Case study: Drinking water supply system for rural population of Eastern Tucuman, Argentina (#437)

Description

The Eastern area of Tucuman province was faced to significant problems of “unsafe water” and inappropriate drinking water supply system. The shallow wells were contaminated by arsenic and other harmful pollutants. Several studies were conducted to solve the problem of insufficient drinking water supply mainly in small rural communities.

Action taken

The provincial government invited the National University of Tucumán to develop a feasibility study and technical projects for a community of 25,000 inhabitants. The University involved lecturers, researchers and students to develop this complex project. It was essential that IWRM aspects were employed: the interdisciplinary approach given to the study, analysing the water resource available, its demand and the evaluation of the best economic and technical alternatives.

The project team conducted a complex study including technical solutions, institutional arrangements of future water supply operation. Both ground and surface water resources were assessed to be used for drinking water purposes. The technical and financial justification favoured the ground water sources. The outcomes of the project contain also non-structural proposals targeting to endow sustainability to the solutions (creation of Cooperatives to manage the services) involving the services users in their management.

Learned lessons

The main lessons are related with the need to develop Water Resources (WR) policies designed to optimise the resource utilisation, and that while developing a sectoral approach, this matter doesn´t leave aside the IWRM nor waste external funding sources opportunities (with a non-refundable nature) in conjunction with the local authorities contribution.

Case importance for the IWRM

In this case, two aspects which are normally not faced together but contrary are prioritised. On one hand, the necessary studies to achieve the basic water resources knowledge in order to have reliable, systematic and normalised information within the hydrological water cycle as well as the water quality and quantity corresponding time-space distributions, for their utilisation as a baseline for future studies. On the other hand, the execution of specific projects to give solution to the health problems together with the future sustainability of water services through the Civil Organised Society participation.

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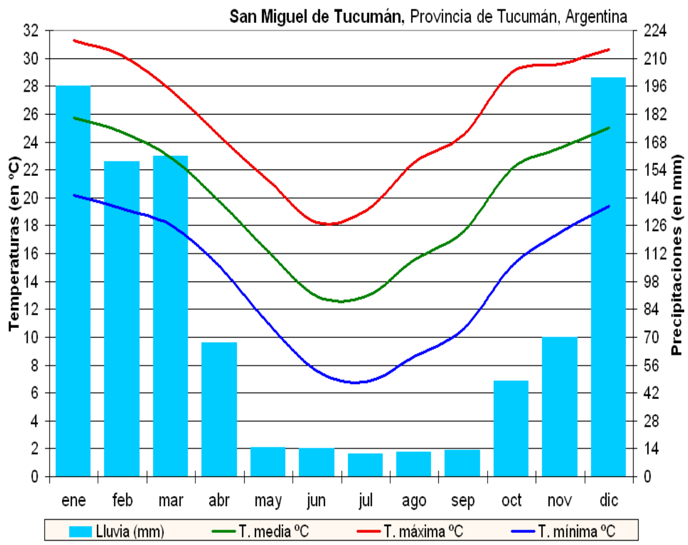
1. Problem Description

Tucumán province is the federal state with the smallest area (22.524 km2) and the highest demographic density of Argentina (population of 1.5mil). It is located in the Northern part of Argentina and has an extreme annual precipitation pattern, vegetation and topographic irregularities caused by the unequal spatial water resource distribution.



The entire province has a seasonal rainfall regime of four rainy months (December, January, February and March) in which almost the 80 % of the annual precipitation is produced.

The Eastern area of the province has scarce surface water resources. The groundwater resources are relatively important, but they present limitations for their use due to their high salts content, arsenic included.

This area, from the social and economic point of view, presents lower indicators than the province average, being the region's departments (Administrative divisions) the most deserted and with a population with unsatisfied basic needs indices (UBN)[1] greater than the provinces' media.

