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OECD Reviews of Regulatory Reform: China
Defining the Boundary between the Market and the State


# *Chapter 7*

# Water

*The People's Republic of China faces many serious challenges in its water sector – including scarcity, pollution and flooding – that constrain economic growth and harm the health of the people. Despite massive investment in the sector, the overall situation of resource availability and water quality continues to worsen as economic development continues.*

*This chapter outlines some to the core challenges of water management in China, which include the fragmentation of the institutional and legal framework and the inefficient co-operation, both vertically and horizontally, among the different departments of government and the different layers at state, provincial and local levels. To understand and analyse how the Chinese authorities can solve these challenges, this chapter will consider the institutional and regulatory issues at river basin level that affect the allocation of water to different users for abstractions for irrigation, rural and urban domestic use, and industry. The chapter also seeks to address some of these points from the perspective of improving the regulatory systems, drawing on experience from OECD countries.*

## Introduction

The People's Republic of China faces many serious challenges in its water sector – including scarcity, pollution and flooding – that constrain economic growth and harm the health of the people. Despite massive investment in, for example, dams and canals for supply, hydropower and flood control, and urban infrastructure for water supply and sanitation, the overall situation of resource availability and water quality continues to worsen as economic development continues.

Unlike government functions for other resources, effective management of water resources has to be organised at a river basin level as well as through the normal geographic administrative divisions, because water moves itself across jurisdictional boundaries while other resources must be actively transported. Water is also a very unusual resource/economic good in that it is universally available (though unevenly distributed spatially and temporally) and may be obtained freely but commonly requires treatment and conveyance, which incurs a high infrastructure and operational cost. It also requires both delivery to the user and collection or disposal of the polluted wastewater. Almost all water supply and wastewater management systems operate as monopolies, since direct competition and trading of the commodity or the service is extremely difficult. It therefore has traditionally been treated as a public good and managed by public rather than private sector organisations. Urban water supply and sanitation may be organised along geographic and local administrative boundaries.

The situation of water management in China is changing with:

- The strengthening of the river basin organisations (at least for quantity management).
- The introduction of water allocation and water right trading systems and a shift in emphasis from supply-side to demand-side management.
- The strengthening of water quality and pollution control through the development of total load management and river basin water quality protection planning to meet specified ambient water quality objectives.
- The continuing introduction and expansion of the private sector in municipal water supply and wastewater treatment.

However, there still remain many challenges, most notably:

- The lack of co-ordination between water resource management and water quality and pollution control management – especially at the river basin level.
- The incomplete nature of the water allocation and water resource assessments, which do not yet account for environmental flows in a scientific manner – resulting in continuing over-abstraction and depletion of surface and underground resources.
- The incomplete incorporation of hydropower development planning into the overall river basin planning process.

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- The uncertain nature of the regulatory environment for municipal water and wastewater companies, leading to risks to municipalities of exploitation by private sector companies and risks to private sector companies of inconsistent or unfair conditions or changes of conditions.

Resolving some of these issues will greatly facilitate both public and private sector investment in water resource and pollution control infrastructure, and allow the development of effective institutional systems with the capacity for better management.

There is a need for far greater levels of investment in water resources and pollution control. The losses to economic growth incurred by water shortages and pollution greatly exceed the costs of addressing the causes of such harm. Well planned investment in improved management and infrastructure should show very positive economic returns.

A key part of implementing more efficient planning and management of water use is by the introduction of water pricing mechanisms that act as effective economic instruments and incites people towards more efficient water use and to making the required investment in water infrastructure. Current Chinese policy for water pricing is to include the full delivery and treatment costs of enterprises supplying and disposing of water (while including mechanisms to protect poorer users), however such financially sustainable levels of charging have so far only been implemented in areas of some major cities while many lower capacity cities are still charging unrealistically low prices for water (and consequently provide low service levels) and relying on local government subsidies to balance their books. Ideally water pricing should also include the external costs of water use such as resource depletion, pollution and ecological impact and a consideration of the economic value of water uses (together these form the MOC or Marginal Opportunity Cost of water). The existing water resources fee is a mechanism by which such costs can begin to be included in water pricing. Gradual introduction of increased water resources fees could be phased in, with excess revenue substituting other forms of taxation and used for environmental infrastructure improvements. The full MOC of water when calculated for specific regions may immediately be used as a planning tool when considering not just water resources investments but Urban, industrial and agricultural development in general.

All improved management systems for water allocation, water pricing, discharge and abstraction permitting designed to encourage more effective water use and reduce waste and pollution through the introduction of economic and administrative incentives will require greatly improved monitoring and supervision otherwise their lofty goals will be thwarted by evasion and cheating. Great care will be required to strengthen the regulatory authorities and ensure that targets that are set do not precipitate counterproductive outcomes.

The Chinese administrative systems for water are complex and comprehensive but suffer from fragmentation across ministries and conflicting goals at the central and local levels. This fragmentation has had particularly serious consequences for water quality management and despite the recent issue of improved legislation (such as the Water Pollution Prevention and Control Law 2008) and reorganisation of some ministries the current institutional set up in China does not appear to be capable of delivering the kind of co-ordinated action required to address the serious crisis presented. Consideration should be given to radical reorganisation of water management to focus on institutions with truly integrated responsibility for the planning, delivery and supervision of water quantity and quality at a river basin level.

The current systems for the regulation of urban water supply and wastewater treatment businesses has overseen a massive increase in private sector involvement over the last decade and have created by far the most active world market in water utility businesses. But still this market is struggling to deliver the levels of investment required to meet China's water infrastructure needs. The system of regulation is rather poorly defined and inconsistently implemented leaving private investors with uncertainty and risks to their business and exposing municipal governments to risk of exploitation by private undertakers. A clearer and stronger regulatory environment coordinated from state to local levels would lead to greater levels of private sector participation, lower risks (and associated risk premiums) and improved levels of service to customers and the environment.

China has a quite different government and political culture to most OECD countries, therefore many models that have previously been successful elsewhere may not be applicable to China. The Chinese system also has some features that can be particularly conducive towards achieving rapid change towards more effective behaviour, particularly through the systems of official performance assessments against specific goals for department and individual senior officials. When considering regulatory reform along legislative and institutional lines china can also incorporate these changes to its comprehensive and well established human resources management systems.

The following sections seek to address some of these points from the perspective of improving the regulatory systems, drawing on experience from OECD countries.

The development of a fully comprehensive and integrated planning and regulatory system for the Chinese water sector should have many positive benefits in terms of reducing pollution, improving sustainable water use and increasing equity of access to resources. However, it will also result in more complex procedures for some activities. Consultation will be required before, say, permitting a major new discharge or abstraction of hydropower scheme, and that will require local government to act in a more co-ordinated way with provincial government, river basin management commissions and central government. The overall outcome should be better, but the pace of development may have to slow a little – as it has in OECD countries – to allow time for proper planning. The advantage here will be greatly increased capital investment efficiency and longer asset life for projects.

## Regulatory reform in China's water sector

When considering regulatory reform in China's water sector, the first step is to clarify what is meant by regulation and how implementing regulatory reform can lead to better governance and a more prosperous and equitable society. This chapter will do so from the perspective of current concepts and practice in OECD countries. These concepts may vary considerably from current Chinese concepts of regulation and governance.

"Regulations" are official documents setting out how things are to be done, defining relationships and responsibilities. They are usually statutory in nature and provisions to clarify or define technical issues through regulations are often made in primary legislation. They can take a variety forms; ultimately, they are the formalising of administrative, technical and contractual relationships.

For regulations to be effective it is necessary that they be based on rules developed by consultation and negotiation among those drafting the regulations, the representatives of those affected, and those responsible for enforcement of the regulations.

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Good regulation builds certainty, stability, confidence and predictability into the institutional frameworks that manage market forces. Along with the written regulation there must be the institutional capacity to implement, inform, monitor, enforce and manage conflicts of interest.

The task of reform is never finished: for every action there is a reaction, and for any sector the boundary conditions are forever changing. A strong yet flexible regulatory environment for the water sector can deliver greater capital investment and operational efficiency. Once the initial objectives have been achieved, reformed systems are required to meet more challenging objectives for service and environmental performance. They must ensure the maintenance of initial gains in the face of changing conditions, the inevitable wearing out and decay of capital assets, and the passing on of human resource capacity.

When developing regulatory systems it is usual to separate the policy, supervisory and operational roles. Roles must be clearly defined and set out in legislation that must provide the powers and duties for the actors to undertake their functions. These will include the ability to grant operating licences, set standards, require information, raise funds, take regulatory sanctions and provide information to the public. Written guidance may clarify roles and provide the technical basis for regulation and monitoring. The people involved in the regulated sector need to be informed and have sufficient training to understand and implement the systems. Technology can greatly increase regulatory capacity; IT communication, databases, Geographical Information Systems (GIS), spreadsheets and decision support tools allow the implementation of efficient systems that would previously have been impossible. The enabling role of technology in effective implementation should be considered when draft both policy and detailed regulation.

The overall government and institutional framework of China has evolved along a path very different to that of most OECD countries. China is currently in transition, with a shift of administrative procedures that date back to the planned economy era to newer economic instruments for managing the emerging market economy. Some systems and processes are familiar to OECD countries, and some are quite different.

China faces great challenges of water scarcity, water pollution and investment to deliver urban water utility services.[1] This chapter reviews the current situation and regulatory environment of the Chinese water sector and draws comparisons to the situations of selected OECD countries. From this it attempts to draw some conclusions and makes some recommendations that might be helpful to those contemplating ongoing reform in China's water sector.

The aim of regulatory reform of the water sector should be to ensure delivery of a public service of safe water supply, sanitation and environmental quality to meet the needs of both rural and urban water users, now and sustainably into the future.

In China at present there are basically three groups of water users with different needs and facing different challenges. They are:

- *Rural agricultural water users,* for whom the requirements are irrigation water for their crops, access to a basic safe water source for their domestic needs, and the provision of improved sanitation to prevent disease and improve quality of life. Many in this group are living in absolute poverty, and the vast majority have individual and communal revenues that are so low as to greatly restrict the choices and options for investment and improvement that are available to them. Under the opening up and reform policies of the past 30 years in China the opportunities available to the rural population have greatly improved, but they are now getting left behind as the urban population attains the trappings of a prosperous industrial society. Rural water users and irrigation are by far the largest users of water resources, responsible for 60% to 70% of abstraction and for a significant proportion of pollution from non-point sources. Rural sources are responsible for much of the nutrient pollution (nitrogen and phosphorus) but a smaller proportion of the organic pollution and ammonia loads. Relatively small levels of investment in infrastructure for this group yield greater returns in water demand reduction and pollution reduction. However, the group has very limited access to the technology and finance required to attain the transition to sustainable resource use and livelihoods that are more harmonious with nature. Investments must be on an individual and communal basis with limited scope for establishment of water sector enterprises. Water resources management is organised by county and village governments, augmented with some stakeholder-led organisations such as water user associations, irrigation district organisations and private contractors providing improved irrigation channels and direct access to groundwater by drilling local deep water wells.

- *Those in smaller, less developed towns and cities,* in transition between agricultural and industrial production based livelihoods with limited infrastructure development. Here the challenge is to provide a reliable piped water supply to homes and enterprises and to provide sewerage and some level of wastewater treatment and industrial pollution control. For this group the quality of water infrastructure available is often very low and it is difficult to form effective water sector enterprises that can maintain and develop the urban water infrastructure on a sustainable cost recovery basis. Reform of the institutional and financial situation together with water price reform can help these small water departments and companies to attain financial independence and the ability to maintain and develop their assets. However, specific local and national capital investment will be required to develop the wastewater collection and treatment systems desperately required to reverse the current gross river water pollution arising from these communities. Water services are provided by the municipal water departments or semi-autonomous companies, supported in part by user fees but generally subsidised from local government budgets. Private sector companies are starting to enter this market.
- *Those in the major cities,* living in an industrial society and engaged primarily in service industries. Comprehensive water supply, wastewater collection and a reasonable degree of wastewater treatment infrastructure are in place. Here the aim is to attain the value for money and capital and operational efficiency of the best examples from OECD countries. Capital maintenance will be an increasing challenge for water companies in major cities as older assets serving the city centre deteriorate and compete for capital investment with the need to extend services to non-core areas of the city and meet tightening environmental and service standards. The water utilities are generally financially independent companies or departments financed operationally by user fees; infrastructure investment is via municipal, provincial and state funds. There is a rapidly growing private sector providing investment and management services to municipal water utilities through a range of contractual and asset transfer methods.

Overall massive investment in water services is required in China, especially in the second-level cities and in wastewater collection and treatment and pollution control. There is also a particular need for investment in sludge management to ensure that the pollutants removed from the wastewater do not re-enter the environment in an even more harmful form, but can instead be put to beneficial or at least harmless use.


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It is also useful to consider from a river basin perspective the water users of each sector and their requirements and impacts on water resources: 71% of water use is by agriculture, 18% by industry and 11% by urban consumption (MWR, 2004). The primary issues affecting each of these sectors are:

- *Agriculture* – Water allocation and water saving/demand management; 44% of agriculture is irrigated, of which 40% has some degree of water-saving irrigation (MWR, 2007). The efficiency of irrigation systems is low by international standards with typically only 40 to 45% of abstracted water reaching the crop (rest lost in channel leakage etc.) (Wang, 2007). Though biggest water user the Economic Value of Water (EVW) for Agriculture is very low compared to industrial or services sectors, but the number of people dependent on agriculture and the social impact of change is very great. The pollution from agriculture is significant; agricultural chemical oxygen demand (COD)[2] discharges have been estimated at 1.4 times that of industrial and urban wastewater combined (ADB, 2006). Intensive livestock raising is increasing rapidly, with significant local pollution impacts. But how much of this pollution actually reaches and affects the main river sections is very difficult to calculate; more research into this is urgently required, especially as the current Chinese systems of pollution control planning barely consider the role of non-point pollution. The impact of runoff of nutrients (Phosporous and Nitrogen) from agriculture is the major cause of eutrophication which is an increasing water quality problem.
- *Industry* – Water use efficiency in Chinese industry is low by International standards and pollution is high. Each enterprise must consider and measure the water it uses and pollution discharged. Water efficiency audits, increased recycling and cleaner production investment can bring great improvements. Stronger control of existing discharges to meet basic discharge standards is essential (not just EIA[3] for new discharges). A move towards discharge standards set on the basis of total load calculations which will meet river water quality objectives has been put into legislation and now needs to be implemented.
- *Urban water* – Infrastructure development. Improved governance of the water utility sector. Investment in wastewater collection and treatment, sludge management, and ensuring water supply service that reliably meets quality standards. Financial basis of water business needs to be sustainable.

To understand and analyse how the water sector in China could meet the above challenges, this chapter considers the institutional and regulatory issues at river basin level that affect the allocation of water to different users for abstractions for irrigation, rural and urban domestic use, and industry. Some attention is given to the need to resolve the often-conflicting requirements of also providing flood protection and extracting hydropower from the rivers.

When conceiving regulatory initiatives for China, an important limitation is the rule that "If you can't measure it, you can't manage it." Co-ordinated monitoring and reporting of hydrology, water quality, abstractions and discharges is fundamental to any river basin management system. For urban water utilities, reporting of the service performance and compliance with standards and guidelines, as well as financial performance, are fundamental to regulation of water and sanitation departments and companies.

With regard to water resources and urban water utilities management, this chapter undertakes a comparative review of the Chinese situation and that in selected OECD countries, and attempts to draw lessons from the successes and risks of OECD experience to identify transferable elements and suggest some policy options for China.

### *Institutional structure of the China water sector*

The principal organisations responsible for the water sector in China are the Ministry of Water Resources (MWR), the Ministry for Environmental Protection (MEP), and the Ministry of Housing and Urban-Rural Development (MOHURD).[4] These are respectively responsible for quantity and quality management of surface and ground water; control of discharges to and pollution of surface waters; provision of urban water supply and wastewater collection and treatment. Each of these ministries operates through a state executive organisation with departments at provincial, municipal and county levels of government. These departments report to and are financed by the corresponding level of local government, rather than to the line ministry. MWR also directly administers the seven river basin commissions for the largest rivers as trans-boundary organisations; these commissions are responsible for managing water resources, protecting the main channels, and co-ordinating the provincial activities to manage the tributaries.

There are also a number of other ministries with important influence on water management, such as the Ministry of Agriculture (rural water use) and the Ministry of Health (drinking water quality).

The state-level ministries generally have corresponding departments at provincial and municipal levels. For example, for MWR there are Water Resources Bureaus (WRB) in local government, and for MEP there are Environmental Protection Bureaus (EPB). The functions of MOHURD are distributed across various offices at local levels.

An important feature of the Chinese government system at provincial level and below is double management, with vertical management and guidance from the line ministry but horizontal administration and finance from the corresponding level of local government.

Through these different levels of government the Ministry of Finance (MoF) and its subordinate offices are responsible for operational budgets, and the National Development and Reform Commission (NDRC) for capital investment planning and regulatory reform. Commodity pricing, such as water tariffs, is also determined through the NDRC and local development and reform bureaus in consultation with other departments.

