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Sustainable Groundwater Management
Lessons from Practice

Case Profile Collection Number 4

Argentina: Mitigation of Groundwater Drainage Problems in the Buenos Aires Conurbation

Technical & Institutional Way Forward

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The objective of this GW•MATE action was to define the profile of a project to address the major groundwater drainage problems widely being experienced in the Buenos Aires conurbation, for possible inclusion in a World Bank-supported national urban infrastructure portfolio. In view of the urgency and sensitivity of the issues under consideration, the assessment was developed through a series of individual consultations. Data was obtained from a variety of unpublished sources together with some published technical papers by Instituto Nacional del Agua staff.

INTRODUCTION TO DRAINAGE PROBLEM

Hydrogeological Setting

- Buenos Aires, and neighboring areas on the Pampa Humeda, have long experienced surface water drainage problems, following periods of exceptionally intense rainfall, as a result of the general terrain characteristics (compounded by the effects of engineering construction and inadequate maintenance).

- However, drainage problems have become much more widespread and persistent in many parts of the conurbation in recent years, as a consequence of a substantial and sustained rise of groundwater levels in the underlying aquifer, such that they are now very close to the land surface in many localities.

- The rise in groundwater levels is associated with the progressive elimination of local water wells from the urban water-supply network, with increasing import of water-supplies from the Río de la Plata, and to lesser degree with reductions in pumping from industrial water wells due to economic decline.

- The groundwater rise has caused flooding of basements, rising damp in domestic dwellings, malfunction of in-situ sanitation systems, overloading and overflowing of sewers, and disruption to the urban infrastructure. The associated social distress, health risk and economic cost in the districts concerned (primarily the inner suburbs with a total population of over 3.5 million) continues to escalate, but actions to mitigate the problem (although well-intentioned) have thus far been piecemeal.

Institutional Situation

- The current institutional position is fairly complex and is summarized in Table 1, although some changes may occur as a result of recent government re-organization.

Table 1: Summary of current water-sector institutional arrangements

INSTITUTION	LEVEL OF OPERATION/ JURISDICTION	AREA OF COMPETENCE/ RESPONSIBILITY
FEDERAL GOVERNMENT		
Secretaria de Recursos Hídricos (SRH)	both currently under Ministerio de Infrastructura y Vivienda with national policy overview responsibility for their respective areas and for issues affecting more that a single province	national water resources policy, planning and finance
Secretaria de Obras Publicas (SOP)		national public works policy, planning and finance
Instituto Nacional del Agua (INA)	semi-autonomous national agency under SRH, with headquarters in PBA	substantial capacity in water resource (incl groundwater) investigation and databasing
Ministerio de Salud Pública (MSP)	federal government ministry with national policy overview	reducing health risks associated with drinking water quality and wastewater disposal
Ente Tripartito de Obras y Servicios Sanitarias (ETOSS)	inter-provincial independent water-services regulatory agency	harmonization of water-service provision across some inter-provincial boundaries
PROVINCIAL GOVERNMENT		
Autoridad Provincial del Agua (PBA-AA)	semi-autonomous authority created by government of Buenos Aires Province	defining water resources policy, regulating water use and promoting resource management
Organismo Regulador de Agua Bonaerense (ORBA)	water services regulator at Buenos Aires provincial level	regulate tariff structures of water-service companies and vigilate continuity/quality of their services
Gobierno de Capital Federal (GCF)	provincial government (council and executive) for the federal capital	includes division dealing with new public works and maintenance of engineering infrastructure
PRIVATE SECTOR		
Aguas Argentinas (AASA)	main water services concessionaire for most of Gran Buenos Aires	
Aguas Bonaerenses (ABSA)	water-supply concessionaire for the city of La Plata and most of the contiguous south eastern districts of Gran Buenos Aires	
Aguas de Gran Buenos Aires (AGSA)	water-supply concessionaire for some outer northern districts of Gran Buenos Aires	

TECHNICAL DIAGNOSIS OF PROBLEM

Underlying Hydrogeological Conditions

- The hydrostratigraphic sequence underlying a broad belt along the southern side of the estuary of the Río de la Plata (including the Buenos Aires Conurbation) is illustrated in Figure 1 and detailed in Table 2. Although some groundwater can be (and is) widely extracted from the blanket of Pampeano loessic sediments, they essentially act as a 'rather leaky surface aquitard' (with a phreatic water-table) overlying the much more productive Puelches Aquifer below, which is usually encountered at between -15 to -25 m MSL.