Specifically, small rural communities and areas of scattered population rely on self-supply drinking water systems with shallow individual wells. Some communities have collective drinking water supply infrastructure in place. The main detected problems are the water uptake through shallow, vulnerable and polluted profiles (up to 30 m) and the existence of variable flows with the presence of incompatible elements, both organic and inorganic (arsenic), for drinking water and without the adequate treatment for its use.

Cuencas Superficiales

2. Action taken

The Provincial Government applied for funds from the Andean Promotion Corporation (*Corporación Andina de Fomento*) - today the Latin America Development Bank (*Banco de Desarrollo de América Latina*) - to develop a feasibility study. The funds were part of an agreement on technical cooperation. The Tucuman Government decided to hire the National University of Tucumán to perform the job, an institution that has almost 100 years experiences in graduate, postgraduate and extension study programs.

[1] Unsatisfied Basic Needs (UBN) is a direct method to identify critical gaps in a population and characterizes its poverty. Usually used indicators directly related to four areas of basic human needs (housing, sanitation, basic education and minimum income), available in the censuses of population and housing.

The Provincial Executing Committee (*Unidad Ejecutora Provincial*) was established to oversee the project.

The agreement foresaw the information review obtained from local and provincial authorities, the presentation of a critical analysis of the sanitation and the water infrastructure situation in the scattered rural population of the Eastern part of the Province with its corresponding diagnosis and alternatives presentation.

The consultancy had to perform a study on water supply and demand in the settlement areas of the affected population. The presentation of proposals for the water use, from surface or groundwater resources was requested, considering the technical, financial, institutional, legal and environmental viability of the different alternatives. A feasibility study also included construction details, technical specifications, budget, financial resources and implementation schedules for the selected alternatives.

What's more, the presentation of specific proposals to improve the sanitation conditions to avoid that water problem solutions generate sanitary problems by the handling of household effluents was required.

The University, decided to create a multi-disciplinary working team formed by professionals covering all the involved aspects and conforming, by operational reasons, sub teams linked to three knowledge areas - social sciences, natural sciences and technologies.

In these teams, students, researchers and professors of different levels worked together allowing not only the extension tasks made by the professionals, but also the practice, the knowledge acquisition and their application to real life problems by the advanced students of the different careers.

Regarding the province government, an inspection and follow commission of the tasks guided by the cited URP was created and different provincial organizations with direct relationship with the subject participated. This commission worked together with the University team presenting policies guidelines, offering pre-existing information, flattening the communication with the local authorities and making the tasks execution possible to achieve the appointed goal.

3. Results

3.1 Situation analysis

The absence of basic general information about drinking water supply existing infrastructure was observed due to institutional changes at provincial administration.

Regarding the natural environment, a great amount of regional information was collected along with specific studies with different approaches. The need to perform specific studies was detected, being the main target for the determination of the presence of water, both in quantity and quality, in order to be used for its supply.

The province stands out for its wealth in water surface and groundwater resources. This is mainly due to important fluvial precipitations in the summer season, allowing the creation of permanent and transient channels and an excellent recharge in the highlands and the valleys. This contributes to a feed in the Eastern plain, where the study area is located, important deep aquifers giving very good flows with great chemical ability for most of the requests (irrigation, industry and human consumption). The water obtained in this environment is in general of good quality, with an increase in salt content to the East, as well as arsenic content in most superficial levels, generally at about 30 m depth.

ARBOLES GRANDES – La Madrid

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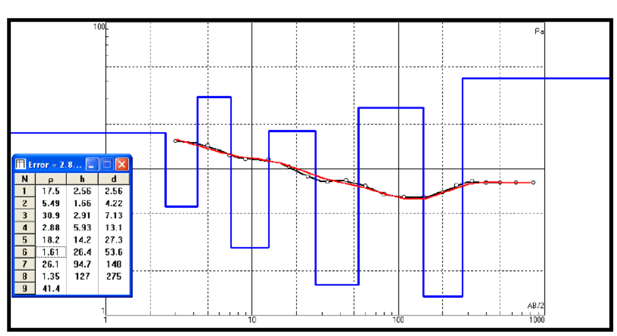

In the Eastern plain basins, due to its hydro geological conditions, the water abstraction for drinking water supply is convenient to be through perforation. Deep perforations may coexist along with shallow perforations under the riverbed of certain rivers like the case of Río Calera.

