contamination of Stored Drinking Water – POU Water Treatment Protocols

As noted in Report 1 on water sources, all source water as well as water samples from household storage containers was highly contaminated with fecal coliform bacteria, indicating a strong likelihood of fecal contamination of all drinking water in Curimaná. These results indicate that current household behaviors for water collection, storage, treatment (boiling), and handling are not sufficient to make drinking water bactriologically safe to consume. Table 2.2, taken from Report 1, is reprinted in this section, and presents findings of the bacteriological testing of 30 sources and six households and one school.

TABLE 2.2: FECAL BACTERIA CONTAMINATION[2] OF WATER SAMPLES ACCORDING TO TYPE OF SOURCE

Source Type	Number of Samples	Mean FC/Median FC (Org/100ml)	Range FC (Org/100ml)	Risk Level*
River	2	19,020/19,020	2,040–36,000	Very High Risk
Stream	2	480/480	60–900	High Risk
SAP Deep Well**	8	4754/700	100–28,200	High Risk
SAP Tapstand**	5	8,308/400	20–40,400	High Risk
Artisan Well	6	8,900/2,700	200–30,000	Very High Risk
Informal Well	6	2,950/3,100	200–4,500	Very High Risk
House/School (not boiled)	*5*	*8,700/8,000*	*100–17,600*	*Very High Risk*
House (boiled)	*2*	*19,700/*	*540–90,000*	*Very High Risk*

* WHO risk classifications based on median fecal coliform counts detected in water sources.
** System water was tested **in 11 communities: Bello Horizonte, Zorrillos, Nueva Alianza, Roca Fuerte, Maronal, Monte Sinai, Las Mercedes, Vista Alegre, Cambio 90, Curimaná, and Malvinas**.

Fecal Coliform Contamination of Household Drinking Water

Table 2.3 presents the results of the fecal coliform testing of all water samples taken from households.

TABLE 2.3: FECAL BACTERIA CONTAMINATION OF SEVEN SAMPLES OF HOUSEHOLD/SCHOOL STORED WATER

Source	Treatment	Fecal Coliforms (Org/100ml)	Risk Level*
River	None	8000	Very High Risk
River	None	3900	Very High Risk
River	None	17600	Very High Risk
Artisan Well	None	100	High risk
SAP	None	16000	Very High Risk
SAP	Boiled	544	High Risk
SAP	Boiled	90000	Very High Risk

* WHO risk classifications based on median fecal coliform counts detected in water samples.

- Water collected from the river was turbid, so the water was regularly collected in the afternoon and left overnight to allow sediment to settle. Two houses reported using Alumbre—aluminum sulfate—to reduce the time needed for the mud to settle (see Section 2.4.3: Pre-treatment Options for Turbidity).

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1 Thermotolerant or fecal coliform bacteria are able to ferment lactose at 44-45°C. Although some thermotolerant species other than *Escherichia coli* can include environmental organisms, in most circumstances populations of thermotolerant coliforms are primarily composed of *E. coli*, which are rarely found in the absence of fecal pollution. As such thermotolerant coliform bacteria are considered a less reliable but acceptable indicator of fecal pollution. The presence of fecal coliform bacteria provides evidence of recent fecal contamination[2]

- Two households stored their drinking water in large buckets fitted with a lid and a plastic spigot that had originally been distributed by PRISMA.
- The first sample of boiled water with 544 org/100mL was stored in a covered bucket with a spigot; while the second sample with an extremely high number of fecal bacteria was stored in a small, covered pan.

Above: Example of plastic PRISMA bucket with lid and spigot.

Fecal Contamination of School Drinking Water

In Pueblo Libre, water was collected from a small bucket with a spigot in one of the classrooms of the local primary school in order to determine the quality of water in schools and the need for school-based point-of-use water treatment promotion.

The community doctor reported that the water was chlorinated, but, when asked, a teacher reported that the water was untreated water from the nearby artisan well. The sample was collected, as the students would collect water to drink, directly from the spigot.

Water from the classroom in Pueblo Libre was fecally-contaminated. Our 100mL water sample contained 100 fecal coliform organisms, which is in the intermediate to high-risk range.

The classroom water had been collected from the artisan well located outside the school. The bacteriological results from this well were 300 Fecal Coliform CFU/100mL. There was less fecal bacterial contamination in the classroom than in the source, perhaps due to settling or time, but present nonetheless.

General Conclusions on Contamination of Water in Households and Schools

- Water stored within the household, even under optimal storage conditions, was highly contaminated.
- Poor storage conditions observed indicate that fecal contamination of already contaminated source waters most-likely occurs within the household.

Left: Water for students in a classroom is stored in plastic buckets, like the one in a Pueblo Libre primary school. The water comes from untreated sources.
Right: Students in a Pueblo Libre classroom.

Above: Water stored in the household is often re-contaminated after treatment, through introduction of dirty dippers, hands, or from pre-existing contamination of the storage container before water was added.

- Drinking water, reported to be treated by boiling and then stored for consumption, contained extremely high amounts of fecal bacteria, indicating that re-contamination of water takes place after treatment.
- Such re-contamination can undermine any treatment protocol, particularly one without residual protection.
- This contamination is likely the result of the introduction of dirty dippers, dirty hands, or contamination existing in the storage container before the water was added.

2.3.3 Turbidity and Other Physical Characteristics of Water – POU Water Treatment

These water quality parameters are presented in more detail in Report 1 on sources.

Turbidity

Table 2.4 is reprinted from Report 1. These turbidities are important given SODIS Foundation recommendations on addressing the effects of turbidity on SODIS CDC recommendations for addressing the effects of turbidity on chlorine demand. Sizable effects are exerted on these POU treatment techniques when turbidities increase above 10 NTUs. For turbidities between 10 NTUs and 30 NTUs, SODIS and chlorine techniques require inputs of longer duration or higher concentration. SODIS and POU chlorination techniques are not recommended for waters with turbidities above 30 NTUs.

TABLE 1.2: TURBIDITY OF WATER FROM DIFFERENT SOURCES

Source Type	Number of Samples (36 total)	Mean/Median NTU	Range NTU	Impact on POU treatment (other than boiling)
River	2	351/NA	129–573	Significant—turbidity removal required
Stream	3*	5.4/5.6	4.4–6.1	Insignificant
SAP Deep Well	8	9.2/1.5	1.3–50	Insignificant. High in Bello Horizonte
SAP Tapstand	7	4.4/1.3	0.8–18	Turbidity of 18 in Cambia 90
Artisan Well	10	8.0/6.6	2–30	Insignificant unless turbidity visible
Informal Well	6	40/43	10–85	Moderate to significant

* Streams measured during dry season. Turbidity typically increases after heavy rains. Most of these samples were stained yellow, most likely indicating a high content of dissolved organic matter (as opposed to iron).

- All sources produced some samples with turbidities in excess of 30 NTUs, save the stream sources. Stream sources showed signs of high levels of dissolved organic matter, which is notable given that organics can exert a significant chlorine demand.
- Turbidity will effect the selection of HH disinfection protocols used, as all sources produced samples with turbidities higher than 30 NTUs
- Turbidity reduction measures must be used on high-turbidity waters (<30NTUs) to render these waters amenable to POU disinfection treatments using SODIS or chlorine.

pH and Other Parameters

Samples were analyzed for pH, conductivity, temperature, and total dissolved solids. The most important of these parameters for the design of a chlorine POU treatment approach are temperature and pH, given that the effectiveness of free chlorine as a disinfectant increases with increasing temperature and decreases with increasing pH (increasing alkalinity). Chlorination is most effective for waters of pH between 6 and 8 with pHs above 8.5 of concern.

Considering that Curimaná is found in a low-lying tropical zone, temperatures of samples taken in Curimaná are above 18 C and will not adversely affect the effectiveness of chlorine as a disinfectant. With respect to pH, only one sample taken from a small surface river had a pH above 8.5 (8.7). This water was passing through a recently excavated quarry, which was a likely source of the alkalinity.

2.3.4 Chlorine Sources and Chlorine Demand of Source Waters, Curimaná

Data collected is sufficient to allow the conclusion that we can propose for Curimaná a chlorine-based POU water treatment system that uses simple treatment protocols that utilize low cost materials and equipment that are locally available.

Developing these POU chlorine disinfection protocols requires that we have quantitative information on the chlorine content of local chlorine products and on the chlorine demand of ambient water sources.

Chlorine Sources – Curimaná

The following reports on the chlorine sources that can be economically obtained and managed by HHs in the district. These are household bleach products that are available over the counter, and a chlorine solution produced at the Curimaná Health Post with a chlorine generator (water, table salt, electricity)

Bleach Products Available over the Counter in Curimaná

Chlorine can be purchased economically by HHs and schools in Curimaná at local shops in every community in the form of household bleach. The chlorine content of these bleaches was analyzed to confirm the reliability of the percent concentration printed on the label of each product.

Three brands of bleach are sold in Curimaná: Clorox, Sapolio, and Reluciente. Sapolio and Clorox are sold in injection molded and sealed plastic containers. Reluciente is sold in *cojines* of soft plastic. All of these are manufactured in Lima, and brought to Curimaná from Pucallpa.

Two samples of each brand were purchased in different stores in Curimaná. The shopkeeper was asked how long ago the bleach products had been purchased and brought from Pucallpa. The average time was approximately two weeks and ranged from four days to 20 days. The samples were transported to Lima and analyzed at a private laboratory.

Above: Bleaches, such as Clorox, Sapolio, and Reluciente, are manufactured in Lima and sold in stores in Curimaná.

TABLE 2.5 FREE CHLORINE CONCENTRATION EVALUATION OF LOCALLY AVAILABLE BLEACH PRODUCTS

Brand	Country	Advertised Percent	Actual Percent	Cost	Size
Clorox	Peru	5.25%	5.0% 5.0%	S/. 0.60 US$ 0.19	230g
Sapolio	Peru	6%	4.2% 4.3%	S/. 0.70 US$ 0.22	250g
Reluciente	Peru	6%	6.3% 6.3%	S/. 0.40 US$ 0.13	140g

Analysis performed at private laboratory in Lima in December 2006.

Chlorine from a Locally Produced Sodium Hypochlorite Solution

In addition to these brands of bleach, sodium hypochlorite is produced in the Curimaná health post and sold at S/.0.50. Initially the post gave away the solution, but now they are charging to cover the price of the bottles, which are donated by the DESA in Pucallpa. A batch (about 20l) of solution is produced about once a month or when the stock runs out. Health post staff members reported that people still buy the solution, and that the post occasionally sells the entire month's supply (about 80 250ml bottles). Many people coming to the health post for treatment for diarrhea buy the solution; while others buy it as they pass the clinic. The respondent reported that the people have noticed a difference in their health after using the solution, and are beginning to confide in its use more.

Above: The chlorine generator at the Curimana Health Post

On a separate visit to the clinic, other staff members explained how the solution is produced. The solution is generated in a 20L plastic bucket. The instructions require 900g of salt for 30 liters of water. The respondents did not know the actual amount of salt used to produce 20L, but they agreed with 600g when I said it. Once mixed, the reaction normally takes about six hours to generate the solution. The respondents did not know at what concentration the solution is produced, but they reported that the original instructions were to add 1 bottle lid (11ml) of the solution to 20L, but this had a strong taste and changed the comparator very pink. Now their instructions are a ½ lid (about 6ml) per 20 liters of water. When asked, the post's staff did not know at what concentration the solution was generated. They quickly located the N,N-dimethyl-p-phenylene-diamine (DPD) pills used to test the solution, but only a few of these had been used. The color comparator from The Ministerio de Salude (MINSA) Health Post took longer to locate and was still wrapped in plastic and unused. The respondent reported that there was another that they used, but she did not know where it was.

Above: Test kits to measure free chlorine concentration in water. These were found at the Health Post.

It must be reported, however, that the staff of the clinic were not officially in charge of the production of the chlorine. According to a source in the Municipality of Curimaná, the doctor of the health post is officially in charge of chlorine production, having been trained and approved by the Dirección Regional de Salud (DIRESA). Once the doctor has been approved the sodium hypochlorite generator is given to the health post. The doctor, who had been trained, however, left the post the week prior to our visit, having completed his obligatory service year for Servicio Rural Urbano Marginal (SERUM). The new doctor has recently arrived and has not been trained and approved by the DIRESA. It is her responsibility to solicit the training from the DIRESA. If she does not complete this, however, and the machine is unused, when the DIRESA comes to monitor the quantity of chlorine distributed, then the machine will be moved to a different health post.

The solution was distributed in 250mL clouded, plastic bottles with a plastic 11mL screw-cap. The content of the bottle was not identified, and there were no instructions on the bottle.

Two bottles of the solution were collected from the clinic itself, and a third bottle was collected from a small informal pharmacy in the town center.

Above: A sodium hypochlorite solution was distributed at the District Health Post, but bottled in containers without identification or mixing instructions, such as the one above.

TABLE 2.6 FREE CHLORINE CONCENTRATION OF LOCALLY GENERATEDAVAILABLE SODIUM HYPOCHLORITE SOLUTION

	Concentration Test #1	Concentration Test #2	Average
Sample #1 – Health Post	0.35%	0.35%	0.35%
Sample #2 – Health Post	0.22%	0.19%	0.21%
Sample #3 – Pharmacy	0.48%	0.46%	0.47%

Note that these concentrations were determined at a laboratory in Lima in November 2006.

Chlorine Demand of Water Sources – Curimaná

The following describes the findings and conclusions of chlorine demand testing done on waters from representative sources from 20 of the 29 communities in the Curimaná District. Although the first round of chlorine demand testing was inconclusive, the second round of testing confirmed the dosing required to disinfect waters to standards set by the CDC SAFEWATER Program. The Centers for Disease Control and Prevention recommends that the chlorine dose used be sufficient so that at 30 minutes after the addition sodium hypochlorite there be no more than 2.0 mg/L of free chlorine residual present in the sample, and after 24 hours of storage there should be a minimum of 0.2mg/L of free residual chlorine in the water. For practical reasons, CDC recommends testing at one hour, two hours, and 24 hours after initial chlorine dosing.

CDC SAFEWATER recommends a test dosage that brings the initial chlorine concentration in a volume of non-turbid water (0 to 10 NTUs) to 1.875 mg/l. For waters with visible turbidity but not excessive turbidity (discoloration or cloudiness is present but sample is still transparent—10 to 30 NTUs), CDC SAFEWATER recommends a test dosage—that is, double that for non-turbid water (3.75mg/l initial concentration of chlorine in the treated water volume).

See Annex 2 for data tables and figures from both rounds of chlorine demand testing.

The chlorine demand findings from the second round of testing for all water sources except the river samples are presented in Table 2.7 and the discussion of these data is organized by water source. The key conclusions are presented for each source and followed by explanatory text and tables.

