Phase One - Report

Developing Regional Water Surveillance in Health Region XIII - Peru -

Submitted by **DelAgua**
c/o CEPIS/PAHO/WHO
Casilla Postal, 4337 Lima, 100

Compiled by

B.Lloyd, M.Pardon

K.Wedgwood, J.Bartram

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Abstract Summary

1) The regional programme of water surveillance in Peru is to be implemented in 4 phases; this report is an appraisal of the Phase 1 preplan and preparation for Phase 2.

2) Phase 1 included a preliminary training course and a preplan study of water quality carried out by laboratory technicians from the Ministry of Health working in the Hospital Areas of Huancayo, Jauja and Tarma.This work was begun in July 1984 and continued through to March 1985.

3) The results of the preplan study provided a clear indication of the health risks associated with rural water supplies.
Between eighty two and eighty nine percent of the 60 systems in study were shown to be fecally contaminated. It was clearly demonstrated that the communities at greatest risk were those with no option other than surface water sources since their systems were routinely grossly contaminated. Where treatment systems exist these have failed to reduce contamination of the supply and present the most urgent priority for rehabilitation. A collaborative pilot programme for treatment plant rehabilitation has already been begun and will form the basis of a separate report. It is essential that the plants are redesigned and the plant operators are trained in routine maintenance procedures.

4) The preplan study demonstrated the appropriateness of the analytical methods developed for routine surveillance but highlighted deficiencies in the preliminary training and the need for coordinated teamwork in each health area. In particular it showed the need for involving sanitary technicians in sanitary inspection which was deficient throughout the preplan.

5) As a result of the preplan and subsequent experience, the WHO Vol III water surveillance sanitary inspection reports were radically revised. The revised reports were then evaluated in a sample diagnostic study of a further 40 systems during the period October- December 1985. The results of the diagnostic study confirmed the water quality findings of the preplan, but more importantly it served to demonstrate how to clearly identify all the common faults in systems in order to develop action plans for remedial work.

6) It was concluded that under the conditions prevailing in Peru it is essential to incorporate two stages in developing water surveillance strategy. The first is diagnostic, involving a detailed sanitary investigation of all water supplies in order to formulate a programme of improvement and rehabilitation. The second is routine surveillance, to which a supply may only be admitted when the system has been improved to a minimum level as judged by service level including both quality and continuity criteria.

7) The lessons learned from the preplan and diagnostic have been incorporated into the regional training programme plans for January 1986.

BL '86

Peruvian pilot programme for surveillance and improvement of water supplies in the XIIIth health region JUNIN/HUANCAVELICA.

1 PROGRAMME OBJECTIVES

The aims and objectives of the programme have been set out in the Terms of Reference of a bilateral aid agreement between Her Majesty's Government of the U.K. and the Government of Peru, as follows:

"....to enable the Peruvian Ministry of Health,Division of the Environment <DIGEMA> to initiate the following activities aimed at compliance with existing water quality legislation:
a. Formulate and revise technical standards for the surveillance and control of drinking water quality.
b. Train and evaluate the work of sanitary and laboratory technicians involved in water surveillance.
c. Promote and develop water quality control at the operator level in the Health Areas.
d.Promote and secure the implementation of water surveillance laboratories.
e. Promote and develop water quality data reporting at regional and national level.
f. Develop regional engineering infrastructure in order to initiate rehabilitation and maintenance of water supply systems in response to reported data."

1.1 Modifications

It is important to note that although the Programme Objectives are agreed the detailed Terms of Reference may be modified as a result of infrastructural changes in the Ministry of Health which are proceeding at the time of preparation of this report.
The Ministry is undergoing a radical reorganisation aimed at decentralisation of administration to the Hospital Areas.In 1986 the 16 Health Regions will cease to represent groups of Hospital Areas and will be replaced by 56 Health Areas. The health areas will correspond closely to the previous hospital areas but will have direct access through area delegates to the office of the Vice Minister of Health.
These changes, which have yet to be realised, have contributed to delays in implementing the pilot phase of this programme. Regional committees for reorganisation were established in the last quarter of 1985 and new health area delegates were to be designated from 1st January 1986.
Additional changes affecting this programme involve a redefinition of the role of DIGEMA and the Division of Rural Sanitation <DISAR>.The latter is to become the Office of Basic Rural Sanitation <OSBR>, and is to assume more administrative than executive functions.This is likely to involve the transfer of a majority of its engineering staff from Lima to the health areas, the possible loss of its laboratory facilities and the eventual transfer of OSBR central staff to the main building of the Ministry.

2.BACKGROUND & INTRODUCTION

The legal, political and administrative basis of the programme derives from Peruvian Water Legislation (Ley de Aguas, 13997, Codigo Sanitaria D.L.17405 and Codigo Sanitario de Alimentos D.L. 102/03).These laws set out the needs for protecting drinking water sources, disinfection and treatment of supplies and water sampling.
The present project is attempting to fulfill the spirit of the law by bringing into effect the **Guidelines for Drinking Water Quality** published by **WHO** and with particular reference to **Vol.III** for rural supplies.

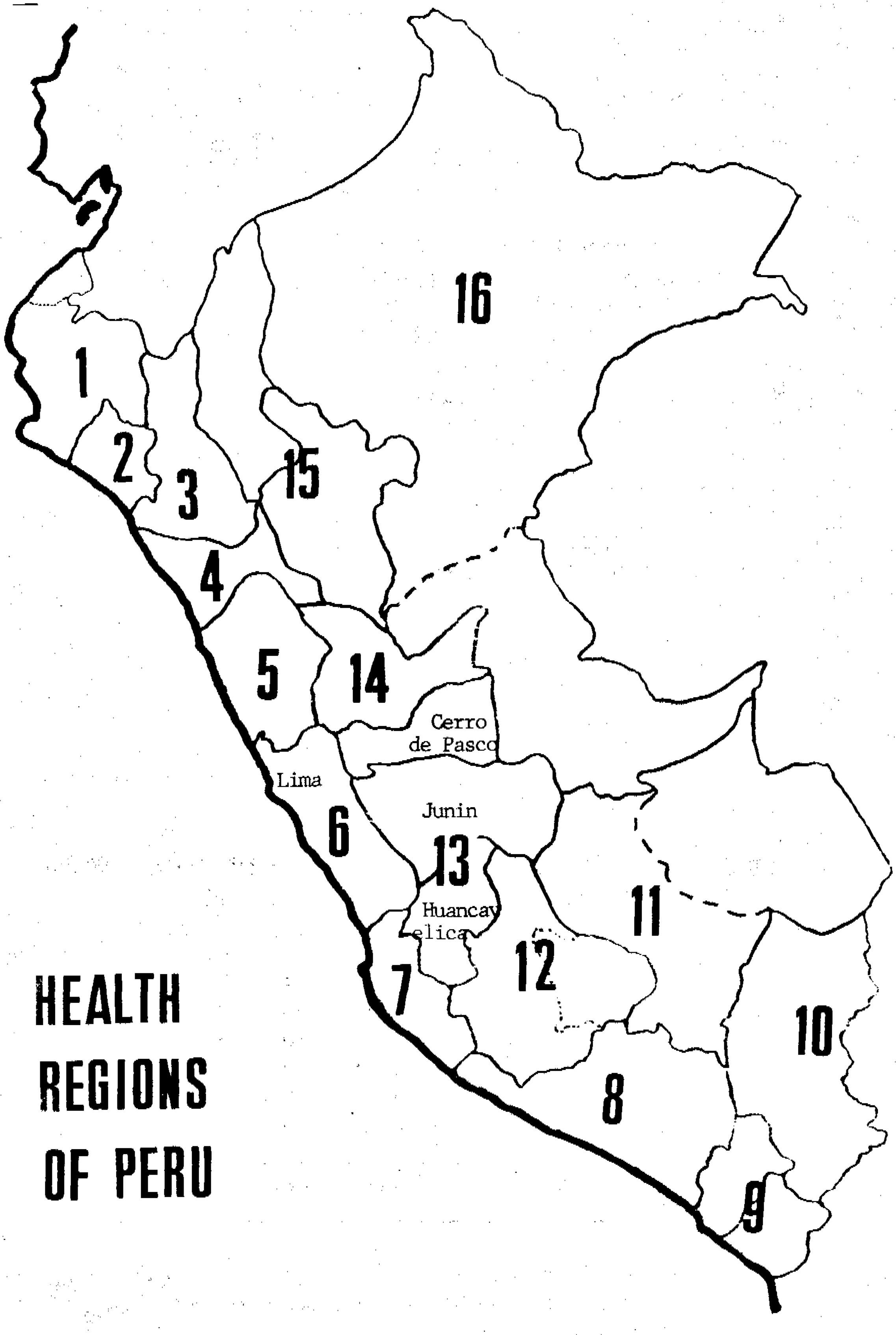
A pre-plan project was initiated by the Division for the Environment of the Ministry of Health in mid-1984 with administrative support from the Division of Basic Rural Sanitation. The DelAgua group, based at CEPIS, was invited to organise training and supply water testing equipment and consumables for a water surveillance course for public health laboratory tecnicians in the Hospital Carrion in the main town of Junin , Huancayo.The pre-plan training course was executed in July 1984 and followed by test surveillance activities limited to 60 villages.

