Beijing's Water Crisis
1949 – 2008 Olympics

Probe International Beijing Group, June 2008

Contents

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Executive Summary

Beijing, China's capital city, and one of its fastest-growing municipalities, is running out of water. Although more than 200 rivers and streams can still be found on official maps of Beijing, the sad reality is that little or no water flows there anymore. Beijing's springs, famous for their sweet-tasting water, have disappeared. Dozens of reservoirs built since the 1950s have dried up. Finding a clean source of water anywhere in the city has become impossible.

As recently as 30 years ago, Beijing residents regarded groundwater as an inexhaustible resource. Now hydrogeologists warn it too is running out. Beijing's groundwater table is dropping, water is being pumped out faster than it can be replenished, and more and more groundwater is becoming polluted.

Today, more than two-thirds of the municipality's total water supply comes from groundwater. The rest is surface water coming from Beijing's dwindling reservoirs and rivers. The municipality's two largest reservoirs, Miyun and Guanting, now hold less than ten percent of their original storage capacity and Guanting is so polluted it hasn't been used as a drinking water source since 1997. This report traces Beijing's 60-year transformation from relative water abundance to water crisis, and the main policy responses to keep water flowing to China's capital.

Official data indicates that Beijing's population growth, industrial development, and its expansion of irrigated farmland have driven huge increases in water consumption since 1949. Meanwhile, 25 years of drought and pollution of the city's reservoirs have contributed to the steady decline in available water resources per person, from about 1,000 cubic metres in 1949 to less than 230 cubic metres in 2007.

The report also argues that drought and rapid demand growth aren't the only factors behind the water crisis. Short-sighted policies since 1949 have degraded Beijing's watershed and promoted the over-use of limited water resources. In particular, the political fixation on large-scale engineering projects to keep urban taps flowing at little or no cost to consumers meant that consumption was divorced from consequence without price signals to indicate scarcity.

Beijing's policy of guaranteeing water supply to the capital at little or no charge to consumers – even as its rivers and reservoirs were drying up – has wreaked havoc on Beijing farmers and encouraged wasteful consumption by industrial and urban consumers. In the last five years, with Beijing's surface and groundwater supplies nearing exhaustion, the State Council and Beijing authorities have announced several policies to guarantee an adequate water supply for Beijing during the 2008 Olympics and beyond. The policies include:

- "emergency water transfers" from existing and proposed reservoirs in Hebei province (2008) and the Yangtze River in Hubei province (starting 2010);
- restrictions on surface and groundwater use in upstream Hebei province in an effort to increase river flow to Beijing;
- extraction of karst groundwater from depths of 1,000 metres or more from Beijing's outlying districts.

Such policies for taking ever more water and from ever further jurisdictions beyond Beijing may be an emergency measure to ease Beijing's water shortages and flush out its polluted waterways, but it is not a fundamental solution. Long distance diversion is extraordinarily expensive and environmentally damaging. Even if water is successfully diverted from Hebei province in 2008 and the Yangtze River in 2010, groundwater will continue to be Beijing's most important water source. The municipality will still need to continue pumping about three billion cubic metres of groundwater annually to keep up with the forecasted growth in demand – that's 500 million cubic metres more than the annual allowable limit for "safe" extraction of groundwater. With each new project to tap water somewhere else, demand for water only increases, and at an ever greater cost to China's environment and economy. Whether diverting surface water or digging ever-deeper for groundwater, the underlying solution proposed is like trying to quench thirst by drinking poison.

The key to addressing Beijing's water crisis is not more engineering projects to deliver new supplies. More dams, diversion canals, pipelines and even desalination plants may be technically feasible but they are economically and environmentally ruinous. A better approach would be to curb demand through efficiency improvements in water supply and consumption using the rule of law and economic incentives.

This approach includes:

- enforcing existing laws and regulations to restrict unaccountable, polluting, and water-profligate development and water use;
- full-cost water pricing to reduce demand and promote efficient resource use;
- a new UK-style economic regulator to oversee Beijing's rising state water and sewerage companies, reward conservation, prevent monopoly abuse and seek maximum value for water consumers;
- tradable water rights to better manage competing water demands within Beijing municipality and thereby reduce pressure on surface and groundwater supplies within and beyond its borders.

Shifting from endless supply expansion to a water system based on the rule of law and economic incentives to promote sustainable water use is a major challenge for Beijing, just as it is for many jurisdictions around the world after decades of water exploitation without the benefit of economic discipline or effective environmental regulation. But it is hard to imagine a city region where the need and potential for success is greater than that of Beijing.

Quick Facts: Beijing Water

Per capita water availability: declined from 1,000 cubic metres in 1949 to less than 230 cubic metres in 2007

Total water use: 3.25 billion cubic metres (2007)

Source: groundwater 70-80%; surface water 20-30%

Estimated supply deficit: 400 million cubic metres

Water consumption: domestic (39%), agriculture (38%), industry (20%), urban environment (3%)

Between 1995 and 2005:
Domestic water use more than doubled
Agricultural water use dropped by one-third
Industrial water use dropped by one quarter

Chapter 1: Beijing Watershed

Beijing is a 3,000-year-old city on the northwest edge of the North China Plain, flanked by mountains to the northwest, the Huabei plain in the Yongding and Chaobai river valleys in the southeast, and the Bohai Sea 150 kilometres to the southeast (see Beijing Municipality Watershed Map). About two-thirds of the municipality is mountainous, the remainder is low-lying plains. Beijing city usually refers to the ancient capital, the four city districts, and its near suburbs. The entire municipality is much larger, covering an area of 16,808 square kilometres, roughly half the size of Belgium. Under its jurisdiction are 16 districts and two rural counties as follows:

- 4 core city districts of 92 square kilometres
- 4 near suburbs of 1,289 square kilometres
- 8 outer suburbs of 12,405 square kilometres
- 2 rural counties of 4,316 square kilometres

Since 1949, the population of Beijing has grown from roughly four million to 17 million, making it China's second largest city after Shanghai. The current estimate of population includes several million people classified by the central government as "floating population" – the official term for temporary residents or migrant workers registered as residents elsewhere. In 2007, Beijing's population expanded by 520,000. Of these people, 157,000 have household registration in Beijing municipality and 363,000 are classified as "floating population."

Figure 1-1 provides a breakdown of Beijing's population by district and county.

Figure 1-1: Beijing's districts and counties

Name of District	Population	
Dongcheng	600,000	Urban
Xicheng	750,000	
Chongwen	410,000	
Xuanwu	550,000	
Chaoyang	2.3 million	Suburban
Haidian	2.24 million	
Fengtai	1.4 million	
Shijingshan	489,000	
Mentougou	270,000	Outlying suburban
Shunyi	637,000	
Tongzhou	870,000	
Fangshan	814,000	
Changping	615,000	
Pinggu	396,000	
Huairou	296,000	
Daxing	671,000	
Miyun	420,000	Counties
Yanqing	275,000	
Total: 14,003,000		

Beijing's rivers

About 90 percent of the surface water flowing through Beijing comes from rivers and streams outside the municipality in neighbouring regions – Hebei province, Shanxi province, and Inner Mongolia. All are part of the much larger Hai river basin which drains into the Bohai Sea. Within Beijing municipality, there are five main rivers and more than 200 smaller rivers, most of them dried out completely. The five main rivers are: Chaobai and Beiyun in the east, Yongding and Juma in the west, and Jiyun in the northeast.

Chaobai River

Chaobai River originates in Hecao village where the Chao and Bai rivers meet north of the Yang Mountains in Hebei province. The second largest river within the municipality, Chaobai flows 118 kilometres through four districts, Miyun, Huairou, Shunyi and Tongzhou, before joining the Chaobaixin River in neighbouring Tianjin municipality and then emptying into the Bohai Sea.

The Chaobai was dammed in the 1960s by the Miyun dam and reservoir, which delivers water to Beijing city through a 95-kilometre-long canal. (See section on the Miyun reservoir.)

Beiyun or North Grand Canal

Beiyun is the 120-kilometre north section of the Grand Canal, which was built 1,300 years ago and links Beijing to Hangzhou in the south. Beiyun served as a major transportation waterway for the nation's capital until the early 20th century. Since the construction of railways, however, Beiyun no longer functions as a transportation route and has become a major drainage channel instead, earning it the nickname "Beijing paiwu he" or Beijing's sewer. Year-round, Beiyun receives a high volume of industrial wastewater and domestic sewage. Beiyun flows 38 kilometres through Beijing then into Hebei province before joining the Hai River at Dahongqiao (Great Red Bridge) in Tianjin municipality.

The upper section of Beiyun, upstream of the Beiguan sluice gate in Tongzhou district, is a natural river, known as Wenyu. Wenyu originates in the Yanshan Mountains in Changping and Haidian districts of Beijing. Wenyu has 39 tributaries, including Nanshahe, Beishahe, Dongsha, Qinghe and Liangshuihe.

Yongding River

Honoured as the "Mother Waters of Beijing," this river was historically an important water source and waterway for Beijing residents. It is Beijing's largest river, originating from the Yang River in Inner Mongolia and the Sanggan River in Shanxi province. It has a total length of 680 kilometres, flowing 174 kilometres eastward through Beijing before joining the Hai River in

Tianjin municipality and emptying into the Bohai Sea. Tributaries include: Naqiu, Qingshuihe, Xiamalinggou, Weidiangou, Qingjian, Yingtaogou, Dalonghe, Xiaolonghe, and Tiantanghe. Prior to construction of the Guanting dam in the 1950s, the swift-flowing river would swell from 500 metres to 2,000 metres wide in the rainy season.

Juma River

Juma River originates in Hebei province and flows through Fanghsan district of Beijing before flowing back into Hebei province and splitting into Nanjuma (South Juma) and Beijuma (North Juma). One of Juma's tributaries is the Dashi River, once known as Shenshui (holy water) because its water was so pure and such an important source for people in the ancient capital. Tributaries include: Dashi and Xiaoqing Rivers.

Ju River

Ju River flows through Pinggu district in northeast Beijing. It originates from the Jiyun River in Sanhe county, Hebei province.

Chapter 2: Beijing’s Water Resources

Beijing’s water resources include surface water and groundwater. Surface water refers to water in rivers, lakes, and reservoirs. The amount of surface water available fluctuates within and between years depending on rainfall.

Beijing’s rainfall varies geographically, seasonally and annually. Eighty-five percent of the annual precipitation falls between July and September. Rainfall also varies between the sub-watersheds within the municipality and particularly between mountainous areas and the low-lying plain.

Beijing’s average yearly precipitation is 590 millimetres (mm) with a recorded high of 1,406 mm in 1959 and a low of 242 mm in 1869. In comparison, Shanghai, a city with roughly the same population as Beijing, receives an average annual rainfall of 1,411 mm. New York City, which is at the same latitude as Beijing, receives an average rainfall of 1,090 mm.

Drought

Beijing has recorded 25 years of drought since the 1970s. Drought, in this context, is broadly defined as below-average rainfall. Meteorologists in Beijing define an extremely dry year as 300 mm of rainfall or less, which is about 50 percent below average. A moderately dry year is defined as 450 mm of rainfall or about 25 percent below average.

Between 1999 and 2008, Beijing's average annual precipitation was 428 mm or 28 percent below average. Figure 2-1 summarizes the decline in average annual precipitation.

