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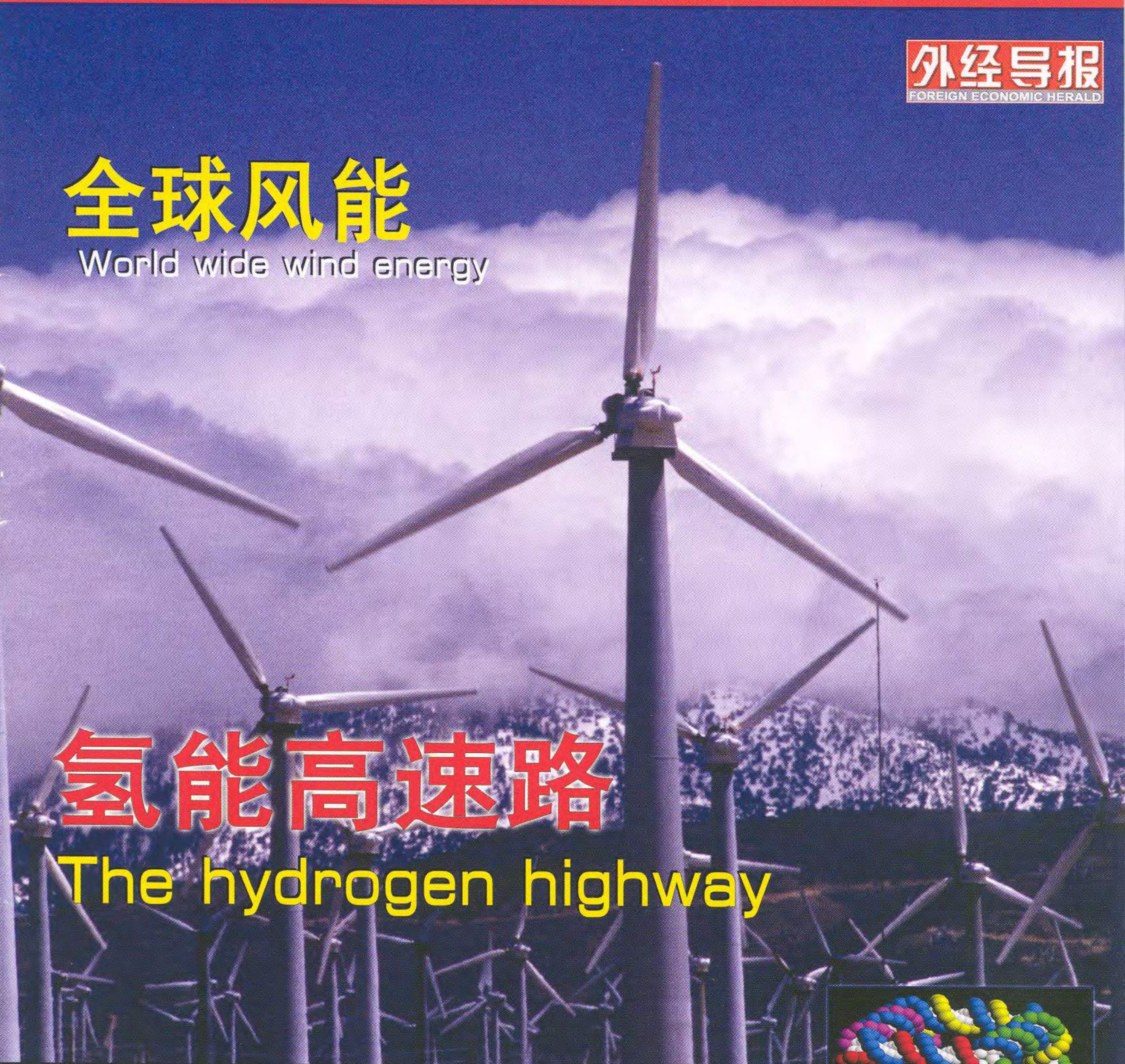

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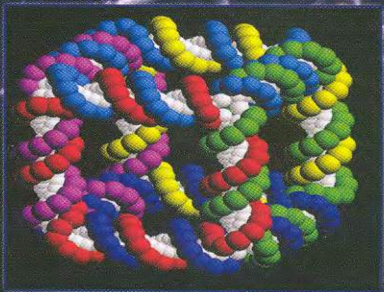


危机管理：二十一世纪的地下水

美国城市和乡村持续的人口增长已经造成了供水管理方式的主要变化

撰文/ 迈克尔·坎贝尔和大卫·坎贝尔

Crisis management: Groundwater in the 21st century

Continued population growth in both urban and rural USA has brought about a major change in the way water supplies are managed