- Over large areas of Buenos Aires Province (and beyond) the Pampeano Formation effectively forms the land surface. The 'relic dune structure' of the Pleistocene Superior can be recognised over large areas in satellite images, and the 'interdunal lows' are those most frequently subject to flooding today.

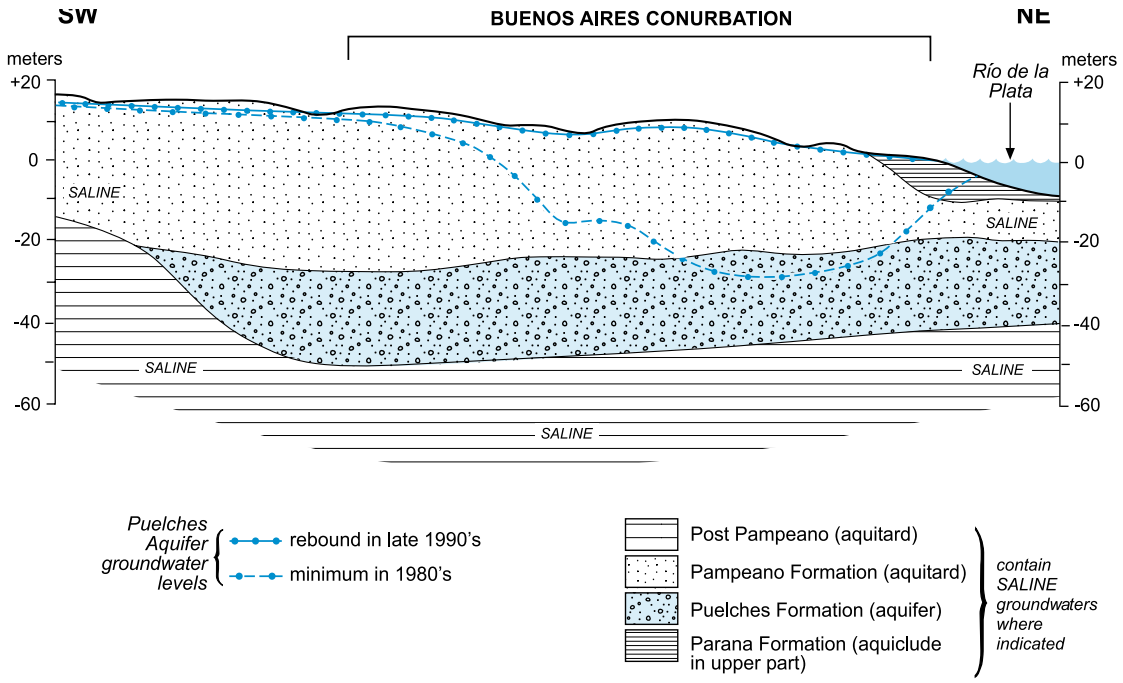
Table 2: Hydrostratigraphical sequence below the Buenos Aires conurbation

GEOLOGICAL FORMATION	DEPTH RANGE (M MSL)	ORIGIN & CHARACTER	HYDROGEOLOGIC ROLE
Pampeano* (Epipuelches)	down to about -25 m maximum	sandy silts of mainly wind-blown loessic deposit	weak aquitard or low-yielding aquifer; no major natural quality problem although can contain some arsenic or fluoride derived from incorporated volcanic dust
Puelches	from -15/-25 m to -50 m maximum	mainly medium sands of fluvial deposition	major aquifer, well flushed with good natural groundwater quality, but sometimes lower quality associated with induced leakage from above
Parana (Hipopuelches)	from -40/-50 m	Marine clays overlying fine sands	upper part forms aquiclude base to Puelches Aquifer and lower part contains saline groundwater

* locally overlain by thin cover of Post-Pampeano estuarine silt deposits

- While the quality of groundwater in the Puelches Aquifer within the Buenos Aires Conurbation is generally high, brackish groundwater is present at depth in the underlying Parana Formation. Moreover, saline groundwater also occurs both:
  - within the Pampeano Formation inland in Buenos Aires Province (at distance from the Río de la Plata)
  - locally in the Post-Pampeano Formation along the existing estuary of the Río de la Plata and groundwater from the Pampeano (and thus the Puelches Aquifer) can also contain somewhat elevated natural concentrations of arsenic and/or fluoride.