TABLE 2.7 RESULTS OF CHLORINE DEMAND TESTING CURIMNA – ROUND 2 NOVEMBER 2006

			Dose	Free Chlorine Measures (mg/L)		
Community	**Source Type**	**Code**	**(mg/L)**	**~1 Hour**	**~2 Hours**	**~24 Hours**
10 de Marzo	Pozo Casero	A	1.875	1.22	1.02	0.50
Vista Alegre	Pozo Profundo	A	1.875	1.71	1.69	0.82
Malvinas	Grifo	A	1.875	1.55	1.43	0.68
Nueva Meriba	Pozo Casero	C	1.875	0.95	0.87	0.36
Pueblo Libre	Pozo Artisano	A	1.875	1.37	1.32	0.73
Canaan de Piedra	Riachuelo	B	3.75	2.46	2.25	1.69
	River	Data presented below with turbidity reduction results				

1) River Sources

- Waters from the large navigable rivers are highly turbid (hot chocolate-colored) during both the dry and rainy seasons.
- A protocol for POU disinfection of river water using chlorine (or SODIS) will require a pre-treatment step to remove turbidity.
- A viable locally appropriate turbidity removal/reduction technique using locally-available aluminum sulfate exists.
- Highly turbid waters properly treated for turbidity removal can be disinfected with an acceptable chlorine dosage of 3.75 mg/l.

During the initial sampling activity, all samples were visibly turbid. Two actual measures of turbidity taken were 573 NTU and 129 NTU. Most samples were too turbid to conduct free chlorine measurements using the colorimetric analysis. Samples that were allowed to settle and dosed at 3.75 mg/l did not show a measurable residual at 24 hours.

During the second round of sampling a local turbidity removal practice was verified. This practice was observed in the field and was also documented in a lengthy and relatively complicated turbidity removal protocol developed by the now ended MIAGUA Project.

TABLE 2.8 TURBIDITY REDUCTION TREATMENT AND SUBSEQUENT CHLORINE TREATMENT*

			Dose	Free Chlorine Measures (mg/L)		
Number	**Source**	**Pre-Treatment**	**(mg/L)**	**~1 Hour**	**~2 Hours**	**~24 Hours**
1	River	~30g Alumbre 60 Stirs 1 Hour Settling	3.75	1.14	0.87	0.08 0.14
2	River		3.75	1.19	0.87	0.12 0.1
3	River	~30g Alumbre 100 Stirs 1 Hour Settling	1.875	0.78	-	0.07 0.07
4	River		3.75	2.52	-	1.12 1.11

*From second round of analysis, November 2007. Turbidity of treated water not measured.

River water can be clarified using Alumbre (100 stirs) and adequately treated with a 3.75mg dose of chlorine. Increasing the number of stirs from 60 to 100 reduced the chlorine demand of river water allowing for a sufficient chlorine residual at 24 hours.

2) Surface Sources – Quebradas, Riachuelos

The quality of these surface sources is the most variable of any of the sources assessed in Curimaná. It is likely that many of these waters carry large loads of dissolved organic materials which exert significant chlorine demand, and the only water in Curimaná with a pH unfavorable to chlorine disinfection was one of these surface waters (pH> 8.5)

It is worth examining the data from the first round of sampling and analysis to observe that several non-turbid waters nonetheless consumed the entire chlorine dose of approximately 1.88 mg/l (in actuality the dosage was likely less than this) in two hours. This is not conclusive given problems with data from the first round of testing, but it is an important trend.

TABLE 2.9 CHLORINE DEMAND RESULTS FOR SURFACE WATERS (NOT RIVERS)*

Name	Turbidity	Temperature	pH	Condition	Dose	Free Chlorine Measures (mg/L)		
	(NTU)	(°C)		(µS)	(mg/L)	1 Hour	2 Hours	24 Hours
Agua Dulce	No, 4.4	26.5	7.34	54	1.05	0.05	0.1	0.04
Zona Patria	No, 5.64	26	7.97	450	0.94	0.02	0.05	0.07
Nueva Meriba	No, 6.11	29.2	8.06	436	0.94	0.04	0.07	0.04
10 de Marzo	No	26.7	7.17	317	1.88	0.11	0.05	0.05
Canaan de Piedra Stream #1	No	26.8	7.75	485	1.88 1.88	0.08 0.08	0.055 0.06	0.06 0.08
Canaan de Piedra Stream #2	No	27.8	6.16	57	3.75	2.74	2.26	1.5
Nuevo Bellavista	No	28.7	8.68	424	3.75 3.75	0.42 0.52	0.19 0.175	0.05 0.06

*Data from first round of testing, October 2006, not considered quantitatively valid. Note that it was not possible to determine if samples taken in different communities were taken from the same or different streams.

One sample was analyzed during the second round of testing in an attempt to validate data from the first round. The results below in Table 2.10 indicate that the 3.75 mg/l dosage created too high a residual after one hour that may adversely affected the taste of the water. The total chorine amount consumed in 24 hours appears to be over 2.0 mg/l, precluding the lower recommended dosage of 1.875mg/l.

TABLE 2.10 CHLORINE DEMAND RESULTS FOR SURFACE WATERS (NOT RIVERS)*

Name	Source Type	Dose	Free Chlorine Measures (mg/L)		
		(mg/L)	1 Hour	2 Hours	24 Hours
Canaan de Piedra Stream #2	Riachuelo	3.75	2.46	2.25	1.69

* Data from second round of testing, November 2006

There does not appear to be sufficient data to select dosing protocols for these smaller surface water sources with a high level of confidence.

3) Water Systems Sources (See Report on SAP Assessment for Details*)*

The chlorine demand of these deep well waters, to maintain CDC-recommended chlorine residual levels, appears to be satisfactorily addressed by the 1.88mg/l CDC recommendation for non-turbid waters.

Turbid waters (greater than 10 NTUs) appear to require the higher chlorine dosage of 3.75 mg/l to ensure CDC chlorine residual recommendations are attained. Note that three deep wells associated with the community water systems built in 2005 have waters with turbidities greater than 10 NTUs: Bello Horizonte: 50 NTUs; Las Mercedes: 11 NTUs; and Cambio: 90 to 18 NTUs.

TABLE 2.11 CHLORINE DEMAND RESULTS FOR WATER SYSTEMS*

Name	Source Type	Turbidity 1st/2nd **	Dose	Free Chlorine Measures (mg/L)		
		NTU	(mg/L)	1 Hour	2 Hours	24 Hours
Vista Alegre	Pozo Profundo	1 / No	1.875	1.71	1.69	0.82
Malvinas	Grifo	1 / No	1.875	1.55	1.43	0.68

* Data from second round of testing, November 2006
**Turbidity measurement from first round of testing, October/second visual November

4) Artisan Wells

It appears that the 1.875 mg/l for non-turbid waters may be best for waters from these hand-dug wells that do not show turbidities grater than 30NTUs. Waters with visible turbidity require a higher dosage—perhaps 3.75mg/l.

From trends observed in the first round of testing, turbidity does not appear to be a reliable determinant for the selection of dose factors in the case of artisan wells, but to be safe, dosage strength should be raised for higher turbidity well waters.

TABLE 2.12 CHLORINE DEMAND RESULTS FOR ARTISAN WELLS*

Name	Source Type	Turbidity 1st/2nd	Dose	Free Chlorine Measures (mg/L)		
		NTU	(mg/L)	1 Hour	2 Hours	24 Hours
Pueblo Libre	Pozo Artisano	5**/ no	1.875	1.37	1.32	0.73

* Data from second round of testing, November 2006
**Turbidity measurement from first round of testing, October/second visual November

5) Hand-dug Informal Wells

It appears that a dosage of 1.875 mg/l for non-turbid waters may be best for waters from these hand-dug wells. Waters with visible turbidity require a higher dosage—3.75mg/l is recommended by CDC. Turbidity levels tend to be high in these most basic of groundwater systems, ranging from 10 to 85 NTUs. Seven of nine samples had turbidities greater than 10 NTUs. The average and mean turbidities were measured as 45 and 43 respectively.

Interestingly, these turbidities were not always associated with excessive chlorine demand. The samples re-tested in the second round of testing that was done in November 2007, show that a 1.875 mg/l dose is sufficient to maintain required chlorine residual concentrations even though the turbidity levels seem to call for a higher initial chlorine dose (i.e., 3.75 mg/l). Nevertheless, to be safe, dosage strength should be raised for higher turbidity well waters.

TABLE 2.13 CHLORINE DEMAND RESULTS FOR INFORMAL HANDUG WELLS*

Name	Source Type	Turbidity 1st/2nd ** NTU	Dose (mg/L)	Free Chlorine Measures (mg/L)		
				1 Hour	2 Hours	24 Hours
10 de Marzo	Pozo Casero	85/ yes high	1.875	1.22	1.02	0.50
Nueva Meriba	Pozo Casero	72 / yes, high	1.875	0.95	0.87	0.36

*Data from second round of testing, November 2006
**Turbidity measurement from first round of testing, October/second visual November

2.4 RECOMMENDATIONS – HH WATER STORAGE AND HANDLING, POU TREATMENT OPTIONS

The recommendations are presented below as follows:

- behaviors and practices around water collection, water storage, and water treatment;
- POU treatment protocols;
- protocols for water handling; and
- protocols for disinfection: wells, containers used for HH storage, or handling of drinking water.

2.4.1 Behaviors and Practices

A series of recommended, small, doable actions was developed for improving household drinking water quality. These actions were based on the findings of the evaluation of current water collection, storage, and treatment practices and their effectiveness and safety in regards to water quality, including user perceptions of water quality and the risk of disease.

Drinking Water Collection

1. Plastic jerrycans are already available in these communities and are being used to collect, transport, and store water. Their use should be recommended primarily for transport purposes since the handle and small opening would prevent the entry of hands, which could introduce further contamination.
2. In circumstances where a jerrycan is not available and a bucket is being used, then a lid should be employed to minimize the introduction of contamination.
3. Bleach was reportedly used with detergent in almost half of the households to clean the water container. This practice could be readily promoted to the remaining families. The use of bleach would remove and prevent the growth of biofilms on the inner surfaces of water containers, which could in turn reduce the possibility of bacterial contamination. Bleach with grains of maize or small stones were also being used and could increase effectiveness
4. In households utilizing a standpipe connection, hosepipes could be a means of minimizing hand contact and facilitating the collection of greater volumes of water, which could benefit general family hygiene and quality of life. Care is needed to maintain the cleanliness of the hosepipe, however, and the local availability and price of hosepiping was not specifically assessed in this study.
5. The same jerrycans used to collect water would be optimal for storage of turbid water during the settling process. Any lidded container that minimizes contact of hands with the water would be sufficient, however.

6. Community residents did report using cloth to strain water to remove insects and visible detritus. This practice should be further evaluated and the effectiveness in regards to turbidity and chlorine demand should be evaluated.

Drinking Water Storage

7. It is emphasized here that drinking water storage be explicitly defined and separated from general storage of water for other household purposes.
8. The effective treatment and safe storage of drinking water precludes the treatment of high enough volumes for general usage, though treated water should be recommended for washing foods to be consumed raw and possibly for cooking.
9. Though possibly beyond the scope of the MSH and USAID/HIP collaboration, the introduction, promotion, and subsidization of Pan American Health Organization (PAHO)-type safe water storage containers that have a narrow mouth, a lid, and a spigot would present an optimal water storage solution.
10. MSH should investigate the possibility of promoting local fabrication of storage containers with spigots. (See Section 2.4.4 for storage protocols and text box)
11. Containers for storing drinking water should be stored in an elevated location, out of the reach of children and animals, to prevent them from playing with/contaminating the water.
12. In situations where the children are left alone during the day, when access to drinking water is a must, then small plastic bottles could be used to store a daily volume of water for the children, which could be chlorine-treated water or SODIS-treated water.
13. Kettles, if cheaply and locally available, should be promoted as the safest form of boiling and storing boiled drinking water. Boiled water should be discarded or re-boiled after six hours.
14. The lack of residual disinfectant from boiling amplifies the importance of storage container hygiene, so the cleanliness and the regular use of bleach to clean these containers must be emphasized.

Drinking Water Treatment

15. The apparent belief that clear water is clean, and that only turbid or visibly polluted water is dirty, makes it critical that educational messages emphasize the clear water can cause disease and must be treated.
16. Poor storage practices may be more difficult to change than treatment methods are promoted and adopted, so the promotion of treatment methods may need to take into account that clean/treated water can become re-contaminated.
17. Bleach and sodium hypochlorite are both locally available and currently used to treat drinking water.
18. Treatment of drinking water by boiling, solar disinfection, or adding free chlorine are all feasible options with varying pros and cons. Therefore it is recommended that community members are presented with all options and encouraged to elect the treatment method they would prefer to employ.

2.4.2 POU Treatment Protocols

A program to improve the quality of drinking water through point-of-use treatment by the consumer must not only be effective but also, and possibly more importantly, acceptable to the user. As such it is recommended that various options for drinking water treatment be presented to users, and they select the method or methods that would work best.

Considering this aim within the overall goal of developing a system for water treatment disinfection protocol for households in the district of Curimaná, the following section describes a few effective methods that could be implemented in the target communities and a few points about the promotion of each method.

It is strongly recommended that a chlorine-based POU water disinfection system be strongly promoted independently in addition to other community or POU drinking water disinfection systems. The principal reasons for this recommendation are:

- economic viability of the chlorine approach;
- ease of application of simple treatment protocols to source waters of variable quality; and
- residual disinfection action provided by chlorine combats recontamination, which, as shown by our bacteriological assessment of stored drinking water is a critical issue in Curimaná.

POU disinfection treatment protocols are presented below for boiling/pasteurization, SODIS, and for chlorine disinfection. Key considerations for each of these methods are:

1. appropriateness (ease) of the technical practice;
2. collection, handling, and storage practices in the HH or school;
3. economic viability of the method—access to materials, equipment, etc; and
4. ambient quality of the source water—turbidity may be the critical parameter.

An additional treatment protocol is presented for turbidity removal.

Disinfection by Boiling & Pasteurization

Boiling is an effective method for destroying all classes of waterborne pathogens (viruses, bacteria and bacterial spores, fungi, protozoan, and helminth ova) and can be applied to all waters, including those high in turbidity or dissolved constituents.[3]

- The WHO recommends bringing water to a rolling boil as an indication that a high enough temperature has been reached to achieve pathogen destruction.[4]

These instructions will probably result in temperature in excess of the conditions necessary to reduce most waterborne pathogens, but they provide a visual assurance that sufficiently high temperatures have been reached.

- Heating water to pasteurization temperatures (~60°C) for an extended period of time will destroy most waterborne pathogens.

The difficulty involved with monitoring the actual temperature achieved indicates the need for caution in attempting to pasteurize waters at non-boiling temperatures. The ambient quality of the source water does not have a large impact on the efficacy of boiling in disinfection of water.

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[3] World Health Organization. Managing water in the home: Accelerated health gains from improved water supply. Geneva: World Health Organization; 2002.