2.1 Location and geographical features of the pilot project area.

The XIIIth health region includes the departments of Junin and Huancavelica.They occupy a central position in Peru in the Andean highlands; bounded on the north by the department of Huanuco, to the south by Ayacucho, to the south-east by Cuzco, to the north-east by Loreto and to the west by Lima and Ica.

The area of the XIIIth region is 70,487 square km and includes 12 provinces in Junin and Huancavelica plus Oxapampa which is part of the department of Pasco.

The region comprises both high sierra and high jungle. By far the highest proportion of the population, greater than 75%, is located in and around a single fertile valley, the Mantaro valley, in the high sierra at about 3,000 to 4,000m above sea level.The Mantaro river together with the rivers Ene, Perene and Palcazu form important head waters for the Amazon. The Mantaro is already included in the GEMS/WATER programme and it was logical to extend monitoring to include the area as a Health Exposure Assessment Location (HEAL).This was readily justifiable in view of the grossly contaminated nature of the Mantaro deriving from the complex of mines in the Oroya and Morococha areas as well as the sewage pollution from the town of Oroya.



HEALTH
REGIONS
OF PERU

2.2 Health Region Population & Administration.

Until the 31st December 1985 the Health Region was administered from the regional capital Huancayo and was responsible for six hospital areas.

Table 1. **The hospital areas**

No.	Name	Population (total).	Rural population*
47	Huancavelica	181,600	22,907
48	Huancayo	549,062	127,523
49	Jauja	189,805	61,950
50	Tarma	119,563	36,593
51	La Merced	280,688	17,441
52	Junin	31,677	5,841
Totals		1,352,395	272,255

*Population centres of <2000 inhabitants.

2.3 Existing rural water supply schemes.

At the time of writing there were 235 piped rural water supply systems spread through 189 districts.These have all been built in the last 25 years, largely under the auspices of a National Plan for Rural Water Supply (PNAPR), administered and executed by the Rural Sanitation Division (DISAR) of the Ministry of Health.

Table 2 **Rural water supplies in the XIIIth health region** (1962-84)

Health area No.	Population served	Coverage (%)	Type of system GST	GCT	BST	Total/area
47	14,439	63.03	14	3	0	17
48	65,665	51.49	83	10	7	100
49	34,716	56.04	50	3	1	54
50	19,303	52.75	28	6	1	34
51	11,208	64.26	15	6	0	21
52	2,869	49.1	4	0	0	4
Totals	148,200	54.4	194	28	9	231

Key: GST=Gravity without treatment.
GCT=Gravity with treatment(sedimentation/filtration)
BST=Pumped without treatment.

3 PROGRAMME IMPLEMENTATION.

Chronological outline

Phase	Date	DelAgua Activities
1. Pre plan	1-6-84	Submit funding proposal to ODA,London and copy to WHO,Geneva.
	6-6-84	Preliminary visit to Health Region to plan training course and pre-plan surveillance in 40 communities in Huancayo, 10 in Tarma and 10 in Jauja.
Phase 1	16-7-84	Execute pre-plan training course in sanitary inspection and water analysis in Hospital Carrion, Huancayo for hospital laboratory technicians and chiefs from hospital areas of Huancayo, Tarma and Jauja.
	1-8-84	Initiate preplan surveillance in 60 selected communities and continue to March'85 using DelAgua prototype testing equipment.
	1-10-84 1-11-84	Revise testing equipment design in UK and transfer production model to CEPIS for field testing in Peru.
	1-12-84	Submit programme terms of reference to ODA/London and British Embassy, Lima for transfer to Ministry of Health, Peru.
Preassignment	20-3-85	Planning meetings with DIGEMA, DISAR and WHO/PAHO representatives in Lima.
	26-3-85	Sign pilot programme agreement with Health Region directorate in Huancayo.
	4-4-85	Transfer ODA terms of reference to DISAR from British Embassy for discussion.Prepare Preliminary Consultancy Report for Ministry of Health and copies to ODA.
	27-6-85	Agree terms of reference with DIGEMA and DISAR, obtain ministerial approval and transfer documents to Instituto Nacional de Planificacion.

Phase	Date	DelAgua Activities
2.Pilot Programme		
Preassignment		
	2-7-85	Visit Huancayo and prepare Landroverspares lists for rehabilitation of Ministry of Health vehicles for pilot programme.
	24-7-85	Visit ODA, London to agree terms of engagement and seek approval to commence purchasing of equipment.
	25-7 to 20-8-85	Order and pack first consignment of pilot programme's equipment.
	21-8-85	Despatch equipment to Callao, Peru.
Phase 2	16-9-85	**Review of preplan data** and prepare for diagnostic study in Junin.
	20-10-85	Commence **diagnostic study** of water supply systems in Junin.
	10-11 to 16-11-85	Visit Ministry of Health, Costa Rica on behalf of CEPIS to advise on water surveillance development (Separate report).
	20-11-85	Clear freighted equipment from Callao.
	25-11 to 29-11-85	Organise and run Peruvian first pilot water **surveillance training course** for staff of Ministry of Health at CEPIS. Coordination with **UNICEF**.
	1-11-85 to 30-12-85	Participate in the production of Audiovisual training material for Juntas Administradoras (Operation, maintenance & administration of treatment systems)Programme of CARE et al.
	2-12-85	Commence **pilot rehabilitation programme** of water treatment system at Cocharcas in Huancayo. Coordination with **CARE**.
	15-12 to 20-12-85	Participate in Ministry of Health (DISAR Rural Sanitation Workshop and Seminar)- Review of national water supply construction programme for the year 1985.
	1-1-86	Prepare review of preplan data and diagnostic study; **(this report)**

4.PREPLAN REVIEW.

4.1 Communities and systems under study

Sixty communities were selected for the preplan water surveillance activities in the Hospital Areas of Huancayo, Jauja and Tarma. The only criteria for inclusion in the preplan were that the selected villages should have an organised piped water supply system registered under the National Plan for Rural Water Supply, and that the survey should include examples of the three principle types of system installed by the Rural Sanitation Division of the Ministry of Health. Since no special funds were available for the preplan the survey villages were mainly those which were more readily accessible from each of the Hospitals Areas listed. Additional community water supplies, including several urban systems, were included in the preplan but have been excluded from this report.

Table 3. **Water supply systems surveyed in the preplan**

Hospital Area	Type of System			Total
	GST	GCT	BST	
48.Huancayo	30	6	4	40
49.Jauja	9	0	1	10
50.Tarma	7	2	1	10
Totals	46	8	6	60

Key:GST=Gravity without treatment.
GCT=Gravity with treatment(sedimentation/filtration)
BST=Pumped without treatment.

4.2 Preplan sampling programme.

Recognising the difficulties and costs involved in visiting and testing samples in remote communities it was decided to confine the preplan mainly to villages which were readily accessible by Ministry of Health Landrovers from each of the three supporting hospitals. A chronogram of visits was planned for a 6 month period which would allow all systems to be visited at least twice. This was organised in geographical clusters of 2-4 locations, so that most clusters could be sampled in a one day excursion and the samples returned to the laboratory for analysis on the same day. More remote clusters, requiring a two day excursion, were analysed in the field using portable testing equipment as described in the DelAgua Users Manual.

During each field visit it was intended that, wherever possible, samples be taken from source (captacion) and reservoir as well as domestic taps and/or stand posts representative of different supply zones in the distribution system. For systems including treatment, each stage of treatment was also sampled.

4.3 Preplan analytical methods

The following parameters were included in the survey:
1) Fecal coliform counts performed by the membrane filtration 44ºC incubation technique.
2) Chlorine residual, free and combined tests, by the DPD 1 and DPD 3 visual colorimetric comparator method.
3) Conductivity , by a proprietary electronic meter including.....
4) a separate stainless steel temperature ºC probe.
5) pH, by a proprietary electronic meter.
6) Organoleptic characteristics by means of sensory tests and visual inspection.

4.4 Results

The water quality results reported here have been reduced to a resume of chlorine residual data and fecal coliform results in line with WHO Volume III Guidelines.

Chlorine residual data. It may be noted that although several villages claim to disinfect their supplies at the reservoir prior to distribution, **NO CHLORINE, FREE OR COMBINED, WAS DETECTED AT ANY TIME IN ANY OF THE SYSTEMS SAMPLED.** This is a major deficiency and requires a reappraisal of the policy of the Ministry of Health and the deficiencies in the pot chlorinator technology which is widely recommended. Hypochlorite disinfection will be the subject of a separate investigation and a subsequent DelAgua report in collaboration with the Ministry of Health.

Fecal Coliform data. The preplan (and subsequent pilot programme) has reduced the bacteriological analysis of water to the use of the membrane fecal coliform test. No apology is made for this since it is the logical extension of the WHO guidelines advice and conforms to the axiom enunciated in the current (1982) and earlier editions of Report Nº 71 HMSO UK on The Bacteriological Examination of Water Supplies, that............