Figure 1: Schematic hydrogeological cross-section of Buenos Aires Conurbation
(vertical exaggeration x20 approx)



Evolution of Groundwater Abstraction

- Over many decades a significant proportion of the water-supply of the Buenos Aires Conurbation was obtained from groundwater, and this depressed the piezometric surface of the Puelches Aquifer to -10 to -25 m MSL over a wide area (Figures 1 & 2). Until the late 1980s the main water-service utility operated some 250 wells with an overall production capacity in excess of 500 Ml/d. To this must be added the abstraction of:
  - a large number of industries operating on self-supply from groundwater
  - larger numbers of individually small private and domestic wells in some areas (perhaps only 20% of which on local government inventory), used for a variety of purposes including amenity irrigation
  - some other local municipality water-utility wells.

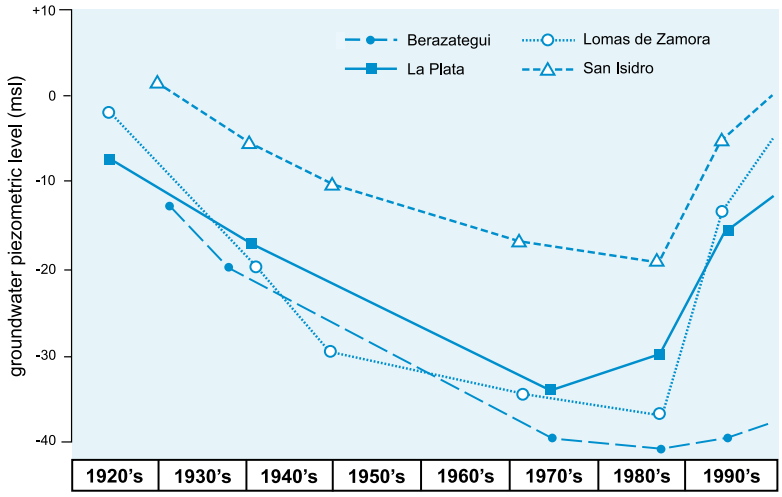
- As a result of growing concern about the level of diffuse groundwater pollution (mainly nitrate derived principally from in-situ disposal of wastewater) and to lesser degree saline intrusion, the new concessionaire was required to improve water-supply quality to WHO potable standards by importing large volumes of treated surface water (from an upstream river intake) and progressive closure of most of the large-capacity water wells within the main urban area.

- At present AASA have only 30 wells operationally-equipped and these are used to maintain water-supply continuity and pressure at the limits of their network. Since the early 1990s this has led to the 'rebound' of groundwater levels (Figure 2 & 3). There is little information on current abstraction by groundwater users other than AASA, but this is believed to have reduced substantially due industrial decline and pollution fears. The exception is abstraction by the other water-service concessionaires (ABSA and AGSA), who continue to depend on groundwater and thus water-levels remain depressed in the areas where these companies operate.

Figure 2: Typical groundwater level evolution in the Puelches Aquifer for various districts of the Buenos Aires Conurbation

Causes of Rising Groundwater Levels

- The serious groundwater drainage problem in the Buenos Aires Conurbation is the result of the combi-



nation of a number of factors:

- import of large volumes of mains water-supply, a substantial proportion of which is lost to the ground by mains leakage and via in-situ sanitation
- limited coverage of main sewerage and stormwater drainage system, which leads to most wastewater and surplus water to be discharged to the ground
- progressive reduction of groundwater pumping, which incidentally provided good 'under-drainage' of the urban area
- increased annual rainfall (perhaps as much as 20%) in recent years.