[4] World Health Organization. Guidelines for drinking-water quality, 3rd ed. Geneva: World Health Organization; 2004.

The Practice of Boiling in Curimaná

- Boiling is a straight-forward technology. It is already being used in these communities to prepare certain drinks, even if the need to treat drinking water in this manner is not recognized. Taste was reported as a problem, but the practice also exists of preparing teas with the boiling water to improve the taste.
- The economics of boiling are attractive for Curimaná. Firewood is amply available in most communities and is already collected for cooking. In the rainy season, the collection and handling of firewood was reported to be more difficult.
- The use of wood fuels contributes to the loss of jungle and the environmental degradation that accompanies deforestation.
- Storage of boiled water may lead to microbial re-contamination of the treated water, particularly as introduced by hands, utensils, and other sources.
- The lack of a water supply has been associated with a greater risk of burns in children because of the need to boil water in poor Peruvian households.

Because boiling does not provide a residual disinfecting action, boiling must be accompanied by protocols for safe storage, handling, and use of water after the boiling treatment is applied.

Boiling Protocol

1. Water should be heated until a rolling boil is reached. Covering the container during heating will reduce the time it takes to attain the rolling boil.
2. Boiled water should be stored in the same container in which it was boiled.
3. Boiled water should be poured from this container into serving containers—nothing should enter the container that contains the boiled water
4. If a dipper must be used, the use of the dipper must be in line with the water handling protocols found in Section 2.4.4
5. The storage container must have a tightly-fitting lid or other protected opening. Kettles, though more expensive, should be promoted. They are a safer container in which to boil water and provide safer storage for the boiled water.
6. All water handling and storage containers must be periodically cleaned/disinfected. Please see container cleaning and disinfection protocols found in Section 2.4.5

Promotion of Boiling

- Consideration of environmental impacts of the use of wood as a fuel must be taken into account prior to initiating any promotion of boiling in a region.
- Consider including boiling promotion as part of an improved, wood conserving stove program.
- Make sure that users are aware of risks of recontamination and adopt a chlorination step after boiling and/or the adoption of recommended water handling/storage protocols recommended herein.
- Ensure that users adopt practice of cleaning/disinfecting all containers that come into contact with drinking water.

Disinfection by SODIS

SODIS is a simple, sustainable, low-cost method of water treatment that utilizes solar energy to improve the quality of drinking water. Utilizing the vulnerability of pathogenic microorganisms to ultraviolet rays (UV) from sunlight. A light and heat, SODIS is an ideal method for treating small volumes of low turbidity water. Key characteristics of the SODIS approach are:

- SODIS cannot be used with water with turbidity greater than 30 NTU. Therefore, in water with higher turbidity, from sources such as hand-dug wells and the river, the pre-treatment methods would be necessary prior to solar treatment.
- Water can be effectively treated with six hours of exposure to sunlight on a clear day, or in one hour if a temperature greater than 50°C is reached. On cloudy or overcast days, laboratory tests have shown that two consecutive days of exposure are necessary. Inactivation of protozoa depends on the water temperature reached during solar exposure.
- SODIS may be an effective option during the dry season when there is ample sunlight, but may be more difficult to employ during the rainy season when the sky is more overcast, air temperatures lower, and the turbidity of water sources increases. Seasonal radiation intensity must be assessed.
- SODIS does not provide any residual protection, so the water can be re-contaminated after treatment. As such, safe storage must be promoted, particularly to address the cleanliness of the plastic bottle, which was found to be a source of contamination in previous SODIS projects.
- SODIS removes 99.9% of bacteria and viruses and to a certain degree parasites, but SODIS-treated water is not sterilized and a subsequent risk of contamination remains. Therefore, SODIS-treated water is not recommended for infants less than 18 months of age, severely ill or malnourished children and adults, patients with decreased immunodeficiency, or patients with gastro-intestinal abnormalities or chronic gastro-intestinal illnesses.

The Practice of SODIS in Curimaná

SODIS was not observed to be practiced in Curimaná, nor is the use of SODIS reported or recognized by the population as an approach to water disinfection. Nevertheless, there appears to exist an opportunity to promote SODIS based on the sunshine and temperature regimes in the area and on the availability of materials required to optimize the results of the approach. With respect to these materials:

- SODIS works best when bottles are placed on a corrugated iron sheet. Few houses in these communities are roofed with this material, but it is available in the area, since some artisan wells, clinics, and schools were roofed with this material.
- SODIS works best with 2L plastic bottles. Two liter plastic bottles are available in most communities from the sale of soda drinks and were observed being used to store water.

Turbidity of the source water is a critical parameter for the success of the SODIS method. This has implications on whether SODIS can be used at all for a particular source water, on the details of the SODIS protocol itself, and perhaps on the use of pre-treatment of water for turbidity removal.

Because SODIS does not provide a residual disinfecting action, SODIS must be accompanied by protocols for safe storage, handling, and use of water after the SODIS treatment is applied.

SODIS Protocol

1. Determine the turbidity of water using visual comparative test (see protocol for this test in turbidity protocol Section 2.4.3, which requires several people to judge the sample's turbidity).
2. If according to the visual test, water is too turbid for SODIS, consider using a turbidity-removal step (Section 2.4.3) or do not use SODIS.
3. If, according to the visual test the water is not too turbid, fill approved clear 2L plastic bottle with source water.
4. Place this bottle out of reach of children and animals on an inclined surface that is observed to receive the most sunlight over the course of the day.
5. If the water visually tested as "no" turbidity, leave the bottle fully exposed to sunshine under bright or up to 50% cloudy sky for six hours. Under 100% cloudy sky, leave the bottle exposed for 2 consecutive days.
6. If the water tested at "yes" turbidity, there is likely a 50% chance that the water is outside of the turbidity parameters for SODIS treatment (that is, there is a 50% chance that the water has a turbidity greater than 30 NTUs—see Table 1.3) and it cannot be recommended that SODIS be used as a treatment method.
7. If weather is continuously rainy, SODIS does not perform satisfactorily and a different treatment method should be used.
8. SODIS effectiveness increases with water temperature, and it is recommended that bottles be placed on surfaces that will conduct and then radiate heat to the bottles. Thatch roofs, prevalent in Curimaná, do not conduct and radiate heat adequately and it is recommended that SODIS practitioners construct *tarimas* of calamine or tin sheeting upon which to place the SODIS bottles.
9. Store the water in this same bottle and pour from this bottle into other serving containers.
10. Periodically clean/disinfect the SODIS bottle each week using the cleaning/disinfection protocol found in Section 2.4.5.
11. Because water treated by SODIS can be re-contaminated, all water handling and storage containers must be periodically cleaned/disinfected. Please see cleaning/disinfection protocol found in Section 2.4.5.

SODIS Promotion

- SODIS could be promoted to the community by its use in schools, and in this manner also provide safer drinking water for students.
- SODIS could be promoted to adults, as a simple, cheap method treat water while working in the *chacra.*
- SODIS-treated water comes in a container suitable for safe storage, easy transport, and easily handled by children.
- SODIS does not change the taste of water, and so may be a more acceptable treatment option for many users.
- SODIS requires little work, only time and sunshine.

- SODIS promotion must be supported over time by follow-up visits to ensure that it is being used correctly.
- Make sure that users are aware of risks of recontamination and adopt a chlorination step after boiling and/or the adoption of recommended water handling/storage protocols recommended herein.
- Ensure that users adopt practice of cleaning/disinfecting all containers that come into contact with drinking water.

Disinfection by Household Chlorination

This section is lengthy because it presents the detailed findings and conclusions of an in-depth analysis of the four key considerations for the viability of the treatment practice.

Chlorine is the most widely used, the easiest, and the most affordable of all drinking water disinfectants. It is highly effective against nearly all waterborne pathogens, except *Cryptosporidium parvum* oocysts and *Mycobacteria* species.

Some Background on HH Chlorine Disinfection

- Chlorine cannot be used with water with turbidity greater than 30 NTU. Therefore, in water with higher turbidity from sources such as hand-dug wells and the river, the pre-treatment methods would be necessary prior to solar treatment.
- Similarly, water to be treated should have a low chlorine demand in order for chlorine treatment to be effective.
- A small dose of free chlorine and a 30-minute contact time inactivates >99.99% of enteric bacteria and viruses.
- Free chlorine residual in treated water provides protection from any subsequent contamination that may occur while drinking water is stored within the home.
- Chlorination and safe storage of drinking water have been shown in field trial interventions to significantly improve the microbial quality of water and reduce the incidence of diarrheal diseases.
- A drawback to free chlorine treatment is the reaction with organic compounds in the water to form potentially harmful levels of the chemical by-products trihalomethanes (THMs) and haloacetic acids, both of which are carcinogenic.

Chlorine POU Disinfection Protocols

1. Prepare stock solution of chlorine that will be used to dose the untreated water (see Annex 4 for calculations).
    - Take 1 sachet of Reluciente bleach (140ml) and mix it with non-turbid water to a total volume of 1½ liters.
    - Store this stock solution in a screw-cap 2 liter bottle.
    - The plastic cap of this screw-cap bottle is to be used as the measuring device for all dosing.
2. Determine the source of the water—large river surface source, small *quebrada/riachuelo* surface source, community water system tapstand, artisan well, informal well, water already treated by boiling, or SODIS.

3. Determine the turbidity of water using visual comparative test (see protocol for this test in turbidity protocol, Section 2.4.3, which requires several people to judge the turbidity).

4. Based on the source of the water and the results of the visual turbidity test, select the proper dosage from this table:

TABLE 2.14: CONCLUSIONS – RECOMMENDED CL DOSES FOR DRINKING WATER BY SOURCE AND TURBIDITY

Water Source and Condition	Recommended Cl Dosage (mg/l) for 20 liters of water	Observations
All Water taken from **tapstands** served by community water systems constructed through the USAID AD Project.	1.88 (1 capful of stock)	None of these systems was observed to practice regular chlorination.
Water of **low turbidity** ("no turbidity" per visual examination protocol) taken from **ground water sources** (deep wells, artisan wells, household wells)	1.88 (1 capful of stock)	Majority of water used by Curimaná households comes from these groundwater sources.
Water of low turbidity ("no turbidity" per visual examination protocol) that has **been previously boiled** in the house or treated with SODIS	1.88 (1 capful of stock)	This dosing concentration may be high (very conservative). Testing of boiled water was not sufficient to establish a lower chlorine dosing recommendation.
All water of lower turbidity ("no turbidity" per visual examination protocol) that is taken from a **surface source.**	3.76 (2 capfuls of stock)	This dosing concentration is not well documented. Data from first round of testing (data not considered valid) implies that the 3.76 mg/l dose is not sufficient, even for surface waters of very low turbidities. These waters, which had a yellow hue, likely contain levels of dissolved organic matter that exert a significant chlorine demand. *This is the one situation where the second round of testing does not appear to be sufficient to completely confirm this dosage.*
Water of **higher turbidity** ("yes turbidity" per visual examination protocol) taken from **groundwater sources** (deep wells, artisan wells, household wells)	3.76 (2 capfuls of stock)	Majority of water used by Curimaná households comes from these groundwater sources. Turbidity can likely be reduced by source improvement actions.
Water from **surface or groundwater sources that is of very high turbidity** (opaque per visual examination). Note that this protocol incorporates steps to reduce turbidity.	3.76 (2 capfuls of stock) **––after Turbidity removal**	Note that no groundwater with turbidity >100NTU was found. Turbidity reduction protocol is detailed below (Section 2.4.3)

5. Apply either 1 or 2 capfuls of the stock chlorine solution (see Table 2.14 for proper dosage) to 20 liters of water to be treated

6. Let water sit for at least 30 minutes before consuming

7. Store the treated water in a properly cleaned, appropriate container. (See Sections 2.4.3 and 2.4.5.)

8. Even though this treated water has a residual disinfecting action, it should be poured from this container into serving containers—nothing should enter the container that contains the treated water.
9. If a dipper must be used to serve the water, the use of the dipper must be in line with the water handling protocols found in Section 2.4.4
10. The storage container must have a tightly-fitting lid or other protected opening.
11. All water handling and storage containers must be periodically cleaned/disinfected. Please see disinfection/cleaning protocols found in Section 2.4.5.
12. If a chlorine taste or smell is present that the users find disagreeable, the water can be poured back and forth between two clean buckets/containers two or three times; or fill a bottle ¾ full with treated water and shake it for 10 seconds and open, then repeated as necessary. This pouring or shaking should be done vigorously to induce the formation of as many bubbles as possible. (These bubbles pull the dissolved chlorine from the water). The water should then be returned to the serving or storage container.

Promotion of a Chlorine-based POU Treatment System

- This treatment system, like any other, requires consumer education, participation, and social marketing in order to achieve acceptance and sustainability.
- Education is important to ensure correct dosage, since an inadequate or overdose of chlorine may respectively decrease the effectiveness of water treatment or the acceptability of the treatment system.
- Education and promotion efforts should address any existing concerns or misinformation in communities about the associated risks of cancer from chlorine usage.

2.4.3 Turbidity Protocols

Visually Estimating Turbidity of a Source Water

Before starting, one must have:

- One clear, colorless glass bottle (Bottle #1) filled with water that is known to have no turbidity (e.g., store-bought bottled water).
- One empty clear colorless glass bottle (Bottle #2) identical to Bottle #1.
- One piece of material of solid and consistent color—e.g., a blue notebook that will provide the background against which the contents of these two bottles will be compared.

To determine turbidity of a source water:

1. If the water is opaque and looks like chocolate milk or coffee with cream the bottle comparison test can be skipped. This water requires turbidity removal prior to POU treatment using chlorine or SODIS approaches (see Section 2.4.3 below).
2. If the water is transparent, fill Bottle #2 with the sample.
3. Place Bottle #1 and Bottle #2 against the background of solid color.
4. Have three people judge whether the sample is either:
    - not turbid (perfectly transparent),

- slightly turbid (is not easy to see the turbidity, but it is there),
- turbid (the sample is transparent enough to see through the bottle, but it is obviously turbid), or
- very turbid (the sample is not transparent enough to see through the bottle but not chocolate milk or coffee with cream).

5. If two out of the three people agree on one of these classifications, the sample is declared to have that agreed-upon level of turbidity and this turbidity classification is used to select the proper protocols for turbidity removal, chlorination, or SODIS

Turbidity Removal Protocols

Water collected from the river flowing though the Curimaná District, had turbidities greater than 500 NTUs. Residents who relied on this water for household uses were observed to remove turbidity in two ways:

- Sedimentation—allowing the water collected in a 20 liter bucket to settle over night and decanting water.
- Flocculation/sedimentation—adding a locally-available crystal of aluminum sulfate to the water in a 20 liter bucket, agitating the water and crystal, allowing to settle for some indeterminate amount of time. Note that a local water project called MIAGUA developed a relatively sophisticated protocol for the use of this aluminum sulfate product, combining dosage and agitation with settling and filtration steps.

