SURVEILLANCE AND IMPROVEMENT OF PERUVIAN DRINKING WATER SUPPLIES

ROBENS

DelAgua

ODA

A project supported by the UK Overseas Development Administration as part of a technical cooperation programme between the Governments of Peru and the United Kingdom.

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Institute of Health and Safety
World Health Organization Collaborating Centre
for the Protection of Drinking Water
Quality and Human Health

DelAgua

ENVIRONMENTAL AND
PUBLIC HEALTH CONSULTANTS

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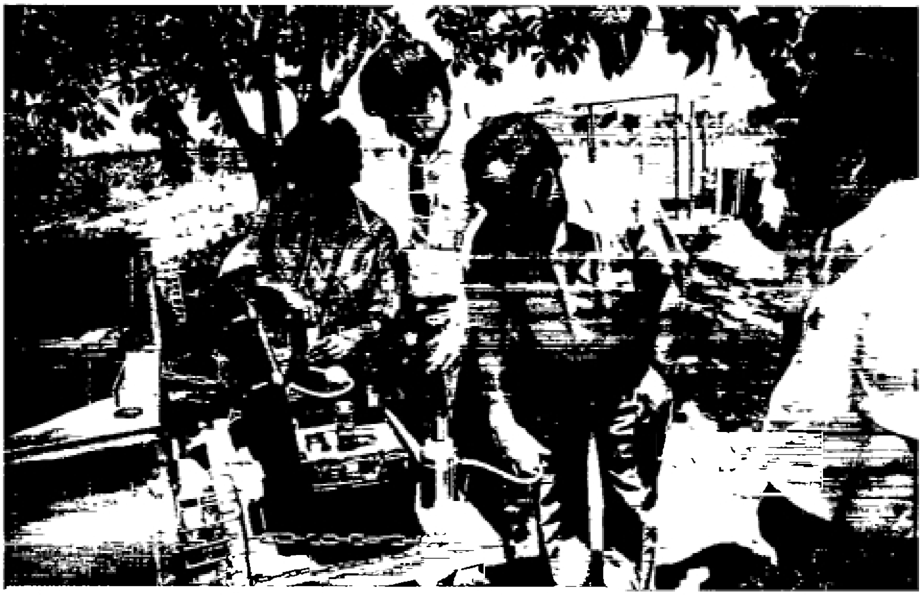

On-site Analysis Using the DelAgua Kit

The DelAgua kit was an important component of the analytical network. On-site analysis using the kit reduced costs, minimised sample deterioration during transport and ensured rapid results were obtained where needed.

Supervision in Huancavelica (High Sierra)

Fieldwork alongside surveillance teams with DITESA staff was undertaken throughout the project and provided opportunities to continue training and assess progress.

Preface

The surveillance and quality control of public water supplies are vital prerequisites for the protection of public health.

In practice however, the two activities of surveillance and quality control are often confused and inadequately implemented, especially in the case of surveillance in less developed countries. The two are clearly distinguished by the World Health Organization (1984):

> *'In general, it is the responsibility of the local water authority to ensure that the water it produces meets the quality defined in drinking water standards. However, the surveillance function (ie a policing function on behalf of the public to oversee operations and ensure the reliability and safety of drinking water) is best conducted in a separate agency (whether national, state, provincial or local). Although these two functions are complementary, experience suggests that they are better carried out in separate agencies because of the conflicting priorities that exist when both functions are combined'*

As a distinct activity, surveillance has been defined as *'the continuous, vigilant, public health assessment and overview of the safety and acceptability of drinking water services'* (WHO, 1976).

Traditionally, surveillance has been linked to monitoring of water quality, although it is clear from the above definition that it is a far broader activity, concerned with all aspects of water supply which may influence health, including both quality and accessibility.

Support for the establishment of a water supply surveillance programme by the Ministry of Health of Peru was provided by the United Kingdom Overseas Development Administration between 1985 and 1990. This largely took the form of technical assistance and the provision of equipment. Particular emphasis was placed on training, institutional development, the formulation and implementation of methods for surveillance, and promotion of remedial measures.

The Programme was designated as one of three WHO demonstration projects for water supply surveillance together with smaller projects in Indonesia and Zambia. Within Peru, the Pan-American Centre for Sanitary Engineering and Environmental Sciences (CEPIS-PAHO/WHO) provided support and an institutional base from which to promote replication in Latin America and the Caribbean.

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List of Acronyms

CARE	Campaign for American Relief Everywhere
CEPIS	Pan-American Centre for Sanitary Engineering and Environmental Sciences (PAHO/WHO)
CONCOSAB	National Committee for Coordination of Basic Sanitation
DIGEMA	General Directorate for the Environment
DISABAR	Directorate of Basic Rural Sanitation
DITESA	Technical Directorate of Environmental Health
IRCWD	International Reference Centre for Waste Disposal (EAWAG-Switzerland)
NGO	Non-Governmental Organisation
ODA	Overseas Development Administration of the Government of the United Kingdom
PAHO	Pan-American Health Organization
SEDAPAL	Lima Potable Water and Sewage Service
SENAPA	National Potable Water and Sewage Service
UNICEF	United Nations Childrens Fund
USAID	United States Agency for International Development
WHO	World Health Organization

Summary

The Peruvian Water Supply Surveillance Programme represented a comprehensive effort to establish routine assessment procedures for water supply services in both rural and urban sectors in Peru. The Programme differed from previously attempted quality control programmes in less developed countries in two significant ways. Firstly, a major objective included the development of strategies for linking the output from water quality testing and sanitary inspection to prioritised action for remedial measures where problems were identified. Secondly, the separate but complementary roles of water supply agency and health authority were accepted and intensive effort was devoted to developing these roles in order to maximise the benefits of water supply surveillance.

The principal conclusions of relevance to the implementation of surveillance in less developed countries are listed below together with the most salient observations from the Peruvian Programme:

1. Surveillance of water supply services can provide the framework for the rational prioritisation of investments in the water sector and hence the reduction in risk of disease associated with unsatisfactory water supplies.

At the United Nations conference in Mar del Plata (1977) which launched the International Drinking Water Supply and Sanitation Decade it was concluded that '*all peoples, whatever their stage of development and their social and economic conditions, have the right to have access to drinking water in quantities and of a quality equal to their basic needs*'. More than any other statement, this declaration established the basic parameters for judging the adequacy of water supply services and it is important to note that equal status was accorded to both quantity (or accessibility) and quality of water supplies. However, the greatest problem in judging the adequacy of services, particularly in rural areas of less developed countries, has been the practical difficulty of assessing drinking water quality and relating this to disease risk.

Thus, whilst immense resources are devoted to improving water availability (including quantity) and attempts are made to quantify trends in this regard (Espinoza, 1989; Watters, 1990), comparatively little effort has been expended in assessing the actual state of water quality in less developed countries (Lloyd and Helmer, 1991). But if the benefits of capital investments are to be maximised, it is essential to undertake surveillance of all aspects of water supply services. Figure 1 places the potential benefits of improved water supply services in their social and economic context.

In the Peruvian Water Supply Surveillance Programme, a system was devised which enables the level of water supply service to be classified with respect to five key indicators: quality, quantity, cost, coverage and continuity. Moreover, in the case of water quality, a scheme of risk assessment was devised which allowed the results of water analysis and sanitary inspection to be combined in a logical and systematic manner.

The generation of such information enabled Peruvian water supply agencies in both rural and urban sectors to address priorities for investment in a more effective and fundamentally more logical manner than was possible prior to the inception of systematic surveillance. As a result, a National Plan for Surveillance of Drinking Water Supply Services was elaborated by the Technical Directorate of Environmental Health with the assistance of the consultants, based on experience gained during the Programme. Furthermore, on 24 November, 1989, Ministerial Resolution 825/89 declared '*in the public and social interest the necessity of the development of the National Plan for Surveillance and Improvement of the Quality of Drinking Water Supply Services.*'

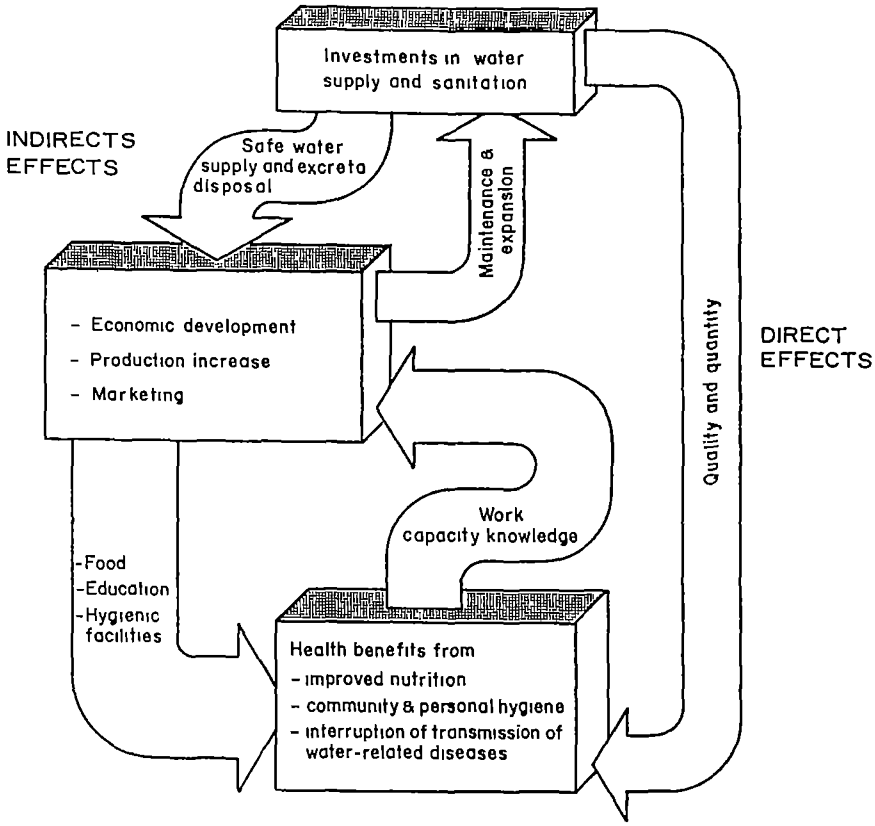


Figure 1: Direct and indirect effects of water supply and sanitation on health: a conceptual framework (after Cvjetanovic, 1986).

2. Appropriate methods for water supply surveillance can be successfully developed and applied in both rural and urban sectors of less developed countries.

As indicated above the most important factor in surveillance is to link the output of surveillance activities to improvements in services. To ensure that such a linkage is established and effectively used, several procedural and methodological requirements must be satisfied. (WHO, 1984):

i) institutions must have well-defined roles and administrative structures;
ii) methods for water sampling and analysis must be appropriate and standardised for both field and laboratory application;
iii) methods for sanitary inspection must be developed in a form appropriate for the particular circumstances of the country and adapted for both rural and urban application;
iv) systems must be developed for data acquisition, storage and retrieval and linked to

effective reporting structures within the appropriate institutions;

v) training strategies must be developed and kept under constant review in order that they may evolve to meet the changing and expanding demands of the surveillance programme;

vi) strategies for repairs, rehabilitations and other improvements to water supply services must be promoted and demonstrated to be practical and appropriate; and

vii) public participation and support must be mobilised and interest maintained by educational and promotional activities and by provision of technical support services to consumers and (where appropriate) caretakers and community drinking water committees.

All of the above systems and procedures were developed, tested and evaluated during the Peruvian Programme. As a result, surveillance methods were considerably refined over a period of five years. The process is summarised in Figure 2.

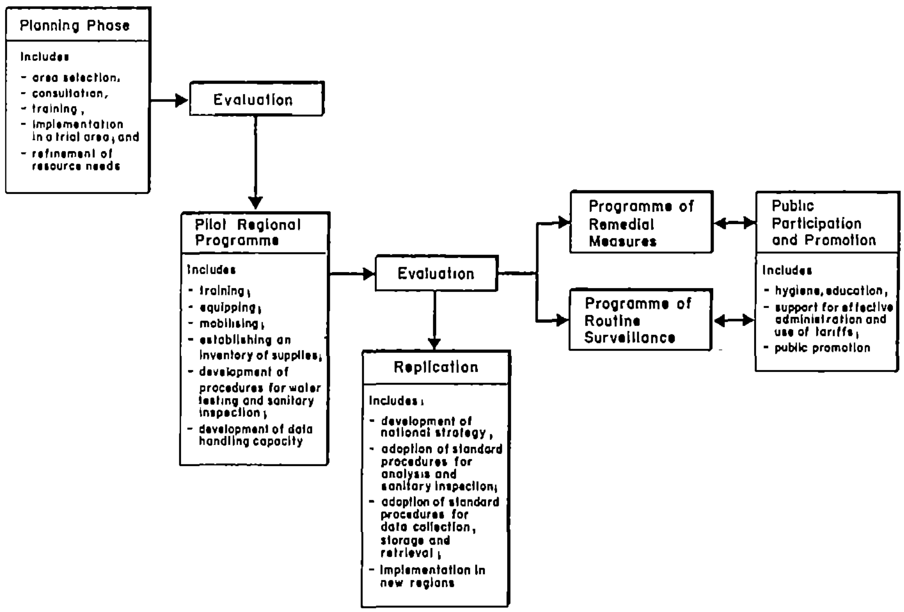


Figure 2: Developing water supply surveillance linked to improvement strategies in Peru, 1985 - 1990.

By mid-1988 the procedures which evolved proved to be sufficiently effective to be incorporated within a draft manual of surveillance methods suitable for long term application in Peru. This manual was tested over the subsequent two years, further refined and presented in its final form in mid-1990 to coincide with the completion of ODA support for the Programme.

In addition to their local applicability, three aspects of the methodology developed within the Programme were of particular note from an international perspective. The first was the development of a water supply surveillance scheme based on five service indicators: quality, quantity, cost, coverage and continuity (Lloyd *et al*, 1987). The second was the development of a risk assessment procedure based on systematic sanitary inspection and water quality analysis

(Lloyd, Pardón and Bartram, 1987). The third was the development and field testing of portable equipment for water analysis (the OXFAM/DelAgua water testing kit) which received a UK Better Environment Award for Appropriate Technology, presented by the Prime Minister, The Rt Hon Margaret Thatcher MP in March 1990.

3. The three most important mechanisms for ensuring the maximum benefits from surveillance in less developed countries are illustrated in Figure 3; they are:

i) the maintenance of rational priorities for investment at both regional and national levels;
ii) the continued monitoring and enforcement of standards of water supply service levels; and
iii) the continuation of promotional and educational activities at all levels.

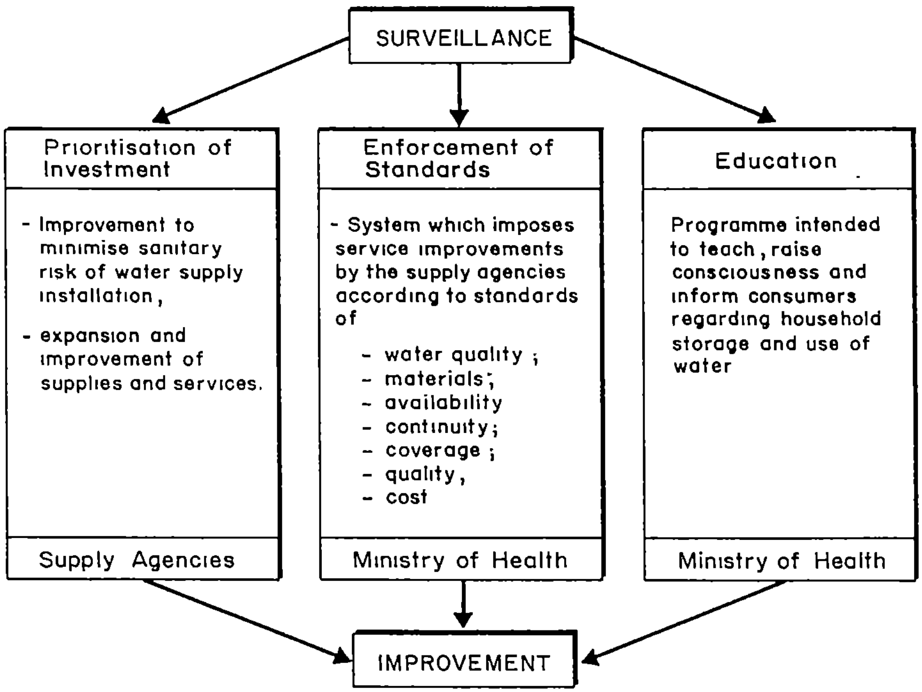


Figure 3: Principal mechanisms by which surveillance promotes improvements in water supply services (after Bartram, 1990).

To maximise the social and economic value of investments in the water supply sector, an optimal balance must be achieved between reduction of risks (through improvement of services) and costs (both capital and recurrent). Water supply surveillance provides both the mechanism for ensuring maximum health benefit and the means for quantifying improvements in service with reference to five key indicators. At regional level such information is of direct practical relevance in targeting resources and contributing to operation and maintenance efficiency, for example by the promotion of preventive and other remedial measures.

At national level, policy makers require reliable information on both costs and health benefits in order to formulate strategies for safeguarding public health. By maximising the effectiveness of investments in water supply, surveillance enables optimisation of the health benefits derived from these investments.