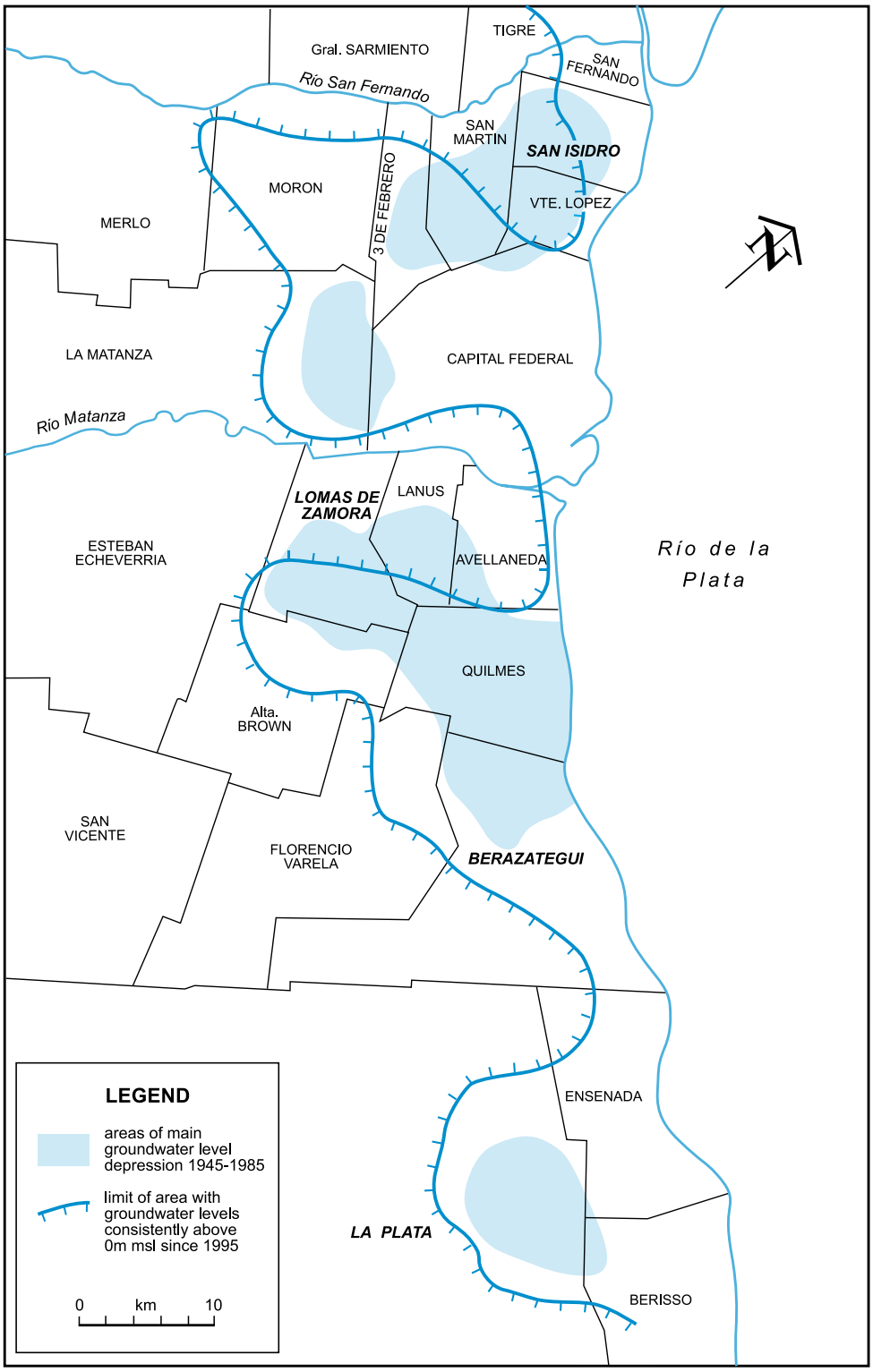
- The importance of the switch from local groundwater supply to imported surface water in the urban groundwater balance cannot be over-emphasised. A gross water-supply rate of 1 m^3/d per 500 m^2 (not excessive by Buenos Aires standards) represents 730 mm/a of water (all of which will be discharged to the ground in areas without mains sewerage), compared to average precipitation of 1020 mm/a and excess rainfall of 240 mm/a (some of which runs-off from paved surfaces).

Groundwater Pollution Situation

- The Puelches Aquifer is of only low-to-moderate pollution vulnerability, although preferential flow paths from the land surface may locally increase vulnerability. Nevertheless, it would be expected to experience groundwater contamination by persistent pollutants discharged continuously and/or heavily.