Based on these observations we present two protocols for removal of high levels of turbidity (>100 NTUs).

Sedimentation protocol (requires further testing on different turbid waters to determine range of turbidities that result from the application of the protocol).

1. Fill a large bucket (20l–40l) with the source water.
2. Cover the bucket and allow it to sit for 12 hours.
3. Carefully decant most of the water from this bucket into another bucket of the same size or greater (or into a number of smaller buckets), being careful to leave the sediments at the bottom of the original bucket.
4. If the turbidity of the resulting water is less than 30 NTUs, treat with a dose of chlorine solution to result in a 3.75 mg/l initial chlorine concentration (2 capfuls of the stock chlorine solution).

The flocculation/sedimentation turbidity removal steps used for the December 2 testing, based on local practice and a protocol developed by the MIAGUA Project were:

1. Add about 27 grams of crystal per 20 liters of turbid river water (each purchased packet of the aluminum sulfate contains one crystal weighing about 27 grams… cost is 1 sole). Not necessary to pulverize crystal prior to adding.
2. Stir this mixture 100 times… most if not all of the crystal should have dissolved.
3. Allow to sit for one hour.
4. Decant 18 or 19 liters of the 20 original liters, leaving the precipitate in the bottom of the original bucket.
5. Dose this decanted water to a 3.76 mg/l of free chlorine.

2.4.4 Water Storage and Handling Protocols

Please see storage and handling recommendations of Section 2.4.1

Wells without Pumps

- Bucket and ropes must be cleaned daily with chlorine cleaning solution (40ppm chlorine).
- A container with chlorine cleaning solution should be present to disinfect hands before handling the rope and bucket; a few drops are sufficient to disinfect the hands.
- The rope and bucket should be hung over the well on a clean hanger and must never touch anything outside of the well water and clean hands.

Collection from Source at a Distance

- Water should be collected into a jerrycan or into a bucket that is covered during transport.
- The container used to collect the water, as well as the transport containers should be clean and disinfected.

Household Storage

- Store the water for drinking in narrow mouth jerrycans—or covered buckets with spigots are best (see text box on buckets with spigots.
- Kettles are a good option for storing boiled water or for short-term storage of water that is soon to be served.
- Drinking water storage containers must be placed and protected to prevent children from putting hands or objects inside the containers.

Handling Water in the HH

- Kettles are an excellent option for storage and serving of boiled water.
- Spigots are the most hygienic means of serving water from a storage container and buckets or jerrycans with spigots are recommended.
- Glass or plastic cups are not appropriate for taking water from storage containers by dipping and should not be promoted.
- Ladles/dippers are a much more hygienic option for serving water from a storage container (that does not have a spigot) and must have handles of at least 25 cm in length.
- Ladles/dippers should be stored in a hanging position out of the reach of children, the cup suspended in the air, never touching hands nor other objects other than the water being served.
- Ladles/dippers should be disinfected once or twice a day with chlorine cleaning solution (see Section 2.4.5).
- Never drink directly from the ladle/dipper.

"Improved" Storage Buckets – Local Installation of Spigots

A more reproducible and sustainable option may be to promote the modification of the existing 20 liter plastic buckets already widely used in these communities.

In Pucallpa, various stores sold small plastic spigots, which could be easily affixed to buckets. An iron reinforcement bar ("re-bar") when heated could be used to create the hole through which the spigot is installed. Lids to match the buckets used could be purchased and distributed for households where the bucket lid had been lost.

These "improved" buckets would be a more durable version of the buckets previously distributed to limited families by PRISMA that could be locally fabricated from cheap and available parts and equipment, creating a local income-generating activity.

The standard size of these buckets would also facilitate accurate chlorine dosing.

Children could easily serve themselves drinking water from the "improved" bucket.

Fitted with a well-fitting lid and a spigot and regularly cleaned and disinfected, these "improved" buckets would provide a container in which to treat and safely store household drinking water.

2.4.5 Cleaning and Disinfection Protocols for Containers and Equipment that Comes into Contact with Drinking Water, and for Shallow Wells

HH Water Storage Containers and Equipment

All containers, dippers, cups, bottles, buckets (including well buckets), etc., that are used to collect, store, transfer, or otherwise handle drinking water must be periodically cleaned/disinfected with a chlorine bleach solution. One cleaning per day is recommended.

1. Using the bleach stock solution (1 sachet of Reluciente bleach (140g) in 1 ½ liters of water), take 2 capfuls (cap from a 1.5 liter or 2 liter plastic Coke bottle) and add to 1 liter of water to make 1 liter of cleaning solution.
2. Using a sponge, cloth, or hand, wash the inside of the container or the surface of the dipper with cleaning solution.
3. If it is not possible to insert a cleaning instrument, add enough cleaning solution to the container to allow it to easily coat all interior surfaces of the container upon agitation. Some HHs use maize grains or gravel with bleach and water to clean out their jerrycans.
4. Rinse the container with cleaning solution and empty the container of all cleaning solution
5. The cleaned container or vessel can be left to dry or put into immediate use.
6. All dippers, well buckets, and cups should be cleaned daily.
7. All storage containers should be cleaned weekly.

Well disinfection

To disinfect a well, a chlorine dosage of between 50 and 100ppm must be induced and maintained over a 12-hour period. Given the economic and logistical resources available in Curimana, it is recommended that disinfection of artisan and informal hand-dug wells be practiced semi-annually—twice a year. Schools should disinfect twice as often—every three months.

Well disinfection is done in five steps:

1. Calculate volume of the water in the well.
2. Determine the proper amount of bleach to add to this volume.
3. Add the bleach to the well water.
4. Allow the well to sit for about 12 hours.
5. Remove water from the well until the water in the well no longer has a strong chlorine odor. (Chlorine can be "stripped" from water harvested from the well by pouring it vigorously from bucket to bucket, promoting the formation of bubbles which will remove the dissolved chlorine from the water).

1. Calculate volume of water in well

- Measure the dimensions of the well in centimeters—rectangular wells (measure length and width) or circular (measure diameter).
- Determine depth of water of well in centimeters.
- Determine the volume of water in the well.
    - Rectangular hole—(length(cm) x width(cm) x depth(cm))/1000 = volume in liters.
    - Circular hole—(0.8 x diameter(cm) x diameter(cm) x depth(cm))/1000 = volume in liters.

2. For every 200 liters add one sachet of Reluciente bleach (140g of) to bring the concentration of chlorine to around 50 ppm.
3. Let the well sit for 12 hours before removing water.
4. Water will likely have a strong Chlorine smell that will disappear with time.
5. In wells served by pumps, this highly chlorinated water is removed from the well by pumping until water no longer has a strong chlorine smell.
6. In wells served by rope and bucket collection systems, removing most of the water volume in a hand-dug well may not be practical. It is easier to strip the chlorine from the well water by pouring the water back and forth between two large buckets four or five times. This should be done vigorously to induce the formation of as many bubbles as possible. (These bubbles pull the dissolved chlorine from the water).

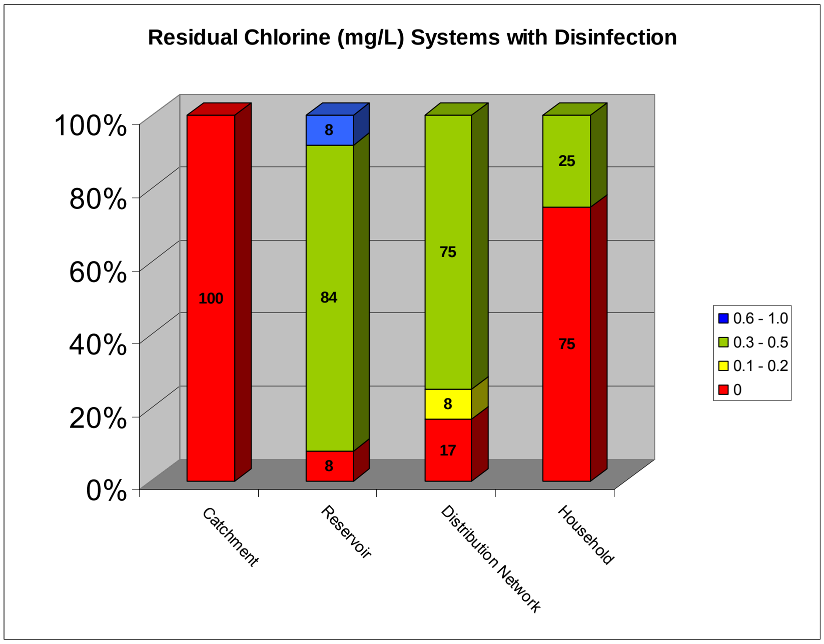
REPORT 3: DEVELOPING A LOCAL NETWORK TO MONITOR AND IMPROVE WATER QUALITY – *RED COMUNITARIA PARA EL MEJORAMIENTO DE AGUA POTABLE (RECO-MAP)*

3.1 BACKGROUND

Peru has achieved fairly high access to water, even in rural areas. The 2000 DHS reports 90.5% access overall, including 94% in urban areas and 84% rural areas. Various sources suggests that while most Peruvians have "access" to water, the water is often not safe for drinking and contributes to diarrhea and other waterborne diseases. During key stakeholder interviews, conducted in the District of Curimaná, Ucayali, Peru, to guide the design of this activity, a wide range of respondents repeatedly mentioned water quality as an overarching issue in settings both with and without water infrastructure.

In both rural and urban settings in Peru, many households depend upon rivers, streams, and unimproved ponds or wells. In areas with a water infrastructure, studies have shown that not all these systems provide sufficient water for the communities they serve and that chlorination and/or other water treatment is inconsistent for both municipally- and community-managed water. Figure 3.1 shows low residual chlorine in household water, which indicates inadequate water treatment by municipal governments.

Figure 3.1 Residual Chlorine (mg/L) Systems with Disinfection



From "Estudio de la Calidad del Agua en Sistemas de Abastecimiento Rural: departments de Ancash, Apurímac, Cajamarca y Cusco." PAHO/WB/Swiss Development Agency, 1999.

USAID/HIP, together with MSH, conducted a series of studies to document current condition of newly placed water sources (SAPs, or *Sistemas de Agua Potable*), and the water quality of rivers, steams, and other water sources used by 28 communities in Pucalpa who participate in the Healthy Municipalities Program. All 13 of the "improved water systems" were found to provide water contaminated with fecal coliform bacteria. All water analyzed from wells, tapstands, and household storage was contaminated to varying degrees and unsafe for household consumption. (See Reports 1and 2 of this Document)

USAID/HIP and MSH also conducted four other studies:

1. A technical and institutional assessment of the SAPS with a focus on improving water quality and overall service;
2. An assessment of all water sources (wells, rivers, etc.) and steps to improve ambient water quality;
3. An assessment of water quality to inform the design of POU water treatment options; and
4. A behavioral assessment to more specifically explore knowledge and practices at the household.

The poor water quality observed at the household is associated with shortcomings in the design and construction of water source infrastructure; extremely low levels of operation and maintenance inputs; lack of access to water from an "improved source;" and improper handling and storage of water in the home. This last issue of improper household water handling also decreases the quality of drinking water in communities served by the SAPs.

The studies confirmed the initial recommendation to USAID to support a local **Network to Monitor and Improve Household Drinking Water.** This Network will be implemented through the Healthy Municipalities/Healthy Communities (HMC) Program.

The objective of Healthy Municipalities/Health Communities Program is to improve the welfare and development of targeted communities in Peru that have high poverty rates and poor health indicators. The HMC Program has been successfully implemented over the past two years in 340 communities in 32 districts. The Program seeks to empower communities through civil participation; promote and implement public health policies; create healthy environments; develop healthy life styles and social skills; and reorient social services toward promotion and prevention. These objectives are being achieved through the creation of community committees, engagement with schools, and through targeting families.[5]

3.2 A NETWORK TO MONITOR AND IMPROVE HOUSEHOLD AND COMMUNITY WATER QUALITY

The proposed Network—***RECO-MAP – Red Comunitaria para el Mejoramiento de Agua Potable*—** will build the capacity level of districts, communities, and households to both monitor and improve water quality at community and household levels. The RECO-MAP will improve the availability of biologically safe water at the household-level by strengthening institutions and mechanisms over time to improve the safety of water provided through community-managed mechanisms/activities for the following purposes:

- To assure that community water systems (SAPs) are providing biologically safe water to households and schools;
- To promote district and community actions to protected water sources from contamination; and
- To promote safe handling and proper treatment of water at the household (and school) levels, to assure that water from any source is safe for drinking.

The success of the Network depends, then, upon the coordination between district and community actors.

Household water treatment and safe storage will be promoted through the **NEPRAM approach, or *Negociacion de Practicas Mejoradas***, which is an innovative approach to behavior change. This approach is presented in more detail in Section 3.2.1.

3.2.1 Proposed Network

This document, that articulates the structure and function of the Network as well as its implementation, consists of:

1. A review of the functional roles and responsibilities of the RECO-MAP Network;
2. A proposed structure for the RECO-MAP, detailing institutional roles and responsibilities;
3. A recommended action plan for establishing a RECO-MAP in Curimaná; and
4. A specific capacity-building strategy to assure that each level of the Network has mastered the key competencies needed to carry-out their functions.

It is noted that this structure as well as the action plan is designed to be easily adapted for implementation in other districts in Peru.

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[5] Now entering Phase II of implementation, leadership and management are critical to sustain and deepen gains already made. The objective of Phase II is to continue to work with the 340 communities and expand to a total of 557 communities. In this phase, the Program will continue to focus on behavioral changes to improve social-health indicators in maternal/child health and will place greater emphasis on a culture of continuous quality improvement among staff of the 411 health facilities involved. Leadership and management capacity at district, community, and facility levels will be developed to achieve these aims.

3.2.2 Functional Roles and Responsibilities of the RECO-MAP

The functional roles and responsibilities of the RECO-MAP are detailed below. The three main functions of the RECO-MAP are to 1) monitor community and household water; 2) promote and negotiate community participation in water source improvements and water system improvement and maintenance, as appropriate; and 3) promote and negotiate safe treatment and storage of household (and school) drinking water.

Monitoring (Vigilance) and Technical Service Delivery

- In communities with community water supply infrastructure (SAPs), provide a monitoring/vigilance function to ensure that the systems are providing high quality service (water of high quality).
- Provide limited water quality monitoring service to households and communities to monitor general water quality of households and of non-improved community water sources (rivers, unimproved wells) as a catalyst to practice source protection, safe water treatment, and storage. [*Note: It is not envisaged that the Network will provide systematic monitoring and testing of all households in participating communities.]*
- As part of the water quality monitoring service, manage simple systems to collect water samples and perform basic water quality tests for turbidity (visual assessment), chlorine residual (using paper strips), and presence of fecal bacteria (simple presence test).
- As part of the water quality monitoring service, manage simple systems for information management and communication that will produce appropriate responses.