Policy priorities, performance assessments and career progression of senior officials against specified targets are affected by the cadre responsibility system, which is managed by the Organisation Department of the Communist Party of China (CPC).

This overall system includes various checks and balances and reporting and assessment procedures. However, with regard to water sector management it is very fragmented. There is a complex split of responsibilities across multiple ministries, and co-ordination between state, provincial, river basin and local levels is not straightforward. Overlap, gaps and conflicting responsibilities result in an incomplete level of communication among the separate institutions involved. This results in notable gaps in effective administration, especially regarding river basin water quality management. For example, the MEP and its Environmental Protection Bureaus at provincial levels are responsible for controlling discharges to the rivers while the MWR and river basin organisations are responsible for protecting the quality of water in the rivers. There is limited co-operation and data sharing between these ministries, and as yet no effective


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system for the application of pollution control to meet river needs (though this is under development).

The legal framework for the management of water resources quantity and quality is set by the Water Law 2002 and the Wastewater Pollution Prevention and Control Law (WPPCL), amended in 2008. The Water Law, drafted primarily by MWR, sets an overall framework for water resources management (amended since the 1988 version) to focus on river basin management rather than administration by administrative boundary. The revised WPPCL, drafted primarily by MEP, aims at better mandating of integrated river basin approaches to water quality management and increases enforcement sanctions available to regulators (see Box 7.1).

### Box 7.1. **Revised Water Pollution Prevention and Control Law, 2008**

A revised Water Pollution Prevention and Control Law that came into effect in June 2008 introduced some key concepts to the Chinese environmental regulation framework. Primary among them was that pollution prevention should be planned in a unified way at river basin level (Article 15) and involve all water bodies and all pollution sources, point and diffuse (Article 3).

Other points are that the revised Law:

- Introduces a basin-wide pollution total load control mechanism that uses a system of indicators to link regional load management to load allocations to individual polluters, so as to meet local environmental needs (Article 18, subject to further definition in a State Decree to follow).
- Requires the introduction of a proper discharge permit system (Article 20) that would apply to existing discharges (subject to further definition in State Decree).
- Requires that water allocation processes now take into account the need to maintain environmental flows (Article 16) to support the aquatic ecology.
- Incorporates environmental targets in national planning process and cadre assessments (Articles 4 and 5).
- Requires the installation of automatic online monitoring, networked to the EPB, of major discharges (Article 23, details subject to further guidance).
- Requires use of the best available technology (BAT) principle for introduction of clean production (Article 41).
- Introduces negotiated water quality standards at trans-jurisdictional boundaries (Article 12).
- Establishes an ecological compensation (Article 7) allowing fiscal transfers to upstream regions providing ecological services for clean drinking water supply.
- Incorporates conflict management (Article 28), referring disputes to local government.

There are still some omissions and differences from the principles embodied in the EU Water Framework Directive (WFD) – most notably the lack of the inclusion of timetables in the legislation and the less specific phrasing of the target of all activity as being an environmental quality outcome of the aquatic ecosystem (summed up in WFD as "good status for water bodies by 2015"). However the provisions of the law are expected to work in the context of the Chinese government's five-year plans, which do introduce timetable elements.

Box 7.1. **Revised Water Pollution Prevention and Control Law, 2008** *(cont.)*

Generally the Chinese water legislation system lacks sufficient supporting detail on procedures for implementation, monitoring, supervision and enforcement. Thus the laws exist to set principles but are not effectively implemented through the different layers and divisions of the government system. For example, the Water Law does not clearly define the authority of local governments and river basin management commissions (RBMCs). Such ambiguity in the provisions causes a vacuum of authority and weakens the effectiveness of the legal system. Thus Article 25 requires environmental protection departments to monitor both discharges and ambient quality and report results in a unified way with the MWR units, and to report data through the river basin water resources protection department (Article 26). The Water Law (Article 32) requires the MWR to monitor water quality and plan total load management to achieve functional zone targets. This should show agreement of purpose but in practice has led to the establishment of two independent monitoring networks that do not share raw data or work toward the same targets. While the amended wording of the Wastewater Pollution Prevention and Control Law (WPPCL) goes some way towards mandating unified working, it does not clearly set out how this is to be done.

Supplementary guidance to be issued in state decrees (currently in preparation) may go some way to clarifying these points, just as state decrees related to water allocation (472) and water abstraction (460) supplement the provisions of the Water Law. But it is still difficult for the implementing authorities to know what is expected of them without direct ministerial guidance – which is likely to differ depending on the ministry involved and which then only applies to its subordinate line organisations and may yet conflict with the local government policies.

Also, the Water Pollution Prevention and Control Law requires that the state establish and improve the compensation mechanism for ecological protection of the water environment, but there are no national laws or regulations to support it. Nor is there a law on water rights or trading.

### *Lessons from the OECD area*

In the European Union, fragmentation is being reduced through the principles embodied in the Water Framework Directive. The WFD promotes integrated river basin management by setting common goals in terms of environmental outcomes to be achieved over a set timetable by the systematic application of river basin management planning, monitoring and integrated pollution prevention and control.

In most OECD countries water utilities are managed at the municipal level, with an increasing degree of association and geographical consolidation. Benchmarking and regulatory oversight are increasingly being introduced, counterbalancing the increased influence of the consolidated water companies.

For example in the United Kingdom, which has the greatest degree of consolidation, a co-ordinated planning approach for water utilities is demonstrated by a regulatory system based on the assessment of the environmental and customer service performance of water companies against defined service performance indicators. Incentives are determined by the quality of the preparation and implementation of integrated business planning relative to competitive benchmarking between companies. A five-yearly review and planning process is in place.

### *Leading groups*

The major institutional barriers to better management of the water sector in China are the incomplete co-ordination between the sectoral ministerial organisations and incomplete co-ordination between and across state, provincial and municipal levels of administration.

To improve the water sector situation, these issues need to be addressed both for river basin management issues of water quantity and quality, and for urban water utility development and performance.

### *River basin management*

While the concepts and principles of Integrated River Basin Management (IRBM) are well accepted in China, the legal and institutional structure does not as yet fully support the implementation of IRBM. Reforms to the Water Law of 2002 and more recently to the Wastewater and Pollution Prevention Law in 2008 go some way toward providing the opening for IRBM and require that the various institutions involved must co-operate in their actions. However these two laws still result in overlapping responsibilities between the principle ministries of MWR and MEP and the many other ministries involved in water management. While co-ordination of the quantity aspects of water resources management and flood control are progressing, requiring mostly interaction between the RBMC and the provincial governments, whose interaction with water quality management is less well defined and still lacking effective integrated planning.

The Water Resources Protection Bureaus (WRPB) of the River Basin Management Commissions are currently nominally joint administrations between MWR and MEP, but in reality they are funded by and very much dominated by MWR in all operational matters. WRPB do act as trans-boundary organisations, co-ordinating planning across provincial boundaries. But the degree to which they co-ordinate MWR activities with EPB and other organisations is very limited. This leaves MEP / EPB without effective trans-boundary institutions through which to implement river basin pollution control planning or management of major pollution incidents.

The key mechanism of IRBM is the preparation of river basin master plans. This process is currently under way for the seven major river basins of China, with plans due to be submitted to the state council in 2009. However the role of the river basin management plan is not clearly defined in Chinese law and the current round of master plan drafting appears to have had limited stakeholder involvement, and security and confidentiality regulations prevent open discussion. Separate plans are produced by MWR and MEP organisations.

The obvious solution is radical reorganisation of the ministerial and provincial departments related to water as unified institutions focused on IRBM and water service delivery under some kind of super ministry. But this is unlikely to be politically acceptable in the foreseeable future. Current regulatory reform approaches therefore need to focus on improving co-ordination between the existing ministries and strengthening the role of the river basin management commissions as trans-boundary and multi-sectoral organisations with greater stakeholder involvement, charged with the preparation and execution of detailed river basin management plans.

Much further study and consultation is required to formulate the road map for such institutional arrangements. However, the key elements may include the establishment at state level of a *Leading Group for River Basin Management Co-ordination*, led by a member of the state council with participation from the relevant ministries. This body would be tasked with co-ordinating policy development and dealing with conflicts among departments and jurisdictions, with the aim of reducing the level of overlap in duties among different departments. As the role of the river basin authorities develops, so this Leading Group could evolve into an IRBM committee co-ordinating the actions of ministries through the river basin authorities and provincial governments.

The *river basin management commissions* may be further empowered to act as integrated management and planning bodies co-ordinating the trans-sector and inter-provincial issues relating to water resource and water quality matters for all parts of the river basin, not just the main river channel.

Achieving this will require the participation of the provincial governments, environmental protection authorities and provincial water resources bureaus; initially a number of Leading Groups could focus on specific issues such as water resources allocation, flood control and water quality planning. In many river basins this has already been achieved for water resources and flood management, but so far only in Songliao has such a leading group been established for water quality management. The cross-sectoral challenges for co-ordinated water quality management are greater than for other topics. From co-ordination through these Leading Groups, the river basin authority may evolve to take a stronger role in the planning process for development of the river basin. Eventually, supported by specific river basin laws, the river basin authorities would take the leading role in financial allocation matters related to IRBM. Ideally the river basin authority should achieve independence from the other government agencies to take on a true trans-sector and trans-boundary role (probably reporting directly to the state council). However, the practicalities of this could be difficult when the existing Chinese river basin authorities incorporate an administrative secretariat very large compared with similar organisations in the European Union or the United States.

The role of *River Basin Planning* should be further strengthened. The current plans being prepared are comprehensive but have as yet unclear legal jurisdiction. In examples seen, they cover flood control, water resources allocation, sediment control, watershed management, water quality management, total load control and demand management and building a water saving society relating to agricultural, domestic and industrial water users. Specific objectives are set in some of these topics and general objectives in others. The plan should be written as an integrated document covering all parts of the river basin and assuming full cross-sectoral and inter-provincial co-ordination.

Such plans should be open and transparent to public scrutiny so that all stakeholders can know what is being planned and have access to the data used to formulate the plans. This information should be made available through multiple channels at stages through its development cycle, with opportunities for formal stakeholder and public consultation. Public participation would be strengthened by further incorporation in the water and environmental protection laws of rights of access to information, participation in decision making, and the right to challenge decisions.

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Aspects that need further development in the river basin planning process are:

- Integration of abstraction and discharge management. This may be achieved via two mechanisms.
  - ❖ It is particularly important that water quality management/pollution control be integrated in the river basin plans by linking individual discharge control (for point sources) and land use management (for non-point sources) to river water quality planning. These plans must incorporate the environmental flow calculations from water allocation management systems. Considerable further scientific research is required to match international methods of environmental flow calculation to the specific conditions and ecology of each river basin in China. The use of Evapotranspiration (ET) calculations can help in the improved management of Agricultural water use (see Box 7.1). The calculation of proper water balances and pollution discharge control through industrial enterprises and urban centres can help reduce water wastage and better understand how human activity results in water moving from one source (say ground water reservoir) to another (say river flows downstream of wastewater discharge) and assess whether that water is still of sufficient quality to be regarded as a resource.
  - ❖ Improved co-ordination and data sharing between EPB and WRPB when implementing total load control calculations and setting discharge permits to meet river needs.
- Better strategic planning of hydropower development. The principle organ for development and supervision of major (>50 MW) hydro-electric schemes is the State Commission for Developing and Restructuring. Mini hydro-electric schemes (<50 MW) are planned by MWR, which is also responsible for resettlement planning. There are various other ministries involved in other aspects of hydro development and supervision; however, no one organisation has strategic responsibility for the hydro-electric development of the river basin. As a result local, political and commercial interests can dominate in the selection of sites for dams. This can result in sub-optimal development of the river basin and projects that do not best balance the multiple requirements of power generation, flood control, water supply, sediment control and especially the maintenance of sufficient environmental flows for ecological and functional use. There is a great need to improve the integration of hydro-electric development with other aspects of river basin planning. Ecological and social impacts must be taken into account as well as economic benefits, and eco-compensation mechanisms should be established to ensure greater fairness and equity in the process of such major developments.

### *Water utility sector*

Though there are various state decrees and guidance documents related to water utility management, China does not yet have a clear regulatory framework for managing transition of the water sector from a planned to a market-based economy.

Water utilities anywhere face particular challenges. Raw water is widely available at relatively low cost but is difficult to transport, making it a largely non-tradable commodity. Water and sanitation services are almost always on a monopoly basis and require very high capital investment to deliver a relatively low value product to customers, many of whom expect it to be free. These features mean that classic free market principles cannot be applied. In most OECD countries water and its provision have undergone a transition from

Box 7.2. **Water resources planning using evapotranspiration quotas**

Past water management in China, based on water abstraction only, has encountered only limited success because the saved water was used to irrigate more land; that is, more water was consumed and less water returned to the surface and underground water systems. Recent advancements in remote sensing and geographic information system (GIS) technologies have made it feasible to manage water resources in terms of the amounts of water actually consumed through evapotranspiration (ET). The portion consumed through ET is the consumptive use that is lost and not available for users downstream, unless its quality has deteriorated to the point that the water cannot be reused, in which case this represents "real" losses. In contrast, the portion that returns to the surface or underground water systems is still available for other users downstream.

This approach encourages farmers to reduce the evaporation and transpiration that does not contribute to plant growth. For example, they will reduce evaporation by changing crop choices, reducing waterlogged areas, irrigating when evaporation is lowest (at night instead of during the day), using moisture-retaining mulches and films, and replacing open canals and ditches with pipes. Where excessive fertiliser and pesticides runoff is a problem, they will be encouraged to reduce non-point pollution, since return flows that are not reusable downstream will be deducted from their ET quota.

ET technology thus makes it feasible for China to adopt a more scientific approach for its water rights allocation

public good to economic commodity, moderated by various defined water rights and responsibilities.

Most water services in China are provided by individual municipal water and urban environmental service departments that are financially autonomous to various degrees. There has been very rapid expansion of private sector involvement, initially through joint ventures with major European water utility companies but increasingly in recent years by joint ventures with regional and local Chinese utility companies.

Treated piped water supply is available to 93% of the urban population, though in some cities during dry periods the supply may be intermittent and quality may be variable, with around 73% of samples meeting national standards. In rural areas 70% of people have access to a safe water supply. However, with 60% of China's surface water polluted to a degree below that suitable for water supply, water quality is a major constraint on resource development. Thus, more than 75% of drinking water supplies are now taken from ground water – which, though levels are mostly falling and quality deteriorating, still provides a cleaner source for drinking water supply.

China now has nearly 800 wastewater treatment plants in more than 400 cities. NDRC, 2008 reported that by end 2007 there is capacity to treat 59% in the major towns and cities (up from 42% in 2003). However, on average Chinese WWTP only operate at around 65% of capacity (so only 36% of urban wastewater is getting treated). In rural areas less than 50% of the population have improved sanitation and there is generally very little formal treatment of waste. Most is collected and used as fertiliser, either directly or mixed with animal waste. Then it may be passed through anerobic digestion (with biogas as by-product) or aquaculture.

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The following section reviews some of the models that might be applied to strengthen regulation of China's water sector, drawing experience from the European and US water sector development.

### *Water and sanitation regulatory models*

#### *Integrated regulation*

In utility regulation there are similarities and differences across sectors such as energy, water, solid waste management, transport, telecoms, healthcare and district heating. Each sector has a requirement to move towards a combination of public and private financing methods to make the required investments in infrastructure, and each sector needs to co-operate with the leading international service and technology providers to make available to China the global best practice in management and operation. However, China also needs to protect itself from suffering a loss of control of strategic assets to commercial interests. Under various economic conditions these assets may be subject to priorities that are at odds with the best interests of the service customers, or the strategic objectives of the wider economy.

When contemplating regulatory models there is a choice to be made between the establishment of multi-utility regulatory body to set the overall rules for private-public partnership in utility management, and the establishment of sector-specific regulatory organisations tailored to a particular utility.

There is also the need to establish regulatory and reporting responsibilities at the state, provincial and municipal levels. The water utility sector is growing rapidly with increasing asset values, revenues and technical complexity. There is an increased requirement for co-ordination and oversight at various levels, and the economic size of the industry justifies the expenditure of establishing properly funded oversight bodies.

There is also a need to greatly increase investment in this sector in China. The economic costs and losses incurred by water scarcity and pollution (World Bank, 2008) greatly exceed the levels of investment being made to address such problems. Thus the return on investments in water infrastructure and management should show positive returns for the overall economy. There are also vital social, health and environmental benefits of improved water management.

The following is a proposal for possible directions for regulation based on an understanding of the Chinese situation. It draws heavily from UK experience and US experience, in the knowledge that the current path in China for water and sanitation is following something closer to the French model. The proposal seeks to draw from the strengths and to address the weaknesses of each of these approaches, to meet the future needs of the Chinese situation.

#### *Possible models*

Meeting the needs mentioned above requires a multi-layer regulatory model. This will in turn require the establishment of temporary and permanent institutions to launch and then grow capacity in utility regulation.

The issues of general utility regulation could initially be developed by an expert group drawn from NDRC, MoF, the academies of science, etc. in order to fully analyse the regulatory models used around the world and make recommendations to the State Council on appropriate models to use in China. This expert group would identify the common and contrasting themes of regulation of different utilities and interaction with general development planning and macroeconomic policy. The group could advise on the establishment of National Leading Groups for the co-ordination of regulation in specific sectors and then change or cease its initial function. It could also research and advise on general reporting and benchmarking protocols for utility regulation appropriate to China.