The typology of the geological profile, the topography, the rain regimen, the permeability conditions, the aquifers vulnerability index and the human burden play an important role in the type of resource to use, whether it is ground or surface water.

The conclusions indicated that the groundwater sources are not uniformly distributed, but appear in deposits of more or less abundance according to the profiles of the sedimentary package.

San Pedro de Colalao – Depto Trancas

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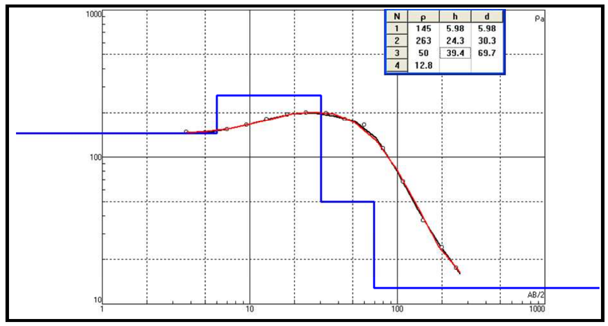


Due to the existence of hydro geological variability, homogeneous areas were determined in order to give similar solutions for each of them. Fifteen areas were determined, some of which included 10 to 12 interest locations and some of them only one.

For each of them, a series of studies with geoelectric polls were performed. These were located in suitable predetermined areas for the creation of wells, either for their vicinity to the population with the highest concentration, or to educative centres, public health centres, administrative centres, and to the legal entitlements to lands (State lands or privately owner's lands with donation records).

Furthermore, when perforations in the places of study or in their surroundings were found, water sample extractions were performed to have a complete physical - chemical analysis in order to evaluate its aptitude as drinking water source.

Socioeconomic analysis showed a deep social transformation comparing the data of the last census (2001). Thus, information from official census were insufficient to assess water demand and supply needs. Therefore, a survey on socio-demographic and socioeconomic population aspects and dwelling features were conducted.

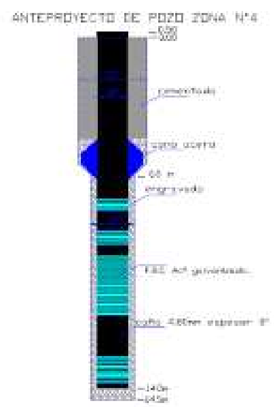
3.2 Alternatives Evaluation

With the obtained data and taking into account the different surface and groundwater exploitation alternatives a comparison of both possibilities was performed.

Water source	Surface water	Groundwater
Seasonal features	**Seasonal variation:** Flows with great seasonal variations depending on the registered rain amount.	**Constant:** Slight variations occured by the lack of aquifers recharge in the winter season.
Regional Location	**Not coincident:** in the plain area, in the East of Tucumán, there aren´t permanent surface water riverbeds.	**Coincident:** the East of the province is the area with the best deep aquifers development that can be beneficial for perforations.
Vicinity to population	**Far away from population:** The water course requires conduits and pumping works, in order to be able to perform the supply.	**According to convenience:** the perforation may be almost always performed where convenient, in order to construct less distribution nets, handle pressures and use existing power lines.
Contamination Risk	**High:** sensitive of being easily contaminated, especially in rivers of great length that flow	**Low:** the groundwater abstraction is performed from deep aquifers that according to the