Enforcement procedures depend on the establishment of national standards and their incorporation into regulations, codes of practice and laws. In this context it is worth emphasising that international guidelines for water quality (or indeed any other service indicator) are not necessarily immutable nor are they automatically transposable into national legislation. Whilst they remain as ideals, it is possible to establish interim national standards which encourage supply agencies to progressively improve services, meeting achievable targets within reasonable timescales.

The Peruvian Water Supply Surveillance Programme institutionalised this approach. For example, water quality was categorised according to degree of contamination as indexed by the levels of thermotolerant (faecal) coliforms. Also, degree of sanitary risk was indexed by a quantitative sanitary inspection score. The categories are summarised below in Tables 1 and 2 .

Table 1: Classification scheme for bacterial contamination of Peruvian drinking water supplies (after Lloyd, 1982).

Grade	Thermotolerant Coliform Density per 100ml	Risk Classification
A	<1	WHO Guideline Value Little/No Risk
B	1-10	Low Risk
C	11-50	Intermediate/High Risk
D	>50	Gross Pollution High Risk

As has been emphasised earlier, the combination of risk factors from bacteriological analysis and sanitary inspection enables, for the first time, the rational prioritisation of water supply improvements for community water supplies. This in turn allows the development of a system of sequential targets and interim standards for water supply provision which will act as a spur to success rather than a censure for failure. The National Plan for Surveillance of Drinking Water Supply Services includes provision for the legal enforcement of water supply standards and makes clear provision for the formulation and progressive implementation of standards.

Table 2: Classification scheme for sanitary inspection scores of Peruvian drinking water supplies

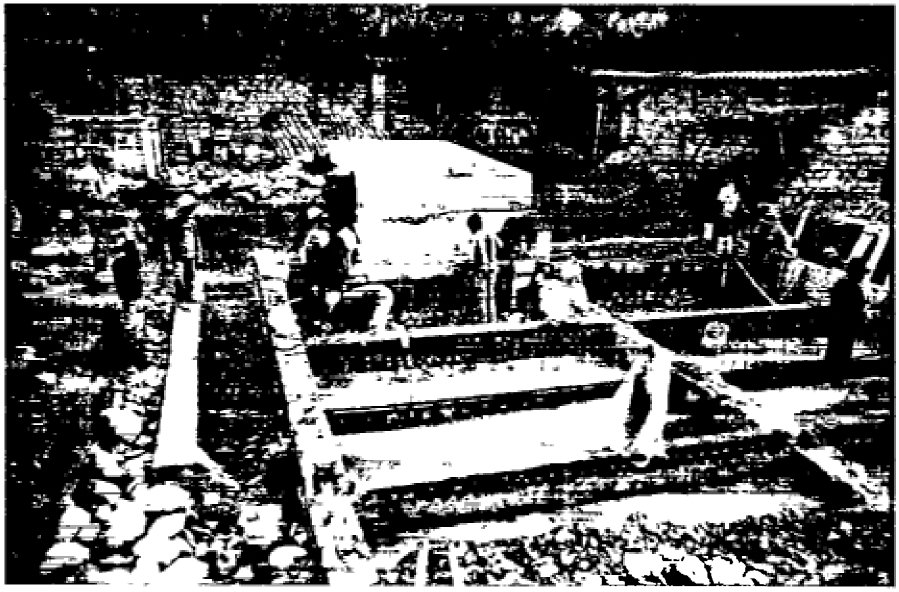
Sanitary Inspection Score		Risk Classification
0	=	No risk
1- 3	=	Low risk
4- 6	=	Intermediate to high risk
7- >10	=	Very high risk

Finally, successful implementation of the National Plan will depend on the continuation of promotional campaigns, public information and popular participation in water supply surveillance in both rural and urban sectors. In the last two years of the Programme, suitable materials were developed for the promotion of surveillance. These included information sheets aimed at policy makers and those responsible for undertaking formal surveillance activities. In addition, educational materials for community-level education were produced and disseminated to environmental health technicians.

As a result of experience gained in the Peruvian Water Supply Surveillance Programme and associated initiatives elsewhere, the Robens Institute of the University of Surrey was invited to coordinate the revision of World Health Organisation guidelines for drinking water quality control in small communities. The UK Overseas Development Administration has agreed to support this activity. In addition, in 1988, the Robens Institute was designated as a WHO Collaborating Centre for the Protection of Drinking Water Quality and Human Health. DelAgua has been invited to develop a project profile for water quality surveillance in the Andean Region as part of a Regional Health Cooperation scheme; it is also now supporting the implementation of improvement strategies, including a UNICEF-funded project in urban fringe areas of metropolitan Lima. In future DelAgua and the Robens Institute will collaborate with CEPIS to promote replication of water supply surveillance throughout Latin America and the Caribbean. At the same time the Robens Institute intends to extend the approach of water resource management and prioritisation of investments according to risk assessments to other parts of the water cycle, including source waters, catchments and recreational waters. In this way, the lessons learned in drinking water supply surveillance may be of greater long term benefit to the protection of human health and the environment worldwide.

Training for Residual Chlorine Measurement

Fieldwork was an important component of training throughout the project. By the end of the five years, three specific training modules had been developed for different levels of Ministry of Health staff.



Community Participation in the Rehabilitation of the Cocharcas Water Treatment Plant

The original plant, comprising sedimentor and two slow sand filters is visible in the background. Incorporation of roughing pre-filters (in construction, foreground) ensured that filter runs were not foreshortened during the wet season.

1 Background

Peru is located on the western coast of South America. It has a surface area of 1,285,216 km^2 and had an estimated total population of 22.3 million in 1990 (Webb and Fernandez, 1990). The country is divided administratively into 25 Departments and may be classified into three geographical areas: coast, Andean highlands and jungle. The population is unevenly distributed between the desertic coast, highlands and jungle (53 per cent, 36 per cent and 11 per cent respectively). Seventy per cent of the population live in areas classified as urban and 30 per cent in rural areas; the top ten cities accommodate 42.7 per cent of the population (Webb and Fernandez, 1990).

Peru is currently undergoing a radical administrative reorganisation which is intended to change the centralised administrative patterns which have been held for 170 years.

Under Peruvian law there are provisions for the protection of drinking water sources, the treatment of drinking water and the surveillance of drinking water quality.[1] During the 1940s the Peruvian Ministry of Health initiated a water surveillance programme, but this gradually lost momentum during the 1960s and effectively disappeared in the 1970s (Cáceres, 1990).

At this point it should be noted that in 1985, for rural communities of less than 2000 inhabitants, both water supply and surveillance functions were the responsibility of the Ministry of Health General Directorate of the Environment (DIGEMA). In these circumstances, it is not surprising that surveillance activities were downgraded in the rural sector. This is a familiar phenomenon, construction taking precedence over quality control.

However, in 1983 new proposals were made for re-establishing an active surveillance capacity within the Peruvian Ministry of Health. It was envisaged that the central laboratory service of the General Directorate for the Environment (DIGEMA) would be supplemented by a regional network of water quality surveillance laboratories and that at the hospital area level, environmental health technicians would have access to basic portable water testing kits. These recommendations were broadly in line with the World Health Organization guidelines for drinking water quality control (WHO, 1984 & 1985). However, at that time, it was still not clear how the complementary, but ideally separate, water supply and surveillance functions were to be administered in small communities by the Ministry of Health.

At the beginning of the Surveillance Programme in 1985, statistics showed the total population coverage with water supplies to be 52.5 per cent. This total comprised 72.9 per cent coverage in the urban areas and 16.7 per cent of the rural population (CONCOSAB, 1986).

Peru has mixed administrative arrangements for water and sanitation services. The National Potable Water and Sewerage Service (SENAPA) provides water supply services to much of the urban sector. Rural communities are defined by Peruvian authorities as those which have populations of less than 2000 inhabitants, for which water supply construction is largely undertaken by the Directorate of Basic Rural Sanitation (DISABAR) of the Ministry of Health.

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1. Ley de Aguas 13997, Codigo Sanitario 17405 and Codigo Sanitario de Alimentos DL 102/03.

2 Programme Development

In 1984, the University of Surrey team based at the Pan-American Health Organization Centre for Sanitary Engineering and Environmental Sciences (CEPIS) in Lima were invited to assist the Peruvian Ministry of Health in organising a short training course in water quality testing for laboratory technicians. The course was executed in Huancayo (Department of Junin) in July 1984 and was followed by a preliminary survey of sixty villages with piped supplies (Lloyd, Pardón and Bartram 1989). This preliminary survey generated useful water quality data and provided the basis for evaluation and refinement of methods for water surveillance and sanitary inspection in the rural sector.

In April 1985, a formal proposal for bilateral support for 'Establishing a Water Surveillance Programme Linked to Maintenance and Rehabilitation in Peru' was submitted to the United Kingdom Overseas Development Administration. The proposal was supported by the World Health Organization. It was based on: i) the findings of a preliminary Consultancy undertaken on behalf of ODA in March/April 1984; ii) the successful experiences of initial training and surveillance activities in Junin; and iii) the transfer of draft terms of reference to the Peruvian Ministry of Health from the British Embassy in Lima in April, 1985. Programme objectives and terms of reference were formally agreed in March 1986. Terms of reference were modified slightly as the Programme developed (see Chapter 6), but the overall objectives remained the same, see box below.

The Consultants shall provide a team to give assistance and advice to the Peruvian Ministry of Health, Division of Environmental Health (DITESA) to enable it to initiate the following activities aimed at compliance with water supply legislation:

a) **Formulate and revise a manual for water supply surveillance procedures.**

b) **Train and evaluate the work of sanitary and laboratory technicians involved in water supply surveillance.**

c) **Identify requirements for, and promote, water quality control at the operator level in the Health Departments.**

d) **Promote and secure the implementation of local and regional water supply surveillance laboratories.**

e) **Promote and develop water supply surveillance data reporting at regional and national levels.**

f) **Identify priority areas for rehabilitation and monitor the progress of improvement of rehabilitation and maintenance of water supply systems in response to reported data.**

The activities described in this report covered the period 1st July 1985 to 30th June 1990. However, it should be noted that the Programme had a sequence of important antecedents. Furthermore, although full ODA support terminated in June 1990, there are excellent prospects for the continued application and development of surveillance within the context of the Peruvian National Plan for Surveillance of Drinking Water Supply Services (Ministry of Health, 1989).

The sequence of contracts awarded by ODA to the Consultants was as follows:

01 July 1985 - 30 June 1987 DelAgua Ltd
01 July 1987 - 31 Aug 1987 DelAgua Ltd
01 Sept 1987 - 30 June 1988 Robens Institute, University of Surrey
01 July 1988 - 30 Sept 1989 Robens Institute, University of Surrey
01 Oct 1989 - 30 June 1990 Robens Institute, University of Surrey

However, the development of the Programme, described in a total of sixteen progress reports, may be more conveniently divided into three phases. These are described in Table 3, together with the principal outputs from each phase.

Table 3: Principal outputs of the three phases of the Peruvian Drinking Water Supply Surveillance Programme.

PHASE	
I 'inception' 1985-1987	• Development and evaluation of methods for surveillance in rural and urban sectors • Development of training • Implementation, supervision and evaluation of surveillance by Ministry of Health technicians in rural and urban sectors • Implementation of demonstration projects in rehabilitation of treatment systems • Provision of equipment and general support for surveillance
II 'consolidation' 1987-1989	• Systematisation of methods and incorporation into comprehensive manual for surveillance • Transfer of shared responsibility for training and supervision to Ministry of Health • Commencement of advanced training programme in UK for key Ministry of Health staff • Development of National Plan for Surveillance of Drinking Water Supply Services • Provision of equipment and general support for surveillance • Development of data management system
III 'replication' 1989-1990	• Application of systematised methods in existing and new surveillance regions by Ministry of Health staff • Completion of specialised consultancy inputs • Continuation of advanced training programme in UK • Transfer of complete responsibility for programme, including training, supervision and operating costs to Ministry of Health • Finalisation of central system for data collection, storage retrieval and reporting • Wide dissemination of outputs of surveillance via information sheets

Phase I was characterised by a great deal of institutional uncertainty. Successive re-organisations in the Ministry of Health executive structure following the change of government in 1985 led to several changes in staffing and reporting structures. However, the situation stabilised in late 1986. An important development was the administrative separation of small community water supply and surveillance functions within the Ministry. The General Directorate for the Environment (DIGEMA) was dissolved at this time and two new agencies were created. One, the Directorate of Basic Rural Sanitation (DISABAR) was to be responsible for the construction of small community sanitation and water supply systems. The other, the Technical Directorate for Environmental Health (DITESA), was to be responsible for all aspects of environmental surveillance and the setting of standards.

Thus, the organisational framework became significantly better suited to the development of a strong agency responsible for the surveillance of water supply services. This was important, since during the establishment of surveillance in the central region, considerable emphasis had been placed on the rural sector (see Chapter 3). Development, application and refinement of rural surveillance methodologies represented the major activities undertaken in Phase I.

In addition, some progress was also made in the development of methods for the urban sector, and this was accelerated by the desire of DITESA to establish surveillance within Lima (see Chapter 4).

Phase II of the programme provided excellent indications of the capacity of DITESA to assume a national role in supervising and promoting water supply surveillance in Peru. The methods developed and refined during the first phase were systematised and agreed between the consultants and DITESA and a draft manual for surveillance was produced in October 1988. Moreover, the consultants assisted DITESA in the formulation of a National Plan for Surveillance of Drinking Water Supply Services which now represents the framework for financing and replicating the experiences to date.

During this second phase, DITESA progressively assumed increasing responsibility for training and supervision of technicians engaged in surveillance activities (see Chapter 5). An encouraging development was the initiation of advanced training for key Peruvian personnel in the UK. Five students were granted British Council scholarships to attend a seven month diploma course on the Management and Scientific Aspects of Water Surveillance and Quality Control held at the Robens Institute, University of Surrey.

In Phase III of the Programme, the methods and systems which were developed and refined in the first two phases were applied and extended in both rural and urban sectors of Peru, including metropolitan Lima, Region Grau and Region Arequipa. In addition, specialist consultancy inputs on community education and participation, analytical techniques (gas chromatography), analytical quality control and database design were undertaken. The overall responsibility for the Programme was successfully transferred to the Ministry of Health and DITESA undertook to secure new funding for the execution of the National Plan in the period 1990-2000.

The consultants' inputs to institutional and human resource development continued through Phase III and a further five key staff received intensive training in the UK, supported by the British Council. Considerable efforts were devoted to the dissemination of information about the programme, including the printing and distribution of several thousand bulletins and several hundred copies of both the National Plan and the Surveillance Methods Manual. In addition, an international conference was organised both to present the outcome of the Programme and to launch the National Plan.

3 The Rural Sector

3.1 Development of a Rural Surveillance Methodology

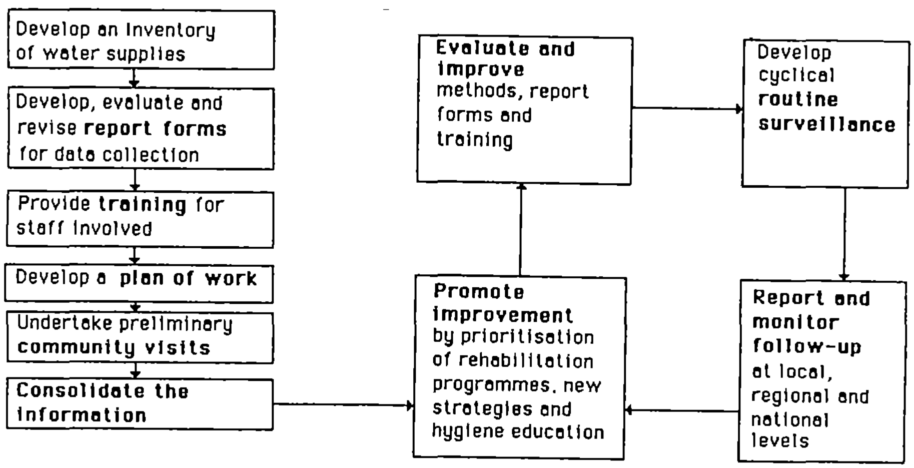
A national surveillance agency is responsible for assessing all aspects of drinking water supply services that influence health. A water supply surveillance programme should therefore include an assessment of the following principal indicators of service quality:

Coverage	percentage of the total population served and by what means: tap, standpipe, well etc
Continuity	hours per day and days per year that water is supplied
Quantity	volume per capita per day supplied for domestic use
Quality	by analysis classified primarily on faecal contamination and by sanitary inspection
Cost	tariff paid per month for domestic use

These service indicators were first employed in Peru (Lloyd, Pardón and Bartram, 1987) and have subsequently been tested in a series of pilot projects in Indonesia, Africa and Latin America (Lloyd and Helmer, 1991).

It is clear that a systematic approach for the assessment of pollution risks and the identification of sources of pollution is required. To this end, a model methodology was developed in the form of a series of procedural steps (Lloyd and Bartram, 1990). The principal elements of the methodology are presented in Figure 4.

Figure 4: Principal elements in the development of drinking water supply surveillance for small community supplies (after Bartram, 1990).