Promotion and Negotiation of Improved Practices for Source Protection, Safe Water Treatment, and Storage

- Provide assistance to households to improve the condition of their respective water sources to provide water of higher quality that is more amenable to treatment by household treatment practices.
- Support households in incorporating consistent and correct practice of key behaviors relating to water collection, handling, treatment, and storage, through behavior change negotiation, promotion, community mobilization, skills training, and education.
- Facilitate household access to the required materials, consumables, and technical assistance for water source improvement and the consistent practice of safe handling and treatment.

The execution of these functions implies mastery of key competencies at the district, community, and household levels. The RECO-MAP identifies those competences and outlines a capacity-building strategy to assure those key competencies.

3.2.3 Proposed Structure for the RECO-MAP

For the RECO-MAP Network to yield the desired results requires the participation and coordination of organizations/institutions at the **district** and the **community** levels. The exact structure of the RECO-MAP and the roles and responsibilities of those institutions that make up the RECO-MAP will vary from district to district and community to community, and will likely evolve over time as governments and personnel change. However, certain key RECO-MAP institutions and functions, at both district and community levels, are fixed and take into account the applicable Peruvian legislation; the sector experience that exists in Peru; and understanding of the resources provided by the MSH Project (Healthy Municipalities and Healthy Communities) in the area.

It can be broadly stated that the role of the District RECO-MAP is to provide overall management and to build capacity in the local (community) RECO-MAP institutions; to support and/or carry out actual water testing; to manage information; and to manage communication with community, regional, and other entities. The principal role of the Community or Local RECO-MAP is to implement—collect water samples for fecal coliform tests, perform simple turbidity and chlorine residual testing, catalyze action in communities, and negotiate improved treatment and storage practices at the household-level through home visits and group events.

District-level institutions will form the RECO-MAP District Team which will provide training to community-level RECO-MAP partners and will oversee testing of water quality (training Local RECO-MAP to do turbidity and residual chlorine tests, coordinating with health posts or others to perform fecal coliform presence tests). The district-level RECO-MAP Team will also be responsible for overall information management and liaison with regional and national institutions. District-level RECO-MAP institutions will not implement local activities to improve water quality, but will build capacity in local institutions to do so. Responsibilities of the district-level RECO-MAP institutions are:

- Overall leadership and management functions;
- Liaising with regional and national institutions;
- Training of community-level RECO-MAP organizations and other key community organizations with potential for influencing household practice;
- Training of community-level RECO-MAP organizations, and other key community organizations in the performance of simple water quality analysis (visual turbidity, chlorine residual);
- Facilitation of limited technical assistance from district or regional resources to communities—e.g., physical improvements to SAP, support to SAP committee, and water source protection;
- Execution of water quality analysis—namely, presence test for fecal coliform bacteria; and
- Information and knowledge management, to ensure that households and communities have the information they need to select and practice proper source protection and POU storage and treatment actions; to raise awareness at community, district, and regional levels for water quality issues confronting the district populace; and to advocate for resources in the annual budget cycle that can be used to strengthen the RECO-MAP and its actions.

MSH will support the RECO-MAP District Team and the community-level trainings carried out by the RECO-MAP District Team for at least the first year of activity.

The ***District Oficina de Desarollo Local*** **(ODL)** is proposed as the lead technical organization for the entire RECO-MAP Network. The ODL will assume RECO-MAP management and liaison responsibilities and will coordinate RECO-MAP inclusion in the annual municipal budget,[6] seeking modest support for materials and logistical support.

The ODL will form the RECO-MAP District Team with the participation of appropriate district-level institutions (local technical teams [LTT], district health centers, schools, etc.), taking advantage of the human resources that each of these institutions can provide. The LTT is seen as a particularly important participant in the district-level RECO-MAP Team.

The District-Level RECO-MAP Team will support community-level extension activities by liaising with a host of community actors to form the Local RECO-MAP team. Likely participants in the local RECO-

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[6] MSH/Peru's Healthy Municipalities Project strongly promotes ODL participation in the annual participatory budgeting process.

MAP include the *Junta Vecinal,* the Local Health Post, community water committees (where present), schools, churches, and NGOs willing to take part in the network because they have an interest or applicable skills or experience.

Members of the District-Level RECO-MAP Team will be responsible for training of all RECO-MAP organizations at the community-level to carry-out water sampling, basic water quality testing, household visits to negotiate improved treatment and storage practice, and limited community mobilization activities to improve certain water sources (such as fencing an unprotected well) and general community support, safe handling, and storage.

The District-Level RECO-MAP Team will also direct the provision of a basic water quality monitoring service (fecal coliform presence, residual chlorine, visual turbidity) to households within the district. At the district-level, this water monitoring service will involve the District Health Center, the LTT, and could also bring in the District SAP committee.

Community-Level Institutions are responsible for field implementation activities that focus primarily on the household, limited community activities to improve certain water sources (such as fencing an unprotected well), and general community support for safe handling and storage.

Community-level institutions receive training, support materials, and coordination from the district-level RECO-MAP. The community-level RECO-MAP institutions are responsible for:

- Selective vigilance[7] (participatory monitoring) of water use, SAP performance, and water source protection;
- Household visits to "negotiate" improved household handling, treatment, and storage practices;
- Local information collection and communication with District-level RECO-MAP institutions;
- Collection of water samples and analysis of turbidity (visual test) and residual chlorine (color strips) to inform the selection and effectiveness of POU treatment protocols; and
- Collection of water samples and coordination with the District RECO-MAP of transport and testing for fecal coliform presence testing.

The ***Junta Vecinal*** **(JV)** is recommended as the lead local/community-level organization in the RECO-MAP Network. As the lead organization, the JV will coordinate participation of other appropriate local institutions and individuals in RECO-MAP functions; facilitate all outreach and training directed at households, communities, and schools; supervise vigilance and monitoring activities; and be responsible for information management and coordinating with the District RECO-MAP (ODL).

Tables 3.1 and 3.2 and Figure 3.1 are presented below to describe the RECO-MAP:

- Table 3.1 lists all possible participating institutions at first the district and then the community/local level. For each institution, its possible roles, responsibilities, and coordinating/liaison links are presented.

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[7] The community or Local RECO-MAP is a voluntary organization, and it is unreasonable to expect it to be able to provide a comprehensive vigilance/monitoring of water quality in a community, let alone all of its households. The monitoring and vigilance service that the Local RECO-MAP can provide is more selective and will be somewhat passive. The RECO-MAP will focus outreach at community gatherings and observations made at household negotiation visits, and will respond to requests and complaints, but cannot do scheduled house-to-house monitoring.

- Table 3.2, organized by district institutions and community/local institutions, lays out the same information as Table 3.1 but organizes the institutional roles and responsibilities of each institution by functional area and actions.
- Figure 3.1 is an organizational chart that indicates the relationship of all RECO-MAP institutions, noting the division of activities between the district and community/local levels.

Table 3.1 Organizational Roles and Responsibilities within the RECO-MAP

INSTITUTION	ROLES AND RESPONSIBILITIES	COORDINATION AND LIAISON
DISTRICT	This level provides the overall management to the RECO-MAP and focuses activities to build the capacity of community-level implementing partners. Water quality monitoring services are directed from the district-level. The ODL manages the RECO-MAP, which operates through the District RECO-MAP Team, made up of individuals from the groups below.	
Local Development Organization (ODL) *(Organizacion de Desarollo Local)*	• Overall Management and leadership of RECO-MAP • Internal RECO-MAP M&E • Annual budgeting with municipal government • Overall knowledge management function • Technical clearinghouse for all activities • Oversee community-level training • Oversee provision of discrete TA to community-level institutions • Coordinate and support community-level IEC	• With other district-level Institutions including the municipal government • With regional and national institutions—e.g., MOH, water testing laboratories, regional government, other Ministry representatives • With Local RECO-MAP Teams, including the JVs • ODL will direct the formation of the District RECO-MAP Team with membership from LTT, District Health Center, schools, etc.
Local Technical Team (LTT)	• As appropriate, given human resources available, will provide support in community-level training, limited technical assistance provision, and IEC	• With ODL to form District RECO-MAP Team
District Health Center (DHC)	• Implement water quality testing • Integrate hygiene, safe water, and sanitation messaging into maternal and child health (MCH) visits and health promotion	• With ODL to form District RECO-MAP Team • Manage information on water quality monitoring
District SAP Committee (DCSAP)	• As appropriate, support in community-level training and technical assistance provision, especially in community SAP operation and maintenance	• With ODL • With community SAP committees
Others—e.g., schools, NGOs, churches,	• As appropriate, given human resources available, support community-level IEC, training, coordination with community-level schools, churches, etc.	• With the ODL, these institutions can participate in RECO-MAP technical arm

Table 3.1 Organizational Roles and Responsibilities within the RECO-MAP

INSTITUTION	ROLES AND RESPONSIBILITIES	COORDINATION AND LIAISON
COMMUNITY	Household (HH)-level extension and community-level vigilance/monitoring are implemented by the local, community-level, operational arm of the RECO-MAP (LOAS), which is made up of individuals from the groups below. The community-level RECO-MAP is supported by the district, receiving training, materials, and support. The JV manages the LOAS and coordinates directly with the ODL.	
Neighborhood *Junta Vecinal* (JV)	• Overall management and leadership of the RECO-MAP at the community-level. • Facilitate as part of the RECO-MAP, training and extension service provision to HHs, schools • Home visits to negotiate improved water treatment, handling, and storage practices • Organize group events to build overall community support for improved water quality; promote/negotiate source protection; provide turbidity analysis and receive samples from fecal bacteria analysis; and to negotiate improved water treatment, handling, and storage practices • Selective sampling and analysis (or facilitation of analysis) of household water storage and community sources to check effectiveness of Community or POU treatment and as a catalyst to improve storage and treatment practices	• With District-level RECO-MAP (ODL), manages actions of all community-level RECO-MAP institutions • With District-level RECO-MAP (ODL) to coordinate fecal coliform presence test and information exchange with respect to the result of that test
Community SAP Committee (CCSAP)*	• Monitor performance and operation of SAP • Possible support to household outreach in POU and source improvement • Possible support to HH monitoring activities	• Receive support and training from district SAP • With JV locally
Local Health Posts (LHP)*	• Integrate hygiene, safe water, and sanitation messaging into MCH visits and health promotion/outreach • Possible role in performing water quality testing	• With District Health Center • With JV locally
Others – Schools, NGOs, Churches	• Home visits to negotiate improved water treatment, handling, and storage practice • Possible role in monitoring household water quality. Selective sampling of household water storage and at community sources as a catalyst to improve storage and treatment practices	• Coordinate with JV

* Not present in all communities

Table 3.2 Summary of RECO-MAP Functional Areas and Institutional Responsibilities – District-Level

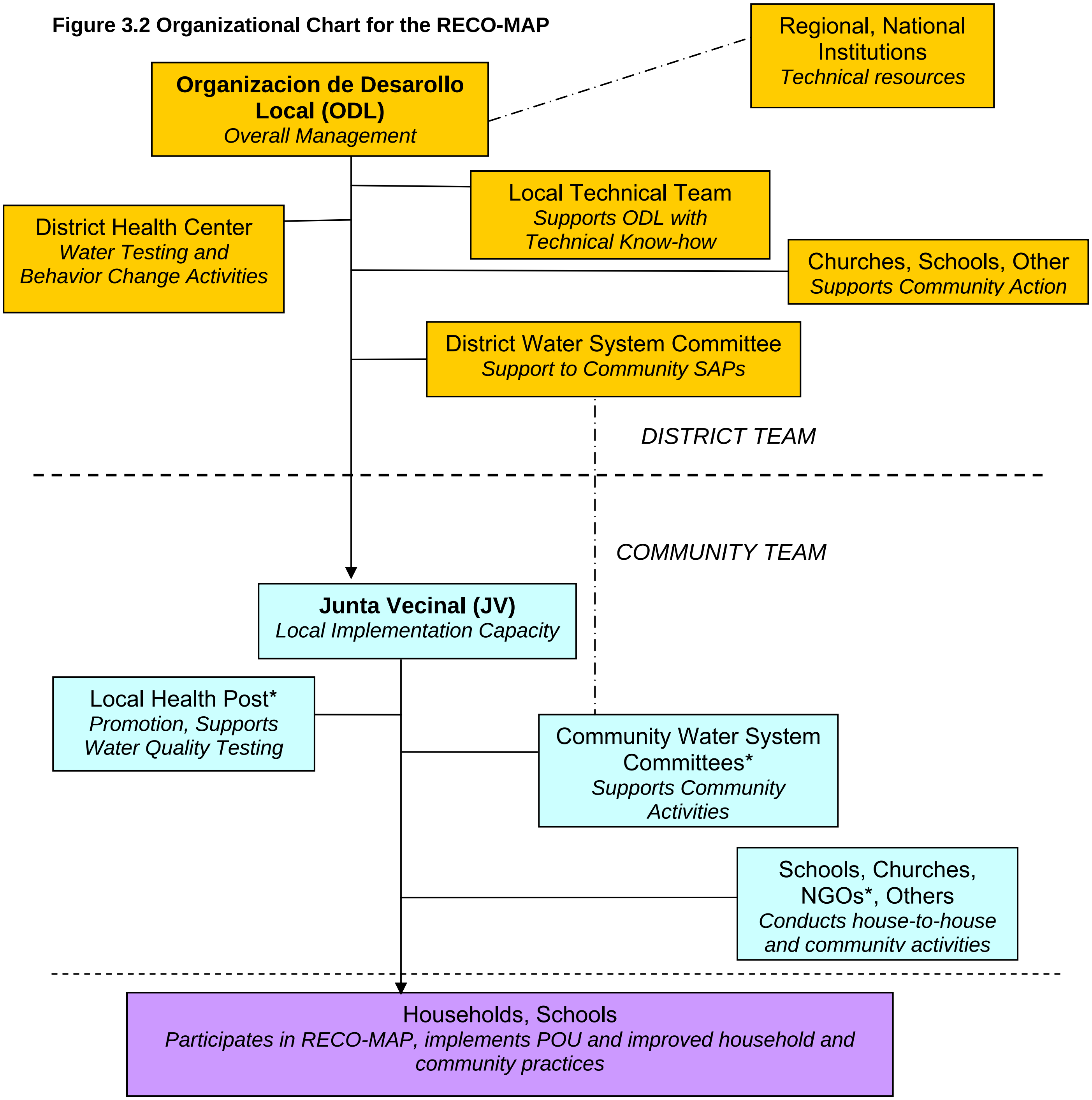
Functional Areas	**Management, Coordination and Capacity-Building Actions Principally Directed Toward Community-level Institutions**						
	Management and Liaison	Vigilance/ Monitoring	IEC	Technical Assistance	Training	Information Management	Technical Service
POU and HH Water Handling	ODL	ODL monitors JVs; DCSAPs monitor CCSAPs	---------	D-RECO-MAP TEAM to L-RECO-MAP	D-RECO-MAP TEAM to JVs and others	ODL to/from JVs; *ODL to district/region*	---------
Source Improvement and disinfection	ODL	ODL monitors JVs	---------	D-RECO-MAP TEAM to L-RECO-MAP	D-RECO-MAP TEAM and DSAP to L-RECO-MAP	ODL to/from JVs; *ODL to district/region*	------
Water Quality Monitoring	ODL	DHC	---------	D-RECO-MAP TEAM and DHC to L-RECO-MAP and CHC	D-RECO-MAP TEAM, DHC to L-RECO-MAP and CHC	ODL and DHC to/from JVs, and CHCs *ODL to district/region*	DHC with D-RECO-MAP TEAM
SAP Service	DSAP to CSAP	DCSAP to CCSAP	---------	DCSAP to CCSAP	DCSAP to CCSAP	DCSAP to/from CCSAP; *ODL to district/region*	DCSAP to CCSAP