By Michael Campbell and David Campbell

清洁的资源正在减少，随着高成本、低质量的地表水资源引入生产，水成本不断增高。在过去一个世纪里，对地下供水的开发、维护和保护始于在地面挖一个坑，然后通过一套工程系统把水抽到地面上来。既没有新技术也不需要新技术。

然而，在过去的30年里，美国城市和乡村人口明显增长，在高人口增长率的地区比较浅而且便宜的地下水资源已经大大地减少了。除了增加的抽水成本之外，地下水资源的减少具有更加深远的影响。例如，蓄水层是由可压缩的非固结沉积物组成的，常年抽水会降低自流压力并导致地面沉降。

如果全世界的人口增长率继续保持不变而没有任何降低的话，现在就需要一个模式变化。新型管理系统项目将会花费更多，而且需要许多技术。

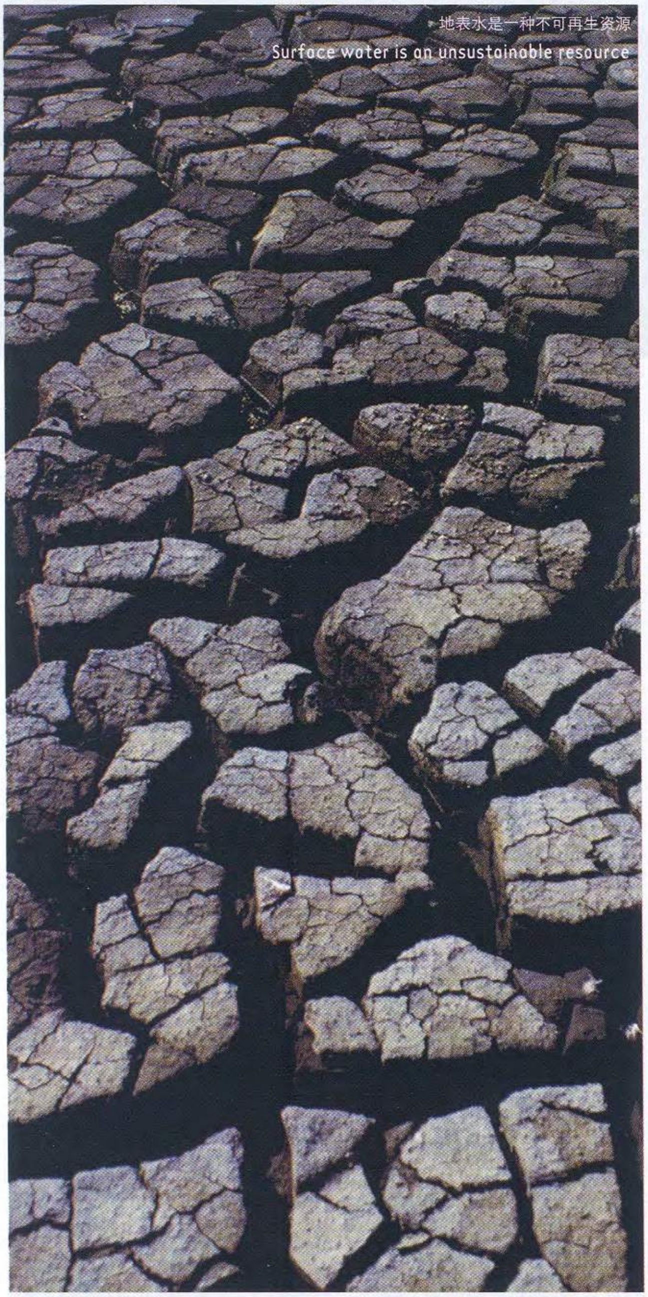
互联网使地下供水行业的技术隔离缩小了。实例和相关的理论现在可以在全世界通用，美国联邦和国家管理机构正在提供在线的重要技术和财政援助。这样的快速的信息获取也许是我们能够对改变使用地下水的老方法的迫切需要做出反应并满足该需要的主要原因之一。它不再是“井水”而是从远离表面污染物的很深的普通蓄水层获得的地下水。

美国很多州、县、市政府常常依赖于像修建水坝这样陈旧的

Clean resources are depleting and water costs are increasing as high-cost, low quality surface water resources are brought online. Developing, maintaining and protecting groundwater supplies over the past century began by drilling a hole in the ground and pumping water to the surface via an engineered system. New technology was neither available nor needed.

Over the past 30 years, however, significant population growth has occurred in both urban and rural US and the relatively shallow, cheap groundwater resources have been seriously depleted in areas of high population growth. The dwindling of groundwater resources has far-reaching consequences beyond increased pumping costs. For example, years of pumping in aquifers consisting of compressible, unconsolidated sediments can lower artesian pressure and cause land subsidence.

A paradigm shift is now required if the rate of population growth is to be maintained without major disruptions in systems throughout the world. Programmes will cost more to operate as new types of managerial systems and technology are required.