Area selection and basic inventories

The surveillance agency and rural water supply agency at national level (DITESA and DISABAR respectively) agreed on the choice of the central region of Peru (then Health Region XIII of Junín - Huancavelica) as the pilot project area. This region served previously as the pilot area of the National Plan for Basic Rural Sanitation and therefore contained considerable and varied rural water supply infrastructure. In addition it varied both in geography and population, including highlands, high plains, high and low jungle, rich valleys dedicated to agriculture and areas of intensive mining and smelting. The area included three Departments, two typical of the country and the third, Huancavelica, being the least developed of all.

Local surveillance teams based in provincial hospitals were chosen to incorporate environmental health technicians and in some cases laboratory staff. The surveillance teams included an area coordinator and were responsible initially for gathering basic data in order to prepare inventories of their area. The teams were required to:

i) record the population in each community and town;
ii) summarise the known existing water supply systems from the water supply agency archives;
iii) identify water supply systems not registered by the supply agencies (for instance those constructed by the community itself or with support of NGOs).

Developing report forms

The observable faults in a drinking water system which may give rise to supply problems and hence to disease can most readily be identified by careful on-site inspection. Every fault should be systematically listed during the sanitary survey and each point may be considered as a sanitary risk factor. Risk factors, such as the construction of a latrine close to a spring source, or the absence of a fence to exclude children and animals can be identified prior to the event that they predict eg pollution of the supply system causing an outbreak of disease.

Although it is possible that one risk factor may increase the chances of epidemic disease more than others, data to allow weighting of individual factors may not be available. However, it is logical that the greater the number of risk factors the greater the probability that the community will receive poor quality water, and as a consequence suffer from increased water-related disease. Every extra fault, or point of exposure to risk, may serve to increase the intensity of contamination and thus the risk to health. Similarly, every remedial action which eliminates a point of risk will reduce the probability of water related disease. Therefore, in the absence of information to the contrary, equal weighting of sanitary risk factors was adopted in the assignment of risk scores.

Sanitary survey forms were designed for each type of supply system (gravity fed without treatment, gravity fed with treatment and pumped without treatment). The objective was to establish a standardised inspection and reporting system which could be rapidly but accurately completed on-site at the same time that sampling and water quality analysis were carried out. The report forms were intended to serve several purposes:

i) identify potential sources of contamination of the supply;
ii) standardise the work and responses of the sanitary technicians to enable data analysis to be undertaken;
iii) quantify the degree of risk of contamination of each facility; and
iv) provide a record for the local surveillance supervisor, as to the remedial action which is required.

An example report form is included as Appendix 1.

Timetabling inspection visits

Transportation and personnel time are the major operating costs and the rural sector is consequently more expensive and less cost effective to cover for any defined community size. Population size therefore determines the frequency of surveys as recommended by WHO (see Table 4). Surveillance procedures for the rural sector required an innovative approach for the development of low-cost risk assessment procedures.

Table 4: Frequency of water supply surveys carried out by the surveillance agency after WHO, 1985

Population size served by source	Maximum interval between sanitary inspections	Maximum interval between bacteriological samples
>100,000	1 year	one day
50,000 to 100,000	1 year	four days
20,000 to 50,000	3 years	two weeks
5,000 to 20,000	3 - 5 years	one month
<5,000		
Community dug wells	Initial, then as situation demands	As situation demands
Deep and shallow tubewells	Initial, then as situation demands	As situation demands
Springs and small borehole piped supplies	Initial & every 5 years, or as situation demands	As situation demands

Organisation of training

Training strategies evolved during the course of the project and are described in detail in Section 5.3 (Human Resource Development). Training was both through intensive courses and field supervision. Topics covered during initial training included: water supply and treatment; critical parameter water quality analysis; sanitary inspection; surveillance planning; and hygiene education.

Supervision was used especially to provide follow-up training concerning sanitary inspection, on site water quality testing and interaction with communities

Initial community visits

On-site, the environmental health technician should first contact the community authorities and then complete the checklist on the report form with the assistance of the operator or community representative.

The visit begins in the community itself with a group of questions to the community authorities to ascertain details of coverage and also of the administration, operation and maintenance of the system. Household visits enable both on-site analysis of water quality in the distribution network as well as interviews to investigate coverage and water use habits within the household. The visit then proceeds to include a systematic inspection of identified points of risk of the entire supply system including source, conduction lines and reservoir using the field report forms.

On-site testing using portable test kits based on standard methods has been described elsewhere (Lloyd, Wheeler and Snook, 1985; Lloyd, Pardon and Bartram, 1986). The importance of quantitative analysis of faecal indicator bacteria eg faecal (thermotolerant) coliforms to enable prioritisation on the basis of health risk cannot be underestimated. An integrated approach to risk assessment is necessary and reliance should be placed on systematic sanitary inspection supplemented where possible with analysis for a simple, robust indicator of health risk due to faecal contamination. Our experience has demonstrated that sanitary technicians can be readily trained to undertake faecal coliform analysis in the field using OXFAM/DelAgua field testing equipment.

Consolidation of findings and identification of potential sources of pollution

The information generated must be fed into an efficient reporting strategy. Development of strategies for data mangement is described in detail in Section 5.1 (Data Management and Promotion). The information generated should also be consolidated and details added to an inventory of supply systems. Data which should be available through the inventory include the parameters of coverage, quality, quantity, continuity and cost. In addition, information regarding administration and operation and maintenance should be included. Where appropriate, these should be supplemented with details of collection and transport, household treatment and storage.

Pollution and water quality problems may be associated with any or all of the following:

a) poor quality source waters, overloading or failure of treatment processes,
b) poor site selection or protection;
c) design or construction deficiencies;
d) operation and maintenance difficulties; and
e) structural deterioration with time.
f) inadequate administration

Many of these problems should be identified by a comprehensive sanitary survey. Whether or not they are detected will depend largely on the thoroughness of the environmental health technician.

Our experience has shown that surveillance data should be used systematically at several levels (as summarised in Figure 3). Locally the results should be used to stimulate the repair and improvement of individual system components. Regionally the output of surveillance is an essential tool for cataloguing system defects in support of budget submissions for regional development projects. Nationally reports are used for strategic planning and resource allocation to water supply development.

Database development

Because of the quantity of the varied manipulations to which it is subjected and the many uses to which it is put, a computerised data storage and retreival system is advisable. A comprehensive data base was therefore developed during the course of the programme described in Chapter 5.

Formulation of prioritised remedial action strategies

The difference between the outputs of water quality analysis and sanitary inspection is that analysis will detect actual contamination and the level of contamination at the moment of sampling, whereas sanitary inspection should identify those points of the system at risk from contamination. The two activities are complementary. A major effort was undertaken to develop a systematic approach based on a combined risk assessment.

The majority of rural supplies in Peru are unchlorinated and it is therefore likely that they will contain large numbers bacteria which may have limited faecal significance (including, for example, total coliforms). It has therefore been recommended that the bacteriological classification scheme be based primarily on the thermotolerant (faecal) coliform bacteria.

In order to distinguish between water sources and systems which conform to WHO guidelines for faecal contamination (zero thermotolerant coliforms per 100ml) and those with different levels of contamination, a classification system was developed based on increasing degrees of thermotolerant coliform contamination (see Table 1).

The most important outcome of the risk assessment approach was the ranking of risk for a collection of sources and systems. This contributes to the assessment of degree of urgency for preventive and remedial action.

The procedures described here were applied in pilot projects in Peru for the first time in the period 1985 - 1988. Systems were classified into levels of action to form the basis of a rational strategy for prioritising remedial action:

1. Very high risk and hence urgent remedial action.
2. Intermediate to high risk requiring action as soon as resources permit.
3. Low risk; low priority for action.
4. No risk; no action.

Establishment of a routine monitoring programme with evaluation

The logical way to implement routine surveillance and monitoring is on an incremental basis. The first stage is a preliminary survey of a limited number of systems in a preliminary study. Following evaluation and revision of methods this may be expanded into a pilot project also followed by evaluation. Subsequently expansion and replication throughout a Department or Region is undertaken and finally national replication. This approach was adopted in Peru.

The frequency of surveillance visits should similarly be gradually increased. In Peru a baseline of one visit per system per year was selected in order to enable the preparation of yearly summary reports. While this frequency may be suitable for sanitary inspection of small water supply systems, it may not be adequate in the long term and the World Health Organization recommended guideline frequencies (see Table 4) should still be considered as a target.

3.2 Implementation of Surveillance in the Rural Sector

The poor state of drinking water supply is the rural sector was clearly demonstrated on completion of a comprehensive survey of central region water supply services. The August 1987 progress report to ODA presented the first application of the five water supply service indicators of coverage, continuity, quantity, quality and cost to water supplies in the rural sector.

Supply Types

The systems which supplied water to the rural population included protected spring sources fed by gravity without treatment, surface water sources (with and without treatment), and pumped systems from wells and springs. Populations served by the various supply types are summarised in Table 5.

Table 5: Populations served and coverage by supply type in the central region of Peru, 1986/7.

System type	Number of Systems	Population Served	Percentage of Population served
Gravity without treatment	273	191,898	84
Gravity with treatment	25	25,924	11
Pumped without treatment	9	10,895	5
TOTAL	307	228,717	100

The great majority (89 per cent) of rural systems were found to be of the simple gravity type. Most of these (74 per cent) took their water from protected spring sources, although there were some simple gravity systems from unprotected springs or surface sources (26 per cent). Of the remaining systems, 3 per cent were pumped systems and 8 per cent were gravity systems with treatment. Treatment almost invariably comprised sedimentation and slow sand filtration.

The rural and dispersed populations of the central region accounted for 39-45 per cent and 20-47 per cent of the total respectively. Population distribution by Department is summarised in Table 6.

Table 6: Population distribution in the central region of Peru by Department and community size

DEPARTMENTS	SURFACE Area (Km^2)	TOTAL Population	URBAN Population (>5000) per cent	RURAL Population (200-5000) per cent	DISPERSED Population (<200) per cent
Junin	43,384	1'037,500	40.6	39.1	20.3
Huancavelica	21,079	371,400	7.2	45.4	47.4
Pasco	23,566	264,800	36.9	40.7	22.4

Coverage

Rural coverage in the central region was claimed by DISABAR to be 54.4 per cent in 1984. However, this figure appears to refer to the percentage of communities in a given size range with a water supply rather than the population actually supplied with water.

Analysis of the data from the preliminary survey showed an average coverage within communities with a water supply of 56 per cent. Further analysis of data for communities of between 200 and 5,000 inhabitants by DITESA estimated coverage to be 32 per cent of communities with a mean coverage of 61 per cent within these communities. This is equivalent to an overall coverage of only 20 per cent of the population living in communities of 200-5,000 inhabitants. However, this figure does not take into account the dispersed population living in communities of less than 200 inhabitants, which comprised between 20 per cent and 47 per cent of the total population according to Department (see Table 6). Coverage here was assumed to be zero. Overall coverage of the population living in communities of less than 5,000 inhabitants was therefore estimated at 8.1 per cent in the central region.

Increasing coverage is clearly a high priority. Strategies should include construction of new systems but also expansion of existing systems. Analysis of water usage and availability showed that quantity was not a common limiting factor. With the support of the consultants, coverage in one community (Canchayllo) was increased from 55 per cent to over 90 per cent in a community of about 2000 inhabitants by an investment of US$2,500 in pipe and connections. Alternative strategies are also necessary to address the specific problems of the dispersed population.

It should be further remembered that even the figure of 20 per cent coverage for communities of 200-5,000 inhabitants represented only that proportion of households with a domestic connection or access to a public standpipe. It does not take into account water shortage or discontinuity which will reduce effective coverage still further, nor of the safety of the water supplied.

Continuity

Analysis of continuity data requires consideration of two principal variables: daily and seasonal continuity. The preliminary survey revealed a variation in continuity of service and consequently one of the important reasons for the reluctance of communities to pay an adequate tariff. The four classes of continuity were defined as:

a) Year round service from a reliable source with no interruption to flow at the tap.
b) Year round service with daily variation.
c) Seasonal service variation due to source fluctuation.
d) Compounded discontinuity (both daily and seasonal).

This classification reflects broad categories of continuity which affect hygiene and thus health. Daily discontinuity results in low supply pressure and consequent risk of in-pipe contamination. This also encourages household storage often in open cylinders resulting in increased risk of contamination in the generally unchlorinated water. Other associated consequences are availability and volume use reduction which limit water available for washing. Seasonal discontinuity forces users to adopt water collection from (usually) inferior and distant sources. Consequences, in addition to the obvious quality and quantity reduction, include the time lost to make regular collections.

During the preliminary survey, 16 per cent of communities had problems of continuity at the time of inspection. Data collection during subsequent years indicated that 78 per cent of rural communities were receiving water 24 hours per day, 10 per cent between 18 and 23 hours per day and 12 per cent between 12 and 17 hours per day.

Quantity

Analysis of the quantity of water used for domestic purposes proved difficult in the central region. The demand for irrigation water in the dry season created problems of competition for source waters. Furthermore, during the eight dry months, household drinking water connections may also have been used for irrigation purposes and apparent domestic usage values were often extremely high. Despite these high apparent values, continuity and effective coverage suffered as water was drained to houses connected to lower parts of the distribution system. This competition pointed to problems of supervision and training of the administrative committees and limited the usefulness of the data as indicators of domestic use habits or acceptability. Of the 307 rural systems inspected in the survey, 99 per cent were supplying an average of over 50 litres per person per day at the time of inspection (an appropriate per capita consumption value for minimum domestic requirements).

Quality

The A-D water quality evaluation scale developed by the consultants and detailed in Table 1 (Chapter 2) was used to analyse the water quality data gathered. The results of the preliminary survey are summarised in Table 7 according to supply type.

Eighty-eight per cent of treatment systems supplied grossly contaminated water (categories C and D). Similarly, pumped systems showed a high frequency of contamination with 70 per cent in these categories. In contrast, of the 275 simple gravity systems, which constituted the majority of the supply capacity, 23 per cent supplied water of category A, 43 per cent of category B, 17 per cent of category C and 18 per cent of category D.

Overall, it was estimated in 1988 that only seven per cent of the total rural population received drinking water of a quality which met national standards and World Health Organization guidelines.

Table 7: Water quality by supply type in the central region of Peru, 1986/7.

System type	Number Existing	Percentage of Systems Supplying Water of Quality*			
		A	B	C	D
Simple, gravity	273	23	43	17	18
Gravity with treatment	25	4	8	12	76
Pumped	9	11	22	22	44
TOTAL	307	21	39	17	23

*Category based on worst result from reservoir or distribution network during a single sampling visit.

Risk

Risk of contamination was assessed by sanitary inspection. The degree of risk presented by each system was estimated by a sanitary risk index. Data analysis at national level also enabled an overview to be developed highlighting the most common deficiencies. Using the example of gravity systems from protected spring sources, Table 8 shows the frequency of occurrence of the twelve most common points of risk.

Table 8: Frequency of occurrence of twelve common risk factors in gravity fed systems from protected spring sources without treatment.

Points of Risk	percentage of systems with fault
No lock on reservoir	98
Chlorination not practised	91
Leaks in adduction line	88
No fence around spring source	87
Leaks in conduction line	87
No disinfection equipment	85
No ditch around spring source against surface water ingress	83
No lock on spring catchment	83
Faecal contamination near catchment	75
No sanitary lid on spring box	55
No concrete cover behind spring box	47
No sanitary lid on reservoir	42

Chlorination

In effect, chlorination was not practised. During the preliminary survey, no rural supply system was found to have detectable chlorine residuals at any point in the distribution network. Only 8 per cent of simple gravity systems contained the elements of flow control to allow chemical dosing, 42 per cent had some type of chlorination apparatus (ranging from a holed plastic bag to a drip chlorinator) and only 1 per cent had any stock of chlorine.

Administration

At the time of the preliminary survey four principal agencies were identified which had been involved in the construction and administration of rural water supplies in the central region. The greatest contribution was that of DISABAR. The other contributors were SENAPA (the national water authority), COOPOP ('Popular Cooperation'), and local councils. Some of the systems were financed and constructed by the communities themselves although the number of these may have been underestimated in the preliminary survey; those identified were the systems known personally by environmental health technicians, and it is likely that others existed. In addition, there were a significant number of systems for which the construction and administrative authority was unknown. (see Table 4)

Table 9: Number of systems in the central region of Peru classified according to original construction agency, 1986/7.

Construction Agency	Number of Systems	Percentage of all Systems
DISABAR	217	70
COOPOP	10	3
SENAPA	4	1
Local Councils	3	1
Self-funded	23	8
Others/Unknown	52	17
TOTAL	309	100

All communities with systems constructed by DISABAR had been obliged to form an administrative committee. This committee accepteda standard constitution and had then to organise tariff collection and operation and maintenance of their system. The supervision of these activities was undertaken by the Programme of Supervision of Community Drinking Water Committees of DISABAR. In contrast, the systems constructed by other agencies had been handed over to the community and these agencies retained no involvement in their subsequent administration or operation and maintenance.

A number of indicators were used during the preliminary survey to assess the administration of systems. These are summarised in Table 10.

Table 10: Indicators of water supply administration as found in rural communities in the central region of Peru, 1986/87.