Functional Areas	**Implementation Actions at Community/Household-Level**					
	Management and Liaison	Vigilance	IEC (Local Outreach)	Technical Assistance	Information Management	Technical Service
POU and HH Water Handling	JV	L-RECO-MAP	L-RECO-MAP	L-RECO-MAP	JV	----------
Source Improvement	JV	L-RECO-MAP-	L-RECO-MAP	L-RECO-MAP w/ CCSAP	JV	----------
Water Quality Monitoring	JV with CHC	L-RECO-MAP w/ CHC	L-RECO-MAP w/ CHC	L-RECO-MAP w/ CHC	JV w/ CHC	L-RECO-MAP w/ CHC
SAP Service	CCSAP	JV	L-RECO-MAP w/ CCSAP	CCSAP to HHs	CCSAP to JV	CCSAP

ODL = *Organizacion de Desarollo Local* (Local Development Organization)
JV = *Junta Vecinal* (Neighborhood Committee)
D-RECOMAP Team – made up of representatives from ODL, local technical team, other institutions
L-RECO-MAP = Local /Community RECO-MAP – made up of representatives from JV, schools, CCSAP, other institutions
DHC = District Health Center
CHC = Community Health Center (not in all communities)
DCSAP = District Committee of the SAP
CCSAP = Community Committee of the SAP (not in all communities)
SAP = *Sistema de Agua Potable* – Potable Water System

Figure 3.2 is an organizational chart that indicates the relationship of all RECO-MAP institutions, noting the division of activities between the district and community/local levels

Figure 3.2 Organizational Chart for the RECO-MAP



* These institutions are not present in all communities

- It is estimated that two members of the ODL will have a management role in the RECO-MAP
- The District Team will consist of up to five people, including the two from the ODL management
- The JV will manage local RECO-MAP implementation with two people
- The Local RECO-MAP will be made up of up to five people, including the two from the JV management

3.3 ESTABLISHING THE RECO-MAP - RECOMMENDED ACTIONS (FOR HIP AND MSH)

Establishing the RECO-MAP and creating in it the capacity to assume the range of responsibilities that are noted in Section 3.2 above requires MSH/Peru and HIP to engage in several discrete activities:

1. Organization of the RECO-MAP at district and local levels;
2. Training/capacity-building of all RECO-MAP organizations and personnel;
3. Development of support materials for all district and community activities; and
4. Facilitation of logistics for acquiring testing materials.

3.3.1 Establish the RECO-MAP Organization

Organize the District-level RECO-MAP Team

With participation of all organizations named above and facilitated by MSH, the District RECO-MAP will be organized through the ODL. This will require MSH outreach, first directly to the ODL and subsequently through a planning activity—likely a one-day workshop.

- The District RECO-MAP Team must have at least two individuals from the ODL who are responsible for management, coordination, and putting RECO-MAP into the annual municipal budget planning process.
- One District RECO-MAP Team member will coordinate technical support to the water testing function at district and community levels, assuring training, supplies, and two-way outreach to the communities and coordination of water quality monitoring activities.
- One ODL individual will manage all RECO-MAP information—storing, sharing, and obtaining.
- District RECO-MAP Team members and other individuals will be trained and nominated “Master Trainers,” responsible for training the community cadre.
- Roles of other district institutions (especially the LTT) to provide an operational arm for the RECO-MAP will be determined by individuals/institutions at the district-level and will reflect the available resources in the district.

Implement Initial Outreach from District to the Communities

MSH will help to organize events that introduce the RECO-MAP and its district institutions and individuals to appropriate community institutions and individuals (JV, CSAP). Initial community activities will be simple and will focus on raising awareness, knowledge, and solidifying the roles of local individuals as participants in the RECO-MAP to improve water quality at the household and community-level.

One of the first activities should present the results of the bacteriological water quality and infrastructure/water source evaluations to convey the magnitude of the water quality problem to these institutions and to community members.

Organize Community-level RECO-MAP Team

MSH will facilitate workshops and training activities that bring together District RECO-MAP representatives with representatives from the JVs and other appropriate community organizations to create structures, delegate responsibilities, and define roles of those who will form the RECO-MAP Team in each community.

3.3.2 Capacity Building Plan

The project structure of RECO-MAP creates two primary groups of individuals—one at the **district**-level and one at the **community**-level—each of whom must master sets of key competencies in order to achieve the ultimate goals of strengthening household water treatment/management, sanitation, and hygiene activities and improving water quality sources.

These competencies will be built and strengthened through a series of training activities.

Training will be structured around a “cascade” model where individuals (primarily drawn from the district-level) will be selected and trained as “master trainers.” The master trainers will in turn train individuals at the community-level who will implement the project activities at the community- and household-level. All training will be based on participatory training techniques.

A key component of the skills training will be the ***Negociación de Prácticas Mejoradas*** (NEPRAM) intervention/training approach. NEPRAM trains any variety of household visitors or community promoters to first identify and then “negotiate” a range of improved practices related to target behaviors, rather than “educate” or promote fixed “ideal” practices that are often not feasible from the householder’s point of view. Household visits or group sessions focus on identifying feasible and effective practices; promoters work with households to “solve problems” and reduce any barriers to the consistent and correct practice of water treatment and storage behaviors at the household-level.

These feasible and effective actions are termed **“small do-able actions”** to reflect that while not necessarily the complete and ideal set of behaviors leading to desired public health outcomes, they reduce risk and move towards the ideal. All small do-able actions are lab-tested for effectiveness, to assure that in the case of household water treatment, storage, and management, they considerably reduce bacterial contamination of drinking water. They are also field-tested to assure that target communities have the resources to consistently practice the behaviors and consider them “feasible” given available time and skills, cultural norms, and resources.

This same approach can be applied to changing the behavior of institutional actors as well, for instance, the ODLs negotiating with the *Juntas Vecinales* or the District Health Centers to incorporate improved practice into their job routines.

La Negociación de Prácticas Mejoradas or NEPRAM is an innovative strategy that combines counseling and behavior change promotion techniques. NEPRAM builds on existing practices, beliefs, customs, and available resources to “negotiate” with housholders to identify and adopt effective and feasible water handling and treatment practices to prevent contamination and ensure that water is free of disease-causing agents.

The NEPRAM strategy is driven by a strong behavior change component that, instead of promoting only one ideal practice or approach, focuses on instituting a process of interchange and negotiation between the NEPRAM extensionists (community change agents) and HHs. This process allows HHs to select the most appropriate options for their situations and also permits HHs to work with the community change agents to confront and solve other problems confronting them. With this community support, and because actions are selected by the HHs themselves, the NEPRAM approach makes rapid integration of new behaviors possible. To practice NEPRAM, change agents must be armed with a range of feasible water treatment and handwashing options for various contexts (water sources, seasonality, available containers). They must be able to practice counseling techniques that identify problems, possible solutions, and get commitment to try a new, effective practice that brings the household closer to consistent and correct practice of water treatment, safe water handling, and general hygiene.

To do this, previous research must identify the range of common options, problems, and solutions under a range of household conditions. Outreach workers are then trained to implement the range of options and solutions.

3.3.2.1 District-Level Training

Master Trainers

Trainers/Trainees

MSH, with the assistance of HIP, will train a group of “master trainers” who will be drawn from organizations/individuals at the district-level, including the ODL, Local Technical Team, District Health Center, and District Water System Committee. Additionally, some master trainers will be selected from the community-level *Juntas Vecinales* from “model communities.”

Content

The primary focus of the master trainings will be to develop the technical capacities in the master trainers that will allow them to train community members to carry out activities at the community-level. Capacity building for master trainers will include:

- Participatory training techniques—to ensure that master trainers have the necessary training skills (techniques for training adult learners, establishing a learning climate, using appropriate vocabulary, doing a demonstration, etc.) to successfully implement the cascade trainings.
- “Hygiene 101” – this will cover basic information on the link between hygiene and diarrhea and hygiene practices necessary to reduce the risk of diarrhea, and (to be determined by MSH and HIP) can include:

  - proper POU water treatment (chlorination, boiling, SODIS);
  - safe water handling and storage at the household-level including disinfection of receptacles;
  - appropriate hand washing at critical moments;
  - safe feces disposal;
  - improving and disinfecting water sources (wells, surface waters);
  - proper food handling; and
  - proper kitchen hygiene and dishwashing.

- Interpersonal communication and counseling.
- Negotiation counseling.
- Use of household-level materials to be provided to household members during home visits. These household materials will include information on water treatment, handling and storage, proper hand washing at critical moments, safe feces disposal, proper food handling and improving and disinfecting water sources.
- Monitoring system and use of monitoring instruments.
- Outreach workers responsibilities—so that they can clearly communicate to community outreach workers how to implement their activities.
- Water sampling and testing—sampling, sample handling, visual turbidity testing, measurement of residual chlorine using strips, and collecting water samples for fecal coliform testing.
- Supervision/support skills and instruments—individuals from the district-level are expected to provide supervision and support to the community outreach agents, so this portion of the training will provide them with the necessary skills to carry out these activities.

Materials

Materials that will be needed for the master trainings include:

- Master trainer's manual. This manual will include all of the information and exercises necessary to gain the capacities outlined in the previous section labeled "Content."
- Outreach workers manual. This manual will include all of the information and exercises necessary to master the capacities outlined in the section labeled "Content" for the community-level trainings (see below).
- Household materials. This includes copies of all the materials (posters, fliers, stickers, reminder materials, etc.) to be used by the community outreach workers while carrying out activities with household members. These household materials will include (as determined by MSH with HIP) information on water treatment, handling and storage, improving and disinfecting water sources, proper hand washing at critical moments, safe feces disposal, proper food handling, and proper kitchen hygiene/dishwashing.
- Monitoring instruments. All instruments that will be used by community outreach workers to capture data on the interventions and progress achieved with households.
- Self assessment tools. Tools will provide supportive self-supervision to outreach workers.

3.3.2.2 Community-Level Training

Outreach Workers

Trainers/Trainees

- The master trainers will train individuals at the community-level, who will form the Local RECO-MAP (L-RECOMAP), and be selected from the *juntas vecinales,* community water system committees (where they exist), local health posts (where they exist), NGOs, churches, schools, and other organizations at the community-level. The individuals who are trained at the community-level will be charged with carrying out the project activities with households in their communities and with working with community-level organizations and governing institutions. The primary goal of the trainings at the community-level will be to provide the outreach workers with the necessary skills in negotiating behavior change, and to understand their responsibilities as outreach/change agents. These behavior changes will help community members improve drinking and cooking water quality, and will address HH water treatment, handling, and storage as well as source maintenance and improvement. Other topics can include proper hand washing at critical moments, safe feces disposal, proper food handling and kitchen hygiene/dishwashing. (The final content of the training will be determined by MSH and HIP.)

The initial trainings at the community-level will be carried out by teams of master trainers. MSH staff will “assist” the master trainers in the first rounds of trainings to assure that the cascade training model retains the level of quality necessary for successful skill transfer to the community outreach workers.

Each community outreach worker from the L-RECO-MAP is expected to be responsible for outreach to their community and to individual households. Each worker will be responsible for a set group of families in their communities, and the exact number of houses assigned to each outreach worker will vary from community to community. The number of families assigned to each worker will be determined by the number of individuals who are members of the L-RECO-MAP for the community, the number of families living in the community, and the geographic distribution of the houses. Each L-RECO-MAP will determine the feasible and realistic assignments of household responsibilities for their members. There will be some variability among communities on the type of community activity or emphasis on household or community promotion.

The primary focus of the trainings for outreach workers will be to instill a basic understanding of the links between water, hygiene, and diarrhea and how to implement negotiation counseling techniques with families in their communities to help them improve their water treatment, handling, and hygiene practices. Outreach workers will also need to guide householders in the selection of a POU treatment method based on source water quality (turbidity and source) and preference, and will have to be able to train the household in the POU protocol. Lastly, outreach workers will be trained to mobilize communities to make “simple” improvements to water sources or simple ways to protect water sources from contamination. The expectation is that there will be multiple opportunities for the master trainers/MSH staff to train and meet with community-level outreach agents, and to provide feedback and supervision on their community and household visits.

Content

The initial training(s) will focus on:

- “Hygiene 101”—this will cover basic information on the link between hygiene and diarrhea and hygiene practices necessary to reduce the risk of diarrhea, and (to be determined by MSH and HIP) can include:

  - proper POU water treatment (chlorination, boiling, SODIS);
  - safe water handling and storage at the household-level;
  - appropriate hand washing at critical moments;
  - safe feces disposal;
  - improving and disinfecting water sources (wells, surface waters);
  - safe food handling practices; and
  - safe dishwashing practices.
- Interpersonal communication and counseling.
- Negotiation counseling.
- Use of household-level materials. These household materials will include information on water treatment, handling and storage, proper hand washing at critical moments, safe feces disposal, safe food handling, and improving and disinfecting water sources.
- Monitoring system and use of monitoring instruments.
- Outreach workers responsibilities—so workers know what they are expected to do and when to do those tasks (including how/when to take water samples and how to get them to the district-level lab).
- Water sampling and testing—in order to understand the process and participate in sampling, sample handling and transport, along with turbidity and residual chlorine testing of samples from households and community water sources.
- Developing local "support group" for outreach workers. Community outreach workers need to be given an opportunity to develop plans for how they can provide support to each other to problem solve as they roll out the project activities.

Materials

Materials that will be needed for the outreach worker trainings include:

- Outreach workers manual. This manual will include all of the information and exercises necessary to master the capacities outlines in the section labeled "Content" for the community-level trainings (see above).
- Household materials. Copies of all the materials (posters, fliers, stickers, reminder materials, etc.) to be used by the community outreach workers while carrying out activities with household members. These household materials will include information on water treatment, handling and storage, proper hand washing at critical moments, safe feces disposal, proper food handling, proper dish washing, and improving and disinfecting water sources.
- Monitoring instruments—all instruments that will be used by community outreach workers to capture data on the interventions and progress carried out with and achieved with households.
- Materials and equipment for testing water. (See Annex 5 for details on testing.)

