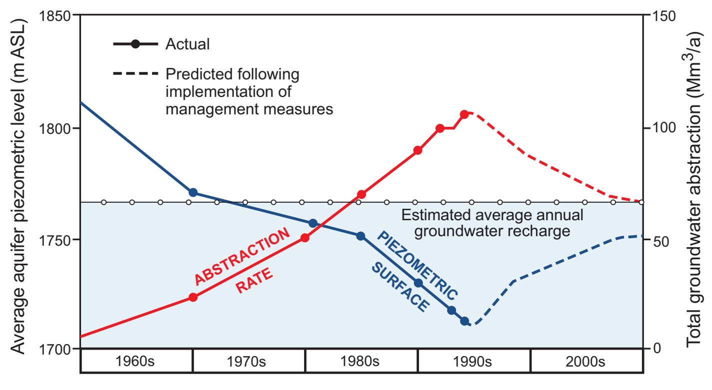
Orientation Material

URBAN AQUIFERS



Role of urban aquifers

It is estimated that half the world's predicted population of 6500 million will live in towns or cities by 2010 (UNCHS, 1987). Much of this increase will be concentrated in the developing world, which accounted for 85% of urban population growth between 1980 and 2000 (Figure 1). The result is that by the year 2000, about twice as many people were living in cities in developing countries (1900 million) as in the developed world (950 million). Fair access to water supply and sanitation has always been a key issue in expanding cities but the sheer scale and extent of global urbanisation is placing unprecedented pressure on regional water resources around urban agglomerations (UNEP 1996). A high proportion of these urban dwellers depends on groundwater for day-to-day domestic, industrial and commercial water supply, and nowhere more so than in the developing world. It has been estimated that about one-third of Asia's population (some 1000-1200 million people) and some 150 million Latin Americans are groundwater-reliant (BGS *et al* 1996). Half of the world's 23 mega-cities as well as hundreds of smaller towns and cities are also groundwater dependent (Table 1).

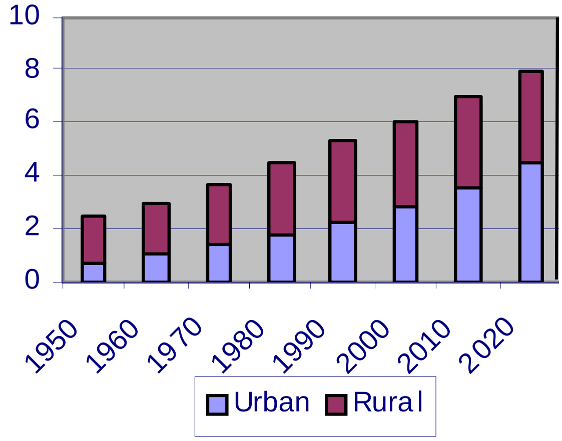


Figure 1 Growth of urban populations

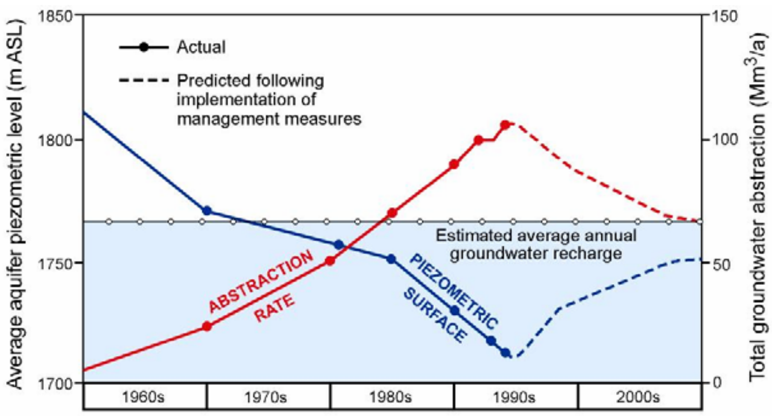


Figure 2 Consequences of uncontrolled groundwater development

Uncontrolled groundwater development and indiscriminate waste disposal often accompany urban expansion, resulting in growing water scarcity and deteriorating water quality (Figures 2 and 3). This degradation, which occurs within the urban area, on the periurban fringes and downstream, is a contributory cause of spiralling water supply costs. Substitution of degraded urban groundwater by alternative 'out-of-town' supplies is expensive, with unit water costs often 2-3 times greater than current costs (Calow *et al*, 1999). Moreover, the ability to replace a degraded urban aquifer by water tapped from the hinterland is a fast-receding luxury because increasingly such catchment resources may already be fully utilised for agricultural or ecological purposes (Burke and Moench, 2000).