Figure 2 - 1: Average annual precipitation

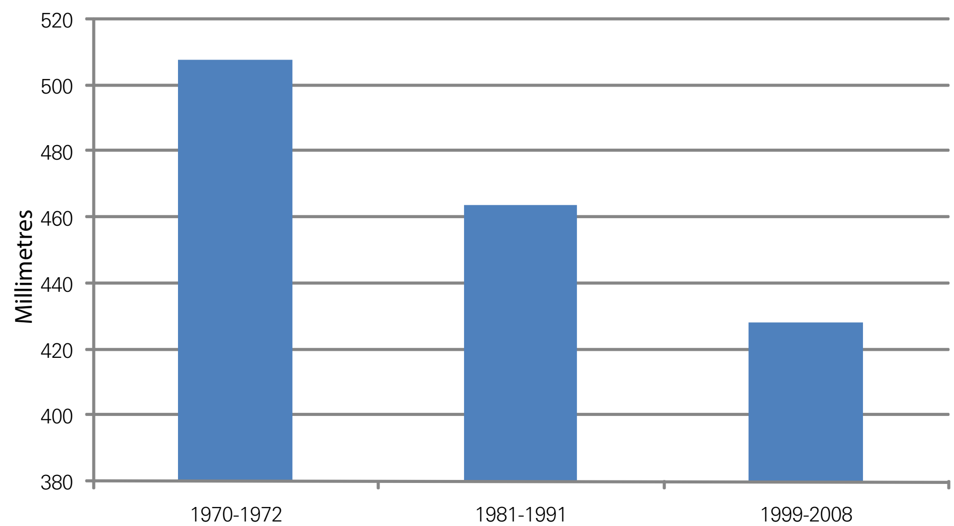
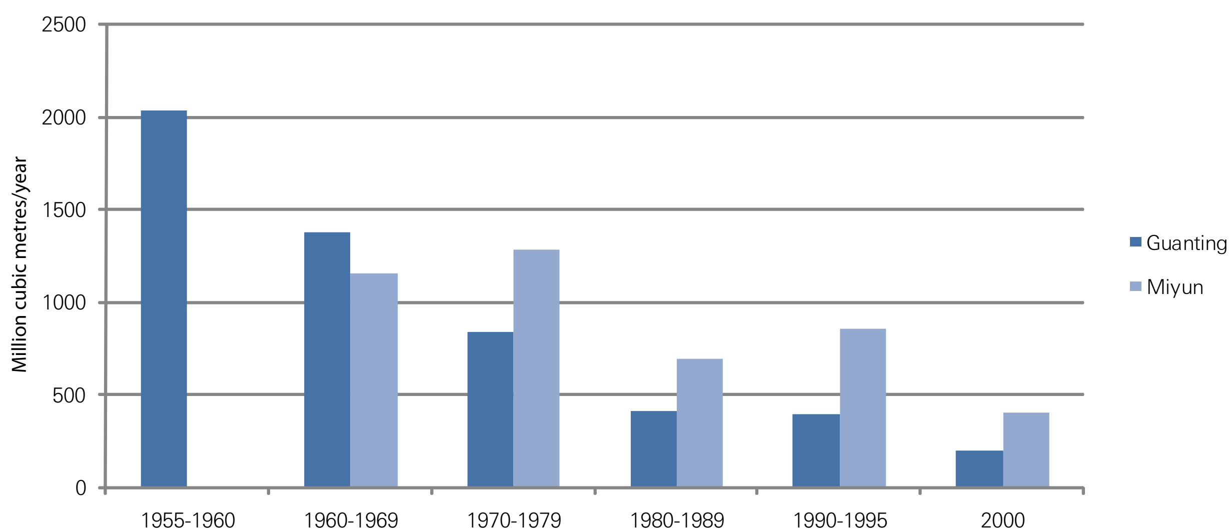


Figure 2 - 2: Declining inflow to Guanting and Miyun reservoirs



Declining surface runoff

The total amount of surface runoff in Beijing's five river systems is estimated to be 4.7 billion cubic metres in a normal year, which drops by 45 percent to 2.6 billion cubic metres in a dry year.

To regulate and store surface runoff, Beijing built a total of 85 dams and reservoirs between 1950 and 1995. The amount of surface water available for use (either from rivers or reservoirs) in an average year is 1.67 billion cubic metres and only 1 billion cubic metres in a dry year.

In the last few decades, the volume of surface runoff entering Beijing's two largest reservoirs, Guanting and Miyun, has dropped sharply. According to Figure 2-2, the average inflow to Guanting reservoir dropped 90 percent between the 1950s and 2000.

By 2005, the total volume of water entering both reservoirs had dropped to just 459 million cubic metres, down 27 percent from 632 million cubic metres in 2004.

Groundwater

Groundwater refers to the water flowing underground between rocks and soil. It can be divided into two types: shallow and deep. In general, the deeper the groundwater, the longer it takes to be replenished by rainfall and seepage. Wherever groundwater is extracted in huge quantities, land subsidence – the loss of surface elevation due to the removal of subsurface support – can occur. The rate of groundwater recharge (or replenishment) is highly variable and uncertain; it varies over time and space and according to precipitation, aquifer structures (i.e. karst, sand, granite), rock properties, ground cover and the rate of extraction.

The shallow groundwater on the Beijing plain is recharged 44 percent by precipitation and 31 percent by seepage of surface water. As the area covered by buildings and roads has increased dramatically in recent years, less water is able to seep through the ground naturally. Both the rate and volume of groundwater recharge are decreasing.

The term "available groundwater" usually refers to water found at shallow depths (i.e. 1 to 100 metres) that is easily extracted, quickly replenished by rainfall and seepage, and doesn't cause subsidence problems when extracted. The Beijing Water Bureau estimates that its available groundwater – that which can be safely extracted without depleting the resource – ranges from 2.0 to 2.45 billion cubic metres per year, depending on rainfall.

Total available water supply

Available water supply refers to the amount of water available for treatment and distribution through the city's water pipeline system. These figures do not include water that is reused after treatment. Taking surface water and groundwater, the Beijing Water Bureau estimates the volume of exploitable water resources ranges from 3.0 to 4.12 billion cubic metres per year, depending on rainfall.

Table 2-1: Total available water supply (billion cubic metres/year)

Available Water Resources	Range	Current
Surface Water	1.0 – 1.67	0.80
Groundwater	2.0 – 2.45	2.45
Total	3.0 – 4.12	3.25

Under present conditions, the Beijing Water Bureau estimates its total available water supply is approximately 3.25 billion cubic metres annually with 0.8 billion cubic metres supplied by the Miyun and Guanting reservoirs and 2.45 billion cubic metres from groundwater sources.

Guanting reservoir

Completed on the Yongding River in the 1950s, Guanting reservoir is situated at the border between Yanqing county (Beijing) and Huailai county, Hebei province.

With a maximum storage capacity of 4.16 billion cubic metres, the Guanting reservoir was originally designed as a multipurpose project that included power generation, fisheries development, and water supply for industry, agriculture, and domestic purposes.

In the 1980s, Guanting was supplying drinking water for tens of thousands of urban households. By 1997, however, the reservoir had become too polluted to use as a source of drinking water.

A brief history of Guanting management follows:

1971

Local residents fell ill after eating fish caught from the reservoir's polluted water. Tens of thousands of fish in the reservoir had died, but at that time few people had any concept of pollution or the environment. Because the incident occurred during the "Great Cultural Revolution" (1966-1976) it was immediately linked to politics. The rumour went that "class enemies" had poisoned the reservoir in an attempt to kill Chairman Mao Zedong and other top Communist Party leaders who were living downstream at Zhongnanhai.

1972

To determine the real cause of the pollution, the central government assembled a team of 300 experts. Their mandate was to assess the state of the reservoir scientifically, including the quality of water flowing into the reservoir and the relationship between pollutants and human health. The team, known as the Guanting Reservoir Conservation Group, quickly discovered that at least 242 industries and factories were polluting the rivers which flow into the reservoir. They identified the worst polluters as 39 state enterprises engaged in mining and the production of pesticides, pharmaceuticals, leather, paper, and rubber.

1973-1983

In response to the Guanting conservation group's findings, the central government set up a special fund of US$4 million (30 million yuan) to address pollution in the reservoir area. Using this fund, the group worked with the polluting enterprises to reduce the volume of wastewater and pollutants entering the reservoir. As a result, there was no further decline in water quality in the reservoir during this period.

The effort to clean up and protect Guanting reservoir marked the beginning of state-led environmental protection in post-1949 China. A number of valuable approaches to water resources management were introduced, such as pollution prevention and treatment.

1984

The central government dismantled the Guanting Reservoir Conservation Group despite its successful efforts to curb pollution in the reservoir. Like most river valleys in China at that time, a surge of small enterprises cropped up along the Yongding tributaries that flow into the reservoir. Also, more and more multipurpose dams were built upstream, holding back the flow of clean water to the reservoir while polluters secretly discharged their untreated wastewater. Water quality quickly deteriorated as inflow declined.

1997

A serious pollution incident prompted Beijing to discontinue the use of Guanting as a source of drinking water for the nation's capital. Its water quality deteriorated from Category II to Category V, which is regarded as unsafe for use, including irrigation (refer to Appendix 1: China's water quality standards).

2005

The Beijing Environmental Protection Bureau reports that its water quality has improved slightly from Category V to Category IV (Appendix 1).

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Miyun reservoir

Officially nicknamed the "Bright Pearl of the Yanshan Mountain."

Situated 100 kilometres from downtown Beijing on the Yanshan Mountain, the Miyun reservoir is Beijing's single largest source of domestic tap water.

Completed in the 1960s, Miyun originally had a surface area of 188 square kilometres and a maximum water storage capacity of 4.375 billion cubic metres. The dam and reservoir were designed as a multi-purpose project, for controlling floods, generating power, irrigating farmland, and providing water to Beijing city.

Miyun's watershed is mostly rural and is considered the only remaining basin with clean water in Beijing. The reservoir supplies the city's tap water and water for refilling Beijing's dried-up lakes that were once fed by springs – including the Summer Palace, Yuyuanta, Beihai Park, and Shenshahai.

In 1981, faced with a serious drought in the nation's capital, the State Council decided that all water released from Miyun would be reserved for Beijing, and no longer allocated to Tianjin municipality (downstream of Beijing). At the same time, the municipal government announced its new water allocation policy: water from Miyun was reserved for domestic water supply and would not be used to supply industry or agriculture.

The goal of protecting Miyun reservoir as a source of tap water for urban Beijing has repeatedly clashed with county-level plans for economic development and revenue generation. A chronology follows:

Tourism development

In the early 1980s, the Miyun county government announced a plan for developing the reservoir area for tourism, which turned out to be a disaster for the reservoir's water quality. The reservoir management agency and other government units built hotels and cottages around the reservoir to accommodate tens of thousands of weekend visitors. The water quickly became fouled by household sewage, garbage, chemicals, and E-coli bacteria.

Eventually, the municipal government intervened, ordering the demolition of the hotels and cottages. It then created a special agency in charge of water conservation which issued regulations to curb commercial activities around the reservoir. Certain areas around the reservoir were declared off-limits by the new agency. Motorboats on the reservoir were banned and roads into the area were ordered closed during the flood season.

Fisheries development

After the tourism industry was shut down, Miyun county government began encouraging villagers living around the reservoir to raise fish in cages, in the belief that it was an environmentally friendly means of generating local income. Within a few years, however, the caged fishery covered an expanse of 4.5 hectares along the reservoir shoreline and a study by Beijing's Environment Protection Bureau found that the fishery was a major threat to the reservoir's water quality. The Bureau reported that the amount of bait and fish waste polluting the reservoir was comparable to the amount of wastewater discharged by a large city. Again the municipality intervened to protect the reservoir and ordered the caged fishery be shut down.