"It is far more important to examine a supply frequently by a simple test than occasionally by a more complicated series of tests"

The membrane fecal coliform test provides the simplest, most rapid, reliable and sensitive test currently available. Furthermore in the type of unchlorinated systems which are encountered in many rural areas of the world it is clear (from the results of other surveys and those presented here) that fecal coliform contamination of the supply is almost inevitable and therefore readily detected on a routine basis. What is more difficult is the interpretation of the sanitary significance of the intensity and frequency of contamination of the supply i.e, risk analysis; and consequently what action should be taken as a result of findings.

7a TABLE 4. BACTERIOLOGICAL QUALITY OF WATER IN PREPLAN STUDY AREA-HUANCAYO PERU

Codigo Area/ 48.local.	Localidad	Tipo de Sistema	NIVEL DE COLIFECAL/100 ml Capta- -cion	Reser- -vorio	Conexiones domiciliaria	Mes de Muestra	Grupo Calidad Agua
48.01	Conchangara	GST	Sellada	0	0,0,0	Agost	A
			"	1	1,	Oct	B
48.01	Huarisca Grande	GST	1	1	0,0	Agost	B
			0	0	0,3	Oct	B
48.12	Vista Alegre	GST	0	0	0,0	Set	A
			0	0	0,0	Nov	A
48.15	Llampsillon	GST	0	0	0,0	Set	A
			0	0	0,0	Nov	A
48.16	Pumpunya	GST	Sellada	392	0,0	Agost	D
			"	0	0,0	Nov	A
48.18	Cochas Chico	GST	0	_	0,0	Agost	A
			0	0	0,0	Oct	A
48.22	Huayao	GCT	10,20	2	0,0,26	Oct	C
	Sedimentador/Filtros		134	3	9,3	Nov	B
48.33	Ingenio	GST	0	0	1,0	Agost	B
			_	0	1,5,8	Oct	B
48.35	Pilcomayo	BST	0	Usan	0,0	Agost	A
			0	BY-PASS	13,0 ,0	Oct	C
48.36	Asca	GST	5	4	2,5	Oct	B
			_	0	0,0	Nov	A
48.37	Pucara	GST	0	0	0,0	Set	A
			0	0	0,2	Nov	B
48.38	Marcavalle	GST		0	0,0	Set	A
			0	_	0,0	Nov	A
48.39	Quichuay	GST	0	1	0,0	Agost	B
			_	1	1,0,0	Oct	B
48.40.	Colpar	GST	0	0	0,0	Set	A
			_	0	0,0,0	Oct	A
48.41	Quilcas	GST	0	0	0,0	Agost	A
			0	0	0,0	Oct	A
[illegible].42	Rangra	GST	3	1	8,1	Set	B
			0	0	0,0	Oct	A
48.50.	San Pedro de Saño	GST	Sellada	0	0,0	Agost	A
			"	50	180,1530,100,	Oct	D
48.73	Alata	GST	0	0	0,0	Agost	A
			0	0	0,0	Oct	A
48.90.	Huanchar	GST	Sellada	0	0,0,	Agost	A
			"	0	0,0,1	Oct	B

CLASIFICACION:Tipo de Sistema	Ranga de contaminacion/reservorio y red	
GST=Gravedad sin tratamiento	A= Coli fecal 0/100ml	C=Coli fecal 11-50
BST=Bombeo sin tratamiento	B=Coli fecal 1-10/100ml	D=Coli fecal >50
GCT=Gravedad + tratamiento		

7b TABLE 5. BACTERIOLOGICAL QUALITY OF WATER IN PREPLAN STUDY AREA-HUANCAYO PERU

Codigo Area/ 48.local	Localidad	Tipo de Sistema	NIVEL DE COLIFECAL/100ml Capta- -cion	Reser- -vorio	Conexiones domiciliaria	Mes de Muestra	Grupo Calidad Agua
48.08	Huacan	BST	54	38	32,	Agost	C
	Bombeo malogrado			0	6,8,	Nov	B
48.10.	Chicche	GST	2	0	0,510,	Set	D
				0	0,0	Nov	A
48.13	Yana Yana	GST	_	112	100,	Set	D
				0	0,0	Nov	A
48.14	Chongos Alto	GST	0	4	44,14	Set	C
			0	0	0,0	Nov	A
48.17	Chupuro	GST	Sellada		13,1	Agost	C
				2	16,	Nov	C
48.19	Paccha	GST	1	5	6,24	Agost	C
			7	18	8,	Oct	C
48.25	Hualhas	GCT	404,	469,	289,239,251	Agost	D
	Sedimentador/Filtros		2100,	1800,	900,	Nov	D
48.28	Palian	GCT	2400,	2200,	1600,600,40	Agost	D
	Sedimentador/Filtros		810,	670,	567,259,163	Nov	D
48.29	Chacapampa	GST	64,	0	24,30,	Set	C
			1,	0	_	Nov	A
48.30.	Uñas	GST	_	_	9,9,0,12,	Agost	C
				31,	30,20,	Oct	C
48.44	Sn.Agustin de Cajas	GCT	35,	162,	17,16	Set	D
	Sedimentador/Filtros		4100,	4800,	4500,3900,	Oct	D
48.45	Sn.Juan de Izcos	GST	8	17,	24,13	Agost	C
			0	76,	42,84	Oct	D
48.50.	Sn.Pedro de Saños	GST	Sellada	0,	0,0	Agost	A
				50,	180,1530,10	Oct	D
48.68	Chambara	GST	0	179,	1300,890,	Agost	D
			7	12,	36,5	Oct	C
48.79	Mito	GST	108,	222,	321,316,	Set	D
			71,	195,	191,190,	Nov	D
48.82	Vicso	GST	_	19,	18,25	Set	C
			0	8,	13,1	Nov	C
48.83	Chaquicocha	GCT	99,	24,	42,44	Agost	D
	Sedimentador/Filtros		82,	1940,	_ _	Oct	D
48.84	Sn.Jose de Quero	GCT	4,10	3	4,8	Nov	B
	Sedimentador/Filtros		144,	69,12	31,	Oct	D
48.85	Usibamba	GST	7	6	5,3,	Agost	B
			81,	101,	89,3,	Oct	D
48.89	Sta.Rosa de Ocopa	GST	Sellada	34,	100,950,53,	Agost	D
				37,	97, 85,80,	Oct	D

CLASIFICACION:Tipo de sistema	Ranga de contaminacion/reservorio y red	
GST=Gravedad sin tratamiento	A=Coli fecal 0/100 ml	
BST=Bombeo sin tratamiento	B=Coli fecal 1-10/100 ml	
GCT=Gravedad + tratamiento	C=Coli fecal 11-50/100ml	D=Coli fecal>50/100ml

7c

TABLE 6 BACTERIOLOGICAL QUALITY OF WATER IN PREPLAN STUDY AREA-HUANCAYO PERU

Codigo Area/ /local	Localidad	Tipo de Sistema	NIVEL DE COLIFECAL/100ml Capta- -cion	Reser- -vorio	Conexiones domiciliaria	Mes de Muestra	Grupo Calidad Agua
JAUJA							
49.04	Yanamarca	GST	38,	14,	3,0	Nov	C
49.05	Apata	GST	0,	0,	0,	Nov	A
49.11	Acaya	GST	0,	0,	10,		C
49.12	Curicaca	GST	0,	0,	1,0	Oct	B
			10,	8,	98,90	Nov	D
49.15	Jisse	GST	0,	0,	0,0	Nov	A
49.19	Llocllapampa	GST	0,	132,	40,32		D
			0,	140,	86,30	Nov	D
49.29	Paccha	GST	_	2,	1,2		B
			_	0,	0,0,0	Nov	A
49.32	Paca	GST	0,	0,	0,0	Nov	A
49.37	Parco	GST Sis1	_	5,	4,		B
		Sis2	4,	56,36	12,4	Nov	D
49.51	Huancas	BST	0,	0,	0,0	Nov	A
TARMA							
50.01	Chipocayo	GST	3,	3,	0,4,1	Set	B
			0,	0,	4,4	Oct	B
50.04	Picoy	GCT	1245,	92,	33,5	Set	D
	(Sedimentador+filtros)		1800,	203,	174,196	Oct	D
50.07	Ruraymarca	GST	Sellada	245,	24,	Set	D
				113,	227,280,220	Oct	D
50.08	Vilcabamba	GST	6,	6,	5,5,3	Set	B
Common source					6,4,2,6	Oct	B
50.08	Morocancha	GST	6,	6,	6,9,9	Set	B
			8,	2,	8,4	Oct	B
50.18	Llacsacaca	GST	0,	4,	0,1	Set	B
			0,	4,	1,35,	Oct	C
50.26	Cochas	GST	1,	2,	0,0	Set	B
			2,	2,	0,1	Oct	B
50.30.	Pomachaca	BST	2,	2,	4,3	Set	B
			16,	6,	12,6	Oct	C
50.32	Sacsamarca	GCT	390,	400,	700,340,	Set	D
	Sedimentador/Filtros		275,	700,	100,	Dec	D
50.36	Muylo	GST	4,	0,	0,28	Set	C
			4,	4,	2,3	Oct	B
	GST=Gravedad sin tratamiento			A=Coli fecal 0/100 ml (Reservorio y red)			
	BST=Bombeo sin tratamiento			B=Coli fecal 1-10/100ml			
	GCT=Gravedad + tratamiento			C=Coli fecal 11-50/100ml D=>50/100ml			