Indicator	Percentage of Communities
Administrative Committee	93
Operator	67
Access to Tools	43
Operator Trained	43
Tariff Collected	71

In only a small proportion of cases were administrative failures attributable to the communities themselves. During the preliminary survey, the environmental health technicians evaluated each community's interest in collaborating with the improvement of their water supply. Ninety-seven per cent of communities were amenable to provide labour, and 39 per cent expressed willingness to contribute financially.

These data implied that with appropriate technical support, self-help programmes of rehabilitation, repair, operation and maintenance by communities could realise substantial improvements in service quality. Moreover, by reducing dependency on centralised agencies, such a strategy would be more cost-effective and by emphasising preventive maintenance, likely to ensure long-term continuity of service quality.

3.3 Improvement of Rural Water Supplies: Promotion of Rehabilitation and Technology Transfer for Rural Water Treatment

CEPIS (1980) reported a total of 957 rural water supply systems in Peru of which 592 (62 per cent) were gravity fed without treatment (generally spring water catchments), 194 (20 per cent) had treatment plants, and 171 (18 per cent) had pumping stations. The existence of between 200 and 300 rural treatment plants in 1990 is an accepted estimate.

A typical rural treatment plant derives its water from small rivers or irrigation canals. It comprises an abstraction box, a settler, two slow sand filters, a reservoir and a distribution system supplying single household taps (see Figure 5).

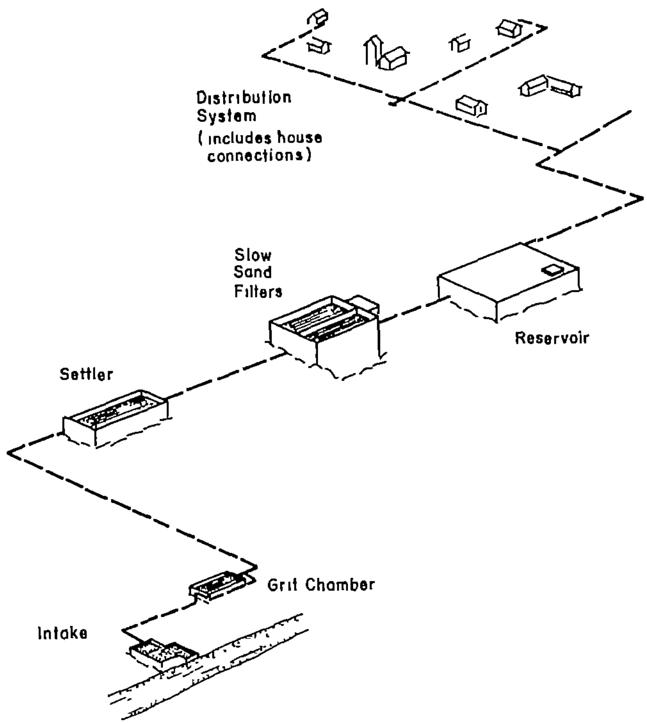


Figure 5: Typical rural water supply system with treatment

The Water Supply Surveillance Programme enabled a critical evaluation of the state of rural treatment plants by systematic sanitary inspection and water quality analysis. A summary diagnostic survey of the 28 surface water treatment systems of the central region is presented in Table 11.

Table 11. Summary Diagnostic Survey of the 28 Surface water treatment systems in small communities of the central region of Peru

COMMUNITY	POPULATION		STUCTURAL & MAINTENANCE PROBLEMS IDENTIFIED								WATER QUALITY		
	Total	Served	Abstraction		Settler	Slow Sand Filters			Disinfection		Turb. (TU)	Thermotolerant coliforms/100ml	
			Flow Control	Performance	Performance	Sand Depth m	Required Action	Operation	Equip-Exist	Operation	Raw Water	Raw Water	Post Treatment
Chaquicocha	600	94	Y	+	+	0 00	R	-	N		100	194	55
Churcampa	1859	715	N	-	-	0.00	P	-	N	-	>10		>10
Cocharcas(1)	624	500	N	-	-	0 20	P	-	N		100	>200	>200
Corpacancha	419	300	N	-	-	0.20	R	-	Y	-		25	15
Hualhuas	1150	230	N	-	-	0.15	P	-	Y	-	>50	150	81
Huasahuasi	1950	1550	N	-	-	(2)			N		30	300	260
Huayao	655	480	N	-	-	0.50	R	-	N		<5		>10
Julcan	1247	800	N	-	-	0.50	P	-	Y	-	10	160	12
Mantaro	2800	2000	N	+	+	0.30	P	-	Y	-	>60	180	180
Marankiari	580	160	N	+	+	0.40	I	-	N		20	37	6
Mazamari	2500	900	Y	-	-	(3)			Y	+		550	22
Palian	3000	1600	N	-	-	0.30	P	-	Y	-	>30	500	500
Pampasilva	1685	331	N	+	+	0.15	R	-	N			18	4
Pariahuanca	400	320	N	-	-	(2)			N		5	178	160
Pichanaki	7060	3300	N	-	-	0 80	I.C	-	Y	-	5	76	400
Picoy	840	-	Y	+	+	0.50	C.I	-	Y	-	300	2000	145
P.Yurinaki	700	80	N	-	+	0 05	R	-	Y	-		700	400
sacsamarca	2205	845	N	-	-	0.20	P	-	N		>50	1400	1200
Sanchirio	2400	70	N	-	+	0.05	R	-	N			200	70
SA Cajas	10000	3000	N	-	-	0 60	P	-	Y	-	>20	650	700
SJ Quero	240	148	Y	-	+	0.50	C.I	-	Y	-	<5		
SH Oangoa	4000	2500	Y	+	-	2.00		+	Y	-		530	180
Sanos Grande	5000	1750	N	-	-	0.20	P	-			>500		>50
Sapallanga	-	-	N	-	+/-	(2)			N			150	150
Tarmatambo	685	510	N	-	-	0 00	R	-	N		25	1600	100
3 Diciembre	2060	240	N	-	+	0.10	R	-	Y	-	10	330	2
Yauli-HVCA	8400	3500	Y	-	(2)	0 20	R	-	N			21	30
Yauli-Yauli	4500	1400	N	-	+	0.30	R	-	N		>30	4	8

Notes
(1) Information of 1980 prior to rehabilitation intervention
(2) No structure
(3) Non-operational rapid sand filter structures, 2 units

N = not existent
Y = existent
+ = adequate
- = inadequate

C = clean sand bed
I = increment of sand bed
R = complete replacement of filter bed
P = complete rehabilitation of structure

The results clearly demonstrate the failure of treatment plants constructed under the National Plan for Rural Water Supply (most of them during the 1970s). Not one system operated effectively, all supplied faecally contaminated water to the distribution systems and 17 of the plants supplied grossly contaminated water with more than 50 thermotolerant coliforms per 100 ml posing a clear risk of waterborne disease. High turbidity readings were indicative of the level of suspended solids concentration to which the treatment plants were subjected.

A summary of the structural problems identified for each element of the treatment plants included the following:

Source	-	inadequate quality for slow sand filtration without pre-treatment, due to seasonally high suspended solids
	-	multi-purpose, often serving both irrigation and drinking water supply; this tended to lead to interference in continuity of flow to the treatment plant,
Abstraction	-	lack of flow control (identified in 80 per cent of systems visited);
	-	structures subject to vandalism;
Settling Tanks:	-	absence of baffles and inadequate inlet and outlet structures; leads to very short retention times;
	-	faulty valves;
Slow Sand Filters.		see following discussion and Table 12;
Disinfection.	-	inadequate dosing device, incorrectly installed;
	-	inadequate distribution of calcium hypochlorite powder.

The inadequate service provided by many water supplies leads in turn to a reluctance to pay tariffs The result is a vicious circle which is especially damaging in systems with treatment: the administration deteriorates and the treatment system is abandoned or by-passed resulting in further deterioration of the service and especially water quality.

Factors relating to the deficient performance of slow sand filters in small community installations are summarised in Table 12. They can be divided into two groups: technological problems (which include design, construction, operation and maintenance); and behavioural or socio-economic difficulties. Both are important and were addressed in the pilot rehabilitation interventions conducted during the years 1986-1988.

Table 12 Factors related to the deficient performance of slow sand filters in small community water supplies

COMPONENT	PROBLEM	CONSEQUENCE	REMEDIAL ACTION REQUIRED
<u>Technological</u>			
Design, construction, operation and maintenance	*Suspended solids concentration in raw water too high for SSF application	- Short filter runs - Breakdown of treatment plant/by pass - Unsatisfactory service	- Careful source selection - Pretreatment
	*Inappropriate flow rate control installations	- Flow rate changes - Overload - Inadequate operation	- Manipulation-free flow controllers, eg inlet V notch weirs, head controlled by overflow structure
	*Inappropropriate sand size and depth of filter bed coarse sand, insufficient depth; sand too fine	- Poor effluent quality - Short filter runs	- Adequate sand grading, washing and supervision of installation by experienced personnel
	*Backfilling structures missing	- Air binding in the sand - High initial filter resistance	- Interconnection of SSF units' outlets
	*Water effluent line lower than top level of sand bed	- Accidental drainage of sand bed, biological layer killed - Negative pressure in sand bed, air release and increase in filter resistance.	- Fixed effluent weir with overflow level above sand bed level
	*Sand washing installations and auxilliary tools missing	- No sand washing - Inadequate maintenance practices	- Provision of sand washing facilities - Provision of tools
	*Untrained caretaker	- Lack of understanding of process - Lack of motivation - Inadequate O+M	- Participation of caretakers in construction stage - Initial training - Continued supervision
<u>Socio-Economic</u>	* Inadequate water tariffs	- Low operator wages - Insufficient operating costs - Insufficient contingency provision	- Legislate for minimum tariff - Supervision - Adequate service as a first step (1)
	* Wastage and misuse of treated water household irrigation eg	- Overload of treatment plant	- Water consumption restriction devices - Communal supervision
	* Lack of (or insufficient) hygiene education	- Water intervention does not correspond to an adequate behavioural attitude of community	- Joint development of water supply, extreta disposal and health education programmes

<u>NOTES</u> (1) It is absolutely vital to avoid the vicious circle inadequate tariff - bad service - less payment by users - deterioration

In Peru as in many other developing countries slow sand filtration technology (SSF) has been widely implemented at small community level. The adoption of slow sand filtration has been due to a number of perceived advantages which include the following:

- appropriateness of the technology
- local availability of materials and skills
- ease of operation and maintenance
- relatively low cost

However, the process of technological transfer has been inadequate. Three key problems were identified: the inability of slow sand filters to sustain adequate filter runs when subject to high turbidity loads (which occur seasonally in Peru); the inadequate adaptation of SSF technology to regional conditions at the design and construction stages by the relevant engineering divisions; and the subsequent failure to adequately support local operation, maintenance and administration of SSF schemes.

The first two problems may be overcome with the use of effective and appropriate pre-treatment technology (for example roughing pre-filtration) while the third should be tackled by institutional development and community education.

The introduction of pre-filtration technology to Peru has followed three well defined stages: a research stage which started in the second half of the 1970s; a development stage which started in 1984 (and included the construction and evaluation of pilot plants within an ODA research project); and adoption of the technology in national construction programmes from 1986. This last stage was promoted through the surveillance programme. The development of these stages and key activities in each are summarised in Table 13.

Table 13. Chronology of the introduction of roughing filtration technology in Perú

ACTIVITY	YEAR 1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
The Research Stage											
1. Preliminary experiments by CEPIS Test rig of La Atarjea (a)	—										
2 CEPIS publication "Modular plants for water treatment in small communities". First Spanish language comprehensive review and design manual introducing roughing filtration technology				●							
3 First collaborative research and development programme (b)											
3.1 Detailed in-situ evaluation of the surface water treatment plant of the rural community of Carhua.						—					
3 2 Research work in the test rig of La Atarjea						—					
The Development Stage											
3.3 Design and construction of the Azpitia water supply scheme incorporating VRF.						—					
3.4 Evaluation of Azpitia							—	—			
4. *Second collaborative* R&D and implementation programme (c).											
4.1 Rehabilitation project of the water supply of the rural community of Cocharcas introducing HRF								—			
4 2 Rehabilitation project of the water supplies of the communities of *La Cuesta* and *Compin* (*HRF* technology).									—		
4.3 Extensive evaluation of the HRF technology.									—	—	
The Implementation Stage											
5 Training courses for design engineers and sanitarians on roughing filtration technology.							●	●	●	●	
6. Full-scale rural water treatment plant rehabilitation programme in the north of Peru using HRF technology. (CARE and the Ministry of Health).										—	—
7. Construction of new rural water supply schemes incorporating HRF technology (DISABAR)									—	—	—

NOTES

(a) La Aterjea is the metropolitan Lima water treatment plant
(b) University of Surrey (funded by ODA), CEPIS (Funded by GTZ) and DISABAR, Ministry of Health
(c) DelAgua (funded by ODA), *IRCWD* (funded by the Swiss Development Agency), CARE - Peru and the Ministry of Health

Further details concerning the interventions are presented in Table 14. After the two new pilot projects of 1985-86, horizontal foughing filters (HRF) were incorporated in both rehabilitations and new construction projects. There is still a long way to go with rehabilitations but meanwhile completely new rural water treatment plants are being constructed incorporating HRF technology. Figure 6 shows the geographical distribution of the projects. They are distributed throughout the country, including coastal, highland and high jungle areas.

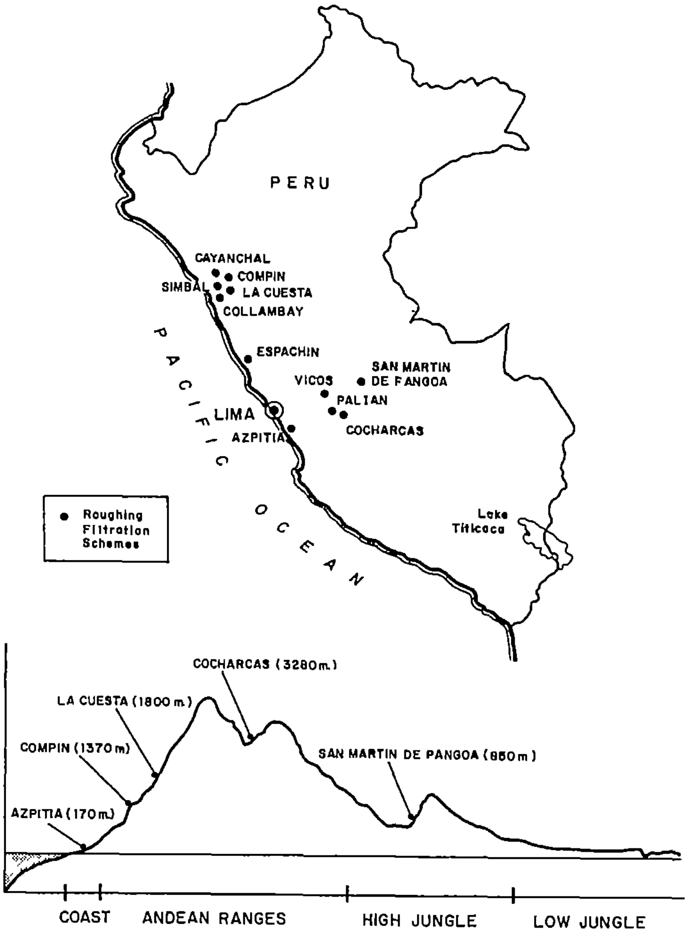


Figure 6: Distribution of roughing filtration technology in Peru (as of 1988).

Table 14: Chronology of implementation of roughing filtration technology in Peru.

Year	Locality Department	Type of Interven-tion	Roughing Filters	Improved Slow Sand Filtration	Training Of Community	Follow-up Evaluation (months)
1985	Azpitia, Lima	N	1 x 3 stage VRF-d	*	*	15
1986	Espachin, Lima	N	2 x HRF	*	*	
1986	Cocharcas, Junin	R	2 x HRF	*		15
1987	La Cuesta La Libertad	R	2 x HRF	*	*	3
1987	Compín, La Libertad	R	2 x HRF	*	*	3
1988	Palian, Junin	R.C.	2 x HRF			
1988	S.M. Pangoa, Junin	R.C.	2 x HRF	*		
1988	Vicco, Junin	N.C.	2 x HRF	*		
1988	Colambay, La Libertad	N	2 x HRF	*	*	
1988	Cayanchal, La Libertad	N	2 x HRF	*	*	
1988	Simbal, La Libertad	N.C.	2 x HRF	*		
1989	Plaza Pampa	R.C	2 x HRF	*	*	

N = new water supply scheme
R = rehabilitation of existing treatment plant
C = under construction

4 The Urban Sector

4.1 Development of an Urban Surveillance Methodology

In late 1986 it was agreed by the Ministry of Health and the consultants that surveillance activities in rural areas should be complemented by a parallel programme for urban areas. The two areas selected for implementation on a pilot scale were metropolitan Lima (the capital of Peru) and the urban centres of the central region.

The development of methodologies for urban water supply surveillance in metropolitan Lima commenced in 1987 following a training seminar involving 60 participants from both water supply and health sectors. In January 1987 it was proposed by the consultants and representatives of the Ministry of Health that urban surveillance in Lima be undertaken in a sequential fashion, commencing with the districts of Independencia, Rimac, San Juan de Lurigancho and San Martín de Porres in the Health Department of Lima North.