There could then be formed a *National Leading Group for water and sanitation* tasked with setting the overall framework for water utility regulation in urban and rural areas and co-ordinating regulatory activity across the sectoral agencies. This organisation should be formed under the State Council and chaired by a deputy prime minister. It should meet monthly or quarterly and establish a secretariat drawn from existing agencies.

It should also co-ordinate activities with the National Leading Group for river basin management, but remain separate in order to maintain focus on the particular economic and environmental issues of water utility regulation.

The core business of utility regulation would be handled by strengthened water and sanitation oversight offices within the provincial governments. Under a Leading Group headed by vice-governors, these offices would constitute a new regulatory affairs office within the provincial government. The newly formed body would consolidate economic regulation of the utilities in a secretariat and co-ordinate environmental regulation with the existing EPB, WRB and public health offices. The water and sanitation office would require some degree of executive power to oversee setting and controlling water tariffs in response to water company performance. In doing so the regulatory executive would have to be subject to scrutiny from representatives of the customers.

The provincial water and sanitation office would provide guidance and undertake periodic benchmarking and performance reviews of the municipal water companies. Direct regulation and oversight of water companies would be undertaken by municipal water and sanitation offices, dealing solely with those companies in their jurisdiction. A municipal water and sanitation office would come under a Leading Group chaired by an executive vice-mayor.

The water services would be delivered by water companies. Though these may take a variety of ownership models, they should be financially autonomous organisations with sufficient transparency of operation that the regulator, with the help of reporters, is able to monitor their financial, service delivery and environmental performance. The companies should be required to clearly separate their regulated water utility operation and accounts from any other unregulated business or regulated business in other utility sectors.

It may be seen that the above proposal achieves a separation between policy, supervision and operational functions within a regulatory structure.

When preparing such a regulatory structure there are a number of key issues to plan for:

- Goal-based rather than activity-based governance.
- Integrated utilities and co-ordinated regulation.
- Strategic investment.
- Reporting and performance benchmarking.
- Financial sustainability.

These are discussed in more detail below.

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### *Goal-based rather than activity-based governance*

Activity-based targets, such as provision of 70% urban wastewater treatment and achievement of a 10% reduction in COD discharges as set out in China's 11$^{th}$ Five Year Plan, are straightforward to understand and practical in an environment of limited data and capacity. But as the China water sector develops, so do more effective targets need to be set based on environmental performance and customer service targets that have been defined in policy.

Standards and targets also need to be appropriate for the capacity of the utility and local government to deliver them, and should incorporate a timetable for compliance in stages. In a major city with established infrastructure and the capacity for high revenues from water tariffs, it is reasonable to set drinking water, effluent and service level targets comparable with OECD countries and WHO guidelines. However, in smaller cities or county towns, applying the same service requirements where there is little existing infrastructure and limited revenue is a major roadblock to investment. In rural areas, totally different solutions may be required to achieve the same ends. It should be possible to negotiate appropriate and achievable standards within a timetable of 10 to 20 years, over which to move towards the higher-level standards. Economic regulation of utilities could reward performance against such a timetable.

### *Integrated utilities and co-ordinated regulation*

The integration of treatment networks and distribution/collection networks has very significant advantages. It can greatly reduce conflicts over demand/supply issues that trouble private sector contracts for a treatment works where the demand from the network or supply from the sewer system does not meet with expectations for flow and quality. This is especially the case for wastewater systems, where the typical administrative separation of sewerage from treatment makes efficient planning and operation very difficult.

Considerable advantages of scale and efficiency can be obtained by combining different services within a company, *e.g.* water supply and wastewater. There are also advantages in companies operating over a greater geographic region or in multiple cities. There are examples of efficient operations from the United Kingdom with very integrated water companies, and from other European countries – especially Germany's non-integrated municipal utilities, each of which is able to attain a high degree of efficiency and good performance. Integrating and combining companies enhances the financial stability and access to additional finance to allow greater investment in the infrastructure.

In the United Kingdom, numerous municipal water companies were combined into a small number of regional water or water and sewerage companies, and then fully privatised, taking the assets into private shareholder ownership (in England and Wales; there is still public ownership in Scotland and Northern Ireland). This provided considerable advantages of enhanced efficiency and access to finance to fund major investment programmes aimed at dramatically improving service quality. In other countries such as the United States, France and Germany, the municipal water companies associate through various mechanisms in order to pool their resources across a number of cities and towns. In many cases that has led to these associations entering into agreements whereby international private water companies either manage or take over their service provision under contract, though with ownership of the assets normally remaining public.

In China there is considerable scope for municipal water companies to associate and so pool resources and expertise. If association includes a degree of financial merger, then this could also improve the creditworthiness of the group and increase the options for financing.

### *Strategic investment planning*

Efficient and co-ordinated planning will be required to tackle the enormous infrastructure investment requirements of the water sector – especially in wastewater collection and treatment and sludge management in secondary urban areas. Rapid development of treatment systems to improve river water quality will require that investments are planned in a strategic manner based on the maximum benefit in terms of progress towards achieving river basin water quality objectives. Thus the potential projects for each town should be assessed and prioritised in relation to benefit-cost ratios. Centralised funding from state and international sources can then be used to promote those schemes with the highest benefit-cost ratios through the development planning process.

The provincial regulators would work closely with river basin Leading Groups for water quality in developing such plans, and then with the NDRC in assigning central funding. The strategic planning process would consider all interventions, including industrial and agricultural discharge controls to attain river basin objectives in a cost-effective manner. The regulated water and sanitation sector would then have to work together to help deliver the resulting plans in an efficient manner.

The river basin strategic planning need not exclude projects in towns, where the environmental benefit of the project is lower, as long as the scheme is able to be sustainably self-financing based on the local revenue available from local government and local private partners. However such strategic planning should be used to target central funding to encourage the most rapid and cost effective improvements.

China has the opportunity to plan wastewater infrastructure investment in a more efficient manner than happened in most OECD countries. The typical path in OECD countries was to do very little until GDP per capita had reach a relatively high level, and then to introduce more or less blanket requirements for wastewater treatment, often with very high levels of central government subsidy. This often led to very expensive schemes with limited environmental benefit being constructed ahead of other schemes that would have had greater benefits. The tools are available to China to plan to improve river water quality in a more optimal manner. This should take account of the application of appropriate standards and investment to reach goals over a defined timetable.

China also now has the opportunity for strategic planning of subsidised investments in wastewater, in order to optimise progress to attain river basin water quality objectives. However this overall macro-environmental goal must be balanced with each community's desire to sort out their own local environmental problems and improve their quality of life. Strategic river basin planning is a good idea where the problems have significant upstream and downstream interactions, but for communities on small tributaries or lakes it is the local impacts that are significant, and systems for prioritisation must take this into account.

The largest cost element in improving wastewater treatment will be the investment in sewerage to collect and convey the wastewater to the treatment works. Major interceptor sewers and pumping stations will be required, the costs of which generally exceed the cost of the treatment works. There are many examples around China of wastewater treatment works having been built but with insufficient investment in sewerage, meaning that much of the wastewater does not reach the works and is discharged directly into the river while the works operate well under capacity.

There is a specific need to strategically plan investment in wastewater sludge management. The expansion of wastewater treatment is rapidly increasing the generation of sludge, the proper disposal of which has not always been planned in detail. Simply sending sludge to landfill can result in problems for landfill management and the production of effluents that end up returning the pollution back to the environment (see Box 7.3).

Wastewater treatment processes rely on maintaining a stable biological assemblage in the plant. Toxic compounds or sudden peaks in industrial discharges can have a very damaging impact upon the ability of the plant to operate, by interfering with the biological processes. High-strength or toxic discharges may also pose a health and safety risk in the sewer system, lead to septicity and odour, and damage the assets by causing accelerated corrosion. The treatment plant operator and sewer system operator need to have clearly defined and direct relations with the industry and knowledge of the flow and load of discharges to the sewer system. This is necessary both to ensure proper commercial compensation for treatment services and to be able to control discharges harmful to the condition and operation of the assets. Such co-ordination between dischargers, operators of sewers, and operators of treatment works is generally very weak in China and needs to be strengthened and formalised.

*Integrated pollution control investment planning*

Raising investment to the levels required to meet water quality needs is a huge challenge. The government of China has set targets for provision of urban wastewater treatment capacity at 70% and discharges of COD to be reduced by 10% over 2006-10 ($11^{th}$ Five-Year Plan). These targets have been written into the letters of responsibility issued to senior officials by the CPC and will comprise part of the criteria upon which their performance will be judged in annual reviews by the CPC Organisation Department. This provides real motivation to achieve such targets. The government is particularly pushing these targets in certain key river basins and lake catchments where plans have been prepared by the local governments.

Though central government funds have been set aside to support these programmes, the bulk of the finance must be raised locally – and ideally, with leveraging from private finance. Projects must be initiated at local level; then the local government should seek additional finance and raise revenues to pay for the investment. The favoured strategy is to seek BOT (build own transfer) partners to take on the development of the project. Success of such BOT initiatives outside major cities has been limited; even where BOT agreements have been entered into, many have collapsed before construction commences (especially with newer local Chinese joint venture partners), based on the late discovery that the conditions and risks are too difficult.

If no loan or private finance can be found, then municipal government is required to proceed anyway. Provincial and state governments may help in setting up financing vehicles and packages of projects. Central government incentives, grants or state bonds may be retrospectively awarded in response to good progress and initiative by the local government. Projects, once constructed, may be "sold" as TOT in order to recover investment capital.

### Box 7.3. **The growing problem of sludge disposal**

The treatment of wastewater extracts a residue of solids and organic matter that has been separated from the incoming waste, or is the surplus of the biological processes that treat the waste. This suspension of solids and liquid is highly polluting, has physical properties difficult to manage and rapidly decays, producing further noxious emissions. Treatment of this generally involves further separating the fluids from the solids and then stabilising the remaining solids. Such treatment processes are difficult and require expensive capital equipment and a high level of operator skill and maintenance.

The resulting treated sludge does have some beneficial properties; it contains organic fertiliser content and has a reasonable energy content. Thus it may be processed to produce energy either by digestion and methane gas production or direct incineration. Treated sludge may also be applied to agricultural land as a fertiliser/soil conditioner.

Current policy in China is mostly to de-water sludge with centrifuges or belt presses to around 20% dry solids (80% water) and then transport it to landfill.

In Europe sludge is largely disposed of by application to agricultural land. For the EU as a whole, over 40% of sludge is disposed of this way. Acceptance of the practice varies from country to country, with 55% of sludge to land in the United Kingdom regulated by voluntary agreements for quality and pathogen reduction. In some countries, such as the Netherlands, the practice is banned due to public concern. Northern Europe generally shows more concern and regulation; in southern Europe the issue receives little attention.[1]

To increase sludge disposal to land in China poses certain challenges. The first is to identify land suitable for the application of sludge. Though the use of latrine waste as fertiliser is standard practice, it is done on an individual basis. Chinese agriculture has very low levels of mechanisation, with each farmer managing a small area 0.1 to 1 ha. Unless highly pre-treated, the safe application of sludge to land requires mechanised spreading. It is very difficult to organise this type of application in a non-mechanised and fragmented farming system.

To allow individuals to apply the sludge as a soil conditioner, the sludge would need to be treated to an advanced level by pasteurisation, and drying to 95% dry solids. This would produce a cake product that can be bagged and easily distributed or sold to farmers either in an open market or with financial or policy incentives. The product can also be incinerated for energy recovery. The capital cost of the equipment to dry sludge is very high, as are the requisite maintenance and operator expertise levels. The market for sludge products does not normally match the cost of production such that disposal to landfill seems cheaper and easier unless landfill disposal charges are very high and tightly enforced. Advanced sludge treatment is only viable when subsidised from wastewater treatment revenue.

Heavy metals and certain other persistent toxic compounds, if present in the sludge, limit the possibilities for land application. They are very difficult to remove during the wastewater treatment process or directly from sludge. It is therefore important to ensure that they do not enter the sewer system, by effectively applying discharge controls from industry to the sewer network.

1. EU Publications (2001), *Disposal and Recycling Routes for Sewage Sludge*, Part 1 – "Sludge Use Acceptance Report", *http://ec.europa.eu/environment/waste/sludge/pdf/sludge_disposal1.pdf*

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For industrial projects there is a serious hurdle to overcome. Standards are tightening and enterprises are being put on notice that they must comply or face closure. In principle it should be "polluter pays" and it is the enterprise's responsibility to meet the cost of compliance. In practice the cost of adding full waste treatment may be so high that the financial burden would be too great and the enterprise would fail anyway. Therefore there is provision for the government to offer 20% subsidies to enterprises that show real initiative in investing in clean tech. The barrier is that the subsidy will not be awarded until after construction has commenced and so cannot form part of the budget or collateral for the investment.[5] The objective for the enterprise is to get itself moved from the "enterprise for closure" list to the "enterprise for subsidy" list of the local government.

Though high-level policy statements have been made committing to high levels of future government spending on water and wastewater infrastructure, the current system of retrospective financing by central government creates a situation of uncertainty among those responsible for making investments, and greatly reduces enthusiasm for such projects. A clear economic regulatory environment is required where the routes for long-term financing of projects are known before the project construction is started.

### *Reporting and performance benchmarking*

To regulate a business, the regulator must be able to scrutinise and understand that business and be able to assess comparative efficiency in order to administer incentive systems to promote best practice. Whether in private or public ownership, the water company is managing the assets on behalf of the customers; therefore the regulator, in supervising this relationship, should issue clear reporting guidelines to know the asset value and condition, and report on:

- *Performance*. Water delivered, sewage collected; property/population and levels of services; interruptions; customer service; sewer flooding.
- *Activities*. Mains/sewers laid, bursts repaired, etc.
- *Finance*. Expenditure on operating (Opex); expenditure on assets (Capex); regulatory accounts.

The provincial water and sanitation office would then be able to compare the reports of different companies and assess comparative performance. This information could be used when making decisions on tariff setting or special measures.

The gathering of the data for reporting to the regulator should be the responsibility of the water company. However, China could consider establishing independent reporters to work with the water companies to ensure the correct collection and compilation of performance data in accordance with regulatory guidelines.

### *Financial sustainability*

Primarily, this means setting water tariffs at levels that achieve cost recovery and some margin to fund investment.

There are many gradations on the road to financial sustainability. The unsustainable water company is one than runs at an operational deficit (let alone with new infrastructure investment) and has to be bailed out by the local government from general taxation at the end of each financial year. This is very common in China. On a higher sustainability rung are companies that can meet all operational costs from revenue, but not new or renewed infrastructure. Further up are those that can fund some investment and capital renewal from revenue, but for whom major projects require periodic subsidy. Higher still are those that can fund all investment from revenue in a sustainable manner. Finally, at the top are those companies that are fully sustainable and reliably profitable, and are therefore creditworthy and able to borrow money on good terms.

Financially sound companies are much better able to raise finance – by joint venture with national or international private water utility companies; either through term contracts; by privatisation; by issuing of municipal bonds; or by debit finance through international or national bank loans or state bonds. The stronger the financial standing of the company, the greater will be the options and the lower the cost of capital. As a monopoly business with long-life assets and reliable revenues, water utilities can become an important part of the financial market.

The basis for water pricing in China is set out in the Administrative Method on Urban Water Supply Price (NDRC, 1998). This establishes *i)* the general principle that water supply pricing should attain cost recovery, reasonable profit, water conservation and social equity, *ii)* that municipalities are responsible for approving water tariffs; *iii)* tariffs should cover operation and maintenance, depreciation, and interest costs; *iv)* tariffs should allow for a return on the net value of fixed assets of 8% for domestic investments, while that for foreign investment is 10%; *v)* tariffs should be appropriate to local characteristics and social affordability; *vi)* municipalities should gradually adopt a two-part tariff consisting of a fixed demand charge and a volumetric charge or increasing block tariffs (IBT), where the first block should meet the basic living needs of residents; and *vii)* public hearings and notice should be conducted in the process of setting water tariffs. These principles are broadly in agreement with International best practice however the implementation of these principles has not been consistent across China, especially in the lower capacity cities.

The need to raise tariffs to financially sustainable levels must be balanced with the affordability of water charges for the users. With much lower per capita incomes in lower capacity cities, the water services are more constrained in how far they can raise water tariffs without imposing a burden on poorer households. This puts pressure on the price bureaus to keep water charges low. However very low charges lead to a lack of investment and it is then the poorest who suffer worst from this. With proper supply to poorer parts of town not being financed, the poorest people ironically end up having to pay the highest rates for water, having to buy from private sellers, and often of lower quality. Introduction of blocked tariffs with increasing unit rates for higher usage can help by lowering the burden on poorer households that tend to use less water overall, and also provides a water-saving incentive to all users. There can also be individual financial relief programmes for customers in most difficult financial circumstances. Such approaches are more effective in poverty relief that blanket low prices, which predominantly benefit the middle and upper income users.