Iron ore mining

The Miyun county government also promoted iron ore mining, ignoring the new conservation agency's regulations prohibiting commercial activities. To extract iron ore, the hills surrounding the reservoir were dynamited, forests were cleared, and soils eroded, filling the reservoir with sediment. Iron ore tailings were discharged directly into the reservoir which caused the worst pollution in the reservoir's history. Eventually, the municipal government issued a regulation banning mining activities in the area but by that time Miyun was already heavily polluted with mining tailings.

In the last decade, Beijing has taken drastic action to cut down on pollution in the Miyun reservoir. It has shut down factories and moved thousands of people away from the reservoir in an effort to reduce the amount of household sewage and other pollution entering the reservoir.

Chapter 3:
Beijing's Water Consumption

Per capita consumption

Beijing Water Bureau estimates the municipality's available water supply (based on a multiyear average) is about 4 billion cubic metres annually. Since 1949, the amount of water resources available per person has dropped from 1000 cubic metres to less than 230 cubic metres as of 2008. As such, Beijing has become one of the world's most water-scarce megacities with per capita water use now less than one-thirtieth of the world average.

Water consumption within Beijing municipality can be categorized by sector as follows:

- Agriculture
- Industry
- Domestic
- Urban Environment
- Golf Courses
- 2008 Olympic Games

Water consumption by sector

Table 3-1 indicates how much water is consumed by each sector. The amounts for domestic, agriculture, industry, and urban environment sectors were obtained from the 2005 Beijing water resources bulletin. Figures for water use by golf courses and the 2008 Olympics are best estimates compiled by Beijing researchers.

Table 3-1: Water consumption by sector (2005)

Sector	Volume (million cubic metres)	Percent of Total Water Supply (%)
Domestic	1,338	39
Agriculture	1,322	38
Industry	680	20
Urban Environment	110	3
TOTAL	3,450	100
2008 Olympics	200 (estimated)	n/a
Golf Courses	27 (estimated)	n/a

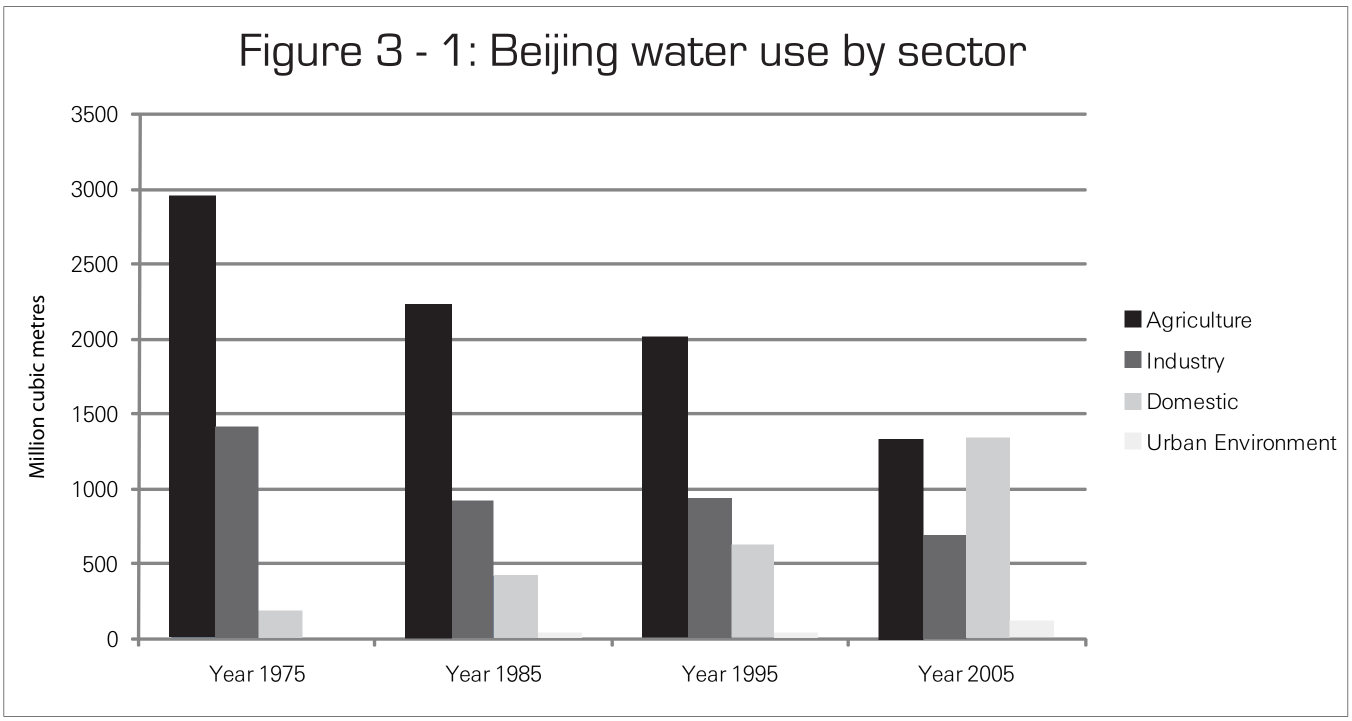
Table 3-2 provides a range of water demand estimates in a normal year of precipitation. Assuming no water is allocated for the urban environment – that is water used for filling Beijing's lakes and irrigating urban landscapes – Beijing's estimated demand for water is between 4.0 and 4.5 billion cubic metres annually. As noted in Chapter 2, Beijing's actual water supply has dropped below 4.0 billion cubic metres in the last few years.

Table 3-2: Estimated water demand by sector in a normal year of precipitation (based on data from 1995, in billion cubic metres)

Sector	Water Demand	Percentage
Agriculture	2.2 – 2.6	56%
Industry	1.2 – 1.4	30%
Domestic	0.5 – 0.7	14%
Urban Environment	n/a	n/a
Total	4.0 – 4.5	100%

From the data presented in Figure 3-1 (and Appendix 2), a number of significant trends in water use by sector emerge:

Figure 3-1 indicates how water use has changed from 1975 to 2005.



- Since 1975, the amount of water used for agriculture has dropped by more than one-half while domestic consumption has increased ten-fold.
- From 1995 to 2005, the volume of water used for domestic purposes has more than doubled, accounting for 39 percent of total water use in 2005, up from 17 percent in 1995.
- The volume of water used for agriculture has dropped by one-third, accounting for just 38 percent of total water use in 2005 compared to 56 percent in 1995.

- The volume of water used by industry has dropped by one quarter, accounting for 20 percent of total water use in 2005 compared to 26 percent in 1995.

A more detailed history of Beijing's water use by sector follows.

Agriculture

For centuries, high quality rice was grown exclusively for imperial families on the Beijing plain. Today, rice cultivation has been replaced by irrigated crops such as wheat, sorghum, corn, and vegetables.

The expansion of irrigated farmland in Beijing municipality corresponds to the availability of water from the Guanting and Miyun reservoirs in the late 1950s and early 1960s. Table 3-3 provides a breakdown of water use for irrigated agriculture and area of irrigated farmland from 1949 to 2005.

Table 3-3: Water use by agriculture

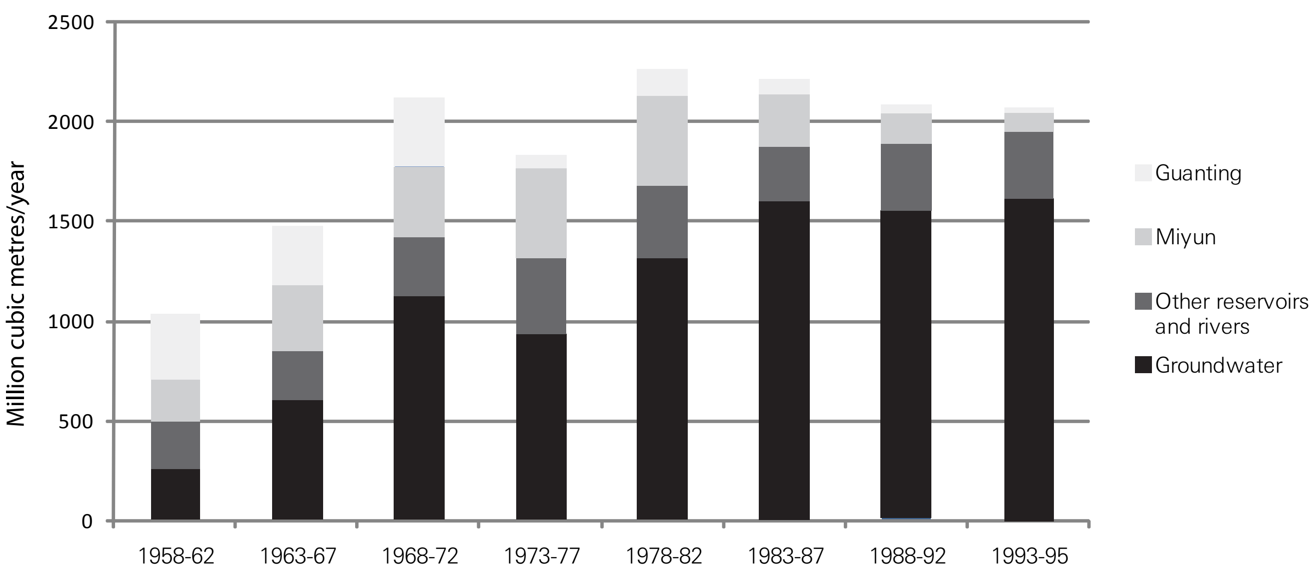
Period	Irrigated farmland (hectares)	Total water consumption (million cubic metres)
Pre-1949	14,200	n/a
1958	95,300	573
1960	n/a	1,373
1965	229,800	1,973
1970	96,800	2,780
1980	340,300	3,050
1985	n/a	2,223
1990	n/a	2,028
1995	n/a	2,010
2005	n/a	1,322

Since the 1970s, drought triggered a number of significant changes in water allocation and use. In the early 1970s, the spectre of water shortages in the capital prompted Beijing to increase its delivery of water to the city and cut back on water supply for irrigation in rural areas. This reallocation forced more than 130,000 hectares of irrigated farmland out of production, or about half the total area under irrigation. To provide farmers with an alternative source of water for irrigation, an estimated 30,000 wells were dug and the area of irrigated farmland quickly expanded to former levels.

Then, in the 1980s, a four-year drought and water shortages in the city due to surging increases in water consumption prompted another round of water reallocation in order to ensure an uninterrupted water supply for urban residents. The municipal government announced that only water from medium and small reservoirs and rivers could be used for field irrigation (i.e., for wheat, sorghum). Water in Miyun and Guanting was reserved for industry, urban households, and irrigated vegetables in suburban areas. The amount of irrigation water released from Miyun and Guanting was cut back by about 90 percent. This led to an increased reliance on groundwater for irrigation.

Figure 3-2 indicates the amount of water used for field irrigation from four sources: Guanting reservoir, Miyun reservoir, other surface resources (i.e., smaller reservoirs and rivers) and groundwater.