4.5 Interpretation of Fecal coliform results.

Of those systems where two sampling visits were possible during the preplan, only 7 of the 60 systems (11 per cent of the total) conformed to WHO guidelines acceptability for the more strigent fecal coliform count of zero per 100ml sample in all samples. All of these were spring water sources classified as gravity without treatment (GST). An additional 4 springwater supplies, visited only once, were also free from fecal coliform contamination. Thus 11 of 60, or <18 per cent of systems conform to WHO guidelines for potability and were subsequently classed as group **A**

Only bacteriological quality is at present under consideration and at this stage no account is taken of service level, including continuity of the supply. However at the start of the decade an international assessment report summarised the level of access to both safe water and supply services in the rural sector. **Peru was categorised in the 21-40 per cent range** for safe water and supply service level. However it was indicated in section **2.3** of this report that 54.4 per cent of the rural population of the health region enjoyed organised water supply services, and our sample suggests that only 18 per cent of the 54.4 per cent **i.e, less than 10 per cent of the total receive fecal coliform free water.** Thus if the WHO guidelines for bacteriological safety are accepted, using the more conservative fecal coliform test, and if the sample quoted is representative then clearly the 1980 categorisation for Peru was over optimistic.

It is important to bear this concept in mind when we attempt to assess the significance of contamination in the remaining **82 per cent of preplan systems which have been demonstrated to be either sporadically or uniformly exposed to fecal contamination.**

It was therefore considered useful to attempt to categorise the bacteriological quality of water from each supply system. In order to do this the range of contamination in a single reservoir and the corresponding distribution system was classified (A-D) for ready comparison with subsequent visits and other systems in study .

4.5.1 Classification:

Group	Range of fecal coliform contamination in service reservoir and distributed supply
A=	**0**/100ml in all samples on one sampling visit i.e, conforms to WHO bacteriological guidelines
B=	**1-10**/100ml in all or any samples on one sampling visit i.e, low level, often sporadic, contamination
C=	**11-50**/100ml in all or any samples on one sampling visit i.e, medium level with significant waterborne disease risk
D=	**>50**/100ml in all or any samples on one sampling visit i.e, grossly contaminated with high waterborne disease risk

The principal objectives in developing a drinking water supply classification system are as follows:

i) to simplify the monitoring of the improvement (or deterioration) of individual systems with time, in order .....

ii) to allow water supply management and health authorities to identify communities at risk from waterborne disease;

iii) to permit water & health authorities to formulate medium term regional and national water quality goals;

iv) to provide the evidence necessary for the planning and execution of programmes for strategic development and rehabilitation of water supplies throughout a region.

In order to examine the reliability of the proposed classification we have applied the classification to all the available data in the preplan as shown in Tables 4,5 & 6. An ideal system evaluation would be one developed from unlimited amounts of data but the cost of sampling is prohibitive and we have had to rely thus far on a maximum of 2 sampling occasions for each system. Category bands A to D have therefore been ascribed to each water supply for each sampling occasion. Thus the category defines the water quality in the reservoir and distribution as though it were a single component. For practical purposes this is valid for the preplan study because the supplies under consideration have small distribution systems equivalent to little more than a single supply zone of a large urban system.

If the category bands for 2 or more sampling occasions are compared the robustness of the classification scheme can be assessed. What one might hope to find is that a system classified as A grade is repeatedly A grade (A A on two sampling occasions), and that a grossly contaminated system (D grade) is repeatedly D D D etc,.

It was therefore gratifying to plot a frequency matrix for all 9 possible combinations of grades and find a majority of systems (28/53) exhibiting homogeneity in grading on successive sampling occasions.

Frequency matrix of 53 preplan systems classifed by water quality group (A-D) on two sampling occasions.

Most homogeneous	**AA**	**BB**	**CC**	**DD**		**Nº (%)**
	7	7	4	10	=	28 (53)
	AB	**BC**	**CD**			
	6	5	2		=	13 (25)
	AC	**BD**				
	3	4			=	7 (13)
Least homogeneous	**AD**					
	5				=	5 (9)
Nº of systems	21 +	16 +	6 +	10	=	53 (100)

The second most common category of water quality was at the second level of homogeneity (AB, BC, CD), containing 13/53 systems.Together the top two levels of homogeneity made up 78% of the classification.

It is noteworthy that the preplan survey was conducted prior to the main rainy season in the Sierra . Increased heterogeneity, and generally higher contamination, might have been expected had the survey overlapped with the rains.

4.5.2 Relationship between gross contamination and type of system.

Sedimentation/Slow sand filtration systems (GCT).
The most worrying and obvious conclusion to be drawn from the preplan data sheets is **the total failure of treatment systems** constructed under the National Plan for Rural Water Supply. Not one of the systems in study operated effectively .This confirms the independent findings of DelAgua in similar systems in the department of Lima , evaluated in 1983/84 under an ODA sponsored research scheme (R3760). Of the 10 Junin preplan supplies classified as uniformly grossly contaminated (DD), six were treatment systems. The remaining two treatment systems supplied water classed as BD and BC. Thus all the treatment systems in the preplan survey supply contaminated water to the distribution system, and **6 of the 8 systems in study supply grossly contaminated water (category DD) which carries a continuous high risk of water borne disease.** Clearly **the rehabilitation of these systems should take a high priority** equal to that of the construction of new systems.

Gravity systems without treatment (GST)
Only four out of 46 spring water supplies fell into the most grossly contaminated category (DD) on both sampling occasions. One of these supplies, 48.79 Mito, was contaminated at the source (captacion). Another, 49.19 Llocllapampa, had uncontaminated source water but contaminated reservoir water and the report failed to record an inspection of the conduction pipe between source and reservoir or the state of the reservoir. Thus the origin of the contamination could not be identified. The other two supplies, 50.07 Huraymarca and 48.09 Sta. Rosa de Ocopa, were deficient in source water data because the captacion was sealed or locked.
AD-represents maximum heterogeneity in contamination on separate sampling occasions and hence spasmodic gross contamination. It was not surprising to find that all 5 systems showing this characteristic were the gravity untreated type (GST). It was however disappointing to be unable to identify the source of contamination in 4/5 systems because the source

spring inspection points were sealed and therefore not sampled. The point of contamination of the fifth system (48.10 Chicche) was localised within the distribution system.
These, above mentioned, points highlight both the importance of a detailed sanitary inspection report to complement the water quality report and the need to provide advance notice and contact with the local Junta Administradora of an intended sampling visit in order to gain access to all components of a system .If both are available then it is usually a more straightforward task to organise the repair and improvement of the supply.

Pumped systems wihout treatment (BST)
One would expect most pumped systems to be derived from good quality sources. Unfortunately only 3/6 in study were uncontaminated at source, a fourth was grossly contaminated at source and beset with maintenance problems, and the remaining two had broken down. For the last reason a sampling visit to one system had to be repeated and in another (48.32 Huayucachi) the pump was still out of use 2 months later.
System 48.35 Pilcomayo was of particular interest since it pumps water from infiltration galleries 100-200m from the polluted Mantaro river; its bacteriological source quality was good but its chemical quality requires detailed investigation. This system, as with many pumped systems, provides an intermittent service of several hours per day because the community cannot or will not pay for the cost of pumping. The reservoir, which is normally by-passed in this system, was grossly contaminated with biota, soil and stones.
The problems involved in maintaining pumped community supplies in Peru were examined by Saenz Forero in a CEPIS report (DTIAPA Investigacion Nº 2, 1982). It was noted that 45 per cent of the total of 153 pumped rural systems were faulty or paralyzed in 1980. It was concluded that a regionalised operational infrastructure to provide technical support to rural systems was required, particularly for pumped systems. We would add the rider that since the CEPIS proposals have not been implemented and the majority of pumped rural systems are intermittent and poorly maintained, wherever possible, pumping should be avoided since **the risk of contamination in supply is greatly increased whenever the supply is interrupted.**

5. Infrastructural & training problems relating to surveillance & preservation.

Paradoxically the existing infrastructure in the Peruvian Ministry of Health may produce difficulties with respect to surveillance management and water supply improvement in the rural areas. On one hand the Ministry's environmental division (DIGEMA) is legally responsible for surveillance, and on the other its rural sanitation division (DISAR) is responsible for construction of rural water supply systems. This might be thought to be a comfortable arrangement, but the WHO Guidelines specifically recommend that

"the water supplier and surveillance agency should be separate bodies and independently controlled".