Wastewater treatment is supposed to be financed from the wastewater component of the water bill charged to water users. In 2006, NDRC set a target minimum tariff of 0.8 RMB/$m^3$ to be added to the water supply tariff; however this level of tariff has not yet been applied in all cities. So far the level of investment has followed the level of prosperity in the cities financing wastewater collection and treatment. Thus the downstream cities of the southern and eastern coastal zones have high levels of treatment, and recover these costs through higher wastewater tariffs (0.7 to 1.0 RMB/$m^3$) (XiaoXiang, 2006) whereas the upstream cities in the central and western regions of China have lower levels of investment and charge lower tariffs (0.25 to 0.5 RMB/$m^3$ where there is any charge at all). This does not represent efficient targeting of investment, as it is in the upstream areas that pollution has the greatest impact and consequence on all users downstream, increasing their water supply costs or even rendering the main rivers unusable for water supply. It is therefore here that the greatest attention should be paid to reducing pollution. The pricing mechanisms need to be adjusted to support this requirement. An attitude must be overcome in upstream local governments regarding impact on downstream cities as being somebody else's problem.

In addition to the water supply fee and the wastewater fees since 2006 water bills are also required to explicitly include a water development fee and a water resource fee. The water development fee goes towards the cost of provision of the raw water infrastructure. The water resource fee is supposed to reflect the scarcity and opportunity cost of the resource. The water resource fee is set by and paid to the local government with a small proportion (around 20%) going to central government. This money is used for further resource development and management.

None of the above charges value water at a level close to its true economic value (*i.e.* the Marginal User Cost – the loss that additional users would suffer were further supplies not available. See Box 7.1). In addition water use also incurs external costs in terms of resource depletion, pollution and environmental degradation that are barely considered in the pricing mechanisms. Adding all of these features together gives the Marginal Opportunity Cost of water (MOC), a true estimate of the full costs incurred in water use. The MOC of water would vary greatly by region depending upon the specific scarcity, pollution impacts and economic uses available. Though theoretically desirable it would not be practical to immediately increase the water tariffs to MOC levels. However MOC water pricing could be considered as an effective planning tool in planning both water resource investment and urban, industrial and agricultural development in general. MOC pricing could be phased in by gradual increases in water resource fees, and applied as part of a block tariff, affecting only the upper tiers of the pricing ladder. Issues with MOC pricing include: the need for much more robust metering – including of rural and agricultural users; the generation of excesses revenues beyond the immediate financial needs of supply which will need to be returned to local or central government as general revenue or in substitution of other forms of taxation.

A fully developed water and sanitation infrastructure most likely represents one of the largest revenue-generating capital asset of an industrial society. The capital cost is high relative to the revenue, but the asset life is very long – 10 to 50 years for above-ground assets and on average greater than 100 years for below-ground assets. Thus these assets become an important component of the macro economy.

The water and sanitation regulatory authorities must themselves be financially sustainable. The easiest way to ensure this is for them to be funded from the water tariffs by payments from the water company, either as a percentage of tariff revenue or as a licence fee.

A key part of establishing the true position of the water company is by undertaking a programme of properly surveying and cataloguing the above- and below-ground assets of the company in order to understand their value, condition and maintenance requirements. A second key part of establishing a viable company is to properly understand the supply-demand balance and projected growth in customers and revenues. The third part is knowing the costs for operation, asset construction, capital finance and tax liability. Even in OECD countries much ongoing effort is required to better define these. In China most water companies and departments have only a very partial knowledge of these factors.

### *Advantages of improved regulation*

#### *Better management of private investment*

With a defined regulatory environment and financially sustainable models for the utilities, local governments will find it much easier to attract private finance to help with infrastructure investment and expansion of services, and to secure such investments on terms that are good for the customers. The approach should be in this direction rather than waiting for a private investor to come along to sort out the problems. They may come, but if they do it will be at a price to cover the risk premium of an uncertain regulatory and financial position**.**

Clear rules and policies for private participation will reduce the risk to the government of entering into agreements with private companies that later have to be revised following negotiations.

#### *Debt financing*

The massive levels of investment required, especially for wastewater infrastructure, cannot easily be raised from local government sources. In many OECD countries the water utility companies, private or public, are able to raise finance through debt, borrowing from state development banks, issuing municipal bonds or borrowing commercially against their assets and revenues, which has a very low risk level. OECD water utility companies are typically geared to 50% of total assets, and in some countries such as the United Kingdom they are geared to as much as 90% of asset value.

Chinese local government financing rules do not allow the provincial or municipal governments to raise debt directly, though they can access debt finance from state bonds or international funding agencies through the NDRC, or borrow from the China Development Bank (CDB). To date most of these funds have been directed towards the larger cities. As the requirement for investment in China's water sector is now shifting to the lower capacity cities, so the criteria for state funding should shift to encourage application to the areas of need. This will mean providing support to smaller municipal governments that apply for funding.

It is possible for the municipal water utility companies to directly raise debt finance from various sources. Doing so could greatly increase the options open to local governments to fund their water investments. A prerequisite for this type of funding is a well and transparently governed, financially autonomous water company or department with water tariffs collected at cost recovery levels. The creditworthiness of the company will determine the funding options and costs involved.

In many of the lower-capacity cities and towns of China it will be difficult to raise the water utilities to a creditworthy status in the short term, and programmes of government subsidy and support to reform will be required to achieve the investments required to meet development goals.

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### *Capital planning and design standards*

When planning any reform or investment in a water company, the fundamental information required is knowledge of the:

- Assets.
- Revenues.
- Costs.

In most OECD countries, advanced Asset Management Planning Systems have been put in place. These catalogue in databases and GIS systems the assets of the company and information on their condition and performance. Risk-based statistical models are used to predict the overall amount of capital maintenance likely to be required each year (a considerable advance on simple asset life assumptions). Though models as yet are poor at predicting exactly where and when failure will occur, the aggregate impacts can be accurately predicted. There is a move to optimising whole-life costs and considering the operational and maintenance costs and the consequent costs of failure, discounted over the life of the asset, rather than just minimising the initial capital cost.

When designing assets it is essential that realistic estimates are made of the supply/demand situation at commissioning time and into the future horizons. Design standards and technical guidelines play an important role in this. If the assumptions used for design are incorrect or there are insufficient data available upon which to base designs, then the resulting assets will not perform well and revenues will not match projections. In China it is commonly the case that the design guidelines of per capita consumption and load are much higher than they are in reality. There is a general assumption that per capita water use will move towards US levels of consumption (around 450 litre/head/day), when there is actually no reason to suppose this, given that most other OECD countries manage on far lower per capita consumption – *e.g.* 150 l/h/d in Germany and about 160 l/h/d in the United Kingdom. Of course these figures depend very much on what is included, such as leakage and commercial use. Nonetheless, in China this often leads to assets being designed with far too much excess capacity. For wastewater there is a common tendency for Chinese urban domestic sewerage to be much weaker than international norms, again leading to operational problems if these assumptions are wrong at design. Such calculations are especially critical when designing biological nutrient removal processes; these are now commonly specified for new Chinese wastewater works on the basis of being the best available technology delivering the highest environmental standards. If the design data or operational procedures are just a bit wrong, these processes will simply not work properly, and the extra cost of providing them is wasted.

Understanding demand, flows and loads to treatment is especially critical for BOT–type contracts commonly being implemented in China. The entire business model is dependent upon the balance between the tariff and the volume. If outcomes do not match expectations, then conflicts are bound to arise. Where BOT contracts are implemented, the contractual terms generally require payment even if demand is greatly below capacity. This then represents an inefficient use of capital and revenue on the part of the municipality.

## Water quantity management

### *The development of water allocation systems*

The Water Law of 2002 confirms that all water resources belong to the state and that the state is responsible for implementing a system for controlling water allocation by quota. It is the State Council that exercises and implements ownership of water resources on behalf of the state. The local government does not have the right to allocate water resources except where delegated or instructed to do so.

River basin regulatory systems for water allocation have evolved by negotiation between state, river basin and regional authorities along different lines in different parts of China. The most clearly developed of these regulatory systems is in the Yellow River Basin. Here, in response to the complete drying of the river for many months each year through the 1990s, the state has been exercising unified allocation of water quantities to each of the riparian provinces and regions. As a result, there have been no further dryings since 1999. In 2006 this system was officially defined in State Decree 472, "Ordinance on Yellow River Water Quantity Allocation".[6] Discussion of the Yellow River System may be used to illustrate and discuss water allocation best practices in China.

The Yellow River Water Allocation Scheme is established by the Yellow River Conservancy Commission (YRCC), in consultation with local governments of the eleven riparian provinces, autonomous regions and municipalities through which the river flows or which receive diverted water.[7] The scheme is audited by the development and reform administrations and the water administrations of the State Council, and then submitted to the State Council for approval.

The Yellow River Water Allocation Scheme is established in accordance with the following principles:

- Operation on the basis of the river basin master plan and mid-term and long-term water supply and demand management plans.
- Emphasis on water demand management and water saving.
- Consideration of the physical conditions of water resources, present water abstraction and consumption, water supply and demand and their development trends in the Yellow River Basin, so as to obtain the comprehensive benefits.
- Integrated management of domestic, agricultural, industrial and environmental water use.
- Co-ordination between upstream and downstream as well as between left bank and right bank.
- Sound definition of sediment transportation, water demand and useable water.

"Useable water", mentioned above, means – putting aside the sediment transportation water use – the maximum water amount that could be used for domestic, agricultural, industrial and environmental requirements in a multi-year average runoff in the Yellow River main stream and tributaries.

As yet, environmental flows – those flows required to meet water quality and ecological objectives – are only partially defined. YRCC is undertaking further research to better define the criteria for these.


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The preparation of the above plans and assessments is the responsibility of YRCC. In doing this YRCC will work closely with the Provincial Water Resources Bureaus, reservoir management bureaus and affiliated institutes.

The approved yearly water allocation plan is implemented through monthly water-regulating schemes and, in times of high water demand, ten-day water regulating schemes. Yearly total water abstraction indices of the Yellow River main stream and tributaries are set by YRCC, which controls abstractions and reservoir releases. These indexes may be adjusted in times of drought. The yearly water allocation planning is to be incorporated into regional socio-economic development plans.

The water allocation regulations affect the amount of surface water users are allowed to abstract and how reservoirs are to be regulated to balance supply and demand.

### *Changing agricultural water use*

From the 1950s to the 1970s, under collectivised agriculture, major investments were made in surface water-based irrigation systems to boost agricultural production. These irrigation districts could cover areas of tens of thousands of hectares. However, following agricultural reform and de-collectivisation in the late 1970s, the smaller, village-level organisations of farmers found it harder to raise the capital and co-ordinate the activities required to take over ownership and then to maintain or extend such systems. As a result, many systems have fallen into disrepair.

In their place, entrepreneurs have established small companies in co-ordination with the village governments that raise capital to sink wells, buy pumps and construct low-pressure underground distribution pipe networks. Farmers then buy water from such an enterprise on a volumetric basis. Private well supplies are often more efficiently managed, as the water suppliers have direct incentives to maintain their assets. Farmers often prefer these sources as being more reliable than district irrigation schemes and offering greater control and autonomy. There are now more than 5 million tubewells in China, 4.6 million of which use electric pumping equipment with an installed capacity of 46 GW; of this capacity, 40 GW is used for irrigation and the rest for water supply. The rural electricity required to operate such systems is subsidised in order to protect farmer income (0.272 Yuan/kWh compared with 0.513 Yuan/kWh for retail electricity) (MWR, 2007).

All ground and surface water abstractions are regulated, with a requirement for a water drawing permit. Procedures are defined in State Decree 460, acted into provincial laws, and then implemented by the Water Resources Bureaus at provincial, municipal and county levels. Volumetric charges apply for these abstractions in the range CNY 0.02 to 0.25/$m^3$ (with an average water cost of 0.14 Yuan/$m^3$ across all uses). However, there are many abstraction sources that escape this levy, or where the metering systems are defective. Recent surveys indicate that less than 10% of small farm abstractions are covered directly by the permit regulations (Lohmar and Wang, 2008).

This situation of rural water supply entrepreneurs has led to a system under which farmers could be directly paying a volumetric fee for their abstractions. However, with a large number of small abstractions, monitoring, reporting and collection of charges are patchy. In fact, these abstraction charges often end up being levied on the village as a whole and then recharged to the farmers – bundled in with other local service charges many months later, and often prorated by land area, thereby breaking the link between water use and charge. This introduces a free-rider incentive for both the well operator (who is not responsible for the sustainability of the common aquifer but only for their own infrastructure assets) and the farmer, who can benefit by taking more than his share of the commonly administered water supply to boost yields while sharing out the additional costs.

Though the abstraction cost of water from a tubewell is low, the pumping cost increases as water table falls (between 1996 and 2004, 75% of the North China Plain experienced falling water tables with 26% falling by more than 3 meters per year). Eventually this cost starts to impact on crop selection. It becomes necessary to switch from grain to more intensive fruit and vegetables, often using greenhouses, in order to maintain margins.

With the abolition of agricultural taxes in 2005, China now has greater flexibility to implement more effective irrigation pricing. In most remaining irrigation districts, fees charged to farmers are much less than the cost of providing the water. Most irrigation supplies are not metered and management systems are vulnerable to abuse of commons, with those who take more than their share benefiting without sanction. Water user associations (WUA) are being established more widely. These take ownership of the assets into a management company responsible for investment in infrastructure and setting and collecting user charges for irrigation water. Managers of WUA are elected by the water users and policy decisions are made collectively. An alternative approach is the village contracting water delivery to individuals or privately run enterprises.

Around 70% of China's rural population have safe and accessible water supplies, up from 60% in 1990. The other 30% have to carry water long distances or only have access to unprotected sources. However, even those with safe sources may lose their water supply during dry seasons. One target of the $11^{th}$ Five-Year Plan is for 100 million more rural people to be provided with safe water by 2010.

New rural water supply schemes in China use water meters as a basis for charging users a fee for domestic water – normally CNY 1 to $2/m^3$, sometimes with a minimum charge of CNY $3/m^3$ per month – payable to the village water committee, which operates and maintains the infrastructure.

### *Challenges to reform*

Water reform initiatives need to take account of the "governor's grain bag policy" to maintain a high level (95%) of self-sufficiency in grain production at national, provincial and regional levels. This policy, introduced in 1995 and retained under the 2004 regulation on grain marketing, makes it difficult to produce the crops that are best suited to local land and water resource characteristics. It responds to government objectives of food security, national security, social and macroeconomic stability rather than sustainable water resource management. Thus despite several factors – reduced availability of water resources; loss of agricultural land to urban development; and switching of prime land to intensive high-value production and slightly marginal land to forestry for ecological protection under "Green for Grain" incentives – grain production in China has been increasing over the past few years, with the 2008 harvest reported to be the largest on record.

Probably the greatest challenge to reform of the agricultural water sector is the incomplete monitoring and control of abstractions. For any system of water rights trading or incentive scheme based on volumetric charging to be effective, there must be full knowledge of water abstractions, uses and returns. No system can be effective if it is easy to cheat, taking incentives for demand reduction then obtaining additional water from alternative sources. Such cheating is not so likely when irrigation water charges remain very low, but once incentives are introduced the benefits of cheating will increase.

### *Policy suggestions*

A challenge for regulatory reform is to help the farmer/village overcome the investment hurdle of switching to more efficient irrigation or intensive cropping with higher margins. A possible solution is applying high fees for volumetric use but returning lump sums for farmed areas; this would create a non-crippling incentive to save water and a means to fund investment. However, it is hard to design and implement such a system in a manner that prevents abuse. Alternative approaches are to provide incentives to the managers of WUA for achieving water saving targets.

In those areas where electric tubewells are the main source of water, direct water metering (the weak link in any incentive scheme) may be replaced with electricity consumption. This is much more easily (and likely to be) reported. The challenge is in obtaining co-operation between electric utility companies and water resource bureaus to share data and enforcement responsibilities.

Water allocation and water rights systems still require further refinement and clarification. The nature and duration of water rights are not clearly defined at state, province, regional, community or individual levels, nor is the transfer of the water right to the water user. There are also inconsistencies between basin and regional water resources allocation plans, as well as between long-term and annual plans.

Improved hydrologic modelling leads to better water resources assessments and allows better calculations for water allocation plans. These plans should combine the elements of:

- Hydrological assessment.
- Environmental flows calculations.
- Supply-demand forecasting.

The process of breaking the water cycle into its components and developing models will provide much greater understanding. Ultimately, the ability to manage the resources is dependent upon knowledge and understanding of the resources. Each of these elements could benefit from the application of improved technologies for analysis. In particular, since there can never be certainty in such assessments, this uncertainty should be formally defined and managed – for example, *headroom* is the margin between supply and demand. The application of the formal analysis of *headroom uncertainty*, as used in the United Kingdom (UKWIR, 2002) allows application of a risk-based approach to water resources planning. That better allows reliability of supply to be managed within the water resources allocation planning system, and also improves long-term policy and infrastructure investment planning.

The allocation plans are implemented through the water abstraction permit system. Though the water-drawing permit system in China is well developed, it does not yet link to the processes of water allocation planning. This is an inconsistency in the system that should be addressed.