Table 3.3 Materials and Equipment Needs for Water Quality Testing

TEST	MATERIAL/EQUIPMENT	AVAILABILITY
Visual Turbidity Assessment. This test is necessary to select POU treatment protocol for a water (how much chlorine solution to add).	Two identical clean, unscratched, smooth-surfaced plastic or glass bottles; 100ml is fine	LOCALLY – bottles must be cared for so they stay in pristine condition.
	Clear bottled-water to serve as standard	LOCALLY – buy 1 unit of bottled water to serve as the standard.
	One standard background—30cm x 30cm; blue, black, brown color must be uniform	LOCALLY – a clip board, folder, etc.
	Notebook	LOCALLY
	Instructions on testing protocol and results reporting protocol	Printed Protocol from HIP/MSH ;
Residual Chlorine Test. Ensures that a chlorine protocol is effective for a particular water, that a SAP is chlorinating.	Bottle to take sample—need less than 50ml	Notebook LOCAL
	Chlorine testing strips and color chart	NOT LOCALLY – District will have to provide (MSH/Peru facilitates). Bottle of strips about US$25 for 50 tests.
	Instructions on testing protocol and results reporting protocol	Protocol from HIP/MSH
	Notebook	LOCALLY
Fecal Coliform Presence Test. Test to catalyze demand for action, to confirm effectiveness of a source improvement or community or HH treatment or water handling action. This analysis can be done at district-level. Or compare to cost of transporting and analyzing sample at lab in regional capital.		
	Sterile bottle to take sample—need at least 500ml. Use tape on bottle to label as sample.	LOCALLY (bottle and tape) – bottle must be cleaned with chlorine cleaning solution, and then thoroughly rinsed with sample water 3 times before filling with sample
	Instructions on sampling, transport and handling protocol	Protocol from HIP/MSH ;
	Container to keep sample cool - below air temperature	LOCALLY available
	Vehicle to transport sample from community to district	LOCALLY available – coordination necessary
	Instructions on results reporting protocol	From MSH/HIP
	Fecal Bacteria Presence Testing Kit	Test done at district; kit is NOT LOCALLY AVAILABLE
	Incubator	Incubator an be purchased in Lima $800
	UV florescent lamp	Lamp costs $200 in Lima?
	Colilert kit	Costs $5.00 per test

- Job aids—to be used by community outreach workers to judge their progress and identify possible areas of improvement.
- Self assessment tools—to provide supportive self-supervision to outreach workers.

3.3.3.3 Additional District-Level Training

Laboratory Staff

Several individuals from the District Health Center will need to be trained to carryout testing of water samples for fecal coliform bacteria presence and must be able to perform and train Local RECO-Map members in the performance of the visual turbidity analysis and the chlorine residual testing. This training can be done at the district- or community-level.

Trainers/Trainees

MSH/HIP staff will train two to four individuals from the District Health Center in the techniques necessary to carry out lab tests of water samples for fecal coliform bacteria.

Content

Training will include:

- Sample collection and labeling—selecting, obtaining, and preparing sampling bottles/containers; collecting the proper amount of the proper sample.
- Sample handling, transport, and logistics—of particular importance for fecal coliform and chlorine residual tests which must occur within a set time after sample is taken.
- Implementing the tests—visual turbidity, chlorine residual with indicator strips, and fecal coliform presence.
- Recording results.
- Communicating results—to proper RECO-MAP representatives, to community, to household, and to district and regional interests.
- Materials—See Table 3.3

ANNEXES

ANNEX 1. FINDINGS – WATER QUALITY ANALYSIS IN CURIMANÁ

ANNEX 2. FINDINGS – CHLORINE DEMAND TESTING RESULTS (AND PROTOCOL DESCRIPTION) IN CURIMANÁ

ANNEX 3. PROBLEMS AND SOLUTIONS – FIELD TESTING CHLORINE DEMAND OF DRINKING WATER IN CURIMANÁ

ANNEX 4. CALCULATION DETAILS – CHLORINE DOSING PROTOCOLS

ANNEX 5: DETAILS ON BUILDING A LOCAL WATER QUALITY TESTING CAPACITY

This annex presents the objectives of a water quality testing capacity, introduces the testing capability of the RECO-MAP, and presents comprehensive protocols/guidelines for sampling, testing, and reporting.

A water quality monitoring service can be used to:

- Raise public awareness of contamination and create demand for improved HH water quality;
- Provide information on the operation of community SAPs;
- Provide information on the quality of water from new and existing water sources;
- Provide information on the effectiveness of household water treatment practices;
- Provide information to guide the selection of a particular water treatment protocol; and
- Manage the information generated for external use (e.g., information required by national agencies and ministries).

Important considerations in implementing a water quality monitoring service in the Curimaná District and in other districts of Peru are:

- The district has limited economic resources to support water quality monitoring and testing;
- The district has limited access to trained human resources who can implement complicated laboratory procedures;
- The district has limited resources to contribute to the logistical requirements of collecting, transporting, and testing water samples;
- There is little institutional or legal pressure to institute a water quality monitoring system; and
- There exists Peruvian policy that supports a particular institutional system for water quality monitoring.

Institutionally, the District Health Center will be the central facility for performing water quality testing and training community groups to collect and transport samples and to perform limited field testing using simple, appropriate methods. At the local level, the LOAS, as directed by the JV, will support water quality monitoring actions.

The Table A-5.1 presents all aspects of the water quality monitoring capacity of the RECO-MAP. The following testing capacity can be maintained by the RECO-MAP at local and district levels:

- Community-level—visual turbidity testing, chlorine residual using testing papers, and pH using testing papers. These tests can be easily and conveniently carried out by a trained community member and are used to select POU treatment protocols, and to monitor the effectiveness of a chlorine treatment.

- District-level—includes the three tests done at the community-level, plus the Colilert fecal coliform presence test. The district must have the capacity to conduct tests for the municipal seat and also to train Local RECO-MAP Team members in how to conduct the visual turbidity, chlorine residual, and the pH tests.

Table A-5.1 Water Quality Monitoring Capacity in Curimaná

Parameter	Type of Test	Rationale for Parameter Selection	Local Organization	Description of Test
Contamination by fecal bacteria	Fecal coliform presence test	To raise awareness of contamination, create demand for service, confirm effectiveness of a treatment method.	District Health Center runs tests.	Colilert water test [8] (about $5.00/sample). Sample handling and transport (cold chain) important (also requires incubator [$800] and fluorescent UV lamp [$200]).
Chlorine concentration	Quantitative chlorine test—low cost	Confirm effectiveness of chlorine treatment process; quantify chlorine concentrations in bleach products.	Tests run in community—should not transport samples to District. LOAS implements.	Paper changes color—pool testing kits for low chlorine concentrations (about $0.50 / sample).
Chlorine concentration	Quantitative chlorine test using colorimetric comparison[9] – higher cost	Confirm effectiveness of chlorine treatment process; quantify chlorine concentrations in bleach products.	DHC does testing using colorimetric analytical equipment and reagents in situ to confirm presence or in district lab to analyze bleaches.	Initial investment is high for equipment; sustainability is low after equipment failure.
Turbidity	Visual turbidity test	Inform selection of POU treatment protocol. Assess effectiveness of turbidity removal protocol.	Community-level; JV with LOAS.	Visual comparison of clear and turbid waters against standards.
Turbidity	Turbidity test using turbidimeter	Inform selection of POU treatment protocol. Assess effectiveness of turbidity removal protocol.	DHC performs analysis in District laboratory.	Initial investment is high for turbidimeter; sustainability of use is low after equipment failure.
pH	Litmus papers	Confirm that pH range is suitable for effective chlorine disinfection.	DHS or JV/LOAS in coordination with a chlorine testing activity.	Water applied to paper. Observed color change indicates pH range.

Dark gray shading indicates tests that are to be performed at DISTRICT by District RECO-MAP.
Light gray shading indicates tests to be perform locally by the Local RECO-MAP.
No shading indicates tests that are outside of normal RECO-MAP capabilities.

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[8] The Colilert water test, produced by IDEXX, is now the most widely used method for coliform and *Escherichia coli* testing in U.S., Canadian, and Japanese drinking-water methods. This simple method allows for rapid and accurate presence/absence testing for coliform bacteria and *E. coli* within 24 hours. The only consumable necessary is the Colilert reagent, which is available in Lima from Kossodo S.A. for about 5 US dollars a test. This powder is added to 100mL of the water sample in a glass, sterilizable bottle, which is then incubated for 24 hours. A change in color indicates the presence of coliform bacteria, and phosphorescence under an economical UV light indicates the presence of *E. coli.*

[9] The DPD1, comparator, and bottles with clear water can be provided by the municipality as part of its healthy municipality strategy.

A-5.1 PROTOCOLS FOR RECO-MAP SAMPLE COLLECTION AND TESTING AND REPORTING

A-5.1.1 Visual Turbidity Test – Performed by Local RECO-MAP

Summary – Visual Turbidity Test

This water quality analysis is of critical importance in selecting a HH POU treatment technique and protocol. With chlorine systems, ambient turbidity and the source of the water are the two criteria that determine chlorine dosage. The turbidity test can also be used to assess the effectiveness of source protection and improvement actions. Visual turbidity examinations will determine if a sample is *not turbid*, is *turbid*, or is *very turbid*.

Table A-5.2 List of Equipment and Materials – Visual Turbidity Test (Test Done by Local RECO-MAP)

MATERIAL/EQUIPMENT	AVAILABILITY
Two identical, clean, unscratched, smooth-surfaced plastic or glass bottles 100ml will work. Bottles must be cared for and kept clean and scratch free.	LOCALLY – bottles must be cared for so they stay in pristine condition.
Clear, bottled-water to serve as standard.	LOCALLY – buy bottled water
One standard background—30cm x 30cm; blue, black, brown color must be uniform. Must be cared for and kept clean and scratch free.	LOCALLY – a clip board, folder, etc.
Instructions on testing protocol.	Protocol from HIP/MSH.
A notebook and pen.	LOCALLY

Collecting sample –- Visual Turbidity Test

Collect sample water from the source taking care not to re-suspend sediments or otherwise capture unrepresentative materials (leaves, twigs, bugs). Rinse the sample container twice with the sample water taking care to not muck up the source water by this activity (do not pour the wasted rinse-water back into the source). After rinsing, collect a full representative sample of a volume at least as great as the volume of the examination bottles. One may just collect the sample directly into the examination bottle.

As for all samples, the bottle must be labeled with tape. On this label must be noted the following information:

- A sample number—if there are multiple samples being taken;
- Sample location and source description;
- Time and date of sample collection; and
- Weather (rain, clouds, sun) and air temperature (hot, warm, cool) at time of sampling.

This information that appears on the label must be recorded in the RECO-MAP water quality notebook as soon as possible.

Handling and Transporting Sample - Visual Turbidity Test

The sample can be collected with one of the two examination bottles or can be collected in another relatively clean (interior free of debris or surface films). There is really no time or special handling requirement with this test. The test should be performed as soon as possible, but the sample can be analyzed a day after it is taken. It is best to not allow the sample to become neither extremely warm (10 degrees higher than daytime temperature in shade), nor extremely cold (near freezing). To test the sample, it must be transferred to one of the two examination bottles. If transferring the sample from another container, gently shake the original container to re-suspend any sediment that may have settled during storage, transport, and handling. After gently shaking the container, pour the sample into the examination bottle, filling it completely.

Analyzing Sample – Visual Turbidity Test

The sample is analyzed by comparing it to a standard of zero turbidity. The standard is the other identical sample bottle filled with store-bought water.

- Fill one sample bottle with sample (following procedure above to re-suspend any sediment that may have settled during handling). If the sample bottle is already filled, gently shake it to ensure that no sediments have settled.
- In sunlight, or under a bright light, place the two bottles (one filled with the clear standard, and one filled with the sample) in front of the dark-colored uniform background sheet (a notebook, folder, etc., of uniform dark color)
- Three people make an examination of the sample water, comparing it to the standard.
- If the sample is as clear as the standard, or just slightly turbid (slight but hard-to notice milkiness, but still easily transparent) the observer notes “not turbid.”
- If the sample is noticeably milky but still transparent the observer notes “turbid.”
- If the sample is milky, not transparent, and of more of a café con leche look, the observer notes “very turbid” (the “very turbid” label typically can be applied to a water without doing this test).
- The three observers compare their judgments. Two of three in agreement signifies that a water sample is either “not turbid,” “turbid,” or “very turbid”—according to the decision of the observers.
- This label, will inform the selection of treatment protocol for the water, and can also be used to make recommendations on source improvements.

Recording Results – Visual Turbidity Test

All information taken at the sample site must be recorded:

- A sample number—if there are multiple samples being taken;
- Sample location and source description;
- Time and date of sample collection; and
- Weather (rain, clouds, sun) and air temperature (hot, warm, cool) at time of sampling.

Along with the sampling information, the turbidity designation is noted as well as any other analysis completed for that particular water source. Any other pertinent observations are recorded as well (e.g., if there was disagreement among the observers, if there is low or high confidence in the designation, etc.). This information is recorded in a field notebook and then transferred to an official RECO-MAP notebook.

Interpreting and Reporting Results – Visual Turbidity Test

Information from this turbidity test will be used to reach appropriate diagnostic conclusions on the use of appropriate POU treatment protocols (i.e., this water's turbidity requires that you use dosing protocol B, or this turbidity indicates that surface runoff might be entering your well and you will need to effect an improvement). It is important therefore that the results and diagnostic interpretation/conclusions of this test be communicated immediately to the household using the source.

It is of interest to the RCO-MAP to catalogue the results of this analysis by water source, but it is likely that the most appropriate way to manage the results of the test is by community, then by date.

RECO-MAP Follow-Up Actions – Visual Turbidity Test

Follow-up turbidity measurements can take place in any before-after scenario—e.g., the effectiveness of improvements made to a source after the first turbidity test can be checked by a follow-up turbidity test. A chlorine residual test might be an appropriate follow-up to confirm the effectiveness of the dosing protocol that was chosen based on the results of the first turbidity test. The Local RECO-MAP would be the group that would implement these follow-up actions, most likely upon request by a HH.

A-5.1.2 Residual Chlorine Test – Performed by Local RECO-MAP

Summary – Residual Chlorine Test

This test is performed locally to confirm the effectiveness of POU and community chlorination treatment actions. The main purpose of the test is to confirm the presence of sufficient amounts of residual chlorine in a water to make it bacteria-free. The test can also be used to confirm that a selected dosing protocol is, for whatever reason, too high for that particular water, and that the chlorine dose can be reduced. (This can be associated with observed aesthetic problems—chlorine taste or smell). The residual chlorine test should be accompanied by a visual turbidity test of the same water.