Figure 3 - 2: Average yearly water consumption in rural areas 1958 - 1995

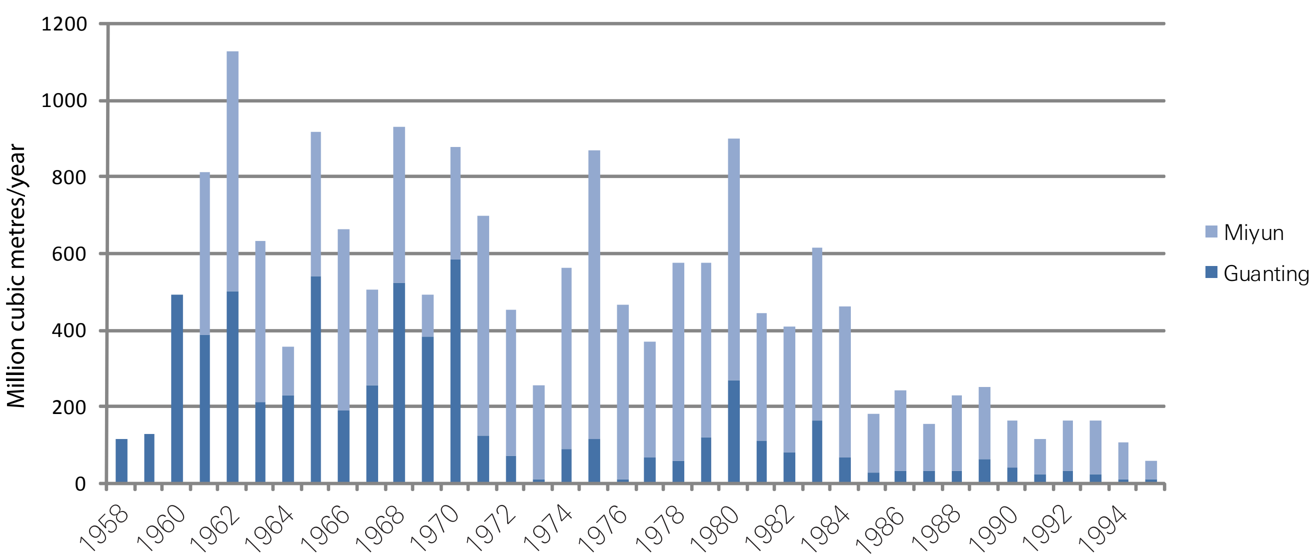


Based on the data presented in Figure 3-2 and Table 3-3, the following water use trends can be observed:

- The amount of water used for irrigated agriculture in 2005 is roughly the same volume as in 1960.
- The amount of water used for irrigation peaked in 1980 and has been declining ever since.
- Use of groundwater for irrigation increased ten-fold between 1958 and 1995, from 257 million cubic metres in 1958 to an average 1,568 million cubic metres between 1985 and 1995.
- Use of groundwater for irrigation averaged 257 million cubic metres in 1958 to about 1,600 million cubic metres between 1985 and 1995.

Figure 3-3 shows yearly water consumption in rural areas since 1958 from the Miyun and Guanting reservoirs.

Figure 3 - 3: Yearly water consumption in rural areas 1958 - 1995 (Guanting and Miyun reservoirs)



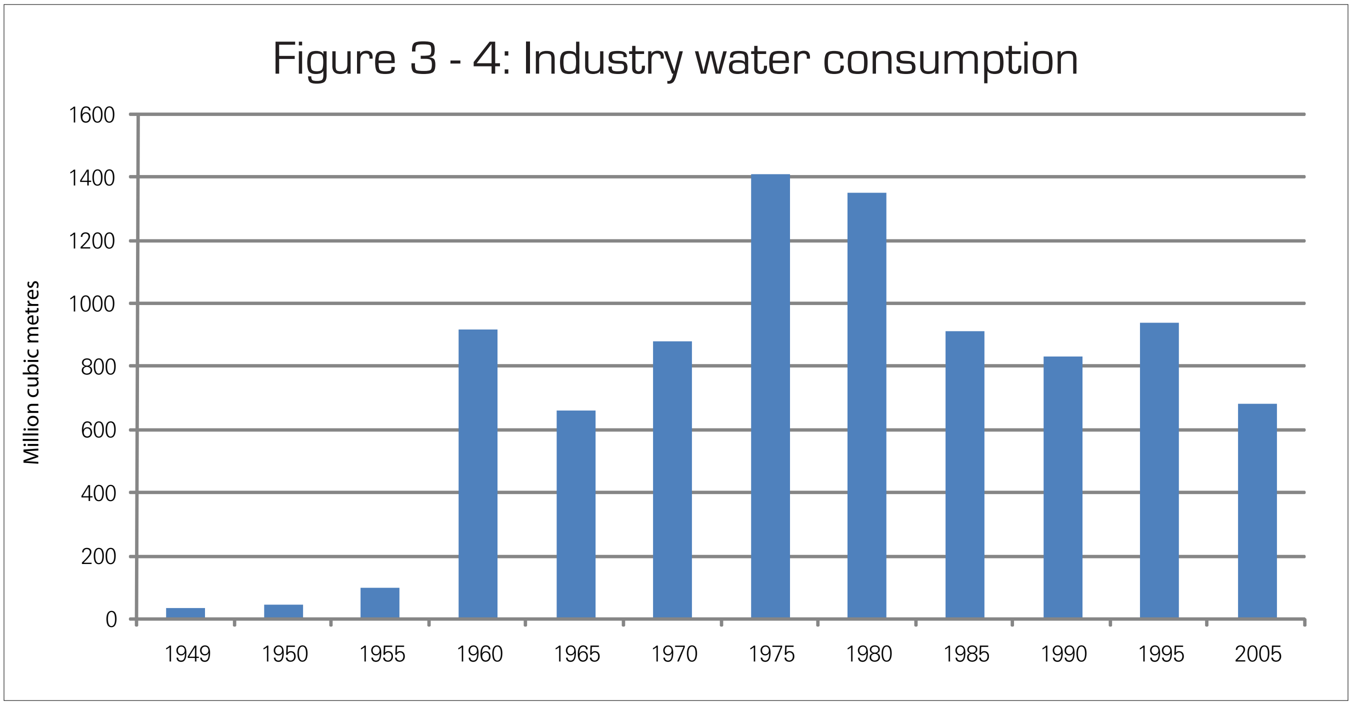
- Use of water from Guanting and Miyun reservoirs for irrigation peaked in 1962 at 1,124 million cubic metres, dropping to an average 622 million cubic metres between 1963 and 1984 and dropping further to a yearly average of 160 million cubic metres between 1985 and 1995.

Industry

Before 1949, there were few industrial enterprises demanding water supply in Beijing, with the exception of the Shijingshan (coal-fired) power plant and the Mentougou coal mine. Half a century later, Beijing had become the largest industrial city in northern China. Under the slogan "transforming a leisure-style town to a production-type city," China's leaders vigorously promoted the development of heavy industry in the nation's capital. As of 1995, there were 34,293 industrial enterprises citywide consuming 934 million cubic metres of water annually.

From 1949 onward, industrial water use increased as industry expanded – including metallurgy, power generation, chemical production, machinery, textiles, and papermaking. By 1963, industry in Beijing was consuming 640 million cubic metres annually compared to just 30 million cubic metres in 1949. By 1975, water consumption peaked at 1,407 million cubic metres, which is more than twice the amount of water used by Beijing industry today.

Figure 3-4 shows annual water consumption by industry for selected years between 1949 and 2005.



When the drought hit in the 1980s, Beijing launched a major water conservation campaign. This included expansion limits on the so-called shui laohu (or water tigers) – a reference to Beijing's water-intensive industries such as metallurgy, chemical production, and papermaking.

According to official data, industrial water use dropped by about 30 percent as a result of the campaign, from 1,350 million cubic metres in 1980 to 934 million cubic metres in 1995.

Urban environment

Since 1980, Beijing has supplied water to the capital's depleted lakes and canals, timed with public holidays and other national celebrations. City parks such as Zizhuyuan, Beijing Zoo, Shenshahai, and Beihai also receive water delivered from Beijing's reservoirs.

The watering of Beijing's urban landscapes is commonly done using rubber dams that block a river channel to store water for irrigation. These dams can be seen, for example, along the east section of the Liangma River and the Ba River. The water stored behind the rubber dams quickly becomes black and fetid. Such projects are implemented in the name of river management, flood control, and even wetlands protection, yet no attention is paid to the effect they have on groundwater levels and water supply downstream. The notion that rivers have a life of their own with specific ecological functions is not considered.

Table 3-4 provides a breakdown of water use for Beijing's urban environment between 1980 and 1995. Note the amount of water used for this purpose nearly tripled in the drought years of the 1980s and peaked in 1987.

By the early 1990s, Beijing's most famous lakes were visibly deteriorating: Kunming Lake, Yuanmingyuan (Old Summer Palace), Beihai (North Sea), Zhongnanhai, Shenshahai, Taoranting, Lianhuachi were drying out. In recent years, Beijing has diverted water to these lakes from Guanting and Miyun reservoirs.

Table 3-4: Water for urban environment (million cubic metres)

Year	Water consumption	Year	Water consumption
1980	17.68	1988	51.30
1981	24.39	1989	41.52
1982	36.18	1990	40.47
1983	28.38	1991	39.46
1984	30.20	1992	41.45
1985	38.51	1993	42.32
1986	44.86	1994	38.15
1987	51.77	1995	34.93

Kunming Lake

In the last three or four years, the Summer Palace, a symbol of Beijing's imperial heritage, has suffered a major water shortage. Kunming Lake, in the heart of the Summer Palace complex, is part of a natural river-lake system in Beijing that once acted as a reservoir for the city's northwest. Today the lake is drying up because of drought and the city's disappearing groundwater table. As the lake dries up, what little water remains evaporates quickly in the summer heat and it becomes more and more difficult to replenish such a large body of water.

In years gone by, water was released from Miyun reservoir to refill Kunming and other man-made lakes in Beijing. But in recent years of drought, the city's first priority for Miyun water is providing Beijing residents with a supply of tap water. Instead, water from the heavily polluted Guanting reservoir is delivered to Kunming Lake through existing river channels. (Note that almost half the diverted water is lost in delivery – a distance of more than 130 kilometres between the reservoir and the lake.)

Water delivery from Guanting to Kunming Lake occurs four times a year: in March, on May 1st (Labour Day), October 1st (National Day) and just before winter before the lake freezes. A total of about 10 million cubic metres of water from Guanting is reserved for Kunming Lake on an annual basis, in order to maintain a depth of 1.5 to 2 metres. In addition, if any special events take place — particularly visits by government leaders from foreign countries — the municipal water bureau will send extra water to the lake.

Old Summer Palace

The Beijing Water Bureau allocates one million cubic metres annually to the lake within the Old Summer Palace grounds (also known as Yuanmingyuan Park) even though the Palace authorities say they need seven or eight times that amount.

In 2004, the Palace authority lined the lake bottom with a plastic membrane in hope that this would prevent water from seeping into the ground and reduce the required number of refillings every year to one instead of three. The US$3.6 million initiative sparked an outcry from academics and environmental groups concerned that the plastic lining would create a stagnant pool and damage the local ecosystem.

Shortly after the controversy erupted, Beijing commissioned a number of international experts in ecological landscape design to propose alternative conservation measures. They proposed a wastewater treatment system that would recycle wastewater and capture rain for irrigating the gardens – an approach that has apparently proven successful in the southwestern United States and Mexico.

Eventually the Xiaojiahe treatment plant was built, but its capacity of 20,000 cubic metres per day is too small. The plant cannot produce enough treated water to meet the required standard for irrigating the gardens. Meanwhile, the Qinghe treatment plant which was recently built nearby, and has a much larger treatment capacity than Xiaojiahe, has had difficulty negotiating a contract with the Palace authorities. For now, the Qinghe plant is dedicated to treating only the water of the Qinghe River, which flows through the Olympic Village.

Domestic water use

Since the Yuan Dynasty (1271), Beijing residents have relied on springs and shallow wells to draw groundwater for household use. Shallow groundwater was plentiful and easily accessible within a few metres of ground level, particularly on the alluvial plains between the Yongding and Chaobai river valleys. Water was also diverted to the city from springs in Beijing's western hills, such as the well-known Yuquanshan, Wanquanzhuang, and Lianhuachi springs.