In urban areas of Peru the supplier and surveillance agency are independent but for rural supplies there is a major anomaly. Following commissioning of a rural water supply scheme the system is transferred, for operational purposes, to the community. It is managed by a locally elected administrative committee (junta administradora). However the system remains the property of the state, but the only professional, technical and managerial intervention derives from spasmodic advisory visits by engineering and sanitary staff of the Ministry of Health.

At a local and area level a number of other critical problems relating to surveillance and preservation of systems may be identified.

1) Only one sanitary technician, the chief of preservation, is dedicated full time to the task of water supply inspection and preservation for the entire health region. He has a budgetary allocation for visiting systems but none for community level education/training in system management or for material assistance.

2) Sanitary technicians are generally multi-functionary field workers working in e.gs.,vaccination programmes, vector control, inspection of industrial premises,food sampling and occasionally in water sampling. Thus they are allocated to activities associated with hospitals and health centres and do not usually appear to be available to provide significant practical support to the engineers in supervising water supply preservation.

3) The training of sanitary technicians has been reduced in recent years from 2 years to reportedly as little as 3 months. At present most of their skills are acquired in-service. This is in marked contrast with Costa Rica (with a similar land area to Junin/Huancavelica) which in 1986 has some 195 sanitary inspectors trained for 1 year at University level in all basic aspects of sanitation.

4) The preplan surveillance activities were undertaken primarily by laboratory technicians who are associated (in the minds of engineers) even more closely with hospital work than are the sanitary technicians. The laboratory technicians were able to execute water analysis effectively, but failed to carry out a detailed sanitary inspection of the system. It was evident from several report forms that they had failed to correctly identify the component of the system which they had sampled e.g., slow sand filters were mistaken for reservoirs.

5) The water quality data were reported to the Area and Regional Health Directors and only belatedly to the area engineering staff and not at all to the Juntas Administradoras.

6) The program of surveillance visits was coordinated by a regional public health laboratory chief without the involvement of the chief of preservation and was conceived and perceived primarily as a laboratory exercise.

Some of the errors committed in the preplan have been indicated above and it is worth spelling out the lessons learned clearly so that they are not carried forward to the pilot programme.

6. LESSONS LEARNED.

1) Conventional water surveillance is inappropriate for regions where professional routine operation and maintenance is deficient. Even the minimal level of surveillance, restricted to coliform and chlorine residual monitoring (recommended in WHO monograph Nº 63, 1977 and in the WHO Volume III Guidelines, 1983) has limited value in rural zones in the absence of detailed sanitary inspection reports.

2) Under the conditions prevailing in the preplan zone, where most systems supply fecally contaminated water and are poorly maintained, a **primary diagnostic survey,** involving detailed sanitary inspection and complementary water analysis, is essential in order to develop a regional strategy of priorities for rehabilitation, repair and improvement of supplies.

3) Only those systems which provide a continuous service of reasonable quality water (classified AA or AB) should be admitted to a routine surveillance programme; the remainder should be excluded until they have been improved to this level. The water quality survey may thus be used to formulate medium term water quality objectives but never in isolation from sanitary surveys.

4) Laboratory technicians should not be expected to work individually on surveillance activities. To accomplish a primary diagnostic survey and subsequent surveillance activities requires the dedication of a small professional team involving a coordinator, sanitary technician and laboratory worker in each health area (area hospitalaria).

5) Because of the cost of transport and importance of coordination it is highly desirable that the sanitary inspection and water quality survey should be carried out at the same time. The close coordination between surveillance agency laboratory staff and engineering staff is also essential if subsequent improvements are to be expected.

6) The preplan training was adequate for training hospital laboratory staff in essential analytical techniques but inadequate in duration to be able to provide them with sufficient practical experience in sanitary inspection. A perception of the importance of basic hygiene in general and in laboratory practice in particular is lacking in the health service. This is reflected in a worse than meagre provision of the entire range of hygiene materials including soap, towels, lavatory paper and disinfectants from the health post level upto metropolitan hospital. Subsequent training should therefore give particular attention to sanitary inspection and hygienic practices.

7) The Spanish draft WHO guidelines Volume III were used in the preplan training course. The sanitary inspection report forms in Volume III were too cumbersome and this discouraged their use in the preplan. They require substantial revision for use in Peru.

8) The Volume III guidelines recommend that coliform, fecal coliform, chlorine residual and turbidity are essential parameters. Investigations by DelAgua suggest that **many laboratories in Latin America use methods for bacteriological analysis of coliforms and fecal coliforms which are incorrect, inappropriate and incorrectly interpreted.**
These criticizms apply to the presumptive multiple tube fermentation (MPN determination) for coliforms at 37ºC as practised in a number of metropolitan and regional laboratories in Peru, Costa Rica and Colombia. In particular lactose peptone water is used as the primary isolation medium in the **absence of a selective agent** (e.gs., bile salts or sodium lauryl sulphate).
Since the test should progress through three distinct stages: the Presumptive Test, the Confirmed Test and the Completed Test, the test is frequently not completed (due to lack of resources and/or manpower). The

results which are often reported present precisely the same count for coliforms and E.coli, indicating that the laboratory has not proceeded to check the thermotoleranc of the coliforms. Indeed to do so would present a significant increased workload.
To carry out the MPN procedure fully and correctly requires considerably more resources and manpower than most small and many regional laboratories possess and even then the results are imprecise.
For these reasons we have elected to use the more precise and rapid membrane technology which provides accurate counts of both coliforms and fecal coliforms following overnight incubation.
In the preplan it was demonstrated that these procedures could be further reduced to membrane fecal coliform count without any real loss of useful information, and consequently considerable economy.

9) WHO volume III draft guidelines recommend the determination of turbidity in treatment plant evaluation. However **the guidelines are deficient in recommending a procedure for measuring turbidity.** This is a parameter which DelAgua has recommended as the third most important of all drinking water parameters, after fecal coliform and chlorine residual determination. We propose that **it should be included routinely in all water surveillance,** and have consequently developed and evaluated a simple routine procedure to this end (Refer to the OXFAM -DELAGUA "Users Manual"). This publication describes a strategy and methodology for rural water quality monitoring which will be used in the phase 2 diagnostic and subsequent pilot programme.

10) It was concluded that preparatory to a regional programme of surveillance a **sample diagnostic study** was essential in order to :

a) test out revised sanitary inspection report forms.
b) identify the principal operation and maintenance problems in a representative selection of 40 systems chosen from a wider range of health areas than that used in the preplan and thus.......
c) formulate an appropriately structured training course
d) demonstrate the effectiveness of using a coordinated team and thus...
e) assess the feasibility of the proposed pilot programme including its extension to the urban areas.

7 SAMPLE DIAGNOSTIC STUDY

A DelAgua consultant (Kate Wedgewood) was commissioned to work with an experienced sanitary technician (Emilio Broy) who is also the chief of preservation for the health region. Together they developed a chronogram of visits to include 20 treatment systems and 20 simple gravity systems during the period October through December 1985. Their experience with the Volume III WHO Sanitary inspection record form in the early weeks of the study was unsatisfactory and a revised form was therefore developed and tested.

7.1 Methods: the **WHO Volume III sanitary report form was unsatisfactory** in the following respects:

a) too long and cumbersome to use in the field.
b) too much time was spent searching for the appropriate part to fill in.
c) in the case of simple gravity systems without treatment much of the form was redundant,
d) parts of the form were difficult for rural communities to provide answers to e.g. . they were never able to supply data concerning total water production (often because the system had never included any form of flow control or measurement), nor data on restrictions in supply (referred to in Sections 1b and 1c) during the year because no records are kept,
e) in the case of surface waters, it does not attempt to collect information about method of flow control at the abstraction point. We consider this to be a major deficiency since one important reason why all rural treatment systems fail is there near total lack of simple flow control at abstraction. In addition there is no place for comment on the existence of straining screens or grills at the abstraction point.
f) there is no section on the "linea de conduccion", including pressure-break boxes , but several systems were found to have problems with this part of the system (Canchapunco, Julcan and Pichanaki).
g) there are no sections on degritting chambers or sedimenters which were found to be problematical at La Merced, Yauli and Tarmatambo.
h) the section on slow sand filters was inadequate as it makes no attempt to identify the source of problems. All slow sand filters had major operational and maintenance problems,
i) it makes no attempt to identify problems with valves in any part of the system,
j) there is no place to indicate what spare parts are needed,
k) the section on water supply operators (Section VII) was inappropriate for rural systems because there was only one operator and his education and training were minimal,
l) there is no section on tarifs or funds,
m) there is no section for recording the composition and names of the local water management committee (Junta Administradora).This is essential for follow up visits.

7.1.1 Proposed sanitary inspection report forms.

Because the majority of rural piped systems in Peru are of the gravity flow type without treatment (GST), it is proposed that the new sanitary report should be based on a format whose main elements comprise the following:

1) General background information, identifying the locality, authorities responsible for administration including the local resources and those of the "Junta Administradora" : a resume of problems and proposed solutions.