Table A-5.3 List of Equipment and Materials – Residual Chlorine Test (Test Done by Local RECO-MAP)

MATERIAL/EQUIPMENT	AVAILABILITY
Clean bottle to take sample—need less than 50 ml.	LOCALLY
Chlorine testing strips and color chart (must be stored appropriately in accordance with test kit instructions).	NOT LOCALLY – District will have to provide (MSH/Peru facilitates). Bottle of strips about US$25 for 50 tests.
Instructions on testing protocol and results reporting protocol.	Protocol from HIP/MSH.
Notebook and a pen.	LOCALLY

Collecting Sample – Residual Chlorine Test

- Water to be tested will have received a dosage of chlorine, either at a community water system treatment facility or through a POU treatment protocol.
- Collect the sample after dosage with the chlorine, noting the exact time that the chlorine dosing took place (not the sampling). Do NOT agitate the water during the sampling process.
- Rinse the already clean sample container twice with the sample water taking care to not pour the wasted rinse water back into the source container. After rinsing, collect 50 to 100ml or more of sample, (noting that whatever container is used as a sample bottle, it must be completely filled—no air in the bottle!).
- Allow the bottle filled with sample to sit quietly in the shade or dark at room temperature for 7 to 10 hours measured from chlorine dosage (not sampling).

As for all samples, the bottle must be labeled with tape. On this label must be noted the following information:

- A sample number—if there are multiple samples being taken;
- Sample location and source description;
- Time and date of sample collection;
- Time and date of chlorine dosage; and
- Weather (rain, clouds, sun) and air temperature (hot, warm, cool) at time of sampling.

This information that appears on the label must be recorded in the RECO-MAP water quality notebook as soon as possible.

Handling and Transporting Sample – Residual Chlorine Test

Remember that the container used to contain the sample must be completely filled—no air in the bottle!

Allow the bottle filled with sample to sit quietly in the shade or dark at room temperature for 7 to 10 hours measured from chlorine dosage (not sampling). Transporting the sample must not agitate the sample nor expose the sample to extremes of heat or cold. It should remain at room temperature.

A water dosed with chlorine in the evening can be tested the next morning, and a water dosed in the morning can be tested that afternoon (remember that good light is needed to interpret results).

Analyzing Sample – Residual Chlorine Test

- The sample is ready to analyze when 7 to 10 hours has elapsed from the time the sample receive a chlorine dose.
- A portion of chlorine testing strip is removed from its roll in accordance with test kit instructions.
- The sample container is opened.
- The end of the strip is dipped into the sample water.
- The sample water reacts with the tape in accordance with test kit instructions.
- The tester waits the proscribed amount of time in accordance with test kit instructions.
- The tester then compares the color of the wetted test strip with the color chart included in the test kit. This color comparison should be done in sunlight or under a bright light.
- The tester selects the appropriate residual chlorine concentration from the matching color as noted in the chart in accordance with test kit instructions.

Recording Results – Residual Chlorine Test

All information taken at the sample site must be recorded:

- A sample number—if there are multiple samples being taken;
- Sample location and source description;
- Time and date of sample collection and dosing;
- Time expired between dosing and testing; and
- Weather (rain, clouds, sun) and air temperature (hot, warm, cool) at time of sampling.

Along with the sampling information the turbidity designation must be recorded, as this information is helpful in interpreting the results of the chlorine residual test. The chlorine residual found in the water is noted in the notebook along with any other pertinent notes—e.g., if there were problems reading the color of the test strip, etc. This information is recorded in a field notebook and then transferred to an official RECO-MAP notebook.

Interpreting and Reporting Results – Residual Chlorine Test

- If the residual chlorine concentration of the water is between 0.2 mg/l (ppm) and 1.0 mg/l (ppm), the chlorine dosage protocol is appropriate for that particular water source.
- Conversely, if the residual chlorine is below 0.2 mg/l, the dosage of chlorine should be increased to that of the higher dosage protocol.
- If the residual chlorine concentration is above 1.0mg/l AND the users complain of aesthetic issues (taste, smell) the chlorine dosage should be decreased to the net lower dosage protocol—and the sample tested again for residual chlorine using the lower dosage protocol.

Test results and interpretation must be recorded in the RCO-MAP records and must be communicated immediately to the household or community water system committee.

RECO-MAP Follow-Up Actions – Residual Chlorine Test

The follow-up required will usually be minimal—reporting the results and the interpretation of the results, which will likely be to simply continue using the same chlorine POU treatment protocol that was tested in this analysis. However, if the results of the test showed that chlorine dosing was too low or too high, the new dosage protocol will likely require the RCO-MAP to provide a follow-up chlorine residual test to confirm that the new dosage is providing appropriate residual disinfection.

A-5.1.3 Fecal Coliform Presence Test – Performed by District RECO-MAP

Summary – Fecal Coliform Presence Test

Coliform presence testing is a qualitative test and will indicate, as the name implies, the PRESENCE of fecal coliform bacteria in a water sample. It is not a quantitative test, and cannot discern whether a positive outcome is an indication of 1 organism or a million organisms in a sample. It is therefore **not** a test to confirm that stepwise improvements are taking place in bacterial water quality—e.g., that because of improvements in household handling the concentration of fecal coliforms has declined from 10,000 in 100ml to 5 in 100 ml in a household's drinking water. The presence test CANNOT make this distinction.

The presence test is useful in showing that contamination is present—and typically is used to confirm that there is or is not contamination. It is a test that produces results that are useful in public outreach campaigns because the test can show that recontamination of treated water is taking place, that sources regarded as safe are not safe, or that treatments that should be producing bacterially sterile water are or are not working.

The presence test is also significantly less expensive and less complicated than a quantitative fecal coliform test. A quantitative test for fecal coliform, although ultimately more useful than the presence test, is considered to be not appropriate for Curimaná given the technical and economic resources available there.

Table A-5.4 List of equipment and materials – Fecal Coliform Presence Test. (Test is Done by District RECO-MAP)

MATERIALS/EQUIPMENT	AVAILABILITY
Sterile bottle to take sample—need at least 100ml.	LOCALLY (bottle and tape) – bottle must be cleaned with chlorine cleaning solution and then thoroughly rinsed with sample water 3 times before filling with sample.
Instructions on sampling, transport, and handling protocol.	Protocol from HIP/MSH.
Container to keep sample cool—below air temperature.	LOCALLY available.
Vehicle to transport sample from community to district.	LOCALLY available, coordination necessary.
Instructions on results reporting protocol.	From MSH/HIP.
Fecal Bacteria Presence Testing Kit	Test done at District; kit is NOT LOCALLY AVAILABLE.
Notebook, masking tape, and pen.	LOCALLY

Collecting Sample – Fecal Coliform Presence Test

(To be completed by Local RECO-MAP representative.)

One hundred milliliters (100 ml) of sample must be collected. Because this is a presence test, it is critical that the bottle used to collect and store and transport the sample be both free of bacterial contamination and free of any chlorine. (One little bacteria in the sample bottle or collection vessel can ruin the test!) This is insured by first rinsing the interior of the sample bottle with a dilute chlorine solution (use the chlorine cleaning solution prepared for disinfection of HH water containers about 40ppm chlorine).

- Add enough cleaning solution to the bottle to be able to shake it and thoroughly coat the interior sides of the sample container with the 40ppm chlorine solution.
- Shake for 20 seconds and dump.
- Rinse the container three times with drinking water—either chlorinated or bottled from store.
- Allow the bottle to dry or if not possible cap immediately.
- Make sure the cap has been disinfected as well and do not touch the inside of the cap or the bottle with anything—especially fingers. If the cap is dropped on the ground it must be rinsed with chlorinated water.
- Any water collecting vessel that must be used to collect the water from the source must also be disinfected in the same way and care taken to not contaminate it prior to use. It must be re-cleaned before using it to collect a different sample.

Collect the sample by pouring water into it using the disinfected sample vessel or by pouring directly from the storage container into the sample vessel. Do not jam the sample vessel into the water source to fill it!

- Fill the sample bottle ¼ with sample water and shake and rinse, discarding the rinse water away from the water source. Rinse the sample bottle in this way with the sample water three times.
- Fill the sample bottle to the top leaving no space for air.

As for all samples, the bottle must be labeled with tape. On this label must be noted the following information:

- A sample number—if there are multiple samples being taken;
- Sample location and source description;
- Time and date of sample collection;
- Time and date of chlorine dosage; and
- Weather (rain, clouds, sun) and air temperature (hot, warm, cool) at time of sampling.

This information that appears on the label must be recorded in the RECO-MAP water quality notebook as soon as possible.

Handling and Transporting Sample – Fecal Coliform Presence Test

Because this is a presence test, there is not the same urgency to immediately test the sample. Nevertheless, testing must take place within 24 hours after sampling, preferably within six hours. Given that samples will be collected in rural communities and that the testing will take place in the municipal seat, it is critical that handling, transport, and testing be well coordinated. A Local RECO-MAP representative must collect samples in the sample bottles, arrange for transport to the municipal seat, and ensure that the samples will indeed be analyzed immediately upon arrival.

- The RECO-MAP representative will coordinate a date and time for sample transport to the municipal seat.
- Based on the availability of the transport, the RECO-MAP representative will coordinate with the district testing entity the time of arrival and time of testing of the sample(s).
- The RECO-MAP representative will then arrange with the local HH or community representatives the timing of the sample collection.
- It is recommended that the RECO-MAP representative collect the water samples in situ. The RECO-MAP representative will collect the sample, noting the exact time of collection, the recommended time of testing (collection + 6 hours) on the label of the sample bottle.
- The sample bottle(s) shall be place in a cooler with ice and transported immediately to the municipal seat for testing. (Transportation will be opportunistically arranged). The cooler should be kept in a shady, cool place in the vehicle to the extent possible.
- The transporter shall endeavor to travel as quickly as possible to the municipal seat and deliver the sample to the testers immediately upon arrival.
- The testers, given the simplicity of the test should be able to initiate the analysis with very little difficulty upon reception of the sample.

Analyzing Sample – Fecal Coliform Presence Test

The Colilert analysis for fecal coliforms will cost about US$5.00 per sample. It is exceedingly simple to use, but does require an incubator to maintain a constant temperature for a significant period of time (24 hours—in accordance with test kit instructions).

- Upon receiving the water samples in the municipal seat, the analyst labels the Colilert bottles appropriately, indicating the time and date that the test is initiated and noting in a notebook both the time of sample collection, the time of testing initiation, and the elapsed time between the two.

- The analyst turns on the incubator and sets it at the appropriate temperature in accordance with test kit instructions.
- The analyst adds the appropriate amount of Colilert "reagents" and mixes in accordance with test kit instructions.
- The analyst places the test bottles into the incubator in accordance with test kit instructions.
- After the appropriate incubation time passes, in accordance with test kit instructions, the analyst removes the Colilert bottles and interprets the results—color change equals fecal coliform presence (in accordance with test kit instructions).

Recording Results – Fecal Coliform Presence Test

The presence and no presence result is noted in a notebook along with all other pertinent data about the sample—in particular, time elapsed between collection and testing. Also important are data on the sample origin, weather at time of collection, etc. These will be important in interpreting the results of the Colilert fecal coliform presence test.

Interpreting and Reporting Results – Fecal Coliform Presence Test

The District RECO-MAP representative along with the analyst will interpret the results of the test for the particular sample taking into account time elapsed between sampling and analysis, the origin of the sample, the conditions during sampling, etc. A summary interpretative conclusion will be prepared for each sample (e.g., Household water sample was tested at nine hours after sample taken; positive presence test confirms contamination of water in HH storage container. Conclude that HH storage, handling, cleaning procedures are not sufficient to keep water potable.)

- The findings and interpretative conclusions must be recorded into District RECO-MAP notebooks immediately.
- The District RECO-MAP must communicate the results and interpretations as soon as possible to the Local RECO-MAP representative. This can be done through various means, such as, Local RECO – MAP representative visits District RECO-MAP and reads notebooks.
- Telephone or radio communication.
- Written message sent to Local RECO-MAP via opportunistic transport (rural transport or vehicle operators should be able to visit the district RECO-MAP as part of their normal operations).

The Local RECO-MAP must in turn communicate the results and interpretative conclusions to the household and help/counsel the household in taking appropriate actions.

RECO-MAP Follow-Up Actions – Fecal Coliform Presence Test

The results of presence test provides a district and Local RECO-MAP with important information that can be used to inform choices and actions for water quality improvement.

- At the community-level the Local RECO-MAP will inform the HH immediately of the results and conclusions of the fecal coliform presence test and help the HH in taking any actions to address contamination.
- The Local and District RECO-MAP must analyze these data to help identify water quality problems and water quality solutions for the population.

- The RECO-MAP must also use the results of these tests to raise general awareness of water quality problems and their solutions through IEC interventions.
- Results of fecal coliform presence tests of water from community SAPs are of particular interest to the operators of community water systems, and the RECO-MAP must ensure that water committees are informed of water quality problems and linked to the resources that can provide solutions (e.g. district water committee, district engineer).

A-5.1.4 pH test – Performed by Local RECO-MAP

Summary

A simple pH test will confirm that the ambient pH is such that pH will not adversely impact the effectiveness of chlorination. pH was not found to be a problem in Curimaná, that is the pH of the waters was in the range for optimal effectiveness of chlorine as a disinfecting agent, typically regarded to be between 6 and 8.5.

List of Equipment and Materials

- pH testing strips that change color in accordance with pH.
- Color key to match strip color and determine pH. (Color key must be stored in darkness, out of the sun, so as not to bleach.)

Collecting Sample

- Sample is collected from source using a clean sample bottle or cup. Note that only a few drops of sample are needed for the test.

Handling and Transporting Sample

- Handling and transportation of samples should be avoided if possible. It is best to analyze for pH on the spot.
- Samples should be in bottles filled completely with no air.
- Samples should be kept as cool as possible during transportation.

Analyzing Sample

- The pH strip (paper) is held while several drops of sample water are applied to half of the paper, saturating the paper, but not “washing” it.
- The paper will change color within 30 seconds.
- The color of the exposed paper is compared to the color chart.
- A pH value is read from the color on the color chart that is closest to the color of the wetted pH paper.

Recording Results

- pH results and the time and date of the analysis are recorded in record book along with all other data on that particular sample: location, sampling time and date, and the results of other water quality analysis.

Interpreting and Reporting Results

- Since the pH is taken to confirm that a source water can be effectively treated using chlorine, the analyst will identify those waters whose pH fall outside of the 6 to 8.5 ph range. Note that the higher pH (>8.5) is of greater concern than the lower pH (<6).

RECO-MAP Follow-Up Actions

- If pH value is of concern to a POU chlorination program, the sample should be re-tested. If the pH is confirmed to be outside of the optimal range, the RECO-MAP should test other nearby sources to investigate the possibility of a more widespread problem.
- If the pH is greater than 8.5, higher chlorine dosages are required for effective disinfection. Another option is to use a non-chlorine treatment (SODIS, boiling). A specialist must be consulted to address issues of proper chlorine dosage for waters with pH greater than 8.5.

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