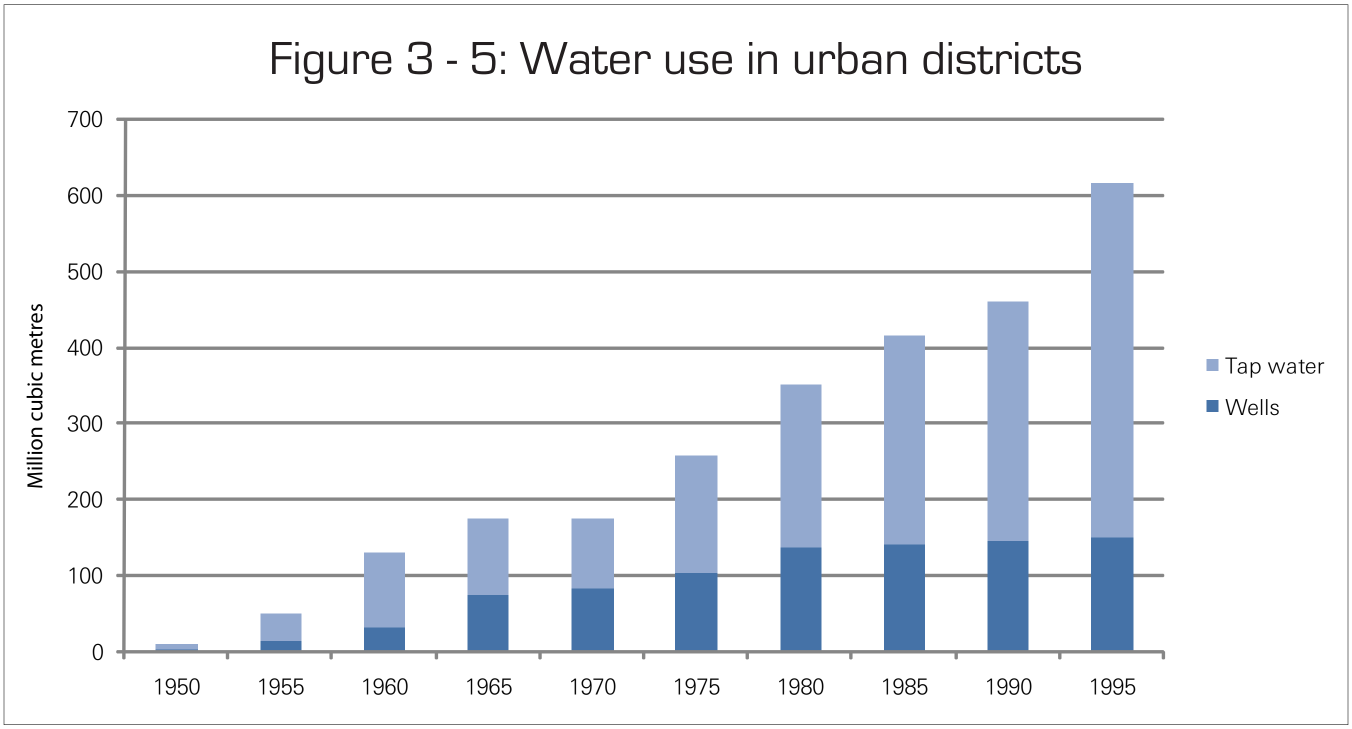
Beijing built its first municipal water treatment works in 1908, which had a daily supply capacity of 25,000 cubic metres. By 1949, the plant's daily supply capacity had increased to 58,000 cubic metres, which was enough to supply one-third of the city's population of 4.14 million.

As Beijing's urban population grew and lifestyles changed, the municipality expanded its water supply system to reach more households. Figure 3-5 shows domestic water use in urban districts between 1950 and 1995.

The data presented in Figure 3-5 and Appendix 5 show the following:

- Daily per capita domestic water use in urban districts increased seventeen-fold from 0.018 cubic metres in 1950 to 0.302 cubic metres in 1995.
- The volume of tap water used in urban districts increased from 7.0 million cubic metres in 1950 to 466 million cubic metres in 1995.
- As of 1995, tap water use had increased to 76 percent of total domestic water supply in urban districts, compared to 49 percent of total water use in 1970.

In the last decade, 10 new waterworks have been built to provide Beijing municipality with a daily water supply capacity of up to 2.68 million cubic metres. By 2010, another five waterworks are to be constructed and three extended which, if completed, will increase the municipality's capacity of water supply to 3.65 million cubic metres daily.



Golf courses

Golf courses in Beijing municipality consume an estimated 27 million cubic metres of water annually (assuming one 18-hole golf course uses about 1,000 cubic metres per day).

Beijing was introduced to this new "water tiger" by high ranking officials and the city's business elite during the 1980s. Almost overnight, golf became a symbol of social status and wealth and it has had a significant impact on water consumption. There are about 38 standard courses within the municipality, including 19 in Chaoyang district and nine in Haidian district, as well as dozens of golf practice ranges.

Golf courses not only consume a great deal of water (usually groundwater) but cause other environmental problems as well. Thousands of hectares of forest or farmland have been appropriated by developers and cleared to make way for golf courses. After the land has been cleared, agricultural chemicals and disinfectants are applied to the imported sod which pollutes the groundwater in the surrounding areas.

2008 Olympics

To host the "Green Olympics," Beijing municipality has developed man-made lakes and streams, musical fountains, and new parks, assuming that water will be taken from neighbouring Hebei province. Total water consumption during the 2008 Olympics is estimated at 200 million cubic metres. Some of the water-intensive sports facilities and waterscapes built for the Olympic Games are described below:

Wenyu – Chaobai Olympics diversion scheme

In January 2007, the Beijing Water Bureau announced a plan to divert water from the Wenyu River to the Chaobai River. The Chaobai River used to flow near the Shunyi Olympic Aquatic Park but has had little or no water for a decade now.

With a budget of 430 million yuan (US$57.3 million), the municipality built a 13-kilometre underground pipeline to take 380,000 cubic metres of water from Wenyu to the Jian River, which joins the lower reach of the Chaobai River just north of the Olympic Aquatic Park in Shunyi district.

Water from Wenyu will not be used by the Olympic Park directly but will be used to improve the scenery around the park during the Olympics. The park is near Shunyi town, one of Beijing's more affluent suburbs.

Prior to diversion, water from Wenyu will require treatment because much of the river is ranked Category V, which means it is too polluted for any human use, including irrigation (see Appendix 1).

Wenyu is the only river still flowing through Beijing with an estimated flow of 400 million cubic metres even in a dry year, consisting mostly of wastewater. Flowing through the heart of one of Beijing's more affluent communities, local residents often complain that its black, stinking water is offensive and disgusting.

Zhongguancun Fountain

This is a super-sized water landscape featuring a huge fountain, lights and music in the crowded Zhongguancun area (known as "Beijing's Silicon Valley") in the centre of Haidian district. Promoted as a "modern symphony in the city," the fountain is expected to operate during the opening ceremony and then only during national holidays due to its high operating costs.

Shunyi Olympic Aquatic Park

Chosen as the rowing base for the 2008 Olympic Games, the Chaobai River, already dry for years, will be filled with water from the Wenyu River this year to form a lake with a surface area of about 4,000 hectares (or 40 square kilometres). In the 2007 warm-up competition, Chaobai's dried-up riverbed was blocked with two rubber dams at either end and filled with groundwater.

Harmony Square (also known as Aquatic Paradise)

Within Shunyi Olympic Aquatic Park, this "fountain in the desert" is designed with a water surface of 11.37 million square metres and a fountain that can shoot up as high as 136.8 metres. The fountain height represents the year Shunyi town was established: 1368.

Olympic Village Lake

This newly-constructed lake in the heart of the Olympic Village will be filled with water that has been diverted from the Qing River and treated at one of the city's waterworks.

Luxury buildings and hotels

To accommodate millions of Olympic spectators, dozens of luxury buildings and hotels that consume a great deal of water have been built. Behind the Haidian Mountain, for example, is the newly-built Daoxianghujing (Fragrant Rice Scenic Lake) Hotel which boasts a new man-made lake fed by pumped groundwater. In addition, a new national theatre (surrounded by 35,000 square metres of water), a CCTV building, and an international airport terminal have recently been completed.

Olympics sports facilities

Thirty-two competition venues and 19 newly-constructed sports facilities, including the main sports centre nicknamed the Bird's Nest, the diving hall nicknamed the Water Cube, and Fengtai baseball stadium. The baseball facilities alone will require at least 100,000 cubic metres of water annually.

Urban parks

A new 12,500-hectare green belt of irrigated trees and shrubs dotted with man-made lakes has been added to the city's urban landscapes.

Chapter 4: Beijing's Water Crisis

From abundance to scarcity in 60 years

Beijing is running out of freshwater. Although more than 200 rivers and streams can still be found on official maps of Beijing, the sad reality is little or no water flows there anymore. Beijing's springs, famous for their sweet-tasting water have disappeared. Finding a clean water source anywhere in the city has become impossible.

As recently as 30 years ago, Beijing residents regarded groundwater as an inexhaustible resource. Now hydrogeologists warn it too is running out. Beijing's groundwater table is dropping, water is being pumped out faster than it can be replenished, and more and more groundwater is becoming polluted.

How did Beijing go from water abundance to its present-day crisis? Certainly, drought is an important factor. The municipality has endured 25 years of below-average rainfall since the 1980s and nine consecutive dry years since 1999. Less rainfall means less surface runoff flowing to Beijing's rivers and reservoirs, and less water available for groundwater recharge. So too, Beijing's growing population and industrial development have driven huge increases in water demand, as the data suggests. But to say that drought and population increase are the main causes behind Beijing's water crisis is an overstatement.

Beijing's water crisis stems more from decades of short-sighted policies that have degraded its watershed and a political fixation on large-scale and environmentally damaging engineering projects to keep the taps flowing at little or no charge to consumers. On the demand side, water consumption has been divorced from consequence without price signals to indicate scarcity.

Beginning after "New China" was established in 1949, state-owned logging companies cut down the forests at the headwaters of Beijing's rivers. People were encouraged to farm every denuded hillside and mountain top, and to create more farmland by draining wetlands. Also, the rivers were dammed: at least 85 reservoirs have been built in Beijing's outlying districts since the 1950s to store water for industrial development and irrigated agriculture. Soon the rivers began drying out as more and more of this water was diverted from the reservoirs to nearby fields and industry, with the balance supplying the city with drinking water via man-made canals.

Beijing's policy of guaranteeing water supply to the capital – even as its rivers and reservoirs were drying up – has wreaked havoc on farmers and encouraged wasteful consumption by industry and urban consumers. The experience with Beijing's two largest reservoirs, Guanting and Miyun, is a case in point. When drought struck in the early 1970s, the central government cut back the amount of water released from the two reservoirs to Beijing's farmers. This forced more than 100,000 hectares of irrigated farmland out of production and prompted the digging of 30,000 wells so that farmers had an alternative supply of irrigation water. So began rural Beijing's exhausting reliance on groundwater for irrigation.

When another drought hit in the early 1980s, once again the authorities cut back water for irrigation in order to guarantee supply to urban residents. By this time, Miyun and Guanting were supplying tap water to millions of urban households. Also, more and more groundwater was being pumped to meet urban demand. So even amidst drought, urban residents and industry were supplied with water without the benefit of price feedback to signal water scarcity and promote conservation.