工程思想来提供地表水。我们已经意识到地下水具有高质量、低成本资源的特征，而地表水则是低质量、高成本的资源，需要相当多的处理和保护。这就是为什么地下水在近几年中在全世界迅猛发展的原因。但是，随着近30年城市和乡镇对水的需求，老思想又重新浮出水面了。

在大多数情况下，地下水与地表水进行成本一效益分析，都是对前者大大有利的。与地表水相比，地下供水开采成本比较低，受污染比较少。在大城市里，水通常是通过一个地下水管道网络来提供的，这些水来自地面水库或者高容量的水井系统。因

The internet is lessening technical isolation in the groundwater supply industry. Case histories and related issues are now available throughout the world, and US federal and state regulatory agencies are providing important technical and financial assistance online. This rapid acquisition of information is one of the major reasons we may be able to respond to and meet the pressing need to change old ways of using groundwater. It is no longer "well" water but ground water obtained from a common aquifer of great aerial extent deep underground away from surface contaminants.

Many state, county, and city agencies in the US often resort to old engineering thinking such as building dams to supply surface water. We have come to realise groundwater is characteristically a high quality, low cost resource, while surface water is a low quality, high cost resource requiring considerable treatment and protection. This is why groundwater has been so aggressively developed in recent years around the world. However, the old thinking has resurfaced as cities and counties attempt to meet the water demands of the approaching 30 years.

The cost-benefit analysis of groundwater versus surface water strongly favours the former over the latter in most cases. Groundwater supplies are less costly to develop and are less susceptible to contamination than surface water. In large cities, water is usually supplied via a network of underground pipes either from a surface reservoir or a system of high-capacity water wells. As suburbs have expanded into rural areas, water wells often coexist with nearby oil and gas wells, landfills, mines and similar industrial operations. Coexistence is a necessity in today's society and planning issues can be resolved without resorting to litigation, often perceived in the US as a solution to diverging opinions.

The process of deciding between a surface water or groundwater source depends on many factors.

Geographic factors

In regions where the land surface is hilly or has some relief, a surface source of water can be developed by damming a river or large stream, or by sculpting a reservoir out of lowlands that receive regular runoff. Such projects are promoted on the basis of multiple use: a reservoir would not only hold a supply of water but also would be used for fishing, boating, and swimming, as well as serve as a focal point for the development of surrounding residential subdivisions.

Hydrogeologic factors

Groundwater supplies are usually available everywhere. Regional variation in water quality depends on the local makeup of the subsurface rocks and sediments within the aquifer produced as a water supply. In high rainfall areas, the depth of water will

地下水资源更加划算
Groundwater resources are more cost-effective

为郊区已经发展到了农村地区，水井通常与附近的油气井、垃圾掩埋场、矿井和类似的工业措施同时存在。在今天的社会里，共存是必要的。规划的问题不用通过打官司就可以解决，而打官司作为一种解决分歧意见的方法在美国是经常可以看到的。

决定地表水或地下水源的过程取决于许多因素。

地理因素

在多丘陵或地表起伏的地区，地表水资源可以通过筑坝拦住河流来进行开发，或者通过在低的地方修筑水库获得定期的水量。这样的项目以多种用途为基础：水库将不仅可以容纳一定量的水，还可以用来钓鱼、划船、游泳以及充当周边住宅区开发的焦点。

水文地质因素

地下供水通常到处都可以得到。水质量的区域性变化取决于地下岩石和作为水源的蓄水层内部的沉淀物的局部组成。在高降雨地带，水深将是最小的，通常小于在地表面以下20英尺，取决于季节变化。地下水储层的顶端通称为地下水位。它的深度随时间变化而变化，并根据渗透的局部降雨量不断变化。在干旱季节，地下水位下降。在降雨量高于正常的年份，地下水位将增长，有时候高到足以形成一个临时的沼泽区。如果经过若干年经常地发生的话，就会形成沼泽地。

地下水位是一个动态的表面，不停在变化。即使是在美国西部和非洲北部所谓的“硬岩石”沙漠区，地下水存在于接缝、裂纹和可渗透的断层带，如果水井受到保护并且水井周围地区得到保护不受污染，大量的可饮用地下水可以被当地城镇和乡村加以使用。然而，井深度最好是在100英尺以上，以避免像城市和农业区的浅层地下水存在的污染问题。

污染因素

地表水容易受到工业和农业过程的广泛污染。来自水库周围民宅的化粪池的排水渗漏的细菌污染将会渗透到供水当中。

地下水不易受到像地表水受到的那些表面溢出物的普遍迅速的污染。但是，它容易受到来自于油气井（废弃的和正在运营的）、采矿工作（新的或旧的）、路面撒盐活动（由州或县机构进行的）、地下贮油罐泄漏、及附近的汽油站的污染。在农村地区，污染源包括化粪池、农畜及其他农业污染物。大的城市的用水井通常不受这些问题的影响，因为它们挖得很深，并且通过设计将浅水井共有的问题最小化了。

be minimal, usually less than 6m below the surface, depending upon the time of the year. The top of the groundwater reservoir is known as the water table. It varies in elevation over the year and adjusts to infiltrating local rainfall. During droughts, the water table declines. During years when rainfall is above normal the water table will rise, sometimes high enough to create a temporary bog or swampy area. If this happens on a regular basis over the years, a wetland may develop.