As well as financial and environmental costs, declining urban water quality may also carry health implications, because in areas where public piped water supply and sanitation are over-stretched, poorer people may be obliged to use the shallow subsurface both as source of supply and as receptor for on-site sanitation. In those groundwater settings where such a combination carries a significant health risk, maintenance/improvement of source water quality may be critical to avoid current microbiological hazards and to prevent the introduction of an exotic pathogen into the community which may provoke an unexpected explosive outbreak (BGS and Robens Centre, 2001). It also avoids the need for water treatment within the home, which is expensive, unreliable and places an additional burden on the urban poor.

Table 1 Groundwater dependence of the world's mega-cities (adapted from Black, 1994)

City and estimated population in 2000 (millions)					
Mexico City	**25.8**	Rio de Janeiro	13.3	**Cairo**	**11.1**
Sao Paulo	24.0	**Shanghai**	**13.3**	Los Angeles	11.0
Tokyo	20.2	**Buenos Aires**	**13.2**	**Bangkok**	**10.7**
Calcutta	**16.5**	Delhi	13.2	**London**	**10.5**
Greater Bombay	16.0	**Jakarta**	**13.2**	Osaka	10.5
New York	15.8	Karachi	12.0	**Beijing**	**10.4**
Seoul	13.8	**Dhaka**	**11.2**	Moscow	10.4
Teheran	**13.6**	**Manila**	**11.1**		

Groundwater-dependent cities in **bold**

In the future, a city fortunate enough to possess a significant urban aquifer resource will no longer be able to assume that it is a disposable asset that can just be abandoned once unacceptably depleted or heavily contaminated. Added to the issue of resource equity is the growing realisation that the water infrastructure of a city and an underlying aquifer system are interdependent. Mis-management, or more commonly absence of management, can result in the same city experiencing drastically falling water levels during early expansion followed by groundwater flooding at later development stages (Morris *et al*, 1997), or incurring unforeseen and expensive future treatment costs to counteract the results of persistent contamination due to poorly planned/controlled activities at the land surface (Ahmed *et al*, 1998; Seddique, 1998).