Today more than two-thirds of the entire municipality's water supply comes from groundwater, having exhausted the city's two largest reservoirs. Guanting and Miyun now hold less than ten percent of their original storage capacity, and Guanting can no longer supply the capital with drinking water because it is too polluted.

Through the 1980s and 1990s, Beijing pumped groundwater at an annual rate of 2.8 or 2.9 billion cubic metres, far exceeding the so-called safe or allowable limit of extraction (where the rate of extraction is lower than the rate of recharge – experts have set this limit at 2.0 to 2.5 billion cubic metres annually.) To date, an estimated 6 billion cubic metres of groundwater has been extracted above the safe limit and may never be replenished.

In the last few decades, Beijing has lost much of its capacity to recharge groundwater. In addition to rising demand (which increases extraction,) the expanse of roads, buildings, and infrastructure now covering the natural ground surface mean that less water is seeping back into the ground. Also, because all the rivers have been dammed, the floodplains downstream no longer receive the floodwaters that used to recharge groundwater naturally.

Official responses to Beijing's drought and competing water demands

The central government's first response to drought and competing demands for water was to reallocate water from Beijing's two largest reservoirs to industry and urban residents, thus depriving farmers of water for irrigation. Then, as Miyun and Guanting lost their capacity to provide water to the city, groundwater use rapidly increased. In the last five years, with Beijing's surface and groundwater supplies nearing exhaustion, the State Council has ordered a series of "emergency water transfers" from outside Beijing municipality via newly-constructed canals and reservoirs. The State Council has also imposed restrictions on water use in upstream Hebei in an effort to increase river flow to Beijing. In this way, Beijing's incessant demand for new supply, and its political authority to take water from other river basins, now threatens millions of water users beyond its watershed.

Beijing's policy responses to the water crisis:

- Reallocate surface water from rural to urban consumers
- Extract ever-deeper groundwater
- Divert surface water to Beijing city from reservoirs and rivers outside Beijing municipality
- Restrict water use in upstream Hebei
- Cut off river flow to downstream Tianjin
- Shut down or relocate polluting and water-intensive industries

Karst groundwater supply expansion

To slow the depletion of groundwater aquifers on Beijing plain, China's Ministry of Water Resources developed a plan to extract groundwater from karst aquifers in Beijing's outlying districts. Traditionally, these karst aquifers – with groundwater at depths of 1,000 metres or more – have been protected as emergency water reserves for use only in times of war or for use by future generations. But in 2004, the national water ministry completed two of five planned deep groundwater extraction projects (See Table 4-1).

The total amount of karst groundwater to be extracted annually from the five sites ranges from 274 to 452 million cubic metres. Notably, an earlier assessment recommended less extraction; no more than 200 million cubic metres annually and an additional 200 to 400 million cubic metres for emergencies. But it is not clear what kind of emergency would trigger the maximum extraction of karst groundwater.

Karst groundwater

Karst refers to a type of terrain, usually formed on carbonate rock (limestone and dolomite) through which groundwater flows to form a subsurface drainage system and discharges at surface level springs. Groundwater flow in karst aquifers is significantly different from that of other aquifers because its flows are turbulent with velocities approaching those of surface streams. Groundwater flow in aquifers composed of sand, gravel or bedrock is usually very slow. Karst groundwater systems are extremely vulnerable to contamination; they can create sinkholes and cause sinkhole collapse. In North China, geologists estimate there are about 100 large karst spring systems each with a watershed area from 500 to over 4,000 square kilometres with an average discharge from 1 to 13 cubic metres per second.

Despite objections raised by some experts, proponents of karst groundwater extraction argued that little harm would be done to the environment apart from a drawdown effect on other wells in the area which are currently used for irrigation. In response to concerns about sustainability, proponents argued that the karst aquifers would be replenished once the years of ample rainfall return.

Table 4-1 Karst groundwater extraction sites (10,000 metres/day)

Site (river basin)	Water supply	Emergency extraction	Status
Pinggu district (Jucuo)	37	50	Completed 2004
Lianghe Village, Huairou county (Chaobai)	10	35	Completed 2004
Changgou Fangshan county (Dashi)	20	30	n/a
Yuquanshan to Kunming Lake(Yongding)	10	30	n/a
Nanshao Changping district (Wenyu)	10	20	n/a

Surface water supply expansion

In 2003, the central government began arranging 'emergency water transfers' from neighbouring regions to Beijing city. (See Table 4-2).

South-North diversion project

The State Council's ultimate solution to Beijing's water crisis is the massive South-North diversion project, first proposed by Mao Zedong in 1952 and approved by the central government in 2001. If all three routes are completed, as much as 48 billion cubic metres of water will be extracted from the Yangtze River and delivered to Beijing at a cost of at least US$60 billion, more than twice the official cost of the Three Gorges dam. South-North diversion proponents talk of quenching Beijing's thirst with "surplus" water from the Yangtze, as if draining China's longest river – Shanghai's water supply – would have little or no economic or environmental consequences for the millions of people in southern and southwestern China.

Table 4-2: Beijing's water transfer schemes

Completion date	Water volume (million cubic metres)	Diversion from:	Diversion to:	Distance (km)
Sep 2003 – Oct 2005	n/a	Cetian reservoir in Datong city, Shanxi province.	Via canals to Sanggan and Yang rivers, which flow into the Yongding river and the Guanting reservoir.	185
Sep 2003 – Oct 2005	142	4 existing reservoirs in Hebei province: Youyi, Xiangshuibao, Huliuhe, and Yunzhou.	See above	80
2004	10	Baihebao reservoir Beijing municipality	Miyun reservoir, Beijing	75

Completion date	Water volume (million cubic metres)	Diversion from:	Diversion to:	Distance (km)
2008	400	Shijiazhuang-Beijing section of the South-North water transfer project (central route). Includes 4 newly-constructed reservoirs in Hebei Province: Gangnan and Huangbizhuang on the Hutuo river; Wangkuai on the Daqing River, and Xidayang on Tongtian, Wuming and Tang rivers.	Beijing	200-300
2010	1,200	Danjiangkou reservoir Han River (Yangtze tributary) Hubei province	Tuancheng Lake, Beijing	1,271

Beijing water policy: 2008 Olympic Games and beyond

With the 2008 Olympic Games imminent, the central government announced its three policies for ensuring Beijing has adequate water supplies for the Olympics and beyond. The policies are:

- Extract water from river basins outside Beijing municipality

  This policy refers to water diversion projects underway to bring water from Hebei in time for the Olympics, and from the Yangtze by 2010. See Table 4-2.

- Increase runoff from upstream areas

  This policy refers to a "water allocation plan" issued earlier this year by China's Ministry of Water Resources and the country's lead planning agency, the National Development and Planning Commission. Under this plan, upstream Shanxi and Hebei provinces must guarantee surface water to Beijing as follows: 420 million cubic metres in a normal year, 215 million cubic metres in a moderately dry year, and 90 million cubic metres in a dry year.

- Exploit and protect groundwater

  As noted earlier, more than two-thirds of Beijing's current water supply comes from groundwater within Beijing municipality, including karst groundwater from depths of 1,000 metres or more. This latest policy announcement refers to restrictions imposed on groundwater use outside Beijing municipality, which the central government claims will help increase surface runoff to Beijing. For example, Hebei province has banned groundwater use in the area where Beijing's largest rivers, Yongding and Chaobai, are said to originate – the Bashang area of Hebei's Zhangjiakou city, northeast of Beijing. Zhangjiakou city has also introduced a water licensing system aimed at restricting the use of groundwater for growing vegetables.

Chapter 5: Reversing Beijing's Water Crisis

Endless supply expansion is not the answer

Taking ever more water from ever further jurisdictions beyond Beijing may be an emergency measure to ease Beijing's water shortages and flush out its polluted waterways, but it is not a fundamental solution. Long distance diversion is extraordinarily expensive and environmentally damaging. Even if water is successfully diverted from Hebei province in 2008 and the Yangtze River in 2010, groundwater will continue to be Beijing's most important water source. The municipality will still need to continue pumping about three billion cubic metres of groundwater annually to keep up with the forecasted growth in demand – that's 500 million cubic metres over the annual allowable limit for "safe" extraction. With each new project to tap water somewhere else, demand for water increases at an ever greater cost to China's environment and economy.

Whether diverting surface water or digging ever-deeper for groundwater, the underlying solution proposed is like trying to "quench thirst by drinking poison." Nor is there more sense in the proposals to move the capital south or resettle downtown residents to new towns in the municipality. This would only transfer the twin problems of shortages and profligate consumption to other areas. There is a better way.

Reduce demand using the rule of law and economic incentives

The key to addressing Beijing's water crisis is not more engineering projects to deliver new supplies. More dams, diversion canals, pipelines and even desalination plants may be technically feasible but they are economically and environmentally ruinous. A better approach would be to curb demand through efficiency improvements in water supply and consumption using the rule of law and economic incentives. A growing number of experts in China recognize the principles and potential of this approach, which is introduced below.

Enforce existing laws and regulations

Experts and environmentalists have long urged Beijing authorities to enforce existing laws and regulations aimed at curbing unaccountable and water-profligate urban development within the municipality. The State Council, for example, has issued regulations requiring that any plan or undertaking to take water or store water in rivers must be subject to approval by the relevant authorities. Enforcing such regulations along with full disclosure would force proponents to account for their proposed actions and would thereby discourage environmentally damaging schemes.

Other laws and regulations, if enforced, would oblige the central and municipal authorities to take the following action within Beijing municipality:

- Shut down polluting factories;
- Prohibit development projects in water source protection zones;
- Prohibit the dumping of untreated industrial wastewater and household sewage into Beijing's waterways;
- Suspend the construction of golf courses;
- Impose fines on water polluters

Impose full-cost water pricing to reduce demand and promote efficiency

China's State Environmental Protection Agency, the country's top environmental regulator, as well as the Beijing Water Bureau and other government authorities have endorsed full-cost pricing as an effective tool for managing demand and promoting efficient water use. In the last 15 years, the municipality has increased water rates nine times. The current residential rate for water is 3.7 yuan per cubic metre, which is the highest in China, and more than 30 times the 1991 price of 0.12 yuan. But like many jurisdictions world-wide, Beijing's water rates do not yet reflect the full cost of water treatment, sewage, delivery, tapping the water source, and the value of the water itself.
In 2006, the National Development and Reform Commission issued a regulation on water pricing, capping certain expenditures and stipulating what should be covered in the rates charged to consumers. Under this regulation, water prices should include the cost of tapping the water resources, providing the running water, constructing the infrastructure required for delivery, and

treating sewage. Capital costs, meanwhile, continue to be subsidized by the central government which means that current rates don't come close to the full cost of supply expansion.

Full-cost pricing is essential for curbing demand: those who pay for and benefit from water and water services are more inclined to conserve water than when the resource (or the service) is given away for free or below-cost. Higher water prices that better reflect the true cost of using water would send important information to consumers and water providers about the value and availability of water. This would enable consumers to make informed decisions about use and limit demand for new supplies.

Introducing higher prices would also encourage investment in sewage and wastewater treatment, encourage factories and other large consumers to recycle water, discourage over-expansion of water-intensive industries, encourage farmers to switch to less water-intensive agriculture or livelihoods, and encourage investments to reduce system losses (i.e., plugging or replacing leaky mains and water pipes).

Table 5-1 provides a breakdown of water and sewerage rates for residential consumers in Beijing in 2003 and 2004. According to the World Bank, full-cost recovery in the water sector would require rates to go up at least another 35 percent, to 5.0 yuan per cubic metre or higher. At current prices, Beijing's state-owned water companies are profitably operating a number of wastewater and sewage treatment plants, although it's not known what, if any, portion of their capital costs are passed on to consumers in the prices they pay. If operated as planned, the new plants may allow Beijing municipality to meet its goal of treating 90 percent of its wastewater by 2008.