- It is, therefore, not surprising that extensive contamination by nitrate has been observed in those districts largely dependent on in-situ sanitation, with levels widely exceeding 50 $mgNO_3$/l and more locally exceeding 100 $mgNO_3$/l, and that localized pollution by persistent synthetic industrial organic compounds (DNAPLs such as TCE) has also been recorded.

Figure 3: Sketch map of Buenos Aires Conurbation showing main area of major groundwater level depression and rebound in 1990's



PROMOTION OF AN INTEGRATED SOLUTION

Preferred Approach to Drainage

- The hydrogeological conditions exercise a strong control over the potential effectiveness of mitigation measures to address drainage problem:
  - surface drains, and even shallow wells or well points, will be inefficient because of the generally low permeability of the surface Pampeano aquitard
  - the most effective solution would be to restore under-drainage through renewed operation of some former municipal and industrial water wells

- It is understood that a maximum of 80 of original AASA pumping wells are capable of being brought back into production (with 50 already having active electrical connection and pumping plant). The potential capacity to lower groundwater levels in the Puelches Aquifer would thus appear to exist, however the question arises of whether the pumped groundwater is of adequate quality to be used for:
  - direct injection to water mains, after adequate dilution of any contamination by blending in mixing tanks and/or specific treatment in small-scale plant
  - low-quality industrial process water, cooling water and/or amenity irrigation.

Appropriate Institutional Arrangement

- To promote the systematic evaluation and integrated solution of the groundwater drainage problem it is essential to establish institutional and financial arrangements which will enable the 'key actors' to participate in a positive fashion, and that this is seen by the general public to be the case.

- The creation of a Greater Buenos Aires Groundwater Management Task Force (involving all the main actors and charged with finding an integrated and sustainable solution to the groundwater drainage and use problem) would appear to be urgently required. The area of remit for this 'task force' should comprise the entire Buenos Aires Conurbation, plus various satellite towns including La Plata (capital of Buenos Aires Province). Beyond the institutions listed in Table 1, it might include representatives of civil society, water users, universities and NGOs.

Development of Investment Plan & Feasibility Study

- The most feasible option would appear to be to establish a 'revolving fund' to finance both the feasibility studies and engineering measures. The 'who in-the-end pays' question obviously has to be addressed and requires political decision — but it would appear advisable for the fund to be regenerated from urban rates and/or water charges, with representation of the urban population on the 'task force'.

- It is very likely that AASA would play a significant role in the feasibility studies and an even more vital role in the engineering measures. It would could thus act as a contractor to the drainage project financed from the 'revolving fund', except where a part of the required works was covered by obligations of the concession contract.

- A detailed technical and economic study of the feasibility of renewing production well operation to effect the required groundwater drainage and to reduce surface water import to the urban area is the first priority. It will include the following:
  - aquifer numerical modelling to simulate the original decline of groundwater levels and the rebound following the major reduction in groundwater pumping, including variations in recharge from the water infrastructure
  - definition of configuration(s) of pumping wells to achieve the required lowering of groundwater levels, reconciling this with the availability of AASA and industrial wells to minimise need for drilling new wells
  - field sampling and laboratory analysis of the quality of groundwater in the boreholes concerned (as regards salinity, F, As, NO_3, NH_4 and NAPLs) to assess potential uses (direct injection into mains, second-class supply as industrial water, amenity irrigation, etc) and blending/treatment requirements
  - refinement of the strategy (in terms of locations of boreholes) in light of quality considerations and assessment of economic cost-benefit of pumping wells selected (including consideration of revised priorities for mains sewerage construction also).

Commissioning Groundwater Drainage Measures

- Overall a long-term operational and financial plan for groundwater abstraction, use and wastewater disposal will need to be defined with adequate monitoring put in place to allow ready periodic assessment of the effectiveness of the drainage measures introduced.

- However, in view of the social urgency of the situation, provision should be made to immediately re-establish pumping from all production wells where use can readily and safely be made of the water or where this water can be evacuated temporarily via the existing sewerage/drainage network, In addition to the immediate drainage benefits, this has the added advantage (if monitored) of providing additional data with which to calibrate the numerical aquifer model which would be used to design the longer-term groundwater abstraction and use plan.

Publication Arrangements

The GW•MATE Case Profile Collection is published by the World Bank, Washington D.C., USA. It is also available in electronic form on the World Bank water resources website (www.worldbank.org/gwmate) and the Global Water Partnership website (www.gwpforum.org).

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