	through industrialised or populated areas.	performed vulnerability analysis have a low vulnerability index.
Maintenance	**High:** The abstractions are located in seasonal rivers with great energy demand in summers. This generates a high risk of partial or total destruction the infrastructure and permanent reconstruction during the rainy season.	**Low:** the elements for the normal operation are held stable. Although pumping equipment problems may appeared, nor is the infrastructure neither the perforation destroyed.
Specialised conduction manpower	**No:** Although a constant maintenance is required, the staff work is limited to maintain the infrastructure or control the water entrance by opening or closing the gates.	**No:** the operation of the pumping equipment with submersible pumps implies counting with some basic electricity and hydraulics knowledge whereby trained staff is necessary.
Electric Energy Demand	**Relative:** if surface abstraction can be built with a dominant level, the gravity distribution can be performed, otherwise pressurised pumping is required.	**Constant:** the power to feed an electric pump is needed according to the well parameters and the distribution net features.
Complementary Facilities	**Higher size:** border enclosures, gates, blasters and treatment plants that need greater surface are required. Not always there is land available.	**Reduced size:** a perforation, with its head, command box and elevated tank can be built with ease in 10 x 15 m terrains, which are easily obtained either by donations or by locations within public spaces.
General Conclusions	• An adequate quality control for its seasonal variability must be taken into consideration. • The treatment system must be dimensioned taking into account the most critical months that makes the work expensive.	• Specific knowledge of the quantity and quality of drinking water in the different reservoirs is obtained. • The depth of wells, quality of the aquifers and a good execution of wells is important.

According to the hydrogeological studies performed and their conclusions, the drinking water supply system through the catchment of groundwater was considered as the most appropriate alternative.



Most of the analysed cases are solved through deep sources whose design is justified in the quoted studies. In those cases, according to the different areas in which the province was subdivided, different types of wells were considered taking into account their depth, filter and diameter disposal.

The necessary complementary facilities were projected in order to give a service with quality, universality and regularity features.

3.3 Technical design

The technical report was arranged with the provincial government and included the application standards, design horizon, calculation methodology, parameters to be adopted, calculation tools, results to be presented, reference system of maps, their content and nomenclature to be used, price analysis format and its content, budget, work schedule and investment phases.

Several activities were performed to be included into a technical report:

- A filed trip and consultation with local administration.
- Visual survey of the current situation and topographic altimetry study with the latest GPS technology.

- Compilation and systematisation of the gathered and province supplied information. Preliminary analysis.
- Particular information survey for the project through survey instrumentation in 39 locations. Socio-demographic and socioeconomic population aspects and dwelling features were surveyed.
- Results analysis and demographic growth projections elaboration.
- Calculation of the future demand based upon population studies, endowment and agreed calculation coefficients.
- Calculation and design of complete services projects following the agreed technical parameters.
- Budgeting of the project according to province financial guidelines.
- Technical and graphical documentation elaboration.

The net calculation takes into account the future population needs. However, the design of sections was not constructed in this stage and remained considered for the future when financing source will be available.

Technical parameters considered in these projects

The design period considered is 20 years, which was scheduled with the "Provincial Executor Unity (*Unidad Ejecutora Provincial*). As for the future estimated population distribution, the forecast follows the current trend in a population growth.

A minimum diameter of 63 mm PVC pipes and a service pressure of 6 meters water column were applied. These were selected according to the Provincial Executor Unity taking into account the rural area features and the morphology of the dwellings that only exceptionally reach two floors. PVC pipes with elastic joints were adopted. Through calculation, the existence of the minimum adopted pressure was verified. It was also verified that in the regular exploitation regime the speeds were within the stated limits.

The design of the distribution of the water net is of a mixed kind in most of the cases. It generally has a main stretch that crosses all the Project area and from which ramifications that follow the trace of the streets where there is settled population are derived. When possible, in places where the streets were opened and where the closure stretches didn´t imply great lengths without served population, closed meshes were designed.