The objectives of the Lima North programme were: a) to diagnose the status of service levels in the four districts; b) to develop coordinated action to promote improvement of services; and c) to evaluate the first phase, thus enabling replication in the metropolitan area. Figure 7 shows the intended sequence for implementation of surveillance in metropolitan Lima.

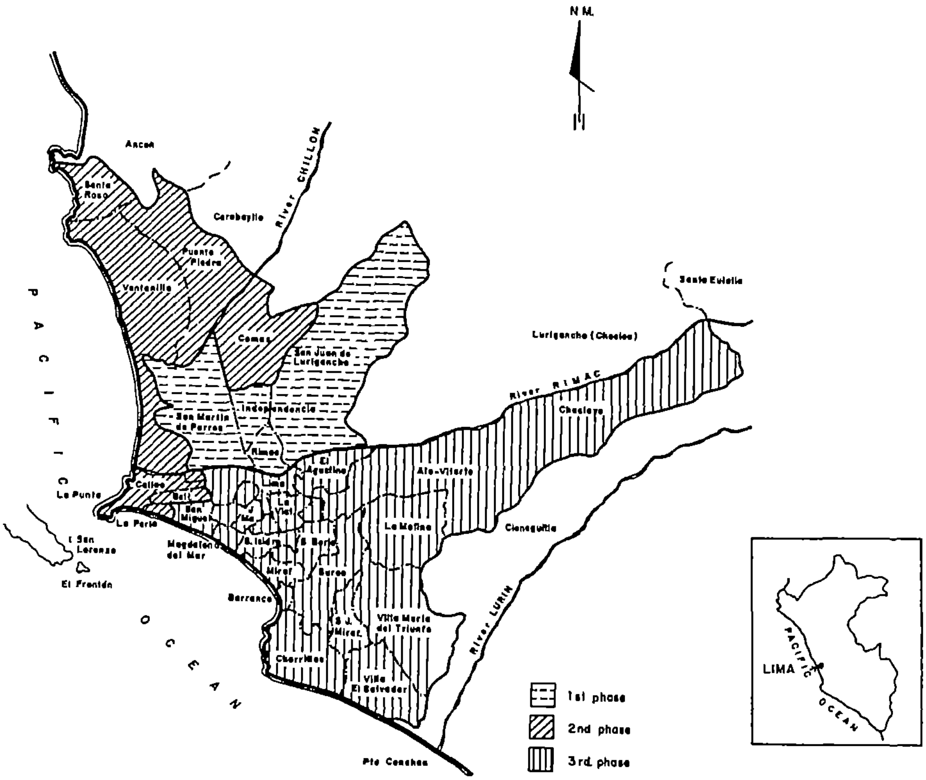


Figure 7: Proposed sequence for implementation of surveillance in metropolitan Lima, January 1987.

Metropolitan Lima - general characteristics

The city of Lima is located in the arid central coastal region of Peru alongside the grossly contaminated Rimac River. The city and the central coastal region as a whole has a moderate, dry climate with seasonal temperature variations between $12^{o}C$ and $30^{o}C$, and minimal rainfall. Lima is the administrative capital of the country and supports 80 per cent of the industry and 30 per cent of the total population (over 6.8 million people). Callao was considered an integral part of the metropolitan Lima conurbation.

Metropolitan Lima has undergone rapid population growth in the past 40 years. This has been accompanied by increasing population density and unplanned occupation of areas unserved by utilities such as sanitation, water and power (see Table 15).

Table 15: Urban fringe areas in metropolitan Lima 1955-1985 (after Matos Mar, 1985) - populations in millions of inhabitants.

YEAR	TOTAL POPULATION (Lima)	PEOPLE LIVING IN URBAN FRINGE AREAS		Number of Recorded Settlements
		Total	Percentage of Total Population	
1955	1.26	0.12	10	56
1961	1.84	0.32	17	-
1972	3.30	0.81	24	-
1981	4.49	1.46	33	408
1985	6.00	2.50	42	620

The water supply services of Lima

Water and sewerage services in metropolitan Lima are managed by the Lima Water Authority (SEDAPAL), part of the National Potable Water and Sewerage Service (SENAPA).

The formal water supply for Lima serves 73 per cent of the metropolitan population and its general characteristics are presented in Table 16. There are two water sources. The main source is surface water from the River Rimac, grossly contaminated with heavy metals derived from the mining activities carried out along the course of the river and its tributaries and by organics discharged from both industrial and domestic sources (Rojas, 1982). No source protection programme exists for the Rimac valley. The second source is groundwater, currently over-exploited by 1 m^3/s producing a fall of 1-2 m/year in the water table (SEDAPAL and Binnie & Partners, 1987). No projects for the recharge of the aquifer are underway.

However, the main problem of the water supply is the scarcity of water in a system that is reported to have a 50 per cent rate of water losses (SEDAPAL, 1988). SEDAPAL estimates that 27 per cent of the population is served by 'alternative' means. This includes water tankers which draw water from tanker truck refill points and deliver it to household cylinders.

Table 16: Water supply scheme of metropolitan Lima: population administered by the Lima Water and Sewerage Service. (after SEDAPAL, 1987)

Total Population	6.5 million
Population supplied by SEDAPAL	73%
Alternative supply-stand pipes and tanker trucks	27%
Total House Connections	556,000
Area Covered by the Sedapal Distribution Scheme	28,000 has
Production System	
- surface water two treatment plants	12.1 m^3/sec
- groundwater - 257 deep wells	6.6 m^3/sec
Distribution and Collection System	
- water supply network (28% of mains are more than 30 years old)	5,900 km
- sewerage scheme	5,600 km

In 1986 it was foreseen that seven principal components of the urban water supply system would merit particular attention. They were: wells, reservoirs, tanker trucks, tanker truck refill points, standpipes, household storage tanks and the piped distribution network. Moreover, it was proposed that for each component, particular emphasis should be devoted to certain service indicators, for example water quality for wells, and coverage, cost and continuity for tanker trucks. An outline strategy was proposed for each component and this was implemented in Lima North commencing January 1987.

After the initiation of pilot surveillance activities in Lima North, the second urban sector to be addressed was the Health Department of Callao which covers the six districts of La Punta, Callao, Bellavista, La Perla, Carmen de la Legua and Ventanilla. In 1988, these districts had an estimated total population of 690,000 inhabitants occupying an area of 14,785 hectares.

Implementation of the Programme in Callao commenced with a training course in November 1988 for thirteen environmental health technicians and one participant from the central region to share experiences from the development of surveillance methods there. Following the established pattern, the first task was to develop an inventory of the components of water supply systems in Callao. The area was then divided into identifiable supply zones. This process was completed in February 1989.

A total of sixty-four zones was identified and service levels assessed for each according to the five indicators of quality, quantity, continuity, cost and coverage. This represented a development of the Lima North strategy which gave emphasis to selected service indicators. However, the components which were identified for the purpose of subsequent sanitary inspection were similar, namely wells, reservoirs, domestic connections, standpipes, tanker trucks (and collection points) and storage tanks. Appropriate sanitary inspection forms were developed for each of the supply components. The distribution of service types in Callao is shown in Table 17.

Table 17: Percentage coverage by supply type in the Health Department of Callao, first quarter, 1989.

Supply Type	Percentage Coverage
Domestic connections	78.0
Tanker trucks	10.8
Public standpipe	6.0
Individual collection	2.8
Mixed (tanker trucks and personal collection)	1.8
Private wells	0.6

Because the basic objective of surveillance is to protect and enhance public health, it is axiomatic that greatest emphasis should be placed on those populations at greatest risk. Thus, in common with the Lima North strategy, the methodology for Callao was developed paying particular attention to urban fringe areas dependent on unpiped supplies (at least 27 per cent of the population, even on official figures). This was particularly important in the initial phase of zoning and cataloguing service components since adequate information was not held by the formal water supply sector. Thus, in the case of Callao, zoning included both a desk study and confirmatory household visits by seven environmental health technicians over a period of two months.

In parallel with the initiation of the programme in Lima North, some urban surveillance methods had been developed in the central region. These took the form of a full diagnostic survey of the city of Huancayo, including water quality analyses in defined supply zones. Because of administrative difficulties this activity did not extend to the introduction of routine sanitary inspection. However, a training course for urban surveillance methods conducted in Lima in February 1989 was attended by thirteen environmental health technicians from the central region with the specific objective of mobilising full surveillance in the nine urban centres of the region.

4.2 Implementation of Urban Water Supply Surveillance

Tanker truck supplies in Lima North

In the first quarter of 1987 an attempt was made to assess the level of service provided by tanker trucks to the four Districts of Lima North. There is a severe problem of availability of water for urban fringe areas, so the assessment was principally concerned with the comparison of actual supply versus potential demand with respect to quantity and continuity of service. In addition, a small experiment was conducted to examine the potential for maintaining residual chlorine more efficiently during transportation and storage of water supplied by tanker truck

Supply volumes and continuity were estimated by environmental health technicians who visited the five principal tanker filling sites to obtain salient information. This included details of the truck itself, the total number and destination of deliveries, and the volume of water transported. A summary of the data obtained is presented in Table 18.

Table 18: Analysis of tanker truck supplies to the Districts of Independencia, Rímac, San Juan de Lurigancho and San Martín de Porres, January 15 - February 15, 1987.

Filling Site	Median Number of Tanker Trucks	Mean Capacity of Tanker (cylinders*)	Mean Number of Cylinders (per day)
La Florida	3	37	777
Hacienda Las Flores	22	37	5840
Canto Rey	20	39	7240
El Naranjal	12	32	3130
Avenida Industrial	25	37	3885
TOTAL	82	-	20872

* One cylinder is approximately 180 litres.

One major problem which was identified in the study period was the variability in continuity of supply from all tanker filling sites due to the difficulty experienced by the Lima water authority, SEDAPAL, in maintaining adequate water pressures. Water demand was estimated by environmental health technicians visiting urban fringe areas and interviewing community representatives using a standard form. A summary of the data obtained is presented in Table 19.

Table 19: Analysis of potential water demand from tanker truck supplies to the Districts of Independencia, Rímac, San Juan de Lurigancho and San Martín de Porres, February 16 - March 14, 1987.

District	Zone	Name	Cylinders per day	
			Potential Demand	Total Potential Demand
	IND-01	Tahuantinsuyo	1689	
Independencia	IND-02	Independencia	0	1822
	IND-03	Ermitano	133	
	RIM-01	Ciudad y Campo	3580	
Rímac	RIM-02	Villacampa	0	3580
	RIM-03	Piedra Liza	0	
	SJL-01	Campoy	0	
	SJL-02	Zarate/Mang.	0	
San Juan de	SJL-03	Chac/Caja Agua	5	
Lurigancho	SJL-04	S. Hilarion	5352	38436
	SJL-05	Canto Grande	21485	
	SJL-06	Bayovar	11594	
	SMP-01	Avenida Peru	306	
	SMP-02	Ingenieria	118	
San Martín	SMP-03	Condevilla	157	
de	SMP-04	Libertadores	702	2181
Porres	SMP-05	Covida	0	
	SMP-06	Naranjal	786	
	SMP-07	Pro	112	
Total				46019

Thus, the total potential demand from tanker truck supplies (46019 cylinders per day) exceeded the actual supply (20872 cylinders per day) by a factor of 2.2. As a result of this analysis, it was recommended that the Lima water authority, SEDAPAL, liaise more closely with the tanker truck drivers association, ATA, with a view to improving water pressure at filling sites.

A limited analysis was undertaken of the potential to improve water quality in household storage tanks supplied by tanker trucks by converting free chlorine into combined chlorine (a more persistent disinfectant). The analysis indicated that both free and combined chlorine supplied at maximum tolerable levels were insufficient to provide a reliable barrier against recontamination caused by water handling in househould cylinders. It was considered prudent to recommend improved hygiene education for consumers reliant on such supplies to avoid post-delivery contamination of the water.

The methodology for surveillance of tanker truck supplies proved useful for the assessment of service levels with respect to quantity and continuity. Other service indicators, for example cost, quality and coverage, could be measured using similar methods in future studies. Thus, it was recommended that the investigation in Lima North be repeated annually and that it be adapted and extended in future diagnostic surveys in metropolitan Lima.

Results of water supply surveillance in Callao

Following the definition of coverage with respect to supply zones and service components, the implementation of surveillance in Callao required the systematic assessment of the other four service indicators namely quality, quantity, continuity and cost. In addition, a risk assessment scheme was required, integrating water quality and sanitary inspection data in order to identify priorities for action by health and water supply agencies. The results of the implementation of surveillance in Callao are summarised in Tables 20 to 23.

From the inventory of service coverage it was found that the proportion of the population of Callao served by a piped supply was 78 per cent (Table 9). Of the remainder, 10 8 per cent were served by tanker trucks, 6.6 per cent by standpipes (including private standpipes), 2 8 per cent by individual collection and 1.8 per cent by a combination of tanker trucks and individual collection.

On the question of water quality (as defined by levels of bacterial contamination), it was apparent that an unacceptably high proportion of the population (40.1 per cent) were receiving faecally contaminated water during the study period. Moreover, a significant number (4.6 per cent) were dependent on supplies which were defined as grossly polluted (more than 50 thermotolerant coliforms per 100 ml); see Table 20.

Table 20: Thermotolerant coliform densities in drinking water in Callao, first quarter 1989 (population figures in thousands of inhabitants)

	Thermotolerant coliforms per 100ml							
	0		1-10		11-50		> 50	
District	Pop.	%	Pop.	%	Pop.	%	Pop.	%
Bellavista	64	81.8	2	2.9	12	15.3	-	-
Callao	294	69.3	69	16.3	31	7.4	30	7.0
Carmen de la Legua	21	48.6	22	51.4	-	-	-	-
La Perla	17	30.0	39	70.0	-	-	-	-
La Punta	6	100	-	-	-	-	-	-
Ventanilla	12	14.6	27	32.2	43	50.7	2	2.5
TOTALS	414	59.9	159	23.1	86	12.4	32	4.6

The quantity of water being consumed was severely inadequate for 25 per cent of the population of Callao. In this category, nearly 70,000 persons were identified as consuming less than 26 litres per day and a further 100,000 received less than 50 litres per day. These data derived partly from the billing and metering system of SEDAPAL, but where there was no piped supply, information was obtained directly from consumers. Data in this latter category (principally for the group consuming less than 50 litres per person per day) were considered to be at least as reliable as the information derived from SEDAPAL bills.

Table 21: Quantity of water used in litres per person per day: Callao, first quarter 1989 (population figures in thousands of inhabitants)

	>150		51-150		26-50		<26	
District	Pop.	%	Pop.	%	Pop.	%	Pop.	%
Bellavista	--	--	78	100.0	--	--	--	--
Callao	15	3.6	312	73.4	45	10.6	52	12.4
Carmen de la Legua	--	--	43	100.0	--	--	--	--
La Perla	--	--	55	100.0	--	--	--	--
La Punta	6	100.0	--	--	--	--	--	--
Ventanilla	12	14.6	--	--	55	65.3	17	20.1
TOTAL	33	4.8	488	70.6	100	14.5	69	10.1

Results of the continuity analysis were no more encouraging. More than 70 per cent of the population had either a 100 per cent reliable piped supply or a tanker truck supply operating six or seven days per week. However, nearly 22,000 people (3 2 per cent) had a supply for less than half of the time and more than 127,000 (18.4 per cent) had a supply for less than three quarters of the time.

Table 22: Continuity of drinking water supplies. Percentage of time full pressure maintained in distribution network or number of days per week (d) supplied by tanker trucks: Callao, first quarter 1989.

	100%/ 6-7d		75-99% 5d		50-74% 3-4d		<50%<3d	
District	Pop.	%	Pop.	%	Pop.	%	Pop.	%
Bellavista	78	100.0	--	--	--	--	--	--
Callao	289	68.2	56	13.2	58	13.7	21	4.9
Carmen de la Legua	43	100.0	--	--	--	--	--	--
La Perla	55	100.0	--	--	--	--	--	--
La Punta	6	100.0	--	--	--	--	--	--
Ventanilla	14	17.1	--	--	69	82.1	1	0.8
TOTALS	496	70.3	56	8.1	127	18.4	22	3.2

The analysis of cost data provided the most extraordinary information. Whilst the majority of the population paid less than US$0.10 per cubic metre, more than 107,000 (15.6 per cent) paid more than four times as much. Furthermore, in those areas with the worst service levels, prices tended to be highest. Thus, areas were found where consumers dependent on infrequent tanker truck deliveries were paying up to US$2.50 per cubic metre.

Table 23: Cost of drinking water in US dollars per cubic metre: Callao, first quarter 1989.

	<0.10		0.10-0.20		0.21-0.40		>0.40	
District	Pop.	%	Pop.	%	Pop.	%	Pop.	%
Bellavista	47020	60.4	11838	15.2	--	--	18926	24.4
Callao	378405	89.2	982	0.2	--	--	45016	10.6
Carmen de la Legua	43351	100.0	--	--	--	--	--	--
La Perla	55137	100.0	--	--	--	--	--	--
La Punta	5790	100.0	--	--	--	--	--	--
Ventanilla	26105	30.9	14880	17.6	--	--	43451	51.5
TOTALS	555808	80.4	27700	4.0	--	--	107393	15.6

The above information demonstrates that it is possible to apply comprehensive and quantitative indicators of service quality in the urban sector. These indicators provide a basis for assessing trends as well as enabling the Ministry of Health to play an active and immediate role in prioritising remedial measures, where necessary ensuring that these are undertaken by the relevant supply agency or municipal authorities.