Flow returns of abstracted water also have important impacts upon both water resource availability and water quality. In the case of industrial and urban water use, around 80% of abstracted water is returned to the resource system but in a transformed state of quality. On the other hand, water abstracted for agricultural use will mostly be "consumed" through evapo-transpiration. The agricultural return and run-off water may have a much lower level of organic pollution (COD and ammonia) than the urban/industrial discharges, but will carry significant loads of nutrients (nitrogen and phosphorus), which can lead to serious water quality problems. The evapo-transpiration (ET) method of water allocation can be applied to consider these factors.

The quality of the water abstracted has a great bearing on its usefulness – the allocation planning system and the abstraction permitting and charging systems need to recognise this. The linking of abstraction and discharge permitting systems will enable the resource and quality/economic value elements of this relationship to be better developed. Understanding of the water quality is also essential to calculations for environmental flows. Thus the planning of abstractions for different purposes should take consideration of the impact of the return flows on water resource quantity and quality downstream.

## River basin water quality and integrated pollution control

The various statistics available indicate that the quality of river water in China is very bad. According to the 700 or so sections monitored by MEP (covering the major river sections of China), in 2006 60% of river reaches failed to meet water quality Grade 3 (suitable for use as a drinking water source), with 28% failing to meet even the lowest Grade 5 (not suitable for any use unless pre-treated) (MEP, 2006). MWR data based on more than 3 200 monitoring stations in 2005 (and so also covering more of the smaller rivers and upper catchments) indicate that 39% of river reaches failed to reach Grade 3 and 21.3% were worse than Grade 5 (MWR, 2005).

The Chinese system for the management of polluting discharges from industry and urban developments is still evolving. Until this year there was no clear legal basis for discharge-permitting systems, apart from in a few pilot areas.[9] The amendments to the WPPC Law (2008) now open the way for a system of discharge permitting linked to total load allocation to meet river water quality targets. The detailed mechanisms of such a system have yet to be published.

Government departments, enterprises and senior officials are now being motivated to achieve defined targets for actions and outcomes, through incorporation of conditions related to environmental performance in the systems of annual performance review against letters of responsibility. Under this system they must ensure provision of treatment capacity and percentage reductions in total COD discharges. They have also been tasked in certain areas to prepare lists of schemes to achieve these defined targets over the 11th Five-Year Plan period and to ensure that such schemes are financed and constructed by 2010. These schemes are generally planned for their overall contribution to the targets of the administrative region; they are not prioritised on the basis of contribution to achieving river basin water quality objectives.

Drawing on the experience of OECD countries and knowledge of currently available technologies, the following is a discussion of how regulations for integrated pollution control could be conceived in China.

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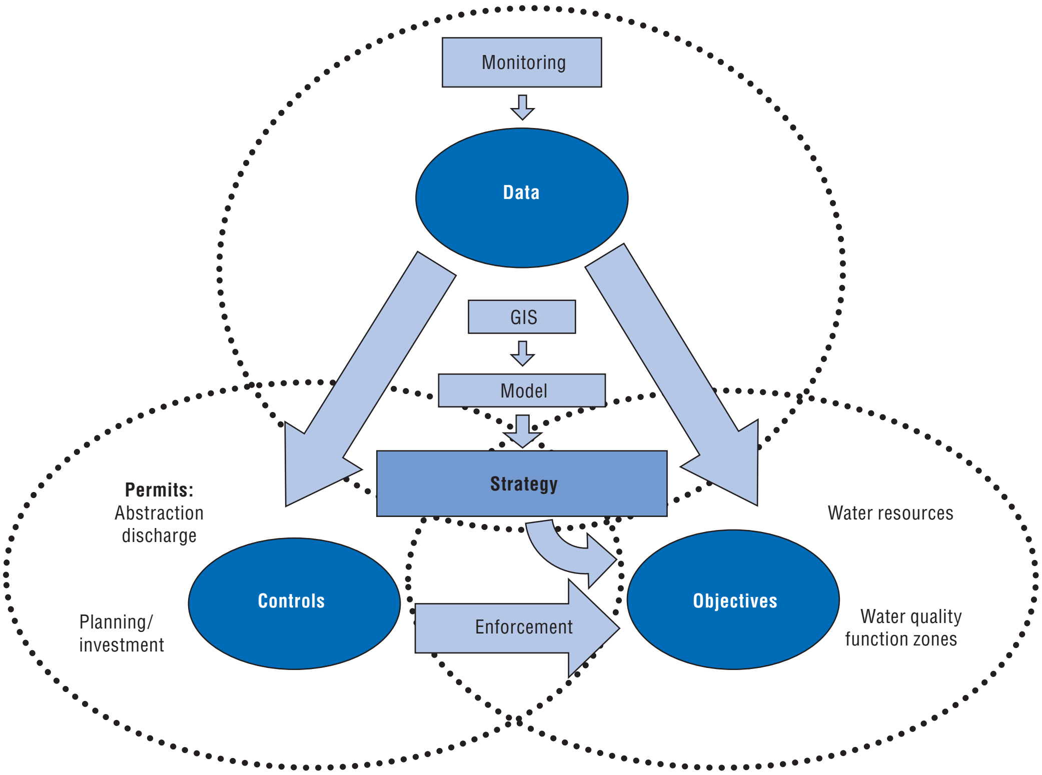
### *Concepts for integrated pollution control*

Conceptually the objective is to create systematic and rational links between monitoring data and legal control instruments, in order to achieve the objectives of an improved environment (in an economically realistic manner). This conceptual principle is illustrated in Figure 7.1.

Figure 7.1. **Conceptual framework for rational management of water quality**




*Source:* Simon Spooner, 2008.

The elements of effective water quality management are:

- Collection of monitoring data.
- Establishment of legal and political instruments for control of human impacts.
- Clearly defined objectives for environmental outcomes.

These elements may be linked by enabling technologies such as databases, GIS and computer models, in order to formulate the *strategy* of investments and interventions that will eventually achieve the objectives in an economically viable manner. The implementation of such a strategy (an integrated pollution control plan) will have to be enforced through legal instruments such as permits, through planned programmes of investments over a defined timetable, and by setting of related performance targets for the people involved.

A systematic approach to pollution control planning will enable the development of much more comprehensive plans for investment at the river basin level. These can be incorporated to the existing five-year development planning process and financed and scheduled in an optimised way.

### *Required elements of the regulatory system for integrated abstraction and discharge control*

The objective is to control polluting discharges to rivers in such a way as to ensure that water quality objectives for each river reach may be achieved and there is sufficient water available to meet human and environmental needs.

The problem is that each polluting discharge from industrial and domestic sources (point sources) must be managed in the context of other point sources and also diffuse sources; and that the pollutants are transformed during transport from source to discharge point; also, once mixed in the river water, they undergo further transformation by decay and dispersion.

Water quality in the river is also dependent upon the available water quantity (dilution). The act of abstracting water from one source (*e.g.* ground water or upstream intake) and discharging to another (*e.g.* downstream river) has implications for both water resource management and water quality. Thus water quality management is strongly linked to water quantity management and the maintenance of environmental flows in rivers.

Such calculations rapidly become excessively complex when trying to apply them to a real river with constantly varying flow conditions. Therefore a regulatory model requires all calculations to be performed for defined reference flow conditions (*e.g.* annual average flow or 75 percentile low flow, etc.). Though an artificial concept, this simplification is necessary to enable the process to be managed. The objective should be an effective management tool and not a simulation of reality.

There is a wide consensus among many key figures in water resources and water quality management in China that the fragmentation between abstraction management and discharge management is a root cause of the difficulties in tackling river water quality, and that a solution must involve integrated abstraction and discharge-permitting systems.[10]

These principles have been incorporated to the Water Law of 2002 and the WPPC Law of 2008. The challenge now is in the effective definition and implementation of systems at river basin, provincial, municipal and county levels that will achieve the policy and direction expressed in the national laws. This will require co-ordinated and co-operative action by the authorities involved.

To understand the linking of these elements and focus on the methods of intervention available, some relevant parts of the water cycle are discussed below. The natural and unnatural physical elements are then considered in the context of the Chinese legal and institutional framework.

The elements that need to be considered for each river reach in an integrated permitting system in China are illustrated in Figure 7.2.

Figure 7.2 illustrates the typical case of an industrial facility drawing clean water from various sources (in accordance with abstraction permits or supply contracts), then discharging polluted water into urban sewers that convey the flow and pollution load to the river.

The quantity of the discharge flow will normally be closely related to the total amount of water consumed by the factory. The concentration of discharge flow will depend on the technology of the industrial production processes and provision/utilisation of wastewater

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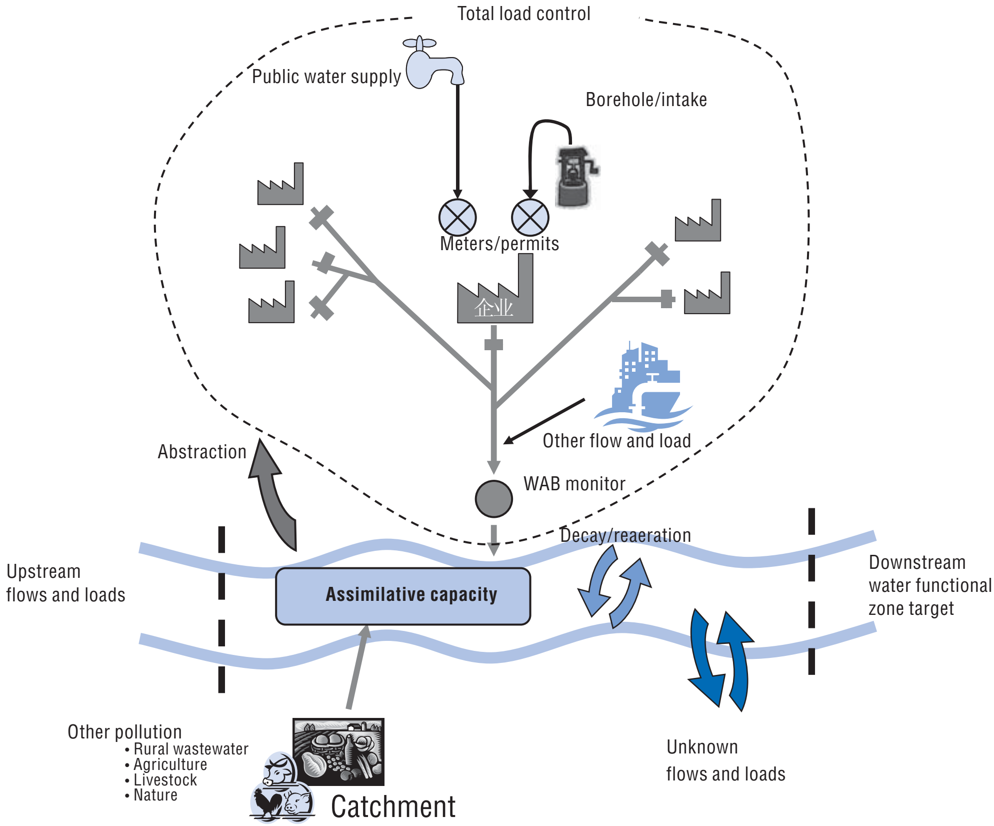
Figure 7.2. **Scope of items to be considered in integrated permitting system**




*Source:* Simon Spooner, 2008.

treatment. Thus the discharge flow may be characterised by volume and load, giving rise to a typical concentration. It is the concentration that is most readily measured by onsite monitoring. Discharge flow volumes are often difficult to measure directly, and so the total load may be better estimated from knowledge of the total inflow to the factory, likely consumptive of evaporative loss in the factory and the discharge concentration.

A key element for linking abstraction and discharge permitting is the calculation of water balance and load contribution for each enterprise. This requires that the authorities responsible for water supply and abstraction monitoring share data with those responsible for discharge monitoring. These data may be self-collected and reported by industry, but if so they must be thoroughly audited and checked by independent authorities.

The pollution load will mix with other sources prior to reaching the river. Some load will also decay or disperse during transport to the river. Thus it is not easy to identify the specific source of pollution in the river, and individual control on the polluter must take place at the point where the polluted flows leave the premises. This is the point at which the factory management is required to ensure their discharge meets the relevant requirements set by the local EPB. The EPB enforces procedures to ensure that all such discharges do not result in the river failing to meet its water quality objectives (Water Environmental Functional Zones, WEFZ).

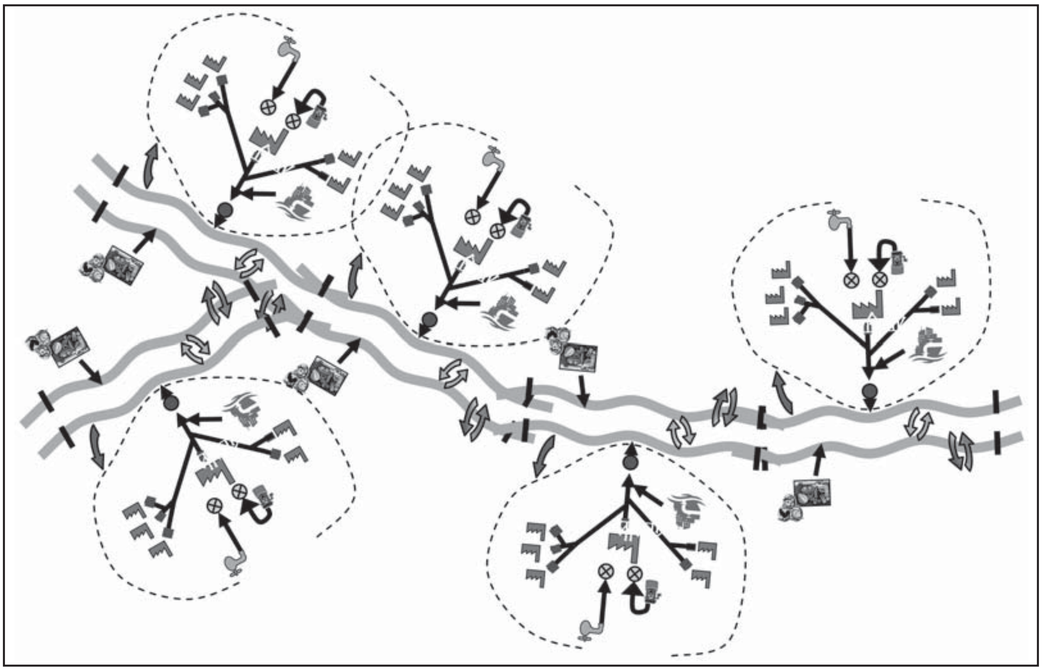
The Water Resources Bureau (WRB)[11] also has responsibility for overall discharges to the river, approval of the structures at the point of discharge, and ensuring that the total discharges from these points do not cause a failure of standards defined for Water Function Use Zones (WFUZ).

The provision of Wastewater Treatment Works (WWTW) prior to discharge to the river considerably modifies the relationship between a discharge from a factory and the impact on the river. The presence of WWTW also modifies the regulatory relationship between the discharger and the authority responsible for river water quality. Discharges to sewers with municipal WWTW may be considered more a commercial relationship between the discharger and the wastewater treatment provider.

The contribution of specific discharges needs to be considered within the context of pollution contributions from many elements as well as the self-purifying capacity of the river. Not all of these sources and processes can be defined with certainty. There will always be unknown elements in the system, and these should be explicitly defined and calculated. The explicit management of uncertainty is a key feature of modern European risk-based management systems.

Furthermore, a river reach cannot be considered in isolation but must account for upstream and downstream reaches, as illustrated in Figure 7.3.

Figure 7.3. **Relationship between each river reach and upstream and downstream river reaches**



*Source:* Simon Spooner, 2008.

River basin water quality management will be based on planning water resource and environmental flow objectives based on total load management at catchment, regional and individual discharge levels, enforced through permit-based controls for abstractions and discharges which are independently monitored and reported with significant penalties for non-compliance or evasion.

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Given the complexities of assessing the impact of multiple discharges in different regions of a river basin against multiple water quality objectives, some form of computer modelling will be required to assist the regulatory authorities. The challenges in formulating such technical tools are not in the design of the software – the calculations required, though very numerous, are not mathematically very difficult – but in the conceptualisation of the calculation process and the provision of required data.

To assist in the understanding and communication of the condition of each river reach, some quantitative indices of performance at individual discharge, river reach, administrative region and river basin levels will be required. Regulatory models will be required for the rational allocation of pollution discharge total loads to each region of the basin, and for the sub-division of these regional loads to the discharge permit for each enterprise. The requirement for this is defined in the WPPC Law of 2008.

Currently in China, procedures for the management of water abstraction allocation by a system of water-drawing permits is well-defined in State Decree 460. These instructions are supported by administrative systems, in some areas utilising databases and GIS.

By contrast, the Chinese framework for discharge permit management and pollution control is not yet very robust, and does not integrate with the water quantity management system. The recent changes to WPPC Law open a framework for discharge management, but the details to be set out in a new state decree are still to be defined.

An integrated system for water quality management will require many elements that can gradually be linked together to form a system.