The hydraulic net calculation was performed employing the EPANET 2.0 hydraulic simulation program which has been developed by the “Water Supply and Water Resources Division of the U.S. Environmental Protection Organization’s National Risk Management Research Laboratory”. This software is free and allows riposting the results at any time and place allowing its easy verification or net modification when necessary.

The installation of the net operation instrumentation such as lock sectioning valves, air valves in the highest points of the net, the installation of drain valves and at least one hydrant, was foreseen.

The gauge height in Hm was calculated, which jointly with the design flow, allow the determination of the necessary pump to equip the well at each location.

Each project was endowed with an elevated tank of 15 m^3, in order to guarantee a fixed reservoir capacity, which covers the variable percentage value indicated for these cases, which is 25 % of the daily volume according to the Project guidelines. Besides covering a part of the service reservoir needs, the tank is also useful to soften the pumps outbursts and stops increasing its service lifespan and the one of the pipelines.

For the elevated reservoir, the support structure and the foundations design and calculation were performed, taking into account the data from the geological and edaphic studies regarding the soil support capacity and seismicity. With this calculation, the structure was dimensioned. As for the barrel a PRFV tank was selected since its features and ease of mounting make it suitable for its implementation in rural areas, avoiding the need for demanding technologies which sometimes aren´t available in such rural areas (concretes with additives, high formworks, etc).

Complementary facilities such as box commands, electric boards, disinfection facilities, security fences, etc., were also designed.

With the performed design for the different service components, the Metric Computation per unit of measurement was performed.

With the agreement of the Province Inspection the prices analysis structure and its basic components were ruled and the unitary analysis for all the projects was standardised. The input values were obtained from consultations to several suppliers in San Miguel de Tucumán, in July 2010. With the relevant price analysis, the budget was determined. Due to an administrative budget limitation, the water supply net had to be redesigned, not considering in this stage some net stretches, so that the performance of the missing stretches was possible without the need to waste the performed initial investments.

Maps with topographic data, net scheme, knots details and standard maps for the rest of the project structures were performed.

As far as investments evaluation is concerned, the calculations were based upon budgets elaborated for each project.

Socioeconomic Evaluation

Taking into account the budgets, the cash flows were elaborated, which in turn allowed both a private and social evaluation of the projects.

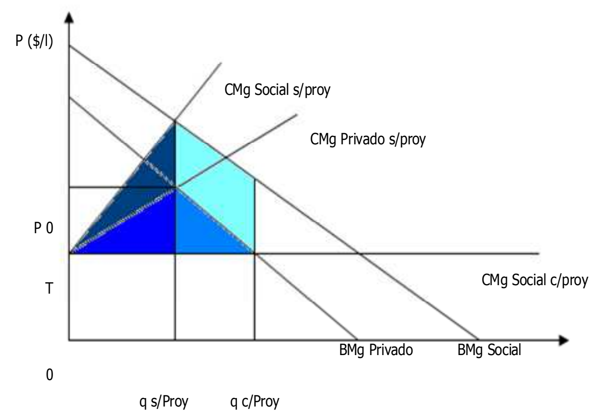
The social evaluation of the project comprises social investments valuations, maintenance and operational costs and income costs generated by the project from a social point of view using different shadow prices calculation methodologies. Three alternative methodologies were analysed and due to feasibility issues only the two latter were studied in detail:

a. Contingent Valuation Method

b. Hedonic Prices Method

c. Benefit and marginal costs method

Figura



As an example, the figure presents the estimation of social benefits generated by a drinking supply that removes the existing inefficiencies in poor households.

Diagnosis and institutional proposal

Progress was done in the elaboration of an institutional model proposal for the services management, taking into account the new paradigms in relation to the water access.

- Water access and sanitation are human rights.
- Drinking water and sanitation are structural health and development human sustainable instruments.

- Drinking water plays an essential role for life, for public health preservation and for the fight against poverty.
- Public services decentralization. In the water and sanitation subject, the community participation and the community management are promoted as key answers to maintain the drinking water and sanitation rural services.
- With this approach, the management rests in the very users who participate in the projects planning and implementation, with the presence of the State, through its organizations, in promoting them and providing technical support in the operational and resource management aspects.