The water table is a dynamic surface, in constant change. Even in so-called "hard rock" desert areas of the western US and in northern Africa where groundwater is present in joints, cracks, and permeable fault zones, substantial volumes of potable groundwater are available for use by local towns and villages if the well is maintained and the area sounding the well is protected from sources of pollution. However, well depths of 30m or more are advisable to avoid contamination often present in shallow groundwater in urban and agricultural areas.

Contamination factors

Surface water is vulnerable to widespread contamination from industrial and agricultural processes. Bacterial contamination from leaking drain fields of septic tanks of homes built around the reservoir can also infiltrate the water supply.

Groundwater is not as vulnerable to widespread, rapid contamination from surface spills as surface water. However, it is subject to subsurface contamination from oil and gas wells (both abandoned fields as well as operating fields), from old and new mining activities, from state and county agencies' road-salting activities, and from leaking underground storage tanks from nearby gasoline stations. In rural areas, sources of contamination include septic tanks, the proximity of farm animals, and other agricultural pollutants. Large municipal water wells are usually unaffected by these issues because they are dug deeper and designed to minimise problems common to shallow water wells.

New groundwater treatment programmes

In the water chemistry area, the typical chlorination treatment process naturally creates unwanted by-products called

新的地下水处理项目

在水化学区域，一般的氯化处理过程自然地产生不需要的称作重矿物总量（THM）（三卤乙基类）的副产物和其他组成部分。新的处理方法正在开发当中，如臭氧化、多种来源的辐射、紫外线处理以及其他方法，有一些今天已经投入使用了。在互联网上报告的实例、成功和失败的经验，将使得技术可以按照它们的优点发展而不是按广告要求。无论如何，在可定义高风险的区域的农村供水应该进行处理以清除饮用水供应的细菌污染。

崭新的大道

在一个过去50年里发展很缓慢的行业里，技术突然变化得很快。随着饮用水资源的价值升高，并且有了来自联邦、州、县和市机构对技术开发和水资源监测的不断支持，供水行业正带来一个崭新的效率水平，将为公众创造健康的水源。这个过渡将包括来自于地下水、地表水或两者优化综合体（包括再使用和再循环）的资源。无论如何，如果这个对人体健康和发展很关键的领域要获得发展的话，对消费者的收费肯定会增加。

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过度抽取地下水会降低水井压力，导致地面下沉
Excessive drilling can lower artesian pressure and cause land subsidence

trihalomethanes (THMs) and other constituents. New treatment methods such as ozonation, radiation from various sources, UV treatments and other approaches are under development and some are in use today. The reporting of case histories, successes and failures on the internet will allow technologies to develop according to their merits rather than advertising claims. In any event, rural water supplies in areas of definable high risk should be treated to eliminate bacterial contamination of the drinking water supply.

The new road

Technology is suddenly changing very quickly in an industry where progress has been slow over the past 50 years. As the value of drinking water resources increases, and with continued assistance in technology development and water resource monitoring from federal, state, county, and city agencies, the water supply industry is bringing a new level of efficiency to create a healthy water supply for the public. This transition will involve resources from groundwater, surface water, or an optimised combination of both including reuse and recycling. In any case, the cost to the consumer will certainly increase if progress is to be made in this vital area of human health and development. ■

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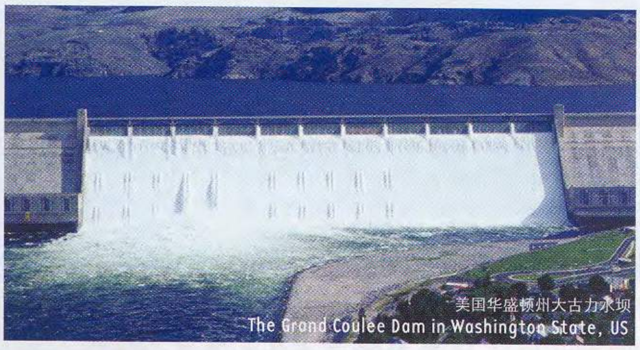

美国华盛顿州大古力水坝
The Grand Coulee Dam in Washington State, US