#### *Combined approach to discharge management*

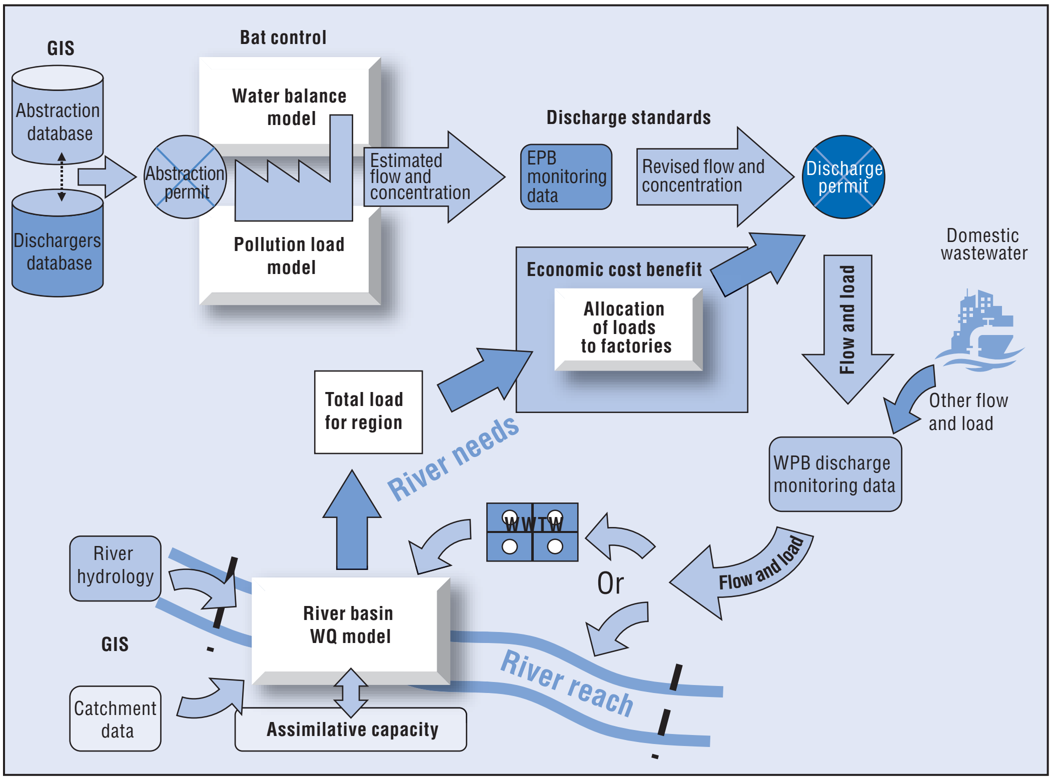
The interventions will be based on plans and investments to reduce loads discharged from polluting facilities such as factories and towns. The reduction of pollution should be based on the combination of three approaches, a key principle expressed in WFD:

- Use of *Best Available Technology* (BAT control) to improve production process water efficiency and reduce pollution generated at source. In EU, BAT for specific processes is defined in BREF notes.[12]
- The setting of general minimum *discharge standards* – basic effluent concentrations not to be exceeded (set at national levels, may be specific to the industry).
- The setting of local *river needs standards* to meet the specific local conditions required to achieve water quality objectives. These may be determined through total load calculations. Generally they are tighter than national standards. Compliance with these will need to be phased with an economically viable timetable.

These conceptual principles may be considered in the context of the Chinese legal and institutional system. That will make it possible to identify how the combined approach to discharge management fits with the technical tools of GIS systems and models, to enable abstraction and discharge permitting – together with total load management – to work towards achieving water quality improvements.

A key feature of the system proposed above is that there is a greater co-ordination between the EPB function and MWR functions. Currently it is very difficult to accurately estimate the load discharged from a factory because the responsible authorities each have only part of the data required to verify the statements of the factory. By sharing data on how much water goes into a factory from abstractions or town water supplies and

Figure 7.4. **Application of combined approach to discharge management for the Yellow River area**




*Source:* Simon Spooner, 2008.

monitoring discharge concentrations, it is easier to estimate the total pollution load of the factory and to analyse the water efficiency and potential for process improvements.

### *Description of an integrated abstraction and discharge management system*

As well as being required to meet the statutory discharge concentrations as set out in GB8978-1996 or local provincial variations, each factory will be allocated a total load that it is permitted to discharge each year. The amount of this permitted load will be determined by calculating the total load for the region and reallocating to each factory. The total load for the region is determined by using river basin water quality models that take account of upstream and downstream balancing, the contributions from other sources in the catchment and the effect of self-purification, and waste treatment investments – and then calculating the reductions in loads required to meet river water quality objectives.

Since it is unlikely (because realistic) to meet the water quality objectives in a single, one-year cycle, a political decision will need to be made annually to determine how large a step is to be taken towards achieving environmental targets. The decision must take full account of the economic consequences and benefits of the required investment or impact on industrial productivity.

Water use by each enterprise is the total of that self-abstracted from boreholes or river intakes and that taken from public supplies. The amount used may be estimated based on water use norms for industry type and production levels, or determined with more accuracy from meter readings. The amount entering the waste stream will depend on industry norms and levels of recycling, incorporation to product and evaporation. Typically, around 80% of water supplied is discharged as wastewater. The load of pollution added to the waste stream may also be estimated from industry norms; it may then be moderated by the presence and use of onsite treatment facilities. The actual flows and loads leaving the factory may be checked by monitoring by the industry itself or by the EPB. This whole process will aim to determine the quantitative and qualitative water balance of the factory and allow the calculation of the total load discharged.

Within the water balance analysis, reports may be prepared for water resource efficiency analysis. These would compare actual water use to that which would be expected for industries of that type, and also in comparison with the total amount permitted by the factory's water drawing permit. Similar comparisons may be drawn for the total discharge load relative to expected norms and the permitted load. Penalty and incentive schemes may be developed to motivate industry to comply with the systems.

Water balance analysis is the key element for linking the abstraction and discharge-permitting systems. Effective implementation of data sharing, compilation of industry norms, methods of calculation and cross-checking/correction against observed data will aid both the WRB and EPB in better understanding, managing and enforcing fair and efficient water use and pollution control.

In order to determine the total load for the region, the impact of loads from each enterprise on the river water quality must be determined, taking account of impacts from other sources and natural processes. Obviously there is a degree of circular feedback in this calculation, and guidelines will need to be developed to ensure a balance between detail and accuracy of calculation, and simplicity and speed of calculation.

River basin pollution indices and discharge impact pollution indices will assist in assessing the relative priorities of discharges in different parts of a sub-catchment or river basin. A high discharge pollution impact index for a factory will indicate that political pressure should be focused on mitigating such discharges, even if the financial incentives on the discharger are the same as for similar industries in less sensitive locations. In devising and using indices and incentives a balance must be struck between requirements to optimise investment in environmental improvement and the need to maintain fair competition between enterprises and to allow enthusiastic local authorities to proceed with schemes of local benefit.

Enterprises may be given financial incentives to achieve discharges that are below the permitted load and financial penalties for exceeding the permitted load. Once a reliable system of monitoring and enforcement has been established, it may be possible to introduce market mechanisms such as trading of permitted loads in order to optimise investment. However, such trading systems can only work reliably where there is a very high and verifiable level of knowledge of the exact amounts discharged by participants. Such confidence in monitoring does not exist at present and would require considerable institutional strengthening to achieve.

The incentives and penalties acting on each enterprise need to be reasonably fair and transparent, but it will not be possible to set regional total load targets that are equally achievable. Areas with lesser discharges but bigger river flows and less stringent functional water use objectives are likely to find it easier to achieve total load targets than areas with smaller receiving waters, more industry or high-grade water functional use objectives. Cross-regional investments or subsidies may be required to even out the economic and political challenges of implementing stricter pollution control in different regions, or for providing ecological services for downstream users.

The consideration of the economic costs and benefits of infrastructure investments can include consideration of the schemes impact on the marginal opportunity cost (MOC) of water, either by making more / less quantity available by improving the quality such that more water is available for specific uses.

Individual factories or treatment works may be motivated by financial penalty and incentive systems related to total load compliance. Consideration could be given to the officials responsible for administration at a regional level being motivated by performance indicators based on the river pollution indexing systems. This will ensure that their decisions on development activity are related to outcomes that will produce improved environmental conditions. These indicators could be linked to ongoing reforms of the assessment procedures of the CPC Organisation Department. The success of any such systems will depend on the separation and independence of monitoring, analysis and assessment activities (see also Box 7.3).

Effective independent monitoring of discharged flow and load needs to be established. Currently the Chinese system is dependent on self-reporting with very occasional checking by EPB, usually with advance notice. The EPBs themselves are not fully independent of the interests of the local government, and in the case of larger state-owned industries they are a department of the factory. In such circumstances even continuous online automatic monitors could not be relied on to provide unbiased data. There needs to be independent monitoring and unannounced inspection visits to ensure compliance. In some EU countries, now that the procedures are established and trusted, it is becoming possible to return to a degree of self-monitoring and audited reporting. The solution to this issue lies in the strengthening of an independent environmental regulator and not in a technical fix of online monitoring; the latter is expensive, unreliable and easily circumvented.

### *Market instruments for industrial pollution control*

There is enormous potential still for major reductions in industrial pollution discharge and water saving by the application of Cleaner Production (CP) technologies. There is not yet a culture in China of operating processes in an efficient and non-polluting manner. Often there are administrative separations within an industrial facility such as between those providing energy or steam, those running the process and those providing the waste treatment process. There may be limited communication and information flow making it very difficult for one part of the business to see the whole operation or take responsibility for integrated solutions.

Clean technology audits of the energy and water balance through the factory and identifying where pollution can be prevented at source by investment in better management and new technology can lead to substantial operational savings. Often simple improvements, better housekeeping and optimised process operation can lead to significant improvements. Thus such investments can give a strong positive economic return. Where more of a step change in environmental performance is required to meet discharge standards then major new investments in plant may be required. The barriers to wider application of CP are a lack of technical capacity to carry out audits and make recommendations, a lack of management awareness and difficulties in raising the finance to make necessary investments.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The investment by industry can be encouraged by the development of economic incentive systems linking – increased penalties / closure for environmental non-compliance with grants, favourable loans tax breaks etc. for enterprises investing in and operating cleaner technologies and improving their environmental performance. Cleaner production is being encouraged in part through financial incentives such as the Green Credit schemes (see Box 7.4).

Box 7.4. **Green Credits and pollution control**

In July 2007, MEP launched China's new Green Credit Policy in partnership with the Central Bank (CB) and the China Banking Regulatory Commission (CBRC). It is anticipated that the policy will encourage the incorporation of environmental costs and benefits in all existing and future development projects, including new funding applications for bank loans and supporting finance from public and private sector banks, plus municipal and provincial development agencies. China's banking sector has willingly co-operated in the "green loan" initiative.

The green loan initiative represents a major attempt by MEP to reform the Government's efforts to internalise environmental costs and benefits in all industrial development projects. In the past, SEPA/MEP and its provincial subsidiaries have struggled to control and enforce industrial discharge standards. Therefore, MEP sought to establish partnerships with other powerful Government departments and agencies to explore market-based approaches to environmental problems. It is argued that market instruments will have a more profound effect on the industrial sector than administrative measures, forcing businesses to internalise environmental costs and impacts from the start, rather than cleaning up afterwards.

In November 2007, CBRC issued new guidelines for energy conservation and emission reductions that apply to all financial institutions nationwide. The guidelines require tight control on lending to highly energy intensive and polluting sectors, while encouraging loans to "green" enterprises. Large commercial banks have begun developing internal mechanisms to incorporate environmental performance into lending operations and to link "green" loans with client rating and risk classification procedures. It is also reported that the Green Credit Policy will be used to assess the environmental performance of senior officials in municipal and provincial government, plus directors and managers of state-owned enterprises.

Trading in pollution discharge permits is a theoretical method of economic optimisation (Coase, 1960). However the implementation of pollution trading requires clearly defined and enforced permits and ambient environmental monitoring. These conditions do not yet exist in China. When such permit control, defined rights and monitoring are in place then more advanced economic regulatory systems may be considered.

## Drawing on the experience of water utility management from OECD countries

In the EU, river basin policy is co-ordinated under the water framework directive implemented by member states in a co-ordinated fashion to meet local quality standards that match the principles of the WFD to attain "good status". Water and sanitation services are managed directly by the member states. On the other hand, blanket standards for wastewater treatment provision in towns with populations over 10 000, 80% reduction in BOD or equivalent, and nutrient removal for discharges to "sensitive" receiving waters are set out in the Urban Wastewater Treatment Directive.

In most OECD countries there is a mix of public and private sector participation in water supply and sanitation. In France and England, private activity in water supply is prevalent; in the United States, Germany, Scotland and Ireland the public sector is prevalent but private sector involvement is increasing. Even where there is extensive private participation, that does not always mean that private entities own the sources of water or the infrastructure for distributing the water or managing wastewater. When water utilities remain publicly operated, the possibility of private alternatives can motivate improved performance by public utilities.

In this section some of the regulatory models used in OECD countries are described, following which there is a more detailed discussion of the UK regulatory model, which has features that may be of interest to those conceiving Chinese regulatory systems.

### *French model*

Water and sanitation services are provided by municipal water corporations. Some municipalities associate to achieve scale economies, and they often combine water supply and wastewater services. Water resources development and water quality investments are subsidised from water abstraction and discharge fees, which are administered by river basin authorities. There is no regulatory authority for water and sanitation (just an audit office). Private contracts for water supply and sanitation are negotiated entirely at a local level. Recent attempts to establish consultative authorities have largely failed. The absence of performance benchmarking in France makes comparisons between the public and private sector performance difficult. Recent simple comparisons of tariff *vs.* service quality indicate a 22% higher tariff where operations are private but the comparison is confounded by the additional tax and land purchase requirements on private sector, and the fact that specialist private sector operators generally are brought in to manage the most difficult cases. However, once a contract has been let there is almost no real competition pressure on the private company, and upon renewal, the lease is re-let to the same company 90% of the time; it is very difficult to take a privatised company back into public ownership. The three big private water companies are in a very much stronger negotiating position than the local municipal authorities. The regulatory negotiation experience is concentrated on the side of the private company undertaking such transactions many times a year and diluted on the side of a local authority, which undertakes negotiation only every decade or so. The system in France does not ensure complete transparency of accounts, making it sometimes difficult to separate the regulated water activities related to the water tariff from other activities of the utility, especially where the company or municipality is engaged in multi-utility administration.

### *Germany*

Water supply and wastewater collection are undertaken by municipal corporations, most of which are in public ownership. Water supply and wastewater treatment within a town are generally managed separately by different companies, and these companies administer both treatment and the supply and collection networks. There are many collaborative associations among the municipalities that allow operational merger and economies of scale. Germany has no federal regulators; six industry associations work to

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maintain standards. These associations are effective in Germany but are not a culture that is easily transferable to China. There is an increasing move towards applying benchmarking to the municipal companies, especially as there is an increasing presence of private water companies (such as Veolia, Suez and RWE) operating under term contracts. Tariffs are full-cost recovery including capital investment. Investments are mostly debt financed, either through development banks such as KfW or by issue of municipal bonds.

### *United States*

Most water service providers are municipal corporations. Investment is mostly by municipal bonds. Much of the wastewater infrastructure construction receives federal subsidy, therefore the business model does not require full cost recovery. Tariff regulation is overseen by state public utility commissions. Penetration into the US market by private water companies has so far been limited. Most of the private operations are foreign owned.

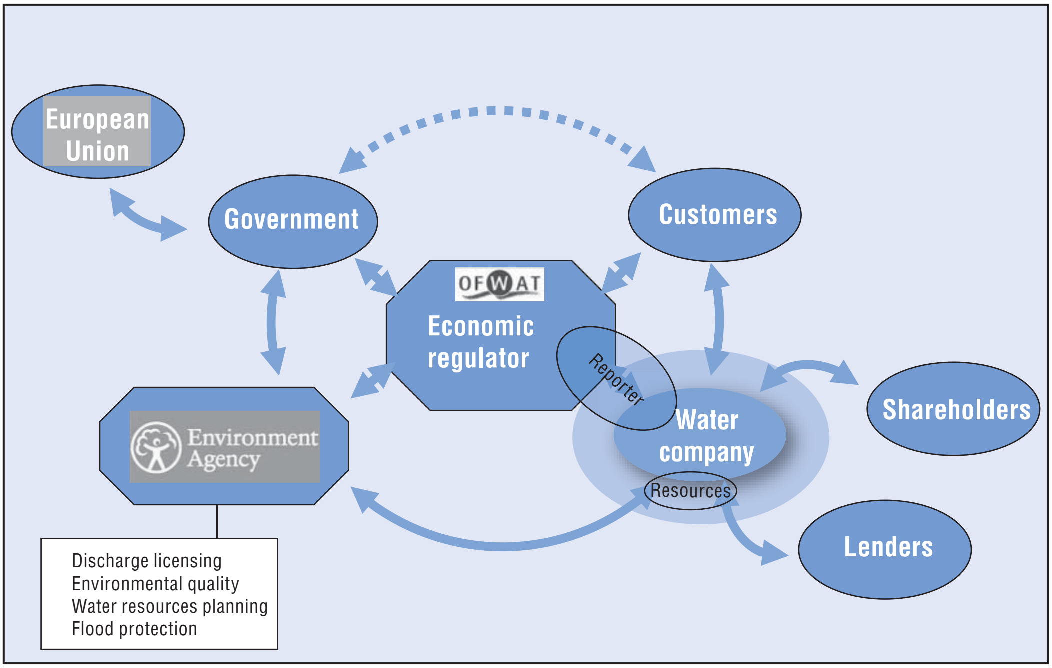
### *The United Kingdom model*

The UK regulatory environment has a significant impact on the behaviour and development of the privatised water industry. It aims to do this through enabling dialogue, partnership, joint development and consultation. However, regulatory instruments are available should the need arise. The ability to use regulatory sanctions is important and is recognised by the water industry, bill payers and the general public as a necessary safety net.