The information collected is reported to water supply agencies and municipalities on a regular basis and it is assumed that unsatisfactory findings will be the subject of effective follow-up and remedy. However, it is appreciated that the acute problems of the urban fringe areas cannot be dealt with by the immediate provision of piped supplies, even if financial and natural resources permitted such a solution. Thus, for the foreseeable future, the Ministry of Health will be committed to a major programme of public education in safe water handling and use, following guidelines developed within the surveillance programme.

In addition, it is intended that surveillance information will be analysed, updated and published on an annual basis in order to provide data of strategic value to policy makers The value of integrating water supply service indicators with health data has already been demonstrated for Lima and Callao (Lloyd *et al*, 1989). Such analyses will be of vital concern to those assessing the social and economic benefits of preventive public health measures, including improved water services to the urban sector of Peru.

4.3 Strategies for the Improvement of Urban Water Supplies: Improvement of Tanker Truck Supplies to Lima North Shanty Towns

Tanker truck delivery to household water tanks and cylinders will be a feature of life in urban fringe areas for the foreseeable future. These supply types are fundamentally inadequate but cannot be eliminated in the short term. Immediate strategies to alleviate health risk are therefore necessary.

A key deficiency identified when evaluating the tanker truck supply in Lima North was the insufficient quantity of water being delivered to the shanty towns of the district of San Juan de Lurigancho. Active coordination led to the installation of two new filling stations in the extreme northern area of the district, significantly improving the service. Reduction of transport time and distance is a key strategy for the immediate improvement of water supplies to urban fringe areas.

The Surveillance Programme evaluation also pointed to the inappropriate configuration of household tanks and cylinders to protect the water against contamination. Contacts with the fibre cement industry led to the development of household tanks incorporating both a sanitary lid and tap which will reduce the need to open lids to fill unhygienic buckets. The tanks are being sold at the rate of 1,200 units per year, amounting to 10 per cent of all household tanks sold in the commercial sector.

5 Institutional Development

5.1 Data Management and Dissemination

The generation of surveillance data alone does not lead to the improvement of water supplies or health. It is the management of the data produced which should dictate cost-effective improvement strategies. The principal mechanisms by which surveillance leads to improvements are summarised in Figure 3.

In order that relevant information is available where needed at the appropriate time, an information management and reporting system was developed. This was based on the 3-tier concept proposed by WHO (1984) for water quality data but modified to incorporate two important additional reporting levels: on-the-spot reporting to communities (both of sanitary inspection and water quality results) and overview reporting to the agency responsible for determining priorities for investment in the water supply sector. In Peru this is the inter-ministry National Committee for the Coordination of Basic Sanitation (CONCOSAB) The overall strategy for information flow and reporting is summarised in Figure 8.

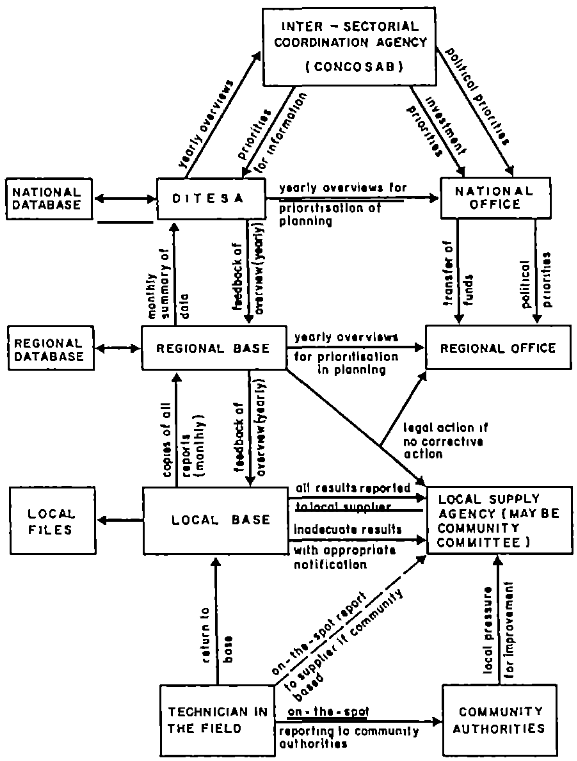


Figure 8: Information management and reporting system for water supply surveillance data in Peru.

At local level, especially in the rural sector, use of portable testing equipment enabled on-the-spot reporting to both the community water committees and the community authorities. This was especially important in areas where results could not effectively be sent on and had to be delivered by hand.

In the rural sector, mixed institutional arrangements also complicated reporting. A community drinking water committee was generally responsible for an individual supply. As noted in Chapter 3, these committees were often established by DISABAR with the main objectives of promoting community participation during the construction stage, partial cost recovery and subsequent administrative responsibility for the service. They received little training or supervision. Thus their capacity for direct involvement in improvement was limited. However, reporting the results of surveillance directly to the community authorities enabled them to exert pressure on both the water committees and appropriate support agencies for assistance.

Rehabilitation and improvement of supplies was undertaken by various construction agencies, most importantly DISABAR and NGOs such as CARE, to whom surveillance results were also reported. Reporting to these agencies was orientated towards prioritisation of communities for intervention and therefore based on yearly overviews which summarised the five water supply service indicators for each community.

For communities of more than 5000 inhabitants, water quality results were reported immediately to the local supply agency, while yearly overviews (similar to those for the rural sector) were delivered to the regional offices of the supply agencies.

Requirements for data management at national level are distinct from those at local and regional levels. Local and regional levels prioritise activities by system or community, whereas the former must orientate policy and investment. It is therefore necessary to analyse trends by region, supply type and population size. Due to the volume of data involved, computerisation is advisable. A preliminary database was designed by the Consultants in 1987 and used for analysis of the data from the central region using OMNIS 3 on Mackintosh. The database underwent revision during 1988 and 1989 and was adapted for and transferred to DITESA's IBM compatible computer hardware during 1990. An example of output from the database is presented in Figure 9. The database incorporates a total of 12 reporting options and is now used at national level . It also incorporates a number of features useful to the regional offices such as the facility to produce reports for local supply agencies.

PROGRAMA DE VIGILANCIA Y MEJORAMIENTO DE LA CALIDAD DE SERVICIOS DE AGUA DE CONSUMO HUMANO- REGION PILOTO

Lista de los Formularios Diagnosticos Codificado a la Computadora,

FECHA: 15 FEB 90 PAGINA 7

Lista Alfabetica de los Sistemas Inspeccionadas por Base PVMCA-JUNIN

Comunidad	Fecha de Inspeccion	Tipo	Fuente	Calidad de agua	%Cobertura	litros /p/d	Tarifa I/f/m
APAN, JUNIN	20 DEC 86	GST	Manantial	B	100	2400	0.0
CANAP, JUNIN	20 DEC 86	GST	Manantial	B	83	36	0.0
CARHUACAYAN-YAULI, LA ORO	15 JAN 87	GST	Manantial	A	36	1037	3.0
CARHUAMAYO, JUNIN	19 JAN 87	GST	Lago-Laguna	D	67	378	7.7
CHOGOTO, JUNIN	20 DEC 86	GST	Manantial	B	100	288	0.0
HUAYRE-JUNIN	17 DEC 86	GST	Manantial	B	38	902	5.0
JACHAHUANCA-JUNIN	6 JAN 87	GST	Manantial	B	36	1152	0.0
JUNIN-JUNIN	18 DEC 86	GST	Rio-Riachue	C	93	143	33.0
LA LIBERTAD-JUNIN	21 JAN 87	GST	Manantial	B	59	1280	5.0
LLAUPI, JUNIN	5 JAN 87	GST	Manantial	B	69	3677	2.5

Figure 9: Example output from the computerised national surveillance database.

Promotion of remedial activities necessitated the production and circulation of information aimed at policy-makers and directors of health and water supply agencies at both national and regional levels. The consultants therefore supported DITESA in producing a series of quarterly bulletins outlining the Programme objectives, progress and findings from March 1989:

March 1989:	Findings of Surveillance in Callao
June 1989:	The Rural Sector of the Central Region
September 1989:	The National Surveillance Plan
December 1989:	Overview of Surveillance
March 1990:	Findings of Surveillance in Metropolitan Lima and Callao

5.2 Systematisation of Surveillance Methods

The surveillance methods initially employed in the rural sector were based on the WHO Guidelines for Drinking Water Quality Volume 3 (1984). These were found to be of limited applicability in Peru. The model report forms were too long, poorly structured, and open to varied interpretation by technicians in the field. They also gave insufficient emphasis to the water supply service indicators of quantity, continuity, coverage and cost. Revised field methods and report forms were devised in 1986 and field tested during 1987.

For the urban sector, initial development of surveillance procedures was undertaken in three locations: in Lima North, in Huancayo in the central region, and in Callao.

The experience gained in preliminary phases was consolidated into a draft surveillance procedures manual in October 1988. Following substantial revision, this was printed in limited quantities and distributed for field evaluation. Final revision was undertaken in April 1990, resulting in a 400 page manual organised into nine modules covering surveillance theory, planning, information gathering and management, data processing and quality assurance, water quality standards, and sampling and analytical methods.

5.3 Human Resource Development

Vocational training for environmental health technicians in Peru was reduced in the 1980s from two years to six months. It was therefore essential that additional training for surveillance was provided for technicians involved in implementation of the Programme. With subsequent Programme expansion and institutional development activities, two further educational packages were required: i) for high-level surveillance managers (national and regional directors); and ii) for mid-level managers in the health and water supply sectors eg Programme coordinators and regional supervisors.

In order to satisfy the training requirements identified above, a comprehensive strategy for human resource development was elaborated (see Figure 10). Three specific training modules were developed within the Programme. External training was necessary where staff numbers or frequency of training did not merit this approach.

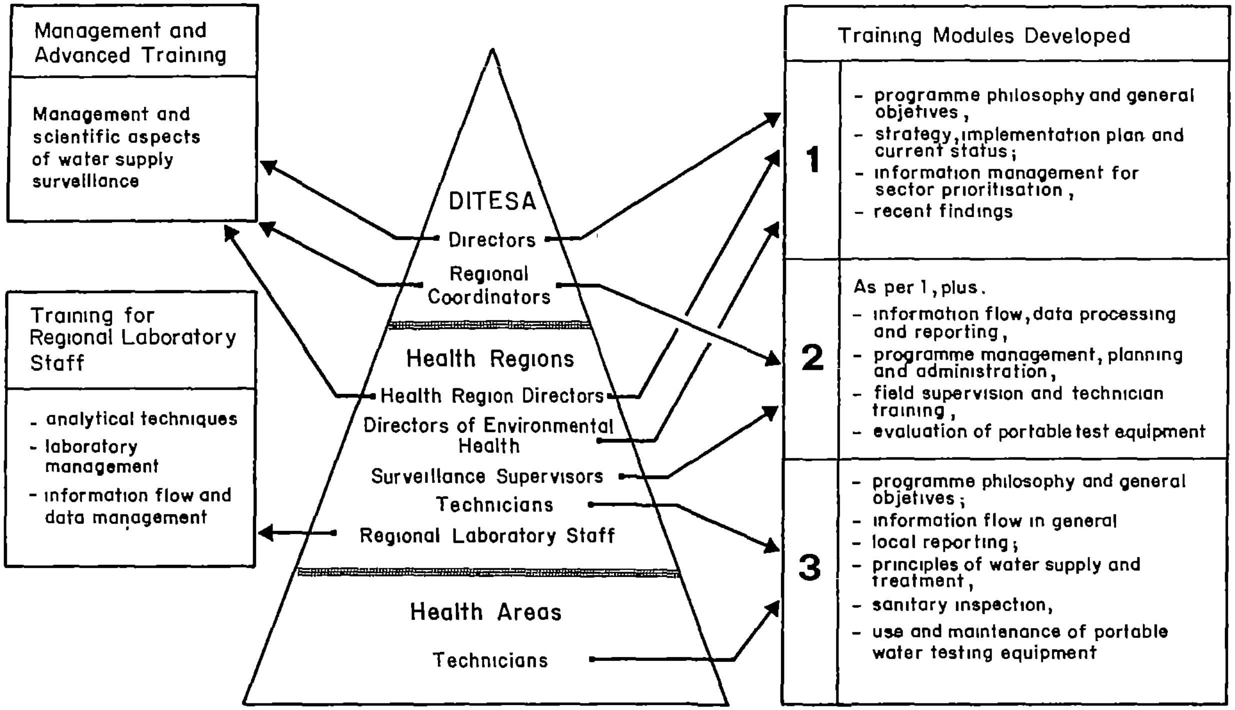


Figure 10: Human resource development for water supply surveillance in Peru.

A total of eight training courses for environmental health technicians were run during the course of the Programme. The content and duration of the courses were tailored to meet the requirements of the Programme. For example, rural and urban methodologies were distinct and new training requirements were identified as the Programme evolved. Training courses were evaluated and the experiences integrated into a standard two week training module for environmental health technicians comprising formal lectures, demonstrations, group-work and laboratory and field practicals. These are summarised in the box below.

Training Module for Environmental Health Technicians (two week course)

Health, faecal-oral disease transmission.
Barriers for the control of transmissible diseases.
Water, food, sanitation and education in health improvement.
Concepts of water supply surveillance and quality control.

Basic concepts of water supply: system types and basic characteristics.
Gravity-fed systems from protected sources - characteristics and terminology.
Components of gravity-fed systems from protected sources-points of risk (slide presentation).
Evaluation and sanitary inspection of rural gravity-fed systems from protected sources.
Field visit to rural gravity-fed system from protected spring source.
Concept of indicators of faecal contamination, water quality standards.
Demonstration and laboratory practical of portable water testing equipment.
Sampling and sample preservation.

Water treatment for the rural sector.
Components of rural drinking water treatment systems (slide presentation).
Field visit to rural treatment plant including inspection, sampling and analysis.

Laboratory practical on disinfection (2 part).
Disinfection Theory.
Disinfection equipment (slide presentation).

Information flow in the surveillance programme, reporting.

Introduction to urban surveillance, zoning.
Service evaluation (cost, quantity, continuity), water quality evaluation.
Field work on evaluation of service quality and water quality in the distribution network.
Sanitary inspections and inspection report forms.
Sanitary inspection (slide presentation).
Field visit: sanitary inspection and sampling.

Round table discussion.
Course evaluation.
Assessment of participants (pre- and post- course).

Further training was provided by the consultants accompanying technicians during fieldwork in 1986. This undoubtedly contributed to the success of training at this time. During 1987, the consultants were sometimes accompanied by DITESA personnel on these supervisory visits but it rapidly became evident that this high input from professional staff would not be sustainable, nor would this be a cost-effective means of providing decentralised supervision for a national programme. An intermediate supervisory tier of Programme staff was therefore created. Supervisors were generally environmental health technicians who were experienced in surveillance. They were given additional responsibility for reporting at regional level, field training and supervision of technicians. The training module developed for supervisors is shown in the box below.

Training Module for Surveillance Programme Supervisors
(one week course)

Annual planning: activities and requirements.
Developing chronogrammes of work.
Planning workshop and discussion.

Data registration and storage.
General schemes for information flow, coordination and communication.

Preparation of data summaries (urban and rural sectors).
Workshop and discussion on data summary preparation.

Control of work and evaluation of progress.
Supervision of personnel.
Role play: direct supervision.
Consistency of information (lecture and workshop).
Reliability.
Discussion on supervision.

Zoning of the urban sector (lecture, workshop and discussion).

Rural water treatment.
Urban water treatment.
Revision and further discussion of technical aspects (reservoirs, tubewells, springs, disinfection)

Course evaluation.
Assessment of participants (pre and post course).

The training modules for technicians and supervisors were intended to ensure the quality of data collection and reporting. In contrast, the third module was designed to promote awareness of Programme objectives and outputs. It was therefore a mechanism for increasing understanding of the Programme by directors and managers of health and water supply sectors in order to enhance the adoption of appropriate remedial strategies. It was found that staff at this level were unable to dedicate protracted periods exclusively to the Programme. Furthermore, due to the continual relocation of staff it was necessary to provide a summary of the programme on each occasion that a meeting was held. This module was therefore designed as a half-day workshop divided into three sesssions. The first session comprised a summary of the National Surveillance Plan, and covered the importance of water supply for health, the definition of surveillance and how it contributes to health improvement, and the objectives and strategy for development of surveillance in Peru. This was followed by a one-hour discussion of surveillance findings regionally or nationally (depending on the area(s) of responsibility of those attending the meeting). The final session of one hour was then dedicated to discussing the findings, their health implications and remedial strategies.