2) Sources of water in use, risks of source contamination and means of abstraction (captacion).The inspector is required to measure the volume of water available at the source(s) and the amount of water entering the system. Thus, in addition to the water testing equipment, the surveillance team will require tape measure, stop watch, cork and bucket. Such basic measurements should at least involve the local operator in order to reinforce the local involvement in operation and maintenance from the start.

3) Conduction pipe, to and from the reservoir.

4) Reservoir and a separate section on disinfection since we propose to recommend disinfection practices in a situation other than within the reservoir.

5) Distribution system

6) Sketch map of the complete system.

7) Water quality report form.

8)For the minority of systems which include treatment or pumping the inspection report form for these will be on separate supplementary sheets.In particular the slow sand filtration section will be extended as this is the component which typically requires rehabilitation and most remedial action.

The new report forms will emphasise not only the identification of problems within the system but also the remedial action and materials required for improvement (Ref Appendix).

7.1.2 Table 7a. Treatment Systems in sample diagnostic study.

Code:	Community:	Admin. Authority:	Total Population:	Population Served	Domestic Connections
47.-	Huancavelica	SENAPA	17,452	11,892	2,500
47.06	Yauli	JAAP	1,868	1,230	800
48.--	Huancayo	SENAPA	192,688	96,120	?
48.28	Palian	JAAP	1,334	693	228
48.51	Cocharcas	JAAP	1,195	355	100
48.53	Sapallanga	CONSEJO	5,831	3,150	500
48.75	San Martin de Porras	JAAP	Pueblo Joven	229	50
48.56	Tres de Diciembre	JAAP	1,002	248	50
48.44	San Agustin de Cajas	JAAP	4,246	1,265	230
48.83	Chaquicocha	JAAP	667	479	87
48.84	San Jose de Quero	JAAP	1,307	644	137 (6 standpipe)
48.22	Huayao	JAAP	655	480	80
48.94	Churcampa	CONSEJO	1,859	715	140
48.25	Hualhuas	JAAP	1,751	1,375	233
48.--	Saños Grande	JAAP	5,000	?	350
49.52	El Mantaro	JAAP	3,016	2,280	420
49.16	Julcan	JAAP	2,126	1,167	200
50.32	Sacsamarca	JAAP	2,205	845	222
50.33	Tarmatambo	JAAP	2,042	1,370	234
51.12	Pichanaki	CONSEJO	1,890	1,364	600

SENAPA=Servicio Nacional de Agua Potable y Alcantarillado
JAAP=Junta Administradora de Agua Potable

Table 7b. Summary diagnostic of twenty treatment systems

		Structural & Maintenance Problems Identified						Water Quality (Res Y Red)		
Code	Community	Cap-tacion	Line	Sedi	Filt-ers	Res	Red Distribution	Clor (mg/l)	Turb (U.T)	Bact (Class)
47.-	Huancavelica SENAPA		(Coagulacion)	+	++	+		0.3	<5	A
47.06	Yauli			+	+		++	00	15-32	D
48.-	Huancayo SENAPA		(Coagulacion)	+	0			0.5	5-6	A
48.28	Palian	+++		+	++++	+		00	15-20	D
48.51	Cocharcas	+++		++	++++			00	<5-15	D
48.53	Sapallanga	++	(Coagulacion)		0		++	00	<5-8	D
48.75	San Martin de Porras	++	(Coagulacion)	++	++	++		00	10-20	D
48.56	Tres de Diciembre	++		+	+	+		00	<5	B
48.44	San Agustin de Cajas	+++	+	++	+++	+	++	00	15-20	D
48.83	Chaquicocha	++		++	++		+	00	<5	C
48.84	San Jose de Quero	+		++	++		+	00	<5	B
48.22	Huayao	+++		+++	++	+	+	00	<5	C
48.94	Churcampa	++		+++	++++	++	+	00	<5-9	A?
48.25	Hualhuas	++++		+++	++++	+	++	00	15-18	D
48.-	Saños Grande	++++		+++	++++	++		00	18-500	D
49.52	El Mantaro			+	+++	++		00	10-60	C
49.16	Julcan	++	+		+	+	+	00	<5	C
49.-	Sacsamarca	+++		++	+++	+	++	00	6-18	A?
50.33	Tarmatambo	+++		++	+	++	+	00	<5	A
51.12	Pichanaki	+	+	+				?	<5	C

+ = Nº of problems identified at each stage. ?=doubtful result
A-D = Fecal coliform/100ml; classification as in earlier tables.
0= Absent. Line=Conduction pipe. Res=Reservoir. Red=Distribution system.
Sedi=Sedimentation tank.Capt=Abstraction.Clor=disinfection.Turb=Turbidity.

7.1.2 Table 7c. Simple Gravity Systems in sample diagnostic study.

Code:Community:	Admin. Authority:	Total Population:	Population Served	Domestic Connections
52.02 Ondores	Consejo	2,698	1,925	300
52.-- Junin	Consejo	38,000	?	?
51.-- La Merced	SENAPA	11,929	5,022	820
51.-- Oxapampa	Consejo	12,000	?	1,000
51.17 Grapanzu	JAAP	185	120	75
51.-- Satipo	Consejo	25,000	?	980
48.11 Quishar	JAAP	871	585	53
48.23 Marcatuna	JAAP	278	180	102
48.31 Huasicancha	JAAP	1,999	1,343	138 (7 standpipes)
48.15 Llampsillon	JAAP	602	420	127
48.18 Vista Alegre	JAAP	515	385	85 (5 standpipes)
48.79 Mito	JAAP	586	678	150 (2 standpipes)
48.68 Chambara	JAAP	3,365	529	125
48.48 Tinyaro G.de	JAAP	657	-	78
.49 Tinyaro chico		627	-	62
49.21 Mata Grande	JAAP	599	450	1 (2 standpipes)
San Lorenzo	JAAP	3,000	?	187 (2 standpipes)
49.-- Iple	Municipalidad	?	?	40
49.30 Canchapunco	JAAP	440	330	23
49.-- Retamayoc	JAAP	>400	?	24
49.-- Jajachaca	JAAP	600	?	67

Table 7d. Summary diagnostic of twenty simple gravity systems

Code	Community	Structural & Maintenance Problems Identified: Cap- -tacion	Line	Res	Red Distribution	Water Quality (Res Y Red): Clor (mg/l)	Turb (U.T)	Bact (Class)
52.02	Ondores	++	+	++	+	00	<5	A
52.--	Junin	Rio	+	+	-	00	<5-6	B
51.--	La Merced	Rio+(Galeria filtrantes)				0<0.1	<5	B
51.--	Oxapampa	Rio+	+	+		00	5-8	D
51.17	Grapanzu	++				00	<5	B
51.--	Satipo	Rio++		+		00	6	D
48.11	Quishar	+			+	00	<5	A
48.23	Marcatuna	+			++	00	-	-
48.31	Huasicancha			+		00	<5	A
48.15	Llampsillon	++			+	00	<5	A
48.18	Vista Alegre	+				00	<5	A
48.79	Mito	+		+		00	<5	C
48.68	Chambara	Bombeo+ (3 sources) (Pump not working)				00	<5	B
48.48 .49	Tinyari G.de Tinyari chico	+ (1 of 2 sources)				00	<5-8	B
49.21	Mata Grande	+++	+	++	++	00	5-38	D
?	San Lorenzo	Rio+		++		00	<5-38	D
49.--	Iple			+	+	00	<5	A
49.30	Canchapunco		+ (3 reservoirs;one contaminated) 2 distribution sytems			00	<5	A/D
49.--	Retamayoc			+		00	<5	B
49.--	Jajachaca	+		+	+	00	<5	B

7.1.2 Appraisal of structural problems.

Sources A number of treatment systems in study (Hualhuas, Tarmatambo and Sacsamarca) derived a substantial part, if not all their water from remote spring sources. The original decision to build a treatment plant may, in these cases, have been based on a cost comparison of "linea de conduccion" pipe set against the cost of sedimenters and slow sand filters where a traditional aqueduct already existed from the source. In all events the results have been that the water is used on its way to the treatment plant, contaminated, sometimes cut completely for irrigation purposes and substantial amounts lost by infiltration through the floor of the channel. In the case of Sacsamarca and Churcampa, the source water was not entering the system because it was being diverted to irrigation. There is widespread ignorance concerning the relatively small quantities of water required for domestic use, typically less than one percent of that used in irrigation, in these rural areas; this ignorance has been reinforced by the failure of Ministry of Health engineers to install systems with operational flow control at the point of abstraction "captacion".

Captacion Of 18 rural treatment plants in study 11 had no flow control of water entering the system; only 2 had weirs (vertederos) and their gate valves (compuertas) could not function adequately when there was an excess of water, because the design would not permit the evacuation of excess water. Two had weirs which were working, although one of these (Tres de Diciembre) was partly broken; another was very battered and the excess water could not drain away. None of the intakes were sufficiently well protected e.g. by grills for screening debri, and only two untreated systems had a series of grills of decreasing coarseness. In the treatment systems where grills existed they were either too coarse or broken.Of the remaining 13 treatment systems studied using the sanitary inspection report 8 had no device for controlling the entry of water into the plant.