The government and regulators have developed clear and complementary roles to provide a framework within which the water industry operates. The government is obliged to make arrangements to ensure compliance with European directives. The government Department of Environment, Food and Rural Affairs (Defra) sets the strategic direction and determines appeals. Ofwat, the economic regulator, sets prices, ensures that companies have sufficient resources to undertake their duties, and protects customers. The Environment Agency, as the environmental regulator, determines the environmental standards, sets permits for abstraction and discharge, and assesses compliance. The Drinking Water Inspectorate sets and monitors the quality of water provided at customers' taps. The Consumer Council for Water represents the views of customers. The Water Companies provide the drinking water and treat the sewerage, maintain and develop infrastructure, and operate their businesses within the terms of their operating licence. They must also deliver financial returns to shareholders and meet debt obligations to banks, who will take a keen interest in their asset values, revenues, and management performance. The economic regulator is assisted in gaining accurate information about the water company activities by independent reporters appointed to each company. These relationships are illustrated in Figure 7.5.

The roles of the regulators and the water industry have been determined by primary legislation, including the Water Industry Act, the Water Resources Act and the Environment Acts. These provide the statutory framework, which is supplemented by regulations and guidance from Defra. In addition, each organisation has developed strategies and guidance, setting aims and objectives and providing clarity on specific technical issues. These guidance documents form the basis of the day-to-day relationships between the organisations, and in many respects drive the behaviour of the water industry in meeting the regulatory requirements.

Figure 7.5. **UK regulatory model**




*Source:* Simon Spooner, 2008.

Each organisation's strategy documents chart key outcomes, activities and costs over a five- to twenty-five-year period. Each will be subject to pubic consultation and discussion with other key organisations, including government departments. This is especially important, as each requires co-ordination with the other regulators and the water industry. At a strategic level these policy statements influence the costs and actions of the water companies and ultimately the cost to customers.

The technical guidance produced by each organisation provides the detailed framework under which the water industry operates. This guidance is developed in order to introduce new requirements or changes to operational practice, or reporting. Whenever possible, guidance is drafted in close association with the water industry to ensure that it is workable and that it will result in the correct outcome. Policy and technical staff from each organisation work together within an agreed framework to draft and test this guidance. It is essential that good working relationships are maintained and that individuals have a good understanding of each other's needs and technical capability.

Agreement on guidance will be sought whenever possible, before it is ratified by the sponsoring organisation. However, on some occasions the responsible regulator will need to determine the guidance unilaterally. Significant guidance documents may be subject to public consultation, especially if there are cost implications or impacts on the public. Once ratified, all guidance is in the public domain and made available on request via websites.

The UK regulators each have slightly different ways of determining national guidance and informing the water companies and the public about this. Ofwat produces a sequence of numbered Managing Director (MD) or Regulatory Director (RD) formal letters. In this way new requirements or guidance are sent directly to prearranged communication routes into each water company and other regulators and interested parties. These letters aggregate into a comprehensive suite of guidance upon which the water companies interact with Ofwat.

The Environment Agency produces an equivalent quality-controlled sequence of guidance notes covering its area of responsibility. These are assembled into a discharge permit manual and an abstraction licence manual. They are publicly available via the agency's website. Any changes to the manuals are sent to the water companies and to operational officers within the Environment Agency. Ultimately this guidance is imposed through changes to permit conditions, and enforced by monitoring and compliance assessments undertaken by the Environment Agency. Prosecutions are taken when necessary in the courts.

The Drinking Water Inspectorate issues similar Information Letters, which are available on their website. Compliance with this guidance is assessed by a self-monitoring and reporting regime, with Drinking Water Inspectors taking regulatory action if required.

Each water company needs to take this guidance into account in the way that it operates. Companies have some latitude in the way that they comply with guidance and achieve permit conditions. However, they must meet the outcomes and satisfy the legal requirements of their permits.

Depending on the regulatory issue, expertise or technical capability, water companies may choose to interact with the regulators at an individual company level or at a national level. The water companies work with their national trade association, Water UK, to co-ordinate responses and to combine their joint knowledge. Water UK facilitates a number of technical committees that work with the regulators to develop and negotiate guidance. Water UK also acts as a national communications facility and will draw experts and senior spokesmen from the industry as need arises.

A feature of the UK water industry – and water industries in most other OECD countries – is the involvement of consultants at every level of the system, from regulatory planning to programme delivery (though not normally operation). These experts and specialists, working mostly for independent private companies, provide a pool of expertise that is constantly moving between the different organisations involved and greatly increasing the capacity of the industry to perform effectively. Individual consultants will move seamlessly among projects for different companies and work for Ofwat, the EA, Water UK and other organisations, including academic institutions, within the space of months and so there is a transfer of knowledge and expertise. Equivalent accessible human resource pools have not yet been developed in China, making it much more difficult to access the particular short-term specialist skills required within programme and project cycles.

With this regulatory framework, occasions arise when there are conflicting requirements or where the water industry believes that the guidance is being disproportionately or unfairly applied. On these occasions the industry or individual companies can appeal, informally or formally. These appeals are determined by an independent inspectorate acting for the Secretary of State, the Planning Inspectorate. In important cases the Secretary of State has the right to "call in" an issue and determine it directly, or to require a public inquiry prior to determination.

There is a need to balance and take an overview of the current and future requirements for the water industry, and this is undertaken on an ongoing basis by the regulators in a series of formal and informal quarterly meetings. Ongoing and frequent dialogue is important for all parties.

The objective of the economic regulatory process is to ensure financeability: the ability of appointed water companies to finance their functions through debt, equity or retained earnings. Companies being able to finance the proper performance of their functions is interpreted to mean two things. First, the companies should receive a return on investment at least equal to the cost of capital. Second, companies' revenues, profits and cash flows should be such that they can borrow as necessary in the debt markets and provide shareholders with sufficient incentives to produce additional funds through equity injections or retained earnings.

The Periodic Review Process (PR) is a five-yearly review of all the obligations and requirements of the water industry; it provides a formal and structured opportunity for dialogue and consultation. Following this, water prices are set for the next five-year period. These prices seek to balance the financeability of the companies with the need for maintained or improved service to customers and the environment, and affordability to the customers. At present the process of determining PR09, which will be used to set prices for the period 2010 to 2015, is ongoing. Box 7.5 describes the price setting mechanism.

### Box 7.5. **How prices are determined in the UK regulatory model**

Economic regulation is by control of prices each company is allowed to charge customers, rather than by control of rate of return on investment as is the case in some other countries.

Ofwat uses company comparisons as a surrogate to mimic market competition. The objective is delivery of service, not infrastructure.

Some key terms:

RCV – *Regulatory Capital Value*. This is the main reference for the market value of the company and its assets under the scrutiny of Ofwat. It works out at about 10% of the replacement cost of the assets. The company is seeking to generate a return on this value.

K – How much a company may raise or must cut its price each year

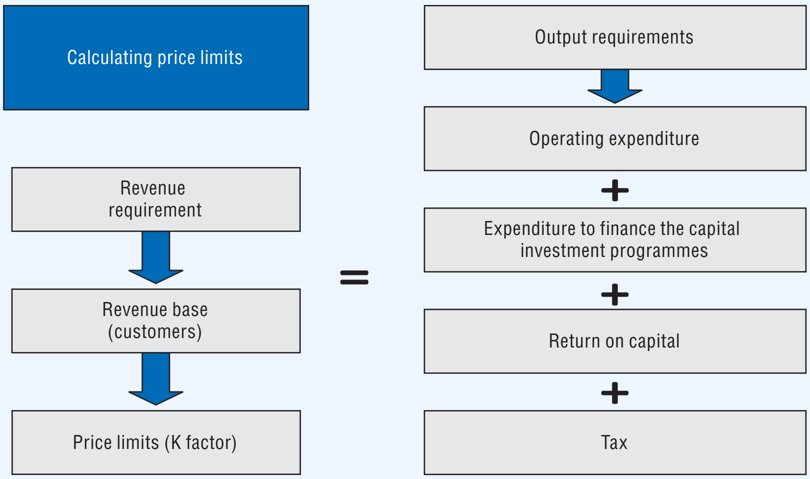
This is controlled by the price limit formula

RPI ± K + U.

K is a number determined by Ofwat at a price review every five years for each company, for each year, to reflect what it needs above inflation in order to finance the provision of services to consumers. It may be changed at an interim adjustment between price reviews. RPI is expressed as the percentage increase in the Retail Price Index in the year and U is the amount of unused K not taken up in previous years.

Many factors are taken into account in the calculation of K, including the past performance of the company as reported to Ofwat, the cost of capital, the investment obligations placed on the company by regulators, efficiency improvements of the company, and the prevailing cost of infrastructure construction. The determination of K is negotiated through the Periodic Review Process by submission and review of detailed company business plans.

Box 7.5. **How prices are determined in the UK regulatory model** *(cont.)*




In addition to these national processes, the water companies must work with their customers and local regulators within their geographical region. Some of these processes are duplicated at regional or company level, but follow and interpret national guidelines. Actual work on the ground, meeting environmental quality conditions and supplying services to customers, is very much a local affair. Local Consumer Councils, local enforcement via Environment Agency area offices, and relationships to local authorities are all critical.

Each abstraction from surface or groundwater will have an individual licence with conditions. Also, discharge permits are set for all discharges from wastewater treatment works and intermittent discharges from sewers and contaminated surface waters. The permits reflect local conditions and environmental need, and will greatly influence the level of treatment, maintenance and operational costs. These are set and maintained at a local level and monitoring and enforcement is also at water company level, although reported as part of the national statistics.

Water companies also operate customer service centres to deal with water supply issues, bill queries and other customer issues and communications.

### *Concerns about the UK water privatisation model*

Prior to 1989, due to overall reductions in public expenditure, there was an acknowledged lack of funding in the water sector. Assets were deteriorating, wastewater treatment works were no longer meeting discharge consents, several pollution incidents occurred and river water quality was declining. A number of new European environmental and drinking water directives were driving further investment. The government was unwilling to increase borrowing or investment in the water industry, and privatisation was seen as a way of introducing private sector investment and more dynamic management to solve these issues.

The privatisation of the water industry in England and Wales was complete. This meant that all the overground and underground assets, buildings, associated land and operation of the infrastructure were sold to the private sector.

In the years since privatisation considerable asset stripping (*e.g.* selling valuable development land in city centres deemed no longer needed) has taken place, adding value to the companies and their shareholders but little to the customers or to the community.

In later UK privatisation models, as in Scotland, private sector investment and engagement has been through granting long-term operating contracts to the private sector, while retaining the assets in public ownership. This was deemed more acceptable to society. The French model is much older but is also similar in principle to that adopted in Scotland.

The water companies have been partitioned into core businesses, supplying water and sewerage services and non-core or unregulated businesses. Many non-core businesses aggressively entered into diversification and acquisitions in the United Kingdom and overseas in the 1980s. Most of these were not successful and, with a few notable exceptions, the UK industry has tended to move back to water and related environmental businesses in the United Kingdom.

In all cases the strong regulatory environment provided by Ofwat protected the core business and continues to prevent excessive movement of funds from the core to more risky investments. The collapse of Enron and its subsidiary Azurix, which owned Wessex Water, was an extreme example, but the core regulated business was protected from the insolvency.

The continued pressure for efficiency from the investors and the economic regulators has led to significant reductions in staff since privatisation. There are concerns that this continued reduction in staff has reduced the skills, knowledge and expertise in the industry, which is increasingly reliant on external contractors to undertake its functions. Some commentators see a focus on financial management and a loss of technical and engineering expertise as being detrimental and unsustainable. In addition, there is an emphasis on short-term delivery and a loss of focus on long-term planning. Some water companies have taken radical approaches; Welsh Water has outsourced all its operations to other water companies and external contractors, leaving a very small core of managers to run the company. Conversely, this outsourcing has allowed the development of centres of excellence that have provided engineering consultancy and technical services to the water industry, with the best teams able to continuously supply services to all or at least many of the companies at once.

There has been an increasingly short-term view being taken by some of the water companies, focusing on pressure for growth and return to shareholders. The economic regulators have provided some protection, and the asset management programmes and the five-year periodic reviews have focused minds. However, many of the companies wait for the regulators to drive investment decisions and then minimise expenditure within the settlement. Ideally they should develop progressive and independent programmes and proactively press the regulators to fund them. Often companies press for minimal investment programmes. In addition, they try to optimise business gain by stop-start construction and investment within the five-year period. This has difficult repercussions for the construction and service industries supplying the water sector.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There are some concerns over the financing models adopted by some companies, especially in the current economic climate. There is considerable diversity in approach, which brings strength and knowledge; however, not all models will work in the long run.

The regulatory capital value of the water companies is now GBP 45 billion (Ofwat, 2007-08). In contrast, the net debt for the water and sewerage sectors now stands at GBP 30.8 billion (Ofwat, 2007-08). According to Ofwat, in 2007-08 the average gearing for all companies was 66% debt/regulatory capital value, a percentage that has been progressively increasing from 59% in 2003-04. Individually, companies range from 53% to 93% gearing, showing the radically different approach of some of them. Investment and ownership is now truly international, following a number of investment models including: original independent water company plc (shares on London stock exchange); multi-utility plc; private equity buy-out; and private buy-out by investment banks on behalf of foreign pension funds.

The UK regulatory process, with risk-based approaches, econometrics and performance benchmarking etc., together with the complex financial arrangements of the water companies, is becoming increasingly sophisticated and optimised. However, there is a danger that it is becoming so complex and technocratic that it will become difficult to gain a real picture or understanding of what is actually going on.

### *Outcome of the UK regulatory model*

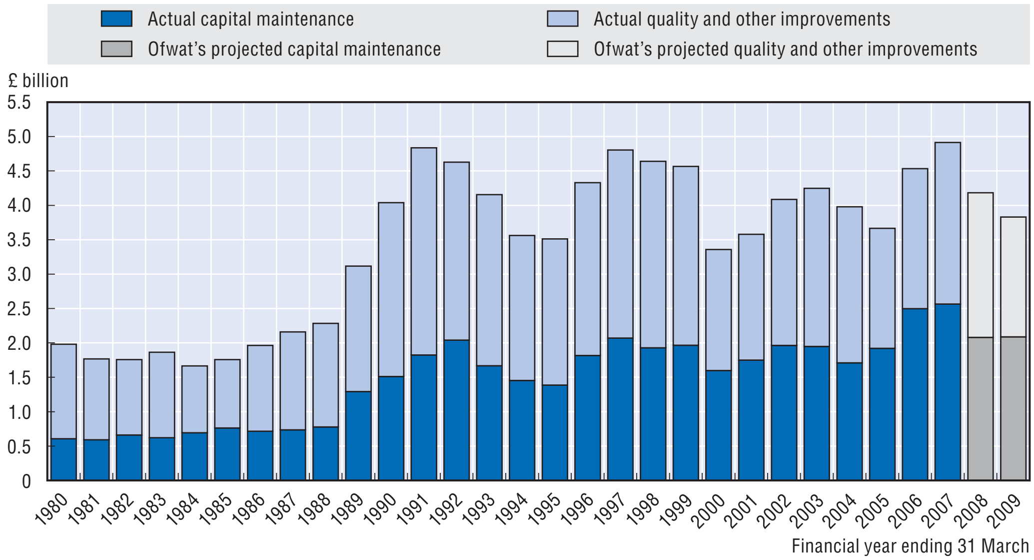
Since privatisation the UK water industry has delivered significantly increased investment in infrastructure and greatly increased the level of service provided while keeping water charges relatively steady. The greatly expanded asset base is being operated more efficiently, with operational costs falling over the period. However, the proportion of revenue required to service debts has increased steadily. The regulatory system has been effective in consistently ensuring that the service targets that were set were achieved at much lower cost than the projections and estimates prepared by the industry; this forces efficiency and innovation if a company wants to maintain their profit margins and survive commercially. Owfat provides data on the capital investment profile of the industry for investment in infrastructure to provide improved services and to maintain existing service levels. Figure 7.6 illustrates the capital investment profile of the industry for investment in infrastructure to provide improved services and investment to maintain existing service levels together with the effect of regulatory controls forcing lower expenditure than projected to achieve the same quality of service. Also shown is the relative apportionment of revenue, illustrated as portions of the average annual domestic water bill.