Course Syllabus for Post-Graduate Training at the Robens Institute

English Language Training and Study skills

Planning and Programme Management:
- Design and institutional development;
- Data bases and design of inventories;
- International standards and guidelines;
- Global monitoring programmes;
- Safety, hygiene and lab. management;
- Sampling and quality assurance;

Analytical Techniques:
- Bacteriology, ecology and biotic indices;
- Pathogens, parasites and viruses;
- Advanced and field testing for inorganics;
- Ecotoxicology and toxicity testing;
- Advanced organics analysis,

Risk Assessment and Control:
- Public health epidemiology;
- Resource protection and management;
- Health impact evaluation, benefit analysis;
- Legislation, regulation and monitoring;
- Emergencies and management;
- Sanitary surveys and risk indicators;
- River and coastal protection;
- Pollution prevention and control;

Engineering Interventions:
- Water resource protection;
- Reservoir and recreational water management;
- Water treatment, supply and quality control;
- Sewage treatment, control and disposal;
- Industrial waste disposal and control;
- Environmental impact assessment;

Diploma Examination and Matriculation for MSc:
- MSc project planning and literature review;
- MSc thesis work.

Although training was provided largely by the consultants in Phase I of the Programme, from 1989 to 1990 DITESA played an increasing role in training. By 1990, training courses for replication of surveillance were being initiated and run by DITESA personnel with the consultants playing an advisory role.

In addition to surveillance programme training modules, additional training was necessary for managers and senior scientists involved in surveillance at national and regional levels. The scope and intensity of training required for these personnel made in-country training impractical. As a result, it was decided to provide training in the United Kingdom. Over a period of two years, a total of ten students received support from the British Council to attend a seven month post-graduate diploma in 'The Management and Scientific Aspects of Water Surveillance and Quality Control' at the Robens Institute of the University of Surrey.

5.4 Community Hygiene and Environmental Education

Background

It is widely recognised that the provision of an improved water supply does not, on its own ensure improved community health. Sanitary facilities and improvements in environmental conditions and behaviour are also needed if water and sanitation related diseases are to be reduced.

The provision of sanitation was outside the remit of this programme. Furthermore, whilst community hygiene and environmental education were not specifically mentioned in the terms of reference, in the early stages of the project the need for them was identified so that the general objectives of water surveillance (that is to contribute to the improvement of community health) could be met.

Unfortunately the formulation of the first plans for community education coincided with a deterioration in the security situation in the central region project area. Thus it was not until the last few months of the project that an alternative rural area where surveillance was being undertaken became available which was appropriate for the initiation of hygiene and environmental education. This was in the Department of Arequipa, to the south of Peru.

Findings of surveillance

As part of the initial phase of introducing rural water supply surveillance, a diagnosis of the physical state of the water supplies and the water quality provided by them was carried out in the rural area of Arequipa in the first few months of 1990. Observations made included serious deterioration of many water supply systems. Furthermore, many of the Community Water Committees were not functioning, water supply operators were in need of training, and there appeared to be little disposition on the part of the communities to concern themselves with the maintenance and effective use of the water supply system. Finally, there was very widespread evidence of poor standards of community, domestic and personal hygiene as well as misuse of water facilities.

These observations highlighted the urgent need for remedial action. This would involve not only the rehabilitation of the supplies, the reformation of the Community Water Committees and the training of the operators, but also include the essential element of community hygiene and environmental education. In order to contribute to the development of these activities by DITESA and the Health Department of Arequipa, preliminary studies were undertaken to produce a strategy document on hygiene education within the National Water Supply Surveillance Programme.

Severe deficiencies had also been identified in water supply services to the urban fringe area surrounding Lima (See Chapter 4). Here as in the rural sector, remedial strategies were required which included promotional activities in support of community hygiene and environmental education. It was hoped that the provision of guidelines and support for the initiation of activities within the surveillance programme would both ensure that they were undertaken on a pilot basis and permit the appropriate authorities to seek further support.

Coordination

Callao, part of metropolitan Lima contains many urban fringe settlements. The Director of Environmental Health for Callao returned from advanced training in the UK in late 1989 with the intention of initiating hygiene education activities in the area. A community was selected and a round table meeting carried out with the active participation of the organised community, the Ministry of Health, the Ministry of Education and the non-formal (popular) education sector.

Likewise, the Director of Environmental Health in Arequipa Region selected several rural communities to participate in a similar round table there.

The purpose of the round tables was to involve all the different sectors who would be participating in a hygiene and environmental education programme and allow them to identify their needs, obstacles and problems as well as their demands on the other participating sectors.

The resulting information was then used to formulate a strategy for action and elaborate a funding proposal. Criteria used in the design of the strategy included allowance for the replication of the pilot projects in other regions without necessarily requiring external funding. To this end it was suggested that DITESA should create a department of Hygiene and Environmental Education whose personnel (trained and experienced health educators) would participate full-time in the pilot projects. Furthermore, experiences should be well-documented and possibly filmed for further dissemination by videotape.

The strategy developed involved the training and subsequent use of organised, interested and motivated members of the community together with school teachers and other members of the education sector. Not only would these educators receive training in hygiene but also in 'popular' education techniques. A specialised group in popular education will carry out this training and actively participate in the communities for the initial six months, to reinforce the activities of the community hygiene educators.

The environmental health technicians involved in the surveillance programme and those based in the health centres will participate in a similar workshop and be expected to support the efforts of the community hygiene educators during their visits to the community.

5.5 Replication of Surveillance by DITESA

Progressive transfer of programme management from the consultants to DITESA personnel was a priority throughout the Programme. The skills necessary for Ministry of Health staff to assume this function were developed by the formal and informal training outlined above.

Due to institutional reorganisations and changes in personnel during the first year of the Programme, training and supervision were largely provided by the Consultants. In addition, ODA financial support represented a substantial contribution to the total cost of implementation. The success of the strategy for Programme development is illustrated by the progressive adoption of responsibility for training, supervision and financial aspects by the Ministry of Health in the period 1987-1990.

During the course of the project, eight formal training inputs (courses and review workshops) were held during which national counterpart staff made an increasing contribution. The gradual transfer of responsibility for teaching to Ministry of Health staff is summarised in Figure 11.

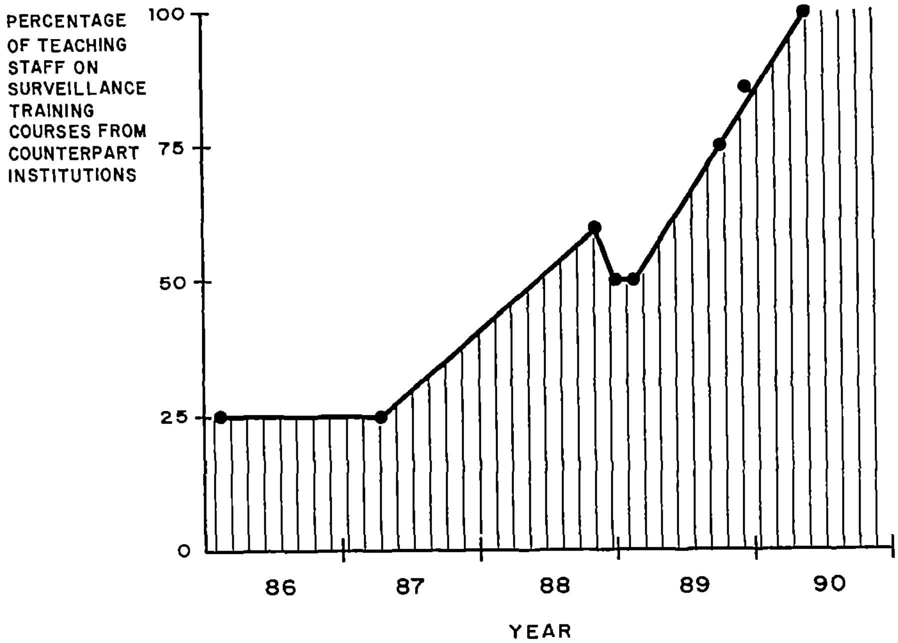


Figure 11: Increasing participation of Ministry of Health staff in training for water supply surveillance in Peru, 1985-1990.

Supervisory activities were progressively assumed by the national counterparts both at regional and national levels during the period 1987-1990. Prior to this period, all supervisory activities were undertaken by the consultants directly and training also depended considerably on these field visits. From 1987, these responsibilities were shared with DITESA and supervision and field training was undertaken jointly. As noted above, direct supervision by central DITESA staff was found to be unsustainable. The supervisory tier of staff was created in 1989. This relieved DITESA of responsibility for field training and supervision of technicians (which were then undertaken by the regional supervisors), leaving them with responsibility for supervision of surveillance planning, estimation of resource requirements and budgeting.

A scheme for the progressive transfer of budgetary responsibility for Programme was applied throughout the Programme and is depicted in Figure 12.

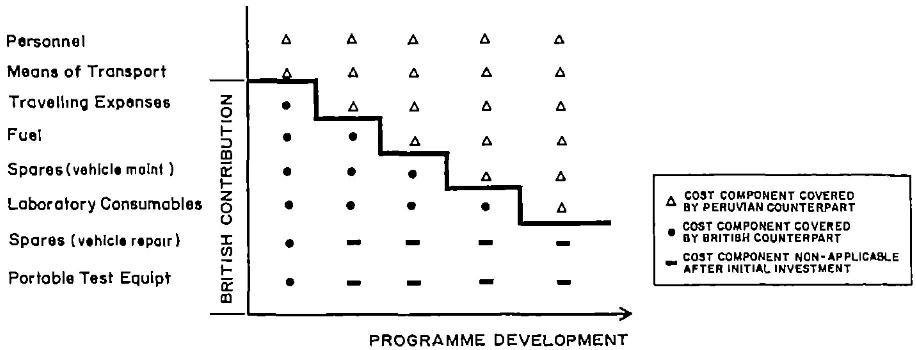


Figure 12: General scheme for the progressive transfer of budgetary responsibility for Programme costs to the Peruvian Ministry of Health.

The success of these strategies for progressive transfer of responsibility for the Programme was further demonstrated by the direct coordination, training and management provided by DITESA personnel for replication of surveillance in Regions Grau and Arequipa during the final phase of ODA support.

5.6 Planning for Replication of Surveillance to National Scale

The experience obtained in the first four years of ODA- supported activities generated an understanding of the water supply situation in Peru and enabled the development of appropriate surveillance methodologies. This in turn provided the basis for preparation of a "National Plan for Surveillance of Drinking Water Supply Services". This was first drafted with DITESA during 1988 and subsequently revised before formal presentation to the National Planning Institute. On 24 November, 1989, Ministerial Resolution 825/89 declared: *'in the public and social interest, the necessity of the development of the National Plan for surveillance and improvement of the quality of drinking water supply services.'*

The aim of the National Plan is to *'contribute to the raising of health standards and the improvement of the quality of life of the Peruvian population served by community water supplies'*. Programmes within the Plan are especially concerned with the under-served populations in low-income areas, both within the urban and rural sectors via the improvement of water supply services.

The National Plan defines those activities necessary for the implementation of surveillance on a national scale in Peru. Activities are divided into core and support programmes. The Plan has been prepared taking into account two broad fields of action: the evaluation of supply systems and components, and the evaluation of service quality.

The results of surveillance are expressed with reference to five key indicators: quality, quantity, coverage, continuity and cost, in order to stimulate progressive improvements towards the following targets:

Quality	Suitable for consumption
Quantity	Sufficient for domestic use
Coverage	Of the greatest percentage of inhabitants
Continuity	All day and all year
Cost	Minimum necessary for adequate operation and maintenance

In addition, sanitary inspection will be used to evaluate the susceptibility of the system to contamination, whether due to poor design, inadequate construction, deterioration, accidental damage or human interference.

Programmes

In order to implement the National Plan for Drinking Water Supply Surveillance, a total of eight programmes were identified·

Core Programmes:

Programme No.1	Sanitary Inspection and Service Quality Evaluation
Programme No 2	Water Quality Analysis

Support Programmes:

Programme No.3	Institutional Development
Programme No.4	Legal Requirements
Programme No.5	Human Resource Development
Programme No 6	Environmental Education
Programme No.7	Epidemiological Surveillance
Programme No.8	Community-Level Surveillance

Programme No 1: Sanitary Inspection and Evaluation of Service Quality

This programme will determine service quality according to the four indicators: quantity, coverage, continuity and cost, and the risk of contamination to which the systems and their components are subjected. For this, standard methods will be adopted alongside a policy of progressive implementation of improvement.

Programme No 2: Water Quality Surveillance

This programme will assess the physico-chemical and bacteriological quality of water supplied for consumption. For this it will be necessary to establish quality standards, a laboratory network, and develop a system of analytical quality control.

Programme No 3: Institutional Development

This programme will establish the organisational structure for surveillance at the central level (DITESA) and at the executive level (health regions). In parallel, institutionalisation of surveillance will be accomplished, including the development of a data management system ie the collection, processing and dissemination of information.

Programme No 4: Legal Requirements

This programme will establish the laws, regulations and standards which will permit the application of sanctions against those agencies which provide inadequate services.

Programme No 5: Human Resource Development

This programme will ensure the adequate training of technical and professional personnel involved in the implementation of surveillance. This includes the preparation of training programmes and modules and their continuous use and revision.

Programme No 6: Environmental Education

This programme will raise the awareness of consumers, especially with respect to household water storage and use in more deprived areas.

Programme No 7: Epidemiological Surveillance

This programme is intended to serve as a means of measuring the potential and actual health benefits derived from water supply improvements stimulated by surveillance activities.

Programme No 8: Community-Level Surveillance

This programme will ensure the appropriate and active participation of the population, especially of the rural and peri-urban areas in the solution of their water supply problems and maintenance of service quality.

Scope of the Plan and stages of implementation

The Plan encompasses surveillance of all community water supplies serving populations greater than 200. At the end of ten years it is anticipated that surveillance will have reached 90 per cent of the population with respect to service quality evaluation and sanitary inspections, and 50 per cent with respect to bacteriological and physico-chemical analysis.

Programme implementation has been planned in two phases. In the first three years, institutionalisation of surveillance will be undertaken and surveillance will be consolidated in the areas where it has already been initiated (Regions Huanca, Grau and Arequipa and the cities of Lima and Callao). Surveillance will also be extended to the regional capitals. A network of regional laboratories will be established and the central laboratory will be reinforced.

In the following seven years, surveillance will be gradually extended to cover the rest of the country.

Institutions involved in water sampling and analysis

Surveillance is the responsibility of the Ministry of Health. The Technical Directorate of Environmental Health (DITESA) is responsible for coordination, planning, supervision and administration at national level. The health regions will be responsible for these activities at regional level and also for implementation.

In cities with more than 50,000 inhabitants, the water supply agency should undertake 85 per cent of sampling and analysis, while the health sector should reserve the remaining 15 per cent. This division of responsibilities obliges the surveillance agency to develop and implement a programme for analytical quality control in order to ensure the reliability of the results reported by the water supply agencies. Figure 13 shows the percentage distribution of participation by supply and surveillance agencies in sampling and analysis.

Institutions involved in water supply improvement

It is important to ensure coordinated action by the institutions involved in water supply in order to optimise the use of human, material and economic resources. The institutions include the National Water Supply and Sewerage Service (SENAPA), the Departmental Water Supply Services (subsidiaries of SENAPA), the Directorate of Basic Rural Sanitation (DISABAR), the National Institute for Municipal Development (INFOM) and the Office of the Prime Minister (Regional Development Corporations).

Coordination will be the responsibility of the National Committee for Coordination of Basic Sanitation (CONCOSAB), which will have responsibility to direct efforts and resources.

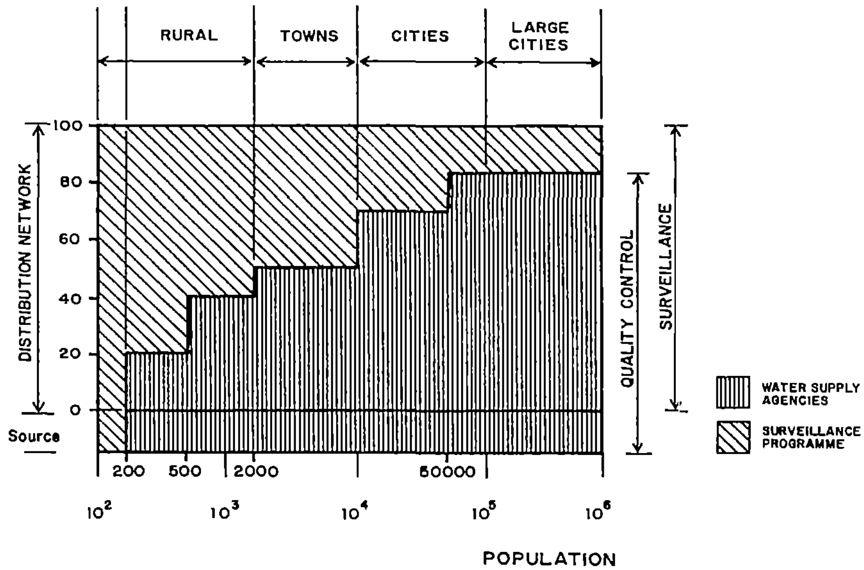


Figure 13: Participation of water supply and surveillance agencies in water sampling and analysis

Impact of surveillance

The overall assessment of water supply services generated by surveillance will be used for the prioritisation of activities and investments in order to optimise increases in coverage, improvements in service quality and the implementation of hygiene education campaigns. These activities will, in turn, be reflected in an improvement in the health and well being of the population.