The two SENAPA plants (Huancavelica & Huancayo) had adequate flow control at the captacion.

Line of conduction. Few problems were encountered in piping water from source to the treatment plant.However in those with pressure break boxes several had no ball valve.

Sedimenters. There were 4 common structural faults in sedimenters. In rank order they were:

1) Absence of baffles. Only 2 rural plants had baffles in place, San Agustin de Cajas and Sapallanga. The latter claimed to practise coagulation.

2) Inlet and outlet weirs frequently provided non laminar flow.
3) Control valves were often inoperative through lack of maintenance.
4) Some sedimenters lacked a by-pass.

Consequently the efficiency of sedimenters in reducing turbidity was minimal. The majority were very dirty, requiring more frequent cleaning.

Four systems claimed to employ **coagulation**; of these only the two SENAPA plants had any form of routine control. It is clear that coagulation is inappropriate for rural systems which suffer from a serious lack of resources and routine control. An appropriate alternative **prefiltration/sedimentation** technology has been developed by DelAgua with CEPIS for application in rural areas.

Filters. Sixteen of the twenty treatment systems had slow sand filters, two had rapid sand filters. Neither the rapid filters at Huancavelica nor San Martin de Porras were working; the former lacked filter medium and the latter had been blocked and by-passed for three years! The filters were the worst maintained of all the system components. None of the slow sand filters had any means of measuring the amount of water leaving the filter and the majority of operators had no understanding of how to operate or maintain them. Most operators attempted to open valves when the amount of water available at the domestic tap decreased. Apart from the general problem of operator training the rural treatment(sedimentation/filtration) plant design is incapable of handling the gross turbidity loading (>15 turbidity units) to which most systems are subjected during and following heavy rainfall. The **Turb**idity values cited in Table 7 are only those encountered during the diagnostic visit,all of which were before the main rainy season and therefore generally an underestimate. It should be noted that these values are for samples taken "after treatment" in the **Res**ervoir and distribution system **(Red)**, although it is also noteworthy that **more than half the plants had marginal or no effect in reducing turbidity or bacterial contamination.** Only 3/16 slow sand filters was clearly producing a reduction in fecal coliform count resulting in water of less than 10/100ml (A or B **Bact**eriological classes).

Every filtration system so far examined **requires rehabilitation.** The minimum actions are refurbishment of the underdrainage and complete replacement of the sand bed with the recommended depth (>60cm) of washed sand, plus overhaul of all valves and drainage pipes.However all systems which are regularly subjected to high turbiditiesrequire prefiltration (Ref:DelAgua /CEPIS reports on multistage rural treatment systems).Some of the main features of slow sand filters are summarised in Table 8 (following).

Table 8. Operational problems of rural sand filters.

Code:Community:	•Depth of sand bed (cm)	Volume of sand reserve. (m3)	Distance to source of sand (km)	Actions required
48.28 Palian	20	00	25	Replace,clean & increase bed
48.51 Cocharcas	00	00	5	Complete rehabilitation
48.75 San Martin de Porras	30	00	10	Replace sand
48.56 Tres de Diciembre	25	200	0.12	Replace,clean & increase bed
48.44 San Agustin de Cajas	55	00	3	Replace & clean sand
48.83 Chaquicocha	10	00	10	Replace,clean & increase bed
48.84 San Jose de Quero	40	00	12	Replace,clean & increase bed
48.22 Huayao	50	00	1	Replace & clean sand
48.94 Churcampa	00	00	?	Complete rehabilitation
48.25 Hualhuas	35	00	18	Complete rehabilitation
48.-- Saños Grande	20	00	25	Complete rehabilitation
49.52 El Mantaro	10	00	?	Replace,clean & increase bed
49.16 Julcan	40	00	15	Clean & increase bed
50.32 Sacsamarca	20	00	50	Replace,clean & increase bed
50.33 Tarmatambo	35	4	55	Replace,clean & increase bed

51.12 Pichanaki; Information deficient: revised sanitary inspection report form not available.

•N.B. Minimum sand depth recommended is 60cm

7.1.3 *Treated and untreated systems.*

Except when qualified the following remarks apply to all 40 systems in the study.

Reservoirs. All **air vents** made of galvanised steel were intact, whereas the majority of those made from plastic were broken. All intact air vents had an inverted U allowing the opening to face down. None of the openings were protected by a screen or grill. 50% of reservoirs allowed rain water to enter either through broken air vents or an inadequate manhole inspection cover.

Over 90% of **inspection covers** were unlocked, many of them were not sanitary. Some were made of concrete requiring three men to remove them and this had presumably resulted, in two instances, in there not being replaced.

In many reservoirs the **valve control box** contained sufficient water to submerge the valves. Such water was derived in some cases from leaking valves but in others to rain water or surface water flooding in.

In one case (Cocharcas) a blocked filter was overflowing to waste and the overflow formed a fecally contaminated pond above a valve box which was completely submerged. Since the outlet pipe in the valve box was broken the main flow of water into distribution was via the pond!

Chlorination Twelve of the 40 systems claimed to practise routine disinfection. At the time of inspection only 2/40 systems revealed residual chlorine in the distribution system. These were the two urban treatment systems of SENAPA at Huancavelica (0.0 - 0.3 mg/l) and Huancayo (0.2 - 0.5 mg/l).

Six rural treatment systems had no means of dosing chlorine; five had a pot chlorinator but did not use it; another seven had a pot chlorinator in place but there was no detectable chlorine residual in the ambient water.

Of the 20 simple gravity systems three were reported to chlorinate (La Merced, Marcatuna and Mito), but on inspection none of them actually revealed the presence of residual chlorine.This confirms the findings of the preplan study of rural systems referred to in section 4.4.

Red/Distribution systems. Many of the simple gravity systems and all of the treatment systems require amplification to increase coverage. The populations served are indicated in Table 7a &7c. Several also require new conduction lines from new sources (Mata Grande & Chambara) or because the existing one has become encrusted and flow is severely reduced e.g., Julcan, which is over 20 years old.

All but two treatment systems required new valves, either for the distribution system or the plant.

Bacteriological quality: (Refer to results presented in Table 7b)

Throughout the study water quality was monitored using the DelAgua test kits.The results of these analyses showed that the 20 simple gravity systems with spring sources generally supplied a superior quality water: 6/20 untreated systems supplied water containing zero faecal coliforms in all samples (A class), and 7/20 had counts between 1 and 10 (B class). Five simple gravity systems abstracted water direct from surface sources without chlorination, unsurprisingly 3/5 of these were grossly contaminated with counts in excess of 100 fecal coliforms/100ml.

Only 3/18 rural treatment plants supplied class A water, and the results of two of these were doubtful and require resampling. 2/18 supplied class B water, another 5 supplied class C water and the remaining 8 were grossly contaminated (class D). These results thus confirmed most of the sanitary inspection findings which revealed the poor operational state of the treatment plants particularly. Exceptional anomalies were those observed for Sacsamarca and Churcampa which produced bacteriological class A water in spite of the presence of gross contamination in the source, turbidity in distribution in excess of WHO guideline values and of considerable operational problems.

The following observations were made on the use of the DelAgua kits by Ministry personnel in the programme.

1) They were often tempted to incubate the fecal coliform plates for only 8 hours. This is unacceptable and should never be incubated for less than 14 hours.
2) Not enough care was taken with preliminary resuscitation. The incubator was being switched on as little as 20 minutes after the last sample was placed in the incubator.
3) Not enough medium was placed in some dishes and not enough care was always taken to ensure that there were no air bubbles between the membrane and the pad. Both of these factors can seriously reduce fecal coliform counts.
4) Some analysts do not take enough care in maintaining the sterility of forceps and in general hygiene e.g.touching the sterile surfaces of the inside of sampling cups and filtration assembly.
5) The pH/chlorine comparator was sometimes incorrectly used: e.gs an inadequate source of light was used and the central control chamber r was not filled with water.
6) The visual turbidimetric measurement was not carried out correctly.
7) The instruction booklet had not been fully studied.

We strongly recommend that **DelAgua kits should not be used by untrained staff** and propose to attempt to rectify these errors in the forthcoming regional training course and subsequent evaluation.

APPENDIX

COMUNIDAD:

Codigo: | Fecha de Inspeccion:

Distrito: | Autoridad de Agua:

Provincia: | Poblacion servida:

Area de Salud: | Poblacion total:

1:GENERALIDADES:

Numero de horas de viaje desde la oficina del Area de Salud :

Distancia : km

Existe un establecimiento de Salud en la comunidad: Puesto?.. Centro?..

2: JUNTA ADMINISTRADORA de AGUA POTABLE:

TARIFAS/mes

Por conexion domiciliario	.......Inti
Por uso de piletas publicos	.......Inti
Por uso comercial	.......Inti
Por uso industrial	.......Inti
FONDO de RESERVA Banco	.......Inti
Caja chica	.......Inti

Junta administradora de agua potable(actual)

Presidente: | Tesorero:

Operador: | Secretario:

3: Datos del OPERADOR: OPERACION Y MANTENIMIENTO

Ha recibido algun entrenamiento el operador?