### *New directions for regulatory reform in UK model*

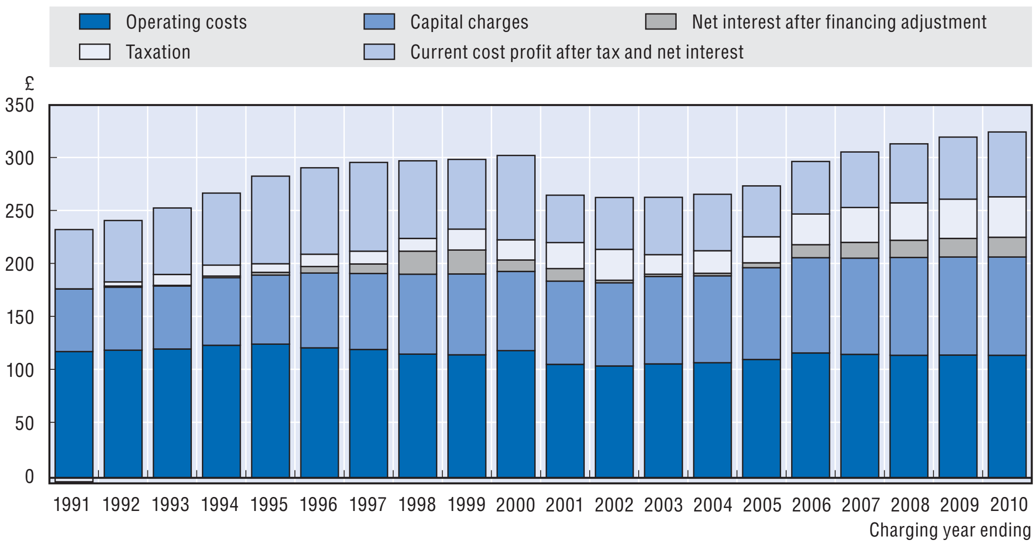
A perceived weakness of the UK water industry economic model is that companies can profit by making excessively high estimates of their capital expenditure requirements for the coming five years, obtaining the price uplifts from Ofwat to fund these investments, then delivering at much lower cost and retaining the difference as high profit margins and paying high dividends to shareholders. Such behaviour is considered unfair to the customer, who has no choice but to pay for it through higher bills. It became clear that the UK water companies indulged in this behaviour particularly during the AMP2 period (asset management plan) (1995 to 2000), which was corrected by a very harsh determination by Ofwat in the AMP3 (2000-05) period. Ofwat would like to move to a capital expenditure incentive scheme (CIS): a system of incentives that explicitly recognises that appointed

Figure 7.6. **Capital investment and revenue profiles of regulated water industries in England and Wales**

Annual capital investment




Average annual water bill proportionally divided by annual revenue expenditure categories




*Source:* Owfat (2008).

water companies have access to better information about their future capital expenditure needs than the regulators do. It offers a system of incentives to deal with this, structured so that the company has an incentive to produce realistic and credible expenditure forecasts before price limits are set. After price limits have been set each company retains the incentives to outperform their regulatory price determinations, with the reward being higher for those companies that have made more challenging expenditure assumptions. However, so far the complexity of settling the detailed mechanism for such an approach has delayed its formal introduction.

Another mechanism through which Ofwat has sought to drive greater capital efficiency has been the increased requirement to demonstrate that projects have undergone cost-benefit analysis (CBA). PR09 for the period 2010 to 2015 is the first periodic review to require detailed CBA for all schemes. However, the reaction from the industry so far suggests that the uncertainties about the many hard-to-define factors required for CBA, and the diversity of approaches, have meant that as yet it does not appear likely that the increased capital efficiency hoped for will be delivered (CIWEN, 2008).

The planning process for price setting is highly dependent on reliable prior knowledge of the cost of various items of infrastructure. Data on past outturn costs have been pooled by each company to form its "cost base" submission, the basis of its future cost estimating. Despite many years of gathering and analysing data for cost bases there remains considerable variation in cost estimates between companies, and this is a significant source of uncertainty in the regulatory process. Great effort is given to the scrutiny of cost base information in the review process. Initiating a similar cost base in China would be a major undertaking, but the earlier it is started the sooner such information would be available to inform decision making.

### *Impact of the credit crunch*

So far the impact of the credit crunch and the deepening recession has been relatively mild on the UK water industry. The share prices of the quoted companies have been more resilient than the market as a whole and may be regarded as relatively safe investments with reliable dividend returns in comparison with other stocks. However, there are a number of factors that can impact upon the profitability of the water companies and influence the Periodic Review Process for price setting. The most significant of these is the cost of capital. As heavily debt-financed businesses, the companies need to regularly renegotiate the loans they hold and to issue corporate bonds. The yield they have to offer on these bonds has increased very significantly. Recently the cost of capital (where available) has increased significantly in the short term. In the longer term the lower interest rates should filter through to lower capital costs. For the next five-year period, about 50% of the GBP 27 billion of new investment required will have to be funded from new sources of finance other than those existing arrangements; this could prove a significant challenge. In the United Kingdom, within the regulatory cycle a decision on the cost of capital must be taken by a committee of Ofwat economists in spring 2009, and will then form the basis of price determination for the following five years. In such an uncertain capital market as exists at present, this is a difficult call to make; some thought may need to be given to revising the basis of such calculations.

Another possible threat to water company operations would be rising customer debt as a result of an increasing number of customers experiencing financial hardship during the downturn. This will reduce revenues and increase costs for the water companies, and will also increase pressure within the Price Review Process for lower tariffs to permit greater affordability. However, just such a low and challenging determination could affect the credit rating of the companies, and so drive up the cost of capital and make programme delivery even more difficult.

## Lessons for China

### *Clarity of role*

The UK system may appear complex, but in fact roles are clear and have been further defined as the system has developed since privatisation. Roles are defined in the legislation governing each body and are set out in the primary legislation (Water Resources Acts and Environment Acts). They may be defined further by ministerial guidance and agreed memoranda of understanding between each regulator. While each organisation operates within this guidance, utilising their prescribed powers and duties, the system operates well. Occasionally one organisation has overstepped the mark and disputes have arisen, most times because of some ambiguity in law. This has usually occurred during price setting and has formed part of the adversarial debate. In this situation the Secretary of State has final jurisdiction and a ruling has been made.

In these respects of both structure and written regulation the UK system is much more transparent compared with the current Chinese situation with multiple and overlapping responsibilities across multiple ministries and levels of government ("9 Dragons") and limited written guidance. However the challenge of size is much greater in China and any Chinese regulatory system would have to be subdivided at a provincial level.

### *Improved standards*

The quality standards for potable water should be set at national level in order to protect and improve public health. These would normally be derived from the best technical practice and would reflect international standards, for example the World Health Authority standards. They should be accompanied by levels of service in terms of availability of water for industry and households. A timetable for achieving these standards should be set and some discretion may be made available for individual provinces to phase implementation to suit local needs. Achieving the standards should be mandatory, but the timescale and how the standards are achieved could be modified with agreement from national government. Strong and clear regulation should be put in place to ensure that these standards and the agreed programmes are met.

A similar approach should be taken with environmental quality objectives – specifically those for water quality, but they may also include air emissions and sludge disposal. The core environmental objectives should be set by national government and would normally reflect international best practice. However, the objectives would also normally reflect the needs of individual water bodies and would be informed by a River Basin Planning approach. As with the drinking water standards, the timescale and the methods of achieving the outcomes should be agreed with the provinces and monitoring put in place to ensure that the improvement programmes are realised through an economically realistic investment programme.

A phased approach to achieving these objectives should be considered, and a 20-year programme with key milestones might be considered.

In the United Kingdom progressive improvement in water quality was achieved by phased investment in response to tightening UK and European laws. Municipal and industrial discharges were improved in a risk-based and progressive way. Freshwaters were improved first with initial emphasis on protecting drinking water sources and then fisheries. Protection was then extended to estuaries and then the marine environments. The EU Urban Wastewater Treatment Directive consolidated the improvements by setting

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minimum standards for sewerage collection and treatment. The Bathing Water and Shellfish Waters Treatment Directives added tertiary treatment at specific sites. The Water Framework Directive promotes a more integrated view of river basin management to further improve environmental protection, based on achieving good ecological quality. It provides an environmental planning framework to set objectives and drive investment for the next 20 years of protection and improvement.

### *Monitoring and reporting*

The clear and well-defined monitoring of investment programmes and performance has proved essential to ensure the delivery of outcomes. The UK water companies have to produce comprehensive reports on their activities and outcomes every year ("June Reports") which are scrutinised and checked by Ofwat and the Reporters.

Monitoring programmes need to be integrated and may be undertaken by a number of different organisations, but co-ordinated and agreed by all. The Ofwat Report "Levels of Service for the Water Industry in England and Wales 2006-07" provides an example; it is compiled by Ofwat from information derived from all regulators. The report focuses on outcomes, related to an agreed statistic or indicator (for example, have drinking water standards been met 95% of the time). It should be noted that the report also monitors key elements of the process. For example, the construction of a treatment works may take a number of years and important milestones need to be reported.

### *Public availability of information*

The majority of regulatory performance information and environmental quality and drinking water quality information is published or can be easily obtained from the regulators or the water companies. Very little information is not in the public domain. Generally only commercially sensitive investment material is restricted. This is very important in maintaining public and customer confidence in the systems and services provided, and in developing a balanced view for future investment and priorities.

The setting of water company prices – the Periodic Review Process – provides an opportunity for public debate and discussion of options and opportunities, which will be paid for by customers. A sequence of consultation documents and open letters forms an important part of the process, leading up to guidance from the Secretary of State, and the final prices set by Ofwat. In the United Kingdom, this process operates separately in England, Scotland and Northern Ireland. A parallel to China would be a nationally consistent approach being operated in each province to a local timescale and data availability.

### *Importance of independent regulation*

The key element of the privatised water industry model is the role and strength of the independent regulators. The water companies are unusual in that they are monopolies with little market choice for customers, unlike electricity or gas. For this reason the role of the economic regulator in setting prices, comparing performance and protecting customers is vital.

The role of the Drinking Water Inspectorate in setting standards for potable water, defining levels of risk in treatment processes and ensuring that national and European standards are met is critical. These standards and their timetable for achievement impact on drinking water treatment processes, networks and monitoring requirements, and the investment required.

In addition, the role of the Environment Agency in protecting the environment in terms of water quality and quantity has been a fundamental component in ensuring the performance of the companies. The statutory water abstraction licences and discharge permits form a key element in regulating the privatised water companies. Permits also influence treatment methods, infrastructure requirements and performance.

Increasingly the views and the needs of customers (who pay for the service) are taken into account directly. To reflect this, the government has strengthened the role of the customer in the decision-making process and set up a new body in 2007 called the Consumer Council for Water. This allows customers' views to be channelled into the discussions at local and national levels.

These quality standards greatly influence costs, and clear regulation – combined with monitoring and enforcement – and are essential to ensure that companies undertake their duties in an effective way.

### *Summary comparison of models*

The typical Chinese privatisation model of letting contracts at a municipal level generally involves establishing a purchase cost for the investor to obtain a 49% stake in a Joint Venture company owning and operating the assets (which they may build) and negotiating a tariff that the local government will pay to the Joint Venture company for each unit of water, usually with conditions for taking guaranteed minimum quantities. The tariff paid by the customer to the local government may or may not be related to the tariff paid to the company, such that there may be a profit, or more often a loss, for the municipality. The tariff paid to the company was formerly related to a fixed return on investment rate, but is now better related to the real costs and revenues of the company. However, the Chinese regulatory models are far less sophisticated than incentive-based regulatory principles and processes that can help to strike the balance between the interests of the firm and the consumer in a fair and transparent way, as developed particularly in the United Kingdom.

During 2010-15, the water industry in England and Wales – serving a population of around 50 million, with around 23 million customers – will invest GBP 27 billion in capital maintenance and new infrastructure for improved service (Ofwat, 2008). That represents more than GBP 230 per year per customer from a total average bill of GBP 330 per customer. Between 1990 and 2010 the total investment in water services is estimated at GBP 70 billion. The industry has delivered a very high quality service, very much improved compared with that provided under public ownership up to 1989. The cost to customers has risen but to a lesser degree than the relative increase in the size of the industry. It is estimated that the efficiency gains of the regulated private industry save GBP 100 per year per customer (or 25%) (Water UK, 2008) compared with similar public provision.

Other OECD countries have found ways to achieve similar improvements in service and efficiency savings. In most areas there has been a move towards increased private participation in the industries, balanced by increased regulation and benchmarking. China can learn from these models but will need to invest considerable effort to establish the necessary institutional structures, reporting procedures and skilled human resource capacity to manage such systems.

The overall level of investment greatly exceeds anything that China has so far undertaken in its water sector. Scaling the UK rate of water investment (around GBP 3.5 billion per year) to China, with an urban population more than ten times the size

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of the UK population, would represent a significant fiscal commitment by the Chinese government. Finding ways to better leverage private sector involvement could lead to a more efficient, diverse and resilient system. Getting the required investment in second-level cities will be more challenging than the initial successes in getting private sector involvement in the capital cities.

### *Future directions for China*

The successes of the UK privatised model relied upon raising capital for investment not from the public sector but from the private sector, effectively by selling the public assets twice: first through the privatisation raising equity for the businesses and their assets through a public offering, and then again in subsequent years by the private companies borrowing against those assets and gearing the businesses to a high degree. Such a strategy reflects the course of capitalism generally over the past few decades – and as the current economic crisis indicates – such debt-based business has vulnerabilities. These problems have not yet precipitated a crisis in the water sector, and it is not certain that they will do so. But China should consider carefully the consequences of following such a privatisation route.

### *Notes*

1. For a full description of the water resource and water quality situation and the legislative and institutional framework in China, see OECD (2007), *Environmental Performance Review of China*. For detailed analysis of the progress made towards integrated river basin management, see the 2007 WWF/AusAUD publication *Taking Stock of Integrated River Basin Management in China*. For a detailed description of the situation of urban water utilities in China, refer to World Bank (2007), "Stepping Up: Improving the Performance of China's Urban Water Utilities". This report draws from these and other sources to identify some of the ways forward.
2. Chemical Oxygen Demand (COD) is a measure of the amount of material in the water that can react with oxygen in the water. The depletion of oxygen in waster is very bad for the health of the river ecosystem. This is a relatively straight forward chemical test that gives a general indication of the degree of pollution. The simple COD test does not differentiate between material that would react quickly or very slowly nor does it indicate chemical toxicity or impact on ecosystems. Other pollution measures such as Biological oxygen demand (BOD), ammonia concentration and the measure of nutrients are also required.
3. Environmental Impact Assessment.
4. There was a major reorganisation of Chinese ministries in 2008, with the former State Environmental Protection Agency (SEPA) being promoted to a full ministry with increased influence and funding.
5. This assertion is based on an interview with officials of MEP.
6. Also translated as "Regulations of Yellow River Water Regulating".
7. The water authorities of Qinghai, Sichuan, Gansu, Ningxia, Inner Mongolia, Shaanxi and Shanxi provinces/autonomous regions are responsible for regulation of the main stream and tributaries.
8. The Henan and Shandong Bureaus are responsible for water regulation of the Yellow River main stream only; the water authorities of Hebei Province and Tianjin Municipality are responsible for regulation of the water diverted from the Yellow River to their jurisdiction.
9. The Implementation Rules (2000) of the WPPC Law mention a discharge-permitting system but do not define it and could be legally challenged. A pilot discharge permit system is defined by SEPA decrees for the Huaihe and Taihu lake areas. Elsewhere discharge permits have been trialled but are not enforceable; nor was there any sanction for an enterprise that refuses to obtain such a discharge licence.
10. For examples see: 7 key tasks in 2007 for the Water Resource Protection Bureau, CWRC (Web news, 2007-2-13); Approval on the implementation scheme for water-saving society 2006-08 developed by

Tianjin WRB; Proposals from Mingjian (a democratic party) in Jinzhou, Liaoning Province: To unify the management of water affairs in city and rural area; Mr. Ye Jianchun, Director of Taihu Water Basin Management Bureau, MWR – To stipulate the integrated water basin management so as to ensue the sustainable water utilization. May, 18, 2006; Mr. Chen Qingqiu, South Institute of Technology, Guangzhou – A study on schemes of reforming Guangdong provincial government institution for unifying water resources administration, web news from Guangdong WRB, April 29, 2006.

11. Here, WRB refers to the provincial or municipal MWR department responsible for water resources management. In some cities the responsibilities of MWR and MOHURD have been combined to form the Water Affairs Bureaus WAB, which holds joint responsibility for water resources, monitoring and provision of water supply and wastewater treatment (where provided).
12. BREF Notes = Reference Document on the application of Best Available Techniques; Origin: European Council, prepared in accordance with EC Directive 96/61/EC on Integrated Pollution Prevention and Control (IPPC) Article 16(2): Exchange of information between EU member states and industry. They compile industry experience and recommended methods of cleaner production for each industry sector for exchange and dissemination.

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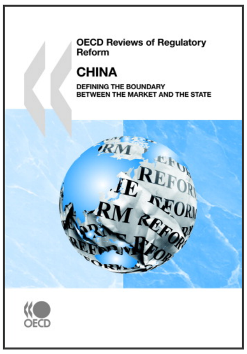


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