Cost

The investment required for the implementation of the National Plan for Drinking Water Supply Surveillance is US$9,600,000 over ten years. This represents approximately 0.7 per cent of the investment budgeted for the National Plan for Basic Sanitation for a similar ten year period (US$1,384,028,000).

6 Completion of Terms of Reference

The consultants' terms of reference were modified slightly during the course of the five years of ODA support for the Programme to accommodate changes in the organisational structures and responsibilities of the Peruvian institutions responsible for the health and water supply sectors.

All the individual terms of reference were met and in some cases exceeded They are detailed below, accompanied by summaries of the activities undertaken in their fulfilment.

The Consultants shall provide a team to give assistance and advice to the Peruvian Ministry of Health, Division of Environmental Health (DITESA) to enable it to initiate the following activities aimed at compliance with water supply legislation:

a) Formulate and revise a manual for water supply surveillance procedures.

Appropriate procedures for water supply surveillance were developed for both the rural and urban sectors.

Initial rural surveillance methods were based on the guidelines proposed by WHO (1984). During preliminary activities these were found to be of limited applicability in Peru for a number of reasons (see Chapter 6). Modified procedures and field report forms were developed and evaluated in the central region. Evaluation was preceded by intensive training and accompanied by regular field supervision.

In rural areas, surveillance of piped water supplies was simplified because, in general, each community had a water supply system and communities could therefore be considered as independent units. This is not the case in large conurbations where an interconnected distribution network receives water at a number of points from a variety of sources. Monitoring of urban water supplies has in the past failed to take into account urban fringe areas without a piped supply. Urban fringe areas frequently represent a substantial population It is precisely these populations which suffer the most severe health problems. Thus, they should be a high priority for the surveillance agency.

Preliminary urban surveillance methodologies were evaluated in Lima North and the central region. These were refined and improved before application in Callao (part of metropolitan Lima). The methods were found to be applicable generally and not limited to the area supplied by the distribution network. The methodology can be summarised as a sequence of activities: identification of supply zones, assessment of service quality, sanitary inspection, analysis of results and promotion of improvements.

Development and field testing of preliminary surveillance procedures for the urban and rural sectors was completed in 1988 and led to the formulation of a draft surveillance procedures manual. The manual was evaluated with the participation of Programme coordinators, supervisors and technicians, including some who had been involved in the initial methodological development as well as others for whom the draft manual and accompanying training represented their first exposure to surveillance.

Final review and revision of the manual was undertaken in a four day workshop after nearly two years of evaluation. The result was a comprehensive manual organised in 9 modules totalling 400 pages. Procedures, activities and responsibilities for Ministry of Health staff involved in surveillance are detailed. The manual has been printed in large numbers and is now in use in all regions of the country where surveillance is practised.

b) Train and evaluate the work of sanitary and laboratory technicians involved in water supply surveillance.

During the course of the Programme, considerable effort was devoted to the development of training strategies and evaluation procedures. In addition, the necessary skills for performing these activities were successfully transferred to the responsible national authority, DITESA.

During the first two years of the Programme, most training (both formal taught courses and field supervision) was provided directly by the consultants. This was not the original intention but was unavoidable due the changes in institutional responsibilities and personnel which occurred in the counterpart institutions during this period.

Systematisation of training and evaluation, and their progressive handover to DITESA were undertaken progressively from 1988 to 1990. DITESA personnel are now able to provide this support for all regions of the country involved in surveillance.

The emphasis placed on training resulted in the development of a comprehensive human resource development strategy. Three training modules were developed, evaluated and revised and are now in use by DITESA. The three modules were designed for the training of environmental health technicians, local and regional surveillance supervisors and coordinators, and national and regional directors and managers (the latter from both surveillance and supply agencies).

Evaluation activities were integrated into the human resource development strategy. Special consideration was given to both direct and indirect supervision of the activities of technicians by regional supervisors and supervision of regional supervisors by DITESA's coordinating team. Evaluation methods were incorporated into the surveillance procedures manual.

c) Identify requirements for and promote water quality control at the operator level in the Health Departments.

The preliminary survey undertaken in the central region up to June 1987 identified the problems associated with operation, maintenance and control of small community water supplies. A major constraint on efficient operation and maintenance was the inadequate training provided for operators. Values for some key indicators in the central region are summarised in Table 9 (Chapter 3).

Following reorganisation of the water supply sector in 1986, most training of system operators was undertaken by one of two agencies. DISABAR (The Directorate of Basic Rural Sanitation) of the Ministry of Health provided some training for operators of small community supplies, and SENAPA (National Drinking Water and Sewerage Service) trained their own operators for those larger water supply systems under their control.

In cooperation with SENAPA, the consultants contributed to the training of supervisors and operators of urban water supplies in the central region through formal training courses. SENAPA subsequently expanded this training to national level by a series of regional workshops for which the consultants provided training inputs for personnel of the central and southern highlands.

Support was also provided for training of rural water supply operators by DISABAR in the central region. Evaluation of this experience, however, underlined the inadequate resources dedicated to community development for water supply. There were approximately 450 small community supplies in the central region with a typical turnover for membership of the drinking water committee of two years. Training should therefore be provided for approximately 225 communities per annum, in addition to the continued supervision of all community drinking water committees In 1988/9 training was actually provided by DISABAR for sixteen communities. Supervision, where undertaken, was largely orientated toward cost recovery in recently constructed systems.

Although it is possible to provide training for system operators in the context of a water supply surveillance programme, it is fundamental that the division of responsibilities for training and supervision between the surveillance and supply agencies be observed.

Pilot hygiene education and promotional initiatives were therefore supported. Problems such as misuse of water were identified in communities from the results of surveillance and key remedial messages formulated. Educational material incorporating these messages was produced and disseminated in target communities.

The consultants also participated in the development of audiovisual training modules, together with CARE, DISABAR and CEPIS. The material is currently in use and is aimed at securing adequate operation, maintenance and administration of rural water supplies, together with active community participation for the preservation of the services.

d) Promote and secure the implementation of local and regional water supply surveillance laboratories

A three tier hierarchical laboratory structure has been proposed by WHO (1984) for quality control and surveillance of small community water supplies. This structure was adopted in Peru.

A total of 16 local surveillance laboratories was established. These were based on the OXFAM/DelAgua portable water testing kit plus some back-up equipment (pressure cooker, hotplate and measuring cylinder). This enabled decentralised testing for the key health-related parameters of faecal contamination, turbidity, chlorine residual and pH at a capital cost of about £1100. These parameters are those which should be analysed most frequently.

Additional health-related water quality parameters were identified from WHO (1984). These were classified according to the degree of centralisation required for testing ie either regional or national. Criteria used included the cost of equipment and consumables, frequency of analysis and the degree of analytical sophistication required. The cost of equipping a regional laboratory was estimated at approximately £13,800. Two such laboratories were established by the Programme, one in Huancayo and the other in Lima. These were established with the capacity to analyse hardness (total, calcium and magnesium), colour, turbidity, chlorides, dissolved solids, total solids, pH and sulphate.

At national level, an important inadequacy in DITESA's laboratory capacity was their inability to analyse for pesticides and organic compounds in water. In the last phase of the Programme a gas liquid chromatograph was installed and commissioned in the national laboratory.

e) Promote and develop water supply surveillance data reporting at regional and national levels.

The efficient reporting and interpretation of data are important components of an effective water supply surveillance programme and vital to the rational prioritisation of improvements in services.

Despite the problems of communication inherent in Peru's geography and population distribution, reporting within the surveillance structure was fairly effective from the beginning of the Programme.

Reporting of results to communities was problematic at first. This was partly due to the delay between sample collection and obtaining results. But more importantly, it was often impractical to send results to rural communities. It was frequently necessary to deliver reports in person. This was largely overcome by the use of portable equipment which enabled technicians to visit a series of communities on successive days without returning to a laboratory base. Thus, technicians were able to process samples and report results directly to the community.

Local reporting encourages the community to undertake simple remedial measures and where appropriate, enables them to formulate requests for assistance from construction agencies. However, more sophisticated data interpretation and management is essential for the formulation of remedial strategies at regional and national levels. Requirements at regional and national levels are different, and complementary strategies were adopted accordingly.

Procedures for regional data storage, analysis and follow-up of reports were developed and tested during the Programme. They are detailed in the surveillance procedures manual. At this level, strategies for improvement are based largely on the prioritisation of supply systems according to health risk. A combined risk analysis using the results of both water quality analysis and sanitary inspection was developed and is described in Chapter 5.

At national level, policy development depends on an overall understanding of trends and recurrent deficiencies in order to orientate investment and training strategies. To facilitate this understanding, a comprehensive national database was developed with DITESA.

In addition, the adoption of appropriate remedial strategies was promoted directly by the publication of quarterly information bulletins by DITESA with the support of the Consultants.

f) Identify priority areas for rehabilitation and monitor the progress of improvement of rehabilitation and maintenance of water supply systems in response to reported data.

In the rural sector, the results of the preliminary survey in the central region highlighted a number of deficiencies in rural water treatment.

Fundamental problems were identified in the selection of technologies for rural water treatment. Promotion of treatment plant rehabilitation, often with the incorporation of roughing pre-filtration (as a protective stage before slow sand filters) was therefore undertaken. The existing water treatment plant serving the community of Cocharas was rehabilitated and horizontal roughing filters were constructed. This plant was the subject of prolonged evaluation with the participation of DISABAR personnel.

Following the reporting of the results of the preliminary survey and the rehabilitation of the Cocharcas treatment plant, DISABAR initiated a series of policy changes. Construction of rural treatment plants was temporarily suspended and further training was provided for regional engineers. This was followed by an increase both in rehabilitation and in roughing prefilter construction. The sequence of events is described in Chapter 3.

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APPENDIX 1
Example Field Report Form

Drinking Water Supply Surveillance Programme

A) Location

Code: ... .
Community .. ..   District ... .
Province .. ..   Department ... .
Date of Visit . ...   Inspector . ...

B) General

In the last two years, has there been a visit by the hygiene education campaign? Yes ( ) No ( )

Population
- Number of dwellings . .. .
- Total Population .. ..

Sanitation (dwellings served by)
- Sewerage ....
- Private latrines ....
- Public latrines ....
- Septic tanks ... .

C) Drinking Water Supply

Tariff and Funds
- Is there a tarriff for domestic use? yes( ) no ( )
- Monthly tarriff for domestic use I/ . . .

Operation and maintenance
- Is there an operator? yes ( ) no ( )
- Has the operator received specific training? yes ( ) no ( )
- Hours worked per week: on demand ( ); <4 ( );4-10 ( ); 10-20 ( ); >20 ( )
- Does the operator have tools? yes ( ) no ( )

Distribution network (dwellings served by)
- Standposts ....
- Domestic connections . . ..
- Are the leaks visible in the network? yes ( ) no ( )

D) General Sanitary State of Community

Visits to households with domestic connection (mark with x)

No	Service Level					Continuity			State of connection		
	Tap		Facilities			hours per day	days per month	months per year	Wastewater Disposal		
	in yard	in house	sink	shower	storage cyl				infiltrates	ditch	pipe
1											
2											
3											
4											
5											
6											

Visits to households supplied from standposts

No	Continuity			State of Standpost			Household Storage								
	hours per day	days per month	months per year	Wastewater Disposal			Distance to Stand post (m)	Collection		Storage			Handling/removal		
				infiltrates	ditch	pipe		Visits per day	Vol per visit	Tank? y/n	State of Tank Lid?	State of Tank Clean	any container	specific container	tap or syphon
1															
2															
3															
4															
5															
6															

General

Drainage for main roads? yes ( ) no ( )

Indiscriminate defecation? yes ( ) no ( )

E) System Evaluation

Aduction Line (reservoir to distribution)

Leaks? Y N

Reservoir

N° ....

Sanitary lid Y N

- locked Y N

Overflowing? yes( ) no( )

Total volume ......m^3

Disinfection

Equipment? Y N

Stock of chlorine? Y N

Operating? Y N

Conduction line (source to reservoir/treatment)

Leaks Y N

Pressure break boxes

Exist yes( ) no( )

- sanitary lid Y N
- locked Y N

Type of System:	GNT	GWT	PNT	PWT

Water Source:	spring captured in eye/infiltration	answer 1 only
	Well	answer 2 only
	Surface water, no treatment	answer 3 only
	Surface water with treatment	answer 3 and 4

1	Source type: Spring ( ); infiltration ( )				
	Protecting plinth?		Y	N	
	Sanitary lid?		Y	N	
	- locked?		Y	N	
	Wall or fence against animals/intruders?		Y	N	
	Ditch against surface run off?		Y	N	
	Overflowing?	yes( ) no( )			
	Excreta disposal within 50m			Y	N
	Source flow	.. .. .. .l/sec			
	Intake flow	. ..... l/sec			
2	Pumping shed?		Y	N	
	- locked?		Y	N	
	Pump properly mounted on concrete plinth?		Y	N	
	Well opening open?			Y	N
	Excreta disposal within 50m?			Y	N
	Pump flow	..........l/sec			
	Hours pumped	..........l/sec			
3	Source: spring (downstream) ( ), river ( ) stream ( ) infiltration gallery ( ) irrigation canal ( ) other				
	Catchment accessible to animals or people?			Y	N
	Excreta disposal within 50m			Y	N
	Flow control?	yes( ) no( )			
	Filter bed intake?	yes( ) no( )			
	a) Pumped				
	- pump flow	..........l/sec			
	- hours pumped	..........hrs/day			
	b) Gravity				
	- source flow	.. ..1/sec			
	- intake flow	.. . .1/sec			
4	Wall or fence against animals/people		Y	N	
	Locked?		Y	N	
	Excreta disposal within 50m			Y	N
	Floculation/coagulation practiced?	yes( ) no( )			
	- equipment for dosing	yes( ) no( )			
	- mixing zone	yes( ) no( )			
	- coagulant stock		Y	N	
	- hydraulic floculator				
	Sedimentor(s) - exist?	yes( ) no( )			
	- N^{o}	... . .			
	- diffusing baffle			Y	N
	- outlet occupies all width			Y	N
	- dimension (m) L...... W ..... D......				
	Pre-filters?	yes( ) no( )			
	Filters - exist?	yes( ) no( )			
	- rapid sand	yes( ) no( )			
	- slow sand	yes( ) no( )			
	- N^{o}	...			
	- dimensions (m) L .... W.. ..			Y	N
	- less than 60 cm sand depth?		Y	N	
	- minimum head mechanism?				

F) Results of Analysis

Sample Site	Turb-idity	Free chlorine (mg/l)	pH	Faecal Coliform			Sample taken for p-ch analysis(I)
				Volume filtered	No Colonies	F C per 100ml	
1 Systems with Treatment 1.1 Source 1.2 Plant outlet							
2. Spring(s) Spring 1 Spring 2 Spring 3							
3. Well							
4. Reservoir							
5. Distribution 1 2 3 4 5 6							

(1) Indicate analysis required physico-chemical ( ), metals ( ), organics ( )

Observations

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Signature of Community Authority Signature of Inspector

DelAgua

A group of scientists and engineers with a special interest in water supply, sanitation and public health formed DelAgua in 1984 as a private non-profit making organisation dedicated to the promotion of the improvement of drinking water supply services in less developed countries. Although DelAgua was originally formed in the UK, it now operates primarily as a non-governmental organisation in Peru working for the Latin American Region.

The objective of the organisation is to contribute to the improvement of public health based on research and practical work in the fields of water supply, hygiene, and management of waste.

The activities of DelAgua include:

Surveillance and Control of Drinking Water Services

- practice and training for managers, professionals, supervisors and technicians;
- practical work in the field undertaken by personnel of professional and technical organisations; and
- supply of equipment and consumables.

Research, Development and Technology Transfer in the Field of Water Supply and Sanitation

- practice and training at professional and technical levels;
- design, construction and evaluation of water supply and wastewater and excreta disposal; and
- wastes management.

For further information contact DelAgua at:

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The Robens Institute

The Robens Institute is a World Health Organization Collaborating Centre for the protection of drinking water quality and human health and as such actively supports the work of WHO, particularly in developing countries, by the following activities:

- collection, evaluation and dissemination of information related to drinking water quality, its measurement and control;
- standardisation of approaches, methods and equipment for the surveillance and assessment of water quality;
- development and field testing of appropriate technology for water analysis and treatment;
- provision of analytical reference material and expert consultancy services, particularly for developing countries;
- participation in and coordination of collaborative research on the assessment of water quality and related health consequences, including promotion of research in developing countries;
- participation in and organisation of inter-regional, regional and national training activities for public health and water industry personnel in developing countries.
- cooperation with other national and international organisations concerned with various aspects of water quality and human health.

The Robens Institutes Overseas Development Service is particularly concerned with the protection of human health and the environment. For example, programmes have been undertaken in risk assessment, environmental surveillance, water supply, sanitation and hygiene education. Staff have been involved in research, training, project design, evaluation and management. Since 1984, water testing equipment and low-cost consumables for water quality testing have been supplied to more than 50 less developed countries.

The Robens Institute has expertise in a wide range of disciplines, including environmental health, psychology, ergonomics, occupational health and safety, environmental policy (including impact assessment and auditing), analytical techniques, toxicology, epidemiology and law.

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