Table 5-1: Residential water and sewerage rates

Fee	2003 (yuan/cubic metre)	2004 (yuan/cubic metre)
Water resource (Includes surface and groundwater)	0.6	1.10
Tap water supply (operation and maintenance costs, as well as some portion of the capital costs)	1.7	1.08
Sewage treatment	0.6	0.9
Tax	0.33	n/a
Wastewater disposal	n/a	0.90
TOTAL	2.9	3.7

*1 yuan = 0.145 USD (June, 2008)

With higher prices for water and water services, the enormous potential for saving water (and thereby reducing demand) is no longer a theoretical proposition. Efficiency improvements will increasingly become an attractive investment opportunity for any number of companies supplying specialized technologies and processes that help consumers reduce their water and sewerage bills. Consider the potential for recycling water as one example: Beijing industries currently recycle only about 15 percent of their water, compared to 85 percent in industrial countries.

Beijing's rising state water companies

Beijing Capital invests in wastewater treatment plants and drinking water facilities in Beijing and in 12 other cities. Its subsidiary, Beijing Water Company is treating 2.1 million cubic metres of wastewater annually.

Beijing Institute of Water Resources and Hydropower Research Corporation was founded in 1993 as a company specializing in water treatment under the China Institute of Water Resources and Hydropower Research. Beijing IWHR Corporation recently formed a partnership with **Mitsubishi** (Japan) and **Anglian Water** (UK) to build a $200 million water processing facility in Chaoyang district. The facility will take untreated water from Miyun reservoir and supply 500,000 cubic metres of potable water per day.

Beijing Waterworks Group is the largest tap water supplier in China and the only tap water supplier in the Beijing area. The company is responsible for supplying urban households in the city centre and in seven suburbs. It operates 20 tap water factories supplying 3.15 million cubic metres per day.

Establish a water industry regulator

Higher water rates on their own don't guarantee benefits to consumers or to the environment. When the job of setting rates is left to proponents of water projects or to politicians, consumers may see rates go up without any measurable improvement in water service or the environment. Conversely, rates could remain below-cost as the government continued to subsidize environmentally damaging supply expansion in the name of cheap water.

In setting rates there are two parties to the contract: water suppliers and water consumers. The latter have the right to demand and receive certain services and the former have the right to recoup costs fairly. To ensure rates are reasonable for both suppliers and consumers, the complex technical task of setting water rates – deciding what goes into prices and who can charge how much for what services – should be given to an economic regulator separate from the water and sewerage service providers and from the politicians. This would enforce the rights and obligations of both suppliers and consumers.

Currently, China's National Development and Reform Commission, the country's top planning agency, issues regulations governing the water industry, but enforcing those regulations is generally left to municipal and district governments and the service providers themselves – including government departments and state-owned water companies. Inevitably, conflicts of interest arise, which create perverse incentives to pollute water, waste water, hide problems and inflate costs. Beijing Capital, for example, is an investor, planner, builder, operator, policy-maker and de facto regulator of its own wastewater treatment business in Beijing. Beijing Capital's investors and customers would benefit from a separate economic regulator that sets price limits, reviews its costs, and ensures that Beijing Capital and other service providers are providing consumers with the best quality water services at fair prices to both parties. (In parallel, the country's environmental regulator, State Environmental Protection Agency, must ensure that water and sewerage companies comply with the country's laws pertaining to water source development and protection.)

Ideally, the economic regulator should ensure that water prices cover the full cost of the infrastructure required to treat, store and distribute the water. Prices should vary depending on the users' distance from the source of supply, since long distance delivery will have higher costs (and more water losses) than local sources. The price should include a charge for the water itself – one that reflects the value of the resource and its scarcity. That portion of the price should vary depending on the availability of water in the watershed; it should vary with season and even in some cases with time of day. Ideally, the price should also reflect how much of the water is lost through evaporation and how much water is eventually returned to the source.

Above all, the regulator must set price limits, review costs and make decisions on awarding or denying rate increases to service providers in a transparent manner to prevent any price manipulation or other forms of monopoly abuse. Consumers are less likely to object to paying higher rates for good service if they can verify and have confidence that their money is going to sensible investments in efficiency improvements and state-of-the-art wastewater treatment facilities, for example, and not to ill-advised investments, inflated staff salaries or Swiss bank accounts.

Regulating the UK water industry: Clean water at fair prices

Ofwat, the Water Services Regulation Authority for England and Wales, regulates water and sewerage companies in England and Wales. www.ofwat.gov.uk

Ofwat sets the maximum price at which water companies can sell their water and other services. Every five years, Ofwat reviews the business plans of the water companies before setting an annual price limit for the next five years for each company. The price limit on rates is meant to allow enough revenue for operations, investment, and a reasonable return on investment. The return on investment is needed to raise financing for reinvestment in the system.

Ofwat requires water and sewerage companies to make efficiency improvements (i.e., plug leaky pipes) and rewards them by allowing them to keep a portion of the cost savings while passing the rest onto customers in the form of lower rates. The regulator also publishes comparisons between companies to help raise the standards of those companies that may be out of compliance with standards and need to improve their performance.

Rates: Ofwat has approved successive rate increases to allow companies to finance improved quality standards and service levels. Note that rate increases would likely have been far greater if the companies had not become more efficient in response to regulation.

According to the World Bank, water consumers in England and Wales currently pay between US$2.20 and $2.70 per cubic metre of water, which is roughly five times the rate of US$0.54 (3.7 yuan) per cubic metre in Beijing. Brazilians pay on average between US$0.65 and $0.80 per cubic metre of water.

Investment: UK water companies have invested US$ 97 billion in upgrading water systems since privatization in 1989. Between 2005 and 2010, UK water companies are planning to invest another US$10.7 billion to further improve drinking water and protect the environment.

Performance: 99.94 percent of the drinking water supplied by UK water companies currently meets international standards. Beaches (historically contaminated by sewage and wastewater) meeting compulsory standards for water quality rose from 66 percent in 1984 to 98.5 percent in 2004.

In the last decade, UK water companies have reduced the amount of water lost to leaks by an average 30 percent. Ofwat reports that London's leakage rates remain unacceptably high so it has set new targets for efficiency improvements to be made in 2009 and 2010.

Assign tradable water rights to manage competing water demands

Another promising tool for making better use of Beijing's scarce water resources is tradable water rights. Earlier this year, the central government introduced a framework for allocating water rights across provinces and municipalities. The Interim Measure for Water Quantity, which came into effect on February 1, 2008, lays out the principles, mechanisms and practices for water allocation. Although a review of this legislation is beyond the scope of this report, proponents believe it could potentially reduce demand and accelerate conservation in jurisdictions with competing water demands and extremely limited water supply, based on the experience in parts of Australia and the western United States.

If regulated properly, a tradable water rights regime within Beijing municipality could potentially shift current water allocations to users that most value the water. So, for example, instead of taking water from farmers, a Beijing water company would have the option to buy water from them or other users with prior rights, whether agricultural or industrial. Other parties, such as conservation groups, resort owners, park authorities and anyone else with an interest in seeing more water left in streams, should also be allowed to purchase water rights for instream flows.

Assigning water rights to existing users or groups of users (i.e., water utilities, farmers, and industry) must come first, however. Such rights would give existing water users the option to buy or sell their water rights. In times of water shortage, the older water rights holders would have priority over newer rights holders. Under such a regime, state or municipal water companies in China could no longer take water from other users and jurisdictions, they would have to buy it, and under strictly regulated terms.

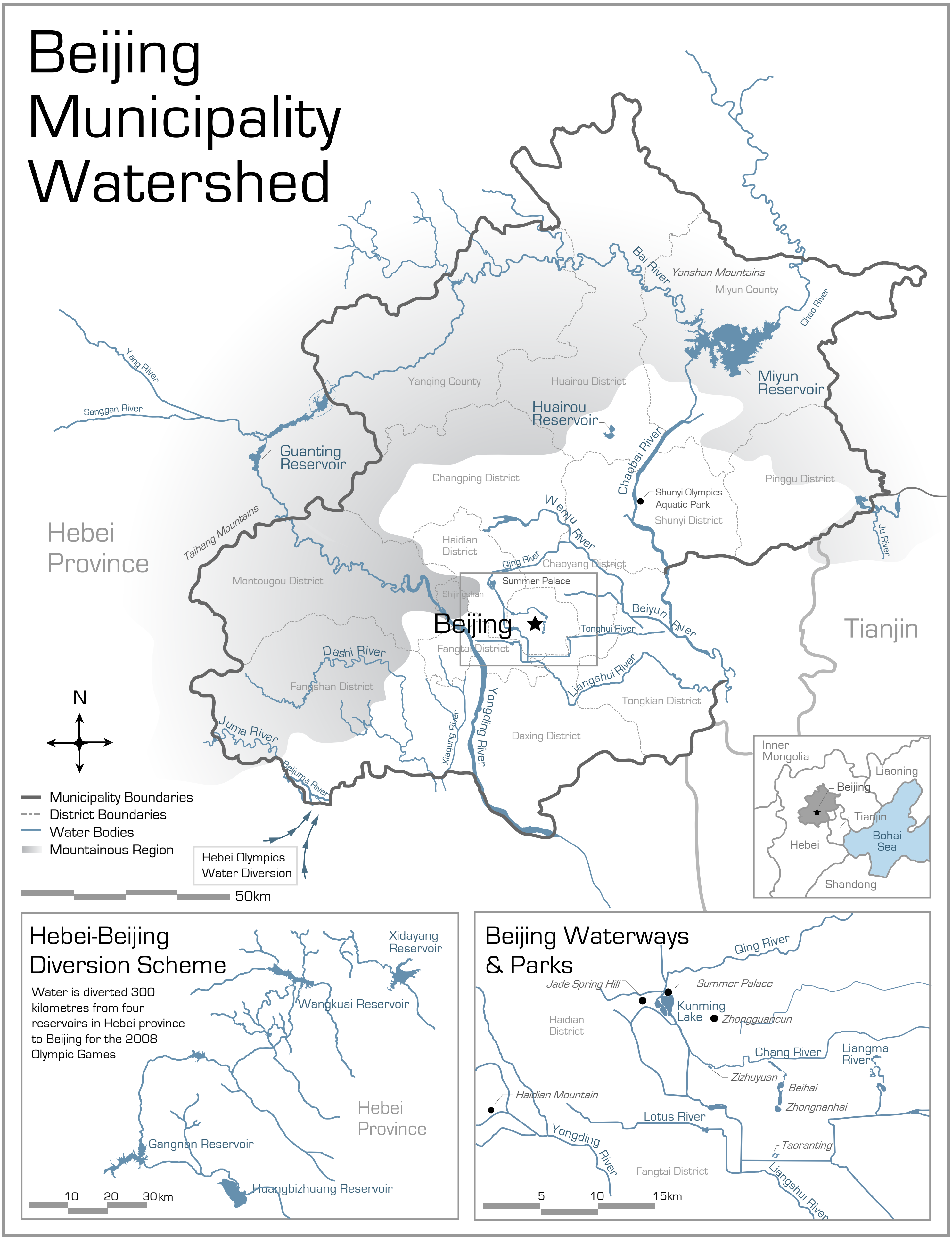
To protect the environment, allocated water rights must reflect not only the amount of water that may be extracted by the rights holder, but also the amount that may be consumed and the amount that must be returned to the source. There would also need to be strict requirements as to the quality of water returned by the rights holder to the source. In Beijing's case, where water in rivers and aquifers is already over-allocated, the total amount of water allocated under the new rights regime would have to be less an amount needed for incremental restoration of its depleted water sources.