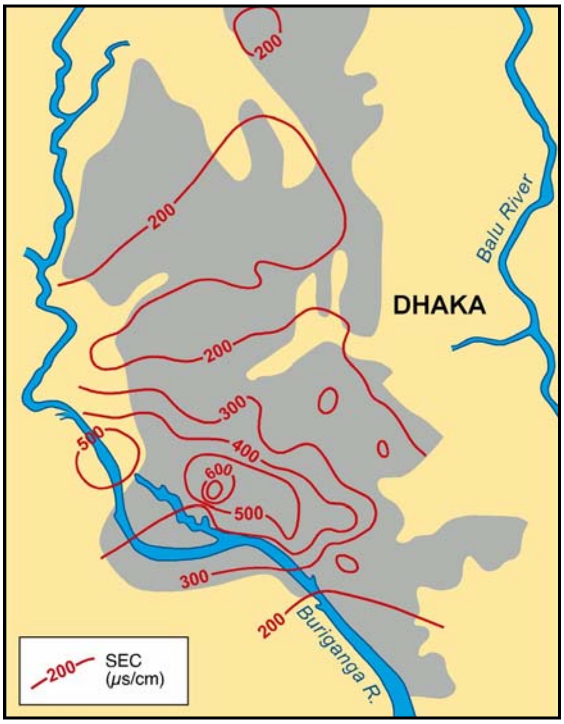


Figure 3 Indiscriminate waste disposal can lead to water quality problems

Growing awareness of need for aquifer management

The realisation that proactive aquifer management needs to become an integral part of development planning in groundwater-dependent cities arose in the mid-1980s. Studies of urbanisation-induced water balance changes (Lazaro, 1979; Geake *et al,* 1986; Lerner, 1986; Van de Ven, 1990, Ku *et al,* 1992; Price & Reed, 1989; Foster *et al,* 1993) demonstrated how radically aquifer replenishment mechanisms were affected, with many cities establishing a dynamic equilibrium between increased recharge availability and pumped abstraction. Urban hydrologists recognised the importance of the shallow subsurface in runoff/drainage control, for instance its ability to attenuate stormwater runoff peaks (Lindt, 1983; Douglas, 1983). Development planners came to realise that local aquifer-dependent water supply and on-site sanitation arrangements were not going to be just a short-term transient phase for many low-income districts of expanding developing-world cities (Postel, 1984; Earthscan, 1990; Briscoe, 1993; Black 1994).

By the mid-1990s urban groundwater had become a topic area in itself, providing the theme for major symposia such as the UN Habitat Conference on Managing Water Resources for Large Cities and Towns (1996, Beijing) and the IAH Congress on Groundwater in the Urban Environment (1997, Nottingham). Urban groundwater management has been embraced and published upon by external support agencies (e.g Foster *et al,* 1998), conscious of the link with sustainability issues aired at the 1992 Earth Summit in Rio de Janeiro. With more than 150 countries signed up to Agenda 21, the manifesto that emerged from the Earth Summit, municipal authorities all round the world are becoming aware of, and responding to, the need to consult with their citizens in developing their own Local Agenda 21 plans for sustainability.

The urban groundwater protection action plan paradox: Patent need, yet virtual absence

Against such a background the need for, and the benefits of, urban groundwater protection policies seem self-evident, if urban aquifers are to be treated as sustainable resources rather than as wasting assets, doomed to eventual abandonment. On the face of it there seems every reason to anticipate that groundwater-dependent cities concerned with the future security of their water supplies, as a Local Agenda 21 issue or otherwise, will be putting in place concise aquifer protection policies, through the medium of an Action Plan, as a matter of course. Yet this does not seem to be the general case, and certainly not in the developing world, where the real need is keenest. The main reasons for the worrying absence of policy guidance from groundwater engineers and scientists for urban decision-makers seem to be:

- *Inability to see 'the big picture':* Groundwater development is by its very nature incremental, and at least initially, speculative rather than planned. Wells may be drilled by a single utility or by any of hundreds of private users, fragmenting the knowledge base. Problems such as overdraft or water quality deterioration are thus less easy to identify in their early stages. Borehole construction, equipping and bringing into production is relatively light in investment requirements in contrast to large river intakes or city hinterland reservoirs, and so it is the latter which tend to be the subject of a city master water plan. The result is that much groundwater development tends to occur by default rather than by design, and it can be a challenge to separate out key elements of the aquifer setting and groundwater use clearly enough to gain an overview.
- *Sustainability linkage unrecognised*: While groundwater engineers and scientists routinely think in time-scales appropriate to groundwater flow, this is much less the case with the general public, for whom reaction/residence times of water in observable features such as rivers are much easier to grasp. It is necessary therefore to actively point out the strong sustainability focus of a resource whose pollution response and replenishment time-scales are typically measured in years→decades→centuries rather than the hours→days→weeks of most city river/reservoir sources. Also that aquifer protection embraces not only security from insidious degradation of water quality but also from erosion of the resource by unregulated overexploitation i.e sustainability needs to be considered in both *quality* and *quantity* terms. Otherwise municipal policymakers will be unaware of the need to include aquifer management in sustainable development initiatives.
- *Lack of data:* If paucity of monitoring information on aquifer development and status is a symptom of the frequent assertion that groundwater is rather taken for granted, then many urban and periurban aquifers are neglected. Even where databases exist, they may not be consciously linked to a management need, and much laboriously collected information is thereby found to be either inapplicable or inappropriate when aquifer assessment is undertaken.

As a result, despite the apparently straightforward techniques required, for the hundreds of groundwater-dependent cities in middle and low-income countries, an aquifer protection Action Plan locally developed to help a particular municipality manage its groundwater resource remains an unusual exercise.