Under these principles institutional model considered a cooperative management. The term “cooperative” designates an autonomous association of people voluntarily united to satisfy their needs and economic, social and cultural aspirations in common through a jointly owned company and of democratic management.

The cooperatives and organizations of social economy have consolidated their active presence in different economy sectors, with a large attention trajectory to the most various social problems, net integrated and committed with the local development.

Thus:

- A survey and analysis of the organizational and management structure of the regional and local supply entities responsible for the supply, administration and operation of the current drinking water and sanitation services was performed.
- Alternative management models, taking into account the advantages and weaknesses, organizational costs, operating costs, economies of scale and financial systems through taxes fixation were presented.
- For the elaboration of cash flows, rate schemes were presented, according to the demand analysis that ensures the economic sustainability and the normal operation in time of each of the projects.

Documentation

The presentation of the 76 Drinking Water Supply Projects was materialized in one folder per Project in order to allow the Province to have them individually in order to proceed with their execution when appropriate considered. Each Project folder includes:

- Descriptive report and Calculation report
- Technical Computation and Budget
- Work Schedule and Investments curves
- Maps

Furthermore, common documentation to all projects was separately delivered. It includes prices analysis, elevated tank structure calculation, standard maps and other folders.

4. Lessons learned

In this case different essential IWRM aspects were employed, from the interdisciplinary approach given to the study, analysing the water resource available, its demand and the evaluation of the best economic and technical alternatives to give solution to an eminently social problems linked to the quality life and the population hold to its habitat.

The study concluded with concrete structural proposals (civil work schedules) in a suitable format to receive funding. It also contains non-structural proposals targeting to endow sustainability to the solutions (creation of Cooperatives to manage the services) involving the services users in their management without implying a State withdrawal of its basic obligations but users right and collaboration in the services administration favouring the water governance.

In the final work, sanitation actions to avoid negative environmental impacts due to the installation of drinking water systems without contemplation of the treatment and disposal of its effluents are proposed.

A weakness of this study is the lack of exhaustive consideration of other water uses in the area (especially irrigation), but its analysis was beyond the objectives and economic availability to perform the works. However, the basic gathered and interpreted information about the water resources vulnerability and availability constitute concrete and detailed basic information, essential for this future analysis and that was inexistent before the performance of these studies.

The active participation of the different sectors, in the tasks planning and execution with the decided involvement of the State and the call to the "local academy" to lead on basic studies, to interpret them and proposing practical solutions with concrete results, achieve a synergistic involvement between the different sectors involved in the decision of solving a concrete and crucial problem for a population sector, in order to allow its social inclusion without the uprooting of its inhabitants.

The present study case is enrolled within the Global Water Partnership mission of supporting the sustainable development and the water resources management, respecting its adopted principles and achieving the proposed targets since:

1. It promotes the water use as a key element for the sustainable development, putting emphasis on an integrated approach, good governance, and the achievement of an adequate infrastructure with sustainable funding to help achieving the growth and water security.
2. Addresses development challenges, defining and proposing solutions to problematic such as public health and the urbanization creating conditions so that the population settles in its area with worthy living conditions fighting one of the high morbidity causes.
3. Reinforces the knowledge, its exchange, developing the ability to share knowledge and its transfer from the academic environment towards the State organizations and the very users.

Also various Toolbox tools are used, especially the ones linked to the policies (A3.2 funding options I), to the institutional roles (B1.06 Service suppliers, B1.10 Local authorities) and the management instruments (C1.1 Base water resources knowledge, C1.2 water resources evaluation).

This is an experience that we hope to repeat, also in other regions, with an equivalent participating scheme, as for other problems linked to the IWRM in the same context.

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Websites and references

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http://www.bancomundial.org/publicaciones/

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