The process of assigning rights and administering the trading of those rights requires systems for accurately measuring and monitoring surface and groundwater use as well as a transparent regulatory system to prevent abuse.

Whether tradable water rights can be made to work for the benefit of water consumers and the environment remains to be seen. For most countries, not just China, establishing tradable water rights is a major challenge after decades of water exploitation without the benefit of economic discipline or effective environmental regulation. But it is hard to imagine a country and a city region where the need and potential for success is greater.

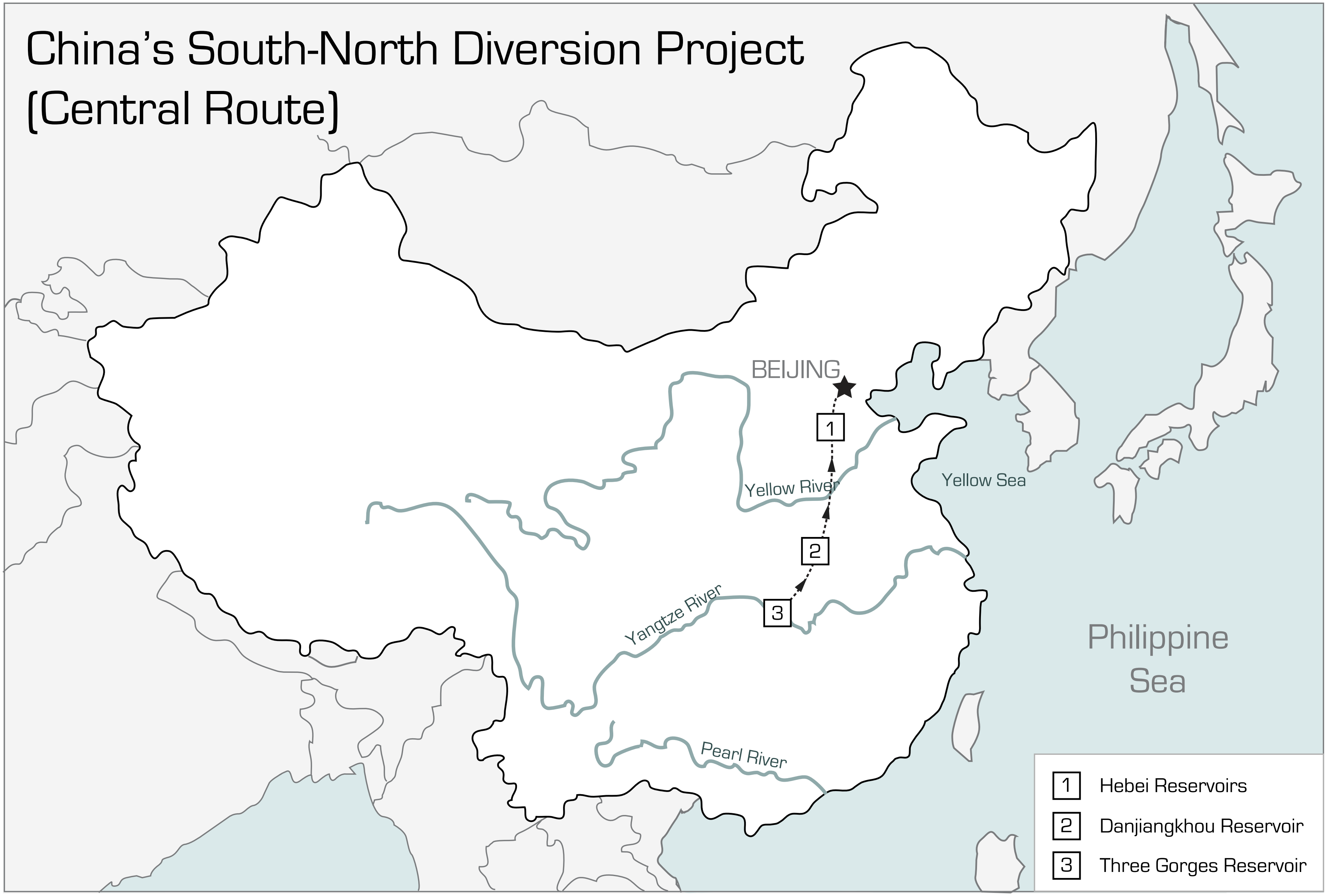
Maps:

Beijing Municipality Watershed
China's South-North Diversion Project



Probe International 2008

China's South-North Diversion Project (Central Route)



Notes

1. Beijing is both a city and a municipality or region that includes rural and urban areas. For the purpose of this report, Beijing refers to the municipality unless otherwise noted.

2. The bulk of the historical water supply and consumption data presented in this report was obtained from the Beijing Water Bureau. The history of Guanting and Miyun reservoir management is provided by sources in Beijing. Information related to water supply and consumption during the 2008 Olympics is based on interviews with government officials and official news sources.

3. Because of the difficulty verifying data, this report represents a best estimate of the current situation based on official sources, eyewitness accounts, and expert opinion.

4. The report acknowledges that government authorities have introduced many water-saving programs and campaigns in response to Beijing's water crisis. However, without access to verifiable data it is not possible to assess what, if any, effect such programs have had on Beijing's water consumption and demand. Open access to data and further investigation is required.

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Appendices:

1: China's water quality standards
2: Water use by sector
3: Water consumption in Beijing municipality's rural area
4: Water use by industry
5: Water use in urban districts
6: Beijing's water and sewerage system

Appendix 1:
China's water quality standards

China's Water Quality Standards

Class	Description
Category I	Applies to water sources and national nature reserves
Category II	Applies to class A water source protection areas for centralized drinking water supply, sanctuaries for rare fish species and spawning grounds for fish and shrimp
Category III	Applies to class B water source protection areas for centralized drinking water supply, sanctuaries for common fish species and swimming zones
Category IV	Applies to water bodies for general industrial water supply and recreational waters in which there is no direct human contact with the water
Category V	Applies to water bodies for agricultural water supply and for general landscape requirements
Category V+	Not to be used

Appendix 2:
Water use by sector

Water use by sector (million cubic metres/year)

Year	Agriculture	Industry	Domestic	Urban Environment	TOTAL
2005	1,322	680	1,338	110	3,450
	38%	20%	39%	3%	100%
1995	2,010	934	616	34.93	3,595
	56%	26%	17%	1%	100%
1985	2,223	909	415	38.51	3,586
	62%	25%	12%	1%	100%
1975	2,938	1,407	185	n/a	4,530
	65%	31%	4%		100%

Appendix 3:
Water consumption in Beijing municipality's rural areas 1958-1995

Water consumption in Beijing municipality's rural areas 1958-1995 (million cubic meters)

Year	Surface Water					Ground Water	Industrial Waste-water	Total
	Guanting reservoir	Miyun reservoir	Sub-total	Other Reservoirs & Rivers	Sub - Total			
1958	114		114	168	282	257	34	573
1959	126		126	211	337	225	98	660
1960	489		489	405	894	215	264	1373
1961	387	424	811	201	1012	365	229	1606
1962	501	623	1124	200	1324	260	156	1740
1963	209	422	631	247	878	316	168	1362
1964	227	128	355	216	571	442	139	1152
1965	538	378	916	279	1195	580	198	1973
1966	189	472	661	226	887	950	263	2100
1967	254	251	505	273	778	739	181	1698
1968	519	409	928	226	1154	1024	245	2423
1969	383	108	491	284	775	900	209	1884
1970	581	297	878	359	1237	1229	314	2780
1971	122	574	669	341	1037	1266	381	2684
1972	69	383	412	269	681	1215	366	2262
1973	7	247	254	298	552	698	333	1583
1974	88	473	561	424	985	730	535	2250
1975	114	751	865	381	1246	1083	609	2938
1976	9	454	463	358	821	1311	421	2553
1977	65	303	366	444	810	869	502	2181
1978	57	515	572	456	1028	846	499	2373
1979	119	453	644	310	954	983	485	2422
1980	269	630	899	372	1271	1379	1379	3172

Year	Surface Water					Ground Water	Industrial Waste-water	Total
	Guanting reservoir	Miyun reservoir	Sub-total	Other Reservoirs & Rivers	Sub - Total			
1981	109	333	442	312	754	1691	405	285
1982	77	331	408	354	762	1696	413	2871
1983	163	449	612	326	938	1729	442	3109
1984	66	392	458	221	679	1674	329	2682
1985	25	155	180	232	412	1569	242	2223
1986	32	211	243	274	517	1586	228	2331
1987	31	121	152	286	438	1471	220	2129
1988	30	196	226	284	510	1514	199	2223
1989	61	188	249	249	311	1617	229	2406
1990	40	124	164	417	581	1447		2028
1991	24	90	114	438	552	1558		2110
1992	30	131	161	301	462	1649		2111
1993	24	138	162	323	385	1620	147	2152
1994	9	96	105	321	426	1643		2069
1995	8	47	55	375	430	1580		2010

Appendix 4:
Water use by industry 1949-1995

Water use by industry 1949-1995 (million cubic meters)

Year	Industrial Output		Power industry	Other Industries			Total Water Consump-tion	Growth rate (%)
	100 million yuan RMB*	Growth rate %		Districts	Counties	Sub-total		
1949	1		24	7	1	8	32	
1950	3	200	36	7	1	8	44	40.3
1955	13	33.8	70	23	3	26	96	16.9
1960	85	46	656	222	3.5	257	913	56.9
1965	54	3.7	353	261	41	303	656	-6.4
1970	118	15.9	432	364	81	445	877	6.0
1975	193	10.5	661	525	221	746	1,407	9.9
1980	305	9.5	590	531	230	760	1,350	-0.8
1985	469	9.0	249	435	228	660	909	-7.6
1990	791	11.0	211	396	223	619	830	-1.8
1995	1363	11.5	210	392	332	724	934	2.1

*Based on the fixed price in 1990

Appendix 5:
Water use in urban districts

Water use in urban districts (million cubic metres)

Year	Water consumption (million cubic metres			Daily per capita (cubic metres)
	Wells	Tap water	Sub-total	
1950	2	7	9	0.018
1955	14	35	48	0.051
1960	32	97	129	0.087
1965	73	102	175	0.119
1970	82	93	175	0.135
1975	103	154	257	0.185
1980	135	215	350	0.220
1985	140	275	415	0.240
1990	145	315	46	0.234
1995	150	466	616	0.302

Appendix 6:
Beijing's water and sewerage system

Beijing's water and sewerage system

Problem	Recent Improvements
Water mains lose 20 percent of water in delivery; more than double the rate of loss in most cities around the world.	**Beijing Waterworks Group** is investing $256 million to upgrade the water system, including $22 million to repair leaking pipes. **Halma Water Management** installed more than 3,000 "loggers" to detect leaks in Beijing's water mains in 2007.
Beijing discharges 1.13 billion cubic metres of wastewater; one-third from industry, two-thirds from domestic households (2005 Beijing Water Resources Bulletin).	**Beijing Sewage Group** is building 10 new sewage plants to meet the goal of treating 90 percent of Beijing's wastewater and sewage by 2008. **Zenon**, a global wastewater technology company, has invested $6 million in 12 industrial wastewater treatment projects in Beijing. One project will allow the **Beijing Yanshan Petrochemical Company** to treat and reuse its wastewater as process water and to feed its boilers. **Praxair**, a global industrial gas company, is supplying oxygen to three wastewater re-use plants operated by **Beijing Drainage Group Company.**

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