Que tipo?

Cuanto tiempo de experiencia tiene? años meses

Cuantos horas trabaja cada semana? ... horas

Que edad tiene? ...años

Que actitud tiene el operador hacia el sistema?

Tiene herramientas?

4:RESUMEN del DIAGNOSTICO

Tipo de sistema; GST( ). GCT( ). BST ( ).

Necesita: Rehabilitacion ( ), Ampliacion ( ), Mejoramiento ( ).

Tiene interes la comunidad en colaborar para rehabilitar su sistema de agua potable? -con mano de obra ( )

-con financiamiento ( )

OBSERVACIONES:

ACCIONES REQUERIDAS:

MATERIALES REQUERIDOS:

Nombre del Supervisor:

COMUNIDAD

5: INVESTIGACION de RIESGOS de CONTAMINACION AMBIENTAL y HIGIENE.

Forma de evacuar el agua de las casas (que cuentan con conexiones domicilarias) : Pozo ciego ( ) Letrina seca ( )
Alcantarilla ( ) Huertas ( ) Pozo de percolacion ( )
Existen letrinas sanitarias? Nº ( ) Si: No:

6: FUENTES de AGUA POTABLE

Fuente(s) :- Rio: ( ) Lago:( ) Manantial: ( ) Pozo: ( )
Nombre:-

Existen fuentes de contaminacion de la fuente(s) de agua potable?
Mineria: Letrinas: Basura: Ganado: Lavanderia:
Animales: Otros:
Cual es la cantidad de agua disponible? l/s
Es esta la cantidad usual? Si: No:
Hay un flujo constante? Si: No:
Cuantos dias en el año no hay agua? Fechas?
La fuente es de su propiedad? Si: No:
Se utiliza para irrigacion? Si: No:
OBSERVACIONES:

El SISTEMA de AGUA POTABLE

Tienen los Planos del sistema de agua ? Si: No:

7: CAPTACION

Es protegida la captacion ? Si: No:
Cantidad de agua que ingresa al sistema (vol= l,t= s). ....l/s
Existe control de flujo? Si: No:
Vertedero V notch 90º Si: No:
Vertedero rectangular Si: No:
De que materiales?
Existe un medio para evacuar el exceso de flujo? Si: No:
Funciona? Si: No:
Existe malla a la entrada? Si: No:
Existe un dispositivo de control de ingreso de agua? Si: No:
OBSERVACIONES:

ACCIONES REQUERIDAS:

MATERIALES REQUERIDOS:

COMUNIDAD:

TRATAMIENTO 1

Si el agua se captara de un canal de regadio, indique:	Si:	No:
Ancho del canal, a= m. Altura del agua en el canal, h= m.		
Distancia, d= m. Tiempo, t= s.		
Calculo :Cantidad de Agua disponible:- d/t x a x h x 0.8	Q=	m3/s
Existe control de flujo (Ver 7:CAPTACION)	Si:	No:
8: DESARENADOR existe?......	Si:	No:
Funciona?	Si:	No:
Hay posibilidad de limpieza?	Si:	No:
Esta de acuerdo con los planos?	Si:	No:
9: FLOCULACION Y COAGULACION Existe?	Si:	No:
Tipo de coagulante?........		
Hay stock de reserva de coagulante?kg....	Si:	No:
Floculador hidraulico?	Si:	No:
Se encuentra limpio?	Si:	No:
10. SEDIMENTADOR Existe?	Si:	No:
Volumen del tanque.........		m3
Esta de acuerdo de los planos?	Si:	No:
Cada cuanto tiempo se limpia?............		dias
Hay lodo al fondo? (Verifique con un palo)	Si:	No:
Hay problemas con las valvulas?	Si:	No:
El flujo a la entrada es laminar?	Si:	No:
El flujo a la salida es laminar?	Si:	No:
Cuenta con bafles (pantalla difusora)	Si:	No:

OBSERVACIONES:

ACCIONES REQUERIDAS:

MATERIALES REQUERIDOS:

Hoja #3

COMUNIDAD:

TRATAMIENTO 2

11: FILTROS

Cuantos: filtros RAPIDOS existen?.... filtros LENTOS.......

Estructura de ENTRADA de agua al filtro.....

Funciona ?

Valvula de entrada	Si:	No:
Valvula de by-pass	Si:	No:
Dispersores	Si:	No:
El agua cae directamente por tubo	Si:	No:

Lecho filtrante de ARENA:

Requiere limpieza	Si:	No:
Requiere cambio	Si:	No:

Altura de arena (h) cm

Determinacion del % de lodo en la arena. Tomar muestras a los siguientes profundidades.......2cm (%) 10cm (%) 25cm (%)

Volumen de arena de reserva (aprox) ... m3

Se podria lavar la arena en un sitio ceracano al filtro	Si:	No:
Existe bancos de arena cerca de la comunidad?	Si:	No:

Donde?

Volumen aproximado? m3

Distancia del bancos de arena a la comunidad........ km

Estructura de SALIDA:

Funcionan las valvulas?	Si:	No:
Se regulan periodicamente?..........	Si:	No:
Existe como medir el agua a la salida?	Si:	No:

Como?......................

OBSERVACIONES:

ACCIONES REQUERIDOS:

MATERIALES REQUERIDOS:

Hoja #4

COMUNIDAD:

12: RESERVORIOS	1	2		
Volumen del reservorio =	m3	m3		
Hay problemas con los valvulas?			Si:	No:
Hay una boca de inspeccion en el reservorio?			Si:	No:
Esta protegido por tapa sanitaria?			Si:	No:
Esta la tapa cerrado con llave?			Si:	No:
Los respiradores tienen la boca hacia abajo?			Si:	No:
Estan los respiradores protegidos por mallas?			Si:	No:
Puede entrar el agua de lluvia?			Si:	No:
de la superficie?			Si:	No:
Se ve seguro?			Si:	No:

OBSERVACIONES:

ACCIONES REQUERIDAS:

MATERIALES REQUERIDOS:

13: DESINFECCION		
Hay desinfeccion?	Si:	No:
Que tipo de equipo clorador?		
Hay cloro en el agua in situ?	Si:	No:
Calcular el tiempo de contacto del cloro en el reservorio(volumen /flujo))=.... minutos		
Esta ubicado el clorador en un lugar donde puede funcionar bien?	Si:	No:
En que lugar?.............		
Hay un stock adecuado de cloro?	Si:	No:
Donde se guarda el stock?		
Cual es la potencia del cloro?............. (haga prueba de comparador)		
Cuanto paga la comunidad por el cloro? Inti/kg		
De donde compran cloro?		

OBSERVACIONES:

ACCIONES REQUERIDAS:

MATERIALES REQUERIDOS:

COMUNIDAD		
14: LINEA DE CONDUCCION		
Hay problemas?	Si:	No:
Especificar..........		
Cajas rompe presion		
Cuentan con valvula de flotador?	Si:	No:
Cuentan con tapa sanitaria?	Si:	No:
Se saca agua de las cajas		
para consumo?	Si:	No:
para irrigacion?	Si:	No:
OBSERVACIONES:		
ACCIONES REQUERIDAS:		
MATERIALES REQUERIDOS:		
15: RED DE DISTRIBUCION		
Numero de conexiones domiciliarias....... Nº		
Numero de piletas publicas.............. Nº		
Hay fugas en la red de distribucion.......	Si:	No:
Donde?		
Hay presencia de cloro en la red	Si:	No:
Cuanto mg/l		
Hay problemas con las valvulas	Si:	No:
Donde?		
Se tiene agua en toda la red..................	Si:	No:
Es la presion adecuada en toda la red	Si:	No:
OBSERVACIONES:		
ACCIONES REQUERIDAS:		
MATERIALES REQUERIDOS:		

Programa Vigilancia Calidad DEL AGUA: -198__

COMUNIDAD____________________________

Diagrama del sistema de agua desde la fuente a la distribucion

(Esquema sencillo)

6:Fuente

7:Captacion

8:Desarenador

9:Floculacion

10:Sedimentador

11:Filtros

12:Reservorio

13:Desinfeccion

14:Red de distribucion

Programa Vigilancia-Informe Calidad DEL AGUA: -198-

Region de Salud ____________ Informe Numero ____________

Area de Salud: ____________

Provincia ____________

LOCALIDAD/Comunidad ____________ Fecha ____________

FUENTE de la MUESTRA.	Hora	Aspecto	Olor/ Sabor	Turbidez UT	Cloro libre mg/l	Cloro total mg/l	temp ºC	pH	Cond-uctiv uS/cm	Coli fecal /100ml
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Cartilla de Supervision del Servicio de Agua Potable

Area Hospitalaria: Fecha ____________

Provincia :

LOCALIDAD/Comunidad

RESUMEN de OBSERVACIONES y RECOMENDACIONES DE INSPECCION SANITARIA

Captacion:

Linea de Conduccion:

Planta:

Reservorio:

Desinfeccion:

Red de distribucion:

RESULTADOS de ANALISIS MALO:

Analista: Jefe (firma) ____________